Relion® 630 series

Transformer Protection and Control RET630 Product Guide

Power and productivity
for a better world™

Contents

1. Description

RET630 is a comprehensive transformer management IED for protection, control, measuring and supervision of power transformers, unit and step-up transformers including power generator-transformer blocks in utility and industry power distribution networks. RET630 is a member of ABB's Relion® product family and a part of its 630 series characterized by functional scalability and flexible configurability. RET630 also features necessary control functions constituting an ideal solution for transformer bay control and voltage regulation.

The supported communication protocols including IEC 61850 offer seamless connectivity to various station automation and SCADA systems.

2. Application

RET630 provides main protection for two-winding power transformers and power generator-transformer blocks. Two pre-defined configurations to match your typical transformer protection and control specifications 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. The optional voltage regulation function is one example of such add-on functions.

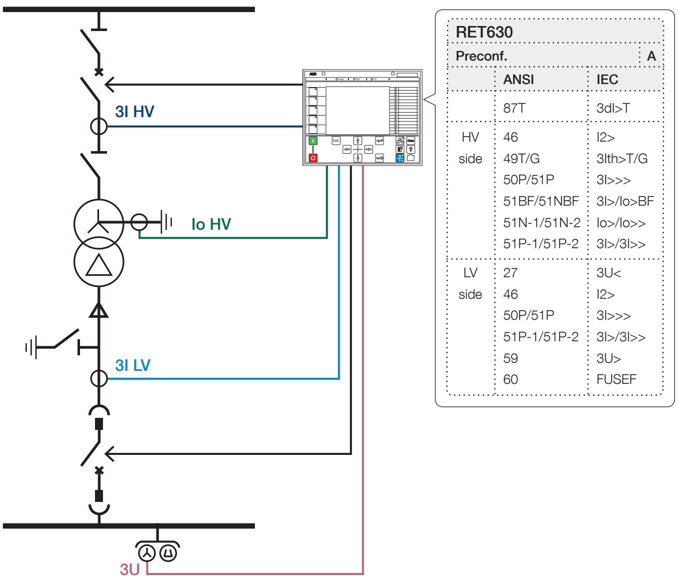

Figure 1. Application example for protection of HV/MV, or MV/MV two winding power transformer with RET630 preconfiguration A with transformer differential protection function

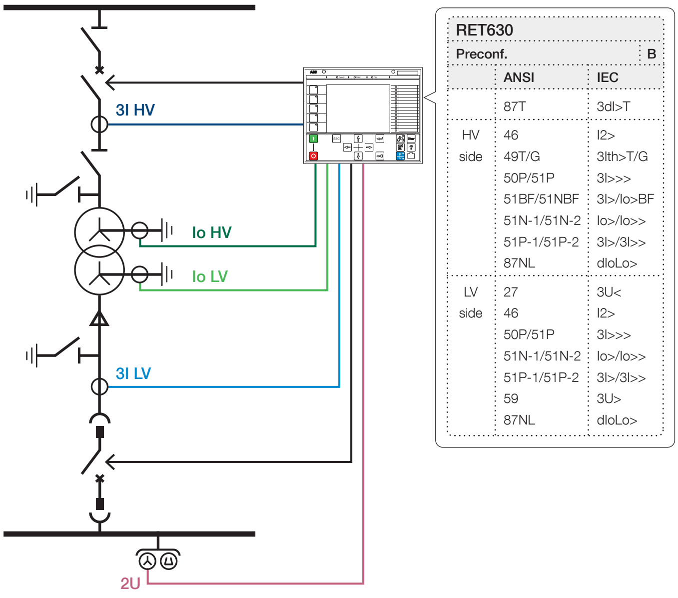

Figure 2. Application example for protection of HV/MV, or MV/MV two winding power transformer with RET630 preconfiguration A with low impedance based restrictre earth-fault protection function on both sides of the transformer

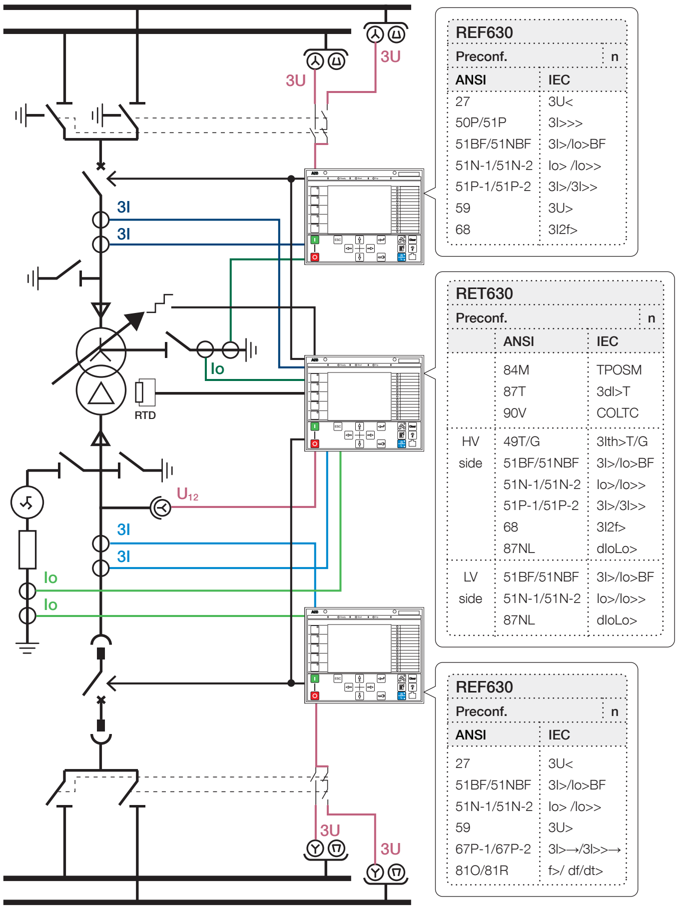

Figure 3. Application example for protection of YNd-connected power transformer, implemented with RET630 as main transformer protection and control relay, two REF630s as feeder protection and control relays for both feeders

The low-voltage side of the transformer is earthed via a zig-zag earthing transformer.

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.

