Relion® 650 series

Breaker protection REQ650
Product Guide
1. 650 series overview
The 650 series IEDs provide both customized and configured solutions. With the customized IEDs you have the freedom to completely adapt the functionality according to your needs.

The 650 series IEDs provide optimum 'off-the-shelf', ready-to-use solutions. It is configured with complete protection functionality and default parameters to meet the needs of a wide range of applications for generation, transmission and sub-transmission grids.

The 650 series IEDs include:
- Customized versions providing the possibility to adapt the functionality to the application needs.
- Configured solutions are completely ready to use solutions optimized for a wide range of applications for generation, transmission and sub-transmission grids.
- Support for user-defined names in the local language for signal and function engineering.
- Minimized parameter settings based on default values and ABB’s new global base value concept. You only need to set those parameters specific to your own application, such as the line data.
- GOOSE messaging for horizontal communication.
- Extended HMI functionality with 15 dynamic three-color-indication LEDs per page, on up to three pages, and configurable push-button shortcuts for different actions.
- Programmable LED text-based labels.
- Settable 1A/5A -rated current inputs.

2. Application
Breaker protection REQ650 IED provides a standalone solution for applications, where the functions related to the breaker is not preferred or suitable to be integrated into the main protection function that is, the line distance protection for a line. The advanced automatic reclosing, synchronizing, synchrocheck and energizing check functions of REQ650 provides an optimized stand alone product. This IED also enables well-structured and reliable protection and control systems especially in systems where complete bay control functionality including interlocking is not required.

REQ650 provides backup to the main protection with redundant protection and control functions.

Three pre-configured packages have been defined for the following applications:
- A01: Backup protection functions in a single busbar single breaker bay with three-phase trip.
- A11: Backup protection functions in a single busbar single breaker bay with single-phase trip.
- B11: Backup protection functions in a double busbar single breaker bay with single-phase trip.

The backup protection is mainly based on current and voltage functions. In line protection applications, autoreclosing with or without synchrocheck is available.

The REQ650 IED is delivered pre-configured and ready for use in the power system. Analogue inputs and binary inputs/outputs circuits are pre-defined.

The pre-configured IED can be modified and adapted to suit specific applications with the graphical configuration tool ACT inside the PCM600 tool. For example, using the glue logic and adjusting the parameter settings.
Figure 1. Typical application example of the REQ650 A01 used as backup protection in a single busbar single breaker arrangement when three-phase trip is required.
Figure 2. Typical application example of the REQ650 A11 used as backup protection in a single busbar single breaker arrangement when single-phase trip is required
Figure 3. Typical application example of the REQ650 B11 used as backup protection in double busbar single breaker arrangement when single-phase trip is required
3. Available functions
## Back-up protection functions

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**Frequency protection**

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### Control and monitoring functions

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**Metering**

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## Communication

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## Breaker protection REQ650

Product version: 1.2

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4. Current protection

**Instantaneous phase overcurrent protection, 3-phase output PHPIOC**
The instantaneous three phase overcurrent function has a low transient overreach and short tripping time to allow use as a high set short-circuit protection function.

**Instantaneous phase overcurrent protection, phase segregated output SPTPIOC**
The instantaneous three phase overcurrent function has a low transient overreach and short tripping time to allow use as a high set short-circuit protection function and where the requirement for tripping is one- and/or three-phase.

**Four step phase overcurrent protection, 3-phase output OC4PTOC**
The four step phase overcurrent protection function OC4PTOC has an inverse or definite time delay independent for step 1 and 4 separately. Step 2 and 3 are always definite time delayed.

All IEC and ANSI inverse time characteristics are available.

The directional function is voltage polarized with memory. The function can be set to be directional or non-directional independently for each of the steps.

A 2nd harmonic blocking can be set individually for each step.

**Four step phase overcurrent protection, phase segregated output OC4SPTOC**
The four step phase overcurrent protection function, phase segregated output (OC4SPTOC) has an inverse or definite time delay independent for each step separately.

All IEC and ANSI time delayed characteristics are available.

The directional function is voltage polarized with memory. The function can be set to be directional or non-directional independently for each of the steps.

**Instantaneous residual overcurrent protection EFPIOC**
The Instantaneous residual overcurrent protection EFPIOC has a low transient overreach and short tripping times to allow the use for instantaneous earth-fault protection, with the reach limited to less than the typical eighty percent of the line at minimum source impedance. EFPIOC can be configured to measure the residual current from the three-phase current inputs or the current from a separate current input. EFPIOC can be blocked by activating the input BLOCK.

**Four step residual overcurrent protection, zero sequence and negative sequence direction EF4PTOC**
The four step residual overcurrent protection, zero or negative sequence direction (EF4PTOC) has a settable inverse or definite time delay independent for step 1 and 4 separately. Step 2 and 3 are always definite time delayed.

All IEC and ANSI inverse time characteristics are available.

EF4PTOC can be set directional or non-directional independently for each of the steps.

The directional part of the function can be set to operate on following combinations:
- Directional current ($I_{3PDir}$) versus Polarizing voltage ($U_{3PPol}$)
- Directional current ($I_{3PDir}$) versus Polarizing current ($I_{3PPol}$)
- Directional current ($I_{3PDir}$) versus Dual polarizing ($U_{Pol} + Z_{Pol} \times I_{Pol}$) where $Z_{Pol} = R_{Pol} + jX_{Pol}$

$IDir$, $UPol$ and $IPol$ can be independently selected to be either zero sequence or negative sequence.

Second harmonic blocking restraint level can be set for the function and can be used to block each step individually.

**Sensitive directional residual overcurrent and power protection SDEPSDE**
In isolated networks or in networks with high impedance earthing, the earth fault current is significantly smaller than the short circuit currents. In addition to this, the magnitude of the fault current is almost independent on the fault location in the network. The protection can be selected to...
use either the residual current or residual power component $3U_0 - 3I_0 \cdot \cos \phi$, for operating quantity. There is also available one non-directional $3I_0$ step and one non-directional $3U_0$ overvoltage tripping step.

**Thermal overload protection, one time constant**
The increasing utilizing of the power system closer to the thermal limits has generated a need of a thermal overload protection also for power lines.

A thermal overload will often not be detected by other protection functions and the introduction of the thermal overload protection can allow the protected circuit to operate closer to the thermal limits.

The three-phase current measuring protection has an $I_2t$ characteristic with settable time constant and a thermal memory. The temperature is displayed in either in Celsius or in Fahrenheit depending on whether the function used is Thermal overload protection one time constant, Celsius LCPTTR or Fahrenheit LFPTTR.

An alarm level gives early warning to allow operators to take action well before the line is tripped.

**Breaker failure protection, 3-phase activation and output**
CCRBRF can be current based, contact based, or an adaptive combination of these two conditions.

Breaker failure protection, 3-phase activation and output (CCRBRF) ensures fast back-up tripping of surrounding breakers in case the own breaker fails to open. CCRBRF can be current based, contact based, or adaptive combination between these two principles.

A current check with extremely short reset time is used as a check criterion to achieve a high security against unnecessary operation.

A contact check criteria can be used where the fault current through the breaker is small.

CCRBRF function current criteria can be fulfilled by one or two phase currents, or one phase current plus residual current. When those currents exceed the user defined settings, the function is activated. These conditions increase the security of the back-up trip command.

CCRBRF can be programmed to give an one- or three-phase re-trip of the own breaker to avoid unnecessary tripping of surrounding breakers.

**Breaker failure protection, phase segregated activation and output**
Breaker failure protection, phase segregated activation and output CSPRBRF ensures fast back-up tripping of surrounding breakers in case of own breaker failure to open. CSPRBRF can be current based, contact based, or adaptive combination between these two principles.

A current check with extremely short reset time is used as a check criterion to achieve a high security against unnecessary operation.

A contact check criteria can be used where the fault current through the breaker is small.

CSPRBRF function current criteria can be fulfilled by one or two phase currents, or one phase current plus residual current. When those currents exceed the user defined settings, the function is activated. These conditions increase the security of the back-up trip command.

CSPRBRF can be programmed to give an one- or three-phase re-trip of the own breaker to avoid unnecessary tripping of surrounding breakers at an incorrect initiation due to mistakes during testing.

**Stub protection STBPTOC**
When a power line is taken out of service for maintenance and the line disconnector is opened the voltage transformers will mostly be outside on the disconnected part. The primary line distance protection will thus not be able to operate and must be blocked.

The stub protection STBPTOC covers the zone between the current transformers and the open disconnector. The three-phase instantaneous overcurrent function is released from a normally open, NO (b) auxiliary contact on the line disconnector.

**Pole discordance protection CCRPLD**
Circuit breakers and disconnectors can end up with these in different positions (close-open), due
to electrical or mechanical failures. An open phase can cause negative and zero sequence currents which cause thermal stress on rotating machines and can cause unwanted operation of zero sequence or negative sequence current functions.

Normally the own breaker is tripped to correct such a situation. If the situation persists the surrounding breakers should be tripped to clear the unsymmetrical load situation.

The pole discordance function operates based on information from the circuit breaker logic with additional criteria from unsymmetrical phase currents when required.

**Broken conductor check BRCPTOC**
Conventional protection functions cannot detect the broken conductor condition. Broken conductor check (BRCPTOC) function, consisting of continuous current unsymmetrical check on the line where the IED is connected will give alarm or trip at detecting broken conductors.

**Directional over/underpower protection GOPPDOP/GUPPDUP**
The directional over-/under-power protection GOPPDOP/GUPPDUP can be used wherever a high/low active, reactive or apparent power protection or alarming is required. The functions can alternatively be used to check the direction of active or reactive power flow in the power system. There are a number of applications where such functionality is needed. Some of them are:

- detection of reversed active power flow
- detection of high reactive power flow

Each function has two steps with definite time delay. Reset times for both steps can be set as well.

**Negative sequence based overcurrent function DNSPTOC**
Negative sequence based overcurrent function (DNSPTOC) is typically used as sensitive earth-fault protection of power lines, where incorrect zero sequence polarization may result from mutual induction between two or more parallel lines.

Additionally, it is applied in applications on cables, where zero sequence impedance depends on the fault current return paths, but the cable negative sequence impedance is practically constant.

The directional function is current and voltage polarized. The function can be set to forward, reverse or non-directional independently for each step.

DNSPTOC protects against all unbalanced faults including phase-to-phase faults. The minimum start current of the function must be set to above the normal system unbalance level in order to avoid unwanted operation.

5. **Voltage protection**

**Two step undervoltage protection UV2PTUV**
Undervoltages can occur in the power system during faults or abnormal conditions. Two step undervoltage protection (UV2PTUV) function can be used to open circuit breakers to prepare for system restoration at power outages or as long-time delayed back-up to primary protection.

UV2PTUV has two voltage steps, where step 1 is settable as inverse or definite time delayed. Step 2 is always definite time delayed.

**Two step overvoltage protection OV2PTOV**
Overvoltages may occur in the power system during abnormal conditions such as sudden power loss, tap changer regulating failures, open line ends on long lines etc.

Two step overvoltage protection (OV2PTOV) function can be used to detect open line ends, normally then combined with a directional reactive over-power function to supervise the system voltage. When triggered, the function will cause an alarm, switch in reactors, or switch out capacitor banks.

OV2PTOV has two voltage steps, where step 1 can be set as inverse or definite time delayed. Step 2 is always definite time delayed.

OV2PTOV has an extremely high reset ratio to allow settings close to system service voltage.

**Two step residual overvoltage protection ROV2PTOV**
Residual voltages may occur in the power system during earth faults.
Two step residual overvoltage protection
ROV2PTOV function calculates the residual voltage from the three-phase voltage input transformers or measures it from a single voltage input transformer fed from an open delta or neutral point voltage transformer.

ROV2PTOV has two voltage steps, where step 1 can be set as inverse or definite time delayed. Step 2 is always definite time delayed.

Loss of voltage check LOVPTUV
Loss of voltage check (LOVPTUV) is suitable for use in networks with an automatic system restoration function. LOVPTUV issues a three-pole trip command to the circuit breaker, if all three phase voltages fall below the set value for a time longer than the set time and the circuit breaker remains closed.

6. Frequency protection

Underfrequency protection SAPTUF
Underfrequency occurs as a result of a lack of sufficient generation in the network.

Underfrequency protection SAPTUF is used for load shedding systems, remedial action schemes, gas turbine startup and so on.

SAPTUF is also provided with undervoltage blocking.

Overfrequency protection SAPTOF
Overfrequency protection function SAPTOF is applicable in all situations, where reliable detection of high fundamental power system frequency is needed.

Overfrequency occurs because of sudden load drops or shunt faults in the power network. Close to the generating plant, generator governor problems can also cause over frequency.

SAPTOF is used mainly for generation shedding and remedial action schemes. It is also used as a frequency stage initiating load restoring.

SAPTOF is provided with an undervoltage blocking.

Rate-of-change frequency protection SAPFRC
Rate-of-change frequency protection function (SAPFRC) gives an early indication of a main disturbance in the system. SAPFRC can be used for generation shedding, load shedding and remedial action schemes. SAPFRC can discriminate between positive or negative change of frequency.

SAPFRC is provided with an undervoltage blocking.

7. Secondary system supervision

Current circuit supervision CCSRDFSIF
Current circuit supervision (CCSRDFSIF) compares the residual current from a three phase set of current transformer cores with the neutral point current on a separate input taken from another set of cores on the current transformer.

A detection of a difference indicates a fault in the circuit and is used as alarm or to block protection functions expected to give unwanted tripping.

Fuse failure supervision SDDRFUF
The aim of the fuse failure supervision function (SDDRFUF) is to block voltage measuring functions at failures in the secondary circuits between the voltage transformer and the IED in order to avoid unwanted operations that otherwise might occur.

The fuse failure supervision function basically has three different algorithms, negative sequence and zero sequence based algorithms and an additional delta voltage and delta current algorithm.

The negative sequence detection algorithm is recommended for IEDs used in isolated or high-impedance earthed networks. It is based on the negative-sequence measuring quantities, a high value of negative sequence voltage 3U2 without
the presence of the negative-sequence current 3I₂.

The zero sequence detection algorithm is recommended for IEDs used in directly or low impedance earthed networks. It is based on the zero sequence measuring quantities, a high value of zero sequence voltage 3U₀ without the presence of the zero sequence current 3I₀.

For better adaptation to system requirements, an operation mode setting has been introduced which makes it possible to select the operating conditions for negative sequence and zero sequence based function. The selection of different operation modes makes it possible to choose different interaction possibilities between the negative sequence and zero sequence based algorithm.

A criterion based on delta current and delta voltage measurements can be added to the fuse failure supervision function in order to detect a three phase fuse failure, which in practice is more associated with voltage transformer switching during station operations.

**Breaker close/trip circuit monitoring TCSSCBR**

The trip circuit supervision function TCSSCBR is designed to supervise the control circuit of the circuit breaker. The invalidity of a control circuit is detected by using a dedicated output contact that contains the supervision functionality.

The function operates after a predefined operating time and resets when the fault disappears.

### 8. Control

**Synchrocheck, energizing check, and synchronizing SESRSYN**

The Synchronizing function allows closing of asynchronous networks at the correct moment including the breaker closing time, which improves the network stability.

Synchrocheck, energizing check, and synchronizing (SESRSYN) function checks that the voltages on both sides of the circuit breaker are in synchronism, or with at least one side dead to ensure that closing can be done safely.

**Autorecloser for 3-phase operation**

The autorecloser SMBRREC function provides high-speed and/or delayed auto-reclosing for single breaker applications.

Up to five three-phase reclosing attempts can be included by parameter setting.

The autoreclosing function can be configured to co-operate with a synchrocheck function.

**Autorecloser for 1/3-phase operation STBRREC**

The autoreclosing function provides high-speed and/or delayed auto-reclosing for single breaker applications.

Up to five reclosing attempts can be included by parameter setting. The first attempt can be single- and/or three phase for single-phase or multi-phase faults respectively.

Multiple autoreclosing functions are provided for multi-breaker arrangements. A priority circuit allows one circuit breaker to close first and the second will only close if the fault proved to be transient.

The autoreclosing function can be configured to co-operate with a synchrocheck function.

**Bay control QCBAY**

The Bay control QCBAY function is used together with Local remote and local remote control functions to handle the selection of the operator place per bay. QCBAY also provides blocking functions that can be distributed to different apparatuses within the bay.
Local remote LOCREM / Local remote control LOCREMCTRL
The signals from the local HMI or from an external local/remote switch are applied via the function blocks LOCREM and LOCREMCTRL to the Bay control (QCBAY) function block. A parameter in function block LOCREM is set to choose if the switch signals are coming from the local HMI or from an external hardware switch connected via binary inputs.

Circuit breaker control for circuit breaker, CBC1
The CBC1 consists of 3 functions:

- SCILO - The Logical node for interlocking. SCILO function is used to enable a switching operation if the interlocking conditions permit. SCILO function itself does not provide any interlocking functionality. The interlocking conditions are generated in separate function blocks containing the interlocking logic.
- SCSWI - The Switch controller initializes and supervises all functions to properly select and operate switching primary apparatuses. The Switch controller may handle and operate on one three-phase device.
- SXCBR - The purpose of SXCBR is to provide the actual status of positions and to perform the control operations, that is, pass all the commands to primary apparatuses in the form of circuit breakers via output boards and to supervise the switching operation and position.

Logic rotating switch for function selection and LHMI presentation SLGGIO
The logic rotating switch for function selection and LHMI presentation (SLGGIO) (or the selector switch function block) is used to get a selector switch functionality similar to the one provided by a hardware selector switch. Hardware selector switches are used extensively by utilities, in order to have different functions operating on pre-set values. Hardware switches are however sources for maintenance issues, lower system reliability and an extended purchase portfolio. The logic selector switches eliminate all these problems.

Selector mini switch VSGGIO
The Selector mini switch VSGGIO function block is a multipurpose function used for a variety of applications, as a general purpose switch.

VSGGIO can be controlled from the menu or from a symbol on the single line diagram (SLD) on the local HMI.

IEC 61850 generic communication I/O functions DPGGIO
The IEC 61850 generic communication I/O functions (DPGGIO) function block is used to send double indications to other systems or equipment in the substation. It is especially used in the interlocking and reservation station-wide logics.

Single point generic control 8 signals SPC8GGIO
The Single point generic control 8 signals (SPC8GGIO) function block is a collection of 8 single point commands, designed to bring in commands from REMOTE (SCADA) to those parts of the logic configuration that do not need extensive command receiving functionality (for example, SCSWI). In this way, simple commands can be sent directly to the IED outputs, without confirmation. Confirmation (status) of the result of the commands is supposed to be achieved by other means, such as binary inputs and SPGGIO function blocks. The commands can be pulsed or steady.

