Relion® 615 series

Feeder Protection and Control REF615 Product Guide

Power and productivity
for a better world™

Contents

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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 including radial, looped and meshed distribution networks with or without distributed power generation. 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-unit 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

REF615 is available in nine alternative standard configurations. The standard signal configuration can be altered by means of the graphical signal matrix or the graphical application functionality of the Protection and Control IED Manager PCM600. Further, the application configuration functionality of PCM600 supports the creation of multi-layer logic functions using various logical elements, including timers and flip-flops. By combining protection functions with logic function blocks, the IED configuration can be adapted to user-specific application requirements.

Table 1. Standard configurations

Description	Std. conf.
Non-directional overcurrent and directional earth-fault protection and CB control	A
Non-directional overcurrent and directional earth-fault protection, CB condition monitoring, CB control and with the optional I/O module control of two network objects	B
Non-directional overcurrent and non-directional earth-fault protection and CB control	C
Non-directional overcurrent and non-directional earth-fault protection, CB condition monitoring, CB control and with the optional I/O module control of two network objects	D
Non-directional overcurrent and directional earth-fault protection with phase-voltage based measurements, CB condition monitoring and CB control	E
Directional overcurrent and directional earth-fault protection with phase-voltage based measurements, undervoltage and overvoltage protection, CB condition monitoring and CB control	F
Directional overcurrent and directional earth-fault protection, phase-voltage based protection and measurement functions, CB condition monitoring, CB control and sensor inputs	G
Non-directional overcurrent and non-directional earth-fault protection, phase-voltage and frequency based protection and measurement functions, synchro-check , CB condition monitoring and CB control	H
Directional overcurrent and directional earth-fault protection, phase-voltage and frequency based protection and measurement functions, synchro check, CB condition monitoring and CB control	J

Table 2. Supported functions

Functionality	A	B	C	D	E	F	G	H	J
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, instance 1	-	-	● 2)	● 2)	-	-	-	● 2)	-
Non-directional earth-fault protection, low stage, instance 2	-	-	● 2)	● 2)	-	-	-	● 2)	-
Non-directional earth-fault protection, high stage, instance 1	-	-	● 2)	● 2)	-	-	-	● 2)	-
Non-directional earth-fault protection, instantaneous stage	-	-	● 2)	● 2)	-	-	-	● 2)	-
Directional earth-fault protection, low stage, instance 1	● 2)3)	● 2)3)	-	-	● 2)5)	● 2)5)	● 2)4)	-	● 2)5)
Directional earth-fault protection, low stage, instance 2	● 2)3)	● 2)3)	-	-	● 2)5)	● 2)5)	● 2)4)	-	● 2)5)
Directional earth-fault protection, high stage	● 2)3)	● 2)3)	-	-	● 2)5)	● 2)5)	● 2)4)	-	● 2)5)
Admittance based earth-fault protection, instance 1	o 2)3)6)	o 2)3)6)	-	-	o 2)5)6)	o 2)5)6)	o 2)6)7)	-	o 2)5)6)
Admittance based earth-fault protection, instance 2	o 2)3)6)	o 2)3)6)	-	-	o 2)5)6)	o 2)5)6)	o 2)6)7)	-	o 2)5)6)
Admittance based earth-fault protection, instance 3	o 2)3)6)	o 2)3)6)	-	-	o 2)5)6)	o 2)5)6)	o 2)6)7)	-	o 2)5)6)
Wattmetric based earth-fault protection, instance 1	o 2)3)6)	o 2)3)6)	-	-	o 2)5)6)	o 2)5)6)	o 2)6)7)	-	o 2)5)6)
Wattmetric based earth-fault protection, instance 2	o 2)3)6)	o 2)3)6)	-	-	o 2)5)6)	o 2)5)6)	o 2)6)7)	-	o 2)5)6)
Wattmetric based earth-fault protection, instance 3	o 2)3)6)	o 2)3)6)	-	-	o 2)5)6)	o 2)5)6)	o 2)6)7)	-	o 2)5)6)

Table 2. Supported functions, continued

Functionality	A	B	C	D	E	F	G	H	J
Transient / intermittent earth-fault protection	● 3)8)	● 3)8)	-	-	● 3)8)	● 3)8)	-	-	● 3)8)
Harmonics based earth-fault protection	-	o 6)8)9)	-	o 6)8)9)	-	o 6)8)9)	-	-	o 6)8)9)
Non-directional (cross-country) earth fault protection, using calculated Io	● 10)	● 10)	-	-	● 10)	● 10)	● 10)	-	● 10)
Negative-sequence overcurrent protection, instance 1	●	●	●	●	●	●	●	●	●
Negative-sequence overcurrent protection, instance 2	●	●	●	●	●	●	●	●	●
Phase discontinuity protection	●	●	●	●	●	●	●	●	●
Residual overvoltage protection, instance 1	● 3)	● 3)	-	-	● 5)	● 5)	● 7)	● 5)	● 5)
Residual overvoltage protection, instance 2	● 3)	● 3)	-	-	● 5)	● 5)	● 7)	● 5)	● 5)
Residual overvoltage protection, instance 3	● 3)	● 3)	-	-	● 5)	● 5)	● 7)	● 5)	● 5)
Three-phase undervoltage protection, instance 1	-	-	-	-	-	●	●	●	●
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, instance 1	-	-	-	-	-	●	●	-	●
Negative-sequence overvoltage protection, instance 1	-	-	-	-	-	●	●	-	●
Frequency protection, instance 1	-	-	-	-	-	-	-	●	●
Frequency protection, instance 2	-	-	-	-	-	-	-	●	●
Frequency protection, instance 3	-	-	-	-	-	-	-	●	●
Three-phase thermal protection for feeders, cables and distribution transformers	●	●	●	●	●	●	●	-	●
Circuit breaker failure protection	●	●	●	●	●	●	●	●	●
Three-phase inrush detector	●	●	●	●	●	●	●	●	●

Table 2. Supported functions, continued

Functionality	A	B	C	D	E	F	G	H	J
Master trip, instance 1	●	●	●	●	●	●	●	●	●
Master trip, instance 2	●	●	●	●	●	●	●	●	●
Arc protection, instance 1	o	o	o	o	o	o	o	o	o
Arc protection, instance 2	o	o	o	o	o	o	o	o	o
Arc protection, instance 3	o	o	o	o	o	o	o	o	o
Control									
Circuit-breaker control	●	●	●	●	●	●	●	●	●
Disconnector control, instance 1	-	●[9)]	-	●[9)]	●[9)]	●[9)]	●[9)]	●[9)]	●[9)]
Disconnector control, instance 2	-	●[9)]	-	●[9)]	●[9)]	●[9)]	●[9)]	●[9)]	●[9)]
Earthing switch control	-	●[9)]	-	●[9)]	●[9)]	●[9)]	●[9)]	●[9)]	●[9)]
Disconnector position indication, instance 1	-	●	-	●	●	●	●	●	●
Disconnector position indication, instance 2	-	●[9)]	-	●[9)]	●[9)]	●[9)]	●[9)]	●[9)]	●[9)]
Disconnector position indication, instance 3	-	●[9)]	-	●[9)]	●[9)]	●[9)]	●[9)]	●[9)]	●[9)]
Earthing switch indication, instance 1	-	●	-	●	●	●	●	●	●
Earthing switch indication, instance 2	-	●[9)]	-	●[9)]	●[9)]	●[9)]	●[9)]	●[9)]	●[9)]
Auto-reclosing	o	o	o	o	o	o	o	o	o
Synchronism and energizing check	-	-	-	-	-	-	-	●	●
Condition Monitoring									
Circuit-breaker condition monitoring	-	●	-	●	●	●	●	●	●
Trip circuit supervision, instance 1	●	●	●	●	●	●	●	●	●
Trip circuit supervision, instance 2	●	●	●	●	●	●	●	●	●
Current circuit supervision	-	-	-	-	●	●	●	●	●
Fuse failure supervision	-	-	-	-	●	●	●	●	●
Power Quality									
Current total demand distortion, instance 1	-	-	-	-	-	-	-	-	o [11)]
Voltage total harmonic distortion, instance 1	-	-	-	-	-	-	-	-	o [11)]
Voltage variation, instance 1	-	-	-	-	-	-	-	-	o [11)]
Measurement									
Disturbance recorder	●	●	●	●	●	●	●	●	●
Three-phase current measurement, instance 1	●	●	●	●	●	●	●	●	●

Table 2. Supported functions, continued

Functionality	A	B	C	D	E	F	G	H	J
Sequence current measurement	●	●	●	●	●	●	●	●	●
Residual current measurement, instance 1	●	●	●	●	●	●	●	●	●
Three-phase voltage measurement	-	-	-	-	●	●	●	●	●
Residual voltage measurement	●	●	-	-	●	●	-	●	●
Sequence voltage measurement	-	-	-	-	●	●	●	●	●
Three-phase power and energy measurement, including power factor	-	-	-	-	●	●	●	●	●
Frequency measurement	-	-	-	-	-	-	-	●	●

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

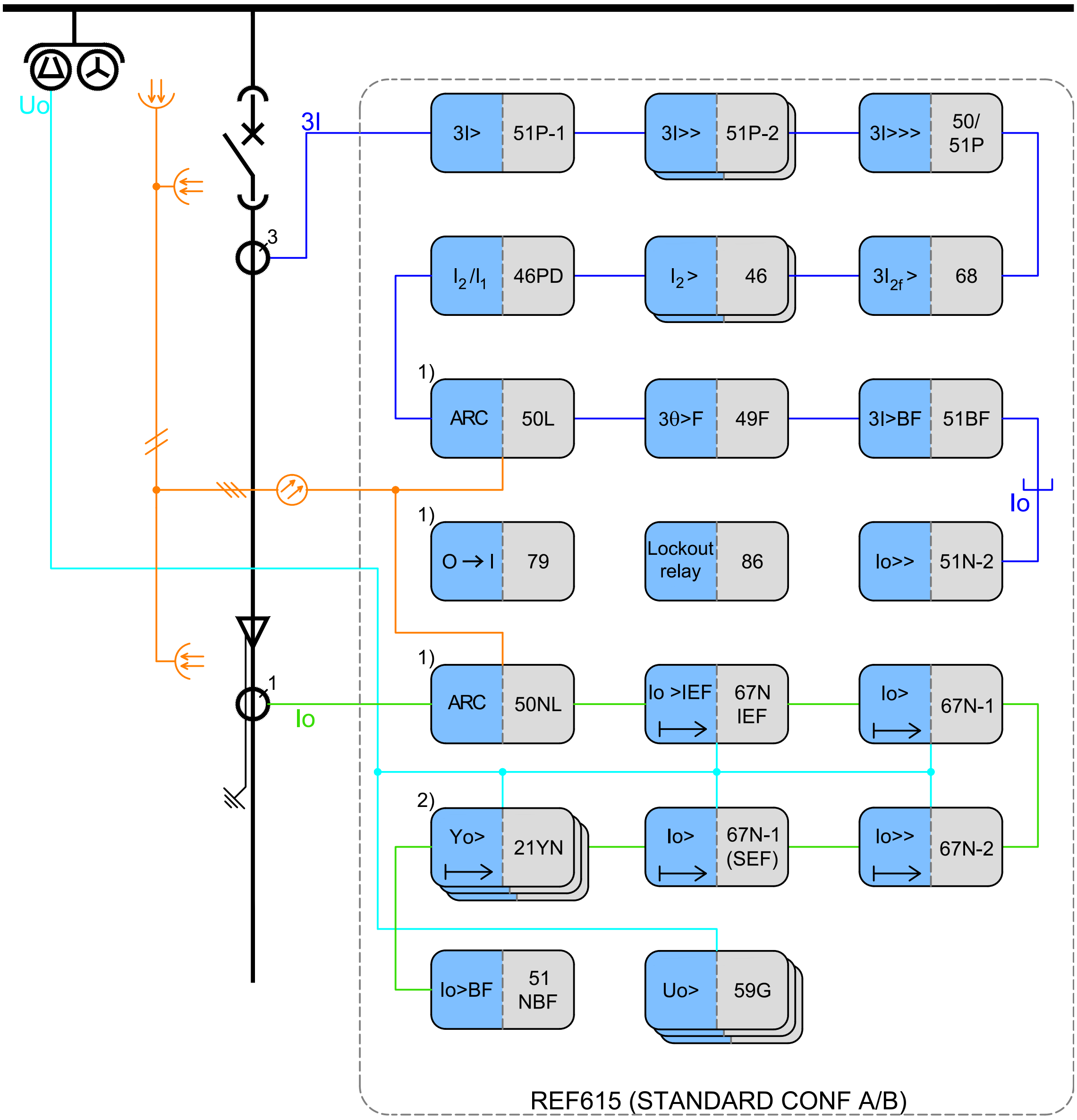
1) The instances of a protection function represent the number of identical function blocks available in a standard configuration. By setting the application specific parameters of an instance, a protection function stage can be established.
2) I_0 selectable by parameter, I_0 measured as default.
3) U_0 measured is always used
4) U_0 calculated and negative sequence voltage selectable by parameter, U_0 calculated as default.
5) U_0 selectable by parameter, U_0 measured as default.
6) One of the following can be ordered as an option: Admittance based E/F, Wattmetric based E/F or Harmonics based E/F. The option is an addition to the existing E/F of the original configuration. The Admittance based and Wattmetric based optional E/F has also a predefined configuration in the relay. The optional E/F can be set on or off.
7) U_0 calculated is always used.
8) I_0 measured is always used.
9) Available in IED and SMT but not connected to anything in logic.
10) Io selectable by parameter, Io calculated as default.
11) This option includes Current total demand distrortion, Voltage total harmonic distortion and Voltage variation.

3. Protection functions

The IED offers directional and non-directional overcurrent and thermal overload protection as well as directional and non-directional earth-fault protection. Some standard configurations allow as an option admittance-based, harmonics-based or wattmetric-based earth-fault protection to be used in addition to directional earth-fault protection. Further, the IED features 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. Frequency protection, including overfrequency, underfrequency and frequency rate-of-change protection, is offered in IEDs with standard configurations H and J. The IED also incorporates optional three-pole multi-shot auto-reclose functions for overhead line feeders.

