SIPROTEC

Multi-Functional Generator Protection Relay 7UM61

V4.1

Manual

C53000-G1176-C127-3

4.10.05

Preface

Purpose of this Manual

This manual describes the functions, operation, installation, and commissioning of the device 7UM61. In particular it contains:

- Information regarding the configuration of the device extent and descriptions of device functions and settings → Chapter 2;
- Instructions for mounting and commissioning → Chapter 3;
- Compilation of technical data→ Chapter 4;
- As well as a compilation of the most significant data for experienced users in Appendix A.

General information about design, configuration, and operation of SIPROTEC® 4 devices is laid down in the SIPROTEC® 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 is valid for: Multi-Functional Generator Protection Relay with Local Control SIPROTEC® 4 7UM61; firmware version V4.1.

Indication of Conformity

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 89/336/EEC) and concerning electrical equipment for use within specified voltage limits (Low-voltage directive 73/23 EEC).
This conformity has been proved by tests conducted by Siemens AG in accordance with Article 10 of the Council Directive in agreement with the generic standards EN 50081 and EN 61000-6-2 (for EMC directive) and the standard EN 60255-6 (for low-voltage directive). This device was designed and produced for industrial use according to the EMC standard.
The product conforms with the international standard of the series IEC 60255 and the German standard VDE 0435.

This product is UL-certified according to the Technical Data:

IND. CONT. EQ.
TYPE 1
69CA

IND. CONT. EQ.
TYPE 1

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.

Training Courses

Individual course offerings may be found in our Training Catalogue, or questions may be directed to our training centre in Nuremberg.

Instructions and Warnings

The warnings and notes contained in this manual serve for your own safety and for an appropriate lifetime of the device. Please observe them!
The following indicators and standard definitions are used:

DANGER

indicates that death, severe personal injury or substantial property damage <u>will</u> result if proper precautions are not taken.

Warning

indicates that death, severe personal injury or substantial property damage <u>can</u> result if proper precautions are not taken.

Caution

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

Note

indicates information about the device or respective part of the instruction manual which is essential to highlight.

WARNING!

When operating an electrical device, certain parts of the device inevitably have dangerous voltages.

Failure to observe these precautions can result in fatality, personal injury, or extensive material damage.

Only qualified personnel shall work on and around this equipment. It must be thoroughly familiar with all warnings and safety notices of this manual as well as with the applicable safety regulations.

The successful and safe operation of this device is dependent on proper handling, installation, operation, and maintenance by qualified personnel under observance of all warnings and hints contained in this manual. In particular the general erection and safety regulations (e.g. IEC, DIN, VDE, EN or other national and international standards) regarding the correct use of hoisting gear must be observed.

Definition

QUALIFIED PERSONNEL

For the purpose of this instruction manual and product labels, a qualified person is one who is familiar with the installation, construction and operation of the equipment and the hazards involved. In addition, he has the following qualifications:

- Is trained and authorized to energize, de-energize, clear, ground and tag circuits and equipment in accordance with established safety practices.
- Is trained in the proper care and use of protective equipment in accordance with established safety practices.
- Is trained in rendering first aid.

Typographic and Graphical Conventions

To designate terms which refer in the text to information of the device or for the device, the following fonts are used:

`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 of a monospace type style. This also applies to header bars for selection menus.

`1234A`

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 Conditions`

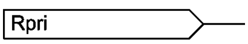
Possible settings of text parameters, which may appear word-for-word in the display of the device or on the screen of a personal computer (with operation software DIGSI®), are additionally written in italics. This also applies to header bars for selection menus.

`“Annunciations”`

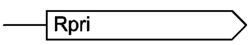
Designators for information, which may be output by the relay or required from other devices or from the switch gear, are marked in a monospace type style in quotation marks.

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

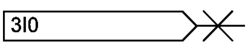
The following symbols are used in drawings:



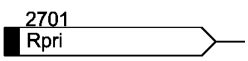
Device-internal logical input signal



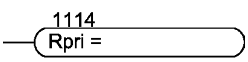
Device-internal (logical) output signal



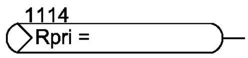
Internal input signal of an analog quantity



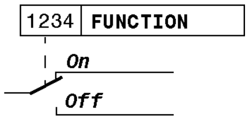
External binary input signal with number (binary input, input indication)



External binary output signal with number (device indication)

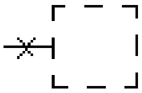


External binary output signal with number (device indication) used as input signal

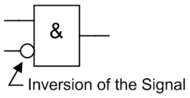


Example of a parameter switch designated **FUNCTION** with the address 1234 and the possible settings ON and OFF

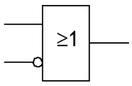
Besides these, graphical symbols are used according to IEC 60617-12 and IEC 60617-13 or symbols derived from these standards. Some of the most frequently used are listed below:



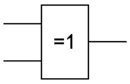
Input signal of an analog quantity



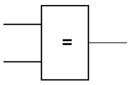
AND gate



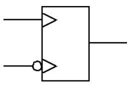
OR gate



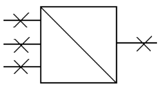
Exclusive–OR gate (antivalence): output is active, if only **one** of the inputs is active



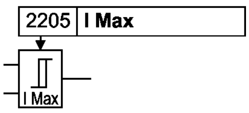
Equivalence: output is active, if **both** inputs are active or in-active at the same time



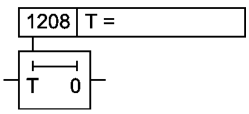
Dynamic inputs (edge–triggered) above with positive, below with negative edge



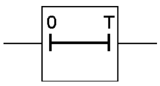
Formation of one analog output signal from a number of analog input signals



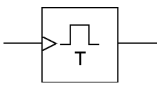
Limit stage with setting address and parameter designator (name)



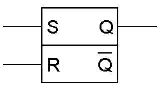
Timer (pickup delay T, example adjustable) with setting address and parameter designator (name)



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 ($\overline{Q}$)

Contents

Introduction 1

The SIPROTEC® 7UM61 devices are introduced in this section. An overview of the 7UM61 is presented with its application areas, features, and scope of functions.

1.1 Overall Operation

The digital Multi-Function Protection SIPROTEC® 7UM61 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) are galvanically isolated, transform the currents and voltages from the primary transformers and adapt them to the internal processing level of the device. The device has 4 current and 4 voltage inputs. Three inputs are used on each side of the protected object for measuring of the phase currents.

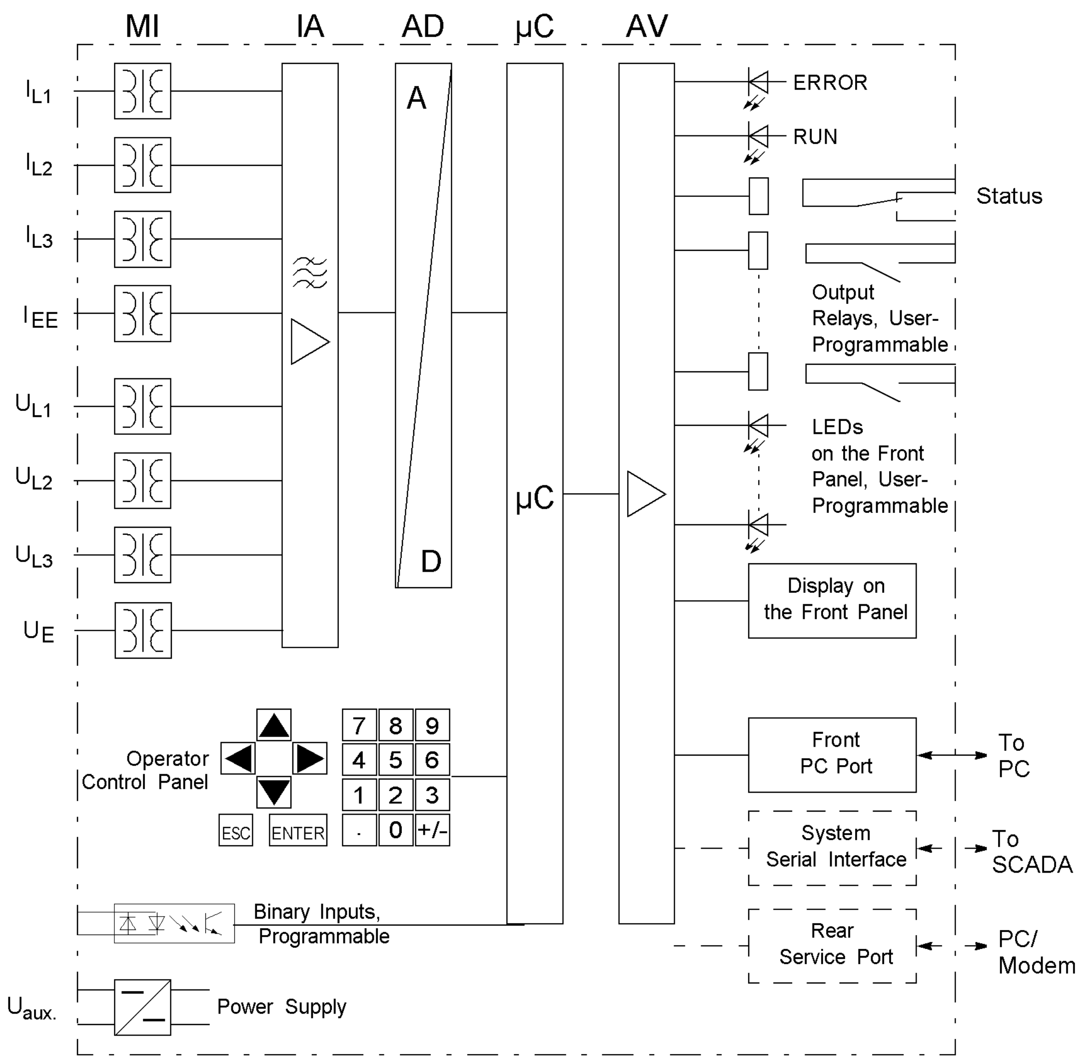


Figure 1-1 Hardware Structure of the Digital Machine Protection Device 7UM61 (maximum configuration)

1 current input is 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 connec-

tion is possible as well). The 4th voltage input is for displacement voltage measurement for stator 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.

Microcomputer System

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

- Filtering and conditioning of the measured signals,
- Continuous monitoring of the measured quantities
- Monitoring of the pickup conditions for the individual protective functions
- Querying of limit values and time sequences,
- Control of signals for logical functions,
- Decision for trip commands
- Signalling of protection behaviour via LEDs, LCD, relays or serial interfaces
- Storage of indications, fault data and fault values for fault analysis,
- Management of the operating system and its associated functions such as data recording, real-time clock, communication, interfaces, etc.

Adaptation of Sampling Frequency

The frequency of the measured quantities is continuously measured and used for adjusting of the actual sampling frequency. This ensures that the protection and measurement functions produce correct results over a wide frequency range. This ensures measuring accuracy in the frequency range from 11 Hz to 69 Hz.

The sampling frequency adaptation 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 mode “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

Optical indicators (LEDs) and a front display panel (LC display) provide information on the function of the device and indicate events, states and measured values. Integrated control and numeric keys in conjunction with the LCD facilitate local interaction with the device. By this means all information on the device such as design and setting parameters, operation and disturbance indications and measured values can be queried, (see also SIPROTEC® System Description /1/), and setting parameters can be changed.

Serial Interfaces

A serial operator interface in the front cover is provided for local communication with a PC, using the operating program DIGSI® 4. This permits convenient operation of all functions of the device.

A serial service interface can likewise make communication via PC with the device possible using DIGSI® 4. This is especially well suited for dedicated connection of the devices to the PC or for operation via a modem. The service interface can be also used for connecting a RTD-Box (see chapter 2.32)

All data can be transferred to a central control or monitoring system via the serial system interface. This interface may be provided with various protocols and physical transmission modes 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 communication protocols.

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® 7UM61 device is a digital multi-function machine protection unit from the 7UM6 Numerical Protection series. It provides all functions necessary for protection of generators and motors. As the scope of functions of the 7UM61 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

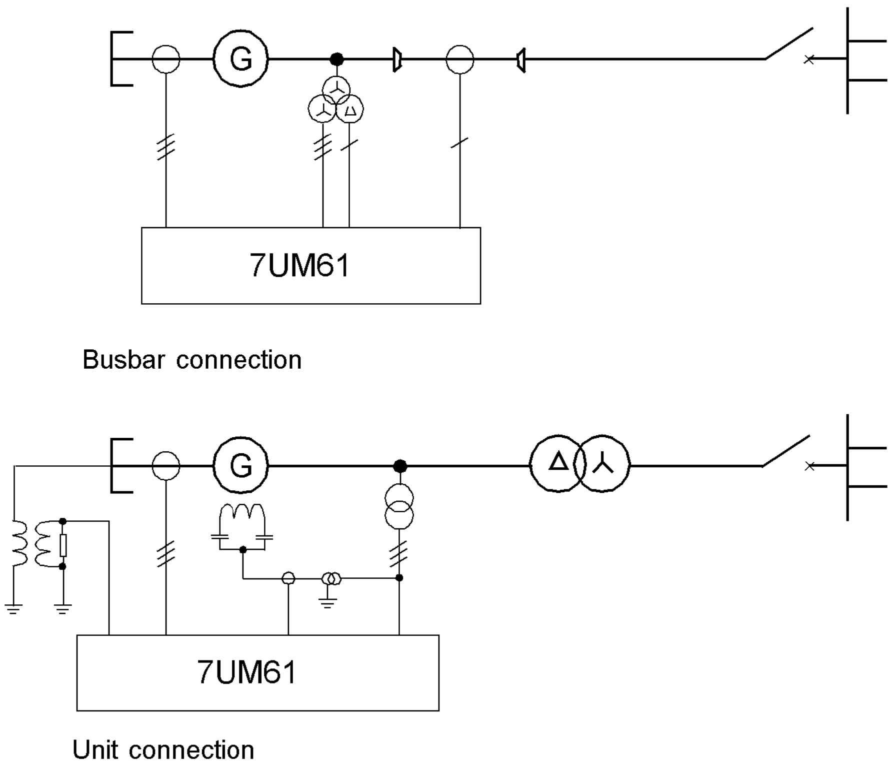


Figure 1-2 Typical Connections

The scalable software allows a wide range of applications. Corresponding function packages can be selected for each particular application. For instance, alone with the 7UM61 device, it is possible to provide comprehensive and reliable protection of generators from small to medium capacity (approx. 0.5 - 5 MW).

Additionally, the device forms the basis for the protection of medium to large size generators (backup protection). In combination with the 7UM62 device (a further device of the 7UM6 series), all protection requirements encountered in practice for the smallest to the largest machines can be met. This makes possible a consistent concept for reserve protection capacity.

The 7UM61 device is usable for further applications such as

- Backup protection, since in addition to overcurrent protection, a large variety of protection functions allow, for example, monitoring of voltage and frequency load.
- Protection of synchronous and asynchronous motors.
- Mains Decoupling Device

Messages and Measured Values; Recording of Event and Fault Data

The operating messages 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.

Annunciations of the devices can be presented by LEDs on the front panel (allocatable), processed further externally using output contacts (allocatable), combined with user-definable logic functions and/or output 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

For communication with external operator, control and storage systems, serial interfaces are available.

Operator Interface on the Front Panel

A 9-pin DSUB socket on the front panel is used for local communication with a personal computer. By means of the SIPROTEC® operating software DIGSI®, all operational and evaluation tasks can be executed via this user 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 devices statuses and measured values.

Rear Panel Interfaces

Depending on the individual ordering variant, additional interfaces are located on the rear panel of the device. These interfaces allow an extensive communication with other digital operating, control and memory components to be set up:

The service interface can be operated through data lines. Also, a modem can be connected to this interface. For this reason, remote operation is possible via PC and the DIGSI® 4 operating software, e.g. to operate several devices from a central PC.

The system interface is used for central communication between the device and a control centre. The data cables or fibre optic cables can be used. Several standard protocols are available for data transmission:

- IEC 60 870–5–103

  Integration of the devices into the substation automation systems SINAUT® LSA and SICAM® can also be done with this profile.
- 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.

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 electrical separation between the internal processing stages of the device and the external transformer, control and DC supply circuits of the system because of the design of the binary inputs, outputs, and the DC converters.
- Simple device operation using the integrated operator and display panel or by means of a connected PC running DIGSI® 4.
- Continuous computation and display of measured quantities.
- 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 Undervoltage Seal-In

- 2 definite time stages I> and I>> for the 3 phase currents (I_{L1}, I_{L2}, I_{L3}).
- Undervoltage seal-in for synchronous machines whose excitation voltage is obtained from the machine terminals;
- Optionally additional directional determination with the high current stage I>>.
- Blocking capability e.g. for reverse-interlocking bus-bar 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

- 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

- 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).

Underexcitation protection

- Conductance measurement from positive sequence components.
- Multi-step characteristic for steady-state and dynamic stability limits;
- Consideration of excitation voltage (only via binary input).

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 of over-power (P>) and/or under-power (P<) of active power output with individually adjustable power limits.
- Optionally 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;

Undervoltage Protection

- Two-stage undervoltage measurement of positive sequence component of voltages.

Overvoltage Protection

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

Frequency Protection

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

Rate-of-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.
- Highly sensitive earth current detection, optional 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 broken delta winding of an earthing transformer.
- In addition to the 90-%-stator earth fault protection there is a protection of the entire stator winding (protective range 100 %).

Motor Starting Time Supervision

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

Restart Inhibit for Motors

- Approximate computation of rotor overtemperature.
- Motor switchon is enabled only a if a restartup limit is undershot.
- Calculation of waiting time until automatic reclosure is enabled.
- Different prolongation of cooldown time constants for standstill/operation period is taken into consideration.
- Possibility for disabling the start inhibit if emergency startup is required.

Breaker Failure Protection

- 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 on 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.

Threshold Supervisions

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

Temperature Detection by Thermoboxes

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

Phase Sequence Inversion

- Selectable 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 positions and interlocking conditions for switching.

Measured Values Monitoring

- Increased reliability thanks to monitoring of internal measuring circuits, of auxiliary power supply, and of 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 numerous functions available on the SIPROTEC® 4 7UM61. It shows the setting possibilities for all the functions in maximum configuration. Instructions for deriving setting values and formulae, where required are provided.

Additionally it may be defined which functions are to be used.

2.1 Introduction, Reference Systems

The following chapters explain the individual protective and additional functions and provide information about the setting values.

2.1.1 Functional Description

Generator

The calculation examples are based on two smaller capacity reference power systems with the two typical basic connections, i.e. the busbar connection and the unit connection (see following figure). All default settings of the relay are adapted accordingly.

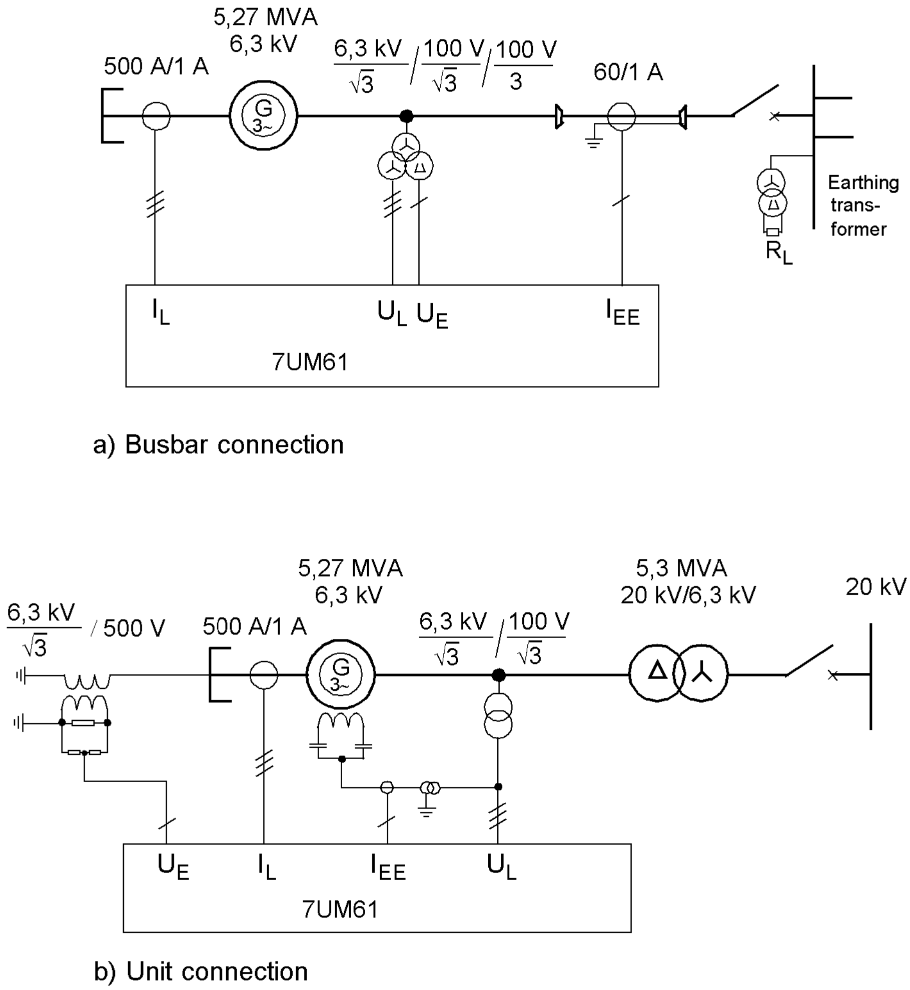


Figure 2-1 Reference Systems

Technical Data of the Reference Power Systems

Generator	$S_{N,\,T}$ = 5.27 MVA	
	$U_{N,\,Gen}$ = 6.3 kV	
	I_{NG} = 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/$\sqrt{3}$) kV	$U_{N,\,sec}$ = (100/$\sqrt{3}$) V
		U_{en}/3 = (100/3) V

Transformer

Transformer:	$S_{N,\,T}$ = 5.3 MVA
	U_{OS} = 20 kV
	U = 6.3 kV
	u_K= 7 %
Zero point transformer:	CT= $\frac{6.3\ \text{kV}}{\sqrt{3}} \Big/ 500\ \text{V}$
Resistor divider:	5 : 1

Motor

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

Further technical data are 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.

For a complete reparametrization the operating program DIGSI® 4 is recommended. In this way, the user can specify primary values in addition to secondary settings. This is done in the 7UM61 as a setting referred to the rated values of the object to be protected (e.g. $I_{N,\,G}$; $U_{N,\,G}$; $S_{N,\,G}$). 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 conversion to secondary values is done by mouse clicking. All necessary conversion formulas of the individual functions are stored in the operating program.

2.2 Functional Scope

The 7UM61 device has 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 UE and IEE respectively. The same input can not be simultaneously fed with different measured values, e.g. for rotor earth fault protection and stator earth fault protection.

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 configured as disabled are not processed by the 7UM61. There are no indications, and corresponding settings (functions, limit values) are not displayed during setting.

2.2.1 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 serial port or the rear service interface. Operation is described in the SIPROTEC ® System Description /1/.

For changing configuration parameters in the device, password no.7 is required (for parameter set). Without the password, the settings may be read, but may not be modified and transferred to the device.

Functional scope and as the case may be possible alternatives are adapted to the power system conditions in the Function Scope dialog box.

Note

Available functions and default settings depend on the ordered device variant (see Appendix for details). Also, not all combinations of protective functions are possible because of certain restrictions imposed by the hardware (see Section 2.2.2).

2.2.2 Setting Notes

Special Cases

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

If use of the setting group change function is desired, address 103 **Grp Chge OPTION** should be set to ***Enabled***. In this case, it is possible to apply two groups of settings for function parameters (refer also to Section 2.4) allowing convenient and fast switch-over between these setting groups. Only one function parameter group may be selected and used if the setting is ***Disabled***.

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 the high-current stage I>> of the overcurrent protection, address 113**O/C PROT. I>>** determines whether ***Non-Directional*** or ***directional*** is to be operative. By selecting ***Disabled***, this overcurrent stage can be excluded altogether. With inverse time overcurrent protection 114**O/C PROT. Ip**, depending on the ordered variant, various characteristics are available for selection, in accordance with IEC or ANSI standard. Selecting 'disabled' deconfigures inverse time overcurrent 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.

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.

2.2.3 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 Enabled	Enabled	Overcurrent Protection I>
113	O/C PROT. I>>	Disabled directional Non-Directional	Non-Directional	Overcurrent Protection I>>
114	O/C PROT. Ip	Disabled with IEC with ANSI	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)
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

Addr.	Parameter	Setting Options	Default Setting	Comments
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)
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 Enabled	Enabled	Sensitive Earth Current Protection
152	SEF 3rd HARM.	Disabled Enabled	Enabled	Stator Earth Fault Prot. 3rd Harmonic
165	STARTUP MOTOR	Disabled Enabled	Enabled	Motor Starting Time Supervision
166	RESTART INHIBIT	Disabled Enabled	Enabled	Restart Inhibit for Motors
170	BREAKER FAILURE	Disabled Enabled	Enabled	Breaker Failure Protection
171	INADVERT. EN.	Disabled Enabled	Enabled	Inadvertent Energisation
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
190	RTD-BOX INPUT	Disabled Port C Port D Port E	Disabled	External Temperature Input
191	RTD CONNECTION	6 RTD simplex 6 RTD HDX 12 RTD HDX	6 RTD simplex	Ext. Temperature Input Connection Type

2.3 Power System Data 1

The device requires certain network and power system data so that it can be adapted to its intended functions in accordance with 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.

2.3.1 Setting Notes

General

The Power System Data 1 can be changed via the operator or service interface from a PC using DIGSI®.

In DIGSI® double-click **Settings** to display the data available.

Connection of the Current Transformer Set

In address 210 **CT Starpoint** the polarity of the current transformers must be entered, i.e. the location of the CT starpoint. This setting determines the measuring direction of the device (forwards = line direction). The following figure shows the definition even in cases where there are no starpoint CTs.

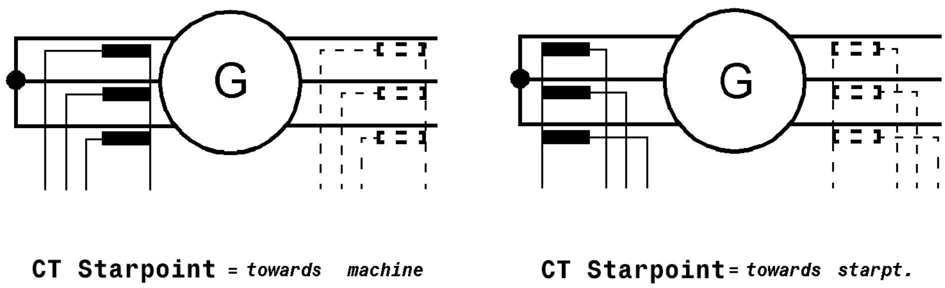


Figure 2-2 Location of the CT Starpoints

Nominal Values of the Transformers

At addresses 211 **CT PRIMARY** and 212 **CT SECONDARY**, information is entered regarding the primary and secondary current rating of the current transformers. 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 incorrectly calculate primary data.

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 CT.

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 transformers and voltage transformers is set. The corrective value can be determined during machine commissioning (see Section Mounting and Commissioning).

Iee Transformation Ratios

For conversion of the ground current Iee in primary quantities, the device requires the primary/secondary transformation ratio of the transformer. This is set at address 213 **FACTOR IEE**.

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.

Voltage Connection U_E

At address 223 **UE CONNECTION** the user specifies to the device which type of voltage is connected to the UE input. The device establishes from this information how to process the input signal. The following table shows the interdependencies for each protection function.

Table 2-1 Setting Options for the UE Input and their Impact on the Protection Functions

Setting for UE CONNECTION (Addr. 0223)	90% Stator Earth Fault Protection	Stator Earth Fault Protection with 3rd Harmonic
not connected	Processing of U0 computed value (exactly: $\sqrt{3}$ U0)	The 3rd harmonic is determined from the computed U0 voltage (U0 3rd harm > stage only usable).
UE connected to any transformer	Processing of UE input (e.g. earth fault protection on transformer side)	–
UE connected to broken delta winding	Processing of UE input	Processing of UE input
UE connected to neutral transformer	Processing of UE input	Processing of UE input

UE Transformation Ratio

For conversion of the displacement voltage U_E to primary quantities, the device requires the primary/secondary transformation ratio of the transformer delivering the UE voltage. With the exception of the rotor earth fault protection, the 224 **FACTOR UE** has an impact on those protection functions which process the UE input directly, as shown in Table 2-1. For this ratio224 **FACTOR UE** the following generally applies:

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

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, unit transformer connection figure, with the power system data selected there and an 1:5 voltage divider ratio

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

Uph/Uen Adaption Factor

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 e-n windings connected to the device (UE input), this must be specified accordingly in address 223 (see above margin heading "UE Input"). Since transformation between voltage transformers usually is as follows:

$$\frac{U_{N\ prim.}}{\sqrt{3}} / \frac{U_{N\ sec.}}{\sqrt{3}} / \frac{U_{N\ sec.}}{3}$$

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

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 2.33).

Figure 2-3 Phase sequences

Operating Mode

The 272 **SCHEME** setting is used for specifying if 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 2.8).

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 7UM61 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.

CommandDuration

Address 280 is used to set the minimum time **TMin TRIP CMD** the tripping contacts will remain closed. This setting applies to all protective functions that initiate tripping.

Current Flow Monitoring

Address 281 **BkrClosed I MIN** corresponds to the threshold value of the integrated current flow monitoring feature. This setting is used for the elapsed-time meter 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.

2.3.2 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
204	CT ANGLE W0		-5.00 .. 5.00 °	0.00 °	Correction Angle CT W0
210	CT Starpoint		towards machine towards starpt.	towards machine	CT Starpoint
211	CT PRIMARY		10 .. 50000 A	500 A	CT Rated Primary Current
212	CT SECONDARY		1A 5A	1A	CT Rated Secondary Current
213	FACTOR IEE		1.0 .. 300.0	60.0	CT Ratio Prim./Sec. Iee
221	Unom PRIMARY		0.10 .. 400.00 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	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
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

Addr.	Parameter	C	Setting Options	Default Setting	Comments
273	STAR-POINT		low-resist. high-resist.	high-resist.	Earthing of Machine Starpoint
274A	ATEX100		YES NO	NO	Storage of th. Replicas w/o Power Supply
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	1A	0.04 .. 1.00 A	0.04 A	Closed Breaker Min. Current Threshold
		5A	0.20 .. 5.00 A	0.20 A	

2.3.3 Information List

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

2.4 Change Group

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

A setting group includes the setting values for all functions that have been selected as **Enabled** during configuration (see Section 2.2). In the 7UM61 device, two independent setting groups (A and B) are available. Whereas setting values may vary, the selected functions of each setting group remain the same.

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 not relevant.

2.4.1 Setting Notes

General

If the changeover option is desired, on function extent configuration 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. How to proceed and how to copy or reset settings groups are described in the SIPROTEC® System Description /1/.

How to switch between setting groups externally using binary inputs is described in the Mounting and Commissioning section.

2.4.2 Settings

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

2.4.3 Information List

No.	Information	Type of Information	Comments
-	Group A	IE	Group A
-	Group B	IE	Group B
7	>Set Group Bit0	EM	>Setting Group Select Bit 0
8	>Set Group Bit1	EM	>Setting Group Select Bit 1

2.5 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.

2.5.1 Functional Description

Setting Groups

In the 7UM61 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.

2.5.2 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***.

Rated Values of the System

At addresses 1101 **U PRIMARY OP.** and 1102 **I PRIMARY OP.**, the primary reference voltage and reference current of the protected motor is entered. These values are important for pickup settings. The allow the device to calculate operational values as percentage values. For example, if a CT ratio of 500/1 is selected and the rated current of the generator is 483 A, a value of 500 A should be entered at address 211 and a value of 483 A under **I PRIMARY OP.**. 483 amps are now displayed as 100% in the percentage metering display.

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.

2.5.3 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
1101	U PRIMARY OP.	0.10 .. 400.00 kV	6.30 kV	Primary Operating Voltage
1102	I PRIMARY OP.	10 .. 50000 A	483 A	Primary Operating Current
1108	ACTIVE POWER	Generator Motor	Generator	Measurement of Active Power for

2.5.4 Information List

No.	Information	Type of Information	Comments
501	Relay PICKUP	AM	Relay PICKUP
511	Relay TRIP	AM	Relay GENERAL TRIP command
533	IL1:	AM	Primary fault current IL1

No.	Information	Type of Information	Comments
534	IL2:	AM	Primary fault current IL2
535	IL3:	AM	Primary fault current IL3
5012	UL1E:	AM	Voltage UL1E at trip
5013	UL2E:	AM	Voltage UL2E at trip
5014	UL3E:	AM	Voltage UL3E at trip
5015	P:	AM	Active power at trip
5016	Q:	AM	Reactive power at trip
5017	f:	AM	Frequency at trip

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

The overcurrent protection is used as backup protection for the short-circuit protection of the protected object. It also provides backup protection for downstream network faults which may be not promptly disconnected thus endangering the protected object.

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 pickup dropout, 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 off and made ineffective via binary input.

2.6.1 Functional Description

I> Stage

Each phase current is compared individually with the **I>** common setting value and signaled separately on overshoot. 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 pickup 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 falls again below the overcurrent value. In this way, the expire 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 expired or if the undervoltage seal-in is blocked via a binary input, e.g. when the voltage transformer mcb trips or if the machine is tripped, protection drops out immediately.

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

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

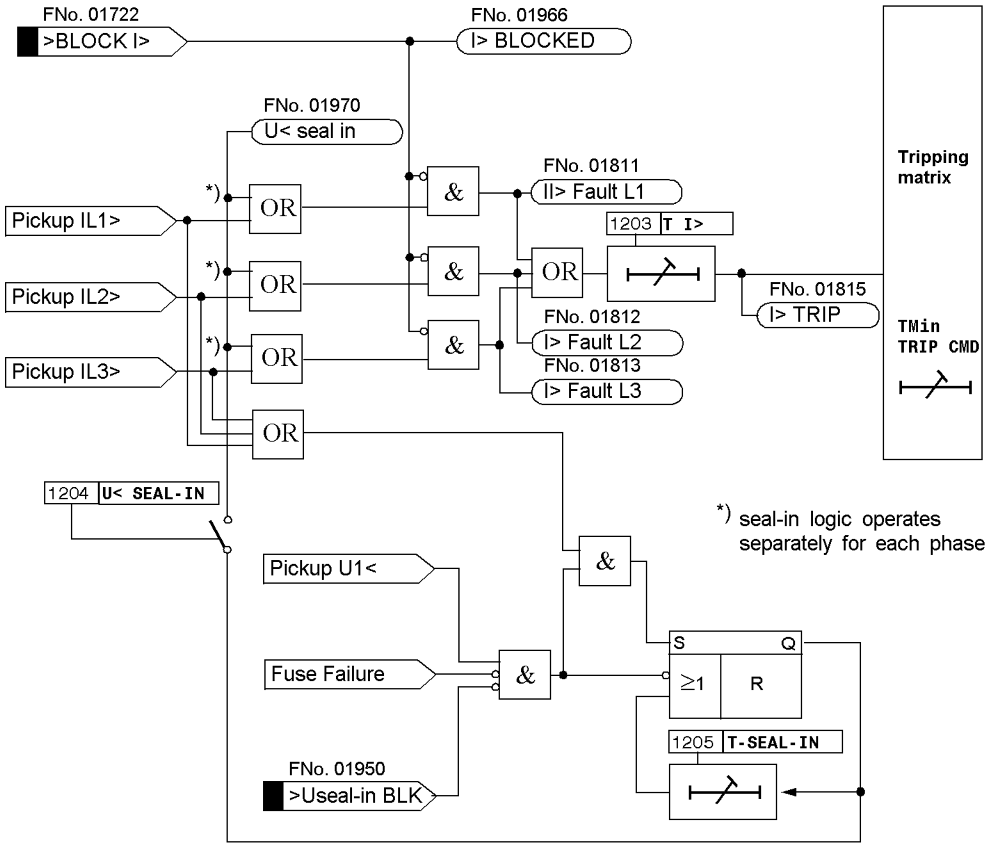


Figure 2-4 Logic Diagram of the Overcurrent Stage I> with Undervoltage Seal-In

2.6.2 Setting Notes

General

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

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***). For setting the **I>** overcurrent stage it is the maximum anticipated load current which is most relevant. 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 ∞. After pickup the element will then not trip. Pickup, however, will be signaled. If the I> stage is not required at all, address 1201 **O/C I>** is set to ***OFF***. This 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_{off}/I_{on} of the overcurrent pickup I> is specified at 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).

Examples:

Pick-up threshold	$1.4 \cdot I_{N\ Mach.}$		
Trip Time Delay	3 sec		
Undervoltage Seal-In	$0.8 \cdot I_{N\ Mach.}$		
Holding time of U<	4 sec		
Dropout Ratio	0.95		
Rated current IN, Mach	483 A	Rated voltage $U_{N,\ Mach}$	6.3 kV
Rated current IN, CT, prim	500 A	Rated voltage $U_{N\ VT.\ prim}$	6.3 kV
Rated current IN, sec	1 A	Rated voltage $U_{N,\ sec}$	100 V

The following secondary setting values result from this specification:

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

$$\mathbf{U<} \quad = \frac{0.8 \cdot U_{N,\ Gen}}{U_{N,\ VT,\ prim}} \cdot U_{N,\ sec} = \frac{0.8 \cdot 6{,}3\ kV}{6.3\ kV} \cdot 100\ V = 80\ V$$

2.6.3 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>	1A	0.05 .. 20.00 A	1.35 A	I> Pickup
		5A	0.25 .. 100.00 A	6.75 A	
1203	T I>		0.00 .. 60.00 sec; ∞	3.00 sec	T I> Time Delay

Addr.	Parameter	C	Setting Options	Default Setting	Comments
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

2.6.4 Information List

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

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

The overcurrent protection is used as backup protection for the short-circuit protection of the protected object. It also provides backup protection for downstream network faults which may be not promptly disconnected thus endangering the protected object.

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 acquisition and switch off a generator short circuit by undelayed tripping without comprising selectivity.

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).

2.7.1 Function Description

I>> Stage

Each phase current is compared individually with the **I>>** common pick-up value and signaled 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

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.

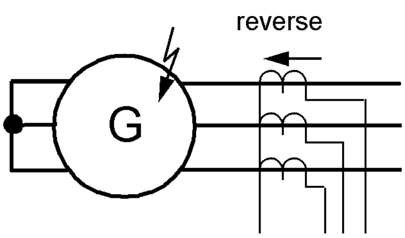


Figure 2-5 Selectivity via Short-Circuit Direction Detection

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 2-6). 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 directional limit lines may change in relation to the collapse of the fault voltage.

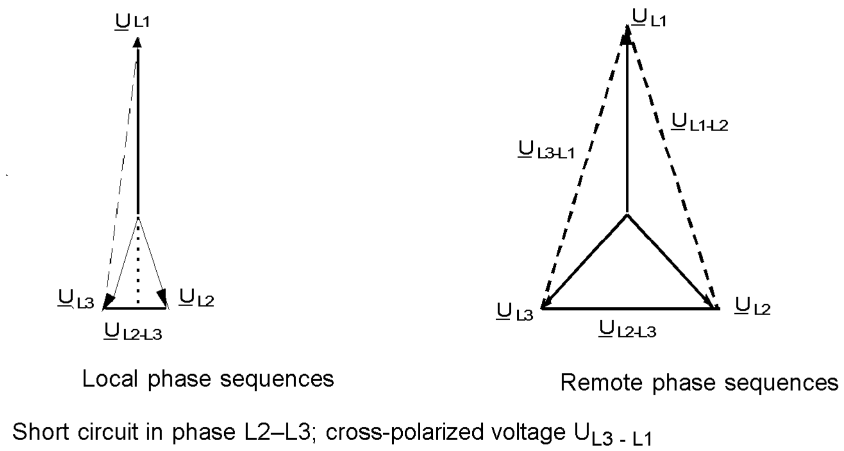


Figure 2-6 Cross-Polarized Voltages for Direction Determination

The phase carrying the highest voltage 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 2-2 Allocation of Measured Values for the Determination Direction

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

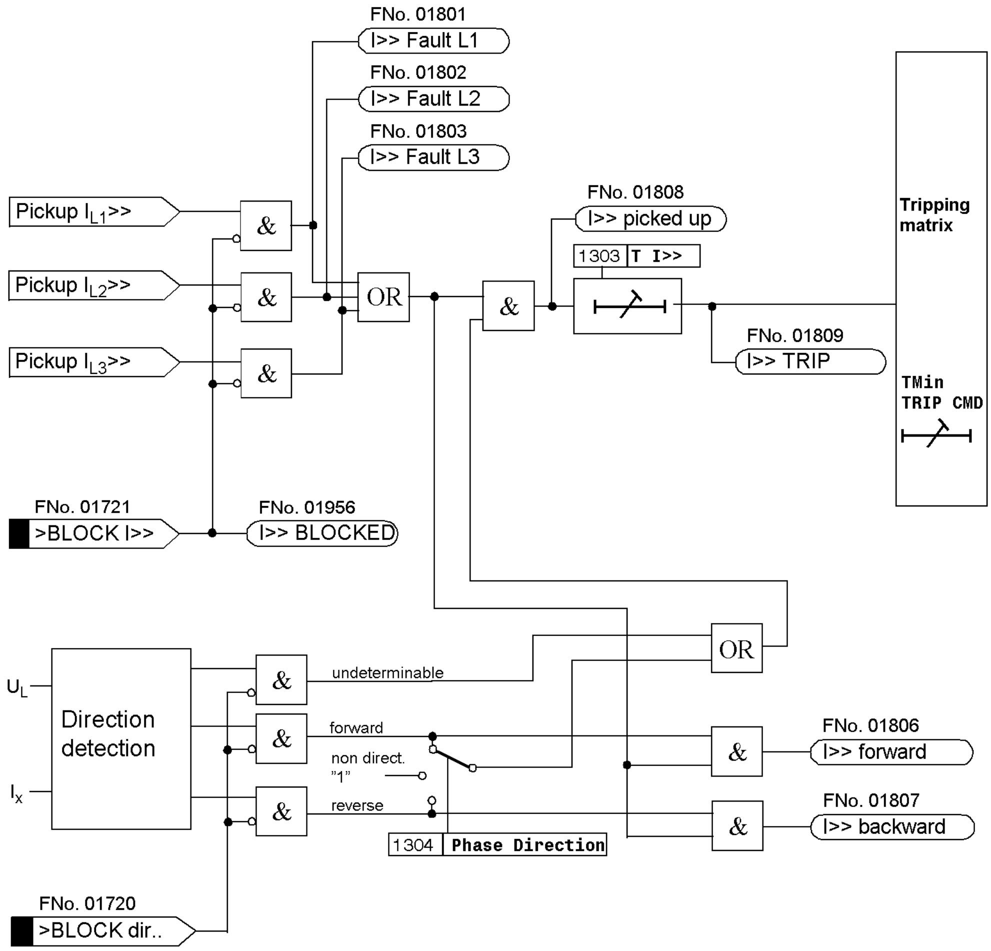


Figure 2-7 Logic Diagram of I>> Stage with Direction Element

2.7.2 Setting Notes

General

The high current stage I>> of the time overcurrent protection will only be effective and available if address 113 **O/C PROT. I>>** is set to either ***directional*** or ***Non-Directional*** on configuration. 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-current Stage I>>

Address 1301 **O/C I>>** is used to switch the definite time I>> 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 set in a way ensuring that it picks up for faults up to this impedance.

Current Transformer in the Starpoint (without direction detection)

Example: Unit Connection

Rated apparent power - generator	$S_{N,\ Mach}$ = 5.27 MVA
Rated voltage - generator	$U_{N,\ Mach}$ = 6.3 kV
Direct-axis transient reactance	x'_d = 29 %
Transient synchronous generated voltage (salient-pole generator)	$U'_P = 1.2 \cdot U_{N,Mach}$
Rated apparent power - transformer	$S_{N,\ T}$ = 5.3 MVA
Rated voltage, on the generator side	$U_{N,\ VT\ prim}$ = 6.3 kV
Transformer impedance	u_{sc} = 7 %
Current transformer	$I_{N,\ CT,\ prim}$ = 500 A $I_{N,\ sec}$ = 1 A

a) Short-circuit calculation

Three-pole short circuit

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

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.

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

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 Transformer 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 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 correctly according to one of the diagrams in the Appendix. A small zone is located between the forward and the reverse zone. Due to phase displacement angles of the transformers, a proper direction decision is not possible. There is no tripping in the configured preferential direction in this zone.

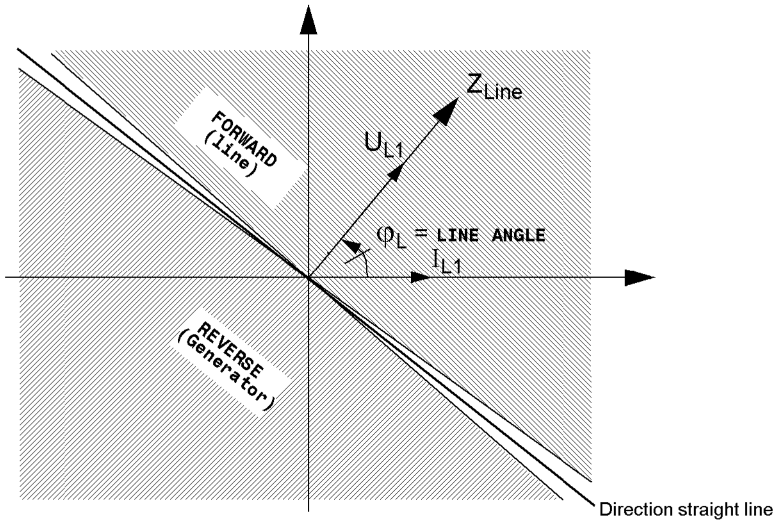


Figure 2-8 Definition of Parameters 1304 Phase Direction and 1305 LINE ANGLE

The setting value of the direction straight line results from the short-circuit angle of the feeding network. As a rule, it will be 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 short tripping delay (TI>> ≈ 0.05 s to 0.1 s) is required to ensure that balancing procedures are finished.

Application Example: Motor Protection

For motors that have no no separate current transformer 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 the basis for this.

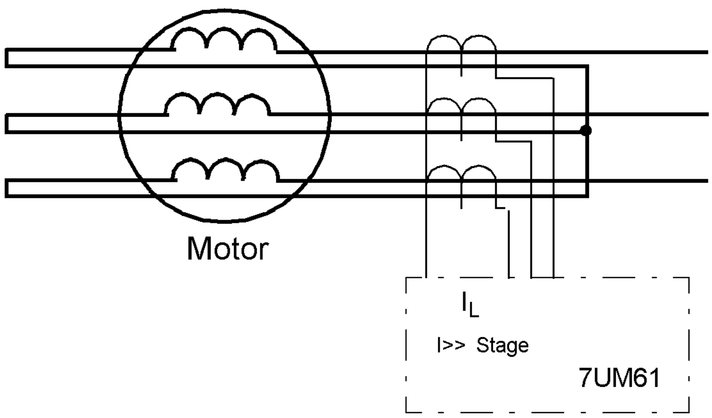


Figure 2-9 I>> Stage as "Differential Protection"

2.7.3 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>>	1A	0.05 .. 20.00 A	4.30 A	I>> Pickup
		5A	0.25 .. 100.00 A	21.50 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

2.7.4 Information List

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

2.8 Inverse-Time Overcurrent Protection (ANSI 51V)

The overcurrent time protection replicates the short-circuit protection for small or low-voltage machines. 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 which may be not promptly disconnected thus endangering the machine.

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. Undervoltage influencing can be disabled.

The protective function operates, depending on the ordering variant, with an inverse current-tripping characteristic according to the IEC or ANSI standards. The characteristics and associated formulas are given in the Technical Data. During configuration of the inverse time curves, the independent stages I>> and I> are enabled (see Section 2.6).

2.8.1 Functional Description

Pickup and Tripping

Each phase current is compared individually with the common **Ip** setting value. If the current exceeds 1.1 times the setting value, the stage picks up and is signaled phase-related. For pickup the rms values of the fundamental harmonic are used. During the pickup of an Ip stage, the tripping time is calculated from the flowing fault current using an integrating measuring procedure, depending on the selected tripping characteristic. After the end of this period a trip command is transmitted.

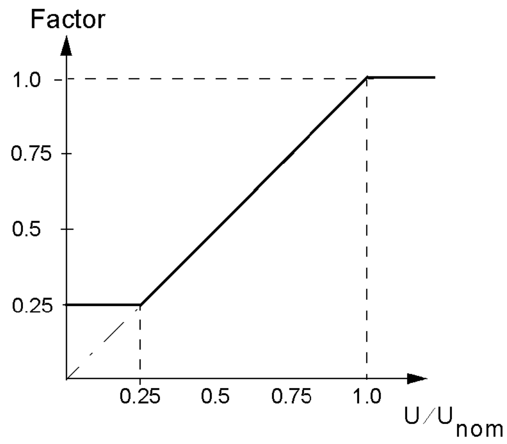
Dropout

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). A renewed pickup will the delay timer to start anew.

Undervoltage Consideration

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 with a lower pick-up value 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 the following figure). A linear, directly proportional dependency is used in the zone between U/U_{Nom} = 1.00 and 0.25. Consequently, the following applies:



$$I(U)_{pickup} = I_p \cdot 1.00 \qquad \text{for } 1.00 \le \frac{U}{U_{nom}} \le \infty$$

$$I(U)_{pickup} = I_p \cdot \frac{U}{U_{nom}} \qquad \text{for } 0.25 \le \frac{U}{U_{nom}} \le 1.00$$

$$I(U)_{pickup} = I_p \cdot 0.25 \qquad \text{for } 0.00 \le \frac{U}{U_{nom}} \le 0.25$$

where U_{nom} – Generator nominal voltage = parameter 1101 **U PRIMARY OP.**

$I(U)_{pickup}$ – Voltage-influenced pickup value

I_p – Pick-up value of inverse characteristic parameter = parameter 1402 **Ip**

Figure 2-10 Pick-up Value Voltage Dependency

The Ip reference value is decreased proportional to voltage decrease. Consequently for constant current I, the I/Ip ratio is increased and the trip time is reduced. Compared with the standard characteristics represented in Section 4 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, conversion of the voltages by the unit 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 2-3 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 or 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 2.28).

The following figure shows the logic diagram of the inverse overcurrent time protection without undervoltage influencing, whereas Figures 2-12 and 2-13 illustrate the logic diagrams with undervoltage influencing.

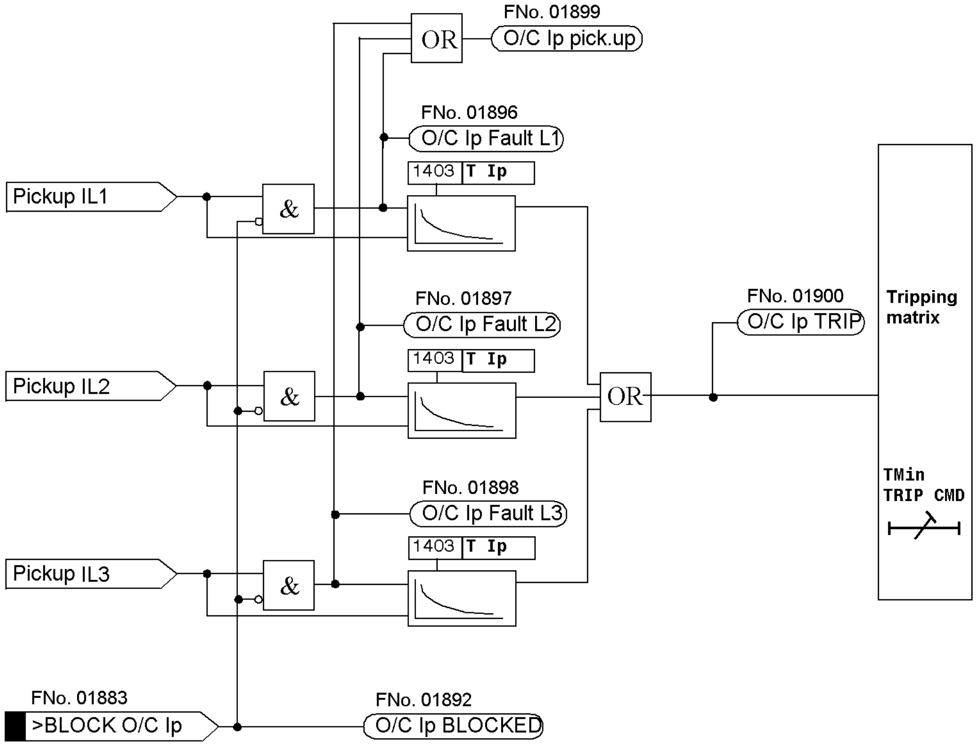


Figure 2-11 Logic Diagram of the Inverse Overcurrent Time Protection without Undervoltage Influencing

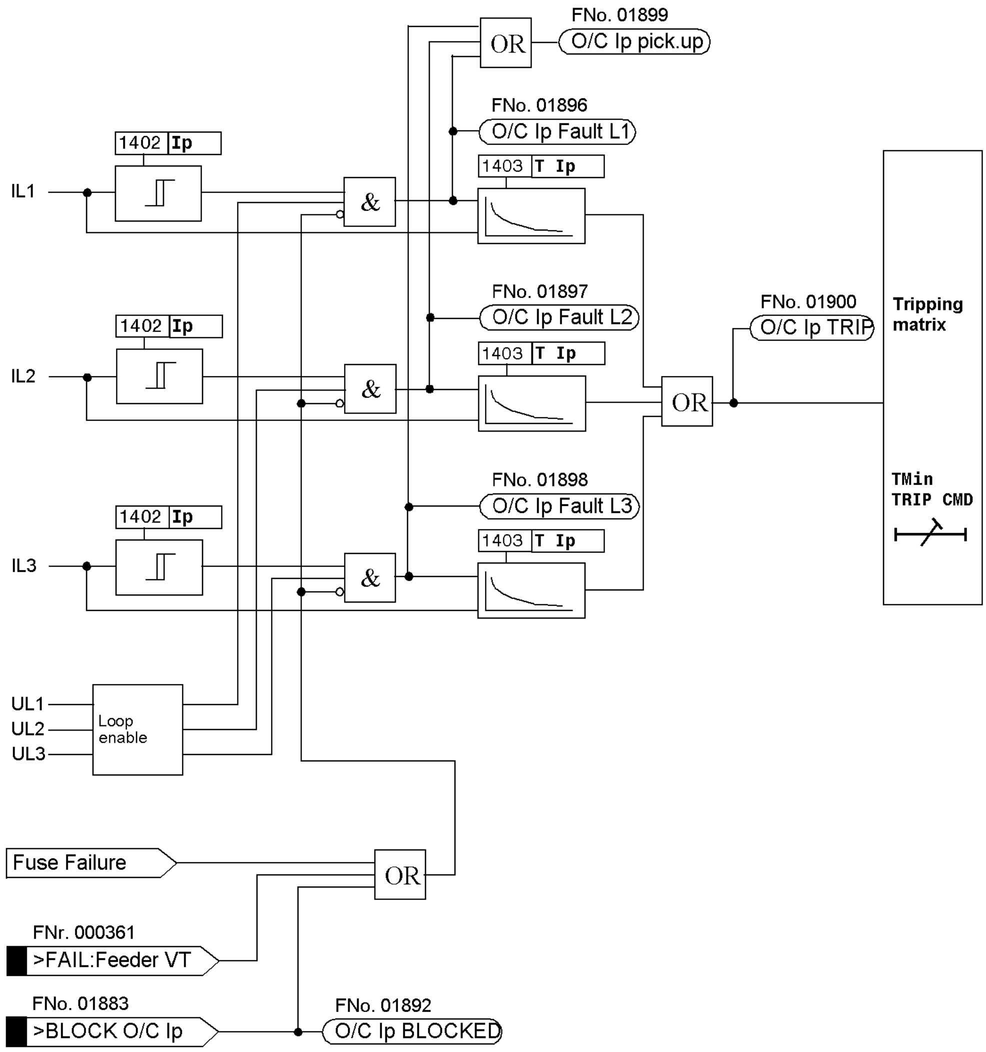


Figure 2-12 Logic Diagram of the Voltage Controlled Inverse Overcurrent Time Protection

The changeover to the lower current pickup value on decreasing voltage (loop enable) is performed on a phase by phase basis in accordance with Table 2-3.

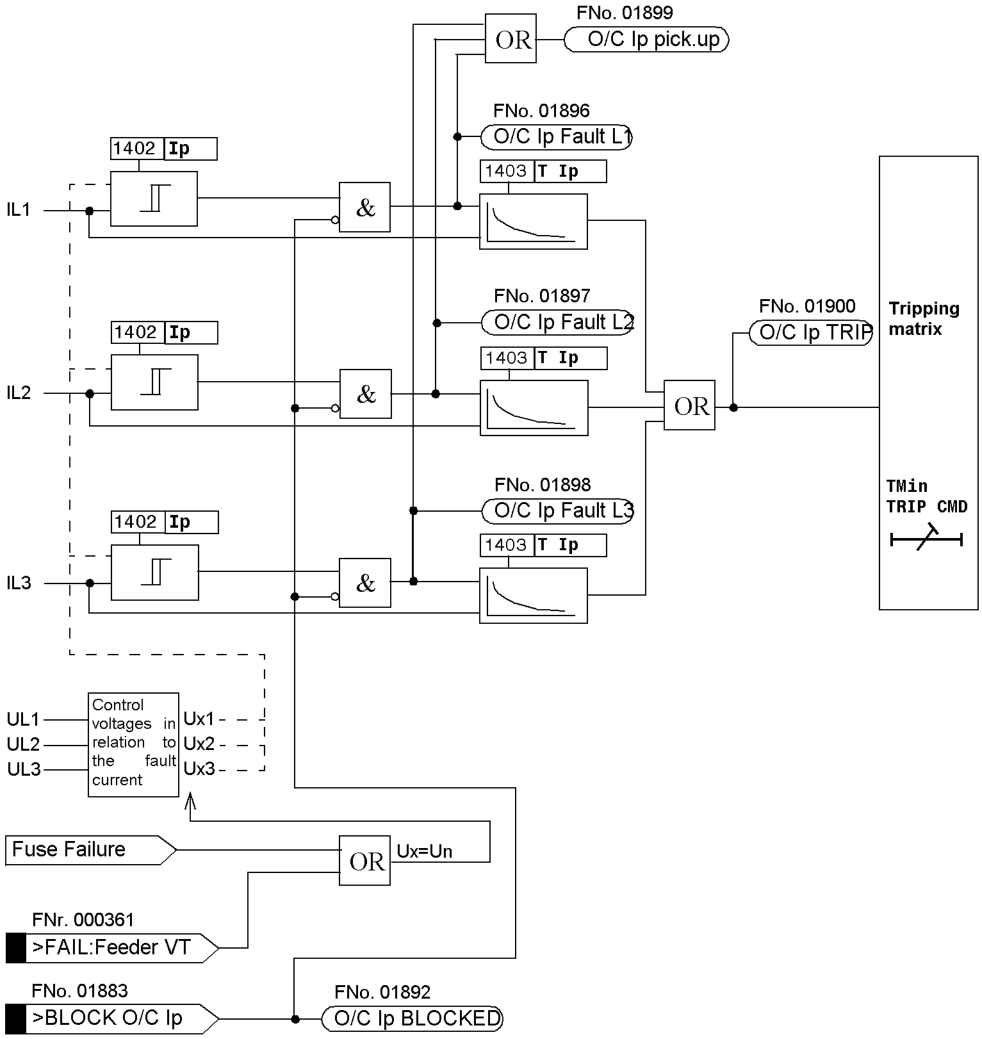


Figure 2-13 Logic Diagram of the Voltage Restraint Inverse Time Overcurrent Protection

The reduction of the current pickup threshold on decreasing voltage (control voltage allocation) is performed phase in accordance with Table 2-3.

2.8.2 Setting Notes

General

Inverse overcurrent time protection is only effective and available if address 114 **O/C PROT. Ip** was set to ***with IEC*** or ***with ANSI***. If the function is not needed it is set to ***Disabled***.

Ip Overcurrent Stage

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

The current value is set at address 1402 **Ip**. The setting is mainly determined by the maximum operating current. Pickup due to overload should never occur, since the device in this operating mode operates 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. P** = ***with IEC***) is accessible under address 1403 **T Ip**.

The corresponding time multiplier for configuration of ANSI characteristics (address 114 **O/C PROT. Ip**= ***with ANSI***) is accessible under address 1404 **TIME DIAL: TD**.

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

The time multipliers can also be set to ∞. After pickup the element will then not trip. Pickup, however, will be signaled. If the Ip stage is not required, on configuration of the protection function (Section 2.2) 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 2.6.2).

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

2.8.3 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	1A	0.10 .. 4.00 A	1.00 A	Ip Pickup
		5A	0.50 .. 20.00 A	5.00 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

Addr.	Parameter	C	Setting Options	Default Setting	Comments
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

2.8.4 Information List

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

2.9 Thermal Overload Protection (ANSI 49)

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

2.9.1 Functional Description

Thermal Profile

The device calculates the excessive temperatures 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	– Current overtemperature as a percent of final overtemperature at the maximum admissible phase current $k \cdot I_N$
Θ_K	– Coolant temperature as a difference to the 40 °C reference temperature
τ	– Thermal time constant for heatup of the equipment being protected
I	– Current rms phase current as a percentage of maximum admissible phase 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 is in steady-state operation an exponential function whose asymptote represents the final temperature Θ_{End} . After an initial settable overtemperature threshold´is reached, an alarm is issued for e.g. load reduction measures. If the second overtemperature threshold, i.e. final overtemperature = trip temperature, is reached, the protected equipment is disconnected from the network. It is also possible, however, to set the overload protection to ***Alarm Only*** . In this case only an indication is issued when 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 admissible continuous current I_{max} is described as a multiple of the nominal current I_N:

$I_{max} = k \cdot I_N$

Apart from the k factor (parameter **K-FACTOR**) the **TIME CONSTANT** τ and the alarm temperature Θ **ALARM** (as a percentage of the trip temperature Θ_{TRIP}) are to be entered.

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

Coolant Temperature (Ambient Temperature)

With 7UM61 the thermal model of the 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 Profibus DP interface/Modbus
- Via temperature detection unit (Thermobox, RTD 1)

The ambient or coolant temperature can also be detected by an external temperature sensor, digitized and fed to the 7UM61 via the **Profibus-DP Interface / Modbus** .

If a temperature supervision feature is implemented using a thermobox (see Section 2.32) 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 that overload protection on occurrence of high fault currents (and with small time constants) does not cause extremely short trip times thereby perhaps affecting time grading of the fault 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. For this reason, 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 in such cases for setting.

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 2.3).

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 overtemperatures can be allowed by blocking the tripping signal 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 will be suppressed 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 in Case of Power Supply Failure

For overload protection, together with all other thermal protection functions of the 7UM61 in the Power System Data 1 (parameter 274 **ATEX100**, see Section 2.3) it is possible to choose whether the calculated overtemperature will be stored throughout a power supply failure, or reset to zero. This last option is the default setting.

The following figure shows the logic diagram for overload protection.

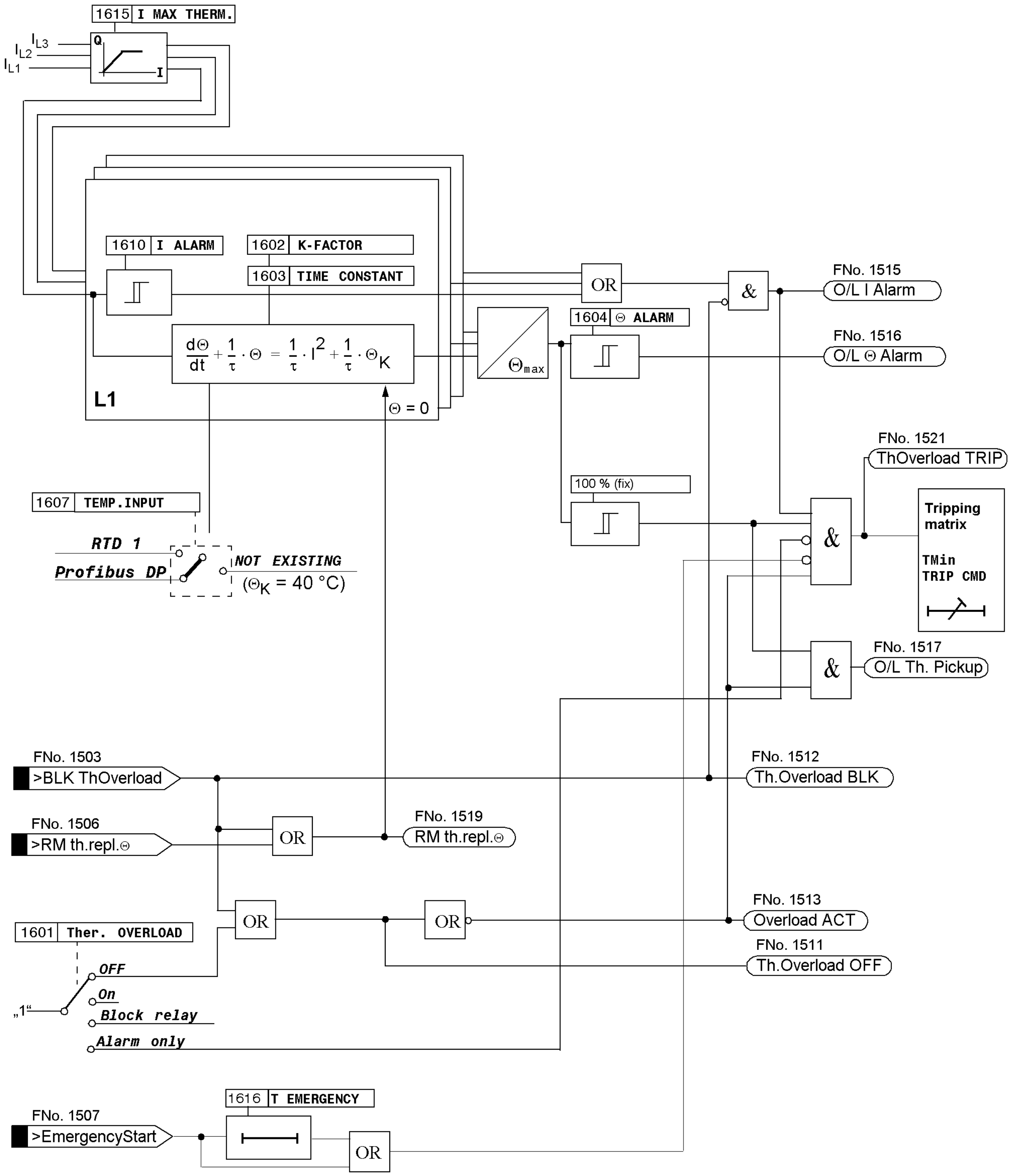


Figure 2-14 Logic Diagram of the Overload Protection

2.9.2 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 ***Disabled*** is set.

Transformers and generators are prone to damage by extended overloads. These overloads cannot and should not be detected by short-circuit protection. Time overcurrent protection should be set high so 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 7UM61 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 $I_{N,\,machine}$ of the object to be protected (generator, motor, transformer) is typically used as base current. The thermally admissible continuous current $I_{max\,prim}$ can be used to calculate a factor k_{prim} :

$$k_{prim} = \frac{I_{max\,prim}}{I_{N,\,Machine}}$$

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

The **K-FACTOR** (address1602) to be set on the device 7UM61 refers to the secondary nominal current (= device current). The following applies for the conversion:

$$\text{Setting value } \textbf{K-FACTOR} = \frac{I_{max\,prim}}{I_{N\,Machine}} \cdot \frac{I_{N\,Machine}}{I_{NCT\,prim}}$$

with

$I_{max\,prim}$	Thermally admissible continuous motor primary current
$I_{N\,Machine}$	Nominal Current of the Machine
$I_{N\,CT\,prim}$	Nominal primary CT current

Example: Generator and current transformer with the following data:

Permissible Continuous Current $I_{max\ prim} = 1.15 \cdot I_{N,\ Machine}$

Generator Nominal Current $I_{N\ Machine} = 483\ A$

Current Transformer 500 A / 1 A

$$\text{Setting value K–FACTOR} = 1.15 \cdot \frac{483\ A}{500\ A} \approx 1.11$$

Time Constant τ

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 excessive 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 alarm level Θ **ALARM** (address 1604), a alarm message can be issued before the tripping temperature is reached, thus avoiding tripping by promptly reducing load. This alarm 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

$$\Theta / \Theta_{Trip} = \frac{1}{1.1^2} = 83\ \%$$

of the tripping temperature. Consequently, the alarm 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:

$$\Theta / \Theta_{Trip} = \frac{1}{1.15^2} = 76\ \%$$

A current-related alarm level is also available (address 1610 **I ALARM**). 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 alarm level by setting the thermal alarm level to 100 % and is then practically inactive.

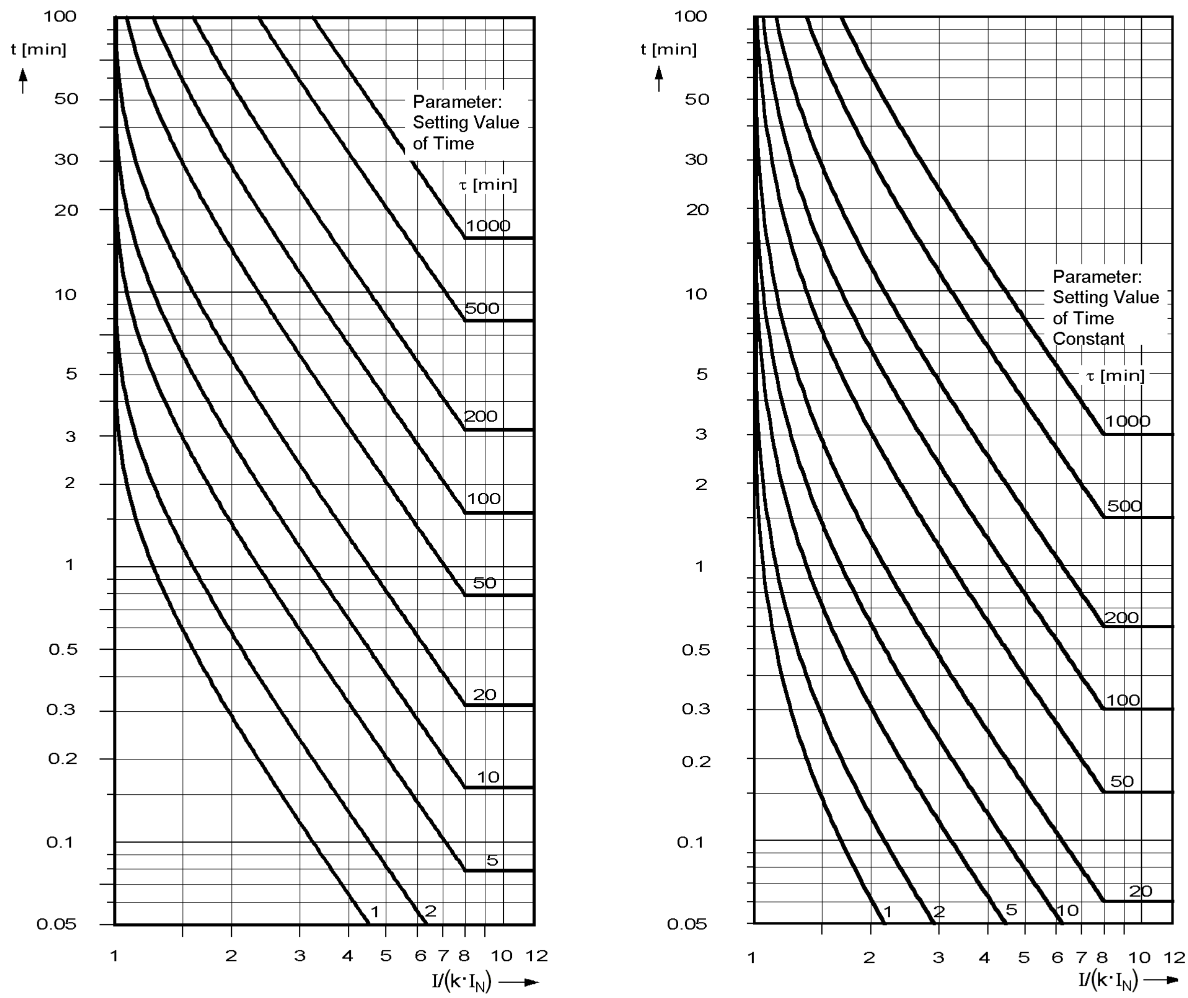
Extension of Time Constants at Machine Standstill

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 falls below 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 the following figure, this limit value determines the transition to the horizontal part of the characteristics, where there is no further trip time reduction for increasing current values. The limit value must ensure that even for the highest possible short-circuit current, the trip times of the overload protection 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.



<u>without</u> pre-load and with $I_{Max\ therm.} = 8 \cdot \frac{I}{k \cdot I_N}$:

$$t = \tau \cdot ln \frac{\left(\frac{I}{k \cdot I_N}\right)^2}{\left(\frac{I}{k \cdot I_N}\right)^2 - 1} \quad \text{[min]}$$

<u>with</u> 90 % pre-load and with $I_{Max\ therm.} = 8 \cdot \frac{I}{k \cdot I_N}$:

$$t = \tau \cdot ln \frac{\left(\frac{I}{k \cdot I_N}\right)^2 - \left(\frac{I_{pre}}{k \cdot I_N}\right)^2}{\left(\frac{I}{k \cdot I_N}\right)^2 - 1} \quad \text{[min]}$$

Figure 2-15 Tripping Characteristics for Overload Protection

EmergencyStartup 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 overtemperature. In addition to this, the machine protection can also process the ambient or coolant temperature. This temperature value must be communicated to the device as digitalized measured value via field bus (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.**. For this the temperature value set here corresponds to the 100% value from Profibus DP. In the default setting, 100% (field bus) correspond to 100°C.

If under address 1607 **TEMP. INPUT** the temperature setting of ***RTD 1*** 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 104.00 °F or 40 °C, i.e. it corresponds to the maximum permissible current at a temperature of 104.00 °F or 40 °C.

All calculations are performed with standardized quantities. The ambient temperature must also be standardized. 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 7UM61 (address 1605 or 1606)

Θ_{NMach} Machine Temperature with Nominal Machine Current

I_{Nprim} Nominal primary CT current

I_{NMach} Nominal Current of the Machine

If the temperature input is not used, the address 1607 **TEMP. INPUT** is to 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 104.00 °F or 40 °C. The following formula can be used to calculate the trip time:

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

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)
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
τ_{th}	= 600 s (thermal time constant of the machine)

Current transformer: 500 A/1 A

$$\textbf{K-FACTOR} = 1.15 \cdot \frac{483\ A}{500\ A} \approx 1.11$$

(to be set at address 1602)

$$\Theta_{Nsec} = 93^\circ C \cdot \left(\frac{500}{483}\right)^2 \approx 100^\circ C$$

(to be set at address 1605 or 1606 **TEMP. RISE I**)

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

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

with Θ_K = 80 °C:
$$t = \left(600\ \text{s} \cdot \ln \frac{\left(\frac{1.5}{1.1}\right)^2 + \frac{80\ °\text{C} - 40\ °\text{C}}{1.1^2 \cdot 100\ °\text{C}} - 0}{\left(\frac{1.5}{1.1}\right)^2 + \frac{80\ °\text{C} - 40\ °\text{C}}{1.1^2 \cdot 100\ °\text{C}} - 1}\right) \approx 366\ \text{s}$$

with Θ_K = 0 °C:
$$t = \left(600\ \text{s} \cdot \ln \frac{\left(\frac{1.5}{1.1}\right)^2 + \frac{0\ °\text{C} - 40\ °\text{C}}{1.1^2 \cdot 100\ °\text{C}} - 0}{\left(\frac{1.5}{1.1}\right)^2 + \frac{0\ °\text{C} - 40\ °\text{C}}{1.1^2 \cdot 100\ °\text{C}} - 1}\right) \approx 637\ \text{s}$$

2.9.3 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 Fieldbus RTD 1	Disabled	Temperature Input

Addr.	Parameter	C	Setting Options	Default Setting	Comments
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	1A	0.10 .. 4.00 A	1.00 A	Current Overload Alarm Setpoint
		5A	0.50 .. 20.00 A	5.00 A	
1612A	Kτ-FACTOR		1.0 .. 10.0	1.0	Kt-Factor when Motor Stops
1615A	I MAX THERM.	1A	0.50 .. 8.00 A	3.30 A	Maximum Current for Thermal Replica
		5A	2.50 .. 40.00 A	16.50 A	
1616A	T EMERGENCY		10 .. 15000 sec	100 sec	Emergency Time

2.9.4 Information List

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

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

Unbalanced load protection detects unbalanced 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 at the rotor surface leading to local overheating in rotor end zones and slot wedges. Another effect of unbalanced loads is overheating of the damper winding. In addition, this protection function may be used to detect interruptions, short circuits and polarity problems with current transformers. It is also useful in detecting 1-pole and 2-pole faults with magnitudes lower than the load currents.

2.10.1 Functional Description

Unbalanced Load Determination

The unbalanced load protection of 7UM61 filters the fundamental component from the phase currents and splits it into symmetrical components. It evaluates the negative-phase sequence system, the negative phase-sequence current I_2. If the negative phase-sequence current exceeds a set threshold value, the trip timer starts. A trip command is transmitted on timeout.

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 2-16).

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. The current-time area is calculated constantly to ensure correct consideration of different 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. 1701), 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 settable cool-down time starts as soon as the constantly permissible unbalanced load **I2>** is undershot. The tripping drops out on dropout of the pickup threshold dropout. 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 image to cool down from 100 % to 0 %. The cool-down time depends on the construction type of the generator, and especially on the damper winding. Preloading is taken into consideration when unbalanced loading occurs during the cool-down period. The protective relay will thus trip in a shorter time.

Tripping Stages

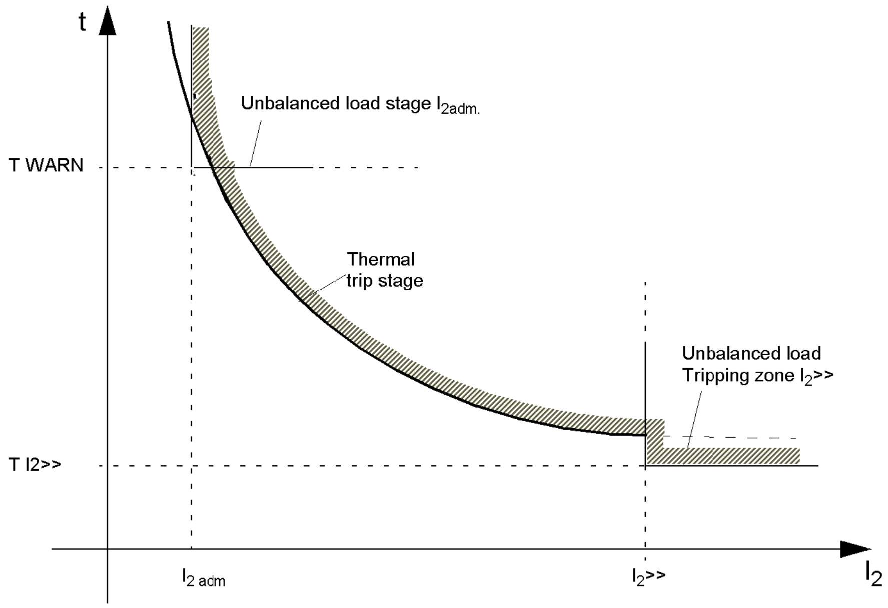


Figure 2-16 Tripping Zone of the Unbalanced Load Protection

Definite Time Tripping Stage

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

Please also observe the instructions regarding phase sequence changeover in Sections 2.3 and 2.33.

Logic

The following figure shows the logic diagram for 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 model are cleared. The binary input “>RM th.rep. I2” only serves to clear metered values of the thermal characteristic.

