Relion® 620 series

Feeder Protection and Control
REF620
Product Guide

Power and productivity
for a better world™

Contents

1. Description

REF620 is a dedicated feeder IED perfectly aligned for the protection, control, measurement and supervision of utility and industrial power distribution systems, including radial, looped and meshed distribution networks. REF620 is a member of ABB's Relion® protection and control product family and its 620 series. The 620 series IEDs are characterized by their functional scalability and withdrawable-unit design. The 620 series has been designed to unleash the full potential of the IEC 61850 standard for communication and interoperability of substation automation devices.

2. Default configurations

The 620 series IEDs are configured with default configurations, which can be used as examples of the 620 series engineering with different function blocks. The default configurations are not aimed to be used as real end-user applications. The end-users always need to create their own application configuration with the configuration tool. However, the default configuration can be used as a starting point by modifying it according to the requirements.

REF620 is available in two alternative default configurations: configuration A with traditional current and voltage measurement transducers and configuration B with current and voltage sensors. The default configuration can be altered by means of the graphical signal matrix or the graphical application functionality of the Protection and Control IED Manager PCM600. Furthermore, 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.

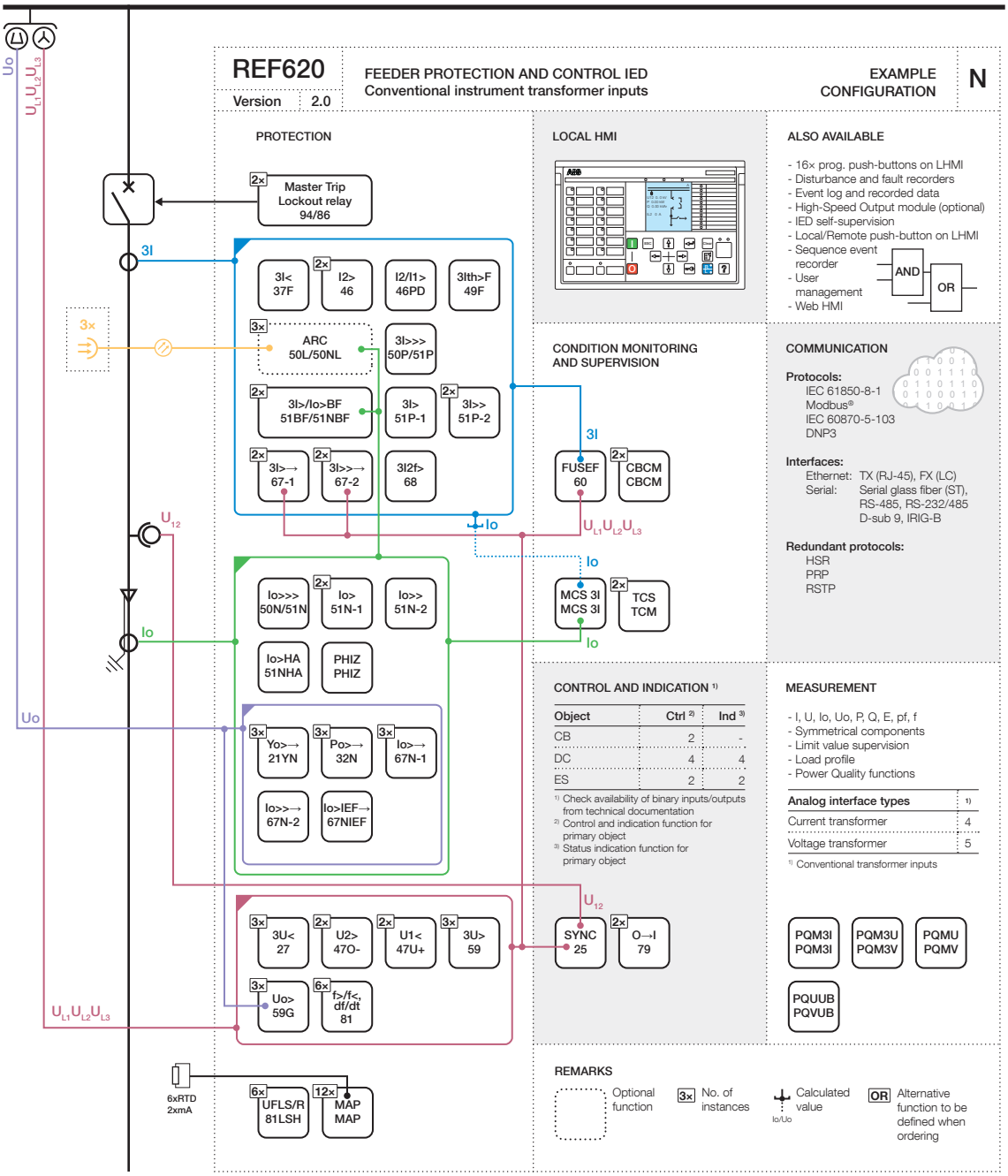

