SIEMENS

SIPROTEC

Multifunctional Machine Protection 7UM62

V4.6

Manual

C53000-G1176-C149-7

Note

For safety purposes, please note instructions and warnings in the Preface.

Disclaimer of liability

We have checked the text of this manual against the hardware and software described. However, deviations from the description cannot be completely ruled out, so that no liability can be accepted for any errors or omissions contained in the information given.

The information given in this document is reviewed regularly and any necessary corrections will be included in subsequent editions. We appreciate any suggestions for improvement.

We reserve the right to make technical improvements without notice.

Document Version V04.63.00

Release date 03.2010

Siemens Aktiengesellschaft

Order no.: C53000-G1176-C147-7

Preface

Purpose of this Manual

This manual describes the functions, operation, installation, and commissioning of devices 7UM62. In particular, one will find:

- Information regarding the configuration of the scope of the device and a description of the device functions and settings → Chapter 2;
- Instructions for Installation and Commissioning → Chapter 3;
- Compilation of the Technical Data → Chapter 4;
- As well as a compilation of the most significant data for advanced users → Appendix A.

General information with regard to design, configuration, and operation of SIPROTEC 4 devices are set out in the SIPROTEC 4 System Description /1/.

Target Audience

Protection engineers, commissioning engineers, personnel concerned with adjustment, checking, and service of selective protective equipment, automatic and control facilities, and personnel of electrical facilities and power plants.

Applicability of this Manual

This manual applies to: SIPROTEC 4 Multifunctional Machine Protection 7UM62; firmware version V4.6.

Indication of Conformity

CE	This product complies with the directive of the Council of the European Communities on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 2004/108/EC) and concerning electrical equipment for use within specified voltage limits (Low-voltage directive 2006/95 EC). This conformity is proved by tests conducted by Siemens AG in accordance with the Council Directives in agreement with the generic standards EN61000-6-2 and EN 61000-6-4 for the EMC directive, and with the standard EN 60255-27 for the low-voltage directive. The device has been designed and produced for industrial use. The product conforms with the international standard of the series IEC 60255 and the German standard VDE 0435.

Additional Standards IEEE Std C37.90 (see Chapter 4, Technical Data")

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IND. CONT. EQ.

Additional Support

Should further information on the System SIPROTEC 4 be desired or should particular problems arise which are not covered sufficiently for the purchaser's purpose, the matter should be referred to the local Siemens representative.

Our Customer Support Center provides a 24-hour service.

Phone: 01 80/5 24 70 00

Fax: 01 80/5 24 24 71

E-mail: support.energy@siemens.com

Training Courses

Enquiries regarding individual training courses should be addressed to our Training Center:

Siemens AG

Power Transmission and Distribution

Siemens Power Academy TD

Humboldt Street 59

90459 Nuremberg

Telephone:0911 / 4 33-70 05

Fax:0911 / 4 33-79 29

Internet: www.siemens.com/power-academy-td

Safety Information

This manual does not constitute a complete index of all required safety measures for operation of the equipment (module, device), as special operational conditions may require additional measures. However, it comprises important information that should be noted for purposes of personal safety as well as avoiding material damage. Information that is highlighted by means of a warning triangle and according to the degree of danger, is illustrated as follows.

DANGER!

Danger indicates that death, severe personal injury or substantial material damage will result if proper precautions are not taken.

WARNING!

indicates that death, severe personal injury or substantial property damage may result if proper precautions are not taken.

Caution!

indicates that minor personal injury or property damage may result if proper precautions are not taken. This particularly applies to damage to or within the device itself and consequential damage thereof.

Note

indicates information on the device, handling of the device, or the respective part of the instruction manual which is important to be noted.

WARNING!

Qualified Personnel

Commissioning and operation of the equipment (module, device) as set out in this manual may only be carried out by qualified personnel. Qualified personnel in terms of the technical safety information as set out in this manual are persons who are authorized to commission, activate, to ground and to designate devices, systems and electrical circuits in accordance with the safety standards.

Use as prescribed

The operational equipment (device, module) may only be used for such applications as set out in the catalogue and the technical description, and only in combination with third-party equipment recommended or approved by Siemens.

The successful and safe operation of the device is dependent on proper handling, storage, installation, operation, and maintenance.

When operating an electrical equipment, certain parts of the device are inevitably subject to dangerous voltage. Severe personal injury or property damage may result if the device is not handled properly.

Before any connections are made, the device must be grounded to the ground terminal.

All circuit components connected to the voltage supply may be subject to dangerous voltage.

Dangerous voltage may be present in the device even after the power supply voltage has been removed (capacitors can still be charged).

Operational equipment with open circuited current transformer circuits may not be operated.

The limit values as specified in this manual or in the operating instructions may not be exceeded. This aspect must also be observed during testing and commissioning.

Typographic and Symbol Conventions

The following text formats are used when literal information from the device or to the device appear in the text flow:

`Parameter Names`

Designators of configuration or function parameters which may appear word-for-word in the display of the device or on the screen of a personal computer (with operation software DIGSI), are marked in bold letters in monospace type style. The same applies to the titles of menus.

`1,234A`

Parameter addresses have the same character style as parameter names. Parameter addresses contain the suffix **A** in the overview tables if the parameter can only be set in DIGSI via the option **Display additional settings**.

`Parameter Options`

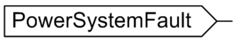
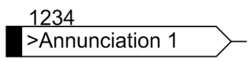
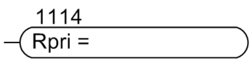
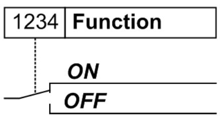
Possible settings of text parameters, which may appear word-for-word in the display of the device or on the screen of a personal computer (with operation software DIGSI), are additionally written in italics. The same applies to the options of the menus.

`„Messages“`

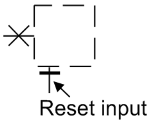
Designators for information, which may be output by the relay or required from other devices or from the switch gear, are marked in a monospace type style in quotation marks.

Deviations may be permitted in drawings and tables when the type of designator can be obviously derived from the illustration.

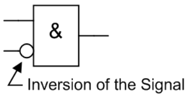
The following symbols are used in drawings:

	Device-internal logical input signal
	Device-internal logical output signal
	Internal input signal of an analog quantity
	External binary input signal with number (binary input, input indication)
	External binary output signal with number (example of a value indication)
	External binary output signal with number (device indication) used as input signal
	Example of a parameter switch designated **FUNCTION** with address 1234 and the possible settings ON and OFF

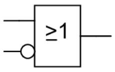
Besides these, graphical symbols are used in accordance with IEC 60617-12 and IEC 60617-13 or similar. Some of the most frequently used are listed below:



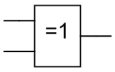
analog input values



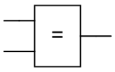
AND-gate operation of input values



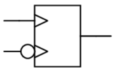
OR-gate operation of input values



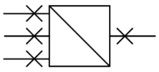
Exclusive OR gate (antivalence): output is active, if only **one** of the inputs is active



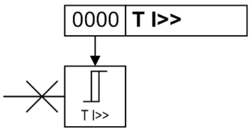
Coincidence gate: output is active, if **both** inputs are active or inactive at the same time



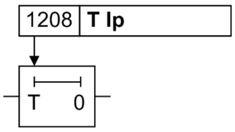
Dynamic inputs (edge-triggered) above with positive, below with negative edge



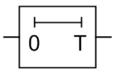
Formation of one analog output signal from a number of analog input signals



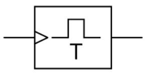
Limit stage with setting address and parameter designator (name)



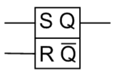
Timer (pickup delay T, example adjustable) with setting address and parameter designator (name)



Timer (dropout delay T, example non-adjustable)



Dynamic triggered pulse timer T (monoflop)



Static memory (RS-flipflop) with setting input (S), resetting input (R), output (Q) and inverted output ($\overline{Q}$)

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Contents

Introduction 1

This chapter introduces the SIPROTEC 4 7UM62. It provides an overview of the scopes of application, features and of the functional scope.

1.1 Overall Operation

The digital multifunctional protective relay 7UM62 is equipped with a high performance microprocessor. All tasks such as the acquisition of the measured values and issuing of commands to circuit breakers and other switching equipment are processed digitally. Figure 1-1 shows the basic structure of the device.

Analog Inputs

The measuring inputs (MI) section effect a gavanic isolation. They convert currents and voltages from the primary transformers to levels appropriate for the internal processing of the device.

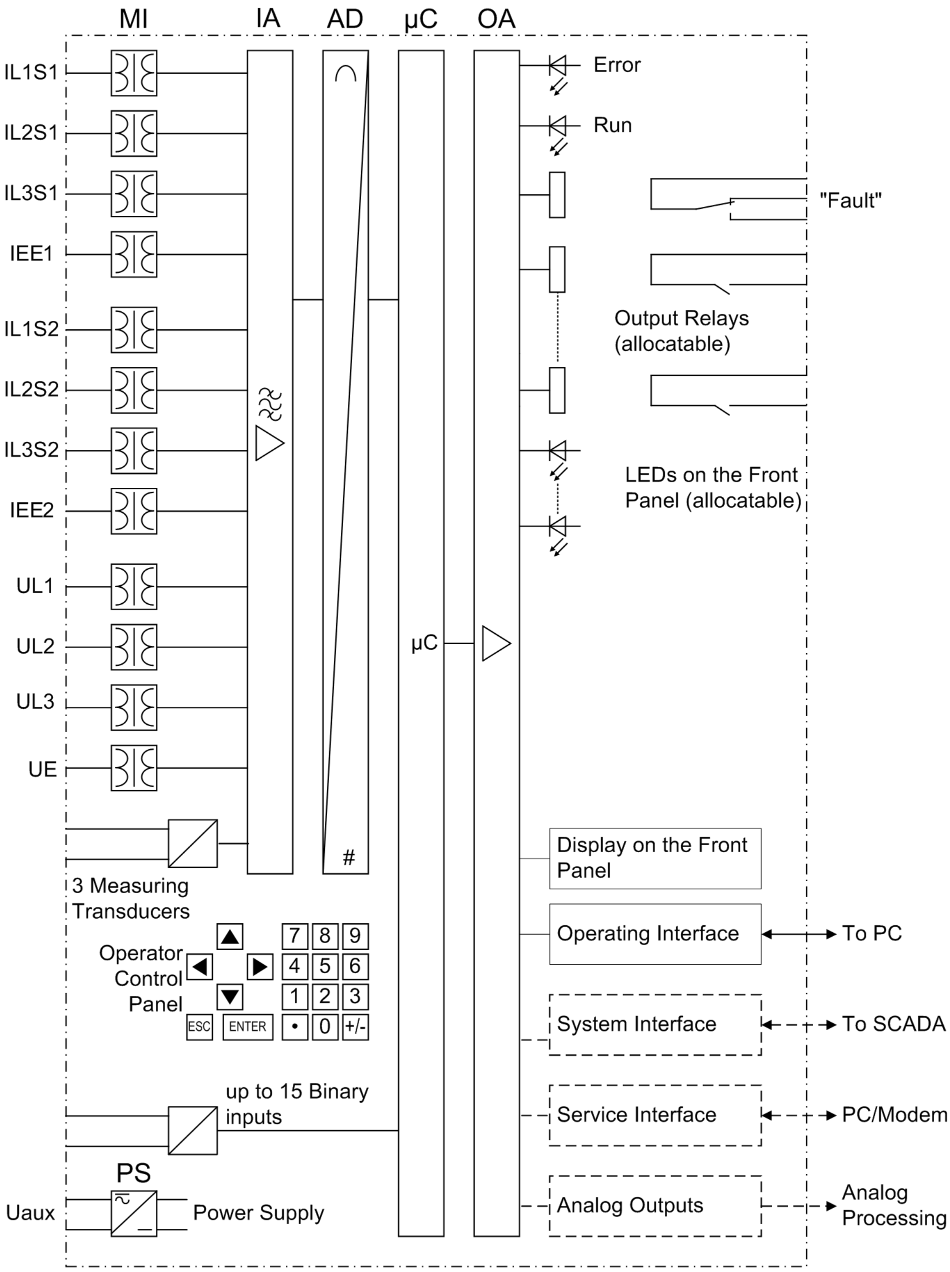


Figure 1-1 Hardware structure of the numerical multi-functional device 7UM62 (Maximum configuration)

The device has 8 current and 4 voltage inputs. Three current inputs are used on each side of the protected object for measuring of the phase currents. 2 current inputs are equipped with sensitive input transformers (I_{EE}) and can measure secondary currents in the mA range. 3 voltage inputs acquire the phase-to-earth voltages (connection to phase-to-phase voltages and voltage transformers in V connection is possible as well). The 4th voltage input is for the displacement voltage measurement for the stator and rotor earth fault protection.

The IA input amplifier group allows high impedance connection for analog input values and contains filters optimized for measured value processing bandwidth and speed.

The AD analog digital converter group contains high-resolution ΣΔ digital converters (22 bits) and memory components for data transfer to the microcomputer.

Micro Computer System

The implemented software is processed in the microcomputer system (µC). Major functions are:

- Filtering and conditioning of the measured signals,
- Continuous monitoring of the measured quantities,
- Monitoring of the pickup conditions for the individual protection functions,
- Querying of limit values and time sequences,
- Controlling signals for logic functions,
- Decision for trip commands,
- Signalling of protective actions via LEDs, LCD, relays or serial interfaces,
- Recording of messages, fault data and fault values for fault analyis,
- Management of the operating system and the associated functions such as data recording, real-time clock, communication, interfaces, etc.

Adaptation of Sampling Frequency

In order for the protection and measurement functions to produce correct results over a wide frequency range, the actual frequency is continuously measured and used for adjusting the sampling frequency for the measured value processing. This ensures measuring accuracy in the frequency range from 11 Hz to 69 Hz.

The sampling frequency adjustment can, however, operate only when at least one a.c. measured quantity is present at one of the analog inputs, with an amplitude of at least 5 % of rated value („operational condition 1“).

If no suitable measured values are present, or if the frequency is below 11 Hz or above 70 Hz, the device operates in „operational condition 0“.

Binary Inputs and Outputs

Binary inputs and outputs from and to the computer system are routed via the I/O modules (inputs and outputs). The computer system obtains the information from the system (e.g remote resetting) or the external equipment (e.g. blocking commands). Outputs are mainly commands that are issued to the switching devices and messages for remote signalling of events and states.

Front Elements

Light-emitting diodes (LEDs) and a display (LCD) on the front panel provide information on the functional status of the device and report events, states and measured values. The integrated control keys and numeric keys in conjunction with the LCD enable local interaction with the device. They allow the user to retrieve any kind of information from the device such as configuration and setting parameters, operational indications and fault messages (see also SIPROTEC 4 System Description /1/) and to change setting parameters.

Serial Interfaces

A personal computer running the DIGSI software can be connected to the serial operator interface (PC port) on the front panel to conveniently operate all device functions.

The serial service interface can equally be connected to a PC running DIGSI that communicates with the device. This port is especially well suited to permanently connect the devices to the PC or for remote operation via modem. The service interface can be also used for connecting a RTD box.

All data can be transferred to a central control or monitoring system via the serial system interface. Various protocols and physical arrangements are available for this interface to suit the particular application.

A further interface is provided for time synchronization of the internal clock through external synchronization sources.

Further communication protocols can be implemented via additional interface modules.

Analog Outputs / Temperature Input

Depending on the ordering variant and configuration, ports B and D can be equipped with analog output modules for the output of selected measured values (0 to 20 mA). If these ports are equipped with input modules (RS485 or optical) instead, temperatures can be fed in from an external temperature sensor.

Power Supply

The functional units described are supplied by a power supply PS with the necessary power in the different voltage levels. Voltage dips may occur if the voltage supply system (substation battery) becomes short-circuited. Usually, they are bridged by a capacitor (see also Technical Data).

1.2 Application Scope

The SIPROTEC 4 7UM62 is a numerical machine protection unit from the „7UM6 Numerical Protection“ series. It provides all functions necessary for protection of generators, motors and transformers. As the scope of functions of the 7UM62 can be customized, it is suited for small, medium-sized and large generators.

The device fulfills the protection requirements for the two typical basic connections:

- Busbar connection
- Unit connection

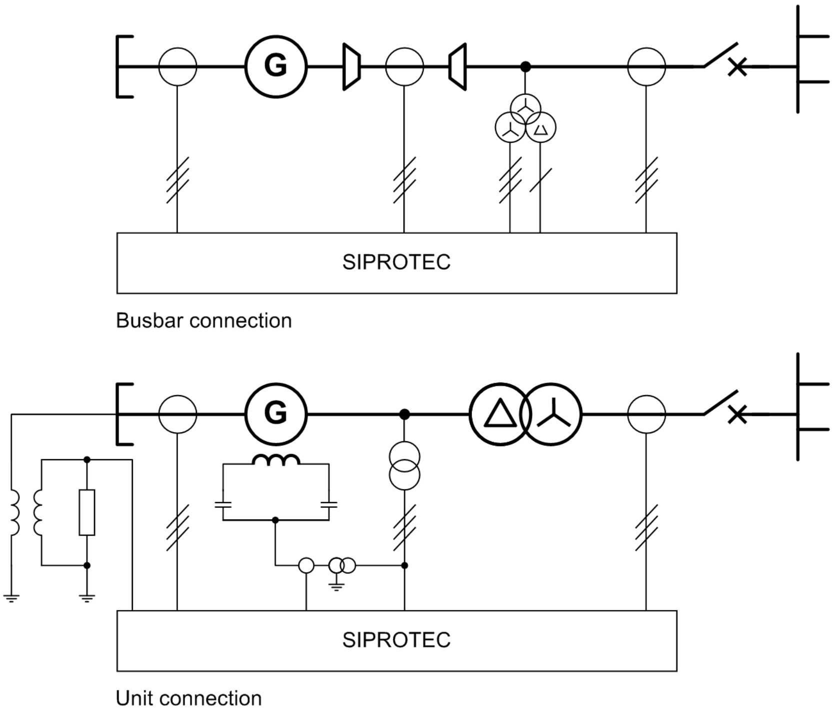


Figure 1-2 Typical connections

The integrated differential protection function can be used for longitudinal or transverse generator differential protection, for protection of the unit transformer or for overall differential protection.

The scalable software allows a wide range of applications, Corresponding function packages can be selected for each particular application. For instance, alone with the 7UM62 device, it is possible to provide comprehensive and reliable protection of generators from small to medium capacity (approx. 5 MW).

Additionally, the device forms the basis for the protection of medium to large size generators. Combined with the 7UM61 (also from the 7UM6 series), all protection requirements encountered in practice can be met from the smallest to the largest machines. This permits to implement a consistent concept for backup protection.

The 7UM62 device is usable for further applications such as

- Transformer protection, as the 7UM62 has in addition to differential and time-overcurrent protection a large variety of protection functions that allow, for instance, monitoring of the voltage and frequency load.
- Protection of large synchronous and asynchronous motors.

Messages and Measured Values; Recording of Event and Fault Data

The operational indications provide information about conditions in the power system and the device itself. Measurement quantities and resulting computed values can be displayed locally and communicated via the serial interfaces.

Device messages can be assigned to a number of LEDs on the front panel (allocatable), can be externally processed via output contacts (allocatable), linked with user-definable logic functions and/or issued via serial interfaces (see Communication below).

During a generator or network fault (fault in the power system), important events and state changes are stored in a fault annunciation buffer. The instantaneous or rms measured values during the fault are also stored in the device and are subsequently available for fault analysis.

Communication

Serial interfaces are available for the communication with operating, control and memory systems.

Front Interface

A 9-pin DSUB socket on the front panel is used for local communication with a personal computer. By means of the SIPROTEC 4 operating software DIGSI, all operational and evaluation tasks can be executed via this operator interface, such as specifying and modifying configuration parameters and settings, configuring user-specific logic functions, retrieving operational and fault messages and measured values, readout and display of fault recordings, querying of device statuses and measured values.

Rear Interfaces

Depending on the individual ordering variant, additional interfaces are located at the rear side of the device. They serve to establish an extensive communication with other digital operating, control and memory components:

The service interface can be operated via electrical data lines and also allows communication via modem. For this reason, remote operation is possible via personal computer and the DIGSI operating software, e.g. to operate several devices via a central PC.

The system interface ensures the central communication between the device and the substation controller. It can be operated via data lines or fibre optic cables. Several standard protocols are available for the data transfer:

- IEC 61850

  An EN 100 module allows to integrate the devices into 100 Mbit Ethernet communication networks used by process control and automation systems and running IEC 61850 protocols. In parallel to the process control integration of the device, this interface can also be used for communication with DIGSI and for inter-relay communication via GOOSE.
- IEC 60870-5-103

  This profile also integrates the devices into the substation automation systems SINAUT LSA and SICAM.
- Profibus DP

  This protocol of automation technology allows transmission of indications and measured values.
- Modbus ASCII/RTU

  This protocol of automation technology allows transmission of indications and measured values.
- DNP 3.0

  This protocol of automation technology allows transmission of indications and measured values.
- It is also possible to provide an analog output (2 x 20 mA) for output of measured values.

1.3 Characteristics

General Features

- Powerful 32-bit microprocessor system.
- Complete digital processing of measured values and control, from sampling and digitalization of measured quantities to tripping circuit breakers or other switchgear devices.
- Total galvanic and disturbance-immune separation between the internal processing stages of the device and the measuring, control and supply circuits of the system using measurement transducers, binary input and output modules and and the DC converters.
- Simple device operation using the integrated operator panel or by means of a connected personal computer running DIGSI.
- Continuous computation and display of operating measurement values.
- Storage of fault messages and instantaneous or rms values for fault recording.
- Continuous monitoring of measured values as well as of the hardware and software of the device.
- Communication with central control and memory storage equipment via serial interfaces, optionally via data cable, modem, or optic fibre lines.
- Battery-buffered clock that can be synchronized with an IRIG-B (via satellite) or DCF77 signal, binary input signal, or system interface command.
- Statistics: Recording of the number of trip signals instigated by the device and logging of currents switched off last by the device, as well as accumulated short-circuit currents of each pole of the circuit breaker.
- Operating Hours Counter: Tracking of operating hours of the equipment under load being protected.
- Commissioning aids such as connection check, field rotation check, status display of all binary inputs and outputs, and test measurement recording.

Definite-Time Overcurrent Protection (I>) with Under-voltage Seal-In

- 2 instantaneous (definite-time) stages, I> and I>>, for the 3 phase currents (I_{L1}, I_{L2}, I_{L3}) on side 1 or side 2.
- Seal-in of overcurrent pickup I> in case of undervoltage (e.g. for synchronous machines whose excitation voltage is obtained from the machine terminals);
- Additional directional determination with the I>> high-current stage optionally available;
- Blocking capability e.g. for reverse-interlocking busbar protection with any stage.

Inverse Time Overcurrent Protection (voltage-controlled)

- Selection possible from various characteristics (IEC, ANSI).
- Optionally voltage-controlled or voltage-dependent alteration of current pick-up behaviour during undervoltage;
- Voltage influencing can be blocked by fuse failure monitor or via voltage transformer protective circuit breaker.

Thermal Overload Protection 49

- Temperature image of current heat losses (overload protection with full memory capability, single body thermal model).
- Additional adjustable warning levels based on temperature rise and current magnitude.
- Consideration of coolant and ambient temperatures possible.

Negative Sequence Protection 46-1, 46-2, 46-TOC

- Precise evaluation of negative sequence component of the three phase currents.
- Alarm stage when a set unbalanced load is exceeded.
- Thermal characteristic with adjustable negative sequence factor and adjustable cooldown time.
- High-speed trip stage for large unbalanced loads (can be used for short-circuit protection).

Startup Overcurrent Protection

- I> stage for lower speed ranges (e.g. startup of generators with startup converter).

Differential Protection

- Use for **generator**, **motor** or **transformer differential protection**
- Tripping characteristic with restraining current;
- High sensitivity.
- Insensitivity to DC components and current transformer saturation;
- High degree of stability even with different degrees of CT saturation.
- Restraint feature against high inrush currents with 2nd harmonic;
- Restraint feature against transient and steady-state fault currents with 3rd or 5th harmonics;
- High-speed tripping in case of high-current faults;
- Integrated matching of transformer vector group.
- Integrated matching of transformation ratio with consideration of different c.t. rated currents.

Ground Current Differential Protection

- Tripping characteristic with restraining current;
- Variable selection of measured quantities for all normal system conditions.
- High sensitivity.
- Additional stabilisation measures against overfunction with external faults.

Underexcitation Protection

- Conductance measurement from positive sequence components.
- Multi-step characteristic for steady-state and dynamic stability limits.
- Consideration of the excitation voltage.

Reverse Power Protection

- Calculation of power from positive sequence components.
- Highly sensitive and precise active power measurement (detection of small motoring powers even with low power factor cos φ, angle error compensation).
- Insensitive to power fluctuations.
- Long-time stage and short-time stage (active with closed emergency tripping valve).

Forward Power Supervision

- Calculation of power from positive sequence components.
- Supervision the active power output for undershooting (P>) or overshooting (P<) the output specified with individually adjustable power limits.
- Optional high-speed or high-accuracy measurement.

Impedance Protection

- Overcurrent pickup with undervoltage seal-in (for synchronous machines which take their excitation voltage from the terminals).
- 2 impedance zones, 1 overreach zone (switchable via binary input), 4 time stages.
- Polygonal tripping characteristics;
- Power Swing Blocking (to be activated)

Out-of-step Protection

- Based on the well-proven impedance measurement method.
- Measurement enabling by positive sequence current component, and measurement blocking by negative sequence component.
- Evaluation of the course of the complex impedance vector;
- Optimum matching to power system conditions by selectable slope of the square wave characteristic.
- Reliable distinction between power swing centre being in the power system network and in the generator unit area.

Undervoltage Protection 27

- Two-stage undervoltage measurement of positive sequence component of voltages.
- Additional stage with settable, voltage-dependent time characteristic.

Overvoltage Protection 59

- Two-stage overvoltage measurement of the highest of the three voltages.
- Optionally with phase-to-phase voltages or phase-to-earth voltages.

Frequency Protection 81 O/U

- Monitoring on undershooting (f<) and/or overshooting (f>) with 4 frequency limits and delay times that are independently adjustable.
- Insensitive to harmonics and abrupt phase angle changes.
- Settable undervoltage threshold.

Overexcitation Protection

- Calculation of the U/f ratio
- Adjustable warning and tripping stage.
- Standard characteristic or arbitrary trip characteristic selectable for calculation of the thermal stress.

Frequency Change Protection

- Monitors whether the frequency overshoots (df/dt>) and/or undershoots (df/dt<) a set limit value, with 4 individually settable limit values or delay times.
- Variable measuring windows
- Coupling to frequency protection pickup.
- Settable undervoltage threshold.

Vector Jump

- Sensitive phase jump detection to be used for network disconnection.

90 % Stator Earth Fault Protection

- Suitable for generators in unit connection and directly connected to busbars.
- Measurement of displacement voltage via the neutral or earthing transformer or by calculation from phase-to-earth voltages.
- Sensitive earth current detection, optionally with or without directional determination with zero sequence components (I_0, U_0).
- Directional characteristic adjustable.
- Determination of the earth-faulted phase.

Sensitive Earth Fault Protection

- Two-stage earth fault current measurement: I_{EE}>> and I_{EE}>.
- High sensitivity (adjustable on the secondary side from 2 mA).
- Can be used for stator earth fault or rotor earth fault detection.
- Measurement circuit monitoring for minimum current flow when used for rotor earth fault protection.

100 % Stator Earth Fault Protection with 3rd Harmonic

- Detection of the 3rd harmonic of the voltage at the starpoint or open delta winding of an earthing transformer.
- Combined with the 90 % stator earth fault protection there is a protection of the entire stator winding (protective range 100 %).

100 % Stator Earth Fault Protection with 20 Hz Bias Voltage

- Evaluation of the 20 Hz measurement (7XT33 and 7XT34).
- Warning and trip stage R< and R<<.
- Trip stage with earth current.
- High sensitivity also with large stator earth capacitances.

Earth Current Protection B

- For various applications such as stator current supervision, any kind of earth current supervision and shaft current protection for detecting faults in bearings .
- Selection of different measurement methods possible (fundamental harmonic, 3rd harmonics and 1st and 3rd harmonics)
- High sensitivity (above 0.5 mA) by selected FIR filter

Interturn Fault Protection

- Detection of interturn faults in generators by measuring the displacement voltage opposite the generator starpoint
- High sensitivity (above 0.3 V)
- Suppression of disturbances by selected FIR filter

Rotor Earth Fault Protection (R, fn)

- 100 % protection for the entire excitation circuit.
- Symmetrical capacitive coupling of a system-frequency AC voltage into the excitation circuit
- with consideration of operational earth impedances and brush resistances
- Calculation of the fault resistance from the total impedance
- Alarm stage and tripping stage directly adjustable in Ohms (rotor-earth resistance)
- Measuring circuit supervision with alarm output.

Sensitive Rotor Earth Fault Protection with 1 to 3 Hz Square Wave Voltage Injection

- Evaluation of the 1 to 3 Hz square-wave voltage injected into the rotor circuit (7XT71).
- Warning and trip stage R< and R<<.
- High sensitivity (max. 80 KΩ).
- Integrated test function.

Motor Starting Time Supervision

- Inverse-time tripping based on an evaluation of the motor starting current
- Definite time delay with blocked rotor.

Restart Inhibit for Motors 66

- Approximate computation of rotor overtemperature.
- Startup is permitted only if the rotor has sufficient thermal reserves for a complete startup
- Calculation of waiting time until restarting is enabled.
- Different prolongation of cooldown time constants for standstill/operation period is taken into consideration.
- Disabling the restart inhibit is possible if an emergency startup is required.

Circuit Breaker Failure Protection 50BF

- By checking the current or evaluation of the breaker auxiliary contacts.
- Initiation of each integrated protection function allocated to the circuit breaker.
- Initiation possible through a binary input from an external protective device.

Inadvertent Energizing Protection

- Damage limitation for inadvertent switching-on of a stationary generator by fast opening of the generator switch.
- Instantaneous value acquisition of the phase currents.
- Operational state and voltage supervision as well as fuse failure monitor are the enable criteria.

DC Voltage / DC Current Protection

- DC voltage acquisition via integrated isolating amplifier.
- Suited for measurement of small DC currents.
- Can be switched for increase or decrease.
- Suitable also for AC voltage measurement (rms values).

Analog Outputs

- Output of up to four analog operational measured values (depending on the variant ordered).

Threshold Supervision

- 10 freely assignable indications for threshold supervision.
- Implementation of fast supervision tasks with CFC.

Temperature Measurement via Thermoboxes

- Acquisition of any ambient temperatures or coolant temperatures using RTD boxes and external temperature sensors.

IPhase Rotation

- Selectable phase sequence L1, L2, L3 or L1, L3, L2 via setting (static) or binary input (dynamic).

User-defined Functions

- Internal and external signals can be logically combined to establish user-defined logic functions.
- All common logic functions (AND, OR, NOT, Exclusive OR, etc.).
- Time delays and limit value interrogations.
- Processing of measured values, including zero suppression, adding a knee characteristic for a transducer input, and live-zero monitoring.

Breaker Control

- Circuit breakers can be opened and closed manually via programmable function keys, via the system interface (e.g. by SICAM or LSA), or via the operating interface (using a PC with DIGSI).
- Feedback information on circuit breakers states via the breaker auxiliary contacts.
- Plausibility monitoring of the circuit breaker position and monitoring of interlocking conditions for switching operations.

Measuring Transducer

- If the 3 measuring transducers present in the unit are not needed by the protection functions, they can be used to connect any type of analog signals (± 10 V, ± 20 mA).
- Threshold processing and logical linking of measurement signals possible.

Measurement Monitoring

- Increased reliability thanks to monitoring of internal measuring circuits, auxiliary power supply, hardware and software.
- Current transformer and voltage transformer secondary circuits are monitored using symmetry checks.
- Trip circuit monitoring possible via external circuitry.
- Phase sequence check.

■

Functions 2

This chapter describes the individual functions of the SIPROTEC 4 device 7UM62. It shows the setting possibilities for each function in maximum configuration. Guidelines for establishing setting values and, where required, formulae are given.

Based on the following information, it can also be determined which of the provided functions should be used.

2.1 Introduction, Reference Power System

The following section will explain the individual protection and additional functions and provide information about the setting values.

2.1.1 Functional Description

Generator

The calculation examples are based on two reference power systems with the two typical basic configurations **busbar connection** and **unit connection**. All default settings of the device are adapted accordingly. The following illustration shows how the measured quantities are assigned to side one or side two.

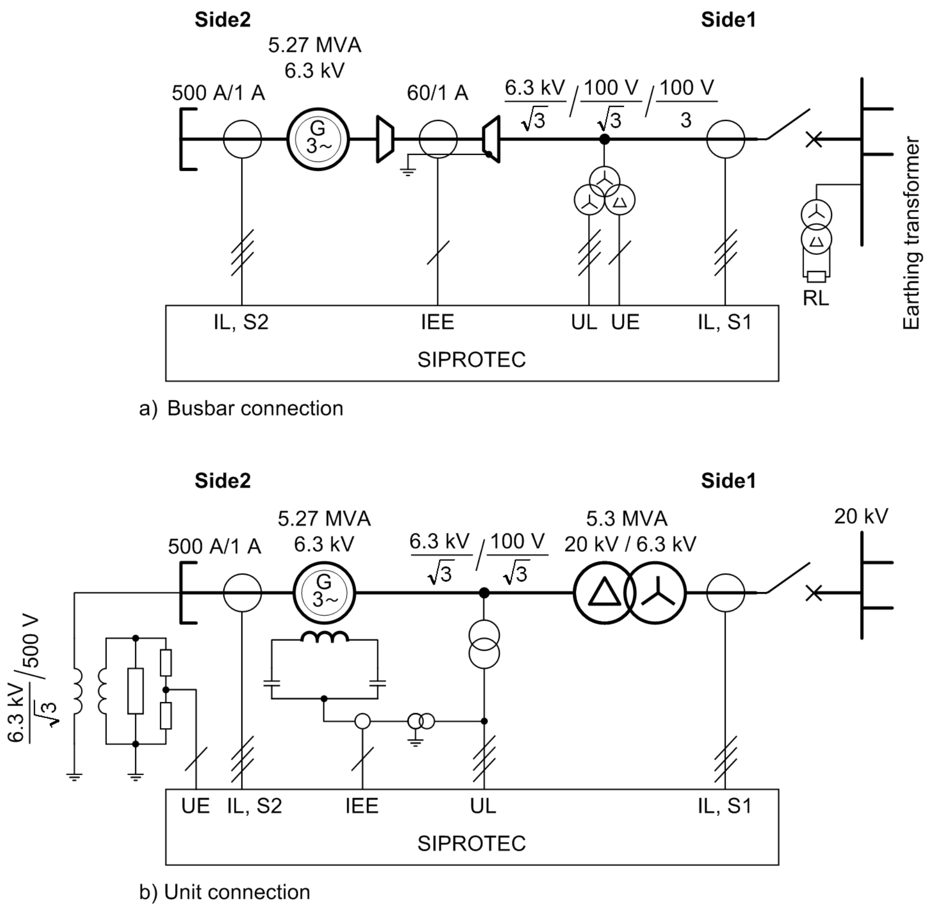


Figure 2-1 Reference Systems

Technical Data of the Reference Power Systems

Generator	$S_{N, G}$ = 5.27 MVA	
	$U_{N, G}$ = 6.3 kV	
	$I_{N, G}$ = 483 A	
	cos φ = 0.8	
Current transformer:	$I_{N,prim}$ = 500 A;	$I_{N, sec}$ = 1 A
Toroidal c.t.:	$I_{N,prim}$ = 60 A;	$I_{N, sec}$ = 1 A
Voltage transformer:	$U_{N, prim}$ = (6.3/√3) kV	$U_{N, sec}$ = (100/√3) V
		U_{en}/3 = (100/3) V

Transformer

Transformer:	$S_{N, T}$ = 5.3 MVA
	U_{prim} = 20 kV
	U = 6.3 kV
	u_{SC} = 7 %
Zero point transformer:	$ü = \frac{6.3\ kV}{\sqrt{3}} / 500\ V$
Resistor divider:	5 : 1

Motor

Motor	$U_{N, M}$ = 6600 V	
	$I_{N, M}$= 126 A	
	I_{START} = 624 A	(Starting current)
	I_{max} = 135 A	(Permissible continuous stator current)
	T_{START} = 8.5 s	(Starting time time at I_{START})
Current transformer:	$I_{N,prim}$ = 200 A;	$I_{N, sec}$ = 1 A

Further technical data is provided within the framework of the functional setting specifications of the individual protective functions.

The calculated setting values are secondary setting values related to the device and can be modified immediately by way of local operation.

The use of the DIGSI operating program is recommended for a complete reparameterization. In this way, the user can specify primary values in addition to secondary settings. Within the framework of the 7UM62 the specification of primary values is performed as a setting related to the nominal quantities of the object to be protected ($I_{N, G}$; $U_{N, G}$; $S_{N, G}$). This procedure has the advantage that system-independent, typical settings of the protective functions can be pre-specified. The data of the individual power system are updated in the **Power System Data 1** or **Power System Data 2** and the conversion to secondary values is executed via a mouse click. All necessary conversion formulas of the individual functions are stored in the operating program.

2.2 Device

The device can issue a serie of general annunciations about itself and the substation. These annunciations are listed in the following information list. Most annunciations are self-explanatory. The special cases are described below:

Reset: Device is reset on each Power ON.

Initial Start: Initial start occurs after initialization of the device by DIGSI.

Restart: Restart occurs after loading a parameter set or after reset.

The indication of messages masked to LEDs, and the maintenance of spontaneous messages, can be made dependent on whether the device has issued a trip command. In this situation, messages are not reported, if one or more protective functions have picked up on a fault, but a trip signal has not been issued yet by the 7UM62, because the fault was cleared by another device (for example, outside the own protection range). These messages are then limited to faults in the line to be protected.

2.2.1 Setting Notes

Spontaneous Fault Display

After a fault has occurred, the device display spontaneously shows the most important fault data. In address 610 **FltDisp.LED/LCD** you can select whether the spontaneous fault display is updated for each fault (***Target on PU***) or only for faults that included a trip (***Target on TRIP***).

For devices with graphical display use parameter 611 **Spont. FltDisp.** to specify whether a spontaneous fault display will be shown automatically (***YES***) or not (***NO***). For devices featuring a text display such displays will always appear a power system fault.

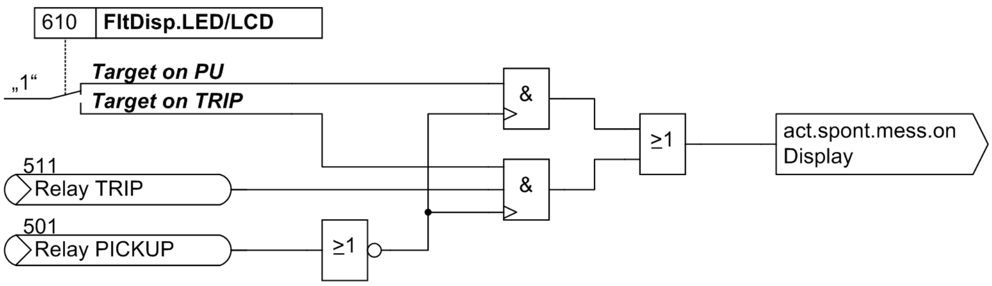


Figure 2-2 Generation of spontaneous fault indications on the display

Resetting stored LEDs / relays

A new pickup will generally erase any stored LEDs/relays so that only the latest fault information is displayed at any time. A time can be set in address 615 **T MIN LED HOLD** during which the stored LEDs and relays will not be deleted. Any information occurring during that period of time will be linked via OR.

The option ***Target on TRIP*** in address 610 **FltDisp.LED/LCD** allows you to delete the information of the most recent fault stored on LEDs and relays provided that this fault has not resulted in a trip command of the device.

Note

Setting address 610 **FltDisp.LED/LCD** to (***Target on TRIP***) is only reasonable if address 615 **T MIN LED HOLD** is set to 0.

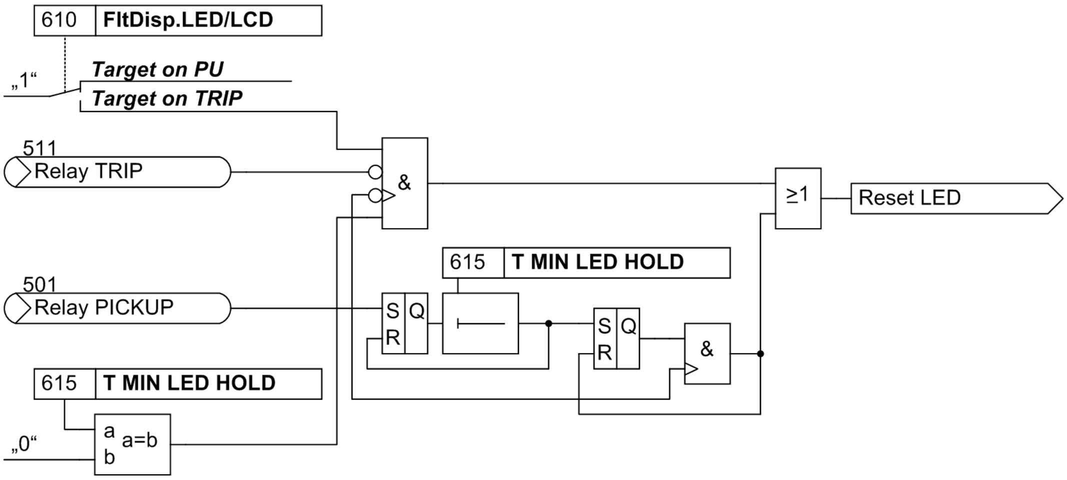


Figure 2-3 Creation of the resetting command for stored LEDs / relays

Default display of a 4-line display

After startup of the device featuring a 4-line display, measured values are displayed by default. The arrow keys on the device front allow different displays of the measured values to be selected for the so-called default display. The start image of the default display, which is displayed by default after startup of the device, can be selected via parameter 640 **Start image DD**. The available representation types for the measured value are listed in the Appendix.

2.2.2 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
610	FltDisp.LED/LCD	Target on PU Target on TRIP	Target on PU	Fault Display on LED / LCD
611	Spont. FltDisp.	YES NO	NO	Spontaneous display of flt.annunciations
615	T MIN LED HOLD	0 .. 60 min	5 min	Minimum hold time of lachted LEDs
640	Start image DD	image 1 image 2 image 3 image 4	image 1	Start image Default Display

2.2.3 Information List

No.	Information	Type of In- formation	Comments
-	Reset LED	IntSP	Reset LED
-	Test mode	IntSP	Test mode
-	DataStop	IntSP	Stop data transmission
-	UnlockDT	IntSP	Unlock data transmission via BI
-	>Light on	SP	>Back Light on
-	SynchClock	IntSP_Ev	Clock Synchronization
-	HWTestMod	IntSP	Hardware Test Mode
-	Distur.CFC	OUT	Disturbance CFC
1	Not configured	SP	No Function configured
2	Non Existent	SP	Function Not Available
3	>Time Synch	SP_Ev	>Synchronize Internal Real Time Clock
5	>Reset LED	SP	>Reset LED
15	>Test mode	SP	>Test mode
16	>DataStop	SP	>Stop data transmission
51	Device OK	OUT	Device is Operational and Protecting
52	ProtActive	IntSP	At Least 1 Protection Funct. is Active
55	Reset Device	OUT	Reset Device
56	Initial Start	OUT	Initial Start of Device
67	Resume	OUT	Resume
69	DayLightSavTime	OUT	Daylight Saving Time
70	Settings Calc.	OUT	Setting calculation is running
71	Settings Check	OUT	Settings Check
72	Level-2 change	OUT	Level-2 change
73	Local change	OUT	Local setting change
125	Chatter ON	OUT	Chatter ON
301	Pow.Sys.Flt.	OUT	Power System fault
302	Fault Event	OUT	Fault Event
320	Warn Mem. Data	OUT	Warn: Limit of Memory Data exceeded
321	Warn Mem. Para.	OUT	Warn: Limit of Memory Parameter exceeded
322	Warn Mem. Oper.	OUT	Warn: Limit of Memory Operation exceeded
323	Warn Mem. New	OUT	Warn: Limit of Memory New exceeded
545	PU Time	VI	Time from Pickup to drop out
546	TRIP Time	VI	Time from Pickup to TRIP

2.3 Ethernet EN100 Modul

2.3.1 Functional Description

An `Ethernet EN100 Modul` allows to integrate the 7UM62 into 100 Mbit Ethernet communication networks used by process control and automation systems and running IEC 61850 protocols. This standard provides consistent inter-relay communication without gateways or protocol converters. This allows open and interoperable use of SIPROTEC 4 devices even in heterogeneous environments. In parallel to the process control integration of the device, this interface can also be used for communication with DIGSI and for inter-relay communication via GOOSE.

2.3.2 Setting Notes

Interface Selection

No settings are required for operation of the Ethernet system interface module (IEC 61850 **Ethernet EN100 Modul**). If the device is equipped with such a module (see MLFB), the module is automatically configured to the interface available for it, namely ***Port B***.

2.3.3 Information List

No.	Information	Type of Information	Comments
009.0100	Failure Modul	IntSP	Failure EN100 Modul
009.0101	Fail Ch1	IntSP	Failure EN100 Link Channel 1 (Ch1)
009.0102	Fail Ch2	IntSP	Failure EN100 Link Channel 2 (Ch2)

2.4 Functional Scope

The 7UM62 device incorporates numerous protection and supplementary functions. The hardware and firmware provided is designed for this scope of functions. Nevertheless a few restrictions apply to the use of the earth fault current and earth fault voltage inputs I_{EE} and U_E respectively. The same input cannot be simultaneously fed with different measured values, e.g. for rotor earth fault protection and stator earth fault protection. Chapter 2.4.2 gives on overview of the particular inputs accessed by the various protection functions.

In addition the command functions can be matched to the system conditions. Also individual functions can be enabled or disabled during configuration. Functions not needed can be thus be deactivated.

The available protection and supplementary functions can be configured as ***Enabled*** or ***Disabled***. For some functions a choice between several alternatives is possible, as described below.

Functions that are configured as ***Disabled*** are not processed by the 7UM62: There are no indications, and corresponding settings (functions, limit values) are not displayed during setting.

2.4.1 Functional Description

Configuration of the Functional Scope

Configuration settings can be entered using a PC and the software program DIGSI and transferred via the front operator interface or the rear service interface. The procedure is described in detail in the SIPROTEC 4 System Description /1/.

Entry of password No. 7 (for parameter set) is required to modify configuration settings. Without the password, the settings may be read, but may not be modified and transmitted to the device.

The functional scope with the available alternatives is set in the Device Configuration dialog box to match equipment requirements.

Note

Available functions and default settings depend on the device variant ordered (see Appendix A.1 for details). Also, not all combinations of protective functions are possible because of certain restrictions imposed by the hardware (see Section 2.4.2).

2.4.2 Setting Notes

Peculiarities

Most settings are self-explanatory. The special cases are described below.

If the setting group change function has to be used, address 103 **Grp Chge OPTION** must be set to enabled. In this case, it is possible to apply two groups of settings for function parameters (refer also to Section 2.6) allowing convenient and fast switch-over between these setting groups. The setting ***Disabled*** implies that only one function parameter setting group can be applied and used.

Parameter 104 **FAULT VALUE** is used to specify whether the oscillographic fault recording should record ***Instant. values*** or ***RMS values***. If ***RMS values*** is stored, the available recording time increases by the factor 16.

For some protection functions you can also choose the measuring inputs of the device to which they will be allocated (side 1 or side 2); for other functions the allocation is fixed (see table 2-1).

For example, address 112 **O/C PROT. I>** allows such a choice for the I> stage of the time-overcurrent protection (= ***Side 1***, ***Side 2*** or ***Disabled***).

For the high-current stage I>> of the overcurrent protection, address 113 **O/C PROT. I>>** determines whether stage ***NonDirec. SIDE1*** or ***NonDirec.SIDE 2*** or ***Direc. SIDE1*** or ***Direc. SIDE2*** is to be operative. By selecting ***Disabled***, this overcurrent stage can be excluded altogether. For the inverse time overcurrent protection 114 **O/C PROT. Ip**, different sets of dependent characteristics are available, depending on the version ordered; they are either according to IEC or according to ANSI. This function, too, can be allocated to either side 1 or side 2 (= ***IEC SIDE 1***, ***ANSI SIDE 1***, ***IEC SIDE 2***, ***ANSI SIDE 2***). Inverse time overcurrent protection can be excluded altogether by selecting ***Disabled***.

The following table shows the allocation of device inputs to the protection functions. The interdependencies shown here must be kept in mind when configuring the power system. This concerns the U_E input, the two sensitive current inputs I_{ee1} and I_{ee2} as well as the 3 measuring transducer inputs (TD). Where the U_E input is used e.g. by the stator earth fault protection functions, it is no longer available for rotor earth fault protection (R, fn). The same interdependencies apply for measured value transformer inputs. They can be used only by one protection function in each case. Where the TDs are not used by any protection function, they are available for general processing by the measured value blocks in CFC.

Table 2-1 Allocation of Device Inputs to Protection Functions

Protection function		**Side 1**			**Side 2**		
	U_{L1}; U_{L2}; U_{L3}	I_{L1S1}; I_{L2S1}; I_{L3S1}	I_{ee1}	U_E	I_{L1S2}; I_{L2S2}; I_{L3S2}	I_{ee2}	**TD**
Definite-time I>; I>> /non-directional	Fixed	Selectable	–	–	Selectable	–	–
Definite-time I>>/directional	Fixed	Selectable	–	–	Selectable	–	–
Inverse-time overcurrent protection	Fixed	Selectable	–	–	Selectable	–	–
Thermal Overload Protection	–	–	–	–	Fixed	–	TD2
Unbalanced load protection	–	–	–	–	Fixed	–	–
Startup Overcurrent Protection	–	Selectable	–	–	Selectable	–	–
Differential Protection (ANSI 87G/87M/87T)	–	Fixed	–	–	Fixed	–	–
Earth Fault Differential Protection	U0 (calculated)	Selectable	–	–	Selectable	Fixed	–
Underexcitation (Loss-of-Field) Protection (ANSI 40)	Fixed	–	–	–	Fixed	–	TD3
Reverse Power Protection (ANSI 32R)	Fixed	–	–	–	Fixed	–	–
Forward power supervision	Fixed	–	–	–	Fixed	–	–
Impedance protection	Fixed	–	–	–	Fixed	–	–

Protection function		Side 1			Side 2		
	U_{L1}; U_{L2}; U_{L3}	I_{L1S1}; I_{L2S1}; I_{L3S1}	I_{ee1}	U_E	I_{L1S2}; I_{L2S2}; I_{L3S2}	I_{ee2}	TD
Out-of-Step Protection (ANSI 78)	Fixed	–	–	–	Fixed	–	–
Undervoltage Protection	Fixed	–	–	–	–	–	–
Overvoltage Protection	Fixed	–	–	–	–	–	–
Frequency Protection	Fixed	–	–	–	Fixed	–	–
Overexcitation protection U/f	Fixed	–	–	–	–	–	–
Inverse undervoltage protection	Fixed	–	–	–	–	–	–
Rate-of-frequency-change protection	Fixed	–	–	–	–	–	–
Jump of Voltage Vector	Fixed	–	–	–	–	–	–
90 % Stator Earth Fault Protection	U0 calculated if REFP is used	–	–	Se-lect-able	–	Fixed	–
Sensitive Earth Fault Protection (ANSI 51GN, 64R)	–	–	–	–	–	Select-able	–
100 % Stator Earth Fault Protection with 3rd Harmonics	Fixed	–	–	Fixed	Fixed	–	–
100 % Stator Earth Fault Protection with 20 Hz Bias Voltage	–	–	Fixed	Fixed	–	–	–
Earth current protection B (IEE-B)	–	–	Select-able	–	–	Select-able	–
Interturn Fault Protection	–	–	–	Fixed	–	–	–
Rotor Earth Fault Protection REFP	–	–	Fixed	Fixed	–	–	–
Sensitive Rotor Earth Fault Protection with 1 to 3 Hz Square Wave Voltage In-jection	–	–	–	–	–	–	TD1 TD2
Motor starting time supervision	–	–	–	–	Fixed	–	–
Restart inibit for motors	–	–	–	–	Fixed	–	–
Breaker Failure Protection	–	Selectable	–	–	Selectable	–	–
Inadvertent Energization (ANSI 50, 27)	Fixed	–	–	–	Fixed	–	–
DC voltage protection	–	–	–	–	–	–	TD1
Fuse Failure Monitor	Fixed	–	–	–	Fixed	–	–
Trip Circuit Monitor (ANSI 74TC)	–	–	–	–	–	–	–
Threshold Supervision	Fixed	–	–	–	Fixed	–	–
External Trip Coupling	–	–	–	–	–	–	–

For the differential protection, address 120 **DIFF. PROT.** allows to specify the type of protected object (***Generator/Motor*** or ***3 phase transf.***); the function can be excluded altogether by setting ***Disabled***.

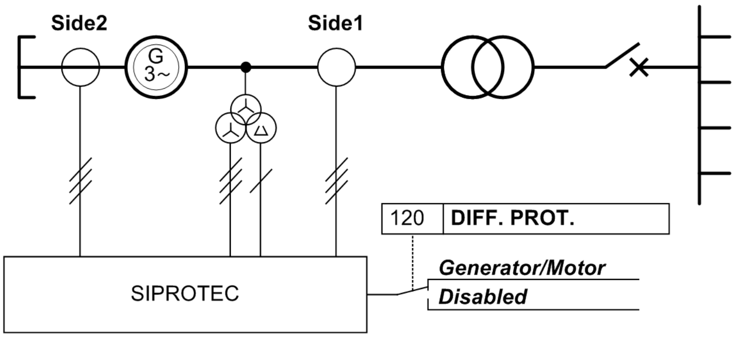


Figure 2-4 Use as Generator Differential Protection

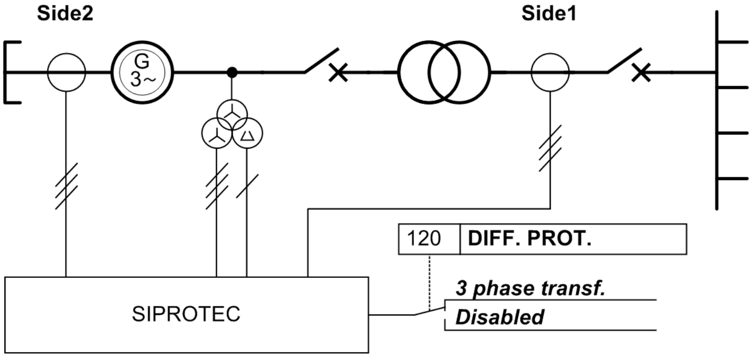


Figure 2-5 Use as Block Differential Protection (Overall Protection)

For the following application, the settings of the generator data under **P.System Data 1** must be same as for the transformer data of side 2:

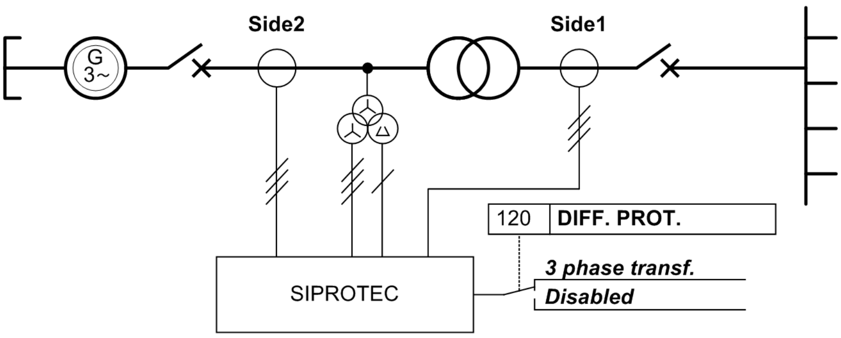


Figure 2-6 Use as Transformer Differential Protection

For the following application, the differential protection of device **A** must be set to ***Generator/Motor***, in the device **B** to ***3 phase transf.***. Also, the settings of the generator data under **P.System Data 1** must be same as for the transformer data of side 2:

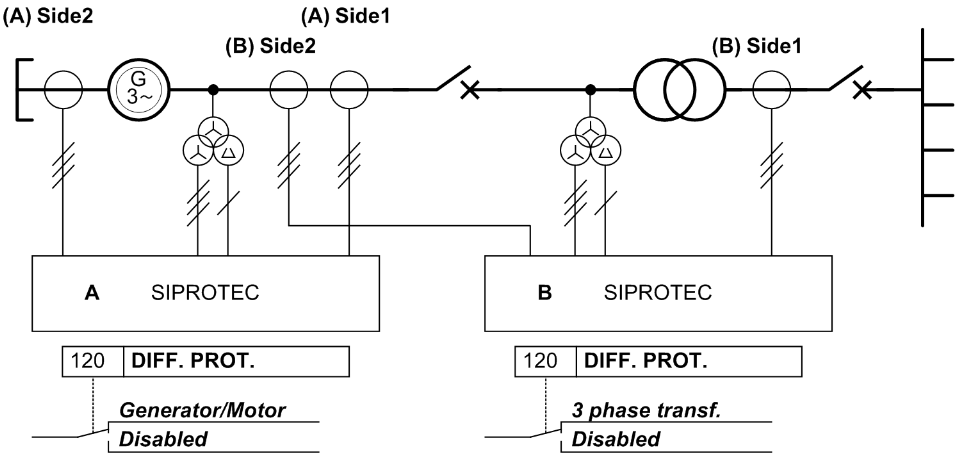


Figure 2-7 Use as Redundant Overall Protection

For earth fault protection, Address 150 **S/E/F PROT.** presents the options ***non-dir. U0***, ***non-dir. U0&I0*** and ***directional***, unless the whole function is ***Disabled***. The first option evaluates only the displacement voltage (to be used with unit connection). The second option evaluates, in addition to the displacement voltage, the magnitude of the earth fault current (or the difference between the starpoint current and the total current of a toroidal CT in busbar systems with low-ohmic switchable starpoint resistors). The third option considers as a further criterion the direction of the earth fault current if with machines in busbar connection the magnitudes of displacement voltage and earth fault current alone are not sufficient to distinguish between system earth faults and machine earth faults.

Address 151 **O/C PROT. IEE>** is used to specify which input will be used for earth fault current measurement (***with IEE1*** or ***with IEE2***).

Address 170 **BREAKER FAILURE** specifies whether the circuit breaker failure protection will apply for ***Side 1*** or ***Side 2***.

If the 7UM62 is equipped with analog outputs and you want to use them, the addresses 173, 174, 175 and 176 allow to allocate the available measured values to the analog outputs. All parameters of the analog outputs are accessed under the block address 7301 to 7308.

For trip circuit monitoring, address 182 **Trip Cir. Sup.** is used to specify whether two binary inputs (***2 Binary Inputs***) or only one (***1 Binary Input***) should be utilized, or whether the function is configured as ***Disabled***.

2.4.3 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
103	Grp Chge OPTION	Disabled Enabled	Disabled	Setting Group Change Option
104	FAULT VALUE	Disabled Instant. values RMS values	Instant. values	Fault values
112	O/C PROT. I>	Disabled Side 1 Side 2	Side 2	Overcurrent Protection I>
113	O/C PROT. I>>	Disabled NonDirec. SIDE1 NonDirec.SIDE 2 Direc. SIDE1 Direc. SIDE2	NonDirec.SIDE 2	Overcurrent Protection I>>
114	O/C PROT. Ip	Disabled IEC SIDE 1 ANSI SIDE 1 IEC SIDE 2 ANSI SIDE 2	Disabled	Inverse O/C Time Protection
116	Therm.Overload	Disabled Enabled	Enabled	Thermal Overload Protection
117	UNBALANCE LOAD	Disabled Enabled	Enabled	Unbalance Load (Negative Sequence)
118	O/C STARTUP	Disabled Side 1 Side 2	Disabled	Startup O/C protection
120	DIFF. PROT.	Disabled Generator/Motor 3 phase transf.	Generator/Motor	Differential Protection
121	REF PROT.	Disabled Gen. with IEE2 Gen. w. 3I0-S2 Transformer S1 Transformer S2	Disabled	Restricted earth fault protection
130	UNDEREXCIT.	Disabled Enabled	Enabled	Underexcitation Protection
131	REVERSE POWER	Disabled Enabled	Enabled	Reverse Power Protection
132	FORWARD POWER	Disabled Enabled	Enabled	Forward Power Supervision
133	IMPEDANCE PROT.	Disabled Enabled	Enabled	Impedance Protection
135	OUT-OF-STEP	Disabled Enabled	Enabled	Out-of-Step Protection
140	UNDERVOLTAGE	Disabled Enabled	Enabled	Undervoltage Protection
141	OVERVOLTAGE	Disabled Enabled	Enabled	Overvoltage Protection
142	FREQUENCY Prot.	Disabled Enabled	Enabled	Over / Underfrequency Protection
143	OVEREXC. PROT.	Disabled Enabled	Enabled	Overexcitation Protection (U/f)

Addr.	Parameter	Setting Options	Default Setting	Comments
144	INV.UNDERVOLT.	Disabled Enabled	Enabled	Inverse Undervoltage Protection Up<
145	df/dt Protect.	Disabled 2 df/dt stages 4 df/dt stages	2 df/dt stages	Rate-of-frequency-change protection
146	VECTOR JUMP	Disabled Enabled	Enabled	Jump of Voltage Vector
150	S/E/F PROT.	Disabled non-dir. U0 non-dir. U0&I0 directional	non-dir. U0&I0	Stator Earth Fault Protection
151	O/C PROT. IEE>	Disabled with IEE1 with IEE2	with IEE2	Sensitive Earth Current Protection
152	SEF 3rd HARM.	Disabled Enabled	Enabled	Stator Earth Fault Prot. 3rd Harmonic
153	100% SEF-PROT.	Disabled Enabled	Enabled	100% Stator-Earth-Fault Protection
154	O/C PROT IEE-B	Disabled with IEE1 with IEE2	with IEE2	Sensitive Earth Current Protection B
155	INTERTURN PROT	Disabled Enabled	Enabled	Interturn Protection
160	ROTOR E/F	Disabled Enabled	Enabled	Rotor Earth Fault Protection (R, fn)
161	REF 1-3Hz	Disabled Enabled	Enabled	Rotor Earth Fault Protection (1-3Hz)
165	STARTUP MOTOR	Disabled Enabled	Enabled	Motor Starting Time Supervision
166	RESTART INHIBIT	Disabled Enabled	Enabled	Restart Inhibit for Motors
170	BREAKER FAILURE	Disabled Side 1 Side 2	Side 2	Breaker Failure Protection
171	INADVERT. EN.	Disabled Enabled	Enabled	Inadvertent Energisation
172	DC PROTECTION	Disabled Enabled	Enabled	DC Voltage/Current Protection

Addr.	Parameter	Setting Options	Default Setting	Comments
173	ANALOGOUTP B1/1	Disabled I1 [%] I2 [%] IEE1 [%] IEE2 [%] U1 [%] U0 [%] U03H [%] |P| [%] |Q| [%] |S| [%] f [%] U/f [%] PHI [%] |PF| [%] ΘR/ΘRmax [%] Θ/Θtrip [%] RE REF [%] RE REF 1-3Hz[%] RE SEF100 [%]	Disabled	Analog Output B1/1 (Port B)
174	ANALOGOUTP B2/1	Disabled I1 [%] I2 [%] IEE1 [%] IEE2 [%] U1 [%] U0 [%] U03H [%] |P| [%] |Q| [%] |S| [%] f [%] U/f [%] PHI [%] |PF| [%] ΘR/ΘRmax [%] Θ/Θtrip [%] RE REF [%] RE REF 1-3Hz[%] RE SEF100 [%]	Disabled	Analog Output B2/1 (Port B)

Addr.	Parameter	Setting Options	Default Setting	Comments
175	ANALOGOUTP D1/1	Disabled I1 [%] I2 [%] IEE1 [%] IEE2 [%] U1 [%] U0 [%] U03H [%] |P| [%] |Q| [%] |S| [%] f [%] U/f [%] PHI [%] |PF| [%] ΘR/ΘRmax [%] Θ/Θtrip [%] RE REF [%] RE REF 1-3Hz[%] RE SEF100 [%]	Disabled	Analog Output D1/1 (Port D)
176	ANALOGOUTP D2/1	Disabled I1 [%] I2 [%] IEE1 [%] IEE2 [%] U1 [%] U0 [%] U03H [%] |P| [%] |Q| [%] |S| [%] f [%] U/f [%] PHI [%] |PF| [%] ΘR/ΘRmax [%] Θ/Θtrip [%] RE REF [%] RE REF 1-3Hz[%] RE SEF100 [%]	Disabled	Analog Output D2/1 (Port D)
180	FUSE FAIL MON.	Disabled Enabled	Enabled	Fuse Failure Monitor
181	M.V. SUPERV	Disabled Enabled	Enabled	Measured Values Supervision
182	Trip Cir. Sup.	Disabled 2 Binary Inputs 1 Binary Input	Disabled	Trip Circuit Supervision
185	THRESHOLD	Disabled Enabled	Enabled	Threshold Supervision
186	EXT. TRIP 1	Disabled Enabled	Enabled	External Trip Function 1
187	EXT. TRIP 2	Disabled Enabled	Enabled	External Trip Function 2
188	EXT. TRIP 3	Disabled Enabled	Enabled	External Trip Function 3
189	EXT. TRIP 4	Disabled Enabled	Enabled	External Trip Function 4

Addr.	Parameter	Setting Options	Default Setting	Comments
190	RTD-BOX INPUT	Disabled Port C Port D	Disabled	External Temperature Input
191	RTD CONNECTION	6 RTD simplex 6 RTD HDX 12 RTD HDX	6 RTD simplex	Ext. Temperature Input Connection Type
200	ANALOGOUTP B1/2	Disabled P [%] Q [%] S [%] f [%] PF [%] PHI [%] U1 [%] I2 [%] I1 [%]	Disabled	Analog Output B1/2 (Port B)
201	ANALOGOUTP B2/2	Disabled P [%] Q [%] S [%] f [%] PF [%] PHI [%] U1 [%] I2 [%] I1 [%]	Disabled	Analog Output B2/2 (Port B)
202	ANALOGOUTP D1/2	Disabled P [%] Q [%] S [%] f [%] PF [%] PHI [%] U1 [%] I2 [%] I1 [%]	Disabled	Analog Output D1/2 (Port D)
203	ANALOGOUTP D2/2	Disabled P [%] Q [%] S [%] f [%] PF [%] PHI [%] U1 [%] I2 [%] I1 [%]	Disabled	Analog Output D2/2 (Port D)

2.5 Power System Data 1

The device requires some plant and power system data to adapt its functions to the actual application. These include, for instance, rated power system and transformer data, measured quantity polarities and connection, breaker properties etc. There are also certain parameters common to all functions, i.e. not associated with a specific protection, control or monitoring function. Section **P.System Data 1** describes these data.

2.5.1 Setting Notes

General

The Power System Data 1 can be changed from the operator or service interface with a personal computer using DIGSI.

In DIGSI double-click on **Settings** to display the relevant selection.

Connection of the Current Transformer Sets

Under address 201 **STRPNT->OBJ S1** the polarity of the current transformers of side 1 of the system needs to be specified, i.e. according to the position of the wye-connected current transformer with reference to the object to be protected. Address 210 **STRPNT->OBJ S2** describes the polarity of the current transformers of side 2. This setting determines the measuring direction of the device (**STRPNT->OBJ S2** = ***YES*** = forward = line direction). The following figure shows the definition even in cases where there are no starpoint CTs.

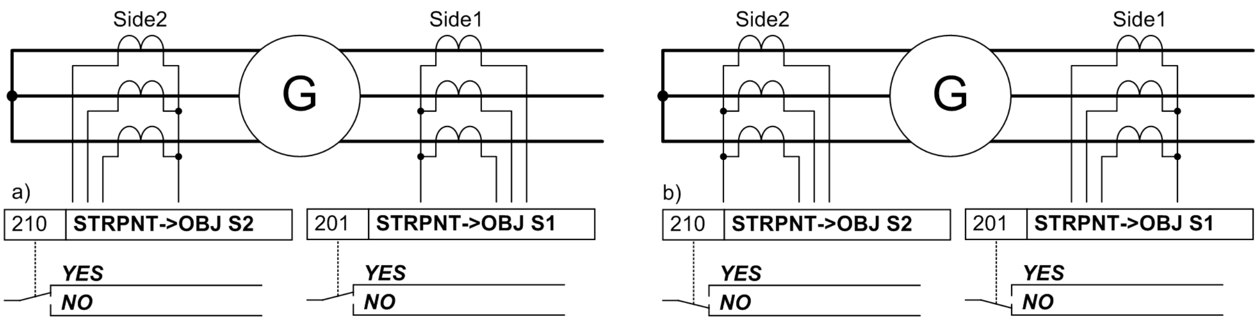


Figure 2-8 Location of starpoints for CTs of S1 and S2 - addresses 201 and 210 -

If the device is applied as transverse differential protection for generators or motors, special considerations must be observed for the CT connections: In a healthy operational state all currents flow into the protected object, i.e. in contrast to the other applications. Therefore you have to set a „wrong“ polarity for one of the current transformer sets. The part windings of the machine windings correspond to the „sides“.

The following figure shows an example. Although the starpoints of both CT sets are turned towards the protected object, „side 2“ is set to the opposite: **STRPNT->OBJ S2** = ***NO***.

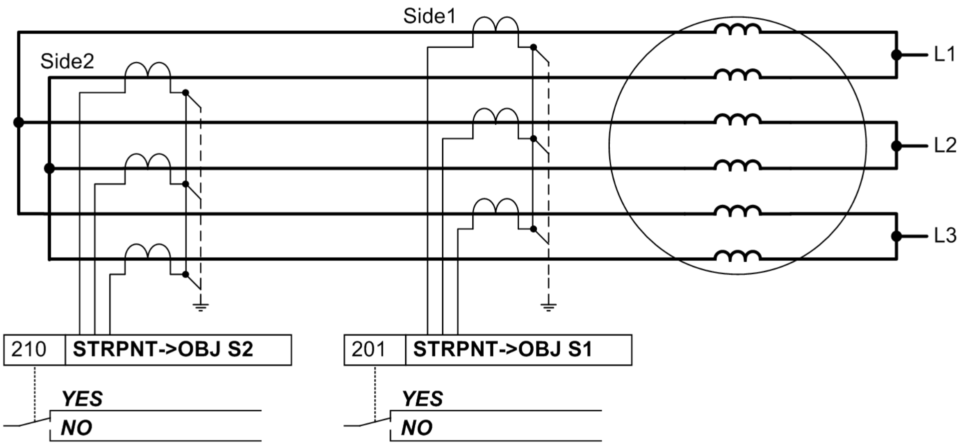


Figure 2-9 Current transformer starpoints in transverse differential protection - Example

Nominal Values of the Transformers on Side 1

At addresses 202 **IN-PRI I-SIDE1** and 203 **IN-SEC I-SIDE1** information is entered regarding the primary and secondary nominal currents of the CTs of side 1. It is important to ensure that the rated secondary current of the current transformer matches the rated current of the device, otherwise the device will calculate incorrectly primary data.

Nominal Values of the Transformers on Side 2

At addresses 211 **IN-PRI I-SIDE2** and 212 **IN-SEC I-SIDE2** information is entered regarding the primary and secondary nominal currents of the CTs of side 2. It is important to ensure that the rated secondary current of the current transformer matches the rated current of the device, otherwise the device will calculate incorrectly primarydata.

W0 Correction Angle

A correction of the angle faults of the current and voltage transformers is particularly important with regard to reverse power protection, as in this case a very low active power is computed from a very high apparent power (for small cos φ).

At address 204 **CT ANGLE W0** a constant correction angle can be entered for the CTs of side 2.

The angle fault difference $\Delta\varphi$ between the current and voltage transformers is particularly important in this context. As a correction, the sum of the mean angle errors of the current and voltage transformers is set. The correction value can be determined during machine commissioning (see Section Installation and Commissioning).

Transformation Ratios IEE

For the conversion of the ground currents Iee in primary quantities, the device requires the primary/secondary transformation ratio of the earth CTs. The transformation ratio for input 1 is set at the address 205 **FACTOR IEE1**, the ratio for input 2 at 213 **FACTOR IEE2** .

Nominal Values of Voltage Transformers

At addresses 221 **Unom PRIMARY** and 222 **Unom SECONDARY**, information is entered regarding the primary nominal voltage and secondary nominal voltages (phase-to-phase) of the connected voltage transformers.

U_E Connection

At address 223 **UE CONNECTION**, the user specifies to the device which type of voltage is connected to the U_E input. The device establishes from this information the type of processing involved. The U_E input is used for either the various stator earth fault protection functions or for rotor earth fault protection using the rated frequency measurement method (see Section 2.34). The following table shows the interdependencies for each protection function.

Table 2-2 Setting Options for the U_E Input and their Impact on the Protection Functions

Setting of Unom SECONDARY	90% Stator Earth Fault Protection	Stator Earth Fault Protection with 3rd Harmonics	100% Stator Earth Fault Protection with Bias Voltage (20 Hz)	Rotor Earth Fault Protection (R, fn)	Interturn Fault Protection
(Addr. 223)	**(Section 2.28)**	**(Section 2.30)**	**(Section 2.31)**	**(Section 2.34)**	**(Section 2.33)**
Not connected	Computed U0 measured value is being processed (precisely: $\sqrt{3}$ U0)	Determination of 3rd harmonics from calculated U0 voltage (only U0 3rd harm > stage usable).	–	–	–
Load. resistor	Computed U0 measured value is being processed (precisely: $\sqrt{3}$ U0)	–	U_E input is being processed	–	–
any VT	U_E input is being processed (e.g. earth fault protection on transformer side)	–	–	–	–
broken delta	Processing of U_E input	Processing of U_E input	U_E input is being processed	–	–
Rotor	Computed U0 measured value is being processed (precisely: $\sqrt{3}$ U0)	–	–	Processing of U_E input	–
neutr. transf.	Processing of U_E input	Processing of U_E input	U_E input is being processed	–	–
Uen-winding	Computed U0 measured value is being processed (precisely: $\sqrt{3}$U0)	Determination of 3rd harmonics from calculated U0 voltage (only U0 3rd harm > stage usable).	–	–	Processing of U_E input

Transformation Ratio UE

For the conversion of the displacement voltage U_E in primary quantities, the device requires the primary/secondary transformation ratio of the transformer delivering the U_E voltage. With the exception of the rotor earth fault protection, the 224 **FACTOR UE** has an impact on those protection functions which process the U_E input directly, in accordance with Table 2-2. For this ratio 224 **FACTOR UE** the following generally applies:

$$0224\ \text{FACTOR UE} = \frac{U_{VT,\ prim.}}{U_{E,\ sec}}$$

In this context, $U_{VT, prim}$ is the primary voltage (generally phase-ground voltage) and $U_{E, sec}$ is the secondary displacement voltage applied to the device. If a voltage divider is used, its division ratio also influences this factor. The following equation results for the example in Section 2.1 Figure 2-1 „Unit connection", with the power system data selected there and an 1:5 voltage divider ratio

$$\text{0224 FACTOR UE} = \frac{6.3\ \text{kV}/(\sqrt{3})}{500\ \text{V}/5} = 36.4$$

Adjustment Factor Uph/Udelta

The address 225 serves to communicate the adaptation factor between the phase voltage and the displacement voltage to the device. This information is relevant for measured quantity monitoring.

If the voltage transformer set has open delta windings and if these windings are connected to the device (U_E input), this must be specified accordingly in address 223 (see above). Since the transformation between voltage transformers usually is as follows:

$$\frac{U_{Nprim}}{\sqrt{3}} / \frac{U_{Nsec}}{\sqrt{3}} / \frac{U_{Nsec}}{3}$$

the factor Uph/Udelta (secondary voltage, address 225 **Uph / Udelta**) in relation to 3/√3 = √3 = 1.73 must be used if the Udelta voltage is connected. For other transformation ratios, i.e. the formation of the displacement voltage via an interconnected transformer set, the factor must be corrected accordingly.

Protected Object: Transformer

If a transformer was specified as the protected object during differential protection configuration, the parameter 241 **UN-PRI SIDE 1** appears in the Power System Data 1. It specifies the nominal primary voltage of side 1 of the protected object (transformer).

At address 242 **STARPNT SIDE 1** you specify how the starpoint (***Solid Earthed***; ***Isolated***) of side 1 is treated. This setting has an influence on the measured value monitoring (summation current monitoring); in transformer differential protection it is also important for vector group correction and the treatment of the zero sequence current.

The setting ***Isolated*** can be chosen if the starpoint has no earthing. If the transformer starpoint is connected to a Petersen coil or a surge voltage arrester, choose the setting ***Solid Earthed***. The same applies to low-ohmic or solid starpoint earthing.

The parameters 243 **UN-PRI SIDE 2** and 244 **STARPNT SIDE 2** determine respectively the rated primary voltage and the starpoint of side 2 of the transformer.

Parameter 246 **VECTOR GRP S2** is used to specify the vector group numeral referred to side 1 of the transformer. It is not necessary to specify whether the connection is delta, wye or zigzag.

At address 249 **SN TRANSFORMER** the rated apparent power is entered. From this the rated currents for sides 1 and 2 are calculated as follows:

$$I_{N,S1} = \frac{S_{N,Transf}}{U_{N,S1} \cdot \sqrt{3}} \qquad I_{N,S2} = \frac{S_{N,Transf}}{U_{N,S2} \cdot \sqrt{3}}$$

These nominal currents are only considered for differential protection and can differ from the generator nominal ratings.

For the overcurrent protection functions (Sections 2.8, 2.9, and 2.10) and for the breaker failure protection, sides 1 and 2 can be allocated freely. If the differential protection is set to 120 ***3 phase transf.***, the following normalizing factors apply for the primary side protection settings in DIGSI.

Side 1:

$$I_{N,\,S1} = \frac{S_{N,\,Transf}}{U_{N,\,S1} \cdot \sqrt{3}}$$

Side 2:

$$I_{N,\,S2} = \frac{S_{N,\,Generator}}{U_{N,\,Generator} \cdot \sqrt{3}}$$

Setting parameters:

$S_{N,\,Transf}$	249 **SN TRANSFORMER**
$U_{N,\,S1}$	241 **UN-PRI SIDE 1**
$S_{N,\,Generator}$	252 **SN GEN/MOTOR**
$U_{N,\,Generator}$	251 **UN GEN/MOTOR**

These normalizing factors apply for transformer protection and overall protection (see Section2.4.2, Figure 2-5 „Block Differential Protection“ and Figure 2-6 „Transformer Differential Protection“).

Protected Object: Generator/Motor

Regardless of the configuration and intended use of the differential protection, the generator/motor ratings must be specified. Parameter 251 **UN GEN/MOTOR** specifies the primary rated voltage of the protected generator or motor. At parameter 252 **SN GEN/MOTOR** the rated apparent power is entered. From these values the nominal generator/motor current for plant side 2 is calculated:

$$I_{N,\,Generator} = \frac{S_{N,\,Generator}}{U_{N,\,Generator} \cdot \sqrt{3}}$$

Setting parameters:

$S_{N,\,Generator}$	252 **SN GEN/MOTOR**
$U_{N,\,Generator}$	251 **UN GEN/MOTOR**

The above formula is also used by the DIGSI program to establish the normalizing factors for the primary side protection settings of the overcurrent protection functions (Sections 2.8, 2.9, and 2.10) and of the breaker failure protection, where the sides 1 and 2 can be freely allocated. Normalization is active if the differential protection in the scope of functions is set to 120 ***Disabled*** or ***Generator/Motor***. It applies for both side 1 and side 2.

At addresses 242 **STARPNT SIDE 1** and 244 **STARPNT SIDE 2** you specify the starpoints. For generator protection applications, set ***Isolated***. This is even valid if a loading resistor is connected to the generator starpoint. An exception from this are low-voltage machines with solid starpoint earthing.

Rated System Frequency

The nominal frequency of the system is set in Address 270 **Rated Frequency**. The factory setting of the model variant must only be changed if the device is to be used for a purpose other than intended when ordering.

Phase Rotation

Address 271 **PHASE SEQ.** is used to change the default phase sequence (***L1 L2 L3*** for clockwise rotation), if your power system permanently has an anti-clockwise phase sequence (***L1 L3 L2***). A temporary reversal of rotation is also possible using binary inputs (see Section 2.47).

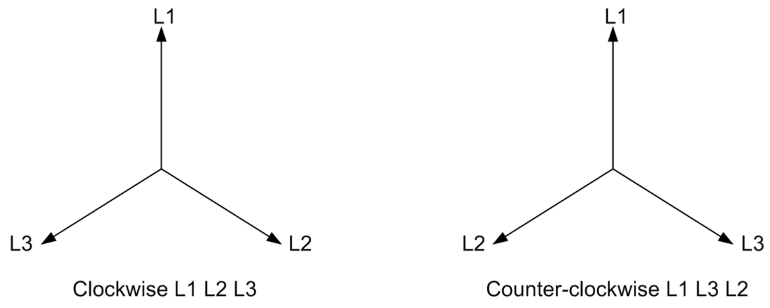


Figure 2-10 Phase sequences

Operating Mode

The 272 **SCHEME** setting specifies whether the generator to be protected is operated in ***Unit transf.*** or in ***Busbar*** mode. This specification is important for stator earth fault connection and for the inverse O/C time protection with undervoltage consideration, as different voltages are used here, depending on the corresponding operating mode (see „Undervoltage Consideration“ in Section 2.10).

ATEX100

Parameter 274 **ATEX100** allows compliance with PTB requirements (special requirements in Germany) for thermal replicas. If this parameter is set to ***YES***, all thermal replicas of the 7UM62 are stored on auxiliary power supply failure. As soon as the supply voltage returns, the thermal replicas continue operating with the stored values. If the parameter is set to ***NO***, the calculated overtemperature values of all thermal replicas are reset to zero on auxiliary power supply failure.

Command Duration

In address 280 the minimum trip command duration **TMin TRIP CMD** is set. This duration is valid for all protection functions which can issue a trip command.

Current-flow Monitoring

Address 281 **BkrClosed I MIN** corresponds to the threshold value of the integrated current flow monitoring system. This parameter is used for the elapsed-time meter, the restart inhibit and the overload protection. If the set threshold current is exceeded, the circuit breaker is considered closed and the power system is considered to be in operation. In the case of overload protection, this criterion distinguishes between standstill and motion of the machine to be protected.

Measuring Transducer 1

Measuring transducer 1 is provided for DC voltage/DC current protection or the rotor earth fault protection with 1 to 3 Hz ($U_{Control}$). Depending on the application, select at address 295 **TRANSDUCER 1** one of the alternatives ***10 V***, ***4-20 mA*** or ***20 mA***. In the first case, the measuring range is between –10 V and +10 V. The ***4-20 mA*** interface is designed for operation with sign, i.e. a current of 12 mA corresponds to an input value of 0. Currents below 2 mA indicate wire break. The disturbance indication drops out at currents above 3 mA. If the alternative ***20 mA*** is selected, the measuring range is between –20 mA and + 20 mA.

Figure 2-11 Relationship between measured quantity and represented input value at measuring transducer TD 1 with setting **4-20 mA**

Measuring Transducer 2

Measuring transducer 2 is provided for overload protection or the rotor earth fault protection at 1 to 3 Hz (U_{Meas}). In combination with an (external) temperature sensor and measuring transducer, it allows input of an ambient or coolant temperature. It is matched to the upstream measuring transducer by selecting at address 296 **TRANSDUCER 2** one of the standard alternatives ***10 V***, ***4-20 mA*** or ***20 mA***.

Measuring Transducer 3

Measuring transducer 3 is provided for underexcitation protection and is therefore designed for voltage input (10 V). The excitation voltage is fed to the measuring transducer via a voltage divider. Where the excitation DC voltage may contain excessive harmonics (e.g. owing to thyristor control), the integrated digital filter should be used; it is selected at the address 297 **TRANSDUCER 3** by setting ***with filter***.

2.5.2 Settings

Addresses which have an appended "A" can only be changed with DIGSI, under Additional Settings.

The table indicates region-specific presettings. Column C (configuration) indicates the corresponding secondary nominal current of the current transformer.

Addr.	Parameter	C	Setting Options	Default Setting	Comments
201	STRPNT->OBJ S1		YES NO	YES	CT-Strpnt. Side1 in Direct. of Object
202	IN-PRI I-SIDE1		1 .. 100000 A	500 A	CT Rated Primary Current Side 1
203	IN-SEC I-SIDE1		1A 5A	1A	CT Rated Secondary Current Side 1
204	CT ANGLE W0		-5.00 .. 5.00 °	0.00 °	Correction Angle CT W0
205	FACTOR IEE1		1.0 .. 100000.0	60.0	CT Ratio Prim./Sec. Iee1
210	STRPNT->OBJ S2		YES NO	YES	CT-Strpnt. Side2 in Direct. of Object
211	IN-PRI I-SIDE2		1 .. 100000 A	500 A	CT Rated Primary Current Side 2
212	IN-SEC I-SIDE2		1A 5A	1A	CT Rated Secondary Current Side 2
213	FACTOR IEE2		1.0 .. 100000.0	60.0	CT Ratio Prim./Sec. Iee2
214	GRD TERM. IEE2		Terminal Q7 Terminal Q8	Terminal Q7	Grounded Terminal CT Iee2
221	Unom PRIMARY		0.10 .. 800.00 kV	6.30 kV	Rated Primary Voltage
222	Unom SECONDARY		100 .. 125 V	100 V	Rated Secondary Voltage (Ph-Ph)
223	UE CONNECTION		neutr. transf. broken delta Not connected any VT Rotor Load. resistor Uen-winding	neutr. transf.	UE Connection
224	FACTOR UE		1.0 .. 2500.0	36.4	VT Ratio Prim./Sec. Ue
225A	Uph / Udelta		1.00 .. 3.00	1.73	Matching Ratio Ph.-VT to Broken-Delta-VT
241	UN-PRI SIDE 1		0.40 .. 800.00 kV	20.00 kV	Rated Primary Voltage Side 1
242	STARPNT SIDE 1		Isolated Solid Earthed	Isolated	Starpoint of Side 1 is
243	UN-PRI SIDE 2		0.40 .. 800.00 kV	6.30 kV	Rated Primary Voltage side 2
244	STARPNT SIDE 2		Isolated Solid Earthed	Isolated	Starpoint of side 2 is
246	VECTOR GRP S2		0 .. 11 *30°	0 *30°	Vector Group Numeral of Side 2

Addr.	Parameter	C	Setting Options	Default Setting	Comments
249	SN TRANSFORMER		0.20 .. 5000.00 MVA	5.30 MVA	Rated Apparent Power of the Transformer
251	UN GEN/MOTOR		0.40 .. 800.00 kV	6.30 kV	Rated Primary Voltage Generator/Motor
252	SN GEN/MOTOR		0.20 .. 5000.00 MVA	5.27 MVA	Rated Apparent Power of the Generator
270	Rated Frequency		50 Hz 60 Hz	50 Hz	Rated Frequency
271	PHASE SEQ.		L1 L2 L3 L1 L3 L2	L1 L2 L3	Phase Sequence
272	SCHEME		Busbar Unit transf.	Busbar	Scheme Configuration
274A	ATEX100		YES NO	NO	Storage of th. Replicas w/o Power Supply
275	FACTOR R SEF		1.0 .. 200.0	37.0	Ratio Prim./Sec. R SEF
276	TEMP. UNIT		Celsius Fahrenheit	Celsius	Unit of temperature measurement
280	TMin TRIP CMD		0.01 .. 32.00 sec	0.15 sec	Minimum TRIP Command Duration
281	BkrClosed I MIN	5A	0.20 .. 5.00 A	0.20 A	Closed Breaker Min. Current Threshold
		1A	0.04 .. 1.00 A	0.04 A	
295	TRANSDUCER 1		10 V 4-20 mA 20 mA	10 V	Transducer 1
296	TRANSDUCER 2		10 V 4-20 mA 20 mA	10 V	Transducer 2
297	TRANSDUCER 3		with filter without filter	with filter	Transducer 3

2.5.3 Information List

No.	Information	Type of Information	Comments
361	>FAIL:Feeder VT	SP	>Failure: Feeder VT (MCB tripped)
5002	Operat. Cond.	OUT	Suitable measured quantities present
5145	>Reverse Rot.	SP	>Reverse Phase Rotation
5147	Rotation L1L2L3	OUT	Phase Rotation L1L2L3
5148	Rotation L1L3L2	OUT	Phase Rotation L1L3L2

2.6 Change Group

Two independent groups of parameters can be set for the device functions. During operation, the user can switch between setting groups locally using the operator panel, binary inputs (if so configured), the operator and service interface from a personal computer or via the system interface.

A setting group comprises the setting values for all functions that have been configured as **Enabled** (see Section 2.4). In the 7UM62 two independent setting groups (A and B) are available. The two setting groups have identical functions but their setting values can be different.

Where different settings are required for operational reasons, e.g. in pumped storage power stations with a machine operating alternately as a generator and a motor, these settings are made in the setting groups and stored in the device. Depending on the operating mode, the applicable setting group is activated, usually via a binary input.

If multiple setting groups are not required, Group A is the default selection. The rest of this section is then not relevant.

2.6.1 Setting Notes

General

If the changeover option is desired, on function extent configuration the group changeover must be set to **Grp Chge OPTION** = ***Enabled*** (address 103). When setting the function parameters, you configure first setting group A, then setting group B. To find out how to proceed for this, how to copy and to reset setting groups, and how to switch between setting groups during operation, please refer to the SIPROTEC 4 System Description /1/.

How to switch between setting groups externally using binary inputs is described in the „Mounting and Connections“ section in Chapter 3.

2.6.2 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
302	CHANGE	Group A Group B Binary Input Protocol	Group A	Change to Another Setting Group

2.6.3 Information List

No.	Information	Type of Information	Comments
-	GroupA act	IntSP	Setting Group A is active
-	GroupB act	IntSP	Setting Group B is active
7	>Set Group Bit0	SP	>Setting Group Select Bit 0

2.7 Power System Data 2

The general protection data (**P.System Data 2**) include settings associated with all functions rather than a specific protection or monitoring function. Parameter settings **P.System Data 2** can be switched using the setting group.

2.7.1 Functional Description

Setting Groups

In the 7UM62 relay, two independent setting groups (A and B) are possible. Whereas setting values may vary, the selected functions of each setting group remain the same.

2.7.2 Setting Notes

General

To enter these group-specific general protection data (**P.System Data 2**), select in the **SETTINGS** menu the ***Group A*** (**Parameter group A**), and in it **P.System Data 2**. The other setting group is accessible under ***Group B***.

Active Power Direction

Address 1108 **ACTIVE POWER** is used to specify the active power direction in the normal mode (***Generator*** = output or ***Motor*** = input) or to adapt it to the power system conditions without device recabling.

2.7.3 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
1108	ACTIVE POWER	Generator Motor	Generator	Measurement of Active Power for

2.7.4 Information List

No.	Information	Type of Information	Comments
501	Relay PICKUP	OUT	Relay PICKUP
511	Relay TRIP	OUT	Relay GENERAL TRIP command
576	IL1 S1:	VI	Primary fault current IL1 Side1
577	IL2 S1:	VI	Primary fault current IL2 Side1
578	IL3 S1:	VI	Primary fault current IL3 Side1
579	IL1 S2:	VI	Primary fault current IL1 Side2
580	IL2 S2:	VI	Primary fault current IL2 Side2
581	IL3 S2:	VI	Primary fault current IL3 Side2
5012	UL1E:	VI	Voltage UL1E at trip
5013	UL2E:	VI	Voltage UL2E at trip
5014	UL3E:	VI	Voltage UL3E at trip
5015	P:	VI	Active power at trip
5016	Q:	VI	Reactive power at trip
5017	f:	VI	Frequency at trip

2.8 Definite-Time Overcurrent Protection (I>, ANSI 50/51) with Undervoltage Seal-In

The time-overcurrent protection is used as backup protection for the short-circuit protection of the protected object. It also provides backup protection for downstream network components if faults there are not disconnected in time thus endangering the protected object.

The 7UM62 relay allows to choose between the input transformers of side 1 and side 2 for allocation of the time-overcurrent protection function. This choice is made during configuration (see Section 2.4).

Initially the currents are numerically filtered so that only the fundamental frequency currents are used for the measurement. This makes the measurement insensitive to transient conditions at the inception of a short-circuit and to asymmetrical short-circuit currents (d.c. component).

In generators where the excitation voltage is taken from the machine terminals, the short-circuit current subsides quickly in the event of adjacent faults (i.e. in the generator or unit transformer region) due to the absence of excitation voltage. Within a few seconds it sinks below the pick-up value of the overcurrent time protection. To avoid that the relay drops out again, the I> stage monitors the positive-sequence component of the voltages and uses it as an additional criterion for detecting a short-circuit. The undervoltage influencing can be disabled and made ineffective via binary input.

2.8.1 Functional Description

I> Stage

Each phase current of side 1 or 2 (depending on configuration) is compared individually with the common setting value **I>** and on overshoot signaled individually. A trip signal is transmitted to the matrix as soon as the corresponding **T I>** time delay has expired. On delivery, the dropout value is set to ± 95 % below the pickup value. For special applications, it is also possible to set a higher value.

Undervoltage Seal-In

The I> stage has a (disconnectable) undervoltage stage. This stage maintains the pick-up signal for a selectable seal-in time if the value falls below a selectable threshold of the positive-sequence component of the voltages after an overcurrent pickup - even if the value again falls below the overcurrent value. In this way, the expiration of the trip time delay and the tripping of the related breakers is also ensured in these cases. If the voltage recovers before the seal-in time has elapsed or if the undervoltage seal-in is blocked via a binary input, e.g. in case of a tripping of the voltage transformer protective breaker or in case of a machine stopping, the protective relay drops out immediately.

The seal-in logic operates separate for each phase. The first pickup starts the timer **T-SEAL-IN**.

The following figure shows the logic diagram of the overcurrent time protection I> with undervoltage seal-in.

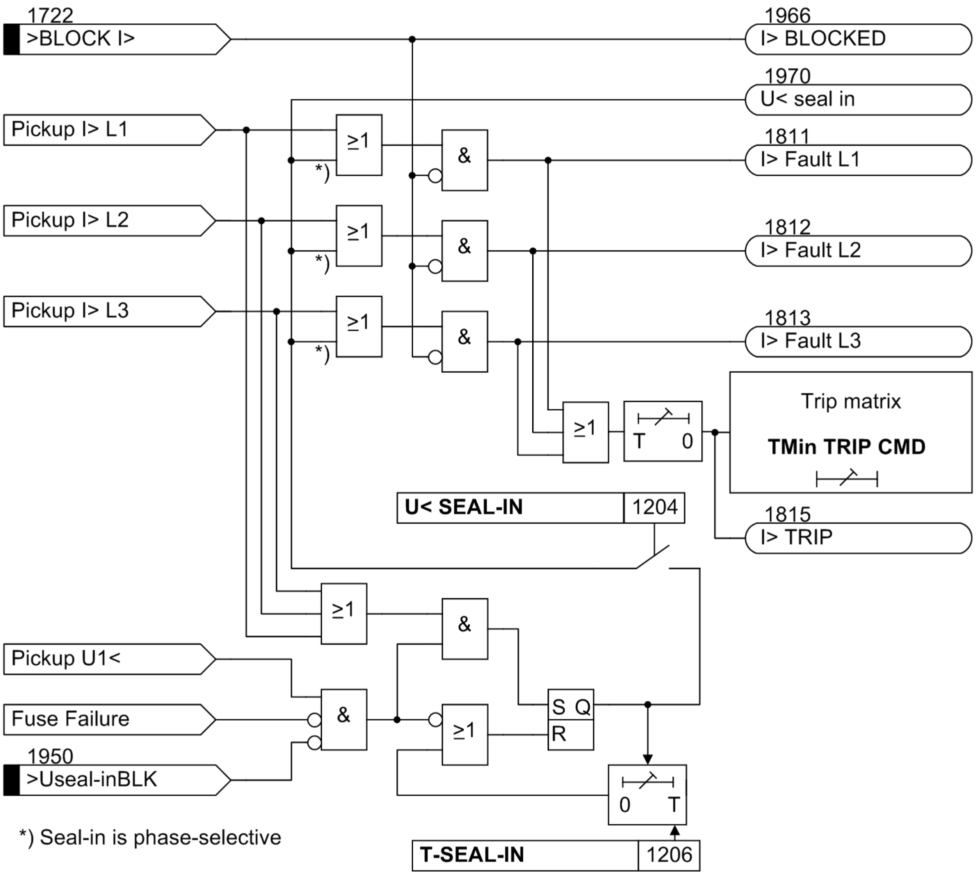


Figure 2-12 Logic Diagram of the Overcurrent Stage I> with Undervoltage Seal-In

2.8.2 Setting Notes

General

Overcurrent protection is only effective and available if address 112 **O/C PROT. I>** is set to ***Side 1*** or ***Side 2*** during configuration. If the function is not needed it is set to ***Disabled***.

Time Overcurrent Stage I>

Address 1201 **O/C I>** is used to switch the definite time-overcurrent stage I> ***ON*** and ***OFF***, or to block only the trip command (***Block relay***). The setting of the **I>** stage is mainly determined by the maximum operating current. Pickup due to overload should never occur since the protection may trip if short command times are set. For this reason, a setting between 20 % and 30 % over the expected peak load is recommended for generators, and a setting of about 40 % for transformers and motors.

The trip time delay (parameter 1203 **T I>**) must be coordinated with the time grading of the network in order to ensure that the protective equipment closest to the corresponding fault location trips first (selectivity).

The selected time is only an additional time delay and does not include the operating time (measuring time, dropout time). The delay can be set to ∞. If set to infinity, the pickup of this function will be indicated but the stage will not trip after pickup. If the I> stage is not required at all, 1201 **O/C I>** = ***OFF*** is set. This setting prevents tripping and the generation of a pickup message.

Undervoltage Seal-In

The 1205 **U<** undervoltage stage (positive-sequence voltage) is set to a value below the lowest phase-to-phase voltage admissible during operation, e.g. 80 V.

The seal-in time 1206 **T-SEAL-IN** limits the pickup seal-in introduced by the overcurrent/undervoltage. It must be set to a value higher than the **T I>** time delay.

The dropout ratio r = I_{DO}/I_{PU} of the overcurrent pickup I> is specified at the address 1207 **I> DOUT RATIO**. The recommended value is r = 0.95. For special applications, e.g. overload warning, it can be set to a higher value (0.98).

Example:

Pick-up threshold	$1,4 \cdot I_{N\ Gen}$		
Trip Time Delay	3 sec		
Undervoltage Seal-In	$0,8 \cdot U_{N\ Gen}$		
Holding time of U<	4 sec		
Dropout Ratio	0.95		
Nominal current $I_{N\ Gen}$	483 A	Nominal voltage $U_{N,\ Gen}$	6.3 kV
Nominal current $I_{N,\ CT,\ prim}$	500 A	Nominal voltage $U_{N,\ VT,\ prim}$	6.3 kV
Nominal current $I_{N,\ sec}$	1 A	Nominal voltage $U_{N,\ sec}$	100 V

The following secondary setting values result from this specification:

$$I> = \frac{1.4 \cdot I_{N,\ Gen}}{I_{N,\ CT,\ prim}} \cdot I_{N,\ sec} = \frac{1.4 \cdot 483\ A}{500\ A} \cdot 1\ A = 1.35\ A$$

$$U< = \frac{0.8 \cdot U_{N,\ Gen}}{U_{N,\ VT,\ prim}} \cdot U_{N,\ sec} = \frac{0.8 \cdot 6.3\ kV}{6.3\ kV} \cdot 100\ V = 80\ V$$

2.8.3 Settings

Addresses which have an appended "A" can only be changed with DIGSI, under Additional Settings.

The table indicates region-specific presettings. Column C (configuration) indicates the corresponding secondary nominal current of the current transformer.

Addr.	Parameter	C	Setting Options	Default Setting	Comments
1201	O/C I>		OFF ON Block relay	OFF	Overcurrent Time Protection I>
1202	I>	5A	0.25 .. 100.00 A	6.75 A	I> Pickup
		1A	0.05 .. 20.00 A	1.35 A	
1203	T I>		0.00 .. 60.00 sec; ∞	3.00 sec	T I> Time Delay
1204	U< SEAL-IN		ON OFF	OFF	State of Undervoltage Seal-in
1205	U<		10.0 .. 125.0 V	80.0 V	Undervoltage Seal-in Pickup
1206	T-SEAL-IN		0.10 .. 60.00 sec	4.00 sec	Duration of Undervoltage Seal-in
1207A	I> DOUT RATIO		0.90 .. 0.99	0.95	I> Drop Out Ratio

2.8.4 Information List

No.	Information	Type of Information	Comments
1722	>BLOCK I>	SP	>BLOCK I>
1811	I> Fault L1	OUT	O/C fault detection stage I> phase L1
1812	I> Fault L2	OUT	O/C fault detection stage I> phase L2
1813	I> Fault L3	OUT	O/C fault detection stage I> phase L3
1815	I> TRIP	OUT	O/C I> TRIP
1950	>Useal-inBLK	SP	>O/C prot. : BLOCK undervoltage seal-in
1965	I> OFF	OUT	O/C prot. stage I> is switched OFF
1966	I> BLOCKED	OUT	O/C prot. stage I> is BLOCKED
1967	I> ACTIVE	OUT	O/C prot. stage I> is ACTIVE
1970	U< seal in	OUT	O/C prot. undervoltage seal-in

2.9 Definite-Time Overcurrent Protection (I>>, ANSI 50, 51, 67) with Direction Detection

The time-overcurrent protection is used as backup protection for the short-circuit protection of the protected object. It also provides backup protection for downstream network components if faults there are not disconnected in time thus endangering the protected object.

The 7UM62 relay allows to choose between the input transformers of side 1 and side 2 for allocation of the time-overcurrent protection function. This choice is made during configuration (see Section 2.4).

In order to ensure that pick-up always occurs even with internal faults, the protection - for generators - is usually connected to the current transformer set in the neutral leads of the machine. If this is not the case for an individual power system, the I>> stage can be combined with a short-circuit direction determination and switch off a generator short circuit instantaneously ; the selectivity is not affected by this.

Initially, the currents are numerically filtered so that only the fundamental frequency currents are used for the measurement. This makes the measurement insensitive to transient conditions at the inception of a short-circuit and to asymmetrical short-circuit currents (d.c. component).

2.9.1 Functional Description

I>> Stage

Each phase-current of side 1 or 2 (depending on the configuration) is compared individually with the common pickup value **I>>**, and indicated on overshoot. A trip signal is transmitted to the matrix as soon as the corresponding **T I>>** time delays have expired. The dropout value is ± 95 % below the pick-up value.

Direction Detection

If this protection function has been assigned to the input transformers of side 1, the I>> stage is equipped with a (disconnectable) direction element permitting a tripping only for faults in backward (i.e. machine) direction.

For this reason, this stage can be used particularly in applications where no current transformers exist in the generator starpoint and undelayed tripping is nevertheless required on generator faults.

The definition of the current direction in Figure 2-13 applies for the CT of side 1. If the CT of side 2 is used, ***Forward*** must be set to determine the current direction.

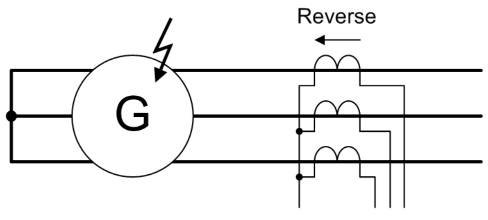


Figure 2-13 Selectivity via Short-Circuit Direction Detection

The direction is detected phase-selectively by means of a cross-polarized voltage. The phase-to-phase voltage normally perpendicular to the fault current vector is used as unfaulted voltage (Figure 2-14). This is considered during the calculation of the direction vector in the clockwise rotating phase sequence by a +90° rotation, and in the anti-clockwise rotating phase by a -90° rotation. For phase-to-phase faults, the position of the direction straight line may change in relation to the collapse of the short-circuit voltage.

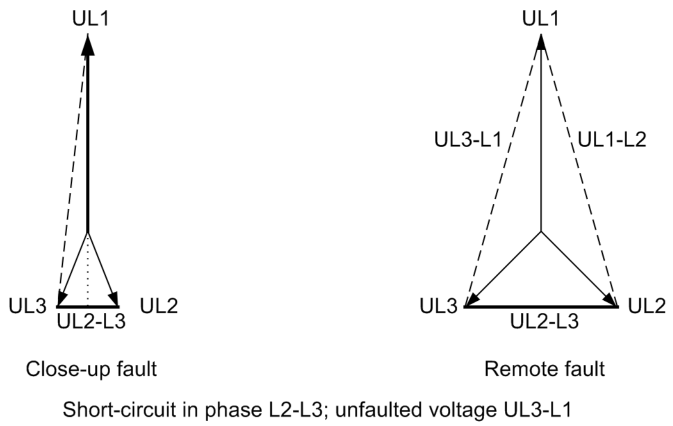


Figure 2-14 Cross-Polarized Voltages for Direction Determination

The phase carrying the highest current is selected for the direction decision. With equal current levels, the phase with the smaller number is chosen (I_{L1} before I_{L2} before I_{L3}). The following table shows the allocation of measured values for various types of short-circuit faults.

Table 2-3 Allocation of Measured Values for the Determination Direction

Pickup	Selected Current	Associated Voltage
L1	I_{L1}	U_{L2} - U_{L3}
L2	I_{L2}	U_{L3} - U_{L1}
L3	I_{L3}	U_{L1} - U_{L2}
L1, L2 with $I_{L1}>I_{L2}$	I_{L1}	U_{L2} - U_{L3}
L1, L2 with $I_{L1}=I_{L2}$	I_{L1}	U_{L2} - U_{L3}
L1, L2 with $I_{L1}<I_{L2}$	I_{L2}	U_{L3} - U_{L1}
L2, L3 with $I_{L2}>I_{L3}$	I_{L2}	U_{L3} - U_{L1}
L2, L3 with $I_{L2}=I_{L3}$	I_{L2}	U_{L3} - U_{L1}
L2, L3 with $I_{L2}<I_{L3}$	I_{L3}	U_{L1} - U_{L2}
L3, L1 with $I_{L3}>I_{L1}$	I_{L3}	U_{L1} - U_{L2}
L3, L1 with $I_{L3}=I_{L1}$	I_{L1}	U_{L2} - U_{L3}
L3, L1 with $I_{L3}<I_{L1}$	I_{L1}	U_{L2} - U_{L3}
L1, L2, L3 with $I_{L1}>(I_{L2}, I_{L3})$	I_{L1}	U_{L2} - U_{L3}
L1, L2, L3 with $I_{L2}>(I_{L1}, I_{L3})$	I_{L2}	U_{L3} - U_{L1}

If the phase-to-phase voltage used for the direction decision is below the minimum value of approx. 7 V, the voltage is taken from a voltage memory. This voltage also allows unambiguous direction determination if the short-circuit voltage has collapsed (short circuit close to generator terminals). After the expiration of the storage time period (2 cycles), the detected direction is saved, as long as no sufficient measuring voltage is available. If a short circuit already exists at generator startup (or for motors or transformers on connection), so that no voltage is present in the memory and no direction can be determined, a trip is issued.

The direction detection can be disabled via binary input.

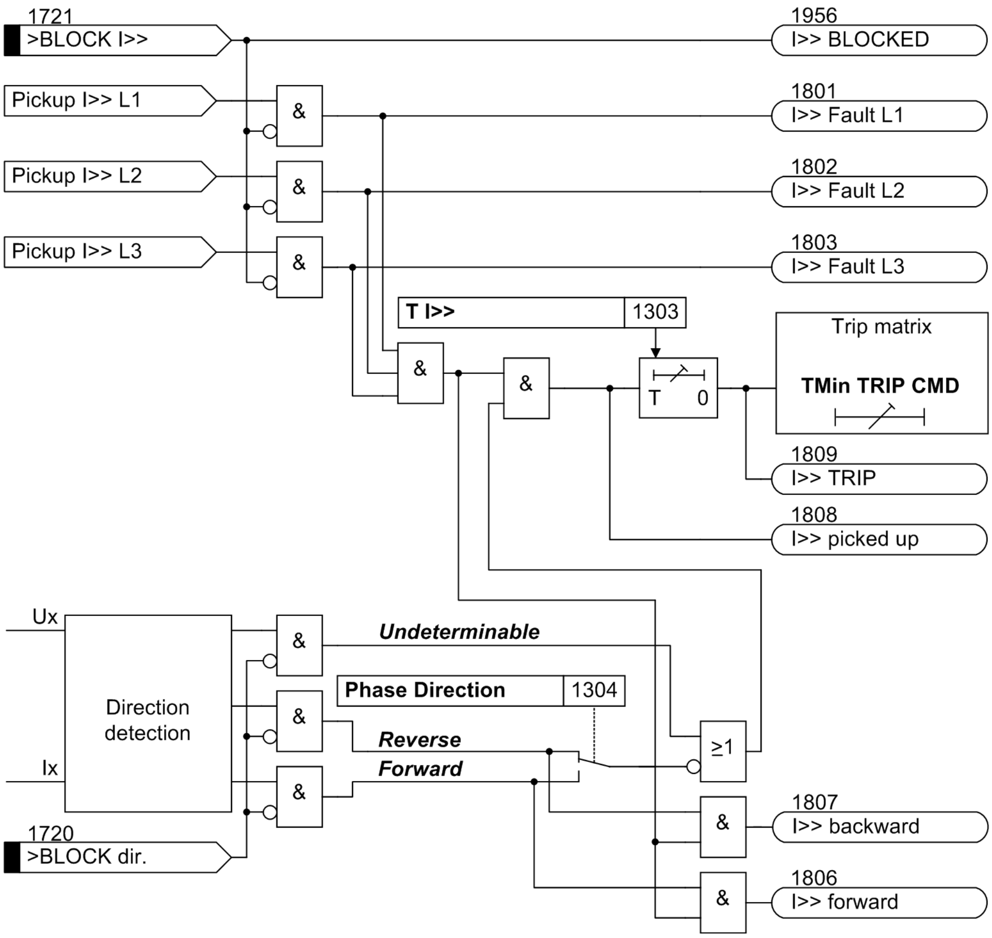


Figure 2-15 Logic Diagram of I>> Stage with Direction Element

2.9.2 Setting Notes

General

The high-current stage I>> of the overcurrent protection is only effective and accessible if it has been assigned within the framework of configuration at address 113 **O/C PROT. I>>** to either side 1 or side 2, i.e. if either set = ***NonDirec. SIDE1***, ***NonDirec.SIDE 2***, ***Direc. SIDE1*** or ***Direc. SIDE2***. If the function is not needed it is set to ***Disabled***.

If direction acquisition is used, make sure that the CT and VT sets are consistent.

High-set Current Stage I>>

Address 1301 **O/C I>>** is used to switch the definite time I>> high-current stage for phase currents ***ON*** and ***OFF***, or to block only the trip command (***Block relay***). The high-current stage **I>>** (Parameter 1302 and its associated delay time **T I>>**, 1303) is used for current grading with large impedances existing for example with transformers, motors or generators. It is specified in a way ensuring that it picks up for faults up to this impedance.

Current Trans-former in the Starpoint (without direction detection)

Example: Unit Connection

Rated apparent power - generator	$S_{N, Gen}$	= 5.27 MVA
Rated voltage - generator	$U_{N\ Gen}$	= 6.3 kV
Direct-axis transient reactance	x_d’	= 29 %
Transient synchronous generated voltage (Salient-pole generator)	U_P’	= 1,2 · $U_{N,Gen}$
Rated apparent power - transformer	$S_{N, T}$	= 5.3 MVA
Rated voltage, on the generator side	$U_{N, VTprim}$	= 6.3 kV
Short-circuit voltage	u_{SC}	= 7 %
Current transformer	$I_{N, CT, prim}$ $I_{N, sec}$	= 500 A = 1 A

a) Short-circuit calculation

Three-pole short circuit

$$I_{SC\ 3pol} \approx \frac{U_P' / (\sqrt{3})}{\frac{x_d'}{100\ \%} \cdot \frac{U_{N,\ Gen}^2}{S_{N,\ Gen}} + 0.5 \cdot \frac{u_{SC}}{100\ \%} \cdot \frac{U_{N,\ VT\ prim}^2}{S_{N,\ Gen}}} \approx \frac{1.2 \cdot 6.3\ kV / (\sqrt{3})}{2.18\ \Omega + 0.26\ \Omega} \approx 1789\ A$$

b) Setting value:

The setting value is achieved by means of a conversion on the secondary side. In order to exclude an unwanted operation caused by overvoltages or transient phenomena, an additional safety factor of about 1.2 to 1.3 is recommended.

$$I>> \ = \ 1.2 \cdot \frac{I_{SC\ 3pol}}{I_{N,\ CT,\ prim}} \cdot I_{N,\ sec} = 1.2 \cdot \frac{1789\ A}{500\ A} \cdot 1\ A = 4.3\ A$$

A value of **T I>>** = 0.1 s is recommended as tripping time delay in order to enable preferred tripping of the differential protection.

Current Trans-former on the Output Side (with direction detection)

If at address 113 **O/C PROT. I>>** was configured as directional, the addresses 1304 **Phase Direction** and 1305 **LINE ANGLE** are accessible. The inclination of the direction straight line (see figure 2-16) representing the separating line between the tripping and the blocking zone can be adapted to the network conditions by way of the **LINE ANGLE** parameter. To do this, the line angle of the network is set. The direction straight line is perpendicular to the set direction angle. Together with the parameter 1304 **Phase Direction** = ***Forward*** or ***Reverse***, this parameter covers the entire impedance level. This is the**reverse** direction, provided that the protective relay has been connected according to Figure 2-13. Between forward and reverse, a small zone is located in which, due to phase displacement angles of the transformers, a safe direction decision is not possible. There is no tripping in the configured preferential direction in this zone.

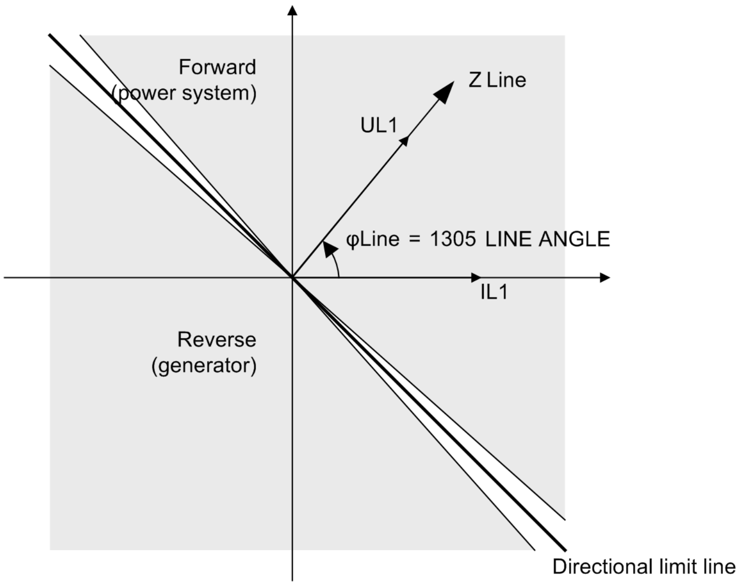


Figure 2-16 Definition of Parameters 1304 Phase Direction and 1305 LINE ANGLE

The setting value of the direction straight line results from the short-circuit angle of the feeding network. As a rule, it will be more than 60°. The current pickup value results from the short-circuit current calculation. Workable pickup values are situated at about (1.5 to 2) · $I_{N, G}$. A tripping time delay of (TI>> ≈ 0.05 s to 0.1 s). is required to ensure that the effect of the transient phenomena is eliminated.

The corrective value can be determined during machine commissioning (see Section Installation and Commissioning under „Tests with the Network“).

Application Example: Motor Protection

For motors that have no separate current transformers in the starpoint, the following figure shows how to use the I>> stage as „differential protection“. The configuration of the protection function depends on the transformers. Since this application is most likely to be used for replacements in an existing system, the settings of that system should be used for orientation.

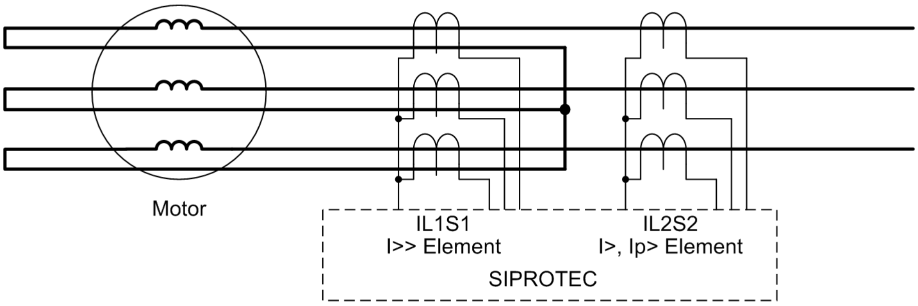


Figure 2-17 I>> Stage as 'Differential Protection'

2.9.3 Settings

The table indicates region-specific presettings. Column C (configuration) indicates the corresponding secondary nominal current of the current transformer.

Addr.	Parameter	C	Setting Options	Default Setting	Comments
1301	O/C I>>		OFF ON Block relay	OFF	Overcurrent Time Protection I>>
1302	I>>	5A	0.25 .. 100.00 A	21.50 A	I>> Pickup
		1A	0.05 .. 20.00 A	4.30 A	
1303	T I>>		0.00 .. 60.00 sec; ∞	0.10 sec	T I>> Time Delay
1304	Phase Direction		Forward Reverse	Reverse	Phase Direction
1305	LINE ANGLE		-90 .. 90 °	60 °	Line Angle

2.9.4 Information List

No.	Information	Type of Information	Comments
1720	>BLOCK dir.	SP	>BLOCK direction I>> stage
1721	>BLOCK I>>	SP	>BLOCK I>>
1801	I>> Fault L1	OUT	O/C fault detection stage I>> phase L1
1802	I>> Fault L2	OUT	O/C fault detection stage I>> phase L2
1803	I>> Fault L3	OUT	O/C fault detection stage I>> phase L3
1806	I>> forward	OUT	O/C I>> direction forward
1807	I>> backward	OUT	O/C I>> direction backward
1808	I>> picked up	OUT	O/C prot. I>> picked up
1809	I>> TRIP	OUT	O/C I>> TRIP
1955	I>> OFF	OUT	O/C prot. stage I>> is switched OFF
1956	I>> BLOCKED	OUT	O/C prot. stage I>> is BLOCKED
1957	I>> ACTIVE	OUT	O/C prot. stage I>> is ACTIVE

2.10 Inverse-Time Overcurrent Protection (ANSI 51V)

The inverse-time overcurrent protection protects extra-low voltage and low-voltage machines against short circuits. For larger machines it is used as back-up protection for the machine short-circuit protection (differential protection and/or impedance protection). It provides back-up protection for network faults that can not be cleared immediately and thus endanger the machine.

The 7UM62 relay allows to choose between the input transformers of side 1 and side 2 for allocation of the inverse-time overcurrent protection function. This choice is made during configuration (see Section 2.4).

In generators where the excitation voltage is taken from the machine terminals, the short-circuit current subsides quickly in the event of adjacent faults (i.e. in the generator or unit transformer region) due to the absence of excitation voltage. Within a few seconds it sinks below the pick-up value of the overcurrent time protection. In order to avoid a dropout of the pickup, the positive-sequence component is monitored additionally. This component can influence the overcurrent detection in accordance with two different methods. The undervoltage influencing can be switched off.

The protective function operates, depending on the ordering variant, with an inverse current-tripping characteristic according to the IEC or ANSI standards. The characteristic curves and the corresponding formulas are represented in Technical Data. If one of the inverse characteristics (IEC or ANSI) is configured, the definite-time stages I>> and I> can be additionally effective (see Section 2.8).

2.10.1 Functional Description

Pickup and Tripping

Each phase current is compared individually with the common **Ip** setting value. If a current exceeds 1.1 times the set value, the stage picks up and is signalled on a per phase basis. The r.m.s. values of the fundamental component are used for the pickup. During the pickup of an Ip stage, the tripping time is calculated from the flowing fault current by means of an integrating measuring procedure, depending on the selected tripping characteristic. After the expiration of this period, a trip command is transmitted.

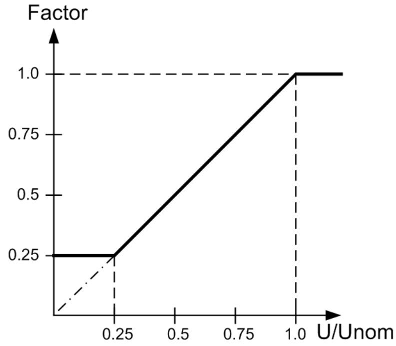
Dropout

The dropout of a picked up stage is performed as soon as the value falls below approximately 95 % of the pickup value (i.e. 0.95 to 1.1 = 1.045 to setting value). The timer will start again for all new pickups.

Undervoltage Detection

The inverse overcurrent time protection is provided with a undervoltage detection that can be disabled. This function can influence overcurrent detection in two different ways:

- **Voltage controlled:**If the value falls below a settable voltage threshold, an overcurrent stage is enabled.
- **Voltage restraint:**The pickup threshold of the overcurrent stage depends on the voltage level. A lower voltage reduces the current pickup value (see Figure 2-18). A linear, directly proportional dependency is realized in the zone between U/U_{Nom} = 1.00 to 0.25. Consequently, the following rule applies:



$$I(U)PU = Ip \cdot 1.00 \qquad \text{for } 1.00 \le \frac{U}{Un} \le \infty$$

$$I(U)PU = Ip \cdot \frac{U}{Un} \qquad \text{for } 0.25 \le \frac{U}{Un} \le 1.00$$

$$I(U)PU = Ip \cdot 0.25 \qquad \text{for } 0.00 \le \frac{U}{Un} \le 0.25$$

with Un = Generator nominal voltage
= 251 UN GEN/MOTOR

Ip = Pick-up value of inverse characterisic
= 1402 **Ip**

I (U) PU = Voltage-influenced pickup value

Figure 2-18 Pick-up Value Voltage Dependency

The Ip reference value is decreased proportional to the voltage decrease. Consequently, for a constant current I, the I/Ip ratio is increased and the trip time is reduced. Compared with the standard characteristics represented in the „Technical Data“ chapter, the tripping characteristic shifts to the left side in relation to decreasing voltage.

The changeover to the lower pick-up value or the reduction of the pickup threshold are performed on a per phase basis. Allocations of voltages to the current-carrying phases represented in the following table apply. As the protection used in the generator range is incorporated in the network grading plan, the conversion of the voltages by the clock transformer must also be considered. Therefore, in principle, a distinction must be made between a unit connection and a busbar connection which must be communicated to the device by the parameter 272 **SCHEME**. As phase-to-phase voltages are referred to in any case, faulty measurements during earth faults are avoided.

Table 2-4 Controlling voltages in relation to the fault currents

Current	**Voltage**	
	Busbar connection	**Unit connection**
I_{L1}	$U_{L1} – U_{L2}$	$((U_{L1} – U_{L2}) – (U_{L3} – U_{L1})) / \sqrt{3}$
I_{L2}	$U_{L2} – U_{L3}$	$((U_{L2} – U_{L3}) – (U_{L1} – U_{L2})) / \sqrt{3}$
I_{L3}	$U_{L3} – U_{L1}$	$((U_{L3} – U_{L1}) – (U_{L2} – U_{L3})) / \sqrt{3}$

In order to avoid unwanted operation during a voltage transformer fault, a function blocking is implemented via a binary input controlled by the voltage transformer protective breaker as well as via the device-internal measuring voltages failure detection ("Fuse-Failure-Monitor", also refer to Section 2.42.1).

The following figure shows the logic diagram of the inverse overcurrent time protection without undervoltage influencing, whereas Figures 2-20 and 2-21 illustrate the logic diagrams with undervoltage influencing.

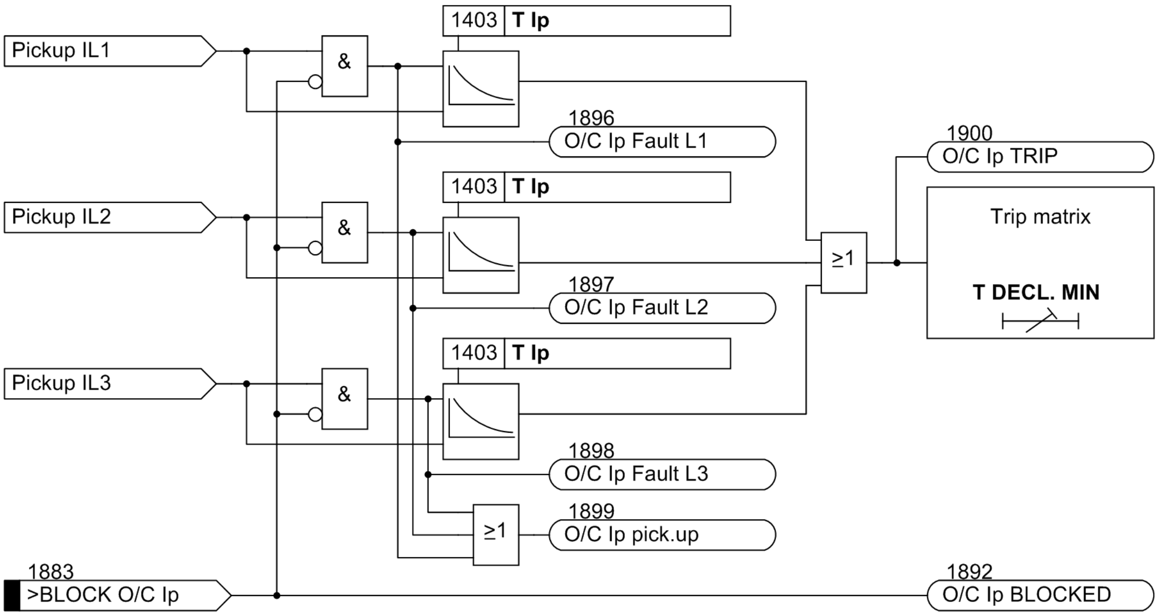


Figure 2-19 Logic Diagram of the Inverse Time Overcurrent Protection without Undervoltage Influencing

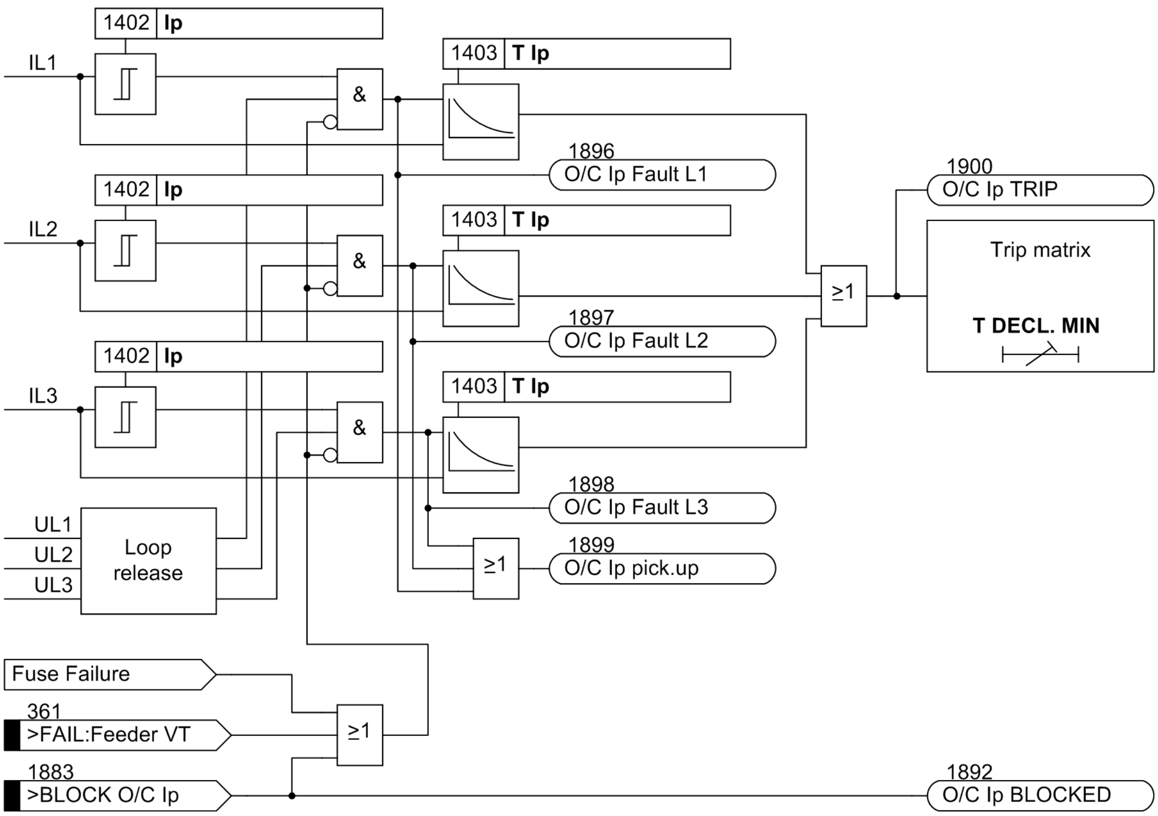


Figure 2-20 Logic Diagram of the Voltage Controlled Inverse Time Overcurrent Protection

The changeover to the lower current pickup value on decreasing voltage (loop release) is performed on a phase by phase basis in accordance with Table 2-4.

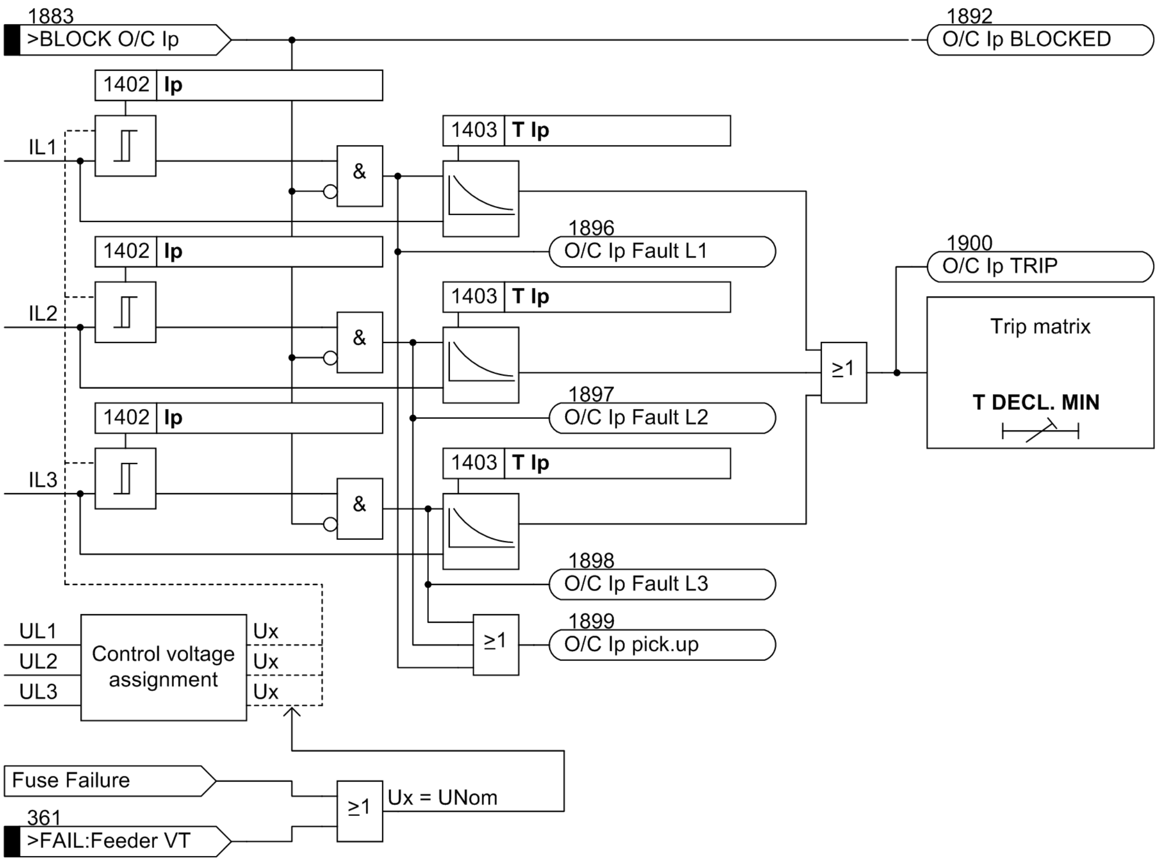


Figure 2-21 Logic Diagram of the Voltage Restraint Inverse Time Overcurrent Protection

The reduction of the current pick-up threshold in case of a decreasing voltage (control voltage assignment) is performed phase by phase according to table 2-4.

2.10.2 Setting Notes

General

The inverse overcurrent time protection is only effective and available if this function was allocated to the input CTs of either side 1 or side 2 during configuration (see Section 2.4), i.e. if address 114 **O/C PROT. Ip** was set to ***IEC SIDE 1***, ***ANSI SIDE 1***, ***IEC SIDE 2*** or ***ANSI SIDE 2***. If the function is not needed it is set to .

Overcurrent Stage Ip

The address 1401 **O/C Ip** serves to switch the function ***ON*** or ***OFF*** or to block only the trip command (***Block relay***). In this context, it must be considered that, for the inverse O/C time protection, a safety factor of about 1.1 has already been included between the pick-up value and the setting value. This means that a pickup is only performed if a current of about 1.1 times the setting value is present. The function will reset as soon as the value falls below 95 % of the pickup value.

The current value is set at address 1402 **Ip**. The maximum operating current is of primary importance for the setting. A pickup caused by an overload must be excluded, as the device operates in this mode as fault protection with correspondingly short tripping times and not as overload protection.

The corresponding time multiplier for configuration of IEC characteristics (address 114 **O/C PROT. Ip** = ***IEC Page n***) is accessible under address 1403 **T Ip**. At address 1405 **IEC CURVE**, 3 IEC characteristics can be selected.

The time multiplier for configuring ANSI characteristics (address 114 **O/C PROT. Ip**= ***ANSI Page***) can be found at address 1404 **TIME DIAL: TD**; parameter 1406 **ANSI CURVE** offers a choice between 5 ANSI characteristics.

The time multipliers must be coordinated with the network grading plan.

The time multipliers can also be set to ∞. If set to infinity, the pickup of this function will be indicated but the stage will not trip after pickup. If the Ip stage is not required, on configuration of the protection function (Section 2.4) address 114 **O/C PROT. Ip** is set to ***Disabled*** or this function switched under 1401 **O/C Ip** = ***OFF***.

The address 1408 serves to predefine the **U<** pick-up value for the undervoltage trip of the Ip pickup value for voltage-controlled inverse overcurrent time protection/AMZ (parameter 1407 **VOLT. INFLUENCE** = ***Volt. controll.***). The parameter is set to a value just below the lowest phase-to-phase voltage admissible during operation, e.g. from 75 to 80 V. In this context, the same rules apply as for the undervoltage seal-in of the definite overcurrent time protection (see also Subsection 2.8.2).

If at address 1407 **VOLT. INFLUENCE** is set to ***without*** or ***Volt. restraint***, the parameter 1408 has no function.

2.10.3 Settings

The table indicates region-specific presettings. Column C (configuration) indicates the corresponding secondary nominal current of the current transformer.

Addr.	Parameter	C	Setting Options	Default Setting	Comments
1401	O/C Ip		OFF ON Block relay	OFF	Inverse O/C Time Protection Ip
1402	Ip	5A	0.50 .. 20.00 A	5.00 A	Ip Pickup
		1A	0.10 .. 4.00 A	1.00 A	
1403	T Ip		0.05 .. 3.20 sec; ∞	0.50 sec	T Ip Time Dial
1404	TIME DIAL: TD		0.50 .. 15.00 ; ∞	5.00	TIME DIAL: TD
1405	IEC CURVE		Normal Inverse Very Inverse Extremely Inv.	Normal Inverse	IEC Curve
1406	ANSI CURVE		Very Inverse Inverse Moderately Inv. Extremely Inv. Definite Inv.	Very Inverse	ANSI Curve
1407	VOLT. INFLUENCE		without Volt. controll. Volt. restraint	without	Voltage Influence
1408	U<		10.0 .. 125.0 V	75.0 V	U< Threshold for Release Ip

2.10.4 Information List

No.	Information	Type of Information	Comments
1883	>BLOCK O/C Ip	SP	>BLOCK inverse O/C time protection
1891	O/C Ip OFF	OUT	O/C protection Ip is switched OFF
1892	O/C Ip BLOCKED	OUT	O/C protection Ip is BLOCKED
1893	O/C Ip ACTIVE	OUT	O/C protection Ip is ACTIVE
1896	O/C Ip Fault L1	OUT	O/C fault detection Ip phase L1
1897	O/C Ip Fault L2	OUT	O/C fault detection Ip phase L2
1898	O/C Ip Fault L3	OUT	O/C fault detection Ip phase L3
1899	O/C Ip pick.up	OUT	O/C Ip picked up
1900	O/C Ip TRIP	OUT	O/C Ip TRIP

2.11 Thermal Overload Protection (ANSI 49)

The thermal overload protection prevents thermal overloading of the stator windings of the machine being protected.

2.11.1 Functional Description

Thermal Profile

The device calculates the overtemperature in accordance with a single-body thermal model, based on the following differential equation:

$$\frac{d\Theta}{dt} + \frac{1}{\tau} \cdot \Theta = \frac{1}{\tau} \cdot I^2 + \frac{1}{\tau} \cdot \Theta_K$$

with

Θ	Actual operating temperature expressed in percent of the operating temperature corresponding to the maximum permissible operating current $k \cdot I_N$
Θ_K	Coolant temperature or ambient temperature as a difference to the 40 °C reference temperature
τ	Thermal time constant for the heating of the equipment being protected
I	Operating current expressed in percent of the maximum permissible operating current $I_{max} = k \cdot I_N$

The protection function models a thermal profile of the equipment being protected (overload protection with memory capability). Both the previous history of an overload and the heat loss to the environment are taken into account.

The solution of this equation in steady-state operation is an e-function whose asymptote represents the final temperature Θ_{End}. After an initial settable overtemperature threshold is reached, an alarm is issued, e.g. for timely prompting of load reduction. If the second overtemperature threshold, i.e. final overtemperature = trip temperature, is reached, the protected equipment is disconnected from the network. The overload protection can, however, also be set to ***Alarm Only***. In this case only an alarm is issued even if the final temperature is reached.

The overtemperature is calculated from the largest of the three phase currents. Since the calculation is based on rms values of currents, harmonics which contribute to a temperature rise of the stator winding are also considered.

The maximum thermally permissible continuous current I_{max} is described as a multiple of the nominal current I_N of the protected object:

$I_{max} = k \cdot I_N$

In addition to the k factor (parameter **K-FACTOR**), the **TIME CONSTANT** τ and the alarm temperature Θ **ALARM** (in percent of the trip temperature Θ_{TRIP}) must be specified.

Overload protection also has a current alarm feature (**I ALARM**) in addition to the temperature alarm stage. The current warning element may report an overload current prematurely (when I_{max} is exceeded), even if the calculated operating temperature has not yet attained the warning or tripping levels.

Coolant Temperature (Ambient Temperature)

With 7UM62, the thermal model considers an external temperature value. Depending on the application, this temperature can be the coolant or ambient temperature or, in the case of gas turbines, the entry temperature of the cold gas.

The temperature to be considered can be input in one of the following ways:

- Via measuring transducer (TD 2)
- via Profibus DP interface/Modbus
- Via temperature detection unit (Thermobox, RTD 1)

An external temperature sensor measures e.g. the coolant temperature and converts it to a temperature-proportional current or voltage. This output quantity can be fed into the 7UM62 via the integrated **measuring transducer TD 2**. If a signal level between 4 mA and 20 mA is used, the measuring circuit for temperature input can additionally be monitored for interruptions. If the measured current of the external amplifier drops below 2 mA, the relay outputs a disturbance indication, and switches at the same time to a fictional coolant temperature of 40 °C (the temperature assumed if there is no coolant temperature detection).

The ambient or coolant temperature can also be detected by an external temperature sensor, digitized and fed to the 7UM62 via the **Profibus-DP Interface / Modbus** .

If a temperature supervision feature is implemented using a thermobox (see Section 2.46) the RTD1 input can be used for temperature inclusion in the overload protection.

With coolant temperature detection in accordance with one of the three methods described, the maximum permissible current I_{max} is influenced by the temperature difference of the coolant. If the ambient or coolant temperature is lower, the machine can support a higher current than when the temperatures are high.

Current Limiting

In order to prevent overload protection on occurrence of high short-circuit currents (and with small time constants) from causing extremely short trip times and thereby perhaps affecting the time grading of the short-circuit protection, it is possible to implement current limiting for the overload protection. Currents exceeding the value specified at parameter 1615 **I MAX THERM.** are limited to this value and thus do they do not further reduce trip time in the thermal memory.

Standstill Time Constant

The above differential equation assumes a constant cooling that is reflected by the time constant $\tau = R_{th} \cdot C_{th}$ (thermal resistance and thermal capacitance). In a self-ventilated machine, however, the thermal time constant at standstill can differ considerably from the time constant of a continually running machine, since then the ventilation provides for cooling whereas at standstill only natural convection takes place.

Therefore, two time constants must be considered for the setting in such cases.

In this context, machine standstill is detected when the current undershoots the threshold value **BkrClosed I MIN** (see margin heading "Current Flow Monitoring" in Subsection 2.5).

Blocking

The thermal memory may be reset via a binary input („>RM th.rep. O/L"). The current-induced excessive temperature value is reset to zero. The same is achieved by entering a blocking („>BLK ThOverload"); in that case the overload protection is blocked completely, including the current alarm stage.

When machines must be started for emergency reasons, operating temperatures above the maximum permissible operating temperatures are allowed (emergency start). Then exclusively the tripping signal can be blocked via a binary input („>Emer.Start O/L"). Since the thermal profile may have exceeded the tripping temperature after startup and dropout of the binary input has taken place, the protection function features a programmable run-on time interval (**T EMERGENCY**) which is started when the binary input drops out and continues suppressing a trip signal. Tripping by the overload protection will be defeated until this time interval elapses. This binary input affects only the tripping signal. It has no effect on the fault condition logging nor does it reset the thermal profile.

Behaviour on Power Supply Failure

For overload protection, together with all other thermal protection functions of the 7UM62 in the Power System Data 1 (parameter 274 **ATEX100**, see Section 2.5), it is possible to choose whether the calculated overtemperature will be stored throughout a power supply failure, or reset to zero. This latter option is the default setting.

The following figure shows the logic diagram for overload protection.

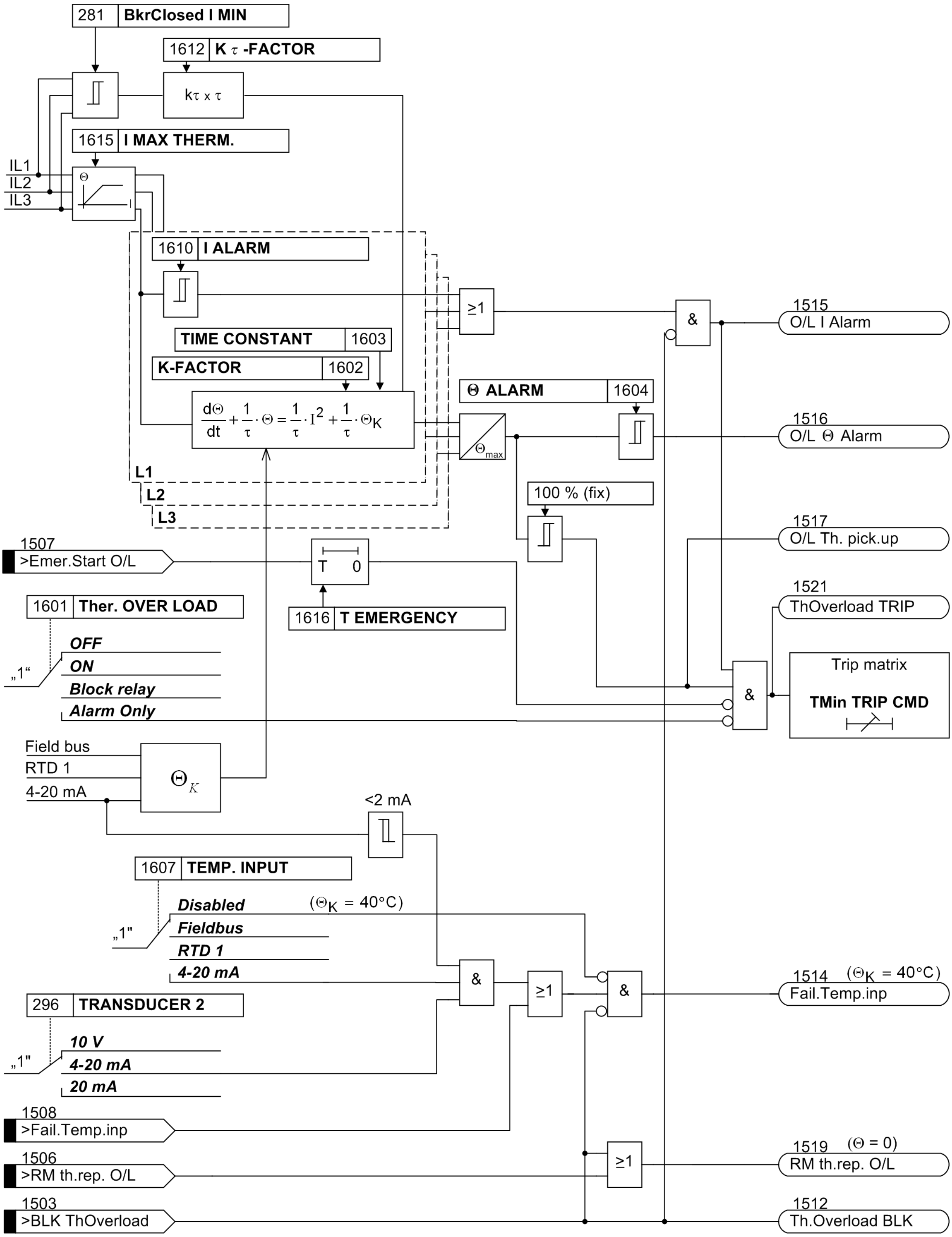


Figure 2-22 Logic of the Overload Protection Function

2.11.2 Setting Notes

General

Overload protection is only effective and accessible if address 116 **Therm.Overload** is set to ***Enabled*** during configuration. If the function is not required, it is set to ***Disabled***.

Transformers and generators are especially prone to damage by extended overloads. These overloads cannot and should not be detected by short-circuit protection. Time overcurrent protection should be set so high that it only detects faults, since short-circuit protection only permits short time delays. Short time delays, however, do not allow measures for unburdening the overloaded equipment nor do they permit advantage to be taken of its (limited) overload capacity.

The 7UM62 protective relay features an overload protective function with thermal tripping characteristic adaptable to the overload capability of the equipment being protected.

At address 1601 **Ther. OVER LOAD** the thermal overload protection ***ON*** or ***OFF*** can be set, the trip command blocked (***Block relay***) or the protection function set to ***Alarm Only***. In the latter case no fault record is created should an overload occur. If overload protection is switched ***ON***, tripping is also possible.

K-Factor

The overload protection is set with quantities per unit. The nominal current $I_{N, Mach}$ of the object to be protected (generator, motor, transformer) is typically used as base current for overload detection. The thermally permissible continuous current $I_{max\ prim}$ can be used to calculate a factor k_{prim}:

$$k_{prim} = \frac{I_{max\ prim}}{I_{N\ Mach}}$$

The thermally admissible continuous current for the equipment being protected is generally obtainable from manufacturer's specifications. If no specifications are available, a value of 1.1 times the nominal current rating is assumed.

The **K-FACTOR** to be set at the 7UM62 (address 1602) refers to the secondary nominal current (= device current). The following applies for the conversion:

$$\text{Setting value K-FACTOR} = \frac{I_{max\ prim}}{I_{N\ Mach}} \cdot \frac{I_{N\ Mach}}{I_{N\ CT\ prim}}$$

with

$I_{max\ prim}$	thermally continuously permissible primary current of the machine
$I_{N\ Mach}$	Nominal Current of the Machine
$I_{NCT\ prim}$	Nominal primary CT current

Example: Generator and current transformer with the following data:

Permissible Continuous Current	$I_{max\ prim} = 1.15 \cdot I_{N, Mach}$
Generator Nominal Current	$I_{N\ Mach}$ = 483 A
Current Transformer	500 A / 1 A

$$\text{Setting Value K-FACTOR} \approx 1.15 \approx \frac{483\text{ A}}{500\text{ A}} \approx 1.11$$

Time Constant

The overload protection tracks overtemperature progression, employing a thermal differential equation whose steady state solution is an exponential function. The **TIME CONSTANT** τ (address 1603) is used in the calculation to determine the threshold of excess temperature and thus the tripping temperature.

If the overload characteristic of the generator to be protected is pre-determined, the user must select the protection trip characteristic so that it largely corresponds the overload characteristic, at least for small overloads.

This is also the case if the admissible power-up time corresponding to a certain overload value is indicated.

Alarm Stages

By setting the thermal warning level Θ **ALARM** (address 1604), a warning message can be issued before the tripping temperature is reached, thus avoiding tripping by promptly reducing load. This warning level simultaneously represents the dropout level for the tripping signal. The tripping signal is interrupted only when this threshold value is again undershot.

The thermal alarm level is given in % of the tripping overtemperature level.

Note: With the typical value of **K-FACTOR** = 1.1, on application of nominal machine current and adapted primary transformer current, the following final tripping overtemperature results

$$\Theta / \Theta_{Trip} = \frac{100\ \%}{1.1^2} = 83\ \%$$

of the tripping temperature. Consequently, the warning stage should be set between the final overtemperature with the nominal current (in this case 83 %) and the tripping overtemperature (100 %).

In the present example, the thermal memory reaches the following value if the nominal current is applied:

$$\Theta / \Theta_{Trip} = \frac{100\ \%}{1.15^2} = 76\ \%$$

A current warning level (parameter 1610 **I ALARM**) is also available. The level is set in secondary amperes and should be set equal to, or slightly less than, the permissible continuous current **K-FACTOR** · $I_{N\ sec}$. It may be used instead of the thermal warning level by setting the thermal warning level to 100 % and is then practically inactive.

Extension of Time Constants at Machine Standstill

The time constant programmed at address 1603 is valid for the running machine. On slowing down or standstill, the machine may cool down much more slowly. This behaviour can be modeled by prolonging the time constant by the **Kτ-FACTOR** (address 1612) on machine standstill. In this context, machine standstill is detected when the current undershoots the threshold value **BkrClosed I MIN** (see margin heading "Current Flow Monitoring" in Section **P.System Data 1**).

If no distinction between time constants is necessary, the prolongation factor **Kτ-FACTOR** can be left as 1.0 (default).

Current Limiting

The parameter 1615 **I MAX THERM.** specifies up to which current value the trip times are calculated in accordance with the prescribed formula. In the trip characteristics of Section „Technical Data“, Subsection „Overload Protection“, this limit value determines the transition to the horizontal part of the characteristics, where there is no further trip time reduction despite increasing current values. The limit value must ensure that even for the highest possible short-circuit current, the trip times of the overload protection definitely exceed the trip times of the short-circuit protection devices (differential protection, impedance protection, time overcurrent protection). As a rule, a limitation to a secondary current corresponding to roughly three times the nominal machine current will be sufficient.

Emergency Start

The run-on time to be entered at address 1616 **T EMERGENCY** must be sufficient to ensure that after an emergency startup and dropout of binary input „>Emer.Start O/L“ the trip command is blocked until the thermal replica is again below the dropout threshold.

Ambient or Coolant Temperature

The specifications given up to now are sufficient for modeling the overtemperature. In addition to this, machine protection can also process the ambient or coolant temperature. This must then be signaled to the device either via the measuring transducer TD2 provided as a temperature-proportional DC current from a measuring transducer with a live zero signal between 4 and 20 mA, linked via the thermobox, or as a digitalized measured value via the fieldbus (e.g. Profibus DP). Address 1607 **TEMP. INPUT** serves to select the temperature input procedure. If there is no coolant temperature detection, address 1607 is set to ***Disabled***. The allocation between the input signal and the temperature can be set at address 1608 (in °C) or 1609 (in °F) **TEMP. SCAL.**. The temperature value set there is equivalent to 100 % of the Profibus DP/Modbus value, or full-scale deflection (20 mA) of the measuring transducer. In the default setting, 100 % (field bus) or 20 mA (measuring transducer TD2) corresponds to 100 °C.

If under address 1607 **TEMP. INPUT** the temperature setting of ***RTD 1*** is selected, the scaling under address1608 or 1609 is ineffective. The works setting can be left as it is.

If the ambient temperature detection is used, the user must be aware that the **K-FACTOR** to be set refers to an ambient temperature of 40 °C, i.e. it corresponds to the maximum permissible current at a temperature of 40 °C.

As all calculations are performed with standardized quantities, the ambient temperature must be standardized, too. The temperature at nominal machine current is used as standardization value. If the nominal machine current deviates from the nominal CT current, the temperature must be adapted according to the following formula. At address 1605 or 1606 **TEMP. RISE I** the temperature adapted to the nominal transformer current is set. This setting value is used as standardization quantity of the ambient temperature input.

$$\Theta_{Nsec} = \Theta_{NMach} \cdot \left(\frac{I_{Nprim}}{I_{NMach}}\right)^2$$

with

Θ_{Nsec}	Machine Temperature with Secondary Nominal Current = Setting at the 7UM62 (address 1605 or 1606)
Θ_{NMach}	Machine Temperature with Nominal Machine Current
I_{Nprim}	Primary nominal current of the current transformer
I_{NMach}	Nominal current of the machine

If the temperature input is not used, the address 1607 **TEMP. INPUT** must be set to ***Disabled***. In this case, the settings of the addresses1605 or 1606 and 1608 or 1609 are not considered.

If the temperature input is used, the trip times change if the coolant temperature deviates from the internal reference temperature of 40 °C. The following formula can be used to calculate the trip time:

$$t = \tau \cdot \ln \frac{\left(\frac{I}{k \cdot I_N}\right)^2 - \left(\frac{I_{pre}}{k \cdot I_N}\right)^2}{\left(\frac{I}{k \cdot I_N}\right)^2 + \frac{\Theta_K - 40\ °C}{k^2 \cdot \Theta_N} - 1}$$

with

τ	**TIME CONSTANT** (address 1603)
k	**K-FACTOR** (address 1602)
I_N	Nominal Device Current
I	Actually Flowing Secondary Current
I_{Pre}	Previous Load Current
Θ_N	Temperature with Nominal Current I_N (address 1605 **TEMP. RISE I**)
Θ_K	Coolant Temperature Input (Scaling with Address 1608 or 1609)

Example:

Machine:

I_{NMach}	= 483 A
$I_{maxMach}$	= 1,15 I_N at Θ_K = 40 °C
Θ_{NMach}	= 93 °C
τ_{th}	= 600 s (thermal time constant of the machine)

Current transformer: 500 A/1 A

$$\text{K-FACTOR} = 1.15 \cdot \frac{483\ A}{500\ A} \approx 1.11$$ (to be set ad address 1602)

$$\Theta_{Nsec} = 93\ °C \cdot \left(\frac{500}{483}\right)^2 \approx 100\ °C$$ (to be set at address 1605 bzw. 1606 TEMP.RISE I)

With a supposed load current of I = 1.5 · $I_{N, Device}$ and a preload I_{Pre} = 0, the following trip times result for different ambient temperatures Θ_K

with $\Theta_K = 40°\ C$ $$t = \left(600\ s \cdot \ln \frac{\left(\frac{1.5}{1.1}\right)^2 - 0}{\left(\frac{1.5}{1.1}\right)^2 + \frac{40°\ C - 40°\ C}{1.1^2 \cdot 100°\ C} - 1}\right) = 463\ s$$

with $\Theta_K = 80°\ C$ $$t = \left(600\ s \cdot \ln \frac{\left(\frac{1.5}{1.1}\right)^2 - 0}{\left(\frac{1.5}{1.1}\right)^2 + \frac{80°\ C - 40°\ C}{1.1^2 \cdot 100°\ C} - 1}\right) = 268\ s$$

with $\Theta_K = 0°\ C$ $$t = \left(600\ s \cdot \ln \frac{\left(\frac{1.5}{1.1}\right)^2 - 0}{\left(\frac{1.5}{1.1}\right)^2 + \frac{0°\ C - 40°\ C}{1.1^2 \cdot 100°\ C} - 1}\right) = 754\ s$$

2.11.3 Settings

Addresses which have an appended "A" can only be changed with DIGSI, under Additional Settings.

The table indicates region-specific presettings. Column C (configuration) indicates the corresponding secondary nominal current of the current transformer.

Addr.	Parameter	C	Setting Options	Default Setting	Comments
1601	Ther. OVER LOAD		OFF ON Block relay Alarm Only	OFF	Thermal Overload Protection
1602	K-FACTOR		0.10 .. 4.00	1.11	K-Factor
1603	TIME CONSTANT		30 .. 32000 sec	600 sec	Thermal Time Constant
1604	Θ ALARM		70 .. 100 %	90 %	Thermal Alarm Stage
1605	TEMP. RISE I		40 .. 200 °C	100 °C	Temperature Rise at Rated Sec. Curr.
1606	TEMP. RISE I		104 .. 392 °F	212 °F	Temperature Rise at Rated Sec. Curr.
1607	TEMP. INPUT		Disabled 4-20 mA Fieldbus RTD 1	Disabled	Temperature Input
1608	TEMP. SCAL.		40 .. 300 °C	100 °C	Temperature for Scaling
1609	TEMP. SCAL.		104 .. 572 °F	212 °F	Temperature for Scaling
1610A	I ALARM	5A	0.50 .. 20.00 A	5.00 A	Current Overload Alarm Setpoint
		1A	0.10 .. 4.00 A	1.00 A	
1612A	Kτ-FACTOR		1.0 .. 10.0	1.0	Kt-Factor when Motor Stops
1615A	I MAX THERM.	5A	2.50 .. 40.00 A	16.50 A	Maximum Current for Thermal Replica
		1A	0.50 .. 8.00 A	3.30 A	
1616A	T EMERGENCY		10 .. 15000 sec	100 sec	Emergency Time

2.11.4 Information List

No.	Information	Type of Information	Comments
1503	>BLK ThOverload	SP	>BLOCK thermal overload protection
1506	>RM th.rep. O/L	SP	>Reset memory for thermal replica O/L
1507	>Emer.Start O/L	SP	>Emergency start O/L
1508	>Fail.Temp.inp	SP	>Failure temperature input
1511	Th.Overload OFF	OUT	Thermal Overload Protection OFF
1512	Th.Overload BLK	OUT	Thermal Overload Protection BLOCKED
1513	Overload ACT	OUT	Overload Protection ACTIVE
1514	Fail.Temp.inp	OUT	Failure temperature input
1515	O/L I Alarm	OUT	Overload Current Alarm (I alarm)
1516	O/L Θ Alarm	OUT	Thermal Overload Alarm
1517	O/L Th. pick.up	OUT	Thermal Overload picked up
1519	RM th.rep. O/L	OUT	Reset memory for thermal replica O/L
1521	ThOverload TRIP	OUT	Thermal Overload TRIP

2.12 Unbalanced Load (Negative Sequence) Protection (ANSI 46)

The unbalanced load protection detects asymmetrical loads of three-phase induction machines. Unbalanced loads create a counter-rotating field which acts on the rotor at double frequency. Eddy currents are induced on the rotor surface, leading to local overheating at the transition between the slot wedges and the winding bundles. Another effect of unbalanced loads is overheating of the damper winding. In addition, this protection function may be used to detect interruptions, faults, and polarity problems with current transformers. It is also useful for detecting 1-pole and 2-pole faults with magnitudes lower than the load currents.

2.12.1 Functional Description

Determining the Unbalanced Load

The unbalanced load protection of 7UM62 filters the fundamental harmonic components from the phase currents into their symmetrical components. These are used to evaluate the negative-phase sequence system, i.e. the negative phase-sequence current I_2. If the negative phase-sequence current exceeds a parameterized threshold value, the trip time starts. A trip command is transmitted as soon as this trip time has expired.

Warning Stage

If the value of the continuously permissible, negative phase-sequence current **I2>** is exceeded, after expiry of a set time **T WARN** a warning message „I2> Warn“ is issued (see Figure 2-23).

Thermal Characteristic

The machine manufacturers indicate the permissible unbalanced load by means of the following formula:

$$t_{perm} = \frac{K}{\left(\frac{I_2}{I_N}\right)^2}$$

where t_{perm} = maximum permissible application time of the negative-sequence current I_2
K = Asymmetry factor (machine constant)
I_2/I_N = Unbal. load (ratio neg. phase-sequ. I_2 nom. cur. I_N)

The asymmetry factor depends on the machine and represents the time in seconds during which the generator can be loaded with a 100 % unbalanced load. This factor is typically in a range between 5 s and 30 s.

The heating up of the object to be protected is calculated in the device as soon as the permissible unbalanced load **I2>** is exceeded. In this context, the current-time-area is calculated constantly to ensure a correct consideration of various load cases. As soon as the current-time-area $((I_2/I_N)^2 \cdot t)$ has reached the K asymmetry factor, the thermal characteristic is tripped.

Limitation

To avoid overfunctioning of the thermal tripping stage during asymmetrical short circuits, the input current I_2 is restricted. This limit is either $10 \cdot I_{2adm.}$ or the setting value of the I_2>> stage (addr. 1706), whichever is smaller. Above this current value the tripping time of the thermal function is constant. In addition the thermal memory is limited to 200% of the tripping temperature. This avoids prolonged cooling after a delayed short circuit tripping.

Cool Down

A cool-down time with adjustable parmeters starts as soon as the constantly permissible unbalanced load **I2>** is undershot. The tripping drops out on dropout of the pickup. However, the counter content is reset to zero with the cooling time parameterized at address 1705 **T COOL DOWN**. In this context, this parameter is defined as the time required by the thermal replica to cool down from 100 % to 0 %. The cool-down time depends on the construction type of the generator, and especially of the damper winding. Preloading is taken into consideration when unbalanced loading occurs again during the cool-down period. The protective relay will thus trip in a shorter time.

Tripping Stages

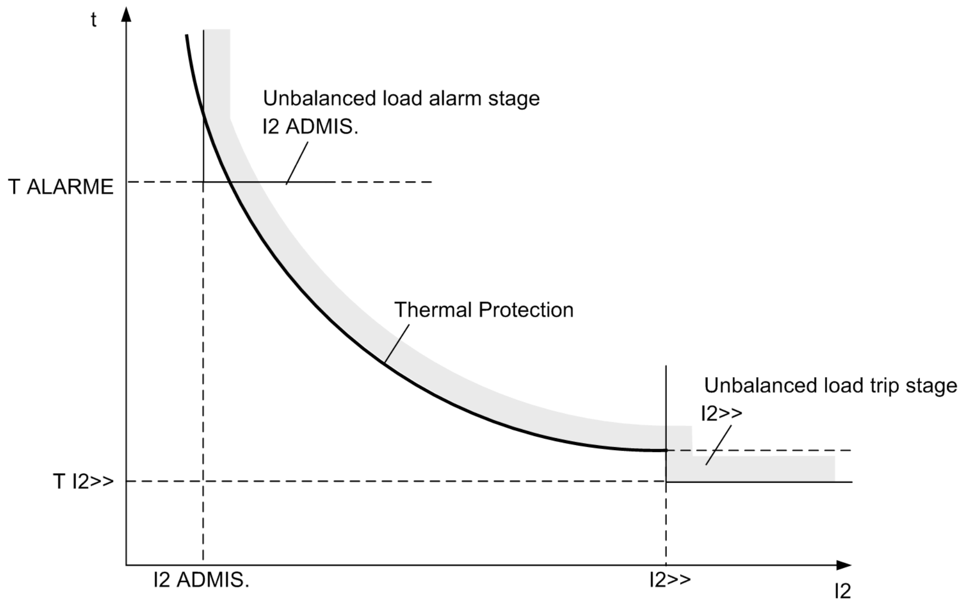


Figure 2-23 Tripping Zone of the Unbalanced Load Protection

Definite Time Tripping Stage

High negative phase sequence currents can only be caused by a two-pole power system short circuit which must be covered in accordance with the network grading plan. For this reason, the thermal characteristic is cut by a selectable, independent negative phase-sequence current stage (parameters 1706 **I2>>** and 1707 **T I2>>**).

Please also observe the instructions regarding phase sequence changeover in Sections 2.5 and 2.47.

Logic

The following figure shows the logic diagram of the unbalanced load protection. The protection may be blocked via a binary input („>BLOCK I2“). Pickups and time stages are reset and the metered values in the thermal replica are cleared. The binary input „>RM th.rep. I2“ only serves to clear metered values of the thermal characteristic.

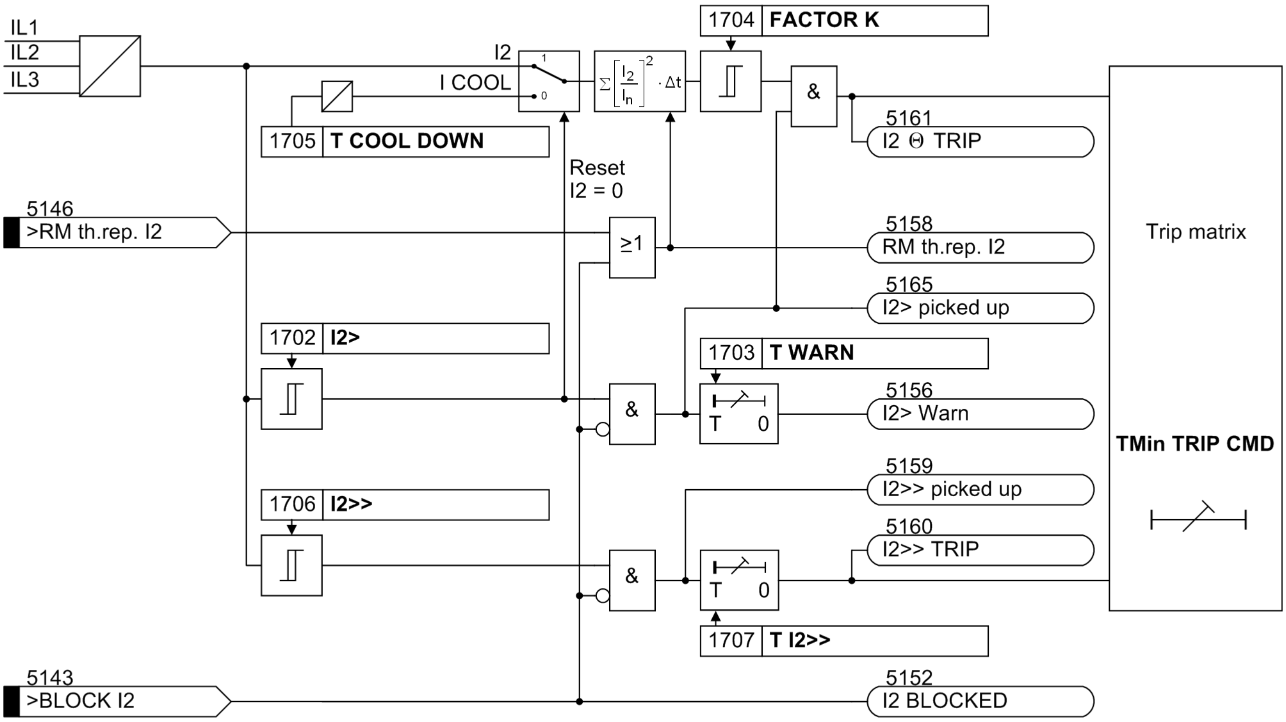


Figure 2-24 Logic diagram of the unbalanced load protection

2.12.2 Setting Notes

General

Unbalanced load protection is only in effect and accessible if address 117 **UNBALANCE LOAD** is set to ***Enabled*** during configuration. If the function is not required, it is set to ***Disabled***.

The address 1701 **UNBALANCE LOAD** serves to switch the unbalanced load protection ***ON*** or ***OFF*** or to block only the trip command (***Block relay***).

The maximum permissible, permanent negative phase-sequence current is important for the thermal model. For machines of up to 100 MVA with non-salient pole rotors, this typically amounts to at least 6 % to 8 % of the nominal machine current, and with salient-pole rotors at least 12 %. For larger machines and in cases of doubt, please refer to the instructions of the machine manufacturer.

It is important to note that the manufacturer's data relate to the primary values of the machine, for example, the maximum permissible permanent inverse current referring to the nominal machine current is indicated. For settings on the protective relay, this data is converted to the secondary inverse current. The following applies

$$\text{Pickup Setting I2>} = \frac{I_{2\,max\,prim}}{I_{N\,Mach}} \cdot \frac{I_{N\,Mach}}{I_{N\,CT\,prim}}$$

with

$I_{2\,max\,prim}$	Permissible long-term thermal inverse current of the machine
$I_{N\,Mach}$	Nominal current of the machine
$I_{N\,CT\,prim}$	Primary nominal current of the current transformer

Pickup Threshold / Warning Stage

The value for **I2>** is set at address 1702. It is at the same time the pickup value for a current warning stage whose delay time **T WARN** is set at address 1703.

<u>Example:</u>

Machine	$I_{N\,Mach}$	= 483 A
	$I_{2\,max\,prim}$ / $I_{N\,Mach}$	= 11 % permanent (salient-pole machine, see Figure 2-25)
Current transformer	$I_{N\,CT\,prim}$	= 500 A
Setting value	$I_{2\,perm.}$	= 11 % · (483 A/500 A) = 10.6 %

Asymmetry factor K

If the machine manufacturer has indicated the loadability duration due to an unbalanced load by means of the constant $K = (I_2/I_N)^2 \cdot t$, it is set immediately at the address 1704 **FACTOR K**. The constant K is proportional to the admissible energy loss.

Conversion to Secondary Values

The factor K can be derived from the unbalanced load characteristic according to the figure below by reading the time corresponding to the **FACTOR K** at the point $I_2/I_N = 1$.

Example:

t_{perm} = 20 s for $I_2/I_N = 1$

The constant $K_{primary}$ = 20 s determined in this way is valid for the machine side (primary side).

The factor $K_{primary}$ can be converted to the secondary side by means of the following formula:

$$K_{sec} = K_{primary} \cdot \left(\frac{I_{N\,Mach}}{I_{N\,CT\,prim}}\right)^2$$

The calculated asymmetry factor K_{sec} is set as **FACTOR K** at address 1704.

Example:

$I_{N\,Mach}$	= 483 A
$I_{N\,CT\,prim}$	= 500 A
Factor $K_{primary}$	= 20 s

Setting value at address1704:

$$\text{FACTOR K} = 20\ \text{s} \cdot \left(\frac{483\ \text{A}}{500\ \text{A}}\right)^2 = 18.7\ \text{s}$$

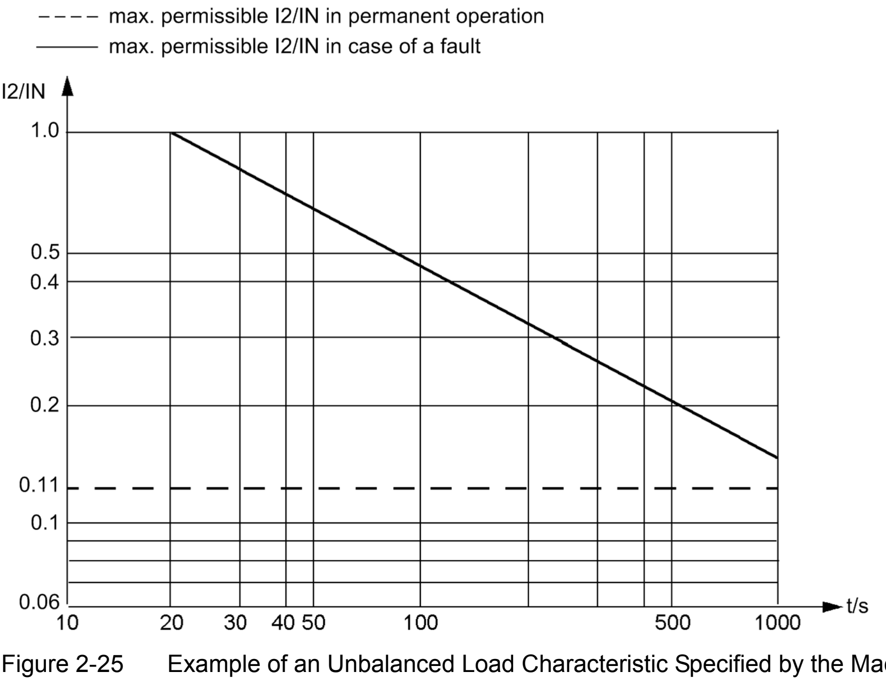


Figure 2-25 Example of an Unbalanced Load Characteristic Specified by the Machine Manufacturer

Cool-down Time

The parameter 1705 **T COOL DOWN** establishes the time required by the protection object to cool down under admissible unbalanced load **I2>** to the initial value. If the machine manufacturer does not provide this information, the setting value can be calculated by assuming an equal value for cool-down time and heatup time of the object to be protected. The formula below shows the relation between the K asymmetry factor and the cool-down time:

$$t_{Cooldown} = \frac{K}{(I_{2\,perm}/I_N)^2}$$

Example:

With an asymmetry factor of K = 20 s and an admissible continual unbalanced load I_2/I_N = 11 %, the following cool-down time results.

$$t_{Cooldown} = \frac{20\text{ s}}{(0.11)^2} \approx 1650\text{ s}$$

This value **T COOL DOWN** is set at address 1705.

Definite-Time Tripping Characteristic

Asymmetrical faults also cause high negative phase-sequence currents. A definite-time negative phase-sequence current stage characteristic 1706 **I2>>** can thus detect asymmetrical power system short circuits. A setting between 60 % and 65 % ensures that tripping always occurs in accordance with the thermal characteristic in case of a phase failure (unbalanced load continually below 100/√3 %, i.e. I_2 < 58 %). On the other hand, a two-pole short circuit can be assumed for an unbalanced load of between 60 % and 65 %. The delay time **T I2>>** (address 1707) must be coordinated with the system grading of phase-to-phase short circuits.

Contrary to time-overcurrent protection, the **I2>>** stage is able to detect fault currents at nominal current. The following conditions apply:

a two-phase fault with fault current I produces a negative sequence current

$$I_2 = \frac{1}{\sqrt{3}} \cdot I = 0.58 \cdot I$$

a single-phase fault with fault current I produces a negative sequence current

$$I_2 = \frac{1}{3} \cdot I = 0.33 \cdot I$$

With an isolated starpoint, the I current value is particularly low and can be neglected. With a low-resistance earthing, however, it is determined by the ground resistance.

2.12.3 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
1701	UNBALANCE LOAD	OFF ON Block relay	OFF	Unbalance Load Protection
1702	I2>	3.0 .. 30.0 %	10.6 %	Continously Permissible Current I2
1703	T WARN	0.00 .. 60.00 sec; ∞	20.00 sec	Warning Stage Time Delay
1704	FACTOR K	1.0 .. 100.0 sec; ∞	18.7 sec	Negativ Sequence Factor K
1705	T COOL DOWN	0 .. 50000 sec	1650 sec	Time for Cooling Down
1706	I2>>	10 .. 200 %	60 %	I2>> Pickup
1707	T I2>>	0.00 .. 60.00 sec; ∞	3.00 sec	T I2>> Time Delay

2.12.4 Information List

No.	Information	Type of In-formation	Comments
5143	>BLOCK I2	SP	>BLOCK I2 (Unbalance Load)
5146	>RM th.rep. I2	SP	>Reset memory for thermal replica I2
5151	I2 OFF	OUT	I2 is switched OFF
5152	I2 BLOCKED	OUT	I2 is BLOCKED
5153	I2 ACTIVE	OUT	I2 is ACTIVE
5156	I2> Warn	OUT	Unbalanced load: Current warning stage
5158	RM th.rep. I2	OUT	Reset memory of thermal replica I2
5159	I2>> picked up	OUT	I2>> picked up
5160	I2>> TRIP	OUT	Unbalanced load: TRIP of current stage
5161	I2 Θ TRIP	OUT	Unbalanced load: TRIP of thermal stage
5165	I2> picked up	OUT	I2> picked up

2.13 Startup Overcurrent Protection (ANSI 51)

Gas turbines can be started by means of a startup converter. A controlled converter feeds a current into the generator creating a rotating field of gradually increasing frequency. This causes the rotor to turn and thus drive the turbine. At approx. 70 % of rated speed, the turbine is ignited and further accelerated until it attains rated speed. The startup converter is thereby switched off.

2.13.1 Functional Description

Startup procedure

The following figure shows the characteristic quantities during startup. Please note that all quantities are scaled to rated values.

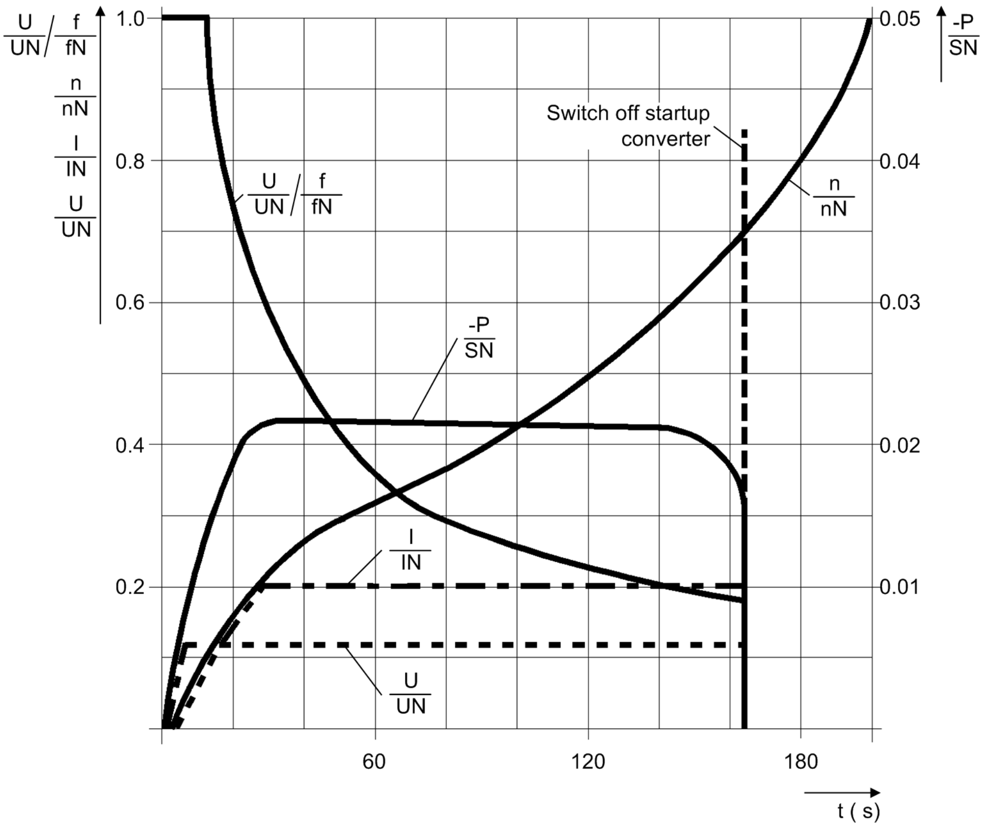


Figure 2-26 Characteristic quantities during startup of a gas turbine (S_N = 150 MVA; U_N = 10.5 kV; $P_{Startup\ Converter}$ = 2.9 MW)

Assuming that a short-circuit can occur in the generator during startup, a short-circuit protection is necessary over the entire frequency range.

The automatic adaptation of sampling frequency to current generator frequency implemented in the 7UM62 offers great advantages for this purpose since sensitivity remains the same over the entire frequency range. This adaptation starts on transition from 10 Hz to 11 Hz. As a result, all short-circuit protection functions, such as time-overcurrent protection, impedance protection and differential protection are active with the same sensitivity as with nominal frequency.

The startup overcurrent protection is a short-circuit protection function that operates below 10 Hz. Its operating range is designed for 2 Hz to approx. 10 Hz (change to operational condition 1). Beyond this range the above short-circuit protection functions are active.

The function is also active above 70 Hz with reduced sensitivity, because at that frequency the protection is again in operational condition 0.

Measuring Principle

At frequencies below 10 Hz, the protection works in operating condition 0, with the sampling frequency automatically set to nominal conditions (f_A = 800 Hz for 50 Hz networks and 960 Hz for 60 Hz networks). From the sampled phase currents, a special algorithm determines the peak values. These are converted into values proportional to the rms values, and compared with the set threshold value.

The logic is shown in the following picture.

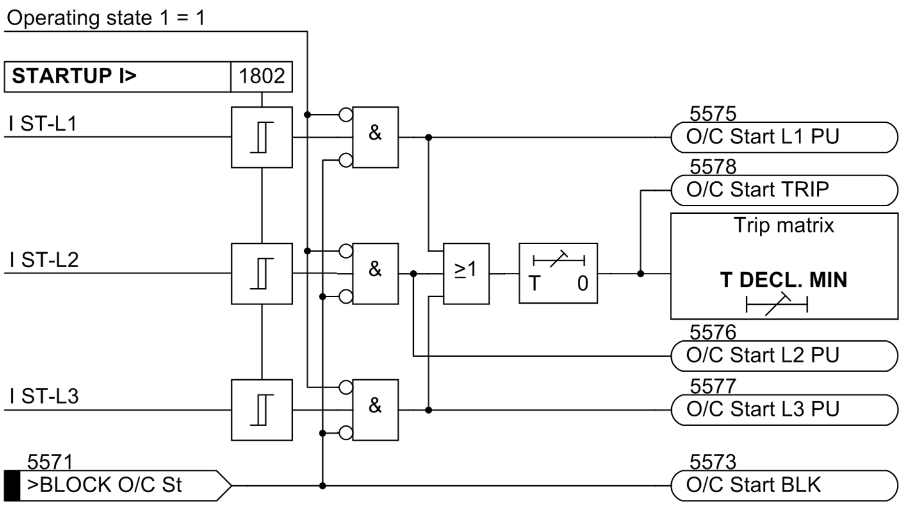


Figure 2-27 Logic diagram of the startup overcurrent protection

2.13.2 Setting Notes

General

Startup overcurrent protection is only effective and available if address 118 **O/C STARTUP** is allocated to ***Side 1*** or ***Side 2*** during configuration. If the function is not needed it is set to ***Disabled***.

Address 1801 serves to switch the function ***ON*** or ***OFF*** or to block only the trip command (***Block relay***).

Pick-up threshold

The characteristic of the startup procedure shows that the currents during startup amount to approx. 20 % of the nominal currents. This allows the protection in principle to be set below nominal current. As shown in the logic diagram, the function is blocked on change from operational state 0 to 1. Also blockage is to be provided for via the binary input.

The figure below shows an example of the estimated short-circuit currents at different frequencies. Short-circuit currents can be a multiple of the rated current. This permits the nominal current to be used for a setting which could be between 1.2 and 1.4 I/I_{NG}.

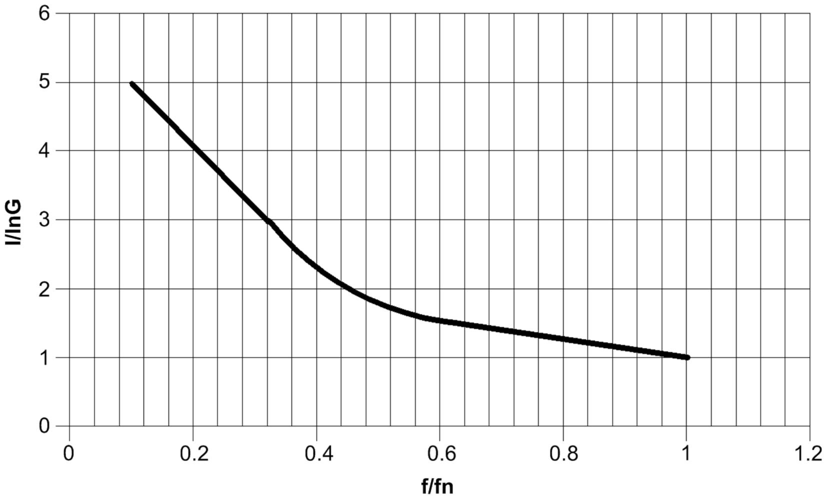


Figure 2-28 Short-circuit currents in the generator during startup (generator: 300 MVA, 15.75 kV, 50 Hz)

Delay

Since the generator circuit breaker is open during startup, there is no need to coordinate the delay time with the network. Wherever possible, no delay time should be effective at all since the operating time of the protection function is extended proportionally to the lower frequency (see Chapter Technical Data).

If a sensitive setting is selected, a delay time may be useful to avoid overfunctioning. This delay time should be based on the lowest detectable frequency of 2 Hz, and set to 0.5 s.

Short-Circuit Protection Coordination

The figure below shows the interaction between the short-circuit protection functions, such as:

- Startup overcurrent protection
- Differential Protection
- I>> stage as back-up stage for 10 Hz and higher

The pickup thresholds here are orientation values.

The differential protection Idiff and the overcurrent protection I>> are effective from approx. 10 - 11 Hz. Additionally the startup overcurrent protection I-ANF operates. It provides protection in the lower frequency range.

The result is a short-circuit protection concept where the functions complement one another.

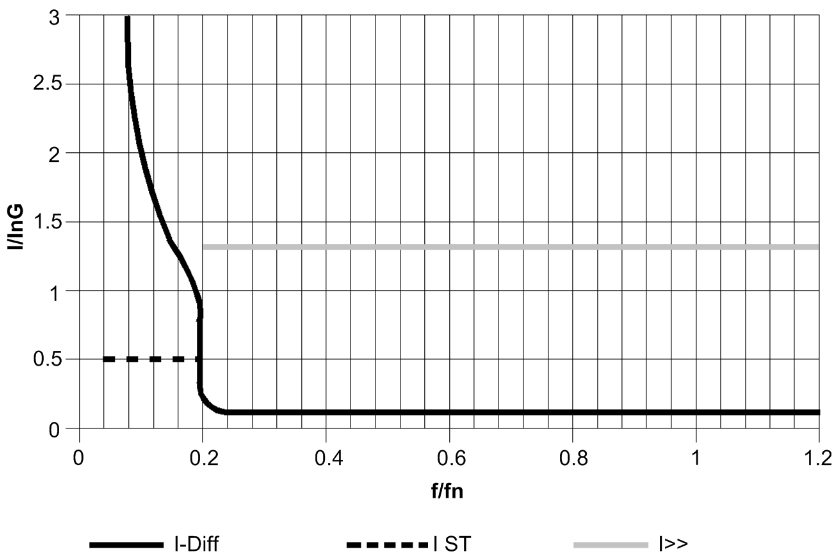


Figure 2-29 Operating range and possible pickup threshold of short-circuit protection functions

2.13.3 Settings

The table indicates region-specific presettings. Column C (configuration) indicates the corresponding secondary nominal current of the current transformer.

Addr.	Parameter	C	Setting Options	Default Setting	Comments
1801	O/C STARTUP		OFF ON Block relay	OFF	Startup O/C protection
1802	STARTUP I>	5A	0.50 .. 100.00 A	6.50 A	I> Pickup
		1A	0.10 .. 20.00 A	1.30 A	
1803	STARTUP T I>		0.00 .. 60.00 sec; ∞	0.50 sec	T I> Time Delay

2.13.4 Information List

No.	Information	Type of Information	Comments
5571	>BLOCK O/C St	SP	>BLOCK startup O/C protection
5572	O/C Start OFF	OUT	Startup O/C protection is switched OFF
5573	O/C Start BLK	OUT	Startup O/C protection is BLOCKED
5574	O/C Start ACT	OUT	Startup O/C protection is ACTIVE
5575	O/C Start L1 PU	OUT	Startup O/C phase L1 picked up
5576	O/C Start L2 PU	OUT	Startup O/C phase L2 picked up
5577	O/C Start L3 PU	OUT	Startup O/C phase L3 picked up
5578	O/C Start TRIP	OUT	Startup O/C protection TRIP

2.14 Differential Protection and Its Protected Objects

The numerical current differential protection of the 7UM62 is a high speed selective short-circuit protection for generators, motors and transformers. The individual application can be configured, which ensures optimum matching to the protected object.

The protected zone is selectively limited by the CTs at its ends.

2.14.1 Differential Protection (ANSI 87G/87M/87T)

The processing of the measured values depends on the way the differential protection is used. This section discusses first the differential protection function in general, regardless of the type of protected object. A single-phase system is referred to. Then particularities of individual protected objects are treated.

2.14.1.1 Functional Description

Basic Principle

Differential protection systems operate according to the principle of current comparison and are therefore also known as current balance protection systems. They utilize the fact that in a healthy protected object the current leaving the protected object is the same as that which entered it (current Ip, dotted in the following figure).

The secondary windings of current transformers **CT1** and **CT2**, which have the same transformation ratio, may be so connected that a closed circuit is formed. If now a measuring element **M** is connected at the electrical balance point, it reveals the current difference. Under undisturbed conditions (e.g. on-load operation) no current flows in the measuring element. In the event of a fault in the protected object, the summation current $\underline{I}_{p1}+\underline{I}_{p2}$ flows on the primary side. The currents on the secondary side $\underline{I}_1$ and $\underline{I}_2$ flow as a summation current $\underline{I}_1+\underline{I}_2$ through the measuring element **M**. As a result, the simple circuit shown in the following figure ensures a reliable tripping of the protection if the fault current flowing into the protected zone (limited by the current transformer) during a fault is high enough for the measuring element **M** to respond.

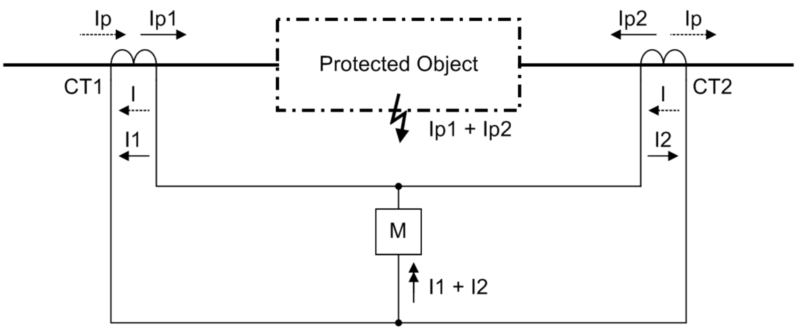


Figure 2-30 Basic Principle of Differential Protection (Single-Phase Representation)
(I_{px} = primary current, I_x = secondary current)

Current Stabilization

When an external fault causes heavy currents to flow through the protected zone, differences in the magnetic characteristics of the current transformers **CT1** and **CT2** under conditions of saturation may cause a significant current to flow through the element **M**, which can cause a tripping. To prevent the protection from such over-functioning, a stabilizing current is imposed.

The stabilizing quantity is derived from the arithmetical sum of the absolute values of $|\underline{I}_1| + |\underline{I}_2|$. The following definitions apply:

a tripping or differential current

$I_{diff} = |\underline{I}_1 + \underline{I}_2|$

and the stabilizing or restraint current

$I_{stab} = |\underline{I}_1| + |\underline{I}_2|$

I_{diff} is derived from the fundamental frequency current and produces the tripping effect, I_{stab} counteracts this effect.

To further illustrate the effect, let´s look at three important operating conditions with ideal and adepted measurement quantities:

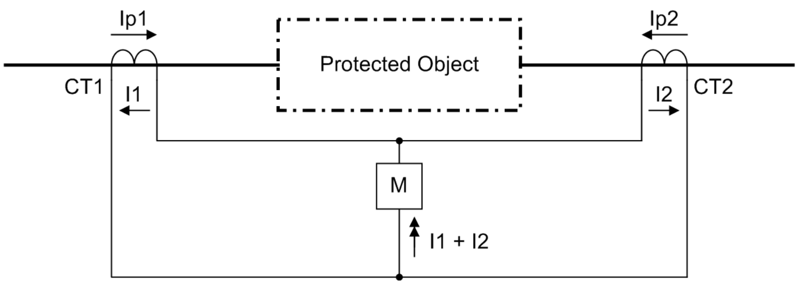


Figure 2-31 Definitions of Currents

1. Through-flowing current under undisturbed conditions or external fault: $\underline{I}_2$ reverts its direction, i.e. changes sign, i.e. $\underline{I}_2 = -\underline{I}_1$; also $|\underline{I}_2| = |\underline{I}_1|$

   $I_{diff} = |\underline{I}_1 + \underline{I}_2| = |\underline{I}_1 - \underline{I}_1| = 0$

   $I_{stab} = |\underline{I}_1| + |\underline{I}_2| = |\underline{I}_1| + |\underline{I}_1| = 2 \cdot |\underline{I}_1|$

   No tripping value (I_{diff}); stabilisation (I_{stab}) corresponds to twice the through-flowing current.
2. Internal short-circuit, e.g. fed with equal currents each side:

   The following then holds: $\underline{I}_2 = \underline{I}_1$; also: $|\underline{I}_2| = |\underline{I}_1|$

   $I_{diff} = |\underline{I}_1 + \underline{I}_2| = |\underline{I}_1 + \underline{I}_1| = 2 \cdot |\underline{I}_1|$

   $I_{stab} = |\underline{I}_1| + |\underline{I}_2| = |\underline{I}_1| + |\underline{I}_1| = 2 \cdot |\underline{I}_1|$

   Tripping value (I_{diff}) and stabilising value (I_{stab}) are equal and correspond to the total fault current.
3. Internal short-circuit, fed from one side only:

   In this case, $I_2 = 0$

   $I_{diff} = |\underline{I}_1 + \underline{I}_2| = |\underline{I}_1 - 0| = |\underline{I}_1|$

   $I_{stab} = |\underline{I}_1| + |\underline{I}_2| = |\underline{I}_1| + 0 = |\underline{I}_1|$

   Tripping value (I_{diff}) and stabilising value (I_{stab}) are equal and correspond to the one-sided fault current.

This result shows that for the internal fault under ideal conditions $I_{diff} = I_{stab}$. Consequently, the characteristic of internal faults is a straight line with a upward slope of 45° (dot-and-dash line in the following figure).