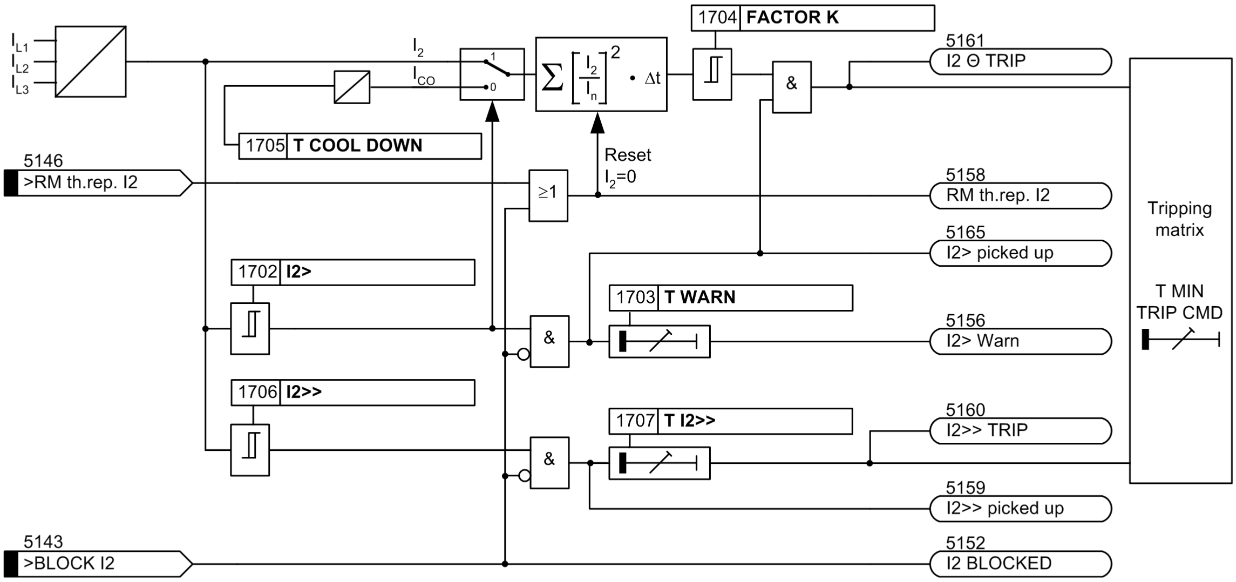


Figure 2-17 Logic diagram of the unbalanced load protection

2.10.2 Setting Notes

General

The 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 ***Disabled*** is set.

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, continual 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 a value in a range from 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 continuous inverse current is referred to the nominal machine current. For settings on the protective relay, this data is converted to the secondary inverse current. The following applies

$$\text{Pickup Setting } \mathbf{I2>} = \left(\frac{I_{2\text{max prim}}}{I_{\text{N Machine}}}\right) \cdot \frac{I_{\text{N Machine}}}{I_{\text{N CT prim}}}$$

with

$I_{2\text{ perm prim}}$	Permissible thermal inverse current of the motor
$I_{\text{N Mach}}$	Nominal current of the machine
$I_{\text{N VT prim}}$	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.

Example:

Machine	$I_{N\ Mach}$	= 483 A
	$I_{2\ perm\ prim}$ / $I_{N\ Mach}$	= 11 % permanent (salient-pole machine, see Figure 2-18)
Current transformer	$I_{N\ CT\ prim}$	= 500 A
Setting value	$I_{2\ adm.}$	= 11 % · (483 A/500 A) = 10.6 %

Negative Sequence 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 directly at address1704 **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 following figure by reading the time at point $I_2/I_N = 1$, corresponding to **FACTOR K** .

Example:

t_{adm} = 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:

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

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 address 1704:

$$\textbf{FACTOR K} = 20\,\text{s} \cdot \left(\frac{483\ \text{A}}{500\ \text{A}}\right)^2 = 18{,}7\ \text{s}$$

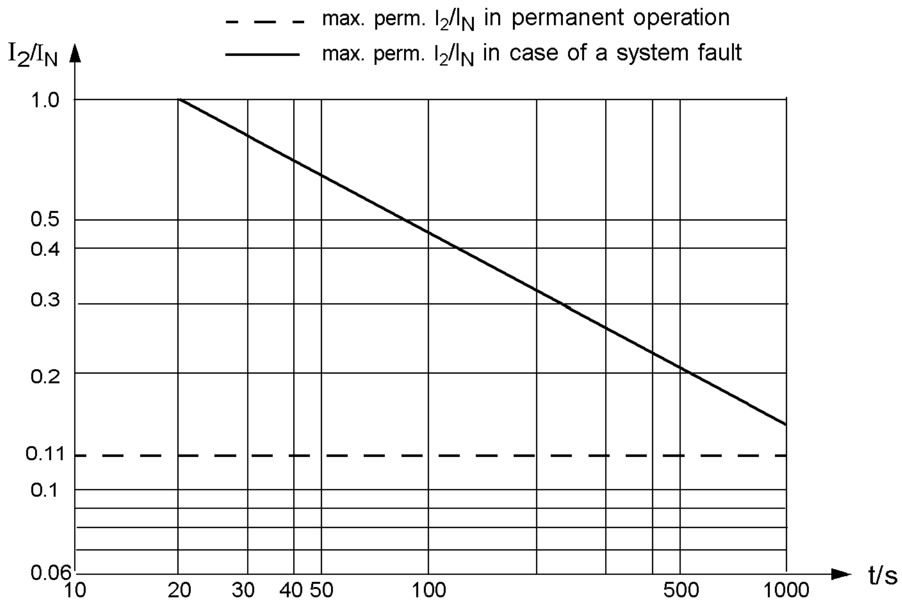


Figure 2-18 Example of an Unbalanced Load Characteristic Specified by the Machine Manufacturer

Cooldown 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:

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

<u>Example:</u>

The following cool-down time results for a K = 20 s and an admissible continual unbalanced load I_2/I_N = 11 %.

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

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 trip 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 more 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 phase-to-ground fault with current I corresponds to a negative sequence current:

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

A phase-to-ground fault with current I corresponds to 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 grounding, however, it is determined by the ground resistance.

2.10.3 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	2.0 .. 100.0 sec; ∞	18.7 sec	Negativ Sequence Factor K
1705	T COOL DOWN	0 .. 50000 sec	1650 sec	Time for Cooling Down

Addr.	Parameter	Setting Options	Default Setting	Comments
1706	I2>>	10 .. 100 %	60 %	I2>> Pickup
1707	T I2>>	0.00 .. 60.00 sec; ∞	3.00 sec	T I2>> Time Delay

2.10.4 Information List

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

2.11 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 avoids endangering network stability by underexcitation of large synchronous machines.

2.11.1 Function Description

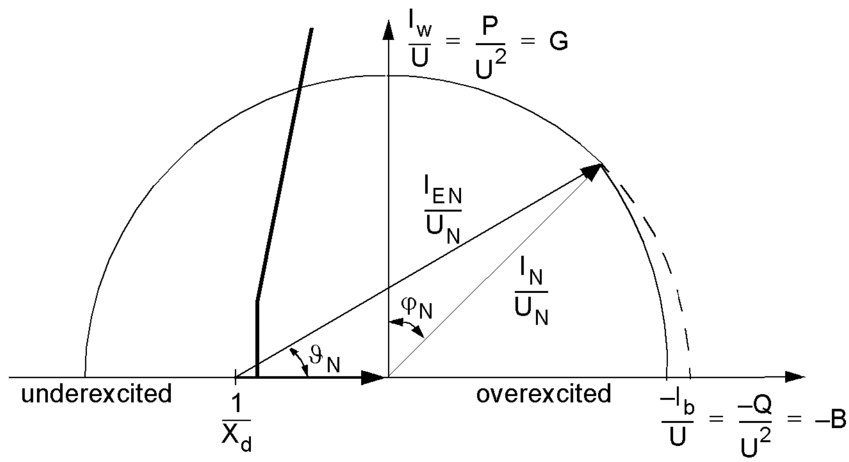
Underexcitation Determination

In order to detect underexcitation, the unit processes all three terminal phase currents and all three terminal voltages to form the stator 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 statistic stability limit which crosses the reactive axis near $1/X_d$ (reciprocal value of the synchronous direct reactance).

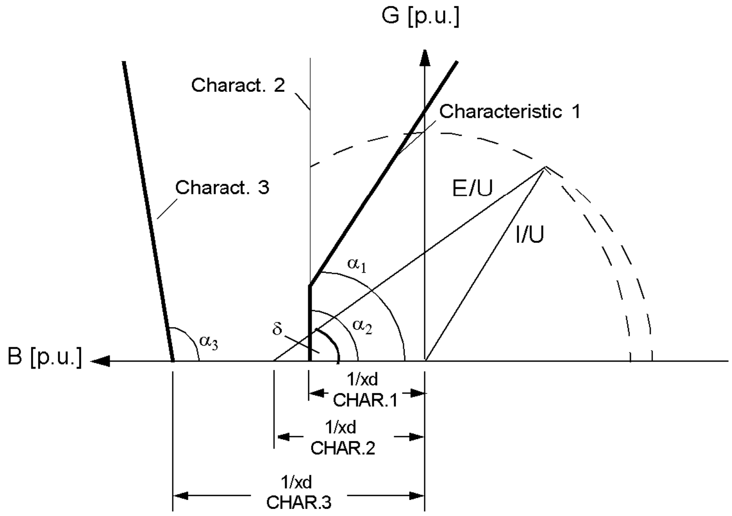


U_N	Rated voltage	I_w	Active current
I_N	Nominal Current	I_b	Reactive current
I_{EN}	Rated excitation current	G	Conductance
ϑ_N	Rated pole angle (rotor angle)	B	Susceptance
φ_N	Rated load angle	P	Active power
X_d	Synchronous reactance	Q	Reactive power
U	Terminal voltage		

Figure 2-19 Admittance Diagram of Turbo Generators

The underexcitation protection in the 7UM61 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.



where

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

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

Figure 2-20 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). For this purpose, excitation voltage failure must be communicated to the device via a binary input.

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.

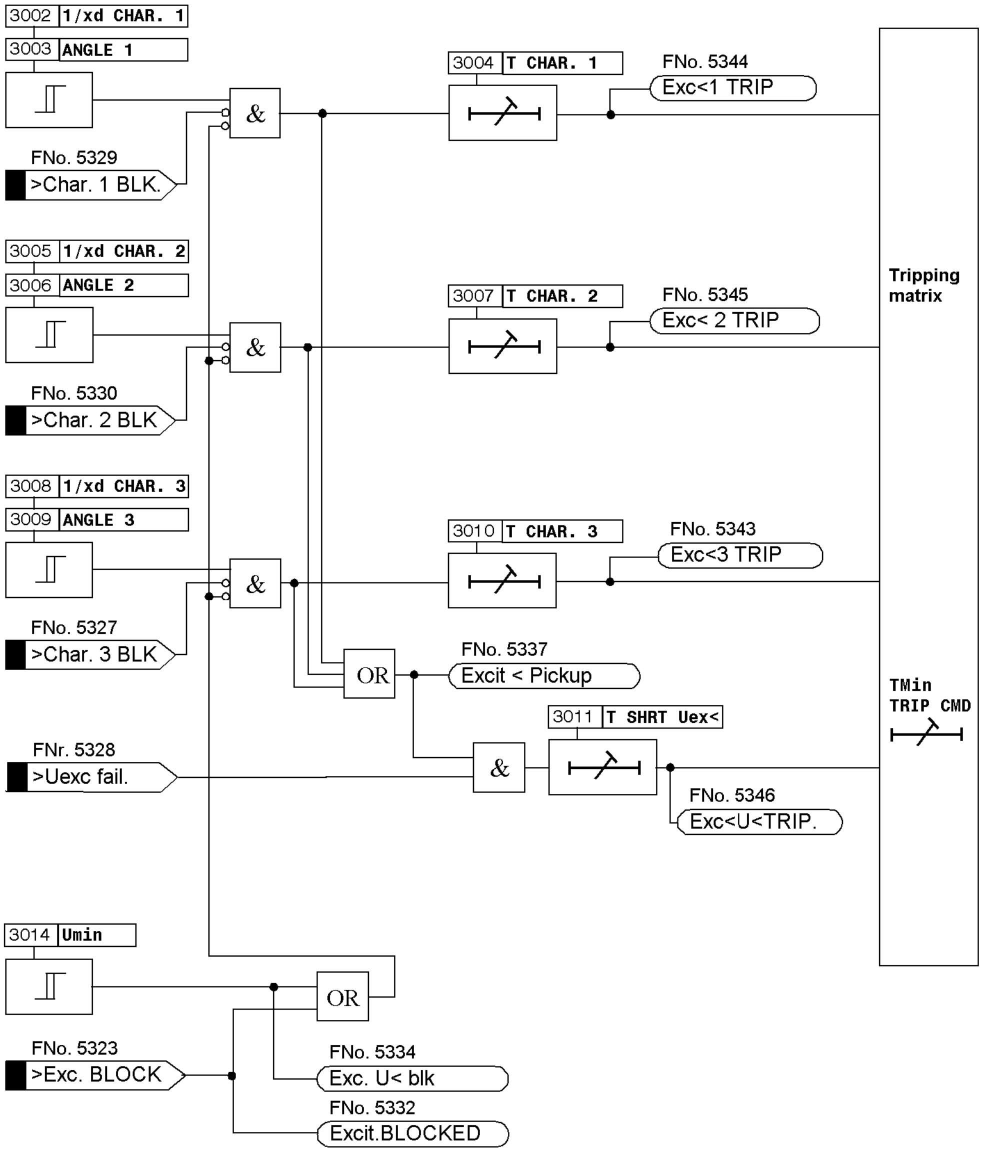


Figure 2-21 Logic diagram of the Underexcitation Protection

2.11.2 Setting Notes

General

The underexcitation protection is only effective and available if this function was set during protective function configuration (Section 2.2, 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 2.3 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 2-24).

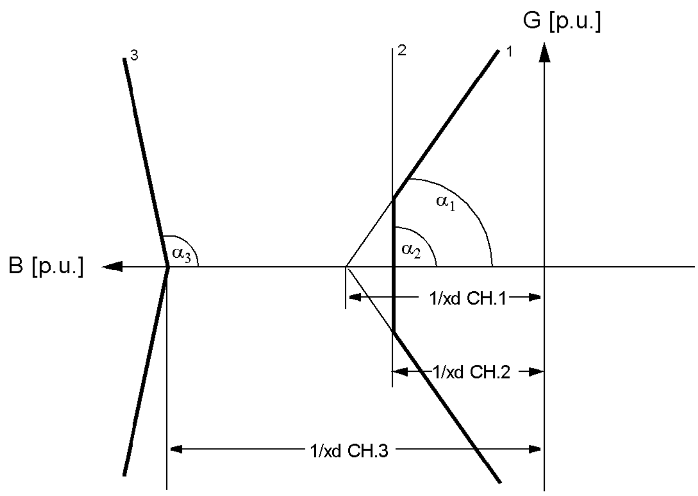


Figure 2-22 Underexcitation Protection Characteristics in the Admittance Plane

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 (this diagram corresponds to a per unit representation of the admittance diagram).

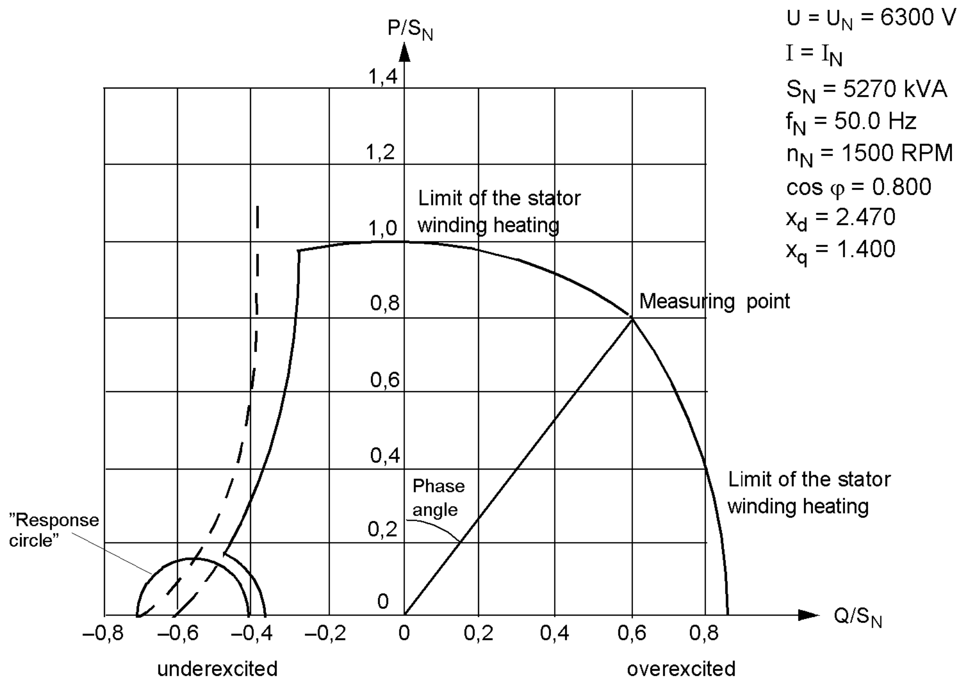


Figure 2-23 Capability Curve of a Salient-Pole Generator, Indicated per Unit

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_{NMach}	Nominal Current of the Machine
U_{NMach}	Nominal Voltage of the Machine
$U_{N\ VT.\ prim}$	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
	$I_{N\ Machine}$	= SN/√3 U_N = 5270 kVA/√3 · 6.3 kV = 483 A
	$X_{d\ mach}$	= 2.47 (read from machine manufacturer's specifications in Figure 2-23)
Current Transformer	$I_{N\ CT\ prim}$	= 500 A
Voltage transformer	$U_{N\ VT.\ prim}$	= 6.3 kV
	$\frac{1}{x_{dsec}} = \frac{1}{2.47} \cdot \frac{483\ A}{6300\ V} \cdot \frac{6300\ V}{500\ A} = 0.39$	

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 2-22 (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**, approximately between the synchronous direct reactance xd 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 2-4.

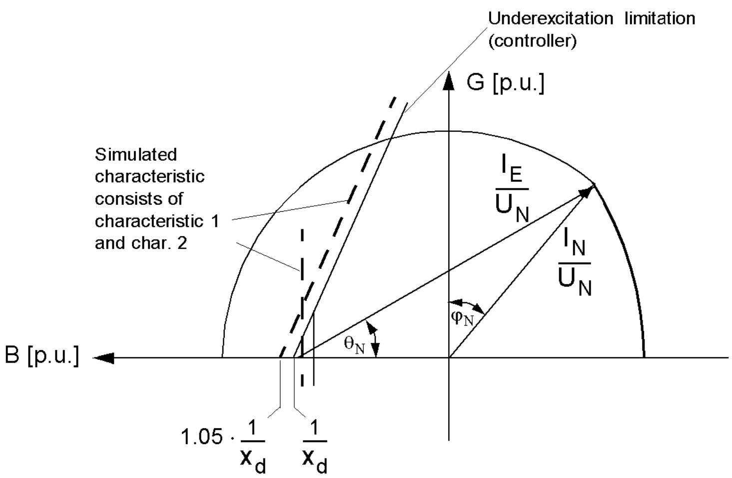


Figure 2-24 Admittance diagram of a turbogenerator

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**).

However if an external excitation monitoring signals the failure of an excitation voltage to the device via a binary input, a switch-off can be performed with a short time delay.

Table 2-4 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.

2.11.3 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	0.25 .. 3.00	0.41	Conductance 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	0.25 .. 3.00	0.36	Conductance 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	0.25 .. 3.00	1.10	Conductance 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

Addr.	Parameter	Setting Options	Default Setting	Comments
3011	T SHRT Uex<	0.00 .. 60.00 sec; ∞	0.50 sec	T-Short Time Delay (Char. & Uexc<)
3014A	Umin	10.0 .. 125.0 V	25.0 V	Undervoltage blocking Pickup

2.11.4 Information List

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

2.12 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 with a malfunctioning residual steam pass (defective stop valves) after the switching off of the circuit breaker the turbine generator unit is accelerated to overspeed. For this reason, the system isolation should only be performed after the detection of active power input into the machine.

2.12.1 Function Description

Reverse Power Determination

The reverse power protection of the 7UM61 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 2.3).

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 adds up and become longer than the time delay.

Trip Signal

For bridging a perhaps short power input during synchronisation 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.

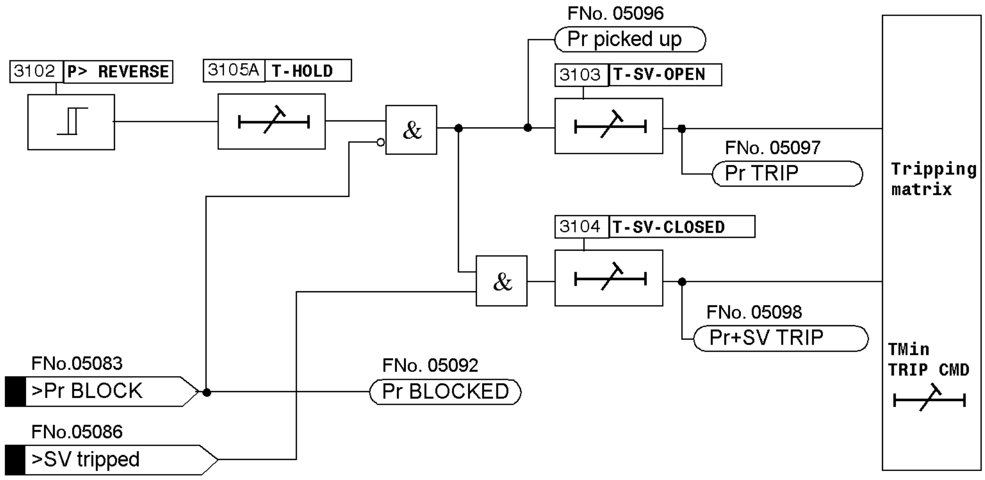


Figure 2-25 Logic Diagram of the Reverse Power Protection

2.12.2 Setting Notes

General

Reverse power protection is only effective and available if this function was set during protective function configuration (Section 2.2, 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 relay. 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 of correcting angle faults of the current and voltage transformers should be used especially in case of very large machines with a particularly low motoring energy (see sections 2.3).

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

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

with

Psec	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
$I_{N\,prim}$	Nominal primary CT current

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 time delays not including the operating times (measuring time, drop-out time) of the protective function.

2.12.3 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

2.12.4 Information List

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

2.13 Forward Active Power Supervision (ANSI 32F)

The machine protection 7UM61 includes an active power supervision which monitors whether the active power undershoots one set value or overshoots a separate second set value. 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 and should be split or for example, an industrial network decoupled from it. As criteria for decoupling, in addition to power flow direction, are undervoltage, overcurrent and frequency. As a result, the 7UM61 can also be used for network decoupling.

2.13.1 Function 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 de-coupling.

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 forward active power supervision.

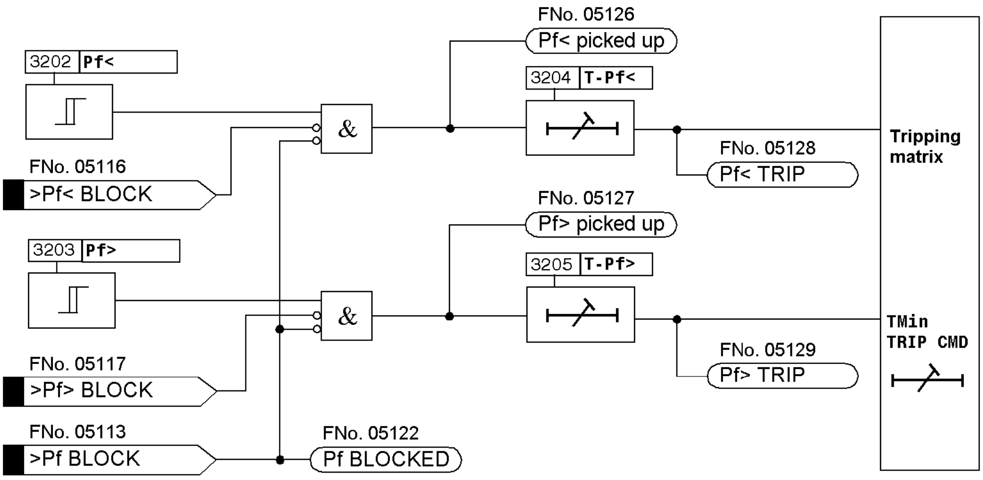


Figure 2-26 Logic Diagram of the Forward Active Power Supervision

2.13.2 Setting Notes

General

The forward active power protection is only effective and available if this function was set on protective functions configuration (section 2.2, address 132, **FORWARD POWER** = 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 very much 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:

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

with

Psec	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
$I_{N\,prim}$	Nominal primary CT current

Address 3202 serves to set the threshold of the forward power to an undershoot (**Pf<**) and address 3204 (**Pf>**) serves to set it to overshoot. Addresses 3203 **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 time delays not including the operating times (measuring time, drop-out time) of the protective function.

2.13.3 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	T-Pf<	0.00 .. 60.00 sec; ∞	10.00 sec	T-P-forw.< Time Delay
3204	Pf>	1.0 .. 120.0 %	96.6 %	P-forw.> Supervision Pickup
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

2.13.4 Information List

No.	Information	Type of Information	Comments
5113	>Pf BLOCK	EM	>BLOCK forward power supervision
5116	>Pf< BLOCK	EM	>BLOCK forw. power superv. Pf< stage
5117	>Pf> BLOCK	EM	>BLOCK forw. power superv. Pf> stage
5121	Pf OFF	AM	Forward power supervis. is switched OFF
5122	Pf BLOCKED	AM	Forward power supervision is BLOCKED
5123	Pf ACTIVE	AM	Forward power supervision is ACTIVE
5126	Pf< picked up	AM	Forward power: Pf< stage picked up
5127	Pf> picked up	AM	Forward power: Pf> stage picked up
5128	Pf< TRIP	AM	Forward power: Pf< stage TRIP
5129	Pf> TRIP	AM	Forward power: Pf> stage TRIP

2.14 Impedance Protection (ANSI 21)

Machine impedance protection is used as a selective time graded protection to provide 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.

2.14.1 Functional Description

Pickup

General

Fault detection 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 Feature

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 pick-up is maintained for a settable time period by means of the undervoltage controlled seal-in circuit using the positive sequence voltage U1. 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 2-27 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 2-5).

Loop Selection

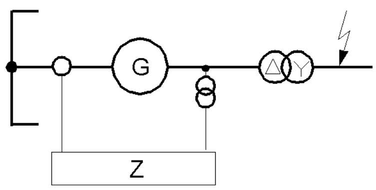
- The corresponding phase-earth loop is used for a 1-pole pickup.
- With a 2-pole pickup, the phase-phase loop with the corresponding phase-to-phase voltage is used for impedance calculation.
- With a 3-pole pickup, the phase-phase loop with the highest current value is used and with equal current amplitudes, the procedure described in the last row of the following of table is applied.

Table 2-5 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 $\underline{U}_{I\,I}$ and $\underline{I}_{I\,I}$	L1– L2 L2– L3 L3– L1
3-pole, with different amplitudes	L1,2*L2,L3 L2.2*L3,L1 L3.2*L2,L3	Phase-ground, selection of loop with the highest current $\underline{U}_{I\,(Imax)}$ and $\underline{I}_{I\,(Imax)}$	L2–E L3–E L1–E
3-pole, with equal amplitudes	L1, L2, L3	Phase-earth, any, maximum current amount	L1=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 2-6 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 loop with highest current	always correct measurement
1–pole short circuit	2–pole short circuit	Phase-phase loop	Impedance measured too high by the zero impedance
			

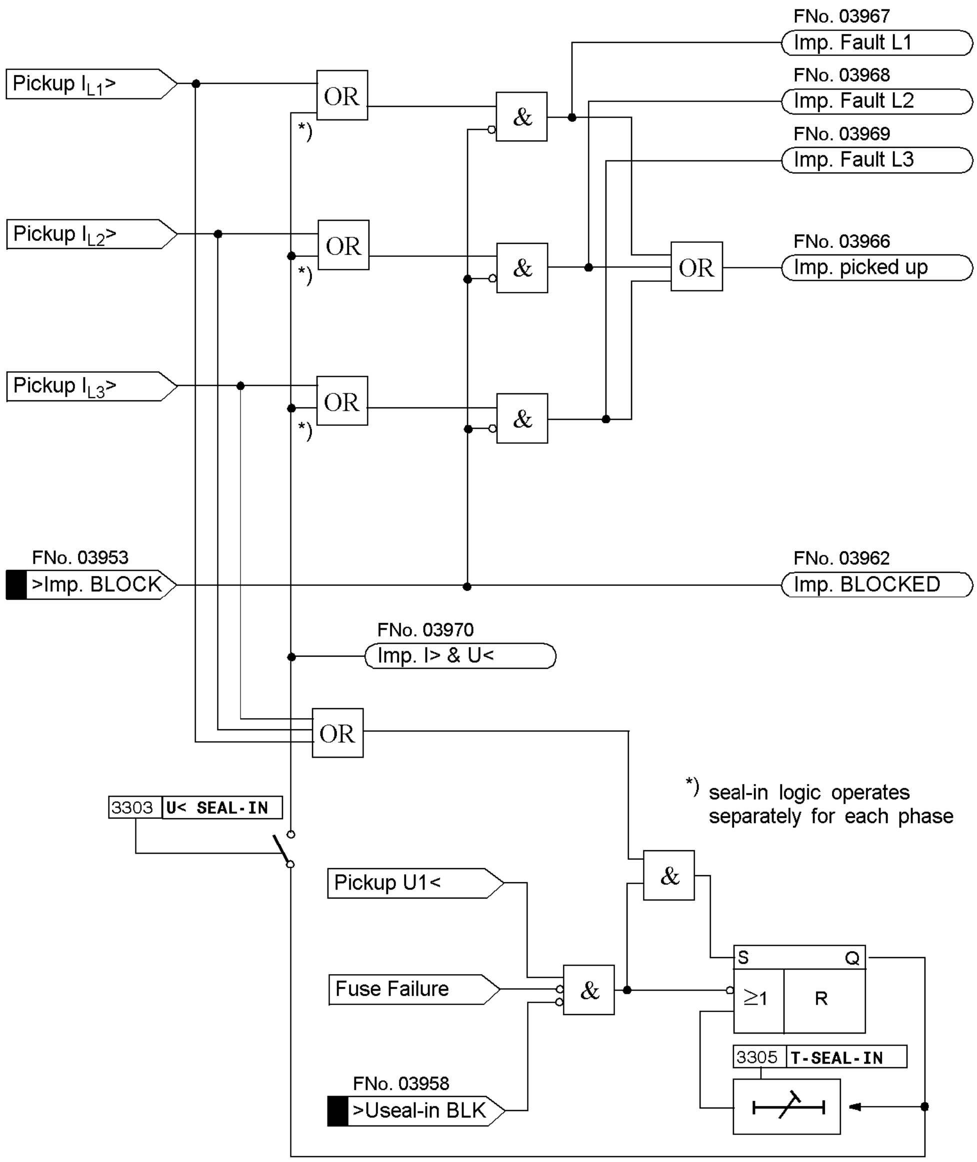


Figure 2-27 Logic Diagram of the Pickup Stage of the Impedance Protection

Tripping Characteristic

The tripping characteristic of the impedance protection is a polygon (see also Figure 2-28). It is a symmetrical characteristic, even though a fault in reverse direction (negative R and/or X values) is 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 criterion is 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 trip characteristic, the protection issues a trip command which may be delayed according to the relevant 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 network. It should be noted that high voltage side 1-pole 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 unit. If consideration of the circuit breaker auxiliary contact is possible, a so-called overreach zone **ZONE Z1B** can be made effective (see also Section 2.14.2, Grading of the Machine Impedance Protection figure).

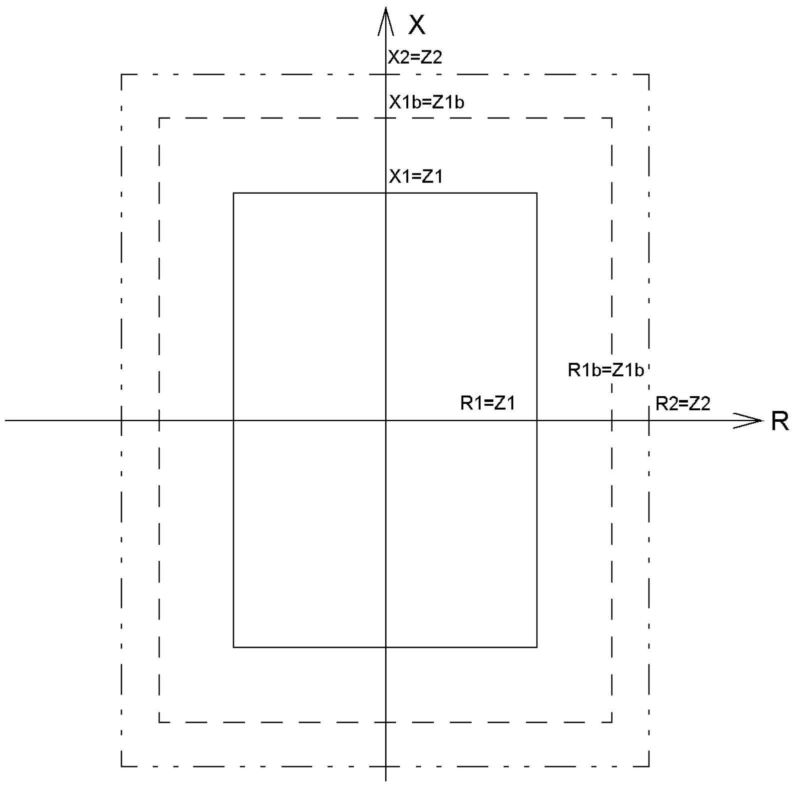


Figure 2-28 Tripping Characteristics of the Impedance Protection

Tripping Logic

The **T END** time delay is started subsequent to the protection pickup, establishing the 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 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.

The following figure shows the logic diagram for the impedance protection.

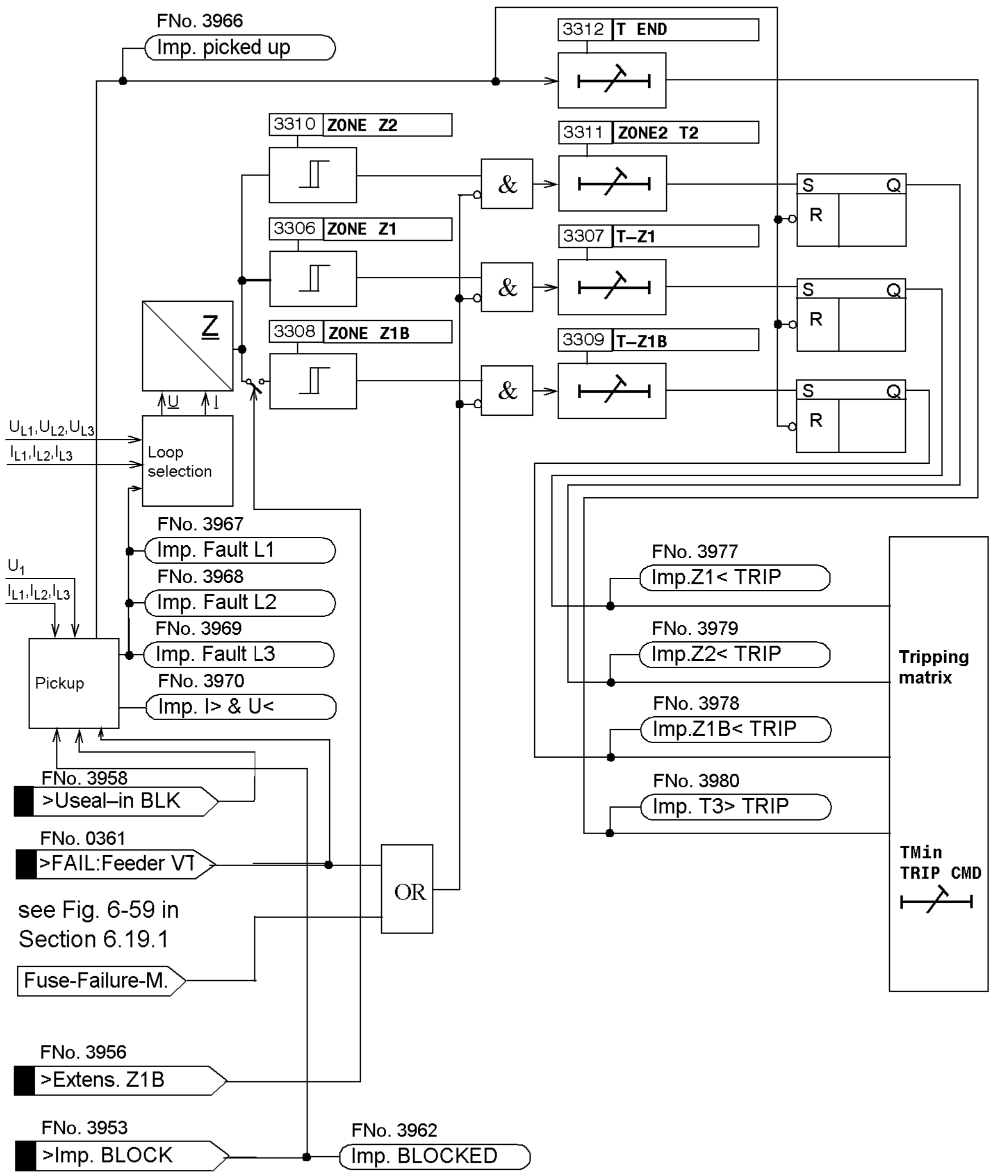


Figure 2-29 Logic Diagram of the Impedance Protection

2.14.2 Setting Notes

General

Machine impedance protection is only effective and available if enabled during configuration (Section 2.2, 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 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 selection must 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_K	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 2.3).

Example:

Transformer data:

u_K	= 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 to a 70 % reach for zone 1:

$$Z1_{prim} = \frac{70}{100} \cdot \frac{7}{100} \cdot \frac{6.3^2}{5.3} = 0.3669\ \Omega$$

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 current 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**:

$$Z2_{\text{secondary}} = \frac{500\ \text{A}/1\ \text{A}}{6.3\ \text{kV}/100\ \text{V}} \cdot 0.5242\ \Omega = 4.16\ \Omega$$

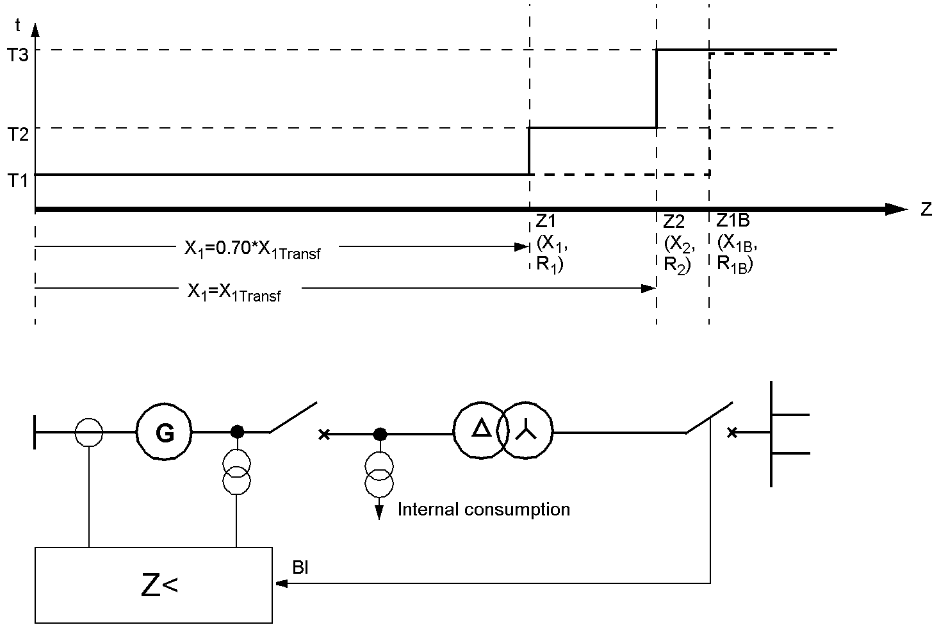


Figure 2-30 Time Grading for Machine Impedance Protection – Example

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 2-30). The overreach zone is allocated an individual 3309 **T-Z1B** time delay.

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.

2.14.3 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
3301	IMPEDANCE PROT.		OFF ON Block relay	OFF	Impedance Protection
3302	IMP I>	1A	0.10 .. 20.00 A	1.35 A	Fault Detection I> Pickup
		5A	0.50 .. 100.00 A	6.75 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	1A	0.05 .. 130.00 Ω	2.90 Ω	Impedance Zone Z1
		5A	0.01 .. 26.00 Ω	0.58 Ω	
3307	T-Z1		0.00 .. 60.00 sec; ∞	0.10 sec	Impedance Zone Z1 Time Delay
3308	ZONE Z1B	1A	0.05 .. 65.00 Ω	4.95 Ω	Impedance Zone Z1B
		5A	0.01 .. 13.00 Ω	0.99 Ω	
3309	T-Z1B		0.00 .. 60.00 sec; ∞	0.10 sec	Impedance Zone Z1B Time Delay
3310	ZONE Z2	1A	0.05 .. 65.00 Ω	4.15 Ω	Impedanz Zone Z2
		5A	0.01 .. 13.00 Ω	0.83 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

2.14.4 Information List

No.	Information	Type of Information	Comments
3953	>Imp. BLOCK	EM	>BLOCK impedance protection
3956	>Extens. Z1B	EM	>Zone 1B extension for impedance prot.
3958	>Useal-in BLK	EM	>Imp. prot. : BLOCK undervoltage seal-in
3961	Imp. OFF	AM	Impedance protection is switched OFF
3962	Imp. BLOCKED	AM	Impedance protection is BLOCKED
3963	Imp. ACTIVE	AM	Impedance protection is ACTIVE
3966	Imp. picked up	AM	Impedance protection picked up
3967	Imp. Fault L1	AM	Imp.: Fault detection , phase L1
3968	Imp. Fault L2	AM	Imp.: Fault detection , phase L2
3969	Imp. Fault L3	AM	Imp.: Fault detection , phase L3

No.	Information	Type of Information	Comments
3970	Imp. I> & U<	AM	Imp.: O/C with undervoltage seal in
3977	Imp.Z1< TRIP	AM	Imp.: Z1< TRIP
3978	Imp.Z1B< TRIP	AM	Imp.: Z1B< TRIP
3979	Imp. Z2< TRIP	AM	Imp.: Z2< TRIP
3980	Imp.T3> TRIP	AM	Imp.: T3> TRIP

2.15 Undervoltage Protection (ANSI 27)

Undervoltage protection detects voltage dips in electrical machines and avoids inadmissible operating states and possible loss of stability. Two-pole short circuits or earth faults cause asymmetrical voltage collapse. Compared with 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.

2.15.1 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. In addition to this, the integrated fuse failure monitor (FFM) blocks both stages (see Section 2.28).

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 occurs. An immediate tripping may be caused 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 protective function after a protection tripping.

The following figure shows the logic diagram for undervoltage protection.

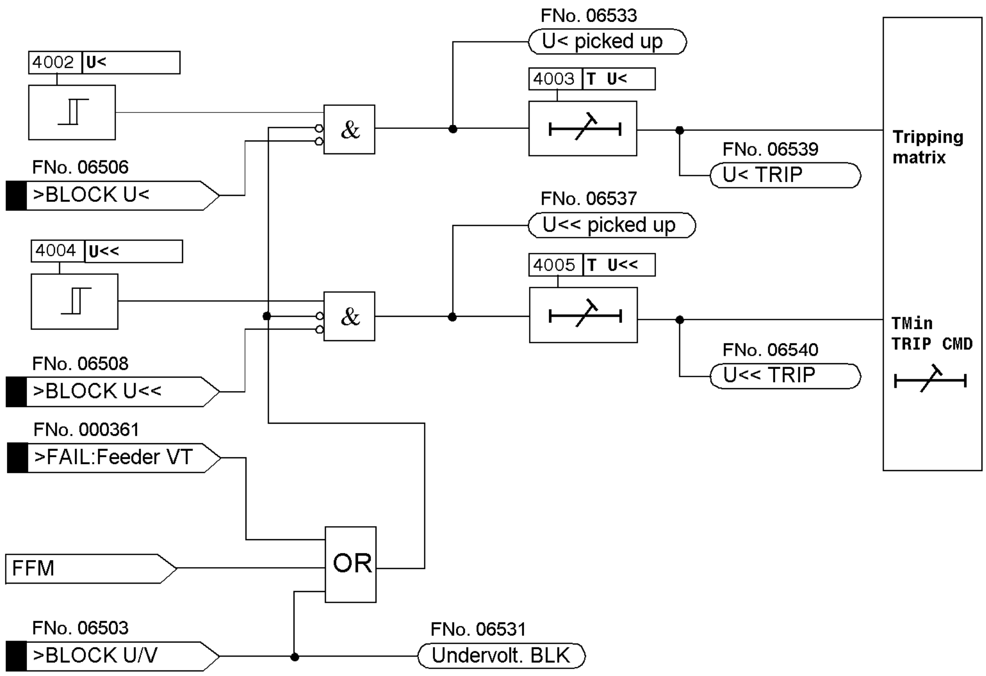


Figure 2-31 Logic diagram of the undervoltage protection

2.15.2 Setting Notes

General

The undervoltage protection is only effective and available if this function was set during protective function configuration (Section 2.2, 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 note 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, drop-out time) of the protective function.

The drop-out ratio can be adapted in small steps to the operating conditions at address 4006 **DOUT RATIO**.

2.15.3 Settings

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

Addr.	Parameter	Setting Options	Default Setting	Comments
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

2.15.4 Information List

No.	Information	Type of Information	Comments
6503	>BLOCK U/V	EM	>BLOCK undervoltage protection
6506	>BLOCK U<	EM	>BLOCK undervoltage protection U<
6508	>BLOCK U<<	EM	>BLOCK undervoltage protection U<<
6530	Undervolt. OFF	AM	Undervoltage protection switched OFF
6531	Undervolt. BLK	AM	Undervoltage protection is BLOCKED
6532	Undervolt. ACT	AM	Undervoltage protection is ACTIVE
6533	U< picked up	AM	Undervoltage U< picked up
6537	U<< picked up	AM	Undervoltage U<< picked up
6539	U< TRIP	AM	Undervoltage U< TRIP
6540	U<< TRIP	AM	Undervoltage U<< TRIP

2.16 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.

2.16.1 Functional Description

Mode of Operation

By means of the overvoltage protection feature, the user can select if he wants to monitor the phase-to-phase voltages or the phase-earth-voltages. In case of a high overvoltage, the switchoff is performed with a short-time delay, whereas in case of lower overvoltages, the switchoff is performed with a longer time delay to allow the voltage regulator to take the voltage back into the nominal range. The user can specify the voltage limit values and the time delays individually for both stages.

Each stage can be blocked individually and/or for both stages can be blocked, via binary input(s).

The following figure shows the logic diagram for the overvoltage protection function.

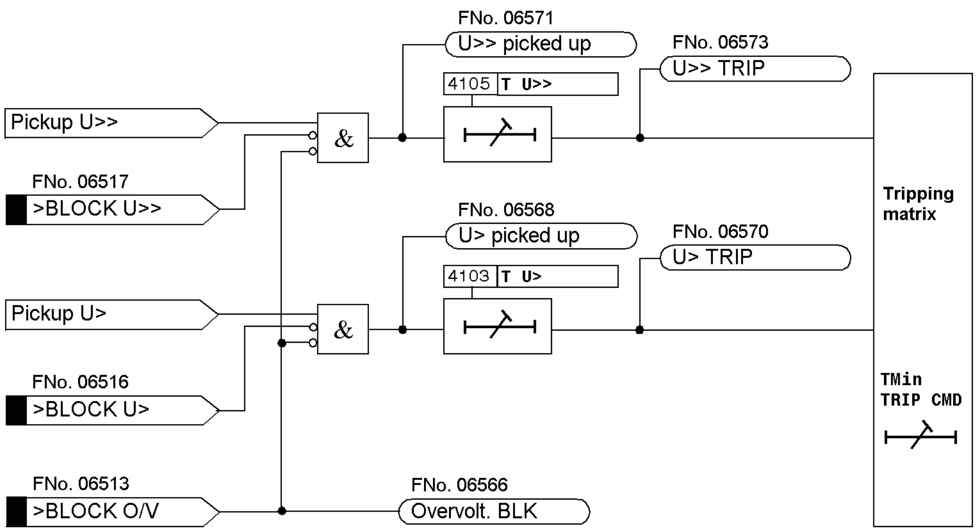


Figure 2-32 Logic Diagram of the Overvoltage Protection

2.16.2 Setting Notes

General

Overvoltage protection is only effective and available if this function was set during protective function configuration (Section 2.2, 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 are referred 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 fault-free 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 the voltage regulator reduces 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 at the address 4106 **DOUT RATIO** can be adapted in small steps to the operating conditions and used for highly precise signalizations (e.g. network infeed of wind power stations).

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
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

2.16.4 Information List

No.	Information	Type of Information	Comments
6513	>BLOCK O/V	EM	>BLOCK overvoltage protection
6516	>BLOCK U>	EM	>BLOCK overvoltage protection U>
6517	>BLOCK U>>	EM	>BLOCK overvoltage protection U>>
6565	Overvolt. OFF	AM	Overvoltage protection switched OFF
6566	Overvolt. BLK	AM	Overvoltage protection is BLOCKED
6567	Overvolt. ACT	AM	Overvoltage protection is ACTIVE
6568	U> picked up	AM	Overvoltage U> picked up
6570	U> TRIP	AM	Overvoltage U> TRIP
6571	U>> picked up	AM	Overvoltage U>> picked up
6573	U>> TRIP	AM	Overvoltage U>> TRIP

2.17 Frequency Protection (ANSI 81)

The frequency protection function detects abnormally high and low frequencies of the generator. If the frequency lies outside the admissible range, appropriate actions are initiated, such as 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 frequency or speed control malfunction occurs. The frequency decrease protection is also used for generators which (for a certain time) function on an island network. This is due to the fact that the reverse power protection cannot operate on drive power failure. The generator can be disconnected from the power system using 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.

Through the use of filters measurement is practically independent of harmonic influences and very accurate.

2.17.1 Functional Description

Frequency Increase and Decrease

Frequency protection consists of 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 parameter setting decides for what purpose the particular stage will be used. For the f4 frequency stage, the user can instead specify independently of the parametrized limit value whether 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 there is a sufficiently strong positive sequence system of voltages. 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 under these conditions.

With <u>over</u>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 <u>under</u>frequency 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 elapsed.

Each of the four frequency stages can be blocked individually by binary inputs.

Figure 2-33 shows the logic diagram for frequency protection.

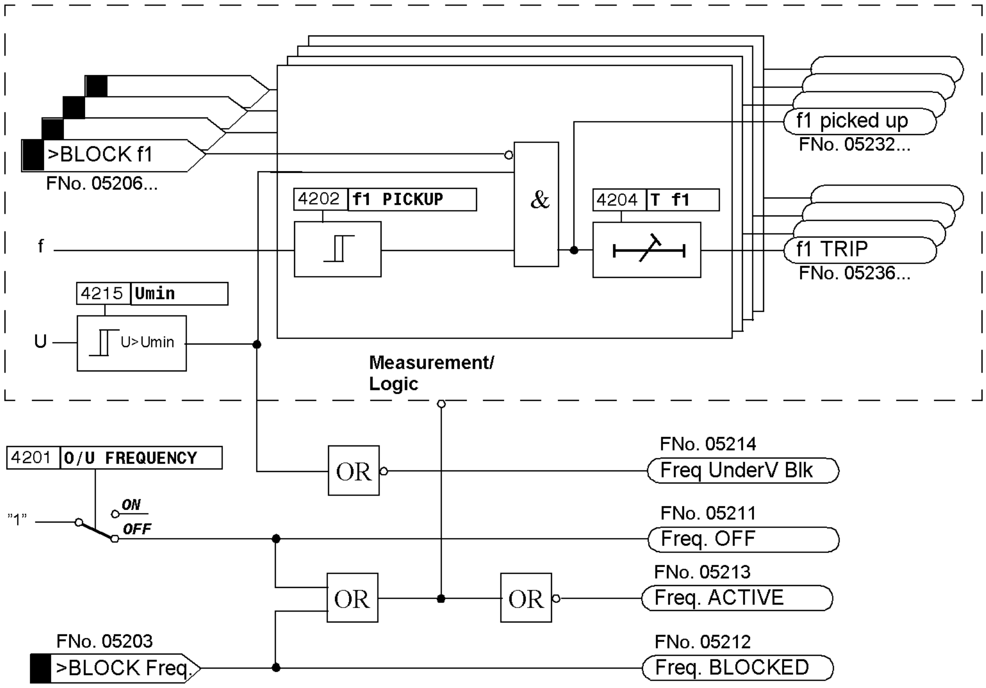


Figure 2-33 Logic diagram of the frequency protection

2.17.2 Setting Notes

General

Frequency protection is only effective and available if address 142 **FREQUENCY Prot.** is set to ***Enabled*** during configuration. 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

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 overfrequency or underfrequency protection. If the threshold is configured as below rated frequency, underfrequency protection is involved. If the threshold is configured as above rated frequency, overfrequency protection is implemented.

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 then regulates the machine set to nominal speed so that the station's own requirements can be continuously provided at rated 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 an island network). In this way, the frequency increase protection can, for example, be used as overspeed 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 time delays **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 time delays not including the operating times (measuring time, drop-out time) of the protective function.

Minimum Voltage

Address 4215 **Umin** is used to set the minimum voltage which if undershot, frequency protection is blocked. 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**.

2.17.3 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 .. 65.00 Hz	48.00 Hz	f1 Pickup
4203	f1 PICKUP	40.00 .. 65.00 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 .. 65.00 Hz	47.00 Hz	f2 Pickup
4206	f2 PICKUP	40.00 .. 65.00 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 .. 65.00 Hz	49.50 Hz	f3 Pickup

Addr.	Parameter	Setting Options	Default Setting	Comments
4209	f3 PICKUP	40.00 .. 65.00 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 .. 65.00 Hz	52.00 Hz	f4 Pickup
4212	f4 PICKUP	40.00 .. 65.00 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

2.17.4 Information List

No.	Information	Type of Information	Comments
5203	>BLOCK Freq.	EM	>BLOCK frequency protection
5206	>BLOCK f1	EM	>BLOCK stage f1
5207	>BLOCK f2	EM	>BLOCK stage f2
5208	>BLOCK f3	EM	>BLOCK stage f3
5209	>BLOCK f4	EM	>BLOCK stage f4
5211	Freq. OFF	AM	Frequency protection is OFF
5212	Freq. BLOCKED	AM	Frequency protection is BLOCKED
5213	Freq. ACTIVE	AM	Frequency protection is ACTIVE
5214	Freq UnderV Blk	AM	Frequency protection undervoltage Blk
5232	f1 picked up	AM	f1 picked up
5233	f2 picked up	AM	f2 picked up
5234	f3 picked up	AM	f3 picked up
5235	f4 picked up	AM	f4 picked up
5236	f1 TRIP	AM	f1 TRIP
5237	f2 TRIP	AM	f2 TRIP
5238	f3 TRIP	AM	f3 TRIP
5239	f4 TRIP	AM	f4 TRIP

2.18 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. Overexcitation protection must intervene when the admissible induction level for the protected object (e.g. unit transformer) is exceeded. The transformer is endangered, for example, if the power station block is disconnected from full-load operation and the voltage regulator does not operate sufficiently fast, or at all, to control the resulting voltage increase. Similarly, a decrease in frequency (speed), e.g. in island systems, can lead to increased induction.

An increase in induction above the rated value very quickly saturates the iron core and causes large eddy current losses.

2.18.1 Function Description

Measurement Method

The overexcitation protection measures the voltage/frequency ratio proportional to the induction B and compares it with rated induction B_N . Voltage and frequency are referred to rated values of the protection object (generator, transformer).

$$B \sim \frac{U}{f}$$

$$\frac{B}{B_{N\ Mach}} = \frac{\frac{U}{U_{N\ Mach}}}{\frac{f}{f_N}} \triangleq \frac{U}{f} \qquad \text{(simplified notation)}$$

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.

Transformer Adaptation

Any deviation between the primary nominal voltage of the voltage transformers and the object to be protected is compensated by an internal correction factor ($U_{N\ VT\ prim}/U_{N\ Gen\ prim}$). 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 2.3 and 2.5.

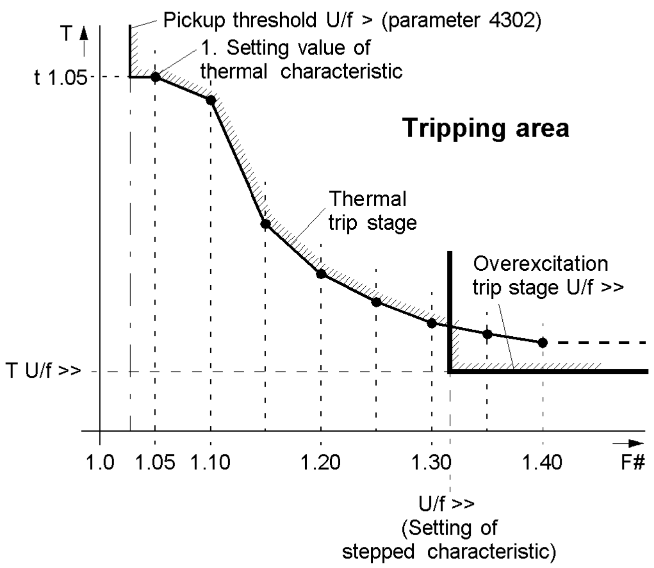
Characteristic Curves

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.

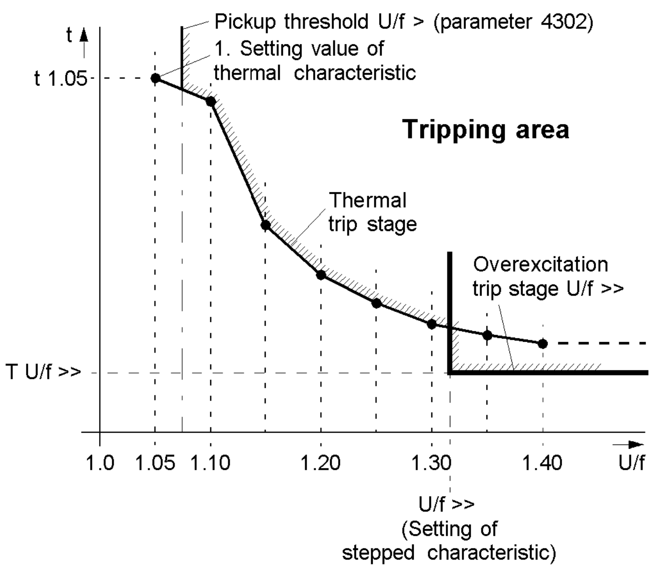
The trip signal is retracted as soon as the value falls below the pickup threshold and the counter is decremented in accordance with a parametrizable cool-down time.

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 behaviour 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.

The characteristic resulting from the device default settings is shown in the Technical Data Section Overexcitation Protection. The following figure illustrates the behaviour of the protection if on pickup threshold configuration (parameter 4302 **U/f >**) lower or higher values than the first setting value of the thermal characteristic are selected.



a) Pickup threshold U/f > is less than the 1st setting value of the thermal characteristic



b) Pickup threshold U/f > is greater than the 1st setting value of the thermal characteristic

Figure 2-34 Tripping Range of the Overexcitation Protection

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.

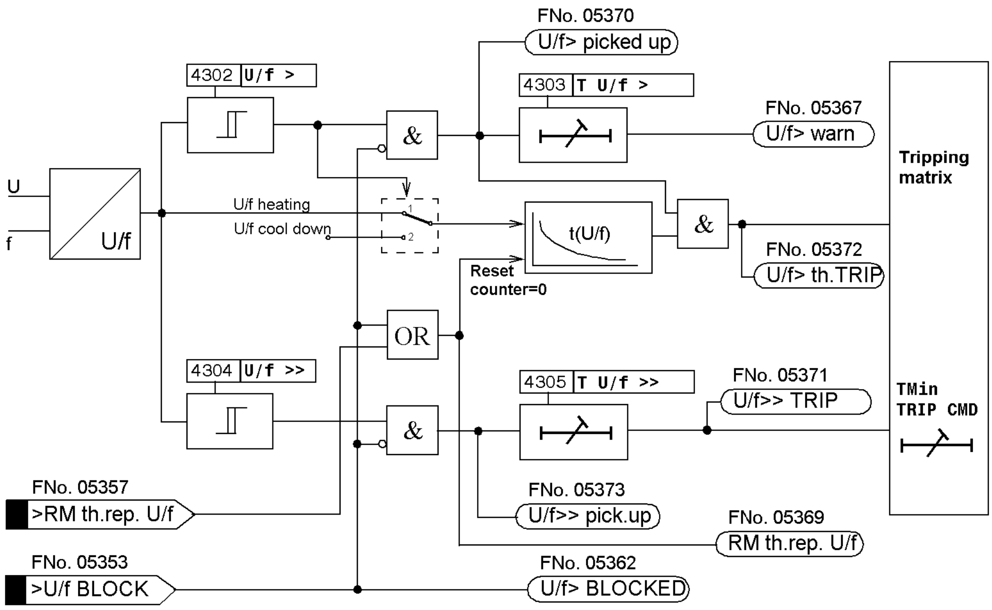


Figure 2-35 Logic Diagram of the Overexcitation Protection

2.18.2 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 ***Disabled*** is set. 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 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 set additionally which causes the tripping after a length of time corresponding to the set characteristic.

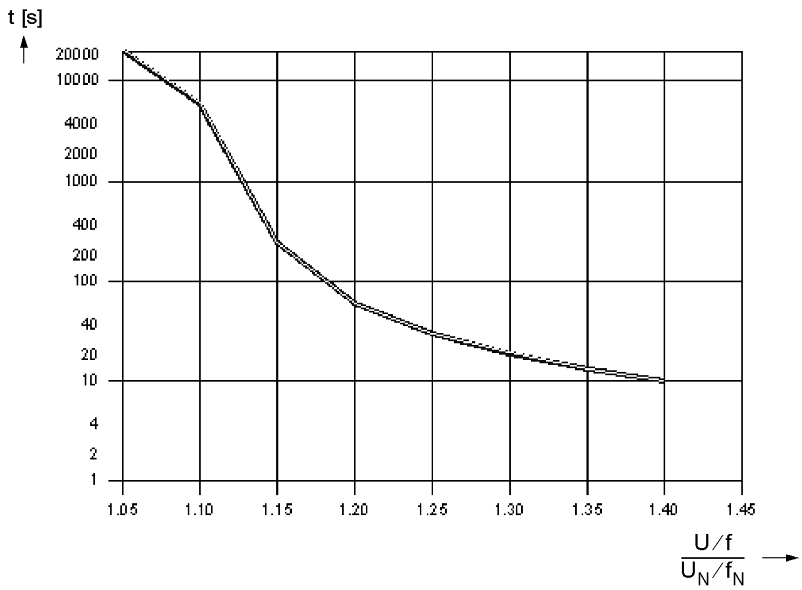


Figure 2-36 Thermal tripping time characteristic (with presettings)

The characteristic of a Siemens standard transformer was selected as a presetting 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 by point-wise entering of parameters for up to 7 straight segments. To do this, the trip times 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 addresses 4306 **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.

Cooldown 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 %.

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 it is necessary that the relevant system parameters 221 **Unom PRIMARY** and 1101 were properly entered in accordance with Section 2.3.

2.18.3 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

2.18.4 Information List

No.	Information	Type of Information	Comments
5353	>U/f BLOCK	EM	>BLOCK overexcitation protection
5357	>RM th.rep. U/f	EM	>Reset memory of thermal replica U/f
5361	U/f> OFF	AM	Overexcitation prot. is swiched OFF
5362	U/f> BLOCKED	AM	Overexcitation prot. is BLOCKED
5363	U/f> ACTIVE	AM	Overexcitation prot. is ACTIVE
5367	U/f> warn	AM	Overexc. prot.: U/f warning stage
5369	RM th.rep. U/f	AM	Reset memory of thermal replica U/f
5370	U/f> picked up	AM	Overexc. prot.: U/f> picked up
5371	U/f>> TRIP	AM	Overexc. prot.: TRIP of U/f>> stage
5372	U/f> th.TRIP	AM	Overexc. prot.: TRIP of th. stage
5373	U/f>> pick.up	AM	Overexc. prot.: U/f>> picked up

2.19 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 2.17) 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 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 a malfunction appears, the more effective they are.

The two main applications for this protection function are thus network decoupling and load shedding.

2.19.1 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 of 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.

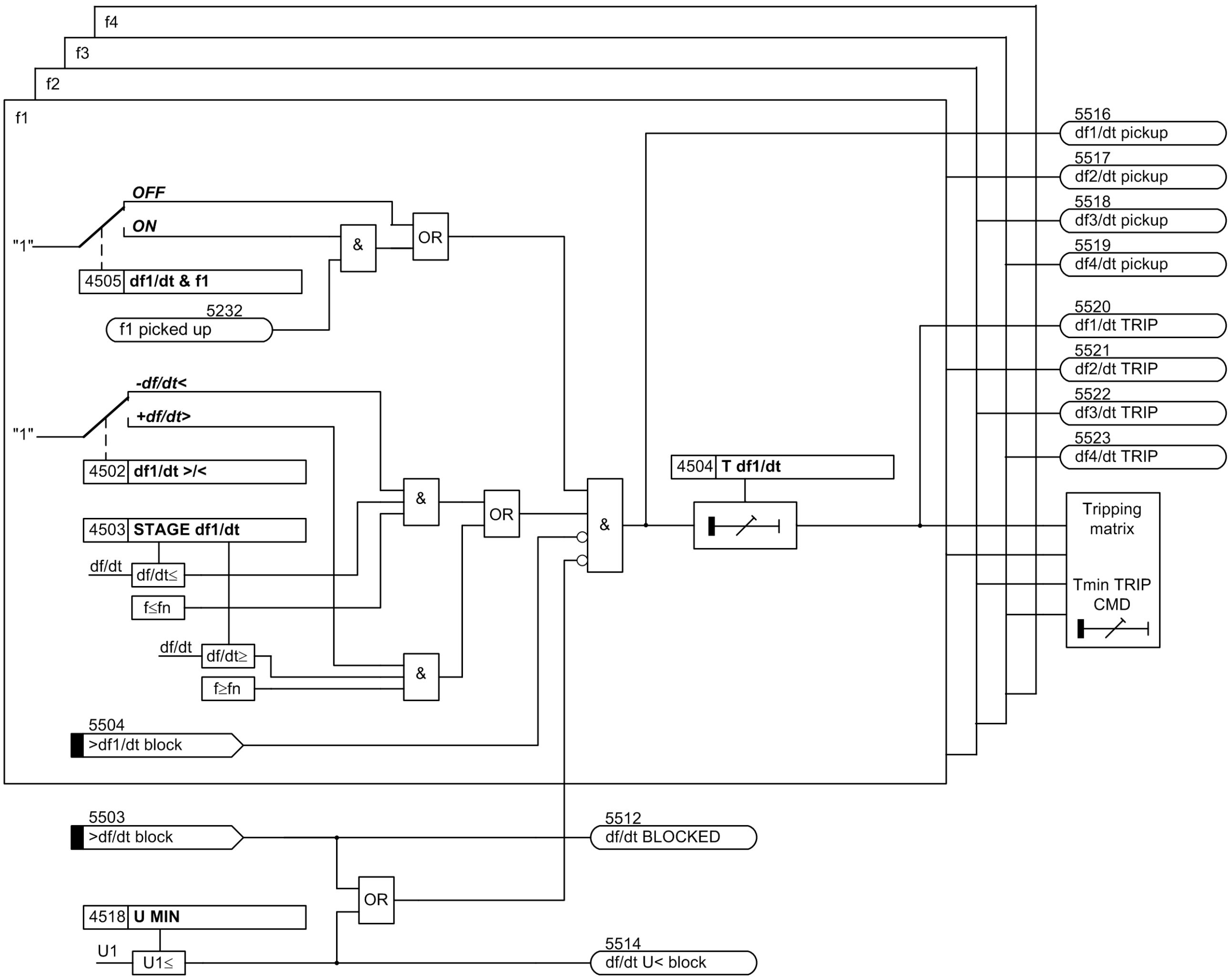


Figure 2-37 Logic Diagram of the Rate-of-Frequency-Change Protection

2.19.2 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. 2 or 4 stages can be selected. 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).

$$\frac{df}{dt} = -\frac{f_N}{2\ H} \cdot \frac{\Delta P}{S_N}$$

Significance:

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

Example:

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 to set for two stages each (e.g. df1/dt and df2/dt) the dropout difference and the measuring window. These parameters can only be set with the DIGSI communication software.

Setting changes are necessary e.g. to obtain a great 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...0.5 Hz/s	≈ 0.2	10...5
5...00.10 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”.

2.19.3 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

Addr.	Parameter	Setting Options	Default Setting	Comments
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

2.19.4 Information List

No.	Information	Type of Information	Comments
5503	>df/dt block	EM	>BLOCK Rate-of-frequency-change prot.
5504	>df1/dt block	EM	>BLOCK df1/dt stage
5505	>df2/dt block	EM	>BLOCK df2/dt stage
5506	>df3/dt block	EM	>BLOCK df3/dt stage
5507	>df4/dt block	EM	>BLOCK df4/dt stage
5511	df/dt OFF	AM	df/dt is switched OFF
5512	df/dt BLOCKED	AM	df/dt is BLOCKED
5513	df/dt ACTIVE	AM	df/dt is ACTIVE
5514	df/dt U< block	AM	df/dt is blocked by undervoltage
5516	df1/dt pickup	AM	Stage df1/dt picked up
5517	df2/dt pickup	AM	Stage df2/dt picked up
5518	df3/dt pickup	AM	Stage df3/dt picked up
5519	df4/dt pickup	AM	Stage df4/dt picked up
5520	df1/dt TRIP	AM	Stage df1/dt TRIP
5521	df2/dt TRIP	AM	Stage df2/dt TRIP
5522	df3/dt TRIP	AM	Stage df3/dt TRIP
5523	df4/dt TRIP	AM	Stage df4/dt TRIP

2.20 Jump of Voltage Vector

Sometimes consumers with their own generating plant feed power directly into a network. The incoming feeder is usually the ownership boundary between the network utility 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, it may meet with asynchronous conditions which 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.

2.20.1 Function 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 2.19 Rate-of-Frequency-Change Protection).

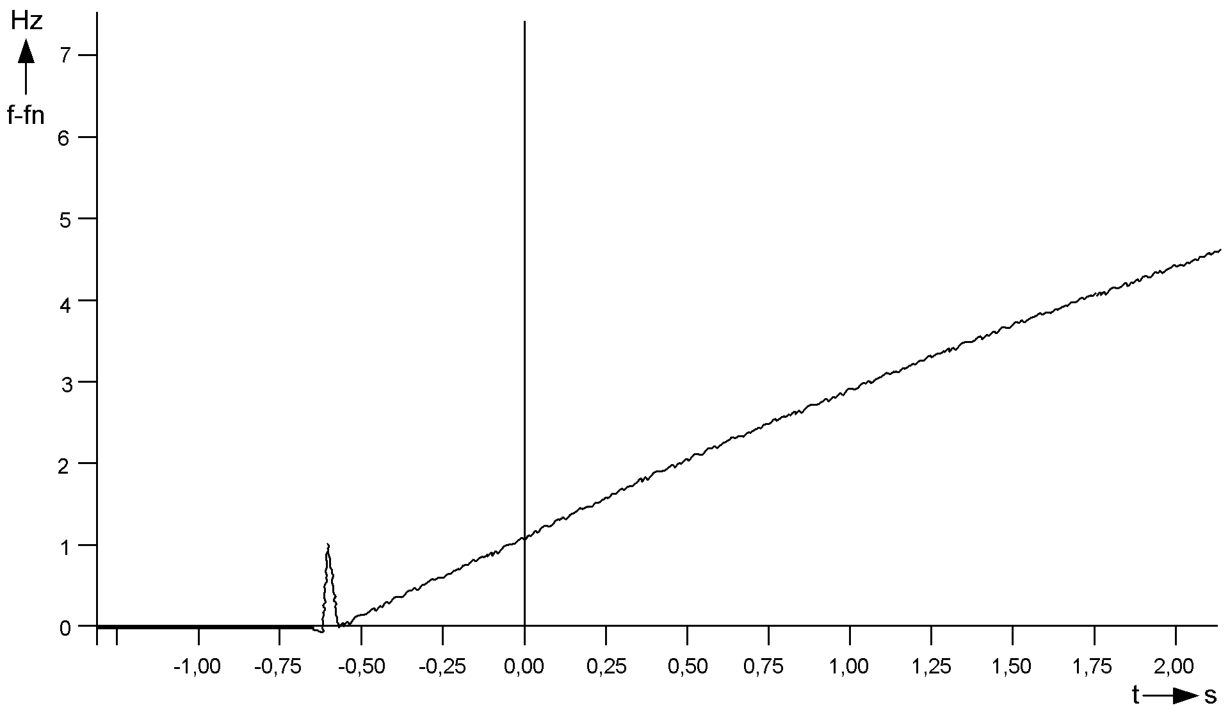


Figure 2-38 Change of the Frequency after Disconnection of a Load (Fault recording with the SIPROTEC® device- the figure shows the deviation from the rated frequency)

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 the following figure. The diagram on the left shows a steady state, and the diagram on the right the vector change following a load shedding. The vector jump is clearly visible.

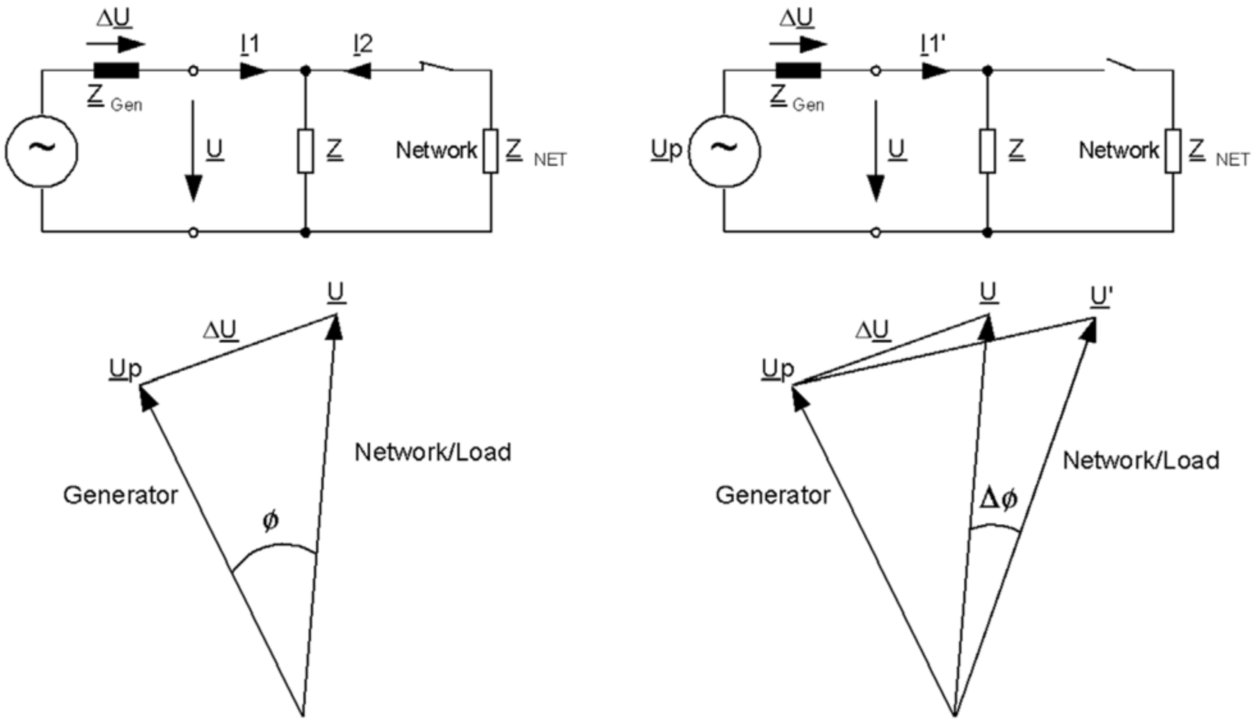


Figure 2-39 Voltage Vector Following Load Shedding

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 $f_N \pm 3$ Hz
- Detection of internal sampling frequency changeover (Sampling frequency adjustment)
- Minimum voltage for enabling
- Blocking on voltage connection or disconnection

Logic

Figure 2-40 shows the logic diagram. 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 an 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.

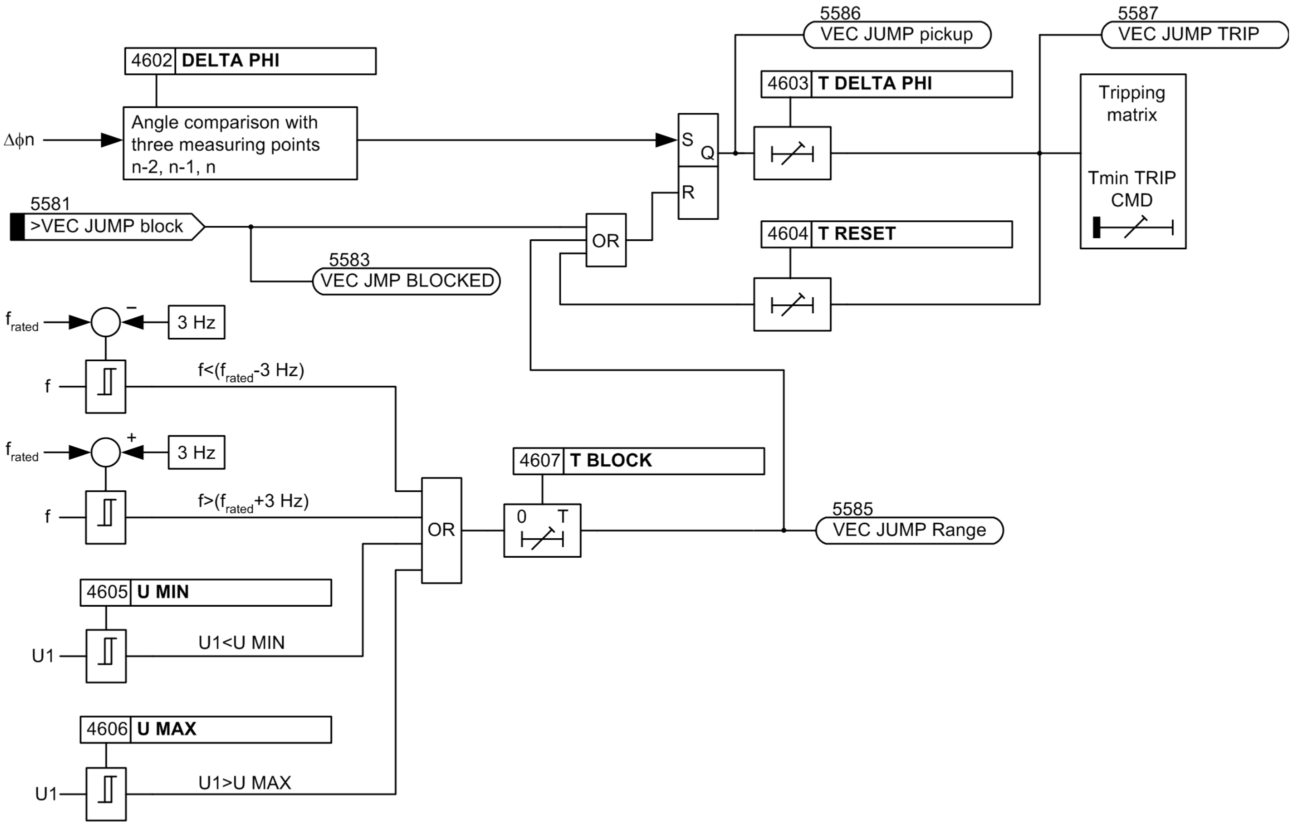


Figure 2-40 Logic Diagram of the Vector Jump Detection

2.20.2 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 after a load shedding” in Section 2.20, 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 rated voltage. For **U MAX** the maximum admissible voltage must be selected. This will be in most cases a voltage of ***130%*** of rated 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).