Figure 1. Functionality overview of conventional instrument transformer inputs

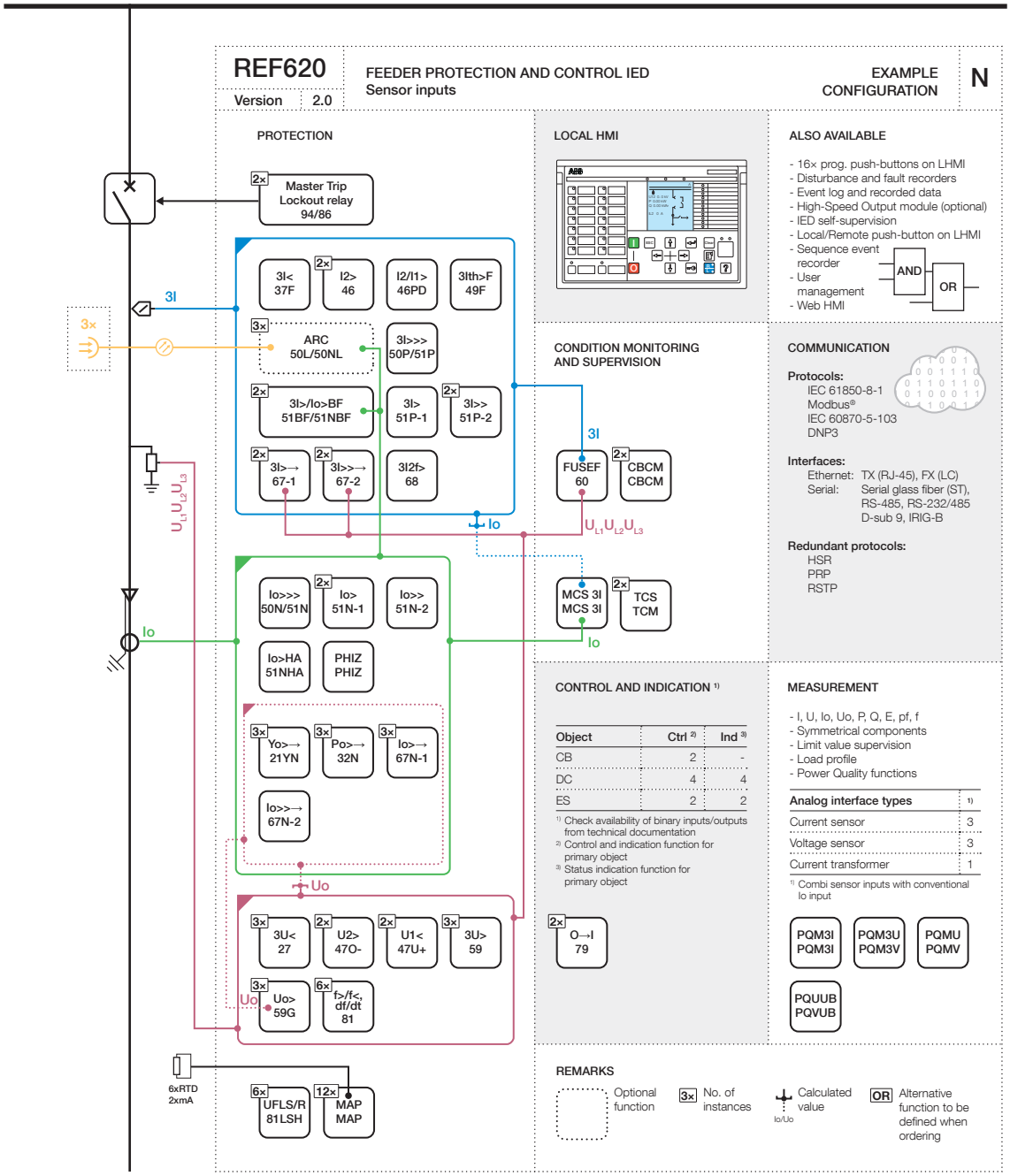

Figure 2. Functionality overview of sensor inputs

Table 1. Supported functions

Functionality	CTs & VTs	Sensors
Protection		
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, instance 1	●	●
Three-phase directional overcurrent protection, high stage, instance 2	●	●
Non-directional earth-fault protection, low stage, instance 1	●	●
Non-directional earth-fault protection, low stage, instance 2	●	●
Non-directional earth-fault protection, high stage, instance 1	●	●
Non-directional earth-fault protection, instantaneous stage, instance 1	●	●
Directional earth-fault protection, low stage, instance 1	●	●[1)]
Directional earth-fault protection, low stage, instance 2	●	●[1)]
Directional earth-fault protection, low stage, instance 3	●	●[1)]
Directional earth-fault protection, high stage, instance 1	●	●[1)]
Admittance based earth-fault protection, instance 1	●	●[1)]
Admittance based earth-fault protection, instance 2	●	●[1)]
Admittance based earth-fault protection, instance 3	●	●[1)]
Wattmetric based earth-fault protection, instance 1	●	●[1)]
Wattmetric based earth-fault protection, instance 2	●	●[1)]
Wattmetric based earth-fault protection, instance 3	●	●[1)]
Transient / intermittent earth-fault protection	●	-
Harmonics-based earth-fault protection	●	●
Negative-sequence overcurrent protection, instance 1	●	●
Negative-sequence overcurrent protection, instance 2	●	●
Phase discontinuity protection	●	●
Residual overvoltage protection, instance 1	●	●[1)]
Residual overvoltage protection, instance 2	●	●[1)]
Residual overvoltage protection, instance 3	●	●[1)]
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	●	●

