Relion® 630 series

Feeder Protection and Control REF630 Product Guide

Power and productivity
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Contents

1. Description

REF630 is a comprehensive feeder management IED for protection, control, measuring and supervision of utility and industrial distribution substations. REF630 is a member of ABB's Relion® product family and a part of its 630 series characterized by functional scalability and flexible configurability. REF630 also features necessary control functions constituting an ideal solution for feeder bay control.

The supported communication protocols including IEC 61850 offer seamless connectivity to industrial automation systems.

2. Application

REF630 provides main protection for overhead lines and cable feeders of distribution networks. The IED fits both isolated neutral networks and networks with resistance or impedance earthed neutral. Four pre-defined configurations to match typical feeder protection and control requirements are available. The pre-defined configurations can be used as such or easily adapted or extended with freely selectable add-on functions, by means of which the IED can be fine-tuned to exactly satisfy the specific requirements of your present application.

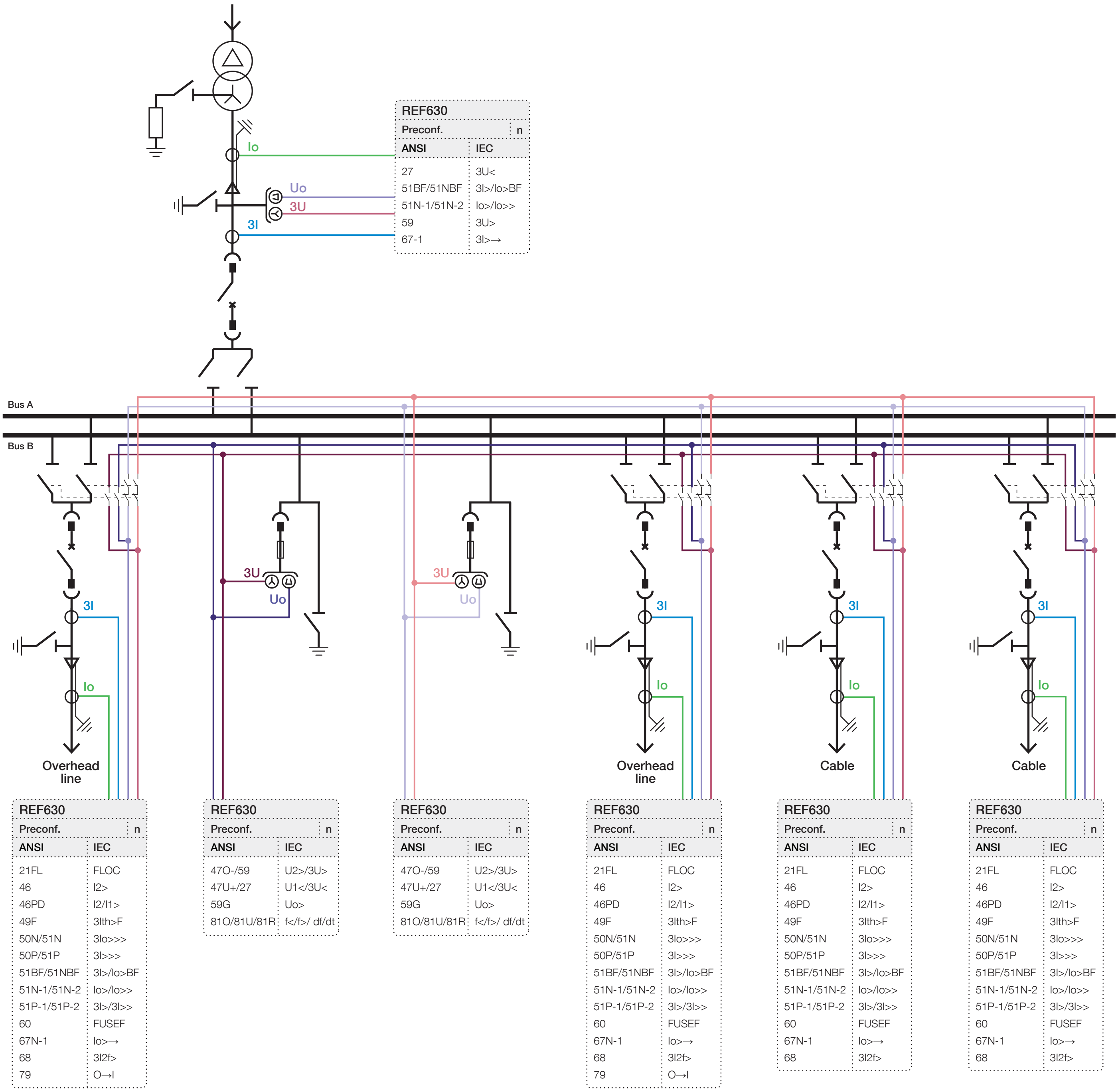

Figure 1. Application example with double busbar switchgear arrangement with one incoming feeder and several outgoing feeders for overhead line and cable feeders in preconfiguration n

Fault locator function is available in all outgoing feeders, and autorecloser is dedicated for overhead line feeders.

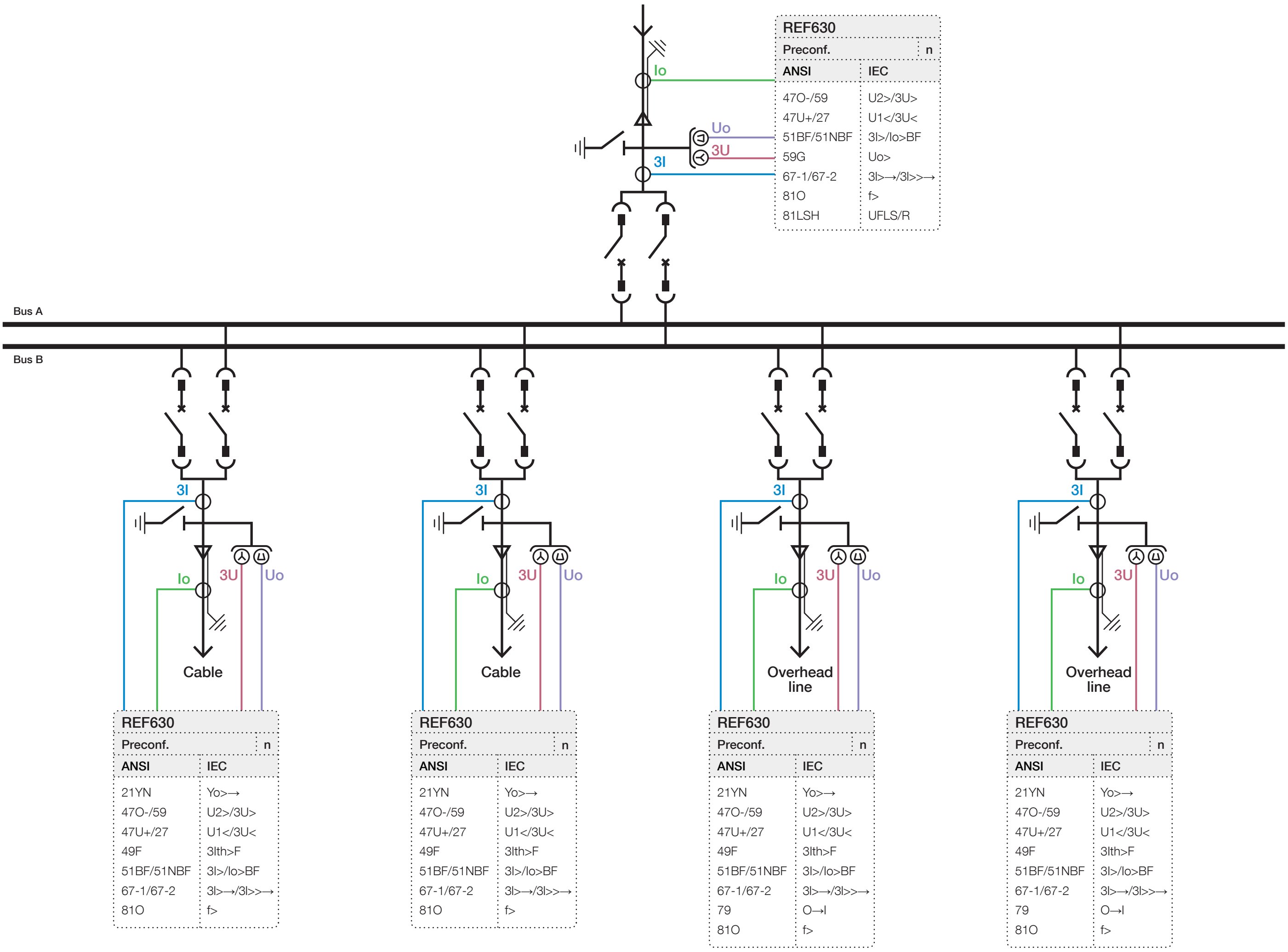

Figure 2. Application example in double busbar, also so called back 2 back, switchgear arrangement with dedicated voltage measurement in each feeder

Admittance-based earth-fault protection is used in all outgoing feeders. The autoreclose function is used in outgoing feeders with overhead lines.

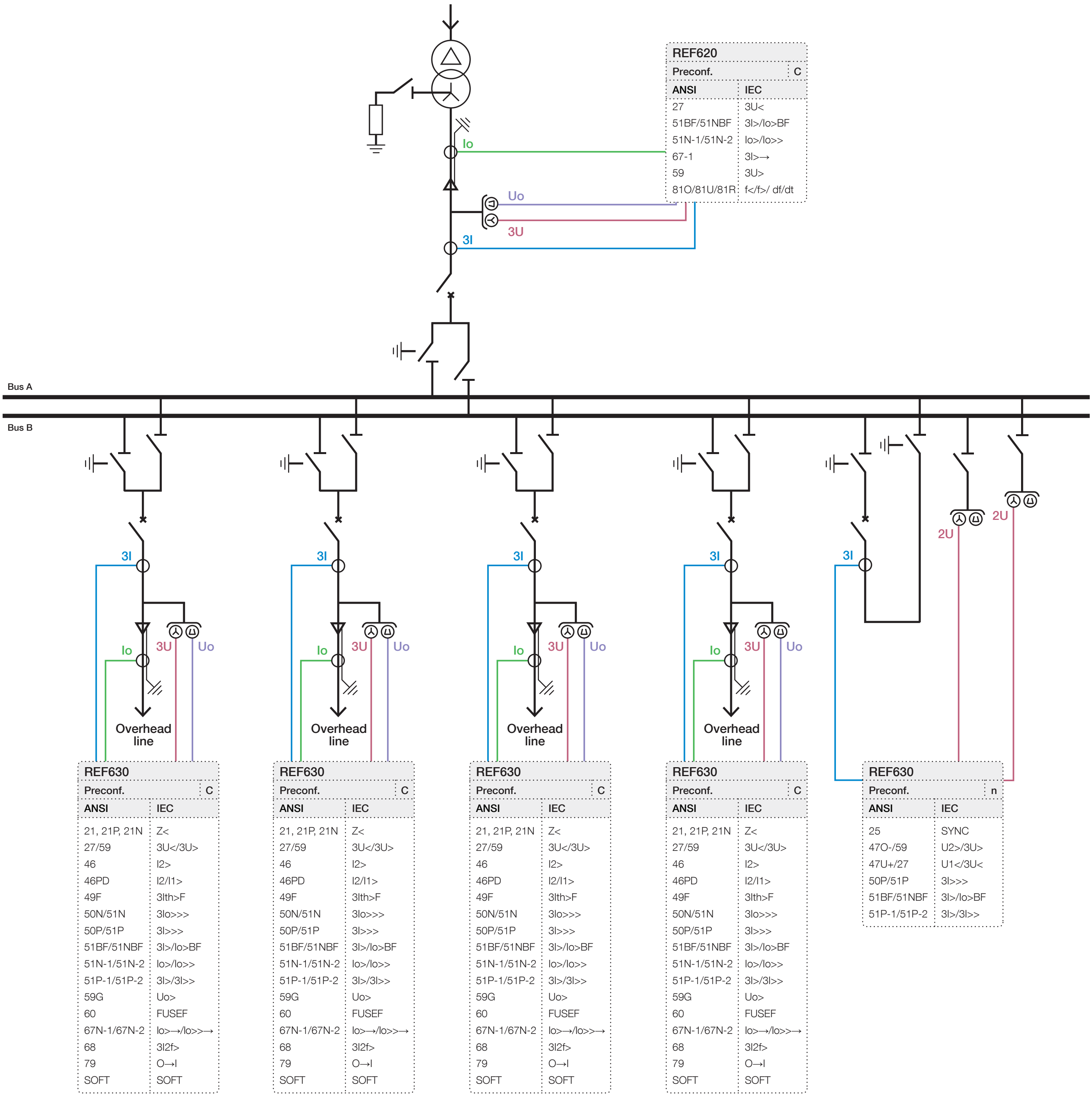

Figure 3. Application example in double busbar arrangement, most typical, for gas insulated switchgear with 3 position disconnector and voltage measurement in each feeder

The bus sectionalizer with also independent voltage measurement on both busbars allows switchgear operation while maintenance works are required on one of the busbar sections. Preconfiguration C with its distance protection is preconfigured for ring and meshed type feeders.

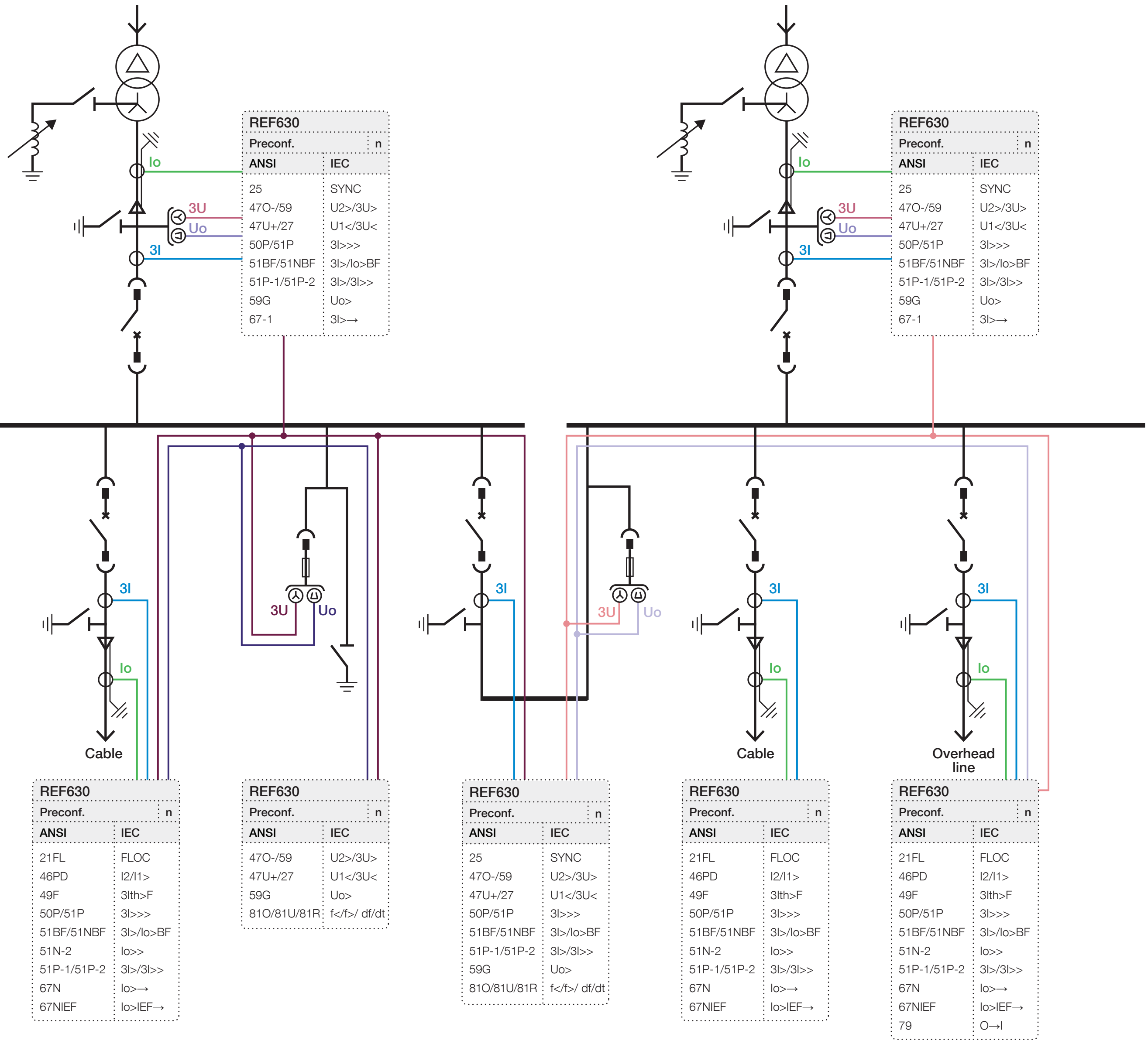

Figure 4. **Application example with single busbar switchgear arranged into two bus sections separated with bus coupler**

High impedance earthed network with preconfigurations N and directional overcurrent and directional earth-fault functions are used. In incoming feeders and bus coupler the synchrocheck functionality is used to prevent unsynchronized connection of two separate networks into each other.

3. Preconfigurations

The 630 series IEDs are offered with optional factory-made preconfigurations for various applications. The preconfigurations contribute to faster commissioning and less engineering of the IED. The preconfigurations include default functionality typically needed for a specific application. Each preconfiguration is adaptable using the Protection and Control IED Manager PCM600. By adapting the preconfiguration the IED can be configured to suit the particular application.

The adaptation of the preconfiguration may include adding or removing of protection, control and other functions according to the specific application, changing of the default parameter settings, configuration of the default alarms and event recorder settings including the texts shown in the HMI, configuration of the LEDs and function buttons, and adaptation of the default single-line diagram.