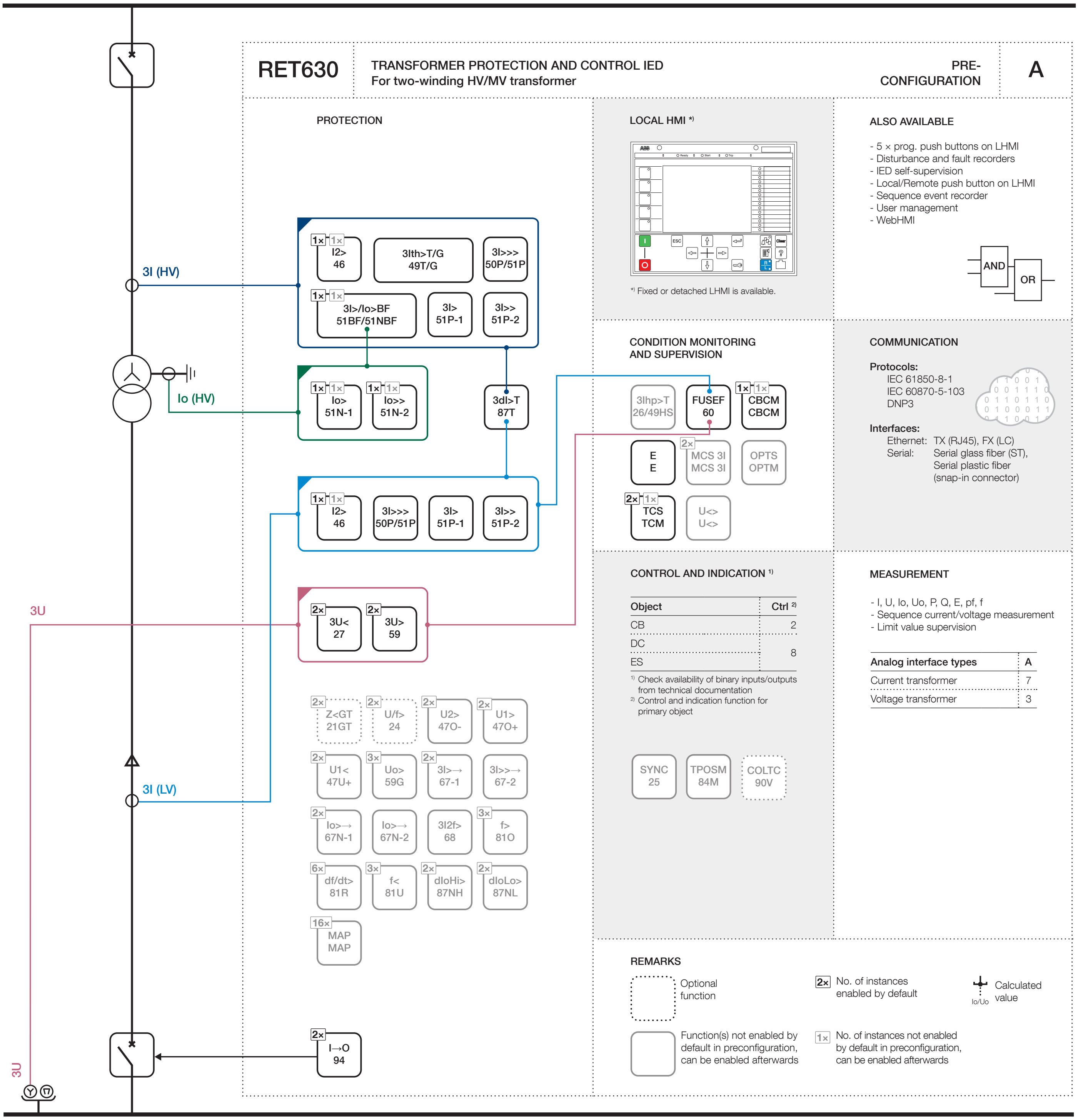

Figure 4. Functionality overview for preconfiguration A

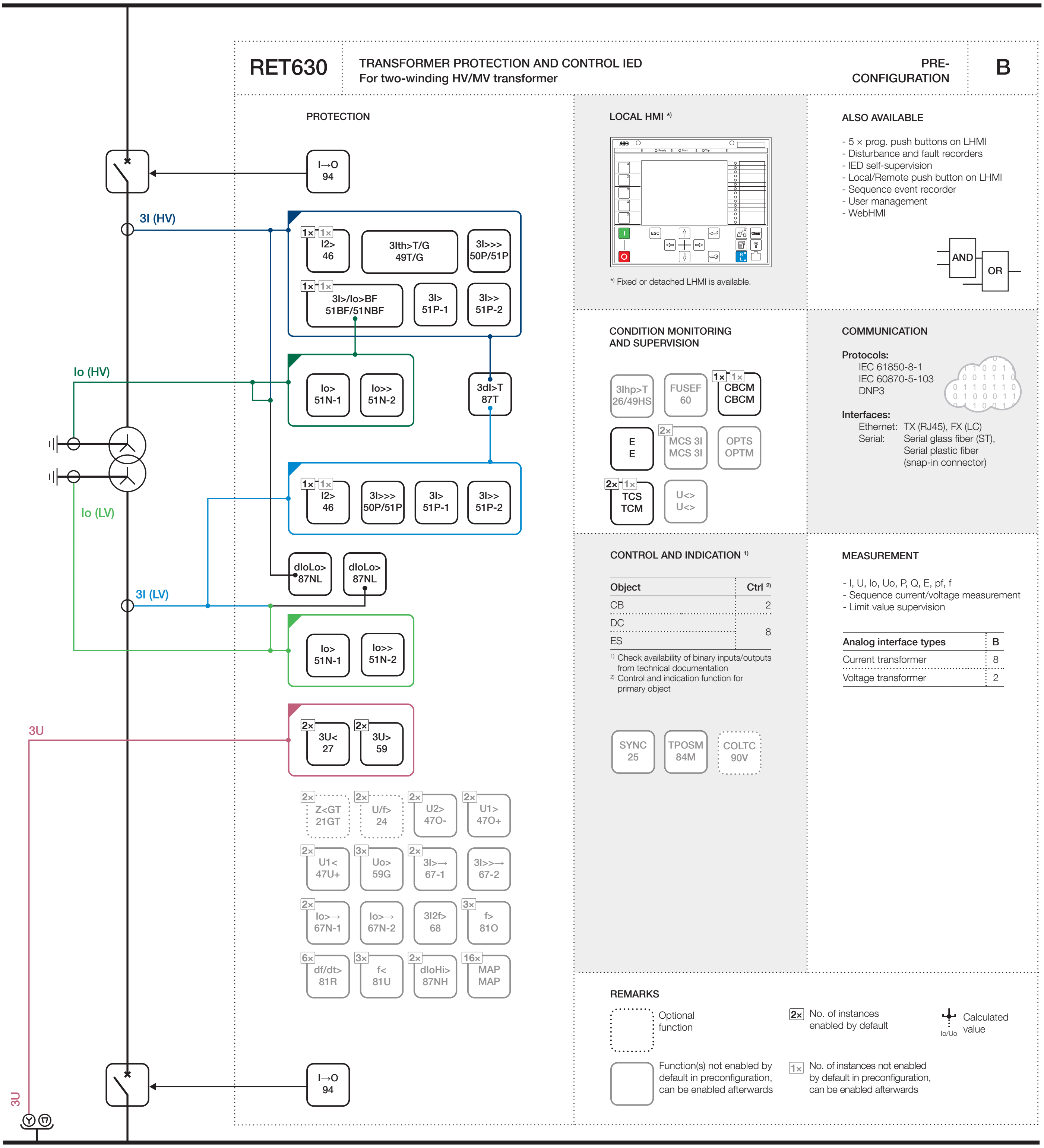

Figure 5. Functionality overview for preconfiguration B

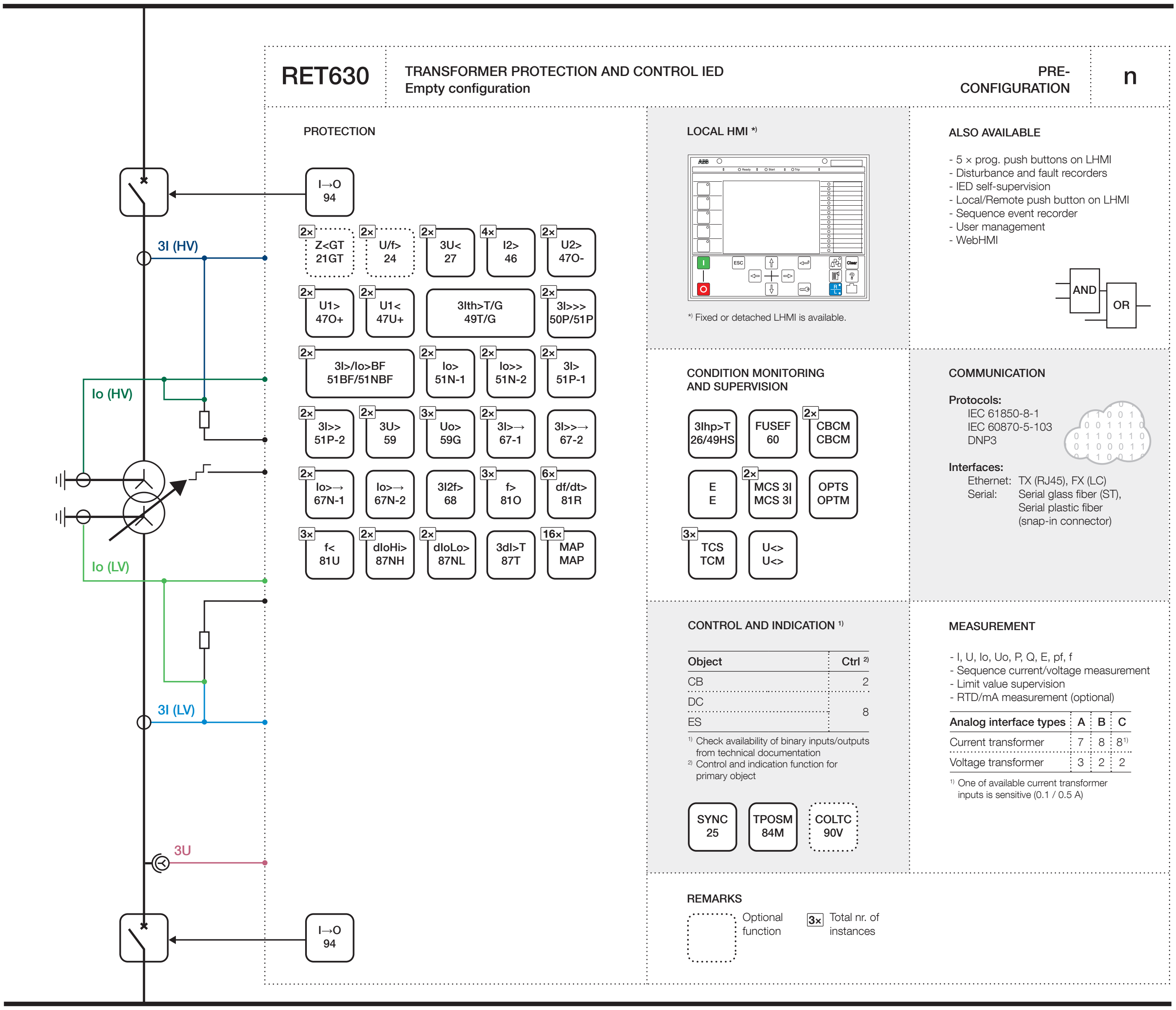

Figure 6. Functionality overview for preconfiguration n

Table 1. RET630 preconfiguration ordering options

Description	Preconfiguration		
Preconfiguration A for two-winding HV/MV transformer	A		
Preconfiguration B for two-winding HV/MV transformer, including numerical REF protection		B	
Number of instances available			n

Table 2. Functions used in preconfigurations

Description	A	B	n
Protection			
Three-phase non-directional overcurrent protection, low stage	2	2	2
Three-phase non-directional overcurrent protection, high stage	2	2	2
Three-phase non-directional overcurrent protection, instantaneous stage	2	2	2
Three-phase directional overcurrent protection, low stage	-	-	2
Three-phase directional overcurrent protection, high stage	-	-	1
Non-directional earth-fault protection, low stage	1 HV	2	2
Non-directional earth-fault protection, high stage	1 HV	2	2
Directional earth-fault protection, low stage	-	-	2
