RELION® PROTECTION AND CONTROL

REX640

Product Guide

Contents

1. Description

REX640 is a powerful all-in-one protection and control relay for use in advanced power distribution and generation applications with unmatched flexibility available during the complete life cycle of the device – from ordering of the device, through testing and commissioning to upgrading the functionality of the modular software and hardware as application requirements change.

The modular design of both hardware and software elements facilitates the coverage of any comprehensive protection application requirement that may arise during the complete life cycle of the relay and substation.

REX640 makes modification and upgrading easy and pushes the limits of what can be achieved with a single device.

2. Application packages

REX640 offers comprehensive base functionality. However, it is possible to further adapt the product to meet special installation needs by including any number of the available optional application packages into a single REX640 relay. For the selected application packages, the functionality can be extended by including the related add-on package. The REX640 connectivity package guides the engineer in optimizing the application configuration and its performance.

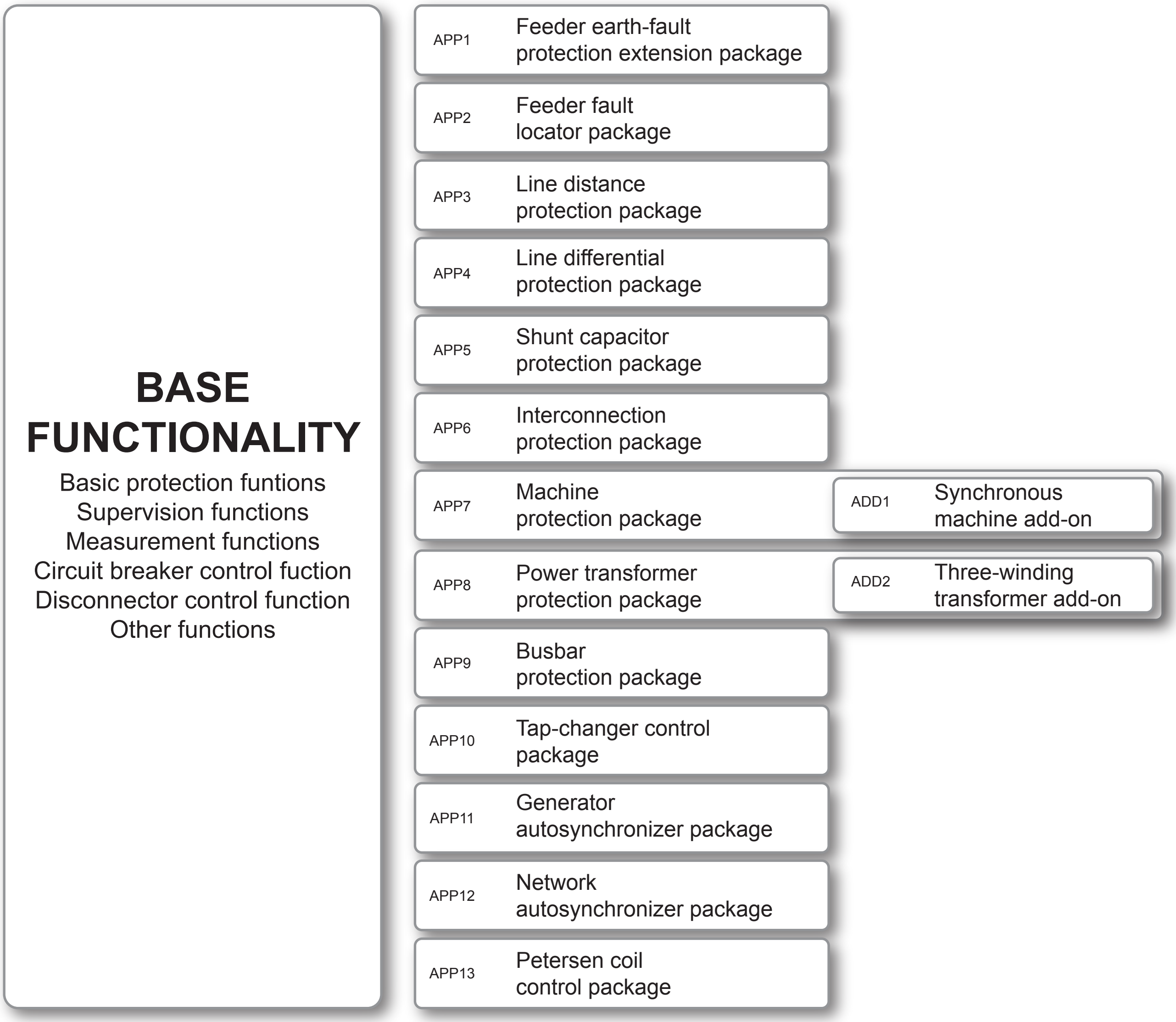

Figure 1. REX640 base and optional functionality

3. Relay hardware

The relay has mandatory and optional slots. A mandatory slot always contains a module but an optional slot may be empty, depending on the composition variant ordered.

Table 1. Module slots

Module	Slot A1	Slot A2	Slot B	Slot C	Slot D	Slot E	Slot F	Slot G
ARC1001	o							
COM1001		•						
COM1002		•						
COM1003		•						
COM1004		•						
COM1005		•						
BIO1001			•	o	o			
BIO1002			•	o	o			
BIO1003						o		
BIO1004						o		
RTD1001				o	o			
AIM1001						o	•	
AIM1002						o	•	
SIM1001						o	•	
PSM1001								•
PSM1002								•
PSM1003								•

• = Mandatory to have one of the allocated modules in the slot
o = Optional to have one of the allocated modules in the slot. The population (order) of the modules in the optional slots depends on the composition variant ordered.

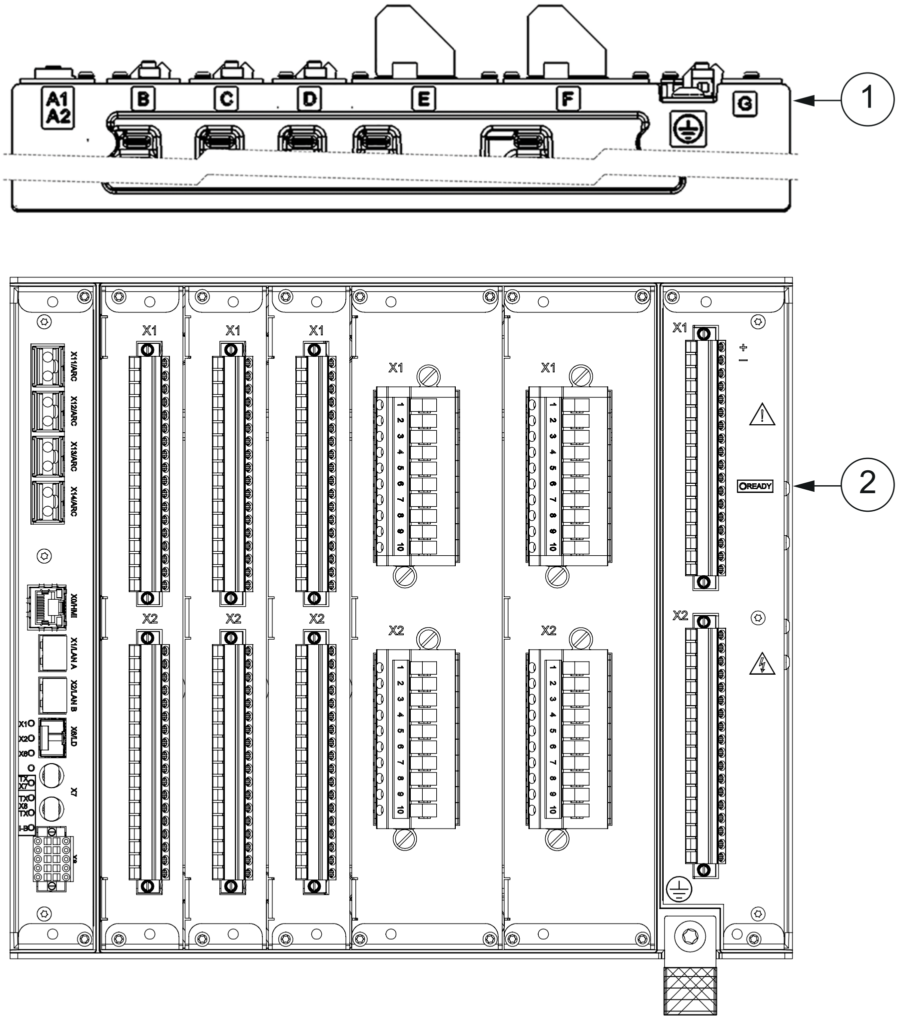

Figure 2. Hardware module slot overview of the REX640 relay

1 Slot markings in enclosure (top and bottom)

2 Ready LED

Table 2. Module description

Module	Description
ARC1001	4 × ARC sensor inputs (lense, loop or mixed)
COM1001	1 × RJ-45 (LHMI port) + 3 × RJ-45 + 1 × LD-SFP[1)]
COM1002	1 × RJ-45 (LHMI port) + 2 × LC + 1 × RJ-45 + 1 × LD-SFP
COM1003	1 × RJ-45 (LHMI port) + 3 × LC + 1 × LD-SFP
COM1004	1 × RJ-45 (LHMI port) + 2 × RJ-45 + 1 × LD-SFP + 1 × RS-485/IRIG-B + 1 × FO UART
COM1005	1 × RJ-45 (LHMI port) + 2 × LC + 1 × LD-SFP + 1 × RS-485/IRIG-B + 1 × FO UART
BIO1001/ BIO1003	14 × BI + 8 × SO
BIO1002/ BIO1004	6 × SPO + 2 × SPO (TCS) + 9 × BI
RTD1001	10 × RTD channels + 2 × mA channels (input/output)
AIM1001	4 × CT + 1 × CT (sensitive, for residual current only) + 5 × VT
AIM1002	6 × CT + 4 × VT
SIM1001	3 × combi sensor inputs + 1 × CT (sensitive, for residual current only) + 1 × VT
PSM1001	24...60 VDC, 3 × PO (TCS) + 2 × PO + 3 × SO + 2 × SSO
PSM1002	48...250 VDC / 100...240 VAC, 3 × PO (TCS) + 2 × PO + 3 × SO + 2 × SSO
PSM1003	110/125 VDC (77...150 VDC), 3 × PO (TCS) + 2 × PO + 3 × SO + 2 × SSO

PO = Power Output
SO = Signal Output
SPO = Static Power Output
SSO = Static Signal Output

1) Line distance/line differential protection communication + binary signal transfer, optical multimode or single-mode LC small form-factor pluggable transceiver (SFP)

The relay has a nonvolatile memory which does not need any periodical maintenance. The nonvolatile memory stores all events, recordings and logs to a memory which retains data if the relay loses its auxiliary supply.

4. Local HMI

The LHMI uses rugged 7-inch high resolution color screen with capacitive touch sensing technology. The user interface has been carefully designed to offer the best situational awareness to the user. Visualization of the primary process measurements, events, alarms and switching objects' statuses makes the local interaction with the relay extremely easy and self-evident. The LHMI provides a control point for the selected primary devices via pop-up operator dialogs.

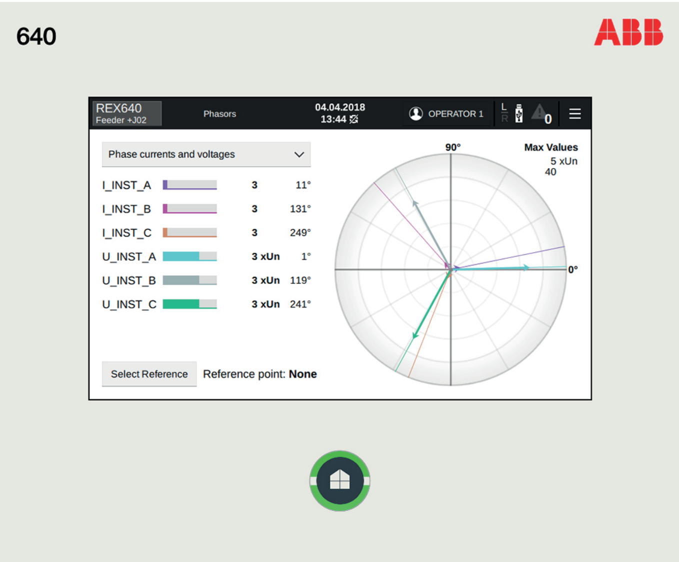

Figure 3. Phasor presentation of measurements as an example of local HMI pages

Additionally, the LHMI supports the engineer during the relay's testing, commissioning and troubleshooting activities. The information, traditionally accessible through different paths within the menu structure, is provided in collectively grouped and visualized format.

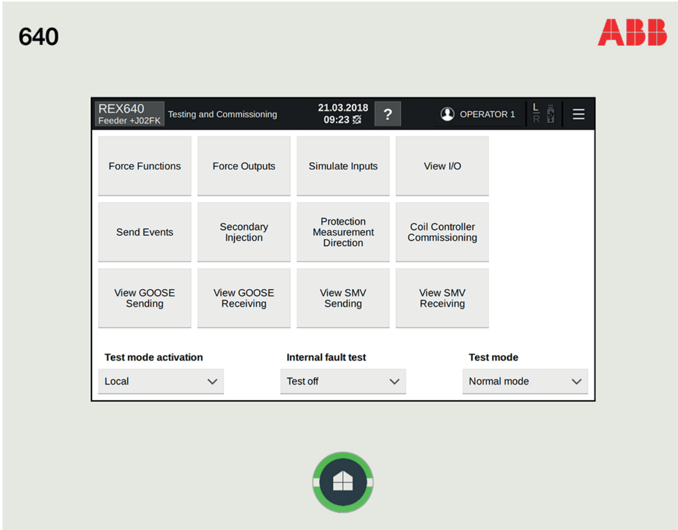

Figure 4. Test and commissioning support in the local HMI

The Home button at the bottom of the LHMI indicates the relay's status at a glance. In normal situations, the Home button shows a steady green light. Any other situation that requires the operator's attention is indicated with a flashing light, a red light or a combination of these.

The LHMI presents pages in two categories: the Operator pages and the Engineer pages. The Operator pages include the ones which are typically required as a part of an operator's normal activities, such as a single-line diagram, controls, measurements, events, alarms, and so on. The Engineer's pages include specifically designed pages supporting relay parametrization, troubleshooting, testing and commissioning activities.

The Operator pages can be used as such or customized according to the project's requirements using Graphical Display Editor (GDE) within the PCM600 software tool. The Engineer pages are fixed and cannot be customized.

The Operator pages can be scrolled either by tapping the Home button or by swiping the actual pages. The Engineer pages are accessible by touching the upper horizontal section of the screen.

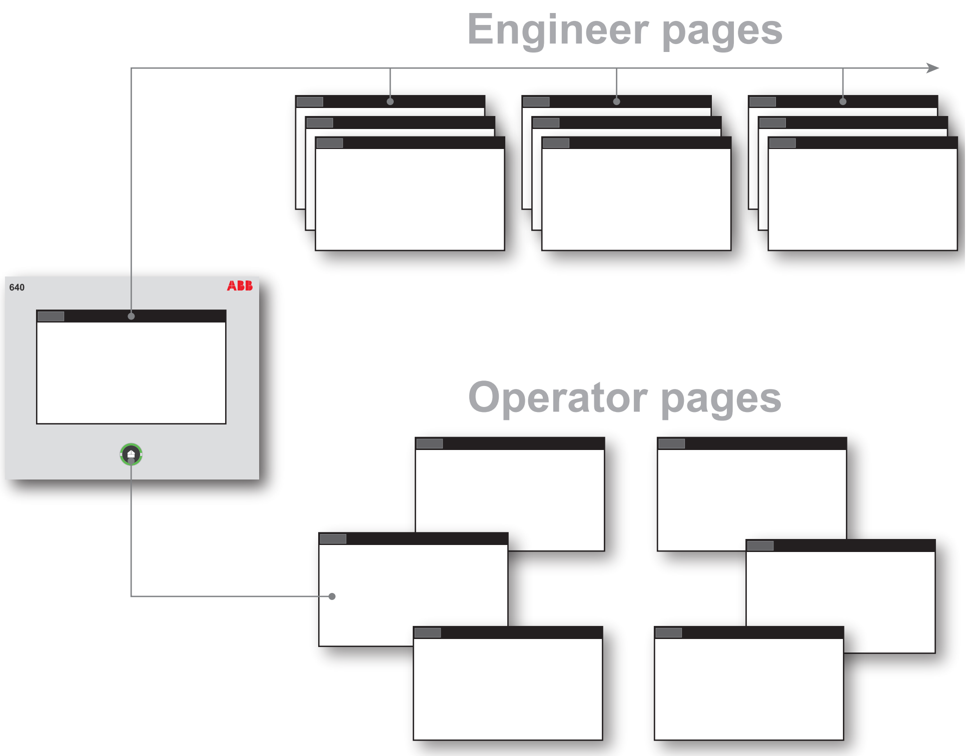

Figure 5. LHMI pages

The LHMI is an accessory for the relay which is fully operational even without the LHMI. The relay communication card has a dedicated port where the LHMI is connected using an RJ-45 connector and a CAT6 S/FTP cable. The LHMI can be connected to the relay also via station communication network if a longer distance is required between the relay and the LHMI.

Additionally, the LHMI contains one Ethernet service port with an RJ-45 connector and one USB port. The service port can be used for the PCM600 connection or for Web HMI connection. Data transfer to a USB memory is enabled via the USB port. By default the USB port is disabled and has to be taken into use with a specific parameter.

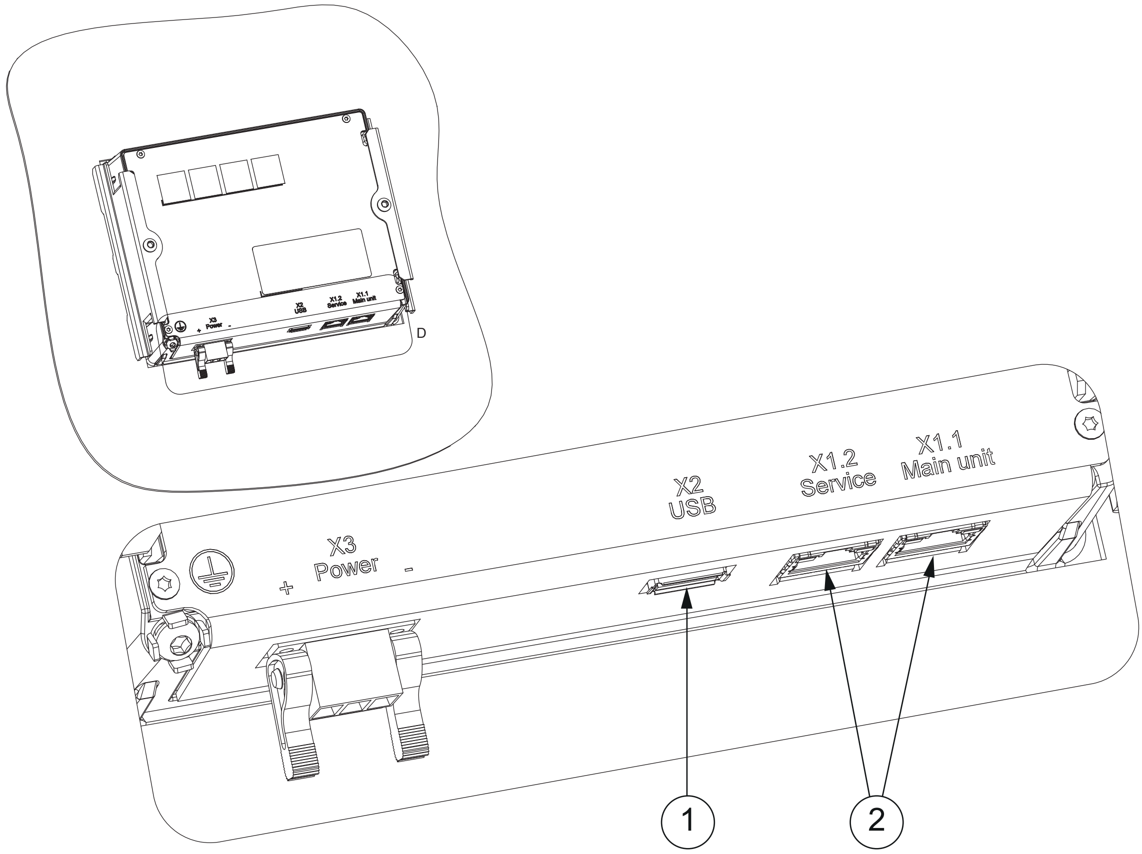

Figure 6. LHMI connectors

1 USB port

2 RJ-45 ports

5. Application

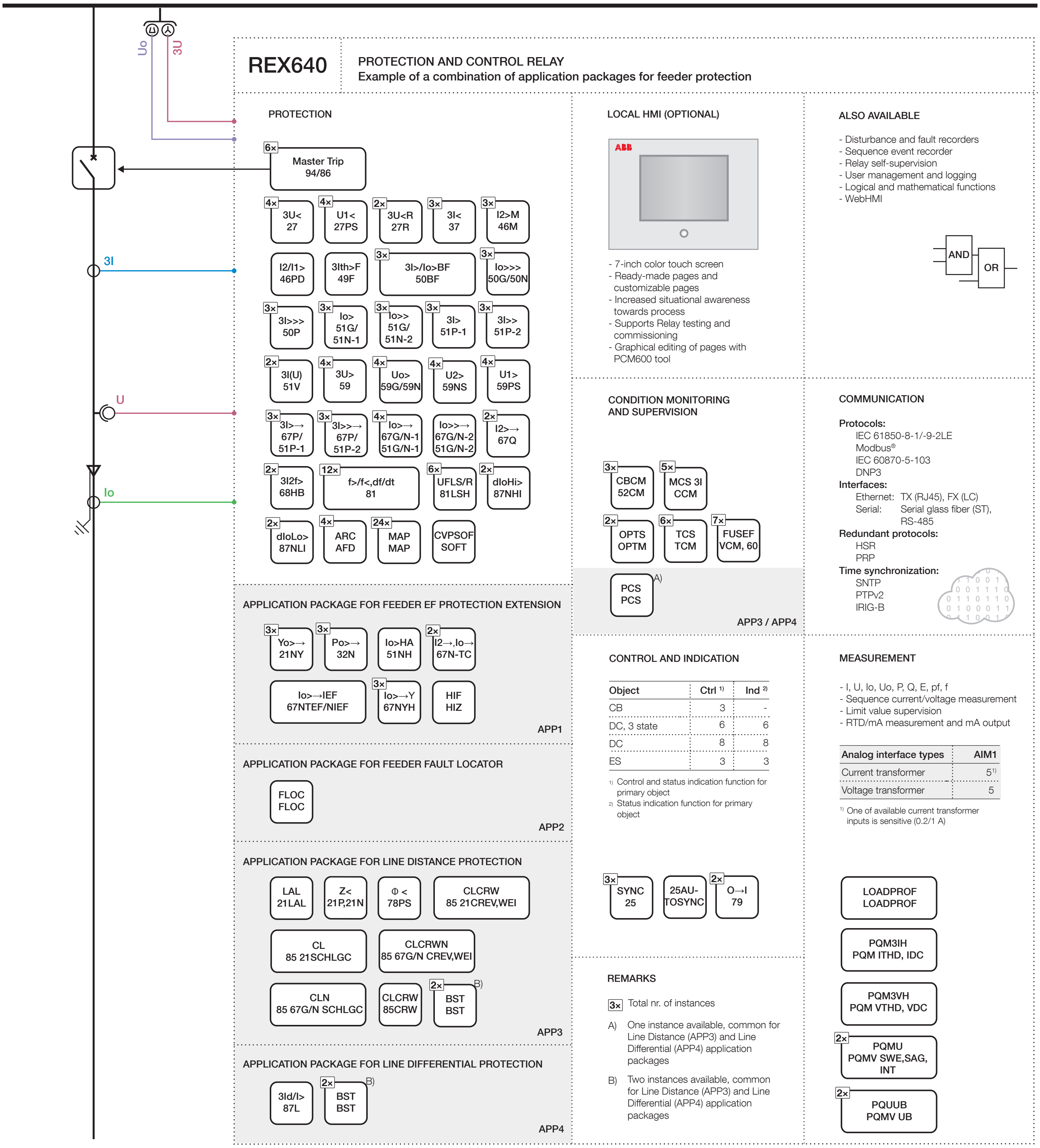

Figure 7. Feeder application

Figure 7 presents REX640 in a feeder application. The base functionality is enhanced with application packages providing both line distance and line differential protections. To provide additional protection against earth faults along the feeder, an additional application package has been selected. Conventional measuring transformers are used in the example case. The AIM1 analog input card provides the best match for them with five voltage and five current inputs, one being a sensitive input.

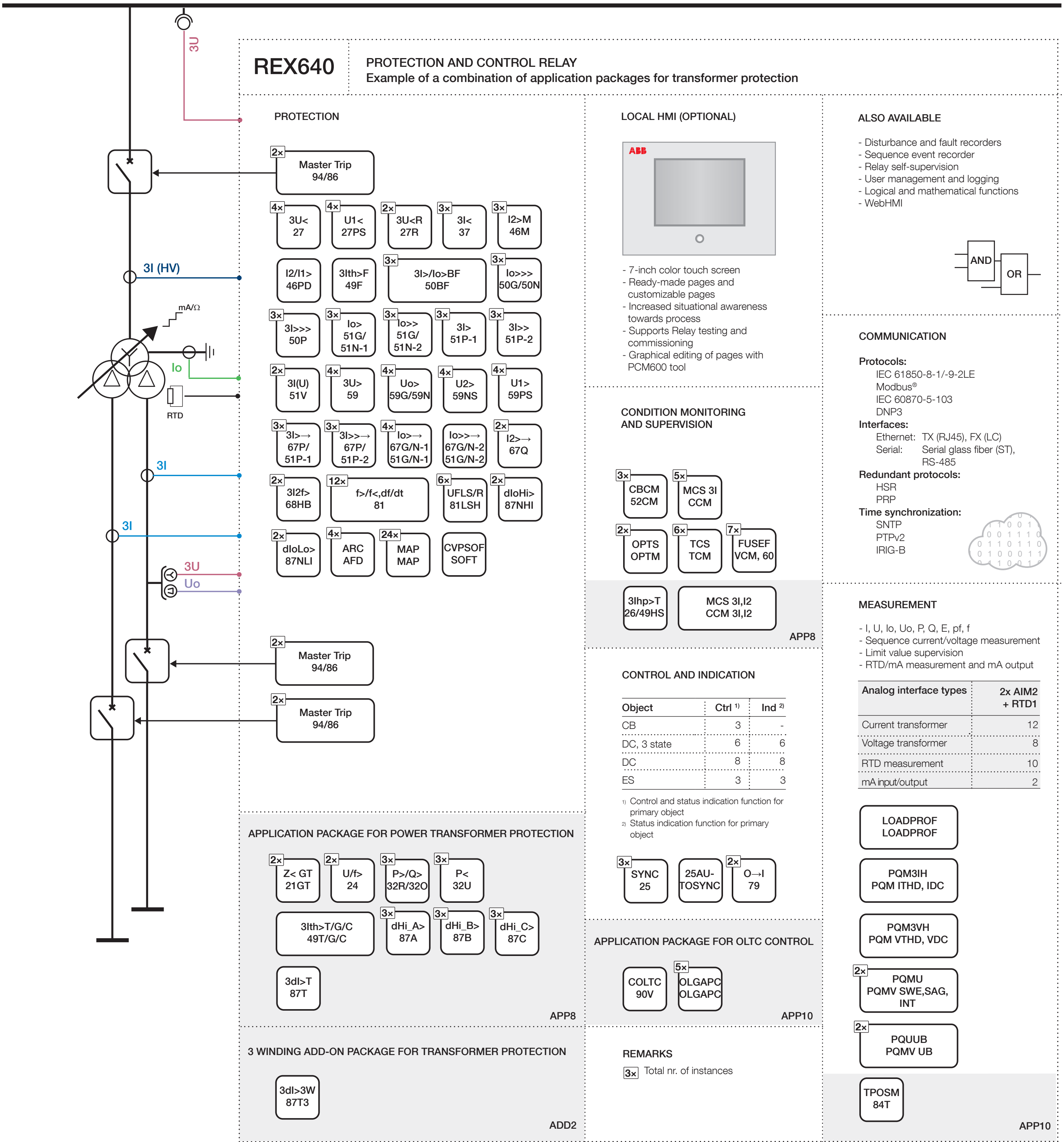

Figure 8. Transformer application

Figure 8 presents REX640 in a three-winding power transformer application. The base functionality is enhanced with a power transformer application package and the related three-winding add-on package. In the example case, REX640 also manages the on-load tap changer's manual and automatic control. For this purpose, the application package for OLTC control has been selected as well. Best match for current and voltage measurement can be managed by selecting two AIM2 cards for the relay. This combination offers 12 current and 8 voltage channels to be freely allocated for the relay functionalities. The OLTC control function requires information on the tap-changer's actual position. To be able to provide this information, the relay is equipped with an RTD card which can measure the OLTC position either as a resistance value or as an mA signal.

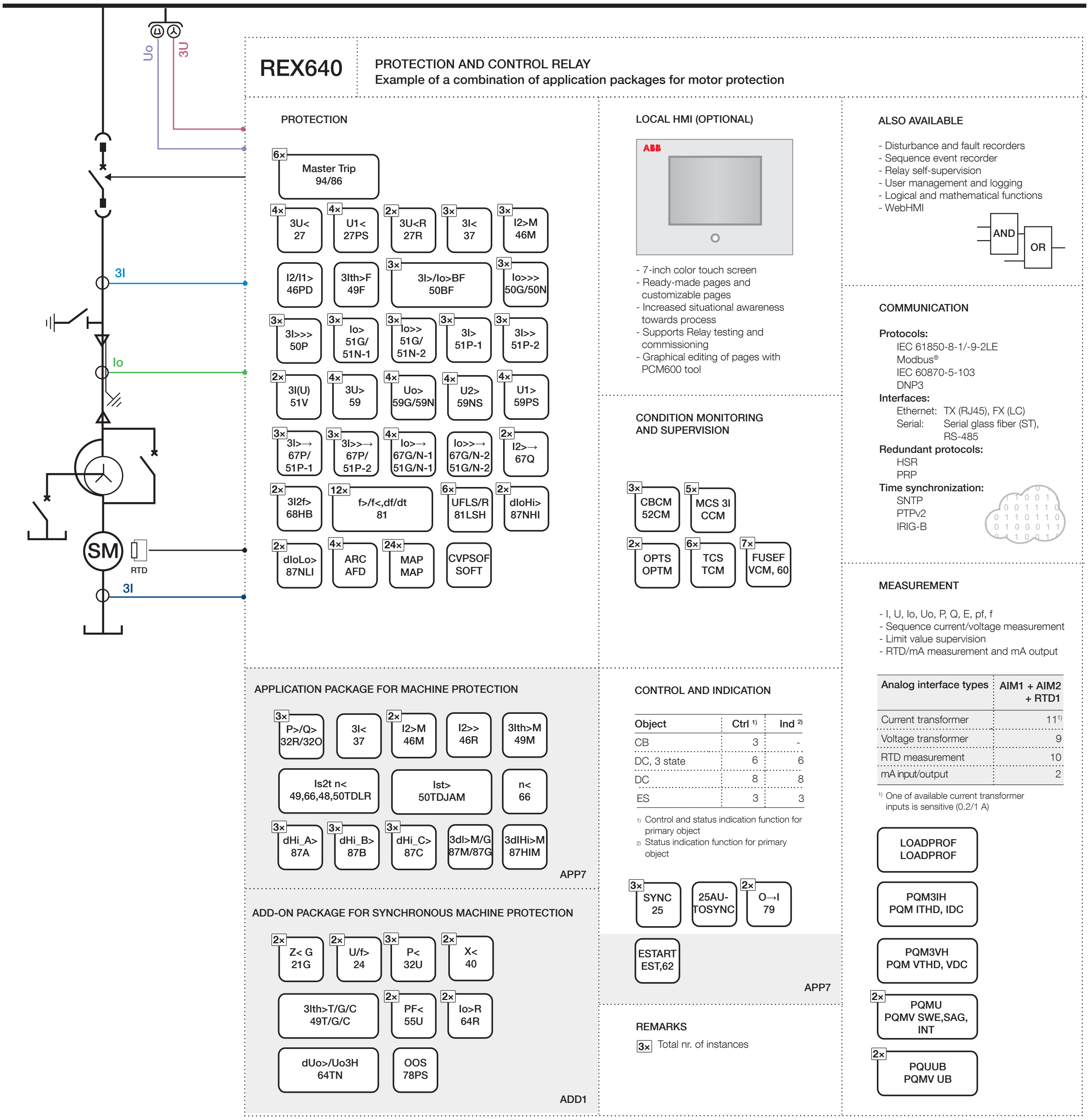

Figure 9. Motor application

Figure 9 presents REX640 in a synchronous motor application. The base functionality is enhanced with a machine protection application package and the related synchronous machine add-on package. Best match for current and voltage measurement can be managed by selecting both AIM1 and AIM2 cards for the relay. This combination offers 11 current and

9 voltage channels to be freely allocated for the relay functionalities. The stator winding temperatures are monitored via the temperature sensors in the motor. These sensors are connected to the RTD card within the relay.