Table 1. Supported functions, continued

Functionality	CTs & VTs	Sensors
Positive-sequence undervoltage protection, instance 1	●	●
Positive-sequence undervoltage protection, instance 2	●	●
Negative-sequence overvoltage protection, instance 1	●	●
Negative-sequence overvoltage protection, instance 2	●	●
Frequency protection, instance 1	●	●
Frequency protection, instance 2	●	●
Frequency protection, instance 3	●	●
Frequency protection, instance 4	●	●
Frequency protection, instance 5	●	●
Frequency protection, instance 6	●	●
Three-phase thermal protection for feeders, cables and distribution transformers	●	●
Loss of phase (undercurrent)	●	●
Circuit breaker failure protection, instance 1	●	●
Circuit breaker failure protection, instance 2	●	●
Three-phase inrush detector	●	●
Master trip, instance 1	●	●
Master trip, instance 2	●	●
Arc protection, instance 1	○	○
Arc protection, instance 2	○	○
Arc protection, instance 3	○	○
High-impedance fault detection	●	●
Multipurpose analog protection, instance 1	●	●
Multipurpose analog protection, instance 2	●	●
Multipurpose analog protection, instance 3	●	●
Multipurpose analog protection, instance 4	●	●
Multipurpose analog protection, instance 5	●	●
Multipurpose analog protection, instance 6	●	●
Multipurpose analog protection, instance 7	●	●
Multipurpose analog protection, instance 8	●	●
Multipurpose analog protection, instance 9	●	●
Multipurpose analog protection, instance 10	●	●
Multipurpose analog protection, instance 11	●	●
Multipurpose analog protection, instance 12	●	●
Control		
Circuit-breaker control, instance 1	●	●
Circuit-breaker control, instance 2	●	●
Disconnector control, instance 1	●	●
Disconnector control, instance 2	●	●

Table 1. Supported functions, continued

Functionality	CTs & VTs	Sensors
Earthing switch control, instance 1	•	•
Disconnector control, instance 3	•	•
Disconnector control, instance 4	•	•
Earthing switch control, instance 2	•	•
Disconnector position indication, instance 1	•	•
Disconnector position indication, instance 2	•	•
Earthing switch position indication, instance 1	•	•
Disconnector position indication, instance 3	•	•
Disconnector position indication, instance 4	•	•
Earthing switch position indication, instance 2	•	•
Auto-reclosing, instance 1	•	•
Auto-reclosing, instance 2	•	•
Synchronism and energizing check, instance 1	•	-
Load shedding and restoration, instance 1	•	•
Load shedding and restoration, instance 2	•	•
Load shedding and restoration, instance 3	•	•
Load shedding and restoration, instance 4	•	•
Load shedding and restoration, instance 5	•	•
Load shedding and restoration, instance 6	•	•
Condition monitoring		
Circuit-breaker condition monitoring, instance 1	•	•
Circuit-breaker condition monitoring, instance 2	•	•
Trip circuit supervision, instance 1	•	•
Trip circuit supervision, instance 2	•	•
Current circuit supervision	•	•
Fuse failure supervision	•	•
Measurement		
Three-phase current measurement	•	•
Sequence current measurement	•	•
Residual current measurement	•	•
Three-phase voltage measurement	•	•
Residual voltage measurement	•	-
Sequence voltage measurement	•	•
Three-phase power and energy measurement	•	•
Frequency measurement	•	•
Power quality		
Current total demand distortion	•	•
Voltage total harmonic distortion	•	•

Table 1. Supported functions, continued

Functionality	CTs & VTs	Sensors
Voltage variation	•	•
Voltage unbalance	•	•
Other		
Minimum pulse timer (2 pcs), instance 1	•	•
Minimum pulse timer (2 pcs), instance 2	•	•
Minimum pulse timer (2 pcs), instance 3	•	•
Minimum pulse timer (2 pcs), instance 4	•	•
Minimum pulse timer (2 pcs, second resolution), instance 1	•	•
Minimum pulse timer (2 pcs, second resolution), instance 2	•	•
Minimum pulse timer (2 pcs, minute resolution), instance 1	•	•
Minimum pulse timer (2 pcs, minute resolution), instance 2	•	•
Pulse timer (8 pcs), instance 1	•	•
Pulse timer (8 pcs), instance 2	•	•
Time delay off (8 pcs), instance 1	•	•
Time delay off (8 pcs), instance 2	•	•
Time delay off (8 pcs), instance 3	•	•
Time delay off (8 pcs), instance 4	•	•
Time delay on (8 pcs), instance 1	•	•
Time delay on (8 pcs), instance 2	•	•
Time delay on (8 pcs), instance 3	•	•
Time delay on (8 pcs), instance 4	•	•
Set reset (8 pcs), instance 1	•	•
Set reset (8 pcs), instance 2	•	•
Set reset (8 pcs), instance 3	•	•
Set reset (8 pcs), instance 4	•	•
Move (8 pcs), instance 1	•	•
Move (8 pcs), instance 2	•	•
Move (8 pcs), instance 3	•	•
Move (8 pcs), instance 4	•	•
Generic control points, instance 1	•	•
Generic control points, instance 2	•	•
Generic control points, instance 3	•	•
Remote generic control points	•	•
Local generic control points	•	•
Generic up-down counters, instance 1	•	•
Generic up-down counters, instance 2	•	•
Generic up-down counters, instance 3	•	•
Generic up-down counters, instance 4	•	•

Table 1. Supported functions, continued

Functionality	CTs & VTs	Sensors
Generic up-down counters, instance 5	•	•
Generic up-down counters, instance 6	•	•
Generic up-down counters, instance 7	•	•
Generic up-down counters, instance 8	•	•
Generic up-down counters, instance 9	•	•
Generic up-down counters, instance 10	•	•
Generic up-down counters, instance 11	•	•
Generic up-down counters, instance 12	•	•
Programmable buttons (16 buttons)	•	•
Logging functions		
Disturbance recorder	•	•
Fault recorder	•	•
Sequence event recorder	•	•
Load profile	•	•

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

1) The function is to be used with calculated Uo only

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. Admittance-based, harmonics-based or wattmetric-based earth-fault protection can be used in addition to directional earth-fault protection. Furthermore, 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 protection and negative-sequence overvoltage protection. The IED offers frequency protection, including overfrequency, underfrequency and frequency rate-of-change protection. The IED also incorporates three-pole multi-shot autoreclosing functions for overhead line feeders.