Directional earth-fault protection, high stage	-	-	1
Stabilised restricted earth-fault protection	-	2	2
High-impedance based restricted earth-fault protection	-	-	2
Negative-sequence overcurrent protection	2	2	4
Three-phase thermal overload protection, two time constants	1 HV	1 HV	1
Three-phase current inrush detection	-	-	1
Transformer differential protection for two-winding transformers	1	1	1
Three-phase overvoltage protection	2 LV	2 LV	2
Three-phase undervoltage protection	2 LV	2 LV	2
Positive-sequence overvoltage protection	-	-	2
Positive-sequence undervoltage protection	-	-	2
Negative-sequence overvoltage protection	-	-	2
Residual overvoltage protection	-	-	3
Frequency gradient protection	-	-	6
Overfrequency protection	-	-	3
Underfrequency protection	-	-	3
Overexcitation protection	-	-	2
Three-phase underimpedance protection	-	-	2
Circuit breaker failure protection	1 HV	1 HV	2
Tripping logic	2	2	2
Multipurpose analog protection	-	-	16
Control			
Bay control	1	1	1
Interlocking interface	4	4	10
Circuit breaker/disconnector control	4	4	10
Circuit breaker	1	1	2
Disconnector	2	2	8
Local/remote switch interface	-	-	1