In addition, the adaptation of the preconfiguration always includes communication engineering to configure the communication according to the functionality of the IED. The communication engineering is done using the communication configuration function of PCM600.

If none of the offered preconfigurations fulfill the needs of the intended area of application, 630 series IEDs can also be ordered without any preconfiguration. In this case the IED needs to be configured from the ground up.

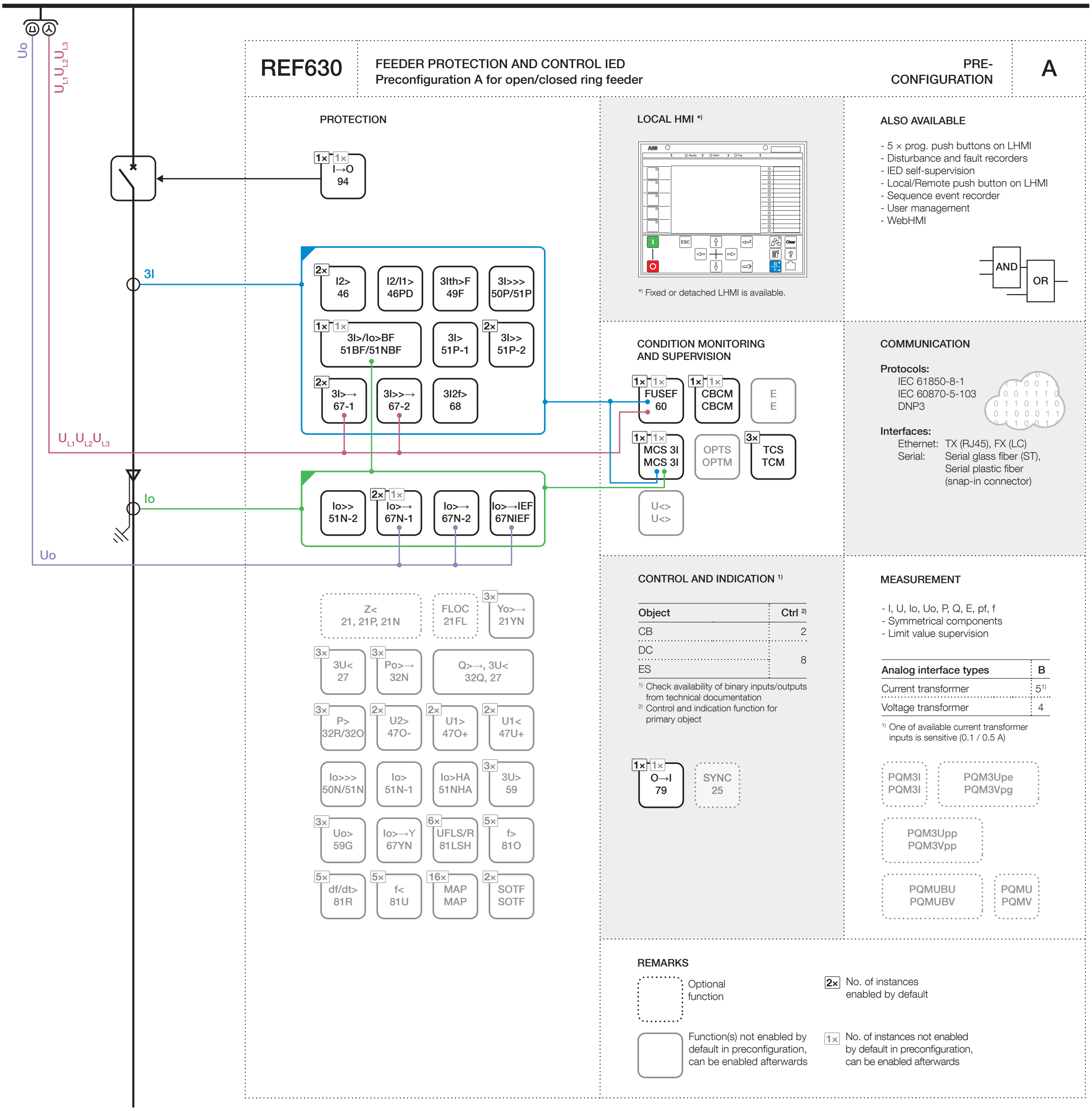

Figure 5. Functionality overview for preconfiguration A

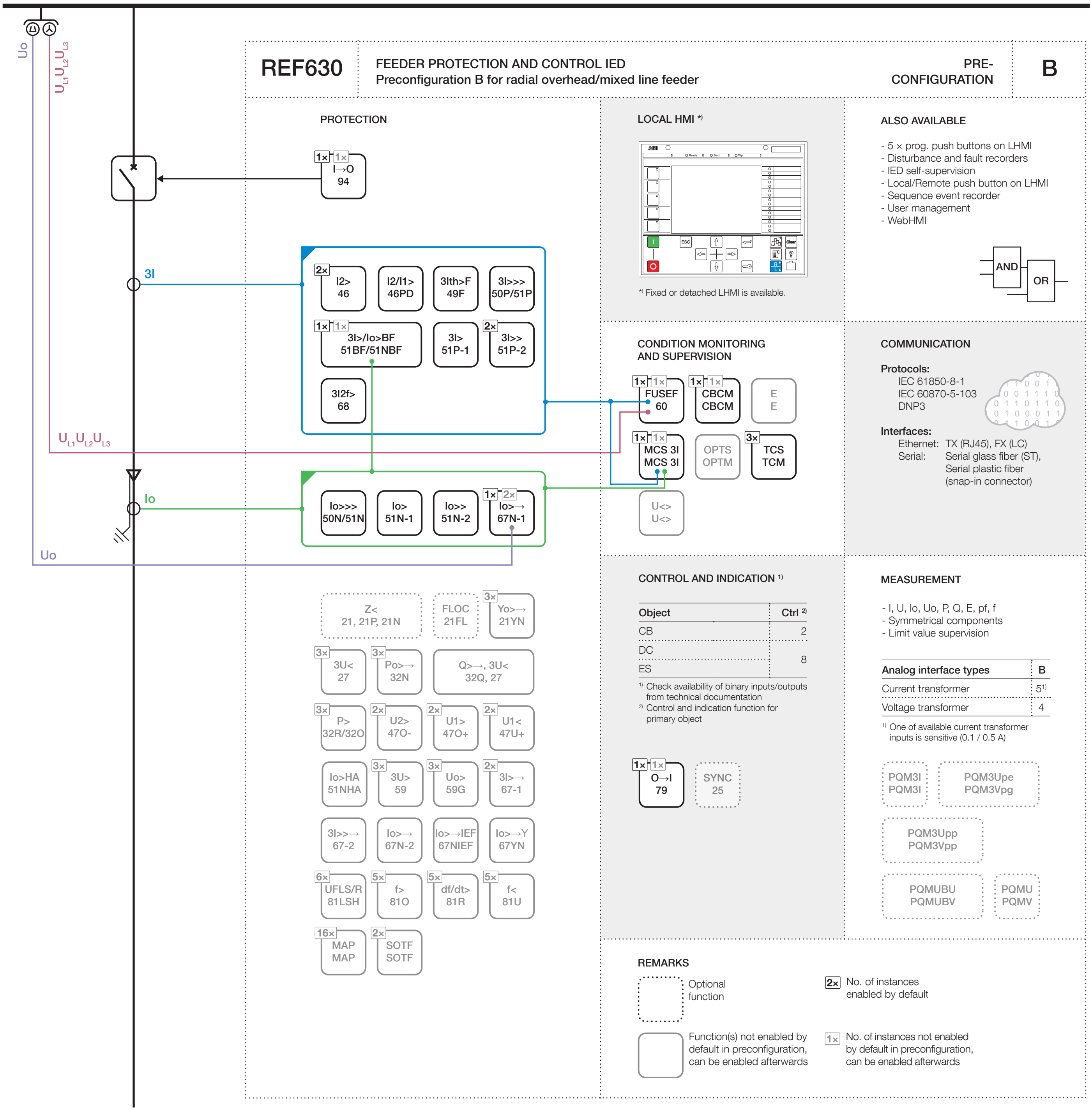

Figure 6. Functionality overview for preconfiguration B

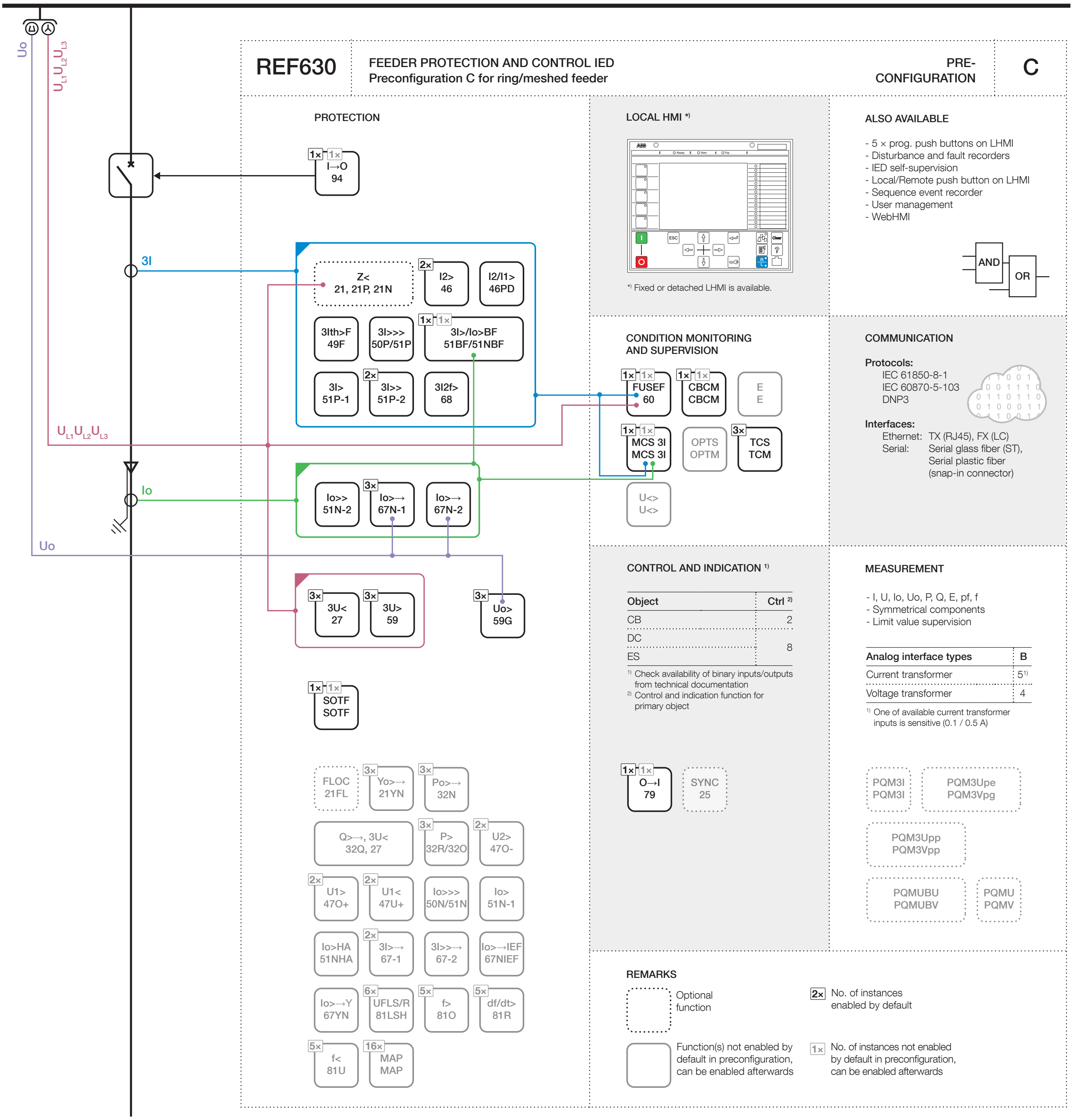

Figure 7. Functionality overview for preconfiguration C

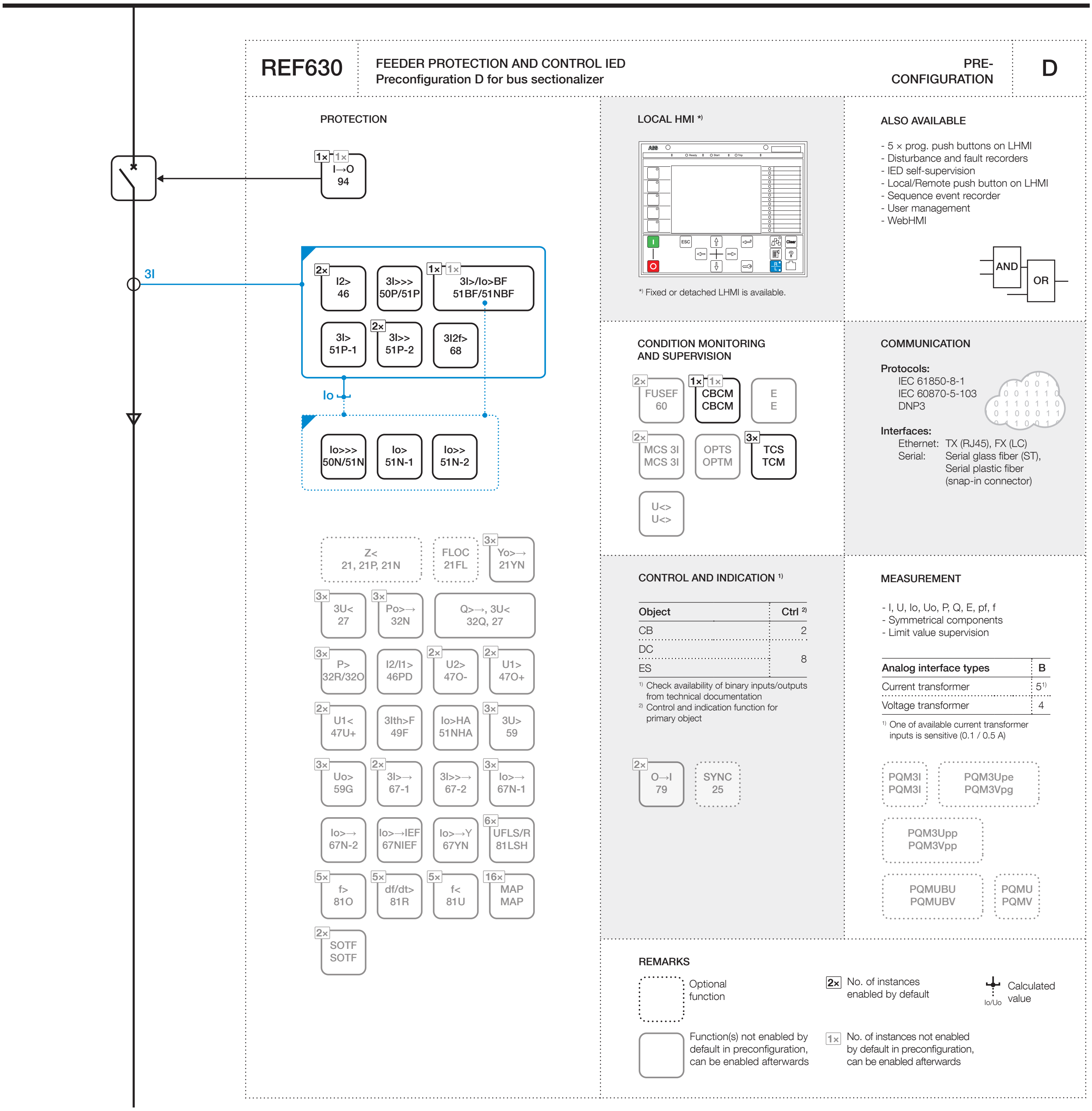

Figure 8. Functionality overview for preconfiguration D

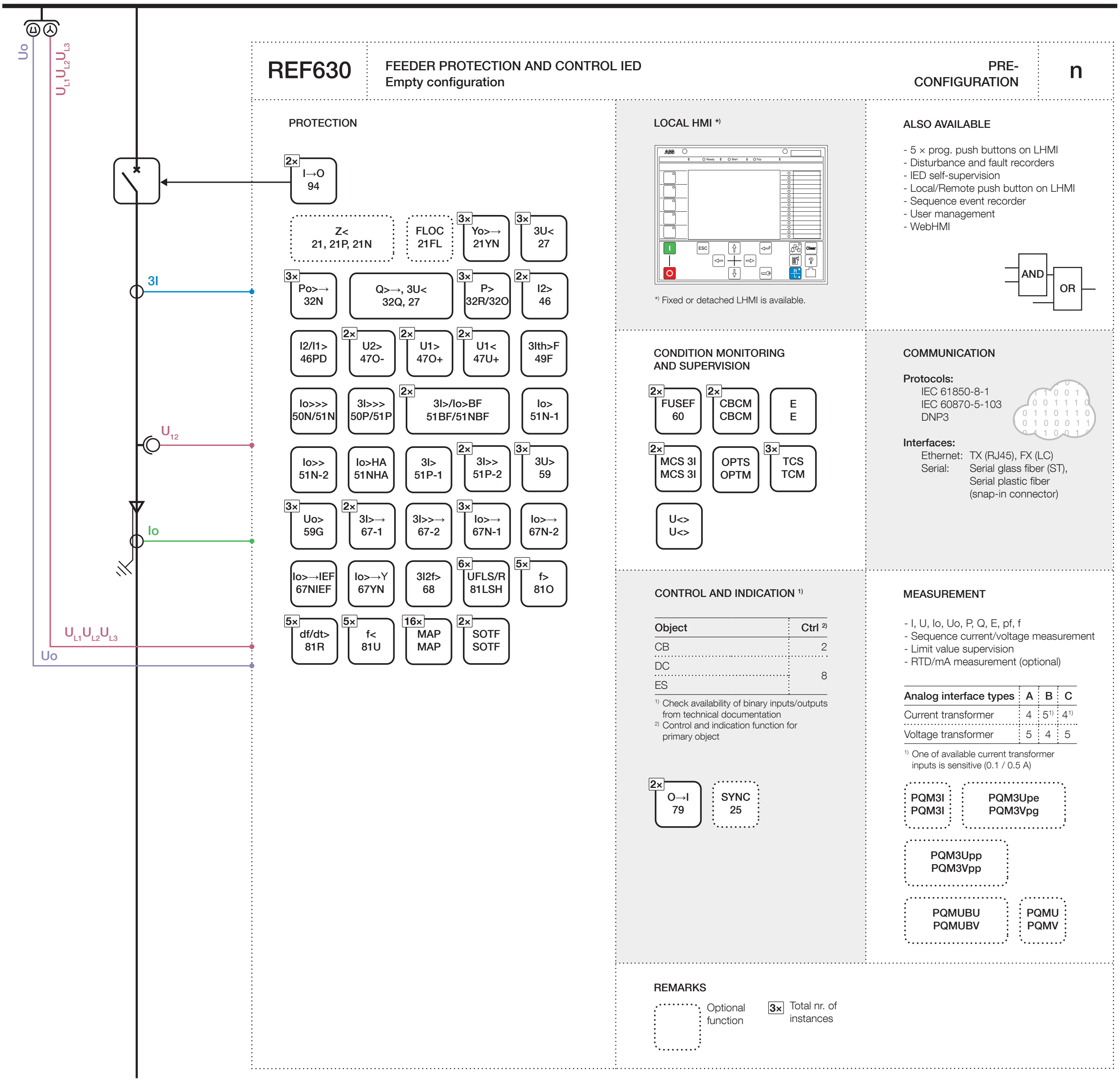

Figure 9. Functionality overview for preconfiguration n

Table 1. REF630 preconfiguration ordering options

Description	Preconfiguration				
Preconfiguration A for open/closed ring feeder	A				
Preconfiguration B for radial overhead/mixed line feeder		B			
Preconfiguration C for ring/meshed feeder			C		
Preconfiguration D for bus sectionalizer				D	
Number of instances available					n