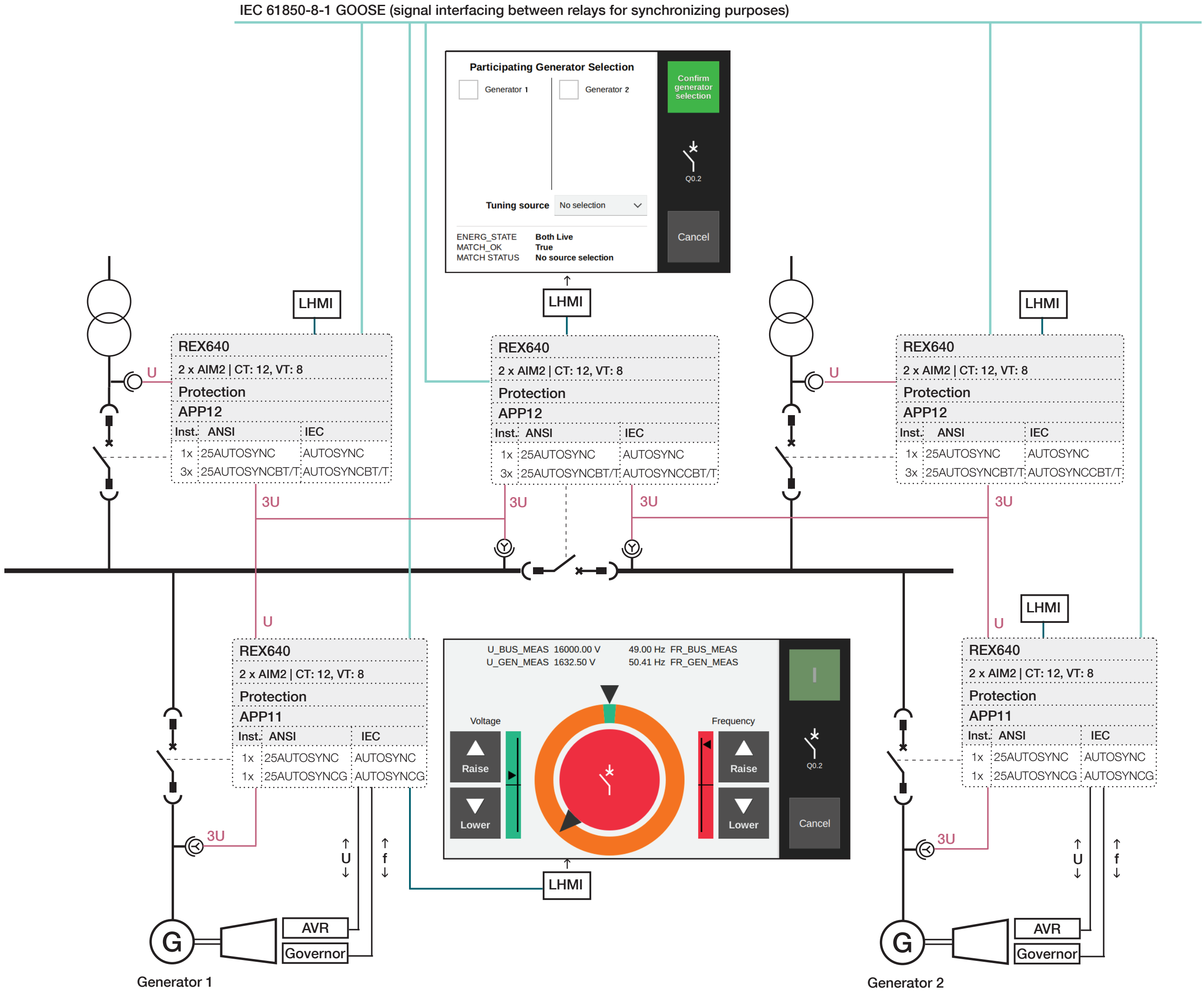

Figure 10. Autosynchronizer application

In addition to conventional protection, control, measurement and supervision duties, REX640 can perform both generator (APP11) and non-generator (APP12) circuit breaker synchronizing. Successful synchronization of two alternating power sources can be done by matching their voltage, frequency, phase sequence and phase angle. The circuit breaker (CB) connects the two sources after a period of CB closing time from the instant of a given close command. Hence, all the conditions of synchronization need to be met at the instant of CB close operation for successful synchronization.

Each REX640, being part of the overall synchronizing scheme, contains its own synchronizer function. When a generator CB is to be synchronized, the related REX640 controls the generator's voltage, frequency and angle difference by requesting the generator's AVR and prime mover's governor to change the set-points accordingly. The generator circuit breaker synchronizing does not require information exchange between other REX640 relays within the scheme.

When a non-generator CB is to be synchronized, all the REX640 relays within the scheme exchange information between themselves in order to identify suitable generator(s) for the voltage and frequency matching. Once the generators are identified and selected, the REX640 related to the circuit breaker to be synchronized sends a request to the selected generator(s) REX640 for the required voltage and frequency corrections. When the voltage, frequency and the angle difference across the CB under synchronization are within the set limits, REX640 closes the circuit breaker. The information exchange between the REX640s takes place using IEC 61850-8-1 binary and analog GOOSE signaling over Ethernet.

The LHMI panels of REX640 can be used as local user interface for circuit breaker synchronization. The upper-level remote control systems like SCADA, DCS or PMS can interact with the synchronizing scheme using MMS or Modbus protocols. The REX640-based synchronizing scheme supports manual, semi-manual and automatic synchronizing modes.

When the synchronizing scheme includes both generator and non-generator CBs, the maximum size of the supported system is eight generator and 17 non-generator CBs.

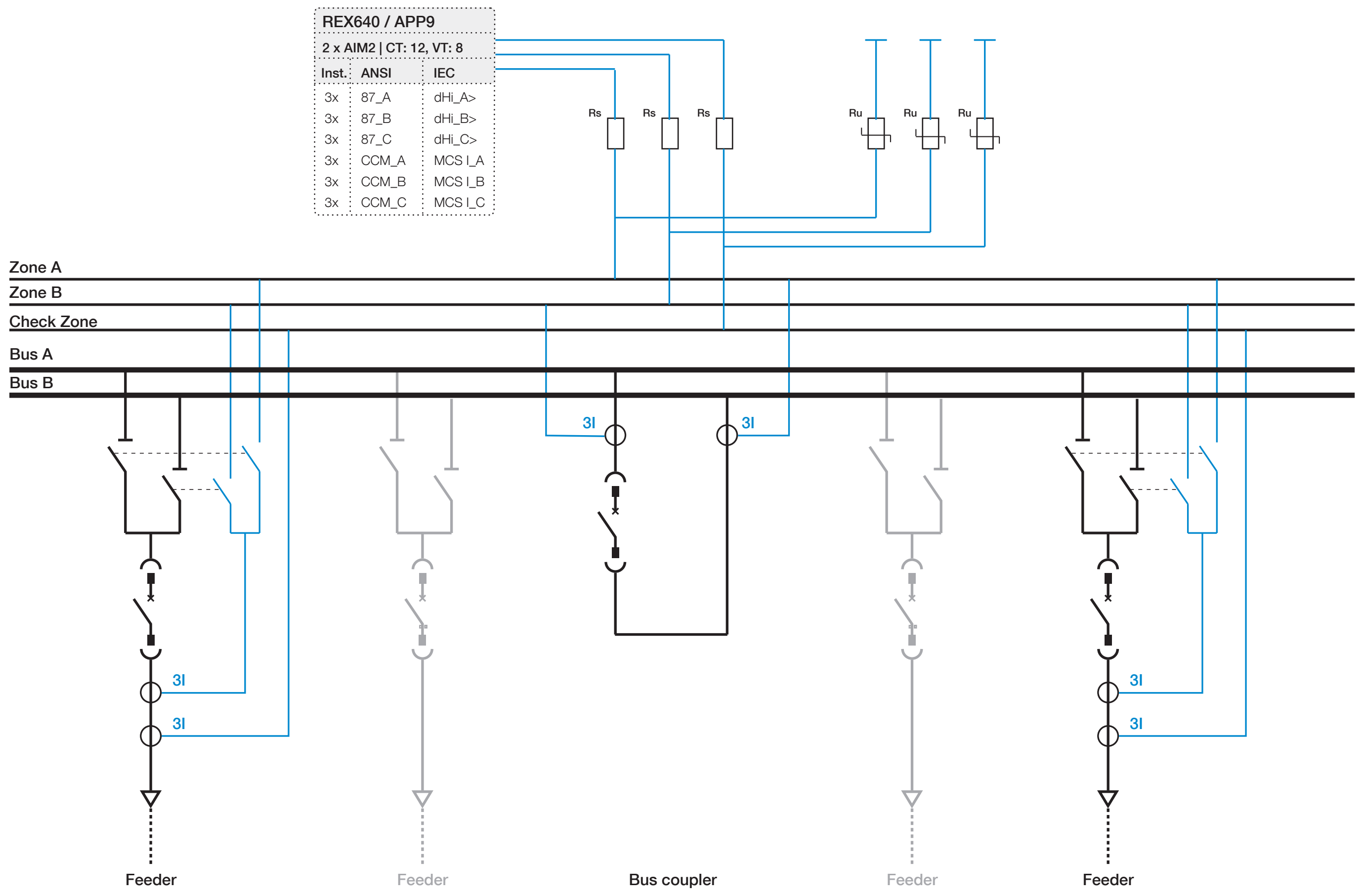

Figure 11. Busbar protection application

Figure 11 presents REX640 in a phase-dedicated high-impedance busbar protection application for a double busbar switchgear. The relay's base functionality is enhanced with the busbar protection application package (APP9). The two AIM2 cards in the relay provide a total of 12 current channels. In the example, 9 out of the 12 current channels are used to create three busbar protection zones. Zones A and B provide selective protection for Bus A and Bus B, respectively. The third zone, called check zone, covers both busbars. The check zone works as the final trip release condition for the selective zones; it provides security against false trip commands initiated by the selective zones, for example, due to a fault within the disconnector's auxiliary switch circuitry. The current transformers' secondary buswires for the three protection zones are supervised by dedicated functions within the relay.

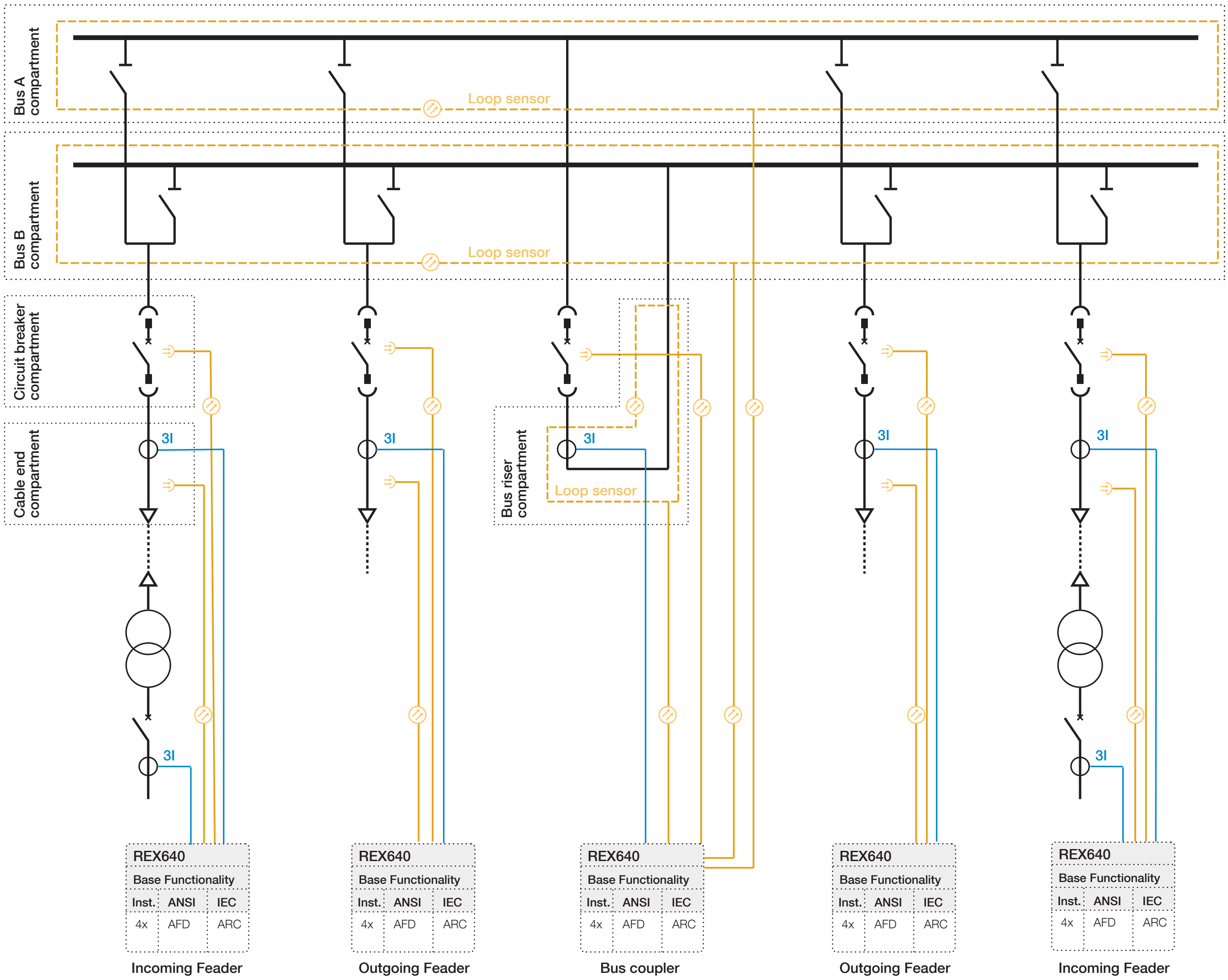

Figure 12. Arc flash protection application

Figure 12 presents an installation-wide arc flash protection scheme for a double busbar switchgear. REX640 protection relays are equipped with arc flash sensor card. The card supports a maximum of four pieces of either loop or lens sensors or a combination thereof. By using suitable sensor combinations for different bays, we can build up a selective arc flash protection scheme for the complete switchgear. The selective operation of the arc flash protection scheme limits the power outage caused by the arc fault to the smallest possible section of the switchgear. The arc flash protection operation is not dependent on light detection only; it is also supervised by arc fault current measurement. Since the arc flash protection operation should be as fast as possible, the use of static power outputs for tripping circuits is highly recommended. The functional condition of the arc flash sensor is continuously supervised and if a problem is detected, an alarm is triggered; this applies to both loop and lens sensors.

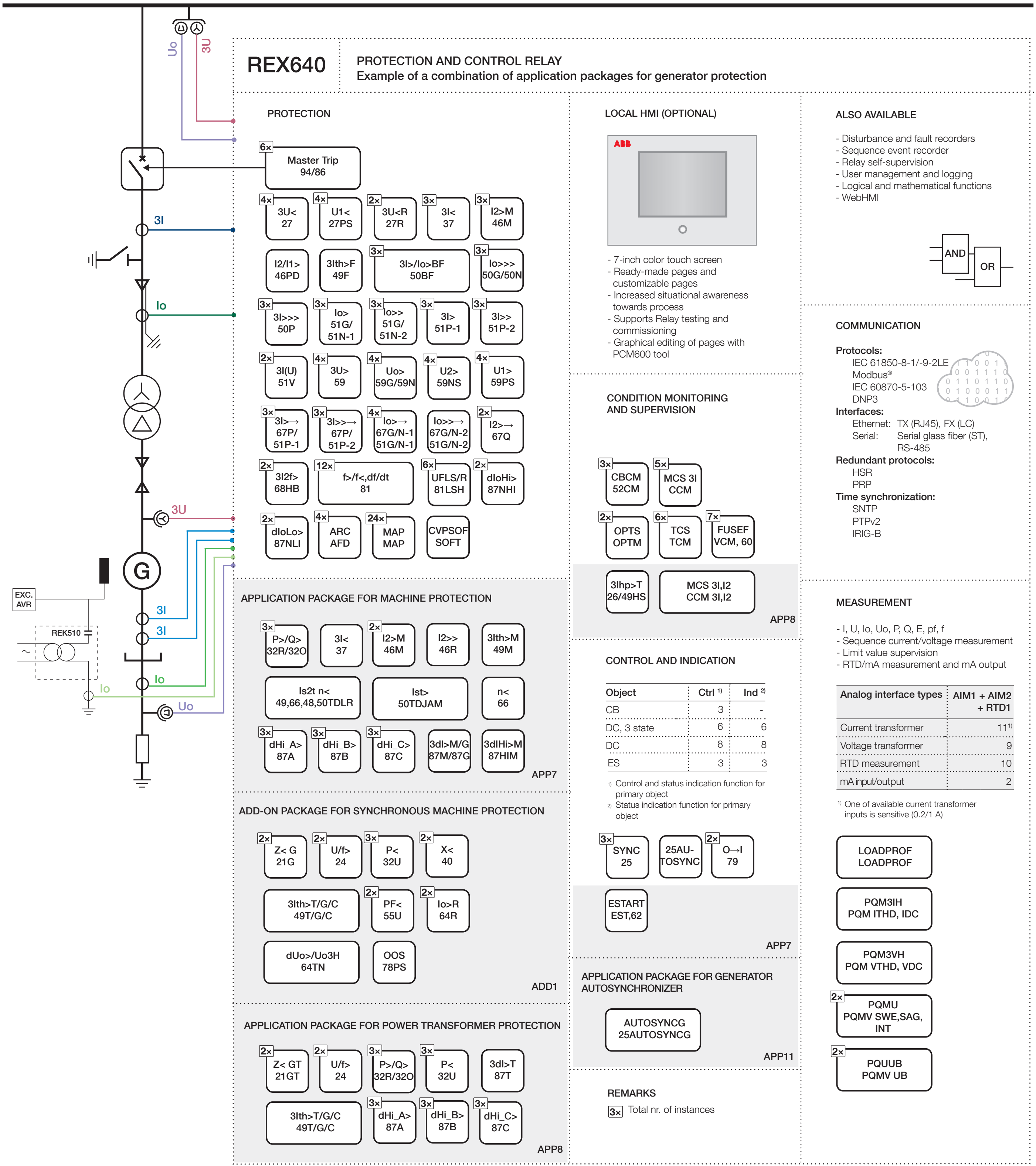

Figure 13. Generator application

Figure 13 presents REX640 in a synchronous generator application including a block transformer. The base functionality is enhanced with the machine protection and transformer protection application packages. The synchronous machine add-on package supports the related protection functions for a synchronous generator. Generator autosynchronizer application packages support the generator's synchronized connection into the busbars, in both manual and auto modes. The relay's LHMI works as the local operator interface for controlling the autosynchronizing sequence. An external injection device (REK 510) enables the generator's excitation circuit supervision against earth faults. Best match for current and voltage measurement needs can be managed by selecting both AIM1 and AIM2 cards for the relay. This combination offers 11 current and 9 voltage channels to be freely allocated to the functionalities in the relay. The generator's stator winding temperatures are monitored using RTD sensors.

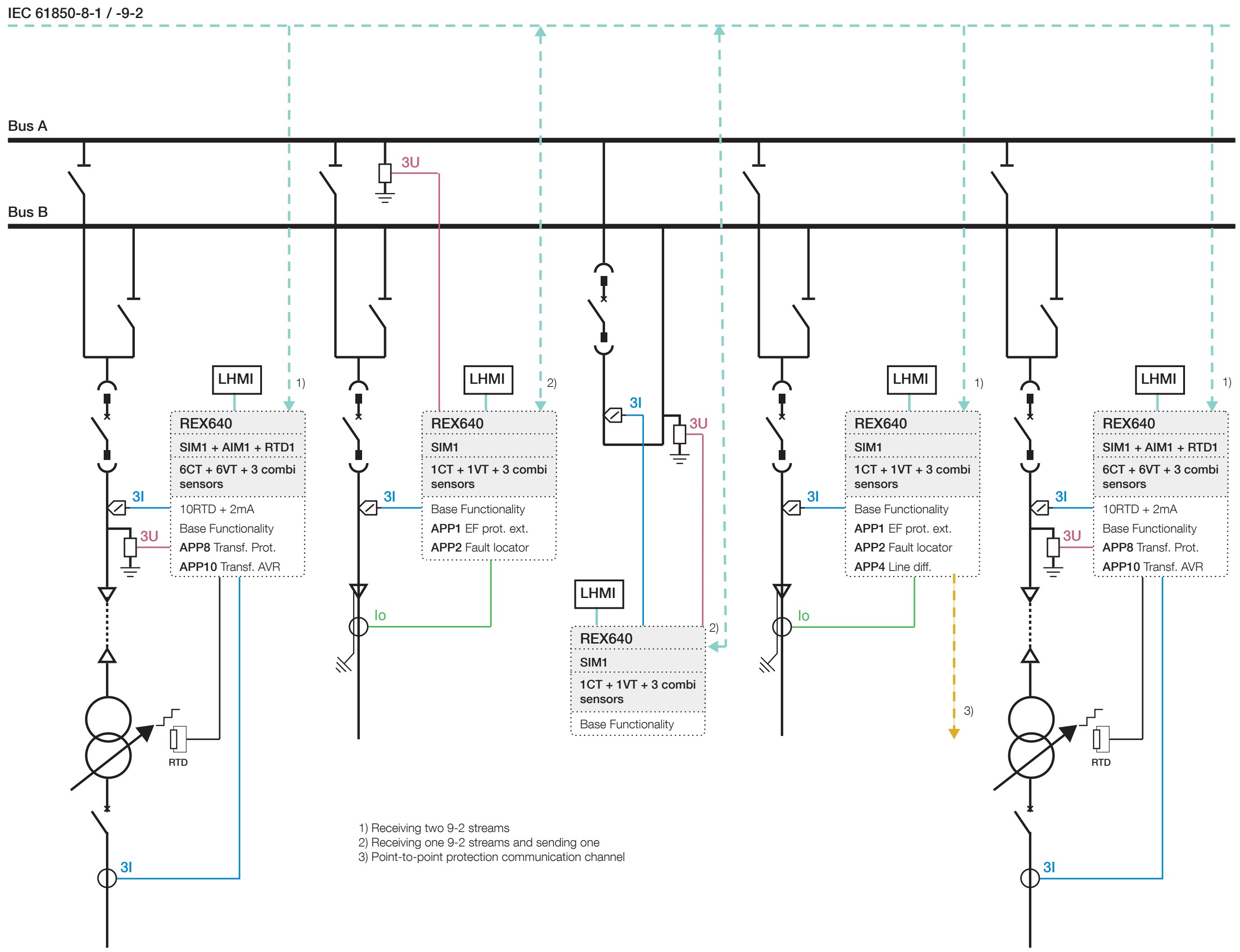

Figure 14. Digital switchgear application

REX640 is perfectly aligned with the needs of digital switchgear. Sensors are used for the local phase current and voltage measurements, apart from the high-voltage side current measurement used for power transformer protection, which is carried out by conventional current transformers. For the outgoing cable feeders, the earth-fault protection uses core balance current transformers. The Bus A voltage is measured by the relay in panel +J2, whereas the Bus B voltage is measured by the relay in panel +J3. Both relays send the measured bus voltages to the Ethernet bus as sampled measured values (SMV) according to IEC 61850-9-2 LE. Depending on the type of the feeder, it receives either one or two SMV streams. The feeders receiving two SMV streams automatically switch between the streams based on the position of the busbar disconnectors. All interlocking signals between the panels use binary GOOSE messaging according to IEC 61850-8-1. The incoming power transformer feeders measure also the cable side voltages to enable automatic voltage regulation (tap changer control) and synchronizing check functionality for circuit breaker closing.

6. Supported ABB solutions

The REX640 protection relay together with the Substation Management Unit COM600S constitutes a genuine IEC 61850 solution for reliable power distribution in utility and industrial power systems. To facilitate the system engineering, ABB's relays are supplied with connectivity packages. The connectivity packages include a compilation of software and relay-specific information, including single-line diagram templates and a full relay data model. The data model includes event and parameter lists. With the connectivity packages, the relays can be readily configured using PCM600 and integrated with COM600S or the network control and management system MicroSCADA Pro.

REX640 offers native support for IEC 61850 Edition 2 including binary and analog horizontal GOOSE messaging. In addition, a process bus enabling sending and receiving of sampled values of analog currents and voltages is supported.

Unlike the traditional hardwired, inter-device signaling, peer-to-peer communication over a switched Ethernet LAN offers an advanced and versatile platform for power system protection. Among the distinctive features of the protection system approach, enabled by the full implementation of the IEC 61850 substation automation standard, are fast communication capability, continuous supervision of the protection and communication system's integrity, and flexible reconfiguration and upgrades. This protection relay series is able to optimally use the interoperability provided by the IEC 61850 Edition 2 features.

At substation level, COM600S uses the data content of the bay level devices to enhance the substation level functionality. COM600S features a Web browser-based HMI, which provides a customizable graphical display for visualizing single-line mimic diagrams for switchgear bay solutions. The Web HMI of COM600S also provides an overview of the whole substation, including relay-specific single-line diagrams, which makes information easily accessible. Substation devices and processes can also be remotely accessed through the Web HMI, which improves personnel safety.

In addition, COM600S can be used as a local data warehouse for the substation's technical documentation and for the network data collected by the devices. The collected network data facilitates extensive reporting and analyzing of network fault situations by using the data historian and event handling features of COM600S. The historical data can be used for accurate monitoring of process and equipment performance, using calculations based on both real-time and historical values. A better understanding of the process dynamics is achieved by combining time-based process measurements with production and maintenance events.

COM600S can also function as a gateway and provide seamless connectivity between the substation devices and network-level control and management systems, such as MicroSCADA Pro and System 800xA.

The GOOSE Analyzer interface in COM600S enables the monitoring and the analysis of the horizontal IEC 61850 application during commissioning and operation at station level. It logs all GOOSE events during substation operation to enable improved system supervision.

Table 3. Supported ABB solutions

Product	Version
Substation Management Unit COM600S	4.0 SP1 or later 4.1 or later (Edition 2)
MicroSCADA Pro SYS 600	9.3 FP2 or later 9.4 or later (Edition 2)
System 800xA	5.1 or later

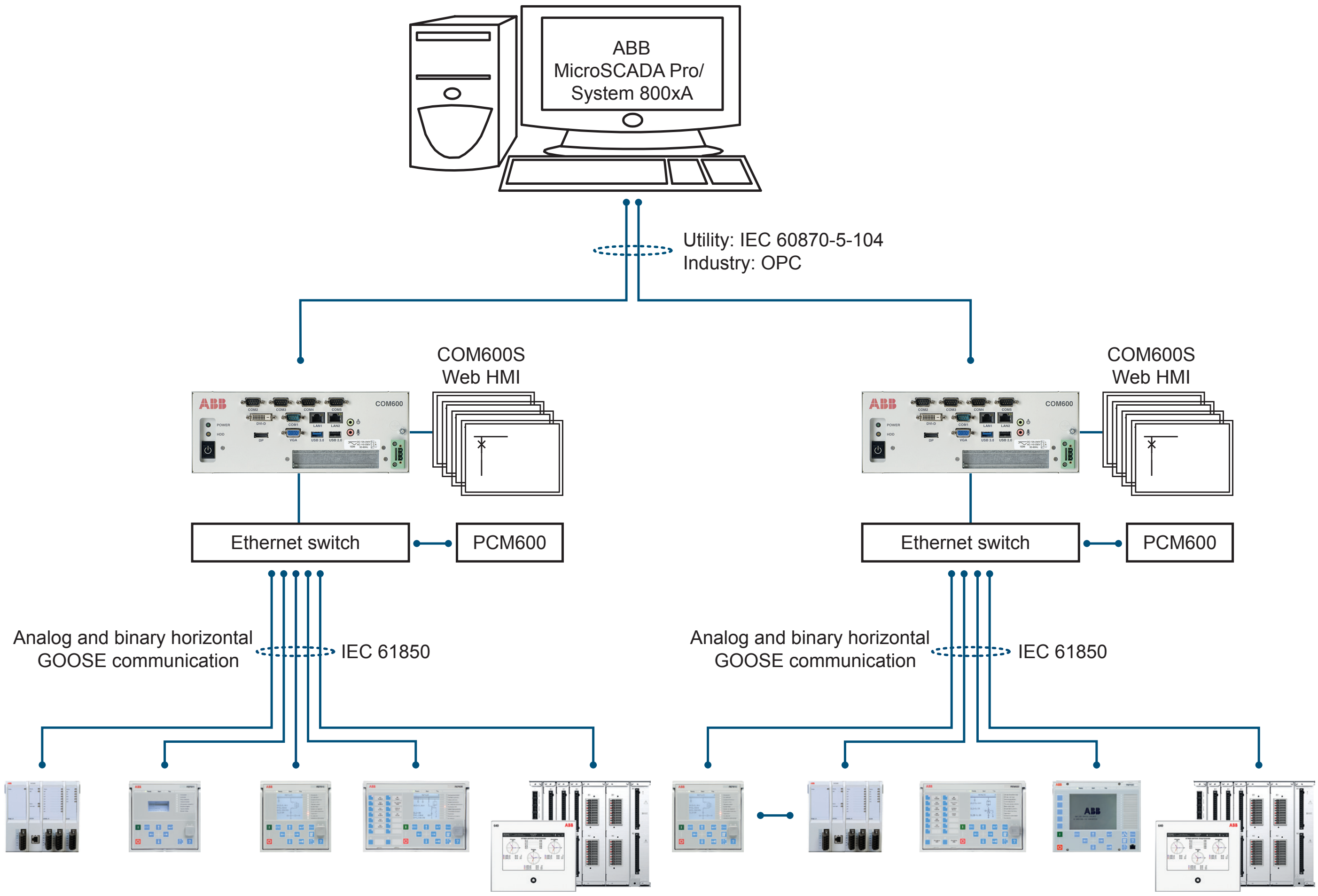

Figure 15. ABB power system example using Relion relays, COM600S and MicroSCADA Pro/System 800xA

7. Control

REX640 integrates functionality for controlling objects such as circuit breakers, disconnectors, earthing switches, on-load tap changers and Petersen coils via the LHMI or by means of remote controls. The relay includes three circuit breaker control blocks. In addition, the relay features 14 disconnector control blocks intended for the motor-operated control of disconnectors or a circuit breaker truck and three control blocks intended for the motor-operated control of the earthing switch. Furthermore, the relay includes eight additional disconnector position indication blocks and three earthing switch position indication blocks that can be used with disconnectors and earthing switches that are only manually controlled.

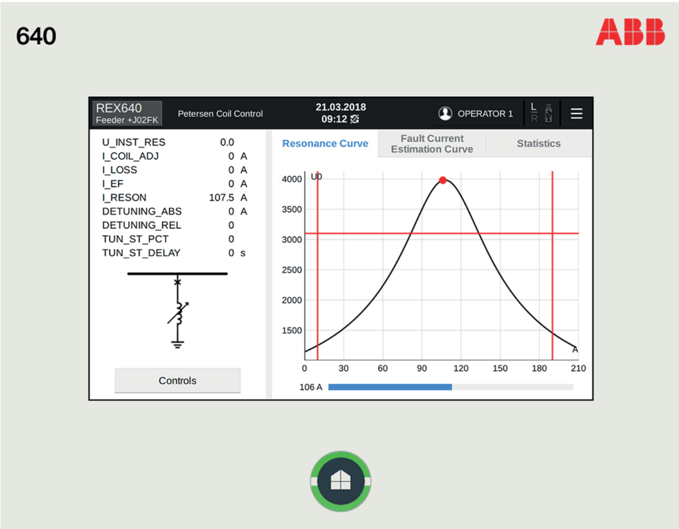

Figure 16. Petersen Coil control page

The touch screen LHMI supports a single-line diagram with control points and position indication for the relevant primary devices. Interlocking schemes required by the application are configured using Signal Matrix or Application Configuration in PCM600.

REX640 includes two autoreclosing functions, each with up to five programmable autoreclosing shots of desired type and duration. A load-shedding function performs load shedding based on underfrequency and the rate of change of the frequency.

To validate correct closing conditions for a circuit breaker, REX640 contains a synchrocheck function. For installations including synchronous generators, REX640 introduces a synchronizer that actively controls the generator's voltage and frequency in order to reach a synchronous situation across the circuit breaker. The synchronizer functionality is available for a generator circuit breaker as well as for a non-generator (network) circuit breaker. A complete installation-wide synchronizing system can be built using the REX640 relays. The maximum size of the synchronizing system is eight generator breakers and 17 non-generator breakers.

Synchronization of a generator circuit breaker can be implemented using a single REX640 relay including the ASGCSYN function block. The relay interfaces the external measurement and control circuitry via hardwired binary and analog signals. The excitation and prime mover control signals are based on pulse commands, either with fixed or variable length. The synchronizer function block has three different function modes: manual, semi-automatic and automatic. In each of these modes, the LHMI acts as the local user interface. The LHMI includes the necessary command, indication and measurement features for each of the modes, thus rendering the conventional dedicated synchronizing panel unnecessary.

REX640 also supports systems in which non-generator circuit breakers are synchronized. The prerequisite is that all the feeders within the system are equipped with REX640 relays. The generator relays have to contain the ASGCSYN function block and all the non-generator relays need to contain the ASNSCSYN function block. In addition, all the REX640 relays have to contain the coordinator function block ASCGAPC. The role of ASCGAPC is to model the system primary circuit connection state to involve the correct generators for the synchronization of a non-generator breaker and to interact between the ASGCSYN and ASNSCSYN function blocks. The information exchange between ASCGAPC, ASGCSYN and ASNSCSYN is carried out via binary and analog GOOSE signalling as per IEC 61850-8-1. The LHMI dedicated to the relay (breaker) works as the local user interface for a non-generator breaker synchronizing. The available synchronizing modes are “automatic” and “semi-automatic”. A manual synchronization of the non-generator breaker can be carried out as a back-up solution in situations where the communication system (IEC 61850-8-1) is not available. This requires operator actions from two LHMIs, namely from the LHMI of the concerned non-generator breaker and the LHMI of the manually selected generator relay.

8. Arc flash protection

The arc flash protection is available on the optional hardware module. The module supports connection of up to four sensors. The sensors can be of lens or loop types, or a free mixture. Both sensor types are supervised against sensor failure. Fast tripping increases staff safety and limits material damage, therefore it is recommended to use static power outputs (SPO) instead of normal power outputs (PO). This typically decreases the total operating time with 4..6 ms compared to the normal power outputs.

9. Power transformer differential protection

The relay offers low-impedance differential protection for two-winding (two restraints) and three-winding (three restraints) power transformers. The power transformer protection application package includes the protection for a two-winding power transformer. If support for three-winding power transformer is needed, the corresponding protection add-on package can be selected. Both low-impedance differential functions feature three-phase multi-slope stabilized stages and an instantaneous stage to provide fast and selective protection against short circuits, winding interturn faults and bushing flash-overs. A second harmonic restraint with advanced waveform-based blocking ensures stability at transformer energization. The fifth harmonic based blocking and unblocking limits stabilize the protection performance in moderate overexcitation situations. In case of three-winding differential protection, the connection group phase shift matching can be done with 0.1 degree resolution supporting cycloconverter applications. If the tap-changer position information is available, it is possible to further increase the protection sensitivity by compensating the tap-changer position error within the measured differential current.

The power transformer protection application package also includes high-impedance differential functions for a phase-segregated protection scheme. If this scheme is applied, the related current transformers have to be correctly selected and the necessary secondary circuit components, external to the relay, defined.

10. Measurements

The base functionality of the REX640 relay contains a number of basic measurement functions for current, voltage, frequency, symmetrical components of currents and voltages, power, power factor and energy. These measurement functions can be freely connected to the measured secondary quantities available in the relay. The relay can also measure various analog signals via RTD and mA inputs. All these measurements can be used within the relay configuration for additional logics. The measurements are available locally on the HMI and can be accessed remotely via communication. The information is also accessible via Web HMI.

