Relion® 615 series

Feeder Protection and Control REF615 Product Guide

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Contents

1. Description

REF615 is a dedicated feeder IED (intelligent electronic device) designed for the protection, control, measurement and supervision of utility substations and industrial power systems. REF615 is a member of ABB's Relion® product family and part of its 615 protection and control product series. The 615 series IEDs are characterized by their compactness and withdrawable design.

Re-engineered from the ground up, the 615 series has been designed to unleash the full potential of the IEC 61850 standard for communication and interoperability between substation automation devices.

The IED provides main protection for overhead lines and cable feeders in distribution networks. The IED is also used as back-up protection in applications, where an independent and redundant protection system is required.

Depending on the chosen standard configuration, the IED is adapted for the protection of overhead line and cable feeders in isolated neutral, resistance earthed, compensated and solidly earthed networks. Once the standard configuration IED has been given the application-specific settings, it can directly be put into service.

The 615 series IEDs support a range of communication protocols including IEC 61850 with GOOSE messaging, IEC 60870-5-103, Modbus® and DNP3.

2. Standard configurations

The feeder protection IED REF615 is available with six alternative standard configurations.

Table 1. Standard configurations

Description	Std. conf.
Non-directional overcurrent and directional earth-fault protection	A and B
Non-directional overcurrent and non-directional earth-fault protection	C and D
Non-directional overcurrent and directional earth-fault protection with phase-voltage based measurements	E
Directional overcurrent and earth-fault protection with phase-voltage based measurements, undervoltage and overvoltage protection	F

Table 2. Supported functions

Functionality	A	B	C	D	E	F
Protection[1)]						
Three-phase non-directional overcurrent protection, low stage, instance 1	●	●	●	●	●	-
Three-phase non-directional overcurrent protection, high stage, instance 1	●	●	●	●	●	-
Three-phase non-directional overcurrent protection, high stage, instance 2	●	●	●	●	●	-
Three-phase non-directional overcurrent protection, instantaneous stage, instance 1	●	●	●	●	●	●
Three-phase directional overcurrent protection, low stage, instance 1	-	-	-	-	-	●
Three-phase directional overcurrent protection, low stage, instance 2	-	-	-	-	-	●
Three-phase directional overcurrent protection, high stage	-	-	-	-	-	●
Non-directional earth-fault protection, low stage (SEF), instance 1	-	-	●	●	-	-
Non-directional earth-fault protection, low stage, instance 2	-	-	●	●	-	-
Non-directional earth-fault protection, high stage, instance 1	-	-	●	●	-	-
Non-directional earth-fault protection, instantaneous stage	-	-	●	●	-	-
Directional earth-fault protection, low stage (SEF), instance 1	●	●	-	-	●	●
Directional earth-fault protection, low stage, instance 2	●	●	-	-	●	●
Directional earth-fault protection, high stage	●	●	-	-	●	●
Transient / intermittent earth-fault protection	●	●	-	-	●	●
Non-directional (cross-country) earth-fault protection, using calculated I_0	●	●	-	-	●	●
Negative-sequence overcurrent protection, instance 1	●	●	●	●	●	●
Negative-sequence overcurrent protection, instance 2	●	●	●	●	●	●
Phase discontinuity protection	●	●	●	●	●	●
Residual overvoltage protection, instance 1	-	-	-	-	-	●
Residual overvoltage protection, instance 2	-	-	-	-	-	●
Residual overvoltage protection, instance 3	-	-	-	-	-	●
Three-phase undervoltage protection, instance 1	-	-	-	-	-	●

Table 2. Supported functions, continued

Functionality	A	B	C	D	E	F
Three-phase undervoltage protection, instance 2	-	-	-	-	-	●
Three-phase undervoltage protection, instance 3	-	-	-	-	-	●
Three-phase overvoltage protection, instance 1	-	-	-	-	-	●
Three-phase overvoltage protection, instance 2	-	-	-	-	-	●
Three-phase overvoltage protection, instance 3	-	-	-	-	-	●
Positive-sequence undervoltage protection	-	-	-	-	-	●
Negative-sequence overvoltage protection	-	-	-	-	-	●
Three-phase thermal protection for feeders, cables and distribution transformers	●	●	●	●	●	●
Circuit breaker failure protection	●	●	●	●	●	●
Three-phase inrush detector	●	●	●	●	●	●
Master trip, instance 1	●	●	●	●	●	●
Master trip, instance 2	●	●	●	●	●	●
Arc protection, instance 1	o	o	o	o	o	o
Arc protection, instance 2	o	o	o	o	o	o
Arc protection, instance 3	o	o	o	o	o	o
Control						
Circuit-breaker control with basic interlocking [2)]	●	●	●	●	●	●
Circuit-breaker control with extended interlocking [3)]	-	●	-	●	●	●
Disconnector position indication, instance 1	-	●	-	●	●	●
Disconnector position indication, instance 2	-	●	-	●	●	●
Disconnector position indication, instance 3	-	●	-	●	●	●
Earthing switch indication	-	●	-	●	●	●
Auto-reclosing of one circuit breaker	o	o	o	o	o	o
Condition Monitoring						
Circuit-breaker condition monitoring	-	●	-	●	●	●
Trip circuit supervision, instance 1	●	●	●	●	●	●
Trip circuit supervision, instance 2	●	●	●	●	●	●
Current circuit supervision	-	-	-	-	●	●
Fuse failure supervision	-	-	-	-	●	●

Table 2. Supported functions, continued

Functionality	A	B	C	D	E	F
Measurement						
Disturbance recorder	●	●	●	●	●	●
Three-phase current measurement	●	●	●	●	●	●
Sequence current measurement	●	●	●	●	●	●
Residual current measurement	●	●	●	●	●	●
Three-phase voltage measurement	-		-	-	●	●
Residual voltage measurement	●	●	-	-	●	●
Sequence voltage measurement	-	-	-	-	●	●
Three-phase power and energy measurement	-	-	-	-	●	●

● = Included,○ = Optional at the time of the order

1) Note that all directional protection functions can also be used in non-directional mode.
2) Basic interlocking functionality: Closing of the circuit breaker can be enabled by a binary input signal. The actual interlocking scheme is implemented outside the relay. The binary input serves as a "master interlocking input" and when energized it will enable circuit breaker closing.
3) Extended interlocking functionality: The circuit breaker interlocking scheme is implemented in the relay configuration, based on primary equipment position information (via binary inputs) and the logical functions available. The signal matrix of PCM600 can be used for modifying the interlocking scheme to suit your application.

3. Protection functions

The IED offers directional and non-directional overcurrent and thermal overload protection, directional and non-directional earth-fault protection, sensitive earth-fault protection, phase discontinuity protection, transient/intermittent earth-fault protection, overvoltage and undervoltage protection, residual overvoltage protection, positive-sequence undervoltage and negative-sequence overvoltage protection. In addition the IED offers three-pole multi-shot auto-reclose functions for overhead line feeders.

Enhanced with optional hardware and software, the IED also features three light detection channels for arc fault protection of the circuit breaker, busbar and cable compartment of metal-enclosed indoor switchgear.

The arc-fault protection sensor interface is available on the optional communication module. Fast tripping increases personal safety and limits material damage within the switchgear in an arc fault situation.