Table 2. Functions used in preconfigurations

Description	A	B	C	D	n
Protection					
Three-phase non-directional overcurrent protection, low stage	1	1	1	1	1
Three-phase non-directional overcurrent protection, high stage	2	2	2	2	2
Three-phase non-directional overcurrent protection, instantaneous stage	1	1	1	1	1
Three-phase directional overcurrent protection, low stage	2	-	-	-	2
Three-phase directional overcurrent protection, high stage	1	-	-	-	1
Distance protection	-	-	1	-	1
Automatic switch-onto-fault logic	-	-	1	-	2
Fault locator	-	-	-	-	1
Autoreclosing	1	1	1	-	2
Non-directional earth-fault protection, low stage	-	1	-	1	1
Non-directional earth-fault protection, high stage	1	1	1	1	1
Non-directional earth-fault protection, instantaneous stage	-	1	-	1	1
Directional earth-fault protection, low stage	2	1	3	-	3
Directional earth-fault protection, high stage	1	-	1	-	1
Harmonics based earth-fault protection	-	-	-	-	1
Transient/intermittent earth-fault protection	1	-	-	-	1
Admittance-based earth-fault protection	-	-	-	-	3
Multi-frequency admittance-based earth-fault protection	-	-	-	-	1
Wattmetric earth-fault protection	-	-	-	-	3
Phase discontinuity protection	1	1	1	-	1
Negative-sequence overcurrent protection	2	2	2	2	2
Three-phase thermal overload protection for feeder	1	1	1	-	1
Three-phase current inrush detection	1	1	1	1	1
Three-phase overvoltage protection	-	-	3	-	3
Three-phase undervoltage protection	-	-	3	-	3
Positive-sequence overvoltage protection	-	-	-	-	2
Positive-sequence undervoltage protection	-	-	-	-	2
Negative-sequence overvoltage protection	-	-	-	-	2
Residual overvoltage protection	-	-	3	-	3
Directional reactive power undervoltage protection	-	-	-	-	2
Reverse power/directional overpower protection	-	-	-	-	3
Frequency gradient protection	-	-	-	-	5
Overfrequency protection	-	-	-	-	5
Underfrequency protection	-	-	-	-	5
Load shedding	-	-	-	-	6
Circuit breaker failure protection	1	1	1	1	2

Table 2. Functions used in preconfigurations, continued

Description	A	B	C	D	n
Tripping logic	1	1	1	1	2
Multipurpose analog protection	-	-	-	-	16
Protection-related functions					
Local acceleration logic	-	-	1	-	1
Communication logic for residual overcurrent	-	-	1	-	1
Scheme communication logic	-	-	1	-	1
Current reversal and WEI logic	-	-	1	-	1
Current reversal and WEI logic for residual overcurrent	-	-	1	-	1
Control					
Bay control	1	1	1	1	1
Interlocking interface	4	4	4	1	10
Circuit breaker/disconnector control	4	4	4	1	10
Circuit breaker	1	1	1	1	2
Disconnector	3	3	3	-	8
Local/remote switch interface	-	-	-	-	1
Synchrocheck	-	-	-	-	1
Generic process I/O					
Single point control (8 signals)	-	-	-	-	5
Double point indication	-	-	-	-	15
Single point indication	-	-	-	-	64
Generic measured value	-	-	-	-	15
Logic Rotating Switch for function selection and LHMI presentation	-	-	-	-	10
Selector mini switch	-	-	-	-	10
Pulse counter for energy metering	-	-	-	-	4
Event counter	-	-	-	-	1
Supervision and monitoring					
Runtime counter for machines and devices	-	-	-	-	1
Circuit breaker condition monitoring	1	1	1	1	2
Fuse failure supervision	1	1	1	-	2
Current circuit supervision	1	1	1	-	2
Trip-circuit supervision	3	3	3	3	3
Station battery supervision	-	-	-	-	1
Energy monitoring	-	-	-	-	1
Measured value limit supervision	-	-	-	-	40
Power quality					
Voltage variation	-	-	-	-	1
Voltage unbalance	-	-	-	-	1
Current harmonics	-	-	-	-	1

Table 2. Functions used in preconfigurations, continued

Description	A	B	C	D	n
Voltage harmonics (phase-to-phase)	-	-	-	-	1
Voltage harmonics (phase-to-earth)	-	-	-	-	1
Measurement					
Three-phase current measurement	1	1	1	1	1
Three-phase voltage measurement (phase-to-earth)	1	1	1	1	2
Three-phase voltage measurement (phase-to-phase)	-	-	-	-	2
Residual current measurement	1	1	1	1	1
Residual voltage measurement	1	1	1	-	1
Power monitoring with P, Q, S, power factor, frequency	1	1	1	1	1
Sequence current measurement	1	1	1	1	1
Sequence voltage measurement	1	1	1	1	1
Disturbance recorder function					
Analog channels 1-10 (samples)	1	1	1	1	1
Analog channels 11-20 (samples)	-	-	-	-	1
Analog channels 21-30 (calc. val.)	-	-	-	-	1
Analog channels 31-40 (calc. val.)	-	-	-	-	1
Binary channels 1-16	1	1	1	1	1
Binary channels 17-32	1	1	1	1	1
Binary channels 33-48	1	1	1	1	1
Binary channels 49-64	1	-	1	-	1
Station communication (GOOSE)					
Binary receive	-	-	-	-	10
Double point receive	-	-	-	-	32
Interlock receive	-	-	-	-	59
Integer receive	-	-	-	-	32
Measured value receive	-	-	-	-	60
Single point receive	-	-	-	-	64

n = total number of available function instances regardless of the preconfiguration selected
1, 2, ... = number of included instances

4. Protection functions

The IED offers selective short-circuit and overcurrent protection including three-phase non-directional overcurrent protection with four independent stages, and three-phase directional overcurrent protection with three independent stages. In addition, the IED includes three-phase current inrush detection for blocking selected overcurrent protection stages or temporarily increasing the setting values. The included thermal overload protection function uses thermal models of overhead lines and cables. The negative-sequence overcurrent protection, with two independent stages, is used for phase-unbalance protection. In addition, the IED offers phase discontinuity.

Further, the IED features selective earth-fault and cross country fault protection for isolated neutral, and for resistance and/or impedance earthed neutral systems including solidly earthed neutral systems. The earth-fault protection includes non-directional earth-fault protection with three independent stages and directional earth-fault protection with four independent stages. Apart from the conventional earth-fault protection, the IED offers wattmetric, admittance-based and harmonics-based earth-fault protection.

The included transient/intermittent earth-fault protection is based on detection of earth-fault transients related to continuous or intermittent faults. Intermittent earth-fault is a special type of earth-fault encountered in compensated networks with underground cables. In solidly earthed or compensated networks the transient earth-fault protection function detects earth-faults with low fault resistance.

Multi-frequency admittance-based earth-fault protection provides selective directional earth-fault protection for high-impedance earthed networks. The operation is based on multi-frequency neutral admittance measurement utilizing fundamental frequency and harmonic components in Uo and Io. A special filtering algorithm enables dependable and secure fault direction also during intermittent/restriking earth faults. It provides a very good combination of reliability and sensitivity of protection with a single function for low ohmic and higher ohmic earth faults and for transient and intermittent/restriking earth faults.

The residual overvoltage protection, with three independent stages, is used for earth-fault protection of the substation bus and the incoming feeder, and for backup protection of the outgoing feeders.

The IED offers distance protection including both circular (mho) and quadrilateral (quad) zone characteristics, three independent zones with separate reach settings for phase-to-phase and phase-to-earth measuring elements and two zones for controlling autoreclosing of circuit breakers. Further, the IED offers automatic switch-onto-fault logic with voltage and current based detection options.

The IED offers voltage protection functions including three-phase undervoltage and overvoltage protection with three independent stages each, both with phase-to-phase or phase-to-earth measurement. The IED also offers overfrequency, underfrequency and rate-of-change of frequency protection to be used in load shedding and network restoration applications.

The reactive power undervoltage protection (QU) can be used at grid connection point of distributed power generation units.

In addition, the IED offers three-pole multi-shot autoreclose functions for overhead line feeders.

The IED incorporates breaker failure protection for circuit breaker re-tripping or backup tripping for the upstream breaker.

5. Control

The IED incorporates local and remote control functions. The IED offers a number of freely assignable binary inputs/outputs and logic circuits for establishing bay control and interlocking functions for circuit breakers and motor operated switch-disconnectors. The IED supports both single and double busbar substation busbar layouts. The number of controllable primary apparatuses depends on the number of available inputs and outputs in the selected configuration. Besides conventional hardwired signaling also GOOSE messaging according to IEC 61850-8-1 can be used for signal interchange between IEDs to obtain required interlockings.

Further, the IED incorporates a synchro-check function to ensure that the voltage, phase angle and frequency on either side of an open circuit breaker satisfy the conditions for safe interconnection of two networks.

6. Fault location

REF630 features an 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. Under circumstances where 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. An estimate of the fault resistance value is also calculated. The estimate provides information about the possible fault cause and the accuracy of the estimated distance to the fault point.

7. Measurement

The IED continuously measures the phase currents, positive and negative sequence currents and the residual current. The IED also measures phase-to earth or phase-to-phase voltages, positive and negative sequence voltages and the residual voltage. In addition, the IED monitors active, reactive and apparent power, the power factor, power demand value over a user-selectable pre-set time frame as well as cumulative active and reactive energy of both directions. Line frequency, the calculated temperature of the feeder, and the phase unbalance value based on the ratio between the negative sequence and positive sequence current are also calculated. Cumulative and averaging calculations utilize the non-volatile memory available in the IED.

The values measured are accessed locally via the front-panel user interface of the IED or remotely via the communication interface of the IED. The values are also accessed locally or remotely using the web-browser based user interface.

8. Disturbance recorder

The IED is provided with a disturbance recorder featuring up to 40 analog and 64 binary signal channels. The analog channels can be set to record the waveform of the currents and voltage measured. The analog channels can be set to trigger the recording when the measured value falls below or exceeds the set values. The binary signal channels can be set to start a recording on the rising or the falling edge of the binary signal. The binary channels are set to record external or internal IED signals, for example the start or operate signals of the protection functions, or external blocking or control signals. Binary IED signals such as a protection start or trip signal, or an external IED control signal over a binary input can be set to trigger the recording. In addition, the disturbance recorder settings include pre- and post triggering times.

The disturbance recorder can store up to 100 recordings. The number of recordings may vary depending on the length of the recording and the number of signals included. The disturbance recorder controls the Start and Trip LEDs on the front-panel user interface. The operation of the LEDs is fully configurable enabling activation when one or several criteria, that is, protection function starting or tripping, are fulfilled.

The recorded information is stored in a non-volatile memory and can be uploaded for subsequent fault analysis.

9. Power quality

Power quality in standards is defined through the characteristics of the supply voltage. Transients, short- and long-duration voltage variations, unbalance and waveform distortion are the key characteristics describing the power quality. The power quality is, however, a customer-driven issue. It can be said that any power problem concerning the voltage or current that results in a failure or misoperation of the customer equipment is a power quality problem.

REF630 has the following power quality monitoring functions.

- Voltage variation
- Voltage unbalance
- Current harmonics
- Voltage harmonics (phase-to-phase and phase-to-earth)

The harmonics measurement functions are used for monitoring the individual harmonic components (up to 20th) and total harmonic distortion (THD). The current harmonic function also monitors total demand distortion (TDD).

The variation in the voltage waveform is evaluated by measuring voltage swells, dips and interruptions. The voltage variation function includes a single-phase, two-phase and three-phase voltage variation measurement. The voltage unbalance function uses five different methods for calculating voltage unbalance.

- Negative-sequence voltage magnitude
- Zero-sequence voltage magnitude
- Ratio of negative-sequence to positive-sequence voltage magnitude
- Ratio of zero-sequence to positive-sequence voltage magnitude
- Ratio of maximum phase voltage magnitude deviation from the mean voltage magnitude to the mean of phase voltage magnitude

10. Event log

The IED features an event log which enables logging of event information. The event log can be configured to log information according to user pre-defined criteria including IED signals. To collect sequence-of-events (SoE) information, the IED incorporates a non-volatile memory with a capacity of storing 1000 events with associated time stamps and user definable event texts. The non-volatile memory retains its data also in case the IED temporarily loses its auxiliary supply. The event log facilitates detailed pre- and post-fault analyses of faults and disturbances.

The SoE information can be accessed locally via the user interface on the IED front panel or remotely via the communication interface of the IED. The information can further be accessed, either locally or remotely, using the web-browser based user interface.

The logging of communication events is determined by the used communication protocol and the communication engineering. The communication events are automatically sent to station automation and SCADA systems once the required communication engineering has been done.

11. Disturbance report

The disturbance report includes information collected during the fault situation. The report includes general information such as recording time, pre-fault time and post fault time. Further, the report includes pre-fault magnitude, pre-fault angle, fault magnitude and fault angle trip values. By default, the disturbance reports are stored in a non-volatile memory. The numerical disturbance report can be accessed via the local front panel user interface. A more comprehensive disturbance report with waveforms is available using PCM600.

12. Circuit-breaker monitoring

The condition monitoring functions of the IED constantly monitors the performance and the condition of the circuit breaker. The monitoring comprises the spring charging time, SF6 gas pressure, the travel-time, operation counter, accumulated energy calculator, circuit-breaker life estimator and the inactivity time of the circuit breaker.

The monitoring functions provide operational circuit breaker history data, which can be used for scheduling preventive circuit-breaker maintenance.

13. 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 its closed and in its open position. It also detects loss of circuit-breaker control voltage.

14. Self-supervision

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

Self-supervision events are saved into an internal event list which can be accessed locally via the user interface on the IED front panel. The event list can also be accessed using the Web-browser based user interface or PCM600.

15. Fuse failure supervision

The fuse failure supervision detects failures between the voltage measurement circuit and the IED. The failures are detected either by the negative sequence-based algorithm or by the delta voltage and delta current algorithm. Upon the detection of a failure, the fuse failure supervision function activates an alarm and blocks voltage-dependent protection functions from unintended operation.

16. Current circuit supervision

Current circuit supervision is used for detecting faults in the current transformer secondary circuits. On detecting of a fault the current circuit supervision function can also activate an alarm LED and block certain protection functions to avoid unintended operation. The current circuit supervision function calculates the sum of the phase currents and compares the sum with the measured single reference current from a core balance current transformer or from another set of phase current transformers.

17. Access control

To protect the IED from unauthorized access and to maintain information integrity, the IED is provided with an authentication system including user management. Using the IED User Management tool in the Protection and Control IED Manager PCM600, an individual password is assigned to each user by the administrator. Further, the user name is associated to one or more of the four available user groups: System Operator, Protection Engineer, Design Engineer and User Administrator. The user group association for each individual user enables the use of the IED according to the profile of the user group.

18. Inputs and outputs

Depending on the hardware configuration selected, the IED is equipped with three phase-current inputs and one or two residual-current inputs for earth-fault protection. The IED always includes one residual voltage input for directional earth-fault protection or residual voltage protection. Further, the IED includes three phase-voltage inputs for overvoltage, undervoltage and directional overcurrent protection and other voltage based protection functions. Depending on the hardware configuration, the IED also includes a dedicated voltage input for synchrocheck.

The phase-current inputs are rated 1/5 A. The IED is equipped with one or two alternative residual-current inputs, that is 1/5 A or 0.1/0.5 A. The 0.1/0.5 A input is normally used in applications requiring sensitive earth-fault protection and featuring a core-balance current transformer.

The three phase-voltage inputs, for either phase-to-phase voltages or phase-to-earth voltages, and the residual-voltage input cover the rated voltages 100 V, 110 V, 115 V and 120 V. The rated values of the current and voltage inputs are selected in the IED software.

In addition, the binary input thresholds are selected by adjusting the IED's parameter settings. The threshold voltage can be set separately for each binary input.