The relay is also provided with a load profile recorder. The load profile feature stores the selected load measurement data captured periodically (demand interval). The records can be viewed on the LHMI and are available in COMTRADE format.

11. Power quality

In the EN standards, power quality is defined through the characteristics of the supply voltage. Transients, short-duration and long-duration voltage variations and unbalance and waveform distortions are the key characteristics describing power quality. The distortion monitoring functions are used for monitoring the current total demand distortion and the voltage total harmonic distortion.

Power quality monitoring is an essential service that utilities can provide for their industrial and key customers. A monitoring system can provide information about system disturbances and their possible causes. It can also detect problem conditions throughout the system before they cause customer complaints, equipment malfunctions and even equipment damage or failure. Power quality problems are not limited to the utility side of the system. In fact, the majority of power quality problems are localized within customer facilities. Thus, power quality monitoring is not only an effective customer service strategy but also a way to protect a utility's reputation for quality power and service.

The protection relay has the following power quality monitoring functions.

- Voltage variation
- Voltage unbalance
- Current harmonics
- Voltage harmonics

The voltage unbalance and voltage variation functions are used for measuring short-duration voltage variations and monitoring voltage unbalance conditions in power transmission and distribution networks.

The voltage and current harmonics functions provide a method for monitoring the power quality by means of the current waveform distortion and voltage waveform distortion. The functions provide selectable short-term 3- or 60- or 300 – second sliding average and a long-term demand for total demand distortion (TDD) and total harmonic distortion (THD). The phase-specific harmonic content is measured for voltages and currents, as well as DC component and fundamental content. The dedicated harmonics measurement page in the LHMI presents the measurements in a user-friendly manner.

12. Fault locator

The relay features an optional impedance-measuring fault location function suitable for locating short circuits in radial distribution systems. Earth faults can be located in effectively and low-resistance earthed networks, as well as in compensated networks. When the fault current magnitude is at least of the same order of magnitude or higher than the load current, earth faults can also be located in isolated neutral distribution networks. The fault location function identifies the type of the fault and then calculates the distance to the fault point. The calculations provide information on the fault resistance value and accuracy of the estimated distance to the fault point.

13. Disturbance recorder

The relay is provided with a disturbance recorder featuring up to 24 analog and 64 binary signal channels. The analog channels can be set to record either the waveform or the trend of the currents and voltages measured.

The analog channels can be set to trigger the recording function when the measured value falls below or exceeds the set values. The binary signal channels can be set to start a recording either on the rising or the falling edge of the binary signal or on both.

The binary channels can be set to record external or internal relay signals, for example, the start or trip signals of the relay stages, or external blocking or control signals. The recorded information is stored in a nonvolatile memory in COMTRADE format and can be uploaded for subsequent fault analysis.

14. Event log

To collect sequence-of-events information, the relay has a nonvolatile memory capable of storing 1024 events with the associated time stamps. The event log facilitates detailed pre- and post-fault analyses of feeder faults and disturbances. The considerable capacity to process and store data and events in the relay supports the growing information demand of future network configurations.

The sequence-of-events information can be accessed either via the LHMI or remotely via the communication interface of the relay. The information can also be accessed locally or remotely using the Web HMI.

15. Recorded data

The relay can store the records of the latest 128 fault events. The records can be used to analyze the power system events. Each record includes, for example, current, voltage and angle values and a time stamp. The fault recording can be triggered by the start or the trip signal of a protection block, or by both. The available measurement modes include DFT, RMS and peak-to-peak. Fault records store relay measurement values when any protection function starts. In addition, the maximum demand current with time stamp is separately recorded. The records are stored in the nonvolatile memory.

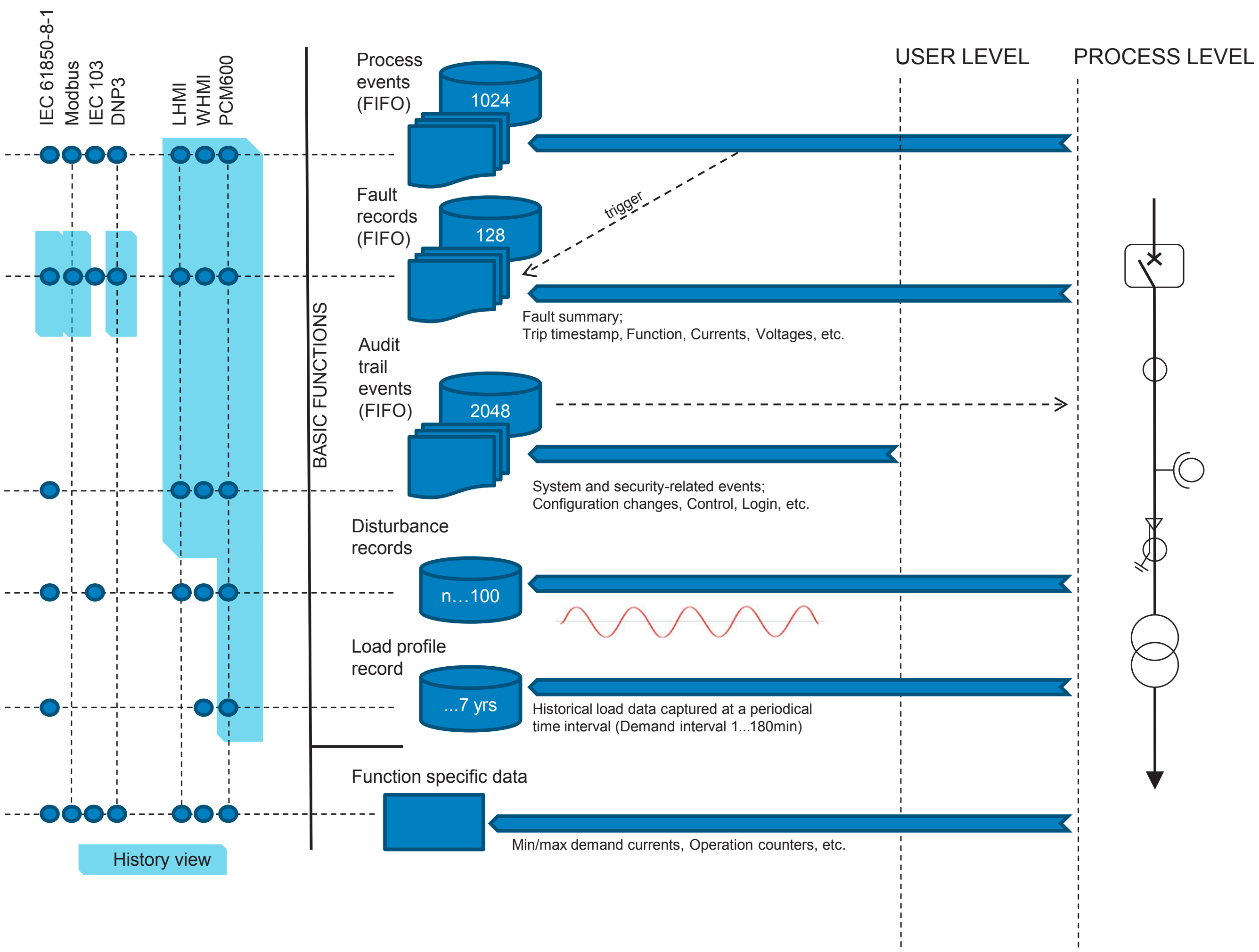

Figure 17. Event recording

16. Load profile

The load profile recorder stores the historical load data captured periodically (demand interval). Up to 12 load quantities can be selected for recording and storing in the nonvolatile memory. The recordable quantities include currents, voltages, power and power factor values. The recording time depends on a settable demand interval parameter and the amount of quantities selected. The quantities' type and amount to be recorded are determined in the application configuration. The recorded quantities are stored in the COMTRADE format.

17. Trip circuit supervision

The trip circuit supervision continuously monitors the availability and operability of the trip circuit. It provides open-circuit monitoring both when the circuit breaker is in closed and in open position. It also detects loss of circuit-breaker control voltage.

18. Self-supervision

The relay's built-in self-supervision system continuously monitors the state of the relay hardware and the operation of the relay software. Any fault or malfunction detected is used for alerting the operator.

A permanent relay fault blocks the protection functions to prevent incorrect operation.

19. Access control and cybersecurity

Cybersecurity measures are implemented to secure safe operation of the protection and control functions. The relay supports these measures with configuration hardening capabilities, encrypted communication, security event logging and user access control.

The relay supports role-based user authentication and authorization with individual user accounts as defined in IEC 62351-8. All user activity is logged as security events to an audit trail in a nonvolatile memory and sent as messages to the SysLog server. The nonvolatile memory does not need battery backup or regular component exchange to maintain the memory storage. File transfer and Web HMI use communication encryption protecting the data in transit. Also, the communication link between the relay configuration tool PCM600 and the relay is encrypted. All rear communication ports and optional protocol services can be activated according to the required system setup.

User accounts can be managed by PCM600 or centrally. A central account management is an authentication infrastructure that offers a secure solution for enforcing access control to relays and other systems within a substation. This incorporates management of user accounts, roles and certificates and the distribution of such, a procedure completely transparent to the user. The central server handling user accounts can be, for example, SDM600 or an Active Directory (AD) server such as Windows AD.

The relay supports full Public Key Infrastructure as defined by IEC 62351-9. With this, the user can ensure that the certificates used in secured communication are from a user-approved provider instead of device self-signed certificates.

20. Station communication

Operational information and controls are available through a wide range of communication protocols including IEC 61850 Edition 2, IEC 61850-9-2 LE, IEC 60870-5-103, Modbus® and DNP3. The Profibus DPV1 communication protocol is supported via the protocol converter SPA-ZC 302. Full communication capabilities, for example, horizontal communication between the relays, are only enabled by IEC 61850.

The IEC 61850 protocol is a core part of the relay as the protection and control application is fully based on standard modelling. The relay supports Edition 2 and Edition 1 versions of the standard. With Edition 2 support, the relay has the latest functionality modelling for substation applications and the best interoperability for modern substations.

The IEC 61850 communication implementation supports monitoring and control functions. Additionally, parameter settings, disturbance recordings and fault records can be accessed using the IEC 61850 protocol. Disturbance recordings are available to any Ethernet-based application in the standard COMTRADE file format. The relay supports simultaneous event reporting to five different clients on the station bus.

The relay can send binary and analog signals to other devices using the IEC 61850-8-1 GOOSE (Generic Object Oriented Substation Event) profile. Binary GOOSE messaging can, for example, be used for protection and interlocking-based protection schemes. The relay meets the GOOSE performance requirements for tripping applications in distribution substations, as defined by the IEC 61850 standard (class P1, <3 ms data exchange between the devices). The relay also supports the sending and receiving of analog values using GOOSE messaging. Analog GOOSE messaging enables easy transfer of analog measurement values over the station bus, thus facilitating, for example, the sending of measurement values between the relays when controlling transformers running in parallel.

The relay also supports IEC 61850 process bus concept by sending sampled values of currents and voltages and by receiving sampled values of voltages. With this functionality the galvanic interpanel wiring can be replaced with Ethernet communication. The analog values are transferred as sampled values using the IEC 61850-9-2 LE protocol. The intended application for sampled values are current-based differential protection functions or sharing the voltage values with the relays that have voltage-based protection or supervision functions. The relay can receive up to four sampled value streams and totally 16 measurements can be connected into the protection relay application.

Relays with process bus based applications use IEEE 1588 edition 2 for high-accuracy time synchronization.

For redundant Ethernet communication in station bus, the relay offers either two optical or two galvanic Ethernet network interfaces. An optional third port with optical or galvanic Ethernet network interface is also available. The relay also provides an optional fiber-optic port for dedicated protection communication which can be used for up to 50 km distances depending on the selected fiber transceiver. The intended teleprotection applications for this port are line differential and line distance protection communication or binary signal transfer. The optional third Ethernet interface provides connectivity for any other Ethernet device to an IEC 61850 station bus inside a switchgear bay, for example connection of a remote I/O. Ethernet network redundancy can be achieved using the high-availability seamless redundancy (HSR) protocol or the parallel redundancy protocol (PRP), or with a self-healing ring using RSTP in the managed switches. Ethernet redundancy can be applied to the Ethernet-based IEC 61850, Modbus and DNP3 protocols.

The IEC 61850 standard specifies network redundancy which improves the system availability for the substation communication. The network redundancy is based on two complementary protocols defined in the IEC 62439-3 standard: PRP and HSR protocols. Both protocols are able to overcome a failure of a link or switch with a zero switchover time. In both protocols, each network node has two identical Ethernet ports dedicated for one network connection.

The protocols rely on the duplication of all transmitted information and provide a zero switchover time if the links or switches fail, thus fulfilling all the stringent real-time requirements of substation automation.

In PRP, each network node is attached to two independent networks operated in parallel. The networks are completely separated to ensure failure independence and can have different topologies. As the networks operate in parallel, they provide zero-time recovery and continuous checking of redundancy to avoid failures.

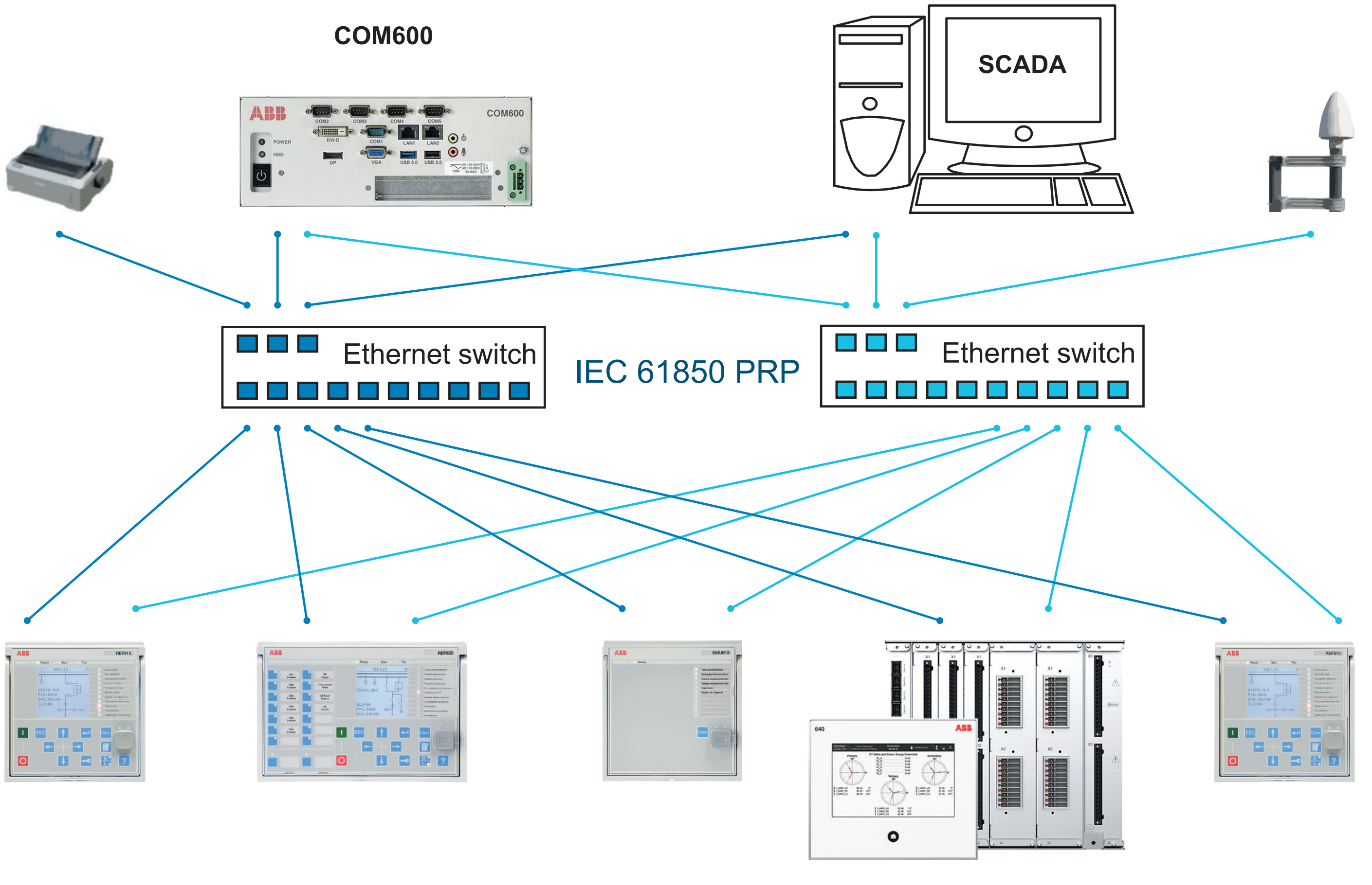

Figure 18. Parallel redundancy protocol (PRP) solution

HSR applies the PRP principle of parallel operation to a single ring. For each message sent, the node sends two frames, one through each port. Both frames circulate in opposite directions over the ring. Every node forwards the frames it receives from one port to another to reach the next node. When the originating sender node receives the frame it sent, the sender node discards the frame to avoid loops. The HSR ring supports the connection of up to 30 relays. If more than 30 relays are to be connected, it is recommended to split the network into several rings to guarantee the performance for real-time applications.

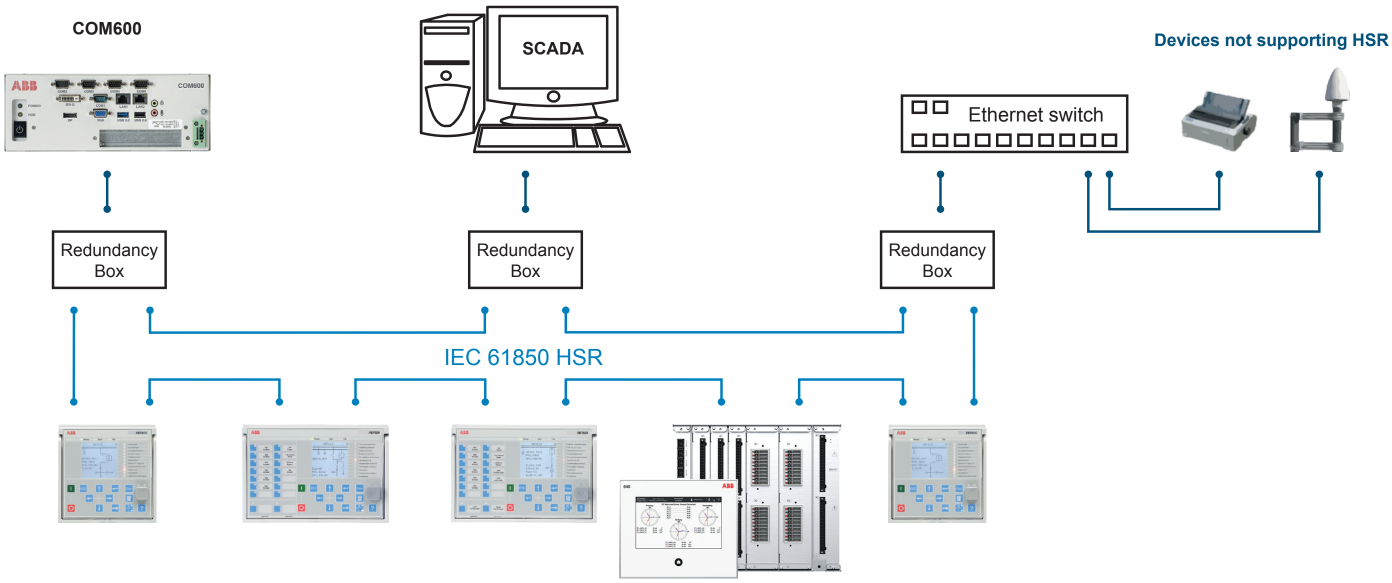

Figure 19. High-availability seamless redundancy (HSR) solution

The relay can be connected to Ethernet-based communication systems in a station bus using the RJ-45 connector (100Base-TX) or the multimode fiber optic LC connector (100Base-FX). A dedicated protection communication port uses a pluggable multimode or single-mode fiber optic LC connector (100Base-FX). If connection to a serial bus is required, the RS-485 or fiber-optic serial communication ports can be used.

Modbus implementation supports RTU, ASCII and TCP modes. Besides standard Modbus functionality, the relay supports retrieval of time-stamped events, changing the active setting group and uploading of the latest fault records. If a Modbus TCP connection is used, five clients can be connected to the relay simultaneously. Further, Modbus serial and Modbus TCP can be used in parallel, and, if required, both IEC 61850 and Modbus can be run simultaneously.

The IEC 60870-5-103 implementation supports two parallel serial bus connections to two different masters. Besides basic standard functionality, the relay supports changing of the active setting group and uploading of disturbance recordings in IEC 60870-5-103 format. Further, IEC 60870-5-103 can be used at the same time with the IEC 61850 protocol.

DNP3 supports both serial and TCP modes for the connection of up to five masters. Changing the active setting and reading fault records are supported. DNP serial and DNP TCP can be used in parallel. If required, both IEC 61850 and DNP can be run simultaneously.

The relay supports Profibus DPV1 with support of SPA-ZC 302 Profibus adapter. If Profibus is required, the relay must be ordered with Modbus serial options. Modbus implementation includes SPA protocol emulation functionality. This functionality enables connection to SPA-ZC 302.

When the relay uses the RS-485 bus for the serial communication, both two- and four-wire connections are supported. Termination and pull-up/down resistors can be configured with DIP switch on the communication card so that external resistors are not needed.

Table 4. Time synchronization methods supported by the relay

Methods	Time-stamping resolution
SNTP (Simple Network Time Protocol)[1)]	1 ms
IRIG-B (Inter-Range Instrumentation Group - Time Code Format B)[2)]	4 μs
PTPv2 (IEEE 1588) with Power Profile (IEEE Std C37.238-2011)	4 μs[3)]

1) Ethernet-based
2) With special time synchronization wiring
3) Required especially in process bus applications

PTPv2 features:

- Ordinary Clock with Best Master Clock algorithm
- One-step Transparent Clock for Ethernet ring topology
- PTPv2 Power Profile
- Receive (slave): 1-step/2-step
- Transmit (master): 1-step
- Layer 2 mapping
- Peer-to-peer delay calculation
- Multicast operation

The required accuracy of the grandmaster clock is +/-1 μs to guarantee performance of protection applications. The relay can work as a backup master clock per BMC algorithm if the external primary grandmaster clock is not available for short term.

In addition, the relay supports time synchronization via Modbus, DNP3 and IEC 60870-5-103 serial communication protocols.

Table 5. Supported station communication interfaces and protocols

Interfaces/Protocols	Ethernet		Serial	
	100BASE-TX RJ-45	100BASE-FX LC	RS-485	Fiber optic ST
IEC 61850-8-1	●	●	-	-
IEC 61850-9-2 LE	●	●	-	-
MODBUS RTU/ASCII	-	-	●	●
MODBUS TCP/IP	●	●	-	-
DNP3 (serial)	-	-	●	●
DNP3 TCP/IP	●	●	-	-
IEC 60870-5-103	-	-	●	●

● = Supported

21. Protection communication and supervision

The protection communication between the relays is enabled by means of a dedicated fiber optic communication channel; 1310 nm multimode or single-mode fibers with LC connectors are used. The communication link transfers analog and binary information between line ends for line differential, line distance and transfer trip functions. No external devices, such as GPS clocks, are needed for the line differential protection communication. Additionally, the link can be used to transfer any freely selectable binary data between line ends. In total, 16 binary signals can be transferred between two REX640 protection relays.

Each REX640 communication card variant contains an SFP rack for dedicated point-to-point protection communication via an SFP plug-in module. Three variants of SFP plug-in modules can be selected. The variants support optical communication for distances typically up to 2 km (multimode), 20 km (single-mode) and 50 km (single-mode). The SFP plug-in unit can be ordered together with the relay or later on when the need to establish the link arises. The line differential protection can be realized between two REX640 relays or between REX640 and RED615 relays. If the line differential protection is to be realized between REX640 and RED615 relays, the SFP plug-in module has to match the RED615 communication card variant. Additionally, the RED615 relay version must be 5.0 FP1 or later.

If a galvanic protection communication link is requested, it can be realized with RPW600 modems. The RPW600 modem offers a 5 kV (RMS) level of isolation between the pilot wire terminals and ground. The RPW600 modems (master and follower) are galvanically connected to either end of the pilot wire and optically connected to the relays using short optical single-mode cables. Using 0.8 mm^2 twisted pair cables, pilot wire link distances up to 8 km are typically supported. However, twisted pair pilot wire cables in good conditions may support even longer distances to be covered. The length of the supported pilot wire link also depends on the noise environment in the installation. Should the need arise to replace the pilot wire cables with fiber optic cables, the single-mode fiber optic LC connectors of the relays can be used for direct connection of the fiber optic communication link.

The protection communication supervision continuously monitors the protection communication link. The line differential protection function can be blocked if severe interference in the communication link, risking the correct operation of the function, is detected. If the interference persists, an alarm signal is triggered indicating permanent failure in the protection communication.

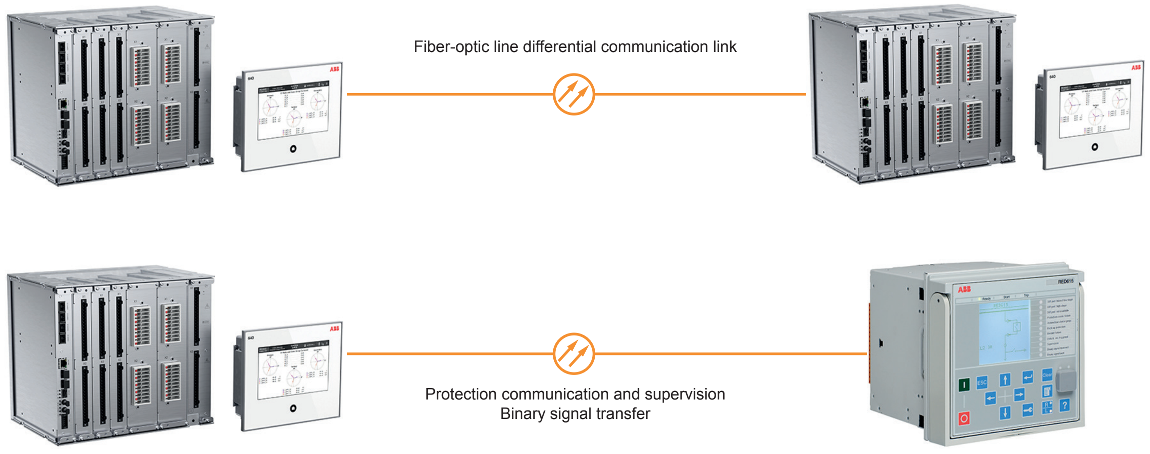

Figure 20. Fiber-optic communication link

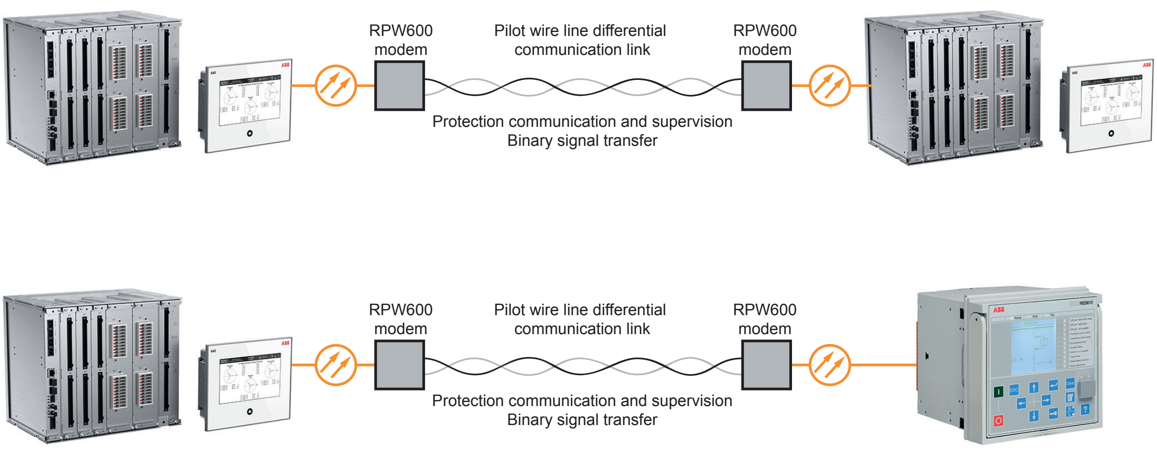

Figure 21. Pilot wire protection communication link

22. Technical data

Table 6. Dimensions of the relay

Description		Value
Width		304.0 mm
Height		264.8 mm
Depth	With compression type CT/VT connectors	242.2 mm
	With ring lug type CT/VT connectors	254.1 mm
	With grounding bar	274.0 mm
Weight box		6.9...8.8 kg

Table 7. Dimensions of the LHMI

Description	Value
Width	212.5 mm
Height	177.5 mm
Depth	57.6 mm
Weight	1.6 kg

Table 8. Power supply for the relay

Description	PSM1001	PSM1002	PSM1003
Nominal auxiliary voltage U_n	24, 30, 48, 60 V DC	100, 110, 120, 220, 240 V AC, 50 and 60 Hz	110, 125 V DC
		48, 60, 110, 125, 220, 250 V DC	
Maximum interruption time in the auxiliary DC voltage without resetting the relay	50 ms at U_n		
Auxiliary voltage variation	50...120% of U_n (12...72 V DC)	38...110% of U_n (38...264 V AC)	70...120% of U_n (77...150 V DC)
		80...120% of U_n (38.4...300 V DC)	
Start-up threshold	16 V DC (24 V DC × 67%)		77 V DC (110 V DC × 70%)
Burden of auxiliary voltage supply under quiescent (P_q)/operating condition	DC <18.0 W (nominal)/<25.0 W (max.)	DC <20.0 W (nominal)/<25.0 W (max.) AC <20.0 W (nominal)/<25.0 W (max.)	DC <17.0 W (nominal)/<25.0 W (max.)
Ripple in the DC auxiliary voltage	Max 15% of the DC value (at frequency of 100 Hz)		
Fuse type	T8A/250 V	T4A/250 V	

Table 9. Power supply for the LHMI

Description	Value
Nominal auxiliary voltage U_n	100, 110, 120, 220, 240 V AC, 50 and 60 Hz
	24, 48, 60, 110, 125, 220, 250 V DC
Auxiliary voltage variation	38...110% of U_n (38...264 V AC)
	80...120% of U_n (19.2...300 V DC)
Start-up threshold	19.2 V DC (24 V DC × 80%)
Burden of auxiliary voltage supply under quiescent (P_q)/operating condition	DC <6.0 W (nominal)/<14.0 W (max.) AC <7.0 W (nominal)/<12.0 W (max.)
Ripple in the DC auxiliary voltage	Max 15% of the DC value (at frequency of 100 Hz)
Fuse type	T3.15A/250V

Table 10. Energizing inputs

Description		Value	
Rated frequency		50/60 Hz	
Current inputs	Rated current, I_n	0.2/1 A	1/5 A[1)]
	Thermal withstand capability: • Continuously • For 1 s	 4 A 100 A	 20 A 500 A
	Dynamic current withstand: • Half-wave value	 250 A	 1250 A
	Input impedance	<100 mΩ	<20 mΩ
Voltage inputs	Rated voltage	57...240 V AC	
	Voltage withstand: • Continuous • For 10 s	 288 V AC 360 V AC	
	Burden at rated voltage	<0.05 VA	

1) Residual current and/or phase current

Table 11. Energizing inputs (sensors)

Description		Value
Current sensor input	Rated current voltage (in secondary side)	75 mV...9000 mV[1)]
	Continuous voltage withstand	125 V
	Input impedance at 50/60 Hz	4 MΩ
Voltage sensor input	Rated primary voltage	6 kV...40.5 kV[2)]
	Continuous voltage withstand	50 V
	Input impedance at 50/60 Hz	8 MΩ

1) Equals the current range of 40...4000 A with a 80 A, 3 mV/Hz Rogowski
2) This range is covered (up to 2*rated) with sensor division ratio of 10 000:1

Table 12. Binary inputs

Description	Value
Operating range	±20% of the rated voltage
Rated voltage	24...250 V DC
Current drain	1.6...1.9 mA
Power consumption	31.0...570.0 mW
Threshold voltage	16...176 V DC
Ripple in the DC auxiliary voltage	Max 15% of the DC value (at frequency of 100 Hz)

Table 13. RTD/mA inputs and mA outputs

Description		Value	
RTD inputs	Supported RTD sensors	100 Ω platinum 250 Ω platinum 100 Ω nickel 120 Ω nickel 250 Ω nickel	TCR 0.00385 (DIN 43760) TCR 0.00385 TCR 0.00618 (DIN 43760) TCR 0.00618 TCR 0.00618
	Supported resistance range	0...4 kΩ	
	Maximum lead resistance (three-wire measurement)	100 Ω per lead	
	Isolation	2 kV (inputs to protective earth)	
	Response time	<1 s	
	RTD/resistance sensing current	<1 mA rms	
	Operation accuracy	Resistance	Temperature
		± 2.0% or ±1 Ω	±1°C
mA inputs	Supported current range	±0…20 mA	
	Current input impedance	44 Ω ±0.1%	
	Operation accuracy	±0.5% or ±0.01 mA	
mA outputs	Supported current range	±0…20 mA	
	Maximum loop impedance	700 Ω	
	Operation accuracy	±0.1 mA	

Table 14. Signal outputs and IRF output

Description	Value
Rated voltage	250 V AC/DC
Maximum continuous burden (resistive load, AC)	1250 VA
Continuous contact carry	5 A
Make and carry for 3.0 s	10 A
Make and carry 0.5 s	15 A
Breaking capacity when the control-circuit time constant L/R<40 ms, at 48/110/220 V DC	1 A/0.25 A/0.15 A
Minimum contact load	10 mA at 5 V AC/DC

Table 15. Single-pole power output relays

Description	Value
Rated voltage	250 V AC/DC
Maximum continuous burden (resistive load, AC)	2000 VA
Continuous contact carry	8 A
Make and carry for 3.0 s	15 A
Make and carry for 0.5 s	30 A
Breaking capacity when the control-circuit time constant L/R<40 ms, at 48/110/220 V DC	5 A/3 A/1 A
Minimum contact load	100 mA at 24 V AC/DC