Enhanced with optional hardware and software, the IED also features three light detection point-to-point lens sensors 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. Optional high speed outputs help to minimize the arc impacts.

4. Application

REF620 provides feeder overcurrent and earth-fault protection for utility and industry distribution networks. REF620 fits both isolated neutral networks and networks with resistance- or impedance-earthed neutrals. Furthermore, using the IED's advanced inter-station communication facilities, REF620 can also be applied for protecting ring-type and meshed distribution networks as well as radial networks.

REF620 can be used with either single- or double-busbar configurations with either one or two breakers, and with numerous switching device configurations. It supports a substantial number of both manually and motor-operated disconnectors and earthing switches, and it is capable of running large configurations. The number of controllable devices depends on the number of inputs and outputs left free from other application needs. The number of available I/Os can be increased with the RIO600 Remote I/O device.

REF620 offers extensive possibilities to tailor the configurations to application requirements. The tool suite for all Relion IEDs is Protection and control IED manager PCM600, which contains all the necessary tools for configuring the device, including functionality, parameterization, the HMI and communication.

REF620 is an ideal IED for more advanced feeder schemes. ABB's continuous investments in research and a close cooperation with customers have resulted in the best earth-

fault protection portfolio on the market. To further improve the arc fault protection and minimize the effects of an arc fault, the 620 series IEDs ordered with the arc fault protection option can be equipped with an I/O card featuring high-speed outputs operating in one millisecond.

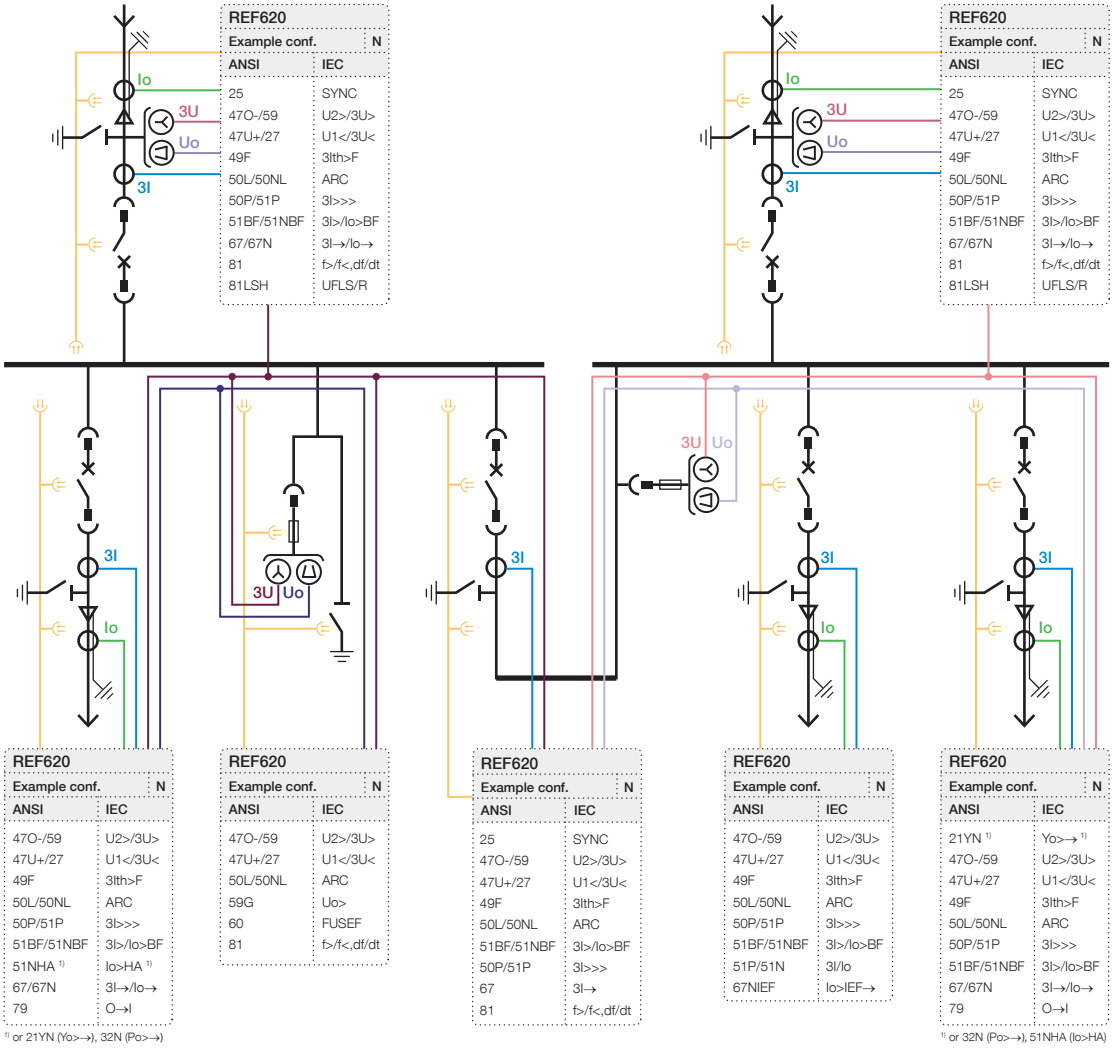

Figure 3. Single busbar AIS 2 section switchgear with conventional instrument transformers