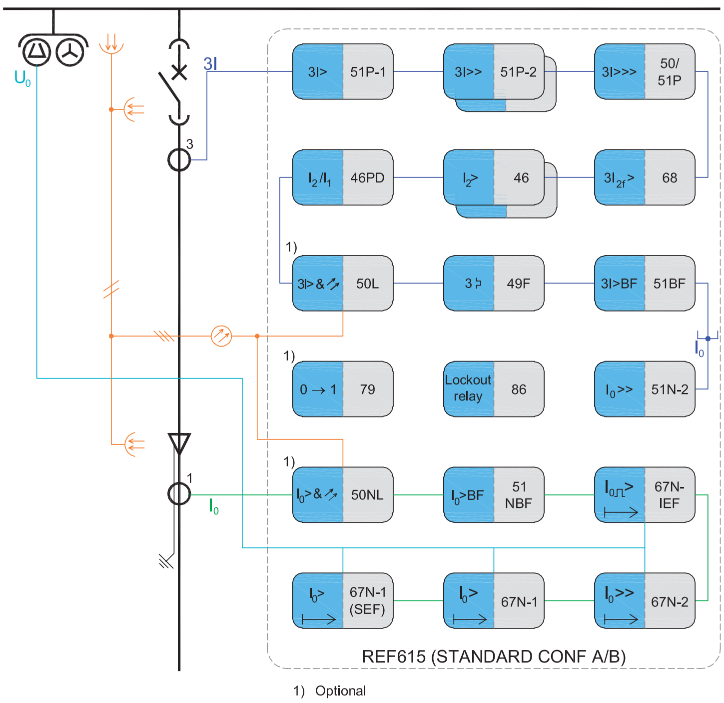

Figure 1. Protection function overview of standard configuration A and B

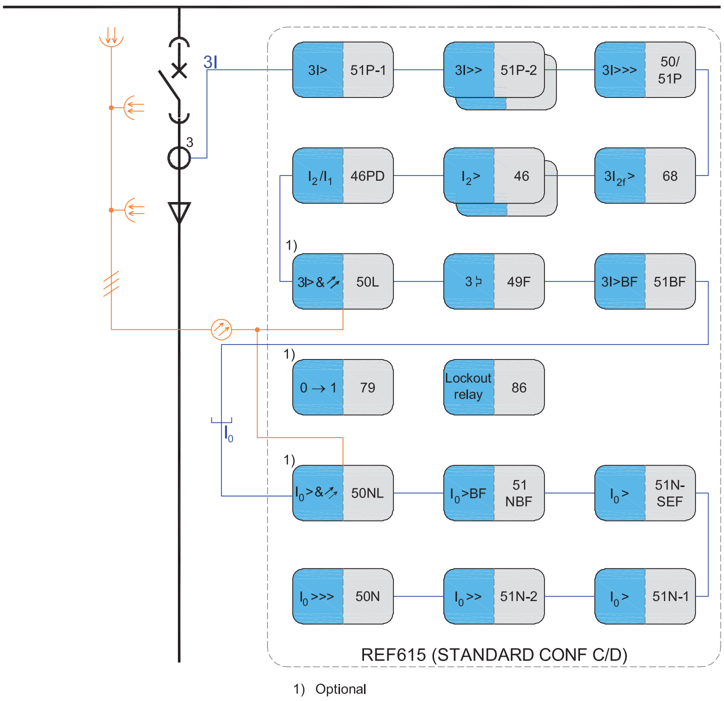

Figure 2. Protection function overview of standard configuration C and D

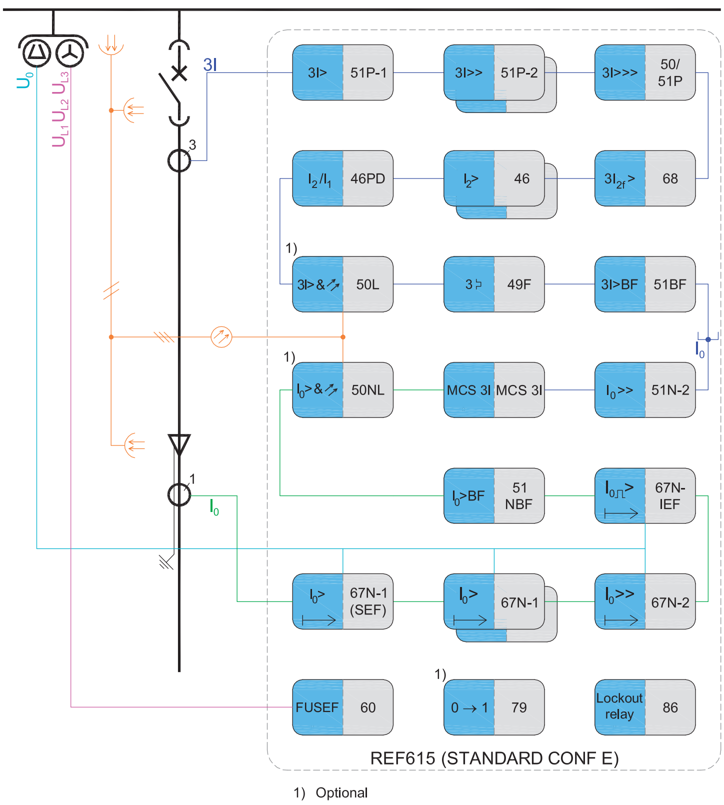

Figure 3. Protection function overview of standard configuration E

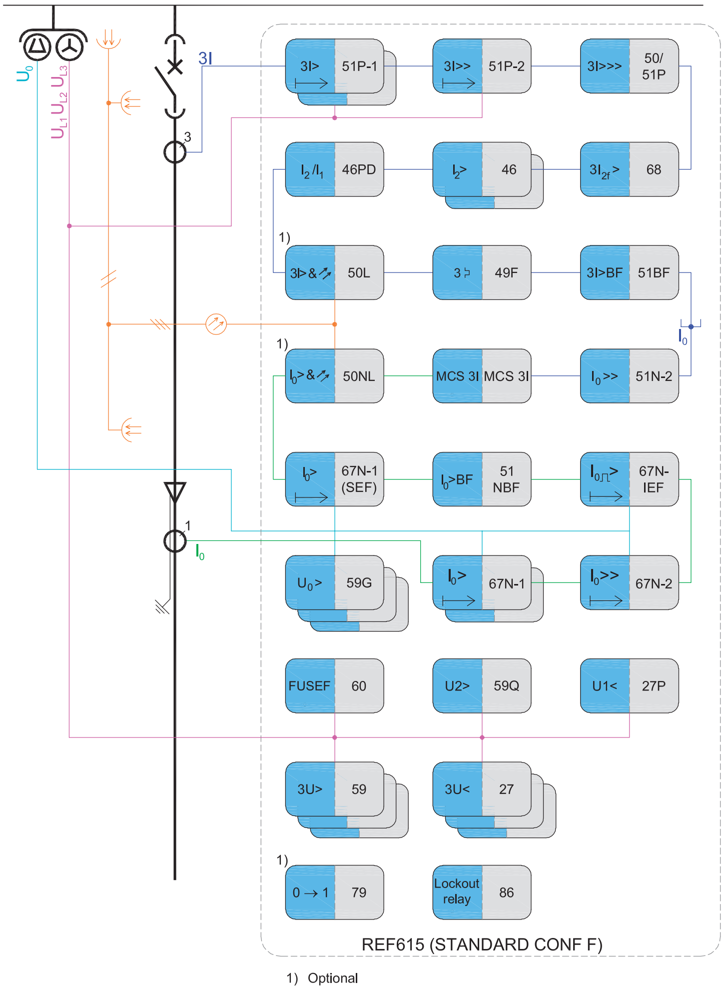

Figure 4. Protection function overview of standard configuration F

4. Application

The feeder protection IED REF615 can be supplied either with directional or non-directional earth-fault protection. Directional earth-fault protection is mainly used in isolated or compensated networks, whereas non-directional earth-fault protection is intended for directly or low impedance earthed networks.

The standard configurations A and B offer directional earth-fault protection, if the outgoing feeder includes phase current transformers, a core-balance current transformer and residual voltage measurement. The residual current calculated from the phase currents can be used for double (cross country) earth-fault protection. The IED further features transient/ intermittent earth-fault protection. The standard configurations C and D offer non-directional earth-fault protection for outgoing feeders including phase current transformers. The residual current for the earth-fault protection is derived from the phase currents. When applicable, the core-balance current transformers can be used for measuring the residual current, especially when sensitive earth-fault protection is required. The standard configurations E and F offer directional earth-fault protection with phase voltage and residual voltage measurement. Further, the two standard configurations include current circuit supervision and fuse failure supervision for incoming feeders with busbar voltage measurement. Standard configuration F offers in addition to standard configuration E directional overcurrent protection, overvoltage and undervoltage protection, positive-sequence undervoltage and negative-sequence overvoltage protection and residual voltage protection.

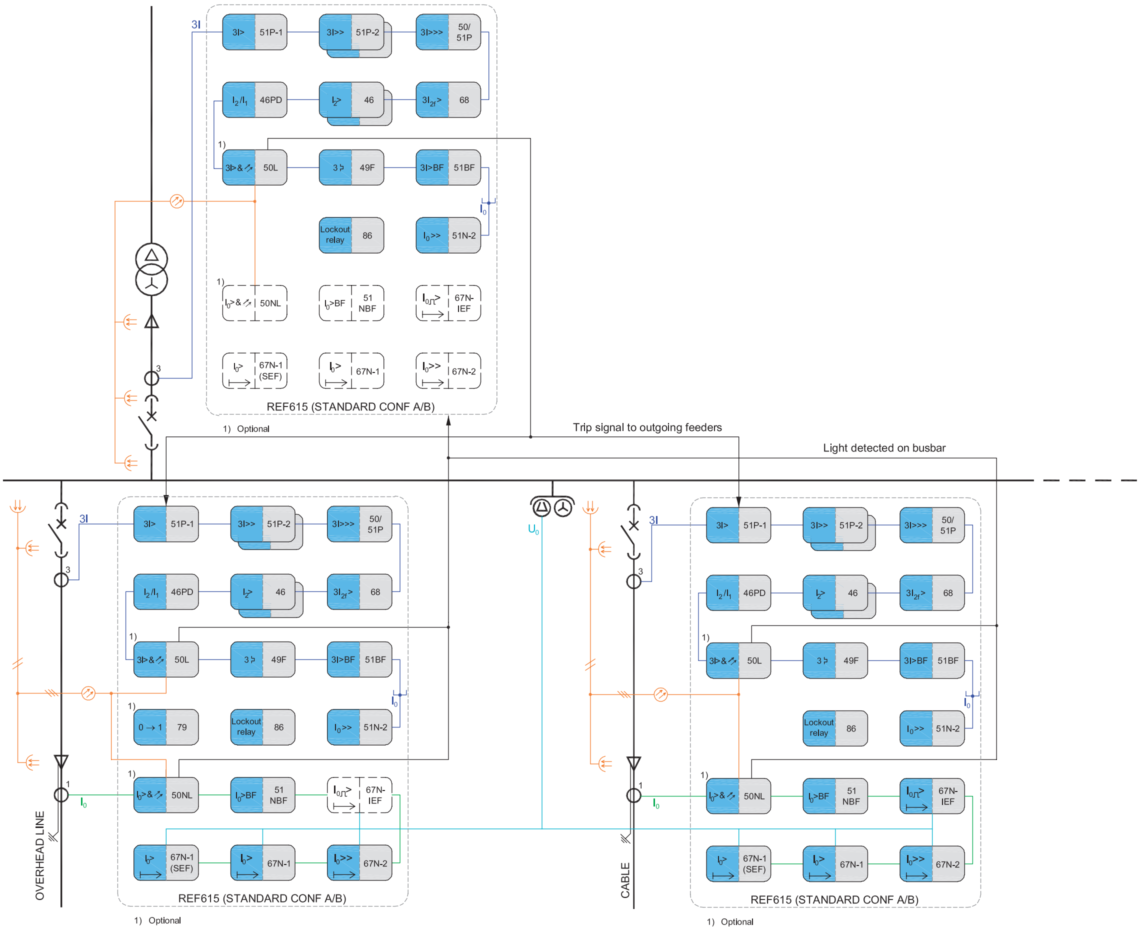

Figure 5. Substation O/C and E/F protection using the standard configuration A or B with relevant options. In the incoming feeder bay, the protection functions not used are uncoloured and indicated with a dashed block outline. The IEDs are equipped with optional arc protection functions, enabling fast and selective arc protection throughout the switchgear.

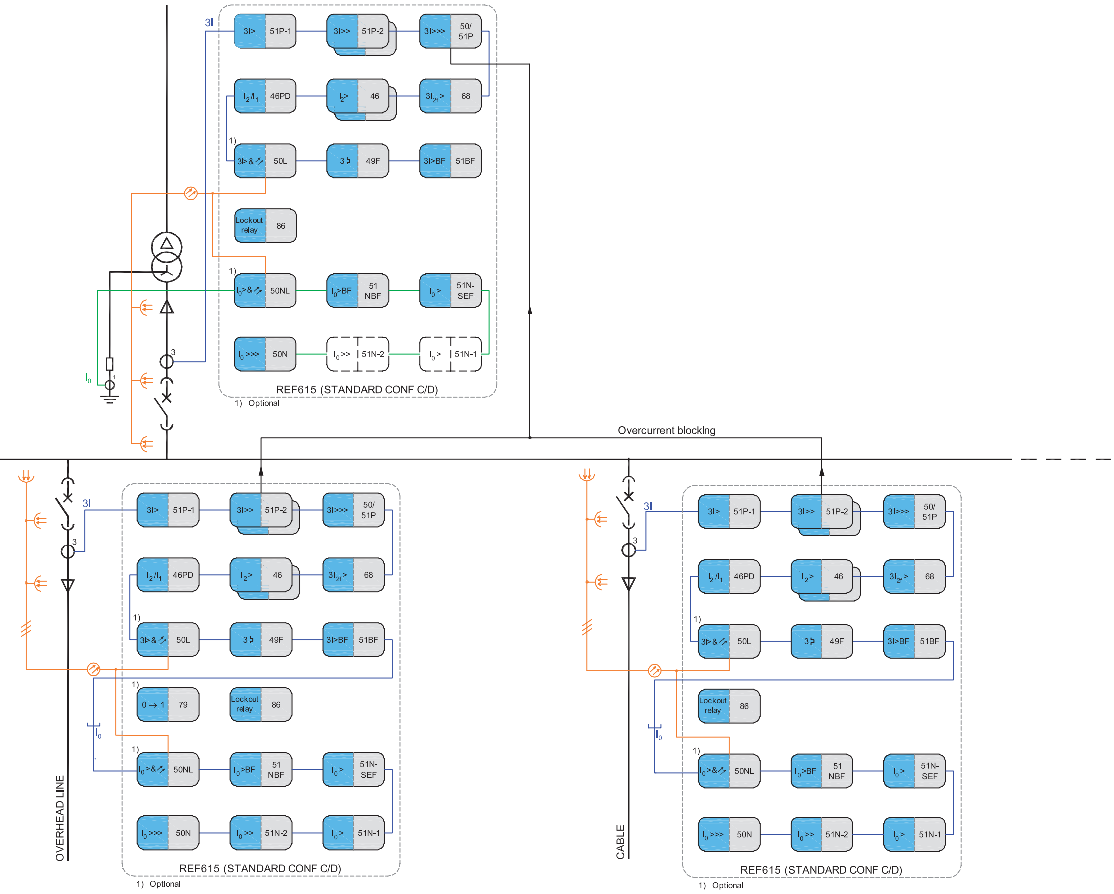

Figure 6. Substation O/C and E/F protection using the standard configuration C or D with relevant options. In the incoming feeder bay the unemployed protection functions are uncoloured and indicated with a dashed block outline. The busbar protection is based on the interlocking principle, where the start of the O/C protection of the outgoing feeder sends a blocking signal to the instantaneous O/C stage of the incoming feeder. In the absence of the blocking signal, the O/C protection of the incoming feeder will clear the internal switchgear (busbar) fault.