2.20.3 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

2.20.4 Information List

No.	Information	Type of Information	Comments
5581	>VEC JUMP block	EM	>BLOCK Vector Jump
5582	VEC JUMP OFF	AM	Vector Jump is switched OFF
5583	VEC JMP BLOCKED	AM	Vector Jump is BLOCKED
5584	VEC JUMP ACTIVE	AM	Vector Jump is ACTIVE
5585	VEC JUMP Range	AM	Vector Jump not in measurement range
5586	VEC JUMP pickup	AM	Vector Jump picked up
5587	VEC JUMP TRIP	AM	Vector Jump TRIP

2.21 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.

2.21.1 Functional Description

Displacement Voltage

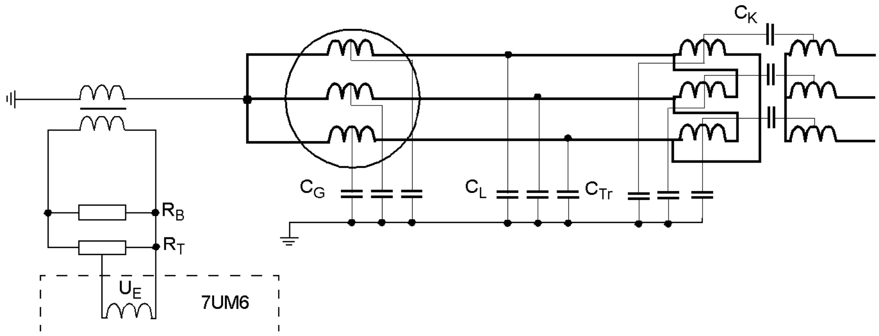
The displacement voltage UE can be measured either at the machine starpoint via voltage transformers or neutral earthing transformers (Figure2-41 2-41) or via the e-n winding (broken delta winding) of a voltage transformer set or at the measurement winding of an earthing transformer (Figure 2-41). Since the neutral or earthing transformers usually supply a displacement voltage of 500 V (with full displacement), a 500 V/100 V voltage divider 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-ground 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 of the displacement voltage is evaluated in the stator earth fault protection. Harmonics are filtered out by numerical filter algorithms.

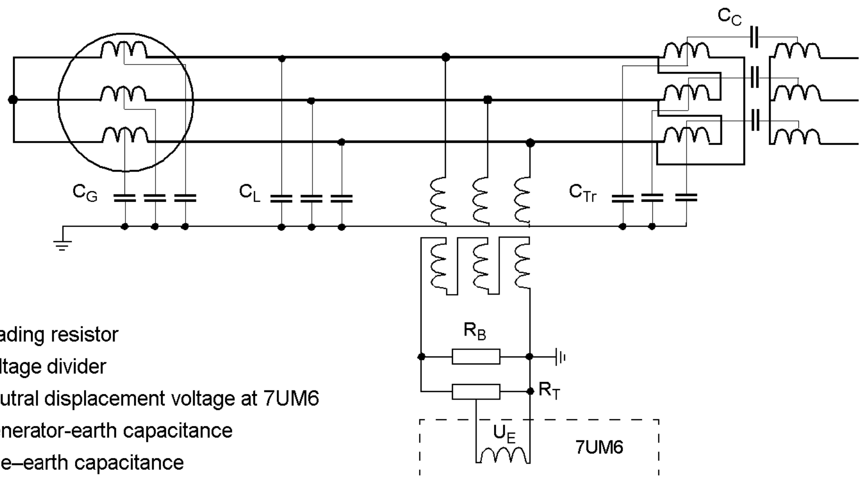
For machines in unit connection the evaluation of the displacement voltage is sufficient. The possible sensitivity of the protection is only limited by power frequency interference voltages during earth faults in the network. These interference voltages are transferred to the machine side via the coupling capacitances 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.



R_B – Loading resistor
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_K – Coupling capacitance of unit transformer

Figure 2-41 Unit Connection with Earthing Transformer



R_B – Loading resistor
R_T – Voltage divider
U_E – Neutral displacement voltage at 7UM6
C_G – Generator-earth capacitance
C_L – Line–earth capacitance
C_{Tr} – Winding–earth capacitance of block transformer
C_C – Coupling capacitance of block transformer

Figure 2-42 Unit Connection with Earthing Transformer

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.

This 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.

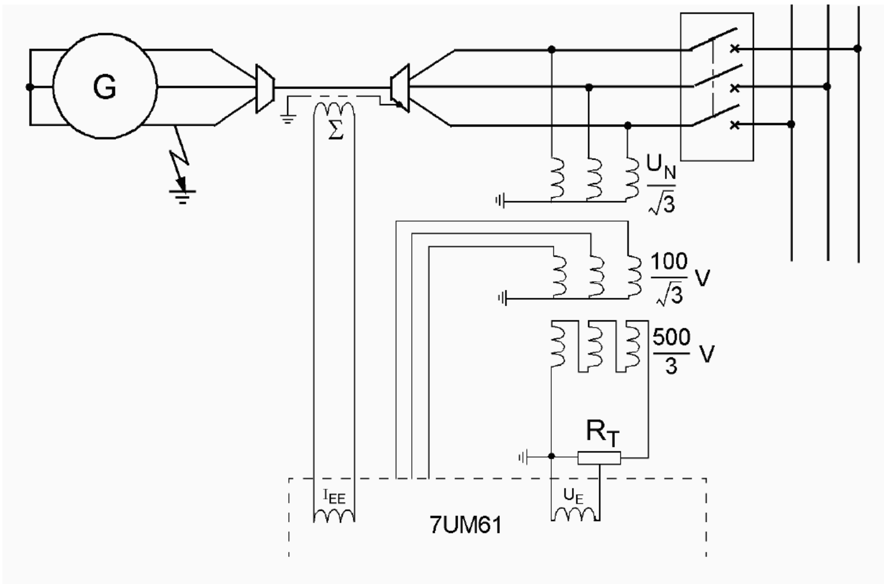


Figure 2-43 Earth Fault Direction Detection with Busbar Connection

Consequently, the loading resistor must be situated on the other side of the measurement location (current transformer, toroidal current transformer) viewed from the machine. The earthing transformer is preferably connected to the busbar. Apart from the magnitude of the earth fault current, the direction of this current in relation to the displacement voltage is needed 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 7UM61 (refer to 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.

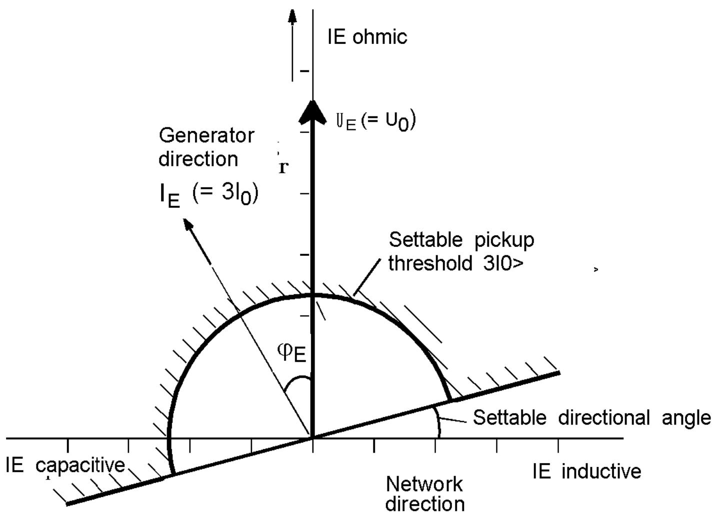


Figure 2-44 Characteristic of the Stator Earth Fault Protection for Busbar Connection

On the occurrence of an earth fault in the machine zone, the disconnection of the machine is initiated after a set delay time.

When the earth current is not decisive 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 2-46 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, this activates the sensitive current measuring input of the 7UM61 device. Note that the sensitive earth fault protection uses the same measuring input and thus accesses 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 2.22). If this is not desired, cancel sensitive earth fault protection configuration at address `151`.

Earth Current Detection (Earth Current Differential Protection with Tripping via DisplacementVoltage)

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 following figure).

The protection feature detects a machine earth fault if the following two criteria are fulfilled:

- Displacement voltage larger than set value **`U0>`**,
- Earth fault current difference ΔI_E larger than setting value **`3I0>`**,

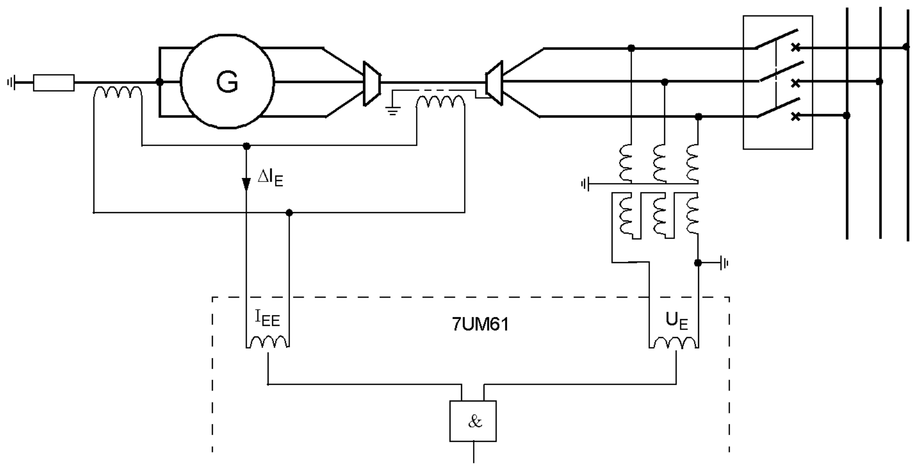


Figure 2-45 Earth Current Differential Protection with Busbar Connection

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.

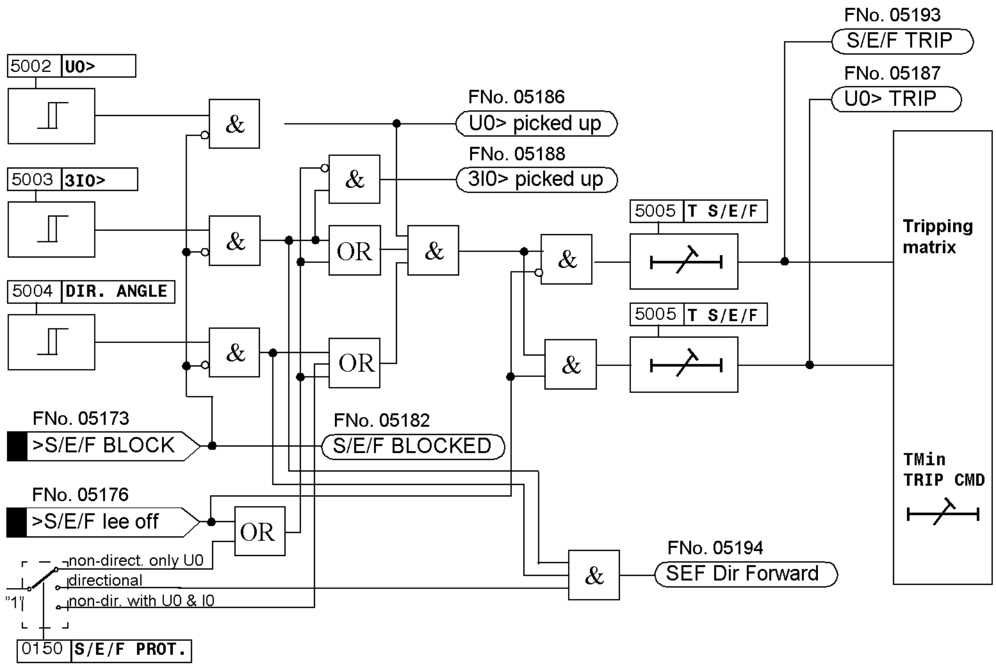


Figure 2-46 Logic Diagram of 100% Stator Earth Fault Protection

2.21.2 Setting Notes

General

The 90% stator earth fault protection is only fully 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 current 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 the dimensioning the loading resistor are given in the publication "Planning Machine Protection Systems", Order No. E50400- U0089-U412-A1-7600. The setting value is twice the displacement voltage which is coupled in at full network displacement. The setting value is finally determined during commissioning with 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&IO*** 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", Order No. E86010-K4500- A111-A1.

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).

<u>Example busbar connection:</u>

Earthing transformer	$\frac{6.3\text{ kV}}{\sqrt{3}} / \frac{500\text{ V}}{3}$ 27 kVA	(limb transformation)
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

$$I_{EE\ prim} = 50\ A \cdot \frac{500/3}{6300\ V/(\sqrt{3})} \cdot 3 = 6.87\ A$$

The secondary current of the toroidal transformer supplies to the input of the device

$$I_{EE\ sec} = \frac{I_{EE\ prim}}{60\ A/1\ A} = \frac{6.87\ A}{60} = 115\ mA$$

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:

$$\text{Setting 3I0>} = \frac{115\ mA}{10} = 11.5\ mA$$

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.

2.21.3 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

2.21.4 Information List

No.	Information	Type of Information	Comments
5173	>S/E/F BLOCK	EM	>BLOCK stator earth fault protection
5176	>S/E/F Iee off	EM	>Switch off earth current detec.(S/E/F)
5181	S/E/F OFF	AM	Stator earth fault prot. is switch OFF
5182	S/E/F BLOCKED	AM	Stator earth fault protection is BLOCK.
5183	S/E/F ACTIVE	AM	Stator earth fault protection is ACTIVE

No.	Information	Type of Information	Comments
5186	U0> picked up	AM	Stator earth fault: U0 picked up
5187	U0> TRIP	AM	Stator earth fault: U0 stage TRIP
5188	3I0> picked up	AM	Stator earth fault: I0 picked up
5189	Uearth L1	AM	Earth fault in phase L1
5190	Uearth L2	AM	Earth fault in phase L2
5191	Uearth L3	AM	Earth fault in phase L3
5193	S/E/F TRIP	AM	Stator earth fault protection TRIP
5194	SEF Dir Forward	AM	Stator earth fault: direction forward

2.22 Sensitive Earth Fault Protection (ANSI 51GN, 64R)

The highly sensitive earth fault protection detects earth faults in systems with isolated or high-impedance earthed starpoint. This stage operates with the magnitude of the earth current. It is intended for use where the earth current amplitude gives an indication of the earth fault. As an example of this is with electrical machines in busbar connection 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 with a network earth fault, the earth fault current is negligible due to the low machine capacitance. The current may be measured using toroidal CTs or CTs in Holmgreen connection.

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 same measured current input is used for sensitive earth current protection as well as for the directional or non–directional stator earth fault protection with busbar-connection. 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***.

2.22.1 Functional Description

Application as Rotor Earth Fault Protection

Alternatively, sensitive earth fault protection can be used as rotor earth fault protection when a system frequency bias voltage is applied to the rotor circuit (see Figure 2-48). In this case, the maximum earth current is determined by the magnitude of the bias voltage U_V and the capacitive coupling of 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 minimal 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 earth current current is numerically filtered so that only the fundamental component of the current is used for the measurement. This makes the measurement insensitive to earth fault transient phenomena 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.

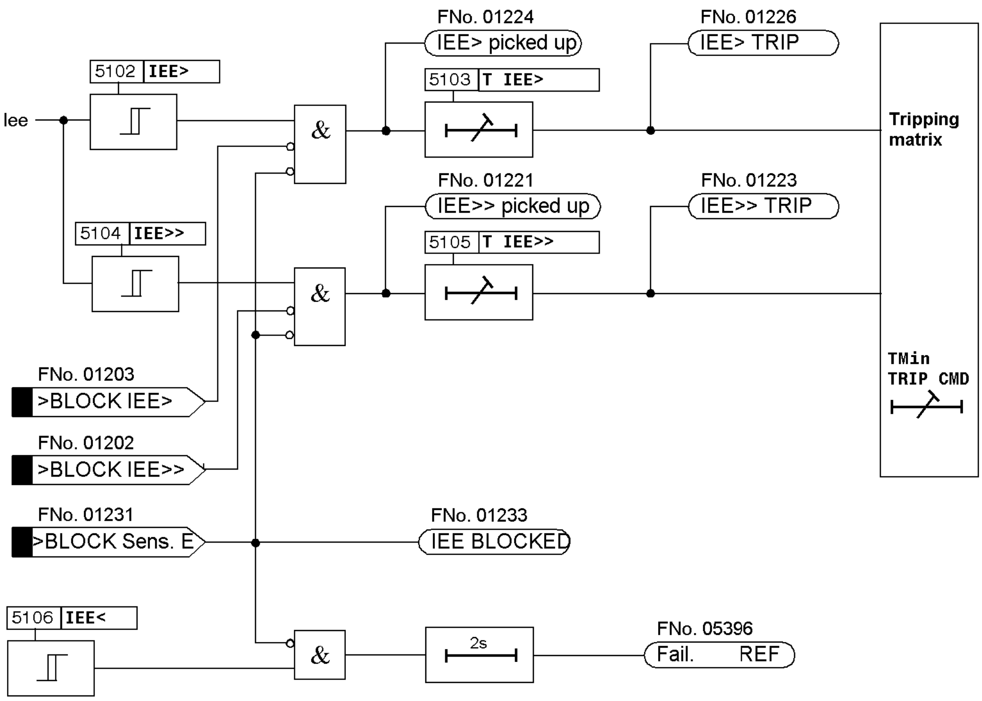


Figure 2-47 Logic Diagram of the Sensitive Earth Fault Protection

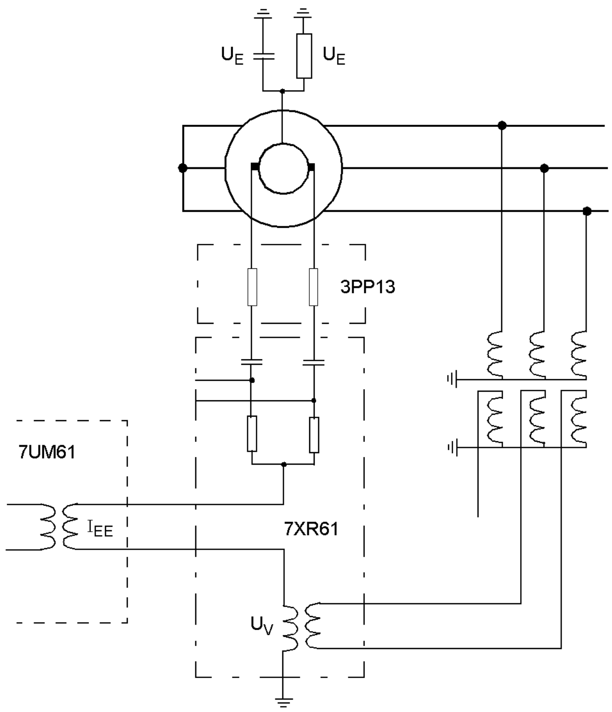


Figure 2-48 Application Case as Rotor Earth Fault Protection (7XR61 – Series Device for Rotor Earth Fault Protection; 3PP13 – from Uexc > 150 V, Resistors in 7XR61 are then to be Shorted!)

2.22.2 Setting Notes

General

Sensitive earth fault detection can only be effective and available if address 151 **O/C PROT. Iee>** is set to ***Enabled*** during configuration. If one of the options with current evaluation was selected during the configuration of the 90% stator earth fault protection (150 **S/E/F PROT.**, see Section 2.2.2) the sensitive current measuring input of the 7UM61 device is allocated. Note that sensitive earth fault detection uses the same measuring input and thus accesses the same measured value. 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 generator. A precondition is 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 earth fault protection is used as rotor fault protection, a system frequency bias voltage ($U_V \approx 42$ V, via 7XR61 series device in figure Application Case as Rotor Earth Fault Protection in Section 2.22) must be applied to the rotor circuit. Because of this bias voltage, with proper earth connection a current flows through the earth capacitance, 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 and 5 kΩ can be detected:

$$\text{Warning stage setting value e.g.:}\quad \text{IEE>} \approx \frac{U_V}{R_E} \approx \frac{42\ \text{V}}{4\ \text{k}\Omega} \approx 10\ \text{mA}$$

On the other hand, 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.

$$\text{Trip stage setting value e.g.:}\quad \text{IEE>>} \approx \frac{U_V}{R_E + Z_{coup}} \approx \frac{42\ \text{V}}{1.5\ \text{k}\Omega + 0.4\ \text{k}\Omega} \approx 23\ \text{mA}$$

with Z_K = Impedance of the series device at nominal frequency.

The 5103 **T IEE>** and 5105 **T IEE>>** tripping time delays do not include the operating times.

Use as Stator Earth Fault Protection

Please also refer to Section 2.21. For use as stator earth fault protection, the earth current must if necessary be increased by an ohmic load resistor at the earthing transformer. Instructions for dimensioning the earth current transformer and loading resistor are contained in the publication "Planning Machine Protection Systems" /5/.

Use as Earth Short-Circuit 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 short-circuit current also flows through the faulty phase. If the sensitive earth current detection nevertheless is be used as earth short-circuit protection, an external intermediate transformer must be employed to ensure that the thermal limit values (15 A continuous, 100 A for <10 s, 300 A for <1 s) of this measuring input are not exceeded by the short-circuit current.

2.22.3 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)

2.22.4 Information List

No.	Information	Type of Information	Comments
1202	>BLOCK IEE>>	EM	>BLOCK IEE>>
1203	>BLOCK IEE>	EM	>BLOCK IEE>
1221	IEE>> picked up	AM	IEE>> picked up
1223	IEE>> TRIP	AM	IEE>> TRIP
1224	IEE> picked up	AM	IEE> picked up
1226	IEE> TRIP	AM	IEE> TRIP
1231	>BLOCK Sens. E	EM	>BLOCK sensitiv earth current prot.
1232	IEE OFF	AM	Earth current prot. is swiched OFF
1233	IEE BLOCKED	AM	Earth current prot. is BLOCKED
1234	IEE ACTIVE	AM	Earth current prot. is ACTIVE
5396	Fail. REF Iee<	AM	Failure R/E/F protection Iee<

2.23 100-%-Stator Earth Fault Protection with 3rd Harmonics (ANSI 27/59TN 3rd Harm.)

As described in Section 2.21, the measuring procedure based on the fundamental wave of the displacement voltage serves to protect maximally 90 % to 95 % of the stator winding. A non-line frequency voltage must be used to implement a 100 % protection range. With the 7UM61 device, the 3rd harmonic is used for this purpose.

2.23.1 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.

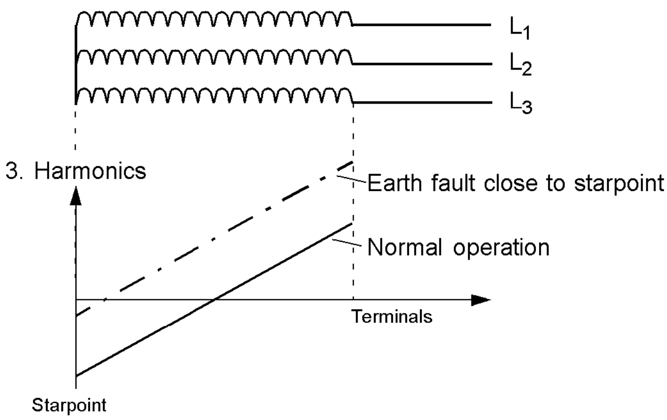


Figure 2-49 Profile of the 3rd Harmonic along the Stator Winding

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.

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 under-voltage stage (5202 **U0 3.HARM<**). This arrangement is the preferred case.

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>**).

Not Connected; Calculation of U_0

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

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.

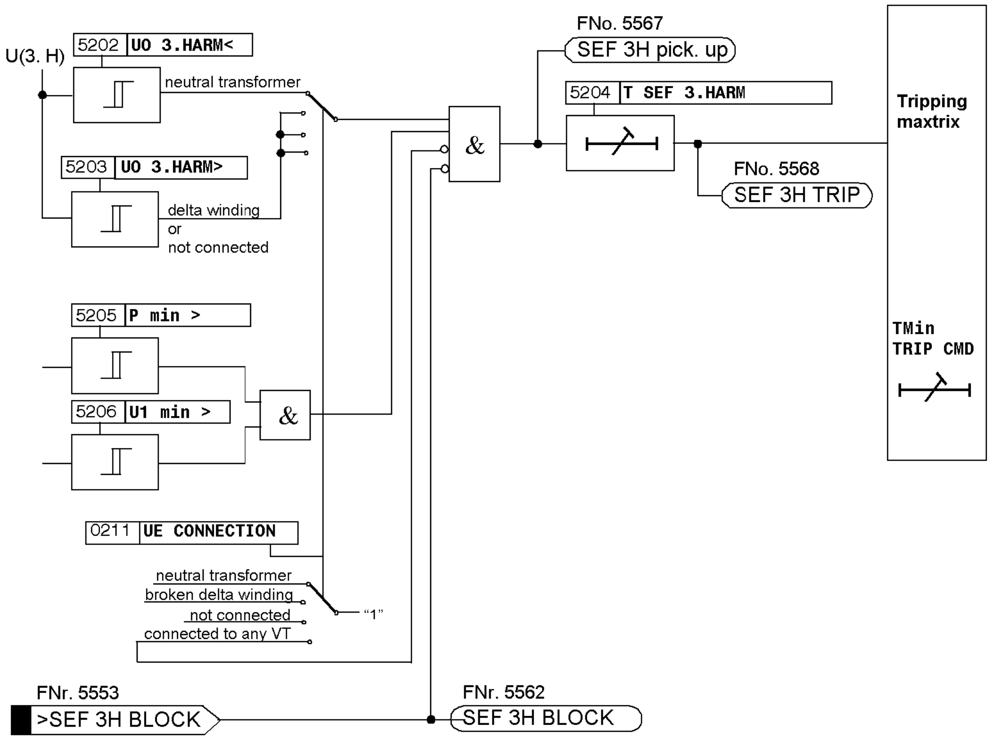


Figure 2-50 Logic Diagram of 100% Stator Earth Fault Protection

2.23.2 Setting Notes

General

The 100% Stator earth fault protection is only fully effective and available if address 152 **SEF 3rd HARM.** is set to ***Enabled*** 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_0 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*** must be set. The option ***any VT*** is selected if the voltage input of the 7UM61 is to be used for measuring any other voltage instead of for earth fault protection. In this case the 100% stator earth fault protection function is ineffective.

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 5202 **U0 3.HARM<** undervoltage stage is relevant for a connection to a transformer in the starpoint. The pickup value should be chosen as low as possible.
- The 5203 **U0 3.HARM>** overvoltage stage is relevant for a connection via the broken delta winding of an earthing transformer and for a not connected, but internally calculated displacement voltage.

Operating Range

Due to the strong dependency of the measurable 3rd harmonic on the corresponding operating point of the generator, the working range of the 100% stator earth fault protection is only enabled above the active-power threshold set via 5205 **P min >** and on transgression of a minimum positive phase-sequence voltage 5206 **U1 min >**.

Recommended setting:

P_{min}>	40 % P/S_N
$U_{1\ min}$>	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.

2.23.3 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>

2.23.4 Information List

No.	Information	Type of Information	Comments
5553	>SEF 3H BLOCK	EM	>BLOCK SEF with 3.Harmonic
5561	SEF 3H OFF	AM	SEF with 3.Harm. is switched OFF
5562	SEF 3H BLOCK	AM	SEF with 3.Harm. is BLOCKED
5563	SEF 3H ACTIVE	AM	SEF with 3.Harm. is ACTIVE
5567	SEF 3H pick.up	AM	SEF with 3.Harm.: picked up
5568	SEF 3H TRIP	AM	SEF with 3.Harm.: TRIP

2.24 Motor Starting Time Supervision (ANSI 48)

When the 7UM61 is used to protect a motor, the startup time monitoring feature supplements overload protection (see Section 2.9) by protecting the motor against extended startup durations. In particular, rotor-critical high-voltage motors can quickly be heated above their thermal limit if multiple consecutive startup attempts are made. If the durations of these starting attempts are prolonged, e.g. by excessive voltage surges during motor startup, by excessive load torques, or by blocked rotor conditions, a tripping signal will be initiated by the protective relay.

2.24.1 Functional Description

Motor Startup

As a criterion for a motor startup, transgression of a (settable) current threshold **I MOTOR START** is assessed and used for enabling calculation of the tripping time.

The protection function consists of one definite time and one inverse time tripping characteristic.

Inverse Time Overcurrent Characteristic

The inverse time tripping delay time operates 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:

$$t_{TRIP} = \left(\frac{I_{StartCurr.}}{I}\right)^2 \cdot t_{Startmax} \qquad \text{where } I > I_{Motor\ Start}$$

with

t_{TRIP}	Actual tripping time for flowing current I
$t_{Startmax}$	Tripping time for nominal startup current I_A (Param. 6503, **STARTING TIME**)
I	Current actually flowing (measured value)
$I_{StartCurr.}$	Nominal starting current of the motor (Parameter 6502, **START. CURRENT**)
$I_{MotorStart.}$	Pickup value for recognition of motor startup (Parameter 6505, **I MOTOR START**)

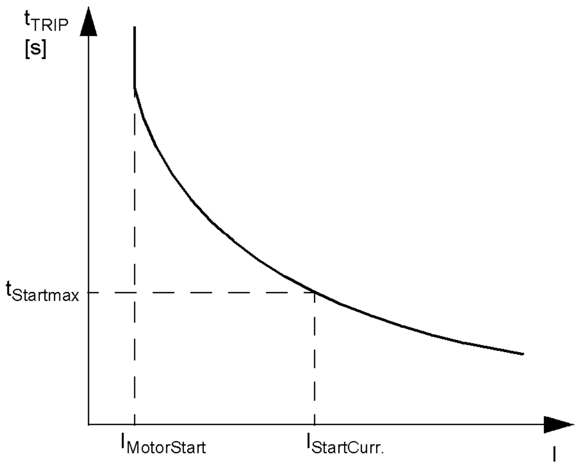


Figure 2-51 Trip Time Depending on Startup Current

Therefore, if the starting current I actually measured is smaller (or larger) than the nominal starting current $I_{StartCurr.}$ (Parameter **START. CURRENT**) entered at Address 6502, the actual tripping time t_{Trip} is prolonged (or shortened) accordingly (see also Figure 2-51).

Definite Time Overcurrent Tripping Characteristic (Blocked Rotor Time)

If the motor starting time exceeds the maximum allowable blocked rotor time t_{BlkRT}, 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 show 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.

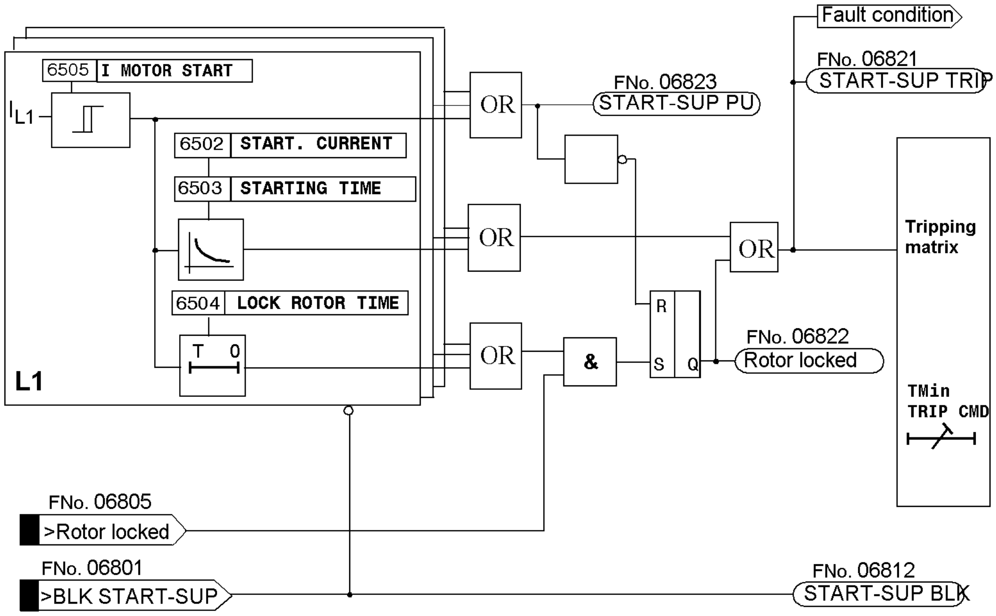


Figure 2-52 Logic Diagram of the Motor Startup Time Monitoring

2.24.2 Setting Notes

General

Motor Starting Time Supervision is only effective and available if address 165 **STARTUP MOTOR** was set to ***Enabled*** during configuration. If the function is not required ***Disabled*** is set. Address 6501 **STARTUP MOTOR** serves to switch the function ***ON*** or ***OFF*** or to block only the trip command (***Block relay***).

Pickup Values

Under normal conditions the values of the startup current are entered at address 6502 **START. CURRENT** and those 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 start-up, but not during a permissible short-time overload.

Example: Motor with the following data:

Rated voltage	U_N = 6600 V
Rated current	$I_{Mot.nom}$ = 126 A
Starting current	$I_{StartCurr.}$ = 624 A
Long-Term Current Rating	I_{max} = 135 A
Startup Duration for $I_{StartCurr.}$	$T_{Startmax}$ = 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:

$$I_{StartCurr,\ sec} = \frac{\text{Start-up current}}{\text{Nominal CT current}} \cdot I_{N\ CT\ sec} = \frac{624\ A}{200\ A} \cdot I_{N\ CT\ sec} = 3.12\ A$$

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: $\frac{135\ A}{200\ A} = 0.68 \cdot I_{N\ CT\ sec}$

$$I_{MotorStart} = \frac{2.5\ I_N + 0.68\ I_N}{2} \approx 1.6 \cdot I_{N\ CT\ sec} \qquad = 1.6\ A$$

The tripping time of the starting time monitoring is calculated as follows:

$$T_{Trip} = \left(\frac{I_{StartCurr.}}{I}\right)^2 \cdot T_{Startmax}$$

Under nominal conditions, the tripping time is the maximum starting time $T_{Max.STARTUP}$. 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 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.

2.24.3 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	1A	0.10 .. 16.00 A	3.12 A	Starting Current of Motor
		5A	0.50 .. 80.00 A	15.60 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	1A	0.60 .. 10.00 A	1.60 A	Current Pickup Value of Motor Starting
		5A	3.00 .. 50.00 A	8.00 A	

2.24.4 Information List

No.	Information	Type of Information	Comments
6801	>BLK START-SUP	EM	>BLOCK Motor Starting Supervision
6805	>Rotor locked	EM	>Rotor is locked
6811	START-SUP OFF	AM	Starting time supervision switched OFF
6812	START-SUP BLK	AM	Starting time supervision is BLOCKED
6813	START-SUP ACT	AM	Starting time supervision is ACTIVE
6821	START-SUP TRIP	AM	Starting time supervision TRIP
6822	Rotor locked	AM	Rotor is LOCKED after Locked Rotor Time
6823	START-SUP PU	AM	Starting time supervision picked up

2.25 Restart Inhibit for Motors (ANSI 66, 49Rotor)

The rotor temperature of a motor generally remains well below its maximum admissible temperature during normal operation and also under increased load conditions. However, with startups and resulting high startup currents caused by small thermal time constants it may suffer more thermal damage than the rotor. To avoid multiple startup attempts causing tripping, a repeated startup of the motor must be prevented, if it may be assumed that admissible rotor heating would be otherwise be exceeded. Therefore the 7UM61 device provides a motor restart blocking feature. An inhibit signal is issued until a new motor startup is admissible (restarting threshold). This blocking signal must be allocated to a binary output of the device whose contact is inserted in the motor starting circuit.

2.25.1 Functional Description

Determining 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 are based on 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. 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.

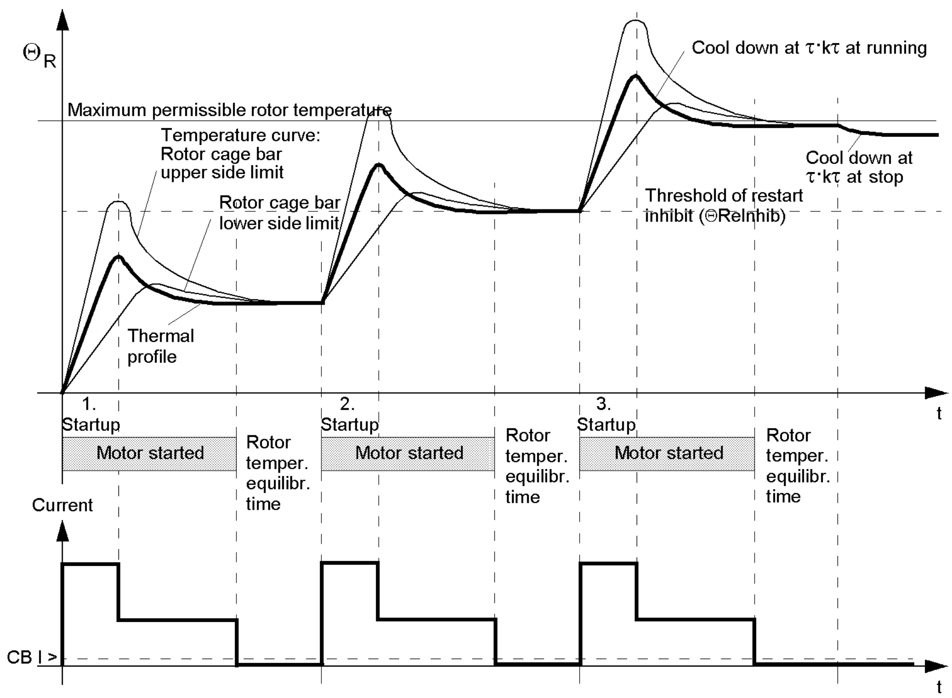


Figure 2-53 Temperature Curve at the Rotor and the Thermal Profile during Repeated Start-Up Attempts

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 2-53). 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 for the restart threshold $\Theta_{Re.Inh.}$, related to maximum admissible rotor overtemperature:

$\Theta_{ReInhib}[\%] = \frac{n_{cold} - 1}{n_{cold}} \cdot 100\ \%$	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. This thermal behaviour is met 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 · 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:

$$T_{ReInhib\ time} = T_{Leveling} + k_\tau \cdot \tau_R \cdot \ln\left[\frac{\Theta_{pre} \cdot n_{cold}}{n_{cold} - 1}\right]$$

with

$T_{Leveling}$ – rotor temperature leveling 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, calculated internally:

$\tau_R = t_{Start} \cdot (n_{cold} - n_{warm}) \cdot I_{Start}{}^2$

where:

t_{Start} = Startup time in s

I_{Start} = Startup current in pu

Θ_{pre} – thermal replica at the instant the motor is switched off (depends on operational condition)

The operational measured value $T_{ReInhib\ time}$ (to be found in the overload measured values) shows the time remaining until the next restart is allowed.

Extension of Cooldown 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 stopped motor is defined by current below an adjustable current flow monitoring threshold **BkrClosed I MIN**. The assumes that the idle current of the motor is greater than this threshold. The pickup threshold **BkrClosed I MIN** also effects the thermal overload protection function (see Section 2.9).

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 $T_{ReInhib\ time}$ 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 in excess of 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 is initiated by the motor restart inhibit, but the calculated overtemperature of the rotor can be observed for risk assessment.

Blocking

If the motor restart blocking function is blocked or switched off, the thermal profile of the rotor overtemperature and the leveling time **T EQUAL** as well as the minimum inhibit time **T MIN. INHIBIT** are reset, and any existing motor start inhibit signal is retracted.

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.

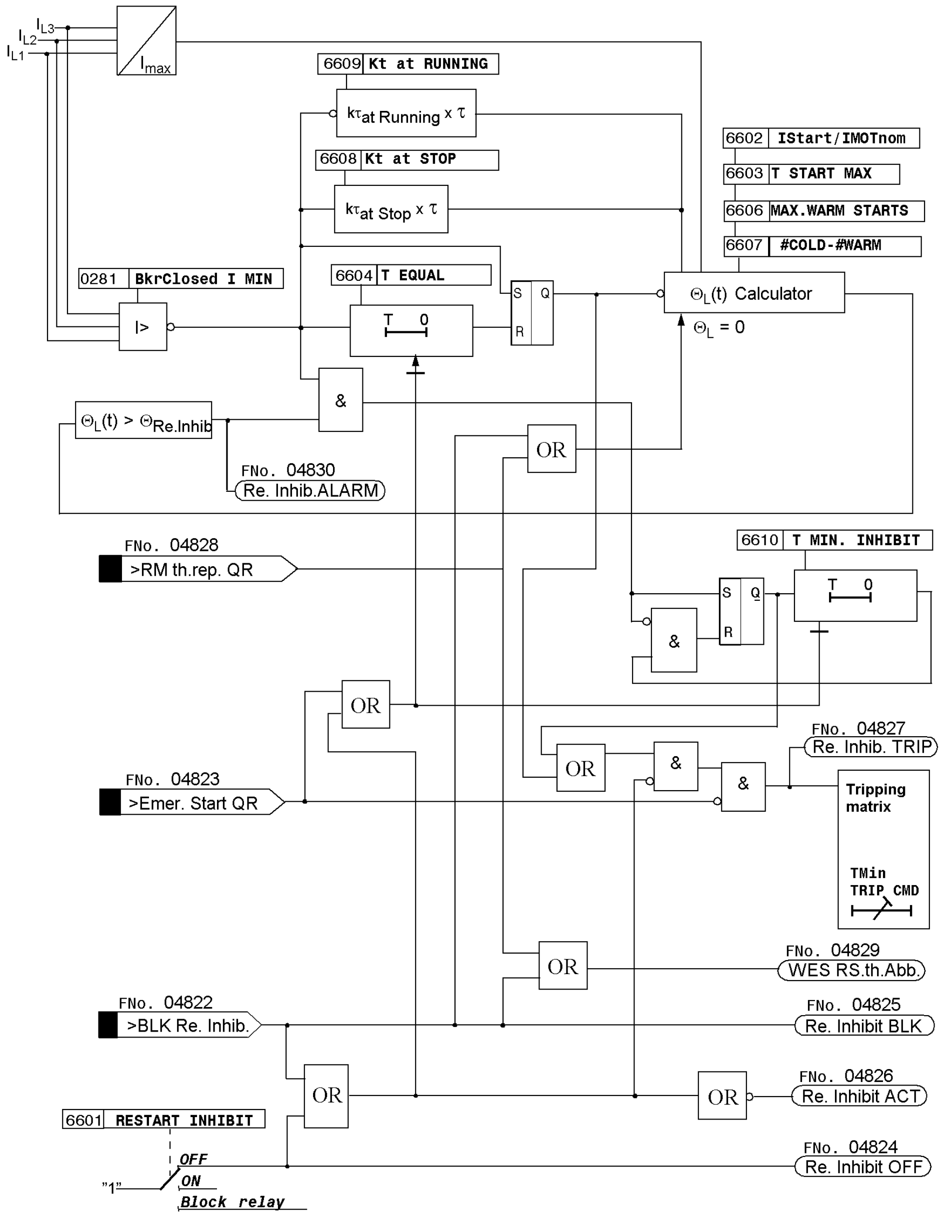


Figure 2-54 Logic diagram of the Restart Inhibit

2.25.2 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

The user communicates to the device the characteristic motor values supplied by the manufacturer, which are necessary for calculation of the rotor temperature. These values include the startup current Istart, the nominal motor current IMot.nom, the maximum admissible startup time **T START MAX** (address 6603), the number of admissible restart attempts under cold (n_{cold}) and (n_{warm}) conditions.

The starting current is entered at address **IStart/IMOTnom**, expressed as a multiple of the nominal motor current (6602). For a correct interpretation of this parameter, it is important that in Power System Data 2 the nominal motor current (address 1102 is correctly set. The number of warm starts allowed is entered at address 6606 (**MAX.WARM STARTS**) and the difference (6607) between the number of allowable cold and warm starts is entered at address **#COLD-#WARM**.

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 constants are the same at operating conditions (I > **BkrClosed I MIN**).

Setting Example:

<u>Example:</u> Motor with the following data:

Rated voltage	U_N = 6600 V
Rated current	$I_{Mot.nom}$ = 126 A
Startup current	I_{Start} = 624 A
Startup Duration for $I_{STARTUP}$	$T_{START\ max}$ = 8.5 s
Allowable Starts with Cold Motor	n_{cold} = 3
Allowable Starts with Warm Motor	n_{warm} = 2
Current Transformer	200 A / 1 A

The ratio between startup current and motor nominal current is:

$$I_{Start}/I_{Mot.nom} = \frac{624\ \text{A}}{126\ \text{A}} = 4.95 \approx 4.9$$

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 leveling 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 of 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 user's requirements 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 a proper functioning, it is also important that the CT values (address 211), the power system data (address 1102) and the current threshold for distinction between standstill and running motor (address 281 **BkrClosed I MIN**, recommended setting ≈ 0.1 · I/IN Motor) have been set correctly. An overview of the parameters and their default settings is given in parameter overviews.

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_L · **Kτ at STOP** ≈ 5 · 204 s = 1020 s. The restart inhibit is effective for about 7 min.

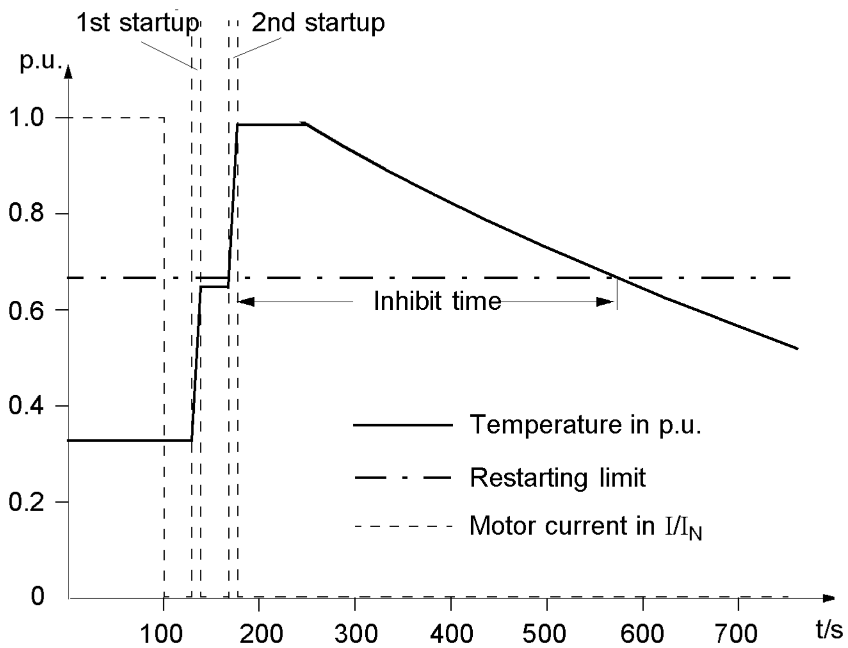


Figure 2-55 Temperature Behaviour during Two Successive Warm Starts

In Figure 2-56, 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 τ_L · **Kτ at STOP** ≈ 5 · 204 s = 1020 s. During the second restart, the starting current causes a temperature rise, whereas the subsequently flowing load current of 0.9 · $I/I_{N\ Motor}$ **Kτ at RUNNING** reduces the temperature. This time, the time constant τ_L · **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.

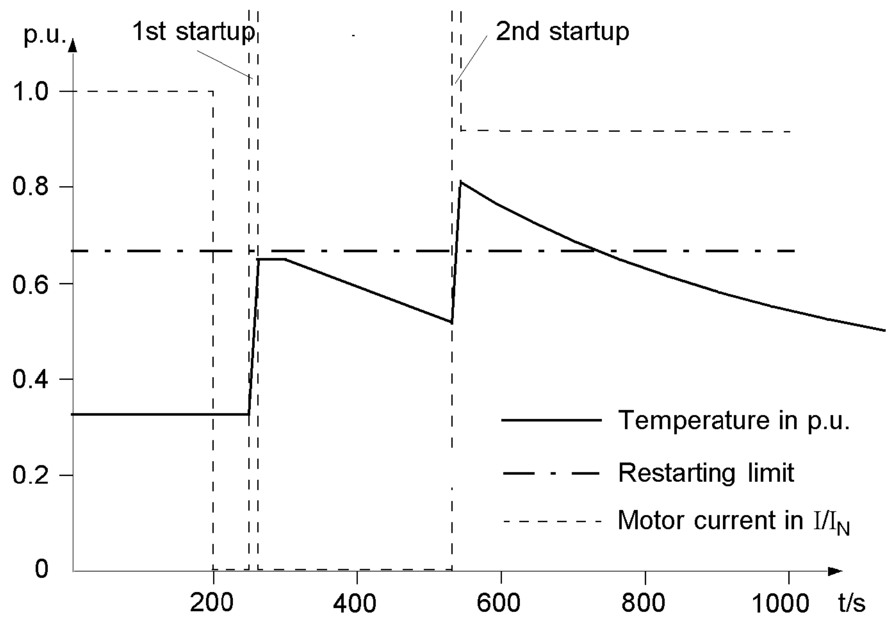


Figure 2-56 Two Warm Restarts Followed by Continuous Running

2.25.3 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

Addr.	Parameter	Setting Options	Default Setting	Comments
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

2.25.4 Information List

No.	Information	Type of Information	Comments
4822	>BLK Re. Inhib.	EM	>BLOCK Restart inhibit motor
4823	>Emer. Start ΘR	EM	>Emergency start rotor
4824	Re. Inhibit OFF	AM	Restart inhibit motor is switched OFF
4825	Re. Inhibit BLK	AM	Restart inhibit motor is BLOCKED
4826	Re. Inhibit ACT	AM	Restart inhibit motor is ACTIVE
4827	Re. Inhib. TRIP	AM	Restart inhibit motor TRIP
4828	>RM th.rep. ΘR	EM	>Reset thermal memory rotor
4829	RM th.rep. ΘR	AM	Reset thermal memory rotor
4830	Re. Inhib.ALARM	AM	Alarm restart inhibit motor

2.26 Breaker Failure Protection (ANSI 50BF)

The breaker failure protection function monitors proper switchoff of a circuit breaker. In machine protection it is typically relates to the mains breaker.

2.26.1 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).

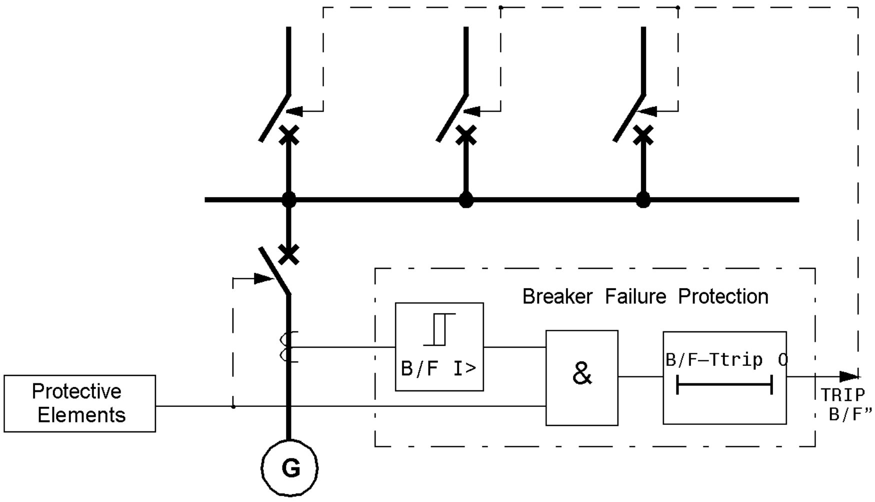


Figure 2-57 Function Principle of the Breaker Failure Protection Function

Initiation

The breaker failure protection function can be initiated by two different sources:

- Internal functions of the 7UM61, 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.

If the binary input of the circuit breaker auxiliary contact is inactive, only the current criterion is effective. 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 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 breaker failure is initiated, an alarm message is generated and a settable delay time is started. 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

- an internal start condition (CFC or BO3) or ">ext.start1 B/F" or ">ext.start2 B/F", causing the pickup, drops off.
- a tripping signal of the protective functions still exists, whereas the current criterion and the auxiliary contact criterion drop out.

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).

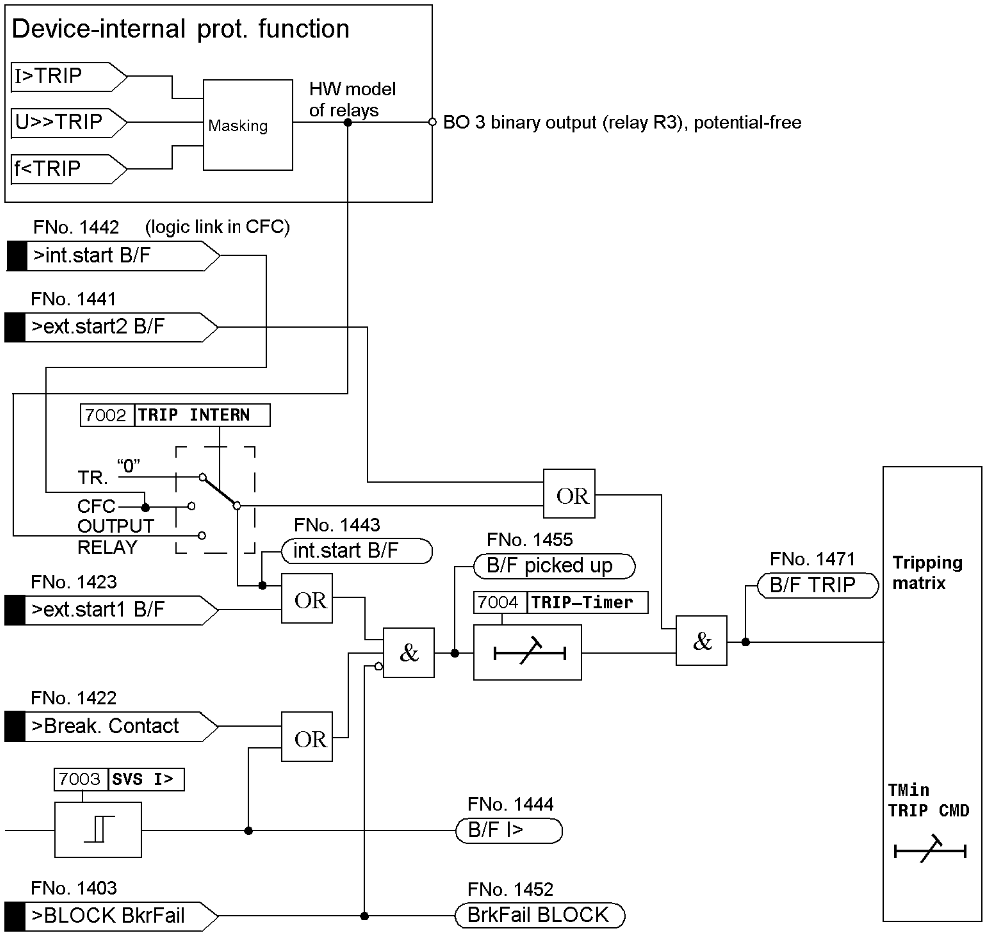


Figure 2-58 Logic Diagram of the Breaker Failure Protection

2.26.2 Setting Notes

General

Breaker failure protection is only effective and available if address 170 **BREAKER FAILURE** is set to ***Enabled*** 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***).

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 BA3 provided for this (7002 **TRIP INTERN** = ***BO3***) or by a logic link created in CFC (= ***CFC***) (message 1442 ">int. start B/F"). It 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 ***BO3*** (relay BO3) 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 a too 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.

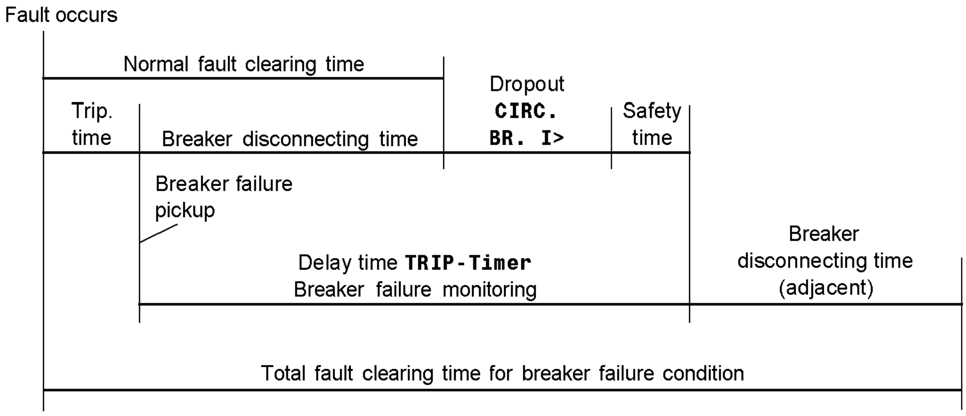


Figure 2-59 Time sequence for Typical Fault Clearance and for Breaker Failure

2.26.3 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 BO3 CFC	OFF	Start with Internal TRIP Command
7003	CIRC. BR. I>	1A	0.04 .. 2.00 A	0.20 A	Supervision Current Pickup
		5A	0.20 .. 10.00 A	1.00 A	
7004	TRIP-Timer		0.06 .. 60.00 sec; ∞	0.25 sec	TRIP-Timer

2.26.4 Information List

No.	Information	Type of Information	Comments
1403	>BLOCK BkrFail	EM	>BLOCK breaker failure
1422	>Break. Contact	EM	>Breaker contacts
1423	>ext.start1 B/F	EM	>ext. start 1 breaker failure prot.

No.	Information	Type of Information	Comments
1441	>ext.start2 B/F	EM	>ext. start 2 breaker failure prot.
1442	>int. start B/F	EM	>int. start breaker failure prot.
1443	int. start B/F	AM	Breaker fail. started intern
1444	B/F I>	AM	Breaker failure I>
1451	BkrFail OFF	AM	Breaker failure is switched OFF
1452	BkrFail BLOCK	AM	Breaker failure is BLOCKED
1453	BkrFail ACTIVE	AM	Breaker failure is ACTIVE
1455	B/F picked up	AM	Breaker failure protection: picked up
1471	BrkFailure TRIP	AM	Breaker failure TRIP

2.27 Inadvertent Energization (ANSI 50, 27)

The inadvertent energizing protection serves to limit damage by accidental connection of the stationary or already started, but not yet synchronized generator, by fast actuation of the mains breaker. A connection to a stationary machine is equivalent to connection 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.

2.27.1 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 addition 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.

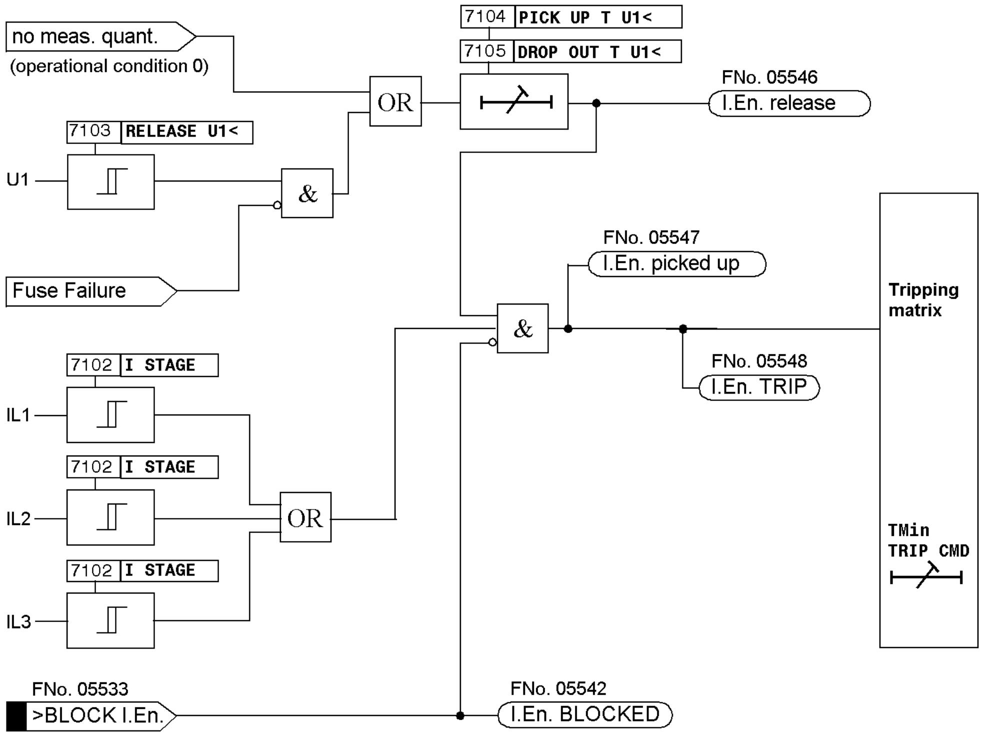


Figure 2-60 Logic Diagram of the Inadvertent Energizing Protection (Dead Machine Protection)

2.27.2 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<** parameter 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, contrast to this, during a voltage collapse on short circuit close to generator terminals.

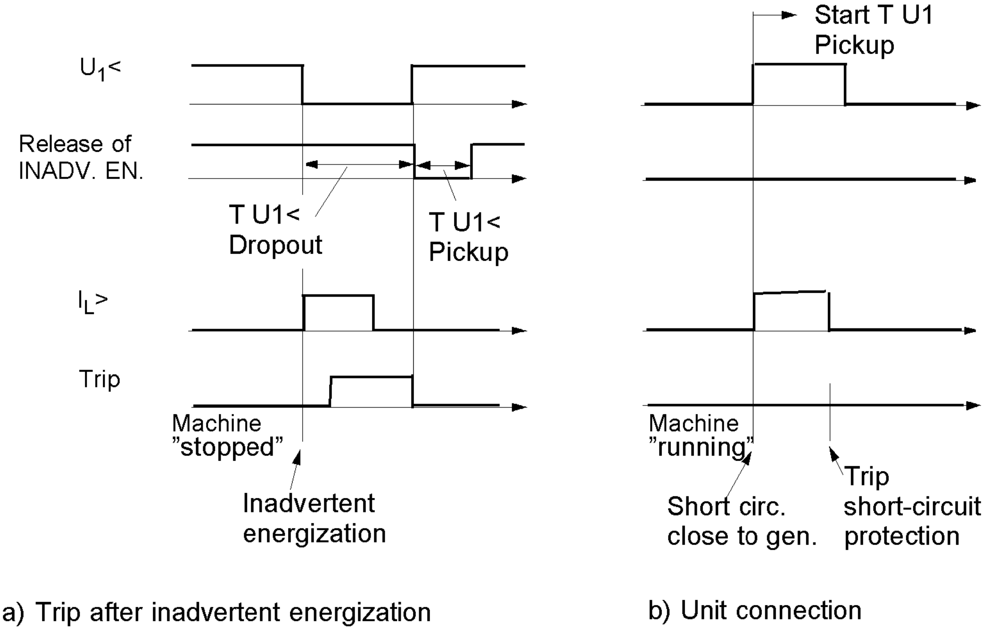


Figure 2-61 Chronological Sequences of the Inadvertent Energizing Protection

2.27.3 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	1A	0.1 .. 20.0 A; ∞	0.3 A	I Stage Pickup
		5A	0.5 .. 100.0 A; ∞	1.5 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<

2.27.4 Information List

No.	Information	Type of Information	Comments
5533	>BLOCK I.En.	EM	>BLOCK inadvertent energ. prot.
5541	I.En. OFF	AM	Inadvert. Energ. prot. is swiched OFF
5542	I.En. BLOCKED	AM	Inadvert. Energ. prot. is BLOCKED
5543	I.En. ACTIVE	AM	Inadvert. Energ. prot. is ACTIVE
5546	I.En. release	AM	Release of the current stage
5547	I.En. picked up	AM	Inadvert. Energ. prot.: picked up
5548	I.En. TRIP	AM	Inadvert. Energ. prot.: TRIP

2.28 Measurement Supervision

The device is equipped with extensive monitoring capabilities - both hardware and software. In addition, the measured values are also constantly checked for plausibility, so that the current and voltage transformer circuits are largely integrated into the monitoring.

2.28.1 Functional Description

Hardware Monitoring

The device is monitored from the measurement inputs to the output relays. Monitoring circuits and processor check the hardware for malfunctions and inadmissible conditions (see also Table 2-7).

Auxiliary and Reference Voltages

The processor voltage of 5 V DC is monitored by the hardware since if it goes below the minimum value, the processor is no longer functional. The device is under such a circumstance removed from 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 offset and reference voltage of the ADC (analog-digital converter). The protection is suspended if the voltages deviate outside an admissible range; prolonged deviations are reported (indication: “`Error A/D-conv.`”).

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. On its undershooting a minimum admissible voltage, the “`Fail Battery`” indication is issued.

If the device is isolated from the auxiliary voltage for several hours, the internal backup battery is switched off automatically, i.e. the time is not registered any more. Messages and fault recordings however are kept stored.

Memory Modules

The working memory (RAM) is tested when the system is started up. If a malfunction occurs then, the starting sequence is interrupted and an LED blinks. During operation, the memory is checked using its checksum.

For the program memory, the cross sum is formed cyclically and compared to the stored program cross sum.

For the settings memory, the cross sum is formed cyclically and compared to the cross sum that is freshly generated each time a setting process takes place.

If a malfunction occurs, the processor system is restarted.

Sampling

Sampling and the synchronization between the internal buffer components are constantly monitored. If any deviations cannot be removed by remedied synchronization, then the processor system is restarted.

Measurement Value Acquisition – Currents

In the current paths there are three input transformers; 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** $\cdot I_N + \Sigma$**I FACTOR** $\cdot I_{max}$

Σ**I THRESHOLD** and Σ**I FACTOR** are programmable settings. The component Σ**I FACTOR** · Imax takes into account the admissible current-proportional transformation error of the input transformer, which can occur particularly when high fault current levels are present (see the following figure). The dropout ratio is about 95 %.

This malfunction is signaled as "Failure Σ I".

The current sum monitoring is not executed if the starpoint was set as 273 at Power System Data 1 (address ***low-resist.***).

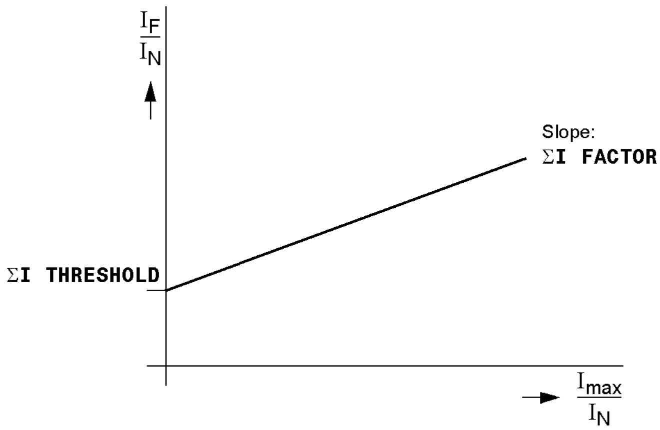


Figure 2-62 Current sum monitoring

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}

Here **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 Section 2.3.1).

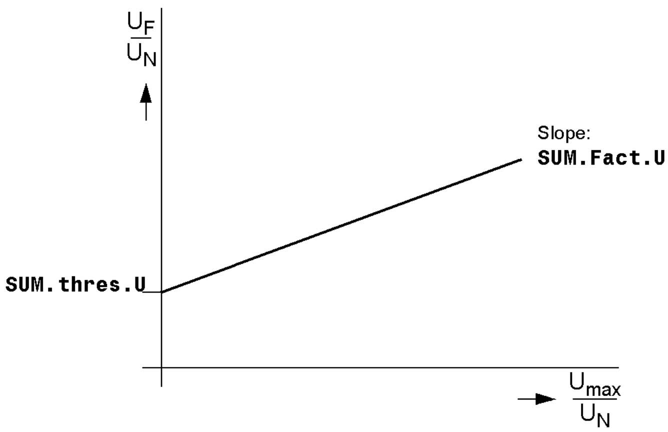


Figure 2-63 Voltage Sum Monitoring

Software Monitorings

Watchdog

For continuous monitoring of the program sequences, a time monitor is provided in the hardware (hardware watchdog) that expires upon failure of the processor or an internal program, and causes a reset of the processor system with complete restart.

An additional software watchdog ensures that malfunctions during the processing of programs are discovered. This also initiates a restart of the processor system.

To the extent 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 ”Fault" LED lights up. The operational readiness relay ("Life contact") opens and issues an indication (alternatively as NO or NC contact).

Monitoring 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 quantities are cyclically checked in the background for this purpose, as long as no system fault is present.

Current Symmetry

During normal system operation a certain degree of symmetry of the currents is expected. The symmetry is monitored in the device by magnitude comparison. The smallest phase current is compared to the largest phase current. Asymmetry is recognised if

$| I_{min} | / | I_{max} | <$ **BAL. FACTOR I** as long as $I_{max} / I_N >$ **BALANCE I LIMIT** $/ I_N$

Thereby I_{max} is the largest of the three phase currents I_{min} the smallest. The symmetry factor **BAL. FACTOR I** represents the allowable asymmetry of the phase currents while the limit value **BALANCE I LIMIT** is the lower limit of the operating range of this monitoring (see the following figure). Both settings are adjustable. The dropout ratio is about 95 %.

This malfunction is signaled as "Fail I balance".

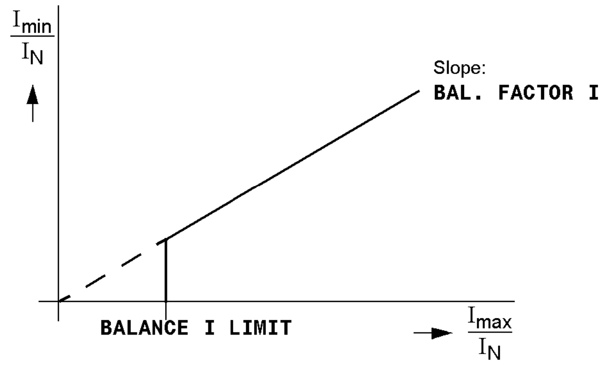


Figure 2-64 Current symmetry monitoring

Voltage Symmetry

From the phase-to-ground voltages, the rectified average value is formed as a check for symmetry of absolute values. The smallest phase voltage is compared to the largest. Asymmetry is recognised if

$| U_{min} | / | U_{max} | <$ **BAL. FACTOR U** as long as $| U_{max} | >$ **BALANCE U-LIMIT**

Thereby 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 settings are adjustable. 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 cause protection pickup, monitoring is relegated to the background and issues no indication.

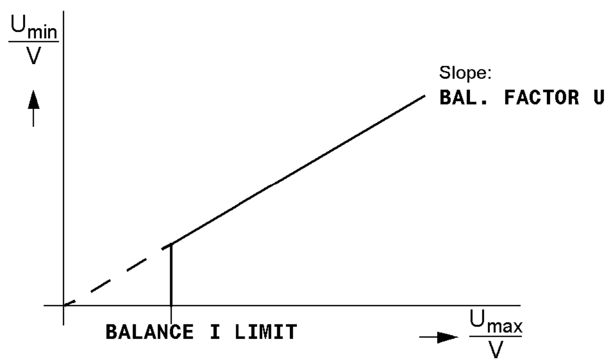


Figure 2-65 Voltage symmetry monitoring

Current and Voltage Phase Sequence

To detect swapped phase connections in the voltage and current input circuits, the phase sequence of the phase-to-phase measured voltages and the phase currents are checked by monitoring the sequence of same polarity zero transitions of the voltages.

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. 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 done when each measured voltage is at least

$|\underline{U}_{L1}|, |\underline{U}_{L2}|, |\underline{U}_{L3}| > 40\ V/\sqrt{3}$,

verification of the current phase rotation is done when each measured current is at least

$|\underline{I}_{L1}|, |\underline{I}_{L2}|, |\underline{I}_{L3}| > 0{,}5\ I_N$.

For counter-clockwise phase sequence (L1, L3, L2), the indications “`Fail Ph. Seq. U`”, (FNo. 176) or “`Fail Ph. Seq. I`”, (FNo. 175) and in addition also the OR-combination of these indications “`Fail Ph. Seq.`”, (FNo. 171) are signaled.

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 thereby changed, in the device phases L2 and L3 are reversed internally for calculation of the symmetrical components, and the positive and negative sequence currents thereby exchanged (see also Section 2.33). The phase- related indications, malfunction values, and measured values are not affected by this.

Fuse Failure Monitoring

In case of a measuring voltage failure caused by a short circuit or a phase failure in the voltage transformer secondary system, a zero voltage can be simulated to individual measuring loops. 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 for example fuses are used instead of a secondary miniature circuit breaker with correspondingly connected auxiliary contacts, then the fuse failure monitoring can become active. Of course the miniature circuit breaker and the fuse failure monitor can be used at the same time.

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**:

$$\frac{U_2}{U_1} = \frac{0.33}{0.66} = 0.5 \quad \text{and} \quad \frac{I_2}{I_1} = 0 \qquad \left(\frac{U_2}{U_1} > \frac{I_2}{I_1}\right)$$

If a fault of the voltage transformers occurs, the following rules apply for a **two-pole failure**:

$$\frac{U_2}{U_1} = \frac{0.33}{0.33} = 1 \quad \text{and} \quad \frac{I_2}{I_1} = 0 \qquad \left(\frac{U_2}{U_1} > \frac{I_2}{I_1}\right)$$

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 - with a too small positive-sequence system - unwanted operation due to inaccuracies of the measuring voltages failure detection, the function is blocked below a minimum threshold of the positive-sequence systems of (U_1 < 10 V) and current ($I_1 < 0{,}1\ I_N$).

3–pole Fuse Fault

A 3–pole fuse fault 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 by 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 under-voltage protection must be set non-delayed and should also evaluate the positive-phase sequence system of the voltages (e.g. 7RW600).

Voltage at U_E Input

Depending on how U_E is connected, it may be necessary to block the voltage measurement of this input. A blocking can be generated with the CFC tool and combined with the indication “`VT Fuse Failure`”.

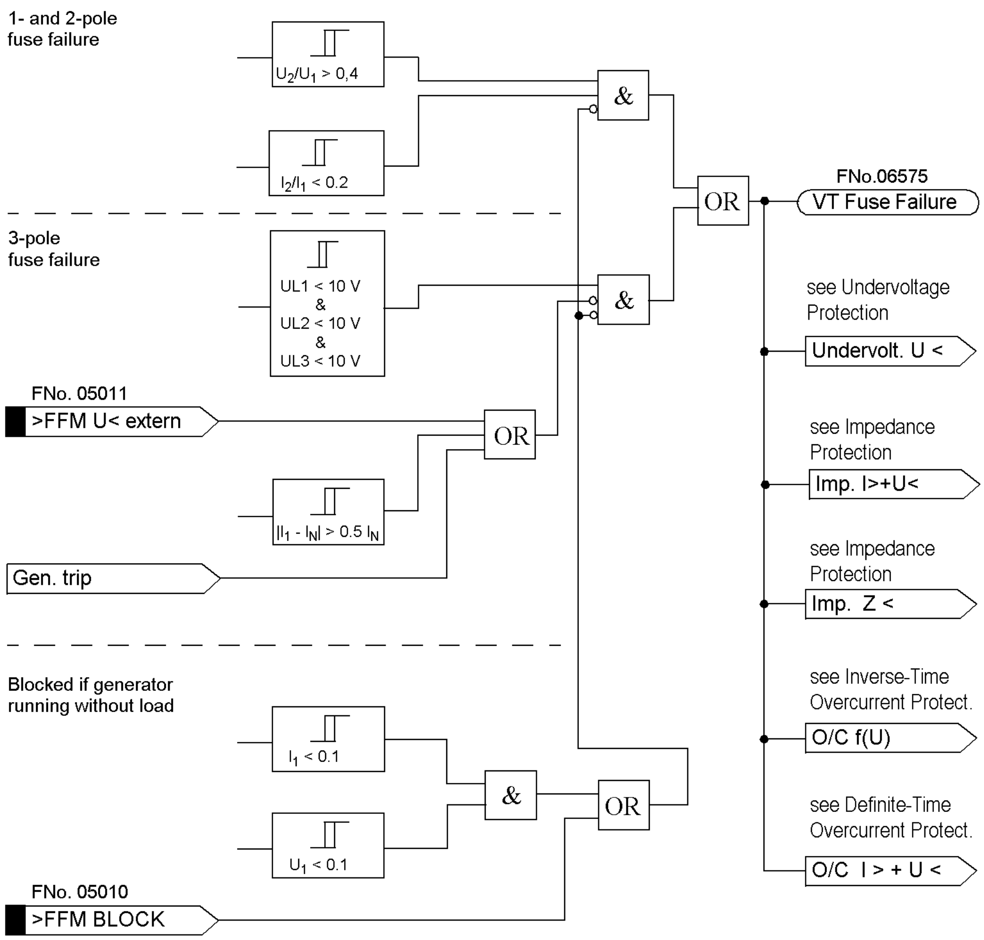


Figure 2-66 Logic Diagram of the Measuring Voltage – Fuse Failure Monitor

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, then all LEDs are dark. The following table summarises the monitoring functions and the malfunction responses of the device.

Table 2-7 Summary of Malfunction Responses of the Device

Monitoring	possible causes	Malfunction Response	Indication (No.)	Output
Auxiliary Supply Voltage Loss	external (aux. voltage) internal (converter)	Device shutdown	all LEDs dark	DOK[2] drops out
Internal Supply Voltages	internal (converter) or reference voltage	Device not in operation	LED ”ERROR" “Error A/D-conv.” (FNo. 181)	DOK[2] drops out
Battery	Internal (battery)	Indication	“Fail Battery” (FNo. 177)	
Hardware Watchdog	internal (processor failure)	Device not in operation [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 not in operation	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 memory	internal (hardware)	Restart attempt [1]	LED ”ERROR"	DOK[2] drops out
Sampling frequency	internal (hardware)	Device not in operation	LED ”ERROR"	DOK[2] drops out
1 A/5 A changeover	Jumper for 1 A/5 A misconnected	Device not in operation indication	LED ”ERROR" “Error1A/5Awrong” (FNo. 192)	DOK drops out [2]
Current Sum	internal (measured value acquisition)	Indication	“Failure Σ I” (FNo. 162)	as allocated
Current Symmetry	External (power system or current transformer)	Indication	“Fail I balance” (FNo. 163)	as allocated
Voltage sum	internal (measured value acquisition)	Indication	“Fail Σ U Ph-E” (FNo. 165)	as allocated
Voltage symmetry	external (power system or voltage transformer)	Indication	“Fail U balance” (FNo. 167)	as allocated
Voltage phase sequence	external (power system or connection)	Indication	“Fail Ph. Seq. U” (FNo. 176)	as allocated
Current phase sequence	external (power system or connection)	Indication	“Fail Ph. Seq. I” (FNo. 175)	as allocated
"Fuse Failure Monitor"	external (voltage transformers)	Indication	“VT Fuse Failure” (FNo. 6575)	as allocated
Trip Circuit Monitoring	external (trip circuit or control voltage)	Indication	“FAIL: Trip cir.” (FNo. 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

2.28.2 Setting Notes

Measured Value Monitoring

Measured value monitoring can be activated at address 8101 **MEASURE. SUPERV** ***ON*** or ***OFF***. In addition the sensitivity of measured value monitorings can be modified. Default values are set at the factory, which are sufficient in most cases. If especially high operating asymmetries in 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 made less sensitive.

Address 8102 **BALANCE U-LIMIT** determines the limit voltage (line–line), above which voltage symmetry monitoring becomes effective (see also Voltage Symmetry Monitoring figure)..