Table 2. Functions used in preconfigurations, continued

Description	A	B	n
Synchrocheck	-	-	1
Tap changer control with voltage regulator	-	-	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 HV	1 HV	2
Fuse failure supervision	1	-	1
Current circuit supervision	-	-	2
Trip-circuit supervision	2	2	3
Station battery supervision	-	-	1
Energy monitoring	1	1	1
Measured value limit supervision	-	-	40
Hot spot and insulation ageing rate monitoring for transformers	-	-	1
Tap position indication	-	-	1
Measurement			
Three-phase current measurement	2	2	2
Three-phase voltage measurement (phase-to-earth)	1	1	2
Three-phase voltage measurement (phase-to-phase)	1	1	2
Residual current measurement	2	2	2
Residual voltage measurement	-	-	1
Power monitoring with P, Q, S, power factor, frequency	1	1	1
Sequence current measurement	-	-	1
Sequence voltage measurement	-	-	1
Disturbance recorder function			
Analog channels 1-10 (samples)	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
Binary channels 17-32	1	1	1

Table 2. Functions used in preconfigurations, continued

Description	A	B	n
Binary channels 33-48	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

HV = The function block is to be used on the high-voltage side in the application.
LV = The function block is to be used on the low-voltage side in the application.
n = total number of available function instances regardless of the preconfiguration selected
1, 2, ... = number of included instances

4. Protection functions

RET630 features transformer differential protection with instantaneous and stabilized stages to provide fast and selective protection for phase-to-phase, winding interturn and bushing short-circuits including most phase-to-earth faults. Besides second harmonic restraint an advanced waveform-based blocking algorithm ensures stability at transformer energization and fifth harmonic restraint ensures stability at moderate overexcitation.

Sensitive restricted earth-fault protection (REF) completes the overall differential protection to detect even single phase-to-earth faults close to the earthing point of the transformer. Either the conventional high-impedance scheme or a numerical low-impedance scheme can be selected for protection of the windings. If the low-impedance REF protection is used neither stabilizing resistors nor varistors are needed and as a further benefit the transforming ratio of the earthing point current transformers can differ from those of the phase current transformers. Due to its unit protection character the REF protection does not need any time grading, and therefore a fast protection operating time can be achieved. The overexcitation protection is used to protect generators and power transformers against an excessive flux density and saturation of the magnetic core.

The IED also incorporates thermal overload protection to prevent an accelerated aging of the transformer isolation. Multiple stages of short-circuit, phase-overcurrent, negative-phase-sequence and earth-fault back-up protection are separately available for both windings. The three-phase underimpedance protection, based on impedance values from voltage and current phasors, provides backup protection against short-circuit faults. Earth-fault protection based on the measured or calculated residual overvoltage is also available.

RET630 also offers directional overcurrent protection for detecting reversed power flow or circulating currents at parallel power transformers. Overfrequency and underfrequency protection, overvoltage and undervoltage protection and circuit-breaker failure protection are also provided.

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. Voltage regulator

The voltage regulator function (on-load tap changer controller) is designed for regulating the voltage of power transformers with on-load tap changers in distribution substations. The voltage regulation function provides a manual or automatic voltage control of the power transformer using the raise and lower signals to the on-load tap changer.

The automatic voltage regulation can be used in single or parallel transformer applications. Parallel operation can be based on master/follower (M/F), negative-reactance principle (NRP) or minimizing circulating current (MCC).

The voltage regulator includes the line drop compensation (LDC) functionality, and the load decrease is possible with a dynamic voltage reduction.

Either definite time (DT) characteristic or inverse definitive time (IDMT) characteristic can be selected for delays between the raise and lower operations.

The function contains a blocking functionality. It is possible to block the voltage control operations with an external signal or with the supervision functionality of the function, if wanted.

7. Measurement

The IED continuously measures the high voltage (HV) side and the low-voltage (LV) side phase currents and the neutral current(s) of the protected transformer. Further, it measures the positive and negative sequence currents on both sides. 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.

System frequency and the temperature of the transformer are also calculated. Cumulative and averaging calculations utilize the non-volatile memory available in the IED. Calculated values are also obtained from the protection and condition monitoring functions of 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. 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.

10. 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.

11. 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.

12. 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.

13. 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.

14. 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.

15. 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.

16. Hot spot and insulation aging rate monitoring

Hot spot and aging rate monitoring allows calculating the hot spot temperature of the transformer winding and the momentary aging rate. This function is used for online monitoring of transformers to estimate the impact that thermal stress has on the transformer lifetime. It can be applied both for new transformers and transformers already in service using the initial loss of life setting.

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 six phase-current inputs (three inputs for the HV side and three inputs for the LV side) and one or two neutral-current inputs for earth-fault protection.

Depending on the selected hardware configuration the IED includes two or three voltage inputs. One of the voltage inputs can be used as a residual voltage input for directional earth-fault protection or residual voltage protection. The voltage inputs can also be used as phase-voltage inputs for overvoltage, undervoltage and directional overcurrent protection and other voltage based protection functions.

The phase-current inputs are rated 1/5 A. Depending on the selected hardware configuration 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 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	7	-	3	-	-
AB	8	-	2	-	-
AC	7	1	2	-	-
BA	7	-	3	8	4
BB	8	-	2	8	4
BC	7	1	2	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. 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 × 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. 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]	±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 [2)3)]	EFIPTOC[1]: 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 [4]
Suppression of harmonics		RMS: No suppression DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5,… Peak-to-Peak: No suppression

1) Not included in RET630
2) *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
3) Includes the delay of the signal output contact
4) Maximum *Start value* = 2.5 × I_n, *Start value* multiples in range of 1.5...20

Table 35. 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[1]	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[1]	0.02...200.00 s	0.01
Operating curve type[2]	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[1]	Definite time	

1) Not included in RET630
2) For further reference, see Operation characteristics table

Table 36. 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 37. 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 38. Stabilised restricted earth-fault protection (LREFPNDF)

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} = 2.0 × set *Operate value* I_{Fault} = 10.0 × set *Operate value*	Typically 18 ms (±5 ms) Typically 12 ms (±5 ms)
Reset time		<50 ms
Reset ratio		Typically 0.96
Retardation time		<35 ms
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms
Suppression of harmonics		DFT: -50 dB at f = n × f_n, where n = 2, 3, 4, 5, …

1) Current before fault = 0.0 × I_n, f_n = 50 Hz
2) Includes the delay of the signal output contact

Table 39. Stabilised restricted earth-fault protection (LREFPNDF) main settings

Parameter	Function	Value (Range)	Step
Operate value	LREFPNDF	5...50%	1
Restraint mode	LREFPNDF	None 2nd harmonic	-
Start value 2.H	LREFPNDF	10...50%	1
Minimum operate time	LREFPNDF	0.040...300.000 s	0.001