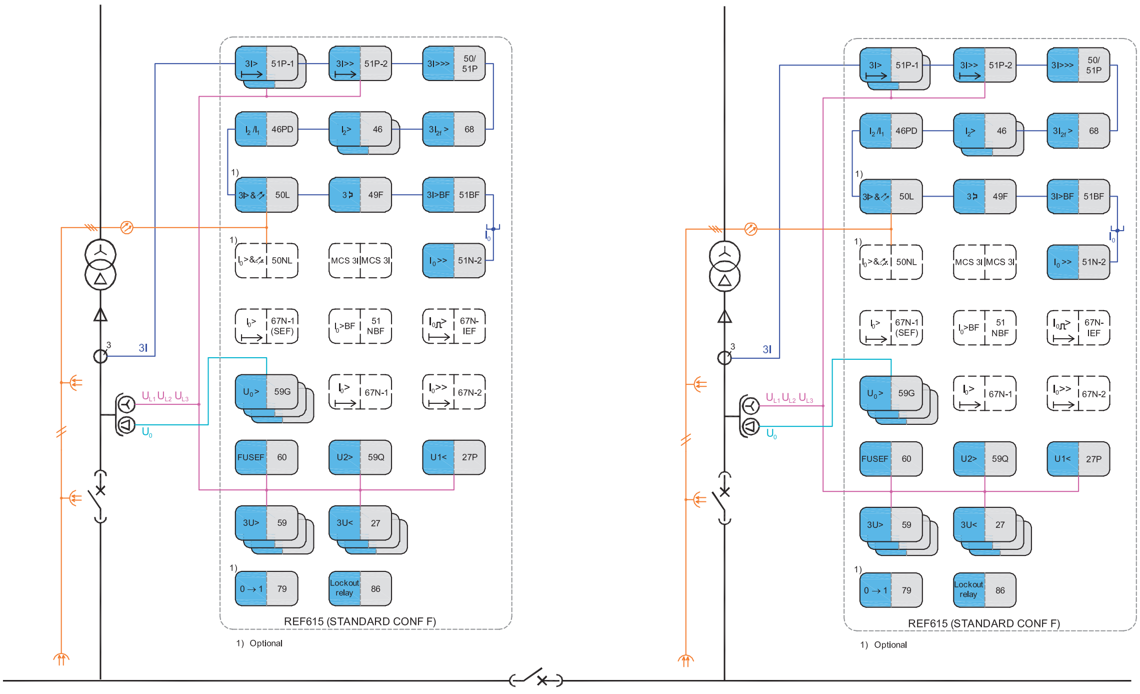

Figure 7. Protection and control of two incoming feeders using IEDs with standard configuration F. The two incoming feeders can be connected in parallel by closing the busbar-sectionalizing breaker. To achieve selective overcurrent protection, directional overcurrent stages are needed. Busbar main and back-up protection for outgoing feeders is implemented using residual overvoltage protection stages. Phase undervoltage and overvoltage protection can be used for tripping or just alarming purposes.

5. Supported ABB solutions

ABB's 615 series protection and control IEDs together with the COM600 Station Automation device 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, 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 COM600 Station Automation device or the MicroSCADA Pro network control and management system.

The 615 series IEDs offer native 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 full implementation of the IEC 61850 substation automation standard.

At the substation level COM600 utilizes the 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 web HMI 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 3. Supported ABB solutions

Product	Version
Station Automation COM600	3.3 or later
MicroSCADA Pro	9.2 SP1 or later

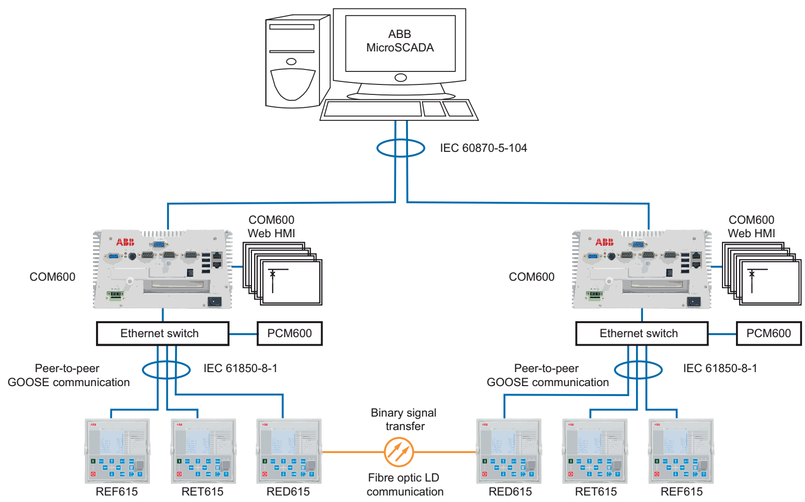

Figure 8. Utility power distribution network example using 615 series IEDs, Station Automation COM600 and MicroSCADA Pro

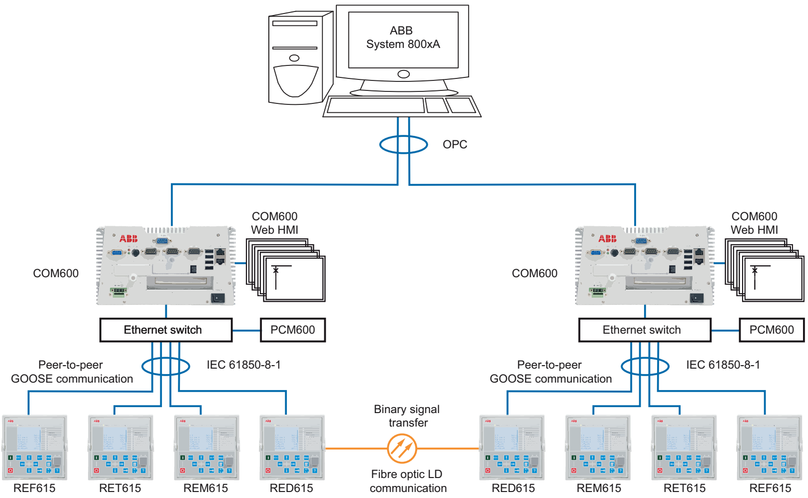

Figure 9. Industrial power system example using 615 series IEDs, Station Automation COM600 and System 800xA

6. Control

The IED offers control of one circuit breaker with dedicated push-buttons for opening and closing. Interlocking schemes required by the application are configured with the signal matrix in PCM600.

7. Measurement

The IED continuously measures the phase currents, the symmetrical components of the currents and the residual current. If the IED includes voltage measurements it also measures the residual voltage, the phase voltages and the voltage sequence components. In addition, the IED calculates the demand value of current over a userselectable pre-set time frames, the thermal overload of the protected object, and the phase unbalance value based on the ratio between the negative sequence and positive sequence current.

The values measured can be accessed locally via the user interface on the IED front panel or remotely via the communication interface of the IED. The values can also be 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 12 analog and 64 binary signal channels. The analog channels can be set to record either the waveform or the trend of the currents and voltage measured.

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

By default, the binary channels are set to record external or internal IED signals, for example the start or trip signals of the IED stages, 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. The recorded information is stored in a non-volatile memory and can be uploaded for subsequent fault analysis.

9. Event log

To collect sequence-of-events (SoE) information, the IED incorporates a non-volatile memory with a capacity of storing 50 event codes with associated time stamps. 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 feeder 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.

10. Recorded data

The IED has the capacity to store the records of four latest fault events. The records enable the user to analyze the four most recent power system events. Each record includes current, voltage and angle values, start times of the protection blocks, time stamp, etc. The fault recording can be triggered by the start signal or the trip signal of a protection block, or by both. The available measurement modes include DFT, RMS and peak-to-peak. In addition, the maximum demand current with time stamp is separately recorded. By default, the records are stored in a non-volatile memory.

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 and the inactivity time of the circuit breaker.

The monitoring functions provide operational CB history data, which can be used for scheduling preventive CB 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 will be used for alerting the operator. A permanent IED fault will block the protection functions to prevent incorrect operation.

14. Fuse failure supervision

Depending on the chosen standard configuration, the IED includes fuse failure supervision functionality. The fuse failure supervision detects failures between the voltage measurement circuit and the IED. The failures are detected 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

Depending on the chosen standard configuration, the IED includes 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 activates an alarm LED and blocks certain protection functions to avoid unintended operation. The current circuit supervision function calculates the sum of the phase currents from the protection cores and compares the sum with the measured single reference current from a core balance current transformer or from separate cores in the phase current transformers.

16. Access control

To protect the IED from unauthorized access and to maintain information integrity, the IED is provided with a four-level, role-based authentication system with administrator-programmable individual passwords for the viewer, operator, engineer and administrator level. The access control applies to the front-panel user interface, the web-browser based user interface and the PCM600 tool.

17. Inputs and outputs

Depending on the standard configuration selected, the IED is equipped with three phase-current inputs and one residual-current input for non-directional earth-fault protection, or three phase-current inputs, one residual-current input and one residual voltage input for directional earth-fault protection or three phase-current inputs, one residual-current input, three phase-voltage inputs and one residual voltage input for directional earth-fault protection and directional overcurrent protection.

The phase-current inputs are rated 1/5 A. Two optional residual-current inputs are available, i.e. 1/5 A or 0.2/1 A. The 0.2/1 A input is normally used in applications requiring sensitive earth-fault protection and featuring core-balance current transformers. The three phase-voltage inputs and the residual-voltage input covers the rated voltages 100, 110, 115 and 120 V. Both phase-to-phase voltages and phase-to-earth voltages can be connected.

The phase-current input 1 A or 5 A, the residual-current input 1 A or 5 A, alternatively 0.2 A or 1 A, and the rated voltage of the residual voltage input are selected in the IED software. In addition, the binary input thresholds 18…176 V DC are selected by adjusting the IED’s parameter settings.

All binary input and output contacts are freely configurable with the signal matrix in PCM600.

Please refer to the Input/output overview table and the terminal diagrams for more detailed information about the inputs and outputs.

Table 4. Input/output overview

Standard configuration	Analog inputs		Binary inputs/outputs	
	CT	VT	BI	BO
A	4	1	3	6
B	4	1	11 (17)[1)]	10 (13)[1)]
C	4	-	4	6
D	4	-	12 (18)[1)]	10 (13)[1)]
E	4	5[2)]	16	10
F	4	5[2)]	16	10

1) With optional binary I/O module ( )
2) One of the five inputs is reserved for future applications

18. Communication

The IED supports a range of communication protocols including IEC 61850, IEC 60870-5-103, Modbus® and DNP3. Operational information and controls are available through these protocols. However, some communication functionality, for example, horizontal communication between the IEDs, is only enabled by the IEC 61850 communication protocol.