Address 8103 **BAL. FACTOR U** is the associated symmetry factor; i.e. the slope of the symmetry characteristic curve (see also Voltage Symmetry Monitoring figure).

Address 8104 **BALANCE I LIMIT** determines the limit current, above which the current symmetry monitor is effective (see also Current Symmetry Monitoring figure).

Address 8105 **BAL. FACTOR I** is the associated symmetry factor; i.e. the slope of the symmetry characteristic curve (see also Current Symmetry Monitoring figure).

Address 8106 **ΣI THRESHOLD** determines the limit current above which the current sum monitor (see also Current Sum Monitoring figure) is activated (absolute portion, only relative to IN). The relative portion (relative to the maximum conductor current) for activating the current sum monitor is set at address 8107 **ΣI FACTOR**.

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.

Fuse Failure Monitoring

Measuring voltages failure detection will only be effective and available if address 180 **FUSE FAIL MON.** is configured to ***Enabled***. If the function is not required ***Disabled*** is set. The function can be turned 8001 or **FUSE FAIL MON.** under address ***ON OFF***.

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.

2.28.3 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
8001	FUSE FAIL MON.		OFF ON	OFF	Fuse Failure Monitor
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	BALANCE I LIMIT	1A	0.10 .. 1.00 A	0.50 A	Current Balance Monitor
		5A	0.50 .. 5.00 A	2.50 A	
8105	BAL. FACTOR I		0.10 .. 0.90	0.50	Balance Factor for Current Monitor
8106	ΣI THRESHOLD	1A	0.05 .. 2.00 A	0.10 A	Summated Current Monitoring Threshold
		5A	0.25 .. 10.00 A	0.50 A	
8107	ΣI FACTOR		0.00 .. 0.95	0.10	Summated Current Monitoring Factor
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

2.28.4 Information List

No.	Information	Type of Information	Comments
161	Fail I Superv.	AM	Failure: General Current Supervision
162	Failure Σ I	AM	Failure: Current Summation
163	Fail I balance	AM	Failure: Current Balance
164	Fail U Superv.	AM	Failure: General Voltage Supervision
165	Fail Σ U Ph-E	AM	Failure: Voltage Summation Phase-Earth
167	Fail U balance	AM	Failure: Voltage Balance
171	Fail Ph. Seq.	AM	Failure: Phase Sequence
175	Fail Ph. Seq. I	AM	Failure: Phase Sequence Current
176	Fail Ph. Seq. U	AM	Failure: Phase Sequence Voltage
197	MeasSup OFF	AM	Measurement Supervision is switched OFF
5010	>FFM BLOCK	EM	>BLOCK fuse failure monitor
5011	>FFM U< extern	EM	>FFM extern undervoltage
6575	VT Fuse Failure	AM	Voltage Transformer Fuse Failure

2.29 Trip Circuit Supervision

The Multi-Functional Protective Relay 7UM61 is equipped with an integrated trip circuit supervision. Depending on the number of available binary inputs (connected or not to a common potential), monitoring with one or two binary inputs can be selected. If allocation of the required binary inputs does not match the selected monitoring type, then an indication to this effect is generated (`“TripC ProgFail”`). When using two binary inputs, malfunctions in the trip circuit can be detected under all circuit breaker conditions. When only one binary input is used, malfunctions in the circuit breaker itself cannot be detected.

2.29.1 Functional Description

Monitoring with Two Binary Inputs (not connected to common potencial)

When using two binary inputs, these are connected according to the following Figure, parallel to the associated trip contact on one side, and parallel to the circuit breaker auxiliary contacts on the other.

A precondition for use of trip circuit supervision is that the control voltage for the circuit breaker is higher than the sum of minimum voltage drops at the two binary inputs ($U_{St} > 2 \cdot U_{BImin}$). Since at least 19 V is needed for each binary input, monitoring can only be used with a system control voltage above 38 V.

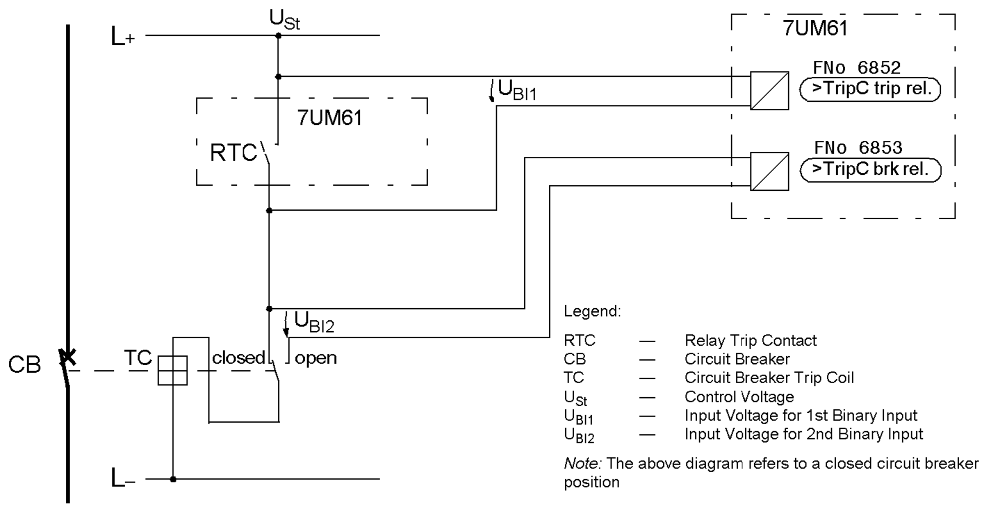


Figure 2-67 Principle of Trip Circuit Monitor with Two Binary Inputs (not connected to common potential)

Monitoring with two 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 conditions of the trip contact and the circuit breaker, the binary inputs are activated (logical condition "H" in Table 2-8), or not activated (logical condition "L").

With intact trip circuits the condition that both binary inputs are not actuated (”L") is possible only during a short transition period (trip contact is closed, but circuit breaker has not yet opened.) 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 2-8 Condition Table for Binary Inputs, Depending on RTC and CB Position

No.	Trip contact	Circuit breaker	AuxCont 1	AuxCont 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 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 the following figure). 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 is removed, the alarm is reset automatically after the same time.

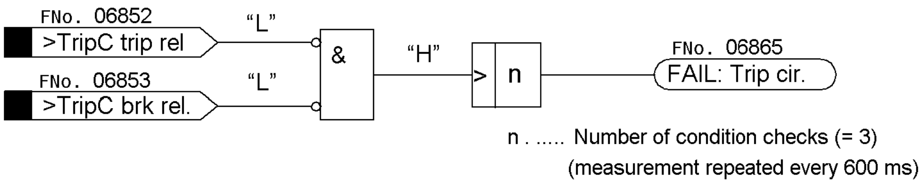


Figure 2-68 Logic diagram of the trip circuit supervision with two binary inputs

Monitoring with Two Binary Inputs (connected to common potential)

If two binary inputs connected to common potential are used, they are connected according to Figure 2-67, to L+ or once in parallel with the corresponding protection command relay contact and to the circuit breaker auxiliary contact 1.

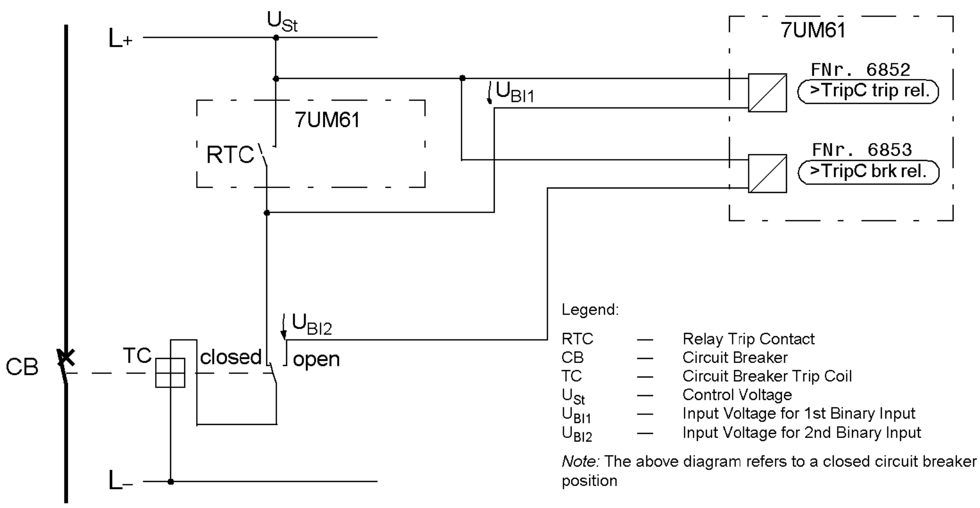


Figure 2-69 Principle of Trip Circuit Monitor with Two Binary Inputs (connected to common potential)

Depending on the conditions of the trip contact and the circuit breaker, the binary inputs are activated (logical condition "H" in the following Table), or not activated (logical condition "L").

Table 2-9 Condition Table for Binary Inputs, Depending on RTC and CB Position

No.	Trip contact	Circuit breaker	AuxCont 1	AuxCont 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 RTC has tripped successfully	
3	Closed	TRIP	Closed	Open	L	L	Transition/fault	Fault
4	Open	TRIP or CLOSE	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 LS" and "KR triggered successfully"). However these two statuses are normal and thus not critical. Status 4 is only theoretical and indicates a hardware error. With intact trip circuits the condition that both binary inputs are not actuated (”L") is possible only during a short transition period (trip contact is closed, but circuit breaker has not yet opened.) 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 2-68). 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 is removed, 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-ohm substitute resistor R.

The control voltage for the circuit breaker should be at least twice as high as the minimum voltage drop at binary input ($U_{St} > 2 \cdot U_{BImin}$ Since the minimum voltage to activate a binary input is 19 V, about 38 V is required for monitoring a power station side control voltage.

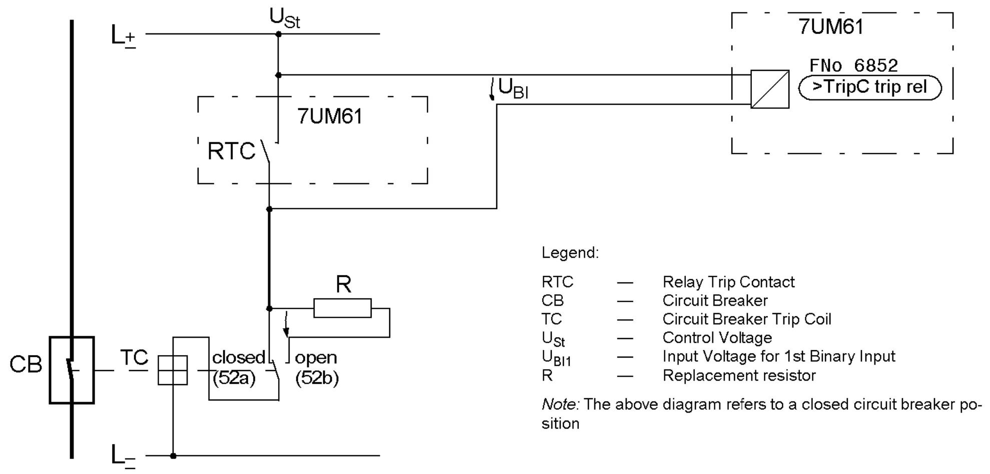


Figure 2-70 Principle of Trip Circuit Monitoring with One Binary Input

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 monitoring circuit is closed by either the circuit breaker auxiliary contact (if the circuit breaker is closed) or through the bypass resistor R. Only as long as the trip contact is closed, the binary input is short circuited and thereby deactivated (logical condition ”L").

If the binary input is continuously deactivated during operation, this leads to the conclusion that there is an interruption in the trip circuit, or a loss of (tripping) control voltage.

Because the trip circuit monitor does not operate during system faults, a closed tripping contact does not lead to a fault message. 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 is removed, 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).

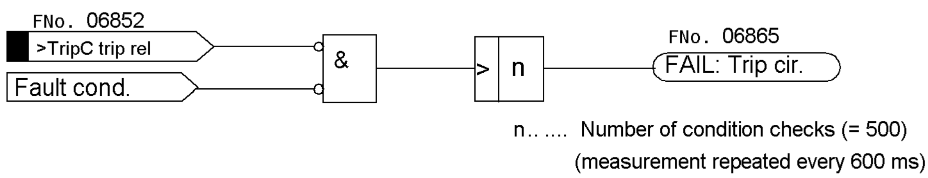


Figure 2-71 Logic diagram for Trip Circuit Monitoring with one binary input

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.

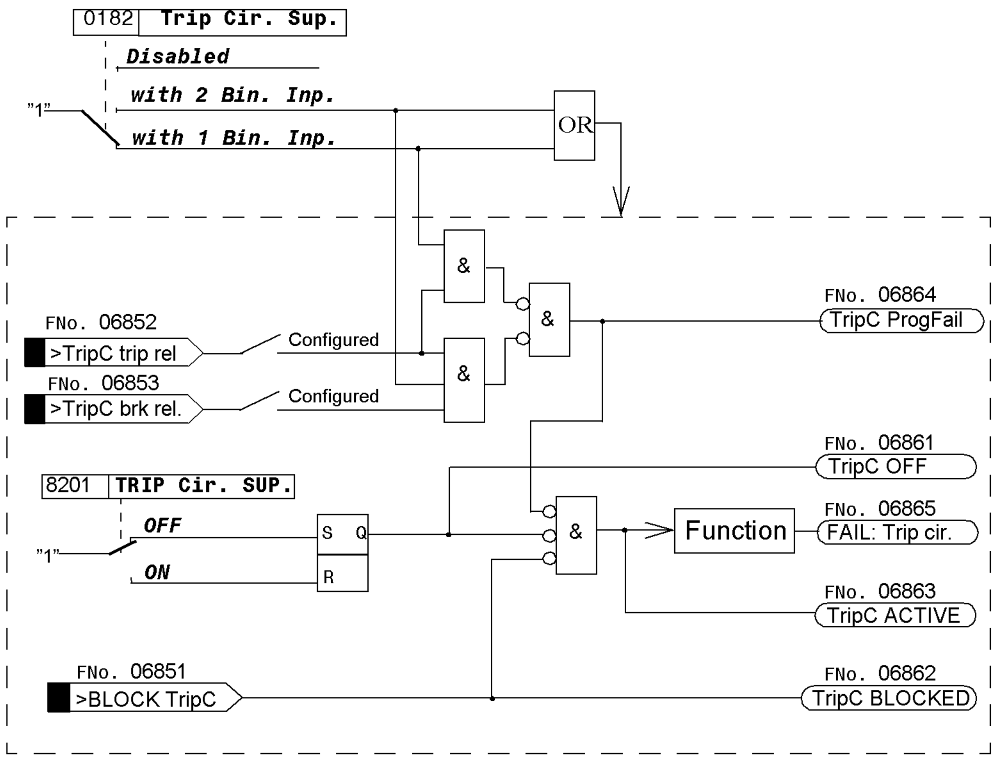


Figure 2-72 Message Logic for the Trip Circuit Monitor

2.29.2 Setting Notes

General

The function is only in effective and available if address 182 **Trip Cir. Sup.** (Section 2.2) 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 as ***ON***. If allocation of the required binary inputs does not match the selected monitoring type, then an indication to this effect is generated ("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 conditions, a lower control voltage can often be sufficient. The resistor R is inserted into the circuit of the second circuit breaker auxiliary contact (AuxCont2) to detect a malfunction also when the circuit breaker auxiliary contact (AuxCont1) is open, and the trip contact has dropped out (see Principle of Trip Circuit Monitoring with One Binary Input figure). 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 AuxCont1 is open and AuxCont2 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 optimal 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, the result for R_{max} is:

$$R_{max} = \left(\frac{U_{St} - U_{BI\,min}}{I_{BI\,(High)}}\right) - R_{TC}$$

So the circuit breaker trip coil does not remain energized in the above case, R_{min} is derived as:

$$R_{min} = R_{TC} \cdot \left(\frac{U_{Ctrl} - U_{TC\,(LOW)}}{U_{TC\,(LOW)}}\right)$$

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_{Ctrl}	Control Voltage for Trip Circuit
R_{CBTC}	DC Resistance of circuit breaker trip coil
$U_{CBTC\,(LOW)}$	Maximum voltage on the circuit breaker trip coil that does not lead to tripping

If the calculation results that $R_{max} < R_{min}$, then the calculation must be repeated, with the next lowest switching threshold UBE min, and this threshold must be implemented in the device using jumper(s).

For power consumption of the resistance:

$$P_R = I^2 \cdot R = \left(\frac{U_{Ctrl}}{R + R_{TC}}\right)^2 \cdot R$$

Example:

$I_{BI\ (HIGH)}$	1.8 mA (from the SIPROTEC® 7UM61)
$U_{BI\ min}$	19 V for delivery setting for nominal voltages 24/48/60 V (for device 7UM61) 88 V for delivery setting for nominal voltages 110/125/220/250 V) (for device 7UM61)
U_{Ctrl}	110 V (system / trip circuit)
R_{CBTC}	500 Ω (from power system / trip circuit)
$U_{CBTC\ (LOW)}$	2 V (system / trip circuit)

$$R_{max} = \left(\frac{110\ V - 19\ V}{1.8\ mA}\right) - 500\ \Omega = 50.1\ k\Omega$$

$$R_{min} = 500\ \Omega \cdot \left(\frac{110\ V - 2\ V}{2\ V}\right) = 27\ k\Omega$$

$$R = \frac{R_{max} + R_{min}}{2} = 38.6\ k\Omega$$

The closest standard value of 39 kΩ is selected; for the power:

$$P_R = \left(\frac{110\ V}{39\ k\Omega + 0.5\ k\Omega}\right)^2 \cdot 39\ k\Omega$$

$$P_R \geq 0.3\ W$$

2.29.3 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
8201	TRIP Cir. SUP.	OFF ON	OFF	TRIP Circuit Supervision

2.29.4 Information List

No.	Information	Type of Information	Comments
6851	>BLOCK TripC	EM	>BLOCK Trip circuit supervision
6852	>TripC trip rel	EM	>Trip circuit supervision: trip relay
6853	>TripC brk rel.	EM	>Trip circuit supervision: breaker relay
6861	TripC OFF	AM	Trip circuit supervision OFF
6862	TripC BLOCKED	AM	Trip circuit supervision is BLOCKED
6863	TripC ACTIVE	AM	Trip circuit supervision is ACTIVE
6864	TripC ProgFail	AM	Trip Circuit blk. Bin. input is not set
6865	FAIL: Trip cir.	AM	Failure Trip Circuit

2.30 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.

The principal use is for high-speed supervision and automatic functions as well as application-specific protection functions (e.g. power plant decoupling) which are not included in the scope of protection functions.

2.30.1 Functional Description

Mode of Operation

There are 6 threshold supervision blocks, 3 each for overshoot and undershoot of the threshold. As result a logical indication is output that can be further processed by the CFC.

A total of 9 processable measured values are available, all of which can be evaluated as percentages. Each threshold block can be allocated one of these 9 measured values. As for all other protection functions, the measured values are referred to as secondary quantities.

The following table shows the useable measured values. The threshold values are queried once per cycle.

The following figure shows an overview of the logic.

Table 2-10 Measured Values

Measured Value	Scaling	Explanation
P (Active power)	$P/S_{N,sec} \cdot 100\ \%$	The positive sequence system quantities for U and I are formed once per cycle from the sampled values. From the result, **P** is calculated. The measuring result is subject to the angle correction (address 204 CT ANGLE W0) in the current path.
Q (Reactive power)	$Q/S_{N,sec} \cdot 100\ \%$	The positive sequence system quantities for U and I are formed once per cycle from the sampled values. From the result, **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)	$\Delta P/S_{N,sec} \cdot 100\ \%$	The active power difference is calculated from the active power over a measuring window of 3 cycles.
U1 (Positive sequence voltage)	$U1/U_{N,sec} \cdot 100\ \%$	The positive sequence voltage is determined from the phase-to-earth voltages on the basis of the definition equation for symmetrical components. The calculation is performed once per cycle.
U2 (Negative sequence voltage)	$U2/U_{N,sec} \cdot 100\ \%$	The negative sequence voltage is determined from the phase-to-earth voltages on the basis of the definition equation for symmetrical components. The calculation is performed once per cycle.

Measured Value	Scaling	Explanation
I0 (Zero sequence current system)	$I0/I_{N,sec} \cdot 100\ \%$	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.
I1 (Positive sequence current system)	$I1/I_{N,sec} \cdot 100\ \%$	The positive 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.
I2 (Negative sequence current system)	$I2/I_{N,sec} \cdot 100\ \%$	The negative 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.
φ (Power angle)	$\varphi/180° \cdot 100\ \%$	The power angle is calculated from the positive sequence voltage and the positive sequence current. The following definition applies: $\varphi = \varphi U - \varphi I$ (A positive angle will appear if the current lags behind the voltage)

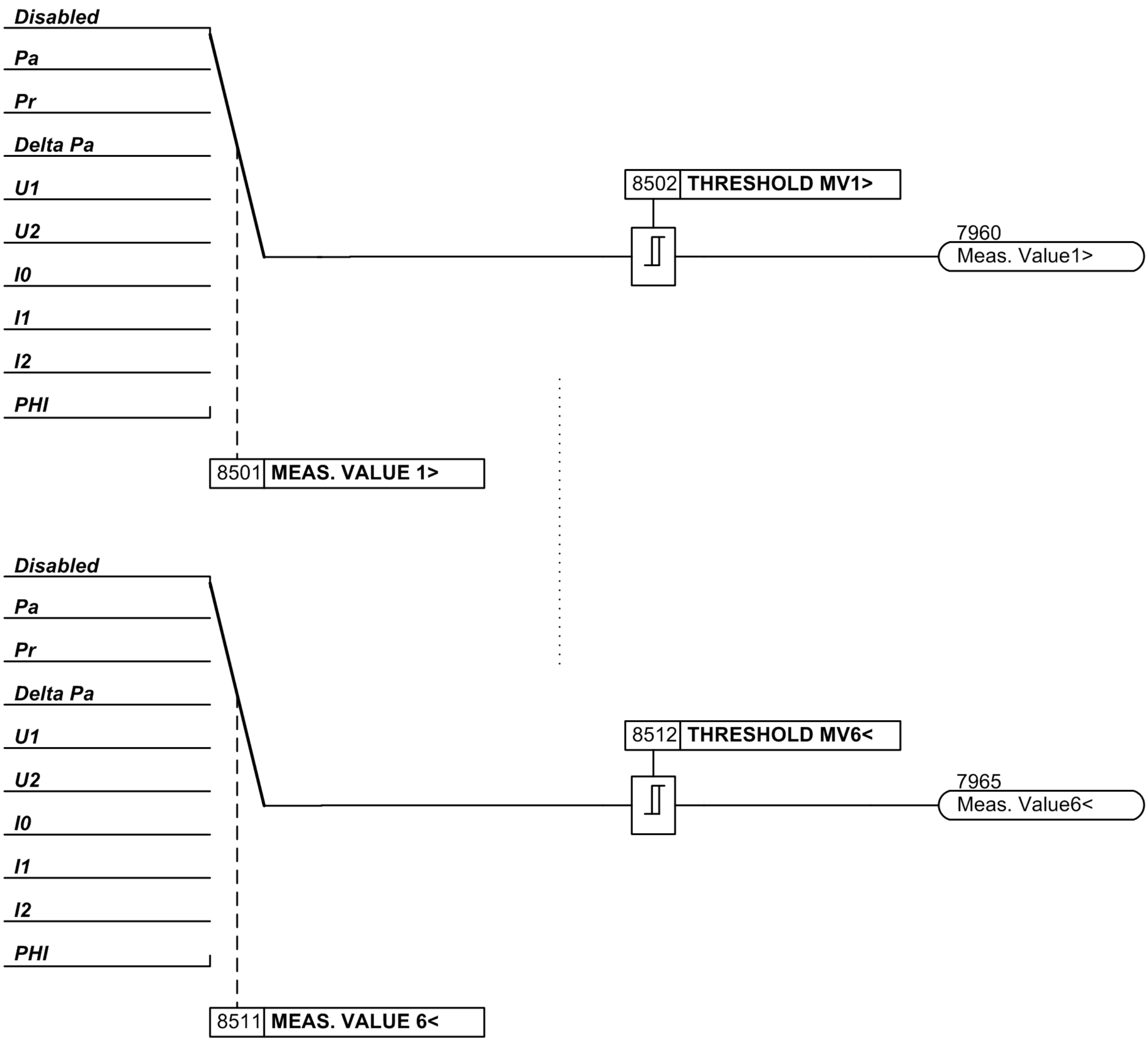


Figure 2-73 Logic of the Threshold Supervision

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.

2.30.2 Setting Notes

General

Threshold supervisions are only effective and available if addresses 185 **THRESHOLD** are set to enabled on configuration.

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 and ΔP 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 from the protection point of view corresponds to a pickup. 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 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 U1, U2, I0, I1 and I2 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 6 measured value monitoring blocks (see information list) are available in the configuration matrix for further logical processing by the CFC.

2.30.3 Settings

Addr.	Parameter	Setting Options	Default Setting	Comments
8501	MEAS. VALUE 1>	Disabled P Q Delta P U1 U2 I0 I1 I2 PHI	Disabled	Measured Value for Threshold MV1>
8502	THRESHOLD MV1>	-200 .. 200 %	100 %	Pickup Value of Measured Value MV1>

Addr.	Parameter	Setting Options	Default Setting	Comments
8503	MEAS. VALUE 2<	Disabled P Q Delta P U1 U2 I0 I1 I2 PHI	Disabled	Measured Value for Threshold MV2<
8504	THRESHOLD MV2<	-200 .. 200 %	100 %	Pickup Value of Measured Value MV2<
8505	MEAS. VALUE 3>	Disabled P Q Delta P U1 U2 I0 I1 I2 PHI	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 U1 U2 I0 I1 I2 PHI	Disabled	Measured Value for Threshold MV4<
8508	THRESHOLD MV4<	-200 .. 200 %	100 %	Pickup Value of Measured Value MV4<
8509	MEAS. VALUE 5>	Disabled P Q Delta P U1 U2 I0 I1 I2 PHI	Disabled	Measured Value for Threshold MV5>
8510	THRESHOLD MV5>	-200 .. 200 %	100 %	Pickup Value of Measured Value MV5>

Addr.	Parameter	Setting Options	Default Setting	Comments
8511	MEAS. VALUE 6<	Disabled P Q Delta P U1 U2 I0 I1 I2 PHI	Disabled	Measured Value for Threshold MV6<
8512	THRESHOLD MV6<	-200 .. 200 %	100 %	Pickup Value of Measured Value MV6<

2.30.4 Information List

No.	Information	Type of Information	Comments
7960	Meas. Value1>	AM	Measured Value MV1> picked up
7961	Meas. Value2<	AM	Measured Value MV2< picked up
7962	Meas. Value3>	AM	Measured Value MV3> picked up
7963	Meas. Value4<	AM	Measured Value MV4< picked up
7964	Meas. Value5>	AM	Measured Value MV5> picked up
7965	Meas. Value6<	AM	Measured Value MV6< picked up

2.31 External Trip Functions

Any signals from external protection or supervision units can be incorporated into the processing of the digital machine protection 7UM61 via binary inputs. Like the internal signals, they can be signaled, time delayed, transmitted to the trip matrix, and also individually blocked. By this means it is possible to include mechanical protection equipment, e.g. Buchholz protection, into the processing of indications and trip commands of the digital protection device. Furthermore interaction between protection functions of different numerical machine protection devices of the 7UM6 series is possible.

2.31.1 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 in all four times in the same manner, the function numbers of the indications are each specified for the first external trip command channel.

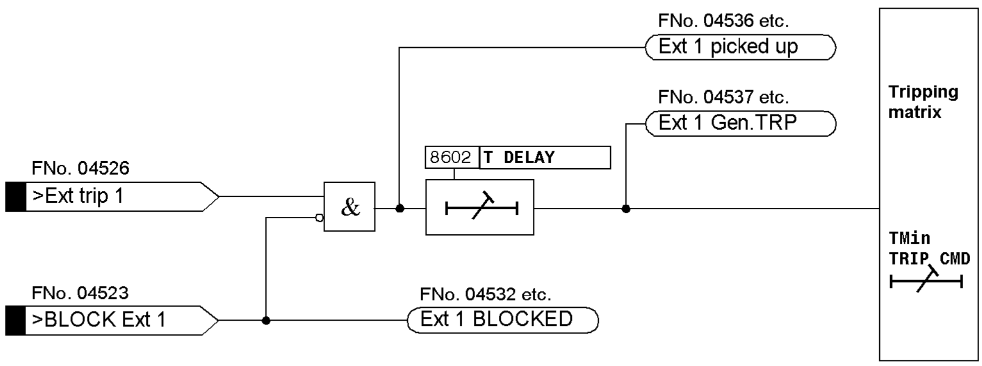


Figure 2-74 Logic Diagram of Direct Input Trippings

2.31.2 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**.

2.31.3 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

2.31.4 Information List

No.	Information	Type of Information	Comments
4523	>BLOCK Ext 1	EM	>Block external trip 1
4526	>Ext trip 1	EM	>Trigger external trip 1
4531	Ext 1 OFF	AM	External trip 1 is switched OFF
4532	Ext 1 BLOCKED	AM	External trip 1 is BLOCKED
4533	Ext 1 ACTIVE	AM	External trip 1 is ACTIVE
4536	Ext 1 picked up	AM	External trip 1: General picked up
4537	Ext 1 Gen.TRP	AM	External trip 1: General TRIP
4543	>BLOCK Ext 2	EM	>BLOCK external trip 2
4546	>Ext trip 2	EM	>Trigger external trip 2
4551	Ext 2 OFF	AM	External trip 2 is switched OFF
4552	Ext 2 BLOCKED	AM	External trip 2 is BLOCKED
4553	Ext 2 ACTIVE	AM	External trip 2 is ACTIVE
4556	Ext 2 picked up	AM	External trip 2: General picked up
4557	Ext 2 Gen.TRP	AM	External trip 2: General TRIP
4563	>BLOCK Ext 3	EM	>BLOCK external trip 3
4566	>Ext trip 3	EM	>Trigger external trip 3
4571	Ext 3 OFF	AM	External trip 3 is switched OFF
4572	Ext 3 BLOCKED	AM	External trip 3 is BLOCKED
4573	Ext 3 ACTIVE	AM	External trip 3 is ACTIVE
4576	Ext 3 picked up	AM	External trip 3: General picked up
4577	Ext 3 Gen.TRP	AM	External trip 3: General TRIP
4583	>BLOCK Ext 4	EM	>BLOCK external trip 4

No.	Information	Type of Information	Comments
4586	>Ext trip 4	EM	>Trigger external trip 4
4591	Ext 4 OFF	AM	External trip 4 is switched OFF
4592	Ext 4 BLOCKED	AM	External trip 4 is BLOCKED
4593	Ext 4 ACTIVE	AM	External trip 4 is ACTIVE
4596	Ext 4 picked up	AM	External trip 4: General picked up
4597	Ext 4 Gen.TRP	AM	External trip 4: General TRIP

2.32 RTD-Box

Up to 2 thermoboxes 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 the bearing temperature thresholds. The temperatures are measured in different locations of the protected object by employing temperature sensors (RTD = Resistance Temperature Detector) and are transmitted to the device via one or two 7XV566 thermoboxes.

2.32.1 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 thermobox (corresponds to RTD 1).

RTD-box 7XV56

The thermobox 7XV566 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 thermobox detects the coolant temperature of each measuring point from the resistance value of the temperature detectors (Pt 100, Ni 100 or Ni 120) connected via 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 thermoboxes via its service port (port C).

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 values are 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 make the corresponding allocations in the configuration matrix.

An alarm is issued for each temperature sensor in the event of a short-circuit or interruption in the sensor circuit.

The following figure shows the logic diagram for temperature processing.

The manual supplied with the thermobox contains a connection diagram and dimensioned drawing.

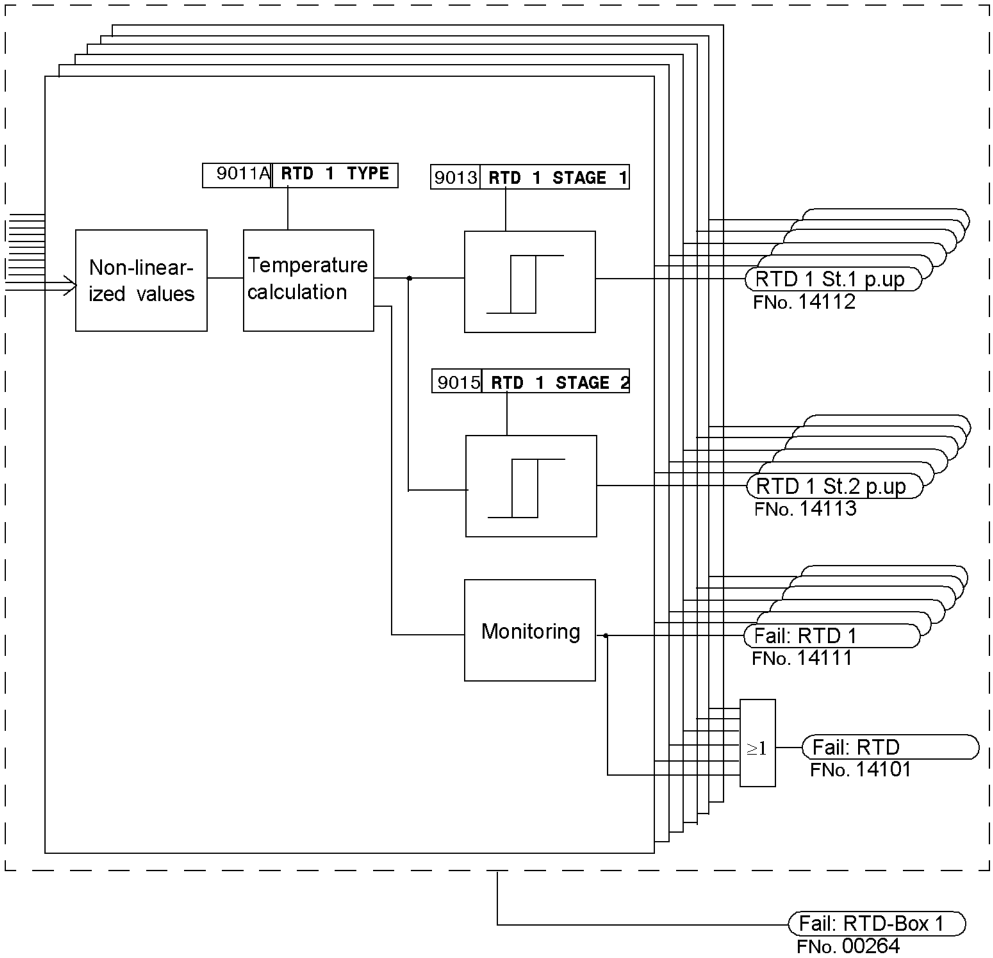


Figure 2-75 Logic Diagram for Temperature Processing

2.32.2 Setting Notes

General

The temperature detection function is only effective and accessible if it has been assigned to an interface during the configuration of the protection functions (Section 2.2). At address 190 **RTD-BOX INPUT** the RTD-box(es) is allocated to the interface 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 operate in half duplex mode, it has to be selected for the Clear-to-Send function (CTS) using plug-in jumpers (see Subsection 3.1.2) “/CTS triggered by /RTS ” must be selected.

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 ***Pt 100*** Ω, ***Ni 120*** Ω and ***Ni 100*** Ω. If no temperature detector is available for RTD 1, set **RTD 1 TYPE** = ***Not connected***. This setting is only possible via DIGSI® at "**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***. This setting is only possible via DIGSI® at "**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 2.2.2 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 0. Modifications at the RTD-box can be made in mode 7. The following convention applies:

Table 2-11 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 7UM61 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-defined logic (CFC) and interconnected as desired. Pickup signals “RTD x St. 1 p.up” and “RTD x St. 2 p.up”, however, 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.

2.32.3 Settings

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

Addr.	Parameter	Setting Options	Default Setting	Comments
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

2.32.4 Information List

No.	Information	Type of Information	Comments
14101	Fail: RTD	AM	Fail: RTD (broken wire/shorted)
14111	Fail: RTD 1	AM	Fail: RTD 1 (broken wire/shorted)
14112	RTD 1 St.1 p.up	AM	RTD 1 Temperature stage 1 picked up
14113	RTD 1 St.2 p.up	AM	RTD 1 Temperature stage 2 picked up
14121	Fail: RTD 2	AM	Fail: RTD 2 (broken wire/shorted)
14122	RTD 2 St.1 p.up	AM	RTD 2 Temperature stage 1 picked up
14123	RTD 2 St.2 p.up	AM	RTD 2 Temperature stage 2 picked up
14131	Fail: RTD 3	AM	Fail: RTD 3 (broken wire/shorted)
14132	RTD 3 St.1 p.up	AM	RTD 3 Temperature stage 1 picked up
14133	RTD 3 St.2 p.up	AM	RTD 3 Temperature stage 2 picked up
14141	Fail: RTD 4	AM	Fail: RTD 4 (broken wire/shorted)
14142	RTD 4 St.1 p.up	AM	RTD 4 Temperature stage 1 picked up
14143	RTD 4 St.2 p.up	AM	RTD 4 Temperature stage 2 picked up
14151	Fail: RTD 5	AM	Fail: RTD 5 (broken wire/shorted)
14152	RTD 5 St.1 p.up	AM	RTD 5 Temperature stage 1 picked up
14153	RTD 5 St.2 p.up	AM	RTD 5 Temperature stage 2 picked up
14161	Fail: RTD 6	AM	Fail: RTD 6 (broken wire/shorted)
14162	RTD 6 St.1 p.up	AM	RTD 6 Temperature stage 1 picked up
14163	RTD 6 St.2 p.up	AM	RTD 6 Temperature stage 2 picked up
14171	Fail: RTD 7	AM	Fail: RTD 7 (broken wire/shorted)
14172	RTD 7 St.1 p.up	AM	RTD 7 Temperature stage 1 picked up
14173	RTD 7 St.2 p.up	AM	RTD 7 Temperature stage 2 picked up
14181	Fail: RTD 8	AM	Fail: RTD 8 (broken wire/shorted)
14182	RTD 8 St.1 p.up	AM	RTD 8 Temperature stage 1 picked up

No.	Information	Type of Information	Comments
14183	RTD 8 St.2 p.up	AM	RTD 8 Temperature stage 2 picked up
14191	Fail: RTD 9	AM	Fail: RTD 9 (broken wire/shorted)
14192	RTD 9 St.1 p.up	AM	RTD 9 Temperature stage 1 picked up
14193	RTD 9 St.2 p.up	AM	RTD 9 Temperature stage 2 picked up
14201	Fail: RTD10	AM	Fail: RTD10 (broken wire/shorted)
14202	RTD10 St.1 p.up	AM	RTD10 Temperature stage 1 picked up
14203	RTD10 St.2 p.up	AM	RTD10 Temperature stage 2 picked up
14211	Fail: RTD11	AM	Fail: RTD11 (broken wire/shorted)
14212	RTD11 St.1 p.up	AM	RTD11 Temperature stage 1 picked up
14213	RTD11 St.2 p.up	AM	RTD11 Temperature stage 2 picked up
14221	Fail: RTD12	AM	Fail: RTD12 (broken wire/shorted)
14222	RTD12 St.1 p.up	AM	RTD12 Temperature stage 1 picked up
14223	RTD12 St.2 p.up	AM	RTD12 Temperature stage 2 picked up

2.33 Phase Rotation Reversal

A phase rotation feature via binary input and parameter is implemented in the 7UM61 device. 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 2.3).

If phase rotation reverses 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.

2.33.1 Functional Description

Logic

Phase rotation is continually set by a Power System Data parameter at address 271 **PHASE SEQ.**. Binary input “>Reverse Rot.” sets the phase rotation to the opposite of the parameter setting.

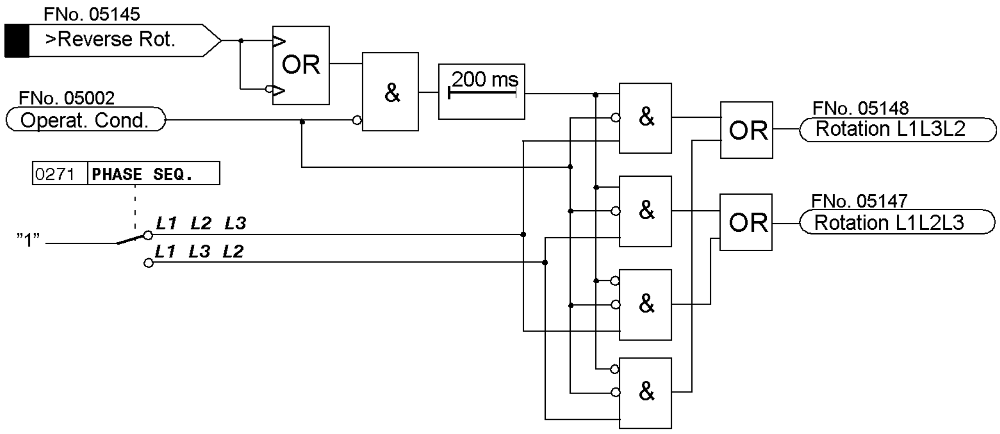


Figure 2-76 Message logic of the phase-sequence reversal

For safety reasons, the device accepts phase rotation 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 rotation 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 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 inversion 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 2.28) which issue an indication if the required and calculated phase rotations do not match.

2.33.2 Setting Notes

Programming Settings

The normal phase sequence is set at `271` (see Subsection 2.3). If, on the system side, phase rotation is temporarily changed, then this is communicated to the protective device using the binary input “`>Reverse Rot.`”, FNo. 5145).

2.34 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.

In particular, this includes:

- Pick-up logic
- Tripping logic
- Fault display on the LEDs/LCD
- Statistics

2.34.1 Pickup Logic of Device

This section describes the general pickup and spontaneous messages in the device display.

2.34.1.1 Functional Description

General 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, ends when the last function drops out and is reported as general device pickup.

General device pickup is a precondition for a series of internal and external subsequent functions. The following are among the internal functions controlled by general device pickup:

- Opening of fault case: From general device pickup to device drop out, all fault messages are entered in the trip log.
- Initialization of fault storage: The storage and maintenance of fault values can also be made dependent on the occurrence of a tripping command.
- Generation of Spontaneous messages in the device display: Certain fault messages are displayed in the device display as so-called spontaneous messages (see below "Display—Spontaneous Messages"). This display can be made dependent on the occurrence of a trip command.

Display Spontaneous Annunciations

Spontaneous messages are fault messages that appear in the display automatically when general device pickup has occurred. For the 7UM61, 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":	the operating time from general pickup to dropout of the device, in ms;
"Trip time":	the operating time from general pickup to the first trip command of the device, in ms;

Note that the thermal overload protection does not have a pickup comparable with the other protection functions. The PU Time is first started with the trip command, thereby opening a fault case. The dropout of the thermal image of the overload protection ends the fault case and, thereby the running PU Time.

2.34.2 Tripping Logic of Device

This section describes general pickup and terminating of the trip command.

2.34.2.1 Functional Description

General Trip

The trip signals for all protective functions are OR-combined and generate the 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 group indication.

Terminating the Trip Signal

For terminating 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 2-77). The minimum trip command duration **T TRIPCOM MIN** is started at the same time. This ensures that the command 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 commands can only be terminated when the last protection function dropped out (i.e. functions no longer pick up) AND the minimum trip signal duration has expired.
- 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 (“>LED-Acknowledgement”). 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.

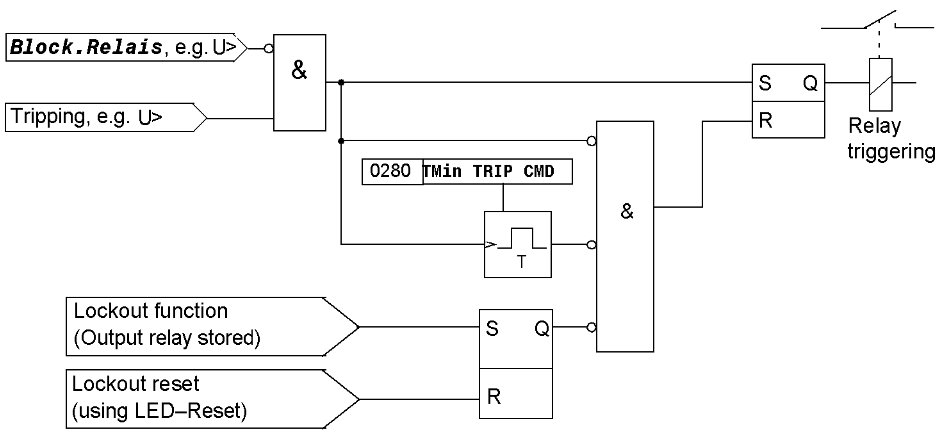


Figure 2-77 Terminating the Trip Signal, Example of a Protective Function

2.34.2.2 Setting Notes

Command Duration

The minimum trip command duration 280 **TMin TRIP CMD** was described already in Section 2.3. This setting applies to all protective functions that initiate tripping.

2.34.3 Fault Display on the LEDs/LCD

The storage of messages masked to local LEDs, and the maintenance of spontaneous messages, can be made dependent on whether the device has issued a trip signal. These messages are not issued if,on a fault, one or more protective functions have only picked up, but a trip signal has not been issued yet by the 7UM61 because the fault was cleared by another device (for instance outside of the own protection range). These messages are then limited to faults in the own protection zone.

2.34.3.1 Functional Description

Creating a Reset Command

The following figure illustrates the creation of the reset command for stored messages. By the moment of the device dropout, the stationary conditions (fault indication with excitation/with trip signal; tripping/no tripping) decide whether the new fault remains stored or is reset.

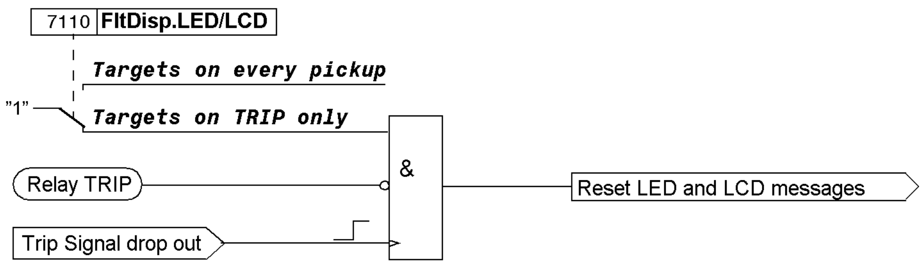


Figure 2-78 Creation of the reset command for the memory of LED and LCD messages

2.34.3.2 Setting Notes

Fault Display on the LEDs/LCD

A new protective pickup generally turns off any previously set light displays, so that only the latest fault is then displayed. It can be selected whether stored LED displays and spontaneous fault messages on the display appear upon renewed pickup, or only after a renewed trip signal is issued. In order to enter the desired type of display, select in menu **PARAMETER** the submenu **Device**. Address 7110 **FltDisp.LED/LCD** offers the two alternatives ***Target on PU*** and ***Target on TRIP***.

2.34.4 Statistics

Tripping commands from the device are counted. Currents of the last disconnections instigated by the device are logged. Disconnected fault currents are accumulated for each breaker pole.

2.34.4.1 Functional Description

Number of Trips

The number of trips initiated by the 7UM61 is counted, as long as the position of the circuit breaker is monitored via binary inputs. Hereby it is necessary that the internal pulse counter is allocated in the matrix to a binary input that is controlled by the circuit breaker OPEN position. The pulse metered value 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:

- the primary currents in all three phases in kA
- the three phase-earth-voltages in kV
- primary active power P in kW, MW or GW (precisely averaged power)
- primary reactive power Q in kVA, MVA or GVA (precisely averaged power)
- Frequency in Hz

Operating Hours

The accumulated operating hours under load are also stored (= current value in at least one phase is greater than the limit value 281 set under address **BkrClosed I MIN**).

Accumulated Shutdown Currents

The shutdown currents for each phase indicated at every trip command individually 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** → **STATISTICS** by overwriting the counter values displayed.

Startup Behaviour

Start

Startup occurs after each switching on of the supply voltage.

Initial Start

Initial start occurs after initialization of the device by DIGSI® 4

Restart

Restart occurs after loading a parameter set or after reset

2.34.4.2 Information List

No.	Information	Type of Information	Comments
-	#of TRIPs=	IPZW	Number of TRIPs
-	#of TRIPs=	IPZW	Number of TRIPs
409	>BLOCK Op Count	EM	>BLOCK Op Counter
1020	Op.Hours=	AM	Counter of operating hours
1021	Σ L1:	AM	Accumulation of interrupted current L1
1022	Σ L2:	AM	Accumulation of interrupted current L2
1023	Σ L3:	AM	Accumulation of interrupted current L3

2.35 Ancillary Functions

Chapter Ancillary Functions describes the general device functions.

2.35.1 Processing of Annunciations

After occurrence of a system fault, data regarding the response of the relay and the measured quantities should be saved for analysis purposes. For this reason indication processing is done in three ways:

2.35.1.1 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. All LEDs and binary outputs indicating specific messages can be freely configured . The relay is usually delivered with a default setting. 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

- on site 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.

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 ("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 device is blocked.

Information via Display Panel or PC

Events and statuses can be read out on the display panel on the device front panel. Using the front interface or the service interface, a PC also can receive the 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 related 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 indications can be displayed on the LCD at any time by keypad selection, or transferred to the PC via the serial service. Readout of indications during operation is described in detail in the SIPROTEC 4 System Description /1/.

Classification of Indications

Indications are categorised as follows:

- Operational indications; these are 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 indication and output functions that can be generated in a device configured for the maximum scope of functions is contained in the Appendix, together with their information number (FNo.). It also indicates where each indication can be sent to. If functions are not present in a not fully equipped version of the device, or are configured to ***Disabled***, then the associated indications cannot appear.

Operational Indications

The operational indications contain information that the device generates during operation and on operational conditions. Up to 200 operational indications are recorded in chronological order in the device. Newly generated indications are added to those already there. If the maximum capacity of the memory is exhausted, the oldest indication is lost.

Fault Events

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 initial time of the short-circuit fault is allocated the internal absolute system clock time. 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 1ms.

Spontaneous Indications on the Device Front

After a fault, automatically and without operator action, the most important fault data from the general device pickup appear on the display in the sequence shown in the following figure.

UO> picked up	Protective Function that picked up first;
S/E/F TRIP	Protective Function that dropped out last;
PU Time 440ms	Running time from general pickup to dropout;
TRIP Time 301ms	Running time from general pickup to the first trip command

Figure 2-79 Display of Spontaneous Annunciations in the Device Display

Retrievable Indications

The indications of the last eight 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 indications can be recorded. Oldest data are erased by newest data when multiple fault indications occur.

General Interrogation

The general interrogation which can be retrieved via DIGSI® 4 enables the current status of the SIPROTEC® device to be read out. It shows all indications subject to general interrogation, with their current value.

Spontaneous Annunciations

The spontaneous indications displayed using DIGSI® 4 reflect the present status of incoming current indications. Each new incoming indication appears immediately, i.e. the user does not have to wait for an update or initiate one.

Statistics

The indications in statistics are counters for breaker switching operations instigated by the 7UM61 as well as for accumulation of short-circuit currents involved in disconnections caused by the device protection functions. Measured values are indicated in primary terms.

They can be viewed on the device front and read out using the DIGSI® 4 program on a PC via the operator or service interface.

A password is not required to read counter and stored values but is required to change or delete the 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.

2.35.2 Measurement

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 2-12, as well as the following list).

2.35.2.1 Functional Description

Display of Measured Values

The operational measured values listed in Table 2-12 can be read out as secondary, primary or percent 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 other equipment, as well as the transformation ratios of the current and voltage transformers in the earth paths, in accordance with Subsections2.3 and 2.5. Table 2-12 lists the formulae for 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 3 U_0 is calculated from the phase-earth voltages: 3 $U_0 = |\underline{U}_{L1} + \underline{U}_{L2} + \underline{U}_{L3}|$. All three voltage inputs must be phase-ground connected for this.

Table 2-12 Conversion formulae between secondary values and primary/percentage values

Measured Values	Secondary	Primary	%
I_{L1}, I_{L2}, I_{L3}, I_1, I_2, $3I_0$	$I_{sec.}$	$\frac{\text{CT PRIMARY}}{\text{CT SECONDARY}} \cdot I_{sec}$	$\frac{I_{prim.}}{\text{I PRIMARY OP.}} \cdot 100$
I_{Ns}	$I_{EE\ sec.}$	$\text{FACTOR IEE} \cdot I_{EE\ sec}$	$\frac{I_{EE\ prim.}}{\text{I PRIMARY OP.}} \cdot 100$
U_{L1E}, U_{L2E}, U_{L3E}, U_0, U_1, U_2	$U_{Ph\text{-}N\ sec.}$	$\frac{\text{Unom PRIMARY}}{\text{UnomSECONDARY}} \cdot U_{L\text{-}E\ sec}$	$\frac{U_{prim.}}{\text{U PRIMARY OP.} / (\sqrt{3})} \cdot 100$
$U_{L1\text{-}L2}$, $U_{L2\text{-}L3}$, $U_{L3\text{-}L1}$	$U_{Ph\ Ph\ sec.}$	$\frac{\text{Unom PRIMARY}}{\text{UnomSECONDARY}} \cdot U_{Ph\text{-}Ph\ sec}$	$\frac{U_{prim.}}{\text{U PRIMARY OP.}} \cdot 100$
U_0	$U_{E\ sec.}$	U_E measured: $\text{FACTOR UE} \cdot U_{E\ sec}$ U_E computed: $\frac{\text{UN – VT PRIMARY}}{\text{UN – VT SECONDARY}} \cdot U_{E\ sec}$	$\frac{U_{E\ prim.}}{\text{U PRIMARY OP.} / (\sqrt{3})} \cdot 100$

Measured Values	Secondary	Primary	%
P, Q, S	P_{sec} Q_{sec} S_{sec}	$\frac{\text{Unom PRIMARY}}{\text{UnomSECONDARY}} \cdot \frac{\text{CT PRIMARY}}{\text{CT PRIMARY}} \cdot P_{sec}$	$\frac{\text{Power}_{prim.} \cdot 100}{\sqrt{3} \cdot \text{U PRIMARY OP.} \cdot \text{I PRIMARY OP.}}$
Angle PHI	φ in °el	φ in °el	φ in °el
Power factor	cos φ	cos φ	cos φ · 100 in %
Frequency	f in Hz	f in Hz	$\frac{\text{f in Hz}}{f_{nom}} \cdot 100$
U/f	$\frac{\frac{U}{f}}{\frac{U_N}{f_N}} \cdot \frac{\text{Unom PRIMARY}}{\text{U PRIMARY OP.}}$		$\frac{\frac{U}{f}}{\frac{U_N}{f_N}} \cdot \frac{\text{Unom PRIMARY}}{\text{U PRIMARY OP.}} \cdot 100$
R, X	S_{sec} X_{sec}	$\frac{\frac{\text{Unom PRIMARY}}{\text{UnomSECONDARY}}}{\frac{\text{CT PRIMARY}}{\text{CT PRIMARY}}} \cdot R_{sec}$	no display of percentage measured values
$U_{E3.H}$	$U_{E3.H,sec}$ in V	$\text{FACTOR UE} \cdot U_{E3.H,sec}$	$\frac{U_{E3.H,prim}}{\text{U PRIMARY OP.} / (\sqrt{3})} \cdot 100$

with

Parameter	Address	Parameter	Address
Unom PRIMARY	221	Uph / Udelta	225
Unom SECONDARY	222	FACTOR IEE	213
CT PRIMARY	211	FACTOR UE	224
CT SECONDARY	212	U PRIMARY OP.	1101
		I PRIMARY OP.	1102

In addition measured values are computed by the protection functions and made available:

Thermal Measured Values

The thermal measured values are as follows:

- Θ_S/Θ_{STrip} Overload protection measured value of the stator winding in % of the tripping overtemperature,
- Θ_S/Θ_{STrip} L1 normalized overload protection measured value of the stator winding for phase L1,
- Θ_S/Θ_{STrip} L2 normalized overload protection measured value of the stator winding for phase L2,
- Θ_S/Θ_{STrip} L3 normalized overload protection measured value of the stator winding for phase L3,
- Θ_L/Θ_{Lmax} normalized rotor temperature in % of the tripping temperature
- $T_{Re.Inhib.\ timet}$ Time until the next admissible 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,
- Coolant temperature

In addition, the following are be available:

Minimum and Maximum Values

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 f 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 7UM61**–*****–3***

Power Metered Values

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 executed during fault. The values are updated at intervals of ≥ 0.3 s and ≤ 1 s.

Power Metered Values: only with version 7UM61**–*****–3***

Transfer of Measured Values

Measured values can be transferred via the interfaces to a central control and storage system.

Definition of Power Measurement

The 7UM61 uses the generator reference-arrow system. The power output is positive.

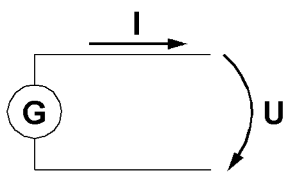
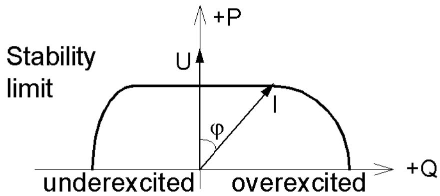
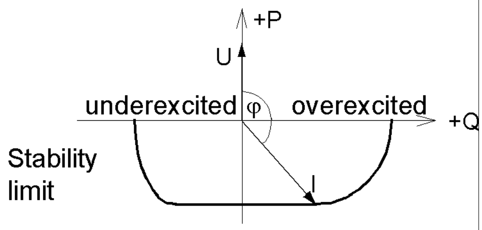


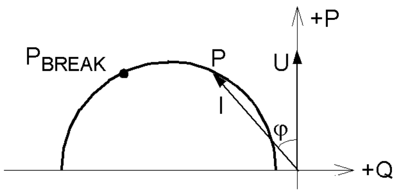
Figure 2-80 Definition of Positive Direction of Reference Arrows

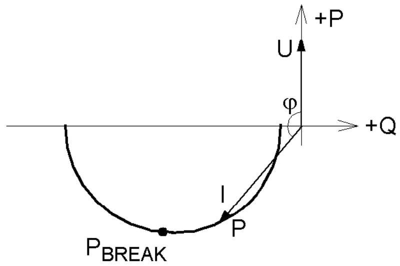
The following table shows the operating ranges for synchronous and asynchronous machines. For this, parameter 1108 **ACTIVE POWER** is set to ***Generator***. "Normal condition" shows the power under normal operating conditions: + means that a positive power is displayed on the protective device, – means that the power is negative.

Table 2-13 Operating Ranges for Synchronous and Asynchronous Machines

<table>
<tr><th>Synchronous generator</th><th>Synchronous motor</th></tr>
<tr><td>

Reactive power Q is controlled by the excitation,
Normal condition: +P and +Q</td>
<td>

Reactive power Q is controlled by the e
citation,
Normal condition: –P and +Q</td></tr>
<tr><th>Asynchronous generator</th><th>Asynchronous motor</th></tr>
<tr><td>

Reactive power is drawn from the system to maintain the excitation;
Normal condition: +P and –Q</td>
<td>

The motor draws both active and reactive power from the system;
Normal condition: –P and –Q</td></tr>
</table>

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 210 **CT Starpoint**) 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.

2.35.2.2 Information List

No.	Information	Type of Information	Comments
601	IL1 =	MW	I L1
602	IL2 =	MW	I L2
603	IL3 =	MW	I L3
605	I1 =	MW	I1 (positive sequence)
606	I2 =	MW	I2 (negative sequence)
621	UL1E=	MW	U L1-E
622	UL2E=	MW	U L2-E
623	UL3E=	MW	U L3-E
624	UL12=	MW	U L12
625	UL23=	MW	U L23
626	UL31=	MW	U L31
627	UE =	MW	Displacement voltage UE
629	U1 =	MW	U1 (positive sequence)
630	U2 =	MW	U2 (negative sequence)
641	P =	MW	P (active power)
642	Q =	MW	Q (reactive power)
644	Freq=	MW	Frequency
645	S =	MW	S (apparent power)
650	UE3h=	MW	UE 3rd harmonic
765	U/f =	MW	(U/Un) / (f/fn)
830	IEE =	MW	Senstive Earth Fault Current
831	3I0 =	MW	3I0 (zero sequence)
832	U0 =	MW	U0 (zero sequence)
901	PF =	MW	Power Factor
902	PHI =	MW	Power angle
903	R =	MW	Resistance
904	X =	MW	Reactance

2.35.3 Set Points (Measured Values)

2.35.3.1 Functional Description

Limit Value Monitorings

SIPROTEC® 7UM61 allows limit levels for important measured and counter values to be set. If during operation a value transgresses one of these limits, the device generates an alarm which is displayed as an operational indication. As for all operational indications, it is possible to output the information to LED and/or output relay and via interfaces. In contrast to the actual protective functions, such as time-overcurrent protection or overload protection, this monitoring program runs in the background and may not respond promptly during a fault if the measured values change rapidly and protective functions pick up. Moreover, since an indication is not generated until the set limit value has been transgressed several times, these monitoring functions cannot respond immediately before a protection trip.

With the 7UM61, 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/).

2.35.3.2 Setting Notes

Limit Values

Limit settings are entered under **MEASUREMENTS** in the sub-menu **LIMITS SETTING** by overwriting the default values.

2.35.3.3 Information List

No.	Information	Type of Information	Comments
-	IL<	GW	IL< under current
284	SP. I<	AM	Set Point I< alarm

2.35.4 Oscillographic Fault Records

The Multi-Functional Protective Relay 7UM61 is equipped with a fault memory which scans either the instantaneous values or the rms values of various measured quantities for storage in a ring buffer.

2.35.4.1 Functional Description

Mode of Operation

The instantaneous values of measured values

i_{L1}, i_{L2}, i_{L3}, i_{EE} and u_{L1}, u_{L2}, u_{L3}, u_E

are scanned at intervals of 1.25 ms (for 50 Hz) or 1.04 ms (for 60 Hz), and stored in a ring buffer (16 samples per cycle). For a fault, the data are stored for an adjustable period of time, but not more than 5 seconds.

The rms values of the measured quantities

I_1, I_2, I_{EE}; U_1, U_E, P, Q, φ, $f–f_N$, R and X

can be deposited in a ring buffer, one measured value per period. R and X are the positive sequence impedances. For a fault, the data are stored for an adjustable period of time, but not more than 80 seconds.

Up to 8 fault records can be recorded 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 PC and evaluated with the protection data processing program DIGSI® 4 and the graphic analysis software SIGRA® 4. 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 recorded.

If the device has a serial system interface (IEC 60870–5–103), 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 recorded.

Transfer to a central device can be polled automatically, either after each fault detection by the protection, or only after a trip.

2.35.4.2 Setting 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 instant is the pickup of the 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 recording criterion.

The actual storage time encompasses the pre-fault time **PRE. TRIG. TIME** (address 404) ahead of the reference instant, the normal recording time and the post-fault time **POST REC. TIME** (address 405) after the storage criterion has reset. The maximum length of time of a fault record **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 address 104). A total of 8 records can be saved in this time.

Note: These times apply for 50 Hz. They will be different with another frequency. If ***RMS values*** are stored, the times stated for parameters 403 to 406 will be 16 times longer.

An oscillographic record can be activated via a binary input, by front panel operation or via the operating interface connected to a PC. Storage is then triggered dynamically. The length of the fault recording is set in address 406 **BinIn CAPT.TIME** (maximum length however is **MAX. LENGTH**, address 403). Pre-fault and post-fault times will be included. If the binary input time is set for ∞, 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.

2.35.4.3 Settings

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 .. 0.60 sec	0.20 sec	Captured Waveform Prior to Trigger

Addr.	Parameter	Setting Options	Default Setting	Comments
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

2.35.4.4 Information List

No.	Information	Type of Information	Comments
-	FltRecSta	IE	Fault Recording Start
4	>Trig.Wave.Cap.	EM	>Trigger Waveform Capture
203	Wave. deleted	AM_W	Waveform data deleted

2.35.5 Date and Time Stamping

The integrated date/time management allows exact time-specific allocation of events, for example in the operational and fault indications or the minimum/maximum value lists.

2.35.5.1 Functional Description

Mode of Operation

The time can be influenced by

- internal RTC (Real Time Clock),
- external synchronisation sources (DCF77, IRIG B, SyncBox, IEC 60 870–5–103),
- external minute pulses via binary input.

Note

On device delivery the internal clock RTC is always set by default as synchronisation source, regardless of whether the device is equipped with a system interface or not. If the time synchronisation is to use an external source, it must be selected.

The procedure for changing the synchronization source is explained in detail in the SIPROTEC® 4 System Description.

No.	Operating Mode	Comments
1	Internal	Internal synchronization using RTC (default)
2	IEC 60870-5-103	External synchronization using system interface (IEC 60 870–5–103)
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 SIMEAS Sync. Box
7	Pulse via binary input	External synchronization with pulse via binary input
8	Field bus	External synchronization using Modbus interface

The time display may be set using either the European format (DD.MM.YYYY) or the US format (MM/DD/YYYY).

To preserve the internal battery, this switches off automatically after some hours in the absence of an auxiliary voltage supply.

2.35.6 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 center.

2.35.6.1 Functional Description

Test 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 in detail how to activate and deactivate test mode and blocked data transmission.

Checking the System Interface

If the device features a system port and uses it to communicate with the control centre, the DIGSI device operation can be used to test if messages are transmitted correctly.

A dialog box shows the display texts of all messages which were allocated to the system interface in the configuration matrix. In another column of the dialog box you can specify a value for the messages you intend to test (e.g. ON/OFF). Having entered password no. 6 (for hardware test menus) a message can then be generated. The corresponding message is issued and can be read out either from the event log of the SIPROTEC® 4 device or from the substation control system.

The procedure is described in detail in Chapter "Mounting and Commissioning".

Checking the Binary Inputs and Outputs

The binary inputs, outputs, and LEDs of a SIPROTEC® 4 device can be individually and precisely controlled in DIGSI. This feature can be used, for example, to verify control wiring from the device to substation equipment (operational checks), during commissioning.

A dialog box shows all binary inputs and outputs and LEDs of the device with their present status. The operating equipment, commands, or messages that are configured (masked) to the hardware components are displayed also. After entering password no. 6 (for hardware test menus), it is possible to switch to the opposite status in another column of the dialog box. 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".

Creating a Test Oscillographic Recording

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 7UM61 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 for the oscillographic recording then occurs, for instance, 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".

2.36 Command Processing

A control command process is integrated in the SIPROTEC ® 7UM61 to coordinate the operation of circuit breakers and other equipment in the power system.

Control commands can originate from four command sources:

- Local operation using the keypad on the local user interface of the device
- Operation using DIGSI®
- Remote operation via network control center or substation controller (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. High security against inadvertent device operations can be ensured if interlocking checks are enabled. A standard set of optional interlocking checks is provided for each command issued to circuit breakers/switchgear.

2.36.1 Control Device

Switchgear can be controlled via the device operator panel, PC interface and the serial interface as well as a switchgear control system connection.

Applications

- Switchgear with Single and Double Busbars

Prerequisites

The number of devices to be controlled is limited by the:

binary inputs present

binary outputs present

2.36.1.1 Functional Description

Operation using the SIPROTEC® 4 Device

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 selected control command is not accepted, because an interlocking condition is not met, then an error message appears in the display. The message indicates why the command was not accepted (see also SIPROTEC® 4 System Description /1/). This message must be acknowledged with Enter before any further control commands can be issued.

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 the SIPROTEC® 4 System Description (Control of Switchgear).

Operation using the System Interface

Control of switching devices can be performed via the serial system interface and a connection to the switchgear control system. For this the required peripherals physically must exist both in the device and in the power system. Within the device also specific settings have to be made for the serial interface (see SIPROTEC® 4 System Description).

2.36.2 Types of Commands

In conjunction with the power system control the following command types can be distinguished for the device:

2.36.2.1 Functional 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/reset the additional "information status" of a process object, such as:
  – Input blocking
  – Output Blocking

2.36.3 Command Sequence

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, for each resource separately further interlocks can be configured. The actual execution of the command job also is then monitored. The entire sequence of a command job is described briefly in the following:

2.36.3.1 Functional 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 (interlocked/non-interlocked) → selection of de-interlocking status.
- User-Configurable Command Checks
  - Switching authority
  - Device Direction Check (scheduled vs. actual comparison)
  - Interlocking, Bay Interlocking (logic using CFC)
  - Interlocking, System Interlocking (centrally, using SICAM)
  - Double Operation Locking (interlocking against parallel switching operations)
  - Protection Blocking (blocking of switching operations by protective functions)
- fixed command checks
  - Timeout Monitoring (time between initiation of the command and its completion).
  - Configuration in Process (if configuration is in process, commands are rejected or delayed)
  - Equipment available as output (if a resource was configured, but not allocated to a binary input, the command is rejected)
  - Output Blocking (if output blocking has set object-specifically and the command is currently active, then the command is rejected)
  - Module hardware error
  - Command for this resource already active (only one command can be processed at a time for a resource, object-related Double Operation Block)
  - 1–of–n check (for multiple allocations such as common contact relays, whether a command procedure was already initiated for the output relays concerned is checked).

Command execution monitoring

The following is monitored:

- Interruption of a command procedure because of a Cancel Command
- Run Time Monitor (feedback indication monitoring time)

2.36.4 System Interlocking

Interlocking can be executed by the user-defined logic (CFC).

2.36.4.1 Functional Description

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).

Deactivated interlock switching means that the configured interlocking conditions are not checked in the relay.

Interlocked switching means that all configured interlocking conditions are checked within the command processing. If a condition is not fulfilled, the command will be rejected by a message with a minus added to it (e.g. "**CO–**"), immediately followed by a message.

The following table shows some types of commands and messages. For the device the messages designated with *) are displayed in the event logs, for DIGSI®, 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. The minus sign means a negative confirmation, the command was rejected. Possible command feedbacks and their causes are dealt with in the SIPROTEC® 4 System Description. The following figure shows the messages relating to command execution and operation response information for a successful operation of the circuit breaker.

The check of interlockings can be programmed separately for all switching devices and tags that were set with a tagging command. Other internal control actions, such as manual entry or cancel are not tested, i.e. carried out independent of the interlocking.

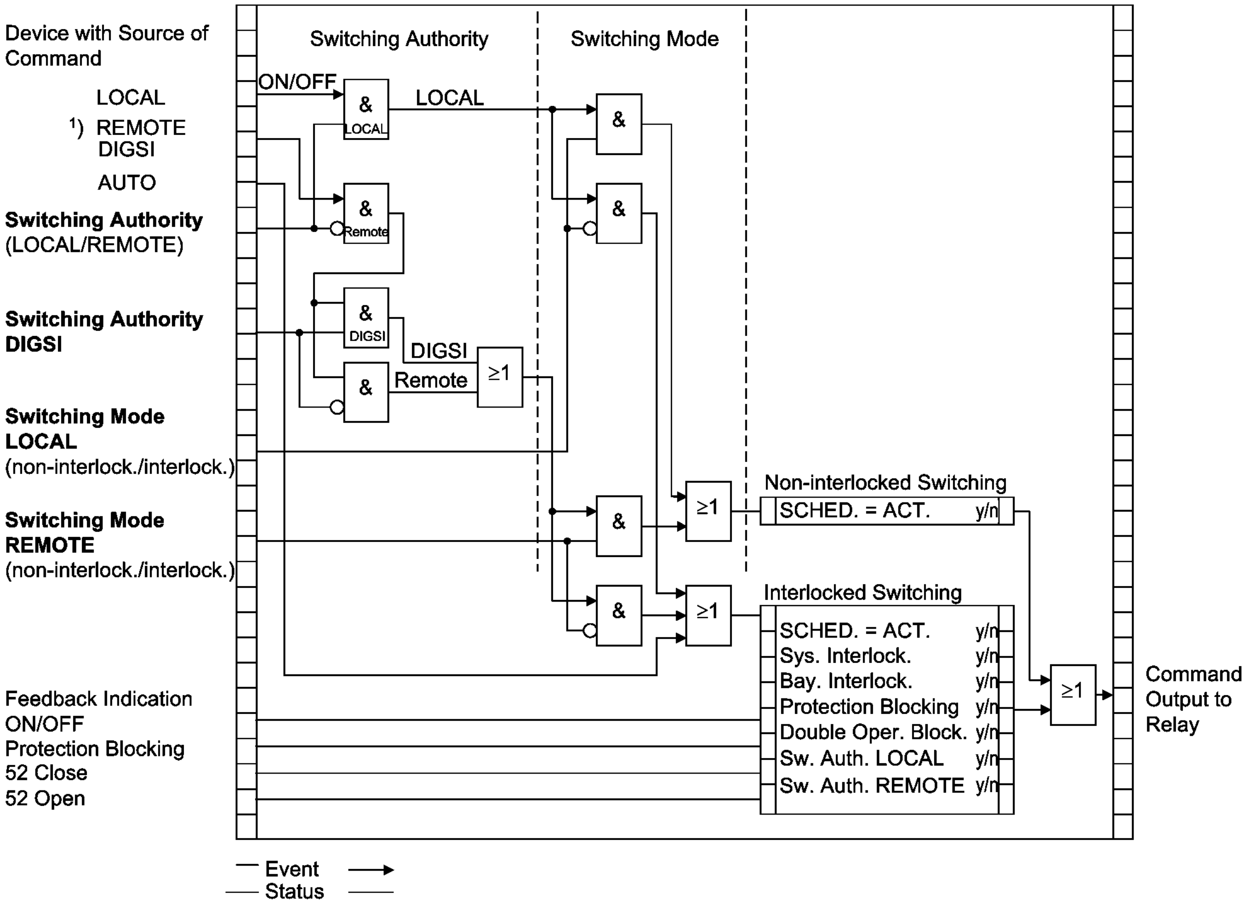
```
EVENT LOG
---------------------
19.06.01 11:52:05,625
Q0           CO+ Close

19.06.01 11:52:06,134
Q0           FB+ Close
```

Figure 2-81 Example of an operational indication for switching circuit breaker 52

Standard Interlocking (fixed programming)

The standard interlockings contain the following fixed programmed tests for each switching device, which can be individually enabled or disabled using parameters:

- Device Status Check (set = actual): The switching command is rejected, and an error indication is displayed if the circuit breaker is already in the set position. If this check is enabled, then it works whether interlocking, e.g. zone controlled, is activated or deactivated.
- System Interlocking: To check system interlocking, a local command is transmitted to the central unit with Switching Authority = LOCAL. A switching device that is subject to system interlocking cannot be switched by DIGSI®.
- Zone Controlled / Bay Interlocking: Logic links in the device which were created via CFC are interrogated and considered during 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 Block: Parallel switching operations are interlocked against one another; while one command is processed, a second one 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®) is only allowed if REMOTE control is admissible at the device (by configuration). If a DIGSI® PC connects to the device, it deposits here its virtual device (VD) number. 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 2-82 Standard interlockings

The following figure shows the configuration of the interlocking conditions using DIGSI®.

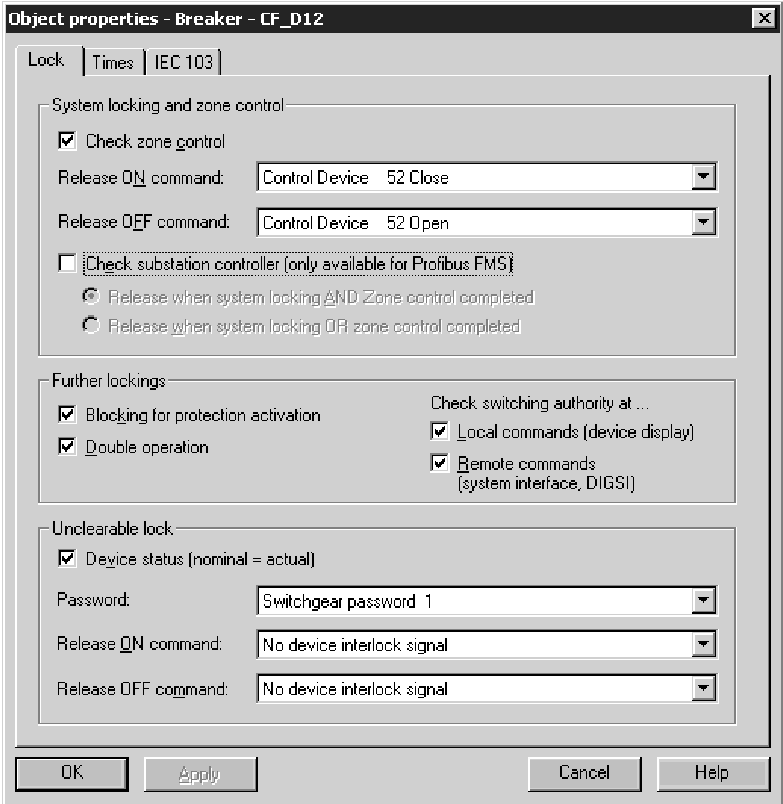


Figure 2-83 DIGSI®–dialog box for setting the interlocking conditions

For devices with operator panel the display shows the configured interlocking reasons. They are marked by letters explained in the following table.

Table 2-14 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)	P	P
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.

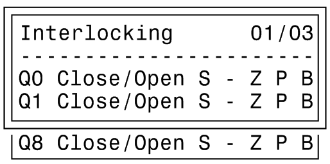


Figure 2-84 Example of configured interlocking conditions

Enabling Logic via CFC

For the bay interlocking a control logic can be structured via the CFC. Via specific release conditions the information "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 command source. The following switching authority zones are defined in the following priority sequence:

- LOCAL
- DIGSI®
- REMOTE

The object "Switching Authority" serves to interlock or enable LOCAL control, but not remote or DIGSI ® commands. For the 7UM61 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.

The "Switching authority DIGSI®" is used for interlocking or allows 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 DIGSI® available	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 ® commands: y/n

Table 2-15 Interlocking logic

Current Switching Authority Status	DIGSI® switching authority:	Command issued with SC[3]=LOCAL	Command issued from SC=LOCAL or REMOTE	Command with SC=DIGSI®
LOCAL (ON)	not logged on	not allocated	interlocked [2] - "interlocked, since control LOCAL"	interlocked - "DIGSI® not logged on"
LOCAL (ON)	logged on	not allocated	interlocked [2] - "interlocked, since control LOCAL"	interlocked [2] - "interlocked, since control LOCAL"
REMOTE (OFF)	not logged on	interlocked [1] - "interlocked, since control REMOTE"	not allocated	interlocked "DIGSI® not logged on"
REMOTE (OFF)	logged on	interlocked [1] - "interlocked, since DIGSI® control"	interlocked "interlocked, since DIGSI® control"	not allocated

[1] also "allowed" for: "Switching Authority LOCAL (check for Local status): is not marked

[2] also "allowed" for: "Switching Authority REMOTE (check for LOCAL, REMOTE, or DIGSI® commands): is not marked

[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 (de-interlocked) switching.

For the 7UM61 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.

The following switching modes (remote) are defined:

- For 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 notes in the CFC manual (component: BOOL to command).

Zone Controlled / Field Interlocking

Zone controlled / field interlockings (e.g. via CFC) includes the verification that predetermined switchgear position conditions are satisfied to prevent switching errors (e.g. disconnector vs. ground switch, ground switch only if no voltage applied) as well as verification of the state of other mechanical interlocking in the switchgear bay (e.g. High Voltage compartment doors open against CB closing).

Interlocking conditions can be programmed separately for device control CLOSE and/or OPEN.

The enable information with the data "switching device is interlocked (OFF/NV/FLT) or enabled (ON)" can be set up,

- directly, using a single point or double point indication, key-switch, or internal indication (marking), or
- by means of a control logic via CFC.

When a switching command is initiated, the actual status is scanned 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. As soon as the command has arrived all command objects subject to the interlocking are checked to know whether a command is being processed. While the command is being executed, interlocking is enabled for other commands.

Blocking by Protection

Protection functions then block switching operations. Protective elements are configured, separately for each switching component, to block specific switching commands sent in CLOSE and TRIP direction.