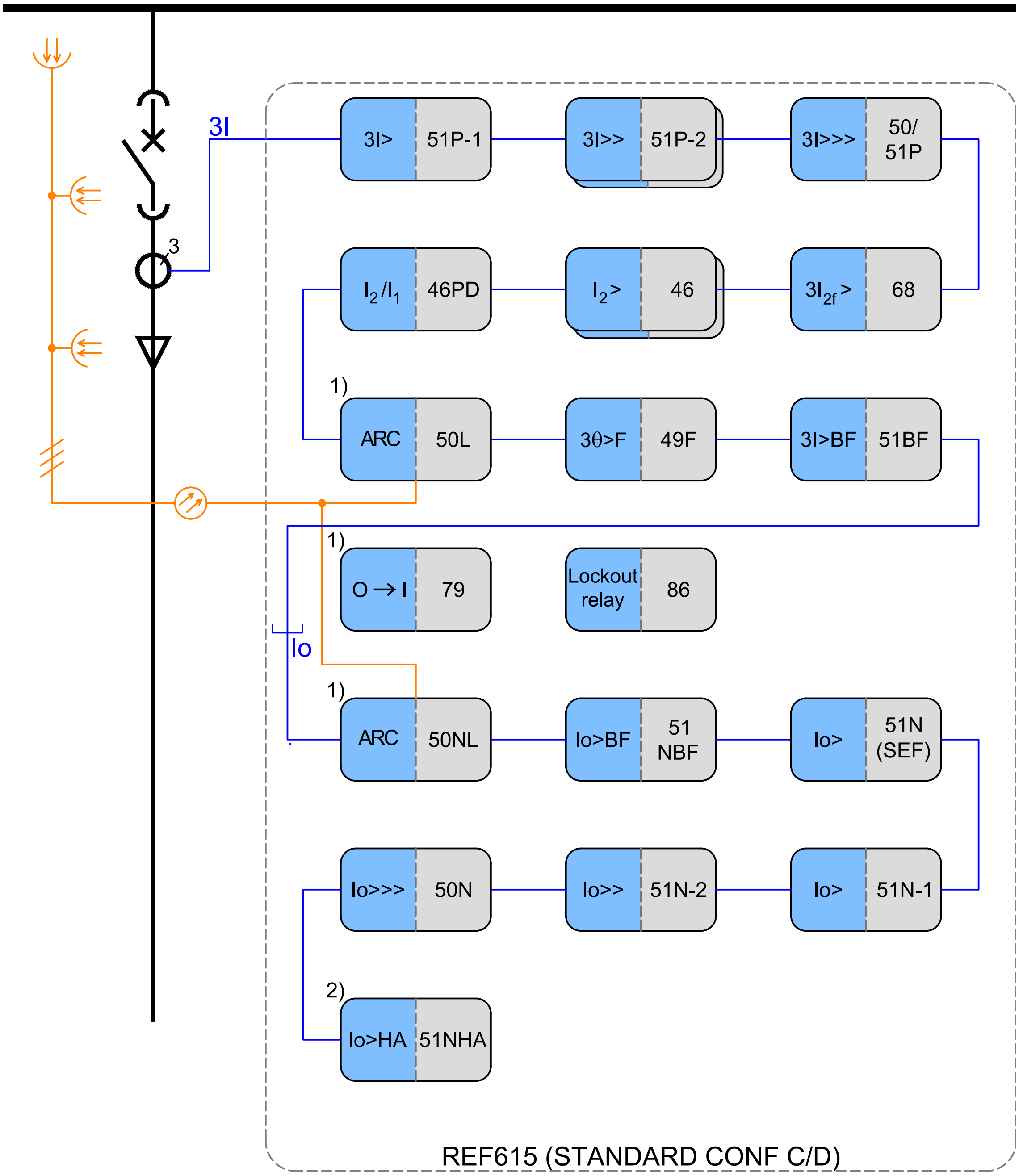
Enhanced with optional hardware and software, the IED also features three light detection channels for arc fault protection of the circuit breaker, busbar and cable compartment of metal-enclosed indoor switchgear.

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



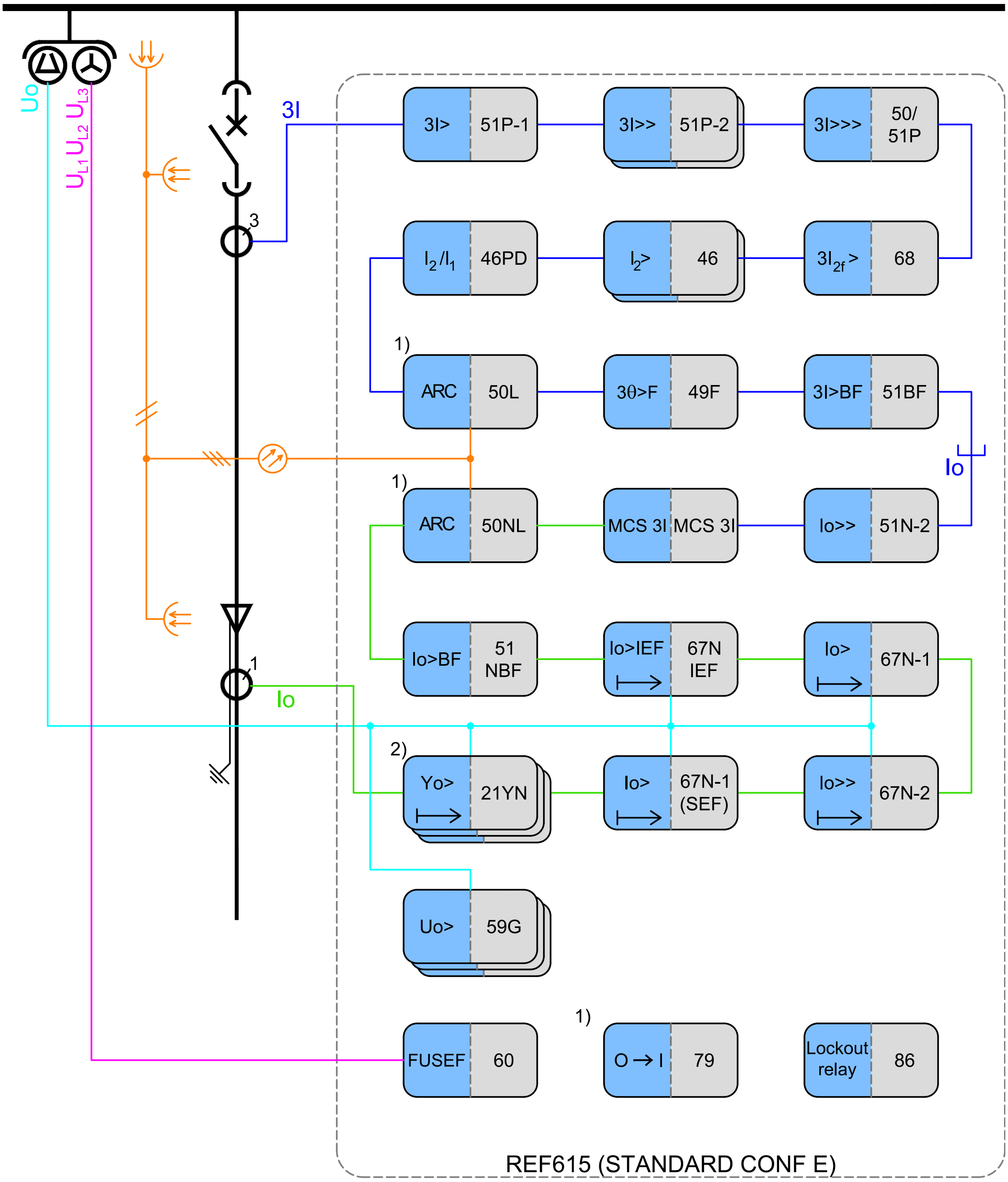
1) Optional
2) Optional admittance, wattmetric or harmonics based E/F in addition to directional E/F (optional harmonics based E/F option available in configuration B)

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



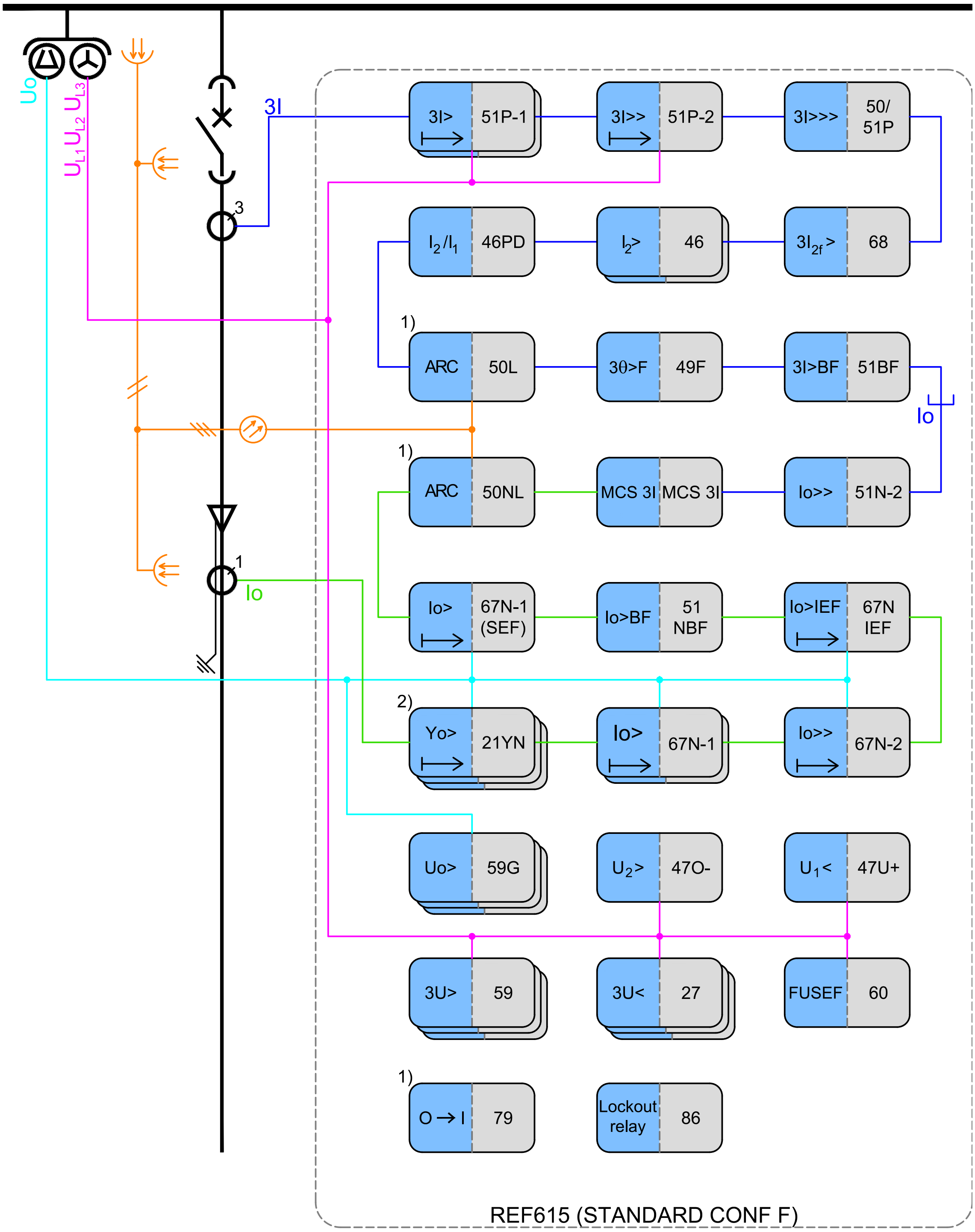
1) Optional
2) Optional harmonics based E/F only available in configuration D

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



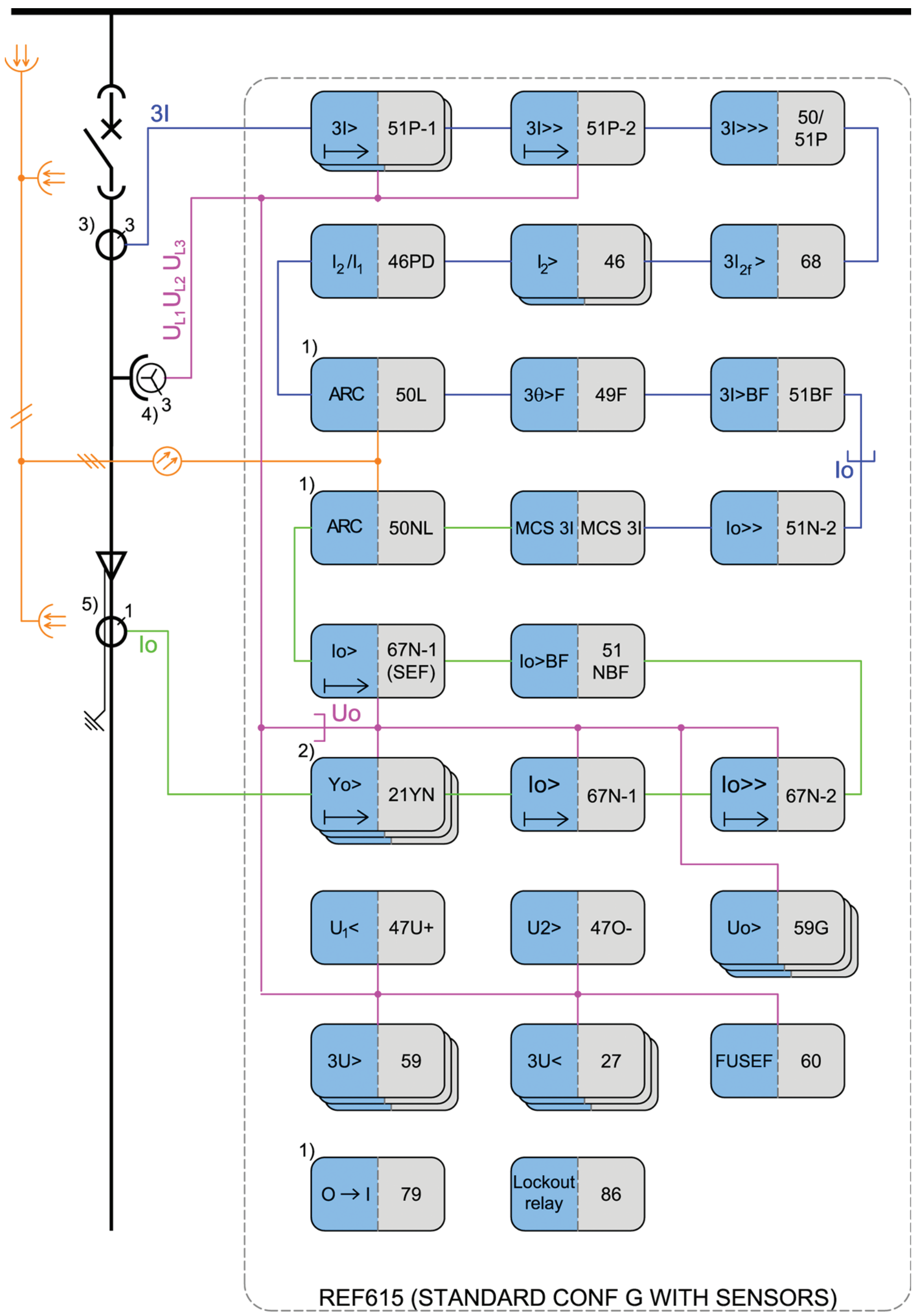
1) Optional
2) Optional admittance, wattmetric or harmonics based E/F in addition to directional E/F