The IEC 61850 communication implementation supports all monitoring and control functions. Additionally, parameter setting and disturbance file records can be accessed using the IEC 61850 protocol. Disturbance files are available to any Ethernet-based application in the standard COMTRADE format. Further, the IED can send and receive binary signals from other IEDs (so called horizontal communication) using the IEC61850-8-1 GOOSE profile. The IED meets the GOOSE performance requirements for tripping applications in distribution substations, as defined by the IEC 61850 standard. The IED can simultaneously report events to five different clients on the station bus.

All communication connectors, except for the front port connector, are placed on integrated optional communication modules. The IED can be connected to Ethernet-based communication systems via the RJ-45 connector (100BASE-TX) or the fibre-optic LC connector (100BASE-FX). If connection to a serial bus is required, the 10-pin RS-485 screw-terminal or the fibre-optic ST connector can be used.

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

The IEC 60870-5-103 implementation supports two parallel serial bus connections to two different masters. Besides basic standard functionality, the IED supports changing of the active setting group and uploading of disturbance files in IEC 60870-5-103 format.

DNP3 supports both serial and TCP modes for connection to one master.

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

The IED supports the following time synchronization methods with a time-stamping resolution of 1 ms:

Ethernet based:

- SNTP (Simple Network Time Protocol)

With special time synchronization wiring:

- IRIG-B (Inter-Range Instrumentation Group - Time Code Format B)

In addition, the IED supports time synchronization via the following serial communication protocols:

- Modbus
- DNP3
- IEC 60870-5-103

Table 5. Supported station communication interfaces and protocols

Interfaces/ Protocols	Ethernet		Serial	
	100BASE-TX RJ-45	100BASE-FX LC	RS-232/RS-485	Fibre-optic ST
IEC 61850	●	●	-	-
MODBUS RTU/ ASCII	-	-	●	●
MODBUS TCP/ IP	●	●	-	-
DNP3 (serial)	-	-	●	●
DNP3 TCP/IP	●	●	-	-
IEC 60870-5-103	-	-	●	●

● = Supported

19. Technical data

Table 6. Dimensions

Description	Value	
Width	frame	179.8 mm
	case	164 mm
Height	frame	177 mm (4U)
	case	160 mm
Depth		194 mm (153 + 41 mm)
Weight	IED	3.5 kg
	spare unit	1.8 kg

Table 7. Power supply

Description	Type 1	Type 2
U_{aux}nominal	100, 110, 120, 220, 240 V AC, 50 and 60 Hz	24, 30, 48, 60 V DC
	48, 60, 110, 125, 220, 250 V DC	
U_{aux}variation	38...110% of U_n (38...264 V AC)	50...120% of U_n (12...72 V DC)
	80...120% of U_n (38.4...300 V DC)	
Start-up threshold		19.2 V DC (24 V DC * 80%)
Burden of auxiliary voltage supply under quiescent (P_q)/operating condition	250 V DC ~ 8.5 W (nominal)/~ 14.1 W (max) 240 V AC ~ 10.2 W (nominal)/ ~ 16.1 W (max)	60 V DC ~ 6.7 W (nominal)/~ 12.9 W (max)
Ripple in the DC auxiliary voltage	Max 12% of the DC value (at frequency of 100 Hz)	
Maximum interruption time in the auxiliary DC voltage without resetting the IED	• 110 V DC: 84 ms • 110 V AC: 116 ms	48 V DC: 68 ms
Fuse type	T4A/250 V	

Table 8. Energizing inputs

Description		Value	
Rated frequency		50/60 Hz ± 5 Hz	
Current inputs	Rated current, I_n	0.2/1 A[1]	1/5 A[2]
	Thermal withstand capability: • Continuously • For 1 s	 4 A 100 A	 20 A 500 A
	Dynamic current withstand: • Half-wave value	 250 A	 1250 A
	Input impedance	<100 mΩ	<20 mΩ
Voltage inputs	Rated voltage	100 V AC/ 110 V AC/ 115 V AC/ 120 V AC (Parametrization)	
	Voltage withstand: • Continuous • For 10 s	 2 x U_n (240 V AC) 3 x U_n (360 V AC)	
	Burden at rated voltage	<0.05 VA	

1) Ordering option for residual current input
2) Residual current and/or phase current

Table 9. Binary inputs

Description	Value
Operating range	±20% of the rated voltage
Rated voltage	24...250 V DC
Current drain	1.6...1.9 mA
Power consumption	31.0...570.0 mW
Threshold voltage	18...176 V DC
Reaction time	3 ms

Table 10. Signal outputs and IRF output

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 48/110/220 V DC	1 A/0.25 A/0.15 A
Minimum contact load	100 mA at 24 V AC/DC

Table 11. Double-pole power output relays with 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 48/110/220 V DC (two contacts connected in series)	5 A/3 A/1 A
Minimum contact load	100 mA at 24 V AC/DC
Trip-circuit supervision (TCS): • Control voltage range • Current drain through the supervision circuit • Minimum voltage over the TCS contact	 20...250 V AC/DC ~1.5 mA 20 V AC/DC (15...20 V)

Table 12. Single-pole power output relays

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 48/110/220 V DC, at 48/110/220 V DC	5 A/3 A/1 A
Minimum contact load	100 mA at 24 V AC/DC

Table 13. Lens sensor and optical fibre for arc protection

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

Table 14. Degree of protection of flush-mounted IED

Description	Value
Front side	IP 54
Rear side, connection terminals	IP 20

Table 15. Environmental conditions

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

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

Table 16. Environmental tests

Description	Type test value	Reference
Dry heat test (humidity <50%)	• 96 h at +55°C • 16 h at +85°C[1)]	IEC 60068-2-2
Dry cold test	• 96 h at -25°C • 16 h at -40°C	IEC 60068-2-1
Damp heat test, cyclic	• 6 cycles (12 h + 12 h) at +25°C…+55°C, humidity >93%	IEC 60068-2-30
Storage test	• 96 h at -40°C • 96 h at +85°C	IEC 60068-2-48

1) For IEDs with an LC communication interface the maximum operating temperature is +70°C

Table 17. Electromagnetic compatibility tests

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

Table 17. Electromagnetic compatibility tests, continued

Description	Type test value	Reference
Power frequency immunity test: • Common mode • Differential mode	Binary inputs only 300 V rms 150 V rms	IEC 61000-4-16 and IEC 60255-22-7, class A
Voltage dips and short interruptions	30%/10 ms 60%/100 ms 60%/1000 ms >95%/5000 ms	IEC 61000-4-11
Electromagnetic emission tests: • Conducted, RF-emission (mains terminal) 0.15...0.50 MHz 0.5...30 MHz • Radiated RF -emission 30...230 MHz 230...1000 MHz	 < 79 dB(µV) quasi peak < 66 dB(µV) average < 73 dB(µV) quasi peak < 60 dB(µV) average < 40 dB(µV/m) quasi peak, measured at 10 m distance < 47 dB(µV/m) quasi peak, measured at 10 m distance	EN 55011, class A and IEC 60255-25

Table 18. Insulation tests

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

Table 19. Mechanical tests

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

Table 20. EMC compliance

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

Table 21. Product safety

Description	Reference
LV directive	2006/95/EC
Standard	EN 60255-27 (2005) EN 60255-6 (1994)

Table 22. RoHS compliance

Description
Complies with RoHS directive 2002/95/EC

Table 23. Front port Ethernet interfaces

Ethernet interface	Protocol	Cable	Data transfer rate
Front	TCP/IP protocol	Standard Ethernet CAT 5 cable with RJ-45 connector	10 MBits/s

Protection functions

Table 24. Three-phase non-directional overcurrent protection (PHxPTOC)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the current measured: f_n ±2Hz		
	PHLPTOC	±1.5% of the set value or ±0.002 x I_n		
	PHHPTOC and PHIPTOC	±1.5% of set value or ±0.002 x I_n (at currents in the range of 0.1…10 x I_n) ±5.0% of the set value (at currents in the range of 10…40 x I_n)		
Start time [1)2)]		Minimum	Typical	Maximum
	PHIPTOC: I_{Fault} = 2 x set *Start value*	16 ms	19 ms	23 ms
	I_{Fault} = 10 x set *Start value*	11 ms	12 ms	14 ms
	PHHPTOC and PHLPTOC: I_{Fault} = 2 x set *Start value*	22 ms	24 ms	25 ms
Reset time		< 40 ms		
Reset ratio		Typical 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: -50dB at f = n x 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 x In, fn = 50 Hz, fault current in one phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact
3) Includes the delay of the heavy-duty output contact

Table 25. Three-phase non-directional overcurrent protection (PHxPTOC) main settings

Parameter	Function	Value (Range)	Step
Start Value	PHLPTOC	0.05...5.00 x I_n	0.01
	PHHPTOC	0.10...40.00 x I_n	0.01
	PHIPTOC	1.00...40.00 x I_n	0.01
Time multiplier	PHLPTOC	0.05...15.00	0.05
	PHHPTOC	0.05...15.00	0.05
Operate delay time	PHLPTOC	40...200000 ms	10
	PHHPTOC	40...200000 ms	10
	PHIPTOC	20...200000 ms	10
Operating curve type[1)]	PHLPTOC	Definite or inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	PHHPTOC	Definite or inverse time Curve type: 1, 3, 5, 9, 10, 12, 15, 17	
	PHIPTOC	Definite time	

1) For further reference please refer to the Operating characteristics table at the end of the Technical data chapter

Table 26. Three-phase directional over current protection (DPHxPDOC)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the current/ voltage measured: f_n ±2Hz		
	DPHLPDOC	Current: ±1.5% of the set value or ±0.002 x I_n Voltage: ±1.5% of the set value or ±0.002 x U_n Phase angle: ±2°		
	DPHHPDOC	Current: ±1.5% of the set value or ±0.002 x I_n (at currents in the range of 0.1…10 x I_n) ±5.0% of the set value (at currents in the range of 10…40 x I_n) Voltage: ±1.5% of the set value or ±0.002 x U_n Phase angle: ±2°		
Start time[1)2)]		Minimum	Typical	Maximum
	I_{Fault} = 2.0 x set *Start value*	37 ms	40 ms	42 ms
Reset time		< 40 ms		
Reset ratio		Typical 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 x f_n, where n = 2, 3, 4, 5, …		

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

Table 27. Three-phase directional overcurrent protection (DPHxPDOC) main settings

Parameter	Function	Value (Range)	Step
Start value	DPHxPDOC	0.05...5.00 x I_n	0.01
Time multiplier	DPHxPDOC	0.05...15.00	0.05
Operate delay time	DPHxPDOC	40...200000 ms	10
Directional mode	DPHxPDOC	1 = Non-directional 2 = Forward 3 = Reverse	
Characteristic angel	DPHxPDOC	-179...180 degrees	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	
	DPHHPTOC	Definite or inverse time Curve type: 1, 3, 5, 9, 10, 12, 15, 17	

1) For further reference please refer to the Operating characteristics table at the end of the Technical data chapter

Table 28. Non-directional EF protection (EFxPTOC)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the current measured: f_n ±2Hz		
	EFLPTOC	±1.5% of the set value or ±0.002 x I_n		
	EFHPTOC and EFIPTOC	±1.5% of set value or ±0.002 x I_n (at currents in the range of 0.1…10 x I_n) ±5.0% of the set value (at currents in the range of 10…40 x I_n)		
Start time [1)2)]		Minimum	Typical	Maximum
	EFIPTOC: I_{Fault} = 2 x set *Start value* I_{Fault} = 10 x set *Start value*	16 ms 11 ms	19 ms 12 ms	23 ms 14 ms
	EFHPTOC and EFLPTOC: I_{Fault} = 2 x set *Start value*	22 ms	24 ms	25 ms
Reset time		< 40 ms		
Reset ratio		Typical 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: -50dB at f = n x f_n, where n = 2, 3, 4, 5, … Peak-to-Peak: No suppression		