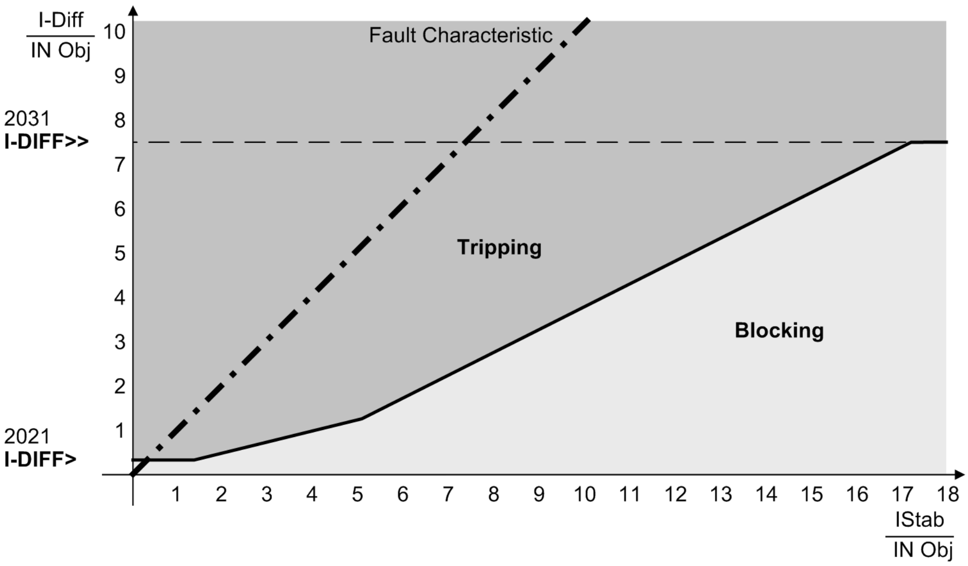


Figure 2-32 Tripping Characteristic of the Differential Protection with Fault Characteristic

Quantitative Matching of Measured values

The rated CT currents are matched to the rated current of the protected object, regardless of what that object is. As a result, all currents are referred to the protected object. To match the currents, the characteristic values of the protected object (apparent power, rated voltage) and the rated primary currents of the CTs are entered in the protective device for each side of the protected object.

Evaluation of Measured Values

The measured values are calculated at each sampling instant and from them the instantaneous values of differential and stabilizing current established. From the differential current, the fundamental frequency component is determined using a Fourier filter, which effectively attenuates interference and aperiodic DC components.

The stabilizing quantity is calculated from the arithmetic average of a rectified value, so that the filter effect is less in this case. As a result, with interference quantities, compared with the differential current, the stabilization component predominates, especially with aperiodic DC components.

Tripping Characteristic

This result shows that for internal fault $I_{diff} = I_{stab}$. Thus the characteristic of internal faults in the tripping diagram (see following figure) is a straight line with a slope of 45°. The following figure illustrates the complete stabilization characteristic of the 7UM62. The characteristic branch **a** represents the sensitivity threshold of the differential protection (setting **`I-DIFF>`**) and considers constant error currents such as magnetizing currents.

Branch **b** considers current-proportional errors which may result from transformation errors of the main CTs and the input CTs of the device, or which for example may be caused by mismatchings or by the influence of tap changers in transformers with voltage control.

For high currents which may give rise to current transformer saturation, characteristic branch **c** provides for additional stabilization.

In the presence of differential currents above branch **d** a trip command is issued regardless of stabilizing current and harmonic stabilization. This is the operating range of the „High Speed Trip StageI_{Diff} >>“.

The area of **add-on stabilization** is determined by the saturation indicator (see margin title "Add-on Stabilization with CT saturation").

The currents II_{diff} and I_{stab} are compared by the differential protection with the operating characteristic according to the following figure. If these values result result in a point within the tripping area, a trip signal is issued. If the current conditions I_{diff} /I_{stab} appear near the fault characteristic (≥ 9 0 % of the slope of the fault characteristic), tripping occurs even when the trip characteristic has been excessively increased due to add-on stabilization, startup or DC current detection.

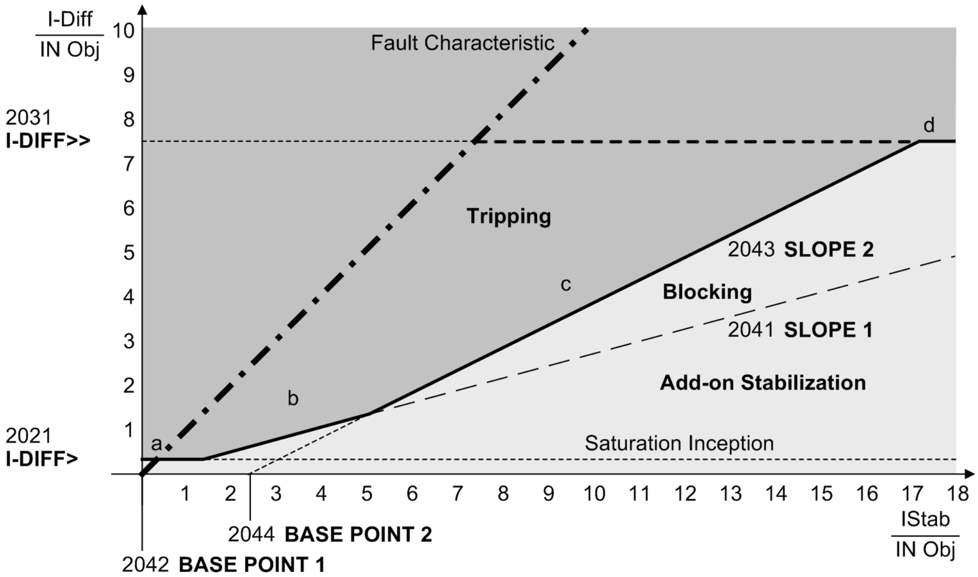


Figure 2-33 Operating Characteristic of the Differential Protection

High-Speed Tripping Stage I_{diff}>>

The high-speed trip stage I_{Diff} >> clears high-current internal faults instantaneously. As soon as the differential current rises above the threshold I_{Diff}>> (branch **d**), a trip signal is issued regardless of the magnitude of the stabilizing current.

This stage can operate even when, for example, a considerable second harmonic is present in the differential current caused by current transformer saturation by a DC component in the short-circuit current, and which could be interpreted by the inrush stabilization function as an inrush current.

Fast tripping uses both the fundamental component of the differential current as well as instantaneous values. Instantaneous value processing ensures fast tripping even if the current fundamental component was strongly attenuated by current transformer saturation.

High-current internal faults in the protected transformer can be cleared instantaneously without regard to the stabilizing currents whenever the current amplitude excludes an external fault. This is always the case when the short-circuit current is higher than $1/u_{SC} \cdot I_{N\ Transf}$.

Add-On Stabilization During Current Transformer Saturation

During an external fault which produces a high through-flowing short-circuit current causing current transformer saturation, a considerable differential current can be simulated, especially when the degree of saturation is different at the two measuring points. If the quantities I_{diff}/I_{stab} result in an operating point which lies in the trip area of the operating characteristic, a trip signal would be the consequence if no special measures were taken.

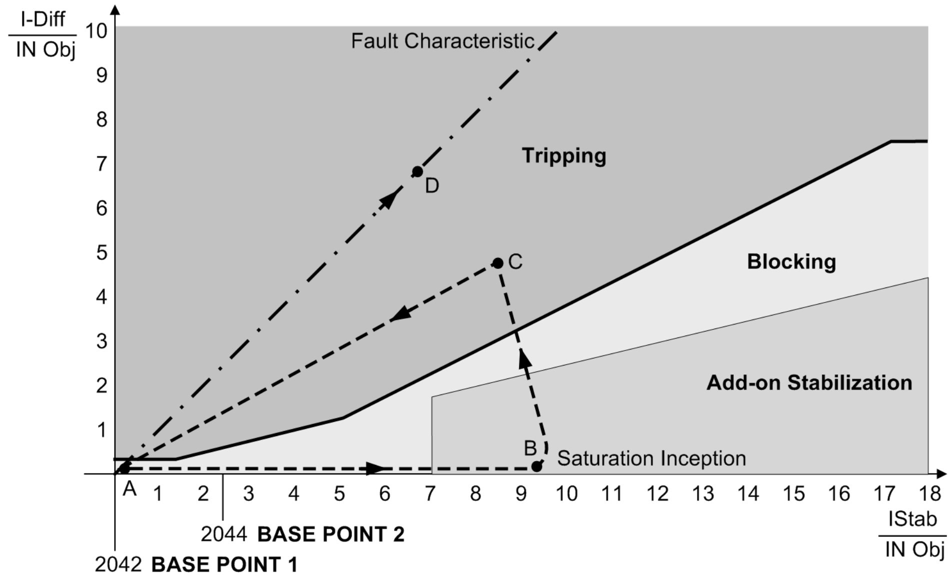


Figure 2-34 Operation Characteristic of the Differential Protection with Fault Characteristic

The 7UM62 provides a saturation indicator which detects such phenomena and initiates add-on stabilization measures. The saturation indicator evaluates the dynamic behaviour of the differential and stabilizing current.

The dotted line in Figure 2-34 shows the instantaneous development of currents in case of a external fault with transformer saturation on one side.

Immediately after the fault (**A**), the short-circuit currents rise strongly, causing a correspondingly high stabilizing current (2 x through-flowing current). Saturation occurring on one side (**B**) now causes a differential current and reduces the stabilizing current, so that the operating point I_{diff}/I_{stab} may move into the tripping area (**C**).

In contrast, the operating point moves immediately along the fault characteristic (**D**) when an internal fault occurs since the stabilization current will barely be higher than the differential current. Therefore, an internal fault is assumed as soon as the ratio I_{diff}/I_{stab} has exceeded an internal threshold for a fixed minimum time.

Current transformer saturation in case of an external fault is thus characterized by a high stabilizing current flowing at the beginning, i.e. by the operating point (diagram see Figure 2-34) moving into an area that is typical for a high-current external fault ("add-on stabilization"). The add-on stabilization area is limited by the parameter **I-ADD ON STAB.** and the first straight line of the characteristic (with **BASE POINT 1** and **SLOPE 1**) (see following figure). The saturation detector makes its decision within the first quarter of a cycle. When an external fault is detected, the differential protection is blocked for a selectable time. The blocking is cancelled as soon as the operating point I_{diff}/I_{stab} moves steadily (i.e. over 2 cycles) within the tripping area. This allows consequential faults in the protected area to be quickly recognized even after an external fault involving current transformer saturation.

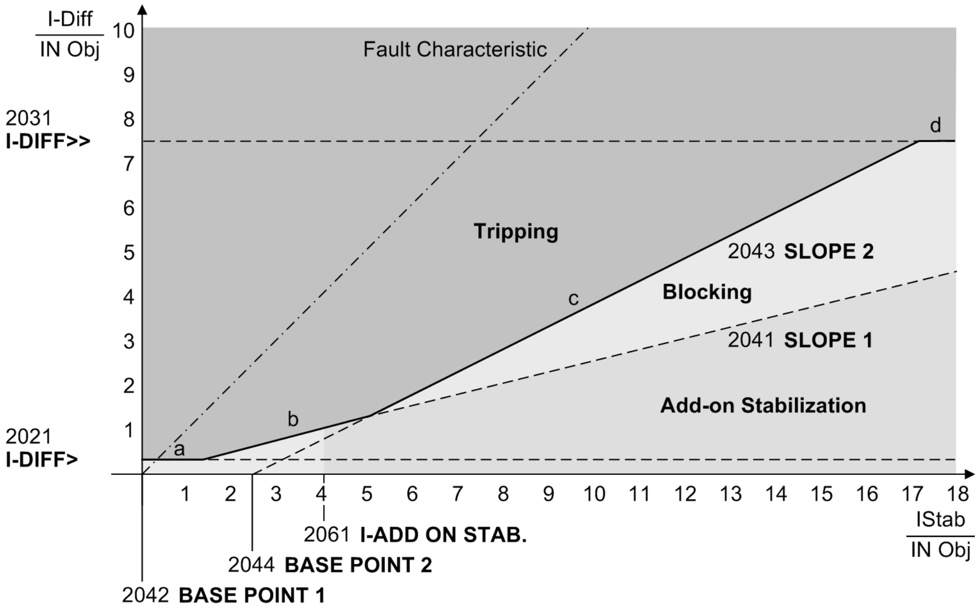


Figure 2-35 Add-on Stabilization During Current Transformer Saturation

Identification of DC Components

A further stabilization (restraint) comes into effect when differential secondary currents are simulated by different transient behaviour of the current transformer sets. This differential current is caused by different DC time constants in the secondary circuits during through-current conditions, i.e. the equal primary DC components are transformed into unequal secondary DC components due to different time constants of the secondary circuits. This produces a DC component in the differential current which increases the pickup values of the differential stage for a short period.

Harmonic Stabilization

In transformers in particular, high short-time magnetizing currents may be present during power-up (inrush currents). These currents enter the protected zone but do not exit it again, so that they produce differential quantities as they seem like single-end fed fault currents. Unwanted differential currents may also be caused by parallel connection of transformers or by transformer overexcitation due to excessive voltage.

The inrush current can amount to a multiple of the rated current and is characterized by a considerable 2nd harmonic content (double rated frequency) which is practically absent during a short-circuit. If the second harmonic content in the differential current exceeds a selectable threshold, tripping is blocked.

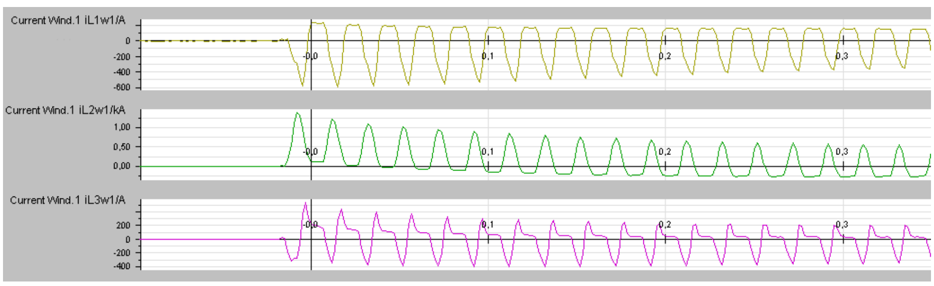


Figure 2-36 Inrush current - Recording Example of the Three Higher-Voltage Currents

Besides the second harmonic, another harmonic can be selected in the 7UM62 to cause stabilization. A choice can be made between the third and fifth harmonic for harmonic stabilization.

Steady-state overexcitation is characterized by odd harmonics. The 3rd or 5th harmonic is suitable to detect overexcitation. Because the third harmonic is often eliminated in power transformers (e.g. in a delta winding), the use of the fifth is more common.

Converter transformers also produce odd harmonics which are practically absent in the case of an internal short-circuit.

The differential currents are analysed for harmonic content. For frequency analysis digital filters are used which perform a Fourier analysis of the differential currents. As soon as the harmonics content exceeds the set thresholds, a stabilization of the respective phase evaluation is started. The filter algorithms are optimized for transient behaviour such that additional measures for stabilization during dynamic conditions are not necessary.

Harmonic stabilization is maintained for two cycles after decrease of the differential current. This prevents unwanted under-stabilization when external faults are cleared and higher-order harmonics disappear.

Since inrush restraint operates individually for each phase, the protection is fully operative even when the transformer is switched onto a single-phase fault, in which case it is possible for an inrush current to flow through one of the undisturbed phases.

In "modern type" transformers in particular, the 2nd harmonics content may not exceed the threshold value in all three phases on switch-on. To avoid spurious tripping, the so-called "crossblock" function must be activated. As soon as an inrush current is detected in one phase, the other phases of the differential protection stage **I-DIFF>** are blocked.

The "crossblock" function can be limited to a selectable duration. After this cross-block time has elapsed, no further cross-block is possible for as long as a current fault condition lasts, i.e. cross-blocking is possible only once after a fault has occurred, and only for the set cross-block time period.

The other harmonic stabilizations also operate individually for each phase. However, it is also possible —as it is for inrush stabilization— to set protection such that on overshooting of the admissible harmonic content in the current of only one phase, the other phases of the differential stage **I-DIFF>** are blocked. This cross-block feature with 3rd or 5th harmonic works in the same way as with the 2nd harmonic.

Pickup Value Increase on Startup

An increase of the pickup value on startup provides additional security against overfunctioning when a non-energized protection object is switched in. As soon as the stabilizing current of one phase has undershot a settable value **I-REST. STARTUP**, the increase of the pickup value is activated for the **I-DIFF>** stage. As the stabilizing current is twice the through-flowing current in normal operation, its undershooting of that threshold is a criterion for detecting that the protected object is not energized. The pickup value **I-DIFF** is now increased by a settable factor (see following figure); the other branches of the I_{diff}> stage are displaced proportionally.

This is done by dividing the DIFF current of the respective phase by the factor **START-FACTOR** before the characteristic monitoring. The differential current for fault recording, tripping current etc. is not affected by this.

The return of the stabilizing current indicates the startup. After a settable time **T START MAX** the increase of the characteristic is retracted.

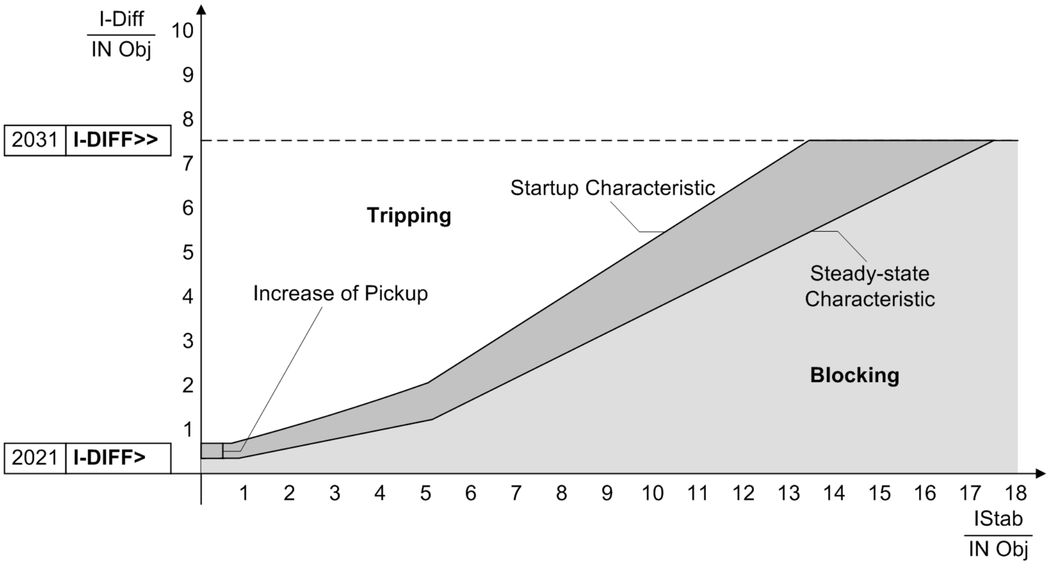


Figure 2-37 Increase of pickup value for stage $I_{DIFF>}$ on startup

Fault Detection, Dropout

The differential protection does not normally use a "pickup", since the detection of a fault is identical with the tripping condition. Like all SIPROTEC 4 devices, however, the differential protection feature of the 7UM62 has a pickup that is the starting point for a number of subsequent activities. The pickup marks the beginning of a fault. This is necessary e.g. for creating fault logs and fault records. The pickup also controls internal function sequences for both internal and external faults (such as necessary actions of the saturation detector).

A pickup is detected as soon as the fundamental wave of the differential current has attained 85 % of the setting value or more than 85 % of the stabilizing current are in the add-on stabilization area (see following figure). A pickup signal is also issued when the high-speed trip stage for high-current faults picks up.

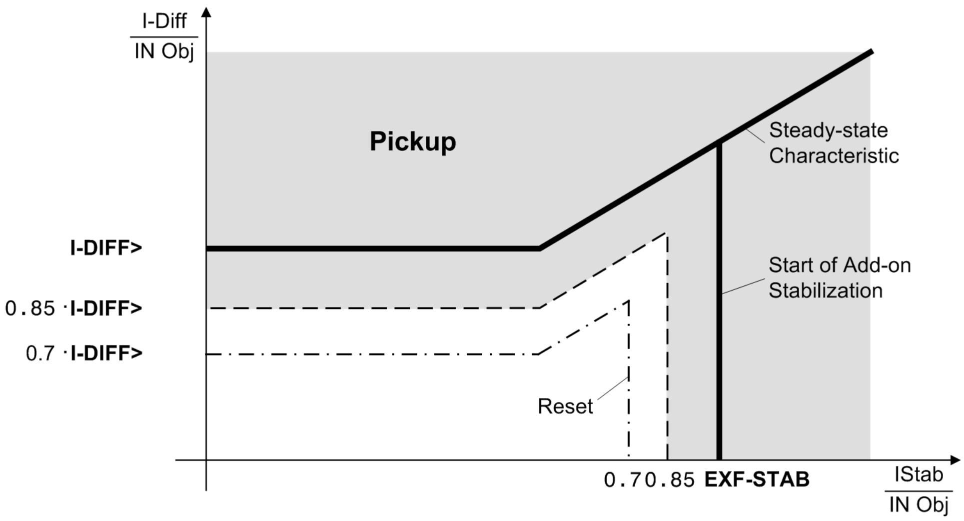


Figure 2-38 Pickup of the Differential Protection

If stabilization by higher-order harmonics is activated, the system first performs a harmonic analysis (approx. 1 cycle) to check the stabilization conditions if necessary. Otherwise, the trip command is issued as soon as the tripping conditions are fulfilled (hatched area in Figure 2-33).

For special cases, the trip command can be delayed.

The following figure shows a simplified diagram of the tripping logic.

A dropout is detected when, during 2 cycles, pick-up is no longer recognized in the differential value, i.e. the differential current has fallen below 70 % of the set value, and the other pickup conditions are no longer fulfilled either.

If a trip command was never initiated, the fault is considered ended on dropout.

If a trip command was initiated, it is maintained for the minimum command duration set in the general device data for all protection functions (see also Section **P.System Data 1**).

Note

The special features of the differential protection for individual protected objects are described in separate chapters.

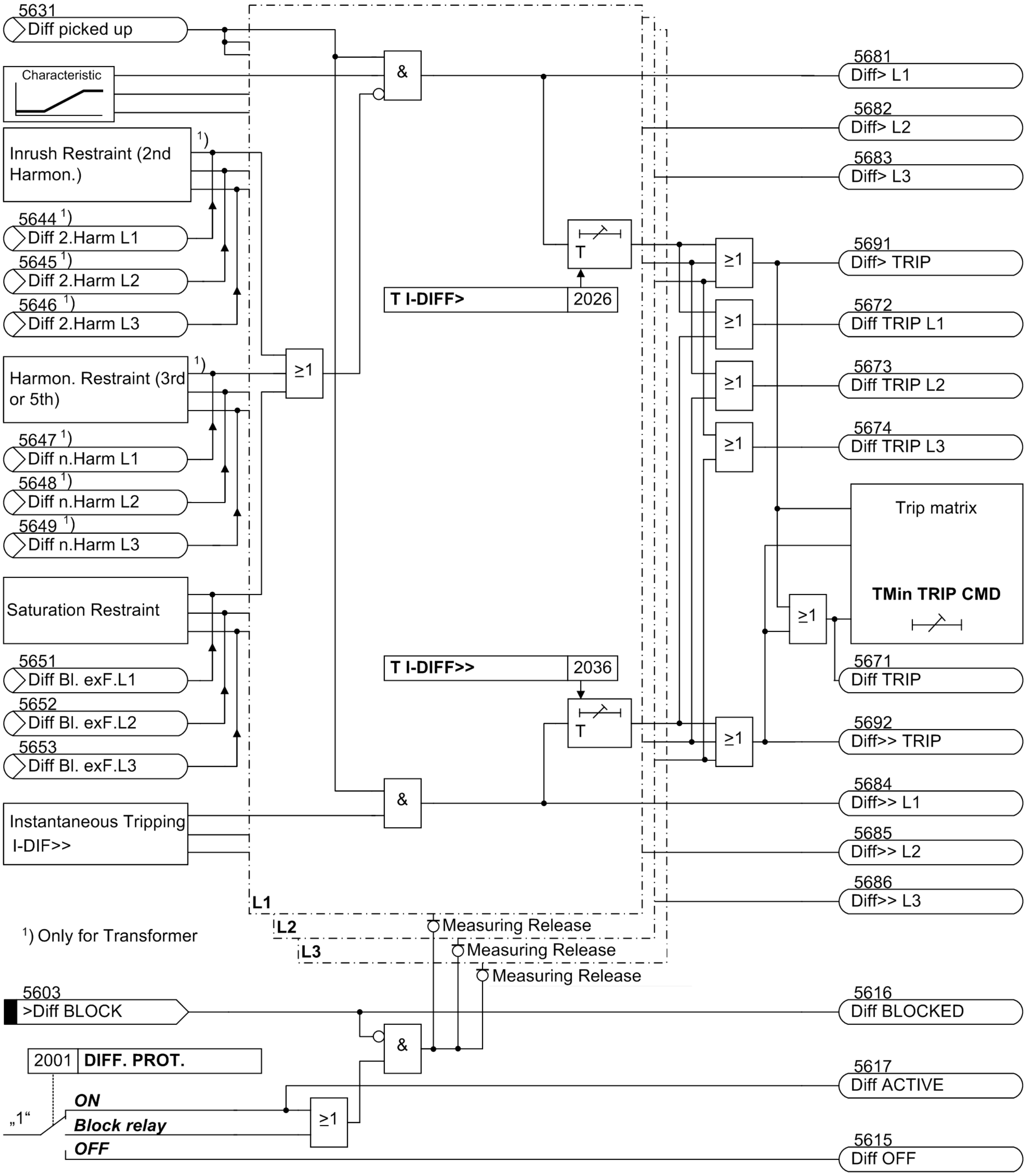


Figure 2-39 Logic Diagram of the Tripping Logic in Differential Protection

2.14.1.2 Setting Notes

General

Differential protection is only effective and available if the type of protected object for this function was set during protective function configuration (Section 2.4, address 120, **DIFF. PROT.** = ***Generator/Motor*** or ***3 phase transf.***). Only the relevant parameters for that object are presented, all others are hidden. If the function is not required ***Disabled*** is set. The address 2001 **DIFF. PROT.** serves to enable the function ***ON*** and ***OFF*** or to block only the trip command (***Block relay***).

Note

When the device is delivered, the differential protection function is switched **OFF**. The reason is that the protection must not be in operation unless at least the connection group (of a transformer) and the matching factors have been set beforehand. Without these settings the device may react unpredictably (e.g. tripping)!

The primary rated current $I_{N\ CTprim}$ of the used CTs should normally be higher than the rated current $I_{N,\ Obj.}$ of the object to be protected. However, at least the following condition should be observed with regard to the upper limit of the linear zone of the 7UM62, which is 20 · I_N:

$I_{N\ CTprim} > 0.75 \cdot I_{N,\ Obj.}$

Additional Settings

Note

Additional parameter settings are given in separate subsections for the respective protected objects.

2.14.1.3 Settings

Addresses which have an appended "A" can only be changed with DIGSI, under Additional Settings.

Addr.	Parameter	Setting Options	Default Setting	Comments
2001	DIFF. PROT.	OFF ON Block relay	OFF	Differential Protection
2005	INC.CHAR.START	OFF ON	OFF	Increase of Trip Char. During Start
2006	INRUSH 2.HARM.	OFF ON	ON	Inrush with 2. Harmonic Restraint
2007	RESTR. n.HARM.	OFF 3. Harmonic 5. Harmonic	OFF	n-th Harmonic Restraint
2021	I-DIFF>	0.05 .. 2.00 I/InO	0.20 I/InO	Pickup Value of Differential Curr.
2026A	T I-DIFF>	0.00 .. 60.00 sec; ∞	0.00 sec	T I-DIFF> Time Delay
2031	I-DIFF>>	0.5 .. 12.0 I/InO; ∞	7.5 I/InO	Pickup Value of High Set Trip
2036A	T I-DIFF>>	0.00 .. 60.00 sec; ∞	0.00 sec	T I-DIFF>> Time Delay
2041A	SLOPE 1	0.10 .. 0.50	0.25	Slope 1 of Tripping Characteristic

Addr.	Parameter	Setting Options	Default Setting	Comments
2042A	BASE POINT 1	0.00 .. 2.00 I/InO	0.00 I/InO	Base Point for Slope 1 of Charac.
2043A	SLOPE 2	0.25 .. 0.95	0.50	Slope 2 of Tripping Characteristic
2044A	BASE POINT 2	0.00 .. 10.00 I/InO	2.50 I/InO	Base Point for Slope 2 of Charac.
2051A	I-REST. STARTUP	0.00 .. 2.00 I/InO	0.10 I/InO	I-RESTRAINT for Start Detection
2052A	START-FACTOR	1.0 .. 2.0	1.0	Factor for Increasing of Char. at Start
2053	T START MAX	0.0 .. 180.0 sec	5.0 sec	Maximum Permissible Starting Time
2061A	I-ADD ON STAB.	2.00 .. 15.00 I/InO	4.00 I/InO	Pickup for Add-on Stabilization
2062A	T ADD ON-STAB.	2 .. 250 Cycle; ∞	15 Cycle	Duration of Add-on Stabilization
2063A	CROSSB. ADD ON	2 .. 1000 Cycle; 0; ∞	15 Cycle	Time for Cross-blocking Add-on Stabiliz.
2071	2. HARMONIC	10 .. 80 %	15 %	2nd Harmonic Content in I-DIFF
2072A	CROSSB. 2. HARM	2 .. 1000 Cycle; 0; ∞	3 Cycle	Time for Cross-blocking 2nd Harm.
2076	n. HARMONIC	10 .. 80 %	30 %	n-th Harmonic Content in I-DIFF
2077A	CROSSB. n.HARM	2 .. 1000 Cycle; 0; ∞	0 Cycle	Time for Cross-blocking n-th Harm.
2078A	IDIFFmax n.HM	0.5 .. 12.0 I/InO	1.5 I/InO	Limit IDIFFmax of n-th Harm.Re-straint

2.14.1.4 Information List

No.	Information	Type of In-formation	Comments
5603	>Diff BLOCK	SP	>BLOCK differential protection
5615	Diff OFF	OUT	Differential protection is switched OFF
5616	Diff BLOCKED	OUT	Differential protection is BLOCKED
5617	Diff ACTIVE	OUT	Differential protection is ACTIVE
5620	Diff Adap.fact.	OUT	Diff: adverse Adaption factor CT
5631	Diff picked up	OUT	Differential protection picked up
5644	Diff 2.Harm L1	OUT	Diff: Blocked by 2.Harmon. L1
5645	Diff 2.Harm L2	OUT	Diff: Blocked by 2.Harmon. L2
5646	Diff 2.Harm L3	OUT	Diff: Blocked by 2.Harmon. L3
5647	Diff n.Harm L1	OUT	Diff: Blocked by n.Harmon. L1
5648	Diff n.Harm L2	OUT	Diff: Blocked by n.Harmon. L2
5649	Diff n.Harm L3	OUT	Diff: Blocked by n.Harmon. L3
5651	Diff Bl. exF.L1	OUT	Diff. prot.: Blocked by ext. fault L1
5652	Diff Bl. exF.L2	OUT	Diff. prot.: Blocked by ext. fault L2
5653	Diff Bl. exF.L3	OUT	Diff. prot.: Blocked by ext. fault.L3
5657	DiffCrosBlk2HM	OUT	Diff: Crossblock by 2.Harmonic
5658	DiffCrosBlknHM	OUT	Diff: Crossblock by n.Harmonic
5660	DiffCrosBlk exF	OUT	Diff: Crossblock by ext. fault
5662	Block Iflt.L1	OUT	Diff. prot.: Blocked by CT fault L1

No.	Information	Type of Information	Comments
5663	Block Iflt.L2	OUT	Diff. prot.: Blocked by CT fault L2
5664	Block Iflt.L3	OUT	Diff. prot.: Blocked by CT fault L3
5666	Diff in.char.L1	OUT	Diff: Increase of char. phase L1
5667	Diff in.char.L2	OUT	Diff: Increase of char. phase L2
5668	Diff in.char.L3	OUT	Diff: Increase of char. phase L3
5671	Diff TRIP	OUT	Differential protection TRIP
5672	Diff TRIP L1	OUT	Differential protection: TRIP L1
5673	Diff TRIP L2	OUT	Differential protection: TRIP L2
5674	Diff TRIP L3	OUT	Differential protection: TRIP L3
5681	Diff> L1	OUT	Diff. prot.: IDIFF> L1 (without Tdelay)
5682	Diff> L2	OUT	Diff. prot.: IDIFF> L2 (without Tdelay)
5683	Diff> L3	OUT	Diff. prot.: IDIFF> L3 (without Tdelay)
5684	Diff>> L1	OUT	Diff. prot: IDIFF>> L1 (without Tdelay)
5685	Diff>> L2	OUT	Diff. prot: IDIFF>> L2 (without Tdelay)
5686	Diff>> L3	OUT	Diff. prot: IDIFF>> L3 (without Tdelay)
5691	Diff> TRIP	OUT	Differential prot.: TRIP by IDIFF>
5692	Diff>> TRIP	OUT	Differential prot.: TRIP by IDIFF>>
5701	Diff L1:	VI	Diff. current in phase L1 at trip
5702	Diff L2:	VI	Diff. current in phase L2 at trip
5703	Diff L3:	VI	Diff. current in phase L3 at trip
5704	Res L1:	VI	Restr. current in phase L1 at trip
5705	Res L2:	VI	Restr. current in phase L2 at trip
5706	Res L3:	VI	Restr. current in phase L3 at trip
5713	Diff CT-S1:	VI	Diff. prot: Adaptation factor CT side 1
5714	Diff CT-S2:	VI	Diff. prot: Adaptation factor CT side 2
5742	Diff DC L1	OUT	Diff: DC L1
5743	Diff DC L2	OUT	Diff: DC L2
5744	Diff DC L3	OUT	Diff: DC L3
5745	Diff DC InCha	OUT	Diff: Increase of char. phase (DC)

2.14.2 Protected Object Generator or Motor

The following section describes the special features of the generator and motor as the protection objects.

2.14.2.1 Functional Description

Definition and Matching of Measured Quantities

The differential protection function of the 7UM62 can be used as longitudinal or as transverse differential protection. The operation modes differ from each other only by the definition of the measured currents and the limits of the protected zone.

Since the current direction is normally defined as positive in the direction of the protected object, the definitions as illustrated in the following figure result. The protected zone is limited by the CTs in the neutral point of generator and the CTs at the terminal side. The differential protection feature of the 7UM62 refers all currents to the rated current of the protected object. The characteristic values of the protected object (apparent power, rated voltage) and the primary rated currents of the CTs are entered in the protective device. Measured value matching is therefore limited to current quantity factors.

Due to their predominantly inductive component, faults in the proximity of the generator have relatively high DC current time constants that cause magnetisation of the current transformers. The CTs should be designed accordingly (see section 2.14.4).

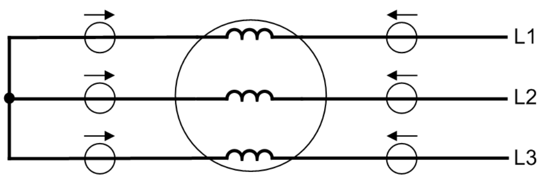


Figure 2-40 Definition of current direction with longitudinal differential protection

Use as transverse differential protection involves a peculiarity. The definition of the measured currents for this application is shown in the figure below.

For transverse differential protection, the phases connected in parallel constitute the border between the protected zone and the network. A differential current appears in this case only, but always, if there is a current difference within the particular parallel phases, so that a fault current in one phase can be assumed.

Since in this case, for normal operation, all currents flow into the protected object, i.e. the opposite of all other applications, the polarity must be reversed for **one** current transformer set, as described in Section 2.5.1 under "Connection of the Current Transformer Sets".

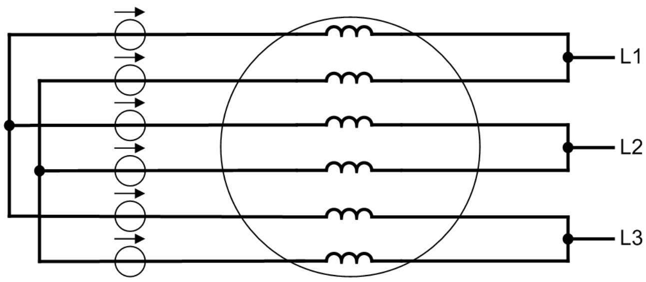


Figure 2-41 Definition of current direction with transverse differential protection

The CTs also determine the limits of sensitivity in the case of motors. In asynchronous motors, the startup operation may be modelled in different ways by the CTs, so that major differential currents occur (see also side title "Increase of Pickup Value on Startup").

2.14.2.2 Setting Notes

Requirement

A precondition for generator or motor differential protection function is that on configuration address 120 **DIFF. PROT.** was set to ***Generator/Motor***.

One important setting is the location of the CT starpoints on both sides of the protected object (addresses 201 **STRPNT->OBJ S1** for side 1 and 210 **STRPNT->OBJ S2** for side 2, see Section **P.System Data 1**).

Also, the nominal values ($S_{N\ GEN/MOTOR}$, $U_{N\ GEN/MOTOR}$) of the machine to be protected, and the primary and secondary nominal currents of the main CTs on both sides must be entered. The settings are referred to these values. They are also used e.g. for determining the primary measured values.

Information as to the treatment of the starpoint on both sides is required for the measured value monitoring; it has already been entered during configuration at the addresses 242 **STARPNT SIDE 1** and 244 **STARPNT SIDE 2** (see Section 2.5.1).

Pickup Value Increase on Startup

For additional security against overfunctioning when a non-energized protection object is switched in, the increase of the pickup value on startup can be set at address 2005 **INC.CHAR.START**. On delivery of the device, this function is switched .

The associated parameters can be found at addresses 2051, 2052 and 2053. Address 2051 **I-REST. STARTUP** is used to set the pickup value for detecting a startup. The function is disabled by setting $I/I_{N\ Obj.}$ = 0. The **START-FACTOR** specifies the increase factor of the pickup values on startup. For generator and motor protection, a setting of 2052 **START-FACTOR** = ***2.0*** is recommended.

Tripping characteristic

The parameters of the tripping characteristic are set at addresses 2021 to 2044. Figure 2-42 illustrates the meaning of the different parameters. The numerical values at the characteristic branches are the parameter addresses.

Address 2021 **I-DIFF>** is the pickup value for the differential current. The pickup value is referred to the nominal current of the generator or motor. For generators and motors, a setting between ***0.1*** and ***0.2*** is recommended.

In addition to the pickup threshold **I-DIFF>**, a second pickup threshold is considered. If this threshold (2031 **I-DIFF>>**) is exceeded, tripping is initiated regardless of the magnitude of the restraint current (unstabilized high-speed trip stage). This stage must be set higher than the **I-DIFF>** stage. Recommendation: Set a value above the steady-state value of the transient short-circuit current, i.e.:

$$\text{I-DIFF>>} \qquad > \frac{1}{x_d'} \cdot I_{N,\ Mach}$$

With values for x_d’ between 0.15 and 0.35, the resulting setting values for **I-DIFF>>** are approx. (3 to 7) $I_{N,\ Mach}$.

The tripping characteristic comprises two further branches. Address 2041 **SLOPE 1** determines the slope of the first branch, whose starting point is specified in the parameter 2042 **BASE POINT 1**. This branch considers current-proportional error currents. These are mainly transformation errors of the main CTs and of the input CTs. If the CTs are identical, the default setting of ***0.25*** can be reduced to ***0.15***.

The second branch produces a higher stabilization in the range of high currents which may lead to current transformer saturation. Its base point is set at address 2044 **BASE POINT 2**. The gradient is set at address 2043 **SLOPE 2**. The stability during current transformer saturation can be influenced by this parameter branch. A higher gradient results in a higher stability. The default setting of ***0.5*** has proven to be a good value.

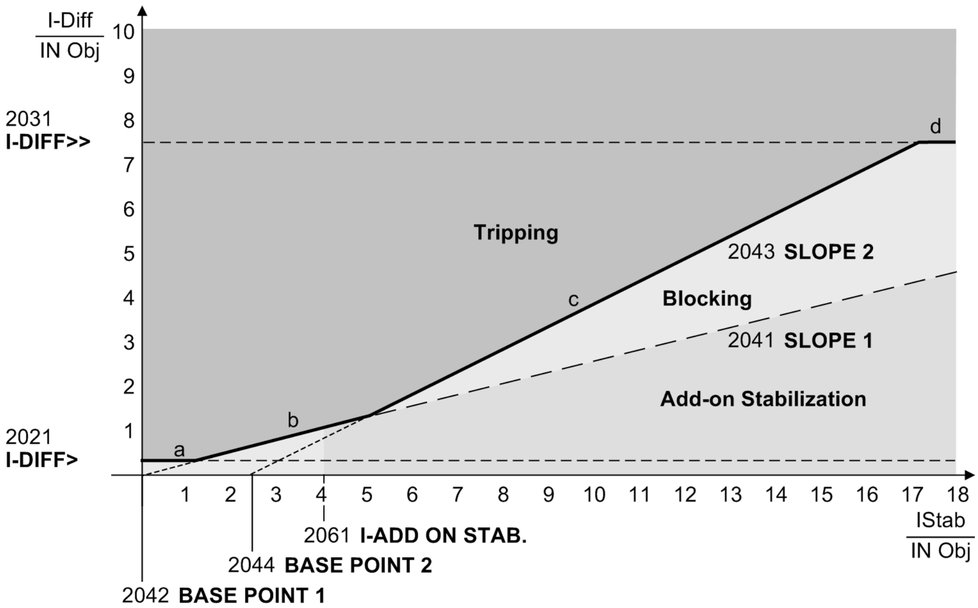


Figure 2-42 Parameters Determining the Shape of the Tripping Characteristic

Add-On Stabilization During Current Transformer Saturation

Where very high currents flow during an external short-circuit, an add-on stabilization takes effect that is set at address 2061 **I-ADD ON STAB.** (saturation stabilization). Please note that the stabilizing current is the arithmetical sum of the currents entering and leaving the protected zone, i.e. that it is twice the actually flowing current. The default setting of 4.00 I/InO should therefore be kept. The maximum duration of the additional stabilization is set at address 2062 **T ADD ON-STAB.** in multiples of one cycle. This time is the maximum duration of blocking after leaving the additional stabilization area during heavy current external faults. The setting depends under certain circumstances on the disconnecting time of the upstream contact. The default setting 20 Cycle is a practical value.

Delay Times

In special cases it may be advantageous to delay the trip signal of the differential protection. For this, an additional delay can be set. The timer 2026 **T I-DIFF>** is started when an internal fault in the generator or the motor has been detected. 2036 **T I-DIFF>>** is the time delay of tripping stage **I-DIFF>>**. A separate time stage is provided for each differential protection stage and for each phase. The dropout delay is linked to the minimum trip command duration that is valid for all protection functions.

All setting times are additional time delays which do not include the operating times (measuring time, dropout time) of the protective function.

2.14.3 Protected Object Transformer

Transformers are subject to a number of influences that induce differential currents even during normal operation:

2.14.3.1 Functional Description

Mismatching of CTs

Differences in the matching of CTs to the transformer rated current are not uncommon. These differences result in an error that leads to a differential current.

Voltage Control by Tap Changers

Voltage control tap changers (usually in-phase regulators) change the transformation ratio and the rated current of the transformer. They cause mismatching of the CTs and thus a differential current.

Inrush Current

Transformers may absorb on power-up considerable magnetising currents (inrush currents) that enter the protected zone but do not exit it. They act therefore like fault currents entering on one side.

The inrush current can amount to a multiple of the rated current and is characterized by a considerable 2nd harmonic content (double rated frequency) which is practically absent during a short-circuit.

Overexcitation

Where a transformer is operated with an excessive voltage, the non-linear magnetising curve leads to increased magnetising currents, which cause in turn an additional differential current.

Vector Group

Depending on their application, transformers have different vector groups, which cause a shift of the phase angles between the primary and the secondary side. Without adequate correction, this phase shift would cause a differential current.

The following paragraphs describe the main functional blocks of the differential protection for managing these influences.

Quantitative matching of Measured values

The input currents are converted in relation to the power transformer rated current. The nominal values of the transformer, i.e. rated apparent power, rated voltages and primary rated CT currents, are entered in the protective device, and a correction factor k_{CT} is calculated according to the following formula:

$$k_{CT} = \frac{I_{N,\ CTprim}}{I_{N,\ Obj.}} = \frac{I_{N,\ CTprim} \cdot \sqrt{3} \cdot U_N}{S_N}$$

with

$I_{N\ CTprim}$	Primary CT rated current
$I_{N,Obj.}$	Nominal primary current of the protected object
S_N	Nominal apparent power of protected object
U_N	Rated voltage
k_{CT}	Correction factor

This correction is performed for each side of the protected object.

Once the vector group has been entered, the protective device is capable of performing the current comparison according to fixed formulae.

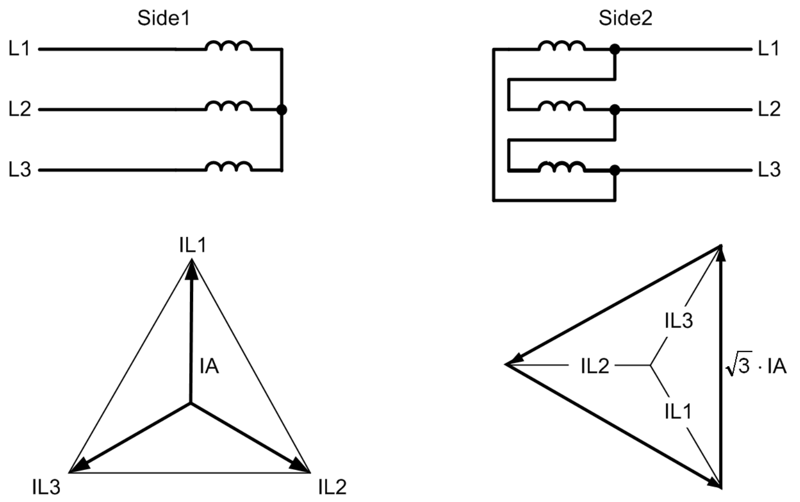
Matching of Vector Group

Unit transformers often have a wye-delta connection, with the delta connection being on the generator side. To allow a maximum of versatility in the use of the 7UM62, all imaginable vector group combinations have been provided for in the software. The basic principle of numerical vector group correction is now explained by way of example for a Y(N)d5 transformer.

The higher voltage side has a wye connection and the lower voltage side a delta connection. The phase rotation is $n \cdot 30°$ (i.e. $5 \cdot 30° = 150°$). Side 1 (higher voltage side) is the reference system. The vector group correction feature transforms the currents flowing from side 2 to side 1.

Isolated Starpoint

The following figure shows the vector group, the vector diagram for symmetrically flowing currents and the transformation rules for a system with an isolated starpoint.



$$\begin{pmatrix} IA \\ IB \\ IC \end{pmatrix} = 1 \cdot \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \cdot \begin{pmatrix} IL1 \\ IL2 \\ IL3 \end{pmatrix} \qquad \begin{pmatrix} IA \\ IB \\ IC \end{pmatrix} = \frac{1}{\sqrt{3}} \cdot \begin{pmatrix} -1 & 0 & 1 \\ 1 & -1 & 0 \\ 0 & 1 & -1 \end{pmatrix} \cdot \begin{pmatrix} IL1 \\ IL2 \\ IL3 \end{pmatrix}$$

Figure 2-43 Vector group matching for a Yd5 transformer (isolated starpoint)

Deducting on side 2 the currents $\underline{I}_{L3} - \underline{I}_{L1}$, results in the current $\underline{I}_A$, which has the same direction as $\underline{I}_A$ on side 1. Multiplying with $1/\sqrt{3}$ matches the quantitative values. The matrix describes the conversion for all three phases.

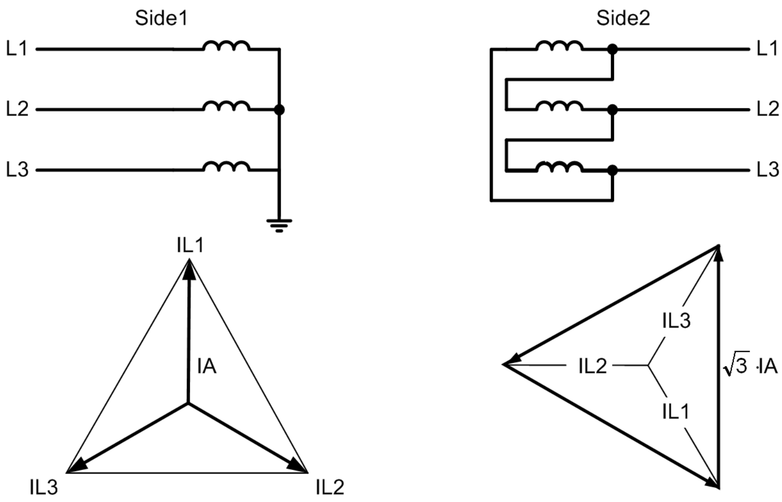
Earthed Transformer Starpoint

The following figure shows an example of a YNd5 vector group with earthed starpoint on the Y-side.

The zero sequence currents are eliminated in this case. In the following figure on the right side, the zero sequence currents are automatically eliminated by the current difference formation, just as in the transformer there can be no zero sequence currents outside the delta winding. On the left-hand side, the elimination of the zero sequence current results from the matrix equation, e.g.

$^1/_3 \cdot (2\,\underline{I}_{L1} - 1\,\underline{I}_{L2} - 1\,\underline{I}_{L3}) = {^1/_3} \cdot (3\,\underline{I}_{L1} - \underline{I}_{L1} - \underline{I}_{L2} - \underline{I}_{L3}) = 1/3 \cdot (3\,\underline{I}_{L1} - 3\,\underline{I}_0) = (\underline{I}_{L1} - \underline{I}_0)$.

Because of the zero sequence current elimination, fault currents which flow through the CTs during earth faults in the network if there is an earthing point in the protected zone (transformer starpoint or starpoint earthing transformer) are neutralised without any special measures from outside.



$$\begin{pmatrix} IA \\ IB \\ IC \end{pmatrix} = \frac{1}{3} \cdot \begin{pmatrix} 2 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & 2 \end{pmatrix} \cdot \begin{pmatrix} IL1 \\ IL2 \\ IL3 \end{pmatrix} \qquad \begin{pmatrix} IA \\ IB \\ IC \end{pmatrix} = \frac{1}{\sqrt{3}} \cdot \begin{pmatrix} -1 & 0 & 1 \\ 1 & -1 & 0 \\ 0 & 1 & -1 \end{pmatrix} \cdot \begin{pmatrix} IL1 \\ IL2 \\ IL3 \end{pmatrix}$$

Figure 2-44 Vector group matching for Y(N) d5 (with earthed starpoint)

In the following figure on the left-hand side, a zero sequence current will occur in case of e.g. an external fault; on the right-hand side, it will not. If the currents were compared without first eliminating the zero sequence current, the result would be wrong (differential current despite external fault). Therefore, the zero sequence current must be eliminated on side 1. The zero sequence current is subtracted from the phase currents. The rule for calculation is shown in the left-hand matrix in Figure 2-44.

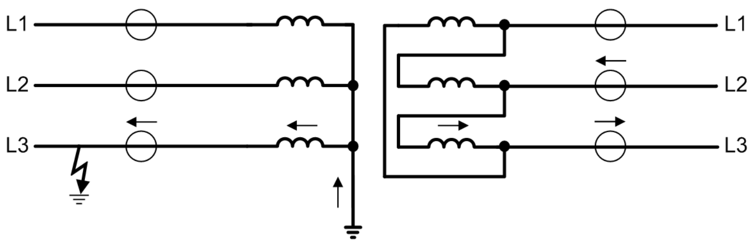


Figure 2-45 Example of an earth fault outside the transformer with distribution of currents

2.14.3.2 Setting Notes

Requirement

A precondition for the transformer differential protection function is that on configuration address 120 **DIFF. PROT.** was set to ***3 phase transf.***.

To ensure the correct polarity for the formation of the differential current, the polarity of the sets of CTs must be specified. This was done during configuration by entering the location of the starpoints of the sets of CTs on both sides of the transformer (addresses 201 **STRPNT->OBJ S1** for side 1 and 210 **STRPNT->OBJ S2** for side 2, see Subsection **P.System Data 1**).

Also the nominal data ($S_{N\,TRANSF}$, U$U_{N\,WIND\,S1}$, $U_{N\,WIND\,S2}$) of both sides of the transformer, as well as the primary and secondary rated currents of the main CTs on both sides were queried. The settings are referred to these values. They are also used e.g. for determining the primary measured values.

Information on starpoint handling on both sides is required for elimination of zero sequence current and for measured value monitoring (summation current monitoring); it has already been entered during configuration at addresses 242 **STARPNT SIDE 1** and 244 **STARPNT SIDE 2** (see Subsection 2.5.1).

Matching of Absolute Values and Vector Groups

When used as transformer protection, the 7UM62 automatically computes from the rated data of the protected transformer the current-matching formulae which are required to match the vector group and the different rated winding currents. The currents are converted such that the sensitivity of the protection always refers to the rated apparent power of the transformer. No circuitry is required in general for vector group matching or for manual conversions for rated currents.

The unit requires the following data for each winding

- Rated apparent power S_N in MVA (see above),
- Rated voltage U_N in kV (see above)
- Vector group numeral,
- Rated current of the current transformer set in A (see above).

Winding 1 is defined as the reference winding and therefore needs no numeral; the other windings are referred to winding 1.

The reference winding is normally that of the higher voltage. If a reference winding other than the higher voltage one is used, it must be noted that this changes the vector group numeral: E.g. a Dy5 transformer is regarded from the Y side as Yd7.

If a transformer winding is regulated, then the actual rated voltage of the winding is not used as U_N, but rather the voltage which corresponds to the average current of the regulated range.

Voltage to be set $$U_N = 2 \cdot \frac{U_{max} \cdot U_{min}}{U_{max} + U_{min}} = \frac{2}{\frac{1}{U_{min}} + \frac{1}{U_{max}}}$$

If the setting of the protection should be performed with secondary values only (e.g. because external matching transformers are present), the factory-set parameters of the transformer data can remain unchanged. With the default setting of transformer data, the device effects a current matching of 1: 1 without phase displacement

Zero Sequence Current Treatment

The treatment of the winding starpoints is of no concern if the zero sequence current is eliminated from the phase currents. By this means fault currents which flow through the CTs during earth faults in the network if there is an earthing point in the protected zone (transformer starpoint or starpoint earthing transformer) are neutralized without any special external measures. Elimination is done by setting **STARPOINT S*** = ***earthed*** (see Figure „Vector Group Adaptation with Earthed Starpoint“in the Functional Description of this subsection).

In resonant-earthed systems or isolated networks, elimination of zero sequence current may be dispensed with provided that the starpoint of the protected transformer winding has no connection to earth, not even via a Petersen coil or a surge arrester! In this case, each double earth fault with one base point in the protected zone will be cleared by the relay, regardless of any double earth fault priority (see side title „Ungrounded Starpoint“ and Figure „Vector Group Matching for Y(N) d5 (isolated starpoint)“).

Pickup Value Increase on Startup

For additional security against overfunctioning when a non-energized protection object is switched in, the increase of the pickup value on startup can be set at address 2005 **INC.CHAR.START**. As this option is mainly provided for generator and motor protection, the default setting is initially ***OFF*** if a **2-winding transformer** is selected as protected object.

The associated parameters can be found at addresses 2051, 2052 and 2053. Address 2051 **I-REST. STARTUP** is used to set the pickup value for detecting a startup. The function is disabled by setting $I/I_{N\ Obj.}$ = 0. The **START-FACTOR** specifies the increase factor of the pickup values on startup. For transformer protection, we recommend to retain the default setting 2052 **START-FACTOR** = **1.0**. For switching external loads such as motors or transformers, it should be increased to ***2.0***. Due to the high time constants, branch **b** of the characteristic may well be exceeded for a short time with nonmatched CTs.

Harmonic Restraint

The inrush restraint of the device can be enabled and disabled at address 2006 **INRUSH 2.HARM.**. It is based on evaluation of the 2nd harmonic present in the switchon inrush current. When the device is delivered from the factory, a ratio I_{2fN}/I_{fN} of 15 % is set and can normally be taken over unchanged. However the component required for restraint can be parameterized. To provide for more restraint in exceptional cases, where switch-on conditions are particularly unfavourable, a smaller value can be set at address 2071 **2. HARMONIC**.

Cross Blocking

The inrush restraint can be extended by the so-called "crossblock" function. This means that on harmonic content overshoot in only one phase all three phases of the differential stage IDIFF> stage are blocked. The duration for which the cross-block function is to remain operative after differential current overshoot, is set at address 2072 **CROSSB. 2. HARM**. Setting is in multiples of an AC-cycle. Setting to **0** means that the protection can initiate a tripping when the transformer is switched onto a single-phase fault, even if an inrush current is flowing in another phase. When set to ∞, the cross-block function is always effective. The duration of the blocking is specified during commissioning. The default setting of 3 cycles has proven to be a practical value.

Besides the second harmonic, the 7UM62 can provide restraint with a further harmonic, the nth harmonic. Address 2007 **RESTR. n.HARM.** is used to disable this harmonics restraint, or to select the harmonic for it. The 3rd or the 5th harmonic are selectable.

Steady-state overexcitation is characterized by odd harmonics. Here the third or fifth harmonic are suitable for restraint purposes. As the third harmonic is often eliminated in transformers (e.g. in a delta winding), the fifth harmonic is more commonly used.

Converter transformers also produce odd harmonics which are practically absent in the case of an internal short-circuit.

The harmonic content which blocks the differential protection is set at address 2076 **n. HARMONIC**. If the 5th harmonic is used as overexcitation stabilization, e.g. 30 % (default setting) is common.

The harmonic restraint operates individually per phase. However, it is also possible – as it is for the inrush restraint – to set the protection such that not only the phase with harmonics content in excess of the permissible value is stabilized but also the other phases of the differential stage IDIFF> are blocked ("cross-block" function). The duration for which the cross-block function is to remain operative after differential current overshoot, is set at address 2077 **CROSSB. n.HARM**. The setting is in multiples of an cycle. When set to 0 Cycle (default setting), the protection can initiate a trip when the transformer is switched onto a single-phase fault, even if a high harmonic content is present in another phase. When set to ∞, the cross-block function is always effective.

If the differential current exceeds a multiple of the rated transformer current specified at address 2078 **IDIFFmax n.HM**, no nth-harmonic restraint takes place.

Tripping Characteristic

The parameters of the tripping characteristic are set in addresses 2021 to 2044. The meaning of the parameters can be seen in the following figure. The numerical values at the characteristic branches are the parameter addresses.

Address 2021 **I-DIFF>** is the pickup value for the differential current. This is the total fault current flowing in the protection area, regardless of the way it is distributed between the windings of the protected transformer. The pickup value is referred to the rated current corresponding to the rated apparent power of the transformer. For transformers, the setting should be between 0.2 and 0.4. It should be checked during commissioning that the selected pickup value is at least twice the maximum differential current present in steady-state operation.

In addition to the pickup threshold **I-DIFF>**, a second pickup threshold is introduced. If this threshold (2031 **I-DIFF>>**) is exceeded, tripping is initiated regardless of the magnitude of the restraint current (unstabilized high-speed trip stage). This stage must be set higher than the **I-DIFF>** stage. As a guide: greater than the reciprocal value of the transformer´s relative short-circuit value $1/u_k$ times the rated transformer current.

The tripping characteristic forms two more branches (see the following figure). Address 2041 **SLOPE 1** determines the slope of the first branch, whose starting point is specified in the parameter 2042 **BASE POINT 1**. This branch covers current-proportional error currents. These are mainly transformation errors of the main CTs and, especially, the differential currents which may occur in the final tap changer positions due to a possible transformer regulation range. This branch of the characteristic limits the stabilization area. The preset slope of 0.25 should be sufficient for regulating ranges up to 20 %. If the transformer has a larger regulated range, the slope must be increased accordingly.

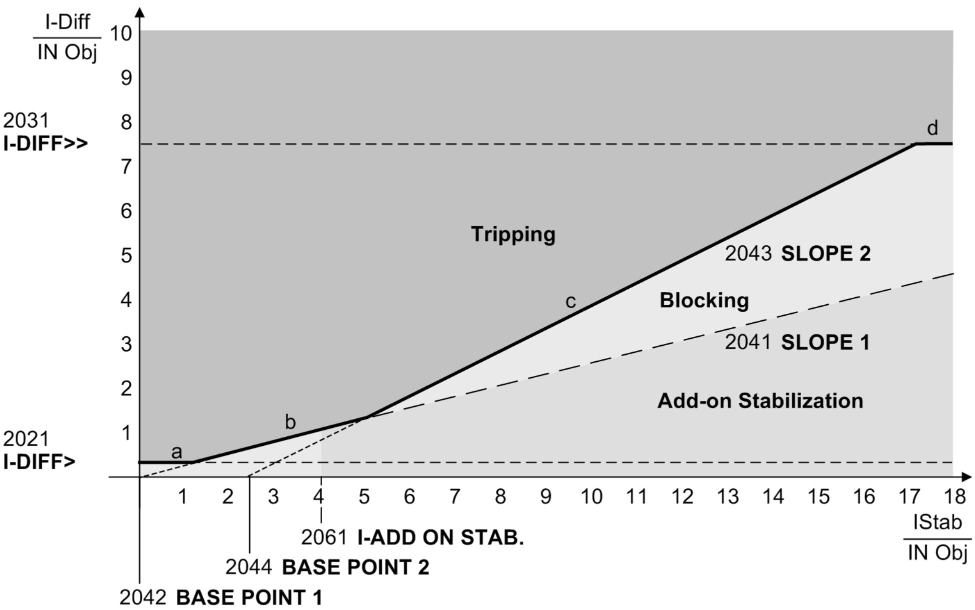


Figure 2-46 Parameters Determining the Shape of the Tripping Characteristic

The second branch produces a higher restraint in the range of high currents which may lead to current transformer saturation. Its base point is set at address 2044 **BASE POINT 2** and is referred to the rated power transformer current. The slope is set at address 2043 **SLOPE 2**. The restraint during current transformer saturation can be influenced by this parameter branch. A higher gradient results in a higher restraint.

Additional Stabilization During Current Transformer Saturation

Where very high currents flow during an external short-circuit, an add-on stabilization takes effect that is set at address 2061 **I-ADD ON STAB.** (saturation stabilization). Please note that the stabilizing current is the arithmetical sum of the currents through the windings, i.e. it is twice the actually flowing current. The default setting of should be maintained. The maximum duration of the additional stabilization is set at address 2062 **T ADD ON-STAB.** in multiples of one cycle. This time is the maximum duration of blocking after leaving the additional stabilization area during heavy current external faults. The setting depends under certain circumstances on the disconnecting time of the upstream contact. The default setting 15 Cycle is a practical value.

Delay Times

In special cases it may be advantageous to delay the trip signal of the differential protection. For this, an additional delay can be set. The delay timer 2026 **T I-DIFF>** is started when an internal fault is detected in the transformer. 2036 **T I-DIFF>>** is the delay time for the tripping stage 2031 **I-DIFF>>**. A separate time stage is provided for each differential protection level and for each phase. The dropout delay is linked to the minimum trip command duration that is valid for all protection functions. All setting times are additional time delays which do not include the operating times (measuring time, dropout time) of the protective function.

2.14.4 Current Transformer Requirements

The differential protection is of decisive importance for the requirements that the current transformers must meet. The high-speed trip stage (IDiff >>) uses instantaneous values and can therefore reliably trip high-current internal short-circuits. For determination of the primary CT rated current, in practice the general usual procedures are used. It must be selected equal to or greater than the rated current of the protected object.

2.14.4.1 Functional Description

Design recommendations

The external short circuit determines the requirements that the current transformers must meet because of the possible DC current component. In case of a short-circuit flowing through the power transformers, a minimum of 5 ms should elapse before current transformer saturation occurs. The two following tables show the design specifications. The IEC 60044-1 and IEC 60044-6 standards were used in these tables. The equations for calculating the requirements as knee-point voltages are listed in table 2-7.

Table 2-5 Overcurrent Factors

Required operational overcurrent factor	Resulting rated overcurrent factor
$K_{ALF}' = K_{td} \cdot \frac{I_{pSSC}}{I_{pN}}$	$K_{ALF} = \frac{R_{BC} + R_{Ct}}{R_{BN} + R_{Ct}} \cdot K_{ALF}'$

with

K_{td}	Transient dimensioning factor
I_{pSSC}	Primary symmetric short circuit current
I_{pN}	Primary CT rated current
R_{BC}	Connected load
R_{BN}	Rated load
R_{Ct}	Internal load

Table 2-6 Transformer Requirements

	Transformer	Generator
Transient dimensioning factor K_{td}	≥ 4 with $\tau_N \leq 100$ ms	> (4 to 5), with $\tau_N > 100$ ms
Symmetrical short circuit current I_{pSSC}	$\approx \frac{1}{u_{SC}} \cdot I_{pN, Tr}$	$\approx \frac{1}{x_d''} \cdot I_{pN, G}$
Example	$u_{SC} = 0.1$ n' > 40	$x_d'' = 0.12$ n' > (34 to 42)
Note: Always use identical transformers	Power ≥ 10 or 15 VA Example of network transform-er: 10P10 10 or 15 VA (I_{sN} = 1 A or 5 A)	Note internal load! Example: $I_{N, G}$approx. 1000 to 2000 A 5P15 15 VA (I_{sN} = 1 A or 5 A) $I_{N, G}$ > 5000 A 5P20 30 VA (I_{sN} = 1 A or 5 A)

with

u_{SC} Transformer impedance

x_d'' Direct-axis transient reactance

I_{sN} Secondary CT rated current

τ_N Power system time constant

Table 2-7 Knee-Point Voltages

IEC	British Standard	ANSI
$U = K_{ALF} \cdot (R_{Ct} + R_{BN}) \cdot I_{sN}$	$U = \frac{(R_{Ct} + R_{BN}) \cdot I_{sN}}{1,3} \cdot K_{ALF}$	$U = 20 \cdot I_{sN} \cdot (R_{Ct} + R_{BN}) \cdot \frac{K_{ALF}}{20}$ $I_{sN} = 5$ A (typical Value)

with

U Knee-point voltages

K_{ALF} Rated overcurrent factor

I_{sN} Secondary CT rated current

R_{BN} Rated load

R_{Ct} Internal load

2.15 Earth Current Differential Protection (ANSI 87GN,TN)

The earth current differential protection detects earth faults in generators and transformers with a low-ohmic or solid starpoint earthing. It is selective, and more sensitive than the classical differential protection (see Section 2.14.1).

A typical application of this protection function are configurations where multiple generators are connected to one busbar and one generator has a low-ohmic earthing. Another application would be transformer windings in wye connection.

For applications such as auto-transformers, starpoint earthing transformers and shunt reactors, Siemens recommends that the 7UT612 protective device be used instead.

For high-ohmic earthing of generators, the earth fault protection function (Section 2.28) is used.

2.15.1 Functional Description

Connection Variants

The following figure shows two typical implementations. In connection scheme 1, the zero sequence current is calculated from the measured phase currents, and the starpoint current is measured directly. This application is the version for transformers and for the generator with direct (low-ohmic) earthing.

In connection scheme 2, both zero sequence currents are calculated from the measured phase currents. The protected object is located between the current transformers. This measuring method should be used for generators in busbar connection, where multiple generators feed the busbar and any one of the generators is earthed.

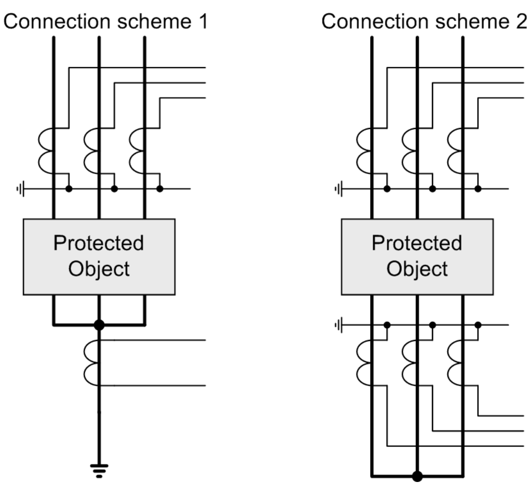


Figure 2-47 Connection schemes of the earth current differential protection

Measuring Principle

The 2 possible implementations of the earth fault differential protection differ only in their method of determining the zero sequence current. This is shown in the following picture. This figure also shows the definition of the current direction. The general definition is: Reference arrows run in positive direction to the protected object.

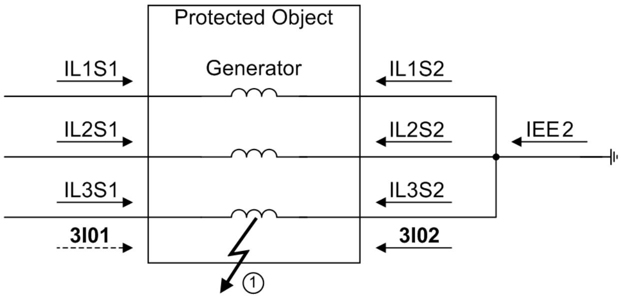


Figure 2-48 Connection scheme and definition of current vectors

In both measuring principles, there is a vector addition of the phase currents on the line side (always side 1 in the 7UM62), which yields the zero sequence current. The rule of calculation for side 1 is:

$3\underline{I}_{01} = \underline{I}_{L1S1} + \underline{I}_{L2S1} + \underline{I}_{L3S1}$

For the second zero sequence current, two methods of determination are possible:

On the one hand it is measured directly as the starpoint current at input I_{EE2} ($I_{St} = I_{EE2}$). Method 2 is to calculate the zero sequence current from the CTs on the starpoint side (always side 2 in the 7UM62). The pertinent formulas are:

$3\underline{I}_{02} = \underline{I}_{St} = \underline{I}_{EE2}$

or

$3\underline{I}_{02} = \underline{I}_{L1S2} + \underline{I}_{L2S2} + \underline{I}_{L3S2}$

When an earth fault occurs in the protected zone, there is always a starpoint current $\underline{I}_{St}$ or zero sequence current flowing through the CTs of side 2 ($3\underline{I}_{02}$). Depending on the network earthing conditions, there may also be an earthing current ($3\underline{I}_{01}$) flowing through the CTs of side 1 to the fault location (dashed arrow). Due to the definition of the current direction, however, the zero sequence current $3\underline{I}_{01}$ is more or less in phase with the starpoint current.

When an earth fault occurs outside the protected zone (see next picture, fault location 2), there is also a starpoint current $\underline{I}_{St}$ or zero sequence current flowing through the CTs of side 2 ($3\underline{I}_{02}$) and a zero sequence current flowing through the CTs of side 1 ($3\underline{I}_{01}$). The zero sequence current must be the same at all three possible measurement locations. As the current direction flowing into the protected object is defined as positive, the zero sequence current flowing on side 1 ($3\underline{I}_{01}$) is in phase opposition to the starpoint current $\underline{I}_{St}$ or to the computed zero phase current of side 2 ($3\underline{I}_{02}$).

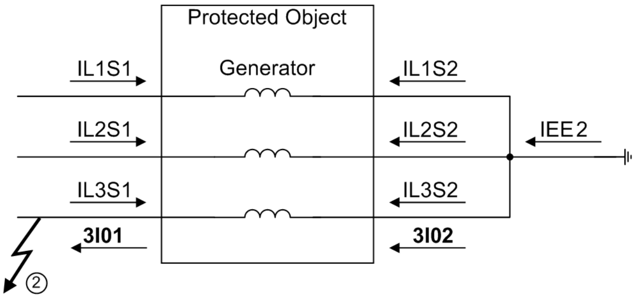


Figure 2-49 Example of an external fault

When an external non-earthed fault causes heavy currents to flow through the protected zone, differences in the magnetic characteristics of the phase current transformers under conditions of saturation may cause a significant summation current which resembles an earth current flowing into the protected zone. Measures must be taken to prevent this current from causing a trip. The same may happen if, for example, significant loads with a high inductive component (and thus large time constants), such as motors or transformers, are switched in.

For these reasons the earth current differential protection provides a number of restraining features which differ significantly from conventional restraining methods (see margin heading "Restraining Measures").

Evaluation of Measured Values

The earth current differential protection compares the fundamental wave of the zero currents on both sides ($3\underline{I}_{01}$ and $3\underline{I}_{02}$) and calculates from them the differential and the restraint (stabilizing) current.

$I_{0\text{-Diff}} = |\ 3\underline{I}_{01} + 3\underline{I}_{02}\ |$

$I_{0\text{-Stab}} = |\ 3\underline{I}_{01}\ 3\underline{I}_{02}\ |$

Depending on the application, current $3\underline{I}_{02}$ may be the calculated zero sequence current of side 2 or the directly measured starpoint current $\underline{I}_{St}$.

Under no-fault conditions, and with ideal CTs, the zero sequence currents would be zero, and consequently the differential and the restraint current zero also. To eliminate the influence of CT errors, the restraint is determined by the characteristic (see following figure).

In case of an external earth fault, the differential current is zero or minimal, and the restraint current is twice the fault current. The measured quantities are within the restraint zone. An internal earth fault, on the other hand, causes a fairly equal differential and restraint current. This is now in the trip zone (along the dashed line).

The pickup threshold is set with the **I-REF>** stage.

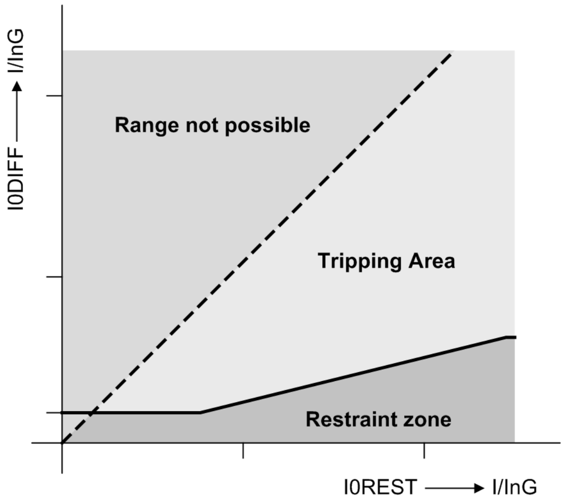


Figure 2-50 Tripping and restraint characteristic

In applications with direct measurement of the starpoint current (e.g. earth current differential protection for transformers), the starpoint current is queried in addition to evaluation of the characteristic. This provides additional restraint against CT problems such as wrong zero sequence current modeling of the phase current transformers on side 1. The starpoint current must have exceeded the pickup current **I-REF>**, too.

In order to compensate differences in the primary CT current ratings, the currents are matched to the current ratings of the protected object.

Restraining Measures

The purpose of the earth current differential protection is the detection of low-current faults. This involves a sensitive setting. A significant source of errors of the protection function are differences in the transient transformation characteristics of the phase CTs. Factors to be considered here are different DC transformation characteristics and saturation conditions.

Spurious tripping of the protection in the presence of external earth faults must be avoided.

An basic rule for this is the use of matched phase current transformers, so that their CT error current (resulting zero sequence current) under steady-state conditions is minimal.

Further restraining measures include:

- Additional evaluation of the starpoint current (see above)

  Only in the presence of an earth fault can a current flow through the starpoint CTs. This helps to avoid spurious tripping under no-fault conditions caused by transmission errors of the phase current transformers. This measure is also effective for faults without earth involvement. A prerequisite for using this measure is the presence of a starpoint CT in the application. It usually cannot be used for generators in busbar connection.

- Evaluation of the zero sequence current direction

  This monitoring functions aims at preventing spurious tripping in the presence of external earth faults. It does so by evaluation of the zero sequence current direction. Under ideal conditions, the currents must be in phase during an internal earth fault, and in phase opposition during an external earth fault. The threshold angle is 90°. The next picture shows that monitoring is divided into 2 zones. Where fault conditions are definite, tripping is immediately activated (zone I) or blocked (zone III). In zone II, an additional measurement is performed before a decision is made. Where the zero phase currents are too small (zone IV), the direction criterion is ineffective, and 0° is assumed.

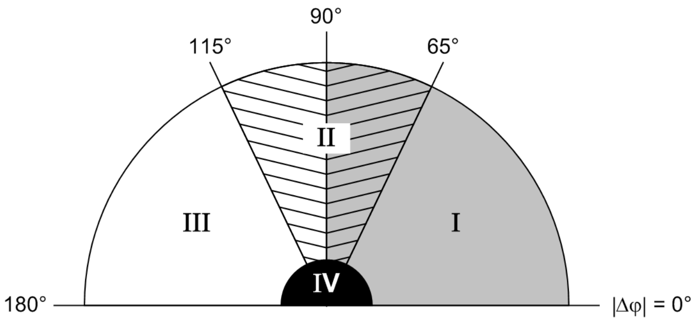


Figure 2-51 Operating ranges of the direction criterion

- Phase current monitoring

  To exclude spurious tripping due to CT saturation in the presence of external faults, the protection function is blocked as soon as a maximum phase current is reached. For this purpose, the phase currents of side 1 are monitored. As soon as one phase current exceeds the threshold, blocking takes effect. This blocking is not a drawback, since high-current faults are sufficiently managed by other protection functions such as differential protection, impedance protection and overcurrent protection.
- Zero sequence voltage monitoring

  Where the phase current transformers model zero sequence currents on the secondary side after load addition, and where there is no direct evaluation of the starpoint current, zero sequence voltage monitoring should be used. It also provides additional restraint in the presence of external faults without earth involvement. The zero sequence voltage is calculated from the phase-to-earth voltages. On detection of a zero sequence voltage, an enable signal is issued.

Logic

The logic interconnection of all signals and the most important settings, as well as the indications output, are shown in the following logic diagram (Figure). The function can be blocked with the input „>BLOCK REF“. Using the CFC, this input also allows blocking of other features such as if the measured zero sequence voltage is to be injected via the U_E input. This is necessary if the voltage inputs are connected to a voltage transformer in V connection (open delta connection).

The following figure shows the blocking of the phase currents and their release on the basis of the calculated zero voltage. This is followed by the monitoring of the operating characteristic with possibly an additional query of the starpoint current, and the angle enabling. When all conditions are met, the earth current differential protection picks up. The subsequent timer **T I-REF>** is usually set to zero.

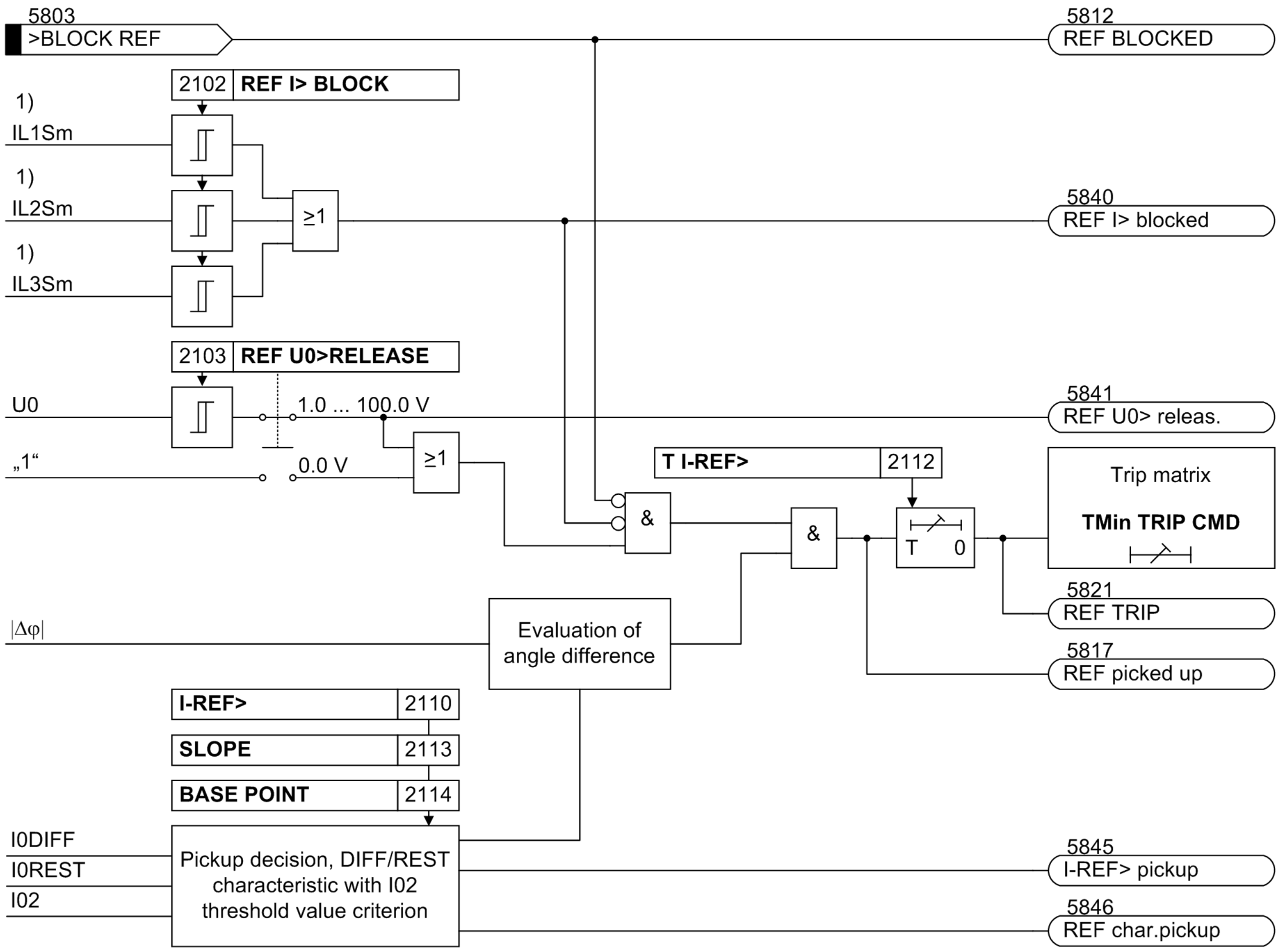


Figure 2-52 Logic Diagram of the Earth Current Differential Protection

with

1) Use of generator: I_{LxSm} always side 1

Use of transformer: I_{LxSm} according to allocation of sides

2.15.2 Setting Notes

General

A precondition for the operation of the earth current differential protection is that during the configuration of the scope of functions (Section 2.4) the correct selection for the application in hand was made at address 121 **REF PROT.**. If the protected object is a generator, the user can select either direct measurement of the starpoint current via I_{EE2} (***Gen. with IEE2***), or computed current (***Gen. w. 3I0-S2***). For the transformer the directly measured zero sequence current is always used. It is however possible to select for the side allocation (***Transformer S1*** or ***Transformer S2***).

In power system data 1 the required settings must have been made. These are also necessary for normalization and direction definition (see also Section 2.5 or 2.14.1). If the I_{EE2} input is used, the protection device must be notified of the neutral point transformer transformation ratio (prim./sec.) and the terminal of the earthing-side CT to which the I_{EE2} input is connected (see comments in Section 2.5).

Note

When using the I_{EE2} input, it must be kept in mind that this is a sensitive current input. The current amplitude is limited to approx. √2 1.6 A. A secondary rated current of 1 A is to be used for the starpoint CT. If a 5-A transformer is used, the appropriate transformation ratio has to be set. When checking the stabilisation during an external single-pole fault, a difference current will occur in the operational measured values at input I_{EE2} due to the current limitation. This fault will not initiate a trip because the current direction is evaluated as well.

Address 2101 **REF PROT.** serves to switch the function ***ON*** or ***OFF*** or to block only the trip command (***Block relay***).

Note

When the device is delivered, the earth current differential protection is set to ***OFF***. The reason is that the protection must not be in operation unless at least the assigned side and CT polarity have been properly set before. Without proper settings, the device may show unexpected reactions (incl. tripping)!

Pickup Values

The sensitivity of the protection is determined by **I-REF>** setting (address 2110). This is the earth fault current flowing in from the starpoint of the protected object (transformer, generator), and in some cases also from the network. This value should be chosen on the basis of the most unfavourable case, i.e. fault currents entering from one side only. The current set refers to the nominal current of the protected object or the protected side. The sensitivity limit is as a rule set by the CTs. A setting between 0.1 and 0.15 I/InO is quite practical.

For the operating characteristic, the default settings can be used. If necessary, these settings can be changed with the DIGSI communication software. The advanced parameters define the slope (2113 **SLOPE**) and the base point (2114 **BASE POINT**) of the characteristic.

To stabilize the protection function, address 2102 can be set to blocking by the phase current (**REF I> BLOCK**). As a rule of thumb, the pickup value should never be more than twice the nominal current. With low-ohmic starpoint earthing, the general formula is: nominal current + earth current resulting from the starpoint resistance.

The zero voltage enabling depends on the operating range of the protection function. 95 % of a generator stator winding is a good value. Therefore, the secondary-side value has been set to 5.0 V (2103 **REF U0>RELEASE**). Where the zero voltage enabling is not used, it must be set to 0.0 V.

Note

For the protection function, the zero voltage calculated from the phase-to-earth voltages has been multiplied with √3, which corresponds to the voltage present in a broken delta winding.

No settings need to be made for the angle enabling and the additional evaluation of the directly measured starpoint current (where used).

For special applications, it may be advantageous to delay the trip command of the protection. This can be done by setting an additional delay time (address 2112 **T I-REF>**). Normally, this delay time is set to 0. A minimum command duration was set in common for all protection functions (see Section 2.5.1 under „Command Duration“).

2.15.3 Settings

Addresses which have an appended "A" can only be changed with DIGSI, under Additional Settings.

Addr.	Parameter	Setting Options	Default Setting	Comments
2101	REF PROT.	OFF ON Block relay	OFF	Restricted Earth Fault Protection
2102	REF I> BLOCK	1.0 .. 2.5 I/InO	1.5 I/InO	REF Pickup of Phase Current Blocking
2103	REF U0>RELEASE	1.0 .. 100.0 V; 0	5.0 V	REF Pickup of U0> Release
2110	I-REF>	0.05 .. 2.00 I/InO	0.10 I/InO	I-REF> Pickup
2112	T I-REF>	0.00 .. 60.00 sec; ∞	0.00 sec	T I-REF> Time Delay
2113A	SLOPE	0.00 .. 0.95	0.25	Slope of Charac. I-REF> = f(I0-Rest)
2114A	BASE POINT	0.00 .. 2.00 I/InO	0.00 I/InO	Base Point for Slope of Characteristic

2.15.4 Information List

No.	Information	Type of Information	Comments
5803	>BLOCK REF	SP	>BLOCK restricted earth fault prot.
5811	REF OFF	OUT	Restricted earth fault is switched OFF
5812	REF BLOCKED	OUT	Restricted earth fault is BLOCKED
5813	REF ACTIVE	OUT	Restricted earth fault is ACTIVE
5817	REF picked up	OUT	REF protection picked up
5821	REF TRIP	OUT	REF protection TRIP
5833	REF CTstar:	VI	REF adaptation factor CT starpnt. wind.
5836	REF Adap.fact.	OUT	REF adverse Adaption factor CT
5837	REF CT-S1:	VI	REF adaptation factor CT side 1
5838	REF CT-S2:	VI	REF adaptation factor CT side 2
5840	REF I> blocked	OUT	REF is blocked by phase current
5841	REF U0> releas.	OUT	REF release by U0>
5845	I-REF> pickup	OUT	REF pickup of I-REF>
5846	REF char.pickup	OUT	REF characteristic picked up
5847	I0-Diff:	VI	I0-Diff at REF-Trip
5848	I0-Res:	VI	I0-Restraint at REF-Trip

2.16 Underexcitation (Loss-of-Field) Protection (ANSI 40)

The underexcitation protection protects a synchronous machine from asynchronous operation in the event of faulty excitation or regulation and from local overheating of the rotor. Furthermore, it prevents that the network stability is endangered by underexcitation of large synchronous machines.

2.16.1 Functional Description

Underexcitation Determination

To assess underexcitation the device processes all three terminal phase currents and all three terminal voltages for the stator circuit criterion. It also processes the excitation voltage made available by the measuring transducer TD3, for the rotor circuit criterion.

For the stator circuit criterion the admittance is calculated from the positive sequence currents and voltages. The admittance measurement always produces the physically appropriate stability limit, independently of voltage deviations from rated voltage. Even in such circumstances the protection characteristic can be thus optimally matched to the stability characteristic of the machine. By virtue of the positive sequence system evaluation, protection operates reliably even during asymmetrical current or voltage conditions.

Characteristic Curves

The following figure shows the loading diagram of the synchronous machine in the admittance plane (P/U^2; $-Q/U^2$) with the static stability limit which crosses the reactive axis near $1/x_d$ (reciprocal value of the synchronous direct reactance).

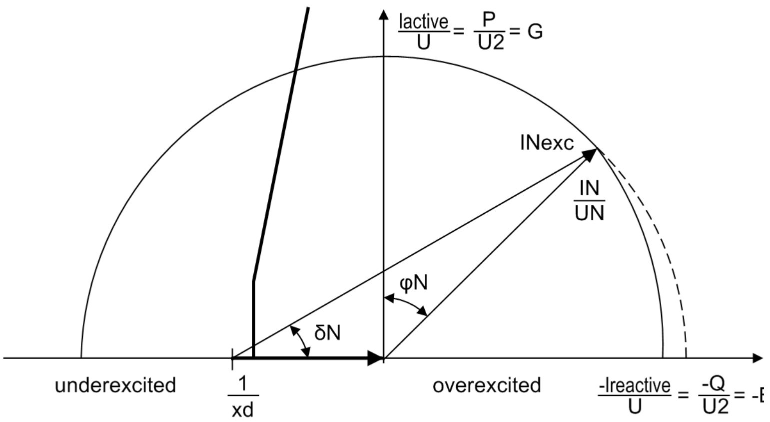
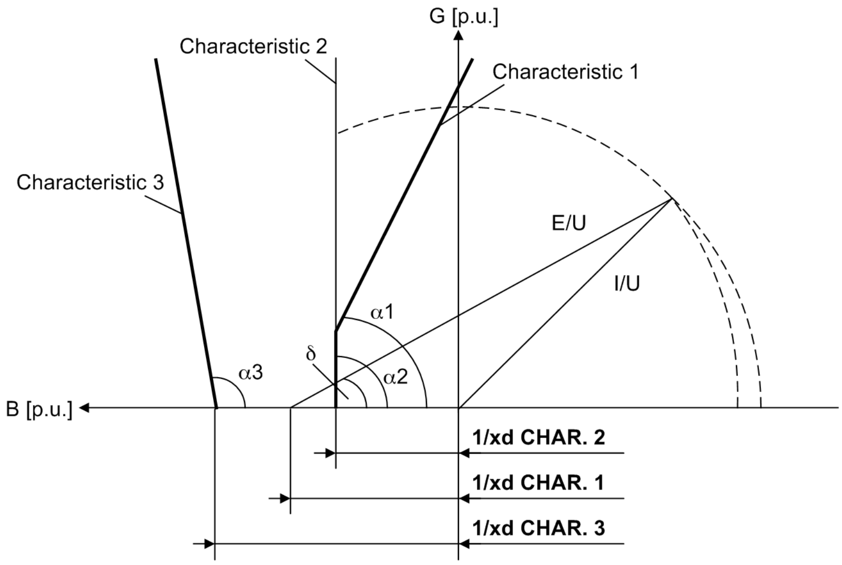


Figure 2-53 Admittance Diagram of Turbo Generators

The underexcitation protection in the 7UM62 makes available three independent, freely combinable characteristics. As illustrated in the following figure, it is possible for example to model static machine stability by means of two partial characteristics with the same time delays (T CHAR. 1 = T CHAR 2). The partial characteristics are distinguished by the corresponding distance from the zero point (1/xd CHAR. 1) and (1/xd CHAR. 2) as well as the corresponding inclination angle α_1 and α_2.

If the resulting characteristic (1/xd CHAR.1)/α_1; (1/xd CHAR.2)/α_2 is exceeded (in the following figure on the left), a delayed warning (e.g. by 10 s) or a trip signal is transmitted. The delay is necessary to ensure that the voltage regulator is given enough time to increase the excitation voltage.



with

$$G\,[\text{p.u.}] = \frac{P/SN}{(U/UN)2} \qquad \text{Conductance per unit}$$

$$B\,[\text{p.u.}] = \frac{-Q/SN}{(U/UN)2} \qquad \text{Susceptance per unit}$$

Figure 2-54 Stator circuit criterion: Pick–Up Characteristic in Admittance Diagram

A further characteristic (1/xd CHAR.3 /α_3 can be matched to the dynamic stability characteristic of the synchronous machine. Since stable operation is impossible if this characteristic is exceeded, immediate tripping is then required (time stage **T CHAR 3**).

Excitation voltage query

With a faulty voltage regulator or excitation voltage failure, it is possible to switch off with a short delay (time stage **T SHRT Uex<**, e.g. 1.5 s). To do so, the device must either be notified of the excitation voltage failure via binary input, or the excitation voltage must be fed in via measuring transducer TD3 and a voltage divider, provided that at address 3012 **EXCIT. VOLT.** the excitation voltage query via measuring transducer has been switched ***ON***.

As soon as the excitation voltage undershoots a settable minimum 3013 **Uexcit. <**, short-time tripping is initiated.

Instead of the excitation voltage acquisition, or also in addition to it, the signal of an external excitation voltage monitoring can be fed in via a binary input. Here also, short-time tripping is initiated as soon as excitation voltage failure is signalled.

Lowpass Filter

As the excitation DC voltage may contain significant AC harmonics (e.g. because of thyristor control), an analog lowpass filter is provided on the C-I/O-6 board for connection of excitation voltage, in addition to the integrated digital filter. This particularly attenuates multiples of the scanning frequency, which cannot be adequately suppressed by the digital filter. The jumper settings for activating this filter are described in the Mounting and Commissioning section. On delivery from the factory, the filter is enabled. The jumper setting must match the setting of the parameter 297 **TRANSDUCER 3** (see Power System Data, Section 2.5.1). If jumper settings and parameters do not match, an alarm is issued and the device is reported faulty and not operative.

Undervoltage Blocking

The admittance calculation requires a minimum measurement voltage. During a severe collapse (short-circuit) or failure of stator voltages, the protection is blocked by an integrated AC voltage monitor whose pickup threshold 3014 **Umin** is set on delivery to 25 V. The parameter value is based on phase-to-phase voltages.

The following figure shows the logic diagram for underexcitation protection.

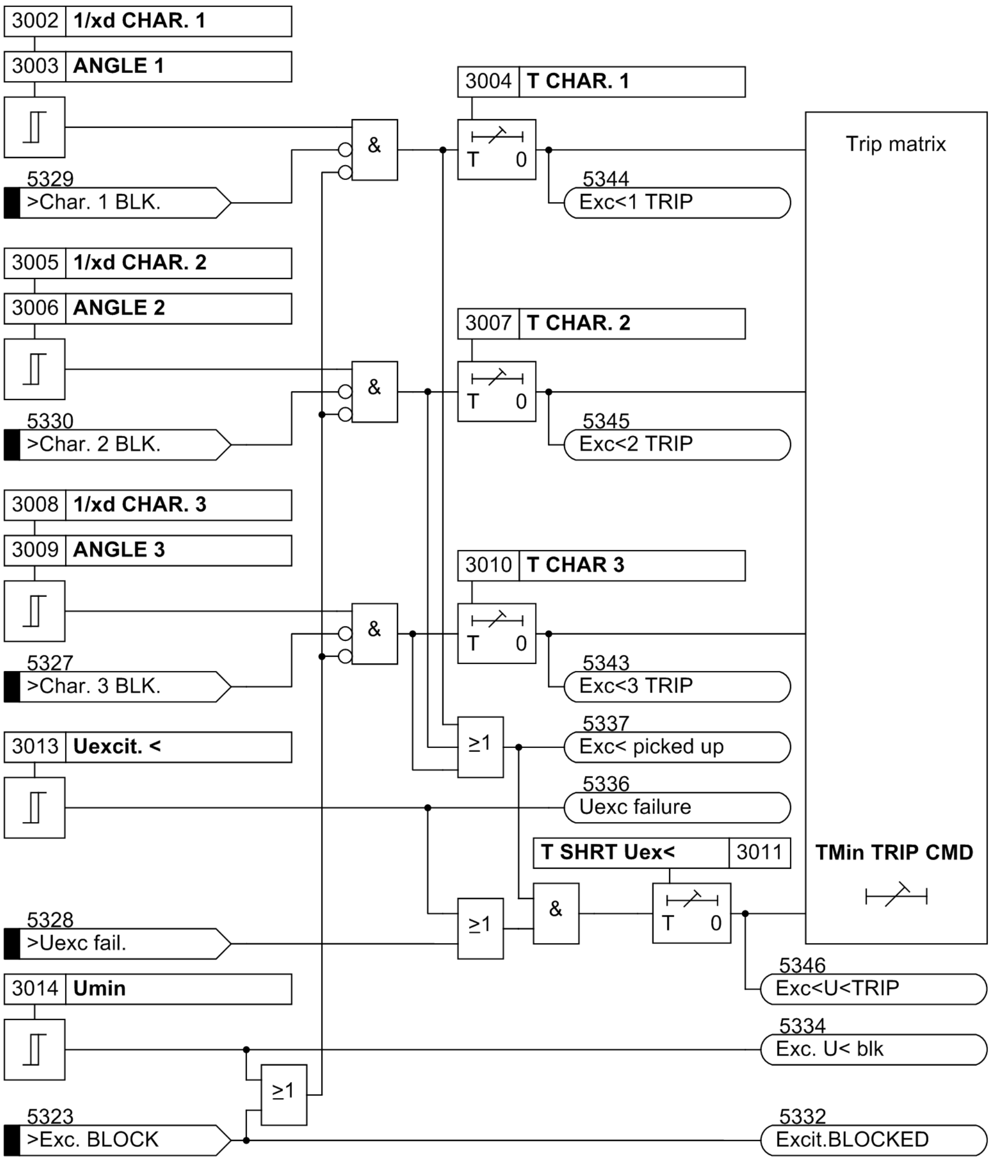


Figure 2-55 Logic diagram of the Underexcitation Protection

2.16.2 Setting Notes

General

The underexcitation protection is only effective and available if this function was set during protective function configuration (Section 2.4), address 130, **UNDEREXCIT.** is set to ***Enabled***. If the function is not required ***Disabled*** is set. The address 3001 **UNDEREXCIT.** serves to enable the function ***ON*** and ***OFF*** or to block only the trip command (***Block relay***).

The correct power system data input according to Section 2.5 is another prerequisite for the parameterization of the underexcitation protection.

The trip characteristics of the underexcitation protection in the admittance value diagram are composed of straight segments which are respectively defined by their admittance 1/xd (=coordinate distance) and their inclination angle α. The straight segments (1/xd CHAR.1)/α_1 (characteristic 1) and (1/xd CHAR.2)/α_2 (characteristic 2) form the static underexcitation limit (see the following figure). (1/xd CHAR.1) corresponds to the reciprocal value of the related synchronous direct reactance.

$$\frac{1}{X_d} = \frac{1}{X_d} \cdot \frac{U_N}{\sqrt{3} \cdot I_N}$$

If the voltage regulator of the synchronous machine has underexcitation limiting, the static characteristics are set in such a way that the underexcitation limiting of the voltage regulator will intervene before characteristic 1 is reached (see figure 2-58).

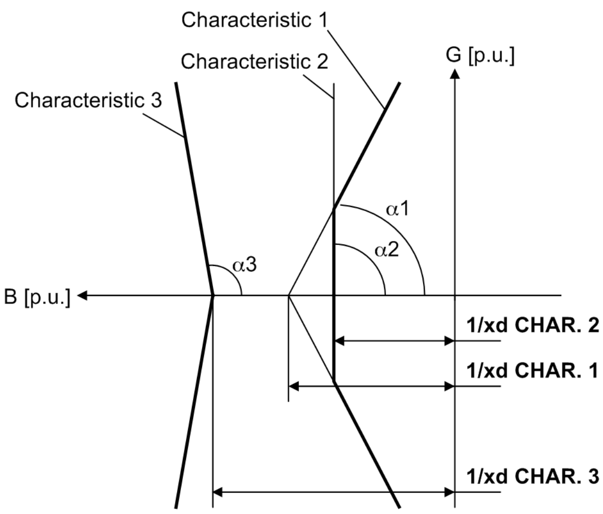


Figure 2-56 Underexcitation Protection Characteristics in the Admittance Plane

Characteristic Curve Values

If the generator capability diagram (see the following figure) in its preferred representation (abscissa = positive reactive power; ordinate = positive active power) is transformed to the admittance plane (division by U^2), the tripping characteristic can be matched directly to the stability characteristic of the machine. If the axis sizes are divided by the nominal apparent power, the generator diagram is indicated per unit (the latter diagram corresponds to a per unit representation of the admittance diagram).

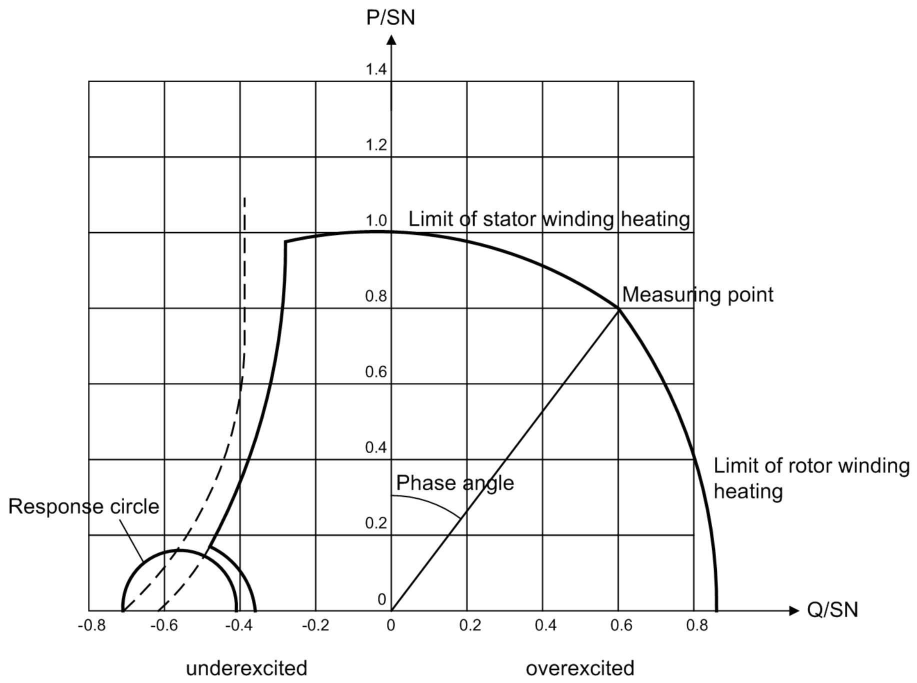


Figure 2-57 Capability Curve of a Salient-Pole Generator, Indicated per Unit

Example:

U =	U_N = 6300 V
I =	I_N
S_N =	5270 kVA
f_N =	50.0 Hz
n_N =	1500 RPM
cos φ =	0,800
x_d =	2,470
x_q =	1,400

The primary setting values can be read out directly from the diagram. The related values must be converted for the protection setting. The same conversion formula can be used if the protection setting is performed with the predefined synchronous direct reactance.

$$\frac{1}{x_{dsec}} = \frac{1}{x_{dMach}} \cdot \frac{I_{NMach}}{U_{NMach}} \cdot \frac{U_{N\ VT\ prim}}{I_{N\ CT\ prim}}$$

with

x_{dsec}	related synchronous direct reactance, secondary,
$x_{d\ Mach}$	related synchronous direct reactance of the machine,
$I_{N\ Mach}$	Nominal current of the machine
$U_{N\ Mach}$	Nominal Voltage of the Machine
$U_{N,\ VTprim}$	Primary Nominal Voltage of the voltage transformers
$I_{N,\ CT\ prim}$	Nominal primary CT current

Instead of $1/x_{d\ Mach}$ the approximate value I_{K0}/I_N can be used (with I_{K0}= short-circuit current at no-load excitation).

Setting example:

Machine	$U_{N\ Mach}$	= 6.3 kV
	$I_{N\ Mach}$	$= S_N/\sqrt{3}\ U_N$ = 5270 kVA/√3 · 6.3 kV = 483 A
	$x_{d\ Mach}$	= 2.47 (read from machine manufacturer's specifications in Figure 2-57)
Current Transformer	$I_{N\ CT\ prim}$	= 500 A
Voltage transformer	$U_{N,\ VTprim}$	= 6.3 kV
	$\frac{1}{x_{d\,sec}} = \frac{1}{2.47} \cdot \frac{483\ A}{6300\ V} \cdot \frac{6300\ V}{500\ A} = 0.39$	

Multiplied by a safety factor of about 1.05, the setting value **1/xd CHAR. 1** results under address 3002.

For α1, the angle of the underexcitation limiting of the voltage regulator is selected or the inclination angle of the machine stability characteristic is used. The setting value **ANGLE 1** is typically situated between 60° and 80°.

In most cases, the machine manufacturer prescribes a minimum excitation value for small active powers. For this purpose, characteristic 1 is cut from characteristic 2 for low active-power load. Consequently, **1/xd CHAR. 2** is set to about 0.9· (**1/xd CHAR. 1**), the **ANGLE 2** to 90°. The kinked tripping limit according to Figure 2-56 (CHAR. 1, CHAR. 2) results in this way, if the corresponding time delays **T CHAR. 1** and **T CHAR. 2** of both characteristics are set equally.

Characteristic 3 serves to adapt the protection to the dynamic machine stability limits. If there are no precise indications, the user must select a value**1/xd CHAR. 3** situated approximately between the synchronous direct reactance x_d and the transient reactance x_d'. However, it should be greater than 1.

A value between 80° and 110° is usually selected for the corresponding **ANGLE 3**, which ensures that only a dynamic instability can lead to a pickup with characteristic 3. The associated time delay is set at address 3010 **T CHAR 3** to the value suggested in Table 2-8.

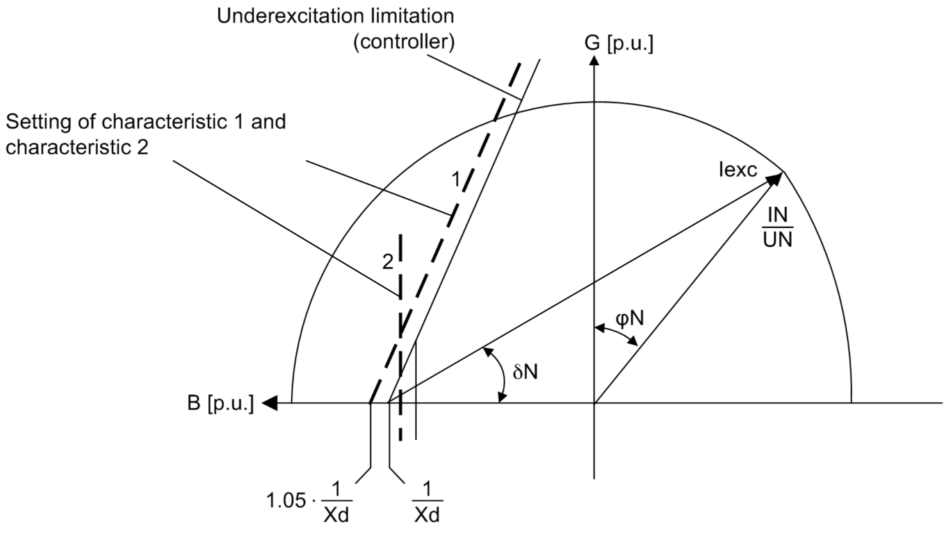


Figure 2-58 Admittance diagram of a turbogenerator

Delay Times

If the static limit curve consisting of the characteristics 1 and 2 is exceeded, the voltage regulator must first have the opportunity of increasing the excitation. For this reason, a warning message due to this criterion is "long-time" delayed (at least 10 s for 3004 **T CHAR. 1** and 3007 **T CHAR. 2**).

If the excitation voltage is missing or too low, the rotor criterion picks up as well, provided that the excitation voltage request feature has been enabled at address 3012 **EXCIT. VOLT.** ***ON*** and under address 3013 the parametrized threshold **Uexcit. <** is undershot or the absence of the excitation voltage has been signalled to the device by binary input. In all these cases tripping is possible with a short delay. This feature is set via parameter 3011 **T SHRT Uex<**. The following messages and trip commands are typically assigned:

Table 2-8 Setting the Underexcitation Protection

Characteristic 1 and 2 static stability	undelayed	Annunciation: Exc < Anr
Characteristic 1 and 2 static stability	long-time delayed T CHAR. 1 = T CHAR. 2 ≈ 10 s	Trippings Err<1 TRIP / Err<2 TRIP
Characteristic 1 and 2 Excitation Voltage Failure	short–time delayed T SHRT Uex< ≈ 1.5 s	Tripping Err< UPU < TRIP
Characteristic 3 dynamic stability	short–time delayed T CHAR 3 ≈ 0.5 s	Tripping Exc<3 TRIP

Note

If very short time delays are selected, dynamic balancing procedures may cause unwanted operations. For this reason, it is recommended to set time values of 0.05 s or higher.

Excitation Voltage Query

The excitation voltage monitoring feature is set to approx. 50 % of the no-load excitation voltage. If the generator is used for phase-shifting, an even lower pickup value must be chosen, depending on the application in hand. It should also be noted that normally a voltage divider is connected between the device and the excitation voltage.

$$\text{Setting U Exc} < \approx 0.50 \cdot \frac{U_{EXc\,0}}{VD_{Ratio}} [V]$$

with

$U_{Exc\,0}$ No-load excitation voltage,

VD_{Ratio} Voltage divider transformation ratio

<u>Example:</u>

$U_{Exc\,N}$ = 110 V

$U_{Exc\,0}$ = 40 V

VD_{Ratio} = 10 : 1

$$\text{Setting U Exc} < \approx 0.50 \cdot \frac{40\text{ V}}{10} = 2.0\text{ V} \qquad (\text{Address 3013})$$

2.16.3 Settings

Addresses which have an appended "A" can only be changed with DIGSI, under Additional Settings.

Addr.	Parameter	Setting Options	Default Setting	Comments
3001	UNDEREXCIT.	OFF ON Block relay	OFF	Underexcitation Protection
3002	1/xd CHAR. 1	0.20 .. 3.00	0.41	Susceptance Intersect Characteristic 1
3003	ANGLE 1	50 .. 120 °	80 °	Inclination Angle of Characteristic 1
3004	T CHAR. 1	0.00 .. 60.00 sec; ∞	10.00 sec	Characteristic 1 Time Delay
3005	1/xd CHAR. 2	0.20 .. 3.00	0.36	Susceptance Intersect Characteristic 2
3006	ANGLE 2	50 .. 120 °	90 °	Inclination Angle of Characteristic 2
3007	T CHAR. 2	0.00 .. 60.00 sec; ∞	10.00 sec	Characteristic 2 Time Delay
3008	1/xd CHAR. 3	0.20 .. 3.00	1.10	Susceptance Intersect Characteristic 3
3009	ANGLE 3	50 .. 120 °	90 °	Inclination Angle of Characteristic 3
3010	T CHAR 3	0.00 .. 60.00 sec; ∞	0.30 sec	Characteristic 3 Time Delay
3011	T SHRT Uex<	0.00 .. 60.00 sec; ∞	0.50 sec	T-Short Time Delay (Char. & Uexc<)
3012	EXCIT. VOLT.	ON OFF	OFF	State of Excitation Volt. Supervision
3013	Uexcit. <	0.50 .. 8.00 V	2.00 V	Excitation Voltage Superv. Pickup
3014A	Umin	10.0 .. 125.0 V	25.0 V	Undervoltage blocking Pickup

2.16.4 Information List

No.	Information	Type of Information	Comments
5323	>Exc. BLOCK	SP	>BLOCK underexcitation protection
5327	>Char. 3 BLK.	SP	>BLOCK underexc. prot. char. 3
5328	>Uexc fail.	SP	>Exc. voltage failure recognized
5329	>Char. 1 BLK.	SP	>BLOCK underexc. prot. char. 1
5330	>Char. 2 BLK.	SP	>BLOCK underexc. prot. char. 2
5331	Excit. OFF	OUT	Underexc. prot. is switched OFF
5332	Excit.BLOCKED	OUT	Underexc. prot. is BLOCKED
5333	Excit.ACTIVE	OUT	Underexc. prot. is ACTIVE
5334	Exc. U< blk	OUT	Underexc. prot. blocked by U<
5336	Uexc failure	OUT	Exc. voltage failure recognized
5337	Exc< picked up	OUT	Underexc. prot. picked up
5343	Exc<3 TRIP	OUT	Underexc. prot. char. 3 TRIP
5344	Exc<1 TRIP	OUT	Underexc. prot. char. 1 TRIP
5345	Exc<2 TRIP	OUT	Underexc. prot. char. 2 TRIP
5346	Exc<U<TRIP	OUT	Underexc. prot. char.+Uexc< TRIP

2.17 Reverse Power Protection (ANSI 32R)

Reverse power protection is used to protect a turbo-generator unit on failure of energy to the prime mover when the synchronous generator runs as a motor and drives the turbine taking motoring energy from the network. This condition leads to overheating of the turbine blades and must be interrupted within a short time by tripping the network circuit-breaker. For the generator, there is the additional risk that, in case of a malfunctioning residual steam pass (defective stop valves) after the switching off of the circuit breakers, the turbine-generator-unit is speeded up, thus reaching an overspeed. For this reason, the system should only be disconnected after active power input into the machine has been detected.

2.17.1 Functional Description

Reverse Power Determination

The reverse power protection of the 7UM62 precisely calculates the active power from the symmetrical components of the fundamental waves of voltages and currents by averaging the values of the last 16 cycles. The evaluation of only the positive phase-sequence systems makes the reverse power determination independent of current and voltage asymmetries and corresponds to actual loading of the drive end. The calculated active power value corresponds to the overall active power. By taking the error angles of the instrument transformers into account, the active power component is exactly calculated even with very high apparent powers and low power factor cos φ. The correction is performed by a W0 constant correction angle determined during commissioning of the protection device in the system. The correction angle is set under Power System Data 1 (see Section 2.5).

Pickup Seal-In Time

To ensure that frequently occurring short pickups can cause tripping, it is possible to perform a selectable prolongation of these pickup pulses at parameter 3105 **T-HOLD**. Each positive edge of the pickup pulses triggers this time stage again. For a sufficient number of pulses, the pickup signals add up and become longer than the time delay.

Trip Signal

For bridging a perhaps short power input during synchronization or during power swings caused by system faults, the trip command is delayed by a selectable time **T-SV-OPEN**. In case of a closed emergency tripping valve, a short delay is, however, sufficient. By means of entering the emergency tripping valve position via a binary input, the short time delay **T-SV-CLOSED** becomes effective under an emergency tripping condition. The time **T-SV-OPEN** is still effective as back-up stage.

It is also possible to block tripping via an external signal.

The following figure shows the logic diagram for the reverse power protection.

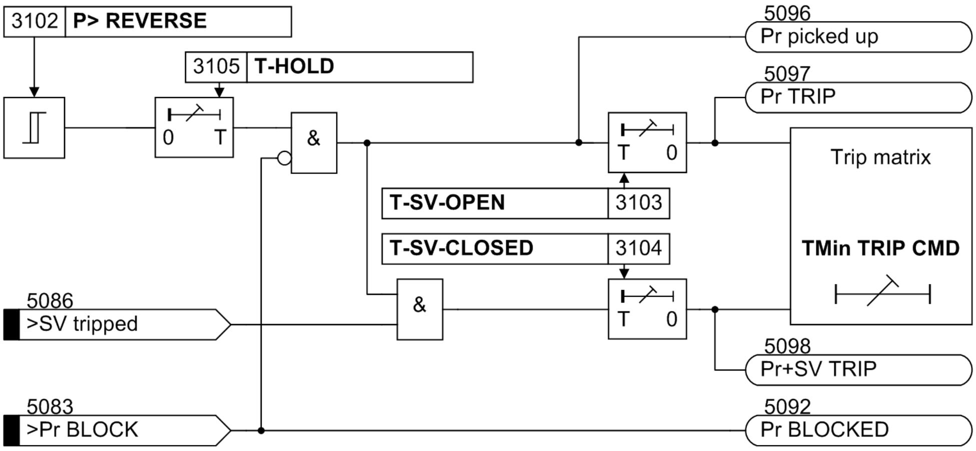


Figure 2-59 Logic Diagram of the Reverse Power Protection

2.17.2 Setting Notes

General

Reverse power protection is only effective and available if this function was set during protective function configuration (Section 2.4), address 131, **REVERSE POWER** is set to ***Enabled***. If the function is not required ***Disabled*** is set. The address 3101 **REVERSE POWER** serves to switch the function ***ON*** or ***OFF*** or to block only the trip command (***Block relay***).

In case of a reverse power, the turbine set must be disconnected from the system as the turbine operation is not permissible without a certain minimum steam throughput (cooling effect) or, in case of a gas turbine set, the motor load would be too heavy for the network.

Pickup Values

The level of the active power input is determined by the friction losses to be overcome and is in the following ranges, depending on the individual system:

- Steam turbines: $P_{Reverse}/S_N \approx 1$ % to 3 %
- Gas turbines: $P_{Reverse}/S_N \approx 3$ % to 5 %
- Diesel drives: $P_{Reverse}/S_N > 5$ %

For the primary test, the reverse power should be measured with the actual protection. The user should select a setting of 0.5 times the value of the measured motoring energy. This value can be found under the percentage operational measured values. The feature to correct angle faults of the current and voltage transformers should be used especially for very large machines with a particularly low motoring energy (see Sections 2.5 and 3.3).

The pickup value 3102 **P> REVERSE** is set in percent of the secondary apparent power rating $S_{Nsek} = \sqrt{3} \cdot U_{Nsec} \cdot I_{Nsec}$. If the primary motoring energy is known, it must be converted to secondary quantities using the following formula:

$$\text{Setting} = \frac{P_{sec}}{S_{N\,sec}} = \frac{P_{Mach}}{S_{N\,Mach}} \cdot \frac{U_{N\,Mach}}{U_{N\,prim}} \cdot \frac{I_{N\,Mach}}{I_{N\,prim}}$$

with

P_{sec}	Secondary power corresponding to setting value
S_{Nsec}	secondary rated power = $\sqrt{3} \cdot U_{Nsec} \cdot I_{Nsec}$
P_{Mach}	Machine power corresponding to setting value
$S_{N,\,Mach}$	Nominal apparent power of the machine
$U_{N\,Mach}$	Nominal Voltage of the Machine
$I_{N\,Mach}$	Nominal current of the machine
$U_{N\,prim}$	Primary Nominal Voltage of the voltage transformers
$I_{N\,prim}$	Primary nominal current of the current transformer

Pickup Seal-In Time

The 3105 **T-HOLD** pickup seal-in time serves to extend pulsed pickups to the parameterized minimum duration.

Delay Times

If reverse power without emergency tripping is used, a corresponding time delay must be implemented to bridge any short reverse power states after synchronization or power swings subsequent to system faults (e.g. 3-pole short circuit). Usually, a delay time 3103 **T-SV-OPEN** = approx. 10 s is set.

Under emergency tripping conditions, the reverse power protection performs a short-time delayed trip subsequent to the emergency tripping via an oil-pressure switch or a position switch at the emergency trip valve. Before tripping, it must be ensured that the reverse power is only caused by the missing drive power at the turbine side. A time delay is necessary to bridge the active power swing in case of sudden valve closing, until a steady state active power value is achieved. A 3104 **T-SV-CLOSED** time delay of about 1 to 3 s is sufficient for this purpose, whereas a time delay of about 0.5 s is recommended for gas turbine sets. The set times are additional delay times not including the operating times (measuring time, dropout time) of the protective function.

2.17.3 Settings

Addresses which have an appended "A" can only be changed with DIGSI, under Additional Settings.

Addr.	Parameter	Setting Options	Default Setting	Comments
3101	REVERSE POWER	OFF ON Block relay	OFF	Reverse Power Protection
3102	P> REVERSE	-30.00 .. -0.50 %	-1.93 %	P> Reverse Pickup
3103	T-SV-OPEN	0.00 .. 60.00 sec; ∞	10.00 sec	Time Delay Long (without Stop Valve)
3104	T-SV-CLOSED	0.00 .. 60.00 sec; ∞	1.00 sec	Time Delay Short (with Stop Valve)
3105A	T-HOLD	0.00 .. 60.00 sec; ∞	0.00 sec	Pickup Holding Time

2.17.4 Information List

No.	Information	Type of Information	Comments
5083	>Pr BLOCK	SP	>BLOCK reverse power protection
5086	>SV tripped	SP	>Stop valve tripped
5091	Pr OFF	OUT	Reverse power prot. is switched OFF
5092	Pr BLOCKED	OUT	Reverse power protection is BLOCKED
5093	Pr ACTIVE	OUT	Reverse power protection is ACTIVE
5096	Pr picked up	OUT	Reverse power: picked up
5097	Pr TRIP	OUT	Reverse power: TRIP
5098	Pr+SV TRIP	OUT	Reverse power: TRIP with stop valve

2.18 Forward Active Power Supervision (ANSI 32F)

The machine protection 7UM62 includes an active power supervision which monitors whether the active power falls below one settable value as well as whether a separate second settable value is exceeded. Each of these functions can initiate different control functions.

When, for example, with generators operating in parallel, the active power output of one machine becomes so small that other generators could take over this power, then it is often appropriate to shut down the lightly loaded machine. The criterion in this case is that the "forwards" power supplied into the network falls below a certain value.

In many applications it can be desirable to issue a control signal if the active power output rises above a certain value.

When a fault in a utility network is not cleared within a critical time, the utility network should be split or for example, an industrial network decoupled from it. Criteria for decoupling, in addition to power flow direction, are undervoltage, overcurrent and frequency. As a result, the 7UM62 can also be used for network decoupling.

2.18.1 Functional Description

Active Power Measuring

Depending on the application either slow high-precision measurement (averaging 16 cycles) or high-speed measurement (without averaging) may be selected. High-speed measurement is particularly suitable for network decoupling.

The device calculates the active power from the positive sequence systems of the generator currents and voltages. The computed value is compared with the set values. Each of the forward active power stages can be blocked individually via binary inputs. In addition the entire active power monitoring can be blocked per binary input.

The following figure shows the logic diagram for the forward active power supervision.

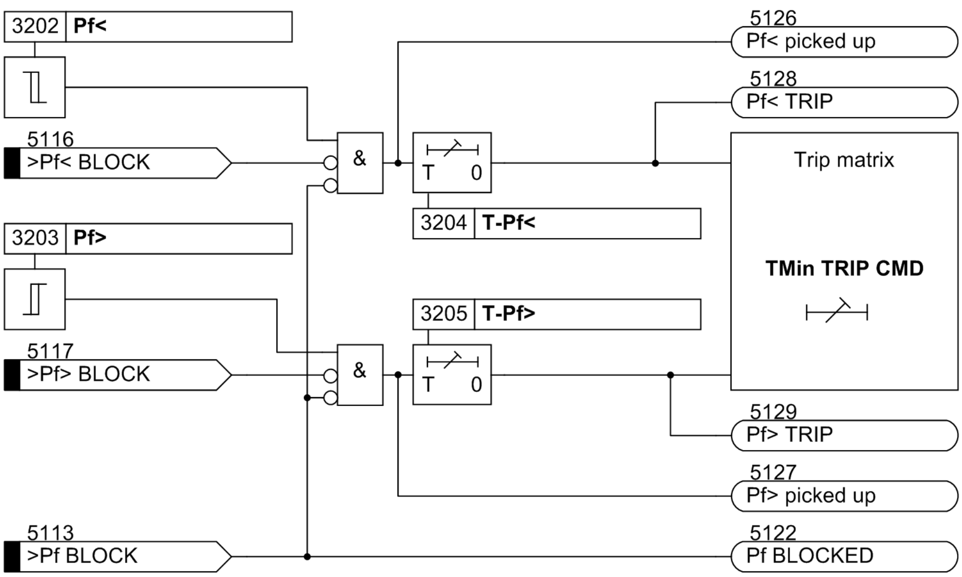


Figure 2-60 Logic Diagram of the Forward Active Power Supervision

2.18.2 Setting Notes

General

Forward active power protection is only effective and available if this function was set during protective function configuration (Section 2.4, address 132, **FORWARD POWER** is set to ***Enabled***). If the function is not required ***Disabled*** is set. The address 3201 **FORWARD POWER** serves to switch the function ***ON*** or ***OFF*** or to block only the trip command (***Block relay***).

Pickup Values, Time Delays

The setting of the forward power protection depends strongly on the intended purpose. General setting guidelines are not possible. The pickup values are set in percent of the secondary apparent power rating $S_{Nsec} = \sqrt{3} \cdot U_{Nsec} \cdot I_{Nsec}$. Consequently, the machine power must be converted to secondary quantities:

$$\text{Setting} = \frac{P_{sec}}{S_{N\,sec}} = \frac{P_{Mach}}{S_{N\,Mach}} \cdot \frac{U_{N\,Mach}}{U_{N\,prim}} \cdot \frac{I_{N\,Mach}}{I_{N\,prim}}$$

with

P_{sec}	Secondary power corresponding to setting value
S_{Nsec}	secondary nominal power = $\sqrt{3} \cdot U_{Nsec} \cdot I_{Nsec}$
P_{Mach}	Machine power corresponding to setting value
$S_{N,\,Mach}$	Nominal apparent power of the machine
$U_{N\,Mach}$	Nominal voltage of the machine
$I_{N\,Mach}$	Nominal current of the machine
$U_{N\,prim}$	Primary Nominal Voltage of the voltage transformers
$I_{N\,prim}$	Primary nominal current of the current transformer

Address 3202 serves to set the threshold of the forward power to an undershoot (**Pf<**) and address 3203 (**Pf>**) serves to set it to overshoot. Addresses 3204 **T-Pf<** and 3205 **T-Pf>** serve to set the associated time delays.

In address 3206 **MEAS. METHOD** the user can select whether a fast or a precise measuring procedure is to be used for the forward power calculation. In most cases, the precise measuring procedure is preferred in the power station sector (as a rule), whereas the fast procedure is applied for use as mains decoupling.

The set times are additional delay times not including the operating times (measuring time, dropout time) of the protective function.

2.18.3 Settings

Addresses which have an appended "A" can only be changed with DIGSI, under Additional Settings.

Addr.	Parameter	Setting Options	Default Setting	Comments
3201	FORWARD POWER	OFF ON Block relay	OFF	Forward Power Supervision
3202	Pf<	0.5 .. 120.0 %	9.7 %	P-forw.< Supervision Pickup
3203	Pf>	1.0 .. 120.0 %	96.6 %	P-forw.> Supervision Pickup
3204	T-Pf<	0.00 .. 60.00 sec; ∞	10.00 sec	T-P-forw.< Time Delay
3205	T-Pf>	0.00 .. 60.00 sec; ∞	10.00 sec	T-P-forw.> Time Delay
3206A	MEAS. METHOD	accurate fast	accurate	Method of Operation

2.18.4 Information List

No.	Information	Type of Information	Comments
5113	>Pf BLOCK	SP	>BLOCK forward power supervision
5116	>Pf< BLOCK	SP	>BLOCK forw. power superv. Pf< stage
5117	>Pf> BLOCK	SP	>BLOCK forw. power superv. Pf> stage
5121	Pf OFF	OUT	Forward power supervis. is switched OFF
5122	Pf BLOCKED	OUT	Forward power supervision is BLOCKED
5123	Pf ACTIVE	OUT	Forward power supervision is ACTIVE
5126	Pf< picked up	OUT	Forward power: Pf< stage picked up
5127	Pf> picked up	OUT	Forward power: Pf> stage picked up
5128	Pf< TRIP	OUT	Forward power: Pf< stage TRIP
5129	Pf> TRIP	OUT	Forward power: Pf> stage TRIP

2.19 Impedance Protection (ANSI 21)

Machine impedance protection is used as a selective time graded protection to provide the shortest possible tripping times for short-circuits in the synchronous machine, on the terminal leads as well as in the unit transformer. It thus also provides backup protection functions to the main protection of a power plant or protection equipment connected in series like generator, transformer differential and system protection devices.

The impedance protection function of 7UM62 always operates with the currents of side 2 ($I_{L1,\ 2\ ,3;\ S2}$).

2.19.1 Functional Description

PICKUP

Pickup is required to detect a faulty condition in the power system and to initiate all the necessary procedures for selective clarification of the fault:

- Start the time delays for the final stage t3,
- Determination of the faulty measuring loop,
- Enabling of impedance calculation,
- Enabling of tripping command,
- Indication/output of the faulty conductor(s).

Pickup is implemented as overcurrent pickup and can be optionally supplemented by an undervoltage seal-in circuit. After numeric filtering, the currents are monitored for over-shooting of a set value. A signal is output for each phase where the set threshold has been exceeded. These pickup signals are considered for choosing the measured values. The pickup is reset when 95% of the pick-up threshold is undershot, unless maintained by the undervoltage seal-in feature.

Undervoltage Seal-In

With excitation systems powered from the network, excitation voltage can drop during a local short circuit, resulting in decreasing short-circuit current which, in spite of the remaining fault, can undershoot the pickup value. In such cases the impedance protection pick-up is maintained for a sufficiently long period by means of an undervoltage controlled seal-in circuit using the positive sequence voltage U_1. Pickup drops off when this holding time has expired or when the restored voltage reaches 105% of the set undervoltage seal-in value.

The seal-in logic operates separate for each phase. The first pickup starts the timer **T-SEAL-IN**.

Figure 2-61 shows the logic diagram of the pickup stage of the impedance protection.

Determination of the Short–Circuit Impedance

For calculating impedance only the currents and voltages of the faulty (shorted) phase loop are decisive. Accordingly the protection, controlled by the pickup, evaluates these measurement values (see also Table 2-9).

Loop Selection

- The corresponding phase-earth loop is used for a 1-pole pickup
- With a 2-pole pickup, the phase-phase loop with the corresponding phase-to-phase voltage is used for impedance calculation.
- With a 3-pole pickup, the phase-earth loop with the highest current value is used and with equal current amplitudes, the procedure described in the last row of the following table is applied.

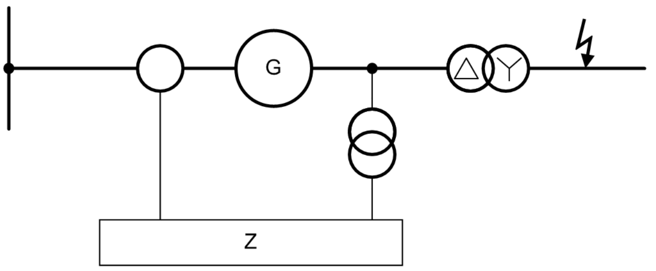
Table 2-9 Measuring Loop Selection

Pickup		Measuring Loop	
1-pole	L1 L2 L3	Phase-earth	L1-E L2-E L3-E
2-pole	L1, L2 L2, L3 L3, L1	Phase-phase, Calculation of $\underline{U}_{LL}$ and $\underline{I}_{LL}$	L1-L2 L2-L3 L3-L1
3-pole, for dissimilar amplitudes	L1,2*L2,L3 L2,2*L3,L1 L3,2*L1,L2	Phase-earth, selection of loop with the highest current $\underline{U}_{L\ (Imax)}$ and $\underline{I}_{L\ (Imax)}$	L2-E L3-E L1-E
3-pole, for identical amplitudes	L1, L2, L3	Phase-earth (any, maximum current amount)	IL1=IL2=IL3 then IL1 IL1=IL2 > IL3 then IL1 IL2=IL3 > IL1 then IL2 IL3=IL1 > IL2 then IL1

This loop selection type ensures that the fault impedance of system faults is measured correctly via the unit transformer. A measuring error occurs with a 1-pole system short-circuit, since the zero phase-sequence system is not transmitted via the machine transformer (switching group e.g. Yd5). The following table describes the fault modeling and the measuring errors.

Table 2-10 Fault Modeling and Measuring Errors on the Generator Side on System Faults

System Faults	Fault Model on the Generator Side	Loop Selection	Measuring Errors
3-pole short-circuit	3-pole short-circuit	Phase-earth	Always correct measurement
2-pole short-circuit	3-pole short-circuit	Phase-earth, selection of loop with the highest current	Always correct measurement
1-pole short-circuit	2-pole short-circuit	Phase-phase loop	Impedance measured too high by the zero impedance



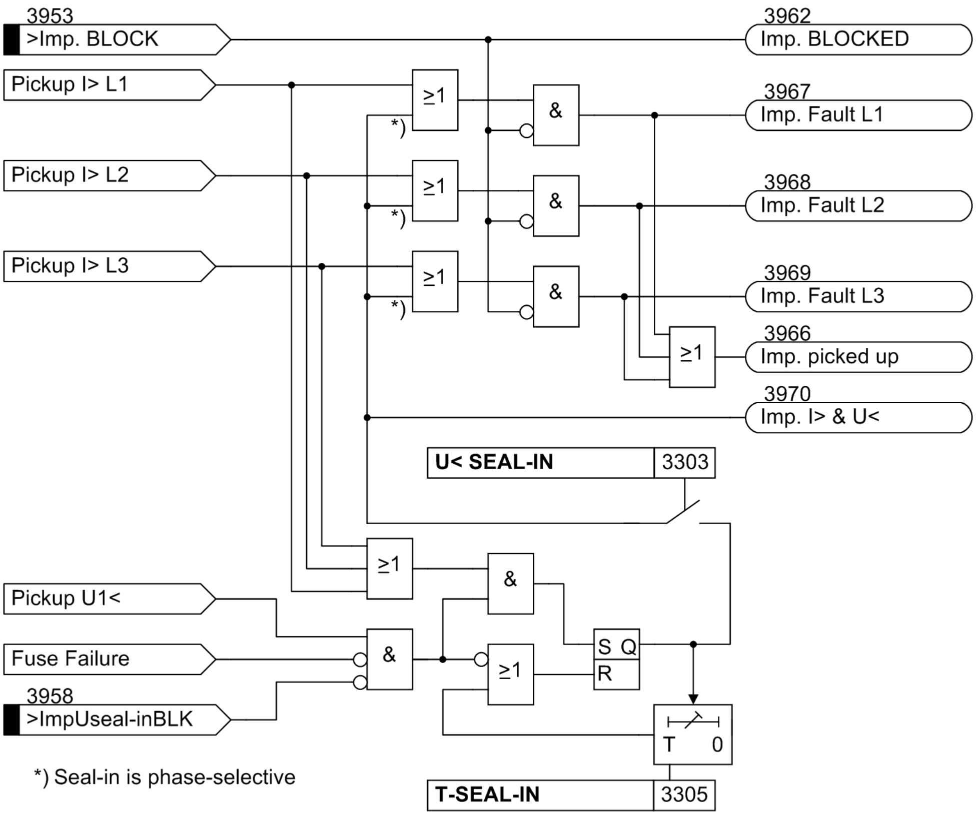


Figure 2-61 Logic Diagram of the Pickup Stage of the Impedance Protection

Tripping Characteristic

The tripping characteristic of the impedance protection is a polygon (see also Figure 2-62). It is symmetrical even though a fault in reverse direction (negative R and/or X values) is physically impossible provided the usual connection to the current transformers at the star-point side of the generator is used. The polygon is fully identified by one parameter (impedance Z).

As long as the pickup criteria are met, impedance calculation is done continuously using the current and voltage vectors derived from the loop selection measured values. If the calculated impedance is within the tripping characteristic, the protection sends a tripping command according to the specified delay time.

Since the impedance protection is multi-stage, the protected zones can be chosen such that the first stage (**ZONE Z1**, **T-Z1**) covers faults in the generator and the lower voltage side of the unit transformer, whereas the second stage (**ZONE Z2**, **ZONE2 T2**) covers the entire power station block. It should be noted, however, that high voltage side 1-pole earth faults cause impedance measurement errors due to the star-delta connection of the unit transformer on the lower voltage side. An unwanted operation of the stage can be excluded since the fault impedances of power system faults are modeled too high.

Faults outside this range are switched off by the **T END** final time stage.

Depending on the switching status of the system, it may be useful to extend the **ZONE Z1**, **T-Z1** undelayed tripping zone. If, for example, the high-voltage side circuit breaker is open, the pickup can only be caused by a fault in the power station block. If consideration of the circuit breaker auxiliary contact is possible, a so-called overreach zone **ZONE Z1B** can be made effective (see also Section 2.19.3, Figure „Grading of the machine impedance protection“).

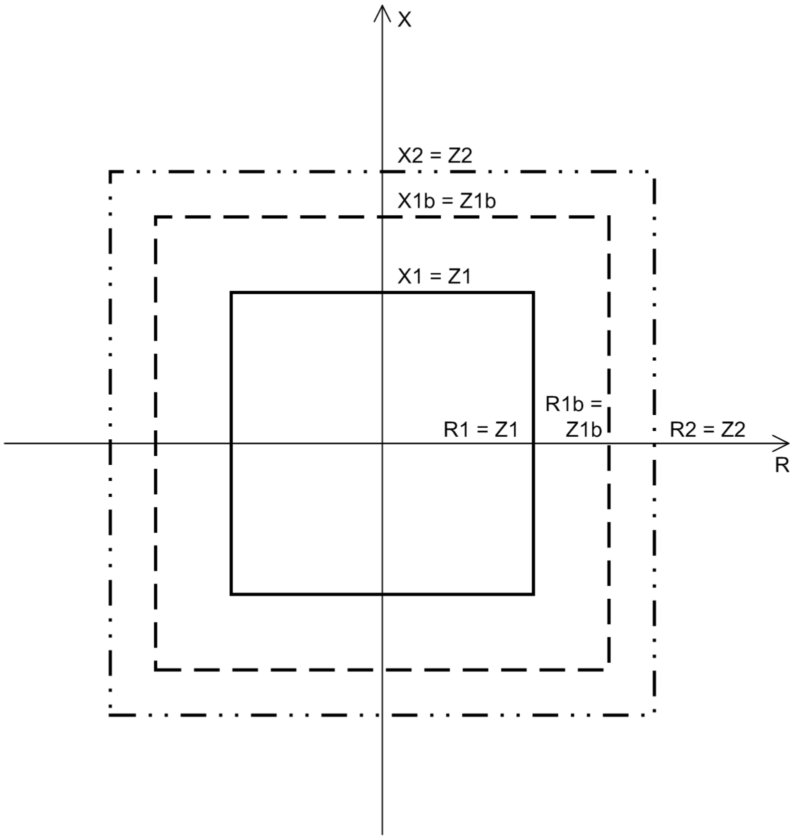


Figure 2-62 Tripping Characteristics of the Impedance Protection

Tripping Logic

The **T END** time delay is started subsequent to the protection pickup, establishing the fault loop. The loop impedance components are compared with the limit values of the zones previously set. The tripping is executed if the impedance is within its zone during the course of the corresponding time stage.

For the first Z1 zone and also for the Z1B overreach zone, the time delay will in most cases be zero or at least very short. i.e. tripping occurs as soon as it is established that the fault is within this zone.

The Z1B overreach stage can be enabled from outside, via a binary input.

For the Z2 zone which may extend into the network, a time delay is selected overreaching the first stage of the power system protection.

A drop-out can only be caused by a drop-out of the overcurrent pickup and not by exiting the tripping polygon.

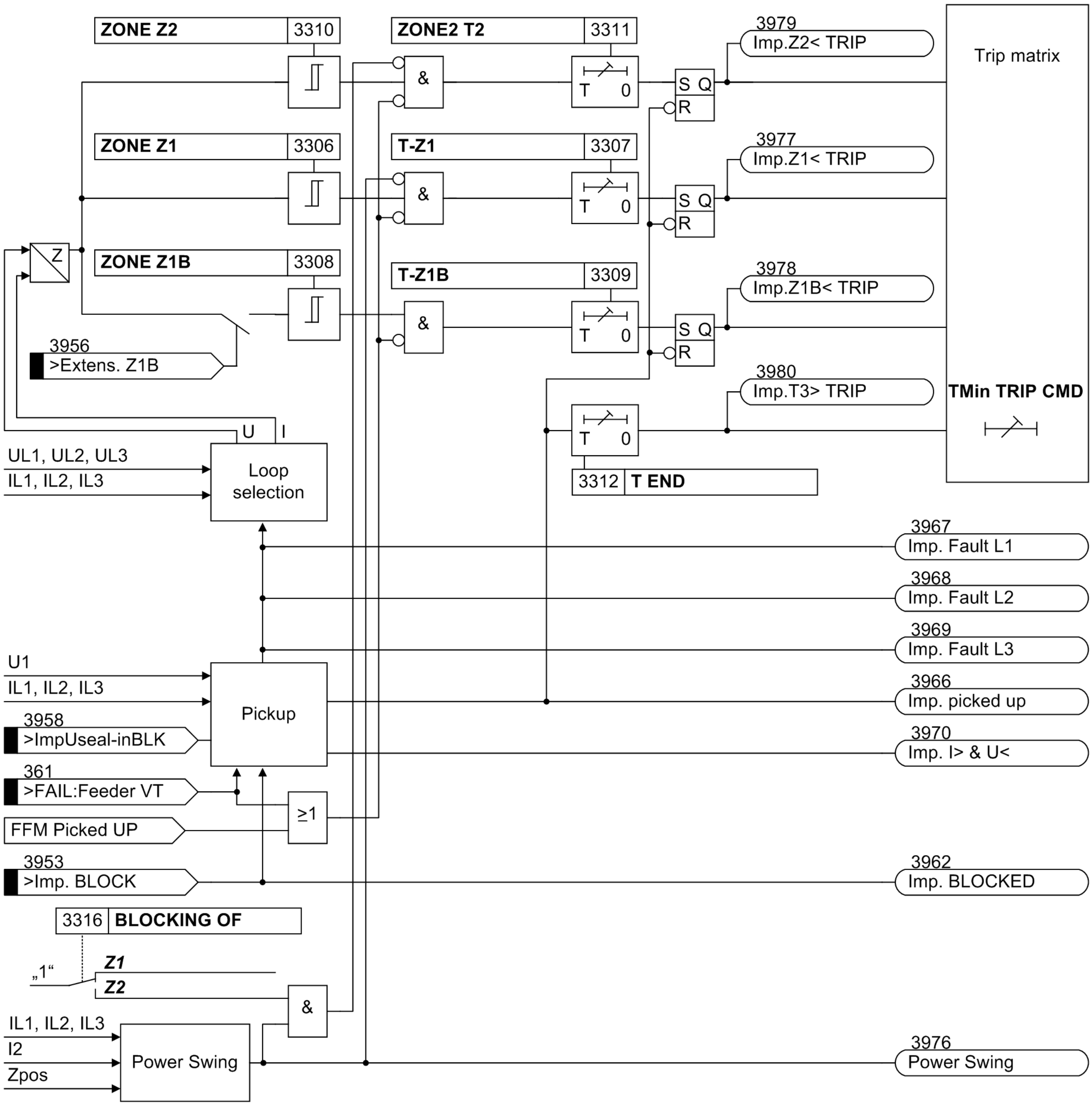


Figure 2-63 Logic Diagram of the Impedance Protection

2.19.2 Power Swing Blocking

General

Dynamic occurrences such as sudden load changes, short circuits, automatic reclosure or switching operations within the power system may cause power swings. Therefore impedance protection is complemented by a power swing blocking function to avoid spurious tripping.

Power swings are three-phase symmetrical occurrences. The first prerequisite is therefore effective symmetry of the three phase currents, which is verified by evaluation of the negative sequence current. This means that asymmetrical (all single-phase and two-phase) short circuits cannot cause the power swing blocking to pick up. Even if a power swing has been detected, the asymmetrical short-circuits following it quickly deactivate the power swing blocking and make tripping by impedance protection possible. Since a power swing happens much more slowly than a short-circuit, the rate of change of the impedance is a reliable criterion for its identification. Because of its symmetrical nature, the positive sequence impedance obtained from the positive sequence components of the currents and voltages is evaluated.

Logic

The figure below shows the logic diagram for the power swing block. The upper section shows the current symmetry monitoring. An enable signal is given if there is a three-pole pickup with no negative sequence system current. For detection of power swings, a power swing polygon (P/SPOL) is used which is greater than the trip polygon (TPOL). The distance between the two polygons can be set (common setting for R and X direction). The user can choose for each setting parameter whether the trip polygon refers only to characteristic Z1 or to characteristics Z1 & Z2. In the latter case, the trip polygon is the maximum impedance value.

Measuring Principle

The criterion for power swing blocking is composed of the power swing polygon, its distance to the trip polygon, the trip polygon itself and the rate of change of the impedance. The first impedance value after entering the power swing polygon (instant Tent) is compared with the last value outside the polygon (instant Tent-Δt). The time Δt is determined by the measuring interval which is one cycle. If the impedance vector rate of change thus determined is less than a set value $\Delta Z/\Delta t$, a power swing is detected. The impedance stage is not blocked, however, until the impedance vector enters the trip polygon TPOL.

If the first impedance value is both inside the P/SPOL and the TPOL, the protection detects immediately a short-circuit, because there must be at least one impedance value between the P/SPOL and the TPOL. The distance between the power swing polygon P/SPOL and the trip polygon TPOL, and the rate of change $\Delta Z/\Delta t$ are matched to one another in such a way that power swings are reliably detected and the desired impedance zone (Z1 or Z1 & Z2) of the impedance protection is blocked. The blocking remains effective until the measured impedance vector has exited the trip polygon or power swing polygon, the change rate is exceeded, or asymmetrical power conditions rule out the possibility of a power swing. The power swing blocking time is also limited by a parameter setting (**T-ACTION P/S**).

Blocking of the Impedance Stages

Power swing blocking is mostly used for impedance stage Z1, because the delay time T1 for this stage is set low. Accordingly, a high delay time T2 must be set high for zone Z2. In the overreach zone Z1B no power swings can occur by definition, since the network breaker is open and there is thus no second machine for power swings. Likewise, the power swing blocking does not block the non-directional overcurrent stage (T3).

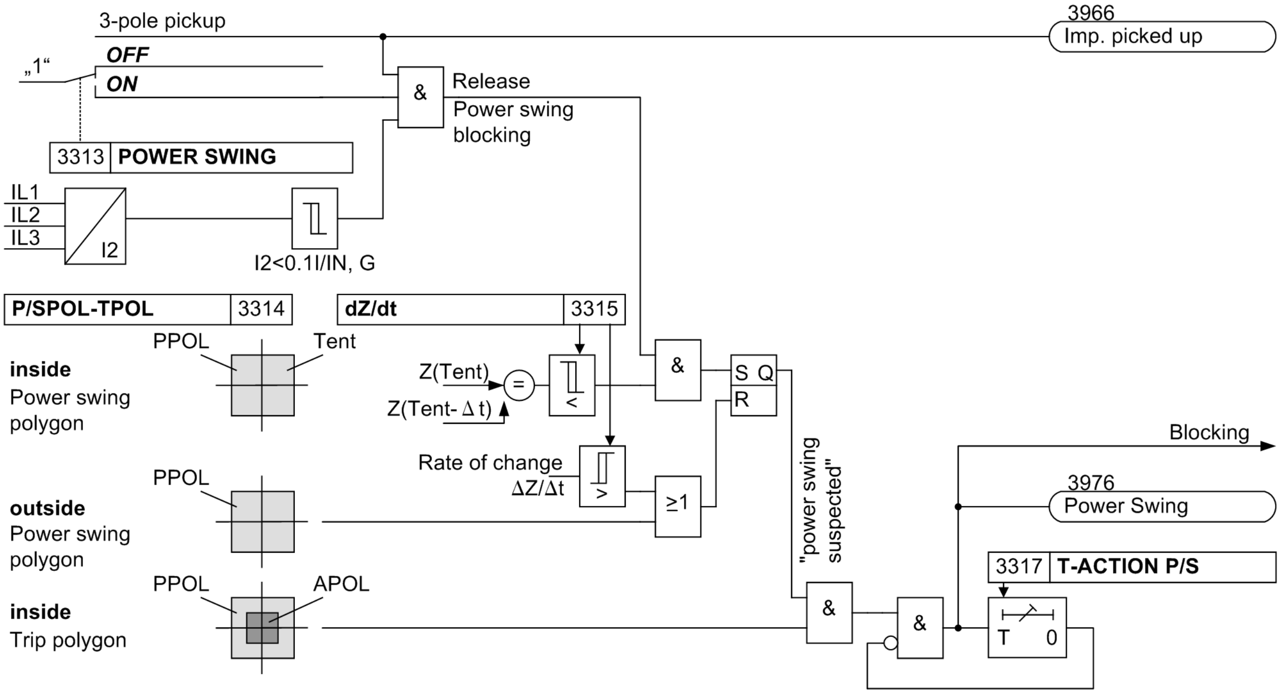


Figure 2-64 Logic Diagram for the Power Swing Blocking of the Impedance Protection

Z(Tent)	First value inside the power swing polygon (at the moment of Tent)
Z(Tent-Δt)	Last value outside the power swing polygon
P/SPOL	Power swing polygon
TPOL	Trip polygon
ΔZ/Δt	Rate of change of the impedance phasor

2.19.3 Setting Notes

General

Machine impedance protection is only effective and available if enabled during configuration (Section 2.4, address 133, **IMPEDANCE PROT.** = ***Enabled***. If the function is not required ***Disabled*** is set. Address 3301 **IMPEDANCE PROT.** serves to switch the function ***ON*** or ***OFF*** or to block only the trip command (***Block relay***).

Pickup

The maximum load current during operation is the most important criterion for setting overcurrent pickup. A pickup by an overload must be excluded! For this reason, the 3302 **IMP I>** pickup value must be set above the maximum (over) load current to be expected. Recommended setting: 1.2 to 1.5 times the nominal machine current. The pickup logic corresponds to the logic of the UMZ I> definite time-overcurrent protection.

If the excitation is derived from the generator terminals with the short circuit current possibly falling below the pickup value (address 3302) due to the collapsing voltage, the undervoltage seal-in feature of the pickup is used, i.e. address 3303 **U< SEAL-IN** is switched to ***ON***.

The undervoltage seal-in setting **U<** (address 3304) is set to a value just below the lowest phase-to-phase voltage occurring during operation, e.g. to **U<** = 75 % to 80 % of the nominal voltage. The seal-in time (address 3305 **T-SEAL-IN**) must exceed the maximum fault clearance time in a back-up case (recommended setting: address 3312 **T END** + 1 s).

Impedance Stages

The protection has the following characteristics which may be set independently:

1. Zone (fast tripping zone Z1) with parameters

ZONE Z1	Reactance = reach,
T-Z1	= 0 or short delay, if required.

Overreach zone Z1B, externally controlled via binary input, with parameters

ZONE Z1B	Reactance = reach,
T-Z1B	T1B = 0 or short delay, if required.

2. Zone (zone Z2) with parameters

ZONE Z2	Reactance = reach,
ZONE2 T2	The user must select a value for T2 above the grading time of the network protection.

Non-directional final stage with parameter

T END	The user must select T END so that the 2nd or 3rd stage of the series-connected power system distance protection is overreached.

As the user may assume that impedance protection measurement extends into the unit transformer, parametrization must be selected to sufficiently consider the transformer control range.

Therefore **ZONE Z1** is normally set to a reach of approx. 70 % of the protected zone (i.e. about 70 % of the transformer reactance), with no or only a small delay (i.e. **T-Z1** = 0.00 s to 0.50 s). Protection then switches off faults on this distance after its operating time or with a slight time delay (high speed tripping). A time delay of 0.1 s is preferred.

For **ZONE Z2** the reach could be set to about 100 % of the transformer reactance, or in addition to a network impedance. The corresponding **ZONE2 T2** time stage is to be set so that it overreaches the power system protective equipment of the following lines. The **T END** time is the last back-up time.

The following formula is generally valid for the primary impedance (with limiting to the unit transformer):

$$Z_{prim} = \frac{k_R}{100} \cdot \frac{u_{SC}}{100} \cdot \frac{U_N^2}{S_N}$$

with

k_R	Protection zone reach [%]
u_{SC}	relative transformer short-circuit voltage [%]
S_N	Rated transformer power [MVA]
U_N	Machine-side rated transformer voltage [kV]

The derived primary impedances must be converted for the secondary side of the current and voltage transformers. In general:

$$Z_{secondary} = \frac{\text{CT transformation ratio}}{\text{VT transformation ratio}} \cdot Z_{primary}$$

The nominal current of the protection device (= secondary nominal current of the current transformer) is automatically considered by the device. You have already communicated the transformation ratios of the current and voltage transformers to the device by entering the nominal transformer values (see section 2.5).

Example:

Transformer data:

u_{SC} = 7 %

S_N = 5.3 MVA

U_N = 6.3 kV

Transformation ratios:

Current transformer ratio = 500 A / 1 A

$$\text{VT transformation ratio} = \frac{6.3\text{ kV}}{\sqrt{3}} \Big/ \frac{100\text{ V}}{\sqrt{3}}$$

This results for a 70 % reach for zone 1 in:

$$Z1_{prim} = \frac{70}{100} \cdot \frac{7}{100} \cdot \frac{6.3^2}{5.3} = 0.3669\ \Omega$$

The following secondary side setting value of zone 1 results at address 3306 **ZONE Z1**:

$$Z1_{secondary} = \frac{500\text{ A}/1\text{ A}}{6.3\text{ kV}/100\text{ V}} \cdot 0.3669\ \Omega = 2.91\ \Omega$$

Note: The following ratio would result from the connection of a 5 A device to a 5 A transformer:

$$Z1_{secondary} = \frac{500\text{ A}/5\text{ A}}{6.3\text{ kV}/100\text{ V}} \cdot 0.3669\ \Omega = 0.58\ \Omega$$

Likewise the following primary reactance results for a 100 % reach for zone 2:

$$Z2_{prim} = \frac{100}{100} \cdot \frac{7}{100} \cdot \frac{6.3^2}{5.3} = 0.5242\ \Omega$$

The following secondary side setting value of zone 2 results at address 3310 **ZONE Z2**:

$$Z2_{secondary} = \frac{500\text{ A}/1\text{ A}}{6.3\text{ kV}/100\text{ V}} \cdot 0.5242\ \Omega = 4.16\ \Omega$$

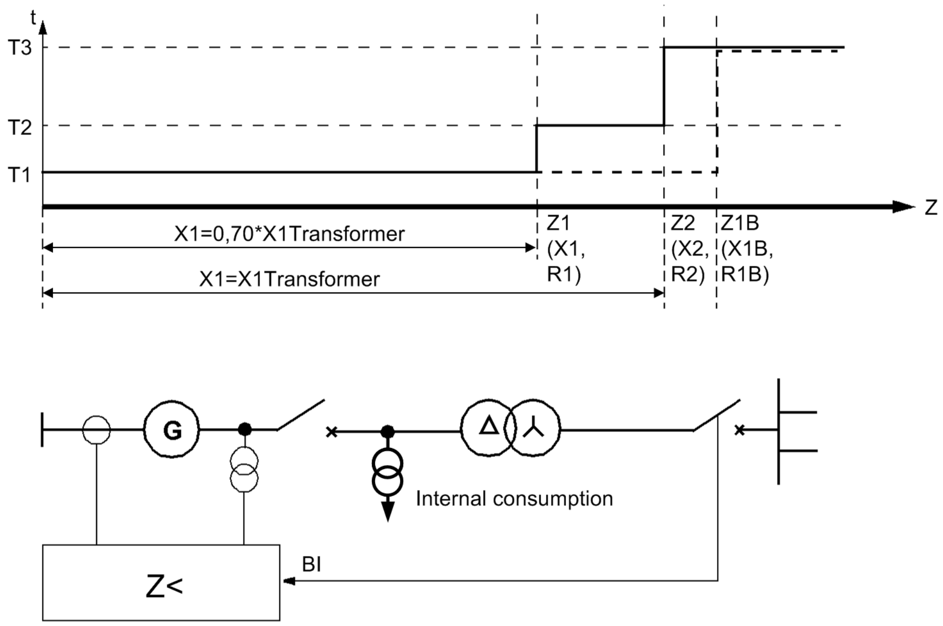


Figure 2-65 Time Grading for Machine Impedance Protection – Example

Z1B Overreach Zone

The Z1B overreach zone (address 3308 **ZONE Z1B**) is an externally controlled stage. It does not influence the Z1 zone normal stage. Consequently there is no changeover, but the overreach zone is enabled or disabled depending on the position of the high-voltage side circuit breaker.

The Z1B zone is usually enabled by an opened high-voltage circuit breaker. In this case every impedance protection pickup can only be due to a fault in the protection zone of the block, since the power system is disconnected from the block. Consequently the fast tripping zone can be extended to between 100 % and 120 % of the protection zone without any loss of selectivity.

The Z1B zone is activated via a binary input controlled by the circuit breaker auxiliary contact (see Figure 2-65). An individual 3309 **T-Z1B** time delay is allocated to the overreach zone.

Final Stage

For short circuits outside the Z1 and Z2 zones, the device functions as a time-delayed overcurrent protection. Its nondirectional final time **T END** is selected so that its time value overreaches the second or third stage of the series-connected network distance protection.

Power Swing Blocking

The power swing blocking is only effective if address 3313 **POWER SWING** has been set to ***ON***.

For the distance between the power swing polygon and trip polygon (parameters: **P/SPOL-TPOL** (address 3314)) and rate of change (parameter: **dZ/dt** (address 3315)) an appropriate compromise must be found. It must be taken into account that the rate of change is not constant. The closer to the coordinates origin, the smaller it becomes. Furthermore the power system conditions such as impedance between swinging systems and the swinging frequency, determine the rate of change (see also Section 2.20 Out-of-Step Protection).

The following relation allows estimation of the rate of change:

$$\frac{dZ(t)}{dt} \approx \frac{dR(t)}{dt} = \frac{X\pi f_p}{2\sin^2(\pi f_p t)} = \frac{X\pi f_p}{2\sin^2\left(\frac{\delta}{2}\right)} \text{ in } \frac{\Omega}{s}$$

Definitions:

X	Reactance between the sources of the power swing
f_p	Swing frequency
δ	Swing angle

Figure 2-66 shows an example of how the rate of change evolves as a function of the power swing angle. For an angle of 180° the rate of change is smallest. The further into the power system network (i.e. larger or smaller angle), the greater the acceleration.

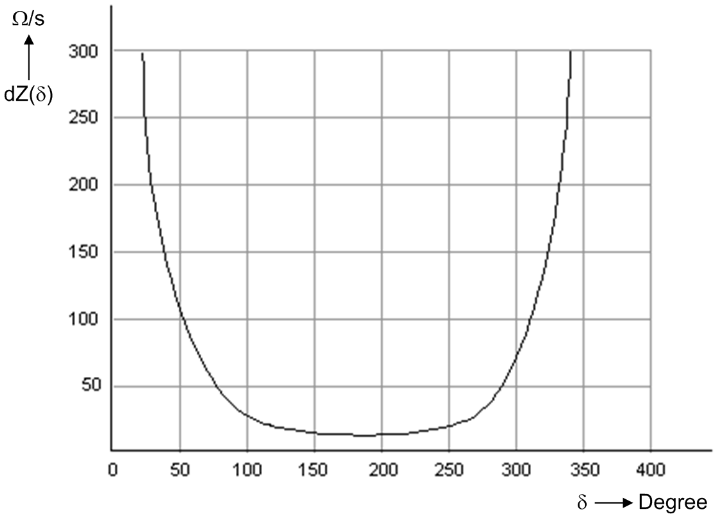


Figure 2-66 Course of the rate of change (f_p = 1 Hz; X = 10 Ω)

For this reason, the setting value dZ/dt must also be coordinated with the impedance jump occurring at the start of a short-circuit.

To do so, you determine the minimum operating impedance (ZL, min), form the difference to the setting of the impedance zone (e.g. Z1) and calculate the impedance gradient, taking into account the one-cycle measuring interval.

<u>Example</u>:

U_{min} = 0,9 U_N, I_{max} = 1,1 I_N, u_{SC} = 10 %, Δ t = 20 ms

U_N = 100 V, I_N = 1 A

$$Z1 = \frac{0.7 \cdot U_{SC} \cdot U_N}{100\ \% \cdot \sqrt{3} \cdot I_N} = 4.04\ \Omega$$

$$Z_{L,\ min} = \frac{0.9 \cdot U_N}{\sqrt{3} \cdot 1.1 \cdot I_N} = 47.24\ \Omega$$

$$\frac{dZ}{dt} = (Z_{L,\ min} - Z1)\Delta / t = 43.20\ \Omega / 20\ \text{ms} = 2160\ \Omega / s$$

If safety factor 4 is chosen, dZ/dt should never be set higher than 500 Ω/s (or 100 Ω/s for 5 A transformers).

The default setting for dZ/dt is 300 Ω/s, which should be adequate for most applications. This is also the basis for the minimum distance P/SPOL - TPOL, assuming that for detection of a power swing there must be one impedance value between P/SPOL and TPOL.

PPOL - APOL > dZ/dt · Δt = 300 Ω/s · 0.02 s = 6 Ω (setting selected: 8 Ω)

All other settable parameters are advanced parameters which need not normally be modified.

Address	Parameters	Comments
3316	BLOCKING OF	The setting is , as there is little or no delay for this stage. The delay time of Z2 is determined by the power system protection, and is longer. (see also the guidelines below)
3317	T-ACTION P/S	The default setting is 3.00 sec. This time depends on the minimum possible power swing frequency.

Whether a power swing can cause an overfunctioning of the impedance protection depends mainly on the time the impedance vector remains inside the trip polygon. This time can only be reliably determined by transient calculations.

If the rate of change in the proximity of 180° is known, it can be the basis for a rough estimation of the time.

$T = 2 \cdot Z_{characteristic} / dZ/dt\ (180°)$

The above data yield the following value:

$Z_{characteristic} = Z1 = 4\ \Omega$

dZ/dt (180°) = 20 Ω/s

T = 2 · 4 Ω/20 Ω/s = 0.4 s

This means that for delay times of more than 0.4 s no power swing blocking is needed.

2.19.4 Settings

Addresses which have an appended "A" can only be changed with DIGSI, under Additional Settings.

The table indicates region-specific presettings. Column C (configuration) indicates the corresponding secondary nominal current of the current transformer.

Addr.	Parameter	C	Setting Options	Default Setting	Comments
3301	IMPEDANCE PROT.		OFF ON Block relay	OFF	Impedance Protection
3302	IMP I>	5A	0.50 .. 100.00 A	6.75 A	Fault Detection I> Pickup
		1A	0.10 .. 20.00 A	1.35 A	
3303	U< SEAL-IN		ON OFF	OFF	State of Undervoltage Seal-in
3304	U<		10.0 .. 125.0 V	80.0 V	Undervoltage Seal-in Pickup
3305	T-SEAL-IN		0.10 .. 60.00 sec	4.00 sec	Duration of Undervoltage Seal-in
3306	ZONE Z1	5A	0.01 .. 26.00 Ω	0.58 Ω	Impedance Zone Z1
		1A	0.05 .. 130.00 Ω	2.90 Ω	

Addr.	Parameter	C	Setting Options	Default Setting	Comments
3307	T-Z1		0.00 .. 60.00 sec; ∞	0.10 sec	Impedance Zone Z1 Time Delay
3308	ZONE Z1B	5A	0.01 .. 13.00 Ω	0.99 Ω	Impedance Zone Z1B
		1A	0.05 .. 65.00 Ω	4.95 Ω	
3309	T-Z1B		0.00 .. 60.00 sec; ∞	0.10 sec	Impedance Zone Z1B Time Delay
3310	ZONE Z2	5A	0.01 .. 13.00 Ω	0.83 Ω	Impedanz Zone Z2
		1A	0.05 .. 65.00 Ω	4.15 Ω	
3311	ZONE2 T2		0.00 .. 60.00 sec; ∞	0.50 sec	Impedance Zone Z2 Time Delay
3312	T END		0.00 .. 60.00 sec; ∞	3.00 sec	T END: Final Time Delay
3313	POWER SWING		ON OFF	OFF	Power Swing Blocking
3314	P/SPOL-TPOL	5A	0.02 .. 6.00 Ω	1.60 Ω	Distance betw. Power Swing - Trip-Pol.
		1A	0.10 .. 30.00 Ω	8.00 Ω	
3315	dZ/dt	5A	0.2 .. 120.0 Ω/s	60.0 Ω/s	Rate of Change of dZ/dt
		1A	1.0 .. 600.0 Ω/s	300.0 Ω/s	
3316A	BLOCKING OF		Z1 Z2	Z1	Power Swing Blocking locks out
3317A	T-ACTION P/S		0.00 .. 60.00 sec; ∞	3.00 sec	Power Swing Action Time

2.19.5 Information List

No.	Information	Type of Information	Comments
3953	>Imp. BLOCK	SP	>BLOCK impedance protection
3956	>Extens. Z1B	SP	>Zone 1B extension for impedance prot.
3958	>ImpUseal-inBLK	SP	>Imp. prot. : BLOCK undervoltage seal-in
3961	Imp. OFF	OUT	Impedance protection is switched OFF
3962	Imp. BLOCKED	OUT	Impedance protection is BLOCKED
3963	Imp. ACTIVE	OUT	Impedance protection is ACTIVE
3966	Imp. picked up	OUT	Impedance protection picked up
3967	Imp. Fault L1	OUT	Imp.: Fault detection , phase L1
3968	Imp. Fault L2	OUT	Imp.: Fault detection , phase L2
3969	Imp. Fault L3	OUT	Imp.: Fault detection , phase L3
3970	Imp. I> & U<	OUT	Imp.: O/C with undervoltage seal in
3976	Power Swing	OUT	Power swing detection
3977	Imp.Z1< TRIP	OUT	Imp.: Z1< TRIP
3978	Imp.Z1B< TRIP	OUT	Imp.: Z1B< TRIP
3979	Imp.Z2< TRIP	OUT	Imp.: Z2< TRIP
3980	Imp.T3> TRIP	OUT	Imp.: T3> TRIP

2.20 Out-of-Step Protection (ANSI 78)

Depending on power network conditions and feeding generators, dynamic occurrences such as load jumps, short-circuits not disconnected quickly enough, auto-reclosure or switching actions, may cause system swings. Such power swings endanger power network stability. Stability problems often result from active power swings which can lead to pole-slipping and generator overloading.

2.20.1 Measuring Principle

General

The out-of-step protection is based on the well-proven impedance measurement and evaluation of the complex impedance vector trajectory. The impedance is calculated from the positive sequence fundamental frequency components of the three voltages and currents. The decision wether or not to separate the generator from the network is made dependent on the course of the impedance vector and the location of the electrical centre of the power swing.

The out-of-step case is illustrated using a simple model. The following figure shows the generator voltage $\underline{U}_G$ and the network equivalent voltage $\underline{U}_N$. The generator, transformer and network impedances lie between these two voltages and constitute a total impedance $\underline{Z}_{tot}$.

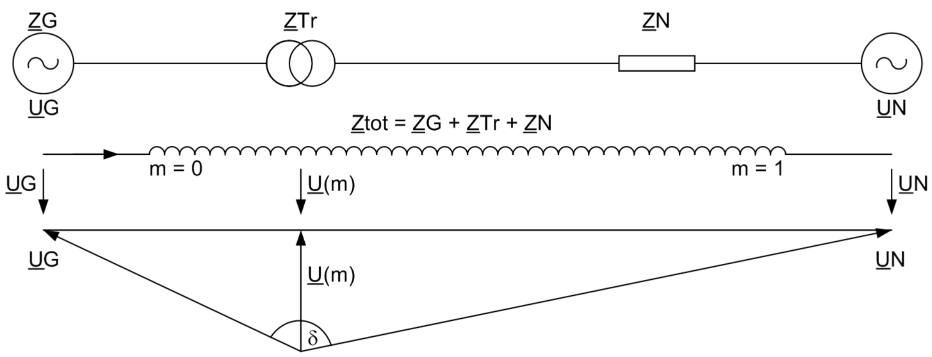


Figure 2-67 Equivalent Model of a Power Swing

The measurement location divides the total impedance into impedances m $\underline{Z}_{tot}$ and (1-m) · $\underline{Z}_{tot}$. The following applies for the impedance at measurement location m:

$$\underline{Z}(m) = \frac{\underline{U}(m)}{\underline{I}(m)}$$

The current I is independent of the location of the measurement:

$$\underline{I}(m) = \underline{I} = \frac{\underline{U}_G - \underline{U}_N}{\underline{Z}_{tot}}$$

The voltage $\underline{U}$ at measurement location m is:

$$\underline{U}(m) = \underline{U}_G - (m \cdot \underline{Z}_{tot} \cdot \underline{I})$$

Thus, this results in:

$$\underline{U}_G = U_G \cdot e^{j\delta_G} \qquad \underline{U}_N = U_N \cdot e^{j\delta_N} \qquad \delta = \delta_G - \delta_N$$

$$\underline{Z}(m) = \left[\frac{1}{1 - \frac{U_N}{U_G} \cdot e^{-j\delta}} - m \right] \cdot \underline{Z}_{tot}$$

where δ is the phase shift angle between the generator voltage and the network equivalent voltage. Under normal conditions, this angle depends on the load situation and is largely constant. In the event of an out-of-step condition, however the angle fluctuates continually and can vary between 0° and 360°. The following figure shows the impedance vector trajectory at measurement location m in accordance with the above formula. The coordinate system origin corresponds to the measurement location (voltage transformer set). When the ratio of the voltage magnitudes U_N/U_G is kept constant and the load angle δ varies, then circular trajectories result. The centre and the radius of the circle are determined by the ratio U_N/U_G. The centre points of the circles are all on an axis line which is determined by the direction of Z_{tot}. Minimum and maximum of the measured impedance magnitude are at δ = 0° and δ = 180°. If the measurement location is at the electrical system centre, measured voltage and thus measured impedance become zero when δ = 180°.

Power Swing Polygon

The measurement characteristic is a power swing polygon adjustable in all four directions and in its inclination angle φ_P. This ensures optimum matching to the conditions in the power system.

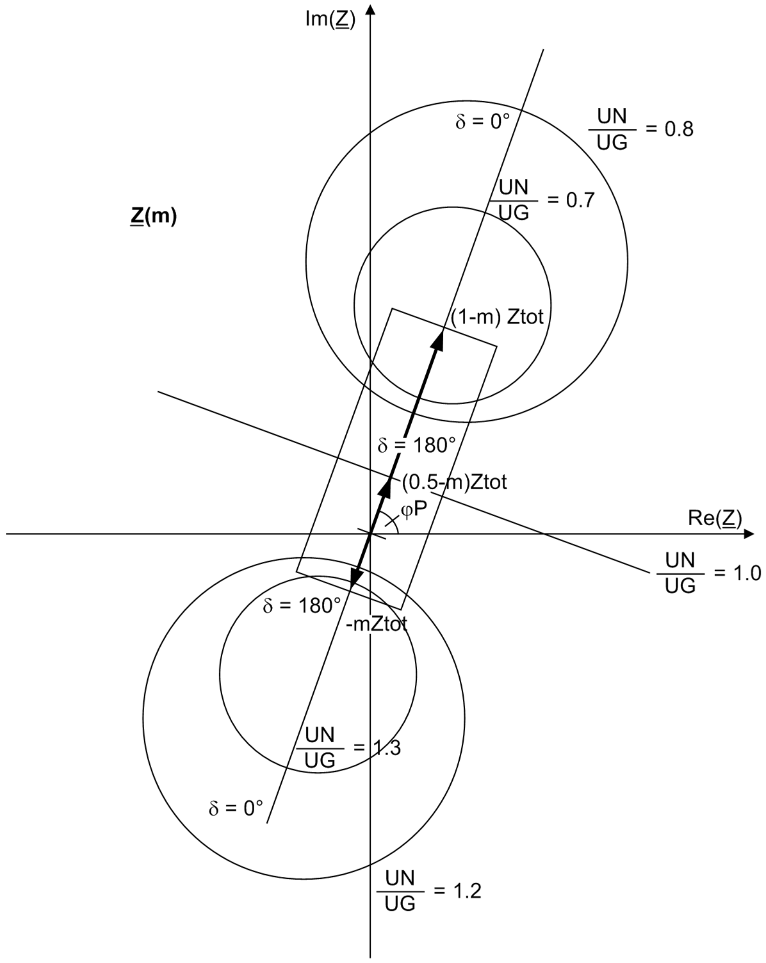


Figure 2-68 Impedance Trajectory at Measurement Location m

2.20.2 Out-of-Step Protection Logic

The following figure shows the power swing polygon in greater detail. For transparency purposes the inclination angle φ_P is assumed to be 90°. The setting parameters of impedances Z_a, Z_b, Z_c and (Z_d–Z_c) determine the power swing polygon. The polygon is symmetrical about its vertical axis. Z_b is measured in reverse direction into the generator, in the forward direction (Z_c) into the unit transformer, and the second stage (Z_d) into the power network. The power swing polygon is divided into two parts. Characteristic 1 (i.e. the non-hatched area) represents the lower section of the rectangle. Characteristic 2 covers the upper hatched area. Depending on the electrical centre of the power swing, or in the vicinity of the power station, the impedance vector progresses through the range of characteristic 1 or that of characteristic 2. The point of crossing of the symmetry (imaginary) axis is decisive for the characteristic assignment.

Power swings are three-phase symmetrical occurrences. The first prerequisite is therefore the symmetry of the measured currents. A condition for power swing detection is that the positive sequence component of the current exceeds an adjustable limit I_2 while the negative sequence current remains below an adjustable value I_1.

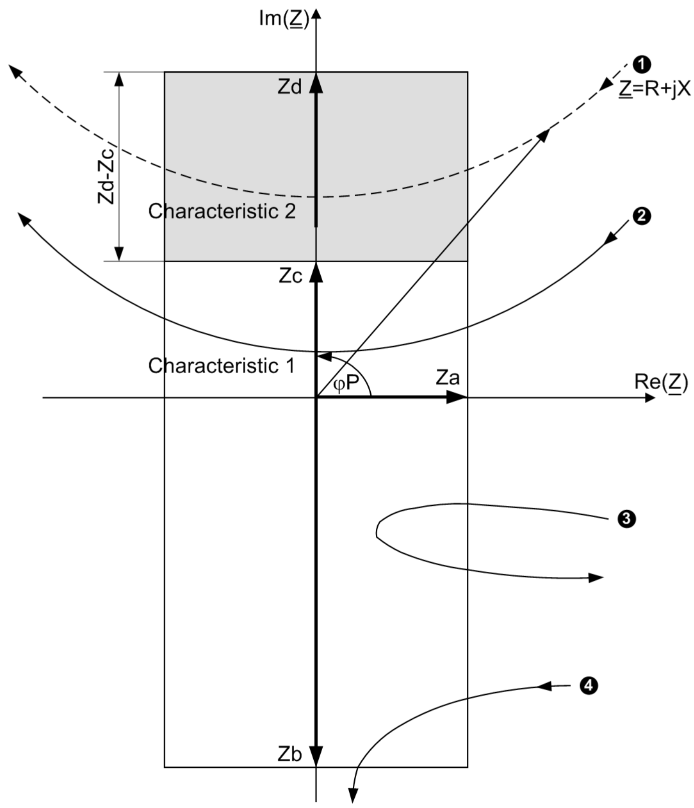


Figure 2-69 Polygonal Out-of-Step Characteristic with Typical Power Swings

Detection of an out-of-step condition requires, additionally, that the impedance vector enters a power swing characteristic at one side, passes through the imaginary axis or characteristic dividing line, and exits the polygon at the opposite side (loss of synchronism, cases (1) and (2)). This is characterized in that the real components of the complex impedances (referred to the coordinate system possibly rotated about φ_P) have changed sign crossing the characteristic.

On the other hand it is also possible for a power swing vector to enter and exit the power swing polygon on the same side. In this case, the power swing tends to stabilize (cases (3) and (4)).

When an out-of-step condition is recognized, i.e. when the impedance vector has passed through a power swing characteristic, an annunciation is issued which also identifies the crossed characteristic. Additionally, a counter n1 (for characteristic 1) or n2 (for characteristic 2) is incremented.

Out-of-step protection pickup is activated when a counter reaches the value 1. A further out-of-step indication is set for an adjustable indication time period, each time a counter is incremented. After a likewise adjustable holding time pick-up resets to zero. The holding time is started anew each time a counter is incremented.

A trip command is issued when the number of power swing polygon crossings has reached a selectable number. This command is maintained for at least the set time **T-HOLDING**. The minimum trip command duration **T TRIPCOM MIN.** does not start until the pickup has reset.

Next comes the logic diagram of the out-of-step protection. The feature has two stages and can be blocked by a binary input.

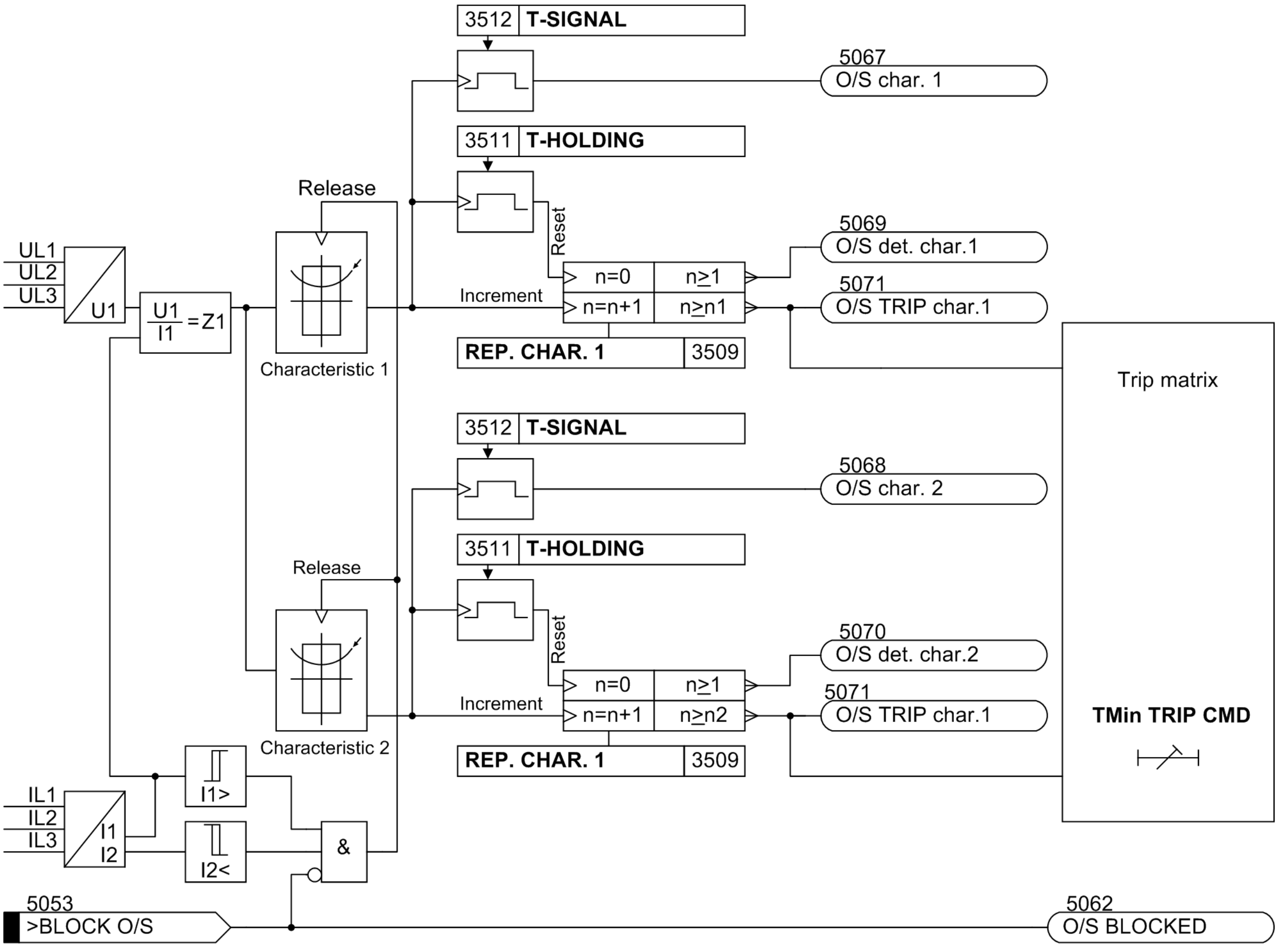


Figure 2-70 Logic Diagram of the Out-of-Step Protection

2.20.3 Setting Notes

General

Out-of-step protection is only effective and available if this function was set during protective function configuration (Section 2.4, address 135, **OUT-OF-STEP** is set to ***Enabled***. If the function is not required ***Disabled*** is set. Address 3501 **OUT-OF-STEP** serves to switch the function ***ON*** or ***OFF*** or to block only the trip command (***Block relay***).

Pickup

Measurement is enabled only if the positive sequence component of the currents has exceeded a minimum threshold 3502 **I1> RELEASE** (overcurrent pickup). Also because of the symmetry condition, a maximum value of negative sequence current 3503 **I2< RELEASE** must not be exceeded.

Generally the setting value **I1> RELEASE** should be set over rated current i.e. about 120 % I_N to avoid pickup on overload. Depending on network conditions, smaller pickup values are admissible so that the measurement (see logic diagram) may be released all the time. As out-of-step conditions are symmetrical occurrences, the pickup threshold of the negative sequence component of the current **I2< RELEASE** should be set to approx. 20 % I_N.

Impedance Values

The measured impedances perceived by the protection device are decisive for the settings. For the direction to the machine (as viewed from the location of the voltage transformers), the power swing reactance of the machine must be considered, which is approximately the transient reactance X_d' of the machine. Consequently, you will calculate the secondary transient reactance and use it for $Z_b \approx X_d$' (see the figure below).

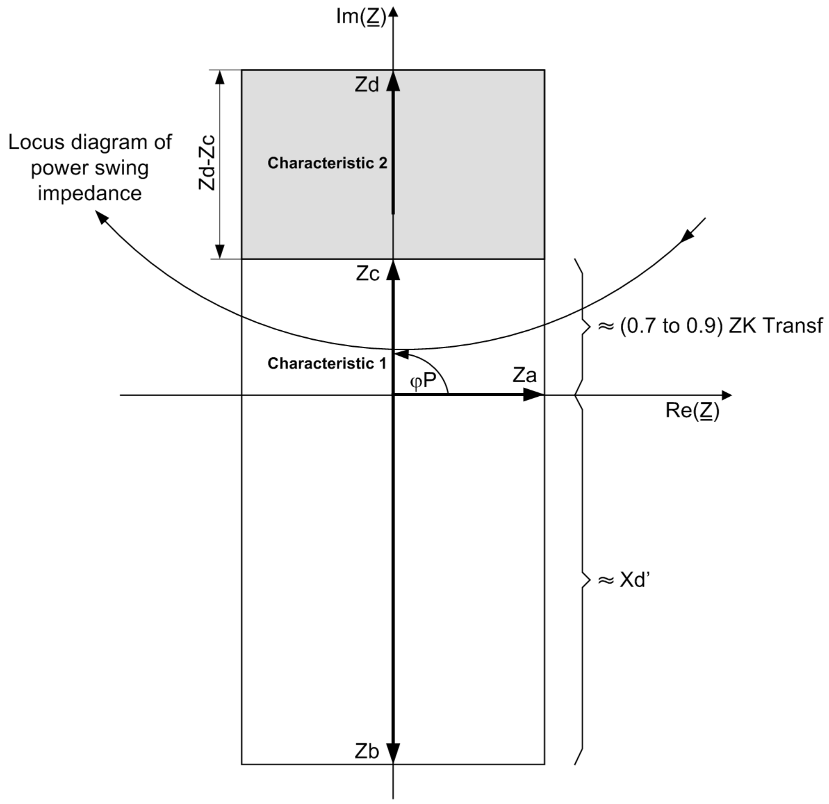


Figure 2-71 Power swing polygon

X_d' can be calculated from the per unit reactance x_d' as follows:

$$X_d' = \frac{U_{N,\ Mach}}{\sqrt{3} \cdot I_{N,\ Mach}} \cdot x_d' \cdot \frac{CT_{Ratio}}{VT_{Ratio}}$$

with

X_d	Transient reactance of the generator
X_d	Transient per unit reactance
$U_{N,\ Gen}$	Primary rated voltage - generator
$I_{N,\ Gen}$	Primary rated current - generator
N_{CTR}	Current transformer ratio
N_{VTR}	Voltage transf. transform. ratio

Dependent on the type of generator and on the secondary current, a secondary voltage U_N = 100 V or 120 V leads to approximately the reactance ranges listed in the table below.

Table 2-11 Transient Machine Reactances (Referred to Secondary Side)

Generator Type	x_d'	X_d ' U_N = 100 V/ I_N = 1 A	X_d ' U_N = 120 V/ I_N = 1 A	X_d ' U_N = 100 V/ I_N = 5 A	X_d ' U_N = 120 V/ I_N = 5 A
Non-salient pole rotor	0,13...0,35	7.5 Ω...20.2 Ω	9.4 Ω...24.3 Ω	1.5 Ω...4.0 Ω	1.9 Ω...4.9 Ω
Salient-pole rotor	0,20...0,45	11.5 Ω...26.0 Ω	13.9 Ω...31.2 Ω	2.3 Ω...5.2 Ω	2.8 Ω...6.2 Ω

As it may be assumed that the generator is connected with the network via a unit transformer, the setting in the network direction is chosen such that the out-of-step protection measures with characteristic 1 approximately 70 % to 90 % of the transformer impedance, and with characteristic 2 right into the network. Parametrization of **Zc** in address 3506 is set between 70 % and 90 % of the short circuit impedance X_K of the transformer. For characteristic 2, in address 3507 **Zd - Zc** the remaining portion of the transformer short circuit impedance is set and if necessary complemented by the impedance of the additional line section to be monitored.

The table below shows typical values of the secondary per unit short circuit impedances X_K of transformers with secondary rated currents of I_N = 1 A and I_N = 5 A, the following formula shows the calculation of the short circuit impedance from the short circuit voltage.

$$X_{SC\ prim} = \frac{U_{SC}}{\sqrt{3} \cdot I_N} = \frac{u_{SC} \cdot U_N}{100 \cdot \sqrt{3} \cdot I_N} = \frac{u_{SC} \cdot U_N^2}{100 \cdot S_N}$$

$$X_{SC} = X_{SC\ prim} \cdot \frac{CT_{Ratio}}{VT_{Ratio}}$$

Table 2-12 Secondary Per Unit Short Circuit Impedances of Transformers

Transformer type	u_{SC}	X_{SC} U_N = 100 V/ I_N = 1 A	X_{SC} U_N = 120 V/ I_N = 1 A	X_{SC} U_N = 100 V/ I_N = 5 A	X_{SC} U_N = 120 V/ I_N = 5 A
Unit transformer	8 %...13 %	4.6 Ω...7.5 Ω	5.5 Ω...9.0 Ω	0.9 Ω...1.5 Ω	1.1 Ω...1.8 Ω
General	3 %...16 %	1.7 Ω...9.2 Ω	2.1 Ω...11.1 Ω	0.3 Ω...1.8 Ω	0.4 Ω...2.2 Ω

The setting Z_a effects the width of the power swing polygon. This setting value 3504 **Za** is determined by the total impedance Z_{tot} and can be derived from the equation in the figure below. With this for Z_{tot} alternately the sum of the values Z_b and Z_d can be used (power swing angle between generator and network) or the sum of Z_b and Z_c (power swing angle between generator and power station unit transformer). The default setting of address 3504 **Za** corresponds to the latter case. For simplification, it isassumed that a power swing angle δ = 120° is strived for and since the generator voltage U_G and the system voltage U_N are quantatively the same:

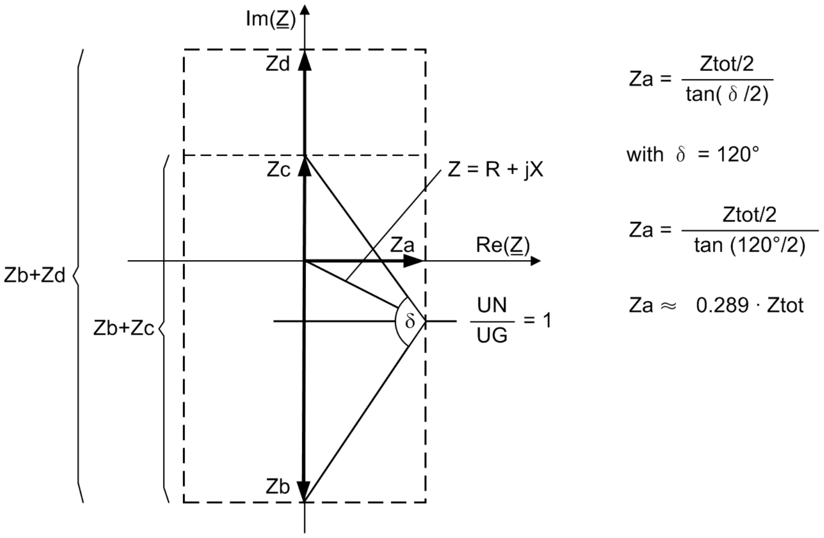


Figure 2-72 Power swing polygon and impedance vectors with angle δ

Maximum power swing frequency

The polygon width Z_a determines also the maximum detectable power swing frequency. Considering that even with rapid power swings, at least two impedance values must have been established within the power swing polygon (which in a limit case differ by the width of the polygon), the following approximative formula can be used for the maximum detectable power swing frequency f_P:

$$f_P = \frac{4}{\pi} \cdot \frac{1}{T} \cdot \frac{Z_a}{Z_{tot}} \qquad \text{with T = a.c. period}$$

At a rated frequency of 50 Hz (i.e. T = 20 ms) the above formula gives:

$Z_a \approx 0.289 \cdot Z_{tot}$

$f_P \approx 10$ Hz

as the maximum power swing frequency.

The inclination angle φ of the power swing polygon can be set at address 3508 **PHI POLYGON** and thereby optimally matched to the particular power system conditions.

Example:

Generator data:

x_d'	= 0,20
U_N	= 6.3 kV
I_N	= 483 A

Transformer data:

u_{SC}	= 7 %
S_N	= 5.3 MVA
U_N	= 6.3 kV

Transformation ratios:

Current Transformer CT_{Ratio} = 500 A/1 A

Voltage transformers $VT_{Ratio} = \frac{6300\ V/(\sqrt{3})}{100\ V/(\sqrt{3})}$

This gives the secondary transient reactance of the generator:

$$X_d' = \frac{U_{N,\,Gen}}{\sqrt{3} \cdot I_{N,\,Gen}} \cdot x_d' \cdot \frac{CT_{Ratio}}{VT_{Ratio}}$$

$$X_d' = \frac{6.3 \cdot 10^3}{\sqrt{3} \cdot 483} \cdot 0.20 \cdot \frac{500/1}{(6.3 \cdot 10^3)/100} = 12\ \Omega$$

$Z_b \approx X_d'$ thus determines the setting of address 3505 **Zb**.

The secondary short circuit reactance of the unit transformer is derived by considering the transformation ratios:

$$X_{SC} = \frac{u_{SC} \cdot U_N^2}{100 \cdot S_N} \cdot \frac{CT_{Ratio}}{VT_{Ratio}} = \frac{7}{100} \cdot \frac{(6.3 \cdot 10^3)^2}{5.3 \cdot 10^6} \cdot \frac{500/1}{(6.3 \cdot 10^3)/100} = 4.2\ \Omega$$

If characteristic 1 covers 85 % of the transformer reactance, this results in the setting of $Z_c \approx 0.85 \cdot 4.2\ \Omega \approx 3.6\ \Omega$.

Assuming that the impedance of the additional line section to be monitored together with the transformer short-circuit impedance amounts to about 10 Ω (for .../1 A transformers), the resulting setting value is 3507 **Zd - Zc** = 6.4 Ω.

The width Za of the polygon is determined by the total impedance Z_{tot} . In this calculation example, the total impedance Z_{tot} is that of characteristic 1 (the sum of generator reactance and one portion of the unit transformer reactance; that is the sum of the setting values for Z_b and Z_c = 12 Ω + 3.6 Ω = 15.6 Ω):

$Z_a \approx 0.289 \cdot 15.6\ \Omega \approx 4.5\ \Omega$.

Number of Power Swings

Address 3509 **REP. CHAR. 1** determines the number of out-of-step cycles which after transgression of characteristic 1 lead to tripping. If no special calculations are available, setting 1 (or 2) is recommended, since power swings within the power station area should not be tolerated too long because the power swing frequency tends to increase causing greater machine stress. On the other hand, for power swings with the electrical centre being in the network itself a higher number of crossings can be tolerated, so that address 3510 **REP. CHAR. 2** can usually be set to 4.

Each time characteristic 1 or 2 is passed through, a holding time set at address 3511**T-HOLDING**) is started. After expiry of the hold time a pickup retracted by resetting counter n_1 or n_2 to zero, i.e. a power swing is again "forgotten". This time should be set higher than the longest expected out-of-step cycle period (i.e. for lowest power swing frequency). Settings between 20 s and 30 s are usual.

Each time one of the counters n_1 or n_2 is incremented, the holding time is restarted, and an annunciation "Out-of-step characteristic 1" or "Out-of-step characteristic 2" is issued. These annunciations disappear after the time set at address 3512 **T-SIGNAL**. If this time is set higher that the time between two power swings, the annunciation "Out-of-step characteristic 1(2)" begins on the first out-of-step detection and ends after the last out-of-step detection, after the set time **T-SIGNAL**.

2.20.4 Settings

The table indicates region-specific presettings. Column C (configuration) indicates the corresponding secondary nominal current of the current transformer.

Addr.	Parameter	C	Setting Options	Default Setting	Comments
3501	OUT-OF-STEP		OFF ON Block relay	OFF	Out-of-Step Protection
3502	I1> RELEASE		20.0 .. 400.0 %	120.0 %	Pickup Current for Measuring Release I1>
3503	I2< RELEASE		5.0 .. 100.0 %	20.0 %	Pickup Current for Measuring Release I2<
3504	Za	5A	0.04 .. 26.00 Ω	0.90 Ω	Resistance Za of the Polygon (width)
		1A	0.20 .. 130.00 Ω	4.50 Ω	
3505	Zb	5A	0.02 .. 26.00 Ω	2.40 Ω	Reactance Zb of the Polygon (reverse)
		1A	0.10 .. 130.00 Ω	12.00 Ω	
3506	Zc	5A	0.02 .. 26.00 Ω	0.72 Ω	Reactance Zc of Polygon (forward char.1)
		1A	0.10 .. 130.00 Ω	3.60 Ω	
3507	Zd - Zc	5A	0.00 .. 26.00 Ω	1.28 Ω	Reactance Dif. Char.1 - Char.2 (forward)
		1A	0.00 .. 130.00 Ω	6.40 Ω	
3508	PHI POLYGON		60.0 .. 90.0 °	90.0 °	Angle of Inclination of the Polygon
3509	REP. CHAR. 1		1 .. 10	1	Number of Power Swing: Characteristic 1
3510	REP. CHAR. 2		1 .. 20	4	Number of Power Swing: Characteristic 2
3511	T-HOLDING		0.20 .. 60.00 sec	20.00 sec	Holding Time of Fault Detection
3512	T-SIGNAL		0.02 .. 0.15 sec	0.05 sec	Min. Signal Time for Annun. Char. 1/2

2.20.5 Information List

No.	Information	Type of Information	Comments
5053	>BLOCK O/S	SP	>BLOCK out-of-step protection
5061	O/S OFF	OUT	Out-of-step protection is switched OFF
5062	O/S BLOCKED	OUT	Out-of-step protection is BLOCKED
5063	O/S ACTIVE	OUT	Out-of-step protection is ACTIVE
5067	O/S char. 1	OUT	Out-of-step pulse of characteristic 1
5068	O/S char. 2	OUT	Out-of-step pulse of characteristic 2
5069	O/S det. char.1	OUT	Out-of-step characteristic 1 picked up
5070	O/S det. char.2	OUT	Out-of-step characteristic 2 picked up
5071	O/S TRIP char.1	OUT	Out-of-step TRIP characteristic 1
5072	O/S TRIP char.2	OUT	Out-of-step TRIP characteristic 2

2.21 Undervoltage Protection (ANSI 27)

The undervoltage protection function detects voltage dips on electrical machines and prevents inadmissible operating states and a possible loss of stability. Two-pole short circuits or ground faults cause a dip in asymmetrical voltages. Compared to three single-phase measuring systems, the detection of the positive phase-sequence system is not influenced by these procedures and is particularly advantageous for assessing stability problems.