Figure 3. Protection function overview of standard configuration E



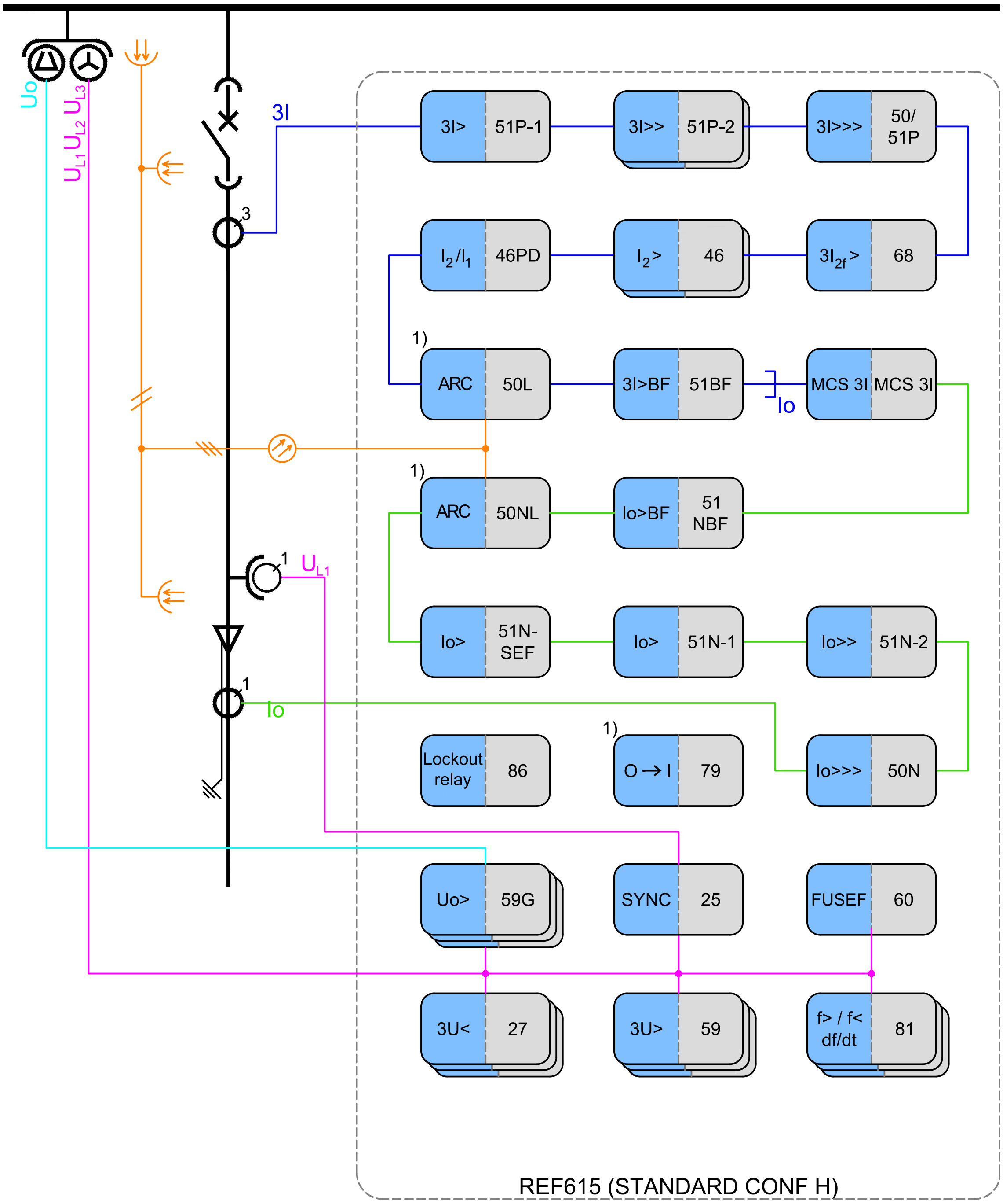
1) Optional
2) Optional admittance, wattmetric or harmonics based E/F in addition to directional E/F

Figure 4. Protection function overview of standard configuration F



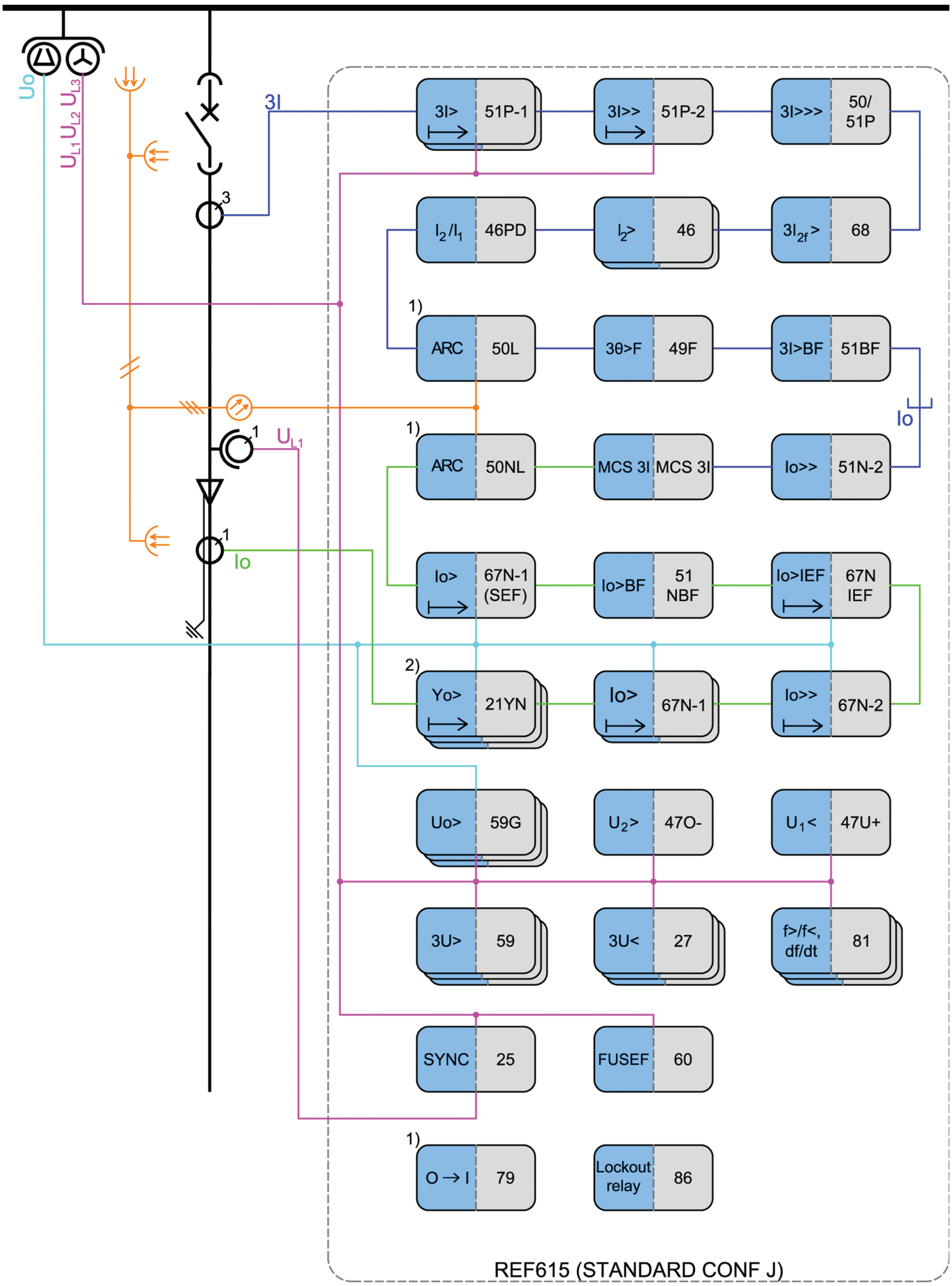
1) Optional
2) Optional admittance or wattmetric based E/F in addition to directional E/F
3) Rogowski coil
4) Voltage divider
5) Core balance CT

Figure 5. Protection function overview of standard configuration G



1) Optional

Figure 6. Protection function overview of standard configuration H



1) Optional
2) Optional admittance, wattmetric or harmonics based E/F in addition to directional E/F

Figure 7. Protection function overview of standard configuration J

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 neutral or compensated networks, whereas non-directional earth-fault protection is intended for directly or low impedance earthed neutral networks. The IED can also be used for protection of ring-type and meshed distribution networks as well of radial networks containing distributed power generation.

The standard configurations A and B offer directional earth-fault protection, if the outgoing feeder is equipped with 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 equipped with 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. Furthermore, the two standard configurations E and F include current circuit supervision and fuse failure supervision for incoming feeders provided with busbar voltage measurement. In addition to the functionality of standard configuration E, the standard configuration F offers directional overcurrent protection, overvoltage and undervoltage protection, positive-sequence undervoltage and negative-sequence overvoltage protection and residual voltage protection.

The standard configuration G includes one conventional residual current (Io) input and three sensor inputs for the connection of three combi-sensors with RJ-45 connectors. The sensor inputs enable the use of the IED in compact medium voltage switchgear with limited space for conventional measuring transformers, thus requiring the use of sensor technology. Compact medium voltage switchgear, such as ABB's SafeRing and SafePlus, are designed for applications like compact secondary substations, wind turbine power plants, small industry installations and large buildings. As an alternative to combi-sensors, separate current and voltage sensors can be utilized using adapters. Further, the adapters also enable the use of sensors with Twin-BNC connectors.

The standard configuration H includes non-directional overcurrent and non-directional earth-fault protection, phase-voltage and frequency based protection and measurement functions. The provided functionality supports the use of the standard configuration in industrial power systems, where the power is generated in the plant itself and/or derived from the distribution network. Completed with the synchro-check function, IEDs with standard configuration H ensure a safe interconnection of two networks.

The standard configuration J includes directional overcurrent and directional earth-fault protection, phase-voltage and frequency based protection and measurement functions. The provided functionality supports the use of the standard configuration in industrial power systems, where the power is generated in the plant itself and/or derived from the distribution network. Completed with the synchro-check function, IEDs with standard configuration J ensure a safe interconnection of two networks. The standard configuration J includes also optional power quality functions which enable monitoring and detecting current and voltage harmonics and short duration system disturbances.

In addition to directional earth-fault protection, one of the three following functions can be ordered as an option: Admittance-based, harmonics-based or wattmetric-based earth-fault protection. Admittance- and Wattmetric-based earth-fault protection functions are available for standard configurations A, B, E, F, G and J. Harmonics-based earth-fault protection is available for standard configurations B, D, F and J. The admittance-based earth-fault protection ensures a correct operation of the protection even though the connection status information of the Petersen coil would be missing.

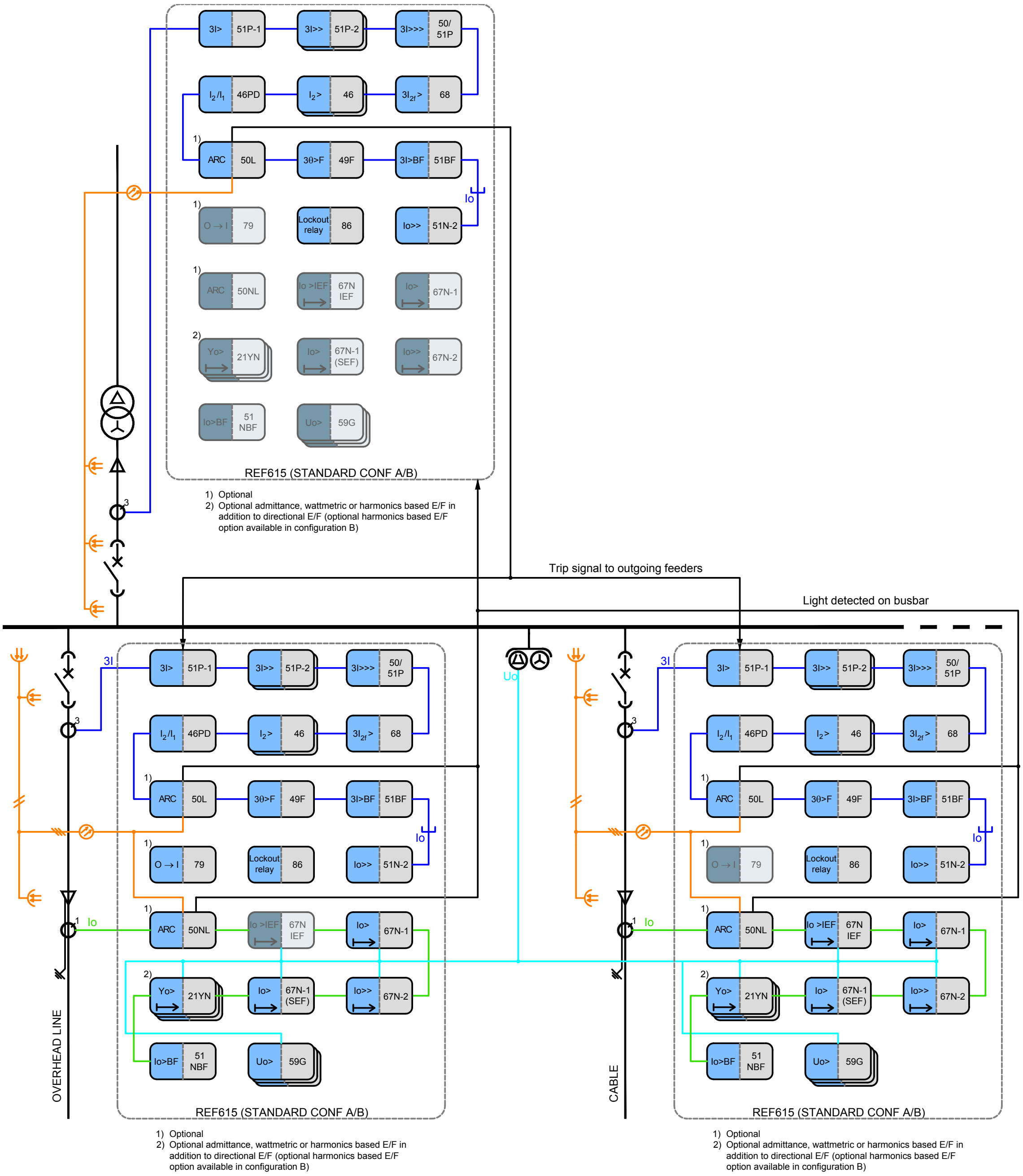


Figure 8. Substation O/C and E/F protection using the standard configuration A or B with relevant options. In the incoming feeder bay, the protection functions not used are uncoloured and indicated with a dashed block outline. The IEDs are equipped with optional arc protection functions, enabling fast and selective arc protection throughout the switchgear.

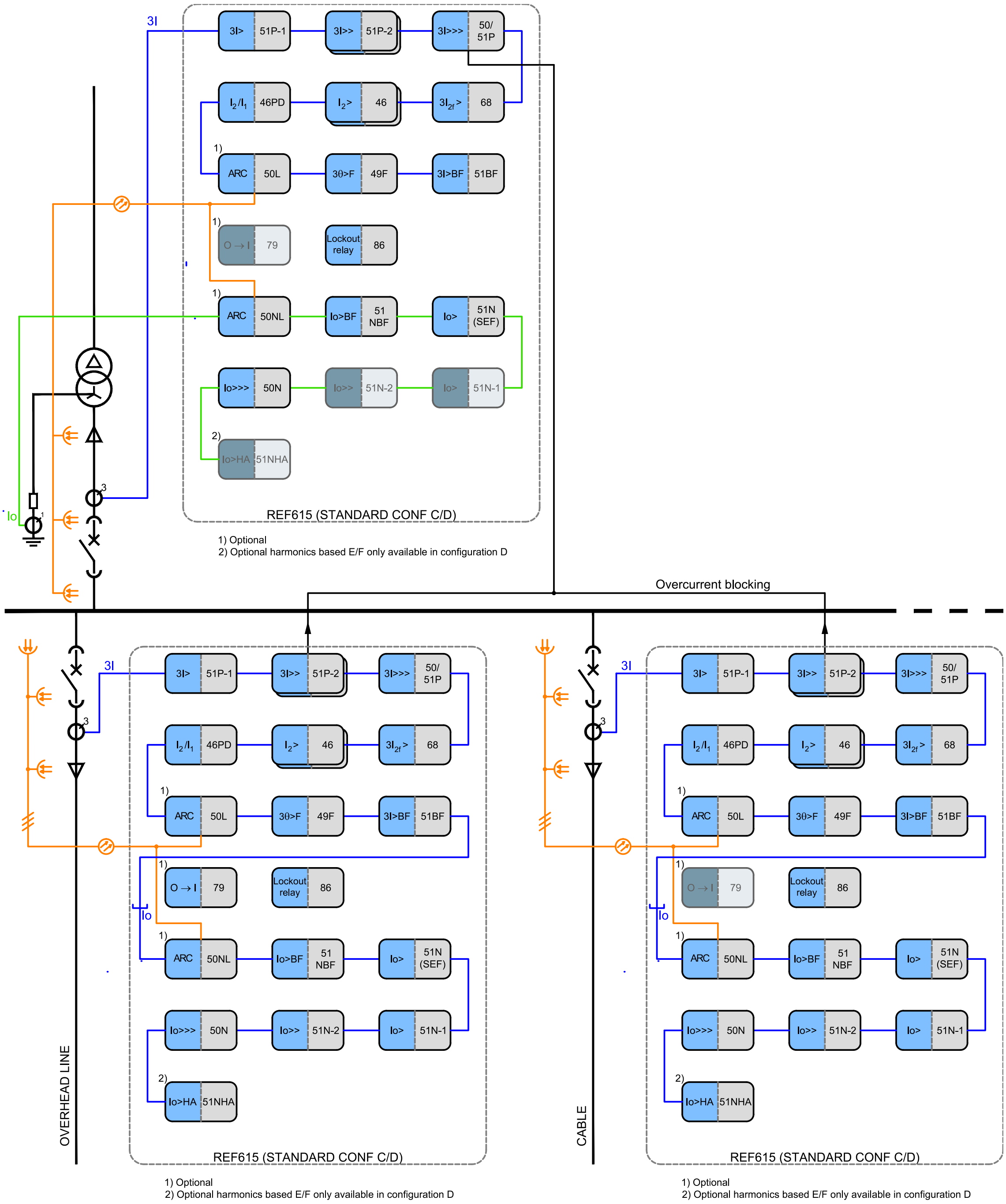


Figure 9. Substation O/C and E/F protection using the standard configuration C or D with relevant options. In the incoming feeder bay the unemployed protection functions are uncoloured and indicated with a dashed block outline. The busbar protection is based on the interlocking principle, where the start 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.