AutomationBits AUTOBITS
The Automation bits function (AUTOBITS) is used to configure the DNP3 protocol command handling.

9. Logic

Tripping logic common 3-phase output SMPPTRC
A function block for protection tripping is provided for each circuit breaker involved in the tripping of the fault. It provides pulse prolongation to ensure a three-phase trip pulse of sufficient length, as well as all functionality necessary for correct co-operation with autoreclosing functions.

The trip function block also includes functionality for breaker lock-out.
A function block for protection tripping is provided for each circuit breaker involved in the tripping of the fault. It provides the pulse prolongation to ensure an one- or three-phase trip pulse of sufficient length, as well as all functionality necessary for correct cooperation with autoreclosing and communication logic functions.

The trip function block includes functionality for evolving faults and breaker lock-out.

**Trip matrix logic TMAGGIO**

The Trip matrix logic TMAGGIO function is used to route trip signals and other logical output signals to the tripping logics SMPPTRC and SPTPTRC or to different output contacts on the IED.

TMAGGIO output signals and the physical outputs allows the user to adapt the signals to the physical tripping outputs according to the specific application needs.

**Configurable logic blocks**

A number of logic blocks and timers are available for the user to adapt the configuration to the specific application needs.

- OR function block.
- INVERTER function blocks that inverts the input signal.
- PULSETIMER function block can be used, for example, for pulse extensions or limiting of operation of outputs, settable pulse time.
- GATE function block is used for whether or not a signal should be able to pass from the input to the output.
- XOR function block.
- LOOPDELAY function block used to delay the output signal one execution cycle.
- TIMERSET function has pick-up and drop-out delayed outputs related to the input signal. The timer has a settable time delay and must be On for the input signal to activate the output with the appropriate time delay.

- AND function block.
- SRMEMORY function block is a flip-flop that can set or reset an output from two inputs respectively. Each block has two outputs where one is inverted. The memory setting controls if the block’s output should reset or return to the state it was, after a power interruption. The SET input has priority if both SET and RESET inputs are operated simultaneously.

- RSMEMORY function block is a flip-flop that can reset or set an output from two inputs respectively. Each block has two outputs where one is inverted. The memory setting controls if the block’s output should reset or return to the state it was, after a power interruption. The RESET input has priority if both SET and RESET are operated simultaneously.

**Boolean 16 to Integer conversion B16I**

Boolean 16 to integer conversion function (B16I) is used to transform a set of 16 binary (logical) signals into an integer.

**Boolean 16 to Integer conversion with logic node representation B16IFCVI**

Boolean 16 to integer conversion with logic node representation function (B16IFCVI) is used to transform a set of 16 binary (logical) signals into an integer.

**Integer to Boolean 16 conversion IB16A**

Integer to boolean 16 conversion function (IB16A) is used to transform an integer into a set of 16 binary (logical) signals.

**Integer to Boolean 16 conversion with logic node representation IB16FCVB**

Integer to boolean conversion with logic node representation function (IB16FCVB) is used to transform an integer to 16 binary (logic) signals.

IB16FCVB function can receive remote values over IEC61850 depending on the operator position input (PSTO).
Monitoring

IEC61850 generic communication I/O function SPGGIO
IEC61850 generic communication I/O functions (SPGGIO) is used to send one single logical signal to other systems or equipment in the substation.

IEC61850 generic communication I/O function 16 inputs
IEC 61850 generic communication I/O functions 16 inputs (SP16GGIO) function is used to send up to 16 logical signals to other systems or equipment in the substation.

Measurements CVMMXN, CMMXU, VNMMXU, VMMXU, CMSQI, VMSQI
The measurement functions are used to get online information from the IED. These service values make it possible to display on-line information on the local HMI and on the Substation automation system about:

- measured voltages, currents, frequency, active, reactive and apparent power and power factor
- primary and secondary phasors
- current sequence components
- voltage sequence components

Event counter CNTGGIO
Event counter (CNTGGIO) has six counters which are used for storing the number of times each counter input has been activated.

Disturbance report DRPRDRE
Complete and reliable information about disturbances in the primary and/or in the secondary system together with continuous event-logging is accomplished by the disturbance report functionality.

Disturbance report DRPRDRE, always included in the IED, acquires sampled data of all selected analog input and binary signals connected to the function block with a maximum of 40 analog and 96 binary signals.

The Disturbance report functionality is a common name for several functions:

- Event list
- Indications
- Event recorder
- Trip value recorder
- Disturbance recorder

A disturbance is defined as an activation of an input to the AxAADR or BxBBDR function blocks, which are set to trigger the disturbance recorder. All signals from start of pre-fault time to the end of post-fault time will be included in the recording.

Every disturbance report recording is saved in the IED in the standard Comtrade format. The same applies to all events, which are continuously saved in a ring-buffer. The local HMI is used to get information about the recordings. The disturbance report files may be uploaded to PCM600 for further analysis using the disturbance handling tool.

Event list DRPRDRE
Continuous event-logging is useful for monitoring the system from an overview perspective and is a complement to specific disturbance recorder functions.

The event list logs all binary input signals connected to the Disturbance report function. The list may contain up to 1000 time-tagged events stored in a ring-buffer.

Indications DRPRDRE
To get fast, condensed and reliable information about disturbances in the primary and/or in the secondary system it is important to know, for example binary signals that have changed status during a disturbance. This information is used in the short perspective to get information via the local HMI in a straightforward way.

There are three LEDs on the local HMI (green, yellow and red), which will display status information about the IED and the Disturbance report function (triggered).

The Indication list function shows all selected binary input signals connected to the Disturbance
report function that have changed status during a disturbance.

**Event recorder DRPRDRE**
Quick, complete and reliable information about disturbances in the primary and/or in the secondary system is vital, for example, time-tagged events logged during disturbances. This information is used for different purposes in the short term (for example corrective actions) and in the long term (for example functional analysis).

The event recorder logs all selected binary input signals connected to the Disturbance report function. Each recording can contain up to 150 time-tagged events.

The event recorder information is available for the disturbances locally in the IED.

The event recording information is an integrated part of the disturbance record (Comtrade file).

**Trip value recorder DRPRDRE**
Information about the pre-fault and fault values for currents and voltages are vital for the disturbance evaluation.

The Trip value recorder calculates the values of all selected analog input signals connected to the Disturbance report function. The result is magnitude and phase angle before and during the fault for each analog input signal.

The trip value recorder information is available for the disturbances locally in the IED.

The trip value recorder information is an integrated part of the disturbance record (Comtrade file).

**Disturbance recorder DRPRDRE**
The Disturbance recorder function supplies fast, complete and reliable information about disturbances in the power system. It facilitates understanding system behavior and related primary and secondary equipment during and after a disturbance. Recorded information is used for different purposes in the short perspective (for example corrective actions) and long perspective (for example functional analysis).

The Disturbance recorder acquires sampled data from selected analog- and binary signals connected to the Disturbance report function (maximum 40 analog and 96 binary signals). The binary signals available are the same as for the event recorder function.

The function is characterized by great flexibility and is not dependent on the operation of protection functions. It can record disturbances not detected by protection functions. Up to three seconds of data before the trigger instant can be saved in the disturbance file.

The disturbance recorder information for up to 100 disturbances are saved in the IED and the local HMI is used to view the list of recordings.

**Measured value expander block MVEXP**
The current and voltage measurements functions (CVMMXN, CMMXU, VMNXM and VNMNXU), current and voltage sequence measurement functions (CMSQI and VMSQI) and IEC 61850 generic communication I/O functions (MVGGIO) are provided with measurement supervision functionality. All measured values can be supervised with four settable limits: low-low limit, low limit, high limit and high-high limit. The measure value expander block has been introduced to enable translating the integer output signal from the measuring functions to 5 binary signals: below low-low limit, below low limit, normal, above high-high limit or above high limit. The output signals can be used as conditions in the configurable logic or for alarming purpose.

**Station battery supervision SPVNZBAT**
The station battery supervision function SPVNZBAT is used for monitoring battery terminal voltage.

SPVNZBAT activates the start and alarm outputs when the battery terminal voltage exceeds the set upper limit or drops below the set lower limit. A time delay for the overvoltage and undervoltage alarms can be set according to definite time characteristics.

In the definite time (DT) mode, SPVNZBAT operates after a predefined operate time and resets when the battery undervoltage or overvoltage condition disappears after reset time.

**Insulation gas monitoring function SSIMG**
Insulation gas monitoring function SSIMG is used for monitoring the circuit breaker condition. Binary
information based on the gas pressure in the circuit breaker is used as input signals to the function. In addition, the function generates alarms based on received information.

**Insulation liquid monitoring function SSIML**
Insulation liquid monitoring function SSIML is used for monitoring the circuit breaker condition. Binary information based on the oil level in the circuit breaker is used as input signals to the function. In addition, the function generates alarms based on received information.

**Circuit breaker monitoring SSCBR**
The circuit breaker condition monitoring function SSCBR is used to monitor different parameters of the circuit breaker. The breaker requires maintenance when the number of operations has reached a predefined value. The energy is calculated from the measured input currents as a sum of I^2t values. Alarms are generated when the calculated values exceed the threshold settings.

The function contains a blocking functionality. It is possible to block the function outputs, if desired.

**11. Metering**

**Pulse counter logic PCGGIO**
Pulse counter (PCGGIO) function counts externally generated binary pulses, for instance pulses coming from an external energy meter, for calculation of energy consumption values. The pulses are captured by the BIO (binary input/output) module and then read by the PCGGIO function. A scaled service value is available over the station bus.

**Function for energy calculation and demand handling ETPMMTR**
Outputs from the Measurements (CVMMXN) function can be used to calculate energy consumption. Active as well as reactive values are calculated in import and export direction. Values can be read or generated as pulses. Maximum demand power values are also calculated by the function.

**12. Human Machine interface**

**Local HMI**

The LHMI of the IED contains the following elements:
- Display (LCD)
- Buttons
- LED indicators
- Communication port

The LHMI is used for setting, monitoring and controlling.

The Local human machine interface, LHMI includes a graphical monochrome LCD with a resolution of 320x240 pixels. The character size may vary depending on selected language. The amount of characters and rows fitting the view depends on the character size and the view that is shown.

The LHMI is simple and easy to understand. The whole front plate is divided into zones, each with a well-defined functionality:
- Status indication LEDs
- Alarm indication LEDs which can indicate three states with the colors green, yellow and red, with user printable label. All LEDs are configurable from the PCM600 tool
- Liquid crystal display (LCD)
- Keypad with push buttons for control and navigation purposes, switch for selection between local and remote control and reset
- Five user programmable function buttons
- An isolated RJ45 communication port for PCM600

**13. Basic IED functions**

**Self supervision with internal event list**
The Self supervision with internal event list (INTERRSIG and SELFSUPEVLST) function reacts
to internal system events generated by the different built-in self-supervision elements. The internal events are saved in an internal event list.

**Time synchronization**
Use a common global source for example GPS time synchronization inside each substation as well as inside the area of the utility responsibility to achieve a common time base for the IEDs in a protection and control system. This makes comparison and analysis of events and disturbance data between all IEDs in the power system possible.

Time-tagging of internal events and disturbances are an excellent help when evaluating faults. Without time synchronization, only the events within the IED can be compared to one another. With time synchronization, events and disturbances within the entire station, and even between line ends, can be compared during evaluation.

In the IED, the internal time can be synchronized from a number of sources:

- SNTP
- IRIG-B
- DNP
- IEC60870-5-103

**Parameter setting groups ACTVGRP**
Use the four different groups of settings to optimize the IED operation for different power system conditions. Creating and switching between fine-tuned setting sets, either from the local HMI or configurable binary inputs, results in a highly adaptable IED that can cope with a variety of power system scenarios.

**Test mode functionality TESTMODE**
The protection and control IEDs may have many included functions. To make the testing procedure easier, the IEDs include the feature that allows individual blocking of all functions except the function(s) the shall be tested.

There are two ways of entering the test mode:

- By configuration, activating an input signal of the function block TESTMODE
- By setting the IED in test mode in the local HMI

While the IED is in test mode, all protection functions are blocked.

Any function can be unblocked individually regarding functionality and event signaling. This enables the user to follow the operation of one or several related functions to check functionality and to check parts of the configuration, and so on.

**Change lock function CHNGLCK**
Change lock function (CHNGLCK) is used to block further changes to the IED configuration and settings once the commissioning is complete. The purpose is to block inadvertent IED configuration changes beyond a certain point in time.

**Authority status ATHSTAT**
Authority status (ATHSTAT) function is an indication function block for user log-on activity.

**Authority check ATHCHCK**
To safeguard the interests of our customers, both the IED and the tools that are accessing the IED are protected, by means of authorization handling. The authorization handling of the IED and the PCM600 is implemented at both access points to the IED:

- local, through the local HMI
- remote, through the communication ports

**14. Station communication**

**IEC 61850-8-1 communication protocol**
The IED supports the communication protocols IEC 61850-8-1 and DNP3 over TCP/IP. All operational information and controls are available through these protocols. However, some communication functions, for example, horizontal communication (GOOSE) between the IEDs, is only enabled by the IEC 61850-8-1 communication protocol.

The IED is equipped with an optical Ethernet rear port for the substation communication standard IEC 61850-8-1. IEC 61850-8-1 protocol allows intelligent electrical devices (IEDs) from different vendors to exchange information and simplifies system engineering. Peer-to-peer communication according to GOOSE is part of the standard. Disturbance files uploading is provided.
Disturbance files are accessed using the IEC 61850-8-1 protocol. Disturbance files are available to any Ethernet based application via FTP in the standard Comtrade format. Further, the IED can send and receive binary values, double point values and measured values (for example from MMXU functions), together with their quality bit, using the IEC 61850-8-1 GOOSE profile. The IED meets the GOOSE performance requirements for tripping applications in substations, as defined by the IEC 61850 standard. The IED interoperates with other IEC 61850-compliant IEDs, tools, and systems and simultaneously reports events to five different clients on the IEC 61850 station bus.

The event system has a rate limiter to reduce CPU load. The event channel has a quota of 10 events/second. If the quota is exceeded the event channel transmission is blocked until the event changes is below the quota, no event is lost.

All communication connectors, except for the front port connector, are placed on integrated communication modules. The IED is connected to Ethernet-based communication systems via the fibre-optic-based communication systems via the fibre-optic multimode LC connector (100BASE-FX).

The IED supports SNTP and IRIG-B time synchronization methods with a time-stamping resolution of 1 ms.

- Ethernet based: SNTP and DNP3
- With time synchronization wiring: IRIG-B

The IED supports IEC 60870-5-103 time synchronization methods with a time-stamping resolution of 5 ms.

### Table 1. Supported station communication interfaces and protocols

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Ethernet</th>
<th>Serial</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100BASE-FX LC</td>
<td>Glass fibre (ST connector)</td>
</tr>
<tr>
<td>IEC 61850–8–1</td>
<td>●</td>
<td>-</td>
</tr>
<tr>
<td>DNP3</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>IEC 60870-5-103</td>
<td>-</td>
<td>●</td>
</tr>
</tbody>
</table>

※ = Supported

---

**Horizontal communication via GOOSE for interlocking**

GOOSE communication can be used for exchanging information between IEDs via the IEC 61850-8-1 station communication bus. This is typically used for sending apparatus position indications for interlocking or reservation signals for 1-of-n control. GOOSE can also be used to exchange any boolean, integer, double point and analog measured values between IEDs.

**DNP3 protocol**

DNP3 (Distributed Network Protocol) is a set of communications protocols used to communicate data between components in process automation systems. For a detailed description of the DNP3 protocol, see the DNP3 Communication protocol manual.

**IEC 60870-5-103 communication protocol**

IEC 60870-5-103 is an unbalanced (master-slave) protocol for coded-bit serial communication exchanging information with a control system, and with a data transfer rate up to 19200 bit/s. In IEC terminology, a primary station is a master and a secondary station is a slave. The communication is based on a point-to-point principle. The master must have software that can interpret IEC 60870-5-103 communication messages.

IEC 60870-5-103 protocol can be configured to use either the optical serial or RS485 serial communication interface on the COM05 communication module. The functions Operation selection for optical serial (OPTICALPROT) and Operation selection for RS485 (RS485PROT) are used to select the communication interface.
The functions IEC60870-5-103 Optical serial communication (OPTICAL103) and IEC60870-5-103 serial communication for RS485 (RS485103) are used to configure the communication parameters for either the optical serial or RS485 serial communication interfaces.

15. Hardware description

Layout and dimensions
Mounting alternatives
The following mounting alternatives are available (IP40 protection from the front):

- 19" rack mounting kit

Rack mounting a single 3U IED

Figure 5. Rack mounted 3U IED

A  224 mm + 12 mm with ring-lug connectors
B  22.5 mm
C  482 mm
D  132 mm, 3U
16. Connection diagrams Customized

Connection diagrams for 650 series

Figure 6. Designation for 3U, 1/1x19" casing with 1 TRM

Figure 7. Designation for 3U, 1/1x19" casing with 1 TRM and 1 AIM
Observe polarity sequence of RL connectors
Figure 9. Power supply module (PSM) 48-125V DC
Breaker protection REQ650

Product version: 1.2

Figure 10. Power supply module (PSM) 110-250V DC, 100-240V AC

Observe polarity sequence

Figure 11. Transformer module (TRM)

Compression or ring lug terminals
- Indicates high polarity. Note that internal polarity can be adjusted by setting analog input CT neutral direction and/or SMAl pre-processing function blocks.