2.21.1 Functional Description

Mode of Operation

For the above reasons, the positive sequence system is calculated from the fundamental waves of the three phase-earth voltages, and fed to the protection function.

Undervoltage protection consists of two stages. A pickup is signalled as soon as selectable voltage thresholds are undershot. A trip signal is transmitted if a voltage pickup exists for a selectable time.

In order to ensure that the protection does not accidentally pick up due to a secondary voltage failure, each stage can be blocked individually or both stages together, via binary input(s), e.g. using a voltage transformer mcb. Also the integrated Fuse-Failure Monitor will block the two stages (see Section 2.42.1).

If a pickup occurs as the device changes to operational condition 0 - i.e. no usable measured quantities are present or the admissible frequency range has been exited - this pickup is maintained. This ensures tripping even under such conditions. This seal-in can be retracted only after the measured value has reverted to a value above the drop-off value or by activation of the blocking input.

If no pickup exists before the device is in operating status 0 (thus e.g. on switchon of the device without available measured values), no pickup and no tripping will occur. An immediate tripping may ensue on transition to operating status 1 (i.e. by application of measured values). For this reason it is recommended that the blocking input of the undervoltage protection is activated via the circuit breaker auxiliary contact, thus, for example, blocking the protection function after a protective tripping.

The following figure shows the logic diagram for undervoltage protection.

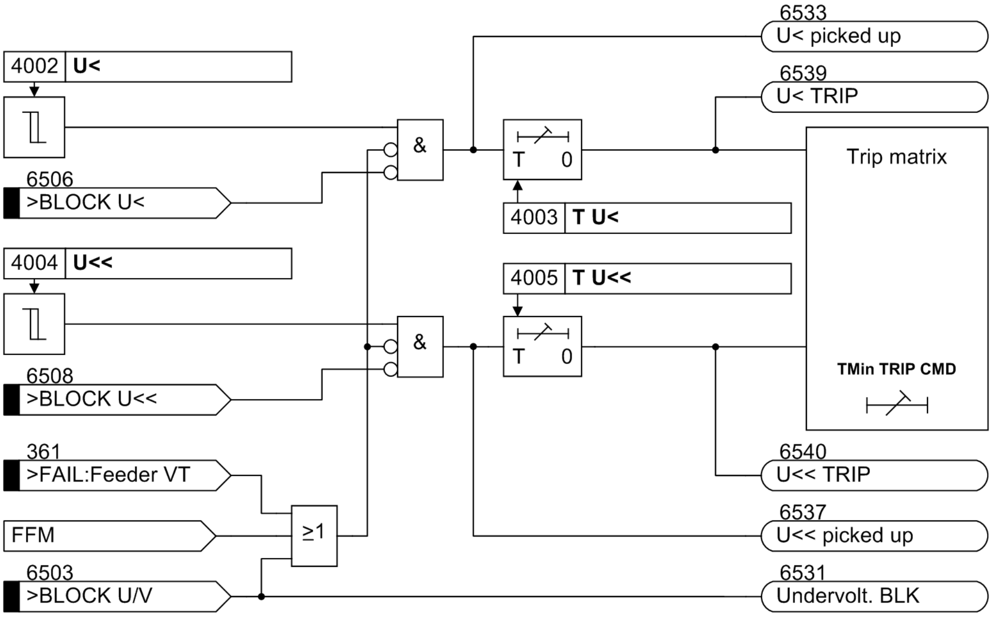


Figure 2-73 Logic diagram of the undervoltage protection

2.21.2 Setting Notes

General

The undervoltage protection is only effective and available if this function was set during protective function configuration (Section 2.4, address 140, **UNDERVOLTAGE** is set to ***Enabled***). If the function is not required ***Disabled*** is set. Address 4001 **UNDERVOLTAGE** serves to switch the function ***ON*** or ***OFF*** or to block only the trip command (***Block relay***).

Settings

It must be noted that the positive phase-sequence voltages and thus also the pickup thresholds are evaluated as phase-to-phase quantities (terminal voltage $\cdot\sqrt{3}$). The first undervoltage protection stage is typically set to about 75% of the nominal machine voltage, i.e. address 4002 **U<** is set to 75 V. The user must select a value for the 4003 **T U<** time setting that ensures that voltage dips which would affect operating stability are disconnected. On the other hand, the time delay must be large enough to avoid disconnections during admissible short-time voltage dips.

For the second stage, a lower pickup threshold 4004 **U<<** e.g. = 65 V should be combined with a shorter trip time 4005 **T U<<** e.g. = 0.5 s to achieve an approximate adaptation to the stability behaviour of the consumers.

All setting times are additional time delays which do not include the operating times (measuring time, dropout time) of the protective function.

The drop-out ratio can be adapted in small steps to the operating conditions at address 4006 **DOUT RATIO**.

2.21.3 Settings

Addresses which have an appended "A" can only be changed with DIGSI, under Additional Settings.

Addr.	Parameter	Setting Options	Default Setting	Comments
4001	UNDERVOLTAGE	OFF ON Block relay	OFF	Undervoltage Protection
4002	U<	10.0 .. 125.0 V	75.0 V	U< Pickup
4003	T U<	0.00 .. 60.00 sec; ∞	3.00 sec	T U< Time Delay
4004	U<<	10.0 .. 125.0 V	65.0 V	U<< Pickup
4005	T U<<	0.00 .. 60.00 sec; ∞	0.50 sec	T U<< Time Delay
4006A	DOUT RATIO	1.01 .. 1.20	1.05	U<, U<< Drop Out Ratio

2.21.4 Information List

No.	Information	Type of Information	Comments
6503	>BLOCK U/V	SP	>BLOCK undervoltage protection
6506	>BLOCK U<	SP	>BLOCK undervoltage protection U<
6508	>BLOCK U<<	SP	>BLOCK undervoltage protection U<<
6530	Undervolt. OFF	OUT	Undervoltage protection switched OFF
6531	Undervolt. BLK	OUT	Undervoltage protection is BLOCKED
6532	Undervolt. ACT	OUT	Undervoltage protection is ACTIVE
6533	U< picked up	OUT	Undervoltage U< picked up
6537	U<< picked up	OUT	Undervoltage U<< picked up
6539	U< TRIP	OUT	Undervoltage U< TRIP
6540	U<< TRIP	OUT	Undervoltage U<< TRIP

2.22 Overvoltage Protection (ANSI 59)

Overvoltage protection serves to protect the electrical machine and connected electrical plant components from the effects of inadmissible voltage increases. Overvoltages can be caused by incorrect manual operation of the excitation system, faulty operation of the automatic voltage regulator, (full) load shedding of a generator, separation of the generator from the system or during island operation.

2.22.1 Functional Description

Mode of Operation

The overvoltage protection provides the option to either select whether the phase-to-phase voltages or the phase-to-ground voltages will be monitored. In case of a high overvoltage, tripping switchoff is performed with a short-time delay, whereas in case of less severe overvoltages, the switchoff is performed with a longer time delay. Voltage thresholds and time delays can be set individually for both elements.

Each stage can be blocked individually, both stages together, via binary input(s).

The following figure shows the logic diagram for the overvoltage protection function.

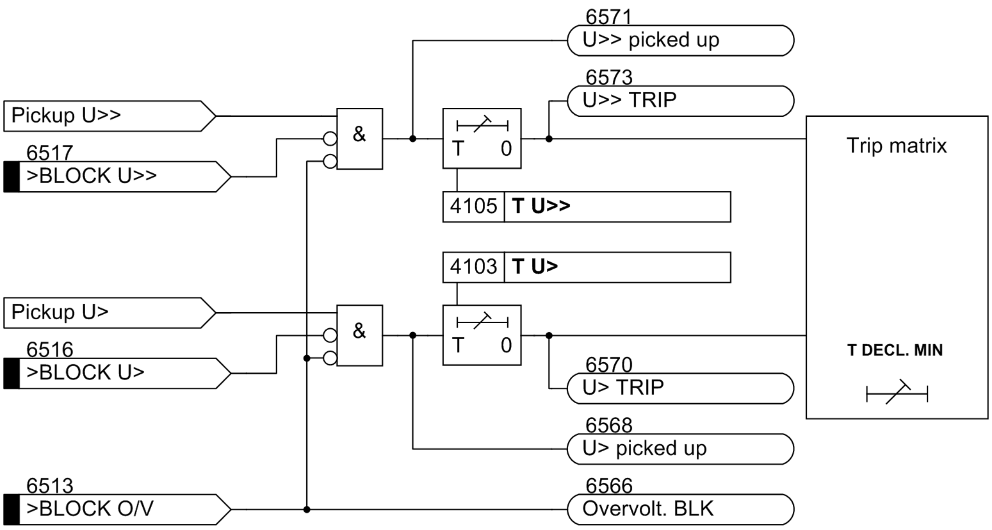


Figure 2-74 Logic Diagram of the Overvoltage Protection

2.22.2 Setting Notes

General

Overvoltage protection is only effective and available if this function was set during protective function configuration (Section 2.4, address 141, **OVERVOLTAGE** is set to ***Enabled***. If the function is not required ***Disabled*** is set. Address 4101 **OVERVOLTAGE** serves to switch the function ***ON*** or ***OFF*** or to block only the trip command (***Block relay***).

Settings

Address 4107 **VALUES** serves to specify the measured quantities used by the protection feature. The default setting (normal case) is specified for phase-to-phase voltages (= ***U-ph-ph***). The phase-earth voltages should be selected for low-voltage machines with grounded neutral conductor (= ***U-ph-e***). It should be noted that even if phase-earth voltages are selected as measured quantities, the setting values of the protection functions refer to phase-to-phase voltages.

The setting of limit values and time delays of the overvoltage protection depends on the speed with which the voltage regulator can regulate voltage variations. The protection must not intervene in the regulation process of the faultlessly functioning voltage regulator. For this reason, the two-stage characteristic must always be above the voltage time characteristic of the regulation procedure.

The long-time stage 4102 **U>** and 4103 **T U>** must intervene in case of steady-state overvoltages. It is set to approximately 110 % to 115 % U_N and, depending on the regulator speed, to a range between 1.5 s and 5 s.

In case of a full-load rejection of the generator, the voltage increases first in relation to the transient voltage. Only then does the voltage regulator reduce it again to its nominal value. The U>> stage is set generally as a short-time stage in a way that the transient procedure for a full-load rejection does not lead to a tripping. For example, for 4104 **U>>** about 130% U_N with a delay 4105 **T U>>** of zero to 0.5 s are typical values.

All setting times are additional time delays which do not include the operating times (measuring time, dropout time) of the protective function.

The dropout ratio can be adapted at the address 4106 **DOUT RATIO** in small stages to the operating conditions and used for highly precise signalizations (e.g. network infeed of wind power stations).

2.22.3 Settings

Addresses which have an appended "A" can only be changed with DIGSI, under Additional Settings.

Addr.	Parameter	Setting Options	Default Setting	Comments
4101	OVERVOLTAGE	OFF ON Block relay	OFF	Overvoltage Protection
4102	U>	30.0 .. 170.0 V	115.0 V	U> Pickup
4103	T U>	0.00 .. 60.00 sec; ∞	3.00 sec	T U> Time Delay
4104	U>>	30.0 .. 170.0 V	130.0 V	U>> Pickup
4105	T U>>	0.00 .. 60.00 sec; ∞	0.50 sec	T U>> Time Delay
4106A	DOUT RATIO	0.90 .. 0.99	0.95	U>, U>> Drop Out Ratio
4107A	VALUES	U-ph-ph U-ph-e	U-ph-ph	Measurement Values

2.22.4 Information List

No.	Information	Type of Information	Comments
6513	>BLOCK O/V	SP	>BLOCK overvoltage protection
6516	>BLOCK U>	SP	>BLOCK overvoltage protection U>
6517	>BLOCK U>>	SP	>BLOCK overvoltage protection U>>
6565	Overvolt. OFF	OUT	Overvoltage protection switched OFF
6566	Overvolt. BLK	OUT	Overvoltage protection is BLOCKED
6567	Overvolt. ACT	OUT	Overvoltage protection is ACTIVE
6568	U> picked up	OUT	Overvoltage U> picked up
6570	U> TRIP	OUT	Overvoltage U> TRIP
6571	U>> picked up	OUT	Overvoltage U>> picked up
6573	U>> TRIP	OUT	Overvoltage U>> TRIP

2.23 Frequency Protection (ANSI 81)

The frequency protection function detects abnormally high and low frequencies in the generator. If the frequency lies outside the permissible range, appropriate switching actions are initiated, e.g. separating the generator from the system.

A decrease in system frequency occurs when the system experiences an increase in real power demand, or when a malfunction occurs with a generator governor or automatic generation control (AGC) system. The frequency protection function is also used for generators which (for a certain time) operator to an island network. This is due to the fact that the reverse power protection cannot operate in case of drive power failure. The generator can be disconnected from the power system by means of the frequency decrease protection.

An increase in system frequency occurs e.g. when large loads (island network) are removed from the system, or on frequency control malfunction. This entails risk of self-excitation for generators feeding long lines under no-load conditions.

Due to the use of filter functions, the frequency evaluation is free from harmonic influences and very accurate.

2.23.1 Functional Description

Frequency Increase and Decrease

Frequency protection consists of the four frequency elements f1 to f4. To make protection flexible for different power system conditions, theses stages can be used alternatively for frequency decrease or increase separately, and can be independently set to perform different control functions. The setting decides on the purpose of the individual frequency stage. For the f4 frequency stage, the user can specify independently of the parameterized limit value if this stage shall function as decrease or increase stage. For this reason, it can also be used for special applications, if, for example, frequency undershoot below the nominal frequency is to be signaled.

Operating Ranges

The frequency can be determined as long as at least one of the phase–to–phase voltages is present and of sufficient magnitude. If the measurement voltage drops below a settable value **Umin**, frequency protection is disabled because precise frequency values can no longer be calculated from the signal.

With over frequency protection, seal-in of the overfrequency pickup occurs during the transition to the 0 mode, if the last measured frequency was above 66 Hz. The switch-off command drops out by a function blocking or on transition to operational condition 1. A pickup drops out if the frequency measured last before the transition into operational condition 0 is below 66 Hz.

With underfrequency protection, there is no precise frequency calculation on transition to the 0 mode due to a too-low frequency. Consequently, the pickup or tripping drop out.

Time Delays/Logic

Trippings can be delayed each using an added time stage. When the time delay expires, a trip signal is generated. After pickup dropout the tripping command is immediately reset, but not before the minimum command duration has expired.

Each of the four frequency stages can be blocked individually by binary inputs.

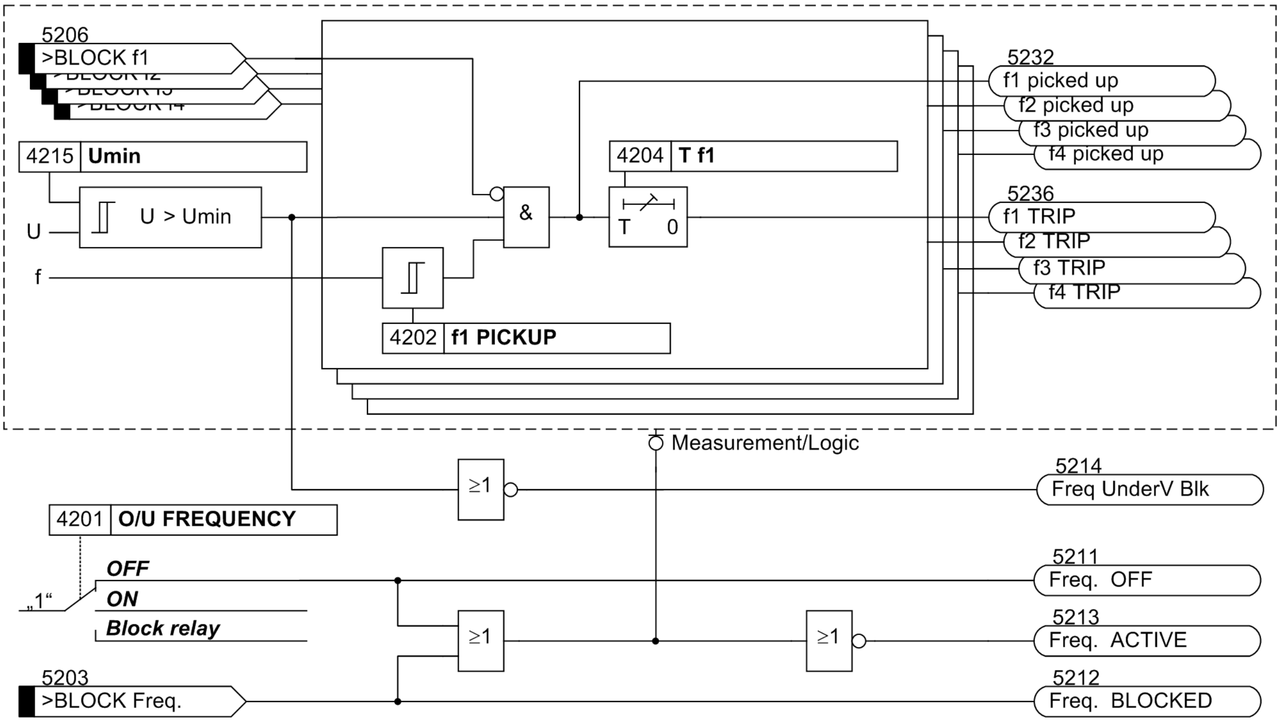


Figure 2-75 Logic diagram of the frequency protection

2.23.2 Setting Notes

General

Frequency protection is only in effect and accessible if address 142 **FREQUENCY Prot.** is set to ***Enabled*** during configuration of protective functions. If the function is not required ***Disabled*** is set. Address 4201 **O/U FREQUENCY** serves to switch the function ***ON*** or ***OFF*** or to block only the trip command (***Block relay***).

Pickup Values

By configuring the rated frequency of the power system and the frequency threshold for each of the stages **f1 PICKUP** to **f4 PICKUP** in each case the function is established as either overvoltage or undervoltage protection. Set the pickup threshold lower than nominal frequency if the element is to be used for underfrequency protection. Set the pickup threshold higher than nominal frequency if the element is to be used for overfrequency protection.

Note

If the threshold is set equal to the nominal frequency, the element is inactive.

For the f4 frequency stage, the former applies only if the parameter 4214 **THRESHOLD f4** is set to ***automatic*** (default setting). If desired, this parameter can also be set to ***f>*** or ***f<***, in which case the evaluation direction (increase or decrease detection) can be specified independent of the parametrized **f4 PICKUP** threshold.

If frequency protection is used for network decoupling and load shedding purposes, settings depend on the actual network conditions. Normally a graded load shedding is strived for that takes into account priorities of consumers or consumer groups.

Further application examples are covered under power stations. The frequency values to be set mainly depend, also in these cases, on power system/power station operator specifications. In this context, frequency decrease protection ensures the power station's own demand by disconnecting it from the power system on time. The turbo regulator regulates the machine set to the nominal speed. Consequently, the station's own demands can be continuously supplied at nominal frequency.

Under the assumption that apparent power is reduced to the same degree, turbine-driven generators can, as a rule, be continuously operated down to 95 % of nominal frequency. However, for inductive consumers, the frequency reduction not only means greater current consumption but also endangers stable operation. For this reason, only a short-time frequency reduction down to about 48 Hz (for f_N = 50 Hz) or 58 Hz (for f_N = 60 Hz) is permissible.

A frequency increase can, for example, occur due to a load shedding or malfunction of the speed regulation (e.g. in a stand-alone system). In this way, the frequency increase protection can, for example, be used as over-speed protection.

Setting example:

Stage	Cause	Settings		
		for f_N = 50 Hz	for f_N = 60 Hz	Delay
f1	Disconnection from the network	48.00 Hz	58.00 Hz	1.00 sec
f2	Shutdown	47.00 Hz	57.00 Hz	6.00 sec
f3	Warning	49.50 Hz	59.50 Hz	20.00 sec
f4	Alarm or tripping	52.00 Hz	62.00 Hz	10.00 sec

Time Delays

The delay times **T f1** to **T f4** entered at addresses 4204, 4207, 4210 and 4213) allow the frequency stages to be graded. The set times are additional delay times not including the operating times (measuring time, dropout time) of the protective function.

Minimum Voltage

Address 4215 **Umin** is used to set the minimum voltage which, if undershot, blocks frequency protection. A value of approx. 65 % U_N is recommended. The parameter value is based on phase-to-phase voltages. The minimum voltage threshold can be deactivated by setting this address to **0**.

2.23.3 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
4201	O/U FREQUENCY	OFF ON Block relay	OFF	Over / Under Frequency Protection
4202	f1 PICKUP	40.00 .. 66.00 Hz	48.00 Hz	f1 Pickup
4203	f1 PICKUP	40.00 .. 66.00 Hz	58.00 Hz	f1 Pickup
4204	T f1	0.00 .. 600.00 sec	1.00 sec	T f1 Time Delay
4205	f2 PICKUP	40.00 .. 66.00 Hz	47.00 Hz	f2 Pickup
4206	f2 PICKUP	40.00 .. 66.00 Hz	57.00 Hz	f2 Pickup
4207	T f2	0.00 .. 100.00 sec	6.00 sec	T f2 Time Delay
4208	f3 PICKUP	40.00 .. 66.00 Hz	49.50 Hz	f3 Pickup

Addr.	Parameter	Setting Options	Default Setting	Comments
4209	f3 PICKUP	40.00 .. 66.00 Hz	59.50 Hz	f3 Pickup
4210	T f3	0.00 .. 100.00 sec	20.00 sec	T f3 Time Delay
4211	f4 PICKUP	40.00 .. 66.00 Hz	52.00 Hz	f4 Pickup
4212	f4 PICKUP	40.00 .. 66.00 Hz	62.00 Hz	f4 Pickup
4213	T f4	0.00 .. 100.00 sec	10.00 sec	T f4 Time Delay
4214	THRESHOLD f4	automatic f> f<	automatic	Handling of Threshold Stage f4
4215	Umin	10.0 .. 125.0 V; 0	65.0 V	Minimum Required Voltage for Operation

2.23.4 Information List

No.	Information	Type of Information	Comments
5203	>BLOCK Freq.	SP	>BLOCK frequency protection
5206	>BLOCK f1	SP	>BLOCK stage f1
5207	>BLOCK f2	SP	>BLOCK stage f2
5208	>BLOCK f3	SP	>BLOCK stage f3
5209	>BLOCK f4	SP	>BLOCK stage f4
5211	Freq. OFF	OUT	Frequency protection is OFF
5212	Freq. BLOCKED	OUT	Frequency protection is BLOCKED
5213	Freq. ACTIVE	OUT	Frequency protection is ACTIVE
5214	Freq UnderV Blk	OUT	Frequency protection undervoltage Blk
5232	f1 picked up	OUT	f1 picked up
5233	f2 picked up	OUT	f2 picked up
5234	f3 picked up	OUT	f3 picked up
5235	f4 picked up	OUT	f4 picked up
5236	f1 TRIP	OUT	f1 TRIP
5237	f2 TRIP	OUT	f2 TRIP
5238	f3 TRIP	OUT	f3 TRIP
5239	f4 TRIP	OUT	f4 TRIP

2.24 Overexcitation (Volt/Hertz) Protection (ANSI 24)

Overexcitation protection is used to detect inadmissibly high induction in generators and transformers, especially in power station unit transformers. The protection must intervene when the limit value for the protected object (e.g. unit transformer) is exceeded. The transformer is endangered, for example, if the power station block is disconnected from the system from full-load, and if the voltage regulator either does not operate or does not operate sufficiently fast to control the associated voltage rise. Similarly a decrease in frequency (speed), e.g. in island systems, can lead to an inadmissible increase in induction.

An increase in induction above the rated value quickly saturates the iron core and causes large eddy current losses.

2.24.1 Functional Description

Measurement Method

The overexcitation protection feature servers to measure the voltageU/frequency ratio f, which is proportional to the B induction and puts it in relation to the B_N nominal induction. In this context, both voltage and frequency are related to nominal values of the object to be protected (generator, transformer).

$$B \sim \frac{U}{f}$$

$$\frac{B}{B_{N\,Mach}} = \frac{\frac{U}{U_{N\,Mach}}}{\frac{f}{f_N}} \hat{=} \frac{U}{f} \qquad \text{(simplified notation)}$$

The calculation is based on the maximum voltage of the three phase-to-phase voltages. The frequency range monitored extends from 10 Hz to 70 Hz.

Voltage Transformer Adaptation

Any deviation between primary nominal voltage of the voltage transformers and of the object to be protected is compensated by an internal correction factor ($U_{N\,prim}/U_{N\,Mach}$). For this reason pickup values and characteristic do not need to be converted to secondary values. However the system primary nominal transformer voltage and the nominal voltage of the object to be protected must be entered correctly (see Sections 2.5 and 2.7).

Characteristic Curves

Overexcitation protection includes two staged characteristics and one thermal characteristic for approximate modeling of the heating of the protection object due to overexcitation. As soon as a first pickup threshold (warning stage 4302 **U/f >**) has been exceeded, a 4303 **T U/f >** time stage is started. On its expiry a warning message is transmitted. At the same time a counter switching is activated when the pickup threshold is exceeded. This weighted counter is incremented in accordance with the current U/f value resulting in the trip time for the parametrized characteristic. A trip signal is transmitted as soon as the trip counter state has been reached.

The trip signal is retracted as soon as the value falls below the pickup threshold and the counter is decremented in accordance with a parametrizable cool-down time.

The thermal characteristic is specified by 8 value pairs for overexcitation U/f (related to nominal values) and trip time t. In most cases, the specified characteristic for standard transformers provides sufficient protection. If this characteristic does not correspond to the actual thermal behavior of the object to be protected, any desired characteristic can be implemented by entering customer-specific trip times for the specified U/f overexcitation values. Intermediate values are determined by a linear interpolation within the device.

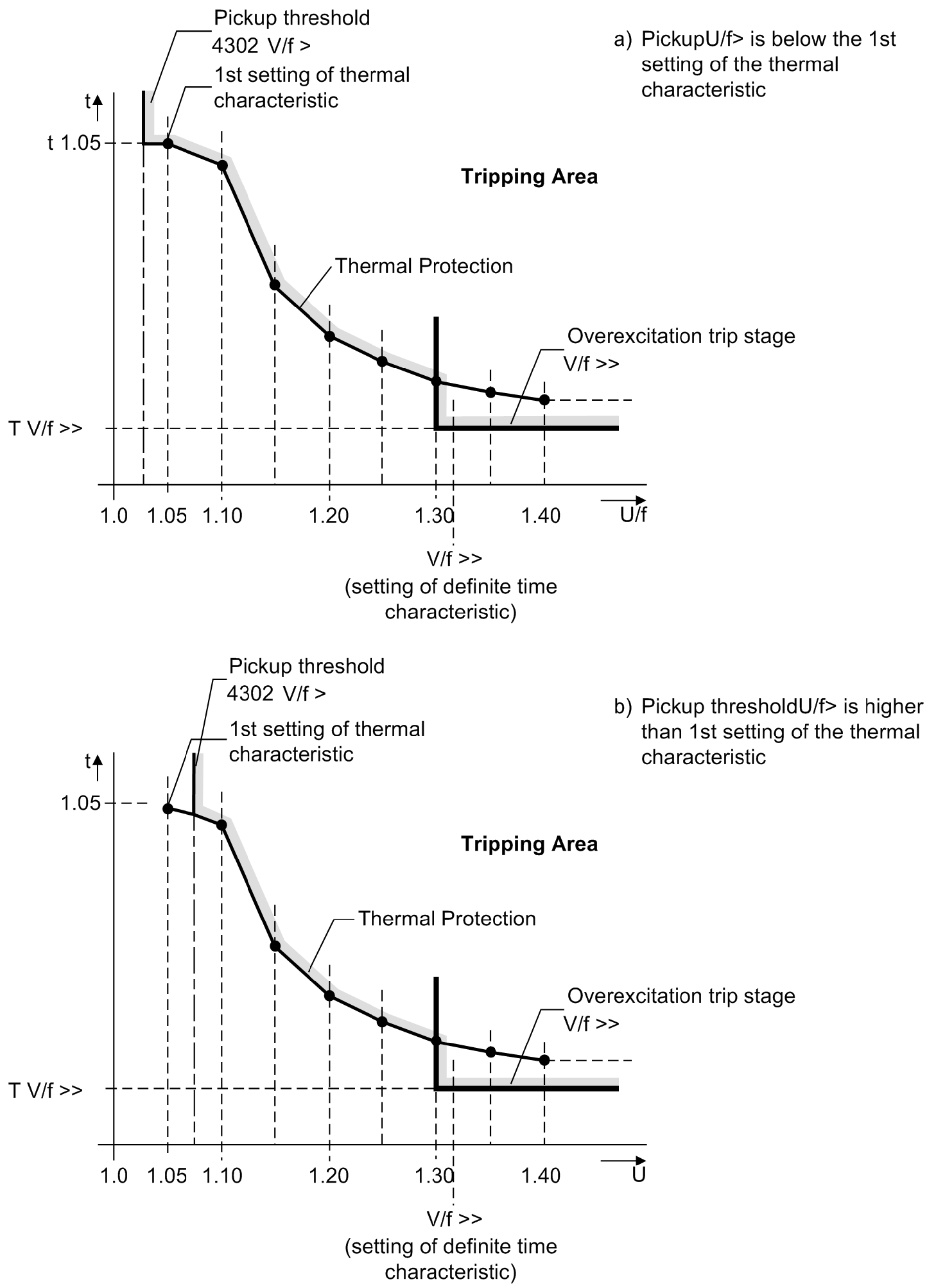


Figure 2-76 Tripping Range of the Overexcitation Protection

The characteristic resulting from the device default settings is shown in the Technical Data Section Overexcitation Protection. Figure 2-76 illustrates the behaviour of the protection on the assumption that within the framework of configuration the setting for the pickup threshold (parameter4302 **U/f >**) was chosen higher or lower than the first setting value of the thermal characteristic.

The following figure shows the logic diagram for overexcitation protection. The counter can be reset to zero by means of a blocking input or a reset input.

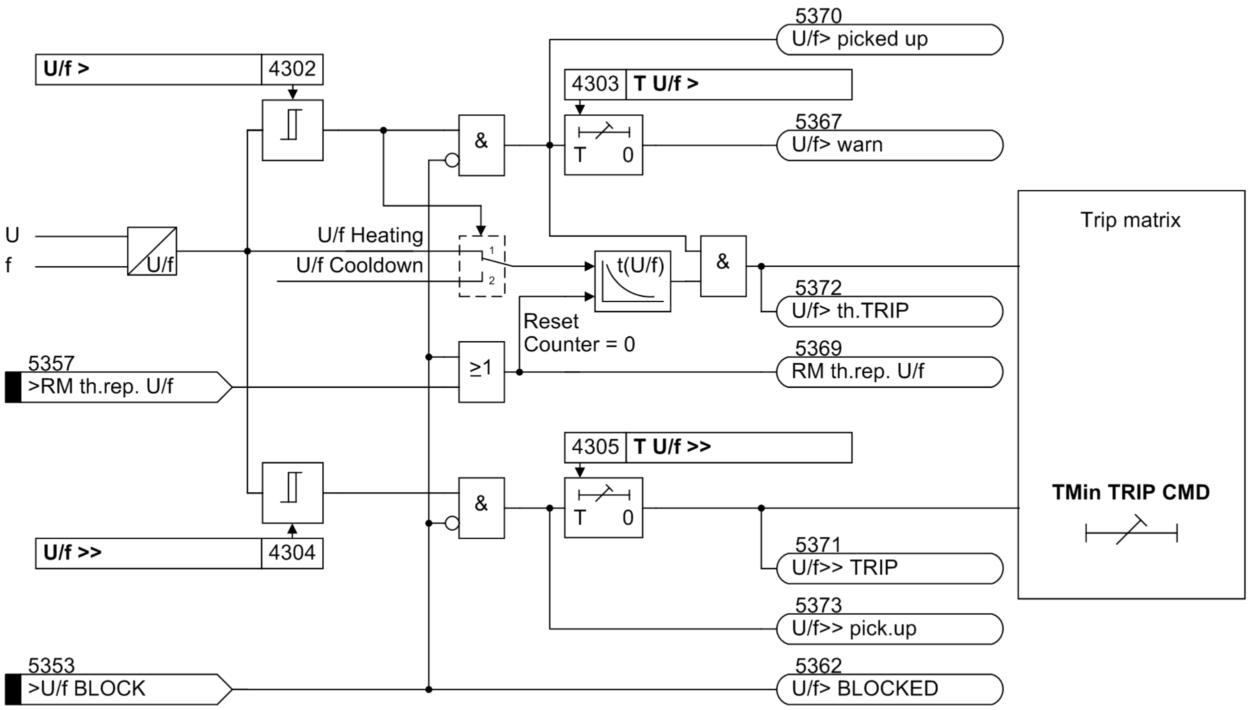


Figure 2-77 Logic Diagram of the Overexcitation Protection

2.24.2 Setting Notes

General

Overexcitation protection is only effective and available if address 143 **OVEREXC. PROT.** is set to ***Enabled*** during configuration. If the function is not required, it is set to ***Disabled***. Address 4301 **OVEREXC. PROT.** serves to switch the function ***ON*** or ***OFF*** or to block only the trip command (***Block relay***).

Overexcitation protection measures the voltage/frequency quotient which is proportional to the induction B. The protection must intervene when the limit value for the protected object (e.g. unit transformer) is exceeded. The transformer is for example endangered if the power station block is switched off at full-load operation and the voltage regulator does not respond fast enough or not at all to avoid related voltage increase.

Similarly a decrease in frequency (speed), e.g. in island systems, can lead to an inadmissible increase in induction.

In this way the U/f protection monitors the correct functioning both of the voltage regulator and of the speed regulation, in all operating states.

Independent Stages

The limit-value setting at address 4302 **U/f >** is based on the induction limit value relation to the nominal induction (B/B_N) as specified by the manufacturer of the object to be protected.

A pickup message is transmitted as soon as the induction limit value U/f set at address 4302 is exceeded. A warning message is transmitted after expiry of the corresponding 4303 **T U/f >** time delay.

The 4304 **U/f >>**, 4305 **T U/f >>** trip stage characteristic serves to rapidly switch off particularly strong overexcitations.

The time set for this purpose is an additional time delay which does not include the operating time (measuring time, drop-out time).

Thermal Characteristic

A thermal characteristic is superimposed on the trip stage characteristic. For this purpose, the temperature rise created by the overexcitation is approximately modeled. Not only the already mentioned pickup signal is generated on transgression of the U/f induction limit set at address 4302, but in addition a counter is activated additionally which causes the tripping after a length of time corresponding to the set characteristic.

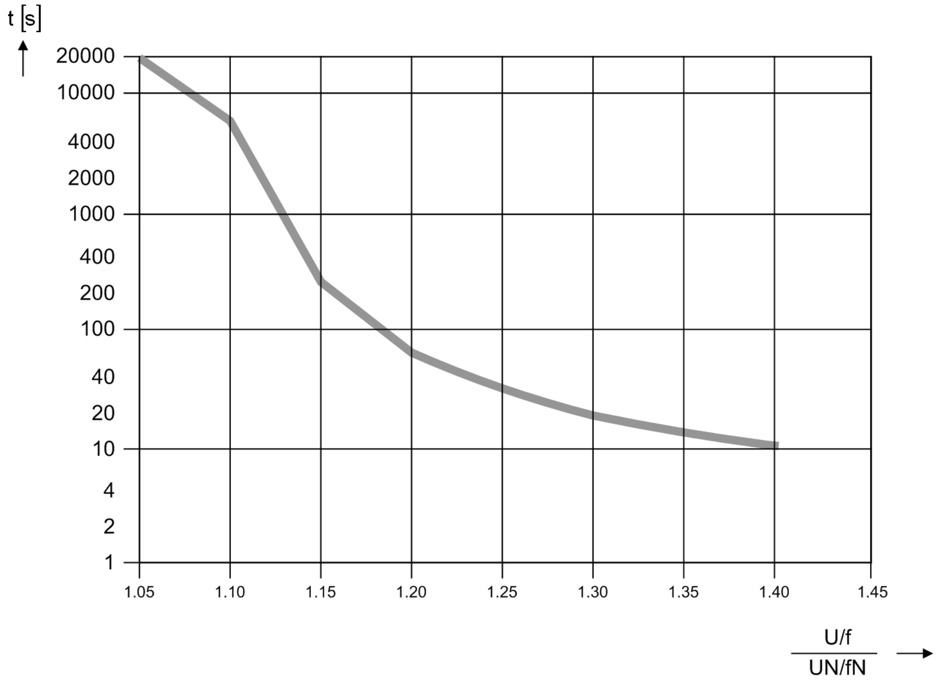


Figure 2-78 Thermal tripping time characteristic (with default settings)

The characteristic of a Siemens standard transformer was selected as a default setting for the parameters 4306 to 4313. If the protection object manufacturer did not provide any information, the preset standard characteristic should be used. Otherwise, any trip characteristic can be specified entering parameters point-bypoint over a maximum of 7 straight lengths. To do this, the trip times t of the overexcitation values U/f = 1.05; 1.10; 1.15; 1.20; 1.25; 1.30; 1.35 and 1.40 are read out from the predefined characteristic and entered at the addresses4306 **t(U/f=1.05)** to 4313 **t(U/f=1.40)**. The protection device interpolates linearly between the points.

Limitation

The heating model of the object to be protected is limited to a 150 % overshoot of the trip temperature.

Cooling Time

Tripping by the thermal image drops out by the time of the pickup threshold dropout. However, the counter content is counted down to zero with the cooldown time parametrized at address 4314 **T COOL DOWN**. In this context this parameter is defined as the time required by the thermal image to cool down from 100 % to 0 %.

Voltage Transformer Adaptation

Any deviation between the primary nominal voltage of the voltage transformers and of the protected object is compensated by an internal correction factor ($U_{N\ prim}/U_{N\ Mach}$). For this it is necessary that the relevant parameters 221 **Unom PRIMARY** and 251 **UN GEN/MOTOR** were properly entered in accordance with Section 2.5.

2.24.3 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
4301	OVEREXC. PROT.	OFF ON Block relay	OFF	Overexcitation Protection (U/f)
4302	U/f >	1.00 .. 1.20	1.10	U/f > Pickup
4303	T U/f >	0.00 .. 60.00 sec; ∞	10.00 sec	T U/f > Time Delay
4304	U/f >>	1.00 .. 1.40	1.40	U/f >> Pickup
4305	T U/f >>	0.00 .. 60.00 sec; ∞	1.00 sec	T U/f >> Time Delay
4306	t(U/f=1.05)	0 .. 20000 sec	20000 sec	U/f = 1.05 Time Delay
4307	t(U/f=1.10)	0 .. 20000 sec	6000 sec	U/f = 1.10 Time Delay
4308	t(U/f=1.15)	0 .. 20000 sec	240 sec	U/f = 1.15 Time Delay
4309	t(U/f=1.20)	0 .. 20000 sec	60 sec	U/f = 1.20 Time Delay
4310	t(U/f=1.25)	0 .. 20000 sec	30 sec	U/f = 1.25 Time Delay
4311	t(U/f=1.30)	0 .. 20000 sec	19 sec	U/f = 1.30 Time Delay
4312	t(U/f=1.35)	0 .. 20000 sec	13 sec	U/f = 1.35 Time Delay
4313	t(U/f=1.40)	0 .. 20000 sec	10 sec	U/f = 1.40 Time Delay
4314	T COOL DOWN	0 .. 20000 sec	3600 sec	Time for Cooling Down

2.24.4 Information List

No.	Information	Type of In-formation	Comments
5353	>U/f BLOCK	SP	>BLOCK overexcitation protection
5357	>RM th.rep. U/f	SP	>Reset memory of thermal replica U/f
5361	U/f> OFF	OUT	Overexcitation prot. is swiched OFF
5362	U/f> BLOCKED	OUT	Overexcitation prot. is BLOCKED
5363	U/f> ACTIVE	OUT	Overexcitation prot. is ACTIVE
5367	U/f> warn	OUT	Overexc. prot.: U/f warning stage
5369	RM th.rep. U/f	OUT	Reset memory of thermal replica U/f
5370	U/f> picked up	OUT	Overexc. prot.: U/f> picked up
5371	U/f>> TRIP	OUT	Overexc. prot.: TRIP of U/f>> stage
5372	U/f> th.TRIP	OUT	Overexc. prot.: TRIP of th. stage
5373	U/f>> pick.up	OUT	Overexc. prot.: U/f>> picked up

2.25 Inverse-Time Undervoltage Protection (ANSI 27)

The inverse undervoltage protection mainly protects consumers (induction machines) from the consequences of dangerous voltage drops in island networks thus avoiding inadmissible operating conditions and possible loss of stability. It can also be used as a criterion for load shedding in interconnected networks. Two-pole short circuits or earth faults cause asymmetrical voltage collapse. Compared with single phase measuring systems, the detection of the positive phase-sequence system is not influenced by these procedures and is therefore especially useful for assessing stability problems.

2.25.1 Functional Description

Measured Quantity

For the above reasons, the positive sequence system is calculated from the fundamental waves of the three phase-earth voltages, and fed to the protection function. After numerical filtering only the fundamental wave is evaluated.

If voltage transformers in open delta connection (V connection) are available on the plant side, protection is applied to the phase-to-phase voltages and the internal starpoint is left empty. A virtual starpoint is thus formed so that the (virtual) phase-to-earth voltages can still be detected (see connection example in Appendix A.3).

Tripping characteristic

By means of a voltage-time dependent tripping characteristic protection can be matched exactly to the stability characteristic of motors. If the motor falls below the stability characteristic, it will stall or run at substantially reduced speed, even if full voltage is restored after a short time. Only squirrel-cage machines for which the torque characteristic of the driven machine lies below the motor characteristic at all speeds will regain their rated speed. All other machines will be thermally and perhaps mechanically overstressed on running down, after return of voltage.

Undervoltage protection consists of one inverse time element. In order to avoid malfunction of the protection in the event of secondary voltage failure, it can be blocked via a binary input, e.g. by a voltage transformer miniature circuit breaker or th auxilary contact of main circuit breaker when the machine is at stand-still. Also the integrated Fuse-Failure Monitor will block the two stage (see section 2.42.2).

If no measured values are available at the device (operation condition 0), no trip signal is issued if there was no pickup. This ensures that the undervoltage protection does not pick up immediately when it is switched on if no measured value is available. Once the protection has been activated, it can only be deactivated again only by blocking.

If a pickup signal is present when the device enters operating condition 0 (i.e. no measured values, or frequency outside the permissible range), it is maintained. The delay time until tripping is calculated in the same way as for a drop to 0V. The sealed-in pickup or tripping signal can only be reset on voltage restoration, or if the blocking input is activated.

The pickup/dropout ratio is 101 % or 0.5 V absolute of the threshold set at address 4402 **Up< PICKUP**. The integral action of the tripping time determination is „frozen“ between the pickup and the dropout value.

The following figure shows the logic diagram of the inverse undervoltage protection.

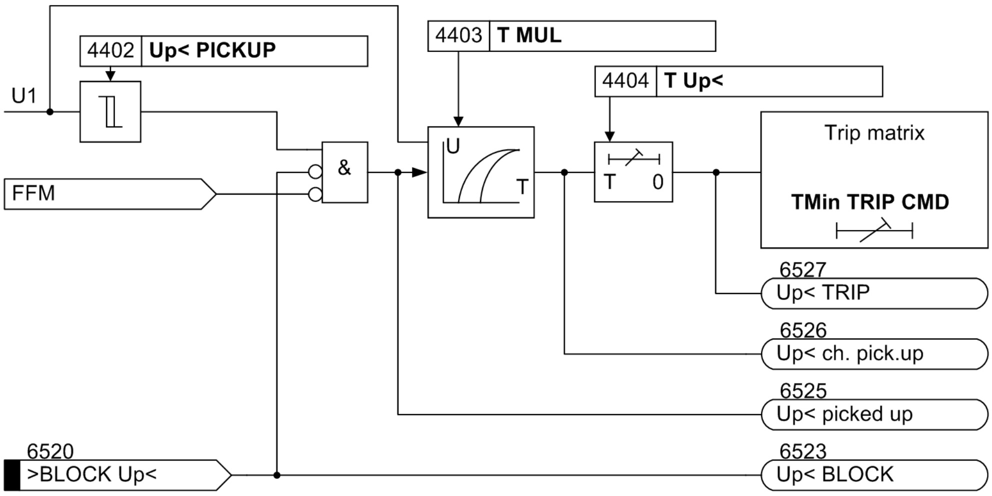


Figure 2-79 Logic Diagram of the Inverse-Time Undervoltage Protection

2.25.2 Setting Notes

General

The inverse-time undervoltage protection is only effective and available if this function was set during protective function configuration (Section 2.4, address 144, **INV.UNDERVOLT.** is set to ***Enabled***. If the function is not required ***Disabled*** is set. Address 4401 **INV. UNDERVOLT.** serves to switch the function ***ON*** or ***OFF*** or to block only the trip command (***Block relay***).

Settings

It must be considered that the positive phase-sequence voltages and thus also the pickup thresholds are evaluated as phase-to-phase quantities (terminal voltage · √3).

There are no clear cut procedures on how to set the pickup values. But since the protection is used mainly to protect consumers (induction machines) from the consequences of voltage drops, and to prevent loss of stability, the value is normally set to approx. 75 % of the nominal machine voltage, i.e. address 4402 **Up< PICKUP** is set to 75 V. In exceptional cases, where the voltage drop during startup is too large, it may be necessary to set the protection to lower values. The time multiplier 4403 **T MUL** must be selected such that voltage drops which would cause unstable operation are reliably disconnected. On the other hand, the time delay must be large enough to avoid disconnections during permissible short-time voltage dips.

If required, the tripping time can also be extended by an additional time stage 4404 **T Up<**.

All setting times are additional time delays which do not include the operating times (measuring time, drop-out time) of the protective function.

2.25.3 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
4401	INV. UNDERVOLT.	OFF ON Block relay	OFF	Inverse Undervoltage Protection Up<
4402	Up< PICKUP	10.0 .. 125.0 V	75.0 V	Up< Pickup
4403	T MUL	0.10 .. 5.00 sec; 0	1.00 sec	Time Multiplier for Characteristic
4404	T Up<	0.00 .. 60.00 sec; ∞	0.00 sec	T Up< Time Delay

2.25.4 Information List

No.	Information	Type of Information	Comments
6520	>BLOCK Up<	SP	>BLOCK inverse undervoltage protection
6522	Up< OFF	OUT	Inv. Undervoltage prot. is switched OFF
6523	Up< BLOCK	OUT	Inv. Undervoltage protection is BLOCKED
6524	Up< ACTIVE	OUT	Inv. Undervoltage protection is ACTIVE
6525	Up< picked up	OUT	Inverse Undervoltage Up< picked up
6526	Up< ch. pick.up	OUT	Inv. Undervoltage Up<-char. picked up
6527	Up< AUS	OUT	Inverse Undervoltage Up< TRIP

2.26 Rate-of-Frequency-Change Protection df/dt (ANSI 81R)

With the rate-of-frequency-change protection, frequency changes can be quickly detected. This allows a prompt response to frequency dips or frequency rises. A trip command can be issued even before the pickup threshold of the frequency protection (see Section 2.23) is reached.

Frequency changes occur for instance when there is an imbalance between the generated and the required active power. They call for control measures on the one hand and for switching actions on the other hand. These can be unburdening measures, such as network decoupling, or disconnection of loads (load shedding). The sooner these measures are taken after malfunctioning, the more effective they will be.

The two main applications for this protection function are thus network decoupling and load shedding.

2.26.1 Functional Description

Measuring Principle

From the positive-sequence voltage, the frequency is determined once per cycle over a measuring window of 3 cycles, and a mean value of two consecutive frequency measurements is formed. The frequency difference is then determined over a settable time interval (default setting 5 cycles). The ratio between frequency difference and time difference corresponds to the frequency change; it can be positive or negative. The measurement is performed continuously (per cycle). Monitoring functions such as undervoltage monitoring, checks for phase angle jumps etc. help to avoid overfunctioning.

Frequency Increase/ Decrease

The rate-of-frequency-change protection has four stages, from df1/dt to df4/dt. This allows the function to be adapted variably to all power system conditions. The stages can be set to detect either frequency decreases (-df/dt) or frequency increases (+df/dt). The -df/dt stage is only active for frequencies below the rated frequency, or less if the underfrequency enabling is activated. Likewise, the df/dt stage is active for frequencies above the rated frequency, or higher, if the overfrequency enabling is activated. The parameter setting decides for what purpose the particular stage will be used.

To avoid a proliferation of setting parameters, the settable measuring window for the frequency difference formation and the dropout difference are each valid for two stages.

Operating Ranges

The frequency can be determined as long as there is a sufficiently strong positive sequence system of voltages. If the measurement voltage drops below a settable value **U MIN**, frequency protection is disabled because precise frequency values can no longer be calculated from the signal.

Time Delays/Logic

Tripping can be delayed by a set time delay associated with each applied time stage. This is recommended for monitoring small gradients. When the time delay expires, a trip signal is generated. After pickup dropout the tripping command is immediately reset, but not before the minimum command duration has expired.

Each of the four frequency change stages can be blocked individually by binary input. The undervoltage blocking acts on all stages simultaneously.

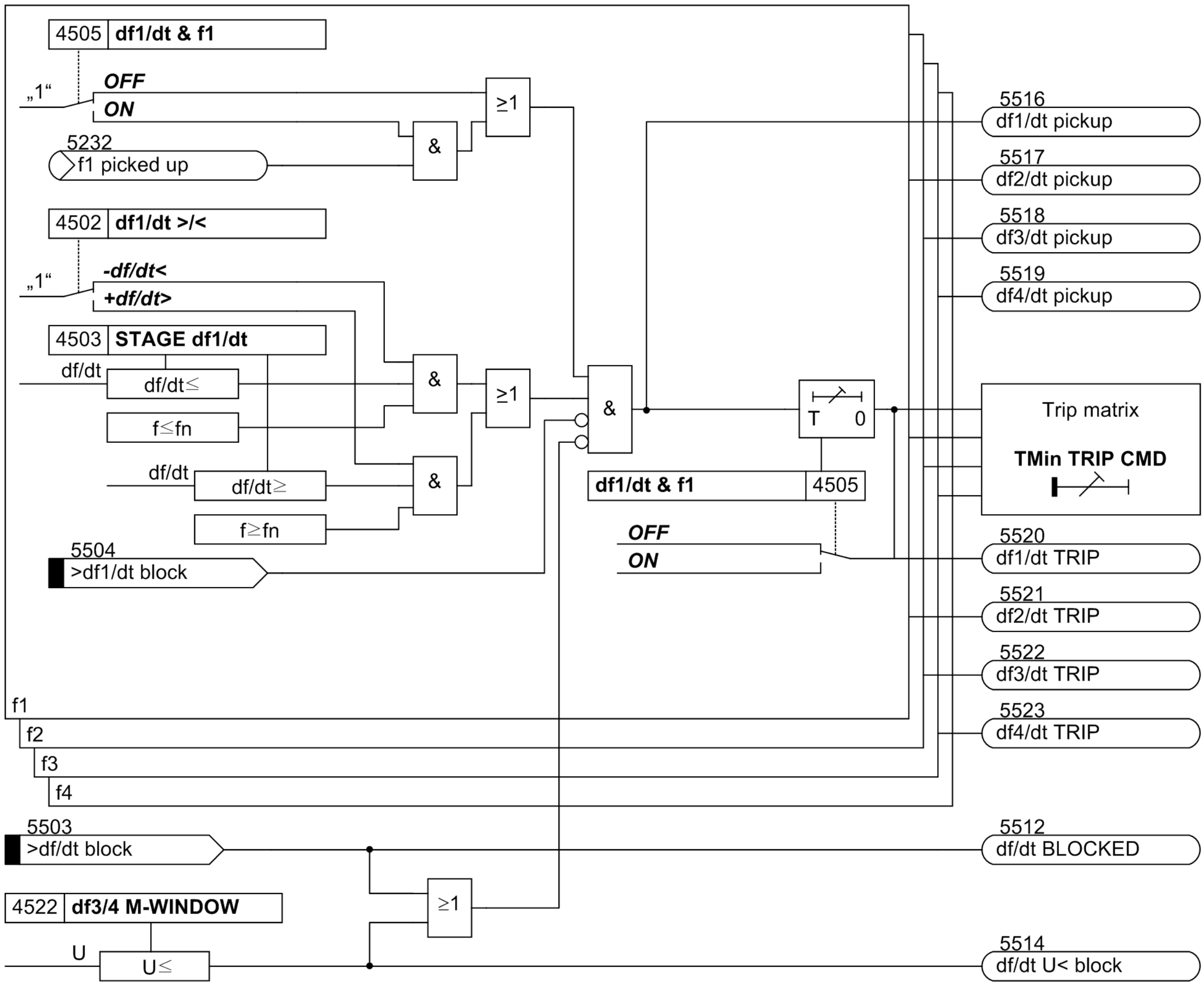


Figure 2-80 Logic Diagram of the Rate-of-Frequency-Change Protection

2.26.2 Setting Notes

General

The rate-of-frequency-change protection is only effective and accessible if during the configuration address 145 **df/dt Protect.** has been set accordingly. The user can select between 2 or 4 stages. The default setting is ***2 df/dt stages***.

Address 4501 **df/dt Protect.** serves to switch the function ***ON*** or ***OFF*** or to block only the trip command (***Block relay***).

Pickup Values

The setting procedure is the same for all stages. In a first step, it must be determined whether the stage is to monitor a frequency rise at $f>f_N$ or a frequency drop at $f<f_N$. For stage 1, for instance, this setting is made at address 4502 **df1/dt >/<**. The pickup value is set as an absolute value at address 4503 **STAGE df1/dt**. The setting of address 4502 informs the protection function of the applicable sign.

The pickup value depends on the application and is determined by power system conditions. In most cases, a network analysis will be necessary. A sudden disconnection of loads leads to a surplus of active power. The frequency rises and causes a positive frequency change. A failure of generators, on the other hand, leads to a deficit of active power. The frequency drops and leads to a negative frequency change.

The following relations can be used as an example for estimation. They apply for the change rate at the beginning of a frequency change (approx. 1 second).

$$\frac{df}{dt} = -\frac{f_N}{2\,H} \cdot \frac{\Delta P}{S_N}$$

Definitions:

f_N	Nominal Frequency
ΔP	Active power change
	$\Delta P = P_{Consumption} - P_{Generation}$
S_N	Nominal apparent power of the machines
H	Inertia constant

Typical values for H are:

for hydro-electric generators (salient-pole machines)	H = 1.5 s to 6 s
for turbine-driven generators (cylindrical-rotor machines)	H = 2 s to 10 s
for industrial turbine-generators	H = 3 s to 4 s

<u>Example:</u>

f_N = 50 Hz

H = 3 s

Case 1: $\Delta P/S_N$ = 0.12

Case 2: $\Delta P/S_N$ = 0.48

Case 1: df/dt = -1 Hz/s

Case 2: df/dt = -4 Hz/s

The default settings are based on the above example. The four stages have been set symmetrically.

Time Delays

The delay time should be set to zero wherever the protection function is supposed to respond very quickly. This will be the case with high setting values. For the monitoring of small changes (< 1Hz/s), on the other hand, a small delay time can be useful to avoid overfunctioning. The delay time for stage 1 is set at address 4504 **T df1/dt**, and the time set there is added to the protection operating time.

Release by the Frequency Protection

The parameter **df1/dt & f1** (Address 4505) is used to set the release of the stage from a certain frequency threshold on. For this the pertinent frequency stage of the frequency protection is queried. In the setting example this is stage f1. To exclude coupling of the two functions, the parameter can be set to ***OFF*** (default setting).

Advanced Parameters

The advanced parameters allow setting each for two stages (e.g. df1/dt and df2/dt) the dropout difference and the measuring window. This setting can only be done with the DIGSI communication software.

Setting changes are necessary e.g. to obtain a large dropout difference. For the detection of very small frequency changes (< 0.5 Hz/s), the default setting of the measuring window should be extended. This is to improve the measuring accuracy.

Setting value Stage df_n/dt	**df/dt HYSTERES.** (Addr. 4519, 4521)	**dfx/dt M-WINDOW** (Addr. 4520, 4522)
0.1...0.5 Hz/s	≈ 0.05	25...10
0.5...1 Hz/s	≈ 0.1	10...5
1...5 Hz/s	≈ 0.2	10...5
5...10 Hz/s	≈ 0.5	5...1

Minimum Voltage

Address 4518 **U MIN** is used to set the minimum voltage below which the frequency change protection will be blocked. A value of approx. 65 % U_N is recommended. The minimum voltage threshold can be deactivated by setting this address to „0“.

2.26.3 Settings

Addresses which have an appended "A" can only be changed with DIGSI, under Additional Settings.

Addr.	Parameter	Setting Options	Default Setting	Comments
4501	df/dt Protect.	OFF ON Block relay	OFF	Rate-of-frequency-change protection
4502	df1/dt >/<	-df/dt< +df/dt>	-df/dt<	Mode of Threshold (df1/dt >/<)
4503	STAGE df1/dt	0.1 .. 10.0 Hz/s; ∞	1.0 Hz/s	Pickup Value of df1/dt Stage
4504	T df1/dt	0.00 .. 60.00 sec; ∞	0.50 sec	Time Delay of df1/dt Stage
4505	df1/dt & f1	OFF ON	OFF	AND logic with pickup of stage f1
4506	df2/dt >/<	-df/dt< +df/dt>	-df/dt<	Mode of Threshold (df2/dt >/<)
4507	STAGE df2/dt	0.1 .. 10.0 Hz/s; ∞	1.0 Hz/s	Pickup Value of df2/dt Stage
4508	T df2/dt	0.00 .. 60.00 sec; ∞	0.50 sec	Time Delay of df2/dt Stage
4509	df2/dt & f2	OFF ON	OFF	AND logic with pickup of stage f2
4510	df3/dt >/<	-df/dt< +df/dt>	-df/dt<	Mode of Threshold (df3/dt >/<)
4511	STAGE df3/dt	0.1 .. 10.0 Hz/s; ∞	4.0 Hz/s	Pickup Value of df3/dt Stage
4512	T df3/dt	0.00 .. 60.00 sec; ∞	0.00 sec	Time Delay of df3/dt Stage
4513	df3/dt & f3	OFF ON	OFF	AND logic with pickup of stage f3
4514	df4/dt >/<	-df/dt< +df/dt>	-df/dt<	Mode of Threshold (df4/dt >/<)
4515	STAGE df4/dt	0.1 .. 10.0 Hz/s; ∞	4.0 Hz/s	Pickup Value of df4/dt Stage
4516	T df4/dt	0.00 .. 60.00 sec; ∞	0.00 sec	Time Delay of df4/dt Stage
4517	df4/dt & f4	OFF ON	OFF	AND logic with pickup of stage f4
4518	U MIN	10.0 .. 125.0 V; 0	65.0 V	Minimum Operating Voltage Umin
4519A	df1/2 HYSTERES.	0.02 .. 0.99 Hz/s	0.10 Hz/s	Reset Hysteresis for df1/dt & df2/dt
4520A	df1/2 M-WINDOW	1 .. 25 Cycle	5 Cycle	Measuring Window for df1/dt & df2/dt
4521A	df3/4 HYSTERES.	0.02 .. 0.99 Hz/s	0.40 Hz/s	Reset Hysteresis for df3/dt & df4/dt
4522A	df3/4 M-WINDOW	1 .. 25 Cycle	5 Cycle	Measuring Window for df3/dt & df4/dt

2.26.4 Information List

No.	Information	Type of Information	Comments
5503	>df/dt block	SP	>BLOCK Rate-of-frequency-change prot.
5504	>df1/dt block	SP	>BLOCK df1/dt stage
5505	>df2/dt block	SP	>BLOCK df2/dt stage
5506	>df3/dt block	SP	>BLOCK df3/dt stage
5507	>df4/dt block	SP	>BLOCK df4/dt stage
5511	df/dt OFF	OUT	df/dt is switched OFF
5512	df/dt BLOCKED	OUT	df/dt is BLOCKED
5513	df/dt ACTIVE	OUT	df/dt is ACTIVE
5514	df/dt U< block	OUT	df/dt is blocked by undervoltage
5516	df1/dt pickup	OUT	Stage df1/dt picked up
5517	df2/dt pickup	OUT	Stage df2/dt picked up
5518	df3/dt pickup	OUT	Stage df3/dt picked up
5519	df4/dt pickup	OUT	Stage df4/dt picked up
5520	df1/dt TRIP	OUT	Stage df1/dt TRIP
5521	df2/dt TRIP	OUT	Stage df2/dt TRIP
5522	df3/dt TRIP	OUT	Stage df3/dt TRIP
5523	df4/dt TRIP	OUT	Stage df4/dt TRIP

2.27 Jump of Voltage Vector

Consumers with their own generating plant, for example, feed power directly into a network. The incoming feeder line is usually the technical and legal ownership boundary between the network operator and these consumers/producers. A failure of the input feeder line, for example, due to a three-pole automatic reclosure, can result in a deviation of the voltage or frequency at the feeding generator which is a function of the overall power balance. When the incoming feeder line is switched on again after the dead time, asynchronous conditions may prevail that cause damage to the generator or the gear train between generator and drive.

One way to identify an interruption of the incoming feeder is to monitor the phase angle in the voltage. If the incoming feeder fails, the abrupt current interruption causes a phase angle jump in the voltage. This jump is detected by means of a delta process. As soon as a preset threshold is exceeded, an opening command for the generator or bus-tie coupler circuit-breaker is issued.

This means that the vector jump function is mainly used for network decoupling.

2.27.1 Functional Description

Frequency Behaviour on Load Shedding

The following figure shows the evolution of the frequency when a load is disconnected from a generator. Opening of the generator circuit breaker causes a phase angle jump that can be observed in the frequency measurement as a frequency jump. The generator is accelerated in accordance with the power system conditions (see also Section 2.26 „Rate-of-Frequency-Change Protection“).

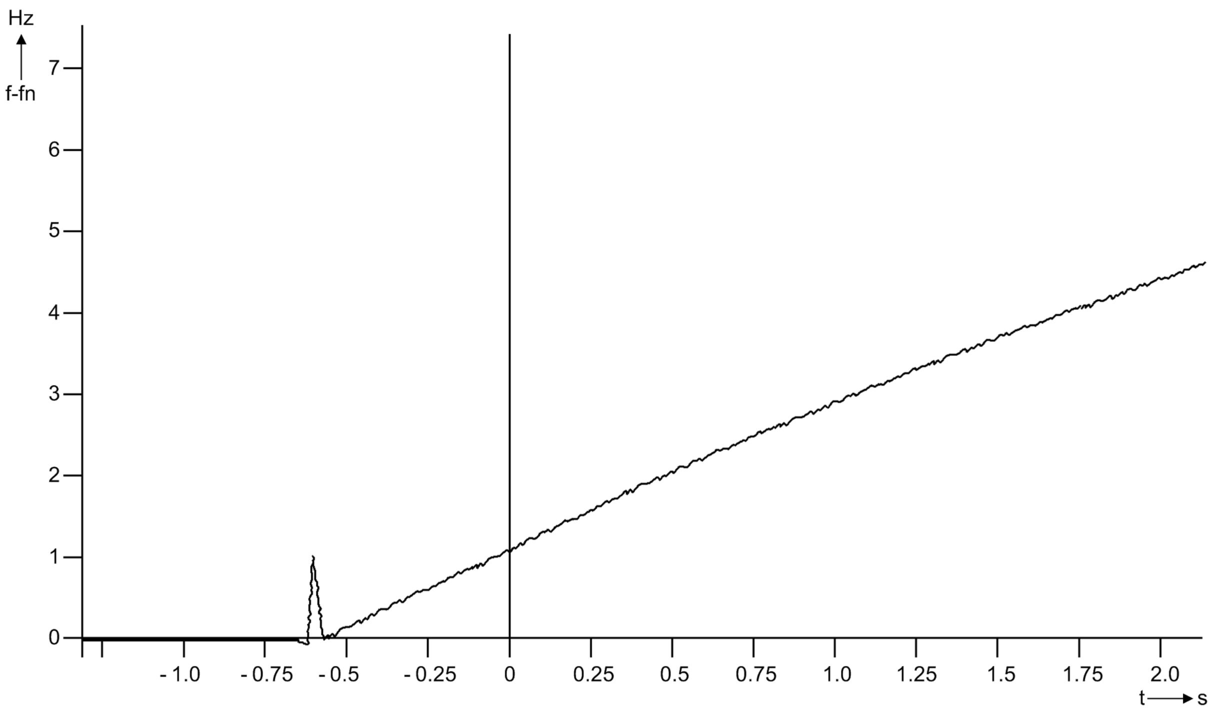


Figure 2-81 Change of the Frequency after Disconnection of a Load (Fault recording with the SIPROTEC 4 device-the figure shows the deviation from the nominal frequency)

Measuring Principle

The vector of the positive sequence system voltage is calculated from the phase-to-earth voltages, and the phase angle change of the voltage vector is determined over a delta interval of 2 cycles. The presence of a phase angle jump indicates an abrupt change of current flow. The basic principle is shown in Figure 2-82. The diagram on the left shows the steady state, and the diagram on the right the vector change following a load shedding. The vector jump is clearly visible.

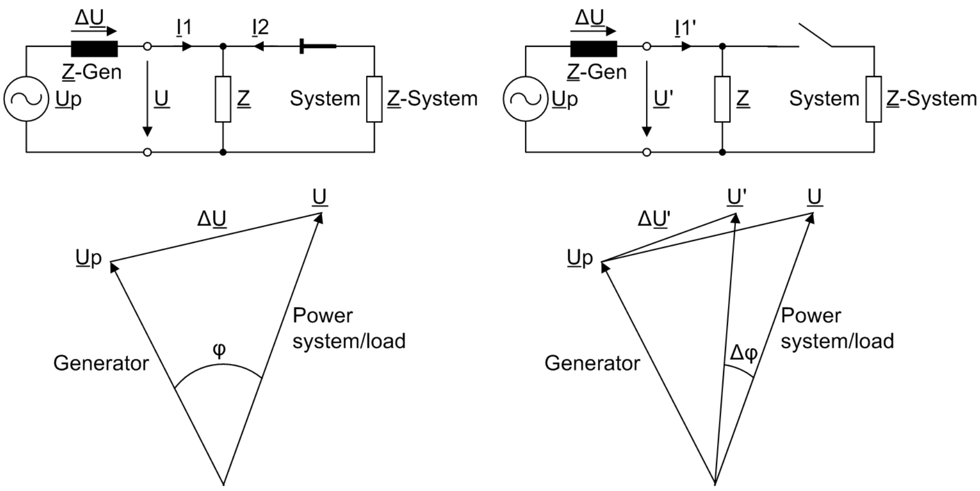


Figure 2-82 Voltage Vector Following Load Shedding

The function features a number of additional measures to avoid spurious tripping, such as:

- Correction of steady-state deviations from rated frequency
- Frequency operating range limited to f_N ± 3 Hz
- Detection of internal scanning frequency changeover (Scanning frequency adjustment)
- Minimum voltage for enabling
- Blocking on voltage connection or disconnection

Logic

The logic is shown in Figure 2-83. The phase angle comparison determines the angle difference, and compares it with the set value. If this value is exceeded, the vector jump is stored in a RS flip-flop. Trippings can be delayed by the associated time delay.

The stored pickup can be reset via a binary input, or automatically by a timer (address 4604 **T RESET**).

The vector jump function becomes ineffective on exiting the admissible frequency band. The same applies for the voltage. In such a case the limiting parameters are **U MIN** and **U MAX**.

If the frequency or voltage range is not maintained, the logic generates a logical 1, and the reset input is continuously active. The result of the vector jump measurement is suppressed. If, for instance, the voltage is connected, and the frequency range is correct, the logical 1 changes to 0. The timer **T BLOCK** with reset delay keeps the reset input active for a certain time, thus preventing a pickup caused by the vector jump function.

If a short-circuit causes the voltage to drop abruptly to a low value, the reset input is immediately activated to block the function. The vector jump function is thus prevented from causing a trip.

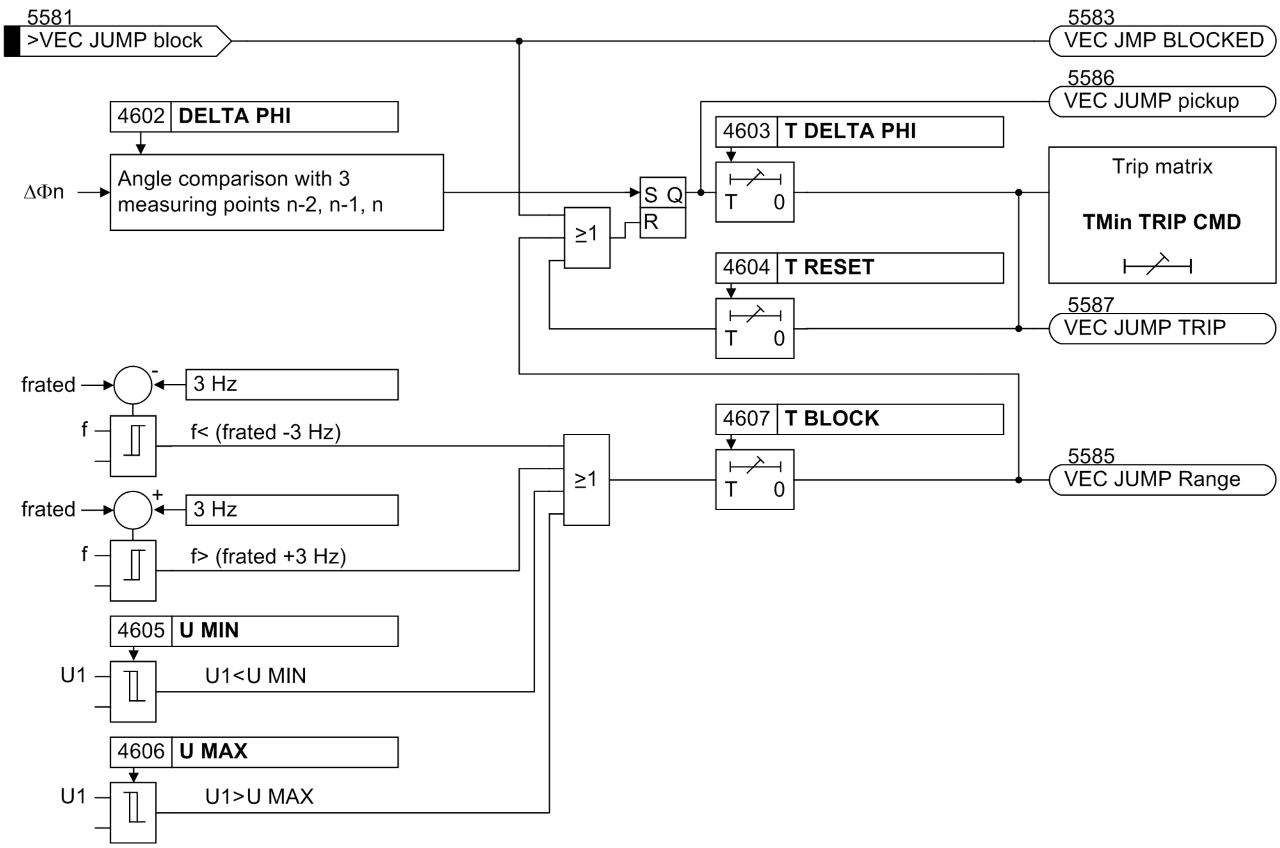


Figure 2-83 Logic diagram of the vector jump detection

2.27.2 Setting Notes

General

The vector jump protection is only effective and available if address 146 **VECTOR JUMP** is set to ***Enabled*** during configuration.

Address 4601 **VECTOR JUMP** serves to switch the function ***ON*** or ***OFF*** or to block only the trip command (***Block relay***).

Pickup Values

The value to be set for the vector jump (address 4602 **DELTA PHI**) depends on the feed and load conditions. Abrupt active power changes cause a jump of the voltage vector. The value to be set must be established in accordance with the particular power system. This can be done on the basis of the simplified equivalent circuit of the diagram „Voltage Vector Following Load Shedding“ in the Functional Description section, or using network calculation software.

If a setting is too sensitive, the protection function is likely to perform a network decoupling every time loads are connected or disconnected. Therefore the default setting is **10°**.

The admissible voltage operating range can be set at addresses 4605 for **U MIN** and 4606 for **U MAX**. Setting range limits are to some extent a matter of the utility's policy. The value for **U MIN** should be below the admissible level of short voltage dips for which network decoupling is desired. The default setting is ***80 %*** of the nominal voltage. For **U MAX** the maximum admissible voltage must be selected. This will be in most cases ***130 %*** of the nominal voltage

Time Delays

The time delay **T DELTA PHI** (address 4603) should be left at zero, unless you wish to transmit the trip indication with a delay to a logic (CFC), or to leave enough time for an external blocking to take effect.

After expiry of the timer **T RESET** (address 4604), the protection function is automatically reset. The reset time depends on the decoupling policy. It must have expired before the circuit breaker is reclosed. Where the automatic reset function is not used, the timer is set to ∞. The reset signal must come in this case from the binary input (circuit breaker auxiliary contact).

The timer **T BLOCK** with reset delay (address 4607) helps to avoid overfunctioning when voltages are connected or disconnected. Normally the default setting need not be changed. Any change can be performed with the DIGSI communication software (advanced parameters). It must be kept in mind that **T BLOCK** should always be set to more than the measuring window for vector jump measurement (2 cycles).

2.27.3 Settings

Addresses which have an appended "A" can only be changed with DIGSI, under Additional Settings.

Addr.	Parameter	Setting Options	Default Setting	Comments
4601	VECTOR JUMP	OFF ON Block relay	OFF	Jump of Voltage Vector
4602	DELTA PHI	2 .. 30 °	10 °	Jump of Phasor DELTA PHI
4603	T DELTA PHI	0.00 .. 60.00 sec; ∞	0.00 sec	T DELTA PHI Time Delay
4604	T RESET	0.10 .. 60.00 sec; ∞	5.00 sec	Reset Time after Trip
4605A	U MIN	10.0 .. 125.0 V	80.0 V	Minimal Operation Voltage U MIN
4606A	U MAX	10.0 .. 170.0 V	130.0 V	Maximal Operation Voltage U MAX
4607A	T BLOCK	0.00 .. 60.00 sec; ∞	0.10 sec	Time Delay of Blocking

2.27.4 Information List

No.	Information	Type of Information	Comments
5581	>VEC JUMP block	SP	>BLOCK Vector Jump
5582	VEC JUMP OFF	OUT	Vector Jump is switched OFF
5583	VEC JMP BLOCKED	OUT	Vector Jump is BLOCKED
5584	VEC JUMP ACTIVE	OUT	Vector Jump is ACTIVE
5585	VEC JUMP Range	OUT	Vector Jump not in measurement range
5586	VEC JUMP pickup	OUT	Vector Jump picked up
5587	VEC JUMP TRIP	OUT	Vector Jump TRIP

2.28 90-%-Stator Earth Fault Protection (ANSI 59N, 64G, 67G)

The stator earth fault protection detects earth faults in the stator windings of three-phase machines. The machine can be operated in busbar connection (directly connected to the network) or in unit connection (via unit transformer). The criterion for the occurrence of an earth fault is mainly the emergence of a displacement voltage, or additionally with busbar connection, of an earth current. This principle makes possible a protected zone of 90 % to 95 % of the stator winding.

2.28.1 Functional Description

Displacement Voltage

The displacement voltage U_E can be measured either at the machine starpoint via voltage transformers or neutral earthing transformers (Figure 2-84) or via the e-n winding (broken delta winding) of a voltage transformer set or the measurement winding of a line connected earthing transformer (Figure 2-85). Since the neutral earthing transformer or the line connected earthing transformer usually supply a displacement voltage of 500 V (with full displacement), a voltage divider 500 V/100 V is to be connected in series in such cases.

If the displacement voltage can not be directly applied to the device as a measured value, the device can calculate the displacement voltage from the phase-to-earth voltages.

Address 223 **UE CONNECTION** serves for notifying the device of the way the displacement voltage is to be measured or calculated.

In all kinds of displacement voltage formation, the components of the third harmonic in each phase are summed since they are in phase in the three-phase system. In order to obtain reliable measured quantities, only the fundamental harmonic of the displacement voltage is evaluated in the stator earth fault protection. Higher harmonics are filtered out by numerical filter algorithms.

For machines in unit connection the evaluation of the displacement voltage is sufficient. The possible sensitivity of the protection is only limited by power frequency interference voltages during earth faults in the network. These interference voltages are transferred to the machine side via the coupling capacitance of the unit transformer. If necessary, a loading resistance can be provided to reduce these interference voltages. The protection initiates disconnection of the machine when an earth fault in the machine zone has been present for a set time.

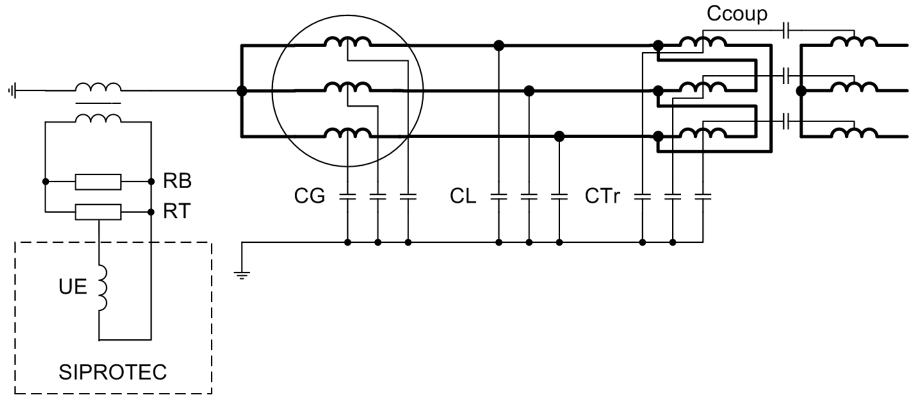


Figure 2-84 Unit Connection with Neutral Transformer

R_B Loading resistance

R_T Voltage divider

U_E Displacement Voltage

C_G Generator earth capacitance

C_L Line earth capacitance

C_{Tr} Unit transformer earth capacitance

C_{coup} Unit transformer coupling capacitance

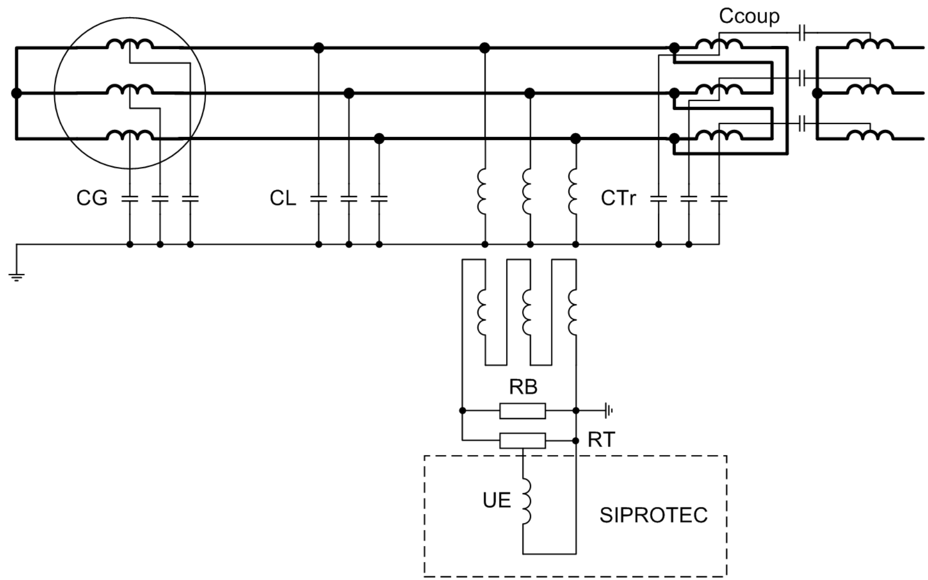


Figure 2-85 Unit Connection with Earthing Transformer

R_B Loading resistance

R_T Voltage divider

U_E Displacement voltage

C_G Generator earth capacitance

C_L Line earth capacitance

C_{Tr} Unit transformer earth capacitance

C_{coup} Unit transformer coupling capacitance

Earth Current Direction Detection

For machines in busbar connection, it is not possible to differentiate between network earth faults and machine earth faults using the displacement voltage alone. In this case the earth fault current is used as a further criterion, and the displacement voltage as a necessary enabling condition.

The earth fault current can be measured using a toroidal current transformer or a set of CTs in Holmgreen connection. During a network earth fault, the machine supplies only a negligible earth fault current across the measurement location, which must be situated between the machine and the network. During a machine earth fault, the earth fault current of the network is available. However, since the network conditions generally vary according to the switching status of the network, a loading resistor, which supplies an increased earth fault current on the occurrence of a displacement voltage, is used in order to obtain definite measurement conditions independent of the switching status of the network. The earth fault current produced by the loading resistor must always flow across the measurement location.

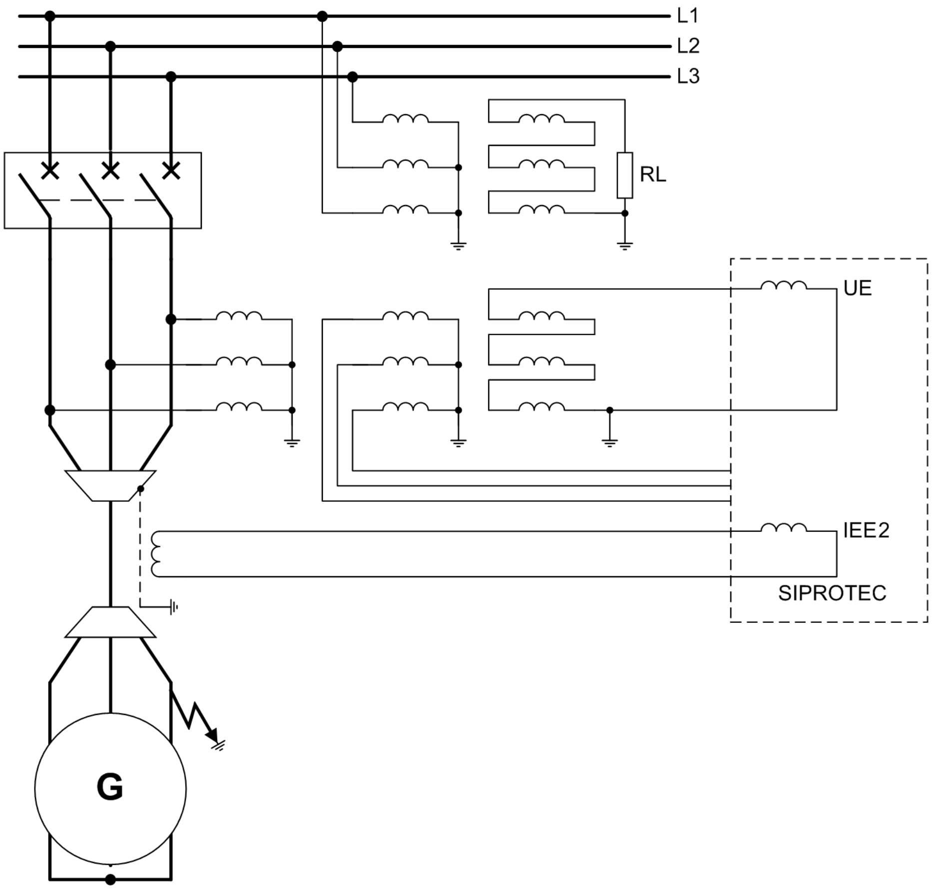


Figure 2-86 Earth Fault Direction Detection with Busbar Connection

Consequently, the loading resistor must be situated on the other side of the measurement location (current transformer, toroidal current transformer) when viewed from the machine. The earthing transformer is preferably connected to the busbar. Apart from the magnitude of the earth fault current, knowledge of the direction of this current in relation to the displacement voltage is necessary for the secure detection of a machine earth fault with busbar connection. The directional border between „machine direction“ and "network direction" can be altered in the 7UM62 (see the following figure).

The protection then detects a machine earth fault if the following three criteria are fulfilled:

- Displacement voltage larger than set value **U0>**,
- Earth fault current across the measurement location larger than set value **3I0>**,
- Earth fault current is flowing in the direction of the protected machine.

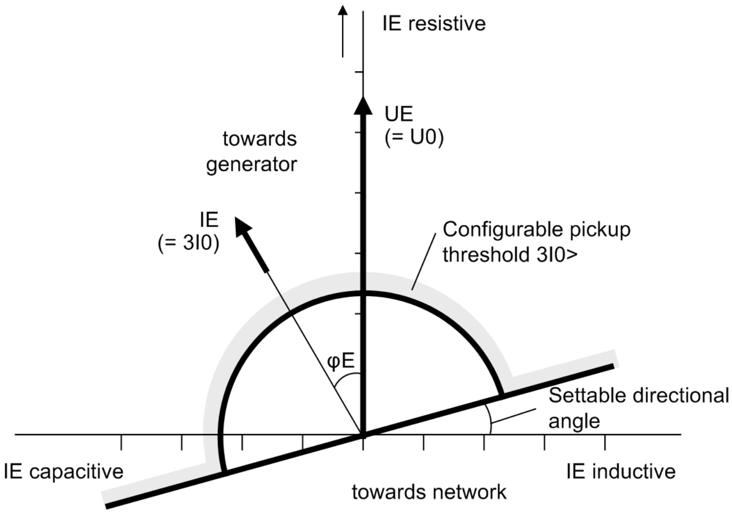


Figure 2-87 Characteristic of the Stator Earth Fault Protection for Busbar Connection

On the occurrence of an earth fault in the machine zone, the disconnection of the machine is initiated after a set delay time.

If the earth fault current fails to provide an unambiguous criterion for detecting an earth fault when the circuit breaker is open, the earth current detection can be switched off for a certain time via a binary input. By this means it is possible to switch to sole evaluation of the displacement voltage e.g. during run-up of the generator.

Figure 2-89 shows the logic diagram of the stator earth fault protection.

If the stator earth fault protection is used as directional or non-directional busbar connection protection, the sensitive current measuring input of the 7UM62 device is thus occupied. The user must be aware that the sensitive earth fault detection can use the same measuring input (if I_{ee2} configured) and thus the same measured value. Thus two additional, independent pickup thresholds Iee> and Iee>> could be formed for this measured value by means of the sensitive earth fault detection (see Section 2.29). If the user does not desire this, he should remove the sensitive earth fault configuration at address 151, or use it with I_{ee1}.

If the rotor earth fault protection (see Section 2.34) is used, it occupies the additional voltage input; the displacement voltage U_0 for the stator earth fault protection is therefore calculated from the phase-earth voltages in that case.

Earth Current Detection (Earth Differential Protection with Displacment Voltage as the Pickup Criterion)

In the industrial sector, busbar systems are designed with high or low resistance, switchable starpoint resistances. For earth-fault detection, the starpoint current and the total current are detected via toroidal current transformers and transmitted to the protective device as current difference. In this way, the earth current portions derived both from the starpoint resistance and from the power system contribute to the total earth current. In order to exclude an unwanted operation due to transformer faults, the displacement voltage is used for tripping (see the following figure).

The protection feature detects a machine earth fault if the following two criteria are fulfilled:

- Displacement voltage greater than set value **U0>**,
- Earth fault current difference ΔI_E larger than setting value **3I0>**,

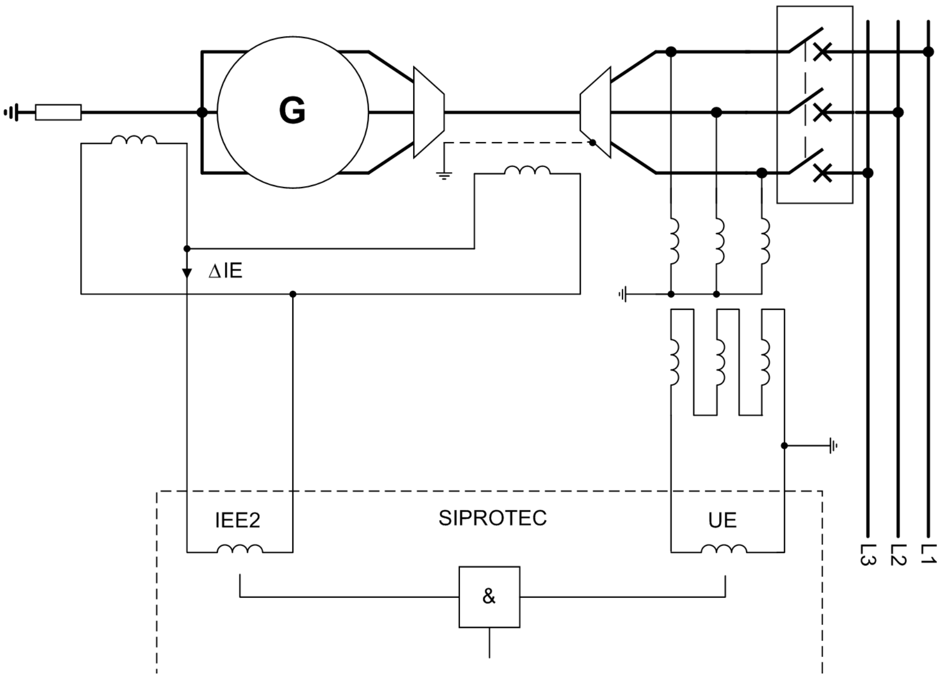


Figure 2-88 Earth Current Differential Protection with Busbar Connection

Determination of the Faulty Phase

In addition to this, a supplementary function serves to determine the faulty phase. As the phase-earth-voltage in the faulty phase is less than in the two remaining phases and as the voltage even increases in the latter ones, the faulty phase can be determined by determining the smallest phase-earth voltage in order to generate a corresponding result as fault message.

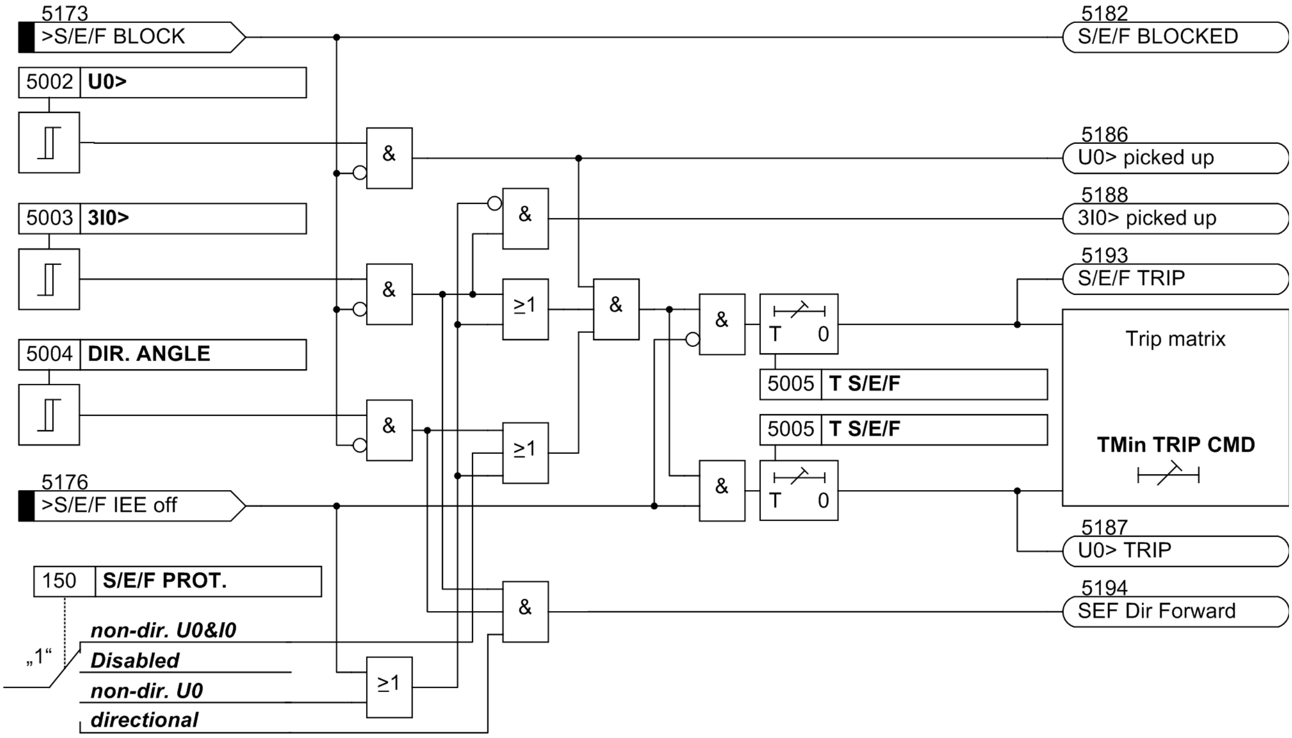


Figure 2-89 Logic Diagram of 90 % Stator Earth Fault Protection

2.28.2 Setting Notes

General

90 % stator earth fault protection is only effective and available if address 150 **S/E/F PROT.** is set to ***directional***; ***non-dir. U0*** or ***non-dir. U0&I0*** during configuration. If ***non-dir. U0*** was selected, the parameters affecting the earth current are not displayed. If one of the options ***directional*** or ***non-dir. U0&I0*** was selected, the parameters affecting the earth current are accessible. For machines in busbar connection, one of the latter options must enabled since differentiation between a power system earth fault and a machine earth fault is only possible by way of the earth current. If used as „earth differential protection“, address 150 **S/E/F PROT.** = ***non-dir. U0&I0*** is set. If the function is not required ***Disabled*** is set. Address 5001 **S/E/F PROT.** serves to switch the function ***ON*** or ***OFF*** or to block only the trip command (***Block relay***).

Displacement Voltage

The criterion for the occurrence of an earth fault in the stator circuit is the emergence of a neutral displacement voltage. Exceeding the set value 5002 **U0>** therefore causes pickup for stator earth protection.

The setting must be chosen such that the protection does not pick up because of operational asymmetries. This is particularly important for machines in busbar connection since all voltage asymmetries of the network affect the voltage starpoint of the machine. The pickup value should be at least twice the value of operational asymmetry. A value between 5% and 10% of the full displacement value is normal.

For machines in unit connection, the pickup value has to be chosen such that displacements during network earth faults which affect the stator circuit via the coupling capacitances of the unit transformer do not lead to pickup. The damping effect of the loading resistor must also be considered here. Instructions for dimensioning the loading resistor are contained in the publication "Planning Machine Protection Systems" /5/. The setting value is twice the displacement voltage which is coupled in at full network displacement. The final setting value is determined during commissioning using primary values.

Delay

The stator earth fault trip is delayed by the time set under address 5005 **T S/E/F**. For the delay time, the overload capacity of the load equipment must be considered. All set times are additional delay times and do not include operating times (measurement time, reset time) of the protection function itself.

Earth Current

Addresses 5003 and 5004 are only of importance for machines in busbar connection, where 150 **S/E/F PROT.** = ***directional*** or ***non-dir. U0&I0*** has been set. The following considerations are not applicable for unit connection.

The pick-up value 5003 **3I0>** is set so that for an earth fault in the protected zone, the earth current safely exceeds the setting.

Since the residual earth current in a resonant-earthed network is very small, also to be independent of network conditions in general, an earthing transformer with an ohmic loading resistor is normally provided to increase the residual wattmetric current in the event of an earth fault. Instructions for dimensioning the earth current transformer and loading resistor are contained in the publication „Planning Machine Protection Systems“, /5/.

Since the magnitude of earth fault current in this case is determined mainly by the loading resistor, a small angle is set for 5004 **DIR. ANGLE**, e.g. ***15°***. If the network capacitances in an isolated network are also to be considered, then a larger angle (approx. ***45°***) can be set which corresponds to the superimposition of the capacitance network current onto the load current.

The directional angle 5004 **DIR. ANGLE** indicates the phase displacement between the neutral displacement voltage and the perpendicular to the directional characteristic, i.e. it is equal to the inclination of the directional characteristic to the reactive axis.

If, in an isolated network, the capacitances to earth of the network are sufficiently large for earth current creation, it is also possible to operate without an earthing transformer. In this case an angle of approximately 90° is set (corresponding to sin φ connection).

Example busbar connection:

Earthing transformer $\frac{6.3\ \text{kV}}{\sqrt{3}} / \frac{500\ \text{V}}{3}$ (limb transformation) 27 kVA		
Loading resistance	10 Ω	
	10 A	continuous
	50 A	for 20s
Voltage divider	500 V / 100 V	
Toroidal c.t.	60 A / 1 A	
Protected zone	90 %	

With full neutral displacement voltage, the load resistor supplies

$$\frac{500\ \text{V}}{10\ \Omega} = 50\ \text{A}$$

Referred to the 6.3 kV side, this results in

$$I_{EE\ prim} = 50\ \text{A} \cdot \frac{500 / 3}{6300\ \text{V} / (\sqrt{3})} \cdot 3 = 6.87\ \text{A}$$

The secondary current of the toroidal transformer supplies to the input of the device

$$I_{EE\ sec} = \frac{I_{EE\ prim}}{60\ \text{A} / 1\ \text{A}} \cdot \frac{6.87\ \text{A}}{60} = 115\ \text{mA}$$

For a protected zone of 90 %, the protection should already operate at 1/10 of the full displacement voltage, whereby only 1/10 of the earth fault current is generated:

$$\text{Setting 3I0>} = \frac{115\ \text{mA}}{10} = 11.5\ \text{mA}$$

In this example **3I0>** is set to 11 mA. For the displacement voltage setting, 1/10 of the full displacement voltage is used (because of the 90% protected zone). Considering a 500 V/100 V voltage divider, this results in:

Setting value **U0>** = 10 V

The time delay must lie below the 50 A capacity time of the loading resistor, i.e. below 20 s. The overload capacity of the earthing transformer must also be considered if it lies below that of the loading resistor.

2.28.3 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
5001	S/E/F PROT.	OFF ON Block relay	OFF	Stator Earth Fault Protection
5002	U0>	2.0 .. 125.0 V	10.0 V	U0> Pickup
5003	3I0>	2 .. 1000 mA	5 mA	3I0> Pickup
5004	DIR. ANGLE	0 .. 360 °	15 °	Angle for Direction Determination
5005	T S/E/F	0.00 .. 60.00 sec; ∞	0.30 sec	T S/E/F Time Delay

2.28.4 Information List

No.	Information	Type of Information	Comments
5173	>S/E/F BLOCK	SP	>BLOCK stator earth fault protection
5176	>S/E/F IEE off	SP	>Switch off earth current detec.(S/E/F)
5181	S/E/F OFF	OUT	Stator earth fault prot. is switch OFF
5182	S/E/F BLOCKED	OUT	Stator earth fault protection is BLOCK.
5183	S/E/F ACTIVE	OUT	Stator earth fault protection is ACTIVE
5186	U0> picked up	OUT	Stator earth fault: U0 picked up
5187	U0> TRIP	OUT	Stator earth fault: U0 stage TRIP
5188	3I0> picked up	OUT	Stator earth fault: I0 picked up
5189	Uearth L1	OUT	Earth fault in phase L1
5190	Uearth L2	OUT	Earth fault in phase L2
5191	Uearth L3	OUT	Earth fault in phase L3
5193	S/E/F TRIP	OUT	Stator earth fault protection TRIP
5194	SEF Dir Forward	OUT	Stator earth fault: direction forward

2.29 Sensitive Earth Fault Protection (ANSI 51GN, 64R)

The sensitive earth current protection detects earth faults in systems with isolated or high-impedance earthed starpoint. This stage operates with the magnitudes of the earth current. It is therefore useful in applications where the magnitude of the earth current is an indicator of the earth fault. This may be the case e.g. in electrical machines in a busbar configuration in an isolated power system where during a machine earth fault of the stator winding, the entire network capacity supplies the earth fault current, but during a network earth fault, the earth fault current is negligible due to the low machine capacitance. The current can be measured using torroidal current transformers or Holmgreen connection.

In the 7UM62, the sensitive earth fault detection feature can be allocated to either input I_{ee1} or I_{ee2}. This choice is made during configuration (see Section 2.4).

Because of the high sensitivity this protection is not suited for detection of high earth fault currents (above approx. 1 A at the terminals for sensitive earth current connection). If this protection feature nevertheless is to be used for earth fault protection, an additional, external current transformer is required as intermediate transformer.

Note: The sensitive earth current protection may use the same current measuring input (I_{ee2}) used for the directional or non–directional stator earth fault protection with busbar-connection. This means that the sensitive earth fault protection thereby uses the same measured values if address 150 **S/E/F PROT.** is set to ***directional*** or ***non-dir. U0&I0***.

2.29.1 Functional Description

Application as Rotor Earth Fault Protection

Also, the highly sensitive earth fault protection can be used for rotor earth fault detection when a system frequency bias voltage is applied to the rotor circuit (see Figure 2-90). In this case, the maximum earth current is determined by the magnitude of the bias voltage U_V and the capacitative coupling to the rotor circuit.

A measured value supervision is provided for this application as rotor earth fault protection. The measurement circuit is assumed closed as long as the earth current, even with intact insulation, exceeds a parametrizable minimum value **IEE<** due to the rotor-earth capacitance. If the value is undershot an alarm is issued after a short delay time of 2 s.

Measurement Method

Initially, the residual current is numerically filtered so that only the fundamental wave of the current is used for the measurement. This makes the measurement insensitive to short-circuit transients and harmonics.

The protection consists of two stages. A pickup is detected as soon as the first parametrized threshold value **IEE>** is exceeded. The trip command is transmitted subsequent to the **T IEE>** delay time. A pickup is detected as soon as the second parametrized threshold value **IEE>>** is exceeded. The trip command is transmitted subsequent to the **T IEE>>** delay time.

Both stages can be blocked via a binary input.

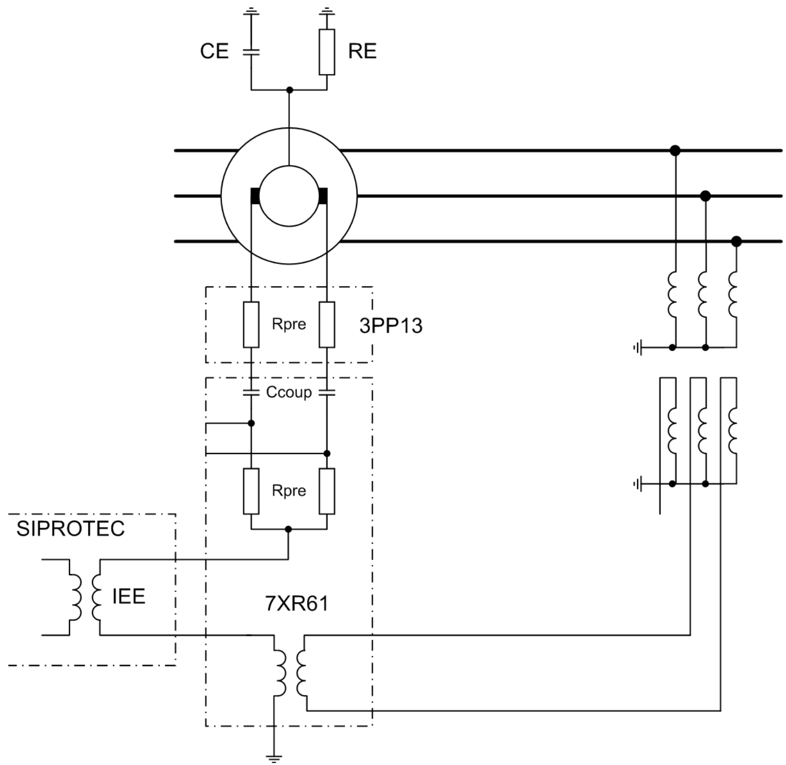


Figure 2-90 Application example as rotor earth fault protection

Note 3PP13 is only necessary if more than 0.2 A_{eff} are flowing permanently; (rule: Uerr load > 150 V). In this case the internal resistors Rpre inside the 7XR61 must be shorted.

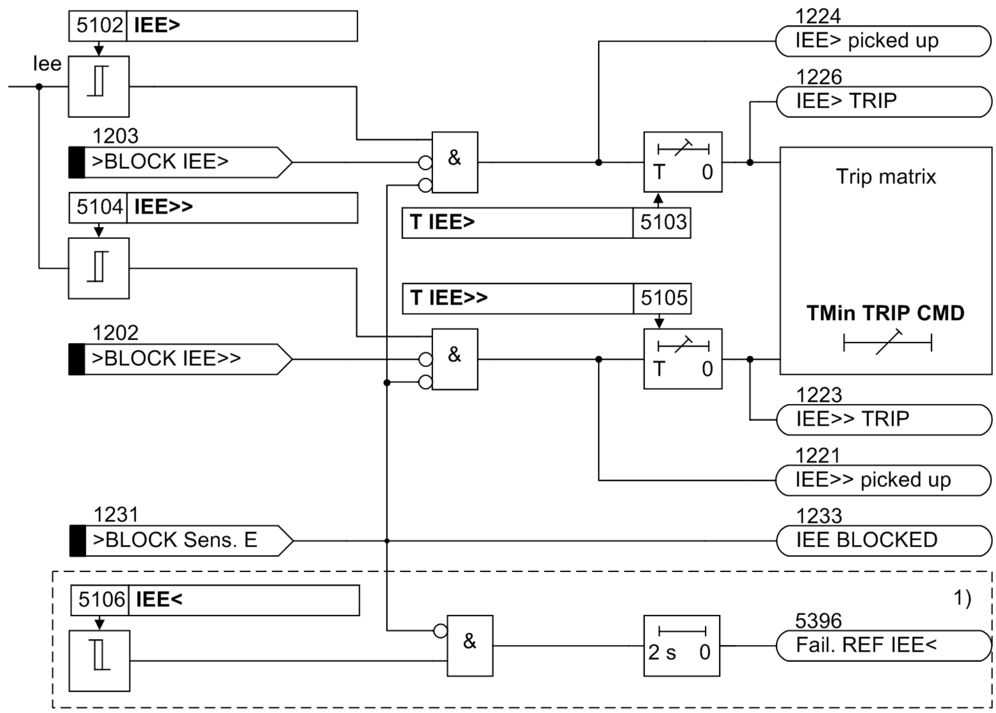


Figure 2-91 Logic Diagram of the Sensitive Earth Fault Detection

1) Parameters and indications are only visible if **Rotor Earth Fault Protection R, fn (ANSI 64R)** address 160 is set to ***Disabled***.

2.29.2 Setting Notes

General

The sensitive earth fault protection is only effective and available if address 151 **O/C PROT. IEE>** = ***with IEE1*** or ***with IEE2*** is assigned. If when configuring the 90 % stator earth fault protection (150 **S/E/F PROT.**, see subsection 2.4) one of the options with current value is chosen, the sensitive current measuring inpu of the device 7UM62 is thus occupied. The user must be aware that the sensitive earth fault detection may use the same measuring input (I_{EE2}) and thus the same measuring quantity. If sensitive earth fault detection is not required, ***Disabled*** is set. Address 5101 **O/C PROT. IEE** serves to switch the function ***ON*** or ***OFF*** or to block only the trip command (***Block relay***).

Use as Rotor Earth Fault Protection

The sensitive earth current protection can be used to detect earth faults either in the stator or in the rotor winding of the generato, provided that the magnitude of the earth current alone is sufficient as a criterion. In very high-ohmic circuits or those isolated from earth, sufficiently large earth currents must be ensured.

When, for example, used as rotor earth fault protection, a system frequency bias voltage ($U_V \approx 42$ V) must be applied to the rotor circuit by means of the 7XR61series device in Figure „ The application case as rotor earth fault protection“ in Section 2.29). Because of this bias voltage, a current flows through the earth capacitance even with proper earth isolation, which can be used as a criterion for a closed measuring circuit (address 5106 **IEE<**). Approximately 2mA is a typical pickup value. The monitoring stage is ineffective is this value is set to 0. This can become necessary if the earth capacitances are too small.

The earth current pick-up value 5102 **IEE>** is chosen such that isolation resistances R_E between 3 kΩ to 5 kΩ can be detected:

Warning stage setting value e.g.: $\text{IEE>} \approx \dfrac{U_V}{R_E + Z_{Coup}} \approx \dfrac{42\text{ V}}{3.6\ \Omega + 0.4\ \Omega} \approx 10\text{ mA}$

Where the setting value should be at least twice the interference current caused by the earth capacitances of the rotor circuit.

The 5104 **IEE>>** trip stage should be dimensioned for a fault resistance of about 1.5 kΩ.

Trip stage setting value e.g. $\text{IEE>>} \approx \dfrac{U_V}{R_E + Z_{Coup}} \approx \dfrac{42\text{ V}}{1.5\ \Omega + 0.4\ \Omega} \approx 23\text{ mA}$

with Z_{Coup} = Impedance of the series device at nominal frequency.

The 5103 **T IEE>** and 5105 **T IEE>>** tripping time delay do not include the operating times.

Use as Stator Earth Fault Protection

Please see also Section 2.28. For use as stator earth fault protection, the earth current may have to be increased by an ohmic load resistor at the earthing transformer. Instructions for dimensioning the earth current transformer and loading resistor are given in the publication "Planning Machine Protection Systems" /5/.

Use as Earth Fault Protection

For low-voltage machines with incorporated neutral conductor or machines with low-impedance earthed starpoint, the time-overcurrent protection of the phase branches already is an earth short-circuit protection, since the earth fault current also flows through the faulty phase . If the sensitive earth current detection nevertheless shall be used as short-circuit to earth protection, an external intermediate transformer must be used to ensure that the short-circuit current does not exceed the thermal limit values (15 A continuous, 100 A for < 10 s, 300 A for < 1 s) of this measuring input..

2.29.3 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
5101	O/C PROT. IEE	OFF ON Block relay	OFF	Sensitive Earth Current Protection
5102	IEE>	2 .. 1000 mA	10 mA	IEE> Pickup
5103	T IEE>	0.00 .. 60.00 sec; ∞	5.00 sec	T IEE> Time delay
5104	IEE>>	2 .. 1000 mA	23 mA	IEE>> Pickup
5105	T IEE>>	0.00 .. 60.00 sec; ∞	1.00 sec	T IEE>> Time Delay
5106	IEE<	1.5 .. 50.0 mA; 0	0.0 mA	IEE< Pickup (Interrupted Circuit)

2.29.4 Information List

No.	Information	Type of Information	Comments
1202	>BLOCK IEE>>	SP	>BLOCK IEE>>
1203	>BLOCK IEE>	SP	>BLOCK IEE>
1221	IEE>> picked up	OUT	IEE>> picked up
1223	IEE>> TRIP	OUT	IEE>> TRIP
1224	IEE> picked up	OUT	IEE> picked up
1226	IEE> TRIP	OUT	IEE> TRIP
1231	>BLOCK Sens. E	SP	>BLOCK sensitive earth current prot.
1232	IEE OFF	OUT	Earth current prot. is swiched OFF
1233	IEE BLOCKED	OUT	Earth current prot. is BLOCKED
1234	IEE ACTIVE	OUT	Earth current prot. is ACTIVE
5396	Fail. REF IEE<	OUT	Failure R/E/F protection IEE<

2.30 100-%-Stator Earth Fault Protection with 3rd Harmonics (ANSI 27/59TN 3rd Harm.)

The measurement method described in section 2.28 is based on the fundamental wave of the displacement voltage and allows protecting up to 90 % to 95 % of the stator winding. A non-line-frequency voltage must be used to achieve 100 % protection. In the 7UM62, the 3rd harmonic is used for this purpose.

2.30.1 Functional Description

Mode of Operation

The 3rd harmonic emerges in each machine in a more or less significant way. It is caused by the shape of the poles. If an earth fault occurs in the generator stator winding, the division ratio of the parasitic capacitances changes, since one of the capacitances is short-circuited by the earth fault. During this procedure, the 3rd harmonic measured in the starpoint decreases, whereas the 3rd harmonic measured at the generator terminals increases (see the following figure). The 3rd harmonic forms a zero phase-sequence system and can thus also be determined by means of the voltage transformer switched in wye/delta or by calculating the zero phase-sequence system from the phase-earth-voltages.

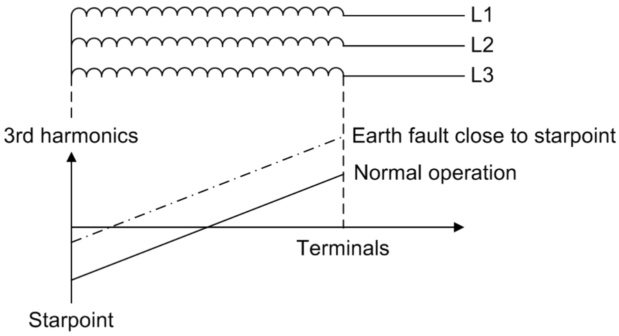


Figure 2-92 Profile of the 3rd Harmonic along the Stator Winding

Moreover, the extent of the 3rd harmonic depends on the operating point of the generator, i.e. a function of active power P and reactive power Q. For this reason, the working range of the stator earth fault protection is restricted in order to increase security.

With busbar connection all machines contribute to the 3rd harmonic, which impedes separation of the individual machines.

Measuring Principle

The content of the 3rd harmonic in the measurement value is the pickup criterion. The 3rd harmonic is determined from the displacement voltage measured over two cycles by means of digital filtering.

Different measuring procedures are applied, depending on how the displacement voltage is detected (configuration parameter 223 **UE CONNECTION**):

1. ***neutr. transf.***: Connection of the U_E input to the voltage transformer at the machine starpoint
2. ***broken delta***: Connection of the U_E input to the broken delta winding
3. ***Not connected***: Calculation of the displacement voltage from the three phase-earth-voltages, if the U_E input is not connected
4. ***any VT***: Connection of any voltage; the 100% stator earth fault protection function is blocked.
5. ***Rotor***: Connection of the bias voltage for rotor earth fault protection; the 100% stator earth fault protection function is then blocked.
6. ***Load. resistor***: Connection of U_E for the 100 % stator earth fault protection with 20 Hz. The function 100% stator earth fault protection with 3rd harmonic is then blocked.
7. ***Uen-winding***: Calculation of the displacement voltage from the three phase-earth-voltages, if the U_E input is not connected

Neutral Transformer

As an earth fault in the starpoint causes a reduction of the measured 3rd harmonic compared with the nonfault case, the protective function is implemented as an undervoltage stage (5202 **U0 3.HARM<**). This arrangement is the preferred application.

Broken Delta Winding

If no neutral transformer exists, the protection function is based on the zero component of the 3rd harmonic of the terminal voltages. This voltage increases in a fault case. In this case, the protection function is an overvoltage stage (5203 **U0 3.HARM>**).

In order to achieve increased sensitivity, the pickup value can be lowered in proportion to the active power. This feature is set at address 5207 **U0 3.H.(V/100%)**. Internally, the current pickup value is calculated from the formula:

$$U_{3H,\ corrected} = U_{3H} + U_{corr} \cdot (100\ \% - P_{meas})$$

Where:

$U_{3H,\ corrected}$	Internally used pickup value
U_{3H}	Value set at address 5203 **U0 3.HARM>** with an active power of 100 %
U_{corr}	Correction factor in volt/percent, set at address 5207 **U0 3.H.(V/100%)** (Note : set negative values)
P_{meas}	Measured active power

Figure 2-93 shows the operating principle.

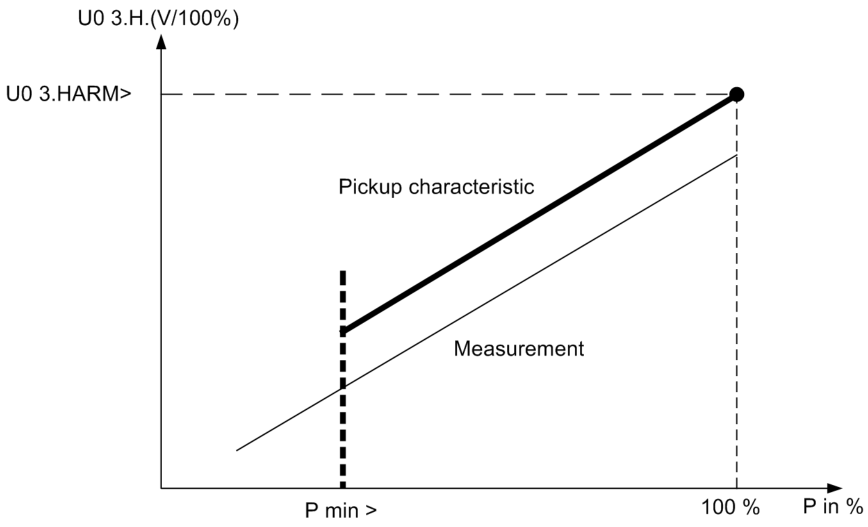


Figure 2-93 Automatic Lowering of Pickup Value **U0 3.HARM>**

The trip characteristic is released as soon as the settable minimum active power is reached. As an additional security feature, the following limitation is provided: If due to the power-dependent correction factor the corrected pickup value $U_{3H,\ corrected}$ drops below the minimum possible setting value (0,2 V), the pickup value will be kept at that setting value.

Not connected/Uen-winding; calculation of U_0

Just as for the connection to the broken delta winding, an increase of the 3rd harmonic during a fault also results for the calculated voltage. The 5203 **U0 3.HARM>** parameter is also relevant.

Connected to any transformer; Rotor

With these connection types, 100% stator earth fault protection is ineffective.

The following figure shows the logic diagram for the 100 % stator earth fault protection function.

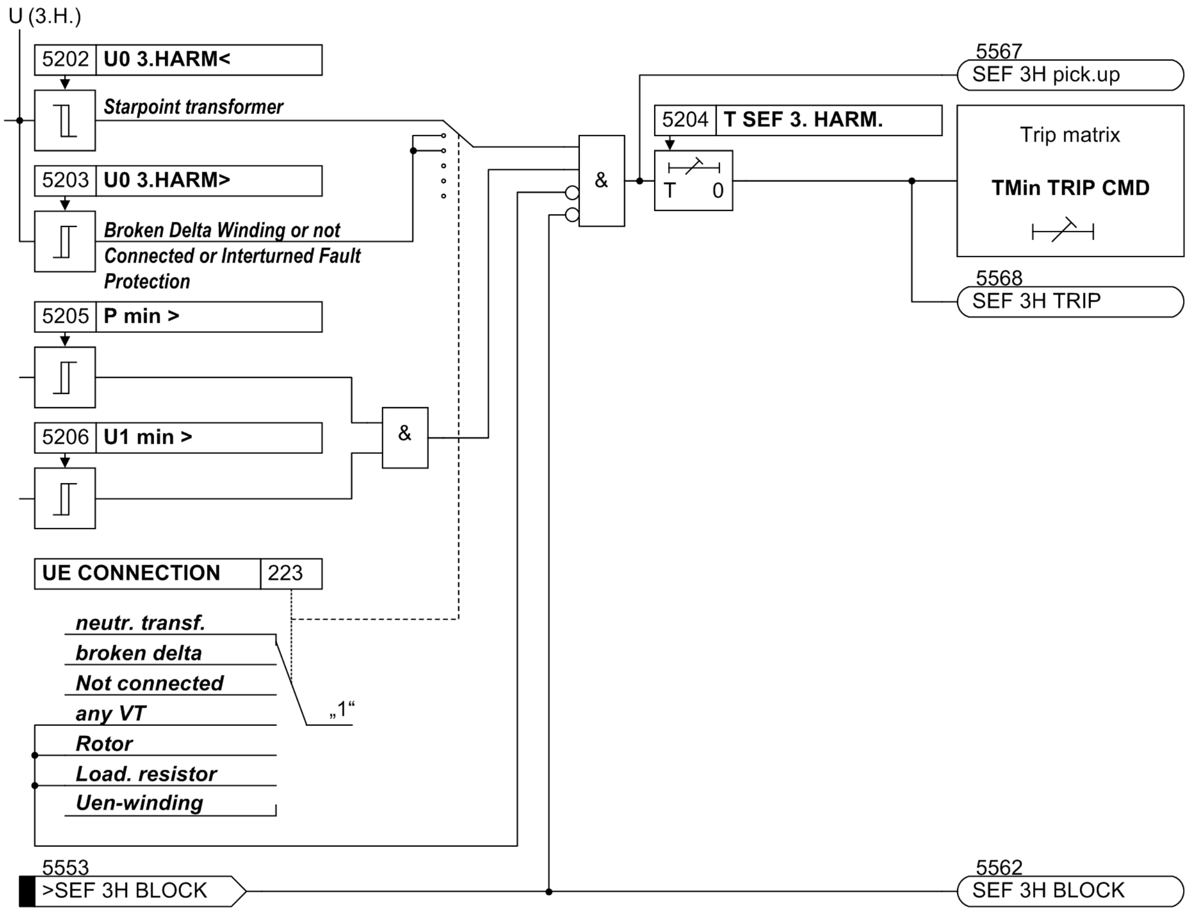


Figure 2-94 Logic diagram of the 100% stator earth fault protection

2.30.2 Setting Notes

General

The 100 % stator earth fault protection is only effective and available if address 152 **SEF 3rd HARM.** = ***Enabled*** is set during configuration. If the function is not required ***Disabled*** is set. Address 5201 **SEF 3rd HARM.** serves to switch the function ***ON*** or ***OFF*** or to block only the trip command (***Block relay***).

Connection Type

Depending on the system conditions, at address 223 **UE CONNECTION** the user specified during the project configuration if the displacement voltage U_{en} is tapped via a neutral transformer (***neutr. transf.***) or via the broken delta winding of an earthing transformer (***broken delta***) and fed to the protection device. If it is not possible to make the displacement voltage available to the protection device as a measured quantity, computed quantities are used and ***Not connected*** or ***Uen-winding*** must be set. The option ***any VT*** is selected if the voltage input of the 7UM62 is to be used for measuring any other voltage instead of for earth fault protection. With this setting the 100% stator earth fault protection function is ineffective. The option ***Rotor*** is selected if the displacement voltage for rotor earth fault connection shall be fed in at this input. In this case, too, the 100% stator earth fault protection function is ineffective.

The option ***Load. resistor*** is selected for 100% stator earth fault protection with 20 Hz bias voltage. With this setting the 100% stator earth fault protection function with 3rd harmonic is blocked.

Pickup Value for 3rd Harmonic

Depending on the selection of the connection type, only one of the two setting parameters 5202 or 5203 is accessible.

The setting values can only be determined within the framework of a primary test. The following applies in general:

- The undervoltage stage, address 5202 **U0 3.HARM<**, is relevant for a connection to a transformer in the starpoint. The pickup value should be chosen as low as possible.
- The overvoltage stage, address 5203 **U0 3.HARM>**, is relevant for a connection via the broken delta winding of an earthing transformer and for a not-connected, but internally calculated displacement voltage.

As mentioned in the Functional Description in Section 2.30, side title „Broken Delta Winding", the sensitivity of the **U0 3.HARM>** stage can be increased if a power-dependent correction of the pickup value is made. The relevant parameter for this is set at address 5207 **U0 3.H.(V/100%)**. The default setting of this parameter is 0, which means that the correction is disabled.

The correction setting is made with the following method:

- Measurement of the 3rd harmonic for different active powers using the operational measured values. For the settings secondary values are recommended.
- Please note that the percentages of the active power operational measured values relate to the protected object ($S_{N\ Gen}$). These measured power values must be converted into nominal device values (see below example).
- Interpolation of the measured values by a straight line. Reading the 3rd harmonic voltage at 100 % $S_{N\ device}$ (P1) and 50 % $S_{N\ device}$ (P2) of the active power. Calculation of the difference based on the following relationship:

$$U_{corr} = -\frac{U_{3H1} - U_{3H2}}{P_1 - P_2}$$

Figure 2-95shows an example of the measurements made on a generator. The active power dependence of the 3rd harmonic has been determined for operation both in underexcitation and in overexcitation conditions.

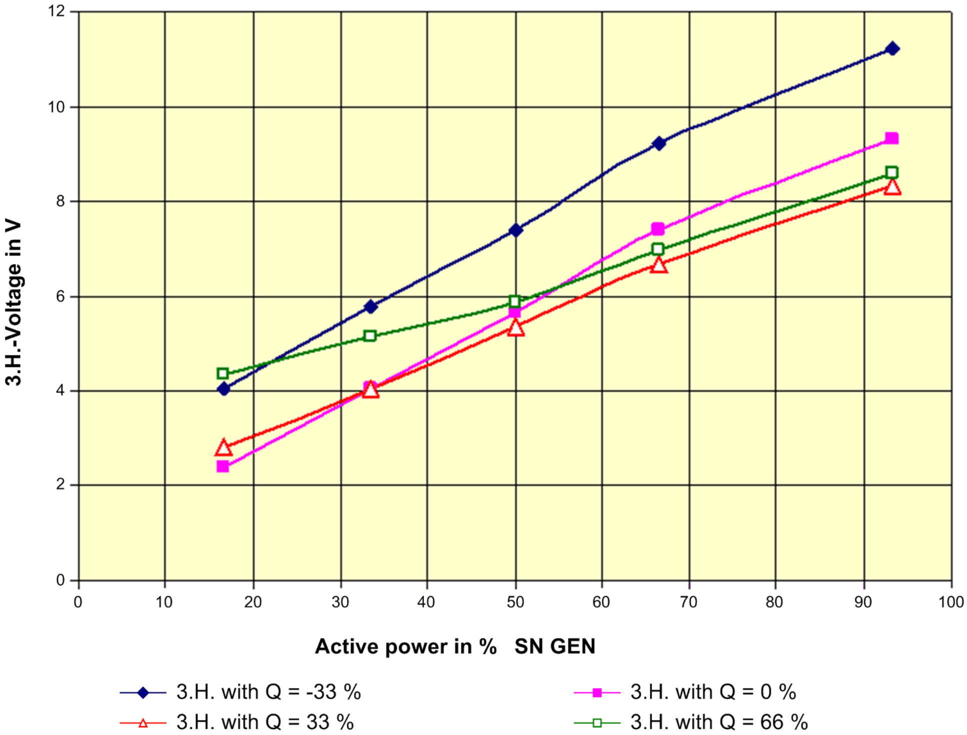


Figure 2-95 3rd harmonic secondary voltage as a function of the active power (reactive power as parameter)

As Figure 2-95 shows, the rise is almost equal in both cases. The most unfavourable case is operation in underexcitation conditions.

In Figure 2-96 this curve is extrapolated to 100 % $S_{N\ device}$

Using the data of the reference system in chapter 2.1, we obtain $S_{N\ Gen}$ = 5.27 MVA and $S_{N\ device} = \sqrt{3} \cdot U_{VT\ prim} \cdot I_{CT\ prim} = \sqrt{3} \cdot 6.3kV \cdot 500A$ = 5.46 MVA.

The x-axis in Figure 2-95 must be multiplied with factor $S_{N\ Gen}/S_{N\ device}$ = 5.27 MVA/5.46 MVA = 0.965 for rescaling.

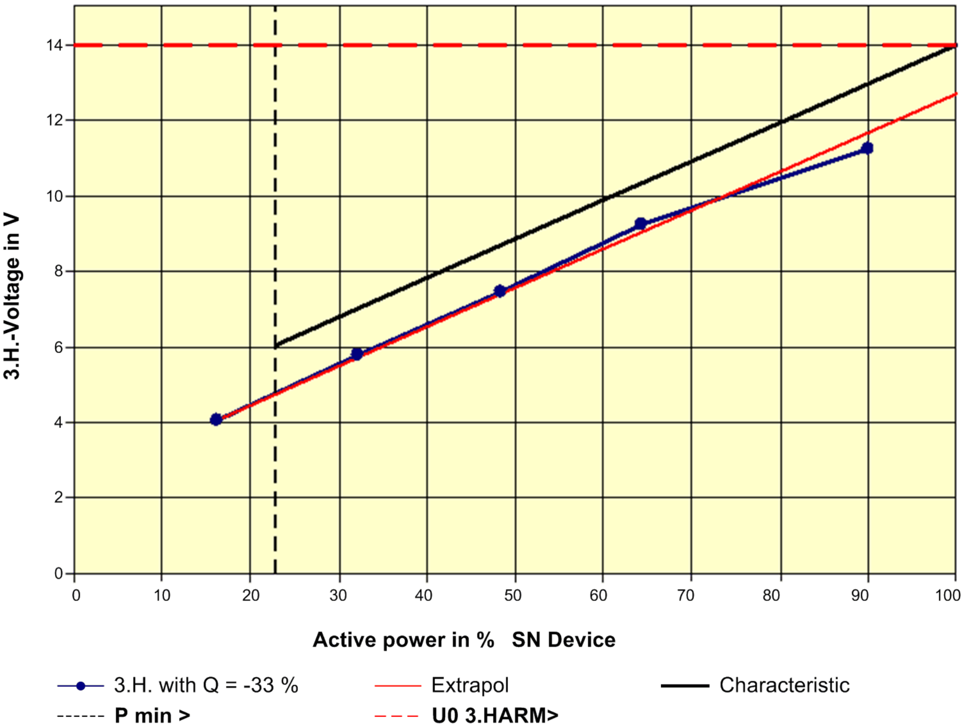


Figure 2-96 3. harmonic secondary voltage as a function of the active power referred to $S_{N\ device}$ (extrapolation of this voltage and final characteristic)

With 100 % active power the extrapolated value is (U_{3H1}) 12.7 V.

With 50 % active power the value is (U_{3H2}) 7.5 V.

The setting value is thus calculated as follows:

$$U_{corr} = -\frac{12.7\ V - 7.5\ V}{100\ \% - 50\ \%} = -\frac{5.2\ V}{50\ \%} = -\frac{10.4\ V}{100\ \%}$$

At address 5207 **U0 3.H.(V/100%)** – 10.4 is set. The pickup value in address 5203 **U0 3.HARM>** must likewise be extrapolated to 100 %. If you choose 14.0 V for it, we obtain a pickup value of 14.0 V – 5.2 V = 8.8 V for 50 % active power (referring to $S_{N\ device}$). The resulting active power dependent characteristic is shown in Figure 2-96. It lies above the extrapolated measured values.

If cos φ = 0.8 and the generator is run at this nominal value, the active power $P_{N\ Gen} = S_{N\ Gen} \cdot \cos\varphi$ = 5.27 MVA · 0.8 = 4.22 MW (80 % $S_{N\ Gen}$) and $P_{N\ Gen}/S_{N\ device}$ = 4.22/5.46 = 77.3%.

The resulting pickup value is 14.0 V – 10.4V/100 % (100% -77.3 %) = 14.0 V – 2.36 V = 11.64 V.

As described under the side title „Operating Range“, the characteristic must be limited by defining the minimum possible active power. Since the 3rd harmonic has been measured in Figure up to P = 20 %, and the behaviour is still almost linear, a setting of parameter 5205 **P min >** = 30 % · $P_{N\ Gen}/S_{N\ device}$ = 0.3 · 4.22/5.46 = 23 % is possible with a selected safety margin of 10 %.

Operating Range

Due to the strong dependency of the measurable 3rd harmonic from the corresponding working point of the generator, the working area of the 100–%–stator earth fault protection is only tripped above the active-power threshold set via 5205 **P min >** and on exceeding a minimum positive phase-sequence voltage 5206 **U1 min >**.

Recommended setting:

P_{min}> 40 % $P/S_{N\ Gen}$

$U_{1\ min}$> 80 % U_N

Time Delay

The tripping in case of an earth fault is delayed by the time set at address 5204 **T SEF 3. HARM.**. The set time is an additional time delay not including the operating time of the protective function.

2.30.3 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
5201	SEF 3rd HARM.	OFF ON Block relay	OFF	Stator Earth Fault Protection 3rdHarm.
5202	U0 3.HARM<	0.2 .. 40.0 V	1.0 V	U0 3rd Harmonic< Pickup
5203	U0 3.HARM>	0.2 .. 40.0 V	2.0 V	U0 3rd Harmonic> Pickup
5204	T SEF 3. HARM.	0.00 .. 60.00 sec; ∞	0.50 sec	T SEF 3rd Harmonic Time Delay
5205	P min >	10 .. 100 %; 0	40 %	Release Threshold Pmin>
5206	U1 min >	50.0 .. 125.0 V; 0	80.0 V	Release Threshold U1min>
5207	U0 3.H.(V/100%)	-40.0 .. 40.0	0.0	Correction Factor for Pickup (V/100%)

2.30.4 Information List

No.	Information	Type of Information	Comments
5553	>SEF 3H BLOCK	SP	>BLOCK SEF with 3.Harmonic
5561	SEF 3H OFF	OUT	SEF with 3.Harm. is switched OFF
5562	SEF 3H BLOCK	OUT	SEF with 3.Harm. is BLOCKED
5563	SEF 3H ACTIVE	OUT	SEF with 3.Harm. is ACTIVE
5567	SEF 3H pick.up	OUT	SEF with 3.Harm. picked up
5568	SEF 3H TRIP	OUT	SEF with 3.Harm. TRIP

2.31 100-%-Stator Earth Fault Protection with 20 Hz Voltage Injection (ANSI 64G - 100%)

The 100 % stator earth fault protection detects earth faults in the stator windings of generators which are connected with the network via a unit transformer. This protection function, which works with a 20 Hz injected voltage, is independent of the network frequency displacement voltage appearing in earth faults, and detects earth faults in all windings including the machine starpoint. The measuring principle used is not influenced at all by the generator operating mode and allows measurements even with the generator at standstill. The two measuring principles – measurement of the displacement voltage and evaluation of the measured quantities at an injected 20 Hz voltage – allow to implement reliable protection concepts that complement one another.

If an earth fault in the generator starpoint or close to the starpoint is not detected, the generator is operated as "earthed". A subsequent fault (e.g. a second earth fault) causes a single-pole short-circuit that may have an extremely high fault current because the generator zero impedance is very small.

The 100 % stator earth fault protection is for this reason a basic function for large generators.

2.31.1 Functional Description

Basic Principle

The basic principle is shown in the following figure. An external low frequency alternating voltage source (20 Hz) injects into the generator starpoint a voltage of max. 1 % of the rated generator voltage. If an earth fault occurs in the generator starpoint, the 20 Hz voltage drives a current through the fault resistance. From the driving voltage and the fault current, the protective relay determines the fault resistance. The protection principle described here also detects earth faults at the generator terminals, including connected components such as voltage transformers.

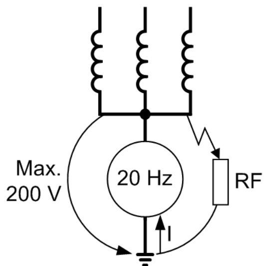


Figure 2-97 Basic Principle of Voltage Injection into the Generator Starpoint

Circuit Design

To implement the above concept, some additional equipment is required. The following picture shows a 20 Hz generator generates a square-wave voltage with an amplitude of approx. 25 V. This square-wave voltage is fed via a bandpass into the loading resistor of the earthing or neutral transformer. The bandpass serves for rounding the square-wave voltage and for storing energy. The 20 Hz resistance of the bandpass is approx. 8 Ω. The bandbass assumes also a protection function. If the load resistor carries the full displacement voltage during a terminal-to-earth fault, the higher series resistance of the bandpass protects the 20 Hz generator from excessive feedback currents.

The driving 20 Hz voltage is taken directly at the loading resistor using a voltage divider. In addition the flowing 20 Hz current is measured using a miniature CT. Both values (U_{SEF} and I_{SEF}) are fed to the protection device.

The voltage to be injected into the generator starpoint depends on the driving 20 Hz voltage (voltage divider: load resistor and bandpass), and on the transformation ratio of the neutral or earthing transformer.

To prevent the secondary load resistance from becoming too small (it should be greater than 0.5 Ω where possible), a high secondary rated voltage should be chosen for the earthing or neutral transformer. 500 V has proven to be a practical value.

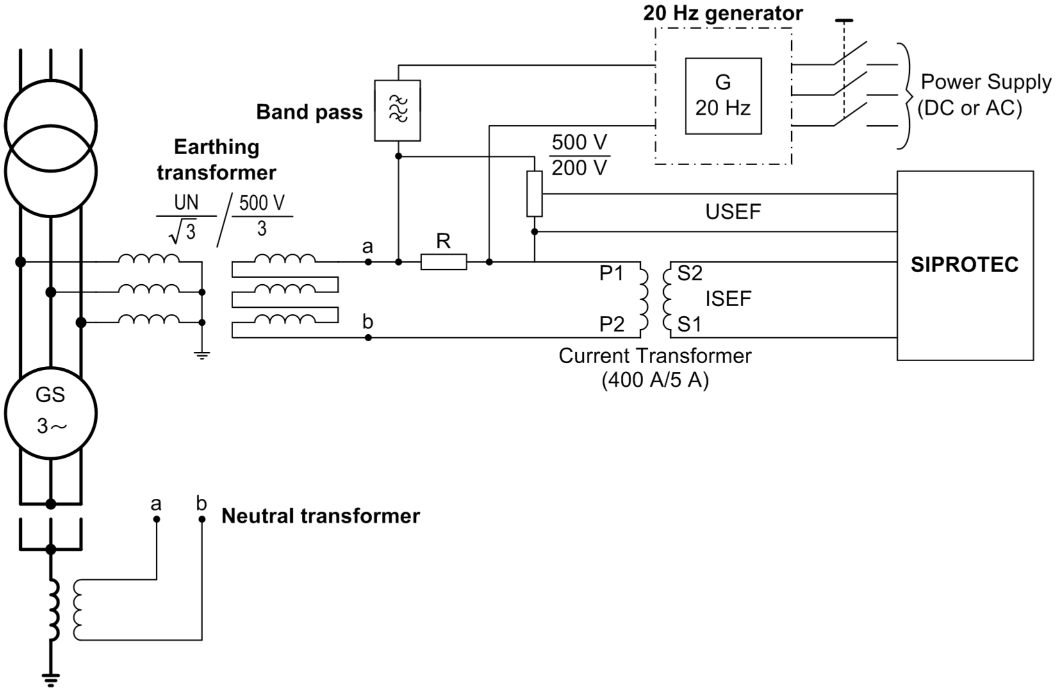


Figure 2-98 Circuit Design of the 100-% Stator Earth Fault Protection with Earthing Transformer or Neutral Transformer

R Loading resistance

U_{SEF} Displacement voltage at the protective relay

I_{SEF} Current measured at the protective relay

The same measuring principle can also be used with a primary loading resistor. The 20 Hz voltage is connected in this case via a voltage transformer, and the starpoint current is directly measured. The setting notes (section 2.31.2) contain the connection scheme and information on the circuit design.

Measurement method

From the two measured quantities U_{SEF} and I_{SEF} in the above picture, the 20 Hz current and voltage vectors are calculated, and from the resulting complex impedance the ohmic fault resistance is determined. This method eliminates disturbances caused by stator earth capacitance and ensures a high sensitivity. The measuring accuracy is further increased by using mean current and voltage values obtained over several cycles for calculating the resistance.

The model takes into account a transfer resistance R_{PS} that may be present at the neutral, earthing or voltage transformer. Other error factors are taken into account in the angle error.

In addition to determination of the earth resistance, an earth current stage is provided which processes the current rms value and thus takes into account all frequency components. It is used as a backup stage and covers approx. 80 to 90 % of the protection zone.

A monitoring circuit checks the coupled fed in 20 Hz voltage and the 20 Hz current and detects by evaluating them any failure of the 20 Hz generator or of the 20 Hz connection. In such a case resistance determination is blocked. The earth current stage remains active.

Logic

The following figure shows the logic diagram. It comprises:

- Monitoring of the 20 Hz connection
- Resistance calculation and threshold value decision
- Independent current measurement stage

The protection function has an alarm stage and a tripping stage. Both stages can be delayed with a timer. The earth current detection acts only on the tripping stage. Evaluation of the earth resistance measurement is blocked between 10 Hz and 40 Hz, because in this frequency range a zero voltage can also be generated by generators starting up or slowing down. This would then be superimposed on the connected 20 Hz voltage, causing measurement errors and overfunctioning.

The resistance measurement function is active for frequencies below 10 Hz (i.e. at standstill) and above 40 Hz. The earth current measurement is active over the entire range.

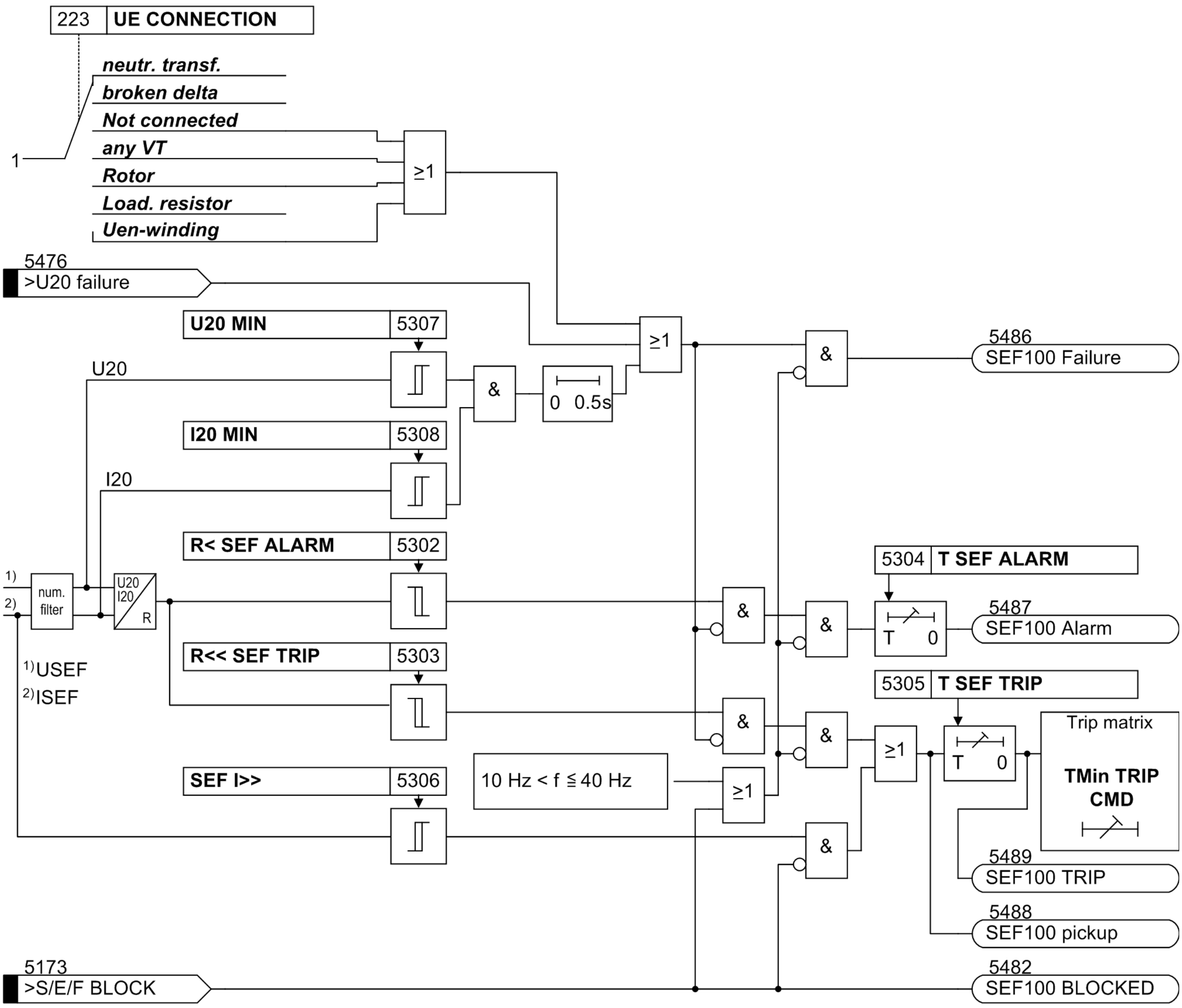


Figure 2-99 Logic Diagram of the 100 % Stator Earth Fault Protection

2.31.2 Setting Notes

General

The 100 % stator earth fault protection is only effective and available if address 153 **100% SEF-PROT.** is set to ***Enabled*** during configuration.

In addition, the function requires the following settings to be made in Power System Data 1:

- Address 275: **FACTOR R SEF**; Sets the resistance transformation ratio (see margin title "Fault Resistances")
- Address 223: **UE CONNECTION** should be set to ***Load. resistor*** for the application. The 20 Hz voltage is in this case measured at the U_E input, and the displacement voltage for the 90 % stator earth fault protection (SEF) is calculated from the phase-to-earth voltages. If the measured voltage is to be used for the 90 % SEF as well, set either ***neutr. transf.*** or ***broken delta***.

Address 5301 **100% SEF-PROT.** serves to switch the function ***ON*** or ***OFF*** or to block only the trip command (***Block relay***).

Fault Resistances

The final setting values are determined in the primary test as described in Section 3 Subsection „Commissioning“.

Please note that the protection calculates the earth resistance from the secondary values USEF and ISEF which are present at the device terminals. Allocation between this calculated value and the actual (primary) stator earth resistance is determined by the transformation ratio of the earthing and the neutral transformer. For the overall transformation, the following formula applies:

$$R_{Esec} = \frac{1}{Tr_{Ratio}^{2}} \cdot \frac{CT_{Ratio}}{VD_{Ratio}} \cdot R_{Eprim}$$

Definitions:

R_{Esec}	Earth resistance, converted to the device side
R_{Eprim}	Primary earth resistance of the stator winding (= fault resistance)
Tr_{Ratio}	Transformation ratio of the earthing or neutral transformer
	Earthing transformer (leg transformation divided by 3): $$Tr_{Ratio} = ET_{Ratio} = \frac{1}{3} \cdot \frac{\frac{U_{Nprim}}{\sqrt{3}}}{\frac{U_{Nsec}}{3}} = \frac{1}{3} \cdot \frac{\frac{U_{Nprim}}{\sqrt{3}}}{\frac{500\ V}{3}}$$
	Neutral transformer: $$Tr_{Ratio} = ET_{Ratio} = \frac{\frac{U_{Nprim}}{\sqrt{3}}}{U_{Nsec}}$$
CT_{Ratio}	Transformation ratio of the miniature CT
VD_{Ratio}	Division Ratio of the Voltage Divider

The conversion factor of the earth resistance is set as **FACTOR R SEF** at address 275 in Power System Data 1. The general formula for calculation (R_{Eprim} / R_{Esec}) is:

$$\text{FACTOR R SEF} = Tr_{Ratio}^{2} \cdot \frac{VD_{Ratio}}{CT_{Ratio}}$$

This formula applies only for almost ideal earthing or neutral transformers. If necessary, the measuring result from the primary tests must be set as **FACTOR R SEF**. For this the inserted fault resistance (trip stage) is related to the measured secondary fault resistance.

The primary fault resistance should be set between 1 and 2 kΩ for the trip stage and to between approx. 3 and 8 kΩ for the alarm stage. The default delay times have proven to be practical.

Example:

Earthing transformer $Tr_{Ratio} = \frac{1}{3} / \frac{10\text{ kV}}{\sqrt{3}} / \frac{500}{3}$		
Loading resistance	R_L	10 Ω (10 A continuously, 50 A for 20 s)
Voltage divider	VD_{Ratio}	500 V/200 V
Miniature CT	CT_{Ratio}	200 A/5 A

The transformation ratio of the miniature CT 400 A:5 A has been halved to 200A:5 A by passing the primary conductor twice through the transformer window.

For **FACTOR R SEF** the following value results:

$$\text{FACTOR R SEF} = \frac{\left(\frac{10\,000\text{ V}}{\sqrt{3}} \cdot \frac{3}{500\text{ V}}\right)^2}{9} \cdot \frac{500/200}{200/5} = 8.33$$

If a generator-side fault resistance of 1000 Ω is selected for the trip stage R<<, a resistance value of **R<< SEF TRIP** = 1000 Ω/8.33 = 120 Ω is set in address 5303. For the warning stage, a primary resistance of 3 kΩ yields a setting value of **R< SEF ALARM** = 360 Ω.

Earth Current Stage

The earth current stage has a backup protection function. It is set to a protected zone of approx. 80 %. Referenced to the maximum secondary fault current, the pickup threshold is at approx. 20 %, and the setting value is calculated as follows:

$$\text{SEF 100 I>>} = 0.2 \cdot \frac{U_{Nsec}}{R_L} \cdot \frac{1}{CT_{Ratio}} = 0.2 \cdot \frac{500\text{ V}}{10\ \Omega} \cdot \frac{5\text{ A}}{200\text{ A}} = 0.25\text{ A}$$

The delay time **T SEF TRIP** (address 5305), which is also relevant for the earth current stage, must be less than the tolerable time of the loading transformer (in this example 50 A for 20 s). The overload capability of the earthing or neutral transformer must also be considered if it lies below that of the loading resistor.

Monitoring

At addresses 5307 and 5308 the monitoring thresholds are set with **U20 MIN** and **I20 MIN**. If the 20 Hz voltage drops below the pickup value without the 20 Hz current rising, there must be a problem with the 20 Hz connection. The default settings will be adequate for most applications. In applications where the loading resistor is less than 1 Ω, the threshold **U20 MIN** must be reduced to 0.5 V. The current threshold **I20 MIN** may be left at 10 mA.

Correction Angle, Transfer Resistance

The parameter **PHI I SEF** (default setting 0 °) at address 5309 is used to compensate the angle errors of the CTs and angle distortions caused by a nonideal earthing or neutral transformer. The correct setting for this parameter can only be determined with a primary test. The adjustment should be made for the tripping value.

The same is true for the transfer resistance of the earthing or neutral transformer. This advanced parameter can be set with the DIGSI communication software (not possible in local operation). As a rule this resistance is negligible. For this reason, the default setting **SEF Rps** = 0.0 Ω was selected at address 5310. However, the transfer resistance of the voltage transformer is no longer negligible if the 20 Hz voltage is fed to a primary-side loading resistor via a voltage transformer.

In large power units with generator circuit breaker, applications arise where there is some additional loading equipment on the low-voltage side of the unit transformer to reduce the influence by the zero voltage when the generator circuit breaker is open. The 20 Hz source is connected via the neutral transformer in the generator starpoint. With the generator circuit breaker closed, the protection measures the loading resistance on the unit transformer side, which can be mistaken for an earth resistance. The advanced parameter address 5311 allows this additional loading resistance to be set. The default setting for **Rl-PARALLEL** is ∞. No additional loading resistance is assumed.

100 % Stator Earth Fault Protection with Primary Load Resistor

Some power systems with generators in unit connection have a load resistor installed directly in the generator starpoint to reduce interference. The following figure shows the necessary connection of the 20 Hz generator and the band pass in this application, and the integration of the protection device. The 20 Hz voltage is injected into the generator starpoint via a powerful voltage transformer and drops off at the primary load resistor. In the presence of an earth fault, an earth current flows through the CT in the starpoint. The protection function detects and processes this current in addition to the 20 Hz voltage.

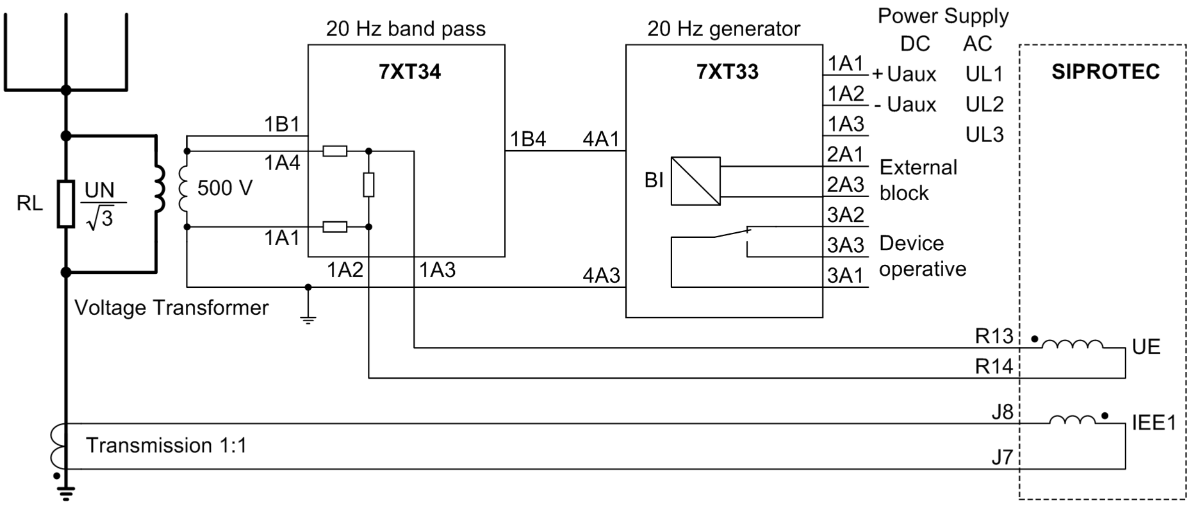


Figure 2-100 Connection: 100 % Stator Earth Fault Protection to a Primary Load Resistor

The connection designations for 7XT3300–0*A00/DD are given in Appendix A.3, Figure A-29.

A **two pole isolated voltage transformer** must be used with low primary/secondary impedance. This applies for the 20 Hz frequency.

Primary voltage:	$U_{N,Generator} / \sqrt{3}$ (non-saturated up to $U_{N,Generator}$)
Secondary voltage:	500 V
Power for 20 s (50 Hz or 60 Hz)	3 kVA
Primary-secondary impedance at 20 Hz	$Zps < R_L$ (but at least < 1000 Ω).
Potential manufacturer:	Ritz Messwandlerbau Salomon-Heine Weg 72 D-20251 Hamburg (Phone +49 (0) 40511123 333)

As the transformation ratio is 1:1, a current transformer with a maximum number of ampere windings must be chosen.

The CT is installed directly in the starpoint on the earth side, downstream of the load resistor.

Type:	5P10 or 5P15 (or 1FS10)
Rated secondary current:	1 A
Transformation Ratio	1 (1A/1A)

During the primary test the correction angle (address 5309 **PHI I SEF**) and the ohmic transfer resistance of the voltage transformer must be determined and set at address 5310 **SEF Rps**.

The conversion factor for the resistance (secondary – primary and vice-versa) is:

$$\text{FACTOR R SEF} = \frac{VT_{Ratio} \cdot VD_{Ratio}}{CT_{Ratio}}$$

<u>Example:</u>

Primary Load Resistor:	R_L = 1250 Ω
Voltage transformer:	10.5 kV/ √3/500 V
Ohmic Divider:	1650 Ω/660 Ω (5:2)
Current transformer:	1 A/1 A

$$\text{FACTOR R SEF} = \frac{\frac{10.5\text{ kV}}{\sqrt{3} \cdot 500\text{ V}} \cdot \frac{5}{2}}{\frac{1\text{ A}}{1\text{ A}}} = 30.3$$

Note

Due to the transfer resistance Rps, an ideal transformation ratio of the voltage transformers is not to be expected. For this reason major deviations of **FACTOR R SEF** can occur. It is recommended to measure the transformation ratio with 20 Hz infeed and the machine standing still. This value should then be set.

Trip stage: primary 2 kΩ, secondary 66 Ω

Alarm stage: primary 5 kΩ, secondary 165 Ω

Current stage

$$\text{SEF100I>>} = 0.1 \cdot \frac{\frac{U_{N,\ Generator}}{\sqrt{3}}}{R_L \cdot CT_{Ratio}} = 0.1 \cdot \frac{\frac{10.5\ \text{kV}}{\sqrt{3}}}{1250\ \Omega \cdot 1\ \text{A} / 1\ \text{A}} \approx 500\ \text{mA}$$

2.31.3 Settings

Addresses which have an appended "A" can only be changed with DIGSI, under Additional Settings.

Addr.	Parameter	Setting Options	Default Setting	Comments
5301	100% SEF-PROT.	OFF ON Block relay	OFF	100% Stator-Earth-Fault Protection
5302	R< SEF ALARM	20 .. 700 Ω	100 Ω	Pickup Value of Alarm Stage Rsef<
5303	R<< SEF TRIP	20 .. 700 Ω	20 Ω	Pickup Value of Tripping Stage Rsef<<
5304	T SEF ALARM	0.00 .. 60.00 sec; ∞	10.00 sec	Time Delay of Alarm Stage Rsef<
5305	T SEF TRIP	0.00 .. 60.00 sec; ∞	1.00 sec	Time Delay of Tripping Stage Rsef<<
5306	SEF I>>	0.02 .. 1.50 A	0.40 A	Pickup Value of I SEF>> Stage
5307	U20 MIN	0.3 .. 15.0 V	1.0 V	Supervision Threshold of 20Hz Voltage
5308	I20 MIN	5 .. 40 mA	10 mA	Supervision Threshold of 20Hz Current
5309	PHI I SEF	-60 .. 60 °	0 °	Correction Angle for I SEF 100%
5310A	SEF Rps	0.0 .. 700.0 Ω	0.0 Ω	Resistance Rps
5311A	RI-PARALLEL	20 .. 700 Ω; ∞	∞ Ω	Parallel Load Resistance

2.31.4 Information List

No.	Information	Type of Information	Comments
5473	>SEF100 BLOCK	SP	>BLOCK Stator earth fault protection
5476	>U20 failure	SP	>Failure 20Hz bias voltage (S/E/F)
5481	SEF100 OFF	OUT	Stator earth flt. prot. 100% is swit.OFF
5482	SEF100 BLOCKED	OUT	Stator earth flt. prot. 100% is BLOCKED
5483	SEF100 ACTIVE	OUT	Stator earth flt. prot. 100% is ACTIVE
5486	SEF100 Failure	OUT	Stator earth flt. prot. 100% Failure
5487	SEF100 Alarm	OUT	Stator earth flt. prot.100% Alarm stage
5488	SEF100 pickup	OUT	Stator earth flt. prot.100% picked up
5489	SEF100 TRIP	OUT	Stator earth flt. prot.100% TRIP

2.32 Sensitive Earth Fault Protection B (ANSI 51GN)

The IEE-B sensitive earth current protection feature of 7UM62 provides greater flexibility and can be used for the following applications.

Applications

- Earth current monitoring to detect earth faults (generator stator, terminal lead, transformer).
- 3rd harmonics earth current measurement for detection of earth faults near the generator star point. The connection is accomplished in the secondary circuit of the neutral transformer.
- Protection against load resistances by means of single-phase current monitoring.
- Shaft current protection in order to detect shaft currents of the generator shaft and prevent that bearings take damage. The function is mainly used for hydro-electric generators.

2.32.1 Functional Description

General

The sensitive earth current protection IEE-B uses either the hardware input I_{ee1} or I_{ee2}. These inputs are designed in a way that allows them to cut off currents greater than 1.6 A (thermal limit, see technical data). This has to be considered for the applications or for the selection of the current transformers.

Application as Shaft Current Protection (Bearing Current Protection)

As most of the applications mentioned above are rather simple, we will focus on the function's application as shaft current protection. This function is of particular interest in conjunction with hydro-electric generators. Due to their construction, the hydro-electric generators have relatively long shafts. The shaft is connected to earth at one point via the turbine wheel and water. In cylindrical-rotor generators the shaft is earthed at one point via the earthing brush. A number of factors such as friction, magnetic fields of the generators and others can build up a voltage across the shaft which then acts as voltage source (electro-motive force - emf). This voltage also contains harmonics with the 3rd harmonic being stronger. This induced voltage is still dependent on the load, the system and the machine. The induced voltage can range between 0.5 and 2 V in cylindrical-rotor generators and between 10 and 30 V in hydro-electric generators. Detection is only possible during operation.

If the oil film covering a bearing is too thin, breakdown can occur. Since the bearing housing is earthed, the electric circuit is now closed. Due to the low resistance (shaft, bearing and earthing), high currents may flow that destroy the bearing. Past experience has shown that currents greater than 1 A are critical for the bearings. As different bearings can be affected, the current is not measured at each bearing, but the current entering the shaft is detected by means of a special transformer. It is a folding transformer that is mounted around the shaft.

The basic connection of the shaft current protection is shown in figure 2-101. The shaft current transformer is then connected to the selected sensitive earth current input (I_{ee1} or I_{ee2}). If the shaft current exceeds a certain value, the generator should be shut down.

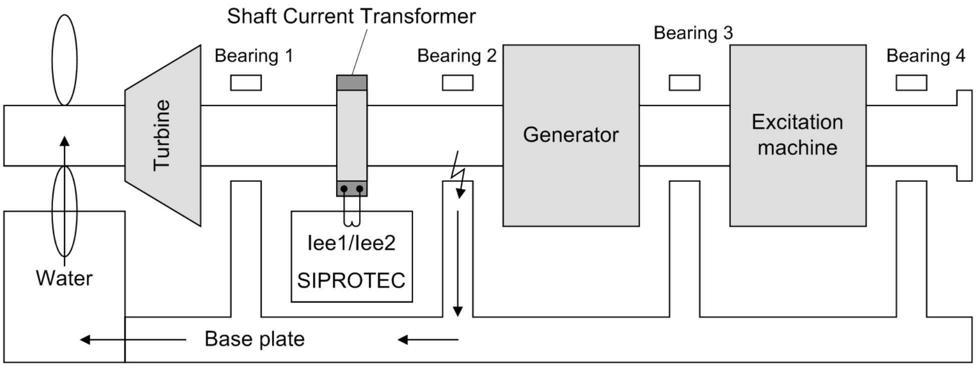


Figure 2-101 Connection of the shaft current transformer (possible current flow in the event of a fault)

The shaft current transformer has to be purchased separately from a transformer manufacturer, or the existing shaft current transformer can be used when replacing the protection. The diameter of the transformer depends on the shaft diameter and can amount up to 2 m. The number of secondary winding turns vary slightly with the diameter. These transformer are available with between 400 and 1000 turns. Transformers with less turns (e.g. 600 turns) should be used so as to provide a sufficiently high measurement current.

Shaft current transformers also have a test winding with usually 4 turns. It allows injecting a test current to check the entire circuit. Figure 2-102 shows an example of the terminals S1-S2: measurement terminal (400 turns) and A-B: test terminal (4 turns).

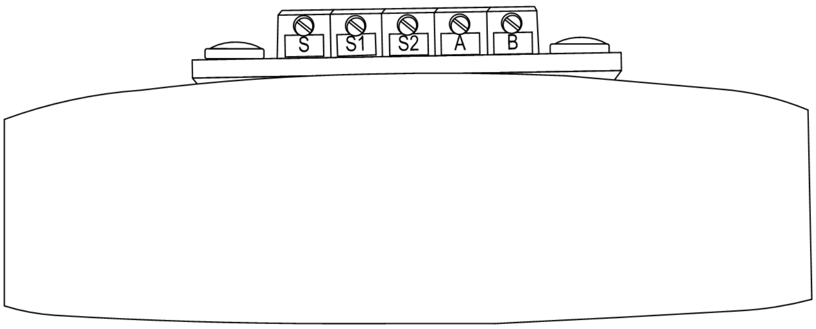


Figure 2-102 Terminals of the shaft current transformer

Measurement Method

In order to preserve the flexibility of the application, there are different measurement methods available for processing the sensitive earth current. The protection setting determines the measurement method to be used. In algorithmic terms, this means that the FIR filter parameters have to be modified. In order to achieve high accuracy, a long filter window is used deliberately.

The following filter options are available:

Filtering	Application
Fundamental component (50 Hz or 60 Hz)	- Normal earth current protection applications - Shaft current protection, if fundamental component is predominant
3rd harmonic (150 Hz or 180 Hz)	- Earth current monitoring in the generator starpoint to detect faults in the vicinity of the starpoint (supplementary logic via CFC if necessary). - Shaft current protection, if 3rd harmonic is predominant
Fumdamental component and 3rd harmonic	- Shaft current protection if both the fundamental component and the 3rd harmonic are predominant

Logic

Figure 2-103 shows the logic diagram. According to the selected measurement method, the measured value is forwarded to the threshold decision logic. Depending on the application, it is possible to monitor a greater or a smaller threshold. To prevent the pickup from „chattering“, a dropout time delay can be implemented. This time is the holding time. A timer furthermore allows to delay the TRIP signal accordingly. Set to 0, the IEE-B<-stage is disabled.

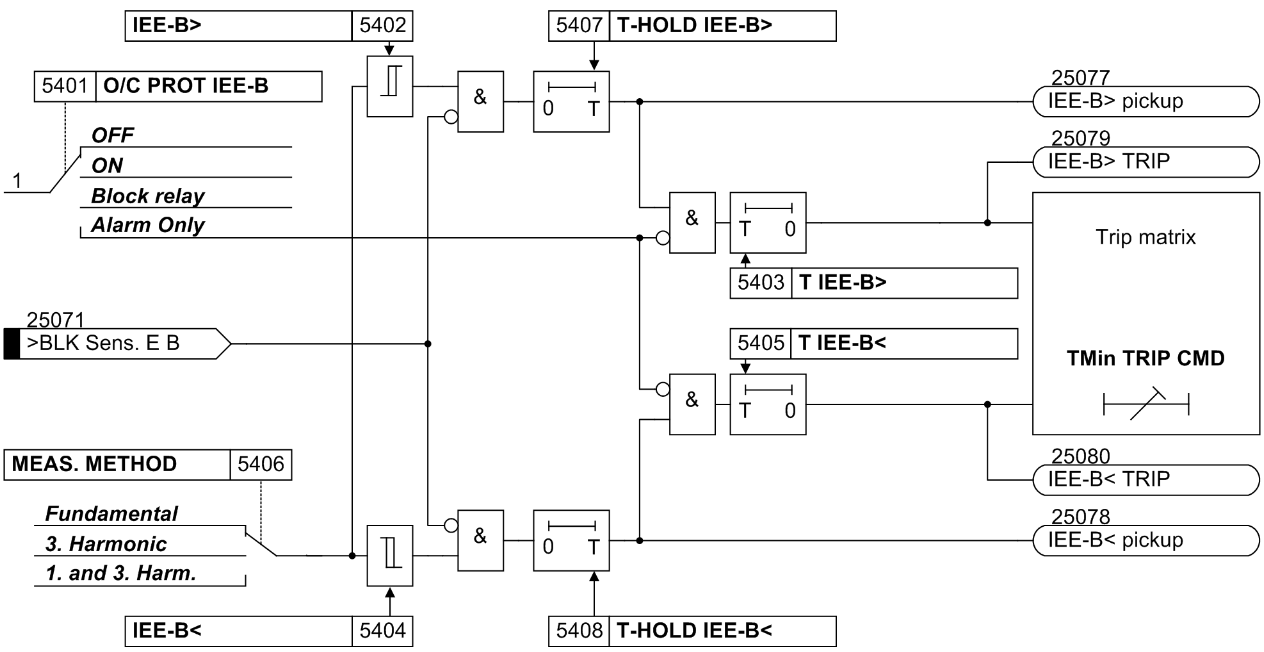


Figure 2-103 Logic diagram of the sensitive earth current protection IEE-B

2.32.2 Setting Notes

General

The sensitive earth fault protection IEE-B is only effective and available if configured to ***with IEE1*** or ***with IEE2*** at address 154.

If the sensitive earth fault detection IEE-B is not required, ***Disabled*** is set.

Address 5401serves to switch the function ***ON*** or ***OFF*** or to block only the trip command (***Block relay***).

In addition, you can set ***Alarm Only***, i.e. these stages operate and send alarms but do not generate any trip command

Use as Shaft Current Protection

The correct setting of the shaft current protection is only possible during the primary check. A fault record is started with the generator running and the harmonic content is determined using the SIGRA graphic software. Depending on which harmonic content is present, the appropriate measuring method is set in address 5406 **MEAS. METHOD**. You can select either ***Fundamental***, ***3. Harmonic*** or ***1. and 3. Harm.***. Once the setting is complete, the respective fault current is read out of the operational measured values with the generator running under load and a setting value is determined on their basis with a safety factor of 1.5 to 2 (see also primary check).

A preliminary setting should be so that it causes the protective function to pick up on fault currents between 0.5 A and 1 A. In case of 600 turns, this yields a pickup value of 1 mA (equivalent to 0.6 A primary).

To ensure that the function also trips in case of intermittent faults, the pickup behaviour has to be set in address 5407 **T-HOLD IEE-B>** (only possible via the DIGSI software). A value of 0.5 s is quite practicable. The trip time delay is usually set to 3 s in address 5403 **T IEE-B>**.

2.32.3 Settings

Addresses which have an appended "A" can only be changed with DIGSI, under Additional Settings.

Addr.	Parameter	Setting Options	Default Setting	Comments
5401	O/C PROT IEE-B	OFF ON Block relay Alarm Only	OFF	Sensitive O/C Protection B
5402	IEE-B>	0.3 .. 1000.0 mA	5.0 mA	IEE-B> Pickup
5403	T IEE-B>	0.00 .. 60.00 sec; ∞	3.00 sec	Time Delay T IEE-B>
5404	IEE-B<	0.3 .. 500.0 mA; 0	0.0 mA	IEE-B< Pickup
5405	T IEE-B<	0.00 .. 60.00 sec; ∞	1.00 sec	Time Delay T IEE-B<
5406	MEAS. METHOD	Fundamental 3. Harmonic 1. and 3. Harm.	Fundamental	Measurement Method
5407A	T-HOLD IEE-B>	0.00 .. 60.00 sec	0.00 sec	Pickup Holding Time IEE-B>
5408A	T-HOLD IEE-B<	0.00 .. 60.00 sec	0.00 sec	Pickup Holding Time IEE-B<

2.32.4 Information List

No.	Information	Type of Information	Comments
25071	>BLK Sens. E B	SP	>BLOCK sensitive earth current prot. B
25072	IEE-B OFF	OUT	Earth current prot. B is switched OFF
25073	IEE-B BLOCKED	OUT	Earth current prot. B is BLOCKED
25074	IEE-B ACTIVE	OUT	Earth current prot. B is ACTIVE
25077	IEE-B> pickup	OUT	IEE-B> picked up
25078	IEE-B< pickup	OUT	IEE-B< picked up
25079	IEE-B> TRIP	OUT	IEE-B> TRIP
25080	IEE-B< TRIP	OUT	IEE-B< TRIP

2.33 Interturn Protection (ANSI 59N (IT))

The interturn fault protection detects faults between turns within a generator winding (phase). This situation may involve relatively high circulating currents that flow in the short-circuited turns and damage the winding and the stator. The protective function is characterized by a high sensitivity.

Given the way the generators are constructed, it is rather unlikely that an interturn fault will occur.

Generators with a separate stator winding (e.g. large-sized hydro-electric generators) are more likely to be affected. In this configuration, the transverse differential protection or the zero sequence current protection are used instead between the connected starpoints.

2.33.1 Functional Description

Basic Principle

Figure 2-104 shows the basic principle of measurement. The displacement voltage is measured at the open delta winding by means of 3 two-phase isolated voltage transformers. So as to be insensitive towards earth faults, the isolated voltage transformer starpoint has to be connected to the generator starpoint by means of a high-voltage cable. The voltage transformer starpoint must not be earthed since this implies that the generator starpoint, too, would be earthed with the consequence that each fault would lead to a single-pole earth fault.

In the event of an interturn fault, the voltage in the affected phase will be reduced ultimately causing a displacement voltage that is detected at the broken delta winding. The sensitivity is limited rather by the winding asymmetries than by the protection device.

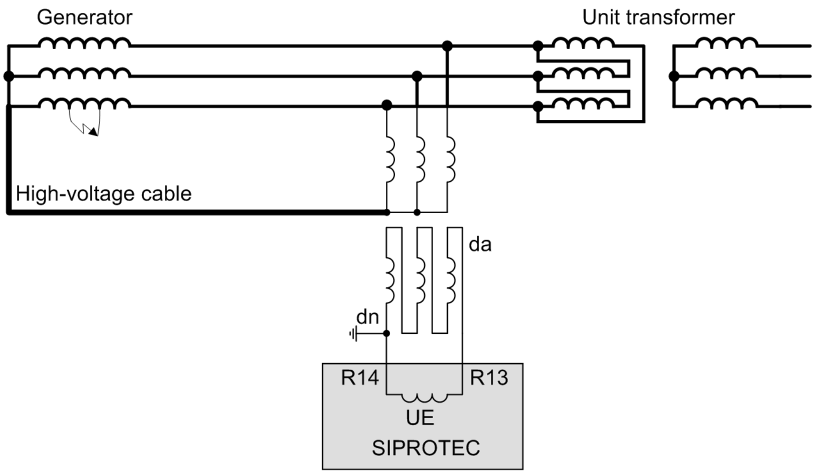


Figure 2-104 Standard connection of the interturn fault protection

Figure 2-105 shows an alternative connection example with limited sensitivity. The loading resistor is located at the generator starpoint and the displacement voltage is measured via the voltage transformer. This voltage transformer is equally used for the stator earth fault protection. The voltage transformer on the outgoing side is earthed and has additionally a broken delta winding. The connection example shown in figure 2-105 has the effect that the displacement voltage becomes zero at the measurement input of the interturn fault protection in the event of an earth fault. In the event of an interturn fault, the displacement voltage occurs only at the open-delta winding that is open on the outgoing side.

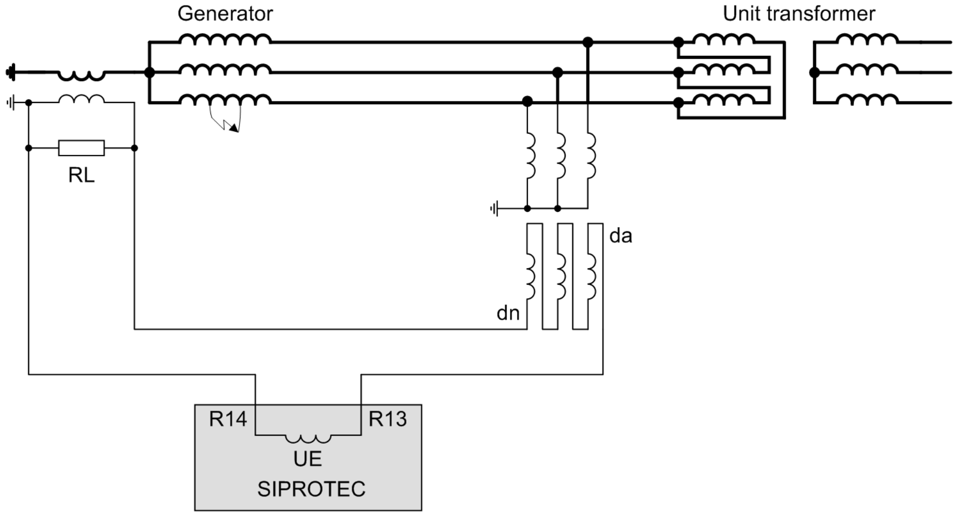


Figure 2-105 Alternative connection of the interturn fault protection

The wide setting range allows the protective function to be used also as single-stage, single-phase overvoltage protection.

Measurement Method

The U_E input of the protection is connected as shown in Figure 2-104 or 2-105. An FIR filter determines the fundamental component of the voltage based on the scanned displacement voltage. Selecting an appropriate window function has the effect that the sensitivity towards higher-frequency oscillations is decreased and the disturbing influence of the third harmonic is eliminated while achieving the required measurement sensitivity.

Logic

Figure 2-106 shows the logic diagram. The measured value of the fundamental component is forwarded to the threshold decision logic. Upon exceeding the threshold, the pickup indication is sent and the timer is started. The trip command is generated after the time has elapsed.

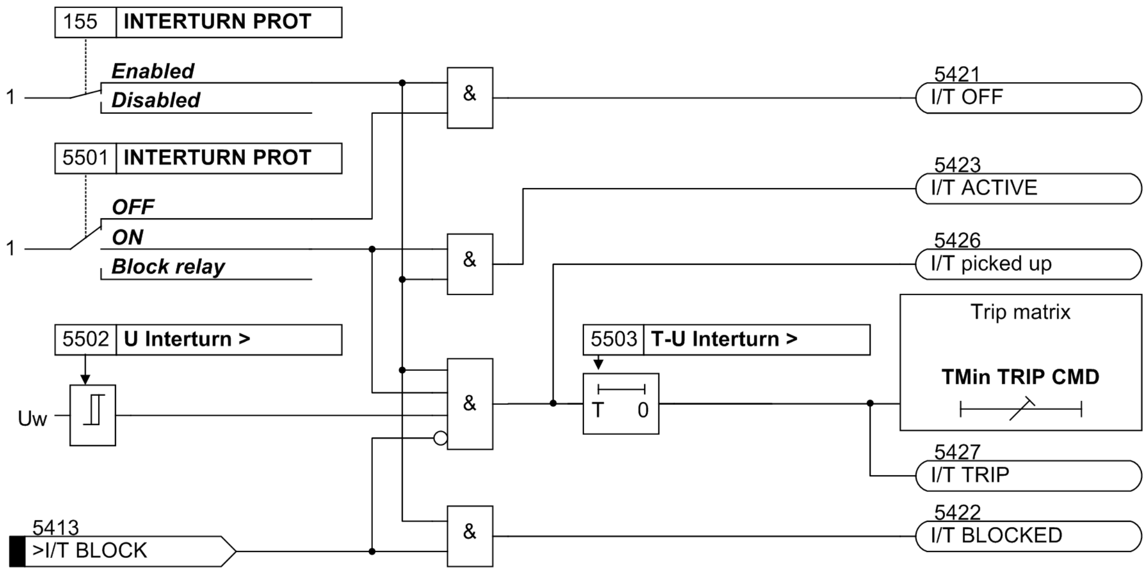


Figure 2-106 Logic diagram of the interturn fault protection

2.33.2 Setting Notes

General

The interturn fault protection is only in effect and accessible if address 155 **INTERTURN PROT** is set to during configuration of protective functions.

Also it has to be specified in the Power System Data 1 that the input U_E is used for the interturn fault protection. The setting can be made at address 223 **UE CONNECTION** = ***Uen-winding***. For factor U_E (address 224) the ratio of the phase-to-earth voltage to the voltage at the broken delta winding (U_E input) is set according to section 2.5.

The address 5501 **INTERTURN PROT** serves to switch the function ***ON*** or ***OFF*** or to block only the trip command (***Block relay***).

Pickup Value

It is desired that the protection has a high sensitivity in order to already detect a fault when it has affected only a few turns. On the other hand, an excessively sensitive setting should not cause overfunctioning. This is why the default setting is 2 % which at a maximum secondary displacement voltage of 100 V corresponds to a pickup value of 2 V.

The final pickup value has to be determined in primary tests. Pickup without an interturn fault being actually present must be excluded! The protection function must not pick up erroneously on interference. Interference is caused by winding asymmetries of the stator winding. Especially in case of a two-pole fault it becomes obvious by the formation of a displacement voltage. Short-circuit tests should be conducted so as to determine this interfering displacement voltage The protection range can thus be determined. The setting should be so as to ensure that the function picks up on a interturn fault at no-load excitation. It should be able to detect a fault already when it affects only one turn.

For the sensitive setting the dropout ratio may have to be reduced slightly. The default setting is 80 % (see address 5504 **RESET RATIO**).

Delays

Delaying the protective function additionally reduces the risk of overfunctioning. But if the delay is too long, there is a risk of the affected stator winding/core taking considerable damage. This is why the default value is (see address 5503 **T-U Interturn >**).

2.33.3 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
5501	INTERTURN PROT	OFF ON Block relay	OFF	Interturn Protection
5502	U Interturn >	0.3 .. 130.0 V	2.0 V	Pick up Value U Interturn>
5503	T-U Interturn >	0.00 .. 60.00 sec; ∞	0.50 sec	Time Delay of Trip Command
5504	RESET RATIO	50 .. 95 %	80 %	Reset Ratio of U Interturn>

2.33.4 Information List

No.	Information	Type of Information	Comments
5413	>I/T BLOCK	SP	>BLOCK interturn fault protection
5421	I/T OFF	OUT	Interturn fault prot. is switched OFF
5422	I/T BLOCKED	OUT	Interturn fault protection is BLOCKED
5423	I/T ACTIVE	OUT	Interturn fault protection is ACTIVE
5426	I/T picked up	OUT	Interturn fault protection picked up
5427	I/T TRIP	OUT	Interturn fault protection TRIP

2.34 Rotor Earth Fault Protection R, fn (ANSI 64R)

Rotor earth fault protection is used to detect earth faults in the excitation circuit of synchronous machines. An earth fault in the rotor winding does not cause immediate damage; however, if a second earth fault occurs it constitutes a winding short-circuit of the excitation circuit. The resulting magnetic imbalances can cause extreme mechanical forces which may destroy the machine.

2.34.1 Functional Description

Measurement Method

The rotor earth fault protection in the 7UM62 uses an external system frequency auxiliary voltage of approximately 36 to 45 V AC, which can be taken e.g. from the voltage transformers via a coupling unit 7XR6100-0*A00. This voltage is symmetrically coupled to the excitation circuit and simultaneously connected to the measurement input U_E of the device provided for this purpose. The capacitors C_{coup} of the 7XR6100 coupling unit are protected by series resistors R_{pre} and - in case high harmonics content is expected in the excitation circuit (e.g. excitation by thyristor circuits) - by an additional filter choke (for a connection example with terminal assignment see Appendix A.3).

The coupled voltage drives a small charging current (normally a few mA) through the coupling unit, as the case may be the brush resistance and the capacitance to earth of the excitation circuit. This current I_{RE} is measured by the device.

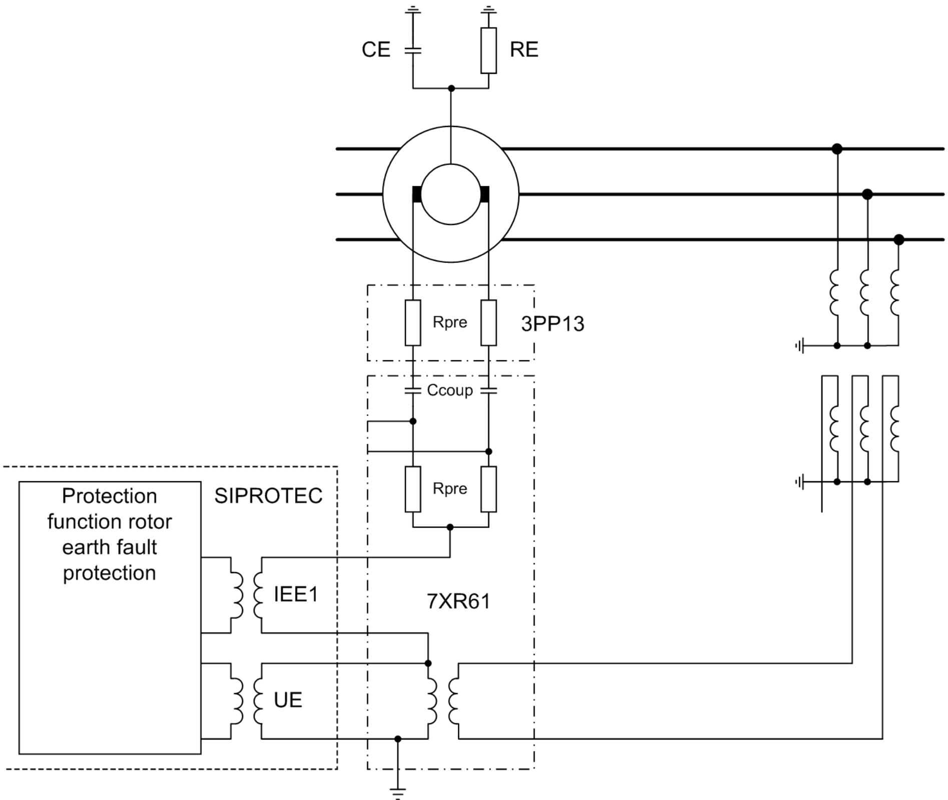


Figure 2-107 Determination of the rotor earth resistance R_E

Note 3PP13 is only necessary if more than 0.2 A_{eff} are flowing permanently; (rule: Uerr load > 150 V). In this case the internal resistors Rpre inside the 7XR61 must be shorted.

The rotor earth fault protection calculates the complex earth impedance from the auxiliary AC voltage U_{RE} and the current I_{RE}. The earth resistance R_E of the excitation circuit is then calculated from the earth impedance. The coupling capacitance of the coupling unit C_{coup}, the series resistance R_{pre} including the brush resistance, and the earth capacitance of the excitation circuit C_E are also considered. This method ensures that even relatively high-ohmic earth faults (up to 30 kΩ under ideal conditions) can be detected.

In order to eliminate the influence of harmonics - such as occur in semiconductor excitation equipment (thyristors or rotating rectifiers) - the measured quantities are filtered prior to their evaluation.

The earth resistance supervision has two stages. Usually an alarm is issued if an initial stage (e.g. 5 kΩ to 10 kΩ) is undershot. If the value falls below the second low-resistance stage (e.g. 2 kΩ to 5 kΩ), tripping will be initiated after a short time delay. The dropout threshold is defined for both stages as 125 % of the set value.

Note

The rotor earth fault protection uses the U_E voltage input of the device for the detection of the voltage U_{RE}. In this case, the displacement voltage for the 90 % stator earth fault protection U_0 is therefore calculated from the phase-to-earth voltages.

Supervision of the Measurement Circuit

Since a current flows even during normal operation, i.e. the charging current of the earth capacity C_E, the protection can recognize and signal interruptions in the measurement circuit, provided the capacitance to earth is at least 0.15 µF.

Stabilization of the Resistance Measurement

If the measuring current I_{RE} exceeds an internal predetermined value (100 mA), a low-resistance earth fault ($R_E \approx 0$) is detected regardless of the calculated resistance. If this current drops below the internal fixed value of 0.3 mA, $R_E \rightarrow \infty$ is determined regardless of the calculated resistance.

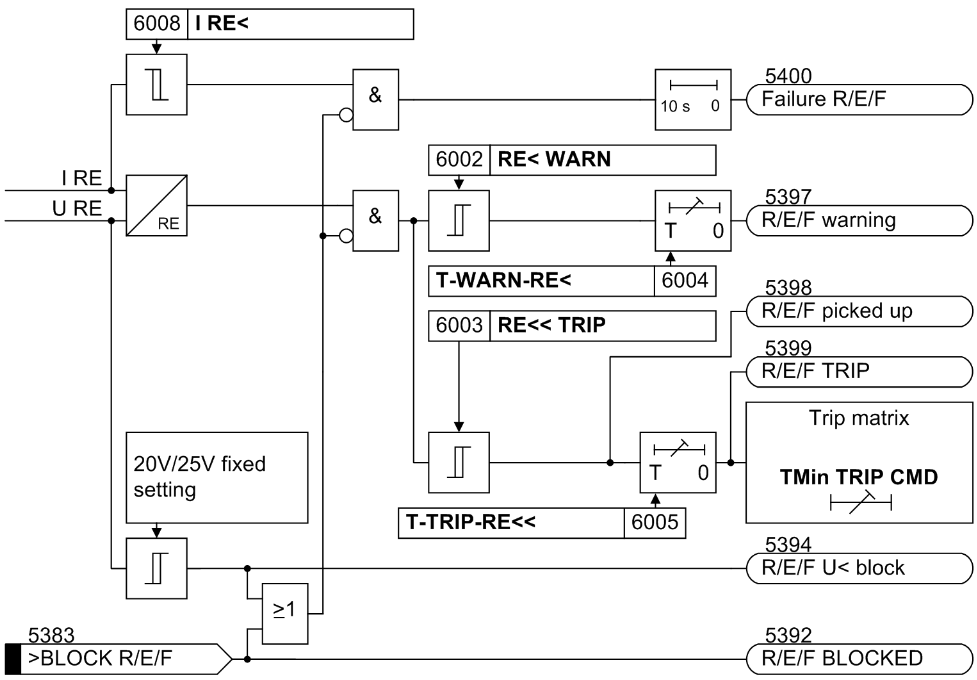


Figure 2-108 Logic Diagram of the Rotor Earth Fault Protection

2.34.2 Setting Notes

General

Rotor earth fault protection protection is only effective and accessible if address 160 **ROTOR E/F** has been set = to ***Enabled***. If the function is not required ***Disabled*** is set. Address 6001 **ROTOR E/F** serves to switch the function ***ON*** or ***OFF*** or to block only the trip command (***Block relay***).

Also, configuration parameter 223 **UE CONNECTION** must be set to ***Rotor***. If this is not the case, a voltage U_{RE} = 0 is displayed and evaluated, so that the protection remains blocked.

Pickup Values

Since the protection calculates the ohmic rotor-earth resistance from the values caused by the applied bias voltage, the thresholds for the warning stage (6002 **RE< WARN**) and for the trip stage (6003 **RE<< TRIP**) can be set directly as resistance values. The default settings are sufficient for the majority of cases. These values can be changed depending on the insulation resistance and the coolant. Care must be taken to allow a sufficient margin between the setting value and the actual insulation resistance.

Time Delays

The time delay for the warning stage 6004 **T-WARN-RE<** is usually set to approximately 10 s, and the delay for the trip stage 6005 **T-TRIP-RE<<** to approximately 0.5 s. The set times are additional delay times not including the operating times (measuring time, dropout time) of the protective function.

Data for the Coupling to the Rotor Circuit

The setting of the coupling reactance 6006 **X COUPLING** and the series resistance 6007 **R SERIES** enable the protection to calculate the earth resistance R_E from the complex equivalent diagram of the coupling capacitance of the coupling unit, the series (e.g. measuring brush) resistance, the capacitance to earth of the excitation circuit, and the earth resistance of the excitation circuit. The equivalent circuit according to the figure below applies.

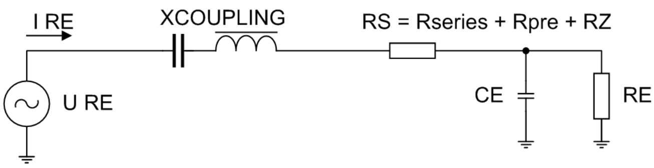


Figure 2-109 Equivalent Measuring Circuit for Rotor Earth Fault Protection

where:

U_{RE}	Rotor circuit bias voltage
I_{RE}	Earth current
$X_{Coupling}$	Total series reactance of the coupling circuit, consisting of coupling capacitance and inductance (if applicable)
R_S	Total resistance of the coupling circuit, consisting of brush resistance, protection resistance (if applicable) and damping resistance (if applicable)
C_E	Rotor earth capacitance
R_E	Rotor earth resistance

The series resistors R_S for the protection of the coupling capacitors can be considered with the total series resistance (address 6007) since the brush resistance and the series resistance are connected in series in the measurement circuit. The resultant resistance applies for **R SERIES**, i.e. the parallel connection in each case of the series resistors R_S and for the resistance of the two brushes. Similarly, the coupling reactance is calculated from the parallel connection of the two coupling capacitors C_{coup}.

In some cases, the inductor integrated in the 7XR6100 is included in the coupling circuit to reduce very high harmonics content of the excitation voltage. This forms, together with the coupling capacitance, a band pass for the system frequency. In these cases, it must be considered that the reactance must not become less than –100 Ω (lower threshold of setting 6006 **X COUPLING**).

Angle Error Correction

Coupling reactance and series resistance can be measured by the protection itself during commissioning (see Subsection 3.3 in the Section „Installation and Commissioning“). It may be advantageous to measure any angle errors of the input CTs of the device and adjust them at address 6009 **PHI I RE** in order to increase accuracy. Thus, if the warning stage in particular does not pick up during testing at the expected insulation resistance level, you should check and correct the correction angle and the coupling reactance (see also Subsection 3.3 in the Section „Installation and Commissioning“).

The values calculated and displayed by the device may become negative due to CT angle errors, wrong settings of the coupling impedance or malfunctions of the excitation equipment. In that case, it is checked whether the current I_{RE} is higher than 7 mA. And if it is, tripping will be initiated. If the current is < 7 mA, the measurement is marked as invalid, and the rotor earth resistance $R_E = \infty$ is displayed. This additional consistency check ensures that even if the setting of the correction angle or the coupling impedance is wrong, tripping in case of low-resistance earth faults is ensured although the warning stage may not pick up correctly.

Measuring Circuit Monitoring

If a sufficiently high rotor capacitance ($C_E \geq 0.15$ µF) is available, an interruption in the measurement circuit can also be recognized. A measurement circuit interruption is assumed when the voltage drops below the threshold set at address 6008 **I RE<**, and the voltage U_{RE} is at the same time above 25 V. The alarm is reset when the current is 0.5 mA or 20 % above the setting value, or when the voltage falls below 20 V. If **I RE<** is set to ***0.0 mA***, there is no current monitoring and no alarm.