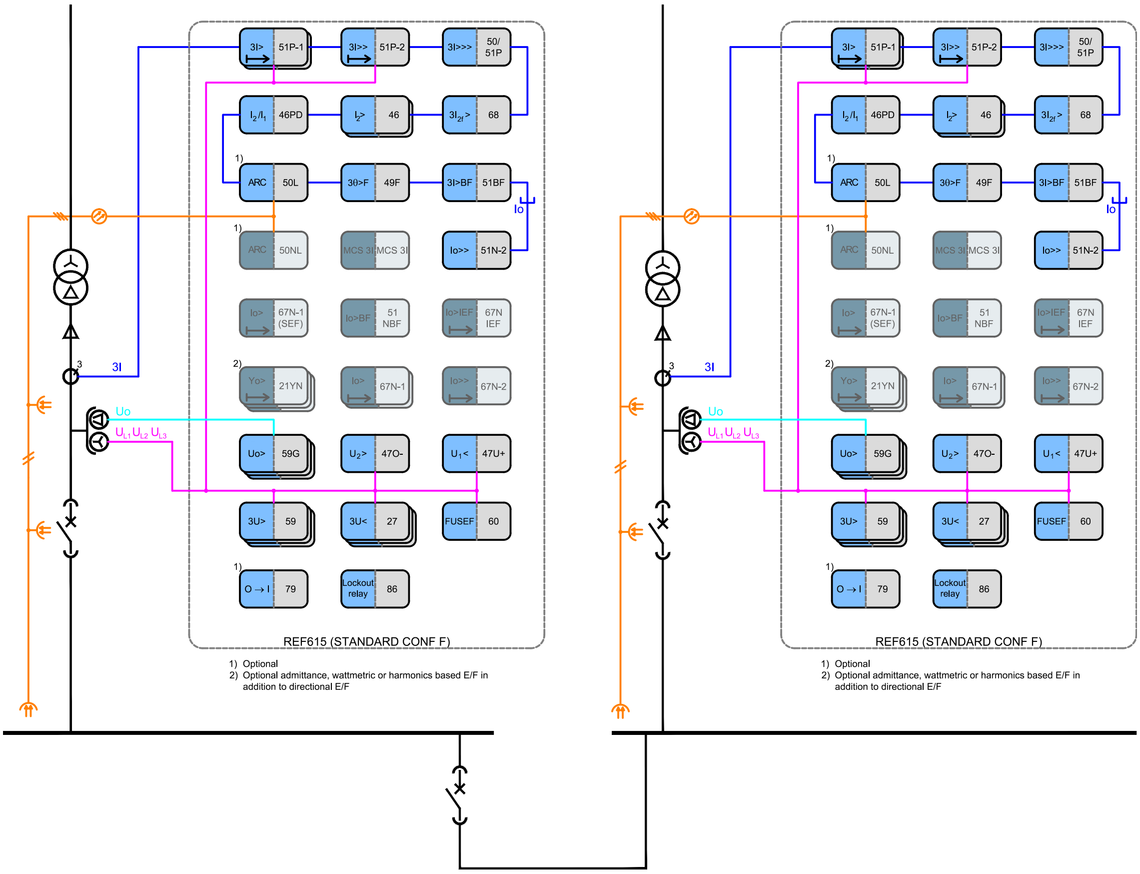


Figure 10. Protection and control of two incoming feeders using IEDs with standard configuration F. The two incoming feeders can be connected in parallel by closing the busbar-sectionalizing breaker. To achieve selective overcurrent protection, directional overcurrent stages are needed. Busbar main and 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.

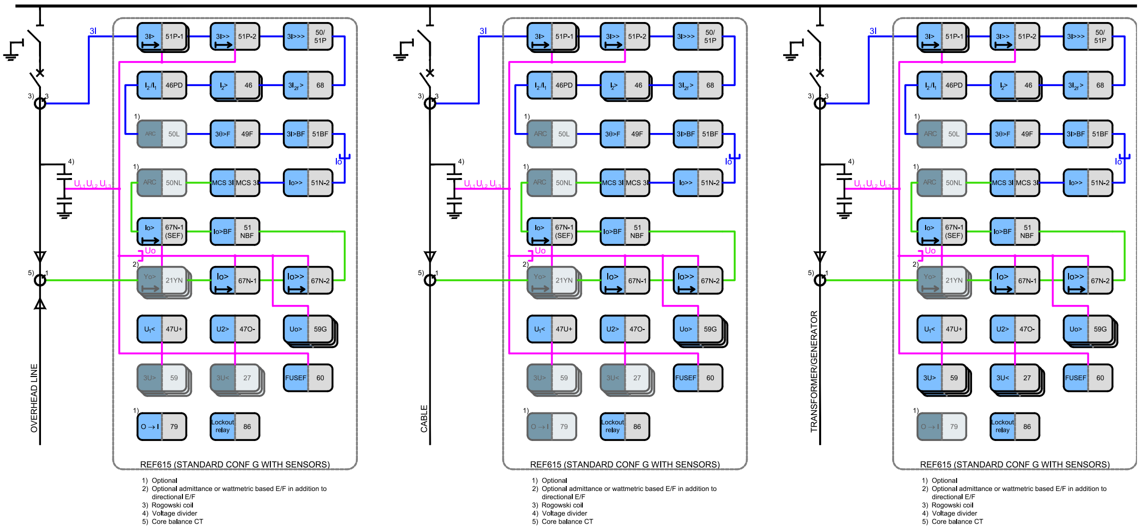


Figure 11. Protection and control of a typical compact medium voltage switchgear using REF615 IEDs with the standard configuration G. The phase currents and phase voltages are measured using combi-sensors supporting the Rogowski current sensor and voltage divider principles. The earth-fault current is measured using a conventional cable current transformer.

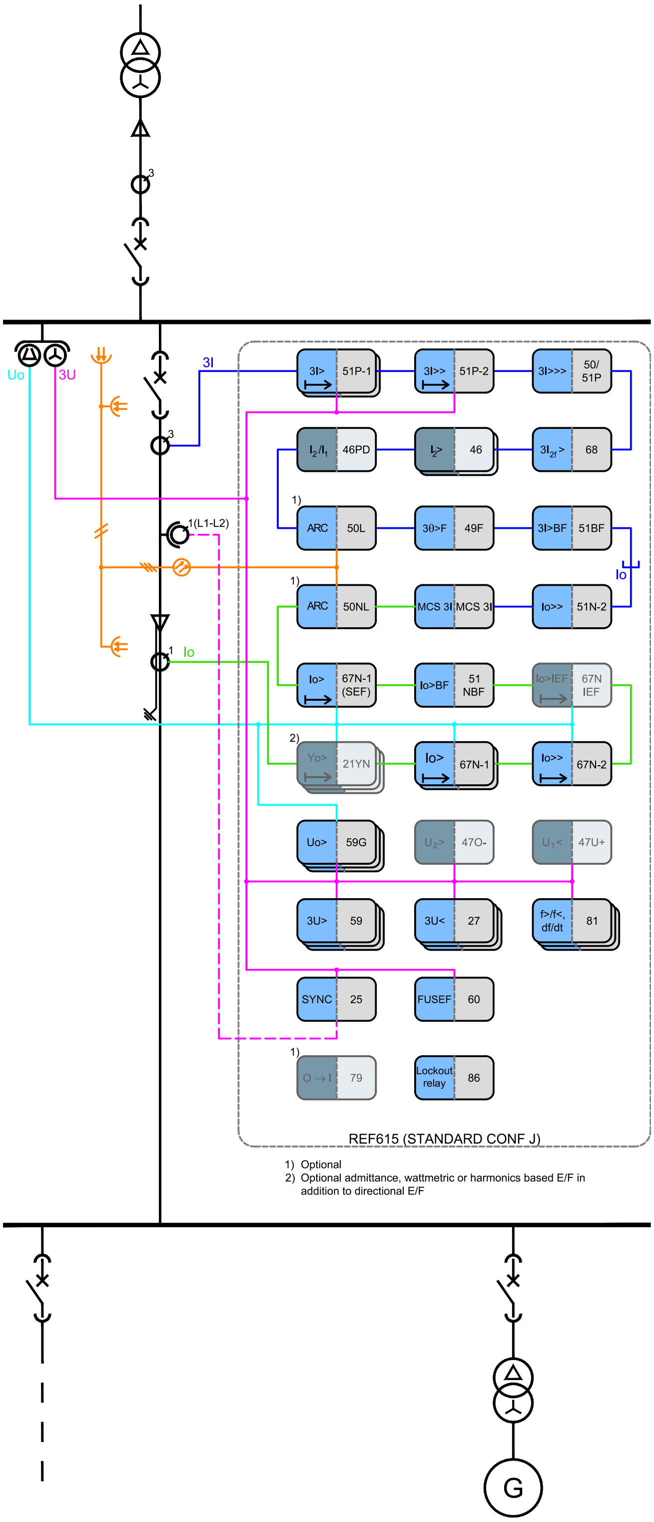


Figure 12. Protection and control of outgoing feeder with standard configuration J

In figure 12 the feeder is interconnecting utility side supply towards the local production. To achieve selective overcurrent protection, directional overcurrent is needed. Synchro-check function prevents closing the breaker in case the two network parts are not running in synchronism.

5. Supported ABB solutions

ABB's 615 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, 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 615 series IEDs offer native support for the IEC 61850 standard also including binary and analog 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 uses 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. The SLD feature is especially useful when 615 series IEDs without the optional single line diagram feature are used. Further, the web HMI of COM600 offers an overview of the whole substation, including IED-specific single line diagrams, thus enabling convenient information accessibility. 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. The data historian can be used for accurate process performance monitoring by following process and equipment performance calculations with real-time and history values. Better understanding of the process behaviour by joining time-based process measurements with production and maintenance events helps the user in understanding the process dynamics.

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
Grid Automation controller COM600	3.5 or later
MicroSCADA Pro SYS 600	9.3 FP1 or later
System 800xA	5.0 Service Pack 2

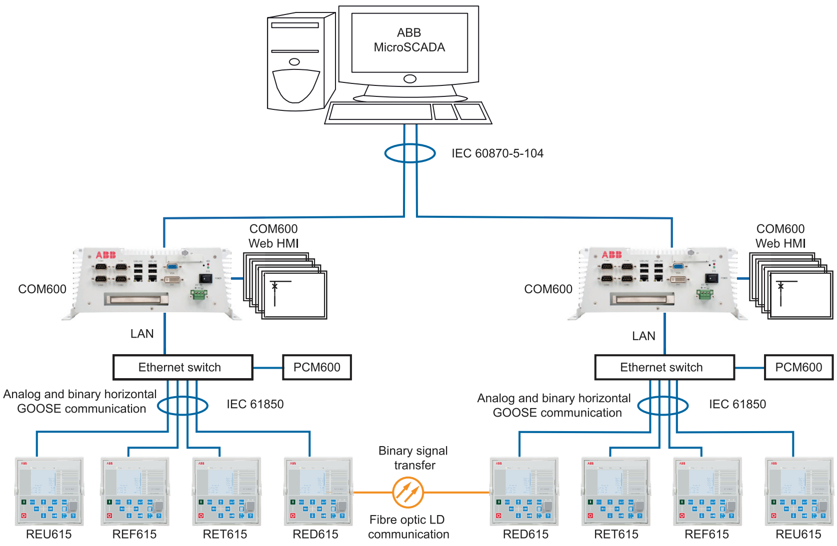


Figure 13. **Utility power distribution network example using 615 series IEDs, Grid Automation controller COM600 and MicroSCADA Pro**

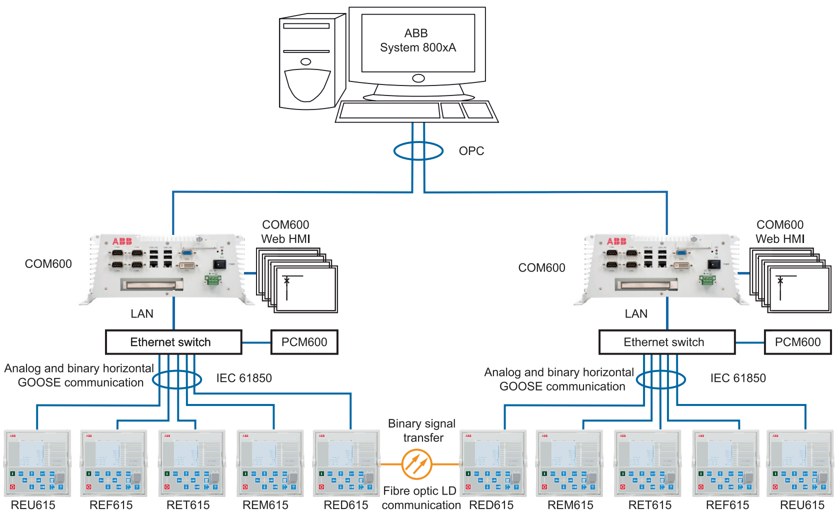


Figure 14. **Industrial power system example using 615 series IEDs, Grid Automation controller COM600 and System 800xA**

6. Control

REF615 integrates functionality for the control of a circuit breaker via the front panel HMI or by means of remote controls. In addition to the circuit-breaker control the IED features two control blocks which are intended for motor-operated control of disconnectors or circuit breaker truck and for their position indications.

Further, the IED offers one control block which is intended for motor-operated control of one earthing switch control and its position indication.

Two physical binary inputs and two physical binary outputs are needed in the IED for each controllable primary device taken into use. Depending on the chosen standard configuration of the IED the number of unused binary inputs and binary outputs varies. Further, some standard configurations also offer optional hardware modules that increase the number of available binary inputs and outputs. The amount of binary inputs and binary outputs freely available per standard configuration in REF615 is listed in the table below.

Table 4. Number of controllable objects in addition to CB

Standard configurations	Optional Binary I/O module	Free BI	Free SO	Controllable objects in addition to CB
A	-	-	-	-
B	-	1	1	0
	•	7	4	2
C	-	-	-	-
D	-	1	1	0
	•	7	4	2
E	-	4	1	0
F	-	4	0	0
G	-	0	0	0
H	-	4	0	0
J	-	4	0	0

In case the amount of available binary inputs and/or outputs of the chosen standard configuration is not sufficient, the following alternatives are recommended:

- To modify the chosen standard configuration of the IED in order to release some binary inputs or binary outputs which have originally been configured for other purposes, when applicable.
- To integrate an external input/output module for example, RIO600 to the IED. The binary inputs and outputs of the external I/O module can be used for the less time critical binary signals of the application. The integration enables releasing of some initially reserved binary inputs and outputs of the IED in the standard configuration.