Table 40. High-impedance based restricted earth-fault protection (HREFPDIF)

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} = 2.0 × set *Operate value* I_{Fault} = 10.0 × set *Operate value*	Typically 22 ms (±5 ms) Typically 15 ms (±5 ms)
Reset time		<60 ms
Reset ratio		Typically 0.96
Retardation time		<60 ms
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms

1) Current before fault = 0.0 × I_n, f_n = 50 Hz
2) Includes the delay of the signal output contact

Table 41. High-impedance based restricted earth-fault protection (HREFPDIF) main settings

Parameter	Function	Value (Range)	Step
Operate value	HREFPDIF	0.5...50.0%	0.1
Minimum operate time	HREFPDIF	0.020...300.000 s	0.001

Table 42. 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 $f = n \times f_n$, 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 43. 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 44. Three-phase thermal overload protection, two time constants (T2PTTR)

Characteristic	Value
Operation accuracy	At the frequency f = f_n
	Current measurement: ±1.5% of the set value or ±0.002 × I_n (at currents in the range of 0.01...4.00 × I_n)
Operate time accuracy[1)]	±2.0% or ±1000 ms

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

Table 45. Three-phase thermal overload protection, two time constants (T2PTTR) main settings

Parameter	Function	Value (Range)	Step
Temperature rise	T2PTTR	0.0...200.0°	0.1
Max temperature	T2PTTR	0.0...200.0°	0.1
Operate temperature	T2PTTR	80.0...120.0%	0.1
Weighting factor p	T2PTTR	0.00...1.00	0.01
Short time constant	T2PTTR	60...60000 s	1
Current reference	T2PTTR	0.05...4.00 pu	0.01

Table 46. 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 47. 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 48. Transformer differential protection for two-winding transformers (TR2PTDF)

Characteristic		Value
Operation accuracy		At the frequency $f = f_n$
		±1.5% of the set value or ±0.002 × I_n
Operate time[1)2)]	Biased low stage Instantaneous high stage	Typically 35 ms (±5 ms) Typically 17 ms (±5 ms)
Reset time		<30 ms
Reset ratio		Typically 0.96
Retardation time		<35 ms
Suppression of harmonics		DFT: -50 dB at $f = n \times f_n$, where n = 2, 3, 4, 5,…

1) Differential current before fault = 0.0 × I_n, f_n = 50 Hz. Injected differential current = 2.0 × set operate value
2) Includes the delay of the output contact value and f_n = 50 Hz

Table 49. Transformer differential protection for two-winding transformers (TR2PTDF) main settings

Parameter	Function	Value (Range)	Step
Restraint mode	TR2PTDF	2.h & 5.h & wav Waveform 2.h & waveform 5.h & waveform	-
High operate value	TR2PTDF	500...3000%	10
Low operate value	TR2PTDF	5...50%	1
Slope section 2	TR2PTDF	10...50%	1
End section 2	TR2PTDF	100...500%	1
Start value 2.H	TR2PTDF	7...20%	1
Start value 5.H	TR2PTDF	10...50%	1
Winding 1 type	TR2PTDF	Y YN D Z ZN	-
Winding 2 type	TR2PTDF	Y YN D Z ZN	-
Zro A elimination	TR2PTDF	Not eliminated Winding 1 Winding 2 Winding 1 and 2	-
Clock number	TR2PTDF	Clk Num 0 Clk Num 1 Clk Num 2 Clk Num 4 Clk Num 5 Clk Num 6 Clk Num 7 Clk Num 8 Clk Num 10 Clk Num 11	-

Table 50. 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 51. 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 52. 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 53. 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 54. 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 55. 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 56. 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 57. 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 58. Negative-sequence overvoltage protection (NSPTOV)

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 (± 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 × f_n, where n = 2, 3, 4, 5,…

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

Table 59. 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 60. Residual overvoltage protection (ROVPTOV)

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*	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 × f_n, where n = 2, 3, 4, 5,…

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

Table 61. 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 62. 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 ±0.002 × 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 × f_n, where n = 2, 3, 4, 5,…

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

Table 63. 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 64. 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 65. 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 66. 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 67. 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 68. Overexcitation protection (OEPVPH)

Characteristic	Value	
Operation accuracy	At the frequency f = f_n	
	±2.5% of the set value or 0.01 × Ub/f	
Start time 1)2)	Frequency change	Typically 200 ms (±20 ms)
	Voltage change	Typically 100 ms (±20 ms)
Reset time	<60 ms	
Reset ratio	Typically 0.96	
Retardation time	<45 ms	
Operate time accuracy in definite-time mode	±1.0% of the set value or ±20 ms	
Operate time accuracy in inverse-time mode	±5.0% of the theoretical value or ±50 ms	

1) Results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact

Table 69. Overexcitation protection (OEPVPH) main settings

Parameter	Function	Value (Range)	Step
Leakage React	OEPVPH	0.0...50.0% Zb	0.1
Start value	OEPVPH	100...200% UB/f	1
Time multiplier	OEPVPH	0.1...100.0	0.1
Operating curve type	OEPVPH	ANSI Def. Time IEC Def. Time OvExt IDMT Crv1 OvExt IDMT Crv2 OvExt IDMT Crv3 OvExt IDMT Crv4	-
Operate delay time	OEPVPH	0.10...200.00 s	0.01

Table 70. Three-phase underimpedance protection (UZPDIS)

Characteristic	Value
Operation accuracy	At the frequency f = f_n
	±3.0% of the set value or ±0.2% × Z_b
Start time	Typically 25 ms (±15 ms)
Reset time	<50 ms
Reset ratio	Typically 1.04
Retardation time	<40 ms
Operate time accuracy in definite-time mode 1)2)	±1.0% of the set value or ±20 ms

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

Table 71. Three-phase underimpedance protection (UZPDIS) main settings

Parameter	Function	Value (Range)	Step
Polar reach	UZPDIS	1...6000% Zb	1
Operate delay time	UZPDIS	0.04...200.00 s	0.01

Table 72. Circuit breaker failure protection (CCBRBRF)

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 ±30 ms

Table 73. 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 74. Multipurpose analog protection (MAPGAPC)

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

Table 75. 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 76. 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

Control functions

Table 77. 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

Table 78. Tap changer control with voltage regulator (OLATCC)

Characteristic	Value
Operation accuracy [1)]	At the frequency $f = f_n$
	Differential voltage Ud: ±1.0% of the measured value or ±0.004 × U_n (in measured voltages <2.0 × U_n)
	Operation value: ±1.0% of the U_d or ±0.004 × U_n for U_s = 1.0 × U_n
Operate time accuracy in definite time mode [1)]	±1.0% of the set value or 0.11 s
Operate time accuracy in inverse time mode [1)]	±15.0% of the set value or 0.15 s (at theoretical B in range of 1.1…5.0) Also note fixed minimum operate time (IDMT) 1 s
Reset ratio for control operation	Typically 0.80 (1.20)
Reset ratio for analog based blockings (except run back raise voltage blocking)	Typically 0.96 (1.04)