The optional RTD/mA module facilitates the measurement of up to eight analog signals via the RTD/mA inputs and provides four mA outputs. With RTD sensors the RTD/mA inputs can for instance be used for temperature measurement stator windings, thus extending the functionality of the thermal overload protection and preventing premature aging of the windings. Furthermore, the RTD/mA inputs can be used for measuring the ambient air or cooling media temperature, or bearing temperatures. The RTD/mA inputs can be used for supervision of analog mA signals provided by external transducers. The RTD/mA inputs can be alternatively used also as resistance input or as an input for voltage transducer. The RTD/mA module enables the use of the multipurpose analog protection functions. These protection functions can be used for tripping and alarm purposes based on RTD/mA measuring data, or analog values communicated via GOOSE messaging. The mA outputs can be used for transferring freely selectable measured or calculated analog values to devices provided with mA input capabilities.

The enhanced scalability of the 6U variant IEDs are intended for optimized medium voltage metal-clad switchgear applications where additional binary inputs and outputs are often required.

All binary input and output contacts are freely configurable using the signal matrix of the application configuration function in PCM600.

Please refer to the Input/output overview tables, the selection and ordering data and the terminal diagrams for more detailed information about the inputs and outputs.

Table 3. Analog input configuration

Analog input configuration	CT (1/5 A)	CT sensitive (0.1/0.5 A)	VT	RTD/mA inputs	mA outputs
AA	4	-	5	-	-
AB	4	1	4	-	-
AC	3	1	5	-	-
BA	4	-	5	8	4
BB	4	1	4	8	4
BC	3	1	5	8	4

Table 4. Binary input/output options for 4U variants

Binary I/O options	Binary input configuration	BI	BO
Default	AA	14	9
With one optional binary I/O module	AB	23	18
With two optional binary I/O modules[1)]	AC	32	27

1) Not possible if RTD/mA module is selected.

Table 5. Binary input/output options for 6U variants

Binary I/O options	Binary input configuration	BI	BO
Default	AA	14	9
With one optional binary I/O module	AB	23	18
With two optional binary I/O modules	AC	32	27
With three optional binary I/O modules	AD	41	36
With four optional binary I/O modules[1)]	AE	50	45

1) Not possible if RTD/mA module is selected.

19. Communication

The IED supports the IEC 61850 substation automation standard including horizontal GOOSE communication as well as the well-established DNP3 (TCP/IP) and IEC 60870-5-103 protocols. All operational information and controls are available through these protocols.

Disturbance files are accessed using the IEC 61850 or IEC 60870-5-103 protocols. Disturbance files are also available to any Ethernet based application in the standard COMTRADE format. The IED can send binary signals to other IEDs (so called horizontal communication) using the IEC 61850-8-1 GOOSE (Generic Object Oriented Substation Event) profile. Binary GOOSE messaging can, for example, be employed for protection and interlocking-based protection schemes. The IED meets the GOOSE performance requirements for tripping applications in distribution substations, as defined by the IEC 61850 standard. Further, the IED supports the sending and receiving of analog values using GOOSE messaging. Analog GOOSE messaging enables fast transfer of analog measurement values over the station bus, thus facilitating for example sharing of RTD input values, such as surrounding temperature values, to other IED applications. Analog GOOSE messages can also be used in load shedding applications. The IED interoperates with other IEC 61850 compliant IEDs, tools and systems and simultaneously reports events to five different clients on the IEC 61850 station bus. For a system using DNP3 over TCP/IP, events can be sent to four different masters. For systems using IEC 60870-5-103 IED can be connected to one master in a station bus with star-topology.

All communication connectors, except for the front port connector, are placed on integrated communication modules. The IED is connected to Ethernet-based communication systems via the RJ-45 connector (10/100BASE-TX) or the fibre-optic multimode LC connector (100BASE-FX).

IEC 60870-5-103 is available from optical serial port where it is possible to use serial glass fibre (ST connector) or serial plastic fibre (snap-in connector).

The IED supports the following time synchronization methods with a timestamping resolution of 1 ms.

Ethernet communication based

- SNTP (simple network time protocol)
- DNP3

With special time synchronization wiring
- IRIG-B (Inter-Range Instrumentation Group - Time Code Format B)

IEC 60870-5-103 serial communication has a time-stamping resolution of 10 ms.

Table 6. Supported communication interface and protocol alternatives

Interfaces/protocols[1)]	Ethernet 100BASE-TX RJ-45	Ethernet 100BASE-FX LC	Serial snap-in	Serial ST
IEC 61850	•	•		
DNP3	•	•		
IEC 60870-5-103			•	•

• = Supported

1) Please refer to the Selection and ordering data chapter for more information

20. Technical data

Table 7. Dimensions

Description	Value
Width	220 mm
Height	177 mm (4U) 265.9 mm (6U)
Depth	249.5 mm
Weight box	6.2 kg (4U) 5.5 kg (6U)[1)]
Weight LHMI	1.0 kg (4U)

1) Without LHMI

Table 8. Power supply

Description	600PSM02	600PSM03
U_{aux}nominal	100, 110, 120, 220, 240 V AC, 50 and 60 Hz	48, 60, 110, 125 V DC
	110, 125, 220, 250 V DC	
U_{aux}variation	85...110% of U_n (85...264 V AC)	80...120% of U_n (38.4...150 V DC)
	80...120% of U_n (88...300 V DC)	
Maximum load of auxiliary voltage supply	35 W	
Ripple in the DC auxiliary voltage	Max 15% of the DC value (at frequency of 100 Hz)	
Maximum interruption time in the auxiliary DC voltage without resetting the IED	50 ms at U_{aux}	
Power supply input must be protected by an external miniature circuit breaker	For example, type S282 UC-K. The rated maximum load of aux voltage which is given as 35 watts. Depending on the voltage used, select a suitable MCB based on the respective current. Type S282 UC-K has a rated current of 0.75 A at 400 V AC.	

Table 9. Energizing inputs

Description		Value	
Rated frequency		50/60 Hz	
Operating range		Rated frequency ±5 Hz	
Current inputs	Rated current, I_n	0.1/0.5 A[1)]	1/5 A[2)]
	Thermal withstand capability:		
	• Continuously	4 A	20 A
	• For 1 s	100 A	500 A
	• For 10 s	25 A	100 A
	Dynamic current withstand:		
	• Half-wave value	250 A	1250 A
	Input impedance	<100 mΩ	<20 mΩ
Voltage inputs	Rated voltage, U_n	100 V AC/ 110 V AC/ 115 V AC/ 120 V AC	
	Voltage withstand:		
	• Continuous	425 V AC	
	• For 10 s	450 V AC	
	Burden at rated voltage	<0.05 VA	

1) Residual current
2) Phase currents or residual current

Table 10. Binary inputs

Description	Value
Operating range	Maximum input voltage 300 V DC
Rated voltage	24...250 V DC
Current drain	1.6...1.8 mA
Power consumption/input	<0.3 W
Threshold voltage	15...221 V DC (parametrizable in the range in steps of 1% of the rated voltage)
Threshold voltage accuracy	±3.0%

Table 11. RTD inputs

Description		Value	
RTD inputs	Supported RTD sensor	100 Ω platinum	TCR 0.00385 (DIN 43760)
		250 Ω platinum	TCR 0.00385
		100 Ω nickel	TCR 0.00618 (DIN 43760)
		120 Ω nickel	TCR 0.00618
		10 Ω copper	TCR 0.00427
	Supported resistance range	0…10 kΩ	
	Maximum leadresistance (three-wire measurement)	100 Ω platinum	25 Ω per lead
		250 Ω platinum	25 Ω per lead
		100 Ω nickel	25 Ω per lead
		120 Ω nickel	25 Ω per lead
		10 Ω copper	2.5 Ω per lead
		Resistance	25 Ω per lead
	Isolation	4 kV	Inputs to all outputs and protective earth
	RTD / resistance sensing current	Maximum 0.275 mA rms	
	Operation accuracy / temperature	• ±1°C	Pt and Ni sensors for measuring range -40°C... 200°C and -40°C...70°C ambient temperature
		• ±2°C	CU sensor for measuring range -40°C...200°C in room temperature
		• ±4°C	CU sensors -40°C...70°C ambient temperature
		• ±5°C	From -40°C...-100ºC of measurement range
	Operation accuracy / Resistance	±2.5 Ω	0...400 Ω range
		±1.25%	400 Ω...10KΩ ohms range
	Response time	< Filter time +350 ms	
mA inputs	Supported current range	-20…+20 mA	
	Current input impedance	100 Ω ±0.1%	
	Operation accuracy	±0.1% ±20 ppm per °C of full-scale	Ambient temperature -40°C... 70°C
Voltage inputs	Supported voltage range	-10 V DC...+10 V DC	
	Operation accuracy	±0.1% ±40 ppm per °C of full-scale	Ambient temperature -40°C... 70°C

Table 12. Signal output and IRF output

IRF relay change over - type signal output relay	
Description	**Value**
Rated voltage	250 V AC/DC
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 U < 48/110/220 V DC	≤0.5 A/≤0.1 A/≤0.04 A
Minimum contact load	100 mA at 24 V AC/DC

Table 13. Power output relays without TCS function

Description	Value
Rated voltage	250 V AC/DC
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 U< 48/110/220 V DC	≤1 A/≤0.3 A/≤0.1 A
Minimum contact load	100 mA at 24 V AC/DC

Table 14. Power output relays with TCS function

Description	Value
Rated voltage	250 V DC
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 U < 48/110/220 V DC	≤1 A/≤0.3 A/≤0.1 A
Minimum contact load	100 mA at 24 V DC
Control voltage range	20...250 V DC
Current drain through the supervision circuit	~1.0 mA
Minimum voltage over the TCS contact	20 V DC

Table 15. mA outputs

Description		Value
mA outputs	Output range	-20 mA…+20 mA
	Operation accuracy	±0.2 mA
	Maximum load (including wiring resistance)	700 Ω
	Hardware response time	~80 ms
	Isolation level	4 kV

Table 16. Ethernet interfaces

Ethernet interface	Protocol	Cable	Data transfer rate
LAN1 (X1)	TCP/IP protocol	Fibre-optic cable with LC connector or shielded twisted pair CAT 5e cable or better	100 MBits/s

Table 17. LAN (X1) fibre-optic communication link

Wave length	Fibre type	Connector	Permitted path attenuation[1)]	Distance
1300 nm	MM 62.5/125 μm or MM 50/125 μm glass fibre core	LC	<7.5 dB	2 km

1) Maximum allowed attenuation caused by connectors and cable together

Table 18. X4/IRIG-B interface

Type	Protocol	Cable
Screw terminal, pin row header	IRIG-B	Shielded twisted pair cable Recommended: CAT 5, Belden RS-485 (9841- 9844) or Alpha Wire (Alpha 6222-6230)

Table 19. X9 Optical serial interface characteristics

Wave length	Fibre type	Connector	Permitted path attenuation	Distance
820 nm	MM 62.5/125	ST	4 dB/km	1000 m
820 mm	MM 50/125	ST	4 dB/km	400 m
660 mm	1 mm	Snap-in		10 m

Table 20. Degree of protection of flush-mounted IED

Description	Value
Front side	IP 40
Rear side, connection terminals	IP 20

Table 21. Degree of protection of the LHMI

Description	Value
Front and side	IP 42

Table 22. Environmental conditions

Description	Value
Operating temperature range	-25...+55ºC (continuous)
Short-time service temperature range	-40...+70ºC (<16h) Note: Degradation in MTBF and HMI performance outside the temperature range of -25...+55ºC
Relative humidity	<93%, non-condensing
Atmospheric pressure	86...106 kPa
Altitude	up to 2000 m
Transport and storage temperature range	-40...+85ºC

Table 23. Environmental tests

Description	Type test value	Reference
Dry heat test (humidity <50%)	• 96 h at +55ºC • 16 h at +85ºC	IEC 60068-2-2
Cold test	• 96 h at -25ºC • 16 h at -40ºC	IEC 60068-2-1
Damp heat test, cyclic	• 6 cycles at +25…55°C, Rh >93%	IEC 60068-2-30
Storage test	• 96 h at -40ºC • 96 h at +85ºC	IEC 60068-2-1 IEC 60068-2-2

Table 24. Electromagnetic compatibility tests

Description	Type test value	Reference
100 kHz and 1 MHz burst disturbance test		IEC 61000-4-18, level 3 IEC 60255-22-1
• Common mode	2.5 kV	
• Differential mode	1.0 kV	
3 MHz, 10 MHz and 30 MHz burst disturbance test		IEC 61000-4-18 IEC 60255-22-1, class III
• Common mode	2.5 kV	
Electrostatic discharge test		IEC 61000-4-2, level 4 IEC 60255-22-2 IEEE C37.90.3.2001
• Contact discharge	8 kV	
• Air discharge	15 kV	
Radio frequency interference tests		
• Conducted, common mode	10 V (rms), f=150 kHz...80 MHz	IEC 61000-4-6 , level 3 IEC 60255-22-6
• Radiated, pulse-modulated	10 V/m (rms), f=900 MHz	ENV 50204 IEC 60255-22-3
• Radiated, amplitude-modulated	10 V/m (rms), f=80...2700 MHz	IEC 61000-4-3, level 3 IEC 60255-22-3
Fast transient disturbance tests		IEC 61000-4-4 IEC 60255-22-4, class A
• All ports	4 kV	
Surge immunity test		IEC 61000-4-5, level 3/2 IEC 60255-22-5
• Communication	1 kV line-to-earth	
• Binary inputs, voltage inputs	2 kV line-to-earth 1 kV line-to-line	
• Other ports	4 kV line-to-earth, 2 kV line-to-line	
Power frequency (50 Hz) magnetic field		IEC 61000-4-8
• 1...3 s	1000 A/m	
• Continuous	300 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	
Power frequency immunity test	Binary inputs only	IEC 60255-22-7, class A IEC 61000-4-16
• 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

Table 24. Electromagnetic compatibility tests, continued

Description	Type test value	Reference
Voltage dips and short interruptions	30%/10 ms 60%/100 ms 60%/1000 ms >95%/5000 ms	IEC 61000-4-11
Electromagnetic emission tests		EN 55011, class A IEC 60255-25
• Conducted, RF-emission (mains terminal)		
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 RF-emission		
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	

Table 25. Insulation tests

Description	Type test value	Reference
Dielectric tests • Test voltage	2 kV, 50 Hz, 1 min 500 V, 50 Hz, 1 min, communication	IEC 60255-5 IEC 60255-27
Impulse voltage test • Test voltage	5 kV, 1.2/50 μs, 0.5 J 1 kV, 1.2/50 μs, 0.5 J, communication	IEC 60255-5 IEC 60255-27
Insulation resistance measurements • Isolation resistance	>100 MΩ, 500 V DC	IEC 60255-5 IEC 60255-27
Protective bonding resistance • Resistance	<0.1Ω, 4 A, 60 s	IEC 60255-27

Table 26. Mechanical tests

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

Table 27. Product safety

Description	Reference
LV directive	2006/95/EC
Standard	EN 60255-27 (2005) EN 60255-1 (2009)

Table 28. EMC compliance

Description	Reference
EMC directive	2004/108/EC
Standard	EN 50263 (2000) EN 60255-26 (2007)

Table 29. RoHS compliance

Description
Complies with RoHS directive 2002/95/EC

Protection functions

Table 30. Three-phase non-directional overcurrent protection (PHxPTOC)

Characteristic		Value
Operation accuracy		At the frequency $f = f_n$
	PHLPTOC	±1.5% of the set value or ±0.002 × I_n
	PHHPTOC and PHIPTOC	±1.5% of 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)2)]	PHIPTOC: I_{Fault} = 2 × set *Start value* I_{Fault} = 10 × set *Start value*	Typically 17 ms (±5 ms) Typically 10 ms (±5 ms)
	PHHPTOC: I_{Fault} = 2 × set *Start value*	Typically 19 ms (±5 ms)
	PHLPTOC: I_{Fault} = 2 × set *Start value*	Typically 23 ms (±15 ms)
Reset time		<45 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 $f = n \times f_n$, where n = 2, 3, 4, 5,… Peak-to-Peak: No suppression P-to-P+backup: No suppression

1) Set *Operate delay time* = 0.02 s, *Operate curve type* = IEC definite time, *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) Includes the delay of the signal output contact
3) Includes the delay of the heavy-duty output contact

Table 31. Three-phase non-directional overcurrent protection (PHxPTOC) main settings

Parameter	Function	Value (Range)	Step
Start Value	PHLPTOC	0.05...5.00 pu	0.01
	PHHPTOC	0.10...40.00 pu	0.01
	PHIPTOC	0.10...40.00 pu	0.01
Time multiplier	PHLPTOC	0.05...15.00	0.01
	PHHPTOC	0.05...15.00	0.01
Operate delay time	PHLPTOC	0.04…200.00 s	0.01
	PHHPTOC	0.02…200.00 s	0.01
	PHIPTOC	0.02…200.00 s	0.01
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	
	PHHPTOC	Definite or inverse time Curve type: 1, 3, 5, 9, 10, 12, 15, 17	
	PHIPTOC	Definite time	

1) For further reference, see Operation characteristics table

Table 32. Three-phase directional overcurrent protection (DPHxPDOC)

Characteristic		Value
Operation accuracy		At the frequency $f = f_n$
	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)]	I_{Fault} = 2.0 × set *Start value*	Typically 24 ms (±15 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 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 P-to-P+backup: No suppression

1) *Measurement mode* = default (depends of 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) 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 33. Three-phase directional overcurrent protection (DPHxPDOC) main settings

Parameter	Function	Value (Range)	Step
Start value	DPHLPDOC	0.05...5.00 pu	0.01
	DPHHPDOC	0.05...5.00 pu	0.01
Time multiplier	DPHxPDOC	0.05...15.00	0.01
Operate delay time	DPHxPDOC	0.04...200.00 s	0.01
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, refer to the Operation characteristics table