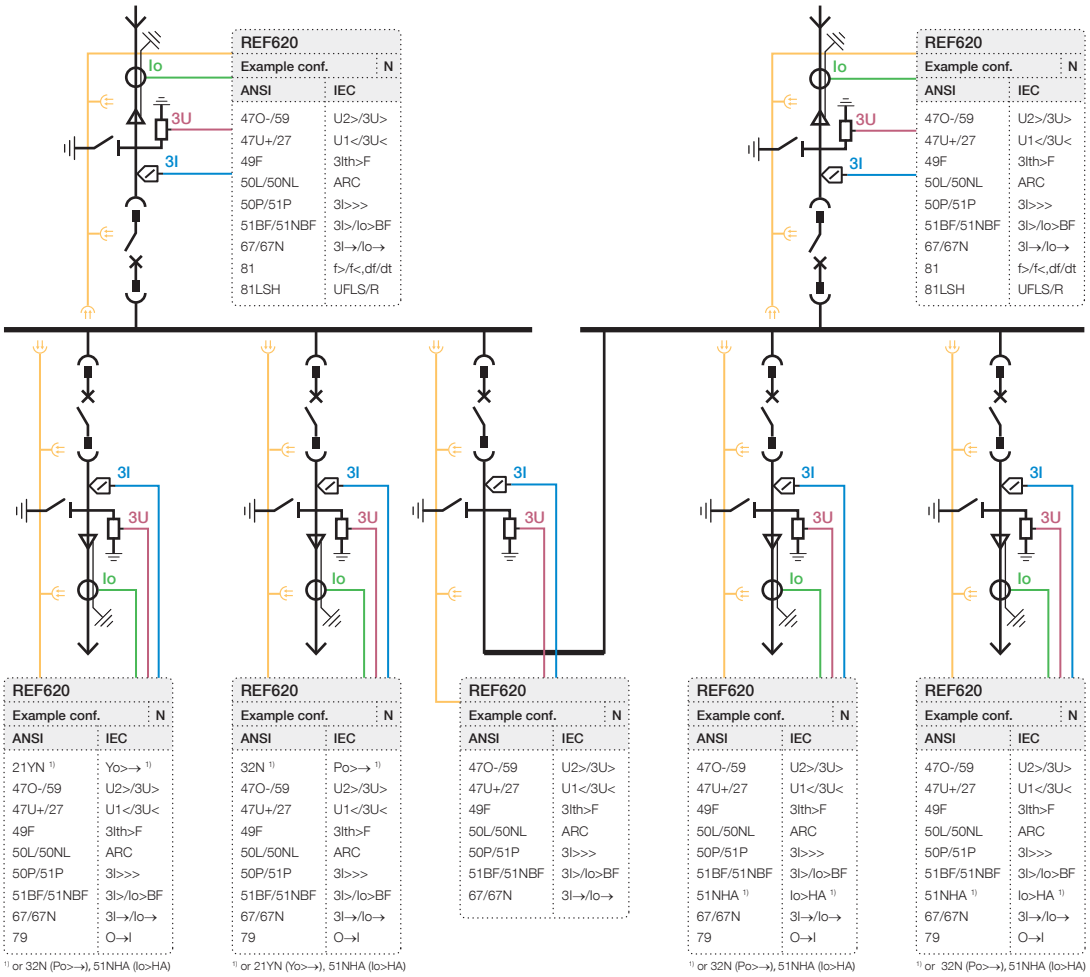

Figure 4. Single busbar AIS switchgear 2 section with sensors

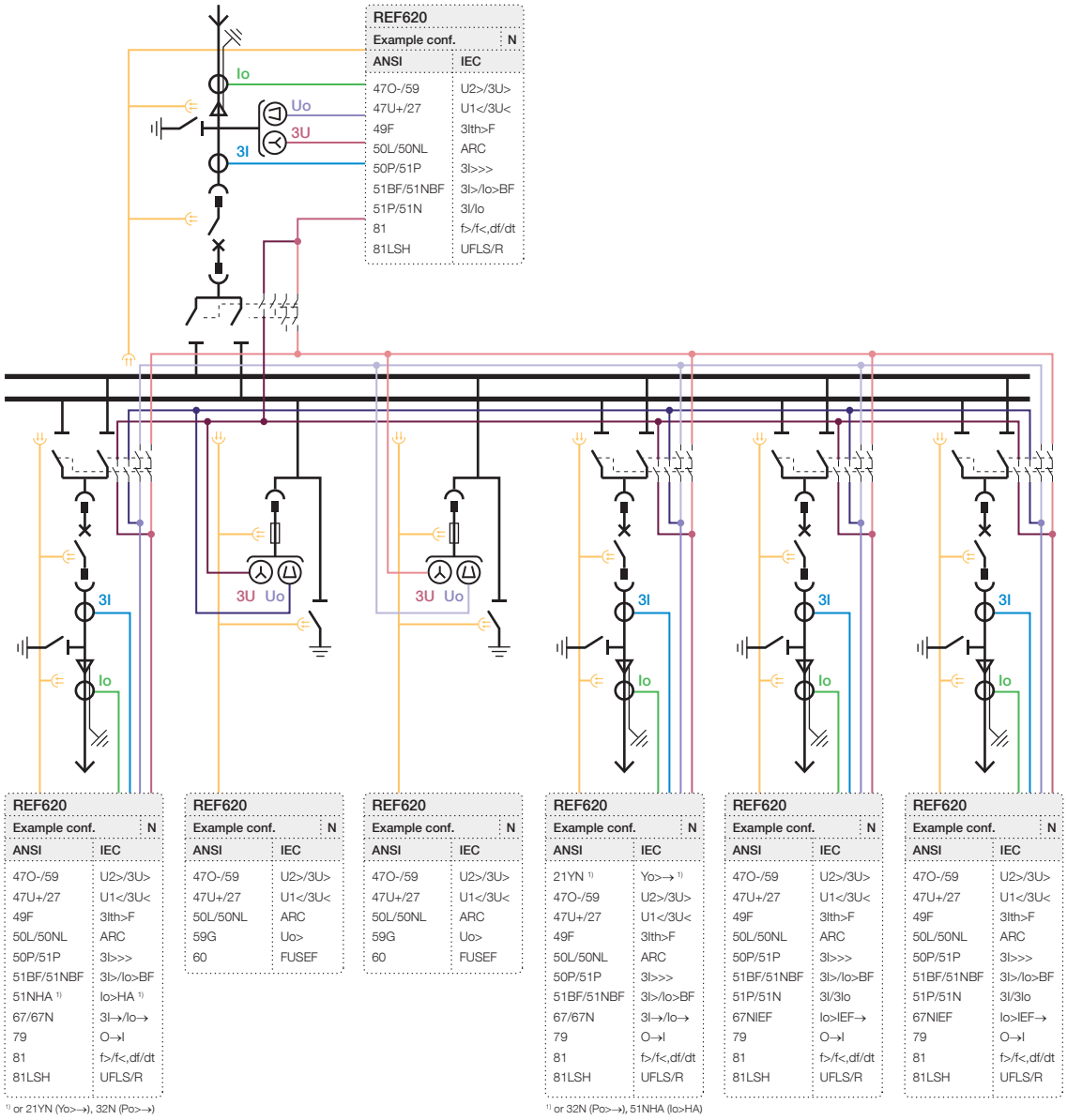

Figure 5. DBB AIS system with one incomer only (with some arrangements simplified)