The suitability of the binary outputs of the IED which have been selected for controlling of primary devices should be carefully verified, for example the make and carry as well as the breaking capacity. In case the requirements for the control-circuit of the primary device are not met, the use of external auxiliary relays should to be considered.

The optional large graphical LCD of the IED's HMI includes a single-line diagram (SLD) with position indication for the relevant primary devices. Interlocking schemes required by the application are configured using the signal matrix or the application configuration functionality of PCM600. Depending on the standard configuration, the IED also 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.

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. Depending on the standard configuration the IED additionally offers frequency measurement. In addition, the IED calculates the demand value of current over a user-selectable 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.

Further, the IED offers three-phase power and energy measurement including power factor.

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 1024 events 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 increased capacity to process and store data and events in the IED offers prerequisites to support the growing information demand of future network configurations.

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 128 latest fault events. The records enable the user to analyze the power system events. Each record includes current, voltage and angle values, 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. Condition 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 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.

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 standard configuration G includes one conventional residual current (Io 0.2/1 A) input and three sensor inputs for the direct connection of three combi-sensors with RJ-45 connectors. As an alternative to combi-sensors, separate current and voltage sensors can be utilized using adapters. Furthermore, the adapters also enable the use of sensors with Twin-BNC connectors.

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 60-210 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 inputs and outputs contacts are freely configurable with the signal matrix or application configuration functionality of PCM600.

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

Table 5. 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	52)	16	10
F	4	52)	16	10
G	3+13)	33)	8	10
H	4	5	16	10
J	4	5	16	10

1) With optional binary I/O module ( )
2) One of the five inputs is reserved for future applications
3) Support for three Combi Sensors and one conventional Io input or three current sensors, three voltage sensors and one conventional Io input

18. Station 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 settings, disturbance recordings and fault records can be accessed using the IEC 61850 protocol. Disturbance recordings are available to any Ethernet-based application in the standard COMTRADE file format. The IED supports simultaneous event reporting to five different clients on the station bus.

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.

For a self-healing Ethernet solution the IED offers an optional fibre-optic communication module providing two optical and one galvanic Ethernet network interfaces. Alternatively, the IED features an optional galvanic communication module with two galvanic and one optical Ethernet network interfaces or three galvanic interfaces. The third Ethernet interface provides connectivity of any other Ethernet devices to an IEC 61850 station bus inside of a switchgear bay.

The self-healing Ethernet ring solution enables a cost efficient communication ring controlled by a managed switch with rapid spanning tree protocol (RSTP) support to be created. The managed switch controls the consistency of the loop, routes the data and corrects the data flow in case of a communication disturbance. The IEDs in the ring topology act as unmanaged switches forwarding unrelated data traffic. The Ethernet ring solution supports the connection of up to thirty 615 series IEDs. If more than 30 IEDs are to be connected, it is recommended that the network is split into several rings with no more than 30 IEDs per ring. The self-healing Ethernet ring solution avoids single point of failure concerns and improves the reliability of the communication. The solution can be applied for the Ethernet-based IEC 61850, Modbus and DNP3 protocols.

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. Further, Modbus serial and Modbus TCP can be used in parallel, and if required both IEC 61850 and 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 recordings in IEC 60870-5-103 format.

DNP3 supports both serial and TCP modes for connection to one master. Further, changing of the active setting group is supported.

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

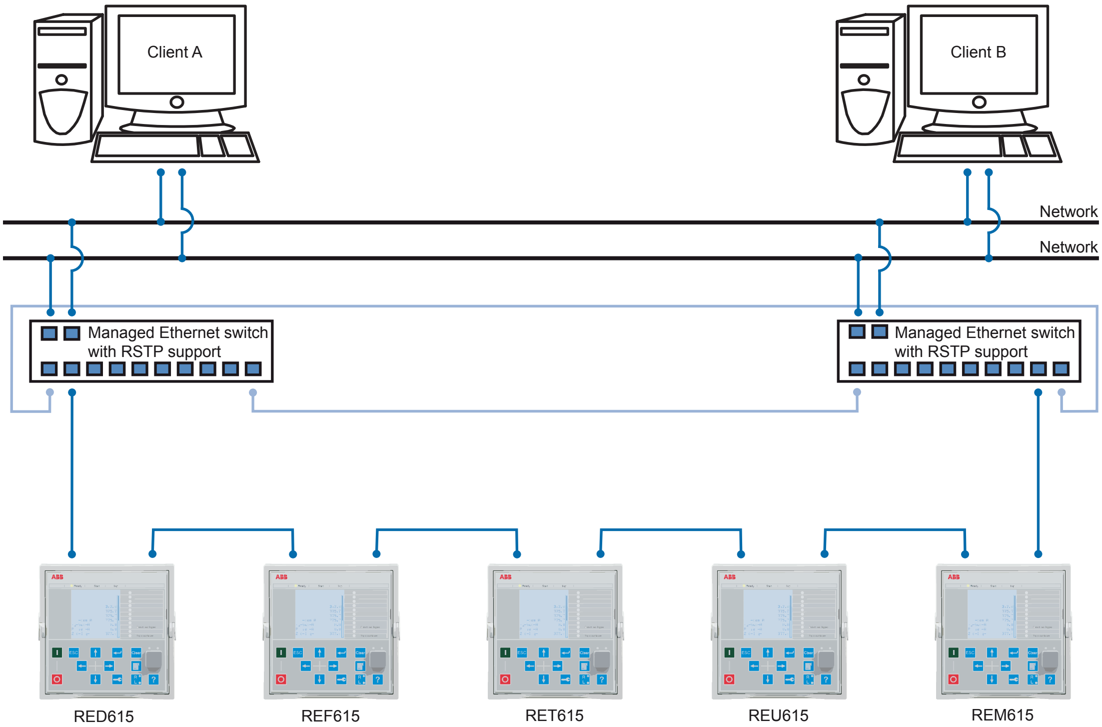


Figure 15. Self-healing Ethernet ring solution

Table 6. 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 7. Dimensions

Description	Value	
Width	frame	177 mm
	case	164 mm
Height	frame	177 mm (4U)
	case	160 mm
Depth		201 mm (153 + 48 mm)
Weight	complete IED	4.1 kg
	plug-in unit only	2.1 kg

Table 8. 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	
Maximum interruption time in the auxiliary DC voltage without resetting the IED	50 ms at $U_n$rated	
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	DC < 12.0 W (nominal)/< 18.0 W (max) AC< 16.0 W (nominal)/< 21.0W (max)	DC < 12.0 W (nominal)/< 18.0 W (max)
Ripple in the DC auxiliary voltage	Max 15% of the DC value (at frequency of 100 Hz)	
Fuse type	T4A/250 V	

Table 9. Energizing inputs

Description		Value	
Rated frequency		50/60 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	60...210 V AC	
	Voltage withstand: • Continuous • For 10 s	 240 V AC 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 10. Energizing inputs

Description		Value
Current sensor input	Rated current voltage (in secondary side)	75 mV...2812.5 mV[1)]
	Continuous voltage withstand	125 V
	Input impedance at 50/60 Hz	2-3 MOhm[2)]
Voltage sensor input	Rated voltage	6 kV...30 kV[3)]
	Continuous voltage withstand	50 V
	Input impedance at 50/60 Hz	3 MOhm

1) Equals the current range of 40A - 1250A with a 80A, 3mV/Hz Rogowski
2) Depending on the used nominal current (hardware gain)
3) This range is covered (up to 2*rated) with sensor division ratio of 10 000 : 1

Table 11. 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 12. Signal output X100: SO1

Description	Value
Rated voltage	250 V AC/DC
Continuous contact carry	5 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	1 A/0.25 A/0.15 A
Minimum contact load	100 mA at 24 V AC/DC

Table 13. 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	10 mA at 5 V AC/DC

Table 14. 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	20...250 V AC/DC
• Current drain through the supervision circuit	~1.5 mA
• Minimum voltage over the TCS contact	20 V AC/DC (15...20 V)

Table 15. Single-pole power output relays

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

Table 16. 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

Table 17. Station communication link, fibre-optic

Connector	Fibre type[1)]	Wave length	Max. distance	Permitted path attenuation[2)]
LC	MM 62.5/125 or 50/125 μm glass fibre core	1300 nm	2 km	<8 dB
ST	MM 62.5/125 or 50/125 μm glass fibre core	820-900 nm	1 km	<11 dB

1) (MM) multi-mode fibre, (SM) single-mode fibre
2) Maximum allowed attenuation caused by connectors and cable together

Table 18. IRIG-B

Description	Value
IRIG time code format	B004, B005 1)
Isolation	500V 1 min.
Modulation	Unmodulated
Logic level	TTL Level
Current consumption	2...4 mA
Power consumption	10...20 mW

1) According to 200-04 IRIG -standard

Table 19. 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 20. Degree of protection of flush-mounted IED

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

Table 21. Environmental conditions

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

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

Table 22. Environmental tests

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

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

Table 23. Electromagnetic compatibility tests

Description	Type test value	Reference
1 MHz/100 kHz burst disturbance test:		IEC 61000-4-18 IEC 60255-22-1, class III IEEE C37.90.1-2002
• Common mode	2.5 kV	
• Differential mode	2.5 kV	
3 MHz, 10 MHz and 30 MHz burst disturbance test:		IEC 61000-4-18 IEC 60255-22-1, class III
• Common mode	2.5 kV	
Electrostatic discharge test:		IEC 61000-4-2 IEC 60255-22-2 IEEE C37.90.3-2001
• Contact discharge	8 kV	
• Air discharge	15 kV	
Radio frequency interference test:		
	10 V (rms) f=150 kHz...80 MHz	IEC 61000-4-6 IEC 60255-22-6, class III
	10 V/m (rms) f=80...2700 MHz	IEC 61000-4-3 IEC 60255-22-3, class III
	10 V/m f=900 MHz	ENV 50204 IEC 60255-22-3, class III
	20 V/m (rms) f=80...1000 MHz	IEEE C37.90.2-2004
Fast transient disturbance test:		IEC 61000-4-4 IEC 60255-22-4 IEEE C37.90.1-2002
• All ports	4 kV	
Surge immunity test:		IEC 61000-4-5 IEC 60255-22-5
• Communication	1 kV, line-to-earth	
• Other ports	4 kV, line-to-earth 2 kV, line-to-line	
Power frequency (50 Hz) magnetic field immunity test:		IEC 61000-4-8
• Continuous • 1...3 s	300 A/m 1000 A/m	
Pulse magnetic field immunity test:	1000 A/m 6.4/16 μs	IEC 61000-4-9
Damped oscillatory magnetic field immunity test:		IEC 61000-4-10
• 2 s	100 A/m	
• 1 MHz	400 transients/s	

Table 23. 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
Power frequency immunity test: • Common mode • Differential mode	Binary inputs only 300 V rms 150 V rms	IEC 61000-4-16 IEC 60255-22-7, class A
Conducted common mode disturbances:	15 Hz...150 kHz Test level 3 (10/1/10 V rms)	IEC 61000-4-16
Emission tests:		EN 55011, class A IEC 60255-25
• Conducted		
0.15-0.50 MHz	< 79 dB(μV) quasi peak < 66 dB(μV) average	
0.5-30 MHz	< 73 dB(μV) quasi peak < 60 dB(μV) average	
• Radiated		
30-230 MHz	< 40 dB(μV/m) quasi peak, measured at 10 m distance	
230-1000 MHz	< 47 dB(μV/m) quasi peak, measured at 10 m distance	

Table 24. Insulation tests

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

Table 25. 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
Seismic test	IEC 60255-21-3	Class 2

Table 26. Product safety

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

Table 27. EMC compliance

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

Table 28. RoHS compliance

Description
Complies with RoHS directive 2002/95/EC

Protection functions

Table 29. Three-phase non-directional overcurrent protection (PHxPTOC)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the current measured: f_n ±2 Hz		
	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: -50 dB 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 30. 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	0.01
	PHHPTOC	0.05...15.00	0.01
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

Table 31. Three-phase directional overcurrent protection (DPHxPDOC)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the current/voltage measured: f_n ±2 Hz		
	DPHLPDOC	Current: ±1.5% of the set value or ±0.002 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 32. Three-phase directional overcurrent protection (DPHxPDOC) main settings

Parameter	Function	Value (Range)	Step
Start value	DPHLPDOC	0.05...5.00 x In	0.01
	DPHHPDOC	0.10...40.00 x In	0.01
Time multiplier	DPHxPDOC	0.05...15.00	0.01
Operate delay time	DPHxPDOC	40...200000 ms	10
Directional mode	DPHxPDOC	1 = Non-directional 2 = Forward 3 = Reverse	
Characteristic angle	DPHxPDOC	-179...180 deg	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 Operating characteristics table

Table 33. Non-directional earth-fault protection (EFxPTOC)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the current measured: f_n ±2 Hz		
	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: -50 dB 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 34. Non-directional earth-fault 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	0.01
	EFHPTOC	0.05...15.00	0.01
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

Table 35. Directional earth-fault protection (DEFxPDEF)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the current measured: f_n ±2 Hz		
	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 I_{Fault} = 2 x set *Start value*	42 ms	44 ms	46 ms
	DEFLPDEF 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: -50 dB 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 36. Directional earth-fault protection (DEFxPDEF) main settings

Parameter	Function	Value (Range)	Step
Start Value	DEFLPDEF	0.010...5.000 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	0.01
	DEFHPDEF	0.05...15.00	0.01
Operate delay time	DEFLPDEF	60...200000 ms	10
	DEFHPDEF	40...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=IoSin 3=IoCos 4=Phase angle 80 5=Phase angle 88	

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

Table 37. Transient/intermittent earth-fault protection (INTRPTEF)

Characteristic	Value
Operation accuracy (Uo criteria with transient protection)	Depending on the frequency of the current measured: f_n ±2 Hz
	±1.5% of the set value or ±0.002 x Uo
Operate time accuracy	±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

Table 38. 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 Un	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	-
Min operate current	INTRPTEF	0.01...1.00 x In	0.01

Table 39. Admittance-based earth-fault protection (EFPADM)

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

1) Uo = 1.0 x Un
2) Includes the delay of the signal output contact. Results based on statistical distribution of 1000 measurements.

Table 40. Admittance-based earth-fault protection (EFPADM) main settings

Parameter	Values (Range)	Unit	Step	Default	Description
Voltage start value	0.05...5.00	xUn	0.01	0.05	Voltage start value
Directional mode	1=Non-directional 2=Forward 3=Reverse			2=Forward	Directional mode
Operation mode	1=Yo 2=Go 3=Bo 4=Yo, Go 5=Yo, Bo 6=Go, Bo 7=Yo, Go, Bo			1=Yo	Operation criteria
Operate delay time	60...200000	ms	10	60	Operate delay time
Circle radius	0.05...500.00	mS	0.01	1.00	Admittance circle radius
Circle conductance	-500.00...500.00	mS	0.01	0.00	Admittance circle midpoint, conductance
Circle susceptance	-500.00...500.00	mS	0.01	0.00	Admittance circle midpoint, susceptance
Conductance forward	-500.00...500.00	mS	0.01	1.00	Conductance threshold in forward direction
Conductance reverse	-500.00...500.00	mS	0.01	-1.00	Conductance threshold in reverse direction
Conductance tilt Ang	-30...30	deg	1	0	Tilt angle of conductance boundary line
Susceptance forward	-500.00...500.00	mS	0.01	1.00	Susceptance threshold in forward direction
Susceptance reverse	-500.00...500.00	mS	0.01	-1.00	Susceptance threshold in reverse direction
Susceptance tilt Ang	-30...30	deg	1	0	Tilt angle of susceptance boundary line

Table 41. Wattmetric based earth-fault protection (WPWDE)

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

1) Io varied during the test. Uo = 1.0 x Un = phase to earth voltage during earth-fault in compensated or un-earthed network. The residual power value before fault = 0.0 p.u., fn = 50 Hz, results based on statistical distribution of 1000 measurement.
2) Includes the delay of the signal output contact.