Table 16. Static signal output (SSO) relays

Description	Value
Rated voltage	250 V AC/DC
Maximum continuous burden (resistive load, AC)	250 VA
Continuous contact carry	1 A
Make and carry for 3.0 s	5 A
Breaking capacity when the control-circuit time constant L/R<40 ms, at 110 V DC	>0.25 A
Minimum load current	1 mA
Maximum operation frequency at 50% duty cycle	10 Hz

Table 17. Double-pole power output relays with TCS function

Description	Value
Rated voltage	250 V AC/DC
Maximum continuous burden (resistive load, AC)	2000 VA
Continuous contact carry	8 A
Make and carry for 3.0 s	15 A
Make and carry for 0.5 s	30 A
Breaking capacity when the control-circuit time constant L/R<40 ms, at 48/110/220 V DC (two contacts connected in series)	5 A/3 A/1 A
Minimum contact load	100 mA at 24 V AC/DC
Trip-circuit supervision (TCS):	
• Control voltage range	20...250 V AC/DC
• Current drain through the supervision circuit	~1.5 mA
• Minimum voltage over the TCS contact	20 V AC/DC (15...20 V)

Table 18. Static power output (SPO) relays

Description	Value
Rated voltage	250 V DC
Maximum continuous burden (resistive load, DC)	2000 VA
Continuous contact carry	5 A (one output at a time) 1 A (multiple outputs simultaneously active)
Make and carry for 3.0 s	15 A
Make and carry for 0.5 s	30 A
Breaking capacity when the control-circuit time constant L/R<40 ms, at 48/110/220 V DC two contacts connected in series	16 A/6 A/3 A
Minimum load current	1 mA
Trip-circuit supervision (TCS) SP06 and SP08:	
• Control voltage range	20...250 V DC
• Current drain through the supervision circuit	~1.5 mA
• Minimum voltage over the TCS contact	20 V DC
SP05 and SP07:	
• Current drain through the circuit	~3 mA

Table 19. Serial rear interface

Type	Counter connector
Serial port X8	10-pin 2-row counter connector
Serial port X7	Optical ST-connector

Table 20. USB interface, LHMI

Type	Description
USB	Hi-Speed USB Type A

Table 21. Ethernet interfaces

Connector	Media	Reach	Rate	Wavelength	Permitted path attenuation
RJ-45	CAT 6 S/FTP	100 m	100 mbits/s	-	–
LC	MM 62.5/125 or 50/125 µm glass fiber core	2 km1)	100 mbits/s	1300 nm	<8 dB2)

1) Maximum length depends on the cable attenuation and quality, the amount of splices and connectors in the path
2) Maximum allowed attenuation caused by connectors and cable togethe

Table 22. Protection communication link

Connector	Part number	Fiber type	Wave Length	Max. length	Permitted path attenuation
SFP	2RCA045621	MM 62.5/125 or 50/125 µm	1310 nm	2 km	<8 dB
SFP	2RCA045622	SM 9/125 µm	1310 nm	20 km	<13 dB
SFP	2RCA045623	SM 9/125 µm	1310 nm	50 km	<26 dB

Table 23. IRIG-B (connector X8)

Description	Value
IRIG time code format	B004, B005[1)]
Isolation	500V 1 min
Modulation	Unmodulated
Logic level	5 V TTL
Current consumption	<1.0 mA
Power consumption	<0.5 W

1) According to the 200-04 IRIG standard

Table 24. Lens sensor and optical fiber for arc protection

Description	Value
Fiber optic cable including lens	1.5 m, 3.0 m or 5.0 m
Normal service temperature range of the lens	-40...+100°C
Maximum service temperature range of the lens, max 1 h	+140°C
Minimum permissible bending radius of the connection fiber	100 mm

Table 25. Degree of protection of flush-mounted protection relay

Description	Value
Front/connector side	IP 20
Top and bottom	IP 30
Rear	IP 40

Table 26. Degree of protection of the LHMI

Description	Value
Front	IP 54
Other sides	IP 20

Table 27. Environmental conditions

Description	Value
Operating temperature range	-25...+55ºC (continuous)
Short-time service temperature range	-40...+85ºC (<16 h)[1)2)]
Relative humidity	<93%, non-condensing
Atmospheric pressure	86...106 kPa
Altitude	Up to 2000 m
Transport and storage temperature range	-40...+85ºC

1) Degradation in MTBF and HMI performance outside the temperature range of -25...+55 ºC
2) For relays with an LC communication interface the maximum operating temperature is +70 ºC

Table 28. Electromagnetic compatibility tests

Description	Type test value	Reference
1 MHz/100 kHz burst disturbance test		IEC 61000-4-18 IEC 60255-26, class III IEEE C37.90.1-2012
• Common mode	2.5 kV	
• Differential mode	2.5 kV	
3 MHz, 10 MHz and 30 MHz burst disturbance test		IEC 61000-4-18 IEC 60255-26, class III
• Common mode	2.5 kV	
Electrostatic discharge test		IEC 61000-4-2 IEC 60255-26 IEEE C37.90.3-2001
• Contact discharge	8 kV	
• Air discharge	15 kV	
Radio frequency interference test		
	10 V (rms) f = 150 kHz...80 MHz	IEC 61000-4-6 IEC 60255-26, class III
	10 V/m (rms) f = 80...2700 MHz	IEC 61000-4-3 IEC 60255-26, class III
	10 V/m f = 900 MHz	ENV 50204 IEC 60255-26, class III
	20 V/m (rms) f = 80...1000 MHz	IEEE C37.90.2-2004
Fast transient disturbance test		IEC 61000-4-4 IEC 60255-26 IEEE C37.90.1-2012
• All ports	4 kV	
Surge immunity test		IEC 61000-4-5 IEC 60255-26
• Communication	1 kV, line-to-earth	
• Other ports	4 kV, line-to-earth 2 kV, line-to-line	
Power frequency (50 Hz) magnetic field immunity test		IEC 61000-4-8
• Continuous • 1...3 s	300 A/m 1000 A/m	
Pulse magnetic field immunity test	1000 A/m 6.4/16 μs	IEC 61000-4-9
Damped oscillatory magnetic field immunity test		IEC 61000-4-10
• 2 s	100 A/m	
• 1 MHz	400 transients/s	
Voltage dips and short interruptions	30%/10 ms 60%/100 ms 60%/1000 ms >95%/5000 ms	IEC 61000-4-11

Table 28. Electromagnetic compatibility tests, continued

Description	Type test value	Reference
Power frequency immunity test	Binary inputs only	IEC 61000-4-16 IEC 60255-26, class A
• Common mode	300 V rms	
• Differential mode	150 V rms	
Conducted common mode disturbances	15 Hz...150 kHz Test level 3 (10/1/10 V rms)	IEC 61000-4-16
Emission tests		EN 55011, class A IEC 60255-26 CISPR 11 CISPR 12
• Conducted		
0.15...0.50 MHz	<79 dB (µV) quasi peak <66 dB (µV) average	
0.5...30 MHz	<73 dB (µV) quasi peak <60 dB (µV) average	
• Radiated		
30...230 MHz	<40 dB (µV/m) quasi peak, measured at 10 m distance	
230...1000 MHz	<47 dB (µV/m) quasi peak, measured at 10 m distance	
1…3 GHz	<76 dB (µV/m) peak <56 dB (µV/m) average, measured at 3 m distance	
3…6 GHz	<80 dB (µV/m) peak <60 dB (µV/m) average, measured at 3 m distance	

Table 29. Insulation tests

Description	Type test value	Reference
Overvoltage category	III	IEC 60255-27
Pollution degree	2	IEC 60255-27
Insulation class	Class I	IEC 60255-27
Dielectric tests	2 kV, 50 Hz, 1 min 1 kV, 50 Hz, 1 min, across open contacts 500 V, 50 Hz, 1 min, communication	IEC 60255-27
Impulse voltage test	5 kV, 1.2/50 µs, 0.5 J 1 kV, 1.2/50 µs, 0.5 J, communication	IEC 60255-27
Insulation resistance measurements	>100 MΩ, 500 V DC	IEC 60255-27
Protective bonding resistance	<0.1 Ω, 4 A, 60 s	IEC 60255-27

Table 30. Mechanical tests

Description	Requirement	Reference
Vibration tests (sinusoidal)	Class 2	IEC 60068-2-6 (test Fc) IEC 60255-21-1
Shock and bump test	Class 2	IEC 60068-2-27 (test Ea shock) IEC 60068-2-29 (test Eb bump) IEC 60255-21-2
Seismic test	Class 2	IEC 60255-21-3

Table 31. Environmental tests

Description	Type test value	Reference
Dry heat test	• 96 h at +55ºC • 16 h at +85ºC1)	IEC 60068-2-2
Dry cold test	• 96 h at -25ºC • 16 h at -40ºC	IEC 60068-2-1
Damp heat test	• 6 cycles (12 h + 12 h) at +25°C…+55°C, humidity >93%	IEC 60068-2-30
Change of temperature test	• 5 cycles (3 h + 3 h) at -25°C...+55°C	IEC60068-2-14
Storage test	• 96 h at -40ºC • 96 h at +85ºC	IEC 60068-2-1 IEC 60068-2-2

1) For relays with an LC communication interface the maximum operating temperature is +70ºC

Table 32. Product safety

Description	Reference
LV directive	2006/95/EC
Standard	EN 60255-27 (2014) EN 60255-1 (2009)

Table 33. EMC compliance

Description	Reference
EMC directive	2004/108/EC
Standard	EN 60255-26 (2013)

Table 34. RoHS compliance

Description
Complies with RoHS Directive 2011/65/EU

Protection functions

Table 35. Distance protection (DSTPDIS)

Characteristic	Value
Operation accuracy	At the frequency $f = f_n$
	Current: ±1.5% of the set value or ±0.002 × I_n Voltage: ±1.5% of the set value or ±0.002 × U_n Impedance: ±2.5% of the set value or ±0.05 Ω Phase angle: ±2°
Shortest operate time[1)] SIR[2)]: 0.1...50	25 ms
Transient overreach SIR = 0.1...50	<8.5%
Reset time	Typically 45 ms
Reset ratio	Typically 0.96/1.04
Operate time accuracy	±1.0% of the set value or ±20 ms

1) Measured with static power output (SPO)
2) SIR = Source impedance ratio

Table 36. Distance protection (DSTPDIS) main settings

Parameter	Function	Value (Range)	Step
Phase Sel mode GFC	DSTPDIS	1 = Overcurrent 2 = Vol Dep Overcur 3 = Under impedance 4 = OC AND Und impedance	-
EF detection Mod GFC	DSTPDIS	1 = Io 2 = Io OR Uo 3 = Io AND Uo 4 = Io AND IoRef	-
Operate delay GFC	DSTPDIS	100...60000 ms	10
Z Chr Mod Ph Sel GFC	DSTPDIS	1 = Quadrilateral 2 = Mho (circular)	-
Directional mode Zn1	DSTPDIS	2 = Forward 3 = Reverse 1 = Non-directional	-
R1 zone 1	DSTPDIS	0.00...3000.00 Ω	0.01
X1 zone 1	DSTPDIS	0.00...3000.00 Ω	0.01
X1 reverse zone 1	DSTPDIS	0.00...3000.00 Ω	0.01
Z1 zone 1	DSTPDIS	0.01...3000.00 Ω	0.01
Z1 angle zone 1	DSTPDIS	15.0...90.0°	0.1
Z1 reverse zone 1	DSTPDIS	0.00...3000.00 Ω	0.01
PP operate delay Zn1	DSTPDIS	20...60000 ms	1
R0 zone 1	DSTPDIS	0.00...3000.00 Ω	0.01
X0 zone 1	DSTPDIS	0.00...3000.00 Ω	0.01
Factor K0 zone 1	DSTPDIS	0.0...4.0	0.1
Factor K0 angle Zn1	DSTPDIS	-135...135°	1
Gnd operate Dl Zn1	DSTPDIS	20...60000 ms	1
Directional mode Zn2	DSTPDIS	1 = Non-directional 2 = Forward 3 = Reverse	-
R1 zone 2	DSTPDIS	0.00...3000.00 Ω	0.01
X1 zone 2	DSTPDIS	0.00...3000.00 Ω	0.01
X1 reverse zone 2	DSTPDIS	0.00...3000.00 Ω	0.01
Z1 zone 2	DSTPDIS	0.01...3000.00 Ω	0.01
Z1 angle zone 2	DSTPDIS	15.0...90.0°	0.1
Z1 reverse zone 2	DSTPDIS	0.00...3000.00 Ω	0.01
PP Op delay Mod Zn2	DSTPDIS	20...60000 ms	1
R0 zone 2	DSTPDIS	0.00...3000.00 Ω	0.01
X0 zone 2	DSTPDIS	0.00...3000.00 Ω	0.01
Factor K0 zone 2	DSTPDIS	0.0...4.0	0.1
Factor K0 angle Zn2	DSTPDIS	-135...135°	1
Gnd operate Dl Zn2	DSTPDIS	20...60000 ms	1

Table 36. Distance protection (DSTPDIS) main settings, continued

Parameter	Function	Value (Range)	Step
Directional mode Zn3	DSTPDIS	1 = Non-directional 2 = Forward 3 = Reverse	-
R1 zone 3	DSTPDIS	0.00...3000.00 Ω	0.01
X1 zone 3	DSTPDIS	0.00...3000.00 Ω	0.01
X1 reverse zone 3	DSTPDIS	0.00...3000.00 Ω	0.01
Z1 zone 3	DSTPDIS	0.01...3000.00 Ω	0.01
Z1 angle zone 3	DSTPDIS	15.0...90.0°	0.1
Z1 reverse zone 3	DSTPDIS	0.00...3000.00 Ω	0.01
PP operate delay Zn3	DSTPDIS	20...60000 ms	1
R0 zone 3	DSTPDIS	0.00...3000.00 Ω	0.01
X0 zone 3	DSTPDIS	0.00...3000.00 Ω	0.01
Factor K0 zone 3	DSTPDIS	0.0...4.0	0.1
Factor K0 angle Zn3	DSTPDIS	-135...135°	1
Gnd operate Dl Zn3	DSTPDIS	20...60000 ms	1
Directional mode Zn4	DSTPDIS	1 = Non-directional 2 = Forward 3 = Reverse	-
R1 zone 4	DSTPDIS	0.00...3000.00 Ω	0.01
X1 zone 4	DSTPDIS	0.00...3000.00 Ω	0.01
X1 reverse zone 4	DSTPDIS	0.00...3000.00 Ω	0.01
Z1 zone 4	DSTPDIS	0.01...3000.00 Ω	0.01
Z1 angle zone 4	DSTPDIS	15.0...90.0°	0.1
Z1 reverse zone 4	DSTPDIS	0.00...3000.00 Ω	0.01
PP operate delay Zn4	DSTPDIS	20...60000 ms	1
R0 zone 4	DSTPDIS	0.00...3000.00 Ω	0.01
X0 zone 4	DSTPDIS	0.00...3000.00 Ω	0.01
Factor K0 zone 4	DSTPDIS	0.0...4.0	0.1
Factor K0 angle Zn4	DSTPDIS	-135...135°	1
Gnd operate Dl Zn4	DSTPDIS	20...60000 ms	1
Directional mode Zn5	DSTPDIS	1 = Non-directional 2 = Forward 3 = Reverse	-
R1 zone 5	DSTPDIS	0.00...3000.00 Ω	0.01
X1 zone 5	DSTPDIS	0.00...3000.00 Ω	0.01
X1 reverse zone 5	DSTPDIS	0.00...3000.00 Ω	0.01
Z1 zone 5	DSTPDIS	0.01...3000.00 Ω	0.01
Z1 angle zone 5	DSTPDIS	15.0...90.0°	0.1
Z1 reverse zone 5	DSTPDIS	0.00...3000.00 Ω	0.01
PP operate delay Zn5	DSTPDIS	20...60000 ms	1

Table 36. Distance protection (DSTPDIS) main settings, continued

Parameter	Function	Value (Range)	Step
R0 zone 5	DSTPDIS	0.00...3000.00 Ω	0.01
X0 zone 5	DSTPDIS	0.00...3000.00 Ω	0.01
Factor K0 zone 5	DSTPDIS	0.0...4.0	0.1
Factor K0 angle Zn5	DSTPDIS	-135...135°	1
Gnd operate Dl Zn5	DSTPDIS	20...60000 ms	1
Select active zones	DSTPDIS	1 = Zone 1 2 = Zones 1-2 3 = Zones 1-3 4 = Zones 1-4 5 = All 5 zones	-

Table 37. Local acceleration logic (DSTPLAL)

Characteristic	Value
Operation accuracy	At the frequency $f = f_n$
	±1.5% of the set value or $\pm 0.002 \times I_n$
Operate time accuracy	±1.0% of the set value or ±20 ms
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$, where n = 2, 3, 4, 5,…

Table 38. Local acceleration logic (DSTPLAL) main settings

Parameter	Function	Value (Range)	Step
Load current value	DSTPLAL	$0.01...1.00 \times I_n$	0.01
Minimum current	DSTPLAL	$0.01...1.00 \times I_n$	0.01
Load release off Tm	DSTPLAL	0...60000 ms	10
Minimum current time	DSTPLAL	0...60000 ms	10
Operation mode	DSTPLAL	1 = Zone extension 2 = Loss of load 3 = Both	-
Load release on time	DSTPLAL	0...60000 ms	10

Table 39. Scheme communication logic (DSOCPSCH)

Characteristic	Value
Operate time accuracy	±1.0% of the set value or ±20 ms

Table 40. Scheme communication logic (DSOCPSCH) main settings

Parameter	Function	Value (Range)	Step
Scheme type	DSOCPSCH	1 = None 2 = Intertrip 3 = Permissive Underreach 4 = Permissive Overreach 5 = Blocking	-
Carrier Min Dur	DSOCPSCH	0...60000 ms	1
Coordination Time	DSOCPSCH	0...60000 ms	1

Table 41. Current reversal and weak-end infeed logic (CRWPSCH)

Characteristic	Value
Operation accuracy	At the frequency $f = f_n$
	±1.5% of the set value or $\pm 0.002 \times U_n$
Operate time accuracy	±1.0% of the set value or ±20 ms

Table 42. Current reversal and weak-end infeed logic (CRWPSCH) main settings

Parameter	Function	Value (Range)	Step
Reversal mode	CRWPSCH	1 = Off 2 = On	-
Wei mode	CRWPSCH	1 = Off 3 = Echo 4 = Echo and Operate	-
PhV level for Wei	CRWPSCH	$0.10...0.90 \times U_n$	0.01
PPV level for Wei	CRWPSCH	$0.10...0.90 \times U_n$	0.01
Reversal time	CRWPSCH	0...60000 ms	10
Reversal reset time	CRWPSCH	0...60000 ms	10
Wei Crd time	CRWPSCH	0...60000 ms	10

Table 43. Communication logic for residual overcurrent (RESCPSCH)

Characteristic	Value
Operate time accuracy	±1.0% of the set value or ±20 ms

Table 44. Communication logic for residual overcurrent (RESCPSCH) main settings

Parameter	Function	Value (Range)	Step
Scheme type	RESCPSCH	1 = None 2 = Intertrip 3 = Permissive Underreach 4 = Permissive Overreach 5 = Blocking	-
Carrier Min Dur	RESCPSCH	0...60000 ms	1
Coordination time	RESCPSCH	0...60000 ms	1

Table 45. Current reversal and weak-end infeed logic for residual overcurrent (RCRWPSCH)

Characteristic	Value
Operation accuracy	At the frequency $f = f_n$
	±1.5% of the set value or $\pm 0.002 \times I_n$
Operate time accuracy	±1.0% of the set value or ±20 ms

Table 46. Current reversal and weak-end infeed logic for residual overcurrent (RCRWPSCH) main settings

Parameter	Function	Value (Range)	Step
Reversal mode	RCRWPSCH	1 = Off 2 = On	-
Wei mode	RCRWPSCH	1 = Off 3 = Echo 4 = Echo and Operate	-
Residual voltage Val	RCRWPSCH	0.05...0.70 × U_n	0.01
Reversal time	RCRWPSCH	0...60000 ms	10
Reversal reset time	RCRWPSCH	0...60000 ms	10
Wei Crd time	RCRWPSCH	0...60000 ms	10

Table 47. Line differential protection with in-zone power transformer (LNPLDF)

Characteristics	Value		
Operation accuracy[1)]	Depending on the frequency of the measured current: f_n ±2 Hz		
	Low stage	±2.5% of the set value	
	High stage	±2.5% of the set value	
High stage, operate time [2)3)]	Minimum	Typical	Maximum
	20 ms	23 ms	27 ms
Reset time	Typically 40 ms		
Reset ratio	Typically 0.96		
Retardation time	<40 ms		
Operate time accuracy in definite time mode	±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode	±5.0% of the set value or ±20 ms [4)]		
Suppression of harmonics	RMS: No suppression DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,… Peak-to-Peak: No suppression		

1) With the symmetrical communication channel (as when using dedicated fiber optic).
2) Without additional delay in the communication channel (as when using dedicated fiber optic).
3) Measured with static power output. When differential current = 2 × *High operate value* and f_n = 50 Hz with galvanic pilot wire link + 5 ms.
4) *Low operate value* multiples in the range of 1.5...20

Table 48. Line differential protection with in-zone power transformer (LNPLDF) main settings

Parameter	Function	Value (Range)	Step
Low operate value	LNPLDF	10...200 % I_r	1
High operate value	LNPLDF	200...4000 % I_r	1
Start value 2.H	LNPLDF	10...50%	1
Time multiplier	LNPLDF	0.05...15.00	0.01
Operating curve type	LNPLDF	1 = ANSI Ext. inv. 3 = ANSI Norm. inv. 5 = ANSI Def. Time 9 = IEC Norm. inv. 10 = IEC Very inv. 12 = IEC Ext. inv. 15 = IEC Def. Time	-
Operate delay time	LNPLDF	45...200000 ms	1
CT ratio correction	LNPLDF	0.200...5.000	0.001

Table 49. Binary signal transfer (BSTGAPC)

Characteristic		Value
Signalling delay	Fiber optic link	<5 ms
	Galvanic pilot wire link	<10 ms

Table 50. Switch-onto-fault protection (CVPSOF)

Characteristic	Value
Operation accuracy	Depending on the frequency of the voltage measured: f_n ±2Hz
	Current: ±1.5% of the set value or ±0.002 × I_n Voltage: ±1.5% of the set value or ±0.002 × U_n
Operate time accuracy	±1.0% of the set value or ±20 ms
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,…

Table 51. Switch-onto-fault protection (CVPSOF) main settings

Parameter	Function	Value (Range)	Step
SOTF reset time	CVPSOF	0...60000 ms	10

Table 52. Three-phase non-directional overcurrent protection (PHxPTOC)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured current: f_n ±2 Hz		
	PHLPTOC	±1.5% of the set value or ±0.002 × I_n		
	PHHPTOC and PHIPTOC	±1.5% of the set value or ±0.002 × I_n (at currents in the range of 0.1…10 × I_n) ±5.0% of the set value (at currents in the range of 10…40 × I_n)		
Start time[1]		Minimum	Typical	Maximum
	PHIPTOC[2]: I_{Fault} = 2 × set *Start value* I_{Fault} = 10 × set *Start value*	8 ms 7 ms	12 ms 9 ms	15 ms 12 ms
	PHHPTOC and PHLPTOC[3]: I_{Fault} = 2 × set *Start value*	23 ms	26 ms	29 ms
Reset time		Typically <40 ms		
Reset ratio		Typically 0.96		
Retardation time		<30 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms		
Suppression of harmonics		RMS: No suppression DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,… Peak-to-Peak: No suppression P-to-P+backup: No suppression		

1) Set *Operate curve type* = IEC definite time, *Measurement mode* = default (depends on stage), current before fault = 0.0 × In, fn = 50 Hz, fault current in one phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Measured with static signal output (SSO)
3) Includes the delay of the signal output contact (SO)

Table 53. Three-phase non-directional overcurrent protection (PHxPTOC) main settings

Parameter	Function	Value (Range)	Step
Start value	PHLPTOC	0.05...5.00 × I_n	0.01
	PHHPTOC and PHIPTOC	0.10...40.00 × I_n	0.01
Time multiplier	PHLPTOC and PHHPTOC	0.025...15.000	0.005
Operate delay time	PHLPTOC and PHHPTOC	40...300000 ms	10
	PHIPTOC	20...300000 ms	10
Operating curve type[1]	PHLPTOC	Definite or inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19, 20	
	PHHPTOC	Definite or inverse time Curve type: 1, 3, 5, 9, 10, 12, 15, 17	
	PHIPTOC	Definite time	

1) For further reference, see the Operation characteristics table

Table 54. Three-phase directional overcurrent protection (DPHxPDOC)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the current/voltage measured: f_n ±2 Hz		
	DPHLPDOC	Current: ±1.5% of the set value or ±0.002 × I_n Voltage: ±1.5% of the set value or ±0.002 × U_n Phase angle: ±2°		
	DPHHPDOC	Current: ±1.5% of the set value or ±0.002 × I_n (at currents in the range of 0.1…10 × I_n) ±5.0% of the set value (at currents in the range of 10…40 × I_n) Voltage: ±1.5% of the set value or ±0.002 × U_n Phase angle: ±2°		
Start time[1)2)]		Minimum	Typical	Maximum
	I_{Fault} = 2.0 × set *Start value*	39 ms	43 ms	47 ms
Reset time		Typically 40 ms		
Reset ratio		Typically 0.96		
Retardation time		<35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms[3)]		
Suppression of harmonics		DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,…		

1) *Measurement mode* and *Pol quantity* = default, current before fault = 0.0 × I_n, voltage before fault = 1.0 × U_n, f_n = 50 Hz, fault current in one phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Maximum *Start value* = 2.5 × I_n, *Start value* multiples in range of 1.5...20

Table 55. Three-phase directional overcurrent protection (DPHxPDOC) main settings

Parameter	Function	Value (Range)	Step
Start value	DPHLPDOC	0.05...5.00 × I_n	0.01
	DPHHPDOC	0.10...40.00 × I_n	0.01
Time multiplier	DPHxPDOC	0.025...15.000	0.005
Operate delay time	DPHxPDOC	40...300000 ms	10
Directional mode	DPHxPDOC	1 = Non-directional 2 = Forward 3 = Reverse	-
Characteristic angle	DPHxPDOC	-179...180°	1
Operating curve type[1)]	DPHLPDOC	Definite or inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	DPHHPDOC	Definite or inverse time Curve type: 1, 3, 5, 9, 10, 12, 15, 17	

1) For further reference, see the Operating characteristics table

Table 56. Non-directional earth-fault protection (EFxPTOC)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured current: f_n ±2 Hz		
	EFLPTOC	±1.5% of the set value or ±0.002 × I_n		
	EFHPTOC and EFIPTOC	±1.5% of the set value or ±0.002 × I_n (at currents in the range of 0.1…10 × I_n) ±5.0% of the set value (at currents in the range of 10…40 × I_n)		
Start time [1]		Minimum	Typical	Maximum
	EFIPTOC[2]: I_{Fault} = 2 × set *Start value* I_{Fault} = 10 × set *Start value*	8 ms 8 ms	11 ms 9 ms	14 ms 11 ms
	EFHPTOC and EFLPTOC[3]: I_{Fault} = 2 × set *Start value*	23 ms	26 ms	29 ms
Reset time		Typically <40 ms		
Reset ratio		Typically 0.96		
Retardation time		<30 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms [4]		
Suppression of harmonics		RMS: No suppression DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,… Peak-to-Peak: No suppression		

1) *Measurement mode* = default (depends on stage), current before fault = 0.0 × I_n, f_n = 50 Hz, fault current in one phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Measured with static signal output (SSO)
3) Includes the delay of the signal output contact (SO)
4) Maximum *Start value* = 2.5 × I_n, *Start value* multiples in the range of 1.5...20

Table 57. Non-directional earth-fault protection (EFxPTOC) main settings

Parameter	Function	Value (Range)	Step
Start value	EFLPTOC	0.010...5.000 × I_n	0.005
	EFHPTOC	0.10...40.00 × I_n	0.01
	EFIPTOC	1.00...40.00 × I_n	0.01
Time multiplier	EFLPTOC and EFHPTOC	0.025...15.000	0.005
Operate delay time	EFLPTOC and EFHPTOC	40...300000 ms	10
	EFIPTOC	20...300000 ms	10
Operating curve type[1]	EFLPTOC	Definite or inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	EFHPTOC	Definite or inverse time Curve type: 1, 3, 5, 9, 10, 12, 15, 17	
	EFIPTOC	Definite time	

1) For further reference, see the Operation characteristics table

Table 58. Directional earth-fault protection (DEFxPDEF)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured current: f_n ±2 Hz		
	DEFLPDEF	Current: ±1.5% of the set value or ±0.002 × I_n Voltage ±1.5% of the set value or ±0.002 × U_n Phase angle: ±2°		
	DEFHPDEF	Current: ±1.5% of the set value or ±0.002 × I_n (at currents in the range of 0.1…10 × I_n) ±5.0% of the set value (at currents in the range of 10…40 × I_n) Voltage: ±1.5% of the set value or ±0.002 × U_n Phase angle: ±2°		
Start time [1)2)]		Minimum	Typical	Maximum
	DEFHPDEF I_{Fault} = 2 × set *Start value*	42 ms	46 ms	49 ms
	DEFLPDEF I_{Fault} = 2 × set *Start value*	58 ms	62 ms	66 ms
Reset time		Typically 40 ms		
Reset ratio		Typically 0.96		
Retardation time		<30 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms [3)]		
Suppression of harmonics		RMS: No suppression DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,… Peak-to-Peak: No suppression		

1) Set *Operate curve type* = IEC definite time, *Measurement mode* = default (depends on stage), current before fault = 0.0 × I_n, f_n = 50 Hz, earth-fault current with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Maximum *Start value* = 2.5 × I_n, *Start value* multiples in range of 1.5...20

Table 59. Directional earth-fault protection (DEFxPDEF) main settings

Parameter	Function	Value (Range)	Step
Start value	DEFLPDEF	0.010...5.000 × I_n	0.005
	DEFHPDEF	0.10...40.00 × I_n	0.01
Directional mode	DEFxPDEF	1 = Non-directional 2 = Forward 3 = Reverse	-
Time multiplier	DEFxPDEF	0.025...15.000	0.005
Operate delay time	DEFLPDEF	50...300000 ms	10
	DEFHPDEF	40...300000 ms	10
Operating curve type[1)]	DEFLPDEF	Definite or inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	DEFHPDEF	Definite or inverse time Curve type: 1, 3, 5, 15, 17	
Operation mode	DEFxPDEF	1 = Phase angle 2 = IoSin 3 = IoCos 4 = Phase angle 80 5 = Phase angle 88	-

1) For further reference, see the Operating characteristics table

Table 60. Three-phase power directional element (DPSRDIR) main settings

Parameter	Function	Value (Range)	Step
Release delay time	DPSRDIR	0...1000 ms	1
Characteristic angle	DPSRDIR	-179...180°	1
Directional mode	DPSRDIR	1 = Non-directional 2 = Forward 3 = Reverse	-

Table 61. Neutral power directional element (DNZSRDIR) main settings

Parameter	Function	Value (Range)	Step
Release delay time	DNZSRDIR	0...1000 ms	10
Directional mode	DNZSRDIR	1 = Non-directional 2 = Forward 3 = Reverse	-
Characteristic angle	DNZSRDIR	-179...180°	1
Pol quantity	DNZSRDIR	3 = Zero seq. volt. 4 = Neg. seq. volt.	-

Table 62. Admittance-based earth-fault protection (EFPADM)

Characteristic	Value		
Operation accuracy[1)]	At the frequency f = f_n		
	±1.0% or ±0.01 mS (In range of 0.5...100 mS)		
Start time[2)]	Minimum	Typical	Maximum
	56 ms	60 ms	64 ms
Reset time	40 ms		
Operate time accuracy	±1.0% of the set value of ±20 ms		
Suppression of harmonics	-50 dB at f = n × f_n, where n = 2, 3, 4, 5,…		

1) Uo = 1.0 × Un
2) Includes the delay of the signal output contact, results based on statistical distribution of 1000 measurements

Table 63. Admittance-based earth-fault protection (EFPADM) main settings

Parameter	Function	Value (Range)	Step
Voltage start value	EFPADM	0.01...2.00 × U_n	0.01
Directional mode	EFPADM	1 = Non-directional 2 = Forward 3 = Reverse	-
Operation mode	EFPADM	1 = Yo 2 = Go 3 = Bo 4 = Yo, Go 5 = Yo, Bo 6 = Go, Bo 7 = Yo, Go, Bo	-
Operate delay time	EFPADM	60...300000 ms	10
Circle radius	EFPADM	0.05...500.00 mS	0.01
Circle conductance	EFPADM	-500.00...500.00 mS	0.01
Circle susceptance	EFPADM	-500.00...500.00 mS	0.01
Conductance forward	EFPADM	-500.00...500.00 mS	0.01
Conductance reverse	EFPADM	-500.00...500.00 mS	0.01
Susceptance forward	EFPADM	-500.00...500.00 mS	0.01
Susceptance reverse	EFPADM	-500.00...500.00 mS	0.01
Conductance tilt Ang	EFPADM	-30...30°	1
Susceptance tilt Ang	EFPADM	-30...30°	1

Table 64. Multifrequency admittance-based earth-fault protection (MFADPSDE)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured voltage: f_n ±2 Hz
	±1.5% of the set value or ±0.002 × U_n
Start time[1]	Typically 35 ms
Reset time	Typically 40 ms
Operate time accuracy	±1.0% of the set value or ±20 ms

1) Includes the delay of the signal output contact, results based on statistical distribution of 1000 measurements

Table 65. Multifrequency admittance-based earth-fault protection (MFADPSDE) main settings

Parameter	Function	Value (Range)	Step
Directional mode	MFADPSDE	2 = Forward 3 = Reverse	-
Voltage start value	MFADPSDE	0.01...1.00 × U_n	0.01
Operate delay time	MFADPSDE	60...1200000 ms	10
Operating quantity	MFADPSDE	1 = Adaptive 2 = Amplitude 3 = Resistive	-
Min operate current	MFADPSDE	0.005...5.000 × I_n	0.001
Operation mode	MFADPSDE	1 = Intermittent EF 2 = Transient EF 3 = General EF 4 = Alarming EF	-
Peak counter limit	MFADPSDE	2...20	1