1) *Measurement mode* = default (depends on stage), current before fault = 0.0 x 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 x I_n, *Start value* multiples in range of 1.5 to 20

Table 29. Non-directional EF protection (EFxPTOC) main settings

Parameter	Function	Value (Range)	Step
Start value	EFLPTOC	0.010...5.000 x I_n	0.005
	EFHPTOC	0.10...40.00 x I_n	0.01
	EFIPTOC	1.00...40.00 x I_n	0.01
Time multiplier	EFLPTOC	0.05...15.00	0.05
	EFHPTOC	0.05...15.00	0.05
Operate delay time	EFLPTOC	40...200000 ms	10
	EFHPTOC	40...200000 ms	10
	EFIPTOC	20...200000 ms	10
Operating curve type[1)]	EFLPTOC	Definite or inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	EFHPTOC	Definite or inverse time Curve type: 1, 3, 5, 9, 10, 12, 15, 17	
	EFIPTOC	Definite time	

1) For further reference please refer to the Operating characteristics table at the end of the Technical data chapter

Table 30. Directional EF protection (DEFxPDEF)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the current measured: f_n ±2Hz		
	DEFLPDEF	Current: ±1.5% of the set value or ±0.002 x I_n Voltage ±1.5% of the set value or ±0.002 x U_n Phase angle: ±2°		
	DEFHPDEF	Current: ±1.5% of the set value or ±0.002 x I_n (at currents in the range of 0.1…10 x I_n) ±5.0% of the set value (at currents in the range of 10…40 x I_n) Voltage: ±1.5% of the set value or ±0.002 x U_n Phase angle: ±2°		
Start time [1)2)]		Minimum	Typical	Maximum
	DEFHPDEF and DEFLPTDEF: I_{Fault} = 2 x set *Start value*	61 ms	64 ms	66 ms
Reset time		< 40 ms		
Reset ratio		Typical 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: -50dB at f = n x 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 x 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 x I_n, *Start value* multiples in range of 1.5 to 20

Table 31. Directional EF protection (DEFxPDEF) main settings

Parameter	Function	Value (Range)	Step
Start Value	DEFLPDEF	0.01...5.00 x I_n	0.005
	DEFHPDEF	0.10...40.00 x I_n	0.01
Directional mode	DEFLPDEF and DEFHPDEF	1=Non-directional 2=Forward 3=Reverse	
Time multiplier	DEFLPDEF	0.05...15.00	0.05
	DEFHPDEF	0.05...15.00	0.05
Operate delay time	DEFLPDEF	60...200000 ms	10
	DEFHPDEF	60...200000 ms	10
Operating curve type[1]	DEFLPDEF	Definite or inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	DEFHPDEF	Definite or inverse time Curve type: 1, 3, 5, 15, 17	
Operation mode	DEFLPDEF and DEFHPDEF	1=Phase angle 2=I_0Sin 3=I_0Cos 4=Phase angle 80 5=Phase angle 88	

1) For further reference please refer to the Operating characteristics table at the end of the Technical data chapter

Table 32. Transient/intermittent earth-fault protection (INTRPTEF)

Characteristic	Value
Operation accuracy (U_0 criteria with transient protection)	Depending on the frequency of the current measured: f_n ±2Hz
	±1.5% of the set value or ±0.002 x U_n
Operate time accuracy	±1.0% of the set value or ±20 ms
Suppression of harmonics	DFT: -50dB at f = n x f_n, where n = 2, 3, 4, 5

Table 33. Transient/intermittent earth-fault protection (INTRPTEF) main settings

Parameter	Function	Value (Range)	Step
Directional mode	INTRPTEF	1=Non-directional 2=Forward 3=Reverse	
Operate delay time	INTRPTEF	40...1200000 ms	10
Voltage start value (voltage start value for transient EF)	INTRPTEF	0.01...0.50 x U_n	0.01
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	

Table 34. Three-phase overvoltage protection (PHPTOV)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the voltage measured: f_n ±2Hz		
		±1.5% of the set value or ±0.002 x U_n		
Start time1)2)		Minimum	Typical	Maximum
	U_{Fault} = 1.1 x set *Start value*	22 ms	24 ms	26 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 ms3)		
Suppression of harmonics		DFT: -50 dB at f = n x f_n, where n = 2, 3, 4, 5, …		

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

Table 35. Three-phase overvoltage protection (PHPTOV) main settings

Parameter	Function	Value (Range)	Step
Start value	PHPTOV	0.05...1.60 x U_n	0.01
Time multiplier	PHPTOV	0.05...15.00	0.05
Operate delay time	PHPTOV	40...300000 ms	10
Operating curve type[1)]	PHPTOV	Definite or inverse time Curve type: 5, 15, 17, 18, 19, 20	

1) For further reference please refer to the Operating characteristics table at the end of the Technical data chapter

Table 36. Three phase undervoltage protection (PHPTUV)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the voltage measured: fn ±2Hz		
		±1.5% of the set value or ±0.002 x U_n		
Start time[1)2)]		Minimum	Typical	Maximum
	U_{Fault} = 0.9 x set *Start value*	62 ms	64 ms	66 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 x f_n, where n = 2, 3, 4, 5, …		

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

Table 37. Three-phase undervoltage protection (PHPTUV) main settings

Parameter	Function	Value (Range)	Step
Start value	PHPTUV	0.05...1.20 x U_n	0.01
Time multiplier	PHPTUV	0.05...15.00	0.05
Operate delay time	PHPTUV	60...300000 ms	10
Operating curve type[1)]	PHPTUV	Definite or inverse time Curve type: 5, 15, 21, 22, 23	

1) For further reference please refer to the Operating characteristics table at the end of the Technical data chapter

Table 38. Positive sequence undervoltage protection (PSPTUV)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the voltage measured: f_n ±2Hz		
		±1.5% of the set value or ±0.002 x U_n		
Start time[1)2)]		Minimum	Typical	Maximum
	U_{Fault} = 0.99 x set *Start value*	51 ms	53 ms	54 ms
	U_{Fault} = 0.9 x set *Start value*	43 ms	45 ms	46 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		
Suppression of harmonics		DFT: -50 dB at f = n x f_n, where n = 2, 3, 4, 5, …		

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

Table 39. Positive sequence undervoltage protection (PSPTUV) main settings

Parameter	Function	Value (Range)	Step
Start value	PSPTUV	0.010...1.200 x U_n	0.001
Operate delay time	PSPTUV	40...120000 ms	10
Voltage block value	PSPTUV	0.01...1.0 x U_n	0.01

Table 40. Negative sequence overvoltage protection (NSPTOV)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the voltage measured: fn ±2Hz		
		±1.5% of the set value or ±0.002 x U_n		
Start time[1)2)]		Minimum	Typical	Maximum
	U_{Fault} = 1.1 x set *Start value* U_{Fault} = 2.0 x set *Start value*	33 ms 24 ms	35 ms 26 ms	37 ms 28 ms
Reset time		< 40 ms		
Reset ratio		Typical 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 x f_n, where n = 2, 3, 4, 5, …		

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

Table 41. Negative sequence overvoltage protection (NSPTOV) main settings

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

Table 42. Residual overvoltage protection (ROVPTOV)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the voltage measured: f_n ±2Hz		
		±1.5% of the set value or ±0.002 x U_n		
Start time[1)2)]		Minimum	Typical	Maximum
	U_{Fault} = 1.1 x set *Start value*	29 ms	31 ms	32 ms
Reset time		< 40 ms		
Reset ratio		Typical 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 x f_n, where n = 2, 3, 4, 5, …		

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

Table 43. Residual overvoltage protection (ROVPTOV) main settings

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

Table 44. Negative phase-sequence overcurrent protection (NSPTOC)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the current measured: f_n ±2Hz		
		±1.5% of the set value or ±0.002 x I_n		
Start time [1)2)]		Minimum	Typical	Maximum
	I_{Fault} = 2 x set *Start value* I_{Fault} = 10 x set *Start value*	22 ms 14 ms	24 ms 16 ms	25 ms 17 ms
Reset time		< 40 ms		
Reset ratio		Typical 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: -50dB at f = n x f_n, where n = 2, 3, 4, 5, …		

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

Table 45. Negative phase-sequence overcurrent protection (NSPTOC) main settings

Parameter	Function	Value (Range)	Step
Start value	NSPTOC	0.01...5.00 x I_n	0.01
Time multiplier	NSPTOC	0.05...15.00	0.05
Operate delay time	NSPTOC	40...200000 ms	10
Operating curve type[1)]	NSPTOC	Definite or inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	

1) For further reference please refer to the Operating characteristics table at the end of the Technical data chapter

Table 46. Phase discontinuity protection (PDNSPTOC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the current measured: f_n ±2Hz
	±2% of the set value
Start time	< 70 ms
Reset time	< 40 ms
Reset ratio	Typical 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: -50dB at f = n x f_n, where n = 2, 3, 4, 5, …

Table 47. 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	100...30000 ms	1
Min phase current	PDNSPTOC	0.05...0.30 x I_n	0.01

Table 48. Circuit breaker failure protection (CCBRBRF)

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

Table 49. Circuit breaker failure protection (CCBRBRF) main settings

Parameter	Function	Value (Range)	Step
Current value (Operating phase current)	CCBRBRF	0.05...1.00 x I_n	0.05
Current value Res (Operating residual current)	CCBRBRF	0.05...1.00 x I_n	0.05
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...60000 ms	10
CB failure delay	CCBRBRF	0...60000 ms	10
CB fault delay	CCBRBRF	0...60000 ms	10

Table 50. Three-phase thermal overload (T1PTTR)

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

1) Overload current > 1.2 x Operate level temperature

Table 51. Three-phase thermal overload (T1PTTR) main settings

Parameter	Function	Value (Range)	Step
Env temperature Set (Ambient temperature used when the AmbSens is set to Off)	T1PTTR	-50...100°C	1
Current multiplier (Current multiplier when function is used for parallel lines)	T1PTTR	1...5	1
Current reference	T1PTTR	0.05...4.00 x I_n	0.01
Temperature rise (End temperature rise above ambient)	T1PTTR	0.0...200.0°C	0.1
Time constant (Time constant of the line in seconds)	T1PTTR	60...60000 s	1
Maximum temperature (temperature level for operate)	T1PTTR	20.0...200.0°C	0.1
Alarm value (Temperature level for start (alarm))	T1PTTR	20.0...150.0°C	0.1
Reclose temperature (Temperature for reset of block reclose after operate)	T1PTTR	20.0...150.0°C	0.1
Initial temperature (Temperature raise above ambient temperature at startup)	T1PTTR	-50.0...100.0°C	0.1

Table 52. Three-phase inrush current detection (INRPHAR)

<table>
<tr><th>Characteristic</th><th>Value</th></tr>
<tr><td rowspan="2">Operation accuracy</td><td>At the frequency $f=f_n$</td></tr>
<tr><td>Current measurement:
±1.5% of the set value or ±0.002 x I_n
Ratio I2f/I1f measurement:
±5.0% of the set value</td></tr>
<tr><td>Reset time</td><td>+35 ms / -0 ms</td></tr>
<tr><td>Reset ratio</td><td>Typical 0.96</td></tr>
<tr><td>Operate time accuracy</td><td>+35 ms / -0 ms</td></tr>
</table>