1) Default setting values used

Table 79. Tap changer control with voltage regulator (OLATCC) main settings

Parameter	Function	Value (Range)	Step
Operation mode	OLATCC	Manual Auto single Auto parallel Input control	-
Custom Man blocking	OLATCC	Custom disabled OC UV OC, UV EXT OC, EXT UV, EXT OC, UV, EXT	-
Delay characteristic	OLATCC	Inverse time Definite time	-
Band width voltage	OLATCC	1.20...18.00%	0.01
Load current limit	OLATCC	0.10...5.00 pu	0.01
Block lower voltage	OLATCC	0.10...1.20 pu	0.01
Runback raise V	OLATCC	0.80...1.60 pu	0.01
Cir current limit	OLATCC	0.10...5.00 pu	0.01
LDC limit	OLATCC	0.00...2.00 pu	0.01
Lower block tap	OLATCC	-36...36	1
Raise block tap	OLATCC	-36...36	1
LDC enable	OLATCC	FALSE TRUE	-
Auto parallel mode	OLATCC	Master Follower NRP MCC	1
Band center voltage	OLATCC	0.000...2.000 pu	0.001
Line drop V Ris	OLATCC	0.0...25.0%	0.1
Line drop V React	OLATCC	0.0...25.0%	0.1
Band reduction	OLATCC	0.0...9.0%	0.1
Stability factor	OLATCC	0.0...70.0%	0.1
Load phase angle	OLATCC	-89...89°	1
Control delay time 1	OLATCC	1.0...300.0 s	0.1
Control delay time 2	OLATCC	1.0...300.0 s	0.1

Supervision and monitoring functions

Table 80. 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 81. 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 82. 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 83. 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 84. Current circuit supervision (CCRDIF)

Characteristic	Value
Operate time 1)	<30 ms

1) Including the delay of the output contact

Table 85. 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 86. Trip-circuit supervision (TCSSCBR)

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

Table 87. 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 88. 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,…

Table 89. Hot-spot and insulation ageing rate monitoring for transformers (HSARSPTR)

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

Table 90. Hot-spot and insulation ageing rate monitoring for transformers (HSARSPTR) main settings

Parameter	Function	Value (Range)	Step
Cooling mode	HSARSPTR	ONAN ONAF OFAF ODAF	-
Alarm level	HSARSPTR	50.0...350.0°C	0.1
Warning level	HSARSPTR	50.0...350.0°C	0.1
Alarm level Age Rte	HSARSPTR	0.10...5.00	0.01
Avg ambient Temp	HSARSPTR	-20.00...70.00°C	0.01
Alarm delay time	HSARSPTR	0.00...3600.00 s	0.01
Warning delay time	HSARSPTR	0.00...3600.00 s	0.01

Table 91. Tap position indication (TPOSSLTC)

Descrpition	Value
Response time for binary inputs	Typically 100 ms

Measurement functions

Table 92. 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 $f = n \times f_n$, where n = 2, 3, 4, 5,… RMS: No suppression

Table 93. 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 $f = n \times f_n$, where n = 2, 3, 4, 5,… RMS: No suppression

Table 94. 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 $f = n \times f_n$, where n = 2, 3, 4, 5,… RMS: No suppression

Table 95. 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 $f = n \times f_n$, where n = 2, 3, 4, 5,… RMS: No suppression

Table 96. 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 $f = n \times f_n$, where n = 2, 3, 4, 5,… RMS: No suppression

Table 97. 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 98. 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 99. 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.

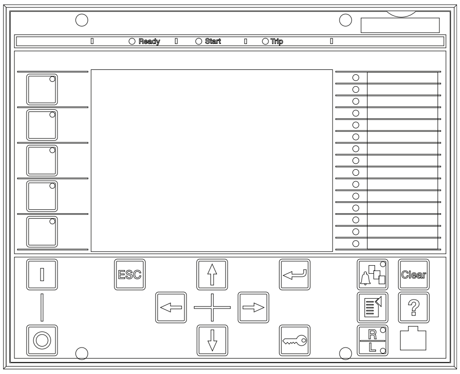

Figure 7. Local user interface

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.

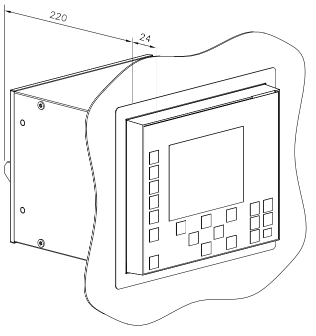

Figure 8. Flush mounting

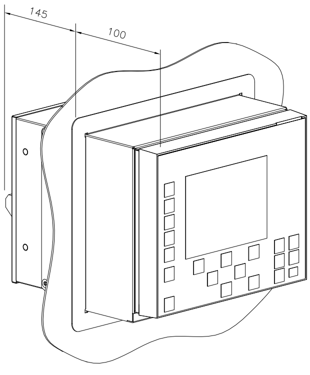

Figure 9. Semi-flush mounting

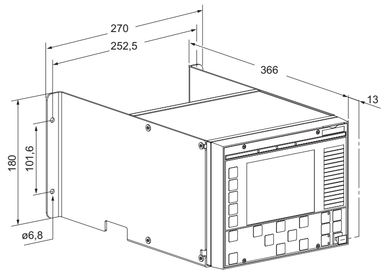

Figure 10. Wall mounting

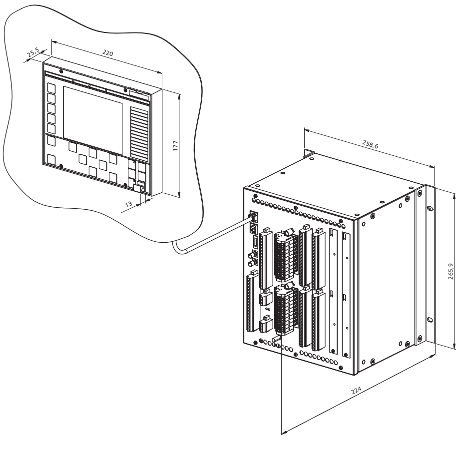

Figure 11. 6U half 19" unit wall mounted with two mounting brackets and detached LHMI

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 T B A B A C B B A Z A A D 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**	
	Transformer protection and control	T