When enabled, "Block CLOSE commands" blocks CLOSE commands, whereas "Block TRIP commands" blocks TRIP signals. Switching operations in progress will immediately be aborted by the pickup of a protective element.

Device Status Check (set = actual)

For switching commands, a check takes place whether the selected switching device is already in the set/desired position (set/actual comparison). This means, if a circuit breaker is already in the CLOSED position and an attempt is made to issue a closing command, the command will be refused, with the operating message "set condition equals actual condition". If the circuit breaker/switchgear device is in the intermediate position, then this check is not performed.

Bypassing Interlocking

Bypassing configured interlocks at the time of the switching action happens device-internal via interlocking recognition in the command job or globally via so-called switching modes.

- SC=LOCAL
  - The switch modes "interlocked" or "non-interlocked" (de-interlocked) can be switched over for the 7UM61 in the operator control panel after password entry.
- 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 <u>one</u> switching operation and for command caused by the same source.
  - Job order: command to object "Switching mode REMOTE", ON
  - Job order: switching command to "switching device"
- Derived commands via CFC (automatic command, SC=Auto):
  - Behaviour configured in the CFC block ("BOOL to command").

2.36.5 Command Logging/Acknowledgement

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.

2.36.5.1 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 monitoring time is started (monitoring of the command execution). This time 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 and a message is output.

The "plus" sign appearing in a feedback information confirms that the command was successful. The command was as expected, in other words positive. 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

General

WARNING!

Warning of improper transport, storage, installation or erection of the device.

Failure to observe these precautions can result in death, personal injury or substantial property damage.

Unproblematic and safe use of this device depends on proper transport, storage, installation and erection of the device taking into account the warnings and instructions of the device manual.

In particular the general installation and safety regulations for working in power current installations (for example, ANSI, IEC, EN, DIN, or other national and international 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 tested as recommended in the SIPROTEC 4 System Description /1/ and their compliance with these data is verified with the Power System Data.

Connection Variants

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 2.3, corresponds with the connections.

Currents / Voltages

Connection diagrams are shown in the Appendix. Current and voltage transformer connection possibilities for busbar connection (address 272 **SCHEME** = ***Busbar***) and for unit connection (address 272 = ***Unit transf.***) are given in the appendix A.3. In all examples the CT starpoints point towards the protection object so that address 210 **CT Starpoint** must be set to ***towards machine***.

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 the 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.

The factor 213 **FACTOR IEE** considers the transformation ratio between the primary and the secondary side of the summation current transformer when using the sensitive current input in the corresponding connection example.

Example:

Summation current transformer 60 A / 1 A

Matching factor for sensitive earth fault current detection: **FACTOR IEE** = ***60***

In the appendix “the busbar system with low-ohmic earthing” is low-ohmic earthed at the generator starpoint. 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_{EE} 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 IEE** is set to ***1***. Balanced DE current transformers (winding balance) are recommended for this type of circuit.

In the appendix the “unit connection example with isolated starpoint”, 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 U_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:

$$\frac{U_{N\ prim.}}{\sqrt{3}} / \frac{U_{N\ sec.}}{\sqrt{3}} / \frac{U_{N\ sec.}}{3}$$

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.

The factor 224 **FACTOR UE** considers the transformation full 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

$$\textbf{FACTOR UE} = \left(\frac{6.3\ \text{kV}/(\sqrt{3})}{500\ \text{V}} \cdot \frac{5}{1}\right) = 36.4$$

Instructions - see section 2.3 under "Transformation ratio CTR_E".

In the “unit connection with neutral transformer” example, in the appendix, 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 higher secondary voltage thereby resulting can be reduced by a voltage divider. Address 223 **UE CONNECTION** is set to ***neutr. transf.***.

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 IEE** considers the transformation ratio between the primary and the secondary side of the summation current transformer when using current input I_{EE}.

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 presettings 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 switch setting groups, the following must be observed:

- If the configuration is performed from the operator panel or using DIGSI®, at address 302 **CHANGE** the option must be set using ***Binary Input***.
- One binary input is sufficient for controlling 2 setting groups, ">Param. This is ">Param.Selection1", since the nonallocated binary input " "Param.Selection2" is considered as not activated.
- 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 that the selected setting group remains active.

Trip Circuit Monitoring

A circuit with two binary inputs (see Section 2.29) 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 2.29). Please note that the response times are as long as approx. 300 s. Section 2.29.2 shows how the resistance is calculated.

3.1.2 Hardware Modifications

3.1.2.1 General

General

Subsequent adaptation of hardware to the power system conditions can be necessary for example with regard to the control voltage for binary inputs or termination of bus-capable interfaces. The specifications of Section should be observed in all cases whenever hardware modifications are made.

Auxiliary Voltage

There are different power supply voltage ranges for the auxiliary voltage (refer to the Ordering Information in Appendix). The versions for 60/110/125 VDC and 110/125/220/250 VDC, 115 VAC are interchangeable by altering jumper settings. 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 B-CPU". When the relay is delivered, all jumpers are set according to the name-plate sticker. In general they need not be altered.

Life Contact

The life contact of the device is a changeover contact, from which either the opener or closer can be applied to the device connections F3 and F4 via a jumper (X40). Allocations of jumpers to the contact type and the spatial layout of the jumpers are described in this section under the margin heading "Processor Board B-CPU".

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. Jumper allocation to nominal current and their spatial arrangement are described in this section under the margin heading "Input/Output Module C–I/O –2". All jumpers must be set for one nominal current, i.e. one jumper (X61 to X64) for each input transformer and additionally the common jumper X60.

If nominal current ratings are changed exceptionally, then the changes must be set in parameters 212 **CT SECONDARY** in the Power System Data (see Section 2.3).

Note

The jumper settings must correspond to the secondary device currents configured at address 212. Otherwise the device is blocked and issues 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.

Type of Contact for Output Relays

Input and output boards can contain relays whose contact can be set as normally closed or normally open. For this it is necessary to alter a jumper. For which relay on which board this applies is described in this section under margin heading "Input/Output Board C–I/O –2" and "Input/Output Board C–I/O -1".

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 RS 485 bus or the electrical Profibus DP must be terminated in each case at the last device on the bus with resistors. The PCB of the B–CPU processor module and the RS485 or Profibus interface module are equipped for this purpose with terminating resistors that are switched in by means of jumpers. Only one of the three options may be used for this. The physical location of the jumpers on the PCB is described in this section under the margin title "Processor Module B–CPU", and under the margin title "Bus-Capable Serial Interfaces" for the interface modules. Both jumpers must be always plugged in identically.

The terminating resistors are disabled on unit delivery.

Spare Parts

Spare parts can be the battery for storage of data in the battery-buffered RAM in case of a power failure, and the internal power supply miniature fuse. Their spacial allocation is shown in Figures 3-3 and 3-4. The ratings of the fuse are printed on the board next the fuse itself. When replacing the fuse, please observe the guidelines given in the SIPROTEC®4 System Description /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.

To perform work on the boards, such as checking or altering switching elements or replacing modules, the buffer battery or the miniature fuse, proceed as follows:

Caution!

Caution when changing jumper settings that affect nominal values of the device

As a consequence, the order number (MLFB) and the ratings on the nameplate no longer match the actual device properties.

If changes are necessary under exceptional circumstances, the changes should be clearly and fully marked on the device. Self adhesive stickers are available that can be used as supplementary nameplates.

To perform work on the PCBs, such as checking or moving switching elements or replacing modules, proceed as follows:

- Prepare area of work: Provide a suitable underlay for electrostatically sensitive components (ESD). Also the following tools are required:
  - screwdriver with a 5 to 6 mm wide tip,
  - a Philips screwdriver size 1,
  - a 4.5mm socket wrench.
- On the rear panel, remove the studs of the DSUB sockets at slots "A" and "C". This is not necessary if the device is designed for surface mounting.
- If there is an additional interface at locations "B" and "D" next to the interfaces at locations "A" and "C", remove in each case the screws located diagonally to the interfaces. This is not necessary if the device is designed for surface mounting.
- Remove the caps on the front cover and loosen the screws that become accessible.
- Remove the front panel and place it carefully to the side.

Work on the Plug Connectors

Caution!

Take caution with 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 with earthed metal parts beforehand.

Do not plug or unplug interface connectors under voltage!

The following must be observed:

- Release the connector of the ribbon cable between B–CPU processor module (1) and front cover at the front cover itself. Press the top latch of the plug connector up and the bottom latch down so that the plug connector of the ribbon cable is pressed out.
- Disconnect the ribbon cables between the B–CPU (1) board and the I/O boards ((2) to (4), depending on the variant ordered).
- Remove the modules and place them on a surface suitable for electrostatically sensitive modules (ESD). In the case of the device variant for panel surface mounting, note that a certain amount of force is required in order to remove the B-CPU board due to the existing plug connector.
- Check the jumpers in accordance with Figures 3-3 to 3-6 and the following information, and as the case may be change or remove them.

The locations of the boards are shown in Figure 3-1 (for 1/3 size housing) and in Figure 3-2 (for 1/2 size Housing).

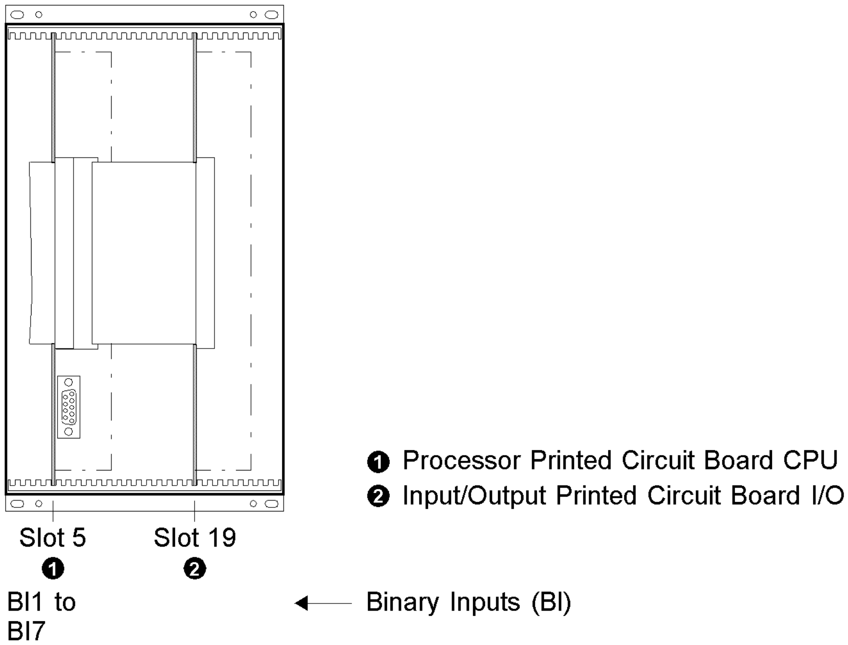


Figure 3-1 7UM611: Front view with housing size 1/3 after removal of the front cover (simplified and scaled down).

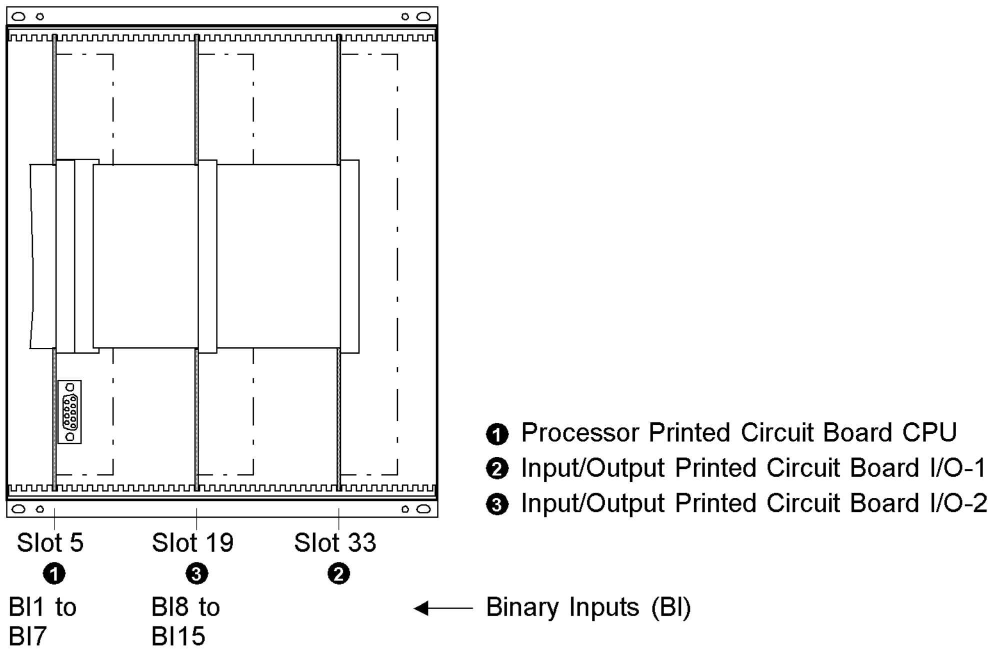


Figure 3-2 7UM612: Front view with housing size 1/2 after removal of the front cover (simplified and scaled down)

3.1.2.3 Switch Elements on the PCBs

Processor board B–CPU for 7UM61.../BB

There are two different releases of the B–CPU board a different layout and setting of the jumpers. The following figure depicts the layout of the PCB for processor board version up to 7UM61.../BB.

The location and ratings of the miniature fuse (F1) and of the buffer battery (G1) are shown in the following figure.

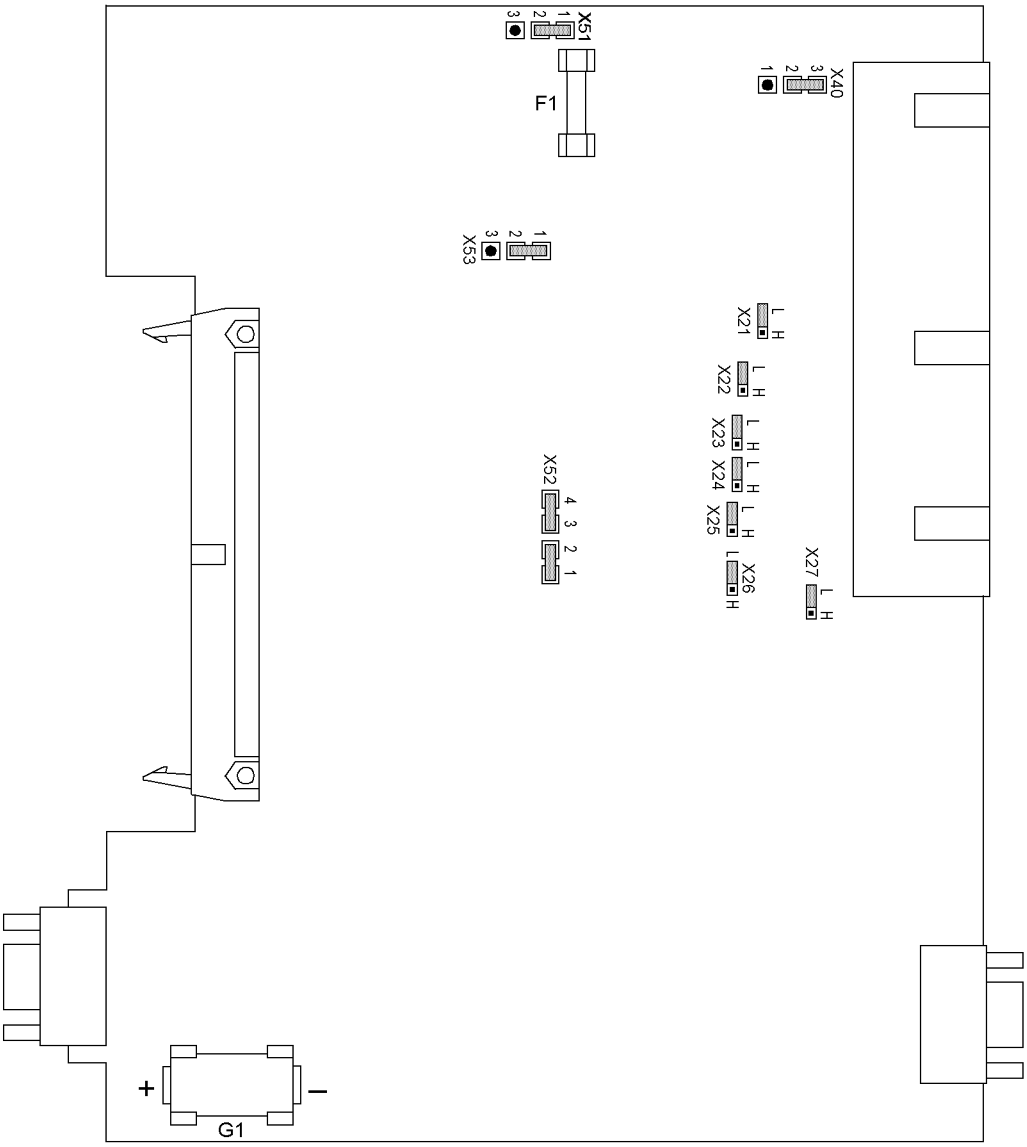


Figure 3-3 Processor module CPU with representation of the jumpers required for checking the settings

For devices up to release 7UM61.../BB check the jumpers for the set nominal voltage of the integrated power supply according to Table 3-1, the quiescent state of the life contact according to Table 3-2 and the selected pickup voltages of the binary inputs BI1 through BI7 according to Table 3-3.

Table 3-1 Jumper settings for nominal voltage of the integrated **power supply** on the processor printed circuit board B–CPU for 7UM61.../BB

Jumper	**Rated voltage**		
	60/110/125 VDC	**110/125/220/250 V DC** **115 V AC**	**24/48 VDC**
X51	1–2	2–3	Jumpers X51 to X53 Not used
X52	1–2 and 3–4	2–3	
X53	1–2	2–3	
	interchangeable		cannot be changed

Table 3-2 Jumper setting for the quiescent state of the **life contact** on the B–CPU processor PCB for 7UM61.../BB

Jumper	Open in the quiescent state	Closed in the quiescent state	Presetting
X40	1–2	2–3	2–3

Table 3-3 Jumper settings for the **control voltages** of binary inputs BI1 through BI7 on the B–CPU processor PCB for 7UM61.../BB

Binary Inputs	Jumper	19 V Threshold 1)	88 V Threshold 2)
BI1	X21	L	H
BI2	X22	L	H
BI3	X23	L	H
BI4	X24	L	H
BI5	X25	L	H
BI6	X26	L	H
BI7	X27	L	H

1) Factory settings for devices with rated power supply voltages 24 VDC to 125 VDC

2) Factory settings for devices with rated power supply voltages 110 VDC to 220 VDC and 115/230 VAC

Processor board B–CPU for 7UM61.../CC

The following figure depicts the PCB layout for devices from version 7UM61.../CC. The location of the miniature fuse (F1) and of the buffer battery (G1) are shown in the following figure.

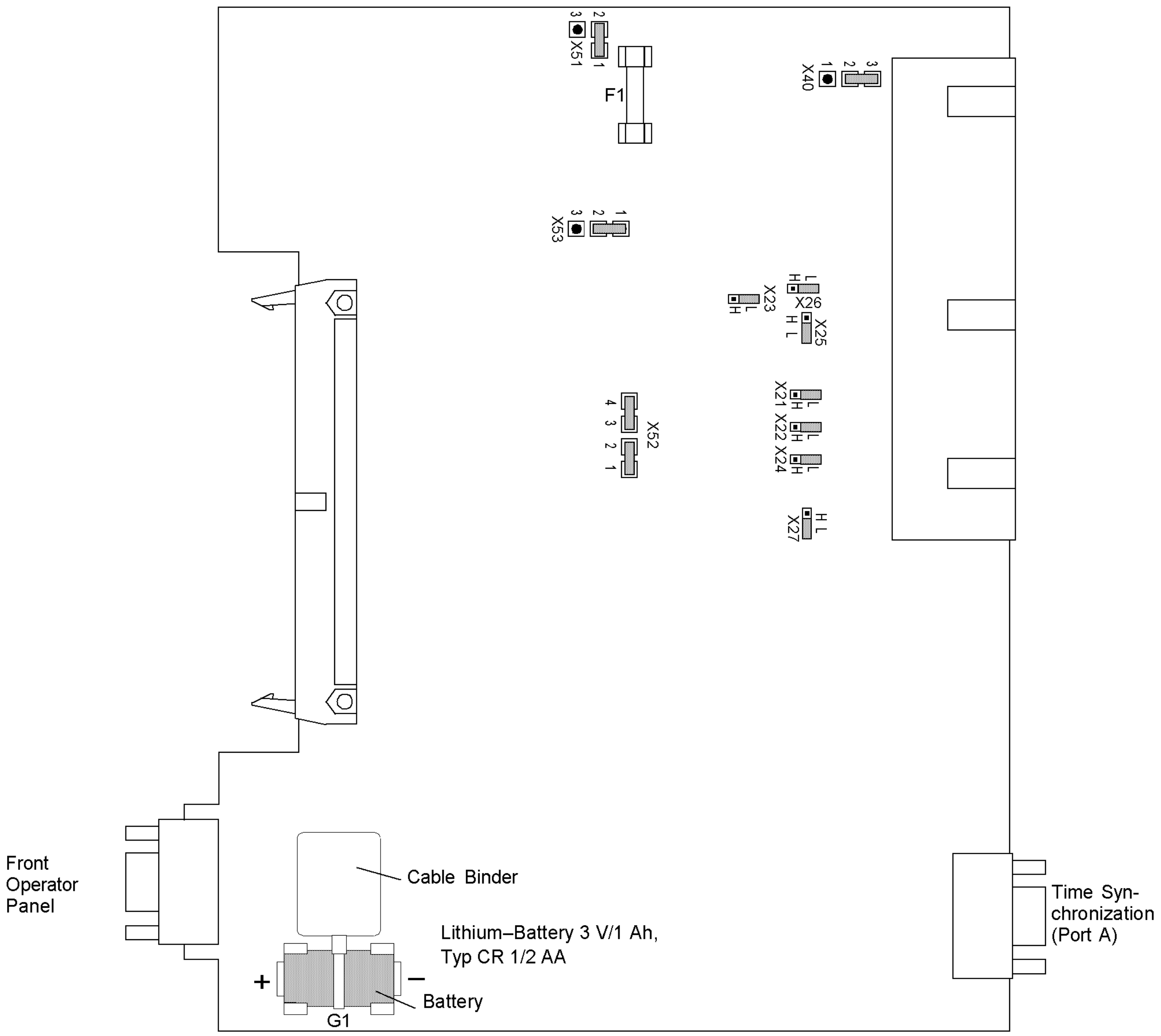


Figure 3-4 B–CPU processor PCB for devices from version.../CC with jumper settings required for checking configuration settings

For devices from version 7UM61.../CC, the jumpers for the set nominal voltage of the integrated power supply are checked in accordance with Table 3-4, the quiescent state of the life contact in accordance with Table 3-5 and the selected control voltages of binary inputs BI1 through BI7 accordance with Table 3-6.

Table 3-4 Jumper setting for nominal voltage of the integrated **power supply** on the B–CPU processor PCB for 7UM61.../**CC**

Jumper	Rated voltage		
	60/110/125 VDC	**220/250 VDC** **115/230 VAC**	**24/48 VDC**
X51	1–2	2–3	1–2
X52	1–2 and 3–4	2–3	none
X53	1–2	2–3	none

Table 3-5 Jumper setting for the quiescent state of the **life contact** on the B–CPU processor PCB for 7UM61.../**CC** devices.

Jumper	Open in the quiescent state	Closed in the quiescent state	Presetting
X40	1–2	2–3	2–3

Table 3-6 Jumper settings for the **control voltages** of binary inputs BI1 through BI7 on the B–CPU processor PCB for 7UM61.../**CC**

Binary Inputs	Jumper	19 V Threshold 1)	88 V Threshold 2)
BI1	X21	L	H
BI2	X22	L	H
BI3	X23	L	H
BI4	X24	L	H
BI5	X25	L	H
BI6	X26	L	H
BI7	X27	L	H

1) Factory settings for devices with rated power supply voltages 24 VDC to 125 VDC

2) Factory settings for devices with power supply voltages of 220 VDC to 250 VDC and 115/230 VAC

C–I/O–1 Input / Output Board

The layout of the input/output board C-I/O-1 is shown in the following Figure.

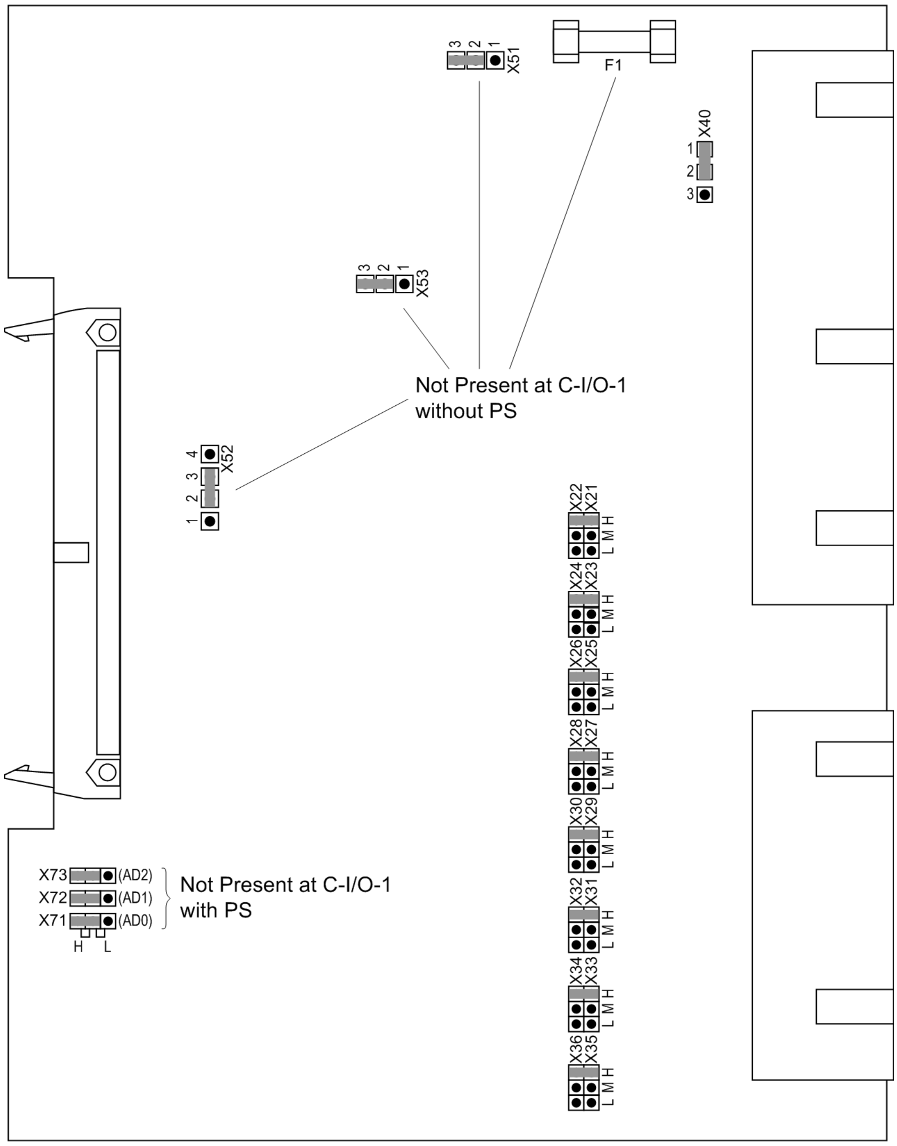


Figure 3-5 Input/output board C-I/O-1 with representation of the jumper settings required for the board configuration

In the version 7UM612 , for the Input/Output module C–I/O–1, binary output BO 4 can be configured as normally open or normally closed (see also overview diagrams in Appendix A.2).

Table 3-7 Jumper Setting for Relay Contact for Binary Output BO4

Jumper	Normally open contactor	Normally closed contact	Presetting
X40	1–2	2–3	1–2

Table 3-8 Jumper setting of control voltages of binary inputs BI1 to BI8 on Input/Output module module C– I/O–1 in the 7UM612

Binary Inputs	Jumper	19 V Threshold 1)	88 V Threshold 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 24 VDC to 125 VDC
2) Factory settings for devices with rated power supply voltages 110 VDC to 220 VDC and 115/230 VAC
3) Use only with control voltages 220 VDC or 250 VDC

Jumpers X71, X72 and X73 on the C–I/O–1 board serve to set the bus address. The jumpers must not be changed. The following table lists the jumper presettings.

The installation locations of the boards are shown in Figures 3-1 to 3-2 .

Table 3-9 Module address jumper setting of input/output module C-I/O-1 for 7UM612

Jumper	**Factory Setting**
X71	L
X72	H
X73	H

C-I/O-2 Input / Output Module

PCB layout for the C-I/O-2 board is shown in the following Figure.

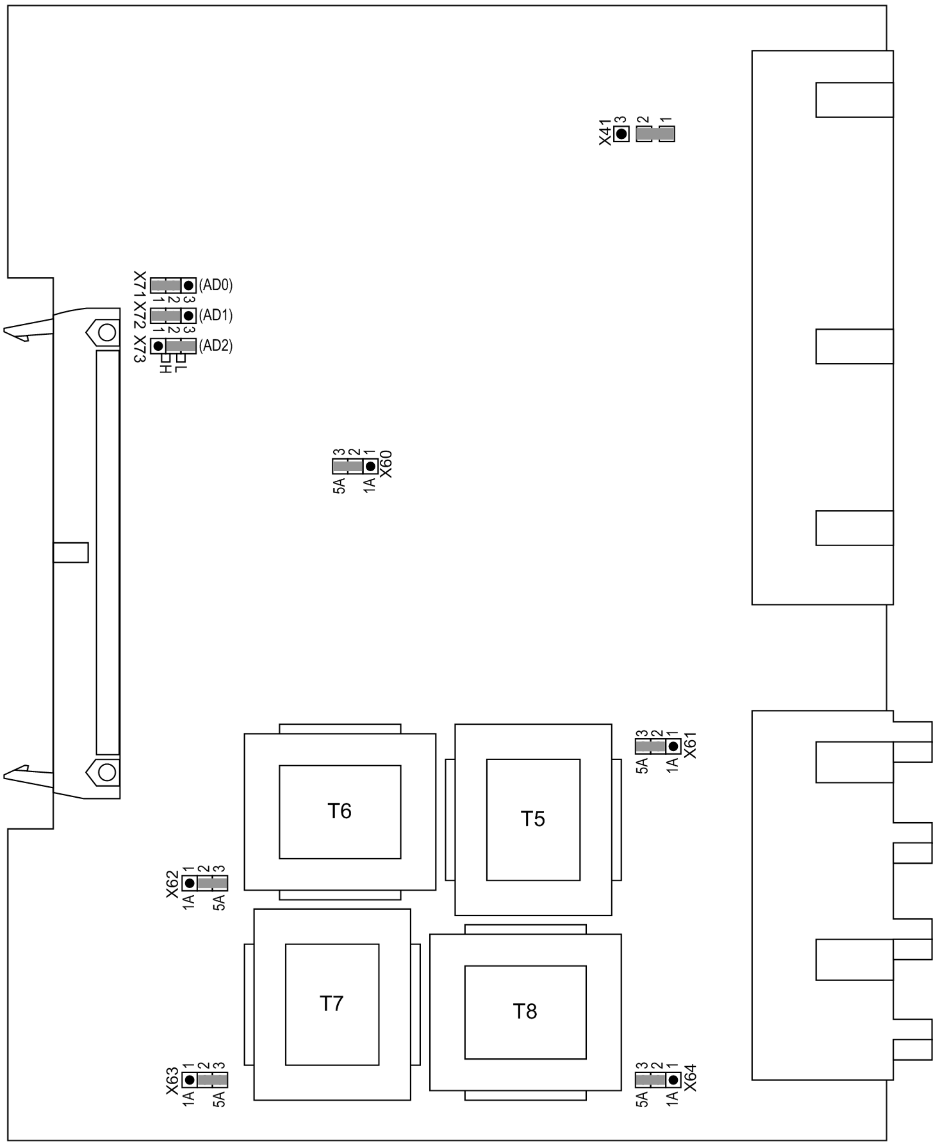


Figure 3-6 Input/output board C–I/O-2 with representation of jumper settings required for checking configuration settings

The relay contact for binary output BO17 can be configured as normally open or normally closed (see overview diagrams in Appendix A.2):

Table 3-10 Jumper Setting for Relay Contact for Binary Output BO17

Jumper	Normally open contactor	Normally closed contact	Presetting
X41	1–2	2–3	1–2

The set rated current settings of the input current transformers are checked on the Input/Output C-I/O-2 board. All jumpers must be in the same position for a rated current, i.e. there must be one jumper each (X61 through X64) for each of the input transformers, and also the common jumper X60. However: In the version with sensitive earth fault current input (input transformer T8) there is no jumper X64.

Jumpers X71, X72 and X73 on the Input/Output C-I/O-2 board are used to set the bus address and may not be changed. The following Table shows the factory setting of the jumpers.

Table 3-11 Module address jumper settings of input/output modules C-I/O-2

Jumper	Factory Setting
X71 (AD0)	1-2 (H)
X72 (AD1)	1-2 (H)
X73 (AD2)	2-3 (L)

3.1.2.4 Interface Modules

Replacing Interface Modules

The interface modules are located on the B–CPU processor board ((1) in Figure 3-1 and 3-2). The following figure shows the PCB with location of the modules.

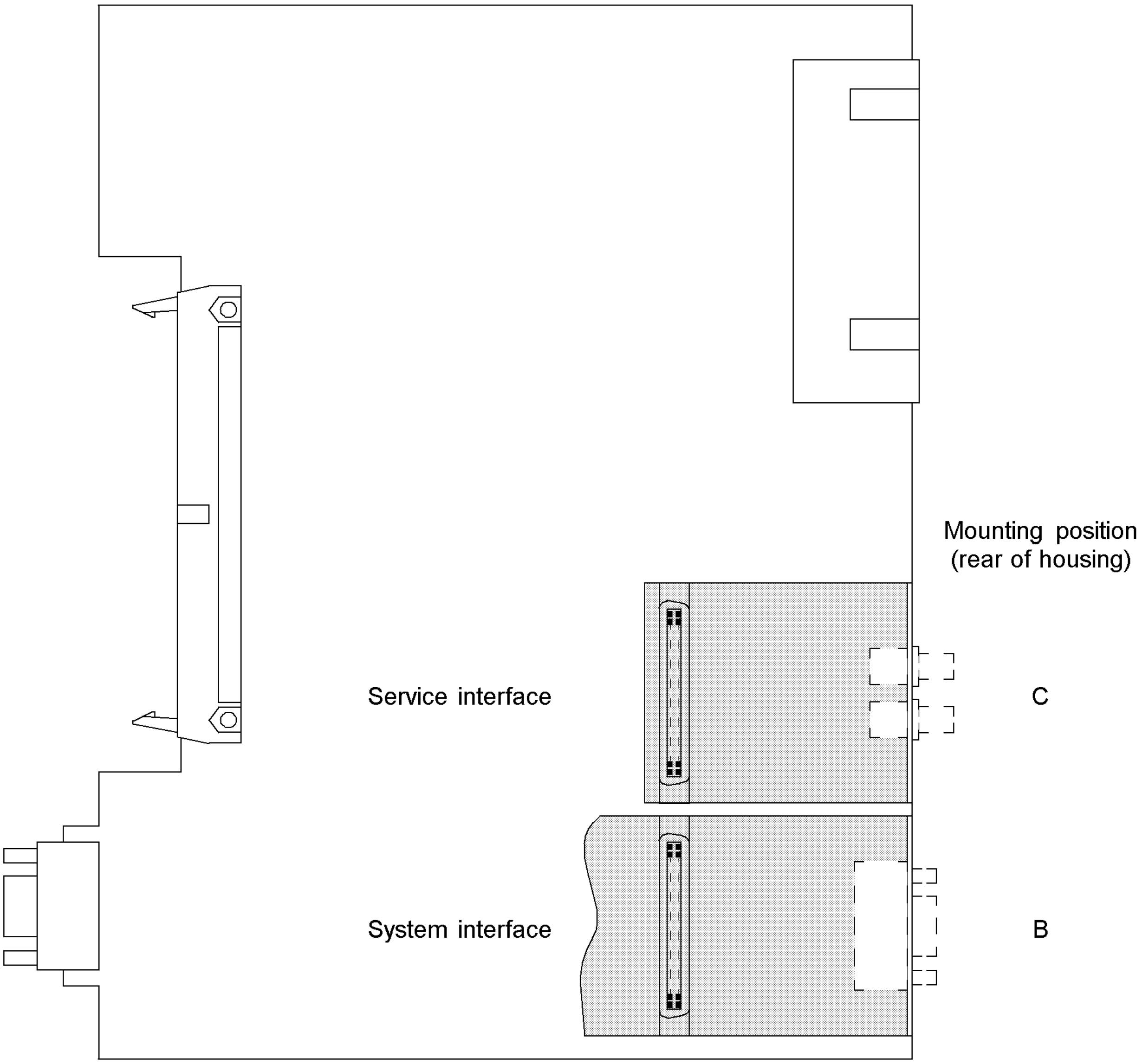


Figure 3-7 Processor board CPU with interface modules

Please note the following:

- Exchange of interface modules is possible only with panel flush mounting and cubicle mounting devices as well as of mounting devices with detached or with no operator panel.

  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 be ordered from the factory also in accordance with the order number (see also Appendix A.1).

Table 3-12 Replacement modules for interfaces

Interface	Mounting Location / Port	Replacement module
System interface	B	RS232
		RS 485
		FO 820 nm
		Profibus DP RS485
		Profibus DP double ring
		Modbus RS 485
		Modbus 820 nm
		DNP3.0, RS 485
		DNP 3.0 820 nm
Service interface	C	RS232
		RS 485
		FO 820 nm

The order numbers of the exchange modules can be found in the Appendix in Section A.1.

Serial Interfaces withBusCapability

For bus-capable interfaces a termination is necessary at the bus for each last device, i.e. termination resistors must be connected. In the case of the 7UM61, these are variants with RS485 or Profibus interfaces.

The terminating resistors are located on the RS485 or Profibus interface module, which is on the B–CPU processor board ((1) in Figure 3-1 and 3-2), or directly on the p.c.b. of the B_CPU processor PCB (see under margin heading "Processor module B–CPU", Table 3-2).

Figure 3-7 shows the B–CPU PCB with location of the modules.

The module for the RS485 interface is shown in Figure 3-8, the module for the Profibus interface in Figure 3-9.

On delivery the jumpers are set so that the termination 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

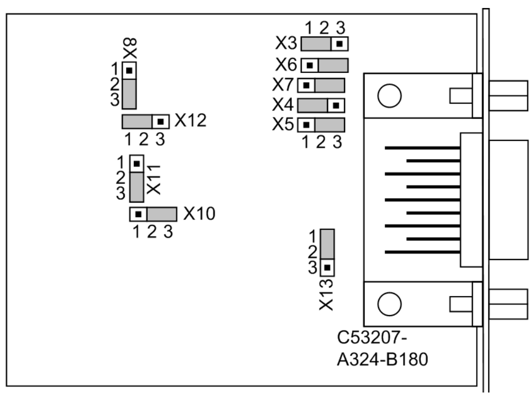


Figure 3-8 Position of terminating resistors and the plug-in jumpers for configuration of the RS485 interface

Jumper	Terminating Resistors	
	Connected	Disconnected
X3	1-2	2-3 *)
X4	1-2	2-3 *)

*) Default Setting

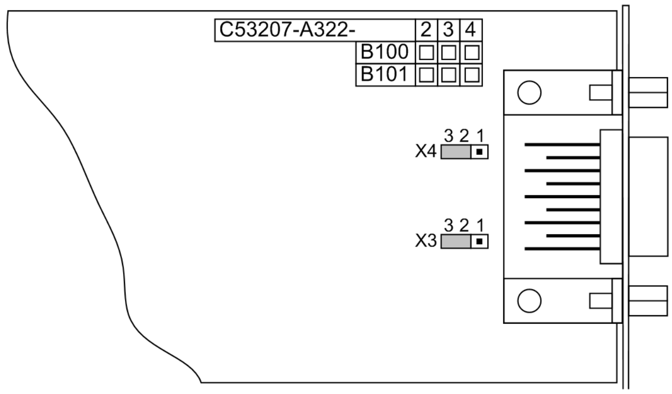


Figure 3-9 Position of the plug-in jumpers for configuration of terminating resistors of the Profibus interface

The terminating resistors can also be connected externally (e.g. to the connection module). In this case the terminating resistors provided on the RS485/Profibus interface module or directly on the B–CPU processor PCB must be switched out.

It is possible to convert the R485 interface to a RS232 interface by changing the jumper positions and vice-versa.

The jumper positions for the alternatives RS232 or RS485 (as in Figure 3-8) are derived from the following Table.

Table 3-13 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!

When the device is delivered from the factory, the jumper settings correspond to the configuration ordered.

3.1.2.5 Reassembly

The device is assembled in the following steps:

- Insert the modules carefully in the housing. The installation locations of the boards are shown in Figures 3-1 to 3-2. For the surface mounting device, press the metal lever when inserting the B–CPU processor PCB. This facilitates connector insertion.
- First, plug the connector of the ribbon cable onto the input/output module I/O and then onto the B–CPU processor module. Be careful that no connector pins are bent! Do not apply force!
- Insert the plug connector of the ribbon cable between the B–CPU processor module and the front cover into the socket of the front cover.
- Press the plug connector interlocks together.
- Replace the front panel and screw it tightly to the housing.
- Replace the covers again.
- Screw tightly again the interfaces on the device rear. This is not necessary if the device is designed for surface mounting.

3.1.3 Mounting

3.1.3.1 Panel Flush Mounting

Depending on the version, the housing size can be $^{1}/_{3}$ or $^{1}/2$.

- Remove the 4 covers on the corners of the front plate. This gives access to the 4 or 6 slots in the mounting flange.
- Insert the device into the control panel section and tighten it with 4 screws. For dimensions refer to Section 4.26.
- Replace the 4 covers.
- Connect a solid low-ohmic protection and system earthing to the rear of the unit with at least one M4 screw. The cross section of the wire used must correspond to the maximum cross section area connection, but 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 circuit 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/ specifications regarding wire cross sections, tightening torques, bending radii and strain relief must always be observed.

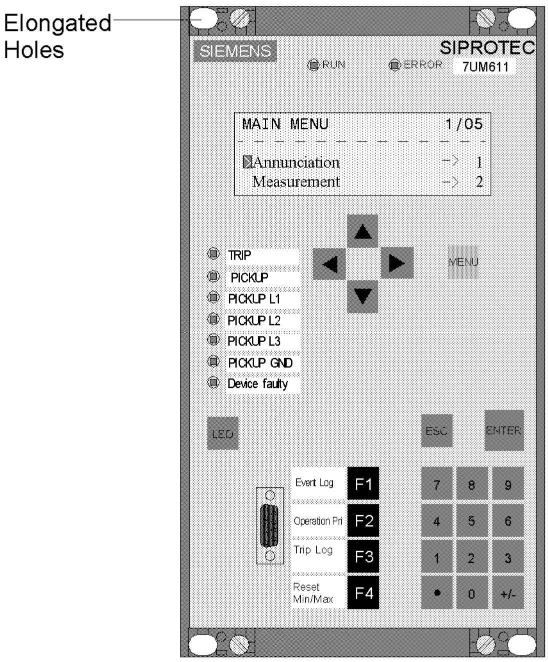


Figure 3-10 Panel flush mounting of a 7UM611

3.1.3.2 Rack Mounting and Cubicle Mounting

For housing size $^1/_3$ and $^1/_2$ 4 covering caps and 4 securing holes are provided.

To install the device in a frame or cubicle, two mounting brackets are required. Order numbers are given in the Appendix under A.1.

- First screw loose the two angle brackets in the rack or cabinet, each with four screws.
- Remove the 4 covers on the corners of the front plate. This accesses the 4 slots in the mounting bracket.
- Tighten the unit with 4 screws at the angle brackets.
- Replace the 4 covers.
- Tighten fast the 8 screws of the angle brackets in the rack or cabinet.
- Connect a solid low-ohmic proection and system earthing to the rear of the unit with at least one M4 screw. The cross section of the wire must be equal to the maximum connection cross section area but be at least 2.5 mm ^{2}.
- Make connections at the device rear using plug or screw terminals in accordance with the circuit diagram. When using spade lugs or directly connecting wires to threaded terminals, before cable insertion the screws must be tightened so that the heads are flush with the outside of the terminal block. A ring lug must be centred in the connection chamber so that the screw thread fits in the hole of the lug. The SIPROTEC 4 System Description /1/ specifications regarding wire cross sections, tightening torques, bending radii and strain relief must always be observed.

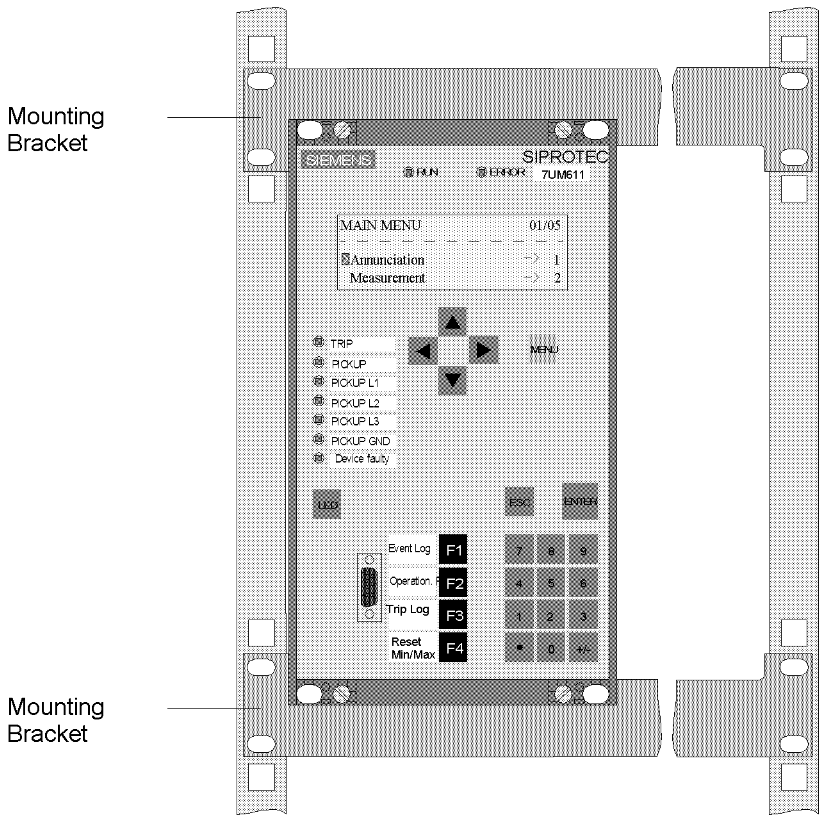


Figure 3-11 Installing a 7UM611 in a rack or cubicle (housing size 1/3)

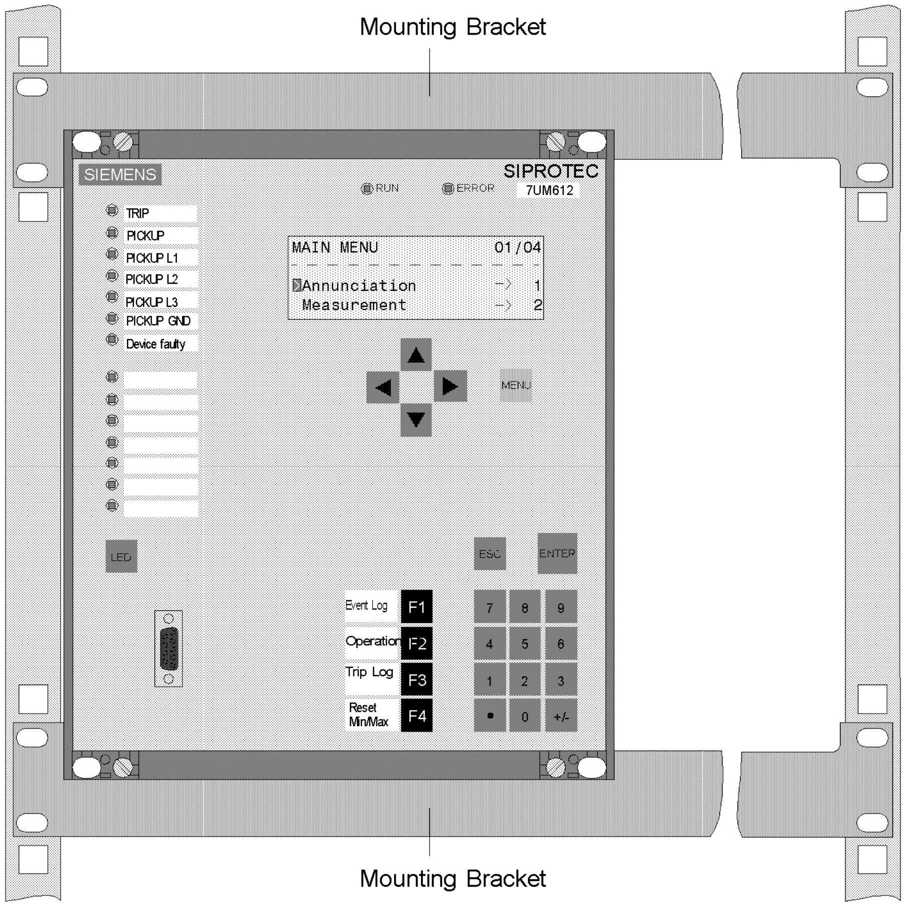


Figure 3-12 Installing a 7UM612 in a rack or cubicle (housing size 1/2)

3.1.3.3 Panel Surface Mounting

For installation proceed as follows:

- Secure the device to the panel with four screws. For dimensions see for the Technical Data in Section 4.26.
- Connect the ground of the device to the protective ground of the panel. 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}.
- Connect solid, low-impedance operational grounding (cross-sectional area = 2.5 mm^2) to the grounding surface on the side. Use at least one M4 screw for the device ground.
- Connect the threaded terminals on the top and bottom of the device according to the elementary diagram for the panel. The SIPROTEC® 4 System Description has pertinent information regarding wire size, lugs, bending radii, etc.

3.2 Checking Connections

3.2.1 Checking Data Connections of Serial Interfaces

Pin assignments

The following tables illustrate the pin assignment of the various serial device interfaces and of the time synchronization interface. The position of the connections can be seen in the following figure.

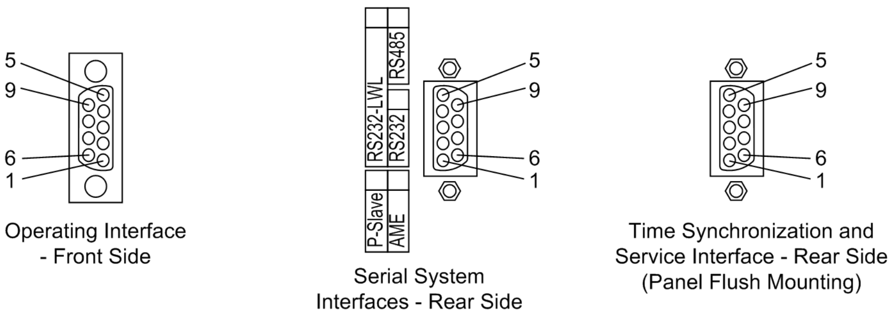


Figure 3-13 9-pin D-subminiature female connectors

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 for an ordering description of the cable.

SystemInterface

When a serial interface of the device is connected to a central substation control system, the data connection must be checked. A visual check of the transmit channel and the receive channel is important. With RS232 and fibre optic interfaces, each connection is dedicated to one transmission direction. The data output of one device must be connected to the data 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 is to be grounded at **both** line ends. In areas of extremely strong EMC interferences, the interference immunity factor can be improved by leading the ground wire in a separate shielded pair of strands.

Table 3-14 DSUB socket connections for the various interfaces

Pin No.	Operation interface	RS232	RS 485	Profibus DP Slave, RS 485	DNP3.0 Modbus, RS485
1	Shield (with shield ends electrically connected)				
2	RxD	RxD	–	–	–
3	TxD	TxD	A/A' (RxD/TxD–N)	B/B' (RxD/TxD–P)	A
4	–	–	–	CNTR–A (TTL)	RTS (TTL level)
5	GND	GND	C/C' (GND)	C/C' (GND)	GND1
6	–	–	–	+5 V (max. load 100 mA)	VCC1
7	–	$\overline{\text{RTS}}$	– [1]	–	–
8	–	$\overline{\text{CTS}}$	B/B' (RxD/TxD–P)	A/A' (RxD/TxD–N)	B
9	–	–	–	–	–

1) Pin 7 also can carry the RS232 RTS signal as an RS485 interface. Pin 7 may therefore not be connected!

Termination

The RS485 interface is capable of semi-duplex operation with signals A/A' and B/B' with the common reference potential C/C' (GND). It is necessary to check that the termination resistors are connected to the bus only at the last unit, and not at other devices on the bus. The jumpers for the terminating resistors are on the interface module RS485 (Figure 3-8) or on the Profibus module RS485 (Figure 3-9). The terminating resistors can also be connected externally (e.g. to the connection module). In this case, the terminating resistors located on the module must be disconnected.

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.

Time Synchronization Interface

It is optionally possible to process 5–V–, 12– V– or 24–V–time synchronization signals, provided that they are carried to the inputs named in the following table.

Table 3-15 D-SUB socket assignment of the time synchronization interface

Pin No.	Description	Signal Meaning
1	P24_TSIG	Input 24 V
2	P5_TSIG	Input 5 V
3	M_TSIG	Return Line
4	– [1]	– [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

Connections for the time synchronization interface for panel surface-mounted devices are described in the appendix.

Optical Fibers

WARNING!

Warning of Laser rays!

Non-observance of the following measures can result in death, personal injury or substantial property damage.

Do not look directly into the fiber-optic elements!

Signals transmitted via optical fibers are unaffected by interference. The fibers guarantee electrical isolation between the connections. Transmit and receive connections are represented by symbols.

The character idle state for the optical fiber 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.

3.2.2 Checking 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 Voltage Supply

Before the device is connected for the first time to voltage, 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 of the cubicle and the devices for damage, quality of connections etc., and earthing of devices.

SecondaryCheck

The check of the individual protection functions with regard to accuracy of pickup values and the characteristic itself should not be part of this check. In contrast to analog electronic or electromechanical protection, is not necessary to carry out this protection function check for the purpose of checking the device itself, since this is done by the works check. The protection function serves only to check the device connection.

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.

For any secondary checks to be carried out, where possible three-phase test equipment with currents and voltages is recommended (e.g. Omicron CMC 56 for manual and automatic checking). The phase angle between currents and voltages should be continuously adjustable.

The measurement accuracy to be achieved depends on the electrical data of the test sources used. The accuracies specified in the technical specifications can be expected only if the reference conditions in accordance with VDE 0435/Part 303 or IEC 60 255 are adhered to, and precision measurement instruments are used.

Tests can be done with the current setting values or with the preset 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 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 should be present in one of the phases.

Wiring

Important is in particular checking of the correct wiring and allocation of all interfaces of the device. The test function described in section 3.3 for checking the binary inputs and outputs is a help here.

The analog inputs can be checked using plausibility checks as described under "Secondary Test".

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 side title “Secondary Testing”).

Undervoltage Protection

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 measured 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 in order that they present information only on the currently executed test. 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 7110 **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.

3.2.3 Checking System Incorporation

General Information

WARNING!

Warning of hazardous voltages

Nonobservance of the following measures can result in fatality, personal injury or substantial material damage.

Only qualified people who are familiar with and observe the safety procedures and precautionary measures shall perform the inspection steps.

With this check of the protection, the correctness incorporation into the power system is 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 drawing records in accordance with functionality, and on the other hand the correctness of cabling between transducer or transformer and protection device.

The check of the protection device functions with regard to accuracy of pickup values and the characteristic itself should not be part of this check, since this is done by the works test.

Auxiliary Voltage Supply

Testing of voltage amplitude 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 connected to a battery charger without a battery

Non-observance of the following measure can lead to unusually high voltages and thus the destruction of the device.

Do not operate the device on a battery charger without a connected battery. (For limit values see also Technical Data Section 4.1).

Visual Check

During the visual check the following must be considered:

- Check of the cubicle and the devices for damage;
- Check of earthing of the cabinet and the device;
- Check of the quality and completeness of external cabling.

Acquisition of Technical Power System Data

For checking protection parametrization (allocation and settings) in accordance with power system requirements, recording of technical data of the individual components is necessary in the primary system. This includes, among others, the generator or motor, the unit transformer and the voltage and current transformers.

On deviations from the planned data the protection settings must be corrected accordingly.

Analog Inputs

Check of the current and voltage transformer circuits includes the following items:

- 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
- Check cabling in accordance with circuit diagram
- Check of the short circuiters of the plug connectors for current circuits

Further checks may be required depending on the contract:

- Insulation measurement of cable
- Measurement of transformation ratio and polarity
- Burden measurement
- If test switches are used for the secondary check, their function must also be checked.

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 indication processing from the indication relays via the indication cable to the control instrumentation technology, by pickup of indication contacts from the protection and checking of texts in the control and instrumentation technology.

- Check control circuits from the output relays via control lines to the circuit breakers and isolators etc.
- Check binary input signals via signal lines up to the protection device by activating the external contacts.

Protective Switches for the Voltage Transformers

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 voltage transformer protection switches.

Check in the operational messages that the VT mcb trip was entered (indication “`>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 indications appear under the "going" operational indications, i.e. with the comment "OFF“ (e.g. “`>FAIL:Feeder VT`” “OFF”).

Note

The definite time overcurrent with undervoltage seal-in blocking must be realized with the input “`>Useal-in BLK`”(FNo. 1950).

If one of the indications does not appear, check the connection and allocation of these signals.

If the "ON" comment and "OFF" comment are interchanged, the contact type (normally closed or normally opened) must be checked and corrected.

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 and Transmission Block

Activation and Deactivation

If the device is connected to a substation control system or a server, the user is able to modify, in some protocols, information that is transmitted to the substation (see the table “Protocol-dependent functions” in Appendix A.

If **Test mode** is active, 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® 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 Ports

Prefacing Remarks

If the device features a system interface and uses it to communicate with the control centre, the DIGSI® 4 device operation can be used to test if messages are transmitted correctly. You must under no circumstances use this test option during "actual" operation.

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 this test, the device will reboot. All annunciation buffers are erased. If required, these buffers should be extracted with DIGSI prior to the test.

The interface test is carried out Online using DIGSI®:

- 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 dialogue box **Testing System Interface** 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 SETPOINT** the user has to define the value for the messages to be tested. Depending on indication type, several input fields are offered (e.g.Indication coming/ Indication going). By clicking on one of the fields you can select the desired value from the pull-down menu.

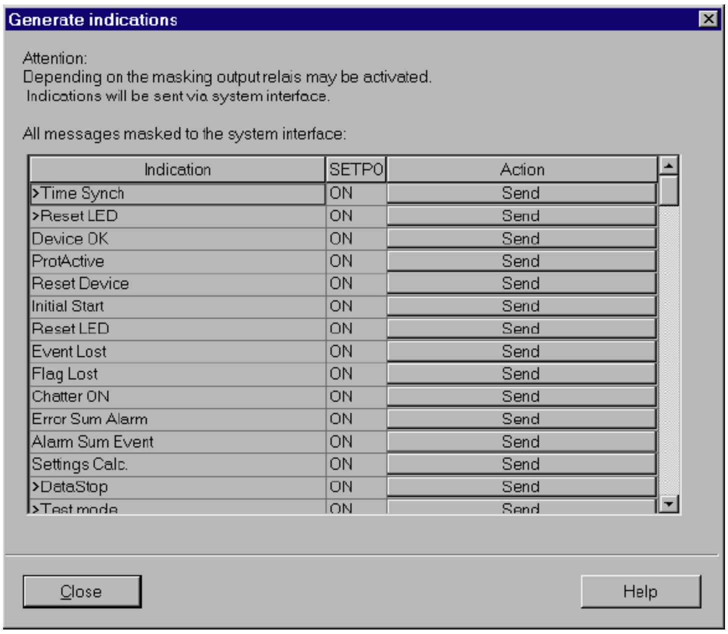


Figure 3-14 System interface test with dialog box: Generate annunciations — example

Changing the Operating State

Following the first operation of one of the keys in the column **Action** you will be asked for the password No. 6 (for hardware test menus). Having entered the correct password indications can be issued individually. To do so, click on **Send**. The corresponding indication is issued and can be read out either from the event log of the SIPROTEC® 4 device or from the central master computer.

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.

Test in Command Direction

The information transmitted in command direction must be indicated by the central station. Check whether the reaction is correct.

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 using DIGSI®. This feature is used to verify control wiring from the device to plant equipment 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 done 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.

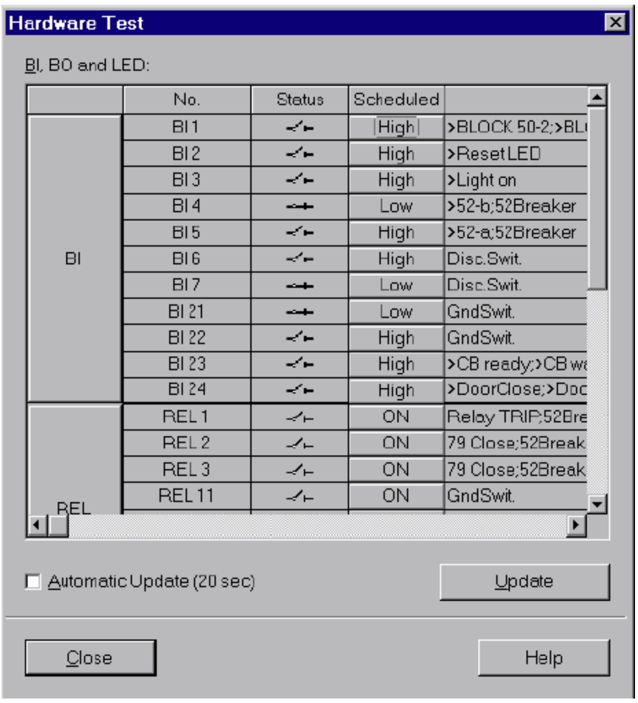


Figure 3-15 Test of the Binary Inputs and Outputs — Example

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 7UM61 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 7UM61 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:

- Each state in the plant which causes a binary input to pick up must be generated.
- 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 the first state change of any LED has been triggered, all LEDs are separated from the internal device functionality and can only be controlled via the hardware test function. This means e.g. that no LED can be switched on anymore by e.g. a protection function or operation of the LED reset key.

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 Testing 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 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.).

3.3.6 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. For this the switch position response indications linked in via binary inputs should be read out at the device and compared with the actual switch position.

The switching procedure is described in the SIPROTEC® system description /1/. The switching authority must be set in correspondence with the source of commands used. With the switch mode it is possible to select between interlocked and non-interlocked switching. Note that non-interlocked switching constitutes a safety risk.

DANGER!

A test cycle successfully started by the automatic reclosure function can lead to the closing of the circuit breaker!

Non-observance of the following statement will result in death, severe personal injury or substantial property damage.

Be fully aware that OPEN-commands sent to the circuit breaker can result in a trip-close-trip event of the circuit breaker by an external reclosing device.

Control from a Remote Control Centre

If the device is connected to a remote substation via a system interface, the corresponding switching tests may also be checked from the substation. Please also take into consideration that the switching authority is set in correspondence with the source of commands used.

3.3.7 Commissioning Test with the Machine

General Information

WARNING!

Warning of hazardous voltages when operating electrical devices

Nonobservance of the following measure will result in fatality, severe personal injury or substantial material 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.

During the commissioning procedure, switching operations must be carried out. The tests described require that they can be done 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

Adherence to appropriate safety rules (e.g. VDE 105, VBG4) is a requirement.

Before undertaking any work, observe the following “5 safety rules”:

- Enable
- Secure against reswitching on
- Establish absence of voltage
- Earth and short circuit
- Cover or separate adjacent parts under voltage

In addition the following must be observed:

- Before making any connections, the device must be earthed at the protection earth 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 given in the Technical Specifications (Section 3.1) must not be exceeded, including during testing and commissioning.

DANGER!

Hazardous voltages during interruptions in secondary circuits of current transformers

Nonobservance of the following measure will result in fatality, severe personal injury or substantial material damage.

Short-circuit the current transformer secondary circuits before current connections to the device are opened.

If a test switch is available that short-circuits automatically the secondary lines of the current transducer, it will be sufficient to set it to "Test" position, provided the short-circuiters have been checked previously.

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

This is accomplished normally in the following order

- Short circuit tests,
- Voltage tests,
- Earth fault tests,
- Synchronization,
- Load tests 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 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 2.2.2). It is then ignored in the 7UM61 device.

The effective switching of a protection function configured as ***Enabled*** can occur in two ways. The setting addresses for this are specified in the corresponding 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 function is not allocated a trip relay, no tripping occurs.

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 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 Adaption

Note:

The device contains integrated sampling frequency adaption; this ensures that the protection functions always operate 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 sampling frequency adaption can operate. If a measurement value is switched from 0 to the device 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 from 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 for the parametrized minimum duration (**TMin TRIP CMD**) (refer also to Section 2.3)

Factory Setting

Note:

When the protection device is delivered from the factory, all protective functions have been 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 Ranges of the Protection Functions

For commissioning tests with the machine, care should be taken that the operating range of the protection functions as specified in Section 4 is not exceeded and that an applied measuring value is 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 of too small measured values, i.e. if operating condition 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.

3.3.8 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!

Energized equipment of the power system ! Capacitive coupled voltages at disconnected equipment of the power system !

Non-observance of the following measure will result in death, severe personal injury or substantial property damage.

Primary measurements must only be carried out 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.

Checking Phase Rotation

The phase rotation must conform with 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.

Calibrate the ImpedanceProtection

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!

Energized equipment of the power system ! Capacitive coupled voltages at disconnected equipment of the power system !

Non-observance of the following measure will result in death, severe personal injury or substantial property damage.

Primary measurements must only be carried out 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 rated generator current is only required for the quantitative calibration of the impedance protection (e.g. if it is necessary to calibrate the transformer uK).

The protection device calculates from the currents and voltages 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_K	- relative transformer short-circuit voltage
U_N	- Rated transformer voltage
S_N	- Rated transformer power

In secondary values:

$$Z_{T\,sec} = Z_{T\,prim} \cdot \frac{N_{CT}}{N_{VT}} = u_{sc} \cdot \frac{U_N^2}{S_N} \cdot \frac{N_{CT}}{N_{VT}}$$

with

N_{CTR}	- Current transformer ratio
N_{VTR}	- Voltage transf. transform. ratio

If substantial deviations or wrong the 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 and impedance protection.**

Activate the overcurrent time protection and the impedance protection (address 1201: **O/C I>** = ***ON*** or address 1401 **O/C Ip** = ***ON***, address 3301: **IMPEDANCE PROT.** = ***ON***) and it works 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***) can be activated. Otherwise, they are set to ***Off***.

3.3.9 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***.

Check in the unexcited condition of the machine 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 indicated phase voltages. If there are significant deviations, the voltage transformer connections are incorrect.

Phase Rotation

The phase rotation must conform with 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 signification 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 $U_1 \neq U_{L\text{-}E}$ 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 protected object
f	Instantaneous frequency, in accordance with the machine frequency in Hz
f_N	Rated frequency

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 set to f_{Nom}).

3.3.10 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 in order 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_K 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 RB 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.

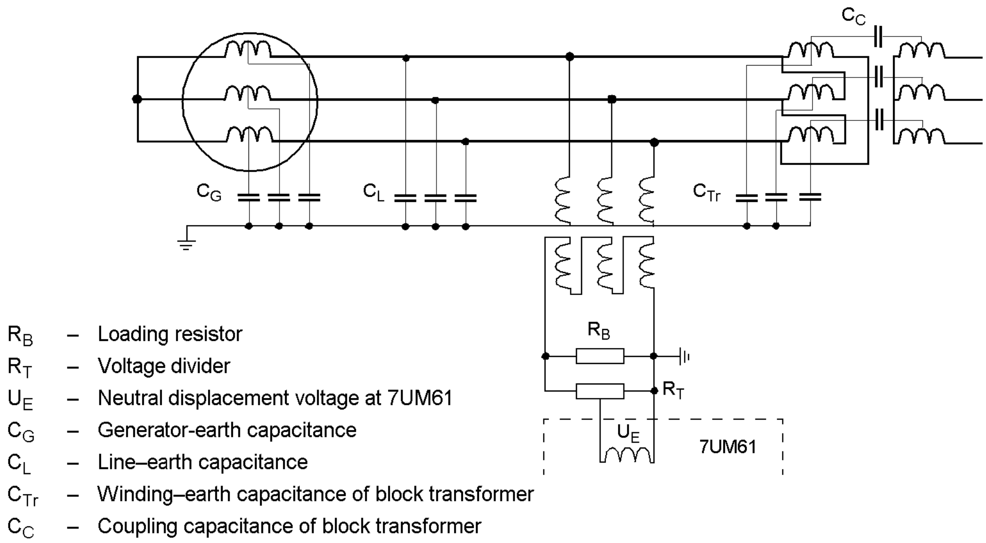
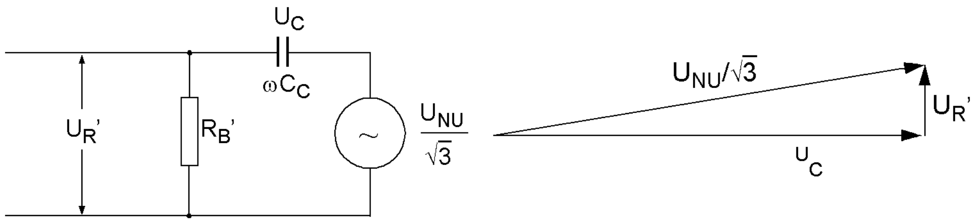


Figure 3-16 Unit Connection with Earthing Transformer

Calculation of Protected Zone

Coupling capacitance C_C and loading resistor R_B represent a voltage divider, whereby R_B is the resistance R_B referred to the machine terminal circuit.



U_{NU}	Rated voltage on upper–voltage side of unit transformer
U_C	Voltage at coupling capacitance C_K
C_C	Total coupling capacitance between upper–voltage and lower–voltage windings
U_R'	Voltage across loading resistor
R_B'	Loading resistor of earthing transformer, referred to machine circuit.

Figure 3-17 Equivalent Diagram and Vector Diagram

Equivalent circuit and vector diagram Since the reactance of the coupling capacitance is much larger than the referred resistance of the loading resistor RB', $U_C \approx U_{NO}/\sqrt{3}$ can be set (see also vector diagram Figure 3-17), where $U_{NO}/\sqrt{3}$ is the neutral displacement voltage with a full displacement of the network voltage starpoint. The following applies:

$$\frac{R_B'}{1/(\omega C_C)} = \frac{U_R'}{U_{NU}/(\sqrt{3})}$$

$$U_R' = R_B' \cdot \omega C_C \cdot U_{NU}/(\sqrt{3})$$

With the voltage transformation ratio TR of the earthing transformer:

$$U_R' = \frac{TR}{3} \cdot U_R \qquad \text{and} \qquad R_B' = \left(\frac{TR}{3}\right)^2 \cdot R_B$$

we obtain:

$$U_R = \frac{TR}{3} \cdot R_B \cdot \omega C_C \cdot U_{NU}/(\sqrt{3})$$

Together with the voltage divider R_T 500 V/100 V this corresponds to a displacement voltage at the input of the device of:

$$U_E = \frac{1}{5} \cdot \frac{TR}{3} \cdot R_B \cdot \omega C_C \cdot U_{NU} / (\sqrt{3})$$

The pickup value **U0>** for the neutral displacement voltage should amount to at least twice the value of this interference voltage.

Example:

Network	U_{NU}	= 110 kV
	f_{Nom}	= 50 Hz
	C_C	= 0.01 μF
Voltage transform-er	10 kV / 0.1 kV	
Earthing transform-er	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 this has only one winding, the result is the same.

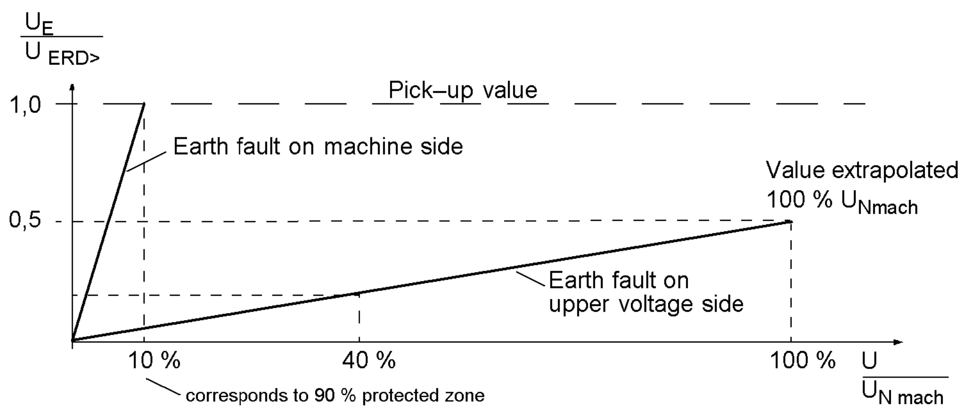


Figure 3-18 Displacement voltage during earth faults

Checking for Generator Earth Fault

Switch stator 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. With the primary equipment disconnected and earthed, insert a single-pole earth fault bridge in the generator terminal circuit.

DANGER!

Energized equipment of the power system ! Capacitive coupled voltages at disconnected equipment of the power system !

Non-observance of the following measure will result in death, severe personal injury or substantial property damage.

Primary measurements must only be carried out on disconnected and grounded equipment of the power system !

Start up 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:

$$Z = \frac{U_{sec\,N} - U0>}{U_{sec\,N}} \cdot 100\ \%$$

<u>Example:</u>

Machine voltage at pick-up 0.1 x $U_{sec\,N}$

Measured value	U_E	= 10 V
Setting value	U0>	= 10 V
Protected zone	Z	= 90 %

Read out the indication “U Earth Lx” in the fault log buffer. "Lx" indicates the faulted phase provided voltages are connected to the voltage 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 primary side of the unit transformer.

DANGER!

Energized equipment of the power system ! Capacitive coupled voltages at disconnected equipment of the power system !

Non-observance of the following measure will result in death, severe personal injury or substantial property damage.

Primary measurements must only be carried out 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 (see example in Figure 3-18). 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.

Activate the stator earth fault protection: Address 5001 **S/E/F PROT.** = ***ON***. If the sensitive earth fault detection is used for stator earth fault protection, activate it as well: Address 5101 **O/C PROT. Iee>** = ***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 5101 also under address ***Block relay***.

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!

Warning of hazardous voltages on equipment components, e.g. due to capacitative coupling with other components!

Nonobservance of the following measure will result in fatality, severe personal injury or substantial material damage.

Primary steps may be undertaken only on machine standstill.

Before carrying out primary steps on components they must be earthed.

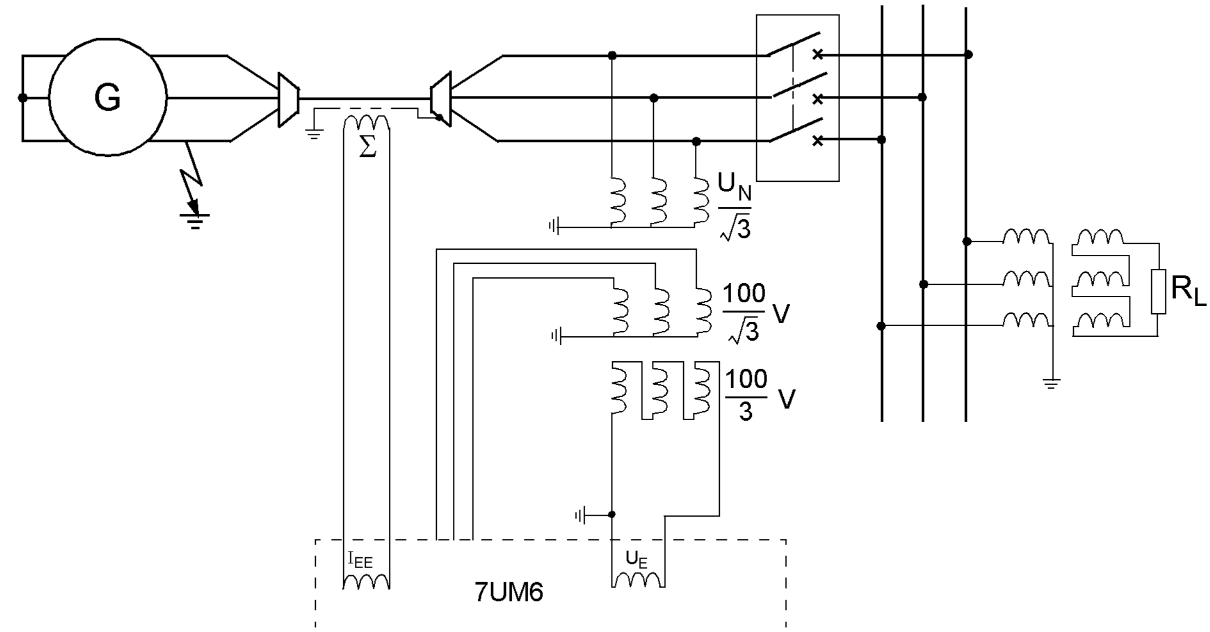


Figure 3-19 Earth Fault with Busbar Connection

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 guidelines on the next page under the margin title "Directional check without Loading Resistor" must be observed.

Start up generator and slowly excite 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_{EE}. 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_{EE} 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 a too slow pickup.

For protection zone Z the following applies:

$$Z = \frac{U_{sec\,N} - U0>}{U_{sec\,N}} \cdot 100\ \%$$

Example:

Machine voltage at pickup 0.1 x U_N

Measured value	U_E	= 10 V
Setting value	U0>	= 10 V
Protected zone	Z	= 90 %

With Directional 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!

Warning of hazardous voltages on equipment components, e.g. due to capacitative coupling with other components!

Nonobservance of the following measure will result in fatality, severe personal injury or substantial material damage.

Primary steps may be undertaken only on machine standstill.

Before carrying out primary steps on components they must be earthed.

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) 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).

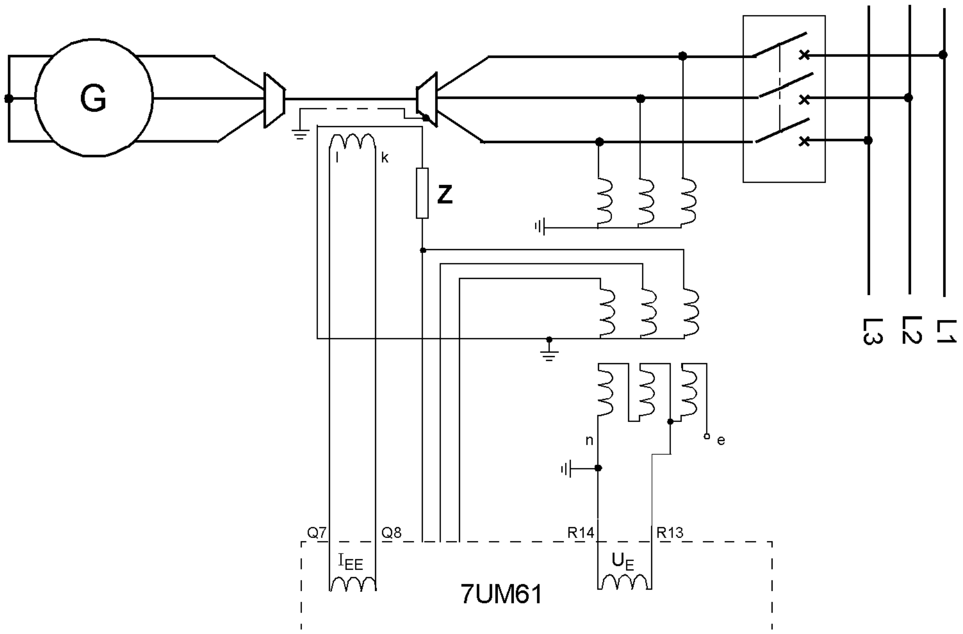


Figure 3-20 Directional Check with Toroidal Transformers

Directional Check with 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.