2.34.3 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
6001	ROTOR E/F	OFF ON Block relay	OFF	Rotor Earth Fault Protection (R, fn)
6002	RE< WARN	3.0 .. 30.0 kΩ	10.0 kΩ	Pickup Value of Warning Stage Re<
6003	RE<< TRIP	1.0 .. 5.0 kΩ	2.0 kΩ	Pickup Value of Tripping Stage Re<<
6004	T-WARN-RE<	0.00 .. 60.00 sec; ∞	10.00 sec	Time Delay of Warning Stage Re<
6005	T-TRIP-RE<<	0.00 .. 60.00 sec; ∞	0.50 sec	Time Delay of Tripping Stage Re<<
6006	X COUPLING	-100 .. 800 Ω	398 Ω	Coupling Reactance
6007	R SERIES	0 .. 999 Ω	50 Ω	Series Resistance (e.g. Meas. Brushes)
6008	I RE<	1.0 .. 50.0 mA; 0	2.0 mA	Pickup Value of Failure Detection Ire<
6009	PHI I RE	-15.0 .. 15.0 °	0.0 °	Correction Angle for Ire

2.34.4 Information List

No.	Information	Type of Information	Comments
5383	>BLOCK R/E/F	SP	>BLOCK rotor earth fault prot. (R,fn)
5391	R/E/F OFF	OUT	Rotor earth fault prot. (R,fn) swit. OFF
5392	R/E/F BLOCKED	OUT	Rotor earth fault prot. (R,fn) BLOCKED
5393	R/E/F AKTIVE	OUT	Rotor earth fault prot. (R,fn) is ACTIVE
5394	R/E/F U< block	OUT	Rot. earth flt. prot. (R,fn) block by U<
5397	R/E/F warning	OUT	Rot. earth flt.prot. (R,fn) Re< warning
5398	R/E/F picked up	OUT	Rot. earth flt.prot. (R,fn) Re<< pick.up
5399	R/E/F TRIP	OUT	Rotor earth fault prot. (R,fn) Re<< TRIP
5400	Failure R/E/F	OUT	Failure rotor earth fault prot. (R,fn)

2.35 Sensitive Rotor Earth Fault Protection with 1 to 3 Hz Square Wave Voltage Injection (ANSI 64R - 1 to 3 Hz)

The rotor earth fault protection detects high and low resistance earth faults in the excitation circuit of synchronous generators. An earth fault in the excitation winding itself causes no direct damage. If however a second earth fault occurs, this results in a winding short-circuit in the excitation circuit. The resulting magnetic imbalances can cause extreme mechanical forces which may destroy the machine. The following protection function differs from the function described in Section 2.34 in that it is far more sensitive; it is used for large generators.

2.35.1 Functional Description

Basic Principle

The rotor earth fault protection works with a direct voltage of approx. 50 V, the polarity of which is reversed between 1 and 4 times per second, depending on the setting. This voltage U_g injected into the rotor circuit is generated in the 7XT71 series device. The voltage passes through a resistor unit 7XR6004 (or 7XR6003) and is symmetrically coupled to the excitation circuit via high-resistance resistors, and at the same time connected to the earthing brush (potential to earth) via a low-resistance measuring shunt R_M (see also Appendix). The voltage taken at the measuring shunt and the control voltage are fed into the protection device via measuring transducers. The control voltage is proportional to the injected 50 V voltage Ug in terms of amplitude and frequency. The earth current flowing in the rotor is reflected by the measurement voltage.

Every time the polarity of the direct voltage U_g is reversed, a charging current I_g is driven across the resistor unit into the earth capacitance of the excitation circuit. This current causes a proportional voltage drop U_{Meas} in the measuring shunt. Once the rotor earth capacitance is charged, the charging current drops to zero. If a rotor earth fault is present a continuous earth current is driven. The amplitude depends on the fault resistance.

The use of a low-frequency square-wave voltage as displacement voltage eliminates the influence of the earth capacitance and ensures at the same time a sufficient margin against interference signals from the excitation system.

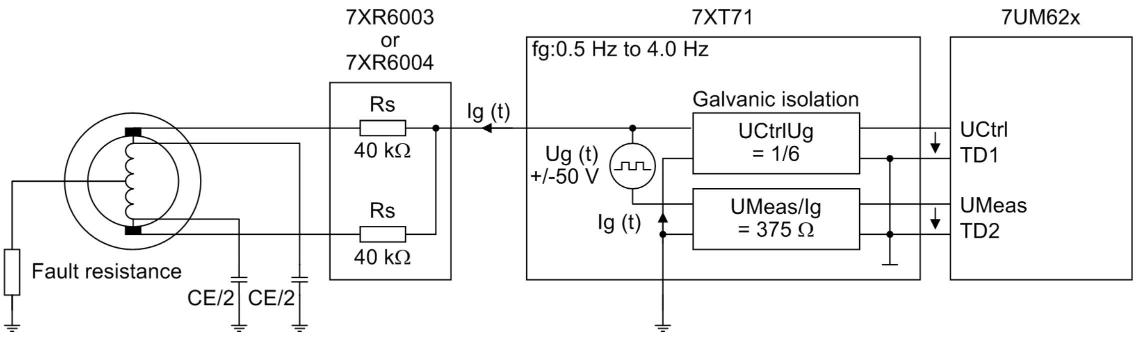


Figure 2-110 Connection Schematic of Voltage Injection into the Rotor Winding

CE	Rotor-earth capacitance
Rs	Series resistor
Ug	Square-wave voltage from 7XT71
Ig	Current flowing from the 7XT71 through the rotor into the earth
fg	Square-wave frquency of the 7XT71

Measurement Method

From the control voltage U_{Ctrl}, the function determines the timing for the polarity reversals and triggers the measurement. At the same time it calculates the voltage amplitude and converts it to the driving voltage U_g. The actual fault resistance is determined from the voltage U_{Meas}, which is proportional to the current I_g. Every time the polarity of the control voltage is reversed, the DC component of the measurement voltage is determined by a mean value filter. The frequency of the series device must be set low enough to ensure that during the mean-value generation the rotor-earth capacitances are charged, so that only the steady-state portion is evaluated. This allows detection of high-resistance faults (max. approx. 80 kΩ) without being influenced by the earth capacitance.

However, the measurement is distorted by two sources of interference. One of them is a DC voltage component in the measurement circuit which depends on the intensity of the excitation voltage and on the location of the earth fault in the excitation winding, and the other are considerable high-frequency AC voltage peaks that may be superimposed on the DC excitation voltage. These peaks are attenuated by a numerical filter.

To eliminate interference from the superimposed DC voltage components, the polarity of the voltage U_g is reversed (square-wave voltage). The measurement voltage calculation described above is performed for both polarities. On formation of the difference between two subsequent measurement results for I_g, namely I_{g1} and I_{g2}, the DC component originating from the excitation circuit (I_{offset}) is eliminated, whereas the DC components originating from the injected voltage U_g accumulate.

With the measured quantity thus obtained, and the calculated amount of the displacement voltage U_g, the earth resistance can be calculated, taking into account the series resistors R_s (see Figure 2-111).

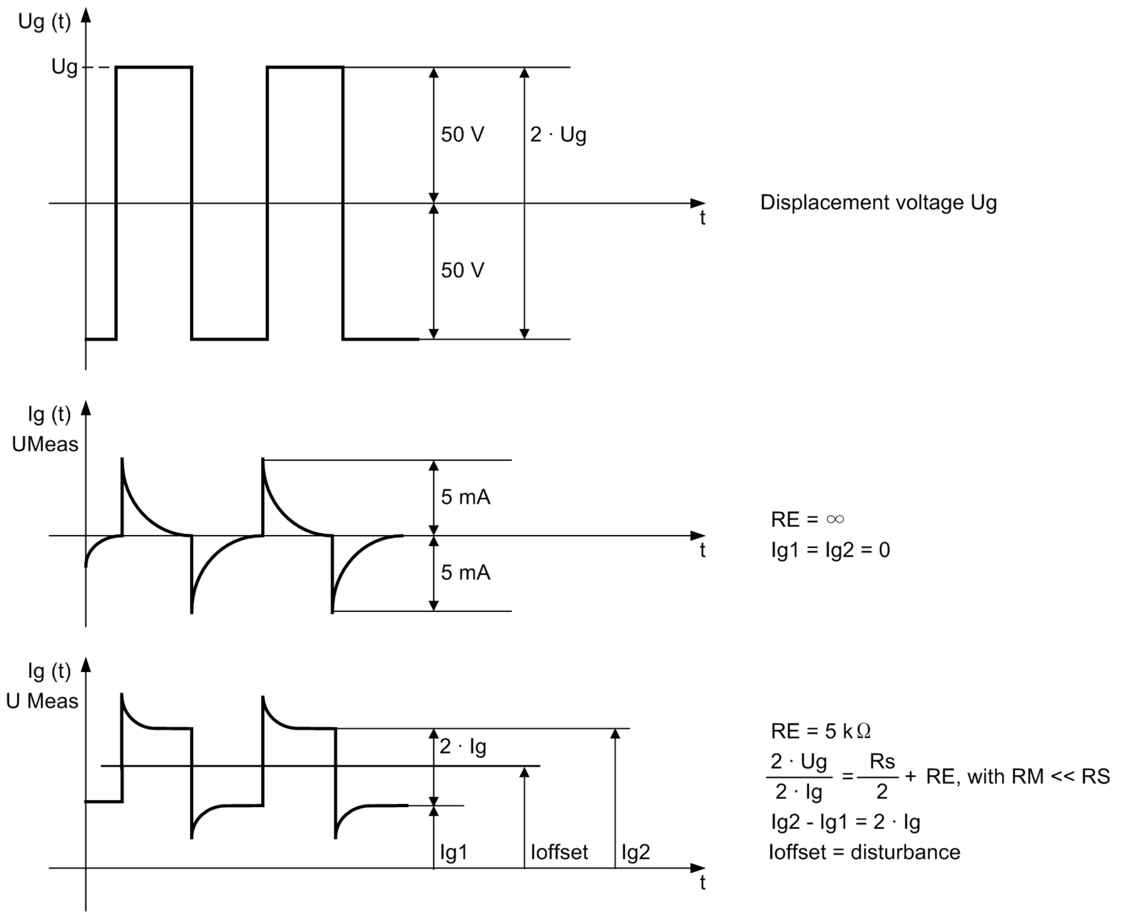


Figure 2-111 Curves of the Displacement Voltage Ug, Shunt Voltage U_{Meas} and the Measurement Current I_g

Monitoring Functions

On each polarity reversal, the charging current of the earth capacitance is determined. If this is undershot, errors in the measuring circuit such as wire break, poor brush contacts etc. can be detected. This is possible however only if the earth capacitances are sufficiently large (> 0.15 µF) and excitation disturbances minimal.

As an alternative, the protection function offers an external test option using a test resistor (included in the 7XR6004 and 7XR6003). The test mode is activated via a binary input, and the fault resistor then connected to a slip ring with an external relay. The protection function must be informed of the relevant test resistance. The protection function issues appropriate indications showing the test results. It is also able to detect one-sided interruptions (such as wire breaks or loose terminals in a coupling).

The evaluation logic is shown in the following figure.

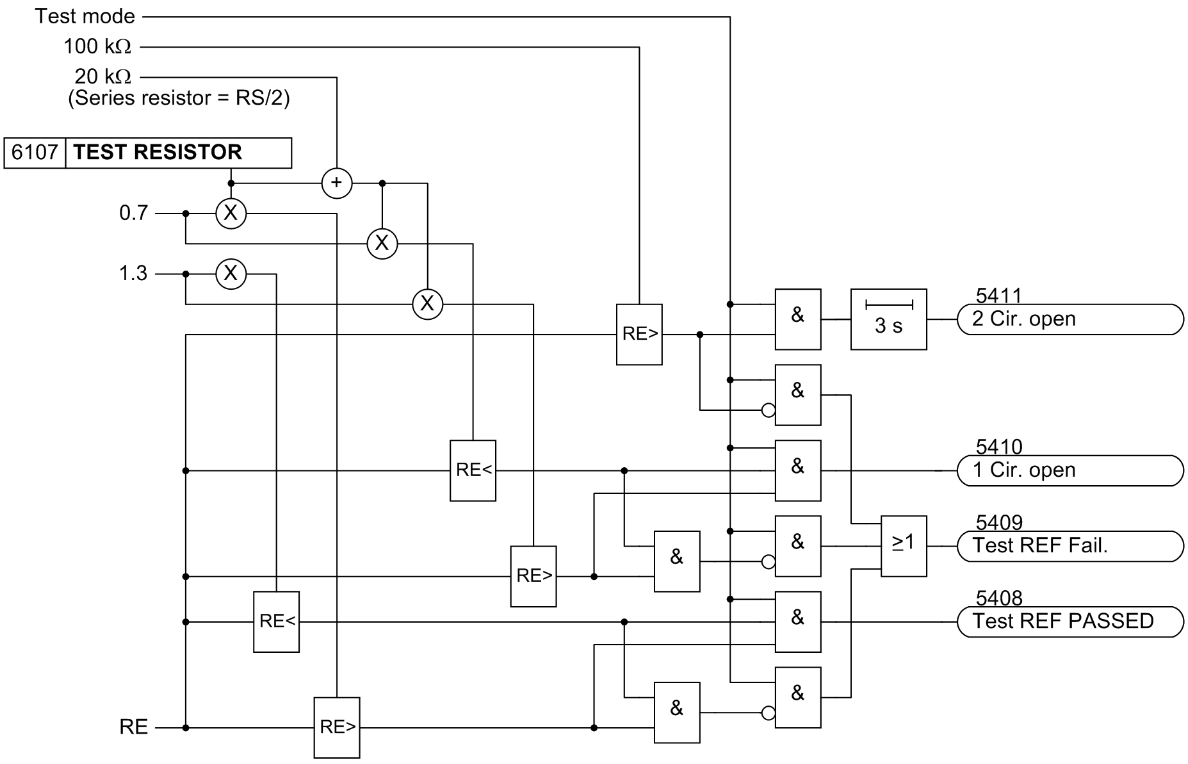


Figure 2-112 Logic Diagram of the Rotor Earth Fault Protection in Test Mode

In addition, the control voltage is monitored. If the control voltage is found to be missing or too low, a failure of the control unit is assumed (see also logic diagram).

Logic

The logic diagram shows the parts:

- Monitoring of the series device
- Supervision of the measurement circuit
- Two-stage protection function
- Effect of the rotor earth fault protection test

If the earth resistance drops below the high-resistance stage RE<, a warning message will normally be issued. If it drops below the second, low-resistance stage RE<<, a trip signal is issued after a short time.

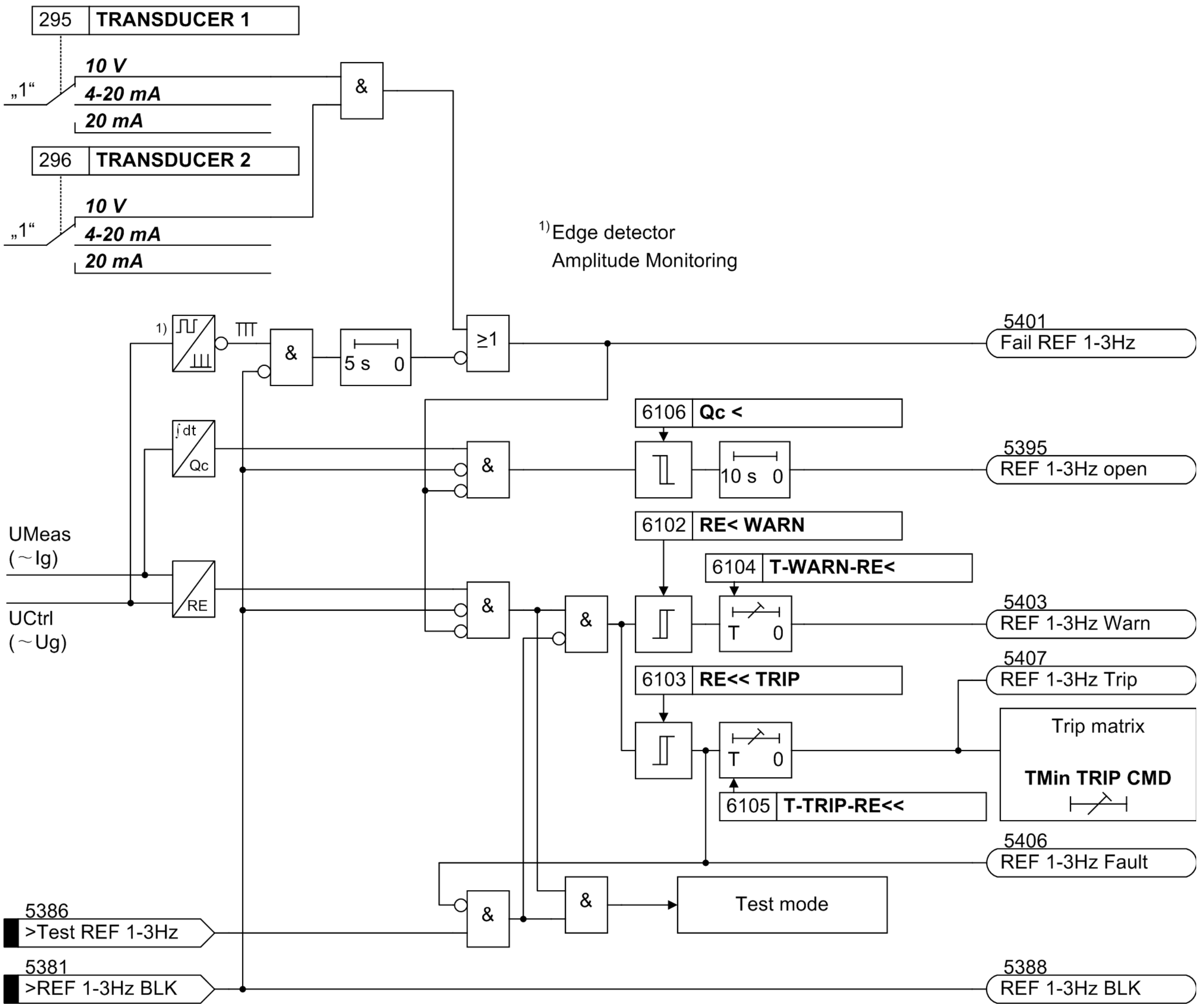


Figure 2-113 Logic Diagram of Sensitive Rotor Earth Fault Protection

2.35.2 Setting Notes

General

Sensitive rotor earth fault protection is only effective and available if configured at address 161 **REF 1-3Hz** to ***Enabled***.

It must also be ensured that the measuring transducer inputs TD1 and TD2 are not used for any other function.

Address 6101 **REF 1-3Hz** serves to switch the function ***ON*** or ***OFF*** or to block only the trip command (***Block relay***).

The delivery setting of the measuring transducers TD1 and TD2 to 10 V must not be changed (see tables 3-18 and 3-19).

Pickup Values

Since the protection calculates the ohmic rotor-earth resistance directly from the values of the applied bias voltage, the series resistor and the flowing earth current, the thresholds for the warning stage (6102 **RE< WARN**) and for the trip stage (6103 **RE<< TRIP**) can be set directly as resistance values. The default settings (**RE< WARN** = 40 kΩ and **RE<< TRIP** = 5 kΩ) are sufficient for the majority of cases. These values can be changed depending on the insulation resistance and the coolant. Care must be taken to allow a sufficient margin between the setting value and the actual insulation resistance.

As interference from the excitation system cannot be excluded, the setting for the warning stage is finally established during primary tests.

Time Delays

The time delay for the warning stage 6104 **T-WARN-RE<** is usually set to approximately 10 s, and the delay for the trip stage 6105 **T-TRIP-RE<<** to approximately 1 s. The set times are additional time delays not including the operating times (measuring time, drop-out time) of the protective function.

Monitoring Functions

The setting value of the measuring circuit monitoring (6106 **Qc <**) is defined during the primary test. For this purpose the operational measured value (Qc) is read out and half of this value is set. If the charge measured is too low, monitoring cannot be effective. The parameter **Qc <** should in that case be set to 0 mAs. No fault indication will be issued in this case.

No setting is required if the external test is done using the test resistor 7XR6004 (3.3 kΩ). If a different resistor is to be used, its resistance must be set as an advanced parameter **TEST RESISTOR** (only via the DIGSI communication software) at address 6107A.

2.35.3 Settings

Addresses which have an appended "A" can only be changed with DIGSI, under Additional Settings.

Addr.	Parameter	Setting Options	Default Setting	Comments
6101	REF 1-3Hz	OFF ON Block relay	OFF	Rotor Earth Fault Protection (1-3Hz)
6102	RE< WARN	5.0 .. 80.0 kΩ	40.0 kΩ	Pickup Value of Warning Stage Re<
6103	RE<< TRIP	1.0 .. 10.0 kΩ	5.0 kΩ	Pickup Value of Tripping Stage Re<<
6104	T-WARN-RE<	0.00 .. 60.00 sec; ∞	10.00 sec	Time Delay of Warning Stage Re<
6105	T-TRIP-RE<<	0.00 .. 60.00 sec; ∞	1.00 sec	Time Delay of Tripping Stage Re<<
6106	Qc <	0.00 .. 1.00 mAs	0.02 mAs	Pickup Value of open Rotor Circuit (Qc)
6107A	TEST RESISTOR	1.0 .. 10.0 kΩ	3.3 kΩ	Testing Resistor

2.35.4 Information List

No.	Information	Type of Information	Comments
5381	>REF 1-3Hz BLK	SP	>BLOCK rotor earth fault prot. (1-3Hz)
5386	>Test REF 1-3Hz	SP	>Test rotor earth fault prot. (1-3Hz)
5387	REF 1-3Hz OFF	OUT	REF protection (1-3Hz) is switched OFF
5388	REF 1-3Hz BLK	OUT	REF protection (1-3Hz) is BLOCKED
5389	REF 1-3Hz ACT	OUT	REF protection (1-3Hz) is ACTIVE
5395	REF 1-3Hz open	OUT	REF protection (1-3Hz) open circuit
5401	Fail REF 1-3Hz	OUT	Failure REF protection (1-3Hz)
5403	REF 1-3Hz Warn	OUT	REF prot. (1-3Hz) warning stage (Re<)
5406	REF 1-3Hz Fault	OUT	REF prot. (1-3Hz) Re<< picked up
5407	REF 1-3Hz Trip	OUT	REF prot. (1-3Hz) Re<< TRIP
5408	Test REF PASSED	OUT	REF prot. (1-3Hz) test passed
5409	Test REF Fail.	OUT	REF prot. (1-3Hz) test NOT passed
5410	1 Cir. open	OUT	REF (1-3Hz) 1 Measuring circuit open
5411	2 Cir. open	OUT	REF (1-3Hz) 2 Measuring circuits open

2.36 Motor Starting Time Supervision (ANSI 48)

When using the 7UM62 to protect motors, the motor starting protection supplements the overload protection described in Section 2.11 by protecting the motor against too long starting procedures. In particular, rotor-critical high-voltage motors can quickly be heated above their thermal limits when multiple starting attempts occur in a short period of time. If the durations of these starting attempts are prolonged by excessive voltage surges during motor starting, by excessive load moments, or by locked rotor conditions, a tripping signal will be initiated by the device.

2.36.1 Functional Description

Motor Startup

The motor starting time monitoring is initiated by the motor starting recognition setting entered at address **I MOTOR START**. This current releases the calculation of the tripping characteristic.

One characteristic is definite time while the other one is inverse time.

Inverse Time Characteristic

The inverse time-overcurrent characteristic is designed to operate only when the rotor is not blocked. With decreased startup current resulting from voltage dips when starting the motor, prolonged starting times are calculated properly and tripping can be performed in time. The tripping time is calculated based on the following formula:

$$t_{TRIP} = \left(\frac{I_{StartCurr.}}{I}\right)^2 \cdot t_{Start\ max} \qquad \text{where } I > I_{Motor\ Start}$$

with

t_{TRIP}	Actual tripping time for flowing current I
$t_{Start\ max}$	Tripping time for nominal startup current $I_{StartCurr}$ (param. 6503, **STARTING TIME**)
I	Current actually flowing (measured value)
$I_{StartCurr}$	Nominal starting current of the motor (Parameter 6502, **START. CURRENT**)
$I_{Motor\ Start}$	Pickup value for recognition of motor startup (Parameter 6505, **I MOTOR START**)

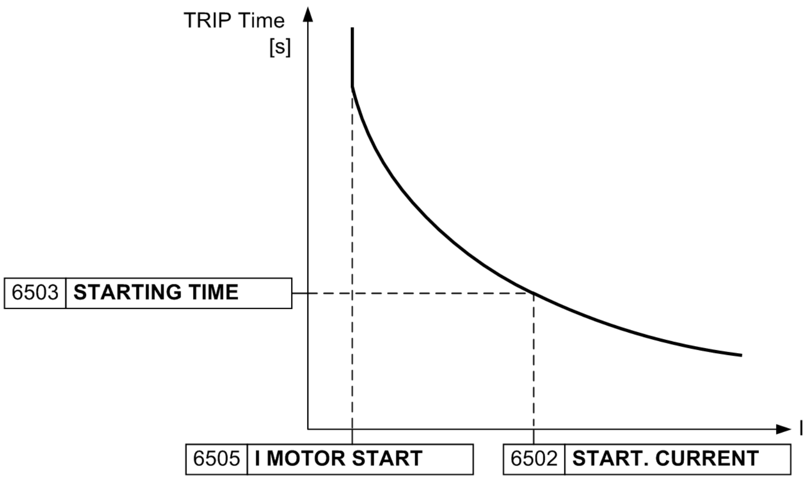


Figure 2-114 Trip Time Depending on Startup Current

Therefore, if the starting current I actually measured is smaller (or larger) than the nominal starting current $I_{Start-Curr}$ entered at address 6502 (parameter **START. CURRENT**), the actual tripping time t_{TRIP} is lengthened (or shortened) accordingly (see also Figure 2-114).

Definite-Time Overcurrent Tripping Characteristic (Locked Rotor Time)

If the motor starting time exceeds the maximum allowable blocked rotor time t_E, tripping must be executed at least with time t_E when the rotor is blocked. The device can detect a blocked rotor condition via a binary input („>Rotor locked“) from an external rpm-counter. If the current in any of the phases exceeds the already mentioned threshold **I MOTOR START**, a motor startup is assumed and in addition to the above inverse time delay, a current-independent delay time (locked rotor time) is started. This happens every time the motor is started and is a normal operating condition that is neither entered in the operational annunciations buffer, nor output to a control centre, nor entered in a fault record.

The locked rotor delay time (**LOCK ROTOR TIME**) is ANDed with the binary input „>Rotor locked“. If the binary input is still activated after the parameterized locked rotor time has expired, tripping is performed immediately, regardless of whether the binary input was activated before or during the delay, or after the delay time had elapsed.

Logic

Motor startup monitoring may be switched on or off using a parameter. It may be blocked via binary input, i.e. times and pickup indications are reset. The following figure shows the indication logic and fault administration. A pickup does not result in a fault record. Fault recording is not started until a trip command has been issued.

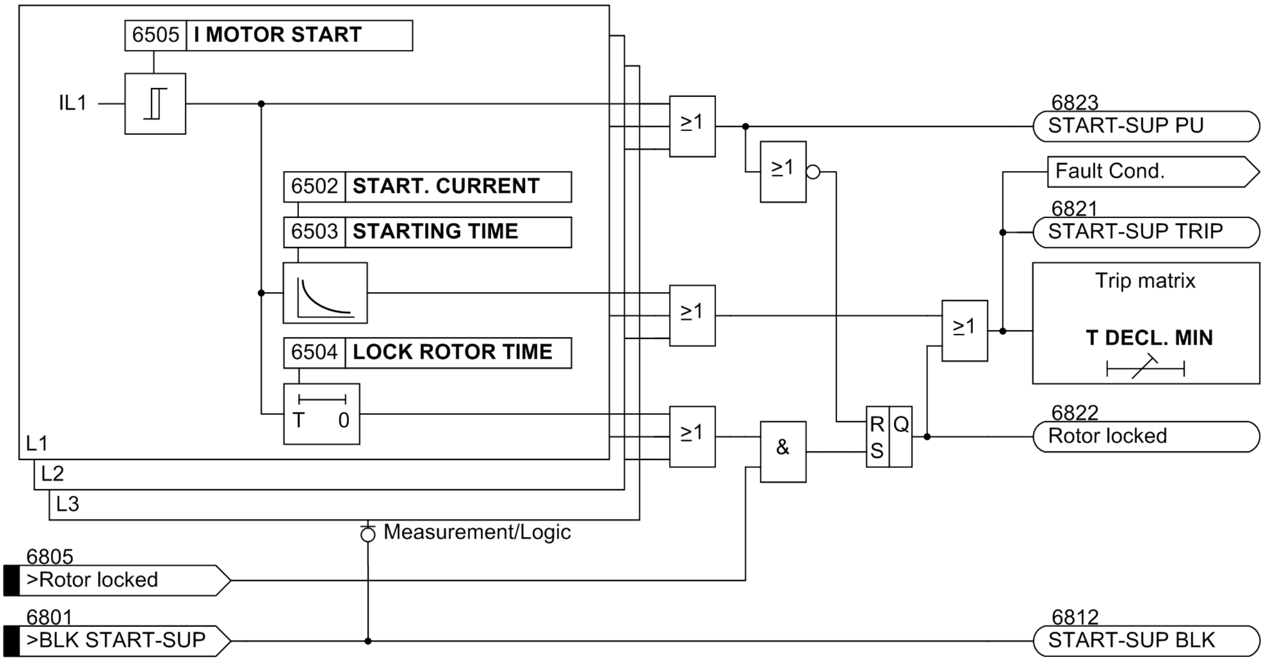


Figure 2-115 Logic Diagram of the Motor Startup Time Monitoring

2.36.2 Setting Notes

General

Startup Time Monitoring is only active and available if address 165 **STARTUP MOTOR** was set to ***Enabled*** during configuration. If the function is not required, it is set to ***Disabled***. Address 6501 **STARTUP MOTOR** serves to switch the function ***ON*** or ***OFF*** or to block only the trip command (***Block relay***).

Pickup Values

The device is informed of the startup current values under normal conditions at address 6502 **START. CURRENT**, and of the startup time at address 6503 **STARTING TIME**. This ensures timely tripping if the value of I^2t calculated by the protection device is exceeded.

If the startup time is longer than the permissible blocked rotor time, an external rpm-counter can initiate the definite-time tripping characteristic via binary input („>Rotor locked“). A locked rotor leads to a loss of ventilation and therefore to a reduced thermal load capacity of the machine. For this reason the motor starting time supervision is to issue a tripping command before reaching the thermal tripping characteristic valid for normal operation.

A current above the threshold 6505 (address **I MOTOR START**) is interpreted as a motor startup. Consequently, this value must be chosen such that it is reliably attained by the actual starting current under any load or voltage conditions during motor startup, but not during a permissible short-time overload.

Example: Motor with the following data:

Nominal voltage	U_N = 6600 V
Nominal current	$I_{Mot.Nom}$ = 126 A
Startup current	$I_{StartCurr}$ = 624 A
Permissible continuous stator current:	I_{max} = 135 A
Starting time at $I_{StartCurr}$	$t_{Start\ max}$ = 8.5 s
CT Ratio $I_{N\ CTprim}/I_{N\ CTsec}$	200 A/1 A

The setting for address **START. CURRENT** is calculated as follows:

$$I_{StartCurr} = \frac{I_{StartCurr}}{I_{N\ CT\ prim}} \cdot I_{N\ CT\ sec} = \frac{624\ A}{200\ A} \cdot I_{N\ CT\ sec} = 3.12\ A$$

For reduced voltage, the startup current is also reduced almost linearly. At 80% nominal voltage, the startup current in this example is reduced to $0.8 \cdot I_{StartCurr} = 2.5 \cdot I_{N\ CTsec}$.

The setting for detection of a motor startup must lie above the maximum load current and below the minimum startup current. If no other influencing factors are present (peak loads), the value for motor startup **I MOTOR START** set at address 6505 may be set to an average value:

Based on the Long-term Current Rating: $\frac{135\ A}{200\ A} = 0.68 \cdot I_{N\ CT\ sec}$

$$I_{MotorStart} = \frac{2.5 I_{N\ CT\ sec} + 0.68 I_{N\ CT\ sec}}{2} \approx 1.6 \cdot I_{N\ CT\ sec} = 1.6\ A$$

The tripping time of the starting time monitoring is calculated as follows:

$$t_{TRIP} = \left(\frac{I_{StartCurr.}}{I}\right)^2 \cdot t_{Start\ max}$$

Under nominal conditions, the tripping time is the maximum starting time $t_{Start\,max}$. For ratios deviating from nominal conditions, the motor tripping time changes. At 80% of nominal voltage (which corresponds to 80% of nominal starting current), the tripping time is for example:

$$t_{Trip} = \left(\frac{624\ A}{0.8 \cdot 624\ A}\right)^2 \cdot 8.5\ s = 13.3\ s$$

After the delay time **LOCK ROTOR TIME** has expired, the binary input becomes effective and initiates a tripping signal. If the blocked rotor time is set to a value that, in a normal startup, the binary input „>Rotor locked“ (No. 6805) is reliably reset during the delay time **LOCK ROTOR TIME**, faster tripping will be available during motor starting under locked rotor conditions.

2.36.3 Settings

The table indicates region-specific presettings. Column C (configuration) indicates the corresponding secondary nominal current of the current transformer.

Addr.	Parameter	C	Setting Options	Default Setting	Comments
6501	STARTUP MOTOR		OFF ON Block relay	OFF	Motor Starting Time Supervision
6502	START. CURRENT	5A	0.50 .. 80.00 A	15.60 A	Starting Current of Motor
		1A	0.10 .. 16.00 A	3.12 A	
6503	STARTING TIME		1.0 .. 180.0 sec	8.5 sec	Starting Time of Motor
6504	LOCK ROTOR TIME		0.5 .. 120.0 sec; ∞	6.0 sec	Permissible Locked Rotor Time
6505	I MOTOR START	5A	3.00 .. 50.00 A	8.00 A	Current Pickup Value of Motor Starting
		1A	0.60 .. 10.00 A	1.60 A	

2.36.4 Information List

No.	Information	Type of Information	Comments
6801	>BLK START-SUP	SP	>BLOCK Motor Starting Supervision
6805	>Rotor locked	SP	>Rotor is locked
6811	START-SUP OFF	OUT	Starting time supervision switched OFF
6812	START-SUP BLK	OUT	Starting time supervision is BLOCKED
6813	START-SUP ACT	OUT	Starting time supervision is ACTIVE
6821	START-SUP TRIP	OUT	Starting time supervision TRIP
6822	Rotor locked	OUT	Rotor is LOCKED after Locked Rotor Time
6823	START-SUP PU	OUT	Starting time supervision picked up

2.37 Restart Inhibit for Motors (ANSI 66, 49Rotor)

The rotor temperature of a motor generally remains well below its admissible limit temperature during normal operation and also under increased load conditions. However, with startups and resulting high startup currents caused by small thermal time constants of the rotor it may suffer more thermal damage than the stator. To avoid that multiple starting attempts result in tripping, a new motor start must be prevented if it can be expected that the allowed rotor heating would be violated by this starting attempt. Therefore the 7UM62 device provides a motor restart blocking feature. An inhibit signal is issued until a new motor start is admissible (restarting threshold). This blocking signal must be configured to a binary output of the device whose contact is inserted in the motor starting circuit.

2.37.1 Functional Description

Determining the Rotor Overtemperature

Because rotor current cannot be measured directly, stator currents must be used. The rms values of the currents are used for this. Rotor overtemperature Θ_R is calculated using the highest of the three phase currents. For this it is assumed that the thermal limits for the rotor winding according to the manufacturer's data regarding nominal startup current, maximum admissible starting time, and the number of starts permitted from cold (n_{cold}) and warm (n_{warm}) state are just reached. From this data, the device calculates values for the thermal rotor profile and issues a blocking signal until this profile decreases below the restarting threshold allowing restart.

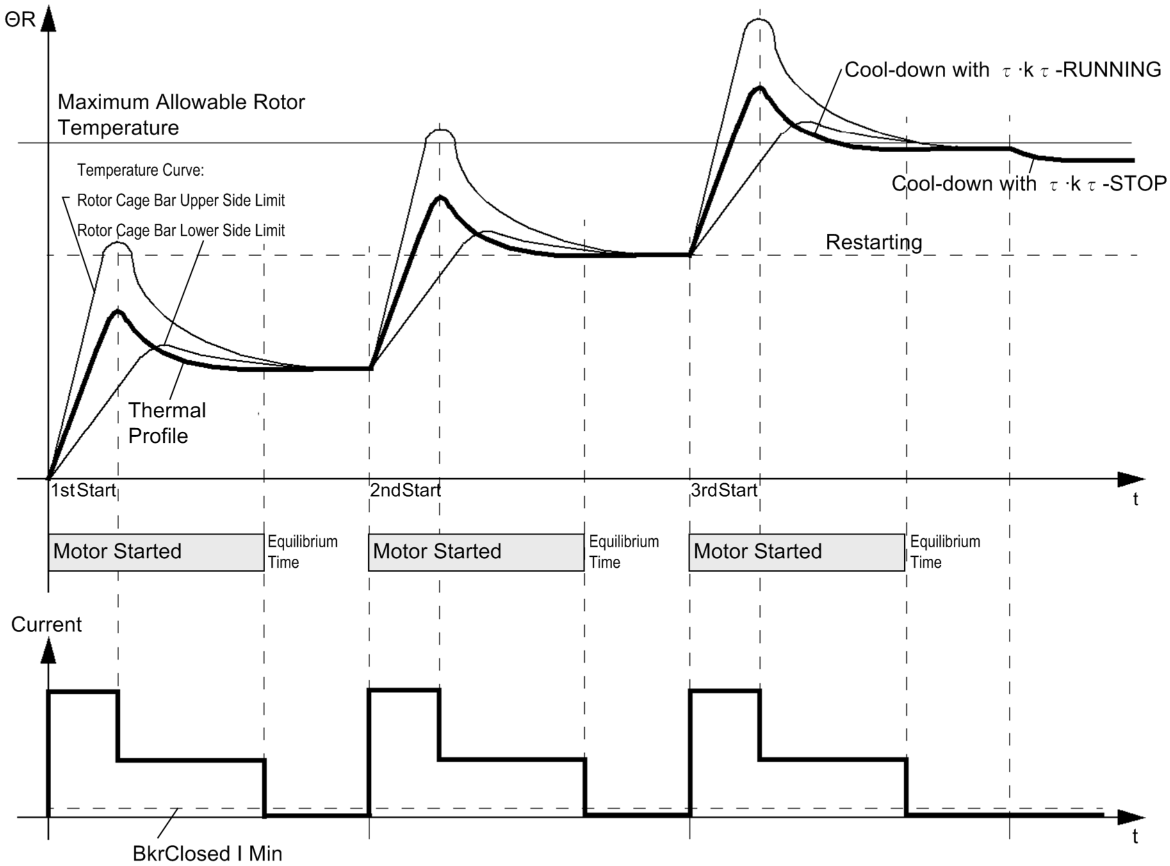


Figure 2-116 Temperature Curve at the Rotor and the Thermal Profile during Repeated Start-Up Attempts

Although the heat distribution at the rotor cage bars can range widely during motor startup, the different maximum temperatures in the rotor do not necessarily affect the motor restart inhibit (see Figure 2-116). It is much more important to establish a thermal profile, after a complete motor startup, that is appropriate for protection of the motor's thermal state. The figure shows, as an example, the heating processes during repeated motor starts (three startups from cold operating condition), as well as the thermal replica of the protection device.

Restart Threshold

If the rotor temperature has exceeded the restart threshold, the motor cannot be restarted. Only when the rotor temperature goes below the restart threshold, i.e. just when a startup becomes possible without exceeding the rotor overtemperature limit, the blocking signal is retracted. Therefore, the following applies for the restart threshold $\Theta_{Re.Inh.}$, related to maximum admissible rotor overtemperature:

$\Theta_{ReInhib}[\%] = \frac{n_{cold} - 1}{n_{cold}} 100\ \%$	n_{cold}	2	3	4
	$\Theta_{Re.Inh.}$ [%]	50 %	66.7 %	75 %

Restart Times

The motor manufacturer allows a number of cold (n_{cold}) and warm (n_{warm}) startups. No subsequent renewed startup is allowed. A corresponding time — the restart time — must expire to allow the rotor to cool down. Thermal behaviour is allowed for as follows: Each time the motor is shutdown, a leveling timer is started (address 6604 **T EQUAL**). This takes into account the different temperatures of the individual motor components at the moment of shutdown. During the leveling time the thermal profile of the rotor is not updated but maintained constant to replicate the leveling processes in the rotor. Then the thermal model cools down with the corresponding time constant (rotor time constant x extension factor). During the leveling time the motor cannot be restarted. As soon as the restart threshold is undershot, a new restart may be attempted.

The total time that must expire before motor restart equals to the leveling time and the time calculated using the thermal model required for the rotor temperature to decrease below the restart threshold:

$$T_{Rem.} = T_{Leveling} + k_\tau \cdot \tau_R \cdot \ln\left[\frac{\Theta_{pre} \cdot n_{cold}}{n_{cold} - 1}\right]$$

with

$T_{Leveling}$ Rotor temperature equilibrium time address 6604

k_τ extension factor for the time constant = **Kτ at RUNNING** address 6609 or **Kτ at STOP** address 6608

τ_R rotor time constant, internally calculated:

$\tau_R = t_{Start} \cdot (n_{cold} - n_{warm}) \cdot I_{on}^2$

where:

t_{Start} = Startup time in s

I_{on} = Startup current in pu

Θ_{pre} thermal profile at the moment of motor shutdown (depends on the operating state)

The operational measured value $T_{Rem.}$= (to be found in the thermal measured values) shows the time remaining until the next restart is allowed.

Prolonging the Cooling Time Constant

In order to properly account for the reduced heat removal when a self-ventilated motor is stopped, the cooldown time constant can be increased relative to the time constants for a running machine with the factor **Kτ at STOP** (address 6608). A motor at standstill is defined by current below an adjustable current threshold **BkrClosed I MIN**. This assumes that the idle current of the motor is greater than this threshold. The pickup threshold **BkrClosed I MIN** also affects the thermal overload protection function (see Section 2.11).

While the motor is running, heating of the thermal profile is modeled with the time constant τ_R calculated from the motor ratings, and the cooldown is calculated with the time constant τ_R · **Kτ at RUNNING** (address 6609). In this way the requirements for a slow cooldown (slow temperature leveling) are met.

Minimum Inhibit Time

Regardless of thermal profiles, some motor manufacturers require a minimum inhibit time after the maximum number of permissible startup attempts has been exceeded.

The duration of the inhibit signal depends on which of the times, $T_{MIN\ INHIBIT}$ or $T_{Rem.}$, is longer.

Behaviour on Power Supply Failure

Depending on the setting of parameter 274 **ATEX100**, the value of the thermal profile is either reset to zero on failure of the power supply voltage, or cyclically buffered in a non-volatile memory until the power supply voltage returns. In the latter case when power supply is restored, the thermal profile uses the stored value for calculation and matches it to the operating conditions.

Emergency Startup

If, for emergency reasons, motor starting that will exceed the maximum allowable rotor temperature must take place, the motor start blocking signal can be terminated via a binary input („>Emer. Start ΘR“), thus allowing a new starting attempt. The thermal rotor profile continues to function, however, and the maximum admissible rotor temperature can be exceeded. No motor shutdown will be initiated by motor start blocking, but the calculated excessive temperature of the rotor can be observed for risk assessment.

Blocking

If the motor start blocking function is blocked or switched off, the thermal profile of the excessive rotor temperature and the equilibrium time **T EQUAL** as well as the minimum inhibit time **T MIN. INHIBIT** are reset, and any existing motor start inhibit signal is terminated.

Logic

The thermal profile can also be reset via a binary input. This may be useful for testing and commissioning, and after power supply voltage restoration.

The following figure shows the logic diagram for the restart inhibit.

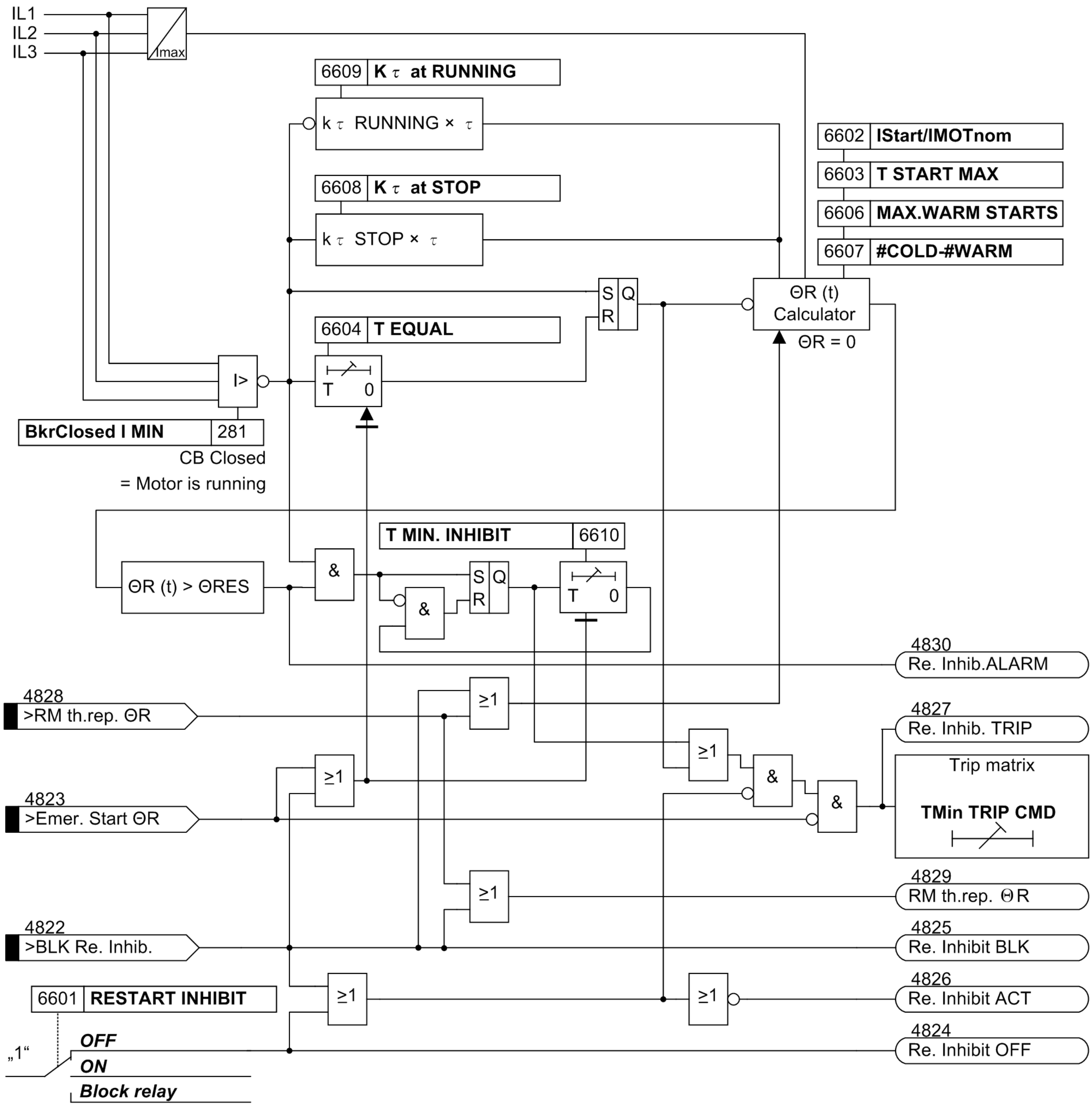


Figure 2-117 Logic diagram of the Restart Inhibit

2.37.2 Setting Notes

General

Restart inhibit is only effective and available if address 166 **RESTART INHIBIT** was set to ***Enabled*** during configuration. If the function is not required ***Disabled*** is set. Address 6601**RESTART INHIBIT** serves to switch the function ***ON*** or ***OFF*** or to block only the trip command (***Block relay***).

Required Characteristic Values

Many of the variables needed to calculate the rotor temperature are supplied by the motor manufacturer. Among these variables are the starting current $I_{StartCurr}$, the nominal motor current $I_{Mot.Nom}$, the maximum allowable starting time **T START MAX** (address 6603), the number of allowable starts from cold conditions (n_{cold}), and the number of allowable starts from warm conditions (n_{warm}).

The starting current is entered at address 6602, expressed as a multiple of the nominal motor current (**IStart/IMOTnom**). For a correct interpretation of this parameter, it is important that in Power System Data 1 the apparent power (address 252 **SN GEN/MOTOR**) and the rated voltage (address 251 **UN GEN/MOTOR**) of the motor are correctly set. The number of warm starts allowed is entered at address 6606 (**MAX.WARM STARTS**) and the difference (**#COLD-#WARM**) between the number of allowable cold and warm starts is entered at address 6607.

For motors without separate ventilation, the reduced cooling at motor standstill can be accounted for by entering at address 6608 the reduced ventilation factor **Kτ at STOP**. As soon as the current no longer exceeds the setting value entered at address 281 **BkrClosed I MIN**, motor standstill is detected and the time constant is increased by the extension factor configured.

If no difference between the time constants is to be used (e.g. externally-ventilated motors), then the extension factor **Kτ at STOP** should be set to ***1***.

Cooling with running motor is influenced by the extension factor **Kτ at RUNNING**. This factor considers that a motor running under load and a stopped motor do not cool down at the same speed. It becomes effective as soon as the current exceeds the value set at address 281 **BkrClosed I MIN**. With **Kτ at RUNNING** = ***1*** the heating and the cooling time constant are the same at operating conditions (I > **BkrClosed I MIN**).

Setting Example:

Example: Motor with the following data:

Nominal voltage	U_N = 6600 V
Nominal current	$I_{Mot.Nom}$ = 126 A
Startup current	$I_{StartCurr}$ = 624 A
Starting time at $I_{StartCurr}$	$t_{Start\ max}$ = 8.5 s
Permissible number of startups with cold motor	n_{cold} = 3
Permissible number of startups with warm motor	n_{warm} = 2
Current transformer	200 A / 1 A

The ratio between startup current and motor nominal current is:

$$I_{StartCurr}/I_{MOTnom} = \frac{624\ A}{126\ A} = 4.95 \approx 4.9$$

The following settings are made:

IStart/IMOTnom .	= ***4.9***
T START MAX .	= ***8.5 sec***
MAX.WARM STARTS .	= ***2***
#COLD-#WARM .	= ***1***

For the rotor temperature equilibrium time, a setting of approx. **T EQUAL** = 1.0 min has proven to be a practical value. The value for the minimum inhibit time **T MIN. INHIBIT** depends on the requirements set by the motor manufacturer, or on the system conditions. It must in any case exceed **T EQUAL**. In this example, a value has been chosen that roughly reflects the thermal profile (**T MIN. INHIBIT** =6.0 min).

The motor manufacturer's or the user's requirements also determine the extension factor for the time constant during cooldown, especially for motor standstill. Where no other specifications are made, the following settings are recommended: **Kτ at STOP** = 5.0 and **Kτ at RUNNING** = 2.0 .

For proper functioning it is also important that the CT values for side 2 (addresses 211 and 212), the power system data (addresses 251, 252) and the current threshold for distinction between stopped and running motor (address 281 **BkrClosed I MIN**, recommended setting ≈ 0.1 · $I/I_{Mot.Nom.}$) were set correctly. An overview of the parameters and their default settings is given in the settings list.

Temperature Behaviour during Changing Operating States

For better understanding of the above considerations, two of the many possible operating states will be discussed in the following paragraph. The examples use the settings indicated above. 3 cold and 2 warm startup attempts have resulted in a restart limit of 66.7 %.

The following figure illustrates the temperature behaviour during 2 warm startup attempts. The motor is continuously operated at nominal current. After the first switchoff **T EQUAL** is effective. 30 s later the motor is restarted and immediately shut down again. After another pause, the 2nd restart attempt is made. The motor is shut down once again. During this 2nd startup attempt, the restart limit is exceeded, so that after shutdown the restart inhibit takes effect. After the temperature leveling time (1 min), the thermal profile cools down with the time constant τ_R · **Kτ at STOP** ≈ 5 · 204 s = 1020 s. The restart inhibit is effective for about 7 min.

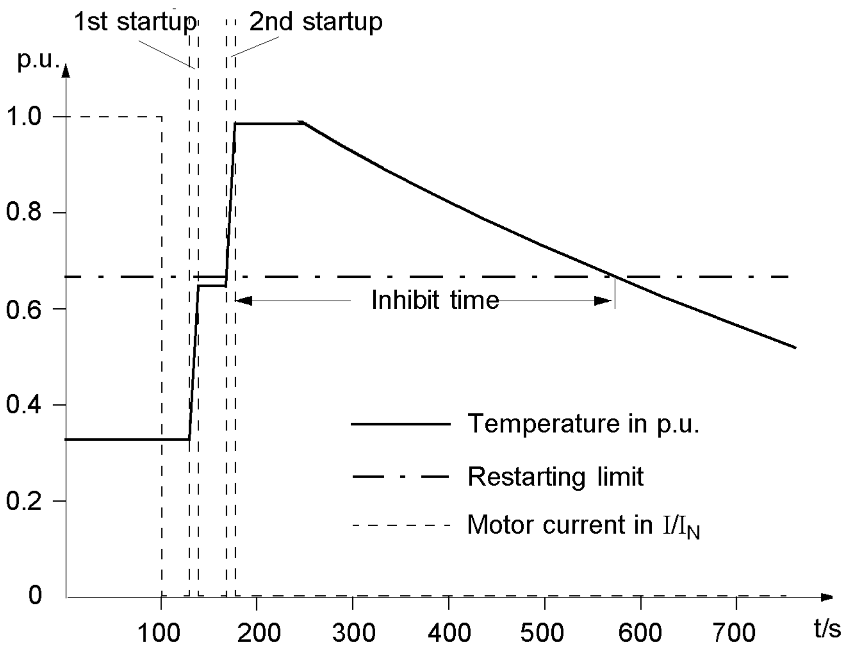


Figure 2-118 Temperature Behaviour during Two Successive Warm Starts

In Figure 2-119, the motor is also restarted twice in warm condition, but the pause between the restart attempts is longer than in the first example. After the second restart attempt, the motor is operated at 90 % nominal current. After the shutdown following the first startup attempt, the thermal profile is "frozen". After the temperature leveling time (1 min), the rotor cools down with the time constant $\tau_R \cdot$ **Kτ at STOP** ≈ 5 · 204 s = 1020 s. During the second restart, the starting current causes a temperature rise, whereas the subsequently flowing on-load current of 0.9 $I/I_{Mot.Nom.}$ **Kτ at RUNNING** reduces the temperature. This time, the time constant $\tau_R \cdot$ **Kτ at STOP** = 2 · 204 s = 408 s is effective.

The fact that the restart limit is exceeded for a short time does not mean a thermal overload. It rather indicates that a thermal overload of the rotor would result if the motor were shut down immediately and restarted.

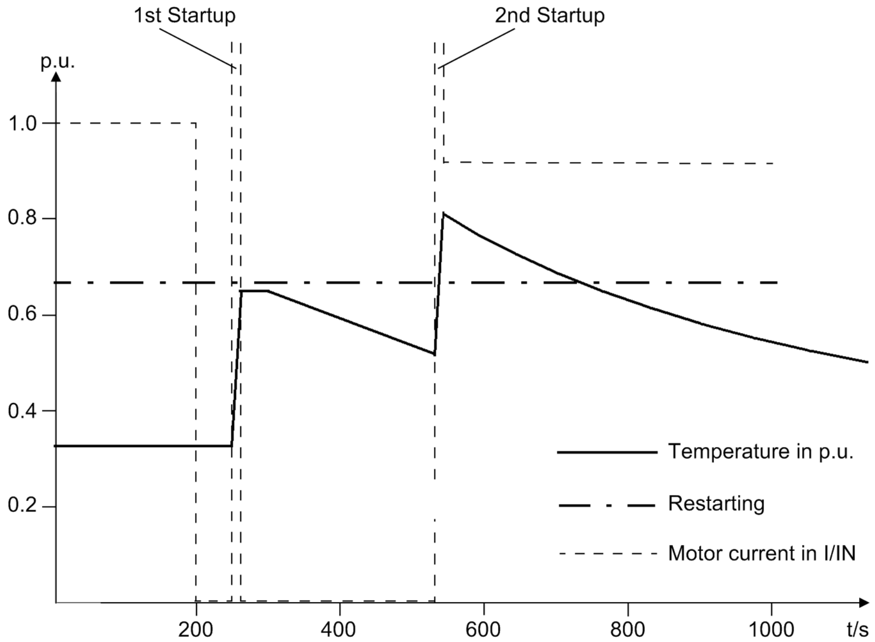


Figure 2-119 Two Warm Restarts Followed by Continuous Running

2.37.3 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
6601	RESTART INHIBIT	OFF ON Block relay	OFF	Restart Inhibit for Motors
6602	IStart/IMOTnom	1.5 .. 10.0	4.9	I Start / I Motor nominal
6603	T START MAX	3.0 .. 320.0 sec	8.5 sec	Maximum Permissible Starting Time
6604	T EQUAL	0.0 .. 320.0 min	1.0 min	Temperature Equalization Time
6606	MAX.WARM STARTS	1 .. 4	2	Permissible Number of Warm Starts
6607	#COLD-#WARM	1 .. 2	1	Number of Cold Starts - Warm Starts
6608	Kτ at STOP	1.0 .. 100.0	5.0	Extension of Time Constant at Stop
6609	Kτ at RUNNING	1.0 .. 100.0	2.0	Extension of Time Constant at Running
6610	T MIN. INHIBIT	0.2 .. 120.0 min	6.0 min	Minimum Restart Inhibit Time

2.37.4 Information List

No.	Information	Type of Information	Comments
4822	>BLK Re. Inhib.	SP	>BLOCK Restart inhibit motor
4823	>Emer. Start ΘR	SP	>Emergency start rotor
4824	Re. Inhibit OFF	OUT	Restart inhibit motor is switched OFF
4825	Re. Inhibit BLK	OUT	Restart inhibit motor is BLOCKED
4826	Re. Inhibit ACT	OUT	Restart inhibit motor is ACTIVE
4827	Re. Inhib. TRIP	OUT	Restart inhibit motor TRIP
4828	>RM th.rep. ΘR	SP	>Reset thermal memory rotor
4829	RM th.rep. ΘR	OUT	Reset thermal memory rotor
4830	Re. Inhib.ALARM	OUT	Alarm restart inhibit motor

2.38 Breaker Failure Protection (ANSI 50BF)

The breaker failure protection can be assigned to the current inputs of side 1 or side 2 during configuration of the protective functions (see Section 2.4). The breaker failure protection monitors whether the associated circuit breaker is opened correctly. In machine protection it concerns usually the mains breaker.

2.38.1 Functional Description

Mode of Operation

The following two criteria are available for circuit breaker failure protection:

- Checking whether the current in all three phases undershoots a set threshold following a trip command,
- Evaluation of the position of a circuit breaker auxiliary contact for protective functions where the current criterion is perhaps not representative, e.g. frequency protection, voltage protection, rotor earth fault protection.

If the circuit breaker has not opened after a programmable time delay (breaker failure), a higher-level circuit breaker can initiate disconnection (see the following example).

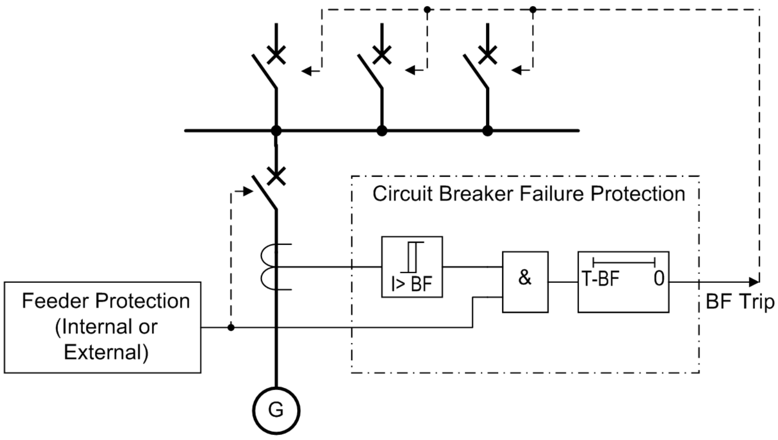


Figure 2-120 Function Principle of the Breaker Failure Protection Function

Initiation

The breaker failure protection function can be initiated by two different sources:

- Internal functions of the 7UM62, e.g. trip commands of protective functions or via CFC (internal logic functions),
- external start commands e.g. via binary input.

Criteria

The two pickup criteria (current criterion, circuit breaker auxiliary contact) are OR-combined. In case of a tripping without short circuit current, e.g. for voltage protection on light load, the current is not a safe criterion for circuit breaker response. For this reason pickup is also made possible using the auxiliary contact criterion.

The current criterion is fulfilled if at least one of the three phase currents exceeds a parametrized threshold value (**CIRC. BR. I>**). The dropout is performed if all three phase currents fall below 95 % of the pickup threshold value.

In the operating condition 0 the current criterion is inactive. In that case, the breaker failure protection will be activated only by the breaker auxiliary contacts.

If the binary input of the circuit breaker auxiliary contact is inactive, only the current criterion is effective and the breaker failure protection cannot become active with a tripping signal if the current is below the **CIRC. BR. I>** threshold.

Two-Channel Feature

To increase security and to protect against possible disturbance impulses the binary input for an external trip signal is stabilized. This external signal must be present during the entire period of the delay time. Otherwise, the timer is reset and no tripping signal is issued. A redundant binary input „>ext.start2 B/F“ is linked to further enhance the security against unwanted operation. This means that no initiation is possible unless both binary inputs are activated. The two-channel feature is also effective for an “internal” initiation.

Logic

If the breaker failure protection has picked up, a corresponding message is transmitted and a parameterized time delay starts. If the pickup criteria are still fulfilled on expiration of this time, a redundant source evaluation before fault clearing is initiated via a further AND combination through a higher level circuit breaker.

A pickup drops off and no trip command is produced by the breaker failure protection if

- one of the internal start conditions (Output relay BO3 or via CFC) or „>ext.start1 B/F“ or „>ext.start2 B/F“ causing the pickup drop off.
- a tripping signal of the protective functions still exists, whereas the current criterion and the auxiliary contact criterion drops off.

The following figure shows the logic diagram for the breaker failure protection function. The overall breaker failure protection can be enabled or disabled via parameters and also blocked dynamically via binary input „>BLOCK BkrFail“ (e.g. during a machine protection check).

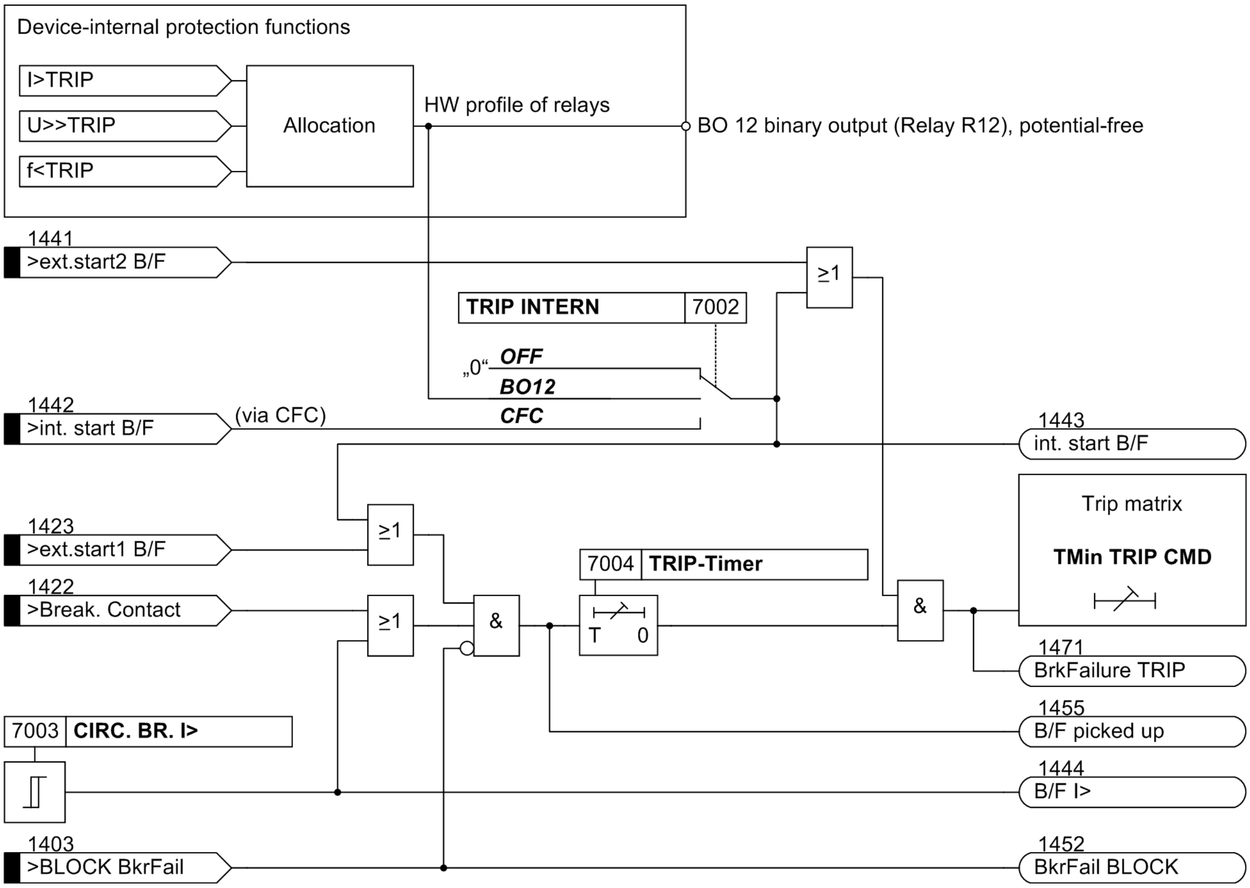


Figure 2-121 Logic Diagram of the Breaker Failure Protection

2.38.2 Setting Notes

General

Breaker failure protection is only effective and available if address 170 **BREAKER FAILURE** is set to ***Side 1*** or ***Side 2*** during configuration. If the function is not required ***Disabled*** is set. Address 7001 **BREAKER FAILURE** serves to switch the function ***ON*** or ***OFF*** or to block only the trip command (***Block relay***).

The current measurement for breaker failure protection can be performed either at side 1 (inputs $I_{L, S1}$) or at side 2 (inputs $I_{L, S2}$). It is recommended to use the terminal-side set of CTs, i.e. side 1.

Criteria

The parameter 7002 **TRIP INTERN** serves to select the OFF criterion of an internal pickup. It can be implemented by reading the switching status of the output relay BO12 provided for this (7002 **TRIP INTERN** = ***BO12***) or by a logic link created in CFC (= ***CFC***) (Message 1442 „>int. start B/F“). The internal source can also be completely deactivated (7002 **TRIP INTERN** = ***OFF***). In this case only external sources have effect.

Note: Be aware that only the potential-free binary output ***BO12*** (relay BO12) can be used for the breaker failure protection. This means that trippings for the mains breaker (or the particular breaker being monitored) must be configured to this binary output.

The pickup threshold 7003 **CIRC. BR. I>** setting of the current criterion applies for all three phases. The user must select a value ensuring that the function still picks up even for the lowest operating current to be expected. For this reason, the value should be set at least 10% below the minimum operating current.

However the pickup value should not be selected lower than necessary, as an excessively sensitive setting risks prolonging the drop-out time due to balancing processes in the current transformer secondary circuit during switchoff of heavy currents.

Time Delay

The time delay is entered at address 7004 **TRIP-Timer** and is based on the maximum breaker disconnecting time, the dropout time of overcurrent detection plus a safety margin which takes into consideration delay time runtime deviation. The time sequences are illustrated in the following figure.

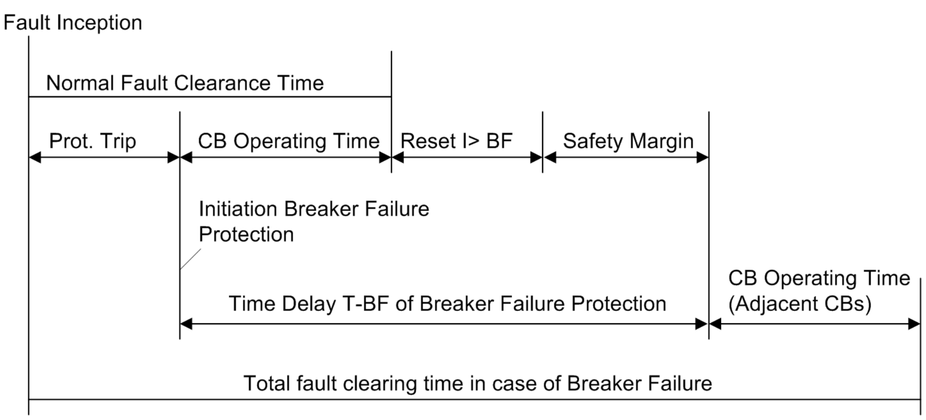


Figure 2-122 Time Sequence for Typical Fault Clearance and for Breaker Failure

2.38.3 Settings

The table indicates region-specific presettings. Column C (configuration) indicates the corresponding secondary nominal current of the current transformer.

Addr.	Parameter	C	Setting Options	Default Setting	Comments
7001	BREAKER FAILURE		OFF ON Block relay	OFF	Breaker Failure Protection
7002	TRIP INTERN		OFF BO12 CFC	OFF	Start with Internal TRIP Command
7003	CIRC. BR. I>	5A	0.20 .. 10.00 A	1.00 A	Supervision Current Pickup
		1A	0.04 .. 2.00 A	0.20 A	
7004	TRIP-Timer		0.06 .. 60.00 sec; ∞	0.25 sec	TRIP-Timer

2.38.4 Information List

No.	Information	Type of Information	Comments
1403	>BLOCK BkrFail	SP	>BLOCK breaker failure
1422	>Break. Contact	SP	>Breaker contacts
1423	>ext.start1 B/F	SP	>ext. start 1 breaker failure prot.
1441	>ext.start2 B/F	SP	>ext. start 2 breaker failure prot.
1442	>int. start B/F	SP	>int. start breaker failure prot.
1443	int. start B/F	OUT	Breaker fail. started intern
1444	B/F I>	OUT	Breaker failure I>
1451	BkrFail OFF	OUT	Breaker failure is switched OFF
1452	BkrFail BLOCK	OUT	Breaker failure is BLOCKED
1453	BkrFail ACTIVE	OUT	Breaker failure is ACTIVE
1455	B/F picked up	OUT	Breaker failure protection: picked up
1471	BrkFailure TRIP	OUT	Breaker failure TRIP

2.39 Inadvertent Energization (ANSI 50, 27)

The inadvertent energization protection has the task to limit damage caused by the accidental energization of the stationary or already started, but not yet synchronized generator by quickly actuating the generator circuit breaker. A connection to a stationary machine is equivalent to connecting to a low-ohmic resistor. Due to the nominal voltage impressed by the power system, the generator starts up with a high slip as an asynchronous machine. Thereby inadmissibly high currents are induced in the rotor which could destroy it.

2.39.1 Functional Description

Criteria

The inadvertent energizing protection only intervenes if measured quantities do not yet exist in the valid frequency working area (operational condition 0, with a stationary machine) or if an undervoltage below the nominal frequency is present (machine already started up, but not yet synchronized). The inadvertent energizing protection is blocked by a voltage criterion on transgression of a minimum voltage, to prevent it picking up during normal operation. This blocking is delayed to avoid protection being blocked immediately in the event of an unintended connection. Another pickup delay is necessary to avoid an unwanted operation during high-current faults with heavy voltage dip. A dropout time delay allows for a measurement limited in time.

As the inadvertent energizing protection must intervene very rapidly, the instantaneous current values are monitored over a large frequency range already in operational condition 0. If valid measured quantities exist (operational condition 1), the positive phase-sequence voltage, the frequency for blocking inadvertent energizing protection as well as the instantaneous current values are evaluated as tripping criterion.

The following figure shows the logic diagram for inadvertent energizing protection. This function can be blocked via a binary input. For example the existence of the excitation voltage can be used here as an additional criterion. As the voltage is a necessary criterion for enabling the inadvertent energizing protection, the voltage transformers must be monitored. This is done by the Fuse-Failure-Monitor (FFM). If it detects a voltage transformer fault, the voltage criterion of the inadvertent energizing protection is deactivated.

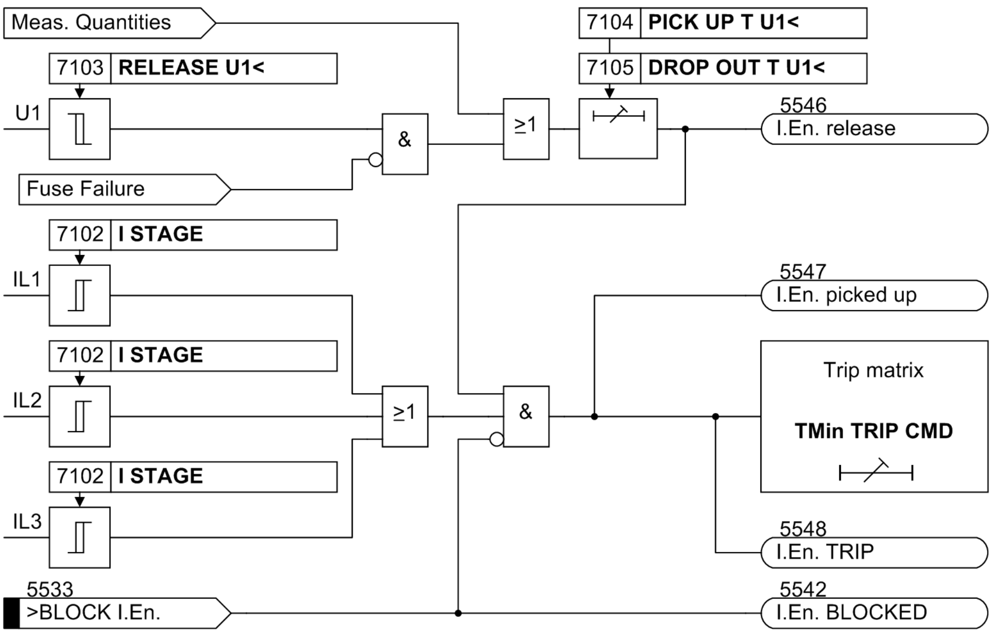


Figure 2-123 Logic Diagram of the Inadvertent Energizing Protection (Dead Machine Protection)

2.39.2 Setting Notes

General

Inadvertent energizing protection is only effective and available if address 171 **INADVERT. EN.** is set to ***Enabled*** during configuration. If the function is not required ***Disabled*** is set. Address 7101 **INADVERT. EN.** serves to switch the function ***ON*** or ***OFF*** or to block only the trip command (***Block relay***).

Criteria

Parameter 7102 **I STAGE** serves to specify the current pickup threshold of the inadvertent energization protection function. As a rule, this threshold value is set more sensitively than the threshold value of the time-overcurrent protection. In this case, the inadvertent energizing protection may only be effective if the device is either in operational condition 0 or if no nominal conditions have been reached yet. The parameter 7103 **RELEASE U1<** serves to define these nominal conditions. The typical setting is about 50 % to 70 % of the nominal voltage. The parameter value is based on phase-to-phase voltages. A 0 V setting deactivates the voltage tripping. However, this should only be used if 7102 **I STAGE** shall be used as 3rd time-overcurrent protection stage, at a very high setting.

The parameter 7104 **PICK UP T U1<** represents the time delay for the release of the tripping condition with undervoltage. The user should select a higher value for this time delay than for the tripping time delay of the time-overcurrent protection.

The delay time to block the tripping conditions when the voltage is above the undervoltage threshold is set at 7105 **DROP OUT T U1<**. The inadvertent energizing protection is blocked only after this time in order to enable a tripping subsequent to connection.

The following figure illustrates the course of events during an unwanted connection at machine standstill and, in contrast to this, during a voltage collapse on short circuit close to generator terminals.

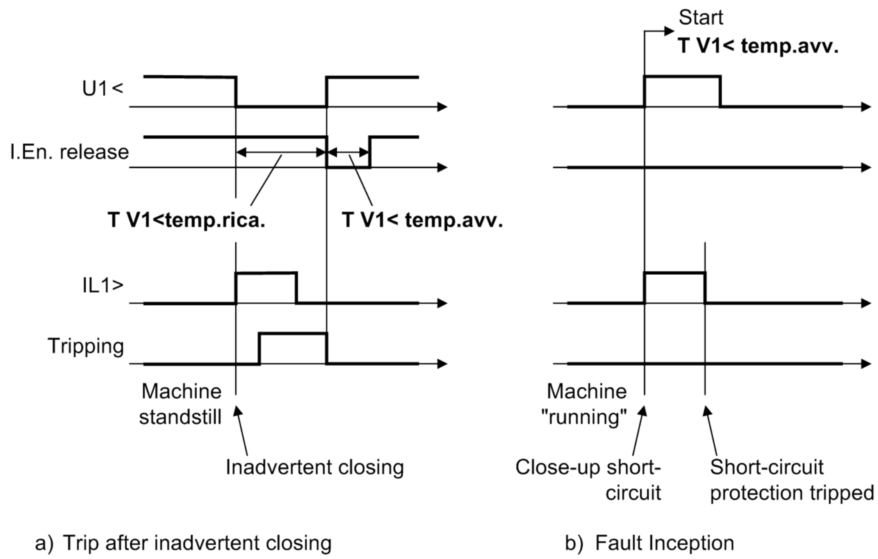


Figure 2-124 Chronological Sequences of the Inadvertent Energizing Protection

2.39.3 Settings

The table indicates region-specific presettings. Column C (configuration) indicates the corresponding secondary nominal current of the current transformer.

Addr.	Parameter	C	Setting Options	Default Setting	Comments
7101	INADVERT. EN.		OFF ON Block relay	OFF	Inadvertent Energisation
7102	I STAGE	5A	0.5 .. 100.0 A; ∞	1.5 A	I Stage Pickup
		1A	0.1 .. 20.0 A; ∞	0.3 A	
7103	RELEASE U1<		10.0 .. 125.0 V; 0	50.0 V	Release Threshold U1<
7104	PICK UP T U1<		0.00 .. 60.00 sec; ∞	5.00 sec	Pickup Time Delay T U1<
7105	DROP OUT T U1<		0.00 .. 60.00 sec; ∞	1.00 sec	Drop Out Time Delay T U1<

2.39.4 Information List

No.	Information	Type of Information	Comments
5533	>BLOCK I.En.	SP	>BLOCK inadvertent energ. prot.
5541	I.En. OFF	OUT	Inadvert. Energ. prot. is swiched OFF
5542	I.En. BLOCKED	OUT	Inadvert. Energ. prot. is BLOCKED
5543	I.En. ACTIVE	OUT	Inadvert. Energ. prot. is ACTIVE
5546	I.En. release	OUT	Release of the current stage
5547	I.En. picked up	OUT	Inadvert. Energ. prot. picked up
5548	I.En. TRIP	OUT	Inadvert. Energ. prot. TRIP

2.40 DC Voltage/Current Protection (ANSI 59NDC/51NDC)

To detect DC voltages, DC currents and small AC quantities, the 7UM62 is equipped with a measuring transducer input (TD1) that can be used either for voltages (± 10V) or currents (± 20mA). Higher DC voltages are connected via an external voltage divider. The DC voltage/DC current protection can be used, for example, for the monitoring of the excitation voltage of synchronous machines or for the detection of earth faults in the DC section of the start-up converter of a gas turbine set.

2.40.1 Functional Description

Principle of Function

A measuring transducer performs the analog/digital conversion of the measured quantity. The measuring transducer provides for galvanic isolation, a digital filter integrates the measurement voltage over two cycles and suppresses high ripple content or non-periodic peaks in the measured value. A mean value of 32 samples is generated. Since the absolute values are sampled, the result is always positive. Thus, the polarity of the voltage is of no concern. When no suitable measured AC quantities are present ("operating condition 0"), the DC voltage protection is still operative. The mean value is then calculated over 4 x 32 measured value samples.

If, in special cases, an AC voltage should be evaluated, select ***RMS*** as measurement method. The input quantity is mathematically rectified, then the mean value calculated and reference to ***RMS*** made using factor 1.11.

Optionally, this function can be used for monitoring small currents, provided that the TD input has been configured as current input and the settings of the associated jumpers on the C-I/O-6 have been changed. If the jumper settings do not match the configuration parameters, an error message is output.

The protection can be set to operate for overvoltage or undervoltage. Pickup can be blocked via a binary input, and the output signal can be time delayed.

Excitation Voltage Monitoring

The following figure shows the excitation voltage monitoring. The excitation voltage is stepped down to a processable level by a voltage divider, and fed to the measuring transducer.

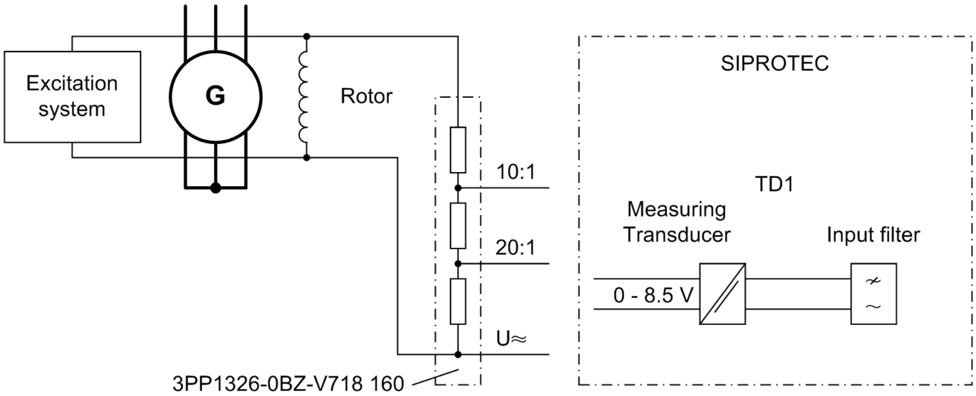


Figure 2-125 DC Voltage Protection for Excitation Voltage Monitoring

Earth Fault Detection in the Startup Converter

If an earth fault occurs in the startup converter circuit, a current flows through all earthed parts of the system because of the DC voltage. As earthing and neutral transformers have a lower ohmic resistance than voltage transformers, the thermal load is the highest on them.

The DC current is converted into a voltage in a shunt, and fed via a shunt converter to the measuring transducer of the device.

Shunt converters can be measuring transducers such as the 7KG6131. For short distances between the shunt converter and the protective device, a voltage input may be used. For longer distances, use the version with current input (-20 to 20 mA or 4 to 20 mA).

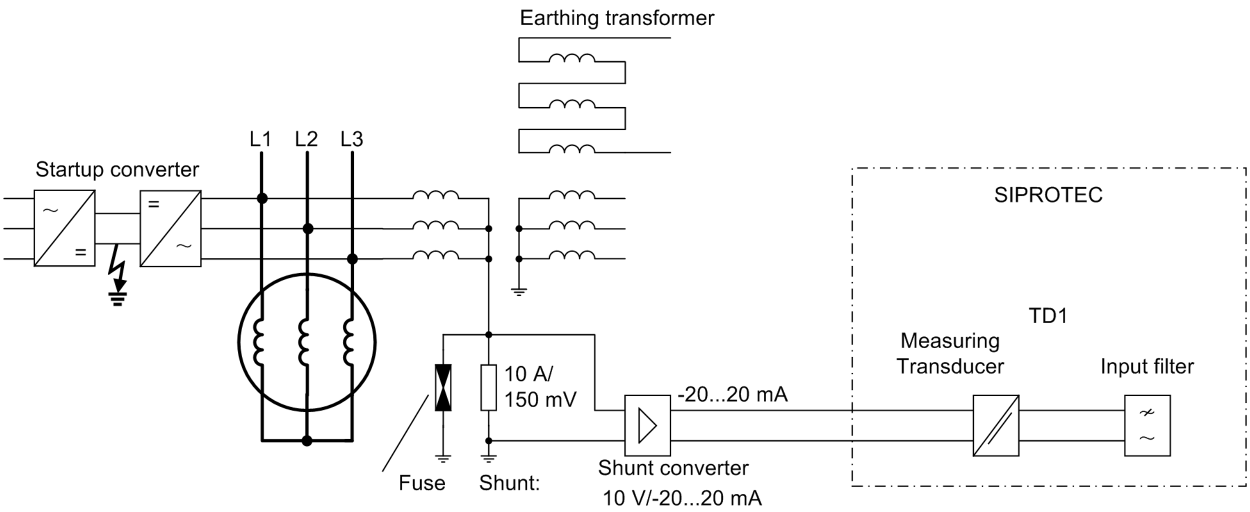


Figure 2-126 DC Voltage Protection for Detecting an Earth Fault in the Startup Converter

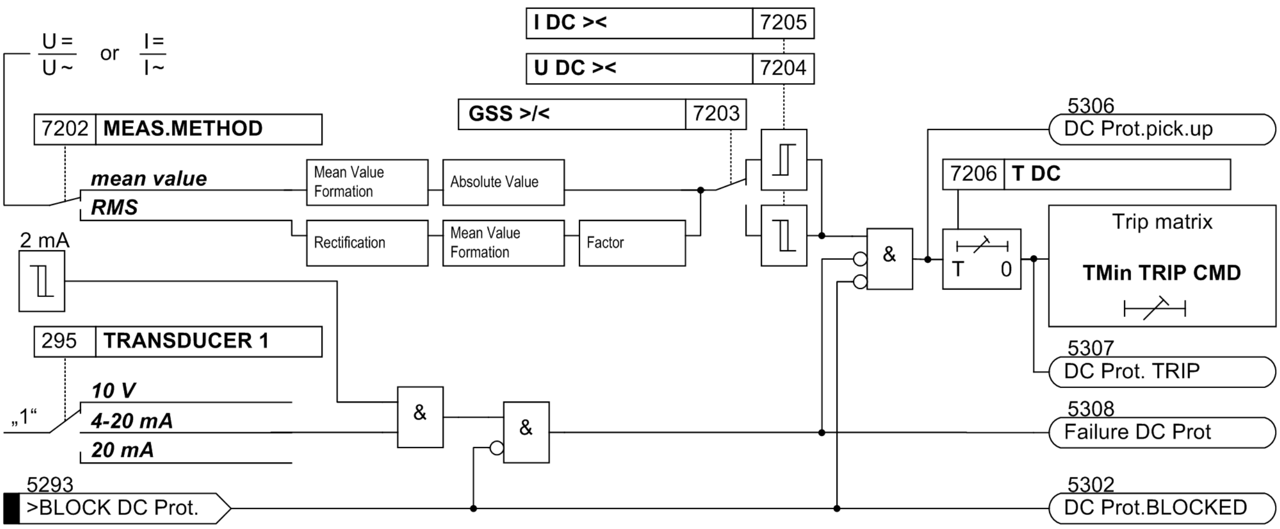


Figure 2-127 Logic Diagram of the DC Voltage Protection

2.40.2 Setting Notes

General

The DC voltage protection is only effective and available if set to ***Enabled*** at address 172 **DC PROTECTION**. If the function is not required, ***Disabled*** is set. For the associated measuring transducer 1, address 295 **TRANSDUCER 1** was set to one of the alternatives ***10 V***, ***4-20 mA*** or ***20 mA*** (see section 2.5).

Jumpers X94, X95 and X67 on the C-I/O-6 module are used to set in the hardware whether the measuring transducer input will be a voltage or a current input (see section 3.1.2 in the chapter „Installation and Commissioning"). Their setting must correspond to the setting at address 295. If it does not, the device is blocked and issues an annunciation to that effect. When the relay is delivered from the factory, the jumpers and configuration parameters are set to voltage measurement.

Address 7201 **DC PROTECTION** serves to switch the function ***ON*** or ***OFF*** or to block only the trip command (***Block relay***).

Measurement Method

Normally, the arithmetic mean of a DC voltage is detected. A high ripple content or non-periodic peaks in the measurement voltage are averaged in this manner. The polarity of the measured voltages is of no concern since the absolute value is taken.

Alternatively, the ***RMS*** of a sinusoidal AC voltage can be measured (address 7202 **MEAS.METHOD** = ***RMS***). The protection then multiplies the rectified average value with 1.11. The frequency of the AC voltage must match the frequency of other input quantities, because the latter determine the sampling rate. The maximum AC amplitude must not exceed 10 V, so that for r.m.s. value measurement a maximum setting of 7.0 V_{rms} is reasonable. The resulting higher secondary voltage can be reduced by means of a voltage divider.

The DC voltage/DC current protection can be set to operate for overvoltage protection at address 7203 **DC >/<** = ***DC >*** or undervoltage protection = ***DC <***.

Pickup Thresholds

Depending on whether current or voltage input has been set at address 295 **TRANSDUCER 1**, one of the following parameters is available, whereas the other is hidden:

- Voltage measurement threshold: 7204 **U DC ><**
- Current measurement threshold: 7205 **I DC ><**

When setting the pickup values (address 7204), the ratio of a voltage divider – if fitted – has to be considered.

Application Examples

When used for excitation voltage monitoring, the DC current protection is configured to operate for undervoltage; the pickup threshold is set to approx. 60 % to 70 % of the no-load excitation voltage. Users should be aware that normally a voltage divider is connected between the protection and the excitation voltage (see above).

Another typical application is the earth fault protection for the startup converter of a gas turbine set. In the case of an earth fault in the DC circuit, half of the DC voltage is present between the transformer starpoint and the earth if the transformer starpoint is not earthed. This voltage can be considered as the voltage feeding the earth current. As the transformer starpoints are earthed, the current flowing is determined by the feeding voltage and the ohmic resistance of all transformers that are galvanically connected to the converter set and earthed. This DC current is normally between about 3 and 4 A.

For a startup converter with a startup transformer of $U_{N,\,ST} \approx 1.4$ kV and a 6-pulse bridge circuit, there will be a DC voltage of $U_{DC} \approx 1.35 \cdot U_{N,\,ST} = 1.89$ kV. In case of an earth fault in the intermediate circuit, the „displacement voltage" will be half of the DC voltage ($U_{DC,\,fault} = 0.5 \quad U_{DC} = 945$ V).

If we assume that the earthing transformer has an ohmic winding resistance of R ≈ 150 Ω, a DC current of I_0 = 945 V/150 Ω = 6.3 A will flow through its starpoint.

Note: The ohmic winding resistances of earthing and neutral transformers can differ widely depending on the type. For a concrete application, they should be obtained from the manufacturer, or determined by measurements.

If not tripped, the earth fault current would cause a temperature overload that would destroy the wye-connected voltage transformers and the earthing transformer. To ensure that the protection will pick up reliably, it is set to a value of less than half the fault current, in this example to 2 A. With the shunt and shunt converter used in the example, this current causes a secondary current of 4 mA (see above) (fault current ≈ 6 A, selected pickup value = 2 A, setting value = 4 mA).

Delay

The tripping delay can be set at address 7206 **T DC**. The set time is an additional time delay not including the operating time of the protective function.

For the startup earth fault current protection **T DC** is determined by the permissible temperature load of the earthing and/or neutral transformer. A value of 2 s or less is quite common.

Note: It should be noted that in operating condition 0, the operating times for pickup and dropout are 4 times longer due to the more complex filter procedure needed to eliminate disturbances.

2.40.3 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
7201	DC PROTECTION	OFF ON Block relay	OFF	DC Voltage/Current Protection
7202	MEAS.METHOD	mean value RMS	mean value	Measurement Method (MEAN/RMS Values)
7203	DC >/<	DC > DC <	DC >	Method of Operation (DC >/<)
7204	U DC ><	0.1 .. 8.5 V	2.0 V	DC Voltage Pickup
7205	I DC ><	0.2 .. 17.0 mA	4.0 mA	DC Current Pickup
7206	T DC	0.00 .. 60.00 sec; ∞	2.00 sec	Time Delay for Trip of DC Protection

2.40.4 Information List

No.	Information	Type of Information	Comments
5293	>BLOCK DC Prot.	SP	>BLOCK DC protection
5301	DC Prot. OFF	OUT	DC protection is switched OFF
5302	DC Prot.BLOCKED	OUT	DC protection is BLOCKED
5303	DC Prot. ACTIVE	OUT	DC protection is ACTIVE
5306	DC Prot.pick.up	OUT	DC protection picked up
5307	DC Prot. TRIP	OUT	DC protection TRIP
5308	Failure DC Prot	OUT	Failure DC protection

2.41 Analog Outputs

Depending on the variant ordered, the 7UM62 machine protection can have up to four analog outputs (plug-in modules on ports B and D).

Starting from firmware version 4.62, the device features a universal analog output (type 2) for additional selected measured values. An output ranging for instance from 4 to 20mA is thus possible with both positive and negative values. The old analog output (type 1) for only positive values can still be used.

2.41.1 Functional Description

When configuring the functional scope, the user can specify which values are transmitted via these outputs. The following table shows which type of analog output is possible for each measured value.

Table 2-13 A maximum of four of the following analog outputs are available:

Measured value	Description	Scaling	Type 1	Type 2
I1	Positive sequence current component	in % based on I_N generator	X	X
I2	Negative sequence current component	in % based on I_N generator	X	
IEE1	Sensitive earth current	in % based on 100 mA	X	
IEE2	Sensitive earth current	in % based on 100 mA	X	
U1	Positive sequence voltage component	in % based on U_N generator/√3	X	X
U0	Zero sequence voltage component	in % based on U_N generator/√3	X	
U03H	3. Harmonic voltage	in % based on 0.1 U_N generator/√3 (relatively small values)	X	
|P|	Absolute amount of real power	in % based on S_N generator	X	
|Q|	Absolute amount of reactive power	in % based on S_N generator	X	
P	Active power	in % based on S_N generator		X
Q	Reactive power	in % based on S_N generator		X
S	Apparent power	in % based on S_N generator	X	X
f	Frequency	in % based on the nominal frequency f_N	X	X
U/f	Overexcitation	in % based on the nominal values of the protected object	X	
PHI	Power angle	in % based on 90° (0° to 360°)	X	
PHI	Power angle	in % based on 90° (–180° to + 180°) ((–180° = –200 % and + 180° = +200 %		X
|cos φ|	Value of the power factor	in % based on 1	X	
cos φ	Power factor	in % based on 1		X
$\Theta_R/\Theta_{R\ Trip}$	Rotor temperature	in % based on the maximum permissible rotor temperature	X	
$\Theta_S/\Theta_{S\ Trip}$	Stator temperature	in % based on the tripping temperature	X	
RE REF	Rotor earth resistance (f_N measuring method)	in % based on 100 kΩ	X	
RE REF 1-3Hz	Rotor earth resistance (1-3 Hz measuring method)	in % based on 100 kΩ	X	
RE SEF	"Secondary" stator earth resistance	in % based on 100 Ω	X	

The operational nominal values are those configured at address 251 **UN GEN/MOTOR** and 252 **SN GEN/MOTOR** (see also section 2.5).

For measured values that can also be negative (power, power factor), absolute values are formed and output in the type-1 analog output. The analog output type 2 (additionally available starting from firmware version V4.62) allows the negative values to be output as well (see 2.41.2, example 2).

Analog values are output as injected currents. The analog outputs have a nominal range between 0 mA and 20 mA, their operating range can be up to 22.5 mA. The conversion factor and the validity range can be set.

Note

If both analog output types are accidentally assigned to one analog channel or if scaling errors are made, a current of 0 mA will be output in response to the error.

2.41.2 Setting Notes

General

You have specified during configuration of the analog outputs (Section 2.4.2, addresses173 to 176) for analog output type 1 and addresses 200 to 203 for analog output type 2 which of the analog inputs in the device will be used for which measured value. Please remember that you can assign only one output type to an analog channel. If a function is not needed, ***Disabled*** is set. The other parameters associated with this analog output are hidden in that case.

Measured Values for Analog Outputs of Type 1

Once the measured values are selected for the analog outputs (Section 2.4.2, Addresses 173 to 176), set the conversion factor and the valid range for the available outputs, as follows:

- For analog output B1 at location "B" (port B1):

  At address 7301 **20 mA (B1/1)** = the percent value to be displayed at 20 mA.

  Address 7302 **MIN VALUE(B1/1)** the smallest valid value.
- For analog output B2 at location "B" (port B2):

  At address 7303 **20 mA (B2/1)** = the percent value to be displayed at 20 mA.

  Address 7304 **MIN VALUE(B2/1)** the smallest valid value.
- For analog output D1 at location "D" (port D1):

  At address 7305 **20 mA (D1/1)** = the percent value to be displayed at 20 mA.

  Address 7306 **MIN VALUE(D1/1)** the smallest valid value.
- For analog output D2 at location "D" (port D2):

  At address 7307 **20 mA (D2/1)** = the percent value to be displayed at 20 mA.

  Address 7308 **MIN VALUE(D2/1)** the smallest valid value.

The maximum possible value is 22.0 mA; in case of an overflow (value outside the maximum permissible range) 22.5 mA is output.

The following diagram illustrates the relationships.

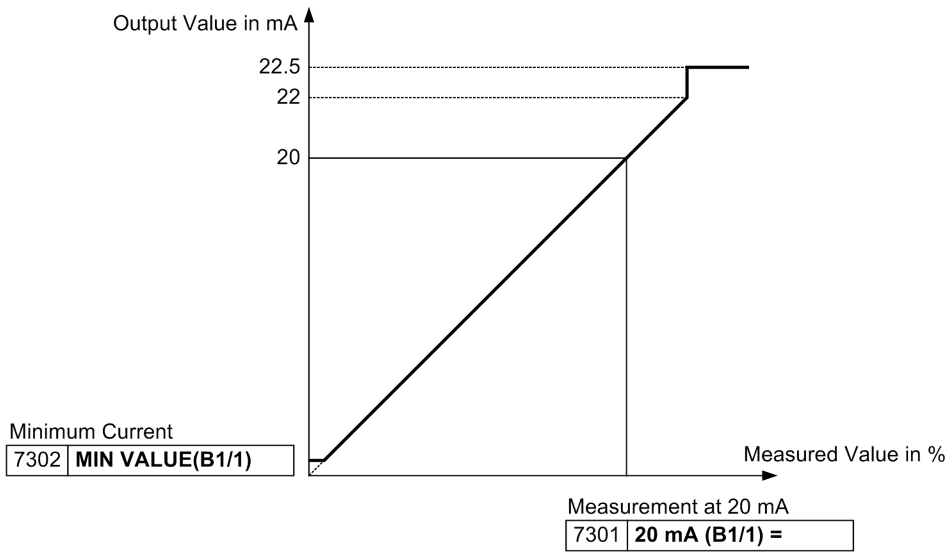


Figure 2-128 Definition of output range display for type 1

Example 1:

The positive sequence components of the currents are to be output as analog output B1 at location "B". 10 mA is to be the value at nominal operational current, consequently 20 mA corresponds to 200 %. Values below 1 mA are invalid.

Settings:

Address 7301 **20 mA (B1/1)** = 200.0 %,

Address 7302 **MIN VALUE(B1/1)** = 1.0 mA.

Measured Values for Analog Outputs of Type 2

This analog output type enables the measured values to be output universally. The value range of the measured values and the current of the analog interface to be output can be selected in a large range.

In the addresses 200, 201, 202 and 203 you can define which of the analog outputs (B1, B2, D1 and D2) are used for which measured value.

If you have selected measured values for the analog outputs, you should make the following settings:

- for analog output 1 at location "B" (port B1):
  Address 7310 **MIN. VALUE B1/2** the minimal reference value in %.
  Address 7311 **MIN.OUTPUT B1/2** the minimal current output value in mA,
  Address 7312 **MAX. VALUE B1/2** the maximum reference value in %.
  Address 7313 **MAX.OUTPUT B1/2** the maximum current output value in mA.
- for analog output 2 at location "B" (port B2):
  Address 7320 **MIN. VALUE B2/2** the minimal reference value in %.
  Address 7321 **MIN.OUTPUT B2/2** the minimal current output value in mA,
  Address 7322 **MAX. VALUE B2/2** the maximum reference value in %.
  Address 7323 **MAX.OUTPUT B2/2** the maximum current output value in mA.
- For analog output 3 at location "D" (port D1):
  Address 7330 **MIN. VALUE D1/2** the minimal reference value in %.
  Address 7331 **MIN.OUTPUT D1/2** the minimal current output value in mA,
  Address 7332 **MAX. VALUE D1/2** the maximum reference value in %.
  Address 7333 **MAX.OUTPUT D1/2** the maximum current output value in mA.
- For analog output 4 at location "D" (port D2):
  Address 7340 **MIN. VALUE D2/2** the minimal reference value in %.
  Address 7341 **MIN.OUTPUT D2/2** the minimal current output value in mA,
  Address 7342 **MAX. VALUE D2/2** the maximum reference value in %.
  Address 7343 **MAX.OUTPUT D2/2** the maximum current output value in mA.

The maximum current output value is determined by the setting parameter (address 73x3). It can be set to a maximum of 22 mA. If measured values are higher than the maximum reference value, this maximum current output value will be output. For measured values below the minimum reference value, the specified mimimum current output value is output. The setting ranges can be selected such that both positive and negative values can be represented over the output range, as is necessary for the display of P, Q, cos j.

The minimum reference value (address 73x0) must always be set smaller than the maximum reference value (address 73x2) (positive increase). Otherwise 0 mA is output.

The following diagram illustrates the relationships.

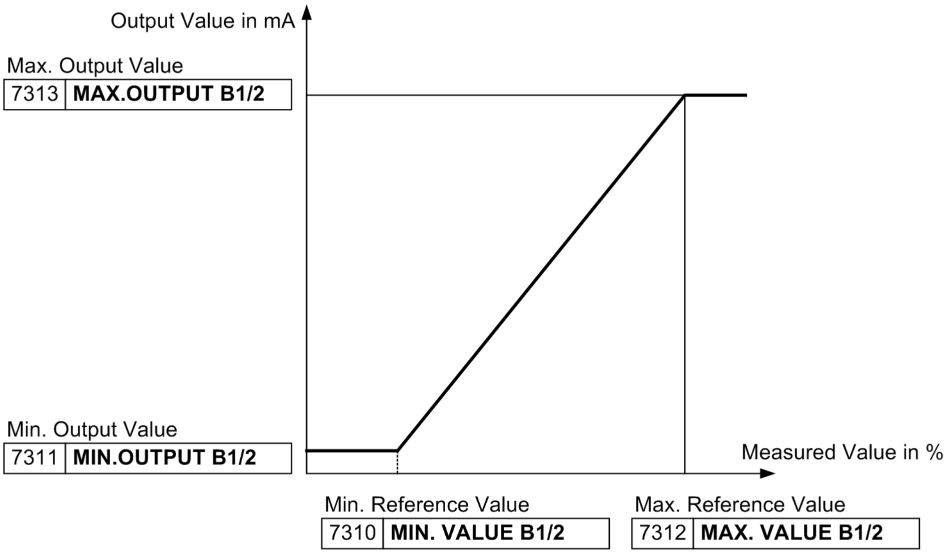


Figure 2-129 Definition of output range display for type 2

Example 2:

The reactive power Q is to be output over analog output D1 with a sign and between 4 to 20 mA. A reactive power Q = 0 % is to be equivalent to a current value of 12 mA. 80 % is sufficient as reference value because the reactive power is referred to the nominal apparent power of the protected object.

We thus obtain the following settings:

Address 7330 **MIN. VALUE D1/2** = -80%

Address 7331 **MIN.OUTPUT D1/2** the minimum current output value in mA, = 4 mA

Address 7332 **MAX. VALUE D1/2** = 80%

Address 7333 **MAX.OUTPUT D1/2** = 20 mA

We thus obtain the relationships between measured values and current output values shown in the following illustration.

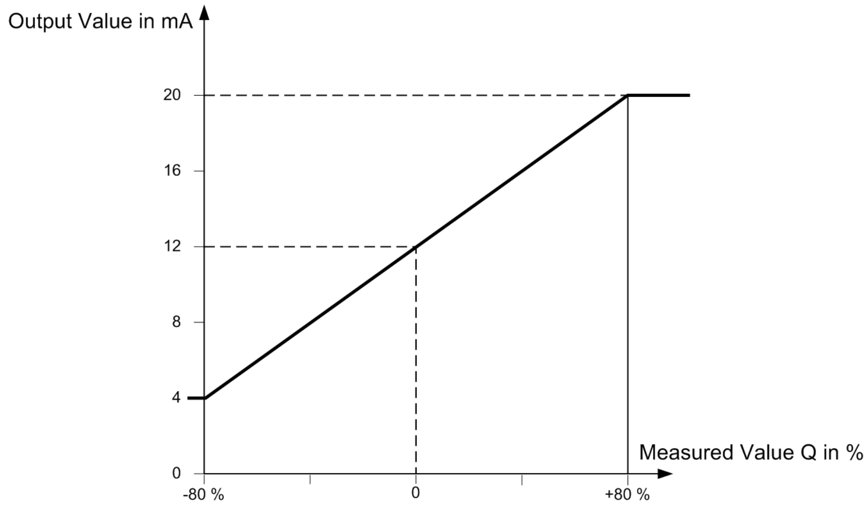


Figure 2-130 Example of a reactive power Q output

If the machine is run with cos j = 0.8, the resulting active power is 80 % referring to the apparent power. The reactive power is correspondingly 60 % of the apparent power. This measured reactive power value results in an output value of 18 mA.

2.41.3 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
7301	20 mA (B1/1) =	10.0 .. 1000.0 %	200.0 %	20 mA (B1/1) correspond to
7302	MIN VALUE(B1/1)	0.0 .. 5.0 mA	1.0 mA	Output value (B1/1) valid from
7303	20 mA (B2/1) =	10.0 .. 1000.0 %	200.0 %	20 mA (B2/1) correspond to
7304	MIN VALUE(B2/1)	0.0 .. 5.0 mA	1.0 mA	Output value (B2/1) valid from
7305	20 mA (D1/1) =	10.0 .. 1000.0 %	200.0 %	20 mA (D1/1) correspond to
7306	MIN VALUE(D1/1)	0.0 .. 5.0 mA	1.0 mA	Output value (D1/1) valid from
7307	20 mA (D2/1) =	10.0 .. 1000.0 %	200.0 %	20 mA (D2/1) correspond to
7308	MIN VALUE(D2/1)	0.0 .. 5.0 mA	1.0 mA	Output value (D2/1) valid from
7310	MIN. VALUE B1/2	-200.00 .. 100.00 %	0.00 %	Minimum Percentage Output Value (B1/2)
7311	MIN.OUTPUT B1/2	0 .. 10 mA	4 mA	Minimum Current Output Value (B1/2)
7312	MAX. VALUE B1/2	10.00 .. 200.00 %	100.00 %	Maximum Percentage Output Value (B1/2)
7313	MAX.OUTPUT B1/2	10 .. 22 mA; 0	20 mA	Maximum Current Output Value (B1/2)
7320	MIN. VALUE B2/2	-200.00 .. 100.00 %	0.00 %	Minimum Percentage Output Value (B2/2)
7321	MIN.OUTPUT B2/2	0 .. 10 mA	4 mA	Minimum Current Output Value (B2/2)
7322	MAX. VALUE B2/2	10.00 .. 200.00 %	100.00 %	Maximum Percentage Output Value (B2/2)
7323	MAX.OUTPUT B2/2	10 .. 22 mA; 0	20 mA	Maximum Current Output Value (B2/2)
7330	MIN. VALUE D1/2	-200.00 .. 100.00 %	0.00 %	Minimum Percentage Output Value (D1/2)
7331	MIN.OUTPUT D1/2	0 .. 10 mA	4 mA	Minimum Current Output Value (D1/2)
7332	MAX. VALUE D1/2	10.00 .. 200.00 %	100.00 %	Maximum Percentage Output Value (D1/2)
7333	MAX.OUTPUT D1/2	10 .. 22 mA; 0	20 mA	Maximum Current Output Value (D1/2)
7340	MIN. VALUE D2/2	-200.00 .. 100.00 %	0.00 %	Minimum Percentage Output Value (D2/2)
7341	MIN.OUTPUT D2/2	0 .. 10 mA	4 mA	Minimum Current Output Value (D2/2)
7342	MAX. VALUE D2/2	10.00 .. 200.00 %	100.00 %	Maximum Percentage Output Value (D2/2)
7343	MAX.OUTPUT D2/2	10 .. 22 mA; 0	20 mA	Maximum Current Output Value (D2/2)

2.42 Monitoring Functions

The device is equipped with extensive monitoring capabilities - both for hardware and software. In addition, the measured values are also constantly monitored for plausibility, therefore, the current transformer and voltage transformer circuits are largely integrated into the monitoring.

2.42.1 Measurement Supervision

2.42.1.1 Hardware Monitoring

The device monitoring extends from the measuring inputs to the binary outputs. Monitoring circuits and processor check the hardware for malfunctions and inadmissible conditions (see also Table 2-14).

Auxiliary and Reference Voltages

The processor voltage of 5 VDC is monitored by the hardware since if it goes below the minimum value, the processor is no longer functional. In that case the device is put out of operation. When the normal voltage returns, the processor system is restarted.

Failure or switching off the supply voltage removes the device from operation and a message is immediately generated by the "life contact" (an alternatively NO or NC contact). Brief auxiliary voltage interruptions of less than 50 ms do not disturb the operational readiness of the device (for nominal auxiliary voltage ≥ 110 VDC).

The processor monitors the reference voltage of the ADC (analog-to-digital converter). In case of inadmissible deviations the protection is blocked; persistent faults are signalled (indication: „`Error A/D-conv.`“).

Buffer Battery

The buffer battery, which ensures operation of the internal clock and storage of counters and messages if the auxiliary voltage fails, is periodically checked for charge status. If it is less than an allowed minimum voltage, then the „`Fail Battery`“ message is issued.

If the device is isolated from the auxiliary voltage for several hours, the internal back-up battery is switched off automatically, i.e. the time is not registered any more. Messages and fault recordings however are kept stored.

Memory Components

All working memories (RAMs) are checked during start-up. If a fault occurs in this process, the start is aborted and an LED starts flashing. During operation the memories are checked by means of their checksum.

For the program memory (EPROM), the cross-check sum is cyclically generated and compared to a stored reference program cross-check sum.

For the settings memory, the cross-check sum is formed cyclically and compared to the cross-check sum that is freshly generated each time a setting process takes place.

If a fault occurs the processor system is restarted.

Probing

The sampling frequency and the synchronism between the internal buffer modules is continuously monitored. If any deviations cannot be removed by renewed synchronisation, then the processor system is restarted.

Measurement Value Acquisition – Currents

In the current paths there are three input transformers each on side 1 and side 2; the digitized sum of the transformer currents of one side must be almost zero for generators with isolated starpoint during earth-fault-free operation. A current circuit fault is detected if

$I_F = | \underline{I}_{L1} + \underline{I}_{L2} + \underline{I}_{L3} | > \Sigma$**I THRESHOLD S1** $\cdot I_N + \Sigma$**I FACTOR S1** $\cdot I_{max}$ or

$I_F = | \underline{I}_{L1} + \underline{I}_{L2} + \underline{I}_{L3} | > \Sigma$**I THRESHOLD S2** $\cdot I_N + \Sigma$**I FACTOR S2** $\cdot I_{max}$

The component Σ**I FACTOR S1** $\cdot I_{max}$ or Σ**I FACTOR S2** $\cdot I_{max}$ takes into account admissible current-proportional transformation errors in the input transducers which may occur especially during high fault currents (see the following figure). The dropout ratio is about 95 %.

This malfunction is reported as „Fail. Σ I Side1“ or „Fail. Σ I Side2“.

The current sum monitoring is only effective for the side for which the starpoint has been configured (address 242 or 244) as ***Isolated*** in the power system data.

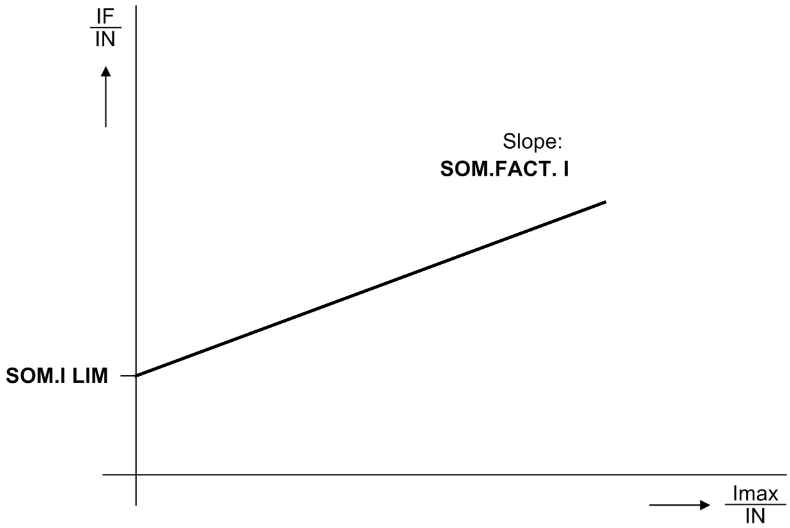


Figure 2-131 Current sum monitoring

Measured-value Acquisition - Voltages

Four measuring inputs are available in the voltage path: if three of them are used for phase-earth voltages, and one input for the displacement voltage (e–n voltage from the broken delta winding or neutral transformer) of the same system, a fault in the phase-earth voltage sum is detected if

$| \underline{U}_{L1} + \underline{U}_{L2} + \underline{U}_{L3} + k_U \cdot \underline{U}_E | >$ **SUM.thres. U** + **SUM.Fact. U** x U_{max}

where **SUM.thres. U** and **SUM.Fact. U** are parameter settings, and U_{max} is the highest of the phase-earth voltages. Factor k_U considers the transformation ratio differences between the displacement voltage input and the phase voltage inputs (parameter k_U = **Uph / Udelta** address 225). The **SUM.Fact. U** x U_{max} component considers admissible voltage-proportional transformation errors of the input transducers, which can be especially large in the presence of high voltages (see the following figure).

This malfunction is reported as „Fail Σ U Ph-E“.

Note

Voltage sum monitoring is only effective if an external displacement voltage is connected at the displacement voltage measuring input and this is also notified via the parameter 223 **UE CONNECTION** to the device.

Voltage sum monitoring can operate properly only if the adaptation factor **Uph / Udelta** at address 225 has been correctly configured (see Subsection 2.5.1).

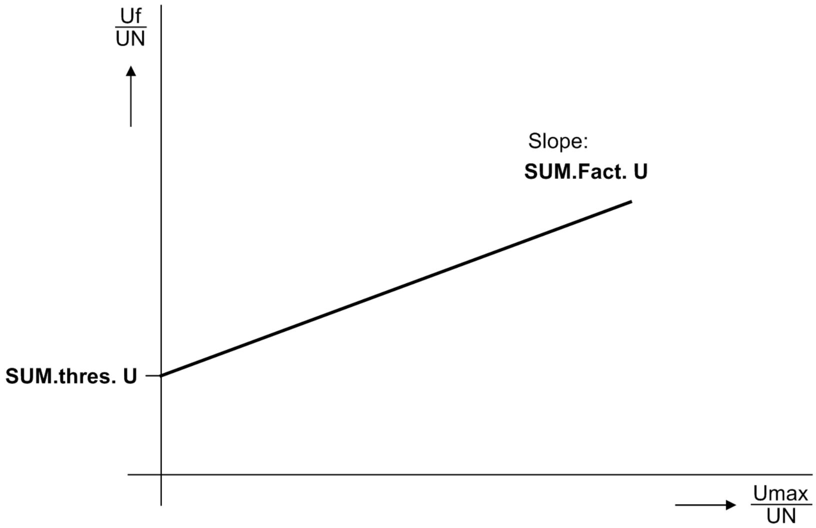


Figure 2-132 Voltage sum monitoring

2.42.1.2 Software Monitoring

Watchdog

For continuous monitoring of the program sequences, a watchdog timer is provided in the hardware (hardware watchdog) which will reset and completely restart the processor system in the event of processor failure or if a program falls out of step.

A further software watchdog ensures that any error in the processing of the programs will be recognized. This also initiates a restart of the processor system.

If such a malfunction is not cleared by the restart, an additional restart attempt is begun. After three unsuccessful restarts within a 30 second window of time, the device automatically removes itself from service and the red "Error" LED lights up. The operational readiness relay ("Life contact") opens and issues an alarm (alternatively as NO or NC contact).

2.42.1.3 Monitoring of External Transformer Circuits

Interruptions or short circuits in the secondary circuits of the current and voltage transformers, as well as faults in the connections (important for commissioning!), are detected and reported by the device. The measured values are cyclically checked in background routines for this purpose, as long as no system fault is present.

Current Symmetry

The currents fed in at the current inputs of side 1 and side 2 are monitored for symmetry. During normal system operation a certain degree of symmetry of the currents is expected. This symmetry is checked by the device, using an amplitude monitor. The smallest phase current is compared to the largest phase current. Asymmetry is recognized if:

$| I_{min} | / | I_{max} | <$ **BAL. FACT. I S1** as long as $I_{max} / I_N >$ **BAL. I LIMIT S1** $/ I_N$

$| I_{min} | / | I_{max} | <$ **BAL. FACT. I S2** as long as $I_{max} / I_N >$ **BAL. I LIMIT S2** $/ I_N$

where I_{max} is the largest of the three phase currents and I_{min} is the smallest. The symmetry factor **BAL. FACT. I S1** or **BAL. FACT. I S2** represents the admissible asymmetry of the phase currents whereas the limit value **BAL. I LIMIT S1** or **BAL. I LIMIT S2** is the lower limit of the operating range of this monitoring (see following figure). The dropout ratio is about 95 %.

This fault is signaled with „Fail. Isym 1“ or „Fail. Isym 2“ separately for side 1 and side 2.

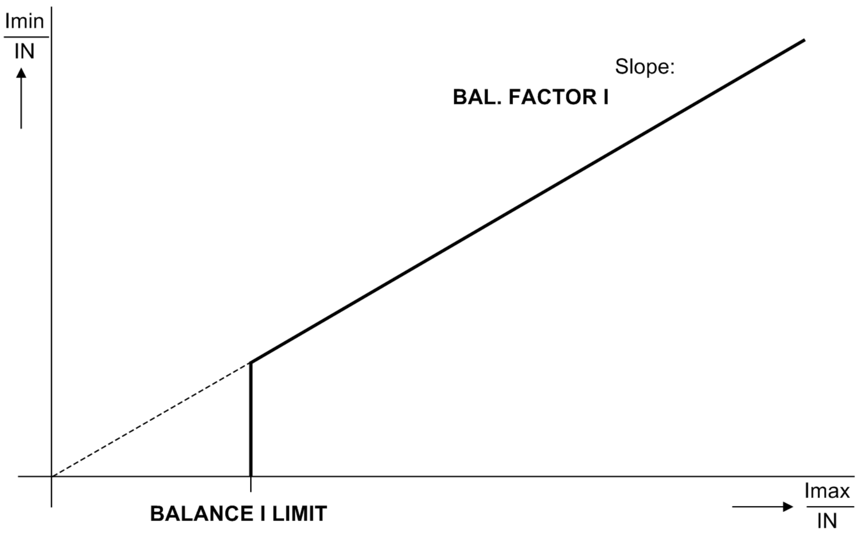


Figure 2-133 Current symmetry monitoring

Voltage Symmetry

During normal system operation a certain degree of symmetry among the voltages is expected. With two phase-phase voltages and the displacement voltage U_E connected to the device, the third phase-phase voltage is calculated. The rectified mean values are formed from the phase-earth voltages, and checked for the symmetry of their amounts. The smallest phase voltage is compared to the largest. Asymmetry is recognized if:

$| U_{min} | / | U_{max} | <$ **BAL. FACTOR U** as long as $| U_{max} | >$ **BALANCE U-LIMIT**

where U_{max} is the highest of the three voltages and U_{min} the smallest. The symmetry factor **BAL. FACTOR U** is the measure for the asymmetry of the conductor voltages; the limit **BALANCE U-LIMIT** is the lower limit of the operating range of this monitoring (see following figure). Both parameters can be set. The dropout ratio is about 95 %.

This malfunction is reported as „Fail U balance“.

If the 90% stator earth fault protection functions are active, a zero voltage results on voltage asymmetry. If this causes protection pickup, monitoring is relegated to the background and issues no indication.

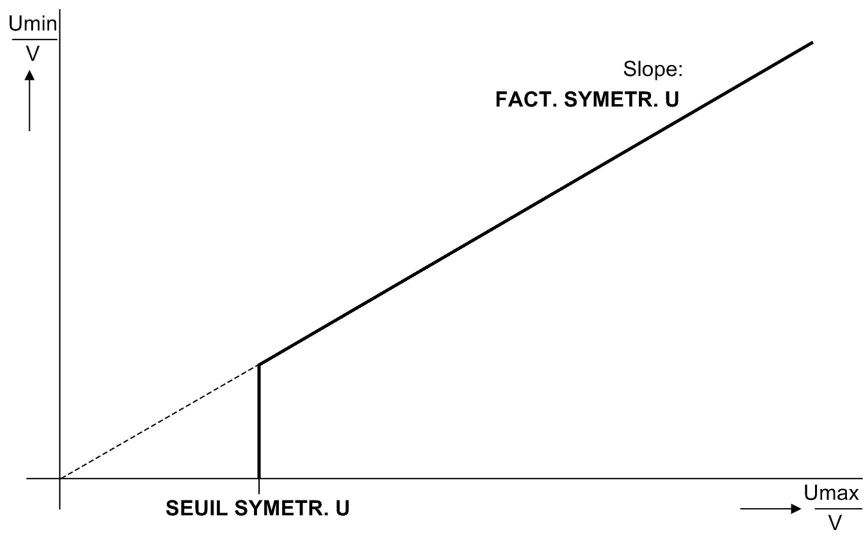


Figure 2-134 Voltage symmetry monitoring

Phase Sequences of Current and Voltage

To detect any swapped phase connections in the voltage and current input circuits, the phase sequence of the phase-to-phase measured voltages and the phase currents is checked by monitoring the sequence of same polarity zero transitions of the voltages having the same sign.

Direction measurement with cross-polarized voltages, path selection for impedance protection, evaluation of positive sequence voltages for undervoltage protection and unbalanced load detection all assume a clockwise phase sequence. The current phase rotation is checked and reported individually for side 1 and side 2.

Phase rotation of measured voltages is checked by verifying the phase sequences of the voltages

$\underline{U}_{L1}$ leads $\underline{U}_{L2}$ leads $\underline{U}_{L3}$

and of the phase currents, in each case

$\underline{I}_{L1}$ leads $\underline{I}_{L2}$ leads $\underline{I}_{L3}$.

Verification of the voltage phase rotation is performed when each measured voltage is at least

$|\underline{U}_{L1}|, |\underline{U}_{L2}|, |\underline{U}_{L3}| > 40 \text{ V}/\sqrt{3}$

Verification of the current phase sequence is performed when each measured current is at least

$|\underline{I}_{L1}|, |\underline{I}_{L2}|, |\underline{I}_{L3}| > 0.5\ I_N$.

For abnormal phase sequences (L1, L3, L2), the indications „Fail Ph. Seq. U“, (No. 176) or „FailPh.Seq I S1“, (No. 265) are issued for side 1, or the indication „FailPh.Seq I S2“, (No. 266) for side 2, as well as an OR combination of these indications „Fail Ph. Seq.“, (No. 171)

For applications where a counter-clockwise measured values phase sequence appears, this must be notified to the device via the parameter 271 **PHASE SEQ.** or an accordingly allocated binary input. If the phase sequence is changed in the relay, phases L2 and L3 internal to the relay are reversed, and the positive and negative sequence currents are thereby exchanged (see also Section 2.47). The phase-related messages, malfunction values, and measured values are not affected by this.

2.42.1.4 Setting Notes

Measured Value Monitoring

Measured value monitoring can be turned ***ON*** or ***OFF*** at address 8101 **MEASURE. SUPERV**. In addition, the sensitivity of measured value monitoring can be modified. Experiential values set ex works are sufficient in most cases. If especially high operating asymmetry in the currents and/or voltages is to be expected for the application, or if it becomes apparent during operation that certain monitoring functions activate sporadically, then the setting should be less sensitive.

Address 8102 **BALANCE U-LIMIT** determines the limit voltage (phase-phase), above which voltage symmetry monitoring becomes effective (see also Voltage Symmetry Monitoring figure). Address 8103 **BAL. FACTOR U** is the associated symmetry factor; that is, the slope of the symmetry characteristic curve.

Address 8104 **BAL. I LIMIT S1** determines for side 1, address 8106 **BAL. I LIMIT S2** for side 2, the limit current above which current symmetry monitoring becomes effective (see also Current Symmetry Monitoring figure). Address 8105 **BAL. FACT. I S1** is the associated symmetry factor for side 1, address 8107 **BAL. FACT. I S2** for side 2, i.e. the slope of the symmetry characteristic.

Address 8110 **ΣI THRESHOLD S1** establishes for side 1 the limit current above which current sum monitoring (see Current Sum Monitoring figure) is activated (absolute component, referred only to I_N). Accordingly address 8112 **ΣI THRESHOLD S2** applies for side 2. The relative component (referred to maximum phase current) for triggering the sum current monitoring is set for side 1 under address 8111 **ΣI FACTOR S1** and for side 2 under 8113 **ΣI FACTOR S2**

Address 8108 **SUM.thres. U** determines the limit voltage above which current sum monitoring becomes active (see also Current Sum Monitoring figure) (absolute component, referred only to U_N). The relative component for triggering the sum current monitoring is set under address 8109 **SUM.Fact. U**.

Note

In power system data 1, the voltage earth path and its matching factor **Uph / Udelta** were specified. Measured value monitorings will only function properly if the setting there is correct.

2.42.1.5 Settings

The table indicates region-specific presettings. Column C (configuration) indicates the corresponding secondary nominal current of the current transformer.

Addr.	Parameter	C	Setting Options	Default Setting	Comments
8101	MEASURE. SUPERV		OFF ON	OFF	Measurement Supervision
8102	BALANCE U-LIMIT		10 .. 100 V	50 V	Voltage Threshold for Balance Monitoring
8103	BAL. FACTOR U		0.58 .. 0.90	0.75	Balance Factor for Voltage Monitor
8104	BAL. I LIMIT S1	5A	0.50 .. 5.00 A	2.50 A	Current Balance Monitor Side 1
		1A	0.10 .. 1.00 A	0.50 A	
8105	BAL. FACT. I S1		0.10 .. 0.90	0.50	Balance Factor for Current Monitor S1
8106	BAL. I LIMIT S2	5A	0.50 .. 5.00 A	2.50 A	Current Balance Monitor Side 2
		1A	0.10 .. 1.00 A	0.50 A	

Addr.	Parameter	C	Setting Options	Default Setting	Comments
8107	BAL. FACT. I S2		0.10 .. 0.90	0.50	Balance Factor for Current Monitor S2
8108	SUM.thres. U		10 .. 200 V	10 V	Summation Thres. for Volt. Monitoring
8109	SUM.Fact. U		0.60 .. 0.95 ; 0	0.75	Factor for Volt. Sum. Monitoring
8110	ΣI THRESHOLD S1	5A	0.25 .. 10.00 A	0.50 A	Summated Cur. Mon. Threshold on Side 1
		1A	0.05 .. 2.00 A	0.10 A	
8111	ΣI FACTOR S1		0.00 .. 0.95	0.10	Summated Current Mon. Factor on Side 1
8112	ΣI THRESHOLD S2	5A	0.25 .. 10.00 A	0.50 A	Summated Cur. Mon. Threshold on Side 2
		1A	0.05 .. 2.00 A	0.10 A	
8113	ΣI FACTOR S2		0.00 .. 0.95	0.10	Summated Current Mon. Factor on Side 2

2.42.1.6 Information List

No.	Information	Type of Information	Comments
161	Fail I Superv.	OUT	Failure: General Current Supervision
164	Fail U Superv.	OUT	Failure: General Voltage Supervision
165	Fail Σ U Ph-E	OUT	Failure: Voltage Summation Phase-Earth
167	Fail U balance	OUT	Failure: Voltage Balance
171	Fail Ph. Seq.	OUT	Failure: Phase Sequence
176	Fail Ph. Seq. U	OUT	Failure: Phase Sequence Voltage
197	MeasSup OFF	OUT	Measurement Supervision is switched OFF
230	Fail. Σ I Side1	OUT	Failure: Current Summation on Side 1
231	Fail. Σ I Side2	OUT	Failure: Current Summation on Side 2
265	FailPh.Seq I S1	OUT	Failure: Phase Sequence I side 1
266	FailPh.Seq I S2	OUT	Failure: Phase Sequence I side 2
571	Fail. Isym 1	OUT	Fail.: Current symm. supervision side 1
572	Fail. Isym 2	OUT	Fail.: Current symm. supervision side 2

2.42.2 Supervision

2.42.2.1 Fuse Failure Monitor

In the event of a measured voltage failure due to a short circuit fault or a broken conductor in the voltage transformer secondary circuit, certain measuring loops may mistakenly see a voltage of zero. The measuring results of the undervoltage protection, the impedance protection and other voltage-dependent protective functions may be falsified in this way, possibly causing an unwanted operation.

If fuses are used instead of a secondary miniature circuit breaker (VT mcb) with connected auxiliary contacts, then the fuse failure monitoring can detect problems in the voltage transformer secondary circuit. Of course the miniature circuit breaker and the fuse failure monitor can be used at the same time.

This function uses the current of side 2.

Measuring Principle for 1-Pole and 2-Pole Fuse Failures

The measuring voltage failure detection is based on the fact a significant negative-phase sequence system is formed in the voltage during a 1- or 2-pole voltage failure, without influencing the current. This enables a clear distinction from asymmetries impressed by the power system. If the negative-phase sequence system is related to the current positive-phase sequence system, the following rules apply for the **fault-free case**:

$$\frac{U_2}{U_1} = 0 \qquad \text{and} \qquad \frac{I_2}{I_1} = 0$$

If a fault of the voltage transformers occurs, the following rules apply for a **single-pole failure**:

$$\frac{U_2}{U_1} = \frac{0.33}{0.66} = 0.5 \qquad \text{and} \qquad \frac{I_2}{I_1} = 0 \qquad \left(\frac{U_2}{U_1} > \frac{I_2}{I_1}\right)$$

If a fault of the voltage transformers occurs, the following rules apply for a **two-pole failure**:

$$\frac{U_2}{U_1} = \frac{0.33}{0.33} = 1 \qquad \text{and} \qquad \frac{I_2}{I_1} = 0 \qquad \left(\frac{U_2}{U_1} > \frac{I_2}{I_1}\right)$$

In case of an outage of one or two phases, the current also shows a negative-phase sequence system of 0.5 or 1. Consequently, the voltage monitoring does not respond since no voltage transformer fault can be present.

In order to avoid - in case of a too small positive-sequence system - an unwanted operation by inaccuracies of the measuring voltages failure detection, the function is blocked below a minimum threshold of the positive-sequence systems of voltage (U_1 < 10 V) and current ($I_1 < 0.1\ I_N$).

3-pole Fuse Failure

A 3–pole fuse failure of the voltage transformer cannot be detected by the positive and negative sequence system as previously described. Here monitoring of the chronological sequence of current and voltage is required. If a voltage dip of approximately zero occurs (or if the voltage is zero), although the current remains unchanged at the same time, this is probably due to a 3-pole voltage transformer failure. The deviation of the actual current value from the nominal current value is evaluated for this purpose. The measuring voltage failure monitoring is blocked if the deviation exceeds a threshold value. Moreover, this function is blocked if a pickup of an (overcurrent) protective function is already present.

Additional Criteria

In addition to this, the function can either be blocked via a binary input or deactivated by an undervoltage protection at a separate voltage transformer set. If an undervoltage is also detected at a separate transformer set, this is most probably not due to a transformer error and the monitoring switching can be blocked. The separate undervoltage protection must be set non-delayed and should also evaluate the positive-phase sequence system of the voltages (e.g. 7RW600).

Voltage at the U_E Input

Depending on how U_E is connected, it may be necessary to block the voltage measurement of this input. A block can be generated with the CFC tool and combined with the indication „VT Fuse Failure“.

Other Blocks

Fuse failure monitores directly blocks functions (see Figure 2-135). If other functions, such as underexcitation protection, need to be blocked, the indication „VT Fuse Failure“ must be used, and combined with the protection fuction via the logic component (CFC).

Logic

When a fuse failure is detected (Figure 2-135 left-hand logic component), this status is stored. This ensures that the fuse failure indication is maintained even in the event of a short circuit. As soon as the fuse failure has been eliminated, and the positive sequence voltage has risen above 85 % of the nominal voltage, the stored value is cancelled, and the fuse failure indication is reset with a delay of 10 s.

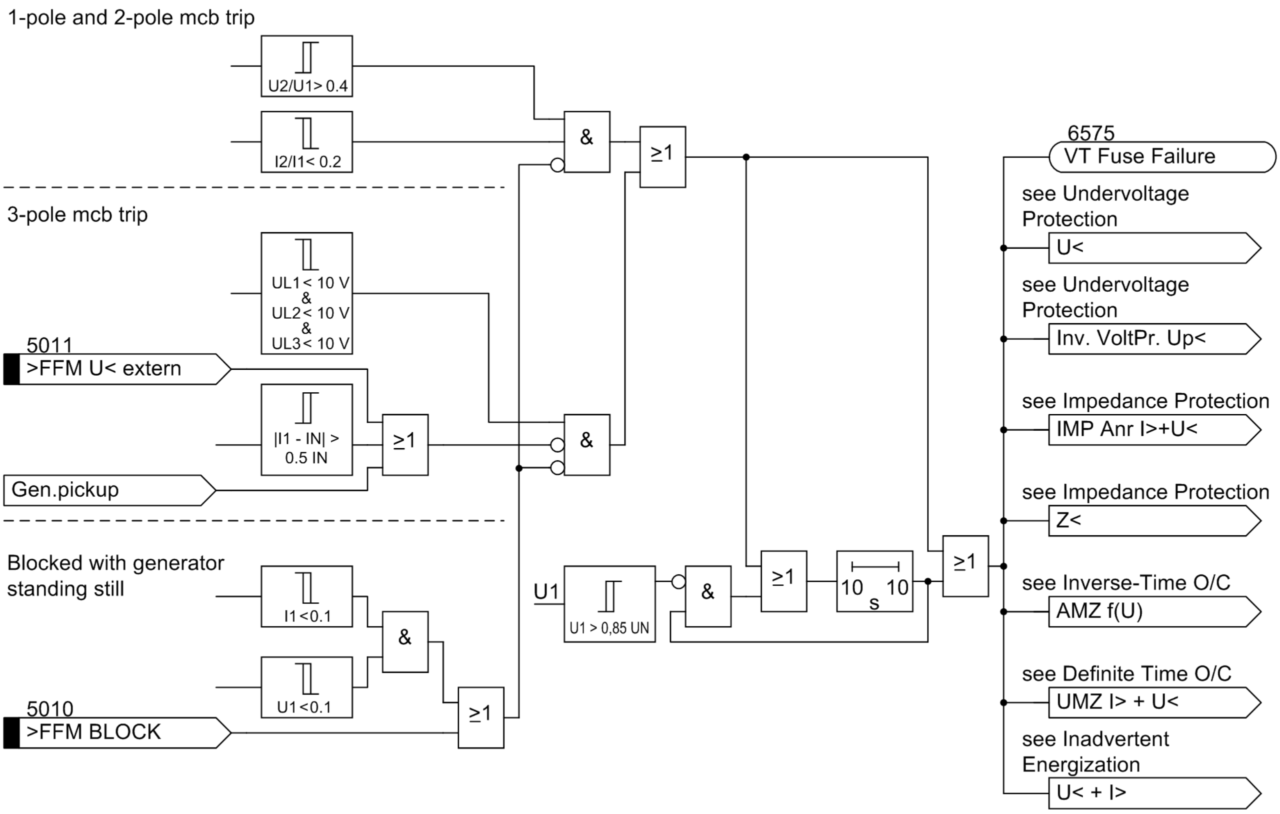


Figure 2-135 Logic Diagram of the Fuse-Failure-Monitor

2.42.2.2 Malfunction Responses of the Monitoring Functions

Depending on the type of malfunction detected, an indication is sent, a restart of the processor system initiated, or the device is taken out of service. After three unsuccessful restart attempts, the device is also taken out of service. The operational readiness NC contact operates to indicate the device is malfunctioning. Also, the red LED "ERROR" lights up on the front cover, if the internal auxiliary voltage is present, and the green "RUN" LED goes out. If the internal auxiliary voltage fails as well, then all LEDs are dark. The following table summarises the monitoring functions and the malfunction responses of the device.

Table 2-14 Summary of Malfunction Responses by the Protection Relay

Monitoring	Possible Causes	Malfunction Response	Message (No.)	Output
Auxiliary Supply Voltage Loss	External (aux. voltage) internal (converter)	Device nonoperational	all LEDs dark	DOK[2)] drops out
Internal Supply Voltages	Internal (converter) or reference voltage	Device shutdown	LED "ERROR" „Error A/D-conv.“ (No.181)	DOK[2)] drops out
Battery	Internal (battery)	Indication	„Fail Battery“ (No. 177)	
Hardware Watchdog	Internal (processor failure)	Device shutdown [1)]	LED "ERROR"	DOK[2)] drops out
Software watchdog	Internal (processor failure)	Restart attempt [1)]	LED "ERROR"	DOK[2)] drops out
Working Memory ROM	Internal (hardware)	Aborted restart, Device shutdown	LED flashes	DOK[2)] drops out
Program Memory RAM	Internal (hardware)	during startup	LED flashes	DOK[2)] drops out
		during operation: Restart attempt [1)]	LED "ERROR"	
Settings store	Internal (hardware)	Restart attempt [1)]	LED "ERROR"	DOK[2)] drops out
Sampling frequency	Internal (hardware)	Device shutdown	LED "ERROR"	DOK[2)] drops out
1 A / 5 A changeover on side 1	Jumper for 1 A/5 A for side 1 misconnected	Device out of service indication	LED "ERROR" „Err1A/5AwrongS1“ (No. 210)	DOK drops out [2)]
1 A / 5 A changeover on side 2	Jumper for 1 A/5 A for side 2 misconnected	Device out of service indication	LED "ERROR" „Err1A/5AwrongS2“ (No. 211)	DOK drops out [2)]
Voltage/current changeover at MU1	Jumper setting for transducer 1 inconsistent with parameter 0295	Device out of service indication	LED "ERROR" „Err. TD1 jumper“ (No. 212)	DOK drops out [2)]
Voltage/current changeover at MU2	Jumper setting for transducer 2 inconsistent with parameter 0296	Device out of service indication	LED "ERROR" „Err. TD2 jumper“ (No. 213)	DOK drops out [2)]
Filter On/Off changeover at MU3	Jumper setting for measuring transducer 1 inconsistent with parameter 0297	Device out of service indication	LED "ERROR" „Err. TD3 jumper“ (No. 214)	DOK drops out [2)]
Current Sum Side 1	Internal (measured value acquisition)	Indication	„Fail. Σ I Side1“ (No. 230)	as allocated
Current Sum Side 2	Internal (measured value acquisition)	Indication	„Fail. Σ I Side2“ (No. 231)	as allocated
Current Symmetry Side 1	External (power system or current transformer)	Indication	„Fail. Isym 1“ (No. 571)	as allocated
Current Symmetry Side 2	External (power system or current transformer)	Indication	„Fail. Isym 2“ (No. 572)	as allocated
Voltage sum	Internal (measured value acquisition)	Indication	„Fail Σ U Ph-E“ (No. 165)	as allocated
Voltage symmetry	External (power system or voltage transformer)	Indication	„Fail U balance“ (No. 167)	as allocated
Voltage phase sequence	external (power system or connection)	Indication	„Fail Ph. Seq. U“ (No. 176)	as allocated
Current Phase Sequence Side 1	External (power system or connection)	Indication	„FailPh.Seq I S1“ (No. 265)	as allocated

Monitoring	Possible Causes	Malfunction Response	Message (No.)	Output
Current Phase Sequence Side 2	External (power system or connection)	Indication	„FailPh.Seq I S2“ (No. 266)	as allocated
Fuse Failure Monitor	External (voltage transformer)	Indication	„VT Fuse Failure“ (No. 6575)	as allocated
Trip Circuit Monitoring	External (trip circuit or control voltage)	Indication	„FAIL: Trip cir.“ (No. 6865)	as allocated

1) After three unsuccessful restarts, the device is taken out of service.

2) DOK = "Device Okay" = Operational readiness relay drops off, protection and control functions are blocked. Operator communication is still possible

2.42.2.3 Setting Notes

Fuse Failure Monitor

The fuse failure monitor will only be effective and accessible if address 180 **FUSE FAIL MON.** is set ***Enabled*** during configuration. If the function is not required, it is set to ***Disabled***. The function ***ON*** or ***OFF*** can be activated at address 8001 **FUSE FAIL MON.**.

The thresholds $U_2/U_1 \geq 40$ % and $I_2/I_1 \leq 20$ % for detecting 1-pole and 2-pole voltage failures are fixed. The thresholds for detecting a 3-pole voltage failure (undervoltage threshold = 10 V, below which the failure detection feature responds unless the current changes significantly and the differential current monitoring = 0.5 I_N) are likewise fixed and need not be set.

2.42.2.4 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
8001	FUSE FAIL MON.	OFF ON	OFF	Fuse Failure Monitor

2.42.2.5 Information List

No.	Information	Type of In-formation	Comments
68	Clock SyncError	OUT	Clock Synchronization Error
110	Event Lost	OUT_Ev	Event lost
113	Flag Lost	OUT	Flag Lost
140	Error Sum Alarm	OUT	Error with a summary alarm
147	Error PwrSupply	OUT	Error Power Supply
160	Alarm Sum Event	OUT	Alarm Summary Event
177	Fail Battery	OUT	Failure: Battery empty
181	Error A/D-conv.	OUT	Error: A/D converter
185	Error Board 3	OUT	Error Board 3
187	Error Board 5	OUT	Error Board 5
188	Error Board 6	OUT	Error Board 6
190	Error Board 0	OUT	Error Board 0
191	Error Offset	OUT	Error: Offset
193	Alarm NO calibr	OUT	Alarm: NO calibration data available
194	Error neutralCT	OUT	Error: Neutral CT different from MLFB
210	Err1A/5AwrongS1	OUT	Err:1A/5Ajumper different from settingS1
211	Err1A/5AwrongS2	OUT	Err:1A/5Ajumper different from settingS2
212	Err. TD1 jumper	OUT	Err: TD1 jumper different from setting
213	Err. TD2 jumper	OUT	Err: TD2 jumper different from setting
214	Err. TD3 jumper	OUT	Err: TD3 jumper different from setting
264	Fail: RTD-Box 1	OUT	Failure: RTD-Box 1
267	Fail: RTD-Box 2	OUT	Failure: RTD-Box 2
5010	>FFM BLOCK	SP	>BLOCK fuse failure monitor
5011	>FFM U< extern	SP	>FFM extern undervoltage
6575	VT Fuse Failure	OUT	Voltage Transformer Fuse Failure

2.43 Trip Circuit Supervision

The 7UM62 multifunctional protection features an integrated trip circuit supervision. Depending on the number of available binary inputs (connected or not connected to a common potential), monitoring with one or two binary inputs can be selected. If the allocation of the necessary binary inputs does not comply with the selected monitoring mode, a corresponding message will be displayed („`TripC ProgFail`“). When using two binary inputs, malfunctions in the trip circuit can be detected for all circuit breaker positions. When only one binary input is used, malfunctions in the circuit breaker itself cannot be detected.

2.43.1 Functional Description

Monitoring with Two Binary Inputs (not connected to common potential)

When using two binary inputs, these are connected according to the figure below, parallel to the associated trip contact on one side, and parallel to the circuit breaker auxiliary contacts on the other.

A precondition for the use of the trip circuit supervision is that the control voltage for the circuit breaker is higher than the total of the minimum voltages drops at the two binary inputs ($U_{CTRL} > 2 \cdot U_{BImin}$). Since at least 19 V are needed for each binary input, the monitor can only be used with a system control voltage of over 38 V.

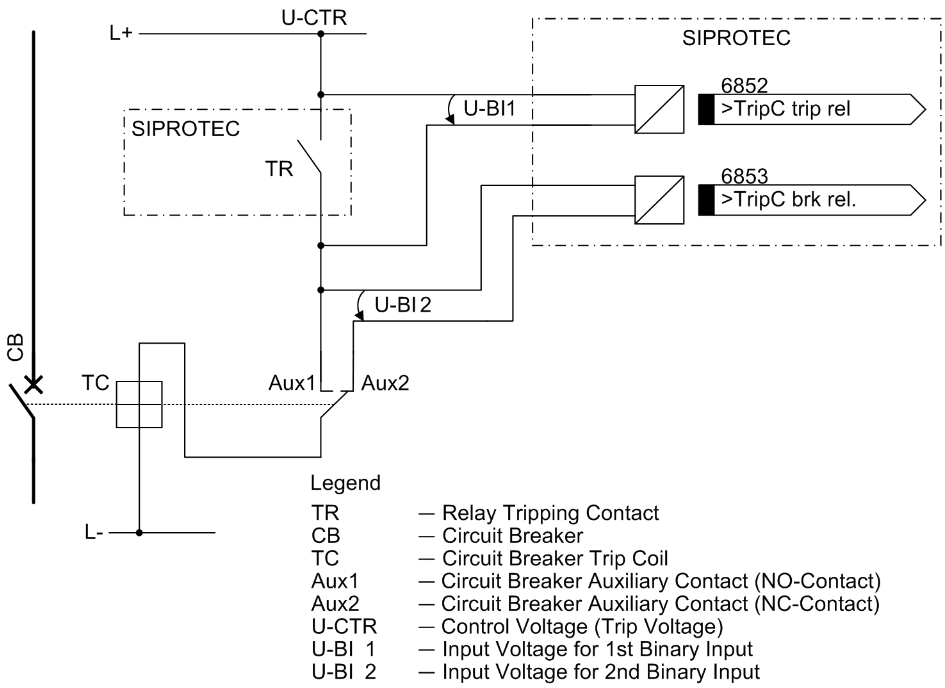


Figure 2-136 Principle of trip circuit monitor with two binary inputs (not connected to common potential)

Monitoring with binary inputs not only detects interruptions in the trip circuit and loss of control voltage, it also monitors the response of the circuit breaker using the position of the circuit breaker auxiliary contacts.

Depending on the switching state of the trip relay and circuit breaker, the binary inputs are initiated (logic state „H“ in Table 2-15) or short circuited (logic state „L“).

The state where both binary inputs are not energized („L“) is only present during a short transition phase (trip relay contact is closed, but the circuit breaker has not yet opened) if the trip circuit is healthy. A continuous state of this condition is only possible when the trip circuit has been interrupted, a short-circuit exists in the trip circuit, battery voltage failure occurs, or malfunctions occur with the circuit breaker mechanism. Accordingly it is used as monitoring criterion.

Table 2-15 Condition Table for Binary Inputs, depending on RTC and CB Position

No.	Trip contact	Circuit breaker	Aux 1	Aux 2	BI 1	BI 2
1	Open	TRIP	Closed	Open	H	L
2	Open	CLOSE	Open	Closed	H	H
3	Closed	TRIP	Closed	Open	L	L
4	Closed	CLOSE	Open	Closed	L	H

The conditions of the two binary inputs are checked periodically. A query takes place about every 600 ms. If three consecutive conditional checks detect an abnormality (after 1.8 s), an annunciation is reported (see the following figure). The repeated measurements determine the delay of the alarm message and avoid that an alarm is output during short transition periods. After the fault in the trip circuit is removed, the alarm is reset automatically after the same time.

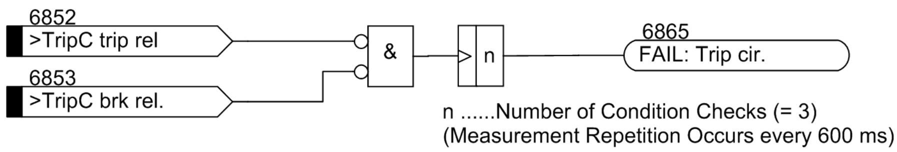


Figure 2-137 Logic Diagram of the Trip Circuit Supervision with Two Binary Inputs

Monitoring with Two Binary Inputs (connected to common potential)

If two binary inputs connected to common potential are used, they are connected according to the figure below, with common connection L+ or once in parallel to the corresponding protection command relay contact and to the CB auxiliary contact 1.

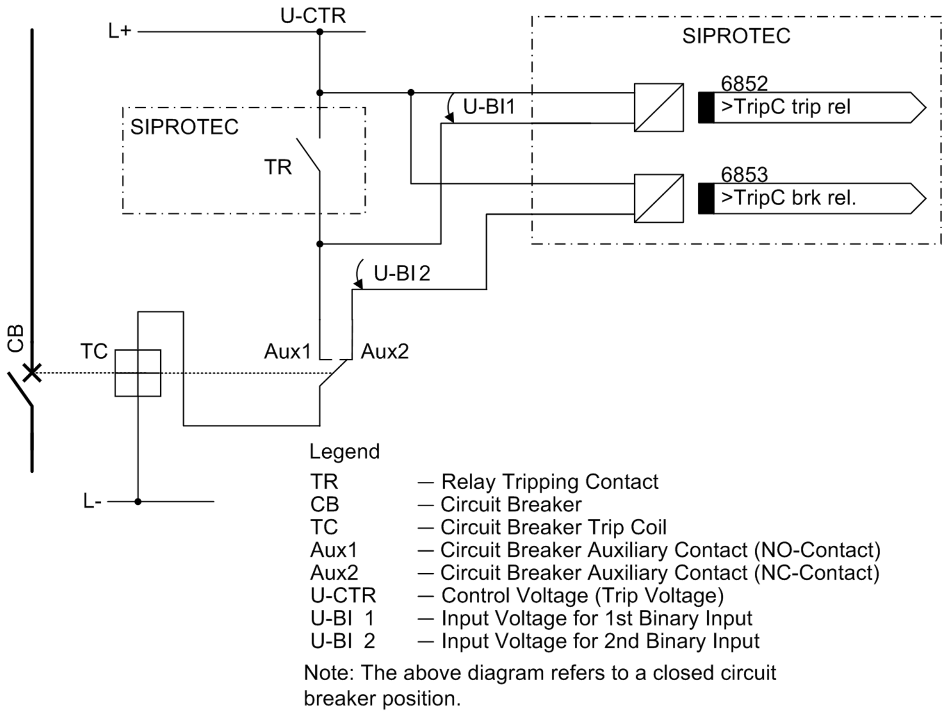


Figure 2-138 Principle of trip circuit monitor with two binary inputs (connected to common potential)

Depending on the switching state of the trip relay and circuit breaker, the binary inputs are initiated (logic state „H“ in the table below) or short circuited (logic state „L“).

Table 2-16 Condition Table for Binary Inputs, depending on RTC and CB Position

No.	Trip contact	Circuit breaker	Aux 1	Aux 2	BI 1	BI 2	dyn. status	stat. status
1	Open	TRIP	Closed	Open	H	L	normal operation with closed CB	
2	Open or Closed	CLOSE	Open	Closed	L	H	Normal operation with open CB or TR has tripped with success	
3	Closed	TRIP	Closed	Open	L	L	Transition/fault	Fault
4	Open	CLOSED or OPEN	Closed	Closed	H	H	Theoretical status: AuxCont defective, BI defective, wrong connection	

With this solution, it is impossible to distinguish between status 2 („normal operation with open CB“ and „RTC has tripped with success“). However these two statuses are normal and thus not critical. Status 4 is only theoretical and indicates a hardware error. The state where both binary inputs are not energized („L“) is only present during a short transition phase (trip relay contact is closed, but the circuit breaker has not yet opened) if the trip circuit is healthy. A continuous state of this condition is only possible when the trip circuit has been interrupted, a short-circuit exists in the trip circuit, battery voltage failure occurs, or malfunctions occur with the circuit breaker mechanism. Accordingly it is used as monitoring criterion.

The conditions of the two binary inputs are scanned periodically. A query takes place about every 600 ms. If three consecutive conditional checks detect an abnormality (after 1.8 s), an annunciation is reported (see Figure 2-137). The repeated measurements help to determine the delay of the alarm message and to avoid that an alarm is output during short-time transition periods. After the fault in the trip circuit has been eliminated, the alarm is reset automatically after the same time.

Monitoring with One Binary Input

The binary input is connected in parallel to the respective command relay contact of the protection device according to the following figure. The circuit breaker auxiliary contact is bridged with a high-ohmic equivalent resistor R.

The control voltage for the circuit breaker should be at least twice as high as the minimum voltage drop at binary input ($U_{CTRL} > 2 \cdot U_{BImin}$ since approximately the same voltage drop occurs at equivalent resistor R). Since at least 19 V are needed for the binary input, the monitor can be used with a system control voltage of over 38 V.

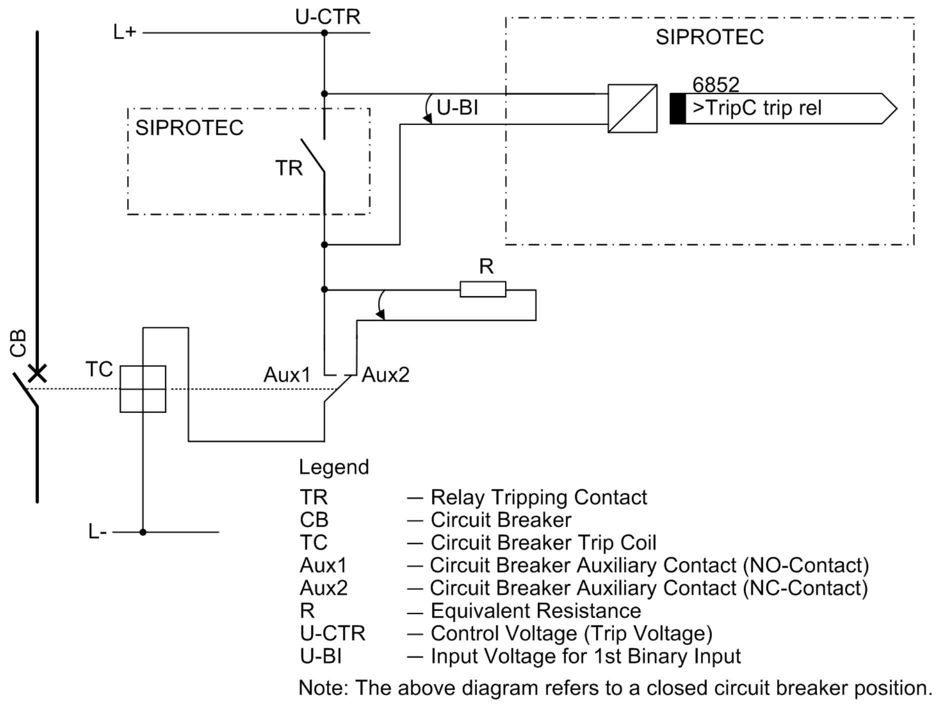


Figure 2-139 Principle of trip circuit monitoring with one binary input

During normal operation, the binary input is activated (logical condition „H“) when the trip contact is open and the trip circuit is intact, because the supervision circuit is closed either by the circuit breaker auxiliary contact (if the circuit breaker is closed) or through the equivalent resistor R. Only as long as the trip contact is closed is the binary input short-circuited and thereby deactivated (logical condition „L“).

If the binary input is permanently deactivated during operation, an interruption in the trip circuit or a failure of the (trip) control voltage can be assumed.

As the trip circuit supervision is not operative during a system fault condition (picked-up status of the device), the closed trip contact does not lead to an alarm. If, however, tripping contacts from other devices operate in parallel with the trip circuit, then the fault annunciation must be delayed (see also the following figure). The conditions of the binary input are therefore checked 500 times before an annunciation is issued. A condition check takes place about every 600 ms, so trip circuit monitoring is only activated during an actual malfunction of the trip circuit (after 300 s). After the fault in the trip circuit has been eliminated, the alarm is reset automatically after the same time.

Note

If the lock-out function is used, the trip circuit monitoring with only one binary input must not be used, as the relay remains permanently picked up after a trip command (longer than 300s).

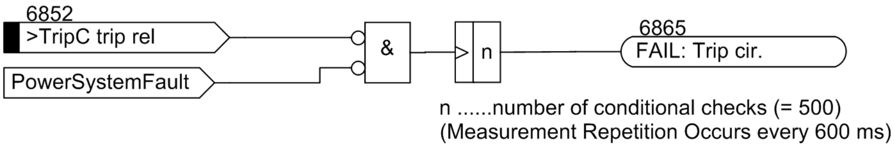


Figure 2-140 Logic diagram for Trip Circuit Monitoring with one binary input

The following figure shows the logic diagram for the message that can be generated by the trip circuit monitor, depending on the control settings and binary inputs.

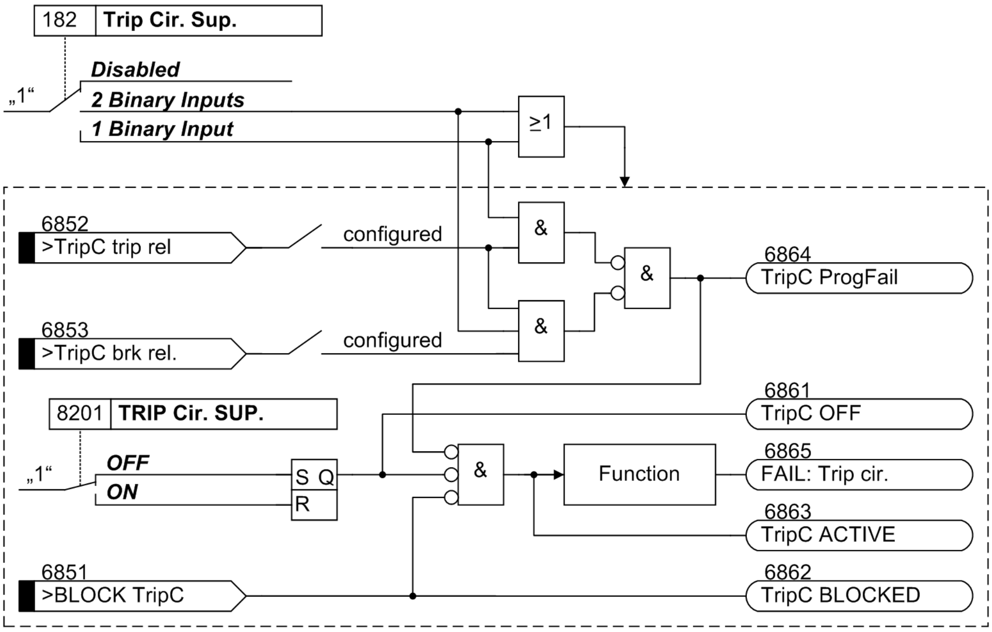


Figure 2-141 Message Logic of the Trip Circuit Supervision

2.43.2 Setting Notes

General

The function is only in effective and available if address 182 **Trip Cir. Sup.** (Section 2.4) was configured to either ***2 Binary Inputs*** or to ***1 Binary Input*** as enabled, and the appropriate number of binary inputs have been allocated for this purpose. The function at address 8201 **TRIP Cir. SUP.** must be set to ***ON***. If the allocation of the necessary binary inputs does not comply with the selected supervision mode, an alarm is given („TripC ProgFail“). If the trip circuit monitor is not to be used at all, then at address 182 ***Disabled*** is set. Further parameters are not needed. The indication of a trip circuit interruption is delayed by a fixed amount of time. For two binary inputs, the delay is about 2 seconds, and for one binary input, the delay is about 300 s. This ensures that the longest possible duration of a trip signal expires, and an indication occurs only if there is a real malfunction in the trip circuit.

Monitoring with One Binary Input

Note: When using only one binary input (BI) for the trip circuit monitor, some malfunctions, such as interruption of the trip circuit or loss of battery voltage, can indeed be detected, but malfunctions with closed trip contacts cannot. Therefore, the measurement must take place over a period of time that bridges the longest possible duration of a closed trip contact. This is ensured by the fixed number of measurement repetitions and the time between the condition checks.

When using only one binary input, a resistor R is inserted into the circuit on the system side, instead of the missing second binary input. Through appropriate sizing of the resistor and depending on the system relationship, a lower control voltage can often be sufficient. The resistor R is inserted into the circuit of the second circuit breaker auxiliary contact (Aux2) to detect a malfunction also when the circuit breaker auxiliary contact (Aux1) is open, and the trip contact has dropped out (see Figure „Principle of Trip Circuit Monitoring with One Binary Input“). This resistor must be sized such that the circuit breaker trip coil (CBTC) is no longer energized when the circuit breaker is open (which means Aux1 is open and Aux2 is closed). Binary input (BI1) should still be picked up when the trip contact is simultaneously opened.

This results in an upper limit for the resistance R_{max}, and a lower limit R_{min}, from which the optimum value of the arithmetic mean R should be selected:

$$R = \frac{R_{max} + R_{min}}{2}$$

In order that the minimum voltage for controlling the binary input is ensured, $R_{max}$is derived as:

$$R_{max} = \left(\frac{U_{CTR} - U_{BI\,min}}{I_{BI\,(High)}}\right) - R_{TC}$$

To keep the circuit breaker trip coil not energized in the above case, R_{min} is derived as:

$$R_{min} = R_{TC} = \left(\frac{U_{CTR} - U_{TC\,(LOW)}}{U_{TC\,(LOW)}}\right)$$

with

$I_{BI\,(HIGH)}$	Constant current with activated BI (= 1.8 mA)
$U_{BI\,min}$	minimum control voltage for BI (19 V for delivery setting for nominal voltages 24/48/60 V; 88 V for delivery setting for nominal voltages 110/125/220/250 V)
U_{CTR}	Control Voltage for Trip Circuit
R_{TC}	DC resistance of circuit breaker trip coil
$U_{TC\,(LOW)}$	Maximum voltage on the circuit breaker trip coil that does not lead to tripping

If the calculation results in $R_{max} < R_{min}$, then the calculation must be repeated, with the next lowest switching threshold $U_{BI\,min}$, and this threshold must be implemented in the relay using plug-in jumper(s).

For power consumption of the resistance:

$$P_R = I^2 \cdot R = \left(\frac{U_{CTR}}{R + R_{TC}}\right)^2 \cdot R$$

Example:

$I_{BI\ (HIGH)}$	1.8 mA (SIPROTEC 4 7UM62)
$U_{BI\ min}$	19 V for delivery setting for nominal voltage 24/48/60 V (from 7UM62), 88 V for delivery setting for nominal voltage 110/125/220/250 V) (from 7UM62)
U_{CTR}	110 V (system / trip circuit)
R_{TC}	500 Ω (system / trip circuit)
$U_{TC\ (LOW)}$	2 V (system / trip circuit)

$$R_{max} = \left(\frac{110\ \text{V} - 19\ \text{V}}{1.8\ \text{mA}}\right) - 500\ \Omega = 50.1\ \text{k}\Omega$$

$$R_{min} = 500\ \Omega \cdot \left(\frac{100\ \text{V} - 2\ \text{V}}{2\ \text{V}}\right) = 27\ \text{k}\Omega$$

$$R = \frac{R_{max} + R_{min}}{2} = 38.6\ \text{k}\Omega$$

The closest standard value of 39 kΩ is selected; the power is:

$$P_R = \left(\frac{110\ \text{V}}{39\ \text{k}\Omega + 0.5\ \text{k}\Omega}\right)^2 \cdot 39\ \text{k}\Omega$$

$$P_R \geq 0.3\ \text{W}$$

2.43.3 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
8201	TRIP Cir. SUP.	OFF ON	OFF	TRIP Circuit Supervision

2.43.4 Information List

No.	Information	Type of Information	Comments
6851	>BLOCK TripC	SP	>BLOCK Trip circuit supervision
6852	>TripC trip rel	SP	>Trip circuit supervision: trip relay
6853	>TripC brk rel.	SP	>Trip circuit supervision: breaker relay
6861	TripC OFF	OUT	Trip circuit supervision OFF
6862	TripC BLOCKED	OUT	Trip circuit supervision is BLOCKED
6863	TripC ACTIVE	OUT	Trip circuit supervision is ACTIVE
6864	TripC ProgFail	OUT	Trip Circuit blk. Bin. input is not set
6865	FAIL: Trip cir.	OUT	Failure Trip Circuit

2.44 Threshold supervision

This function monitors the thresholds of selected measured values (for overshoot or undershoot). The processing speed of this function is so high that it can be used for protection applications. The necessary logical combinations can be implemented by means of CFC.

It is mainly used for high-speed supervision and automatic functions and application-specific protection functions (e.g. disconnecting power plants) which are not included in the scope of protection functions.

2.44.1 Functional Description

Mode of Operation

There are 10 threshold supervision blocks, 5 each for reacting to overshoot and undershoot of the threshold. As a result a logical indication is output that can be further processed by the CFC.

A total of 19 processable measured values are available, all of which can be evaluated as percentages. Each threshold block can be allocated one of these 19 measured values.

The following table shows the useable measured values. The threshold values are queried once per cycle.

Note

The scaling of the percentage threshold values is exactly the same as for the operational measured values (see Table 2-19 in Section 2.49.3). The settings of the power system data 1 are considered in the calculation. This has to be taken into account for the applications.

Table 2-17 Measured Values

Measured Value	Scaling	Explanation
P (Active power)	$P_{prim}/S_{N,G,M} \cdot 100$ % (normalized with addr. 252)	The positive sequence system quantities for U and I are formed once per cycle from the scanned values. From the result, the primary active power **P** is calculated. The measuring result is subject to the angle correction (address 204 CT ANGLE W0) in the current path.
Q (Reactive power)	$Q_{prim}/S_{N,G,M} \cdot 100$ % (normalized with addr. 252)	The positive sequence system quantities for U and I are formed once per cycle from the scanned values. From the result, the primary reactive power **Q** is calculated. The measuring result is subject to the angle correction (address 204 CT ANGLE W0) in the current path.
ΔP (Active power change)	$\Delta P_{prim}/S_{N,G,M} \cdot 100$ % (normalized with addr. 252)	The active power difference is calculated from the active power over a measuring window of 3 cycles.
UL1E (phase-earth voltage)	$U_{L1prim}/(U_{N,G,M}/\sqrt{3}) \cdot 100$ % (normalized via addr. 251/√3)	The voltage connected to the U_{L1}input is processed directly, and converted into the primary phase-earth voltage. The calculation is performed once per cycle. **Note**: The 100% value refers to the phase-earth voltage of the protected object.
UL2E (phase-earth voltage)	$U_{L2prim}/(U_{N,G,M}/\sqrt{3}) \cdot 100$ % (normalized via addr. 251/√3)	The voltage connected to the U_{L2}input is processed directly, and converted into the primary phase-earth voltage. The calculation is performed once per cycle. **Note**: The 100% value refers to the phase-earth voltage of the protected object.

Measured Value	Scaling	Explanation
UL3E (phase-earth voltage)	$U_{L3prim}/(U_{N,G,M}/\sqrt{3}) \cdot 100$ % (normalized via addr. 251/√3)	The voltage connected to the U_{L3} input is processed directly, and converted into the primary phase-earth voltage. The calculation is performed once per cycle. **Note**: The 100% value refers to the phase-earth voltage of the protected object.
UE (voltage at the U_E input)	$U_{Eprim}/(U_{N,G,M}/\sqrt{3}) \cdot 100$ % (normalized via addr. 251/√3)	The voltage connected to the U_E input is converted into a primary voltage via FACTOR UE (addr. 224). The calculation is performed once per cycle. Observe the applications as per Table 2-2. **Note**: The 100% value refers to the phase-earth voltage of the protected object.
U0 (Zero system voltage)	$U0_{prim}/(U_{N,G,M}/\sqrt{3}) \cdot 100$ % (normalized via addr. 251/√3)	The zero system voltage is determined from the phase-to-earth voltages on the basis of the definition equation for symmetrical components, and converted into primary values. The calculation is performed once per cycle. **Note**: The 100% value refers to the phase-earth voltage of the protected object.
U1 (positive-sequence voltage)	$U1_{prim}/(U_{N,G,M}/\sqrt{3}) \cdot 100$ % (normalized via addr. 251/√3)	The positivev sequence voltage is determined from the phase-to-earth voltages on the basis of the definition equation for symmetrical components, and converted into primary values. The calculation is performed once per cycle. **Note**: The 100% value refers to the phase-earth voltage of the protected object.
U2 (Negative sequence voltage)	$U2_{prim}/(U_{N,G,M}/\sqrt{3}) \cdot 100$ % (normalized via addr. 251/√3)	The negative sequence voltage is determined from the phase-to-earth voltages on the basis of the definition equation for symmetrical components, and converted into primary values. The calculation is performed once per cycle. **Note**: The 100% value refers to the phase-earth voltage of the protected object.
UE3h (3. harmonic voltage at the U_E input)	$U_{E3hprim}/(U_{N,G,M}/\sqrt{3}) \cdot 100$ % (normalized via addr. 251/√3)	From the voltage connected to the U_E input, the 3rd harmonic voltage is computed and converted into a primary voltage via FACTOR UE (addr. 224). The calculation is performed once per cycle. Observe the applications as per Table 2-2. **Note**: The 100% value refers to the phase-earth voltage of the protected object.
3I0 (zero-sequence current system side 2)	$3I0_{prim}/(S_{N,G,M}/(\sqrt{3} \cdot U_{N,G,M})) \cdot 100$ % (normalized with addr. 251 and 252)	The zero sequence current is determined from the phase currents on the basis of the definition equation for symmetrical components. The calculation is performed once per cycle. **Note**: The 100% value refers to the nominal current of the protected object.
I1 (positive sequence current system side 2)	$I1_{prim}/(S_{N,G,M}/(\sqrt{3} \cdot U_{N,G,M})) \cdot 100$ % (normalized with addr. 251 and 252)	The positive sequence current is determined from the phase currents on the basis of the definition equation for symmetrical components, and converted into primary values. The calculation is performed once per cycle. **Note**: The 100% value refers to the nominal current of the protected object.
I2 (Negative sequence current system side 2)	$I2_{prim}/(S_{N,G,M}/(\sqrt{3} \cdot U_{N,G,M})) \cdot 100$ % (normalized with addr. 251 and 252)	The negative sequence current is determined from the phase currents on the basis of the definition equation for symmetrical components, and converted into primary values. The calculation is performed once per cycle. **Note**: The 100% value refers to the nominal current of the protected object.
IEE1 (Sensitive earth current)	$I_{EE1}/0.5\ A \cdot 100$ %	The fundamental frequency component is determined from the current connected to the I_{EE1} input. The calculation is performed once per cycle. **Note**: Unlike the scaling of the operational measured values, scaling is not to primary values. The 100 % value results with a secondary infeed current of 0.5 A.

Measured Value	Scaling	Explanation
IEE2 (Sensitive earth current)	I_{EE2}/0.5 A · 100 %	The fundamental frequency component is determined from the current connected to the I_{EE2} input. The calculation is performed once per cycle. **Note**: Unlike the scaling of the operational measured values, scaling is not to primary values. The 100 % value results with a secondary infeed current of 0.5 A.
φ (Power angle)	φ/180° · 100 %	The power angle is calculated from the positive sequence voltage and the positive sequence current. The following definition applies: φ = φU – φI (A positive angle will appear if the current lags behind the voltage).
cos PHI	cos φ · 100 %	The power factor is calculated from the power angle. Positive values result for the angle range between (–90° and +90°).
Measuring Transducer1 (Voltage or current at measuring transducer TD1)	U/10 V · 100 % or I/20 mA · 100 %	The DC quantity is calculated from the measured quantity present at TD1. Depending on the connection, the results can be positive or negative. Depending on the jumper setting, a voltage or a current is calculated. **Note**: The 100% value refers to an input voltage of 10 V or an input current of 20 mA.

The following figure shows an overview of the logic.

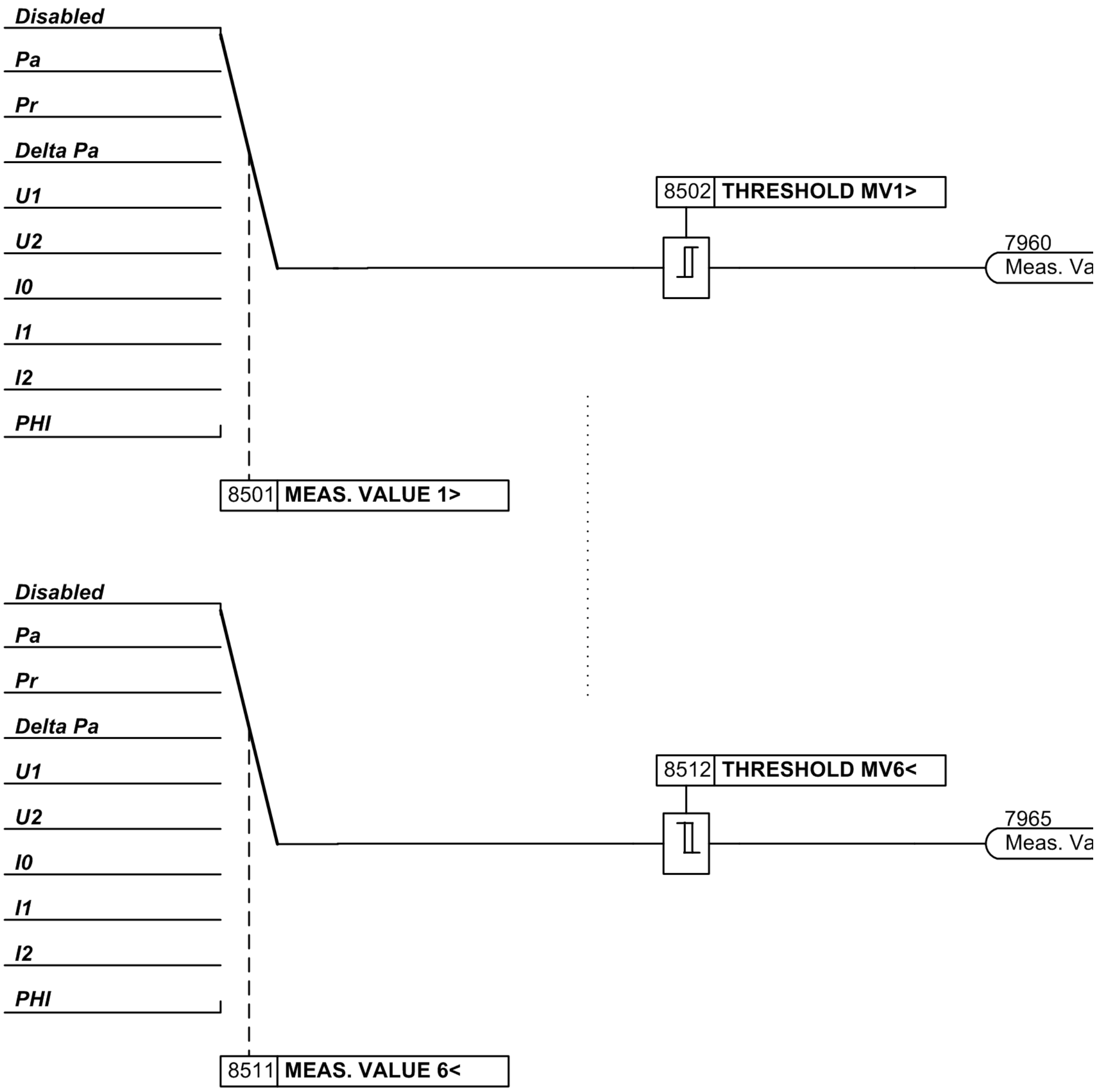


Figure 2-142 Logic of the Threshold Supervision

The figure shows that the measured values can be freely allocated to the threshold supervision blocks. The dropout ratio for the MVx> stage is 0.95 or 1 %. Accordingly, it is 1.05 or 1 % for the MVx< stage.

2.44.2 Setting Notes

General

The threshold supervision function is only effective and accessible if address 185 **THRESHOLD** has been set to ***Enabled*** during the configuration of the protection functions.

Pickup Values

The pickup values are set as percentages. Note the scaling factors listed in the **Measured values** table.

The measured values for power P, Q, ΔP and cosφ as well as the phase angle can be either positive or negative. If a negative threshold value is to be monitored, the number line definition applies (–10 is smaller than –5).

Example:

The measured quantity P (active power) is allocated to MV1> and set to –5 %.

If the actual measured value is higher than –5 % (e.g. –4 % or even +100 %), the indication „Meas. Value1>“ is output as a logical „1“, which means a pickup in terms of protection engineering. A dropout signal (indication „Meas. Value1>“ logical "0") is output if the measured value drops to less than –5 % · 1.05 = –5.25 %.

With the measured quantity P is allocated to MV2<, monitoring checks for an undershoot.

A pickup signal is output if the measured value becomes less than –5 % (e.g. –8 %). The dropout value is then –5 % · 0.95 = –4.75 %.

Note

The measured values U_{L1E}, U_{L2E}, U_{L3E}, U_E, U_0, U_1, U_2, U_{E3h}, I_{EE1}, I_{EE2} $3I_0$, I_1, I_2 and measuring transducer 1 are always greater than 0. Care should be taken here to use only positive threshold values which allow the indication to drop out.

With the power angle φ it should be kept in mind that this angle is only defined for ± 100 % (equivalent to ± 180°) or less. The threshold value should be chosen accordingly, taking into account the dropout ratio.

Further Processing of Indications

The indications of the 10 measured value monitoring blocks (see information overview) are available in the configuration matrix for further logical processing by the CFC.

2.44.3 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
8501	MEAS. VALUE 1>	Disabled P Q Delta P UL1E UL2E UL3E UE U0 U1 U2 UE3h IEE1 IEE2 3I0 I1 I2 PHI PF Transducer 1	Disabled	Measured Value for Threshold MV1>
8502	THRESHOLD MV1>	-200 .. 200 %	100 %	Pickup Value of Measured Value MV1>
8503	MEAS. VALUE 2<	Disabled P Q Delta P UL1E UL2E UL3E UE U0 U1 U2 UE3h IEE1 IEE2 3I0 I1 I2 PHI PF Transducer 1	Disabled	Measured Value for Threshold MV2<
8504	THRESHOLD MV2<	-200 .. 200 %	100 %	Pickup Value of Measured Value MV2<

Addr.	Parameter	Setting Options	Default Setting	Comments
8505	MEAS. VALUE 3>	Disabled P Q Delta P UL1E UL2E UL3E UE U0 U1 U2 UE3h IEE1 IEE2 3I0 I1 I2 PHI PF Transducer 1	Disabled	Measured Value for Threshold MV3>
8506	THRESHOLD MV3>	-200 .. 200 %	100 %	Pickup Value of Measured Value MV3>
8507	MEAS. VALUE 4<	Disabled P Q Delta P UL1E UL2E UL3E UE U0 U1 U2 UE3h IEE1 IEE2 3I0 I1 I2 PHI PF Transducer 1	Disabled	Measured Value for Threshold MV4<
8508	THRESHOLD MV4<	-200 .. 200 %	100 %	Pickup Value of Measured Value MV4<

Addr.	Parameter	Setting Options	Default Setting	Comments
8509	MEAS. VALUE 5>	Disabled P Q Delta P UL1E UL2E UL3E UE U0 U1 U2 UE3h IEE1 IEE2 3I0 I1 I2 PHI PF Transducer 1	Disabled	Measured Value for Threshold MV5>
8510	THRESHOLD MV5>	-200 .. 200 %	100 %	Pickup Value of Measured Value MV5>
8511	MEAS. VALUE 6<	Disabled P Q Delta P UL1E UL2E UL3E UE U0 U1 U2 UE3h IEE1 IEE2 3I0 I1 I2 PHI PF Transducer 1	Disabled	Measured Value for Threshold MV6<
8512	THRESHOLD MV6<	-200 .. 200 %	100 %	Pickup Value of Measured Value MV6<

Addr.	Parameter	Setting Options	Default Setting	Comments
8513	MEAS. VALUE 7>	Disabled P Q Delta P UL1E UL2E UL3E UE U0 U1 U2 UE3h IEE1 IEE2 3I0 I1 I2 PHI PF Transducer 1	Disabled	Measured Value for Threshold MV7>
8514	THRESHOLD MV7>	-200 .. 200 %	100 %	Threshold of Measured Value MV7>
8515	MEAS. VALUE 8<	Disabled P Q Delta P UL1E UL2E UL3E UE U0 U1 U2 UE3h IEE1 IEE2 3I0 I1 I2 PHI PF Transducer 1	Disabled	Measured Value for Threshold MV8<
8516	THRESHOLD MV8<	-200 .. 200 %	100 %	Threshold of Measured Value MV8<

Addr.	Parameter	Setting Options	Default Setting	Comments
8517	MEAS. VALUE 9>	Disabled P Q Delta P UL1E UL2E UL3E UE U0 U1 U2 UE3h IEE1 IEE2 3I0 I1 I2 PHI PF Transducer 1	Disabled	Measured Value for Threshold MV9>
8518	THRESHOLD MV9>	-200 .. 200 %	100 %	Threshold of Measured Value MV9>
8519	MEAS. VALUE 10<	Disabled P Q Delta P UL1E UL2E UL3E UE U0 U1 U2 UE3h IEE1 IEE2 3I0 I1 I2 PHI PF Transducer 1	Disabled	Measured Value for Threshold MV10<
8520	THRESHOLD MV10<	-200 .. 200 %	100 %	Threshold of Measured Value MV10<

2.44.4 Information List

No.	Information	Type of In-formation	Comments
7960	Meas. Value1>	OUT	Measured Value MV1> picked up
7961	Meas. Value2<	OUT	Measured Value MV2< picked up
7962	Meas. Value3>	OUT	Measured Value MV3> picked up
7963	Meas. Value4<	OUT	Measured Value MV4< picked up
7964	Meas. Value5>	OUT	Measured Value MV5> picked up
7965	Meas. Value6<	OUT	Measured Value MV6< picked up
25083	Meas. Value7>	OUT	Measured Value MV7> picked up
25084	Meas. Value8<	OUT	Measured Value MV8< picked up
25085	Meas. Value9>	OUT	Measured Value MV9> picked up
25086	Meas. Value10<	OUT	Measured Value MV10< picked up

2.45 External Trip Functions

Any signals from external protection or supervision units can be incorporated and processed in the digital machine protection 7UM62 via binary inputs. Like the internal signals, they can be signaled, time delayed, transmitted to the trip matrix, and also individually blocked. This way it is possible to include mechanical protection equipment, e.g. Buchholz protection, in the processing of messages of the digital protection device. Furthermore, interaction of protection functions in different devices of the machine protection devices of the 7UM6 series is possible.

2.45.1 Functional Description

Mode of Operation

The logic status of the corresponding assigned binary inputs is checked at cyclic intervals. Change of input status is considered only if at least two consecutive status checks have the same result. An additional time delay 8602 **T DELAY** is available for the trip command.

The following figure shows the logic diagram for direct input trippings. This logic is implemented four times in the same manner, the function numbers of the indications are each specified for the first external trip command channel.

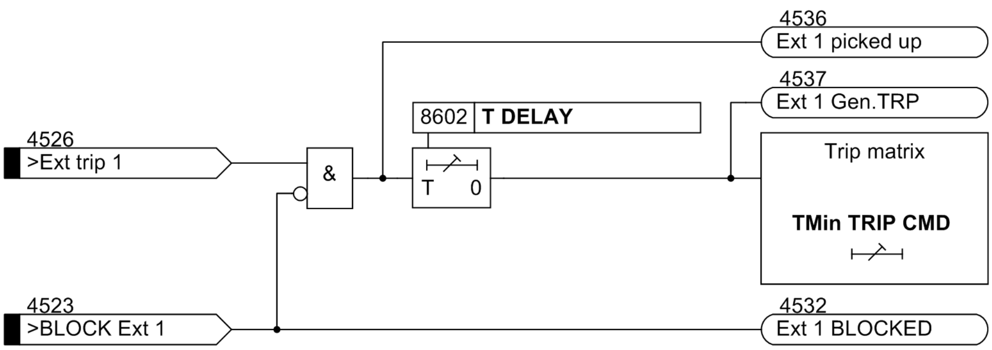


Figure 2-143 Logic Diagram of Direct Input Trippings

2.45.2 Setting Notes

General

External trip command via binary inputs is only effective and available if configured at addresses 186 **EXT. TRIP 1** to 189 **EXT. TRIP 4** as ***Enabled***. ***Disabled*** is set if the functions are not required. Addresses 8601 **EXTERN TRIP 1** to 8901 **EXTERN TRIP 4** are used to switch the functions individually***ON*** or ***OFF***, or to block only the trip command (***Block relay***).

Like the internal signals, they can be indicated as external trippings, time delayed and transmitted to the trip matrix. The delay times are set at addresses 8602 **T DELAY** through 8902 **T DELAY**. Like for the protective functions, the dropout of the direct input trippings is extended by the parametrized minimum duration **TMin TRIP CMD**.

2.45.3 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
8601	EXTERN TRIP 1	OFF ON Block relay	OFF	External Trip Function 1
8602	T DELAY	0.00 .. 60.00 sec; ∞	1.00 sec	Ext. Trip 1 Time Delay
8701	EXTERN TRIP 2	OFF ON Block relay	OFF	External Trip Function 2
8702	T DELAY	0.00 .. 60.00 sec; ∞	1.00 sec	Ext. Trip 2 Time Delay
8801	EXTERN TRIP 3	OFF ON Block relay	OFF	External Trip Function 3
8802	T DELAY	0.00 .. 60.00 sec; ∞	1.00 sec	Ext. Trip 3 Time Delay
8901	EXTERN TRIP 4	OFF ON Block relay	OFF	External Trip Function 4
8902	T DELAY	0.00 .. 60.00 sec; ∞	1.00 sec	Ext. Trip 4 Time Delay

2.45.4 Information List

No.	Information	Type of Information	Comments
4523	>BLOCK Ext 1	SP	>Block external trip 1
4526	>Ext trip 1	SP	>Trigger external trip 1
4531	Ext 1 OFF	OUT	External trip 1 is switched OFF
4532	Ext 1 BLOCKED	OUT	External trip 1 is BLOCKED
4533	Ext 1 ACTIVE	OUT	External trip 1 is ACTIVE
4536	Ext 1 picked up	OUT	External trip 1: General picked up
4537	Ext 1 Gen.TRP	OUT	External trip 1: General TRIP
4543	>BLOCK Ext 2	SP	>BLOCK external trip 2
4546	>Ext trip 2	SP	>Trigger external trip 2
4551	Ext 2 OFF	OUT	External trip 2 is switched OFF
4552	Ext 2 BLOCKED	OUT	External trip 2 is BLOCKED
4553	Ext 2 ACTIVE	OUT	External trip 2 is ACTIVE
4556	Ext 2 picked up	OUT	External trip 2: General picked up
4557	Ext 2 Gen.TRP	OUT	External trip 2: General TRIP
4563	>BLOCK Ext 3	SP	>BLOCK external trip 3
4566	>Ext trip 3	SP	>Trigger external trip 3
4571	Ext 3 OFF	OUT	External trip 3 is switched OFF
4572	Ext 3 BLOCKED	OUT	External trip 3 is BLOCKED
4573	Ext 3 ACTIVE	OUT	External trip 3 is ACTIVE
4576	Ext 3 picked up	OUT	External trip 3: General picked up
4577	Ext 3 Gen.TRP	OUT	External trip 3: General TRIP
4583	>BLOCK Ext 4	SP	>BLOCK external trip 4
4586	>Ext trip 4	SP	>Trigger external trip 4
4591	Ext 4 OFF	OUT	External trip 4 is switched OFF
4592	Ext 4 BLOCKED	OUT	External trip 4 is BLOCKED
4593	Ext 4 ACTIVE	OUT	External trip 4 is ACTIVE
4596	Ext 4 picked up	OUT	External trip 4: General picked up
4597	Ext 4 Gen.TRP	OUT	External trip 4: General TRIP

2.46 Temperature Detection by Thermoboxes

Up to two RTD boxes with a total of 12 measuring points can be used for temperature detection and evaluated by the protection device. In particular they enable the thermal status of motors, generators and transformers to be monitored. Rotating machines are additionally monitored for a violation of bearing temperature thresholds. The temperatures are measured in different locations of the protected object by temperature sensors (RTD = Resistance Temperature Detector) and are transmitted to the device via one or two 7XV566 RTD boxes.

2.46.1 Functional Description

Interaction with the Overload Protection

The ambient or coolant temperature can be fed via the thermobox to the overload protection function of the device. For this purpose the required temperature sensor must be connected to sensor input 1 of the 1st RTD box (corresponds to RTD 1).

RTD Box 7XV56

The 7XV566 RTD box is an external device mounted on a standard DIN rail. It features 6 temperature inputs and one RS 485 interface for communication with the protection device. The RTD box detects the coolant temperature of each measuring point from the resistance value of the temperature detectors (Pt 100, Ni 100 or Ni 120) connected with a two- or three-wire line and converts it to a digital value. The digital values are made available at a serial port.

Communication with the Protection Device

The protection device can communicate with up to 2 RTD boxes via its service port (port C or D).

Up to 12 temperature measuring points are in this way available. For greater distances to the protection device, a fibre optic link is recommended. Possible communication structures are shown in the appendix.

Temperature Evaluation

The transmitted temperature raw data is converted to a temperature in degrees Celsius or Fahrenheit. The conversion depends on the temperature sensor used.

For each measuring point two thresholds decisions can be performed which are available for further processing. The user can allocate the pickup signals in the configuration matrix as required.

To each temperature detector is assigned an alarm which is issued in case of a short-circuit or an interruption of the sensor circuit.

The following figure shows the logic diagram for temperature processing.

The manual supplied with the RTD box contains a diagram and dimensioned drawing.

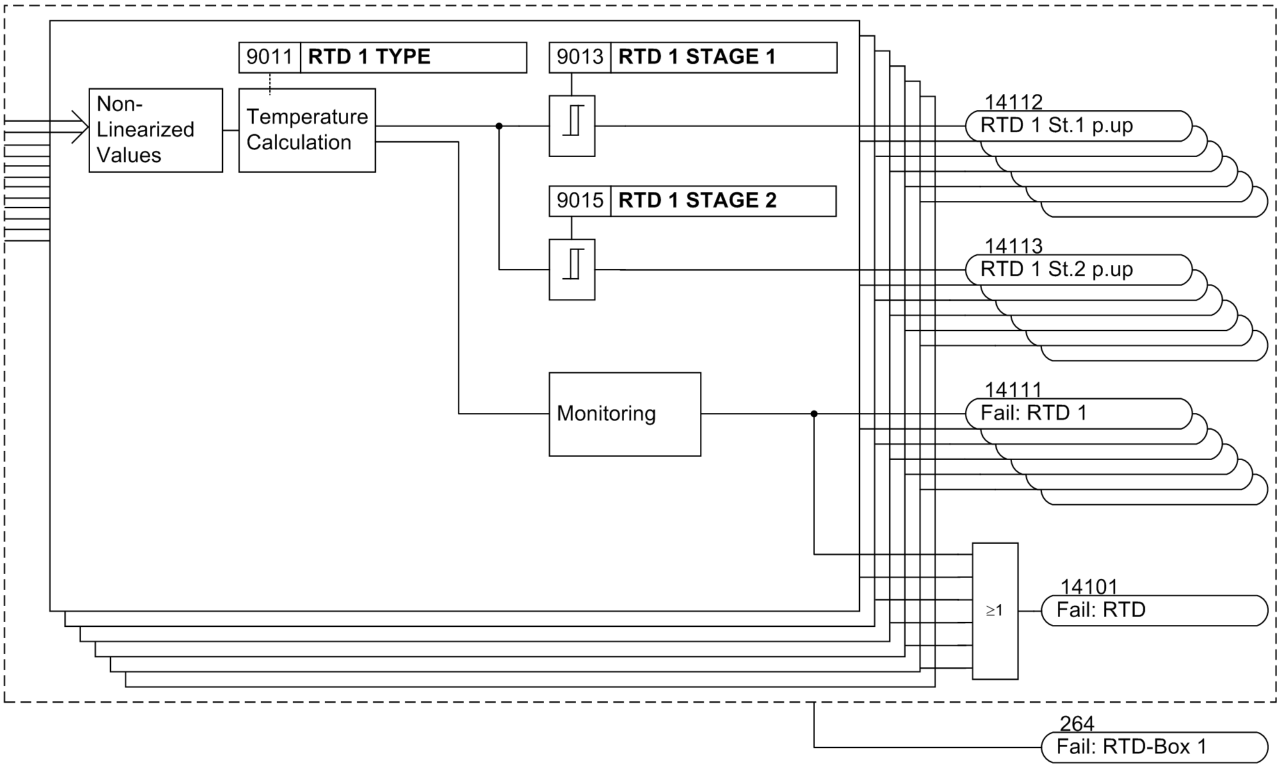


Figure 2-144 Logic Diagram for Temperature Processing

2.46.2 Setting Notes

General

The temperature detection is only active and accessible if it has been assigned to a port during configuration of the protection functions (Section 2.4). At address 190 **RTD-BOX INPUT** the RTD box(es) is allocated to the port at which it will be operated (e.g. port C). The number of sensor inputs and the communication mode were set at address 191 **RTD CONNECTION**. The temperature unit (°C or °F) was set in the Power System Data 1 at address 276 **TEMP. UNIT**.

If the RTD boxes are operated in half-duplex mode, „/CTS controlled by /RTS“ must be selected for flow control (CTS). This is done using a jumper (see Section 3.1.2 in the Chapter „Installation and Commissioning“)

Device Settings

The settings are the same for each input and are here shown at the example of measuring input 1.

Set the type of temperature detector for RTD 1 (temperature sensor for measuring point 1) at address 9011 **RTD 1 TYPE**. You can choose between , ***Ni 120*** Ω and ***Ni 100*** Ω. If no temperature detector is available for RTD 1, set **RTD 1 TYPE** = ***Not connected***. This parameter can only be changed in DIGSI at „Display Additional Settings“.

Address 9012 **RTD 1 LOCATION** informs the device on the mounting location of RTD 1. You can choose between ***Oil***, ***Ambient***, ***Winding***, ***Bearing*** and ***Other***. The selected location is not evaluated in the device; it merely informs about the medium in which the temperature measurement is performed. This parameter can only be changed in DIGSI at „Display Additional Settings“.

Furthermore, you can set an alarm temperature and a tripping temperature. Depending on the temperature unit selected in the Power System Data (Section 2.4.2 in address 276 **TEMP. UNIT**), the alarm temperature can be expressed in Celsius (°C) (address 9013 **RTD 1 STAGE 1**) or Fahrenheit (°F) (address 9014 **RTD 1 STAGE 1**). The tripping temperature is set at address 9015 **RTD 1 STAGE 2** in degree Celsius (°C) or degree Fahrenheit (°F) at address 9016 **RTD 1 STAGE 2**.

The settings for all temperature detectors connected are made accordingly:

RTD Box Settings

If temperature detectors are used with two-wire connection, the line resistance (for short-circuited temperature detector) must be measured and adjusted. For this purpose, select mode 6 in the RTD-box and enter the resistance value for the corresponding temperature detector (range 0 to 50.6 Ω). If a 3-wire connection is used, no further settings are required to this end.

A baudrate of 9600 bits/s ensures communication. Parity is even. The factory setting of the bus number is 0. Modifications at the RTD-box can be made in mode 7. The following convention applies:

Table 2-18 Setting the bus address at the RTD-box

Mode	Number of RTD-boxes	Address
simplex	1	0
half duplex	1	1
half duplex	2	1. RTD-box: 1
		2. RTD-box: 2

Further information is provided in the operating manual of the RTD-box.

Processing Measured Values and Messages

The RTD box is visible in DIGSI as part of the 7UM62 protection devices, i.e. messages and measured values appear in the configuration matrix just like those of internal functions, and can be masked and processed in the same way. Messages and measured values can thus be forwarded to the integrated user-definable logic (CFC) and linked as desired. But the pickup signals „RTD x St. 1 p.up“ and „RTD x St. 2 p.up“ are neither included in the group alarms 501 „Relay PICKUP“ and 511 „Relay TRIP“ nor do they trigger a fault record.