Table 42. Wattmetric based earth-fault protection (WPWDE) main settings

Parameter	Function	Values (Range)	Step
Directional mode	WPWDE	2=Forward 3=Reverse	
Current start value	WPWDE	0.010...5.000 x I_n	0.001
Voltage start value	WPWDE	0.010...1.000 x U_n	0.001
Power start value	WPWDE	0.003...1.000 x P_n	0.001
Reference power	WPWDE	0.050...1.000 x P_n	0.001
Characteristic angle	WPWDE	-179...180 deg	1
Time multiplier	WPWDE	0.05...2.00	0.01
Operating curve type	WPWDE	Definite or inverse time Curve type: 5, 15, 20	
Operate delay time	WPWDE	60...200000 ms	10
Min operate current	WPWDE	0.010...1.000 x I_n	0.001
Min operate voltage	WPWDE	0.01...1.00 x U_n	0.01

Table 43. Harmonics earth-fault protection (HAEFPTOC)

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

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

Table 44. HAEFPTOC main settings

Parameter	Function	Values (Range)	Step
Start value	HAEFPTOC	0.05...5.00 x I_n	0.01
Time multiplier	HAEFPTOC	0.05...15.00	0.01
Operate delay time	HAEFPTOC	100...200000 ms	10
Minimum operate time	HAEFPTOC	100...200000 ms	10
Operating curve type	HAEFPTOC	Definite or inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	

Table 45. Three-phase overvoltage protection (PHPTOV)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the voltage measured: f_n ±2 Hz		
		±1.5% of the set value or ±0.002 x U_n		
Start time[1)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 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 = 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 46. 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	0.01
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

Table 47. Three phase undervoltage protection (PHPTUV)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the voltage measured: fn ±2 Hz		
		±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 on the set *Relative hysteresis*		
Retardation time		< 35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms[3)]		
Suppression of harmonics		DFT: -50 dB at f = n 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 48. 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	0.01
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

Table 49. Positive-sequence undervoltage protection (PSPTUV)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the voltage measured: f_n ±2 Hz		
		±1.5% of the set value or ±0.002 x U_n		
Start time[1)2)]		Minimum	Typical	Maximum
	U_{Fault} = 0.99 x set *Start value* U_{Fault} = 0.9 x set *Start value*	51 ms 43 ms	53 ms 45 ms	54 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 50. 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 51. Frequency protection (FRPFRQ)

Characteristic		Value
Operation accuracy	f>/f<	±10 mHz
	df/dt	±100 mHz/s (in range |df/dt| < 5 Hz/s) ± 2.0% of the set value (in range 5 Hz/s < |df/dt| < 15 Hz/s)
Start time	f>/f<	< 80 ms
	df/dt	< 120 ms
Reset time		< 150 ms
Operate time accuracy		±1.0% of the set value or ±30 ms

Table 52. Frequency protection (FRPFRQ) main settings

Parameter	Values (Range)	Unit	Step	Default	Description
Operation mode	1=Freq< 2=Freq> 3=df/dt 4=Freq< + df/dt 5=Freq> + df/dt 6=Freq< OR df/dt 7=Freq> OR df/dt			1=Freq<	Frequency protection operation mode selection
Start value Freq>	0.900...1.200	xFn	0.001	1.050	Frequency start value overfrequency
Start value Freq<	0.800...1.100	xFn	0.001	0.950	Frequency start value underfrequency
Start value df/dt	-0.200...0.200	xFn /s	0.005	0.010	Frequency start value rate of change
Operate Tm Freq	80...200000	ms	10	200	Operate delay time for frequency
Operate Tm df/dt	120...200000	ms	10	400	Operate delay time for frequency rate of change

Table 53. Negative-sequence overvoltage protection (NSPTOV)

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

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

Table 54. 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 55. Residual overvoltage protection (ROVPTOV)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the voltage measured: f_n ±2 Hz		
		±1.5% of the set value or ±0.002 x U_n		
Start time[1)2)]		Minimum	Typical	Maximum
	U_{Fault} = 1.1 x set *Start value*	55 ms	56 ms	58 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 56. 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 57. Negative phase-sequence overcurrent protection (NSPTOC)

Characteristic		Value		
Operation accuracy		Depending on the frequency of the current measured: f_n ±2 Hz		
		±1.5% of the set value or ±0.002 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: -50 dB 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 58. 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	0.01
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

Table 59. Phase discontinuity protection (PDNSPTOC)

Characteristic	Value
Operation accuracy	Depending on the frequency of the current measured: f_n ±2 Hz
	±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: -50 dB at f = n x f_n, where n = 2, 3, 4, 5,…

Table 60. 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 61. Circuit breaker failure protection (CCBRBRF)

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

Table 62. 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 63. Three-phase thermal overload protection for feeders (T1PTTR)

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

1) Overload current > 1.2 x Operate level temperature

Table 64. 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 65. Three-phase inrush current detection (INRPHAR)

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

Table 66. 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 67. Arc protection (ARCSARC)

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

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 68. 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 69. 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 70. Autoreclosing (DARREC)

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

Table 71. Synchrocheck (SECRSYN)

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

Table 72. Synchronism and energizing check (SECRSYN) main settings

Parameter	Values (Range)	Unit	Step	Default	Description
Live dead mode	-1=Off 1=Both Dead 2=Live L, Dead B 3=Dead L, Live B 4=Dead Bus, L Any 5=Dead L, Bus Any 6=One Live, Dead 7=Not Both Live			1=Both Dead	Energizing check mode
Difference voltage	0.01...0.50	xUn	0.01	0.05	Maximum voltage difference limit
Difference frequency	0.001...0.100	xFn	0.001	0.001	Maximum frequency difference limit
Difference angle	5...90	deg	1	5	Maximum angle difference limit
Synchrocheck mode	1=Off 2=Synchronous 3=Asynchronous			2=Synchronous	Synchrocheck operation mode
Control mode	1=Continuous 2=Command			1=Continuous	Selection of the synchrocheck command or continuous control mode
Dead line value	0.1...0.8	xUn	0.1	0.2	Voltage low-limit line for energizing check
Live line value	0.2...1.0	xUn	0.1	0.5	Voltage high-limit line for energizing check
Close pulse	200...60000	ms	10	200	Breaker-closing pulse duration
Max energizing V	0.50...1.15	xUn	0.01	1.05	Maximum voltage for energizing
Phase shift	-180...180	deg	1	180	Correction of phase difference between measured U_BUS and U_LINE
Minimum Syn time	0...60000	ms	10	0	Minimum time to accept synchronizing

Table 72. Synchronism and energizing check (SECRSYN) main settings, continued

Parameter	Values (Range)	Unit	Step	Default	Description
Maximum Syn time	100...6000000	ms	10	2000	Maximum time to accept synchronizing
Energizing time	100...60000	ms	10	100	Time delay for energizing check
Closing time of CB	40...250	ms	10	60	Closing time of the breaker

Measurement functions

Table 73. Three-phase current measurement (CMMXU)

Characteristic	Value
Operation accuracy	Depending on the frequency of the current measured: f_n ±2 Hz
	±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: -50 dB at f = n x f_n, where n = 2, 3, 4, 5,… RMS: No suppression

Table 74. Current sequence components (CSMSQI)

Characteristic	Value
Operation accuracy	Depending on the frequency of the current measured: f/f_n = ±2 Hz
	±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: -50 dB at f = n x f_n, where n = 2, 3, 4, 5,…

Table 75. Three-phase voltage measurement (VMMXU)

Characteristic	Value
Operation accuracy	Depending on the frequency of the voltage measured: f_n ±2 Hz At voltages in range 0.01…1.15 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 76. Voltage sequence components (VSMSQI)

Characteristic	Value
Operation accuracy	Depending on the frequency of the voltage measured: f_n ±2 Hz At voltages in range 0.01…1.15 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 77. Residual current measurement (RESCMMXU)

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

Table 78. Residual voltage measurement (RESVMMXU)

Characteristic	Value
Operation accuracy	Depending on the frequency of the current measured: f/f_n = ±2 Hz
	±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 79. 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 ±1 Hz 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,…

Table 80. Frequency measurement (FMMXU)

Characteristic	Value
Operation accuracy	±10 mHz (in measurement range 35 - 75 Hz)

Supervision functions

Table 81. Current circuit supervision (CCRDIF)

Characteristic	Value
Operate time[1]	< 30 ms

1) Including the delay of the output contact.

Table 82. 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 83. 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. Local HMI

The IED is available with two optional displays, a large one and a small one. The large display is suited for IED installations where the front panel user interface is frequently used and a single line diagram is required. The small display is suited for remotely controlled substations where the IED is only occasionally accessed locally via the front panel user interface.

Both LCD displays offer front-panel user interface functionality with menu navigation and menu views. However, the large display offers increased front-panel usability with less menu scrolling and improved information overview. In addition, the large display includes a user-configurable single line diagram (SLD) with position indication for the associated primary equipment. Depending on the chosen standard configuration, the IED displays the related measuring values, apart from the default single line diagram. The SLD view can also be accessed using the web-browser based user interface. The default SLD can be modified according to user requirements by using the graphical display editor in PCM600.

The local HMI includes a push button (L/R) for local/remote operation of the IED. When the IED is in the local mode, the IED can be operated only by using the local front panel user interface. When the IED is in the remote mode, the IED can execute commands sent from a remote location. The IED supports the remote selection of local/remote mode via a binary input. This feature facilitates, for example, the use of an external switch at the substation to ensure that all IEDs are in the local mode during maintenance work and that the circuit breakers cannot be operated remotely from the network control centre.

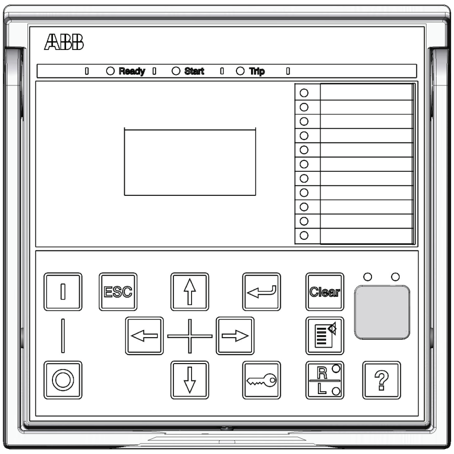


Figure 16. Small display

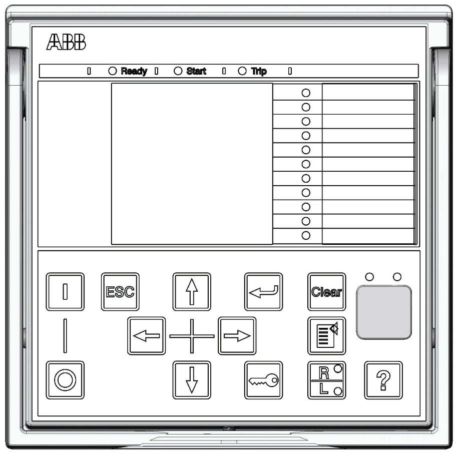


Figure 17. Large display

Table 84. 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 85. 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

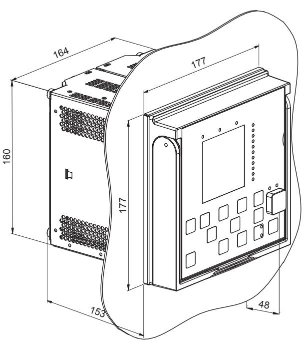


Figure 18. Flush mounting

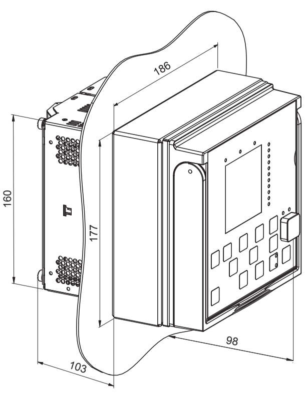


Figure 19. Semi-flush mounting

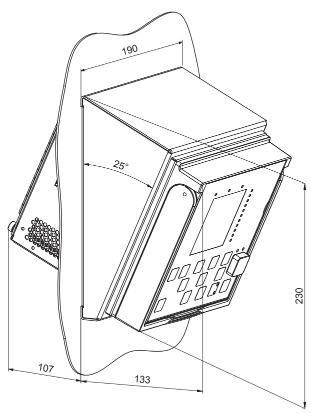


Figure 20. Semi-flush with a 25° tilt

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 F A E A G B C C 1 B C A 1 X E

#	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. Not available for standard configuration "G".	K
	615 series IED (including case) with test switch, wired and in - stalled in a mounting bracket for CombiFlex rack mounting (RGHT 19" 4U variant C). Not available for standard configuration "G".	L
2	Standard	
	IEC	B
3	Main application	
	Feeder protection and control	F

The standard configuration determines the I/O hardware and available options. The example below shows standard configuration “F” with chosen options.

H B F F A E A G B C C 1 B C A 1 X E

#	Description		
4-8	Standard configurations, analog and binary I/O options Standard configuration descriptions in short: A = Non-directional O/C and directional E/F protection and CB control B = Non-directional O/C and directional E/F protection, CB condition monitoring and control and with the optional I/O module control of two network objects C = Non-directional O/C and non-directional E/F protection and CB control D = Non-directional O/C and non-directional E/F protection, CB condition monitoring and control and with the optional I/O module control of two network objects E = Non-directional O/C and directional E/F protection with phase-voltage based measurements, CB condition monitoring and control F = Directional O/C and directional E/F protection with phase-voltage based measurements, undervoltage and overvoltage protection, CB condition monitoring and control G = Directional O/C and directional E/F protection, phase-voltage based protection and measurement functions, CB condition monitoring and control and (sensor inputs) H = Non-directional O/C and non-directional E/F protection, phase-voltage and frequency based protection and measurement functions, synchro check, CB condition monitoring and control J = Directional O/C and directional E/F protection, phase-voltage and frequency based protection and measurement functions, synchro check, CB condition monitoring and control		
	Std. conf.	I/O options	
	A	4I + Uo (Io 1/5 A) + 3 BI + 6 BO	AAAAA
	A	4I + Uo (Io 0.2/1 A) + 3 BI + 6 BO	AABAA
	B	4I +Uo (Io 1/5 A) + 11 BI + 10 BO	BAAAC
	B	4I +Uo (Io 1/5 A) + 17 BI + 13 BO	BAAAE*
	B	4I +Uo (Io 0.2/1 A) + 11 BI + 10 BO	BABAC
	B	4I +Uo (Io 0.2/1 A) + 17 BI + 13 BO	BABAE*
	C	4I (Io 1/5 A) + 4 BI + 6 BO	CACAB
	C	4I (Io 0.2/1 A) + 4 BI + 6 BO	CADAB
	D	4I (Io 1/5 A) + 12 BI + 10 BO	DACAD
	D	4I (Io 1/5 A) + 18 BI + 13 BO	DACAF*
	D	4I (Io 0.2/1 A) + 12 BI + 10 BO	DADAD
	D	4I (Io 0.2/1 A) + 18 BI + 13 BO	DADAF*
	E	4I (Io 1/5 A) + 5U + 16 BI + 10 BO	EAEAG
	E	4I (Io 0.2/1 A) + 5U + 16 BI + 10 BO	EAFAG
	F	4I (Io 1/5 A) + 5U + 16 BI + 10 BO	FAEAG
	F	4I (Io 0.2/1 A) + 5U + 16 BI + 10 BO	FAFAG
	G	3Is + 3Us +Io (Io 0.2/1 A) + 8 BI + 10 BO	GDAAH
	H	4I (Io 1/5 A) + 5U + 16 BI + 10 BO	HAEAG
	H	4I (Io 0.2/1 A) + 5U + 16 BI + 10 BO	HAFAG
	J	4I (Io 1/5 A) + 5U + 16 BI + 10 BO	JAEAG
	J	4I (Io 0.2/1 A) + 5U + 16 BI + 10 BO	JAFAG

* = The optional I/O module included.