Table 53. Three-phase 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	20...60000 ms	1

Table 54. Arc protection (ARCSARC)

<table>
<tr><th colspan="2">Characteristic</th><th colspan="3">Value</th></tr>
<tr><td colspan="2">Operation accuracy</td><td colspan="3">±3% of the set value or ±0.01 x I_n</td></tr>
<tr><td rowspan="3">Operate time</td><td></td><td>Minimum</td><td>Typical</td><td>Maximum</td></tr>
<tr><td>Operation mode = "Light+current"[1)2)]</td><td>9 ms</td><td>12 ms</td><td>15 ms</td></tr>
<tr><td>Operation mode = "Light only"[2)]</td><td>9 ms</td><td>10 ms</td><td>12 ms</td></tr>
<tr><td colspan="2">Reset time</td><td colspan="3">< 40 ms</td></tr>
<tr><td colspan="2">Reset ratio</td><td colspan="3">Typical 0.96</td></tr>
</table>

1) *Phase start value* = 1.0 x I_n, current before fault = 2.0 x set *Phase start value*, f_n = 50 Hz, fault with nominal frequency, results based on statistical distribution of 200 measurements
2) Includes the delay of the heavy-duty output contact

Table 55. Arc protection (ARCSARC) main settings

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

Table 56. Operation characteristics

Parameter	Values (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 57. Autoreclosure (DARREC)

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

Measurement functions

Table 58. Three-phase current measurement (CMMXU)

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

Table 59. Current sequence components (CSMSQI)

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

Table 60. Three-phase voltage measurement (VMMXU)

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

Table 61. Voltage sequence components (VSMSQI)

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

Table 62. Residual current measurement (RESCMMXU)

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

Table 63. Residual voltage measurement (RESVMMXU)

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

Table 64. Three-phase power and energy (PEMMXU)

Characteristic	Value
Operation accuracy	At all three currents in range 0.10…1.20 x I_n At all three voltages in range 0.50…1.15 x U_n At the frequency f_n ±1Hz 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 ±1.5% for energy
Suppression of harmonics	DFT: -50 dB at f = n x f_n, where n = 2, 3, 4, 5, …

Supervision functions

Table 65. Current circuit supervision (CCRDIF)

Characteristic	Value
Operate time[1)]	< 30 ms

1) Including the delay of the output contact.

Table 66. Current circuit supervision (CCRDIF) main settings

Parameter	Values (Range)	Unit	Description
Start value	0.05...0.20	x I_n	Minimum operate current differential level
Maximum operate current	1.00...5.00	x I_n	Block of the function at high phase current

Table 67. Fuse failure supervision (SEQRFUF)

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

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

20. Display options

The IED is available with two optional displays, a large one and a small one. Both LCD displays offer full front-panel user-interface functionality with menu navigation and menu views.

The large display offers increased front-panel usability with less menu scrolling and improved information overview. The large display is suited for IED installations where the front panel user interface is frequently used, whereas the small display is suited for remotely controlled substations where the IED is only occasionally accessed locally via the front panel user interface.

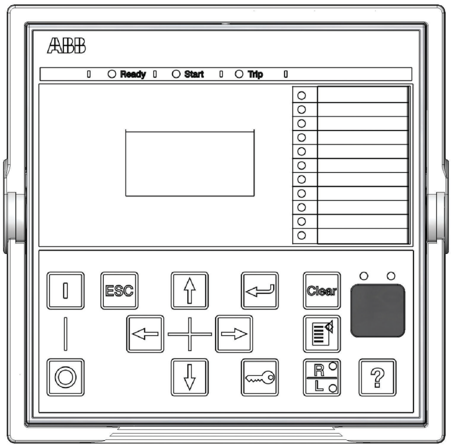

Figure 10. Small display

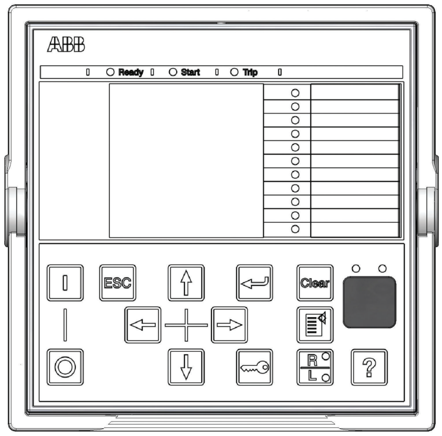

Figure 11. Large display

Table 68. Small display

Character size[1]	Rows in the view	Characters per row
Small, mono-spaced (6x12 pixels)	5	20
Large, variable width (13x14 pixels)	4	8 or more

1) Depending on the selected language

Table 69. Large display

Character size[1]	Rows in the view	Characters per row
Small, mono-spaced (6x12 pixels)	10	20
Large, variable width (13x14 pixels)	8	8 or more

1) Depending on the selected language

21. Mounting methods

By means of appropriate mounting accessories the standard IED case for the 615 series IED can be flush mounted, semi-flush mounted or wall mounted. The flush mounted and wall mounted IED cases can also be mounted in a tilted position (25°) using special accessories.

Further, the IEDs can be mounted in any standard 19” instrument cabinet by means of 19” mounting panels available with cut-outs for one or two IEDs. Alternatively, the IED can be mounted in 19” instrument cabinets by means of 4U Combiflex equipment frames.

For the routine testing purposes, the IED cases can be equipped with test switches, type RTXP 18, which can be mounted side by side with the IED cases.

Mounting methods:

- Flush mounting
- Semi-flush mounting
- Semi-flush mounting in a 25° tilt
- Rack mounting
- Wall mounting
- Mounting to a 19" equipment frame
- Mounting with a RTXP 18 test switch to a 19" rack

Panel cut-out for flush mounting:

- Height: 161.5±1 mm
- Width: 165.5±1 mm

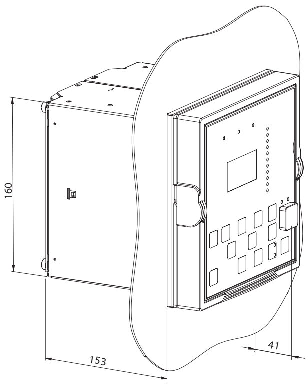

Figure 12. Flush mounting

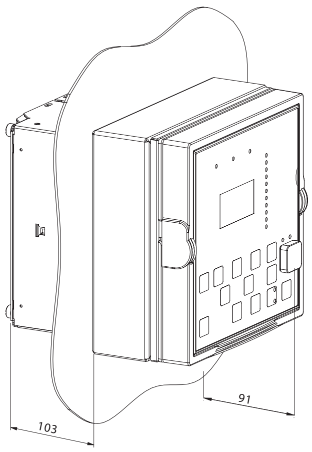

Figure 13. Semi-flush mounting

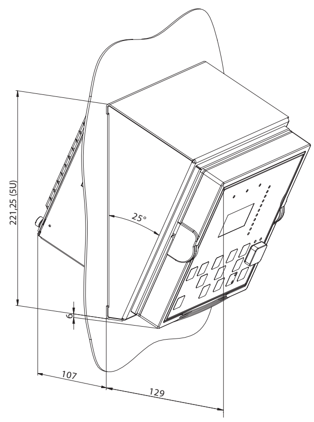

Figure 14. Semi-flush with a 25° tilt

22. IED case and IED plug-in unit

For safety reasons, the IED cases for current measuring IEDs are provided with automatically operating contacts for short-circuiting the CT secondary circuits when a IED unit is withdrawn from its case. The IED case is further provided with a mechanical coding system preventing current measuring IED units from being inserted into a IED case for a voltage measuring IED unit and vice versa, i.e. the IED cases are assigned to a certain type of IED plug-in unit.

23. Selection and ordering data

The IED type and serial number label identifies the protection IED. The label is placed above the HMI on the upper part of the plug-in-unit. An order number label is placed on the side of the plug-in unit as well as inside the case. The order number consists of a string of codes generated from the IED's hardware and software modules.

Use the ordering key information to generate the order number when ordering complete IEDs.

H B F C A C A B N B B 1 A C N 1 X C

#	DESCRIPTION	
1	**IED**	
	615 series IED (including case)	H
	615 series IED (including case) with test switch, wired and installed in a 19” equipment panel	K
	615 series IED (including case) with test switch, wired and installed in a mounting bracket for CombiFlex rack mounting (RGHT 19” 4U variant C)	L
2	**Standard**	
	IEC	B
3	**Main application**	
	Feeder protection and control	F

The standard configuration determines the I/O hardware and available options. Choose the digits from one of the blue standard configuration rows below to define the corect digits for # 4-8. The example below shows standard configuration "C" with chosen options.

H B F **C A C A B** N B B 1 A C N 1 X C

#	DESCRIPTION		
4-8	**Standard configuration descriptions in short:** **A** = Non-dir. O/C and dir. E/F prot. **B** = Non-dir. O/C and dir. E/F prot. **C** = Non-dir. O/C and non-dir. E/F prot. **D** = Non-dir. O/C and non-dir. E/F prot. **E** = Non-dir. O/C and dir. E/F prot. with phase-voltage based measurements **F** = Dir. O/C and dir. E/F prot. with phase-voltage based measurements, undervoltage and overvoltage prot.		
	Std. conf. # 4	**Available analog inputs options # 5-6**	**Available binary inputs/output options # 7-8**
	A	**AA = (4 I + U_0 (I_0 1/5 A)** or **AB = (4 I + U_0 (I_0 0.2/1 A)**	**AA =** 3 BI + 6 BO
	B	**AA = (4 I + U_0 (I_0 1/5 A)** or **AB = (4 I + U_0 (I_0 0.2/1 A)**	**AC =** 11 BI + 10 BO or **AE =** 17 BI + 13 BO
	C	**AC** = 4 I (I_0 1/5 A) or **AD** = 4 I (I_0 0.2/1 A)	**AB** = 4 BI + 6 BO
	D	**AC** = 4 I (I_0 1/5 A) or **AD** = 4 I (I_0 0.2/1 A)	**AD** = 12 BI + 10 BO or **AF** = 18 BI + 13 BO
	E	**AE** = 4 I (I_0 1/5 A) + 5U or **AF** = 4 I (I_0 0.2/1 A) + 5U	**AG** = 16 BI + 10 BO
	F	**AE** = 4 I (I_0 1/5 A) + 5U or **AF** = 4 I (I_0 0.2/1 A) + 5U	**AG** = 16 BI + 10 BO

The communication module harware determines the available communication protocols. Choose the digits from one of the blue communication rows below to define the corect digits for digits 9-11. Note that the communication options are not dependant on the chosen standard configuration.