Table 34. Distance protection (DSTPDIS)

Characteristic	Value
Operation accuracy	At the frequency $f = f_n$
	Current: ±1.5% of the set value or ±0.003 × I_n Voltage: ±1.0% of the set value or ±0.003 × U_n Impedance: ±2.0% of the set value or ±0.01 Ω static accuracy Phase angle: ±2°
Start time [1)2)] SIR[3)]: 0.1...60	Typically 40...50 ms (±15 ms)
Transient overreach SIR = 0.1...60	<6%
Reset time	<65 ms
Reset ratio	Typically 0.95/1.05
Operate time accuracy	±1.0% of the set value or ±20 ms

1) Includes the delay of the signal output contact
2) Relates to start signals of the Zone Z1–Zone ZAR2
3) SIR = Source impedance ratio

Table 35. Distance protection (DSTPDIS) main settings

Parameter	Function	Value (Range)	Steps
Phase voltage Meas	DSTPDIS	Accurate PP without Uo	-
System grounding GFC	DSTPDIS	High impedance Low impedance From input	-
Phase Sel mode GFC	DSTPDIS	Overcurrent Voltdep overcur Under impedance Overcur/underZ	-
EF detection Mod GFC	DSTPDIS	Io Io OR Uo Io AND Uo Io AND Ioref	-
Operate delay GFC	DSTPDIS	0.100...60.000 s	0.001
Ph Str A Ph Sel GFC	DSTPDIS	0.10...10.00 pu	0.01
Ph Lo A Ph Sel GFC	DSTPDIS	0.10...10.00 pu	0.01
Ph V Ph Sel GFC	DSTPDIS	0.10...1.00 pu	0.01
PP V Ph Sel GFC	DSTPDIS	0.10...1.00 pu	0.01
Z Chr Mod Ph Sel GFC	DSTPDIS	Quadrilateral Mho (circular)	-
Load Dsr mode GFC	DSTPDIS	Off On	-
X Gnd Fwd reach GFC	DSTPDIS	0.01...3000.00 Ω	0.01
X Gnd Rv reach GFC	DSTPDIS	0.01...3000.00 Ω	0.01
Ris Gnd Rch GFC	DSTPDIS	0.01...500.00 Ω	0.01
X PP Fwd reach GFC	DSTPDIS	0.01...3000.00 Ω	0.01
X PP Rv reach GFC	DSTPDIS	0.01...3000.00 Ω	0.01
Resistive PP Rch GFC	DSTPDIS	0.01...100.00 Ω	0.01
Ris reach load GFC	DSTPDIS	1.00...3000.00 Ω	0.01
Angle load area GFC	DSTPDIS	5...45°	1
Z Max Ph load GFC	DSTPDIS	1.00...10000.00 Ω	0.01
Gnd Op current GFC	DSTPDIS	0.01...10.00 pu	0.01
Gnd Op A Ref GFC	DSTPDIS	0.01...10.00 pu	0.01
Gnd Str voltage GFC	DSTPDIS	0.02...1.00 pu	0.01
Ph Prf mode Hi Z GFC	DSTPDIS	No filter No preference Cyc A-B-C-A Cyc A-C-B-A Acyc A-B-C Acyc A-C-B Acyc B-A-C Acyc B-C-A Acyc C-A-B Acyc C-B-A	-

Table 35. Distance protection (DSTPDIS) main settings, continued

Parameter	Function	Value (Range)	Steps
Ph Prf mode Lo Z GFC	DSTPDIS	All loops PE only PP only BLK leading PE BLK lagging PE	-
Gnd Op A XC GFC	DSTPDIS	0.10...10.00 pu	0.01
PP voltage XCF GFC	DSTPDIS	0.10...1.00 pu	0.01
Cross-country Dl GFC	DSTPDIS	0.00...10.00 s	0.01
Impedance mode Zn	DSTPDIS	Rectangular Polar	-
Impedance Chr Gnd Zn	DSTPDIS	Quadrilateral Mho (circular) Mho dir line Offset dir line Bullet (combi)	-
Impedance Chr PP Zn	DSTPDIS	Quadrilateral Mho (circular) Mho dir line Offset dir line Bullet (combi)	-
Max phase angle zone	DSTPDIS	0...45°	1
Min phase angle zone	DSTPDIS	90...135°	1
Pol quantity zone	DSTPDIS	Pos. seq. volt. Self pol Cross Pol	-
Directional mode Zn1	DSTPDIS	Non-directional Forward Reverse	-
Op Mod PP loops Zn1	DSTPDIS	Disabled Enabled	-
PP Op delay Mod Zn1	DSTPDIS	Disabled Enabled	-
R1 zone 1	DSTPDIS	0.01...3000.00 Ω	0.01
X1 zone 1	DSTPDIS	0.01...3000.00 Ω	0.01
X1 reverse zone 1	DSTPDIS	0.01...3000.00 Ω	0.01
Z1 zone 1	DSTPDIS	0.01...3000.00 Ω	0.01
Z1 angle zone 1	DSTPDIS	15...90°	1
Z1 reverse zone 1	DSTPDIS	0.01...3000.00 Ω	0.01
Min Ris PP Rch Zn1	DSTPDIS	0.01...100.00 Ω	0.01
Max Ris PP Rch Zn1	DSTPDIS	0.01...100.00 Ω	0.01
R0 zone 1	DSTPDIS	0.01...3000.00 Ω	0.01
X0 zone 1	DSTPDIS	0.01...3000.00 Ω	0.01
Factor K0 zone 1	DSTPDIS	0.0...4.0	0.1
Factor K0 angle Zn1	DSTPDIS	-135...135°	1

Table 35. Distance protection (DSTPDIS) main settings, continued

Parameter	Function	Value (Range)	Steps
Min Ris Gnd Rch Zn1	DSTPDIS	0.01...500.00 Ω	0.01
Max Ris Gnd Rch Zn1	DSTPDIS	0.01...500.00 Ω	0.01
Gnd operate Dl Zn1	DSTPDIS	0.030...60.000 s	0.001

Table 36. Automatic switch-onto-fault function (CVRSOF)

Characteristic	Value
Operation accuracies	At the frequency $f = f_n$
	Current: ±1.5% of the set value or $\pm 0.002 \times I_n$ Voltage: ±1.5% of the set value or $\pm 0.002 \times U_n$
Operate time accuracy	±1.0% of the set value or ±35 ms
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$, where n = 2, 3, 4, 5,…

Table 37. Fault locator (SCEFRFLO)

Characteristic	Value
Operation accuracies	At the frequency $f = f_n$
	Current: ±1.5% of the set value or $\pm 0.002 \times I_n$ Voltage: ±1.5% of the set value or $\pm 0.002 \times U_n$ Fault location accuracy: ±2.5% of the line length or ±0.2 km/0.13 mile. Actual fault location accuracy depends on the fault and the power system characteristics.
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$, where n = 2, 3, 4, 5,…

Table 38. Fault locator (SCEFRFLO) main settings

Parameter	Function	Value (Range)	Step
Phase voltage Meas	SCEFRFLO	Accurate PP without Uo	-
Calculation Trg mode	SCEFRFLO	External Internal Continuous	-
Pre fault time	SCEFRFLO	0.100...300.000 s	0.001
Z Max phase load	SCEFRFLO	1.00...10000.00 Ω	0.01
Ph leakage Ris	SCEFRFLO	1...1000000 Ω	1
Ph capacitive React	SCEFRFLO	1...1000000 Ω	1
R1 line section A	SCEFRFLO	0.001...1000.000 Ω/pu	0.001
X1 line section A	SCEFRFLO	0.001...1000.000 Ω/pu	0.001
R0 line section A	SCEFRFLO	0.001...1000.000 Ω/pu	0.001
X0 line section A	SCEFRFLO	0.001...1000.000 Ω/pu	0.001
Line Len section A	SCEFRFLO	0.001...1000.000 pu	0.001

Table 39. Autoreclosing (DARREC)

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

Table 40. Non-directional earth-fault protection (EFxPTOC)

Characteristic		Value
Operation accuracy		At the frequency f = f_n
	EFLPTOC	±1.5% of the set value or ±0.001 × I_n
	EFHPTOC and EFIPTOC	±1.5% of 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)2)]	EFIPTOC: I_{Fault} = 2 × set *Start value*	Typically 12 ms (±5 ms)
	EFHPTOC: I_{Fault} = 2 × set *Start value*	Typically 19 ms (±5 ms)
	EFLPTOC: I_{Fault} = 2 × set *Start value*	Typically 23 ms (±15 ms)
Reset time		<45 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) *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 41. Non-directional earth-fault protection (EFxPTOC) main settings

Parameter	Function	Value (Range)	Step
Start value	EFLPTOC	0.010...5.000 pu	0.005
	EFHPTOC	0.10...40.00 pu	0.01
	EFIPTOC	0.10...40.00 pu	0.01
Time multiplier	EFLPTOC	0.05...15.00	0.01
	EFHPTOC	0.05...15.00	0.01
Operate delay time	EFLPTOC	0.04...200.00 s	0.01
	EFHPTOC	0.02...200.00 s	0.01
	EFIPTOC	0.02...200.00 s	0.01
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 Operation characteristics table

Table 42. Directional earth-fault protection (DEFxPDEF)

Characteristic		Value
Operation accuracy		At the frequency $f = f_n$
	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)	DEFHPDEF and DEFLPTDEF: I_{Fault} = 2 × set *Start value*	Typically 54 ms (±15 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 delay time* = 0.06 s, *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 to 20

Table 43. Directional earth-fault protection (DEFxPDEF) main settings

Parameter	Function	Value (Range)	Step
Start Value	DEFLPDEF	0.010...5.000 pu	0.005
	DEFHPDEF	0.10...40.00 pu	0.01
Directional mode	DEFLPDEF and DEFHPDEF	1=Non-directional 2=Forward 3=Reverse	
Time multiplier	DEFLPDEF	0.05...15.00	0.01
	DEFHPDEF	0.05...15.00	0.01
Operate delay time	DEFLPDEF	0.06...200.00 s	0.01
	DEFHPDEF	0.06...200.00 s	0.01
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	DEFLPDEF and DEFHPDEF	1=Phase angle 2=IoSin 3=IoCos 4=Phase angle 80 5=Phase angle 88	

1) For further reference, refer to the Operation characteristics table

Table 44. Harmonics based earth-fault protection (HAEFPTOC)

Characteristic	Value
Operation accuracy	At the frequency $f = f_n$ ±5% of the set value or $\pm 0.004 \times I_n$
Start time [1)2)]	Typically 83 ms
Reset time	<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	-80 dB at $f = f_n$ -3 dB at $f = 11 \times f_n$

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

Table 45. Harmonics based earth-fault protection (HAEFPTOC) main settings

Parameter	Function	Value (Range)	Step
Start value	HAEFPTOC	0.05...5.00 pu	0.01
Time multiplier	HAEFPTOC	0.05...15.00	0.01
Operating curve type	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	
Operate delay time	HAEFPTOC	0.10...200.00 s	0.01
Minimum operate time	HAEFPTOC	0.10...200.00 s	0.01

Table 46. Transient/intermittent earth-fault protection (INTRPTEF)

Characteristic	Value
Operation accuracy (Uo criteria with transient protection)	At the frequency $f = f_n$
	±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 $f = n \times f_n$, where n = 2, 3, 4, 5

Table 47. 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	0.04...1200.00 s	0.01
Voltage start value (voltage start value for transient EF)	INTRPTEF	0.005...0.500 pu	0.001
Operation mode	INTRPTEF	1=Intermittent EF 2=Transient EF	-
Peak counter limit (Min requirement for peak counter before start in IEF mode)	INTRPTEF	2...20	-
Min operate current	INTRPTEF	0.01...1.00 × In	0.01

Table 48. 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)]	Typically 65 ms (±15 ms)
Reset time	<50 ms
Operate time accuracy in definite time mode	±1.0% of the set value or ±20 ms
Suppression of harmonics	-50dB at $f = n \times f_n$, 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 unearthed network.
2) Includes the delay of the signal output contact. Results based on statistical distribution of 1000 measurements.

Table 49. Admittance-based earth-fault protection (EFPADM) main settings

Parameter	Function	Value (Range)	Step
Operation mode	EFPADM	Yo Go Bo Yo, Go Yo, Bo Go, Bo Yo, Go, Bo	-
Directional mode	EFPADM	Non-directional Forward Reverse	-
Voltage start value	EFPADM	0.01...2.00 pu	0.01
Circle conductance	EFPADM	-500.00...500.00 mS	0.01
Circle susceptance	EFPADM	-500.00...500.00 mS	0.01
Circle radius	EFPADM	0.05...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
Operate delay time	EFPADM	0.06...200.00 s	0.01

Table 50. Multi-frequency admittance-based earth-fault protection (MFADPSDE)

Characteristic	Value
Operation accuracy	At the frequency $f = f_n$ ±1.5% of the set value or ±0.002 × U_n
Start time [1)]	Typically 50 ms (±10 ms)
Reset time	<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 51. Multi-frequency admittance-based earth-fault protection (MFADPSDE) main settings

Parameter	Function	Value (Range)	Step
Directional mode	MFADPSDE	Forward Reverse	-
Voltage start value	MFADPSDE	0.01...1.00 pu	0.01
Operate delay time	MFADPSDE	0.06...200.00 s	0.01
Operating quantity	MFADPSDE	Adaptive Amplitude	-
Operation mode	MFADPSDE	Intermittent EF General EF Alarming EF	-
Min Fwd Op current	MFADPSDE	0.01...1.00 pu	0.01
Min Rev Op current	MFADPSDE	0.01...1.00 pu	0.01
Peak counter limit	MFADPSDE	3...20	1

Table 52. Wattmetric earth-fault protection (WPWDE)

Characteristic	Value
Operation accuracy	At the frequency $f = f_n$
	±3.0% of the set value or ±0.002 × S_n
Start time[1)2)]	Typically 65 ms (±15 ms)
Reset time	<45 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 $f = n \times f_n$, 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 53. Wattmetric earth-fault protection (WPWDE) main settings

Parameter	Function	Value (Range)	Step
Directional mode	WPWDE	Forward Reverse	-
Current start value	WPWDE	0.01...5.00 pu	0.01
Voltage start value	WPWDE	0.010...1.000 pu	0.001
Power start value	WPWDE	0.003...1.000 pu	0.001
Reference power	WPWDE	0.050...1.000 pu	0.001
Characteristic angle	WPWDE	-179...180°	1
Time multiplier	WPWDE	0.05...2.00	0.01
Operating curve type	WPWDE	ANSI Def. Time IEC Def. Time WattMetric IDMT	-
Operate delay time	WPWDE	0.06...200.00 s	0.01

Table 54. Phase discontinuity protection (PDNSPTOC)

Characteristic	Value
Operation accuracy	At the frequency $f = f_n$
	±2% of the set value
Start time	Typically 15 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 or ±20 ms
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$, where n = 2, 3, 4, 5,…

Table 55. Phase discontinuity protection (PDNSPTOC) main settings

Parameter	Function	Value (Range)	Step
Start value (Current ratio setting I_2/I_1)	PDNSPTOC	10...100%	1
Operate delay time	PDNSPTOC	0.100...30.000 s	0.001
Min phase current	PDNSPTOC	0.05...0.30 pu	0.01

Table 56. Negative-sequence overcurrent protection (NSPTOC)

Characteristic		Value
Operation accuracy		At the frequency $f = f_n$
		±1.5% of the set value or ±0.002 × I_n
Start time [1)2)]	I_{Fault} = 2 × set *Start value* I_{Fault} = 10 × set *Start value*	Typically 23 ms (±15 ms) Typically 16 ms (±15 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 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) *Operate curve type* = IEC definite time, negative sequence current before fault = 0.0, f_n = 50 Hz
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 to 20

Table 57. Negative-sequence overcurrent protection (NSPTOC) main settings

Parameter	Function	Value (Range)	Step
Start value	NSPTOC	0.01...5.00 pu	0.01
Time multiplier	NSPTOC	0.05...15.00	0.01
Operate delay time	NSPTOC	0.04...200.00 s	0.01
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 Operation characteristics table

Table 58. Three-phase thermal overload protection for feeder (T1PTTR)

Characteristic	Value
Operation accuracy	At the frequency $f = f_n$
	Current measurement: ±0.5% 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% or ±0.50 s

1) Overload current > 1.2 × Operate level temperature, *Current reference* > 0.50 pu

Table 59. Three-phase thermal overload protection for feeder (T1PTTR) main settings

Parameter	Function	Value (Range)	Step
Env temperature Set (Ambient temperature used when the AmbSens is set to Off)	T1PTTR	50...100°	1
Current multiplier (Current multiplier when function is used for parallel lines)	T1PTTR	1...5	1
Current reference	T1PTTR	0.05...4.00 pu	0.01
Temperature rise (End temperature rise above ambient)	T1PTTR	0.0...200.0°	0.1
Time constant (Time constant of the line in seconds)	T1PTTR	1...1000 min	1
Maximum temperature (temperature level for operate)	T1PTTR	20.0...200.0°	0.1
Alarm value (Temperature level for start (alarm)	T1PTTR	20.0...150.0°	0.1
Reclose temperature (Temperature for reset of block reclose after operate)	T1PTTR	20.0...150.0°	0.1
Initial temperature (Temperature raise above ambient temperature at startup)	T1PTTR	-50.0...100.0°	0.1

Table 60. Three-phase current inrush detection (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	+30 ms / -0 ms

Table 61. Three-phase current inrush detection (INRPHAR) main settings

Parameter	Function	Value (Range)	Step
Start value (Ratio of the 2nd to the 1st harmonic leading to restraint)	INRPHAR	5...100%	1
Operate delay time	INRPHAR	0.02...60.00 s	0.001

Table 62. Three-phase overvoltage protection (PHPTOV)