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

S B T B A B A C B B A Z A A D B X D

#	Description		
4-8	**Functional application, preconfigurations:** **A** = Preconfiguration A for two-winding transformers **B** = Preconfiguration B for two-winding transformers, including numerical restricted earth-fault protection **N** = None		
	Pre-conf.	**Available analog input options**	**Available binary input/ output options**
	A	AA = 7 I (I_0 1/5A) + 3U	AB = 23 BI + 18 BO AC = 32 BI + 27 BO AD[1)] = 41 BI + 36 BO AE[1)] = 50 BI + 45 BO
	B	AB = 8 I (I_0 1/5A) + 2U	AB = 23 BI + 18 BO AC = 32 BI + 27 BO AD[1)] = 41 BI + 36 BO AE[1)] = 50 BI + 45 BO
	N	AA = 7 I (I_0 1/5A) + 3U AB = 8 I (I_0 1/5A) + 2U AC = 7 I (I_0 1/5A) + 1 I (I_0 0.1/0.5A) + 2U BA = 7 I (I_0 1/5A) + 3U + 8mA/RTD in + 4mA out BB = 8 I (I_0 1/5A) + 2U +8mA/RTD in + 4mA out BC = 7 I (I_0 1/5A) + 1 I (I_0 0.1/0.5A) + 2U + 8mA/RTD in + 4mA out	AA = 14 BI + 9 BO AB = 23 BI + 18 BO AC[2)] = 32 BI + 27 BO AD[1)] = 41 BI + 36 BO AE[1,3)] = 50 BI + 45 BO

1) Binary input/output options AD and AE require 6U half 19" IED housing (digit #1 = T or V)
2) 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)
3) 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 T B A B A C **B** **B** **A** Z A A D 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 T B A B A C B B A **Z** **A** **A** **D** **B** **X** **D**

#	Description	
12	Language	
	Language package	Z
13	Front panel	
	Integrated LHM[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)]	
	Automatic voltage regulator and underimpedance protection	A
	Automatic voltage regulator and overexcitation protection	B
	Underimpedance and overexcitation protections	C
	All options	Z
	None	N
15	Option 2[3)]	
	Automatic voltage regulator	B
	Underimpedance protection	C
	Overexcitation protection	D
	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)

Example code: S B T B A B A C B B A Z A A D 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 12. Ordering key for complete IEDs

24. Accessories

Table 100. 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 101. 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 102. Connector sets

Item	Order number
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 103. 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 104. 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
RET630 Connectivity Package	1.3 or later

Table 105. 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 106. 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