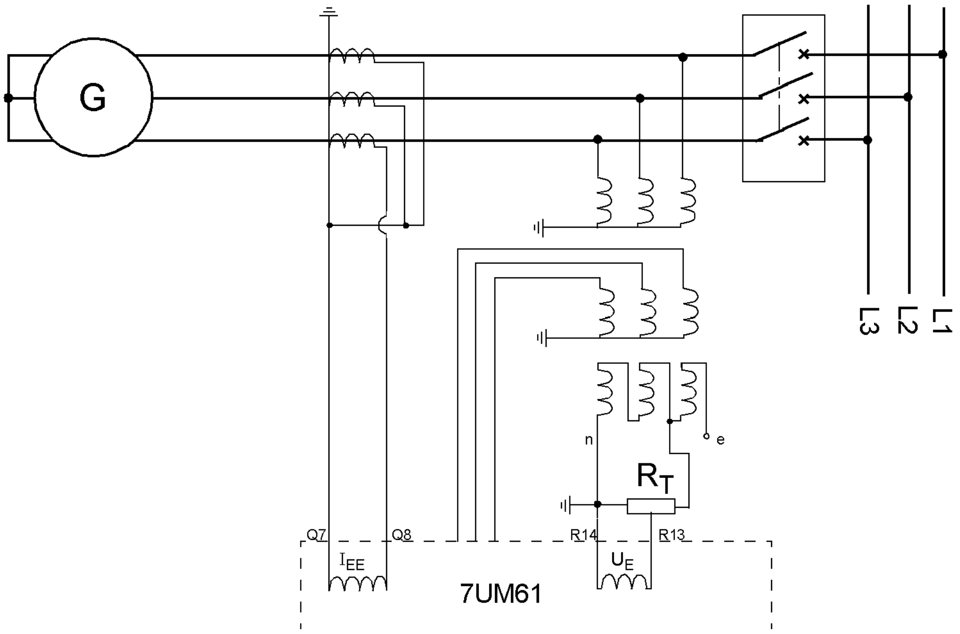


Figure 3-21 Directional Check with Holmgreen Connection

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 re-established and re-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 until the rated machine current is reached.

Read out the operational measured value I_{EE}. This measured values 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***.

3.3.11 Checking the Sensitive Earth Fault Protection when Used for Rotor Earth Fault Protection

If the sensitive earth fault protection is used for rotor earth fault protection, it must first be set to 5101 under address **O/C PROT. Iee>** ***Block relay***.

Caution!

A rotor circuit not isolated from earth can result in a double fault in conjunction with an earth resistor inserted for checking purposes!

Nonobservance of the following procedures can result in minor injury or material damage.

Make sure that the checked rotor circuit is completely isolated from the earth, to avoid the earthing resistor interposed for test purposes causing 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 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 fault current IIEE now flowing can be read out on the protection 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 is 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.

3.3.12 Tests with the Network

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 to be displayed, direction allocation between the CT set and the voltage transformer set does not correspond with the configuration under address 210 (**CT Starpoint** = ***towards machine*** or ***towards starpt.***), or configuration of address 1108 (ACTIVE POWER = ***Generator*** or ***Motor***) is not properly selected. Address 210 is to be reconfigured, as the case may be.

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 for this 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 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 real power axis of 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!

Underexcitation may cause the generator fall out of step!

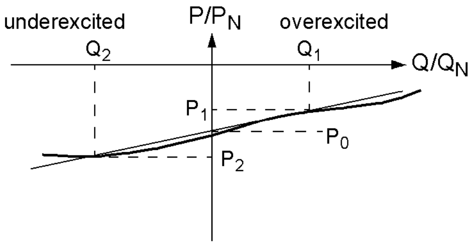
Nonobservance of the following procedures can result in minor injury or material damage.

Operation with underexcitation is admissible only for a short period

Proceed as follows:

- Adjust excitation until the reactive power Q = 0. To check this, read out the active power P_0 and the reactive power Q_0 with sign and note it down (see table below).
- Slowly increase excitation to 30% of rated apparent power of generator (overexcited).
  - Read out the motoring power P_1 with polarity (negative) in the operational measured values and note it (see table below).
  - Read out the reactive power Q_1 with polarity (positive) and note it (see table below).

- Reduce excitation slowly to approximately 30% rated apparent power of generator (underexcited).
  - Read out the motoring power P_2 with polarity (negative) in the operational measured values and note it (see table below).
  - Read out reactive power Q_2 with polarity (negative) in the operational measured values and note it (see table below).
- Adjust generator to no-load excitation and shut it down or select the desired operational state.



Item	Active power	Reactive power
1	P_0	Q_0
2	P_1	Q_1
3	P_2	Q_2

Figure 3-22 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 reversed 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 $P_1 + P_2$ 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 trip 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 device can be derived. 50% of that value should be taken as the setting for the reverse power protection.

Increase driving power.

On 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.

Activate the reverse power protection (address 3101) and - if used - the forward power supervision (address 3201).

Checking the Underexcitation Protection

The angle error correction value W0 determined and configured with regard to reverse power protection under address 204 applies also 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!

Underexcitation may cause the generator 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

---

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 2.7) 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 indication (FNo. 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” (FNo. 1806) must appear.
- Reset the pickup value in address 1302 back to the original value and the protection function in address 1301 **O/C I>>** to ***ON***.

3.3.13 Setup of a test fault recording

General

In order to be able to test the stability of the protection during switchon procedures also, switchon trials can also be carried out at the end. A maximum of information on protection behaviour is supplied by fault recordings.

Requirement

Along with the capability of storing fault recordings via pickup of the protection function, the 7UM61 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.

Such externally started test fault recordings (that is, 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.

Start Waveform 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.

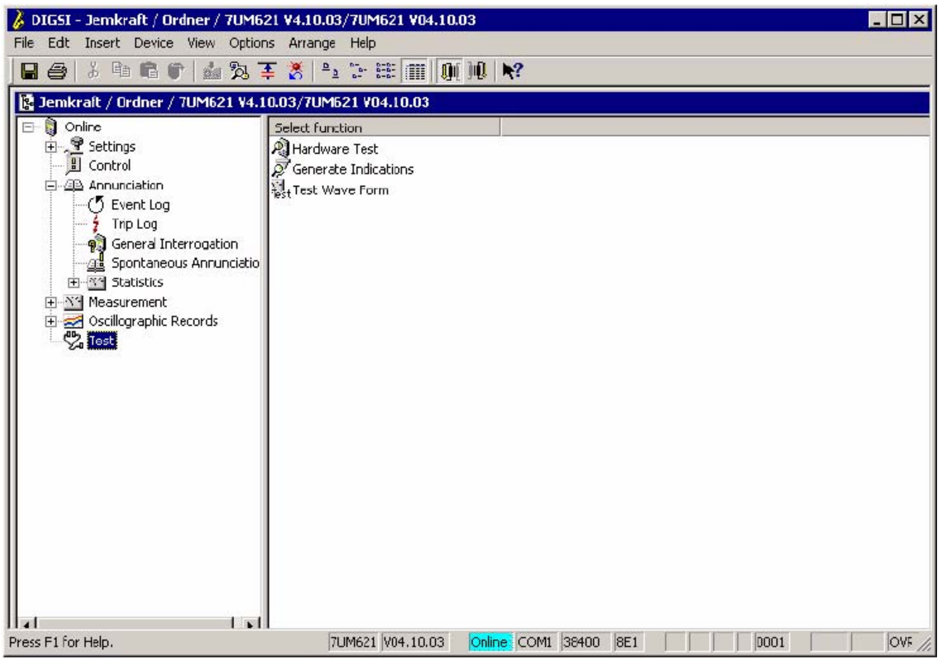


Figure 3-23   Triggering oscillographic recording with DIGSI® — Example

Test measurement recording is immediately started. During the recording, an indication is output in the left area of the status line. 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**. Ensure that a copy of the setting values is stored on the PC.

The user should check the device-internal clock and set/synchronize it if necessary, provided that it is not synchronized automatically. Refer to the SIPROTEC® System Description /1/ for more information on this.

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® 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 SIPROTEC® 7UM61 device and its individual functions, including the limit values that under no circumstances may be exceeded. The electrical and functional data for the maximum functional extent are followed by the mechanical specifications with dimension diagrams.

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_{Ns}	≤ 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)	
Loadability Input for Sensitive Earth Fault Detection 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 225 V
Measuring range		0 V to 170 V
Burden	at 100 V	Approx. 0.3 VA
Voltage path overload capacity		
- Thermal (rms)		230 V continuous

4.1.2 Auxiliary Voltage

DC Voltage

Voltage supply using integrated converter		
Rated auxiliary DC voltage U_{Aux}	24/48 V DC	60/110/125 V DC
Admissible voltage ranges	19 to 58 V DC	48 to 150 V DC
Rated auxiliary DC U_{Aux}	110/125/220/250 V DC	
Admissible voltage ranges	88 to 300 V DC	
superimposed AC ripple voltage, peak to peak, IEC 60 255–11	≤15 % of the auxiliary voltage	
Power input		
7UM611	quiescent	approx. 4 W
7UM612		approx. 4.5 W

7UM611	energized	approx. 9.5 W
7UM612		approx. 12.5 W
Bridging time on failure or short circuit	≥ 50 ms at V ≥ 110 V DC	
	≥ 20 ms at V ≥ 24 V DC	

AC Voltage

Voltage supply using integrated converter		
Nominal Auxiliary AC Voltage U_{Aux}	115 VAC (50/60 Hz)	230 V AC (50/60 Hz)
admissible voltage ranges	92 to 132 V AC	184 to 265 V AC
Quiescent power consumption	approx. 4 VA	
Quiescent power consumption	approx. 12 VA	
Bridging time on failure or short circuit	≥ 200 ms	

4.1.3 Binary Inputs and Outputs

Binary Inputs

Variant	Number	
7UM611*–	7 (configurable)	
7UM612*–	15 (configurable)	
Rated Voltage Range	24 V DC to 250 V DC, bipolar	
Current Consumption, Energized	approx. 1.8 mA, independent of control voltage	
Switching Thresholds	adjustable with jumpers	
Binary Inputs BI1 to BI7		
for rated voltages	24/48/ 60/110/125 V DC	U_{high} ≥ 19 V DC U_{low} ≤ 10 V DC
for rated voltages	110/125/ 220/250 V DC	U_{high} ≥ 88 V DC U_{low} ≤ 44 V DC
Binary Inputs BI8 to BI15		
for rated voltages	24/48/ 60/110/125 V DC	U_{high} ≥ 19 V DC U_{low} ≤ 10 V DC
for rated voltages	110/125/ 220/250 V DC	U_{high} ≥ 88 V DC U_{low} ≤ 44 V DC
for rated voltages	220/250 V DC	U_{high} ≥ 176 V DC U_{low} ≤ 88 V DC
Maximum admissible voltage	300 V DC	
Input Impulse suppression	220 nF coupling capacity at 220 V with recovery time > 60 ms	

Output Relays

Indication/command relay [1])		
Number:	7UM611*–	11 (each with 1 NO contact)
	7UM612*–	19 (each with 1 NO contact)
Make/break capacity	MAKE	1000 W/VA
	BREAK	30 VA 40 W resistive 25 W at L/R ≤ 50 ms
Switching Voltage	250 V	
admissible current per contact	5 A continuous 30 A for 0.5 s	
admissible total current on common path contacts	5 A continuous 30 A ≤ 0.5 s	
[1]) UL–listed with the following nominal values:		
	120 V AC	Pilot duty, B300
	240 V AC	Pilot duty, B300
	240 V AC	5 A General Purpose
	24 V DC	5 A General Purpose
	48 V DC	0.8 A General Purpose
	240 V DC	0.1 A General Purpose
	120 V AC	1/6 hp (4.4 FLA)
	240 V AC	1/2 hp (4.9 FLA)

LEDs

Number		
RUN (green)	1	
ERROR (red)	1	
allocatable LEDs (red)	7UM611	7UM612
	7	14

4.1.4 Communication Interfaces

Operating Interface

Connection	front side, non-isolated, RS 232, 9-pin DSUB socket for connecting a PC
Operation	with DIGSI® 4
Transmission Speed	min. 4 800 Baud; max. 115 200 Baud Factory Setting: 38 400 Baud; Parity: 8E1
bridgeable distance	15 m

Service / Modem Interface

	Connection	isolated interface for data transfer
	Operation	with DIGSI® 4
	Transmission Speed	min. 4 800 Baud; max. 115 200 Baud Factory Setting: 38,400 Baud Parity: 8E1
RS232/RS485		RS232/RS485 according to the ordering variant
	Connection for flush-mounted case	rear panel, slot "C", 9-pin DSUB socket
	Surface-mounting case	In the housing on the case bottom; shielded data cable
	Test voltage	500 VAC
RS232		
	bridgeable distance	15 m
RS485		
	bridgeable distance	1,000 m

System Interface

IEC 60 870-5-103		
	RS232/RS485 acc. to ordered version	isolated interface for data transfer to a master terminal
RS232		
	Connection for flush-mounted case	rear panel, slot "B", 9-pin D-SUB socket
	for surface-mounted case	in console housing at case bottom
	Test voltage	500 VAC
	Transmission Speed	min. 4,800 Baud; max. 200 Baud Factory setting 38,400 Baud
	bridgeable distance	15 m
RS485		
	Connection for flush-mounted case	rear panel, slot "B", 9-pin D-SUB socket
	for surface-mounted case	in console housing at bottom side I
	Test voltage	500 VAC
	Transmission Speed	min. 4,800 Baud; max. 115,200 Baud Factory setting 38,400 Baud
	bridgeable distance	max. 1 km (0.6 miles)

Fibre optic cable (FO)		
	Fibre optic connector type	ST connector
	Connection for flush-mounted case	rear panel, mounting location "B"
	for surface-mounted case	in console housing at case bottom
	optical wavelength	λ = 820 nm
	Laser Class 1 according to EN 60825–1/–2	Using glass fibre 50/125 µm or using glass fibre 62.5/125 µm
	admissible link signal attenuation	max. 8 dB, with glass fibre 62.5/125 µm
	bridgeable distance	max. 1.5 km (0.6 miles)
	Character idle state	configurable; factory setting "Light off"
Profibus RS 485 (FMS and DP)		
	Connection for flush-mounted case	rear panel, slot "B", 9-pin D-SUB socket
	for surface-mounted case	in console housing at case bottom
	Test voltage	500 VAC
	Transmission Speed	up to 12 MBd
	bridgeable distance	1,000 m / 3300 feet at ≤ 93.75 kBd 500 m / 1666 feet at ≤ 187.5 kBd 200 m/ 660 feet at ≤ 1.5 MBd 100 m/ 330 feet at ≤ 12 MBd
DPN3.0 RS485		
	Connection for flush-mounted case	rear panel, slot "B", 9-pin D-SUB socket
	for surface-mounted case	in console housing at case bottom
	Test voltage	500 VAC
	Transmission Speed	up to 19200 Bd
	bridgeable distance	max. 1,000 m (3300 feet)
MODBUS RS485		
	Connection for flush-mounted case	rear panel, slot "B", 9-pin D-SUB socket
	for surface-mounted case	in console housing at bottom side
	Test voltage	500 VAC
	Transmission Speed	up to 19200 Bd
	bridgeable distance	max. 1,000 m (3300 feet)

Profibus FO (FMS and DP)		
	Fibre optic 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 surface-mounted case	in console housing at case bottom
	Transmission Speed	up to 1.5 MBd
	recommended:	> 500 kBd
	optical wavelength	λ = 820 nm
	Laser Class 1 according to EN 60825–1/–2	Using glass fibre 50/125 µm or using glass fibre 62.5/125 µm
	admissible link signal attenuation	max. 8 dB, with glass fibre 62.5/125 µm
	bridgeable distance	max. 1.5 km (0.94 miles)
DNP3.0 Fibre Optical Link		
	Fibre optic connector type	ST connector transmitter/receiver
	Connection for flush-mounted case	rear panel, mounting location "B"
	for surface-mounted case	in console housing at case bottom
	Transmission Speed	up to 19,200 Bd
	optical wavelength	λ = 820 nm
	Laser Class 1 according to EN 60825–1/–2	Using glass fibre 50/125 µm or using glass fibre 62.5/125µm
	admissible link signal attenuation	max. 8 dB, with glass fibre 62.5/125 µm
	bridgeable distance	max. 1.5 km (0.94 miles)
MODBUS Fibre Optical Link		
	Fibre optic connector type	ST connector transmitter/receiver
	Connection for flush-mounted case	rear panel, mounting location "B"
	for surface-mounted case	in console housing at case bottom
	Transmission Speed	up to 19,200 Bd
	optical wavelength	λ = 820 nm
	Laser Class 1 according to EN 60825-1/-2	Using glass fibre 50/125 µm or using glass fibre 62.5/125 µm
	admissible link signal attenuation	max. 8 dB, with glass fibre 62.5/125 µm
	bridgeable distance	max. 1.5 km (0.94 miles)

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-pin D-SUB socket
for surface-mounted case	at two-tier terminals on case bottom
Signal Nominal Voltages	selectable 5 V, 12 V or 24 V

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 60,255 (product standards) IEEE C37.90.0/.1/.2 UL 508 DIN 57 435 Part 303 See also standards for individual tests

Insulation Test

Standards:	IEC 60,255-5, IEC 60,870-2-1
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	3.5 kV DC
High voltage test (routine test) measuring transducers TD1-TD3	3.0 kV DC
Impulse Voltage Test (Routine Test) Only Isolated Communications and Time Synchronization Interfaces and Analog Outputs (Ports A -D)	500 V (rms), 50 Hz
Impulse voltage test (type test) all circuits except communication and time synchronization interfaces, analog outputs	5 kV (peak): 1.2/50 µs: 0.5 J: 3 positive and 3 negative impulses in intervals of 5 s

EMC Tests for Interference Immunity (type tests)

Standards:	IEC 60,255-6 and -22 (product standards) EN 50,082-2 (Generic standard) DIN VDE 0435-110
High Frequency Test IEC 60,255-22-1, 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 60,255-22-2, Class IV and IEC 61,000-4-2, 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 60,255-22-3, Class III IEC 61,000-4-3, 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 60,255-22-3, IEC 61,000-4-3 – amplitude-modulated – pulse-modulated	Class III: 10 V/m; 80/160/450/900 MHz; 80 % AM; 1 kHz, duty cycle > 10 s 900 MHz; 50 % PM, repetition frequency 200 Hz
Fast Transient Disturbance Variables / Burst IEC 60,255-22-4 and IEC 61,000-4-4, 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 impulse voltages (SURGE), IEC 61 000-4-5 Installation class 3	Impulse: 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 61 000-4-6, Class III	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz
Power System Frequency Magnetic Field IEC 61,000-4-8, Class IV IEC 60,255-6	30 A/m continuous; 300 A/m for 3 s; 50 Hz, 0.5 mT; 50 Hz
Oscillatory Surge Withstand Capability IEEE C37.90.1	2.5 kV (peak value); 1 MHz; τ = 15 μs, 400 surges per s; Test Duration 2 s; R_i = 200 Ω
Fast Transient Surge Withstand Cap. IEEE 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 C37.90.2	35 V/m: 25 MHz to 1000 MHz
Damped Oscillations IEC 60,694, IEC 61,000-4-12	2.5 kV (Peak Value), polarity alternating 100 kHz, 1 MHz, 10 MHz and 50 MHz, R_i = 200 Ω

EMC Tests For Noise Emission (type test)

Standard:	EN 50,081-* (technical 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 B

4.1.6 Mechanical Tests

Vibration and Shock Stress During Steady State Operation

Standards:	IEC 60 255-21 and IEC 60 068
Vibration IEC 60 255-21-1,Class 2 IEC 60,068-2-6	sinusoidal 10 Hz to 60 Hz: ±0.075 mm amplitude; 10 Hz to 60 Hz: 1g acceleration frequency sweep 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60 255-21-2, Class 1 IEC 60 068-2-27	semi-sinusoidal acceleration 5 g, duration 11 ms, 3 shocks each in both directions of the 3 orthogonal axes
Seismic vibration IEC 60 255-21-2, Class 1 IEC 60 068-3-3	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 rate 1 octave/min 1 cycles in 3 orthogonal axes

Vibration and Shock Stress During Transport

Standards:	IEC 60 255-21 and IEC 60 068-2
Vibration 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 rate 1 octave/min 20 cycles in 3 orthogonal axes
Shock IEC 60 255-21-2, Class 1 IEC 60 068-2-27	semi-sinusoidal acceleration 15 g, duration 11 ms, 3 shocks each in both directions of the 3 orthogonal axes
Continuous Shock IEC 60 255-21-2, Class 1 IEC 60 068-2-29	semi-sinusoidal acceleration 10 g, duration 16 ms, 1000 shocks each in both directions of the 3 orthogonal axes

4.1.7 Climatic Stress Tests

Temperatures[1])

Standards:	IEC 60255-6
Type tested (acc. IEC 60086-2-1 and -2, Test Bd, for 16 h)	–25 °C to +85 °C / –13 °F to +185 °F
admissible temporary operating temperature (tested for 96 h)	– 4.00 °F to +158.00 °F / –20 °C to +70 °C (legibility of display may be restricted from +131.00 °F / +55 °C)
recommended for permanent operation (according to IEC 60255–6)	-5 °C to +55 °C / +23 °F to +131 °F
Limit temperatures for storage	–25 °C to +55 °C / –13 °F to +131 °F
Limit temperatures during transport	–25 °C to +70 °C / –13 °F to +158 °F
Storage and transport of the device with factory packaging!	
[1]) UL–certified according to Standard 508 (Industrial Control Equipment):	
Limit temperatures for normal operation (i.e. output relays not energized)	-20 °C to +70 °C / –4 °F to +158 °F
Limit temperatures under maximum load (max. cont. admissible input and output values)	-5 °C to +55 °C / +23 °F to +131 °F

Humidity

admissible humidity	annual 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 Deployment 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:

- Contacts and relays operating within the same cabinet or on the same relay board with digital protection equipment, should be in principle provided with suitable fuses.
- For substations with operating voltages of 100 kV and above, all external cables should be shielded with a conductive shield grounded at both ends. Normally in medium voltage systems no special procedures are necessary.
- Do not withdraw or insert individual modules/boards while the protective device is energized. In withdrawn condition, some components are electrostatically endangered; during handling the ESD standards (for **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	
7UM61**–*B***–****	Models with screw terminals	7UM61**–*B***–****	Models with plug–in terminals
7UM61**–*B***–****			

4.1.10 Construction

Case	7XP20
Dimensions	See dimensional drawings, Section 4.26

Weight approx.	
in flush mounting, housing size 1/3	about 12 pounds (5.5 kg)
in flush mounting, housing size 1/2	about 12 pounds (7 kg)
in surface mounting, housing size 1/3	about 17 pounds (7.5 kg)
in surface mounting, housing size 1/2	about 27 pounds (12 kg)

Protection class acc. to IEC 60 529		
for surface mounting case equipment		IP 51
in flush mounted case		
	Front	IP 51
	Rear	IP 50
for personnel protection		IP 2x with cover in place

4.2 Definite-Time Overcurrent Protection (I>, ANSI 50/51; I>>, 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 0.05 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 0.05 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 0.01V
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 (without inrush restraint, with restraint add 10 ms)	
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 overcurrent I>	approx. 0.95 for $I/I_N \geq 0.3$
Dropout ratio overcurrent I>>	0.90 to 0.99 (Increments 0.01)
Dropout ratio undervoltage	approx. 1.05
Dropout difference $\Delta\varphi$	2 ° electrical

Tolerances

Pickup current I>, I>>	for I_N = 1 A	1 % of setting value or 10 mA
	for I_N = 5 A	5 % 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

Auxiliary direct voltage in range $0.8 \leq U_A/U_{AN} \leq 1.15$	≤ 1 %
Temperature in Range 23°F or –5 °C ≤ Θ_{amb} ≤ 131°F or 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 %

4.3 Inverse-Time Overcurrent Protection (ANSI 51V)

Setting Ranges / Increments

Pickup current I_p (Phase)	for I_N = 1 A	0.10 A to 4.00 A	Increments 0.01 A
	for I_N = 5A	0.50 A to 20.00 A	Increments 0.05 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 enableU<		10.0 V to 125.0 V	Increments 0.1V

Trip Time Curves acc. to IEC

As per IEC 60255-3, Section 3.5.2 or BS 142 (see also Figure 4-1)

NORMAL INVERSE (Type A)

$$t = \frac{0.14}{(I/I_p)^{0.02} - 1} \cdot T_p \ [s]$$

VERY INVERSE (Type B)

$$t = \frac{13.5}{(I/I_p)^{1} - 1} \cdot T_p \ [s]$$

EXTREMELY INV. (Type C)

$$t = \frac{80}{(I/I_p)^{2} - 1} \cdot T_p \ [s]$$

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 trip times for $I/I_p \geq 20$ are identical to those for $I/I_p = 20$.

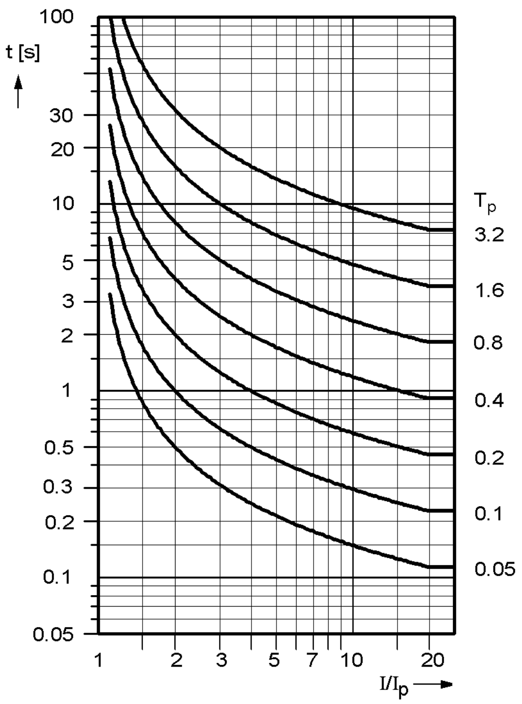
Pickup Threshold	approx. $1.10 \cdot I_p$
Dropout Threshold	Approx. $1.05 \cdot I_p$ for $I_p/I_N \geq 0.3$

Tolerances

Pickup Currents I_p	for I_N = 1 A	1 % of setting value or 10 mA
	for I_N = 5A	5 % of setting value or 50 mA
Pickup Threshold 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

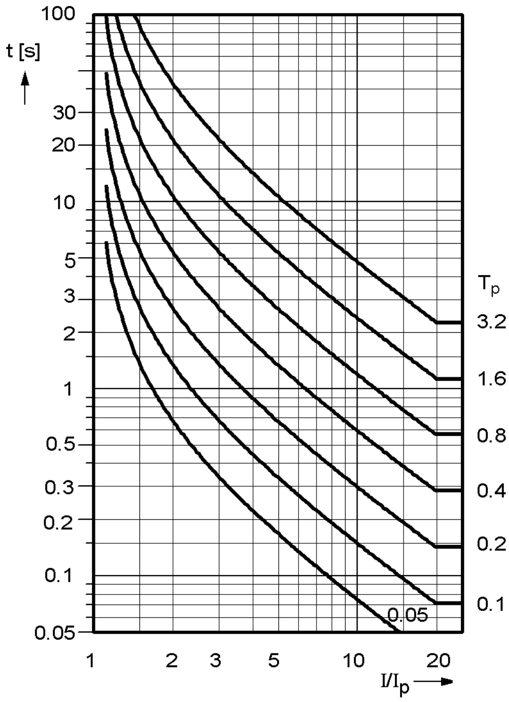
Influencing Variables for Pickup Values

Auxiliary DC voltage in range $0.8 \leq U_{Aux}/U_{AuxN} \leq 1.15$	≤ 1 %
Temperature in Range 23°F or –5 °C ≤ Θ_{amb}≤ 131°F or 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 %



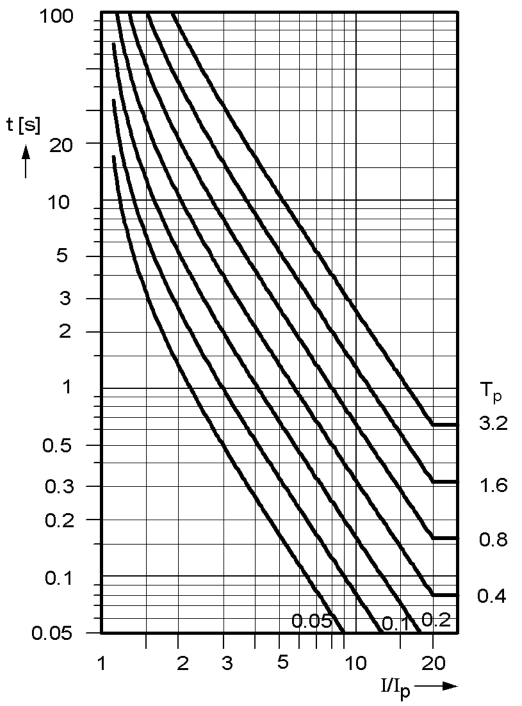
Normal inverse:
(Type A)

$$t = \frac{0,14}{(I/I_p)^{0,02} - 1} \cdot T_p \ \ [s]$$



Very inverse:
(Type B)

$$t = \frac{13,5}{(I/I_p)^{1} - 1} \cdot T_p \ \ [s]$$



Extremely inverse:
(Type C)

$$t = \frac{80}{(I/I_p)^{2} - 1} \cdot T_p \ \ [s]$$

t	Trip time in seconds
T_p	Setting value of the time factor
I	Fault current
I_p	Setting value of the pickup current

Figure 4-1 Trip Characteristics of the Inverse-time Overcurrent Protection, as per IEC

Trip Time Curves acc. to ANSI

As per ANSI/IEEE (see also Figures 4-2 and 4-3)	
VERY INVERSE	$t = \left(\frac{3.922}{(I/I_p)^2 - 1} + 0.0982\right) \cdot D \quad [s]$
INVERSE	$t = \left(\frac{8.9341}{(I/I_p)^{2.0938} - 1} + 0.17966\right) \cdot D \quad [s]$
MODERATELY INV.	$t = \left(\frac{0.0103}{(I/I_p)^{0.02} - 1} + 0.0228\right) \cdot D \quad [s]$
EXTREMELY INVERSE	$t = \left(\frac{5.64}{(I/I_p)^2 - 1} + 0.02434\right) \cdot D \quad [s]$
DEFINITE INVERSE	$t = \left(\frac{0.4797}{(I/I_p)^{1.5625} - 1} + 0.21359\right) \cdot D \quad [s]$
	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 trip times for $I/I_p \geq 20$ are identical to 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

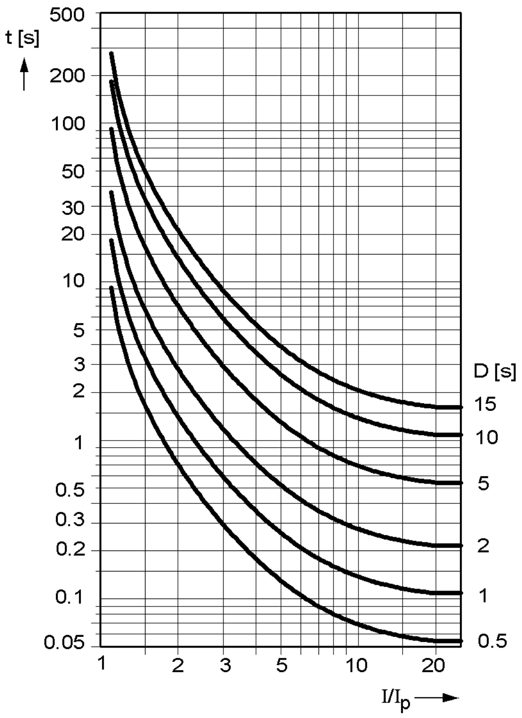
Tolerances

Pickup and Dropout Thresholds I_p	for I_N = 1 A	1 % of setting value or 10 mA
	for I_N = 5A	5 % of setting value or 50 mA
Pickup Threshold 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, respectively 40 ms

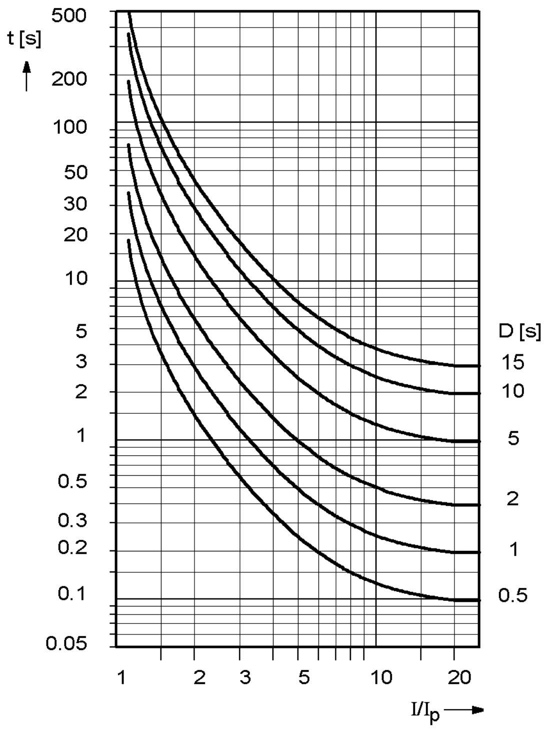
Influencing Variables

Auxiliary DC voltage in range $0.8 \leq U_{Aux}/U_{AuxN} \leq 1.15$	≤ 1 %

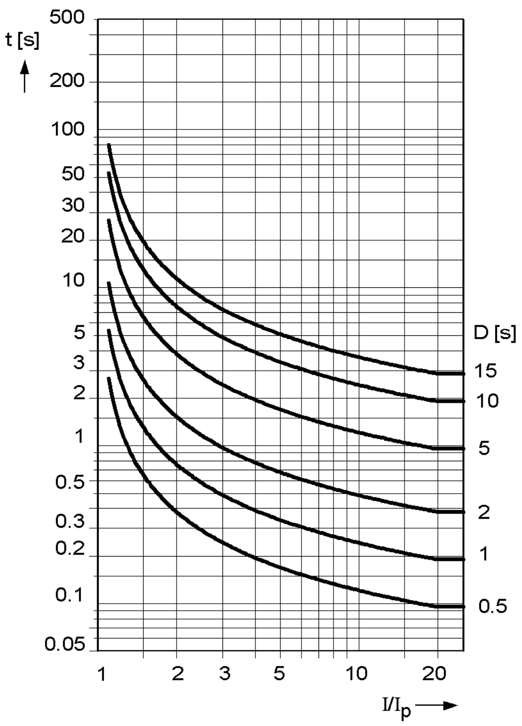
Temperature in Range 23°F or –5 °C ≤ Θ_{amb}≤ 131°F or 55 °C	≤ 0.5 % / 10 K
Frequency in range 0.95 ≤ f/f_N ≤ 1.05	1 %



VERY INVERSE $t = \left(\frac{3,922}{(I/I_p)^2 - 1} + 0,0982\right) \cdot D\ [s]$



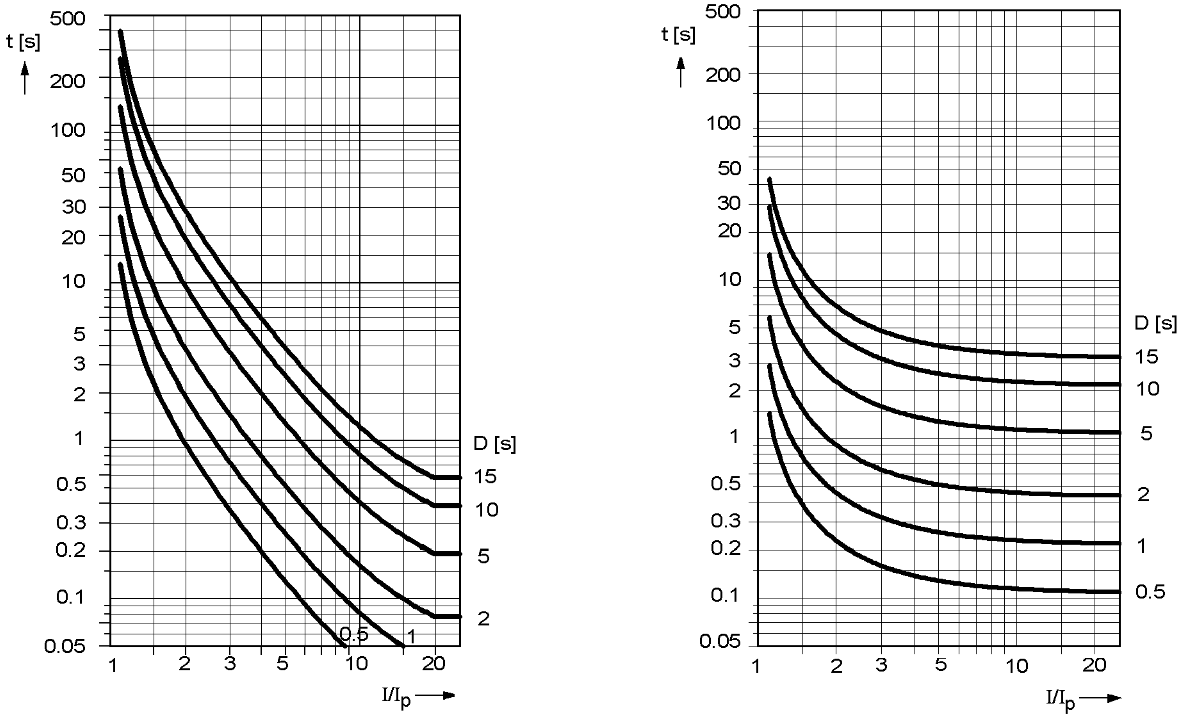
INVERSE $t = \left(\frac{8,9341}{(I/I_p)^{2,0938} - 1} + 0,17966\right) \cdot D\ [s]$



MODERATELY INVERSE $t = \left(\frac{0,0103}{(I/I_p)^{0,02} - 1} + 0,0228\right) \cdot D[s]$

t	trip time in seconds
D	setting value of the time factor
I	fault current
I_p	setting value of the pickup 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 in seconds
D	Setting value of the time factor
I	Fault current
I_p	Setting value of the pickup 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

K-Factor per IEC 60,255-8		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
Warning overtemperature $\Theta_{Alarm}/\Theta_{Trip}$ 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 = 1 A	0.50 A to 20.00 A	Increments 0.05 A
Nominal Overtemperature (for I_{Nom})		40° to 200 °C / 104 °F to 392 °F	(Increments 1 °C) (Increments 1.8 °F)
Coolant Temperature for Scaling		40° to 300 °C / 104 °F to 572 °F	(Increments 1 °C) (Increments 1.8 °F)
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 0.05 A
Dropout Time after Emergency Starting $T_{Emergency\ Start}$		10 s to 15000 s	Increments 1 s

Tripping Characteristics

see also Figure 2-15

Trip Characteristic Curve

for $(I/ k \cdot I_N) \leq I_{Max\ therm.}$

$$t = \tau \cdot ln \frac{\left(\frac{I}{k \cdot I_N}\right)^2 - \left(\frac{I_{pre}}{k \cdot I_N}\right)^2}{\left(\frac{I}{k \cdot I_N}\right)^2 - 1}$$

Where:

t	Trip time
τ	Temperature rise time constant
I	Load current
I_{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

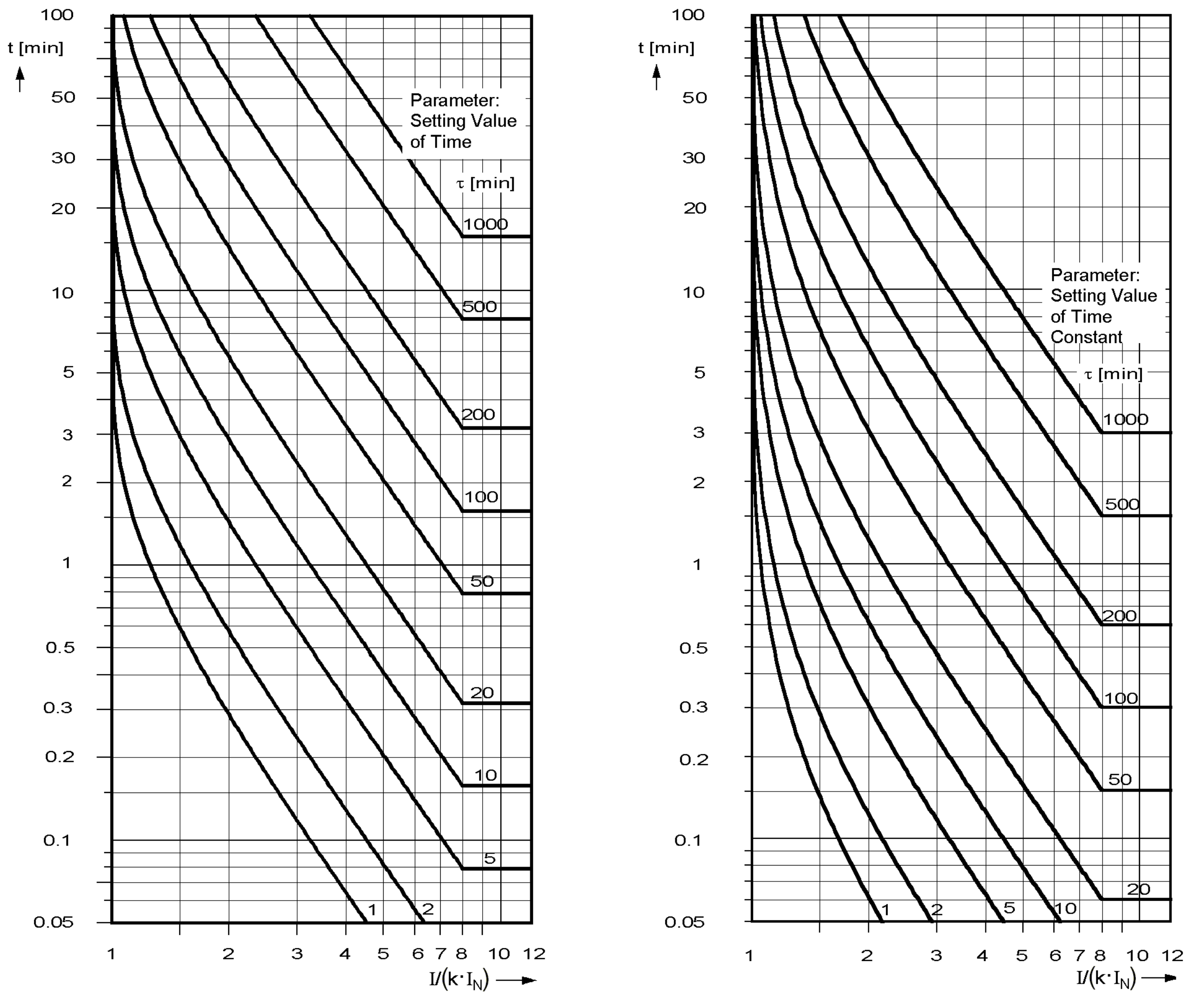
Θ/Θ_{Off}	Dropout with Θ_{Alarm}
Θ/Θ_{Alarm}	approx. 0.99
I/IAlarm	approx. 0.95

Tolerances

referred 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 s, Class 3 % acc. to IEC 60255-8 for $I/(k \cdot I_N)$ > 1,25

Influencing Variables Referred to $k \cdot I_N$

Auxiliary DC voltage in range $0.8 \le U_{Aux}/U_{AuxN} \le 1.15$	≤ 1 %
Temperature in Range 23°F or –5 °C ≤ Θ_{amb}≤ 131°F or 55 °C	≤ 0.5 % / 10 K
Frequency in Range $0.95 \le f/f_N \le 1.05$	≤ 1 %



without pre-load and with $I_{Max\ therm.} = 8 \cdot \frac{I}{k \cdot I_N}$:

$$t = \tau \cdot ln\frac{\left(\frac{I}{k \cdot I_N}\right)^2}{\left(\frac{I}{k \cdot I_N}\right)^2 - 1} \quad [min]$$

with 90 % pre-load and with $I_{Max\ therm.} = 8 \cdot \frac{I}{k \cdot I_N}$:

$$t = \tau \cdot ln\frac{\left(\frac{I}{k \cdot I_N}\right)^2 - \left(\frac{I_{pre}}{k \cdot I_N}\right)^2}{\left(\frac{I}{k \cdot I_N}\right)^2 - 1} \quad [min]$$

Figure 4-4 Tripping Characteristics for Overload Protection

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

Setting Ranges / Increments

Admissible unbalanced load $I_{2\ Adm.}/I_N$ (also alarm stage)	3.0 % to 30.0 %	Increments 0.1 %
Unbalanced load tripping stage I_2>>/I_N	10 % to 100 %	Increments 0.1 %
Delay times T_{Alarm}, $T_{I2>>}$	0.00 s to 60.00 s or ∞ (ineffective)	Increments 0.01 s
Asymmetry factor FACTOR K	2.0 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
- $I_{2\ perm.}$ – Continuously permissible negative sequence current

Times

Pickup Times (Stage characteristic) Dropout Times (Stage characteristic)	approx. 50 ms approx. 50 ms

Dropout Conditions

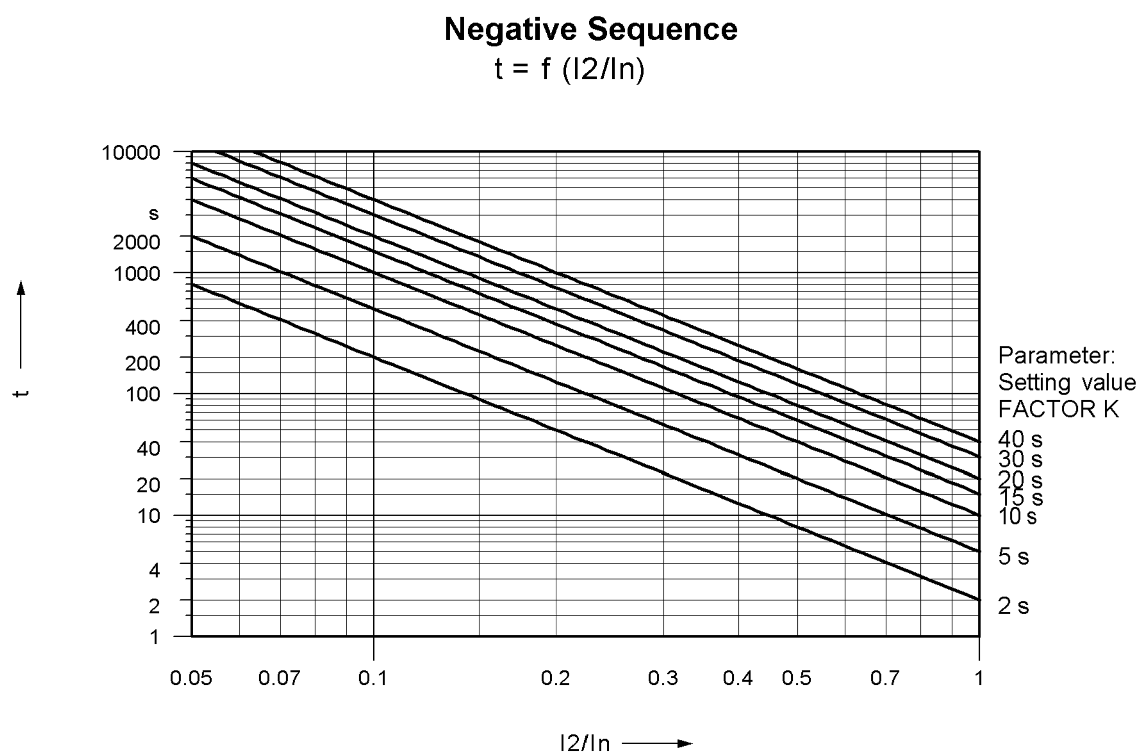
Warning Stage$I_{2\ adm.}$, Tripping stage I2>>	Approx. 0.95
Thermal tripping stage	Dropout on undershoot of $I_{2\ Adm.}$

Tolerances

Pickup Values $I_{2\ Adm.}$, I_2>>	3 % of setting value or 0.3 % unbal. load
Delay Times	1 % or 10 ms
thermal characteristic Time for $2 \leq I_2/I_{2\ Adm.} \leq 20$	5 % of reference (calculated) value +1 % current tolerance, or 600 ms

Influencing Variables for Pickup Values

Auxiliary DC voltage in range $0.8 \leq U_{Aux}/U_{AuxN} \leq 1.15$	≤ 1 %
Temperature in Range 23°F or –5 °C ≤ Θ_{amb}≤ 131°F or 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 %



$$t = \frac{K}{(I_2/I_N)^2}$$

Figure 4-5 Trip times of the Thermal Characteristic for Unbalanced Load Protection

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

Setting Ranges / Increments

Conductance Sections 1/xd Char.	0.25 to 3.00	Increments 0.01
Slope angle α1, α2, α3	50° to 120°	Increments 1°
Delay times T	0.00 to 60.00 or ∞ (ineffective)	Increments 0.01 s
Undervoltage Blocking	10.0 V to 125.0 V	Increments 0.1V

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

Stator criterion 1/xd Char.	3 % of setting value
Stator Criterion α	1° electrical
Undervoltage Blocking	1 % of setting value or 0.5 V
Delay times T	1 % or 10 ms

Influencing Variables for Pickup Values

Auxiliary DC voltage in range $0.8 \le U_{Aux}/U_{AuxN} \le 1.15$	≤ 1 %
Temperature in Range 23°F or –5 °C ≤ Θ_{amb} ≤ 131°F or 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 %

4.7 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 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 SN: Rated apparent power, Q: Reactive power
– Delay times T	1 % or 10 ms

Influencing Variables for Pickup Values

Auxiliary DC voltage in range $0.8 \leq U_{Aux}/U_{AuxN} \leq 1.15$	≤ 1 %
Temperature in Range 23°F or –5 °C ≤ Θ_{amb}≤ 131°F or 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 %

4.8 Forward Active Power Supervision (ANSI 32F)

Setting Ranges / Increments

Reverse power $P_{reverse}$>/S_N	0.5 % to 120.0 %	Increments 0.1 %
Reverse power $P_{reverse}$>/S_N	1.0 % to 120.0 %	Increments 0.1 %
Delay times T	0.00 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 measurement (S_N: Rated apparent power)
Delay times T	1 % or 10 ms

Influencing Variables for Pickup Values

Auxiliary DC voltage in range $0.8 \leq U_{Aux}/U_{AuxN} \leq 1.15$	≤ 1 %
Temperature in Range 23°F or –5 °C ≤ Θ_{amb}≤ 131°F or 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 %

4.9 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	Increments 0.1 %
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, Based on I_N = 1 A)	0,05 Ω up to 130.00 Ω	Increments 0.01 Ω
Impedance Z1 (secondary, Based on I_N = 5 A)	0,01 Ω up to 26.00 Ω	
Impedance Z1B (secondary, Based on I_N = 1 A)	0,05 Ω up to 65.00 Ω	Increments 0.01 Ω
Impedance Z1B (secondary, Based on I_N = 5 A)	0,01 Ω up to 13.00 Ω	
Impedance Z2 (secondary, Based on I_N = 1 A)	0,05 Ω up to 65.00 Ω	Increments 0.01 Ω
Impedance Z2 (secondary, Based on I_N = 5 A)	0,01 Ω up to 13.00 Ω	
Measuring Tolerances as per VDE0435 part 303 with Sinusoidal Quantities	$\lvert\Delta Z/Z\rvert \leq$ 5 % for 30° $\leq \varphi_K \leq$ 90° or 10 mΩ	

Times

Delay Times	0.00 s to 60.00 s	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

Auxiliary DC voltage in range $0.8 \leq U_{Aux}/U_{AuxN} \leq 1.15$	≤ 1 %
Temperature in Range 23°F or –5 °C ≤ Θ_{amb}≤ 131°F or 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 %

4.10 Undervoltage Protection (ANSI 27)

Setting Ranges / Increments

Measured Quantity	Positive Sequence phase-to-earth voltages as phase-to-phase values	
Pickup thresholds U, U<<, Up<	10.0 V to 125.0 V	Increments 0.1V
Dropout ratio RV U< (only stages U<, U<<)	1.01 to 1.20	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.		

Operating Times

Pickup Times	approx. 50 ms
Dropout Times	approx. 50 ms

Tolerances

Pickup voltages U<, U<<	1 % of setting value or 0.5 V
Delay times T	1 % of setting value or 10 ms

Influencing Variables

Auxiliary DC voltage in range $0.8 \le U_{Aux}/U_{AuxN} \le 1.15$	≤ 1 %
Temperature in Range $-5\ °C \le \Theta_{amb} \le 55\ °C$	≤ 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 %

4.11 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<<, Up<	30.0 V to 170.0 V	Increments 0.1V
Dropout ratio RV U< (Stages 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

Pickup 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 DC Voltage in Range $0{,}8 \leq U_{PS}/U_{PSN} \leq 1.15$	≤ 1 %
Temperature in Range 23°F or –5 °C ≤ Θ_{amb} ≤ 131°F or 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 %

4.12 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 65.00 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

f = I Pickup Value – Dropout Value I	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 DC Voltage in Range $0.8 \leq U_{PS}/U_{PSN} \leq 1.15$	1 %
Temperature in Range 23°F or –5 °C ≤ Θ_{amb}≤ 131°F or 55 °C	0.5 %/10 K
Harmonics - Up to 10 % 3rd harmonic - Up to 10 % 5th harmonic	 1 % 1 %

4.13 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>>Warning Stage 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. 0.95

Tripping Characteristic

thermal replica (default setting) and stage characteristic)	see Figure 4-6

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

Auxiliary DC voltage in range $0.8 \le U_{Aux}/U_{AuxN} \le 1.15$	≤ 1 %
Temperature in Range 23°F or –5 °C ≤ Θ_{amb}≤ 131°F or 55 °C	≤ 0.5 % / 10 K
Harmonics – Up to 10 % 3rd harmonic – Up to 10 % 5th harmonic	 ≤ 1 % ≤ 1 %

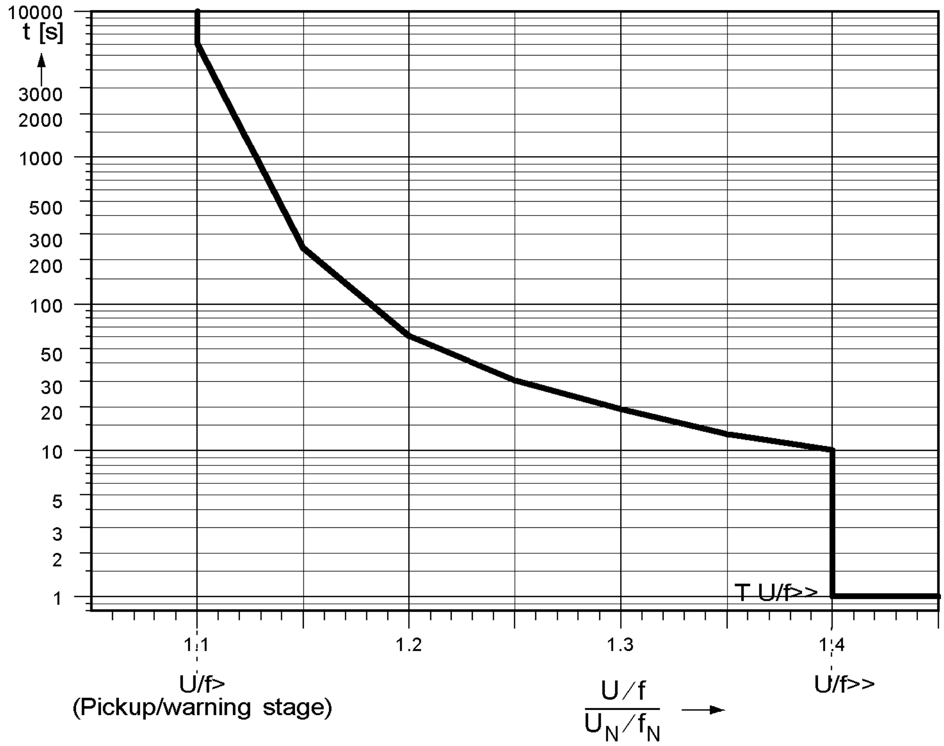


Figure 4-6 Resulting Tripping Characteristic from Thermal Replica and Stage Characteristic of the Overexcitation Protection (Default Setting)

4.14 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 to 10 Hz/s	Increments 0.1 Hz/s
Delay times T	0.00 to 60.00 s	Increments 0.01 s or ineffective
Undervoltage Blocking U1>	10.0 to 125.0 V	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 to 0.99 Hz/s (settable)
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 DC Voltage in Range $0.8 \leq U_{PS}/U_{PSN} \leq 1.15$	≤ 1 %
Temperature in Range 23°F or –5 °C ≤ Θ_{amb}≤ 131°F or 55 °C	≤ 0.5 % / 10 K
Harmonics - Up to 10 % 3rd harmonic - Up to 10 % 5th harmonic	 ≤ 1 % ≤ 1 %

4.15 Jump of Voltage Vector

Setting Ranges / Increments

Stage Δ_{φ}	2° to 30°	Increments 1°
Delay Time T	0.00 to 60.00 s	Increments 0.01 s or ineffective
Reset Time T_{Reset}	0.00 to 60.00 s	Increments 0.01 s or ineffective
Undervoltage Blocking U1>	10.0 to 125.0 V	Increments 0.1V

Times

Pickup Times Δ_{φ}	approx. 75 ms
Dropout Times Δ_{φ}	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 $0.8 \leq U_{PS}/U_{PSN} \leq 1.15$	≤ 1 %
Temperature in Range 23°F or –5 °C ≤ Θ_{amb} ≤ 131°F or 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 %

4.16 90-%-Stator Earth Fault Protection (ANSI 59N, 64G, 67G)

Setting Ranges / Increments

Displacement Voltage U_{Earth}	2.0 V to 125.0 V	Increments 0.1V
Earth current I_{Earth}	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 U_{Earth} I_{Earth} directional	 approx. 50 ms approx. 50 ms approx. 70 ms
Dropout Times U_{Earth} I_{Earth} directional	 approx. 50 ms approx. 50 ms approx. 70 ms

Dropout Ratio / Dropout Difference

Displacement voltage U_{Earth}	approx. 0.70
Earth current I_{Earth}	approx. 0.70
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 DC Voltage in Range $0,8 \leq U_{PS}/U_{PSN} \leq 1.15$	≤ 1 %
Temperature in Range 23°F or –5 °C ≤ Θ_{amb} ≤ 131°F or 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 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 currents 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 DC Voltage in Range $0{,}8 \leq U_{PS}/U_{PSN} \leq 1.15$	≤ 1 %
Temperature in Range 23°F or –5 °C ≤ Θ_{amb} ≤ 131°F or 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 ground fault acquisition is from 2 mA to 1600 mA.	

4.18 100-%-Stator Earth Fault Protection with 3rd Harmonics (ANSI 27/59TN 3rd Harm.)

Setting Ranges / Increments

Pickup Value for 3rd Harmonic in Undervoltage Stage $U_{0\ (3.\ Harmon.)}<$	0.2 V to 40.0 V	Increments 0.1V
Pickup Value for 3rd Harmonic in Undervoltage Stage $U_{0\ (3.\ Harmon.)}>$	0.2 V to 40.0 V	Increments 0.1V
Delay Time $T_{SEF\ (3rd\ HARM)}$	0.00 s to 60.00 s or ∞ (ineffective)	Increments 0.01 s
Enabling conditions		
P/P_{min} >	0 % to 100 % or (ineffective)	Increments 1 %
$U/U_{1\ min}>$	50.0 V to 125.0 V or (ineffective)	Increments 0.1V

Times

Pickup Times	approx. 80 ms
Dropout Times	approx. 80 ms

Dropout Ratios

Undervoltage stage U0 (3rd Harmon.)<	approx. 1.10 or 0.1 mA
Overvoltage stage U0 (3rd Harmon.)>	approx. 0.90 or 0.1 mA
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 DC Voltage in Range $0,8 \le U_{PS}/U_{PSN} \le 1.15$	≤ 1 %
Temperature in Range 23°F or –5 °C ≤ Θ_{amb}≤ 131°F or 55 °C	≤ 0.5 % / 10 K
Frequency in Range $0,95 \le f/f_N \le 1.05$	≤ 1 %

4.19 Motor Starting Time Supervision (ANSI 48)

Setting Ranges / Increments

Motor Startup Current $I_{STARTUP}$	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 0.05 A
Pickup Threshold for Startup Detection $I_{STRT\ DETECT.}$	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 0.05 A
Maximum Startup Time $T_{Max.\ STARTUP}$		1.0 s to 180.0 s	Increments 0.1 s
Admissible Locked Rotor Time $T_{LOCKED\text{-}ROTOR}$		0.05 s to 120.0 s or ∞ (ineffective)	Increments 0.1 s

Tripping Characteristic

Trip Time Characteristics for $I_{rms} > I_{MOTOR\ START}$	$t = \left(\frac{I_{STARTUP}}{I_{rms}}\right)^2 \cdot T_{STARTUP}$	
Meaning:	$I_{STARTUP}$	Motor starting current setting
	I_{rms}	Actual current flowing
	$I_{MOTOR\ START}$	Pickup threshold setting, used to detect motor startup
	t	Trip time in seconds

Dropout Ratio

$I_{rms}/I_{STARTUP\ DETECT.}$	approx. 0.95

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 DC Voltage in Range $0{,}8 \leq U_{PS}/U_{PSN} \leq 1.15$	≤ 1 %
Temperature in Range 23°F or –5 °C ≤ Θ_{amb} ≤ 131°F or 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 %

4.20 Restart Inhibit for Motors (ANSI 66, 49Rotor)

Setting Ranges / Increments

Motor starting current relative to Nominal Motor Current $I_{Start}/I_{Motor\ Nom}$	1.5 to 10.0	Increments 0.1
Max. admissible Startup Time $T_{Start\ Max}$	3.0 s to 120.0 s	Increments 1 s
Leveling Time T_{LEVEL}	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 between 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
Extension Factor on Motor Operation $k_{\tau\ OPERATION}$	1.0 to 100.0	Increments 0.1
Minimum Restart Inhibit Time	0.2 to 120.0 min	Increm. 0.1 min

Restart Threshold

$$\Theta_{Re.Inh.} = \Theta_{L\ max\ perm} \cdot \frac{n_{COLD} - 1}{n_{COLD}}$$

Restart Times

$$T_{Wait\ time} = T_{Leveling} + T_{Re.Inh.}$$

$$T_{Re.Inh.} = \tau \cdot \ln\left(\frac{\Theta_{Pre}}{\Theta_{Re.Inh.}}\right) = \tau \cdot \ln\left(\frac{\Theta_{Pre} \cdot n_{COLD}}{n_{COLD} - 1}\right)$$

Significance:	
$\Theta_{Re.Inh.}$	Temperature limit below which a restart is possible
$\Theta_{L\ max\ adm}$	maximum admissible rotor overtemperature (= 100 % of operational value Θ_L/Θ_L from)
n_{cold}	number of admissible starts from cold
$T_{Wait\ Time}$	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_{Hist}	Rotor temperature past history
t	Rotor time constant, internally calculated

4.21 Breaker Failure Protection (ANSI 50BF)

Setting Ranges / Increments

Pickup thresholds BF 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 0.05 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 – For external Start Dropout Time	 approx. 50 ms approx. 50 ms approx. 50 ms approx. 50 ms

Tolerances

Pickup Threshold BF 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 DC Voltage in Range $0,8 \leq U_{PS}/U_{PSN} \leq 1.15$	≤ 1 %
Temperature in Range $-5\ °C \leq \Theta_{amb} \leq 55\ °C$	≤ 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 Inadvertent Energization (ANSI 50, 27)

Setting Ranges / Increments

Pickup Current I>>>	for I_N = 1 A	0.1 A to 20.0 A	Increments 0.1 A
	for I_N = 5 A	0.5 A to 20.0 A	Increments 0.5 A
		or ∞ (ineffective)	
Tripping Enabling U_1<		10.0 V to 125.0 V or 0 V (no enable)	Increments 0.1V
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

I>>>	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 DC Voltage in Range $0,8 \le U_{PS}/U_{PSN} \le 1.15$	≤ 1 %
Temperature in Range $-5\ °C \le \Theta_{amb} \le 55\ °C$	≤ 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 %

4.23 RTD-Box

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	–50 °C to 250 °C –58 °F to 482 °F or ∞ (no indication)	(in increments of 1°C) (in increments of 1.8 °F)
Stage 2	-50 °C to 250 °C –50.00 °C to 250.00 °C or ∞ (no indication)	(in increments of 1 °C) (in increments of 1.8 °F)

4.24 Auxiliary Functions

Operational Measured Values

Operational Measured Values for Currents	I_{L1}, I_{L2}, I_{L3} in A (kA) primary and in A secondary or in % of I_N $3I_0$ in A (kA) primary and in A secondary
Range	10 % to 200 % I_N
Tolerance	0.2 % of measured value, or ±10 mA ±1 digit
Operational Measured Values for Currents	I_{Ns}
Range	0 mA to 1600 mA
Tolerance	0.2 % of measured value, or ±10 mA ±1 digit
	Positive sequence I_1 in A (kA) primary and in A secondary or in % I_N
	Negative sequence I_2 in A (kA) primary and in A secondary or in % I_N
Operational Measured Values for Voltages (Phase–Ground)	U_{L1}, U_{L2}, U_{L3} in kV primary, in V secondary or in % of U_N $U_{L1–L2}$, $U_{L2–L3}$, $U_{L3–L1}$ in kV primary, in V secondary or in % of U_N U_E or $3U_0$ in kV primary, in V secondary or in % of U_N Positive sequence component U1 and negative sequence component U_2 in kV primary, in V secondary or in % of U_N
Range	10 % to 120 % of U_N
Tolerance	0.2 % of measured value, or ±0.2 mA ±1 digit
Operating Measured Values for Impedanc-es	R, X in Ω primary and secondary
Tolerance	1 %
Operational Measured Values for Powers	S, apparent power in kVAr (MVAr or GVAr) primary and in % of S_N P, active power (with sign) in kVAr (MVAr or GVAr) primary and in % of S_N Q, reactive power (with sign) in kVAr (MVAr or GVAr) primary and in % of S_N
Range	0 % to 120 % S_N
Tolerance	1 % ± 0,25 % S_N with SN = $\sqrt{3} \cdot U_N \cdot I_N$
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°

Meter Values for Energy	Wp, Wq (real 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 < 65 Hz
Tolerance	10 mHz at $U > 0.5 \cdot U_N$
Overexcitation	$(U/U_N)/(f/f_N)$
Range	0 to 2.4
Tolerance	2 %
Thermal 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_L/Θ_{trip}
– of the Unbalanced Load Protection	$\Theta_{i2}/\Theta_{trip}$
– of the Overexcitation Protection	$\Theta_{U/f}/\Theta_{trip}$
– Coolant temperature	depends on connected temperature sensor
Range	0 % to 400 %
Tolerance	5 %

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_{E3H}
Min/Max Values for Power	P, Q
Min/Max Values for Frequency f	f

Local Measured Values Monitoring

Current Asymmetry	I_{max}/I_{min} > balance factor, for $I > I_{lim}$
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 value, with k_U = Uph/Uen WDL
Current Phase Sequence	Clockwise/ counter-clockwise phase sequence

Voltage Phase Sequence	Clockwise/ counter-clockwise phase sequence
	I_L< limit value I_L< configurable using CFC

Fault Logging

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 Message "Battery fault" for insufficient 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
Scanning Rate with 50 Hz Scanning Rate with 60 Hz	1 sample/1.25 ms each 1 sample/1.04 ms each
Channels	u_{L1}, u_{L2}, u_{L3}, u_E, i_{L1}, i_{L2}, i_{L3}, i_{EE}
rms values:	
Recording Time	total 80 s Pre-event and post-event recording and memory time adjustable
Scanning Rate with 50 Hz Scanning Rate with 60 Hz	1 sample/20 ms 1 sample/16.67 ms
Channels	U_1, U_E, I_1, I_2, I_{EE}, P, Q, φ, R, X, f–f_N

Energy Meter

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 separate per breaker pole

Operating Hours Counter

Display Range	up to 6 digits
Criterion	Overshoot of an adjustable current threshold (CB I>)

Trip Circuit Monitoring

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

User Defined Functions (CFC)

Function Modules and Possible Allocation to Task Levels					
Function Module	**Explanation**	**Sequence Level**			
		MW_ BEARB	**PLC1_ BEARB**	**PLC1_ BEARB**	**SFS_ BEARB**
ABSVALUE	Amplitude formation	X	—	—	—
ADD	Addition	X	X	X	X
AND	AND Gate	—	X	X	X
BOOL_TO_CO	Boolean to Command (Conversion)	—	X	X	—
BOOL_TO_DI	Boolean to Double Point Indication (Conversion)	—	X	X	X
BOOL_TO_IC	Boolean to Internal Single Point Indication (Conversion)	—	X	X	X
BUILD_DI	Create a Double Point Indication	—	X	X	X
CMD_CHAIN	Switching sequence	—	X	X	—
CMD_INF	Command Information	—	—	—	X
CONNECT	Connection	—	X	X	X
D_FF	D–Flipflop	—	X	X	X
D_FF_MEMO	Status Memory for Restart	—	X	X	X
DI_TO_BOOL	Double Point Indication to Boolean (Conversion)	—	X	X	X
DIV	Division	X	—	—	—
DM_DECODE	Decode Double Point Indication	X	X	X	X
DYN_OR	Dynamic OR gate	X	X	X	X
LIVE_ZERO	Live–zero Monitoring, Nonlinear Characteristic	X	—	—	—
LONG_TIMER	Timer (max. 1193 h)	X	X	X	X

Function Modules and Possible Allocation to Task Levels					
Function Module	**Explanation**	**Sequence Level**			
		MW_ BEARB	**PLC1_ BEARB**	**PLC1_ BEARB**	**SFS_ BEARB**
LOOP	Signal Feedback	—	X	—	—
LOWER_SETPOINT	Limit value undershoot	X	—	—	—
MUL	Multiplication	X	—	—	—
NAND	NAND Gate	—	X	X	X
NEG	Negator	—	X	X	X
NOR	NORNOR Gate	—	X	X	X
OR	OR Gate	—	X	X	X
RS_FF	RS–Flipflop	—	X	X	X
SQUARE_ROOT	Square Root Extractor	X	—	—	—
SR_FF	SR–Flipflop	—	X	X	X
SUB	Subtraction	X	—	—	—
TIMER	Universal Timer	—	X	X	—
UPPER_SETPOINT	Upper Limit	X	—	—	—
X_OR	XOR Gate	—	X	X	X
ZERO_POINT	Zero Suppression	X	—	—	—

Maximum number of TICKS in the task levels	
Sequence Level	Limit in TICKS
MW_BEARB (Measured value processing)	2 500
PLC1_BEARB (slow PLC processing)	250
PLC_BEARB (fast PLC processing)	130
SFS_BEARB (interlocking)	2 100

The following table shows the number of required TICKS for the individual elements of a CFC chart. A generic module is one where the number of inputs can be changed; typical are the logic functions AND, NAND, OR, NOR.