Designation corresponding to Transformer module

<table>
<thead>
<tr>
<th>Designation</th>
<th>Current configuration</th>
<th>Voltage configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>A01</td>
<td>1.5A</td>
<td>1.5A</td>
</tr>
<tr>
<td>A02</td>
<td>1.5A</td>
<td>1.5A</td>
</tr>
<tr>
<td>A03</td>
<td>1.5A</td>
<td>1.5A</td>
</tr>
<tr>
<td>A04</td>
<td>1.5A</td>
<td>1.5A</td>
</tr>
<tr>
<td>A05</td>
<td>1.5A</td>
<td>3.15A</td>
</tr>
<tr>
<td>A06</td>
<td>1.75A</td>
<td>1.75A</td>
</tr>
<tr>
<td>A07</td>
<td>100-220V</td>
<td>100-220V</td>
</tr>
<tr>
<td>A08</td>
<td>100-220V</td>
<td>100-220V</td>
</tr>
<tr>
<td>A10</td>
<td>100-220V</td>
<td>100-220V</td>
</tr>
</tbody>
</table>
Figure 12. Analog input (AIM)

Designation corresponding to Analog input module

<table>
<thead>
<tr>
<th>CT/VT Input</th>
<th>Current/voltage configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>designation</td>
<td>E (Am)</td>
</tr>
<tr>
<td>A01</td>
<td>1/5A</td>
</tr>
<tr>
<td>A02</td>
<td>1/5A</td>
</tr>
<tr>
<td>A03</td>
<td>1/5A</td>
</tr>
<tr>
<td>A04</td>
<td>1/5A</td>
</tr>
<tr>
<td>A05</td>
<td>1/5A</td>
</tr>
<tr>
<td>A06</td>
<td>1/5A</td>
</tr>
<tr>
<td>A07</td>
<td>100-220V</td>
</tr>
<tr>
<td>A08</td>
<td>100-220V</td>
</tr>
<tr>
<td>A09</td>
<td>100-220V</td>
</tr>
<tr>
<td>A10</td>
<td>100-220V</td>
</tr>
</tbody>
</table>

Compression or ring lug terminals

* Indicates high priority. Note that internal priority can be adjusted by setting of analog input CT neutral direction and or on SNAI pre-processing function blocks.

Figure 13. Binary input/output (BIO) option

Designation in correspondence to the load in the rock

<table>
<thead>
<tr>
<th>pN</th>
<th>XA</th>
<th>XB</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>X31</td>
<td>X32</td>
</tr>
<tr>
<td>#2</td>
<td>X32</td>
<td>X32</td>
</tr>
<tr>
<td>#3</td>
<td>X33</td>
<td>X33</td>
</tr>
<tr>
<td>#4</td>
<td>X33</td>
<td>X33</td>
</tr>
</tbody>
</table>

Observe polarity sequence of RL connectors
17. Connection diagrams Configured

Figure 14. Designation for 3U, 1/1x19" casing with 1 TRM
Connection diagrams for REQ650 A01

Figure 15. Communication module (COM)

Observe polarity sequence of RL connectors.
Figure 16. Power supply module (PSM) 48–125 V DC

Observe polarity sequence
Figure 17. Power supply module (PSM), 110–250 VDC, 100–240 VAC (PSM)

Observe polarity sequence

Power supply module 110–250 VDC, 100–240 VAC (PSM)

T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T11
T12
T13
T14
T15
T16
T17
T18

CONFIGURATION

DAT_TIP
SPARE
SPARE
AUTO_SC_OK
MAN_SC_OK
GENERAL_ALARM
S1
SPARE
S2
SPARE
S3
GENERAL_TRI

INTERNAL_FAIL

PROTECTIVE_Earth

X317
X318
X319

Ready
Fall

ABB
**Breaker protection REQ650**

**Product version: 1.2**

---

### Transformer module (TRM)

<table>
<thead>
<tr>
<th>Terminals</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>X101</td>
<td>CT/VT CONFO = 4+11+5U</td>
</tr>
<tr>
<td>LINE_CT_L1</td>
<td>AIO1 1/5A</td>
</tr>
<tr>
<td>LINE_CT_L2</td>
<td>AIO2 1/5A</td>
</tr>
<tr>
<td>LINE_CT_L3</td>
<td>AIO3 1/5A</td>
</tr>
<tr>
<td>SPARE</td>
<td>AIO4 1/5A</td>
</tr>
<tr>
<td>LINE_CT_NSEN</td>
<td>AIO5 0.1/0.5A</td>
</tr>
<tr>
<td>X102</td>
<td></td>
</tr>
<tr>
<td>LINE_VT_L1</td>
<td>AIO6 100–220V</td>
</tr>
<tr>
<td>LINE_VT_L2</td>
<td>AIO7 100–220V</td>
</tr>
<tr>
<td>LINE_VT_L3</td>
<td>AIO8 100–220V</td>
</tr>
<tr>
<td>BUS_WA1_UL1L2</td>
<td>AIO9 100–220V</td>
</tr>
<tr>
<td>SPARE</td>
<td>AIO10 100–220V</td>
</tr>
</tbody>
</table>

---

**Compression or ringlug terminals**

- Indicates high polarity. Note that internal polarity can be adjusted by setting of analog input CT neutral direction and or on SMAI pre-processing function blocks.

---

**Figure 18. Transformer module (TRM)**
Figure 19. Binary input/output (BIO) option

Observe polarity sequence of RL connectors
Connection diagrams for REQ650 A11

Observe polarity sequence of RL connectors

Figure 20. Communication module (COM)
Figure 21. Power supply module (PSM) 48-125V DC
Figure 22. Power supply module (PSM), 110–250 VDC, 100–240 VAC (PSM)

Breaker protection REQ650

Product version: 1.2

Observe polarity sequence

Power supply module 110–250 VDC, 100–240 VAC (PSM)
Breaker protection REQ650

Product version: 1.2

Figure 23. Transformer module (TRM)

Transformar module (TRM)

CT/VT CONFIG=4+11+5L

<table>
<thead>
<tr>
<th>X101</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>LINE_CT_L1</td>
<td>2</td>
</tr>
<tr>
<td>LINE_CT_L2</td>
<td>3</td>
</tr>
<tr>
<td>LINE_CT_L3</td>
<td>4</td>
</tr>
<tr>
<td>SPARE</td>
<td>5</td>
</tr>
<tr>
<td>LINE_CT_INSEN</td>
<td>6</td>
</tr>
<tr>
<td>LINE_VT_L1</td>
<td>7</td>
</tr>
<tr>
<td>LINE_VT_L2</td>
<td>8</td>
</tr>
<tr>
<td>LINE_VT_L3</td>
<td>9</td>
</tr>
<tr>
<td>BUS_WA1_UL1L2</td>
<td>10</td>
</tr>
<tr>
<td>SPARE</td>
<td>11</td>
</tr>
</tbody>
</table>

Compression or ring lug terminals

- Indicates high polarity. Note that internal polarity can be adjusted by setting of analog input CT neutral direction and or on SMAI pre-processing function blocks.

ABB
Figure 24. Binary input/output (BIO) option

Observe polarity sequence of RL connectors.
Figure 25. Binary input/output (BIO) option
Connection diagrams for REQ650 B11

Figure 26. Communication module (COM)

Observe polarity sequence of RL connectors
Figure 27. Power supply module (PSM) 48–125V DC
Breaker protection REQ650

Product version: 1.2

Power supply module 110–250 VDC, 100–240 VAC (PSM)

Figure 28. Power supply module (PSM), 110-250V DC, 100–240V AC

Observe polarity sequence
Figure 29. Transformer module (TRM)

Compression or ring lug terminals

- Indicates high polarity. Note that internal polarity can be adjusted by setting of analog input CT neutral direction and on SMAI pre-processing function blocks.
Figure 30. Binary input/output (BIO) option
Figure 31. Binary input/output (BIO) option
18. Technical data

General

**Definitions**

<table>
<thead>
<tr>
<th><strong>Reference value</strong></th>
<th>The specified value of an influencing factor to which are referred the characteristics of the equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nominal range</strong></td>
<td>The range of values of an influencing quantity (factor) within which, under specified conditions, the equipment meets the specified requirements</td>
</tr>
<tr>
<td><strong>Operative range</strong></td>
<td>The range of values of a given energizing quantity for which the equipment, under specified conditions, is able to perform its intended functions according to the specified requirements</td>
</tr>
</tbody>
</table>

**Energizing quantities, rated values and limits**

**Analog inputs**

**Table 2. Energizing inputs**

<table>
<thead>
<tr>
<th><strong>Description</strong></th>
<th><strong>Value</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated frequency</td>
<td>50/60 Hz</td>
</tr>
<tr>
<td>Operating range</td>
<td>Rated frequency ± 5 Hz</td>
</tr>
<tr>
<td><strong>Current inputs</strong></td>
<td><strong>Rating</strong>, (I_n)</td>
</tr>
<tr>
<td>Thermal withstand capability:</td>
<td></td>
</tr>
<tr>
<td>• Continuously</td>
<td>4 A</td>
</tr>
<tr>
<td>• For 1 s</td>
<td>100 A</td>
</tr>
<tr>
<td>• For 10 s</td>
<td>20 A</td>
</tr>
<tr>
<td>Dynamic current withstand:</td>
<td></td>
</tr>
<tr>
<td>• Half-wave value</td>
<td>250 A</td>
</tr>
<tr>
<td>Input impedance</td>
<td>&lt;100 mΩ</td>
</tr>
<tr>
<td><strong>Voltage inputs</strong></td>
<td><strong>Rating</strong>, (U_n)</td>
</tr>
<tr>
<td>Voltage withstand:</td>
<td></td>
</tr>
<tr>
<td>• Continuous</td>
<td>420 V rms</td>
</tr>
<tr>
<td>• For 10 s</td>
<td>450 V rms</td>
</tr>
<tr>
<td>Burden at rated voltage</td>
<td>&lt;0.05 VA</td>
</tr>
</tbody>
</table>

*) max. 350 A for 1 s when COMBITEST test switch is included.

1) Residual current
2) Phase currents or residual current
Auxiliary AC and DC voltage

Table 3. Power supply

<table>
<thead>
<tr>
<th>Description</th>
<th>600PSM02</th>
<th>600PSM03</th>
</tr>
</thead>
<tbody>
<tr>
<td>$U_{aux}^{\text{nominal}}$</td>
<td>48, 60, 110, 125 V DC</td>
<td>100, 110, 120, 220, 240 V AC, 50 and 60 Hz</td>
</tr>
<tr>
<td></td>
<td></td>
<td>110, 125, 220, 250 V DC</td>
</tr>
<tr>
<td>$U_{aux}^{\text{variation}}$</td>
<td>80...120% of $U_n$ (38.4...150 V DC)</td>
<td>85...110% of $U_n$ (85...264 V AC)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>80...120% of $U_n$ (88...300 V DC)</td>
</tr>
<tr>
<td>Maximum load of auxiliary voltage supply</td>
<td>35 W for DC</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>40 W for AC</td>
</tr>
<tr>
<td>Ripple in the DC auxiliary voltage</td>
<td>Max 15% of the DC value (at frequency of 100 and 120 Hz)</td>
<td></td>
</tr>
<tr>
<td>Maximum interruption time in the auxiliary DC voltage without resetting the IED</td>
<td>50 ms at $U_{aux}$</td>
<td></td>
</tr>
</tbody>
</table>

Binary inputs and outputs

Table 4. Binary inputs

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating range</td>
<td>Maximum input voltage 300 V DC</td>
</tr>
<tr>
<td>Rated voltage</td>
<td>24...250 V DC</td>
</tr>
<tr>
<td>Current drain</td>
<td>1.6...1.8 mA</td>
</tr>
<tr>
<td>Power consumption/input</td>
<td>&lt;0.38 W</td>
</tr>
<tr>
<td>Threshold voltage</td>
<td>15...221 V DC (parametrizable in the range in steps of 1% of the rated voltage)</td>
</tr>
</tbody>
</table>

Table 5. Signal output and IRF output

IRF relay change over - type signal output relay

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated voltage</td>
<td>250 V AC/DC</td>
</tr>
<tr>
<td>Continuous contact carry</td>
<td>5 A</td>
</tr>
<tr>
<td>Make and carry for 3.0 s</td>
<td>10 A</td>
</tr>
<tr>
<td>Make and carry 0.5 s</td>
<td>30 A</td>
</tr>
<tr>
<td>Breaking capacity when the control-circuit time constant L/R&lt;40 ms, at U&lt; 48/110/220 V DC</td>
<td>≤0.5 A/≤0.1 A/≤0.04 A</td>
</tr>
</tbody>
</table>
### Table 6. Power output relays without TCS function

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated voltage</td>
<td>250 V AC/DC</td>
</tr>
<tr>
<td>Continuous contact carry</td>
<td>8 A</td>
</tr>
<tr>
<td>Make and carry for 3.0 s</td>
<td>15 A</td>
</tr>
<tr>
<td>Make and carry for 0.5 s</td>
<td>30 A</td>
</tr>
<tr>
<td>Breaking capacity when the control-circuit time constant (L/R&lt;40\ ms, \text{at } U&lt;48/110/220\ V\ DC)</td>
<td>(\leq 1\ A/\leq 0.3\ A/\leq 0.1\ A)</td>
</tr>
</tbody>
</table>

### Table 7. Power output relays with TCS function

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated voltage</td>
<td>250 V DC</td>
</tr>
<tr>
<td>Continuous contact carry</td>
<td>8 A</td>
</tr>
<tr>
<td>Make and carry for 3.0 s</td>
<td>15 A</td>
</tr>
<tr>
<td>Make and carry for 0.5 s</td>
<td>30 A</td>
</tr>
<tr>
<td>Breaking capacity when the control-circuit time constant (L/R&lt;40\ ms, \text{at } U&lt;48/110/220\ V\ DC)</td>
<td>(\leq 1\ A/\leq 0.3\ A/\leq 0.1\ A)</td>
</tr>
<tr>
<td>Control voltage range</td>
<td>20...250 V DC</td>
</tr>
<tr>
<td>Current drain through the supervision circuit</td>
<td>~1.0 mA</td>
</tr>
<tr>
<td>Minimum voltage over the TCS contact</td>
<td>20 V DC</td>
</tr>
</tbody>
</table>

### Table 8. Ethernet interfaces

<table>
<thead>
<tr>
<th>Ethernet interface</th>
<th>Protocol</th>
<th>Cable</th>
<th>Data transfer rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>100BASE-TX</td>
<td>-</td>
<td>CAT 6 S/FTP or better</td>
<td>100 MBits/s</td>
</tr>
<tr>
<td>100BASE-FX</td>
<td>TCP/IP</td>
<td>Fibre-optic cable with LC connector</td>
<td>100 MBits/s</td>
</tr>
</tbody>
</table>

### Table 9. Fibre-optic communication link

<table>
<thead>
<tr>
<th>Wave length</th>
<th>Fibre type</th>
<th>Connector</th>
<th>Permitted path attenuation(^1)</th>
<th>Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1300 nm</td>
<td>MM 62.5/125 μm glass fibre core</td>
<td>LC</td>
<td>&lt;8 dB</td>
<td>2 km</td>
</tr>
</tbody>
</table>

\(^1\) Maximum allowed attenuation caused by connectors and cable together
Table 10. X8/IRIG-B and EIA-485 interface

<table>
<thead>
<tr>
<th>Type</th>
<th>Protocol</th>
<th>Cable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Screw terminal, pin row header</td>
<td>IRIG-B</td>
<td>Shielded twisted pair cable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Recommended: CAT 5, Belden RS-485 (9841-9844) or Alpha Wire (Alpha 6222-6230)</td>
</tr>
<tr>
<td>Screw terminal, pin row header</td>
<td></td>
<td>Shielded twisted pair cable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Recommended: DESCASFLLEX RD-H(ST)H-2x2x0.22mm², Belden 9729, Belden 9829</td>
</tr>
</tbody>
</table>

Table 11. IRIG-B

<table>
<thead>
<tr>
<th>Type</th>
<th>Value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input impedance</td>
<td>430 Ohm</td>
<td>—</td>
</tr>
<tr>
<td>Minimum input voltage HIGH</td>
<td>4.3 V</td>
<td>—</td>
</tr>
<tr>
<td>Maximum input voltage LOW</td>
<td>0.8 V</td>
<td>—</td>
</tr>
</tbody>
</table>

Table 12. EIA-485 interface

<table>
<thead>
<tr>
<th>Type</th>
<th>Value</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum differential driver output voltage</td>
<td>1.5 V</td>
<td>—</td>
</tr>
<tr>
<td>Maximum output current</td>
<td>60 mA</td>
<td>—</td>
</tr>
<tr>
<td>Minimum differential receiver input voltage</td>
<td>0.2 V</td>
<td>—</td>
</tr>
<tr>
<td>Supported bit rates</td>
<td>300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200</td>
<td>—</td>
</tr>
<tr>
<td>Maximum number of 650 IEDs supported on the same bus</td>
<td>32</td>
<td>—</td>
</tr>
<tr>
<td>Max. cable length</td>
<td>925 m (3000 ft)</td>
<td>Cable: AWG24 or better, stub lines shall be avoided</td>
</tr>
</tbody>
</table>

Table 13. Serial rear interface

<table>
<thead>
<tr>
<th>Type</th>
<th>Counter connector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serial port (X9)</td>
<td>Optical serial port, type ST for IEC 60870-5-103 and DNP serial</td>
</tr>
</tbody>
</table>
Table 14. Optical serial port (X9)

<table>
<thead>
<tr>
<th>Wave length</th>
<th>Fibre type</th>
<th>Connector</th>
<th>Permitted path attenuation¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>820 nm</td>
<td>MM 62.5/125 µm glass fibre core</td>
<td>ST</td>
<td>6.8 dB (approx. 1700m length with 4 db / km fibre attenuation)</td>
</tr>
<tr>
<td>820 nm</td>
<td>MM 50/125 µm glass fibre core</td>
<td>ST</td>
<td>2.4 dB (approx. 600m length with 4 db / km fibre attenuation)</td>
</tr>
</tbody>
</table>

¹) Maximum allowed attenuation caused by fibre

Influencing factors

Table 15. Degree of protection of rack-mounted IED

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front side</td>
<td>IP 40</td>
</tr>
<tr>
<td>Rear side, connection terminals</td>
<td>IP 20</td>
</tr>
</tbody>
</table>

Table 16. Degree of protection of the LHMI

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front and side</td>
<td>IP40</td>
</tr>
</tbody>
</table>

Table 17. Environmental conditions

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating temperature range</td>
<td>-25...+55°C (continuous)</td>
</tr>
<tr>
<td>Short-time service temperature range</td>
<td>-40...+70°C (&lt;16h)</td>
</tr>
<tr>
<td></td>
<td>Note: Degradation in MTBF and HMI performance outside the temperature range of -25...+55°C</td>
</tr>
<tr>
<td>Relative humidity</td>
<td>&lt;93%, non-condensing</td>
</tr>
<tr>
<td>Atmospheric pressure</td>
<td>86...106 kPa</td>
</tr>
<tr>
<td>Altitude</td>
<td>up to 2000 m</td>
</tr>
<tr>
<td>Transport and storage temperature range</td>
<td>-40...+85°C</td>
</tr>
</tbody>
</table>
Table 18. Environmental tests

