Feeder Terminal

Product Guide

REF 541, REF 543, REF 545

ABB

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Features

- Feeder terminal for protection, control, measurement and supervision of medium voltage networks.
- Voltage and current measurement via conventional measuring transformers or current sensors and voltage dividers.
- Fixed human-machine interface including a large graphic display, or an external display module for flexible switchgear installation.
- Protection functions including e.g. non-directional and directional overcurrent and earth-fault protection, residual voltage, overvoltage and undervoltage protection, thermal overload protection, CBFP and auto-reclosing.
- Control functions including local and remote control of switching objects with synchro-check, status indication of the switching objects and interlockings on bay and station level
- Measurement of phase currents, phase-to-phase and phase-to-neutral voltages, neutral current and residual voltage, frequency, power factor, active and reactive power and energy.
- Advanced power quality measurement capabilities. Total harmonic distortion (THD) measurements for both currents and voltages. Measurement for short duration voltage variations like sags, swells and short interruptions.
- Condition monitoring including circuit-breaker condition monitoring, trip circuit supervision and internal self-supervision of the feeder terminal.
- Time synchronization via binary input. Synchronization pulse once per second or once per minute.
- Fault locator for short circuits in all kinds of network and for earth-faults in effectively earthed and low resistance/low reactance earthed networks.
- Additional functions including synchro-check, frequency protection, capacitor bank protection and control.
- RTD/analogue module for temperature measurement, current/voltage measurement and mA-outputs.
- Communication over three communication interfaces: one for local communication with a PC and two for simultaneous dual port communication for e.g. a substation communication system and a substation monitoring system.
- Selectable function block naming: ANSI device numbers, IEC symbols or ABB naming.
- Support for IEC 61850 protocol through the SPA-ZC 400 adapter.
- Support for Profibus-DPV1 protocol through the SPA-ZC 302 adapter
- Part of the ABB Distribution Automation system.

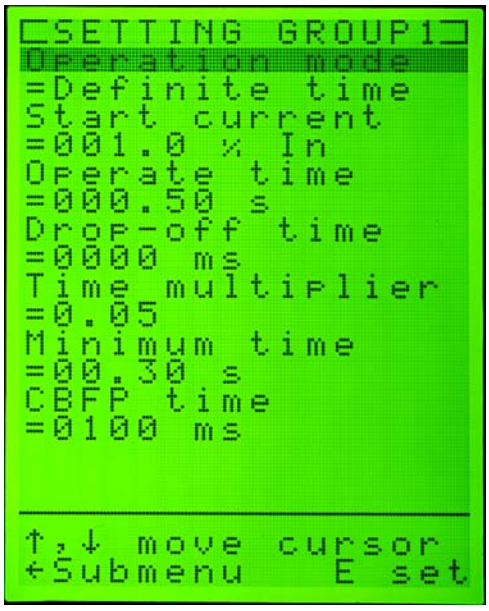

Fig. 1 Setting group example window.

Application

The REF 541, REF 543 and REF 545 feeder terminals are designed to be used for protection, control, measurement and supervision of medium voltage networks.

They can be used with different kinds of switchgear including single busbar, double busbar and duplex systems. The protection functions also support different types of networks such as isolated neutral networks, resonant-earthed networks and partially earthed networks..

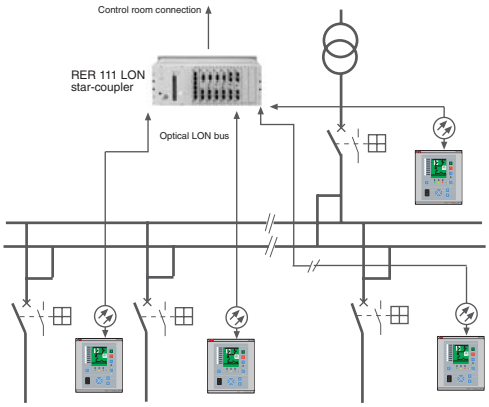

Fig. 2 Distributed protection and control system based on REF 54_ feeder terminals.

Application area also covers protection functions for a large variety of applications, e.g. frequency and voltage based protection, motor protection, thermal overload protection, capacitor bank protection and synchrocheck/voltage check function.

In addition to protection, measurement, control and condition monitoring functions, the feeder terminals are provided with a large amount of PLC functions allowing several automation and sequence logic functions needed for substation automation to be integrated into one unit.

The data communication properties include the following communications: SPA bus, LON bus, IEC 60870-5-103, IEC 61850, Profibus-DPV1, DNP 3.0 or Modbus communication with higher-level equipment. Further, LON communication, together with PLC functions, minimizes the need for hardwiring between the units.

Design

The feeder terminals REF 541, REF 543 and REF 545 differ from each other regarding the number of digital inputs and outputs available. Please, refer to section “Ordering” for more details.

The REF 54_ feeder terminals incorporate a wide range of feeder terminal functions:

- Protection functions
- Measurement functions
- Disturbance recorder
- Power quality functions
- Control functions
- Fault locator
- Condition monitoring functions
- General functions
- Communication functions
- Standard functions

The function blocks are documented on the CD-ROM “Technical Descriptions of Functions” (1MRS 750889-MCD).

Protection functions

Protection is one of the most important functions of the REF 54_ feeder terminal. The protection function blocks (e.g. NOC3Low) are independent of each other and have e.g. their own setting groups and data recording. The non-directional overcurrent protection includes e.g. the three stages NOC3Low, NOC3High and NOC3Inst, each with independent protection functions.

Either Rogowski coils or conventional current transformers can be used for protection functions based on current measurement. Correspondingly, voltage dividers or voltage transformers are used for protection functions based on voltage measurement

For further information about functionality levels and the protection functions included in them, refer to the table “Functionality levels, protection functions” in section “Ordering”.

Measurement functions

The measurement functions include three-phase currents, neutral current, three-phase voltages, residual voltage, frequency, active

and reactive power and power factor. In addition, other measurement functions are available.

As a standard feature the REF 54_ terminal includes pulse counter inputs. The number of pulse inputs varies from 7 (REF 541) to 10 (REF 545) according to the REF variant.

Disturbance recorder

The transient disturbance recorder is able to record 16 current or voltage waveforms and 16 logic digital signals. The sampling frequency of the analogue inputs is 2 kHz at the rated frequency of 50 Hz and 2.4 kHz at the rated frequency of 60 Hz.

The user can set the length of a recording within a range determined by the number of analogue inputs used. The number of recordings depends on the sampling frequency, length of recordings and number of analogue inputs.

The recordings can be uploaded with a DR-Collector Tool which converts the data to a COMTRADE format. The DR-Collector Tool is supported in CAP501 and CAP505 relay tools.

Power quality functions

Power quality functions enable measurement of total harmonic distortion (THD) of voltage and current, and total demand distortion (TDD) of current. Individual harmonics are measured up to 13th.

Power quality functions also include measurement of short duration voltage variations like sags, swells and short interruptions. Measurements are done according to the IEC standard 61000-4-30.

LIB 510 supports tools for presentation of harmonics and short duration voltage variations.

Control functions

The control functions are used to indicate the position of switching devices, i.e. circuit breakers and disconnectors, and to execute open and close commands for controllable switching devices in the switchgear. Furthermore, there are supplementary functions for control logic purposes, e.g. on/off switches, MIMIC alarm, LED control, numerical data for the MIMIC and logic controlled position selection.

The control functions configured using the *Relay Configuration Tool* can be associated with position indicators that are part of the MIMIC configuration picture displayed on the HMI. Position indicators are used to indicate the position of switching devices via the MIMIC picture and to control them locally. The status of different objects, e.g. open/close/undefined, displayed in the MIMIC view can be freely designed.

Fault locator

The fault locator function for radial distribution systems. Short-circuit localization in all kind of distribution networks. Earth-fault localization in effectively earthed networks and in low reactance/low resistance earthed networks. Assists fast power restoration after the fault. Improves system availability and performance.

Condition monitoring functions

Condition monitoring function blocks such as supervision of the energizing current and voltage input circuit, operation time counter, circuit breaker electric wear, scheduled maintenance, trip circuit supervision and breaker travel time are available for the REF 54_ feeder terminals.

General functions

Additional functions are available for different general purposes to be used in logics such as activation of HMI backlight, switchgroups, and resetting of operation indications, latched output signals, registers and disturbance recorder.

Communication functions

The REF 54_ feeder terminal provides the IEC 60870-5-103, IEC 61850, Profibus-DPV1, Modbus, DNP 3.0, SPA and LON serial communication protocols.

In a customer-specific feeder terminal configuration, special events can be generated via an EVENT230 event function.

Standard functions

Standard functions are used for logics such as interlocking, alarming and control sequencing. The use of logic functions is not limited and the functions can be interconnected with each other as well as with protection, measurement, power quality, control, condition monitoring and general functions. In addition, the digital inputs and outputs as well as LON inputs and outputs can be connected to standard functions by using the *Relay Configuration Tool*.

Other functions

Low auxiliary voltage indication
The REF 54_ feeder terminal is provided with a low auxiliary voltage indication feature. The power supply module issues an internal alarm signal when a drop in the power supply voltage is detected (ACFail, active low). The alarm signal is activated if the power supply voltage falls about 10% below the lowest rated DC input voltage of the power supply module.

The indication of a low auxiliary voltage is available in the feeder terminal configuration and can be connected to any signal output of the REF 54_.

Overtemperature indication
The REF 54_ feeder terminal includes an internal temperature supervision function. The power supply module issues an internal alarm signal when overtemperature has been detected inside the terminal enclosure. The alarm signal will be activated once the temperature inside the terminal enclosure increases to +78°C (+75°...+83°C). Overtemperature indication is available in the feeder terminal configuration and can be connected to any signal output of the terminal.

Analog channels
The feeder terminal measures the analogue signals needed for protection, measuring, etc. via sensors or galvanically separated matching transformers.

Depending on whether sensors are included or not, REF 54_ feeder terminals have 9 (without sensors) or 10 (with sensors) analogue channels. The number of channels used depends on the feeder terminal configuration and the kind of matching transformers or sensor inputs used. Furthermore, the feeder terminal includes virtual analogue channels for calculating the phase-to-phase voltages, neutral current and residual voltage from phase currents and voltages.

In addition to 9 conventional matching transformers, sensors developed by ABB can be used parallel in REF 54_ feeder terminals. The feeder terminal has 9 sensor inputs. A current sensor (Rogowski coil) or a voltage divider can be connected to each sensor input. Please, see the connection diagram for details. When ordering, please note the type of analogue inputs.

Each analog channel is separately configured with the *Relay Configuration Tool*. Both the measuring unit for each analog channel and the type of signal to be measured are to be configured.

A separate scaling factor can be set for each analogue channel. The factors enable differences between the ratings of the protected unit and those of the measuring device (CTs, VTs etc.). The setting value 1.00 means that the rated value of the protected unit is exactly the same as that of the measuring device.

Calculated analogue channels
The REF 54_ feeder terminal includes virtual channels to obtain phase-to-phase voltages, neutral current and residual voltage when sensors are used. Sensors are connected to the feeder terminal via coaxial cables and therefore a residual connection of phase currents or an open-delta connection of phase voltages cannot be made. Both the amplitude and the phase angle are calculated for the virtual channels.

Though primarily meant to be used with sensors, the calculated analogue channels can also be used with conventional current and voltage transformers.

Note! When sensitive earth-fault protection is needed, core balance transformers are not recommended to be replaced with the numerically derived sum of phase currents. Normally, an earth-fault setting below 10% of the rated value requires the use of a core balance transformer.

Digital inputs
The digital inputs of the feeder terminals are voltage-controlled and optically isolated. The function of a digital input can be inverted. The programmable filter time removes debounces and short disturbances on a digital input. The filter time can be set for each digital input separately.

Some specific digital inputs can be programmed to operate either as digital inputs, as pulse counters or as used for time synchronization. When a digital input operates as a pulse counter, pulse counting frequency can be up to100 Hz.

Oscillation suppression
The feeder terminals have two global parameters for the suppression of digital input oscillation. The settings of these parameters

determine the oscillation level and hysteresis for all digital inputs. Event is generated in case oscillation is detected.

Attributes of a digital input for feeder terminal configuration

For each digital input, the status of the input (value), the time tag for the status change (time) and the validity of the digital input (invalidity) can be issued by the attributes. These attributes are available in the feeder terminal configuration and can be used for various purposes.

RTD/analogue inputs

The REF 541 and REF 543 feeder terminals equipped with an RTD/analogue module (RTD1) have eight general purpose analogue inputs for DC measurement. The RTD/analogue inputs are galvanically isolated from the feeder terminal power supply and enclosure. However, the inputs have a common ground. The general purpose RTD/analogue inputs accept voltage-, current- or resistance-type signals. For each measuring mode, a separate parameter is provided for choosing between the available measurement ranges. RTD/analogue inputs can be applied for e.g. temperature measurement.

Digital outputs

The outputs of the feeder terminal are categorized as follows:

- HSPO: High-speed power output, double-pole contact, preferred for tripping purposes and for circuit breaker and disconnector control
- PO: Power output, either single-pole or double-pole contact, preferred for circuit breaker and disconnector control
- SO: Signal output, either NO (Normally Open) or NO/NC (Normally Open/Normally Closed) contact. The output contact is a normal-duty contact and cannot be used for controlling a heavy load such as a circuit breaker.

Analogue outputs

The REF 541 and REF 543 feeder terminals equipped with an RTD/analogue module have four general purpose 0...20 mA analogue current outputs. All outputs are galvanically isolated from the supply and enclosure of the feeder terminal and from each other.

Analogue outputs can be utilized for transferring any measured or calculated information to panel meters or e.g. PLCs.

Alarm LED indicators

The feeder terminal offers eight alarm LED indicators to be configured with the Relay Mimic Editor. The LED colours (green, yellow, red), their use, and the ON and OFF state texts can be freely defined. Three basic operation modes are supported: non-latched, latched-steady and latched flashflashing. Alarms can be acknowledged remotely, locally or by using logic of the feeder terminal.

The alarm channels include time tagging for detected alarms. The time tagging principle used depends on the operation mode.

Interlocking LED indicator

The interlocking LED indicates that control operation has been interlocked or that the interlocking is in bybass mode, e.g. when control is possible despite of interlocking.

Trip Circuit Supervision

The purpose of this function is to supervise the tripping circuitry of the circuit breaker. An alarm will be generated in case a faulty tripping circuit, e.g. a circuit is not able to perform a trip, is detected.

The supervision is based on the constant-current injection through the tripping circuitry.

Display panel

The feeder terminal is provided with either a fixed display or an external display module. The external display module requires a separate voltage supply from a common source with the main unit. The display consists of 19 rows divided into two windows: a main window (17 rows) and an assisting window (2 rows).

The graphic display presents detailed information on MIMIC, objects, events, measurements, control alarms, and parameters. The assisting window is used for terminal-dependent indications/alarms and help messages.

Additionally, the panel includes the following HMI items:

- three push-buttons for object control (I, O, object selection)
- eight freely programmable alarm LEDs with different colours and modes according to the configuration
- LED indicator for control interlocking
- three protection LED indicators
- HMI push-button section with four arrow buttons and buttons for clear and enter

- optically isolated serial communication port
- backlight and contrast control
- freely programmable button (F) which can be used in the configuration of the feeder terminal
- a button for remote/local control

HMI has two main levels, the user level and the technical level. The user level is for “everyday” measurements and monitoring whereas the technical level is intended for advanced feeder terminal programming.

Serial communication

The feeder terminal has three serial communication ports, one on the front panel and two on the rear panel.

Front panel optical connection for PC

The front panel is intended for the connection of a PC for configuring the feeder terminal with the CAP 50_ tools. The front interface uses the SPA bus protocol.

The optical connector on the front panel isolates the PC galvanically from the feeder terminal. The front connector for the PC is standardized for ABB relay products and requires a specific opto cable. The cable is connected to the serial RS-232 port of the PC. The other communication parameters for the rear RS-485 interface are also set in the Communication menu of the REF 54_ feeder terminal.

SPA/IEC_103 communication on the rear connector X3.2

The 9-pin D-type subminiature male connector (RS-232 connection) on the rear panel connects the feeder terminal to the distribution automation system via the SPA bus or the IEC_103. The fibre-optic interface module type RER 123 is used for connecting the feeder terminal to the fibre-optic communication bus for SPA and IEC_103 protocol.

DNP3.0/Modbus communication on the rear connector X3.2

The 9-pin D-type subminiature male connector (RS-232 connection) on the rear panel connects the feeder terminal to the distribution automation system via the DNP 3.0 or the Modbus protocol. The interface between the feeder terminal and a RS-485 communication bus can be made through the RER 133 Bus Connection Module. The interface between the feeder terminal and an optical bus can be made through the RER 123 Bus Connection Module.

IEC 61850 communication using SPA-ZC 400 on the rear connector X3.2

The 9-pin D-type subminiature male connector (RS-232 connection) on the rear panel connects the feeder terminal to the distribution automation system via the IEC 61850 protocol. In the IEC 61850 mode, the SPA-ZC 400 Bus Connection Module is needed.

Profibus-DPV1 communication using SPA-ZC 302 on the rear connector X3.2

The 9-pin D-type subminiature male connector (RS-232 connection) on the rear panel connects the feeder terminal to the distribution automation system via the Profibus protocol. The interface between the feeder terminal and Profibus can be made through the SPA-ZC 302 Gateway.

LON/SPA bus communication on the rear connector X3.3

The 9-pin D-type subminiature female connector (RS-485 connection) on the rear panel connects the feeder terminal to the substation automation system via the SPA bus or the LON bus. The fibre-optic interface module type RER 103 is used to connect the feeder terminal to the fibre-optic communication bus. The RER 103 module supports both SPA bus and LON bus communication.

Self-supervision

The feeder terminal REF 54_ is provided with an extensive self-supervision system. The self-supervision system handles run-time fault situations and informs the user of faults via the HMI and LON/SPA bus communication.

When a fault has been detected, the green Ready indicator starts flashing, a fault indication text is displayed on the HMI and an event 0/E57 is generated. The fault indication text on the HMI consists of two rows: a general message ‘internal fault’, followed by the generated IRF code of the fault.

The relay will try to recover from a fault either by restarting the module (I/O module or HMI) that reported the fault, or by restarting the whole relay. During restarting the IRF state will remain active until the internal self-supervision program has determined that the relay is operating normally. If the fault is still persistent after restarting three times, the relay will be in permanent IRF state.

Feeder terminal configuration

The Relay Configuration Tool, based on the IEC 61131-3 standard, is used for configuring the basic terminal, protection and logic function blocks, control and measurement functions, timers and other functional elements included in the logic functions category.

The programmable system of REF 54_ feeder terminals allows the output contacts to be operated in accordance with the state of the logic inputs and the outputs of the protection, control, measurement and condition monitoring functions. The PLC functions (e.g. interlocking and alarm logic) are programmed with Boolean functions, timers, counters, comparators and flip-flops. The program is written in a function block diagram language by using the configuration software.

Mimic configuration

The control functions configured using the *Relay Configuration Tool* can be associated with position indicators that are part of the MIMIC configuration picture displayed on the graphic LCD of the HMI. The MIMIC configuration picture is designed with the *Relay Mimic Editor.* In addition, the editor is used to define the eight programmableLED indicators and the corresponding alarm texts on the front panel, the alarm modes, and the interlocking LED texts.

The MIMIC picture may include a single-line diagram, measured values with units, free texts, etc. The position indicators (open, closed, undefined) are drawn according to the customer's requirements. Note that the operation of the objects themselves is determined by means of the *Relay Configuration Tool*.

All of the eight alarm function blocks can be configured in the same alarm view of the mimic editor. ON and OFF state texts (only one language version at a time can be supported for the alarm) and LED colours can be defined. Three different colours can be used to define the ON and OFF state. Three basic modes are available:

- non-latched
- latched-steady
- latched flashing

Interlocking LED texts can also be defined in the same alarm view but the colour of the interlocking LED cannot be changed.

Lon network configuration

The *LON Network Tool* is used for binding network variables between RED 500 terminals. Typically, LON is used for transferring object status data (open, close, undefined) between units for interlocking sequences running in the units.

DNP 3.0 and Modbus configuration

The *Protocol Mapping Tool* included in the CAP 505 is used for configuring the DNP 3.0 and Modbus interfaces of the feeder terminal.

Feeder terminal parameterization

The parameters of the feeder terminal units can be set either locally over the HMI or externally via the serial communication.

Local parameterization

When the parameters are set locally via the HMI, the setting parameters can be chosen from the hierarchical menu structure. The desired language for parameter description can be selected.

External parameterization

The *Relay Setting Tool* is used for parameterizing and setting the feeder terminals externally. The parameters can be set off-line on a PC and downloaded to the feeder terminal over a communication port. The menu structure of the setting tool, including views for parameterization and settings, is the same as the menu structure of the feeder terminal.

Terminal connections

All external circuits are connected to the terminal blocks on the rear panel. The terminal block for the measuring transformers consists of fixed screw terminals.

ABB sensors (Rogowski coil or voltage divider) are connected to the feeder terminal with special type of shielded twin BNC connectors. This type of connectors are used to improve reliability and protection against disturbances. Unused sensor inputs must be short-circuited with special connectors, type 1MRS 120515.

The RS232 serial interface on the rear panel is used to connecting the feeder terminal to the SPA, the IEC_103, Modbus, DNP 3.0, Profibus, or IEC 61850 bus. The SPA, IEC_103, Modbus and DNP 3.0 bus is connected through RER 123 Bus Connection Module. DNP 3.0/Modbus can also be connected through the RER 133 Bus Connection Module.

Profibus is available through the SPA-ZC 302 Gateway and IEC 61850 is available through the SPA-ZC 400 Ethernet Adapter

The serial interface RS-485 on the rear panel is used for connecting the feeder terminal to the SPA bus or the LON bus. The SPA/LON bus is connected via the RER 103 Connection Module fitted to the 9-pin D-type subminiature connector and screwed to the rear panel.

The digital input and output contacts of the feeder terminal are connected to the multipole connectors.

Protective earth is connected to the screw marked with the earth symbol.