The communication module hardware determines the available communication protocols. Choose the hardware from one of the rows below to define the digits # 9-10.

H B F F A E A G B C C 1 B C A 1 X E

#	Description	
9 - 10	Communication modules (Serial/Ethernet)	
	Serial RS-485, incl. an input for IRIG-B + Ethernet 100Base-FX (1 x LC)	AA
	Serial RS-485, incl. an input for IRIG-B + Ethernet 100Base-TX (1 x RJ-45)	AB
	Serial RS-485, incl. an input for IRIG-B	AN
	Serial glass fibre (ST), incl. an RS-485 connector and an input for IRIG-B (cannot be combined with arc protection)	BN
	Serial glass fibre (ST) + Ethernet 100Base-TX (1 x RJ-45) + Serial RS-485 connector, RS-232/485 D-Sub 9 connector + input for IRIG-B (cannot be combined with arc protection)	BB
	Serial glass fibre (ST) + Ethernet 100Base-TX (3 x RJ-45)	BD
	Serial glass fibre (ST) + Ethernet 100Base-TX and -FX (2 x RJ-45 + 1 x LC)	BC
	Serial glass fibre (ST) + Ethernet 100Base-TX and -FX (1 x RJ-45 + 2 x LC)	BE
	Ethernet 100Base-FX (1 x LC)	NA
	Ethernet 100Base-TX (1 x RJ-45)	NB
	Ethernet 100Base-TX and -FX (2 x RJ-45 + 1 x LC)	NC
	Ethernet 100Base-TX (3 x RJ-45)	ND
	Ethernet 100Base-TX and -FX (1 x RJ-45 + 2 x LC)	NE
	No communication module	NN

If serial communication is chosen, please choose a serial communication module including Ethernet (for example "BC") if a service bus for PCM600 or the WebHMI is required.

H B F F A E A G B C C 1 B C A 1 X E

#	Description	
11	Communication protocols	
	IEC 61850 (for Ethernet communication modules and IEDs without a communication module)	A
	Modbus (for Ethernet/serial or Ethernet + serial communication modules)	B
	IEC 61850 + Modbus (for Ethernet or serial + Ethernet communication modules)	C
	IEC 60870-5-103 (for serial or Ethernet + serial communication modules)	D
	DNP3 (for Ethernet/serial or Ethernet + serial communication modules)	E

HBF FAEAGBCC 1 B C A 1 XE

#	Description	
12	Language	
	English	1
	English and German	3
	English and Swedish	4
	English and Spanish	5
	English and Russian	6
	English and Polish	7
	English and Portuguese (Brazilian)	8
	English and Italian	A
	English and French	C
	English and Czech	E
13	Front panel	
	Small LCD	A
	Large LCD with single line diagram (SLD)	B
14	Option 1	
	Auto-reclosing	A
	Arc protection (requires a communication module, cannot be combined with communication modules BN or BB)	B
	Arc protection and auto-reclosing (requires a communication module, cannot be combined with communication modules BN, BB)	C
	Power quality (only for std configuration J)	D
	Power quality and auto-reclosing (only for std configuration J)	E
	Power quality and arc protection (only for std configuration J, requires a communication module, cannot be combined with communication modules BN or BB)	F
	Power quality, arc protection and auto-reclosing (only for std configuration J, requires a communication module, cannot be combined with communication modules BN or BB)	G
	None	N
15	Option 2	
	Directional earth-fault protection (only for std configuration: A, B, E, F, G, J)	A
	Admittance based earth-fault protection (only for std configura - tion: A, B, E, F, G, J)	B
	Wattmetric based earth-fault protection and directional earth-fault protection (only for std configuration: A, B, E, F, G, J)	C
	Harmonics based earth-fault protection and directional earth-fault protection (only for std configuration: B, F, J)	D
	Harmonics based earth-fault protection (only for std configuration: D)	E
	None (only for std configuration: C, D, H)	N
16	Power supply	
	48...250 V DC, 100...240 V AC	1
	24...60 V DC	2
17 - 18	Version	
	Version 4.0	XE

Example code: H B F F A E A G B C C 1 B C A 1 X E

Your ordering code:

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

Figure 21. Ordering key for complete IEDs

24. Accessories and ordering data

Table 86. 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 87. 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
Replacement kit for a Strömberg SP_J40 series relay (cut-out in the center of the installation plate)	2RCA027871A0001
Replacement kit for a Strömberg SP_J40 series relay (cut-out on the left or the right of the installation plate)	2RCA027874A0001
Replacement kit for two Strömberg SP_J3 series relays	2RCA027880A0001
19” rack replacement kit for Strömberg SP_J3/J6 series relays (one cut-out)	2RCA027894A0001
19” rack replacement kit for Strömberg SP_J3/J6 series relays (two cut-outs)	2RCA027897A0001
Replacement kit for a Strömberg SP_J6 series relay	2RCA027881A0001
Replacement kit for three BBC S_ series relays	2RCA027882A0001
Replacement kit for a SPA 300 series relay	2RCA027885A0001

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.

The Protection and Control IED Manager PCM600 is available in two different variants, that is PCM600 Basic/Engineering and PCM600 Engineering Pro. Depending on the chosen variant, PCM600 offers extensive IED configuration functions such as IED signal configuration, application configuration, graphical display configuration including single line diagram configuration, and IEC 61850 communication configuration including horizontal GOOSE communication.

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 IE 8.0 or IE 9.0). 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. Further, the Connectivity Packages for the 615 series IEDs include a flexible update tool for adding one additional local HMI language to the IED. The update tool is activated using PCM600 and enables multiple updates of the additional HMI language, thus offering flexible means for possible future language updates.

Table 88. Tools

Configuration and setting tools	Version
PCM600	2.4 SP1 or later
Web-browser based user interface	IE 7.0, IE 8.0 or IE 9.0
REF615 Connectivity Package	4.0 or later