Table 66. Wattmetric-based earth-fault protection (WPWDE)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: f_n ±2 Hz
	Current and voltage: ±1.5% of the set value or ±0.002 × I_n Power: ±3% of the set value or ±0.002 × P_n
Start time [1][2]	Typically 63 ms
Reset time	Typically 40 ms
Reset ratio	Typically 0.96
Operate time accuracy in definite time mode	±1.0% of the set value or ±20 ms
Operate time accuracy in IDMT mode	±5.0% of the set value or ±20 ms
Suppression of harmonics	-50 dB at f = n × f_n, where n = 2,3,4,5,…

1) Io varied during the test, Uo = 1.0 × U_n = phase to earth voltage during earth fault in compensated or un-earthed network, the residual power value before fault = 0.0 pu, f_n = 50 Hz, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 67. Wattmetric-based earth-fault protection (WPWDE) main settings

Parameter	Function	Value (Range)	Step
Directional mode	WPWDE	2 = Forward 3 = Reverse	-
Current start value	WPWDE	0.010...5.000 × I_n	0.001
Voltage start value	WPWDE	0.010...1.000 × U_n	0.001
Power start value	WPWDE	0.003...1.000 × S_n	0.001
Reference power	WPWDE	0.050...1.000 × S_n	0.001
Characteristic angle	WPWDE	-179...180°	1
Time multiplier	WPWDE	0.025...2.000	0.005
Operating curve type[1)]	WPWDE	Definite or inverse time Curve type: 5, 15, 20	
Operate delay time	WPWDE	60...300000 ms	10
Min operate current	WPWDE	0.010...1.000 × I_n	0.001
Min operate voltage	WPWDE	0.01...1.00 × U_n	0.01

1) For further reference, see the Operating characteristics table

Table 68. Transient/intermittent earth-fault protection (INTRPTEF)

Characteristic	Value
Operation accuracy (Uo criteria with transient protection)	Depending on the frequency of the measured current: f_n ±2 Hz
	±1.5% of the set value or ±0.002 × Uo
Operate time accuracy	±1.0% of the set value or ±20 ms
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5

Table 69. Transient/intermittent earth-fault protection (INTRPTEF) main settings

Parameter	Function	Value (Range)	Step
Directional mode	INTRPTEF	1 = Non-directional 2 = Forward 3 = Reverse	-
Operate delay time	INTRPTEF	40...1200000 ms	10
Voltage start value	INTRPTEF	0.05...0.50 × U_n	0.01
Operation mode	INTRPTEF	1 = Intermittent EF 2 = Transient EF	-
Peak counter limit	INTRPTEF	2...20	1
Min operate current	INTRPTEF	0.01...1.00 × I_n	0.01

Table 70. Harmonics-based earth-fault protection (HAEFPTOC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: f_n ±2 Hz
	±5% of the set value or ±0.004 × I_n
Start time [1)2)]	Typically 77 ms
Reset time	Typically 40 ms
Reset ratio	Typically 0.96
Operate time accuracy in definite time mode	±1.0% of the set value or ±20 ms
Operate time accuracy in IDMT mode [3)]	±5.0% of the set value or ±20 ms
Suppression of harmonics	-50 dB at f = f_n
	-3 dB at f = 13 × f_n

1) Fundamental frequency current = 1.0 × I_n, harmonics current before fault = 0.0 × I_n, harmonics fault current 2.0 × *Start value*, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Maximum *Start value* = 2.5 × I_n, *Start value* multiples in range of 2...20

Table 71. Harmonics-based earth-fault protection (HAEFPTOC) main settings

Parameter	Function	Value (Range)	Step
Start value	HAEFPTOC	0.05...5.00 × I_n	0.01
Time multiplier	HAEFPTOC	0.025...15.000	0.005
Operate delay time	HAEFPTOC	100...300000 ms	10
Operating curve type[1)]	HAEFPTOC	Definite or inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
Minimum operate time	HAEFPTOC	100...200000 ms	10

1) For further reference, see the Operation characteristics table

Table 72. Negative-sequence overcurrent protection (NSPTOC)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured current: f_n ±2 Hz		
		±1.5% of the set value or ±0.002 × I_n		
Start time [1)2)]		Minimum	Typical	Maximum
	I_{Fault} = 2 × set *Start value* I_{Fault} = 10 × set *Start value*	23 ms 15 ms	26 ms 18 ms	28 ms 20 ms
Reset time		Typically 40 ms		
Reset ratio		Typically 0.96		
Retardation time		<35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms [3)]		
Suppression of harmonics		DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,…		

1) Negative sequence current before fault = 0.0, f_n = 50 Hz, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Maximum *Start value* = 2.5 × I_n, *Start value* multiples in range of 1.5...20

Table 73. Negative-sequence overcurrent protection (NSPTOC) main settings

Parameter	Function	Value (Range)	Step
Start value	NSPTOC	0.01...5.00 × I_n	0.01
Time multiplier	NSPTOC	0.025...15.000	0.005
Operate delay time	NSPTOC	40...200000 ms	10
Operating curve type[1)]	NSPTOC	Definite or inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	

1) For further reference, see the Operation characteristics table

Table 74. Phase discontinuity protection (PDNSPTOC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: f_n ±2 Hz
	±2% of the set value
Start time	<70 ms
Reset time	Typically 40 ms
Reset ratio	Typically 0.96
Retardation time	<35 ms
Operate time accuracy in definite time mode	±1.0% of the set value or ±20 ms
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,…

Table 75. Phase discontinuity protection (PDNSPTOC) main settings

Parameter	Function	Value (Range)	Step
Start value	PDNSPTOC	10...100%	1
Operate delay time	PDNSPTOC	100...30000 ms	1
Min phase current	PDNSPTOC	0.05...0.30 × I_n	0.01

Table 76. Residual overvoltage protection (ROVPTOV)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured voltage: f_n ±2 Hz		
		±1.5% of the set value or ±0.002 × U_n		
Start time[1)2)]		Minimum	Typical	Maximum
	U_{Fault} = 2 × set *Start value*	48 ms	51 ms	54 ms
Reset time		Typically 40 ms		
Reset ratio		Typically 0.96		
Retardation time		<35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Suppression of harmonics		DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,…		

1) Residual voltage before fault = 0.0 × U_n, f_n = 50 Hz, residual voltage with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 77. Residual overvoltage protection (ROVPTOV) main settings

Parameter	Function	Value (Range)	Step
Start value	ROVPTOV	0.010...1.000 × U_n	0.001
Operate delay time	ROVPTOV	40...300000 ms	1

Table 78. Three-phase undervoltage protection (PHPTUV)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the voltage measured: f_n ±2 Hz		
		±1.5% of the set value or ±0.002 × U_n		
Start time[1)2)]		Minimum	Typical	Maximum
	U_{Fault} = 0.9 × set *Start value*	62 ms	66 ms	70 ms
Reset time		Typically 40 ms		
Reset ratio		Depends on the set *Relative hysteresis*		
Retardation time		<35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms[3)]		
Suppression of harmonics		DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,…		

1) *Start value* = 1.0 × U_n, Voltage before fault = 1.1 × U_n, f_n = 50 Hz, undervoltage in one phase-to-phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Minimum *Start value* = 0.50, *Start value* multiples in range of 0.90...0.20

Table 79. Three-phase undervoltage protection (PHPTUV) main settings

Parameter	Function	Value (Range)	Step
Start value	PHPTUV	0.05...1.20 × U_n	0.01
Time multiplier	PHPTUV	0.025...15.000	0.005
Operate delay time	PHPTUV	60...300000 ms	10
Operating curve type[1)]	PHPTUV	Definite or inverse time Curve type: 5, 15, 21, 22, 23	

1) For further reference, see the Operation characteristics table

Table 80. Three-phase overvoltage variation protection (PHVPTOV)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured voltage: f_n
	±1.5% of the set value or ±0.002 × U_n
Reset ratio	Depends on the set *Relative hysteresis*
Operate time accuracy in definite time mode	±1.0% of the set value or ±20 ms

Table 81. Three-phase overvoltage variation protection (PHVPTOV) main settings

Parameter	Function	Value (Range)	Step
Start value	PHVPTOV	0.05...3.00 × U_n	0.01
Time interval	PHVPTOV	1...120 min	1
Num of start phases	PHVPTOV	1 = 1 out of 3 2 = 2 out of 3 3 = 3 out of 3	-
Voltage selection	PHVPTOV	1 = phase-to-earth 2 = phase-to-phase	-

Table 82. Three-phase overvoltage protection (PHPTOV)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured voltage: f_n ±2 Hz		
		±1.5% of the set value or ±0.002 × U_n		
Start time[1)2)]		Minimum	Typical	Maximum
	U_{Fault} = 1.1 × set *Start value*	23 ms	27 ms	31 ms
Reset time		Typically 40 ms		
Reset ratio		Depends on the set *Relative hysteresis*		
Retardation time		<35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms[3)]		
Suppression of harmonics		DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,…		

1) *Start value* = 1.0 × U_n, Voltage before fault = 0.9 × U_n, f_n = 50 Hz, overvoltage in one phase-to-phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Maximum *Start value* = 1.20 × U_n, *Start value* multiples in range of 1.10...2.00

Table 83. Three-phase overvoltage protection (PHPTOV) main settings

Parameter	Function	Value (Range)	Step
Start value	PHPTOV	0.05...1.60 × U_n	0.01
Time multiplier	PHPTOV	0.025...15.000	0.005
Operate delay time	PHPTOV	40...300000 ms	10
Operating curve type[1)]	PHPTOV	Definite or inverse time Curve type: 5, 15, 17, 18, 19, 20	

1) For further reference, see the Operation characteristics table

Table 84. Positive-sequence overvoltage protection (PSPTOV)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured current: f_n ±2 Hz		
		±1.5% of the set value or ±0.002 × U_n		
Start time[1)2)]		Minimum	Typical	Maximum
	U_{Fault} = 1.1 × set *Start value*	29 ms	32 ms	34 ms
	U_{Fault} = 2 × set *Start value*	32 ms	24 ms	26 ms
Reset time		Typically 40 ms		
Reset ratio		Typically 0.96		
Retardation time		<35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Suppression of harmonics		DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,…		

1) Positive-sequence voltage before fault = 0.0 × U_n, f_n = 50 Hz, positive-sequence overvoltage of nominal frequency injected from random phase angle
2) Measured with static signal output (SSO)

Table 85. Positive-sequence overvoltage protection (PSPTOV) main settings

Parameter	Function	Value (Range)	Step
Start value	PSPTOV	0.400...1.600 × U_n	0.001
Operate delay time	PSPTOV	40...120000 ms	10

Table 86. Positive-sequence undervoltage protection (PSPTUV)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured voltage: f_n ±2 Hz		
		±1.5% of the set value or ±0.002 × U_n		
Start time[1)2)]		Minimum	Typical	Maximum
	U_{Fault} = 0.99 × set *Start value* U_{Fault} = 0.9 × set *Start value*	52 ms 44 ms	55 ms 47 ms	58 ms 50 ms
Reset time		Typically 40 ms		
Reset ratio		Depends on the set *Relative hysteresis*		
Retardation time		<35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Suppression of harmonics		DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,…		

1) *Start value* = 1.0 × U_n, positive-sequence voltage before fault = 1.1 × U_n, f_n = 50 Hz, positive sequence undervoltage with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 87. Positive-sequence undervoltage protection (PSPTUV) main settings

Parameter	Function	Value (Range)	Step
Start value	PSPTUV	0.010...1.200 × U_n	0.001
Operate delay time	PSPTUV	40...120000 ms	10
Voltage block value	PSPTUV	0.01...1.00 × U_n	0.01

Table 88. Negative-sequence overvoltage protection (NSPTOV)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the voltage measured: f_n		
		±1.5% of the set value or ±0.002 × U_n		
Start time[1)2)]		Minimum	Typical	Maximum
	U_{Fault} = 1.1 × set *Start value* U_{Fault} = 2.0 × set *Start value*	33 ms 24 ms	35 ms 26 ms	37 ms 28 ms
Reset time		Typically 40 ms		
Reset ratio		Typically 0.96		
Retardation time		<35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Suppression of harmonics		DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,…		

1) Negative-sequence voltage before fault = 0.0 × U_n, f_n = 50 Hz, negative-sequence overvoltage with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 89. Negative-sequence overvoltage protection (NSPTOV) main settings

Parameter	Function	Value (Range)	Step
Start value	NSPTOV	0.010...1.000 × U_n	0.001
Operate delay time	NSPTOV	40...120000 ms	1

Table 90. Frequency protection (FRPFRQ)

Characteristic		Value
Operation accuracy	f>/f<	±5 mHz
	df/dt	±50 mHz/s (in range |df/dt| <5 Hz/s) ±2.0% of the set value (in range 5 Hz/s < |df/dt| < 15 Hz/s)
Start time	f>/f<	<80 ms
	df/dt	<120 ms
Reset time		<150 ms
Operate time accuracy		±1.0% of the set value or ±30 ms

Table 91. Frequency protection (FRPFRQ) main settings

Parameter	Function	Value (Range)	Step
Operation mode	FRPFRQ	1 = Freq< 2 = Freq> 3 = df/dt 4 = Freq< + df/dt 5 = Freq> + df/dt 6 = Freq< OR df/dt 7 = Freq> OR df/dt	-
Start value Freq>	FRPFRQ	0.9000...1.2000 × f_n	0.0001
Start value Freq<	FRPFRQ	0.8000...1.1000 × f_n	0.0001
Start value df/dt	FRPFRQ	-0.2000...0.2000 × f_n/s	0.0001
Operate Tm Freq	FRPFRQ	80...200000 ms	10
Operate Tm df/dt	FRPFRQ	120...200000 ms	10

Table 92. Three-phase voltage-dependent overcurrent protection (PHPVOC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current and voltage: f_n ±2 Hz
	Current: ±1.5% of the set value or ± 0.002 × I_n Voltage: ±1.5% of the set value or ±0.002 × U_n
Start time[1)2)]	Typically 26 ms
Reset time	Typically 40 ms
Reset ratio	Typically 0.96
Operate time accuracy in definite time mode	±1.0% of the set value or ±20 ms
Operate time accuracy in inverse time mode	±5.0% of the set value or ±20 ms
Suppression of harmonics	-50 dB at f = n × f_n, where n = 2, 3, 4, 5,…

1) *Measurement mode* = default, current before fault = 0.0 × I_n, f_n = 50 Hz, fault current in one phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 93. Three-phase voltage-dependent overcurrent protection (PHPVOC) main settings

Parameter	Function	Value (Range)	Step
Start value	PHPVOC	0.05...5.00 × I_n	0.01
Start value low	PHPVOC	0.05...1.00 × I_n	0.01
Voltage high limit	PHPVOC	0.01...1.00 × U_n	0.01
Voltage low limit	PHPVOC	0.01...1.00 × U_n	0.01
Start value Mult	PHPVOC	0.8...10.0	0.1
Time multiplier	PHPVOC	0.05...15.00	0.01
Operating curve type[1)]	PHPVOC	Definite or inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
Operate delay time	PHPVOC	40...200000 ms	10

1) For further reference, see the Operation characteristics table

Table 94. Overexcitation protection (OEPVPH)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: f_n ±2 Hz
	±3.0% of the set value
Start time [1]	Frequency change: Typically 200 ms
	Voltage change: Typically 40 ms
Reset time	Typically 40 ms
Reset ratio	Typically 0.96
Retardation time	<35 ms
Operate time accuracy in definite-time mode	±1.0% of the set value or ±20 ms
Operate time accuracy in inverse-time mode	±5.0% of the theoretical value or ±50 ms

1) Includes the delay of the signal output contact

Table 95. Overexcitation protection (OEPVPH) main settings

Parameter	Function	Value (Range)	Step
Start value	OEPVPH	100...200%	1
Operating curve type[1]	OEPVPH	Definite or inverse time Curve type: 5, 15, 17, 18, 19, 20	
Time multiplier	OEPVPH	0.1...100.0	0.1
Operate delay time	OEPVPH	200...200000 ms	10
Cooling time	OEPVPH	5...10000 s	1

1) For further reference, see the Operation characteristics table

Table 96. Three-phase thermal protection for feeders, cables and distribution transformers (T1PTTR)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: f_n ±2 Hz
	Current measurement: ±1.5% of the set value or ±0.002 × I_n (at currents in the range of 0.01...4.00 × I_n)
Operate time accuracy[1]	±2.0% of the theoretical value or ±0.50 s

1) Overload current > 1.2 × Operate level temperature

Table 97. Three-phase thermal protection for feeders, cables and distribution transformers (T1PTTR) main settings

Parameter	Function	Value (Range)	Step
Env temperature Set	T1PTTR	-50...100°C	1
Current reference	T1PTTR	0.05...4.00 × I_n	0.01
Temperature rise	T1PTTR	0.0...200.0°C	0.1
Time constant	T1PTTR	60...60000 s	1
Maximum temperature	T1PTTR	22.0...200.0°C	0.1
Alarm value	T1PTTR	20.0...150.0°C	0.1
Reclose temperature	T1PTTR	20.0...150.0°C	0.1
Current multiplier	T1PTTR	1...5	1
Initial temperature	T1PTTR	-50.0...100.0°C	0.1

Table 98. Three-phase thermal overload protection, two time constants (T2PTTR)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: f_n ±2 Hz
	Current measurement: ±1.5% of the set value or ±0.002 x I_n (at currents in the range of 0.01...4.00 x I_n)
Operate time accuracy[1)]	±2.0% of the theoretical value or ±0.50 s

1) Overload current > 1.2 x Operate level temperature

Table 99. Three-phase thermal overload protection, two time constants (T2PTTR) main settings

Parameter	Function	Value (Range)	Step
Temperature rise	T2PTTR	0.0...200.0°C	0.1
Max temperature	T2PTTR	22.0...200.0°C	0.1
Operate temperature	T2PTTR	80.0...120.0%	0.1
Short time constant	T2PTTR	6...60000 s	1
Weighting factor p	T2PTTR	0.00...1.00	0.01
Current reference	T2PTTR	0.05...4.00 × I_n	0.01
Operation	T2PTTR	1 = on 5 = off	-

Table 100. Three-phase overload protection for shunt capacitor banks (COLPTOC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: f_n ±2 Hz, and no harmonics
	5% of the set value or 0.002 × I_n
Start time for overload stage[1)2)]	Typically 75 ms
Start time for under current stage[2)3)]	Typically 26 ms
Reset time for overload and alarm stage	Typically 60 ms
Reset ratio	Typically 0.96
Operate time accuracy in definite time mode	1% of the set value or ±20 ms
Operate time accuracy in inverse time mode	10% of the theoretical value or ±20 ms
Suppression of harmonics for under current stage	DFT: -50 dB at f = n × f_n, where n = 2,3,4,5,..

1) Harmonics current before fault = 0.5 × I_n, harmonics fault current 1.5 × *Start value*, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Harmonics current before fault = 1.2 × I_n, harmonics fault current 0.8 × *Start value*, results based on statistical distribution of 1000 measurements

Table 101. Three-phase overload protection for shunt capacitor banks (COLPTOC) main settings

Parameter	Function	Value (Range)	Step
Start value overload	COLPTOC	0.30...1.50 × I_n	0.01
Alarm start value	COLPTOC	80...120%	1
Start value Un Cur	COLPTOC	0.10...0.70 × I_n	0.01
Time multiplier	COLPTOC	0.05...2.00	0.01
Alarm delay time	COLPTOC	500...6000000 ms	100
Un Cur delay time	COLPTOC	100...120000 ms	100

Table 102. Current unbalance protection for shunt capacitor banks (CUBPTOC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: f_n ±2 Hz
	1.5% of the set value or 0.002 × I_n
Start time[1)2)]	Typically 26 ms
Reset time	Typically 40 ms
Reset ratio	Typically 0.96
Operate time accuracy in definite time mode	1% of the theoretical value or ±20 ms
Operate time accuracy in inverse definite minimum time mode	5% of the theoretical value or ±20 ms
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2,3,4,5,..

1) Fundamental frequency current = 1.0 × I_n, current before fault = 0.0 × I_n, fault current = 2.0 × *Start value*, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 103. Current unbalance protection for shunt capacitor banks (CUBPTOC) main settings

Parameter	Function	Value (Range)	Step
Alarm mode	CUBPTOC	1 = Normal 2 = Element counter	-
Start value	CUBPTOC	0.01...1.00 × I_n	0.01
Alarm start value	CUBPTOC	0.01...1.00 × I_n	0.01
Time multiplier	CUBPTOC	0.05...15.00	0.01
Operating curve type[1)]	CUBPTOC	Definite or inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
Operate delay time	CUBPTOC	50...200000 ms	10
Alarm delay time	CUBPTOC	50...200000 ms	10

1) For further reference, see the Operating characteristics table

Table 104. Three-phase current unbalance protection for shunt capacitor banks (HCUBPTOC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: f_n ±2 Hz
	1.5% of the set value or 0.002 × I_n
Start time[1)2)]	Typically 26 ms
Reset time	Typically 40 ms
Reset ratio	Typically 0.96
Operate time accuracy in definite time mode	1% of the theoretical value or ±20 ms
Operate time accuracy in IDMT mode	5% of the theoretical value or ±20 ms
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2,3,4,5,..

1) Fundamental frequency current = 1.0 × I_n, current before fault = 0.0 × I_n, fault current = 2.0 × *Start value*, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 105. Three-phase current unbalance protection for shunt capacitor banks (HCUBPTOC) main settings

Parameter	Function	Value (Range)	Step
Start value	HCUBPTOC	0.01...1.00 × I_n	0.01
Alarm start value	HCUBPTOC	0.01...1.00 × I_n	0.01
Time multiplier	HCUBPTOC	0.05...15.00	0.01
Operating curve type [1)]	HCUBPTOC	Definite or inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
Operate delay time	HCUBPTOC	40...200000 ms	10
Alarm delay time	HCUBPTOC	40...200000 ms	10

1) For further reference, see the Operating characteristics table

Table 106. Shunt capacitor bank switching resonance protection, current based (SRCPTOC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: fn ±2 Hz
	Operate value accuracy: ±3% of the set value or ±0.002 × I_n (for 2nd order Harmonics) ±1.5% of the set value or ±0.002 × I_n (for 3rd order < Harmonics < 10th order) ±6% of the set value or ±0.004 × I_n (for Harmonics >= 10th order)
Reset time	Typically 45 ms or maximum 50 ms
Retardation time	Typically 0.96
Retardation time	<35 ms
Operate time accuracy in definite time mode	±1.0% of the set value or ±20 ms
Suppression of harmonics	-50 dB at f = f_n

Table 107. Shunt capacitor bank switching resonance protection, current based (SRCPTOC) main settings

Parameter	Function	Value (Range)	Step
Alarm start value	SRCPTOC	0.03...0.50 × I_n	0.01
Start value	SRCPTOC	0.03...0.50 × I_n	0.01
Tuning harmonic Num	SRCPTOC	1...11	1
Operate delay time	SRCPTOC	120...360000 ms	1
Alarm delay time	SRCPTOC	120...360000 ms	1

Table 108. Compensated neutral unbalance voltage protection (CNUPTOV)

Characteristic		Value
Operation accuracy		Depending on the frequency of the measured voltage: f_n ±2 Hz
		±1.5% of the set value or ±0.002 × U_n
Start time[1)2)]	U_{Fault} = 1.1 × set *Start value*	Typically 75 ms
Reset time		Typically 40 ms
Reset ratio		Typically 0.96
Retardation time		<35 ms
Operate time accuracy		±1.0% of the set value or ±20 ms
Suppression of harmonics		DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,…

1) *Start value* = 0.1 × U_n, Voltage before fault = 0.9 × U_n, f_n = 50 Hz, overvoltage in one phase-to-earth with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Measured with static signal output (SSO)

Table 109. Compensated neutral unbalance voltage protection (CNUPTOV) main settings

Parameter	Function	Value (Range)	Step
Start value	CNUPTOV	0.01...1.00 × U_n	0.01
Operate delay time	CNUPTOV	100...300000 ms	100

Table 110. Directional negative-sequence overcurrent protection (DNSPDOC)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured current: f_n ±2 Hz		
		Current: ±1.5% of the set value or ±0.002 × I_n Voltage: ±1.5% of the set value or ±0.002 × U_n Phase angle: ±2°		
Start time[1)2)]		Minimum	Typical	Maximum
	I_{Fault} = 2 × set *Start value*	31 ms	34 ms	37 ms
Reset time		Typically 40 ms		
Reset ratio		Typically 0.96		
Retardation time		<35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Suppression of harmonics		RMS: No suppression DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,… Peak-to-Peak: No suppression		

1) Measurement mode NPS, NPS current before fault = 0.0 × I_n, f_n = 50 Hz, fault NPS current with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Measured with static signal output (SSO)

Table 111. Directional negative-sequence overcurrent protection (DNSPDOC) main settings

Parameter	Function	Value (Range)	Step
Start value	DNSPDOC	0.05...5.00 × I_n	0.01
Directional mode	DNSPDOC	1 = Non-directional 2 = Forward 3 = Reverse	-
Operate delay time	DNSPDOC	40...300000 ms	10
Characteristic angle	DNSPDOC	-179...180°	1

Table 112. Low-voltage ride-through protection (LVRTPTUV)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured voltage: f_n ±2 Hz
	±1.5% of the set value or ±0.002 × U_n
Start time[1)2)]	Typically 40 ms
Reset time	Based on maximum value of *Recovery time* setting
Operate time accuracy	±1.0% of the set value or ±20 ms
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,…

1) Tested for *Number of Start phases* = 1 out of 3, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 113. Low-voltage ride-through protection (LVRTPTUV) main settings

Parameter	Function	Value (Range)	Step
Voltage start value	LVRTPTUV	0.05...1.20 × U_n	0.01
Num of start phases	LVRTPTUV	4 = Exactly 1 of 3 5 = Exactly 2 of 3 6 = Exactly 3 of 3	-
Voltage selection	LVRTPTUV	1 = Highest Ph-to-E 2 = Lowest Ph-to-E 3 = Highest Ph-to-Ph 4 = Lowest Ph-to-Ph 5 = Positive Seq	-
Active coordinates	LVRTPTUV	1...10	1
Voltage level 1	LVRTPTUV	0.00...1.20 xUn	0.01
Voltage level 2	LVRTPTUV	0.00...1.20 xUn	0.01
Voltage level 3	LVRTPTUV	0.00...1.20 xUn	0.01
Voltage level 4	LVRTPTUV	0.00...1.20 xUn	0.01
Voltage level 5	LVRTPTUV	0.00...1.20 xUn	0.01
Voltage level 6	LVRTPTUV	0.00...1.20 xUn	0.01
Voltage level 7	LVRTPTUV	0.00...1.20 xUn	0.01
Voltage level 8	LVRTPTUV	0.00...1.20 xUn	0.01
Voltage level 9	LVRTPTUV	0.00...1.20 xUn	0.01
Voltage level 10	LVRTPTUV	0.00...1.20 xUn	0.01
Recovery time 1	LVRTPTUV	0...300000 ms	1
Recovery time 2	LVRTPTUV	0...300000 ms	1
Recovery time 3	LVRTPTUV	0...300000 ms	1
Recovery time 4	LVRTPTUV	0...300000 ms	1
Recovery time 5	LVRTPTUV	0...300000 ms	1
Recovery time 6	LVRTPTUV	0...300000 ms	1
Recovery time 7	LVRTPTUV	0...300000 ms	1
Recovery time 8	LVRTPTUV	0...300000 ms	1
Recovery time 9	LVRTPTUV	0...300000 ms	1
Recovery time 10	LVRTPTUV	0...300000 ms	1

Table 114. Voltage vector shift protection (VVSPPAM)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured voltage: f_n ±1 Hz
	±1°
Operate time[1)2)]	Typically 53 ms

1) f_n = 50 Hz, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 115. Voltage vector shift protection (VVSPPAM) main settings

Parameter	Function	Value (Range)	Step
Start value	VVSPPAM	2.0...30.0°	0.1
Over Volt Blk value	VVSPPAM	0.40...1.50 × Un	0.01
Under Volt Blk value	VVSPPAM	0.15...1.00 × Un	0.01
Phase supervision	VVSPPAM	7 = Ph A + B + C 8 = Pos sequence	-

Table 116. Directional reactive power undervoltage protection (DQPTUV)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current and voltage: f_n ±2 Hz Reactive power range |PF| <0.71
	Power: ±3.0% or ±0.002 × Q_n Voltage: ±1.5% of the set value or ±0.002 × U_n
Start time[1)2)]	Typically 46 ms
Reset time	<50 ms
Reset ratio	Typically 0.96
Operate time accuracy	±1.0% of the set value or ±20 ms
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,…

1) *Start value* = 0.05 × S_n, reactive power before fault = 0.8 × *Start value*, reactive power overshoot 2 times, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 117. Directional reactive power undervoltage protection (DQPTUV) main settings

Parameter	Function	Value (Range)	Step
Voltage start value	DQPTUV	0.20...1.20 × U_n	0.01
Operate delay time	DQPTUV	100...300000 ms	10
Min reactive power	DQPTUV	0.01...0.50 × S_n	0.01
Min Ps Seq current	DQPTUV	0.02...0.20 × I_n	0.01
Pwr sector reduction	DQPTUV	0...10°	1

Table 118. Reverse power/directional overpower protection (DOPPDPR)

Characteristic	Value
Operation accuracy 1)	Depending on the frequency of the measured current and voltage: $f = f_n$ ±2 Hz
	Power measurement accuracy ±3% of the set value or ±0.002 × S_n Phase angle: ±2°
Start time2)3)	Typically 45 ms
Reset time	Typically 30 ms
Reset ratio	Typically 0.94
Operate time accuracy	±1.0% of the set value of ±20 ms
Suppression of harmonics	-50 dB at f = n × f_n, where n = 2, 3, 4, 5,…

1) *Measurement mode* = “Pos Seq” (default)
2) $U = U_n$, f_n = 50 Hz, results based on statistical distribution of 1000 measurements
3) Includes the delay of the signal output contact

Table 119. Reverse power/directional overpower protection (DOPPDPR) main settings

Parameter	Function	Value (Range)	Step
Start value	DOPPDPR	0.01...2.00 × S_n	0.01
Operate delay time	DOPPDPR	40...300000 ms	10
Directional mode	DOPPDPR	2 = Forward 3 = Reverse	-
Power angle	DOPPDPR	-90...90°	1

Table 120. Underpower protection (DUPPDPR)

Characteristic	Value
Operation accuracy 1)	Depending on the frequency of the measured current and voltage: f_n ±2 Hz
	Power measurement accuracy ±3% of the set value or ±0.002 × S_n Phase angle: ±2°
Start time2)3)	Typically 45 ms
Reset time	Typically 30 ms
Reset ratio	Typically 1.04
Operate time accuracy	±1.0% of the set value of ±20 ms
Suppression of harmonics	-50 dB at f = n × f_n, where n = 2, 3, 4, 5,…

1) *Measurement mode* = “Pos Seq” (default)
2) $U = U_n$, f_n = 50 Hz, results based on statistical distribution of 1000 measurements
3) Includes the delay of the signal output contact

Table 121. Underpower protection (DUPPDPR) main settings

Parameter	Function	Value (Range)	Step
Start value	DUPPDPR	0.01...2.00 × S_n	0.01
Operate delay time	DUPPDPR	40...300000 ms	10
Pol reversal	DUPPDPR	0 = False 1 = True	-
Disable time	DUPPDPR	0...60000 ms	1000

Table 122. Three-phase underimpedance protection (UZPDIS)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current and voltage: f_n ±2 Hz
	±3.0% of the set value or ±0.2 %Zb
Start time[1)2)]	Typically 50 ms
Reset time	Typically 40 ms
Reset ratio	Typically 1.04
Retardation time	<40 ms
Operate time accuracy	±1.0% of the set value or ±20 ms

1) f_n = 50 Hz, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 123. Three-phase underimpedance protection (UZPDIS) main settings

Parameter	Function	Value (Range)	Step
Polar reach	UZPDIS	1...6000 %Z_n	1
Operate delay time	UZPDIS	40...200000 ms	10

Table 124. Three-phase underexcitation protection (UEXPDIS)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current and voltage: $f = f_n \pm 2$ Hz
	±3.0% of the set value or ±0.2% Zb
Start time[1)2)]	Typically 45 ms
Reset time	Typically 30 ms
Reset ratio	Typically 1.04
Retardation time	Total retardation time when the impedance returns from the operating circle <40 ms
Operate time accuracy	±1.0% of the set value or ±20 ms
Suppression of harmonics	-50 dB at $f = n \times f_n$, where n = 2, 3, 4, 5,…

1) f_n= 50Hz, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 125. Three-phase underexcitation protection (UEXPDIS) main settings

Parameter	Function	Value (Range)	Step
Diameter	UEXPDIS	1...6000 %Z_n	1
Offset	UEXPDIS	-1000...1000 %Z_n	1
Displacement	UEXPDIS	-1000...1000 %Z_n	1
Operate delay time	UEXPDIS	60...200000 ms	10
External Los Det Ena	UEXPDIS	0 = Disable 1 = Enable	-

Table 126. Third harmonic-based stator earth-fault protection (H3EFPSEF)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured voltage: f_n ±2 Hz
	±5% of the set value or ±0.004 × U_n
Start time[1)2)]	Typically 35 ms
Reset time	Typically 35 ms
Reset ratio	Typically 0.96 (differential mode) Typically 1.04 (undervoltage mode)
Operate time accuracy	±1.0% of the set value of ±20 ms

1) f_n = 50 Hz, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 127. Third harmonic-based stator earth-fault protection (H3EFPSEF) main settings

Parameter	Function	Value (Range)	Step
Beta	H3EFPSEF	0.50...10.00	0.01
Voltage N 3.H Lim	H3EFPSEF	0.005...0.200 × U_n	0.001
Operate delay time	H3EFPSEF	20...300000 ms	10
Voltage selection	H3EFPSEF	1 = No voltage 2 = Uo 4 = Phase A 5 = Phase B 6 = Phase C	-
CB open factor	H3EFPSEF	1.00...10.00	0.01

Table 128. Rotor earth-fault protection, injection method (MREFPTOC)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the current measured: f_n ±2 Hz		
		±1.5% of the set value or ±0.002 × I_n		
Start time[1)2)]		Minimum	Typical	Maximum
	I_{Fault} = 1.2 × set *Start value*	30 ms	34 ms	38 ms
Reset time		<50 ms		
Reset ratio		Typically 0.96		
Retardation time		<50 ms		
Operate time accuracy		±1.0% of the set value of ±20 ms		
Suppression of harmonics		-50 dB at f = n × f_n, where n = 2, 3, 4, 5,…		

1) Current before fault = 0.0 × I_n, f_n = 50 Hz, earth-fault current with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 129. Rotor earth-fault protection, injection method (MREFPTOC) main settings

Parameter	Function	Value (Range)	Step
Operate start value	MREFPTOC	0.010...2.000 × I_n	0.001
Alarm start value	MREFPTOC	0.010...2.000 × I_n	0.001
Operate delay time	MREFPTOC	40...20000 ms	1
Alarm delay time	MREFPTOC	40...200000 ms	1

Table 130. High-impedance or flux-balance based differential protection (MHZPDIF)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured current: f_n ±2 Hz		
		±1.5% of the set value or 0.002 × I_n		
Start time [1)2)]		Minimum	Typical	Maximum
	I_{Fault} = 2.0 × set *Start Value* (one phase fault)	13 ms	17 ms	21 ms
	I_{Fault} = 2.0 × set *Start Value* (three phases fault)	11 ms	14 ms	17 ms
Reset time		<40 ms		
Reset ratio		Typically 0.96		
Retardation time		<35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value of ±20 ms		

1) *Measurement mode* = "Peak-to-Peak", current before fault = 0.0 × I_n, f_n = 50 Hz, fault current with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 131. High-impedance or flux-balance based differential protection (MHZPDIF) main settings

Parameter	Function	Value (Range)	Step
Operate value	MHZPDIF	0.5...50.0 %I_n	0.1
Minimum operate time	MHZPDIF	20...300000 ms	10

Table 132. Out-of-step protection OOSRPSB

Characteristic	Value
Impedance reach	Depending on the frequency of the measured current and voltage: f_n ±2 Hz
	±3.0% of the reach value or ±0.2% of $U_n/(\sqrt{3} \cdot I_n)$
Reset time	±1.0% of the set value or ±40 ms
Operate time accuracy	±1.0% of the set value or ±20 ms
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5...