Basic connection diagrams

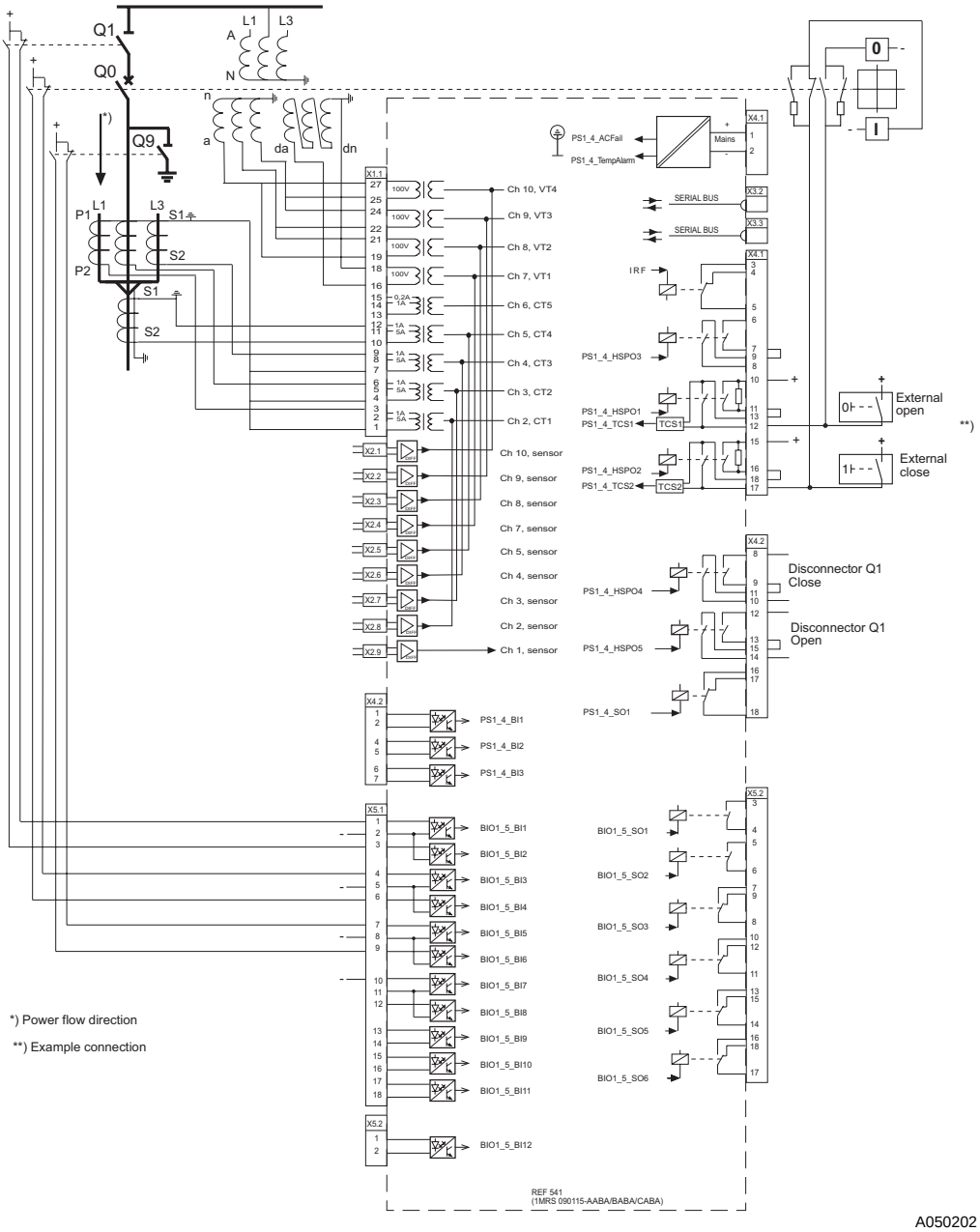

Fig. 3 Basic connection diagram of REF 541.

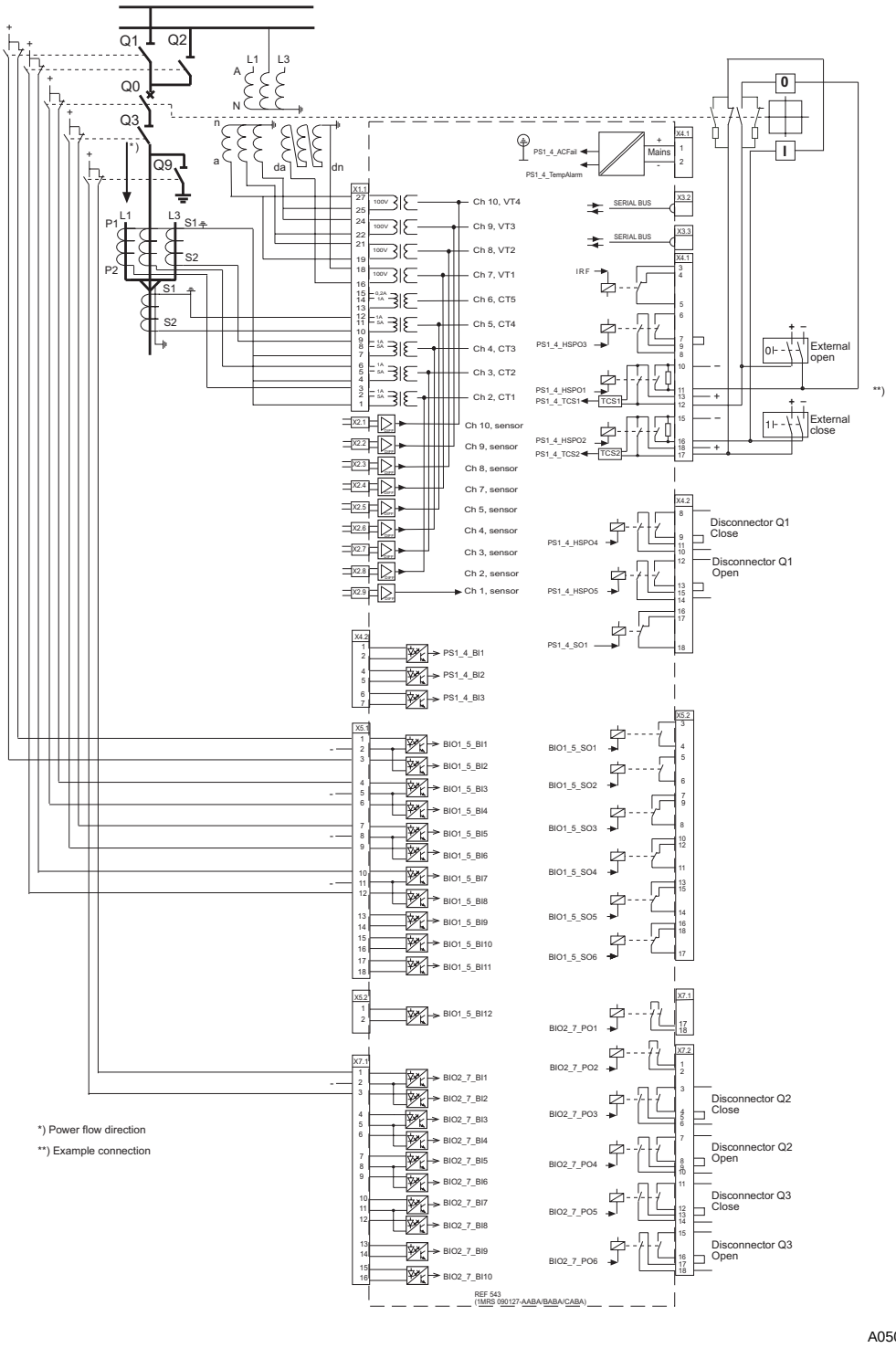

Fig. 4 Basic connection diagram of REF 543.

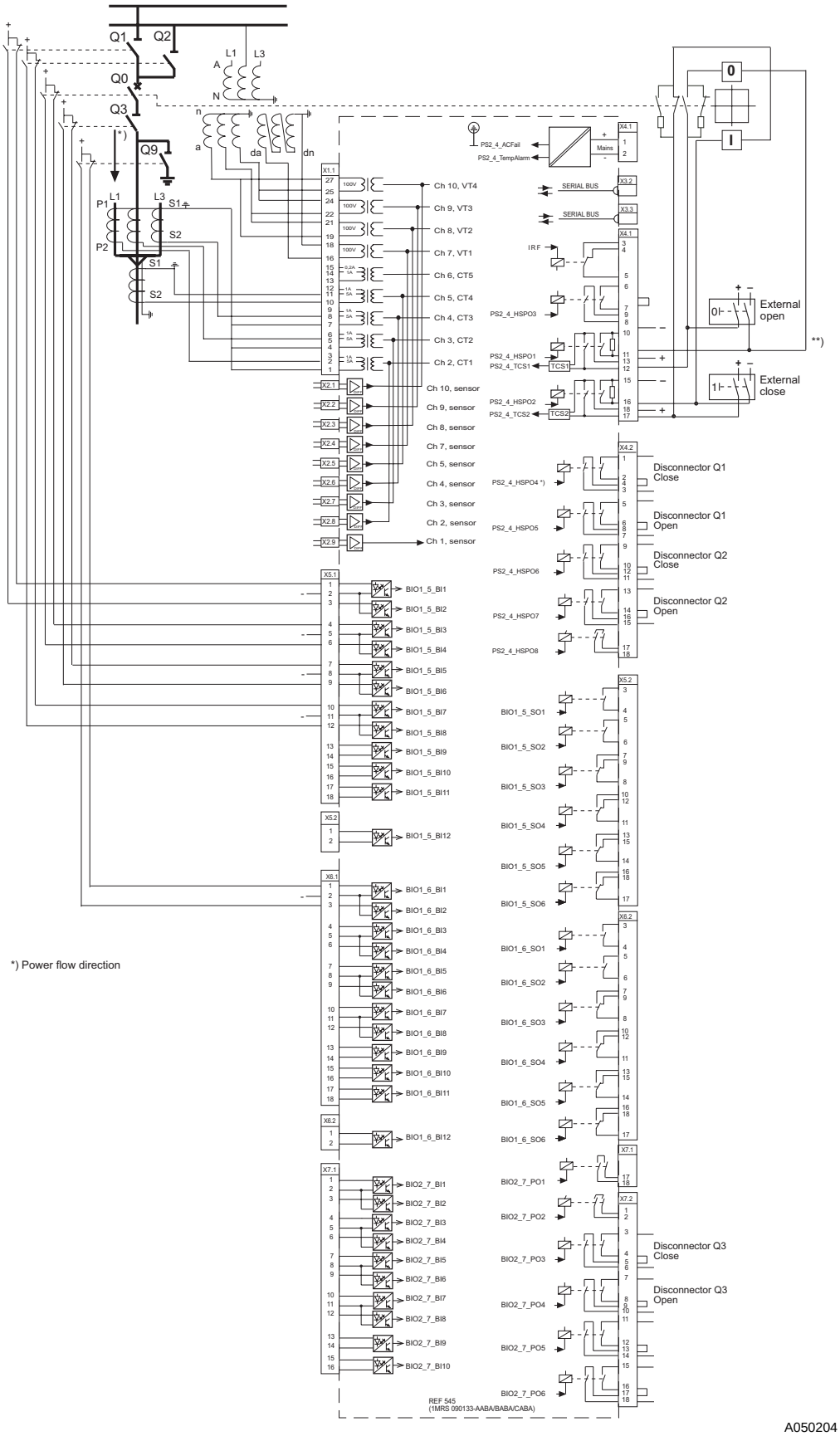

Fig. 5 Basic connection diagram of REF 545.

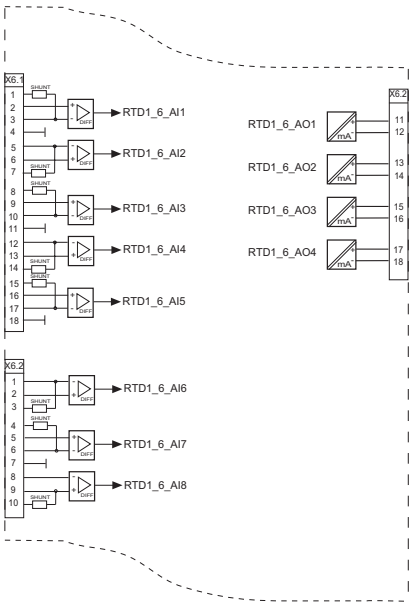

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Fig. 6 Terminal diagram of the RTD/analog module

Auxiliary voltage

For its operation, the REF 54_ terminal, including the external display module, requires a secured auxiliary voltage supply. The feeder terminal's internal power supply module forms the voltages required by the feeder terminal electronics. The power supply module is a galvanically isolated (fly-back type) dc/dc converter. A green protection LED indicator on the front panel is lit when the power supply module is in operation.

The feeder terminal is provided with a 48-hour capacitor back-up protection that enables the internal clock to keep time in case of an auxiliary power failure.

Power supply

There are two basic types of power supply modules available for the REF 54_: type PS1/_ and type PS2/_. See Tecnical data table 9.The operating range of digital inputs depends on the type of the power supply module. See Technical data table 10.

Technical data .

Table 1: General functions

Function	Description
INDRESET	Resetting of operation indicators, latched output signals, registers and waveforms i.e. the disturbance recorder
MMIWAKE	Activation of HMI backlight
SWGRP1	Switchgroup SWGRP1
SWGRP2	Switchgroup SWGRP2
SWGRP3	Switchgroup SWGRP3
...	...
SWGRP20	Switchgroup SWGRP20

Table 2: Standard functions

Function	Description
ABS	Absolute value
ACOS	Principal arc cosine
ADD	Extensible adder
AND	Extensible AND connection
ASIN	Principal arc sine
ATAN	Principal arc tangent
BITGET	Get one bit
BITSET	Set one bit
BOOL_TO_*	Type conversion from BOOL to WORD / USINT / UINT / UDINT / SINT / REAL / INT / DWORD / DINT / BYTE
BOOL2INT	Type conversion from BOOL inputs to INT output
BYTE_TO_*	Type conversion from BYTE to WORD / DWORD
COMH	Hysteresis comparator
COS	Cosine in radians
CTD	Down-counter
CTUD	Up-down counter
CTU	Up-counter
DATE_TO_UDINT	Type conversion from DATE to UDINT
DINT_TO_*	Type conversion from DINT to SINT / REAL / INT
DIV	Divider
DWORD_TO_*	Type conversion from DWORD to WORD / BYTE
EQ	Extensible comparison to equal
EXP	Natural exponential
EXPT	Exponentiation
F_TRIG	Falling edge detector
GE	Extensible comparison to greater or equal
GT	Extensible comparison to greater
INT_TO_*	Type conversion from INT to REAL / DINT
INT2BOOL	Type conversion from INT input to BOOL outputs
LE	Extensible comparison to less or equal
LIMIT	Limitation
LN	Natural logarithm
LOG	Logarithm base 10
LT	Extensible comparison to less
MAX	Extensible maximum
MIN	Extensible minimum
MOD	Modulo
MOVE	Move
MUL	Extensible multiplier
MUX	Extensible multiplexer

Table 2: Standard functions

Function	Description
NE	Comparison to greater or less
NOT	Complement
OR	Extensible OR connection
R_TRIG	Rising edge detector
REAL_TO_*	Type conversion from REAL to USINT / UINT / UDINT / SINT / INT / DINT
ROL	Rotate to left
ROR	Rotate to right
RS	Reset dominant bistable function block
RS_D	Reset dominant bistable function block with data input
SEL	Binary selection
SHL	Bit-shift to left
SHR	Bit-shift to right
SIN	Sine in radians
SINT_TO_*	Type conversion from SINT to REAL / INT / DINT
SUB	Subtractor
SQRT	Square root
SR	Set dominant bistable function block
XOR	Extensible exclusive OR connection
TAN	Tangent in radians
TIME_TO_*	Type conversion from TIME to UDINT / TOD / REAL
TOD_TO_*	Type conversion from TOD to UDINT / TIME / REAL
TOF	Off-delay timer
TON	On-delay timer
TP	Pulse
TRUNC_*	Truncation toward zero
UDINT_TO_*	Type conversion from UDINT to USINT / UINT / REAL
UINT_TO_*	Type conversion from UINT to USINT / UDINT / REAL / BOOL
USINT_TO_*	Type conversion from USINT to UINT / UDINT / REAL
WORD_TO_*	Type conversion from WORD to DWORD / BYTE

Table 3: Condition monitoring functions

Function	ANSI device no.	IEC symbol	Description
CMBWEAR1	CB wear1	CB wear1	Circuit-breaker electric wear 1
CMBWEAR2	CB wear2	CB wear2	Circuit-breaker electric wear 2
CMCU3	MCS 3I	MCS 3I	Supervision function of the energizing current input circuit
CMGAS1	CMGAS1	GAS1	Gas pressure monitoring
CMGAS3 [1)]	CMGAS3	GAS3	Three-pole gas pressure monitoring
CMSCHED	CMSCHED	SCHED	Scheduled maintenance
CMSPRC1	CMSPRC1	SPRC1	Spring charging control 1
CMTCS1	TCS1	TCS1	Trip circuit supervision 1
CMTCS2	TCS2	TCS2	Trip circuit supervision 2
CMTIME1	TIME1	TIME1	Operate time counter 1 for the operate time used (e.g. motors)
CMTIME2	TIME2	TIME2	Operate time counter 2 for the operate time used (e.g. motors)
CMTRAV1	CMTRAV1	TRAV1	Breaker travel time 1
CMVO3	MCS 3U	MCS 3U	Supervision function of the energizing voltage input circuit

1) This function is only supported in the feeder terminal revisions of Release 2.0 or later.

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Table 4: Control functions

Function	ANSI device no.	IEC symbol	Description
CO3DC1	CO3DC1	I<->O 3DC1	Three-state disconnector (1) with indication
CO3DC2	CO3DC2	I<->O 3DC2	Three-state disconnector (2) with indication
COCB1	COCB1	I<->O CB1	Circuit breaker 1 control with indication
COCB2	COCB2	I<->O CB2	Circuit breaker 2 control with indication
COCBDIR	COCBDIR	CBDIR	Direct open for CBs via HMI
CODC1	CODC1	I<->O DC1	Disconnector 1 control with indication
CODC2	CODC2	I<->O DC2	Disconnector 2 control with indication
CODC3	CODC3	I<->O DC3	Disconnector 3 control with indication
CODC4	CODC4	I<->O DC4	Disconnector 4 control with indication
CODC5	CODC5	I<->O DC5	Disconnector 5 control with indication
COIND1	COIND1	I<->O IND1	Switching device 1 indication
COIND2	COIND2	I<->O IND2	Switching device 2 indication
COIND3	COIND3	I<->O IND3	Switching device 3 indication
COIND4	COIND4	I<->O IND4	Switching device 4 indication
COIND5	COIND5	I<->O IND5	Switching device 5 indication
COIND6	COIND6	I<->O IND6	Switching device 6 indication
COIND7	COIND7	I<->O IND7	Switching device 7 indication
COIND8	COIND8	I<->O IND8	Switching device 8 indication
COLOCAT	COLOCAT	I<->O POS	Logic-controlled control position selector
COPFC [1)]	55	COPFC	Power factor controller
COSW1	COSW1	SW1	On/off switch 1
COSW2	COSW2	SW2	On/off switch 2
COSW3	COSW3	SW3	On/off switch 3
COSW4	COSW4	SW4	On/off switch 4
MMIALAR1	ALARM1	ALARM1	Alarm channel 1, LED indicator
MMIALAR2	ALARM2	ALARM2	Alarm channel 2, LED indicator
MMIALAR3	ALARM3	ALARM3	Alarm channel 3, LED indicator
MMIALAR4	ALARM4	ALARM4	Alarm channel 4, LED indicator
MMIALAR5	ALARM5	ALARM5	Alarm channel 5, LED indicator
MMIALAR6	ALARM6	ALARM6	Alarm channel 6, LED indicator
MMIALAR7	ALARM7	ALARM7	Alarm channel 7, LED indicator
MMIALAR8	ALARM8	ALARM8	Alarm channel 8, LED indicator
MMIDATA1	MMIDATA1	MMIDATA1	MIMIC data monitoring point 1
MMIDATA2	MMIDATA2	MMIDATA2	MIMIC data monitoring point 2
MMIDATA3	MMIDATA3	MMIDATA3	MIMIC data monitoring point 3
MMIDATA4	MMIDATA4	MMIDATA4	MIMIC data monitoring point 4
MMIDATA5	MMIDATA5	MMIDATA5	MIMIC data monitoring point 5

1) This function is only supported in the feeder terminal revisions of Release 2.0 or later.

Power factor controller settings

Power factor controller, COPFC	
The number of capacitor banks to be controlled	1...4
The relational step sizes and the type of the switching sequence	1:1:1:1 linear; 1:1:1:1 circul.; 1:1:2:2 circul.; 1:2:2:2 linear; 1:2:2:2 circul.; 1:2:4:4 linear; 1:2:4:4 circul.; 1:2:4:8
Size of the first capacitor bank (should be the smallest)	10.0...50000.0 kvar
Target value for daytime cos φ	0.70...1.00
Day unit	Inductive; Capacitive
Target value for night-time cos φ	0.70...1.00
Night unit	Inductive; Capacitive
Setting the reconnection inhibit time (discharge time)	0.5...6000.0 s
Sensitivity in the inductive side	60.0...200.0%
Sensitivity in the capacitive side	0.0...100.0%
Alarm limit for the maximum reactive power	0.1...100.0 Mvar
Alarm limit for the minimum reactive power	-100.0...0.0 Mvar
Overvoltage limit when the switching in is inhibited	0.80...1.60 x Un
Operation mode	Not in use; Automatic mode; Manual mode; Testing mode
Starting the automatic testing sequence	Not activated; Start
Calculation method	Normal; Integral
Control principle	Progressive; Direct
Duration demand	0.5...6000.0 s
Day&night switch	Not in use; Digital input; Internal clock; By setting
Manual command	Not activated; Remove one step; Add one step; Disconnect all
Recorded data	
Number of switching operations per day	0...65535
Number of switching operations per week	0...65535
Operation accuracies	±2.0% of set value or ±0.02 x rated value
Accuracy class of operation	2.0

Table 5: Measurement functions

Function	ANSI device no.	IEC symbol	Description
MEAI1 2)	AI1	AI1	General measurement 1 / analog input on RTD/analog module
MEAI2 2)	AI2	AI2	General measurement 2 / analog input on RTD/analog module
MEAI3 2)	AI3	AI3	General measurement 3 / analog input on RTD/analog module
MEAI4 2)	AI4	AI4	General measurement 4 / analog input on RTD/analog module
MEAI5 2)	AI5	AI5	General measurement 5 / analog input on RTD/analog module
MEAI6 2)	AI6	AI6	General measurement 6 / analog input on RTD/analog module
MEAI7 2)	AI7	AI7	General measurement 7 / analog input on RTD/analog module
MEAI8 2)	AI8	AI8	General measurement 8 / analog input on RTD/analog module
MEAO1 2)	AO1	AO1	Analog output 1 on RTD/analog module
MEAO2 2)	AO1	AO1	Analog output 2 on RTD/analog module
MEAO3 2)	AO3	AO3	Analog output 3 on RTD/analog module
MEAO4 2)	AO4	AO4	Analog output 4 on RTD/analog module
MECU1A	Io	Io	Neutral current measurement, stage A
MECU1B	Io_B	Io_B	Neutral current measurement, stage B
MECU3A	3I	3I	Three-phase current measurement, stage A
MECU3B 2)	3I_B	3I_B	Three-phase current measurement, stage B
MEDREC16 1)	DREC	DREC	Transient disturbance recorder

Table 5: Measurement functions

Function	ANSI device no.	IEC symbol	Description
MEFR1	f	f	System frequency measurement
MEPE7	PQE	PQE	Three-phase power and energy measurement
MEVO1A	Uo	Uo	Residual voltage measurement, stage A
MEVO1B [2)]	Uo_B	Uo_B	Residual voltage measurement, stage B
MEVO3A	3U	3U	Three-phase voltage measurement, stage A
MEVO3B [2)]	3U_B	3U_B	Three-phase voltage measurement, stage B

1) These functions are only supported in the feeder terminal revisions of Release 1.5 or later

2) These functions are only supported in the feeder terminal revisions of Release 2.0 or later.