Processing times in TICKS required by the individual elements	
Individual Element	Number of TICKS
Module, basic requirement	5
each input from the 3rd additional input for generic modules	1
Connection to an input margin	6
Combination with output signal border	7
additionally for each chart	1

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® 4 using the operating interface with protocol via system interface Binary Input

4.25 Operating Ranges of the Protection Functions

	Operational condition 0	Operational condition 1		Operational condition 0
Protection function	**f ≤ 0 Hz**	**11 Hz < f/Hz ≤ 40**	**40 Hz ≤ f/Hz ≤ 69**	**f ≥ 70 Hz**
Definite-Time Overcurrent Protection (ANSI 50,51,67)	**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)]
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
Undervoltage Protection (ANSI 27)	inactive [2)]	**active**	**active**	inactive [2)]
Overvoltage Protection (ANSI 59)	**active**	**active**	**active**	**active**
Frequency Protection (ANSI 81)	inactive	**active**	**active**	inactive [3)]
Underfrequency protection	inactive	**active**	**active**	inactive
Overexcitation (Volt/Hertz) Protection (ANSI 24)	inactive [1)]	**active**	**active**	inactive [1)]
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
Motor Starting Time Supervision (ANSI 48)	inactive	**active**	**active**	inactive
Restart Inhibit for Motors (ANSI 66, 49Rotor)	inactive	**active**	**active**	inactive
Breaker Failure Protection (ANSI 50BF)	inactive	**active**	**active**	inactive
Inadvertent Energization (ANSI 50, 27)	**active**	**active**	**active**	**active**
Threshold supervision	inactive	**active**	**active**	inactive
External Trip Functions	**active**	**active**	**active**	**active**
RTD-Box	**active**	**active**	**active**	**active**
Operational Condition 1:	At at least one of the measuring inputs (I_{L1}, I_{L2}, I_{L3}, U_{L1}, U_{L2} U_{L3}) of the device, at least 5% of the rated voltage is present so that the sampling frequency for the measured value processing can be adjusted.			
Operational Condition 0:	If no suitable measured values are present, or if the frequency is below 11 Hz or above 70 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 pick -up – 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

4.26 Dimensions

4.26.1 Panel Flush and Cubicle Mounting – 7UM611

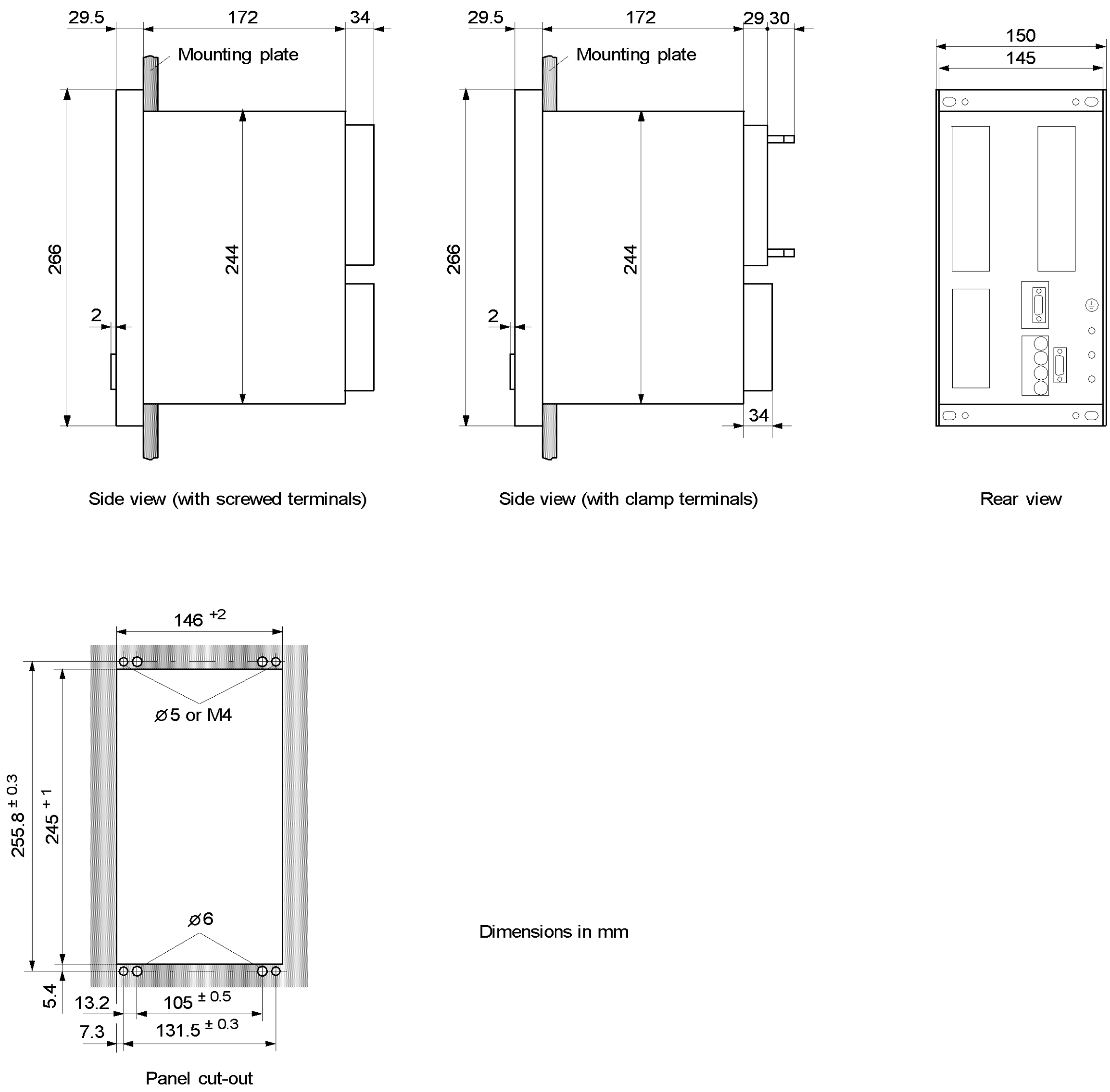


Figure 4-7 Dimensions of a 7UM611 for panel flush mounting or cubicle installation (Housing type 7XP2030-2)

4.26.2 Panel Flush and Cubicle Mounting – 7UM612

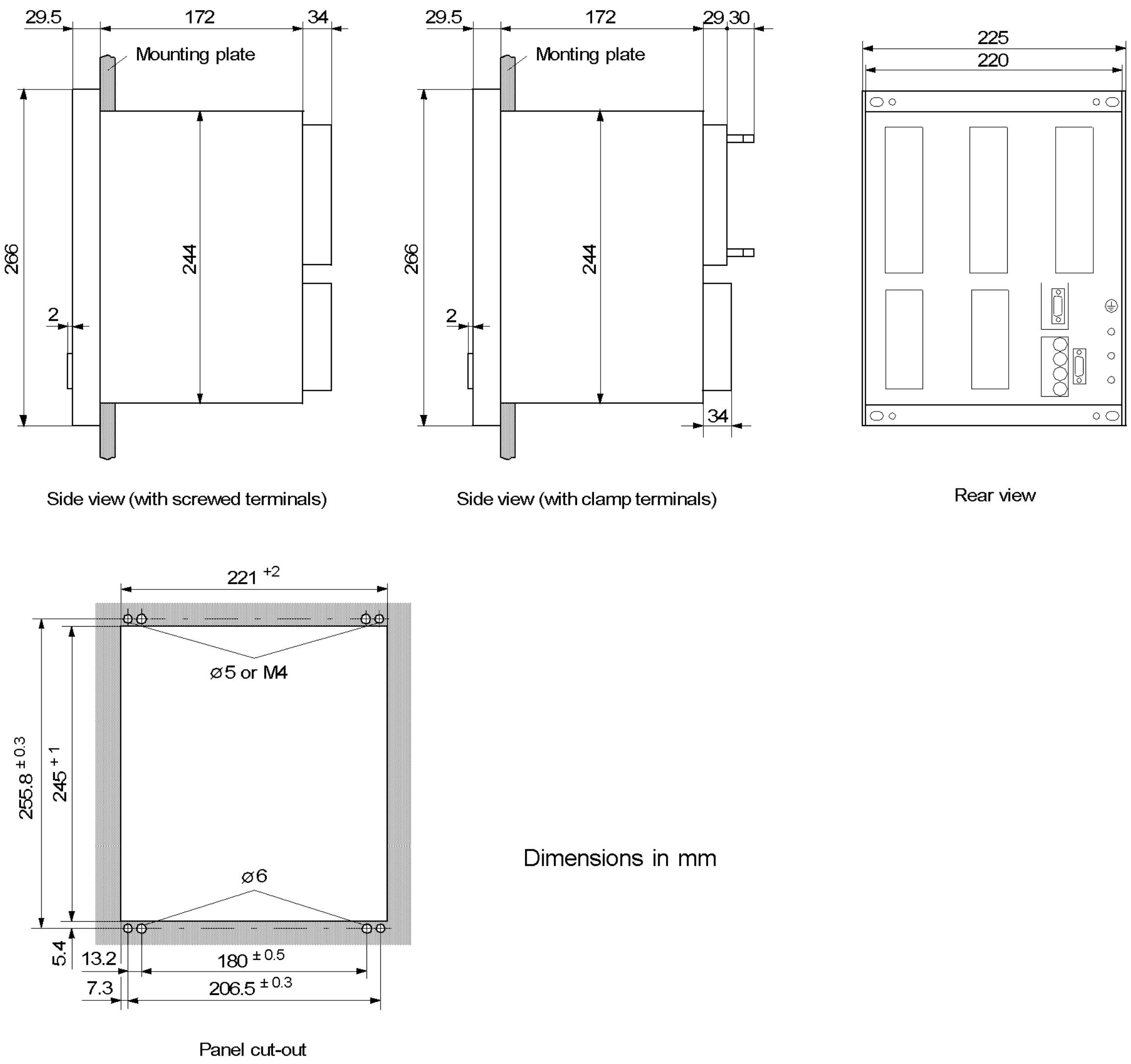


Figure 4-8 Dimensions of a 7UM612 for panel flush mounting or cubicle installation (housing size 1/2)

4.26.3 Panel Flush Mounting – 7UM611

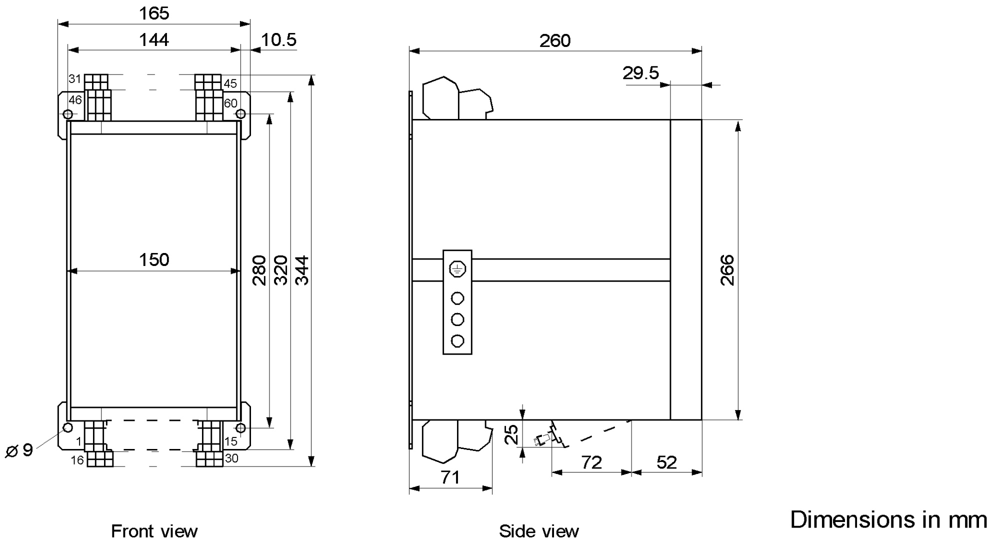


Figure 4-9 Dimensions of a 7UM611 for panel surface mounting

4.26.4 Panel Flush Mounting – 7UM611

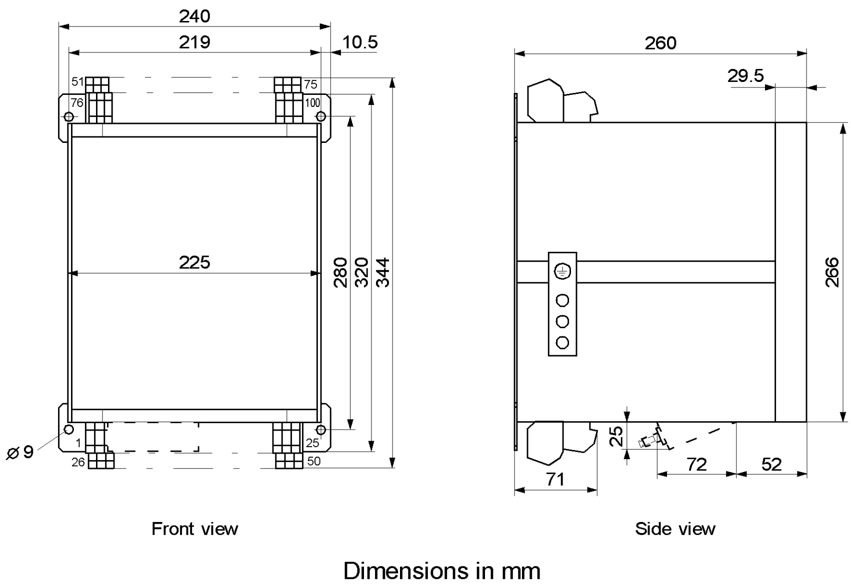


Figure 4-10 Dimensions of a 7UM621 for panel surface mounting (housing size 1/2)

4.26.5 Dimensions of Coupling Unit 7XR6100-0CA0 for Panel Flush Mounting

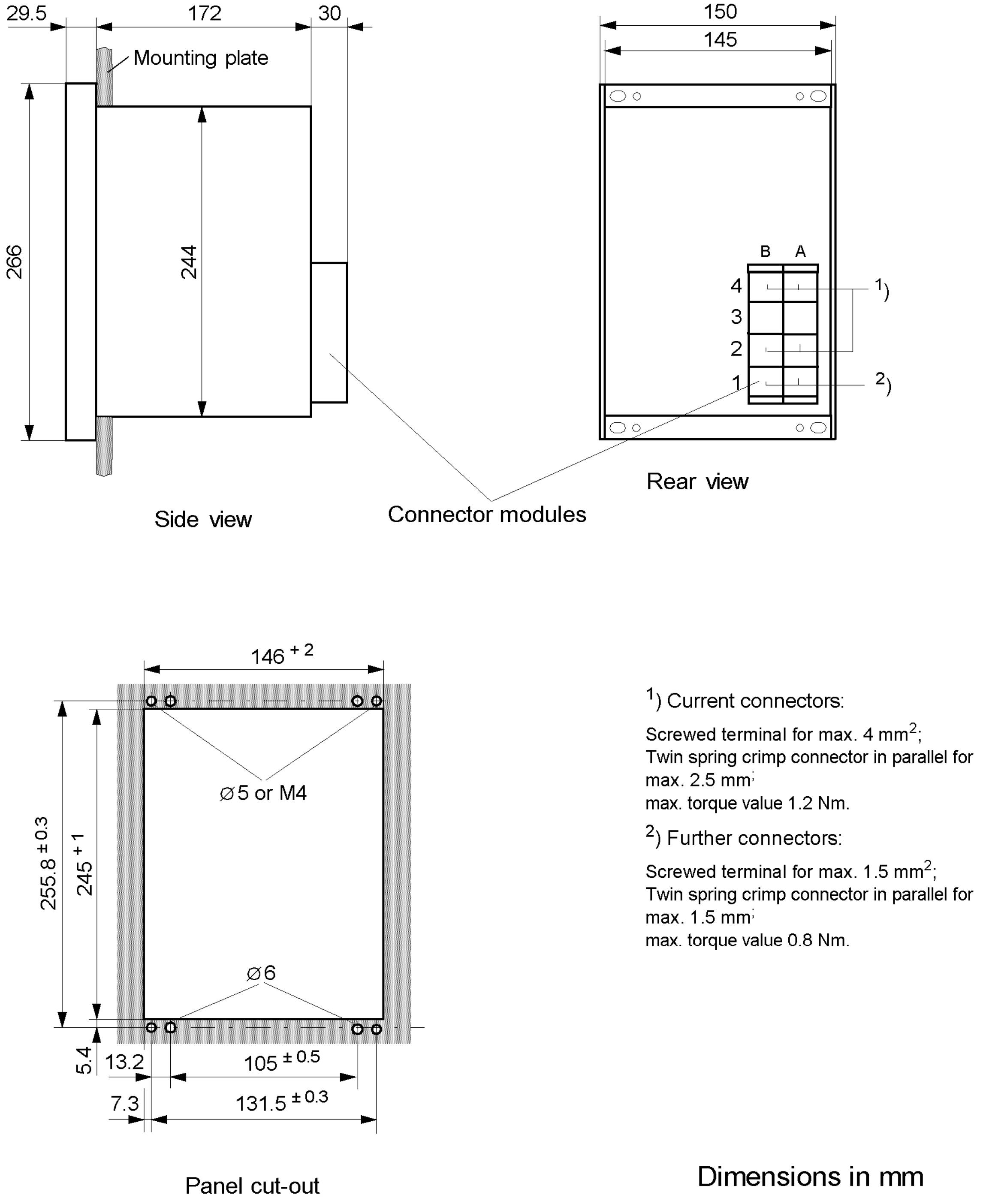


Figure 4-11 Dimensions of Coupling Unit 7XR6100-0CA0 for Panel Flush Mounting

4.26.6 Dimensions of Coupling Unit 7XR6100-0BA0 for Panel Flush Mounting

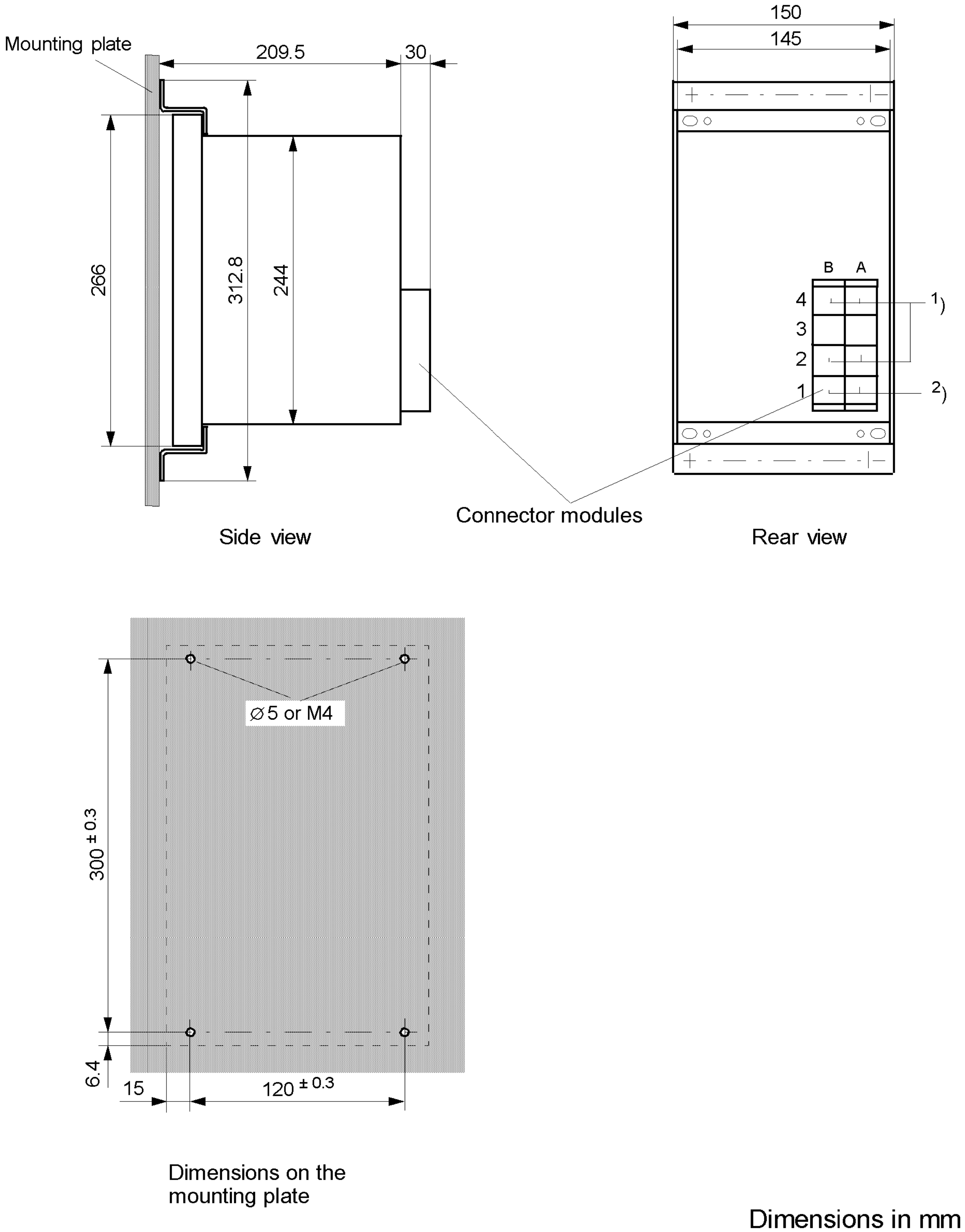
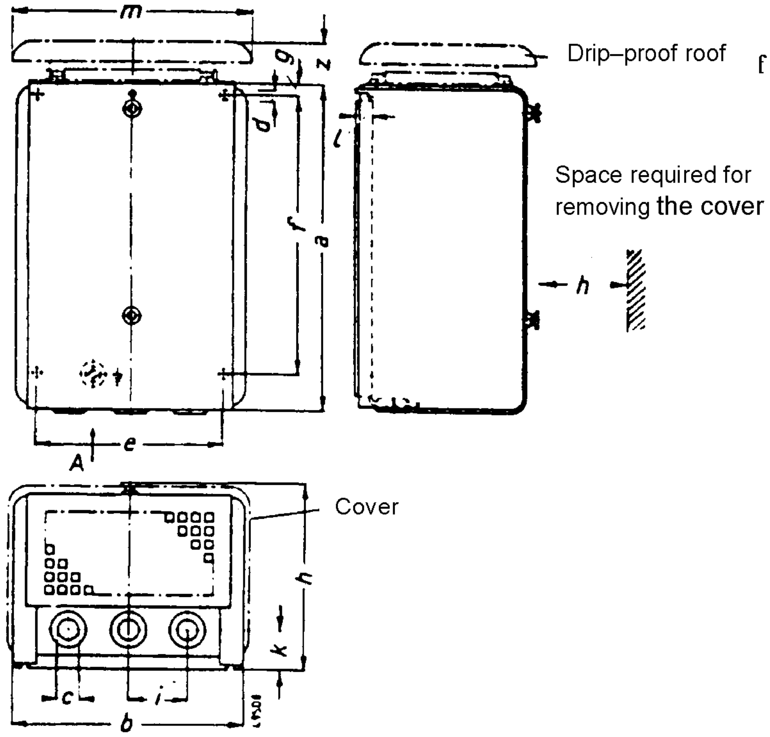


Figure 4-12 Dimensions of Coupling Unit 7XR6100-0BA0 for Panel Surface Mounting

4.26.7 Dimension diagrams 3PP13



3PP1 Degree of Protection IP 20 (with Drip–Proof Roof IP 23); Dimensions in mm

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 4-13 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

■

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 7UM61

						6	7		8	9	10	11	12		13	14				17	18	19
Machine Protection	7	U	M	6	1			—						—			A	0	+			

Number of Binary Inputs and Outputs	Pos. 6
Housing 1/3 19", 7 BI, 11 BO, 1 Live Status Contact	1
Housing 1/2 19", 15 BI, 19 BO, 1 Live Status Contact	2

Nominal current	Pos. 7
I_N = 1 A	1
I_N = 5 A	5

Auxiliary Voltage (Power Supply, Binary Input Threshold)	Pos. 8
DC 24 to 48 V, binary input threshold 19 V	2
DC 60 to 125 V, binary input threshold 19 V	4
DC 110 to 250 V, AC 115/230 V, Binary Input Threshold DC 88 V	5

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, Language German (Language can be changed)	A
Region World, 50/60 Hz, IEC/ANSI, Language English (Language can be changed)	B
Region US, 60 Hz, ANSI, Language American English (Language can be changed)	C

System Interface (Rear Side, 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
for more interface options see Additional Information L	9

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 [2)]
DNP3.0, RS485	L	0	G
DNP3.0, 820 nm, optical, ST connector	L	0	H [2)]

[1)] not for “B” at position 9; if the optical interface is required, then the device must be ordered with the following: 11th digit = 4 (RS485) and in addition a separate Optical-Fibre-converter

[2)] cannot be delivered in connection with “B” at position 9.

DIGSI 4/Modem Interface (Rear Side, Port C)	Pos. 12
no rear DIGSI 4 interface	0
DIGSI 4, electrical RS232	1
DIGSI 4, electrical RS458	2
DIGSI 4, Optical 820 nm, ST Connector	3

Measuring functions	Pos. 13
without extended measuring functionality	0
Min/Max values, energy metering	3

Functionality			Pos. 14
Generator Basis, comprising:		ANSI No.	A
Stator Earth Fault Protection, undirected, directed	U_0>, $3I_0$>, $-U_0$, $3I_0$	59N, 64G, 67G	
Sensitive earth fault detection (also as rotor earth fault protection	I_{EE}>	50/51GN,(64R)	
Overload protection	I^2t	49	
Overcurrent protection with Undervoltage Seal-In	I> +U<	51	
Overcurrent protection, directed	I>>, Direct.	50/51/67	
Inverse Time Overcurrent Protection	t=f(I) +U<	51V	
Overvoltage Protection	U>	59	
Undervoltage Protection	U<	27	
Frequency Protection	f<, f>	81	
Reverse Power Protection	–P	32R	
Overexcitation protection	V/f	24	
Fuse Failure Monitor	U_2/U_1; I_1/I_2	60FL	
External trippings (7UM611/7UM612)	Ext. tr.	—	
Trip Circuit Monitoring	TC mon	74TC	
Threshold Supervision	—	—	
RTD-Box	—	—	
Generator Standard, comprising:		ANSI No.	B
Generator Basis and in addition:			
Forward power supervision	P>, P<	32F	
Underexcitation protection	1/xd	40	

Functionality			**Pos. 14**
Unbalanced load protection	I_2>, t=f(I_2)	46	
Breaker Failure Protection	I_{min}>	50BF	
Generator Full, comprising:		ANSI No.	C
Generator Standard and in addition:			
Inadvertent Energizing Protection	I>, U<	50/27	
100% Stator Earth Fault Protection with 3rd Harmonic	$U_{0\ (3rd\ Harm.)}$	59TN 27TN(3.H)	
Impedance Protection with (I>+U<) Excitation	Z<	21	
Asynchronous Motor, comprising:		ANSI No.	F
Generator Standard and in addition:			
Motor startup time supervision	I_{st}^2t	48	
Restart Inhibit	I^2t	49 Rotor	
without			
Overexcitation protection	V/f	24	
Underexcitation protection	1/xd	40	

Functionality/Additional Functions	ANSI No.	Pos. 15
without		A
Rate-of-Frequency-Change Protection df/dt and Vector Jump (Voltage)	81R Δφ>	F
Sample order: 7UM6121–4EA91–0BA0 + L0A here: Position 11 = 9 stands for L0A, i.e. version with rear Profibus DP system interface, Slave, RS485		

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-D631-1
DNP3.0 820 nm	C53207-A351-D633-1

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

Angle brackets for mounting in 19"-racks

Name	Order No.
Angle Strip (Mounting Rail)	C73165-A63-C200-3

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	Order No.
Coupling unit	7XR6100-0CA00

Series Resistor

Series resistor for rotor earth fault protection	Order No.
Series resistor (2 x 105 Ω)	3PP1336-0DZ-013002

Voltage divider

Voltage divider	Order No.
Voltage divider 5:1; 5:2	3PP1336-1CZ-013001
Voltage divider 10:1; 20:1	3PP1326-0BZ-012009

Interface Cable

Interface cable between PC and SIPROTEC device	Order No.
Cable with 9-pole male/female connector	7XV5100-4

Operating Software DIGSI® 4

Protection operating and configuration software DIGSI® 4	Order No.
DIGSI® 4, basic version with license for 10 computers	7XS5400-0AA00
DIGSI® 4, complete version with all option packages	7XS5402-0AA0

Graphical analysis program SIGRA

Graphical analysis program SIGRA®	Order No.
Full version with license for 10 computers	7XS5410-0AA0

Graphic Tools

Graphic Tools 4	Order No.
Full version with license for 10 computers	7XS5430-0AA0

DIGSI REMOTE 4

Software for remotely operating protective devices via a modem (and possibly a star connector) using DIGSI® 4 (option package of the complete version of DIGSI® 4)	Order No.
DIGSI REMOTE 4; Full version with license for 10 computers; Language: German	7XS5440-1AA0

SIMATIC CFC 4

Graphical software for setting interlocking (latching) conditions and creating extended functions (option package of the complete version of DIGSI® 4)	Order No.
SIMATIC CFC 4; Full version with license for 10 computers	7XS5450-0AA0

A.2 Terminal Assignments

A.2.1 General Diagram

7UM611*-

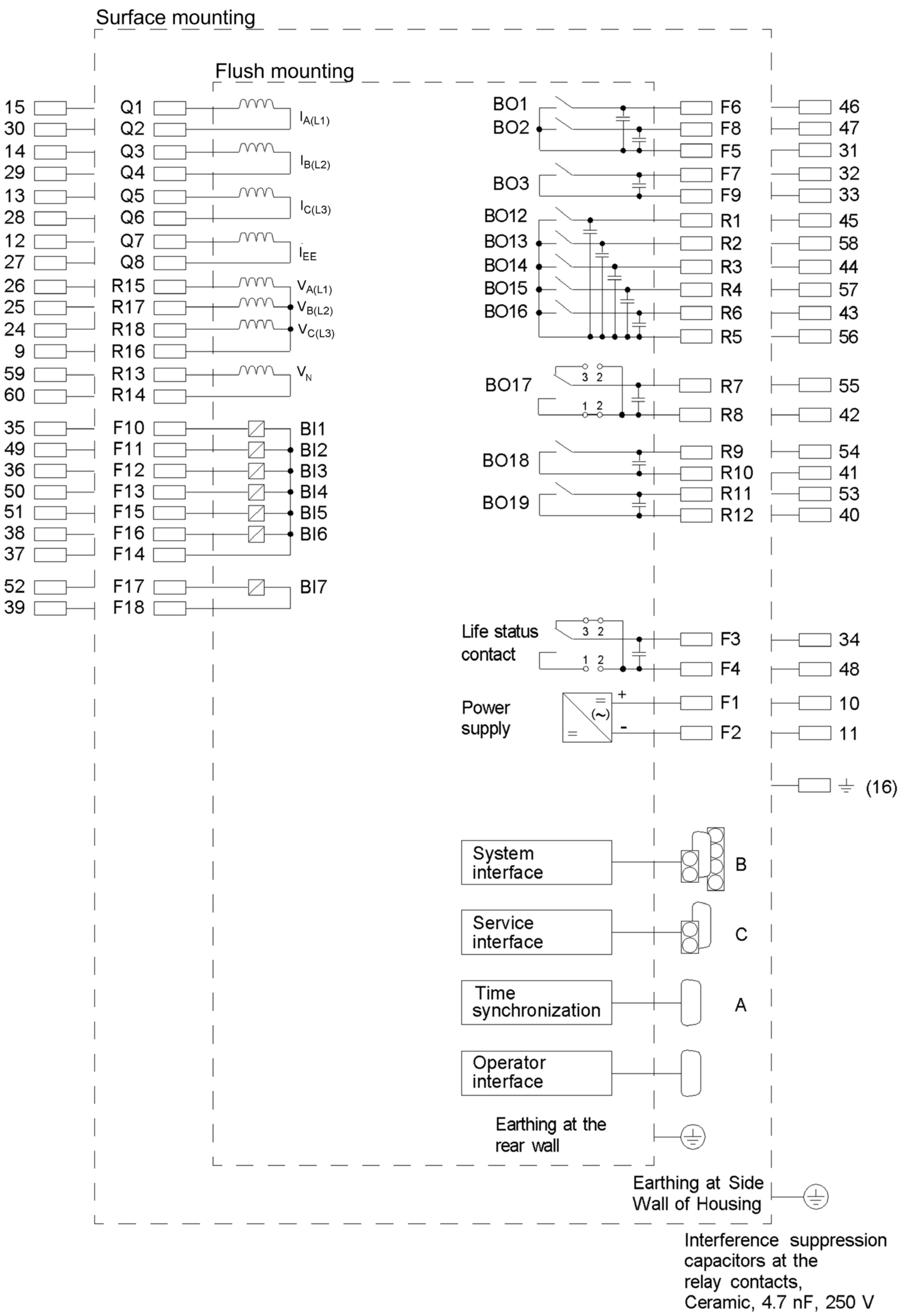


Figure A-1 General Diagram 7UM611

A.2.2 General Diagram (Surface Mounting Version)

7UM611*–*B

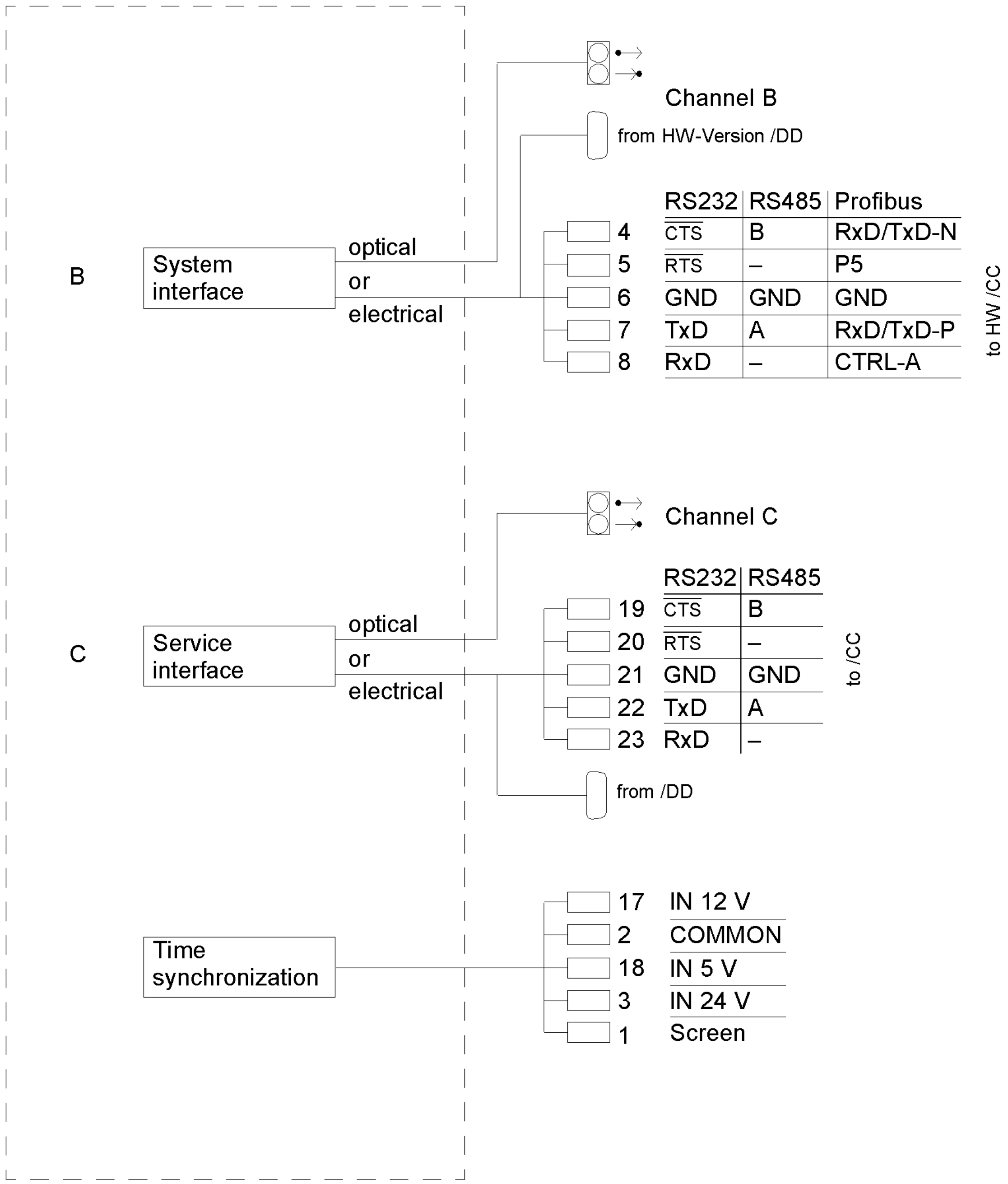


Figure A-2 General diagram 7UM611*–*B (panel surface mounted)

A.2.3 General Diagram

7UM612*-

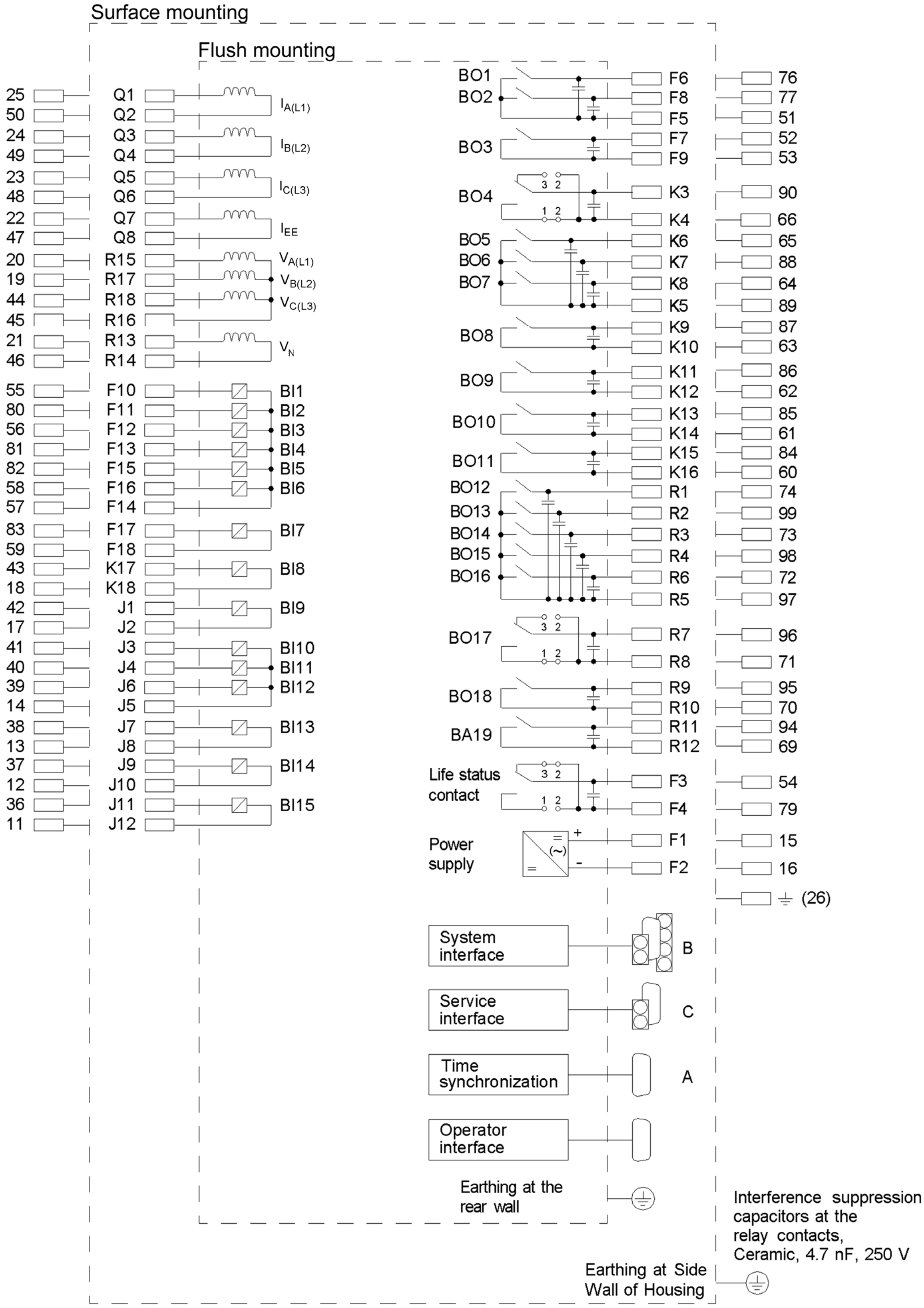


Figure A-3 General diagram 7UM612

A.2.4 General Diagram (Surface Mounting Version)

7UM612–*B

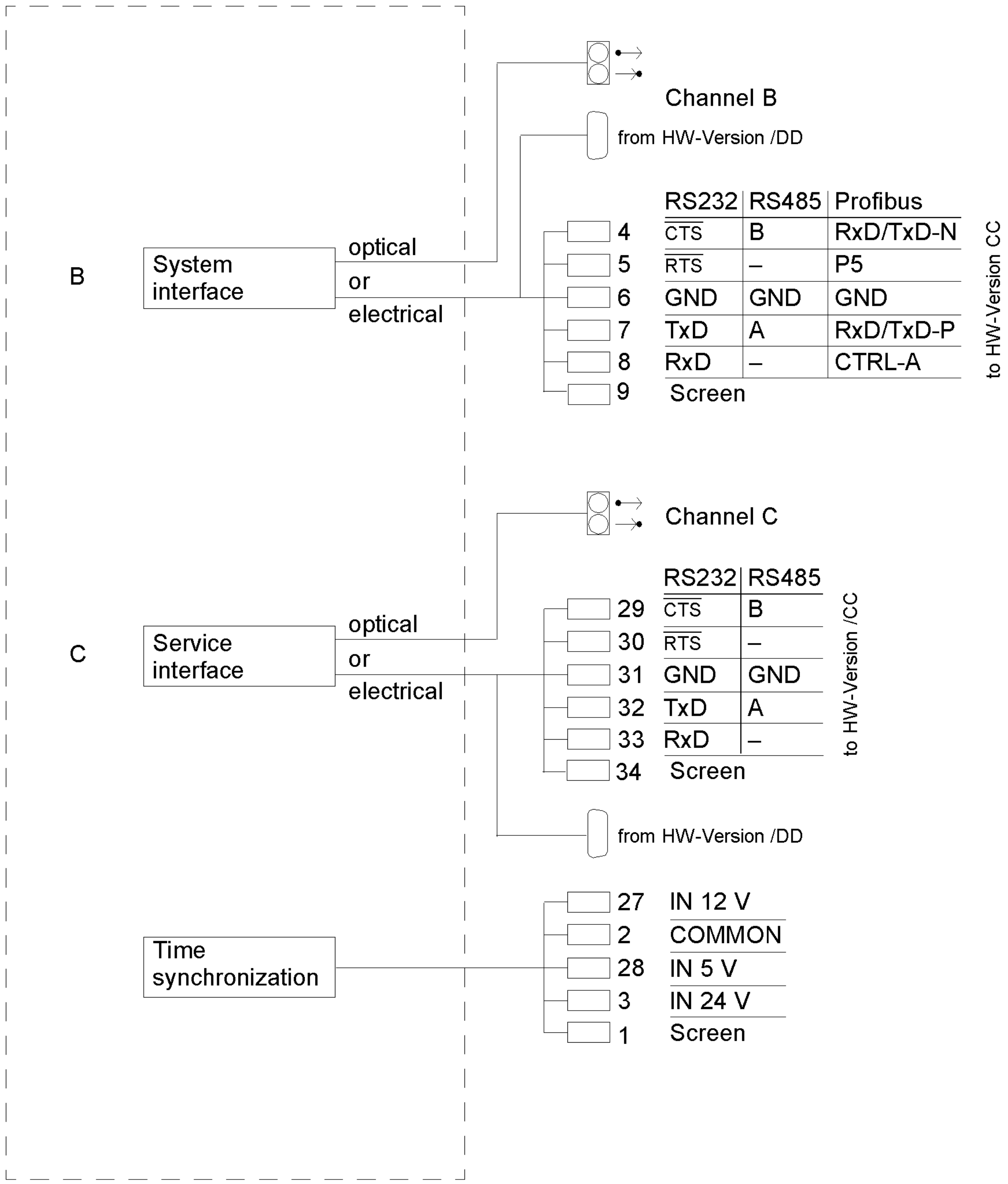


Figure A-4 General diagram 7UM612*–*B (panel surface mounted)

A.3 Connection Examples

A.3.1 Connection Examples

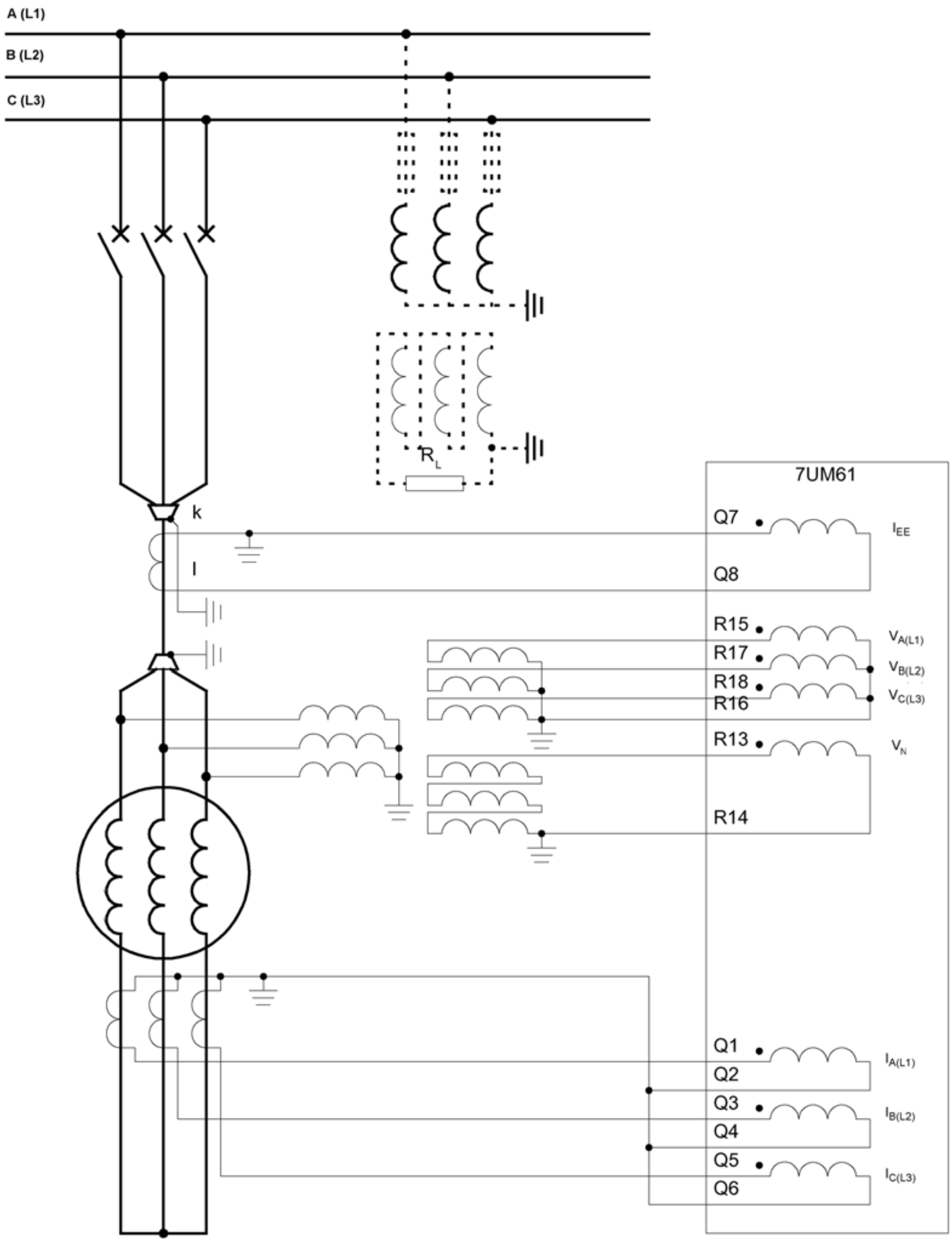


Figure A-5 **Busbar connection:** Current and voltage connections to three transformers (phase-earth-voltages) and in each case three current transformers, – earth current from additional summation current transformer for sensitive earth fault detection; Displacement voltage detection at broken delta winding (e–n).

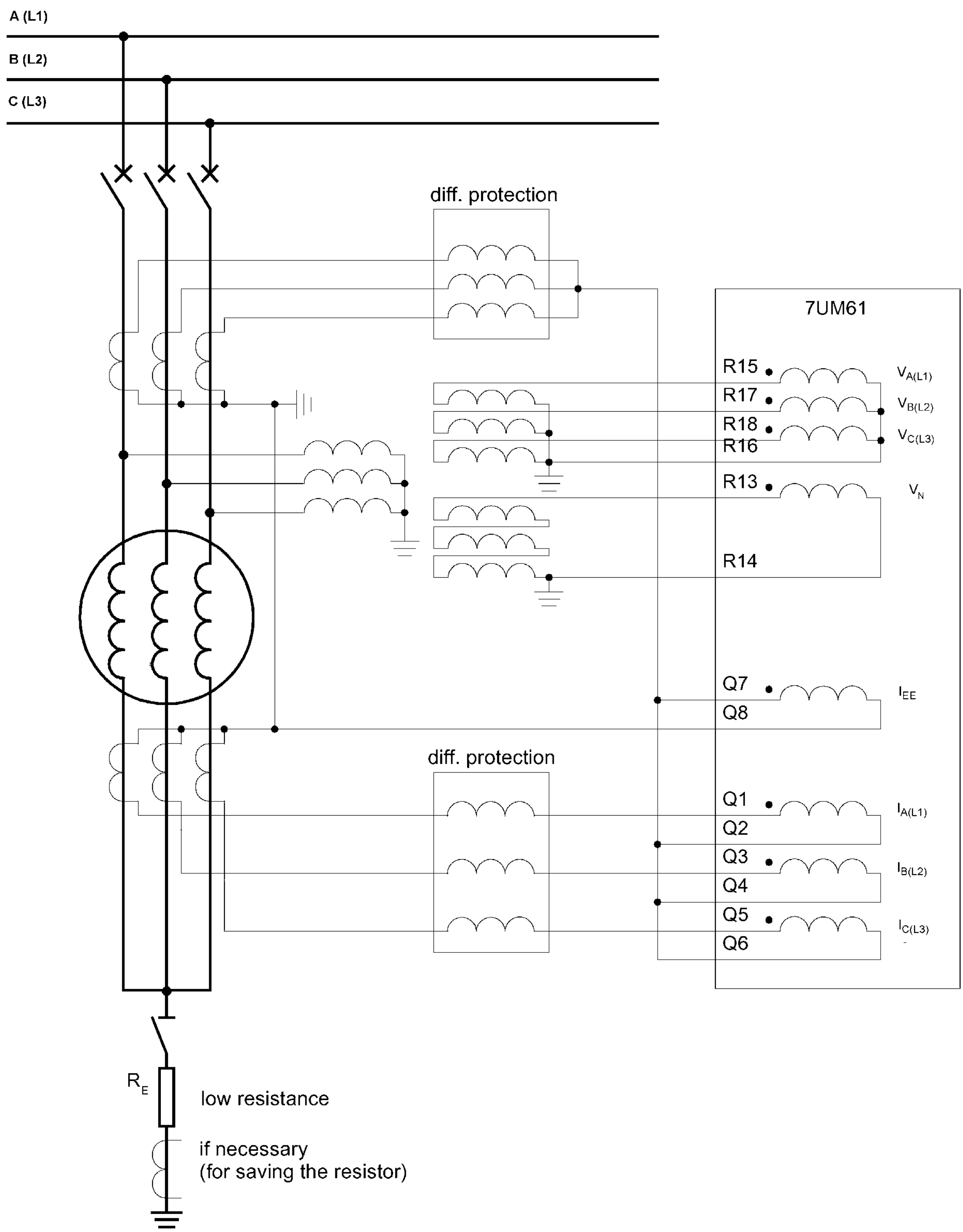


Figure A-6 **Busbar System with Low-Ohmic Earthing**: CT connections to three voltage transformers (phase-to-ground voltages) and in each case three current transformers – earth fault detection as differential current measuring of two CT sets; detection of displacement voltage at broken delta winding (e–n) as an additional criterion.

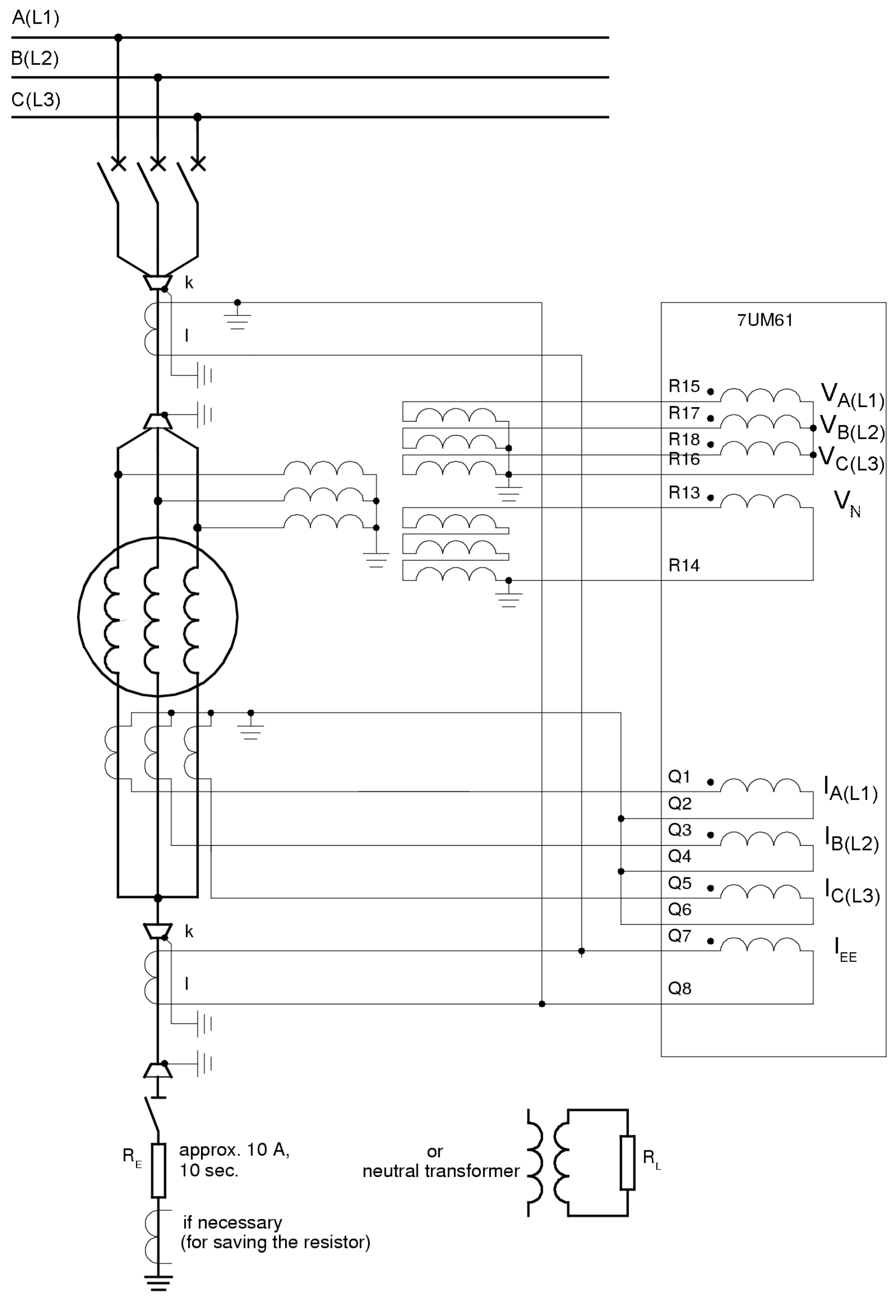


Figure A-7 Busbar system with high-ohmic, switchable starpoint resistors ,CT connection to three current transformers and three voltage transformers (phase-to-ground voltages) –earth fault detection as differential current measuring between star-point current and summation current measured via toroidal CTs; detection of displacement voltage at open delta winding (e–n).

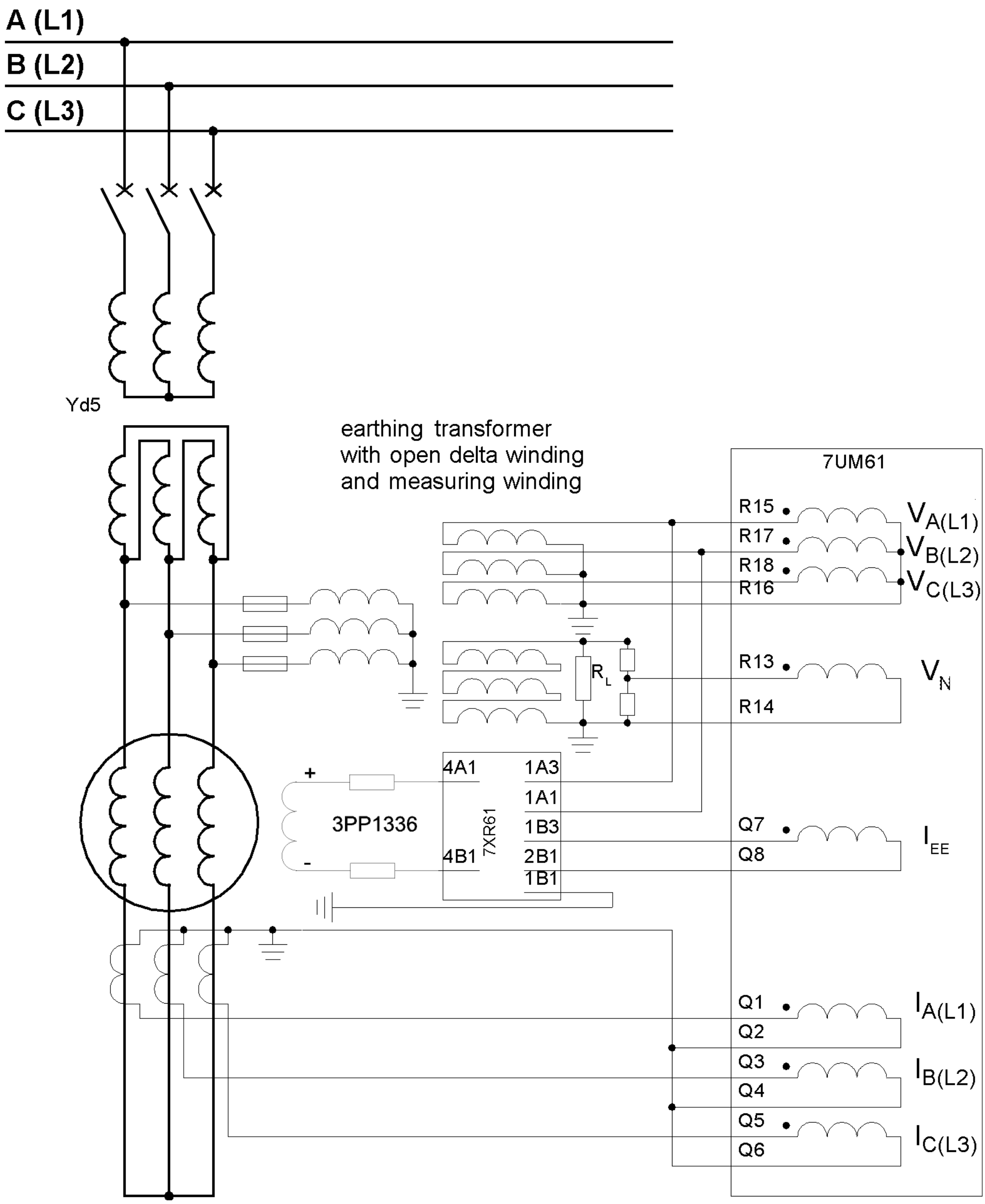


Figure A-8 **Unit Connection with Isolated Starpoint:** Connection to three current transformers and three voltage transformers (phase-to-earth voltages) –with series device 7XR61 for rotor circuit injection and with supervision of the rotor ground insulation by sensitive earth fault detection; detection of displacement voltage at open delta winding (e–n).

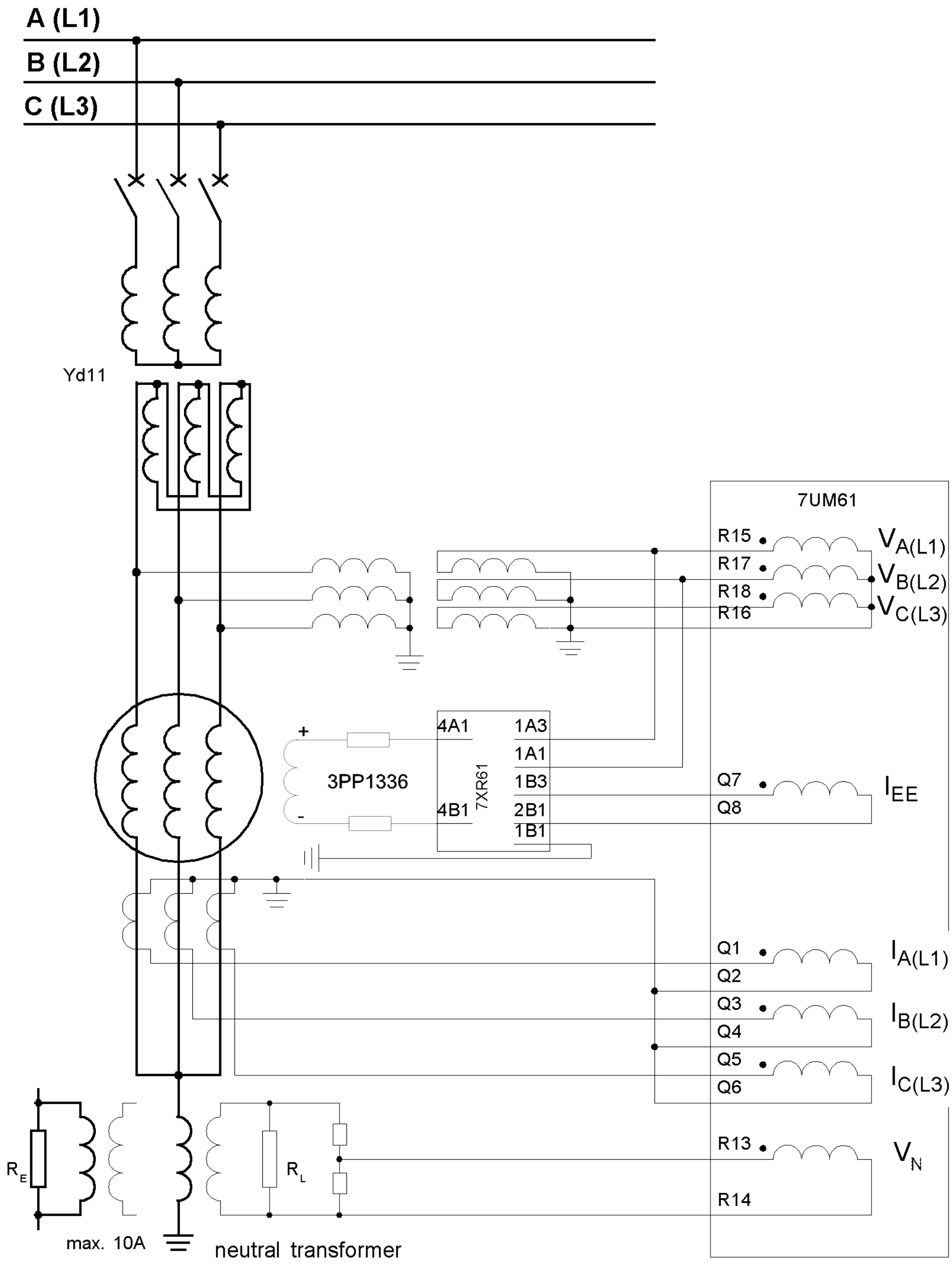


Figure A-9 **Unit Connection with Isolated Starpoint:** CT connections to three voltage transformers (phase-to-earth voltages) and three voltage transformers each; Loading resistor connected either directly to starpoint circuit or via intermediate transformer.

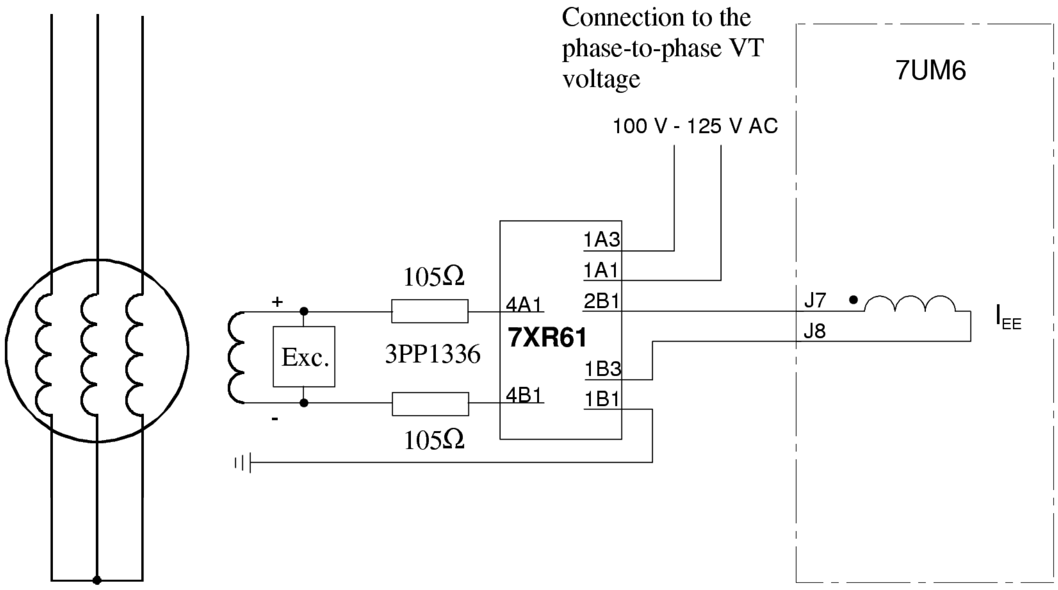


Figure A-10 **Rotor earth fault protection** – with series device 7XR61 for injection of a rated-frequency voltage into the rotor circuit if the sensitive earth current input is used.

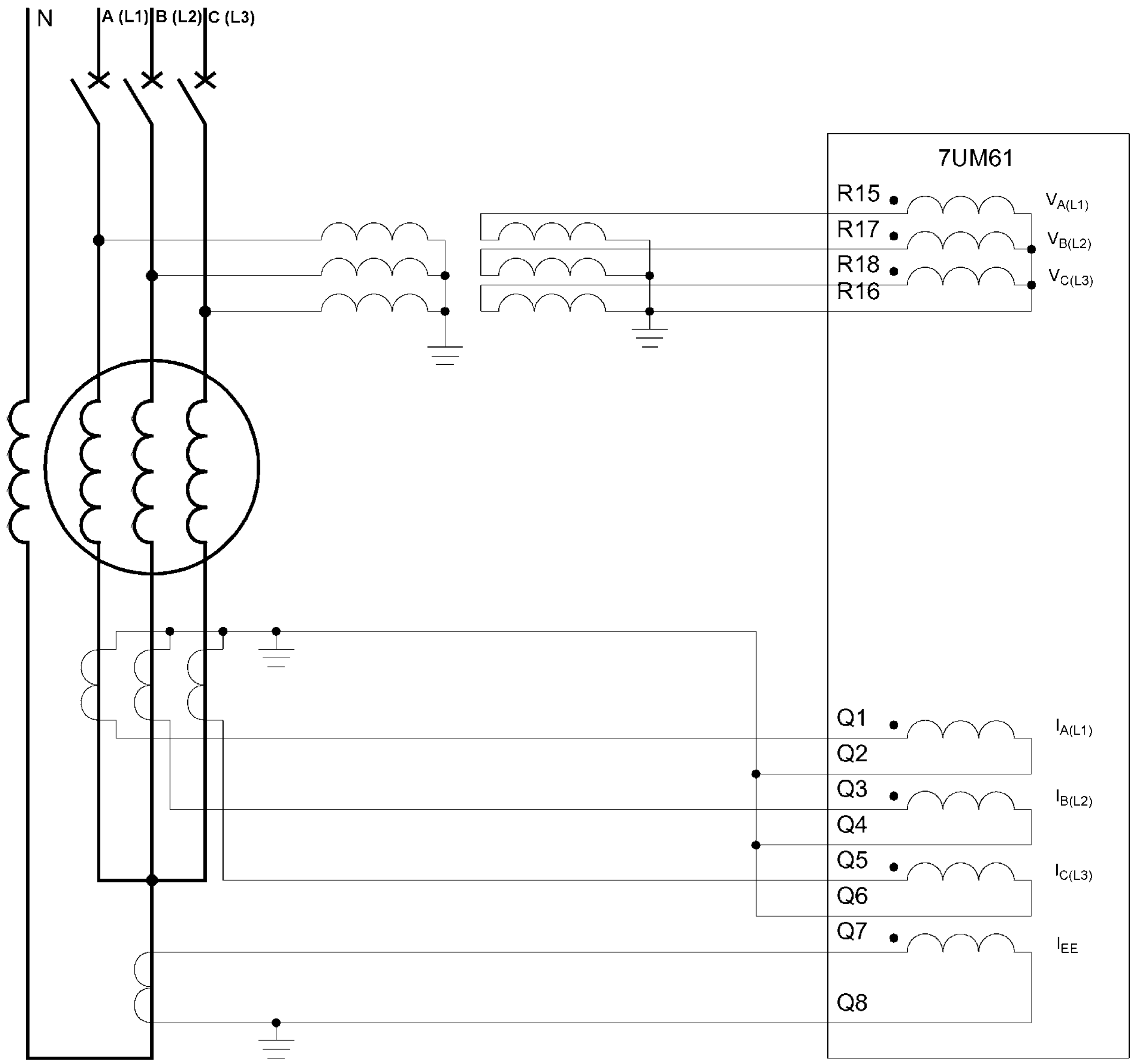


Figure A-11 Generator with Neutral Conductor

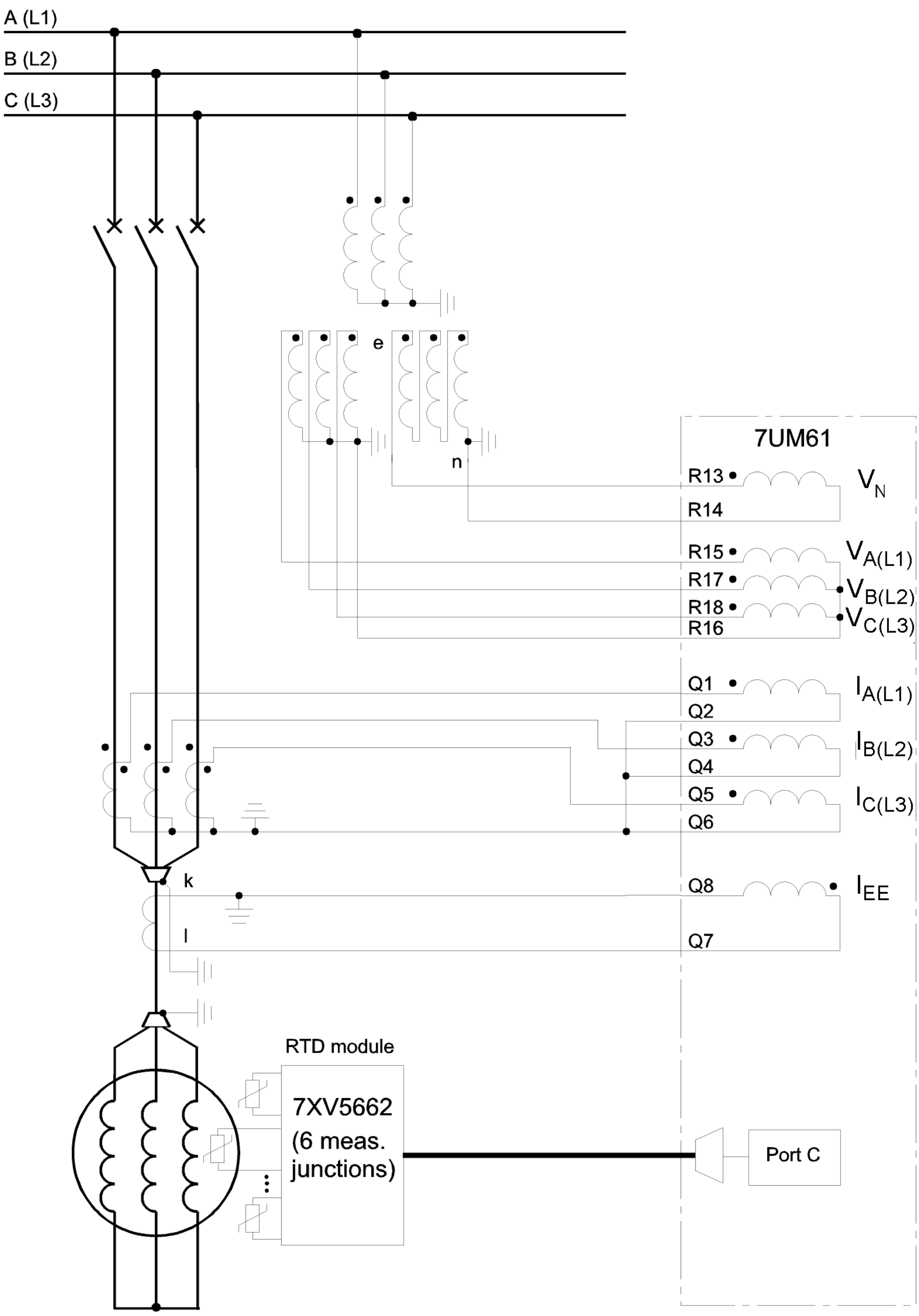


Figure A-12 **Asynchronous motor:**Connection to three voltage transformers (phase-to-earth voltages, usually from the busbar); Displacement voltage detection at broken delta winding, three current transformers; Earth fault direction detection by toroidal CTs

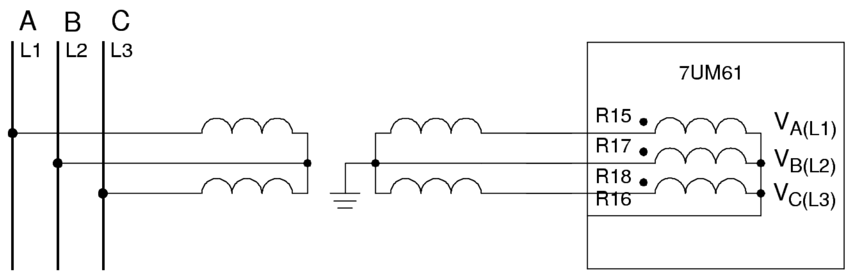


Figure A-13 Voltage Transformer Connections for Two Voltage Transformers in Open Delta Connection (V Connection)

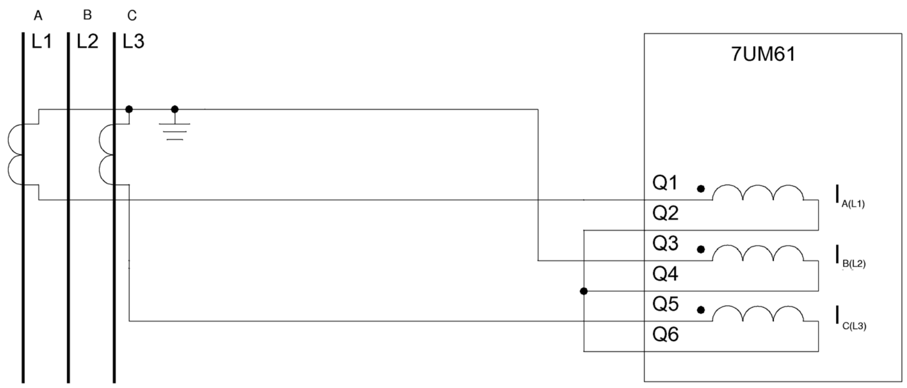


Figure A-14 Current Transformer Connections with only Two System-Side Current Transformers

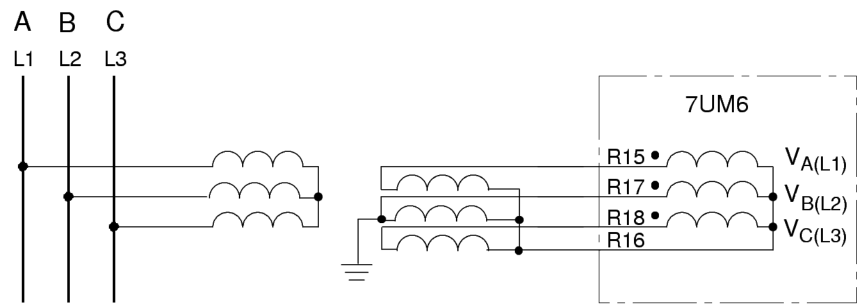


Figure A-15 Voltage Transformer Connection with L2 Earthed on the Secondary Side

A.3.2 Connection Examples for Thermobox

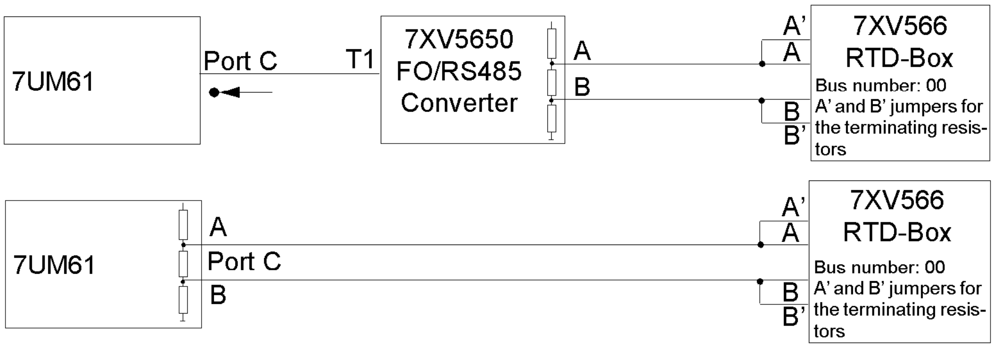


Figure A-16 Simplex operation with one Thermobox

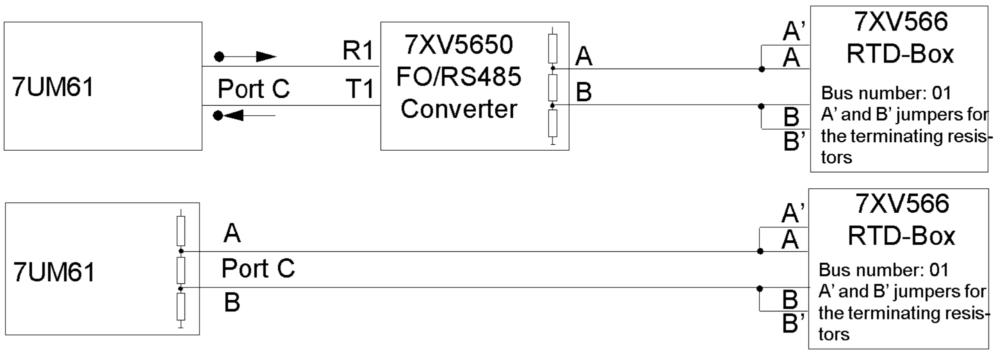


Figure A-17 Semiduplex operation with one thermobox

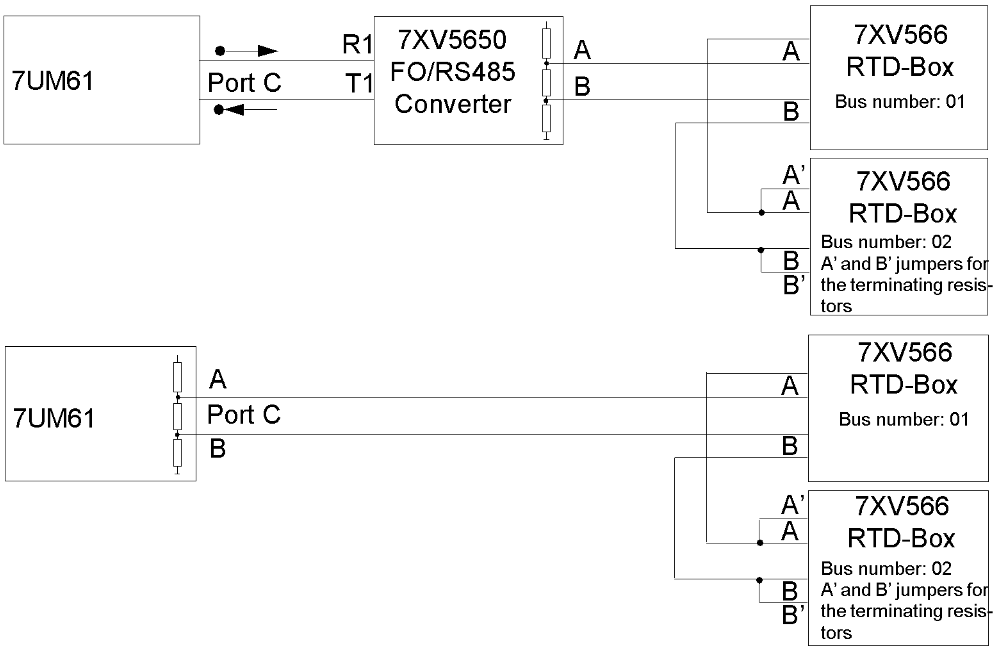


Figure A-18 Semiduplex operation with two thermoboxes

A.3.3 Schematic Diagram of Accessories

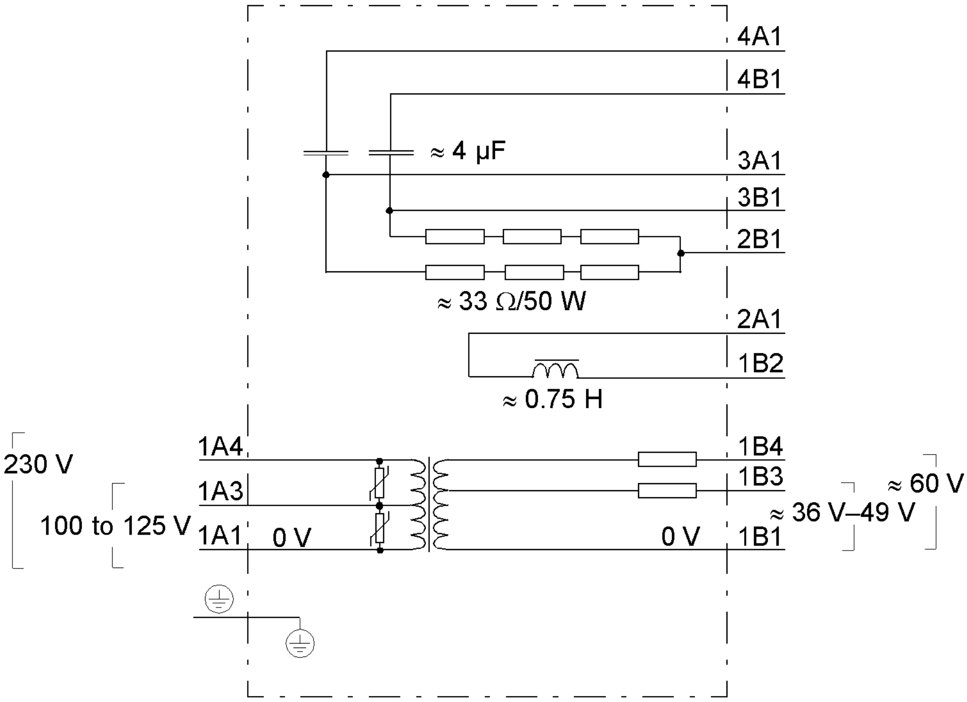


Figure A-19 Schematic Diagram of Coupling Unit 7XR6100-0*A00 for Rotor Earth Fault Protection

Figure A-20 Schematic Diagram of Series Resistor 3PP1336-0DZ-013002

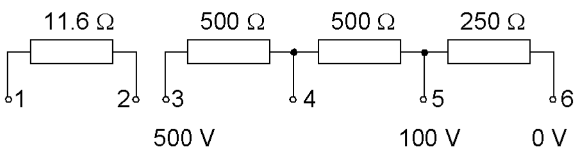


Figure A-21 Schematic Diagram of Voltage Divider 5:1; 5:2; 3PP1336-1CZ-013001

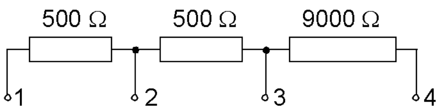


Figure A-22 Schematic Diagram of Voltage Divider 10:1; 20:1; 3PP1326-0BZ-012009

A.4 Default Settings

A.4.1 LEDs

Table A-1 LED indication presettings

LEDs	Short Text	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	List Empty	-	-[1]

1) Only for 7UM612

A.4.2 Binary Input

Table A-2 Binary input presettings for all devices and ordering variants

Binary Input	Short Text	Function No.	Description
BI1	>SV tripped	5086	>Stop valve tripped
BI2	>Uexc fail.	5328	>Exc. voltage failure recognized
BI3	>BLOCK f1 >BLOCK U< >S/E/F Iee off	5206 6506 5176	>BLOCK stage f1 >BLOCK undervoltage protection U< >Switch off earth current de-tec.(S/E/F)[1]
BI4	>FAIL:Feeder VT >Useal-in BLK >BLOCK U/V	361 1950 6503	>Failure: Feeder VT (MCB tripped) >O/C prot. : BLOCK undervoltage seal-in >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 ... 14	List Empty	-	-[2]

1) Only Busbar Connection
2) Only for 7UM612

A.4.3 Binary Output

Table A-3 Output relay presettings for all devices and ordering variants

Binary Output	Short Text	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	List Empty	-	-
BO4 ... 11	List Empty	-	-[1]
BO12	I> TRIP	1815	O/C I> TRIP
BO13	IEE> TRIP	1226	IEE> TRIP
	U0> TRIP	5187	Stator earth fault: U0 stage TRIP
	S/E/F TRIP	5193	Stator earth fault protection TRIP
BO14	U< TRIP	6539	Undervoltage U< TRIP
	U> TRIP	6570	Overvoltage U> TRIP
	U>> TRIP	6573	Overvoltage U>> TRIP
BO15	f1 TRIP	5236	f1 TRIP
	f2 TRIP	5237	f2 TRIP
BO16	Exc<3 TRIP	5343	Underexc. prot. char. 3 TRIP
	Exc<U<TRIP	5346	Underexc. prot. char.+Uexc< TRIP
BO17	f1 TRIP	5236	f1 TRIP[2]
	f2 TRIP	5237	f2 TRIP[2]
	I> TRIP	1815	O/C I> TRIP[2]
	U>> TRIP	6573	Overvoltage U>> TRIP[2]
	Pr TRIP	5097	Reverse power: TRIP[2]
	Pr+SV TRIP	5098	Reverse power: TRIP with stop valve[2]
	S/E/F TRIP	5193	Stator earth fault protection TRIP[2]
	I2 Θ TRIP	5161	Unbalanced load: TRIP of thermal stage[2]
	Exc<3 TRIP	5343	Underexc. prot. char. 3 TRIP[2]
	Exc<U<TRIP	5346	Underexc. prot. char.+Uexc< TRIP[2]
BO18	f2 TRIP	5237	f2 TRIP[3]
	I> TRIP	1815	O/C I> TRIP[3]
	U>> TRIP	6573	Overvoltage U>> TRIP[3]
	Pr+SV TRIP	5098	Reverse power: TRIP with stop valve[3]
	S/E/F TRIP	5193	Stator earth fault protection TRIP[3]
	I2 Θ TRIP	5161	Unbalanced load: TRIP of thermal stage[3]
	Exc<3 TRIP	5343	Underexc. prot. char. 3 TRIP[3]
	Exc<U<TRIP	5346	Underexc. prot. char.+Uexc< TRIP[3]
BO19	f2 TRIP	5237	f2 TRIP[4]
	I> TRIP	1815	O/C I> TRIP[4]
	S/E/F TRIP	5193	Stator earth fault protection TRIP[4]
	I2 Θ TRIP	5161	Unbalanced load: TRIP of thermal stage[4]