Table 133. Out-of-step protection (OOSRPSB) main settings

Parameter	Function	Value (Range)	Step
Oos operate mode	OOSRPSB	1 = Way in 2 = Way out 3 = Adaptive	-
Forward reach	OOSRPSB	0.00...6000.00 Ω	0.01
Reverse reach	OOSRPSB	0.00...6000.00 Ω	0.01
Inner blinder R	OOSRPSB	1.00...6000.00 Ω	0.01
Outer blinder R	OOSRPSB	1.01...10000.00 Ω	0.01
Impedance angle	OOSRPSB	10.0...90.0°	0.1
Swing time	OOSRPSB	20...300000 ms	10
Zone 1 reach	OOSRPSB	1...100%	1
Operate delay time	OOSRPSB	20...60000 ms	10

Table 134. Negative-sequence overcurrent protection for machines (MNSPTOC)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured current: f_n		
		±1.5% of the set value or ±0.002 x I_n		
Start time[1)2)]		Minimum	Typical	Maximum
	I_{Fault} = 2.0 × set *Start value*	23	25 ms	28 ms
Reset time		Typically 40 ms		
Reset ratio		Typically 0.96		
Retardation time		<35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms[3)]		
Suppression of harmonics		DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,…		

1) Negative-sequence current before = 0.0, f_n = 50 Hz, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) *Start value* multiples in range of 1.10...5.00

Table 135. Negative-sequence overcurrent protection for machines (MNSPTOC) main settings

Parameter	Function	Value (Range)	Step
Start value	MNSPTOC	0.01...0.50 × I_n	0.01
Operating curve type	MNSPTOC	Definite or inverse time Curve type: 5, 15, 17, 18	
Operate delay time	MNSPTOC	100...120000 ms	10
Operation	MNSPTOC	1 = on 5 = off	-
Cooling time	MNSPTOC	5...7200 s	1

Table 136. Loss of phase, undercurrent (PHPTUC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the current measured: f_n ±2 Hz
	±1.5% of the set value or ±0.002 × I_n
Start time	Typically <55 ms
Reset time	<40 ms
Reset ratio	Typically 1.04
Retardation time	<35 ms
Operate time accuracy in definite time mode	mode ±1.0% of the set value or ±20 ms

Table 137. Loss of phase, undercurrent (PHPTUC) main settings

Parameter	Function	Value (Range)	Step
Current block value	PHPTUC	0.00...0.50 × I_n	0.01
Start value	PHPTUC	0.01...1.00 × I_n	0.01
Operate delay time	PHPTUC	50...200000 ms	10

Table 138. Loss of load supervision (LOFLPTUC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: f_n ±2 Hz
	±1.5% of the set value or ±0.002 × I_n
Start time	Typically 300 ms
Reset time	Typically 40 ms
Reset ratio	Typically 1.04
Retardation time	<35 ms
Operate time accuracy in definite time mode	±1.0% of the set value or ±20 ms

Table 139. Loss of load supervision (LOFLPTUC) main settings

Parameter	Function	Value (Range)	Step
Start value low	LOFLPTUC	0.01...0.50 × I_n	0.01
Start value high	LOFLPTUC	0.01...1.00 × I_n	0.01
Operate delay time	LOFLPTUC	400...600000 ms	10
Operation	LOFLPTUC	1 = on 5 = off	-

Table 140. Motor load jam protection (JAMPTOC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: f_n ±2 Hz
	±1.5% of the set value or ±0.002 × I_n
Reset time	Typically 40 ms
Reset ratio	Typically 0.96
Retardation time	<35 ms
Operate time accuracy in definite time mode	±1.0% of the set value or ±20 ms

Table 141. Motor load jam protection (JAMPTOC) main settings

Parameter	Function	Value (Range)	Step
Operation	JAMPTOC	1 = on 5 = off	-
Start value	JAMPTOC	0.10...10.00 × I_n	0.01
Operate delay time	JAMPTOC	100...120000 ms	10

Table 142. Motor start-up supervision (STTPMSU)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured current: f_n ±2 Hz		
		±1.5% of the set value or ±0.002 × I_n		
Start time[1)2)]		Minimum	Typical	Maximum
	I_{Fault} = 1.1 × set *Start detection A*	27 ms	30 ms	34 ms
Operate time accuracy		±1.0% of the set value or ±20 ms		
Reset ratio		Typically 0.90		

1) Current before = 0.0 × I_n, f_n = 50 Hz, overcurrent in one phase, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 143. Motor start-up supervision (STTPMSU) main settings

Parameter	Function	Value (Range)	Step
Motor start-up A	STTPMSU	1.0...10.0 × I_n	0.1
Motor start-up time	STTPMSU	1...80 s	1
Lock rotor time	STTPMSU	2...120 s	1
Operation	STTPMSU	1 = on 5 = off	-
Operation mode	STTPMSU	1 = IIt 2 = IIt, CB 3 = IIt + stall 4 = IIt + stall, CB	-
Restart inhibit time	STTPMSU	0...250 min	1

Table 144. MSCPMRI Group settings (Basic)

Parameter	Function	Value (Range)	Step
Warm start level	MSCPMRI	20.0...100.0%	0.1
Max Num cold start	MSCPMRI	1...10	1
Max Num warm start	MSCPMRI	1...10	1

Table 145. Phase reversal protection (PREVPTOC)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured current: f_n ±2 Hz		
		±1.5% of the set value or ±0.002 × I_n		
Start time[1)2)]		Minimum	Typical	Maximum
	I_{Fault} = 2.0 × set *Start value*	23 ms	25 ms	28 ms
Reset time		Typically 40 ms		
Reset ratio		Typically 0.96		
Retardation time		<35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Suppression of harmonics		DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,…		

1) Negative-sequence current before = 0.0, f_n = 50 Hz, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 146. Phase reversal protection (PREVPTOC) main settings

Parameter	Function	Value (Range)	Step
Start value	PREVPTOC	0.05...1.00 x I_n	0.01
Operate delay time	PREVPTOC	100...60000 ms	10
Operation	PREVPTOC	1 = on 5 = off	-

Table 147. Thermal overload protection for motors (MPTTR)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: f_n ±2 Hz
	Current measurement: ±1.5% of the set value or ±0.002 × I_n (at currents in the range of 0.01...4.00 × I_n)
Operate time accuracy[1)]	±2.0% of the theoretical value or ±0.50 s

1) Overload current > 1.2 × Operate level temperature

Table 148. Thermal overload protection for motors (MPTTR) main settings

Parameter	Function	Value (Range)	Step
Overload factor	MPTTR	1.00...1.20	0.01
Alarm thermal value	MPTTR	50.0...100.0%	0.1
Restart thermal Val	MPTTR	20.0...80.0%	0.1
Weighting factor p	MPTTR	20.0...100.0%	0.1
Time constant normal	MPTTR	80...4000 s	1
Time constant start	MPTTR	80...4000 s	1
Env temperature mode	MPTTR	1 = FLC Only 2 = Use input 3 = Set Amb Temp	-
Env temperature Set	MPTTR	-20.0...70.0°C	0.1
Operation	MPTTR	1 = on 5 = off	-

Table 149. Stabilized and instantaneous differential protection for machines (MPDIF)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured current: f_n ±2 Hz		
		±3.0% of the set value or ±0.002 x I_n		
Operate time [1)2)]		Minimum	Typical	Maximum
	Low stage	32 ms	35 ms	37 ms
	High stage	9 ms	13 ms	19 ms
Reset time		Typically 40 ms		
Reset ratio		Typically 0.95		
Retardation time		<20 ms		
Suppression of harmonics		DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5...		

1) F_n = 50 Hz, results based on statistical distribution of 1000 measurements
2) Measured with static power output (SPO)

Table 150. Stabilized and instantaneous differential protection for machines (MPDIF) main settings

Parameter	Function	Value (Range)	Step
Low operate value	MPDIF	5...30 %Ir	1
High operate value	MPDIF	100...1000 %Ir	10
Slope section 2	MPDIF	10...50%	1
End section 1	MPDIF	0...100 %Ir	1
End section 2	MPDIF	100...300 %Ir	1
DC restrain enable	MPDIF	0 = False 1 = True	-
CT connection type	MPDIF	1 = Type 1 2 = Type 2	-
CT ratio Cor Line	MPDIF	0.40...4.00	0.01
CT ratio Cor Neut	MPDIF	0.40...4.00	0.01

Table 151. Underpower factor protection (MPUPF)

Characteristic	Value
Operation accuracy	Dependent on the frequency of the current measured: f_n ±2 Hz
	±0.018 for power factor
Operate time accuracy	±(1.0% or 30 ms)
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5, 6, 7
Reset time	<40 ms

Table 152. Underpower factor protection (MPUPF) main settings

Parameter	Function	Value (Range)	Step
Min operate current	MPUPF	0.05...0.65 × I_n	0.01
Min operate voltage	MPUPF	0.05...0.50 × U_n	0.01
Disable time	MPUPF	0...60000 ms	1
Voltage reversal	MPUPF	0 = No 1 = Yes	-

Table 153. Stabilized and instantaneous differential protection for two- or three-winding transformers (TR3PTDF)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured current: f_n ±2 Hz		
		±3.0% of the set value or ±0.002 × I_n		
Start time [1)2)]		Minimum	Typical	Maximum
	Low stage High stage	30 ms 17 ms	35 ms 18 ms	40 ms 20 ms
Reset time		Typically 40 ms		
Reset ratio		Typically 0.96		
Suppression of harmonics		DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5...		

1) Current before fault = 0.0 × I_n, f_n = 50 Hz. Injected differential current = 2.0 × set operation value.
2) Measured with static power output (SPO)

Table 154. Stabilized and instantaneous differential protection for two- or three-winding transformers (TR3PTDF) main settings

Parameter	Function	Value (Range)	Step
High operate value	TR3PTDF	500...3000 %Ir	10
Low operate value	TR3PTDF	5...50 %Ir	1
Slope section 2	TR3PTDF	10...50%	1
End section 2	TR3PTDF	100...500 %Ir	1
Restraint mode	TR3PTDF	5 = Waveform 6 = 2.h + waveform 8 = 5.h + waveform 9 = 2.h + 5.h + wav	-
Start value 2.H	TR3PTDF	7...20%	1
Start value 5.H	TR3PTDF	10...50%	1
Stop value 5.H	TR3PTDF	10...50%	1
Slope section 3	TR3PTDF	10...100%	1
Current group 3 type	TR3PTDF	1 = Not in use 2 = Winding 3 3 = Wnd 1 restraint 4 = Wnd 2 restraint	-
Zro A elimination	TR3PTDF	1 = Not eliminated 2 = Winding 1 3 = Winding 2 4 = Winding 1 and 2 5 = Winding 3 6 = Winding 1 and 3 7 = Winding 2 and 3 8 = Winding 1, 2, 3	-
Phase shift Wnd 1-2	TR3PTDF	0.0...359.9°	0.1
Phase shift Wnd 1-3	TR3PTDF	0.0...359.9°	0.1

Table 155. Stabilized and instantaneous differential protection for two-winding transformers (TR2PTDF)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured current: f_n ±2 Hz		
		±3.0% of the set value or ±0.002 × I_n		
Operate time[1)2)]		Minimum	Typical	Maximum
	Low stage High stage	31 ms 15 ms	35 ms 17 ms	40 ms 20 ms
Reset time		<40 ms		
Reset ratio		Typically 0.96		
Suppression of harmonics		DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5, …		

1) Current before fault = 0.0 × I_n, f_n = 50 Hz. Injected differential current = 2.0 × set operation value
2) Measured with static power output. f_n = 50 Hz

Table 156. Stabilized and instantaneous differential protection for two-winding transformers (TR2PTDF) main settings

Parameter	Function	Value (Range)	Step
High operate value	TR2PTDF	500...3000 %I_r	10
Low operate value	TR2PTDF	5...50 %I_r	1
Slope section 2	TR2PTDF	10...50%	1
End section 2	TR2PTDF	100...500 %I_r	1
Restraint mode	TR2PTDF	5 = Waveform 6 = 2.h + waveform 8 = 5.h + waveform 9 = 2.h + 5.h + wav	-
Start value 2.H	TR2PTDF	7...20%	1
Start value 5.H	TR2PTDF	10...50%	1
Operation	TR2PTDF	1 = on 5 = off	-
Winding 1 type	TR2PTDF	1 = Y 2 = YN 3 = D 4 = Z 5 = ZN	-
Winding 2 type	TR2PTDF	1 = y 2 = yn 3 = d 4 = z 5 = zn	-
Zro A elimination	TR2PTDF	1 = Not eliminated 2 = Winding 1 3 = Winding 2 4 = Winding 1 and 2	-

Table 157. Numerical stabilized low-impedance restricted earth-fault protection (LREFPNDF)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured current: f_n ±2 Hz		
		±2.5% of the set value or ±0.002 x I_n		
Start time[1)2)]		Minimum	Typical	Maximum
	I_{Fault} = 2.0 × set *Operate value*	37 ms	41 ms	45 ms
Reset time		Typically 40 ms		
Reset ratio		Typically 0.96		
Retardation time		<35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Suppression of harmonics		DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5, …		

1) Current before fault = 0.0, f_n = 50 Hz, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 158. Numerical stabilized low-impedance restricted earth-fault protection (LREFPNDF) main settings

Parameter	Function	Value (Range)	Step
Operate value	LREFPNDF	5.0...50.0 %I_n	1
Minimum operate time	LREFPNDF	40...300000 ms	1
Restraint mode	LREFPNDF	1 = None 2 = Harmonic2	-
Start value 2.H	LREFPNDF	10...50%	1
Operation	LREFPNDF	1 = on 5 = off	-

Table 159. High-impedance based restricted earth-fault protection (HREFPDIF)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the measured current: f_n ±2 Hz		
		±1.5% of the set value or ±0.002 × I_n		
Start time[1)2)]		Minimum	Typical	Maximum
	I_{Fault} = 2.0 × set *Operate value* I_{Fault} = 10.0 × set *Operate value*	16 ms 11 ms	21 ms 13 ms	23 ms 14 ms
Reset time		Typically 40 ms		
Reset ratio		Typically 0.96		
Retardation time		<35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		

1) Current before fault = 0.0, f_n = 50 Hz, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 160. High-impedance based restricted earth-fault protection (HREFPDIF) main settings

Parameter	Function	Value (Range)	Step
Operate value	HREFPDIF	1.0...50.0 %I_n	0.1
Minimum operate time	HREFPDIF	40...300000 ms	1
Operation	HREFPDIF	1 = on 5 = off	-

Table 161. High-impedance differential protection (HIxPDIF)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the current measured: f_n ±2 Hz		
		±1.5% of the set value or ±0.002 × I_n		
Start time 1)2)		Minimum	Typical	Maximum
	I_{Fault} = 2.0 × set *Start value*	8 ms	11 ms	19 ms
	I_{Fault} = 10 × set *Start value*	7 ms	9 ms	11 ms
Reset time		Typically <40 ms		
Reset ratio		Typically 0.96		
Retardation time		<35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		

1) *Measurement mode* = default (depends on stage), current before fault = 0.0 × I_n, f_n = 50 Hz, fault current in one phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Measured with static signal output (SSO)

Table 162. High-impedance differential protection (HIxPDIF) main settings

Parameter	Function	Value (Range)	Step
Operate value	HIxPDIF	1.0...200.0 %I_n	1.0
Minimum operate time	HIxPDIF	20...300000 ms	10

Table 163. Circuit breaker failure protection (CCBRBRF)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: f_n ±2 Hz
	±1.5% of the set value or ±0.002 × I_n
Operate time accuracy	±1.0% of the set value or ±20 ms
Reset time	Typically 40 ms
Retardation time	<20 ms

Table 164. Circuit breaker failure protection (CCBRBRF) main settings

Parameter	Function	Value (Range)	Step
Current value	CCBRBRF	0.05...2.00 × I_n	0.01
Current value Res	CCBRBRF	0.05...2.00 × I_n	0.01
CB failure trip mode	CCBRBRF	1 = 2 out of 4 2 = 1 out of 3 3 = 1 out of 4	-
CB failure mode	CCBRBRF	1 = Current 2 = Breaker status 3 = Both (AND) -1 = Both (OR)	-
Retrip time	CCBRBRF	0...60000 ms	10
CB failure delay	CCBRBRF	0...60000 ms	10
CB fault delay	CCBRBRF	0...60000 ms	10

Table 165. Three-phase inrush detector (INRPHAR)

Characteristic	Value
Operation accuracy	At the frequency f = f_n
	Current measurement: ±1.5% of the set value or ±0.002 × I_n Ratio I2f/I1f measurement: ±5.0% of the set value
Reset time	+35 ms / -0 ms
Reset ratio	Typically 0.96
Operate time accuracy	+35 ms / -0 ms

Table 166. Three-phase inrush detector (INRPHAR) main settings

Parameter	Function	Value (Range)	Step
Start value	INRPHAR	5...100%	1
Operate delay time	INRPHAR	20...60000 ms	1

Table 167. Arc protection (ARCSARC)

Characteristic		Value		
Operation accuracy		±3.0% of the set value or ±0.01 × I_n		
Operate time TC		Minimum	Typical	Maximum
	Operation mode = "Light +current"1)	9 ms2) 3 ms3)	10 ms2) 5 ms3)	13 ms2) 6 ms3)
	Operation mode = "Light only"2)	8 ms2) 3 ms3)	10 ms2) 5 ms3)	13 ms2) 6 ms3)
Reset time		Typically 50 ms		
Reset ratio		Typically 0.96		

1) *Phase start value* = 1.0 × I_n, current before fault = 2.0 × set *Phase start value*, f_n = 50 Hz, fault with nominal frequency, results based on statistical distribution of 200 measurements
2) Includes the delay of the power output (PO) contact
3) Measured with static power output (SPO)

Table 168. Arc protection (ARCSARC) main settings

Parameter	Function	Value (Range)	Step
Phase start value	ARCSARC	0.50...40.00 × I_n	0.01
Ground start value	ARCSARC	0.05...8.00 × I_n	0.01
Operation mode	ARCSARC	1 = Light+current 2 = Light only 3 = BI controlled	-

Table 169. High-impedance fault detection (PHIZ) main settings

Parameter	Function	Value (Range)	Step
Security Level	PHIZ	1...10	1
System type	PHIZ	1 = Grounded 2 = Ungrounded	-

Table 170. Fault locator (SCEFRFLO)

Characteristic	Value
Measurement accuracy	At the frequency $f = f_n$ Impedance: ±2.5% or ±0.05 Ω Distance: ±2.0% or ±0.04 km/0.025 mile XC0F_CALC: ±3% or ±0.01 Zn/1.15 Ω IFLT_PER_ILD: ±5% or ±0.05

Table 171. Fault locator (SCEFRFLO) main settings

Parameter	Function	Value (Range)	Step
Z Max phase load	SCEFRFLO	1.0...10000.0 Ω	0.1
Ph leakage Ris	SCEFRFLO	20...1000000 Ω	1
Ph capacitive React	SCEFRFLO	10...1000000 Ω	1
R1 line section A	SCEFRFLO	0.000...1000.000 Ω/pu	0.001
X1 line section A	SCEFRFLO	0.000...1000.000 Ω/pu	0.001
R0 line section A	SCEFRFLO	0.000...1000.000 Ω/pu	0.001
X0 line section A	SCEFRFLO	0.000...1000.000 Ω/pu	0.001
Line Len section A	SCEFRFLO	0.000...1000.000 pu	0.001

Table 172. Load-shedding and restoration (LSHDPFRQ)

Characteristic		Value
Operation accuracy	f<	±5 mHz
	df/dt	±100 mHz/s (in range |df/dt| < 5 Hz/s) ± 2.0% of the set value (in range 5 Hz/s < |df/dt| < 15 Hz/s)
Start time	f<	<80 ms
	df/dt	<120 ms
Reset time		<150 ms
Operate time accuracy		±1.0% of the set value or ±30 ms

Table 173. Load-shedding and restoration (LSHDPFRQ) main settings

Parameter	Function	Value (Range)	Step
Load shed mode	LSHDPFRQ	1 = Freq< 6 = Freq< OR df/dt 8 = Freq< AND df/dt	-
Restore mode	LSHDPFRQ	1 = Disabled 2 = Auto 3 = Manual	-
Start value Freq	LSHDPFRQ	0.800...1.200 × f_n	0.001
Start value df/dt	LSHDPFRQ	-0.2000...0.0050 × f_n/s	0.0001
Operate Tm Freq	LSHDPFRQ	80...200000 ms	10
Operate Tm df/dt	LSHDPFRQ	120...200000 ms	10
Restore start Val	LSHDPFRQ	0.800...1.200 × f_n	0.001
Restore delay time	LSHDPFRQ	80...200000 ms	10

Table 174. Multipurpose protection (MAPGAPC)

Characteristic	Value
Operation accuracy	±1.0% of the set value or ±20 ms

Table 175. Multipurpose protection (MAPGAPC) main settings

Parameter	Function	Value (Range)	Step
Start value	MAPGAPC	-10000.0...10000.0	0.1
Operate delay time	MAPGAPC	0...200000 ms	100
Operation mode	MAPGAPC	1 = Over 2 = Under	-

Table 176. Operation characteristics

Parameter	Value (Range)
Operating curve type	1 = ANSI Ext. inv. 2 = ANSI Very. inv. 3 = ANSI Norm. inv. 4 = ANSI Mod inv. 5 = ANSI Def. Time 6 = L.T.E. inv. 7 = L.T.V. inv. 8 = L.T. inv. 9 = IEC Norm. inv. 10 = IEC Very inv. 11 = IEC inv. 12 = IEC Ext. inv. 13 = IEC S.T. inv. 14 = IEC L.T. inv 15 = IEC Def. Time 17 = Programmable 18 = RI type 19 = RD type 20 = UK rectifier
Operating curve type (voltage protection)	5 = ANSI Def. Time 15 = IEC Def. Time 17 = Inv. Curve A 18 = Inv. Curve B 19 = Inv. Curve C 20 = Programmable 21 = Inv. Curve A 22 = Inv. Curve B 23 = Programmable

Control functions

Table 177. Emergency start-up (ESMGAPC)

Characteristic	Value
Operation accuracy	At the frequency $f = f_n$
	±1.5% of the set value or ±0.002 × U_n

Table 178. Emergency start-up (ESMGAPC) main settings

Parameter	Function	Value (Range)	Step
Motor standstill A	ESMGAPC	0.05...0.20 × I_n	0.01
Operation	ESMGAPC	1 = on 5 = off	-

Table 179. Autoreclosing (DARREC)

Characteristic	Value
Operate time accuracy	±1.0% of the set value or ±20 ms

Table 180. Autosynchronizer for generator breaker (ASGCSYN)

Characteristic	Value
Measurement accuracy	Depending on the frequency of the voltage measured: f_n ±2 Hz
	Voltage difference: ±1.0% or ±0.004 × U_n Frequency difference: ±10 mHz Phase angle difference: ±1°
Operation accuracy	MATCH_OK for voltage: ±0.001 × U_n MATCH_OK for frequency: ±10 mHz
Operation time accuracy	Raise/Lower output pulse width: ±1.0% of the set value or ±20 ms *Energizing time* for dead-bus closing: ±1.0% of the set value or ±35 ms *Minimum Syn time* for SYNC_OK: ±1.0% of the set value or ±60 ms
Reset time	Typically 20 ms
Closing angle accuracy	±1°

Table 181. Autosynchronizer for generator breaker (ASGCSYN) main settings

Parameter	Function	Value (Range)	Step
Live dead mode	ASGCSYN	-1 = Off -2 = Command 1 = Both Dead 4 = Dead B, G Any 2 = Live G, Dead B	-
Angle Diff positive	ASGCSYN	5...90°	1
Angle Diff negative	ASGCSYN	5...90°	1
Phase shift	ASGCSYN	-180...180°	1
Closing time of CB	ASGCSYN	40...250 ms	1
Synchronization Dir	ASGCSYN	1 = Always over synchronous 2 = Both direction	-
Synchrocheck mode	ASGCSYN	1 = Off 3 = Asynchronous 4 = Command	-
Dead voltage value	ASGCSYN	0.10...0.80 × U_n	0.10
Live voltage value	ASGCSYN	0.20...1.00 × U_n	0.10
Voltage match mode	ASGCSYN	1 = Off 2 = Variable Pulse 3 = Variable Interval	-
Frequency match mode	ASGCSYN	1 = Off 2 = Variable Pulse 3 = Variable Interval	-

Table 182. Autosynchronizer for network breaker (ASNSCSYN)

Characteristic	Value
Measurement accuracy	Depending on the frequency of the voltage measured: f_n ±2 Hz
	Voltage difference: ±1.0% or ±0.004 × U_n Frequency difference: ±10 mHz Phase angle difference: ±1°
Operation accuracy	MATCH_OK for voltage: ±0.001 × U_n MATCH_OK for frequency: ±10 mHz
Operation time accuracy	*Energizing time* for dead-bus closing: ±1.0% of the set value or ±35 ms *Minimum Syn time* for SYNC_OK: ±1.0% of the set value or ±60 ms
Reset time	Typically 20 ms
Closing angle accuracy	±1°

Table 183. Autosynchronizer for network breaker (ASNSCSYN) main settings

Parameter	Function	Value (Range)	Step
Live dead mode	ASNSCSYN	-2 = Command -1 = Off 1 = Both Dead 2 = Live B, Dead A 3 = Dead B, Live A 4 = Dead A, B Any 5 = Dead B, A Any 6 = One Live, Dead 7 = Not Both Live	-
Diff voltage	ASNSCSYN	0.01...0.50 × U_n	0.01
Diff frequency	ASNSCSYN	0.001...0.060 × f_n	0.001
Diff angle	ASNSCSYN	5...90°	1
Synchrocheck mode	ASNSCSYN	1 = Off 2 = Synchronous 3 = Asynchronous 4 = Command	-
Dead bus voltage	ASNSCSYN	0.1...0.8 × U_n	0.1
Live bus voltage	ASNSCSYN	0.2...1.0 × U_n	0.1
Phase shift	ASNSCSYN	-180...180°	1
Closing time of CB	ASNSCSYN	40...250 ms	1

Table 184. Synchronism and energizing check (SECRSYN)

Characteristic	Value
Operation accuracy	Depending on the frequency of the voltage measured: f_n ±1 Hz
	Voltage: ±3.0% of the set value or ±0.01 × U_n Frequency: ±10 mHz Phase angle: ±3°
Reset time	<50 ms
Reset ratio	Typically 0.96
Operate time accuracy in definite time mode	±1.0% of the set value or ±20 ms

Table 185. Synchronism and energizing check (SECRSYN) main settings

Parameter	Function	Value (Range)	Step
Live dead mode	SECRSYN	-1 = Off 1 = Both Dead 2 = Live L, Dead B 3 = Dead L, Live B 4 = Dead Bus, L Any 5 = Dead L, Bus Any 6 = One Live, Dead 7 = Not Both Live	-
Difference voltage	SECRSYN	0.01...0.50 × U_n	0.01
Difference frequency	SECRSYN	0.0002...0.1000 × f_n	0.0001
Difference angle	SECRSYN	5...90°	1
Synchro check mode	SECRSYN	1 = Off 2 = Synchronous 3 = Asynchronous	-
Dead line value	SECRSYN	0.1...0.8 × U_n	0.1
Live line value	SECRSYN	0.2...1.0 × U_n	0.1
Max energizing V	SECRSYN	0.50...1.15 × U_n	0.01
Control mode	SECRSYN	1 = Continuous 2 = Command	-
Close pulse	SECRSYN	200...60000 ms	10
Phase shift	SECRSYN	-180...180°	1
Minimum Syn time	SECRSYN	0...60000 ms	10
Maximum Syn time	SECRSYN	100...6000000 ms	10
Energizing time	SECRSYN	100...60000 ms	10
Closing time of CB	SECRSYN	40...250 ms	10

Table 186. Tap changer control with voltage regulator (OL5ATCC)

Characteristic	Value
Operation accuracy[1]	Depending on the frequency of the measured current: f_n ±2 Hz
	Differential voltage U_d = ±0.5% of the measured value or ±0.005 × U_n (in measured voltages <2.0 × U_n) Operation value = ±1.5% of the U_d for Us = 1.0 × U_n
Operate time accuracy in definite time mode[2]	+4.0%/-0% of the set value
Operate time accuracy in inverse time mode[2]	+8.5%/-0% of the set value (at theoretical B in range of 1.1…5.0) Also note fixed minimum operate time (IDMT) 1 s
Reset ratio for control operation Reset ratio for analog based blockings (except run back raise voltage blocking)	Typically 0.80 (1.20) Typically 0.96 (1.04)

1) Default setting values used
2) Voltage before deviation = set *Band center voltage*

Table 187. Tap changer control with voltage regulator (OL5ATCC) main settings

Parameter	Function	Value (Range)	Step
LDC enable	OL5ATCC	0 = False 1 = True	-
Parallel mode	OL5ATCC	2 = Master 3 = Follower 5 = NRP 7 = MCC -1 = Input control -2 = Command	-
Band center voltage	OL5ATCC	0.000...2.000 × U_n	0.001
Line drop V Ris	OL5ATCC	0.0...25.0%	0.1
Line drop V React	OL5ATCC	0.0...25.0%	0.1
Band reduction	OL5ATCC	0.00...9.00 %U_n	0.01
Stability factor	OL5ATCC	0.0...70.0%	0.1
Rv Pwr flow allowed	OL5ATCC	0 = False 1 = True	-
Operation mode	OL5ATCC	1 = Manual 2 = Auto single 3 = Parallel manual 4 = Auto parallel 5 = Input control 6 = Command	-
Parallel trafos	OL5ATCC	0...10	1
Delay characteristic	OL5ATCC	0 = Inverse time 1 = Definite time	-
Band width voltage	OL5ATCC	1.20...18.00 %U_n	0.01
Load current limit	OL5ATCC	0.10...5.00 × I_n	0.01
Block lower voltage	OL5ATCC	0.10...1.20 × U_n	0.01
LTC pulse time	OL5ATCC	500...10000 ms	100

Table 188. Petersen coil controller (PASANCR)

Characteristic	Value
Measuring accuracy	Resistance: ±2% or ±1 Ω
Operation accuracy[1)]	I_RESONANCE: Typically ±2 A
	I_DAMPING: Typically ±2 A

1) Network resonance point voltage must be at least 0.01 × U_n, where U_n = nominal phase-to-earth voltage

Table 189. Petersen coil controller (PASANCR) main settings

Parameter	Function	Value (Range)	Step
Compensation mode	PASANCR	1 = Absolute 2 = Relative	-
Detuning level	PASANCR	-100...100 A	1
Detuning level Rl	PASANCR	-100.0...100.0%	0.1
Tuning delay	PASANCR	0...3600 s	1
V Res variation	PASANCR	0.1...100.0 %U_n	0.1
Tuning mode	PASANCR	1 = Coil movement 2 = Resistor switching	-
V Res EF level	PASANCR	0.00...100.00 %U_n	0.01
EF mode	PASANCR	1 = Blocked during EF 2 = Resonance 3 = Tuning during EF	-
Resistor healthy St	PASANCR	0 = Off 1 = On	-
Resistor repeats	PASANCR	0...100	1
Resistor pause	PASANCR	0...100000000 ms	1
Coil V Nom	PASANCR	0...400000 V	1
Fix coil V Nom	PASANCR	0...400000 V	1
Auxiliary Wnd V Nom	PASANCR	0...10000 V	1
Controller mode	PASANCR	0 = Manual 1 = Automatic	-
Parallel resistor	PASANCR	0 = False 1 = True	-
R0Transformer	PASANCR	0...100 Ω	1
X0Transformer	PASANCR	0...100 Ω	1
Voltage measurement	PASANCR	1 = Busbar 2 = Coil	-
Resistor control	PASANCR	1 = OFF 2 = ON 3 = Automatic	-
Resistor Nom value	PASANCR	0.00...100.00 Ω	0.01
Fix coil value	PASANCR	0...10000 A	1
Fix coil type	PASANCR	1 = OFF 2 = ON 3 = Automatic	-

Condition monitoring and supervision functions

Table 190. Circuit-breaker condition monitoring (SSCBR)

Characteristic	Value
Current measuring accuracy	±1.5% or ±0.002 × I_n (at currents in the range of 0.1…10 × I_n) ±5.0% (at currents in the range of 10…40 × I_n)
Operate time accuracy	±1.0% of the set value or ±20 ms
Travelling time measurement	+10 ms / -0 ms

Table 191. Hot-spot and insulation ageing rate monitoring for transformers (HSARSPTR)

Characteristic	Value
Warning/alarm time accuracy	±1.0% of the set value or ±0.50 s

Table 192. Hot-spot and insulation ageing rate monitoring for transformers (HSARSPTR) main settings