If it is desired that a message should appear in the event buffer, a cross must be entered in the intersecting box of column/row.

2.46.3 Settings

Addresses which have an appended "A" can only be changed with DIGSI, under Additional Settings.

Addr.	Parameter	Setting Options	Default Setting	Comments
9011A	RTD 1 TYPE	Not connected Pt 100 Ω Ni 120 Ω Ni 100 Ω	Pt 100 Ω	RTD 1: Type
9012A	RTD 1 LOCATION	Oil Ambient Winding Bearing Other	Winding	RTD 1: Location
9013	RTD 1 STAGE 1	-50 .. 250 °C; ∞	100 °C	RTD 1: Temperature Stage 1 Pickup
9014	RTD 1 STAGE 1	-58 .. 482 °F; ∞	212 °F	RTD 1: Temperature Stage 1 Pickup
9015	RTD 1 STAGE 2	-50 .. 250 °C; ∞	120 °C	RTD 1: Temperature Stage 2 Pickup
9016	RTD 1 STAGE 2	-58 .. 482 °F; ∞	248 °F	RTD 1: Temperature Stage 2 Pickup
9021A	RTD 2 TYPE	Not connected Pt 100 Ω Ni 120 Ω Ni 100 Ω	Not connected	RTD 2: Type
9022A	RTD 2 LOCATION	Oil Ambient Winding Bearing Other	Other	RTD 2: Location
9023	RTD 2 STAGE 1	-50 .. 250 °C; ∞	100 °C	RTD 2: Temperature Stage 1 Pickup
9024	RTD 2 STAGE 1	-58 .. 482 °F; ∞	212 °F	RTD 2: Temperature Stage 1 Pickup
9025	RTD 2 STAGE 2	-50 .. 250 °C; ∞	120 °C	RTD 2: Temperature Stage 2 Pickup
9026	RTD 2 STAGE 2	-58 .. 482 °F; ∞	248 °F	RTD 2: Temperature Stage 2 Pickup
9031A	RTD 3 TYPE	Not connected Pt 100 Ω Ni 120 Ω Ni 100 Ω	Not connected	RTD 3: Type
9032A	RTD 3 LOCATION	Oil Ambient Winding Bearing Other	Other	RTD 3: Location
9033	RTD 3 STAGE 1	-50 .. 250 °C; ∞	100 °C	RTD 3: Temperature Stage 1 Pickup

Addr.	Parameter	Setting Options	Default Setting	Comments
9034	RTD 3 STAGE 1	-58 .. 482 °F; ∞	212 °F	RTD 3: Temperature Stage 1 Pickup
9035	RTD 3 STAGE 2	-50 .. 250 °C; ∞	120 °C	RTD 3: Temperature Stage 2 Pickup
9036	RTD 3 STAGE 2	-58 .. 482 °F; ∞	248 °F	RTD 3: Temperature Stage 2 Pickup
9041A	RTD 4 TYPE	Not connected Pt 100 Ω Ni 120 Ω Ni 100 Ω	Not connected	RTD 4: Type
9042A	RTD 4 LOCATION	Oil Ambient Winding Bearing Other	Other	RTD 4: Location
9043	RTD 4 STAGE 1	-50 .. 250 °C; ∞	100 °C	RTD 4: Temperature Stage 1 Pickup
9044	RTD 4 STAGE 1	-58 .. 482 °F; ∞	212 °F	RTD 4: Temperature Stage 1 Pickup
9045	RTD 4 STAGE 2	-50 .. 250 °C; ∞	120 °C	RTD 4: Temperature Stage 2 Pickup
9046	RTD 4 STAGE 2	-58 .. 482 °F; ∞	248 °F	RTD 4: Temperature Stage 2 Pickup
9051A	RTD 5 TYPE	Not connected Pt 100 Ω Ni 120 Ω Ni 100 Ω	Not connected	RTD 5: Type
9052A	RTD 5 LOCATION	Oil Ambient Winding Bearing Other	Other	RTD 5: Location
9053	RTD 5 STAGE 1	-50 .. 250 °C; ∞	100 °C	RTD 5: Temperature Stage 1 Pickup
9054	RTD 5 STAGE 1	-58 .. 482 °F; ∞	212 °F	RTD 5: Temperature Stage 1 Pickup
9055	RTD 5 STAGE 2	-50 .. 250 °C; ∞	120 °C	RTD 5: Temperature Stage 2 Pickup
9056	RTD 5 STAGE 2	-58 .. 482 °F; ∞	248 °F	RTD 5: Temperature Stage 2 Pickup
9061A	RTD 6 TYPE	Not connected Pt 100 Ω Ni 120 Ω Ni 100 Ω	Not connected	RTD 6: Type
9062A	RTD 6 LOCATION	Oil Ambient Winding Bearing Other	Other	RTD 6: Location

Addr.	Parameter	Setting Options	Default Setting	Comments
9063	RTD 6 STAGE 1	-50 .. 250 °C; ∞	100 °C	RTD 6: Temperature Stage 1 Pickup
9064	RTD 6 STAGE 1	-58 .. 482 °F; ∞	212 °F	RTD 6: Temperature Stage 1 Pickup
9065	RTD 6 STAGE 2	-50 .. 250 °C; ∞	120 °C	RTD 6: Temperature Stage 2 Pickup
9066	RTD 6 STAGE 2	-58 .. 482 °F; ∞	248 °F	RTD 6: Temperature Stage 2 Pickup
9071A	RTD 7 TYPE	Not connected Pt 100 Ω Ni 120 Ω Ni 100 Ω	Not connected	RTD 7: Type
9072A	RTD 7 LOCATION	Oil Ambient Winding Bearing Other	Other	RTD 7: Location
9073	RTD 7 STAGE 1	-50 .. 250 °C; ∞	100 °C	RTD 7: Temperature Stage 1 Pickup
9074	RTD 7 STAGE 1	-58 .. 482 °F; ∞	212 °F	RTD 7: Temperature Stage 1 Pickup
9075	RTD 7 STAGE 2	-50 .. 250 °C; ∞	120 °C	RTD 7: Temperature Stage 2 Pickup
9076	RTD 7 STAGE 2	-58 .. 482 °F; ∞	248 °F	RTD 7: Temperature Stage 2 Pickup
9081A	RTD 8 TYPE	Not connected Pt 100 Ω Ni 120 Ω Ni 100 Ω	Not connected	RTD 8: Type
9082A	RTD 8 LOCATION	Oil Ambient Winding Bearing Other	Other	RTD 8: Location
9083	RTD 8 STAGE 1	-50 .. 250 °C; ∞	100 °C	RTD 8: Temperature Stage 1 Pickup
9084	RTD 8 STAGE 1	-58 .. 482 °F; ∞	212 °F	RTD 8: Temperature Stage 1 Pickup
9085	RTD 8 STAGE 2	-50 .. 250 °C; ∞	120 °C	RTD 8: Temperature Stage 2 Pickup
9086	RTD 8 STAGE 2	-58 .. 482 °F; ∞	248 °F	RTD 8: Temperature Stage 2 Pickup
9091A	RTD 9 TYPE	Not connected Pt 100 Ω Ni 120 Ω Ni 100 Ω	Not connected	RTD 9: Type

Addr.	Parameter	Setting Options	Default Setting	Comments
9092A	RTD 9 LOCATION	Oil Ambient Winding Bearing Other	Other	RTD 9: Location
9093	RTD 9 STAGE 1	-50 .. 250 °C; ∞	100 °C	RTD 9: Temperature Stage 1 Pickup
9094	RTD 9 STAGE 1	-58 .. 482 °F; ∞	212 °F	RTD 9: Temperature Stage 1 Pickup
9095	RTD 9 STAGE 2	-50 .. 250 °C; ∞	120 °C	RTD 9: Temperature Stage 2 Pickup
9096	RTD 9 STAGE 2	-58 .. 482 °F; ∞	248 °F	RTD 9: Temperature Stage 2 Pickup
9101A	RTD10 TYPE	Not connected Pt 100 Ω Ni 120 Ω Ni 100 Ω	Not connected	RTD10: Type
9102A	RTD10 LOCATION	Oil Ambient Winding Bearing Other	Other	RTD10: Location
9103	RTD10 STAGE 1	-50 .. 250 °C; ∞	100 °C	RTD10: Temperature Stage 1 Pickup
9104	RTD10 STAGE 1	-58 .. 482 °F; ∞	212 °F	RTD10: Temperature Stage 1 Pickup
9105	RTD10 STAGE 2	-50 .. 250 °C; ∞	120 °C	RTD10: Temperature Stage 2 Pickup
9106	RTD10 STAGE 2	-58 .. 482 °F; ∞	248 °F	RTD10: Temperature Stage 2 Pickup
9111A	RTD11 TYPE	Not connected Pt 100 Ω Ni 120 Ω Ni 100 Ω	Not connected	RTD11: Type
9112A	RTD11 LOCATION	Oil Ambient Winding Bearing Other	Other	RTD11: Location
9113	RTD11 STAGE 1	-50 .. 250 °C; ∞	100 °C	RTD11: Temperature Stage 1 Pickup
9114	RTD11 STAGE 1	-58 .. 482 °F; ∞	212 °F	RTD11: Temperature Stage 1 Pickup
9115	RTD11 STAGE 2	-50 .. 250 °C; ∞	120 °C	RTD11: Temperature Stage 2 Pickup
9116	RTD11 STAGE 2	-58 .. 482 °F; ∞	248 °F	RTD11: Temperature Stage 2 Pickup

Addr.	Parameter	Setting Options	Default Setting	Comments
9121A	RTD12 TYPE	Not connected Pt 100 Ω Ni 120 Ω Ni 100 Ω	Not connected	RTD12: Type
9122A	RTD12 LOCATION	Oil Ambient Winding Bearing Other	Other	RTD12: Location
9123	RTD12 STAGE 1	-50 .. 250 °C; ∞	100 °C	RTD12: Temperature Stage 1 Pickup
9124	RTD12 STAGE 1	-58 .. 482 °F; ∞	212 °F	RTD12: Temperature Stage 1 Pickup
9125	RTD12 STAGE 2	-50 .. 250 °C; ∞	120 °C	RTD12: Temperature Stage 2 Pickup
9126	RTD12 STAGE 2	-58 .. 482 °F; ∞	248 °F	RTD12: Temperature Stage 2 Pickup

2.46.4 Information List

No.	Information	Type of Information	Comments
14101	Fail: RTD	OUT	Fail: RTD (broken wire/shorted)
14111	Fail: RTD 1	OUT	Fail: RTD 1 (broken wire/shorted)
14112	RTD 1 St.1 p.up	OUT	RTD 1 Temperature stage 1 picked up
14113	RTD 1 St.2 p.up	OUT	RTD 1 Temperature stage 2 picked up
14121	Fail: RTD 2	OUT	Fail: RTD 2 (broken wire/shorted)
14122	RTD 2 St.1 p.up	OUT	RTD 2 Temperature stage 1 picked up
14123	RTD 2 St.2 p.up	OUT	RTD 2 Temperature stage 2 picked up
14131	Fail: RTD 3	OUT	Fail: RTD 3 (broken wire/shorted)
14132	RTD 3 St.1 p.up	OUT	RTD 3 Temperature stage 1 picked up
14133	RTD 3 St.2 p.up	OUT	RTD 3 Temperature stage 2 picked up
14141	Fail: RTD 4	OUT	Fail: RTD 4 (broken wire/shorted)
14142	RTD 4 St.1 p.up	OUT	RTD 4 Temperature stage 1 picked up
14143	RTD 4 St.2 p.up	OUT	RTD 4 Temperature stage 2 picked up
14151	Fail: RTD 5	OUT	Fail: RTD 5 (broken wire/shorted)
14152	RTD 5 St.1 p.up	OUT	RTD 5 Temperature stage 1 picked up
14153	RTD 5 St.2 p.up	OUT	RTD 5 Temperature stage 2 picked up
14161	Fail: RTD 6	OUT	Fail: RTD 6 (broken wire/shorted)
14162	RTD 6 St.1 p.up	OUT	RTD 6 Temperature stage 1 picked up
14163	RTD 6 St.2 p.up	OUT	RTD 6 Temperature stage 2 picked up
14171	Fail: RTD 7	OUT	Fail: RTD 7 (broken wire/shorted)
14172	RTD 7 St.1 p.up	OUT	RTD 7 Temperature stage 1 picked up
14173	RTD 7 St.2 p.up	OUT	RTD 7 Temperature stage 2 picked up
14181	Fail: RTD 8	OUT	Fail: RTD 8 (broken wire/shorted)
14182	RTD 8 St.1 p.up	OUT	RTD 8 Temperature stage 1 picked up
14183	RTD 8 St.2 p.up	OUT	RTD 8 Temperature stage 2 picked up
14191	Fail: RTD 9	OUT	Fail: RTD 9 (broken wire/shorted)
14192	RTD 9 St.1 p.up	OUT	RTD 9 Temperature stage 1 picked up
14193	RTD 9 St.2 p.up	OUT	RTD 9 Temperature stage 2 picked up
14201	Fail: RTD10	OUT	Fail: RTD10 (broken wire/shorted)
14202	RTD10 St.1 p.up	OUT	RTD10 Temperature stage 1 picked up
14203	RTD10 St.2 p.up	OUT	RTD10 Temperature stage 2 picked up
14211	Fail: RTD11	OUT	Fail: RTD11 (broken wire/shorted)
14212	RTD11 St.1 p.up	OUT	RTD11 Temperature stage 1 picked up
14213	RTD11 St.2 p.up	OUT	RTD11 Temperature stage 2 picked up
14221	Fail: RTD12	OUT	Fail: RTD12 (broken wire/shorted)
14222	RTD12 St.1 p.up	OUT	RTD12 Temperature stage 1 picked up
14223	RTD12 St.2 p.up	OUT	RTD12 Temperature stage 2 picked up

2.47 Phase Rotation

A phase sequence reversal feature via binary input and parameter is implemented in the 7UM62. This permits all protection and monitoring functions to operate correctly even with phase rotation reversal, without the need for two phases to be reversed.

If an anti-clockwise rotating phase sequence permanently exists, this should be entered in the power system data (see Section 2.5).

If phase rotation can reverse during operation (e.g. in a pumped storage power station, transition from generator to pumping operation is done by changing the phase rotation), then a reversal signal at the input allocated is sufficient to inform the protection device of phase-sequence reversal.

2.47.1 Functional Description

Logic

The phase rotation is permanently set in a parameter of the power system data at address 271 **PHASE SEQ.**. Binary input „>Reverse Rot.“ sets the phase rotation to the opposite of the parameter setting.

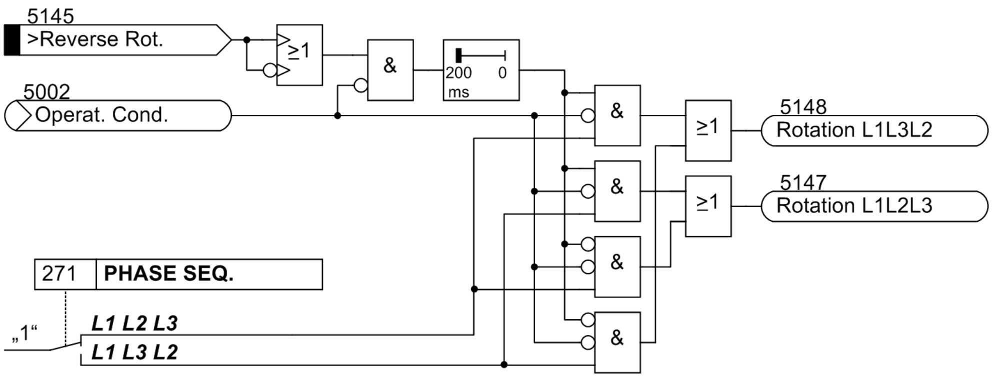


Figure 2-145 Message logic of the phase-sequence reversal

For safety reasons, the device accepts phase sequence reversal only when no usable measured quantities are current. The binary input is scanned only if operational condition 1 is not current. If a reverse command is present for at least 200 ms, the measured quantities of phases L2 and L3 are exchanged.

If operational condition 1 is reached before the minimum control time of 200 ms has expired, phase sequence reversal does not become effective.

As no phase rotation reversal is possible in operational condition 1, the control signal could be retracted in operational condition 1 without a phase rotation reversal occurring. For safety reasons, the control signal should be permanently present in order to avoid malfunctions also on device reset (e.g. due to configuration change).

Influence on Protective Functions

Swapping phases with a phase sequence reversal affects exclusively calculation of positive and negative sequence quantities, as well as phase-to-phase voltages by subtraction of one phase-to-ground voltage from another, so that phase related indications, fault values, and operating measurement values are not distorted. Thus this function influences almost all protection functions and some of the monitoring functions (see Section 2.42.1) which issue an indication if the required and calculated phase rotations do not match.

2.47.2 Setting Notes

Programming Settings

The normal phase sequence is set at 271 (see Subsection 2.5). If, on the system side, phase rotation is temporarily changed, then this is communicated to the protective device using the binary input „>Reverse Rot.“ (5145).

2.48 Protection Function Control

The function logic coordinates the sequence of both the protective and ancillary functions, processes the functional decisions, and data received from the system.

2.48.1 Pickup Logic for the Entire Device

This section describes the general pickup and spontaneous messages in the device display.

2.48.1.1 Functional Description

General Device Pickup

The pickup signals for all protection functions in the device are logically OR-combined, and lead to the general device pickup. It is initiated by the first function to pickup and drops out when the last function drops out. In consequence, the following message is reported: „Relay PICKUP“.

The general pickup is the precondition for a number of internal and external consequential functions. The following are among the internal functions controlled by general device pickup:

- Start of Trip Log: From general device pickup to general device dropout, all fault indications are entered in the trip log.
- Initialization of Oscillographic Records: the storage and maintenance of fault values can also be made dependent on the occurrence of a trip command.
- Generation of Spontaneous Messages: Certain fault messages are displayed in the device display as so-called spontaneous messages (see below „Spontaneous Messages“). This indication can also be made dependent on the general device trip.

Spontaneous Display Messages

Spontaneous messages are fault messages that appear in the display automatically when general device pickup has occurred. For the 7UM62, these messages include:

„**Relay PICKUP**“:	the protection function that last picked up
„**Relay TRIP**“:	the protection function that last initiated a trip signal;
„**PU Time**“:	running time from general device pickup to dropout of the device, in ms;
„**Trip time**“:	running time from general device pickup to initiation of the first trip signal by the device, with time indicated in ms;

If you use a graphical display, spontaneous messages are only displayed if parameter **Spont. FltDisp.** is set to ***YES*** (see also Section 2.2). On the 4-line display this parameter is hidden.

Note that the thermal overload protection does not have a pickup comparable with the other protection functions. The general device pickup time (PU Time) is started with the trip signal, which starts the trip log. The dropout of the thermal image of the overload protection ends the fault case and, thereby the running PU Time.

2.48.2 Tripping Logic for the Entire Device

This section comprises a description regarding the general trip and termination of the trip command.

2.48.2.1 Functional Description

General Trip

The tripping signals for all protective functions are connected by ”OR” and generate a message „Relay TRIP“.

This annunciation, like individual trip indications, can be allocated to an LED or an output relay. It can also be used as a sum event.

Control of the Trip Command

For controlling the trip command the following applies:

- If a protective function is set to ***Block. Relay***, it is blocked for the activation of the output relay. The other protective functions are not affected by this.
- A trip command once transmitted is stored (see Figure 2-146). At the same time, the minimum trip command duration **T TRIPCOM MIN** is started. This trip signal duration timer ensures the trip signal is transmitted to the circuit breaker for a sufficient amount of time, even if the function which issued the trip signal drops out quickly. The trip signal is only terminated after all protection Functions drop out AND the minimum trip signal duration expires.
- Finally, it is possible to latch the trip signal until it is manually reset (lockout function). This allows interlocking the circuit breaker against reclosing until the cause of the malfunction has been clarified and the interlock has been manually reset. The reset takes place either by pressing the LED reset key or by activating an appropriately masked binary input („>Reset LED“). A precondition, of course, is that the circuit breaker trip coil – as usual – remains blocked as long as the trip signal is present, and the trip coil current is interrupted by the auxiliary contact of the circuit breaker.

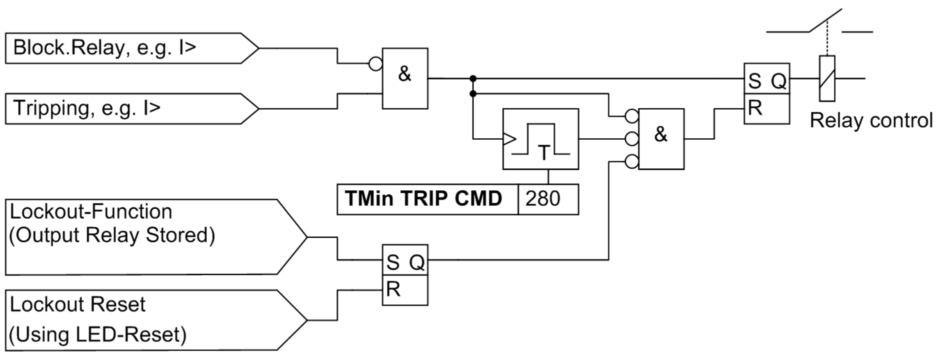


Figure 2-146 Terminating the trip signal, example of a protection function

2.48.2.2 Setting Notes

Command Duration

The minimum trip command duration 280 **TMin TRIP CMD** has already been described in Section 2.5. It is valid for all protection functions which can issue a trip command.

2.49 Auxiliary Functions

The general functions of the device are described in chapter "Additional Functions".

2.49.1 Processing of Annunciation

After occurrence of a system fault, data on the device response and the measured quantities are significant for analysis purposes. For this purpose, the device provides annunciations processing which operates in a three-fold manner:

2.49.1.1 Functional Description

Displays and Binary Outputs (output relays)

Important events and statuses are displayed using front panel LEDs. The relay also contains output relays for remote signaling. Most indications and displays can be configured differently to the delivery default settings. The SIPROTEC 4 System Description /1/ gives a detailed description of the configuration procedure. The allocation settings on delivery are listed in the Appendix of this manual.

The output relays and the LEDs may be operated in a latched or unlatched mode (each may be individually set).

The latched conditions are protected against loss of the auxiliary voltage. They are reset

- Locally by pressing the LED key on the relay,
- Remotely using a binary input configured for that purpose,
- Using one of the serial interfaces,
- Automatically at the beginning of a new pickup (please observe the LED minimum hold time, see Section 2.2)).

Status messages should not be stored. Also, they cannot be reset until the criterion to be reported is remedied. This applies to indications from monitoring functions or similar.

A green LED displays operational readiness of the relay („RUN“), and cannot be reset. It goes out if the self-check feature of the microprocessor recognizes an abnormal occurrence, or if the auxiliary voltage fails.

When auxiliary voltage is present, but the relay has an internal malfunction, then the red LED („ERROR“) lights up and the relay is blocked.

Information on the Integrated Display (LCD) or to a Personal Computer

Events and states can be obtained from the LCD on the front plate of the device. A personal computer can be connected to the front interface or the service interface for retrieval of information.

In the quiescent condition, as long as no system fault is present, the display panel can display selected operating information (overview of operating measurement values). In the event of a system fault, fault information, so-called spontaneous display indications, appear instead. After the fault indications have been acknowledged, the quiescent data are shown again. Acknowledgement can be performed by pressing the LED buttons on the front panel (see above).

The device is equipped with several event buffers, for operational messages, circuit breaker statistics, etc., which are protected against loss of the auxiliary voltage by a buffer battery. These messages can be retrieved, at any time, using the operating keypad in the display field, or transferred to a personal computer, using the serial operating interface. Readout of indications during operation is described in detail in the SIPROTEC 4 System Description /1/.

Classification of Messages

The indications are categorized as follows:

- Operational indications; indications generated while the device is operating: Information regarding the status of device functions, measured data, power system data, control command logs etc.
- Fault indications: indications from the last 8 network faults that were processed by the device.
- Indications on "Statistics": they include a counter for the trip commands initiated by the device, possibly reclose commands as well as values of interrupted currents and accumulated fault currents.

A complete list of all indications and output functions that can be generated by the device, with the associated information number (No.), can be found in the Appendix. The list also shows where each indication can be sent to. If functions are absent in a not fully equipped version of the device, or are configured as ***Disabled***, then the associated indications cannot appear.

Operational Annunciations (Buffer: Event Log)

Operational annunciations are information generated by the device in operation, and concerning the operation. Up to 200 operational annunciations are stored chronologically in the device. Newly generated annunciations are added to those already there. When the maximum capacity of the memory is exhausted, the oldest annunciation is lost.

Fault Annunciations (Buffer: Trip Log)

After a fault on the system, for example, important information about the progression of the fault can be retrieved, such as the pickup or initiation of a trip signal. The start of the fault is time stamped with the absolute time of the internal system clock. The course of the disturbance is output with a relative time referred to the pickup instant, so that the duration until tripping and up to reset of the trip command can be ascertained. The resolution of the time information is 1 ms.

Spontaneous Messages From the Device Front

After a fault the most important data of the fault appear on the display automatically after a general device pickup without any further operating actions.

When a graphical display is used, spontaneous messages can also be set in parameters (see also Section 2.2).

Retrievable Annunciations

The annunciations of the last eight network faults can be retrieved and output. Where a generator fault causes several protective functions to pick up, the fault is considered to include all that occurred between pickup of the first protective function and dropout of the last protective function.

In total 600 annuncations can be recorded. Oldest data are erased for newest data when the buffer is full.

General Interrogation

The present condition of a SIPROTEC 4 device can be examined with DIGSI by viewing the contents of the General Interrogation. It shows all annunciations that are subject to general interrogation with their current value.

Spontaneous Messages

The spontaneous annunciations displayed using DIGSI reflect the present status of incoming information. Each new incoming annunciation appears immediately, i.e. the user does not have to wait for an update or initiate one.

Statistics

The annunciations in statistics are counters for breaker switching operations instigated by the 7UM62 as well as for accumulation of short-circuit currents involved in disconnections caused by the device protection functions. The interrupted currents are in primary terms.

Statistics can be viewed on the LCD of the device, or on a PC running DIGSI, and connected to the operator or service interface.

A password is not required to read counter and stored values but is required to change or delete them.

Information to a Control Centre

If the device has a serial system interface, stored information may additionally be transferred via this interface to a centralised control and storage device. Transmission is possible via different transmission protocols.

2.49.2 Statistics

The trip commands initiated by the device are counted. Currents of the last disconnections initiated by the device are recorded. Disconnected fault currents are accumulated for each breaker pole.

2.49.2.1 Functional Description

Number of Trips

The number of trips initiated by the 7UM62 is counted, as long as the position of the circuit breaker is monitored via breaker auxiliary contacts and binary inputs. To use this function, the internal pulse counter „#of TRIPs=“ has to be masked in the matrix to a binary input that is controlled by the circuit breaker OPEN position. The pulse metered value „#of TRIPs=“ can be found in the "**Statistics**" group if the option "Measured and Metered Values Only" was enabled in the configuration matrix.

Switch-Off Values (at Trip)

Additionally, the following switch-off values appear in the fault indications for each trip signal:

- If earth differential protection is configured, an indication „I0-Diff:“ and „I0-Stab:“ is issued in I/I_{nO}.
- the total of the primary fault currents per phase and side in kA
- the primary currents in all three phases in kA, individually for side 1 and side 2
- If differential protection is configured, the differential and stabilization (restraint) currents of all three phases are indicated.
- the three phase-to-earth voltages in kV
- primary active power P in MW (precisely averaged power)
- primary reactive power Q in MVAR (precisely averaged power)
- Frequency in Hz

Operating Hours

The operating hours under load are also stored (= current value in at least one phase is greater than the limit value **BkrClosed I MIN** set under address 281) are also accumulated.

Accumulated Shutdown Currents

The shutdown currents for each phase, which are indicated at every trip command individually for side 1 and side 2, are accumulated and stored.

The counter and memory levels are secured against loss of auxiliary voltage.

Setting / Resetting

Setting or resetting of these statistical counters takes place under the menu item **ANNUNCIATION** → **STATISTIC** by overwriting the counter values displayed.

2.49.2.2 Information List

No.	Information	Type of Information	Comments
-	#of TRIPs=	PMV	Number of TRIPs
409	>BLOCK Op Count	SP	>BLOCK Op Counter
1020	Op.Hours=	VI	Counter of operating hours
30607	ΣIL1 S1:	VI	Accumulation of interrupted curr. L1 S1
30608	ΣIL2 S1:	VI	Accumulation of interrupted curr. L2 S1
30609	ΣIL3 S1:	VI	Accumulation of interrupted curr. L3 S1
30610	ΣIL1 S2:	VI	Accumulation of interrupted curr. L1 S2
30611	ΣIL2 S2:	VI	Accumulation of interrupted curr. L2 S2
30612	ΣIL3 S2:	VI	Accumulation of interrupted curr. L3 S2

2.49.3 Measurement (Secondary/Primary/Percentage Values)

A series of measured values and the values derived from them are constantly available for call up on site, or for data transfer (see table 2-19, as well as the following list).

Measured values can be retrieved by a central control system (SCADA).

2.49.3.1 Functional Description

Display of Measured Values

The operational measured values listed in Table 2-19 can be read out as secondary, primary or percentage values. A precondition for correctly displaying the primary and percentage values is complete and correct entry of the nominal values for the current transformers, and protected equipment as well as current and voltage transformer ratios in the ground paths, in accordance with Subsections 2.5 and 2.7. Table 2-19 lists the formulae for the conversion of secondary into primary or percentage values.

Depending on the version ordered, the type of device connection and the configured protection functions, only a part of the operational measured values listed in the following table may be available. The displacement voltage U_0 is calculated from the phase-earth voltages: $U_0 = {}^1/_3 \cdot |\underline{U}_{L1} + \underline{U}_{L2} + \underline{U}_{L3}|$. For this, the three voltage inputs phase-to-earth must be connected.

Table 2-19 Conversion formulae between secondary values and primary/percentage operational measuring values

Measured Values	secondary	primary	%
$I_{L1\ S2}$, $I_{L2\ S2}$, $I_{L3\ S2}$, $I_{1\ S2}$, $I_{2\ S2}$, $3I_{0\ S2}$,	$I_{sec\ S2}$	$\frac{\text{IN-PRI I-SIDE2}}{\text{IN-SEC I-SIDE2}} \cdot I_{sec\ S2}$	$\frac{I_{prim.\ S2}}{\text{SN GEN/MOTOR}/(\sqrt{3} \cdot \text{UN GEN/MOTOR})} \cdot 1$
$I_{L1\ S1}$, $I_{L2\ S1}$, I_{L3S1}	$I_{sec\ S1}$	$\frac{\text{IN-PRI I-SIDE1}}{\text{IN-SEC I-SIDE1}} \cdot I_{sec\ S1}$	Differential Protection for Generators and Motors: $\frac{I_{prim.\ S1}}{\text{SN GEN/MOTOR}/(\sqrt{3} \cdot \text{UN GEN/MOTOR})} \cdot$ Differential Protection for Three Phase Transformer: $\frac{I_{prim.\ S1}}{\text{SN TRANSFORMER}/(\sqrt{3} \cdot \text{UN-PRI SIDE1})} \cdot$
I_{Ns1}	$I_{EE1\ sec}$	FACTOR IEE1 · $I_{EE1\ sec.}$	$\frac{I_{EE1\ prim.}}{\text{SN GEN/MOTOR}/(\sqrt{3} \cdot \text{UN GEN/MOTOR})} \cdot$
I_{Ns2}	$I_{EE2\ sec.}$	FACTOR IEE2 · $I_{EE1\ sec.}$	$\frac{I_{EE2\ prim.}}{\text{SN GEN/MOTOR}/(\sqrt{3} \cdot \text{UN GEN/MOTOR})} \cdot$

Measured Values	second-ary	primary	%
I_{EE0}	$I_{EE1\ sec}$ or $I_{EE2\ sec}$	$\text{FACTOR IEE1} \cdot I_{EE1\ sec}$ or $\text{FACTOR IEE2} \cdot I_{EE2\ sec}$	$\frac{I_{EE1\ prim.}}{\text{SN GEN/MOTOR}/(\sqrt{3} \cdot \text{UN GEN/MOTOR})} \cdot$ or $\frac{I_{EE2\ prim.}}{\text{SN GEN/MOTOR}/(\sqrt{3} \cdot \text{UN GEN/MOTOR})} \cdot$
U_{L1E}, U_{L2E}, U_{L3E}, U_0 U_1, U_2	$U_{L\text{-}E\ sec.}$	$\frac{\text{UN-VT PRIMARY}}{\text{UN-VT SECONDARY}} \cdot U_{L-E\ sec}$	$\frac{U_{prim}}{\text{UN GEN/MOTOR}/(\sqrt{3})} \cdot 100$
$U_{L1\text{-}L2}$, $U_{L2\text{-}L3}$, $U_{L3\text{-}L1}$	$U_{LL\ sec.}$	$\frac{\text{UN-VT PRIMARY}}{\text{UN-VT SECONDARY}} \cdot U_{LL\ sec}$	$\frac{U_{prim}}{\text{UN GEN/MOTOR}} \cdot 100$
U_G	measured: $U_{E\ sec.}$	measured: $\text{FACTOR UE} \cdot U_{E\ sec.}$	$\frac{U_{E\ prim}}{\text{UN GEN/MOTOR}/(\sqrt{3})} \cdot 100$
	calculated: $U_{E\ sec.} = U0 \cdot \sqrt{3}$	calculated: $\frac{\text{Unom PRIMARY}}{\text{Unom SECONDARY}} \cdot U_{E3.H,\ sec}$	
$U_{I/T}$	$U_{I/T\ sec}$	$\text{FACTOR UE} \cdot U_{I/T\ sec}$	$\frac{U_{I/Tprim}}{\text{UN GEN/MOTOR}/(\sqrt{3})} \cdot 100$
P, Q, S	P_{sec} Q_{sec} S_{sec}	$\frac{\text{Unom PRIMARY}}{\text{Unom SECONDARY}} \cdot \frac{\text{IN-PRI I-SIDE2}}{\text{IN-SEC I-SIDE2}} \cdot P_{sec}$	$\frac{Power_{prim} \cdot 100}{\text{SN GEN/MOTOR}}$
Angle PHI	φ	φ	no display of percentage measured values
Power factor	$\cos \varphi$	$\cos \varphi$	$\cos \varphi \cdot 100$
Frequency	f	f	$\frac{f}{f_{Nom}} \cdot 100$
U/f	$\frac{U/f}{U_N/f_N} \cdot \frac{\text{Unom PRIMARY}}{\text{UN-GEN/MOTOR}}$		$\frac{U/f}{U_N/f_N} \cdot \frac{\text{Unom PRIMARY}}{\text{UN-GEN/MOTOR}} \cdot 100$
R, X	$R_{sec\ S2}$ $X_{sec\ S2}$	$\frac{\frac{\text{Unom PRIMARY}}{\text{Unom SECONDARY}}}{\frac{\text{IN-PRI I-SIDE2}}{\text{IN-SEC I-SIDE2}}} \cdot R_{sec\ S2}$	no display of percentage measured values
$U_{E3.H}$	measured: $U_{E3.H,sec}$	measured: $\text{FACTOR UE} \cdot U_{E3.H,\ sec}$	$\frac{U_{E3.H.prim}}{\text{UN GEN/MOTOR}/(\sqrt{3})} \cdot 100$
	calculated: $U_{E3.H,sec} = U0 \cdot \sqrt{3}$	calculated: $\frac{\text{Unom PRIMARY}}{\text{Unom SECOMDARY}} \cdot U_{E3.H,sec}$	

Measured Values	secondary	primary	%
U_{DC}/I_{DC} (measuring transducer 1)	U_{DC} in V-	no primary values	$\frac{U_{DC}}{10\ V} \cdot 100$
	I_{DC} in mA-		$\frac{I_{DC}}{20\ mA} \cdot 100$
U_{exc} (measuring transducer 3)	U_{exc}	no primary value	$\frac{U_{err}}{10\ V} \cdot 100$

With the following parameters from the Power System Data 1:

Parameter	Address	Parameter	Address
Unom PRIMARY	221	FACTOR IEE1	205
Unom SECONDARY	222	FACTOR IEE2	213
IN-PRI I-SIDE1	202	FACTOR UE	224
IN-SEC I-SIDE1	203	UN GEN/MOTOR	251
IN-PRI I-SIDE2	211	SN GEN/MOTOR	252
IN-SEC I-SIDE2	212	Uph / Udelta	225
UN-PRI SIDE 1	241	SN TRANSFORMER	249

In addition measured values are computed by the protection functions and made available:

Measured Values of Rotor Earth Fault Protection (Rn, fn)

The following secondary values are available: System-frequency displacement voltage U_{RE} (= U_E), earth fault current II_{RE} (= I_{ee1}) and rotor earth resistance R_{earth}, total resistance R_{tot}, total reactance X_{tot} and phase angle φZ_{tot} of the total resistance of the rotor earth fault protection.

Measured Values of the Rotor Earth Fault Protection (1–3 Hz)

Frequency and amplitude of the 1-3 Hz generator (7XT71) f_g, U_g, current in the rotor circuit I_g, charge at polarity reversal Q_C and rotor earth resistance R_{earth}.

Measured Values of the Stator Earth Fault Protection (20 Hz)

Voltage and current in the stator earth circuit U_{SES} and I_{SEF}, the specific stator earth resistances R_{sef} and R_{sefp} (primary) and the phase angle φ_{SEF} between the current and the voltage at 20 Hz.

Definition of Power Measurement

The 7UM62 uses the generator reference-arrow system. The power output is positive.

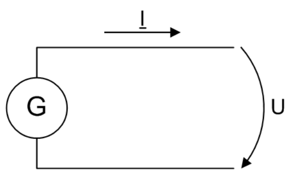
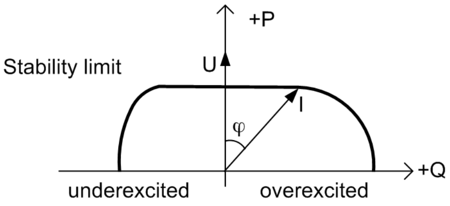
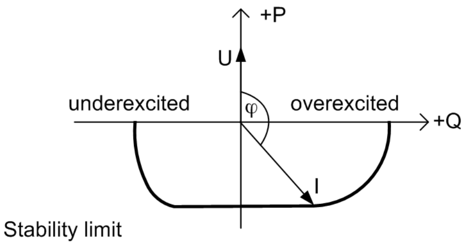
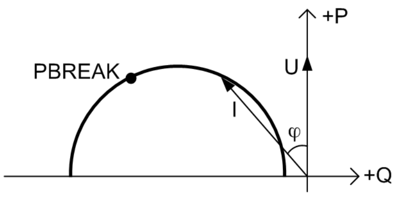
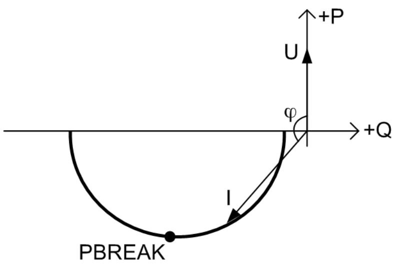


Figure 2-147 Definition of Positive Direction of Reference Arrows

The following table shows the operating ranges for synchronous and asynchronous machines. For this, parameter 1108 **ACTIVE POWER** is set to ***Generator***. „Normal condition“ shows the active power under normal operating conditions: + means that a positive power is displayed on the protective device, – means that the power is negative.

Table 2-20 Operating Ranges for Synchronous and Asynchronous Machines

Synchronous generator	Synchronous motor
 Reactive power Q is controlled by the excitation. Normal situation: +P and +Q	 Reactive power Q is controlled by the excitation. Normal situation: -P and +Q
Asynchronous generator	**Asynchronous motor**
 Reactive power is drawn from the system to maintain the exitation. Normal situation: +P and -Q	 In motor operation both active and reactive power is drawn from the system. Normal situation: -P and -Q

The table shows that the operating ranges in generator and motor operation are mirrored around the reactive power axis. The measured power values also result from the above definition.

If, for instance, the forward power monitoring or the reverse power protection is to be used in a synchronous motor, parameter 1108 **ACTIVE POWER** must be set to ***Motor***. This multiplies the actual active power (according to the above definition) with –1. This means that the power diagram is symmetrical around the reactive power axis and the interpretation of active power changes. This effect must be considered when evaluating the metered energy values.

If for instance positive power values are to be obtained with an asynchronous motor, the current direction at the allocated CT set (e.g. parameter 201 **STRPNT->OBJ S1**) must be reversed. Parameter 1108 **ACTIVE POWER** remains in the default setting ***Generator***. This means that because of the generator reference-arrow system, the earthing of the CTs that must be entered in the device is the opposite of the actual earthing. This leads to results that are comparable to those of a consumer reference-arrow system.

2.49.3.2 Information List

No.	Information	Type of Information	Comments
605	I1 =	MV	I1 (positive sequence)
606	I2 =	MV	I2 (negative sequence)
621	UL1E=	MV	U L1-E
622	UL2E=	MV	U L2-E
623	UL3E=	MV	U L3-E
624	UL12=	MV	U L12
625	UL23=	MV	U L23
626	UL31=	MV	U L31
627	UE =	MV	Displacement voltage UE
629	U1 =	MV	U1 (positive sequence)
630	U2 =	MV	U2 (negative sequence)
641	P =	MV	P (active power)
642	Q =	MV	Q (reactive power)
644	Freq=	MV	Frequency
645	S =	MV	S (apparent power)
650	UE3h =	MV	UE 3rd harmonic
662	I DC =	MV	DC Current
669	U20=	MV	SEF 100%: 20 Hz voltage stator circuit
670	I20=	MV	SEF 100%: 20 Hz current stator circuit
693	Rtot =	MV	REF(R,fn): Total Resistance (R total)
696	Xtot =	MV	REF(R,fn): Total Reactance (X total)
697	φ Ztot=	MV	REF(R,fn): Phase Angle of Z total
700	Re =	MV	REF(R,fn): Fault Resistance (R earth)
721	IL1S1=	MV	Operat. meas. current L1 side 1 [%] is
722	IL2S1=	MV	Operat. meas. current L2 side 1 [%] is
723	IL3S1=	MV	Operat. meas. current L3 side 1 [%] is
724	IL1S2=	MV	Operat. meas. current L1 side 2 [%] is
725	IL2S2=	MV	Operat. meas. current L2 side 2 [%] is
726	IL3S2=	MV	Operat. meas. current L3 side 2 [%] is
755	fgen =	MV	REF(1-3Hz): Freq. of square-wave gen.
757	Ugen =	MV	REF(1-3Hz): Volt. of square-wave gen.
758	Imeas. =	MV	REF(1-3Hz): Curr. of rotor meas. circuit
759	Qc =	MV	REF(1-3 Hz): Charge at polarity rev.(Qc)
760	RSEFp=	MV	SEF100%: Prim. stator earth resistance
761	R earth=	MV	REF(1-3Hz): Fault Resistance (R earth)
762	U SEF=	MV	SEF100%: Bias volt. for stator circuit
763	I SEF=	MV	SEF100%: Earth curr. in stator circuit
764	R SEF=	MV	SEF100%: Stator earth resistance
765	U/f =	MV	(U/Un) / (f/fn)
769	U I/T =	MV	Displacement voltage U Interturn
827	IEE-B=	MV	Sensitive Current IEE-B
828	IEE1=	MV	Senstive Earth Current 1
829	IEE2=	MV	Senstive Earth Current 2
831	3I0 =	MV	3I0 (zero sequence)

No.	Information	Type of Information	Comments
832	U0 =	MV	U0 (zero sequence)
894	U DC =	MV	DC voltage
896	U RE =	MV	REF(R,fn): Injected Voltage (U RE)
897	I RE =	MV	REF(R,fn): Curr. in the Circuit (I RE)
901	PF =	MV	Power Factor
902	PHI=	MV	Power angle
903	R=	MV	Resistance
904	X=	MV	Reactance
909	Uexcit.=	MV	Excitation voltage
995	φ SEF=	MV	SEF100%: Phase angle in stator circuit
996	Td1=	MV	Transducer 1
997	Td2=	MV	Transducer 2
998	Td3=	MV	Transducer 3
7740	φIL1S1=	MV	Phase angle in phase IL1 side 1
7741	φIL2S1=	MV	Phase angle in phase IL2 side 1
7749	φIL3S1=	MV	Phase angle in phase IL3 side 1
7750	φIL1S2=	MV	Phase angle in phase IL1 side 2
7759	φIL2S2=	MV	Phase angle in phase IL2 side 2
7760	φIL3S2=	MV	Phase angle in phase IL3 side 2

2.49.4 Thermal Measurement

2.49.4.1 Description

The thermal measured values are as follows:

- $\Theta_S/\Theta_{S\ Trip}$ Overload protection measured value of the stator winding in % of the tripping overtemperature,
- $\Theta_S/\Theta_{S\ TripL1}$ Normalized overload protection measured value of the stator winding for phase L1,
- $\Theta_S/\Theta_{S\ TripL2}$ Normalized overload protection measured value of the stator winding for phase L2,
- $\Theta_S/\Theta_{S\ TripL3}$ Normalized overload protection measured value of the stator winding for phase L3,
- Θ_R/Θ_{Rmax}: Normalized rotor temperature in % of the tripping temperature,
- $T_{Rem.}$: Time until the next permissible restart,
- $I_{Neg\ th.}$: Rotor overtemperature due to the negative phase-sequence component of the current, in % of the tripping overtemperature,
- U/f th.: Overtemperature caused by overexcitation, in % of tripping overtemperature,
- „AMB.TEMP =“ Coolant temperature
- Θ RTD 1 to Θ RTD 12: Temperature at sensors 1 to 12

2.49.4.2 Information List

No.	Information	Type of Information	Comments
660	T Rem.=	MV	Remaining Time for Switch ON
661	Θ REST. =	MV	Threshold of Restart Inhibit
766	U/f th. =	MV	Calculated temperature (U/f)
801	Θ/Θtrip =	MV	Temperat. rise for warning and trip
802	Θ/ΘtripL1=	MV	Temperature rise for phase L1
803	Θ/ΘtripL2=	MV	Temperature rise for phase L2
804	Θ/ΘtripL3=	MV	Temperature rise for phase L3
805	ΘR/ΘRmax =	MV	Temperature of Rotor
910	ThermRep.=	MV	Calculated rotor temp. (unbal. load)
911	AMB.TEMP =	MV	Cooling medium temperature
1068	Θ RTD 1 =	MV	Temperature of RTD 1
1069	Θ RTD 2 =	MV	Temperature of RTD 2
1070	Θ RTD 3 =	MV	Temperature of RTD 3
1071	Θ RTD 4 =	MV	Temperature of RTD 4
1072	Θ RTD 5 =	MV	Temperature of RTD 5
1073	Θ RTD 6 =	MV	Temperature of RTD 6
1074	Θ RTD 7 =	MV	Temperature of RTD 7
1075	Θ RTD 8 =	MV	Temperature of RTD 8
1076	Θ RTD 9 =	MV	Temperature of RTD 9
1077	Θ RTD10 =	MV	Temperature of RTD10
1078	Θ RTD11 =	MV	Temperature of RTD11
1079	Θ RTD12 =	MV	Temperature of RTD12

2.49.5 Diff- and Rest. Measurement

Differential and restraint currents (stabilized currents) $I_{diff\ L1}$, $I_{diff\ L2}$, $I_{diff\ L3}$, $I_{stab\ L1}$, $I_{stab\ L2}$, $I_{stab\ L3}$, $I0_{diff}$, $I0_{stab}$, 3I0-1, 3I0-2 in percent of the nominal values of the protected object.

2.49.5.1 Information List

No.	Information	Type of Information	Comments
7742	IDiffL1=	MV	IDiffL1(I/Inominal object [%])
7743	IDiffL2=	MV	IDiffL2(I/Inominal object [%])
7744	IDiffL3=	MV	IDiffL3(I/Inominal object [%])
7745	IRestL1=	MV	IRestL1(I/Inominal object [%])
7746	IRestL2=	MV	IRestL2(I/Inominal object [%])
7747	IRestL3=	MV	IRestL3(I/Inominal object [%])
30654	I0-Diff=	MV	I0-Diff REF (I/Inominal object [%])
30655	I0-Rest=	MV	I0-Rest REF (I/Inominal object [%])
30659	3I0-1 =	MV	3I0-1 REF (I/Inominal object [%])
30660	3I0-2 =	MV	3I0-2 REF (I/Inominal object [%])

2.49.6 Min/Max Measurement Setup

Minimum and maximum values for the positive-sequence components I_1 and U_1, the active power P, reactive power Q, in primary values, of the frequency and of the 3rd harmonic content in the displacement voltage, in secondary values $U_{3.H}$. Included are the date and time they were last updated. The minimum/maximum values can be reset via binary inputs or, in the delivery status of the device, also via the F4 function key.

Minimum and maximum values: only with version 7UM62**–*****–3***

2.49.6.1 Information List

No.	Information	Type of Information	Comments
-	ResMinMax	IntSP_Ev	Reset Minimum and Maximum counter
394	>UE3h MiMa Res.	SP	>UE 3rd Harm. MIN/MAX Buffer Reset
396	>I1 MiMaReset	SP	>I1 MIN/MAX Buffer Reset
399	>U1 MiMa Reset	SP	>U1 MIN/MAX Buffer Reset
400	>P MiMa Reset	SP	>P MIN/MAX Buffer Reset
402	>Q MiMa Reset	SP	>Q MIN/MAX Buffer Reset
407	>Frq MiMa Reset	SP	>Frq. MIN/MAX Buffer Reset
639	UE3h min=	MVT	UE 3rd Harmonic Voltage Minimum
640	UE3h max=	MVT	UE 3rd Harmonic Voltage Maximum
857	I1 Min=	MVT	Positive Sequence Minimum
858	I1 Max=	MVT	Positive Sequence Maximum
874	U1 Min =	MVT	U1 (positive sequence) Voltage Minimum
875	U1 Max =	MVT	U1 (positive sequence) Voltage Maximum
876	PMin=	MVT	Active Power Minimum
877	PMax=	MVT	Active Power Maximum
878	QMin=	MVT	Reactive Power Minimum
879	QMax=	MVT	Reactive Power Maximum
882	fMin=	MVT	Frequency Minimum
883	fMax=	MVT	Frequency Maximum

2.49.7 Energy

W_p, W_q, metered values of the active and reactive energy in kilowatt, megawatt or gigawatt hours primary or in kVARh, MVARh or GVARh primary, separately according to the input and output, or capacitive and inductive.

The calculation of the operational measured values is also performed during a fault. The values are updated in intervals of ≥ 0.3 s and ≤ 1 s.

Power metered values: only with version 7UM62**–*****–**3*****

2.49.7.1 Information List

No.	Information	Type of Information	Comments
-	Meter res	IntSP_Ev	Reset meter
888	Wp(puls)	PMV	Pulsed Energy Wp (active)
889	Wq(puls)	PMV	Pulsed Energy Wq (reactive)
916	WpΔ=	-	Increment of active energy
917	WqΔ=	-	Increment of reactive energy
924	WpForward	MVMV	Wp Forward
925	WqForward	MVMV	Wq Forward
928	WpReverse	MVMV	Wp Reverse
929	WqReverse	MVMV	Wq Reverse

2.49.8 Set Points (Measured Values)

The SIPROTEC 4 device 7UM62 allows to set warning levels for important measured and metered values. If one of these limit values is reached or exceeded positively or negatively during operation, the device generates an alarm which is displayed as an operational indication. As for all operational messages, it is possible to output the information to LEDs and/or output relays and via the serial interfaces. Unlike real protection functions such as time overcurrent protection or overload protection, this supervision routine runs in the background, so that in the case of a fault and rapidly changing measured values it may not respond when protection functions pick up. Also, the supervision does not respond immediately before a trip because an alarm is only output if the set-point are repeatedly violated.

With the 7UM62, only the limit value of the undercurrent protection IL< is configured when the device is delivered from the factory. Further limit values can be configured if their measured and metered values have been set accordingly in CFC (see SIPROTEC 4 System Description /1/).

Limit settings are entered under **MEASUREMENTS** in the sub-menu **LIMITS (MV)** by overwriting the default limit values.

If the phase current drops below the limit „IL<“, the indication „SP. I<“ (No. 284) will be issued.

2.49.8.1 Information List

No.	Information	Type of Information	Comments
-	IL<	LV	IL< under current
284	SP. I<	OUT	Set Point I< alarm

2.49.9 Set Points (Statistic)

SIPROTEC 4 device 7UM62 allows limit levels for important statistic values to be set. If during operation a value reaches or exceeds one of these limits, the device generates an alarm which is displayed as an operational indication.

If the limit „OpHour>“ is exceeded, the indication „SP. Op Hours>“ (No. 272) will be issued.

2.49.9.1 Information List

No.	Information	Type of Information	Comments
-	OpHour>	LV	Operating hours greater than
272	SP. Op Hours>	OUT	Set Point Operating Hours

2.49.10 Oscillographic Fault Records

The multi-functional 7UM62 is equipped with a fault memory which optionally scans either the instantaneous values or the rms values of various measured quantities for storage in a ring buffer.

2.49.10.1Functional Description

Mode of Operation

The instantaneous values of the measured quantities

$i_{L1\,S1}$, $i_{L2\,S1}$, $i_{L3\,S1}$, i_{EE1}, $i_{L1\,S2}$, $i_{L2\,S2}$, $i_{L3\,S2}$, i_{EE2} and u_{L1}, u_{L2}, u_{L3}, u_E, I_{diffL1}, I_{diffL2}, I_{diffL3}, I_{stabL1}, I_{stabL2}, I_{stabL3} (referred to the nominal object current) and $u_=$ or $i_=$ of the three measuring transducers

are sampled at intervals of 1,25 ms (for 50 Hz)and stored in a ring buffer (16 samples per cycle). In the event of a fault, the data are recorded for a set period of time, but not for more than 5 seconds.

The rms values of the measured quantities

I_1, I_2, I_{ee2}, I_{ee1}, U_1, U_E, P, Q, φ, $f–f_N$, R and X

can be deposited in a ring buffer, one measured value per cycle. R and X are the positive sequence impedances. In the event of a fault, the data are recorded for a set period of time, but not for more than 80 seconds.

Up to 8 fault records can be stored in this buffer. The fault record memory is automatically updated with every new fault, so no acknowledgment is required. The fault record buffer can also be started with protection pickup, via binary input, operator interface or serial interface.

The data can be retrieved via the serial interfaces by means of a personal computer and evaluated with the protection data processing program DIGSI and the graphic analysis software SIGRA. The latter graphically represents the data recorded during the system fault and calculates additional information such as impedance or rms values from the measured values. Currents and voltages can be presented as desired as primary or secondary values. Binary signal traces (marks) of particular events, e.g. „pickup“, „tripping“ are also represented.

If the device has a serial system interface, the fault recording data can be passed on to a central device (e.g. SICAM) via this interface. Data are evaluated by appropriate programs in the central device. Currents and voltages are referred to their maximum values, scaled to their rated values and prepared for graphic presentation. Binary signal traces (marks) of particular events, e.g. „pickup“, „tripping“ are also represented.

In the event of transfer to a central device, the request for data transfer can be executed automatically and can be selected to take place after each pickup by the protection, or only after a tripping.

2.49.10.2Setting Notes

Fault Recording

Fault recording (waveform capture) will only take place if address 104 **FAULT VALUE** is set to ***Instant. values*** or ***RMS values***. Other settings pertaining to fault recording (waveform capture) are found under the submenu **OSC. FAULT REC.** of the **PARAMETER** menu. Waveform capture makes a distinction between the trigger instant for an oscillographic record and the criterion to save the record (address 401 **WAVEFORMTRIGGER**). Normally the trigger is the pickup of a protective element, i.e. when a protective element picks up the time is 0. The criterion for saving may be both the device pickup (***Save w. Pickup***) or the device trip (***Save w. TRIP***). A trip command issued by the device can also be used as trigger instant (***Start w. TRIP***); in this case it is also the saving criterion.

A waveform capture includes in machine protection the complete course of a fault. An event of fault begins with the pickup by any protective function and ends with the last dropout of a protective function.

The actual storage time begins at the pre-fault time **PRE. TRIG. TIME** (address 404) ahead of the reference instant, and ends at the post-fault time **POST REC. TIME** (address 405) after the storage criterion has reset. The maximum recording duration for each fault (**MAX. LENGTH**) is entered in address 403. The setting depends on the criterion for storage, the delay time of the protective functions and the desired number of stored fault events. The largest value here is 5 s for fault recording of instantaneous values, 80 s for recording of rms values (see also address 104). A total of 8 records can be saved in this time.

Note: If ***RMS values*** are stored, the times stated for parameters 403 to 406 will be 16 times longer.

An oscillographic record can be triggered by a change in status of a binary input, or through the operating interface via PC. The trigger is dynamic. The length of a record for these special triggers is set in address 406 **BinIn CAPT.TIME** (upper bound is **MAX. LENGTH**, address 403). Pre-fault and post-fault times will be added. If the binary input time is set to ∞, then the length of the record equals the time that the binary input is activated (static), or the **MAX. LENGTH** setting in address 403, whichever is shorter.

2.49.10.3Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
401	WAVEFORMTRIGGE R	Save w. Pickup Save w. TRIP Start w. TRIP	Save w. Pickup	Waveform Capture
403	MAX. LENGTH	0.30 .. 5.00 sec	1.00 sec	Max. length of a Waveform Capture Record
404	PRE. TRIG. TIME	0.05 .. 4.00 sec	0.20 sec	Captured Waveform Prior to Trigger
405	POST REC. TIME	0.05 .. 0.50 sec	0.10 sec	Captured Waveform after Event
406	BinIn CAPT.TIME	0.10 .. 5.00 sec; ∞	0.50 sec	Capture Time via Binary Input

2.49.10.4Information List

No.	Information	Type of Information	Comments
-	FltRecSta	IntSP	Fault Recording Start
4	>Trig.Wave.Cap.	SP	>Trigger Waveform Capture
203	Wave. deleted	OUT_Ev	Waveform data deleted
30053	Fault rec. run.	OUT	Fault recording is running

2.49.11 Date and Time Stamping

The integrated date/clock management enables the exact timely assignment of events e.g., those in the operational messages and fault messages or in the lists of the minimum/maximum values.

2.49.11.1Functional Description

Mode of Operation

The time can be influenced by

- internal RTC (Real Time Clock),
- external synchronization sources (e.g. DCF77, IRIG B),
- external minute pulses via binary input.

Note

Upon delivery of the device, the internal clock RTC is always set by default as synchronization source, regardless of whether the device is equipped with a system interface or not. If the time synchronization is to use an external source, this must be selected.

The procedure for changing the synchronization source is described in detail in the SIPROTEC 4- System Description.

The following operating modes can be selected :

No.	Operating Mode	Comments
1	Internal	Internal synchronization using RTC (default)
2	IEC 60870-5-103	External synchronization via system interface (IEC 60870-5-103)
3	PROFIBUS DP	External synchronization using PROFIBUS interface
4	IRIG B Time signal	External synchronization using IRIG B (telegram format IRIG-B000)
5	DCF77 Time signal	External synchronization using DCF 77
6	Sync. Box Time signal	External synchronization using the SIMEAS-Synch.Box time signal
7	Pulse via binary input	External synchronization with pulse via binary input
8	Field bus (DNP, Modbus)	External synchronization using field bus
9	NTP (IEC 61850)	External synchronization using system interface (IEC 61850)

Either the European time format (DD.MM.YYYY) or the US format (MM/DD/YYYY) can be specified for the device display

To preserve the internal battery, this switches off automatically after some hours in the absence of an auxiliary voltage supply.

2.49.12 Commissioning Aids

Device data sent to a central or master computer system during test mode or commissioning can be influenced. There are tools for testing the system interface and the binary inputs and outputs of the device.

Applications

- Test Mode
- Commissioning

Prerequisites

To be able to use the commissioning aids described below, the following must apply:

– The device must be equipped with an interface.

– The device has to be connected to a control centre.

2.49.12.1Test Messages to the SCADA Interface during Test Operation

If the device is connected to a central or main computer system via the SCADA interface, then the information that is transmitted can be influenced.

Depending on the type of protocol, all messages and measured values transferred to the central control system can be identified with an added message "test operation"-bit while the device is being tested on site (test mode). This identification prevents the messages from being incorrectly interpreted as resulting from an actual power system disturbance or event. As another option, all messages and measured values normally transferred via the system interface can be blocked during the testing ("block data transmission").

Data transmission block can be accomplished by controlling binary inputs, by using the operating panel on the device, or with a PC and DIGSI via the operator interface.

The SIPROTEC 4 System Description describes how to activate and deactivate test mode and blocked data transmission.

2.49.12.2Checking the System Interface

If the device features a system interface and uses it to communicate with the control centre, the DIGSI device operation can be used to test if indications are transmitted correctly.

A dialog box displays the texts of all annunciations that have been masked to the system interface in the matrix. In another column of the dialog box you can specify a value for the annunciations that you want to test (e.g. coming/ going)to generate an annunciation as soon as you have entered password no. 6 (for hardware test menus). The annunciation is output and can now be read both in the operational annunciations of the SIPROTEC 4 device and in the station control center.

The procedure is described in detail in Chapter "Mounting and Commissioning".

2.49.12.3 Checking the Binary Inputs and Outputs

The binary inputs, outputs, and LEDs of a SIPROTEC 4 device can be individually controlled. This feature can be, for example, to verify control wiring from the device to substation equipment (operational checks), during commissioning.

A dialog box displays all binary inputs and outputs existing in the device, and the LEDs with their current state. It also shows which commands or annunciations are masked to which hardware component. In another column of the dialog box you can switch each item to the opposite state after entering password no. 6 (for hardware test menus). Thus, you can energize every single output relay to check the wiring between protected device and the system without having to create the alarm allocated to it.

The procedure is described in detail in Chapter "Mounting and Commissioning".

2.49.12.4 Creating a Test Fault Record

During commissioning energization sequences should be carried out, to check the stability of the protection also during closing operations. Oscillographic event recordings contain the maximum information about the behaviour of the protection.

Along with the capability of storing fault recordings via pickup of the protection function, the 7UM62 also has the capability of initiating a measured value recording using the operator control program DIGSI, via the serial interface and via binary inputs. For the latter, event „`>Trig.Wave.Cap.`“ must be allocated to a binary input. Triggering of the recording then occurs, for example, via the binary input when the protection object is energized.

An oscillographic recording that is externally triggered (that is, without a protective element pickup or device trip) is processed by the device as a normal oscillographic recording, and has a number for establishing a sequence. However, these recordings are not displayed in the fault log buffer in the display, as they are not network fault events.

The procedure is described in detail in Chapter "Mounting and Commissioning".

2.50 Command Processing

The SIPROTEC 4 7UM62 includes a command processing function for initiating switching operations in the system.

Control can originate from four command sources:

- Local operation using the keypad on the local user interface of the device
- Operation using DIGSI
- Remote operation using a substation automation and control system (e.g. SICAM)
- Automatic functions (e.g., using a binary input)

Switchgear with single and multiple busbars are supported. The number of switchgear devices to be controlled is limited only by the number of binary inputs and outputs present. Therefore, the variant 7UM622 should be the preferred version. High security against inadvertent device operations can be ensured by interlocking checks. Additionally, there is a large variety of switching device types and operational modes.

2.50.1 Control Device

Switchgear can be controlled via the device operator panel, PC interface and the serial interface as well as a connection to the control system for switchgear with single and double busbars.

The number of switchgear devices to be controlled is limited by the number of binary inputs and outputs.

2.50.1.1 Description

Operation via integrated control panel

Using the navigation keys ▲, ▼, ◄, ►, the control menu can be accessed and the switchgear to be operated selected. After entering a password, a new window is displayed where multiple control options (ON, OFF, ABORT) are available using the ▼ and ▲ keys. Then a safety query appears. Only after repeated confirmation using the ENTER key is the command action performed. If this enabling does not occur within one minute, the process is aborted. Cancellation via the ESC key is possible at any time before the control command is issued or during breaker selection.

If the attempted command fails, because an interlocking condition is not met, an error message appears in the display. The message indicates why the control command was not accepted (see also SIPROTEC 4 System Description). This annunciation must be acknowledged with ENTER before further operation of the unit is possible.

Operation using DIGSI

Switchgear devices can be controlled via the operator control interface with a PC using the DIGSI operating program. The procedure is described in detail in the SIPROTEC 4 System Description (Control of Switchgear).

Operation using the System Interface

Control commands for switchgear can also be entered through the serial SCADA interface communicating with the substation control and protection system. A prerequisite for this is that the required peripherals physically exist in the device and the substation. Also, specific settings to the serial interface must be made in the device (see SIPROTEC 4 System Description).

2.50.2 Types of Commands

In conjunction with the power system control the following command types can be distinguished for the device:

2.50.2.1 Description

Commands to the System

These are all commands that are directly output to the switchgear to change their process state:

- Switching commands for the control of circuit breakers (not synchronized), disconnectors and ground electrode,
- Step Commands, e.g. raising and lowering transformer LTCs
- Set-point commands with configurable time settings, e.g. to control Petersen coils

Internal / Pseudo Commands

They do not directly operate binary outputs. They serve to initiate internal functions, simulate changes of state or to acknowledge changes of state.

- Manual overriding commands to manually update information on process-dependent objects such as indications and switching states, e.g. if the communication with the process is interrupted. Manually overridden objects are flagged as such in the information status and can be displayed accordingly.
- Tagging commands (for "Setting") for internal object information values, e.g. deleting / presetting switching authority (remote vs. local), parameter set changeovers, data transmission blockage and metered values.
- Acknowledgment and resetting commands for setting and resetting internal buffers or data states.
- Information status command to set/delete the additional "information status" of a process object, such as:
  – Input blocking
  – Output Blocking

2.50.3 Command Processing

Security mechanisms in the command path ensure that a switch command can be carried out only if the test of previously established criteria has been successfully completed. In addition to general fixed prescribed tests, further interlocks can be configured for each resource separately. The actual execution of the command job also is then monitored. The entire sequence of a command job is described briefly in the following:

2.50.3.1 Description

Checking a Command Job

Please observe the following:

- Command Entry, e.g. using the integrated operator interface
  - Check Password → access rights
  - Check Switching Mode (interlocking activated/deactivated) → Selection of Deactivated Interlocking Recognition.
- User-Configurable Command Checks
  - Switching Authority
  - Device position check (set vs. actual comparison)
  - Interlocking, Zone Controlled (logic using CFC)
  - Interlocking, System Interlocking (centrally, using SICAM)
  - Double Operation Locking (interlocking of parallel switching operations)
  - Protection Blocking (blocking of switching operations by protective functions)
- Fixed Command Checks
  - Timeout Monitoring (time between command issue and processing is monitored)
  - Configuration in Process (if configuration is in process, commands are denied or delayed)
  - Operating Equipment Enabled as Output (if an operating equipment component was configured, but not configured to a binary input, the command is denied)
  - Output Block (if an output block has been programmed for the circuit breaker, and is active at the moment the command is processed, then the command is denied)
  - Module Hardware Malfunction
  - Command in Progress (only one command can be processed at a time for one operating equipment, object-related Double Operation Block)
  - 1–of–n Check (for multiple allocations such as common contact relays, check whether a command procedure has already been initiated for the output relays concerned).

Command execution monitoring

The following is monitored:

- Interruption of a command procedure because of a Cancel Command
- Run Time Monitor (feedback indication monitoring time)

2.50.4 Interlocking

Interlocking is implemented via the user-definable logic (CFC).

2.50.4.1 Description

Switchgear interlocking checks in a SICAM/SIPROTEC 4 system are normally divided in the following groups:

- System interlocking, using the system database in the central control system
- Bay interlocking, based on the object database (feedbacks) in the bay unit.
- Cross-bay interlocking via GOOSE messages sent directly between the bay controllers and protection devices (with IEC 61850: inter relay communication with GOOSE is accomplished via the EN100 module)

The extent of the interlocking checks is determined by the configuration of the relay. For more information on GOOSE please refer to the SIPROTEC System Description /1/.

Switching objects that require system interlocking in a central control system are assigned to a specific parameter inside the bay unit (via configuration matrix).

For all commands, operation with interlocking (normal mode) or without interlocking (Interlocking OFF) can be selected:

- For local commands by reprogramming the settings with password check,
- for automatic commands via command processing with CFC, by deactivated interlocking status,
- For local / remote commands, using an additional interlocking disable command via PROFIBUS.

Interlocked/non-interlocked switching

The configurable command checks in the SIPROTEC 4 devices are also called "standard interlocking". These checks can be activated via DIGSI (interlocked switching/tagging) or deactivated (non-interlocked).

De-interlocked or non-interlocked switching means that the configured interlock conditions are not tested.

Interlocked switching means that all configured interlocking conditions are checked within the command processing. If a condition could not be fulfilled, the command will be rejected by a message with a minus added to it, e.g. **CO–**, followed by an operation response information.

The following table shows the possible types of commands to a breaker and associated indications. For the device the messages designated with *) are displayed in the event logs, for DIGSI 4 they appear in spontaneous messages.

Type of Command	Control	Cause	Message
Control issued	Switching	CO	CO+/–
Manual tagging (positive / negative)	Manual tagging	MT	MT+/–
Information state command, Input blocking	Input blocking	ST	ST+/– *)
Output Blocking	Output blocking	ST	ST+/– *)
Cancel command	Cancel	CA	CA+/–

The "plus" appearing in the message is a confirmation of the command execution. The command execution was as expected, in other words positive. A minus sign means a negative, i.e. an unexpected result; the command was rejected. Possible command feedbacks and their causes are dealt with in the SIPROTEC 4 System Description. The following figure shows operational indications relating to command execution and operation response information for successful switching of the circuit breaker.

The check of interlockings can be configured separately for all switching devices and taggings. Other internal commands such as overriding or abort are not tested, i.e. are executed independently of the interlockings.

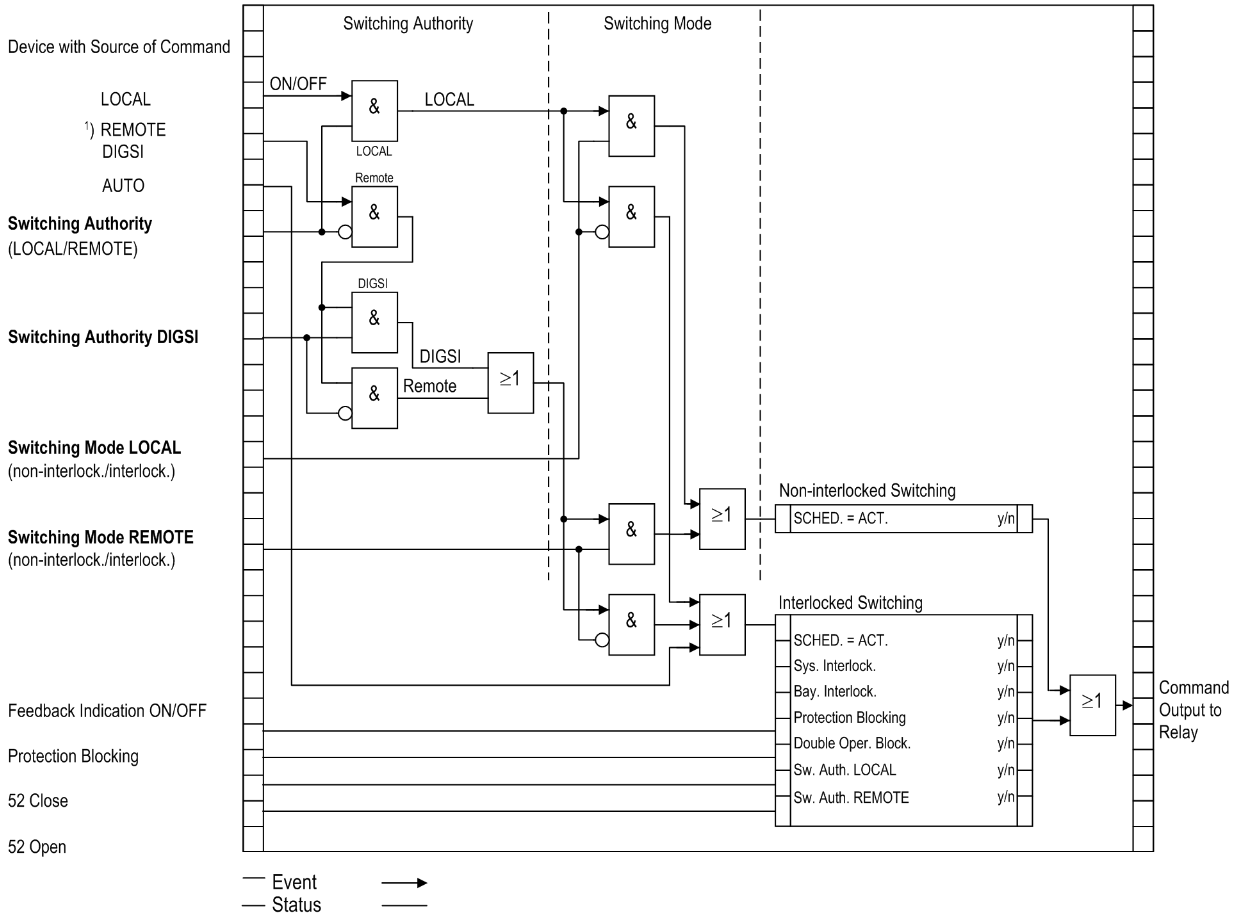
```
EVENT LOG
---------------------
19.06.01 11:52:05,625
Q0          CO+ Close

19.06.01 11:52:06,134
Q0          FB+ Close
```

Figure 2-148 Example of an operational indication for switching circuit breaker (Q0)

Standard Interlocking (hard-coded)

The following is a list of Standard Interlocking Conditions that can be selected for each controllable device. All of these are enabled as a default.

- Device Position (scheduled vs. actual comparison): The switching command is rejected, and an error indication is displayed if the circuit breaker is already in the scheduled (desired) position. (If this check is enabled, then it works whether interlocking, e.g. zone controlled, is activated or deactivated.)
- System Interlocking: The system interlocking is checked by transmitting a local command to the central controller with the switching authority set to = Local. Switchgear that is subject to system interlocking cannot be switched by DIGSI.
- Bay Interlocking: Logic combinations deposited in the device using CFC are scanned and taken into consideration for interlocked switching.
- Blocked by Protection: A CLOSE-command is rejected as soon as one of the protective elements in the relay picks up. The OPEN-command, in contrast, can always be executed. Please be aware, activation of thermal overload protection elements or sensitive ground fault detection can create and maintain a fault condition status, and can therefore block CLOSE commands. If the interlocking is removed, consider that, on the other hand, the restart inhibit for motors will not automatically reject a CLOSE command to the motor. Restarting would then have to be interlocked in some other way. One method would be to use a specific interlocking in the CFC logic.
- Double Operation: parallel switching operations are interlocked against one another; while one command is processed, a second cannot be carried out.
- Switching Authority LOCAL: A switching command of the local control (command with command source LOCAL) is only allowed if a LOCAL control is allowed at the device (by configuration).
- Switching Authority DIGSI: Switching commands that are issued locally or remotely via DIGSI (command with command source DIGSI) are only allowed if remote control is admissible for the device (by configuration). When a DIGSI-computer logs on to the device, it enters its Virtual Device Number (VD). Only commands with this VD (when Switching Authority = REMOTE) will be accepted by the device. Remote switching commands will be rejected.
- Switching Authority REMOTE: A switching control command (command with source of command REMOTE) is only allowed if REMOTE control is admissible at the device (by configuration).



¹) Source REMOTE also includes SAS.
(LOCAL Command using substation controller
REMOTE Command using remote source such as SCADA through controller to device.)

Figure 2-149 Standard interlockings

The following figure shows the configuration of the interlocking conditions using DIGSI.

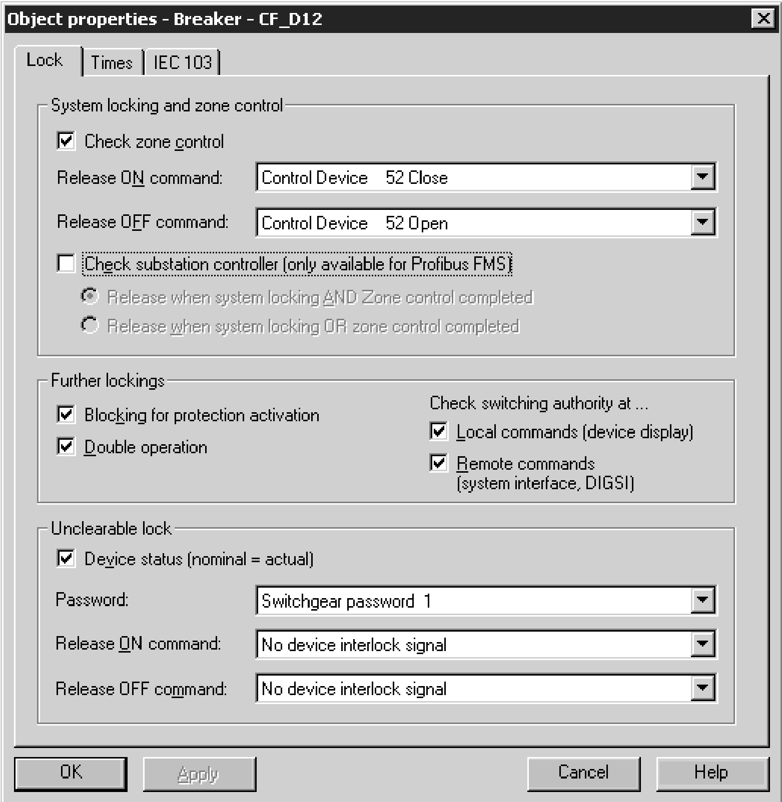


Figure 2-150 DIGSI-Dialog Box for Setting the Interlocking Conditions

The display shows the configured interlocking reasons. They are marked by letters explained in the following table.

Table 2-21 Command types and corresponding messages

Interlocking Commands	Abbrev.	Message
Switching authority	L	L
System interlocking	S	S
Zone controlled	Z	Z
SET= ACTUAL (switch direction check)	SI	I
Protection blockage	B	B

The following figure shows all interlocking conditions (which usually appear in the display of the device) for three switchgear items with the relevant abbreviations explained in the previous table. All parameterized interlocking conditions are indicated.

```
Interlocking      01/03
----------------------
Q0 Close/Open S - Z P B
Q1 Close/Open S - Z P B

Q8 Close/Open S - Z P B
```

Figure 2-151 Example of configured interlocking conditions

Enabling Logic via CFC

For bay interlocking, an enable logic can be created using CFC. Via specific release conditions the information „released“ or „bay interlocked“ are available, e.g. object „52 Close“ and „52 Open“ with the data values: ON / OFF).

Switching Authority

The interlocking condition "Switching Authority" serves to determine the switching authorization. It enables the user to select the authorized switching source. The following switching authority zones are defined in consecutive priority sequence:

- LOCAL
- DIGSI
- REMOTE

The DIGSI object "Switching authority" serves to interlock or enable LOCAL control, but not remote or DIGSI commands. For the 7UM621 and 7UM622 the switching authority can be changed between "REMOTE" and "LOCAL" in the operator panel by password or by means of CFC also via binary input and function key. For the 7UM623 the switching authority can be changed by means of the keyswitch.

The object "Switching authority DIGSI" is used for interlocking and enabling of commands to be initiated using DIGSI. Commands are allowed for both a remote and a local DIGSI connection. When a (local or remote) DIGSI PC logs on to the device, it enters its Virtual Device Number (VD). The device only accepts commands having that VD (with switching authority = OFF or REMOTE). When the DIGSI PC logs off, the VD is cancelled.

Commands are checked for their source SC and the device settings, and compared to the information set in the objects "Switching authority" and "Switching authority DIGSI".

Configuration

Switching authority available	y/n (create appropriate object)
Switching authority available DIGSI	y/n (create appropriate object)
Specific Device (e.g. switching device)	Switching authority LOCAL (check for Local status): y/n
Specific Device (e.g. switching device)	Switching authority REMOTE (check for LOCAL, REMOTE, or DIGSI status): y/n

Table 2-22 Interlocking logic

Current switching authority status	Switching authority DIGSI	Command with SC[3] = DIGSI	Command issued from SC=LOCAL or REMOTE	Command issued from SC=DIGSI
LOCAL	Not logged on	Enabled	Interlocked [2] "interlocked because of LOCAL control"	Interlocked "DIGSI not registered"
LOCAL	Logged on	Enabled	Interlocked [2] "interlocked because of LOCAL control"	Interlocked [2] "interlocked because of LOCAL control"
REMOTE	Not logged on	Interlocked [1] "interlocked because of REMOTE control"	Enabled	Interlocked "DIGSI not registered"
REMOTE	Logged on	Interlocked [1] "interlocked because of DIGSI control"	Interlocked [2] "interlocked because of DIGSI control"	Enabled

[1] also "Enabled" for: ”Switching authority LOCAL (check for Local status): n"

[2] also "Enabled" for: ”Switching authority REMOTE (check for LOCAL, REMOTE, or DIGSI status): n"

[3] SC = Source of command

SC = Auto:

Commands that are derived internally (command processing in the CFC) are not subject to switching authority and are therefore always "enabled".

Switching Mode

The switching mode determines whether selected interlocking conditions will be activated or deactivated at the time of the switching operation.

The following switching modes (local) are defined:

- Local commands (SC=LOCAL)
  - interlocked (normal), or
  - non-interlocked switching.

For the 7UM621 and 7UM622 the switching authority can be changed between "Interlocked" and "Non-interlocked" in the operator panel by password or by means of CFC also via binary input and function key. For the 7UM623 this is done by means of a keyswitch.

The following switching modes (remote) are defined:

- Remote or DIGSI commands (SC = LOCAL, REMOTE, or DIGSI)
  - interlocked, or
  - non-interlocked switching. Here, deactivation of interlocking is accomplished via a separate command.
  - For commands from CFC (SC = Auto), please observe the guidelines in the CFC manual (component: BOOL to command).

Zone Controlled / Field Interlocking

Zone Controlled (field interlocking) includes the verification that predetermined switchgear position conditions are satisfied to prevent switching errors as well as the use of other mechanical interlocking, such as High Voltage compartment doors etc.

Interlocking conditions can be configured separately for each switching device, for MAKE and/or TRIP switching.

Processing of the status of the release condition for an operation switching device can be based on information acquired:

- directly, using a single point or double point indication, key-switch, or internal indication (tagging), or
- by means of a control logic via CFC.

When a switching command is initiated, the actual status is scanned and updated cyclically. The assignment is done via Release object CLOSE/OPEN command.

System Interlocking

Substation Controller (System interlocking) involves switchgear conditions of other bays evaluated by a central control system.

Double Activation Blockage

Parallel switching operations are interlocked. When a control command is received, all objects that are subject to double operation inhibit are checked for control commands in progress. While the command is being executed, the block is in turn active for all other commands.

Blocking by Protection

With this function, switching operations are blocked by the pickup of protective elements. Blocking is configurable separately for both closing and tripping commands.

When configured, "Block CLOSE commands" blocks CLOSE commands, whereas "Block TRIP commands" blocks TRIP signals. Operations in progress will also be aborted by the pickup of a protective element.

Device Status Check (set = actual)

For switching commands it is checked whether a switching device is already in the desired position (comparison between desired and actual position). This means that if a circuit breaker is already in the CLOSED position and an attempt is made to send a closing command, the command will be rejected with the response "scheduled condition equals actual condition". Switching devices in the fault position are not interlocked by software means.

Bypassing Interlocks

Interlockings can be bypassed to perform switching operations. This is either done in-ternally by adding a bypass code to the command, or globally by so-called switching modes.

- SC=LOCAL
  - The switching modes "interlocked" or "non-interlocked" (de-interlocked) can be switched over for the 7UM621 and 7UM62 in the operator control panel after password entry; for the 7UM623 this is done by means of a keyswitch.
- REMOTE and DIGSI
  - Commands issued by SICAM or DIGSI are unlocked via a global switching mode REMOTE. A separate job order must be sent for the unlocking. The unlocking applies only for one switching operation and for commands caused by the same source.
  - Job order: command to object "Switching mode REMOTE", ON
  - Job order: switching command to "switching device"
- Derived commands from CFC (automatic command, SC=Auto):
  - Behaviour configured in the CFC block ("BOOL to command").

2.50.5 Command Logging

During the processing of the commands, independent of the further message routing and processing, command and process feedback information are sent to the message processing centre. These messages contain information on the cause. With the corresponding allocation (configuration) these messages are entered in the event list, thus serving as a report.

Prerequisites

A listing of possible operating messages and their meaning as well as the command types needed for tripping and closing of the switchgear or for raising and lowering of transformer taps are described in the SIPROTEC 4 System Description.

2.50.5.1 Description

Acknowledgement of Commands to the Device Front

All messages with the source of command LOCAL are transformed into a corresponding response and shown in the display of the device.

Acknowledgement of Commands to Local / Remote / Digsi

The acknowledgement of messages with source of command Local/ Remote/DIGSI are sent back to the initiating point independent of the routing (configuration on the serial digital interface).

The acknowledgement of commands is therefore not executed by a response indication as it is done with the local command but by ordinary command and feedback information recording.

Monitoring of Feedback Information

The processing of commands monitors the command execution and timing of feedback information for all commands. At the same time the command is sent, the moni-toring time is started (monitoring of the command execution) which controls whether the device achieves the required final result within the monitoring time. The monitoring time is stopped as soon as the feedback information arrives. If no feedback information arrives, a response "Timeout command monitoring time" appears and the process is terminated.

Commands and information feedback are also recorded in the event list. Normally the execution of a command is terminated as soon as the feedback information (**FB+**) of the relevant switchgear arrives or, in case of commands without process feedback information, the command output resets.

The “plus” appearing in a feedback information confirms that the command was executed successfully as expected. The "minus" is a negative confirmation and means that the command was not executed as expected.

Command Output and Switching Relays

The command types needed for tripping and closing of the switchgear or for raising and lowering of transformer taps are described under configuration in /1/.

■

Mounting and Commissioning 3

This chapter is intended for experienced commissioning staff. They should be familiar with the commissioning of protection and control equipment, with operation of the power system network and with the safety rules and regulations. Certain adaptations of the hardware to the power system specifications may be necessary. For primary testing, the object to be protected (generator, motor, transformer) must be started up and in put into service.

3.1 Mounting and Connections

WARNING!

Warning of improper transport, storage, installation, and application of the device.

Non-observance can result in death, personal injury or substantial property damage.

Trouble free and safe use of this device depends on proper transport, storage, installation, and application of the device according to the warnings in this instruction manual.

Of particular importance are the general installation and safety regulations for work in a high-voltage environment (for example, ANSI, IEC, EN, DIN, or other national and international regulations). These regulations must be observed.

3.1.1 Configuration Information

Prerequisites

For mounting and connection, the following requirements and conditions must be met:

The rated device data has been checked as recommended in the SIPROTEC 4 System Description /1/ and their compliance with these data is verified with the Power System Data.

Connection Options

Overview diagrams are shown in Appendix A.2. Connection examples for current and voltage transformer circuits are given in Appendix A.3. It must be checked that the setting configuration of the **Power System Data 1**, Section 2.5, corresponds with the connections.

Currents/Voltages

Connection diagrams are shown in the Appendix. Examples show connection options for current and voltage transformers with busbar connection (address 272 **SCHEME** = ***Busbar***) and unit connection (address 272 = ***Unit transf.***) can be found in Appendix A.3. In all examples, the CT starpoints point towards the protected object so that addresses 201 **STRPNT->OBJ S1** and 210 **STRPNT->OBJ S2** must be set to ***YES***.

In the connection examples, the U_E input of the device is always connected to the open delta winding of a voltage transformer set. Accordingly address 223 **UE CONNECTION** must be set to ***broken delta***.

A standard connection where one busbar is fed by several generators can be found in Appendix, A.3. The earth fault current can be increased by an earthing transformer connected to the busbar (approx. 10 A max.), allowing a protection range of up to 90 % to be achieved. The earth current is measured using the toroidal current transformer to achieve the necessary sensitivity. During startup of the machine, the displacement voltage can be used as a criterion for detecting an earth fault until synchronization is completed.

Factor 213 **FACTOR IEE2** considers the transformation ratio between the primary and the secondary side of the summation current transformer when the sensitive current input of side 2 in the corresponding connection example is used. Accordingly, when the input of side 1 is used, 205 **FACTOR IEE1** applies.

Example:

Summation current transformer 60 A / 1 A

Matching factor for sensitive earth fault current detection: **FACTOR IEE2** = ***60*** (if the input on side 2 is used)

If the sensitive current input of side 1 is used for rotor earth fault current detection (see Appendix A.3), **FACTOR IEE1** = ***1*** is selected.

In Figure „Busbar System“ in Appendix A.3 the generator starpoint has a low-resistance earthing. To avoid circulating currents (3rd harmonic) in multi-generator connections, the resistor should be connected to only one generator. For selective earth fault detection, the sensitive earth fault current input I_{EE2} is looped into the common return line of the two sets of CTs (current differential measurement). The current transformers are earthed in one place only. **FACTOR IEE2** is set to ***1***. Balanced DE current transformers (winding balance) are recommended for this type of circuit.

In Figure „Block Connection“ with isolated starpoint in Appendix A.3 earth fault detection uses the displacement voltage. A load resistor is provided on the broken delta winding to avoid spurious tripping during earth faults in the power system. The UU_E input of the device is connected via a voltage divider to the broken delta winding of an earthing transformer (address 223 **UE CONNECTION** = ***broken delta***). Factor 225 **Uph / Udelta** is determined by the transformation ratio of the secondary-side voltages:

$$\frac{U_{Nprim}}{\sqrt{3}} / \frac{U_{Nsec}}{\sqrt{3}} / \frac{U_{Nsec}}{3}$$

The resulting factor between the secondary windings is 3/√3 = 1.73. For other transformation ratios, e.g. where the displacement voltage is measured using an inserted CT set, the factor must be modified accordingly.

Factor 224 **FACTOR UE** considers the full transformation ratio between the primary voltage and the voltage fed to the device terminals, i.e. it includes the voltage divider that is connected upstream. For a primary nominal transformer voltage of 6.3 kV, a secondary voltage of 500 V with full displacement and a voltage divider ratio of 1:5, this factor would be for example

$$\text{FACTOR UE} = \left(\frac{6.3\ \text{kV} / (\sqrt{3})}{500\ \text{V}} \cdot \frac{5}{1}\right) = 36.4$$

In Figure „Block Connection with neutral transformer“ in Appendix A.3, a load resistor connected to the generator starpoint reduces the interference voltage from network-side earth faults. The maximum earth fault current is limited to approx. 10A. The resistor can be a primary or secondary resistor with neutral transformer. The neutral transformer should have a low transformation ratio to avoid a small secondary resistance. The resulting higher secondary voltage can be reduced by a voltage divider. Address 223 **UE CONNECTION** is set to ***neutr. transf.***.

The Figure „Startup Earth Fault Protection“ in Appendix A.3 shows the connection of the DC voltage protection for systems with startup converter. The amplifier 7KG6 amplifies the signal measured at the shunt to a maximum of 10 V or 20 mA, depending on the equipment. Input TD1 can be adapted to the type of signal (voltage or current) by means of wire jumpers (see also 3.1.2 "Switching Elements on Printed Circuit Boards").

Figure „Rotor Earth Fault Protection“ in Appendix A.3 shows in an exemplary way how the rotor earth fault protection is connected to a generator with static excitation. The earthing must be connected to the earthing brush. The coupling device 7XR61 must be extended by the external resistors 3PP1336 if the circulating current can exceed 0.2 A due to the 6th harmonic component in the excitation voltage. This can be the cause with excitation voltages UU_{Exc} above 150 V. The $I_{EE\,1}$ input evaluates the earth fault current flowing between the rotor and the ground as a result of injecting a voltage into the rotor circuit. The matching factor **FACTOR IEE1** is set to ***1***.

Figure „Voltage Transformer Connections for Two Voltage Transformers in Open Delta Connection (V Connection)“ in Appendix A.3 shows how a connection is made with only two system-side voltage transformers in open delta connection (V connection).

Figure „Asynchronous Motor“ in Appendix A.3 shows a typical connection of the protection relay to a large asynchronous motor. The voltages for voltage and zero voltage monitoring are usually taken at the busbar. Where several motors are connected to the busbar, the directional earth fault protection detects single-pole earth faults and can thus open breakers selectively. A toroidal transformer is used for detection of the earth fault current.

Factor 213 **FACTOR IEE2** considers the transformation ratio between the primary and the secondary side of the summation current transformer I_{EE2}.

Binary Inputs and Outputs

Allocation possibilities of binary inputs and outputs, i.e. the individual matching to the system, are described in the SIPROTEC 4 System Description /1/. The default settings of the device are listed in Appendix A, Section A.4. Check also whether the labelling corresponds to the allocated message functions.

Changing Setting Groups

If binary inputs are used to change setting groups, please observe the following:

- If the configuration is performed from the operator panel or using DIGSI, the option via ***Binary Input*** must be selected at address 302 **CHANGE** .
- One binary input is sufficient for controlling 2 setting groups, „>Param. Selec.1“.
- If the binary input is configured as a make circuit, i.e. as active when voltage is applied (H active), the significance is as follows:

  - not activated: Parameter set A

  - activated: Parameter set B
- The control signal must be continuously present or absent in order for the selected setting group to be and remain active.

Trip Circuit Supervision

A circuit with two binary inputs (see Section 2.43) is recommended for trip circuit monitoring. The binary inputs must have no common potential, and their operating point must well below half the rating of the DC control voltage.

Alternately when using only one binary input, a resistor R is inserted (see Section 2.43). Please note that the response times are as long as approx. 300 s. Section 2.43.2 shows how the resistance is calculated.

3.1.2 Hardware Modifications

3.1.2.1 General

General

A subsequent adaptation of the hardware to the power system conditions can, for example, become necessary with regard to the control voltage for binary inputs or the termination of bus-capable interfaces. Follow the procedure described in this section, whenever hardware modifications are done.

Auxiliary Voltage

There are different power supply voltage ranges for the auxiliary voltage (see Ordering Information in the Appendix). The power supplies with the ratings 60/110/125 VDC and 110/125/220/250 VDC / 115/230 VAC are interconvertible. Jumper settings determine the rating. Jumper setting allocation to the rated voltage ranges, and their location on the PCB are described in this Section under the margin title „Processor Board C-CPU-2“. When the device is delivered, these jumpers are set according to the name-plate sticker. Generally, they need not be altered.

Life Status Contact

The life contact of the device is a changeover contact, from which either the NC or NO contact can be connected to the device terminals F3 and F4 via a jumper (X40). Assignments of the jumpers to the contact type and the spatial layout of the jumpers are described in Section at margin heading „Processor Board C-CPU-2“.

Nominal Currents

The input transformers of the devices are set to a rated current of 1 A or 5 A by burden switching. Jumpers are set according to the name-plate sticker. Location layout of these jumpers and their current rating allocation are described in this Section under „C-I/O-2 Input/Output Board“ for side 2 and „ C-I/O-6 Input/Output Board“ for side 1. All the relevant jumpers of one side must be set uniformly for a rated current, i.e. one jumper each (X61 through X63) for each of the input transformers and additionally the common jumper X60.

If nominal current ratings are to be changed exceptionally, then the device must be notified to change at addresses 203 **IN-SEC I-SIDE1** or 212 **IN-SEC I-SIDE2** in the Power System Data (see Section 2.5).

Note

The jumper settings must correspond to the secondary device currents configured at addresses 203, 212. Otherwise the device is blocked and outputs an alarm.

Control Voltage for Binary Inputs

When the device is delivered, the binary inputs are set to operate with a voltage that corresponds to the rated voltage of the power supply. If the rated values differ from the power system control voltage, it may be necessary to change the switching threshold of the binary inputs.

To change the switching threshold of a binary input, one jumper must be changed for each input. The allocation of the plug-in jumpers to the binary inputs and their actual positioning are described in this Section.

Note

If binary inputs are used for trip circuit monitoring, note that two binary inputs (or one binary input and an equivalent resistor) are connected in series. The switching threshold must be significantly less than one half of the rated control voltage.

Contact Mode for Binary Outputs

Input/output modules can have relays that are equipped with optionally NO or NC contacts. For this it is necessary to rearrange a jumper. For which relay on which board this applies is described in this Section under „Input/Output Board C–I/O -2“ and „Input/Output Board C–I/O -6“.

Measured Value Transformer

The measuring transducers TD 1 (e.g. for DC voltage/DC current protection) and TD 2 (e.g. for input of temperature for overload protection) can process either voltage or current values. To change the default setting (measured values to be voltages) jumpers must be changed. Tables in this Section give an overview under „Input/Output Board C–I/O-6“.

Caution!

False connection for „Current“ jumper setting!

If with "Current" jumper setting an input voltage is applied, this may destroy the board.

For an input voltage, the "Voltage" jumper must set.

For measuring transducer TD 3 (detects e.g. excitation voltage for underexcitation protection) an analog lowpass can be activated or deactivated by jumpers. For detailed information, see the table under margin titel „Input/Output Board C–I/O-6“.

Note

The jumper settings must correspond to the mode set at addresses 295, 296 (voltage or current input) and 297 (with/without filter). Otherwise the device is blocked and outputs an alarm.

Replacing Interfaces

The serial interfaces can only be exchanged in the versions for panel flush mounting and cubicle mounting. Which interfaces can be exchanged, and how this is done, is described in this Section under the margin title „Replacing Interface Modules“.

Terminating Resistors for RS485 and Profibus DP (electrical)

For reliable data transmission, the RS485 bus or the electrical Profibus DP must be terminated with resistors at the respective last device on the bus. For this purpose termination resistors are provided on the PCB of the C-CPU-2 processor board and on the RS485 or PROFIBUS interface module which can be connected via jumpers. Only one of the three options may be used. The physical location of the jumpers on the PCB is described in this Section under the margin title „Processor Board C–CPU-2“, and under the margin title „Bus-Capable Serial Interfaces“ for the interface modules. Both jumpers must always be plugged in the same way.

The terminating resistors are disabled on unit delivery.

Spare Parts

Spare parts may be the backup battery that maintains the data in the battery-buffered RAM when the voltage supply fails, and the miniature fuse of the internal power supply. Their physical location is shown in Figure 3-3. The ratings of the fuse are printed on the board next to the fuse itself. When replacing the fuse, please observe the guidelines given in the SIPROTEC 4 System Manual /1/ in the chapter „Maintenance“ and „Corrective Action / Repairs“.

3.1.2.2 Disassembly

Disassembly of the Device

Note

It is assumed for the following steps that the device is not in operation.

Caution!

Caution when changing jumper settings that affect nominal values of the device

As a consequence, the ordering number (MLFB) and the ratings that are stated on the nameplate do no longer match the actual device properties.

If such changes are necessary, the changes should be clearly and fully noted on the device. Self adhesive stickers are available that can be used as replacement nameplates.

To perform work on the printed circuit boards, such as checking or moving switching elements or exchanging modules, proceed as follows:

- Prepare area of work: Provide a surface appropriate to electrostatic sensitive devices (EGB). In addition to this, the following tools are required:
  - screwdriver with a 5 to 6 mm wide tip,
  - a Phillips screwdriver size 1,
  - 5 mm socket or nut driver.
- Unfasten the screw-posts of the D-subminiature connectors on the back panel at location „A“ and „C“. This activity does not apply if the device is for surface mounting.
- If the device has additional communication interfaces at the locations „A“, „C“ and/or „B“ „D“ on the rear, the screws located diagonally to the interfaces must be removed. This activity does not apply if the device is for surface mounting.
- Remove the caps on the front cover and loosen the screws then accessible.
- Remove the front panel and tilt it to the side.

Work on the Plug Connectors

Caution!

Mind electrostatic discharges

Non–observance can result in minor personal injury or material damage.

Electrostatic discharges through the connections of the components, printed conductors and connector pins must be avoided by touching earthed metal parts beforehand.

Do not plug or withdraw interface connections under power!

The following must be observed:

- Disconnect the ribbon cable between the front cover and the C-CPU-2 board (No. 1 in Figures 3-1 and 3-2) at the front cover side. To do this, spread the latches on the upper and lower end of the plug connector to release the plug connector of the ribbon cable.
- Disconnect the ribbon cables between the C-CPU-2 board (1) and the I/O boards (2) to (4), depending on the variant ordered.
- Remove the boards and set them on the grounded mat to protect them from ESD damage. In the case of the device variant for panel surface mounting, please be aware of the fact that a certain amount of force is required in order to remove the C-CPU-2 module due to the existing plug connectors.
- Check the jumpers in accordance with Figures 3-3 to 3-8and change or remove them as required.

The allocation of the boards for housing size $^1/_2$ is shown in Figure 3-1 and for housing size $^1/_1$ in Figure 3-2.

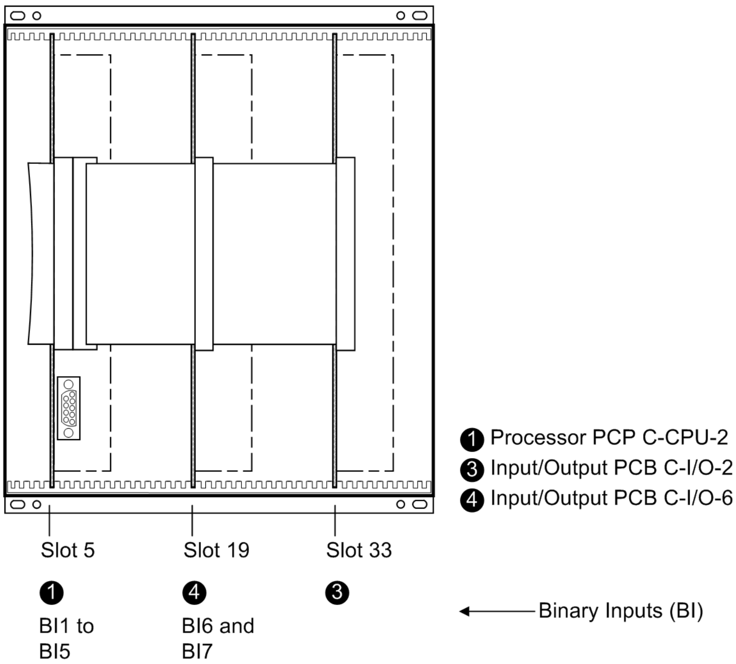


Figure 3-1 Front view of a 7UM621/623 (housing size 1/2) after removal of the front cover (simplified and scaled down)

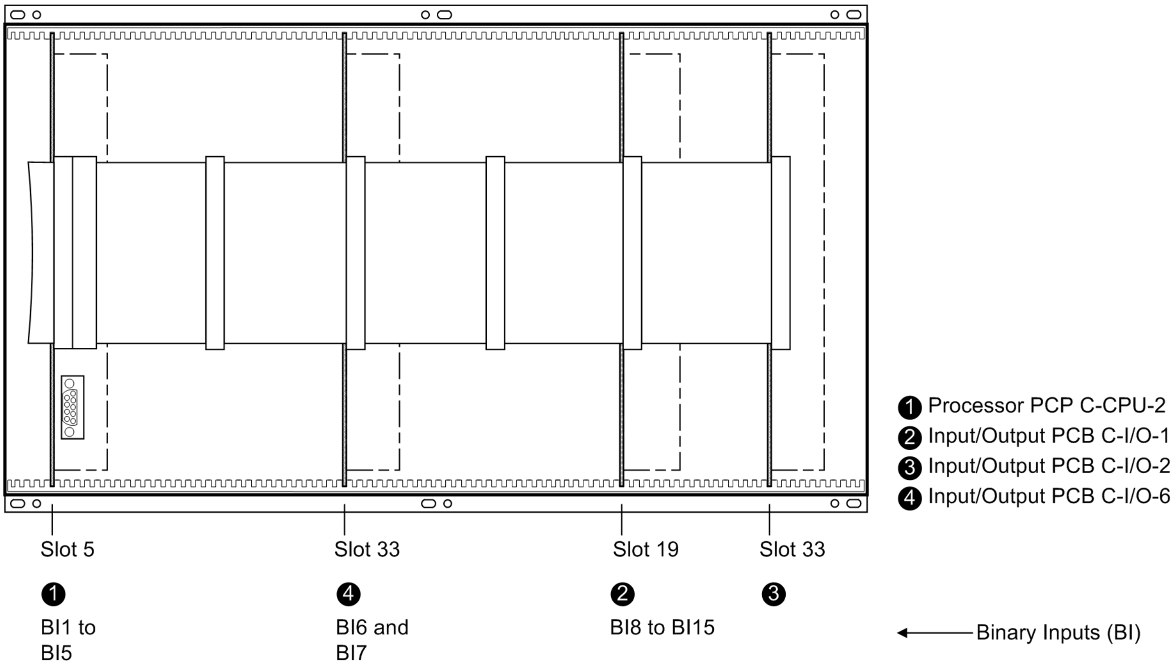


Figure 3-2 Front view of a 7UM622 (housing size 1/1) after removal of the front cover (simplified and scaled down)

3.1.2.3 Switching Elements on the Printed Circuit Boards

Processor Board C-CPU-2

The PCB layout of the processor board C-CPU-2 is illustrated in the following Figure. The set nominal voltage of the integrated power supply is checked according to Table 3-1, the quiescent state of the life contact according to Table 3-2, the selected operating voltages of binary inputs BI1 to BI5 according to Table 3-3 and the integrated interface RS232 / RS485 according to Tables 3-4 to 3-6. The location and ratings of the miniature fuse (F1) and of the buffer battery (G1) are shown in the following Figure.

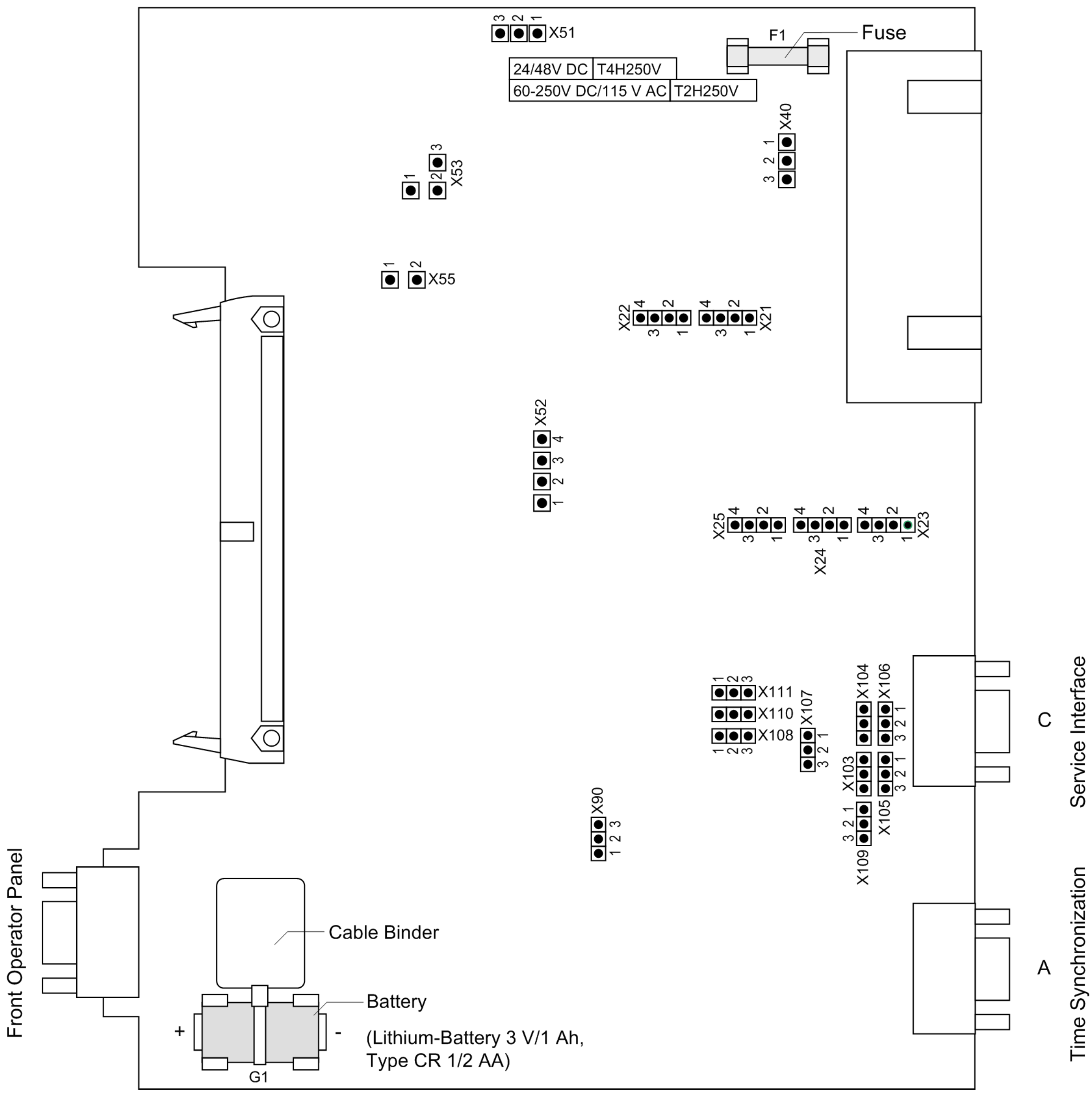


Figure 3-3 Processor board C–CPU with jumper settings required for the board configuration, of the battery and miniature fuse

Table 3-1 Jumper setting of the rated voltage of the integrated **Power Supply** on the C-CPU-2 processor board

Jumper	Nominal Voltage		
	24 to 48 VDC	**60 to 125 VDC**	**110 to 250 VDC** **115/230 VAC**
X51	not used	1-2	2-3
X52	not used	1-2 and 3-4	2-3
X53	not used	1-2	2-3
X55	not used	not used	1-2
	cannot be changed	interchangeable	

Table 3-2 Jumper setting of the **Quiescent State of the Life Contact** on the C–CPU-2 processor board

Jumper	Open in the quiescent state (NO contact)	Closed in the quiescent state (NC contact)	Presetting
X40	1-2	2-3	2-3

Table 3-3 Jumper setting of the **Control Voltages** of binary inputs BI1 to BI5 on the C–CPU-2 processor board

Binary inputs	Jumper	19 V Threshold [1)]	88 V Threshold [2)]	176 V Threshold [3)]
BI1	X21	1-2	2-3	3-4
BI2	X22	1-2	2-3	3-4
BI3	X23	1-2	2-3	3-4
BI4	X24	1-2	2-3	3-4
BI5	X25	1-2	2-3	3-4

1) Factory settings for devices with rated power supply voltages of 24 VDC to 125 VDC

2) Factory settings for devices with power supply voltages of 110 VDC to 250 VDC and 115/230 VAC

3) Use only with control voltages 220 or 250 VDC

The R485 interface can be converted into an RS232 interface by modifying the jumpers.

Jumpers X105 to X110 must be set to the same position !

Table 3-4 Jumper setting of the integrated **RS232/RS485 Interface** on the C–CPU-2 board

Jumper	RS232	RS485
X103 and X104	1-2	1-2
X105 to X110	1-2	2-3

The jumpers are preset at the factory according to the configuration ordered.

With interface RS232 jumper X111 is needed to activate CTS which enables the communication with the modem.

Table 3-5 Jumper setting for **CTS** (flow control) on the C–CPU-2 processor board

Jumper	/CTS from interface RS232	/CTS triggered by /RTS
X111	1-2	2-3 [1)]

[1)] Default setting of releases 7UM62..../CC and higher

Jumper setting 2-3: The connection to the modem is usually established with a star coupler or fibre-optic converter. Therefore the modem control signals according to RS232 standard DIN 66020 are not available. Modem signals are not required since the connection to the SIPROTEC 4 devices is always operated in the half-duplex mode. Please use the connection cable with order number 7XV5100-4.

Jumper setting 1-2: This setting makes the modem signals available, i. e. for a direct RS232-connection between the SIPROTEC 4 device and the modem, this setting can be selected optionally. We recommend use of a standard RS232 modem connection cable (converter 9-pole to 25-pole).

Note

For a direct DIGSI connection to interface RS232 jumper X111 must be plugged in position 2-3.

If there are no external terminating resistors in the system, the last devices on a RS485 bus must be configured via jumpers X103 and X104.

Table 3-6 Jumper setting of the **Terminating Resistors of Interface RS485** on the C-CPU-2 processor board

Jumper	Terminating resistor Connected	Terminating resistor Disconnected	Presetting
X103	2-3	1-2	1-2
X104	2-3	1-2	1-2

Note

Both jumpers must always be plugged in the same way!

Jumper X90 has currently no function. The factory setting is 1-2.

The terminating resistors can also be connected externally (e.g. to the connection module). In this case, the terminating resistors located on the RS485 or PROFIBUS interface module or directly on the PCB of the processor board C-CPU-2 must be de-energized.

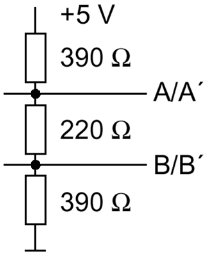


Figure 3-4 Termination of the RS485 interface (external)

Input/Output Board C-I/O-1

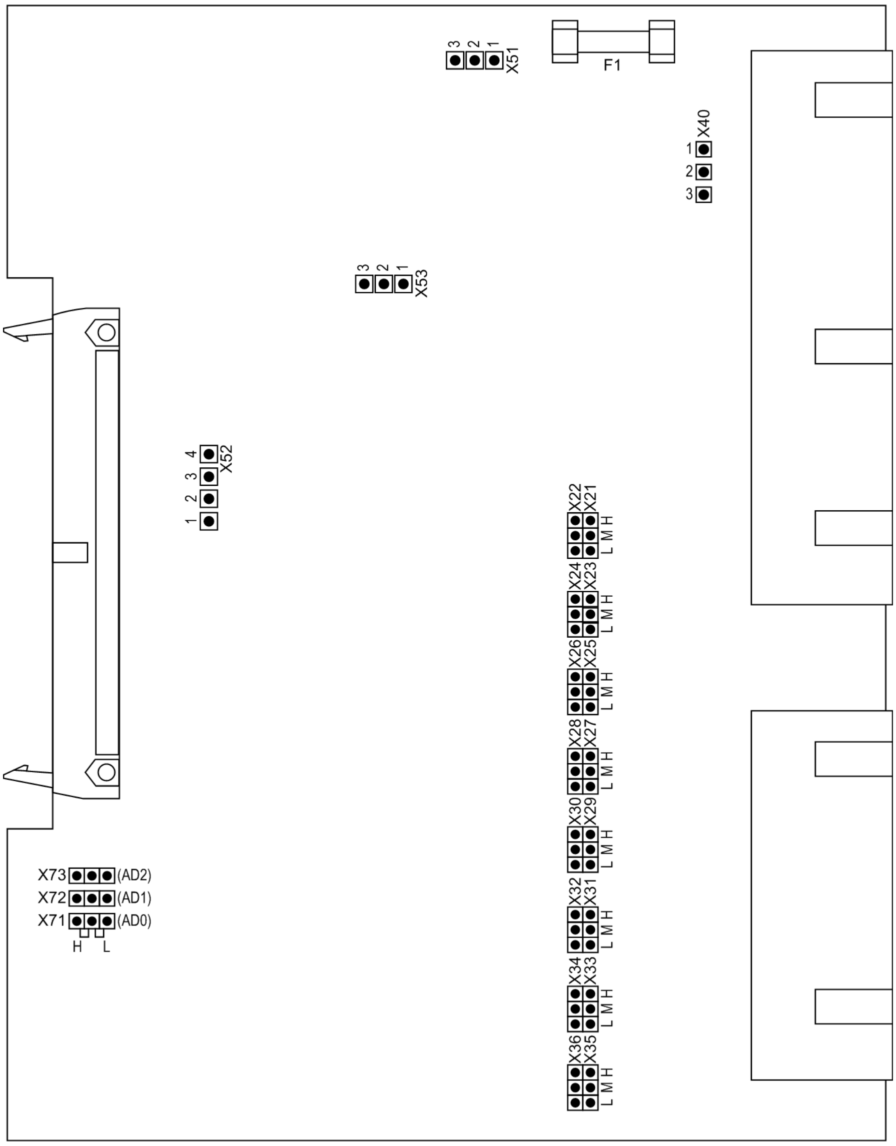


Figure 3-5 Input/output board C-I/O-1 with representation of the jumper settings required for the board configuration

In the version 7UM622, binary output BO 13 on the input/output board C–I/O-1 can be configured as normally open or normally closed (see also overview diagrams in Appendix A.2).

Table 3-7 Jumper setting for the **Contact Type** of the relay for BO13

Jumper	Open in quiescent state (NO)	Closed in quiescent state (NC)	Presetting
X40	1-2	2-3	1-2

Table 3-8 Jumper setting of **Control Voltages** of binary inputs BI8 to BI15 on input/output board C– I/O–1 in the 7UM622

Binary inputs	Jumper	19 VDC Pickup 1)	88 VDC Pickup 2)	176 V Threshold 3)
BI8	X21/X22	L	M	H
BI9	X23/X24	L	M	H
BI10	X25/X26	L	M	H
BI11	X27/X28	L	M	H
BI12	X29/X30	L	M	H
BI13	X31/X32	L	M	H
BI14	X33/X34	L	M	H
BI15	X35/X36	L	M	H

1) Factory settings for devices with rated power supply voltages of 24 VDC to 125 VDC

2) Factory settings for devices with power supply voltages of 110 VDC to 250 VDC and 115/230 VAC

3) Use only with control voltages 220 to 250 VDC

Jumpers X71, X72 and X73 on the input/output module C-I/O-1 are used to set the bus address and must not be changed. The following table lists the jumper presettings.

Mounting locations of modules are shown in Figures 3-1 to 3-2.

Table 3-9 Jumper setting of the **Bus Address** of the input/output board C-I/O-1 for 7UM622

Jumper	**Presetting**
X71	L
X72	H
X73	H

Input/Output Board C-I/O-2

Two different releases of the input output board C-I/O-2 are available. For devices up to release 7UM62.../DD the layout of the printed circuit board is shown in Figure 3-6, for devices of release 7UM62.../EE and higher it is shown in Figure 3-7.

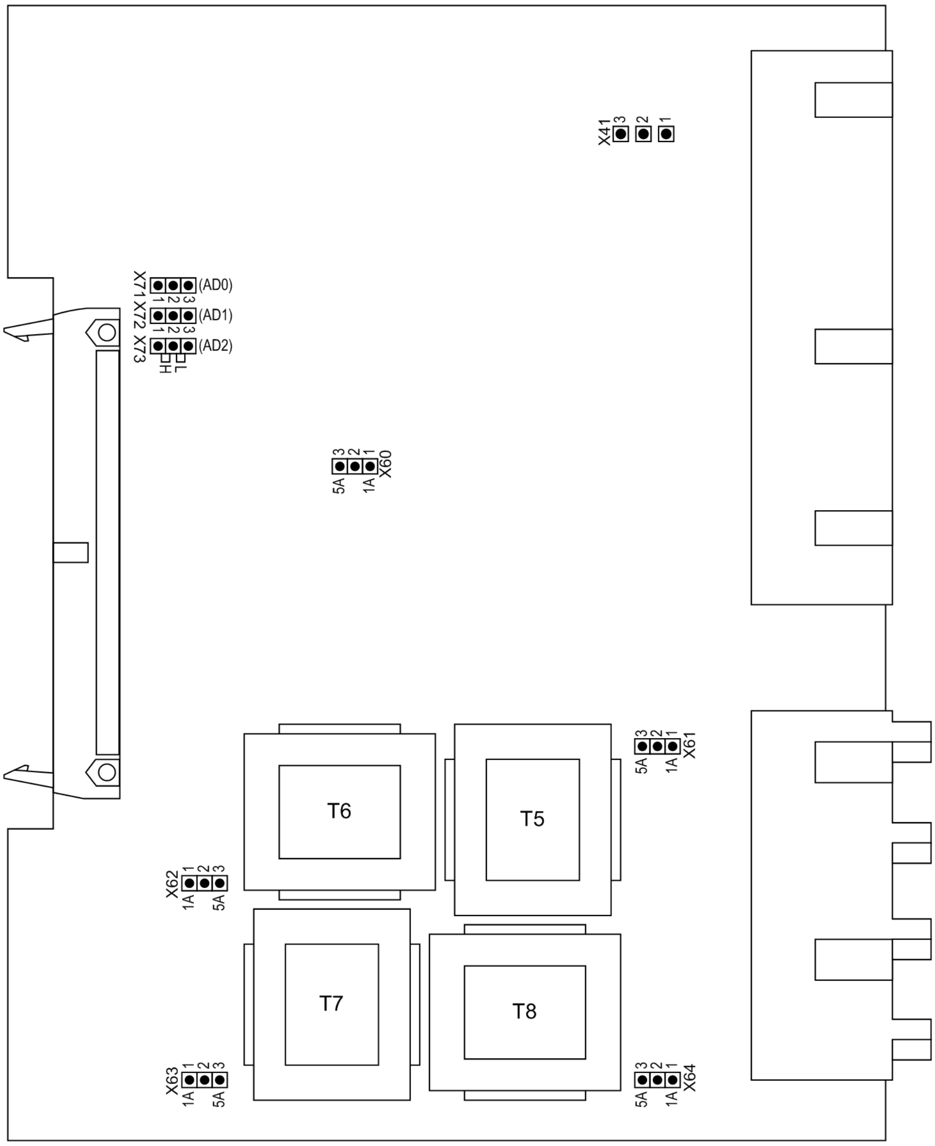


Figure 3-6 Input/output board C-I/O-2 up to release 7UM62.../DD, with representation of the jumper settings required for checking the configuration settings

The contact type of binary output BO6 can be changed from normally open to normally closed (see overview diagrams in section A.2 of the Appendix):

with housing size $^1/_2$: No. 3 in Figure , slot 33

with housing size $^1/_1$: No. 3 in Figure , slot 33 right.

Table 3-10 Jumper setting for the **Contact Type** of binary output BO6

Jumper	Open in quiescent state (NO)	Closed in quiescent state (NC)	Presetting
X41	1-2	2-3	1-2

The set nominal currents of the current input transformers are to be checked on the input/output board C-I/O-2. All jumpers must be set for one nominal current, i.e. respectively one jumper (X61 to X63) for each input transformer and additionally the common jumper X60. There is no jumper X64 because all versions of the 7UM62 have a sensitive earth fault current input (input transformer T8).

Jumpers X71, X72 and X73 on the input/output board C-I/O-2 are used to set the bus address and must not be changed. The following Table lists the jumper presettings.

Mounting location:

with housing size $^1/_2$: No. 3 in Figure , slot 33

with housing size $^1/_1$: No. 3 in Figure , slot 33 right.

Table 3-11 Jumper settings of **Bus Address** of the input/output board C-I/O-2

Jumper	Presetting
X71	1-2(H)
X72	1-2(H)
X73	2-3(L)

Input/Output Module C-I/O-2 (from release 7)

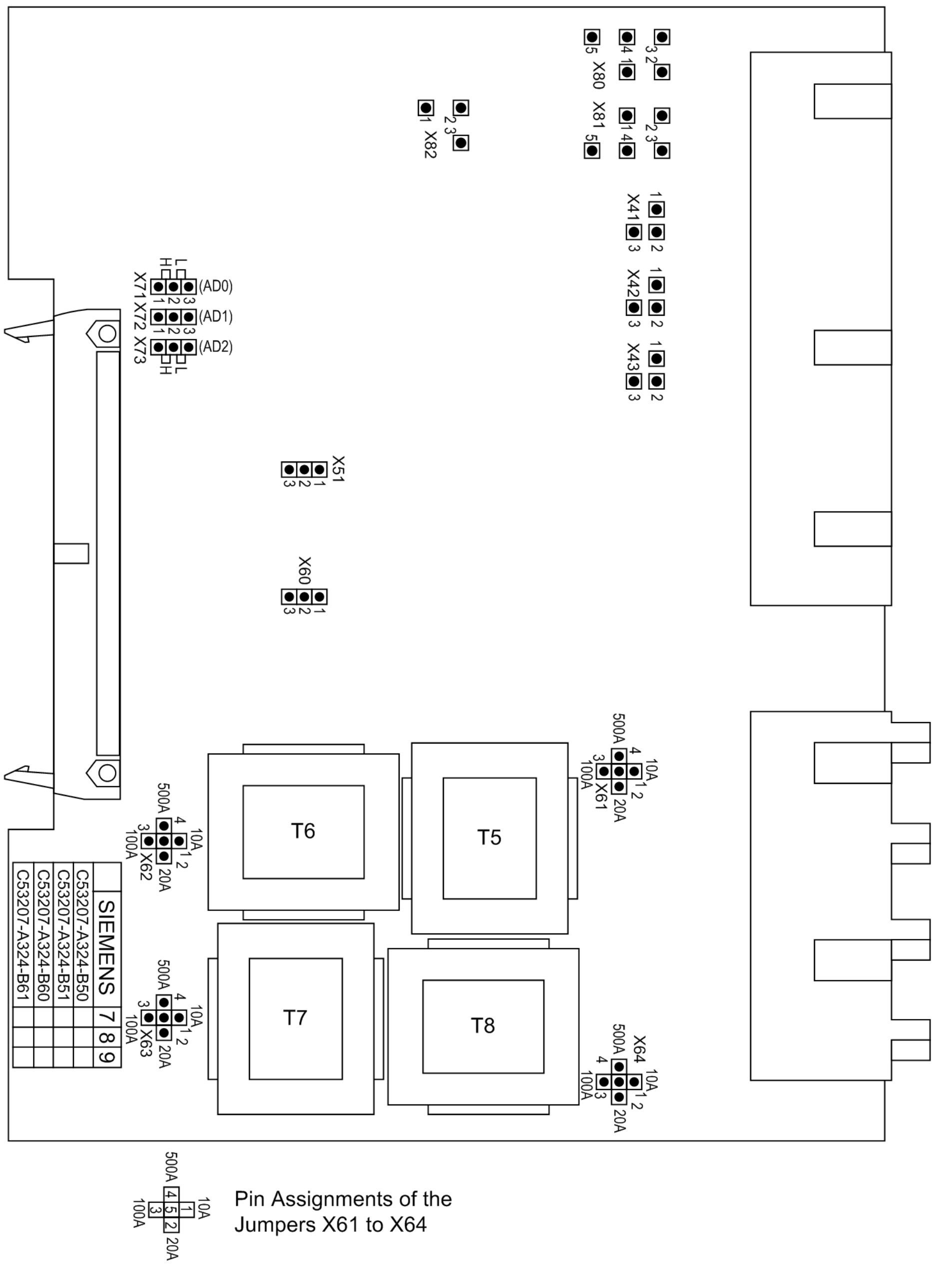


Figure 3-7 C-I/O-2 input/output board release 7UM62* .../EE or higher, with representation of jumper settings required for checking configuration settings

Table 3-12 Jumper setting for **Nominal Current** or **Measuring Range**

Jumper	Nominal current 1 A Measuring range 20 A	Nominal current 5 A Measuring range 100 A
X51	1-2	1-2
X60	1-2	2-3
X61	2-5	3-5
X62	2-5	3-5
X63	2-5	3-5
X64[1)]	2-5	3-5

[1)] Not for version with sensitive earth fault detection

Contacts of relays for binary outputs BO6, BO7 and BO8 can be configured as normally open or normally closed (see also General Diagrams in the Appendix).

Table 3-13 Jumper setting for the **Contact Type** of the relays for BO6, BO7 and BO8

For	Jumper	Open in quiescent state (NO) [1)]	Closed in quiescent state (NC)
BO6	X41	1-2	2-3
BO7	X42	1-2	2-3
BO8	X43	1-2	2-3

[1)] Factory setting

The relays for binary outputs BO1 through BO5 can be connected to common potential, or configured individually for BO1, BO4 and BO5 (BO2 and BO3 are without function in this context) (see also General Diagrams in the Appendix).

Table 3-14 Jumper settings for the configuration of the **Common Potential** of BO1 through BO5 or for configuration of BO1, BO4 and BO5 as **Single Relays**

Jumper	BO1 through BO5 connected to common potential [1)]	BO1, BO4, BO5 configured as single relays (BO2, BO3 without function)
X80	1-2, 3-4	2-3, 4-5
X81	1-2, 3-4	2-3, 4-5
X82	2-3	1-2

[1)] Factory setting

Jumpers X71, X72 through X73 serve for setting the bus address. Their position may not be changed. The following table shows the preset jumper positions.

Table 3-15 Jumper settings of **Bus address** of the input/output board C-I/O-2

Jumper	Factory setting
X71	1-2 (H)
X72	1-2 (H)
X73	2-3 (L)

Input/Output Board C-I/O-6

PCB layout for the Input/Output C-I/O-6 board is shown in the following Figure.

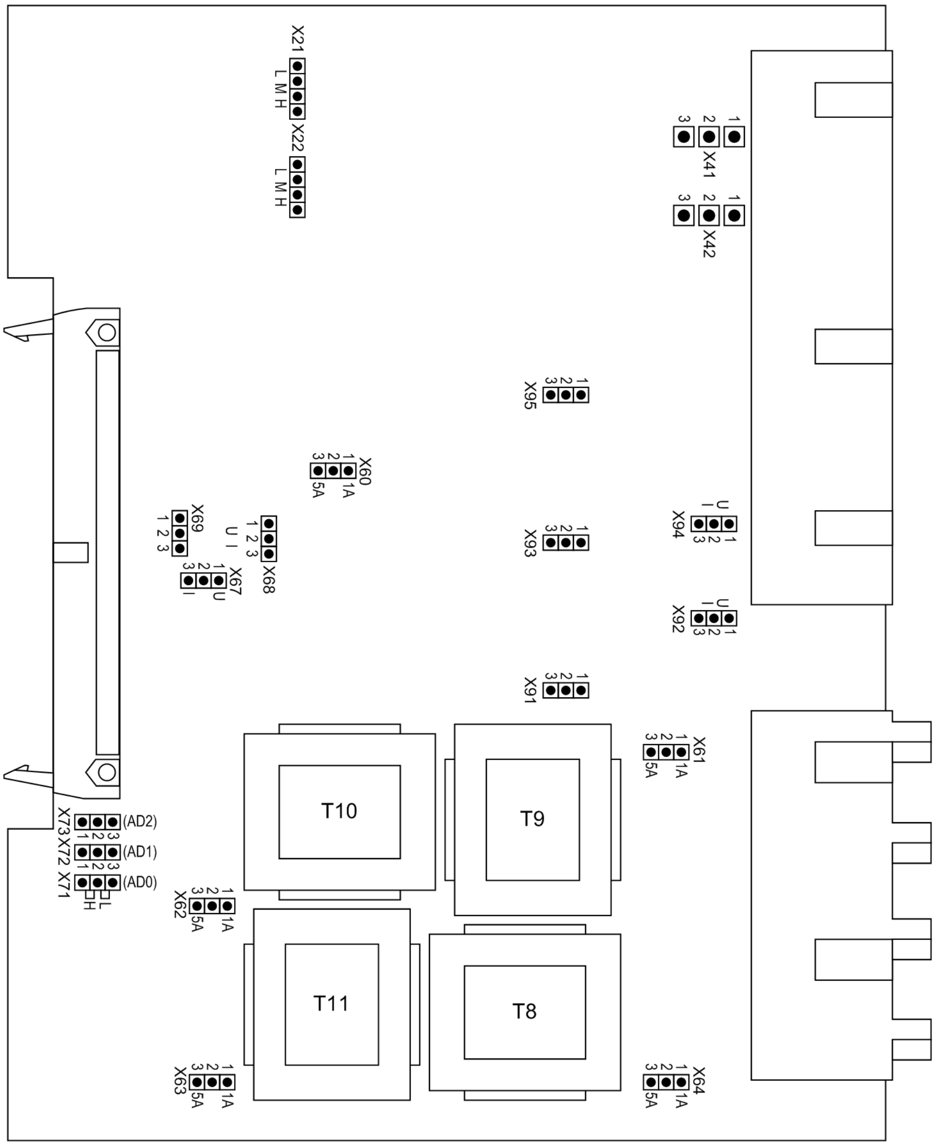


Figure 3-8 C-I/O-6 input/output board with representation of jumper settings required for checking configuration settings

Table 3-16 Jumper setting for **Control Voltages** of binary inputs BI6 and BI7 on the C–I/O-6 input/output board

Binary Inputs	Jumper	19 VDC Pickup 1)	88 VDC Pickup 2)	176 V Threshold 3)
BI6	X21	L	M	H
BI7	X22	L	M	H

1) Factory settings for devices with rated power supply voltages of 24 VDC to 125 VDC
2) Factory settings for devices with power supply voltages of 110 VDC to 250 VDC and 115/230 VAC
3) Use only with pickup voltages 220 or 250 VDC

Contacts of relays for binary outputs BO11 and BO12 can be configured as normally open or normally closed (see overview diagrams in Appendix A.2):

Table 3-17 Jumper setting for **Contact Type** of relays for BO11 and BO12

Binary output	Jumper	Normally open contactor	Normally closed contactor	Presetting
BO11	X41	1-2	2-3	1-2
BO12	X42	1-2	2-3	1-2

The set nominal currents of the current input transformers are to be checked on the input/output board C-I/O-6. All jumpers must be set for one nominal current, i.e. respectively one jumper (X61 to X63) for each input transformer and additionally the common jumper X60. There is no jumper X64 because all versions of the 7UM62 have a sensitive earth fault current input (input transformer T8).

Table 3-18 Jumper setting for the **Input Characteristic (U/I)** of measuring transducer 1

Jumper	Voltage Input ±10 V	Current Input (4-20/20 mA)	Presetting
X94	1-2	2-3	1-2
X95	1-2	2-3	1-2
X67	1-2	2-3	1-2

Table 3-19 Jumper settings for the **Input Characteristic (U/I)** of measuring transducer 2

Jumper	Voltage Input ±10 V	Current Input (4-20/20 mA)	Presetting
X92	1-2	2-3	1-2
X93	1-2	2-3	1-2
X68	1-2	2-3	1-2

Caution!

False connection for "Current" jumper setting!

If with "Current" jumper setting an input voltage is applied, this may destroy the board.

For an input voltage, the "Voltage" jumper must set.

Table 3-20 Jumper setting for activating/deactivating the $f_g \approx$ 10 Hz low-pass filter of measuring transducer 3

Jumper	Low-Pass Filter Inactive	Low-Pass Filter Active	Presetting
X91	1-2	2-3	2-3
X69	1-2	2-3	2-3

Note

The jumper settings must correspond to the mode set at addresses 295, 296 (voltage or current input) and 297 (with/without filter). Otherwise the device is blocked and outputs an alarm. After any changes to the jumper settings, you should therefore immediately change the corresponding parameter settings using DIGSI.

Note

Unused measuring transducers should be shorted at the input terminals!

Jumpers X71, X72 and X73 on the input/output module C-I/O-6 are used to set the bus address and must not be changed. The following table lists the jumper presettings.

Table 3-21 Jumper settings of the **Bus Address** of the input/output board C-I/O-6

Jumper	Factory Setting
X71 (AD0)	1-2 (H)
X72 (AD1)	2-3 (L)
X73 (AD2)	1-2 (H)

3.1.2.4 Interface Modules

Replacing Interface Modules

The interface modules are located on the C–CPU-2 board ((1) in Figure 3-1 and 3-2). The following figure shows the PCB with location of the modules.

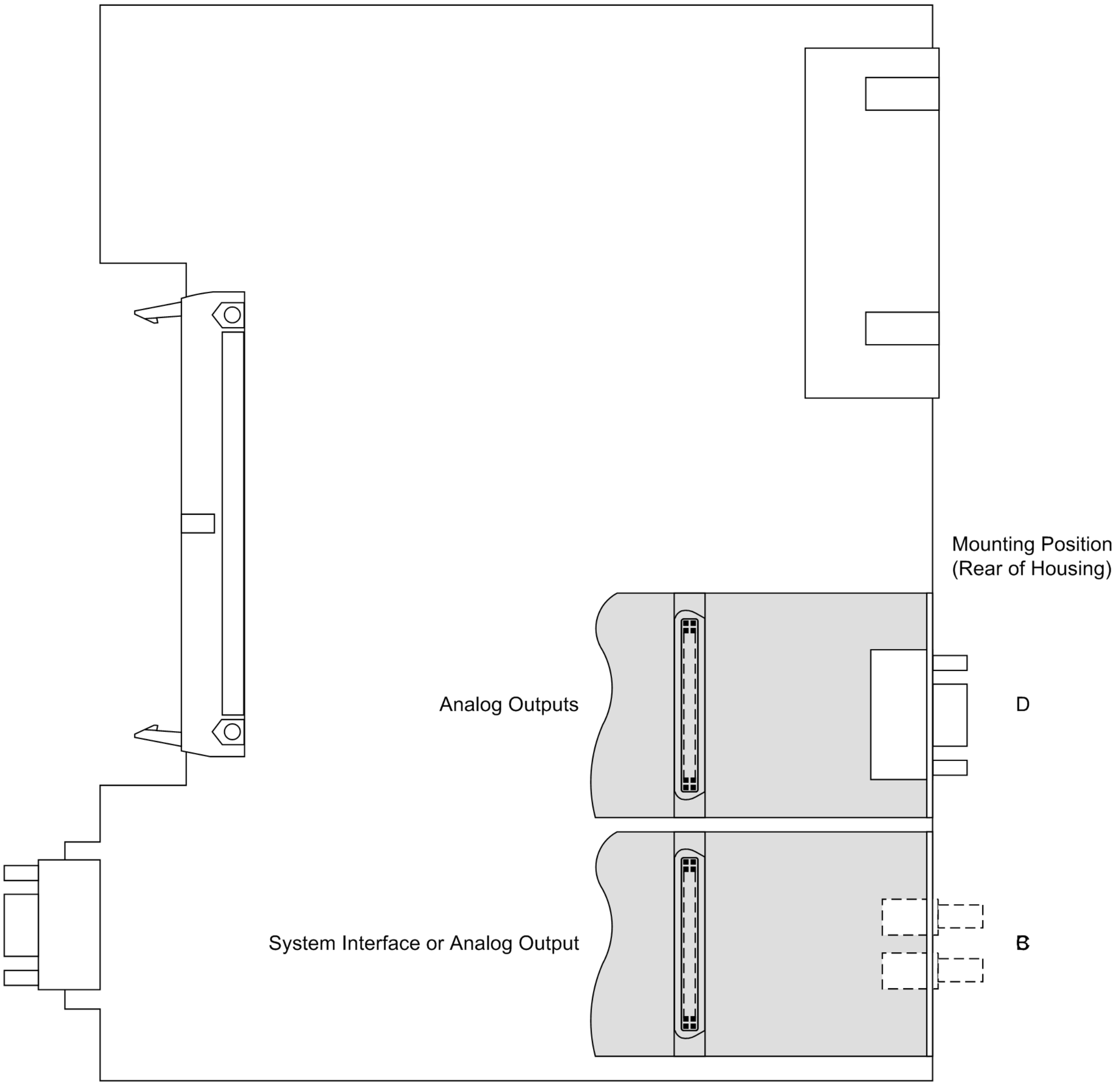


Figure 3-9 C-CPU-2 board with interface modules

Please note the following:

- The interface modules can only be replaced in devices for panel flush mounting and cubicle mounting.

  Devices in surface mounting housings with double-level terminals can be changed only in our manufacturing centre.
- Only interface modules can be used with which the device can also be ordered from the factory in accordance with the order number (see also Appendix A.1).

Table 3-22 Replacing interface modules

Interface	Mounting Location / Interface	Replacement module
System interface	B	Only interface modules that can be ordered in our facilities via the order key (see Appendix, Section A.1).
Analog Output		2 x 0 to 20 mA or 4 to 20 mA
Analog Output	D	2 x 0 to 20 mA or 4 to 20 mA
RTD-box		RS485 FO

The order numbers of the replacement modules can be found in the Appendix in Section A.1.

EN100 Ethernet Module (IEC 61850)

The Ethernet interface module has no jumpers. No hardware modifications are required to use it.

Termination

For bus-capable interfaces, a termination is necessary at the bus for each last device, i.e. terminating resistors must be connected. With the 7UM62 device, this concerns the variants with RS485 or PROFIBUS interfaces.

The terminating resistors are located on the RS485 or Profibus interface module, which is on the C–CPU-2 board ((1) in Figures 3-1 and 3-2), or directly on the PCB of the C-CPU-2 board (see margin title „C-CPU-2 Processor Board“, Table 3-2).

Figure 3-9 shows the PCB of the C-CPU-2 with the layout of the boards.

The module for the RS485 interface is shown in Figure 3-10, the module for the Profibus interface in Figure 3-11.

On delivery, the jumpers are set so that the terminating resistors are disconnected. Both jumpers of a module must always be plugged in the same way.

Jumper	Terminating Resistors	
	Connected	Disconnected
X3	2-3	1-2 *)
X4	2-3	1-2 *)

*) Default Setting

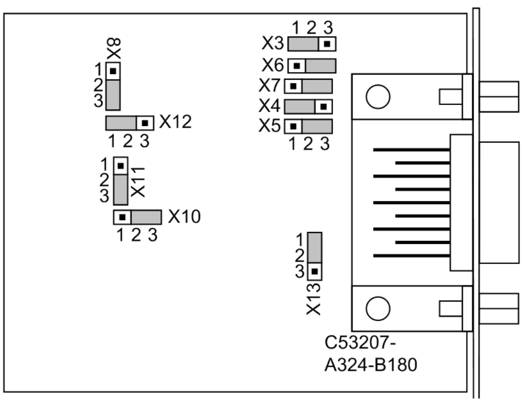


Figure 3-10 Position of terminating resistors and the plug-in jumpers for configuration of the RS485 interface

Jumper	Terminating Resistors	
	Connected	Disconnected
X3	1-2	2-3 *)
X4	1-2	2-3 *)

*) Default Setting

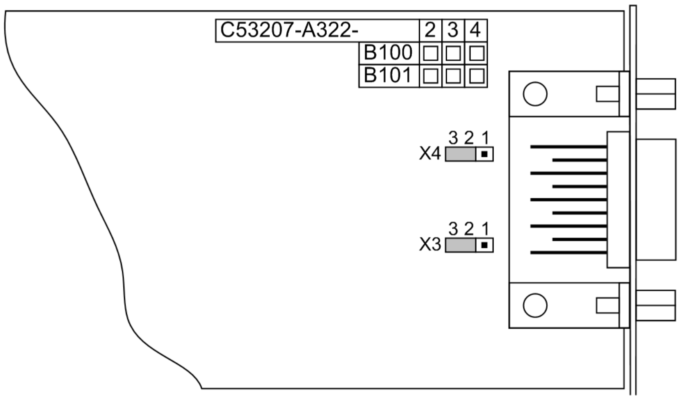


Figure 3-11 Position of the plug-in jumpers for the configuration of the terminating resistors at the Profibus (FMS and DP), DNP 3.0 and Modbus interfaces

The terminating resistors can also be connected externally (e.g. to the terminal block), see Figure 3-4. In this case, the terminating resistors located on the RS485 or PROFIBUS interface module or directly on the PCB of the C-CPU-2 board of must be disabled.

It is possible to convert the R485 interface to a RS232 interface by changing the jumper positions and vice-versa.

Jumper positions for the alternatives RS232 or RS485 (as in Figure 3-10) are derived from the following Table.

Table 3-23 Configuration for RS232 or RS485 on the interface module

Jumper	X5	X6	X7	X8	X10	X11	X12	X13
RS232	1-2	1-2	1-2	1-2	1-2	2-3	1-2	1-2
RS 485	2-3	2-3	2-3	2-3	2-3	2-3	1-2	1-2

The jumpers X5 to X10 must be plugged in the same way!

The jumpers are preset at the factory according to the configuration ordered.

Analog Output

The AN20 analog output interface module (see Figure 3-12) has 2 floating channels with a current range of 0 to 20 mA (unipolar, max. 350 Ω).

The location on the C–CPU-2 board is „B“ or/and „D“ depending on the variant ordered (see Figure 3-9).

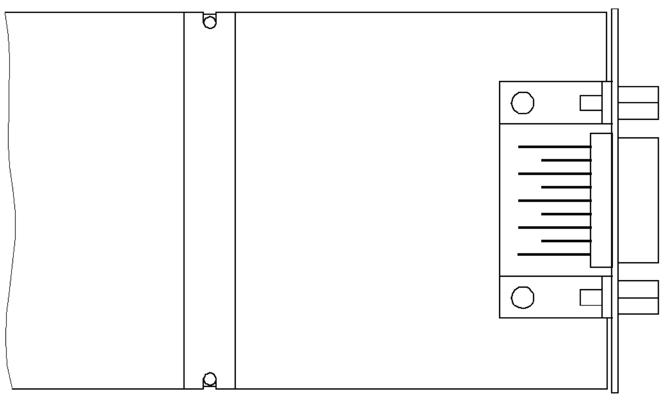


Figure 3-12 AN20 analog output interface board

3.1.2.5 Reassembly

The device is assembled in the following steps:

- Insert the boards carefully in the housing. The mounting locations are shown in Figures 3-1 to 3-2. For the model of the device designed for surface mounting, use the metal lever to insert the C-CPU-2 board. The installation is easier with the lever.
- Plug in the plug connectors of the ribbon cable onto the input/output modules I/O and then onto the processor board C-CPU-2. Be careful not to bend any connector pins! Do not apply force!
- Connect the plug connectors of the ribbon cable between the C-CPU-2 board and the front panel to the front panel plug connector.
- Press the plug connector interlocks back together.
- Replace the front panel and screw it tightly to the housing.
- Put the covers back on.
- Screw the interfaces on the rear panel of the device tight again.

  This activity does not apply if the device is for surface mounting.

3.1.3 Mounting

3.1.3.1 Panel Flush Mounting

Depending on the version, the device housing can be $^1/_2$ or $^1/_1$. For the $^1/_3$ housing size (Figure 3-13), there are four covers and four holes. For the $^1/_1$ housing size (Figure 3-14) there are six covers and six holes.

- Remove the 4 covers at the corners of the front cover, for size $^1/_1$ the two covers located centrally at the top and bottom also have to be removed. The 4 or 6 elongated holes in the mounting bracket are revealed and can be accessed.
- Insert the device into the panel cut-out and fasten it with four or six screws. For dimensions refer to Section 4.39.
- Mount the four or six covers.
- Connect the ground on the rear plate of the device to the protective ground of the panel. Using at least one M4 screw. The cross-sectional area of the ground wire must be equal to the cross-sectional area of any other control conductor connected to the device. The cross-section of the ground wire must be at least 2.5 mm ^{2}.
- Connections are realised via the plug terminals or screw terminals on the rear side of the device in accordance with the circuit diagram. For screw connections with forked lugs or direct connection the screws must be tightened before inserting wires so that the screw heads are flush with the outer edge of the connection block. A ring lug must be centred in the connection chamber in such a way that the screw thread fits in the hole of the lug. The SIPROTEC 4 System Description has pertinent information regarding wire size, tightening torques, bending radii and strain relief.

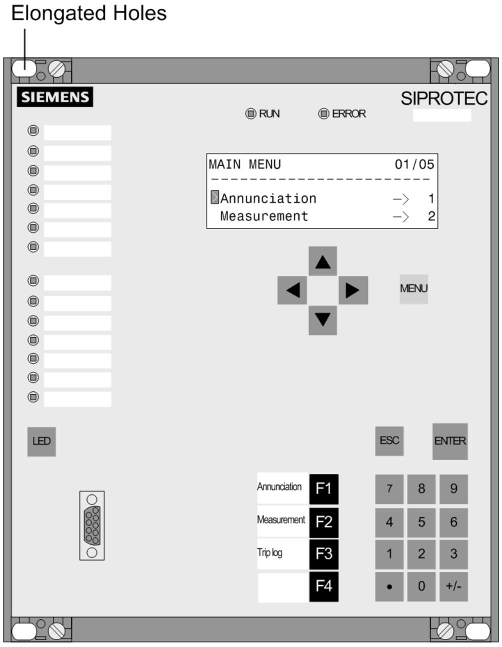


Figure 3-13 Panel flush mounting of a device (housing size $^1/_2$)

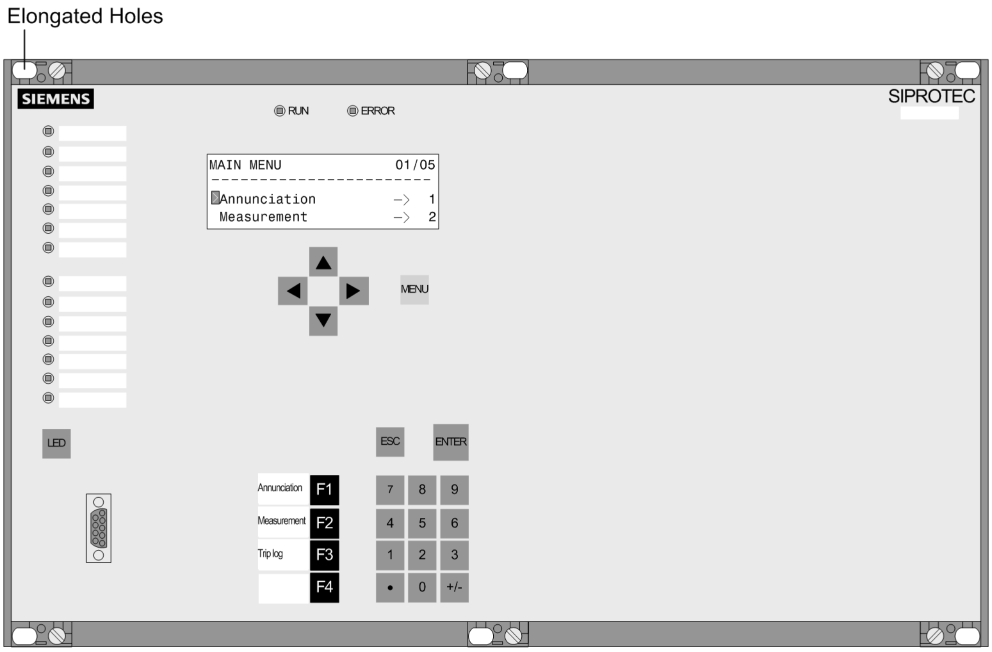


Figure 3-14 Panel flush mounting of a device (housing size $^1/_1$)

3.1.3.2 Rack and Cubicle Mounting

For the $^1/_2$ housing size (Figure 3-15), there are four covers and four holes. For the $^1/_1$ housing size (Figure 3-16) there are six covers and six holes.

To install the device in a frame or cubicle, two mounting brackets are required. The ordering codes are stated in Appendix, Section A.1.

- Loosely screw the two mounting brackets in the rack or cubicle with four screws.
- Remove the 4 covers at the corners of the front cover, for size $^1/_1$ the two covers located centrally at the top and bottom also have to be removed. Thus the 4 respectively 6 slots in the mounting flange are revealed and can be accessed.
- Fasten the device to the mounting brackets with four or six screws.
- Mount the four or six covers.
- Tighten fast the eight screws of the angle brackets in the rack or cubicle.
- Connect the ground on the rear plate of the device to the protective ground of the panel. Using at least one M4 screw. The cross-sectional area of the ground wire must be equal to the cross-sectional area of any other control conductor connected to the device. The cross-section of the ground wire must be at least 2.5 mm ^{2}.
- Connections use the plug terminals or screw terminals on the rear side of the device in accordance the wiring diagram. For screw connections with forked lugs or direct connection, before inserting wires the screws must be tightened so that the screw heads are flush with the outer edge of the connection block. A ring lug must be centred in the connection chamber, in such a way that the screw thread fits in the hole of the lug. The SIPROTEC 4 System Description /1/ has pertinent information regarding wire size, lugs, bending radii, etc.

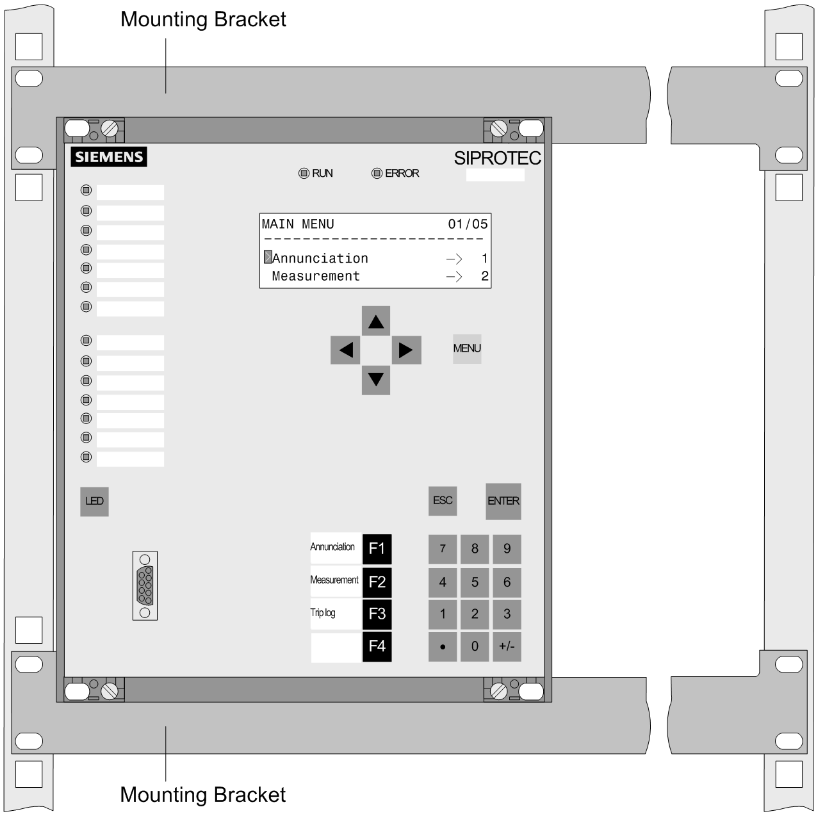


Figure 3-15 Rack or cubicle mounting of a device (housing size $^1/_2$)

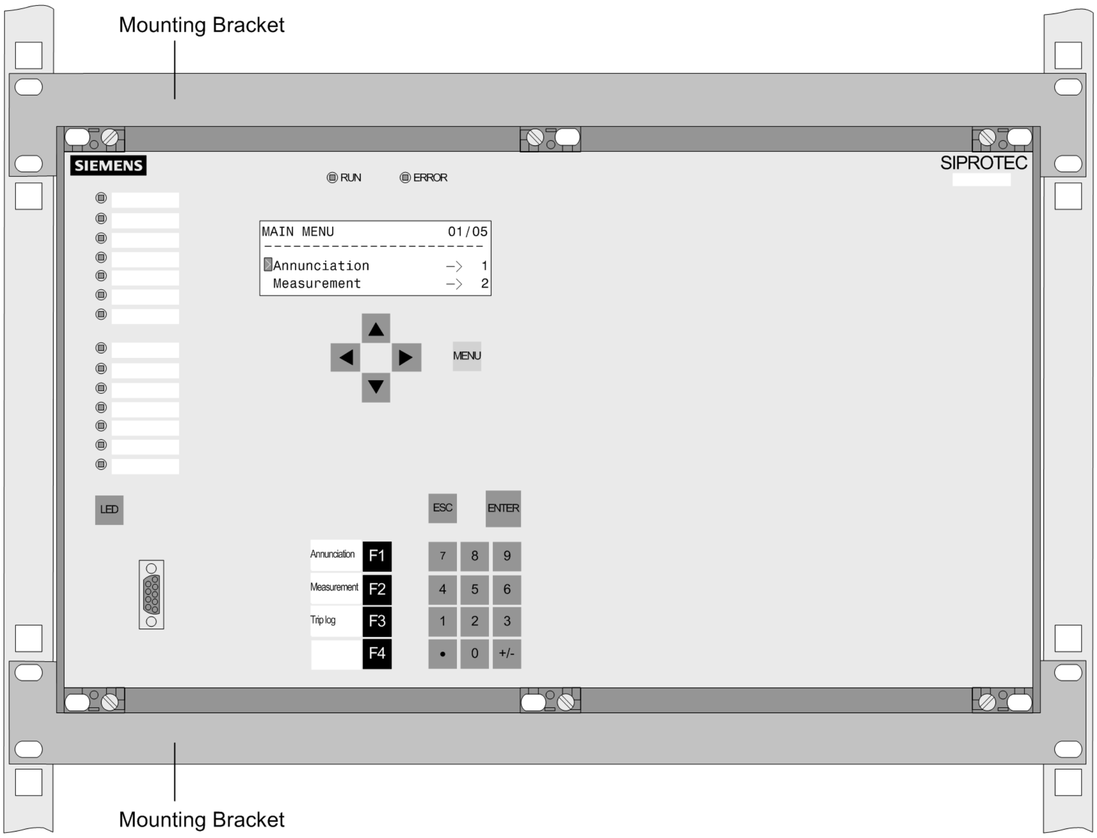


Figure 3-16 Rack or cubicle mounting of a device (housing size $^1/_1$)

3.1.3.3 Panel Surface Mounting

For panel surface mounting of the device proceed as follows:

- Secure the device to the panel with four screws. For dimensions refer to Section 4.39.
- Connect the low-resistance operational and protective earth to the ground terminal of the device. The cross-sectional area of the ground wire must be equal to the cross-sectional area of any other control conductor connected to the device. It must thus be at least 2.5 mm^2.
- Alternatively, there is the possibility to connect the aforementioned earthing to the lateral grounding surface with at least one M4 screw.
- Make the connections according to the circuit diagram via the screw-type terminals. Fibre-optic cables and electrical communication modules are connected at the inclined housings. The SIPROTEC 4 System Description /1/ has pertinent information regarding wire size, lugs, bending radii, etc.

3.2 Checking Connections

3.2.1 Checking Data Connections of Interfaces

The tables in the following sections list the pin assignments for the different serial interfaces, the time synchronization interface and the Ethernet interface of the device. The position of the connectors is depicted in the following figures.

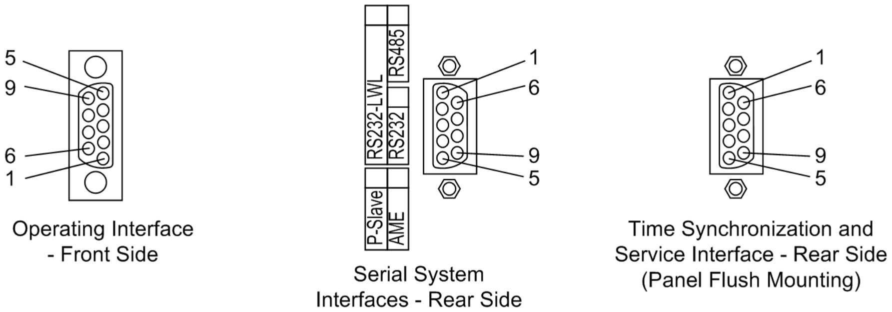


Figure 3-17 9-pin D-subminiature female connectors

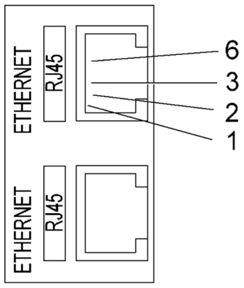


Figure 3-18 Ethernet connector

Operator Interface

When the recommended communication cable is used, correct connection between the SIPROTEC 4 device and the PC is automatically ensured. See the Appendix A.1 for an ordering description of the cable.

3.2.2 System Interface

For versions equipped with a serial interface to a control center, the user must check the data connection. The visual check of the assignment of the transmission and reception channels is of particular importance. With RS232 and fibre optic interfaces, each connection is dedicated to one transmission direction. Therefore the output of one device must be connected to the input of the other device and vice versa.

With data cables, the connections are designated according to DIN 66020 and ISO 2110:

- TxD = Data Output
- RxD = Data Input
- $\overline{\text{RTS}}$ = Request to Send
- $\overline{\text{CTS}}$ = Clear to Send
- GND = Signal / Chassis Ground

The cable shield has to be earthed at **both** line ends. For extremely EMC-loaded environments the GND may be integrated into a separate individually shielded wire pair to improve the immunity to interference.

Table 3-24 The assignments of the D-subminiature and RJ45 connector for the various interfaces

Pin No.	Operator interface	RS232	RS 485	Profibus DP Slave, RS 485	DNP3.0 Modbus, RS485	Ethernet EN100
1	Shield (with shield ends electrically connected)					Tx+
2	RxD	RxD	–	–	–	Tx-
3	TxD	TxD	A/A’ (RxD/TxD-N)	B/B’ (RxD/TxD-P)	A	Rx+
4	–	–	–	CNTRA-(TTL)	RTS (TTL level)	–
5	GROUND	EARTH	C/C' (EARTH)	C/C' (EARTH)	EARTH1	–
6	–	–	–	+5 V (max. load < 100 mA)	VCC1	Rx-
7	$\overline{\text{RTS}}$	$\overline{\text{RTS}}$	– [1]	–	–	–
8	$\overline{\text{CTS}}$	$\overline{\text{CTS}}$	B/B’ (RxD/TxD-P)	A/A’ (RxD/TxD-N)	B	–
9	–	–	–	–	–	Disabled

[1] Pin 7 also carries the RTS signal with RS232 level when operated as RS485 Interface. Pin 7 may therefore not be connected!

3.2.3 Termination

The RS485 interface is capable of half-duplex service with the signals A/A' and B/B' with a common relative potential C/C' (GND). Verify that only the last device on the bus has the terminating resistors connected, and that the other devices on the bus do not. The jumpers for the terminating resistors are located on the interface module RS485 (see Figure 3-10) or on the PROFIBUS module RS485 (see Figure 3-11). The terminating resistors can also be connected externally (e.g. to the connection module as illustrated in Figure 3-4). In this case, the terminating resistors located on the module must be disabled.

If the bus is extended, make sure again that only the last device on the bus has the terminating resistors switched-in, and that all other devices on the bus do not.

3.2.4 Analog Output

The two analog values are output as currents on a 9-pin DSUB socket. The outputs are isolated.

Table 3-25 Pin assignment of DSUB socket for analog output

Pin No.	Code
1	Channel 1 positive
2	–
3	–
4	–
5	Channel 2 positive
6	Channel 1 negative
7	–
8	–
9	Channel 2 negative

3.2.5 Time Synchronization Interface

Either 5 VDC, 12 VDC or 24 VDC time synchronization signals can be processed if the connections are made as indicated in the table below.

Table 3-26 D-subminiature connector assignment of the time synchronization interface

Pin No.	Designation	Signal Meaning
1	P24_TSIG	Input 24 V
2	P5_TSIG	Input 5 V
3	M_TSIG	Return Line
4	M_TSYNC 1)	Return Line 1)
5	Shield	Shield Potential
6	–	–
7	P12_TSIG	Input 12 V
8	P_TSYNC 1)	Input 24 V 1)
9	SHIELD	Shield Potential

1) assigned, but not used

For the pin assignment of the time synchronization interface in panel surface-mounted devices, please refer to the Appendix (Figures A-3 and A-4).

3.2.6 Optical Fibres

WARNING!

Laser Radiation!

Do not look directly into the fibre-optic elements!

The transmission via fibre optics is particularly insensitive to electromagnetic interference and thus ensures galvanic isolation of the connection. Transmit and receive connections are shown with the symbols for transmit and for receive.

The normal setting of the character idle state for the optical fibre interface is „Light off“. If the character idle state is to be changed, use the operating program DIGSI, as described in the SIPROTEC 4 System Description.

3.2.7 Checking the Device Connections

General

By checking the device connections, the correct installation of the protection device e.g. in the cubicle must be tested and ensured. This includes wiring check and functionality as per drawings, visual assessment of the protection system, and a simplified functional check of the protection device.

Auxiliary Power Supply

Before the device is connected to voltage for the first time, it should be have been at least 2 hours in its operating room, in order to attain temperature equilibrium and to avoid dampness and condensation.

Note

If a redundant supply is used, there must be a permanent, i.e. uninterruptible connection between the minus polarity connectors of system 1 and system 2 of the DC voltage supply (no switching device, no fuse), because otherwise there is a risk of voltage doubling in case of a double earth fault.

Switch on the auxiliary voltage circuit breaker (supply protection), check voltage polarity and amplitude at the device terminals or at the connection modules.

Visual Check

Check the cubicle and the devices for damage, condition of the connections etc., and device earthing.

Secondary Check

Testing the individual protection functions for the accuracy of their pickup values and characteristics proper should not be part of this check. Unlike analog electronic or electromechanical protective devices, no protection function test is required within the framework of the device test, since this is ensured by the factory tests. Protection functions are only used to check the device connections.

A plausibility check of the analog-digital converter with the operational measured values is sufficient since the subsequent processing of the measured values is numerical and thus internal failures of protection functions can be ruled out.

Where secondary tests are to be performed, a three-phase test equipment providing test currents and voltages is recommended (e.g. Omicron CMC 56 for manual and automatic testing). The phase angle between currents and voltages should be continuously controllable.

The accuracy which can be achieved during testing depends on the accuracy of the testing equipment. The accuracy values specified in the Technical Data can only be reproduced under the reference conditions set down in IEC 60 255 resp. VDE 0435/part 303 and with the use of precision measuring instruments.

Tests can be performed using the currently set values or the default values.

If unsymmetrical currents and voltages occur during the tests it is likely that the asymmetry monitoring will frequently pickup. This is of no concern because the condition of steady-state measured values is monitored which, under normal operating conditions, are symmetrical; under short circuit conditions these monitorings are not effective.

Note

If during dynamic testing, measured values are connected from or reduced to zero, a sufficiently high value should be present in at least one other measuring circuit (in general a voltage), to permit frequency adaptation.

Measured values in earth paths of voltage or current (I_{EE}, U_E) can not adapt the scanning frequency. To check them, a sufficiently high value measured value must be present in at least one of the phases.

Secondary Test of the Differential Protection

A test set with 6 current outputs is recommended for secondary testing. The following section gives hints how to proceed for testing with fewer current sources. The test current can be injected individually for each winding, thus simulating each time a transformer fault with single-ended infeed.

For three or two-phase testing the parameter (address 2021) set for **I-DIFF>** is valid as the pickup value on presetting. The pickup value for single-phase testing depends on how the zero sequence current is treated:

If the zero sequence current is eliminated, the pickup value increases to 1.5 times the set value; this corresponds to conventional circuitry when current is fed in via matching transformers.

If the zero sequence current is not eliminated (isolated starpoint), the pickup current corresponds to the setting value **I-DIFF>** even during single-phase testing.

Checking the pickup value is performed by slowly increasing the test current for each winding with the secondary test set. Tripping is initiated when the converted pickup value is reached. When the test current reaches 0.7 times the pickup value, the tripping command drops off.

In the method described above, the pickup values for single-ended infeed are tested in each case. It is also possible to check the entire characteristic. Since trip current and restraint current cannot be fed in separately (they can, however, be read out separately in the test measurements), a separate test current has to be applied to each of the two windings.

When testing with the operational parameters, it should be noted that the setting value **I-DIFF>** refers to the rated current of the transformer, i.e. current which results from

for three-phase transformers $$I_{N\ Transf} = \frac{S_{N\ Transf}\,[MVA] \cdot 1000}{\sqrt{3} \cdot U_{N\ Winding}\,[kV]} = [A]$$

with

$S_{N,\ Transf}$	Nominal apparent power of the transformer
$U_{N\ Winding}$	Rated voltage of the respective winding; for a winding with regulated voltage, the voltage computed in accordance with Section 2.14.1.2 applies

Furthermore, the pickup values can change with single and two-phase testing depending on the vector group of the protected transformer; this corresponds to conventional circuitry, when currents are applied via matching current transformers. Table 3-27 shows these changes as a factor k_{VG} depending on the vector group and the type of fault, for three-phase transformers.

In order to obtain the pickup value, the setting value **I-DIFF>** (parameter address 2021) must be multiplied by the factor

$$\frac{I_{N\ Transf}}{I_{N\ CT\ (primary)}} \cdot k_{VG}$$

Table 3-27 Correction factor k_{VG} depending on vector group and fault type

Type of Fault	Reference winding (High Voltage)	Even VG Numeral (0, 2, 4, 6, 8, 10)	Odd VG Numeral (1, 3, 5, 7, 9, 11)
Three-phase	1	1	1
Two-Phase	1	1	√3/2 = 0.866
single-phase with I_0 elimination	3/2 = 1.5	3/2 = 1.5	√3 = 1.73
single-phase without I_0 elimination	1	1	√3 = 1.73

The pickup values are checked for each winding by slowly increasing the test current with the secondary test set. Tripping is initiated when the converted pickup value is reached.

Example (Application as „mere transformer protection“):

Three-phase transformer $S_{N\ Transf}$ = 57 MVA, vector group Yd5

High Voltage 110 kV

Current Transformer 300 A / 1 A

Undervoltage 25 kV

Current Transformer 1500 A / 1 A

The following applies for the high voltage winding:

$$I_{N\ Transf} = \frac{S_{N\ Transf}\,[MVA] \cdot 1000}{\sqrt{3} \cdot U_{N\ Winding}\,[kV]}[A] = \frac{57[MVA] \cdot 1000}{(\sqrt{3} \cdot 110)[kV]}[A] = 299.2\ A$$

In this case the rated current of the winding is practically equal to the current transformer rated current. Thus, the pickup value (referred to the rated relay current) complies with the setting value I DIFF> of the relay when three or two-phase testing is performed (k_{VG} = 1 for reference winding). For single-phase testing with zero sequence current elimination, a pickup value 1.5 times higher must be expected.

The following applies for the secondary winding:

$$I_{N\ Transf} = \frac{S_{N\ Transf}[MVA] \cdot 1000}{\sqrt{3} \cdot U_{N\ Winding}\,[kV]}[A] = \frac{57[MVA] \cdot 1000}{(\sqrt{3} \cdot 25)[kV]}[A] = 1316\ A$$

When testing this winding, the pickup value (referred to the rated device current) will amount to

$$\frac{I_{N\ Transf}}{I_{N\ Relay}} = \frac{I_{N\ Transf}}{I_{N\ CT\ (primary)}} \cdot k_{VG} \cdot IDIFF> = \frac{1316\ A}{1500\ A} \cdot k_{VG} \cdot IDIFF>$$
$$= (0.877 \cdot k_{VG} \cdot IDIFF>)$$

Because of the odd vector group numeral, the following pickup values apply

Three-phase $k_{VG} = 1$ $\qquad \frac{I_{Pickup}}{I_{N\ Relay}} = 0.877 \cdot \text{IDIFF >}$

Two-phase $k_{VG} = \sqrt{3/2}$ $\qquad \frac{I_{Pickup}}{I_{N\ Relay}} = 0.760 \cdot \text{IDIFF >}$

Single-phase $k_{VG} = \sqrt{3}$ $\qquad \frac{I_{Pickup}}{I_{N\ Relay}} = 1.52 \cdot \text{IDIFF >}$

Wiring

It is particularly important to check the correct wiring and allocation of all device interfaces. The margin heading titled„Test function for checking the binary inputs and outputs“ provides additional information to this end.

For checking the analog inputs a plausibility check can be conducted as described above under the margin title „Secondary Testing“

Function Check

The only functional test required for protective relays is a plausibility check of the operational measured values by means of some secondary test equipment; this is to ensure that no damage has occurred during transit (see also margin title „Secondary Testing“).

Undervoltage Protection 27

Note

If in the device undervoltage protection function is configured and activated, the following must be considered: Special measures have been taken to ensure that the device does not pick up immediately after applying the auxiliary power supply, as a result of the absent measuring voltage. However, the device does pick up as soon as operating state 1 (measured values exist) has been attained.

LEDs

After tests where the displays appear on the LEDs, these should be reset so that they supply only information on the test just performed. This should be done at least once each using the reset button on the front panel and via the binary input for remote reset (if allocated). Observe that an independent reset occurs also on the arrival of a new fault and that setting of new indications can be optionally made dependent on the pickup or a trip command (parameter 610 **FltDisp.LED/LCD**).

Test Switch

Check the functions of all test switches that are installed for the purposes of secondary testing and isolation of the device. Of particular importance are „test switches “ in current transformer circuits. Be sure these switches short-circuit the current transformers when they are in the test mode.

3.2.8 Checking System Incorporation

General Information

WARNING!

Warning of dangerous voltages

Non-observance of the following measures can result in death, personal injury or substantial property damage.

Therefore, only qualified people who are familiar with and adhere to the safety procedures and precautionary measures shall perform the inspection steps.

With this check of the protection, the correct incorporation of the device into the power system must be tested and ensured.

Checking of protection parametrization (allocations and settings) in accordance with the power system requirements, is an important test step here.

The interface-wide incorporation check in the power system results on the one hand in testing of cubicle wiring and functionality in accordance with the drawing record, and on the other hand the correctness of cabling between transducer or transformer and protection device.

Auxiliary Power Supply

Check the voltage magnitude and polarity at the input terminals.

Note

If a redundant supply is used, there must be a permanent, i.e. uninterruptible connection between the minus polarity connectors of system 1 and system 2 of the DC voltage supply (no switching device, no fuse), because otherwise there is a risk of voltage doubling in case of a double earth fault.

Caution!

Be careful when operating the device on a battery charger without a battery

Non-observance of the following measure can lead to unusually high voltages and consequently, the destruction of the device.

Do not operate the device on a battery charger without a connected battery. (Limit values can be found in the technical data).

Visual Check

In the visual check the following must be included:

- Check the cubicle and the devices for damage;
- Check earthing of the cabinet and the device;
- Check quality and and completeness of externl cabling.

Acquisition of Technical Power System Data

For checking protection parameterization (allocation and settings) in accordance with power system requirements, it is necessary to record the technical data of the individual components in the primary system. This includes, among others, the data of generator or motor, unit transformer and voltage and current transformers.

Where deviations from the planning data are found, the settings of the protection must be modified accordingly.

Analog Inputs

The check of the current and voltage transformer circuits includes:

- Acquisition of technical data
- Visual check of transformers, e.g. for damage, assembly position, connections
- Check of transformer earthing, especially earthing of the broken delta winding in only one phase
- Checking the cabling in accordance with the circuit diagram
- Check of the short circuiters of the plug connectors for current circuits

Further tests may be required, depending on contract:

- Insulation measurement of cables
- Measurement of transformation ratio and polarity
- Burden measurement
- Checking the functions of test switches, if used for secondary testing.
- Measuring transducers/ Measuring transducer connection

Binary Inputs and Outputs

For more information, see also Section 3.3.

- Setting of binary inputs:
  - Check and match jumper allocation for pickup thresholds (see Section 3.1)
  - Check the pickup threshold – if possible – with a variable DC voltage source
- Check the tripping circuits from the command relays and the tripping lines down to the various components (circuit breakers, excitation circuit, emergency tripping, switchover devices etc.)
- Check the signal processing from the signal relays and the signal lines down to the station control and protection system; to do so, energize the signal contacts of the protective device and check the texts in the station control and protection system
- Check the control circuits from the output relays and the control lines down to the circuit breakers and disconnectors etc.
- Check the binary input signals from the signal lines down to the protective device by activating the external contacts

Voltage Transformer-Protective Switch

Since it is very important for the undervoltage protection, impedance protection and voltage-dependent definite time and inverse time overcurrent protection that these functions are blocked automatically if the circuit breaker for the voltage transformers has tripped, the blocking should be checked along with the voltage circuits. Switch off the voltage transformer protection switches.

One should check in the operational annunciations that the VT mcb trip was detected (annunciation „>FAIL:Feeder VT“ „ON“). A requirement for this is that the auxiliary contact of the VT mcb is connected and correspondingly allocated.

Close the VT mcb again: The above annunciations appear under the „going“ operational annunciations, i.e. with the comment „OFF“ (e.g. „>FAIL:Feeder VT“ „OFF“).

Note

The definite time overcurrent with undervoltage seal-in blocking must be realised with the binary input „>Useal-inBLK“ (1950)

If one of the indications does not appear, check the connection and allocation of these signals.

If the „ON“ and „OFF“ messages are exchanged, then the breaker auxiliary contact type should be checked and corrected if necessary.

3.3 Commissioning

WARNING!

Warning of dangerous voltages when operating an electrical device

Non-observance of the following measures can result in death, personal injury or substantial property damage.

Only qualified people shall work on and around this device. They must be thoroughly familiar with all warnings and safety notices in this instruction manual as well as with the applicable safety steps, safety regulations, and precautionary measures.

The device is to be grounded to the substation ground before any other connections are made.

Hazardous voltages can exist in the power supply and at the connections to current transformers, voltage transformers, and test circuits.

Hazardous voltages can be present in the device even after the power supply voltage has been removed (capacitors can still be charged).

After removing voltage from the power supply, wait a minimum of 10 seconds before re-energizing the power supply. This wait allows the initial conditions to be firmly established before the device is re-energized.

The limit values given in Technical Data (Chapter 10) must not be exceeded, neither during testing nor during commissioning.

When testing the device with secondary test equipment, make sure that no other measurement quantities are connected and that the TRIP command lines and possibly the CLOSE command lines to the circuit breakers are interrupted, unless otherwise specified.

DANGER!

Hazardous voltages during interruptions in secondary circuits of current transformers

Non-observance of the following measure will result in death, severe personal injury or substantial property damage.

Short-circuit the current transformer secondary circuits before current connections to the device are opened.

For the commissioning switching operations have to be carried out. A prerequisite for the prescribed tests is that these switching operations can be executed without danger. They are accordingly not meant for operational checks.

WARNING!

Warning of dangers evolving from improper primary tests

Non-observance of the following measures can result in death, personal injury or substantial property damage.

Primary test may only be carried out by qualified personnel, who are familiar with the commissioning of protection systems, the operation of the plant and the safety rules and regulations (switching, earthing, etc.).

3.3.1 Test Mode / Transmission Block

If the device is connected to a central or main computer system via the SCADA interface, then the information that is transmitted can be influenced. This is only possible with some of the protocols available (see Table „Protocol-dependent functions“ in the Appendix A.5).

If **Test mode** is set ON, then a message sent by a SIPROTEC 4 device to the main system has an additional test bit. This bit allows the message to be recognized as resulting from testing and not an actual fault or power system event. Furthermore it can be determined by activating the **Transmission block** that no indications at all are transmitted via the system interface during test mode.

The SIPROTEC 4 System Description /1/ describes how to activate and deactivate test mode and blocked data transmission. Note that when DIGSI is being used, the program must be in the **Online** operating mode for the test features to be used.

3.3.2 Testing System Interfaces

Prefacing Remarks

If the device features a system interface and uses it to communicate with the control centre, the DIGSI device operation can be used to test if messages are transmitted correctly. This test option should however definitely **not** be used while the device is in service on a live system.

DANGER!

Danger evolving from operating the equipment (e.g. circuit breakers, disconnectors) by means of the test function

Non-observance of the following measure will result in death, severe personal injury or substantial property damage.

Equipment used to allow switching such as circuit breakers or disconnectors is to be checked only during commissioning. Do not under any circumstances check them by means of the testing mode during „real“ operation performing transmission and reception of messages via the system interface.

Note

After termination of the hardware test, the device will reboot. Thereby, all annunciation buffers are erased. If required, these buffers should be extracted with DIGSI prior to the test.

The interface test is carried out using DIGSI in the Online operating mode:

- Open the **Online** directory by double-clicking; the operating functions for the device appear.
- Click on **Test**; the function selection appears in the right half of the screen.
- Double-click on **Testing Messages for System Interface** shown in the list view. The dialog box **Generate Annunciations** opens (refer to the following figure).

Structure of the Test Dialogue Box

In the column **Indication** the display texts of all indications are displayed which were allocated to the system interface in the matrix. In the column **Status SCHEDULED** the user has to define the value for the messages to be tested. Depending on the indication type, several input fields are offered (e.g. „ON“/ „OFF“). By double-clicking onto one of the fields the required value can be selected from the list.

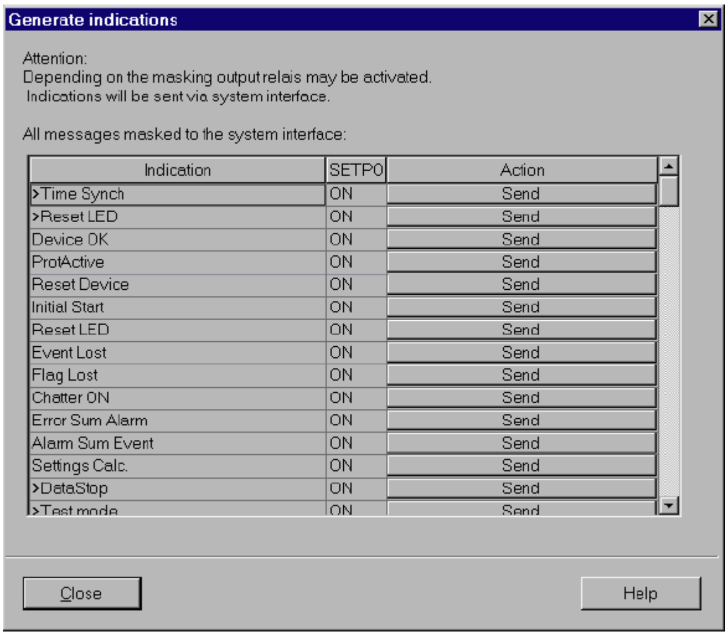


Figure 3-19 System interface test with dialog box: Generating indications – Example

Changing the Operating State

On clicking one of the buttons in the column **Action** you will be prompted for the password No. 6 (for hardware test menus). After correct entry of the password, individual annunciations can be initiated. To do so, click on the button **Send** in the corresponding line. The corresponding annunciation is issued and can be read out either from the event log of the SIPROTEC 4 device or from the substation control center.

As long as the window is open, further tests can be performed.

Test in Message Direction

For all information that is transmitted to the central station test in **Status Scheduled** the desired options in the list which appears:

- Make sure that each checking process is carried out carefully without causing any danger (see above and refer to DANGER!)
- Click on Send in the function to be tested and check whether the transmitted information reaches the central station and shows the desired reaction. Data which are normally linked via binary inputs (first character „>“) are likewise indicated to the central station with this procedure. The function of the binary inputs itself is tested separately.

Exiting the Test Mode

To end the System Interface Test, click on **Close**. The device is briefly out of service while the start-up routine is executed. The dialogue box closes.

3.3.3 Checking the Binary Inputs and Outputs

Prefacing Remarks

The binary inputs, outputs, and LEDs of a SIPROTEC 4 device can be individually and precisely controlled in DIGSI. This feature is used to verify control wiring from the device to plant equipment (operational checks) during commissioning. This test option should however definitely „not" be used while the device is in service on a live system.

DANGER!

Danger evolving from operating the equipment (e.g. circuit breakers, disconnectors) by means of the test function

Non-observance of the following measure will result in death, severe personal injury or substantial property damage.

Equipment used to allow switching such as circuit breakers or disconnectors is to be checked only during commissioning. Do not under any circumstances check them by means of the testing mode during „real" operation performing transmission and reception of messages via the system interface.

Note

After termination of the hardware test, the device will reboot. Thereby, all annunciation buffers are erased. If required, these buffers should be extracted with DIGSI prior to the test.

The hardware test can be carried out using DIGSI in the Online operating mode:

- Open the **Online** directory by double-clicking; the operating functions for the device appear.
- Click on **Test**; the function selection appears in the right half of the screen.
- Double-click in the list view on **Hardware Test**. The dialog box of the same name opens (see the following figure).

Structure of the Test Dialogue Box

The dialog box is divided into three groups: **BI** for binary inputs, **REL** for output relays, and **LED** for light-emitting diodes. On the left of each group is an accordingly labelled button. By double-clicking these buttons you can show or hide the individual information of the selected group.

In the column **Status** the current status of the particular hardware component is displayed. It is displayed symbolically. The actual states of the binary inputs and outputs are displayed by the symbol of opened and closed switch contacts, those of the LEDs by a symbol of a lit or extinguished LED.

The opposite state of each element is displayed in the column **Scheduled**. The display is made in plain text.

The right-most column indicates the commands or messages that are configured (masked) to the hardware components.

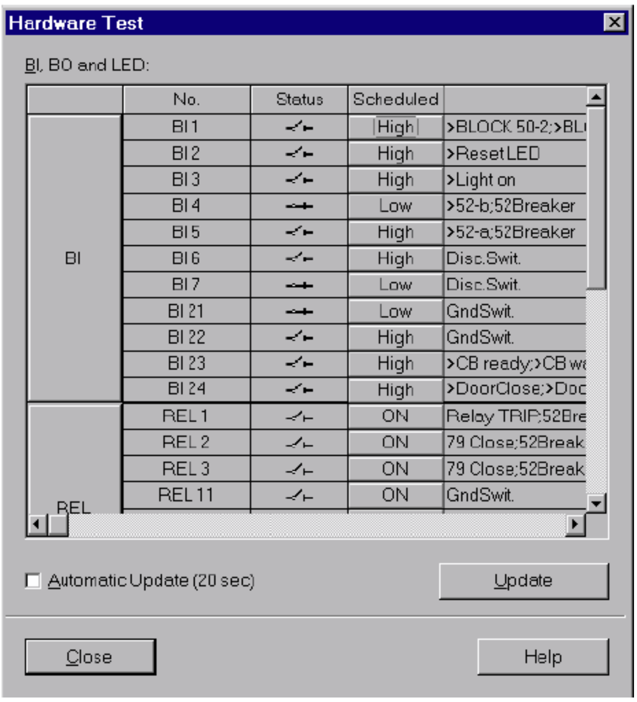


Figure 3-20 Test of the Binary Inputs and Outputs — Example

Changing the Operating State

To change the condition of a hardware component, click on the associated switching field in the **Scheduled** column.

Password No. 6 (if activated during configuration) will be requested before the first hardware modification is allowed. After entry of the correct password a condition change will be executed. Further condition changes remain possible while the dialog box is open.

Test of the Binary Outputs

Each individual output relay can be energized allowing a check of the wiring between the output relay of the 7UM62 and the system, without having to generate the message that is assigned to the relay. As soon as the first change of state for any of the output relays is initiated, all output relays are separated from the internal device functions, and can only be operated by the hardware test function. This means, that e.g. a TRIP command coming from a control command from the operator panel to an output relay cannot be executed.

Proceed as follows in order to check the output relay :

- Ensure that the switching of the output relay can be executed without danger (see above under DANGER!).
- Each output relay must be tested via the corresponding **Scheduled**-cell in the dialog box.
- The test sequence must be terminated (refer to margin heading „Exiting the Procedure“), to avoid the initiation of inadvertent switching operations by further tests.

Test of the Binary Inputs

To test the wiring between the plant and the binary inputs of the 7UM62, the condition in the system which initiates the binary input must be generated and the response of the device checked.

To do this, the dialog box **Hardware Test** must again be opened to view the physical state of the binary inputs. The password is not yet required.

Proceed as follows in order to check the binary inputs:

- Activate in the system each of the functions which cause the binary inputs.
- The response of the device must be checked in the **Status** column of the dialog box. To do this, the dialog box must be updated. The options may be found below under the margin heading „Updating the Display“.
- Terminate the test sequence (see below under the margin heading „Exiting the Procedure“).

If however the effect of a binary input must be checked without carrying out any switching in the plant, it is possible to trigger individual binary inputs with the hardware test function. As soon as the first state change of any binary input is triggered and the password no. 6 has been entered, all binary inputs are separated from the plant and can only be activated via the hardware test function.

Test of the LEDs

The LEDs may be tested in a similar manner to the other input/output components. As soon as you have initiated the first state change for any LED, all LEDs are disconnected from the functionality of the device and can only be operated by the hardware test function. This means e.g. that no LED is illuminated anymore by a device function or by pressing the LED reset button.

Updating the Display

During the opening of the dialog box **Hardware Test** the operating states of the hardware components which are current at this time are read in and displayed.

An update occurs:

- for each hardware component, if a command to change the condition is successfully performed,
- for all hardware components if the **Update** button is clicked,
- for all hardware components with cyclical updating (cycle time is 20 seconds) if the **Automatic Update (20sec)** field is marked.

Exiting the Test Mode

To end the hardware test, click on **Close**. The dialog box closes. The device becomes unavailable for a brief start-up period immediately after this. Then all hardware components are returned to the operating conditions determined by the plant settings.

3.3.4 Tests for Circuit Breaker Failure Protection

General

If the device is equipped with the breaker failure protection and this function is used, its interaction with the breakers of the power plant must be tested in practice.

Especially important for checking the system is the correct distribution of the trip commands to the adjacent circuit breakers in the event of breaker failure.

Adjacent circuit breakers are those which must trip in the event of a breaker failure in order to cut off the short-circuit current. Therefore these are the circuit breakers that feed the faulted line.

It is not possible to define a generally applicable, detailed test specification since the definition of adjacent circuit breakers depends to a large extent of the plant layout.

3.3.5 Testing Analog Outputs

The SIPROTEC devices 7UM62 can be equipped with up to 2x2 analog outputs. Where analog outputs are provided and used, their functioning should be tested.

Since various types of measured values or events can be output, the test to be performed depends on the values involved. These values must be generated (e.g. with secondary test equipment).

Make sure that the proper values are correctly output at their destination.

3.3.6 Testing User-defined Functions

CFC Logic

The device has a vast capability for allowing functions to be defined by the user, especially with the CFC logic. Any special function or logic added to the device must be checked.

Naturally, general test procedures cannot be given. Rather, the configuration of these user defined functions and the necessary associated conditions must be known and verified. Of particular importance are possible interlocking conditions of the switchgear (circuit breakers, isolators, etc.).

3.3.7 Checking the Rotor Earth Fault Protection at Standstill

Rotor Earth Fault Protection (R, fn)

The rotor earth fault protection can be checked with the machine at standstill. For this purpose, the coupling device must be fed an external AC voltage. This may be 100 V to 125 V or 230 V (see also connection example in Section 2.34).

Switch rotor earth fault protection (address 6001 **ROTOR E/F**) to ***Block relay***.

In the case of machines with rotating rectifier excitation (following Figure, left), a dead earth fault is applied between the two measurement slip rings with measurement brushes in place, for machines with excitation via slip rings (following Figure, right) between one slip ring and earth. The device now measures as earth impedance only the reactance of the coupling unit and the brush resistance (as the case may be in series with a protection resistor for the coupling capacitors and a current-limiting resistor with inductive/capacitive coupling).

These values can be read out with the phase angle of this complex resistance under the earth fault measured values:

Rtot = x.xx kΩ

Xtot = y.yy kΩ

φ**Ztot** = z.z °

$R_{tot.}$ corresponds to the series resistance (brushes plus protection and limiting resistor) and $X_{tot.}$ to the coupling reactance. If both for $R_{tot.}$ and for $X_{tot.}$ values are indicated as 0, then the connections of U_{RE} or I_{RE} have wrong polarity. Change the polarity of one of the connections and repeat the measurement.

It must then be checked/remedied that the setting values

R SERIES = xxx Ω (address 6007)

X COUPLING = yyy Ω (address 6006)

correspond to the above values. Remove earth fault bridge.

Now using a resistor of the size of the warning resistance (**RE< WARN**, address 6002, 10 kΩ on delivery) an earth fault is simulated as above. The earth resistance calculated by the unit can be read out under the Operational Measured Values as R_{earth}. If substantial deviation occurs between the actual and the indicated earth resistances, the matching improvement can be attempted by correcting the preset angle error forI_{RE} **PHI I RE** at address 6009. This angle error correction is only effective for the rotor earth fault protection function.

An earth fault is now simulated as above using a resistor of approximately 90% of the trip resistance (**RE<< TRIP**, address 6003, 2 kΩ on delivery). The rotor earth fault protection initiates a pickup signal and after 6005 **T-TRIP-RE<<** (0.5 s on delivery) a trip indication (LED 1 and output relay 2), in both cases as a group indication device trip).

For machines with excitation via slip rings, the last test is repeated for the other slip ring.

Remove earth fault resistor.

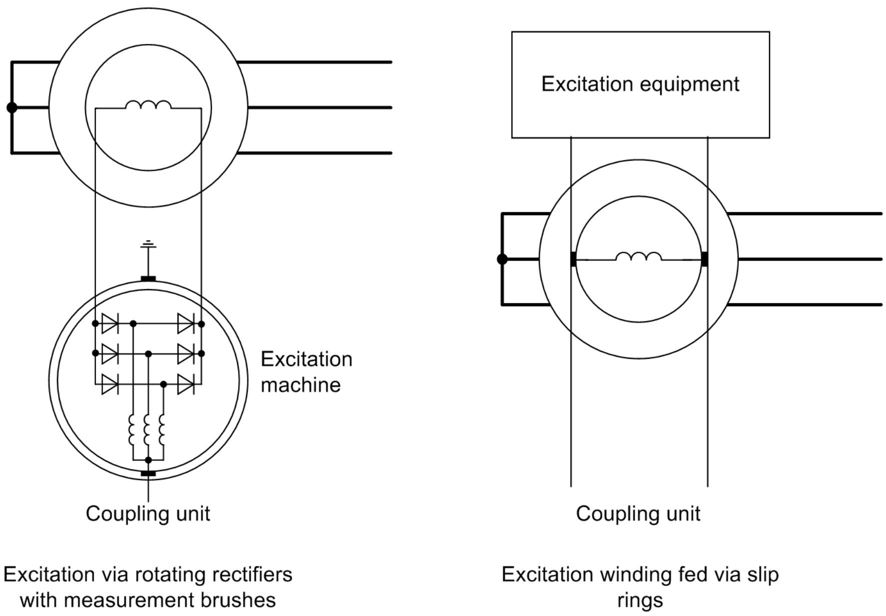


Figure 3-21 Types of excitation

Lift measurement brushes or interrupt measurement circuit. After a delay of approx. 5 s, the indication „Fail. REF IEE<“ is issued (not allocated on delivery). Reclose the measuring circuit.

If the indication „Fail. REF IEE<“ is present even with closed measuring circuit, the rotor-earth capacity is less than 0.15 µF. In this case, measuring circuit monitoring is not possible; the indication „Fail. REF IEE<“ should not be allocated to a binary output and deactivated (parameter 5106 **IEE<** = 0).

Finally check that all provisional measures for testing have been removed:

- Earthing bridge or resistor has been removed,
- Measurement circuits have been closed,
- Coupling unit connected to its AC supply voltage (see also connection example in Section 2.34).

An operational test with the running machine will be done later as described in Section “Checking the Rotor Earth Fault Protection During Operation“.

Rotor Earth Fault Protection (1 to 3 Hz)

The rotor earth fault protection can be checked with the machine at standstill. For this the series device 7XT71 must be fed an external AC voltage. This is 100 V to 125 V AC (see also connection example in Appendix A.3).

Switch rotor earth fault protection (address 6101 **REF 1-3Hz**) to ***Block relay***.

The following operational measured values are read out and evaluated under fault-free conditions (see Table 3-28). The operational measured values are under earth fault measured values (in DIGSI see tab „Earth Fault Measured Values“).