Measurement function settings

General measurement/ analogue input on RTD/analogue module, MEAI1...8 (AI1...AI8)	
The general measurement function blocks can be used to measure general purpose dc or ac voltage signals with a sensor input. They also include a REAL type input which can be used to monitor any internal REAL type IEC 61131-3 based signal, e.g. input data from the RTD/analogue module.	
GE1…3 (V dc/ac) General REAL type input	-10000.00000...10000.00000 -10000.00000...10000.00000

Neutral current measurement, MECU1A and MECU1B (Io, Io_B)	
Io (A) Io (%)	0.0…20000.0 A 0.0…80.0% In

Three-phase current measurement, MECU3A and MECU3B (3I, 3I_B)	
IL1	0.0…20000.0 A
IL2	0.0…20000.0 A
IL3	0.0…20000.0 A
IL1	0.0…1000.0% In
IL2	0.0…1000.0% In
IL3	0.0…1000.0% In
IL1 demand	0.0…20000.0 A
IL2 demand	0.0…20000.0 A
IL3 demand	0.0…20000.0 A
IL1 demand	0.0…1000.0% In
IL2 demand	0.0…1000.0% In
IL3 demand	0.0…1000.0% In

Transient disturbance recorder for 16 analogue channels, MEDREC16 (DREC)	
The transient disturbance recorder MEDREC16 is used for recording the current and voltage waveforms, as well as the status data of internal IEC 61131-3 based logic signals and digital inputs connected to the feeder terminals. The maximum number of analogue inputs and logic signals is 16. One fundamental cycle contains 40 samples.	
Operation mode	Saturation Overwrite Extension
Pre-trg time	0…100%
Over limit ILx	0.00…40.00 x In
Over limit Io	0.00…40.00 x In
Over limit Iob	0.00…40.00 x In
Over limit Uo	0.00…2.00 x Un
Over limit Ux	0.00…2.00 x Un
Over limit Uxy	0.00…2.00 x Un
Over limit U12b	0.00…2.00 x Un
Over limit ILxb	0.00…40.00 x In
Under limit Ux	0.00…2.00 x Un
Under limit Uxy	0.00…2.00 x Un
AI filter time	0.000…60.000 s

Analogue output on RTD/analogue module, MEAO1...4 (AO1...AO4)	
The analogue output function blocks handle the scaling of any internal REAL type IEC 61131-3 based signal to fit a selectable 0…20 mA or 4…20 mA range for use with the outputs on the RTD/analogue module.	
General REAL type input	-10000.00000...10000.00000

The recording can be triggered by any (or several) of the alternatives listed below:

- triggering on the rising or falling edge of any (or several) of the digital inputs
- triggering on overcurrent, overvoltage or undervoltage
- manual triggering via the menu or with the push-button F on the front panel (if configured)
- triggering via serial communication
- periodic triggering

The recording length depends on the number of recordings and inputs used. For example, the following combination of recording length, number of recordings and number of inputs is available at 50 Hz:

# recordings \ # inputs	1	3	10
1	1163 cyc. 23.2 s	412 cyc. 8.2 s	126 cyc. 2.5 s
5	232 cyc. 4.6 s	82 cyc. 1.6 s	25 cyc. 0.5 s
10	115 cyc. 2.3 s	41 cyc. 0.8 s	12 cyc. 0.24 s

System frequency measurement, MEFR1 (f)	
Frequency	10.00…75.00 Hz
Average Freq.	10.00…75.00 Hz
Voltage U	0.0…2.0 x Un

Three-phase power and energy measurement, MEPE7 (PQE)	
P3 (kW)	-999999…999999 kW
Q3 (kvar)	-999999…999999 kvar
Power factor DPF	-1.00…1.00
Power factor PF	-1.00…1.00
P3 demand (kW)	-999999…999999 kW
Q3 demand (kvar)	-999999…999999 kvar
Energy kWh	0…999999999 kWh
Reverse kWh	0…999999999 kWh
Energy kvarh	0…999999999 kvarh
Reverse kvarh	0…999999999 kvarh

Residual voltage measurement, MEVO1A and MEVO1B (Uo, Uo_B)	
Uo	0…150000 V
Uo	0.0…120.0% Un

Three-phase voltage measurement, MEVO3A and MEVO3B (3U, 3U_B)	
UL1_U12	0.00…999.99 kV
UL2_U23	0.00…999.99 kV
UL3_U31	0.00…999.99 kV
UL1_U12	0.00…2.00 x Un
UL2_U23	0.00…2.00 x Un
UL3_U31	0.00…2.00 x Un
UL1_U12 average	0.00…999.99 kV
UL2_U23 average	0.00…999.99 kV
UL3_U31 average	0.00…999.99 kV
UL1_U12 average	0.00…2.00 x Un
UL2_U23 average	0.00…2.00 x Un
UL3_U31 average	0.00…2.00 x Un

Table 6: Protection functions

Function	ANSI device no.	IEC symbol	Description
AR5Func	79	O-->I	Auto-reclose function (5 shots)
CUB1Cap [2]	51NC-1	dI>C	Current unbalance protection for shunt capacitor banks
CUB3Cap [3]	51NC-2	3dI>C	Three-phase current unbalance protection for H-bridge connected shunt capacitor
CUB3Low	46	Iub>	Phase discontinuity protection
DEF2Low	67N-1	Io>-->	Directional earth-fault protection, low-set stage
DEF2High	67N-2	Io>>-->	Directional earth-fault protection, high-set stage
DEF2Inst	67N-3	Io>>>-->	Directional earth-fault protection, instantaneous stage
DOC6Low [1]	67-1	3I>-->	Three-phase directional overcurrent protection, low-set stage
DOC6High [1]	67-2	3I>>-->	Three-phase directional overcurrent protection, high-set stage
DOC6Inst [1]	67-3	3I>>>-->	Three-phase directional overcurrent protection, instantaneous stage
FLOC [4]	21FL	FLOC	Fault locator
Freq1St1 [1]	81-1	f1	Underfrequency or overfrequency protection, stage 1
Freq1St2 [1]	81-2	f2	Underfrequency or overfrequency protection, stage 2
Freq1St3 [1]	81-3	f3	Underfrequency or overfrequency protection, stage 3
Freq1St4 [1]	81-4	f4	Underfrequency or overfrequency protection, stage 4
Freq1St5 [1]	81-5	f5	Underfrequency or overfrequency protection, stage 5
FuseFail [3]	60	FUSEF	Fuse failure supervision
Inrush3	68	3I2f>	Three-phase transformer inrush and motor start-up current detector
MotStart [2]	48	Is2t n<	Three-phase start-up supervision for motors
NEF1Low	51N-1	Io>	Non-directional earth-fault protection, low-set stage
NEF1High	51N-2	Io>>	Non-directional earth-fault protection, high-set stage
NEF1Inst	51N-3	Io>>>	Non-directional earth-fault protection, instantaneous stage
NOC3Low	51-1	3I>	Three-phase non-directional overcurrent protection, low-set stage
NOC3High	51-2	3I>>	Three-phase non-directional overcurrent protection, high-set stage
NOC3Inst	51-3	3I>>>	Three-phase non-directional overcurrent protection, instantaneous stage
OL3Cap [2]	51C	3I>3I<	Three-phase overload protection for shunt capacitor banks
OV3Low	59-1	3U>	Three-phase overvoltage protection, low-set stage
OV3High	59-2	3U>>	Three-phase overvoltage protection, high-set stage
PSV3St1 [2]	47-1	U1U2<>_1	Phase-sequence voltage protection, stage 1
PSV3St2 [2]	47-2	U1U2<>_2	Phase-sequence voltage protection, stage 2
ROV1Low	59N-1	Uo>	Residual overvoltage protection, low-set stage
ROV1High	59N-2	Uo>>	Residual overvoltage protection, high-set stage
ROV1Inst	59N-3	Uo>>>	Residual overvoltage protection, instantaneous stage
SCVCSt1 [1]	25-1	SYNC1	Synchro-check / voltage-check function, stage 1
SCVCSt2 [1]	25-2	SYNC2	Synchro-check / voltage-check function, stage 2
TOL3Cab [1]	49F	3Ith>	Three-phase thermal overload protection for cables
TOL3Dev [2]	49M/G/T	3Ithdev>	Three-phase thermal overload protection for devices
UV3Low	27-1	3U<	Three-phase undervoltage protection, low-set stage
UV3High	27-2	3U<<	Three-phase undervoltage protection, high-set stage

1) These functions are only supported in the feeder terminal revisions of Release 1.5 or later.
2) These functions are only supported in the feeder terminal revisions of Release 2.0 or later.
3) These functions are only supported in the feeder terminal revisions of Release 2.5 or later.
4) This function is only supported in the feeder terminal revisions of Release 3.5 or later.

Settings of protection functions

Three-phase non-directional overcurrent protection, low-set stage, NOC3Low, 3I> (51-1)	
Start current	0.10…5.00 x In
Operate time at DT mode	0.05…300.00 s
Time multiplier at IDMT mode	0.05…1.00
Operation mode	Not in use Definite time Extremely inverse Very inverse Normal inverse Long time inverse RI-type inverse RD-type inverse IEEE Extremely inverse IEEE Very inverse IEEE Short time inverse IEEE Short time extremely inverse IEEE Long time extremely inverse IEEE Long time very inverse IEEE Long time inverse
Measuring mode	Peak-to-peak Fundamental frequency
Drop-off time of the operate time counter	0...1000 ms
	Note! The values below apply when f/fn = 0.95...1.05
Operation accuracy	±2.5% of set value or ±0.01 x In
Start time	Injected currents > 2.0 x start current: internal time < 32 ms total time < 40 ms
Reset time	40...1000 ms (depends on the minimum pulse width set for the trip output)
Reset ratio, typically	0.95
Retardation time	< 45 ms
Operate time accuracy at DT mode	±2% of set value or ±20 ms
Accuracy class index E at IDMT mode	Class index E = 5.0 or ±20 ms

Three-phase non-directional overcurrent protection, high-set stage, NOC3High, 3I>> (51-2) and instantaneous stage, NOC3Inst, 3I>>> (51-3)	
Start current	0.10…40.00 x In
Operate time	0.05…300.00 s
Operation mode	Not in use Definite time Instantaneous
Measuring mode	Peak-to-peak Fundamental frequency
Drop-off time of the operate time counter	0...1000 ms
	Note! The values below apply when f/fn = 0.95...1.05
Operation accuracy	0.1...10 x In: ±2.5% of set value or ±0.01 x In 10...40 x In: ±5.0% of set value
Start time	Injected currents > 2.0 x start current: internal time < 32 ms total time < 40 ms
Reset time	40...1000 ms (depends on the minimum pulse width set for the trip output)
Reset ratio, typically	0.95
Retardation time	< 45 ms
Operate time accuracy at DT mode	±2% of set value or ±20 ms

Three-phase directional O/C function, low-set stage, DOC6Low, 3I>→ (67-1)	
Operation mode	Not in use; Definite time Extremely inv.; Very inverse Normal inverse Long-time inv.; RI-type inverse RD-type inverse
Start current	0.05…40.00 x In
Operate time	0.05…300.00 s
Time multiplier	0.05…1.00
Basic angle φ_b	0…90°
Operation direction	Forward Reverse
Earth-fault protection	Disabled Enabled
Measuring mode	Phase-to-phase voltages, peak-to-peak measurement Phase-to-phase voltages, fundamental freq. measurement Phase-to-earth voltages, peak-to-peak measurement Phase-to-earth voltages, fundamental freq. measurement
Drop-off time of the operate time counter	0...1000 ms
	Note! The values below apply when f/fn = 0.95...1.05
Operation accuracy	0.1...10 x In: ±2.5% of set value or ±0.01 x In 10...40 x In: ±5.0% of set value ±2.5% of measured voltage or ±0.01 x Un ±2°
Start time	Injected currents > 2.0 x start current: internal time < 42 ms total time < 50 ms
Reset time	40...1000 ms (depends on the minimum pulse width set for the trip output)
Reset ratio, typically	0.95
Retardation time	< 45 ms
Operate time accuracy at DT mode	±2% of set value or ±20 ms
Accuracy class index E at IDMT mode	Class index E = 5.0 or ±20 ms

Three-phase directional O/C function, high-set stage, DOC6High, I>>→ (67-2), and instantaneous stage, DOC6Inst, I>>>→ (67-3)	
Operation mode	Not in use Definite time Instantaneous
Start current	0.05…40.00 x In
Operate time	0.05…300.00 s
Basic angle φ_b	0…90°
Operation direction	Forward Reverse
Earth-fault protection	Disabled Enabled
Non-directional operation (when the direction cannot be determined)	Disabled Enabled
Measuring mode	Phase-to-phase voltages, peak-to-peak measurement Phase-to-phase voltages, fundamental freq. measurement Phase-to-earth voltages, peak-to-peak measurement Phase-to-earth voltages, fundamental freq. measurement
Drop-off time of the operate time counter	0...1000 ms

	Note! The values below apply when f/fn = 0.95...1.05
Operation accuracy	0.1...10 x In: ±2.5% of set value or ±0.01 x In 10...40 x In: ±5.0% of set value ±2.5% of measured voltage or ±0.01 x Un ±2°
Start time	Injected currents > 2.0 x start current: internal time < 42 ms total time < 50 ms
Reset time	40...1000 ms (depends on the minimum pulse width set for the trip output)
Reset ratio, typically	0.95
Retardation time	< 45 ms
Operate time accuracy at DT mode	±2% of set value or ±20 ms

Non-directional earth-fault protection, low-set stage, NEF1Low, Io> (51N-1)	
Start current	1.0…500.0% of In
Operate time at DT mode	0.05…300.00 s
Time multiplier at IDMT mode	0.05…1.00
Operation mode	Not in use Definite time Extremely inverse Very inverse Normal inverse Long time inverse RI-type inverse RD-type inverse IEEE Extremely inverse IEEE Very inverse IEEE Short time inverse IEEE Short time extremely inverse IEEE Long time extremely inverse IEEE Long time very inverse IEEE Long time inverse
Measuring mode	Peak-to-peak Fundamental frequency
Drop-off time of the operate time counter	0...1000 ms
	Note! The values below apply when f/fn = 0.95...1.05
Operation accuracy	±2.5% of set value + 0.0005 x In
Start time	Injected currents > 2.0 x start current: internal time < 32 ms total time < 40 ms
Reset time	40...1000 ms (depends on the minimum pulse width set for the trip output)
Reset ratio, typically	0.95
Retardation time	< 45 ms
Operate time accuracy at DT mode	±2% of set value or ±20 ms
Accuracy class index E at IDMT mode	Class index E = 5.0 or ±20 ms

Non-directional earth-fault protection, high-set stage, NEF1High, Io>> (51N-2), and instantaneous stage, NEF1Inst, Io>>> (51N-3)	
Start current	0.10…12.00 x In
Operate time	0.05…300.00 s
Operation mode	Not in use Definite time Instantaneous
Measuring mode	Peak-to-peak Fundamental frequency
Drop-off time of the operate time counter	0...1000 ms

	Note! The values below apply when f/fn = 0.95...1.05
Operation accuracy	±2.5% of set value or + 0.01 x In
Start time	Injected currents > 2.0 x start current: internal time < 32 ms total time < 40 ms
Reset time	40...1000 ms (depends on the minimum pulse width set for the trip output)
Reset ratio, typically	0.95
Retardation time	< 45 ms
Operate time accuracy at DT mode	±2% of set value or ±20 ms

Directional earth-fault protection, low-set stage, DEF2Low, Io>→ (67N-1)	
Start current	1.0…500.0% of In
Start voltage	2.0…100.0% of Un
Operate time at DT mode	0.1…300.0 s
Time multiplier at IDMT mode	0.05…1.00
Operation mode	Not in use Definite time Extremely inverse Very inverse Normal inverse Long time inverse
Operation criteria	Basic angle & Uo Basic angle IoSin/Cos & Uo IoSin/Cos Non-directional Io Non-directional Uo
Operation direction	Forward Reverse
Basic angle φ_b	-90°... 60°
Operation characteristic	IoSin(φ) IoCos(φ)
Intermittent E/F	Not active Active
Measuring mode	Peak-to-peak Fundamental frequency
Drop-off time of the operate time counter	0...1000 ms
	Note! The values below apply when f/fn = 0.95...1.05
Operation accuracy	±2.5% of set value + 0.0005 x In ±2.5% of set value or + 0.01 x Un Phase angle ±2°
Start time	Injected neutral current > 2.0 x start current and residual voltage > 2.0 x start voltage: internal time < 72 ms total time < 80 ms
Reset time	40...1000 ms (depends on the minimum pulse width set for the trip output)
Reset ratio, typically	0.95
Retardation time	< 50 ms
Operate time accuracy at DT mode	±2% of set value or ±20 ms
Accuracy class index E at IDMT mode	Class index E = 5.0 or ±20 ms

Directional earth-fault protection, high-set stage, DEF2High, Io>>→ (67N-2), and instantaneous stage, DEF2Inst, Io>>>→ (67N-3)	
Start current	1.0…500.0% of In
Start voltage	2.0…100.0% of Un
Operate time	0.1…300.0 s
Operation mode	Not in use Definite time Instantaneous
Operation criteria	Basic angle & Uo Basic angle IoSin/Cos & Uo IoSin/Cos Non-directional Io Non-directional Uo
Operation direction	Forward Reverse
Basic angle φ_b	-90°... 60°
Operation characteristic	IoSin(φ) IoCos(φ)
Intermittent E/F	Not active Active
Measuring mode	Peak-to-peak Fundamental frequency
Drop-off time of the operate time counter	0...1000 ms
	Note! The values below apply when f/fn = 0.95...1.05
Operation accuracy	±2.5% of set value + 0.0005 x In ±2.5% of set value or + 0.01 x Un Phase angle ±2°
Start time	Injected neutral current > 2.0 x start current and residual voltage > 2.0 x start voltage: internal time < 72 ms total time < 80 ms
Reset time	40...1000 ms (depends on the minimum pulse width set for the trip output)
Reset ratio, typically	0.95
Retardation time	< 50 ms
Operate time accuracy at DT mode	±2% of set value or ±20 ms

Residual overvoltage protection, low-set stage, ROV1Low, Uo> (59N-1)	
Start voltage	2.0…100.0% of Un
Operate time	0.05…300.00 s
Operation mode	Not in use Definite time
Measuring mode	Peak-to-peak Fundamental frequency
	Note! The values below apply when f/fn = 0.95...1.05
Operation accuracy	±2.5% of set value or ±0.01 x Un
Start time	Injected voltages >2 x start voltage: internal time < 32 ms total time < 40 ms
Reset time	40...1000 ms (depends on the minimum pulse width set for the trip output)
Reset ratio, typically	0.95
Retardation time	Total time for blocking: < 25 ms Total time when voltage drops below start value: < 50 ms
Operate time accuracy at DT mode	±2% of set value or ±20 ms

Residual overvoltage protection, high-set stage, ROV1High, Uo>> (59N-2), and instantaneous stage, ROV1Inst, Uo>>> (59N-3)	
Start voltage	2.0…100.0% of Un
Operate time	0.05…300.00 s
Operation mode	Not in use Definite time
Measuring mode	Peak-to-peak Fundamental frequency
	Note! The values below apply when f/fn = 0.95...1.05
Operation accuracy	±2.5% of set value or ±0.01 x Un
Start time	Injected voltages >2 x start voltage: internal time < 32 ms total time < 40 ms
Reset time	40...1000 ms (depends on the minimum pulse width set for the trip output)
Reset ratio, typically	0.95
Retardation time	Total time for blocking: < 25 ms Total time when voltage drops below start value: < 50 ms
Operate time accuracy at DT mode	±2% of set value or ±20 ms

Three-phase thermal overload protection for cables, TOL3Cab, 3Ith> (49F)	
Time constant for the cable	1…999 min
Maximum load current for the cable	1.0…5000.0 A
Maximum temperature of conductor	40.0…150.0°C
Reference temperature	-50.0…100.0°C
Trip temperature	80.0…120.0%
Prior alarm temperature	40.0…100.0%
Reclosure temperature	40.0…100.0%
Ambient temperature	-50.0…100.0°C
Operation mode (principle of ambient temperature compensation)	Not in use No sensors; the set ambient temperature 1 sensor used 2 sensors used
	Note! The values below apply when f/fn = 0.95...1.05
Operation accuracy	±1.0%, I = 0.1...10.0 x In
Reset ratio	Trip: (Calculated temp. rise - 0.1) / Trip temperature Start: (Calculated temp. rise - 0.1) / Prior alarm temperature

Three-phase thermal overload protection for motors, generators and transformers, TOL3Dev, 3Ithdev> (49M/G/T)	
BASIC SETTINGS	
Starting current of the motor	0.10...10.00 x In
Max. starting time permitted for the motor	0.1...120.0 s
Number of starts allowed from cold state	1...3
Type of device to be protected	Motor; through-ventilated, rated power < 1500 kW Motor; through-ventilated, rated power > 1500 kW Motor; surface cooling, rated power < 500 kW Motor; surface cooling, rated power > 500 kW Generator; hydro or small air-cooled turbine generators Generator; large turbine generators Transformer
Trip temperature	80.0…120.0%
Prior alarm temperature	40.0…100.0%
Restart inhibit (temperature limit for successful restarting)	40.0…100.0%
Ambient temperature	-50.0…100.0°C
Cooling time-constant	1.0...10.0 x time constant
Heating time-constant for generator or transformer	1...999 min
ADVANCED SETTINGS	
Short time-constant for stator	0.0...999.0 min
Long time-constant for stator	0.0...999.0 min
Weighting factor of the short time-constant for stator	0.00...1.00
Temperature rise of stator at rated current	0.0...350.0 °C
Maximum temperature of stator	0.0...350.0 °C
Short time-constant for rotor	0.0...999.0 min
Long time-constant for rotor	0.0...999.0 min
Weighting factor of the short time-constant for rotor	0.00...1.00
Temperature rise of rotor at rated current	0.0...350.0 °C
Maximum temperature of rotor	0.0...350.0 °C
Operation mode (principle of ambient temperature compensation)	Not in use No sensors; the set ambient temperature 1 sensor used 2 sensors used
Waiting time for a successful restart (Read-only parameter)	0...99999 s
Predicted time to the trip (Read-only parameter)	0...99999 s
Operation accuracy Reset ratio	Note! The values below apply when f/fn = 0.95...1.05 ±1.0%, I = 0.1...10.0 x In Trip: (Calculated temp. rise - 0.1) / Trip temperature Start: (Calculated temp. rise - 0.1) / Prior alarm temperature Restart: (Calculated temp. rise - 0.1) / Restart inhibit temperature limit