Parameter	Function	Value (Range)	Step
Cooling mode	HSARSPTR	1 = ONAN 2 = ONAF 3 = OFAF 4 = ODAF	-
Alarm level	HSARSPTR	50.0...350.0°C	0.1
Warning level	HSARSPTR	50.0...350.0°C	0.1
Alarm delay time	HSARSPTR	0...3600000 ms	10
Warning delay time	HSARSPTR	0...3600000 ms	10
Average ambient Tmp	HSARSPTR	-20.00...70.00°C	0.01
Alarm level Age Rte	HSARSPTR	0.00...100.00	1

Table 193. Current circuit supervision (CCSPVC)

Characteristic	Value
Operate time 1)	<30 ms

1) Including the delay of the output contact

Table 194. Current circuit supervision (CCSPVC) main settings

Parameter	Function	Value (Range)	Step
Start value	CCSPVC	0.05...0.20 × I_n	0.01
Max operate current	CCSPVC	1.00...5.00 × I_n	0.01

Table 195. Current circuit supervision for transformers (CTSRCTF)

Characteristic	Value
Operate time1)	<30 ms

1) Including the delay of the output contact

Table 196. Current circuit supervision for transformers (CTSRCTF) main settings

Parameter	Function	Value (Range)	Step
Min operate current	CTSRCTF	0.01...0.50 × I_n	0.01
Max operate current	CTSRCTF	1.00...5.00 × I_n	0.01
Max Ng Seq current	CTSRCTF	0.01...1.00 × I_n	0.01

Table 197. Current transformer supervision for high-impedance protection scheme (HZCCxSPVC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the current measured: f_n ±2 Hz
	±1.5% of the set value or ±0.002 × I_n
Reset time	<40 ms
Reset ratio	Typically 0.96
Retardation time	<35 ms
Operate time accuracy in definite time mode	±1.0% of the set value or ±20 ms

Table 198. Current transformer supervision for high-impedance protection scheme (HZCCxSPVC) main settings

Parameter	Function	Value (Range)	Step
Start value	HZCCxSPVC	1.0...100.0 %I_n	0.1
Alarm delay time	HZCCxSPVC	100...300000 ms	10
Alarm output mode	HZCCxSPVC	1 = Non-latched 3 = Lockout	-

Table 199. Fuse failure supervision (SEQSPVC)

Characteristic		Value	
Operate time[1)]	NPS function	U_{Fault} = 1.1 × set *Neg Seq voltage Lev*	<33 ms
		U_{Fault} = 5.0 × set *Neg Seq voltage Lev*	<18 ms
	Delta function	ΔU = 1.1 × set *Voltage change rate*	<30 ms
		ΔU = 2.0 × set *Voltage change rate*	<24 ms

1) Includes the delay of the signal output contact, f_n = 50 Hz, fault voltage with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements

Table 200. Runtime counter for machines and devices (MDSOPT)

Description	Value
Motor runtime measurement accuracy[1)]	±0.5%

1) Of the reading, for a stand-alone relay, without time synchronization

Table 201. Runtime counter for machines and devices (MDSOPT) main settings

Parameter	Function	Value (Range)	Step
Warning value	MDSOPT	0...299999 h	1
Alarm value	MDSOPT	0...299999 h	1
Initial value	MDSOPT	0...299999 h	1
Operating time hour	MDSOPT	0...23 h	1
Operating time mode	MDSOPT	1 = Immediate 2 = Timed Warn 3 = Timed Warn Alm	-

Table 202. Three-phase remanent undervoltage supervision (MSVPR)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured voltage:
	20 Hz < f ≤ 70 Hz: ±1.5% of the set value or ±0.002 × U_n 10 Hz < f ≤ 20 Hz: ±4.0% of the set value or ±0.002 × U_n
Reset time	Typically 40 ms
Reset ratio	Typically 1.04
Operate time accuracy in definite time mode	±1.0% of the set value or ±20 ms

Table 203. Three-phase remanent undervoltage supervision (MSVPR) main settings

Parameter	Function	Value (Range)	Step
Start value	MSVPR	0.05...1.20 × U_n	0.01
Operate delay time	MSVPR	100...300000 ms	100
Voltage selection	MSVPR	1 = phase-to-earth 2 = phase-to-phase	-
Num of phases	MSVPR	1 = 1 out of 3 2 = 2 out of 3 3 = 3 out of 3	-

Measurement functions

Table 204. Three-phase current measurement (CMMXU)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: f_n ±2 Hz
	±0.5% or ±0.002 × I_n (at currents in the range of 0.01...4.00 × I_n)
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,… RMS: No suppression

Table 205. Sequence current measurement (CSMSQI)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured current: f/f_n = ±2 Hz
	±1.0% or ±0.002 × I_n at currents in the range of 0.01...4.00 × I_n
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,…

Table 206. Residual current measurement (RESCMMXU)

Characteristic	Value
Operation accuracy	At the frequency f = f_n
	±0.5% or ±0.002 × I_n (at currents in the range of 0.01...4.00 × I_n)
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,… RMS: No suppression

Table 207. Three-phase voltage measurement (VMMXU)

Characteristic	Value
Operation accuracy	Depending on the frequency of the voltage measured: f_n ±2 Hz At voltages in range 0.01…1.15 × U_n
	±0.5% or ±0.002 × U_n
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,… RMS: No suppression

Table 208. Single-phase voltage measurement (VAMMXU)

Characteristic	Value
Operation accuracy	Depending on the frequency of the voltage measured: f_n ±2 Hz At voltages in range 0.01…1.15 × U_n
	±0.5% or ±0.002 × U_n
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,… RMS: No suppression

Table 209. Residual voltage measurement (RESVMMXU)

Characteristic	Value
Operation accuracy	Depending on the frequency of the measured voltage: f/f_n = ±2 Hz
	±0.5% or ±0.002 × U_n
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,… RMS: No suppression

Table 210. Sequence voltage measurement (VSMSQI)

Characteristic	Value
Operation accuracy	Depending on the frequency of the voltage measured: f_n ±2 Hz At voltages in range 0.01…1.15 × U_n
	±1.0% or ±0.002 × U_n
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,…

Table 211. Three-phase power and energy measurement (PEMMXU)

Characteristic	Value
Operation accuracy	At all three currents in range 0.10…1.20 × I_n At all three voltages in range 0.50…1.15 × U_n At the frequency f_n ±1 Hz
	±1.5% for apparent power S ±1.5% for active power P and active energy[1)] ±1.5% for reactive power Q and reactive energy[2)] ±0.015 for power factor
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,…

1) |PF| >0.5 which equals |cosφ| >0.5
2) |PF| <0.86 which equals |sinφ| >0.5

Table 212. Frequency measurement (FMMXU)

Characteristic	Value
Operation accuracy	±5 mHz (in measurement range 35...75 Hz)

Table 213. Tap changer position indication (TPOSYLTC)

Descrpition	Value
Response time for binary inputs	Typical 100 ms

Power quality functions

Table 214. Current total demand, harmonic distortion, DC component (TDD, THD, DC) and individual harmonics (CHMHAI)

Characteristic	Value
Operation accuracy1)	±3.0% or ±0.2

1) Nominal frequency 50 Hz. Harmonics in the range 0…0.21 × fundamental amplitude

Table 215. Current total demand, harmonic distortion, DC component (TDD, THD, DC) and individual harmonics (CHMHAI) main settings

Parameter	Function	Value (Range)	Step
Sliding interval	CHMHAI	1 = 3 seconds 2 = 1 minute 3 = 5 minutes	-
Reference Cur Sel	CHMHAI	0 = fundamental 2 = absolute	-
Demand current	CHMHAI	0.10...1.00 × I_n	0.01

Table 216. Voltage total harmonic distortion, DC component (THD, DC) and individual harmonics (VHMHAI)

Characteristic	Value
Operation accuracy1)	±3.0% or ±0.2

1) Nominal frequency 50 Hz. Harmonics in the range 0…0.21 × fundamental amplitude

Table 217. Voltage total harmonic distortion, DC component (THD, DC) and individual harmonics (VHMHAI) main settings

Parameter	Function	Value (Range)	Step
Sliding interval	VHMHAI	1 = 3 seconds 2 = 1 minute 3 = 5 minutes	-

Table 218. Voltage variation (PHQVVR)

Characteristic	Value
Operation accuracy	±1.5% of the set value or ±0.2% of reference voltage
Reset ratio	Typically 0.96 (Swell), 1.04 (Dip, Interruption)

Table 219. Voltage variation (PHQVVR) main settings

Parameter	Function	Value (Range)	Step
Voltage dip set 1	PHQVVR	10.0...100.0%	0.1
Voltage dip set 2	PHQVVR	10.0...100.0%	0.1
Voltage dip set 3	PHQVVR	10.0...100.0%	0.1
Voltage swell set 1	PHQVVR	100.0...140.0%	0.1
Voltage swell set 2	PHQVVR	100.0...140.0%	0.1
Voltage swell set 3	PHQVVR	100.0...140.0%	0.1
Voltage Int set	PHQVVR	0.0...100.0%	0.1
VVa Dur Max	PHQVVR	100...3600000 ms	100

Table 220. Voltage unbalance (VSQVUB)

Characteristic	Value
Operation accuracy	±1.5% of the set value or ±0.002 × U_n
Reset ratio	Typically 0.96

Table 221. Voltage unbalance (VSQVUB) main settings

Parameter	Function	Value (Range)	Step
Operation	VSQVUB	1 = on 5 = off	-
Unb detection method	VSQVUB	1 = Neg Seq 2 = Zero Seq 3 = Neg to Pos Seq 4 = Zero to Pos Seq 5 = Ph vectors Comp	-

Logging functions

Table 222. Disturbance recorder, common functionality (RDRE) main settings

Parameter	function	Value (Range)	Step
Record length	RDRE	10...500 cycles	1
Pre-trg length	RDRE	0...100%	1
Operation mode	RDRE	1 = Overwrite 2 = Saturation	-
Storage rate	RDRE	32, 16, 8 samples per fundamental cycle	-

Other functionality

Table 223. Pulse timer, eight channels (PTGAPC)

Characteristic	Value
Operate time accuracy	±1.0% of the set value or ±20 ms

Table 224. Time delay off, eight channels (TOFPAGC)

Characteristic	Value
Operate time accuracy	±1.0% of the set value or ±20 ms

Table 225. Time delay on, eight channels (TONGAPC)

Characteristic	Value
Operate time accuracy	±1.0% of the set value or ±20 ms

23. Mounting methods

With appropriate mounting accessories, the protection relay can be rack mounted, wall mounted, roof mounted or door mounted. The LHMI can be mounted either on a door or a surface, or in a tilted position (25°) using special accessories. It is also possible to rack mount or door mount the protection relay together with the LHMI.

Mounting options for the relay:

- Rack mounting
- Rack mounting with the LHMI
- Wall mounting
- Roof mounting
- Door mounting
- Door mounting with the LHMI

Mounting options for the LHMI:

- Rack mounting
- Door mounting
- Mounting in a 25° tilt

24. Selection and ordering data

Use ABB Library to access the selection and ordering information and to generate the order number.

Product Selection Tool (PST), a Next-Generation Order Number Tool, supports order code creation for ABB Distribution Automation IEC products with emphasis on, but not exclusively for, the Relion product family. PST is an easy-to-use, online tool always containing the latest product information. The complete order code can be created with detailed specification and the result can be printed and mailed. Registration is required.

25. Modification Sales

Modification Sales is a concept that provides modification support for already delivered relays. Under Modification Sales it is possible to modify both the hardware and software capabilities of the existing relay. The same options are available as when a new relay variant is configured and ordered from the factory: it is possible to add new hardware modules into empty slots, change the type of the existing modules within the slots or add software functions by adding application and, if necessary, add-on packages. If it is needed to use the possibilities provided by the Modification Sales concept, please contact your local ABB unit. The information that is requested by ABB is a) Relay serial number, b) Relay order code and c) The requested modification, separately stated for each relay.

Modification Sales is based on license handling within the relay. Modifying the relay without proper new license from ABB puts the relay in internal relay failure mode.

26. Accessories and ordering data

Table 226. Local HMI

Item	Order number
LHMI	2RCA033008A0001
LHMI, conformal coated	2RCA033008A0901
1 m connection cable for LHMI	1MRS120549-1
2 m connection cable for LHMI	1MRS120549-2
3 m connection cable for LHMI	1MRS120549-3
5 m connection cable for LHMI	1MRS120549-5

Table 227. Communication

Item	Order number
LC SFP plug-in connector for optical multimode media 100M	2RCA045621
LC SFP plug-in connector for optical single-mode media 100M, 20 km	2RCA045622
LC SFP plug-in connector for optical single-mode media 100M, 40 km	2RCA045623

Table 228. Mounting

Item	Order number
Back wall / side wall mounting kit	2RCA040872A0001
Roof mounting kit	2RCA040873A0001
Door mounting with LHMI	2RCA040882A0001
19" relay rack mounting with LHMI	2RCA041125A0001
19" relay rack mounting without LHMI	2RCA041127A0001
Surface mounting kit for LHMI	2RCA038783A0001
Tilt mounting kit for LHMI	2RCA038782A0001
Grounding bar kit for RTD module	2RCA039981A0001

Table 229. Arc sensors

Item	Order number
ARC lens sensor cable 1.5 m	2RCA040290A0001
ARC lens sensor cable 3 m	2RCA040290A0003
ARC lens sensor cable 5 m	2RCA040290A0005
ARC lens sensor cable 7.5 m	2RCA040290A0007
ARC lens sensor cable 15 m	2RCA040290A0015
ARC loop sensor cable 5 m	2RCA041050A0005
ARC loop sensor cable 10 m	2RCA041050A0010
ARC loop sensor cable 15 m	2RCA041050A0015
ARC loop sensor cable 20 m	2RCA041050A0020
ARC loop sensor cable 25 m	2RCA041050A0025
ARC loop sensor cable 30 m	2RCA041050A0030
ARC loop sensor cable 40 m	2RCA041050A0040
ARC loop sensor cable 50 m	2RCA041050A0050
ARC loop sensor cable 60 m	2RCA041050A0060

Table 230. Connectors

Item	Order number
Compression type signal connectors	SYJ-ZRK 2Z18P1
Ring lug type signal connectors	SYJ-ZRK 33X18
Push-in type signal connectors	SYJ-ZRK 53P18PM
1 CT-1 VT compression type connector	2RCA040474A0004
5 CT compression type connector	2RCA040474A0001
5 VT compression type connector	2RCA040474A0002
1 CT-4 VT compression type connector	2RCA040474A0003
1 CT-1 VT ring lug type connector	2RCA041297A0004
5 CT ring lug type connector	2RCA041297A0001
5 VT ring lug type connector	2RCA041297A0002
1 CT-4 VT ring lug type connector	2RCA041297A0003
RS-485/IRIG-B connector	SYJ-ZRK 44P10

27. Tools

The protection relay is delivered with the correct protection and control functionality included but it needs some engineering to fit in the needed application. The default parameter setting values can be changed from the LHMI, the Web browser-based user interface (Web HMI) or Protection and Control IED Manager PCM600 in combination with the relay-specific connectivity package.

PCM600 offers extensive relay configuration functions. For example, the setting parameters, relay application, graphical display and IEC 61850 communication, including horizontal GOOSE communication, can be modified with PCM600.

The REX640 relay's LHMI pages can be customized and shared between devices with a dedicated Display Editor which offers intuitive graphical drawing tools with editable symbols for single-line diagrams. In addition, it is possible to create personalized views for every supported application. The page access can be customized for every user to enable simple operational usage for all user levels.

When the Web HMI is used, the protection relay can be accessed from any of the relay's access points, including the Ethernet connection on the LHMI. For security reasons, the Web HMI is disabled by default, but it can be enabled via the LHMI. The Web HMI functionality can be limited to read-only access.

The relay connectivity package is a collection of software and specific relay information which enables system products and tools to connect and interact with the protection relay. The connectivity packages reduce the risk of errors in system integration, minimizing device configuration and setup times.

Further, the connectivity package for REX640 includes a flexible update tool for adding one additional LHMI language and new functionalities to the protection relay. The flexible modification support of the relay enables adding new protection functionalities whenever the protection and control needs are changing.

Table 231. Tools

Description	Version
PCM600	2.9 HF1 or later
Web browser	IE 11, Microsoft Edge, Google Chrome and Mozilla Firefox
REX640 connectivity package	1.0 or later

Table 232. Supported functions

Function	Web HMI	PCM600
Relay parameter setting	●	●
Saving of relay parameter settings in the relay	●	●
Signal monitoring	●	●
Disturbance recorder handling	●	●
Alarm LED viewing	●	●
Access control management	●	●
Relay signal configuration (Signal Matrix)	-	●
Modbus® communication configuration (communication management)	-	●
DNP3 communication configuration (communication management)	-	●
IEC 60870-5-103 communication configuration (communication management)	-	●
Saving of relay parameter settings in the tool	-	●
Disturbance record analysis	-	●
XRIO parameter export/import	●	●
Graphical display configuration	-	●
Application configuration	-	●
IEC 61850 communication configuration, GOOSE (communication configuration)	-	●
Phasor diagram viewing	●	-
Event viewing	●	●
Saving of event data on the user's PC	●	●
Online monitoring	-	●