Table 3-28 Operational measured values of the rotor earth fault protection

Measured Value	Explanation
fgen = xx.x Hz	Shows the frequency of the injected square-wave voltage. The frequency can be set by a jumper in the 7XT71. The default setting is approx. 1.5 Hz (tolerance approx. ± 10 %).
Ugen = xx.x V	This measured value indicates the present amplitude of the injected square-wave voltage. The measured value amounts to approx. 50 V (tolerance of the 7XT71 can be up to ± 4 V).
Igen = X.xx mA	This measured value is nearly zero in fault-free conditions. If a fault resistor is installed between rotor and earth, the current to be expected can be estimated as follows: $I_{gen} \approx \frac{U_{gen}}{R_E + R_{tot}}$ R_E: Fault resistance R_{tot}: Coupling resisitance (20 kΩ + 720 Ω = 20.720 kΩ)
Qc = x.xxx mAs	This measured value indicates the charge which is a function of the rotor earth capacitance. Half of the measured value must be set at address 6106 as **Qc** <. If the capacitance is very small, it may be necessary to deactivate the measuring circuit monitoring (setting value 0).
Rearth = xxx.x kΩ	This measured value indicates the rotor earth resistance. In fault-free condition, the upper limit value 999.9 kΩ is displayed. If it is not, there must be some additional capacitances in the excitation system. The square-wave voltage frequency in the 7XT71 must be reduced by a jumper. No polarity reversal may occur in the measuring current **Igen** for at least 3 cycles. To visualise what is going on, a test fault record (instantaneous values record) should be started and track TD2, which traces Igen, should be checked (see following Figure).

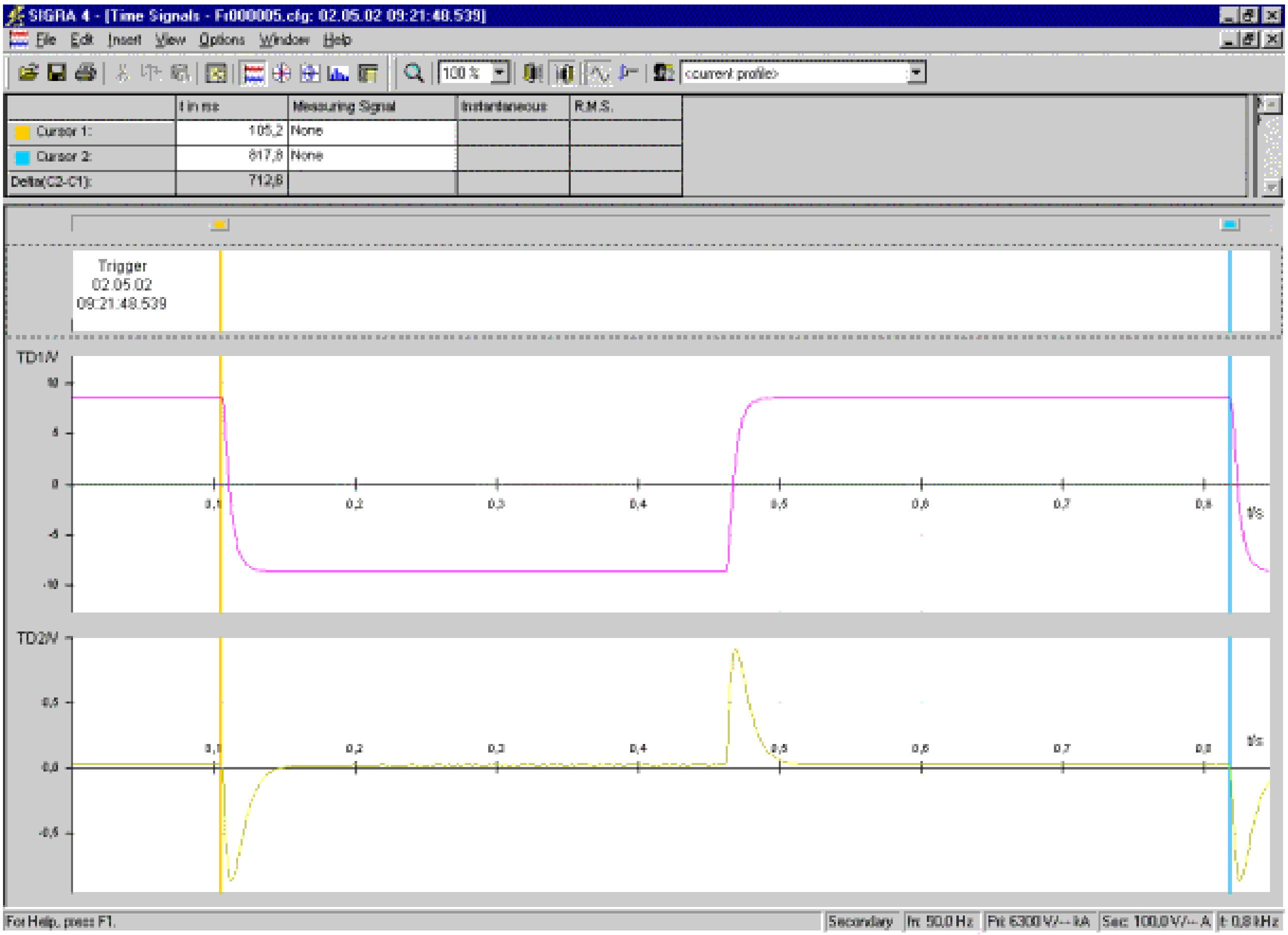


Figure 3-22 Test fault recording

After this the fault resistors for the warning and the trip stage are installed, and the operational measured value R_{earth} is read out. The two measured values are the basis for the setting values of the warning stage (address 6102 **RE< WARN**) and the trip stage (address 6103 **RE<< TRIP**).

Finally, the warning and the trip stage are checked. The test resistance for this is approx. 90 % of the set value. On machines with slipring excitation, the test is performed for both sliprings.

Remove the earth fault resistor and lift the measuring brushes or interrupt the measuring circuit. After a delay of approx. 10 s, the indication „REF 1-3Hz open“ is issued (not allocated on delivery). Reclose the measuring circuit.

If you want to perform an automatic test by means of a test resistor, this mechanism needs to be tested as well. For this purpose, connect the test resistor at the slipring to the earth, and activate the test via binary input („>Test REF 1-3Hz“).

Next check the indications for the four test steps to be performed.

1. Measurement circuit has been closed, Indications „Test REF PASSED“

2. Open connection at 1st coupling resistor Indication „1 Cir. open“

3. Open connection at 2nd coupling resistor Indication „2 Cir. open“

4. Reestablish connections Indication „Test REF PASSED“

Stop the automatic test and check again the operational measured value R_{earth}. It must display 999.9 kΩ.

Finally switch the AC voltage source of the 7XT71 off. After about 5 s the protection device issues the indication „`Fail REF 1-3Hz`“ (not allocated on delivery).

To eliminate interference which might originate from the running machine, in particular from the excitation system, it is recommended to perform an additional operational check.

3.3.8 Checking the 100 % Stator Earth Fault Protection

100 % Stator Earth Fault Protection

The 100-% stator earth fault protection can be checked with the machine at standstill, because the measuring principle for the earth resistance calculation is independent of whether the machine is at standstill, rotating or excited. A prerequisite is, however, that the 20 Hz generator 7XT33 must be supplied with a DC voltage or an external voltage source (3 x 100 V, 50/60 Hz), depending on the project, (see also the connection examples in Section 2.31).

Switch the 100-% stator earth fault protection (address 5301 **100% SEF-PROT.**) to ***Block relay***).

The following parameter default settings must be maintained for a first commissioning.

5309 **PHI I SEF** = 0 °

5310 **SEF Rps** = 0.0 Ω

5311 **Rl-PARALLEL** = ∞ Ω

The measured quantities U_{SEF} and I_{SEF} fed to the device can now be read out in the earth fault measured values (in DIGSI under Earth fault measured values):

„U SEF=“ xx.x V

„U20=“ xx.x V

„I SEF=“ xx.x mA

„I20=“ xx.x mA

Please note that these measurements U SEF and I SEF are pure rms values which only correspond to the 20 Hz quantities (U20 and I20) if the generator is at standstill. The voltage measured is influenced by the loading resistor R_L, the 20 Hz resistance of the bandpass (R_{BP} approx. 8 Ω), the voltage divider ($ü_{Vlt.Divider}$, usually 5/2) and, in the final analysis, by the 20 Hz supply voltage ($U_{20Hz\text{-}Generator}$, approx. 25 V). The value can be estimated as follows:

$$U_{SEF} = \frac{R_L}{R_{BP} + R_L} \cdot \frac{U_{20\ Hz\text{-}Generator}}{VD_{Ratio}}$$

The flowing current I_{SEF} is determined by the stator earth capacitance and is very small.

From these values, the device calculates the earth resistance R_{SEF} referred to the protection device side. The primary earth resistance R_{SEFp}on the machine side is obtained by multiplying the secondary value with the conversion factor set in the Power System Data 1 (address 275 **FACTOR R SEF**). Both resistance values, including the phase angle between the 20 Hz voltage and the 20 Hz current ($\varphi_{SEF} = \varphi_U - \varphi_I$) can be read out in the operational measured values:

„R SEF=“ xxxx Ω

„RSEFp=“ xxx.xx kΩ

PHI I SEF xx.x°

DANGER!

In the generator, voltage hazardous to the stator winding can be caused by external 20 Hz bias voltage, even at standstill.

Non-observance of the following procedures will result in death, serious injury or substantial property damage, since 1% to 3% of the primary rated voltage of the generator being protected may be present.

The external 20 Hz bias voltage of the stator winding must be disconnected before doing work on the generator at standstill.

Proceed as follows:

- Under fault-free conditions (R_E infinite), the measured angle must be negative due to the capacitive earth current. If it is not, the connection at the current input must be rotated. The phase angle „φ SEF=“ should be about –90° due to the existing stator capacitances. If it is not, the value to complement it to –90° must be determined and set as **PHI I SEF** = –90° – φ SEF. For a display value of e.g. „φ SEF=“ –75°, under address 5309 **PHI I SEF** = –15° is set. This will change the measured value to approx. –90°.

  In fault-free condition, the value displayed for **R SEF** must be in fault-free condition the maximum possible value of 9999 Ω. The maximum value for the primary earth resistance **R SEFp** depends on the selected conversion factor (**FACTOR R SEF** address 275).

- A short-circuit (R_E = 0 Ω) is created in the generator starpoint, and the measured fault resistance (address „R SEF=“) read out from the operational measured values. This resistance is set at address 5310 **SEF Rps**.

- Insert now on the primary side a resistance which corresponds to the tripping value (e.g. 2 kΩ). Check the measured fault resistance („R SEF=“). If this resistance differs very much from the value expected, modify **SEF Rps** accordingly and, if necessary, make a fine adjustment with the correction angle (**PHI I SEF**). Read out finally the fault resistance, and set this value as the tripping threshold at address 5303 **R<< SEF TRIP**.

  Next, insert a fault resistance for the alarm stage (e.g. 5 kΩ) on the primary side, and read out the fault resistance („R SEF=“) from the operational measured values. This value is set at address 5302 as **R< SEF ALARM**.

- Switch off the voltage supply for the 20 Hz generator, or block the binary input. The indication „SEF100 Failure“ will appear (not allocated on delivery). This ensures that a failure of the 20 Hz generator is reliably detected. If this indication occurs already with the 20 Hz generator in operation, the monitoring threshold (address 5307 **U20 MIN**) should be reduced. This can be the case if the loading resistances are very small (< 1 Ω).

- Finally, a series of measurements is performed, starting with 0 kΩ and proceeding in steps of 1 kΩ. If changes are made to the correction angle (**PHI I SEF** address 5309) or to the contact resistance (**SEF Rps**, address 5310), the settings for the trip stage (**R<< SEF TRIP**) and the alarm stage (**R< SEF ALARM**) must be matched as required.

- Now the earth resistance is reduced to about 90 % of the resistance for the alarm stage (address 5302 **R< SEF ALARM**). After the delay time **T SEF ALARM** (10.00 s on delivery), set at address 5303, the stator earth fault protection issues an alarm „SEF100 Alarm“ (not allocated on delivery).

  Further reduce the earth resistance to 90 % of what the trip stage pickup value would be for the protection device side (**R< SEF ALARM**, address 5303). The protection issues a pickup indication and after **T SEF TRIP** address 5305 (on delivery), a trip indication.

  Remove the test resistor.

Note

For the settings, only secondary values should be used. If you find during the conversion from secondary to primary values that the theoretical conversion factor is not quite correct, **FACTOR R SEF** should be modified to match the measuring results (for conversion formulae refer to Section 2.31.2).

If the indication „20 Hz voltage missing“ to be received from the 20 Hz generator is allocated to one of the binary inputs, and the delivery setting of this input has been changed for this purpose, the binary input can be checked as well.

Switch off the supply voltages of the 20 Hz generator.

Feedback „>U20 failure“ (not allocated on delivery).

Indication „SEF100 Failure“ (not allocated on delivery).

Reconnect the supply voltages of the 20 Hz generator.

If you make use of the possibility to block the 100% stator earth fault protection by binary input, the functioning of the input should be checked.

Activate binary input „>SEF100 BLOCK“.

Feedback „SEF100 BLOCKED“.

Further tests are performed with the machine running.

Note

If within the framework of routine tests the band pass 7XT34 is to be checked as well, short-circuit the earthing or neutral transformer on the secondary side with the machine standing still, and switch the 20 Hz generator on. Multiply the operational measured value I_{SEF} with the transformation ratio of the miniature CT (e.g. 400 A/ 5 A). The flowing current must exceed 3 A. If the current is significantly less, the resonance frequency of the bandpass has changed. It can be better matched by adding or removing capacitors (see also operating instructions for the 7XT33, Order No. C53000–B1174–C129).

Finally, remove the shorting link and check the galvanic isolation with the operational measured value **U SEF** .

3.3.9 Checking the DC Voltage / DC Current Circuit

Preparation

Set the DC voltage/DC current protection (address 7201 **DC PROTECTION**) to ***Block relay***.

You can now modify the plant voltage to match the conditions of the intended application, and verify the response of the 7UM62. Overshoot or undershoot (selected at address 7203) of the threshold voltage (address 7204) is followed by indication „DC Prot.pick.up“ (not allocated on delivery), and after a time **T DC** = (address 7206) indication „DC Prot. TRIP“ (not allocated on delivery).

The DC voltage protection is then enabled (address 7201 **DC PROTECTION** = ***ON***) or – if it will not be used – disabled (**DC PROTECTION** = ***OFF***).

3.3.10 Trip/Close Tests for the Configured Operating Devices

Control by Local Command

If the configured operating devices were not switched sufficiently in the hardware test already described, all configured switching devices must be switched on and off from the device via the integrated control element. The feedback information of the circuit breaker position injected via binary inputs is read out at the device and compared with the actual breaker position. For devices with graphic display, this is easy to do with the control display.

The switching procedure is described in the SIPROTEC 4 System Description. The switching authority must be set in correspondence with the source of commands used. With the switching mode, you can choose between locked and unlocked switching. In this case, you must be aware that unlocked switching is a safety risk.

Switching from a Remote Control Centre

If the device is connected to a control centre via a system interface, the corresponding switching tests may also be checked from the control centre. Please also take into consideration that the switching authority is set in accordance with the source of commands used.

3.3.11 Commissioning Test with the Machine

General Information

WARNING!

Warning of hazardous voltages when operating electrical devices

Nonobservance of the following measure will result in death, severe personal injury or substantial property damage.

Only qualified people shall work on and around this device. They must be thoroughly familiar with all warnings and safety notices in this instruction manual as well as with the applicable safety regulations, and precautionary measures.

For the commissioning switching operations have to be carried out. A prerequisite for the prescribed tests is that these switching operations can be executed without danger. They are accordingly not meant for operational checks.

WARNING!

Warning of dangers evolving from improper primary tests

Non-observance of the following measures can result in death, personal injury or substantial property damage.

Primary test may only be carried out by qualified personnel, who are familiar with the commissioning of protection systems, the operation of the plant and the safety rules and regulations (switching, earthing, etc.).

Safety Instructions

All relevant safety rules and regulations (e.g. VDE 105, VBG4 or comparable national regulations) must be complied with.

Before undertaking any work, observe the following „5 safety rules“:

- De-energize
- Secure against reswitching on
- Establish absence of voltage
- Earth and short circuit
- Cover or fence in live parts in the vicinity

In addition the following must be observed:

- Before making any connections, the device must be earthed at the protective conductor terminal.
- Hazardous voltages can exist in all switchgear components connected to the power supply and to measurement and test circuits.
- Hazardous voltages can be present in the device even after the power supply voltage has been removed (capacitors can still be charged).
- After removing voltage from the power supply, wait a minimum of 10 seconds before reenergizing the power supply. This allows defined initial conditions when the device is re-energized.
- The limit values specified in the Technical Data (section 4.1) must not be exceeded, not even during testing and commissioning.

DANGER!

Hazardous voltages during interruptions in secondary circuits of current transformers

Nonobservance of the following measure will result in death, severe personal injury or substantial property damage.

Short-circuit the current transformer secondary circuits before current connections to the device are opened.

If test switches are installed that automatically short-circuit the current transformer secondary circuits it is sufficient to place them into the „Test“ position provided the short-circuit functions have been previously tested.

All secondary test equipment should be removed and the measurement voltages connected. The operational preparations must be completed. Primary tests are performed with the generator.

Testing Sequence

Primary testing is usually performed in the following order:

- Short circuit tests
- Voltage tests
- Earth fault tests
- Synchronization
- Load measurements at the network

The following instructions are arranged in this sequence. All protection functions should be initially switched off (condition as delivered from factory) so that they do not influence one another. With the primary tests, they will then be activated one after the other. If a protection function is not required at all, it should be set in the configuration as ***Disabled*** (see Section 2.4.2). It is then ignored in the 7UM62device.

The effective switching of a protection function configured as ***existing*** can occur in two ways. The setting addresses concerned are shown in the respective sections.

- Protection function ***Block. Relay*** : The protection function is operative and outputs indications (also tripping indications) and measured values. However, the trip commands are blocked and not transmitted to the trip matrix.
- Protection function ***On***: The protection function operates and issues indications. The trip command activates the trip relay allocated for the protection function. If the protection command is not allocated to any trip relay, tripping does not occur.

Preparation

Please perform the following preparatory commissioning steps:

- Install an EMERGENCY OFF button for direct trip of the excitation
- Block all protection functions (= ***Block. Relay***)
- Set the instantaneous time-overcurrent protection function roughly to the nominal generator current, with tripping for excitation
- Set the instantaneous overvoltage protection function roughly to 30 % of the nominal generator voltage for the short-circuit test, and to roughly 110 % of the nominal voltage for the voltage tests, with tripping for excitation

Sampling Frequency Adaptation

The device contains integrated frequency correction; this ensures that the protection functions are always processed with algorithms matched to the actual frequency. This explains the wide frequency range and the small frequency influence (refer to Section 4.34, Technical Data). However this requires that measurement values be present before a dynamic test can take place, so that the frequency correction can operate. If a measurement value of 0 is switched in without a different measurement value having been present beforehand, an additional time delay of approximately 120 ms is incurred since the device must firstly calculate the frequency based on the measurement value. Likewise no output signal is possible if no measurement value is connected. A trip signal, once issued, of course, is maintained for at least the duration of the parameterized reset time (**TMin TRIP CMD**) (refer also to Section 2.5)

Factory Setting

When the protection device is delivered from the factory, all protective functions are switched off. This has the advantage that each function can be separately tested without being influenced by other functions. The required functions must be activated for testing and commissioning.

Operating Range of the Protection Functions

For commissioning tests with the generator, care should be taken that the operating range of the protection functions as specified in section 4 is not exceeded and that the measuring quantities applied are high enough. Where tests are performed with reduced pickup values, the pickup value may appear to deviate from the setting value (e.g. in the unbalance load stage or the earth fault protection) if the protection function is blocked because the measured values are still too small, i.e. if operating state 1 (= protection function active) is not yet attained.

However, this effect will not interfere with commissioning since no checks of the pickup values are performed that involve the machine anyway.

Commissioning Tool Using a WEB Browser

The 7UM62 features a web-based commissioning tool, to assist during commissioning, and to perform routine tests. With this tool all indications and measured values can be easily read out. For testing purposes, vector diagrams and selected characteristics can be visualized.

If you want to use the „commissioning tool“, please refer to the „help files“ provided on the subject. You will find the Web Monitor on the Internet (www.siprotec.de) under download area → Programs.

The IP address required for the browser depends on the port used for connecting the PC. The following IP addresses are preset:

- Connection to the front **operator interface:**
  - **IP address 141.141.255.160** for 7UM62 V4.0 to V4.1
  - **IP address 192.168.2.1** for 7UM62 V4.6
- Connection to the rear **service interface** (port C):
  - **IP address 141,143,255,160** for 7UM62 V4.0 to V4.1
  - **IP address 192.168.2.1** for 7UM62 V4.6
- Connection to the rear **system interface** if Ethernet is used (port B):
  - **IP address 0.0.0.0** (7UM62 V4.6 or better)

The procedure is described in detail in the SIPROTEC 4 System Description /1/ under „Setting Interface Settings for a SIPROTEC 4 Device“.

To give you a first idea of the possibilities available, the figures below present a selection of displays.

The following Figure shows the vectors of flowing currents. As the current direction towards the protected object is defined as positive, the angle of the phase currents is rotated by 180°. The magnitudes are the same, and the phase rotation is the same as well. This means that the current connection on side 1 and side 2 is OK. A similar display is available for the voltage and current vectors of side 2.

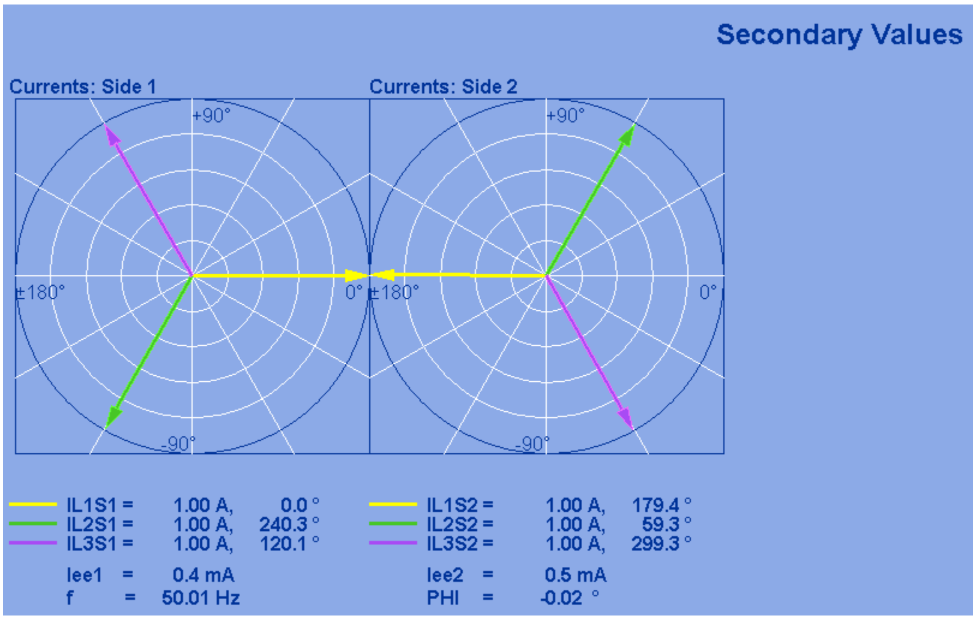


Figure 3-23 Phasor diagram of the secondary measured values — Example

For a test of the differential protection, the differential and restraint currents are entered in the characteristic. The characteristic shown is a result of the settings for the differential protection. In Figure 3-24, a load current has been simulated. A small differential current in phase L3 is visible.

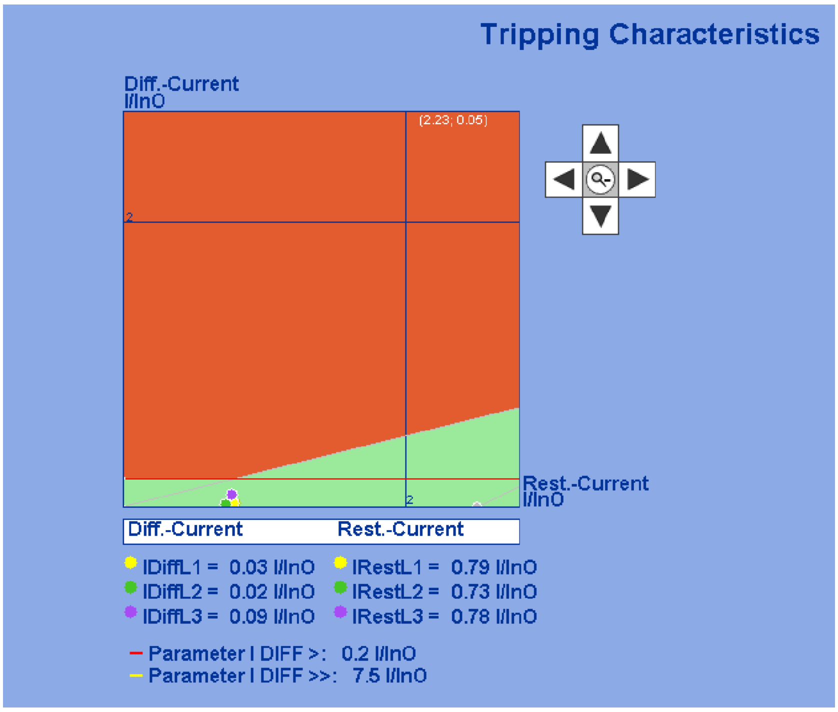


Figure 3-24 Differential and Stabilization (Restraint) Currents — Example for Plausible Currents

3.3.12 Checking the Current Circuits

General

The checks of the current circuits are performed with the generator to ensure correct CT circuit connections with regard to cabling, polarity, phase sequence, CT ratio etc., not in order to verify individual protection functions in the device.

Preparation

Switch unbalanced load protection (address 1701) and overload protection (address 1601) to ***Block. Relay***. With the primary system voltage-free and earthed, install a three-pole short-circuit bridge which is capable of carrying rated current (e.g. earthing isolator) to the generator line-side terminals.

DANGER!

Primary measurements may only be carried out with the generator at stand–still on disconnected and grounded equipment of the power system.

After the preparatory measures all current transformer circuits (protection, measuring, metering etc.) can be checked with the remanent excitation.

Test Instruction

Then the checks of the current transformer circuits are carried out with max. 20 % of the rated transformer current. Tests with generator currents of more than 20 % are not normally required for digital protection. Operation of the generator at rated current during commissioning may only be necessary when the short-circuit characteristic is measured for the first time.

Amplitude Values

The currents can be read out from the device front panel or from the PC via the operator interface under operational measured values and compared with the actual measured values. If significant deviations are found, the CT connections are not correct.

Phase Rotation

The phase rotation must conform to the configured phase sequence (address 271 under **Power System Data 1**); otherwise an indication „Fail Ph. Seq.“ will be output. The allocation of measured values to phases must be checked and corrected, if necessary. The negative sequence component I2 of the currents can be read out under the operational measured values. It must be approximately zero. If this is not the case, check for crossed current transformer leads:

If the unbalanced load amounts to about **1/3** of the phase currents then current is flowing in **only one** or in **only two** of the phases.

If the unbalanced load amounts to about **2/3** of the phase currents, then one current transformer has **wrong polarity**.

If the unbalanced load is about **the same** as the phase currents, then two phases have been **crossed**.

After correcting the wrong connection, the test must be repeated.

Remove short circuit bridges.

Calibrating the Impedance Protection

Switch impedance protection (address 3301) to **IMPEDANCE PROT.** = ***Block relay***.

With the primary system voltage-free and earthed, install a three-pole short-circuit bridge which is capable of carrying rated current (e.g. earthing isolator) to the primary side of the unit transformer.

DANGER!

Primary measurements may only be carried out with the generator at stand–still on disconnected and grounded equipment of the power system.

Start up machine slowly and excite to 20 % of rated machine current.

Test Instruction

A test with about 20 % of the rated generator current is sufficient for checking the transformer connections and the operational measured values. If the relative short-circuit voltage of the transformer is small, the voltage values measured are very low, so that it may be necessary to increase the generator current somewhat. A test with the full rated generator current is only required for the quantitative calibration of the impedance protection (e.g. for calibrating the transformer u_{SC}).

From the currents and voltages, the protection device calculates the impedance between the point of installation of the voltage transformer set and the short-circuit position, which is mainly established by the short-circuit impedance of the unit transformer. Reactance and resistance values can be read out under operational measured values. For this the protection device automatically considers the rated device current 1 A or 5 A. In the present case for transformer impedance, the following results:

Primary transformer impedance:

$$Z_{T\ prim} = u_{SC} \cdot \frac{U_N^2}{S_N}$$

with

u_{SC} . - relative transformer short-circuit voltage

U_N . - Rated transformer voltage

S_N . - Rated transformer power

In secondary values:

$$Z_{T\ sec} = Z_{T\ prim} \cdot \frac{CT_{Ratio}}{VT_{Ratio}} = u_{SC} \cdot \frac{U_N^2}{S_N} \cdot \frac{CT_{Ratio}}{VT_{Ratio}}$$

with

CT_{Ratio}. - Current transformer ratio

VT_{Ratio}. - Voltage transformer ratio

If substantial deviations or wrong sign occur, then the voltage transformer connections are incorrect.

After shutdown and de-excitation of the generator, and removal of the short-circuit bridge, the short-circuit tests are completed. **No further tests are required for unbalanced load protection, overcurrent time protection, thermal overload protection, impedance protection and out-of-step protection.**

The time-overcurrent protection and the impedance protection are activated (address 1201: **O/C I>** = ***ON*** or address 1401 **O/C Ip** = ***ON***, address 3301: **IMPEDANCE PROT.** = ***ON***) and work immediately as a short-circuit protection for all subsequent tests. If used, address 1301 **O/C I>>** = ***ON***, the thermal overload protection (address 1601: **Ther. OVER LOAD** = ***ON***), the unbalanced load protection (address1701: **UNBALANCE LOAD** = ***ON***) and the out-of-step protection (address 3501: **OUT-OF-STEP** = ***ON***) can be activated. Otherwise, they are set to ***Off***.

3.3.13 Checking the Differential Protection

Preparation

Before commencing any primary tests, make sure that the configured object is actually the one you want to protect, and that the amplitude matching for the current ratings of the protected object and the main primary CTs, and the vector group matching are correctly set.

Switch differential protection (address 2001) to **`Block relay`** or interrupt the tripping commands.

The test arrangement varies with the application.

On network power transformers and asynchronous machines, a low-voltage test is preferably conducted, where low-voltage current source is used to energize the protected object, which is completely disconnected from the network (Figure 3-25). A short-circuit bridge, which is capable of carrying the test current, is installed outside the protected zone and allows the symmetrical test current to flow.

For power station unit transformers and synchronous machines, the tests are performed during the current tests, with the generator itself supplying the test current (Figure 3-26). The current is produced by a short-circuit bridge which is installed outside the protected zone and is capable of carrying generator rated current for a short time. In such a case after the machine is started but not yet excited, a check is made using remanence currents that no current transformer circuit is open or short-circuited. In order to achieve this, read out the operational measured values and check all operational currents one by one. Even if the currents and the measurement accuracy are very small, such errors can actually be detected.

The current for commissioning tests must be at least 2 % of the rated device current.

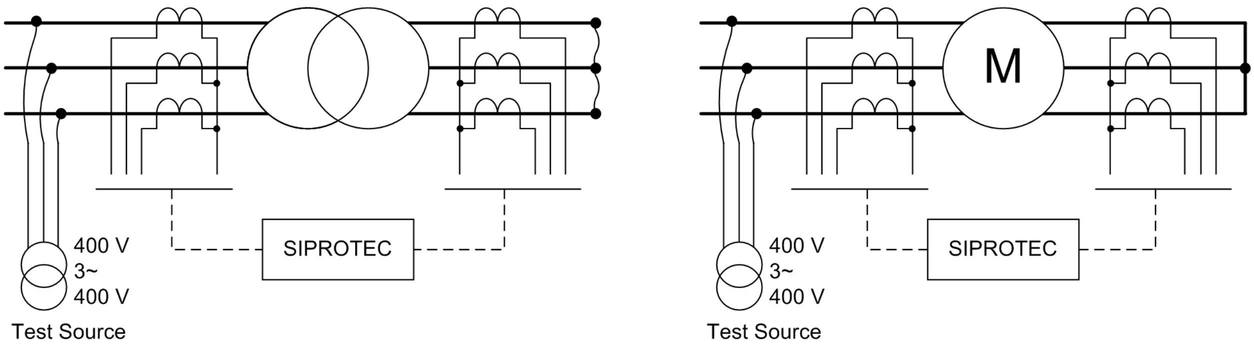


Figure 3-25 Current check with low-voltage current source

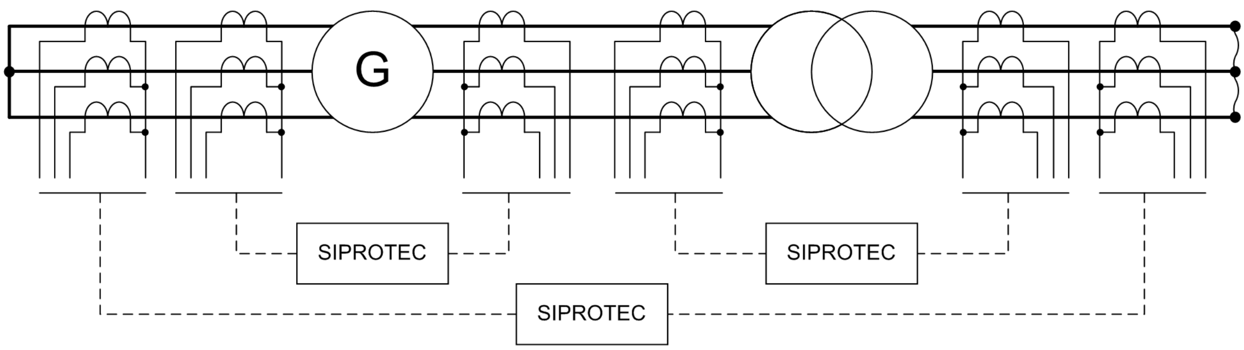


Figure 3-26 Current test in the power station

Symmetrical Current Test

The operational measured values supplied by the 7UM62 device allow a fast commissioning without external instruments. The indices of the measured currents are as follows:

The symbol for current I is followed by the phase identifier Lx and by the index of the side of the protected object (e.g. the transformer winding). Example:

IL1S1 Current in phase L1 on side 1.

Absolute Value Measurement

Compare the current magnitudes under **Measurement → Secondary Values → Operational values secondary** with the actually flowing values:

IL1S1 =

IL2S1 =

IL3S1 =

IL1S2 =

IL2S2 =

IL3S2 =

If deviations occur that cannot be explained by measuring tolerances, either a connection or the test setup is wrong:

- Disconnect the protected object (shut down generator), and earth it,
- Re-check the plant connections to the device and the test arrangement and correct them.
- Repeat measurement and recheck measured values.

Angle Measurement

If the current magnitudes are consistent, the next step is to check the phase angle relations between the currents (φIL1S1, φIL2S1, φIL3S1, φIL1S2, φIL2S2, φIL3S2). The angle differences are in each case referred to winding L1 of side 1.

Check the phase angle under **Measurement → Secondary Values → Phase angles** of side 1 of the protected object. All angles are referred to IL1S1.

Consequently, a clockwise phase rotation should produce roughly the following results:

φL1S1 = 0°

φL2S1 = 240°

φL3S1 = 120°

If the angles are not correct, wrong polarity or connection phase interchange at side 1 is the cause.

- Disconnect the protected object (shut down generator), and earth it,
- Re-check the plant connections to the device and the test arrangement and correct them.
- Repeat measurement and recheck measured values.

Check the phase angle under **Measurement → Secondary Values → Phase angles** of side 2 of the device. All angles are referred to IL1S1. If the angles are not correct, wrong polarity or line phase interchange at side 2 is the cause; proceed as for side 1.

The angles of the through-flowing currents between the different sides of the protection object are defined such that a current of equal phase flowing through the protected object, provided that the connections are correct, produces the angle difference at the two measuring points of 180° between currents of the same phase. Exception:Transverse differential protection where both currents must be in phase!

The theoretical angles depend on the protected object and – in the case of transformers – on the vector group. They are listed in Table 3-29 for clockwise phase rotation.

The polarity of the CT connections and the parameterized polarity are taken into consideration for the angles displayed. Thus, if all three angles differ by 180° from the theoretical value, the polarity of one complete transformer set is wrong.

This can be corrected by checking and changing the corresponding system parameters:

Address 201 **STRPNT->OBJ S1** for primary winding,

Address 210 **STRPNT->OBJ S2** for secondary winding

Table 3-29 Displayed phase angle dependent on the protected object (three phase)

Protected object →	**Generator/Motor**	**Transformer with Vector Group Numeral [1)]**											
→ Power Angle		**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
φL1L2	180°	180°	150°	120°	90°	60°	30°	0°	330°	300°	270°	240°	210°
φL2L2	60°	60°	30°	0°	330°	300°	270°	240°	210°	180°	150°	120°	90°
φL3L2	300°	300°	270°	240°	210°	180°	150°	120°	90°	60°	30°	0°	330°

[1)] Angles are valid if the high voltage side is defined as side 1, Otherwise, the angles of vector group 12–x (x = set vector group) apply.

Differential and Restraint Currents

Before the tests with symmetrical currents are terminated, the differential and restraint currents are examined. Even though the symmetrical tests which have been carried out so far should have revealed more or less all possible connection errors, matching errors or wrong vector group allocations cannot be ruled out.

Under the operational mesured values you can read out the calculated values. Note that differential and restraint values are referred to the rated current of the protected object. This must be considered when they are compared with the test currents.

If considerable differential currents occur, recheck the following parameters:

For transformer protection:

Addresses 241, 249 and 202 (matching winding 1), 243, 249 and 211 (matching and vector group winding 2);

For generator or motor protection:

Addresses 251 and 252 (matching of machine ratings);

The symmetrical current tests are now completed. Disconnect the protected object (shut down generator) and earth it, remove the test setup.

Switch the differential protection to active (address 2001: **DIFF. PROT.** = ***ON***) and it works immediately as a short-circuit protection for all subsequent tests.

3.3.14 Checking the Earth Current Differential Protection

Preparation

The primary test checks correct integration into the system, especially the CT connection. Before commencing any primary tests, make sure that the configured object is actually the one you want to protect. To do so, verify the settings used in the configuration of the protection function, Power System Data 1 and in the protection function itself.

Before test commencement, set the earth current differential protection (address2101 **REF PROT.**) to ***Block relay***, or interrupt the trip command lines.

Primary tests of power units are performed with the generator itself. On transformers, a low-voltage test source is used.

Before the test, the CT connections have to be visually checked for correctness.

Note

When performing the short-circuit test (3-phase short-circuit) for the earth current differential protection, check that the three current transformers (side 1 or side 2 – whichever side is used for the earth current differential protection) are identical in design. To do so, read out the percentages of the operational measured values **3I0-1** and **3I0-2** (in DIGSI under Differential Protection Measured Values). If the CTs are well matched, the values must be zero. Values that are not zero must be taken into account for the protection settings.

Primary Test with Generator

This test is performed in addition to the current test. For this the protection must be set to maximum sensitivity. Zero voltage release must be blocked (address 2103 **REF U0>RELEASE** = ***0***).

For the test, one phase is earthed and the generator is excited (see the following Figure). The test current may not exceed the admissible negative-sequence current. If this current amounts e.g. to $I_{2adm.}$ = 10 % $I_{N,G}$, the test current must be less than 30 % I $I_{N,G}$. On the other hand, the current is determined by the low-resistance star-point earthing. 10 % of the rated generator current is sufficient for testing.

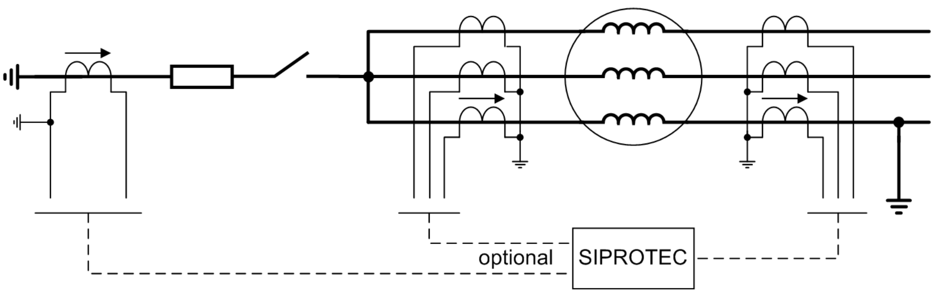


Figure 3-27 Testing the earth current differential protection on the generator

For the external fault, the percentages of the operational measured values are (on the device: **Measurement** → **I-Diff, I-Rest**) to be read out:

3I0-1 Calculated zero sequence current of side 1

3I0-2 calculated zero sequence current of side 2 or measured earth current I_{EE2} (depending on configuration)

I0-Diff calculated differential current

I0-Rest calculated restraint (stabilizing) current

Both zero component currents **3I0-1** and **3I0-2** must be equal and correspond to the injected current. The differential current **I0-Diff** is almost zero. The restraint (stabilising) current **I0-Stab** is twice the flowing current. If the differential and the restraint current are equal, the polarity of one CT must be wrong. Minor deviations are caused by CT errors.

If there are deviations, connection error are normally assumed. If necessary modify the wiring, or in Power System Data 1, the allocation of the CT starpoint for the phase CTs or the earth CT I_{EE2}. For the phase CTs, keep in mind that they are also used by other protection functions, such as the differential current protection. Feedback effects should be examined. If the differential current protection has already been checked, and the CTs of side 1 and 2 are used for the earth current differential protection, the above errors can be excluded. If the I_{EE2} input is used, a wrong polarity of the connections is not uncommon. Check the connection and/or the starpoint allocation in Power System Data 1 (address 214 **GRD TERM. IEE2**). The default setting assumes that terminal 7 is looking towards the protected object. If there are deviations in the measured values, the measured quantities are probably not properly matched. Check the parameter settings of the protected object and of the CTs in Power System Data 1. The default setting assumes that terminal 7 is looking towards the protected object.

If there are deviations in the measured values, the measured quantities are probably not properly matched. Check the parameter settings of the protected object and of the CTs in Power System Data 1.

Proceed as follows:

- Shut down and earth generator
- Check and correct connections, if necessary, or modify settings in Power System Data 1
- Repeat measurement

If the earth current differential protection is used on a transformer, a comparative test is performed (see Figure 3-26). The measured value **3I0-1** is allocated to side 1 and **3I0-2** to the earth currrent I_{EE2}. The test method is similar to the one described above. For the test current, it is essential to ensure that on the generator side the continuously admissible unbalanced load current is not exceeded. With a wye-delta connection, the single-phase fault is modeled on the generator side as a phase to phase fault.

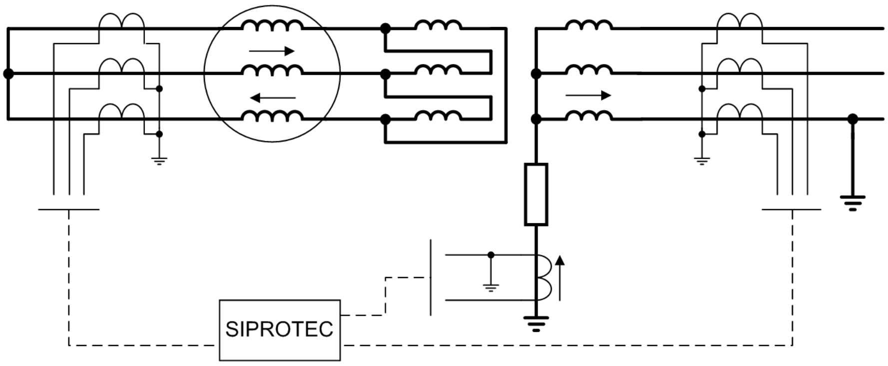


Figure 3-28 Testing the earth current differential protection on the transformer

Test with Secondary Test Equipment

Measurements are always performed from the side with the earthed starpoint. In transformers, there must be a delta winding (d-winding or compensating winding). The side which is not included in the tests remains open as the delta winding ensures low-ohmic termination of the current path.

The test setup varies dependent of the application. Figures 3-29 to 3-32 show schematic examples of the test setup, with Figure 3-29 mainly for generator protection applications.

DANGER!

Primary measurements must only be carried out on disconnected and earthed equipment of the power system! Perilous voltages may occur even on voltage-free plant sections due to capacitive influence caused by other live sections.

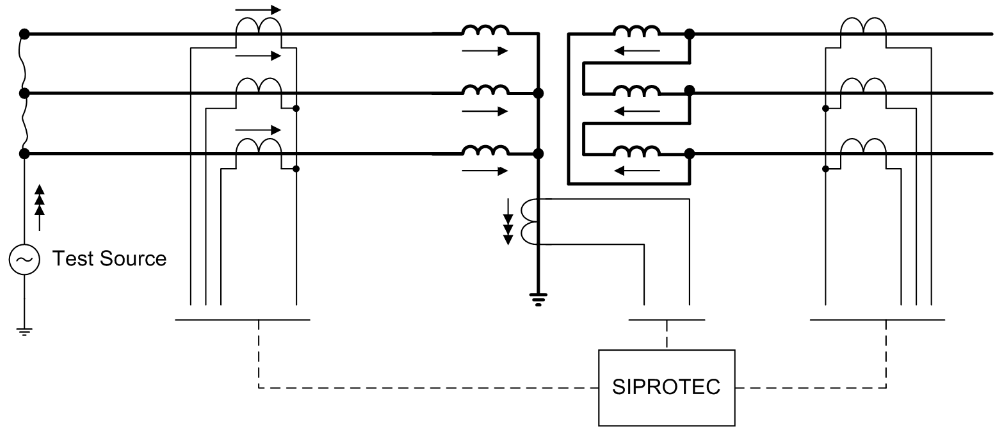


Figure 3-29 Zero sequence current measurement on a star-delta transformer

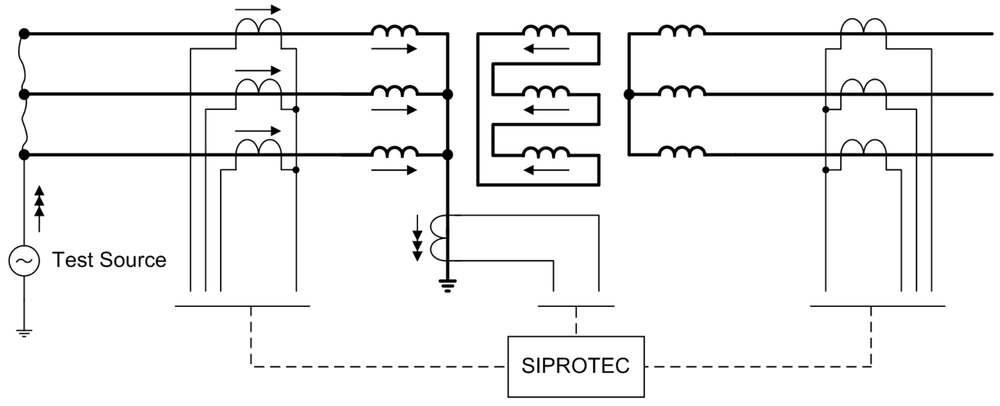


Figure 3-30 Zero sequence current measurement on a star-star transformer with compensation winding

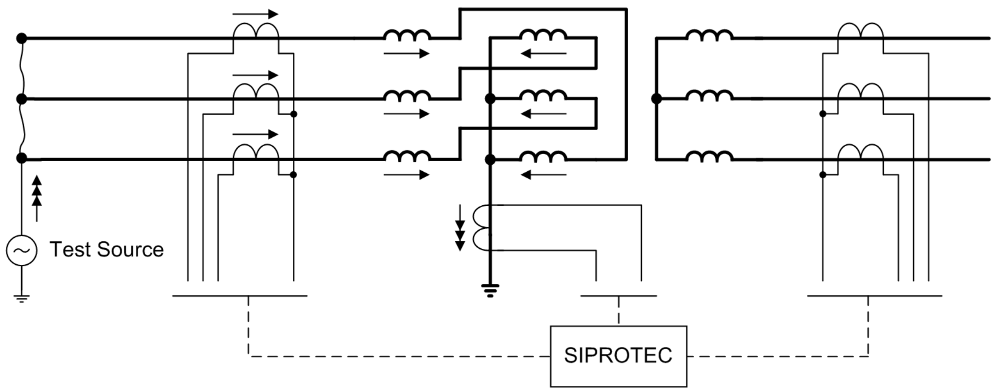


Figure 3-31 Zero sequence current measurement on a zig-zag-winding

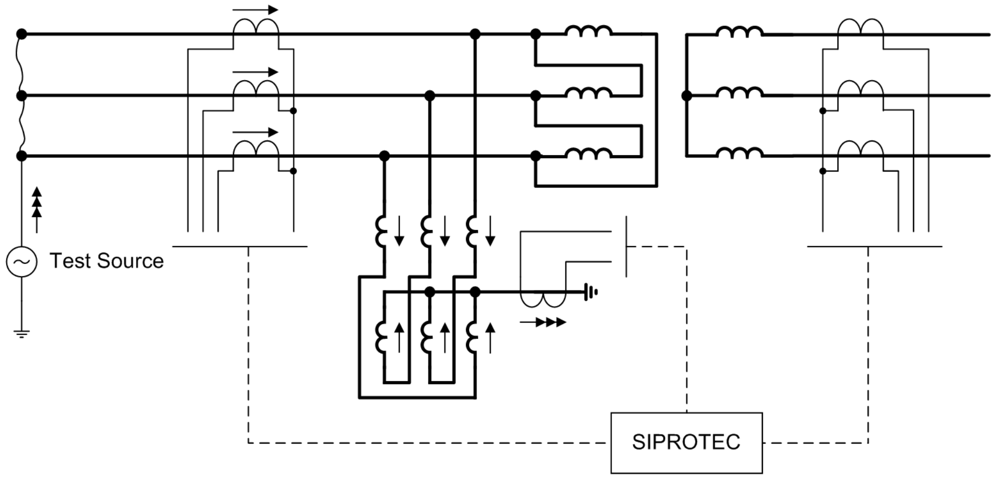


Figure 3-32 Zero sequence current measurement on a delta winding with artificial starpoint

A zero sequence current of at least 2 % the rated generator current is required for tests per phase, i.e. the test current is at least 6 %.

In the protection function, the most sensitive pickup threshold must be set, and the zero voltage release disabled.

- Switch on test current
- Amplitude measurement with switched on test current

In the device at: **Measurement** → **I-Diff, I-Rest**) read out the measured values:

3I0-1	calculated zero sequence current of side 1 or side 2 (depending on configuration)
3I0-2	measured earth current I_{EE2}
I0-Diff	calculated differential current
I0-Rest	calculated restraint (stabilizing) current

Both zero component currents **3I0-1** and **3I0-2** must be equal and correspond to the injected current. The differential current **I0-Diff** is almost zero. The restraint (stabilising) current **I0-Stab** is twice the flowing current. If the differential and the restraint current are equal, the polarity of one CT must be wrong. Minor deviations are caused by CT errors.

When checking the phase CTs of the allocated side, the measured values correspond (device: **Measurement** → **Operational values, secondary**) per phase will each be $^1/_3$ of the injected zero sequence current. The phase angle is the same in all 3 phases due to the zero sequence current.

If there are deviations, connection errors are normally assumed (see margin title „Primary test with generator“)

- Disconnect test source and protected object
- Check and correct connections and test setup
- Repeat measurement

Checking the Zero Voltage Release

If the zero voltage release is used, it must be checked during the test of the stator earth fault protection. In the presence of an earth fault, the indication 5841 „REF U0> releas.“ must appear. When performing the test, keep in mind that the zero voltage is calculated from the three phase voltages and converted on the secondary side to the phase-to-phase voltage (equivalent to $\sqrt{3}$ U0). The value thus obtained is the same as for a broken delta winding.

Blocking by Overcurrent

If the above measurements have been successfully performed, and the measured phase currents were plausible, it can be assumed that the current measurement works correctly. You only need to check the correct setting in the protection function (address 2102 = **REF I> BLOCK**).

The pickup values are checked by injecting a current using secondary test equipment (CTs need not be disconnected).

- After completion of the tests, disconnect the test source and the protected object (shut down generator)
- If parameter settings have been changed for the tests, reset them to the values necessary for operation.
- After completion of the earth fault protection tests, activate the earth current differential protection.

3.3.15 Checking the Voltage Circuits

General

The voltage circuits of the machine are checked to ensure the correct cabling, polarity, phase sequence, transformer ratio etc. of the voltage transformers - not to check individual protection functions of the device.

Earthing of the Voltage Transformers

When checking the voltage transformers, particular attention should be paid to the broken delta windings because these windings may only be earthed in one phase.

Preparation

Set the overvoltage protection function to about 110 % of the rated generator voltage with trip on excitation.

Switch frequency protection (address 4201) and overexcitation protection (address 4301) to ***Block relay***.

Already in the unexcited condition of the machine make sure, with the help of remanent voltages, that all short-circuit bridges are removed.

Test Instruction

The checks of all voltage transformer circuits (protection, measuring, metering etc.) are carried out with about 30 % of the rated transformer voltage. Tests with generator voltages of more than 30 % rated voltage are only required when the idle characteristic is measured for the first time.

The measuring circuit supervision of the rotor earth fault protection (see below) can be checked when testing the voltage circuits, or after the synchronization.

Amplitudes

Read out voltages in all three phases in the operational measured values and compare with the actual voltages. The voltage of the positive sequence system U_1 must be approximately the same as the voltage values indicated for the phase-earth voltages. If there are significant deviations, the voltage transformer connections are incorrect.

Phase Rotation

The phase rotation must conform to the configured phase sequence (address 271 **PHASE SEQ.** under **Power System Data 1**); otherwise an indication „Fail Ph. Seq.“ will be output. The allocation of measured values to phases must be checked and corrected, if necessary. If significant deviations are found, check, and if necessary correct, the voltage transformer circuits and repeat the test. It is also possible to use for this check the operational measured value of positive-sequence component U1 of the voltages: With $U_1 \neq U_{L-E}$ a wiring error is indicated.

Measuring Circuit Supervision of the Rotor Earth Fault Protection

If the sensitive earth fault protection is used for rotor earth fault protection, the measuring circuit supervision of that protection function can be checked with the generator under voltage:

- Start up the generator and excite it to rated voltage. Apply measurement brushes if necessary. Inject a test voltage between the rotor circuit and the earth by interposing the additional source device 7XR61. The earth current I_{EE} that is flowing now can be read out on the device under the earth fault measured values. The value obtained is the capacitive spill current flowing in fault-free operation.
- **IEE<** (address 5106) should be set to about 50 % of this capacitive spill current. It should also be checked that the set value **IEE>** (address 5102) is at least twice this measured spill current. Correct the set value if necessary.

Frequency

The frequency protection function is verified by a plausibility check of the instantaneous machine speed and the operational measured value indicated.

Overexcitation

The frequency protection function is verified by a plausibility check of the instantaneous machine speed and the operational measured value indicated.

$$\text{Instant. overexcitation} = \frac{U}{f} \cdot \frac{f_N}{U_N}$$

U Instantaneous Machine Voltage
U_N Rated Primary Voltage of the Protection Object
f Instantaneous frequency, in Accordance with the Machine Frequency in Hz
f_N Rated Frequence

The voltage tests are completed after the generator has been shut down. The required voltage and frequency protection functions are activated (address 4001: **UNDERVOLTAGE** = ***ON*** or ***OFF***, address 4101: **OVERVOLTAGE** = ***ON*** or ***OFF***, address 4201: **O/U FREQUENCY** = ***ON*** or ***OFF***, address 4301: **OVEREXC. PROT.** = ***ON*** or ***OFF***). Partial functions can be disabled by appropriate limit value settings (e.g. frequency f* set to f_{Nom}).

3.3.16 Checking the Stator Earth Fault Protection

General

The procedure for checking the stator earth fault protection depends mainly on whether the generator is connected to the network in unit connection or in busbar connection. In both cases correct functioning and protected zone must be checked.

In order to check interference suppression of the loading resistor, and to verify the protected zone of the earth fault protection, it is appropriate to test once with an earth fault at the machine terminals (e.g. with 20 % of the rated transformer voltage) and once with a network earth fault.

Unit Connection

In the event of an external (high-voltage side) short-circuit, an interference voltage is transmitted via the coupling capacitance C_{coup} which induces a displacement voltage on the generator side. To ensure that this voltage is not interpreted by the protection as an earth fault within the generator, it is reduced by a suitable loading resistor R_L to a value which corresponds to approximately one half the pick-up voltage **U0>** (address 5002). On the other hand, the earth fault current resulting from the loading resistor in the event of an earth fault at the generator terminals should not exceed 10 A, if possible.

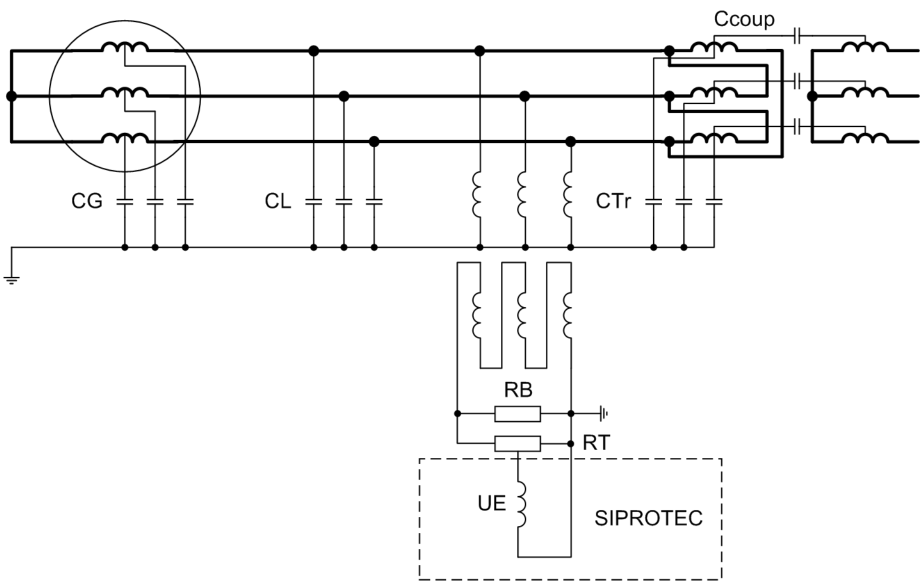


Figure 3-33 Unit connection with earthing transformer

Calculation of Protected Zone

Coupling capacitance C_{coup} and loading resistor R_B represent a voltage divider, where R_B' is the resistance R_B referred to the machine terminal circuit.

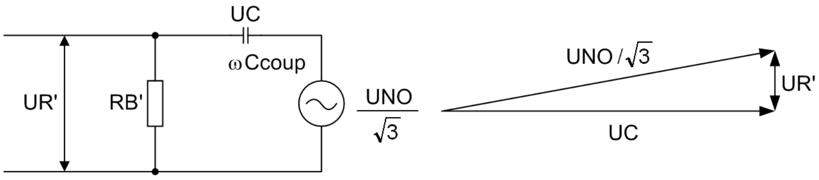


Figure 3-34 Equivalent diagram and vector diagram

Since the reactance of the coupling capacitance is much larger than the referred resistance of the loading resistor R_B', U_C can be assumed to be $U_{NO}/\sqrt{3}$ (compare also vector diagram Figure 3-34), where $U_{NO}/\sqrt{3}$ is the neutral displacement voltage with a full displacement of the network (upper-voltage) neutral. The following applies:

$$\frac{R_B'}{1/(\omega C_{Coup})} = \frac{U_R'}{U_{N0}/(\sqrt{3})}$$

$$U_R' = R_B' \cdot \omega C_{Coup} \cdot U_{NO}/(\sqrt{3})$$

With the voltage transformation ratio TR of the earthing transformer:

$$U_R' = \frac{TR}{3} \cdot U_R \quad \text{and} \quad R_B' = \left(\frac{TR}{3}\right)^2 \cdot R_B$$

we obtain:

$$U_R = \frac{TR}{3} \cdot R_B \cdot \omega C_{Coup} \cdot U_{NO}/(\sqrt{3})$$

Together with the voltage divider R_T (500 V/100 V), this corresponds to a displacement voltage at the input of the device of:

$$U_E = \frac{1}{5} \cdot \frac{TR}{3} \cdot R_B \cdot \omega C_{Coup} \cdot U_{NO}/(\sqrt{3})$$

The pickup value **U0>** for the neutral displacement voltage should amount to at least twice the value of this interference voltage.

Example:

Network	U_{NO}	= 110 kV
	f_{Nom}	= 50 Hz
	C_{coup}	= 0.01 µF
Voltage transformer	10 kV / 0.1 kV	
Earthing transformer	TR	= 36
Loading resistance	R_B	= 10 Ω

$$U_E = \frac{1}{5} \cdot \frac{36}{3} \cdot 10\ \Omega \cdot 314\ s^{-1} \cdot 0.01 \cdot 10^{-6} F \cdot \frac{110}{\sqrt{3}} \cdot 10^3 V = 4.8\ V$$

10 V has been chosen as the setting value for 5002 in address **U0>** which corresponds to a protective zone of 90% (see the following Figure).

Note

For use as a neutral transformer the voltage transformation ratio TR instead of TR/3 should be used. As neutral transformer has only one winding, the result is the same.

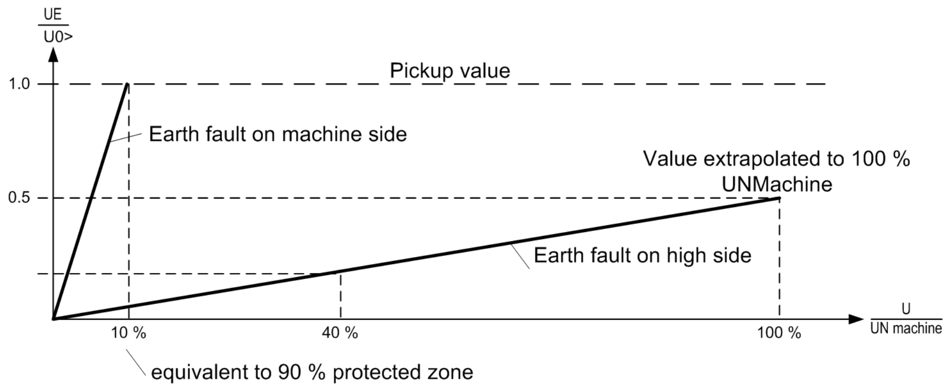


Figure 3-35 Displacement voltage during earth faults

Checking for Generator Earth Fault

Switch rotor earth fault protection **S/E/F PROT.** (address 5001) to ***Block relay***. If the sensitive earth fault detection is used for stator earth fault protection, switch it to ***Block relay*** also under address 5101 as well.

With the primary equipment disconnected and earthed, insert a single-pole earth fault bridge in the generator terminal circuit.

DANGER!

Primary measurements may only be carried out with the generator at stand–still on disconnected and grounded equipment of the power system.

Start generator and slowly excite to about 20 % U_N.

Read out U_E from the operational measured values and check for plausibility.

If the plant has more voltage transformers with broken delta windings, the voltage U_E must be measured on them as well.

For protection zone Z the following applies:

$$Z = \frac{U_{sec\,N} - U0>}{U_{sec\,N}} \cdot 100\ \%$$

Example:

Machine voltage at pick-up 0.1 x $U_{sec\,N}$

Measured value	U_G	= 10 V
Setting value	U0>	= 10 V
Protection range	L	= 90 %

When reading the fault log buffer „U Earth Lx“ „Lx“ indicates the faulted phase provided voltages are connected to the voltage protection inputs of the device.

Shut down generator. Remove earth fault bridge.

Check Using Network Earth Fault

With the primary plant voltage-free and earthed, install a single-pole earth fault bridge on the high voltage side of the unit transformer.

DANGER!

Primary measurements may only be carried out with the generator at stand–still on disconnected and grounded equipment of the power system.

Caution!

Possible starpoint earthing at transformer with simultaneous earthing on high voltage side during test!

Nonobservance of the following procedures can result in minor injury or material damage.

The starpoints of the unit transformer must be disconnected from earth during this test!

Start up machine and slowly excite to 30 % of rated machine voltage.

Read out under operational measured values: U_E This value is extrapolated to rated machine voltage (Figure 3-35). The fault value thus calculated should correspond, at the most, to half the pickup value **U0>** (address 5002), in order to achieve the desired safety margin.

Shut down and de-excite the generator. Remove earth fault bridge.

If the starpoint of the high-voltage side of the unit transformer is to be earthed during normal operation, re-establish starpoint earthing now.

Activate the stator earth fault protection: set address 5001 **S/E/F PROT.** to ***ON***. If the sensitive earth fault detection is used for stator earth fault protection, activate it as well: set address 5101 **O/C PROT. IEE** to ***ON***.

Busbar Connection

Firstly, the correct functioning and data of the loading equipment must be checked: sequencing, time limit, etc., as well as the plant data: Earthing transformer and the value of the load resistor (tapping).

Switch rotor earth fault protection (address 5001) to ***Block relay***. If the sensitive earth fault detection is used for stator earth fault protection, switch it to ***Block relay*** also under address 5101.

With the primary plant earthed and voltage-free, install a single pole earth fault bridge between generator terminals and toroidal current transformer (see the following Figure).

DANGER!

Primary measurements may only be carried out with the generator at stand–still on disconnected and grounded equipment of the power system.

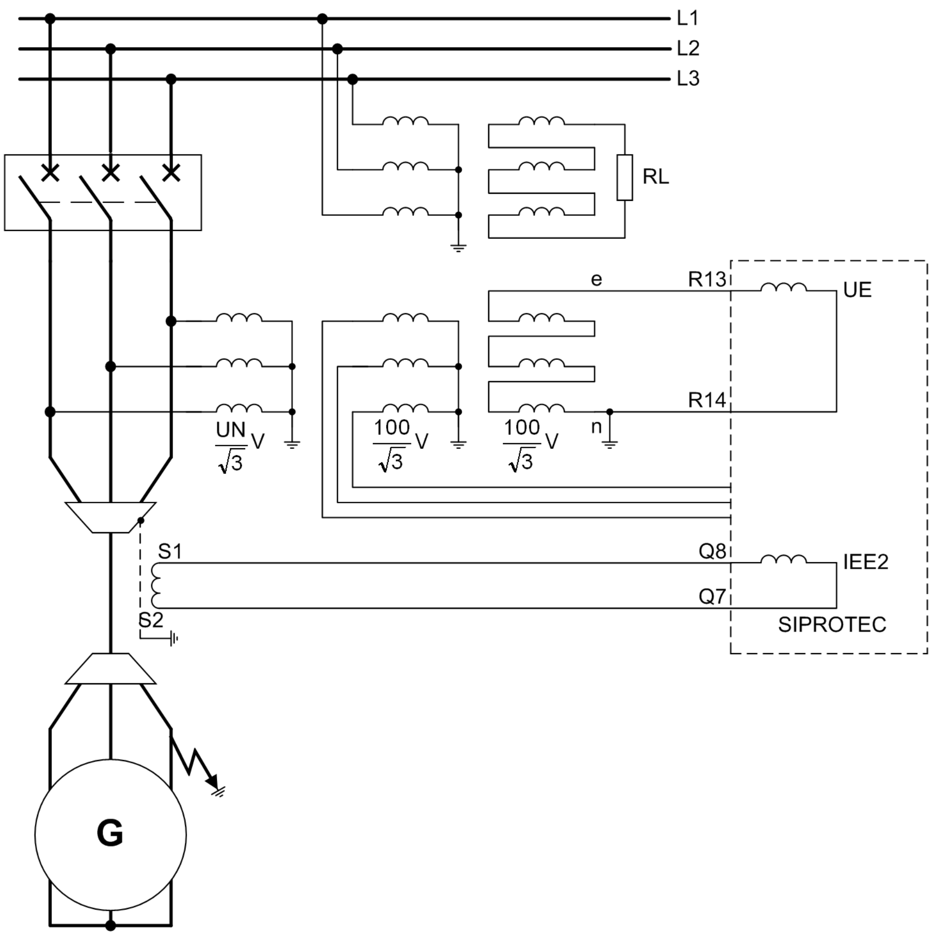


Figure 3-36 Earth fault with busbar connection

For this test, connections must be such that the generator is galvanically connected with the load equipment. If the plant conditions do not allow this, the hints given overleaf under the side title „Directional check without Loading Resistor“ must be observed.

Start up generator and slowly excite it until the stator earth fault protection picks up: Indication „`U0> picked up`“ (not allocated when delivered from factory). At the same time the indication „`3I0> picked up`“ should appear (not allocated when delivered from factory).

Read out operational measured values U_E and I_{EE2}. If the connections are correct, this value corresponds to the machine terminal voltage percentage, referred to rated machine voltage (if applicable, deviating rated primary voltage of earthing transformer or neutral earthing transformer must be taken into account). This value also corresponds to the setting value **U0>** in address 5002.

The measured value I_{EE2} should be approximately equal to or slightly higher than the setting value **3I0>** under address 5003. This is to ensure that the protection zone that is determined by the setting value **U0>** is not reduced by too slow pick-up.

For protection zone Z, the following applies:

$$Z = \frac{U_{sec\,N} - U0>}{U_{sec\,N}} \cdot 100\ \%$$

Example:

Machine voltage at pick-up 0.1 x U_N

Measured value	U_G	= 10 V
Setting value	U0>	= 10 V
Protection range	L	= 90 %

With Direction Determination

The earth fault directional determination requires a check of the current and voltage connections for correctness and correct polarity. The machine is excited to a voltage that corresponds to a displacement voltage above the pickup value. If the polarity is correct, the trip indication „`S/E/F TRIP`“ is output (LED 6 when delivered from factory).

A cross check is then performed. After the generator has been de-excited and shut down, the earth fault bridge is installed on the other side of the current transformers (as viewed from the machine).

DANGER!

Primary measurements may only be carried out with the generator at stand–still on disconnected and grounded equipment of the power system.

After restarting and exciting the generator above the pickup value of the displacement voltage, „`U0> picked up`“ picks up (LED 2 for group indication of a device pickup when delivered from factory), however the „`3I0> picked up`“ indication does not appear and tripping does not occur. The measured value IEE should be negligible and on no account at nominal excitation should it be larger then half the setting value **`3I0>`**.

Shut down and de-excite the generator. Remove earth fault bridge.

Directional Check with Toroidal CTs without Loading Resistor

If loading equipment is not available and if an earth fault test with the network is not possible, then the following test can be performed with secondary measures, however with the symmetrical primary load current:

With current supplied from a toroidal residual current transformer, a voltage transformer (e.g. L1) is by-passed which simulates the formation of a displacement voltage (see the following Figure). From the same phase, a test current is fed via an impedance Z through the toroidal transformer. The connection and direction of the current conductor through the toroidal transformer is to be closely checked. If the current is too small for the relay to pickup, then its effect can be increased by looping the conductor several times through the toroidal transformer.

For Z, either a resistor (30 to 500 Ω) or a capacitor (10 to 100 μF) connected in series with an inrush-current-limiting resistor (approximately 50 to 100 Ω) is used. With correct connections, the described circuit results in indications „`U0> picked up`“, „`3I0> picked up`“ and finally „`S/E/F TRIP`“ (LED 6).

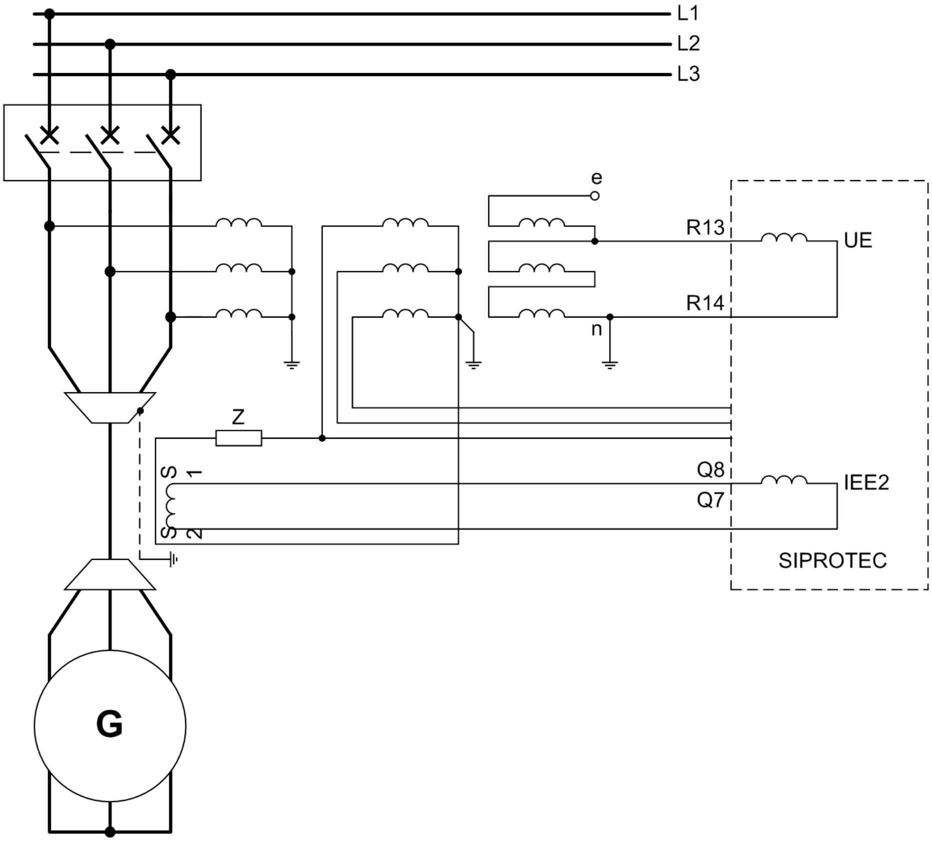


Figure 3-37 Directional check with toroidal transformers

Directional Check in Holmgreen Connection

If the current is supplied from a Holmgreen connection, the displacement voltage is obtained in the same manner as in the above circuit. Only the current of that current transformer which is in the same phase as the by-passed voltage transformer in the delta connection is fed via the current path. In case of active power in generator direction, the same conditions apply for the relay - in principle - as with an earth fault in generator direction in a compensated network and vice versa.

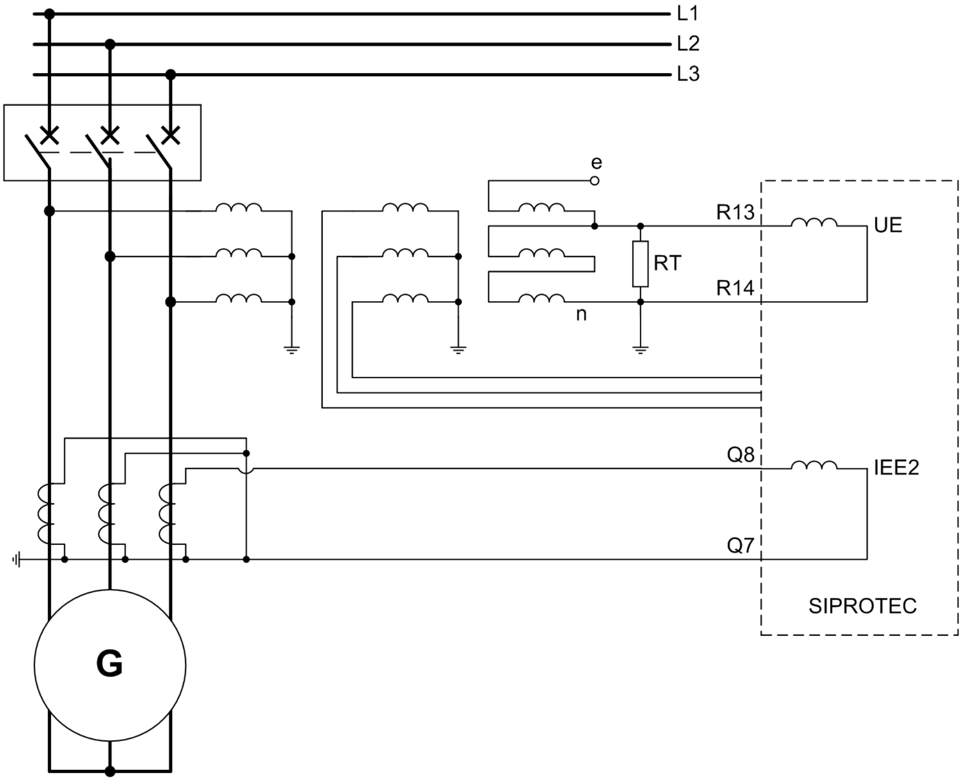


Figure 3-38 Directional check with holmgreen connection

If in an isolated network the voltage connections for the reactive current measurement should be kept for testing, then it should be noted that for a power flow with inductive component in forwards direction a backwards direction results (contrary to an earth fault in this direction).

Shut down generator after completion of the directional tests. Correct connections must be restored and double-checked.

Spill Current

For calibration to the spill current, a three-pole short-circuit bridge that is able to withstand rated current is installed at the circuit breaker. Start up generator and slowly excite it until the rated machine current is reached.

Read out the operational measured value I_{EE2}. This measured value determines the setting value of address 5003 **3I0>**. Parameter **3I0>** should be about twice that measured value to ensure a sufficient security margin between the earth fault current used for directional determination and the spill current. Next, check whether the protection zone determined by the setting value **U0>** must be reduced.

Activate the stator earth fault protection: Address 5001 **S/E/F PROT.** = ***ON***.

3.3.17 Checking the 100 % Stator Earth Fault Protection

General

The 100% stator earth fault connection is tested together with the 90% stator earth fault protection.

Set the 100% stator earth fault protection (address 5301 **100% SEF-PROT.**) to ***Block relay*** (if not done so already). Also, the accessories of the protection device must be operational.

The tests to be performed are described in more detail below.

Check without Earth Fault

Start up the generator and excite it to maximum generator voltage. The protection does not pick up.

The operational measured values need to be checked as well. Read out the rms current **I SEF**. The fault value thus calculated should correspond at most to half the pickup value **SEF I>>** (address 5306), in order to achieve the desired safety margin.

Shut down generator.

Check Performed with an Earth Fault in the Machine Zone

Connect the 20 Hz generator 7XT33 to the DC voltage or to an external three-phase voltage source.

With the primary equipment disconnected and earthed, insert a single-pole earth fault bridge in the generator terminal circuit.

DANGER!

Primary measurements may only be carried out with the generator at stand–still on disconnected and grounded equipment of the power system.

Start up the generator and excite it slowly (but under $U_N/\sqrt{3}$) until the 90% earth fault protection (Pickup threshold **U0>**) has picked up.

With the earth fault bridge in place, the resistance stages of the 100% protection (warning and trip stage) must pick up immediately on switching in the supply voltage of the 20 Hz generator.

To check the pickup behaviour of the current stage **SEF I>>**, read out the measured value **I SEF** from the operational measured values at approx. 10 % to 20 % of the displacement voltage. The value thus obtained should be about the same as the pickup value **SEF I>>** selected at address 5306. This ensures that the current stage of the 100% stator earth fault protection covers a protection zone of about 80 % to 90 % of the winding in addition to the 100 % resistance calculation.

Check Using Network Earth Fault

With the primary plant voltage-free and earthed, install a single-pole earth fault bridge on the high voltage side of the unit transformer.

DANGER!

Primary measurements may only be carried out with the generator at stand–still on disconnected and grounded equipment of the power system.

Caution!

Possible starpoint earthing at transformer with simultaneous earthing on high voltage side during test!

Nonobservance of the following procedures can result in minor injury or material damage.

The starpoints of the unit transformer must be disconnected from earth during this test!

Start up the generator and slowly excite it to 30 % of rated machine voltage (max. 60 %).

The 100 % and 90 % stator earth fault protection does not pick up.

The checks to be performed for the 90% stator earth fault protection are described under margin title „Check in Case of Network Earth Fault“ in the previous section.

For the 100-% stator earth fault protection, read out the operational measured value **I SEF**. This value is extrapolated to approx. 1.3 times the rated machine voltage. The current thus extrapolated should not exceed half the pickup value **SEF I>>** (address 5306) in order to achieve the desired safety margin of the current stage of the 100% stator earth fault protection.

Shut down and de-excite the generator. Remove earth fault bridge.

If the starpoint of the high-voltage side of the unit transformer is to be earthed during normal operation, now reestablish starpoint earthing.

If the 20 Hz generator is to be fed by the voltage transformers of the machine terminals, this or a different type of supply connection (e.g. DC voltage supply from a battery) must permanently be established.

If no more special tests are to be made, activate the 100% stator earth fault protection: set address 5301 **100% SEF-PROT.** to ***ON***.

3.3.18 Checking the Sensitive Earth Fault Protection as Rotor Earth Fault Protection

If the sensitive earth fault protection is used for rotor earth fault protection, it must first be set to **O/C PROT. IEE** ***Block relay*** at addresse 5101.

Caution!

A rotor circuit not isolated from earth can result in a double earth fault in conjunction with an earth resistor inserted for checking purposes!

Nonobservance of the following procedures can result in material damage to the machine.

Make sure that the checked rotor circuit is completely isolated from the earth, to avoid that the earthing resistor interposed for test purposes causes a double earth fault!

An earth fault is simulated via a resistor which is roughly equivalent to the desired trip resistance. In generators with rotating rectifier excitation, the resistor is placed between the two measurement slip rings; in generators with excitation via slip rings between one slip ring and earth.

Start up generator and excite it to rated voltage. If applicable, place measurement brushes into operation. It is irrelevant in this context whether the sensitive earth fault protection picks up or not. The earth current I_{EE} that is flowing now can be read out on the device under the operational measured values.

Check that this measured earth fault current is roughly equal to the pickup value 5102 for sensitive earth fault detection that has been set in address **IEE>**. However, it must not be set to less than double the value of the spill current that has been determined for healthy insulation.

For generators with excitation via slip rings, the test can be repeated for the other slip ring.

Shut down generator. Remove earth fault resistor.

The sensitive earth fault detection used for rotor earth fault protection is then activated: **O/C PROT. IEE** = ***ON*** in address 5101.

3.3.19 Checking the Rotor Earth Fault Protection during Operation

Rotor Earth Fault Protection (R, fn)

In Section 3.3, the rotor earth fault protection with earth resistance measurement was checked with the machine at standstill. In order to exclude possible interference on the measurement circuit by the running generator, an additional test during operation is recommended.

Caution!

A rotor circuit not isolated from earth can result in a double earth fault in conjunction with an earth resistor inserted for checking purposes!

Nonobservance of the following procedures can result in material damage to the machine.

Make sure that the checked rotor circuit is completely isolated from the earth, to avoid that the earthing resistor interposed for test purposes causes a double earth fault!

An earth fault is simulated via a resistor of approximately 90% of the trip resistance (**RE<< TRIP**, address 6003). In machines with rotating rectifier excitation, the resistor is placed between the measurement slip rings; in machines with excitation via slip rings between one slip ring and earth.

Start up generator and excite it to rated voltage. If applicable, place measurement brushes into operation.

The rotor earth fault protection initiates pickup and, after **T-TRIP-RE<<** (10 s when delivered from factory), trip indication (LED 2 and LED 1 as group indications for device pickup and device trip).

The earth resistance calculated by the device can be read out in the earth fault annunciations as „Re =“.

For generators with excitation via slip rings, the test can be repeated for the other slip ring.

Shut down generator. Remove earth fault resistor.

Activate the rotor earth fault protection: **ROTOR E/F** = ***ON*** in address 6001.

Rotor Earth Fault Protection (1 to 3 Hz)

In Section 3.3, the rotor earth fault protection was checked with the machine at standstill. In order to exclude possible interference on the measurement circuit by the running generator, and specifically by the excitation system, an additional test during operation is recommended.

Caution!

A rotor circuit not isolated from earth can result in a double earth fault in conjunction with an earth resistor inserted for checking purposes!

Nonobservance of the following procedures can result in material damage to the machine.

Make sure that the checked rotor circuit is completely isolated from the earth, to avoid that the earthing resistor interposed for test purposes causes a double earth fault!

An earth fault is simulated via a resistor of approximately 90% of the trip resistance (6103, address **RE<< TRIP**). In machines with rotating rectifier excitation, the resistor is placed between the measurement slip rings; in machines with excitation via slip rings between one slip ring and earth.

Start up the generator and excite it to the rated voltage. If applicable place measurement brushes into operation.

Check the operational measured value Rearth and the pickup indication („`REF 1-3Hz Fault`“) and, after **`T-TRIP-RE<<`** (10 s on delivery) has expired, check the trip indication („`REF 1-3Hz Trip`“).

Set the resistance to approx. 90 % of the warning stage (address 6102 **`RE< WARN`**), read out the operational measured value „`Re =`“, and check the warning message („`REF 1-3Hz Warn`“). If there is heavy interference from the excitation system, it may be necessary to reduce the high-omic resistance set for the warning threshold.

Remove the earthing resistor and check the operational measured values as well as the measuring circuit supervision „`REF 1-3Hz open`“ under fault-free conditions. If spontaneous indications are issued by the measuring circuit monitoring, reduce the pickup value (address 6106 **`Qc <`**) or deactivate the monitoring.

For generators with excitation via slip rings, the test is repeated for the other slip ring.

Shut down generator. Remove earth fault resistor.

Activate the rotor earth fault protection: **`REF 1-3Hz`** = ***`ON`*** in address 6101.

3.3.20 Checking the Interturn Fault Protection

Switch the interturn fault protection (address 5501) to ***`Block relay`***.

Asymmetries in the stator windings impair the sensitivity of the protection. The two-pole fault is particularly critical in this context.

Caution!

Even fault currents which are significantly smaller than the nominal current can thermally endanger the generator due to the unbalanced load (negative sequence current)!

First, the maximum permissible fault current has to be determined.

If the generator is excited using nominal current, the following negative sequence currents are obtained as a result:

Single-pole fault	Two-pole fault
100/3 = 33,3 %	100/√3 = 57,7 %

If, for instance, the permanently admissible unbalanced load current is 11 %, the following generator currents must not be exceeded:

Single-pole fault	Two-pole fault
11 %/33,3 % · I_{NG} = 0.33 I_{NG}	11 %/57,7 % · I_{NG} = 0.19 I_{NG}
selected 0.3 I_{NG}	selected 0.17 I_{NG}

The same percentages apply to the excitation current.

Install a two-pole short-circuit bridge, which can also conduct fault currents, at the generator terminals.

DANGER!

Primary measurements may only be carried out with the generator at standstill on disconnected and earthed equipment of the power system.

Run up machine until it has reached permissible excitation and measure the excitation current and the displacement voltage at the device under the operational measured values.

Shut down the generator. Remove short-circuit bridge.

The measured displacement voltage has to be extrapolated to the nominal excitation current to make sure that the function does not pick up erroneously on external short-circuits. The function is then set to at least twice the fault value at nominal excitation.

If the field forcing current is known, the fault voltage has to be extrapolated to this value. The protection is then set to 1.5 times the fault value.

To find out how sensitive the protection is, determine the content of the protected phase winding at no-load excitation. For this purpose, insert a single-phase short-circuit between a conductor and the starpoint.

DANGER!

Primary measurements may only be carried out with the generator at standstill on disconnected and earthed equipment of the power system.

Adjust the excitation to „manual“ mode.

Run up the generator, but not higher than the excitation at which the above calculated unbalanced load (for single-pole fault) is not exceeded. Read the measured displacement voltage out of the operational measured values.

Shut down the generator. Remove short-circuit bridge.

Extrapolate the measured voltage to the value at no-load excitation. The percentage of the protected winding area can be derived from this value.

$$\frac{U_{\text{Interturn (No-load excitation)}} - U_{\text{Setting Value}}}{U_{\text{Interturn (No-load excitation)}}} \cdot 100\ \%$$

We assume that the Uwin voltage increases linearly with the number of short-circuited turns. Actually, the voltage increase of an interturn fault with only a few turns is rather high, i.e. the protection is more sensitive than calculated. To simplify matters, the linear approach was used.

After the test is completed, activate the interturn fault protection by setting address 5501 to **INTERTURN PROT** = ***ON***.

3.3.21 Checks with the Network

Note

Since the protective function adjusts the scanning frequency, the test requires that a nominal-frequency phase-to-earth voltage (e.g. U_{L1}) is injected at least at one voltage input.

Checking the Correct Connection Polarity

The following test instructions apply to a synchronous **generator**.

Start up generator and synchronize with network. Slowly increase driving power input (up to approximately 5%).

The active power is read out under the operational measured values (percent values) as a positive active power P in percent of the rated apparent power S_N.

If a negative power value is displayed, allocation direction between the CT set of side 2 and the voltage transformer set does not correspond with the configuration under address 210 (**STRPNT->OBJ S2**: ***YES***/***NO***), or the configuration of address 1108 **ACTIVE POWER** = ***Generator*** or ***Motor***) is not properly selected. Address 210 is to be reconfigured, as required.

If the power continues being incorrect, there must be an error in the transformer wiring (e.g. cyclical phase swap):

- Remedy faults of the transformer lines (current and/or voltage transformers) observing the safety rules,
- Repeat test.

Measurement of Motoring Power and Angle Error Correction

Leave the reverse power protection (address 3101) and the forward active power supervision (address 3201) switched to ***Off*** for now. For motors, this and the following measurements are not required.

Independent of the excitation current of the generator, i.e. of the reactive power Q, the motoring power is – as an active power – practically constant. However, the protection device may detect and display different motoring power values because of possible angle errors of the current and voltage transformers. The motoring power/reactive power curve then would not be a straight line parallel with the abscissa (active Power = 0) in the machine power diagram. Therefore, the angle deviations should be measured at three measuring points and the correction parameter W0 established. The angle errors caused by the device internal input transformers have already been compensated in the factory. This check is recommended if the reverse power protection is set to sensitive.

Reduce driving power to zero by closing the regulating valves. The generator now takes motoring energy from the network.

Caution!

Overheating on input of reverse power by the generator

Operating the turbine without a minimum steam throughput (cooling effect) can cause the turbine blades to overheat!

Input of reverse power is admissible with a turboset only for a short period.

Caution!

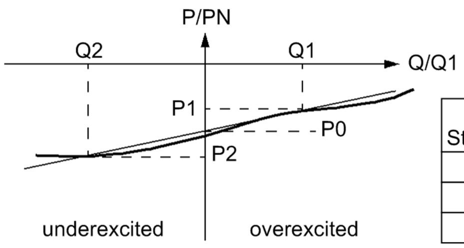
Under-excitation may cause the generator to fall out of step!

Nonobservance of the following procedures can result in minor injury or material damage.

Operation with underexcitation is admissible only for a short period

Proceed as follows:

1. Adjust excitation until the reactive power amounts to approximately Q = 0. To check this, read out the active power $\mathbf{P_0}$ and the reactive power $\mathbf{Q_0}$ with their respective signs and note them down (see table below).
2. Slowly increase excitation to 30% of rated apparent power of generator (overexcited).
   – Read out the motoring power with polarity (negative sign) in the operational measured values and note it down as $\mathbf{P_1}$ (see table below).
   – Read out the reactive power $\mathbf{Q_1}$ with polarity (positive sign) and write it down.
3. Reduce excitation slowly to approximately 30% rated apparent power of generator (underexcited).
   – Read out the motoring power $\mathbf{P_2}$ with polarity (negative sign) in the operational measured values under and write it down (see table below).
   – Read out the reactive power $\mathbf{Q_2}$ with polarity (negative sign) in the operational measured values and write it down (see table below).
4. Adjust generator to no-load excitation and shut it down or select the desired operational state.



Status	Motoring power	Reactive power
1	P0	Q0
2	P1	Q1
3	P2	Q2

Figure 3-39 Determination of the correction angle W0

The read-out measured values P_1, and P_2 are now used to carry out CT angle error correction. First calculate a correction angle from the measured value pairs according to the following formula:

$$\varphi_{corr} = \operatorname{atan}\frac{P_1 - P_2}{Q_1 - Q_2}$$

The power values must be inserted with their correct polarity as read out! Otherwise faulty result!

This angle φ_{corr} is entered **with identical sign** as the new correction angle under address 204 **CT ANGLE W0**:

Setting value **CT ANGLE W0** = φ_{corr}

A quarter of the sum of the measured values $P_1 + P_2$, also with negative signs, is set as pickup value of the reverse power protection **P> REVERSE** under address 3102.

Calibrating the Reverse Power Protection

If a generator is connected with the network, reverse power can be caused by

- closing of the regulating valves,
- closing of the stop valve

Because of possible leakages in the valves, the reverse power test should – if possible – be performed for both cases.

In order to confirm the correct settings, repeat the reverse power measurement again. For this, the reverse power protection (address 3101) is set to ***Block relay*** in order to check its effectiveness (using the indications).

Start up generator and synchronize with network. Close regulating valves.

From the operational measured value for the active power, the motoring power measured with the protection device can be derived. 50% of that value should be taken as the setting for the reverse power protection.

Increase driving power.

In a further test, check the **stop valve criterion** . It is assumed that the binary input „>SV tripped“ is allocated correctly and is controlled by the stop valve criterion (by a pressure switch or a limit switch at the stop valve).

Close stop valve.

From the operational measured value for the active power, the motoring power measured with the protection device can be derived.

If that value should be found to be unexpectedly less than the reverse power with the stop valves closed, 50% of that value should be taken as the setting for the reverse power protection.

Shut down the generator by activating the reverse power protection.

Switch ***ON*** the reverse power protection (address 3101) and - if used - the forward power supervision (address 3201).

Checking the Under-excitation Protection

The angle error correction value W0 determined and configured with regard to reverse power protection under address 204 also applies for the underexcitation protection.

In this section, the measured values of the reactive power have been read out, and thus a plausibility check of that measured value with directional check has been carried out. No further checks are required.

If nevertheless by an additional load level measurement a directional check is to be performed, proceed as described in the following.

Caution!

Under-excitation may cause the generator to fall out of step, in particular with increased active power!

Nonobservance of the following procedures can result in minor injury or material damage.

Operation with underexcitation is admissible only for a short period

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For **checking under load** , set the underexcitation protection (address 3001) to ***Block relay***.

The proper functioning is checked by approaching freely selected load levels under overexcited and then underexcited conditions. The plausibility check is carried out by reading out the relevant operational measured values from the protection device and comparing them with the measured values obtained from the control and instrumentation system.

Set the underexcitation protection to 3001 (address ***ON***).

Note

If operation with capacitive load is not possible, then load points in the underexcited range can be achieved by changing the polarity of the current transformer connections (address 210). Thereby the characteristics of the underexcitation protection are mirrored around the zero point. It must be noted that the reverse power protection must be set to ***OFF*** (address 3101) as its characteristic is also mirrored from the motor into the generator range.

Since the protective device shows each load level through the operational measured values, it is not necessary to approach the underexcitation limit line.

Checking the Directional Function of the Overcurrent Time Protection

When the polarity of the connections is checked, the direction of the protection function I>> (Section 2.9) is unambiguously determined by the definition of the reference arrow in the protection device. When the generator produces an active power (operational measured value P is positive), and address 1108 **ACTIVE POWER** is set to ***Generator***, the network is in the forwards direction.

In order to exclude accidental misconnections, it is recommended to carry out a check with a low load current. Proceed as follows:

- Set the directional high current stage 1301 **O/C I>>**to ***Block relay*** and the pickup value **I>>** (parameter 1302) to the most sensitive value (= 0.05A with a rated current of 1A and 0.25 A with a rated current of 5 A).
- Increase the load current (ohmic, or ohmic inductive) above the pickup value, and as soon as the pickup indications (No. 1801 to 1803) appear, query the indications 1806 „I>> forward“ and 1807 „I>> backward“.
- Compare the indicated direction with the setpoint (setting value and address 1304 **Phase Direction**). In the standard application with terminal-side current transformers, address 1304 **Phase Direction** must be set to reverse and indication „I>> forward“ (No. 1806).
- Reset the pickup value in address 1302 back to the original value and the protection function in address 1301 **O/C I>>** to ***ON***.

Checking the Sensitive Earth Current Protection IEE-B

Set the sensitive earth current protection IEE-B to ***Block relay*** at address 5401.

With the generator stationary, a current (determined by the number of test turns among others) has to be injected over the test winding of the shaft current transformer and pickup of the protective function has to be checked using the default value (test current should be twice the value). This is primarily a wiring check and an additional check of the function's pickup behaviour and the correct allocation (signalling).

The subsequent primary tests have to be conducted after commissioning the „synchronization“.

Proceed as follows:

- Synchronise the generator with the power grid and run it under load.
- Trigger a fault record in DIGSI and determine the predominant frequency component using SIGRA. Depending on the connection, evaluate the fault record track of input I_{ee1} or I_{ee2}. Depending on the outcome, select the appropriate measurement method at address 5406. It is possible to check all 3 variants (***Fundamental***, ***3. Harmonic*** and ***1. and 3. Harm.***) and subsequently select the method that has yielded the best result.
- After setting the measurement method, read the fault current out of the operational measured values.
- Calculate the pickup value of the function by multiplying the fault current with a safety factor (min. 1.5) and then enter it in address 5402.

- Make sure that the protective function does not pick up on this current. It may be necessary to use different excitation states.
- With the generator running, connect a test resistor (0 - 30 Ω) between generator shaft and earth using a slip-ring in the vicinity of the bearing. Reduce the resistance value until the protection picks up. If the pickup condition „chatters", increase the holding time slightly at address 5407. This time should not be longer than one second.

After the test is completed, activate the sensitive earth current protection by setting address 5401 to = ***ON***.

3.3.22 Creating Oscillographic Fault Recordings for Tests

General

At the end of commissioning, closing tests may be carried out to assure the stability of the protection during the dynamic processes. A maximum of information on protection behaviour is supplied by fault recordings.

Prerequisite

Along with the possibility of storing fault recordings via pickup of the protection function, the 7UM62 also has the capability of capturing the same data when commands are given to the device via the service program DIGSI, the serial interface, or a binary input. For the latter event, „>Trig.Wave.Cap." must be allocated to a binary input. Triggering of the recording then occurs, for example, via the binary input when the protected object is energised.

Such externally started test fault recordings (i.e., without a protection pickup) are handled by the device as normal fault recordings, i.e. for each measurement record a fault log is opened with its own number, for unequivocal allocation. However, these recordings are not displayed in the fault indication buffer, as they are not fault events.

Triggering Oscillographic Recording

To trigger test measurement recording with DIGSI, click on **Test** in the left part of the window. Double click the entry **Test Wave Form** in the list of the window.

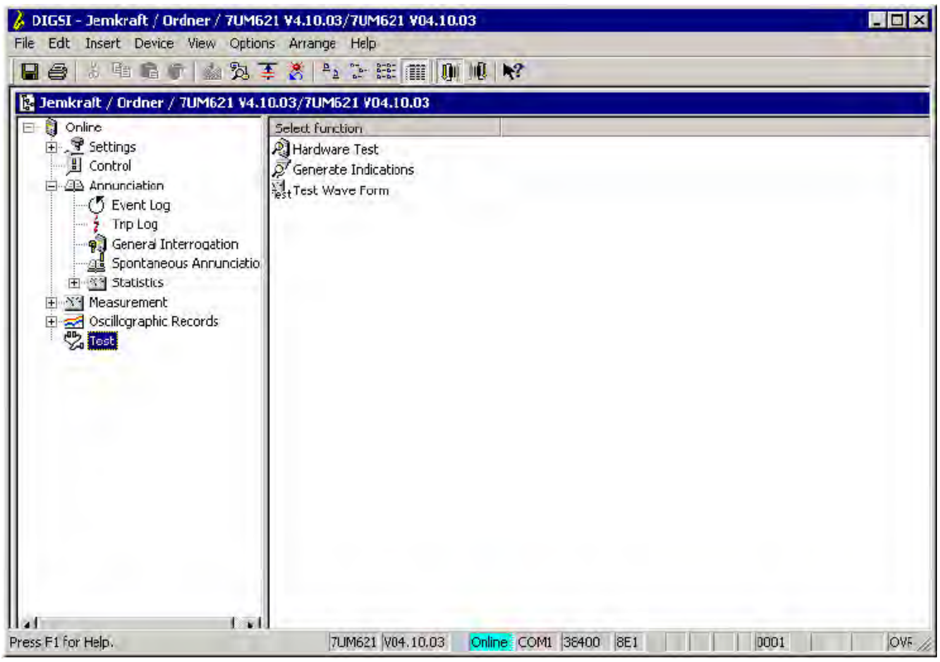


Figure 3-40 Triggering oscillographic recording with DIGSI — Example

A test measurement record is immediately started. During recording, an indication is given in the left part of the status bar. Bar segments additionally indicate the progress of the procedure.

For display and evaluation of the recording, you require one of the programs SIGRA or ComtradeViewer.

3.4 Final Preparation of the Device

Firmly tighten all screws. Tighten all terminal screws, including those that are not used.

Caution!

Inadmissable tightening torques

Non–observance of the following measure can result in minor personal injury or property damage.

The tightening torques must not be exceeded as the threads and terminal chambers may otherwise be damaged!

In case service settings were changed, check if they are correct. Check if power system data, control and auxiliary functions to be found with the configuration parameters are set correctly (Section 2). All desired elements and functions must be set **ON**. Keep a copy of all of the in-service settings on a PC.

Check the internal clock of the device. If necessary, set the clock or synchronize the clock if the element is not automatically synchronized. For assistance, refer to the SIPROTEC 4 System Description /1/.

The indication buffers are deleted under **MAIN MENU** → **Annunciation** → **Set/Reset**, so that in the future they only contain information on actual events and states (see also /1/). The counters in the switching statistics should be reset to the values that were existing prior to the testing (see also SIPROTEC 4 System Description /1/).

The counters of the operational measured values (e.g. operation counter, if available) are reset under **Main Menu** → **Measurement** → **Reset**.

Press the ESC key, several times if necessary, to return to the default display. The default display appears in the display (e.g. display of operation measured values).

Clear the LEDs on the front panel by pressing the LED key, so that they only show real events and states. In this context, also output relays probably memorized are reset. Pressing the LED key also serves as a test for the LEDs on the front panel because they should all light when the button is pushed. Any LEDs that are lit after the clearing attempt are displaying actual conditions.

The green „RUN“ LED must be on. The red „ERROR“ LED must not be lit.

Close the protective switches. If test switches are available, then these must be in the operating position.

The device is now ready for operation.

■

Technical Data 4

This chapter presents the technical data of the SIPROTEC 4 7UM62 device and its individual functions, including the limit values that must not be exceeded under any circumstances. The electrical and functional data for devices equipped with all options are followed by the mechanical data with dimensional drawings.

4.1 General

4.1.1 Analog Inputs/Outputs

Current Inputs

Rated system frequency	f_N	50 Hz or 60 Hz	(adjustable)
Rated current	I_N	1 A or 5 A	
Earth Current, Sensitive	I_{EE}	Linear range ≤ 1.6 A	
Burden per Phase and Earth Path			
- at I_N = 1 A		Approx. 0.05 VA	
- at I_N = 5 A		Approx. 0.3 VA	
- for Sensitive Earth Fault Detection at 1 A		Approx. 0.05 VA	
Current Path Loadability			
- Thermal (rms)		100· I_N for 1 s 30· I_N for 10 s 4· I_N continuous	
- Dynamic (peak value)		250· I_N (half-cycle)	
Current overload capability for high-sensitivity input I_{EE}			
- Thermal (rms)		300 A for 1 s	
		100 A for 10 s	
		15 A continuous	
- Dynamic (peak value)		750 A (Half-cycle)	

Voltage Inputs

Secondary nominal voltage		100 V to 125 V
Measuring range		0 V to 200 V
Burden	at 100 V	Approx. 0.3 VA
Voltage path overload capacity		
- Thermal (rms)		230 V continuous

Measuring Transducer Inputs

Measuring range	-10 V to +10 V or -20 mA to +20 mA
Input resistance for DC voltage	approx. 1 MΩ
Input resistance for DC voltage	Approx. 10 Ω
Voltage Input Overload Capacity	DC 60 V continuous
Current Input Overload Capacity	100 mA continuous

Analog output (for operational measured values)

Nominal Range	0 mA to 20 mA or 4 mA to 20 mA
Operating Range	0 mA to 22.5 mA or 4 mA to 22.5 mA
Connection for flush-mounted case	Rear panel, mounting location "B" or/and "D" 9-pin DSUB female connector
For Panel Surface-Mounted Case	At the terminal on the case bottom or/and at the housing top
Max. Burden	350 Ω

4.1.2 Auxiliary Voltage

DC Voltage

Voltage Supply via Integrated Converter		
Nominal auxiliary voltage DC U_{Aux}	DC 24 V/48 V	DC 60 V/110 V/125 V
Admissible voltage ranges	DC 19 V to 58 V	DC 48 V to 150 V
Nominal auxiliary voltage DC U_{Aux}	DC 110 V/125 V/220 V/250 V	
Permissible voltage ranges	DC 88 V to 300 V	
Admissible AC ripple voltage, Peak to Peak, IEC 60255-11	≤15 % of the Auxiliary Voltage	
Power input		
7UM621	Quiescent	approx. 5.5 W
7UM622		approx. 5.7 W
7UM623		approx. 8.1 W
7UM621	Energized	approx. 12.5 W
7UM622		approx. 14.6 W
7UM623		approx. 14.6 W
Bridging time in the event of power failure/short circuit	≥ 50 ms at U ≥ DC 48 V ($U_{Aux,N}$ = 24 V/48 V)	
	≥ 50 ms at U ≥ DC 110 V ($U_{Aux,N}$ = 60 V to 125 V)	
	≥ 20 ms at U ≥ DC 24 V ($U_{Aux,N}$ = 24 V/48 V)	
	≥ 20 ms at U ≥ DC 60 V ($U_{Aux,N}$ = 60 V to 125 V)	

AC Voltage

Voltage supply via integrated converter		
Nominal auxiliary voltage AC U_{Aux}	AC 115 V (50 Hz or 60 Hz)	AC 230 V (50 Hz or 60 Hz)
Admissible voltage ranges	AC 92 V to 132 V	AC 184 V to 265 V
Power input		
7UM621	Quiescent	approx. 5.5 VA
7UM622		approx. 5.5 VA
7UM623		approx. 5.5 VA
7UM621	Energized	approx. 13 VA
7UM622		approx. 15 VA
7UM623		approx. 13 VA
Bridging time in the event of power failure/short circuit		≥ 200 ms

4.1.3 Binary Inputs and Outputs

Binary inputs

Variant	Number	
7UM621*-	7 (configurable)	
7UM623*-		
7UM622*-	15 (configurable)	
Rated Voltage Range	DC24 V to 250 V, bipolar	
Current Consumption, Energized	Approx. 1.8 mA, independent of the control voltage	
Switching Thresholds	adjustable with jumpers	
For rated voltages	DC 24 V/48 V/60 V/110 V/125 V	U_{high} ≥ DC 19 V U_{low} ≤ DC 10 V
For rated voltages	DC 110 V/125 V/220 V/250 V and AC 115 V/230 V	U_{high} ≥ DC 88 V U_{low} ≤ DC 44 V
For nominal voltages	DC 220 V/250 V and AC 115 V/230 V	U_{high} ≥ DC 176 V U_{low} ≤ DC 88 V
Maximum permissible voltage	DC 300 V	
Input impulse filtering	220 nF coupling capacity at 220 V with recovery time > 60 ms	

Binary Outputs

Signalling/trip relays [1] (see also terminal assignments in Appendix A.2))		
Number:	According to the order variant (allocatable)	
	7UM621*-	12 (1 NO contact each, 3 optionally as NC contacts)
	7UM623*-	
	7UM622*-	20 (1 NO contact each, 4 optionally as NC contacts) 1 Life contact (NC contact or NO contact, selectable)
Make/break capacity	CLOSE	1000 W/VA
	BREAK	30 VA 40 W resistive 25 W/VA at L/R ≤ 50 ms
Switching voltage	250 V	
Permissible current per contact (continuous)	5 A	
Permissible current per contact (close and hold)	30 A for 0.5 S (NO contact)	
Permissible total current on common path	5 A continuous 30 A for 0.5 s	

[1]) UL-listed with the following rated data:		
	AC 120 V	Pilot duty, B300
	AC 240 V	Pilot duty, B300
	AC 240 V	5 A General Purpose
	DC 24 V	5 A General Purpose
	DC 48 V	0.8 A General Purpose
	DC 240 V	0.1 A General Purpose
	AC 120 V	1/6 hp (4.4 FLA)
	AC 240 V	1/2 hp (4.9 FLA)

LEDs

Number	
RUN (green)	1
ERROR (red)	1
allocatable LEDs (red)	14

4.1.4 Communication Interfaces

Operating Interface

Connection	Front side, non-isolated, RS232, 9-pin DSUB port for connection of a PC
Operation	With DIGSI
Transmission Speed	min. 4 800 Bd to 115 200 Bd Factory setting: 38 400 Bd; Parity: 8E1
bridgeable distance	15 m

Service / Modem Interface

	Connection	isolated interface for data transfer
	Operation	With DIGSI
	Transmission Speed	min. 4,800 Bd to 115,200 Bd Factory setting: 38,400 Bd; Parity: 8E1
RS232/RS485		RS232/RS485 according to the ordering variant
	Connection for flush-mounted case	Rear panel, mounting location "C" 9-pole DSUB port
	Surface-mounting case	At the console housing mounted case on the case bottom; Shielded data cable
	Test voltage	AC 500 V, 50 Hz
RS232		
	bridgeable distance	15 m
RS485		
	bridgeable distance	1,000 m

System Interface

IEC 60870-5-103		
	RS232/RS485 Acc. to ordered variant	Isolated interface for data transfer to a master terminal
RS232		
	Connection for flush mounted case	Rear panel, mounting location "B" 9-pole DSUB port
	For panel surface-mounted case	in console housing at case bottom side
	Test voltage	500 V; 50 Hz
	Transmission speed	min. 4,800 Bd, max. 115,200 Bd Factory setting 38,400 Bd
	Bridgeable distance	15 m / 50 feet

RS485		
	Connection for flush mounted case	Rear panel, mounting location "B" 9-pin DSUB port
	For panel surface-mounted case	in console housing at case bottom side
	Test voltage	500 V; 50 Hz
	Transmission speed	min. 4,800 Bd, max. 115,200 Bd Factory setting 38,400 Bd
	Bridgeable distance	Max. 1,000 m / 3,280 feet
Fibre optic cable (FO)		
	FO connector type	ST connector
	Connection for flush mounted case	Rear panel, mounting location "B"
	For panel surface-mounted case	in console housing at case bottom side
	Optical wavelength	λ = 820 nm
	Laser class 1 acc. to EN 60825-1/-2	Using glass fiber 50/125 µm or Using glass fiber 62.5/125 µm
	Permissible optical link signal attenuation	Max. 8 dB, with glass fibre 62.5/125 µm
	Bridgeable distance	Max. 1,500 m
	Character idle state	Configurable; factory setting: “Light off”
Profibus RS485 (DP)		
	Connection for flush mounted case	Rear panel, mounting location "B"
	For panel surface-mounted case	in console housing at case bottom side
	Test voltage	500 V; 50 Hz
	Transmission speed	up to 12 MBd
	Bridgeable distance	1,000 m / 3,280 feet at ≤ 93.75 kBd 500 m / 1,640 feet at ≤ 187.5 kBd 200 m / 656 feet at ≤ 1.5 MBd 100 m / 328 feet at ≤ 12 MBd
DNP 3.0 RS485		
	Connection for flush mounted case	Rear panel, mounting location "B" 9-pin DSUB port
	For panel surface-mounted case	in console housing at case bottom side
	Test voltage	500 V; 50 Hz
	Transmission speed	up to 19,200 Bd
	Bridgeable distance	Max. 1,000 m / 3,280 feet
MODBUS RS485		
	Connection for flush mounted case	Rear panel, mounting location "B" 9-pin DSUB port
	for surface-mounting case	in console housing at case bottom side
	Test voltage	500 V; 50 Hz
	Transmission speed	up to 19,200 Bd
	Bridgeable distance	Max. 1,000 m / 3,280 feet

Profibus FO (DP)		
	FO connector type	ST-connector: single ring / double ring according to the order for FMS; for DP only double ring available
	Connection for flush mounted case	Rear panel, mounting location "B"
	For panel surface-mounted case	Please use version with Profibus RS485 in the console housing as well as separate electrical/optical converter.
	Transmission speed	up to 1.5 MBd
	Recommended	> 500 kBd
	Optical wavelength	λ = 820 nm
	Laser class 1 acc. to EN 60825-1/-2	Using glass fiber 50/125 µm or Using glass fiber 62.5/125 µm
	Permissible optical link signal attenuation	Max. 8 dB, with glass fibre 62.5/125 µm
	Bridgeable distance	Max. 1,500 m / 0.93 miles
DNP 3.0 FO		
	FO connector type	ST connector receiver/transmitter
	Connection for flush mounted case	Rear panel, mounting location "B"
	For panel surface-mounted case	Please use version with DNP 3.0 RS485 in the console housing as well as separate electrical/optical converter.
	Transmission speed	up to 19,200 Bd
	Optical wavelength	λ = 820 nm
	Laser class 1 acc. to EN 60825-1/-2	Using glass fiber 50/125 µm or Using glass fiber 62.5/125 µm
	Permissible optical link signal attenuation	Max. 8 dB, with glass fibre 62.5/125 µm
	Bridgeable distance	Max. 1,500 m / 0.93 miles
MODBUS FO		
	FO connector type	ST connector receiver/transmitter
	Connection for flush mounted case	Rear panel, mounting location "B"
	For panel surface-mounted case	Please use version with MODBUS RS485 in the console housing as well as separate electrical/optical converter.
	Transmission speed	up to 19,200 Bd
	Optical wavelength	λ = 820 nm
	Laser class 1 acc. to EN 60825-1/-2	Using glass fiber 50/125 µm or Using glass fiber 62.5/125 µm
	Permissible optical link signal attenuation	Max. 8 dB, with glass fibre 62.5/125 µm
	Bridgeable distance	Max. 1,500 m / 0.93 miles

Analog output module (electrical)	2 ports with 0 mA to 20 mA	
	Connection for flush mounted case	Rear panel, mounting location "B" and "D" 9-pin DSUB port
	For panel surface-mounted case	in console housing at case bottom side
	Test voltage	500 V; 50 Hz
Ethernet electrical (EN 100) for IEC 61850 and DIGSI		
	Connection for flush mounted case	Rear panel, mounting location "B" 2 x RJ45 female connector 100BaseT acc. to IEEE802.3
	For panel surface-mounted case	in console housing at case bottom side
	Test voltage (female connector)	500 V; 50 Hz
	Transmission speed	100 Mbits/s
	Bridgeable distance	20 m / 66 feet
Ethernet optical (EN 100) for IEC 61850 and DIGSI		
	FO connector type	ST connector receiver/transmitter
	Connection for flush mounted case	Rear panel, mounting location "B"
	For panel surface-mounted case	Not available
	Optical wavelength	λ = 1350 nm
	Transmission speed	100 Mbits/s
	Laser class 1 acc. to EN 60825-1/-2	Using glass fiber 50/125 µm or Using glass fiber 62.5/125 µm
	Permissible optical link signal attenuation	Max. 5 dB, with glass fibre 62.5/125 µm
	Bridgeable distance	Max. 800 m / 0.5 mile

Time Synchronization Interface

Time synchronization	DCF 77 / IRIG B Signal (telegram format IRIG-B000)
Connection for flush-mounted case	rear panel, mounting location "A"; 9-pole D-subminiature Female Connector
for surface-mounted case	at two-tier terminals on case bottom
Signal nominal voltages	selectable 5 V, 12 V or 24 V
Test voltage	500 V; 50 Hz

Signal levels and burdens			
	Nominal signal voltage		
	5 V	**12 V**	**24 V**
U_{IHigh}	6.0 V	15.8 V	31 V
U_{ILow}	1.0 V at I_{ILow} = 0.25 mA	1.4 V at I_{ILow} = 0.25 mA	1.9 V at I_{ILow} = 0.25 mA
I_{IHigh}	4.5 mA to 9.4 mA	4.5 mA to 9.3 mA	4.5 mA to 8.7 mA
R_I	890 Ω at U_I = 4 V	1930 Ω at U_I = 8.7 V	3780 Ω at U_I = 17 V
	640 Ω at U_I = 6 V	1700 Ω at U_I = 15.8 V	3560 Ω at U_I = 31 V

4.1.5 Electrical Tests

Regulations

Standards:	IEC 60255 (product standards) IEEE C37.90.0/.1/.2 UL 508 VDE 0435 See also standards for individual tests

Insulation Test

Standards:	IEC 60255-5 and IEC 60870-2-1
High voltage test (routine test) current inputs, voltage inputs, output relays	2.5 kV (rms), 50 Hz
High voltage test (routine test) Auxiliary voltage and binary inputs	DC 3.5 kV
High voltage test (routine test) Measuring transducers MU1-MU3	DC 3.0 kV
Impulse voltage test (type test) only isolated communication and time synchronization interfaces or analog outputs (port A –D)	500 V (rms), 50 Hz
Impulse voltage test (type test) All circuits except communication and time synchronization interfaces, analog outputs class III	5 kV (peak): 1.2/50 μs: 0.5 J, 3 positive and 3 negative impulses in intervals of 5 s

EMC Tests for Immunity (Type Tests)

Standards:	IEC 60 255-6 and -22 (product standards) EN 61000-6-2 (generic standard) VDE 0435 Part 301 DIN VDE 0435-110
High frequency test IEC 60255-22-1, Class III and VDE 0435 Part 303, Class III	2.5 kV (peak); 1 MHz; τ = 15 μs; 400 surges per s; test duration 2 s; R_i = 200 Ω
Electrostatic discharge IEC 60 55-22-2, Class IV and IEC 61000-4-2, Class IV	8 kV contact discharge; 15 kV air discharge, both polarities; 150 pF; R_i = 330 Ω
Irradiation with HF field, frequency sweep IEC 60255-22-3, Class III IEC 61000-4-3, Class III	10 V/m; 80 MHz to 1000 MHz; 10 V/m; 800 MHz to 960 MHz; 20 V/m; 1.4 GHz to 2.0 GHz; 80 % AM; 1 kHz
Irradiation with HF field, single frequencies IEC 60255-22-3, IEC 61000-4-3, amplitude-modulated	Class III: 10 V/m 80/160/450/900 MHz 80 % AM 1 kHz; duty cycle > 10 s
Fast transient disturbance/burst IEC 60255-22-4 and IEC 61000-4-4, Class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities: R_i = 50 Ω; test duration 1 min
High energy surge voltages (SURGE), IEC 61000-4-5 Installation Class 3	Pulse: 1.2/50 μs

	Auxiliary voltage	Common mode: 2 kV; 12 Ω; 9 μF Diff. mode: 1 kV; 2 Ω; 18 μF
	Measuring Inputs, Binary Inputs, Relay Outputs	Common mode: 2 kV; 42 Ω; 0.5 μF Diff. mode: 1 kV; 42 Ω; 0.5 μF
Line conducted HF, amplitude modulated IEC 61000-4-6, Class III		10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz
Power System Frequency Magnetic Field IEC 61000-4-8, Class IV IEC 60255-6		30 A/m; continuous; 300 A/m for 3 s; 50 Hz 0.5 mT; 50 Hz
Oscillatory Surge Withstand Capability IEEE Std C37.90.1		2.5 kV (peak value); 1 MHz; τ = 15 μs; 400 pulses per s; test duration 2 s; R_i = 200 Ω
Fast transient surge withstand cap. IEEE Std C37.90.1		4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities: R_i = 50 Ω; test duration 1 min
Radiated electromagnetic interference IEEE Std C37.900.2		35 V/m; 25 MHz to 1000 MHz
Damped oscillations IEC 60694, IEC 61000-4-12		2.5 kV (peak value), polarity alternating 100 kHz, 1 MHz, 10 MHz and 50 MHz, R_L = 200 Ω

EMC Tests For Noise Emission (Type Test)

Standard:	EN 61000-6-3 (generic standard)
Radio Noise Voltage to Lines, Only Power Supply Voltage IEC-CISPR 22	150 kHz to 30 MHz Limit Class B
Radio Noise Field Strength IEC-CISPR 11	30 MHz to 1000 MHz Limit Class A

4.1.6 Mechanical Stress Tests

Vibration and Shock Stress During Stationary Operation

Standards:	IEC 60255-21 and IEC 60068
Oscillation IEC 60255-21-1, Class 2 IEC 60068-2-6	sinusoidal 10 Hz to 60 Hz: ±0.075 mm amplitude; 60 Hz to 150 Hz: 1g acceleration Frequency Sweep Rate 1 octave/min, 20 Cycles in 3 Orthogonal Axes
Shock IEC 60255-21-2, Class 1 IEC 60068-2-27	Semi-sinusoidal 5 g acceleration, duration 11 ms, each 3 shocks (in both directions of the 3 axes)
Seismic Vibration IEC 60255-21-3, Class 1 IEC 60068-3-3	sinusoidal 1 Hz to 8 Hz: ±3.5 mm amplitude; (Horizontal axis) 1 Hz to 8 Hz: ±1.5 mm amplitude; (vertical axis) 8 Hz to 35 Hz: 1 g acceleration (horizontal axis); 8 Hz to 35 Hz: 0.5 g acceleration (vertical axis) Frequency Sweep 1 octave/min 1 Cycle in 3 Orthogonal Axes

Vibration and Shock Stress During Transport

Standards:	IEC 60255-21 and IEC 60068
Oscillation IEC 60255-21-1, Class 2 IEC 60068-2-6	sinusoidal 5 Hz to 8 Hz: ±7.5 mm amplitude; 8 Hz to 15 Hz: 2 g Acceleration Frequency Sweep 1 octave/min 20 Cycles in 3 Orthogonal Axes
Shock IEC 60255-21-2, Class 1 IEC 60068-2-27	Semi-sinusoidal 15 g acceleration, duration 11 ms, each 3 shocks (in both directions of the 3 axes)
Continuous Shock IEC 60255-21-2, Class 1 IEC 60068-2-29	Semi-sinusoidal 10 g acceleration, duration 16 ms, 1000 shocks in each direction of 3 orthogonal axes

4.1.7 Climatic Stress Tests

Temperatures

Type test (acc. to IEC 60068-2-1 and -2, Test Bd for 16 h)	-25 °C to +85 °C
Limiting temporary (transient) operating temperature (tested for 96 h)	–20 °C to +70 °C or –4 °F to +158 °F (Visibility of display may be impaired above +55 °C or 130 °F)
Recommended for continuous operation (acc. to IEC 60255-6)	23 °F to +131 °F or –5 °C to +55 °C
Limit temperatures for longterm storage	-25 °C to +131 °F or –5 °C to +55 °C
Limit temperatures during transport	-25 °C to +70 °C or –5 °C to +55 °C
Storage and transport of the device with factory packaging!	

Humidity

Admissible humidity	yearly average ≤ 75 % relative humidity; On 56 days of the year up to 93% relative humidity. Condensation must be avoided in operation!
Siemens recommends that all devices be installed so that they are not exposed to direct sunlight nor subject to large fluctuations in temperature that may cause condensation to occur.	

4.1.8 Service Conditions

The protection device is designed for installation in normal relay rooms and plants, so that electromagnetic compatibility (EMC) is ensured if installation is done properly.

In addition the following is recommended:

- Contactors and relays operating within the same cubicle or on the same relay board with digital protection equipment should always be provided with suitable quenching equipment.
- For substations with operating voltages of 100 kV and above, all external cables should be shielded with a conductive shield grounded at both ends. For substations with lower operating voltages, no special measures are normally required.
- Do not withdraw or insert individual modules or boards while the protective device is energized. When handling the modules or the boards outside of the case, standards for components sensitive to electrostatic discharge (**E**lectrostatic **S**ensitive **D**evices) must be observed. They are not endangered when inserted into the case.

4.1.9 Certifications

UL Listing		**UL recognition**	
7UM62**-*B***-****	Models with screw terminals	7UM62**-*D***-****	Models with plug–in terminals
7UM62**-*E***-****			

4.1.10 Design

Case	7XP20
Dimensions	See dimensional drawings, Section 4.39

Weight approx.	
in flush mounted case	
7UM621* (case size 1/2)	Approx. 7.5 kg (16.5 pounds)
7UM623* (case size 1/2)	
7UM622* (case size 1/1)	Approx. 9.5 kg (22 pounds)
in surface mounted case	
7UM621* (case size 1/2)	Approx. 12 kg (26.5 pounds)
7UM623* (case size 1/2)	
7UM622* (case size 1/1)	Approx. 15 kg (33 pounds)

Degree of protection acc. to IEC 60529		
for surface mounting case equipment		IP 51
in flush mounted case		
	Front	IP 51
	Rear	IP 50
For personal protection		IP 2x with cover in place

4.2 Definite-Time Overcurrent Protection (ANSI 50, 51, 67)

Setting Ranges / Increments

Pickup current I>	for I_N = 1 A	0.05 A to 20.00 A	Increments 0.01 A
	for I_N = 5 A	0.25 A to 100.00 A	Increments 0.01 A
Pickup current I>>	for I_N = 1 A	0.05 A to 20.00 A	Increments 0.01 A
	for I_N = 5 A	0.25 A to 100.00 A	Increments 0.01 A
Delay times T		0.00 s to 60.00 s or ∞ (ineffective)	Increments 0.01 s
Undervoltage seal-in U< (phase-to-phase)		10.0 V to 125.0 V	Increments 0.1 V
Holding Time of Undervoltage Seal-In		0.10 s to 60.00 s	Increments 0.01 s
Directional limit line angle tolerance I>>		–90° el. to +90° el.	Increments 1°
The set times are pure delay times.			

Times

Pickup times	
I >, I>> Current = 2 × Pickup Value Current = 10 × Pickup Value	 approx. 35 ms approx. 25 ms
Dropout times I >, I>>	approx. 50 ms

Dropout Ratio

Dropout ratio overcurren I>	0.90 to 0.99	
Dropout ratio overcurren I>>	approx. 0.95 for I/I_N ≥ 0,3	(Increments 0.01)
Dropout ratio undervoltage	approx. 1.05	
Dropout difference Δφ	2° elektrical	

Tolerances

Pickup current I >, I>>	for I_N = 1 A	1 % of setting value or 10 mA
	for I_N = 5 A	1 % of setting value or 50 mA
Undervoltage seal–in U<		1 % of setting value or 0.5 V
Delay times T		1 % or 10 ms
Directional limit lines angle		1° electrical

Influencing Variables for Pickup Values

Power supply direct voltage in range 0.8 ≤ U_{Aux}/U_{AuxN} ≤ 1.15	≤ 1 %
Temperature in range 23.00 °F (–5 °C) ≤ Θ_{amb} ≤ 131.00 °F (55 °C)	≤ 0.5 % / 10 K
Frequency in range 0.95 ≤ f/f_N ≤ 1.05	≤ 1 %
Harmonics – Up to 10 % 3rd harmonic – Up to 10 % 5th harmonic	 ≤ 1 % ≤ 1 %

4.3 Inverse-Time Overcurrent Protection (ANSI 51V)

Setting Ranges / Increments

Pickup current I_p (phases)	for I_N = 1 A	0.10 A to 4.00 A	Increments 0.01 A
	for I_N = 5 A	0.50 A to 20.00 A	Increments 0.01 A
Time Multipliers T for I_p IEC curves		0.05 s to 3.20 s or ∞ (ineffective)	Increments 0.01 s
Time Multiplier D for I_p ANSI curves		0.50 to 15.00 or ∞ (ineffective)	Increments 0.01
Undervoltage enable U<		10.0 V to 125.0 V	Increments 0.1V

Trip Time Characteristics according to IEC

As per IEC 60255-3 (see also Figure 4-1)

NORMAL INVERSE (Type A)

$$t = \frac{0.14}{(I/I_p)^{0.02} - 1} \cdot T_p$$

VERY INVERSE (Type B)

$$t = \frac{13.5}{(I/I_p)^{1} - 1} \cdot T_p$$

EXTREMELY INVERSE (Type C)

$$t = \frac{80}{(I/I_p)^{2} - 1} \cdot T_p$$

For All Characteristics:
- t Trip Time in Seconds
- T_p Setting Value of the Time Multiplier
- I Fault Current
- I_p Setting Value of the Pickup Current

The tripping times for $I/I_p \geq 20$ are identical with those for $I/I_p = 20$.

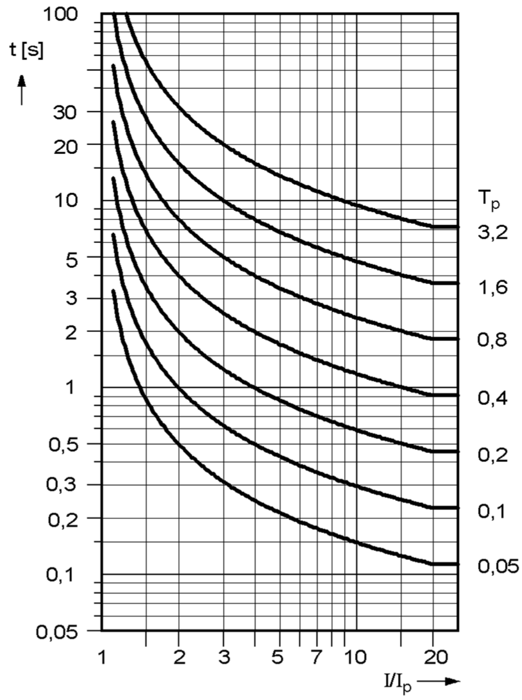
Pickup Threshold	approx. $1.10 \cdot I_p$
Dropout Threshold	approx. $1.05 \cdot I_p$ for $I_p/I_N \geq 0.3$,

Tolerances

Pickup currents I_p	for I_N = 1 A	1 % of setting value or 10 mA
	for I_N = 5 A	1 % of setting value or 50 mA
Pickup of U<		1 % of setting value, or 0.5 V
Time for $2 \leq I/I_p \leq 20$		5 % of reference (calculated) value +1 % current tolerance, or 40 ms

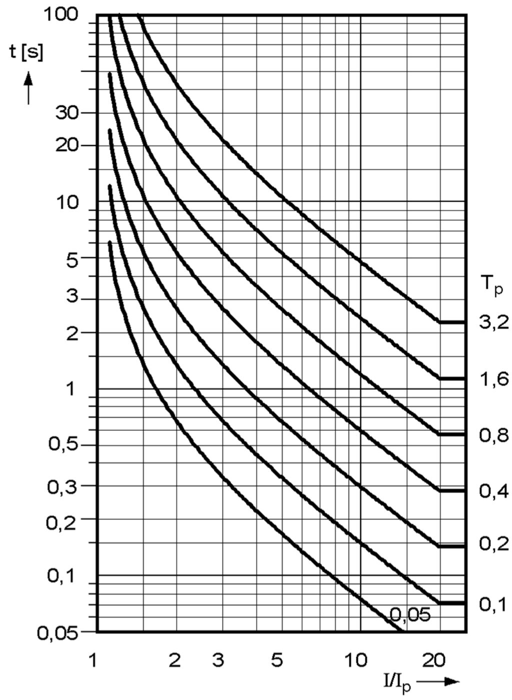
Influencing Variables for Pickup Values

Power supply direct voltage in range $0.8 \leq U_{Aux}/U_{AuxN} \leq 1.15$	≤ 1 %	
Temperature in range 23.00 °F (–5 °C) ≤ Θ_{amb} ≤ 131.00 °F (55 °C)	≤ 0.5 % / 10 K	
Frequency in range $0.95 \leq f/f_N \leq 1.05$	≤ 1 %	
Harmonics – Up to 10 % 3rd harmonic – Up to 10 % 5th harmonic	 ≤ 1 % ≤ 1 %	



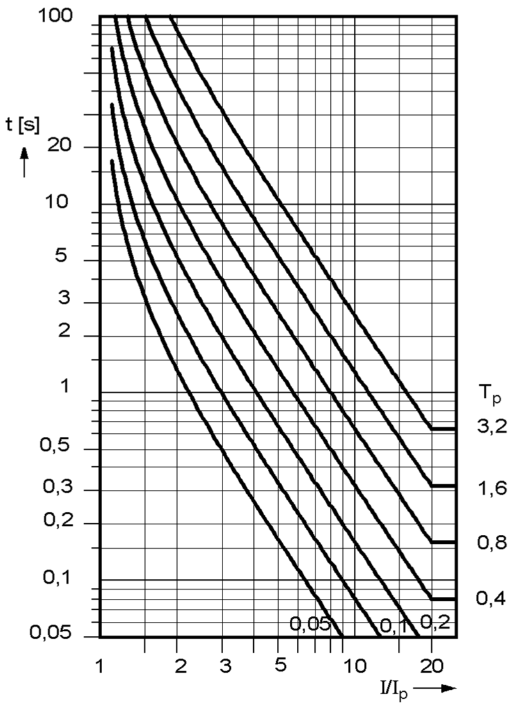
Normal inverse:
(Type A)

$$t = \frac{0,14}{(I/I_p)^{0,02} - 1} \cdot T_p \quad [s]$$



Very inverse:
(Type B)

$$t = \frac{13,5}{(I/I_p)^{1} - 1} \cdot T_p \quad [s]$$



Extremely Inverse:
(Type C)

$$t = \frac{80}{(I/I_p)^{2} - 1} \cdot T_p \quad [s]$$

t Trip Time
T_p Setting Value of the time multiplier
I Fault current
I_p Setting value current

Figure 4-1 Trip Characteristics of the Inverse-time Overcurrent Protection, acc. to IEC

Trip Time Characteristics according to ANSI

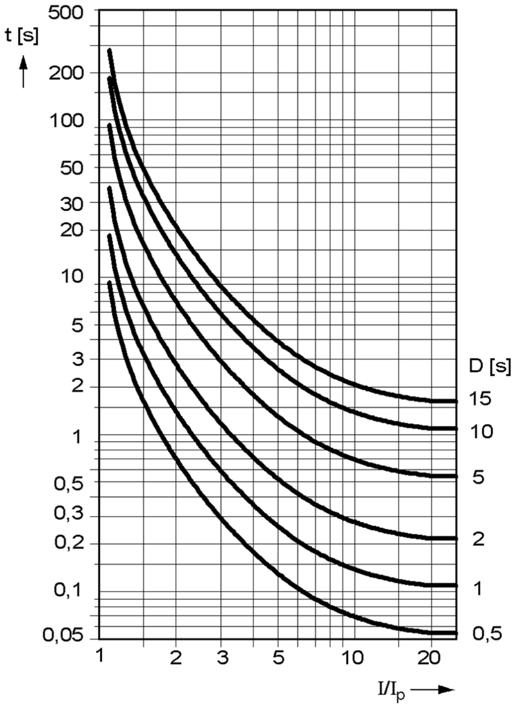
As per ANSI/IEEE (see also Figures 4-2 and 4-3)	
VERY INVERSE	$t = \left(\frac{3.922}{(I/I_p)^2 - 1} + 0.0982\right) \cdot D$
INVERSE	$t = \left(\frac{8.9341}{(I/I_p)^{2.0938} - 1} + 0.17966\right) \cdot D$
MODERATELY INVERSE	$t = \left(\frac{0.0103}{(I/I_p)^{0.02} - 1} + 0.0228\right) \cdot D$
EXTREMELY INVERSE	$t = \left(\frac{5.64}{(I/I_p)^2 - 1} + 0.02434\right) \cdot D$
DEFINITE INVERSE	$t = \left(\frac{0.4797}{(I/I_p)^{1.5625} - 1} + 0.21359\right) \cdot D$
	For all Characteristics: t Trip Time in Seconds D Setting Value of the Time Multiplier I Fault Current I_p Setting Value of the Pickup Current
The tripping times for $I/I_p \geq 20$ are identical with those for $I/I_p = 20$.	
Pickup Threshold	approx. $1.10 \cdot I_p$
Dropout Threshold	approx. $1.05 \cdot I_p$ for $I_p/I_N \geq 0.3$, this corresponds to approx. 0,95 · pickup value

Tolerances

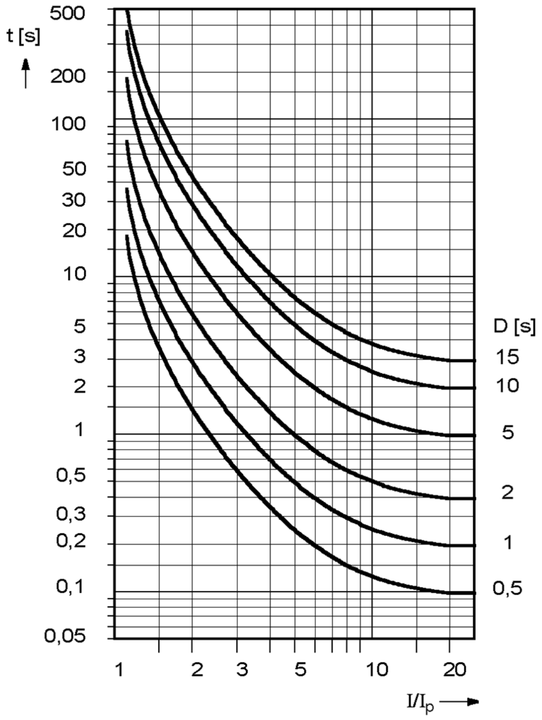
Pickup and dropout thresholds I_p	for I_N = 1 A	1 % of setting value or 10 mA
	for I_N = 5 A	1 % of setting value or 50 mA
Pickup of U<		1 % of setting value or 0.5 V
Time for $2 \leq I/I_p \leq 20$		5 % of reference (calculated) value +1 % current tolerance, or 40 ms

Influencing Variables

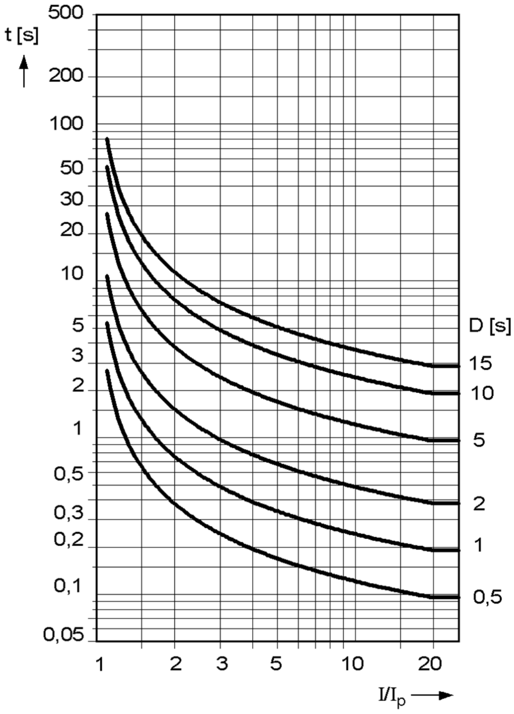
Power supply direct voltage in range $0.8 \leq U_{Aux}/U_{AuxN} \leq 1.15$	≤ 1 %
Temperature in range 23.00 °F (–5 °C) ≤ Θ_{amb} ≤ 131.00 °F (55 °C)	≤ 0.5 % / 10 K
Frequency in range $0.95 \leq f/f_N \leq 1.05$	1 %



Very inverse: $t = \left(\frac{3,922}{(I/I_p)^2 - 1} + 0,0982\right) \cdot D \text{ [s]}$



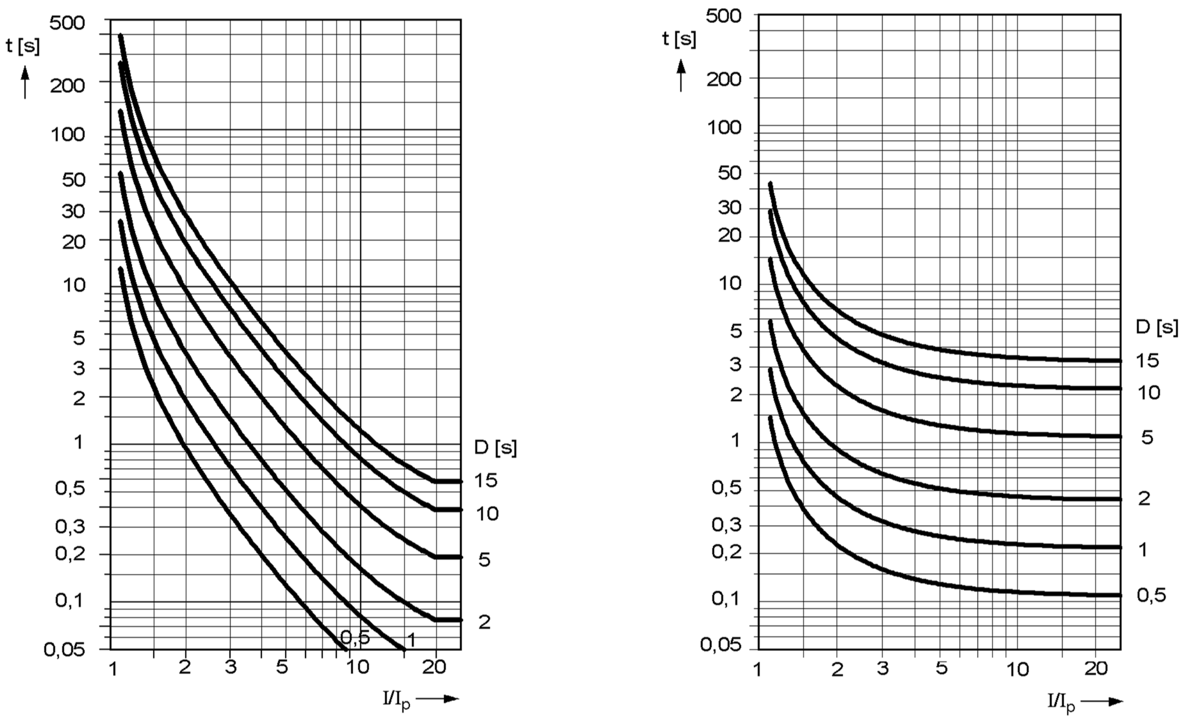
INVERSE $t = \left(\frac{8,9341}{(I/I_p)^{2,0938} - 1} + 0,17966\right) \cdot D \text{ [s]}$



MODERATELY INVERSE $t = \left(\frac{0,0103}{(I/I_p)^{0,02} - 1} + 0,0228\right) \cdot D \text{[s]}$

t Trip time in Seconds
D Setting Value of the time multiplier
I Fault current
I_p Setting value current

Figure 4-2 Trip Time Characteristics of the Inverse-time Overcurrent Protection, acc. to ANSI/IEEE



Extremely Inverse: $t = \left(\frac{5,64}{(I/I_p)^2 - 1} + 0,02434\right) \cdot D \quad [s]$

DEFINITE INVERSE $t = \left(\frac{0,4797}{(I/I_p)^{1,5625} - 1} + 0,21359\right) \cdot D \quad [s]$

t Trip Time
D Setting Value of the time multiplier
I Fault current
I_p Setting value current

Figure 4-3 Trip Time Characteristics of the Inverse-time Overcurrent Protection, acc. to ANSI/IEEE

4.4 Thermal Overload Protection (ANSI 49)

Setting Ranges / Increments

Factor k according to IEC 60255-8		0.10 to 4.00	Increments 0.01
Time constant τ		30 s to 32000 s	Increments 1 s
Extension of Time Constant at Standstill		1.0 to 10.0	Increments 0.1
Thermal alarm $\Theta_{Alarm}/\Theta_{Trip}$ referred to the tripping temperature		70 % to 100 %	Increments 1 %
Current Overload I_{Alarm}	for I_N = 1 A	0.10 A to 4.00 A	Increments 0.01 A
	for I_N = 5 A	0.50 A to 20.00 A	Increments 0.01 A
Nominal Overtemperature (for I_N)		40 °C to 200 °C	Increments 1 °C
Coolant Temperature for Scaling		40 °C to 300 °C	Increments 1 °C
Limit current I_{Limit}	for I_N = 1 A	0.50 A to 8.00 A	Increments 0.01 A
	for I_N = 5 A	2.00 A to 40.00 A	Increments 0.01 A
Emergency time $T_{Emergency\ Start}$		10 s to 15000 s	Increments 1 s

Tripping Characteristic

see also Figure 4-4

Trip Cahracteristic Curve for $(I/k \cdot I_N) \leq I_{Max\ therm.}$

$$t = \tau \cdot l_n \frac{\left(\frac{I}{k \cdot I_N}\right)^2 - \left(\frac{I_{pre}}{k \cdot I_N}\right)^2}{\left(\frac{I}{k \cdot I_N}\right)^2 - 1}$$

Where:

t	Trip time
τ	Temperature rise time constant
I	Load current
t_{pre}	Pre-load current
k	Setting factor per VDE 0435 Part 3011 and IEC 60255-8
I_N	Nominal current of the device
$I_{Max\ therm.}$	Current threshold up to which the above formula is valid

Dropout Ratios

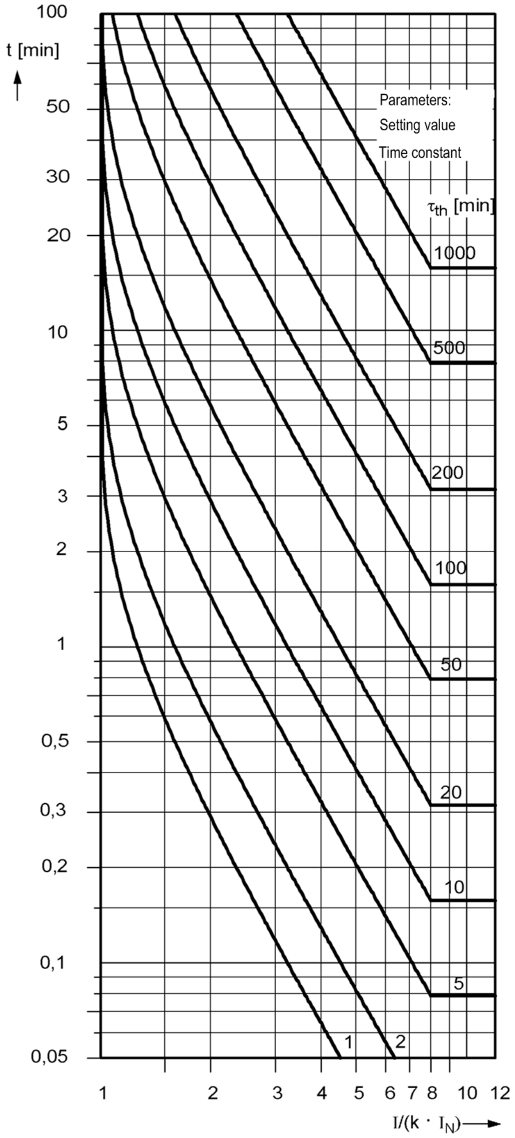
Θ/Θ_{Off}	Dropout with Θ_{Alarm}
Θ/Θ_{Alarm}	approx. 0.99
I/I_{Warn}	approx. 0.95

Tolerances

Referring to $k \cdot I_N$	for I_N = 1 A	2 % or 10 mA ; class 2 % acc. to IEC 60255-8
	for I_N = 5 A	2 % or 50 mA ; class 2 % acc. to IEC 60255-8
referred to Trip Time		3 % or 1 mA ; class 3 % acc. to IEC 60255-8 for $I/(k \cdot I_N) > 1.25$

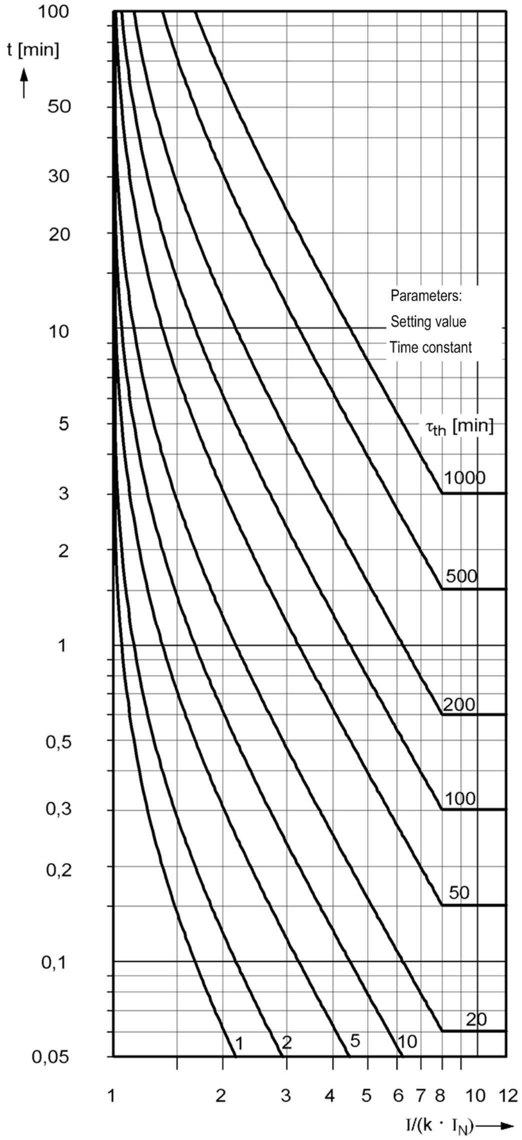
Influencing Variables referring to $k \cdot I_N$

Power supply direct voltage in range $0.8 \leq U_{Aux}/U_{AusN} \leq 1.15$	≤ 1 %
Temperature in range 23.00 °F (–5 °C) ≤ Θ_{amb} ≤ 131.00 °F (55 °C)	≤ 0.5 % / 10 K
Frequency in range $0.95 \leq f/f_N \leq 1.05$	≤ 1 %



without pre-load and with IMax therm. = 8 x k x IN:

$$t = \tau \cdot \ln \frac{\left(\frac{I}{k \cdot I_N}\right)^2}{\left(\frac{I}{k \cdot I_N}\right)^2 - 1} [\text{min}]$$



with pre-load and with IMax therm. = 8 x k x IN:

$$t = \tau \cdot \ln \frac{\left(\frac{I}{k \cdot I_N}\right)^2 - \left(\frac{I_{pre}}{k \cdot I_N}\right)^2}{\left(\frac{I}{k \cdot I_N}\right)^2 - 1} [\text{min}]$$

Figure 4-4 Tripping Characteristics for Overload Protection

4.5 Unbalanced Load (Negative Sequence) Protection (ANSI 46)

Setting Ranges / Increments

Admissible unbalanced load $I_{2\,perm.}/I_N$ (also alarm stage)	3.0 % to 30.0 %	Increments 0.1 %
Unbalanced load tripping stage I_2>>/I_N	10 % to 200 %	Increments 1 %
Delay times T_{Alarm}, $T_{I2>>}$	0.00 s to 60.00 s or ∞ (ineffective)	Increments 0.01 s
Asymmetry factor FACTOR K	1.0 s to 100.0 s or ∞ (ineffective)	Increments 0.1 s
Cooling time factor T_{Cool}	0 s to 50,000 s	Increments 1 s

Trip Time Characteristics

see also Figure 4-5

Trip Characteristic of the Thermal Replica:

$$t = \frac{K}{(I_2/I_N)^2}$$

Where:

t	Tripping time
K	Asymmetry factor
I_2	Negative sequence current
I_N	Nominal current of the device

Times

Pickup Times (Stage characteristic) Dropout Times (Stage characteristic)	approx. 50 ms approx. 50 ms

Dropout Conditions

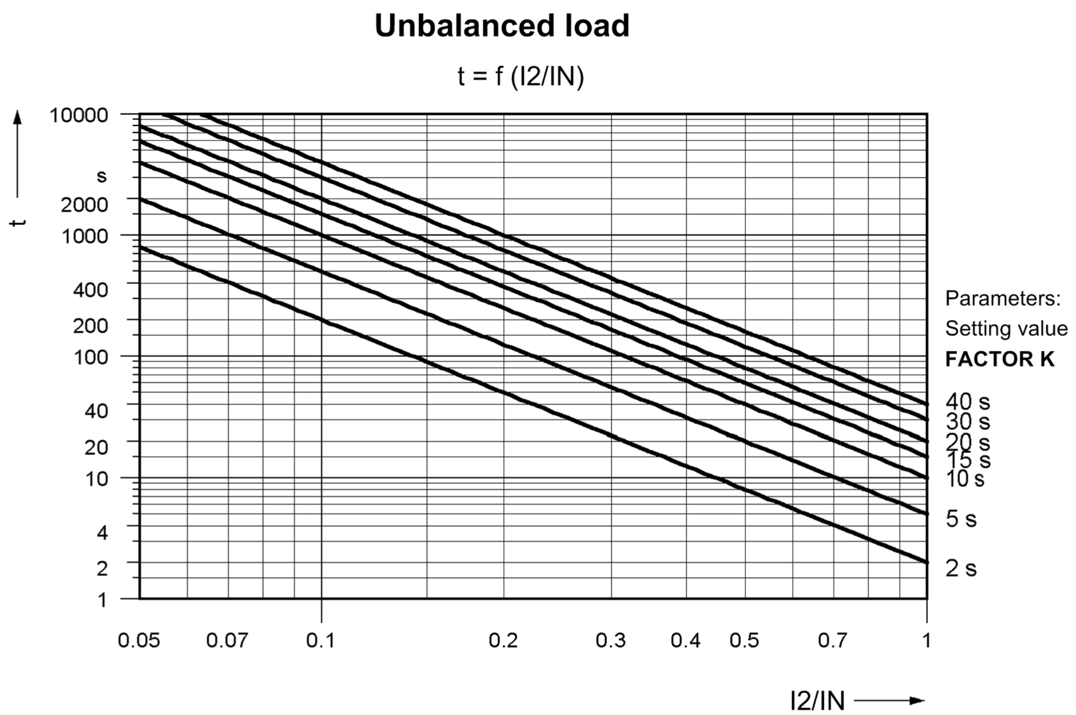
Alarm stage $I_{2\,perm.}$, Tripping stage I2>>	Approx. 0.95
Thermal tripping stage	Dropout on undershoot of $I_{2\,perm.}$

Tolerances

Pickup values $I_{2\,perm.}$, I_2>>	3 % of setting value or 0.3 % unbal. load
Delay Times	1 % or 10 ms
thermal characteristic Time for $2 \leq I_2/I_{2\,perm.} \leq 20$	5 % of reference (calculated) value +1 % current tolerance, or 600 ms

Influencing Variables for Pickup Values

Power supply direct voltage in range $0.8 \leq U_{Aux}/U_{AuxN} \leq 1.15$	≤ 1 %
Temperature in range 23.00 °F (–5 °C) ≤ Θ_{amb} ≤ 131.00 °F (55 °C)	≤ 0.5 %/10 K
Frequency in range $0.95 \leq f/f_N \leq 1.05$	≤ 1 %
Harmonics – Up to 10 % 3rd harmonic – Up to 10 % 5th harmonic	 ≤ 1 % ≤ 1 %



$$t = \frac{K}{(I2/IN)^2}$$

Figure 4-5 Trip times of the Thermal Characteristic for Unbalanced Load Protection

4.6 Startup Overcurrent Protection (ANSI 51)

Setting Ranges / Increments

Pickup current I>	for I_N = 1 A	0.10 A to 20.00 A	Increments 0.01 A
	for I_N = 5 A	0.50 A to 100.00 A	Increments 0.01 A
Delay times T		0.00 s to 60.00 s or ineffective	Increments 0.01 s

Times

Pickup Times I>	120 ms or higher (dep. on signal frequency)
Dropout times I>	120 ms or higher (dep. on signal frequency)

Dropout Conditions

Current threshold I>	80 % or 0.05 I/In

Tolerances

Current threshold I> f ≥ 3 Hz, I/I_N < 5	≤ 10 %
Delay times T	1 % or 10 ms

Influencing Variables for Pickup Values

Power supply direct voltage in range 0.8 ≤ U_{Aux}/U_{AuxN} ≤ 1.15	≤ 1 %
Temperature in range 23.00 °F (–5 °C) ≤ Θ_{amb} ≤ 131.00 °F (55 °C)	≤ 0.5 % / 10 K
Frequency in range 0.95 ≤ f/f_N ≤ 1.05	≤ 10 %
Harmonics - Up to 10 % 3rd harmonic - Up to 10 % 5th harmonic	 ≤ 100 % (considered in calculation) ≤ 100 % (considered in calculation)

4.7 Differential Protection (ANSI 87G/87M) for Generators and Motors

Setting Ranges / Increments

Differential current I_{DIFF}>/$I_{N\ Gen}$	0.05 to 2.00	Increments 0.01
High-current stage I_{DIFF}>>/$I_{N\ Gen}$	0.5 to 12.0 or ∞ (ineffective)	Increments 0.1

Pickup Characteristic

see also Figure 4-6		
Slope 1	0.10 to 0.50	Increments 0.01
Base point 1 $I/I_{N\ Gen}$	0.00 to 2.00	Increments 0.01
Slope 2	0.25 to 0.95	Increments 0.01
Base point 2 $I/I_{N\ Gen}$	0.00 to 10.00	Increments 0.01
Startup recognition $I/I_{N\ Gen}$	0.00 to 2.00	Increments 0.01
Pickup Value Increase on Startup	1.0 to 2.0	Increments 0.1
Max. Starting Time	0.0 s to 180.0 s	Increments 0.1 s
Add-on stabilization $I/I_{N\ Gen}$	2.00 to 15.00	Increments 0.01
Duration of Add-on stabilization	(2 to 250) · Cycle duration (Network frequency) or ∞ (ineffective)	
Tripping delay time for I_{DIFF}> and I_{DIFF}>>	0.00 s to 60.00 s or ∞ (ineffective)	Increments 0.01 s

Pickup Times

with single side feed (without parallel operation of other protection functions)

	50 Hz	60 Hz
with ≥ 1.5 · setting I_{DIFF}>/$I_{N\ Gen}$, approx.	35 ms	35 ms
with ≥ 1.5 · setting I_{DIFF}>>/$I_{N\ Gen}$, approx.	25 ms	22 ms
with ≥ 5 · setting I_{DIFF}>>/$I_{N\ Gen}$, approx.	18 ms	17 ms

Dropout Ratio	approx. 0.7

Tolerances

With preset parameters	
- Pickup Characteristic	± 3 % of setpoint (for $I < 5 \cdot I_N$)
- Additional Delay Times	± 1 % of setting value or 10 ms

Influencing Variables for Pickup Values

Power supply direct voltage in range $0.8 \leq U_{Aux}/U_{AuxN} \leq 1.15$	≤ 1 %
Temperature in range 23.00 °F (–5 °C) ≤ Θ_{amb}≤ 131.00 °F (55 °C)	≤ 0.5 % / 10 K
Frequency in range $0.95 \leq f/f_N \leq 1.05$	≤ 1 % (see also Figure 4-7)

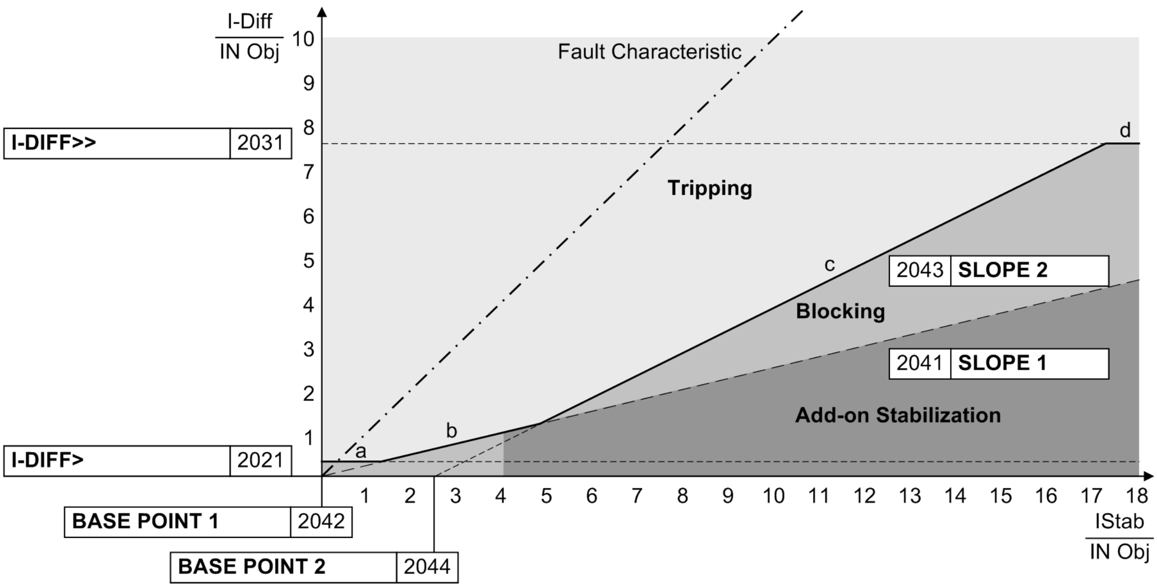


Figure 4-6 Pickup Characteristic for Use as Generator or Motor Differential Protection

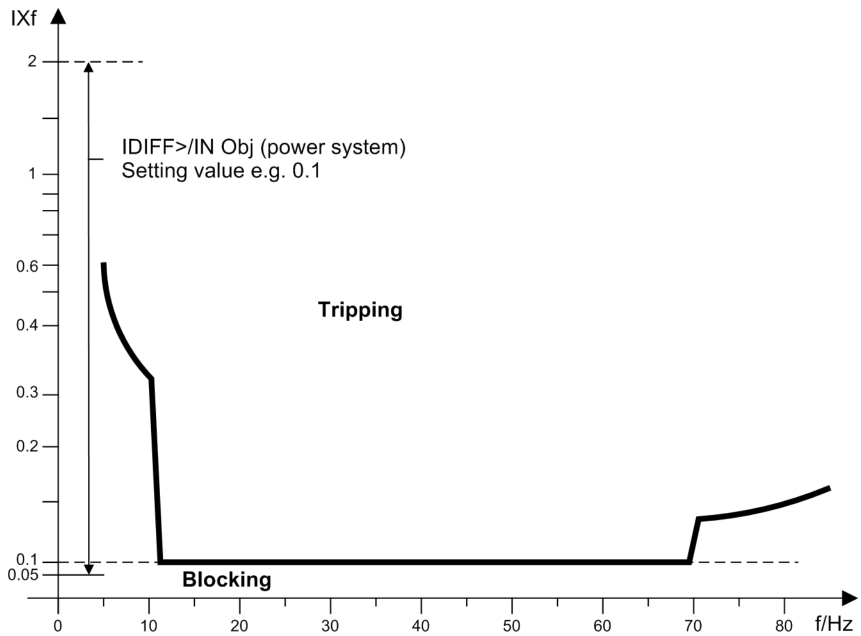


Figure 4-7 Influence of Frequency in Generator or Motor Differential Protection

where:

I_{DIFF} Differential current = $|I_1 + I_2|$

$I_{N\,Obj}$ Nominal current of the protected object

I_{Xf} Current at any frequency within specified range

4.8 Differential Protection (ANSI 87T) for Transformers

Setting Ranges / Increments

Differential current $I_{DIFF}>/I_{N\ Transf}$	0.05 to 2.00	Increments 0.01
High-current stage $I_{DIFF}>>/I_{N\ Transf}$	0.5 to 12.0 or ∞ (ineffective)	Increments 0.1

Trip Time Curves acc. to ANSI

see also Figure 4-8		
Slope 1	0.10 to 0.50	Increments 0.01
Base point 1 $I/I_{N\ Transf}$	0.00 to 2.00	Increments 0.01
Slope 2	0.25 to 0.95	Increments 0.01
Base point 2 $I/I_{N\ Transf}$	0.00 to 10.00	Increments 0.01
Startup recognition $I/I_{N\ Transf}$	0.00 to 2.00	Increments 0.01
Pickup Value Increase on Startup	1.0 to 2.0	Increments 0.1
Max. Startup Time	0.0 to 180.0 s	Increments 0.1 s
Add-on stabilization $I/I_{N\ Transf}$	2.00 to 15.00	Increments 0.01
Inrush stabilization I_{2fN}/I_{fN} (2nd Harmonic)	10 % to 80 % see also Figure 4-9	Increments 1 %
Stabilization (nth harm.) I_{nfN}/I_{fN} (n = 3rd or 5th harmonic)	10 % to 80 % see also Figure 4-10	Increments 1 %
Retract blocking $I/I_{N\ Transf}$	0.5 to 12.0	Increments 0.1
Tripping delay time for $I_{DIFF}>$ and $I_{DIFF}>>$	0.00 s to 60.00 s or ∞ (ineffective)	Increments 0.01 s
Duration of Add-on stabilization	(2 to 250) · Cycle duration (Network frequency) or ∞ (ineffective)	
Time for cross blocking for 2nd, 3rd or 5th harmonics	(0 to 1000) · Cycle duration (Network frequency) or ∞ (continuous)	
Tripping delay time for $I_{DIFF}>$ and $I_{DIFF}>>$	0.00 s to 60 s or ∞ (ineffective)	Increments 0.01 s

Pickup Times

with single side feed (without parallel operation of other protection functions)

	50 Hz	60 Hz
with ≥ 1.5 · setting $I_{DIFF}>/I_{N\ Transf}$, approx.	35 ms	35 ms
with ≥ 1.5 · setting $I_{DIFF}>>/I_{N\ Transf}$, approx.	25 ms	22 ms
with ≥ 5 · setting $I_{DIFF}>>/I_{N\ Transf}$, approx.	18 ms	17 ms

Dropout Ratio	Approx. 0.7

Tolerances

With Preset Transformer Parameters	
- Pickup Characteristic	± 3 % of setpoint (for $I < 5 \cdot I_N$)
- Inrush Restraint	± 3 % of setting value (for $I_{2fN}/I_{fN} \geq 15$ %)
- Additional Delay Times	± 1 % of setting value or 10 ms

Influencing Variables for Pickup Values

Power supply direct voltage in range $0.8 \leq U_{Aux}/U_{AuxN} \leq 1.15$	≤ 1 %
Temperature in range 23.00 °F (–5 °C) ≤ $\Theta_{amb} \leq$ 131.00 °F (55 °C)	≤ 0.5 % / 10 K
Frequency in range $0.95 \leq f/f_N \leq 1.05$	≤ 1 % (see also Figure 4-11)

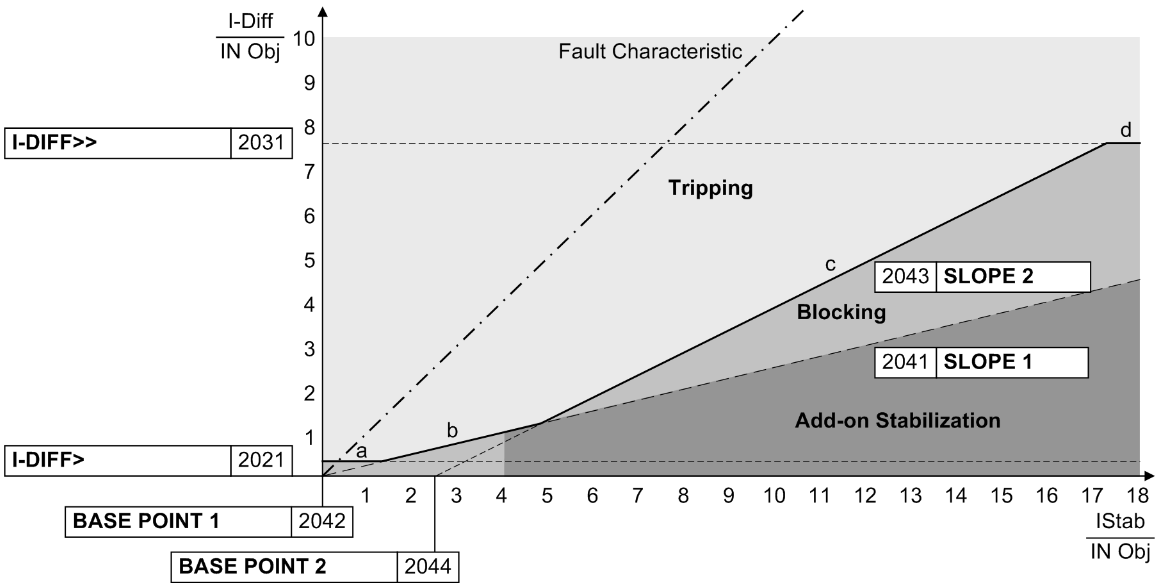


Figure 4-8 Pickup Characteristic of the Transformer Differential Protection

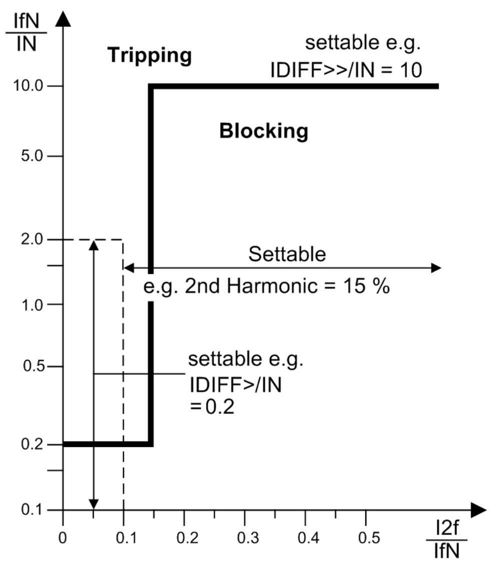


Figure 4-9 Restraining Influence of 2nd Harmonic in Transformer Differential Protection

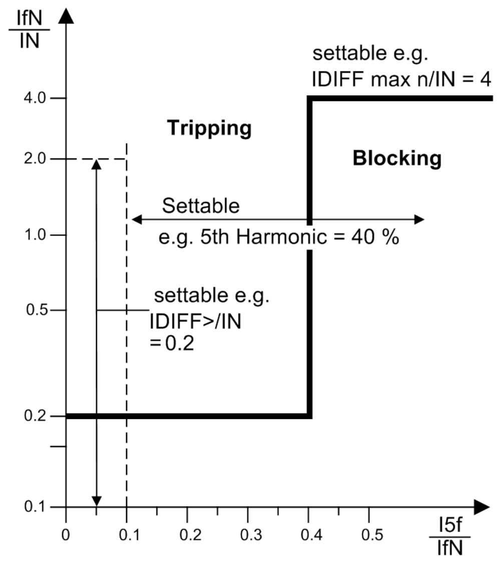


Figure 4-10 Restraining Influence of Higher-Order Harmonics

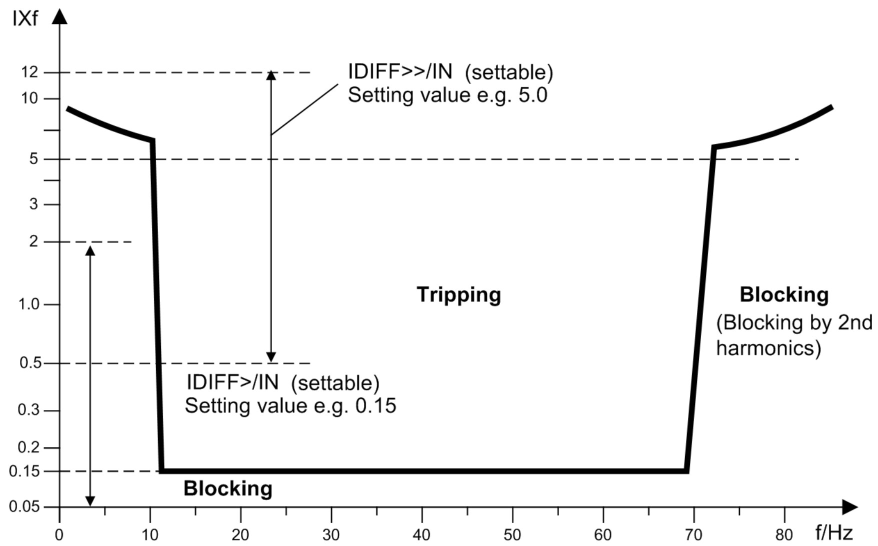


Figure 4-11 Influence of Frequency in Transformer Differential Protection

where:

I_{DIFF} Differential current = $|I_1 + I_2|$

I_{fN} Current at nominal frequency

I_{Xf} Current at any frequency within specified range

4.9 Earth Current Differential Protection (ANSI 87GN,TN)

Setting Ranges / Increments

Differential current I-REF> $I/I_{N\ Obj}$.	0.05 to 2.00	Increments 0.01
Characteristic: base point $I/I_{N\ Obj.}$	0.00 to 2.00	Increments 0.01
Characteristic: Slope	0.00 to 0.95	Increments 0.01
Delay times T	0.00 s to 60.00 s or ∞ (ineffective)	Increments 0.01 s
Phase current blocking I> $I/I_{N\ Obj.}$	1.0 to 2.5	Increments 0.1
Zero Voltage Enable U0	1.0 V to100.0 V or 0 (ineffective)	Increments 0.1V

Times

Pickup Times Dropout Times	approx. 25 ms to 55 ms approx. 60 ms

Dropout Ratios

Trip Characteristic	approx. 0.90
Dropout Ratio	approx. 0.95ms

Tolerances

Trip Characteristic	5 % of setpoint value or 0.02 I/InO
Phase Current Blocking I>	1 % of setting value or 0.01 I/InO
Zero Voltage Enable U0>	1 % of setting value or 0.5 V
Delay times T	1 % of setting value or 10 ms

Influencing Variables for Pickup Values

Power supply direct voltage in range $0.8 \le U_{Aux}/U_{AuxN} \le 1.15$	≤ 1 %
Temperature in range 23.00 °F (–5 °C) ≤ Θ_{amb}≤ 131.00 °F (55 °C)	≤ 0.5 % / 10 K
Frequency in range $0.95 \le f/f_N \le 1.05$	≤ 1 %
Harmonics - Up to 10 % 3rd harmonic - Up to 10 % 5th harmonic	 ≤ 1 % ≤ 1 %

4.10 Underexcitation (Loss-of-Field) Protection (ANSI 40)

Setting Ranges / Increments

Conductance Sections 1/xd Char.	0.20 to 3.00	Increments 0.01
Slope angle α1, α2, α3	50° to 120°	Increments 1°
Delay times T	0.00 s to 60.00 s or ∞ (ineffective)	Increments 0.01 s
Undervoltage Blocking	10.0 V to 125.0 V	Increments 0.1V
Excitation DC voltage Uexc < (via external upstream voltage divider)	0.50 V to 8.00 V	Increments 0.01V

Times

Pickup Times	
Conductance Sections 1/xd Char.	approx. 60 ms
Rotor circuit criterion Uexc	approx. 60 ms
Undervoltage Blocking	approx. 50 ms

Dropout Ratios

Conductance Sections 1/xd Char., α	approx. 0.95
Rotor circuit criterion Uexc	approx. 1.05 or pickup value + 0.5 V
Undervoltage Blocking	approx. 1.1

Tolerances

Conductance Sections 1/xd Char.	3 % of setting value
Stator Criterion α	1° electrical
Rotor circuit criterion Uexc	1° or 0.1 V
Undervoltage Blocking	1 % of setting value or 0.5 V
Delay times T	1 % or 10 ms

Influencing Variables for Pickup Values

Power supply direct voltage in range $0.8 \leq U_{Aux}/U_{AuxN} \leq 1.15$	≤ 1 %
Temperature in range 23.00 °F (–5 °C) $\leq \Theta_{amb} \leq$ 131.00 °F (55 °C)	≤ 0.5 % / 10 K
Frequency in range $0.95 \leq f/f_N \leq 1.05$	≤ 1 %
Harmonics - Up to 10 % 3rd harmonic - Up to 10 % 5th harmonic	 ≤ 1 % ≤ 1 %

4.11 Reverse Power Protection (ANSI 32R)

Setting Ranges / Increments

Reverse power $P_{reverse}$>/S_N	–0.50 % to –30.00 %	Increments 0.01 %
Delay times T	0.00 s to 60.00 s or ∞ (ineffective)	Increments 0.01 s

Times

Pickup Times – Reverse power $P_{reverse}$>	 approx. 360 ms at f = 50 Hz approx. 300 ms at f = 60 Hz
Dropout Times – Reverse power $P_{reverse}$>	 approx. 360 ms at f = 50 Hz approx. 300 ms at f = 60 Hz

Dropout Ratios

– Reverse power $P_{reverse}$>	approx. 0.6

Tolerances

– Reverse power $P_{reverse}$>	0.25 % S_N ± 3 % of setting value for Q < 0.5 S_N (S_N: Rated apparent power, Q: Reactive power
– Delay times T	1 % or 10 ms

Influencing Variables for Pickup Values

Power supply direct voltage in range 0.8 ≤ U_{Aux}/U_{AuxN} ≤ 1.15	≤ 1 %
Temperature in range 23.00 °F (–5 °C) ≤ Θ_{amb}≤ 131.00 °F (55 °C)	≤ 0.5 % / 10 K
Frequency in range 0.95 ≤ f/f_N ≤ 1.05	≤ 1 %
Harmonics – Up to 10 % 3rd harmonic – Up to 10 % 5th harmonic	 ≤ 1 % ≤ 1 %

4.12 Forward Active Power Supervision (ANSI 32F)

Setting Ranges / Increments

Forward power $P_{Forward}$ </S_{Nenn}	0.5 % to 120.0 %	Increments 0.1 %
Forward power $P_{Forward}$>/S_N	1.0 % to 120.0 %	Increments 0.1 %
Delay times T	0.00 s to 60.00 s or ∞ (ineffective)	Increments 0.01 s

Times

Pickup Times – Active power P<, P>	with high–accuracy measurement: approx. 360 ms at f = 50 Hz approx. 300 ms at f = 60 Hz with high–speed measurement: approx. 60 ms at f = 50 Hz approx. 50 ms at f = 60 Hz
Dropout Times – Active power P<, P>	with high–accuracy measurement: approx. 360 ms at f = 50 Hz approx. 300 ms at f = 60 Hz with high–speed measurement: approx. 60 ms at f = 50 Hz approx. 50 ms at f = 60 Hz

Dropout ratios

Active power P_{Act}<	approx. 1.10 or 0.5 % of S_N
Active power P_{Act}>	approx. 0.90 or -0.5 % of S_N

Tolerances

Active power P<, P>	0,25 % S_N ±3 % of set value with high-accuracy measurement 0,5 % S_N ±3 % of set value with high-speed mesurement (S_N: Rated apparent power)
Delay times T	1 % or 10 ms

Influencing Variables for Pickup Values

Power supply direct voltage in range $0.8 \leq U_{Aux}/U_{AuxN} \leq 1.15$	≤ 1 %
Temperature in range 23.00 °F (–5 °C) ≤ Θ_{amb} ≤ 131.00 °F (55 °C)	≤ 0.5 % / 10 K
Frequency in range $0.95 \leq f/f_N \leq 1.05$	≤ 1 %
Harmonics – Up to 10 % 3rd harmonic – Up to 10 % 5th harmonic	 ≤ 1 % ≤ 1 %

4.13 Impedance Protection (ANSI 21)

Pickup

Pickup current IMP I>	for I_N = 1 A	0.10 A to 20.00 A	Increments 0.01 A
	for I_N = 5 A	0.50 A to 100.00 A	Increments 0.05 A
Dropout Ratio		approx. 0.95	
Measuring Tolerances acc. to VDE 0435	for I_N = 1 A	1 % of setting value or 10 mA	
	for I_N = 5 A	1 % of setting value or 50 mA	
Undervoltage seal–in U<		10.0 V to 125.0 V	Increments 0.1 V
Dropout Ratio		approx. 1.05	

Impedance Measurement

Characteristic		Polygonal, 3 independent stages	
Impedance Z1 (secondary)	for I_N = 1 A	0.05 Ω to 130.00 Ω	Increments 0.01 Ω
Impedance Z1 (secondary)	for I_N = 5 A	0.01 Ω to 26.00 Ω	
Impedance Z1B (secondary)	for I_N = 1 A	0.05 Ω to 65.00 Ω	Increments 0.01 Ω
Impedance Z1B (secondary)	for I_N = 5 A	0.01 Ω to 13.00 Ω	
Impedance Z2 (secondary)	for I_N = 1 A	0.05 Ω to 65.00 Ω	Increments 0.01 Ω
Impedance Z2 (secondary	for I_N = 5 A	0.01 Ω to 13.00 Ω	
Measuring tolerances acc. to VDE 0435 with sinusoidal quantities		$\|\Delta Z/Z\| \leq 5$ % for 30° ≤ φ_K ≤ 90° or 10 mΩ	

Power Swing Blocking

Power swing polygon-trip polygon (secondary)	for I_N = 1 A	0,10 Ω up to 30.00 Ω	Increments 0.01 Ω
Power swing polygon-trip polygon (secondary)	for I_N = 5 A	0,02 Ω up to 6.00 Ω	
Rate of change dz/dt	for I_N = 1 A	1,0 Ω/s to 600.0 Ω/s	Increments 0.1 Ω/s
Rate of change dz/dt	for I_N = 5 A	0,2 Ω/s to 120.0 Ω/s	
Power Swing Blocking Action Time		0,00 s to 60,00 s or ∞ (ineffective)	Increments 0.01 s

Times

Delay Times	0.00 s to 60.00 s or ∞ (ineffective)	Increments 0.01 s
Shortest Tripping Time	35 ms	
Typical Tripping Time	approx. 40 ms	
Dropout Time	approx. 50 ms	
Holding Time of Undervoltage Seal-In	0.10 s to 60.00 s	Increments 0.01 s
Delay Time Tolerances	1 % of setting value or 10 ms	

Influencing Variables for Pickup Values

Power supply direct voltage in range $0.8 \le U_{Aux}/U_{AuxN} \le 1.15$	≤ 1 %
Temperature in range 23.00 °F (–5 °C) ≤ Θ_{amb}≤ 131.00 °F (55 °C)	≤ 0.5 % / 10 K
Frequency in range $0.95 \le f/f_N \le 1.05$	≤ 1 %
Harmonics - Up to 10 % 3rd harmonic - Up to 10 % 5th harmonic	 ≤ 1 % ≤ 1 %

4.14 Out-of-Step Protection (ANSI 78)

Pickup

Positive sequence current $I_1>/I_N$	20.0 % to 400.0 %	Increments 0.1 %
Negative sequence current $I_2</I_N$	5.0 % to 100.0 %	Increments 0.1 %
Dropout ratios - $I_1>$ - I2<	 approx. 0.95ms approx. 1.05	
Measuring tolerances acc. to VDE 0435 Part 303	3 % of setting value	

Power Swing Polygon

Impedance Za (secondary)	for I_N = 1 A	0,20 Ω up to 130.00 Ω	Increments 0.01 Ω
Impedance Za (secondary	for I_N = 5 A	0,04 Ω up to 26.00 Ω	
Impedance Zb (secondary)	for I_N = 1 A	0,10 Ω up to 130.00 Ω	Increments 0.01 Ω
Impedance Zb (secondary)	for I_N = 5 A	0,02 Ω up to 26.00 Ω	
Impedance Zc (secondary)	for I_N = 1 A	0,10 Ω up to 130.00 Ω	Increments 0.01 Ω
Impedance Zc (secondary)	for I_N = 5 A	0,02 Ω up to 26.00 Ω	
Impedance Zd-Zc (secondary)	for I_N = 1 A	0,00 Ω up to 130.00 Ω	Increments 0.01 Ω
Impedance Zd-Zc (secondary)	for I_N = 5 A	0,00 Ω up to 26.00 Ω	
Angle of Inclination of the Polygon		60.0° to 90.0°	Increments 0.1°
Number of permissible power swings - on crossing characteristic 1 - on crossing characteristic 2		 1 to 10 1 to 20	
Measuring tolerances acc. to VDE 0435 with sinusoidal quantities		$\lvert\Delta Z/Z\rvert \leq 5$ % for 30° ≤ φ_K ≤ 90° or 10 mΩ	

Times

Pickup Seal-In Time T_H	0.20 s to 60.00 s	Increments 0.01 s
Holding Time of Out-of-Step Indication	0.02 s to 0.15 s	Increments 0.01 s
Delay Time Tolerances	1 % of setting value or 10 ms	

Influencing Variables for Pickup Values

Power supply direct voltage in range $0.8 \leq U_{Aux}/U_{AuxN} \leq 1.15$	≤ 1 %
Temperature in range 23.00 °F (–5 °C) ≤ Θ_{amb} ≤ 131.00 °F (55 °C)	≤ 0.5 % / 10 K
Frequency in range $0.95 \leq f/f_N \leq 1.05$	≤ 1 %
Harmonics - Up to 10 % 3rd harmonic - Up to 10 % 5th harmonic	 ≤ 1 % ≤ 1 %

4.15 Undervoltage Protection (ANSI 27)

Setting Ranges / Increments

Measured Quantity	Positive Sequence phase-to-earth voltages as phase-to-phase Values	
Pickup voltages U<, U<<, Up<	10.0 V to 125.0 V	Increments 0.1 V
Rückfallverhältnis RV U< (nur Stufen U<, U<<)	1.01 to 1.20	Increments 0.01
Time delays T U<, T U<<	0.00 s to 60.0 s or ∞ (ineffective)	Increments 0.01 s
Time multiplication factor T_{MUL} for Inverse Characteristic	0.10 s to 5.00 s	Increments 0.01 s
Additional delay time T_{Up}< for Inverse Characteristic	0.00 s to 60.00 s or ∞ (ineffective)	Increments 0.01 s
The set times are pure delay times.		

Operating Times

Pickup Times	approx. 50 ms
Dropout Times	approx. 50 ms

Dropout Ratio

from the pickup value of the inverse characteristic	1.01 or 0.5 V absolute

Tripping Characteristic

see also Figure 4-12

$$t = \frac{1}{1 - \frac{U}{U_p}} \cdot T_{MUL} + T_{Up<}$$

Meaning:

Meaning:	t	Tripping time
	U	Current voltage
	U_p	Pickup voltage being ∞ at that (= Parameter 4402)
	T_{MUL}	Time multiplier (= Parameter 4403)
	$T_{Up<}$	Add-on delay time (= Parameter 4404)

Tolerances

Pickup voltages U<, U<<, Up<	1 % of setting value or 0.5 V
Time delays T, T_{Up}<	1 % of setting value or 10 ms
Voltage-Time Characteristic	1 % based on U, or 30 ms

Influencing Variables

Power supply direct voltage in range $0.8 \leq U_{Aux}/U_{AuxN} \leq 1.15$	≤ 1 %
Temperature in range 23.00 °F (–5 °C) ≤ $\Theta_{amb} \leq$ 131.00 °F (55 °C)	≤ 0.5 % / 10 K
Frequency in range $0.95 \leq f/f_N \leq 1.05$	≤ 1 %
Harmonics - Up to 10 % 3rd harmonic - Up to 10 % 5th harmonic	 ≤ 1 % ≤ 1 %

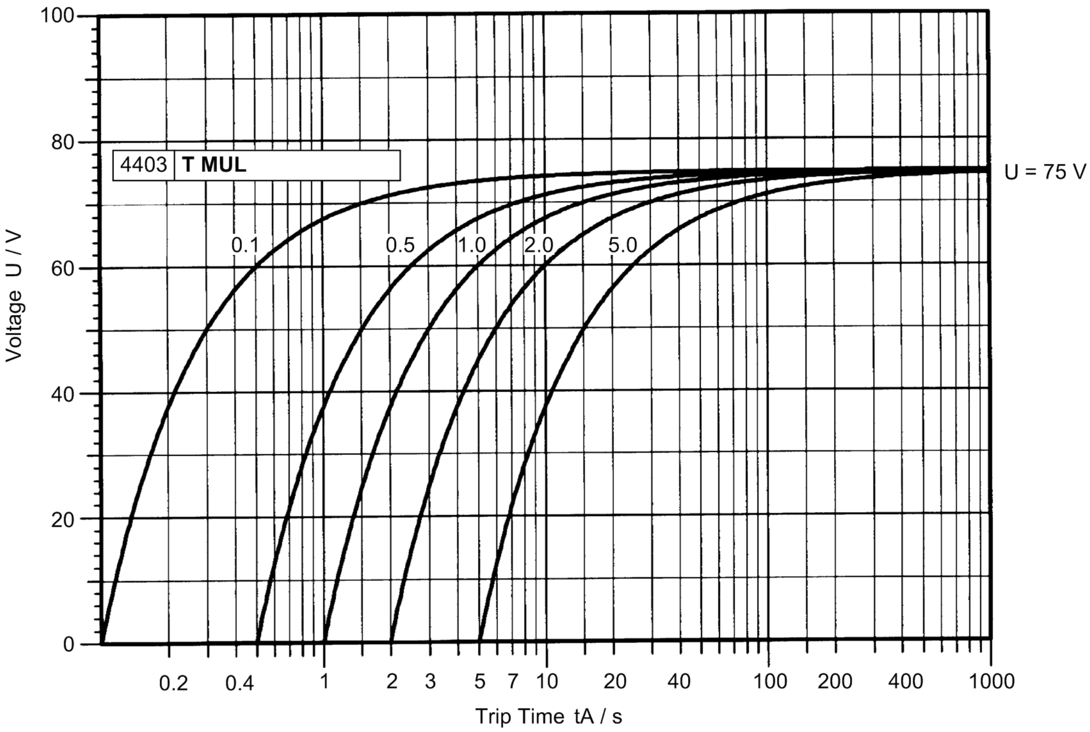


Figure 4-12 Tripping Times of the Inverse Undervoltage Protection for Setting Value Up <= 75 V, without Additional Tripping Delay ($T_{Up<} = 0$)

4.16 Overvoltage Protection (ANSI 59)

Setting Ranges / Increments

Measured Quantity	Maximum of the phase-to-phase voltages, calculated from the phase-to-earth voltages	
Pickup thresholds U>, U>>	30.0 V to 170.0 V	Increments 0.1V
Rückfallverhältnis RV U> (Stufen U>, U>>)	0.90 to 0.99	Increments 0.01
Time delays T U>, T U>>	0.00 s to 60.00 s or ∞ (ineffective)	Increments 0.01 s
The set times are pure delay times.		

Times

Pick-up times U>, U>>	approx. 50 ms
Dropout times U>, U>>	approx. 50 ms

Tolerances

Pickup Voltage Limits	1 % of setting value or 0.5 V
Delay times T	1 % of setting value or 10 ms

Influencing Variables

Power supply direct voltage in range $0.8 \leq U_{Aux}/U_{AuxN} \leq 1.15$	≤ 1 %
Temperature in range 23.00 °F (–5 °C) ≤ Θ_{amb} ≤ 131.00 °F (55 °C)	≤ 0.5 % / 10 K
Frequency in range $0.95 \leq f/f_N \leq 1.05$	≤ 1 %
Harmonics – Up to 10 % 3rd harmonic – Up to 10 % 5th harmonic	 ≤ 1 % ≤ 1 %

4.17 Frequency Protection (ANSI 81)

Setting Ranges / Increments

Number of Frequency Elements	4; can be set to f> or f<	
Pickup Frequency f> or f<	40 Hz to 66.00 Hz	Increments 0.01 Hz
Delay Times T f1 T f2 to T f4	 0.00 s to 600.00 s 0.00 s to 100.00 s	 Increments 0.01 s Increments 0.01 s
Undervoltage Blocking (positive sequence component U_1)	10.0 V to 125.0 V and 0 V (no blocking)	Increments 0.1V
The set times are pure delay times.		