Table 89. Supported functions

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

● = Supported

26. Terminal diagrams

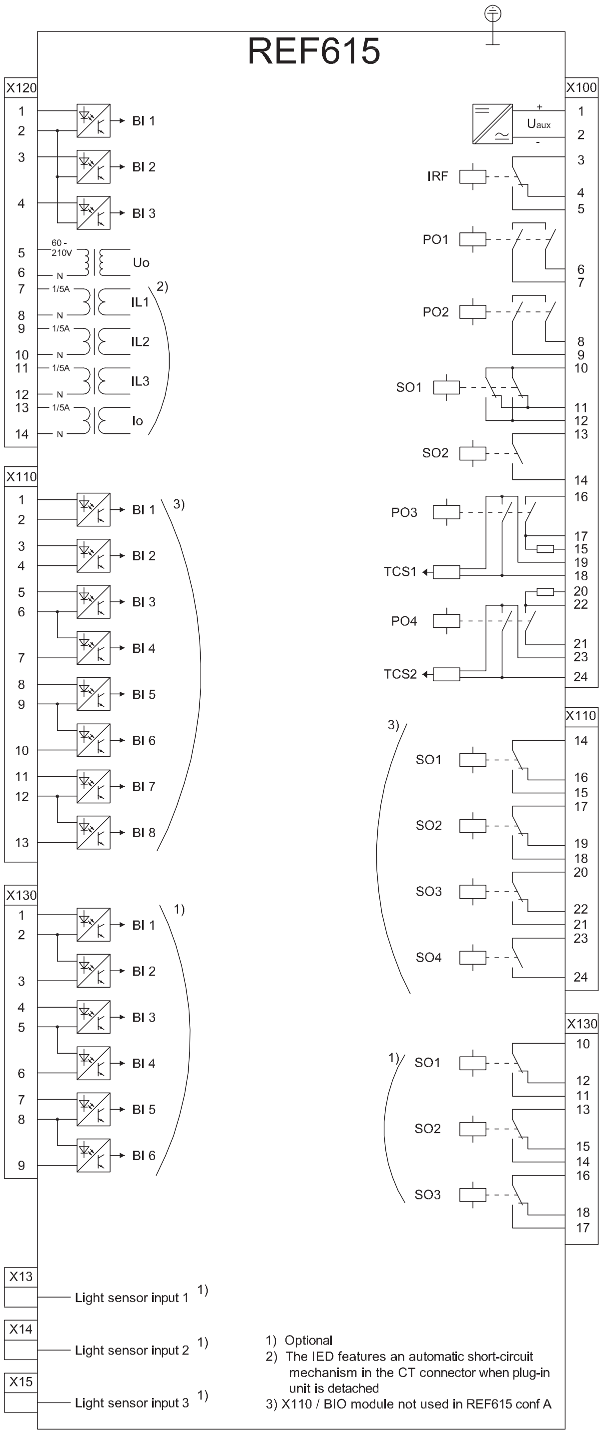


Figure 22. Terminal diagram of standard configurations A and B

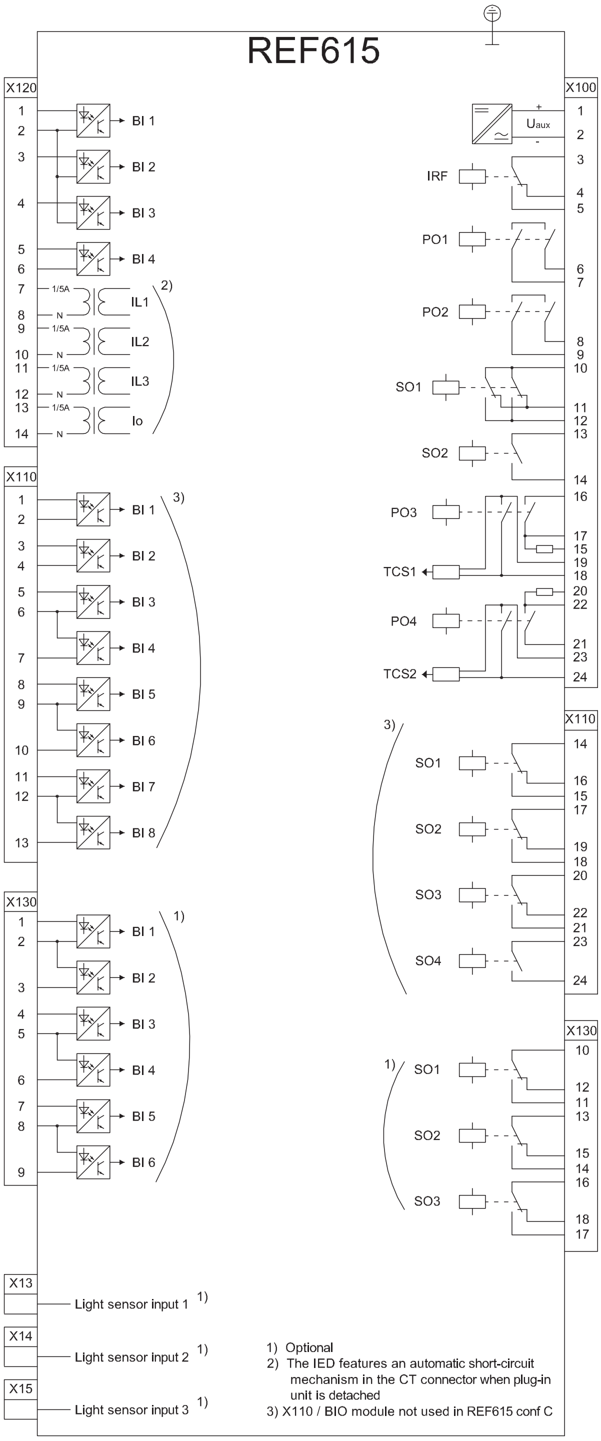


Figure 23. Terminal diagram of standard configurations C and D

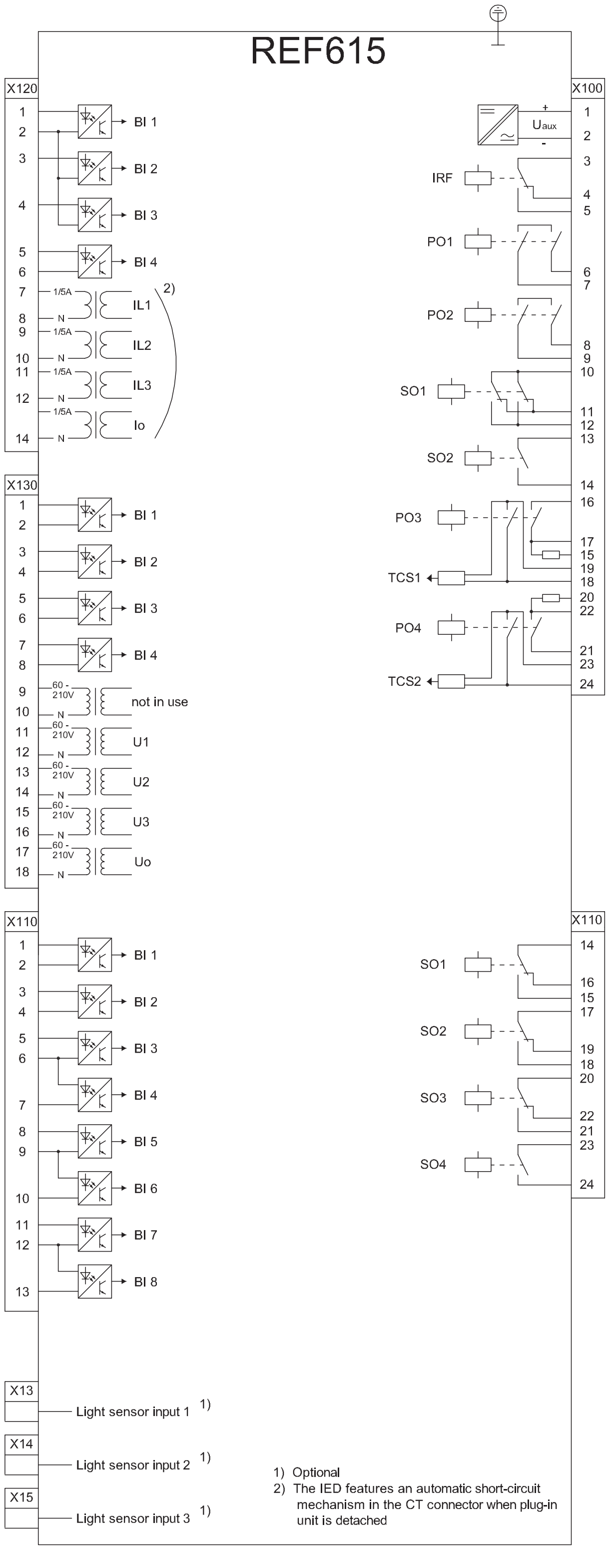


Figure 24. Terminal diagram of standard configurations E and F

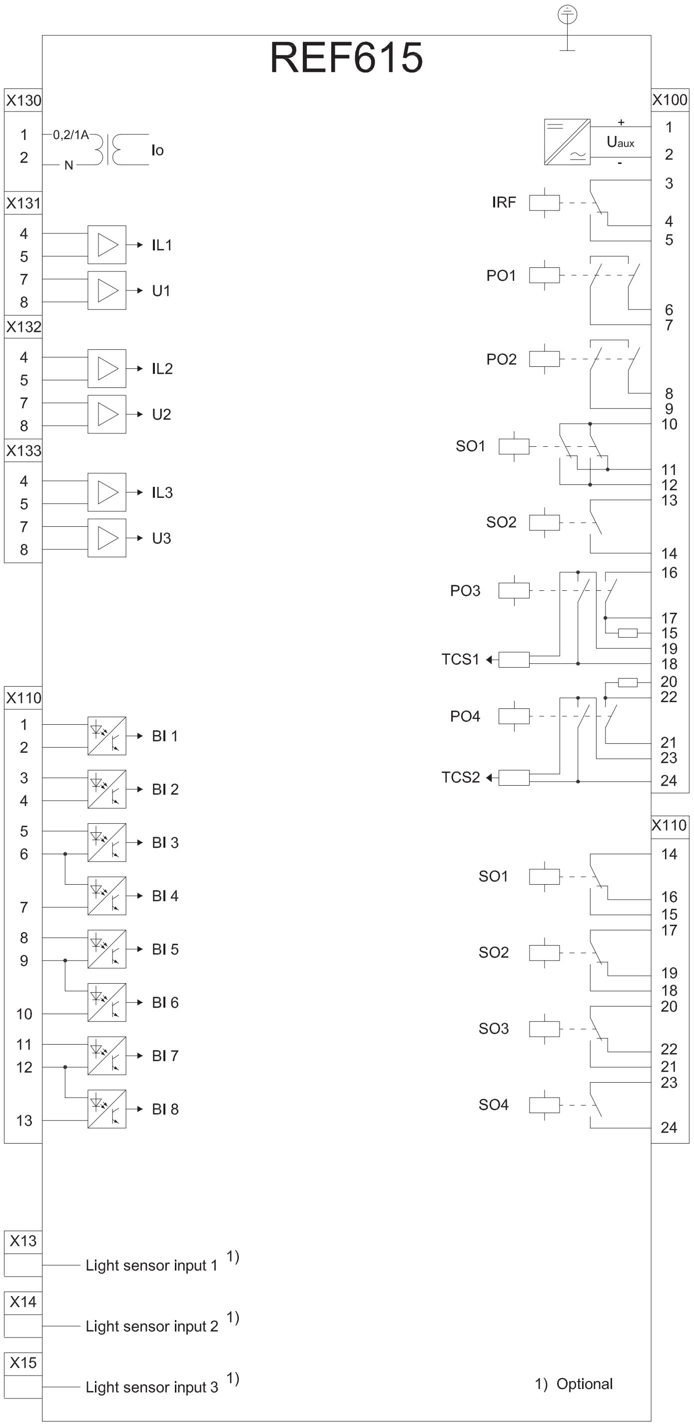


Figure 25. Terminal diagram of standard configuration G

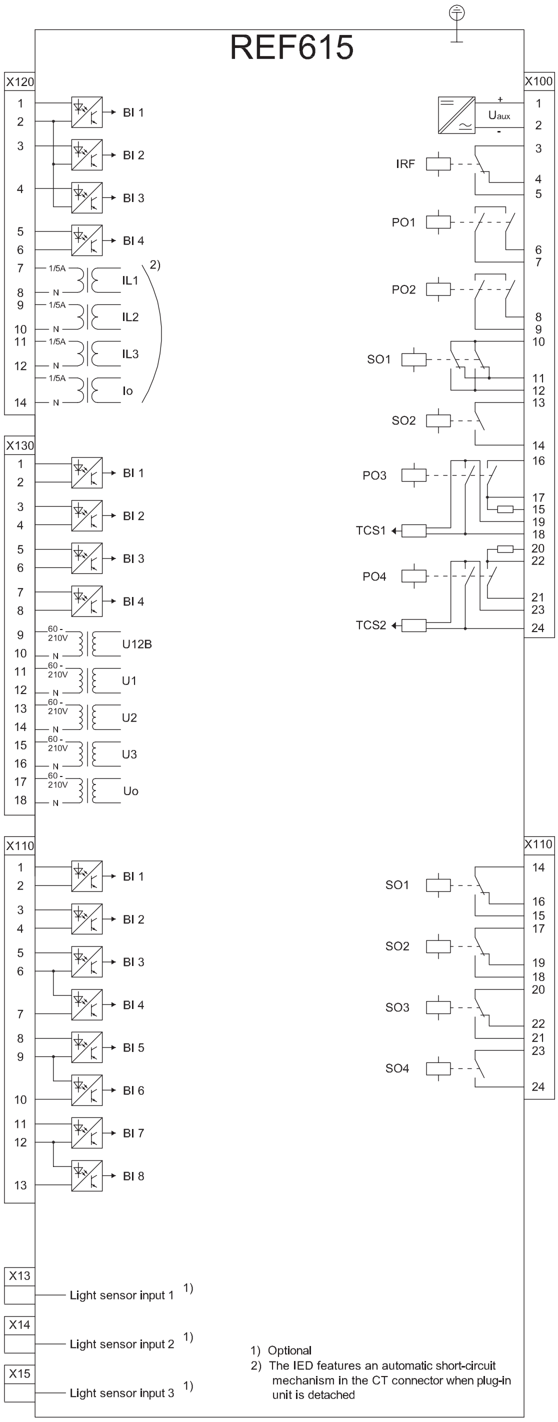


Figure 26. Terminal diagram of standard configurations H and J

27. Certificates

KEMA has issued an IEC 61850 Certificate Level A1 for Relion® 615 series. Certificate number: 30920420-Consulting 09-1712.

Det Norske Veritas (DNV) has issued a Type Approval Certificate for REF615. Certificate number: E-11189.

28. Inspection reports

KEMA has issued an Inspection report for REF615, "Comparison between hardwired and GOOSE performance of UniGear switchgear panels with REF615 and REF630 Feeder Protection and Control IEDs based on IEC 62271-3". Report number: 70972064-TDT 09-1398.

The Inspection report concludes in its summary, apart from the performance comparisons, that "both the REF630 and REF615 comply to the performance class P1 message type 1A "Trip" for distribution bays (transfer time <10 msec) as defined in IEC 61850-5".

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 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 manual, installation manual, operation manual, etc.

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

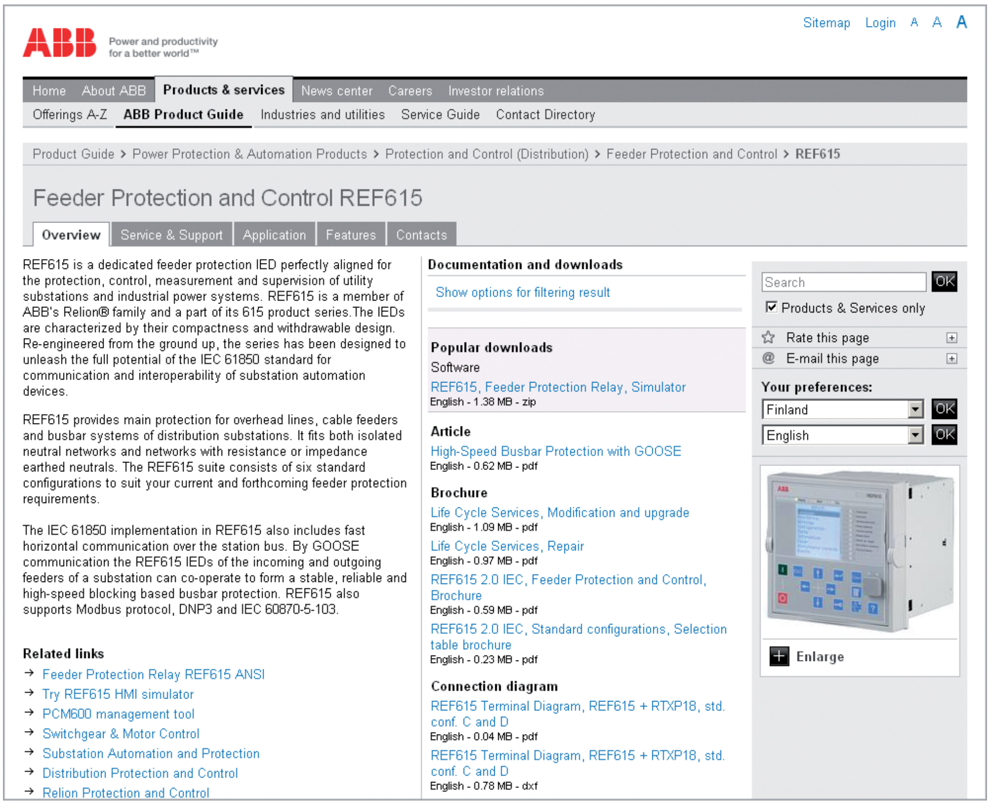


Figure 27. Product page

30. Functions, codes and symbols

Table 90. REF615 functions, codes and symbols

Function	IEC 61850	IEC 60617	IEC-ANSI
Protection			
Three-phase non-directional overcurrent protection, low stage	PHLPTOC1	3I> (1)	51P-1 (1)
Three-phase non-directional overcurrent protection, high stage	PHHPTOC1	3I>> (1)	51P-2 (1)
	PHHPTOC2	3I>> (2)	51P-2 (2)
Three-phase non-directional overcurrent protection, instantaneous stage	PHIPTOC1	3I>>> (1)	50P/51P (1)
Three-phase directional overcurrent protection, low stage	DPHLPDOC1	3I> -> (1)	67-1 (1)
	DPHLPDOC2	3I> -> (2)	67-1 (2)
Three-phase directional overcurrent protection, high stage	DPHHPDOC1	3I>> ->	67-2
Non-directional earth-fault protection, low stage	EFLPTOC1	Io> (1)	51N-1 (1)
	EFLPTOC2	Io> (2)	51N-1 (2)
Non-directional earth-fault protection, high stage	EFHPTOC1	Io>> (1)	51N-2 (1)
Non-directional earth-fault protection, instantaneous stage	EFIPTOC1	Io>>>	50N/51N
Directional earth-fault protection, low stage	DEFLPDEF1	Io> -> (1)	67N-1 (1)
	DEFLPDEF2	Io> -> (2)	67N-1 (2)
Directional earth-fault protection, high stage	DEFHPDEF1	Io>> ->	67N-2
Admittance based earth-fault protection	EFPADM1	Yo> -> (1)	21YN (1)
	EFPADM2	Yo> -> (2)	21YN (2)
	EFPADM3	Yo> -> (3)	21YN (3)
Wattmetric based earth-fault protection	WPWDE1	Po> -> (1)	32N (1)
	WPWDE2	Po> -> (2)	32N (2)
	WPWDE3	Po> -> (3)	32N (3)
Transient / intermittent earth-fault protection	INTRPTEF1	Io> -> IEF	67NIEF
Harmonics based earth-fault protection	HAEFPTOC1	Io>HA	51NHA
Non-directional (cross-country) earth fault protection, using calculated Io	EFHPTOC1	Io>> (1)	51N-2 (1)
Negative-sequence overcurrent protection	NSPTOC1	I2> (1)	46 (1)
	NSPTOC2	I2> (2)	46 (2)
Phase discontinuity protection	PDNSPTOC1	I2/I1>	46PD
Residual overvoltage protection	ROVPTOV1	Uo> (1)	59G (1)
	ROVPTOV2	Uo> (2)	59G (2)
	ROVPTOV3	Uo> (3)	59G (3)

Table 90. REF615 functions, codes and symbols, continued

Function	IEC 61850	IEC 60617	IEC-ANSI
Three-phase undervoltage protection	PHPTUV1	3U< (1)	27 (1)
	PHPTUV2	3U< (2)	27 (2)
	PHPTUV3	3U< (3)	27 (3)
Three-phase overvoltage protection	PHPTOV1	3U> (1)	59 (1)
	PHPTOV2	3U> (2)	59 (2)
	PHPTOV3	3U> (3)	59 (3)
Positive-sequence undervoltage protection	PSPTUV1	U1< (1)	47U+ (1)
Negative-sequence overvoltage protection	NSPTOV1	U2> (1)	47O- (1)
Frequency protection	FRPFRQ1	f>/f<,df/dt (1)	81 (1)
	FRPFRQ2	f>/f<,df/dt (2)	81 (2)
	FRPFRQ3	f>/f<,df/dt (3)	81 (3)
Three-phase thermal protection for feeders, cables and distribution transformers	T1PTTR1	3Ith>F	49F
Circuit breaker failure protection	CCBRBRF1	3I>/Io>BF	51BF/51NBF
Three-phase inrush detector	INRPHAR1	3I2f>	68
Master trip	TRPPTRC1	Master Trip (1)	94/86 (1)
	TRPPTRC2	Master Trip (2)	94/86 (2)
Arc protection	ARCSARC1	ARC (1)	50L/50NL (1)
	ARCSARC2	ARC (2)	50L/50NL (2)
	ARCSARC3	ARC (3)	50L/50NL (3)
Power quality			
Current total demand distortion	CMHAI1	PQM3I (1)	PQM3I (1)
Voltage total harmonic distortion	VMHAI1	PQM3U (1)	PQM3V (1)
Voltage variation	PHQVVR1	PQMU (1)	PQMV (1)
Control			
Circuit-breaker control	CBXCBR1	I <-> O CB	I <-> O CB
Disconnector control	DCXSWI1	I <-> O DCC (1)	I <-> O DCC (1)
	DCXSWI2	I <-> O DCC (2)	I <-> O DCC (2)
Earthing switch control	ESXSWI1	I <-> O ESC	I <-> O ESC
Disconnector position indication	DCSXSWI1	I <-> O DC (1)	I <-> O DC (1)
	DCSXSWI2	I <-> O DC (2)	I <-> O DC (2)
	DCSXSWI3	I <-> O DC (3)	I <-> O DC (3)
Earthing switch indication	ESSXSWI1	I <-> O ES (1)	I <-> O ES (1)
	ESSXSWI2	I <-> O ES (2)	I <-> O ES (2)
Auto-reclosing	DARREC1	O -> I	79

Table 90. REF615 functions, codes and symbols, continued

Function	IEC 61850	IEC 60617	IEC-ANSI
Synchronism and energizing check	SECRSYN1	SYNC	25
Condition monitoring			
Circuit-breaker condition monitoring	SSCBR1	CBCM	CBCM
Trip circuit supervision	TCSSCBR1	TCS (1)	TCM (1)
	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	CMMXU1	3I	3I
Sequence current measurement	CSMSQI1	I1, I2, I0	I1, I2, I0
Residual current measurement	RESCMMXU1	Io	In
Three-phase voltage measurement	VMMXU1	3U	3U
Residual voltage measurement	RESVMMXU1	Uo	Vn
Sequence voltage measurement	VSMSQI1	U1, U2, U0	U1, U2, U0
Three-phase power and energy measurement	PEMMXU1	P, E	P, E
Frequency measurement	FMMXU1	f	f

31. Document revision history

Document revision/date	Product version	History
A/2007-12-20	1.0	First release
B/2008-02-22	1.0	Content updated
C/2008-06-20	1.1	Content updated to correspond to the product version
D/2009-03-03	2.0	Content updated to correspond to the product version. New layout on front and back page
E/2009-07-03	2.0	Content updated
F/2009-10-01	2.0	Content updated
G/2010-06-11	3.0	Content updated to correspond to the product version
H/2010-06-29	3.0	Terminology updated
K/2010-09-07	3.0	Content updated
L/2012-05-11	4.0	Content updated to correspond to the product version

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