H B F C A C A B **N B B** 1 A C N 1 X C

#	DESCRIPTION		
9 - 11	**Communication descriptions in short:** Serial communication options digit #9 Ethernet communication options digit #10 Communication protocol options #11		
	Serial options # 9	**Ethernet options # 10**	**Protocol options # 11**
	A = RS-485 (incl. IRIG-B)	**A** = Ethernet 100BaseFX (LC) or **B** = Ethernet 100BaseTX (RJ-45)	**B** = Modbus or **C** = IEC 61850 and Modbus or **D** = IEC 60870-5-103 or **E** = DNP3
	A = RS-485 (incl. IRIG-B)	**N** = None	**B** = Modbus or **D** = IEC 60870-5-103 or **E** = DNP3
	B = Glass fibre (ST) [1) 2)]	**B** = Ethernet 100BaseTX (RJ-45)	**B** = Modbus or **C** = IEC 61850 and Modbus or **D** = IEC 60870-5-103 or **E** = DNP3
	B = Glass fibre (ST) [1) 2)]	**N** = None	**B** = Modbus or **D** = IEC 60870-5-103 or **E** = DNP3
	N = None	**A** = Ethernet 100BaseFX (LC) or **B** = Ethernet 100BaseTX (RJ-45)	**A** = IEC 61850 or **B** = Modbus or **C** = IEC 61850 and Modbus or **E** = DNP3
	N = None	**N** = None	**A** = IEC 61850

1) Serial communication using glass fibre (ST) cannot be combined with arc protection.

2) The communication card includes an RS-485 connector and an input for IRIG-B.

In addition to a serial communication option for station bus communication to gateways and SCADA systems, an Ethernet communication option can be chosen. This enables the use of an Ethernet based service bus for PCM600 and the WebHMI. However, this requires that an Ethernet communication option is chosen in addition to the serial communication (digit #10 = RJ-45 or LC).

H B F C A C A B N B B 1 A C N 1 X C

#	DESCRIPTION	
12	**Language**	
	English	1
	English and German	3
	English and Spanish	5
	English and Russian	6
	English and Portugese (Brasilian)	8
13	**Front panel**	
	Small LCD	A
	Large LCD	B
14	**Option 1**	
	Auto-reclosing	A
	Arc protection [1)]	B
	Arc protection and auto-reclosing [1)]	C
	None	N
15	**Option 2**	
	None	N
16	**Power supply**	
	48...250 V DC, 100...240 V AC	1
	24...60 V DC	2
17	**Vacant digit**	
	Vacant	X
18	**Version**	
	Version 2.0	C

[1)] The arc protection hardware is located on the communication module (digit 9-10). Thus a communication module is always required to enable arc protection. Note that arc protection or arc protection and reclosing cannot be combined with serial communication using glass fibre (ST).

Example code: H B F C A C A B N B B 1 A C N 1 X C

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 and ordering data

Table 70. Cables

Item	Order number
Cable for optical sensors for arc protection 1.5 m	1MRS120534-1.5
Cable for optical sensors for arc protection 3.0 m	1MRS120534-3.0
Cable for optical sensors for arc protection 5.0 m	1MRS120534-5.0

Table 71. Mounting accessories

Item	Order number
Semi-flush mounting kit	1MRS050696
Wall mounting kit	1MRS050697
Inclined semi-flush mounting kit	1MRS050831
19” rack mounting kit with cut-out for one IED	1MRS050694
19” rack mounting kit with cut-out for two IEDs	1MRS050695
Mounting bracket for one IED with test switch RTXP in 4U Combiflex (RHGT 19” variant C)	2RCA022642P0001
Mounting bracket for one IED in 4U Combiflex (RHGT 19” variant C)	2RCA022643P0001
19” rack mounting kit for one IED and one RTXP18 test switch (the test switch is not included in the delivery)	2RCA021952A0003
19” rack mounting kit for one IED and one RTXP24 test switch (the test switch is not included in the delivery)	2RCA022561A0003

25. Tools

The IED is delivered as a pre-configured unit. 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 signal configuration using the signal matrix, and IEC 61850 communication configuration including horizontal peer-to-peer 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 can be limited to read-only access by means of PCM600.

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 72. Tools

Configuration and setting tools	Version
PCM600	2.0 SP2 or later
Web-browser based user interface	IE 7.0 or later
REF615 Connectivity Package	2.5 or later

Table 73. Supported functions

Function	WebHMI	PCM600
IED signal configuration (signal matrix)	-	●
IEC 61850 communication configuration, GOOSE (communication configuration)	-	●
Modbus® communication configuration (communication management)	-	●
DNP3 communication configuration (communication management)	-	●
IEC 60870-5-103 communication configuration (communication management)	-	●
IED parameter setting	●	●
Saving of IED parameter settings in the IED	●	●
Saving of IED parameter settings in the tool	-	●
Signal monitoring	●	●
Disturbance recorder handling	●	●
Disturbance record analysis	-	●
Event viewing	●	-
Saving of event data on the user's PC	●	-
Alarm LED viewing	●	●
Phasor diagram viewing	●	-
Access control management	●	●