<table>
<thead>
<tr>
<th>Description</th>
<th>Type test value</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold tests</td>
<td>operation</td>
<td>IEC 60068-2-1/ANSI C37.90-2005 (chapter 4)</td>
</tr>
<tr>
<td></td>
<td>storage</td>
<td></td>
</tr>
<tr>
<td></td>
<td>96 h at -25°C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>16 h at -40°C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>96 h at -40°C</td>
<td></td>
</tr>
<tr>
<td>Dry heat tests</td>
<td>operation</td>
<td>IEC 60068-2-2/ANSI C37.90-2005 (chapter 4)</td>
</tr>
<tr>
<td></td>
<td>storage</td>
<td></td>
</tr>
<tr>
<td></td>
<td>16 h at +70°C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>96 h at +85°C</td>
<td></td>
</tr>
<tr>
<td>Damp heat tests</td>
<td>steady state</td>
<td>IEC 60068-2-78</td>
</tr>
<tr>
<td></td>
<td>cyclic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>240 h at +40°C, humidity 93%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6 cycles at +25 to +55°C, humidity 93...95%</td>
<td>IEC 60068-2-30</td>
</tr>
</tbody>
</table>
### Type tests according to standards

#### Table 19. Electromagnetic compatibility tests

<table>
<thead>
<tr>
<th>Description</th>
<th>Type test value</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 kHz and 1 MHz burst disturbance test</td>
<td></td>
<td>IEC 61000-4-18, level 3</td>
</tr>
<tr>
<td>• Common mode</td>
<td>2.5 kV</td>
<td>IEC 60255-22-1, ANSI C37.90.1-2002</td>
</tr>
<tr>
<td>• Differential mode</td>
<td>2.5 kV</td>
<td></td>
</tr>
<tr>
<td>Electrostatic discharge test</td>
<td></td>
<td>IEC 61000-4-2, level 4</td>
</tr>
<tr>
<td>• Contact discharge</td>
<td>8 kV</td>
<td>IEC 60255-22-2, ANSI C37.90.3-2001</td>
</tr>
<tr>
<td>• Air discharge</td>
<td>15 kV</td>
<td></td>
</tr>
<tr>
<td>Radio frequency interference tests</td>
<td></td>
<td>IEC 61000-4-6, level 3</td>
</tr>
<tr>
<td>• Conducted, common mode</td>
<td>10 V (emf), f=150 kHz...80 MHz</td>
<td>IEC 60255-22-6</td>
</tr>
<tr>
<td>• Radiated, amplitude-modulated</td>
<td>20 V/m (rms), f=60...1000 MHz and f=1.4...2.7 GHz</td>
<td>IEC 60255-22-3, ANSI C37.90.2-2004</td>
</tr>
<tr>
<td>Fast transient disturbance tests</td>
<td></td>
<td>IEC 61000-4-4</td>
</tr>
<tr>
<td>• Communication ports</td>
<td>4 kV</td>
<td>IEC 60255-22-4, class A, ANSI C37.90.1-2002</td>
</tr>
<tr>
<td>• Other ports</td>
<td>4 kV</td>
<td></td>
</tr>
<tr>
<td>Surge immunity test</td>
<td></td>
<td>IEC 61000-4-5, level 3/2</td>
</tr>
<tr>
<td>• Communication</td>
<td>1 kV line-to-earth</td>
<td>IEC 60255-22-5</td>
</tr>
<tr>
<td>• Other ports</td>
<td>2 kV line-to-earth, 1 kV line-to-line</td>
<td></td>
</tr>
<tr>
<td>Power frequency (50 Hz) magnetic field</td>
<td></td>
<td>IEC 61000-4-8, level 5</td>
</tr>
<tr>
<td>• 3 s</td>
<td>1000 A/m</td>
<td></td>
</tr>
<tr>
<td>• Continuous</td>
<td>100 A/m</td>
<td></td>
</tr>
<tr>
<td>Pulse magnetic field immunity test</td>
<td>1000A/m</td>
<td>IEC 61000-4-9, level 5</td>
</tr>
<tr>
<td>Power frequency immunity test</td>
<td></td>
<td>IEC 60255-22-7, class A</td>
</tr>
<tr>
<td>• Common mode</td>
<td>300 V rms</td>
<td>IEC 61000-4-16</td>
</tr>
<tr>
<td>• Differential mode</td>
<td>150 V rms</td>
<td></td>
</tr>
</tbody>
</table>
### Table 19. Electromagnetic compatibility tests, continued

<table>
<thead>
<tr>
<th>Description</th>
<th>Type test value</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage dips and short interruptions on DC power supply</td>
<td>Dips: 40%/200 ms 70%/500 ms Interruptions: 0-50 ms: No restart 0...∞ s: Correct behaviour at power down</td>
<td>IEC 60255-11  IEC 61000-4-11</td>
</tr>
<tr>
<td>Voltage dips and interruptions on AC power supply</td>
<td>Dips: 40% 10/12 cycles at 50/60 Hz 70% 25/30 cycles at 50/60 Hz Interruptions: 0–50 ms: No restart 0...∞ s: Correct behaviour at power down</td>
<td>IEC 60255–11  IEC 61000–4–11</td>
</tr>
<tr>
<td>Electromagnetic emission tests</td>
<td></td>
<td>EN 55011, class A IEC 60255-25</td>
</tr>
<tr>
<td>• Conducted, RF-emission (mains terminal)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.15...0.50 MHz</td>
<td>&lt; 79 dB(µV) quasi peak &lt; 66 dB(µV) average</td>
<td></td>
</tr>
<tr>
<td>0.5...30 MHz</td>
<td>&lt; 73 dB(µV) quasi peak &lt; 60 dB(µV) average</td>
<td></td>
</tr>
<tr>
<td>• Radiated RF-emission</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30...230 MHz</td>
<td>&lt; 40 dB(µV/m) quasi peak, measured at 10 m distance</td>
<td></td>
</tr>
<tr>
<td>230...1000 MHz</td>
<td>&lt; 47 dB(µV/m) quasi peak, measured at 10 m distance</td>
<td></td>
</tr>
</tbody>
</table>
### Table 20. Insulation tests

<table>
<thead>
<tr>
<th>Description</th>
<th>Type test value</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dielectric tests:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Test voltage</td>
<td>2 kV, 50 Hz, 1 min</td>
<td>IEC 60255-5, ANSI C37.90-2005</td>
</tr>
<tr>
<td></td>
<td>1 kV, 50 Hz, 1 min, communication</td>
<td></td>
</tr>
<tr>
<td><strong>Impulse voltage test:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Test voltage</td>
<td>5 kV, unipolar impulses, waveform 1.2/50 μs, source energy 0.5 J</td>
<td>IEC 60255-5, ANSI C37.90-2005</td>
</tr>
<tr>
<td></td>
<td>1 kV, unipolar impulses, waveform 1.2/50 μs, source energy 0.5 J, communication</td>
<td></td>
</tr>
<tr>
<td><strong>Insulation resistance measurements</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Isolation resistance</td>
<td>&gt;100 MQ, 500 V DC</td>
<td>IEC 60255-5, ANSI C37.90-2005</td>
</tr>
<tr>
<td><strong>Protective bonding resistance</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Resistance</td>
<td>&lt;0.1 Ω (60 s)</td>
<td>IEC 60255-27</td>
</tr>
</tbody>
</table>

### Table 21. Mechanical tests

<table>
<thead>
<tr>
<th>Description</th>
<th>Reference</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vibration response tests (sinusoidal)</td>
<td>IEC 60255-21-1</td>
<td>Class 2</td>
</tr>
<tr>
<td>Vibration endurance test</td>
<td>IEC 60255-21-1</td>
<td>Class 1</td>
</tr>
<tr>
<td>Shock response test</td>
<td>IEC 60255-21-2</td>
<td>Class 1</td>
</tr>
<tr>
<td>Shock withstand test</td>
<td>IEC 60255-21-2</td>
<td>Class 1</td>
</tr>
<tr>
<td>Bump test</td>
<td>IEC 60255-21-2</td>
<td>Class 1</td>
</tr>
<tr>
<td>Seismic test</td>
<td>IEC 60255-21-3</td>
<td>Class 2</td>
</tr>
</tbody>
</table>

### Product safety

### Table 22. Product safety

<table>
<thead>
<tr>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>LV directive</td>
<td>2006/95/EC</td>
</tr>
<tr>
<td>Standard</td>
<td>EN 60255-27 (2005)</td>
</tr>
</tbody>
</table>
EMC compliance

Table 23. EMC compliance

<table>
<thead>
<tr>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMC directive</td>
<td>2004/108/EC</td>
</tr>
<tr>
<td>Standard</td>
<td>EN 50263 (2000)</td>
</tr>
<tr>
<td></td>
<td>EN 60255-26 (2007)</td>
</tr>
</tbody>
</table>

Current protection

Table 24. Instantaneous phase overcurrent protection, 3-phase output PHPIOC

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operate current</td>
<td>(5-2500)% of IBase</td>
<td>± 1.0% of I ( \leq I_r )</td>
</tr>
<tr>
<td></td>
<td></td>
<td>± 1.0% of I ( I &gt; I_r )</td>
</tr>
<tr>
<td>Reset ratio</td>
<td>&gt; 95%</td>
<td>-</td>
</tr>
<tr>
<td>Operate time</td>
<td>20 ms typically at 0</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>to 2 ( \times I_{set} )</td>
<td></td>
</tr>
<tr>
<td>Reset time</td>
<td>30 ms typically at 2</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>( \times I_{set} )</td>
<td></td>
</tr>
<tr>
<td>Critical impulse time</td>
<td>10 ms typically at 0</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>( \times 2 \times I_{set} )</td>
<td></td>
</tr>
<tr>
<td>Operate time</td>
<td>10 ms typically at 0</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>( \times 5 \times I_{set} )</td>
<td></td>
</tr>
<tr>
<td>Reset time</td>
<td>40 ms typically at 5</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>( \times I_{set} )</td>
<td></td>
</tr>
<tr>
<td>Critical impulse time</td>
<td>2 ms typically at 0</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>( \times 5 \times I_{set} )</td>
<td></td>
</tr>
<tr>
<td>Dynamic overreach</td>
<td>&lt; 5% at ( \tau = 100 ) ms</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 25. Instantaneous phase overcurrent protection, phase segregated output SPTPIOC

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operate current</td>
<td>(5-2500)% of IBase</td>
<td>± 1.0% of I ( \leq I_r )</td>
</tr>
<tr>
<td></td>
<td></td>
<td>± 1.0% of I ( I &gt; I_r )</td>
</tr>
<tr>
<td>Reset ratio</td>
<td>&gt; 95%</td>
<td>-</td>
</tr>
<tr>
<td>Operate time</td>
<td>20 ms typically at 0</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>( \times 2 \times I_{set} )</td>
<td></td>
</tr>
<tr>
<td>Reset time</td>
<td>30 ms typically at 2</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>( \times I_{set} )</td>
<td></td>
</tr>
<tr>
<td>Critical impulse time</td>
<td>10 ms typically at 0</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>( \times 2 \times I_{set} )</td>
<td></td>
</tr>
<tr>
<td>Operate time</td>
<td>10 ms typically at 0</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>( \times 5 \times I_{set} )</td>
<td></td>
</tr>
<tr>
<td>Reset time</td>
<td>40 ms typically at 5</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>( \times I_{set} )</td>
<td></td>
</tr>
<tr>
<td>Critical impulse time</td>
<td>2 ms typically at 0</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>( \times 5 \times I_{set} )</td>
<td></td>
</tr>
<tr>
<td>Dynamic overreach</td>
<td>&lt; 5% at ( \tau = 100 ) ms</td>
<td>-</td>
</tr>
</tbody>
</table>
Table 26. Four step phase overcurrent protection, 3-phase output OC4PTOC

<table>
<thead>
<tr>
<th>Function</th>
<th>Setting range</th>
<th>Accuracy</th>
</tr>
</thead>
</table>
| Operate current                 | (5-2500)% of \(I_{Base}\) | ± 1.0% of \(I_{r}\) at \(I \leq I_{r}\)  
  ± 1.0% of \(I\) at \(I > I_{r}\) |
| Reset ratio                     | > 95%         | -                                                                        |
| Min. operating current          | (1-10000)% of \(I_{Base}\) | ± 1.0% of \(I_{r}\) at \(I \leq I_{r}\)  
  ±1.0% of \(I\) at \(I > I_{r}\) |
| 2nd harmonic blocking           | (5–100)% of fundamental | ± 2.0% of \(I_{r}\)   |
| Independent time delay          | (0.000-60.000) s | ± 0.5% ±25 ms  |
| Minimum operate time for inverse characteristics | (0.000-60.000) s | ± 0.5% ±25 ms  |
| Inverse characteristics, see table 73, table 74 and table 75 | 17 curve types | 1) ANSI/IEEE C37.112 IEC 60255–151 ±3% or ±40 ms  
  0.10 ≤ \(k\) ≤ 3.00  
  1.5 × \(I_{set}\) ≤ \(I\) ≤ 20 × \(I_{set}\) |
| Operate time, nondirectional start function | 25 ms typically at 0 to 2 × \(I_{set}\) | - |
| Reset time, nondirectional start function | 30 ms typically at 2 to 0 × \(I_{set}\) | - |
| Operate time, directional start function | 50 ms typically at 0 to 2 × \(I_{set}\) | - |
| Reset time, directional start function | 35 ms typically at 2 to 0 × \(I_{set}\) | - |
| Critical impulse time           | 10 ms typically at 0 to 2 × \(I_{set}\) | - |
| Impulse margin time             | 15 ms typically | - |

1) **Note:** Timing accuracy only valid when 2nd harmonic blocking is turned off
Table 27. Four step phase overcurrent protection, phase segregated output OC4SPTOC

<table>
<thead>
<tr>
<th>Function</th>
<th>Setting range</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operate current</td>
<td>(5-2500)% of iBase</td>
<td>± 1.0% of Iᵣ at I ≤ Iᵣ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>± 1.0% of I at I &gt; Iᵣ</td>
</tr>
<tr>
<td>Reset ratio</td>
<td>&gt; 95%</td>
<td>-</td>
</tr>
<tr>
<td>Min. operating current</td>
<td>(1-10000)% of iBase</td>
<td>± 1.0% of Iᵣ at I &lt; Iᵣ ± 1.0% of I at I &gt; Iᵣ</td>
</tr>
<tr>
<td>Independent time delay</td>
<td>(0.000-60.000) s</td>
<td>± 0.5% ± 25 ms</td>
</tr>
<tr>
<td>Minimum operate time for inverse</td>
<td>(0.000-60.000) s</td>
<td>± 0.5% ± 25 ms</td>
</tr>
<tr>
<td>characteristics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inverse characteristics, see</td>
<td>17 curve types</td>
<td></td>
</tr>
<tr>
<td>table 73, table 74 and table 75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operate time, nondirectional</td>
<td>25 ms typically at 0 to 2 x Iₛₑₜ</td>
<td>-</td>
</tr>
<tr>
<td>start function</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reset time, nondirectional start</td>
<td>30 ms typically at 2 to 0 x Iₛₑₜ</td>
<td>-</td>
</tr>
<tr>
<td>function</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operate time, directional start</td>
<td>50 ms typically at 0 to 2 x Iₛₑₜ</td>
<td>-</td>
</tr>
<tr>
<td>function</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reset time, directional start</td>
<td>35 ms typically at 2 to 0 x Iₛₑₜ</td>
<td>-</td>
</tr>
<tr>
<td>function</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Critical impulse time</td>
<td>10 ms typically at 0 to 2 x Iₛₑₜ</td>
<td>-</td>
</tr>
<tr>
<td>Impulse margin time</td>
<td>15 ms typically</td>
<td>-</td>
</tr>
</tbody>
</table>

1) **Note:** Timing accuracy only valid when 2nd harmonic blocking is turned off.

Table 28. Instantaneous residual overcurrent protection EFPIOC

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operate current</td>
<td>(1-2500)% of iBase</td>
<td>± 1.0% of Iᵣ at I ≤ Iᵣ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>± 1.0% of I at I &gt; Iᵣ</td>
</tr>
<tr>
<td>Reset ratio</td>
<td>&gt; 95%</td>
<td>-</td>
</tr>
<tr>
<td>Operate time</td>
<td>20 ms typically at 0 to 2 x Iₛₑₜ</td>
<td>-</td>
</tr>
<tr>
<td>Reset time</td>
<td>30 ms typically at 2 to 0 x Iₛₑₜ</td>
<td>-</td>
</tr>
<tr>
<td>Critical impulse time</td>
<td>10 ms typically at 0 to 2 x Iₛₑ₅</td>
<td>-</td>
</tr>
<tr>
<td>Operate time</td>
<td>10 ms typically at 0 to 5x Iₛₑ₅</td>
<td>-</td>
</tr>
<tr>
<td>Reset time</td>
<td>40 ms typically at 5 to 0x Iₛₑ₅</td>
<td>-</td>
</tr>
<tr>
<td>Critical impulse time</td>
<td>2 ms typically at 0 to 5 x Iₛₑ₅</td>
<td>-</td>
</tr>
<tr>
<td>Dynamic overreach</td>
<td>&lt; 5% at t = 100 ms</td>
<td>-</td>
</tr>
</tbody>
</table>
Table 29. Four step residual overcurrent protection EF4PTOC