Three-phase overvoltage protection, low-set stage, OV3Low, 3U> (59-1)	
Start voltage	0.10…1.60 x Un
Operate time	0.05…300.00 s
Time multiplier	0.05…1.00
Operation mode	Not in use Definite time A curve B curve
Measuring mode	Phase-to-phase voltages; peak-to-peak measurement Phase-to-phase voltages; fundamental freq. measurement Phase-to-earth voltages; fundamental freq. measurement
Operation hysteresis	1.0...5.0%
	Note! The values below apply when f/fn = 0.95...1.05
Operation accuracy	±35 ms
Start time	Injected voltages = 1.1 x start voltage: internal time < 42 ms total time < 50 ms
Reset time	40...1000 ms (depends on the minimum pulse width set for the trip output)
Reset ratio	0.96 (range0.95...0.99)
Retardation time	< 50 ms
Operate time accuracy at DT mode	±2% of set value or ±20 ms
Accuracy class index E at IDMT mode, typically	±20 ms

Three-phase overvoltage protection, high-set stage, OV3High, 3U>> (59-2)	
Start voltage	0.10…1.60 x Un
Operate time	0.05…300.00 s
Operation mode	Not in use Definite time
Measuring mode	Phase-to-phase voltages; peak-to-peak measurement Phase-to-phase voltages; fundamental freq. measurement Phase-to-earth voltages; fundamental freq. measurement
Operation hysteresis	1.0...5.0%
	Note! The values below apply when f/fn = 0.95...1.05
Operation accuracy	±2.5% of set value
Start time	Injected voltages = 1.1 x start voltage: internal time < 42 ms total time < 50 ms
Reset time	40...1000 ms (depends on the minimum pulse width set for the trip output)
Reset ratio	0.96 (range 0.95...0.99)
Retardation time	< 50 ms
Operate time accuracy at DT mode	±2% of set value or ±20 ms

Three-phase undervoltage protection, low-set stage, UV3Low, 3U< (27-1)	
Start voltage	0.10…1.20 x Un
Operate time	0.1…300.0 s
Time multiplier	0.1…1.0
Operation mode	Not in use Definite time C curve
Measuring mode	Phase-to-phase voltages; peak-to-peak measurement Phase-to-phase voltages; fundamental freq. measurement Phase-to-earth voltages; fundamental freq. measurement
Operation hysteresis	1.0...5.0%

	Note! The values below apply when f/fn = 0.95...1.05
Operation accuracy	±35 ms
Start time	Injected voltages < 0.5 x start voltage: internal time < 32 ms total time < 40 ms
Reset time	40...1000 ms (depends on the minimum pulse width set for the trip output)
Reset ratio	1.04 (range 1.01...1.05)
Retardation time	< 60 ms
Operate time accuracy at DT mode	±2.5% of set value
Accuracy class index E at IDMT mode, typically	±35 ms

Three-phase undervoltage protection, high-set stage, UV3High, 3U<< (27-2)	
Start voltage	0.10…1.20 x Un
Operate time	0.1…300.0 s
Operation mode	Not in use Definite time
Measuring mode	Phase-to-phase voltages; peak-to-peak measurement Phase-to-phase voltages; fundamental freq. measurement Phase-to-earth voltages; fundamental freq. measurement
Operation hysteresis	1.0...5.0%
	Note! The values below apply when f/fn = 0.95...1.05
Operation accuracy	±2.5% of set value
Start time	Injected voltages < 0.5 x start voltage: internal time < 32 ms total time < 40 ms
Reset time	40...1000 ms (depends on the minimum pulse width set for the trip output)
Reset ratio	1.04 (range 1.01...1.05)
Retardation time	< 60 ms
Operate time accuracy at DT mode	±2.5% of set value

Phase-sequence voltage protection, PSV3St1 and PSV3St2, U_1 U_2< >_1,U_1 U_2< >_2 (47-1, 47-2)	
Start value U2>	0.01…1.00 x Un
Start value U1<	0.01…1.20 x Un
Start value U1>	0.80…1.60 x Un
Operate time U2>	0.04…60.00 s
Operate time U1<	0.04…60.00 s
Operate time U1>	0.04…60.00 s
Operation mode	Not in use; U1< & U2> & U1>; U1< & U2>; U2> & U1>; U1< & U1>; U2>; U1<; U1>
Dir. selection	Forward; Reverse; Input ROT_DIR

	Note! The values below apply when f/fn = 0.95...1.05
Operation accuracy	± 2.5% of set value or ± 0.01 x Un
Trip time	U2> operation: Injected negative-seq. voltage = 1.1 x start value: internal time < 42 ms total time < 50 ms U1< operation: Injected positive-seq. voltage = 0.50 x start value: internal time < 32 ms total time < 40 ms U1> operation: Injected positive-seq. voltage = 1.1 x start value: internal time < 42 ms total time < 50 ms
Reset time	70...1030 ms (depends on the minimum pulse width set for the TRIP output)
Reset ratio, typically	U2> operation: 0.96 U1< operation: 1.04 U1> operation: 0.99
Retardation time	< 45 ms (for all operations)
Operate time accuracy	± 2% of set value or ± 20 ms

Underfrequency or overfrequency protection, 5 stages, Freq1St1… Freq1St5, f1 ... f5 (81-1 ... 81-5)	
Operation mode	Not in use f</f> 1 timer f</f> 2 timers f</f> OR df/dt> f</f> AND df/dt> f</f> OR df/dt< f</f> AND df/dt<
Undervoltage limit for blocking	0.30…0.90 x Un
Start value for under-/overfrequency prot.	25.00…75.00 Hz
Operate time for under-/overfrequency prot.	0.10…300.00 s
Start value for df/dt protection	0.2…10.0 Hz/s
Operate time for df/dt protection	0.12…300.00 s
Operation accuracy	Under-/overfrequency (f</f>): ±10 mHz Frequency rate of change (df/dt); real df/dt < ±5 Hz/s: ±100 mHz/s real df/dt < ±15 Hz/s: ±2.0% of real df/dt Undervoltage blocking: ±1.0% of set value
Start time	Total start times at fn = 50 Hz: Frequency measurement < 100 ms Df/dt measurement < 120 ms
Reset time	140...1000 ms (depends on the minimum pulse width set for the trip output)
Operate time accuracy	±2% of set value or ±30 ms

Start-up supervision for motors, MotStart, I_s^2t n< (48)	
Start current (for motor)	1.0...10.0 x In
Start time (for motor)	0.3...250.0 s
Time-based restart inhibit limit	1.0...500.0 s
Countdown rate of the time counter	2.0...250.0 s/h
Stalling time permitted for rotor	2.0...120.0 s
Operation mode	Not in use I^2t I^2t & Stall
Start counter (Read-only parameter)	0...99999
Time to restart enable (Read-only parameter)	0...99999 min
Stall input (signal for motor stalling indication; read-only parameter)	Not active Active
Operation accuracy	f/fn = 0.95...1.05: ±2.5% of set value or ±0.01 x In
Start time	f/fn = 0.95...1.50: internal time < 22 ms total time < 30 ms f/fn = 0.50...0.95: internal time < 32 ms total time < 40 ms
Reset ratio, typically	0.95
Retardation time	< 50 ms

Three-phase overload protection for shunt capacitor banks, OL3Cap, 3I>3I< (51C)			
Operate times of the overload stage Ib>			
I/Ib>	t [s]	Standard durations [s]	Standard
1.15	1799	1800	IEC 60871-1
1.20	299	300	IEC 60871-1
1.30	58	60	ANSI/IEEE 37.99, IEC 60871-1
1.40	13.5	15	ANSI/IEEE 37.99
1.70	0.9	1	ANSI/IEEE 37.99
2.00	0.29	0.3	ANSI/IEEE 37.99
2.20	0.1	0.12	ANSI/IEEE 37.99
Note! The minimum operate time is 100 ms			
Start current of trip stage		0.30...1.50 x In	
Time multiplier k for trip stage		0.05...2.0	
Start current of alarm stage		0.80...1.20 x Ib	
Operate time of alarm stage		0.5...6000.0 s	
Start current of undercurrent stage		0.10...0.70 x Ib	
Operate time of undercurrent stage		0.1...120 s	
Setting of reconnection inhibit time t_{rec}		0.5...6000 s	
Operation accuracies		Note! The values below apply when f/f_n=0.95...1.05 ±2.5% of set value or ±0.01 x I_n	
Start time		Injected currents = 2.0 x start current internal time < 32 ms total time < 40 ms	
Reset time		40...1000 ms (depends on the minimum pulse width set for the TRIP output)	
Reset ratio		Overload stages: Typ. 0.95 Undercurrent stage: Typ. 1.05	
Retardation time		Total retardation time when the current exceeds the start value: < 50 ms	
Operate time accuracy at definite time mode (alarm stage I_a>, undercurrent stage I<)		±2% of set value or ±20 ms	
Operate time accuracy at inverse time mode (trip stage I_b>)		Depends on the frequency of the current measured: ±10% of theoretical value or ±40 ms	

Current unbalance protection for shunt capacitor banks, CUB1Cap, dI>C (51NC-1)	
Operation mode	Not in use; Definite time; Extremely inv.; Very inv.; Normal inv.; Long-time inv.; RI-type inv.; RD-type inv.
Alarm mode	Normal mode; Element counter
Start current of the tripping stage	1.0...100.0%dIn
Operate time of the tripping stage in DT mode	1.0...300 s
Time multiplier k for the tripping stage in IDMT mode	0.05...2.0
Start current of the alarm stage	1.0...100.0%dIn
Operate time of the alarm stage	1.0...300 s
Disallowed number of faulty elements	1...100
Level of natural unbalance compensation	0.0...20.0%dIn
Recording of the natural unbalance phasor	Do not activate; Activate
Location of capacitor fuses	External; Internal
Faulty elements counter	
Amount of faulty elements in branch 1 of phase IL1	0...100
Amount of faulty elements in branch 2 of phase IL1	0...100
Amount of faulty elements in branch 1 of phase IL2	0...100
Amount of faulty elements in branch 2 of phase IL2	0...100
Amount of faulty elements in branch 1 of phase IL3	0...100
Amount of faulty elements in branch 2 of phase IL3	0...100
Operation accuracies	Note! The values below apply when f/f_n=0.95...1.05 ±2.5% of set value + 0.001 x dI_n Phase angle measurement: ±2°
Start time	Injected currents = 2.0 x start current internal time <32 ms total time <40 ms
Reset time	40...1000 ms (depends on the minimum pulse width set for the TRIP output)
Reset ratio	Typ. 0.95
Retardation time	< 45 ms
Operate time accuracy at definite-time mode	±2% of set value or ±20 ms
Operate time accuracy at inverse-time mode	Class index E = 5.0 or ±20 ms

Three-phase current unbalance protection for H-bridge connected shunt capacitor banks, CUB3Cap, 3dI>C (51NC-2)	
Operation mode	Not in use; Definite time; Extremely inv.; Very inv.; Normal inv.; Long-time inv.; RI-type inv.; RD-type inv.
Start current of the tripping stage	1.0...100.0% dIn
Operate time of the tripping stage in DT mode	1.0...300 s
Time multiplier k for the tripping stage in IDMT mode	0.05...2.0
Start current of the alarm stage	1.0...100.0% dIn
Operate time of the alarm stage	1.0...300.0 s
Comp natural dI1	0.0...20.0% dIn
Comp natural dI2	0.0...20.0% dIn
Comp natural dI3	0.0...20.0% dIn
Rec natural dI	Do not activate; Rec all phasors; Rec phasor dI1, Rec phasor dI2, Rec phasor dL3
Operation accuracies	Note! The values below apply when f/f_n=0.95...1.05 ±2.5% of set value + 0.0005 x dI_n Phase angle measurement: ±2°
Start time	Injected currents = 2.0 x start current internal time <32 ms total time <40 ms
Reset time	40...1000 ms (depends on the minimum pulse width set for the TRIP output)
Reset ratio, typically	0.95
Retardation time	< 45 ms
Operate time accuracy at definite-time mode	±2.5% of set value or 0.1% dIn
Operate time accuracy at inverse-time mode	±2.5% of set value or 0.1% dIn

Auto-reclosure function, AR5Func, O → I (79)	
Number of reclosures	0…5
Initiation mode	Trip Start
AR1, AR2, AR3, AR4 starting line operation mode	No operation AR shot initiated Initiation of AR shot blocked
AR1 AR2, AR3, AR4 start delay	0…10.00 s
Dead time	0.20…300.00 s
Synchro-check	Not in use; ARSYNC in use
Discriminating time td	0…30.00 s
Operation accuracy	±1% of setting value or ±30 ms

Synchro-check/voltage check function stage 1 and stage 2, SCVCSt1 & SCVCSt2, SYNC1, SYNC2 (25-1, 25-2)	
Upper threshold voltage Umax	0.50…1.00 x Un
Lower threshold voltage Umin	0.10…0.80 x Un
Voltage difference ΔU	0.02…0.60 x Un
Phase angle difference Δphase	5…90°
Frequency difference Δf	0.02…5.00 Hz
Operation accuracy	Note! The values below apply when f/fn = 0.95...1.05 ±2.5% of set value or ±0.01 x Un ±10 mHz ±2°
Reset time	< 50 ms
Reset ratio	0.975 x Un
Operate time accuracy	±2% of set value or ±20 ms

Phase discontinuity protection, CUB3Low, Iub> (46)	
Start unbalance	10.0…95.0%
Operate time	1.0…300.0 s
Operation mode	Not in use Definite time
	Note! The values below apply when f/fn = 0.95...1.05
Operation accuracy	±2.5% of set value or ±1% unit
Start time	internal time < 95 ms total time < 100 ms
Reset time	40...1000 ms (depends on the minimum pulse width set for the trip output)
Reset ratio, typically	0.95
Retardation time	Total time for blocking: < 25 ms Total time when current drops below start value: < 50 ms
Operate time accuracy at DT mode	±2% of set value or ±50 ms

Fuse failure supervision, FuseFail, FUSEF (60)	
Ratio U2/U1>	10...50%
Ratio I2/I1<	10...50%
Operation accuracy	When f/fn = 0.98...1.02 ±2.0 percentage units (of settings Ratio U2/U1> and Ratio I2/I1<) When f/fn = 0.95...1.05 ±4.0 percentage units (of settings Ratio U2/U1> and Ratio I2/I1<)
BSOUT activation time (when the task interval is 10 ms)	Injected negative-sequence voltage = 2.00 x Ratio U2/U1> (f/fn=0.98...1.02: < 35 ms (within the same task)
Reset time	20 ms (within the same task)
Reset ratio	for Ratio U2/U1>: 0.8...0.96 for Ratio I2/I1<: 1.04...1.2

Fault locator, FLOC (21FL)	
The fault locator function for radial distribution systems. Short-circuit localization in all kinds of distribution networks. Earth fault localizations in effectively earthed networks and in low reactance/low resistance earthed networks.	
Fault localization accuracy	±2.5% of the line length. Actual fault localization accuracy depends on the fault and the power system characteristics as described in the FLOC function block manual, section “Result validity indicator for earth faults”.

Table 7: Power quality functions

Function	ANSI device no.	IEC symbol	Description
PQCU3H [1)]	PQ 3Inf	PQ 3Inf	Current waveform distortion measurement
PQVO3H [1)]	PQ 3Unf	PQ 3Unf	Voltage waveform distortion measurement
PQVO3Sd [2)]	PQ 3U<>	PQ 3U<>	Short duration voltage variations

1) These functions are only supported in the feeder terminal revisions of Release 2.0 or later.

2) This function is only supported in the feeder terminal revisions of Release 3.5 or later

Settings of power quality functions

Current waveform distortion measurement, PQCU3H, PQ 3inf (PQ 3inf)	
The current waveform distortion measurement PQCU3H is used for measurement and statistical analysis of current waveform distortion. The standards concerning voltage distortion measurement are applied to current distortion measurement in PQCU3H. Data collection and analysis is done according to EN 50160. Measuring principles for individual harmonics and THD are adapted from the International standard IEC 61000-4-7. The American standard IEEE Std 1159 is also partly supported. Analysis can be done for one selected phase current or most distorted phase current can be tracked.	
Measuring modes Measurement activation Triggering mode Distortion factor	Not in use; L1; L2; L3; Worst phase Triggering by: setting parameter, binary input, date & time setting Single; Continuous; Periodic THD; TDD
Monitored values THD (3 sec and 10 min mean values) Harmonic components from 1st to 13th (3 sec mean values) Harmonic components from 2nd to 13th (10 min mean values)	 0.0 ... 1000.0% 0.0 ... 1000.0% In 0.0 ... 1000.0% In
Statistics Observation times for statistics Percentile setting Percentiles for each harmonic and THD Five fixed percentiles (1,5,50,95,99) for one selectable harmonic or THD Maximum values for each harmonic and THD Recorded data	 1 hour; 12 hours; 1 day; 2 days; 3 days; 4 days; 5 days; 6 days; 1 week 90.0 ... 99.5% 0.0 ... 1000.0% In 0.0 ... 1000.0% In 0.0 ... 1000.0% In One data set for updating; One data set from the previous observation period
Harmonic limit supervision Limit for THD Limits for each harmonic Recorded data	 0.0 ... 60.0% 0.0 ... 40.0% In If any limit should be exceeded, the whole harmonic set will be recorded during the maximum THD (3 sec values)
Operation criteria Fundamental frequency Frequency deviation Amplitude of the fundamental wave	 0.9 ... 1.1 Fn ≤ 0.5 Hz (difference between max and min values within one second) ≥ 1% In
Measurement accuracy Measured harmonic Im = 1st, ... , 10th Measured harmonic Im = 11th, ... , 13th	 In accordance with IEC 61000-4-7 ± 1.0% In, if Im < 10% In; ± 10% Im, if Im ≥ 10% In

Voltage waveform distortion measurement, PQVO3H, PQ 3unf (PQ 3unf)	
The voltage waveform distortion measurement PQVO3H is used for measurement and statistical analysis of voltage waveform distortion. Data collection and analysis is done according to EN 50160. Measuring principles for individual harmonics and THD are adapted from the International standard IEC 61000-4-7. The American standard IEEE Std 1159 is also partly supported. Analysis can be done for one selected phase or phase-to-phase voltage or most distorted phase or phase-to-phase voltage can be tracked.	
Measuring modes Measurement activation Triggering mode	Not in use; L1; L2; L3; Worst phase; L1-L2; L2-L3; L3-L1; Worst main Triggering by: setting parameter, binary input, date & time setting Single; Continuous; Periodic

Monitored values	
THD (3 sec and 10 min mean values)	0.0 ... 120.0%
Harmonic components from 1st to 13th (3 sec mean values)	0.0 ... 120.0% Un
Harmonic components from 2nd to 13th (10 min mean values)	0.0 ... 120.0% Un
Statistics	
Observation times for statistics	1 hour; 12 hours; 1 day; 2 days; 3 days; 4 days; 5 days; 6 days; 1 week
Percentile setting	90.0 ... 99.5%
Percentiles for each harmonic and THD	0.0 ... 120.0% Un
Five fixed percentiles (1,5,50,95,99) for one selectable harmonic or THD	0.0 ... 120.0% Un
Maximum values for each harmonic and THD	0.0 ... 120.0% Un
Recorded data	One data set for updating; One data set from the previous observation period
Harmonic limit supervision	
Limit for THD	0.0 ... 30.0%
Limits for each harmonic	0.0 ... 20.0% Un
Recorded data	If any limit should be exceeded, the whole harmonic set will be recorded during the maximum THD (3 sec values)
Operation criteria	
Fundamental frequency	0.9 ... 1.1 Fn
Frequency deviation	≤ 0.5 Hz (difference between max and min values within one second)
Amplitude of the fundamental wave	≥ 0.7 Un
Measurement accuracy	
Measured harmonic Um = 1st, ... , 10th	In accordance with IEC 61000-4-7
Measured harmonic Um = 11th, ... , 13th	± 0.3% Un, if Um < 3% Un; ± 10% Um, if Um ≥ 3% Un

Short duration voltage variation measurement, PQVO3Sd, PQ3U< > (PQ3U< >)	
The PQVO3Sd function block is used for measuring short duration voltage variations. Power quality is being evaluated in the voltage waveform by measuring voltage swells, sags and interruptions. Power quality measurements carried out by the function block PQVO3Sd follow the European Standard EN 50160. Measuring principles are taken from the International standard IEC 61000-4-30.	
Swell start voltage	100.0 … 200.0%
Sag start voltage	0.0 … 100.0%
Interruption start voltage	0.0 … 100.0%
Minimum duration	8 … 60000ms
Maximum duration	8 … 60000ms
Measurement accuracy (in normal operating conditions)	
Duration measurement	In accordance with IEC 61000-4-30 Class A
Voltage and current measurement	In accordance with IEC 61000-4-30 Class B
Reset ratio, typically	0.95

Table 8: Energizing inputs

Rated frequency		50.0/60.0 Hz	
Current inputs	rated current		0.2 A/1 A/5 A
	thermal withstand capability	continuously	1.5 A/4 A/20 A
		for 1 s	20 A/100 A/500 A
	dynamic current withstand, half-wave value		50 A/250 A/1250 A
	input impedance		<750 mΩ/<100mΩ/ <20 mΩ

Table 8: Energizing inputs

Voltage inputs	rated voltage	100 V/110 V/115 V/120 V (parameterization)
	voltage withstand, continuously	2 x U_n (240 V)
	burden at rated voltage	<0.5 VA
Sensor inputs, max 9	AC voltage range	9.4 V RMS
	DC voltage range	±13.3 V
	input impedance	> 4.7 MΩ
	input capacitance	< 1 nF

Table 9: Auxiliary power supplies

Type	PS1/240V (REF 541, REF 543)	PS2/240V (REF 545 only)	External display module	PS1/48V (REF 541, REF 543)	PS2/48V (REF 545 only)
Input voltage, ac	110/120/220/240 V			-	
Input voltage, dc	110/125/220 V			24/48/60 V	
Voltage variation	ac 85…110%, dc 80…120% of rated value			dc 80…120% of rated value	
Burden	<50 W				
Ripple in dc auxiliary voltage	max. 12% of the dc value				
Interruption time in auxiliary dc voltage without resetting	<40 ms, 110 V and <100 ms, 200 V			<60 ms, 48 V and <100 ms, 60 V	
Internal overtemperature indication	+78°C (+75…+83°C)				