Times

Pickup times f>, f< Dropout Times f>, f<	approx. 100 ms approx. 100 ms

Dropout Difference

Δf = | Pickup Value – Dropout Value |	approx. 20 mHz

Dropout Ratio

Dropout ratio for undervoltage blocking	approx. 1.05

Tolerances

Frequencies f>, f< Undervoltage Blocking Time Delays T(f<, f<)	10 mHz (at $U = U_N$, $f = f_N$) 1 % of setting value or 0.5 V 1 % of setting value or 10 ms

Influencing Variables

Power supply direct voltage in range $0.8 \leq U_{Aux}/U_{AuxN} \leq 1.15$	1 %
Temperature in range 23.00 °F (–5 °C) ≤ Θ_{amb} ≤ 131.00 °F (55 °C)	0.5 %/10 K
Harmonics - Up to 10 % 3rd harmonic - Up to 10 % 5th harmonic	 1 % 1 %

4.18 Overexcitation (Volt/Hertz) Protection (ANSI 24)

Setting Ranges / Increments

Pickup threshold (Alarm Stage) $\frac{U/U_N}{f/f_N}$	1.00 to 1.20	Increments 0.01
Pickup threshold of stage characteristic $\frac{U/U_N}{f/f_N}$	1.00 to 1.40	Increments 0.01
Time delays T U/f>, T U/f>> (Alarm and stage characteristic)	0.00 s to 60.00 s or ∞ (ineffective)	Increments 0.01 s
Characteristic value pairs U/f	1,05/1,10/1,15/1,20/1,25/1,30/1,35/1,40	
Associated time delay for t (U/f thermal replica	0 s to 20,000 s	Increments 1 s
Cooling time T_{COOL}	0 s to 20,000 s	Increments 1 s

Times

Alarm and Stage Characteristic	
Pickup times for 1.1 · Setting value	approx. 60 ms
Dropout Times	approx. 60 ms

Dropout Ratios

Dropout/Pickup	approx. 0.98

Tripping Characteristic

Thermal replica (presetting and stage characteristic)	see Figure 4-13

Tolerances

Pickup on U/f	3 % of setting value
Delay times T (Alarm and Stage Characteristic)	1 % of setting value or 10 ms
thermal replica (time characteristic)	5 %, related to U/f ± 600 ms

Influencing Variables

Power supply direct voltage in range 0.8 ≤ U_{Aux}/U_{AuxN} ≤ 1.15	≤ 1 %
Temperature in range 23.00 °F (–5 °C) ≤ Θ_{amb} ≤ 131.00 °F (55 °C)	≤ 0.5 % / 10 K
Harmonics – Up to 10 % 3rd harmonic – Up to 10 % 5th harmonic	 ≤ 1 % ≤ 1 %

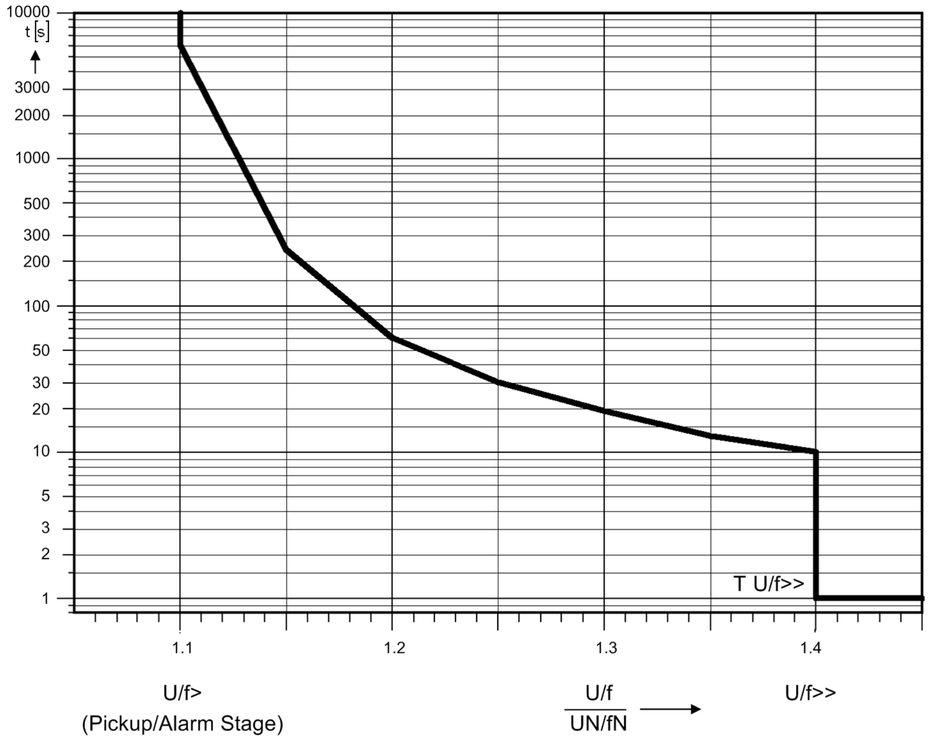


Figure 4-13 Resulting Tripping Characteristic from Thermal Replica and Stage Characteristic of the Overexcitation Protection (Default Setting)

4.19 Rate-of-Frequency-Change Protection df/dt (ANSI 81R)

Setting Ranges / Increments

Stages, can be +df/dt> or –df/dt	4	
Pickup values df/dt	0.1 Hz/s to 10.0 Hz/s	Increments 0.1 Hz/s
Delay times T	0.00 s to 60.00 s or ∞ (ineffective)	Increments 0.01 s
Undervoltage blocking U1>	10.0 V to 125.0 V or 0 (ineffective)	Increments 0.1 V
Window Length	1 to 25 cycles	

Times

Pickup Times df/dt	approx.. 150 ms to 500 ms (dep. on window length)
Dropout Times df/dt	approx. 150 ms to 500 ms (dep. on window length)

Dropout Ratios

Dropout Difference Δf/dt	0.02 Hz/s to 0.99 Hz/s (adjustable)
Dropout Ratio	approx. 1.05

Tolerances

Frequency Rise	
–Measuring Window < 5	Approx. 5 % or 0.15 Hz/s at U > 0,5 U_N
– Measuring Window ≥ 5	Approx. 3 % or 0.1 Hz/s at U > 0,5 U_N
Undervoltage Blocking	1 % of setting value or 0.5 V
Delay Times	1 % or 10 ms

Influencing Variables for Pickup Values

Power supply direct voltage in range 0.8 ≤ U_{Aux}/U_{AuxN} ≤ 1.15	≤ 1 %
Temperature in range 23.00 °F (–5 °C) ≤ Θ_{amb}≤ 131.00 °F (55 °C)	≤ 0.5 % / 10 K
Harmonics - Up to 10 % 3rd harmonic - Up to 10 % 5th harmonic	 ≤ 1 % ≤ 1 %

4.20 Jump of Voltage Vector

Setting Ranges / Increments

Stufe $\Delta\varphi$	2° to 30°	Increments 1°
Delay Time T	0.00 to 60.00 s or ∞ (ineffective)	Increments 0.01 s
Reset Time T_{Reset}	0.00 to 60.00 s or ∞ (ineffective)	Increments 0.00 s
Undervoltage Blocking U1>	10.0 to 125.0 V	Increments 0.1 V

Times

Ansprechzeiten $\Delta\varphi$	approx. 75 ms
Rückfallzeiten $\Delta\varphi$	approx. 75 ms

Dropout Ratios

–	–

Tolerances

Angle Jump	0.5° at U > 0.5 U_N
Undervoltage Blocking	1 % of setting value or 0.5 V
Delay times T	1 % or 10 ms

Influencing Variables

Power Supply DC Voltage in Range $0,8 \leq U_{Aux}/U_{Aux,N} \leq 1.15$	≤ 1 %
Temperature in range 23.00 °F (–5 °C) ≤ Θ_{amb} ≤ 131.00 °F (55 °C)	≤ 0.5 % / 10 K
Frequency in Range $0.95 \leq f/f_N \leq 1.05$	≤ 1 %
Harmonics - Up to 10 % 3rd harmonic - Up to 10 % 5th harmonic	 ≤ 1 % ≤ 1 %

4.21 90-%-Stator Earth Fault Protection (ANSI 59N, 64G, 67G)

Setting Ranges / Increments

Displacement voltage U0>	2.0 V to 125.0 V	Increments 0.1 V
Earth current 3I0>	2 mA to 1000 mA	Increments 1 mA
Earth current angle criterion	0° to 360°	Increments 1°
Delay Time T_{SEF}	0.00 s to 60.00 s or ∞ (ineffective)	Increments 0.01 s
The set times are pure delay times.		

Times

Pickup Times U0 3I0 directional	 approx. 50 ms approx. 50 ms approx. 70 ms
Dropout Times U0 3I0 directional	 approx. 50 ms approx. 50 ms approx. 70 ms

Dropout Ratio / Dropout Difference

Displacement voltage U0	approx. 0.70
Earth current 3I0	approx. 0.70 or 1 mA
Angle criterion (dropout difference)	10° towards network

Tolerances

Displacement Voltage	1 % of setting value or 0.5 V
Earth current	1 % of setting value or 0.5 mA
Delay times T	1 % of setting value or 10 ms

Influencing Variables

Power supply direct voltage in range $0.8 \leq U_{Aux}/U_{AuxN} \leq 1.15$	≤ 1 %
Temperature in range 23.00 °F (–5 °C) ≤ Θ_{amb} ≤ 131.00 °F (55 °C)	≤ 0.5 % / 10 K
Frequency in range $0.95 \leq f/f_N \leq 1.05$	≤ 1 %
Harmonics – Up to 10 % 3rd harmonic – Up to 10 % 5th harmonic	 ≤ 1 % ≤ 1 %

4.22 Sensitive Earth Fault Protection (ANSI 51GN, 64R)

Setting Ranges / Increments

Pickup current $I_{EE}>$	2 mA to 1000 mA	Increments 1 mA
Delay Time $T_{IEE}>$	0.00 s to 60.00 s or ∞ (ineffective)	Increments 0.01 s
Pickup current $I_{EE}>>$	2 mA to 1000 mA	Increments 1 mA
Delay time $T_{IEE}>>$	0.00 s to 60.00 s or ∞ (ineffective)	Increments 0.01 s
Measuring circuit supervision when used as rotor earth fault protection $I_{EE}<$	1.5 mA to 50.0 mA or 0.0 mA (ineffective)	Increments 0.1 mA

Times

Pickup Times	approx. 50 ms
Dropout Times	approx. 50 ms
Measuring Circuit Supervision (Delay)	approx. 2 s

Dropout Ratios

Pickup current $I_{EE}>$, $I_{EE}>>$	approx. 0.95 or 1 mA
Measuring circuit supervision $I_{EE}<$	approx. 1.10 or 1 mA

Tolerances

Pickup current	1 % of setting value or 0.5 mA
Time Delay	1 % of setting value or 10 ms

Influencing Variables

Power supply direct voltage in range $0.8 \leq U_{Aux}/U_{AuxN} \leq 1.15$	≤ 1 %
Temperature in range 23.00 °F (–5 °C) $\leq \Theta_{amb} \leq$ 131.00 °F (55 °C)	≤ 0.5 % / 10 K
Frequency in range $0.95 \leq f/f_N \leq 1.05$	≤ 1 %
Harmonics - Up to 10 % 3rd harmonic - Up to 10 % 5th harmonic	 ≤ 1 % ≤ 1 %
Note: For the purpose of high sensitivity, the linear range of the measuring input for the sensitive earth fault acquisition is from 2 mA to 1600 mA.	

4.23 100-%-Stator Earth Fault Protection with 3rd Harmonics (ANSI 27/59TN 3rd Harm.)

Setting Ranges / Increments

Pickup value for 3rd harmonic in undervoltage stage $U_{0\ (3rd\ harmon.)}$<	0.2 V to 40.0 V	Increments 0.1 V
Pickup value for 3rd harmonic in overvoltage stage $U_{0\ (3rd\ harmon.)}$>	0.2 V to 40.0 V	Increments 0.1 V
Delay Time $T_{SEF\ (3rd\ HARM)}$	0.00 s to 60.00 s or ∞ (ineffective)	Increments 0.01 s
Enabling conditions		
P/P_{min} >	10 % to 100 % or 0 (ineffective)	Increments 1 %
$U/U_{1\ min}$>	50.0 V to 125.0 V or 0 (ineffective)	Increments 0.1 V
Correction factor U_{03h}(V/100%) for stage $U_{0(3rd\ harmon.)}$>	–40.0 to +40.0	Increments 0.1

Times

Pickup Times	approx. 80 ms
Dropout Times	approx. 80 ms

Dropout Ratios

Undervoltage stage U0 (3rd harmon.)<	approx. 1.10 V or 0.1 V
Overvoltage stage U0 (3rd harmon.)>	approx. 0.90 V or -0.1 V
Enabling conditions	
P/P_{min} >	approx. 0.90
$U/U_{1\ min}$>	approx. 0.95

Tolerances

Displacement Voltage	3 % of setting value or 0.1 V
Delay Time $T_{SEF\ (3rd\ HARM)}$	1 % of setting value or 10 ms

Influencing Variables

Power supply direct voltage in range $0.8 \leq U_{Aux}/U_{AuxN} \leq 1.15$	≤ 1 %
Temperature in range 23.00 °F (–5 °C) ≤ Θ_{amb}≤ 131.00 °F (55 °C)	≤ 0.5 % / 10 K
Frequency in range $0.95 \leq f/f_N \leq 1.05$	≤ 1 %

4.24 100-%-Stator Earth Fault Protection with 20 Hz Voltage Injection (ANSI 64G - 100%)

Setting Ranges / Increments

Alarm Stage R_{SEF}<	20 Ω to 700 Ω	Increments 1 Ω
Tripping Stage R_{SEF}<<	20 Ω to 700 Ω	Increments 1 Ω
Earth currrent stage I_{SEF}>	0.02 A to 1.50 A	Increments 0.01 A
Time Delay	0.00 s to 60.00 s or ∞ (ineffective)	Increments 0.01 s
Failure Monitoring 20 HZ Generator		
U20	0.3 V to 15 V	Increments 0.1V
I20	5 mA to 40 mA	Increments 1 mA
Correction Angle	-60° to +60°	Increments 1°

Times

Pickup Time R_{SEF}<, R_{SEF}<<	≤ 1.3 s
Pickup Time I_{SEF}>	≤ 250 ms
Dropout Times R_{SEF}<, R_{SEF}<<	≤ 0.8 s
Dropout Times I_{SEF}>	≤ 120 ms

Dropout Ratios

Dropout Ratio	Approx. 1.2 to 1.7

Tolerances

Resistance	approx. 5 % or 2 Ω
Current	3 % or 3 mA
Time Delay	1 % or 10 ms

Influencing Variables for Pickup Values

Power supply direct voltage in range 0.8 ≤ U_{Aux}/U_{AuxN} ≤ 1.15	≤ 1 %
Temperature in range 23.00 °F (–5 °C) ≤ Θ_{amb}≤ 131.00 °F (55 °C)	≤ 0.5 %/10 K
Frequency in range 0.95 ≤ f/f_N ≤ 1.05	≤ 1 %
Harmonics - Up to 10 % 3rd harmonic - Up to 10 % 5th harmonic	 ≤ 1 % ≤ 1 %

4.25 Sensitive Earth Fault Protection B (ANSI 51GN)

Setting Ranges / Increments

Pickup Current I_{EE-B}>	0.3 mA to 1000.0 mA	Increments 0.1 mA
Delay Time T_{IEE-B}>	0.00 s to 60.00 s or ∞ (ineffective)	Increments 0.01 s
Pickup Current I_{EE-B}<	0.3 mA to 500.0 mA or 0 (ineffective)	Increments 0.1 mA
Delay Time T_{IEE-B}>	0.00 s to 60.00 s or ∞ (ineffective)	Increments 0.01 s
Pickup Seal-In Time IeeB>	0.00 s to 60.00 s	Increments 0.01 s
Pickup Seal-In Time IeeB<	0.00 s to 60.00 s	Increments 0.01 s
Measurement Method when Used as Rotor Earth Fault Protection	- Fundamental - 3. Harmonics - 1. and 3rd harmonic	

Times

Pick-up times	approx. 50 ms
Dropout times	approx. 50 ms

Drop-off to pick-up ratio

Pickup Current I_{EE-B}>	approx. 0.90 or 0.15 mA
I_{Ns-B}<	approx. 1.10 or 0.15 mA

Tolerances

Pickup current	1 % of setting value or 0.1 mA
Time delay	1 % of set value or 10 ms

Influencing Variables

Power supply direct voltage in range $0.8 \leq U_{Aux}/U_{AuxN} \leq 1.15$	≤ 1 %
Temperature in range 23.00 °F (–5 °C) ≤ Θ_{amb} ≤ 131.00 °F (55 °C)	≤ 0.5 %/10 K
Frequency in range $0.95 \leq f/f_N \leq 1.05$	≤ 1 %
Harmonics - Up to 10 % 3rd harmonic - Up to 10 % 5th harmonic	 ≤ 1 % ≤ 1 %

4.26 Interturn Protection (ANSI 59N (IT))

Setting Ranges / Increments

Pickup thresholds of displacement voltage Uw>	0.3 V to 130.0 V	Increments 0.1 V
$T_{Interturn}$>	0.00 s to 60.00 s or ∞ (ineffective)	Increments 0.01 s

Times

Pick-up times	approx. 60 ms
Dropout times	approx. 60 ms

Drop-off to pickup ratio

Pickup stage $U_{Interturn}$>	approx. 0.5 to 0.95 (adjustable) or. 0,1 V

Tolerances

Displacement voltage	1 % of setting value or 0.1 V
Time delay	1 % of set value or 10 ms

Influencing Variables

Power supply direct voltage in range $0.8 \leq U_{Aux}/U_{AuxN} \leq 1.15$	≤ 1 %
Temperature in range 23.00 °F (–5 °C) ≤ Θ_{amb} ≤ 131.00 °F (55 °C)	≤ 0.5 %/10 K
Frequency in range $0.95 \leq f/f_N \leq 1.05$	≤ 1 %
Harmonics - Up to 10 % 3rd harmonic - Up to 10 % 5th harmonic	 ≤ 1 % ≤ 1 %

4.27 Rotor Earth Fault Protection R, fn (ANSI 64R)

Setting Ranges / Increments

Alarm Stage $R_{E\ ALARM}$	3.0 kΩ to 30.0 kΩ	Increments 0.1 kΩ
Tripping Stage $R_{E\ TRIP}$	1.0 kΩ to 5.0 kΩ	Increments 0.1 kΩ
Delay Times		
$T_{RE\ ALARM}$	0.00 s to 60.00 s or ∞ (ineffective)	Increments 0.01 s
$T_{RE\ TRIP}$	0.00 s to 60.00 s or ∞ (ineffective)	Increments 0.01 s
Reactance in $X_{COUPLING}$ in coupling circuit (capacitive)	–100 Ω up to 800 Ω	Increments 1 Ω
Resistance in $R_{BRUSHES}$ in coupling circuit	0 Ω up to 999 Ω	Increments 1 Ω
Pickup value of I RE< disturbance indication	1.0 mA to 50.0 mA or 0.0 (stage is inactive)	Increments 0.1 mA
Correction angle W0 I RE for rotor earth fault current	-15.0° to +15.0°	Increments 0.1°

Admissible Rotor Earth Capacity C_E

For the tolerances stated, and for detecting an interruption of the measuring circuit	0.15 μF ≤ C_E ≤ 3.0 μF
Admissible Operating Range of Injected Voltage (Alarm U_{RE}< at U ≤ 20 V)	AC 20 V to 100 V

Times

Pickup Times - Alarm Stage, Tripping Stage	≤ 80 ms
Dropout Times - Alarm Stage, Tripping Stage	≤ 80 ms

Dropout Ratios

$R_{E\ ALARM}$, $R_{E\ TRIP}$	approx. 1.25
Alarm I_{RE}<	approx. 1.20 or 0.5 mA dropout difference
Alarm U_{RE}<	approx. 5 V dropout difference

Tolerances

Alarm Stage, Tripping Stage	5 % for $R_E \leq 5$ kΩ and $0.15 \leq C_E$/µF≤ 3 10 % for $R_E \leq 10$ kΩ and $0.15 \leq C_E$/µF≤ 3 10 % for $10 \leq R_E$/kΩ ≤ 3 and $C_E \leq 1$ µF
Delay times T	1 % or 10 ms

Influencing Variables for Pickup Values

Power supply direct voltage in range $0.8 \leq U_{Aux}/U_{AuxN} \leq 1.15$	≤ 1 %
Temperature in range 23.00 °F (–5 °C) ≤ Θ_{amb}≤ 131.00 °F (55 °C)	≤ 0.5 % / 10 K
Frequency in range $0.95 \leq f/f_N \leq 1.05$	≤ 1 %

4.28 Sensitive Rotor Earth Fault Protection with 1 to 3 Hz Square Wave Voltage Injection (ANSI 64R - 1 to 3 Hz)

Setting Ranges / Increments

Alarm Stage $R_{E\ ALARM}$	5 kΩ to 80 kΩ	Increments 1 kΩ
Tripping Stage $R_{E\ TRIP}$	1 kΩ to 10 kΩ	Increments 1 kΩ
Time Delay	0.00 s to 60.00 s or ∞ (ineffective)	Increments 0.01 s
Pickup threshold Q_C< of alarm indication	0.00 mAs to 1.00 mAs	Increments 0.01 mAs

Times

Pickup Time	approx. 1 to 1.5 s (depends on 7XT71)
Dropout Time	approx. 1 s to 1.5 s

Dropout Ratios

Resistance R_E	approx. 1.25
Charge Q_C<	1.2 or 0.01 mAs

Tolerances

Resistance	approx. 5 % or 0.5 kΩ at 0.15 µF ≤ C_E< 1 µF approx. 10 % or 0.5 kΩ at 0.15 µF ≤ C_E< 3 µF
Time Delay	1 % or 10 ms
Admissible Rotor-Earth Capacitance	0.15 µF to 3 µF

Influencing Variables for Pickup Values

Power Supply DC Voltages in Range 0.8 ≤ U_{Aux}/U_{AuxN} ≤ 1.15	≤ 1 %
Temperature in range 23.00 °F (–5 °C) ≤ Θ_{amb}≤ 131.00 °F (55 °C)	≤ 0.5 % / 10 K
Frequency in Range 0.95 ≤ f/f_N ≤ 1.05	≤ 1 %

4.29 Motor Starting Time Supervision (ANSI 48)

Setting Ranges / Increments

Anlaufstrom des Motors I_A	for I_N = 1 A	0.10 A to 16.00 A	Increments 0.01 A
	for I_N = 5 A	0.50 A to 80.00 A	Increments 0.01 A
Pickup Threshold for Startup Detection $I_{STARTUP\ DETECT.}$	for I_N = 1 A	0.60 A to 10.0 A	Increments 0.01 A
	for I_N = 5 A	3.00 A to 50.00 A	Increments 0.01 A
Maximale Anlaufzeit $t_{A\ max}$		1.0 s to 180.0 s	Increments 0.1 s
Zulässige Festbremszeit $T_{FESTBREMS}$		0.5 s to 120.0 s or ∞ (ineffective)	Increments 0.1 s

Tripping Characteristic

Trip Time Characteristics for
$I > I_{MOTOR\ START}$

$$t_{TRIP} = \left(\frac{I_{StartCurr}}{I}\right)^2 \cdot t_{Start\ max}$$

Meaning:

$I_{StartCurr}$	Motor Starting Current Setting
I	Actual Current Flowing
$I_{MOTOR\ START}$	Pickup Threshold Setting, used to Detect Motor Startup
t_{TRIP}	Trip Time in Seconds
$t_{Start\ max}$	max. permissible starting time

Dropout Ratio

$I/I_{ANL\ ERKENN}$	approx. 0.95 or 0.01 I_N

Tolerances

Pickup Threshold	for I_N = 1 A	1 % of setting value or 10 mA
	for I_N = 5 A	1 % of setting value or 50 mA
Time Delay		5 % or 30 ms

Influencing Variables for Pickup Values

Power supply direct voltage in range $0.8 \leq U_{Aux}/U_{AuxN} \leq 1.15$	≤ 1 %
Temperature in range 23.00 °F (–5 °C) ≤ Θ_{amb} ≤ 131.00 °F (55 °C)	≤ 0.5 % / 10 K
Frequency in range $0.95 \leq f/f_N \leq 1.05$	≤ 1 %
Harmonics - Up to 10 % 3rd harmonic - Up to 10 % 5th harmonic	 ≤ 1 % ≤ 1 %

4.30 Restart Inhibit for Motors (ANSI 66, 49Rotor)

Setting Ranges / Increments

Motor starting current relative to the Nominal Motor Current $I_{StartCurr}/I_{Mot.Nenn}$	1.5 to 10.0	Increments 0.1
Max. admissable Startup Timen $t_{Start\ Max.}$	3.0 s to 120.0 s	Increments 0.1 s
Leveling Time $T_{Leveling}$	0.0 min to 60.0 min	Increments 0.1 min
Maximum admissible Number of Warm Starts n_{WARM}	1 to 4	Increments 1
Difference betwwen Cold and Warm Starts n_{cold} - n_{WARM}	1 to 2	Increments 1
Extension Factor at Standstill $k_{\tau\ Standstill}$	1.0 to 100.0	Increments 0.1
Extesion of Time Constant at Motor Running $k_{\tau\ Operation}$	1.0 to 100.0	Increments 0.1
Minimum Restart Inhibit Time	0.2 min to 120.0 min	Increments 0.1 min

Restart Threshold

$$\Theta_{Re.Inh.} = \Theta_{R\ max\ perm} \cdot \frac{n_{COLD} - 1}{n_{COLD}}$$

Restarting Times

$$T_{Rem.} = T_{Leveling} + T_{Re.Inh.}$$

$$T_{Re.Inh.} = k_\tau \cdot \tau_R \cdot \ln\left(\frac{\Theta_{Pre}}{\Theta_{Re.Inh.}}\right) = k_\tau \cdot \tau_R \cdot \ln\left(\frac{\Theta_{Pre} \cdot n_{COLD}}{n_{COLD} - 1}\right)$$

Significance:

$\Theta_{Re.Inh.}$	Temperature limit below which a restart is possible
$\Theta_{R\ max\ perm}$	Maximum admissible rotor overtemperature (= 100 % of operational value $\Theta_R/\Theta_{R\ Trip}$)
n_{cold}	number of admissible starts from cold
$T_{Rem.}$	Time after which motor may be reswitched on
$T_{Leveling}$	Leveling time during which the thermal replica is "frozen"
$T_{Re.Inh.}$	Time until the thermal replica is again below the restart threshold depends on:
Θ_{pre}	Rotor temperature past history
τ_R	Rotor time constant, internally calculated
k_τ	Extension factor for the time constant $k_{\tau\ OPERATION}$ or $k_{\tau\ STANDSTILL}$

4.31 Breaker Failure Protection (ANSI 50BF)

Setting Ranges / Increments

Pickup thresholds B/F I>	for I_N = 1 A	0.04 A to 2.00 A	Increments 0.01 A
	for I_N = 5 A	0.20 A to 10.00 A	Increments 0.01 A
Delay Time BF-T		0.06 s to 60.00 s or ∞	Increments 0.01 s

Times

Pickup Times – On Internal Start – Using Controls (CFC) – For external Start	 approx. 50 ms approx. 50 ms approx. 50 ms
Dropout Time	approx. 50 ms

Tolerances

Pickup threshol B/F I>	for I_N = 1 A	1 % of setting value or 10 mA
	for I_N = 5 A	1 % of setting value or 50 mA
Delay Time BF-T		1 % or 10 ms

Influencing Variables for Pickup Values

Power supply direct voltage in range $0.8 \leq U_{Aux}/U_{AuxN} \leq 1.15$	≤ 1 %
Temperature in range 23.00 °F (–5 °C) ≤ Θ_{amb} ≤ 131.00 °F (55 °C)	≤ 0.5 %/10 K
Frequency in range $0.95 \leq f/f_N \leq 1.05$	≤ 1 %
Harmonics – Up to 10 % 3rd harmonic – Up to 10 % 5th harmonic	 ≤ 1 % ≤ 1 %

4.32 Inadvertent Energization (ANSI 50, 27)

Setting Ranges / Increments

Pickup current I >>>	for I_N = 1 A	0.1 A to 20.0 A or ∞ (ineffective)	Increments 0.1 A
	for I_N = 5 A	0.5 A to 100.0 A or ∞ (ineffective)	Increments 0.1 A
Tripping Enabling U_1<		10.0 V to 125.0 V or 0 V (no enable)	Increments 0.1 V
Delay time T U_1<PICKUP		0.00 s to 60.00 s or ∞ (ineffective)	Increments 0.01 s
Dropout time T U_1<DROPOUT		0.00 s to 60.00 s or ∞ (ineffective)	Increments 0.01 s

Times

Response time	approx. 25 ms
Dropout Time	approx. 35 ms

Dropout Ratios

50-3	for I_N = 1 A	approx. 0.80 or 50 mA
	for I_N = 5 A	approx. 0.80 or 250 mA
Tripping enabling U1<		approx. 1.05

Tolerances

Pickup current I >>>	for I_N = 1 A	5 % of setting value or 20 mA
	for I_N = 5 A	5 % of setting value or 100 mA
Tripping Enabling U_1<		1 % of setting value or 0.5 V
Delay Time T		1 % or 10 ms

Influencing Variables for Pickup Values

Power supply direct voltage in range $0.8 \leq U_{Aux}/U_{AuxN} \leq 1.15$	≤ 1 %
Temperature in range 23.00 °F (–5 °C) ≤ Θ_{amb}≤ 131.00 °F (55 °C)	≤ 0.5 %/10 K
Frequency in range $0.95 \leq f/f_N \leq 1.05$	≤ 1 %
Harmonics – Up to 10 % 3rd harmonic – Up to 10 % 5th harmonic	 ≤ 1 % ≤ 1 %

4.33 DC Voltage/Current Protection (ANSI 59NDC/51NDC)

Setting Ranges / Increments

Voltage increase U≥	0.1 V to 8.5 V	Increments 0.1V
Voltage Decrease U≤	0.1 V to 8.5 V	Increments 0.1V
Current Increase I≥	0.2 mA to 17.0 mA	Increments 0.1 mA
Current Decrease I≤	0.2 mA to 17.0 mA	Increments 0.1 mA
For Measurement of Sinusoidal Voltages	0.1 V_{rms} to 7.0 V_{rms}	Increments 0.1 V_{rms}
For Measurement of Sinusoidal Currents	0.2 mA to 14.0 mA	Increments 0.1 mA
Delay Time T_{DC}	0.00 s to 60.00 s or ∞ (ineffective)	Increments 0.01 s
The set times are pure delay times.		

Times

Pickup Times		
Increase U>, I> in Operating State 1 in Operating State 0	 ≤ 60 ms ≤ 200 ms	at f = f_N
Decrease U<, I< in Operating State 1 in Operating State 0	 ≤ 60 ms ≤ 200 ms	at f = f_N
Dropout Times	Same as pickup times	

Dropout Ratios

Voltage Increase U≥	approx. 0.95 or -0.05 V
Voltage Decrease U≤	approx. 1.05 or +0.05 V
Current Increase I≥	approx. 0.95 or. –0.15 mA
Current Decrease I≤	approx. 1.05 or +0.15 mA

Tolerances

Voltage Limits	1 % of setting value or 0.1 V
Current Thresholds	1 % of setting value or 0.1 mA
Delay Time T	1 % of setting value or 10 ms

Influencing Variables for Pickup Values

Power supply direct voltage in range 0.8 ≤ U_{Aux}/U_{AuxN} ≤ 1.15	≤ 1 %
Temperature in range 23.00 °F (–5 °C) ≤ Θ_{amb}≤ 131.00 °F (55 °C)	≤ 0.5 % / 10 K
Frequency in Range 0.95 ≤ f/f_N ≤ 1.05	≤ 1 %

4.34 Temperature Detection by Thermoboxes

Temperature Detectors

connectable thermoboxes	1 or 2
Number of temperature detectors per thermobox	Max. 6
Measuring Method	Pt 100 Ω or Ni 100 Ω or Ni 120 Ω
Mounting Identification	„Oil“ or „Ambient“ or „Winding“ or „Bearing“ or „Other“

Thresholds for Indications

for each measuring point:		
Stage 1	–58 °F to 482 °F (–50 °C to 250 °C) or ∞ (no indication)	Increments 1 °F Increments 1 °C
Stage 2	–58 °F to 482 °F (–50 °C to 250 °C) or ∞ (no indication)	Increments 1 °F Increments 1 °C

4.35 Threshold supervision

Setting Ranges / Increments

Threshold MV1> to MV10<	–200 % to +200 %	Increments 1 %
Assignable Measured Values	P, Active Power Q, Reactive Power Change of active power ΔP Voltage U_{L1} Voltage U_{L2} Voltage U_{L3} Voltage U_E Voltage U0 Voltage U1 Voltage U2 Voltage U_{E3h} Current 3I0 Current I1 Current I2 Current I_{EE1} Current I_{EE2} Power angle φ Power factor $\cos\varphi$ Value at TD1	

Times

Pick-up times	approx. 20 ms to 40 ms
Dropout times	approx. 20 ms to 40 ms

Drop-off to pickup ratio

Threshold MVx>	0.95
Threshold MVx<	1.05

Tolerances

See also operational measured values in Section „Additional Functions“.

4.36 User-defined Functiones (CFC)

Function Modules and Possible Assignments to Task Levels

Function Module	Explanation	Task Level			
		MW_ BEARB	PLC1_ BEARB	PLC_ BEARB	SFS_ BEARB
ABSVALUE	Magnitude Calculation	X	—	—	—
ADD	Addition	X	X	X	X
ALARM	Alarm clock	X	X	X	X
AND	AND - Gate	X	X	X	X
FLASH	Blink block	X	X	X	X
BOOL_TO_CO	Boolean to Control (conversion)	—	X	X	—
BOOL_TO_DI	Boolean to Double Point (conversion)	—	X	X	X
BOOL_TO_IC	Bool to Internal SI, Conversion	—	X	X	X
BUILD_DI	Create Double Point Annunciation	—	X	X	X
CMD_CANCEL	Command cancelled	X	X	X	X
CMD_CHAIN	Switching Sequence	—	X	X	—
CMD_INF	Command Information	—	—	—	X
COMPARE	Metered value compar-ison	X	X	X	X
CONNECT	Connection	—	X	X	X
COUNTER	Counter	X	X	X	X
DI_GET_STATUS	Decode double point indication	X	X	X	X
DI_SET_STATUS	Generate double point indication with status	X	X	X	X
D_FF	D- Flipflop	—	X	X	X
D_FF_MEMO	Status Memory for Restart	X	X	X	X
DI_TO_BOOL	Double Point to Boolean (conversion)	—	X	X	X
DINT_TO_REAL	Adaptor	X	X	X	X
DIST_DECODE	Conversion double point indication with status to four single in-dications with status	X	X	X	X
DIV	Division	X	X	X	X
DM_DECODE	Decode Double Point	X	X	X	X
DYN_OR	Dynamic OR	X	X	X	X
INT_TO_REAL	Conversion	X	X	X	X
LIVE_ZERO	Live-zero, non-linear Curve	X	—	—	—
LONG_TIMER	Timer (max.1193h)	X	X	X	X
LOOP	Feedback Loop	X	X	—	X
LOWER_SETPOINT	Lower Limit	X	—	—	—

Function Module	Explanation	Task Level			
		MW_ BEARB	PLC1_ BEARB	PLC_ BEARB	SFS_ BEARB
MUL	Multiplication	X	X	X	X
MV_GET_STATUS	Decode status of a value	X	X	X	X
MV_SET_STATUS	Set status of a value	X	X	X	X
NAND	NAND - Gate	X	X	X	X
NEG	Negator	X	X	X	X
NOR	NOR - Gate	X	X	X	X
OR	OR - Gate	X	X	X	X
REAL_TO_DINT	Adaptor	X	X	X	X
REAL_TO_INT	Conversion	X	X	X	X
REAL_TO_UINT	Conversion	X	X	X	X
RISE_DETECT	Rise detector	X	X	X	X
RS_FF	RS- Flipflop	—	X	X	X
RS_FF_MEMO	RS- Flipflop with state memory	—	X	X	X
SQUARE_ROOT	Root Extractor	X	X	X	X
SR_FF	SR- Flipflop	—	X	X	X
SR_FF_MEMO	SR- Flipflop with state memory	—	X	X	X
ST_AND	AND gate with status	X	X	X	X
ST_NOT	Inverter with status	X	X	X	X
ST_OR	OR gate with status	X	X	X	X
SUB	Substraction	X	X	X	X
TIMER	Timer	—	X	X	—
TIMER_SHORT	Simple timer	—	X	X	—
UINT_TO_REAL	Conversion	X	X	X	X
UPPER_SETPOINT	Upper Limit	X	—	—	—
X_OR	XOR - Gate	X	X	X	X
ZERO_POINT	Zero Supression	X	—	—	—

General Limits

Description	Limit	Comments
Maximum number of all CFC charts considering all task levels	32	When the limit is exceeded, the device rejects the parameter set displaying an error message, restores the last valid parameter set and uses it for restarting.
Maximum number of all CFC charts considering one task level	16	When the limit is exceeded, an error message is output by the device. Consequently, the device is put into monitoring mode. The red ERROR-LED lights up.
Maximum number of all CFC inputs considering all charts	400	When the limit is exceeded, an error message is output by the device. Consequently, the device starts monitoring. The red ERROR-LED lights up.
Maximum number of reset-resistant flipflops D_FF_MEMO	350	When the limit is exceeded, an error message is output by the device. Consequently, the device starts monitoring. The red ERROR-LED lights up.

Device-specific Limits

Description	Limit	Comments
Maximum number of synchronous changes of chart inputs per task level	165	When the limit is exceeded, an error message is output by the device. Consequently, the device starts monitoring. The red ERROR-LED lights up.
Maximum number of chart outputs per task level	150	

Additional Limits

Additional limits 1) for the following CFC blocks:		
Task Level	Maximum Number of Modules in the Task Levels	
	TIMER 2) 3)	TIMER_SHORT 2) 3)
MW_BEARB	—	—
PLC1_BEARB	15	30
PLC_BEARB		
SFS_BEARB	—	—

1) When the limit is exceeded, an error message is output by the device. Consequently, the device starts monitoring. The red ERROR-LED lights up.

2) The following condition applies for the maximum number of timers: (2 · number of TIMER + number of TIMER_SHORT) < 30. TIMER and TIMER_SHORT hence share the available timer resources within the frame of this inequation. The limit does not apply to the LONG_TIMER.

3) The time values for the blocks TIMER and TIMER_SHORT must not be selected shorter than the time resolution of the device, as the blocks will not then start with the starting pulse.

Maximum Number of TICKS in the Task Levels

Task Level	Limit in TICKS 1)
MW_BEARB (Measured Value Processing)	10000
PLC1_BEARB (Slow PLC Processing)	2000
PLC_BEARB (Fast PLC Processing)	400
SFS_BEARB (Interlocking)	10000

1) When the sum of TICKS of all blocks exceeds the limits before-mentioned, an error message is output by CFC.

Processing Times in TICKS Required by the Individual Elements

Individual Element		Number of TICKS
Block, basic requirement		5
Each input more than 3 inputs for generic modules		1
Connection to an input signal		6
Connection to an output signal		7
Additional for each chart		1
Arithmetic	ABS_VALUE	5
	ADD	26
	SUB	26
	MUL	26
	DIV	54
	SQUARE_ROOT	83
Basic logic	AND	5
	CONNECT	4
	DYN_OR	6
	NAND	5
	NEG	4
	NOR	5
	OR	5
	RISE_DETECT	4
	X_OR	5
Information status	SI_GET_STATUS	5
	CV_GET_STATUS	5
	DI_GET_STATUS	5
	MV_GET_STATUS	5
	SI_SET_STATUS	5
	DI_SET_STATUS	5
	MV_SET_STATUS	5
	ST_AND	5
	ST_OR	5
	ST_NOT	5
Memory	D_FF	5
	D_FF_MEMO	6
	RS_FF	4
	RS_FF_MEMO	4
	SR_FF	4
	SR_FF_MEMO	4
Control commands	BOOL_TO_CO	5
	BOOL_TO_IC	5
	CMD_INF	4
	CMD_CHAIN	34
	CMD_CANCEL	3
	LOOP	8

Individual Element		Number of TICKS
Type converter	BOOL_TO_DI	5
	BUILD_DI	5
	DI_TO_BOOL	5
	DM_DECODE	8
	DINT_TO_REAL	5
	DIST_DECODE	8
	UINT_TO_REAL	5
	REAL_TO_DINT	10
	REAL_TO_UINT	10
Comparison	COMPARE	12
	LOWER_SETPOINT	5
	UPPER_SETPOINT	5
	LIVE_ZERO	5
	ZERO_POINT	5
Metered value	COUNTER	6
Time and clock pulse	TIMER	5
	TIMER_LONG	5
	TIMER_SHORT	8
	ALARM	21
	FLASH	11

Configurable in Matrix

In addition to the defined preassignments, indications and measured values can be freely configured to buffers, preconfigurations can be removed.

4.37 Additional Functions

Operational Measured Values

Operational Measured Values for Currents	$I_{L1, S1}$, $I_{L2, S1}$, $I_{L3, S1}$, $I_{L1, S2}$, $I_{L2, S2}$, $I_{L3, S2}$ in A (kA) primary and in A secondary or in % I_N	
	Range	10 % to 200 % I_N
	Tolerance	0.2 % of measured value, or ±10 mA ±1 digit
	$3I_0$ in A (kA) primary and in A secondary	
	I_{Ns1}, I_{Ns2}	
	Range	0 mA to 1600 mA
	Tolerance	0.2 % of measured value, or ±10 mA ±1 digit
	Positive sequence component I_1 in A (kA) primary and in A secondary or in % I_N	
	Negative sequence component I_2 in A (kA) primary and in A secondary or in % IN	
Differential Protection Currents	I_{DiffL1}, I_{DiffL2}, I_{DiffL3}, I_{RestL1}, I_{RestL2}, I_{RestL3} in I/I_{NO}	
	Range	10 % to 200 % I_N
	Tolerance	3 % of measured value, or ±10 mA ±1 digit
Operational Measurement Values for Voltages (Phase-Ground)	U_{L1-E}, U_{L2-E}, U_{L3-E} in kV primary, in V secondary or in % U_N	
	Range	10 % to 120 % U_N
	Tolerance	0.2 % of measured value or ±0.2 mA ±1 digit
Operational Measurement Values for Voltages (Phase-Phase)	U_{L1-L2}, U_{L2-L3}, U_{L3-L1} in kV primary, in V secondary or in % U_N	
	Range	10 % to 120 % U_N
	Tolerance	0.2 % of measured value or ±0.2 mA ±1 digit
	U_E or $3U_0$ in kV primary, in V secondary or in % U_N	
	Positive sequence component U_1 and negative sequence component U_2 in kV primary, in V secondary or in % U_N	
Operational Measurement Values for Impedances	R, X in Ω primary and secondary	
	Tolerance	1 %

Operational Measurement Values for Power	S, apparent power in kVAr (MVAr or GVAr) primary and in % S_N	
	Range	0 % to 120 % S_N
	Tolerance	1 % ±0,25 % S_N, with SN = $\sqrt{3} \cdot U_N \cdot I_N$
	P, active power (with sign) in kVAr (MVAr or GVAr) primary and in % S_N	
	Range	0 % to 120 % S_N
	Tolerance	1 % ±0.25 % S_N with $S_N = \sqrt{3} \cdot U_N \cdot I_N$
	Q, reactive power (with sign) in kVAr (MVAr or GVAr) primary and in % S_N	
	Range	0 % to 120 % S_N
	Tolerance	1 % ±0.25 % S_N with $S_N = \sqrt{3} \cdot U_N \cdot I_N$
Operating Measured Value for Power Factor	cos φ	
	Range	–1 to +1
	Tolerance	1 % ± 1 Digit
	Power angle	φ
	Range	-90° to +90°
	Tolerance	0.1°
Counter Values for Energy	Wp, Wq (active and reactive energy) in kWh (MWh or GWh) and in kVARh (MVARh or GVARh)	
	Range	8 1/2 digits (28 bit) for VDEW protocol 9 1/2 digits (31 bit) in the device
	Tolerance	1 % ± 1 Digit
Operational Measured Values for Frequency	f in Hz	
	Range	40 Hz < f < 66 Hz
	Tolerance	10 mHz at U > 0.5 · U_N
Overexcitation	$U/U_N/f/f_N$	
	Range	0 to 2.4
	Tolerance	2 %
Thermical Measured Values		
- of the Stator (Overload Protection)		$\Theta_S/\Theta_{trip\ L1}$, $\Theta_S/\Theta_{trip\ L2}$, $\Theta_S/\Theta_{trip\ L3}$
- of the Rotor (Restart Inhibit)		Θ_R/Θ_{trip}
- of the Unbalanced Load Protection		$\Theta_{i2}/\Theta_{trip}$
– of the Overexcitation Protection		$\Theta_{U/f}/\Theta_{trip}$
- of coolant temperature		Depends on the connected temperature sensor
Range		0 % to 400 %
Tolerance		5 %
Operational Measured Values for Rotor Earth Fault Protection (1-3 Hz)		
	Range	0.5 Hz to 4.0 Hz
	Tolerance	0.1 Hz

Amplitude of Rotor Voltage Injection	U_{gen} in V	
	Range	0.0 V to 60.0 V
	Tolerance	0.5 V
Rotor Circuit Current	$I_{N, Gen}$ in mA	
	Range	0.00 mA to 20.00 mA
	Tolerance	0.05 mA
Charge at Polarity Reversal	Q_C in mAs	
	Range	0.00 mAs to 1.00 mAs
	Tolerance	0.01 mAs
Rotor Earth Resistance	R_{Earth} in kΩ	
	Range	0.0 kΩ to 999.9 kΩ
	Tolerance	< 5 % or 0.5 kΩ for R_{earth} < 100 kΩ and for C_e< 1μF < 10 % or 0.5 kΩ for R_{earth} < 100 kΩ and for C_e< 4μF
Operational measured values of 100-%-Stator Earth Fault Protection (20 Hz)		
Stator circuit bias voltage	U_{SEF} in V	
	Range	0.0 V to 200.0 V
	Tolerance	0.2 % of measured value, or ± 0.2 V ± 1 digit
Earth Current of Stator Circuit	I_{SEF} in A	
	Range	0.0 mA to 1600.0 mA
	Tolerance	0.2 % of measured value, or ± 0.1 mA ± 1 digit
20 Hz Phase Angle	φ_{SEF} in °	
	Range	– 180.0° to +180.0°
	Tolerance	1.0 %
Stator Earth Resistance (sec.)	R_{SEF} in Ω	
	Range	0 Ω up to 9999 Ω
	Tolerance	5 % or 2 Ω
Stator Earth Resistance (prim.)	R_{SEFP} in Ω	
	Range	0 kΩ to 9999.99 kΩ
	Tolerance	5 % or (5 kΩ · conversion factor)

Min / Max Report

Report of Measured Values	with date and time
Reset manual	using binary input using keypad using communication
Min/Max Values for Current Positive Sequence Components	I_1
Min/Max Values for Voltage Positive Sequence Components	U_1
Min/Max Values for 3rd Harmonics in Displacement Voltage	U_{G3H}
Min/Max Values for Power	P, Q
Min/Max Values for Frequency f	f

Analog Outputs (optional)

Number	max. 4 (depending on variant)
possible measured values	I1, I2, IEE1, IEE2, U1, U0, U03h, |P|, |Q|, S, |cos φ|, f, U/f, φ, $\Theta_S/\Theta_{S\ trip}$, $\Theta_R/\Theta_{R\ trip}$, RE LES, RE LES 1-3 Hz, RE SEF in %
Range	0.0 mA to 22.5 mA
Minimum threshold (limit of validity:)	0.0 mA to 5.0 mA (increments 0.1 mA)
Maximum Threshold	22.0 mA (fixed)
Configurable Reference Value 20 mA	10.0 % to 1.000.0 % (0.1 % increments)

Local Measured Values Monitoring

Current Asymmetry	I_{max}/I_{min} > balance factor, for $I > I_{balance\ limit}$
Voltage Asymmetry	U_{max}/U_{min} > balance factor, for $U > U_{lim}$
Current Sum	$\| i_{L1} + i_{L2} + i_{L3} \|$ > limit
Voltage sum	$\| \underline{U}_{L1} + \underline{U}_{L2} + \underline{U}_{L3} + k_U \cdot \underline{U}_E \|$ > limit, with k_U = Uph/Uen CT
Current Phase Sequence	Clockwise/ counter-clockwise phase sequence
Voltage Phase Sequence	Clockwise/ counter-clockwise phase sequence
Limit Value Monitoring	I_L< limit value I_L<, configurable using CFC

Fault Event Recording

Indications memory for the last 8 fault cases (max. 600 indications)

Time Allocation

Resolution for Event Log (Operational Indications)	1 ms
Resolution for Fault Log (Fault Indications)	1 ms
Maximum Time Deviation (Internal Clock)	0.01 %
Battery	Lithium battery 3 V/1 Ah, type CR 1/2 AA "Flt. Battery" on low battery charge

Fault Recording

Maximum 8 fault records saved by buffer battery also through auxiliary voltage failure	
Instantaneous Values:	
Recording Time	total 5 s Pre-event and post-event recording and memory time adjustable
Sampling grid for 50 Hz Sampling grid for 60 Hz	1 sample/1.25 ms 1 sample/1.04 ms
Channels	u_{L1}, u_{L2}, u_{L3}, u_E, $i_{L1,S1}$, $i_{L2,S1}$, $i_{L3,S1}$, i_{EE1}, $i_{L1,S2}$, $i_{L2,S2}$, $i_{L3,S2}$, i_{EE}, $I_{Diff-L1}$, $I_{Diff-L2}$, $I_{Diff-L3}$, $I_{Stab-L1}$, $I_{Stab-L2}$, $I_{Stab-L3}$, u= or i= of the three measuring transducers TD
rms values:	
Recording Time	total 80 s Pre-event and post-event recording and memory time adjustable
grid for 50 Hz grid for 60 Hz	1 sample/20 ms 1 sample/16.67 ms
Channels	U_1, U_G, I_1, I_2, I_{Ns1}, I_{Ns2}, P, Q, φ, R, X, f-f_{Nom}

Energy Counter

Four-Quadrant Meter	W_{P+}, W_{P-}, W_{Q+}, W_{Q-}
Tolerance	1 %

Statistics

Stored Number of Trips	up to 9 digits
accumulated Interrupted Current	Up to 4 digits (kA) per pole

Operating Hours Counter

Display Range	up to 6 digits
Criterion	Overshoot of an adjustable current threshold (CB I>)

Trip Circuit Supervision

Number of monitorable circuits	1 with one or two binary inputs

Commissioning Aids

	Phase Rotation Field Check Operational measured values Switching device test Creation of a Test Measurement Report

Clock

Time synchronization	DCF 77 / IRIG B Signal (telegram format IRIG-B000) Binary Input Communication

Group Switchover of the Function Parameters

Number of Available Setting Groups	2 (parameter group A and B)
Switchover can be performed	using the keypad DIGSI using the operating interface with protocol via system interface Binary Input

4.38 Operating Range of the Protection Functions

Table 4-1 Operating ranges of the protection functions

	Operational state 0	Operational state 1		Operational state 0
Protective Elements	**f ≤ 10 Hz**	**11 Hz < f/Hz ≤ 40**	**40 Hz ≤ f/Hz ≤ 69**	**f ≥ 70 Hz**
Definite-Time Overcurrent Protection (I>/I>>)	**active**	**active**	**active**	**active**
Inverse-Time Overcurrent Protection (ANSI 51V)	inactive	**active**	**active**	inactive
Thermal Overload Protection (ANSI 49)	inactive 1)	**active**	**active**	inactive 1)
Unbalanced Load (Negative Sequence) Protection (ANSI 46)	inactive 1)	**active**	**active**	inactive 1)
Startup Overcurrent Protection (ANSI 51)	**active**	inactive	inactive	**active**
Differential Protection (ANSI 87G/87M/87T)	**active**	**active**	**active**	**active**
Earth Current Differential Protection (ANSI 87GN,TN)	inactive	**active**	**active**	inactive
Underexcitation (Loss-of-Field) Protection (ANSI 40)	inactive	**active**	**active**	inactive
Reverse Power Protection (ANSI 32R)	inactive	**active**	**active**	inactive
Forward Active Power Supervision (ANSI 32F)	inactive	**active**	**active**	inactive
Impedance Protection (ANSI 21)	inactive	**active**	**active**	inactive
Out-of-Step Protection (ANSI 78)	inactive	**active**	**active**	inactive
Undervoltage Protection (ANSI 27)	inactive 2)	**active**	**active**	inactive 2)
Overvoltage Protection (ANSI 59)	**active**	**active**	**active**	**active**
Frequency increase protection	inactive	**active**	**active**	inactive 3)
Underfrequency protection	inactive	**active**	**active**	inactive
Overexcitation (Volt/Hertz) Protection (ANSI 24)	inactive 1)	**active**	**active**	inactive 1)
Inverse-Time Undervoltage Protection (ANSI 27)	inactive 2)	**active**	**active**	inactive 2)
Rate-of-Frequency-Change Protection df/dt (ANSI 81R)	inactive	**active** 4)	**active**	inactive
Jump of Voltage Vector	inactive	**active** 5)	**active** 5)	inactive
90-%-Stator Earth Fault Protection (ANSI 59N, 64G, 67G)	**active**	**active**	**active**	**active**
Sensitive Earth Fault Protection (ANSI 51GN, 64R)	inactive	**active**	**active**	inactive
100-%-Stator Earth Fault Protection with 3rd Harmonics (ANSI 27/59TN 3rd Harm.)	inactive	**active**	**active**	inactive
100-%-Stator Earth Fault Protection with 20 Hz Voltage Injection (ANSI 64G - 100%)	**active**	**active**	**active**	**active**
Rotor Earth Fault Protection R, fn (ANSI 64R)	**active**	**active**	**active**	**active**
Sensitive Rotor Earth Fault Protection with 1 to 3 Hz Square Wave Voltage Injection (ANSI 64R - 1 to 3 Hz)	**active**	**active**	**active**	**active**

	Operational state 0	Operational state 1		Operational state 0
Protective Elements	**f ≤ 10 Hz**	**11 Hz < f/Hz ≤ 40**	**40 Hz ≤ f/Hz ≤ 69**	**f ≥ 70 Hz**
Motor Starting Time Supervision (ANSI 48)	inactive	**active**	**active**	inactive
Restart Inhibit for Motors (ANSI 66, 49Rotor)	**active**	**active**	**active**	**active**
Breaker Failure Protection (ANSI 50BF)	**active**[7)]	**active**	**active**	**active**[7)]
Inadvertent Energization (ANSI 50, 27)	**active**	**active**	**active**	**active**
DC Voltage/Current Protection (ANSI 59NDC/51NDC)	**active**	**active**	**active**	**active**
Threshold supervision	inactive [6)]	**active**	**active**	inactive [6)]
External Trip Functions	**active**	**active**	**active**	**active**
Temperature Detection by Thermoboxes	**active**	**active**	**active**	**active**
Fuse Failure Monitor	inactive	**active**	**active**	inactive
Sensitive Earth Fault Protection B (ANSI 51GN)	inactive	**active**	**active**	inactive
Interturn Protection (ANSI 59N (IT))	inactive	**active**	**active**	inactive
Operational Condition 1:	At at least one of the measuring inputs (U_{L1}, U_{L2} U_{L3}, $I_{L1, S2}$, $I_{L2, S2}$, $I_{L3, S2}$) of the device, at least 5% of the nominal value is present, so that the sampling frequency for measurement acquisition can be tracked.			
Operational Condition 0:	If no suitable measured values are present, or if the frequency is below 11 Hz or above 69 Hz, the device cannot operate (operational condition 0) and no measured value processing occurs.			

1) The thermal replica registers cooling-down
2) A pickup – if already present – is maintained
3) A pickup – if already present – is maintained, if the measured voltage is not too small
4) 25 Hz < f/Hz ≤ 40 Hz
5) The function is only active at rated frequency ± 3 Hz
6) If using the measured value of measuring transducer1
7) Only if auxiliary contacts of the circuit breaker connected

4.39 Dimensions

4.39.1 Panel Flush and Cubicle Mounting (Housing Size $^{1}/_{2}$)

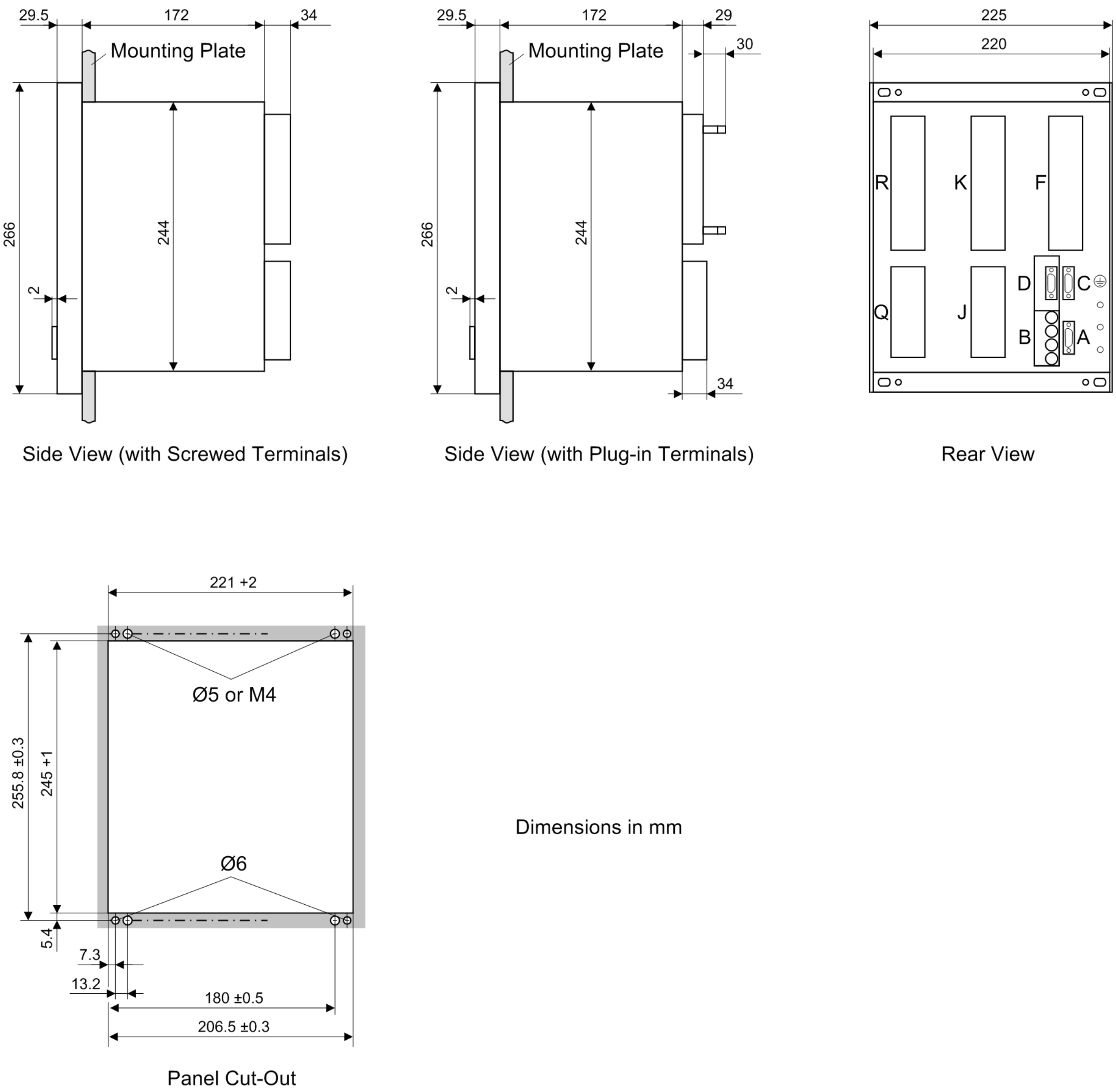


Figure 4-14 Dimensions of a 7UM621 or a 7UM623 for Panel Flush Mounting or Cubicle Installation (size 1/2)

4.39.2 Housing for Panel Flush Mounting or Cubicle Mounting (Size 1/1)

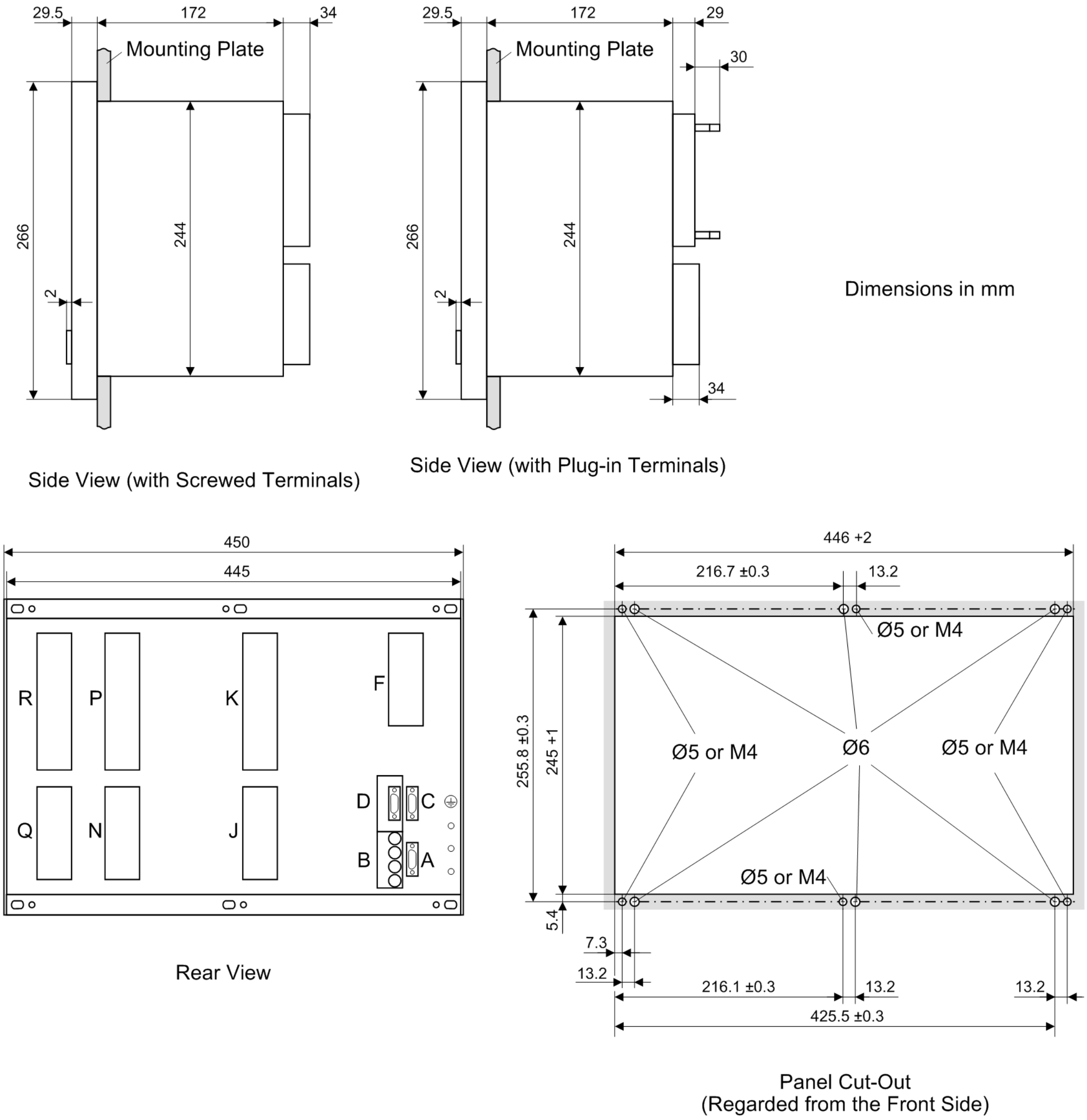


Figure 4-15 Dimensions of a 7UM622 for Panel Flush Mounting or Cubicle Installation (size 1/1)

4.39.3 Panel Flush Mounting (Housing Size $^1/_2$)

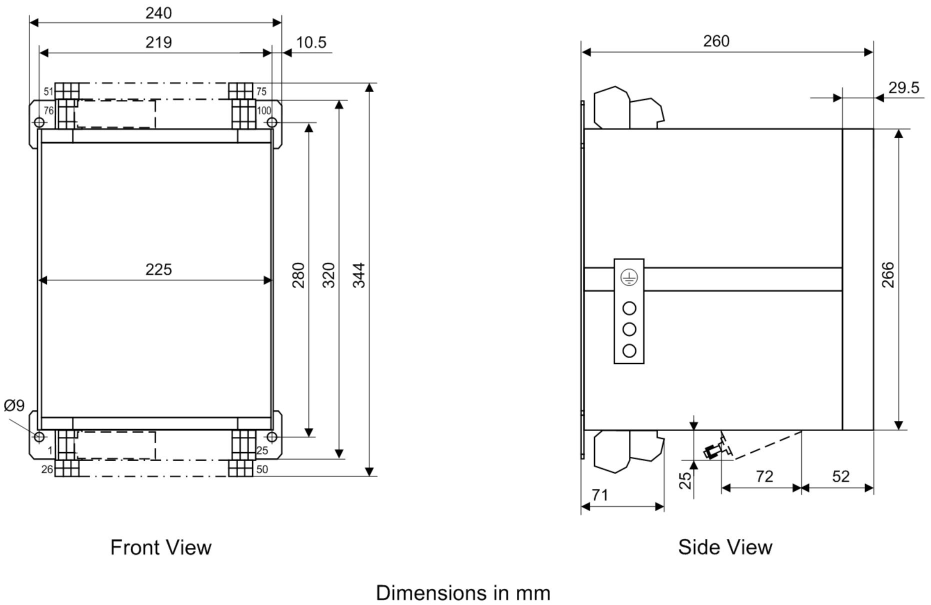


Figure 4-16 Dimensions of a 7UM621 for Panel Surface Mounting (housing size 1/2)

4.39.4 Housing for Panel Surface Mounting (Size $^1/_1$)

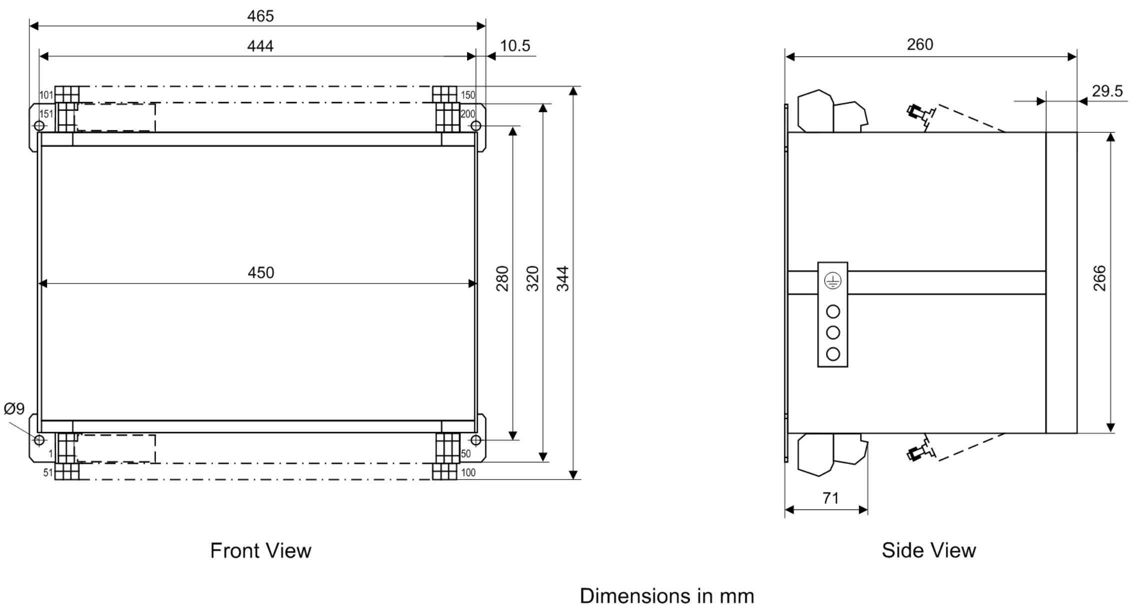


Figure 4-17 Dimensions of a 7UM622 for Panel Surface Mounting (housing size 1/1)

4.39.5 Dimensional Drawing of Coupling Device 7XR6100-0CA0 for Panel Flush Mounting

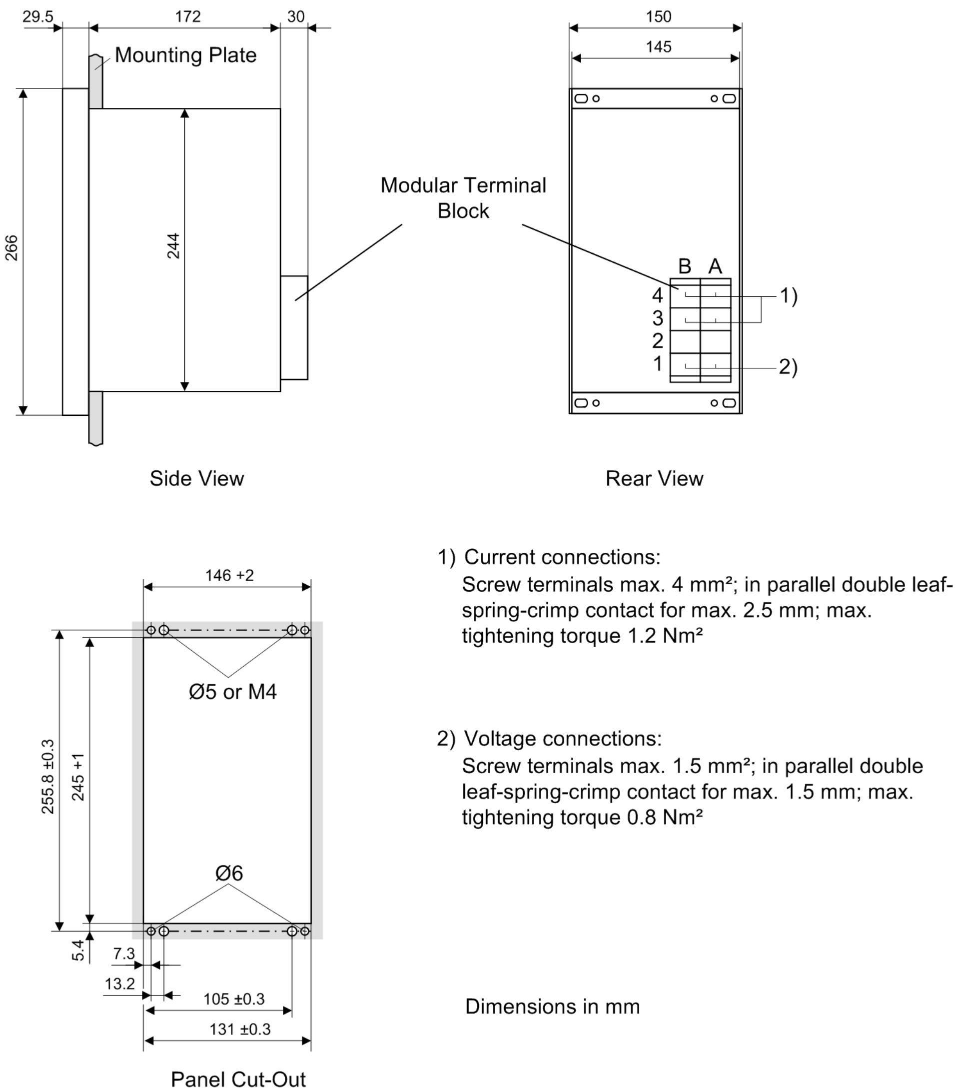


Figure 4-18 Dimensions of Coupling Unit 7XR6100-0CA0 for Panel Flush Mounting

4.39.6 Dimensions of Coupling Unit 7XR6100-0BA0 for Panel Surface Mounting

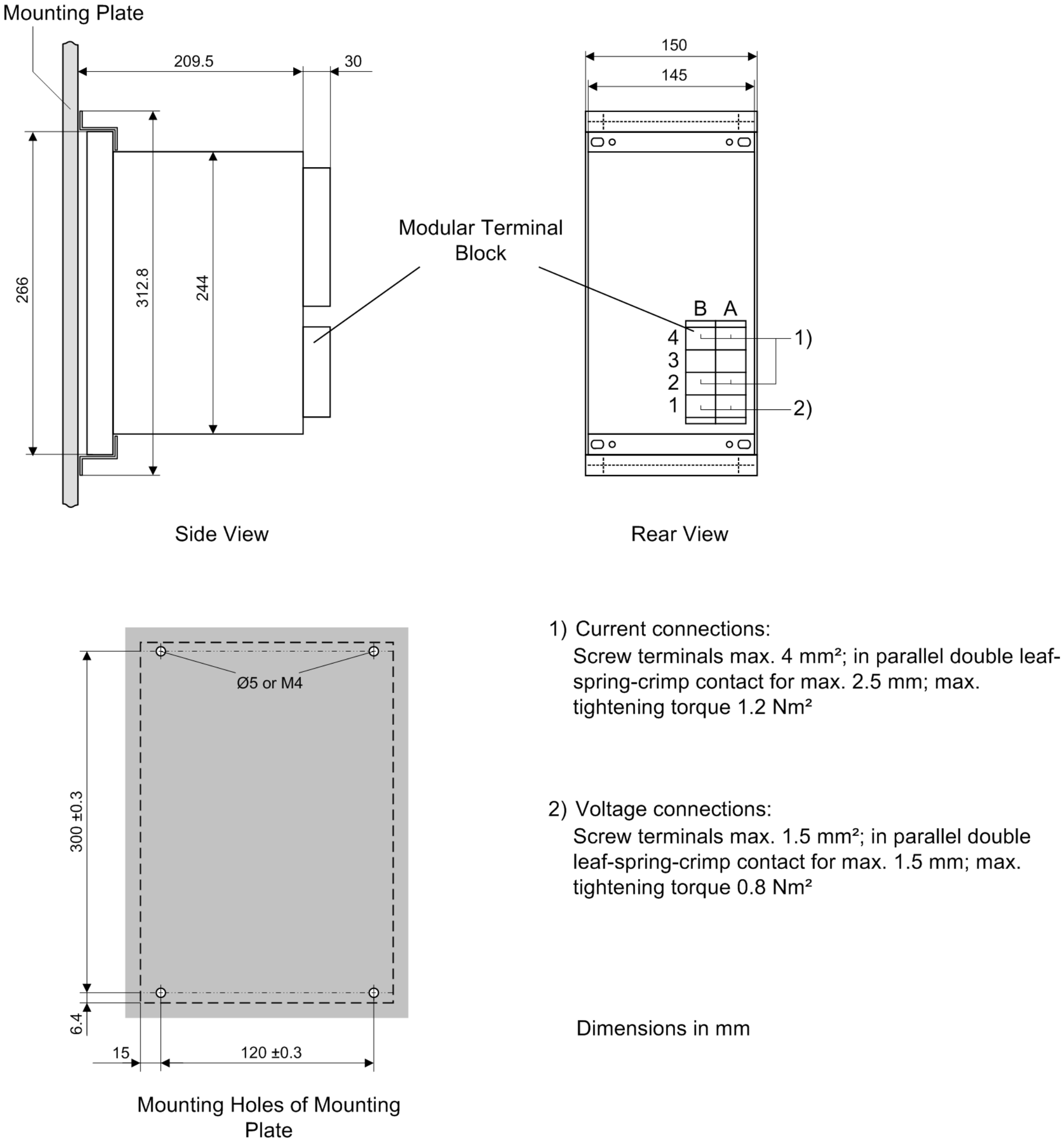
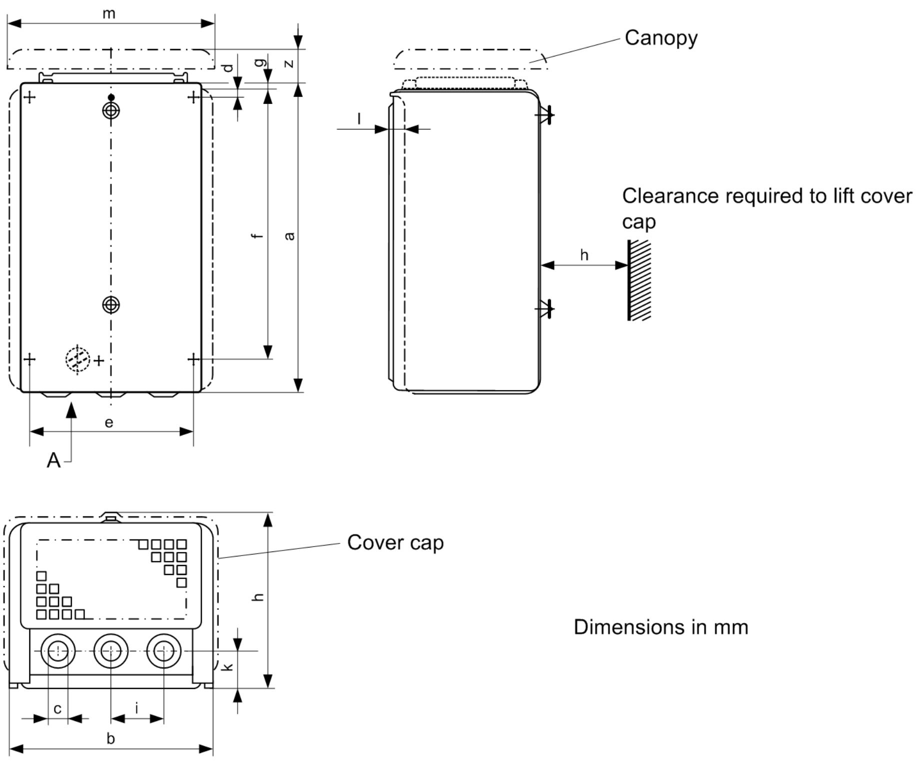


Figure 4-19 Dimensions of Coupling Unit 7XR6100-0BA0 for Panel Surface Mounting

4.39.7 Dimensional Drawing of 3PP13



3PP1 in degree of protection IP 20 (with canopy in IP 23)

Type	a	b	c	d	e	f	g	h	i	k	l	m	z
3PP1 32	267	187	3 x 16	7	160	230	10	110	50	30	10	196	33
3PP1 33	267	187	3 x 16	7	160	230	10	146	50	30	10	196	33

Figure 4-20 Dimension Diagrams 3PP13:

3PP132 for voltage divider 3PP1326-0BZ-012009 (20 : 10 : 1)

3PP133 for voltage divider 3PP1336-1CZ-013001 (5 : 2 : 1)

for series resistor 3PP1336-0DZ-013002

4.39.8 Dimensional Drawing of Series Device 7XT7100-0BA00 for Panel Surface Mounting

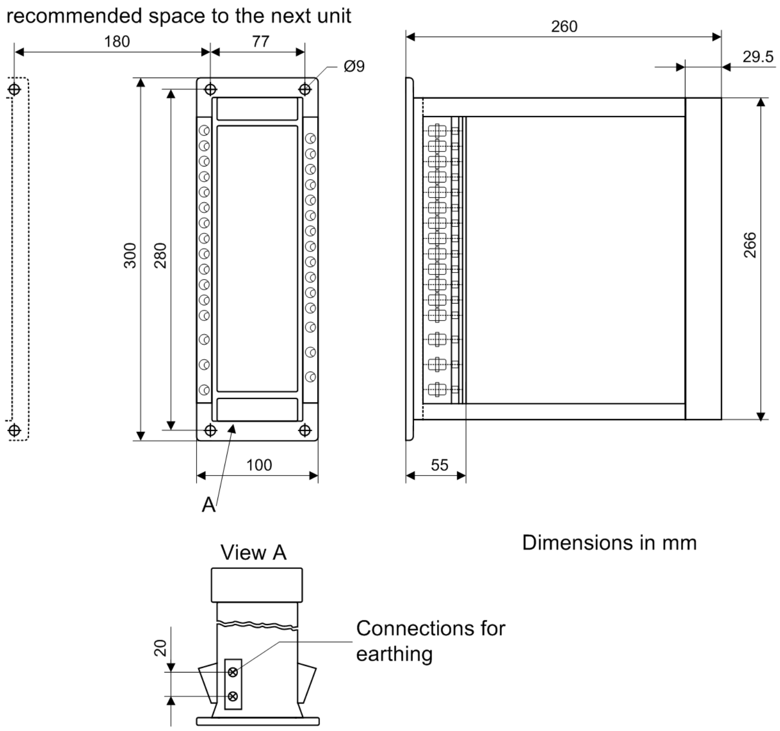


Figure 4-21 Dimensions of Series Device 7XT7100-0BA00 for Panel Surface Mounting

where:

Current connections (terminals 1 to 6) not used in 7XT71

Control connections (terminals 7 to 31) insulated ring-type cable lug:

for bolts of 4 mm, max. outside diameter 9 mm, type: e.g. PIDG from Tyco Electronics AMP for copper cable cross-sections of 1.0 mm^2 to 2.6 mm^2. AWG 17 to 13

stripped copper cable, directly

Cross-sections between 0.5 and 2.6 mm^2. AWG 20 to 13

with stranded conductors:

Cable end sleeve required, maximum tightening torque 1.8 Nm.

4.39.9 Dimensions of Series Unit 7XT7100-0EA00 for Panel Flash Mounting

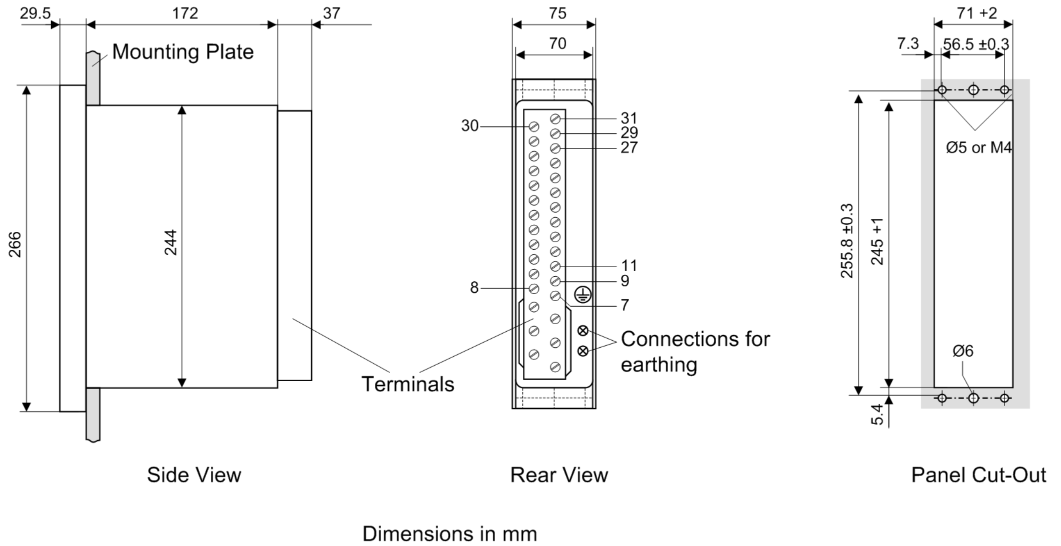


Figure 4-22 Dimensions of Series Unit 7XT7100-0EA00 for Panel Flash Mounting

where:

Current connections (terminals 1 to 6)
not used in 7XT71
Control connections (terminals 7 to 31)
Screw terminals (ring-type cable lug):
for bolts of 4 mm, max. outside diameter 9 mm
Type: e.g. PIDG of Messrs. Tyco Electronics AMP
for copper cable cross-sections between 1.0 mm^2 and 2.6 mm^2
AWG 17 to 13
in parallel double leaf-spring-crimp contact:
for copper cable cross-sections between 0.5 mm^2 and 2.5 mm^2
AWG 20 to 13
Maximum tightening torque 1.8 Nm.

4.39.10 Dimensional Drawing of Resistor Unit 7XR6004-0CA00 for Panel Surface Mounting or Cubicle Flush Mounting

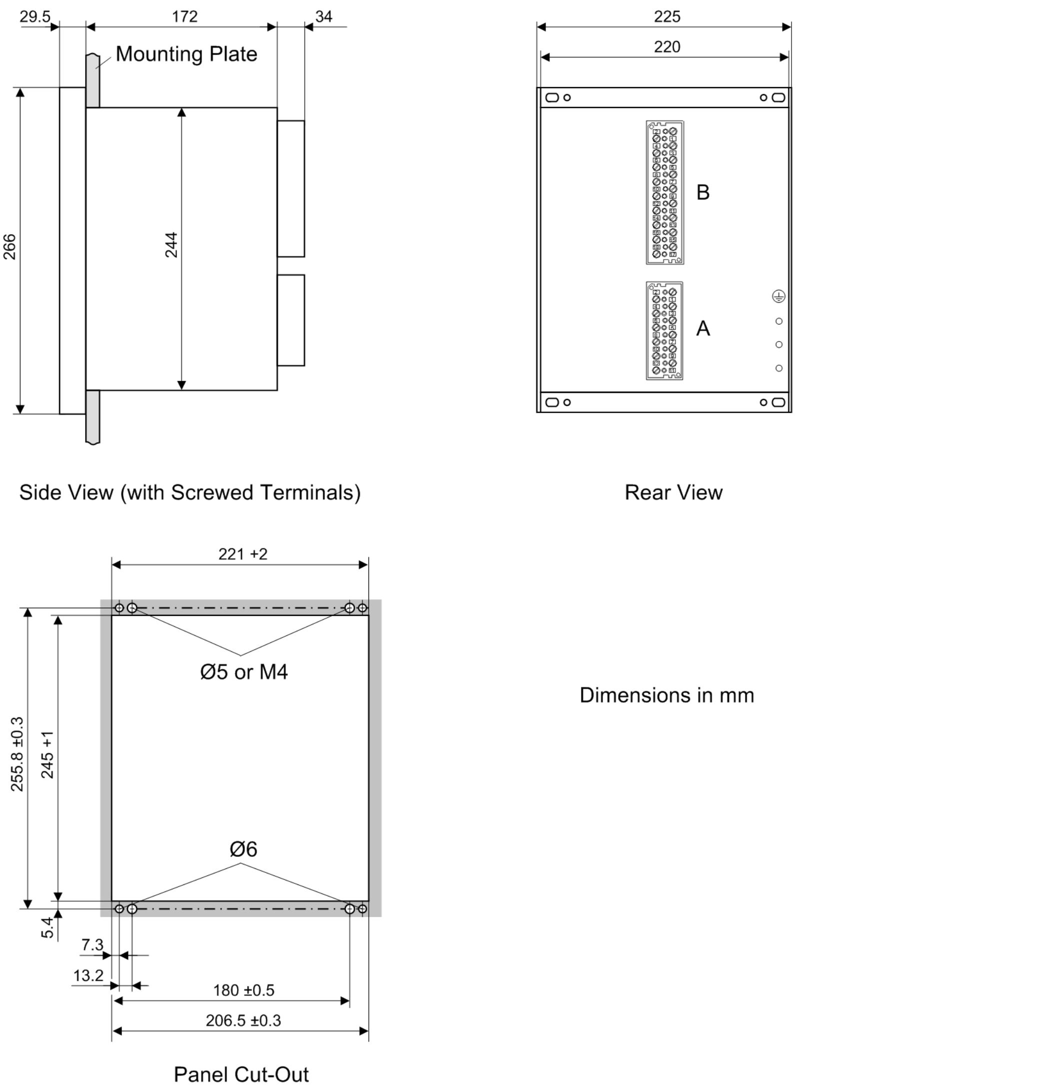


Figure 4-23 Dimensions of Resistor Unit 7XR6004-0CA00 for Panel Flush or Cubicle Mounting

4.39.11 Dimensions of Resistor Unit 7XR6004-0BA00 for Panel Surface Mounting

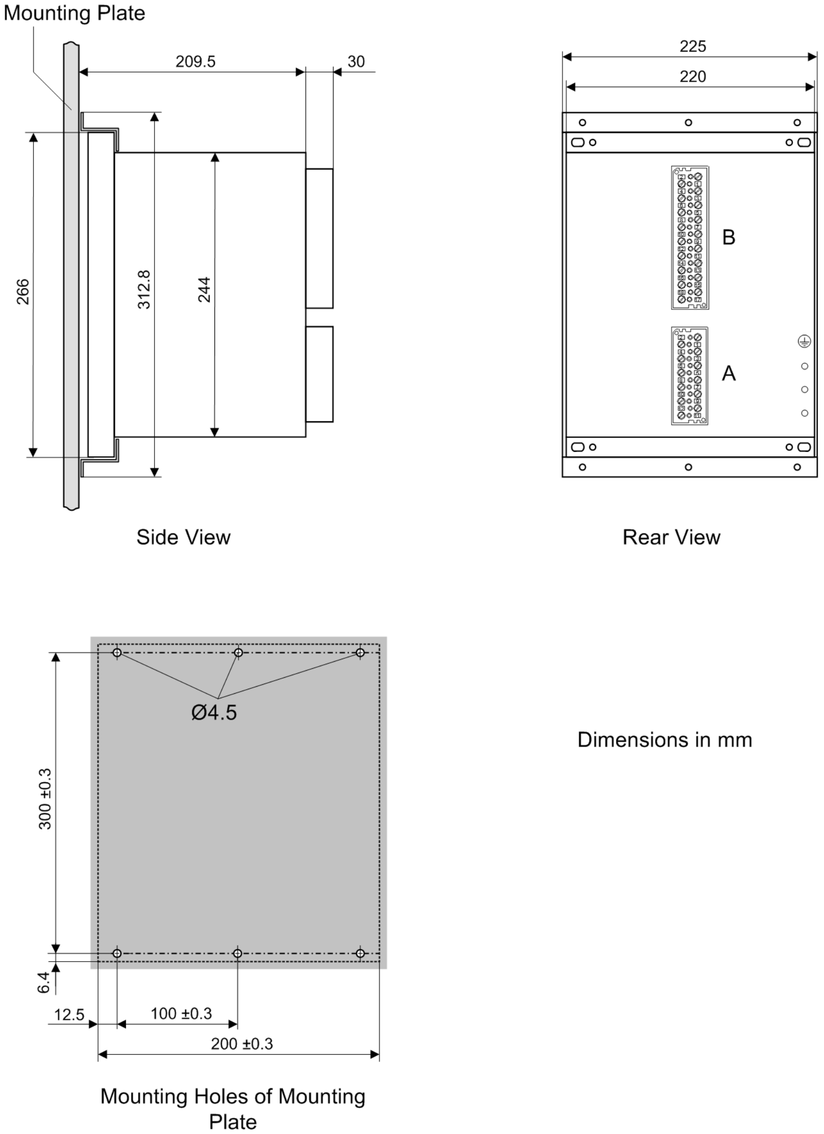


Figure 4-24 Dimensions of Resistor Unit 7XR6004-0BA00 for Panel Surface Mounting

4.39.12 Dimensional Drawing of 20 Hz Generator 7XT3300-0CA00 for Panel Surface Mounting or Cubicle Flush Mounting

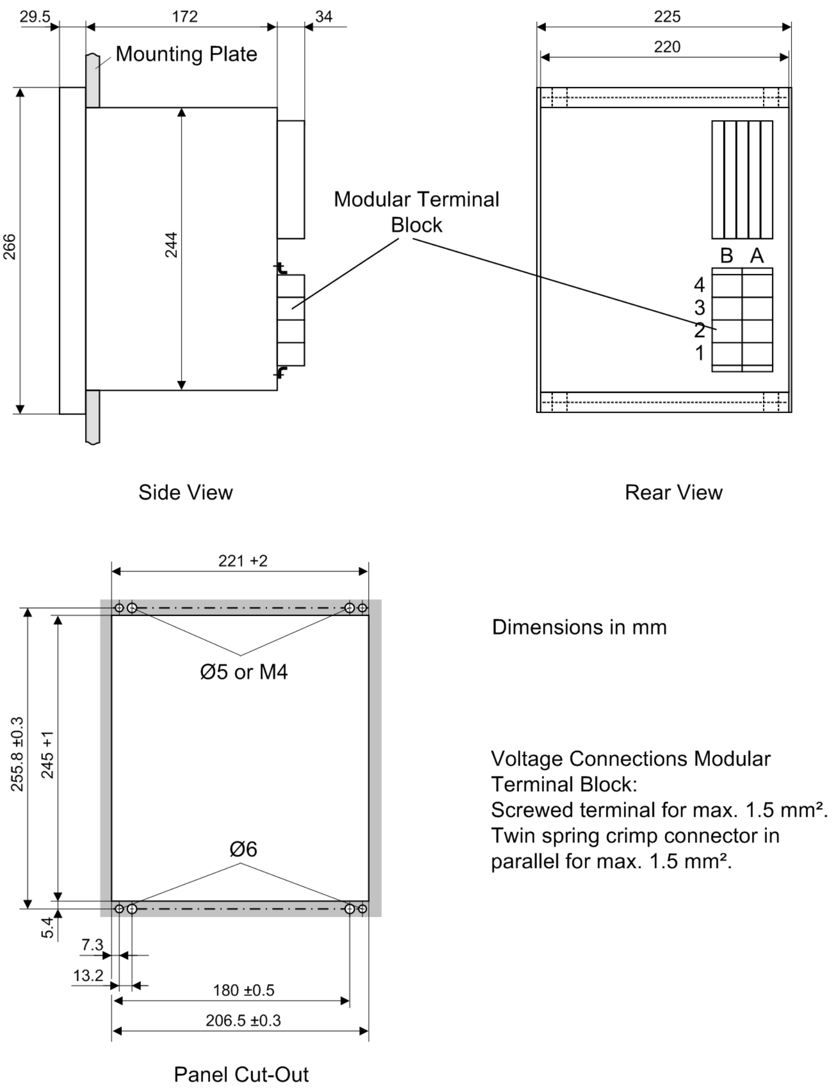


Figure 4-25 Dimensions of 20 Hz Generator 7XT3300-0CA00 for Panel Flash or Cubicle Mounting

4.39.13 Dimensional Drawing of 20 Hz-Generator 7XT3300-0CA00/DD for Panel Surface Mounting oe Cubicle Flush Mounting

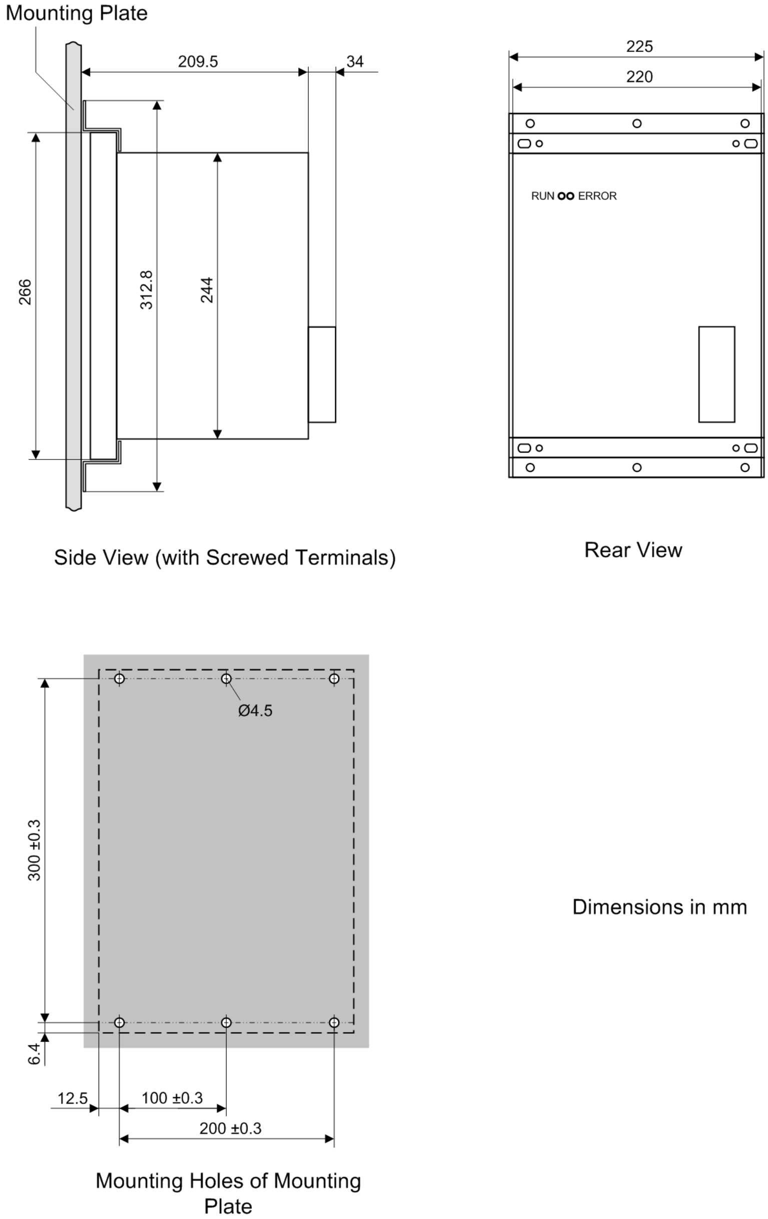


Figure 4-26 Dimensions of a 20-Hz Generator 7XT3300-0CA00/DD for Panel Flush or Cubicle Mounting

4.39.14 Dimensional Drawing of 20 Hz Generator 7XT3300-0BA00 for Panel Surface Mounting

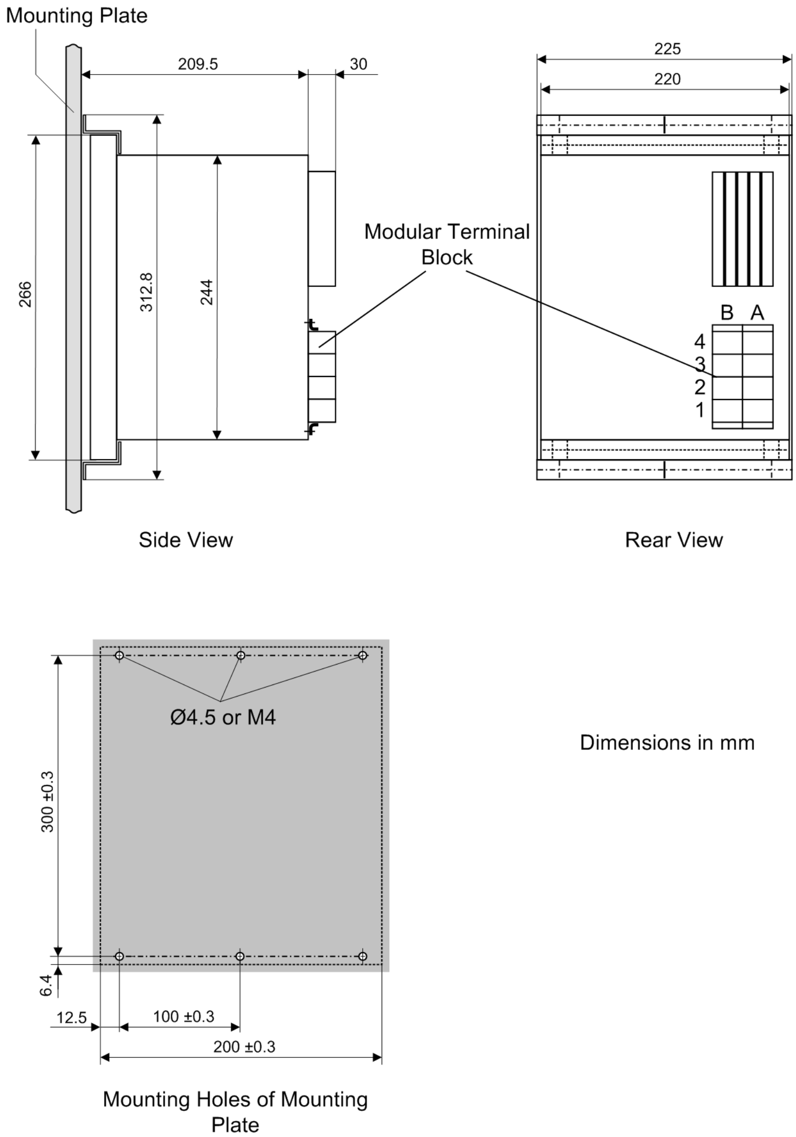


Figure 4-27 Dimensions of 20 Hz Generator 7XT3300-0BA00 for Panel Surface Mounting

4.39.15 Dimensional Drawing of 20 Hz-Generator 7XT3300-0BA00/DD for Panel Surface Mounting

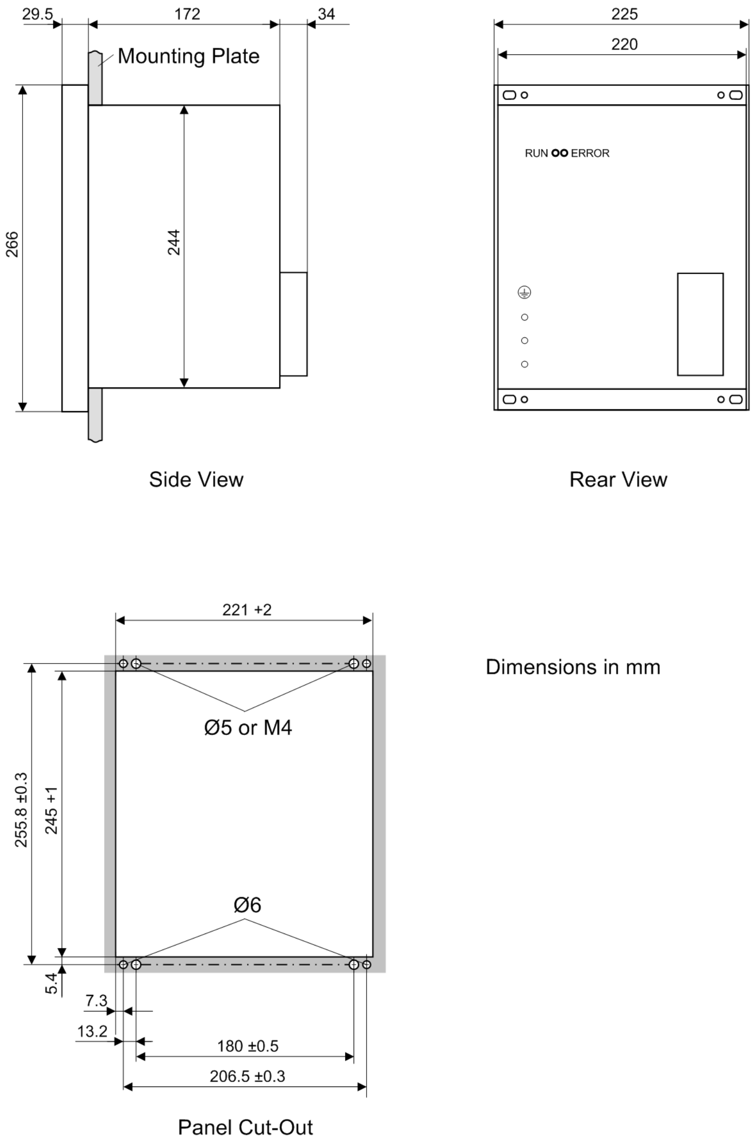


Figure 4-28 Dimensions of a 20-Hz-Generator 7XT3300-0BA00/DD for Panel Surface Mounting

4.39.16 Dimensional Drawing of 20 Hz Bandpass 7XT3400-0CA00 for Panel Surface Mounting or Cubicle Flush Mounting

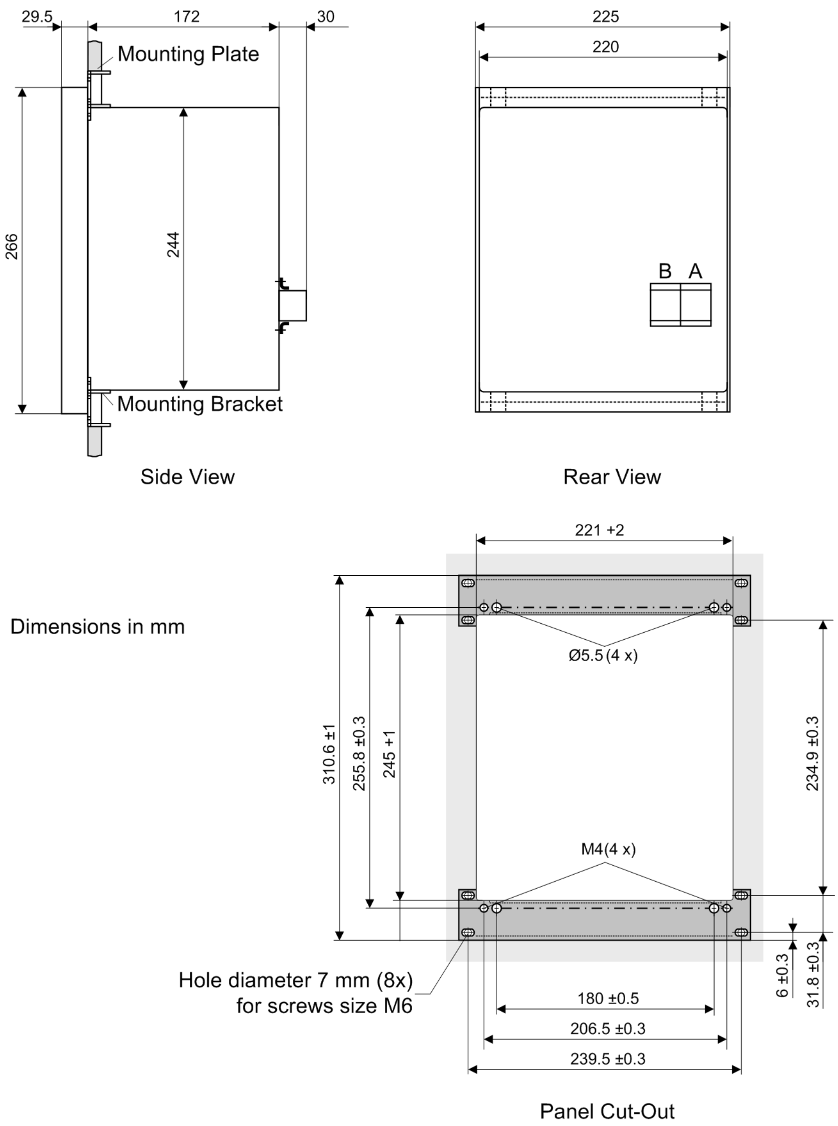


Figure 4-29 Dimensions of 20-Hz-Band-Pass Filter 7XT3400-0CA00 for Panel Flush or Cubicle Mounting

*) For panel flush mounting, 2 set squares C73165- A63-C201-1 are necessary since the mounting rails of the device housing are not sufficient for the high weight of the 7XT34 device.

Fix the set squares to the panel, using screws size M6, according to the drawing.

Mount the 7XT34 device to the set squares using screws size M4 (no hexagon screws).

If the device is mounted in switchgear cabinets, the set squares can be omitted provided the cabinet posesses adequate solid mounting rails.

If not, use 2 set squares C73165-A63-C200-3 (size 28 SEP = 19 inches).

4.39.17 Dimensional Drawing of 20 Hz Bandpass 7XT3400-0BA00 for Panel Surface Mounting

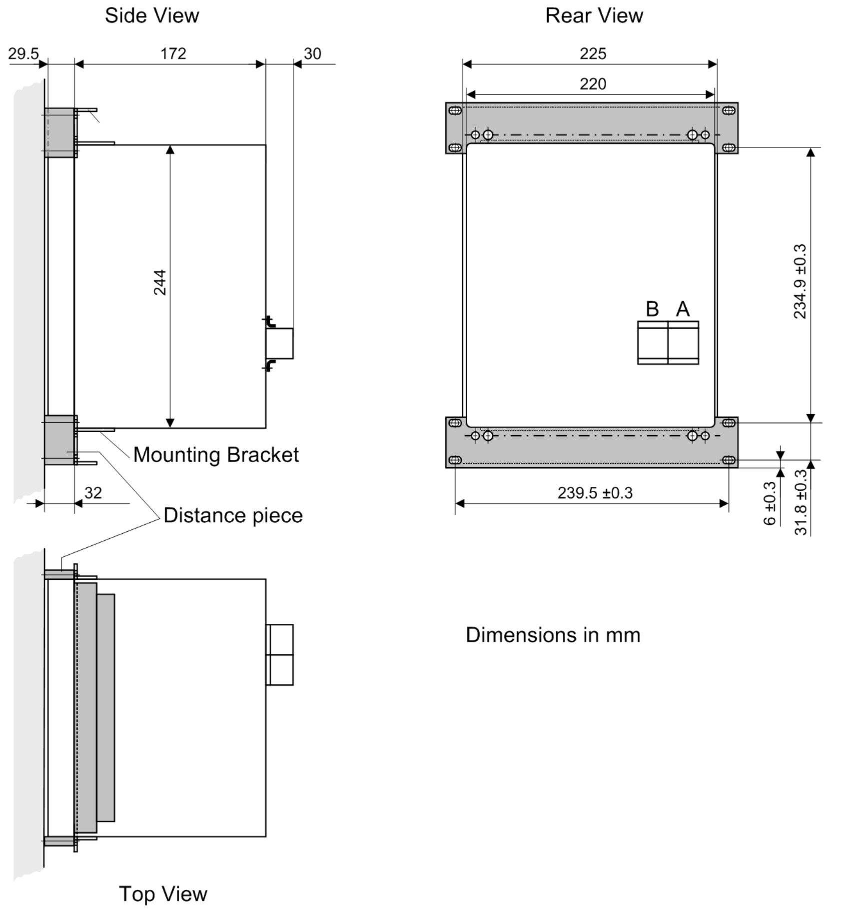


Figure 4-30 Dimensions of 20 Hz Bandpass Filter 7XT3400-0BA00 for Panel Surface Mounting

*) Two set squares C73165-A63-C201-1 and 4 distance pieces C73165-A63-C203-1 are necessary for panel surface mounting.

Fix the set squares to the mounting rails of the device, using screws size M4.

Fit threaded holes size M6, bolts size M6 or appropriately sized dowel holes into the panel, according to the above drawing.

Fasten the 7XT34 device with the fixed set squares to the panel using 6 mm screws, and ensure correct distance by means of the distance pieces.

When using fixed bolts: Fit the distance pieces onto the bolts and fasten the set squares by means of female screws.

■

Appendix A

This appendix is primarily a reference for the experienced user. This section provides ordering information for the models of this device. Connection diagrams for indicating the terminal connections of the models of this device are included. Following the general diagrams are diagrams that show the proper connections of the devices to primary equipment in many typical power system configurations. Tables with all settings and all information available in this device equipped with all options are provided. Default settings are also given.

A.1 Ordering Information and Accessories

A.1.1 Ordering Information

A.1.1.1 Order Key

						6	7		8	9	10	11	12		13	14	15			17	18	19
Multi-Functional Protective Relay with Local Control	**7**	**U**	**M**	**6**	**2**			—						—				**0**	+			

Housing, Number of Binary Inputs and Outputs	Pos. 6
Housing 1/2 19", 7 BI, 12 BO, 1 Live Status Contact	1
Housing 1/1 19", 15 BI, 20 BO, 1 Live Status Contact	2
Graphic Display, Housing 1/2 19", 7 BI, 12 BO, 1 Live Status Contact	3

Rated current	Pos. 7
I_N = 1 A, Iee (sensitive)	1
I_N = 5 A, Iee (sensitive)	5

Auxiliary Voltage (Power Supply, Binary Input Threshold)	Pos. 8
24 to 48 VDC, binary input threshold 19 V [1)]	2
60 to 125 VDC, binary input threshold 19 V [1)]	4
110 to 250 VDC, 115 to 230 VAC, binary input threshold 88 VDC [1)]	5
220 to 250 VDC, 115 to 230 VAC, binary input threshold 176 VDC [1)]	6

Construction	Pos. 9
Surface-mounting case for panel, 2-tier terminals top/bottom	B
Flush mounting case, plug-in terminals (2/3-pole connector)	D
Flush mounting case, screw-type terminals (direct connection / ring and spade lugs)	E

Region-specific Default / Language Settings and Function Versions	Pos. 10
Region DE, 50 Hz, IEC, German Language (Language can be changed)	A
Region World, 50/60 Hz, IEC/ANSI, Language English (Language can be changed)	B
Region US, 60 Hz, ANSI, American English Language (Language can be changed)	C

System Interfaces or Analog Output (Port B)	Pos. 11
No system interface	0
IEC Protocol, electrical RS 232	1
IEC-Protocol, electrical RS 485	2
IEC Protocol, Optical, 820 nm, ST Connector	3
Analog outputs 2 x (0 to 20 mA)	7
for more interface options see Additional Information L	9

[1)] for each binary input the pickup threshold ranges are interchangeable via plug-in jumpers

Additional Information L	Pos. 17	Pos. 18	Pos. 19
(Port B)			
Profibus DP Slave, RS485	L	0	A
Profibus DP Slave, optical 820 nm, double ring, ST connector	L	0	B [1]
Modbus electrical RS485	L	0	D
Modbus, 820 nm, optical, ST connector	L	0	E [1]
DNP3.0, RS485	L	0	G
DNP3.0, 820 nm, optical, ST connector	L	0	H[1]
IEC 61850, electrical with EN100, with RJ45 connector	L	0	R
IEC 61850, optical with EN100, with ST connector	L	0	S [2]

1) Cannot be delivered in connection with 9th digit = „B". If an optical interface is needed, order RS485, plus the necessary converter.

2) Cannot be delivered in connection with 9th digit = „B". Only EN100 electrical possible (see Table A-1)

Optical interfaces are not possible with surface mounting housings. Please order in this case a device with the appropriate electrical RS485 interface, and the additional OLM converters listed in Table A-1.

Table A-1 Additional device/module for surface-mounted housing

Protocol	Converter Module	Order No.	Remark
Profibus DP	SIEMENS OLM[1]	6GK1502-2CB10	For single ring
		6GK1502-3CB10	For double ring
Modbus	RS485/FO	7XV5651-0BA00	–
DNP 3.0 820 nm	RS485/FO		

1) The OLM converter requires an operating voltage of 24 VDC. If the operating voltage is > 24 VDC the additional power supply 7XV5810-0BA00 is required.

Service Interface (Port C)	Pos. 12
DIGSI, Modem RS232	1
DIGSI, Modem/RTD box RS485	2
with analog output interface (port D) see Additional Information M	9

Additional information M	Pos. 17	Pos. 18	Pos. 19
(Port C)			
DIGSI, Modem RS232	M	1	
DIGSI, Modem/RTD box RS485	M	2	
(Port D)	M		
RTD Box [1], optical 820 nm, ST connector [2]	M		A
RTD-Box [1], electrical RS 485	M		F
Analog outputs 2 x (0 to 20 mA)	M		K

1) RTD Box 7XV5662-*AD10

2) If you want to run the RTD-Box at an optical interface, you need also the RS485-FO-converter 7XV5650–0*A00.

Measuring functions	**Pos. 13**
without extended measuring functionality	0
Min/Max Values, Energy Metering	3

Functionality			**Pos. 14**
Generator Basis, comprising:		ANSI No.	A
Overcurrent protection with Undervoltage Seal-In	I> +U<	51	
Overcurrent protection, directed	I>>, dir.	50/51/67	
Inverse Time Overcurrent Protection	t=f(I) +U<	51V	
Overload Protection	I^2t	49	
Unbalanced load protection	I_2>, t=f(I_2)	46	
Differential Protection	ΔI	87G/87M/87T	
Underexcitation protection	1/xd	40	
Reverse Power Protection	–P	32R	
Forward power supervision	P>, P<	32F	
Undervoltage Protection	U<, t=f(U)	27	
Overvoltage Protection	U>	59	
Frequency Protection	f<, f>	81	
Overexcitation protection	U/f	24	
Stator Earth Fault Protection, undirected, directed	U_0>, $3I_0$>, $\angle U_0$, $3I_0$	59N, 64G, 67G	
Sensitive earth fault detection (also as rotor earth fault protection	I_{EE}>	50/51GN,(64R)	
Sensitive earth fault protection I_{EE-B} (as shaft current protection)	I_{EE-B}>, I_{EE-B}<	50/51GN	
Rotor earth fault protection (fn, R measurement)	R_E<	64R (fN)	
Motor startup time supervision	I_{Start}^2t	48	
Breaker Failure Protection	I_{min}>	50BF	
Phase sequence supervision	L1; L2; L3	47	
4 external trip commands	Ext. tr.	—	
Trip Circuit Supervision	TC mon	74TC	
Fuse Failure Monitor	U_2/U_1; I_1/I_2	60FL	
Threshold Supervision			
Restart Inhibit	I^2t	66, 49 Rotor	
Generator Standard, comprising:		ANSI No.	B
Basic Generator and in addition:			
Impedance protection	Z<	21	
Stator Earth Fault Protection with 3rd Harmonic	$U_{0\ (3rd\ harm.)}$	59TN 27TN3.H	
Interturn Fault Protection	$U_{Interturn}$>	64S (Interturn)	
Inadvertent Energizing Protection	I>, U<	50/27	
Generator Full, comprising:		ANSI No.	C
Standard Generator and in addition:			
Out-of-Step Protection	$\Delta Z/\Delta t$	78	
DC Voltage/DC Current Protection	Udc>/Idc>	59N (DC)/51N (DC)	
Startup overcurrent protection	I>	51	
Earth current differential protection	ΔI_0	87N	

Functionality		**Pos. 14**
Asynchronous Motor, comprising:	ANSI No.	F
Basic Generator but without underexcitation protection, overexcitation protection and rotor earth fault protection (fn, R measurement)		
Transformer, comprising:	ANSI No.	H
Basic generator but without underexcitation protection, unbalanced load protection, motor starting time supervision and rotor earth fault protection (fn, R measurement)		

Functionality/Additional Functions	ANSI No.	Pos. 15
Without		A
Sensitive Rotor Earth Fault Protection with square-wave voltage injection of 1-3 Hz, Re<80 kΩ and 100% Stator Earth Fault Protection with principle of 20 Hz voltage injection	64R (1 Hz to 3 Hz) 64G (100 %)	B
Earth current differential protection	87N	C
Network Decoupling (df/dt and vector jump)	81R	E
all additional functions		G

Sample order:
7UM6211-4EA99-0BA0 + L0A + M1K
here: Pos. 11 = 9 stands for L0A, i.e. version with Profibus DP Slave system port on the rear, RS485
here: Pos. 12 = 9 stands for M1K, i.e. version with rear service port DIGSI, modem RS232 and
Analog outputs 2 x (0 to 20 mA)

A.1.2 Accessories

Replacement modules for interfaces

Name	Order No.
RS232	C73207-A351-D641-1
RS 485	C73207-A351-D642-1
FO 820 nm	C73207-A351-D643-1
Profibus DP RS485	C53207-A351-D611-1
Profibus DP double ring	C53207-A351-D613-1
Modbus RS 485	C53207-A351-D621-1
Modbus opt. 820 nm	C53207-A351-D623-1
DNP3.0 RS485	C53207-A351-D631-3
DNP3.0 820 nm	C53207-A351-D633-3
Ethernet electrical (EN 100)	C53207-A351-D675-1
Ethernet optical (EN 100)	C53207-A322-B150-1
Analog output AN20	C53207-A351-D661-1

Cover caps

Covering cap for terminal block type	Order No.
18-pole voltage terminal, 12-pole current terminal	C73334-A1-C31-1
12-pole voltage terminal, 8-pole current terminal	C73334-A1-C32-1

Short-circuit links

Short circuit jumpers for terminal type	Order No.
Voltage terminal, 18-pole terminal, or 12-pole terminal	C73334-A1-C34-1
Current terminal,12-pole terminal, or 8-pole terminal	C73334-A1-C33-1

Socket housing

Socket housing	Order No.
2-pole	C73334-A1-C35-1
3-pole	C73334-A1-C36-1

Mounting Brackets for 19" Racks

Name	Order No.
2 mounting brackets	C73165-A63-C200-1

Battery

Lithium Battery 3 V/1 Ah, Type CR 1/2 AA	Order No.
VARTA	6127 101 501

Coupling unit

Coupling unit for rotor earth fault protection (R, f_N)	Order No.
Coupling device for panel surface mounting	7XR6100-0CA00
Coupling device for panel flush mounting	7XR6100-0BA00

Series Resistor

Series resistor for rotor earth fault protection (R, f_N)	Order No.
Series resistor (2 x 105 Ω)	3PP1336-0DZ-K2Y

Voltage divider

Voltage divider	Order No.
Voltage divider 5:1; 5:2	3PP1336-1CZ-K2Y
Voltage divider 10:1; 20:1	3PP1326-0BZ-K2Y

Series device

Series device for rotor earth fault protection (1-3 Hz)	Order No.
Surface-mounted housing with terminals at both sides	7XT7100-0BA00
In housing with rear terminals	7XT7100-0EA00

Resistor Unit

Resistor device for rotor earth fault protection (1-3 Hz)	Order No.
Surface-mounted housing with screw terminals	7XR6004-0BA00
In housing with screw terminals	7XR6004-0CA00

20 Hz Generator

20 Hz Generator	Order No.
Surface-mounted housing with screw terminals	7XT3300-0BA00
In housing with screw terminals	7XT3300-0CA00

20 Hz Bandpass Filter

20 Hz Bandpass Filter	Order No.
Surface-mounted housing with screw terminals	7XT3400-0BA00
In housing with screw terminals	7XT3400-0CA00

Interface Cable

Interface cable between PC and SIPROTEC device	Order Number
Cable with 9-pole male / female connector	7XV5100-4

A.2 Terminal Assignments

A.2.1 Panel Flush Mounting or Cubicle Mounting

7UM621/623*-*D/E

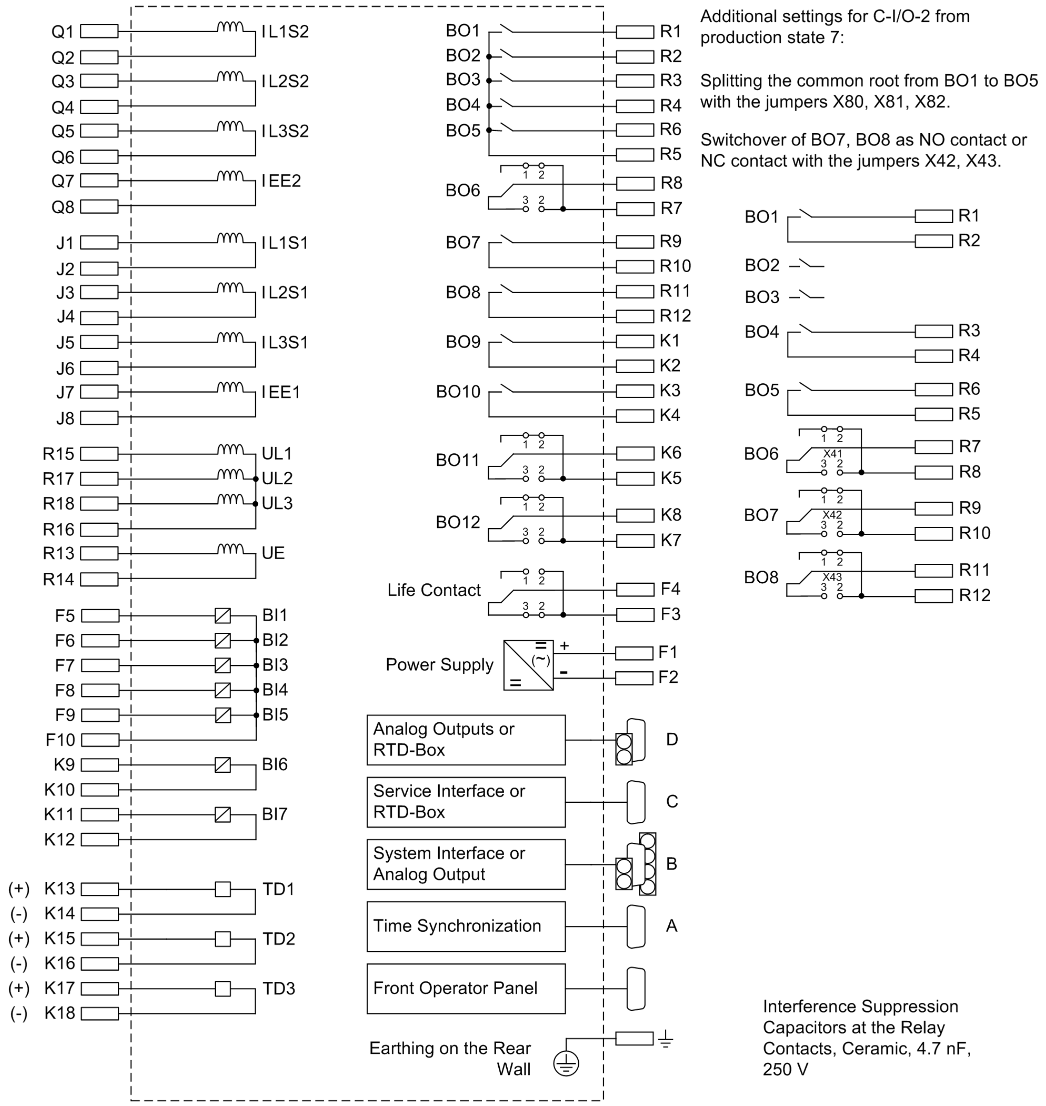


Figure A-1 General Diagram for 7UM621/623*-*D/E (panel flush mounting or cubicle mounting)

7UM622*-*D/E

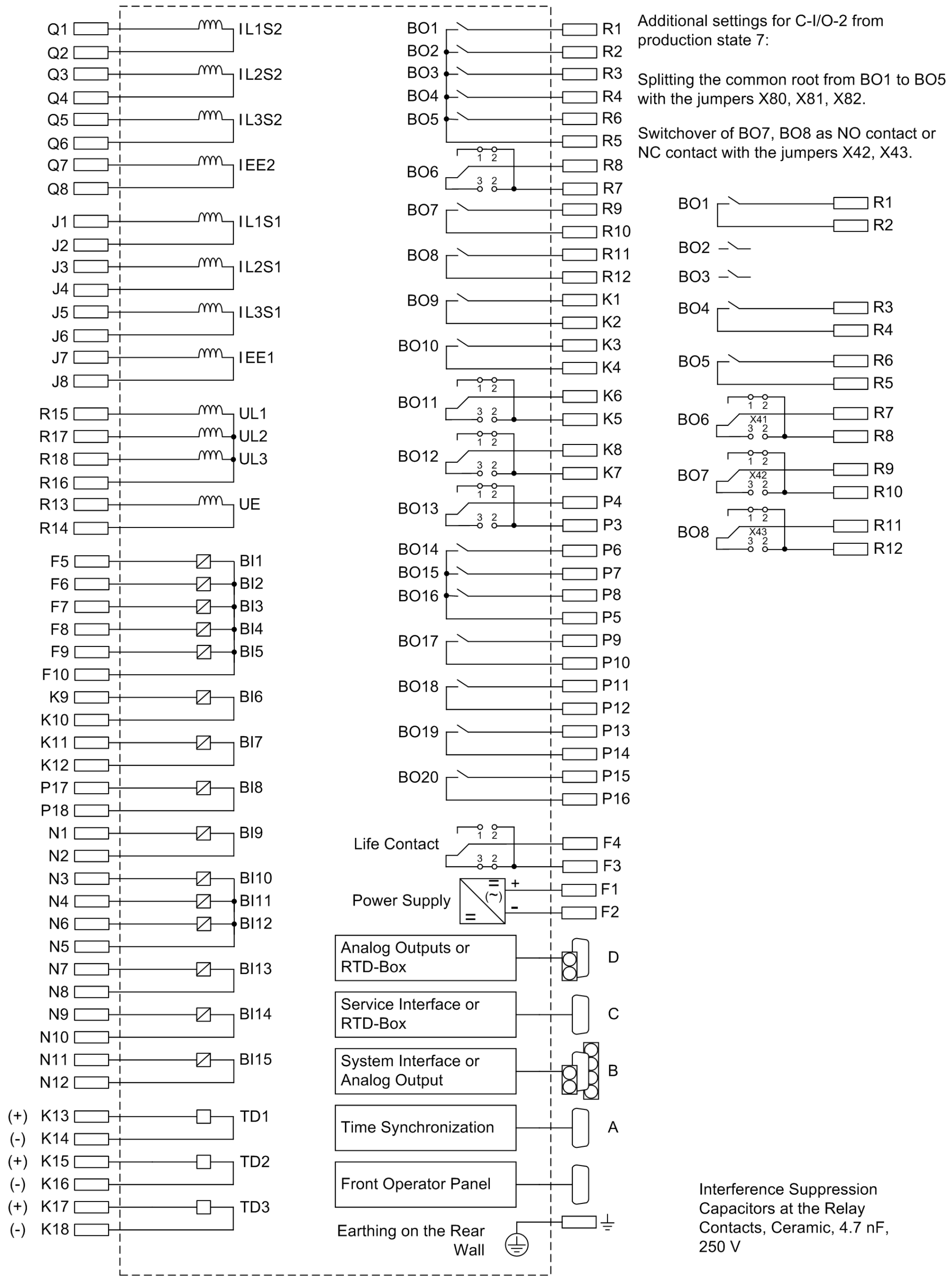


Figure A-2 General Diagram for 7UM622*–*D/E (panel flush mounting or cubicle mounting)

A.2.2 Panel Surface Mounting

7UM621/623*-*B

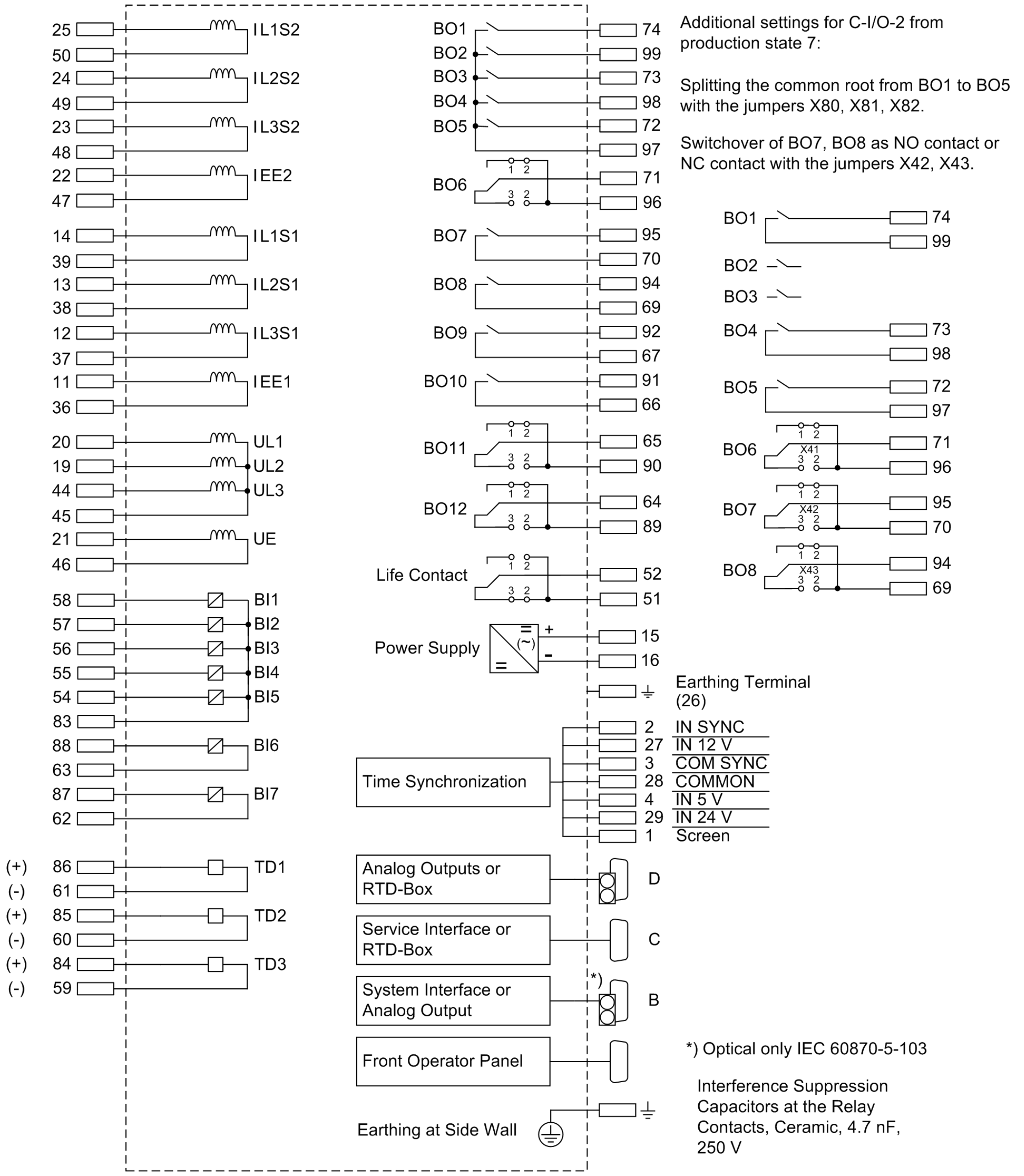


Figure A-3 General Diagram for 7UM621/623*-*B (panel surface mounting)

7UM622*-*B

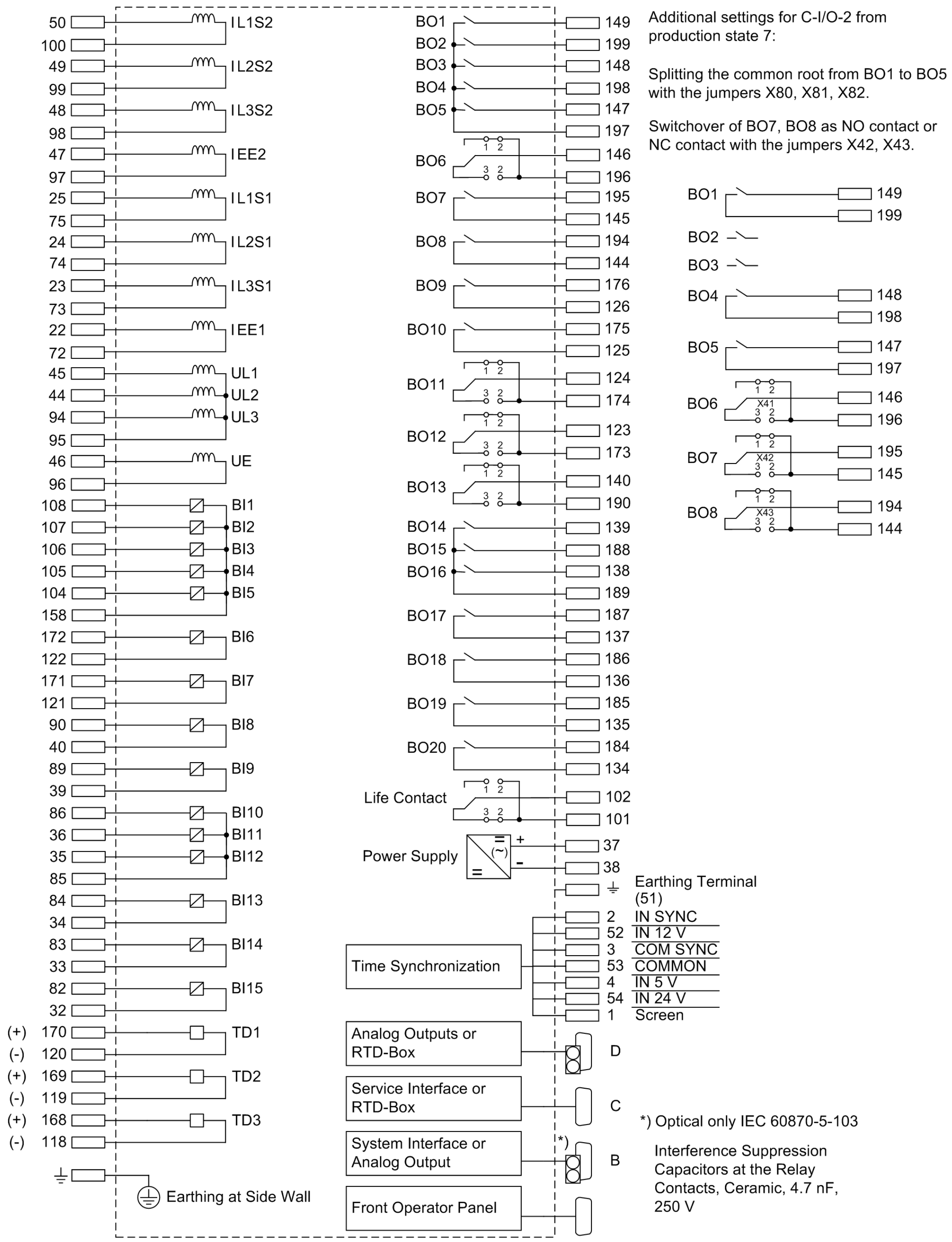


Figure A-4 General Diagram for 7UM622*-*B (panel surface mounting)

A.3 Connection Examples

A.3.1 7UM62 - Connection Examples

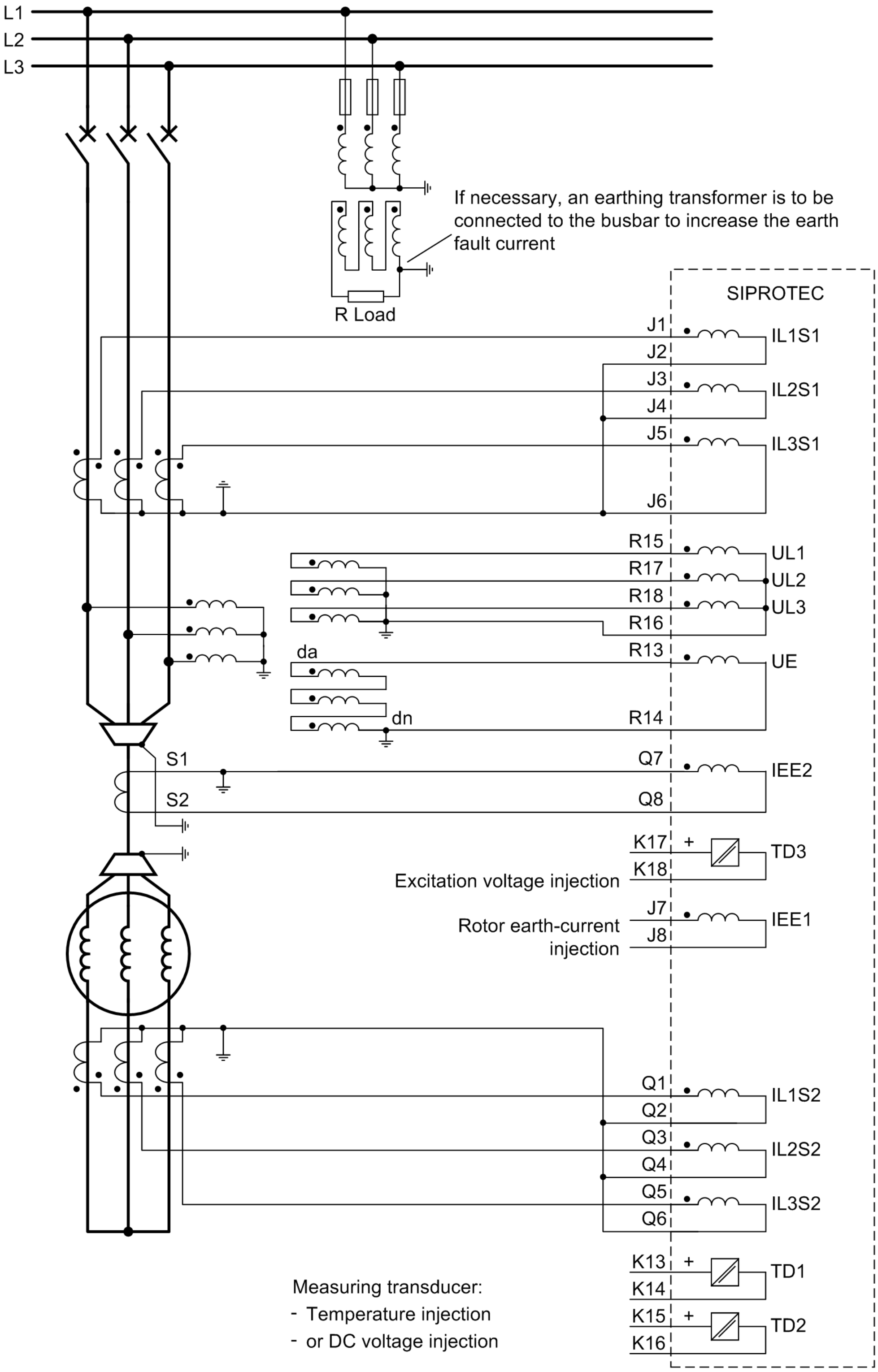


Figure A-5 **Busbar Connection**
Current and voltage connections to three transformers (phase-to-ground voltages), and in each case three CTs, earth current from an additional summation current transformer for sensitive earth fault detection; detection of displacement voltage at broken delta winding (da–dn).

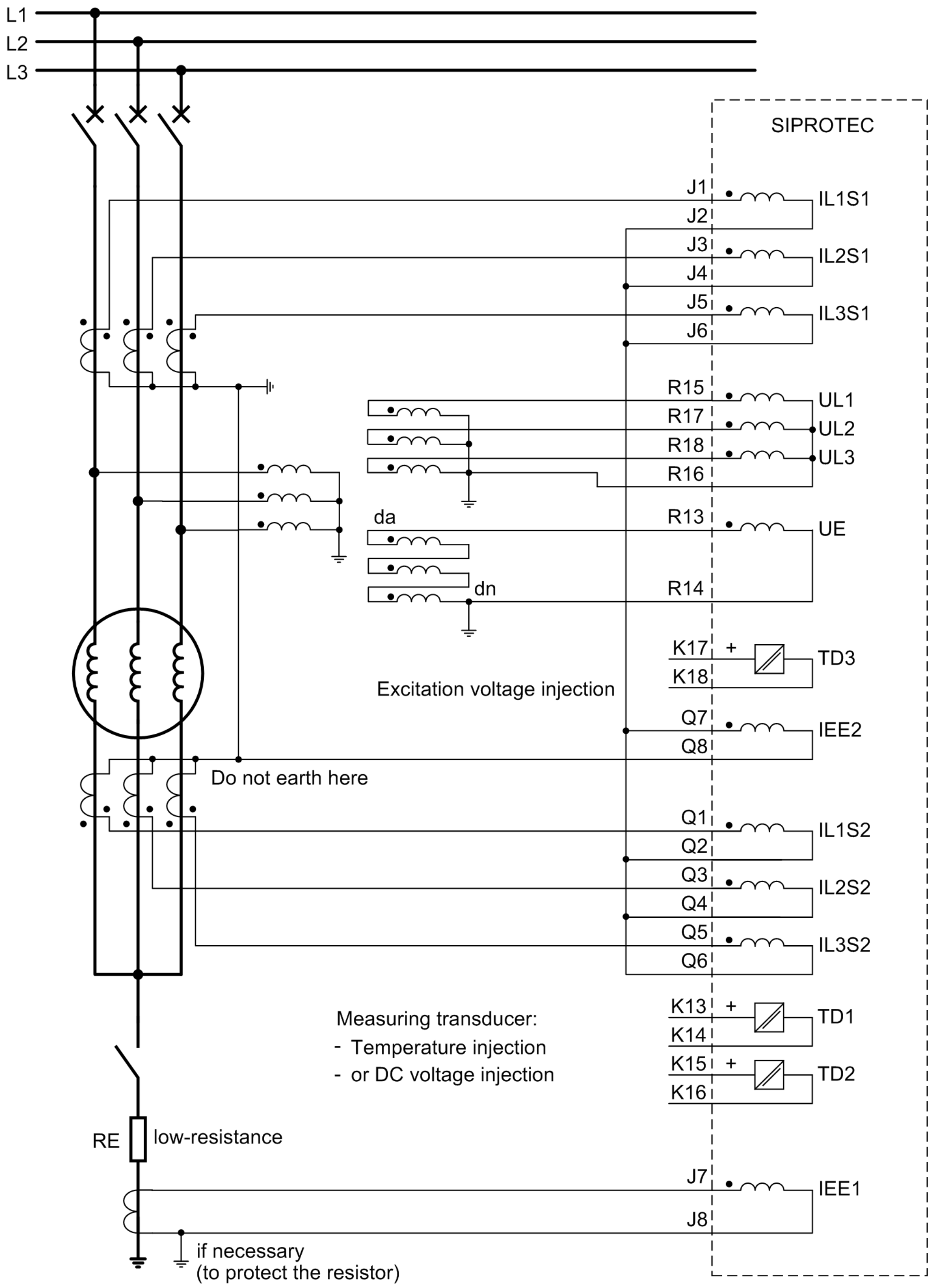


Figure A-6 **Busbar System with Low-resistance Earthing**
Transformer connections to three voltage transformers (phase-to-earth voltages) and in each case three CTs - earth fault detection as differential current measuring by two CT sets; detection of displacement voltage at broken delta winding (da–dn) as additional criterion.

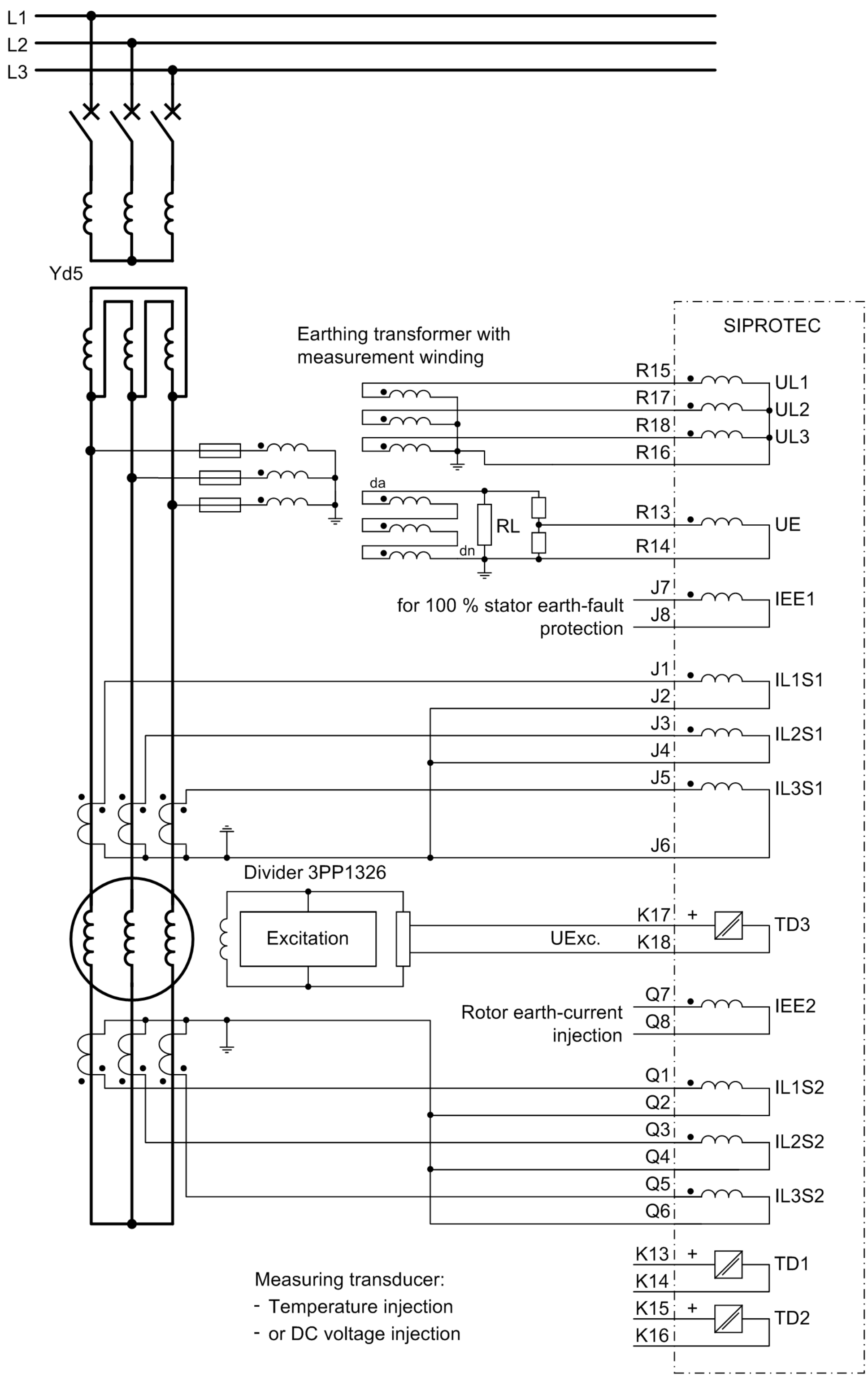


Figure A-7 **Unit Connection with Isolated Starpoint**
Transformer connections to three voltage transformers (phase-to-earth voltages) and in each case three current transformers, differential protection function used only for the generator; Detection of displacement voltage at a broken delta winding (da–dn).

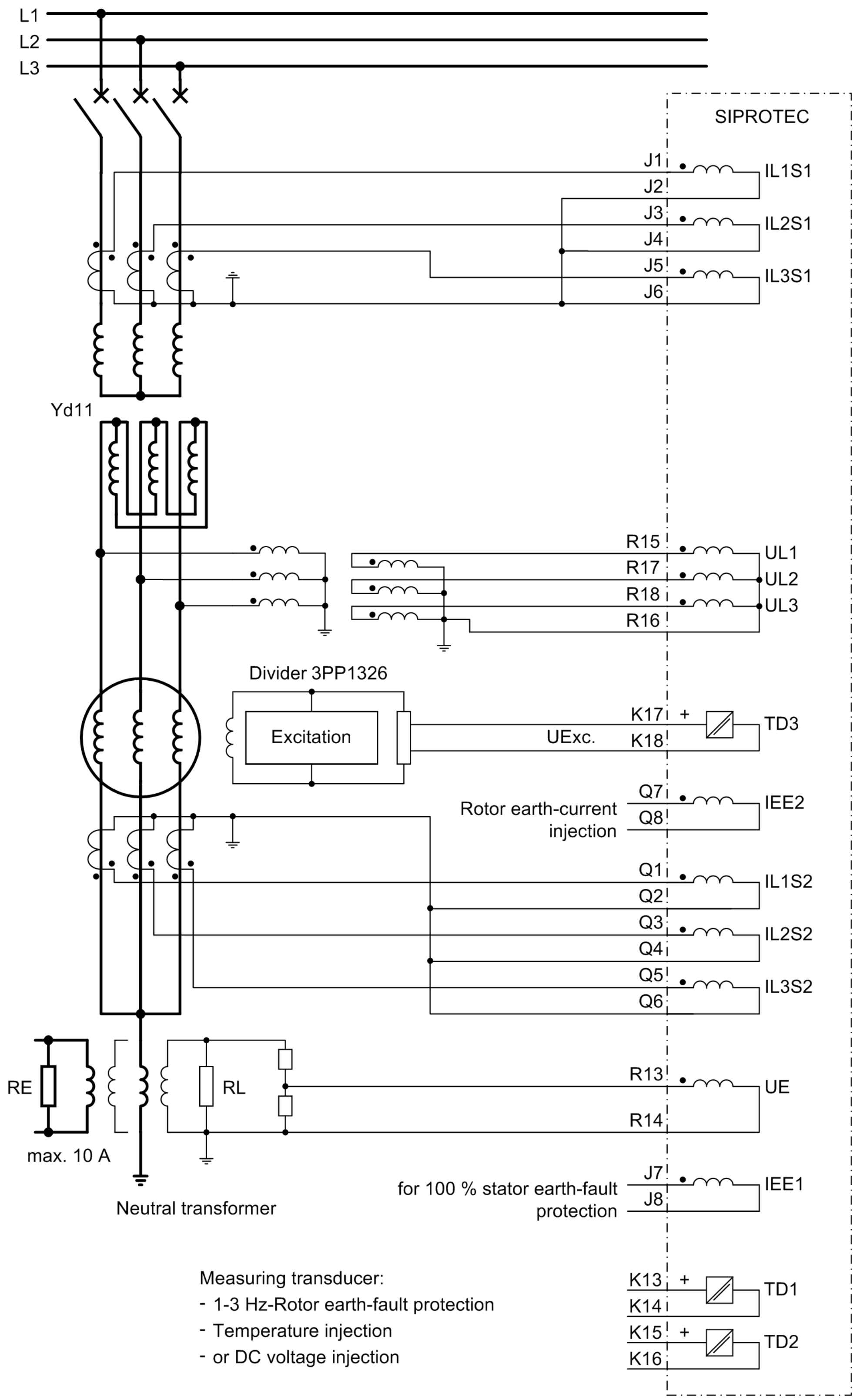


Figure A-8 **Unit Connection with Neutral Transformer**
Connections to three voltage transformers (phase-to-earth voltages) and in each case three current transformers, differential protection function connected via generator and unit transformer;
Loading resistor connected either directly to starpoint circuit or via matching transformers.

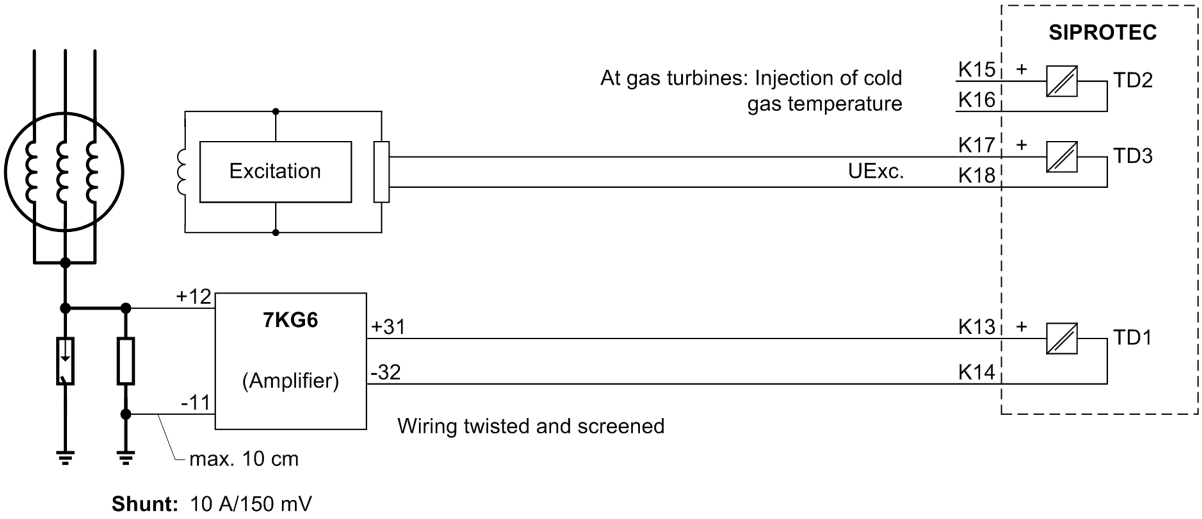


Figure A-9 **Startup Earth Fault Protection**
Connection of DC Voltage Input TD1 with Series-Connected Amplifier 7KG6 for Systems with Startup Converter

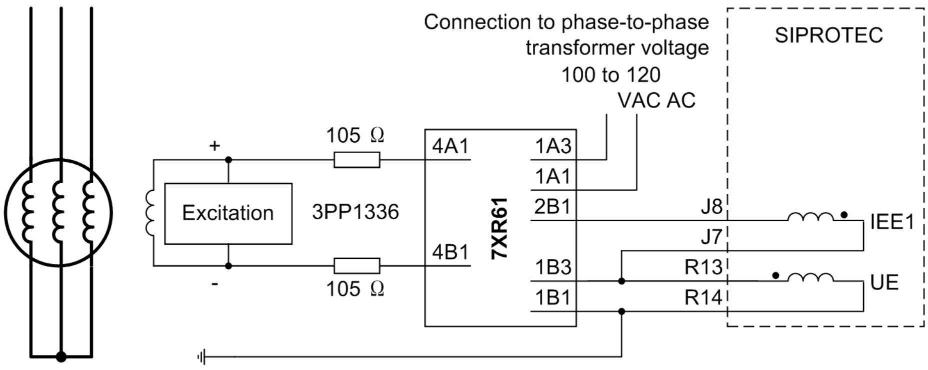


Figure A-10 **Rotor Earth Fault Protection**
with additional unit 7XR61 for injecting nominal-frequency voltage in the rotor circuit using series resistor 3PP1336

Note 3PP13 is only necessary if more than 0.2 A_{eff} are flowing permanently; (rule: UExc. load > 150 V).
In this case the internal resistors of the 7XR61series device are to be shorted.

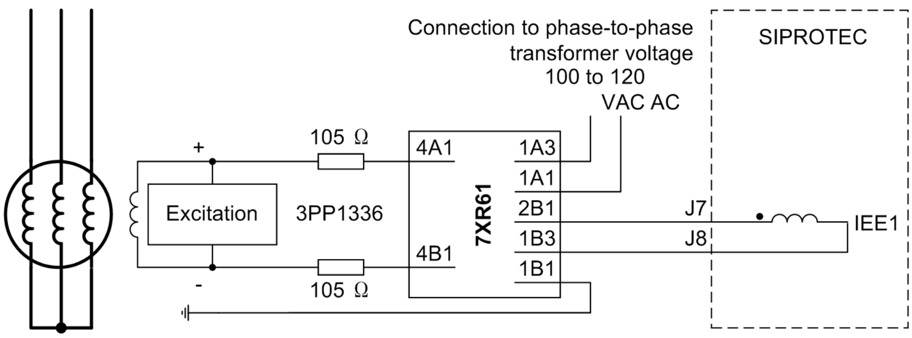


Figure A-11 **Rotor Earth Fault Protection**
with series device 7XR61 for injection of a rated-frequency voltage into the rotor circuit if the sensitive earth current input is used.

Note 3PP13 is only necessary if more than 0.2 A_{eff} are flowing permanently; (rule: UExc. load > 150 V).
In this case the internal resistors of the 7XR61series device are to be shorted.

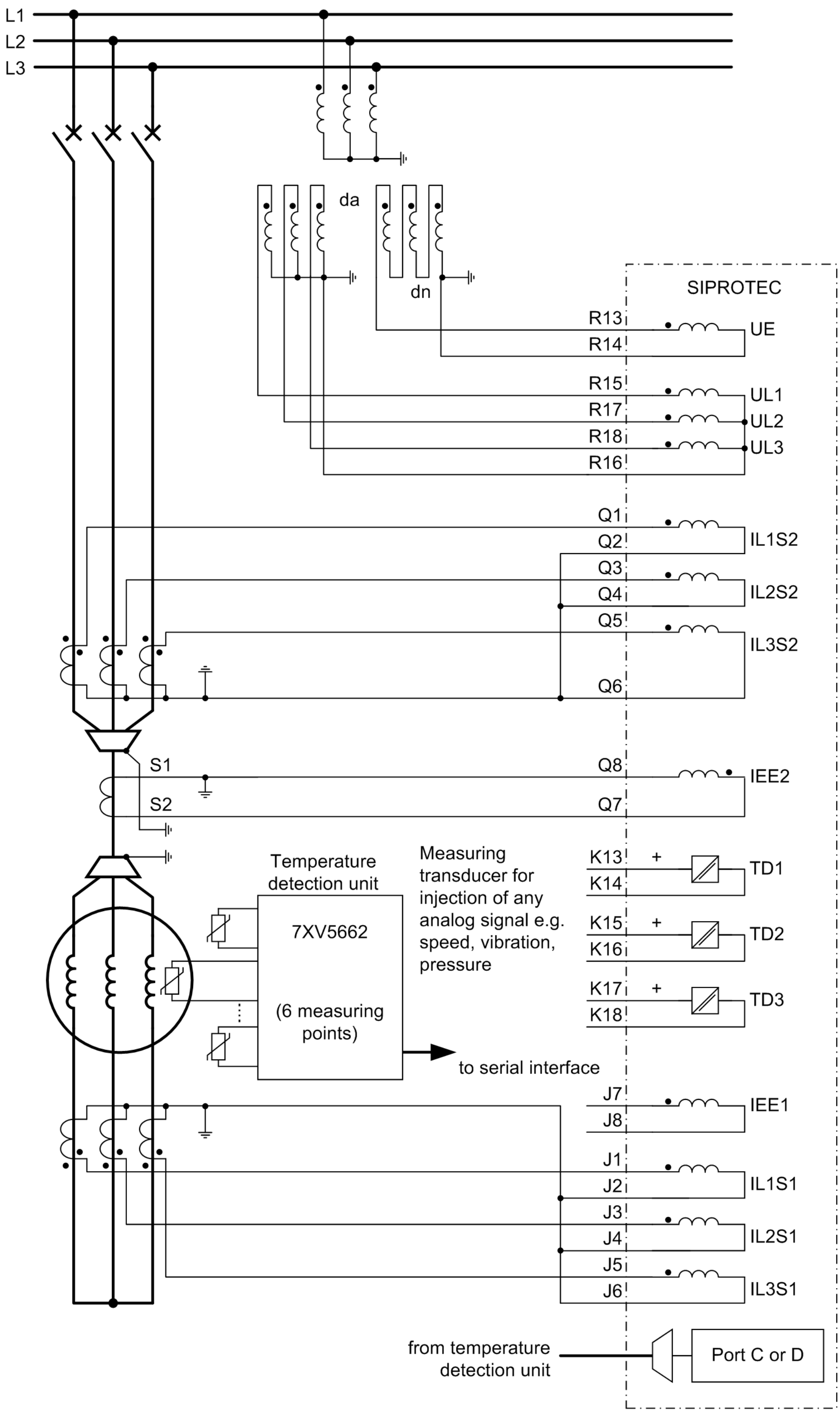


Figure A-12 **Asynchronous Motor**
Connection to three voltage transformers (phase-to-earth voltages, usually from the busbar);
Displacement voltage detection at broken delta winding, and three current transformers on each side;
Earth fault direction detection using toroidal CT(s)

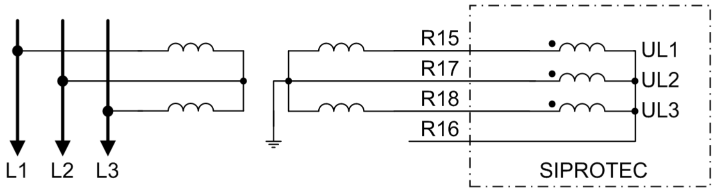


Figure A-13 Voltage Transformer Connections for Two Voltage Transformers in Open Delta Connection (V Connection)

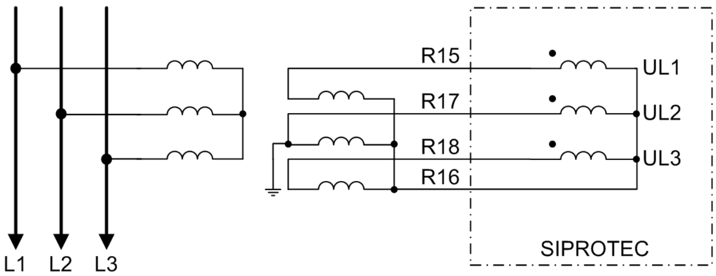


Figure A-14 Voltage Transformer Connection with L2 Earthed on the Secondary Side

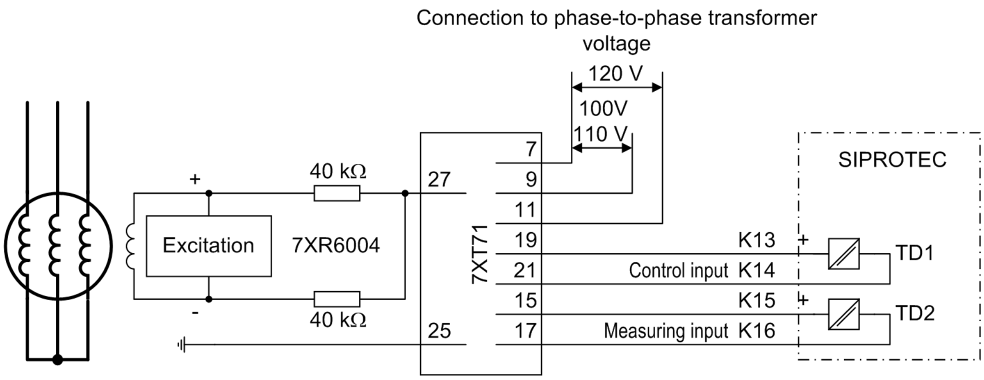


Figure A-15 **Rotor Earth Fault Protection 1-3 Hz** – with 1- 3-Hz-Generator 7XT71 and resistor device 7XR6004.

Note For further examples see manual 7XR6004

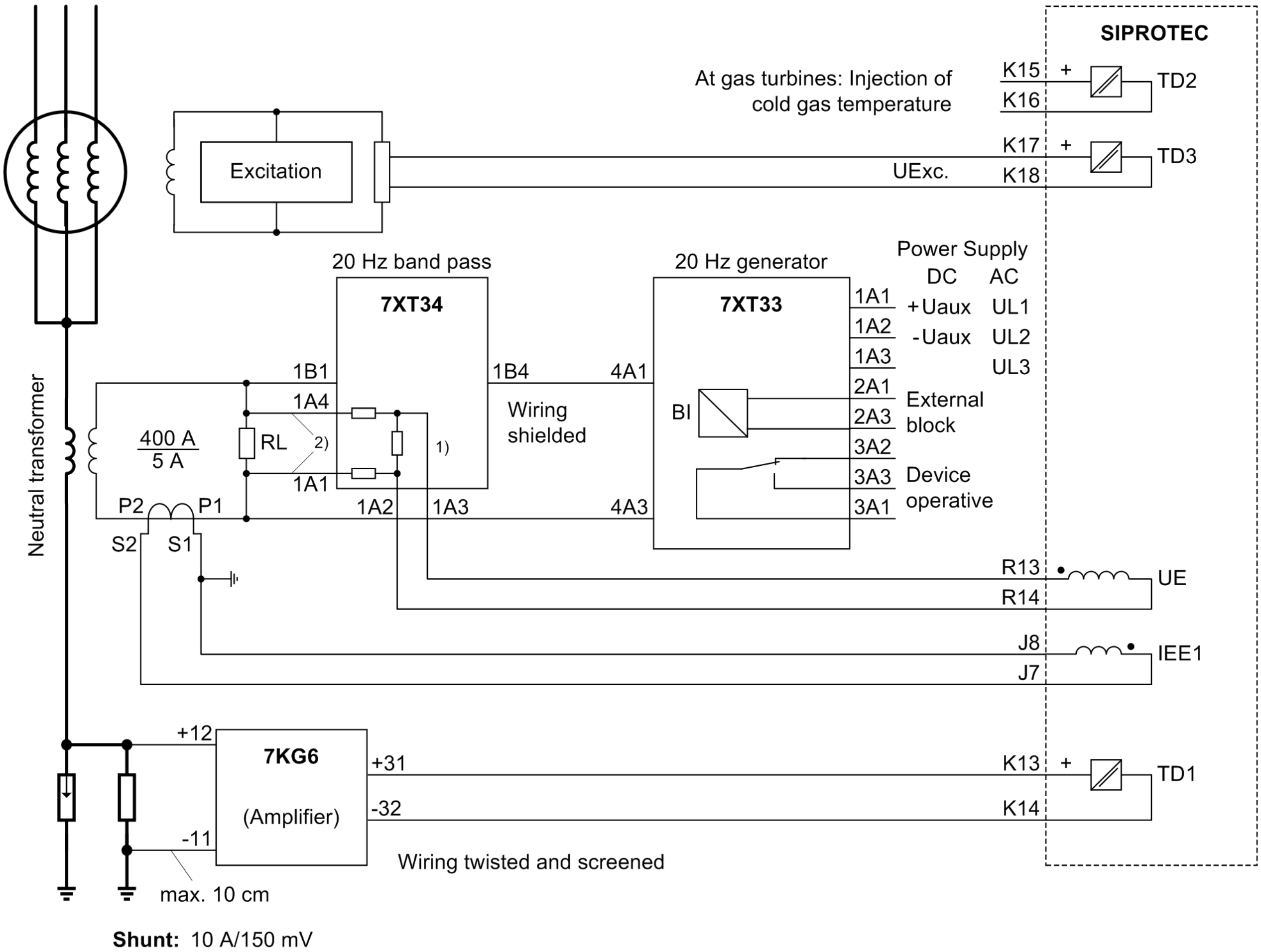


Figure A-16 **100 % Stator Earth Fault Protection**
with 20 Hz generator 7XT33, bandpass 7XT34 and startup earth fault protection –
with shunt 10 A/150 mV and measuring transducer 7KG6.

1) The voltage divider is only requred for secondary-side voltages > 200 V.

2) The voltage divider must be connected directly to the load resistor R_L via two lines.

The connection designations for 7XT3300–0*A00/DD are given in Appendix A.3, Figure A-29.

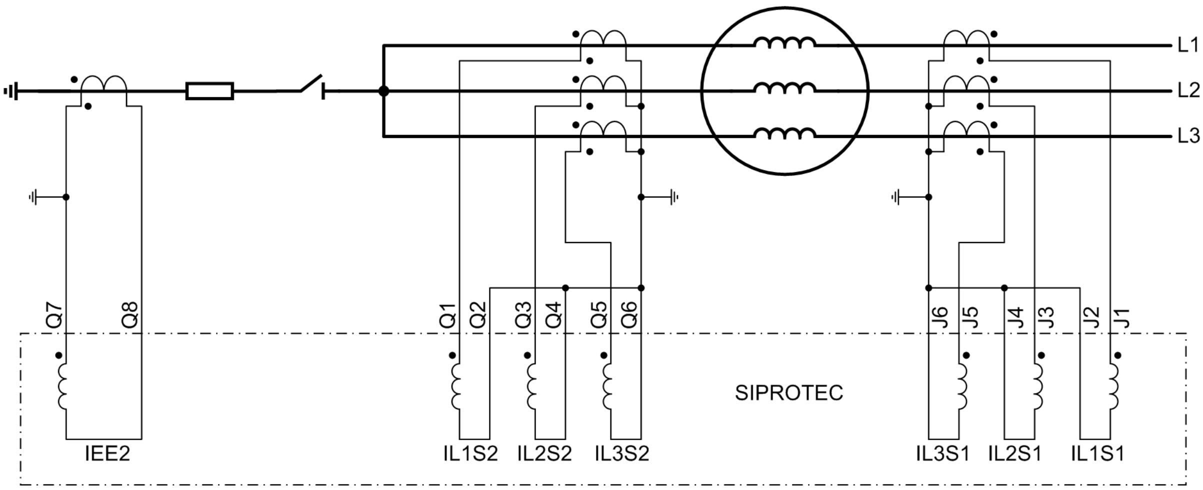


Figure A-17 Earth Current Differential Protection (Generator)

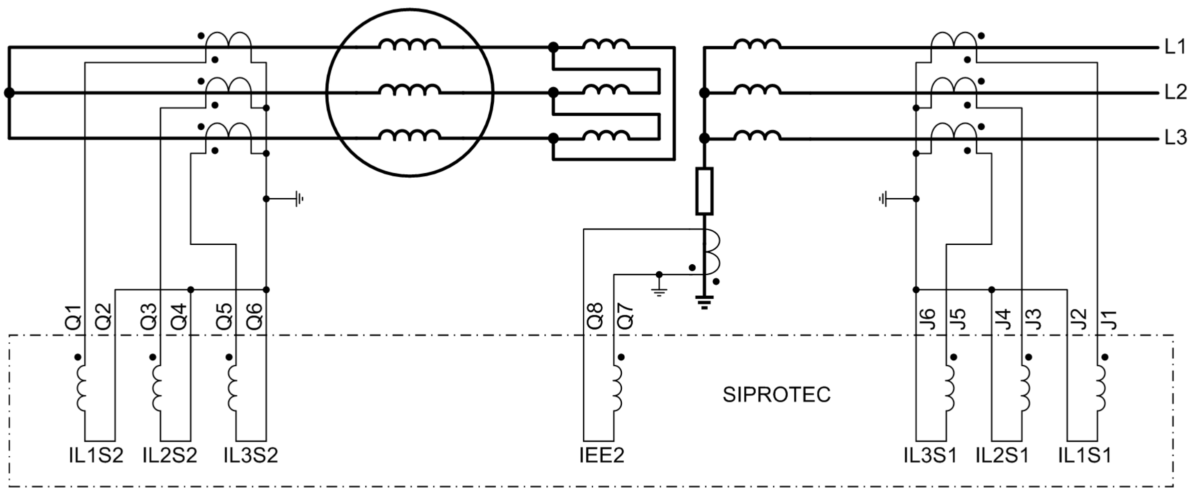


Figure A-18 Earth Current Differential Protection (Transformer)

A.3.2 Connection Examples for RTD Box

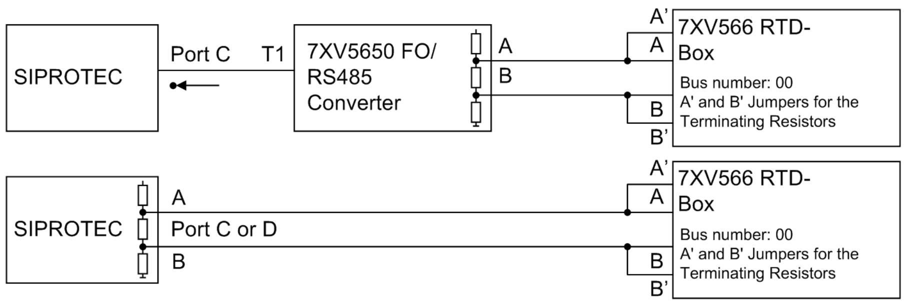


Figure A-19 Simplex Operation with one RTD Box

above: optical design (1 FOs)

below: design with RS485

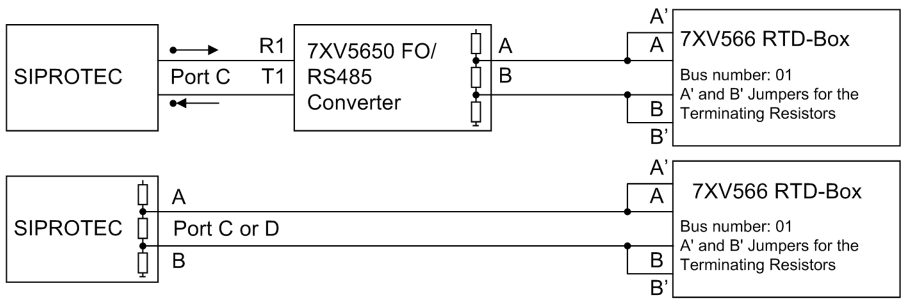


Figure A-20 Semiduplex Operation with one RTD Box

above: optical design (2 FOs)

below: design with RS485

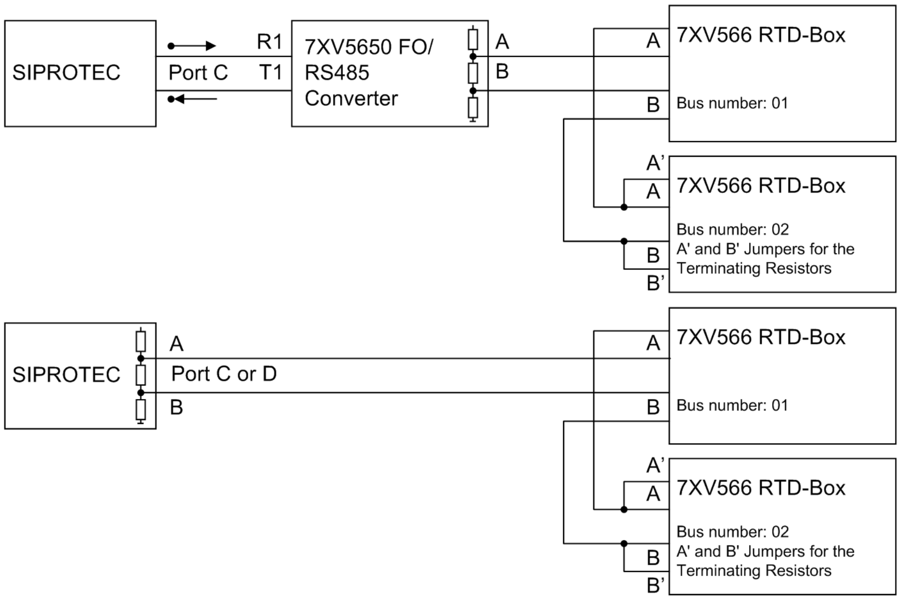


Figure A-21 Semiduplex Operation with two RTD Boxes
above: optical design (2 FOs)
below: design with RS485

A.3.3 Schematic Diagram of Accessories

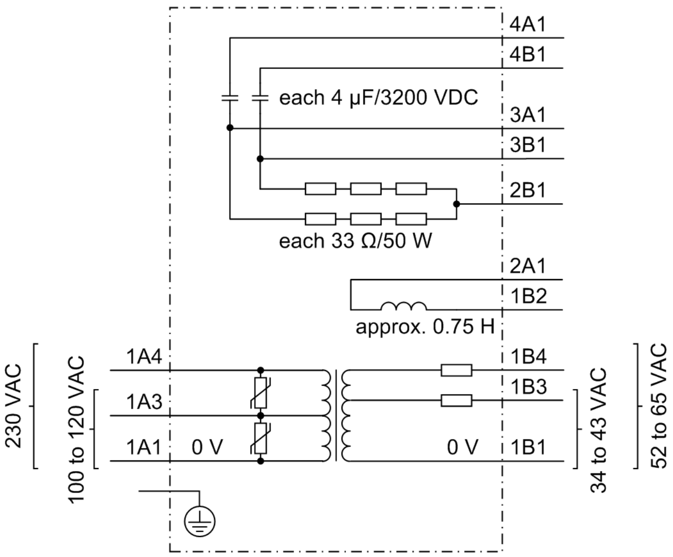


Figure A-22 Schematic Diagram of Coupling Unit 7XR6100-0*A00 for Rotor Earth Fault Protection

Figure A-23 Schematic Diagram of Series Resistor 3PP1336-0DZ-K2Y

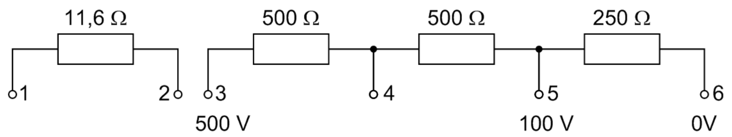


Figure A-24 Schematic Diagram of Voltage Divider 5:1; 5:2; 3PP1336-1CZ-K2Y

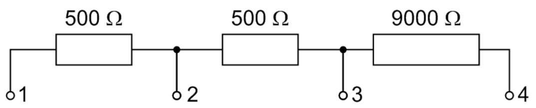


Figure A-25 Schematic Diagram of Voltage Divider 10:1; 20:1; 3PP1326-0BZ-K2Y

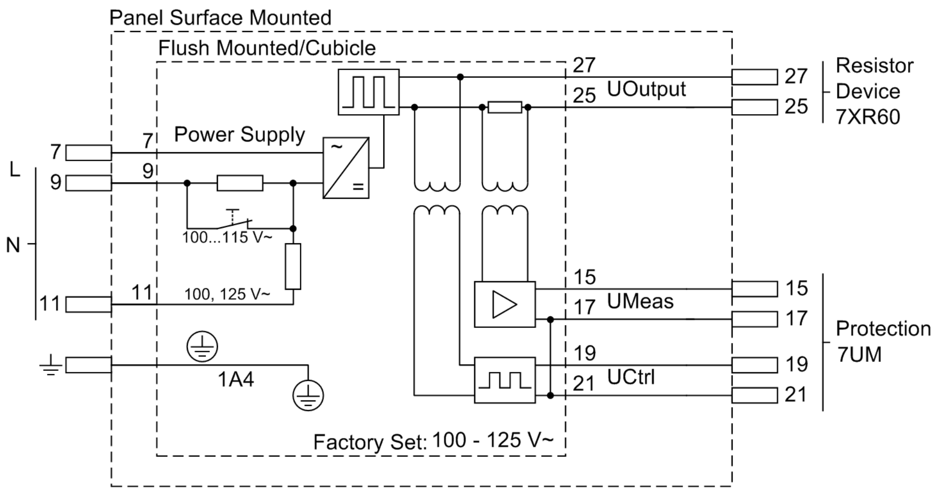


Figure A-26 General Diagram of Series Device 7XT7100-0*A00

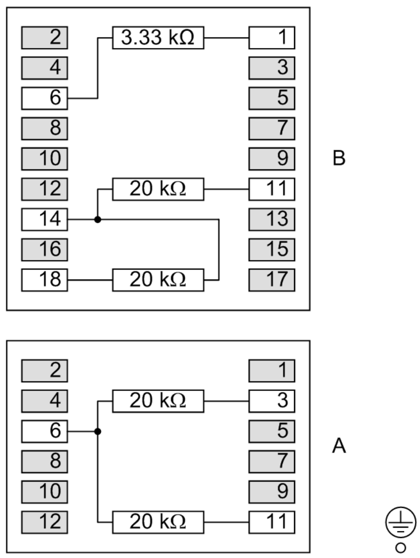


Figure A-27 General Diagram of Resistor Unit 7XR6004-0*A00

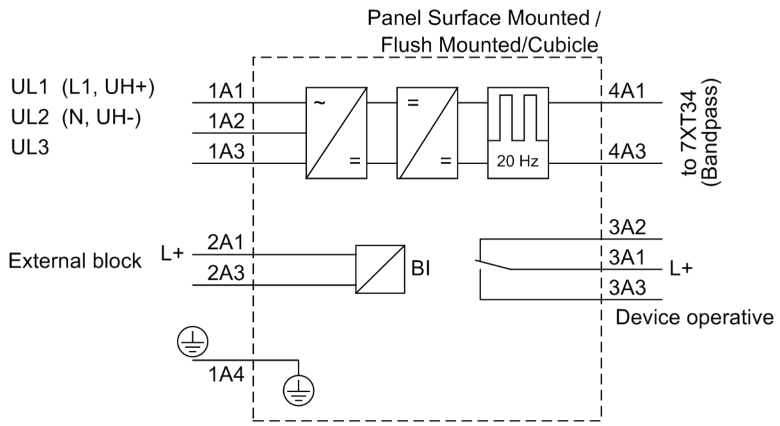


Figure A-28 General Diagram of 20-Hz-Generator 7XT3300-0*A00

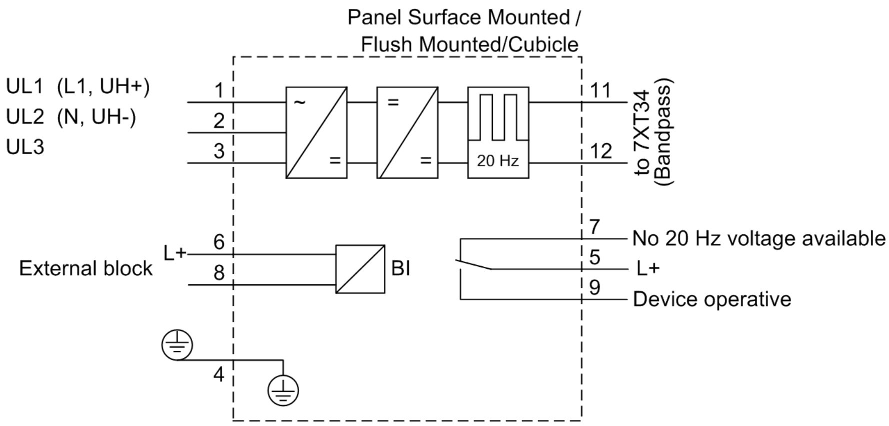


Figure A-29 General Diagram of the 20-Hz-Generator 7XT3300-0*A00/DD

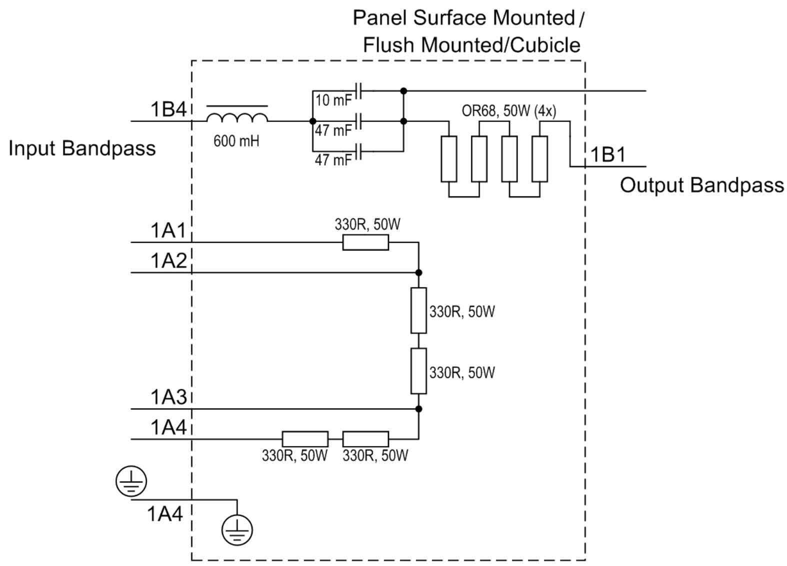


Figure A-30 General Diagram of 20-Hz Bandpass Filter 7XT3400-0*A00

A.4 Default Settings

When the device leaves the factory, a large number of LED indicators, binary inputs and outputs as well as function keys are already preset. They are summarized in the following table.

A.4.1 LEDs

Table A-2 LED Indication Presettings

LEDs	Allocated Function	Function No.	Description
LED1	Relay TRIP	511	Relay GENERAL TRIP command
LED2	Relay PICKUP	501	Relay PICKUP
LED3	I> Fault L1	1811	O/C fault detection stage I> phase L1
LED4	I> Fault L2	1812	O/C fault detection stage I> phase L2
LED5	I> Fault L3	1813	O/C fault detection stage I> phase L3
LED6	IEE> TRIP U0> TRIP S/E/F TRIP	1226 5187 5193	IEE> TRIP Stator earth fault: U0 stage TRIP Stator earth fault protection TRIP
LED7	Error PwrSupply Fail Battery	147 177	Error Power Supply Failure: Battery empty
LED8	Diff TRIP	5671	Differential protection TRIP
LED9	Pr TRIP Pr+SV TRIP	5097 5098	Reverse power: TRIP Reverse power: TRIP with stop valve
LED10	Exc<3 TRIP Exc<1 TRIP Exc<2 TRIP Exc<U<TRIP	5343 5344 5345 5346	Underexc. prot. char. 3 TRIP Underexc. prot. char. 1 TRIP Underexc. prot. char. 2 TRIP Underexc. prot. char.+Uexc< TRIP
LED11	I2>> TRIP I2 Θ TRIP	5160 5161	Unbalanced load: TRIP of current stage Unbalanced load: TRIP of thermal stage
LED12	f1 TRIP f2 TRIP f3 TRIP	5236 5237 5238	f1 TRIP f2 TRIP f3 TRIP
LED13	f4 TRIP	5239	f4 TRIP
LED14	U> TRIP U>> TRIP	6570 6573	Overvoltage U> TRIP Overvoltage U>> TRIP

A.4.2 Binary Input

Table A-3 Binary input presettings for all devices and ordering variants

Binary Input	Allocated Function	Function No.	Description
BI1	>SV tripped	5086	>Stop valve tripped
BI2	>Uexc fail.	5328	>Exc. voltage failure recognized
BI3	>BLOCK f1	5206	>BLOCK stage f1
	>BLOCK U<	6506	>BLOCK undervoltage protection U<
	>S/E/F IEE off	5176	>Switch off earth current detec.(S/E/F)[1)]
BI4	>FAIL:Feeder VT	361	>Failure: Feeder VT (MCB tripped)
	>Useal-inBLK	1950	>O/C prot. : BLOCK undervoltage seal-in
	>BLOCK U/V	6503	>BLOCK undervoltage protection
BI5	>Ext trip 1	4526	>Trigger external trip 1
BI6	>Ext trip 2	4546	>Trigger external trip 2
BI7	>Trig.Wave.Cap.	4	>Trigger Waveform Capture
BI8 ... 15	No functions configured (reserve)	-	-[2)]

[1)] Only Busbar Connection

[2)] Only for 7UM622

A.4.3 Binary Output

Table A-4 Output relay presettings for all devices and ordering variants

Binary Output	Allocated Function	Function No.	Description
BO1	Error PwrSupply	147	Error Power Supply
	Fail Battery	177	Failure: Battery empty
BO2	Relay TRIP	511	Relay GENERAL TRIP command
BO3	I> TRIP	1815	O/C I> TRIP
	Diff TRIP	5671	Differential protection TRIP
	Imp.Z1< TRIP	3977	Imp.: Z1< TRIP
	Imp.Z1B< TRIP	3978	Imp.: Z1B< TRIP
	Imp.Z2< TRIP	3979	Imp.: Z2< TRIP
	Imp.T3> TRIP	3980	Imp.: T3> TRIP
	I>> TRIP	1809	O/C I>> TRIP
	O/C Ip TRIP	1900	O/C Ip TRIP
BO4	IEE>> TRIP	1223	IEE>> TRIP
	U0> TRIP	5187	Stator earth fault: U0 stage TRIP
	S/E/F TRIP	5193	Stator earth fault protection TRIP
BO5	U< TRIP	6539	Undervoltage U< TRIP
	U> TRIP	6570	Overvoltage U> TRIP
	U>> TRIP	6573	Overvoltage U>> TRIP
BO6	f1 TRIP	5236	f1 TRIP
	f2 TRIP	5237	f2 TRIP
BO7	Exc<3 TRIP	5343	Underexc. prot. char. 3 TRIP
	Exc<U<TRIP	5346	Underexc. prot. char.+Uexc< TRIP

Binary Output	Allocated Function	Function No.	Description
BO8	I> TRIP	1815	O/C I> TRIP[1]
	S/E/F TRIP	5193	Stator earth fault protection TRIP[1]
	U>> TRIP	6573	Overvoltage U>> TRIP[1]
	f1 TRIP	5236	f1 TRIP[1]
	f2 TRIP	5237	f2 TRIP[1]
	Exc<3 TRIP	5343	Underexc. prot. char. 3 TRIP[1]
	Exc<U<TRIP	5346	Underexc. prot. char.+Uexc< TRIP[1]
	Pr TRIP	5097	Reverse power: TRIP[1]
	Pr+SV TRIP	5098	Reverse power: TRIP with stop valve[1]
	I2 Θ TRIP	5161	Unbalanced load: TRIP of thermal stage[1]
	Diff TRIP	5671	Differential protection TRIP[1]
BO9	I> TRIP	1815	O/C I> TRIP[2]
	S/E/F TRIP	5193	Stator earth fault protection TRIP[2]
	U>> TRIP	6573	Overvoltage U>> TRIP[2]
	f2 TRIP	5237	f2 TRIP[2]
	Exc<3 TRIP	5343	Underexc. prot. char. 3 TRIP[2]
	Exc<U<TRIP	5346	Underexc. prot. char.+Uexc< TRIP[2]
	Pr+SV TRIP	5098	Reverse power: TRIP with stop valve[2]
	I2 Θ TRIP	5161	Unbalanced load: TRIP of thermal stage[2]
	Diff TRIP	5671	Differential protection TRIP[2]
BO10	I> TRIP	1815	O/C I> TRIP[3]
	S/E/F TRIP	5193	Stator earth fault protection TRIP[3]
	f2 TRIP	5237	f2 TRIP[3]
	I2 Θ TRIP	5161	Unbalanced load: TRIP of thermal stage[3]
	Diff TRIP	5671	Differential protection TRIP[3]
BO11	No functions configured (reserve)	-	-
BO12	reserved for Breaker failure protection	-	-
BO13 ... 20	No functions configured (reserve)	-	-[4]

1) Generator Circuit Breaker
2) De-excitation
3) Emergency Tripping
4) Only for 7UM622

A.4.4 Function Keys

Table A-5 Applies to all devices and ordered variants

Function Keys	Allocated Function
F1	Display of Operational Annunciations
F2	Display of Primary Operational Values
F3	Jumping to heading for last eight fault annunciations
F4	Jumping to the reset menu of the min/max values

A.4.5 Default Display

4-line Display

Table A-6 This selection is available as start page which may be configured.

Page 1	I1: 0.50kA cosφ:0.80 U : 6.30kV f:50.00Hz P : 4361.4kW Q : -3286.8kVAR
Page 2	1▌ 0.50kA 12▌ 6.30kV 2▌ 0.50kA 23▌ 6.30kV 3▌ 0.50kA 31▌ 6.30kV E▌ 0.0A E ▌ 0V
Page 3	Pri▌ Side1 Side2 L1 ▌ 0.50kA 0.50kA L2 ▌ 0.50kA 0.50kA L3 ▌ 0.50kA 0.50kA
Page 4	▌ Diff Stab L1 ▌ 0.00 2.08 L2 ▌ 0.00 2.09 L3 ▌ 0.00 2.06

Graphic Display

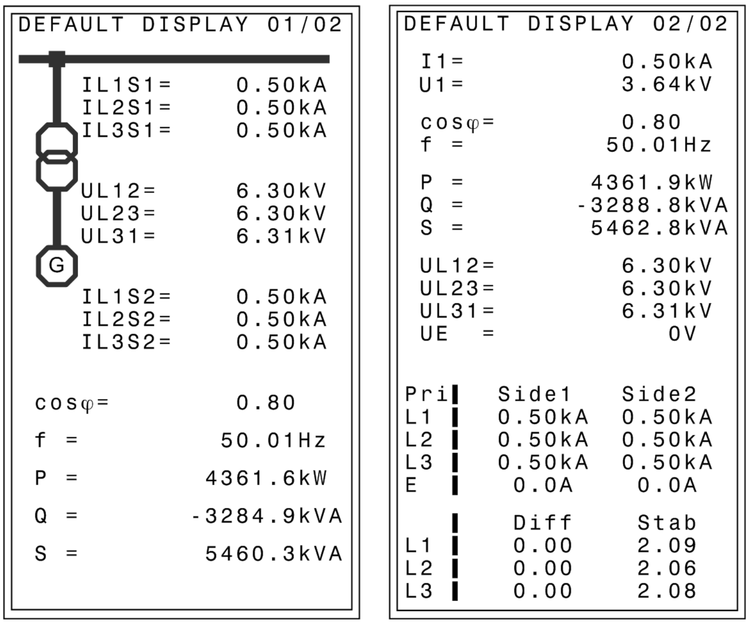


Figure A-31 Default displays of a graphical display

Spontaneous Fault Message Display

The spontaneous display messages appear automatically in the display, after a general pick-up of the 7UM62. The most important data about a fault can be viewed on the device front in the sequence shown in Figure A-32.

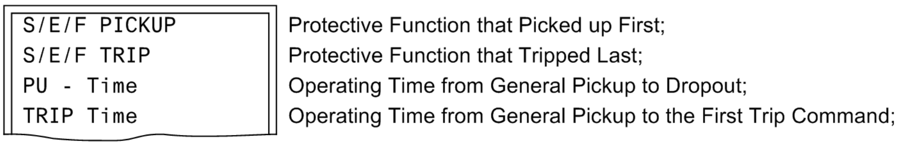


Figure A-32 Display of spontaneous messages in the device display

Spontaneous Fault Indication of the Graphic Display

All devices featuring a graphic display allow you to select whether or not to view automatically the most important fault data on the display after a general interrogation.

A.4.6 Pre-defined CFC Charts

Some CFC charts are already supplied with the SIPROTEC 4 device:

Device and System Logic

The single-point indication „DataStop“ that can be injected by binary inputs is converted by means of a NEGATOR block into an indication „UnlockDT“ that can be processed internally (internal single point indication, IntSP), and assigned to an output. This would not be possible directly, i.e. without the additional block.