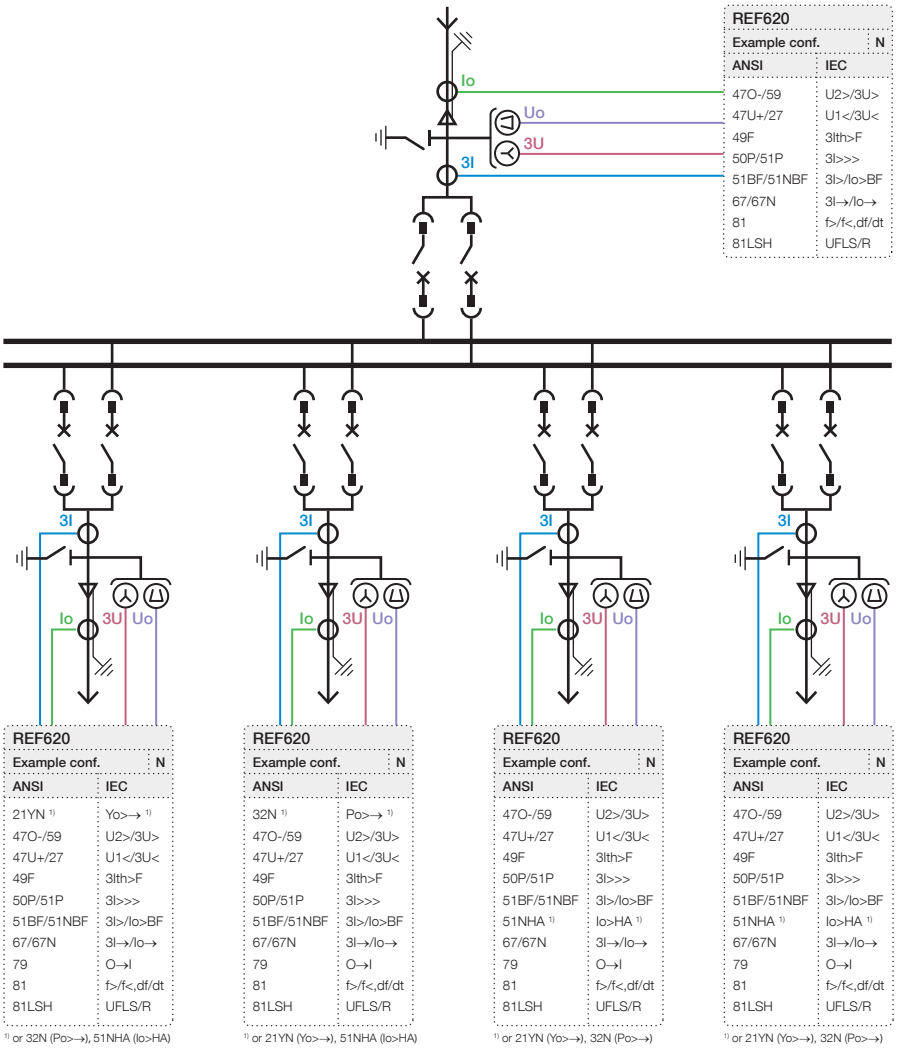

Figure 6. Back-to-back arrangement of AIS switchgear (two single-busbar panels with back walls facing each other), with two circuit breakers and a higher number of disconnectors available. A type of DBB system.