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operate current</td>
<td>(1-2500)% of ( I_{\text{Base}} )</td>
<td>( \pm 1.0% \text{ of } I_r ) at ( I &lt; I_r ) ( \pm 1.0% \text{ of } I ) at ( I &gt; I_r )</td>
</tr>
<tr>
<td>Reset ratio</td>
<td>&gt; 95%</td>
<td>-</td>
</tr>
<tr>
<td>Operate current for directional comparison, Zero sequence</td>
<td>(1–100)% of ( I_{\text{Base}} )</td>
<td>( \pm 2.0% \text{ of } I_r )</td>
</tr>
<tr>
<td>Operate current for directional comparison, Negative sequence</td>
<td>(1–100)% of ( I_{\text{Base}} )</td>
<td>( \pm 2.0% \text{ of } I_r )</td>
</tr>
<tr>
<td>Min. operating current</td>
<td>(1-10000)% of ( I_{\text{Base}} )</td>
<td>( \pm 1.0% \text{ of } I_r ) at ( I &lt; I_r ) ( \pm 1.0% \text{ of } I ) at ( I &gt; I_r )</td>
</tr>
<tr>
<td>Minimum operate time for inverse characteristics</td>
<td>(0.000-60.000) s</td>
<td>( \pm 0.5% \pm 25 \text{ ms} )</td>
</tr>
<tr>
<td>Timers</td>
<td>(0.000-60.000) s</td>
<td>( \pm 0.5% \pm 25 \text{ ms} )</td>
</tr>
<tr>
<td>Inverse characteristics, see table 73, table 74 and table 75</td>
<td>17 curve types</td>
<td>1) ANSI/IEEE C37.112 IEC 60255–151 ( \pm 3% \text{ or } \pm 40 \text{ ms} ) ( 0.10 \leq k \leq 3.00 ) ( 1.5 \times I_{\text{set}} \leq I \leq 20 \times I_{\text{set}} )</td>
</tr>
<tr>
<td>Minimum polarizing voltage, Zero sequence</td>
<td>(1–100)% of ( U_{\text{Base}} )</td>
<td>( \pm 0.5% \text{ of } U_r )</td>
</tr>
<tr>
<td>Minimum polarizing voltage, Negative sequence</td>
<td>(1–100)% of ( U_{\text{Base}} )</td>
<td>( \pm 0.5% \text{ of } U_r )</td>
</tr>
<tr>
<td>Minimum polarizing current, Zero sequence</td>
<td>(2–100)% of ( I_{\text{Base}} )</td>
<td>( \pm 1.0% \text{ of } I_r )</td>
</tr>
<tr>
<td>Minimum polarizing current, Negative sequence</td>
<td>(2–100)% of ( I_{\text{Base}} )</td>
<td>( \pm 1.0% \text{ of } I_r )</td>
</tr>
<tr>
<td>Real part of source Z used for current polarization</td>
<td>(0.50-1000.00) ( \Omega/\text{phase} )</td>
<td>-</td>
</tr>
<tr>
<td>Imaginary part of source Z used for current polarization</td>
<td>(0.50–3000.00) ( \Omega/\text{phase} )</td>
<td>-</td>
</tr>
<tr>
<td>Operate time, non-directional start function</td>
<td>30 ms typically at 0.5 to 2 ( x I_{\text{set}} )</td>
<td>-</td>
</tr>
<tr>
<td>Reset time, non-directional start function</td>
<td>30 ms typically at 2 to 0.5 ( x I_{\text{set}} )</td>
<td>-</td>
</tr>
<tr>
<td>Operate time, directional start function</td>
<td>30 ms typically at 0.5 to 2 ( x I_N )</td>
<td>-</td>
</tr>
<tr>
<td>Reset time, directional start function</td>
<td>30 ms typically at 2 to 0.5 ( x I_N )</td>
<td>-</td>
</tr>
</tbody>
</table>

1) **Note:** Timing accuracy only valid when 2nd harmonic blocking is turned off.
Table 30. Sensitive directional residual overcurrent and power protection SDEPSDE

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operate level for $3I_0 \cdot \cos\phi$ directional residual overcurrent</td>
<td>$(0.25-200.00)%$ of $I_{Base}$</td>
<td>$\pm 1.0%$ of $I_r$ at $I \leq I_r$</td>
</tr>
<tr>
<td>At low setting:</td>
<td>$(2.5-10)$ mA</td>
<td>$\pm 0.5$ mA</td>
</tr>
<tr>
<td></td>
<td>$(10-50)$ mA</td>
<td>$\pm 1.0$ mA</td>
</tr>
<tr>
<td>Operate level for $3I_0 \cdot 3U_0 \cdot \cos\phi$ directional residual power</td>
<td>$(0.25-200.00)%$ of $S_{Base}$</td>
<td>$\pm 2.0%$ of $S_r$ at $S \leq S_r$</td>
</tr>
<tr>
<td>At low setting:</td>
<td>$(0.25-5.00)%$ of $S_{Base}$</td>
<td>$\pm 2.0%$ of $S$ at $S &gt; S_r$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$\pm 10%$ of set value</td>
</tr>
<tr>
<td>Operate level for $3I_0$ and $\phi$ residual overcurrent</td>
<td>$(0.25-200.00)%$ of $I_{Base}$</td>
<td>$\pm 1.0%$ of $I_r$ at $I \leq I_r$</td>
</tr>
<tr>
<td>At low setting:</td>
<td>$(2.5-10)$ mA</td>
<td>$\pm 0.5$ mA</td>
</tr>
<tr>
<td></td>
<td>$(10-50)$ mA</td>
<td>$\pm 1.0$ mA</td>
</tr>
<tr>
<td>Operate level for non-directional overcurrent</td>
<td>$(1.00-400.00)%$ of $I_{Base}$</td>
<td>$\pm 1.0%$ of $I_r$ at $I \leq I_r$</td>
</tr>
<tr>
<td>At low setting:</td>
<td>$(10-50)$ mA</td>
<td>$\pm 1.0$ mA</td>
</tr>
<tr>
<td>Operate level for non-directional residual overvoltage</td>
<td>$(1.00-200.00)%$ of $I_{Base}$</td>
<td>$\pm 0.5%$ of $U_r$ at $U \leq U_r$</td>
</tr>
<tr>
<td>Residual release current for all directional modes</td>
<td>$(0.25-200.00)%$ of $I_{Base}$</td>
<td>$\pm 1.0%$ of $I_r$ at $I \leq I_r$</td>
</tr>
<tr>
<td>At low setting:</td>
<td>$(2.5-10)$ mA</td>
<td>$\pm 0.5$ mA</td>
</tr>
<tr>
<td></td>
<td>$(10-50)$ mA</td>
<td>$\pm 1.0$ mA</td>
</tr>
<tr>
<td>Residual release voltage for all directional modes</td>
<td>$(1.00 - 300.00)%$ of $U_{Base}$</td>
<td>$\pm 0.5%$ of $U_r$ at $U \leq U_r$</td>
</tr>
<tr>
<td>Reset ratio</td>
<td>$&gt; 95%$</td>
<td>-</td>
</tr>
<tr>
<td>Timers</td>
<td>$(0.000-60.000)$ s</td>
<td>$\pm 0.5% \pm 25$ ms</td>
</tr>
<tr>
<td>Inverse characteristics, see table 73, table 74 and table 75</td>
<td>17 curve types</td>
<td>ANSI/IEEE C37.112</td>
</tr>
<tr>
<td></td>
<td></td>
<td>IEC 60255–151</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$+100$ ms: (3% or 90 ms)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$0.10 \leq k \leq 3.00$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$1.5 \times I_{set} \leq I \leq 20 \times I_{set}$</td>
</tr>
<tr>
<td>Relay characteristic angle RCA</td>
<td>$(-179$ to $180)$ degrees</td>
<td>$\pm 2.0$ degrees</td>
</tr>
<tr>
<td>Relay open angle ROA</td>
<td>$(0-90)$ degrees</td>
<td>$\pm 2.0$ degrees</td>
</tr>
<tr>
<td>Operate time, non-directional residual over current</td>
<td>$80$ ms typically at $0.5$ to $2 \times I_{set}$</td>
<td>-</td>
</tr>
<tr>
<td>Reset time, non-directional residual over current</td>
<td>$90$ ms typically at $1.2$ to $0.5 \times I_{set}$</td>
<td>-</td>
</tr>
<tr>
<td>Operate time, non-directional residual overvoltage</td>
<td>$70$ ms typically at $0.8$ to $1.5 \times U_{set}$</td>
<td>-</td>
</tr>
</tbody>
</table>
### Table 30. Sensitive directional residual overcurrent and power protection SDEPSDE, continued

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reset time, non-directional residual overvoltage</td>
<td>120 ms typically at 1.2 to 0.8 x ( U_{set} )</td>
<td>-</td>
</tr>
<tr>
<td>Operate time, directional residual over current</td>
<td>260 ms typically at 0.5 to 2 x ( I_{set} )</td>
<td>-</td>
</tr>
<tr>
<td>Reset time, directional residual over current</td>
<td>170 ms typically at 2 to 0.5 x ( I_{set} )</td>
<td>-</td>
</tr>
<tr>
<td>Critical impulse time non-directional residual over current</td>
<td>100 ms typically at 0 to 2 x ( I_{set} )</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>20 ms typically at 0 to 10 x ( I_{set} )</td>
<td>-</td>
</tr>
<tr>
<td>Impulse margin time non-directional residual over current</td>
<td>25 ms typically</td>
<td>-</td>
</tr>
</tbody>
</table>

### Table 31. Thermal overload protection, one time constant LCPTTR/LFPTTR

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference current</td>
<td>((0-400)%) of ( I_{Base} )</td>
<td>± 1.0% of ( I_r )</td>
</tr>
<tr>
<td>Reference temperature</td>
<td>((0-300)\C, (0 - 600)\F)</td>
<td>± 2.0°C, ±2°F</td>
</tr>
<tr>
<td>Operate time:</td>
<td>( t = \tau \cdot \ln \left( \frac{I^2 - I_p^2}{I^2 - I_b^2} \right) )</td>
<td>Time constant ( \tau = (0-1000) ) minutes</td>
</tr>
<tr>
<td>Alarm temperature</td>
<td>((0-200)\C, (0-400)\F)</td>
<td>± 2.0°C</td>
</tr>
<tr>
<td>Trip temperature</td>
<td>((0-300)\C, (0-600)\F)</td>
<td>± 2.0°C</td>
</tr>
<tr>
<td>Reset level temperature</td>
<td>((0-300)\C, (0-600)\F)</td>
<td>± 2.0°C</td>
</tr>
</tbody>
</table>
### Table 32. Breaker failure protection, 3-phase activation and output CCRBRF

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
</table>
| Operate phase current                        | (5-200)% of \(i_{\text{Base}}\) | ± 1.0% of \(i_r\) at \(i \leq i_r\)  

± 1.0% of \(i\) at \(i > i_r\) |
| Reset ratio, phase current                   | > 95%          | -                                                                        |
| Operate residual current                      | (2-200)% of \(i_{\text{Base}}\) | ± 1.0% of \(i_r\) at \(i \leq i_r\)  

± 1.0% of \(i\) at \(i > i_r\) |
| Reset ratio, residual current                 | > 95%          | -                                                                        |
| Phase current level for blocking of contact function | (5-200)% of \(i_{\text{Base}}\) | ± 1.0% of \(i_r\) at \(i \leq i_r\)  

± 1.0% of \(i\) at \(i > i_r\) |
| Reset ratio                                   | > 95%          | -                                                                        |
| Timers                                        | (0.000-60.000) s | ± 0.5% ±10 ms                                                           |
| Operate time for current detection            | 35 ms typically | -                                                                        |
| Reset time for current detection              | 10 ms maximum  | -                                                                        |

### Table 33. Breaker failure protection, phase segregated activation and output CSPRBRF

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
</table>
| Operate phase current                        | (5-200)% of \(i_{\text{Base}}\) | ± 1.0% of \(i_r\) at \(i \leq i_r\)  

± 1.0% of \(i\) at \(i > i_r\) |
| Reset ratio, phase current                   | > 95%          | -                                                                        |
| Operate residual current                      | (2-200)% of \(i_{\text{Base}}\) | ± 1.0% of \(i_r\) at \(i \leq i_r\)  

± 1.0% of \(i\) at \(i > i_r\) |
| Reset ratio, residual current                 | > 95%          | -                                                                        |
| Phase current level for blocking of contact function | (5-200)% of \(i_{\text{Base}}\) | ± 1.0% of \(i_r\) at \(i \leq i_r\)  

± 1.0% of \(i\) at \(i > i_r\) |
| Reset ratio                                   | > 95%          | -                                                                        |
| Timers                                        | (0.000-60.000) s | ± 0.5% ±10 ms                                                           |
| Operate time for current detection            | 35 ms typically | -                                                                        |
| Reset time for current detection              | 10 ms maximum  | -                                                                        |
Table 34. Stub protection STBPTOC

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating current</td>
<td>(1-2500)% of I_base</td>
<td>± 1.0% of I at I ≤ I_r</td>
</tr>
<tr>
<td></td>
<td></td>
<td>± 1.0% of I at I &gt; I_r</td>
</tr>
<tr>
<td>Reset ratio</td>
<td>&gt; 95%</td>
<td></td>
</tr>
<tr>
<td>Operate time</td>
<td>20 ms typically at 0 to 2 x I_set</td>
<td></td>
</tr>
<tr>
<td>Reset time</td>
<td>30 ms typically at 2 to 0 x I_set</td>
<td></td>
</tr>
<tr>
<td>Critical impulse time</td>
<td>10 ms typically at 0 to 2 x I_set</td>
<td></td>
</tr>
<tr>
<td>Impulse margin time</td>
<td>15 ms typically</td>
<td></td>
</tr>
</tbody>
</table>

Table 35. Pole discordance protection CCRPLD

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operate value, current asymmetry level</td>
<td>(0-100) %</td>
<td>± 1.0% of I_r</td>
</tr>
<tr>
<td>Reset ratio</td>
<td>&gt;95%</td>
<td></td>
</tr>
<tr>
<td>Time delay</td>
<td>(0.000-60.000) s</td>
<td>± 0.5% ± 25 ms</td>
</tr>
</tbody>
</table>

Table 36. Broken conductor check BRCPTOC

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum phase current for operation</td>
<td>(5–100)% of I_base</td>
<td>± 1.0% of I_r</td>
</tr>
<tr>
<td>Unbalance current operation</td>
<td>(50-90)% of maximum current</td>
<td>± 2.0% of I_r</td>
</tr>
<tr>
<td>Timer</td>
<td>(0.00-60.000) s</td>
<td>± 0.5% ± 25 ms</td>
</tr>
<tr>
<td>Operate time for start function</td>
<td>35 ms typically</td>
<td></td>
</tr>
<tr>
<td>Reset time for start function</td>
<td>30 ms typically</td>
<td></td>
</tr>
<tr>
<td>Critical impulse time</td>
<td>15 ms typically</td>
<td></td>
</tr>
<tr>
<td>Impulse margin time</td>
<td>10 ms typically</td>
<td></td>
</tr>
</tbody>
</table>

Table 37. Directional over/underpower protection GOPPDOP, GUPPDUP

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power level</td>
<td>(0.0–500.0)% of S_base</td>
<td>± 1.0% of S at S &lt; S_r</td>
</tr>
<tr>
<td></td>
<td>(1.0-2.0)% of S_base</td>
<td>&lt; ± 50% of set value</td>
</tr>
<tr>
<td></td>
<td>(2.0-10)% of S_base</td>
<td>&lt; ± 20% of set value</td>
</tr>
<tr>
<td>Characteristic angle</td>
<td>(-180.0–180.0) degrees</td>
<td>2 degrees</td>
</tr>
<tr>
<td>Timers</td>
<td>(0.010 - 6000.000) s</td>
<td>± 0.5% ± 25 ms</td>
</tr>
</tbody>
</table>
Table 38. Negative sequence based overcurrent function DNSPTOC

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operate current</td>
<td>(2.0 - 5000.0) % of I&lt;sub&gt;Base&lt;/sub&gt;</td>
<td>± 1.0% of I&lt;sub&gt;r&lt;/sub&gt; at I &lt; I&lt;sub&gt;r&lt;/sub&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>± 1.0% of I at I &gt; I&lt;sub&gt;r&lt;/sub&gt;</td>
</tr>
<tr>
<td>Reset ratio</td>
<td>&gt; 95 %</td>
<td></td>
</tr>
<tr>
<td>Low voltage level for memory</td>
<td>(0.0 - 5.0) % of U&lt;sub&gt;Base&lt;/sub&gt;</td>
<td>&lt; ± 0.5% of U&lt;sub&gt;r&lt;/sub&gt;</td>
</tr>
<tr>
<td>Relay characteristic angle</td>
<td>(-180 - 180) degrees</td>
<td>± 2.0 degrees</td>
</tr>
<tr>
<td>Relay operate angle</td>
<td>(1 - 90) degrees</td>
<td>± 2.0 degrees</td>
</tr>
<tr>
<td>Timers</td>
<td>(0.00 - 6000.00) s</td>
<td>± 0.5% ± 25 ms</td>
</tr>
<tr>
<td>Operate time, non-directional</td>
<td>30 ms typically at 0 to 2 x I&lt;sub&gt;set&lt;/sub&gt;</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>20 ms typically at 0 to 10 x I&lt;sub&gt;set&lt;/sub&gt;</td>
<td>-</td>
</tr>
<tr>
<td>Reset time, non-directional</td>
<td>40 ms typically at 2 to 0 x I&lt;sub&gt;set&lt;/sub&gt;</td>
<td>-</td>
</tr>
<tr>
<td>Operate time, directional</td>
<td>30 ms typically at 0 to 2 x I&lt;sub&gt;set&lt;/sub&gt;</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>20 ms typically at 0 to 10 x I&lt;sub&gt;set&lt;/sub&gt;</td>
<td>-</td>
</tr>
<tr>
<td>Reset time, directional</td>
<td>40 ms typically at 2 to 0 x I&lt;sub&gt;set&lt;/sub&gt;</td>
<td>-</td>
</tr>
<tr>
<td>Critical impulse time</td>
<td>10 ms typically at 0 to 2 x I&lt;sub&gt;set&lt;/sub&gt;</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>2 ms typically at 0 to 10 x I&lt;sub&gt;set&lt;/sub&gt;</td>
<td>-</td>
</tr>
<tr>
<td>Impulse margin time</td>
<td>15 ms typically</td>
<td>-</td>
</tr>
<tr>
<td>Dynamic overreach</td>
<td>&lt; 10% at t = 300 ms</td>
<td>-</td>
</tr>
</tbody>
</table>

Voltage protection

Table 39. Two step undervoltage protection UV2PTUV

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operate voltage, low and high step</td>
<td>(1–100)% of U&lt;sub&gt;Base&lt;/sub&gt;</td>
<td>± 0.5% of U&lt;sub&gt;r&lt;/sub&gt;</td>
</tr>
<tr>
<td>Reset ratio</td>
<td>&lt;105%</td>
<td>-</td>
</tr>
<tr>
<td>Inverse time characteristics for low and high step, see table 77</td>
<td>-</td>
<td>See table 77</td>
</tr>
<tr>
<td>Definite time delay, step 1</td>
<td>(0.00 - 6000.00) s</td>
<td>± 0.5% ± 25 ms</td>
</tr>
<tr>
<td>Definite time delays, step 2</td>
<td>(0.000-60.000) s</td>
<td>± 0.5% ±25 ms</td>
</tr>
<tr>
<td>Minimum operate time, inverse characteristics</td>
<td>(0.000–60.000) s</td>
<td>± 0.5% ± 25 ms</td>
</tr>
<tr>
<td>Operate time, start function</td>
<td>30 ms typically at 1.2 to 0.5 x U&lt;sub&gt;set&lt;/sub&gt;</td>
<td>-</td>
</tr>
<tr>
<td>Reset time, start function</td>
<td>40 ms typically at 0.5 to 1.2 x U&lt;sub&gt;set&lt;/sub&gt;</td>
<td>-</td>
</tr>
<tr>
<td>Critical impulse time</td>
<td>10 ms typically at 1.2 to 0.8 x U&lt;sub&gt;set&lt;/sub&gt;</td>
<td>-</td>
</tr>
<tr>
<td>Impulse margin time</td>
<td>15 ms typically</td>
<td>-</td>
</tr>
</tbody>
</table>
### Table 40. Two step overvoltage protection OV2PTOV