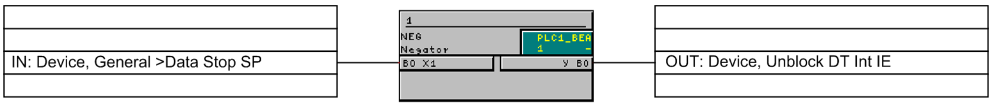


Figure A-33 Link between Input and Output for Transmission Block

Limit value handling MW

Using modules on the running sequence "measured value processing", an undercurrent monitor for the three phase currents is implemented. The output indication is issued as soon as one of the three phase currents undershoots the set threshold:

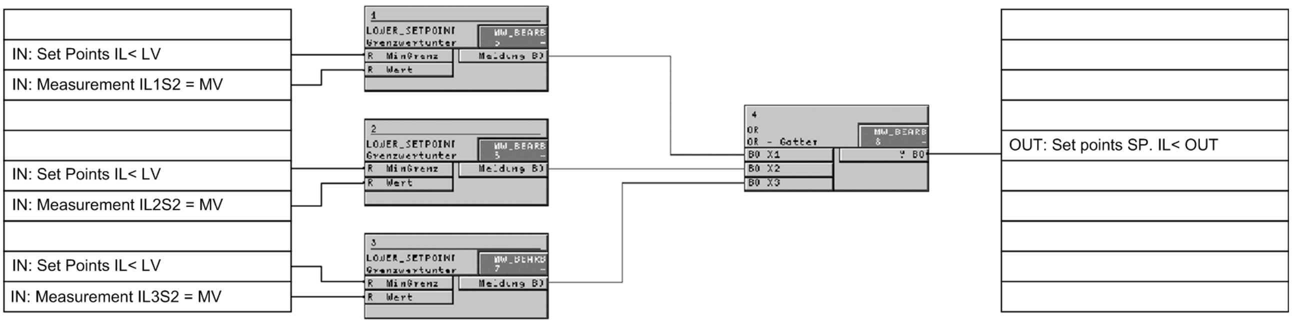


Figure A-34 Undercurrent monitoring

A.5 Protocol-dependent Functions

Protocol → Function ↓	IEC 60870-5-103	IEC 61850 Ethernet (EN-100)	Profibus DP	DNP3.0	Modbus ASCII/RTU	Additional Service Interface (optional)
Operational measured values	Yes (fixed values)	Yes	Yes	Yes	Yes	Yes
Metered values	Yes	Yes	Yes	Yes	Yes	Yes
Fault Recording	Yes	Yes	No. Only via additional service interface	No. Only via additional service interface	No. Only via additional service interface	Yes
Remote protection setting	No. Only via additional service interface	No. Only via additional service interface	No. Only via additional service interface	No. Only via additional service interface	No. Only via additional service interface	Yes
User-defined indications and switching objects	Yes	Yes	Yes	Yes	Yes	Yes
Time synchronization	Via Protocol; DCF77/IRIG B; Interface; Binary Input	Via Protocol (NTP); DCF77/IRIG B; Interface; Binary Input	Via DCF77/IRIG B; Interface; Binary Input Protocol	Via Protocol; DCF77/IRIG B; Interface; Binary Input	Via DCF77/IRIG B; Interface; Binary Input Protocol	—
Indications with time stamp	Yes	Yes	Yes	Yes	Yes	Yes
Commissioning tools						
Measured value indication blocking	Yes	Yes	No	No	No	Yes
Test Mode	Yes	Yes	No	No	No	Yes
Physical mode	Asynchronous	Synchronous	Asynchronous	Asynchronous	Asynchronous	—
Transmission Mode	Cyclically/Event	Cyclically/Event	Cyclically	Cyclically/Event	Cyclically	—
Baudrate	4800 to 38400	Up tp 100 MBaud	Up to 1.5 MBaud	4800 to 19200	2400 to 19200	4800 to 115200
Type	RS232 RS485 Optical Fiber	Ethernet TP	RS485 Optical Fiber; Double ring	RS485 Optical Fiber	RS485 Optical Fiber	RS232 RS485

A.6 Functional Scope

Addr.	Parameter	Setting Options	Default Setting	Comments
103	Grp Chge OPTION	Disabled Enabled	Disabled	Setting Group Change Option
104	FAULT VALUE	Disabled Instant. values RMS values	Instant. values	Fault values
112	O/C PROT. I>	Disabled Side 1 Side 2	Side 2	Overcurrent Protection I>
113	O/C PROT. I>>	Disabled NonDirec. SIDE1 NonDirec.SIDE 2 Direc. SIDE1 Direc. SIDE2	NonDirec.SIDE 2	Overcurrent Protection I>>
114	O/C PROT. Ip	Disabled IEC SIDE 1 ANSI SIDE 1 IEC SIDE 2 ANSI SIDE 2	Disabled	Inverse O/C Time Protection
116	Therm.Overload	Disabled Enabled	Enabled	Thermal Overload Protection
117	UNBALANCE LOAD	Disabled Enabled	Enabled	Unbalance Load (Negative Sequence)
118	O/C STARTUP	Disabled Side 1 Side 2	Disabled	Startup O/C protection
120	DIFF. PROT.	Disabled Generator/Motor 3 phase transf.	Generator/Motor	Differential Protection
121	REF PROT.	Disabled Gen. with IEE2 Gen. w. 3I0-S2 Transformer S1 Transformer S2	Disabled	Restricted earth fault protection
130	UNDEREXCIT.	Disabled Enabled	Enabled	Underexcitation Protection
131	REVERSE POWER	Disabled Enabled	Enabled	Reverse Power Protection
132	FORWARD POWER	Disabled Enabled	Enabled	Forward Power Supervision
133	IMPEDANCE PROT.	Disabled Enabled	Enabled	Impedance Protection
135	OUT-OF-STEP	Disabled Enabled	Enabled	Out-of-Step Protection
140	UNDERVOLTAGE	Disabled Enabled	Enabled	Undervoltage Protection
141	OVERVOLTAGE	Disabled Enabled	Enabled	Overvoltage Protection
142	FREQUENCY Prot.	Disabled Enabled	Enabled	Over / Underfrequency Protection

Addr.	Parameter	Setting Options	Default Setting	Comments
143	OVEREXC. PROT.	Disabled Enabled	Enabled	Overexcitation Protection (U/f)
144	INV.UNDERVOLT.	Disabled Enabled	Enabled	Inverse Undervoltage Protection Up<
145	df/dt Protect.	Disabled 2 df/dt stages 4 df/dt stages	2 df/dt stages	Rate-of-frequency-change protection
146	VECTOR JUMP	Disabled Enabled	Enabled	Jump of Voltage Vector
150	S/E/F PROT.	Disabled non-dir. U0 non-dir. U0&I0 directional	non-dir. U0&I0	Stator Earth Fault Protection
151	O/C PROT. IEE>	Disabled with IEE1 with IEE2	with IEE2	Sensitive Earth Current Protection
152	SEF 3rd HARM.	Disabled Enabled	Enabled	Stator Earth Fault Prot. 3rd Harmonic
153	100% SEF-PROT.	Disabled Enabled	Enabled	100% Stator-Earth-Fault Protection
154	O/C PROT IEE-B	Disabled with IEE1 with IEE2	with IEE2	Sensitive Earth Current Protection B
155	INTERTURN PROT	Disabled Enabled	Enabled	Interturn Protection
160	ROTOR E/F	Disabled Enabled	Enabled	Rotor Earth Fault Protection (R, fn)
161	REF 1-3Hz	Disabled Enabled	Enabled	Rotor Earth Fault Protection (1-3Hz)
165	STARTUP MOTOR	Disabled Enabled	Enabled	Motor Starting Time Supervision
166	RESTART INHIBIT	Disabled Enabled	Enabled	Restart Inhibit for Motors
170	BREAKER FAILURE	Disabled Side 1 Side 2	Side 2	Breaker Failure Protection
171	INADVERT. EN.	Disabled Enabled	Enabled	Inadvertent Energisation
172	DC PROTECTION	Disabled Enabled	Enabled	DC Voltage/Current Protection

Addr.	Parameter	Setting Options	Default Setting	Comments
173	ANALOGOUTP B1/1	Disabled I1 [%] I2 [%] IEE1 [%] IEE2 [%] U1 [%] U0 [%] U03H [%] |P| [%] |Q| [%] |S| [%] f [%] U/f [%] PHI [%] |PF| [%] ΘR/ΘRmax [%] Θ/Θtrip [%] RE REF [%] RE REF 1-3Hz[%] RE SEF100 [%]	Disabled	Analog Output B1/1 (Port B)
174	ANALOGOUTP B2/1	Disabled I1 [%] I2 [%] IEE1 [%] IEE2 [%] U1 [%] U0 [%] U03H [%] |P| [%] |Q| [%] |S| [%] f [%] U/f [%] PHI [%] |PF| [%] ΘR/ΘRmax [%] Θ/Θtrip [%] RE REF [%] RE REF 1-3Hz[%] RE SEF100 [%]	Disabled	Analog Output B2/1 (Port B)

Addr.	Parameter	Setting Options	Default Setting	Comments
175	ANALOGOUTP D1/1	Disabled I1 [%] I2 [%] IEE1 [%] IEE2 [%] U1 [%] U0 [%] U03H [%] |P| [%] |Q| [%] |S| [%] f [%] U/f [%] PHI [%] |PF| [%] ΘR/ΘRmax [%] Θ/Θtrip [%] RE REF [%] RE REF 1-3Hz[%] RE SEF100 [%]	Disabled	Analog Output D1/1 (Port D)
176	ANALOGOUTP D2/1	Disabled I1 [%] I2 [%] IEE1 [%] IEE2 [%] U1 [%] U0 [%] U03H [%] |P| [%] |Q| [%] |S| [%] f [%] U/f [%] PHI [%] |PF| [%] ΘR/ΘRmax [%] Θ/Θtrip [%] RE REF [%] RE REF 1-3Hz[%] RE SEF100 [%]	Disabled	Analog Output D2/1 (Port D)
180	FUSE FAIL MON.	Disabled Enabled	Enabled	Fuse Failure Monitor
181	M.V. SUPERV	Disabled Enabled	Enabled	Measured Values Supervision
182	Trip Cir. Sup.	Disabled 2 Binary Inputs 1 Binary Input	Disabled	Trip Circuit Supervision
185	THRESHOLD	Disabled Enabled	Enabled	Threshold Supervision
186	EXT. TRIP 1	Disabled Enabled	Enabled	External Trip Function 1
187	EXT. TRIP 2	Disabled Enabled	Enabled	External Trip Function 2
188	EXT. TRIP 3	Disabled Enabled	Enabled	External Trip Function 3
189	EXT. TRIP 4	Disabled Enabled	Enabled	External Trip Function 4

Addr.	Parameter	Setting Options	Default Setting	Comments
190	RTD-BOX INPUT	Disabled Port C Port D	Disabled	External Temperature Input
191	RTD CONNECTION	6 RTD simplex 6 RTD HDX 12 RTD HDX	6 RTD simplex	Ext. Temperature Input Connection Type
200	ANALOGOUTP B1/2	Disabled P [%] Q [%] S [%] f [%] PF [%] PHI [%] U1 [%] I2 [%] I1 [%]	Disabled	Analog Output B1/2 (Port B)
201	ANALOGOUTP B2/2	Disabled P [%] Q [%] S [%] f [%] PF [%] PHI [%] U1 [%] I2 [%] I1 [%]	Disabled	Analog Output B2/2 (Port B)
202	ANALOGOUTP D1/2	Disabled P [%] Q [%] S [%] f [%] PF [%] PHI [%] U1 [%] I2 [%] I1 [%]	Disabled	Analog Output D1/2 (Port D)
203	ANALOGOUTP D2/2	Disabled P [%] Q [%] S [%] f [%] PF [%] PHI [%] U1 [%] I2 [%] I1 [%]	Disabled	Analog Output D2/2 (Port D)

A.7 Settings

Addresses which have an appended "A" can only be changed with DIGSI, under Additional Settings.

The table indicates region-specific presettings. Column C (configuration) indicates the corresponding secondary nominal current of the current transformer.

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
201	STRPNT->OBJ S1	P.System Data 1		YES NO	YES	CT-Strpnt. Side1 in Direct. of Object
202	IN-PRI I-SIDE1	P.System Data 1		1 .. 100000 A	500 A	CT Rated Primary Current Side 1
203	IN-SEC I-SIDE1	P.System Data 1		1A 5A	1A	CT Rated Secondary Current Side 1
204	CT ANGLE W0	P.System Data 1		-5.00 .. 5.00 °	0.00 °	Correction Angle CT W0
205	FACTOR IEE1	P.System Data 1		1.0 .. 100000.0	60.0	CT Ratio Prim./Sec. Iee1
210	STRPNT->OBJ S2	P.System Data 1		YES NO	YES	CT-Strpnt. Side2 in Direct. of Object
211	IN-PRI I-SIDE2	P.System Data 1		1 .. 100000 A	500 A	CT Rated Primary Current Side 2
212	IN-SEC I-SIDE2	P.System Data 1		1A 5A	1A	CT Rated Secondary Current Side 2
213	FACTOR IEE2	P.System Data 1		1.0 .. 100000.0	60.0	CT Ratio Prim./Sec. Iee2
214	GRD TERM. IEE2	P.System Data 1		Terminal Q7 Terminal Q8	Terminal Q7	Grounded Terminal CT Iee2
221	Unom PRIMARY	P.System Data 1		0.10 .. 800.00 kV	6.30 kV	Rated Primary Voltage
222	Unom SECONDARY	P.System Data 1		100 .. 125 V	100 V	Rated Secondary Voltage (Ph-Ph)
223	UE CONNECTION	P.System Data 1		neutr. transf. broken delta Not connected any VT Rotor Load. resistor Uen-winding	neutr. transf.	UE Connection
224	FACTOR UE	P.System Data 1		1.0 .. 2500.0	36.4	VT Ratio Prim./Sec. Ue
225A	Uph / Udelta	P.System Data 1		1.00 .. 3.00	1.73	Matching Ratio Ph.-VT to Broken-Delta-VT
241	UN-PRI SIDE 1	P.System Data 1		0.40 .. 800.00 kV	20.00 kV	Rated Primary Voltage Side 1
242	STARPNT SIDE 1	P.System Data 1		Isolated Solid Earthed	Isolated	Starpoint of Side 1 is
243	UN-PRI SIDE 2	P.System Data 1		0.40 .. 800.00 kV	6.30 kV	Rated Primary Voltage side 2
244	STARPNT SIDE 2	P.System Data 1		Isolated Solid Earthed	Isolated	Starpoint of side 2 is
246	VECTOR GRP S2	P.System Data 1		0 .. 11 *30°	0 *30°	Vector Group Numeral of Side 2
249	SN TRANSFORMER	P.System Data 1		0.20 .. 5000.00 MVA	5.30 MVA	Rated Apparent Power of the Transformer
251	UN GEN/MOTOR	P.System Data 1		0.40 .. 800.00 kV	6.30 kV	Rated Primary Voltage Generator/Motor
252	SN GEN/MOTOR	P.System Data 1		0.20 .. 5000.00 MVA	5.27 MVA	Rated Apparent Power of the Generator
270	Rated Frequency	P.System Data 1		50 Hz 60 Hz	50 Hz	Rated Frequency
271	PHASE SEQ.	P.System Data 1		L1 L2 L3 L1 L3 L2	L1 L2 L3	Phase Sequence
272	SCHEME	P.System Data 1		Busbar Unit transf.	Busbar	Scheme Configuration
274A	ATEX100	P.System Data 1		YES NO	NO	Storage of th. Replicas w/o Power Supply
275	FACTOR R SEF	P.System Data 1		1.0 .. 200.0	37.0	Ratio Prim./Sec. R SEF
276	TEMP. UNIT	P.System Data 1		Celsius Fahrenheit	Celsius	Unit of temperature measurement
280	TMin TRIP CMD	P.System Data 1		0.01 .. 32.00 sec	0.15 sec	Minimum TRIP Command Duration

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
281	BkrClosed I MIN	P.System Data 1	5A	0.20 .. 5.00 A	0.20 A	Closed Breaker Min. Current Threshold
			1A	0.04 .. 1.00 A	0.04 A	
295	TRANSDUCER 1	P.System Data 1		10 V 4-20 mA 20 mA	10 V	Transducer 1
296	TRANSDUCER 2	P.System Data 1		10 V 4-20 mA 20 mA	10 V	Transducer 2
297	TRANSDUCER 3	P.System Data 1		with filter without filter	with filter	Transducer 3
302	CHANGE	Change Group		Group A Group B Binary Input Protocol	Group A	Change to Another Setting Group
401	WAVEFORMTRIGGER	Osc. Fault Rec.		Save w. Pickup Save w. TRIP Start w. TRIP	Save w. Pickup	Waveform Capture
403	MAX. LENGTH	Osc. Fault Rec.		0.30 .. 5.00 sec	1.00 sec	Max. length of a Waveform Capture Record
404	PRE. TRIG. TIME	Osc. Fault Rec.		0.05 .. 4.00 sec	0.20 sec	Captured Waveform Prior to Trigger
405	POST REC. TIME	Osc. Fault Rec.		0.05 .. 0.50 sec	0.10 sec	Captured Waveform after Event
406	BinIn CAPT.TIME	Osc. Fault Rec.		0.10 .. 5.00 sec; ∞	0.50 sec	Capture Time via Binary Input
610	FltDisp.LED/LCD	Device		Target on PU Target on TRIP	Target on PU	Fault Display on LED / LCD
611	Spont. FltDisp.	Device		YES NO	NO	Spontaneous display of flt.an-nunciations
615	T MIN LED HOLD	Device		0 .. 60 min	5 min	Minimum hold time of lachted LEDs
640	Start image DD	Device		image 1 image 2 image 3 image 4	image 1	Start image Default Display
1108	ACTIVE POWER	P.System Data 2		Generator Motor	Generator	Measurement of Active Power for
1201	O/C I>	O/C Prot. I>		OFF ON Block relay	OFF	Overcurrent Time Protection I>
1202	I>	O/C Prot. I>	5A	0.25 .. 100.00 A	6.75 A	I> Pickup
			1A	0.05 .. 20.00 A	1.35 A	
1203	T I>	O/C Prot. I>		0.00 .. 60.00 sec; ∞	3.00 sec	T I> Time Delay
1204	U< SEAL-IN	O/C Prot. I>		ON OFF	OFF	State of Undervoltage Seal-in
1205	U<	O/C Prot. I>		10.0 .. 125.0 V	80.0 V	Undervoltage Seal-in Pickup
1206	T-SEAL-IN	O/C Prot. I>		0.10 .. 60.00 sec	4.00 sec	Duration of Undervoltage Seal-in
1207A	I> DOUT RATIO	O/C Prot. I>		0.90 .. 0.99	0.95	I> Drop Out Ratio
1301	O/C I>>	O/C Prot. I>>		OFF ON Block relay	OFF	Overcurrent Time Protection I>>
1302	I>>	O/C Prot. I>>	5A	0.25 .. 100.00 A	21.50 A	I>> Pickup
			1A	0.05 .. 20.00 A	4.30 A	
1303	T I>>	O/C Prot. I>>		0.00 .. 60.00 sec; ∞	0.10 sec	T I>> Time Delay
1304	Phase Direction	O/C Prot. I>>		Forward Reverse	Reverse	Phase Direction
1305	LINE ANGLE	O/C Prot. I>>		-90 .. 90 °	60 °	Line Angle
1401	O/C Ip	O/C Prot. Ip		OFF ON Block relay	OFF	Inverse O/C Time Protection Ip
1402	Ip	O/C Prot. Ip	5A	0.50 .. 20.00 A	5.00 A	Ip Pickup
			1A	0.10 .. 4.00 A	1.00 A	
1403	T Ip	O/C Prot. Ip		0.05 .. 3.20 sec; ∞	0.50 sec	T Ip Time Dial
1404	TIME DIAL: TD	O/C Prot. Ip		0.50 .. 15.00 ; ∞	5.00	TIME DIAL: TD

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
1405	IEC CURVE	O/C Prot. Ip		Normal Inverse Very Inverse Extremely Inv.	Normal Inverse	IEC Curve
1406	ANSI CURVE	O/C Prot. Ip		Very Inverse Inverse Moderately Inv. Extremely Inv. Definite Inv.	Very Inverse	ANSI Curve
1407	VOLT. INFLUENCE	O/C Prot. Ip		without Volt. controll. Volt. restraint	without	Voltage Influence
1408	U<	O/C Prot. Ip		10.0 .. 125.0 V	75.0 V	U< Threshold for Release Ip
1601	Ther. OVER LOAD	Therm. Overload		OFF ON Block relay Alarm Only	OFF	Thermal Overload Protection
1602	K-FACTOR	Therm. Overload		0.10 .. 4.00	1.11	K-Factor
1603	TIME CONSTANT	Therm. Overload		30 .. 32000 sec	600 sec	Thermal Time Constant
1604	Θ ALARM	Therm. Overload		70 .. 100 %	90 %	Thermal Alarm Stage
1605	TEMP. RISE I	Therm. Overload		40 .. 200 °C	100 °C	Temperature Rise at Rated Sec. Curr.
1606	TEMP. RISE I	Therm. Overload		104 .. 392 °F	212 °F	Temperature Rise at Rated Sec. Curr.
1607	TEMP. INPUT	Therm. Overload		Disabled 4-20 mA Fieldbus RTD 1	Disabled	Temperature Input
1608	TEMP. SCAL.	Therm. Overload		40 .. 300 °C	100 °C	Temperature for Scaling
1609	TEMP. SCAL.	Therm. Overload		104 .. 572 °F	212 °F	Temperature for Scaling
1610A	I ALARM	Therm. Overload	5A	0.50 .. 20.00 A	5.00 A	Current Overload Alarm Setpoint
			1A	0.10 .. 4.00 A	1.00 A	
1612A	Kτ-FACTOR	Therm. Overload		1.0 .. 10.0	1.0	Kt-Factor when Motor Stops
1615A	I MAX THERM.	Therm. Overload	5A	2.50 .. 40.00 A	16.50 A	Maximum Current for Thermal Replica
			1A	0.50 .. 8.00 A	3.30 A	
1616A	T EMERGENCY	Therm. Overload		10 .. 15000 sec	100 sec	Emergency Time
1701	UNBALANCE LOAD	Unbalance Load		OFF ON Block relay	OFF	Unbalance Load Protection
1702	I2>	Unbalance Load		3.0 .. 30.0 %	10.6 %	Continously Permissible Current I2
1703	T WARN	Unbalance Load		0.00 .. 60.00 sec; ∞	20.00 sec	Warning Stage Time Delay
1704	FACTOR K	Unbalance Load		1.0 .. 100.0 sec; ∞	18.7 sec	Negativ Sequence Factor K
1705	T COOL DOWN	Unbalance Load		0 .. 50000 sec	1650 sec	Time for Cooling Down
1706	I2>>	Unbalance Load		10 .. 200 %	60 %	I2>> Pickup
1707	T I2>>	Unbalance Load		0.00 .. 60.00 sec; ∞	3.00 sec	T I2>> Time Delay
1801	O/C STARTUP	O/C Startup		OFF ON Block relay	OFF	Startup O/C protection
1802	STARTUP I>	O/C Startup	5A	0.50 .. 100.00 A	6.50 A	I> Pickup
			1A	0.10 .. 20.00 A	1.30 A	
1803	STARTUP T I>	O/C Startup		0.00 .. 60.00 sec; ∞	0.50 sec	T I> Time Delay
2001	DIFF. PROT.	Diff. Prot		OFF ON Block relay	OFF	Differential Protection
2005	INC.CHAR.START	Diff. Prot		OFF ON	OFF	Increase of Trip Char. During Start
2006	INRUSH 2.HARM.	Diff. Prot		OFF ON	ON	Inrush with 2. Harmonic Restraint
2007	RESTR. n.HARM.	Diff. Prot		OFF 3. Harmonic 5. Harmonic	OFF	n-th Harmonic Restraint
2021	I-DIFF>	Diff. Prot		0.05 .. 2.00 I/InO	0.20 I/InO	Pickup Value of Differential Curr.
2026A	T I-DIFF>	Diff. Prot		0.00 .. 60.00 sec; ∞	0.00 sec	T I-DIFF> Time Delay

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
2031	I-DIFF>>	Diff. Prot		0.5 .. 12.0 I/InO; ∞	7.5 I/InO	Pickup Value of High Set Trip
2036A	T I-DIFF>>	Diff. Prot		0.00 .. 60.00 sec; ∞	0.00 sec	T I-DIFF>> Time Delay
2041A	SLOPE 1	Diff. Prot		0.10 .. 0.50	0.25	Slope 1 of Tripping Characteristic
2042A	BASE POINT 1	Diff. Prot		0.00 .. 2.00 I/InO	0.00 I/InO	Base Point for Slope 1 of Charac.
2043A	SLOPE 2	Diff. Prot		0.25 .. 0.95	0.50	Slope 2 of Tripping Characteristic
2044A	BASE POINT 2	Diff. Prot		0.00 .. 10.00 I/InO	2.50 I/InO	Base Point for Slope 2 of Charac.
2051A	I-REST. STARTUP	Diff. Prot		0.00 .. 2.00 I/InO	0.10 I/InO	I-RESTRAINT for Start Detection
2052A	START-FACTOR	Diff. Prot		1.0 .. 2.0	1.0	Factor for Increasing of Char. at Start
2053	T START MAX	Diff. Prot		0.0 .. 180.0 sec	5.0 sec	Maximum Permissible Starting Time
2061A	I-ADD ON STAB.	Diff. Prot		2.00 .. 15.00 I/InO	4.00 I/InO	Pickup for Add-on Stabilization
2062A	T ADD ON-STAB.	Diff. Prot		2 .. 250 Cycle; ∞	15 Cycle	Duration of Add-on Stabilization
2063A	CROSSB. ADD ON	Diff. Prot		2 .. 1000 Cycle; 0; ∞	15 Cycle	Time for Cross-blocking Add-on Stabiliz.
2071	2. HARMONIC	Diff. Prot		10 .. 80 %	15 %	2nd Harmonic Content in I-DIFF
2072A	CROSSB. 2. HARM	Diff. Prot		2 .. 1000 Cycle; 0; ∞	3 Cycle	Time for Cross-blocking 2nd Harm.
2076	n. HARMONIC	Diff. Prot		10 .. 80 %	30 %	n-th Harmonic Content in I-DIFF
2077A	CROSSB. n.HARM	Diff. Prot		2 .. 1000 Cycle; 0; ∞	0 Cycle	Time for Cross-blocking n-th Harm.
2078A	IDIFFmax n.HM	Diff. Prot		0.5 .. 12.0 I/InO	1.5 I/InO	Limit IDIFFmax of n-th Harm.Restraint
2101	REF PROT.	REF		OFF ON Block relay	OFF	Restricted Earth Fault Protection
2102	REF I> BLOCK	REF		1.0 .. 2.5 I/InO	1.5 I/InO	REF Pickup of Phase Current Blocking
2103	REF U0>RELEASE	REF		1.0 .. 100.0 V; 0	5.0 V	REF Pickup of U0> Release
2110	I-REF>	REF		0.05 .. 2.00 I/InO	0.10 I/InO	I-REF> Pickup
2112	T I-REF>	REF		0.00 .. 60.00 sec; ∞	0.00 sec	T I-REF> Time Delay
2113A	SLOPE	REF		0.00 .. 0.95	0.25	Slope of Charac. I-REF> = f(I0-Rest)
2114A	BASE POINT	REF		0.00 .. 2.00 I/InO	0.00 I/InO	Base Point for Slope of Characteristic
3001	UNDEREXCIT.	Underexcitation		OFF ON Block relay	OFF	Underexcitation Protection
3002	1/xd CHAR. 1	Underexcitation		0.20 .. 3.00	0.41	Susceptance Intersect Characteristic 1
3003	ANGLE 1	Underexcitation		50 .. 120 °	80 °	Inclination Angle of Characteristic 1
3004	T CHAR. 1	Underexcitation		0.00 .. 60.00 sec; ∞	10.00 sec	Characteristic 1 Time Delay
3005	1/xd CHAR. 2	Underexcitation		0.20 .. 3.00	0.36	Susceptance Intersect Characteristic 2
3006	ANGLE 2	Underexcitation		50 .. 120 °	90 °	Inclination Angle of Characteristic 2
3007	T CHAR. 2	Underexcitation		0.00 .. 60.00 sec; ∞	10.00 sec	Characteristic 2 Time Delay
3008	1/xd CHAR. 3	Underexcitation		0.20 .. 3.00	1.10	Susceptance Intersect Characteristic 3
3009	ANGLE 3	Underexcitation		50 .. 120 °	90 °	Inclination Angle of Characteristic 3
3010	T CHAR 3	Underexcitation		0.00 .. 60.00 sec; ∞	0.30 sec	Characteristic 3 Time Delay
3011	T SHRT Uex<	Underexcitation		0.00 .. 60.00 sec; ∞	0.50 sec	T-Short Time Delay (Char. & Uexc<)
3012	EXCIT. VOLT.	Underexcitation		ON OFF	OFF	State of Excitation Volt. Supervision
3013	Uexcit. <	Underexcitation		0.50 .. 8.00 V	2.00 V	Excitation Voltage Superv. Pickup
3014A	Umin	Underexcitation		10.0 .. 125.0 V	25.0 V	Undervoltage blocking Pickup

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
3101	REVERSE POWER	Reverse Power		OFF ON Block relay	OFF	Reverse Power Protection
3102	P> REVERSE	Reverse Power		-30.00 .. -0.50 %	-1.93 %	P> Reverse Pickup
3103	T-SV-OPEN	Reverse Power		0.00 .. 60.00 sec; ∞	10.00 sec	Time Delay Long (without Stop Valve)
3104	T-SV-CLOSED	Reverse Power		0.00 .. 60.00 sec; ∞	1.00 sec	Time Delay Short (with Stop Valve)
3105A	T-HOLD	Reverse Power		0.00 .. 60.00 sec; ∞	0.00 sec	Pickup Holding Time
3201	FORWARD POWER	Forward Power		OFF ON Block relay	OFF	Forward Power Supervision
3202	Pf<	Forward Power		0.5 .. 120.0 %	9.7 %	P-forw.< Supervision Pickup
3203	Pf>	Forward Power		1.0 .. 120.0 %	96.6 %	P-forw.> Supervision Pickup
3204	T-Pf<	Forward Power		0.00 .. 60.00 sec; ∞	10.00 sec	T-P-forw.< Time Delay
3205	T-Pf>	Forward Power		0.00 .. 60.00 sec; ∞	10.00 sec	T-P-forw.> Time Delay
3206A	MEAS. METHOD	Forward Power		accurate fast	accurate	Method of Operation
3301	IMPEDANCE PROT.	Impedance		OFF ON Block relay	OFF	Impedance Protection
3302	IMP I>	Impedance	5A	0.50 .. 100.00 A	6.75 A	Fault Detection I> Pickup
			1A	0.10 .. 20.00 A	1.35 A	
3303	U< SEAL-IN	Impedance		ON OFF	OFF	State of Undervoltage Seal-in
3304	U<	Impedance		10.0 .. 125.0 V	80.0 V	Undervoltage Seal-in Pickup
3305	T-SEAL-IN	Impedance		0.10 .. 60.00 sec	4.00 sec	Duration of Undervoltage Seal-in
3306	ZONE Z1	Impedance	5A	0.01 .. 26.00 Ω	0.58 Ω	Impedance Zone Z1
			1A	0.05 .. 130.00 Ω	2.90 Ω	
3307	T-Z1	Impedance		0.00 .. 60.00 sec; ∞	0.10 sec	Impedance Zone Z1 Time Delay
3308	ZONE Z1B	Impedance	5A	0.01 .. 13.00 Ω	0.99 Ω	Impedance Zone Z1B
			1A	0.05 .. 65.00 Ω	4.95 Ω	
3309	T-Z1B	Impedance		0.00 .. 60.00 sec; ∞	0.10 sec	Impedance Zone Z1B Time Delay
3310	ZONE Z2	Impedance	5A	0.01 .. 13.00 Ω	0.83 Ω	Impedanz Zone Z2
			1A	0.05 .. 65.00 Ω	4.15 Ω	
3311	ZONE2 T2	Impedance		0.00 .. 60.00 sec; ∞	0.50 sec	Impedance Zone Z2 Time Delay
3312	T END	Impedance		0.00 .. 60.00 sec; ∞	3.00 sec	T END: Final Time Delay
3313	POWER SWING	Impedance		ON OFF	OFF	Power Swing Blocking
3314	P/SPOL-TPOL	Impedance	5A	0.02 .. 6.00 Ω	1.60 Ω	Distance betw. Power Swing - Trip-Pol.
			1A	0.10 .. 30.00 Ω	8.00 Ω	
3315	dZ/dt	Impedance	5A	0.2 .. 120.0 Ω/s	60.0 Ω/s	Rate of Change of dZ/dt
			1A	1.0 .. 600.0 Ω/s	300.0 Ω/s	
3316A	BLOCKING OF	Impedance		Z1 Z2	Z1	Power Swing Blocking locks out
3317A	T-ACTION P/S	Impedance		0.00 .. 60.00 sec; ∞	3.00 sec	Power Swing Action Time
3501	OUT-OF-STEP	Out-of-Step		OFF ON Block relay	OFF	Out-of-Step Protection
3502	I1> RELEASE	Out-of-Step		20.0 .. 400.0 %	120.0 %	Pickup Current for Measuring Release I1>
3503	I2< RELEASE	Out-of-Step		5.0 .. 100.0 %	20.0 %	Pickup Current for Measuring Release I2<
3504	Za	Out-of-Step	5A	0.04 .. 26.00 Ω	0.90 Ω	Resistance Za of the Polygon (width)
			1A	0.20 .. 130.00 Ω	4.50 Ω	
3505	Zb	Out-of-Step	5A	0.02 .. 26.00 Ω	2.40 Ω	Reactance Zb of the Polygon (re-verse)
			1A	0.10 .. 130.00 Ω	12.00 Ω	
3506	Zc	Out-of-Step	5A	0.02 .. 26.00 Ω	0.72 Ω	Reactance Zc of Polygon (for-ward char.1)
			1A	0.10 .. 130.00 Ω	3.60 Ω	

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
3507	Zd - Zc	Out-of-Step	5A	0.00 .. 26.00 Ω	1.28 Ω	Reactance Dif. Char.1 - Char.2 (forward)
			1A	0.00 .. 130.00 Ω	6.40 Ω	
3508	PHI POLYGON	Out-of-Step		60.0 .. 90.0 °	90.0 °	Angle of Inclination of the Polygon
3509	REP. CHAR. 1	Out-of-Step		1 .. 10	1	Number of Power Swing: Characteristic 1
3510	REP. CHAR. 2	Out-of-Step		1 .. 20	4	Number of Power Swing: Characteristic 2
3511	T-HOLDING	Out-of-Step		0.20 .. 60.00 sec	20.00 sec	Holding Time of Fault Detection
3512	T-SIGNAL	Out-of-Step		0.02 .. 0.15 sec	0.05 sec	Min. Signal Time for Annun. Char. 1/2
4001	UNDERVOLTAGE	Undervoltage		OFF ON Block relay	OFF	Undervoltage Protection
4002	U<	Undervoltage		10.0 .. 125.0 V	75.0 V	U< Pickup
4003	T U<	Undervoltage		0.00 .. 60.00 sec; ∞	3.00 sec	T U< Time Delay
4004	U<<	Undervoltage		10.0 .. 125.0 V	65.0 V	U<< Pickup
4005	T U<<	Undervoltage		0.00 .. 60.00 sec; ∞	0.50 sec	T U<< Time Delay
4006A	DOUT RATIO	Undervoltage		1.01 .. 1.20	1.05	U<, U<< Drop Out Ratio
4101	OVERVOLTAGE	Overvoltage		OFF ON Block relay	OFF	Overvoltage Protection
4102	U>	Overvoltage		30.0 .. 170.0 V	115.0 V	U> Pickup
4103	T U>	Overvoltage		0.00 .. 60.00 sec; ∞	3.00 sec	T U> Time Delay
4104	U>>	Overvoltage		30.0 .. 170.0 V	130.0 V	U>> Pickup
4105	T U>>	Overvoltage		0.00 .. 60.00 sec; ∞	0.50 sec	T U>> Time Delay
4106A	DOUT RATIO	Overvoltage		0.90 .. 0.99	0.95	U>, U>> Drop Out Ratio
4107A	VALUES	Overvoltage		U-ph-ph U-ph-e	U-ph-ph	Measurement Values
4201	O/U FREQUENCY	Frequency Prot.		OFF ON Block relay	OFF	Over / Under Frequency Protection
4202	f1 PICKUP	Frequency Prot.		40.00 .. 66.00 Hz	48.00 Hz	f1 Pickup
4203	f1 PICKUP	Frequency Prot.		40.00 .. 66.00 Hz	58.00 Hz	f1 Pickup
4204	T f1	Frequency Prot.		0.00 .. 600.00 sec	1.00 sec	T f1 Time Delay
4205	f2 PICKUP	Frequency Prot.		40.00 .. 66.00 Hz	47.00 Hz	f2 Pickup
4206	f2 PICKUP	Frequency Prot.		40.00 .. 66.00 Hz	57.00 Hz	f2 Pickup
4207	T f2	Frequency Prot.		0.00 .. 100.00 sec	6.00 sec	T f2 Time Delay
4208	f3 PICKUP	Frequency Prot.		40.00 .. 66.00 Hz	49.50 Hz	f3 Pickup
4209	f3 PICKUP	Frequency Prot.		40.00 .. 66.00 Hz	59.50 Hz	f3 Pickup
4210	T f3	Frequency Prot.		0.00 .. 100.00 sec	20.00 sec	T f3 Time Delay
4211	f4 PICKUP	Frequency Prot.		40.00 .. 66.00 Hz	52.00 Hz	f4 Pickup
4212	f4 PICKUP	Frequency Prot.		40.00 .. 66.00 Hz	62.00 Hz	f4 Pickup
4213	T f4	Frequency Prot.		0.00 .. 100.00 sec	10.00 sec	T f4 Time Delay
4214	THRESHOLD f4	Frequency Prot.		automatic f> f<	automatic	Handling of Threshold Stage f4
4215	Umin	Frequency Prot.		10.0 .. 125.0 V; 0	65.0 V	Minimum Required Voltage for Operation
4301	OVEREXC. PROT.	Overexcitation		OFF ON Block relay	OFF	Overexcitation Protection (U/f)
4302	U/f >	Overexcitation		1.00 .. 1.20	1.10	U/f > Pickup
4303	T U/f >	Overexcitation		0.00 .. 60.00 sec; ∞	10.00 sec	T U/f > Time Delay
4304	U/f >>	Overexcitation		1.00 .. 1.40	1.40	U/f >> Pickup
4305	T U/f >>	Overexcitation		0.00 .. 60.00 sec; ∞	1.00 sec	T U/f >> Time Delay
4306	t(U/f=1.05)	Overexcitation		0 .. 20000 sec	20000 sec	U/f = 1.05 Time Delay
4307	t(U/f=1.10)	Overexcitation		0 .. 20000 sec	6000 sec	U/f = 1.10 Time Delay
4308	t(U/f=1.15)	Overexcitation		0 .. 20000 sec	240 sec	U/f = 1.15 Time Delay
4309	t(U/f=1.20)	Overexcitation		0 .. 20000 sec	60 sec	U/f = 1.20 Time Delay

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
4310	t(U/f=1.25)	Overexcitation		0 .. 20000 sec	30 sec	U/f = 1.25 Time Delay
4311	t(U/f=1.30)	Overexcitation		0 .. 20000 sec	19 sec	U/f = 1.30 Time Delay
4312	t(U/f=1.35)	Overexcitation		0 .. 20000 sec	13 sec	U/f = 1.35 Time Delay
4313	t(U/f=1.40)	Overexcitation		0 .. 20000 sec	10 sec	U/f = 1.40 Time Delay
4314	T COOL DOWN	Overexcitation		0 .. 20000 sec	3600 sec	Time for Cooling Down
4401	INV. UNDERVOLT.	Inv.Undervolt.		OFF ON Block relay	OFF	Inverse Undervoltage Protection Up<
4402	Up< PICKUP	Inv.Undervolt.		10.0 .. 125.0 V	75.0 V	Up< Pickup
4403	T MUL	Inv.Undervolt.		0.10 .. 5.00 sec; 0	1.00 sec	Time Multiplier for Characteristic
4404	T Up<	Inv.Undervolt.		0.00 .. 60.00 sec; ∞	0.00 sec	T Up< Time Delay
4501	df/dt Protect.	df/dt Protect.		OFF ON Block relay	OFF	Rate-of-frequency-change protection
4502	df1/dt >/<	df/dt Protect.		-df/dt< +df/dt>	-df/dt<	Mode of Threshold (df1/dt >/<)
4503	STAGE df1/dt	df/dt Protect.		0.1 .. 10.0 Hz/s; ∞	1.0 Hz/s	Pickup Value of df1/dt Stage
4504	T df1/dt	df/dt Protect.		0.00 .. 60.00 sec; ∞	0.50 sec	Time Delay of df1/dt Stage
4505	df1/dt & f1	df/dt Protect.		OFF ON	OFF	AND logic with pickup of stage f1
4506	df2/dt >/<	df/dt Protect.		-df/dt< +df/dt>	-df/dt<	Mode of Threshold (df2/dt >/<)
4507	STAGE df2/dt	df/dt Protect.		0.1 .. 10.0 Hz/s; ∞	1.0 Hz/s	Pickup Value of df2/dt Stage
4508	T df2/dt	df/dt Protect.		0.00 .. 60.00 sec; ∞	0.50 sec	Time Delay of df2/dt Stage
4509	df2/dt & f2	df/dt Protect.		OFF ON	OFF	AND logic with pickup of stage f2
4510	df3/dt >/<	df/dt Protect.		-df/dt< +df/dt>	-df/dt<	Mode of Threshold (df3/dt >/<)
4511	STAGE df3/dt	df/dt Protect.		0.1 .. 10.0 Hz/s; ∞	4.0 Hz/s	Pickup Value of df3/dt Stage
4512	T df3/dt	df/dt Protect.		0.00 .. 60.00 sec; ∞	0.00 sec	Time Delay of df3/dt Stage
4513	df3/dt & f3	df/dt Protect.		OFF ON	OFF	AND logic with pickup of stage f3
4514	df4/dt >/<	df/dt Protect.		-df/dt< +df/dt>	-df/dt<	Mode of Threshold (df4/dt >/<)
4515	STAGE df4/dt	df/dt Protect.		0.1 .. 10.0 Hz/s; ∞	4.0 Hz/s	Pickup Value of df4/dt Stage
4516	T df4/dt	df/dt Protect.		0.00 .. 60.00 sec; ∞	0.00 sec	Time Delay of df4/dt Stage
4517	df4/dt & f4	df/dt Protect.		OFF ON	OFF	AND logic with pickup of stage f4
4518	U MIN	df/dt Protect.		10.0 .. 125.0 V; 0	65.0 V	Minimum Operating Voltage Umin
4519A	df1/2 HYSTERES.	df/dt Protect.		0.02 .. 0.99 Hz/s	0.10 Hz/s	Reset Hysteresis for df1/dt & df2/dt
4520A	df1/2 M-WINDOW	df/dt Protect.		1 .. 25 Cycle	5 Cycle	Measuring Window for df1/dt & df2/dt
4521A	df3/4 HYSTERES.	df/dt Protect.		0.02 .. 0.99 Hz/s	0.40 Hz/s	Reset Hysteresis for df3/dt & df4/dt
4522A	df3/4 M-WINDOW	df/dt Protect.		1 .. 25 Cycle	5 Cycle	Measuring Window for df3/dt & df4/dt
4601	VECTOR JUMP	Vector Jump		OFF ON Block relay	OFF	Jump of Voltage Vector
4602	DELTA PHI	Vector Jump		2 .. 30 °	10 °	Jump of Phasor DELTA PHI
4603	T DELTA PHI	Vector Jump		0.00 .. 60.00 sec; ∞	0.00 sec	T DELTA PHI Time Delay
4604	T RESET	Vector Jump		0.10 .. 60.00 sec; ∞	5.00 sec	Reset Time after Trip
4605A	U MIN	Vector Jump		10.0 .. 125.0 V	80.0 V	Minimal Operation Voltage U MIN
4606A	U MAX	Vector Jump		10.0 .. 170.0 V	130.0 V	Maximal Operation Voltage U MAX
4607A	T BLOCK	Vector Jump		0.00 .. 60.00 sec; ∞	0.10 sec	Time Delay of Blocking
5001	S/E/F PROT.	Stator E Fault		OFF ON Block relay	OFF	Stator Earth Fault Protection
5002	U0>	Stator E Fault		2.0 .. 125.0 V	10.0 V	U0> Pickup

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
5003	3I0>	Stator E Fault		2 .. 1000 mA	5 mA	3I0> Pickup
5004	DIR. ANGLE	Stator E Fault		0 .. 360 °	15 °	Angle for Direction Determination
5005	T S/E/F	Stator E Fault		0.00 .. 60.00 sec; ∞	0.30 sec	T S/E/F Time Delay
5101	O/C PROT. IEE	Sens. E Fault		OFF ON Block relay	OFF	Sensitive Earth Current Protec- tion
5102	IEE>	Sens. E Fault		2 .. 1000 mA	10 mA	IEE> Pickup
5103	T IEE>	Sens. E Fault		0.00 .. 60.00 sec; ∞	5.00 sec	T IEE> Time delay
5104	IEE>>	Sens. E Fault		2 .. 1000 mA	23 mA	IEE>> Pickup
5105	T IEE>>	Sens. E Fault		0.00 .. 60.00 sec; ∞	1.00 sec	T IEE>> Time Delay
5106	IEE<	Sens. E Fault		1.5 .. 50.0 mA; 0	0.0 mA	IEE< Pickup (Interrupted Circuit)
5201	SEF 3rd HARM.	SEF 3.Harm.		OFF ON Block relay	OFF	Stator Earth Fault Protection 3rdHarm.
5202	U0 3.HARM<	SEF 3.Harm.		0.2 .. 40.0 V	1.0 V	U0 3rd Harmonic< Pickup
5203	U0 3.HARM>	SEF 3.Harm.		0.2 .. 40.0 V	2.0 V	U0 3rd Harmonic> Pickup
5204	T SEF 3. HARM.	SEF 3.Harm.		0.00 .. 60.00 sec; ∞	0.50 sec	T SEF 3rd Harmonic Time Delay
5205	P min >	SEF 3.Harm.		10 .. 100 %; 0	40 %	Release Threshold Pmin>
5206	U1 min >	SEF 3.Harm.		50.0 .. 125.0 V; 0	80.0 V	Release Threshold U1min>
5207	U0 3.H.(V/100%)	SEF 3.Harm.		-40.0 .. 40.0	0.0	Correction Factor for Pickup (V/100%)
5301	100% SEF-PROT.	100% SEF-PROT.		OFF ON Block relay	OFF	100% Stator-Earth-Fault Protec- tion
5302	R< SEF ALARM	100% SEF-PROT.		20 .. 700 Ω	100 Ω	Pickup Value of Alarm Stage Rsef<
5303	R<< SEF TRIP	100% SEF-PROT.		20 .. 700 Ω	20 Ω	Pickup Value of Tripping Stage Rsef<<
5304	T SEF ALARM	100% SEF-PROT.		0.00 .. 60.00 sec; ∞	10.00 sec	Time Delay of Alarm Stage Rsef<
5305	T SEF TRIP	100% SEF-PROT.		0.00 .. 60.00 sec; ∞	1.00 sec	Time Delay of Tripping Stage Rsef<<
5306	SEF I>>	100% SEF-PROT.		0.02 .. 1.50 A	0.40 A	Pickup Value of I SEF>> Stage
5307	U20 MIN	100% SEF-PROT.		0.3 .. 15.0 V	1.0 V	Supervision Threshold of 20Hz Voltage
5308	I20 MIN	100% SEF-PROT.		5 .. 40 mA	10 mA	Supervision Threshold of 20Hz Current
5309	PHI I SEF	100% SEF-PROT.		-60 .. 60 °	0 °	Correction Angle for I SEF 100%
5310A	SEF Rps	100% SEF-PROT.		0.0 .. 700.0 Ω	0.0 Ω	Resistance Rps
5311A	RI-PARALLEL	100% SEF-PROT.		20 .. 700 Ω; ∞	∞ Ω	Parallel Load Resistance
5401	O/C PROT IEE-B	Sens. E Fault B		OFF ON Block relay Alarm Only	OFF	Sensitive O/C Protection B
5402	IEE-B>	Sens. E Fault B		0.3 .. 1000.0 mA	5.0 mA	IEE-B> Pickup
5403	T IEE-B>	Sens. E Fault B		0.00 .. 60.00 sec; ∞	3.00 sec	Time Delay T IEE-B>
5404	IEE-B<	Sens. E Fault B		0.3 .. 500.0 mA; 0	0.0 mA	IEE-B< Pickup
5405	T IEE-B<	Sens. E Fault B		0.00 .. 60.00 sec; ∞	1.00 sec	Time Delay T IEE-B<
5406	MEAS. METHOD	Sens. E Fault B		Fundamental 3. Harmonic 1. and 3. Harm.	Fundamental	Measurement Method
5407A	T-HOLD IEE-B>	Sens. E Fault B		0.00 .. 60.00 sec	0.00 sec	Pickup Holding Time IEE-B>
5408A	T-HOLD IEE-B<	Sens. E Fault B		0.00 .. 60.00 sec	0.00 sec	Pickup Holding Time IEE-B<
5501	INTERTURN PROT	Interturn Prot.		OFF ON Block relay	OFF	Interturn Protection
5502	U Interturn >	Interturn Prot.		0.3 .. 130.0 V	2.0 V	Pick up Value U Interturn>
5503	T-U Interturn >	Interturn Prot.		0.00 .. 60.00 sec; ∞	0.50 sec	Time Delay of Trip Command
5504	RESET RATIO	Interturn Prot.		50 .. 95 %	80 %	Reset Ratio of U Interturn>
6001	ROTOR E/F	Rotor E/F		OFF ON Block relay	OFF	Rotor Earth Fault Protection (R, fn)

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
6002	RE< WARN	Rotor E/F		3.0 .. 30.0 kΩ	10.0 kΩ	Pickup Value of Warning Stage Re<
6003	RE<< TRIP	Rotor E/F		1.0 .. 5.0 kΩ	2.0 kΩ	Pickup Value of Tripping Stage Re<<
6004	T-WARN-RE<	Rotor E/F		0.00 .. 60.00 sec; ∞	10.00 sec	Time Delay of Warning Stage Re<
6005	T-TRIP-RE<<	Rotor E/F		0.00 .. 60.00 sec; ∞	0.50 sec	Time Delay of Tripping Stage Re<<
6006	X COUPLING	Rotor E/F		-100 .. 800 Ω	398 Ω	Coupling Reactance
6007	R SERIES	Rotor E/F		0 .. 999 Ω	50 Ω	Series Resistance (e.g. Meas. Brushes)
6008	I RE<	Rotor E/F		1.0 .. 50.0 mA; 0	2.0 mA	Pickup Value of Failure Detection Ire<
6009	PHI I RE	Rotor E/F		-15.0 .. 15.0 °	0.0 °	Correction Angle for Ire
6101	REF 1-3Hz	REF 1-3Hz		OFF ON Block relay	OFF	Rotor Earth Fault Protection (1-3Hz)
6102	RE< WARN	REF 1-3Hz		5.0 .. 80.0 kΩ	40.0 kΩ	Pickup Value of Warning Stage Re<
6103	RE<< TRIP	REF 1-3Hz		1.0 .. 10.0 kΩ	5.0 kΩ	Pickup Value of Tripping Stage Re<<
6104	T-WARN-RE<	REF 1-3Hz		0.00 .. 60.00 sec; ∞	10.00 sec	Time Delay of Warning Stage Re<
6105	T-TRIP-RE<<	REF 1-3Hz		0.00 .. 60.00 sec; ∞	1.00 sec	Time Delay of Tripping Stage Re<<
6106	Qc <	REF 1-3Hz		0.00 .. 1.00 mAs	0.02 mAs	Pickup Value of open Rotor Circuit (Qc)
6107A	TEST RESISTOR	REF 1-3Hz		1.0 .. 10.0 kΩ	3.3 kΩ	Testing Resistor
6501	STARTUP MOTOR	Start Motor		OFF ON Block relay	OFF	Motor Starting Time Supervision
6502	START. CURRENT	Start Motor	5A	0.50 .. 80.00 A	15.60 A	Starting Current of Motor
			1A	0.10 .. 16.00 A	3.12 A	
6503	STARTING TIME	Start Motor		1.0 .. 180.0 sec	8.5 sec	Starting Time of Motor
6504	LOCK ROTOR TIME	Start Motor		0.5 .. 120.0 sec; ∞	6.0 sec	Permissible Locked Rotor Time
6505	I MOTOR START	Start Motor	5A	3.00 .. 50.00 A	8.00 A	Current Pickup Value of Motor Starting
			1A	0.60 .. 10.00 A	1.60 A	
6601	RESTART INHIBIT	Restart Motor		OFF ON Block relay	OFF	Restart Inhibit for Motors
6602	IStart/IMOTnom	Restart Motor		1.5 .. 10.0	4.9	I Start / I Motor nominal
6603	T START MAX	Restart Motor		3.0 .. 320.0 sec	8.5 sec	Maximum Permissible Starting Time
6604	T EQUAL	Restart Motor		0.0 .. 320.0 min	1.0 min	Temperature Equalization Time
6606	MAX.WARM STARTS	Restart Motor		1 .. 4	2	Permissible Number of Warm Starts
6607	#COLD-#WARM	Restart Motor		1 .. 2	1	Number of Cold Starts - Warm Starts
6608	Kτ at STOP	Restart Motor		1.0 .. 100.0	5.0	Extension of Time Constant at Stop
6609	Kτ at RUNNING	Restart Motor		1.0 .. 100.0	2.0	Extension of Time Constant at Running
6610	T MIN. INHIBIT	Restart Motor		0.2 .. 120.0 min	6.0 min	Minimum Restart Inhibit Time
7001	BREAKER FAILURE	Breaker Failure		OFF ON Block relay	OFF	Breaker Failure Protection
7002	TRIP INTERN	Breaker Failure		OFF BO12 CFC	OFF	Start with Internal TRIP Command
7003	CIRC. BR. I>	Breaker Failure	5A	0.20 .. 10.00 A	1.00 A	Supervision Current Pickup
			1A	0.04 .. 2.00 A	0.20 A	
7004	TRIP-Timer	Breaker Failure		0.06 .. 60.00 sec; ∞	0.25 sec	TRIP-Timer

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
7101	INADVERT. EN.	Inadvert. En.		OFF ON Block relay	OFF	Inadvertent Energisation
7102	I STAGE	Inadvert. En.	5A	0.5 .. 100.0 A; ∞	1.5 A	I Stage Pickup
			1A	0.1 .. 20.0 A; ∞	0.3 A	
7103	RELEASE U1<	Inadvert. En.		10.0 .. 125.0 V; 0	50.0 V	Release Threshold U1<
7104	PICK UP T U1<	Inadvert. En.		0.00 .. 60.00 sec; ∞	5.00 sec	Pickup Time Delay T U1<
7105	DROP OUT T U1<	Inadvert. En.		0.00 .. 60.00 sec; ∞	1.00 sec	Drop Out Time Delay T U1<
7201	DC PROTECTION	DC Protection		OFF ON Block relay	OFF	DC Voltage/Current Protection
7202	MEAS.METHOD	DC Protection		mean value RMS	mean value	Measurement Method (MEAN/RMS Values)
7203	DC >/<	DC Protection		DC > DC <	DC >	Method of Operation (DC >/<)
7204	U DC ><	DC Protection		0.1 .. 8.5 V	2.0 V	DC Voltage Pickup
7205	I DC ><	DC Protection		0.2 .. 17.0 mA	4.0 mA	DC Current Pickup
7206	T DC	DC Protection		0.00 .. 60.00 sec; ∞	2.00 sec	Time Delay for Trip of DC Protection
7301	20 mA (B1/1) =	Analog Outputs		10.0 .. 1000.0 %	200.0 %	20 mA (B1/1) correspond to
7302	MIN VALUE(B1/1)	Analog Outputs		0.0 .. 5.0 mA	1.0 mA	Output value (B1/1) valid from
7303	20 mA (B2/1) =	Analog Outputs		10.0 .. 1000.0 %	200.0 %	20 mA (B2/1) correspond to
7304	MIN VALUE(B2/1)	Analog Outputs		0.0 .. 5.0 mA	1.0 mA	Output value (B2/1) valid from
7305	20 mA (D1/1) =	Analog Outputs		10.0 .. 1000.0 %	200.0 %	20 mA (D1/1) correspond to
7306	MIN VALUE(D1/1)	Analog Outputs		0.0 .. 5.0 mA	1.0 mA	Output value (D1/1) valid from
7307	20 mA (D2/1) =	Analog Outputs		10.0 .. 1000.0 %	200.0 %	20 mA (D2/1) correspond to
7308	MIN VALUE(D2/1)	Analog Outputs		0.0 .. 5.0 mA	1.0 mA	Output value (D2/1) valid from
7310	MIN. VALUE B1/2	Analog Outputs		-200.00 .. 100.00 %	0.00 %	Minimum Percentage Output Value (B1/2)
7311	MIN.OUTPUT B1/2	Analog Outputs		0 .. 10 mA	4 mA	Minimum Current Output Value (B1/2)
7312	MAX. VALUE B1/2	Analog Outputs		10.00 .. 200.00 %	100.00 %	Maximum Percentage Output Value (B1/2)
7313	MAX.OUTPUT B1/2	Analog Outputs		10 .. 22 mA; 0	20 mA	Maximum Current Output Value (B1/2)
7320	MIN. VALUE B2/2	Analog Outputs		-200.00 .. 100.00 %	0.00 %	Minimum Percentage Output Value (B2/2)
7321	MIN.OUTPUT B2/2	Analog Outputs		0 .. 10 mA	4 mA	Minimum Current Output Value (B2/2)
7322	MAX. VALUE B2/2	Analog Outputs		10.00 .. 200.00 %	100.00 %	Maximum Percentage Output Value (B2/2)
7323	MAX.OUTPUT B2/2	Analog Outputs		10 .. 22 mA; 0	20 mA	Maximum Current Output Value (B2/2)
7330	MIN. VALUE D1/2	Analog Outputs		-200.00 .. 100.00 %	0.00 %	Minimum Percentage Output Value (D1/2)
7331	MIN.OUTPUT D1/2	Analog Outputs		0 .. 10 mA	4 mA	Minimum Current Output Value (D1/2)
7332	MAX. VALUE D1/2	Analog Outputs		10.00 .. 200.00 %	100.00 %	Maximum Percentage Output Value (D1/2)
7333	MAX.OUTPUT D1/2	Analog Outputs		10 .. 22 mA; 0	20 mA	Maximum Current Output Value (D1/2)
7340	MIN. VALUE D2/2	Analog Outputs		-200.00 .. 100.00 %	0.00 %	Minimum Percentage Output Value (D2/2)
7341	MIN.OUTPUT D2/2	Analog Outputs		0 .. 10 mA	4 mA	Minimum Current Output Value (D2/2)
7342	MAX. VALUE D2/2	Analog Outputs		10.00 .. 200.00 %	100.00 %	Maximum Percentage Output Value (D2/2)
7343	MAX.OUTPUT D2/2	Analog Outputs		10 .. 22 mA; 0	20 mA	Maximum Current Output Value (D2/2)
8001	FUSE FAIL MON.	Supervision		OFF ON	OFF	Fuse Failure Monitor
8101	MEASURE. SUPERV	Measurem.Superv		OFF ON	OFF	Measurement Supervision

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
8102	BALANCE U-LIMIT	Measurem.Superv		10 .. 100 V	50 V	Voltage Threshold for Balance Monitoring
8103	BAL. FACTOR U	Measurem.Superv		0.58 .. 0.90	0.75	Balance Factor for Voltage Monitor
8104	BAL. I LIMIT S1	Measurem.Superv	5A	0.50 .. 5.00 A	2.50 A	Current Balance Monitor Side 1
			1A	0.10 .. 1.00 A	0.50 A	
8105	BAL. FACT. I S1	Measurem.Superv		0.10 .. 0.90	0.50	Balance Factor for Current Monitor S1
8106	BAL. I LIMIT S2	Measurem.Superv	5A	0.50 .. 5.00 A	2.50 A	Current Balance Monitor Side 2
			1A	0.10 .. 1.00 A	0.50 A	
8107	BAL. FACT. I S2	Measurem.Superv		0.10 .. 0.90	0.50	Balance Factor for Current Monitor S2
8108	SUM.thres. U	Measurem.Superv		10 .. 200 V	10 V	Summation Thres. for Volt. Monitoring
8109	SUM.Fact. U	Measurem.Superv		0.60 .. 0.95 ; 0	0.75	Factor for Volt. Sum. Monitoring
8110	ΣI THRESHOLD S1	Measurem.Superv	5A	0.25 .. 10.00 A	0.50 A	Summated Cur. Mon. Threshold on Side 1
			1A	0.05 .. 2.00 A	0.10 A	
8111	ΣI FACTOR S1	Measurem.Superv		0.00 .. 0.95	0.10	Summated Current Mon. Factor on Side 1
8112	ΣI THRESHOLD S2	Measurem.Superv	5A	0.25 .. 10.00 A	0.50 A	Summated Cur. Mon. Threshold on Side 2
			1A	0.05 .. 2.00 A	0.10 A	
8113	ΣI FACTOR S2	Measurem.Superv		0.00 .. 0.95	0.10	Summated Current Mon. Factor on Side 2
8201	TRIP Cir. SUP.	TripCirc.Superv		OFF ON	OFF	TRIP Circuit Supervision
8501	MEAS. VALUE 1>	Threshold		Disabled P Q Delta P UL1E UL2E UL3E UE U0 U1 U2 UE3h IEE1 IEE2 3I0 I1 I2 PHI PF Transducer 1	Disabled	Measured Value for Threshold MV1>
8502	THRESHOLD MV1>	Threshold		-200 .. 200 %	100 %	Pickup Value of Measured Value MV1>
8503	MEAS. VALUE 2<	Threshold		Disabled P Q Delta P UL1E UL2E UL3E UE U0 U1 U2 UE3h IEE1 IEE2 3I0 I1 I2 PHI PF Transducer 1	Disabled	Measured Value for Threshold MV2<
8504	THRESHOLD MV2<	Threshold		-200 .. 200 %	100 %	Pickup Value of Measured Value MV2<

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
8505	MEAS. VALUE 3>	Threshold		Disabled P Q Delta P UL1E UL2E UL3E UE U0 U1 U2 UE3h IEE1 IEE2 3I0 I1 I2 PHI PF Transducer 1	Disabled	Measured Value for Threshold MV3>
8506	THRESHOLD MV3>	Threshold		-200 .. 200 %	100 %	Pickup Value of Measured Value MV3>
8507	MEAS. VALUE 4<	Threshold		Disabled P Q Delta P UL1E UL2E UL3E UE U0 U1 U2 UE3h IEE1 IEE2 3I0 I1 I2 PHI PF Transducer 1	Disabled	Measured Value for Threshold MV4<
8508	THRESHOLD MV4<	Threshold		-200 .. 200 %	100 %	Pickup Value of Measured Value MV4<
8509	MEAS. VALUE 5>	Threshold		Disabled P Q Delta P UL1E UL2E UL3E UE U0 U1 U2 UE3h IEE1 IEE2 3I0 I1 I2 PHI PF Transducer 1	Disabled	Measured Value for Threshold MV5>
8510	THRESHOLD MV5>	Threshold		-200 .. 200 %	100 %	Pickup Value of Measured Value MV5>

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
8511	MEAS. VALUE 6<	Threshold		Disabled P Q Delta P UL1E UL2E UL3E UE U0 U1 U2 UE3h IEE1 IEE2 3I0 I1 I2 PHI PF Transducer 1	Disabled	Measured Value for Threshold MV6<
8512	THRESHOLD MV6<	Threshold		-200 .. 200 %	100 %	Pickup Value of Measured Value MV6<
8513	MEAS. VALUE 7>	Threshold		Disabled P Q Delta P UL1E UL2E UL3E UE U0 U1 U2 UE3h IEE1 IEE2 3I0 I1 I2 PHI PF Transducer 1	Disabled	Measured Value for Threshold MV7>
8514	THRESHOLD MV7>	Threshold		-200 .. 200 %	100 %	Threshold of Measured Value MV7>
8515	MEAS. VALUE 8<	Threshold		Disabled P Q Delta P UL1E UL2E UL3E UE U0 U1 U2 UE3h IEE1 IEE2 3I0 I1 I2 PHI PF Transducer 1	Disabled	Measured Value for Threshold MV8<
8516	THRESHOLD MV8<	Threshold		-200 .. 200 %	100 %	Threshold of Measured Value MV8<

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
8517	MEAS. VALUE 9>	Threshold		Disabled P Q Delta P UL1E UL2E UL3E UE U0 U1 U2 UE3h IEE1 IEE2 3I0 I1 I2 PHI PF Transducer 1	Disabled	Measured Value for Threshold MV9>
8518	THRESHOLD MV9>	Threshold		-200 .. 200 %	100 %	Threshold of Measured Value MV9>
8519	MEAS. VALUE 10<	Threshold		Disabled P Q Delta P UL1E UL2E UL3E UE U0 U1 U2 UE3h IEE1 IEE2 3I0 I1 I2 PHI PF Transducer 1	Disabled	Measured Value for Threshold MV10<
8520	THRESHOLD MV10<	Threshold		-200 .. 200 %	100 %	Threshold of Measured Value MV10<
8601	EXTERN TRIP 1	External Trips		OFF ON Block relay	OFF	External Trip Function 1
8602	T DELAY	External Trips		0.00 .. 60.00 sec; ∞	1.00 sec	Ext. Trip 1 Time Delay
8701	EXTERN TRIP 2	External Trips		OFF ON Block relay	OFF	External Trip Function 2
8702	T DELAY	External Trips		0.00 .. 60.00 sec; ∞	1.00 sec	Ext. Trip 2 Time Delay
8801	EXTERN TRIP 3	External Trips		OFF ON Block relay	OFF	External Trip Function 3
8802	T DELAY	External Trips		0.00 .. 60.00 sec; ∞	1.00 sec	Ext. Trip 3 Time Delay
8901	EXTERN TRIP 4	External Trips		OFF ON Block relay	OFF	External Trip Function 4
8902	T DELAY	External Trips		0.00 .. 60.00 sec; ∞	1.00 sec	Ext. Trip 4 Time Delay
9011A	RTD 1 TYPE	RTD-Box		Not connected Pt 100 Ω Ni 120 Ω Ni 100 Ω	Pt 100 Ω	RTD 1: Type
9012A	RTD 1 LOCATION	RTD-Box		Oil Ambient Winding Bearing Other	Winding	RTD 1: Location
9013	RTD 1 STAGE 1	RTD-Box		-50 .. 250 °C; ∞	100 °C	RTD 1: Temperature Stage 1 Pickup
9014	RTD 1 STAGE 1	RTD-Box		-58 .. 482 °F; ∞	212 °F	RTD 1: Temperature Stage 1 Pickup

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
9015	RTD 1 STAGE 2	RTD-Box		-50 .. 250 °C; ∞	120 °C	RTD 1: Temperature Stage 2 Pickup
9016	RTD 1 STAGE 2	RTD-Box		-58 .. 482 °F; ∞	248 °F	RTD 1: Temperature Stage 2 Pickup
9021A	RTD 2 TYPE	RTD-Box		Not connected Pt 100 Ω Ni 120 Ω Ni 100 Ω	Not connected	RTD 2: Type
9022A	RTD 2 LOCATION	RTD-Box		Oil Ambient Winding Bearing Other	Other	RTD 2: Location
9023	RTD 2 STAGE 1	RTD-Box		-50 .. 250 °C; ∞	100 °C	RTD 2: Temperature Stage 1 Pickup
9024	RTD 2 STAGE 1	RTD-Box		-58 .. 482 °F; ∞	212 °F	RTD 2: Temperature Stage 1 Pickup
9025	RTD 2 STAGE 2	RTD-Box		-50 .. 250 °C; ∞	120 °C	RTD 2: Temperature Stage 2 Pickup
9026	RTD 2 STAGE 2	RTD-Box		-58 .. 482 °F; ∞	248 °F	RTD 2: Temperature Stage 2 Pickup
9031A	RTD 3 TYPE	RTD-Box		Not connected Pt 100 Ω Ni 120 Ω Ni 100 Ω	Not connected	RTD 3: Type
9032A	RTD 3 LOCATION	RTD-Box		Oil Ambient Winding Bearing Other	Other	RTD 3: Location
9033	RTD 3 STAGE 1	RTD-Box		-50 .. 250 °C; ∞	100 °C	RTD 3: Temperature Stage 1 Pickup
9034	RTD 3 STAGE 1	RTD-Box		-58 .. 482 °F; ∞	212 °F	RTD 3: Temperature Stage 1 Pickup
9035	RTD 3 STAGE 2	RTD-Box		-50 .. 250 °C; ∞	120 °C	RTD 3: Temperature Stage 2 Pickup
9036	RTD 3 STAGE 2	RTD-Box		-58 .. 482 °F; ∞	248 °F	RTD 3: Temperature Stage 2 Pickup
9041A	RTD 4 TYPE	RTD-Box		Not connected Pt 100 Ω Ni 120 Ω Ni 100 Ω	Not connected	RTD 4: Type
9042A	RTD 4 LOCATION	RTD-Box		Oil Ambient Winding Bearing Other	Other	RTD 4: Location
9043	RTD 4 STAGE 1	RTD-Box		-50 .. 250 °C; ∞	100 °C	RTD 4: Temperature Stage 1 Pickup
9044	RTD 4 STAGE 1	RTD-Box		-58 .. 482 °F; ∞	212 °F	RTD 4: Temperature Stage 1 Pickup
9045	RTD 4 STAGE 2	RTD-Box		-50 .. 250 °C; ∞	120 °C	RTD 4: Temperature Stage 2 Pickup
9046	RTD 4 STAGE 2	RTD-Box		-58 .. 482 °F; ∞	248 °F	RTD 4: Temperature Stage 2 Pickup
9051A	RTD 5 TYPE	RTD-Box		Not connected Pt 100 Ω Ni 120 Ω Ni 100 Ω	Not connected	RTD 5: Type
9052A	RTD 5 LOCATION	RTD-Box		Oil Ambient Winding Bearing Other	Other	RTD 5: Location
9053	RTD 5 STAGE 1	RTD-Box		-50 .. 250 °C; ∞	100 °C	RTD 5: Temperature Stage 1 Pickup
9054	RTD 5 STAGE 1	RTD-Box		-58 .. 482 °F; ∞	212 °F	RTD 5: Temperature Stage 1 Pickup

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
9055	RTD 5 STAGE 2	RTD-Box		-50 .. 250 °C; ∞	120 °C	RTD 5: Temperature Stage 2 Pickup
9056	RTD 5 STAGE 2	RTD-Box		-58 .. 482 °F; ∞	248 °F	RTD 5: Temperature Stage 2 Pickup
9061A	RTD 6 TYPE	RTD-Box		Not connected Pt 100 Ω Ni 120 Ω Ni 100 Ω	Not connected	RTD 6: Type
9062A	RTD 6 LOCATION	RTD-Box		Oil Ambient Winding Bearing Other	Other	RTD 6: Location
9063	RTD 6 STAGE 1	RTD-Box		-50 .. 250 °C; ∞	100 °C	RTD 6: Temperature Stage 1 Pickup
9064	RTD 6 STAGE 1	RTD-Box		-58 .. 482 °F; ∞	212 °F	RTD 6: Temperature Stage 1 Pickup
9065	RTD 6 STAGE 2	RTD-Box		-50 .. 250 °C; ∞	120 °C	RTD 6: Temperature Stage 2 Pickup
9066	RTD 6 STAGE 2	RTD-Box		-58 .. 482 °F; ∞	248 °F	RTD 6: Temperature Stage 2 Pickup
9071A	RTD 7 TYPE	RTD-Box		Not connected Pt 100 Ω Ni 120 Ω Ni 100 Ω	Not connected	RTD 7: Type
9072A	RTD 7 LOCATION	RTD-Box		Oil Ambient Winding Bearing Other	Other	RTD 7: Location
9073	RTD 7 STAGE 1	RTD-Box		-50 .. 250 °C; ∞	100 °C	RTD 7: Temperature Stage 1 Pickup
9074	RTD 7 STAGE 1	RTD-Box		-58 .. 482 °F; ∞	212 °F	RTD 7: Temperature Stage 1 Pickup
9075	RTD 7 STAGE 2	RTD-Box		-50 .. 250 °C; ∞	120 °C	RTD 7: Temperature Stage 2 Pickup
9076	RTD 7 STAGE 2	RTD-Box		-58 .. 482 °F; ∞	248 °F	RTD 7: Temperature Stage 2 Pickup
9081A	RTD 8 TYPE	RTD-Box		Not connected Pt 100 Ω Ni 120 Ω Ni 100 Ω	Not connected	RTD 8: Type
9082A	RTD 8 LOCATION	RTD-Box		Oil Ambient Winding Bearing Other	Other	RTD 8: Location
9083	RTD 8 STAGE 1	RTD-Box		-50 .. 250 °C; ∞	100 °C	RTD 8: Temperature Stage 1 Pickup
9084	RTD 8 STAGE 1	RTD-Box		-58 .. 482 °F; ∞	212 °F	RTD 8: Temperature Stage 1 Pickup
9085	RTD 8 STAGE 2	RTD-Box		-50 .. 250 °C; ∞	120 °C	RTD 8: Temperature Stage 2 Pickup
9086	RTD 8 STAGE 2	RTD-Box		-58 .. 482 °F; ∞	248 °F	RTD 8: Temperature Stage 2 Pickup
9091A	RTD 9 TYPE	RTD-Box		Not connected Pt 100 Ω Ni 120 Ω Ni 100 Ω	Not connected	RTD 9: Type
9092A	RTD 9 LOCATION	RTD-Box		Oil Ambient Winding Bearing Other	Other	RTD 9: Location
9093	RTD 9 STAGE 1	RTD-Box		-50 .. 250 °C; ∞	100 °C	RTD 9: Temperature Stage 1 Pickup
9094	RTD 9 STAGE 1	RTD-Box		-58 .. 482 °F; ∞	212 °F	RTD 9: Temperature Stage 1 Pickup

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
9095	RTD 9 STAGE 2	RTD-Box		-50 .. 250 °C; ∞	120 °C	RTD 9: Temperature Stage 2 Pickup
9096	RTD 9 STAGE 2	RTD-Box		-58 .. 482 °F; ∞	248 °F	RTD 9: Temperature Stage 2 Pickup
9101A	RTD10 TYPE	RTD-Box		Not connected Pt 100 Ω Ni 120 Ω Ni 100 Ω	Not connected	RTD10: Type
9102A	RTD10 LOCATION	RTD-Box		Oil Ambient Winding Bearing Other	Other	RTD10: Location
9103	RTD10 STAGE 1	RTD-Box		-50 .. 250 °C; ∞	100 °C	RTD10: Temperature Stage 1 Pickup
9104	RTD10 STAGE 1	RTD-Box		-58 .. 482 °F; ∞	212 °F	RTD10: Temperature Stage 1 Pickup
9105	RTD10 STAGE 2	RTD-Box		-50 .. 250 °C; ∞	120 °C	RTD10: Temperature Stage 2 Pickup
9106	RTD10 STAGE 2	RTD-Box		-58 .. 482 °F; ∞	248 °F	RTD10: Temperature Stage 2 Pickup
9111A	RTD11 TYPE	RTD-Box		Not connected Pt 100 Ω Ni 120 Ω Ni 100 Ω	Not connected	RTD11: Type
9112A	RTD11 LOCATION	RTD-Box		Oil Ambient Winding Bearing Other	Other	RTD11: Location
9113	RTD11 STAGE 1	RTD-Box		-50 .. 250 °C; ∞	100 °C	RTD11: Temperature Stage 1 Pickup
9114	RTD11 STAGE 1	RTD-Box		-58 .. 482 °F; ∞	212 °F	RTD11: Temperature Stage 1 Pickup
9115	RTD11 STAGE 2	RTD-Box		-50 .. 250 °C; ∞	120 °C	RTD11: Temperature Stage 2 Pickup
9116	RTD11 STAGE 2	RTD-Box		-58 .. 482 °F; ∞	248 °F	RTD11: Temperature Stage 2 Pickup
9121A	RTD12 TYPE	RTD-Box		Not connected Pt 100 Ω Ni 120 Ω Ni 100 Ω	Not connected	RTD12: Type
9122A	RTD12 LOCATION	RTD-Box		Oil Ambient Winding Bearing Other	Other	RTD12: Location
9123	RTD12 STAGE 1	RTD-Box		-50 .. 250 °C; ∞	100 °C	RTD12: Temperature Stage 1 Pickup
9124	RTD12 STAGE 1	RTD-Box		-58 .. 482 °F; ∞	212 °F	RTD12: Temperature Stage 1 Pickup
9125	RTD12 STAGE 2	RTD-Box		-50 .. 250 °C; ∞	120 °C	RTD12: Temperature Stage 2 Pickup
9126	RTD12 STAGE 2	RTD-Box		-58 .. 482 °F; ∞	248 °F	RTD12: Temperature Stage 2 Pickup

A.8 Information List

Indications for IEC 60 870-5-103 are always reported ON / OFF if they are subject to general interrogation for IEC 60 870-5-103. If not, they are reported only as ON.

New user-defined indications or such newly allocated to IEC 60 870-5-103 are set to ON / OFF and subjected to general interrogation if the information type is not a spontaneous event („.._Ev“). Further information on indications can be found in detail in the SIPROTEC 4 System Description, Order No. E50417-H1100-C151.

In columns „Event Log“, „Trip Log“ and „Ground Fault Log“ the following applies:

UPPER CASE NOTATION “ON/OFF”: definitely set, not allocatable

lower case notation “on/off”: preset, allocatable

*: not preset, allocatable

<blank>: neither preset nor allocatable

In column „Marked in Oscill.Record“ the following applies:

UPPER CASE NOTATION “M”: definitely set, not allocatable

lower case notation “m”: preset, allocatable

*: not preset, allocatable

<blank>: neither preset nor allocatable

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log On/Off	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	Information Number	Data Unit	General Interrogation
-	Reset LED (Reset LED)	Device	IntSP	on	*		*	LED			BO		70	19	1	No
-	Test mode (Test mode)	Device	IntSP	on off	*		*	LED			BO		70	21	1	Yes
-	Stop data transmission (DataStop)	Device	IntSP	on off	*		*	LED			BO		70	20	1	Yes
-	Unlock data transmission via BI (UnlockDT)	Device	IntSP				*									
-	>Back Light on (>Light on)	Device	SP	on off	*		*	LED	BI		BO					
-	Clock Synchronization (SynchClock)	Device	IntSP_Ev	*	*		*	LED			BO					
-	Hardware Test Mode (HWTestMod)	Device	IntSP	on off	*		*	LED			BO					
-	Disturbance CFC (Distur.CFC)	Device	OUT	on off	*			LED			BO					
-	Setting Group A is active (GroupA act)	Change Group	IntSP	ON OFF	*		*	LED			BO		70	23	1	Yes
-	Setting Group B is active (GroupB act)	Change Group	IntSP	ON OFF	*		*	LED			BO		70	24	1	Yes
-	Fault Recording Start (FltRecSta)	Osc. Fault Rec.	IntSP	ON OFF	*		*	LED			BO					
-	Control Authority (Cntrl Auth)	Cntrl Authority	DP	on off	*			LED			BO		101	85	1	Yes
-	Controlmode LOCAL (ModeLOCAL)	Cntrl Authority	DP	on off	*			LED			BO		101	86	1	Yes
-	Controlmode REMOTE (ModeREMOTE)	Cntrl Authority	IntSP	on off	*			LED			BO					

No.	Description	Function	Type of Information	Log Buffers: Event Log ON/OFF	Log Buffers: Trip (Fault) Log On/Off	Log Buffers: Ground Fault Log ON/OFF	Log Buffers: Marked in Oscill. Record	Configurable in Matrix: LED	Configurable in Matrix: Binary Input	Configurable in Matrix: Function Key	Configurable in Matrix: Relay	Configurable in Matrix: Chatter Suppression	IEC 60870-5-103: Type	IEC 60870-5-103: Information Number	IEC 60870-5-103: Data Unit	IEC 60870-5-103: General Interrogation
-	Control Authority (Cntrl Auth)	Cntrl Authority	IntSP	on off	*			LED			BO					
-	Controlmode LOCAL (ModeLOCAL)	Cntrl Authority	IntSP	on off	*			LED			BO					
-	Reset Minimum and Maximum counter (ResMinMax)	Min/Max meter	IntSP_Ev	on	*			LED	BI		BO					
-	Reset meter (Meter res)	Energy	IntSP_Ev	on	*			LED	BI		BO					
-	Error Systeminterface (SysIntErr.)	Protocol	IntSP	on off	*			LED			BO					
1	No Function configured (Not configured)	Device	SP													
2	Function Not Available (Non Existent)	Device	SP													
3	>Synchronize Internal Real Time Clock (>Time Synch)	Device	SP_Ev	*	*		*	LED	BI		BO		135	48	1	No
4	>Trigger Waveform Capture (>Trig.Wave.Cap.)	Osc. Fault Rec.	SP	*	*		m	LED	BI		BO		135	49	1	Yes
5	>Reset LED (>Reset LED)	Device	SP	*	*		*	LED	BI		BO		135	50	1	Yes
7	>Setting Group Select Bit 0 (>Set Group Bit0)	Change Group	SP	*	*		*	LED	BI		BO		135	51	1	Yes
009.0100	Failure EN100 Modul (Failure Modul)	EN100-Modul 1	IntSP	on off	*		*	LED			BO					
009.0101	Failure EN100 Link Channel 1 (Ch1) (Fail Ch1)	EN100-Modul 1	IntSP	on off	*		*	LED			BO					
009.0102	Failure EN100 Link Channel 2 (Ch2) (Fail Ch2)	EN100-Modul 1	IntSP	on off	*		*	LED			BO					
15	>Test mode (>Test mode)	Device	SP	*	*		*	LED	BI		BO		135	53	1	Yes
16	>Stop data transmission (>DataStop)	Device	SP	*	*		*	LED	BI		BO		135	54	1	Yes
51	Device is Operational and Protecting (Device OK)	Device	OUT	ON OFF	*		*	LED			BO		135	81	1	Yes
52	At Least 1 Protection Funct. is Active (ProtActive)	Device	IntSP	ON OFF	*		*	LED			BO		70	18	1	Yes
55	Reset Device (Reset Device)	Device	OUT	ON	*		*	LED			BO					
56	Initial Start of Device (Initial Start)	Device	OUT	ON	*		*	LED			BO		70	5	1	No
67	Resume (Resume)	Device	OUT	ON	*		*	LED			BO					
68	Clock Synchronization Error (Clock SyncError)	Supervision	OUT	ON OFF	*		*	LED			BO					
69	Daylight Saving Time (DayLightSavTime)	Device	OUT	on off	*		*	LED			BO					
70	Setting calculation is running (Settings Calc.)	Device	OUT	ON OFF	*		*	LED			BO		70	22	1	Yes
71	Settings Check (Settings Check)	Device	OUT	*	*		*	LED			BO					
72	Level-2 change (Level-2 change)	Device	OUT	ON OFF	*		*	LED			BO					
73	Local setting change (Local change)	Device	OUT	*	*		*									
110	Event lost (Event Lost)	Supervision	OUT_Ev	ON	*		*	LED			BO		135	130	1	No
113	Flag Lost (Flag Lost)	Supervision	OUT	ON	*		m	LED			BO		135	136	1	Yes
125	Chatter ON (Chatter ON)	Device	OUT	on off	*		*	LED			BO		135	145	1	Yes
140	Error with a summary alarm (Error Sum Alarm)	Supervision	OUT	*	*		*	LED			BO					

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log On/Off	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	Information Number	Data Unit	General Interrogation
147	Error Power Supply (Error Pwr-Supply)	Supervision	OUT	ON OFF	*		*	LED			BO					
160	Alarm Summary Event (Alarm Sum Event)	Supervision	OUT	*	*		*	LED			BO		70	46	1	Yes
161	Failure: General Current Supervision (Fail I Superv.)	Measurem.Superv	OUT	on off	*		*	LED			BO		70	32	1	Yes
164	Failure: General Voltage Supervision (Fail U Superv.)	Measurem.Superv	OUT	on off	*		*	LED			BO		70	33	1	Yes
165	Failure: Voltage Summation Phase-Earth (Fail Σ U Ph-E)	Measurem.Superv	OUT	on off	*		*	LED			BO		135	184	1	Yes
167	Failure: Voltage Balance (Fail U balance)	Measurem.Superv	OUT	on off	*		*	LED			BO		135	186	1	Yes
171	Failure: Phase Sequence (Fail Ph. Seq.)	Measurem.Superv	OUT	on off	*		*	LED			BO		70	35	1	Yes
176	Failure: Phase Sequence Voltage (Fail Ph. Seq. U)	Measurem.Superv	OUT	on off	*		*	LED			BO		135	192	1	Yes
177	Failure: Battery empty (Fail Battery)	Supervision	OUT	ON OFF	*		*	LED			BO					
181	Error: A/D converter (Error A/D-conv.)	Supervision	OUT	ON OFF	*		*	LED			BO					
185	Error Board 3 (Error Board 3)	Supervision	OUT	ON OFF												
187	Error Board 5 (Error Board 5)	Supervision	OUT	ON OFF												
188	Error Board 6 (Error Board 6)	Supervision	OUT	ON OFF												
190	Error Board 0 (Error Board 0)	Supervision	OUT	ON OFF												
191	Error: Offset (Error Offset)	Supervision	OUT	ON OFF	*		*	LED			BO					
193	Alarm: NO calibration data available (Alarm NO calibr)	Supervision	OUT	ON OFF	*		*	LED			BO					
194	Error: Neutral CT different from MLFB (Error neutralCT)	Supervision	OUT	ON OFF	*		*	LED			BO					
197	Measurement Supervision is switched OFF (MeasSup OFF)	Measurem.Superv	OUT	on off	*		*	LED			BO		135	197	1	Yes
203	Waveform data deleted (Wave. deleted)	Osc. Fault Rec.	OUT_Ev	ON	*		*	LED			BO		135	203	1	No
210	Err:1A/5Ajumper different from settingS1 (Err1A/5AwrongS1)	Supervision	OUT	ON OFF	*		*	LED			BO					
211	Err:1A/5Ajumper different from settingS2 (Err1A/5AwrongS2)	Supervision	OUT	ON OFF	*		*	LED			BO					
212	Err: TD1 jumper different from setting (Err. TD1 jumper)	Supervision	OUT	ON OFF	*		*	LED			BO					
213	Err: TD2 jumper different from setting (Err. TD2 jumper)	Supervision	OUT	ON OFF	*		*	LED			BO					
214	Err: TD3 jumper different from setting (Err. TD3 jumper)	Supervision	OUT	ON OFF	*		*	LED			BO					
230	Failure: Current Summation on Side 1 (Fail. Σ I Side1)	Measurem.Superv	OUT	on off	*		*	LED			BO		135	155	1	Yes
231	Failure: Current Summation on Side 2 (Fail. Σ I Side2)	Measurem.Superv	OUT	on off	*		*	LED			BO		135	158	1	Yes
264	Failure: RTD-Box 1 (Fail: RTD-Box 1)	Supervision	OUT	ON OFF	*		*	LED			BO		135	208	1	Yes
265	Failure: Phase Sequence I side 1 (FailPh.Seq I S1)	Measurem.Superv	OUT	on off	*		*	LED			BO		135	156	1	Yes

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				Event Log ON/OFF	Trip (Fault) Log On/Off	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	Information Number	Data Unit	General Interrogation
266	Failure: Phase Sequence I side 2 (FailPh.Seq I S2)	Measurem.Superv	OUT	on off	*		*	LED			BO		135	157	1	Yes
267	Failure: RTD-Box 2 (Fail: RTD-Box 2)	Supervision	OUT	ON OFF	*		*	LED			BO		135	209	1	Yes
272	Set Point Operating Hours (SP. Op Hours>)	SetPoint(Stat)	OUT	on off	*		*	LED			BO		135	229	1	Yes
284	Set Point I< alarm (SP. I<)	Set Points(MV)	OUT	*	*		*	LED			BO		135	244	1	Yes
301	Power System fault (Pow.Sys.Flt.)	Device	OUT	ON OFF	ON OFF		*						135	231	2	Yes
302	Fault Event (Fault Event)	Device	OUT	*	ON		*						135	232	2	Yes
320	Warn: Limit of Memory Data exceeded (Warn Mem. Data)	Device	OUT	on off	*		*	LED			BO					
321	Warn: Limit of Memory Parameter exceeded (Warn Mem. Para.)	Device	OUT	on off	*		*	LED			BO					
322	Warn: Limit of Memory Operation exceeded (Warn Mem. Oper.)	Device	OUT	on off	*		*	LED			BO					
323	Warn: Limit of Memory New exceeded (Warn Mem. New)	Device	OUT	on off	*		*	LED			BO					
361	>Failure: Feeder VT (MCB tripped) (>FAIL:Feeder VT)	P.System Data 1	SP	on off	*		*	LED	BI		BO		150	38	1	Yes
394	>UE 3rd Harm. MIN/MAX Buffer Reset (>UE3h MiMa Res.)	Min/Max meter	SP	on	*		*	LED	BI		BO					
396	>I1 MIN/MAX Buffer Reset (>I1 MiMaReset)	Min/Max meter	SP	on	*		*	LED	BI		BO					
399	>U1 MIN/MAX Buffer Reset (>U1 MiMa Reset)	Min/Max meter	SP	on	*		*	LED	BI		BO					
400	>P MIN/MAX Buffer Reset (>P MiMa Reset)	Min/Max meter	SP	on	*		*	LED	BI		BO					
402	>Q MIN/MAX Buffer Reset (>Q MiMa Reset)	Min/Max meter	SP	on	*		*	LED	BI		BO					
407	>Frq. MIN/MAX Buffer Reset (>Frq MiMa Reset)	Min/Max meter	SP	on	*		*	LED	BI		BO					
409	>BLOCK Op Counter (>BLOCK Op Count)	Statistics	SP	on off	*		*	LED	BI		BO					
501	Relay PICKUP (Relay PICKUP)	P.System Data 2	OUT	*	ON		m	LED			BO		150	151	2	Yes
511	Relay GENERAL TRIP command (Relay TRIP)	P.System Data 2	OUT	*	ON		m	LED			BO		150	161	2	Yes
545	Time from Pickup to drop out (PU Time)	Device	VI													
546	Time from Pickup to TRIP (TRIP Time)	Device	VI													
571	Fail.: Current symm. supervision side 1 (Fail. Isym 1)	Measurem.Superv	OUT	on off	*		*	LED			BO		150	196	1	Yes
572	Fail.: Current symm. supervision side 2 (Fail. Isym 2)	Measurem.Superv	OUT	on off	*		*	LED			BO		150	197	1	Yes
576	Primary fault current IL1 Side1 (IL1 S1:)	P.System Data 2	VI	*	ON OFF								150	193	4	No
577	Primary fault current IL2 Side1 (IL2 S1:)	P.System Data 2	VI	*	ON OFF								150	194	4	No
578	Primary fault current IL3 Side1 (IL3 S1:)	P.System Data 2	VI	*	ON OFF								150	195	4	No
579	Primary fault current IL1 Side2 (IL1 S2:)	P.System Data 2	VI	*	ON OFF								150	190	4	No
580	Primary fault current IL2 Side2 (IL2 S2:)	P.System Data 2	VI	*	ON OFF								150	191	4	No

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				Event Log ON/OFF	Trip (Fault) Log On/Off	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	Information Number	Data Unit	General Interrogation
581	Primary fault current IL3 Side2 (IL3 S2:)	P.System Data 2	VI	*	ON OFF								150	192	4	No
916	Increment of active energy (WpΔ=)	Energy	-													
917	Increment of reactive energy (WqΔ=)	Energy	-													
1020	Counter of operating hours (Op.Hours=)	Statistics	VI													
1202	>BLOCK IEE>> (>BLOCK IEE>>)	Sens. E Fault	SP	on off	*		*	LED	BI		BO		151	102	1	Yes
1203	>BLOCK IEE> (>BLOCK IEE>)	Sens. E Fault	SP	on off	*		*	LED	BI		BO		151	103	1	Yes
1221	IEE>> picked up (IEE>> picked up)	Sens. E Fault	OUT	*	on off		*	LED			BO		151	121	2	Yes
1223	IEE>> TRIP (IEE>> TRIP)	Sens. E Fault	OUT	*	on		*	LED			BO		151	123	2	Yes
1224	IEE> picked up (IEE> picked up)	Sens. E Fault	OUT	*	on off		*	LED			BO		151	124	2	Yes
1226	IEE> TRIP (IEE> TRIP)	Sens. E Fault	OUT	*	on		*	LED			BO		151	126	2	Yes
1231	>BLOCK sensitive earth current prot. (>BLOCK Sens. E)	Sens. E Fault	SP	*	*		*	LED	BI		BO					
1232	Earth current prot. is swiched OFF (IEE OFF)	Sens. E Fault	OUT	on off	*		*	LED			BO		151	132	1	Yes
1233	Earth current prot. is BLOCKED (IEE BLOCKED)	Sens. E Fault	OUT	on off	on off		*	LED			BO		151	133	1	Yes
1234	Earth current prot. is ACTIVE (IEE ACTIVE)	Sens. E Fault	OUT	on off	*		*	LED			BO		151	134	1	Yes
1403	>BLOCK breaker failure (>BLOCK BkrFail)	Breaker Failure	SP	*	*		*	LED	BI		BO					
1422	>Breaker contacts (>Break. Contact)	Breaker Failure	SP	on off	*		*	LED	BI		BO		166	120	1	Yes
1423	>ext. start 1 breaker failure prot. (>ext.start1 B/F)	Breaker Failure	SP	on off	*		*	LED	BI		BO		166	121	1	Yes
1441	>ext. start 2 breaker failure prot. (>ext.start2 B/F)	Breaker Failure	SP	on off	*		*	LED	BI		BO		166	122	1	Yes
1442	>int. start breaker failure prot. (>int. start B/F)	Breaker Failure	SP	on off	*		*	LED	BI		BO		166	123	1	Yes
1443	Breaker fail. started intern (int. start B/F)	Breaker Failure	OUT	on off	*		*	LED			BO		166	190	1	Yes
1444	Breaker failure I> (B/F I>)	Breaker Failure	OUT	on off	*		*	LED			BO		166	191	1	Yes
1451	Breaker failure is switched OFF (BkrFail OFF)	Breaker Failure	OUT	on off	*		*	LED			BO		166	151	1	Yes
1452	Breaker failure is BLOCKED (BkrFail BLOCK)	Breaker Failure	OUT	on off	on off		*	LED			BO		166	152	1	Yes
1453	Breaker failure is ACTIVE (Bkr-Fail ACTIVE)	Breaker Failure	OUT	on off	*		*	LED			BO		166	153	1	Yes
1455	Breaker failure protection: picked up (B/F picked up)	Breaker Failure	OUT	*	on off		*	LED			BO		166	155	2	Yes
1471	Breaker failure TRIP (BrkFailure TRIP)	Breaker Failure	OUT	*	on		m	LED			BO		166	171	2	Yes
1503	>BLOCK thermal overload protection (>BLK ThOverload)	Therm. Overload	SP	*	*		*	LED	BI		BO					
1506	>Reset memory for thermal replica O/L (>RM th.rep. O/L)	Therm. Overload	SP	on off	*		*	LED	BI		BO					
1507	>Emergency start O/L (>Emer.Start O/L)	Therm. Overload	SP	on off	*		*	LED	BI		BO		167	7	1	Yes

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log On/Off	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	Information Number	Data Unit	General Interrogation
1508	>Failure temperature input (>Fail.Temp.inp)	Therm. Overload	SP	on off	*		*	LED	BI		BO		167	8	1	Yes
1511	Thermal Overload Protection OFF (Th.Overload OFF)	Therm. Overload	OUT	on off	*		*	LED			BO		167	11	1	Yes
1512	Thermal Overload Protection BLOCKED (Th.Overload BLK)	Therm. Overload	OUT	on off	on off		*	LED			BO		167	12	1	Yes
1513	Overload Protection ACTIVE (Overload ACT)	Therm. Overload	OUT	on off	*		*	LED			BO		167	13	1	Yes
1514	Failure temperature input (Fail.Temp.inp)	Therm. Overload	OUT	on off	*		*	LED			BO		167	14	1	Yes
1515	Overload Current Alarm (I alarm) (O/L I Alarm)	Therm. Overload	OUT	on off	*		*	LED			BO		167	15	1	Yes
1516	Thermal Overload Alarm (O/L Θ Alarm)	Therm. Overload	OUT	on off	*		*	LED			BO		167	16	1	Yes
1517	Thermal Overload picked up (O/L Th. pick.up)	Therm. Overload	OUT	on off	*		*	LED			BO		167	17	1	Yes
1519	Reset memory for thermal replica O/L (RM th.rep. O/L)	Therm. Overload	OUT	on off	*		*	LED			BO		167	19	1	Yes
1521	Thermal Overload TRIP (ThOverload TRIP)	Therm. Overload	OUT	*	on		*	LED			BO		167	21	2	Yes
1720	>BLOCK direction I>> stage (>BLOCK dir.)	O/C Prot. I>>	SP	on off	*		*	LED	BI		BO		60	18	1	Yes
1721	>BLOCK I>> (>BLOCK I>>)	O/C Prot. I>>	SP	*	*		*	LED	BI		BO					
1722	>BLOCK I> (>BLOCK I>)	O/C Prot. I>	SP	*	*		*	LED	BI		BO					
1801	O/C fault detection stage I>> phase L1 (I>> Fault L1)	O/C Prot. I>>	OUT	*	on off		*	LED			BO		60	46	2	Yes
1802	O/C fault detection stage I>> phase L2 (I>> Fault L2)	O/C Prot. I>>	OUT	*	on off		*	LED			BO		60	47	2	Yes
1803	O/C fault detection stage I>> phase L3 (I>> Fault L3)	O/C Prot. I>>	OUT	*	on off		*	LED			BO		60	48	2	Yes
1806	O/C I>> direction forward (I>> forward)	O/C Prot. I>>	OUT	*	on off		*	LED			BO		60	208	2	Yes
1807	O/C I>> direction backward (I>> backward)	O/C Prot. I>>	OUT	*	on off		*	LED			BO		60	209	2	Yes
1808	O/C prot. I>> picked up (I>> picked up)	O/C Prot. I>>	OUT	*	on off		*	LED			BO		60	210	2	Yes
1809	O/C I>> TRIP (I>> TRIP)	O/C Prot. I>>	OUT	*	on		m	LED			BO		60	211	2	Yes
1811	O/C fault detection stage I> phase L1 (I> Fault L1)	O/C Prot. I>	OUT	*	on off		*	LED			BO		60	50	2	Yes
1812	O/C fault detection stage I> phase L2 (I> Fault L2)	O/C Prot. I>	OUT	*	on off		*	LED			BO		60	51	2	Yes
1813	O/C fault detection stage I> phase L3 (I> Fault L3)	O/C Prot. I>	OUT	*	on off		*	LED			BO		60	52	2	Yes
1815	O/C I> TRIP (I> TRIP)	O/C Prot. I>	OUT	*	on		m	LED			BO		60	71	2	Yes
1883	>BLOCK inverse O/C time protection (>BLOCK O/C Ip)	O/C Prot. Ip	SP	*	*		*	LED	BI		BO					
1891	O/C protection Ip is switched OFF (O/C Ip OFF)	O/C Prot. Ip	OUT	on off	*		*	LED			BO		60	180	1	Yes
1892	O/C protection Ip is BLOCKED (O/C Ip BLOCKED)	O/C Prot. Ip	OUT	on off	on off		*	LED			BO		60	181	1	Yes
1893	O/C protection Ip is ACTIVE (O/C Ip ACTIVE)	O/C Prot. Ip	OUT	on off	*		*	LED			BO		60	182	1	Yes
1896	O/C fault detection Ip phase L1 (O/C Ip Fault L1)	O/C Prot. Ip	OUT	*	on off		*	LED			BO		60	184	2	Yes

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				Event Log ON/OFF	Trip (Fault) Log On/Off	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	Information Number	Data Unit	General Interrogation
1897	O/C fault detection Ip phase L2 (O/C Ip Fault L2)	O/C Prot. Ip	OUT	*	on off		*	LED			BO		60	185	2	Yes
1898	O/C fault detection Ip phase L3 (O/C Ip Fault L3)	O/C Prot. Ip	OUT	*	on off		*	LED			BO		60	186	2	Yes
1899	O/C Ip picked up (O/C Ip pick.up)	O/C Prot. Ip	OUT	*	on off		*	LED			BO		60	183	2	Yes
1900	O/C Ip TRIP (O/C Ip TRIP)	O/C Prot. Ip	OUT	*	on		m	LED			BO		60	187	2	Yes
1950	>O/C prot. : BLOCK undervoltage seal-in (>Useal-inBLK)	O/C Prot. I>	SP	on off	*		*	LED	BI		BO		60	200	1	Yes
1955	O/C prot. stage I>> is switched OFF (I>> OFF)	O/C Prot. I>>	OUT	on off	*		*	LED			BO		60	205	1	Yes
1956	O/C prot. stage I>> is BLOCKED (I>> BLOCKED)	O/C Prot. I>>	OUT	on off	on off		*	LED			BO		60	206	1	Yes
1957	O/C prot. stage I>> is ACTIVE (I>> ACTIVE)	O/C Prot. I>>	OUT	on off	*		*	LED			BO		60	207	1	Yes
1965	O/C prot. stage I> is switched OFF (I> OFF)	O/C Prot. I>	OUT	on off	*		*	LED			BO		60	215	1	Yes
1966	O/C prot. stage I> is BLOCKED (I> BLOCKED)	O/C Prot. I>	OUT	on off	on off		*	LED			BO		60	216	1	Yes
1967	O/C prot. stage I> is ACTIVE (I> ACTIVE)	O/C Prot. I>	OUT	on off	*		*	LED			BO		60	217	1	Yes
1970	O/C prot. undervoltage seal-in (U< seal in)	O/C Prot. I>	OUT	*	on off		*	LED			BO		60	220	2	Yes
3953	>BLOCK impedance protection (>Imp. BLOCK)	Impedance	SP	*	*		*	LED	BI		BO					
3956	>Zone 1B extension for imped-ance prot. (>Extens. Z1B)	Impedance	SP	on off	*		*	LED	BI		BO		28	222	1	Yes
3958	>Imp. prot. : BLOCK undervolt-age seal-in (>ImpUseal-inBLK)	Impedance	SP	on off	*		*	LED	BI		BO		28	30	1	Yes
3961	Impedance protection is switched OFF (Imp. OFF)	Impedance	OUT	on off	*		*	LED			BO		28	226	1	Yes
3962	Impedance protection is BLOCKED (Imp. BLOCKED)	Impedance	OUT	on off	on off		*	LED			BO		28	227	1	Yes
3963	Impedance protection is ACTIVE (Imp. ACTIVE)	Impedance	OUT	on off	*		*	LED			BO		28	228	1	Yes
3966	Impedance protection picked up (Imp. picked up)	Impedance	OUT	*	on off		*	LED			BO		28	229	2	Yes
3967	Imp.: Fault detection , phase L1 (Imp. Fault L1)	Impedance	OUT	*	on off		*	LED			BO		28	230	2	Yes
3968	Imp.: Fault detection , phase L2 (Imp. Fault L2)	Impedance	OUT	*	on off		*	LED			BO		28	231	2	Yes
3969	Imp.: Fault detection , phase L3 (Imp. Fault L3)	Impedance	OUT	*	on off		*	LED			BO		28	232	2	Yes
3970	Imp.: O/C with undervoltage seal in (Imp. I> & U<)	Impedance	OUT	*	on off		*	LED			BO		28	233	2	Yes
3976	Power swing detection (Power Swing)	Impedance	OUT	*	on off		*	LED			BO		28	239	2	Yes
3977	Imp.: Z1< TRIP (Imp.Z1< TRIP)	Impedance	OUT	*	on		m	LED			BO		28	240	2	Yes
3978	Imp.: Z1B< TRIP (Imp.Z1B< TRIP)	Impedance	OUT	*	on		m	LED			BO		28	241	2	Yes
3979	Imp.: Z2< TRIP (Imp.Z2< TRIP)	Impedance	OUT	*	on		m	LED			BO		28	242	2	Yes
3980	Imp.: T3> TRIP (Imp.T3> TRIP)	Impedance	OUT	*	on		m	LED			BO		28	243	2	Yes
4523	>Block external trip 1 (>BLOCK Ext 1)	External Trips	SP	*	*		*	LED	BI		BO					
4526	>Trigger external trip 1 (>Ext trip 1)	External Trips	SP	on off	*		*	LED	BI		BO		51	126	1	Yes

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				Event Log ON/OFF	Trip (Fault) Log On/Off	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	Information Number	Data Unit	General Interrogation
4531	External trip 1 is switched OFF (Ext 1 OFF)	External Trips	OUT	on off	*		*	LED			BO		51	131	1	Yes
4532	External trip 1 is BLOCKED (Ext 1 BLOCKED)	External Trips	OUT	on off	on off		*	LED			BO		51	132	1	Yes
4533	External trip 1 is ACTIVE (Ext 1 ACTIVE)	External Trips	OUT	on off	*		*	LED			BO		51	133	1	Yes
4536	External trip 1: General picked up (Ext 1 picked up)	External Trips	OUT	*	on off		*	LED			BO		51	136	2	Yes
4537	External trip 1: General TRIP (Ext 1 Gen.TRP)	External Trips	OUT	*	on		*	LED			BO		51	137	2	Yes
4543	>BLOCK external trip 2 (>BLOCK Ext 2)	External Trips	SP	*	*		*	LED	BI		BO					
4546	>Trigger external trip 2 (>Ext trip 2)	External Trips	SP	on off	*		*	LED	BI		BO		51	146	1	Yes
4551	External trip 2 is switched OFF (Ext 2 OFF)	External Trips	OUT	on off	*		*	LED			BO		51	151	1	Yes
4552	External trip 2 is BLOCKED (Ext 2 BLOCKED)	External Trips	OUT	on off	on off		*	LED			BO		51	152	1	Yes
4553	External trip 2 is ACTIVE (Ext 2 ACTIVE)	External Trips	OUT	on off	*		*	LED			BO		51	153	1	Yes
4556	External trip 2: General picked up (Ext 2 picked up)	External Trips	OUT	*	on off		*	LED			BO		51	156	2	Yes
4557	External trip 2: General TRIP (Ext 2 Gen.TRP)	External Trips	OUT	*	on		*	LED			BO		51	157	2	Yes
4563	>BLOCK external trip 3 (>BLOCK Ext 3)	External Trips	SP	*	*		*	LED	BI		BO					
4566	>Trigger external trip 3 (>Ext trip 3)	External Trips	SP	on off	*		*	LED	BI		BO		51	166	1	Yes
4571	External trip 3 is switched OFF (Ext 3 OFF)	External Trips	OUT	on off	*		*	LED			BO		51	171	1	Yes
4572	External trip 3 is BLOCKED (Ext 3 BLOCKED)	External Trips	OUT	on off	on off		*	LED			BO		51	172	1	Yes
4573	External trip 3 is ACTIVE (Ext 3 ACTIVE)	External Trips	OUT	on off	*		*	LED			BO		51	173	1	Yes
4576	External trip 3: General picked up (Ext 3 picked up)	External Trips	OUT	*	on off		*	LED			BO		51	176	2	Yes
4577	External trip 3: General TRIP (Ext 3 Gen.TRP)	External Trips	OUT	*	on		*	LED			BO		51	177	2	Yes
4583	>BLOCK external trip 4 (>BLOCK Ext 4)	External Trips	SP	*	*		*	LED	BI		BO					
4586	>Trigger external trip 4 (>Ext trip 4)	External Trips	SP	on off	*		*	LED	BI		BO		51	186	1	Yes
4591	External trip 4 is switched OFF (Ext 4 OFF)	External Trips	OUT	on off	*		*	LED			BO		51	191	1	Yes
4592	External trip 4 is BLOCKED (Ext 4 BLOCKED)	External Trips	OUT	on off	on off		*	LED			BO		51	192	1	Yes
4593	External trip 4 is ACTIVE (Ext 4 ACTIVE)	External Trips	OUT	on off	*		*	LED			BO		51	193	1	Yes
4596	External trip 4: General picked up (Ext 4 picked up)	External Trips	OUT	*	on off		*	LED			BO		51	196	2	Yes
4597	External trip 4: General TRIP (Ext 4 Gen.TRP)	External Trips	OUT	*	on		*	LED			BO		51	197	2	Yes
4822	>BLOCK Restart inhibit motor (>BLK Re. Inhib.)	Restart Motor	SP	*	*		*	LED	BI		BO					
4823	>Emergency start rotor (>Emer. Start ΘR)	Restart Motor	SP	on off	*		*	LED	BI		BO		168	51	1	Yes

No.	Description	Function	Type of Information	Log Buffers: Event Log ON/OFF	Log Buffers: Trip (Fault) Log On/Off	Log Buffers: Ground Fault Log ON/OFF	Log Buffers: Marked in Oscill. Record	Configurable in Matrix: LED	Configurable in Matrix: Binary Input	Configurable in Matrix: Function Key	Configurable in Matrix: Relay	Configurable in Matrix: Chatter Suppression	IEC 60870-5-103: Type	IEC 60870-5-103: Information Number	IEC 60870-5-103: Data Unit	IEC 60870-5-103: General Interrogation
4824	Restart inhibit motor is switched OFF (Re. Inhibit OFF)	Restart Motor	OUT	on off	*		*	LED			BO		168	52	1	Yes
4825	Restart inhibit motor is BLOCKED (Re. Inhibit BLK)	Restart Motor	OUT	on off	*		*	LED			BO		168	53	1	Yes
4826	Restart inhibit motor is ACTIVE (Re. Inhibit ACT)	Restart Motor	OUT	on off	*		*	LED			BO		168	54	1	Yes
4827	Restart inhibit motor TRIP (Re. Inhib. TRIP)	Restart Motor	OUT	on	*		*	LED			BO		168	55	1	Yes
4828	>Reset thermal memory rotor (>RM th.rep. ΘR)	Restart Motor	SP	on off	*		*	LED	BI		BO					
4829	Reset thermal memory rotor (RM th.rep. ΘR)	Restart Motor	OUT	on off	*		*	LED			BO		168	50	1	Yes
4830	Alarm restart inhibit motor (Re. Inhib.ALARM)	Restart Motor	OUT	on off	*		*	LED			BO					
5002	Suitable measured quantities present (Operat. Cond.)	P.System Data 1	OUT	on off	*		*	LED			BO		71	2	1	Yes
5010	>BLOCK fuse failure monitor (>FFM BLOCK)	Supervision	SP	on off	on off		*	LED	BI		BO		71	7	1	Yes
5011	>FFM extern undervoltage (>FFM U< extern)	Supervision	SP	on off	*		*	LED	BI		BO		71	8	1	Yes
5012	Voltage UL1E at trip (UL1E:)	P.System Data 2	VI	*	ON OFF								71	38	4	No
5013	Voltage UL2E at trip (UL2E:)	P.System Data 2	VI	*	ON OFF								71	39	4	No
5014	Voltage UL3E at trip (UL3E:)	P.System Data 2	VI	*	ON OFF								71	40	4	No
5015	Active power at trip (P:)	P.System Data 2	VI	*	ON OFF								71	41	4	No
5016	Reactive power at trip (Q:)	P.System Data 2	VI	*	ON OFF								71	42	4	No
5017	Frequency at trip (f:)	P.System Data 2	VI	*	ON OFF								71	43	4	No
5053	>BLOCK out-of-step protection (>BLOCK O/S)	Out-of-Step	SP	*	*		*	LED	BI		BO					
5061	Out-of-step protection is switched OFF (O/S OFF)	Out-of-Step	OUT	on off	*		*	LED	BI		BO		70	56	1	Yes
5062	Out-of-step protection is BLOCKED (O/S BLOCKED)	Out-of-Step	OUT	on off	on off		*	LED			BO		70	57	1	Yes
5063	Out-of-step protection is ACTIVE (O/S ACTIVE)	Out-of-Step	OUT	on off	*		*	LED			BO		70	58	1	Yes
5067	Out-of-step pulse of characteristic 1 (O/S char. 1)	Out-of-Step	OUT	*	on off		*	LED			BO		70	60	2	Yes
5068	Out-of-step pulse of characteristic 2 (O/S char. 2)	Out-of-Step	OUT	*	on off		*	LED			BO		70	61	2	Yes
5069	Out-of-step characteristic 1 picked up (O/S det. char.1)	Out-of-Step	OUT	*	on off		*	LED			BO		70	62	2	Yes
5070	Out-of-step characteristic 2 picked up (O/S det. char.2)	Out-of-Step	OUT	*	on off		*	LED			BO		70	63	2	Yes
5071	Out-of-step TRIP characteristic 1 (O/S TRIP char.1)	Out-of-Step	OUT	*	on		m	LED			BO		70	64	2	Yes
5072	Out-of-step TRIP characteristic 2 (O/S TRIP char.2)	Out-of-Step	OUT	*	on		m	LED			BO		70	65	2	Yes
5083	>BLOCK reverse power protection (>Pr BLOCK)	Reverse Power	SP	*	*		*	LED	BI		BO					
5086	>Stop valve tripped (>SV tripped)	Reverse Power	SP	on off	*		*	LED	BI		BO		70	77	1	Yes

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log On/Off	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	Information Number	Data Unit	General Interrogation
5091	Reverse power prot. is switched OFF (Pr OFF)	Reverse Power	OUT	on off	*		*	LED			BO		70	81	1	Yes
5092	Reverse power protection is BLOCKED (Pr BLOCKED)	Reverse Power	OUT	on off	on off		*	LED			BO		70	82	1	Yes
5093	Reverse power protection is ACTIVE (Pr ACTIVE)	Reverse Power	OUT	on off	*		*	LED			BO		70	83	1	Yes
5096	Reverse power: picked up (Pr picked up)	Reverse Power	OUT	*	on off		*	LED			BO		70	84	2	Yes
5097	Reverse power: TRIP (Pr TRIP)	Reverse Power	OUT	*	on		m	LED			BO		70	85	2	Yes
5098	Reverse power: TRIP with stop valve (Pr+SV TRIP)	Reverse Power	OUT	*	on		m	LED			BO		70	86	2	Yes
5113	>BLOCK forward power supervision (>Pf BLOCK)	Forward Power	SP	*	*		*	LED	BI		BO					
5116	>BLOCK forw. power superv. Pf< stage (>Pf< BLOCK)	Forward Power	SP	on off	*		*	LED	BI		BO		70	102	1	Yes
5117	>BLOCK forw. power superv. Pf> stage (>Pf> BLOCK)	Forward Power	SP	on off	*		*	LED	BI		BO		70	103	1	Yes
5121	Forward power supervis. is switched OFF (Pf OFF)	Forward Power	OUT	on off	*		*	LED			BO		70	106	1	Yes
5122	Forward power supervision is BLOCKED (Pf BLOCKED)	Forward Power	OUT	on off	on off		*	LED			BO		70	107	1	Yes
5123	Forward power supervision is ACTIVE (Pf ACTIVE)	Forward Power	OUT	on off	*		*	LED			BO		70	108	1	Yes
5126	Forward power: Pf< stage picked up (Pf< picked up)	Forward Power	OUT	*	on off		*	LED			BO		70	109	2	Yes
5127	Forward power: Pf> stage picked up (Pf> picked up)	Forward Power	OUT	*	on off		*	LED			BO		70	110	2	Yes
5128	Forward power: Pf< stage TRIP (Pf< TRIP)	Forward Power	OUT	*	on		m	LED			BO		70	111	2	Yes
5129	Forward power: Pf> stage TRIP (Pf> TRIP)	Forward Power	OUT	*	on		m	LED			BO		70	112	2	Yes
5143	>BLOCK I2 (Unbalance Load) (>BLOCK I2)	Unbalance Load	SP	*	*		*	LED	BI		BO					
5145	>Reverse Phase Rotation (>Reverse Rot.)	P.System Data 1	SP	on off	*		*	LED	BI		BO		71	34	1	Yes
5146	>Reset memory for thermal replica I2 (>RM th.rep. I2)	Unbalance Load	SP	on off	*		*	LED	BI		BO					
5147	Phase Rotation L1L2L3 (Rotation L1L2L3)	P.System Data 1	OUT	on off	*		*	LED			BO		70	128	1	Yes
5148	Phase Rotation L1L3L2 (Rotation L1L3L2)	P.System Data 1	OUT	on off	*		*	LED			BO		70	129	1	Yes
5151	I2 is switched OFF (I2 OFF)	Unbalance Load	OUT	on off	*		*	LED			BO		70	131	1	Yes
5152	I2 is BLOCKED (I2 BLOCKED)	Unbalance Load	OUT	on off	on off		*	LED			BO		70	132	1	Yes
5153	I2 is ACTIVE (I2 ACTIVE)	Unbalance Load	OUT	on off	*		*	LED			BO		70	133	1	Yes
5156	Unbalanced load: Current warning stage (I2> Warn)	Unbalance Load	OUT	on off	*		*	LED			BO		70	134	1	Yes
5158	Reset memory of thermal replica I2 (RM th.rep. I2)	Unbalance Load	OUT	on off	*		*	LED			BO		70	137	1	Yes
5159	I2>> picked up (I2>> picked up)	Unbalance Load	OUT	*	on off		*	LED			BO		70	138	2	Yes
5160	Unbalanced load: TRIP of current stage (I2>> TRIP)	Unbalance Load	OUT	*	on		m	LED			BO		70	139	2	Yes
5161	Unbalanced load: TRIP of thermal stage (I2 Θ TRIP)	Unbalance Load	OUT	*	on		*	LED			BO		70	140	2	Yes

No.	Description	Function	Type of Information	Log Buffers: Event Log ON/OFF	Log Buffers: Trip (Fault) Log On/Off	Log Buffers: Ground Fault Log ON/OFF	Log Buffers: Marked in Oscill. Record	Configurable in Matrix: LED	Configurable in Matrix: Binary Input	Configurable in Matrix: Function Key	Configurable in Matrix: Relay	Configurable in Matrix: Chatter Suppression	IEC 60870-5-103: Type	IEC 60870-5-103: Information Number	IEC 60870-5-103: Data Unit	IEC 60870-5-103: General Interrogation
5165	I2> picked up (I2> picked up)	Unbalance Load	OUT	*	on off		*	LED			BO		70	150	2	Yes
5173	>BLOCK stator earth fault protection (>S/E/F BLOCK)	Stator E Fault	SP	*	*		*	LED	BI		BO					
5176	>Switch off earth current detec.(S/E/F) (>S/E/F IEE off)	Stator E Fault	SP	on off	*		*	LED	BI		BO		70	152	1	Yes
5181	Stator earth fault prot. is switch OFF (S/E/F OFF)	Stator E Fault	OUT	on off	*		*	LED			BO		70	156	1	Yes
5182	Stator earth fault protection is BLOCK. (S/E/F BLOCKED)	Stator E Fault	OUT	on off	on off		*	LED			BO		70	157	1	Yes
5183	Stator earth fault protection is ACTIVE (S/E/F ACTIVE)	Stator E Fault	OUT	on off	*		*	LED			BO		70	158	1	Yes
5186	Stator earth fault: U0 picked up (U0> picked up)	Stator E Fault	OUT	*	on off		*	LED			BO		70	159	2	Yes
5187	Stator earth fault: U0 stage TRIP (U0> TRIP)	Stator E Fault	OUT	*	on		m	LED			BO		70	160	2	Yes
5188	Stator earth fault: I0 picked up (3I0> picked up)	Stator E Fault	OUT	*	on off		*	LED			BO		70	168	2	Yes
5189	Earth fault in phase L1 (Uearth L1)	Stator E Fault	OUT	*	on off		*	LED			BO		70	169	2	Yes
5190	Earth fault in phase L2 (Uearth L2)	Stator E Fault	OUT	*	on off		*	LED			BO		70	170	2	Yes
5191	Earth fault in phase L3 (Uearth L3)	Stator E Fault	OUT	*	on off		*	LED			BO		70	171	2	Yes
5193	Stator earth fault protection TRIP (S/E/F TRIP)	Stator E Fault	OUT	*	on		m	LED			BO		70	173	2	Yes
5194	Stator earth fault: direction forward (SEF Dir Forward)	Stator E Fault	OUT	on off	*		*	LED			BO		70	174	1	Yes
5203	>BLOCK frequency protection (>BLOCK Freq.)	Frequency Prot.	SP	*	*		*	LED	BI		BO					
5206	>BLOCK stage f1 (>BLOCK f1)	Frequency Prot.	SP	on off	*		*	LED	BI		BO		70	177	1	Yes
5207	>BLOCK stage f2 (>BLOCK f2)	Frequency Prot.	SP	on off	*		*	LED	BI		BO		70	178	1	Yes
5208	>BLOCK stage f3 (>BLOCK f3)	Frequency Prot.	SP	on off	*		*	LED	BI		BO		70	179	1	Yes
5209	>BLOCK stage f4 (>BLOCK f4)	Frequency Prot.	SP	on off	*		*	LED	BI		BO		70	180	1	Yes
5211	Frequency protection is OFF (Freq. OFF)	Frequency Prot.	OUT	on off	*		*	LED			BO		70	181	1	Yes
5212	Frequency protection is BLOCKED (Freq. BLOCKED)	Frequency Prot.	OUT	on off	on off		*	LED			BO		70	182	1	Yes
5213	Frequency protection is ACTIVE (Freq. ACTIVE)	Frequency Prot.	OUT	on off	*		*	LED			BO		70	183	1	Yes
5214	Frequency protection undervoltage Blk (Freq UnderV Blk)	Frequency Prot.	OUT	on off	on off		*	LED			BO		70	184	1	Yes
5232	f1 picked up (f1 picked up)	Frequency Prot.	OUT	*	on off		*	LED			BO		70	230	2	Yes
5233	f2 picked up (f2 picked up)	Frequency Prot.	OUT	*	on off		*	LED			BO		70	231	2	Yes
5234	f3 picked up (f3 picked up)	Frequency Prot.	OUT	*	on off		*	LED			BO		70	232	2	Yes
5235	f4 picked up (f4 picked up)	Frequency Prot.	OUT	*	on off		*	LED			BO		70	233	2	Yes
5236	f1 TRIP (f1 TRIP)	Frequency Prot.	OUT	*	on		m	LED			BO		70	234	2	Yes
5237	f2 TRIP (f2 TRIP)	Frequency Prot.	OUT	*	on		m	LED			BO		70	235	2	Yes
5238	f3 TRIP (f3 TRIP)	Frequency Prot.	OUT	*	on		m	LED			BO		70	236	2	Yes
5239	f4 TRIP (f4 TRIP)	Frequency Prot.	OUT	*	on		m	LED			BO		70	237	2	Yes

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log On/Off	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	Information Number	Data Unit	General Interrogation
5293	>BLOCK DC protection (>BLOCK DC Prot.)	DC Protection	SP	*	*		*	LED	BI		BO					
5301	DC protection is switched OFF (DC Prot. OFF)	DC Protection	OUT	on off	*		*	LED			BO		71	181	1	Yes
5302	DC protection is BLOCKED (DC Prot.BLOCKED)	DC Protection	OUT	on off	on off		*	LED			BO		71	182	1	Yes
5303	DC protection is ACTIVE (DC Prot. ACTIVE)	DC Protection	OUT	on off	*		*	LED			BO		71	183	1	Yes
5306	DC protection picked up (DC Prot.pick.up)	DC Protection	OUT	*	on off		*	LED			BO		71	186	2	Yes
5307	DC protection TRIP (DC Prot. TRIP)	DC Protection	OUT	*	on		*	LED			BO		71	187	2	Yes
5308	Failure DC protection (Failure DC Prot)	DC Protection	OUT	on off	*		*	LED			BO		71	184	1	Yes
5323	>BLOCK underexcitation protection (>Exc. BLOCK)	Underexcitation	SP	*	*		*	LED	BI		BO					
5327	>BLOCK underexc. prot. char. 3 (>Char. 3 BLK.)	Underexcitation	SP	on off	*		*	LED	BI		BO		71	53	1	Yes
5328	>Exc. voltage failure recognized (>Uexc fail.)	Underexcitation	SP	on off	*		*	LED	BI		BO		71	54	1	Yes
5329	>BLOCK underexc. prot. char. 1 (>Char. 1 BLK.)	Underexcitation	SP	on off	*		*	LED	BI		BO		71	64	1	Yes
5330	>BLOCK underexc. prot. char. 2 (>Char. 2 BLK.)	Underexcitation	SP	on off	*		*	LED	BI		BO		71	65	1	Yes
5331	Underexc. prot. is switched OFF (Excit. OFF)	Underexcitation	OUT	on off	*		*	LED			BO		71	55	1	Yes
5332	Underexc. prot. is BLOCKED (Excit.BLOCKED)	Underexcitation	OUT	on off	on off		*	LED			BO		71	56	1	Yes
5333	Underexc. prot. is ACTIVE (Excit.ACTIVE)	Underexcitation	OUT	on off	*		*	LED			BO		71	57	1	Yes
5334	Underexc. prot. blocked by U< (Exc. U< blk)	Underexcitation	OUT	on off	on off		*	LED			BO		71	58	1	Yes
5336	Exc. voltage failure recognized (Uexc failure)	Underexcitation	OUT	*	on off		*	LED			BO		71	59	2	Yes
5337	Underexc. prot. picked up (Exc< picked up)	Underexcitation	OUT	*	on off		*	LED			BO		71	60	2	Yes
5343	Underexc. prot. char. 3 TRIP (Exc<3 TRIP)	Underexcitation	OUT	*	on		m	LED			BO		71	63	2	Yes
5344	Underexc. prot. char. 1 TRIP (Exc<1 TRIP)	Underexcitation	OUT	*	on		m	LED			BO		71	66	2	Yes
5345	Underexc. prot. char. 2 TRIP (Exc<2 TRIP)	Underexcitation	OUT	*	on		m	LED			BO		71	67	2	Yes
5346	Underexc. prot. char.+Uexc< TRIP (Exc<U<TRIP)	Underexcitation	OUT	*	on		m	LED			BO		71	68	2	Yes
5353	>BLOCK overexcitation protection (>U/f BLOCK)	Overexcitation	SP	*	*		*	LED	BI		BO					
5357	>Reset memory of thermal replica U/f (>RM th.rep. U/f)	Overexcitation	SP	on off	*		*	LED	BI		BO					
5361	Overexcitation prot. is swiched OFF (U/f> OFF)	Overexcitation	OUT	on off	*		*	LED			BO		71	83	1	Yes
5362	Overexcitation prot. is BLOCKED (U/f> BLOCKED)	Overexcitation	OUT	on off	on off		*	LED			BO		71	84	1	Yes
5363	Overexcitation prot. is ACTIVE (U/f> ACTIVE)	Overexcitation	OUT	on off	*		*	LED			BO		71	85	1	Yes
5367	Overexc. prot.: U/f warning stage (U/f> warn)	Overexcitation	OUT	on off	*		*	LED			BO		71	86	1	Yes

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log On/Off	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	Information Number	Data Unit	General Interrogation
5369	Reset memory of thermal replica U/f (RM th.rep. U/f)	Overexcitation	OUT	on off	*		*	LED			BO		71	88	1	Yes
5370	Overexc. prot.: U/f> picked up (U/f> picked up)	Overexcitation	OUT	*	on off		*	LED			BO		71	89	2	Yes
5371	Overexc. prot.: TRIP of U/f>> stage (U/f>> TRIP)	Overexcitation	OUT	*	on		m	LED			BO		71	90	2	Yes
5372	Overexc. prot.: TRIP of th. stage (U/f> th.TRIP)	Overexcitation	OUT	*	on		*	LED			BO		71	91	2	Yes
5373	Overexc. prot.: U/f>> picked up (U/f>> pick.up)	Overexcitation	OUT	*	on off		*	LED			BO		71	92	2	Yes
5381	>BLOCK rotor earth fault prot. (1-3Hz) (>REF 1-3Hz BLK)	REF 1-3Hz	SP	*	*		*	LED	BI		BO					
5383	>BLOCK rotor earth fault prot. (R,fn) (>BLOCK R/E/F)	Rotor E/F	SP	*	*		*	LED	BI		BO					
5386	>Test rotor earth fault prot. (1-3Hz) (>Test REF 1-3Hz)	REF 1-3Hz	SP	on off	*		*	LED	BI		BO		71	116	1	Yes
5387	REF protection (1-3Hz) is switched OFF (REF 1-3Hz OFF)	REF 1-3Hz	OUT	on off	*		*	LED			BO		71	117	1	Yes
5388	REF protection (1-3Hz) is BLOCKED (REF 1-3Hz BLK)	REF 1-3Hz	OUT	on off	on off		*	LED			BO		71	118	1	Yes
5389	REF protection (1-3Hz) is ACTIVE (REF 1-3Hz ACT)	REF 1-3Hz	OUT	on off	*		*	LED			BO		71	119	1	Yes
5391	Rotor earth fault prot. (R,fn) swit. OFF (R/E/F OFF)	Rotor E/F	OUT	on off	*		*	LED			BO		71	121	1	Yes
5392	Rotor earth fault prot. (R,fn) BLOCKED (R/E/F BLOCKED)	Rotor E/F	OUT	on off	on off		*	LED			BO		71	122	1	Yes
5393	Rotor earth fault prot. (R,fn) is ACTIVE (R/E/F AKTIVE)	Rotor E/F	OUT	on off	*		*	LED			BO		71	123	1	Yes
5394	Rot. earth flt. prot. (R,fn) block by U< (R/E/F U< block)	Rotor E/F	OUT	on off	*		*	LED			BO		71	124	1	Yes
5395	REF protection (1-3Hz) open circuit (REF 1-3Hz open)	REF 1-3Hz	OUT	on off	*		*	LED			BO		71	125	1	Yes
5396	Failure R/E/F protection IEE< (Fail. REF IEE<)	Sens. E Fault	OUT	on off	*		*	LED			BO		71	126	1	Yes
5397	Rot. earth flt.prot. (R,fn) Re< warning (R/E/F warning)	Rotor E/F	OUT	on off	*		*	LED			BO		71	127	1	Yes
5398	Rot. earth flt.prot. (R,fn) Re<< pick.up (R/E/F picked up)	Rotor E/F	OUT	*	on off		*	LED			BO		71	128	2	Yes
5399	Rotor earth fault prot. (R,fn) Re<< TRIP (R/E/F TRIP)	Rotor E/F	OUT	*	on		m	LED			BO		71	129	2	Yes
5400	Failure rotor earth fault prot. (R,fn) (Failure R/E/F)	Rotor E/F	OUT	on off	*		*	LED			BO		71	130	1	Yes
5401	Failure REF protection (1-3Hz) (Fail REF 1-3Hz)	REF 1-3Hz	OUT	on off	*		*	LED			BO		71	131	1	Yes
5403	REF prot. (1-3Hz) warning stage (Re<) (REF 1-3Hz Warn)	REF 1-3Hz	OUT	on off	*		*	LED			BO		71	133	1	Yes
5406	REF prot. (1-3Hz) Re<< picked up (REF 1-3Hz Fault)	REF 1-3Hz	OUT	*	on off		*	LED			BO		71	136	2	Yes
5407	REF prot. (1-3Hz) Re<< TRIP (REF 1-3Hz Trip)	REF 1-3Hz	OUT	*	on		*	LED			BO		71	137	2	Yes
5408	REF prot. (1-3Hz) test passed (Test REF PASSED)	REF 1-3Hz	OUT	on off	*		*	LED			BO		71	138	1	Yes
5409	REF prot. (1-3Hz) test NOT passed (Test REF Fail.)	REF 1-3Hz	OUT	on off	*		*	LED			BO		71	139	1	Yes
5410	REF (1-3Hz) 1 Measuring circuit open (1 Cir. open)	REF 1-3Hz	OUT	on off	*		*	LED			BO					

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log On/Off	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	Information Number	Data Unit	General Interrogation
5411	REF (1-3Hz) 2 Measuring circuits open (2 Cir. open)	REF 1-3Hz	OUT	on off	*		*	LED			BO					
5413	>BLOCK interturn fault protection (>I/T BLOCK)	Interturn Prot.	SP	*	*		*	LED	BI		BO					
5421	Interturn fault prot. is switched OFF (I/T OFF)	Interturn Prot.	OUT	on off	*		*	LED			BO		71	142	1	Yes
5422	Interturn fault protection is BLOCKED (I/T BLOCKED)	Interturn Prot.	OUT	on off	on off		*	LED			BO		71	143	1	Yes
5423	Interturn fault protection is ACTIVE (I/T ACTIVE)	Interturn Prot.	OUT	on off	*		*	LED			BO		71	144	1	Yes
5426	Interturn fault protection picked up (I/T picked up)	Interturn Prot.	OUT	*	on off		*	LED			BO		71	145	2	Yes
5427	Interturn fault protection TRIP (I/T TRIP)	Interturn Prot.	OUT	*	on		*	LED			BO		71	146	2	Yes
5473	>BLOCK Stator earth fault protection (>SEF100 BLOCK)	100% SEF-PROT.	SP	*	*		*	LED	BI		BO					
5476	>Failure 20Hz bias voltage (S/E/F) (>U20 failure)	100% SEF-PROT.	SP	on off	*		*	LED	BI		BO		71	227	1	Yes
5481	Stator earth flt. prot. 100% is swit.OFF (SEF100 OFF)	100% SEF-PROT.	OUT	on off	*		*	LED			BO		71	228	1	Yes
5482	Stator earth flt. prot. 100% is BLOCKED (SEF100 BLOCKED)	100% SEF-PROT.	OUT	on off	on off		*	LED			BO		71	229	1	Yes
5483	Stator earth flt. prot. 100% is ACTIVE (SEF100 ACTIVE)	100% SEF-PROT.	OUT	on off	*		*	LED			BO		71	230	1	Yes
5486	Stator earth flt. prot. 100% Failure (SEF100 Failure)	100% SEF-PROT.	OUT	on off	*		*	LED			BO		71	231	1	Yes
5487	Stator earth flt. prot.100% Alarm stage (SEF100 Alarm)	100% SEF-PROT.	OUT	on off	*		*	LED			BO		71	232	1	Yes
5488	Stator earth flt. prot.100% picked up (SEF100 pickup)	100% SEF-PROT.	OUT	*	on off		*	LED			BO		71	233	2	Yes
5489	Stator earth flt. prot.100% TRIP (SEF100 TRIP)	100% SEF-PROT.	OUT	*	on		*	LED			BO		71	234	2	Yes
5503	>BLOCK Rate-of-frequency-change prot. (>df/dt block)	df/dt Protect.	SP	*	*		*	LED	BI		BO					
5504	>BLOCK df1/dt stage (>df1/dt block)	df/dt Protect.	SP	on off	*		*	LED	BI		BO		72	1	1	Yes
5505	>BLOCK df2/dt stage (>df2/dt block)	df/dt Protect.	SP	on off	*		*	LED	BI		BO		72	2	1	Yes
5506	>BLOCK df3/dt stage (>df3/dt block)	df/dt Protect.	SP	on off	*		*	LED	BI		BO		72	3	1	Yes
5507	>BLOCK df4/dt stage (>df4/dt block)	df/dt Protect.	SP	on off	*		*	LED	BI		BO		72	4	1	Yes
5511	df/dt is switched OFF (df/dt OFF)	df/dt Protect.	OUT	on off	*		*	LED			BO		72	5	1	Yes
5512	df/dt is BLOCKED (df/dt BLOCKED)	df/dt Protect.	OUT	on off	on off		*	LED			BO		72	6	1	Yes
5513	df/dt is ACTIVE (df/dt ACTIVE)	df/dt Protect.	OUT	on off	*		*	LED			BO		72	7	1	Yes
5514	df/dt is blocked by undervoltage (df/dt U< block)	df/dt Protect.	OUT	on off	on off		*	LED			BO		72	8	1	Yes
5516	Stage df1/dt picked up (df1/dt pickup)	df/dt Protect.	OUT	*	on off		*	LED			BO		72	9	2	Yes
5517	Stage df2/dt picked up (df2/dt pickup)	df/dt Protect.	OUT	*	on off		*	LED			BO		72	10	2	Yes
5518	Stage df3/dt picked up (df3/dt pickup)	df/dt Protect.	OUT	*	on off		*	LED			BO		72	11	2	Yes

No.	Description	Function	Type of In-for-mation	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log On/Off	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	Information Number	Data Unit	General Interrogation
5519	Stage df4/dt picked up (df4/dt pickup)	df/dt Protect.	OUT	*	on off		*	LED			BO		72	12	2	Yes
5520	Stage df1/dt TRIP (df1/dt TRIP)	df/dt Protect.	OUT	*	on		*	LED			BO		72	13	2	Yes
5521	Stage df2/dt TRIP (df2/dt TRIP)	df/dt Protect.	OUT	*	on		*	LED			BO		72	14	2	Yes
5522	Stage df3/dt TRIP (df3/dt TRIP)	df/dt Protect.	OUT	*	on		*	LED			BO		72	15	2	Yes
5523	Stage df4/dt TRIP (df4/dt TRIP)	df/dt Protect.	OUT	*	on		*	LED			BO		72	16	2	Yes
5533	>BLOCK inadvertent energ. prot. (>BLOCK I.En.)	Inadvert. En.	SP	*	*		*	LED	BI		BO					
5541	Inadvert. Energ. prot. is swiched OFF (I.En. OFF)	Inadvert. En.	OUT	on off	*		*	LED			BO		72	31	1	Yes
5542	Inadvert. Energ. prot. is BLOCKED (I.En. BLOCKED)	Inadvert. En.	OUT	on off	on off		*	LED			BO		72	32	1	Yes
5543	Inadvert. Energ. prot. is ACTIVE (I.En. ACTIVE)	Inadvert. En.	OUT	on off	*		*	LED			BO		72	33	1	Yes
5546	Release of the current stage (I.En. release)	Inadvert. En.	OUT	on off	*		*	LED			BO		72	34	1	Yes
5547	Inadvert. Energ. prot. picked up (I.En. picked up)	Inadvert. En.	OUT	*	on off		*	LED			BO		72	35	2	Yes
5548	Inadvert. Energ. prot. TRIP (I.En. TRIP)	Inadvert. En.	OUT	*	on		m	LED			BO		72	36	2	Yes
5553	>BLOCK SEF with 3.Harmonic (>SEF 3H BLOCK)	SEF 3.Harm.	SP	*	*		*	LED	BI		BO					
5561	SEF with 3.Harm. is switched OFF (SEF 3H OFF)	SEF 3.Harm.	OUT	on off	*		*	LED			BO		72	51	1	Yes
5562	SEF with 3.Harm. is BLOCKED (SEF 3H BLOCK)	SEF 3.Harm.	OUT	on off	on off		*	LED			BO		72	52	1	Yes
5563	SEF with 3.Harm. is ACTIVE (SEF 3H ACTIVE)	SEF 3.Harm.	OUT	on off	*		*	LED			BO		72	53	1	Yes
5567	SEF with 3.Harm. picked up (SEF 3H pick.up)	SEF 3.Harm.	OUT	*	on off		*	LED			BO		72	54	2	Yes
5568	SEF with 3.Harm. TRIP (SEF 3H TRIP)	SEF 3.Harm.	OUT	*	on		m	LED			BO		72	55	2	Yes
5571	>BLOCK startup O/C protection (>BLOCK O/C St)	O/C Startup	SP	*	*		*	LED	BI		BO					
5572	Startup O/C protection is switched OFF (O/C Start OFF)	O/C Startup	OUT	on off	*		*	LED			BO		72	62	1	Yes
5573	Startup O/C protection is BLOCKED (O/C Start BLK)	O/C Startup	OUT	on off	on off		*	LED			BO		72	63	1	Yes
5574	Startup O/C protection is ACTIVE (O/C Start ACT)	O/C Startup	OUT	on off	*		*	LED			BO		72	64	1	Yes
5575	Startup O/C phase L1 picked up (O/C Start L1 PU)	O/C Startup	OUT	*	on off		*	LED			BO		72	65	2	Yes
5576	Startup O/C phase L2 picked up (O/C Start L2 PU)	O/C Startup	OUT	*	on off		*	LED			BO		72	66	2	Yes
5577	Startup O/C phase L3 picked up (O/C Start L3 PU)	O/C Startup	OUT	*	on off		*	LED			BO		72	67	2	Yes
5578	Startup O/C protection TRIP (O/C Start TRIP)	O/C Startup	OUT	*	on		*	LED			BO		72	68	2	Yes
5581	>BLOCK Vector Jump (>VEC JUMP block)	Vector Jump	SP	*	*		*	LED	BI		BO					
5582	Vector Jump is switched OFF (VEC JUMP OFF)	Vector Jump	OUT	on off	*		*	LED			BO		72	72	1	Yes
5583	Vector Jump is BLOCKED (VEC JMP BLOCKED)	Vector Jump	OUT	on off	on off		*	LED			BO		72	73	1	Yes

No.	Description	Function	Type of Information	Log Buffers: Event Log ON/OFF	Trip (Fault) Log On/Off	Ground Fault Log ON/OFF	Marked in Oscill. Record	Configurable in Matrix: LED	Binary Input	Function Key	Relay	Chatter Suppression	IEC 60870-5-103: Type	Information Number	Data Unit	General Interrogation
5584	Vector Jump is ACTIVE (VEC JUMP ACTIVE)	Vector Jump	OUT	on off	*		*	LED			BO		72	74	1	Yes
5585	Vector Jump not in measurement range (VEC JUMP Range)	Vector Jump	OUT	on off	*		*	LED			BO		72	75	1	Yes
5586	Vector Jump picked up (VEC JUMP pickup)	Vector Jump	OUT	*	on off		*	LED			BO		72	76	2	Yes
5587	Vector Jump TRIP (VEC JUMP TRIP)	Vector Jump	OUT	*	on		*	LED			BO		72	77	2	Yes
5603	>BLOCK differential protection (>Diff BLOCK)	Diff. Prot	SP	*	*		*	LED	BI		BO					
5615	Differential protection is switched OFF (Diff OFF)	Diff. Prot	OUT	on off	*		*	LED			BO		75	15	1	Yes
5616	Differential protection is BLOCKED (Diff BLOCKED)	Diff. Prot	OUT	on off	on off		*	LED			BO		75	16	1	Yes
5617	Differential protection is ACTIVE (Diff ACTIVE)	Diff. Prot	OUT	on off	*		*	LED			BO		75	17	1	Yes
5620	Diff: adverse Adaption factor CT (Diff Adap.fact.)	Diff. Prot	OUT	on	*		*	LED			BO					
5631	Differential protection picked up (Diff picked up)	Diff. Prot	OUT	*	on off		m	LED			BO		75	31	2	Yes
5644	Diff: Blocked by 2.Harmon. L1 (Diff 2.Harm L1)	Diff. Prot	OUT	*	on off		*	LED			BO		75	44	2	Yes
5645	Diff: Blocked by 2.Harmon. L2 (Diff 2.Harm L2)	Diff. Prot	OUT	*	on off		*	LED			BO		75	45	2	Yes
5646	Diff: Blocked by 2.Harmon. L3 (Diff 2.Harm L3)	Diff. Prot	OUT	*	on off		*	LED			BO		75	46	2	Yes
5647	Diff: Blocked by n.Harmon. L1 (Diff n.Harm L1)	Diff. Prot	OUT	*	on off		*	LED			BO		75	47	2	Yes
5648	Diff: Blocked by n.Harmon. L2 (Diff n.Harm L2)	Diff. Prot	OUT	*	on off		*	LED			BO		75	48	2	Yes
5649	Diff: Blocked by n.Harmon. L3 (Diff n.Harm L3)	Diff. Prot	OUT	*	on off		*	LED			BO		75	49	2	Yes
5651	Diff. prot.: Blocked by ext. fault L1 (Diff Bl. exF.L1)	Diff. Prot	OUT	*	on off		*	LED			BO		75	51	2	Yes
5652	Diff. prot.: Blocked by ext. fault L2 (Diff Bl. exF.L2)	Diff. Prot	OUT	*	on off		*	LED			BO		75	52	2	Yes
5653	Diff. prot.: Blocked by ext. fault.L3 (Diff Bl. exF.L3)	Diff. Prot	OUT	*	on off		*	LED			BO		75	53	2	Yes
5657	Diff: Crossblock by 2.Harmonic (DiffCrosBlk2HM)	Diff. Prot	OUT	*	on off		*	LED			BO					
5658	Diff: Crossblock by n.Harmonic (DiffCrosBlknHM)	Diff. Prot	OUT	*	on off		*	LED			BO					
5660	Diff: Crossblock by ext. fault (DiffCrosBlk exF)	Diff. Prot	OUT	*	on off		*	LED			BO					
5662	Diff. prot.: Blocked by CT fault L1 (Block Iflt.L1)	Diff. Prot	OUT	on off	on off		*	LED			BO		75	62	1	Yes
5663	Diff. prot.: Blocked by CT fault L2 (Block Iflt.L2)	Diff. Prot	OUT	on off	on off		*	LED			BO		75	63	1	Yes
5664	Diff. prot.: Blocked by CT fault L3 (Block Iflt.L3)	Diff. Prot	OUT	on off	on off		*	LED			BO		75	64	1	Yes
5666	Diff: Increase of char. phase L1 (Diff in.char.L1)	Diff. Prot	OUT	on off	on off		*	LED			BO					
5667	Diff: Increase of char. phase L2 (Diff in.char.L2)	Diff. Prot	OUT	on off	on off		*	LED			BO					
5668	Diff: Increase of char. phase L3 (Diff in.char.L3)	Diff. Prot	OUT	on off	on off		*	LED			BO					

No.	Description	Function	Type of In-for-matio n	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log On/Off	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	Information Number	Data Unit	General Interrogation
5671	Differential protection TRIP (Diff TRIP)	Diff. Prot	OUT	*	*		*	LED			BO		75	71	1	Yes
5672	Differential protection: TRIP L1 (Diff TRIP L1)	Diff. Prot	OUT	*	*		*	LED			BO		75	72	1	Yes
5673	Differential protection: TRIP L2 (Diff TRIP L2)	Diff. Prot	OUT	*	*		*	LED			BO		75	73	1	Yes
5674	Differential protection: TRIP L3 (Diff TRIP L3)	Diff. Prot	OUT	*	*		*	LED			BO		75	74	1	Yes
5681	Diff. prot.: IDIFF> L1 (without Tdelay) (Diff> L1)	Diff. Prot	OUT	*	on off		*	LED			BO		75	81	2	Yes
5682	Diff. prot.: IDIFF> L2 (without Tdelay) (Diff> L2)	Diff. Prot	OUT	*	on off		*	LED			BO		75	82	2	Yes
5683	Diff. prot.: IDIFF> L3 (without Tdelay) (Diff> L3)	Diff. Prot	OUT	*	on off		*	LED			BO		75	83	2	Yes
5684	Diff. prot: IDIFF>> L1 (without Tdelay) (Diff>> L1)	Diff. Prot	OUT	*	on off		*	LED			BO		75	84	2	Yes
5685	Diff. prot: IDIFF>> L2 (without Tdelay) (Diff>> L2)	Diff. Prot	OUT	*	on off		*	LED			BO		75	85	2	Yes
5686	Diff. prot: IDIFF>> L3 (without Tdelay) (Diff>> L3)	Diff. Prot	OUT	*	on off		*	LED			BO		75	86	2	Yes
5691	Differential prot.: TRIP by IDIFF> (Diff> TRIP)	Diff. Prot	OUT	*	on		m	LED			BO		75	91	2	Yes
5692	Differential prot.: TRIP by IDIFF>> (Diff>> TRIP)	Diff. Prot	OUT	*	on		m	LED			BO		75	92	2	Yes
5701	Diff. current in phase L1 at trip (Diff L1:)	Diff. Prot	VI	*	ON OFF								75	101	4	No
5702	Diff. current in phase L2 at trip (Diff L2:)	Diff. Prot	VI	*	ON OFF								75	102	4	No
5703	Diff. current in phase L3 at trip (Diff L3:)	Diff. Prot	VI	*	ON OFF								75	103	4	No
5704	Restr. current in phase L1 at trip (Res L1:)	Diff. Prot	VI	*	ON OFF								75	104	4	No
5705	Restr. current in phase L2 at trip (Res L2:)	Diff. Prot	VI	*	ON OFF								75	105	4	No
5706	Restr. current in phase L3 at trip (Res L3:)	Diff. Prot	VI	*	ON OFF								75	106	4	No
5713	Diff. prot: Adaptation factor CT side 1 (Diff CT-S1:)	Diff. Prot	VI	ON OFF												
5714	Diff. prot: Adaptation factor CT side 2 (Diff CT-S2:)	Diff. Prot	VI	ON OFF												
5742	Diff: DC L1 (Diff DC L1)	Diff. Prot	OUT	*	on off		*	LED			BO		75	120	2	Yes
5743	Diff: DC L2 (Diff DC L2)	Diff. Prot	OUT	*	on off		*	LED			BO		75	121	2	Yes
5744	Diff: DC L3 (Diff DC L3)	Diff. Prot	OUT	*	on off		*	LED			BO		75	122	2	Yes
5745	Diff: Increase of char. phase (DC) (Diff DC InCha)	Diff. Prot	OUT	*	on off		*	LED			BO		75	123	2	Yes
5803	>BLOCK restricted earth fault prot. (>BLOCK REF)	REF	SP	*	*		*	LED	BI		BO					
5811	Restricted earth fault is switched OFF (REF OFF)	REF	OUT	on off	*		*	LED			BO		76	11	1	Yes
5812	Restricted earth fault is BLOCKED (REF BLOCKED)	REF	OUT	on off	on off		*	LED			BO		76	12	1	Yes
5813	Restricted earth fault is ACTIVE (REF ACTIVE)	REF	OUT	on off	*		*	LED			BO		76	13	1	Yes
5817	REF protection picked up (REF picked up)	REF	OUT	*	on off		*	LED			BO		76	17	2	Yes

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log On/Off	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	Information Number	Data Unit	General Interrogation
5821	REF protection TRIP (REF TRIP)	REF	OUT	*	on		*	LED			BO		76	21	2	Yes
5833	REF adaptation factor CT starpnt. wind. (REF CTstar:)	REF	VI	ON OFF												
5836	REF adverse Adaption factor CT (REF Adap.fact.)	REF	OUT	on	*		*	LED			BO					
5837	REF adaptation factor CT side 1 (REF CT-S1:)	REF	VI	ON OFF												
5838	REF adaptation factor CT side 2 (REF CT-S2:)	REF	VI	ON OFF												
5840	REF is blocked by phase current (REF I> blocked)	REF	OUT	on off	*		*	LED			BO		76	40	1	Yes
5841	REF release by U0> (REF U0> releas.)	REF	OUT	on off	*		*	LED			BO		76	41	1	Yes
5845	REF pickup of I-REF> (I-REF> pickup)	REF	OUT	*	*		*	LED			BO		76	42	1	Yes
5846	REF characteristic picked up (REF char.pickup)	REF	OUT	*	*		*	LED			BO		76	43	1	Yes
5847	I0-Diff at REF-Trip (I0-Diff:)	REF	VI	*	ON OFF								76	47	4	No
5848	I0-Restraint at REF-Trip (I0-Res:)	REF	VI	*	ON OFF								76	48	4	No
6503	>BLOCK undervoltage protection (>BLOCK U/V)	Undervoltage	SP	*	*		*	LED	BI		BO					
6506	>BLOCK undervoltage protection U< (>BLOCK U<)	Undervoltage	SP	on off	*		*	LED	BI		BO		74	6	1	Yes
6508	>BLOCK undervoltage protection U<< (>BLOCK U<<)	Undervoltage	SP	on off	*		*	LED	BI		BO		74	8	1	Yes
6513	>BLOCK overvoltage protection (>BLOCK O/V)	Overvoltage	SP	*	*		*	LED	BI		BO					
6516	>BLOCK overvoltage protection U> (>BLOCK U>)	Overvoltage	SP	on off	*		*	LED	BI		BO		74	20	1	Yes
6517	>BLOCK overvoltage protection U>> (>BLOCK U>>)	Overvoltage	SP	on off	*		*	LED	BI		BO		74	21	1	Yes
6520	>BLOCK inverse undervoltage protection (>BLOCK Up<)	Inv.Undervolt.	SP	*	*		*	LED	BI		BO					
6522	Inv. Undervoltage prot. is switched OFF (Up< OFF)	Inv.Undervolt.	OUT	on off	*		*	LED			BO		74	95	1	Yes
6523	Inv. Undervoltage protection is BLOCKED (Up< BLOCK)	Inv.Undervolt.	OUT	on off	on off		*	LED			BO		74	96	1	Yes
6524	Inv. Undervoltage protection is ACTIVE (Up< ACTIVE)	Inv.Undervolt.	OUT	on off	*		*	LED			BO		74	97	1	Yes
6525	Inverse Undervoltage Up< picked up (Up< picked up)	Inv.Undervolt.	OUT	*	on off		*	LED			BO		74	98	2	Yes
6526	Inv. Undervoltage Up<-char. picked up (Up< ch. pick.up)	Inv.Undervolt.	OUT	*	on off		*	LED			BO		74	99	2	Yes
6527	Inverse Undervoltage Up< TRIP (Up< AUS)	Inv.Undervolt.	OUT	*	on		*	LED			BO		74	100	2	Yes
6530	Undervoltage protection switched OFF (Undervolt. OFF)	Undervoltage	OUT	on off	*		*	LED			BO		74	30	1	Yes
6531	Undervoltage protection is BLOCKED (Undervolt. BLK)	Undervoltage	OUT	on off	on off		*	LED			BO		74	31	1	Yes
6532	Undervoltage protection is ACTIVE (Undervolt. ACT)	Undervoltage	OUT	on off	*		*	LED			BO		74	32	1	Yes
6533	Undervoltage U< picked up (U< picked up)	Undervoltage	OUT	*	on off		*	LED			BO		74	33	2	Yes

No.	Description	Function	Type of In-for-matio n	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log On/Off	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	Information Number	Data Unit	General Interrogation
6537	Undervoltage U<< picked up (U<< picked up)	Undervoltage	OUT	*	on off		*	LED			BO		74	37	2	Yes
6539	Undervoltage U< TRIP (U< TRIP)	Undervoltage	OUT	*	on		m	LED			BO		74	39	2	Yes
6540	Undervoltage U<< TRIP (U<< TRIP)	Undervoltage	OUT	*	on		m	LED			BO		74	40	2	Yes
6565	Overvoltage protection switched OFF (Overvolt. OFF)	Overvoltage	OUT	on off	*		*	LED			BO		74	65	1	Yes
6566	Overvoltage protection is BLOCKED (Overvolt. BLK)	Overvoltage	OUT	on off	on off		*	LED			BO		74	66	1	Yes
6567	Overvoltage protection is ACTIVE (Overvolt. ACT)	Overvoltage	OUT	on off	*		*	LED			BO		74	67	1	Yes
6568	Overvoltage U> picked up (U> picked up)	Overvoltage	OUT	*	on off		*	LED			BO		74	68	2	Yes
6570	Overvoltage U> TRIP (U> TRIP)	Overvoltage	OUT	*	on		m	LED			BO		74	70	2	Yes
6571	Overvoltage U>> picked up (U>> picked up)	Overvoltage	OUT	*	on off		*	LED			BO		74	71	2	Yes
6573	Overvoltage U>> TRIP (U>> TRIP)	Overvoltage	OUT	*	on		m	LED			BO		74	73	2	Yes
6575	Voltage Transformer Fuse Failure (VT Fuse Failure)	Supervision	OUT	on off	*		*	LED			BO		74	74	1	Yes
6801	>BLOCK Motor Starting Supervi-sion (>BLK START-SUP)	Start Motor	SP	*	*		*	LED	BI		BO					
6805	>Rotor is locked (>Rotor locked)	Start Motor	SP	on off	*		*	LED	BI		BO					
6811	Starting time supervision switched OFF (START-SUP OFF)	Start Motor	OUT	on off	*		*	LED			BO		169	51	1	Yes
6812	Starting time supervision is BLOCKED (START-SUP BLK)	Start Motor	OUT	on off	on off		*	LED			BO		169	52	1	Yes
6813	Starting time supervision is ACTIVE (START-SUP ACT)	Start Motor	OUT	on off	*		*	LED			BO		169	53	1	Yes
6821	Starting time supervision TRIP (START-SUP TRIP)	Start Motor	OUT	*	on		*	LED			BO		169	54	2	Yes
6822	Rotor is LOCKED after Locked Rotor Time (Rotor locked)	Start Motor	OUT	*	on		*	LED			BO		169	55	2	Yes
6823	Starting time supervision picked up (START-SUP PU)	Start Motor	OUT	on off	*		*	LED			BO		169	56	1	Yes
6851	>BLOCK Trip circuit supervision (>BLOCK TripC)	TripCirc.Superv	SP	*	*		*	LED	BI		BO					
6852	>Trip circuit supervision: trip relay (>TripC trip rel)	TripCirc.Superv	SP	on off	*		*	LED	BI		BO		170	51	1	Yes
6853	>Trip circuit supervision: breaker relay (>TripC brk rel.)	TripCirc.Superv	SP	on off	*		*	LED	BI		BO		170	52	1	Yes
6861	Trip circuit supervision OFF (TripC OFF)	TripCirc.Superv	OUT	on off	*		*	LED			BO		170	53	1	Yes
6862	Trip circuit supervision is BLOCKED (TripC BLOCKED)	TripCirc.Superv	OUT	on off	on off		*	LED			BO		153	16	1	Yes
6863	Trip circuit supervision is ACTIVE (TripC ACTIVE)	TripCirc.Superv	OUT	on off	*		*	LED			BO		153	17	1	Yes
6864	Trip Circuit blk. Bin. input is not set (TripC ProgFail)	TripCirc.Superv	OUT	on off	*		*	LED			BO		170	54	1	Yes
6865	Failure Trip Circuit (FAIL: Trip cir.)	TripCirc.Superv	OUT	on off	*		*	LED			BO		170	55	1	Yes
7960	Measured Value MV1> picked up (Meas. Value1>)	Threshold	OUT	*	*		*	LED			BO					

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log On/Off	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	Information Number	Data Unit	General Interrogation
7961	Measured Value MV2< picked up (Meas. Value2<)	Threshold	OUT	*	*		*	LED			BO					
7962	Measured Value MV3> picked up (Meas. Value3>)	Threshold	OUT	*	*		*	LED			BO					
7963	Measured Value MV4< picked up (Meas. Value4<)	Threshold	OUT	*	*		*	LED			BO					
7964	Measured Value MV5> picked up (Meas. Value5>)	Threshold	OUT	*	*		*	LED			BO					
7965	Measured Value MV6< picked up (Meas. Value6<)	Threshold	OUT	*	*		*	LED			BO					
14101	Fail: RTD (broken wire/shorted) (Fail: RTD)	RTD-Box	OUT	on off	*		*	LED			BO					
14111	Fail: RTD 1 (broken wire/shorted) (Fail: RTD 1)	RTD-Box	OUT	on off	*		*	LED			BO					
14112	RTD 1 Temperature stage 1 picked up (RTD 1 St.1 p.up)	RTD-Box	OUT	on off	*		*	LED			BO					
14113	RTD 1 Temperature stage 2 picked up (RTD 1 St.2 p.up)	RTD-Box	OUT	on off	*		*	LED			BO					
14121	Fail: RTD 2 (broken wire/shorted) (Fail: RTD 2)	RTD-Box	OUT	on off	*		*	LED			BO					
14122	RTD 2 Temperature stage 1 picked up (RTD 2 St.1 p.up)	RTD-Box	OUT	on off	*		*	LED			BO					
14123	RTD 2 Temperature stage 2 picked up (RTD 2 St.2 p.up)	RTD-Box	OUT	on off	*		*	LED			BO					
14131	Fail: RTD 3 (broken wire/shorted) (Fail: RTD 3)	RTD-Box	OUT	on off	*		*	LED			BO					
14132	RTD 3 Temperature stage 1 picked up (RTD 3 St.1 p.up)	RTD-Box	OUT	on off	*		*	LED			BO					
14133	RTD 3 Temperature stage 2 picked up (RTD 3 St.2 p.up)	RTD-Box	OUT	on off	*		*	LED			BO					
14141	Fail: RTD 4 (broken wire/shorted) (Fail: RTD 4)	RTD-Box	OUT	on off	*		*	LED			BO					
14142	RTD 4 Temperature stage 1 picked up (RTD 4 St.1 p.up)	RTD-Box	OUT	on off	*		*	LED			BO					
14143	RTD 4 Temperature stage 2 picked up (RTD 4 St.2 p.up)	RTD-Box	OUT	on off	*		*	LED			BO					
14151	Fail: RTD 5 (broken wire/shorted) (Fail: RTD 5)	RTD-Box	OUT	on off	*		*	LED			BO					
14152	RTD 5 Temperature stage 1 picked up (RTD 5 St.1 p.up)	RTD-Box	OUT	on off	*		*	LED			BO					
14153	RTD 5 Temperature stage 2 picked up (RTD 5 St.2 p.up)	RTD-Box	OUT	on off	*		*	LED			BO					
14161	Fail: RTD 6 (broken wire/shorted) (Fail: RTD 6)	RTD-Box	OUT	on off	*		*	LED			BO					
14162	RTD 6 Temperature stage 1 picked up (RTD 6 St.1 p.up)	RTD-Box	OUT	on off	*		*	LED			BO					
14163	RTD 6 Temperature stage 2 picked up (RTD 6 St.2 p.up)	RTD-Box	OUT	on off	*		*	LED			BO					
14171	Fail: RTD 7 (broken wire/shorted) (Fail: RTD 7)	RTD-Box	OUT	on off	*		*	LED			BO					
14172	RTD 7 Temperature stage 1 picked up (RTD 7 St.1 p.up)	RTD-Box	OUT	on off	*		*	LED			BO					
14173	RTD 7 Temperature stage 2 picked up (RTD 7 St.2 p.up)	RTD-Box	OUT	on off	*		*	LED			BO					
14181	Fail: RTD 8 (broken wire/shorted) (Fail: RTD 8)	RTD-Box	OUT	on off	*		*	LED			BO					

No.	Description	Function	Type of In-for-matio n	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log On/Off	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	Information Number	Data Unit	General Interrogation
14182	RTD 8 Temperature stage 1 picked up (RTD 8 St.1 p.up)	RTD-Box	OUT	on off	*		*	LED			BO					
14183	RTD 8 Temperature stage 2 picked up (RTD 8 St.2 p.up)	RTD-Box	OUT	on off	*		*	LED			BO					
14191	Fail: RTD 9 (broken wire/shorted) (Fail: RTD 9)	RTD-Box	OUT	on off	*		*	LED			BO					
14192	RTD 9 Temperature stage 1 picked up (RTD 9 St.1 p.up)	RTD-Box	OUT	on off	*		*	LED			BO					
14193	RTD 9 Temperature stage 2 picked up (RTD 9 St.2 p.up)	RTD-Box	OUT	on off	*		*	LED			BO					
14201	Fail: RTD10 (broken wire/short-ed) (Fail: RTD10)	RTD-Box	OUT	on off	*		*	LED			BO					
14202	RTD10 Temperature stage 1 picked up (RTD10 St.1 p.up)	RTD-Box	OUT	on off	*		*	LED			BO					
14203	RTD10 Temperature stage 2 picked up (RTD10 St.2 p.up)	RTD-Box	OUT	on off	*		*	LED			BO					
14211	Fail: RTD11 (broken wire/short-ed) (Fail: RTD11)	RTD-Box	OUT	on off	*		*	LED			BO					
14212	RTD11 Temperature stage 1 picked up (RTD11 St.1 p.up)	RTD-Box	OUT	on off	*		*	LED			BO					
14213	RTD11 Temperature stage 2 picked up (RTD11 St.2 p.up)	RTD-Box	OUT	on off	*		*	LED			BO					
14221	Fail: RTD12 (broken wire/short-ed) (Fail: RTD12)	RTD-Box	OUT	on off	*		*	LED			BO					
14222	RTD12 Temperature stage 1 picked up (RTD12 St.1 p.up)	RTD-Box	OUT	on off	*		*	LED			BO					
14223	RTD12 Temperature stage 2 picked up (RTD12 St.2 p.up)	RTD-Box	OUT	on off	*		*	LED			BO					
25071	>BLOCK sensitive earth current prot. B (>BLK Sens. E B)	Sens. E Fault B	SP	*	*		*	LED	BI		BO					
25072	Earth current prot. B is switched OFF (IEE-B OFF)	Sens. E Fault B	OUT	on off	*		*	LED			BO		151	182	1	Yes
25073	Earth current prot. B is BLOCKED (IEE-B BLOCKED)	Sens. E Fault B	OUT	on off	on off		*	LED			BO		151	183	1	Yes
25074	Earth current prot. B is ACTIVE (IEE-B ACTIVE)	Sens. E Fault B	OUT	on off	*		*	LED			BO		151	184	1	Yes
25077	IEE-B> picked up (IEE-B> pickup)	Sens. E Fault B	OUT	*	on off		*	LED			BO		151	185	2	Yes
25078	IEE-B< picked up (IEE-B< pickup)	Sens. E Fault B	OUT	*	on off		*	LED			BO		151	186	2	Yes
25079	IEE-B> TRIP (IEE-B> TRIP)	Sens. E Fault B	OUT	*	on		*	LED			BO		151	187	2	Yes
25080	IEE-B< TRIP (IEE-B< TRIP)	Sens. E Fault B	OUT	*	on		*	LED			BO		151	188	2	Yes
25083	Measured Value MV7> picked up (Meas. Value7>)	Threshold	OUT	*	*		*	LED			BO					
25084	Measured Value MV8< picked up (Meas. Value8<)	Threshold	OUT	*	*		*	LED			BO					
25085	Measured Value MV9> picked up (Meas. Value9>)	Threshold	OUT	*	*		*	LED			BO					
25086	Measured Value MV10< picked up (Meas. Value10<)	Threshold	OUT	*	*		*	LED			BO					
30053	Fault recording is running (Fault rec. run.)	Osc. Fault Rec.	OUT	*	*		*	LED			BO					
30607	Accumulation of interrupted curr. L1 S1 (ΣIL1 S1:)	Statistics	VI													
30608	Accumulation of interrupted curr. L2 S1 (ΣIL2 S1:)	Statistics	VI													

No.	Description	Function	Type of Information	Log Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log ON/OFF	Trip (Fault) Log On/Off	Ground Fault Log ON/OFF	Marked in Oscill. Record	LED	Binary Input	Function Key	Relay	Chatter Suppression	Type	Information Number	Data Unit	General Interrogation
30609	Accumulation of interrupted curr. L3 S1 (ΣIL3 S1:)	Statistics	VI													
30610	Accumulation of interrupted curr. L1 S2 (ΣIL1 S2:)	Statistics	VI													
30611	Accumulation of interrupted curr. L2 S2 (ΣIL2 S2:)	Statistics	VI													
30612	Accumulation of interrupted curr. L3 S2 (ΣIL3 S2:)	Statistics	VI													

A.9 Group Alarms

No.	Description	Function No.	Description
140	Error Sum Alarm	181 191 264 267	Error A/D-conv. Error Offset Fail: RTD-Box 1 Fail: RTD-Box 2
160	Alarm Sum Event	161 164 171 147 6575 193 177	Fail I Superv. Fail U Superv. Fail Ph. Seq. Error PwrSupply VT Fuse Failure Alarm NO calibr Fail Battery
161	Fail I Superv.	230 231 571 572	Fail. Σ I Side1 Fail. Σ I Side2 Fail. Isym 1 Fail. Isym 2
164	Fail U Superv.	165 167	Fail Σ U Ph-E Fail U balance
171	Fail Ph. Seq.	265 266 176	FailPh.Seq I S1 FailPh.Seq I S2 Fail Ph. Seq. U
181	Error A/D-conv.	210 211 194 212 213 214 190 185 187 188	Err1A/5AwrongS1 Err1A/5AwrongS2 Error neutralCT Err. TD1 jumper Err. TD2 jumper Err. TD3 jumper Error Board 0 Error Board 3 Error Board 5 Error Board 6

A.10 Measured Values

No.	Description	Function	IEC 60870-5-103					Configurable in Matrix		
			Type	Information Number	Compatibility	Data Unit	Position	CFC	Control Display	Default Display
-	IL< under current (IL<)	Set Points(MV)	-	-	-	-	-	CFC	CD	DD
-	Number of TRIPs (#of TRIPs=)	Statistics	-	-	-	-	-	CFC	CD	DD
-	Operating hours greater than (OpHour>)	SetPoint(Stat)	-	-	-	-	-	CFC	CD	DD
605	I1 (positive sequence) (I1 =)	Measurement	134	147	No	9	5	CFC	CD	DD
606	I2 (negative sequence) (I2 =)	Measurement	134	147	No	9	6	CFC	CD	DD
621	U L1-E (UL1E=)	Measurement	134	147	No	9	7	CFC	CD	DD
622	U L2-E (UL2E=)	Measurement	134	147	No	9	8	CFC	CD	DD
623	U L3-E (UL3E=)	Measurement	134	147	No	9	9	CFC	CD	DD
624	U L12 (UL12=)	Measurement	-	-	-	-	-	CFC	CD	DD
625	U L23 (UL23=)	Measurement	-	-	-	-	-	CFC	CD	DD
626	U L31 (UL31=)	Measurement	-	-	-	-	-	CFC	CD	DD
627	Displacement voltage UE (UE =)	Measurement	134	147	No	9	10	CFC	CD	DD
629	U1 (positive sequence) (U1 =)	Measurement	134	147	No	9	11	CFC	CD	DD
630	U2 (negative sequence) (U2 =)	Measurement	-	-	-	-	-	CFC	CD	DD
639	UE 3rd Harmonic Voltage Minimum (UE3h min=)	Min/Max meter	-	-	-	-	-	CFC	CD	DD
640	UE 3rd Harmonic Voltage Maximum (UE3h max=)	Min/Max meter	-	-	-	-	-	CFC	CD	DD
641	P (active power) (P =)	Measurement	134	147	No	9	12	CFC	CD	DD
642	Q (reactive power) (Q =)	Measurement	134	147	No	9	13	CFC	CD	DD
644	Frequency (Freq=)	Measurement	134	147	No	9	15	CFC	CD	DD
645	S (apparent power) (S =)	Measurement	-	-	-	-	-	CFC	CD	DD
650	UE 3rd harmonic (UE3h =)	Measurement	-	-	-	-	-	CFC	CD	DD
660	Remaining Time for Switch ON (T Rem.=)	Meas. Thermal	-	-	-	-	-	CFC	CD	DD
661	Threshold of Restart Inhibit (Θ REST. =)	Meas. Thermal	-	-	-	-	-	CFC	CD	DD
662	DC Current (I DC =)	Measurement	-	-	-	-	-	CFC	CD	DD
669	SEF 100%: 20 Hz voltage stator circuit (U20=)	Measurement	-	-	-	-	-	CFC	CD	DD
670	SEF 100%: 20 Hz current stator circuit (I20=)	Measurement	-	-	-	-	-	CFC	CD	DD
693	REF(R,fn): Total Resistance (R total) (Rtot =)	Measurement	-	-	-	-	-	CFC	CD	DD
696	REF(R,fn): Total Reactance (X total) (Xtot =)	Measurement	-	-	-	-	-	CFC	CD	DD
697	REF(R,fn): Phase Angle of Z total (φ Ztot=)	Measurement	-	-	-	-	-	CFC	CD	DD
700	REF(R,fn): Fault Resistance (R earth) (Re =)	Measurement	134	148	No	9	5	CFC	CD	DD
721	Operat. meas. current L1 side 1 [%] is (IL1S1=)	Measurement	134	148	No	9	1	CFC	CD	DD
722	Operat. meas. current L2 side 1 [%] is (IL2S1=)	Measurement	134	148	No	9	2	CFC	CD	DD
723	Operat. meas. current L3 side 1 [%] is (IL3S1=)	Measurement	134	148	No	9	3	CFC	CD	DD
724	Operat. meas. current L1 side 2 [%] is (IL1S2=)	Measurement	134	147	No	9	1	CFC	CD	DD
725	Operat. meas. current L2 side 2 [%] is (IL2S2=)	Measurement	134	147	No	9	2	CFC	CD	DD
726	Operat. meas. current L3 side 2 [%] is (IL3S2=)	Measurement	134	147	No	9	3	CFC	CD	DD
755	REF(1-3Hz): Freq. of square-wave gen. (fgen =)	Measurement	-	-	-	-	-	CFC	CD	DD

No.	Description	Function	IEC 60870-5-103					Configurable in Matrix		
			Type	Information Number	Compatibility	Data Unit	Position	CFC	Control Display	Default Display
757	REF(1-3Hz): Volt. of square-wave gen. (Ugen =)	Measurement	-	-	-	-	-	CFC	CD	DD
758	REF(1-3Hz): Curr. of rotor meas. circuit (Imeas. =)	Measurement	-	-	-	-	-	CFC	CD	DD
759	REF(1-3 Hz): Charge at polarity rev.(Qc) (Qc =)	Measurement	-	-	-	-	-	CFC	CD	DD
760	SEF100%: Prim. stator earth resistance (RSEFp=)	Measurement	-	-	-	-	-	CFC	CD	DD
761	REF(1-3Hz): Fault Resistance (R earth) (R earth=)	Measurement	134	148	No	9	6	CFC	CD	DD
762	SEF100%: Bias volt. for stator circuit (U SEF=)	Measurement	-	-	-	-	-	CFC	CD	DD
763	SEF100%: Earth curr. in stator circuit (I SEF=)	Measurement	-	-	-	-	-	CFC	CD	DD
764	SEF100%: Stator earth resistance (R SEF=)	Measurement	134	148	No	9	7	CFC	CD	DD
765	(U/Un) / (f/fn) (U/f =)	Measurement	134	147	No	9	16	CFC	CD	DD
766	Calculated temperature (U/f) (U/f th. =)	Meas. Thermal	-	-	-	-	-	CFC	CD	DD
769	Displacement voltage U Interturn (U I/T =)	Measurement	-	-	-	-	-	CFC	CD	DD
801	Temperat. rise for warning and trip (Θ/Θtrip =)	Meas. Thermal	-	-	-	-	-	CFC	CD	DD
802	Temperature rise for phase L1 (Θ/ΘtripL1=)	Meas. Thermal	-	-	-	-	-	CFC	CD	DD
803	Temperature rise for phase L2 (Θ/ΘtripL2=)	Meas. Thermal	-	-	-	-	-	CFC	CD	DD
804	Temperature rise for phase L3 (Θ/ΘtripL3=)	Meas. Thermal	-	-	-	-	-	CFC	CD	DD
805	Temperature of Rotor (ΘR/ΘRmax =)	Meas. Thermal	-	-	-	-	-	CFC	CD	DD
827	Sensitive Current IEE-B (IEE-B=)	Measurement	-	-	-	-	-	CFC	CD	DD
828	Senstive Earth Current 1 (IEE1=)	Measurement	134	148	No	9	4	CFC	CD	DD
829	Senstive Earth Current 2 (IEE2=)	Measurement	134	147	No	9	4	CFC	CD	DD
831	3I0 (zero sequence) (3I0 =)	Measurement	-	-	-	-	-	CFC	CD	DD
832	U0 (zero sequence) (U0 =)	Measurement	-	-	-	-	-	CFC	CD	DD
857	Positive Sequence Minimum (I1 Min=)	Min/Max meter	-	-	-	-	-	CFC	CD	DD
858	Positive Sequence Maximum (I1 Max=)	Min/Max meter	-	-	-	-	-	CFC	CD	DD
874	U1 (positive sequence) Voltage Minimum (U1 Min =)	Min/Max meter	-	-	-	-	-	CFC	CD	DD
875	U1 (positive sequence) Voltage Maximum (U1 Max =)	Min/Max meter	-	-	-	-	-	CFC	CD	DD
876	Active Power Minimum (PMin=)	Min/Max meter	-	-	-	-	-	CFC	CD	DD
877	Active Power Maximum (PMax=)	Min/Max meter	-	-	-	-	-	CFC	CD	DD
878	Reactive Power Minimum (QMin=)	Min/Max meter	-	-	-	-	-	CFC	CD	DD
879	Reactive Power Maximum (QMax=)	Min/Max meter	-	-	-	-	-	CFC	CD	DD
882	Frequency Minimum (fMin=)	Min/Max meter	-	-	-	-	-	CFC	CD	DD
883	Frequency Maximum (fMax=)	Min/Max meter	-	-	-	-	-	CFC	CD	DD
888	Pulsed Energy Wp (active) (Wp(puls))	Energy	133	55	No	205	-	CFC	CD	DD
889	Pulsed Energy Wq (reactive) (Wq(puls))	Energy	133	56	No	205	-	CFC	CD	DD
894	DC voltage (U DC =)	Measurement	-	-	-	-	-	CFC	CD	DD
896	REF(R,fn): Injected Voltage (U RE) (U RE =)	Measurement	-	-	-	-	-	CFC	CD	DD
897	REF(R,fn): Curr. in the Circuit (I RE) (I RE =)	Measurement	-	-	-	-	-	CFC	CD	DD
901	Power Factor (PF =)	Measurement	134	147	No	9	14	CFC	CD	DD
902	Power angle (PHI=)	Measurement	-	-	-	-	-	CFC	CD	DD
903	Resistance (R=)	Measurement	-	-	-	-	-	CFC	CD	DD
904	Reactance (X=)	Measurement	-	-	-	-	-	CFC	CD	DD
909	Excitation voltage (Uexcit.=)	Measurement	-	-	-	-	-	CFC	CD	DD

No.	Description	Function	IEC 60870-5-103					Configurable in Matrix		
			Type	Information Number	Compatibility	Data Unit	Position	CFC	Control Display	Default Display
910	Calculated rotor temp. (unbal. load) (Therm-Rep.=)	Meas. Thermal	-	-	-	-	-	CFC	CD	DD
911	Cooling medium temperature (AMB.TEMP =)	Meas. Thermal	-	-	-	-	-	CFC	CD	DD
924	Wp Forward (WpForward)	Energy	133	51	No	205	-	CFC	CD	DD
925	Wq Forward (WqForward)	Energy	133	52	No	205	-	CFC	CD	DD
928	Wp Reverse (WpReverse)	Energy	133	53	No	205	-	CFC	CD	DD
929	Wq Reverse (WqReverse)	Energy	133	54	No	205	-	CFC	CD	DD
995	SEF100%: Phase angle in stator circuit (φ SEF=)	Measurement	-	-	-	-	-	CFC	CD	DD
996	Transducer 1 (Td1=)	Measurement	-	-	-	-	-	CFC	CD	DD
997	Transducer 2 (Td2=)	Measurement	-	-	-	-	-	CFC	CD	DD
998	Transducer 3 (Td3=)	Measurement	-	-	-	-	-	CFC	CD	DD
1068	Temperature of RTD 1 (Θ RTD 1 =)	Meas. Thermal	134	146	No	9	1	CFC	CD	DD
1069	Temperature of RTD 2 (Θ RTD 2 =)	Meas. Thermal	134	146	No	9	2	CFC	CD	DD
1070	Temperature of RTD 3 (Θ RTD 3 =)	Meas. Thermal	134	146	No	9	3	CFC	CD	DD
1071	Temperature of RTD 4 (Θ RTD 4 =)	Meas. Thermal	134	146	No	9	4	CFC	CD	DD
1072	Temperature of RTD 5 (Θ RTD 5 =)	Meas. Thermal	134	146	No	9	5	CFC	CD	DD
1073	Temperature of RTD 6 (Θ RTD 6 =)	Meas. Thermal	134	146	No	9	6	CFC	CD	DD
1074	Temperature of RTD 7 (Θ RTD 7 =)	Meas. Thermal	134	146	No	9	7	CFC	CD	DD
1075	Temperature of RTD 8 (Θ RTD 8 =)	Meas. Thermal	134	146	No	9	8	CFC	CD	DD
1076	Temperature of RTD 9 (Θ RTD 9 =)	Meas. Thermal	134	146	No	9	9	CFC	CD	DD
1077	Temperature of RTD10 (Θ RTD10 =)	Meas. Thermal	134	146	No	9	10	CFC	CD	DD
1078	Temperature of RTD11 (Θ RTD11 =)	Meas. Thermal	134	146	No	9	11	CFC	CD	DD
1079	Temperature of RTD12 (Θ RTD12 =)	Meas. Thermal	134	146	No	9	12	CFC	CD	DD
7740	Phase angle in phase IL1 side 1 (φIL1S1=)	Measurement	-	-	-	-	-	CFC	CD	DD
7741	Phase angle in phase IL2 side 1 (φIL2S1=)	Measurement	-	-	-	-	-	CFC	CD	DD
7742	IDiffL1(I/Inominal object [%]) (IDiffL1=)	Meas. Dif/Rest.	-	-	-	-	-	CFC	CD	DD
7743	IDiffL2(I/Inominal object [%]) (IDiffL2=)	Meas. Dif/Rest.	-	-	-	-	-	CFC	CD	DD
7744	IDiffL3(I/Inominal object [%]) (IDiffL3=)	Meas. Dif/Rest.	-	-	-	-	-	CFC	CD	DD
7745	IRestL1(I/Inominal object [%]) (IRestL1=)	Meas. Dif/Rest.	-	-	-	-	-	CFC	CD	DD
7746	IRestL2(I/Inominal object [%]) (IRestL2=)	Meas. Dif/Rest.	-	-	-	-	-	CFC	CD	DD
7747	IRestL3(I/Inominal object [%]) (IRestL3=)	Meas. Dif/Rest.	-	-	-	-	-	CFC	CD	DD
7749	Phase angle in phase IL3 side 1 (φIL3S1=)	Measurement	-	-	-	-	-	CFC	CD	DD
7750	Phase angle in phase IL1 side 2 (φIL1S2=)	Measurement	-	-	-	-	-	CFC	CD	DD
7759	Phase angle in phase IL2 side 2 (φIL2S2=)	Measurement	-	-	-	-	-	CFC	CD	DD
7760	Phase angle in phase IL3 side 2 (φIL3S2=)	Measurement	-	-	-	-	-	CFC	CD	DD
30654	I0-Diff REF (I/Inominal object [%]) (I0-Diff=)	Meas. Dif/Rest.	-	-	-	-	-	CFC	CD	DD
30655	I0-Rest REF (I/Inominal object [%]) (I0-Rest=)	Meas. Dif/Rest.	-	-	-	-	-	CFC	CD	DD
30659	3I0-1 REF (I/Inominal object [%]) (3I0-1 =)	Meas. Dif/Rest.	-	-	-	-	-	CFC	CD	DD
30660	3I0-2 REF (I/Inominal object [%]) (3I0-2 =)	Meas. Dif/Rest.	-	-	-	-	-	CFC	CD	DD

■

Literature

/1/ SIPROTEC 4 System Description; E50417-H1176-C151-A9

/2/ SIPROTEC DIGSI, Start Up; E50417-G1176-C152-A3

/3/ DIGSI CFC, Manual; E50417-H1176-C098-A9

/4/ SIPROTEC SIGRA 4, Manual; E50417-H1176-C070-A4

/5/ Planning Machine Protection Systems, E50400-U0089-U412-A1-7600.

Glossary

Battery

The buffer battery ensures that specified data areas, flags, timers and counters are retained retentively.

Bay controllers

Bay controllers are devices with control and monitoring functions without protective functions.

Bit pattern indication

Bit pattern indication is a processing function by means of which items of digital process information applying across several inputs can be detected together in parallel and processed further. The bit pattern length can be specified as 1, 2, 3 or 4 bytes.

BP_xx

→ Bit pattern indication (Bitstring Of x Bit), x designates the length in bits (8, 16, 24 or 32 bits).

C_xx

Command without feedback

CF_xx

Command with feedback

CFC

Continuous Function Chart. CFC is a graphical editor with which a program can be created and configured by using ready-made blocks.

CFC blocks

Blocks are parts of the user program delimited by their function, their structure or their purpose.

Chatter blocking

A rapidly intermittent input (for example, due to a relay contact fault) is switched off after a configurable monitoring time and can thus not generate any further signal changes. The function prevents overloading of the system when a fault arises.

Combination devices

Combination devices are bay devices with protection functions and a control display.

Combination matrix

From DIGSI V4.6 onward, up to 32 compatible SIPROTEC 4 devices can communicate with one another in an Inter Relay Communication combination (IRC combination). Which device exchanges which information is defined with the help of the combination matrix.

Communication branch

A communications branch corresponds to the configuration of 1 to n users that communicate by means of a common bus.

Communication reference CR

The communication reference describes the type and version of a station in communication by PROFIBUS.

Component view

In addition to a topological view, SIMATIC Manager offers you a component view. The component view does not offer any overview of the hierarchy of a project. It does, however, provide an overview of all the SIPROTEC 4 devices within a project.

COMTRADE

Common Format for Transient Data Exchange, format for fault records.

Container

If an object can contain other objects, it is called a container. The object Folder is an example of such a container.

Control display

The display which is displayed on devices with a large (graphic) display after you have pressed the control key is called the control display. It contains the switchgear that can be controlled in the feeder with status display. It is used to perform switching operations. Defining this display is part of the configuration.

Data pane

→ The right-hand area of the project window displays the contents of the area selected in the → navigation window, for example indications, measured values, etc. of the information lists or the function selection for the device configuration.

DCF77

The extremely precise official time is determined in Germany by the "Physikalisch-Technische-Bundesanstalt PTB" in Braunschweig. The atomic clock station of the PTB transmits this time via the long-wave time-signal transmitter in Mainflingen near Frankfurt/Main. The emitted time signal can be received within a radius of approx. 1,500 km from Frankfurt/Main.

Device container

In the Component View, all SIPROTEC 4 devices are assigned to an object of type Device container. This object is a special object of DIGSI Manager. However, since there is no component view in DIGSI Manager, this object only becomes visible in conjunction with STEP 7.

Double command

Double commands are process outputs which indicate 4 process states at 2 outputs: 2 defined (for example ON/OFF) and 2 undefined states (for example intermediate positions)

Double-point indication

Double-point indications are items of process information which indicate 4 process states at 2 inputs: 2 defined (for example ON/OFF) and 2 undefined states (for example intermediate positions).

DP

→ Double-point indication

DP_I

→ Double point indication, intermediate position 00

Drag and drop

Copying, moving and linking function, used at graphics user interfaces. Objects are selected with the mouse, held and moved from one data area to another.

Earth

The conductive earth whose electric potential can be set equal to zero at every point. In the area of earth electrodes the earth can have a potential deviating from zero. The term "Earth reference plane" is often used for this state.

Earth (verb)

This term means that a conductive part is connected via an earthing system to the → earth.

Earthing

Earthing is the total of all means and measures used for earthing.

Electromagnetic compatibility

Electromagnetic compatibility (EMC) is the ability of an electrical apparatus to function fault-free in a specified environment without influencing the environment unduly.

EMC

→ Electromagnetic compatibility

ESD protection

ESD protection is the total of all the means and measures used to protect electrostatic sensitive devices.

ExBPxx

External bit pattern indication via an ETHERNET connection, device-specific → Bit pattern indication

ExC

External command without feedback via an ETHERNET connection, device-specific

ExCF

External command with feedback via an ETHERNET connection, device-specific

ExDP

External double point indication via an ETHERNET connection, device-specific → Double point indication

ExDP_I

External double point indication via an ETHERNET connection, intermediate position 00, device-specific → Double point indication

ExMV

External metered value via an ETHERNET connection, device-specific

ExSI

External single point indication via an ETHERNET connection, device-specific → Single point indication

ExSI_F

External single point indication via an ETHERNET connection, device-specific → Transient information, → Single point indication

Field devices

Generic term for all devices assigned to the field level: Protection devices, combination devices, bay controllers.

Floating

→ Without electrical connection to the → Earth.

FMS communication branch

Within an FMS communication branch, the users communicate on the basis of the PROFIBUS FMS protocol via a PROFIBUS FMS network.

Folder

This object type is used to create the hierarchical structure of a project.

General interrogation (GI)

During the system start-up the state of all the process inputs, of the status and of the fault image is sampled. This information is used to update the system-end process image. The current process state can also be sampled after a data loss by means of a GI.

GOOSE message

GOOSE messages (Generic Object Oriented Substation Event) are data packets which are transferred event-controlled via the Ethernet communication system. They serve for direct information exchange among the relays. This mechanism implements cross-communication between bay units.

GPS

Global Positioning System. Satellites with atomic clocks on board orbit the earth twice a day on different paths in approx. 20,000 km. They transmit signals which also contain the GPS universal time. The GPS receiver determines its own position from the signals received. From its position it can derive the delay time of a satellite signal and thus correct the transmitted GPS universal time.

Hierarchy level

Within a structure with higher-level and lower-level objects a hierarchy level is a container of equivalent objects.

HV field description

The HV project description file contains details of fields which exist in a ModPara-project. The actual field information of each field is stored in a HV field description file. Within the HV project description file, each field is allocated such a HV field description file by a reference to the file name.

HV project description

All the data is exported once the configuration and parameterization of PCUs and sub-modules using ModPara has been completed. This data is split up into several files. One file contains details about the fundamental project structure. This also includes, for example, information detailing which fields exist in this project. This file is called a HV project description file.

ID

Internal double point indication → Double point indication

ID_S

Internal double point indication, intermediate position 00 → Double point indication

IEC

International Electrotechnical Commission, international standardisation body

IEC address

Within an IEC bus a unique IEC address has to be assigned to each SIPROTEC 4 device. A total of 254 IEC addresses are available for each IEC bus.

IEC communication branch

Within an IEC communication branch the users communicate on the basis of the IEC60-870-5-103 protocol via an IEC bus.

IEC61850

International communication standard for communication in substations. The objective of this standard is the interoperability of devices from different manufacturers on the station bus. An Ethernet network is used for data transfer.

Initialization string

An initialization string comprises a range of modem-specific commands. These are transmitted to the modem within the framework of modem initialization. The commands can, for example, force specific settings for the modem.

Inter relay communication

→ IRC combination

IRC combination

Inter Relay Communication, IRC, is used for directly exchanging process information between SIPROTEC 4 devices. You require an object of type IRC combination to configure an inter relay communication. Each user of the combination and all the necessary communication parameters are defined in this object. The type and scope of the information exchanged between the users is also stored in this object.

IRIG-B

Time signal code of the Inter-Range Instrumentation Group

IS

Internal single point indication → Single point indication

IS_F

Internal indication transient → Transient information, → Single point indication

ISO 9001

The ISO 9000 ff range of standards defines measures used to assure the quality of a product from the development stage to the manufacturing stage.

Link address

The link address gives the address of a V3/V2 device.

List view

The right window section of the project window displays the names and icons of objects which represent the contents of a container selected in the tree view. Because they are displayed in the form of a list, this area is called the list view.

LV

Limit value

LVU

Limit value, user-defined

Master

Masters may send data to other users and request data from other users. DIGSI operates as a master.

Metered value

Metered values are a processing function with which the total number of discrete similar events (counting pulses) is determined for a period, usually as an integrated value. In power supply companies the electrical work is usually recorded as a metered value (energy purchase/supply, energy transportation).

MLFB

MLFB is the abbreviation for "MaschinenLesbare FabrikateBezeichnung" (machine-readable product designation). This is the equivalent of an order number. The type and version of a SIPROTEC 4 device are coded in the order number.

Modem connection

This object type contains information on both partners of a modem connection, the local modem and the remote modem.

Modem profile

A modem profile consists of the name of the profile, a modem driver and may also comprise several initialization commands and a user address. You can create several modem profiles for one physical modem. To do so you need to link various initialization commands or user addresses to a modem driver and its properties and save them under different names.

Modems

Modem profiles for a modem connection are stored in this object type.

MV

Measured value

MVMV

Metered value which is formed from the measured value

MVT

Measured value with time

MVU

Measured value, user-defined

Navigation pane

The left pane of the project window displays the names and symbols of all containers of a project in the form of a folder tree.

Object

Each element of a project structure is called an object in DIGSI.

Object properties

Each object has properties. These might be general properties that are common to several objects. An object can also have specific properties.

Off-line

In offline mode a connection to a SIPROTEC 4 device is not required. You work with data which are stored in files.

OI_F

Output Indication Transient → Transient information

On-line

When working in online mode, there is a physical connection to a SIPROTEC 4 device. This connection can be implemented as a direct connection, as a modem connection or as a PROFIBUS FMS connection.

OUT

Output indication

Parameter set

The parameter set is the set of all parameters that can be set for a SIPROTEC 4 device.

Phone book

User addresses for a modem connection are saved in this object type.

PMV

Pulse metered value

Process bus

Devices with a process bus interface allow direct communication with SICAM HV modules. The process bus interface is equipped with an Ethernet module.

PROFIBUS

PROcess FIeld BUS, the German process and field bus standard, as specified in the standard EN 50170, Volume 2, PROFIBUS. It defines the functional, electrical, and mechanical properties for a bit-serial field bus.

PROFIBUS address

Within a PROFIBUS network a unique PROFIBUS address has to be assigned to each SIPROTEC 4 device. A total of 254 PROFIBUS addresses are available for each PROFIBUS network.

Project

Content-wise, a project is the image of a real power supply system. Graphically, a project is represented as a number of objects which are integrated in a hierarchical structure. Physically, a project consists of a number of directories and files containing project data.

Protection devices

All devices with a protective function and no control display.

Reorganizing

Frequent addition and deletion of objects results in memory areas that can no longer be used. By reorganizing projects, you can release these memory areas again. However, a cleanup also reassigns the VD addresses. The consequence is that all SIPROTEC 4 devices have to be reinitialized.

RIO file

Relay data Interchange format by Omicron.

RSxxx-interface

Serial interfaces RS232, RS422/485

SCADA Interface

Rear serial interface on the devices for connecting to a control system via IEC or PROFIBUS.

Service port

Rear serial interface on the devices for connecting DIGSI (for example, via modem).

Setting parameters

General term for all adjustments made to the device. Parameterization jobs are executed by means of DIGSI or, in some cases, directly on the device.

SI

→ Single point indication

SI_F

→ Single point indication transient → Transient information, → Single point indication

SICAM WinCC

The SICAM WinCC operator control and monitoring system displays the state of your network graphically, visualizes alarms, interrupts and indications, archives the network data, offers the possibility of intervening manually in the process and manages the system rights of the individual employee.

SICAM PAS (Power Automation System)

Substation control system: The range of possible configurations spans from integrated standalone systems (SICAM PAS and M&C with SICAM PAS CC on one computer) to separate hardware for SICAM PAS and SICAM PAS CC to distributed systems with multiple SICAM Station Units. The software is a modular system with basic and optional packages. SICAM PAS is a purely distributed system: the process interface is implemented by the use of bay units / remote terminal units.

SICAM Station Unit

The SICAM Station Unit with its special hardware (no fan, no rotating parts) and its Windows XP Embedded operating system is the basis for SICAM PAS.

Single command

Single commands are process outputs which indicate 2 process states (for example, ON/OFF) at one output.

Single point indication

Single indications are items of process information which indicate 2 process states (for example, ON/OFF) at one output.

SIPROTEC

The registered trademark SIPROTEC is used for devices implemented on system base V4.

SIPROTEC 4 device

This object type represents a real SIPROTEC 4 device with all the setting values and process data it contains.

SIPROTEC 4 variant

This object type represents a variant of an object of type SIPROTEC 4 device. The device data of this variant may well differ from the device data of the original object. However, all variants derived from the original object have the same VD address as the original object. For this reason they always correspond to the same real SIPROTEC 4 device as the original object. Objects of type SIPROTEC 4 variant have a variety of uses, such as documenting different operating states when entering parameter settings of a SIPROTEC 4 device.

Slave

A slave may only exchange data with a master after being prompted to do so by the master. SIPROTEC 4 devices operate as slaves.

Time stamp

Time stamp is the assignment of the real time to a process event.

Topological view

DIGSI Manager always displays a project in the topological view. This shows the hierarchical structure of a project with all available objects.

Transformer Tap Indication

Transformer tap indication is a processing function on the DI by means of which the tap of the transformer tap changer can be detected together in parallel and processed further.

Transient information

A transient information is a brief transient → single-point indication at which only the coming of the process signal is detected and processed immediately.

Tree view

The left pane of the project window displays the names and symbols of all containers of a project in the form of a folder tree. This area is called the tree view.

TxTap

→ Transformer Tap Indication

User address

A user address comprises the name of the user, the national code, the area code and the user-specific phone number.

Users

From DIGSI V4.6 onward , up to 32 compatible SIPROTEC 4 devices can communicate with one another in an Inter Relay Communication combination. The individual participating devices are called users.

VD

A VD (Virtual Device) includes all communication objects and their properties and states that are used by a communication user through services. A VD can be a physical device, a module of a device or a software module.

VD address

The VD address is assigned automatically by DIGSI Manager. It exists only once in the entire project and thus serves to identify unambiguously a real SIPROTEC 4 device. The VD address assigned by DIGSI Manager must be transferred to the SIPROTEC 4 device in order to allow communication with DIGSI Device Editor.

VFD

A VFD (Virtual Field Device) includes all communication objects and their properties and states that are used by a communication user through services.

VI

VI stands for Value Indication.

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