● = Supported

28. Module diagrams

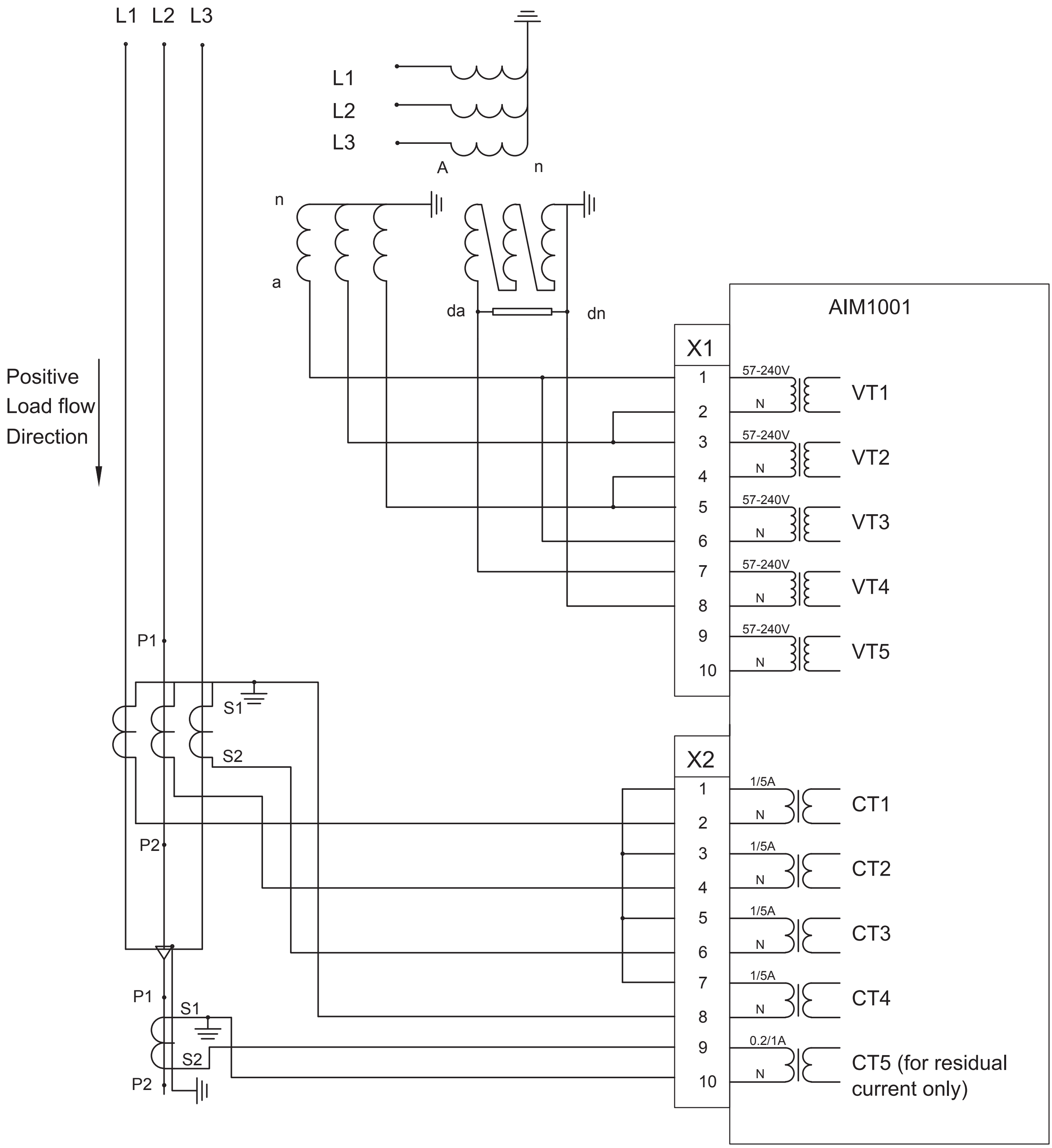

Figure 22. AIM1001 module

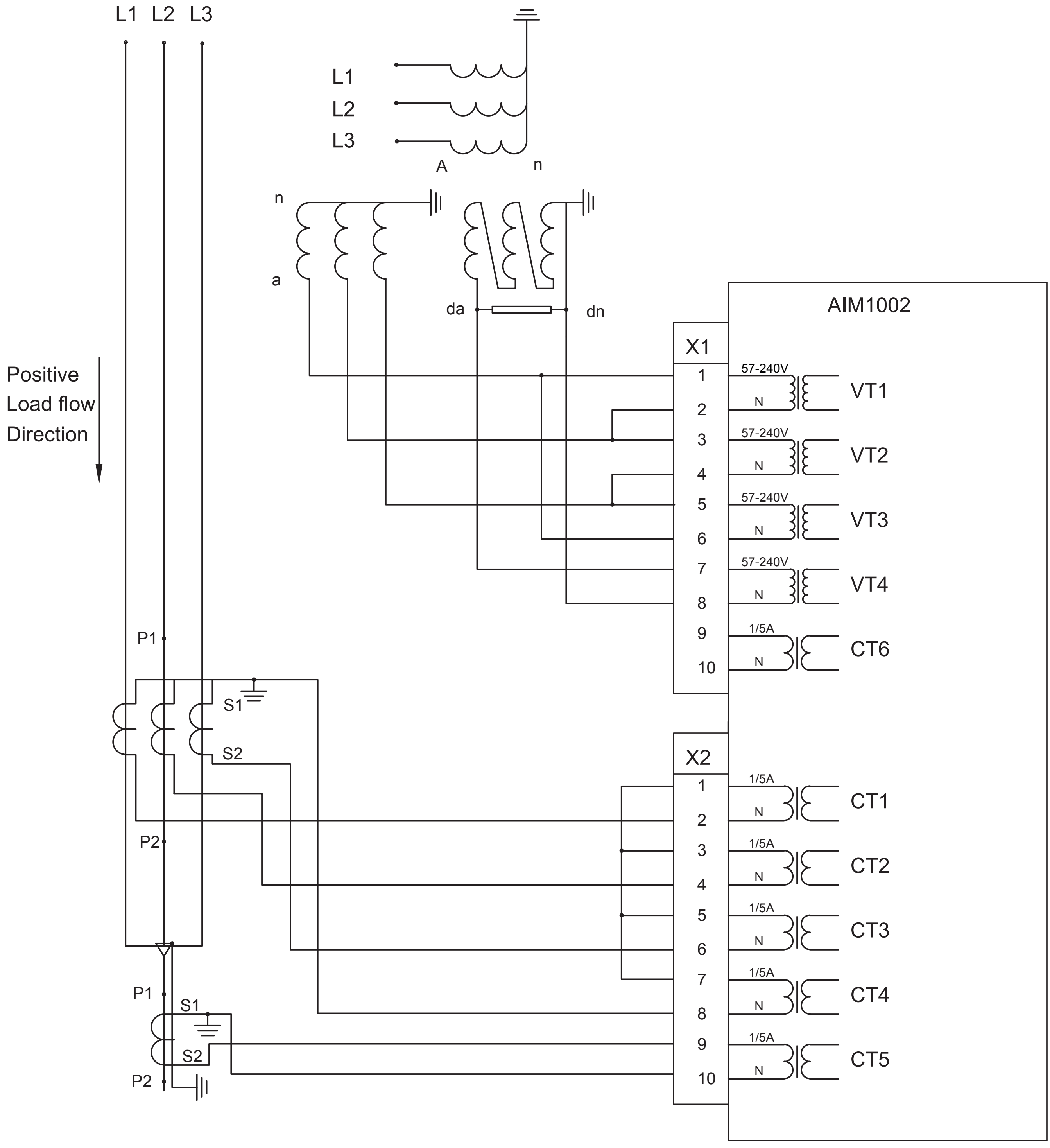

Figure 23. AIM1002 module

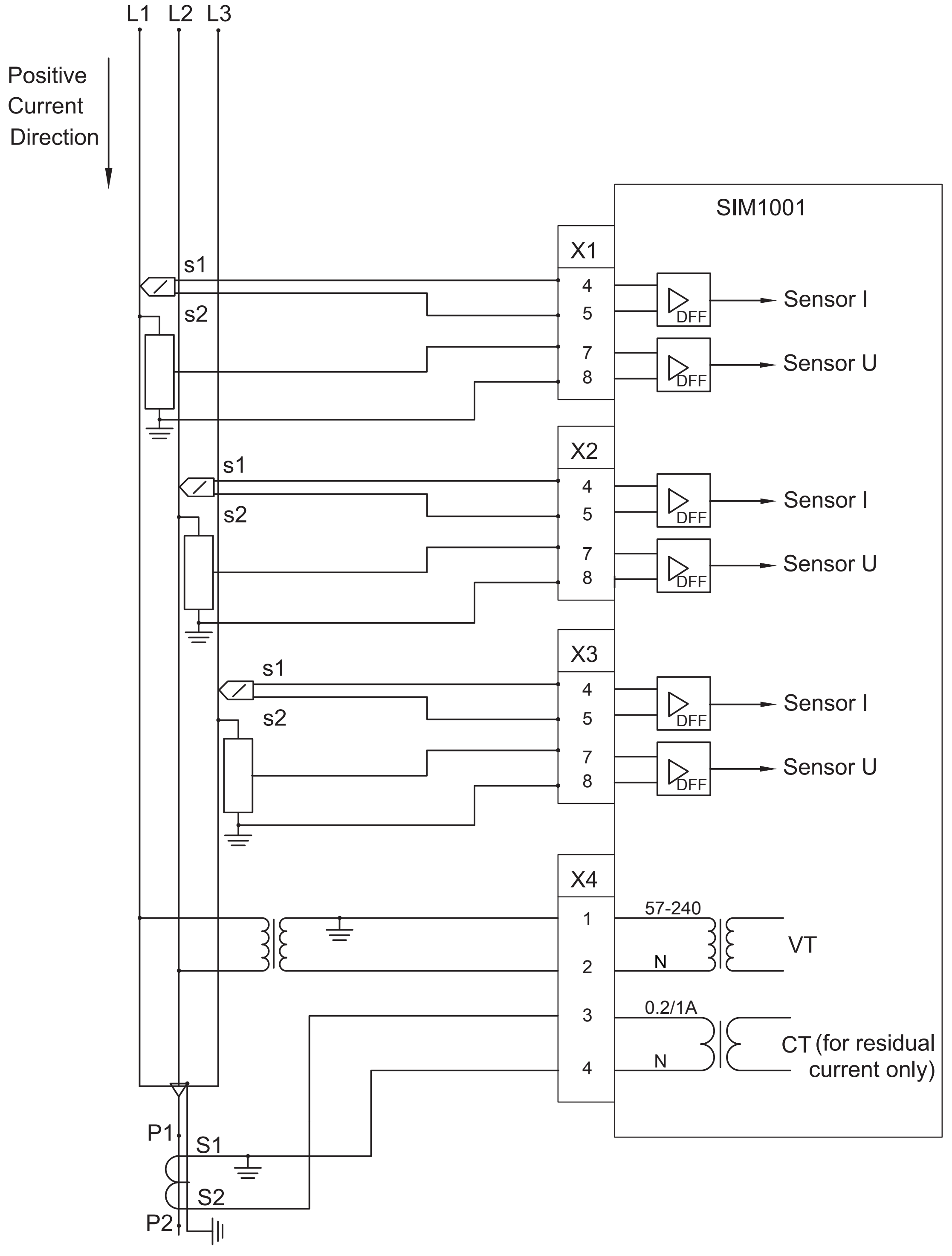

Figure 24. SIM1001 module

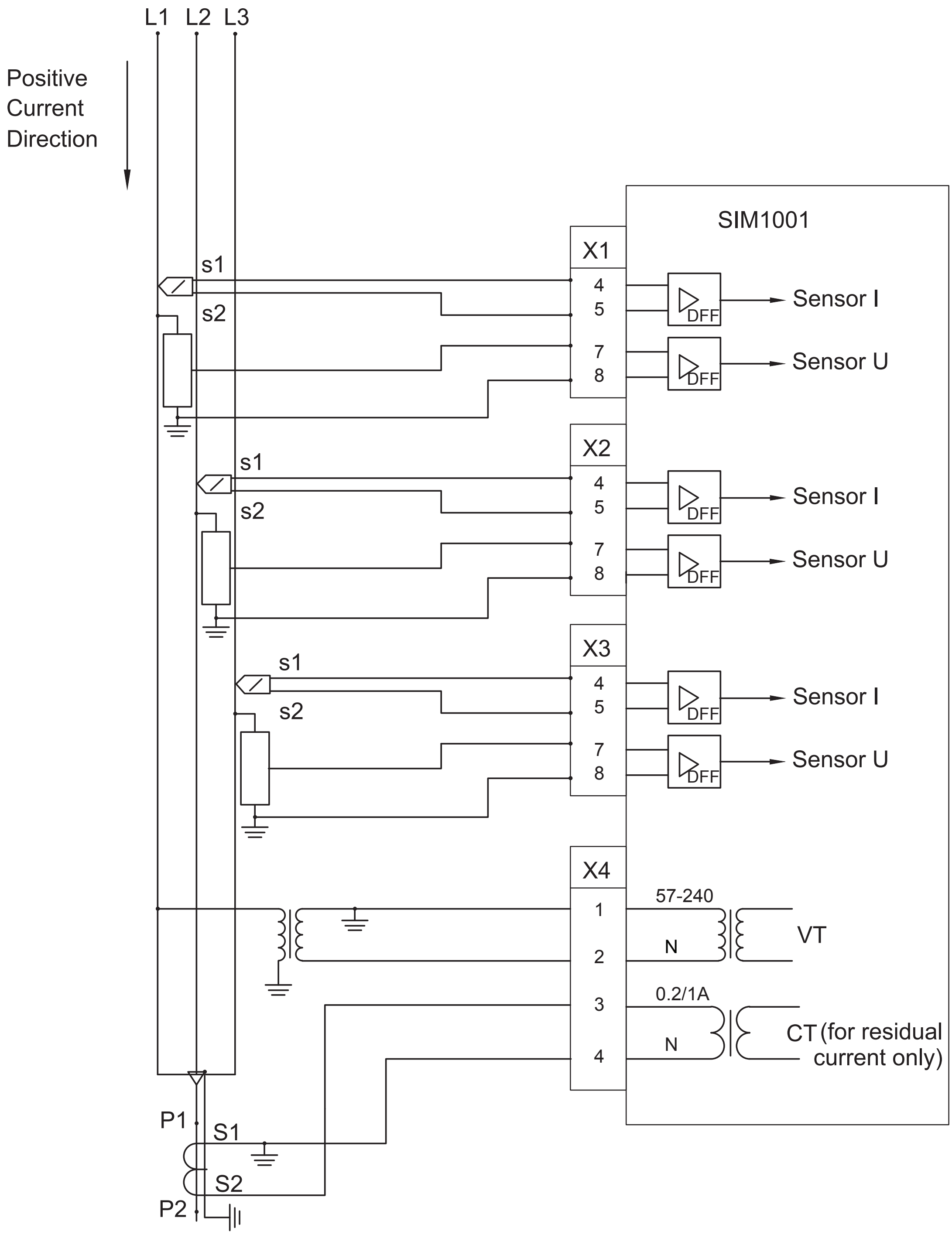

Figure 25. SIM1001 module

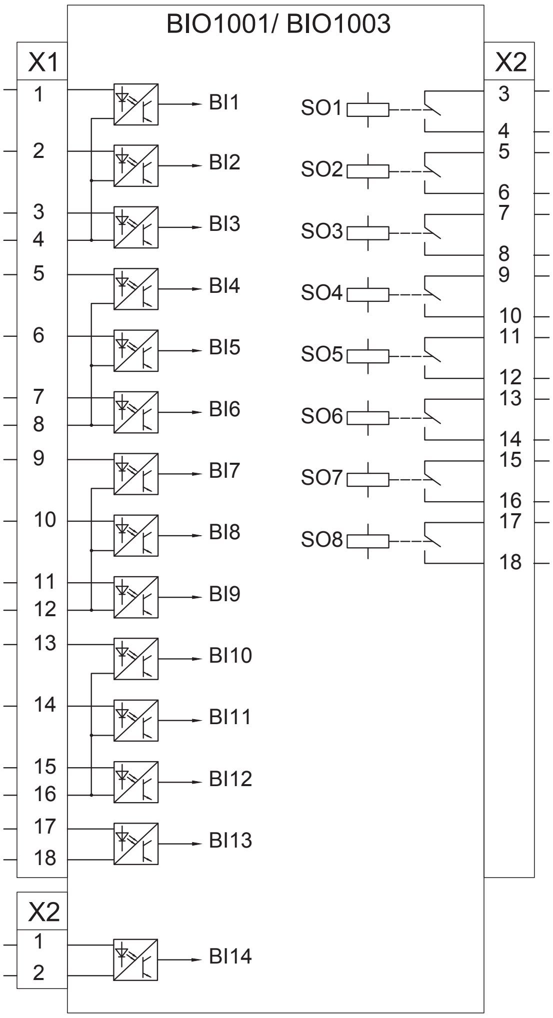

Figure 26. BIO1001/BIO1003 modules

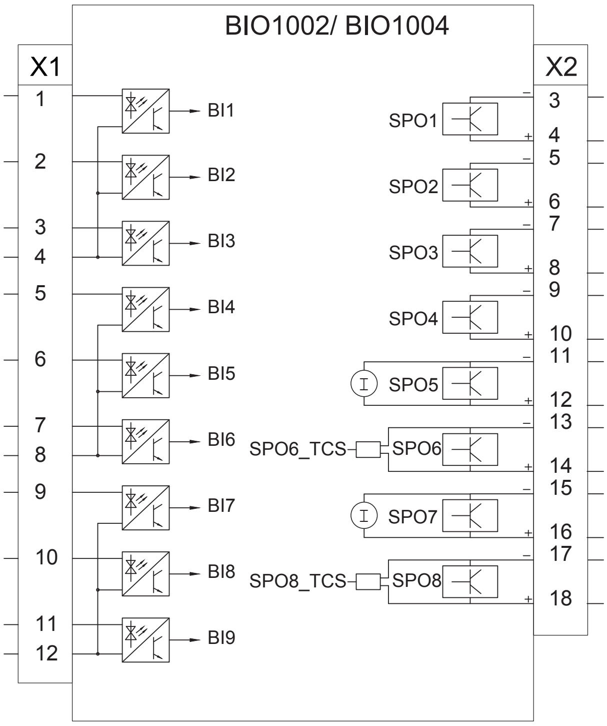

Figure 27. BIO1002/BIO1004 modules

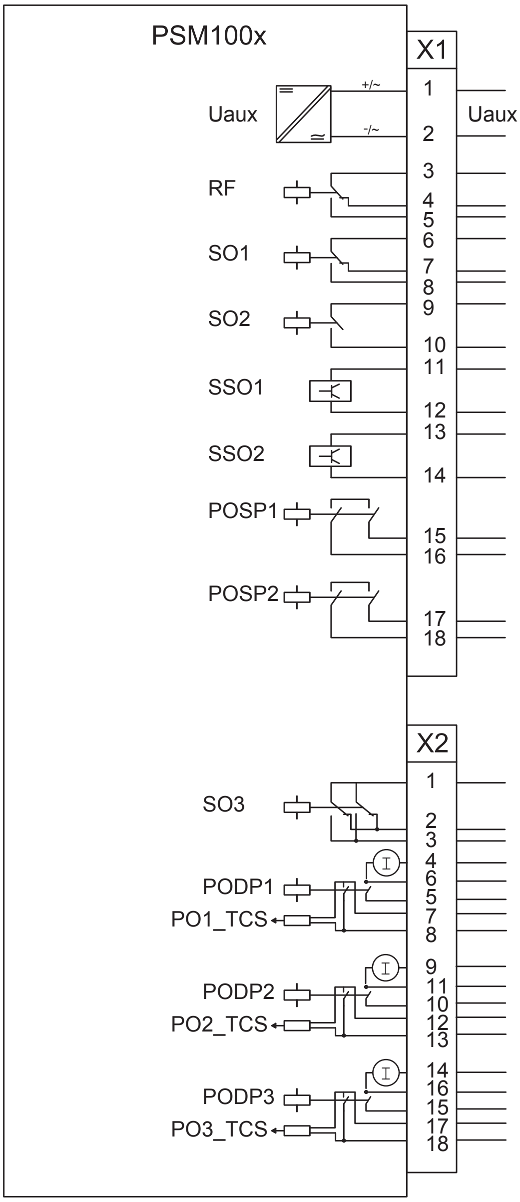

Figure 28. PSM100x module

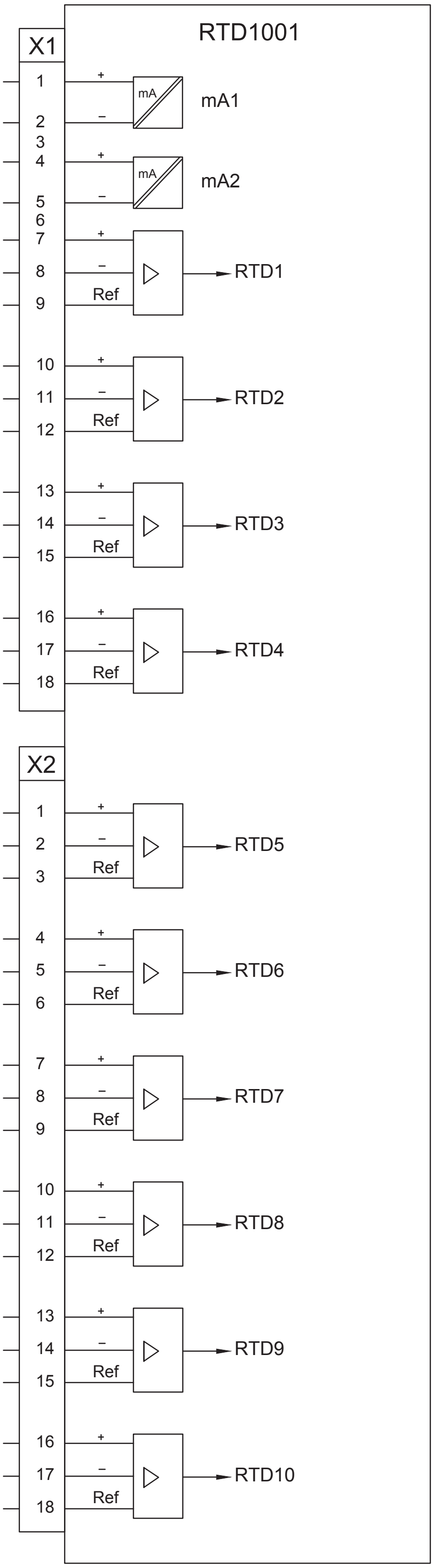

Figure 29. RTD1001 module

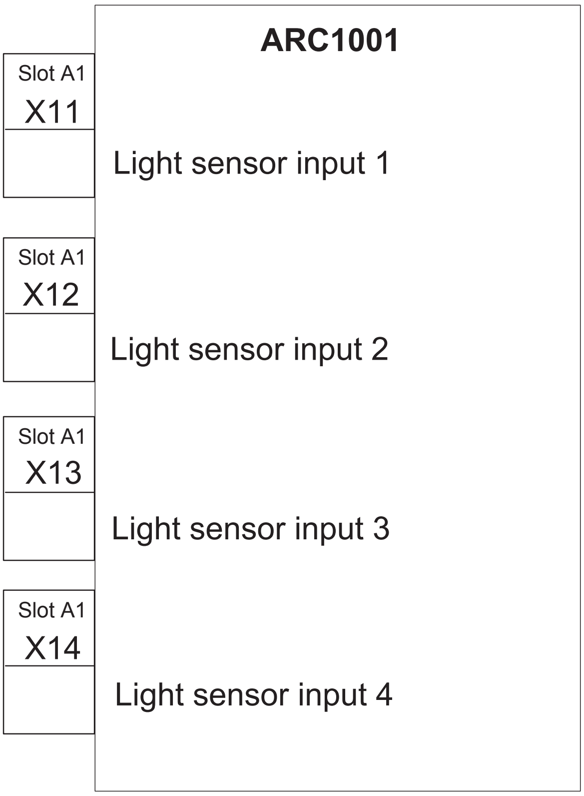

Figure 30. Arc module

29. Certificates

DNV GL has issued an IEC 61850 Edition 2 Certificate Level A1 for REX640 Protection and Control relay. Certificate number: 10096267-INC 18-2859.

Additional certificates can be found on the product page.

30. References

The www.abb.com/substationautomation portal provides information on the entire range of distribution automation products and services.

The latest relevant information on the REX640 protection and control relay is found on the product page. Scroll down the page to find and download the related documentation.

31. Functions, codes and symbols

Table 233. Functions included in the relay

Function	IEC 61850	IEC 60617	ANSI
Protection			
Distance protection	DSTPDIS	Z<	21P,21N
Local acceleration logic	DSTPLAL	LAL	21LAL
Scheme communication logic	DSOCPSCH	CL	85 21SCHLGC
Current reversal and weak-end infeed logic	CRWPSCH	CLCRW	85 21CREV,WEI
Communication logic for residual overcurrent	RESCPSCH	CLN	85 67G/N SCHLGC
Current reversal and weak-end infeed logic for residual overcurrent	RCRWPSCH	CLCRWN	85 67G/N CREV,WEI
Line differential protection with inzone power transformer	LNPLDF	3Id/I>	87L
Binary signal transfer	BSTGAPC	BST	BST
Switch-onto-fault protection	CVPSOF	CVPSOF	SOTF
Three-phase non-directional overcurrent protection, low stage	PHLPTOC	3I>	51P-1
Three-phase non-directional overcurrent protection, high stage	PHHPTOC	3I>>	51P-2
Three-phase non-directional overcurrent protection, instantaneous stage	PHIPTOC	3I>>>	50P
Three-phase directional overcurrent protection, low stage	DPHLPDOC	3I> ->	67P/51P-1
Three-phase directional overcurrent protection, high stage	DPHHPDOC	3I>> ->	67P/51P-2
Non-directional earth-fault protection, low stage	EFLPTOC	Io>	51G/51N-1
Non-directional earth-fault protection, high stage	EFHPTOC	Io>>	51G/51N-2
Non-directional earth-fault protection, instantaneous stage	EFIPTOC	Io>>>	50G/50N
Directional earth-fault protection, low stage	DEFLPDEF	Io> ->	67G/N-1 51G/N-1
Directional earth-fault protection, high stage	DEFHPDEF	Io>> ->	67G/N-1 51G/N-2
Three-phase power directional element	DPSRDIR	I1 ->	67P-TC
Neutral power directional element	DNZSRDIR	I2 ->, Io ->	67N-TC
Admittance-based earth-fault protection	EFPADM	Yo> ->	21NY
Multifrequency admittance-based earth-fault protection	MFADPSDE	Io> -> Y	67NYH
Wattmetric-based earth-fault protection	WPWDE	Po> ->	32N
Transient/intermittent earth-fault protection	INTRPTEF	Io> -> IEF	67NTEF/NIEF
Harmonics-based earth-fault protection	HAEFPTOC	Io>HA	51NH
Negative-sequence overcurrent protection	NSPTOC	I2>M	46M
Phase discontinuity protection	PDNSPTOC	I2/I1>	46PD
Residual overvoltage protection	ROVPTOV	Uo>	59G/59N
Three-phase undervoltage protection	PHPTUV	3U<	27

Table 233. Functions included in the relay, continued

Function	IEC 61850	IEC 60617	ANSI
Three-phase overvoltage variation protection	PHVPTOV	3Urms>	59.S1
Three-phase overvoltage protection	PHPTOV	3U>	59
Positive-sequence overvoltage protection	PSPTOV	U1>	59PS
Positive-sequence undervoltage protection	PSPTUV	U1<	27PS
Negative-sequence overvoltage protection	NSPTOV	U2>	59NS
Frequency protection	FRPFRQ	f>/f<,df/dt	81
Three-phase voltage-dependent overcurrent protection	PHPVOC	3I(U)>	51V
Overexcitation protection	OEPVPH	U/f>	24
Three-phase thermal protection for feeders, cables and distribution transformers	T1PTTR	3Ith>F	49F
Three-phase thermal overload protection, two time constants	T2PTTR	3Ith>T/G/C	49T/G/C
Three-phase overload protection for shunt capacitor banks	COLPTOC	3I> 3I<	51,37,86C
Current unbalance protection for shunt capacitor banks	CUBPTOC	dI>C	60N
Three-phase current unbalance protection for shunt capacitor banks	HCUBPTOC	3dI>C	60P
Shunt capacitor bank switching resonance protection, current based	SRCPTOC	TD>	55ITHD
Compensated neutral unbalance voltage protection	CNUPTOV	CNU>	59NU
Directional negative-sequence overcurrent protection	DNSPDOC	I2> ->	67Q
Low-voltage ride-through protection	LVRTPTUV	UU	27RT
Voltage vector shift protection	VVSPPAM	VS	78VS
Directional reactive power undervoltage protection	DQPTUV	Q> -> ,3U<	32Q,27
Reverse power/directional overpower protection	DOPPDPR	P>/Q>	32R/32O
Underpower protection	DUPPDPR	P<	32U
Three-phase underimpedance protection	UZPDIS	ZZ	21G
Three-phase underexcitation protection	UEXPDIS	X<	40
Third harmonic-based stator earth-fault protection	H3EFPSEF	dUo>/Uo3H	64TN
Rotor earth-fault protection (injection method)	MREFPTOC	Io>R	64R
High-impedance or flux-balance based differential protection	MHZPDIF	3dIHi>M	87HIM
Out-of-step protection with double blinders	OOSRPSB	OOS	78PS
Negative-sequence overcurrent protection for machines	MNSPTOC	I2>M	46M
Loss of phase, undercurrent	PHPTUC	3I<	37
Loss of load supervision	LOFLPTUC	3I<	37
Motor load jam protection	JAMPTOC	Ist>	50TDJAM
Motor start-up supervision	STTPMSU	Is2t n<	49,66,48,50TDLR
Motor start counter	MSCPMRI	n<	66

Table 233. Functions included in the relay, continued

Function	IEC 61850	IEC 60617	ANSI
Phase reversal protection	PREVPTOC	I2>>	46R
Thermal overload protection for motors	MPTTR	3Ith>M	49M
Stabilized and instantaneous differential protection for machines	MPDIF	3dI>M/G	87M/87G
Underpower factor protection	MPUPF	PF<	55U
Stabilized and instantaneous differential protection for two- or three-winding transformers	TR3PTDF	3dI>3W	87T3
Stabilized and instantaneous differential protection for two-winding transformers	TR2PTDF	3dI>T	87T
Numerical stabilized low-impedance restricted earth-fault protection	LREFPNDF	dIoLo>	87NLI
High-impedance based restricted earth-fault protection	HREFPDIF	dIoHi>	87NHI
High-impedance differential protection for phase A	HIAPDIF	dHi_A>	87_A
High-impedance differential protection for phase B	HIBPDIF	dHi_B>	87_B
High-impedance differential protection for phase C	HICPDIF	dHi_C>	87_C
Circuit breaker failure protection	CCBRBRF	3I>/Io>BF	50BF
Three-phase inrush detector	INRPHAR	3I2f>	68HB
Master trip	TRPPTRC	Master Trip	94/86
Arc protection	ARCSARC	ARC	AFD
High-impedance fault detection	PHIZ	HIF	HIZ
Fault locator	SCEFRFLO	FLOC	FLOC
Load-shedding and restoration	LSHDPFRQ	UFLS/R	81LSH
Multipurpose protection	MAPGAPC	MAP	MAP
Control			
Circuit-breaker control	CBXCBR	I <-> O CB	52
Three-state disconnector control	P3SXSWI	I<->O P3S	29DS/GS
Disconnector control	DCXSWI	I <-> O DCC	29DS
Earthing switch control	ESXSWI	I <-> O ESC	29GS
Three-state disconnector position indication	P3SSXSWI	I<->O P3SS	29DS/GS
Disconnector position indication	DCSXSWI	I <-> O DC	29DS
Earthing switch position indication	ESSXSWI	I <-> O ES	29GS
Emergency start-up	ESMGAPC	ESTART	EST,62
Autoreclosing	DARREC	O -> I	79
Autosynchronizer for generator breaker	ASGCSYN	AUTOSYNCG	25AUTOSYNCG
Autosynchronizer for network breaker	ASNSCSYN	AUTOSYNCBT/T	25AUTOSYNCBT/T
Autosynchronizer co-ordinator	ASCGAPC	AUTOSYNC	25AUTOSYNC
Synchronism and energizing check	SECRSYN	SYNC	25
Tap changer control with voltage regulator	OL5ATCC	COLTC	90V
Transformer data combiner	OLGAPC	OLGAPC	OLGAPC

Table 233. Functions included in the relay, continued

Function	IEC 61850	IEC 60617	ANSI
Petersen coil controller	PASANCR	ANCR	90
Condition monitoring and supervision			
Circuit-breaker condition monitoring	SSCBR	CBCM	52CM
Hot-spot and insulation ageing rate monitoring for transformers	HSARSPTR	3Ihp>T	26/49HS
Trip circuit supervision	TCSSCBR	TCS	TCM
Current circuit supervision	CCSPVC	MCS 3I	CCM
Current circuit supervision for transformers	CTSRCTF	MCS 3I,I2	CCM 3I,I2
Current transformer supervision for high-impedance protection scheme for phase A	HZCCASPVC	MCS I_A	CCM_A
Current transformer supervision for high-impedance protection scheme for phase B	HZCCBSPVC	MCS I_B	CCM_B
Current transformer supervision for high-impedance protection scheme for phase C	HZCCCSPVC	MCS I_C	CCM_C
Fuse failure supervision	SEQSPVC	FUSEF	VCM, 60
Protection communication supervision	PCSITPC	PCS	PCS
Runtime counter for machines and devices	MDSOPT	OPTS	OPTM
Three-phase remanent undervoltage supervision	MSVPR	3U<R	27R
Measurement			
Three-phase current measurement	CMMXU	3I	IA, IB, IC
Sequence current measurement	CSMSQI	I1, I2, I0	I1, I2, I0
Residual current measurement	RESCMMXU	Io	IG
Three-phase voltage measurement	VMMXU	3U	VA, VB, VC
Single-phase voltage measurement	VAMMXU	U_A	V_A
Residual voltage measurement	RESVMMXU	Uo	VG/VN
Sequence voltage measurement	VSMSQI	U1, U2, U0	V1, V2, V0
Three-phase power and energy measurement	PEMMXU	P, E	P, E
Load profile recorder	LDPRLRC	LOADPROF	LOADPROF
Frequency measurement	FMMXU	f	f
Tap changer position indication	TPOSYLTC	TPOSM	84T
Power quality			
Current total demand, harmonic distortion, DC component (TDD, THD, DC) and individual harmonics	CHMHAI	PQM3IH	PQM ITHD,IDC
Voltage total harmonic distortion, DC component (THD, DC) and individual harmonics	VHMHAI	PQM3VH	PQM VTHD,VDC
Voltage variation	PHQVVR	PQMU	PQMV SWE,SAG,INT
Voltage unbalance	VSQVUB	PQUUB	PQMV UB
Traditional LED indication			
LED indication control	LEDPTRC	LEDPTRC	LEDPTRC
Virtual programmable LED control	LED	LED	LED

Table 233. Functions included in the relay, continued

Function	IEC 61850	IEC 60617	ANSI
Logging functions			
Disturbance recorder (common functionality)	RDRE	DR	DFR
Disturbance recorder, analog channels 1...12	A1RADR	A1RADR	A1RADR
Disturbance recorder, analog channels 13...24	A2RADR	A2RADR	A2RADR
Disturbance recorder, binary channels 1...32	B1RBDR	B1RBDR	B1RBDR
Disturbance recorder, binary channels 33...64	B2RBDR	B2RBDR	B2RBDR
Fault recorder	FLTRFRC	FAULTREC	FR
Other functionality			
Parameter setting groups	PROTECTION	PROTECTION	PROTECTION
Time master supervision	GNRLLTMS	GNRLLTMS	GNRLLTMS
Serial port supervision	SERLCCH	SERLCCH	SERLCCH
IEC 61850-1 MMS	MMSLPRT	MMSLPRT	MMSLPRT
IEC 61850-1 GOOSE	GSELPRT	GSELPRT	GSELPRT
IEC 60870-5-103 protocol	I3CLPRT	I3CLPRT	I3CLPRT
DNP3 protocol	DNPLPRT	DNPLPRT	DNPLPRT
Modbus protocol	MBSLPRT	MBSLPRT	MBSLPRT
OR gate with two inputs	OR	OR	OR
OR gate with six inputs	OR6	OR6	OR6
OR gate with twenty inputs	OR20	OR20	OR20
AND gate with two inputs	AND	AND	AND
AND gate with six inputs	AND6	AND6	AND6
AND gate with twenty inputs	AND20	AND20	AND20
XOR gate with two inputs	XOR	XOR	XOR
NOT gate	NOT	NOT	NOT
Real maximum value selector	MAX3R	MAX3R	MAX3R
Real minimum value selector	MIN3R	MIN3R	MIN3R
Rising edge detector	R_TRIG	R_TRIG	R_TRIG
Falling edge detector	F_TRIG	F_TRIG	F_TRIG
Real switch selector	SWITCHR	SWITCHR	SWITCHR
Integer 32-bit switch selector	SWITCHI32	SWITCHI32	SWITCHI32
SR flip-flop, volatile	SR	SR	SR
RS flip-flop, volatile	RS	RS	RS
Minimum pulse timer, two channels	TPGAPC	TP	62TP
Minimum pulse timer second resolution, two channels	TPSGAPC	TPS	62TPS
Minimum pulse timer minutes resolution, two channels	TPMGAPC	TPM	62TPM
Pulse counter for energy measurement	PCGAPC	PCGAPC	PCGAPC
Pulse timer, eight channels	PTGAPC	PT	62PT
Time delay off, eight channels	TOFGAPC	TOF	62TOF

Table 233. Functions included in the relay, continued

Function	IEC 61850	IEC 60617	ANSI
Time delay on, eight channels	TONGAPC	TON	62TON
Daily timer	DTMGAPC	DTM	DTM
Calendar function	CALGAPC	CAL	CAL
SR flip-flop, eight channels, nonvolatile	SRGAPC	SR	SR
Boolean value event creation	MVGAPC	MV	MV
Integer value event creation	MVI4GAPC	MVI4	MVI4
Analog value event creation with scaling	SCA4GAPC	SCA4	SCA4
Generic control points	SPCGAPC	SPC	SPCG
Generic up-down counter	UDFCNT	UDCNT	UDCNT
Local/Remote control	CONTROL	CONTROL	CONTROL
External HMI wake-up	EIHMI	EIHMI	EIHMI
Real addition	ADDR	ADDR	ADDR
Real subtraction	SUBR	SUBR	SUBR
Real multiplication	MULR	MULR	MULR
Real division	DIVR	DIVR	DIVR
Real equal comparator	EQR	EQR	EQR
Real not equal comparator	NER	NER	NER
Real greater than or equal comparator	GER	GER	GER
Real less than or equal comparator	LER	LER	LER
Voltage switch	VMSWI	VSWI	VSWI
Current sum	CMSUM	CSUM	CSUM
Current switch	CMSWI	CMSWI	CMSWI
Phase current preprocessing	ILTCTR	ILTCTR	ILTCTR
Residual current preprocessing	RESTCTR	RESTCTR	RESTCTR
Phase and residual voltage preprocessing	UTVTR	UTVTR	UTVTR
SMV stream receiver (IEC 61850-9-2LE)	SMVRCV	SMVRCV	SMVRCV
SMV stream sender (IEC 61850-9-2LE)	SMVSENDER	SMVSENDER	SMVSENDER
Redundant Ethernet channel supervison	RCHLCCH	RCHLCCH	RCHLCCH
Ethernet channel supervision	SCHLCCH	SCHLCCH	SCHLCCH
HMI Ethernet channel supervision	HMILCCH	HMILCCH	HMILCCH
Received GOOSE binary information	GOOSERCV_BIN	GOOSERCV_BIN	GOOSERCV_BIN
Received GOOSE double binary information	GOOSERCV_DP	GOOSERCV_DP	GOOSERCV_DP
Received GOOSE measured value information	GOOSERCV_MV	GOOSERCV_MV	GOOSERCV_MV
Received GOOSE 8b-it integer value information	GOOSERCV_INT8	GOOSERCV_INT8	GOOSERCV_INT8
Received GOOSE 32-bit integer value information	GOOSERCV_INT32	GOOSERCV_INT32	GOOSERCV_INT32
Received GOOSE interlocking information	GOOSERCV_INTL	GOOSERCV_INTL	GOOSERCV_INTL
Received GOOSE measured value (phasor) information	GOOSERCV_CMV	GOOSERCV_CMV	GOOSERCV_CMV

Table 233. Functions included in the relay, continued

Function	IEC 61850	IEC 60617	ANSI
Received GOOSE enumerator value information	GOOSERCV_ENUM	GOOSERCV_ENUM	GOOSERCV_ENUM
Bad signal quality	QTY_BAD	QTY_BAD	QTY_BAD
Good signal quality	QTY_GOOD	QTY_GOOD	QTY_GOOD
GOOSE communication quality	QTY_GOOSE_COMM	QTY_GOOSE_COMM	QTY_GOOSE_COMM
GOOSE data health	T_HEALTH	T_HEALTH	T_HEALTH
Fault direction evaluation	T_DIR	T_DIR	T_DIR
Enumerator to boolean conversion	T_TCMD	T_TCMD	T_TCMD
32-bit integer to binary command conversion	T_TCMD_BIN	T_TCMD_BIN	T_TCMD_BIN
Binary command to 32-bit integer conversion	T_BIN_TCMD	T_BIN_TCMD	T_BIN_TCMD
Switching device status decoder - CLOSE position	T_POS_CL	T_POS_CL	T_POS_CL
Switching device status decoder - OPEN position	T_POS_OP	T_POS_OP	T_POS_OP
Switching device status decoder - OK status	T_POS_OK	T_POS_OK	T_POS_OK
Controllable gate, 8 Channels	GATEGAPC	GATEGAPC	GATEGAPC
Security application	GSAL	GSAL	GSAL
Hotline tag	HLTGAPC	HLTGAPC	HLTGAPC
16 settable 32-bit integer values	SETI32GAPC	SETI32GAPC	SETI32GAPC
16 settable real values	SETRGAPC	SETRGAPC	SETRGAPC
Boolean to integer 32-bit conversion	T_B16_TO_I32	T_B16_TO_I32	T_B16_TO_I32
Integer 32-bit to boolean conversion	T_I32_TO_B16	T_I32_TO_B16	T_I32_TO_B16
Integer 32-bit to real conversion	T_I32_TO_R	T_I32_TO_R	T_I32_TO_R
Real to integer 8-bit conversion	T_R_TO_I8	T_R_TO_I8	T_R_TO_I8
Real to integer 32-bit conversion	T_R_TO_I32	T_R_TO_I32	T_R_TO_I32
Constant FALSE	FALSE	FALSE	FALSE
Constant TRUE	TRUE	TRUE	TRUE

32. Contents of application packages

Table 234. Application packages

Description	ID
Feeder earth-fault protection extension package	APP1
Feeder fault locator package	APP2
Line distance protection package	APP3
Line differential protection package	APP4
Shunt capacitor protection package	APP5
Interconnection protection package	APP6
Machine protection package	APP7
Power transformer protection package	APP8
Busbar protection package	APP9
OLTC control package	APP10
Generator autosynchronizer package	APP11
Network autosynchronizer package	APP12
Petersen coil control package	APP13
Synchronous machine add-on	ADD1
3-winding transformer add-on	ADD2

Table 235. Base and optional functionality

IEC 61850	Pcs	Base	APP 1	APP 2	APP 3	APP 4	APP 5	APP 6	APP 7	APP 8	APP 9	APP 10	APP 11	APP 12	APP 13	ADD 1	ADD 2
Protection																	
DSTPDIS	1				•												
DSTPLAL	1				•												
DSOCPSCH	1				•												
CRWPSCH	1				•												
RESCPSCH	1				•												
RCRWPSCH	1				•												
LNPLDF	1					•											
BSTGAPC	2				•	•											
CVPSOF	1	•															
PHLPTOC	3	•															
PHHPTOC	3	•															
PHIPTOC	3	•															
DPHLPDOC	3	•															
DPHHPDOC	3	•															
EFLPTOC	3	•															
EFHPTOC	3	•															
EFIPTOC	3	•															
DEFLPDEF	4	•															
DEFHPDEF	4	•															
DPSRDIR	2							•									
DNZSRDIR	2		•														
EFPADM	3		•														
MFADPSDE	3		•														
WPWDE	3		•														
INTRPTEF	1		•														
HAEFPTOC	1		•														
NSPTOC	3	•															
PDNSPTOC	1	•															
ROVPTOV	4	•															
PHPTUV	4	•															
PHVPTOV	2							•									
PHPTOV	4	•															
PSPTOV	4	•															
PSPTUV	4	•															
NSPTOV	4	•															
FRPFRQ	12	•															
PHPVOC	2	•															
OEPVPH	2									•						•	
T1PTTR	1	•															
T2PTTR	1									•						•	
COLPTOC	1						•										
CUBPTOC	3						•										
HCUBPTOC	2						•										
SRCPTOC	1						•										
CNUPTOV	2						•										
DNSPDOC	2	•															
LVRTPTUV	3							•									
VVSPPAM	1							•									
DQPTUV	2							•									
DOPPDPR	3							•	•	•							
DUPPDPR	3									•						•	
UZPDIS	2									•						•	
UEXPDIS	2															•	

Table 235. Base and optional functionality, continued

IEC 61850	Pcs	Base	APP 1	APP 2	APP 3	APP 4	APP 5	APP 6	APP 7	APP 8	APP 9	APP 10	APP 11	APP 12	APP 13	ADD 1	ADD 2
H3EFPSEF	1															•	
MREFPTOC	2															•	
MHZPDIF	1								•								
OOSRPSB	1				•											•	
MNSPTOC	2								•								
PHPTUC	3	•															
LOFLPTUC	1								•								
JAMPTOC	1								•								
STTPMSU	1								•								
MSCPMRI	1								•								
PREVPTOC	1								•								
MPTTR	1								•								
MPDIF	1								•								
MPUPF	2															•	
TR3PTDF	1																•
TR2PTDF	1									•							
LREFPNDF	2	•															
HREFPDIF	2	•															
HIAPDIF	3								•	•	•						
HIBPDIF	3								•	•	•						
HICPDIF	3								•	•	•						
CCBRBRF	3	•															
INRPHAR	2	•															
TRPPTRC	6	•															
ARCSARC	4	•															
PHIZ	1		•														
SCEFRFLO	1			•													
LSHDPFRQ	6	•															
MAPGAPC	24	•															
Control																	
CBXCBR	3	•															
P3SXSWI	6	•															
DCXSWI	8	•															
ESXSWI	3	•															
P3SSXSWI	6	•															
DCSXSWI	8	•															
ESSXSWI	3	•															
ESMGAPC	1								•								
DARREC	2	•															
ASGCSYN	1												•				
ASNSCSYN	3													•			
ASCGAPC	1	•															
SECRSYN	3	•															
OL5ATCC	1											•					
OLGAPC	5											•					
PASANCR	1														•		
Condition monitoring and supervision																	
SSCBR	3	•															
HSARSPTR	1									•							
TCSSCBR	6	•															
CCSPVC	5	•															
CTSRCTF	1									•							
HZCCASPVC	3										•						
HZCCBSPVC	3										•						
HZCCCSPVC	3										•						

Table 235. Base and optional functionality, continued

IEC 61850	Pcs	Base	APP 1	APP 2	APP 3	APP 4	APP 5	APP 6	APP 7	APP 8	APP 9	APP 10	APP 11	APP 12	APP 13	ADD 1	ADD 2
SEQSPVC	7	•															
PCSITPC	1				•	•											
MDSOPT	2	•															
MSVPR	2	•															
Measurement																	
CMMXU	8	•															
CSMSQI	8	•															
RESCMMXU	8	•															
VMMXU	8	•															
VAMMXU	4	•															
RESVMMXU	8	•															
VSMSQI	8	•															
PEMMXU	3	•															
LDPRLRC	1	•															
FMMXU	5	•															
TPOSYLTC	1											•					
Power quality																	
CHMHAI	1	•															
VHMHAI	1	•															
PHQVVR	2	•															
VSQVUB	2	•															
Traditional LED indication																	
LEDPTRC	1	•															
LED	33	•															
Logging functions																	
RDRE	1	•															
A1RADR	1	•															
A2RADR	1	•															
B1RBDR	1	•															
B2RBDR	1	•															
FLTRFRC	1	•															
Other functionality																	
PROTECTION	1	•															
GNRLLTMS	1	•															
SERLCCH	2	•															
MMSLPRT	1	•															
GSELPRT	1	•															
I3CLPRT	2	•															
DNPLPRT	5	•															
MBSLPRT	5	•															
OR	400	•															
OR6	400	•															
OR20	20	•															
AND	400	•															
AND6	400	•															
AND20	20	•															
XOR	400	•															
NOT	400	•															
MAX3R	20	•															
MIN3R	20	•															
R_TRIG	10	•															
F_TRIG	10	•															
SWITCHR	30	•															
SWITCHI32	30	•															
SR	10	•															

Table 235. Base and optional functionality, continued

IEC 61850	Pcs	Base	APP 1	APP 2	APP 3	APP 4	APP 5	APP 6	APP 7	APP 8	APP 9	APP 10	APP 11	APP 12	APP 13	ADD 1	ADD 2
RS	10	•															
TPGAPC	4	•															
TPSGAPC	2	•															
TPMGAPC	2	•															
PCGAPC	4	•															
PTGAPC	2	•															
TOFGAPC	4	•															
TONGAPC	4	•															
DTMGAPC	4	•															
CALGAPC	4	•															
SRGAPC	4	•															
MVGAPC	4	•															
MVI4GAPC	4	•															
SCA4GAPC	4	•															
SPCGAPC	3	•															
UDFCNT	12	•															
CONTROL	1	•															
EIHMI	1	•															
ADDR	10	•															
SUBR	10	•															
MULR	10	•															
DIVR	10	•															
EQR	10	•															
NER	10	•															
GER	10	•															
LER	10	•															
VMSWI	3	•															
CMSUM	1	•															
CMSWI	3	•															
ILTCTR	8	•															
RESTCTR	8	•															
UTVTR	8	•															
SMVRCV	4	•															
SMVSENDER	1	•															
RCHLCCH	1	•															
SCHLCCH	5	•															
HMILCCH	1	•															
GOOSERCV_BIN	200	•															
GOOSERCV_DP	100	•															
GOOSERCV_MV	50	•															
GOOSERCV_INT8	50	•															
GOOSERCV_INT32	50	•															
GOOSERCV_INTL	100	•															
GOOSERCV_CMV	9	•															
GOOSERCV_ENUM	100	•															
QTY_BAD	20	•															
QTY_GOOD	20	•															
QTY_GOOSE_COMM	100	•															
T_HEALTH	100	•															
T_DIR	50	•															
T_TCMD	100	•															
T_TCMD_BIN	100	•															
T_BIN_TCMD	100	•															
T_POS_CL	150	•															
T_POS_OP	150	•															

Table 235. Base and optional functionality, continued

IEC 61850	Pcs	Base	APP 1	APP 2	APP 3	APP 4	APP 5	APP 6	APP 7	APP 8	APP 9	APP 10	APP 11	APP 12	APP 13	ADD 1	ADD 2
T_POS_OK	150	•															
GATEGAPC	1	•															
GSAL	1	•															
HLTGAPC	1	•															
SETI32GAPC	2	•															
SETRGAPC	2	•															
T_B16_TO_I32	10	•															
T_I32_TO_B16	10	•															
T_I32_TO_R	10	•															
T_R_TO_I8	10	•															
T_R_TO_I32	10	•															
FALSE	10	•															
TRUE	10	•															

33. Document revision history

Document revision/date	Product connectivity level (PCL)	History
A/2018-12-14	1	First release

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