● = Supported

26. Terminal diagrams

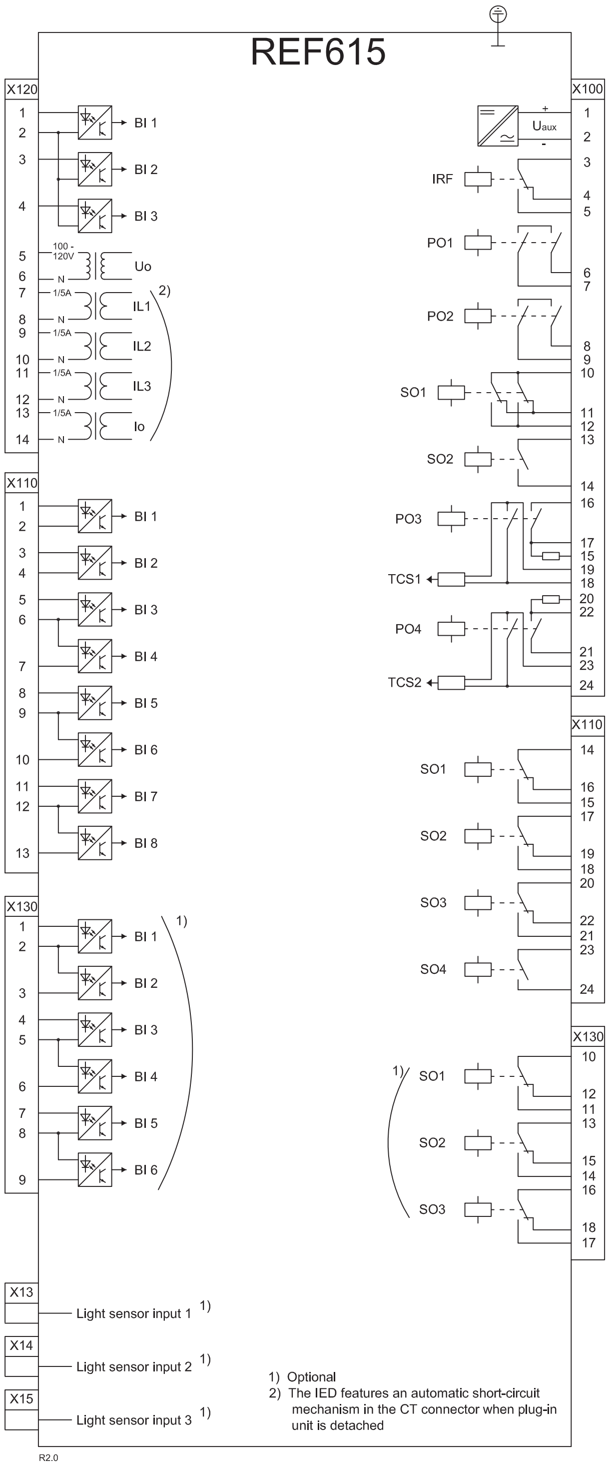

Figure 16. Terminal diagram of standard configuration B

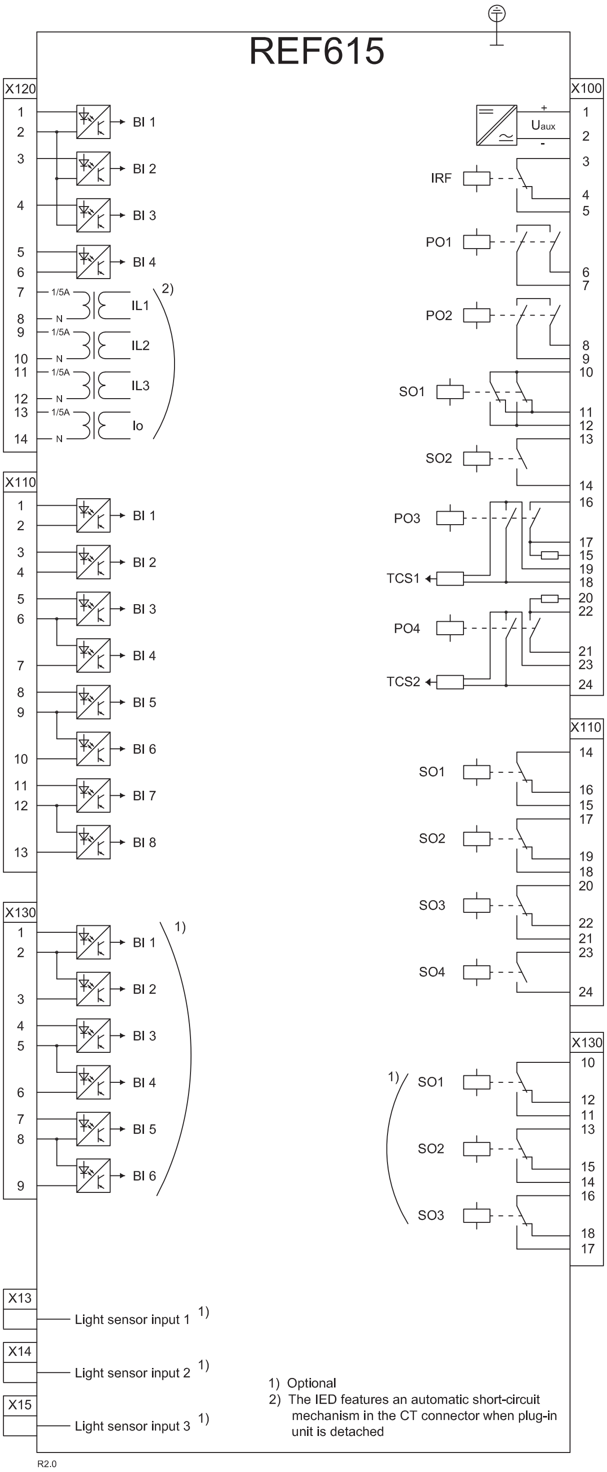

Figure 17. Terminal diagram of standard configuration D

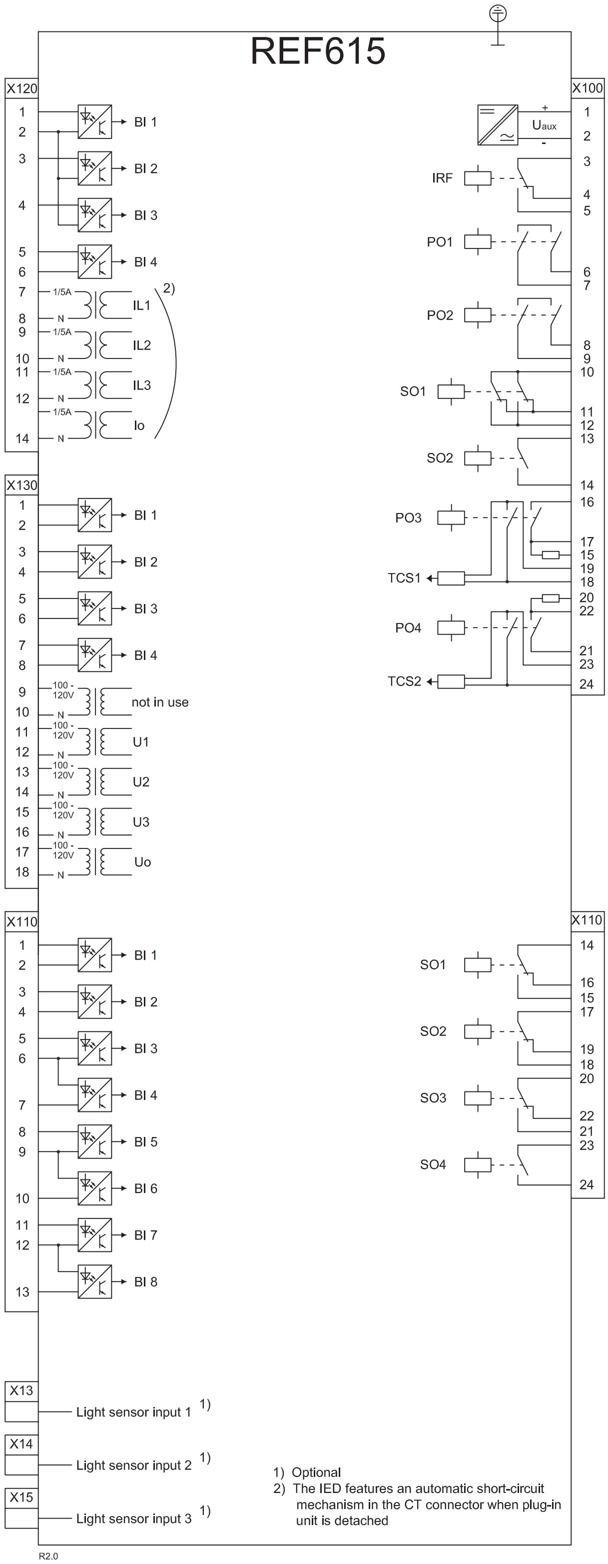

Figure 18. Terminal diagram of standard configuration E and F

27. Certificates

KEMA has issued an IEC 61850 Certificate Level A[1] for REF615. Certificate number: 30710144-Consulting 08-0115.

28. 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 REF615 protection IED on the product page.

The download area on the right hand side of the web page contains the latest product documentation, such as technical reference manual, installation manual, operators manual, etc. The selection tool on the web page helps you find the documents by the document category and language.

The Features and Application tabs contain product related information in a compact format.

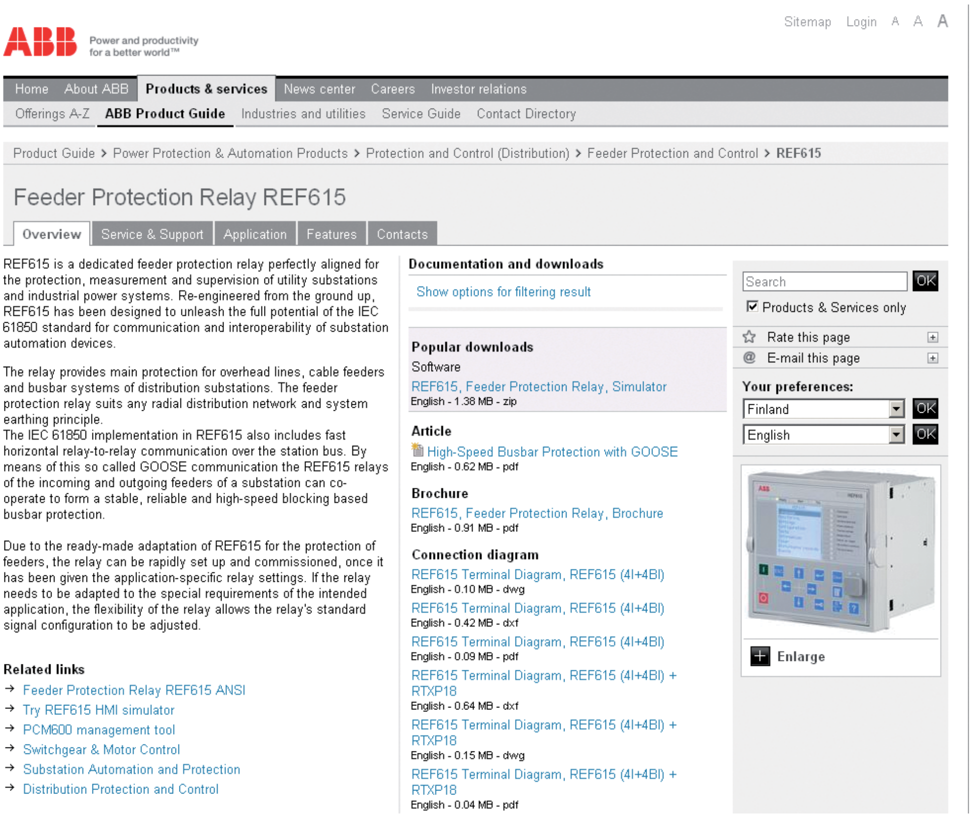

Figure 19. Product page

29. Functions, codes and symbols

Table 74. REF615 Functions, codes and symbols

Function	IEC 61850	IEC 60617	IEC-ANSI
Protection			
Three-phase non-directional overcurrent protection, low stage, instance 1	PHLPTOC1	3I> (1)	51P-1 (1)
Three-phase non-directional overcurrent protection, high stage, instance 1	PHHPTOC1	3I>> (1)	51P-2 (1)
Three-phase non-directional overcurrent protection, high stage, instance 2	PHHPTOC2	3I>> (2)	51P-2 (2)
Three-phase non-directional overcurrent protection, instantaneous stage, instance 1	PHIPTOC1	3I>>> (1)	50P/51P (1)
Three-phase directional overcurrent protection, low stage, instance 1	DPHLPDOC1	3I> → (1)	67-1 (1)
Three-phase directional overcurrent protection, low stage, instance 2	DPHLPDOC2	3I> → (2)	67-1 (2)
Three-phase directional overcurrent protection, high stage	DPHHPDOC1	3I>> →	67-2
Non-directional earth-fault protection, low stage, instance 1	EFLPTOC1	I_0> (1)	51N-1 (1)
Non-directional earth-fault protection, low stage, instance 2	EFLPTOC2	I_0> (2)	51N-1 (2)
Non-directional earth-fault protection, high stage, instance 1	EFHPTOC1	I_0>> (1)	51N-2 (1)
Non-directional earth-fault protection, instantaneous stage	EFIPTOC1	I_0>>>	50N/51N
Directional earth-fault protection, low stage, instance 1	DEFLPDEF1	I_0> → (1)	67N-1 (1)
Directional earth-fault protection, low stage, instance 2	DEFLPDEF2	I_0> → (2)	67N-1 (2)
Directional earth-fault protection, high stage	DEFHPDEF1	I_0>> →	67N-2

Table 74. REF615 Functions, codes and symbols, continued

Function	IEC 61850	IEC 60617	IEC-ANSI
Transient / intermittent earth-fault protection	INTRPTEF1	I_0> → IEF	67NIEF
Non-directional (cross-country) earth fault protection, using calculated I0	EFHPTOC1	I_0>>	51N-2
Negative-sequence overcurrent protection, instance 1	NSPTOC1	I_2> (1)	46 (1)
Negative-sequence overcurrent protection, instance 2	NSPTOC2	I_2> (2)	46 (2)
Phase discontinuity protection	PDNSPTOC1	I_2/I_1>	46PD
Residual overvoltage protection, instance 1	ROVPTOV1	U_0> (1)	59G (1)
Residual overvoltage protection, instance 2	ROVPTOV2	U_0> (2)	59G (2)
Residual overvoltage protection, instance 3	ROVPTOV3	U_0> (3)	59G (3)
Three-phase undervoltage protection, instance 1	PHPTUV1	3U< (1)	27 (1)
Three-phase undervoltage protection, instance 2	PHPTUV2	3U< (2)	27 (2)
Three-phase undervoltage protection, instance 3	PHPTUV3	3U< (3)	27 (3)
Three-phase overvoltage protection, instance 1	PHPTOV1	3U> (1)	59 (1)
Three-phase overvoltage protection, instance 2	PHPTOV2	3U> (2)	59 (2)
Three-phase overvoltage protection, instance 3	PHPTOV3	3U> (3)	59 (3)
Positive-sequence undervoltage protection	PSPTUV1	U1<	47U+
Negative-sequence overvoltage protection	NSPTOV1	U2>	47O-
Three-phase thermal protection for feeders, cables and distribution transformers	T1PTTR1	3Ith>F	49F
Circuit breaker failure protection	CCBRBRF1	3I>/I_0>BF	51BF/51NBF

Table 74. REF615 Functions, codes and symbols, continued

Function	IEC 61850	IEC 60617	IEC-ANSI
Three-phase inrush detector	INRPHAR1	3I2f>	68
Master trip, instance 1	TRPPTRC1	Master Trip (1)	94/86 (1)
Master trip, instance 2	TRPPTRC2	Master Trip (2)	94/86 (2)
Arc protection, instance 1	ARCSARC1	ARC (1)	50L/50NL (1)
Arc protection, instance 2	ARCSARC2	ARC (2)	50L/50NL (2)
Arc protection, instance 3	ARCSARC3	ARC (3)	50L/50NL (3)
Control			
Circuit-breaker control	CBXCBR1	I ↔ O CB	I ↔ O CB
Disconnector position indication, instance 1	DCSXSWI1	I ↔ O DC (1)	I ↔ O DC (1)
Disconnector position indication, instance 2	DCSXSWI2	I ↔ O DC (2)	I ↔ O DC (2)
Disconnector position indication, instance 3	DCSXSWI3	I ↔ O DC (3)	I ↔ O DC (3)
Earthing switch indication	ESSXSWI1	I ↔ O ES	I ↔ O ES
Auto-reclosing	DARREC1	O → I	79
Condition Monitoring			
Circuit-breaker condition monitoring	SSCBR1	CBCM	CBCM
Trip circuit supervision, instance 1	TCSSCBR1	TCS (1)	TCM (1)
Trip circuit supervision, instance 2	TCSSCBR2	TCS (2)	TCM (2)
Current circuit supervision	CCRDIF1	MCS 3I	MCS 3I
Fuse failure supervision	SEQRFUF1	FUSEF	60
Measurement			
Disturbance recorder	RDRE1	-	-
Three-phase current measurement, instance 1	CMMXU1	3I	3I
Sequence current measurement	CSMSQI1	I_1, I_2, I_0	I_1, I_2, I_0
Residual current measurement, instance 1	RESCMMXU1	I_0	I_n
Three-phase voltage measurement	VMMXU1	3U	3U

Table 74. REF615 Functions, codes and symbols, continued

Function	IEC 61850	IEC 60617	IEC-ANSI
Residual voltage measurement	RESVMMXU1	U_0	V_n
Sequence voltage measurement	VSMSQI1	U_1, U_2, U_0	U_1, U_2, U_0
Three-phase power and energy measurement	PEMMXU1	P, E	P, E

30. Document revision history

Document revision/ date	Product version	History
A/20.12.2007	1.0	First release
B/22.02.2008	1.0	Content updated
C/20.06.2008	1.1	Content updated to correspond to the product version
D/03.03.2009	2.0	Content updated to correspond to the product version. New layout on front and back page
E/03.07.2009	2.0	Content updated

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