Characteristic		Value
Operation accuracy		At the frequency $f = f_n$
		±1.5% of the set value or ±0.002 × U_n
Start time[1)2)]	U_{Fault} = 2.0 × set *Start value*	Typically 17 ms (±15 ms)
Reset time		<40 ms
Reset ratio		Depends of 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
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 63. Three-phase overvoltage protection (PHPTOV) main settings

Parameter	Function	Value (Range)	Step
Start value	PHPTOV	0.05...1.60 pu	0.01
Time multiplier	PHPTOV	0.05...15.00	0.01
Operate delay time	PHPTOV	0.40...300.000 s	0.10
Operating curve type[1)]	PHPTOV	Definite or inverse time Curve type: 5, 15, 17, 18, 19, 20	

1) For further reference, see Operation characteristics table

Table 64. Three-phase undervoltage protection (PHPTUV)

Characteristic		Value
Operation accuracy		At the frequency $f = f_n$
		±1.5% of the set value or ±0.002 × U_n
Start time[1)2)]	U_{Fault} = 0.9 × set *Start value*	Typically 24 ms (±15 ms)
Reset time		<40 ms
Reset ratio		Depends of 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
2) Includes the delay of the signal output contact
3) Minimum *Start value* = 0.50 × U_n, *Start value* multiples in range of 0.90...0.20

Table 65. Three-phase undervoltage protection (PHPTUV) main settings

Parameter	Function	Value (Range)	Step
Start value	PHPTUV	0.05...1.20 pu	0.01
Time multiplier	PHPTUV	0.05...15.00	0.01
Operate delay time	PHPTUV	0.040...300.000 s	0.010
Operating curve type[1]	PHPTUV	Definite or inverse time Curve type: 5, 15, 21, 22, 23	

1) For further reference, see Operation characteristics table

Table 66. Positive-sequence overvoltage protection (PSPTOV)

Characteristic		Value
Operation accuracy		At the frequency $f = f_n$
		±1.5% of the set value or ±0.002 × U_n
Start time[1)2)]	U_{Fault} = 1.1 × set *Start value* U_{Fault} = 2.0 × set *Start value*	Typically 29 ms (±15 ms) Typically 24 ms (±15 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 or ±20 ms
Suppression of harmonics		DFT: -50 dB at $f = n \times f_n$, 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) Includes the delay of the signal output contact

Table 67. Positive-sequence overvoltage protection (PSPTOV) main settings

Parameter	Function	Value (Range)	Step
Start value	PSPTOV	0.800...1.600 pu	0.001
Operate delay time	PSPTOV	0.040...120.000 s	0.001

Table 68. Positive-sequence undervoltage protection (PSPTUV)

Characteristic		Value
Operation accuracy		At the frequency $f = f_n$
		±1.5% of the set value or ±0.002 × U_n
Start time[1)2)]	U_{Fault} = 0.9 × set *Start value*	Typically 28 ms (±15 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 or ±20 ms
Suppression of harmonics		DFT: -50 dB at $f = n \times f_n$, where n = 2, 3, 4, 5,…

1) Positive-sequence voltage before fault = 1.1 × U_n, f_n = 50 Hz, positive-sequence undervoltage of nominal frequency injected from random phase angle
2) Includes the delay of the signal output contact

Table 69. Positive-sequence undervoltage protection (PSPTUV) main settings

Parameter	Function	Value (Range)	Step
Start value	PSPTUV	0.010...1.200 pu	0.001
Operate delay time	PSPTUV	0.040...120.000 s	0.001
Voltage block value	PSPTUV	0.01...1.0 pu	0.01

Table 70. Negative-sequence overvoltage protection (NSPTOV)

Characteristic		Value
Operation accuracy		At the frequency $f = f_n$
		±1.5% of the set value or $\pm 0.002 \times U_n$
Start time[1)2)]	$U_{Fault} = 1.1 \times$ set *Start value* $U_{Fault} = 2.0 \times$ set *Start value*	Typically 29 ms (± 15ms) Typically 24 ms (± 15ms)
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
Suppression of harmonics		DFT: -50 dB at $f = n \times f_n$, where n = 2, 3, 4, 5,…

1) Negative-sequence voltage before fault = $0.0 \times U_n$, f_n = 50 Hz, negative-sequence overvoltage of nominal frequency injected from random phase angle
2) Includes the delay of the signal output contact

Table 71. Negative-sequence overvoltage protection (NSPTOV) main settings

Parameter	Function	Value (Range)	Step
Start value	NSPTOV	0.010...1.000 pu	0.001
Operate delay time	NSPTOV	0.040...120.000 s	0.001

Table 72. Residual overvoltage protection (ROVPTOV)

Characteristic		Value
Operation accuracy		At the frequency $f = f_n$
		±1.5% of the set value or $\pm 0.002 \times U_n$
Start time[1)2)]	$U_{Fault} = 1.1 \times$ set *Start value*	Typically 27 ms (± 15 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 or ±20 ms
Suppression of harmonics		DFT: -50 dB at $f = n \times f_n$, where n = 2, 3, 4, 5,…

1) Residual voltage before fault = $0.0 \times U_n$, f_n = 50 Hz, residual voltage with nominal frequency injected from random phase angle
2) Includes the delay of the signal output contact

Table 73. Residual overvoltage protection (ROVPTOV) main settings

Parameter	Function	Value (Range)	Step
Start value	ROVPTOV	0.010...1.000 pu	0.001
Operate delay time	ROVPTOV	0.040...300.000 s	0.001

Table 74. Directional reactive power undervoltage protection (DQPTUV)

Characteristic	Value
Operation accuracy	At the frequency $f = f_n$ Power: 1.5% or $0.002 \times Q_n$ (±1.5%) for power, PF -0.71...0.71 Voltage: ±1.5% of the set value or $\pm 0.002 \times U_n$
Start time [1]	Typically 22 ms
Reset time	<40 ms
Reset ratio	Typically 0.96
Operate time accuracy in definite time mode	±1.0% of the set value or ±20 ms
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$, where n = 2, 3, 4, 5 and so on

1) *Start value* = $0.05 \times S_n$, Reactive power before fault = 0.8 × *Start value*. Reactive power overshoot 2 times. Results based on statistical distribution of 1000 measurement.

Table 75. Directional reactive power undervoltage protection (DQPTUV) main settings

Parameter	Function	Value (Range)	Step
Voltage start value	DQPTUV	0.20...1.20 pu	0.01
Operate delay time	DQPTUV	0.1...300.00 s	0.01
Min reactive power	DQPTUV	0.01...0.50 pu	0.01
Min PS current	DQPTUV	0.02...0.20 pu	0.01
Pwr sector reduction	DQPTUV	0.0...10.0°	1.0

Table 76. Frequency gradient protection (DAPFRC)

Characteristic		Value
Operation accuracy		df/dt < ±10 Hz/s: ±10 mHz/s Undervoltage blocking: ±1.5% of the set value or $\pm 0.002 \times U_n$
Start time [1][2]	*Start value* = 0.05 Hz/s df/dt_{FAULT} = ±1.0 Hz/s	Typically 110 ms (±15 ms)
Reset time		<150 ms
Operate time accuracy in definite time mode		±1.0% of the set value or ±30 ms
Suppression of harmonics		DFT: -50 dB at $f = n \times f_n$, where n = 2, 3, 4, 5,…

1) Frequency before fault = $1.0 \times f_n$, f_n = 50 Hz
2) Includes the delay of the signal output contact

Table 77. Frequency gradient protection (DAPFRC) main settings

Parameter	Function	Value (Range)	Step
Start value	DAPFRC	-10.00...10.00 Hz/s	0.01
Operate delay time	DAPFRC	0.120...60.000 s	0.001

Table 78. Overfrequency protection (DAPTOF)

Characteristic		Value
Operation accuracy		At the frequency f = 35...66 Hz
		±0.003 Hz
Start time[1)2)]	f_{Fault} = 1.01 × set *Start value*	Typically <190 ms
Reset time		<190 ms
Operate time accuracy in definite time mode		±1.0% of the set value or ±30 ms
Suppression of harmonics		DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,…

1) Frequency before fault = 0.99 × f_n, f_n = 50 Hz
2) Includes the delay of the signal output contact

Table 79. Overfrequency protection (DAPTOF) main settings

Parameter	Function	Value (Range)	Step
Start value	DAPTOF	35.0...64.0 Hz	0.1
Operate delay time	DAPTOF	0.170...60.000 s	0.001

Table 80. Underfrequency protection (DAPTUF)

Characteristic		Value
Operation accuracy		At the frequency f = 35...66 Hz
		±0.003 Hz
Start time[1)2)]	f_{Fault} = 0.99 × set *Start value*	Typically <190 ms
Reset time		<190 ms
Operate time accuracy in definite time mode		±1.0% of the set value or ±30 ms
Suppression of harmonics		DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,…

1) Frequency before fault = 1.01 × f_n, f_n = 50 Hz
2) Includes the delay of the signal output contact

Table 81. Underfrequency protection (DAPTUF) main settings

Parameter	Function	Value (Range)	Step
Start value	DAPTUF	35.0...64.0 Hz	0.1
Operate delay time	DAPTUF	0.170...60.000 s	0.001

Table 82. Load shedding (LSHDPFRQ)

Characteristic		Value
Operation accuracy		At the frequency f = 35...66 Hz
		±0.003 Hz
Start time[1)2)]	*Load shed mode*	
	Freq<: f_{Fault} = 0.80 × set *Start value*	Typically 175 ms (±15 ms)
	freq< AND dfdt>: df/dt = 0.3 Hz/s	Typically 250 ms (±15 ms)
Reset time		<190 ms
Operate time accuracy in definite time mode		±1.0% of the set value or ±30 ms
Suppression of harmonics		DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,…

1) Frequency before fault = 1.2 × f_n, f_n = 50 Hz
2) Includes the delay of the signal output contact

Table 83. Load shedding (LSHDPFRQ) main settings

Parameter	Function	Value (Range)	Step
Load shed mode	LSHDPFRQ	Freq< freq< AND dfdt> Freq< OR dfdt>	-
Restore mode	LSHDPFRQ	Disabled Auto Manual	-
Start Val frequency	LSHDPFRQ	35.00...60.00 Hz	0.01
Start value df/dt	LSHDPFRQ	0.10...10.00 Hz/s	0.01
Frequency Op delay	LSHDPFRQ	0.08...200.00 s	0.01
Df/dt operate delay	LSHDPFRQ	0.12...60.00 s	0.01
Restore start Val	LSHDPFRQ	45.00...60.00 Hz	0.01
Restore delay time	LSHDPFRQ	0.17...60.00 s	0.01

Table 84. Reverse power/directional overpower protection (DOPPDPR)

Characteristic	Value
Operation accuracy	At the frequency f = f_n
	±3% of the set value or ±0.002 × S_n
Start time[1)2)]	Typically 20 ms (±15 ms)
Reset time	<40 ms
Reset ratio	Typically 0.94
Retardation time	<45 ms
Operate time accuracy	±1.0% of the set value of ±20 ms

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

Table 85. Reverse power/directional overpower protection (DOPPDPR) main settings

Parameter	Function	Value (Range)	Step
Directional mode	DOPPDPR	Forward Reverse	-
Start value	DOPPDPR	0.01...2.00 pu	0.01
Power angle	DOPPDPR	-90.00...90.00°	0.01
Operate delay time	DOPPDPR	0.04...300.00 s	0.01

Table 86. Circuit breaker failure protection (CCBRBRF)

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 ±30 ms

Table 87. Circuit breaker failure protection (CCBRBRF) main settings

Parameter	Function	Value (Range)	Step
Current value (Operating phase current)	CCBRBRF	0.05...1.00 pu	0.01
Current value Res (Operating residual current)	CCBRBRF	0.05...1.00 pu	0.01
CB failure mode (Operating mode of function)	CCBRBRF	1 = Current 2 = Breaker status 3 = Both	-
CB fail trip mode	CCBRBRF	1 = Off 2 = Without check 3 = Current check	-
Retrip time	CCBRBRF	0.00...60.00 s	0.01
CB failure delay	CCBRBRF	0.00...60.00 s	0.01
CB fault delay	CCBRBRF	0.00...60.00 s	0.01

Table 88. Multipurpose analog protection (MAPGAPC)

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

Table 89. Multipurpose analog protection (MAPGAPC) main settings

Parameter	Function	Value (Range)	Step
Operation mode	MAPGAPC	Over Under	-
Start value	MAPGAPC	-10000.0...10000.0	0.1
Start value Add	MAPGAPC	-100.0...100.0	0.1
Operate delay time	MAPGAPC	0.00...200.00 s	0.01

Table 90. 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
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

Protection-related functions

Table 91. Local acceleration logic (DSTPLAL)

Characteristic	Value
Operation accuracy	At the frequency $f = f_n$
	±1.5% of the set value or ±0.002 × 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 92. Local acceleration logic (DSTPLAL) main settings

Parameter	Function	Value (Range)	Step
Load current value	DSTPLAL	0.01...1.00 pu	0.01
Minimum current	DSTPLAL	0.01...1.00 pu	0.01
Minimum current time	DSTPLAL	0.000...60.000 s	0.001
Load release on time	DSTPLAL	0.000...60.000 s	0.001
Load release off Tm	DSTPLAL	0.000...60.000 s	0.001
Loss of load Op	DSTPLAL	Disabled Enabled	-
Zone extension	DSTPLAL	Disabled Enabled	-

Table 93. Communication logic for residual overcurrent (RESCPSCH)

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

Table 94. Communication logic for residual overcurrent (RESCPSCH) main settings

Parameter	Function	Value (Range)	Step
Scheme type	RESCPSCH	Off Intertrip Permissive UR Permissive OR Blocking	-
Coordination time	RESCPSCH	0.000...60.000 s	0.001
Carrier Min Dur	RESCPSCH	0.000...60.000 s	0.001

Table 95. Scheme communication logic (DSOCPSCH)

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

Table 96. Scheme communication logic (DSOCPSCH) main settings

Parameter	Function	Value (Range)	Step
Scheme type	DSOCPSCH	Off Intertrip Permissive UR Permissive OR Blocking	-
Coordination time	DSOCPSCH	0.000...60.000 s	0.001
Carrier dur time	DSOCPSCH	0.000...60.000 s	0.001

Table 97. Current reversal and WEI logic (CRWPSCH)

Characteristic	Value
Operation accuracy	At the frequency $f = f_n$
	±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 $f = n \times f_n$, where n = 2, 3, 4, 5,…

Table 98. Current reversal and WEI logic (CRWPSCH) main settings

Parameter	Function	Value (Range)	Step
Reversal mode	CRWPSCH	Off On	-
Wei mode	CRWPSCH	Off Echo Echo & Trip	-
PhV level for Wei	CRWPSCH	0.10...0.90 pu	0.01
PPV level for Wei	CRWPSCH	0.10...0.90 pu	0.01
Reversal time	CRWPSCH	0.000...60.000 s	0.001
Reversal reset time	CRWPSCH	0.000...60.000 s	0.001
Wei Crd time	CRWPSCH	0.000...60.000 s	0.001

Table 99. Current reversal and WEI logic for residual overcurrent (RCRWPSCH)

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

Table 100. Current reversal and WEI logic for residual overcurrent (RCRWPSCH) main settings

Parameter	Function	Value (Range)	Step
Reversal mode	RCRWPSCH	Off On	-
Wei mode	RCRWPSCH	Off Echo Echo & Trip	-
Residual voltage Val	RCRWPSCH	0.05...0.70 pu	0.01
Reversal time	RCRWPSCH	0.000...60.000 s	0.001
Reversal reset time	RCRWPSCH	0.000...60.000 s	0.001
Wei Crd time	RCRWPSCH	0.000...60.000 s	0.001

Control functions

Table 101. Synchrocheck (SYNCRSYN)

Characteristic	Value
Operation accuracy	At the frequency $f = f_n$
	Voltage: ±1.0% or ±0.002 × U_n Frequency: ±10 mHz Phase angle ±2°
Reset time	<50 ms
Reset ratio	Typically 0.96
Operate time accuracy	+90ms/0 ms

Supervision and monitoring functions

Table 102. Runtime counter for machines and devices (MDSOPT)

Characteristic	Value
Motor run-time measurement accuracy [1]	±0.5%

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

Table 103. 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	Immediate Timed Warn Timed Warn Alm	-

Table 104. Circuit breaker condition monitoring (SSCBR)

Characteristic	Value
Current measuring accuracy	At the frequency $f = f_n$
	±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
Traveling time measurement	±10 ms

Table 105. Fuse failure supervision (SEQRFUF)

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	
Operate time[1]	• NPS function	U_{Fault} = 1.1 × set *Neg Seq voltage Lev* U_{Fault} = 5.0 × set *Neg Seq voltage Lev*	Typically 35 ms (±15 ms) Typically 25 ms (±15 ms)
	• Delta function	ΔU = 1.1 × set *Voltage change rate* ΔU = 2.0 × set *Voltage change rate*	Typically 35 ms (±15 ms) Typically 28 ms (±15 ms)

1) Includes the delay of the signal output contact, f_n = 50 Hz, fault voltage with nominal frequency injected from random phase angle

Table 106. Current circuit supervision (CCRDIF)

Characteristic	Value
Operate time[1]	<30 ms

1) Including the delay of the output contact

Table 107. Current circuit supervision (CCRDIF) main settings

Parameter	Function	Value (Range)	Step
Start value	CCRDIF	0.05...2.00 pu	0.01
Maximum operate current	CCRDIF	0.05...5.00 pu	0.01

Table 108. Trip-circuit supervision (TCSSCBR)

Characteristic	Value
Time accuracy	±1.0% of the set value or ±40 ms

Table 109. Station battery supervision (SPVNZBAT)

Characteristic	Value
Operation accuracy	±1.0% of the set value
Operate time accuracy	±1.0% of the set value or ±40 ms

Table 110. Energy monitoring (EPDMMTR)