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operate voltage, low and high step</td>
<td>(1-200)% of U_{Base}</td>
<td>± 0.5% of U_{r} at U &lt; U_{r}</td>
</tr>
<tr>
<td></td>
<td></td>
<td>± 0.5% of U at U &gt; U_{r}</td>
</tr>
<tr>
<td>Reset ratio</td>
<td>&gt;95%</td>
<td>-</td>
</tr>
<tr>
<td>Inverse time characteristics for low and high step, see table 76</td>
<td>-</td>
<td>See table 76</td>
</tr>
<tr>
<td>Definite time delay, step 1</td>
<td>(0.00 - 6000.00) s</td>
<td>± 0.5% ± 25 ms</td>
</tr>
<tr>
<td>Definite time delays, step 2</td>
<td>(0.000-60.000) s</td>
<td>± 0.5% ± 25 ms</td>
</tr>
<tr>
<td>Minimum operate time, Inverse characteristics</td>
<td>(0.000-60.000) s</td>
<td>± 0.5% ± 25 ms</td>
</tr>
<tr>
<td>Operate time, start function</td>
<td>30 ms typically at 0 to 2 x U_{set}</td>
<td>-</td>
</tr>
<tr>
<td>Reset time, start function</td>
<td>40 ms typically at 2 to 0 x U_{set}</td>
<td>-</td>
</tr>
<tr>
<td>Critical impulse time</td>
<td>10 ms typically at 0 to 2 x U_{set}</td>
<td>-</td>
</tr>
<tr>
<td>Impulse margin time</td>
<td>15 ms typically</td>
<td>-</td>
</tr>
</tbody>
</table>

### Table 41. Two step residual overvoltage protection ROV2PTOV

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operate voltage, step 1</td>
<td>(1-200)% of U_{Base}</td>
<td>± 0.5% of U_{r} at U &lt; U_{r}</td>
</tr>
<tr>
<td></td>
<td></td>
<td>± 0.5% of U at U &gt; U_{r}</td>
</tr>
<tr>
<td>Operate voltage, step 2</td>
<td>(1–100)% of U_{Base}</td>
<td>± 0.5% of U_{r} at U &lt; U_{r}</td>
</tr>
<tr>
<td></td>
<td></td>
<td>± 0.5% of U at U &gt; U_{r}</td>
</tr>
<tr>
<td>Reset ratio</td>
<td>&gt;95%</td>
<td>-</td>
</tr>
<tr>
<td>Inverse time characteristics for low and high step, see table 78</td>
<td>-</td>
<td>See table 78</td>
</tr>
<tr>
<td>Definite time setting, step 1</td>
<td>(0.00–6000.00) s</td>
<td>± 0.5% ± 25 ms</td>
</tr>
<tr>
<td>Definite time setting, step 2</td>
<td>(0.000-60.000) s</td>
<td>± 0.5% ± 25 ms</td>
</tr>
<tr>
<td>Minimum operate time for step 1 inverse characteristic</td>
<td>(0.000-60.000) s</td>
<td>± 0.5% ± 25 ms</td>
</tr>
<tr>
<td>Operate time, start function</td>
<td>30 ms typically at 0 to 2 x U_{set}</td>
<td>-</td>
</tr>
<tr>
<td>Reset time, start function</td>
<td>40 ms typically at 2 to 0 x U_{set}</td>
<td>-</td>
</tr>
<tr>
<td>Critical impulse time</td>
<td>10 ms typically at 0 to 1.2 x U_{set}</td>
<td>-</td>
</tr>
<tr>
<td>Impulse margin time</td>
<td>15 ms typically</td>
<td>-</td>
</tr>
</tbody>
</table>
Table 42. Loss of voltage check LOVPTUV

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operate voltage</td>
<td>(0–100)% of UBase</td>
<td>± 0.5% of U_r</td>
</tr>
<tr>
<td>Reset ratio</td>
<td>&lt;105%</td>
<td>-</td>
</tr>
<tr>
<td>Pulse timer</td>
<td>(0.050–60.000) s</td>
<td>± 0.5% ± 25 ms</td>
</tr>
<tr>
<td>Timers</td>
<td>(0.000–60.000) s</td>
<td>± 0.5% ± 25 ms</td>
</tr>
</tbody>
</table>

Frequency protection

Table 43. Under frequency protection SAPTUF

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operate value, start function</td>
<td>(35.00-75.00) Hz</td>
<td>± 2.0 mHz</td>
</tr>
<tr>
<td>Operate value, restore frequency</td>
<td>(45 - 65) Hz</td>
<td>± 2.0 mHz</td>
</tr>
<tr>
<td>Reset ratio</td>
<td>&lt;1.001</td>
<td>-</td>
</tr>
<tr>
<td>Operate time, start function</td>
<td>At 50 Hz: 200 ms typically at f_{set} +0.5 Hz to f_{set} -0.5 Hz At 60 Hz: 170 ms typically at f_{set} +0.5 Hz to f_{set} -0.5 Hz</td>
<td>-</td>
</tr>
<tr>
<td>Reset time, start function</td>
<td>At 50 Hz: 60 ms typically at f_{set} -0.5 Hz to f_{set} +0.5 Hz At 60 Hz: 50 ms typically at f_{set} -0.5 Hz to f_{set} +0.5 Hz</td>
<td>-</td>
</tr>
<tr>
<td>Operate time delay</td>
<td>(0.000-60.000)s</td>
<td>&lt;250 ms</td>
</tr>
<tr>
<td>Restore time delay</td>
<td>(0.000-60.000)s</td>
<td>&lt;150 ms</td>
</tr>
</tbody>
</table>

Table 44. Overfrequency protection SAPTOF

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operate value, start function</td>
<td>(35.00-75.00) Hz</td>
<td>± 2.0 mHz at symmetrical three-phase voltage</td>
</tr>
<tr>
<td>Reset ratio</td>
<td>&gt;0.999</td>
<td>-</td>
</tr>
<tr>
<td>Operate time, start function</td>
<td>At 50 Hz: 200 ms typically at f_{set} -0.5 Hz to f_{set} +0.5 Hz At 60 Hz: 170 ms typically at f_{set} -0.5 Hz to f_{set} +0.5 Hz</td>
<td>-</td>
</tr>
<tr>
<td>Reset time, start function</td>
<td>At 50 and 60 Hz: 55 ms typically at f_{set} +0.5 Hz to f_{set}-0.5 Hz</td>
<td>-</td>
</tr>
<tr>
<td>Timer</td>
<td>(0.000-60.000)s</td>
<td>&lt;250 ms</td>
</tr>
</tbody>
</table>
Table 45. Rate-of-change frequency protection SAPFRC

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operate value, start function</td>
<td>(-10.00-10.00) Hz/s</td>
<td>± 10.0 mHz/s</td>
</tr>
<tr>
<td>Operate value, restore enable frequency</td>
<td>(45.00 - 65.00) Hz</td>
<td>± 2.0 mHz</td>
</tr>
<tr>
<td>Timers</td>
<td>(0.000 - 60.000) s</td>
<td>&lt;130 ms</td>
</tr>
<tr>
<td>Operate time, start function</td>
<td>At 50 Hz: 100 ms typically</td>
<td></td>
</tr>
<tr>
<td></td>
<td>At 60 Hz: 80 ms typically</td>
<td></td>
</tr>
</tbody>
</table>

Secondary system supervision

Table 46. Current circuit supervision CCSRDIF

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operate current</td>
<td>(5-200)% of I_r</td>
<td>± 10.0% of I_r at I ≤ I_r, ± 10.0% of I at I &gt; I_r</td>
</tr>
<tr>
<td>Block current</td>
<td>(5-500)% of I_r</td>
<td>± 5.0% of I_r at I ≤ I_r, ± 5.0% of I at I &gt; I_r</td>
</tr>
</tbody>
</table>

Table 47. Fuse failure supervision SDDRFUF

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operate voltage, zero sequence</td>
<td>(1-100)% of UBase</td>
<td>± 1.0% of U_r</td>
</tr>
<tr>
<td>Operate current, zero sequence</td>
<td>(1–100)% of IBase</td>
<td>± 1.0% of I_r</td>
</tr>
<tr>
<td>Operate voltage, negative sequence</td>
<td>(1–100)% of UBase</td>
<td>± 0.5% of U_r</td>
</tr>
<tr>
<td>Operate current, negative sequence</td>
<td>(1–100)% of IBase</td>
<td>± 1.0% of I_r</td>
</tr>
<tr>
<td>Operate voltage change level</td>
<td>(1–100)% of UBase</td>
<td>± 5.0% of U_r</td>
</tr>
<tr>
<td>Operate current change level</td>
<td>(1–100)% of IBase</td>
<td>± 5.0% of I_r</td>
</tr>
<tr>
<td>Operate phase voltage</td>
<td>(1–100)% of UBase</td>
<td>± 0.5% of U_r</td>
</tr>
<tr>
<td>Operate phase current</td>
<td>(1–100)% of IBase</td>
<td>± 1.0% of I_r</td>
</tr>
<tr>
<td>Operate phase dead line voltage</td>
<td>(1–100)% of UBase</td>
<td>± 0.5% of U_r</td>
</tr>
<tr>
<td>Operate phase dead line current</td>
<td>(1–100)% of IBase</td>
<td>± 1.0% of I_r</td>
</tr>
</tbody>
</table>

Table 48. Breaker close/trip circuit monitoring TCSSCBR

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operate time delay</td>
<td>(0.020 - 300.000) s</td>
<td>± 0.5% ± 110 ms</td>
</tr>
</tbody>
</table>
### Table 49. Synchronizing, synchrocheck and energizing check SESRSYN

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase shift, $\varphi_{\text{line}} - \varphi_{\text{bus}}$</td>
<td>(-180 to 180) degrees</td>
<td>-</td>
</tr>
<tr>
<td>Voltage ratio, $U_{\text{bus}}/U_{\text{line}}$</td>
<td>0.500 - 2.000</td>
<td>-</td>
</tr>
<tr>
<td>Reset ratio, synchrocheck</td>
<td>&gt; 95%</td>
<td>-</td>
</tr>
<tr>
<td>Frequency difference limit between bus and line for synchrocheck</td>
<td>(0.003-1.000) Hz</td>
<td>± 2.0 mHz</td>
</tr>
<tr>
<td>Phase angle difference limit between bus and line for synchrocheck</td>
<td>(5.0-90.0) degrees</td>
<td>± 2.0 degrees</td>
</tr>
<tr>
<td>Voltage difference limit between bus and line for synchronizing and synchrocheck</td>
<td>0.03-0.50 p.u</td>
<td>± 0.5% of $U_r$</td>
</tr>
<tr>
<td>Time delay output for synchrocheck</td>
<td>(0.000-60.000) s</td>
<td>± 0.5% ± 25 ms</td>
</tr>
<tr>
<td>Frequency difference minimum limit for synchronizing</td>
<td>(0.003-0.250) Hz</td>
<td>± 2.0 mHz</td>
</tr>
<tr>
<td>Frequency difference maximum limit for synchronizing</td>
<td>(0.050-0.500) Hz</td>
<td>± 2.0 mHz</td>
</tr>
<tr>
<td>Maximum allowed frequency rate of change</td>
<td>(0.000-0.500) Hz/s</td>
<td>± 10.0 mHz/s</td>
</tr>
<tr>
<td>Closing time of the breaker</td>
<td>(0.000-60.000) s</td>
<td>± 0.5% ± 10 ms</td>
</tr>
<tr>
<td>Breaker closing pulse duration</td>
<td>(0.000-60.000) s</td>
<td>± 0.5% ± 10 ms</td>
</tr>
<tr>
<td>$t_{\text{MaxSynch}}$, which resets synchronizing function if no close has been made before set time</td>
<td>(0.000-60.000) s</td>
<td>± 0.5% ± 10 ms</td>
</tr>
<tr>
<td>Minimum time to accept synchronizing conditions</td>
<td>(0.000-60.000) s</td>
<td>± 0.5% ± 10 ms</td>
</tr>
<tr>
<td>Frequency difference minimum limit for synchronizing</td>
<td>(0.003-0.250) Hz</td>
<td>± 2.0 mHz</td>
</tr>
<tr>
<td>Frequency difference maximum limit for synchronizing</td>
<td>(0.050-0.500) Hz</td>
<td>± 2.0 mHz</td>
</tr>
<tr>
<td>Closing time of the breaker</td>
<td>(0.000-60.000) s</td>
<td>± 0.5% ± 10 ms</td>
</tr>
<tr>
<td>Breaker closing time duration</td>
<td>(0.050-60.000) s</td>
<td>± 0.5% ± 10 ms</td>
</tr>
<tr>
<td>$t_{\text{MaxSynch}}$, which resets synchronizing function if no close has been made before set time</td>
<td>(0.00-6000.00) s</td>
<td>± 0.5% ± 10 ms</td>
</tr>
<tr>
<td>Time delay output for energizing check</td>
<td>(0.000-60.000) s</td>
<td>± 0.5% ± 10 ms</td>
</tr>
<tr>
<td>Operate time for synchrocheck function</td>
<td>160 ms typically</td>
<td>-</td>
</tr>
<tr>
<td>Operate time for energizing function</td>
<td>80 ms typically</td>
<td>-</td>
</tr>
<tr>
<td>Minimum time to accept synchronizing conditions</td>
<td>(0.000-60.000) s</td>
<td>± 0.5% ± 10 ms</td>
</tr>
<tr>
<td>Maximum allowed frequency rate of change</td>
<td>(0.000-0.500) Hz/s</td>
<td>± 10.0 mHz/s</td>
</tr>
</tbody>
</table>
Table 50. Autorecloser for 3-phase operation SMBREC

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of autoreclosing shots</td>
<td>1 - 5</td>
<td>-</td>
</tr>
<tr>
<td>Autoreclosing open time:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>shot 1 - t1 3Ph</td>
<td>(0.000-60.000) s</td>
<td>± 0.5% ± 25 ms</td>
</tr>
<tr>
<td>shot 2 - t2 3Ph</td>
<td>(0.00-6000.00) s</td>
<td></td>
</tr>
<tr>
<td>shot 3 - t3 3Ph</td>
<td>(0.00-6000.00) s</td>
<td></td>
</tr>
<tr>
<td>shot 4 - t4 3Ph</td>
<td>(0.00-6000.00) s</td>
<td></td>
</tr>
<tr>
<td>shot 5 - t5 3Ph</td>
<td>(0.00-6000.00) s</td>
<td></td>
</tr>
<tr>
<td>Autorecloser maximum wait time for sync</td>
<td>(0.00-6000.00) s</td>
<td></td>
</tr>
<tr>
<td>Maximum trip pulse duration</td>
<td>(0.000-60.000) s</td>
<td></td>
</tr>
<tr>
<td>Inhibit reset time</td>
<td>(0.000-60.000) s</td>
<td></td>
</tr>
<tr>
<td>Reclaim time</td>
<td>(0.00-6000.00) s</td>
<td></td>
</tr>
<tr>
<td>Minimum time CB must be closed before AR becomes</td>
<td>(0.00-6000.00) s</td>
<td></td>
</tr>
<tr>
<td>ready for autoreclosing cycle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CB check time before unsuccessful</td>
<td>(0.00-6000.00) s</td>
<td></td>
</tr>
<tr>
<td>Wait for master release</td>
<td>(0.00-6000.00) s</td>
<td></td>
</tr>
<tr>
<td>Wait time after close command before proceeding to</td>
<td>(0.000-60.000) s</td>
<td></td>
</tr>
</tbody>
</table>
### Table 51. Autorecloser for 1/3-phase operation STBRREC

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of autoreclosing shots</td>
<td>1-5</td>
<td>-</td>
</tr>
<tr>
<td>Autoreclosing open time: Shot 1 - t1</td>
<td>(0.000-60.000) s</td>
<td>± 0.5% ± 25 ms</td>
</tr>
<tr>
<td>3Ph</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shot 1 - t1 1Ph</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shot 2 - t2 3Ph</td>
<td>(0.00-6000.00) s</td>
<td>(0.00-6000.00) s</td>
</tr>
<tr>
<td>shot 3 - t3 3Ph</td>
<td></td>
<td></td>
</tr>
<tr>
<td>shot 4 - t4 3Ph</td>
<td></td>
<td></td>
</tr>
<tr>
<td>shot 5 - t5 3Ph</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Autorecloser maximum wait time for sync</td>
<td>(0.00-6000.00) s</td>
<td>(0.00-6000.00) s</td>
</tr>
<tr>
<td>Open time extension for long trip time</td>
<td>(0.00-6000.00) s</td>
<td>(0.00-6000.00) s</td>
</tr>
<tr>
<td>Maximum trip pulse duration</td>
<td>(0.00-60.000) s</td>
<td>(0.00-60.000) s</td>
</tr>
<tr>
<td>Inhibit reset time</td>
<td>(0.00-60.000) s</td>
<td>(0.00-60.000) s</td>
</tr>
<tr>
<td>Reclaim time</td>
<td>(0.00-6000.00) s</td>
<td>(0.00-6000.00) s</td>
</tr>
<tr>
<td>Minimum time CB must be closed before AR becomes ready for autoreclosing cycle</td>
<td>(0.00-6000.00) s</td>
<td>(0.00-6000.00) s</td>
</tr>
<tr>
<td>CB check time before unsuccessful</td>
<td>(0.00-6000.00) s</td>
<td>(0.00-6000.00) s</td>
</tr>
<tr>
<td>Wait for master release</td>
<td>(0.00-6000.00) s</td>
<td>(0.00-6000.00) s</td>
</tr>
<tr>
<td>Wait time after close command before proceeding to next shot</td>
<td>(0.00-6000.00) s</td>
<td>(0.00-6000.00) s</td>
</tr>
</tbody>
</table>

### Logic

### Table 52. Tripping logic common 3-phase output SMPPTRC

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trip action</td>
<td>3-ph</td>
<td>-</td>
</tr>
<tr>
<td>Timers</td>
<td>(0.000-60.000) s</td>
<td>± 0.5% ± 10 ms</td>
</tr>
</tbody>
</table>