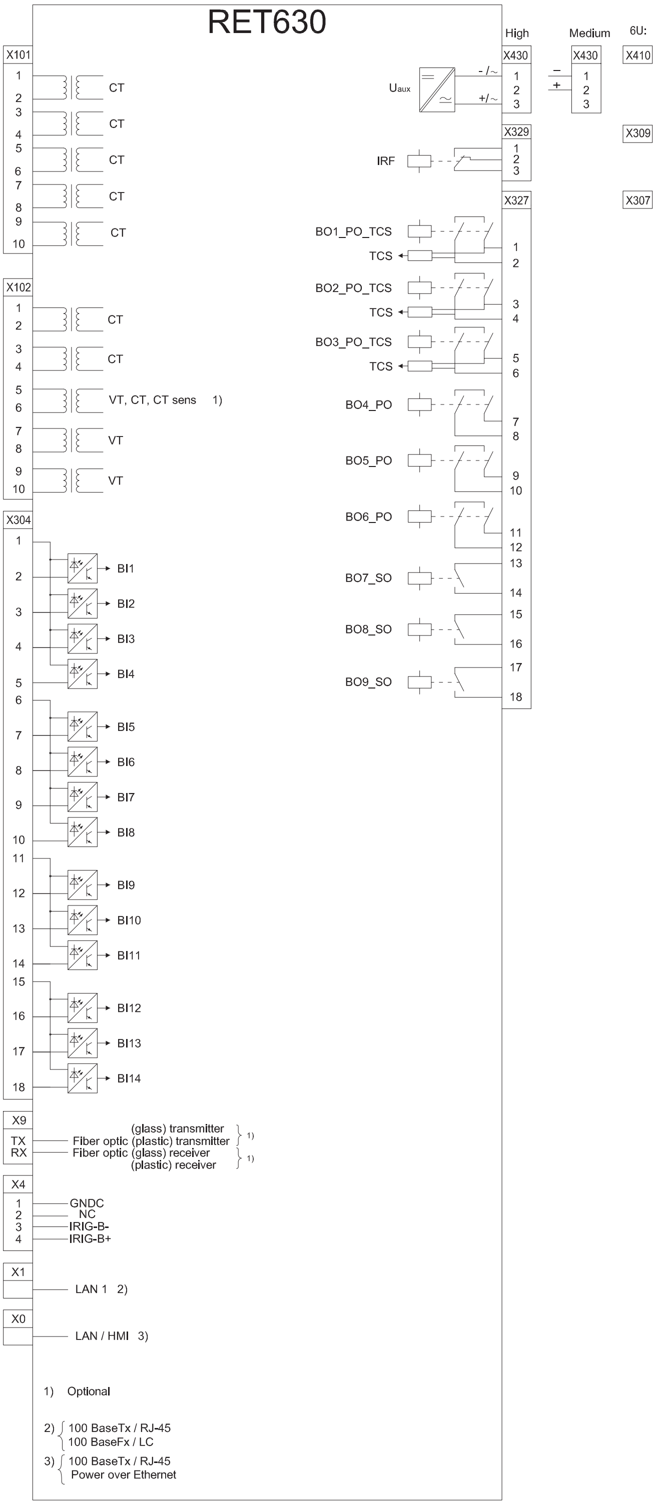

Figure 13. Terminal diagram for RET630

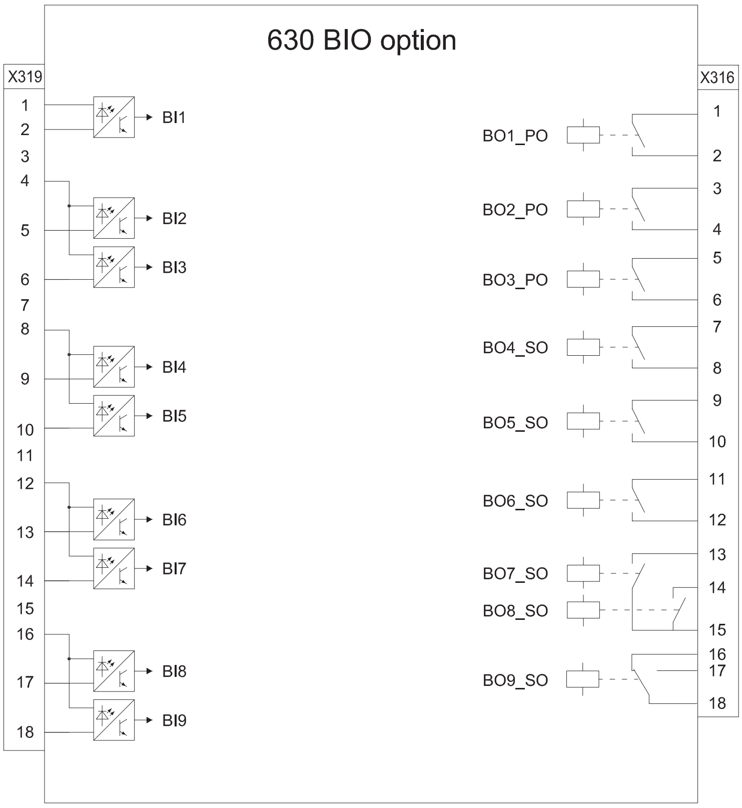

Figure 14. 630 series BIO module option

Table 107. 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

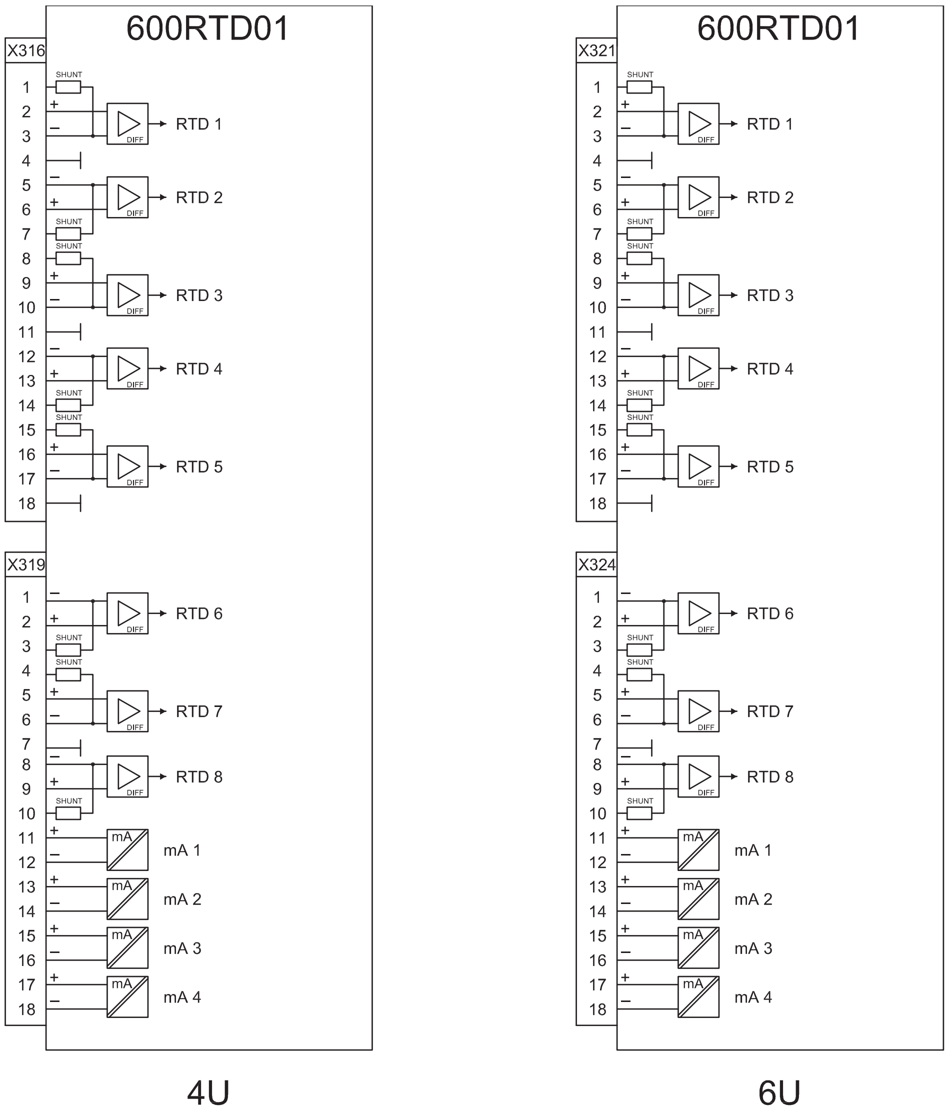

Figure 15. 630 series RTD module option

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 RET630 protection IED on the product page. Scroll down the page to find and download the related documentation.

30. Functions, codes and symbols

Table 108. 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
Non-directional earth-fault protection, low stage	EFLPTOC	I0>	51N-1
Non-directional earth-fault protection, high stage	EFHPTOC	I0>>	51N-2
Directional earth-fault protection, low stage	DEFLPDEF	I0> ->	67N-1
Directional earth-fault protection, high stage	DEFHPDEF	I0>> ->	67N-2
Stabilised restricted earth-fault protection	LREFPNDF	dI0Lo>	87NL
High-impedance based restricted earth-fault protection	HREFPDIF	dI0Hi>	87NH
Negative-sequence overcurrent protection	NSPTOC	I2>	46
Three-phase thermal overload protection, two time constants	T2PTTR	3Ith>T/G	49T/G
Three-phase current inrush detection	INRPHAR	3I2f>	68
Transformer differential protection for two-winding transformers	TR2PTDF	3dI>T	87T
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
Frequency gradient protection	DAPFRC	df/dt>	81R
Overfrequency protection	DAPTOF	f>	81O
Underfrequency protection	DAPTUF	f<	81U
Overexcitation protection	OEPVPH	U/f>	24
Three-phase underimpedance protection	UZPDIS	Z< GT	21GT
Circuit breaker failure protection	CCBRBRF	3I>/I0>BF	51BF/51NBF
Tripping logic	TRPPTRC	I -> O	94
Multipurpose analog protection	MAPGAPC	MAP	MAP
Control			
Bay control	QCCBAY	CBAY	CBAY
Interlocking interface	SCILO	3	3

Table 108. Functions included in the IED, continued

Description	IEC 61850	IEC 60617	ANSI
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
Tap changer control with voltage regulator	OLATCC	COLTC	90V
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	-	-
Hot-spot and insulation ageing rate monitoring for transformers	HSARSPTR	3Ihp>T	26/49HS
Tap position indication	TPOSSLTC	TPOSM	84M
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

Table 108. Functions included in the IED, continued

Description	IEC 61850	IEC 60617	ANSI
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/2011-12-05	1.1	Content updated
F/2012-08-29	1.2	Content updated to correspond to the product version
G/2014-12-03	1.3	Content updated to correspond to the product version

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