Table 10: Digital inputs

Power supply version	PS1/240 V (High)	PS1/240 V (Medium), PS2/240 V	PS1/48 V (Low), PS2/48V
Input voltage, dc	220 V	110/125/220 V	24/48/60/110/125/ 220 V
Operating range, dc	155…265 V	80...265 V	18...265 V
Current drain	~2…25 mA		
Power consumption/input	<0.8 W		
Pulse counting (specific digital inputs), frequency range	0…100 Hz		
Time synchronization (specific digital inputs) synchronization rate	once per minute or once per second		

Table 11: RTD/analogue inputs

Supported RTD sensors	100 Ω Platinum	TCR 0.00385 (DIN 43760)
	250 Ω Platinum	TCR 0.00385
	1000 Ω Platinum	TCR 0.00385
	100 Ω Nickel	TCR 0.00618 (DIN 43760)
	120 Ω Nickel	TCR 0.00618
	250 Ω Nickel	TCR 0.00618
	1000 Ω Nickel	TCR 0.00618
	10 Ω Copper	TCR 0.00427
	120 Ω Nickel	TCR 0.00672 (MIL-T-24388C)
Max lead resistance (three-wire measurement)	200 Ω per lead	
Accuracy	±0.5% of full scale ±1.0% of full scale for 10 Ω Copper RTD	
Isolation	2 kV (inputs to outputs and inputs to protective earth)	
Sampling frequency	5 Hz	
Response time	≤ Filter time + 30 ms (430 ms...5.03 s)	
RTD/ Resistance sensing current	max 4.2 mA RMS 6.2 mA RMS for 10 Ω Copper	
Current input impedance	274 Ω ±0.1%	

Table 12: Signal outputs

Max system voltage	250 V ac/dc
Continuous carry	5 A
Make and carry for 0.5 s	10 A
Make and carry for 3 s	8 A
Breaking capacity when control circuit time-constant L/R <40 ms, at 48/110/220 V dc	1 A/0.25 A/0.15 A

Table 13: Power outputs

Max system voltage		250 V ac/dc
Continuous carry		5 A
Make and carry for 0.5 s		30 A
Make and carry for 3 s		15 A
Breaking capacity when control circuit time constant L/R <40 ms, at 48/110/220 V dc		5 A/3 A/1 A
Minimum contact load		100 mA, 24 V ac/dc (2.4 VA)
TCS (Trip Circuit Supervision)	Control voltage range	20…265 V ac/dc
	Current drain through the supervision circuit	approx. 1.5 mA (0.99…1.72 mA)
	Minimum voltage (threshold) over a contact	20 V ac/dc (15…20 V)

Table 14: Analogue outputs

Output range	0...20 mA
Accuracy	±0.5% of full scale
Max load	600 Ω
Isolation	2 kV (output to output, output to inputs and output to protective earth)
Response time	≤ 85 ms

Table 15: Environmental conditions

Specified service temperature range		-10…+55°C
Transport and storage temperature range		-40…+70°C
Degree of protection by enclosure	Front side, flush-mounted	IP 54
	Rear side, connection terminals	IP 20
Dry heat test		according to IEC 60068-2-2
Dry cold test		according to IEC 60068-2-1
Damp heat test, cyclic		according to IEC 60068-2-30 r.h. = 95%, T = 20°…55°C
Storage temperature tests		according to IEC 60068-2-48

Table 16: Standard tests

Insulation tests	Dielectric test IEC 60255-5	Test voltage	2 kV, 50 Hz, 1 min.
	Impulse voltage test IEC 60255-5	Test voltage	5 kV, unipolar impulses, waveform 1.2/50 μs, source energy 0.5 J
	Insulation resistance measurements IEC 60255-5	Insulation resistance	> 100 MΩ, 500 V dc
Mechanical tests	Vibration tests (sinusoidal)		IEC 60255-21-1, class I
	Shock and bump test		IEC 60255-21-2, class I
	Seismic test		IEC 60255-21-3, class 2

Table 17: Electromagnetic compatibility tests

The EMC immunity test level fulfills the requirements listed below		
1 MHz burst disturbance test, class III, IEC 60255-22-1	common mode	2.5 kV
	differential mode	1.0 kV
Electrostatic discharge test, class III, IEC 61000-4-2 and IEC 60255-22-2	for contact discharge	6 kV
	for air discharge	8 kV
Radio frequency interference test	conducted, common mode IEC 61000-4-6	10 V (rms), f = 150 kHz…80 MHz
	radiated, amplitude-modulated IEC 61000-4-3	10 V/m (rms), f = 80…1000 MHz
	radiated, pulse-modulated ENV 50204	10 V/m, f = 900 MHz
	radiated, test with a portable transmitter IEC 60255-22-3, method C	f = 77.2 MHz, P = 6 W; f = 172.25 MHz, P = 5 W
Fast transient disturbance test (IEC 60255-22-4 and IEC 61000-4-4)	power supply	4 kV
	I/O ports	2 kV
Surge immunity test (IEC 61000-4-5)	power supply	4 kV, common mode 2 kV, differential mode
	I/O ports	2 kV, common mode 1 kV, differential mode
Power frequency (50 Hz) magnetic field, IEC 61000-4-8	100 A/m	
Voltage dips and short interruptions, IEC 61000-4-11	30%, 10 ms >90%, 5000 ms	
Electromagnetic emission tests EN 55011 and EN 50081-2	conducted RF emission (mains terminal)	EN 55011, class A
	radiated RF emission	EN 55011, class A
CE approval	Complies with the EMC directive 89/336/EEC and the LV directive 73/23/EEC	

Table 18: Data communication

Rear interface, connector X3.1	not used, reserved for future purposes	
Rear interface, connector X3.2	RS-232 connection	
	RER 123 fibre-optic Bus Connection Module	
	protocols	SPA, IEC_103, DNP 3.0[1)], Modbus[1)]
	RER 133 RS-485 Bus Connection Module	
	protocols	DNP 3.0 [2)], Modbus [2)]
	data transfer rates	DNP 3.0 and Modbus: 300 bps...19.2 kbps, selectable
	SPA-ZC 302 Profibus-DPV1/SPA Gateway	
	protocol	Profibus-DPV1 [1)]
	SPA-ZC 400 SPA/ Ethernet Adapter	
	protocol	IEC 61850 [1)]
Rear interface, connector X3.3	RS-485 connection	
	protocol	SPA, LON
	the fibre-optic interface module RER 103 is needed for galvanic isolation	
	data transfer rates	SPA: 4.8/9.6/19.2 kbps, selectable LON: 78.0 kbps/1.2 Mbps, selectable
Rear interface, connector X3.4	RJ45 connection	
	galvanically isolated RJ45 connection for an external display panel	
	protocol	CAN
	communication cable	1MRS 120511.001 (1 m) 1MRS 120511.003 (3 m)
Front panel	optical connection	
	protocol	SPA
	communication cable	1MKC 9500011
SPA protocol	bit rates	4.8/9.6/19.2 kbps
	start bits	1
	data bits	7
	parity	even
	stop bits	1
LON protocol	bit rates	78.0 kbps/1.2 Mbps
IEC_103 protocol	bit rates	9.6/19.2 kbps
	data bits	8
	parity	even
	stop bits	1
DNP 3.0	bit rates	0.3/0.6/1.2/2.4/4.8/9.6/19.2 kbps
	data bits	8
	stop bits	1, 2
	parity	none, odd, even
Modbus	bit rates	0.3/0.6/1.2/2.4/4.8/9.6/19.2 kbps
	data bits	5, 6, 7, 8
	stop bits	1, 2
	parity	none, odd, even

1) These functions are only supported in the feeder terminal revisions of Release 3.5 or later.
2) These functions are only supported in the feeder terminal revisions of Release 3.0 or later.

Table 19: General

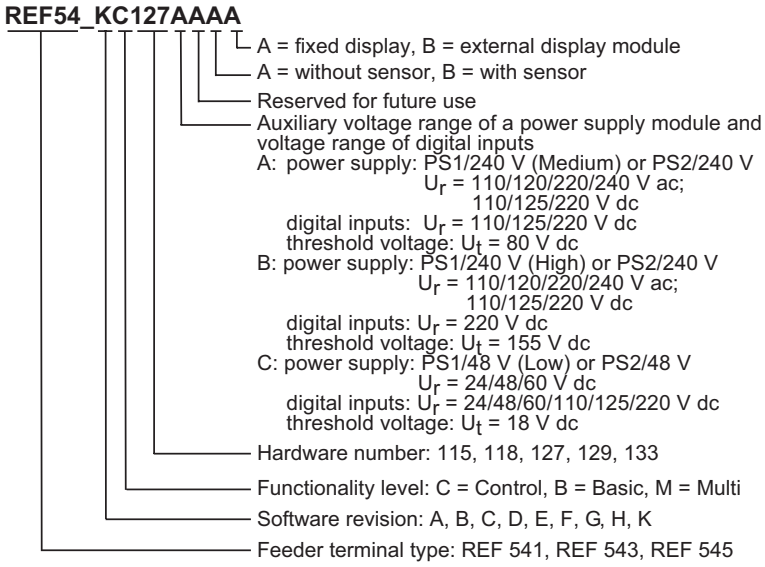
Toolboxes	CAP 501 CAP 505 LNT 505	
Event recording	all events are recorded in higher level syntax: reason, time, date the last 100 events are recorded	
Data recording	records operate values	
Protection functions Control functions Condition monitoring functions Measurement functions Power quality functions	see Technical Descriptions of Functions, CD-ROM (1MRS 750889-MCD)	
Self-supervision	RAMs ROMs EEPROMs all analogue reference voltages automatic test sequences for I/Os and HMI modules output contact condition monitoring (all contacts)	
Mechanical dimensions	Width: 223.7 mm (1/2 of a 19” rack) Height, frame: 265.9 mm (6U) Height, box: 249.8 mm Depth: 235 mm	
	External display module	Width: 223.7 mm Height: 265.9 mm Depth: 74 mm
Weight of the unit	~8 kg	

Ordering

The following is to be specified when ordering REF 54_ terminals: order number, display language combination and quantity of feeder terminals.

Each REF 54_ feeder terminal has a specific order number that identifies the feeder terminal type as well as the hardware and the software as described below.

The order number is labelled on the marking strip on the front panel of the feeder terminal delivered, e.g. Order No: REF543KC127AAAA.



A050601

The functionality level (C) determines the extent of the selection of function blocks available for the feeder terminal. For more detailed information on the separate function blocks included in each selection, please see the table *Functionality levels, protection functions* on the next page or consult your relay supplier.

Functionality level	Selection of function blocks
C (Control)	All control, condition monitoring and measurement functions
B (Basic)	All control, condition monitoring and measurement functions, basic protection functions
M (Multi)	All control, condition monitoring, measurement and protection functions

In addition, optional functions, such as fault locator, power quality, capacitor bank protection and power factor control functions are available.

The display language combination (see table below) is identified by a three-digit suffix in the software number labelled on the front panel of the feeder terminal, e.g. Software 1MRS110028-0__.

Language combinations

Suffix	Language combination
001	English-German
002	English-Swedish
003	English-Finnish
007	English-Portuguese
008	English-Polish
009	English-Russian
010	English-Spanish
012	English-Czech

The REF 541, REF 543 and REF 545 feeder terminals differ from each other as to the number of digital inputs and outputs as follows.

Terminals can optionally be ordered with an ANSI front panel.

Number of inputs/outputs

Number of inputs/outputs	REF 541	REF 543	REF 545
Digital inputs	15	25	34
Trip circuit supervision inputs	2	2	2
Power outputs (NO single-pole)	0	2	3
Power outputs (NO double-pole)	5	9	11
Signal outputs (NO)	2	2	4
Signal outputs (NO/NC)	5	5	8
Self-supervision outputs	1	1	1

The functionality level determines the extent of the selection of function blocks available for the feeder terminal. For more detailed information on the separate function blocks included in each selection, please consult your relay supplier.

Functionality levels, protection functions

				FUNCTIONALITY LEVELS		
ANSI Code	**IEC Symbol**	**Function**	**Code**	**REF541/3/5 CONTROL**	**REF541/3/5 BASIC**	**REF541/3/5 MULTI**
		SHORT CIRCUITS				
51-1	3I >	Three-phase non-directional overcurrent, low-set stage	NOC3Low		X	X
51-2	3I >>	Three-phase non-dir. overcurrent, high-set stage / blockable overcurrent	NOC3High		X	X
51-3	3I >>>	Three-phase non-dir. overcurrent, inst. stage / blockable overcurrent	NOC3Inst		X	X
67-1	3I > ->	Three-phase directional o/c, low-set stage	DOC6Low		X	X
67-2	3I >> ->	Three-phase directional o/c, high-set stage / blockable overcurrent	DOC6High		X	X
67-3	3I >>> ->	Three-phase directional o/c, high-set stage / blockable overcurrent	DOC6Inst		X	X
		EARTH-FAULTS				
51N-1	Io >	Non-directional earth-fault, low-set stage	NEF1Low		X	X
51N-2	Io >>	Non-directional earth-fault, high-set stage	NEF1High		X	X
50N-3	Io >>>	Non-directional earth-fault, instantaneous stage	NEF1Inst		X	X
67N-1	Io > ->	Directional earth-fault, low-set stage	DEF2Low		X	X
67N-2	Io >> ->	Directional earth-fault, high-set stage	DEF2High		X	X
67N-3	Io >>> ->	Directional earth-fault, instantaneous stage	DEF2Inst		X	X
59N-1	Uo >	Residual overvoltage, low-set stage	ROV1Low		X	X
59N-2	Uo >>	Residual overvoltage, high-set stage	ROV1High		X	X

Functionality levels, protection functions

				FUNCTIONALITY LEVELS		
ANSI Code	**IEC Symbol**	**Function**	**Code**	**REF541/3/5 CONTROL**	**REF541/3/5 BASIC**	**REF541/3/5 MULTI**
59N-3	Uo >>>	Residual overvoltage, instantaneous stage	ROV1Inst		X	X
		OVERLOAD				
49F	3Ith>	Three-phase thermal overload (feeders & cables)	TOL3Cab		X	X
		OVER / UNDERVOLTAGE				
59-1	3U >	Three-phase overvoltage, low-set stage	OV3Low			X
59-2	3U >>	Three-phase overvoltage, high-set stage	OV3High			X
27-1	3U <	Three-phase undervoltage, low-set stage	UV3Low			X
27-2	3U <<	Three-phase undervoltage, high-set stage	UV3High			X

Functionality levels, protection functions

				FUNCTIONALITY LEVELS		
ANSI Code	**IEC Symbol**	**Function**	**Code**	**REF541/3/5 CONTROL**	**REF541/3/5 BASIC**	**REF541/3/5 MULTI**
		LOAD SHEDDING AND RESTORATION				
81-1	f1	Underfrequency or overfrequency inc. rate of change, stage 1	Freq1St1			X
81-2	f2	Underfrequency or overfrequency incl. rate of change, stage 2	Freq1St2			X
81-3	f3t	Underfrequency or overfrequency incl. rate of change, stage 3	Freq1St3			X
81-4	f4	Underfrequency or overfrequency incl. rate of change, stage 4	Freq1St4			X
81-5	f5	Underfrequency or overfrequency incl. rate of change, stage 5	Freq1St5			X
		ADDITIONAL FUNCTIONS				
79	O → I	Auto-reclosure	AR5Func	X	X	X
25-1	SYNC1	Synchro-check/voltage check, stage 1	SCVCSt1	X	X	X
25-2	SYNC2	Synchro-check/voltage check, stage 2	SCVCSt2	X	X	X
68	3I2f >	Three-phase inrush detector	Inrush3		X	X
60	FUSEF	Fuse failure supervision	FuseFail	X	X	X
46	Iub>	Phase discontinuity	CUB3Low		X	X
62BF	CBFP	Circuit breaker failure	-	X	X	X
49M/G/T	3Ithdev>	Three-phase thermal overload protection for devices	TOL3Dev			X
48	Is2t n<	Start-up supervision for motors	MotStart			X
47-1	U1U2<>_1	Three-phase phase-sequency voltage protection, stage 1	PSV3St1			X
47-2	U1U2<>_2	Three-phase phase-sequency voltage protection, stage 2	PSV3St2			X

Functionality levels, other functions

				FUNCTIONALITY LEVELS		
ANSI Code	**IEC Symbol**	**Function**	**Code**	**REF541/3/5 CONTROL**	**REF541/3/5 BASIC**	**REF541/3/5 MULTI**
		MEASUREMENT FUNCTIONS				
		CURRENT				
3I	3I	Three-phase current	MECU3A	X	X	X
3I_B	3I_B	Three-phase current, B stage	MECU3B	X	X	X
Io	Io	Neutral current	MECU1A	X	X	X
Io_B	Io_B	Neutral current, B stage	MECU1B	X	X	X
		VOLTAGE				
3U	3U	Three-phase voltage	MEVO3A	X	X	X

Functionality levels, other functions

				FUNCTIONALITY LEVELS		
ANSI Code	**IEC Symbol**	**Function**	**Code**	**REF541/3/5 CONTROL**	**REF541/3/5 BASIC**	**REF541/3/5 MULTI**
3U_B	3U_B	Three-phase voltage, B stage	MEVO3B	X	X	X
Uo	Uo	Residual voltage	MEVO1A	X	X	X
Uo_B	Uo_B	Residual voltage, B stage	MEVO1B	X	X	X
		ENERGY / POWER				
PQE	PQE	Three-phase power and energy (incl. cos φ)	MEPE7	X	X	X
		FREQUENCY				
f	f	System frequency	MEFR1	X	X	X
		RECORDING				
DREC	DREC	Transient disturbance recorder	MEDREC16	X	X	X
		RTD -MODULE				
AI1...AI8	AI1..AI8	Measurement of RTD/analogue inputs, general measurement	MEAI1…8	X	X	X
AO1... AO4	AO1... AO4	Measurement of analogue outputs (Note! Only in products with an RTD/analogue module)	MEAO1…4	X	X	X
		CONDITION MONITORING FUNCTION				
		CIRCUIT BREAKER				
CB wear1	CB wear1	CB electric wear 1	CMBWEAR1	X	X	X
CB wear2	CB wear2	CB electric wear 2	CMBWEAR2	X	X	X
TIME1	TIME1	Operate Time Counter 1 (e.g. motors)	CMTIME1	X	X	X
TIME2	TIME2	Operate Time Counter 2 (e.g. motors)	CMTIME2	X	X	X
CMGAS1	GAS1	Gas pressure supervision	CMGAS1	X	X	X
CMGAS3	GAS3	Gas pressure supervision for three poles	CMGAS3	X	X	X
CMSPRC1	SPRC1	Spring charging control 1	CMSPRC1	X	X	X
CMTRAV1	TRAV1	Breaker travel time 1	CMTRAV1	X	X	X
CMSCHED	SCHED	Scheduled maintenance	CMSCHED	X	X	X
		TRIP CIRCUIT				
TCS1	TCS1	Trip Circuit Supervision 1	CMTCS1	X	X	X
TCS2	TCS2	Trip Circuit Supervision 2	CMTCS2	X	X	X
		MEASURING CIRCUIT				
MCS 3I	MCS 3I	Supervision of the energizing current input circuit	CMCU3	X	X	X
MCS 3U	MCS 3U	Supervision of the energizing voltage input circuit	CMVO3	X	X	X
		CONTROL FUNCTION				
		CIRCUIT BREAKERS, DISCONNECTORS / EARTHING SWITCH				
COCB1 COCB2	I<->O CB1 CB2	Circuit breaker 1, 2 (2 state inputs / 2 control outputs)	COCB1...2	X	X	X
CODC1…5	I<->O DC1... DC5	Disconnector 1….5 (2 state inputs / 2 control outputs)	CODC1…5	X	X	X

Functionality levels, other functions

				FUNCTIONALITY LEVELS		
ANSI Code	**IEC Symbol**	**Function**	**Code**	**REF541/3/5 CONTROL**	**REF541/3/5 BASIC**	**REF541/3/5 MULTI**
CO3DC1 CO3DC2	I<->O 3DC1, 3DC2	Three state disconnector 1, 2 (3 state inputs / 4 control outputs)	CO3DC1...2	X	X	X
COIND1…8	I<->O IND1... IND8	Object indication 1…8 (2 state inputs)	COIND1…8	X	X	X
MMIDATA 1…5	MMIDATA 1…5	MIMIC dynamic data point 1…5 on HMI (single line diagram)	MMIDATA 1…5	X	X	X
MMIALAR 1…8	MMIALAR 1…8	Alarm 1…8 on HMI (alarm view)	MMIALAR 1…8	X	X	X
COSW1...4	SW1...4	On/off switch 1…4 on HMI (single-line diagram)	COSW1…4	X	X	X
COCBDIR	CBDIR	Direct open for CBs via HMI	COCBDIR	X	X	X
COLOCAT	I<->O POS	Logic control position selector	COLOCAT	X	X	X
		ADDITIONAL FUNCTIONS				
		Interlocking	-	X	X	X
		Command control	-	X	X	X
		STANDARD FUNCTIONS				
		Operation indication, relay and register reset	INDRESET	X	X	X
		Activation of HMI backlight	MMIWAKE	X	X	X
		Switchgroups SWGRP1...SWGRP20	SWGRP 1....20	X	X	X
		PLC logics (AND, OR, timers etc.) acc. to IEC 61131-3	-	X	X	X
		DATA COMMUNICATION				
		Event to be defined by the customer, E0...E63	EVENT230	X	X	X
		SPA bus	-	X	X	X
		LON bus	-	X	X	X
		IEC_103	-	X	X	X
		GENERAL FUNCTIONS				
		Main / secondary setting		X	X	X
		Remote setting		X	X	X
		Self-supervision		X	X	X
		Annunciating, event generating and value recording		X	X	X
		Measurement, parameter and switching device status display		X	X	X
		Remote-end binary signal transfer		X	X	X
		Binary signal interbay transfer		X	X	X

Optional functionality

Function			Code	Ordering number
	ANSI device no.	**IEC Symbol**	**Function**	**Order Code**
CAPACITOR BANK PROTECTION				
Three-phase overload protection for shunt capacitor banks	51C	3I>3I<	OL3Cap	1MRS100116
Current unbalance protection for shunt capacitor banks	51NC-1	dI>C	CUB1Cap	1MRS100117
Three-phase current unbalance protection for H-bridge connected shunt capacitor banks	51NC-2	3dI>C	CUB3Cap	1MRS100052
CAPACITOR BANK CONTROL				
Power factor controller	55	COPFC	COPFC	1MRS100143
POWER QUALITY				
Current waveform distortion measurement	PQ 3Inf	PQ 3Inf	PQCU3H	1MRS100512
Voltage waveform distortion measurement	PQ 3Unf	PQ 3Unf	PQVO3H	1MRS100513
Short duration voltage variations	PQ 3U<>	PQ 3U<>	PQVO3Sd	1MRS100514
FAULT LOCATOR				
Fault locator	21FL	FLOC	FLOC	1MRS100058
ANSI HMI				
ANSI display model				1MRS121026