### Table 53. Tripping logic phase segregated output SPTPTRC

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trip action</td>
<td>3-Ph, 1/3-Ph</td>
<td>-</td>
</tr>
<tr>
<td>Timers</td>
<td>(0.000-60.000) s</td>
<td>± 0.5% ± 10 ms</td>
</tr>
</tbody>
</table>
Table 54. Configurable logic blocks

<table>
<thead>
<tr>
<th>Logic block</th>
<th>Quantity with cycle time</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>5 ms</td>
<td>20 ms</td>
</tr>
<tr>
<td>AND</td>
<td>60</td>
<td>60</td>
<td>160</td>
</tr>
<tr>
<td>OR</td>
<td>60</td>
<td>60</td>
<td>160</td>
</tr>
<tr>
<td>XOR</td>
<td>10</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>INVERTER</td>
<td>30</td>
<td>30</td>
<td>80</td>
</tr>
<tr>
<td>SRMEMORY</td>
<td>10</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>RSMEMORY</td>
<td>10</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>GATE</td>
<td>10</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>PULSETIMER</td>
<td>10</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>TIMERSET</td>
<td>10</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>LOOPDELAY</td>
<td>10</td>
<td>10</td>
<td>20</td>
</tr>
</tbody>
</table>

Monitoring

Table 55. Technical data covering measurement functions: CVMMXN, CMMXU, VMUXU, CMSQI, VMSQI, VNMMXU

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage</td>
<td>(0.1-1.5) × U_r</td>
<td>± 0.5% of U_r at U ≤ U_r, ± 0.5% of U at U &gt; U_r</td>
</tr>
<tr>
<td>Connected current</td>
<td>(0.2-4.0) × I_r</td>
<td>± 0.5% of I_r at I ≤ I_r, ± 0.5% of I at I &gt; I_r</td>
</tr>
<tr>
<td>Active power, P</td>
<td>0.1 × U_r &lt; U &lt; 1.5 × U_r, 0.2 × I_r &lt; I &lt; 4.0 × I_r</td>
<td>± 1.0% of S_r at S ≤ S_r, ± 1.0% of S at S &gt; S_r</td>
</tr>
<tr>
<td>Reactive power, Q</td>
<td>0.1 × U_r &lt; U &lt; 1.5 × U_r, 0.2 × I_r &lt; I &lt; 4.0 × I_r</td>
<td>± 1.0% of S_r at S ≤ S_r, ± 1.0% of S at S &gt; S_r</td>
</tr>
<tr>
<td>Apparent power, S</td>
<td>0.1 × U_r &lt; U &lt; 1.5 × U_r, 0.2 × I_r &lt; I &lt; 4.0 × I_r</td>
<td>± 1.0% of S_r at S ≤ S_r, ± 1.0% of S at S &gt; S_r</td>
</tr>
<tr>
<td>Apparent power, S Three phase settings</td>
<td>cos phi = 1</td>
<td>± 0.5% of S at S &gt; S_r, ± 0.5% of S_r at S ≤ S_r</td>
</tr>
<tr>
<td>Power factor, cos (φ)</td>
<td>0.1 × U_r &lt; U &lt; 1.5 × U_r, 0.2 × I_r &lt; I &lt; 4.0 × I_r</td>
<td>&lt; 0.02</td>
</tr>
</tbody>
</table>

Table 56. Event counter CNTGGIO

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Counter value</td>
<td>0–10000</td>
<td>-</td>
</tr>
<tr>
<td>Max. count up speed</td>
<td>10 pulses/s</td>
<td>-</td>
</tr>
</tbody>
</table>
Table 57. Disturbance report DRPRDRE

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current recording</td>
<td>-</td>
<td>± 1,0% of I, at I ≤ Iₜ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>± 1,0% of I at I &gt; Iₜ</td>
</tr>
<tr>
<td>Voltage recording</td>
<td>-</td>
<td>± 1,0% of U, at U ≤ Uₜ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>± 1,0% of U at U &gt; Uₜ</td>
</tr>
<tr>
<td>Pre-fault time</td>
<td>(0.05–3.00) s</td>
<td>-</td>
</tr>
<tr>
<td>Post-fault time</td>
<td>(0.1–10.0) s</td>
<td>-</td>
</tr>
<tr>
<td>Limit time</td>
<td>(0.5–8.0) s</td>
<td>-</td>
</tr>
<tr>
<td>Maximum number of recordings</td>
<td>100, first in - first out</td>
<td>-</td>
</tr>
<tr>
<td>Time tagging resolution</td>
<td>1 ms</td>
<td>See time synchronization technical data</td>
</tr>
<tr>
<td>Maximum number of analog inputs</td>
<td>30 + 10 (external + internally derived)</td>
<td>-</td>
</tr>
<tr>
<td>Maximum number of binary inputs</td>
<td>96</td>
<td>-</td>
</tr>
<tr>
<td>Maximum number of phasors in the Trip Value recorder per recording</td>
<td>30</td>
<td>-</td>
</tr>
<tr>
<td>Maximum number of indications in a disturbance report</td>
<td>96</td>
<td>-</td>
</tr>
<tr>
<td>Maximum number of events in the Event recording per recording</td>
<td>150</td>
<td>-</td>
</tr>
<tr>
<td>Maximum number of events in the Event list</td>
<td>1000, first in - first out</td>
<td>-</td>
</tr>
<tr>
<td>Maximum total recording time (3.4 s recording time and maximum number of channels, typical value)</td>
<td>340 seconds (100 recordings) at 50 Hz, 280 seconds (80 recordings) at 60 Hz</td>
<td>-</td>
</tr>
<tr>
<td>Sampling rate</td>
<td>1 kHz at 50 Hz</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>1.2 kHz at 60 Hz</td>
<td>-</td>
</tr>
<tr>
<td>Recording bandwidth</td>
<td>(5-300) Hz</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 58. Event list DRPRDRE

<table>
<thead>
<tr>
<th>Function</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buffer capacity</td>
<td>Maximum number of events in the list</td>
</tr>
<tr>
<td>Resolution</td>
<td>1 ms</td>
</tr>
<tr>
<td>Accuracy</td>
<td>Depending on time synchronizing</td>
</tr>
</tbody>
</table>

Table 59. Indications DRPRDRE

<table>
<thead>
<tr>
<th>Function</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buffer capacity</td>
<td>Maximum number of indications presented for single disturbance</td>
</tr>
<tr>
<td></td>
<td>Maximum number of recorded disturbances</td>
</tr>
</tbody>
</table>

Breaker protection REQ650  
1MRK 505 283-BEN -  
Product version: 1.2
### Table 60. Event recorder DRPRDRE

<table>
<thead>
<tr>
<th>Function</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buffer capacity</td>
<td>Maximum number of events in disturbance report 150</td>
</tr>
<tr>
<td></td>
<td>Maximum number of disturbance reports 100</td>
</tr>
<tr>
<td>Resolution</td>
<td>1 ms</td>
</tr>
<tr>
<td>Accuracy</td>
<td>Depending on time synchronizing</td>
</tr>
</tbody>
</table>

### Table 61. Trip value recorder DRPRDRE

<table>
<thead>
<tr>
<th>Function</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buffer capacity</td>
<td>Maximum number of analog inputs 30</td>
</tr>
<tr>
<td></td>
<td>Maximum number of disturbance reports 100</td>
</tr>
</tbody>
</table>

### Table 62. Disturbance recorder DRPRDRE

<table>
<thead>
<tr>
<th>Function</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buffer capacity</td>
<td>Maximum number of analog inputs 40</td>
</tr>
<tr>
<td></td>
<td>Maximum number of binary inputs 96</td>
</tr>
<tr>
<td></td>
<td>Maximum number of disturbance reports 100</td>
</tr>
<tr>
<td></td>
<td>Maximum total recording time (3.4 s recording time and maximum number of channels, typical value) 340 seconds (100 recordings) at 50 Hz, 280 seconds (80 recordings) at 60 Hz</td>
</tr>
</tbody>
</table>

### Table 63. Station battery supervision SPVNZBAT

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower limit for the battery terminal voltage</td>
<td>(60-140) % of Ubat</td>
<td>± 1.0% of set battery voltage</td>
</tr>
<tr>
<td>Reset ratio, lower limit</td>
<td>&lt;105 %</td>
<td>-</td>
</tr>
<tr>
<td>Upper limit for the battery terminal voltage</td>
<td>(60-140) % of Ubat</td>
<td>± 1.0% of set battery voltage</td>
</tr>
<tr>
<td>Reset ratio, upper limit</td>
<td>&gt;95 %</td>
<td>-</td>
</tr>
<tr>
<td>Timers</td>
<td>(0.000-60.000) s</td>
<td>± 0.5% ± 110 ms</td>
</tr>
</tbody>
</table>

### Table 64. Insulation gas monitoring function SSIMG

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure alarm</td>
<td>0.00-25.00</td>
<td>-</td>
</tr>
<tr>
<td>Pressure lockout</td>
<td>0.00-25.00</td>
<td>-</td>
</tr>
<tr>
<td>Temperature alarm</td>
<td>-40.00-200.00</td>
<td>-</td>
</tr>
<tr>
<td>Temperature lockout</td>
<td>-40.00-200.00</td>
<td>-</td>
</tr>
<tr>
<td>Timers</td>
<td>(0.000-60.000) s</td>
<td>± 0.5% ± 110 ms</td>
</tr>
</tbody>
</table>
### Table 65. Insulation liquid monitoring function SSIML

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alarm, oil level</td>
<td>0.00-25.00</td>
<td>-</td>
</tr>
<tr>
<td>Oil level lockout</td>
<td>0.00-25.00</td>
<td>-</td>
</tr>
<tr>
<td>Temperature alarm</td>
<td>-40.00-200.00</td>
<td>-</td>
</tr>
<tr>
<td>Temperature lockout</td>
<td>-40.00-200.00</td>
<td>-</td>
</tr>
<tr>
<td>Timers</td>
<td>(0.000-60.000) s</td>
<td>± 0.5% ± 110 ms</td>
</tr>
</tbody>
</table>

### Table 66. Circuit breaker condition monitoring SSCBR

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alarm levels for open and close travel time</td>
<td>(0-200) ms</td>
<td>± 0.5% ± 25 ms</td>
</tr>
<tr>
<td>Alarm levels for number of operations</td>
<td>(0 - 9999)</td>
<td>-</td>
</tr>
<tr>
<td>Setting of alarm for spring charging time</td>
<td>(0.00-60.00) s</td>
<td>± 0.5% ± 25 ms</td>
</tr>
<tr>
<td>Time delay for gas pressure alarm</td>
<td>(0.00-60.00) s</td>
<td>± 0.5% ± 25 ms</td>
</tr>
<tr>
<td>Time delay for gas pressure lockout</td>
<td>(0.00-60.00) s</td>
<td>± 0.5% ± 25 ms</td>
</tr>
</tbody>
</table>

### Metering

### Table 67. Pulse counter PCGGIO

<table>
<thead>
<tr>
<th>Function</th>
<th>Setting range</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cycle time for report of counter value</td>
<td>(1–3600) s</td>
<td>-</td>
</tr>
</tbody>
</table>

### Table 68. Function for energy calculation and demand handling ETPMMTR

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy metering</td>
<td>MWh Export/Import, MVArh Export/Import</td>
<td>Input from MMXU. No extra error at steady load</td>
</tr>
</tbody>
</table>
## Station communication

Table 69. Communication protocol

<table>
<thead>
<tr>
<th>Function</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protocol TCP/IP</td>
<td>Ethernet</td>
</tr>
<tr>
<td>Communication speed for the IEDs</td>
<td>100 Mbit/s</td>
</tr>
<tr>
<td>Protocol</td>
<td>IEC 61850–8–1</td>
</tr>
<tr>
<td>Communication speed for the IEDs</td>
<td>100BASE-FX</td>
</tr>
<tr>
<td>Protocol, serial</td>
<td>DNP3.0/TCP</td>
</tr>
<tr>
<td>Communication speed for the IEDs</td>
<td>100BASE-FX</td>
</tr>
<tr>
<td>Protocol, serial</td>
<td>IEC 60870–5–103</td>
</tr>
<tr>
<td>Communication speed for the IEDs</td>
<td>9600 or 19200 Bd</td>
</tr>
<tr>
<td>Protocol, serial</td>
<td>DNP3.0</td>
</tr>
<tr>
<td>Communication speed for the IEDs</td>
<td>300–19200 Bd</td>
</tr>
</tbody>
</table>

## Hardware

### IED

Table 70. Degree of protection of rack-mounted IED

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front side</td>
<td>IP 40</td>
</tr>
<tr>
<td>Rear side, connection terminals</td>
<td>IP 20</td>
</tr>
</tbody>
</table>

Table 71. Degree of protection of the LHMI

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front and side</td>
<td>IP 40</td>
</tr>
</tbody>
</table>

## Dimensions

Table 72. Dimensions of the IED - 3U full 19" rack

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width</td>
<td>442 mm (17.40 inches)</td>
</tr>
<tr>
<td>Height</td>
<td>132 mm (5.20 inches), 3U</td>
</tr>
<tr>
<td>Depth</td>
<td>249.5 mm (9.82 inches)</td>
</tr>
<tr>
<td>Weight box</td>
<td>10 kg (&lt;22.04 lbs)</td>
</tr>
<tr>
<td>Weight LHMI</td>
<td>1.3 kg (2.87 lbs)</td>
</tr>
</tbody>
</table>
### Inverse time characteristics

#### Table 73. ANSI Inverse time characteristics

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating characteristic:</td>
<td>$k = (0.05-999)$ in steps of 0.01</td>
<td>-</td>
</tr>
<tr>
<td>$t = \left( \frac{A}{(t^p - 1)} + B \right)^-k$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I = $\frac{l_{\text{measured}}}{l_{\text{set}}}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ANSI Extremely Inverse</td>
<td>$A=28.2$, $B=0.1217$, $P=2.0$</td>
<td></td>
</tr>
<tr>
<td>ANSI Very inverse</td>
<td>$A=19.61$, $B=0.491$, $P=2.0$</td>
<td></td>
</tr>
<tr>
<td>ANSI Normal Inverse</td>
<td>$A=0.0086$, $B=0.0185$, $P=0.02$, $t_r=0.46$</td>
<td></td>
</tr>
<tr>
<td>ANSI Moderately Inverse</td>
<td>$A=0.0515$, $B=0.1140$, $P=0.02$</td>
<td></td>
</tr>
<tr>
<td>ANSI Long Time Extremely Inverse</td>
<td>$A=64.07$, $B=0.250$, $P=2.0$</td>
<td></td>
</tr>
<tr>
<td>ANSI Long Time Very Inverse</td>
<td>$A=28.55$, $B=0.712$, $P=2.0$</td>
<td></td>
</tr>
<tr>
<td>ANSI Long Time Inverse</td>
<td>$A=0.086$, $B=0.185$, $P=0.02$</td>
<td></td>
</tr>
</tbody>
</table>

#### Table 74. IEC Inverse time characteristics

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating characteristic:</td>
<td>$k = (0.05-999)$ in steps of 0.01</td>
<td>-</td>
</tr>
<tr>
<td>$t = \left( \frac{A}{(t^p - 1)} \right)^-k$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I = $\frac{l_{\text{measured}}}{l_{\text{set}}}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IEC Normal Inverse</td>
<td>$A=0.14$, $P=0.02$</td>
<td></td>
</tr>
<tr>
<td>IEC Very inverse</td>
<td>$A=13.5$, $P=1.0$</td>
<td></td>
</tr>
<tr>
<td>IEC Inverse</td>
<td>$A=0.14$, $P=0.02$</td>
<td></td>
</tr>
<tr>
<td>IEC Extremely inverse</td>
<td>$A=80.0$, $P=2.0$</td>
<td></td>
</tr>
<tr>
<td>IEC Short time inverse</td>
<td>$A=0.05$, $P=0.04$</td>
<td></td>
</tr>
<tr>
<td>IEC Long time inverse</td>
<td>$A=120$, $P=1.0$</td>
<td></td>
</tr>
</tbody>
</table>
### Table 75. RI and RD type inverse time characteristics

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>RI type inverse characteristic</td>
<td></td>
<td>k = (0.05-999) in steps of 0.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Equation 1137</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$I = \frac{I_{\text{measured}}}{I_{\text{set}}}$</td>
</tr>
<tr>
<td>RD type logarithmic inverse characteristic</td>
<td></td>
<td>k = (0.05-999) in steps of 0.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Equation 1138</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$I = \frac{I_{\text{measured}}}{I_{\text{set}}}$</td>
</tr>
</tbody>
</table>

### Table 76. Inverse time characteristics for overvoltage protection

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type A curve:</td>
<td></td>
<td>k = (0.05-1.10) in steps of 0.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td>±5% +60 ms</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Equation 1436</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$U &gt; U_{\text{set}}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$U = U_{\text{measured}}$</td>
</tr>
<tr>
<td>Type B curve:</td>
<td></td>
<td>k = (0.05-1.10) in steps of 0.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Equation 1437</strong></td>
</tr>
<tr>
<td>Type C curve:</td>
<td></td>
<td>k = (0.05-1.10) in steps of 0.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Equation 1438</strong></td>
</tr>
</tbody>
</table>

Breaker protection REQ650

Product version: 1.2
Table 77. Inverse time characteristics for undervoltage protection

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type A curve:</td>
<td>$t = \frac{k}{U &lt; -U}$</td>
<td>$k = (0.05-1.10)$ in steps of 0.01</td>
</tr>
<tr>
<td>(U \leq U_{\text{set}}) (U = U_{\text{measured}})</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type B curve:</td>
<td>$t = \frac{k \cdot 480}{32 \left( \frac{U_{&gt;}}{U} - 0.5 \right)^{2.0} - 0.035}$</td>
<td>$k = (0.05-1.10)$ in steps of 0.01</td>
</tr>
<tr>
<td>(U &gt; U_{\text{set}}) (U = U_{\text{measured}})</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 78. Inverse time characteristics for residual overvoltage protection

<table>
<thead>
<tr>
<th>Function</th>
<th>Range or value</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type A curve:</td>
<td>$t = \frac{k}{U &gt;}$</td>
<td>$k = (0.05-1.10)$ in steps of 0.01</td>
</tr>
<tr>
<td>(U &gt; U_{\text{set}}) (U = U_{\text{measured}})</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type B curve:</td>
<td>$t = \frac{k \cdot 480}{32 \left( \frac{U_{&gt;}}{U} - 0.5 \right)^{3.0} - 0.035}$</td>
<td>$k = (0.05-1.10)$ in steps of 0.01</td>
</tr>
<tr>
<td>(U &gt; U_{\text{set}}) (U = U_{\text{measured}})</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type C curve:</td>
<td>$t = \frac{k \cdot 480}{32 \left( \frac{U_{&gt;}}{U} - 0.5 \right)^{3.0} - 0.035}$</td>
<td>$k = (0.05-1.10)$ in steps of 0.01</td>
</tr>
<tr>
<td>(U &gt; U_{\text{set}}) (U = U_{\text{measured}})</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
19. Ordering for Customized IED

Guidelines

Carefully read and follow the set of rules to ensure problem-free order management. Be aware that certain functions can only be ordered in combination with other functions and that some functions require specific hardware selections.