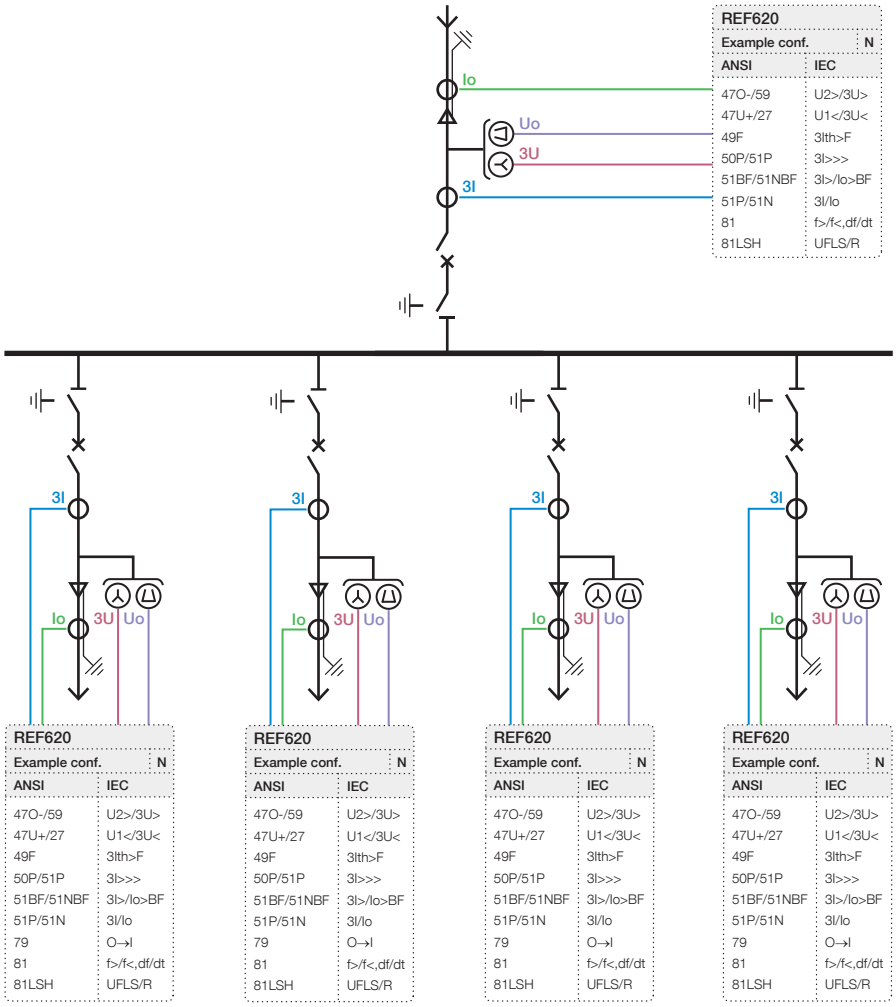

Figure 7. SBB GIS switchgear with the possibility to control the three-position disconnector switch

5. Supported ABB solutions

ABB's 620 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 620 series IEDs offer native support for the IEC 61850 standard also including binary and analog horizontal GOOSE messaging. Compared to 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. Furthermore, 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 2. Supported ABB solutions

Product	Version
Grid Automation controller COM600	4.0 or later
MicroSCADA Pro SYS 600	9.3 FP2 or later
System 800xA	5.1 or later

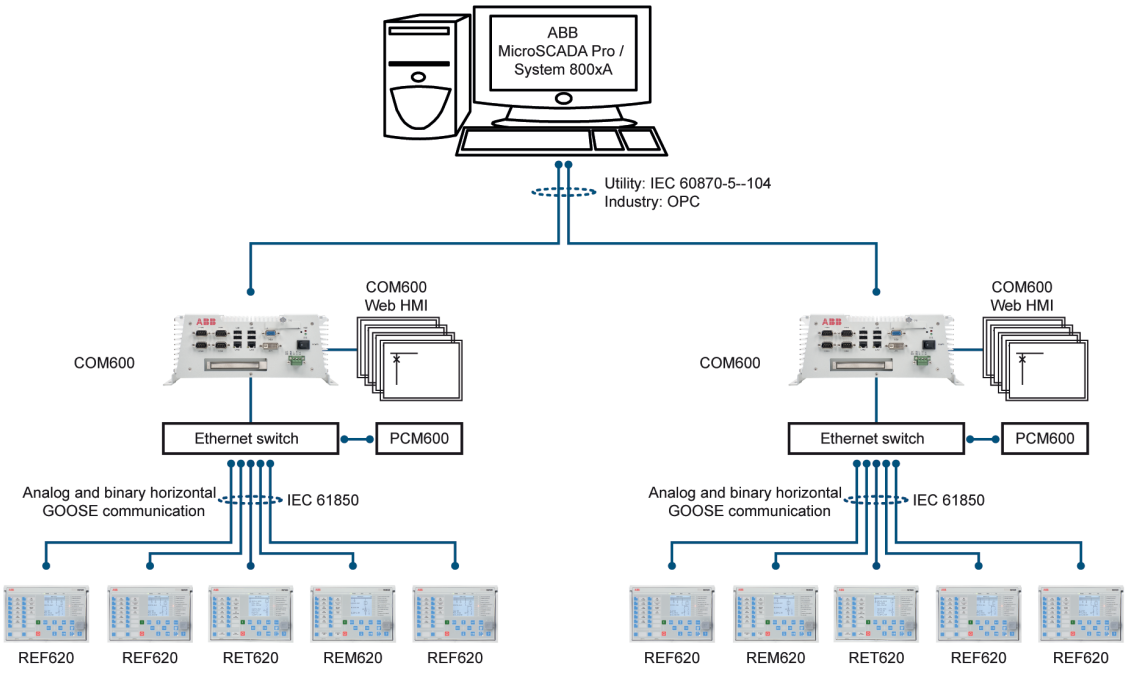

Figure 8. Industrial power system example using 620 series IEDs, Grid Automation controller COM600 and System 800xA

6. Control

REF620 integrates functionality for the control of circuit breakers, disconnectors and earth switches via the front panel HMI or by means of remote controls. The IED includes two circuit breaker control blocks. In addition to the circuit breaker control, the IED features four disconnector control blocks intended for the motor-operated control of disconnectors or circuit breaker truck. Furthermore, the IED offers two control blocks intended for the motor-operated control of earthing switch. On top of that, the IED includes additional four disconnector position indication blocks and two earth switch position indication blocks usable with manually-only controlled disconnectors and earth switches.