Characteristic	Value
Operation accuracy	At all three currents in range 0.10…1.20 × In_n At all three voltages in range 0.50…1.15 × U_n At the frequency $f = f_n$ Active power and energy in range |PF| > 0.71 Reactive power and energy in range |PF| < 0.71
	±1.5% for energy
Suppression of harmonics	DFT: -50 dB at $f = n \times f_n$, where n = 2, 3, 4, 5,…

Power quality functions

Table 111. 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 112. Voltage variation (PHQVVR) main settings

Parameter	Function	Value (Range)	Step
Voltage swell set	PHQVVR	100.0...200.0%	0.1
Voltage dip set	PHQVVR	0.0...100.0%	0.1
Voltage Int set	PHQVVR	0.0...100.0%	0.1
V Var Dur point 1	PHQVVR	0.008...60.000 s	0.001
V Var Dur point 2	PHQVVR	0.008...60.000 s	0.001

Table 113. Voltage unbalance (VSQVUB) main settings

Parameter	Function	Value (Range)	Step
Operation	VSQVUB	Off On	-
Unb detection method	VSQVUB	Negative Seq Zero sequence Neg to Pos Seq Zero to Pos Seq Ph vectors Comp	-

Table 114. Current harmonics (CMHAI) main settings

Parameter	Function	Value (Range)	Step
Operation	CMHAI	Off On	-
Measuring mode	CMHAI	Phase A Phase B Phase C Worst case	-
Low limit	CMHAI	1.0...50%	0.1

Table 115. Voltage harmonics (phase-to-phase) (VPPMHAI) main settings

Parameter	Function	Value (Range)	Step
Operation	VPPMHAI	On Off	-
Measuring mode	VPPMHAI	Phase AB Phase BC Phase CA Worst case	-
Low limit	VPPMHAI	1.0...50%	0.1

Table 116. Voltage harmonics (phase-to-earth) (VPHMHAI) main settings

Parameter	Function	Value (Range)	Step
Operation	VPHMHAI	On Off	-
Measuring mode	VPHMHAI	Phase A Phase B Phase C Worst case	-
Low limit	VPHMHAI	1.0...50%	0.1

Measurement functions

Table 117. Three-phase current measurement (CMMXU)

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 118. Three-phase voltage measurement (phase-to-earth) (VPHMMXU)

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

Table 119. Three-phase voltage measurement (phase-to-phase) (VPPMMXU)

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

Table 120. 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 121. Residual voltage measurement (RESVMMXU)

Characteristic	Value
Operation accuracy	At the frequency f = f_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 122. Power monitoring with P, Q, S, power factor, frequency (PWRMMXU)

Characteristic	Value
Operation accuracy	At all three currents in range 0.10…1.20 × In_n At all three voltages in range 0.50…1.15 × U_n At the frequency f = f_n Active power and energy in range |PF| > 0.71 Reactive power and energy in range |PF| < 0.71
	±1.5% for power (S, P and Q) ±0.015 for power factor
Suppression of harmonics	DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,…

Table 123. Sequence current measurement (CSMSQI)

Characteristic	Value
Operation accuracy	At the frequency f = f_n
	±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 124. Sequence voltage measurement (VSMSQI)

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

21. Front panel user interface

The 630 series IEDs can be ordered with a detached front-panel user interface (HMI). An integrated HMI is available for 4U high housing. The local HMI includes a large graphical monochrome LCD with a resolution of 320 x 240 pixels (width x height). The amount of characters and rows fitting the view depends on the character size as the characters' width and height may vary.

In addition, the local HMI includes dedicated open/close operating buttons and five programmable function buttons with LED indicators. The 15 programmable alarm LEDs can indicate a total of 45 alarms. The local HMI offers full front-panel user-interface functionality with menu navigation, menu views and operational data. In addition, the local HMI can, using PCM600, be configured to show a single-line diagram (SLD). The SLD view displays the status of the primary apparatus such as circuit breakers and disconnectors, selected measurement values and busbar arrangements.

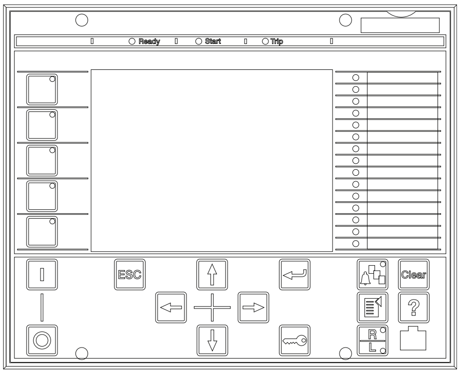

Figure 10. Local user interface

22. Mounting methods

By means of appropriate mounting accessories the standard IED case for the 630 series IEDs can be flush mounted, semi-flush mounted or wall mounted. Detachable HMI is intended for optimized mounting in medium voltage metal-clad switchgear, thus reducing wiring between the low-voltage compartment and the panel door. Further, the IEDs can be mounted in any standard 19” instrument cabinet by means of 19” rack mounting accessories.

For the routine testing purposes, the IED cases can be installed with RTXP test switches (RTXP8, RTXP18 or RTXP24) which can be mounted side by side with the IED case in a 19” rack.

Mounting methods:
- Flush mounting
- Semi-flush mounting
- Overhead/ceiling mounting
- 19” rack mounting
- Wall mounting
- Mounting with a RTXP8, RTXP18 or RTXP24 test switch to a 19”rack
- Door mounting of the local HMI, IED case mounted in the low-voltage compartment of the switchgear

To ensure grounding of the RTD channels, a separate cable shield rail is included in the IED delivery when the optional RTD/mA module is ordered.

For further information regarding different mounting options see the installation manual.

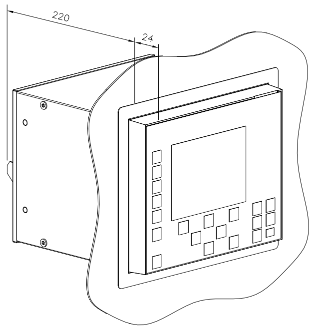

Figure 11. Flush mounting

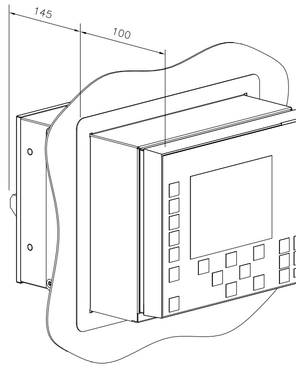

Figure 12. Semi-flush mounting

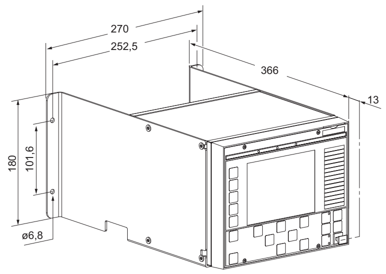

Figure 13. Wall mounting

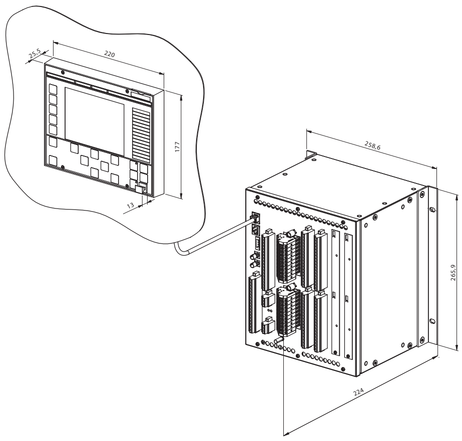

Figure 14. 6U half 19" unit wall mounted with two mounting brackets and detached LHMI

23. Selection and ordering data

The IED type and serial number label identifies the protection and control IED. The label placed is on the side of the IED case. The IED labels include a set of smaller size labels, one label for each module in the IED. The module labels state the type and serial number of each module.

The order code consists of a string of letters and digits generated from the hardware and software modules of the IED. Use the ordering key information in tables to generate the order code when ordering protection and control IEDs.

S B F A A B A B B B A Z A Z N B X D

#	Description	
1	**IED**	
	630 series, 4U half 19" housing	S
	630 series, 6U half 19" housing	T
	630 series, 4U half 19" housing & connector set	U
	630 series, 6U half 19" housing & connector set	V
2	**Standard**	
	IEC	B
3	**Main application**	
	Feeder protection and control	F

The preconfiguration determines the analog input and binary I/O options.
The example below shows standard configuration "A" with chosen options.

S B F A A B A B B B A Z A Z N B X D

#	Description		
4-8	**Functional application, preconfigurations:** **A** = Preconfiguration A for open/closed ring feeder **B** = Preconfiguration B for radial overhead/mixed line feeder **C** = Preconfiguration C for ring/meshed feeder[1] **D** = Preconfiguration D for bus sectionalizer **N** = None		
	Pre-conf.	**Available analog input options**	**Available binary input/ output options**
	A	AB = 4I (I_0 1/5 A) + 1I (I_0 0.1/0.5 A) + 4U	AB = 23 BI + 18 BO AC = 32 BI + 27 BO AD[2] = 41 BI + 36 BO AE[2] = 50 BI + 45 BO
	B	AB = 4I (I_0 1/5 A) + 1I (I_0 0.1/0.5 A) + 4U	AB = 23 BI + 18 BO AC = 32 BI + 27 BO AD[2] = 41 BI + 36 BO AE[2] = 50 BI + 45 BO
	C[1]	AB = 4I (I_0 1/5 A) + 1I (I_0 0.1/0.5 A) + 4U	AB = 23 BI + 18 BO AC = 32 BI + 27 BO AD[2] = 41 BI + 36 BO AE[2] = 50 BI + 45 BO
	D	AB = 4I (I_0 1/5 A) + 1I (I_0 0.1/0.5 A) + 4U	AB = 23 BI + 18 BO AC = 32 BI + 27 BO AD[2] = 41 BI + 36 BO AE[2] = 50 BI + 45 BO
	N	AA = 4I (I_0 1/5 A) + 5U AB = 4I (I_0 1/5 A) + 1I (I_0 0.1/0.5 A) + 4U AC = 3I + 1I (I_0 0.1/0.5 A) + 5U BA = 4I (I_0 1/5 A) + 5U + 8mA/RTD in + 4mA out BB = 4I (I_0 1/5 A) + 1I (I_0 0.1/0.5 A) + 4U 8mA/RTD in + 4mA out BC = 3I + 1I (I_0 0.1/0.5 A) + 5U + 8mA/RTD in + 4mA out	AA = 14 BI + 9 BO AB = 23 BI + 18 BO AC[3] = 32 BI + 27 BO AD[2] = 41 BI + 36 BO AE[2,4] = 50 BI + 45 BO

1) Preconfiguration C requires that the distance protection option is chosen for digit #14 or digit #15
2) Binary input/output options AD and AE require 6U half 19" IED housing (digit #1 = T or V)
3) Binary input/output option AC is not available for 4U high variant (digit #1 = S or U) with RTD card options (digit #5-6 = BA, BB or BC)
4) Binary input/output option AE is not available for 6U high variant (digit #1 = T or V) with RTD card options (digit #5-6 = BA, BB or BC)

S B F A A B A B **B** **B** **A** Z A Z N B X D

#	Description	
9	Communication modules (Serial)	
	Serial glass fibre (ST connector)	A
	Serial plastic fibre (Snap-in connector)	B
10	Communication modules (Ethernet)	
	Ethernet 100Base-FX (LC connector)	A
	Ethernet 100Base-TX (RJ-45 connector)	B
11	Communication (Protocol)	
	IEC 61850 protocol	A
	IEC 61850 and DNP3 TCP/IP protocols	B
	IEC 61850 and IEC 60870-103 protocols	C

S B F A A B A B B B A Z A Z N B X D

#	Description	
12	**Language**	
	Language package	Z
13	**Front panel**	
	Integrated LHMI[1]	A
	Detached LHMI + 1 m cable	B
	Detached LHMI + 2 m cable	C
	Detached LHMI + 3 m cable	D
	Detached LHMI + 4 m cable	E
	Detached LHMI + 5 m cable	F
	No LHMI[2]	N
14	**Option 1**[3]	
	Fault locator and synchro-check	A
	Fault locator and distance protection [4]	B
	Fault locator and power quality [5]	C
	Synchro-check and distance protection [4]	D
	Synchro-check and power quality[5]	E
	Distance protection and power quality [4,5]	F
	All options	Z
	None	N
15	**Option 2**[3]	
	Fault locator	A
	Synchro-check	B
	Distance protection[4]	D
	Power quality[5]	E
	None	N
16	**Power supply**	
	Power supply 48-125 VDC	A
	Power supply 110-250 VDC, 100-240 VAC	B
17	**Reserved**	
	Undefined	X
18	**Version**	
	Version 1.3	D

1) Integrated HMI is not available for 6 U high variant (digit #1 = T or V)
2) Preconfiguration requires HMI, so option N is not valid if preconfiguration is selected. A detached LHMI cannot be used if No LHMI configuration has been chosen
3) Any optional function can be chosen only once. Due to this, the option 2 (digit 15) has limitations based on the selection in option 1 (digit 14).
4) Preconficuration C requires that the distance protection option is chosen for digit #14 or #15
5) Power quality functions: Voltage variation, voltage unbalance, current harmonics, voltage harmonics (phase-to-phase) and voltage harmonics (phase-to-earth)

Example code: S B F A A B A B B B A Z A Z N B X D

Your ordering code:

Digit (#)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Code																		

Figure 15. Ordering key for complete IEDs

24. Accessories

Table 125. Mounting accessories

Item	Order number
Flush mounting kit for one 4U half 19” housing IED	1KHL400040R0001
Semi-flush mounting kit for one 4U half 19” housing IED	1KHL400444R0001
Wall-mounting kit (cabling towards the mounting wall) for one 4U half 19” housing IED	1KHL400067R0001
Wall-mounting kit (cabling to the front) for one 4U half 19” housing IED	1KHL400449R0001
19" rack mounting kit for one 4U half 19” housing IED	1KHL400236R0001
19" rack mounting kit for two 4U half 19” housing IEDs	1KHL400237R0001
Overhead/ceiling mounting kit (with cable space) for one 4U half 19” housing IED	1KHL400450R0001
Wall-mounting kit for direct rear wall mounting (with cabling to the front) of one 6U half 19" housing IED	1KHL400452R0001
Wall-mounting kit (with cabling towards the mounting wall) for one 6U half 19" housing IED	1KHL400200R0001
Overhead/ceiling mounting kit (with cable space) for one 6U half 19" housing IED	1KHL400464R0001

Table 126. Test switch mounting accessories

Item	Order number
19" rack mounting kit for one RTXP8 test switch (the test switch is not included in the delivery)	1KHL400465R0001
19" rack mounting kit for one RTXP18 test switch (the test switch is not included in the delivery)	1KHL400467R0001
19" rack mounting kit for one RTXP24 test switch (the test switch is not included in the delivery)	1KHL400469R0001

Table 127. Connector sets

Item	Order number
Connector set for one 4U housing IED including analog input variant 4I + 5U or 5I + 4U	2RCA021735
Connector set for one 6U housing IED including analog input variant 4I + 5U or 5I + 4U	2RCA021736
Connector set for one 4U housing IED including analog input variant 7I + 3U	2RCA023041
Connector set for one 6U housing IED including analog input variant 7I + 3U	2RCA023042
Connector set for one 4U housing IED including analog input variant 8I + 2U	2RCA023039
Connector set for one 6U housing IED including analog input variant 8I + 2U	2RCA023040

Table 128. Optional cables for external display module

Items	Order number
LHMI cable (1 m)	2RCA025073P0001
LHMI cable (2 m)	2RCA025073P0002
LHMI cable (3 m)	2RCA025073P0003
LHMI cable (4 m)	2RCA025073P0004
LHMI cable (5 m)	2RCA025073P0005

26. Tools

The IED is delivered either with or without an optional factory made preconfiguration. The default parameter setting values can be changed from the front-panel user interface, the web-browser based user interface (WebHMI) or the PCM600 tool in combination with the IED specific connectivity package.

PCM600 offers extensive IED configuration functions such as IED application configuration, signal configuration, DNP3 communication configuration and IEC 61850 communication configuration including horizontal communication, GOOSE.

When the web-browser based user interface is used, the IED can be accessed either locally or remotely using a web browser (IE 7.0 or later). For security reasons, the web-browser based user interface is disabled by default. The interface can be enabled with the PCM600 tool or from the front panel user interface. The functionality of the interface is by default limited to read-only, but can be configured to enable read and write access by means of PCM600 or the local HMI.

The IED connectivity package is a collection of software and specific IED information, which enable system products and tools to connect and interact with the IED. The connectivity packages reduce the risk of errors in system integration, minimizing device configuration and set-up times.

Table 129. Tools

Configuration and setting tools	Version
PCM600	2.5 or later
Web-browser based user interface	IE 8.0, IE 9.0 or IE 10.0
REF630 Connectivity Package	1.3 or later

Table 130. Supported functions

Function	WebHMI	PCM600
Parameter setting	●	●
Disturbance handling	●	●
Signal monitoring	●	●
Event viewer	●	●
Alarm LED viewing	●	●
Hardware configuration	-	●
Signal matrix	-	●
Graphical display editor	-	●
IED configuration templates	-	●
Communication management	-	●
Disturbance record analysis	-	●
IED user management	-	●
User management	-	●
Creating/handling projects	-	●
Graphical application configuration	-	●
IEC 61850 communication configuration, including GOOSE	-	●
IED Compare	-	●

27. Supported ABB solutions

ABB's 630 series protection and control IEDs together with the Grid Automation controller COM600 constitute a genuine IEC 61850 solution for reliable power distribution in utility and industrial power systems. To facilitate and streamline the system engineering ABB's IEDs are supplied with Connectivity Packages containing a compilation of software and IED-specific information including single-line diagram templates, manuals, a full IED data model including event and parameter lists. By utilizing the Connectivity Packages the IEDs can be readily configured via the PCM600 Protection and Control IED Manager and integrated with the Grid Automation controller COM600 or the MicroSCADA Pro network control and management system.