Overview of REF hardware configurations

Hardware modules of REF 541	Order number																			
	REF541K_115AAAA	REF541K_115BAAA	REF541K_115CAAA	REF541K_115AABA	REF541K_115BABA	REF541K_115CABA	REF541K_115AAAB	REF541K_115BAAB	REF541K_115AABB	REF541K_115BABB	REF541K_118AAAA	REF541K_118BAAA	REF541K_118CAAA	REF541K_118AABA	REF541K_118BABA	REF541K_118CABA	REF541K_118AAAB	REF541K_118BAAB	REF541K_118AABB	REF541K_118BABB
Analogue interface																				
Sensor channels (current or voltage)				9	9	9			9	9				9	9	9			9	9
Current transformer 1/5 A	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Current transformer 0.2/1 A	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Voltage transformer 100 V	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Main processor boards																				
CPU module	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Power supply boards																				
PS1: 80...265 Vdc/ac (High)		1			1			1		1		1			1			1		1
PS1: 80...265 Vdc/ac (Medium)	1			1			1		1		1			1			1		1	
PS1: 18...80 Vdc/ac(Low)			1			1							1			1				
PS2: 80...265 Vdc																				
PS2: 18...80 Vdc																				
Digital I/O boards																				
BIO1: threshold voltage 155 Vdc		1			1			1		1		1			1			1		1
BIO1: threshold voltage 80 Vdc	1			1			1		1		1			1			1		1	
BIO1: threshold voltage 18 Vdc			1			1							1			1				
BIO2: threshold voltage 155 Vdc																				
BIO2: threshold voltage 80 Vdc																				
BIO2: threshold voltage 18 Vdc																				
Analogue I/O board																				
RTD/analogue module											1	1	1	1	1	1	1	1	1	1
Display boards																				
Graphic HMIHMI display, fixed	1	1	1	1	1	1					1	1	1	1	1	1				
Graphic HMI display, external							1	1	1	1							1	1	1	1
Mechanical design																				
1/2 enclosure	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Digital inputs	15										15									
Power outputs, single-pole	0										0									
Power outputs, double-pole	5										5									
Signal outputs (NO)	2										2									
Signal outputs (NO/NC)	5										5									
Supervised trip circuits	2										2									
IRF outputs	1										1									
RTD/analogue inputs	0										8									
Analogue outputs	0										4									

Hardware modules of REF 543	Order number																			
	REF543K_127AAAA	REF543K_127BAAA	REF543K_127CAAA	REF543K_127AABA	REF543K_127BABA	REF543K_127CABA	REF543K_127AAAB	REF543K_127BAAB	REF543K_127AABB	REF543K_127BABB	REF543K_129AAAA	REF543K_129BAAA	REF543K_129CAAA	REF543K_129AABA	REF543K_129BABA	REF543K_129CABA	REF543K_129AAAB	REF543K_129BAAB	REF543K_129AABB	REF543K_129BABB
Analogue interface																				
Sensor channels (current or voltage)				9	9	9			9	9				9	9	9			9	9
Current transformer 1/5 A	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Current transformer 0.2/1 A	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Voltage transformer 100 V	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Main processor boards																				
CPU module	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Power supply boards																				
PS1: 80...246 Vdc/ac (High)		1			1			1		1		1			1			1		1
PS1: 80...265 Vdc/ac (Medium)	1			1			1		1		1			1			1		1	
PS1: 18...80 Vdc/ac (Low)			1			1							1			1				
PS2: 80...265 Vdc																				
PS2: 18...80 Vdc																				
Digital I/O boards																				
BIO1: threshold voltage 155 Vdc		1			1			1		1		1			1			1		1
BIO1: threshold voltage 80 Vdc	1			1			1		1		1			1			1		1	
BIO1: threshold voltage 18 Vdc			1			1							1			1				
BIO2: threshold voltage 155 Vdc		1			1			1		1		1			1			1		1
BIO2: threshold voltage 80 Vdc	1			1			1		1		1			1			1		1	
BIO2: threshold voltage 18 Vdc			1			1							1			1				
Analogue I/O board																				
RTD/analogue module											1	1	1	1	1	1	1	1	1	1
Display boards																				
Graphic HMI display, fixed	1	1	1	1		1					1	1	1	1	1	1				
Graphic HMI display, external							1	1	1	1							1	1	1	1
Mechanical design																				
1/2 enclosure	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Digital inputs	25										25									
Power outputs, single-pole	2										2									
Power outputs, double-pole	9										9									
Signal outputs (NO)	2										2									
Signal outputs (NO/NC)	5										5									
Supervised trip circuits	2										2									
IRF outputs	1										1									
RTD/analogue inputs	0										8									
Analogue outputs	0										4									

Hardware modules of REF 545	Order number									
	REF545K_133AAAA	REF545K_133BAAA	REF545K_133CAAA	REF545K_133AABA	REF545K_133BABA	REF545K_133CABA	REF545K_133AAAB	REF545K_133BAAB	REF545K_133AABB	REF545K_133BABB
Analogue interface										
Sensor channels (current or voltage)				9	9	9			9	9
Current transformer 1/5 A	4	4	4	4	4	4	4	4	4	4
Current transformer 0.2/1 A	1	1	1	1	1	1	1	1	1	1
Voltage transformer 100 V	4	4	4	4	4	4	4	4	4	4
Main processor boards										
CPU module	1	1	1	1	1	1	1	1	1	1
Power supply boards										
PS1: 80...265 Vdc/ac (High)										
PS1: 80...265 Vdc/ac (Medium)										
PS1: 18...80 Vdc/ac (Low)										
PS2: 80...265 Vdc	1	1		1	1		1	1	1	1
PS2: 18...80 Vdc			1			1				
Digital I/O boards										
BIO1: threshold voltage 155 Vdc		2			2			2		2
BIO1: threshold voltage 80 Vdc	2			2			2		2	
BIO1: threshold voltage 18 Vdc			2			2				
BIO2: threshold voltage 155 Vdc		1			1			1		1
BIO2: threshold voltage 80 Vdc	1			1			1		1	
BIO2: threshold voltage 18 Vdc			1			1				
Analogue I/O board										
RTD/analogue module										
Display boards										
Graphic HMI display, fixed	1	1	1	1	1	1				
Graphic HMI display, external							1	1	1	1
Mechanical design										
1/2 enclosure	1	1	1	1	1	1	1	1	1	1
Digital inputs	34									
Power outputs, single-pole	3									
Power outputs, double-pole	11									
Signal outputs (NO)	4									
Signal outputs (NO/NC)	8									
Supervised trip circuits	2									
IRF outputs	1									
RTD/analogue inputs	0									
Analogue outputs	0									

Hardware versions of REF 541, REF 543 and REF 545

For the number of digital inputs and outputs of REF 54_ feeder terminals, refer to the tables above. The number of matching transformers, sensor inputs and analogue inputs and outputs, and the auxiliary voltage range vary between the different hardware versions of REF54_. Each hardware version of REF 541 and REF 543 can be supplied with an RTD/analogue module.

Software configuration

Each REF 54_ feeder terminal allows various software configurations based on separate functions. Functions included in the selected functionality level can be activated within the scope of the I/O connections and considering the total CPU load of the functions.

Parts and assembly descriptions

To achieve the best possible operation accuracy, all parts of a REF 54_ product have been calibrated together. Thus, each product forms a whole for which no separate spare parts can be supplied. In the event of malfunction, please consult your feeder terminal supplier.

Application examples

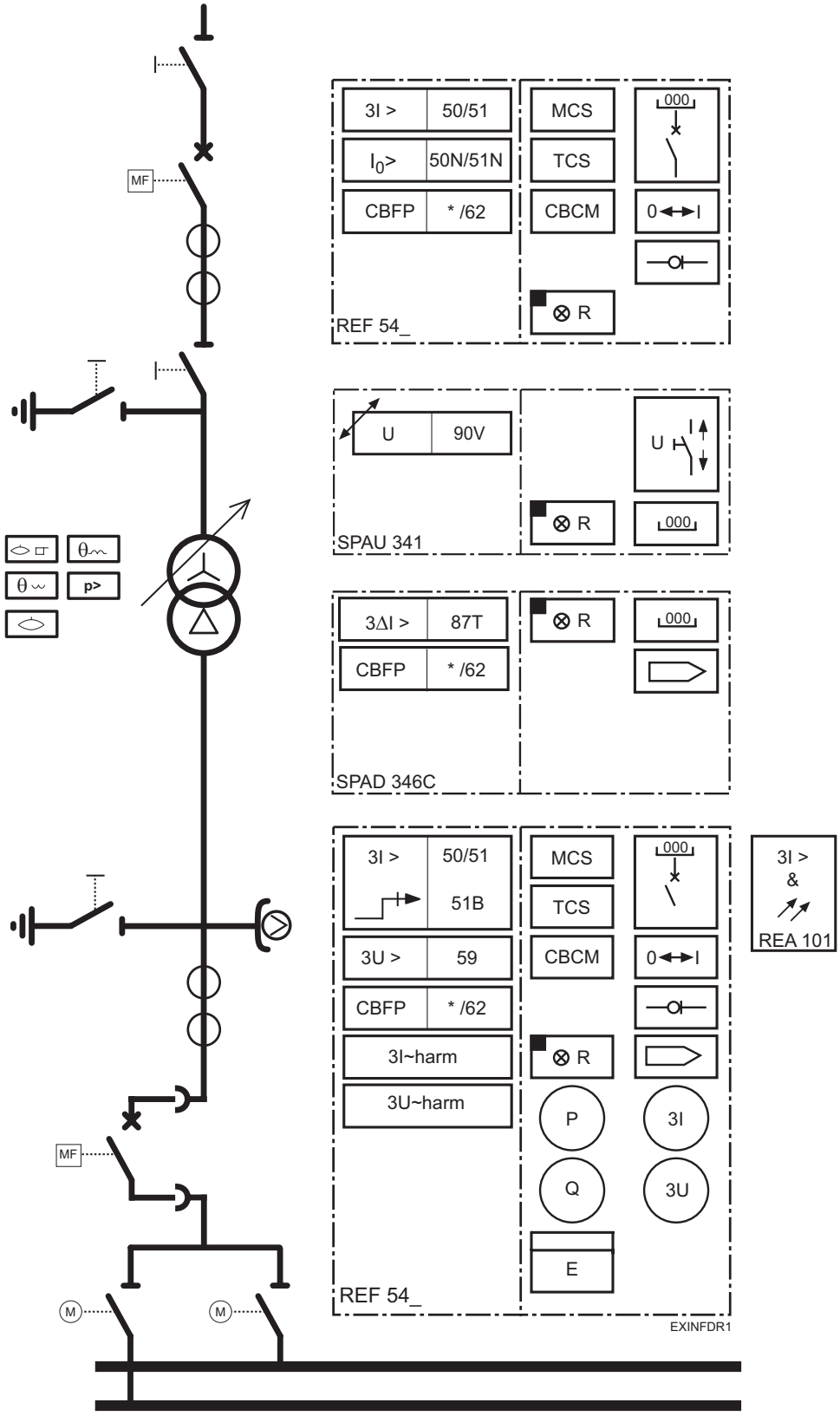


Fig. 7 Protection, control, measurement and supervision functions of a utility infeeder, implemented with REF 54_ feeder terminals, an REA arc monitoring system and SPACOM differential relay and voltage regulator (main single-line diagram presentation). The neutral point of the MV network supplied by the infeeder is isolated.

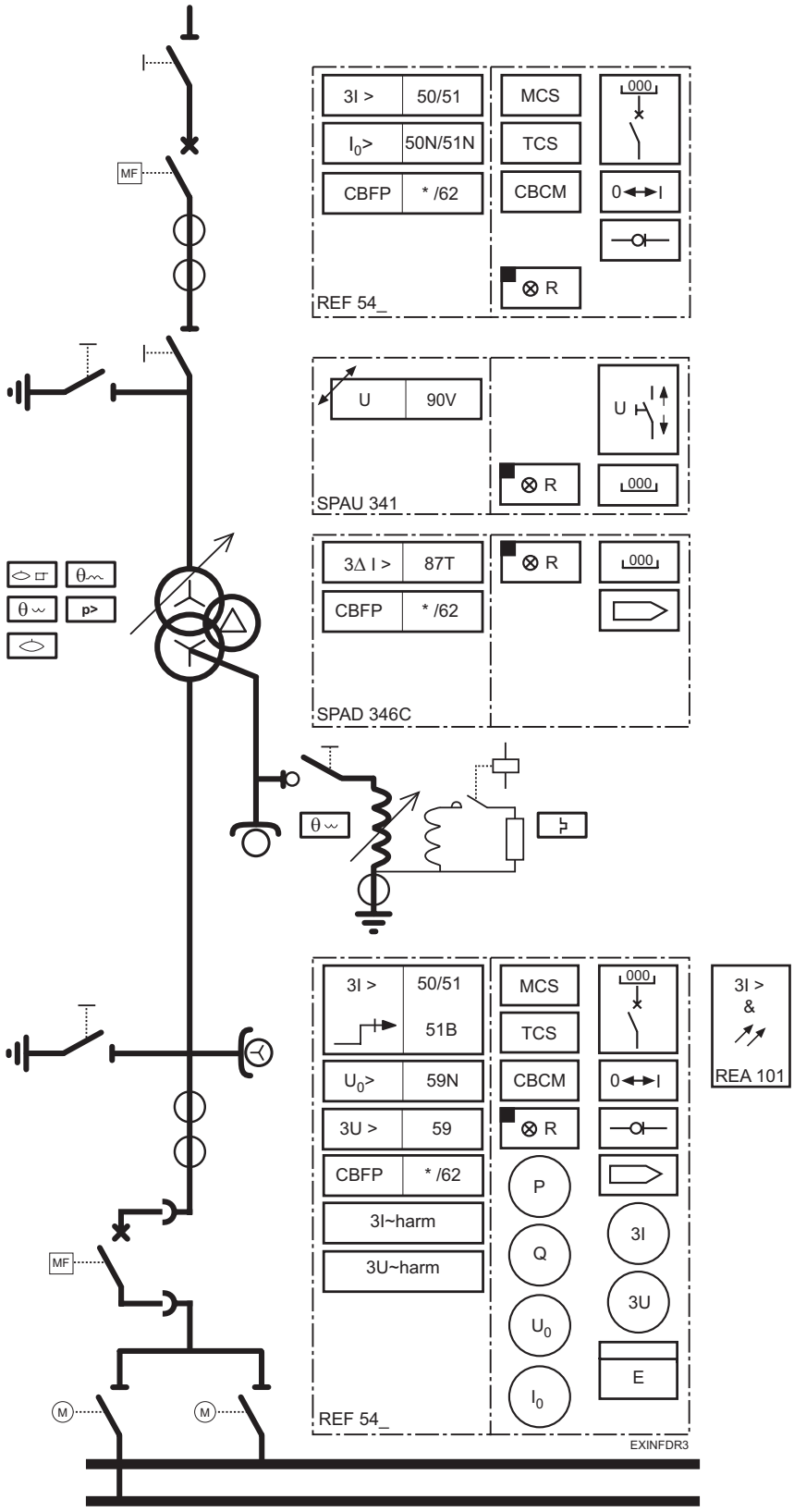


Fig. 8 Protection, control, measurement and supervision functions of a utility infeeder, implemented with REF 54_ feeder terminals, an REA arc monitoring system and SPACOM differential relay and voltage regulator (main single-line diagram presentation). The neutral point of the MV network supplied by the infeeder is earthed via the Petersen coil.

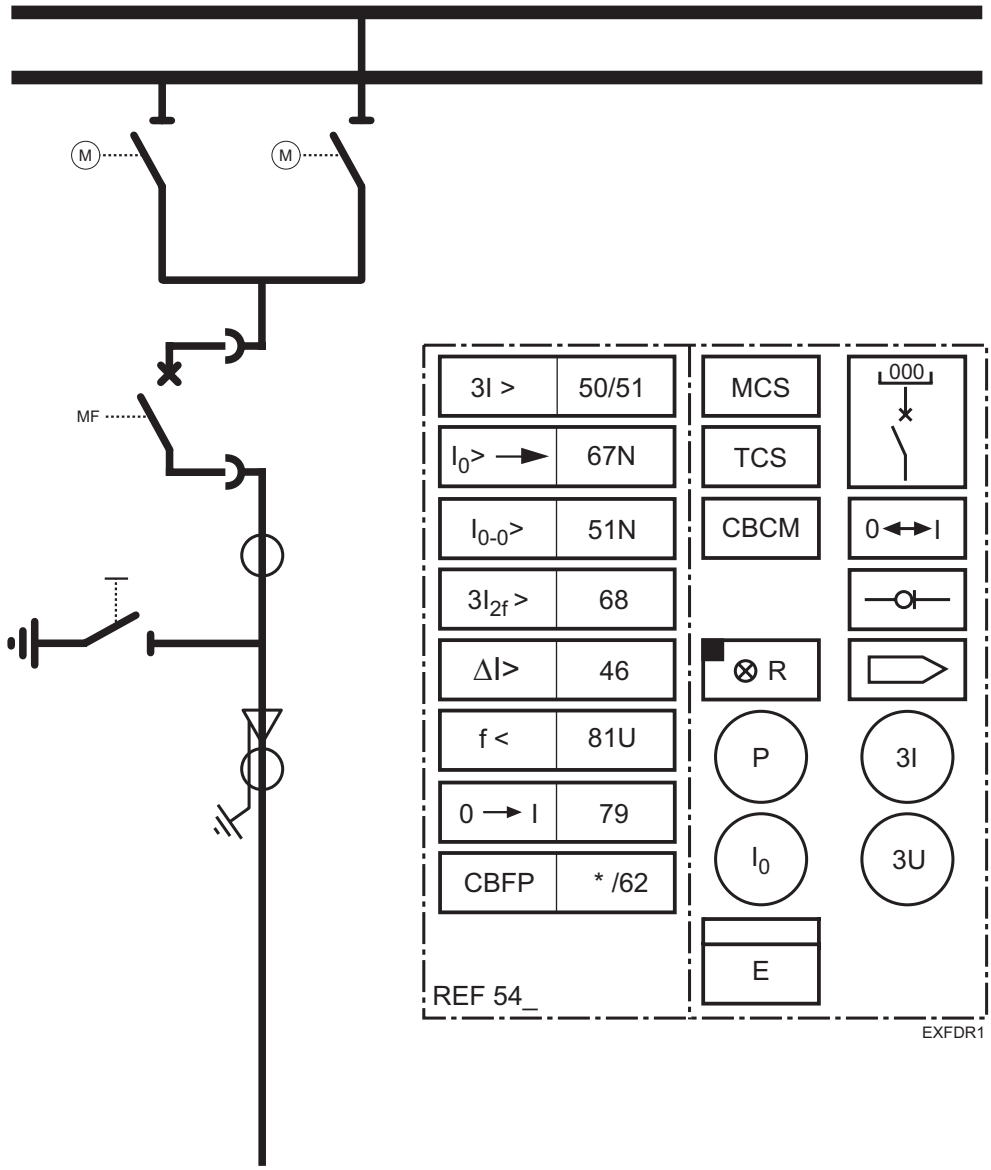


Fig. 9 An REF 54_ feeder terminal used for the protection, control, measurement and supervision functions of a utility feeder (main single-line diagram presentation). The neutral point of the supplying network is isolated. The scheme is also fully applicable in high-impedance earthed networks, where the neutral point is earthed via a high resistance or a Petersen coil.

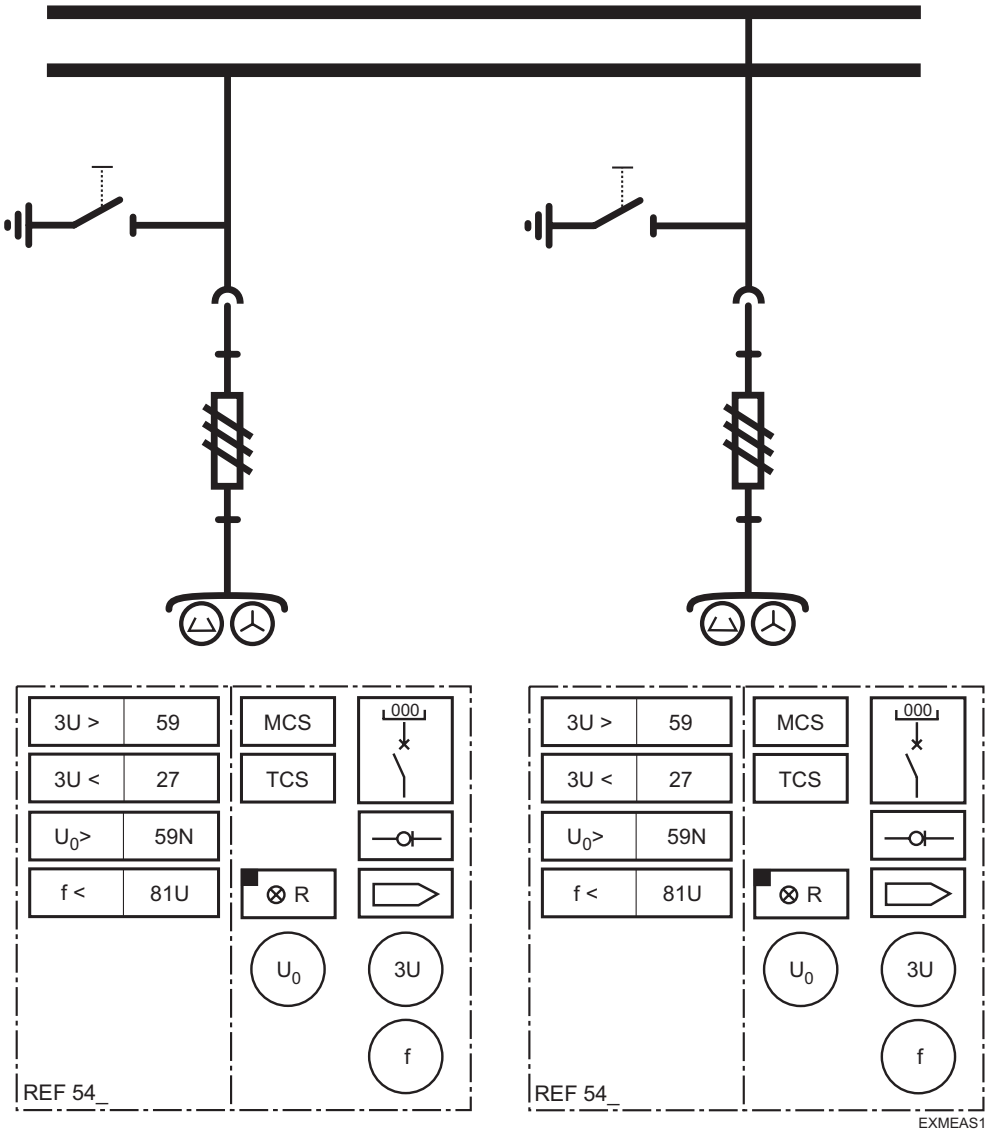


Fig. 10 REF 54_ feeder terminals used for the protection, control, measurement and supervision functions of a utility/industrial measurement cubicle (main single-line diagram presentation). The neutral point of the supplying network is isolated. The scheme is also fully applicable in high-impedance earthed networks, where the neutral point is earthed via a high resistance or a Petersen coil.