Product specification

Basic IED 650 platform and common functions housed in 3U 1/1 sized 19" casing

<table>
<thead>
<tr>
<th>Product</th>
<th>Quantity</th>
<th>Option</th>
<th>Connection type for Analog modules</th>
</tr>
</thead>
<tbody>
<tr>
<td>REQ650</td>
<td></td>
<td>On request</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Compression terminals</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ring lug terminals</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Connection type for Power supply, Input/Output and communication modules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compression terminals</td>
</tr>
<tr>
<td>Ring lug terminals</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Power supply module (PSM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>48-125 VDC</td>
</tr>
<tr>
<td>110-250 VDC, 100–240V AC</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Current protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breaker failure protection, 3–phase activation and output (CCRBRF) Qty:</td>
</tr>
<tr>
<td>Breaker failure protection, phase segregated activation and output (CSPRBRF) Qty:</td>
</tr>
</tbody>
</table>
## Logic

**Rule:** One tripping logic type only must be ordered  
**Note:** Selection of Tripping Logic type rules the selection of Instantaneous phase Overcurrent protection, Four step phase Overcurrent protection, Breaker Failure protection and Autorecloser.

<table>
<thead>
<tr>
<th>Tripping logic, common 3–phase output (SMPPTRC)</th>
<th>Qty:</th>
<th>1MRK 004 922-AA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tripping logic, phase segregated output (SPTPTRC)</td>
<td>Qty:</td>
<td>1MRK 004 922-UA</td>
</tr>
</tbody>
</table>

## Optional functions

### Current protection

**Rule:** Only one Instantaneous phase overcurrent protection can be ordered

**Rule:** If 3 ph tripping logic has been selected only PHPIOC can be selected. If Phase segregated tripping logic has been selected only SPTPIOC can be selected.

<table>
<thead>
<tr>
<th>Instantaneous phase overcurrent protection, 3–phase output (PHPIOC)</th>
<th>Qty:</th>
<th>1MRK 004 908-AA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instantaneous phase overcurrent protection, phase segregated output (SPTPIOC)</td>
<td>Qty:</td>
<td>1MRK 004 908-XA</td>
</tr>
</tbody>
</table>

**Rule:** Only one Four step phase overcurrent protection can be ordered.  
**Rule:** If 3 ph tripping logic has been selected only OC4PTOC can be selected. If Phase segregated tripping logic has been selected only OC4SPTOC can be selected.

<table>
<thead>
<tr>
<th>Four step phase overcurrent protection, 3–phase output (OC4PTOC)</th>
<th>Qty:</th>
<th>1MRK 004 908-BB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Four step phase overcurrent protection, phase segregated output (OC4SPTOC)</td>
<td>Qty:</td>
<td>1MRK 004 908-VB</td>
</tr>
<tr>
<td>Instantaneous residual overcurrent protection (EFPIOC)</td>
<td>Qty:</td>
<td>1MRK 004 908-CA</td>
</tr>
<tr>
<td>Four step residual overcurrent protection, zero/negative sequence direction (EF4PTOC)</td>
<td>Qty:</td>
<td>1MRK 004 908-FA</td>
</tr>
<tr>
<td>Sensitive directional residual overcurrent and power protection (SDEPSDE)</td>
<td>Qty:</td>
<td>1MRK 004 908-EA</td>
</tr>
<tr>
<td>Thermal overload protection, one time constant, Celsius (LCPTTR)</td>
<td>Qty:</td>
<td>1MRK 004 908-HC</td>
</tr>
<tr>
<td>Thermal overload protection, one time constant, Fahrenheit (LFPTTR)</td>
<td>Qty:</td>
<td>1MRK 004 908-HD</td>
</tr>
<tr>
<td>Stub protection (STBPTOC)</td>
<td>Qty:</td>
<td>1MRK 004 908-MA</td>
</tr>
<tr>
<td>Pole discordance protection (CCRPLD)</td>
<td>Qty:</td>
<td>1MRK 004 908-NA</td>
</tr>
<tr>
<td>Broken conductor check (BRCPTOC)</td>
<td>Qty:</td>
<td>1MRK 004 908-PA</td>
</tr>
<tr>
<td>Directional underpower protection (GUPPDUP)</td>
<td>Qty:</td>
<td>1MRK 004 908-RB</td>
</tr>
<tr>
<td>Directional overpower protection (GOPPDUP)</td>
<td>Qty:</td>
<td>1MRK 004 908-SB</td>
</tr>
<tr>
<td>Negative sequence based overcurrent function (DNSPTOC)</td>
<td>Qty:</td>
<td>1MRK 004 908-TA</td>
</tr>
</tbody>
</table>
### Breaker protection REQ650

**Product version:** 1.2

<table>
<thead>
<tr>
<th>Component Description</th>
<th>Qty</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage protection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Two step undervoltage protection (UV2PTUV)</td>
<td></td>
<td>1MRK 004 910-AB</td>
</tr>
<tr>
<td>Two step overvoltage protection (OV2PTOV)</td>
<td></td>
<td>1MRK 004 910-BB</td>
</tr>
<tr>
<td>Two step residual overvoltage protection (ROV2PTOV)</td>
<td></td>
<td>1MRK 004 910-CB</td>
</tr>
<tr>
<td>Loss of voltage check (LOVPTUV)</td>
<td></td>
<td>1MRK 004 910-EA</td>
</tr>
<tr>
<td>Frequency protection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Underfrequency protection (SAPTFU)</td>
<td>1</td>
<td>1MRK 004 912-AA</td>
</tr>
<tr>
<td>Overfrequency protection (SAPTOF)</td>
<td>1</td>
<td>1MRK 004 912-BA</td>
</tr>
<tr>
<td>Rate-of-change frequency protection (SAPFRC)</td>
<td>1</td>
<td>1MRK 004 912-CA</td>
</tr>
<tr>
<td>Secondary system supervision</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current circuit supervision (CCSRDIF)</td>
<td></td>
<td>1MRK 004 914-AA</td>
</tr>
<tr>
<td>Fuse failure supervision (SDDRFUF)</td>
<td></td>
<td>1MRK 004 914-BBA</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Synchrocheck, energizing check and synchronizing (SESRSYN)</td>
<td></td>
<td>1MRK 004 917-AC</td>
</tr>
<tr>
<td>Rule: Only one of Autorecloser can be ordered</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rule: If 3 ph tripping logic has been selected only SMBRREC can be selected. If Phase segregated tripping logic has been selected only STBRREC can be selected.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Autorecloser for 3–phase operation (SMBRREC)</td>
<td></td>
<td>1MRK 004 917-BA</td>
</tr>
<tr>
<td>Autorecloser for 1/3–phase operation (STBRREC)</td>
<td></td>
<td>1MRK 004 917-SA</td>
</tr>
<tr>
<td>Monitoring</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Station battery supervision (SPVNZBAT)</td>
<td></td>
<td>1MRK 004 925-HB</td>
</tr>
<tr>
<td>Insulation gas monitoring function (Ssimg,)</td>
<td></td>
<td>1MRK 004 925-KA</td>
</tr>
<tr>
<td>Insulation liquid monitoring function (SSIML)</td>
<td></td>
<td>1MRK 004 925-LA</td>
</tr>
<tr>
<td>Circuit breaker condition monitoring (SSCBR)</td>
<td></td>
<td>1MRK 004 925-MA</td>
</tr>
<tr>
<td>First local HMI user dialogue language</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HMI language, English IEC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Additional local HMI user dialogue language</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HMI language, English US</td>
<td></td>
<td>1MRK 002 940-MA</td>
</tr>
</tbody>
</table>

**Note:** Always included

ABB
Optional hardware

Human machine interface

Rule: One must be ordered.

<table>
<thead>
<tr>
<th>Display type</th>
<th>Keypad symbol</th>
<th>Case size</th>
<th>Qty:</th>
<th>1KHL160055R0001</th>
<th>1KHL160042R0001</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local human machine interface (LHMI)</td>
<td>IEC</td>
<td>3U 1/1 19&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Local human machine interface (LHMI)</td>
<td>ANSI</td>
<td>3U 1/1 19&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Analog system

Rule: One Transformer input module must be ordered

<table>
<thead>
<tr>
<th>Transformer module (TRM)</th>
<th>Qty:</th>
<th>1KHL178083R0001</th>
<th>1KHL178083R0013</th>
<th>1KHL178083R0016</th>
<th>1KHL178083R0003</th>
</tr>
</thead>
<tbody>
<tr>
<td>6I+4U, 1/5A, 100/220V</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8I+2U, 1/5A, 100/220V</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4I, 1/5A+1I, 0.1/0.5A+5U, 100/220V</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4I+6U, 1/5A, 100/220V</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Rule: Only one Analog input module can be ordered

<table>
<thead>
<tr>
<th>Analog input module (AIM)</th>
<th>Qty:</th>
<th>1KHL178083R0001</th>
<th>1KHL178083R0016</th>
</tr>
</thead>
<tbody>
<tr>
<td>6I+4U, 1/5A, 100/220V</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4I, 1/5A+1I, 0.1/0.5A+5U, 100/220V</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Binary input/output modules

Note: If analog input module (AIM) is ordered only 2 BIO modules can be ordered

<table>
<thead>
<tr>
<th>Binary input/output module (BIO)</th>
<th>Qty:</th>
<th>1KHL178074R0001</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

Rack mounting kit

<table>
<thead>
<tr>
<th>Rack mounting kit for 3U 1/1 x 19&quot; case</th>
<th>Quantity:</th>
<th>1KHL400352R0001</th>
</tr>
</thead>
</table>
20. Ordering for Configured IED

**Guidelines**
Carefully read and follow the set of rules to ensure problem-free order management.
Please refer to the available functions table for included application functions.

To obtain the complete ordering code, please combine code from the tables, as given in the example below.

**Exemple code:** REQ650*1.2-A01X00-X00-B1A5-B-A-SA-AB1-RA3-AXXX-E. Using the code of each position #1-11 specified as REQ650*1-2 2-3-4 4-5-6-7 7-8 8-9 9-10 10 10 10-11

<table>
<thead>
<tr>
<th>#</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<th>7</th>
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<tr>
<td>REQ650*</td>
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<table>
<thead>
<tr>
<th>Position</th>
<th>Notes and Rules</th>
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<tbody>
<tr>
<td>SOFTWARE</td>
<td>#1</td>
</tr>
<tr>
<td>Version number</td>
<td>1.2</td>
</tr>
<tr>
<td>Selection for position #1.</td>
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<table>
<thead>
<tr>
<th>Configuration alternatives</th>
<th>#2</th>
<th>Notes and Rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single breaker, 3-phase, 1 busbar</td>
<td>A01</td>
<td></td>
</tr>
<tr>
<td>Single breaker, single phase, 1 busbar</td>
<td>A11</td>
<td></td>
</tr>
<tr>
<td>Single breaker, single phase, 2 busbars</td>
<td>B11</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>ACT configuration</th>
<th>#2</th>
<th>Notes and Rules</th>
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<tbody>
<tr>
<td>ABB standard configuration</td>
<td>X00</td>
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<tr>
<td>Selection for position #2.</td>
<td>X00</td>
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<tr>
<th>Software options</th>
<th>#3</th>
<th>Notes and Rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>No option</td>
<td>X00</td>
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<tr>
<td>Selection for position #3</td>
<td>X00</td>
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<tr>
<th>First HMI language</th>
<th>#4</th>
<th>Notes and Rules</th>
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<tbody>
<tr>
<td>English IEC</td>
<td>B1</td>
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<td>Selection for position #4.</td>
<td>B1</td>
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<table>
<thead>
<tr>
<th>Additional HMI language</th>
<th>#4</th>
<th>Notes and Rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>No second HMI language</td>
<td>X0</td>
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<tr>
<td>Selection for position #4.</td>
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<table>
<thead>
<tr>
<th>Casing</th>
<th>#5</th>
<th>Notes and Rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rack casing, 3U 1/1 x 19&quot;</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>Selection for position #5.</td>
<td>D</td>
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</tr>
</tbody>
</table>
### Mounting details with IP40 of protection from the front

<table>
<thead>
<tr>
<th>#6</th>
<th>Notes and Rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>No mounting kit included</td>
<td>X</td>
</tr>
<tr>
<td>Rack mounting kit for 3U 1/1 x 19&quot;</td>
<td>H</td>
</tr>
</tbody>
</table>

Selection for position #6.

### Connection type for Power supply, Input/output and Communication modules

<table>
<thead>
<tr>
<th>#7</th>
<th>Notes and Rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compression terminals</td>
<td>S</td>
</tr>
<tr>
<td>Ringlug terminals</td>
<td>R</td>
</tr>
</tbody>
</table>

**Power supply**

**Slot position:**

- 100-240V AC, 110-250V DC, 9BO: A
- 48-125V DC, 9BO: B

Selection for position #7.

### Human machine interface

<table>
<thead>
<tr>
<th>#8</th>
<th>Notes and Rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local human machine interface, OL8000, IEC 3U 1/1 x 19&quot;, Basic</td>
<td>E</td>
</tr>
<tr>
<td>Detached LHMI</td>
<td>X0</td>
</tr>
</tbody>
</table>

No detached mounting of LHMI

Selection for position #8.

### Connection type for Analog modules

<table>
<thead>
<tr>
<th>#9</th>
<th>Notes and Rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compression terminals</td>
<td>S</td>
</tr>
<tr>
<td>Ringlug terminals</td>
<td>R</td>
</tr>
</tbody>
</table>

**Analog system**

**Slot position:**

- Transformer module, 4I, 1/5A+1I, 0.1/0.5A+5U, 100/220V: A3

Selection for position #9.

### Binary input/output module

<table>
<thead>
<tr>
<th>#10</th>
<th>Notes and Rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slot position (rear view)</td>
<td></td>
</tr>
<tr>
<td>Available slots in 1/1 case</td>
<td></td>
</tr>
<tr>
<td>No board in slot</td>
<td>X X X</td>
</tr>
<tr>
<td>Binary input/output module 9 BI, 3 NO Trip, 5 NO Signal, 1 CO Signal</td>
<td>A A A A p4, p5, p6 optional for A01 p4=A, p5, p6 optional for A11/B11</td>
</tr>
</tbody>
</table>

Selection for position #10.
## Communication and processing module

<table>
<thead>
<tr>
<th>Slot position (rear view)</th>
<th>#11</th>
<th>Notes and Rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>pCOM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12BI, IRIG-B, RS485, Ethernet, LC optical, ST serial</td>
<td>F</td>
<td></td>
</tr>
</tbody>
</table>

**Selection for position #11.**

F
21. Ordering for Accessories

Configuration and monitoring tools

Front connection cable between LCD-HMI and PC  Quantity: 1MRK 001 665-CA

LED Label special paper A4, 1 pc  Quantity: 1MRK 002 038-CA

LED Label special paper Letter, 1 pc  Quantity: 1MRK 002 038-DA

Manuals

Note: One (1) IED Connect DVD containing user documentation
Operation manual
Technical manual
Installation manual
Commissioning manual
Application manual
Communication protocol manual, DNP3
Communication protocol manual, IEC61850-8-1
Communication protocol manual, IEC60870-5-103
Cyber security deployment guidelines
Type test certificate
Engineering manual
Point list manual, DNP3
Connectivity packages and LED label template is always included for each IED

Rule: Specify additional quantity of IED Connect DVD requested
User documentation  Quantity: 1MRK 003 500-AA
**Rule: Specify the number of printed manuals requested**

<table>
<thead>
<tr>
<th>Manual Type</th>
<th>IEC</th>
<th>Quantity</th>
<th>Code</th>
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</thead>
<tbody>
<tr>
<td>Operation manual</td>
<td>IEC</td>
<td>Quantity</td>
<td>1MRK 500 095-UEN</td>
</tr>
<tr>
<td>Technical manual</td>
<td>IEC</td>
<td>Quantity</td>
<td>1MRK 505 281-UEN</td>
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<tr>
<td>Commissioning manual</td>
<td>IEC</td>
<td>Quantity</td>
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<td>Application manual</td>
<td>IEC</td>
<td>Quantity</td>
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<td>Communication protocol manual, DNP3</td>
<td>IEC</td>
<td>Quantity</td>
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<td>Communication protocol manual, IEC 61850-8-1</td>
<td>IEC</td>
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<td>Communication protocol manual, IEC 60870-5-103</td>
<td>IEC</td>
<td>Quantity</td>
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<tr>
<td>Engineering manual</td>
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<td>Installation manual</td>
<td>IEC</td>
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<td>1MRK 514 015-UEN</td>
</tr>
<tr>
<td>Point list manual, DNP3</td>
<td>IEC</td>
<td>Quantity</td>
<td>1MRK 511 260-UEN</td>
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<tr>
<td>Cyber Security deployment guidelines</td>
<td>IEC</td>
<td>Quantity</td>
<td>1MRK 511 268-UEN</td>
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</tbody>
</table>

**Reference information**

For our reference and statistics we would be pleased to be provided with the following application data:

Country:                        End User:

Station name:                   Voltage level:  kV

ABB
### Related documents

#### Documents related to REQ650

<table>
<thead>
<tr>
<th>Document Type</th>
<th>Identity number</th>
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<tbody>
<tr>
<td>Application manual</td>
<td>1MRK 505 280-UEN</td>
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<tr>
<td>Technical manual</td>
<td>1MRK 505 281-UEN</td>
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<tr>
<td>Commissioning manual</td>
<td>1MRK 505 282-UEN</td>
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<tr>
<td>Product Guide</td>
<td>1MRK 505 283-BEN</td>
</tr>
<tr>
<td>Type test certificate</td>
<td>1MRK 505 283-TEN</td>
</tr>
<tr>
<td>Application notes for Circuit Breaker Control</td>
<td>1MRG006806</td>
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#### 650 series manuals

<table>
<thead>
<tr>
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<tbody>
<tr>
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<td>1MRK 511 257-UEN</td>
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