The 630 series IEDs offer support for the IEC 61850 standard also including horizontal GOOSE messaging. Compared with traditional hard-wired inter-device signaling, peer-to-peer communication over a switched Ethernet LAN offers an advanced and versatile platform for power system protection. Fast software-based communication, continuous supervision of the integrity of the protection and communication system, and inherent flexibility for reconfiguration and upgrades are among the distinctive features of the protection system approach enabled by the implementation of the IEC 61850 substation automation standard.

At the substation level COM600 utilizes the logic processor and data content of the bay level IEDs to offer enhanced substation level functionality. COM600 features a Web-browser based HMI providing a customizable graphical display for visualizing single line mimic diagrams for switchgear bay solutions. To enhance personnel safety, the WebHMI also enables remote access to substation devices and processes. Furthermore, COM600 can be used as a local data warehouse for technical documentation of the substation and for network data collected by the IEDs. The collected network data facilitates extensive reporting and analyzing of network fault situations using the data historian and event handling features of COM600.

COM600 also features gateway functionality providing seamless connectivity between the substation IEDs and network-level control and management systems such as MicroSCADA Pro and System 800xA.

Table 131. Supported ABB solutions

Product	Version
Grid Automation Controller COM600	3.5 or later
MicroSCADA Pro SYS 600	9.3 FP1 or later
System 800xA	5.1 or later

28. Terminal diagrams

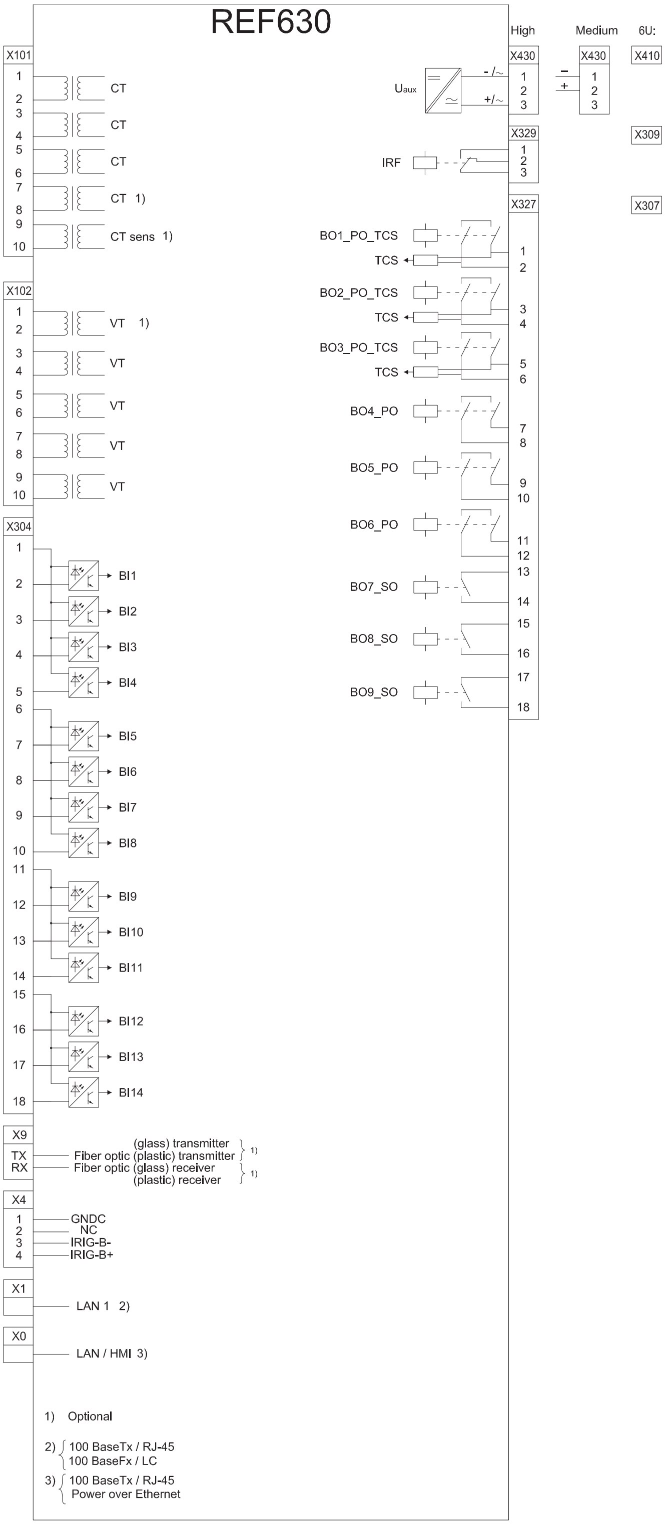

Figure 16. Terminal diagram for REF630

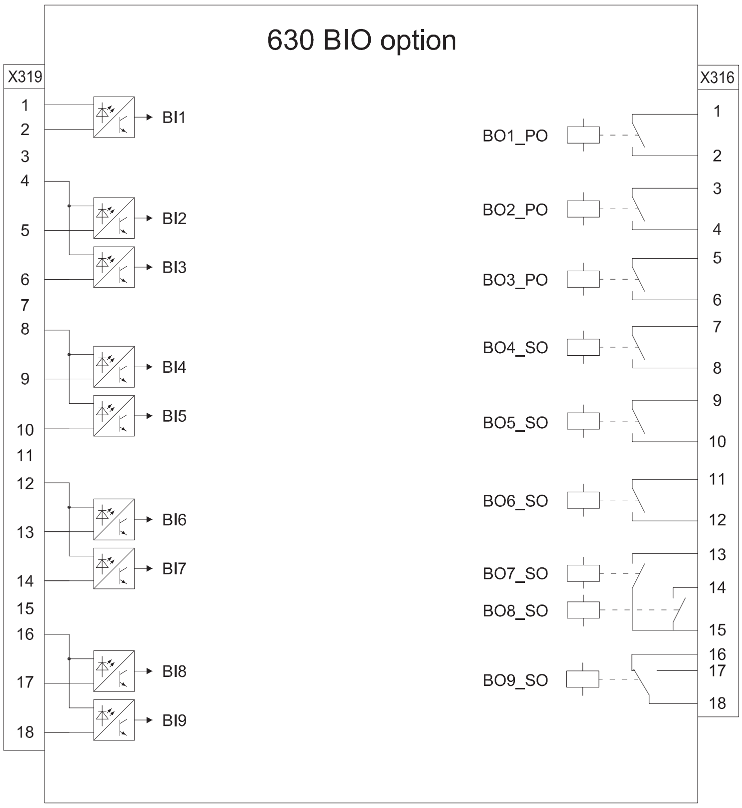

Figure 17. 630 series BIO module option

Table 132. BIO options

Unit	BI/BO
4U	X319 + X316 1)
	X324 + X321
6U	X324 + X321 1)
	X329 + X326
	X334 + X331
	X339 + X336

1) Occupied by RTD module when ordered

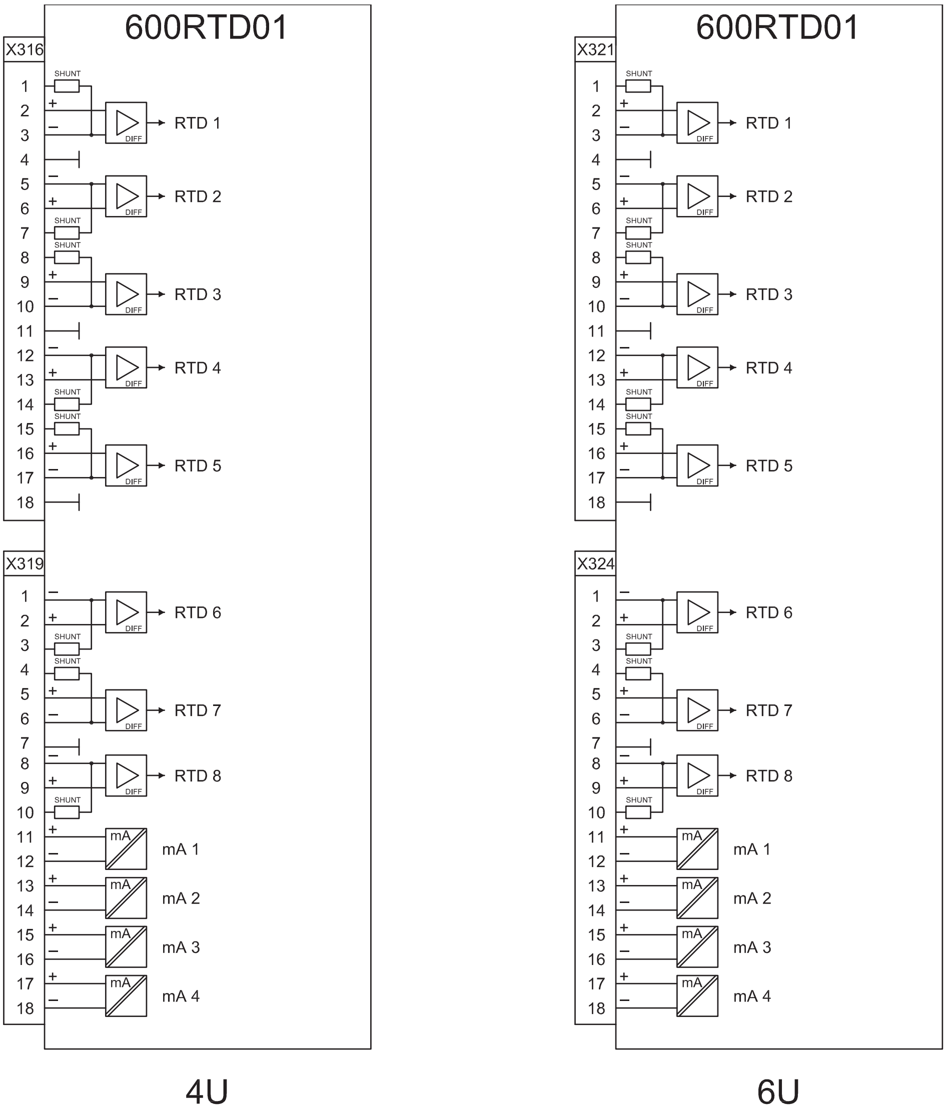

Figure 18. 630 series RTD module option

29. References

The www.abb.com/substationautomation portal offers you information about the distribution automation product and service range.

You will find the latest relevant information on the REF630 protection IED on the product page. Scroll down the page to find and download the related documentation.

30. Functions, codes and symbols

Table 133. Functions included in the IED

Description	IEC 61850	IEC 60617	ANSI
Protection			
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/51P
Three-phase directional overcurrent protection, low stage	DPHLPDOC	3I> ->	67-1
Three-phase directional overcurrent protection, high stage	DPHHPDOC	3I>> ->	67-2
Distance protection	DSTPDIS	Z<	21, 21P, 21N
Automatic switch-onto-fault logic	CVRSOF	SOTF	SOTF
Fault locator	SCEFRFLO	FLOC	21FL
Autoreclosing	DARREC	O -> I	79
Non-directional earth-fault protection, low stage	EFLPTOC	I0>	51N-1
Non-directional earth-fault protection, high stage	EFHPTOC	I0>>	51N-2
Non-directional earth-fault protection, instantaneous stage	EFIPTOC	I0>>>	50N/51N
Directional earth-fault protection, low stage	DEFLPDEF	I0> ->	67N-1
Directional earth-fault protection, high stage	DEFHPDEF	I0>> ->	67N-2
Harmonics based earth-fault protection	HAEFPTOC	Io>HA	51NHA
Transient/intermittent earth-fault protection	INTRPTEF	I0> -> IEF	67NIEF
Admittance-based earth-fault protection	EFPADM	Yo>->	21YN
Multi-frequency admittance-based earth-fault protection	MFADPSDE	I0> ->Y	67YN
Wattmetric earth-fault protection	WPWDE	Po>->	32N
Phase discontinuity protection	PDNSPTOC	I2/I1>	46PD
Negative-sequence overcurrent protection	NSPTOC	I2>	46
Three-phase thermal overload protection for feeder	T1PTTR	3Ith>F	49F
Three-phase current inrush detection	INRPHAR	3I2f>	68
Three-phase overvoltage protection	PHPTOV	3U>	59
Three-phase undervoltage protection	PHPTUV	3U<	27
Positive-sequence overvoltage protection	PSPTOV	U1>	47O+
Positive-sequence undervoltage protection	PSPTUV	U1<	47U+
Negative-sequence overvoltage protection	NSPTOV	U2>	47O-
Residual overvoltage protection	ROVPTOV	U0>	59G
Directional reactive power undervoltage protection	DQPTUV	Q>-->,3U<	32Q,27
Reverse power/directional overpower protection	DOPPDPR	P>	32R/32O
Frequency gradient protection	DAPFRC	df/dt>	81R
Overfrequency protection	DAPTOF	f>	81O
Underfrequency protection	DAPTUF	f<	81U

Table 133. Functions included in the IED, continued

Description	IEC 61850	IEC 60617	ANSI
Load shedding	LSHDPFRQ	UFLS/R	81LSH
Circuit breaker failure protection	CCBRBRF	3I>/I0>BF	51BF/51NBF
Tripping logic	TRPPTRC	I -> O	94
Multipurpose analog protection	MAPGAPC	MAP	MAP
Protection-related functions			
Local acceleration logic	DSTPLAL	LAL	LAL
Communication logic for residual overcurrent	RESCPSCH	CLN	85N
Scheme communication logic	DSOCPSCH	CL	85
Current reversal and WEI logic	CRWPSCH	CLCRW	85CRW
Current reversal and WEI logic for residual overcurrent	RCRWPSCH	CLCRWN	85NCRW
Control			
Bay control	QCCBAY	CBAY	CBAY
Interlocking interface	SCILO	3	3
Circuit breaker/disconnector control	GNRLCSWI	I <-> O CB/DC	I <-> O CB/DC
Circuit breaker	DAXCBR	I <-> O CB	I <-> O CB
Disconnector	DAXSWI	I <-> O DC	I <-> O DC
Local/remote switch interface	LOCREM	R/L	R/L
Synchrocheck	SYNCRSYN	SYNC	25
Generic process I/O			
Single point control (8 signals)	SPC8GGIO	-	-
Double point indication	DPGGIO	-	-
Single point indication	SPGGIO	-	-
Generic measured value	MVGGIO	-	-
Logic Rotating Switch for function selection and LHMI presentation	SLGGIO	-	-
Selector mini switch	VSGGIO	-	-
Pulse counter for energy metering	PCGGIO	-	-
Event counter	CNTGGIO	-	-
Supervision and monitoring			
Runtime counter for machines and devices	MDSOPT	OPTS	OPTM
Circuit breaker condition monitoring	SSCBR	CBCM	CBCM
Fuse failure supervision	SEQRFUF	FUSEF	60
Current circuit supervision	CCRDIF	MCS 3I	MCS 3I
Trip-circuit supervision	TCSSCBR	TCS	TCM
Station battery supervision	SPVNZBAT	U<>	U<>
Energy monitoring	EPDMMTR	E	E
Measured value limit supervision	MVEXP	-	-
Power quality			

Table 133. Functions included in the IED, continued

Description	IEC 61850	IEC 60617	ANSI
Voltage variation	PHQVVR	PQMU	PQMV
Voltage unbalance	VSQVUB	PQMUBU	PQMUBV
Current harmonics	CMHAI	PQM3I	PQM3I
Voltage harmonics (phase-to-phase)	VPPMHAI	PQM3Upp	PQM3Vpp
Voltage harmonics (phase-to-earth)	VPHMHAI	PQM3Upe	PQM3Vpg
Measurement			
Three-phase current measurement	CMMXU	3I	3I
Three-phase voltage measurement (phase-to-earth)	VPHMMXU	3Upe	3Upe
Three-phase voltage measurement (phase-to-phase)	VPPMMXU	3Upp	3Upp
Residual current measurement	RESCMMXU	I0	I0
Residual voltage measurement	RESVMMXU	U0	U0
Power monitoring with P, Q, S, power factor, frequency	PWRMMXU	PQf	PQf
Sequence current measurement	CSMSQI	I1, I2	I1, I2
Sequence voltage measurement	VSMSQI	U1, U2	V1, V2
Analog channels 1-10 (samples)	A1RADR	ACH1	ACH1
Analog channels 11-20 (samples)	A2RADR	ACH2	ACH2
Analog channels 21-30 (calc. val.)	A3RADR	ACH3	ACH3
Analog channels 31-40 (calc. val.)	A4RADR	ACH4	ACH4
Binary channels 1-16	B1RBDR	BCH1	BCH1
Binary channels 17 -32	B2RBDR	BCH2	BCH2
Binary channels 33 -48	B3RBDR	BCH3	BCH3
Binary channels 49 -64	B4RBDR	BCH4	BCH4
Station communication (GOOSE)			
Binary receive	GOOSEBINRCV	-	-
Double point receive	GOOSEDPRCV	-	-
Interlock receive	GOOSEINTLKRCV	-	-
Integer receive	GOOSEINTRCV	-	-
Measured value receive	GOOSEMVRCV	-	-
Single point receive	GOOSESPRCV	-	-

31. Document revision history

Document revision/date	Product version	History
A/2009-10-26	1.0	First release
B/2009-12-23	1.0	Content updated
C/2011-02-23	1.1	Content updated to correspond to the product version
D/2011–05-18	1.1	Content updated
E/2012-08-29	1.2	Content updated to correspond to the product version
F/2014-12-03	1.3	Content updated to correspond to the product version
G/2015-03-31	1.3	Content updated

Contact us

ABB Oy
Medium Voltage Products,
Distribution Automation
P.O. Box 699
FI-65101 VAASA, Finland
Phone +358 10 22 11
Fax +358 10 22 41094

www.abb.com/substationautomation

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