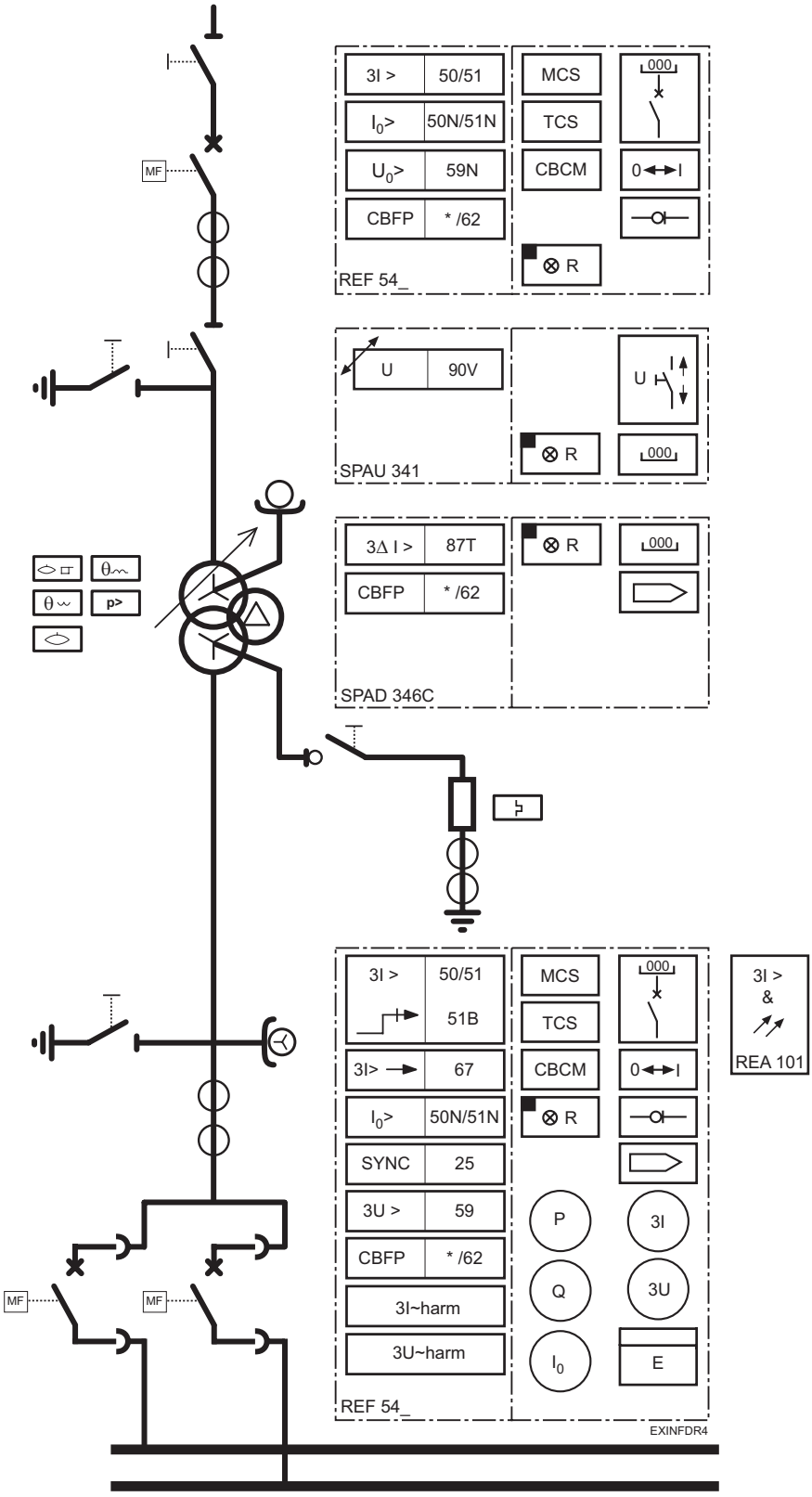


Fig. 11 Protection, control, measurement and supervision functions of a utility/industrial infeeder, implemented with REF 54_ feeder terminals, an REA arc monitoring system and SPACOM differential relay and voltage regulator (main single-line diagram presentation). The neutral point of the MV network supplied by the infeeder is earthed via a high resistance.

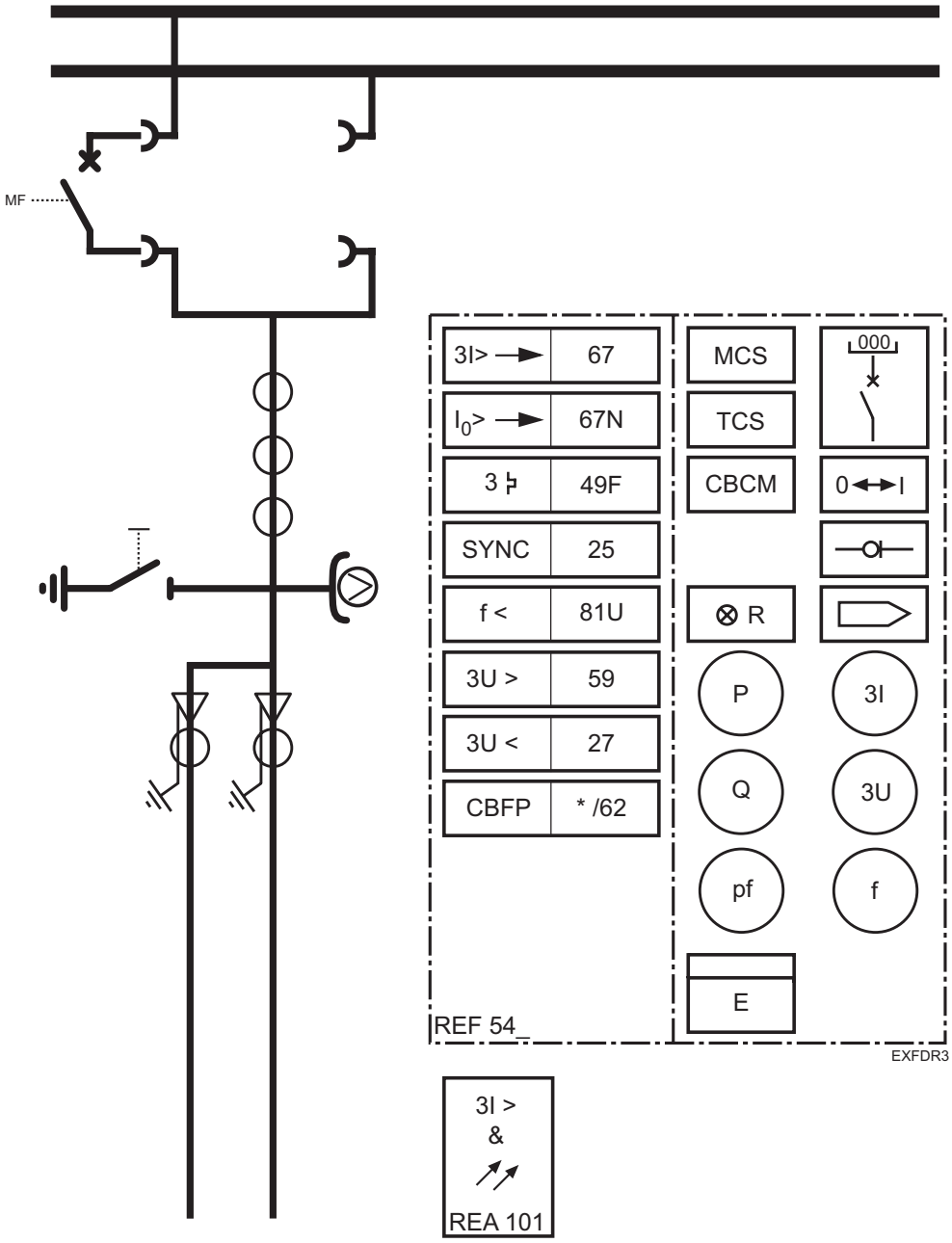


Fig. 12 An REF 54_ feeder terminal and an REA arc monitoring system (main single-line diagram presentation) used for the protection, control, measurement and supervision functions of a utility/industrial ring/meshed network cable feeder. The earthing of the supplying network can be of low or high impedance type.

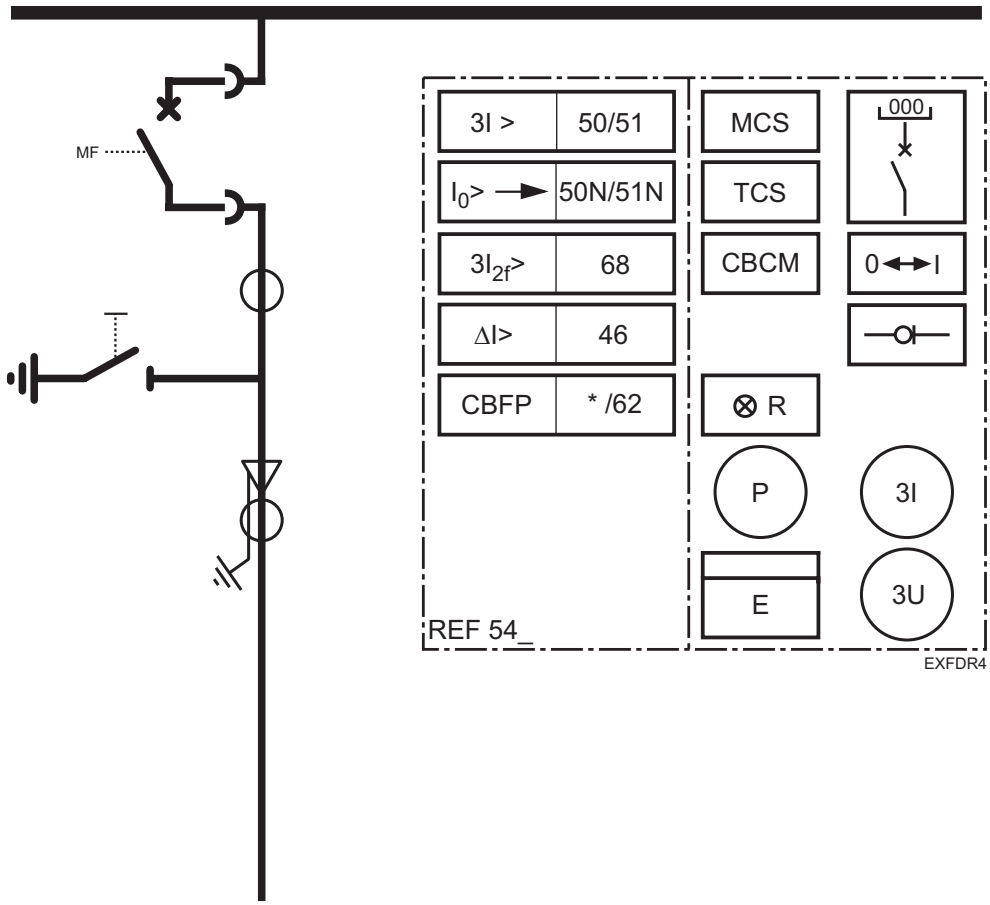


Fig. 13 An REF 54_ feeder terminal used for the protection, control, measurement and supervision functions of a utility/light industrial cable feeder (main single line diagram presentation). The earthing of the supplying network can be of low or high impedance type.

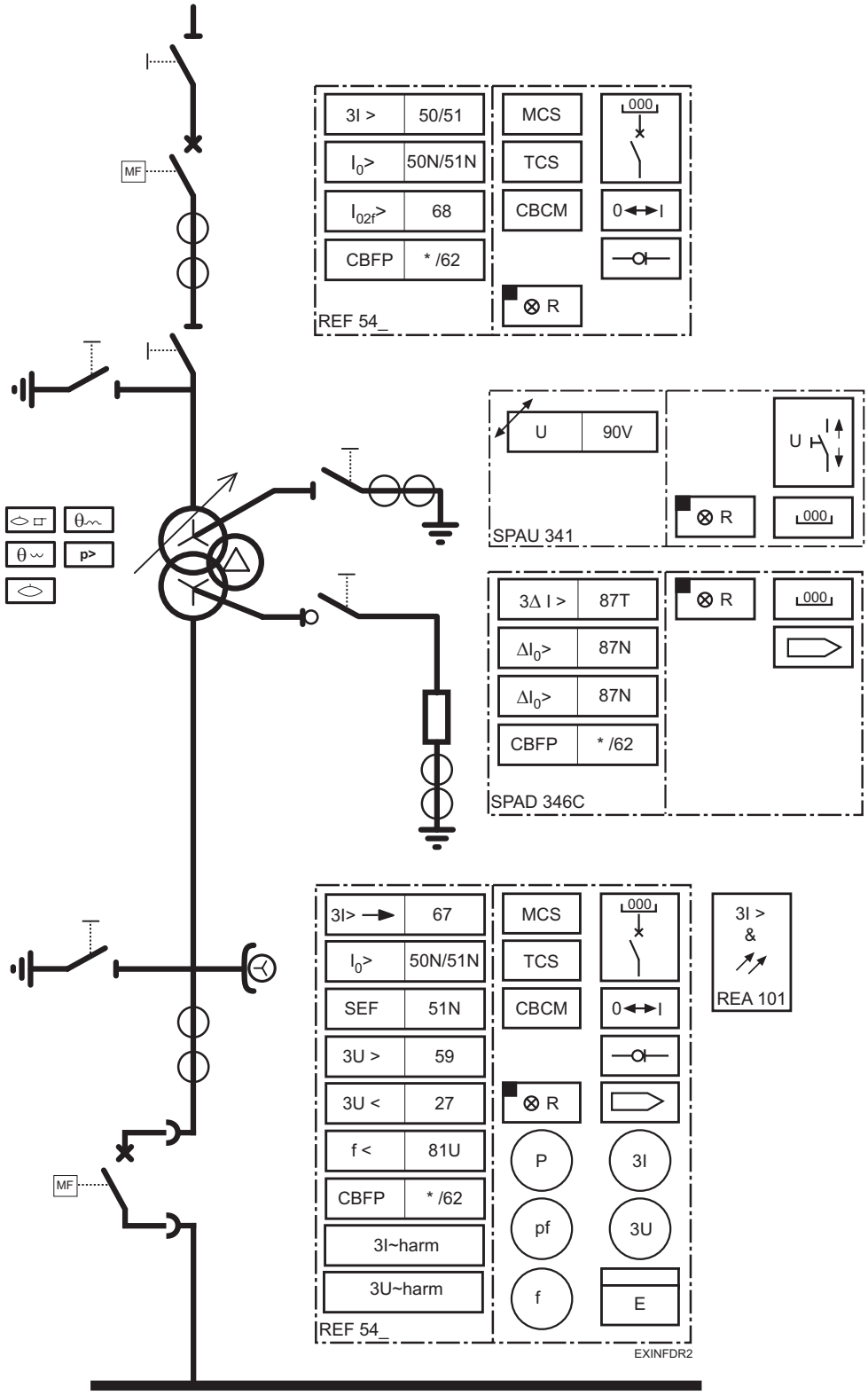


Fig. 14 Protection, control, measurement and supervision functions of a utility infeeder, implemented with REF 54_ feeder terminals, an REA arc monitoring system and SPACOM differential relay and voltage regulator (main single-line diagram presentation). The neutral point of the MV network supplied by the infeeder is earthed via a low resistance. The scheme is also fully applicable to other types of low-impedance earthed networks, where the neutral point is earthed effectively or via a low reactance.

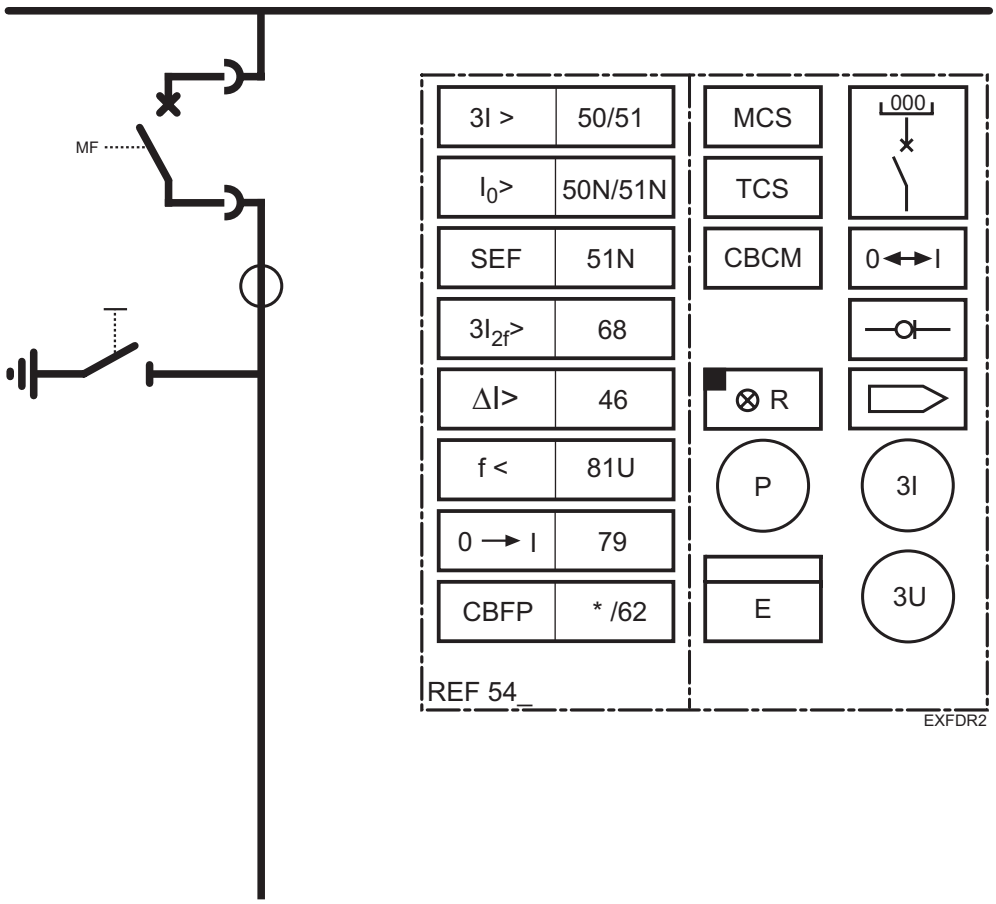


Fig. 15 An REF 54_ feeder terminal used for the protection, control, measurement and supervision functions of a utility feeder (main single-line diagram presentation). The neutral point of the supplying network is earthed via a low resistance. The scheme is also fully applicable to other types of low-impedance earthed networks, where the neutral point is earthed effectively or via a low reactance.