1) Only for 7UM612
2) Generator Circuit Breaker
3) De-excitation
4) Emergency Tripping

A.4.4 Function Keys

Table A-4 Applies to all devices and ordered variants

Function Keys	Presetting
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

```
I1: 0.50kA  cosφ:0.80
U : 10.93kV f:50.00Hz
P :      4.64MW
Q :      2.86MVAR
```

```
1▮ 0.50kA  12▮ 6.31kV
2▮ 0.50kA  23▮ 6.30kV
3▮ 0.50kA  31▮ 6.29kV
E▮  0.0A   E ▮    2V
```

Figure A-23 Basic Displays of the 7UM61

Spontaneous Fault Message Display

After a fault the device presents the most important fault data after general pickup of the 7UM61, automatically and without any operator action on its LCD display, in the sequence shown in the following figure.

```
U0> picked up
S/E/F TRIP
PU Time   440ms
TRIP Time 301ms
```

Protective Function that picked up first;
Protective Function that dropped out last;
Running time from general pickup to dropout;
Running time from general pickup to the first trip command

Figure A-24 Display of spontaneous messages in the device display

A.4.6 Pre-defined CFC Charts

Some CFC Charts are already supplied with the SIPROTEC® 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-25 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:

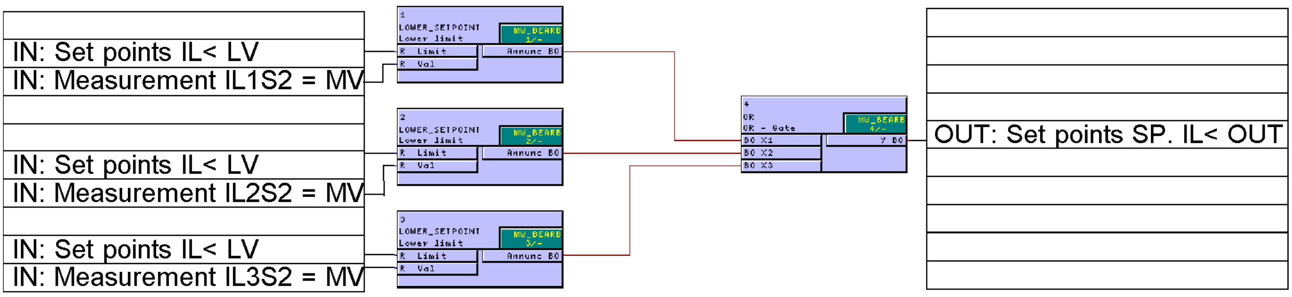


Figure A-26 Undercurrent monitoring

A.5 Protocol-dependent Functions

Protocol → Function ↓	IEC 60870–5–103	Profibus FMS (on request)	Profibus DP	DNP3.0	Modbus ASCII/RTU	Additional Service Interface (optional)
Operational measured values	Yes	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	Yes	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	Pre-defined "User-defined message" in CFC	Pre-defined "User-defined message" in CFC	Pre-defined "User-defined message" in CFC	Yes
Time synchronization	Via protocol; DCF77/IRIG B; Interface; Binary input	Via protocol; DCF77/IRIG B; Interface; Binary input	Via DCF77/IRIG B; Interface; Binary input	Via protocol; DCF77/IRIG B; Interface; Binary input	Via protocol; DCF77/IRIG B; Interface; Binary input Protocol	—
Messages with time stamp	Yes	Yes	No	Yes	No	Yes
Commissioning tools						
Measured value indication blocking	Yes	Yes	No	No	No	Yes
Test Mode	Yes	Yes	No	No	No	Yes
Physical mode	Asynchronous	Asynchronous	Asynchronous	Asynchronous	Asynchronous	—
Transmission Mode	Cyclically/Event	Cyclically/Event	Cyclically	Cyclically/Event	Cyclically	—
Baud rate	4800 to 38400	Up to 1.5 MBaud	Up to 1.5 MBaud	4800 to 19200	2400 to 19200	2400 to 38400
Type	RS 232 RS 485 Fibre Optic Cable	RS 485 Fibre Optic Cable: Single Ring, Double Ring	RS 485 Fibre Optic Cable: Double ring	RS 485 Fibre Optic Cable	RS 485 Fibre Optic Cable	RS 232 RS 485 Fibre Optic Cable

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 Enabled	Enabled	Overcurrent Protection I>
113	O/C PROT. I>>	Disabled directional Non-Directional	Non-Directional	Overcurrent Protection I>>
114	O/C PROT. Ip	Disabled with IEC with ANSI	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)
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
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)
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 Enabled	Enabled	Sensitive Earth Current Protection
152	SEF 3rd HARM.	Disabled Enabled	Enabled	Stator Earth Fault Prot. 3rd Harmonic
165	STARTUP MOTOR	Disabled Enabled	Enabled	Motor Starting Time Supervision

Addr.	Parameter	Setting Options	Default Setting	Comments
166	RESTART INHIBIT	Disabled Enabled	Enabled	Restart Inhibit for Motors
170	BREAKER FAILURE	Disabled Enabled	Enabled	Breaker Failure Protection
171	INADVERT. EN.	Disabled Enabled	Enabled	Inadvertent Energisation
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
190	RTD-BOX INPUT	Disabled Port C Port D Port E	Disabled	External Temperature Input
191	RTD CONNECTION	6 RTD simplex 6 RTD HDX 12 RTD HDX	6 RTD simplex	Ext. Temperature Input Connection Type

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
204	CT ANGLE W0	P.System Data 1		-5.00 .. 5.00 °	0.00 °	Correction Angle CT W0
210	CT Starpoint	P.System Data 1		towards machine towards starpt.	towards machine	CT Starpoint
211	CT PRIMARY	P.System Data 1		10 .. 50000 A	500 A	CT Rated Primary Current
212	CT SECONDARY	P.System Data 1		1A 5A	1A	CT Rated Secondary Current
213	FACTOR IEE	P.System Data 1		1.0 .. 300.0	60.0	CT Ratio Prim./Sec. Iee
221	Unom PRIMARY	P.System Data 1		0.10 .. 400.00 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	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
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
273	STAR-POINT	P.System Data 1		low-resist. high-resist.	high-resist.	Earthing of Machine Starpoint
274A	ATEX100	P.System Data 1		YES NO	NO	Storage of th. Replicas w/o Power Supply
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
281	BkrClosed I MIN	P.System Data 1	1A	0.04 .. 1.00 A	0.04 A	Closed Breaker Min. Current Threshold
			5A	0.20 .. 5.00 A	0.20 A	
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 .. 0.60 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
1101	U PRIMARY OP.	P.System Data 2		0.10 .. 400.00 kV	6.30 kV	Primary Operating Voltage
1102	I PRIMARY OP.	P.System Data 2		10 .. 50000 A	483 A	Primary Operating Current
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>

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
1202	I>	O/C Prot. I>	1A	0.05 .. 20.00 A	1.35 A	I> Pickup
			5A	0.25 .. 100.00 A	6.75 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>>	1A	0.05 .. 20.00 A	4.30 A	I>> Pickup
			5A	0.25 .. 100.00 A	21.50 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	1A	0.10 .. 4.00 A	1.00 A	Ip Pickup
			5A	0.50 .. 20.00 A	5.00 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
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 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	1A	0.10 .. 4.00 A	1.00 A	Current Overload Alarm Setpoint
			5A	0.50 .. 20.00 A	5.00 A	
1612A	Kτ-FACTOR	Therm. Overload		1.0 .. 10.0	1.0	Kt-Factor when Motor Stops
1615A	I MAX THERM.	Therm. Overload	1A	0.50 .. 8.00 A	3.30 A	Maximum Current for Thermal Replica
			5A	2.50 .. 40.00 A	16.50 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

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
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		2.0 .. 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 .. 100 %	60 %	I2>> Pickup
1707	T I2>>	Unbalance Load		0.00 .. 60.00 sec; ∞	3.00 sec	T I2>> Time Delay
3001	UNDEREXCIT.	Underexcitation		OFF ON Block relay	OFF	Underexcitation Protection
3002	1/xd CHAR. 1	Underexcitation		0.25 .. 3.00	0.41	Conductance Intersect Charac-teristic 1
3003	ANGLE 1	Underexcitation		50 .. 120 °	80 °	Inclination Angle of Characteris-tic 1
3004	T CHAR. 1	Underexcitation		0.00 .. 60.00 sec; ∞	10.00 sec	Characteristic 1 Time Delay
3005	1/xd CHAR. 2	Underexcitation		0.25 .. 3.00	0.36	Conductance Intersect Charac-teristic 2
3006	ANGLE 2	Underexcitation		50 .. 120 °	90 °	Inclination Angle of Characteris-tic 2
3007	T CHAR. 2	Underexcitation		0.00 .. 60.00 sec; ∞	10.00 sec	Characteristic 2 Time Delay
3008	1/xd CHAR. 3	Underexcitation		0.25 .. 3.00	1.10	Conductance Intersect Charac-teristic 3
3009	ANGLE 3	Underexcitation		50 .. 120 °	90 °	Inclination Angle of Characteris-tic 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<)
3014A	Umin	Underexcitation		10.0 .. 125.0 V	25.0 V	Undervoltage blocking Pickup
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	T-Pf<	Forward Power		0.00 .. 60.00 sec; ∞	10.00 sec	T-P-forw.< Time Delay
3204	Pf>	Forward Power		1.0 .. 120.0 %	96.6 %	P-forw.> Supervision Pickup
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	1A	0.10 .. 20.00 A	1.35 A	Fault Detection I> Pickup
			5A	0.50 .. 100.00 A	6.75 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	1A	0.05 .. 130.00 Ω	2.90 Ω	Impedance Zone Z1
			5A	0.01 .. 26.00 Ω	0.58 Ω	
3307	T-Z1	Impedance		0.00 .. 60.00 sec; ∞	0.10 sec	Impedance Zone Z1 Time Delay
3308	ZONE Z1B	Impedance	1A	0.05 .. 65.00 Ω	4.95 Ω	Impedance Zone Z1B
			5A	0.01 .. 13.00 Ω	0.99 Ω	

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
3309	T-Z1B	Impedance		0.00 .. 60.00 sec; ∞	0.10 sec	Impedance Zone Z1B Time Delay
3310	ZONE Z2	Impedance	1A	0.05 .. 65.00 Ω	4.15 Ω	Impedanz Zone Z2
			5A	0.01 .. 13.00 Ω	0.83 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
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 .. 65.00 Hz	48.00 Hz	f1 Pickup
4203	f1 PICKUP	Frequency Prot.		40.00 .. 65.00 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 .. 65.00 Hz	47.00 Hz	f2 Pickup
4206	f2 PICKUP	Frequency Prot.		40.00 .. 65.00 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 .. 65.00 Hz	49.50 Hz	f3 Pickup
4209	f3 PICKUP	Frequency Prot.		40.00 .. 65.00 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 .. 65.00 Hz	52.00 Hz	f4 Pickup
4212	f4 PICKUP	Frequency Prot.		40.00 .. 65.00 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
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

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
4314	T COOL DOWN	Overexcitation		0 .. 20000 sec	3600 sec	Time for Cooling Down
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
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 Protection
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

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
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>
6501	STARTUP MOTOR	Start Motor		OFF ON Block relay	OFF	Motor Starting Time Supervision
6502	START. CURRENT	Start Motor	1A	0.10 .. 16.00 A	3.12 A	Starting Current of Motor
			5A	0.50 .. 80.00 A	15.60 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	1A	0.60 .. 10.00 A	1.60 A	Current Pickup Value of Motor Starting
			5A	3.00 .. 50.00 A	8.00 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 BO3 CFC	OFF	Start with Internal TRIP Command
7003	CIRC. BR. I>	Breaker Failure	1A	0.04 .. 2.00 A	0.20 A	Supervision Current Pickup
			5A	0.20 .. 10.00 A	1.00 A	
7004	TRIP-Timer	Breaker Failure		0.06 .. 60.00 sec; ∞	0.25 sec	TRIP-Timer
7101	INADVERT. EN.	Inadvert. En.		OFF ON Block relay	OFF	Inadvertent Energisation
7102	I STAGE	Inadvert. En.	1A	0.1 .. 20.0 A; ∞	0.3 A	I Stage Pickup
			5A	0.5 .. 100.0 A; ∞	1.5 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<
7110	FltDisp.LED/LCD	Device		Target on PU Target on TRIP	Target on PU	Fault Display on LED / LCD
8001	FUSE FAIL MON.	Measurem.Superv		OFF ON	OFF	Fuse Failure Monitor
8101	MEASURE. SUPERV	Measurem.Superv		OFF ON	OFF	Measurement Supervision
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

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
8104	BALANCE I LIMIT	Measurem.Superv	1A	0.10 .. 1.00 A	0.50 A	Current Balance Monitor
			5A	0.50 .. 5.00 A	2.50 A	
8105	BAL. FACTOR I	Measurem.Superv		0.10 .. 0.90	0.50	Balance Factor for Current Monitor
8106	ΣI THRESHOLD	Measurem.Superv	1A	0.05 .. 2.00 A	0.10 A	Summated Current Monitoring Threshold
			5A	0.25 .. 10.00 A	0.50 A	
8107	ΣI FACTOR	Measurem.Superv		0.00 .. 0.95	0.10	Summated Current Monitoring Factor
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
8201	TRIP Cir. SUP.	TripCirc.Superv		OFF ON	OFF	TRIP Circuit Supervision
8501	MEAS. VALUE 1>	Threshold		Disabled P Q Delta P U1 U2 I0 I1 I2 PHI	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 U1 U2 I0 I1 I2 PHI	Disabled	Measured Value for Threshold MV2<
8504	THRESHOLD MV2<	Threshold		-200 .. 200 %	100 %	Pickup Value of Measured Value MV2<
8505	MEAS. VALUE 3>	Threshold		Disabled P Q Delta P U1 U2 I0 I1 I2 PHI	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 U1 U2 I0 I1 I2 PHI	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 U1 U2 I0 I1 I2 PHI	Disabled	Measured Value for Threshold MV5>

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
8510	THRESHOLD MV5>	Threshold		-200 .. 200 %	100 %	Pickup Value of Measured Value MV5>
8511	MEAS. VALUE 6<	Threshold		Disabled P Q Delta P U1 U2 I0 I1 I2 PHI	Disabled	Measured Value for Threshold MV6<
8512	THRESHOLD MV6<	Threshold		-200 .. 200 %	100 %	Pickup Value of Measured Value MV6<
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
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

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
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
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

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
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
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

Addr.	Parameter	Function	C	Setting Options	Default Setting	Comments
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 messages 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
-	>Back Light on (>Light on)	Device	EM	ON OFF	*		*	LED	BI		BO					
-	Unlock data transmission via BI (UnlockDT)	Device	IE				*									
-	Stop data transmission (DataStop)	Device	IE	ON OFF	*		*	LED			BO		70	20	1	Yes
-	Test mode (Test mode)	Device	IE	ON OFF	*		*	LED			BO		70	21	1	Yes
-	Hardware Test Mode (HWTestMod)	Device	IE	ON OFF	*		*	LED			BO					
-	Clock Synchronization (SynchClock)	Device	IE_W	*	*		*	LED			BO					
-	Group A (Group A)	Change Group	IE	ON OFF	*		*	LED			BO		70	23	1	Yes
-	Group B (Group B)	Change Group	IE	ON OFF	*		*	LED			BO		70	24	1	Yes
-	Fault Recording Start (FltRecSta)	Osc. Fault Rec.	IE	ON OFF	*		*	LED			BO					
-	Controlmode REMOTE (ModeREMOTE)	Cntrl Authority	IE	ON OFF	*			LED								
-	Control Authority (Cntrl Auth)	Cntrl Authority	IE	ON OFF	*			LED					101	85	1	Yes
-	Controlmode LOCAL (ModeLOCAL)	Cntrl Authority	IE	ON OFF	*			LED					101	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
-	Reset Minimum and Maximum counter (ResMinMax)	Min/Max meter	IE_W	ON	*											
-	Reset meter (Meter res)	Energy	IE_W	ON	*				BI							
-	Error Systeminterface (SysIntErr.)	Protocol	IE	ON OFF	*			LED			BO					
1	No Function configured (Not configured)	Device	EM													
2	Function Not Available (Non Existent)	Device	EM													
3	>Synchronize Internal Real Time Clock (>Time Synch)	Device	EM_W	*	*		*	LED	BI		BO		135	48	1	No
4	>Trigger Waveform Capture (>Trig.Wave.Cap.)	Osc. Fault Rec.	EM	*	*		m	LED	BI		BO		135	49	1	Yes
5	>Reset LED (>Reset LED)	Device	EM	*	*		*	LED	BI		BO		135	50	1	Yes
7	>Setting Group Select Bit 0 (>Set Group Bit0)	Change Group	EM	*	*		*	LED	BI		BO		135	51	1	Yes
8	>Setting Group Select Bit 1 (>Set Group Bit1)	Change Group	EM													
15	>Test mode (>Test mode)	Device	EM	*	*		*	LED	BI		BO		135	53	1	Yes
16	>Stop data transmission (>DataStop)	Device	EM	*	*		*	LED	BI		BO		135	54	1	Yes
51	Device is Operational and Protecting (Device OK)	Device	AM	ON OFF	*		*	LED			BO		135	81	1	Yes
52	At Least 1 Protection Funct. is Active (ProtActive)	Device	IE	ON OFF	*		*	LED			BO		70	18	1	Yes
55	Reset Device (Reset Device)	Device	AM	ON	*		*	LED			BO					
56	Initial Start of Device (Initial Start)	Device	AM	ON	*		*	LED			BO		70	5	1	No
60	Reset LED (Reset LED)	Device	AM_W	ON	*		*	LED			BO		70	19	1	No
67	Resume (Resume)	Device	AM	ON	*		*	LED			BO					
68	Clock Synchronization Error (Clock SyncError)	Device	AM	ON OFF	*		*	LED			BO					
69	Daylight Saving Time (DayLightSavTime)	Device	AM	ON OFF	*		*	LED			BO					
70	Setting calculation is running (Settings Calc.)	Device	AM	ON OFF	*		*	LED			BO		70	22	1	Yes
71	Settings Check (Settings Check)	Device	AM	*	*		*	LED			BO					
72	Level-2 change (Level-2 change)	Device	AM	ON OFF	*		*	LED			BO					
73	Local setting change (Local change)	Device	AM	*	*		*									
110	Event lost (Event Lost)	Device	AM_W	ON	*		*	LED			BO		135	130	1	No
113	Flag Lost (Flag Lost)	Device	AM	ON	*		m	LED			BO		135	136	1	Yes
125	Chatter ON (Chatter ON)	Device	AM	ON OFF	*		*	LED			BO		135	145	1	Yes
140	Error with a summary alarm (Error Sum Alarm)	Device	AM	*	*		*	LED			BO					
147	Error Power Supply (Error PwrSupply)	Device	AM	ON OFF	*		*	LED			BO					
160	Alarm Summary Event (Alarm Sum Event)	Device	AM	*	*		*	LED			BO		70	46	1	Yes
161	Failure: General Current Supervision (Fail I Superv.)	Measurem.Superv	AM	ON OFF	*		*	LED			BO		70	32	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
162	Failure: Current Summation (Failure Σ I)	Measurem.Superv	AM	ON OFF	*		*	LED			BO		135	182	1	Yes
163	Failure: Current Balance (Fail I balance)	Measurem.Superv	AM	ON OFF	*		*	LED			BO		135	183	1	Yes
164	Failure: General Voltage Supervision (Fail U Superv.)	Measurem.Superv	AM	ON OFF	*		*	LED			BO		70	33	1	Yes
165	Failure: Voltage Summation Phase-Earth (Fail Σ U Ph-E)	Measurem.Superv	AM	ON OFF	*		*	LED			BO		135	184	1	Yes
167	Failure: Voltage Balance (Fail U balance)	Measurem.Superv	AM	ON OFF	*		*	LED			BO		135	186	1	Yes
171	Failure: Phase Sequence (Fail Ph. Seq.)	Measurem.Superv	AM	ON OFF	*		*	LED			BO		70	35	1	Yes
175	Failure: Phase Sequence Current (Fail Ph. Seq. I)	Measurem.Superv	AM	ON OFF	*		*	LED			BO		135	191	1	Yes
176	Failure: Phase Sequence Voltage (Fail Ph. Seq. U)	Measurem.Superv	AM	ON OFF	*		*	LED			BO		135	192	1	Yes
177	Failure: Battery empty (Fail Battery)	Device	AM	ON OFF	*		*	LED			BO					
181	Error: A/D converter (Error A/D-conv.)	Device	AM	ON OFF	*		*	LED			BO					
183	Error Board 1 (Error Board 1)	Device	AM	ON OFF	*		*	LED			BO					
184	Error Board 2 (Error Board 2)	Device	AM	ON OFF	*		*	LED			BO					
185	Error Board 3 (Error Board 3)	Device	AM	ON OFF	*		*	LED			BO					
186	Error Board 4 (Error Board 4)	Device	AM	ON OFF	*		*	LED			BO					
187	Error Board 5 (Error Board 5)	Device	AM	ON OFF	*		*	LED			BO					
188	Error Board 6 (Error Board 6)	Device	AM	ON OFF	*		*	LED			BO					
189	Error Board 7 (Error Board 7)	Device	AM	ON OFF	*		*	LED			BO					
190	Error Board 0 (Error Board 0)	Device	AM	ON OFF	*		*	LED			BO					
191	Error: Offset (Error Offset)	Device	AM	ON OFF	*		*	LED			BO					
192	Error:1A/5Ajumper different from setting (Error1A/5Awrong)	Device	AM	ON OFF	*		*	LED			BO					
193	Alarm: NO calibration data available (Alarm NO calibr)	Device	AM	ON OFF	*		*	LED			BO					
194	Error: Neutral CT different from MLFB (Error neutralCT)	Device	AM	ON OFF	*		*	LED			BO					
197	Measurement Supervision is switched OFF (MeasSup OFF)	Measurem.Superv	AM	ON OFF	*		*	LED			BO		135	197	1	Yes
203	Waveform data deleted (Wave. deleted)	Osc. Fault Rec.	AM_W	ON	*		*	LED			BO		135	203	1	No
264	Failure: RTD-Box 1 (Fail: RTD-Box 1)	Device	AM	ON OFF	*		*	LED			BO		135	208	1	Yes
267	Failure: RTD-Box 2 (Fail: RTD-Box 2)	Device	AM	ON OFF	*		*	LED			BO		135	209	1	Yes
272	Set Point Operating Hours (SP. Op Hours>)	SetPoint(Stat)	AM	ON OFF	*		*	LED			BO		135	229	1	Yes
284	Set Point I< alarm (SP. I<)	Set Points(MV)	AM	*	*		*	LED			BO		135	244	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
301	Power System fault (Pow.Sys.Flt.)	Device	AM	ON OFF	ON OFF		*						135	231	2	Yes
302	Fault Event (Fault Event)	Device	AM	*	ON		*						135	232	2	Yes
361	>Failure: Feeder VT (MCB tripped) (>FAIL:Feeder VT)	P.System Data 1	EM	ON OFF	*		*	LED	BI		BO		150	38	1	Yes
394	>UE 3rd Harm. MIN/MAX Buffer Reset (>UE3h MiMa Res.)	Min/Max meter	EM	ON	*		*		BI		BO					
396	>I1 MIN/MAX Buffer Reset (>I1 MiMaReset)	Min/Max meter	EM	ON	*		*		BI		BO					
399	>U1 MIN/MAX Buffer Reset (>U1 MiMa Reset)	Min/Max meter	EM	ON	*		*		BI		BO					
400	>P MIN/MAX Buffer Reset (>P MiMa Reset)	Min/Max meter	EM	ON	*		*		BI		BO					
402	>Q MIN/MAX Buffer Reset (>Q MiMa Reset)	Min/Max meter	EM	ON	*		*		BI		BO					
407	>Frq. MIN/MAX Buffer Reset (>Frq MiMa Reset)	Min/Max meter	EM	ON	*		*		BI		BO					
409	>BLOCK Op Counter (>BLOCK Op Count)	Statistics	EM	ON OFF	*		*	LED	BI		BO					
501	Relay PICKUP (Relay PICKUP)	P.System Data 2	AM	*	ON		m	LED			BO		150	151	2	Yes
511	Relay GENERAL TRIP command (Relay TRIP)	P.System Data 2	AM	*	ON		m	LED			BO		150	161	2	Yes
533	Primary fault current IL1 (IL1:)	P.System Data 2	AM	*	ON OFF								150	177	4	No
534	Primary fault current IL2 (IL2:)	P.System Data 2	AM	*	ON OFF								150	178	4	No
535	Primary fault current IL3 (IL3:)	P.System Data 2	AM	*	ON OFF								150	179	4	No
545	Time from Pickup to drop out (PU Time)	Device	AM													
546	Time from Pickup to TRIP (TRIP Time)	Device	AM													
916	Increment of active energy (WpΔ=)	Energy	-													
917	Increment of reactive energy (WqΔ=)	Energy	-													
1020	Counter of operating hours (Op.Hours=)	Statistics	AM													
1021	Accumulation of interrupted current L1 (Σ L1:)	Statistics	AM													
1022	Accumulation of interrupted current L2 (Σ L2:)	Statistics	AM													
1023	Accumulation of interrupted current L3 (Σ L3:)	Statistics	AM													
1202	>BLOCK IEE>> (>BLOCK IEE>>)	Sens. E Fault	EM	ON OFF	*		*	LED	BI		BO		151	102	1	Yes
1203	>BLOCK IEE> (>BLOCK IEE>)	Sens. E Fault	EM	ON OFF	*		*	LED	BI		BO		151	103	1	Yes
1221	IEE>> picked up (IEE>> picked up)	Sens. E Fault	AM	*	ON OFF		*	LED			BO		151	121	2	Yes
1223	IEE>> TRIP (IEE>> TRIP)	Sens. E Fault	AM	*	ON		m	LED			BO		151	123	2	Yes
1224	IEE> picked up (IEE> picked up)	Sens. E Fault	AM	*	ON OFF		*	LED			BO		151	124	2	Yes
1226	IEE> TRIP (IEE> TRIP)	Sens. E Fault	AM	*	ON		m	LED			BO		151	126	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
1231	>BLOCK sensitiv earth current prot. (>BLOCK Sens. E)	Sens. E Fault	EM	*	*		*	LED	BI		BO					
1232	Earth current prot. is swiched OFF (IEE OFF)	Sens. E Fault	AM	ON OFF	*		*	LED			BO		151	132	1	Yes
1233	Earth current prot. is BLOCKED (IEE BLOCKED)	Sens. E Fault	AM	ON OFF	ON OFF		*	LED			BO		151	133	1	Yes
1234	Earth current prot. is ACTIVE (IEE ACTIVE)	Sens. E Fault	AM	ON OFF	*		*	LED			BO		151	134	1	Yes
1403	>BLOCK breaker failure (>BLOCK BkrFail)	Breaker Failure	EM	*	*		*	LED	BI		BO					
1422	>Breaker contacts (>Break. Con-tact)	Breaker Failure	EM	ON OFF	*		*	LED	BI		BO		166	120	1	Yes
1423	>ext. start 1 breaker failure prot. (>ext.start1 B/F)	Breaker Failure	EM	ON OFF	*		*	LED	BI		BO		166	121	1	Yes
1441	>ext. start 2 breaker failure prot. (>ext.start2 B/F)	Breaker Failure	EM	ON OFF	*		*	LED	BI		BO		166	122	1	Yes
1442	>int. start breaker failure prot. (>int. start B/F)	Breaker Failure	EM	ON OFF	*		*	LED	BI		BO		166	123	1	Yes
1443	Breaker fail. started intern (int. start B/F)	Breaker Failure	AM	ON OFF	*		*	LED			BO		166	190	1	Yes
1444	Breaker failure I> (B/F I>)	Breaker Failure	AM	ON OFF	*		*	LED			BO		166	191	1	Yes
1451	Breaker failure is switched OFF (BkrFail OFF)	Breaker Failure	AM	ON OFF	*		*	LED			BO		166	151	1	Yes
1452	Breaker failure is BLOCKED (BkrFail BLOCK)	Breaker Failure	AM	ON OFF	ON OFF		*	LED			BO		166	152	1	Yes
1453	Breaker failure is ACTIVE (Bkr-Fail ACTIVE)	Breaker Failure	AM	ON OFF	*		*	LED			BO		166	153	1	Yes
1455	Breaker failure protection: picked up (B/F picked up)	Breaker Failure	AM	*	ON OFF		*	LED			BO		166	155	2	Yes
1471	Breaker failure TRIP (BrkFailure TRIP)	Breaker Failure	AM	*	ON		m	LED			BO		166	171	2	Yes
1503	>BLOCK thermal overload pro-tection (>BLK ThOverload)	Therm. Overload	EM	*	*		*	LED	BI		BO					
1506	>Reset memory for thermal replica O/L (>RM th.rep. O/L)	Therm. Overload	EM	ON OFF	*		*	LED	BI		BO					
1507	>Emergency start O/L (>Em-er.Start O/L)	Therm. Overload	EM	ON OFF	*		*	LED	BI		BO		167	7	1	Yes
1508	>Failure temperature input (>Fail.Temp.inp)	Therm. Overload	EM	ON OFF	*		*	LED	BI		BO		167	8	1	Yes
1511	Thermal Overload Protection OFF (Th.Overload OFF)	Therm. Overload	AM	ON OFF	*		*	LED			BO		167	11	1	Yes
1512	Thermal Overload Protection BLOCKED (Th.Overload BLK)	Therm. Overload	AM	ON OFF	ON OFF		*	LED			BO		167	12	1	Yes
1513	Overload Protection ACTIVE (Overload ACT)	Therm. Overload	AM	ON OFF	*		*	LED			BO		167	13	1	Yes
1514	Failure temperature input (Fail.Temp.inp)	Therm. Overload	AM	ON OFF	*		*	LED			BO		167	14	1	Yes
1515	Overload Current Alarm (I alarm) (O/L I Alarm)	Therm. Overload	AM	ON OFF	*		*	LED			BO		167	15	1	Yes
1516	Thermal Overload Alarm (O/L Θ Alarm)	Therm. Overload	AM	ON OFF	*		*	LED			BO		167	16	1	Yes
1517	Thermal Overload picked up (O/L Th. pick.up)	Therm. Overload	AM	ON OFF	*		*	LED			BO		167	17	1	Yes
1519	Reset memory for thermal replica O/L (RM th.rep. O/L)	Therm. Overload	AM	ON OFF	*		*	LED			BO		167	19	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
1521	Thermal Overload TRIP (ThOverload TRIP)	Therm. Overload	AM	*	ON		m	LED			BO		167	21	2	Yes
1720	>BLOCK direction I>> stage (>BLOCK dir.)	O/C Prot. I>>	EM	ON OFF	*		*	LED	BI		BO		60	18	1	Yes
1721	>BLOCK I>> (>BLOCK I>>)	O/C Prot. I>>	EM	*	*		*	LED	BI		BO					
1722	>BLOCK I> (>BLOCK I>)	O/C Prot. I>	EM	*	*		*	LED	BI		BO					
1801	O/C fault detection stage I>> phase L1 (I>> Fault L1)	O/C Prot. I>>	AM	*	ON OFF		*	LED			BO		60	46	2	Yes
1802	O/C fault detection stage I>> phase L2 (I>> Fault L2)	O/C Prot. I>>	AM	*	ON OFF		*	LED			BO		60	47	2	Yes
1803	O/C fault detection stage I>> phase L3 (I>> Fault L3)	O/C Prot. I>>	AM	*	ON OFF		*	LED			BO		60	48	2	Yes
1806	O/C I>> direction forward (I>> forward)	O/C Prot. I>>	AM	*	ON OFF		*	LED			BO		60	208	2	Yes
1807	O/C I>> direction backward (I>> backward)	O/C Prot. I>>	AM	*	ON OFF		*	LED			BO		60	209	2	Yes
1808	O/C prot. I>> picked up (I>> picked up)	O/C Prot. I>>	AM	*	ON OFF		*	LED			BO		60	210	2	Yes
1809	O/C I>> TRIP (I>> TRIP)	O/C Prot. I>>	AM	*	ON		m	LED			BO		60	211	2	Yes
1811	O/C fault detection stage I> phase L1 (I> Fault L1)	O/C Prot. I>	AM	*	ON OFF		*	LED			BO		60	50	2	Yes
1812	O/C fault detection stage I> phase L2 (I> Fault L2)	O/C Prot. I>	AM	*	ON OFF		*	LED			BO		60	51	2	Yes
1813	O/C fault detection stage I> phase L3 (I> Fault L3)	O/C Prot. I>	AM	*	ON OFF		*	LED			BO		60	52	2	Yes
1815	O/C I> TRIP (I> TRIP)	O/C Prot. I>	AM	*	ON		m	LED			BO		60	71	2	Yes
1883	>BLOCK inverse O/C time protection (>BLOCK O/C Ip)	O/C Prot. Ip	EM	*	*		*	LED	BI		BO					
1891	O/C protection Ip is switched OFF (O/C Ip OFF)	O/C Prot. Ip	AM	ON OFF	*		*	LED			BO		60	180	1	Yes
1892	O/C protection Ip is BLOCKED (O/C Ip BLOCKED)	O/C Prot. Ip	AM	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	AM	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	AM	*	ON OFF		*	LED			BO		60	184	2	Yes
1897	O/C fault detection Ip phase L2 (O/C Ip Fault L2)	O/C Prot. Ip	AM	*	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	AM	*	ON OFF		*	LED			BO		60	186	2	Yes
1899	O/C Ip picked up (O/C Ip pick.up)	O/C Prot. Ip	AM	*	ON OFF		*	LED			BO		60	183	2	Yes
1900	O/C Ip TRIP (O/C Ip TRIP)	O/C Prot. Ip	AM	*	ON		m	LED			BO		60	187	2	Yes
1950	>O/C prot. : BLOCK undervoltage seal-in (>Useal-in BLK)	O/C Prot. I>	EM	ON OFF	*		*	LED	BI		BO		60	200	1	Yes
1955	O/C prot. stage I>> is switched OFF (I>> OFF)	O/C Prot. I>>	AM	ON OFF	*		*	LED			BO		60	205	1	Yes
1956	O/C prot. stage I>> is BLOCKED (I>> BLOCKED)	O/C Prot. I>>	AM	ON OFF	ON OFF		*	LED			BO		60	206	1	Yes
1957	O/C prot. stage I>> is ACTIVE (I>> ACTIVE)	O/C Prot. I>>	AM	ON OFF	*		*	LED			BO		60	207	1	Yes
1965	O/C prot. stage I> is switched OFF (I> OFF)	O/C Prot. I>	AM	ON OFF	*		*	LED			BO		60	215	1	Yes
1966	O/C prot. stage I> is BLOCKED (I> BLOCKED)	O/C Prot. I>	AM	ON OFF	ON OFF		*	LED			BO		60	216	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
1967	O/C prot. stage I> is ACTIVE (I> ACTIVE)	O/C Prot. I>	AM	ON OFF	*		*	LED			BO		60	217	1	Yes
1970	O/C prot. undervoltage seal-in (U< seal in)	O/C Prot. I>	AM	*	ON OFF		*	LED			BO		60	220	2	Yes
3953	>BLOCK impedance protection (>Imp. BLOCK)	Impedance	EM	*	*		*	LED	BI		BO					
3956	>Zone 1B extension for impedance prot. (>Extens. Z1B)	Impedance	EM	ON OFF	*		*	LED	BI		BO		28	222	1	Yes
3958	>Imp. prot. : BLOCK undervoltage seal-in (>Useal-in BLK)	Impedance	EM	ON OFF	*		*	LED	BI		BO		28	30	1	Yes
3961	Impedance protection is switched OFF (Imp. OFF)	Impedance	AM	ON OFF	*		*	LED			BO		28	226	1	Yes
3962	Impedance protection is BLOCKED (Imp. BLOCKED)	Impedance	AM	ON OFF	ON OFF		*	LED			BO		28	227	1	Yes
3963	Impedance protection is ACTIVE (Imp. ACTIVE)	Impedance	AM	ON OFF	*		*	LED			BO		28	228	1	Yes
3966	Impedance protection picked up (Imp. picked up)	Impedance	AM	*	ON OFF		*	LED			BO		28	229	2	Yes
3967	Imp.: Fault detection , phase L1 (Imp. Fault L1)	Impedance	AM	*	ON OFF		*	LED			BO		28	230	2	Yes
3968	Imp.: Fault detection , phase L2 (Imp. Fault L2)	Impedance	AM	*	ON OFF		*	LED			BO		28	231	2	Yes
3969	Imp.: Fault detection , phase L3 (Imp. Fault L3)	Impedance	AM	*	ON OFF		*	LED			BO		28	232	2	Yes
3970	Imp.: O/C with undervoltage seal in (Imp. I> & U<)	Impedance	AM	*	ON OFF		*	LED			BO		28	233	2	Yes
3977	Imp.: Z1< TRIP (Imp.Z1< TRIP)	Impedance	AM	*	ON		m	LED			BO		28	240	2	Yes
3978	Imp.: Z1B< TRIP (Imp.Z1B< TRIP)	Impedance	AM	*	ON		m	LED			BO		28	241	2	Yes
3979	Imp.: Z2< TRIP (Imp. Z2< TRIP)	Impedance	AM	*	ON		m	LED			BO		28	242	2	Yes
3980	Imp.: T3> TRIP (Imp.T3> TRIP)	Impedance	AM	*	ON		m	LED			BO		28	243	2	Yes
4523	>Block external trip 1 (>BLOCK Ext 1)	External Trips	EM	*	*		*	LED	BI		BO					
4526	>Trigger external trip 1 (>Ext trip 1)	External Trips	EM	ON OFF	*		*	LED	BI		BO		51	126	1	Yes
4531	External trip 1 is switched OFF (Ext 1 OFF)	External Trips	AM	ON OFF	*		*	LED			BO		51	131	1	Yes
4532	External trip 1 is BLOCKED (Ext 1 BLOCKED)	External Trips	AM	ON OFF	ON OFF		*	LED			BO		51	132	1	Yes
4533	External trip 1 is ACTIVE (Ext 1 ACTIVE)	External Trips	AM	ON OFF	*		*	LED			BO		51	133	1	Yes
4536	External trip 1: General picked up (Ext 1 picked up)	External Trips	AM	*	ON OFF		*	LED			BO		51	136	2	Yes
4537	External trip 1: General TRIP (Ext 1 Gen.TRP)	External Trips	AM	*	ON		*	LED			BO		51	137	2	Yes
4543	>BLOCK external trip 2 (>BLOCK Ext 2)	External Trips	EM	*	*		*	LED	BI		BO					
4546	>Trigger external trip 2 (>Ext trip 2)	External Trips	EM	ON OFF	*		*	LED	BI		BO		51	146	1	Yes
4551	External trip 2 is switched OFF (Ext 2 OFF)	External Trips	AM	ON OFF	*		*	LED			BO		51	151	1	Yes
4552	External trip 2 is BLOCKED (Ext 2 BLOCKED)	External Trips	AM	ON OFF	ON OFF		*	LED			BO		51	152	1	Yes
4553	External trip 2 is ACTIVE (Ext 2 ACTIVE)	External Trips	AM	ON OFF	*		*	LED			BO		51	153	1	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
4556	External trip 2: General picked up (Ext 2 picked up)	External Trips	AM	*	ON OFF		*	LED			BO		51	156	2	Yes
4557	External trip 2: General TRIP (Ext 2 Gen.TRP)	External Trips	AM	*	ON		*	LED			BO		51	157	2	Yes
4563	>BLOCK external trip 3 (>BLOCK Ext 3)	External Trips	EM	*	*		*	LED	BI		BO					
4566	>Trigger external trip 3 (>Ext trip 3)	External Trips	EM	ON OFF	*		*	LED	BI		BO		51	166	1	Yes
4571	External trip 3 is switched OFF (Ext 3 OFF)	External Trips	AM	ON OFF	*		*	LED			BO		51	171	1	Yes
4572	External trip 3 is BLOCKED (Ext 3 BLOCKED)	External Trips	AM	ON OFF	ON OFF		*	LED			BO		51	172	1	Yes
4573	External trip 3 is ACTIVE (Ext 3 ACTIVE)	External Trips	AM	ON OFF	*		*	LED			BO		51	173	1	Yes
4576	External trip 3: General picked up (Ext 3 picked up)	External Trips	AM	*	ON OFF		*	LED			BO		51	176	2	Yes
4577	External trip 3: General TRIP (Ext 3 Gen.TRP)	External Trips	AM	*	ON		*	LED			BO		51	177	2	Yes
4583	>BLOCK external trip 4 (>BLOCK Ext 4)	External Trips	EM	*	*		*	LED	BI		BO					
4586	>Trigger external trip 4 (>Ext trip 4)	External Trips	EM	ON OFF	*		*	LED	BI		BO		51	186	1	Yes
4591	External trip 4 is switched OFF (Ext 4 OFF)	External Trips	AM	ON OFF	*		*	LED			BO		51	191	1	Yes
4592	External trip 4 is BLOCKED (Ext 4 BLOCKED)	External Trips	AM	ON OFF	ON OFF		*	LED			BO		51	192	1	Yes
4593	External trip 4 is ACTIVE (Ext 4 ACTIVE)	External Trips	AM	ON OFF	*		*	LED			BO		51	193	1	Yes
4596	External trip 4: General picked up (Ext 4 picked up)	External Trips	AM	*	ON OFF		*	LED			BO		51	196	2	Yes
4597	External trip 4: General TRIP (Ext 4 Gen.TRP)	External Trips	AM	*	ON		*	LED			BO		51	197	2	Yes
4822	>BLOCK Restart inhibit motor (>BLK Re. Inhib.)	Restart Motor	EM	*	*		*	LED	BI		BO					
4823	>Emergency start rotor (>Emer. Start ΘR)	Restart Motor	EM	ON OFF	*		*	LED	BI		BO		168	51	1	Yes
4824	Restart inhibit motor is switched OFF (Re. Inhibit OFF)	Restart Motor	AM	ON OFF	*		*	LED			BO		168	52	1	Yes
4825	Restart inhibit motor is BLOCKED (Re. Inhibit BLK)	Restart Motor	AM	ON OFF	*		*	LED			BO		168	53	1	Yes
4826	Restart inhibit motor is ACTIVE (Re. Inhibit ACT)	Restart Motor	AM	ON OFF	*		*	LED			BO		168	54	1	Yes
4827	Restart inhibit motor TRIP (Re. Inhib. TRIP)	Restart Motor	AM	ON	*		*	LED			BO		168	55	1	Yes
4828	>Reset thermal memory rotor (>RM th.rep. ΘR)	Restart Motor	EM	ON OFF	*		*	LED	BI		BO					
4829	Reset thermal memory rotor (RM th.rep. ΘR)	Restart Motor	AM	ON OFF	*		*	LED			BO		168	50	1	Yes
4830	Alarm restart inhibit motor (Re. In-hib.ALARM)	Restart Motor	AM	ON OFF	*		*	LED			BO					
5002	Suitable measured quantities present (Operat. Cond.)	P.System Data 1	AM	ON OFF	*		*	LED			BO		71	2	1	Yes
5010	>BLOCK fuse failure monitor (>FFM BLOCK)	Measurem.Superv	EM	ON OFF	ON OFF		*	LED	BI		BO		71	7	1	Yes
5011	>FFM extern undervoltage (>FFM U< extern)	Measurem.Superv	EM	ON OFF	*		*	LED	BI		BO		71	8	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
5012	Voltage UL1E at trip (UL1E:)	P.System Data 2	AM	*	ON OFF								71	38	4	No
5013	Voltage UL2E at trip (UL2E:)	P.System Data 2	AM	*	ON OFF								71	39	4	No
5014	Voltage UL3E at trip (UL3E:)	P.System Data 2	AM	*	ON OFF								71	40	4	No
5015	Active power at trip (P:)	P.System Data 2	AM	*	ON OFF								71	41	4	No
5016	Reactive power at trip (Q:)	P.System Data 2	AM	*	ON OFF								71	42	4	No
5017	Frequency at trip (f:)	P.System Data 2	AM	*	ON OFF								71	43	4	No
5083	>BLOCK reverse power protection (>Pr BLOCK)	Reverse Power	EM	*	*		*	LED	BI		BO					
5086	>Stop valve tripped (>SV tripped)	Reverse Power	EM	ON OFF	*		*	LED	BI		BO		70	77	1	Yes
5091	Reverse power prot. is switched OFF (Pr OFF)	Reverse Power	AM	ON OFF	*		*	LED			BO		70	81	1	Yes
5092	Reverse power protection is BLOCKED (Pr BLOCKED)	Reverse Power	AM	ON OFF	ON OFF		*	LED			BO		70	82	1	Yes
5093	Reverse power protection is ACTIVE (Pr ACTIVE)	Reverse Power	AM	ON OFF	*		*	LED			BO		70	83	1	Yes
5096	Reverse power: picked up (Pr picked up)	Reverse Power	AM	*	ON OFF		*	LED			BO		70	84	2	Yes
5097	Reverse power: TRIP (Pr TRIP)	Reverse Power	AM	*	ON		m	LED			BO		70	85	2	Yes
5098	Reverse power: TRIP with stop valve (Pr+SV TRIP)	Reverse Power	AM	*	ON		m	LED			BO		70	86	2	Yes
5113	>BLOCK forward power supervision (>Pf BLOCK)	Forward Power	EM	*	*		*	LED	BI		BO					
5116	>BLOCK forw. power superv. Pf< stage (>Pf< BLOCK)	Forward Power	EM	ON OFF	*		*	LED	BI		BO		70	102	1	Yes
5117	>BLOCK forw. power superv. Pf> stage (>Pf> BLOCK)	Forward Power	EM	ON OFF	*		*	LED	BI		BO		70	103	1	Yes
5121	Forward power supervis. is switched OFF (Pf OFF)	Forward Power	AM	ON OFF	*		*	LED			BO		70	106	1	Yes
5122	Forward power supervision is BLOCKED (Pf BLOCKED)	Forward Power	AM	ON OFF	ON OFF		*	LED			BO		70	107	1	Yes
5123	Forward power supervision is ACTIVE (Pf ACTIVE)	Forward Power	AM	ON OFF	*		*	LED			BO		70	108	1	Yes
5126	Forward power: Pf< stage picked up (Pf< picked up)	Forward Power	AM	*	ON OFF		*	LED			BO		70	109	2	Yes
5127	Forward power: Pf> stage picked up (Pf> picked up)	Forward Power	AM	*	ON OFF		*	LED			BO		70	110	2	Yes
5128	Forward power: Pf< stage TRIP (Pf< TRIP)	Forward Power	AM	*	ON		m	LED			BO		70	111	2	Yes
5129	Forward power: Pf> stage TRIP (Pf> TRIP)	Forward Power	AM	*	ON		m	LED			BO		70	112	2	Yes
5143	>BLOCK I2 (Unbalance Load) (>BLOCK I2)	Unbalance Load	EM	*	*		*	LED	BI		BO					
5145	>Reverse Phase Rotation (>Reverse Rot.)	P.System Data 1	EM	ON OFF	*		*	LED	BI		BO		71	34	1	Yes
5146	>Reset memory for thermal replica I2 (>RM th.rep. I2)	Unbalance Load	EM	ON OFF	*		*	LED	BI		BO					
5147	Phase Rotation L1L2L3 (Rotation L1L2L3)	P.System Data 1	AM	ON OFF	*		*	LED			BO		70	128	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
5148	Phase Rotation L1L3L2 (Rotation L1L3L2)	P.System Data 1	AM	ON OFF	*		*	LED			BO		70	129	1	Yes
5151	I2 switched OFF (I2 OFF)	Unbalance Load	AM	ON OFF	*		*	LED			BO		70	131	1	Yes
5152	I2 is BLOCKED (I2 BLOCKED)	Unbalance Load	AM	ON OFF	ON OFF		*	LED			BO		70	132	1	Yes
5153	I2 is ACTIVE (I2 ACTIVE)	Unbalance Load	AM	ON OFF	*		*	LED			BO		70	133	1	Yes
5156	Unbalanced load: Current warning stage (I2> Warn)	Unbalance Load	AM	ON OFF	*		*	LED			BO		70	134	1	Yes
5158	Reset memory of thermal replica I2 (RM th.rep. I2)	Unbalance Load	AM	ON OFF	*		*	LED			BO		70	137	1	Yes
5159	I2>> picked up (I2>> picked up)	Unbalance Load	AM	*	ON OFF		*	LED			BO		70	138	2	Yes
5160	Unbalanced load: TRIP of current stage (I2>> TRIP)	Unbalance Load	AM	*	ON		m	LED			BO		70	139	2	Yes
5161	Unbalanced load: TRIP of thermal stage (I2 Θ TRIP)	Unbalance Load	AM	*	ON		m	LED			BO		70	140	2	Yes
5165	I2> picked up (I2> picked up)	Unbalance Load	AM	*	ON OFF		*	LED			BO		70	150	2	Yes
5173	>BLOCK stator earth fault protection (>S/E/F BLOCK)	Stator E Fault	EM	*	*		*	LED	BI		BO					
5176	>Switch off earth current detec.(S/E/F) (>S/E/F Iee off)	Stator E Fault	EM	ON OFF	*		*	LED	BI		BO		70	152	1	Yes
5181	Stator earth fault prot. is switch OFF (S/E/F OFF)	Stator E Fault	AM	ON OFF	*		*	LED			BO		70	156	1	Yes
5182	Stator earth fault protection is BLOCK. (S/E/F BLOCKED)	Stator E Fault	AM	ON OFF	ON OFF		*	LED			BO		70	157	1	Yes
5183	Stator earth fault protection is ACTIVE (S/E/F ACTIVE)	Stator E Fault	AM	ON OFF	*		*	LED			BO		70	158	1	Yes
5186	Stator earth fault: U0 picked up (U0> picked up)	Stator E Fault	AM	*	ON OFF		*	LED			BO		70	159	2	Yes
5187	Stator earth fault: U0 stage TRIP (U0> TRIP)	Stator E Fault	AM	*	ON		m	LED			BO		70	160	2	Yes
5188	Stator earth fault: I0 picked up (3I0> picked up)	Stator E Fault	AM	*	ON OFF		*	LED			BO		70	168	2	Yes
5189	Earth fault in phase L1 (Uearth L1)	Stator E Fault	AM	*	ON OFF		*	LED			BO		70	169	2	Yes
5190	Earth fault in phase L2 (Uearth L2)	Stator E Fault	AM	*	ON OFF		*	LED			BO		70	170	2	Yes
5191	Earth fault in phase L3 (Uearth L3)	Stator E Fault	AM	*	ON OFF		*	LED			BO		70	171	2	Yes
5193	Stator earth fault protection TRIP (S/E/F TRIP)	Stator E Fault	AM	*	ON		m	LED			BO		70	173	2	Yes
5194	Stator earth fault: direction forward (SEF Dir Forward)	Stator E Fault	AM	ON OFF	*		*	LED			BO		70	174	1	Yes
5203	>BLOCK frequency protection (>BLOCK Freq.)	Frequency Prot.	EM	*	*		*	LED	BI		BO					
5206	>BLOCK stage f1 (>BLOCK f1)	Frequency Prot.	EM	ON OFF	*		*	LED	BI		BO		70	177	1	Yes
5207	>BLOCK stage f2 (>BLOCK f2)	Frequency Prot.	EM	ON OFF	*		*	LED	BI		BO		70	178	1	Yes
5208	>BLOCK stage f3 (>BLOCK f3)	Frequency Prot.	EM	ON OFF	*		*	LED	BI		BO		70	179	1	Yes
5209	>BLOCK stage f4 (>BLOCK f4)	Frequency Prot.	EM	ON OFF	*		*	LED	BI		BO		70	180	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
5211	Frequency protection is OFF (Freq. OFF)	Frequency Prot.	AM	ON OFF	*		*	LED			BO		70	181	1	Yes
5212	Frequency protection is BLOCKED (Freq. BLOCKED)	Frequency Prot.	AM	ON OFF	ON OFF		*	LED			BO		70	182	1	Yes
5213	Frequency protection is ACTIVE (Freq. ACTIVE)	Frequency Prot.	AM	ON OFF	*		*	LED			BO		70	183	1	Yes
5214	Frequency protection undervolt-age Blk (Freq UnderV Blk)	Frequency Prot.	AM	ON OFF	ON OFF		*	LED			BO		70	184	1	Yes
5232	f1 picked up (f1 picked up)	Frequency Prot.	AM	*	ON OFF		*	LED			BO		70	230	2	Yes
5233	f2 picked up (f2 picked up)	Frequency Prot.	AM	*	ON OFF		*	LED			BO		70	231	2	Yes
5234	f3 picked up (f3 picked up)	Frequency Prot.	AM	*	ON OFF		*	LED			BO		70	232	2	Yes
5235	f4 picked up (f4 picked up)	Frequency Prot.	AM	*	ON OFF		*	LED			BO		70	233	2	Yes
5236	f1 TRIP (f1 TRIP)	Frequency Prot.	AM	*	ON		m	LED			BO		70	234	2	Yes
5237	f2 TRIP (f2 TRIP)	Frequency Prot.	AM	*	ON		m	LED			BO		70	235	2	Yes
5238	f3 TRIP (f3 TRIP)	Frequency Prot.	AM	*	ON		m	LED			BO		70	236	2	Yes
5239	f4 TRIP (f4 TRIP)	Frequency Prot.	AM	*	ON		m	LED			BO		70	237	2	Yes
5323	>BLOCK underexcitation protec-tion (>Exc. BLOCK)	Underexcitation	EM	*	*		*	LED	BI		BO					
5327	>BLOCK underexc. prot. char. 3 (>Char. 3 BLK.)	Underexcitation	EM	ON OFF	*		*	LED	BI		BO		71	53	1	Yes
5328	>Exc. voltage failure recognized (>Uexc fail.)	Underexcitation	EM	ON OFF	*		*	LED	BI		BO		71	54	1	Yes
5329	>BLOCK underexc. prot. char. 1 (>Char. 1 BLK.)	Underexcitation	EM	ON OFF	*		*	LED	BI		BO		71	64	1	Yes
5330	>BLOCK underexc. prot. char. 2 (>Char. 2 BLK.)	Underexcitation	EM	ON OFF	*		*	LED	BI		BO		71	65	1	Yes
5331	Underexc. prot. is switched OFF (Excit. OFF)	Underexcitation	AM	ON OFF	*		*	LED			BO		71	55	1	Yes
5332	Underexc. prot. is BLOCKED (Excit.BLOCKED)	Underexcitation	AM	ON OFF	ON OFF		*	LED			BO		71	56	1	Yes
5333	Underexc. prot. is ACTIVE (Ex-cit.ACTIVE)	Underexcitation	AM	ON OFF	*		*	LED			BO		71	57	1	Yes
5334	Underexc. prot. blocked by U< (Exc. U< blk)	Underexcitation	AM	ON OFF	ON OFF		*	LED			BO		71	58	1	Yes
5336	Exc. voltage failure recognized (Uexc failure)	Underexcitation	AM	*	ON OFF		*	LED			BO					
5337	Underexc. prot. picked up (Exc< picked up)	Underexcitation	AM	*	ON OFF		*	LED			BO		71	60	2	Yes
5343	Underexc. prot. char. 3 TRIP (Exc<3 TRIP)	Underexcitation	AM	*	ON		m	LED			BO		71	63	2	Yes
5344	Underexc. prot. char. 1 TRIP (Exc<1 TRIP)	Underexcitation	AM	*	ON		m	LED			BO		71	66	2	Yes
5345	Underexc. prot. char. 2 TRIP (Exc<2 TRIP)	Underexcitation	AM	*	ON		m	LED			BO		71	67	2	Yes
5346	Underexc. prot. char.+Uexc< TRIP (Exc<U<TRIP)	Underexcitation	AM	*	ON		m	LED			BO		71	68	2	Yes
5353	>BLOCK overexcitation protec-tion (>U/f BLOCK)	Overexcitation	EM	*	*		*	LED	BI		BO					
5357	>Reset memory of thermal replica U/f (>RM th.rep. U/f)	Overexcitation	EM	ON OFF	*		*	LED	BI		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
5361	Overexcitation prot. is swiched OFF (U/f> OFF)	Overexcitation	AM	ON OFF	*		*	LED			BO		71	83	1	Yes
5362	Overexcitation prot. is BLOCKED (U/f> BLOCKED)	Overexcitation	AM	ON OFF	ON OFF		*	LED			BO		71	84	1	Yes
5363	Overexcitation prot. is ACTIVE (U/f> ACTIVE)	Overexcitation	AM	ON OFF	*		*	LED			BO		71	85	1	Yes
5367	Overexc. prot.: U/f warning stage (U/f> warn)	Overexcitation	AM	ON OFF	*		*	LED			BO		71	86	1	Yes
5369	Reset memory of thermal replica U/f (RM th.rep. U/f)	Overexcitation	AM	ON OFF	*		*	LED			BO		71	88	1	Yes
5370	Overexc. prot.: U/f> picked up (U/f> picked up)	Overexcitation	AM	*	ON OFF		*	LED			BO		71	89	2	Yes
5371	Overexc. prot.: TRIP of U/f>> stage (U/f>> TRIP)	Overexcitation	AM	*	ON		m	LED			BO		71	90	2	Yes
5372	Overexc. prot.: TRIP of th. stage (U/f> th.TRIP)	Overexcitation	AM	*	ON		m	LED			BO		71	91	2	Yes
5373	Overexc. prot.: U/f>> picked up (U/f>> pick.up)	Overexcitation	AM	*	ON OFF		*	LED			BO		71	92	2	Yes
5396	Failure R/E/F protection Iee< (Fail. REF Iee<)	Sens. E Fault	AM	ON OFF	*		*	LED			BO		71	126	1	Yes
5503	>BLOCK Rate-of-frequency-change prot. (>df/dt block)	df/dt Protect.	EM	*	*		*	LED	BI		BO					
5504	>BLOCK df1/dt stage (>df1/dt block)	df/dt Protect.	EM	ON OFF	*		*	LED	BI		BO		72	1	1	Yes
5505	>BLOCK df2/dt stage (>df2/dt block)	df/dt Protect.	EM	ON OFF	*		*	LED	BI		BO		72	2	1	Yes
5506	>BLOCK df3/dt stage (>df3/dt block)	df/dt Protect.	EM	ON OFF	*		*	LED	BI		BO		72	3	1	Yes
5507	>BLOCK df4/dt stage (>df4/dt block)	df/dt Protect.	EM	ON OFF	*		*	LED	BI		BO		72	4	1	Yes
5511	df/dt is switched OFF (df/dt OFF)	df/dt Protect.	AM	ON OFF	*		*	LED			BO		72	5	1	Yes
5512	df/dt is BLOCKED (df/dt BLOCKED)	df/dt Protect.	AM	ON OFF	ON OFF		*	LED			BO		72	6	1	Yes
5513	df/dt is ACTIVE (df/dt ACTIVE)	df/dt Protect.	AM	ON OFF	*		*	LED			BO		72	7	1	Yes
5514	df/dt is blocked by undervoltage (df/dt U< block)	df/dt Protect.	AM	ON OFF	ON OFF		*	LED			BO		72	8	1	Yes
5516	Stage df1/dt picked up (df1/dt pickup)	df/dt Protect.	AM	*	ON OFF		*	LED			BO		72	9	2	Yes
5517	Stage df2/dt picked up (df2/dt pickup)	df/dt Protect.	AM	*	ON OFF		*	LED			BO		72	10	2	Yes
5518	Stage df3/dt picked up (df3/dt pickup)	df/dt Protect.	AM	*	ON OFF		*	LED			BO		72	11	2	Yes
5519	Stage df4/dt picked up (df4/dt pickup)	df/dt Protect.	AM	*	ON OFF		*	LED			BO		72	12	2	Yes
5520	Stage df1/dt TRIP (df1/dt TRIP)	df/dt Protect.	AM	*	ON		*	LED			BO		72	13	2	Yes
5521	Stage df2/dt TRIP (df2/dt TRIP)	df/dt Protect.	AM	*	ON		*	LED			BO		72	14	2	Yes
5522	Stage df3/dt TRIP (df3/dt TRIP)	df/dt Protect.	AM	*	ON		*	LED			BO		72	15	2	Yes
5523	Stage df4/dt TRIP (df4/dt TRIP)	df/dt Protect.	AM	*	ON		*	LED			BO		72	16	2	Yes
5533	>BLOCK inadvertent energ. prot. (>BLOCK I.En.)	Inadvert. En.	EM	*	*		*	LED	BI		BO					
5541	Inadvert. Energ. prot. is swiched OFF (I.En. OFF)	Inadvert. En.	AM	ON OFF	*		*	LED			BO		72	31	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
5542	Inadvert. Energ. prot. is BLOCKED (I.En. BLOCKED)	Inadvert. En.	AM	ON OFF	ON OFF		*	LED			BO		72	32	1	Yes
5543	Inadvert. Energ. prot. is ACTIVE (I.En. ACTIVE)	Inadvert. En.	AM	ON OFF	*		*	LED			BO		72	33	1	Yes
5546	Release of the current stage (I.En. release)	Inadvert. En.	AM	ON OFF	*		*	LED			BO		72	34	1	Yes
5547	Inadvert. Energ. prot.: picked up (I.En. picked up)	Inadvert. En.	AM	*	ON OFF		*	LED			BO		72	35	2	Yes
5548	Inadvert. Energ. prot.: TRIP (I.En. TRIP)	Inadvert. En.	AM	*	ON		m	LED			BO		72	36	2	Yes
5553	>BLOCK SEF with 3.Harmonic (>SEF 3H BLOCK)	SEF 3.Harm.	EM	*	*		*	LED	BI		BO					
5561	SEF with 3.Harm. is switched OFF (SEF 3H OFF)	SEF 3.Harm.	AM	ON OFF	*		*	LED			BO		72	51	1	Yes
5562	SEF with 3.Harm. is BLOCKED (SEF 3H BLOCK)	SEF 3.Harm.	AM	ON OFF	ON OFF		*	LED			BO		72	52	1	Yes
5563	SEF with 3.Harm. is ACTIVE (SEF 3H ACTIVE)	SEF 3.Harm.	AM	ON OFF	*		*	LED			BO		72	53	1	Yes
5567	SEF with 3.Harm.: picked up (SEF 3H pick.up)	SEF 3.Harm.	AM	*	ON OFF		*	LED			BO		72	54	2	Yes
5568	SEF with 3.Harm.: TRIP (SEF 3H TRIP)	SEF 3.Harm.	AM	*	ON		m	LED			BO		72	55	2	Yes
5581	>BLOCK Vector Jump (>VEC JUMP block)	Vector Jump	EM	*	*		*	LED	BI		BO					
5582	Vector Jump is switched OFF (VEC JUMP OFF)	Vector Jump	AM	ON OFF	*		*	LED			BO		72	72	1	Yes
5583	Vector Jump is BLOCKED (VEC JMP BLOCKED)	Vector Jump	AM	ON OFF	ON OFF		*	LED			BO		72	73	1	Yes
5584	Vector Jump is ACTIVE (VEC JUMP ACTIVE)	Vector Jump	AM	ON OFF	*		*	LED			BO		72	74	1	Yes
5585	Vector Jump not in measurement range (VEC JUMP Range)	Vector Jump	AM	ON OFF	*		*	LED			BO		72	75	1	Yes
5586	Vector Jump picked up (VEC JUMP pickup)	Vector Jump	AM	*	ON OFF		*	LED			BO		72	76	2	Yes
5587	Vector Jump TRIP (VEC JUMP TRIP)	Vector Jump	AM	*	ON		*	LED			BO		72	77	2	Yes
6503	>BLOCK undervoltage protection (>BLOCK U/V)	Undervoltage	EM	*	*		*	LED	BI		BO					
6506	>BLOCK undervoltage protection U< (>BLOCK U<)	Undervoltage	EM	ON OFF	*		*	LED	BI		BO		74	6	1	Yes
6508	>BLOCK undervoltage protection U<< (>BLOCK U<<)	Undervoltage	EM	ON OFF	*		*	LED	BI		BO		74	8	1	Yes
6513	>BLOCK overvoltage protection (>BLOCK O/V)	Overvoltage	EM	*	*		*	LED	BI		BO					
6516	>BLOCK overvoltage protection U> (>BLOCK U>)	Overvoltage	EM	ON OFF	*		*	LED	BI		BO		74	20	1	Yes
6517	>BLOCK overvoltage protection U>> (>BLOCK U>>)	Overvoltage	EM	ON OFF	*		*	LED	BI		BO		74	21	1	Yes
6530	Undervoltage protection switched OFF (Undervolt. OFF)	Undervoltage	AM	ON OFF	*		*	LED			BO		74	30	1	Yes
6531	Undervoltage protection is BLOCKED (Undervolt. BLK)	Undervoltage	AM	ON OFF	ON OFF		*	LED			BO		74	31	1	Yes
6532	Undervoltage protection is ACTIVE (Undervolt. ACT)	Undervoltage	AM	ON OFF	*		*	LED			BO		74	32	1	Yes
6533	Undervoltage U< picked up (U< picked up)	Undervoltage	AM	*	ON OFF		*	LED			BO		74	33	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
6537	Undervoltage U<< picked up (U<< picked up)	Undervoltage	AM	*	ON OFF		*	LED			BO		74	37	2	Yes
6539	Undervoltage U< TRIP (U< TRIP)	Undervoltage	AM	*	ON		m	LED			BO		74	39	2	Yes
6540	Undervoltage U<< TRIP (U<< TRIP)	Undervoltage	AM	*	ON		m	LED			BO		74	40	2	Yes
6565	Overvoltage protection switched OFF (Overvolt. OFF)	Overvoltage	AM	ON OFF	*		*	LED			BO		74	65	1	Yes
6566	Overvoltage protection is BLOCKED (Overvolt. BLK)	Overvoltage	AM	ON OFF	ON OFF		*	LED			BO		74	66	1	Yes
6567	Overvoltage protection is ACTIVE (Overvolt. ACT)	Overvoltage	AM	ON OFF	*		*	LED			BO		74	67	1	Yes
6568	Overvoltage U> picked up (U> picked up)	Overvoltage	AM	*	ON OFF		*	LED			BO		74	68	2	Yes
6570	Overvoltage U> TRIP (U> TRIP)	Overvoltage	AM	*	ON		m	LED			BO		74	70	2	Yes
6571	Overvoltage U>> picked up (U>> picked up)	Overvoltage	AM	*	ON OFF		*	LED			BO		74	71	2	Yes
6573	Overvoltage U>> TRIP (U>> TRIP)	Overvoltage	AM	*	ON		m	LED			BO		74	73	2	Yes
6575	Voltage Transformer Fuse Failure (VT Fuse Failure)	Measurem.Superv	AM	ON OFF	*		*	LED			BO		74	74	1	Yes
6801	>BLOCK Motor Starting Supervision (>BLK START-SUP)	Start Motor	EM	*	*		*	LED	BI		BO					
6805	>Rotor is locked (>Rotor locked)	Start Motor	EM	ON OFF	*		*	LED	BI		BO					
6811	Starting time supervision switched OFF (START-SUP OFF)	Start Motor	AM	ON OFF	*		*	LED			BO		169	51	1	Yes
6812	Starting time supervision is BLOCKED (START-SUP BLK)	Start Motor	AM	ON OFF	ON OFF		*	LED			BO		169	52	1	Yes
6813	Starting time supervision is ACTIVE (START-SUP ACT)	Start Motor	AM	ON OFF	*		*	LED			BO		169	53	1	Yes
6821	Starting time supervision TRIP (START-SUP TRIP)	Start Motor	AM	*	ON		*	LED			BO		169	54	2	Yes
6822	Rotor is LOCKED after Locked Rotor Time (Rotor locked)	Start Motor	AM	*	ON		*	LED			BO		169	55	2	Yes
6823	Starting time supervision picked up (START-SUP PU)	Start Motor	AM	ON OFF	*		*	LED			BO		169	56	1	Yes
6851	>BLOCK Trip circuit supervision (>BLOCK TripC)	TripCirc.Superv	EM	*	*		*	LED	BI		BO					
6852	>Trip circuit supervision: trip relay (>TripC trip rel)	TripCirc.Superv	EM	ON OFF	*		*	LED	BI		BO		170	51	1	Yes
6853	>Trip circuit supervision: breaker relay (>TripC brk rel.)	TripCirc.Superv	EM	ON OFF	*		*	LED	BI		BO		170	52	1	Yes
6861	Trip circuit supervision OFF (TripC OFF)	TripCirc.Superv	AM	ON OFF	*		*	LED			BO		170	53	1	Yes
6862	Trip circuit supervision is BLOCKED (TripC BLOCKED)	TripCirc.Superv	AM	ON OFF	ON OFF		*	LED			BO		153	16	1	Yes
6863	Trip circuit supervision is ACTIVE (TripC ACTIVE)	TripCirc.Superv	AM	ON OFF	*		*	LED			BO		153	17	1	Yes
6864	Trip Circuit blk. Bin. input is not set (TripC ProgFail)	TripCirc.Superv	AM	ON OFF	*		*	LED			BO		170	54	1	Yes
6865	Failure Trip Circuit (FAIL: Trip cir.)	TripCirc.Superv	AM	ON OFF	*		*	LED			BO		170	55	1	Yes
7960	Measured Value MV1> picked up (Meas. Value1>)	Threshold	AM	*	*		*	LED			BO					

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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
7961	Measured Value MV2< picked up (Meas. Value2<)	Threshold	AM	*	*		*	LED			BO					
7962	Measured Value MV3> picked up (Meas. Value3>)	Threshold	AM	*	*		*	LED			BO					
7963	Measured Value MV4< picked up (Meas. Value4<)	Threshold	AM	*	*		*	LED			BO					
7964	Measured Value MV5> picked up (Meas. Value5>)	Threshold	AM	*	*		*	LED			BO					
7965	Measured Value MV6< picked up (Meas. Value6<)	Threshold	AM	*	*		*	LED			BO					
14101	Fail: RTD (broken wire/shorted) (Fail: RTD)	RTD-Box	AM	ON OFF	*		*	LED			BO					
14111	Fail: RTD 1 (broken wire/shorted) (Fail: RTD 1)	RTD-Box	AM	ON OFF	*		*	LED			BO					
14112	RTD 1 Temperature stage 1 picked up (RTD 1 St.1 p.up)	RTD-Box	AM	ON OFF	*		*	LED			BO					
14113	RTD 1 Temperature stage 2 picked up (RTD 1 St.2 p.up)	RTD-Box	AM	ON OFF	*		*	LED			BO					
14121	Fail: RTD 2 (broken wire/shorted) (Fail: RTD 2)	RTD-Box	AM	ON OFF	*		*	LED			BO					
14122	RTD 2 Temperature stage 1 picked up (RTD 2 St.1 p.up)	RTD-Box	AM	ON OFF	*		*	LED			BO					
14123	RTD 2 Temperature stage 2 picked up (RTD 2 St.2 p.up)	RTD-Box	AM	ON OFF	*		*	LED			BO					
14131	Fail: RTD 3 (broken wire/shorted) (Fail: RTD 3)	RTD-Box	AM	ON OFF	*		*	LED			BO					
14132	RTD 3 Temperature stage 1 picked up (RTD 3 St.1 p.up)	RTD-Box	AM	ON OFF	*		*	LED			BO					
14133	RTD 3 Temperature stage 2 picked up (RTD 3 St.2 p.up)	RTD-Box	AM	ON OFF	*		*	LED			BO					
14141	Fail: RTD 4 (broken wire/shorted) (Fail: RTD 4)	RTD-Box	AM	ON OFF	*		*	LED			BO					
14142	RTD 4 Temperature stage 1 picked up (RTD 4 St.1 p.up)	RTD-Box	AM	ON OFF	*		*	LED			BO					
14143	RTD 4 Temperature stage 2 picked up (RTD 4 St.2 p.up)	RTD-Box	AM	ON OFF	*		*	LED			BO					
14151	Fail: RTD 5 (broken wire/shorted) (Fail: RTD 5)	RTD-Box	AM	ON OFF	*		*	LED			BO					
14152	RTD 5 Temperature stage 1 picked up (RTD 5 St.1 p.up)	RTD-Box	AM	ON OFF	*		*	LED			BO					
14153	RTD 5 Temperature stage 2 picked up (RTD 5 St.2 p.up)	RTD-Box	AM	ON OFF	*		*	LED			BO					
14161	Fail: RTD 6 (broken wire/shorted) (Fail: RTD 6)	RTD-Box	AM	ON OFF	*		*	LED			BO					
14162	RTD 6 Temperature stage 1 picked up (RTD 6 St.1 p.up)	RTD-Box	AM	ON OFF	*		*	LED			BO					
14163	RTD 6 Temperature stage 2 picked up (RTD 6 St.2 p.up)	RTD-Box	AM	ON OFF	*		*	LED			BO					
14171	Fail: RTD 7 (broken wire/shorted) (Fail: RTD 7)	RTD-Box	AM	ON OFF	*		*	LED			BO					
14172	RTD 7 Temperature stage 1 picked up (RTD 7 St.1 p.up)	RTD-Box	AM	ON OFF	*		*	LED			BO					
14173	RTD 7 Temperature stage 2 picked up (RTD 7 St.2 p.up)	RTD-Box	AM	ON OFF	*		*	LED			BO					
14181	Fail: RTD 8 (broken wire/shorted) (Fail: RTD 8)	RTD-Box	AM	ON OFF	*		*	LED			BO					

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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
14182	RTD 8 Temperature stage 1 picked up (RTD 8 St.1 p.up)	RTD-Box	AM	ON OFF	*		*	LED			BO					
14183	RTD 8 Temperature stage 2 picked up (RTD 8 St.2 p.up)	RTD-Box	AM	ON OFF	*		*	LED			BO					
14191	Fail: RTD 9 (broken wire/shorted) (Fail: RTD 9)	RTD-Box	AM	ON OFF	*		*	LED			BO					
14192	RTD 9 Temperature stage 1 picked up (RTD 9 St.1 p.up)	RTD-Box	AM	ON OFF	*		*	LED			BO					
14193	RTD 9 Temperature stage 2 picked up (RTD 9 St.2 p.up)	RTD-Box	AM	ON OFF	*		*	LED			BO					
14201	Fail: RTD10 (broken wire/shorted) (Fail: RTD10)	RTD-Box	AM	ON OFF	*		*	LED			BO					
14202	RTD10 Temperature stage 1 picked up (RTD10 St.1 p.up)	RTD-Box	AM	ON OFF	*		*	LED			BO					
14203	RTD10 Temperature stage 2 picked up (RTD10 St.2 p.up)	RTD-Box	AM	ON OFF	*		*	LED			BO					
14211	Fail: RTD11 (broken wire/shorted) (Fail: RTD11)	RTD-Box	AM	ON OFF	*		*	LED			BO					
14212	RTD11 Temperature stage 1 picked up (RTD11 St.1 p.up)	RTD-Box	AM	ON OFF	*		*	LED			BO					
14213	RTD11 Temperature stage 2 picked up (RTD11 St.2 p.up)	RTD-Box	AM	ON OFF	*		*	LED			BO					
14221	Fail: RTD12 (broken wire/shorted) (Fail: RTD12)	RTD-Box	AM	ON OFF	*		*	LED			BO					
14222	RTD12 Temperature stage 1 picked up (RTD12 St.1 p.up)	RTD-Box	AM	ON OFF	*		*	LED			BO					
14223	RTD12 Temperature stage 2 picked up (RTD12 St.2 p.up)	RTD-Box	AM	ON OFF	*		*	LED			BO					

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.	162 163	Failure Σ I Fail I balance
164	Fail U Superv.	165 167	Fail Σ U Ph-E Fail U balance
171	Fail Ph. Seq.	175 176	Fail Ph. Seq. I Fail Ph. Seq. U
181	Error A/D-conv.	192 194 190 185 188	Error1A/5Awrong Error neutralCT Error Board 0 Error Board 3 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	-	-	-	-	-		CD	DD
-	Number of TRIPs (#of TRIPs=)	Statistics	-	-	-	-	-		CD	DD
-	Operating hours greater than (OpHour>)	SetPoint(Stat)	-	-	-	-	-		CD	DD
601	I L1 (IL1 =)	Measurement	134	147	No	9	1	CFC	CD	DD
602	I L2 (IL2 =)	Measurement	134	147	No	9	2	CFC	CD	DD
603	I L3 (IL3 =)	Measurement	134	147	No	9	3	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
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
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
830	Senstive Earth Fault Current (IEE =)	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 (I1Min=)	Min/Max meter	-	-	-	-	-	CFC	CD	DD
858	Positive Sequence Maximum (I1Max=)	Min/Max meter	-	-	-	-	-	CFC	CD	DD
874	U1 (positive sequence) Voltage Minimum (U1Min=)	Min/Max meter	-	-	-	-	-	CFC	CD	DD
875	U1 (positive sequence) Voltage Maximum (U1Max=)	Min/Max meter	-	-	-	-	-	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
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	-		CD	DD
888	Pulsed Energy Wp (active) (Wp(puls))	Energy	-	-	-	-	-		CD	DD
889	Pulsed Energy Wq (reactive) (Wq(puls))	Energy	133	56	No	205	-		CD	DD
889	Pulsed Energy Wq (reactive) (Wq(puls))	Energy	-	-	-	-	-		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
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 (Wp+=)	Energy	133	51	No	205	-		CD	DD
924	Wp Forward (Wp+=)	Energy	-	-	-	-	-		CD	DD
925	Wq Forward (Wq+=)	Energy	133	52	No	205	-		CD	DD
925	Wq Forward (Wq+=)	Energy	-	-	-	-	-		CD	DD
928	Wp Reverse (Wp-=)	Energy	133	53	No	205	-		CD	DD
928	Wp Reverse (Wp-=)	Energy	-	-	-	-	-		CD	DD
929	Wq Reverse (Wq-=)	Energy	133	54	No	205	-		CD	DD
929	Wq Reverse (Wq-=)	Energy	-	-	-	-	-		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

■

Literature

/1/ SIPROTEC 4 System Description; E50417-H1176-C151-A2

/2/ SIPROTEC DIGSI, Start UP; E50417-G1176-C152-A2

/3/ DIGSI CFC, Manual; E50417-H1176-C098-A4

/4/ SIPROTEC SIGRA 4, Manual; E50417-H1176-C070-A2

/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 graphics 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 Up to 16 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 which 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-Technischen-Bundesanstalt PTB" in Braunschweig. The atomic clock unit 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.

GPS Global Positioning System. Satellites with atomic clocks on board orbit the earth twice a day in different parts 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 running time of a satellite 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 memorized 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 parameterisation of PCUs and submodules 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

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.

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 among 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	Single-point indication fleeting → Transient information, → Single point indication
ISO 9001	The ISO 9000 ff range of standards defines measures used to ensure 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 pane 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 number	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 saved 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 Off-line mode a link with the SIPROTEC 4 device is not necessary. You work with data which are stored in files.

OI_F Output indication fleeting → Transient information

On-line When working in On-line mode, there is a physical link to a SIPROTEC 4 device which can be implemented in various ways. This link 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 by a number of objects which are integrated in a hierarchical structure. Physically, a project consists of a series of folders and files containing project data.

Protection devices All devices with a protective function and no control display.

Reorganizing Frequent addition and deletion of objects gives rise to memory areas that can no longer be used. By cleaning up projects, you can release these memory areas again. However, a clean up also reassigns the VD addresses. The consequence of that is that all SIPROTEC 4 devices have to be reinitialised.

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 fleeting → Transient information, → Single point indication

SICAM SAS Modularly structured station control system, based on the substation controller → SICAM SC and the SICAM WinCC operator control and monitoring system.

SICAM SC Substation Controller. Modularly structured substation control system, based on the SIMATIC M7 automation system.

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.

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 source object. However, all variants derived from the source object have the same VD address as the source object. For this reason they always correspond to the same real SIPROTEC 4 device as the source 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 station, the national code, the area code and the user-specific phone number.

Users Up to 16 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.

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