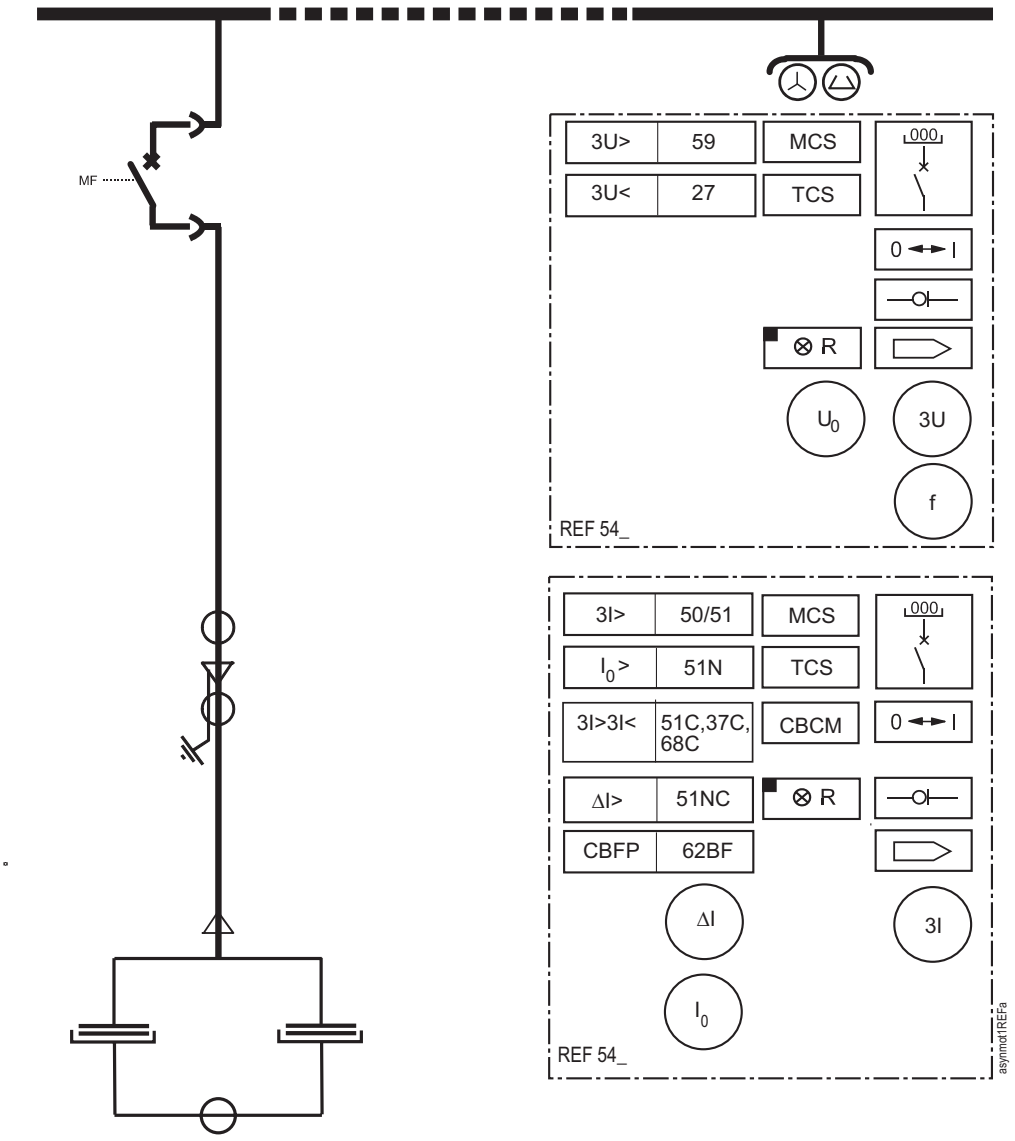


Fig. 16 REF 54_ used for the protection of a double **Y** connected capacitor bank

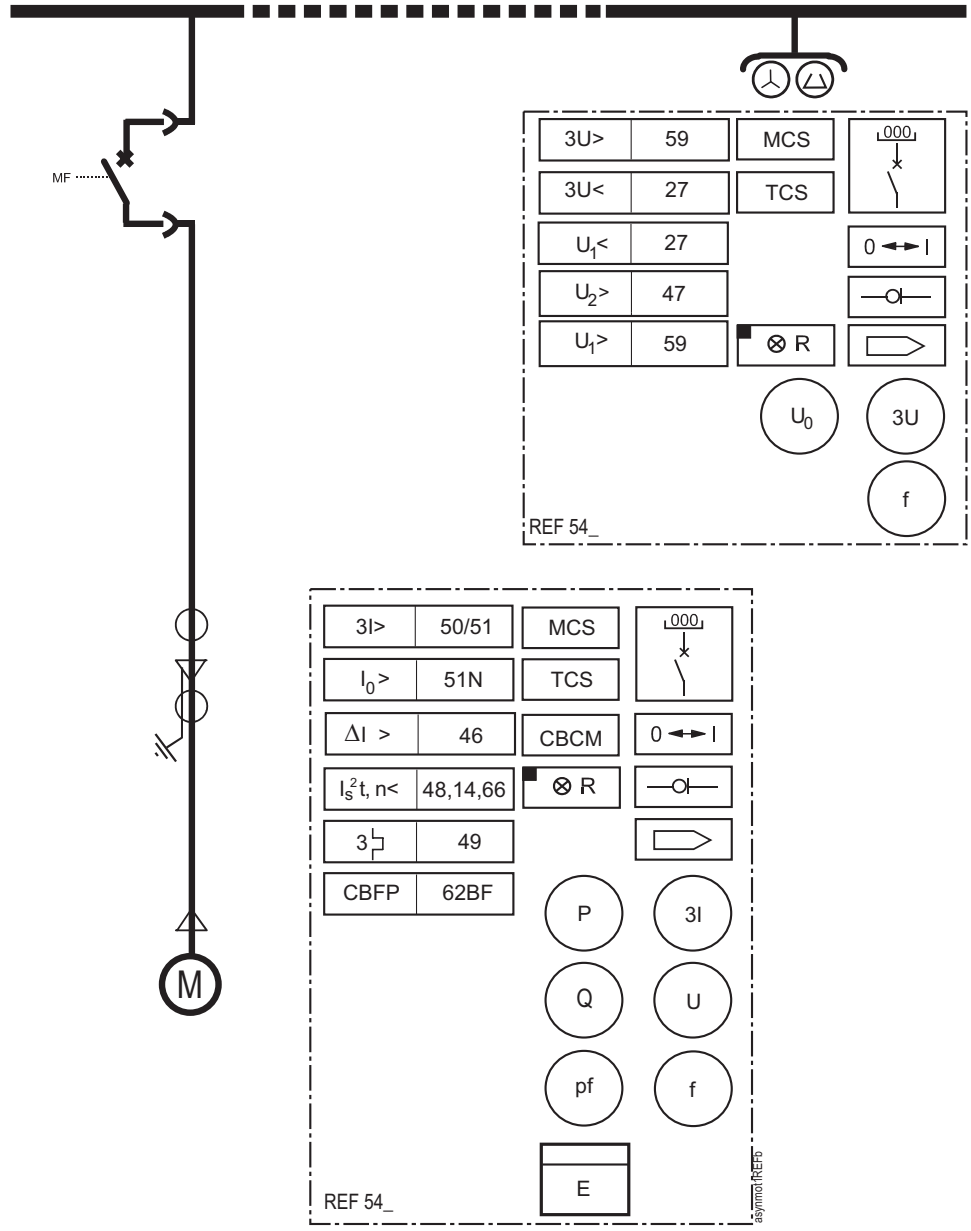


Fig. 17 REF 54_ used for the protection of a motor with direct-on-line starting

3I >	50/51	= multiple-stage three-phase overcurrent protection, low-set, high-set and instantaneous stage available
3I> →	67	= multiple-stage three-phase directional overcurrent protection, low-set, high-set and instantaneous stage available
I_0> →	67N	= multiple-stage directional earth-fault protection, low-set, high-set and instantaneous stage available
I_{0-0}>	51N	= instantaneous stage for earth-fault protection, to operate in the event of a double earth fault in isolated or impedance earthed networks
I_0>	50N/51N	= multiple-stage earth-fault protection, low-set, high-set and instantaneous stage available
SEF	51N	= low-set stage for sensitive earth-fault protection, to operate in the event of a high resistive earth fault in effectively or low-impedance earthed networks
3I > 	50/51 51B	= multiple-stage three-phase overcurrent protection, one stage dedicated for blockable busbar overcurrent protection
3U >	59	= three-phase overvoltage protection, low-set and high-set stage available
3U <	27	= three-phase undervoltage protection, low-set and high-set stage available
U_0>	59N	= multiple-stage residual overvoltage protection, low-set, high-set and instantaneous stage available
3I_{2f} >	68	= inrush detection based on the 2nd harmonic content of phase currents, applied for preventing possible unnecessary operation of overcurrent or earth-fault protection during transformer switching-in or to start cold load pick-up logic
ΔI>	46	= phase discontinuity protection
f <	81U	= underfrequency protection/load shedding scheme
3 ϑ	49F	= thermal overload protection for feeders
0 → I	79	= multiple-shot auto-recloser
SYNC	25	= circuit breaker synchro-check/direction of energizing check function
3Δ I >	87T	= differential protection for transformers
ΔI_0>	87N	= restricted earth-fault protection, low- or high-impedance type
I_{02f}>	68	= inrush detection based on the 2nd harmonic content of neutral current, applied to prevent possible unnecessary operation of the earth-fault protection during transformer switching-in
CBFP	* /62	= circuit-breaker failure protection

SYMNOT1

Fig. 18 Symbol notations, part I

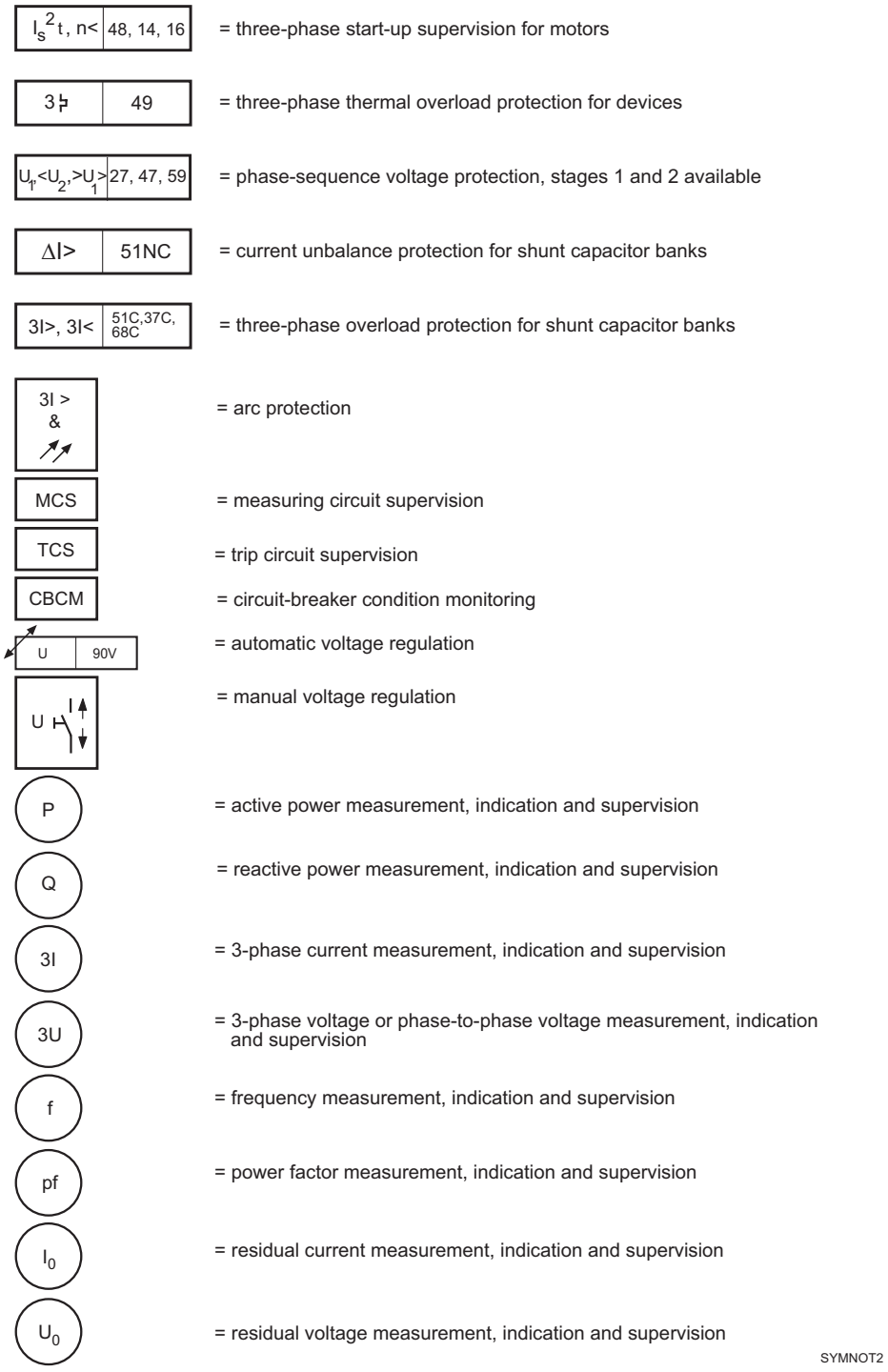


Fig. 19 Symbol notations, part II

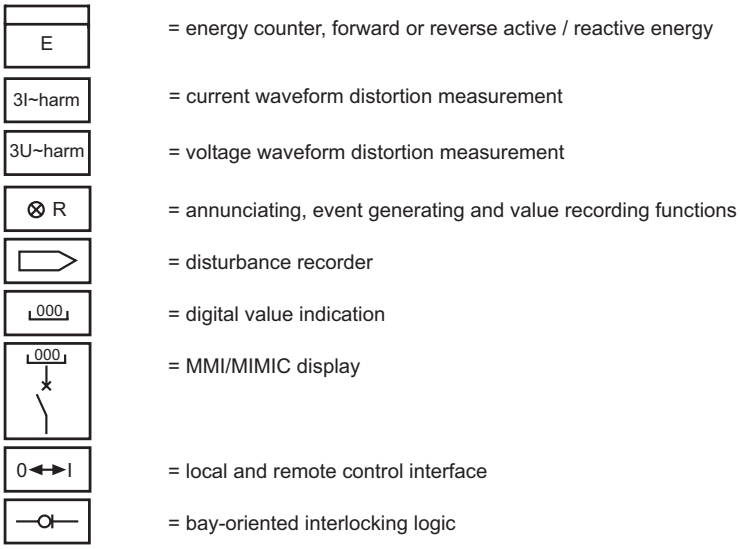


Fig. 20 Symbol notations, part III

Application selection tables for REF 541, REF 543 and REF 545 functions

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Table 20: Protection functions

Function	ANSI device no.	IEC symbol	Description
AR5Func	79	O-->I	Auto-reclose function (5 shots)
CUB1Cap [2]	51NC-1	dI>C	Current unbalance protection for shunt capacitor banks
CUB3Cap [3]	51NC-2	3dI>C	Three-phase current unbalance protection for H-bridge connected shunt capacitor
CUB3Low	46	Iub>	Phase discontinuity protection
DEF2Low	67N-1	Io-->	Directional earth-fault protection, low-set stage
DEF2High	67N-2	Io>>-->	Directional earth-fault protection, high-set stage
DEF2Inst	67N-3	Io>>>-->	Directional earth-fault protection, instantaneous stage
DOC6Low [1]	67-1	3I>-->	Three-phase directional overcurrent protection, low-set stage
DOC6High [1]	67-2	3I>>-->	Three-phase directional overcurrent protection, high-set stage
DOC6Inst [1]	67-3	3I>>>-->	Three-phase directional overcurrent protection, instantaneous stage
FLOC [4]	21FL	FLOC	Fault locator
Freq1St1 [1]	81-1	f1	Underfrequency or overfrequency protection, stage 1
Freq1St2 [1]	81-2	f2	Underfrequency or overfrequency protection, stage 2
Freq1St3 [1]	81-3	f3	Underfrequency or overfrequency protection, stage 3
Freq1St4 [1]	81-4	f4	Underfrequency or overfrequency protection, stage 4
Freq1St5 [1]	81-5	f5	Underfrequency or overfrequency protection, stage 5
FuseFail [3]	60	FUSEF	Fuse failure supervision
Inrush3	68	3I2f>	Three-phase transformer inrush and motor start-up current detector
MotStart [2]	48	Is2t n<	Three-phase start-up supervision for motors
NEF1Low	51N-1	Io>	Non-directional earth-fault protection, low-set stage
NEF1High	51N-2	Io>>	Non-directional earth-fault protection, high-set stage
NEF1Inst	51N-3	Io>>>	Non-directional earth-fault protection, instantaneous stage
NOC3Low	51-1	3I>	Three-phase non-directional overcurrent protection, low-set stage
NOC3High	51-2	I>>	Three-phase non-directional overcurrent protection, high-set stage
NOC3Inst	51-3	3I>>>	Three-phase non-directional overcurrent protection, instantaneous stage
OL3Cap [2]	51C	3I>3I<	Three-phase overload protection for shunt capacitor banks
OV3Low	59-1	3U>	Three-phase overvoltage protection, low-set stage
OV3High	59-2	3U>>	Three-phase overvoltage protection, high-set stage
PSV3St1 [2]	47-1	U1U2<>_1	Phase-sequence voltage protection, stage 1
PSV3St2 [2]	47-2	U1U2<>_2	Phase-sequence voltage protection, stage 2
ROV1Low	59N-1	Uo>	Residual overvoltage protection, low-set stage
ROV1High	59N-2	Uo>>	Residual overvoltage protection, high-set stage
ROV1Inst	59N-3	Uo>>>	Residual overvoltage protection, instantaneous stage
SCVCSt1 [1]	25-1	SYNC1	Synchro-check / voltage-check function, stage 1
SCVCSt2 [1]	25-2	SYNC2	Synchro-check / voltage-check function, stage 2
TOL3Cab [1]	49F	3Ith>	Three-phase thermal overload protection for cables
TOL3Dev [2]	49M/G/T	3Ithdev>	Three-phase thermal overload protection for devices
UV3Low	27-1	3U<	Three-phase undervoltage protection, low-set stage
UV3High	27-2	3U<<	Three-phase undervoltage protection, high-set stage

1) These functions are only supported in the feeder terminal revisions of Release 1.5 or later.
2) These functions are only supported in the feeder terminal revisions of Release 2.0 or later
3) These functions are only supported in the feeder terminal revisions of Release 2.5 or later.
4) This function is only supported in the feeder terminal revisions of Release 3.5 or later.

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Table 21: Measurement functions

Function	ANSI device no.	IEC symbol	Description
MEAI1 2)	AI1	AI1	General measurement 1 / analog input on RTD/analog module
MEAI2 2)	AI2	AI2	General measurement 2 / analog input on RTD/analog module
MEAI3 2)	AI3	AI3	General measurement 3 / analog input on RTD/analog module
MEAI4 2)	AI4	AI4	General measurement 4 / analog input on RTD/analog module
MEAI5 2)	AI5	AI5	General measurement 5 / analog input on RTD/analog module
MEAI6 2)	AI6	AI6	General measurement 6 / analog input on RTD/analog module
MEAI7 2)	AI7	AI7	General measurement 7 / analog input on RTD/analog module
MEAI8 2)	AI8	AI8	General measurement 8 / analog input on RTD/analog module
MEAO1 2)	AO1	AO1	Analog output 1 on RTD/analog module
MEAO2 2)	AO1	AO1	Analog output 2 on RTD/analog module
MEAO3 2)	AO3	AO3	Analog output 3 on RTD/analog module
MEAO4 2)	AO4	AO4	Analog output 4 on RTD/analog module
MECU1A	Io	Io	Neutral current measurement, stage A
MECU1B	Io_B	Io_B	Neutral current measurement, stage B
MECU3A	3I	3I	Three-phase current measurement, stage A
MECU3B 2)	3I_B	3I_B	Three-phase current measurement, stage B
MEDREC16 1)	DREC	DREC	Transient disturbance recorder
MEFR1	f	f	System frequency measurement
MEPE7	PQE	PQE	Three-phase power and energy measurement
MEVO1A	Uo	Uo	Residual voltage measurement, stage A
MEVO1B 2)	Uo_B	Uo_B	Residual voltage measurement, stage B
MEVO3A	3U	3U	Three-phase voltage measurement, stage A
MEVO3B 2)	3U_B	3U_B	Three-phase voltage measurement, stage B

1) These functions are only supported in the feeder terminal revisions of Release 1.5 or later.

2) These functions are only supported in the feeder terminal revisions of Release 2.0 or later

Table 22: Power quality functions

Function	ANSI device no.	IEC symbol	Description
PQCU3H 1)	PQ 3Inf	PQ 3Inf	Current waveform distortion measurement
PQVO3H 1)	PQ 3Unf	PQ 3Unf	Voltage waveform distortion measurement
PQVO3Sd 2)	PQ 3U<>	PQ 3U<>	Short duration voltage variations

1) These functions are only supported in the feeder terminal revisions of Release 2.0 or later.

2) This function is only supported in the feeder terminal revisions of Release 3.5 or later

Table 23: Control functions

Function	ANSI device no.	IEC symbol	Description
CO3DC1	CO3DC1	I<->O 3DC1	Three-state disconnector (1) with indication
CO3DC2	CO3DC2	I<->O 3DC2	Three-state disconnector (2) with indication
COCB1	COCB1	I<->O CB1	Circuit breaker 1 control with indication
COCB2	COCB2	I<->O CB2	Circuit breaker 2 control with indication
COCBDIR	COCBDIR	CBDIR	Direct open for CBs via HMI
CODC1	CODC1	I<->O DC1	Disconnector 1 control with indication
CODC2	CODC2	I<->O DC2	Disconnector 2 control with indication
CODC3	CODC3	I<->O DC3	Disconnector 3 control with indication
CODC4	CODC4	I<->O DC4	Disconnector 4 control with indication
CODC5	CODC5	I<->O DC5	Disconnector 5 control with indication
COIND1	COIND1	I<->O IND1	Switching device 1 indication

Table 23: Control functions

Function	ANSI device no.	IEC symbol	Description
COIND2	COIND2	I<->O IND2	Switching device 2 indication
COIND3	COIND3	I<->O IND3	Switching device 3 indication
COIND4	COIND4	I<->O IND4	Switching device 4 indication
COIND5	COIND5	I<->O IND5	Switching device 5 indication
COIND6	COIND6	I<->O IND6	Switching device 6 indication
COIND7	COIND7	I<->O IND7	Switching device 7 indication
COIND8	COIND8	I<->O IND8	Switching device 8 indication
COLOCAT	COLOCAT	I<->O POS	Logic-controlled control position selector
COPFC [1)]	55	COPFC	Power factor controller
COSW1	COSW1	SW1	On/off switch 1
COSW2	COSW2	SW2	On/off switch 2
COSW3	COSW3	SW3	On/off switch 3
COSW4	COSW4	SW4	On/off switch 4
MMIALAR1	ALARM1	ALARM1	Alarm channel 1, LED indicator
MMIALAR2	ALARM2	ALARM2	Alarm channel 2, LED indicator
MMIALAR3	ALARM3	ALARM3	Alarm channel 3, LED indicator
MMIALAR4	ALARM4	ALARM4	Alarm channel 4, LED indicator
MMIALAR5	ALARM5	ALARM5	Alarm channel 5, LED indicator
MMIALAR6	ALARM6	ALARM6	Alarm channel 6, LED indicator
MMIALAR7	ALARM7	ALARM7	Alarm channel 7, LED indicator
MMIALAR8	ALARM8	ALARM8	Alarm channel 8, LED indicator
MMIDATA1	MMIDATA1	MMIDATA1	MIMIC data monitoring point 1
MMIDATA2	MMIDATA2	MMIDATA2	MIMIC data monitoring point 2
MMIDATA3	MMIDATA3	MMIDATA3	MIMIC data monitoring point 3
MMIDATA4	MMIDATA4	MMIDATA4	MIMIC data monitoring point 4
MMIDATA5	MMIDATA5	MMIDATA5	MIMIC data monitoring point 5

Table 24: Condition monitoring functions

Function	ANSI device no.	IEC symbol	Description
CMBWEAR1	CB wear1	CB wear1	Circuit-breaker electric wear 1
CMBWEAR2	CB wear2	CB wear2	Circuit-breaker electric wear 2
CMCU3	MCS 3I	MCS 3I	Supervision function of the energizing current input circuit
CMGAS1	CMGAS1	GAS1	Gas pressure monitoring
CMGAS3 [1)]	CMGAS3	GAS3	Three-pole gas pressure monitoring
CMSCHED	CMSCHED	SCHED	Scheduled maintenance
CMSPRC1	CMSPRC1	SPRC1	Spring charging control 1
CMTCS1	TCS1	TCS1	Trip circuit supervision 1
CMTCS2	TCS2	TCS2	Trip circuit supervision 2
CMTIME1	TIME1	TIME1	Operate time counter 1 for the operate time used (e.g. motors)
CMTIME2	TIME2	TIME2	Operate time counter 2 for the operate time used (e.g. motors)
CMTRAV1	CMTRAV1	TRAV1	Breaker travel time 1
CMVO3	MCS 3U	MCS 3U	Supervision function of the energizing voltage input circuit

1) This function is only supported in the feeder terminal revisions of Release 2.0 or later

References

Additional information

Feeder Terminal REF 54_ Technical ReferenceManual, General	1MRS750527-MUM
Technical Descriptions of Functions	1MRS750889-MCD (CD-ROM only)
Installation Manual	1MR 750526-MUM
Operator’s Manual	1MR 750500-MUM
Technical Reference Manual RER 103	1MRS750532-MUM
Technical Reference Manual RER 123	1MRS751143-MUM
Protection & Control Terminals REF 54_, REM 54_, REC 523 Configuration Guideline	1MRS750745-MUM
Bus Connection Module RER 133 Technical Description	1MRS755163

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