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 hardware configuration of the IED, the number of binary inputs and binary outputs varies. In case the amount of available binary inputs or outputs of the chosen hardware configuration is not sufficient, connecting an external input or output module, for

example RIO600, to the IED can extend binary inputs and outputs utilizable in the IED configuration. 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.

The suitability of the binary outputs of the IED which have been selected for the 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 be considered.

The 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 tools in PCM600.

Default configuration A incorporates a synchrocheck function to ensure that the voltage, phase angle and frequency on either side of an open circuit breaker satisfy the conditions for a safe interconnection of two networks. An autoreclosing function attempts to restore the power by reclosing the breaker with one to five programmable autoreclosing shots of desired type and duration. The function can be used with every circuit breaker that has the ability for a reclosing sequence. A load-shedding function is capable of performing load shedding based on underfrequency and the rate of change of the frequency.

7. Measurement

The IED continuously measures the phase currents and the neutral current. Furthermore, the IED measures the phase voltages and the residual voltage. In addition, the IED calculates the symmetrical components of the currents and voltages, the system frequency, the active and reactive power, the power factor, the active and reactive energy values as well as the demand value of current and power over a user-selectable preset time frame. Calculated values are also obtained from the protections and condition monitoring functions of the IED.

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. Power quality

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

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

REF620 has the following power quality monitoring functions.

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

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

The voltage and current harmonics functions provide a method for monitoring the power quality by means of the current waveform distortion and voltage waveform distortion. The functions provides a short-term 3-second average and a long-term demand for total demand distortion TDD and total harmonic distortion THD.

9. 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 voltages measured.

The analog channels can be set to trigger the recording function when the measured value falls below or exceeds the set values. The binary signal channels can be set to start a recording 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 nonvolatile memory and can be uploaded for subsequent fault analysis.

10. 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.

11. 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. The available measurement modes include DFT, RMS and peak-to-peak. Fault records store IED measurement values at the moment when any protection function starts. Both Min. and Max. current demand values are recorded with time stamp. Also both Min. and Max. power demand values (P, Q, S) are recorded with time stamp. By default, the records are stored in a nonvolatile memory.

Furthermore, the IED includes a load profile recorder capable of storing measurement values into the IED's memory. The selected measurement values averaged over the selected period, ranging from one minute to three hours, are stored in a nonvolatile memory. Depending on the selected measurements and averaging period, the overall length of the load profile recording ranges from some days to several months, even a year, making this feature suitable for monitoring long-time load behavior for the interested loads.

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.

14. Fuse failure supervision

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

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

REF620 can be selected to measure currents and voltages either with conventional current transducers and voltage transducers or with current sensors and voltage sensors. The IED variant with conventional transducers is equipped with three phase current inputs, one residual-current input, three phase voltage inputs, one residual-voltage input and one phase-to-phase voltage for syncrocheck input. In addition to current and voltage measurements, the IED's basic configuration includes 24 binary inputs and 14 binary outputs. The phase current inputs and the residual-current inputs are rated 1/5 A, that is, the inputs allow the connection of either 1 A or 5 A secondary current transformers. The optional sensitive residual-current input 0.2/1 A 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 IED variant equipped with current and voltage sensors has three sensor inputs for the direct connection of three combisensors with RJ-45 connectors. As an alternative to the combisensors, separate current and voltage sensors can be utilized using adapters. Furthermore, the adapters also enable the use of sensors with Twin-BNC connectors. Additionally, the IED includes one conventional residual-current input 0.2/1 A normally used in applications requiring sensitive earth-fault protection and featuring core balance current transformers. In

addition to current and voltage measurements, the IED basic configuration includes 16 binary inputs and 14 binary outputs.

As an optional addition, the IED basic configuration includes one empty slot which can be equipped with one of the following optional modules. The first option, additional binary inputs and outputs module, adds eight binary inputs and four binary outputs to the IED. This option is especially needed when connecting the IED to several controllable objects, still leaving room for additional inputs and outputs for other signals needed in configuration. The second option, an additional RTD/mA input module, increases the IED with six RTD inputs and two mA inputs when additional sensor measurements e.g. for temperatures, pressures, levels and so on are of interest. The third option is a high-speed output board including eight binary inputs and three high-speed outputs. The high-speed outputs have a shorter activation time compared to the conventional mechanical output relays, shortening the overall IED operation time with very time-critical applications like arc protection. The high-speed outputs are freely configurable in the IED application and not limited to arc protection only.

The rated values of the current and voltage inputs are settable parameters of the IED. In addition, the binary input thresholds are selectable within the range of 18…176 V DC by adjusting the IED's parameter settings.

All binary input and output contacts are freely configurable with the Signal Matrix or Application Configuration tool of PCM600.

See the Input/output overview table and the terminal diagrams for detailed information about the inputs and outputs.

If the number of the IED's own inputs and outputs does not cover all the intended purposes, connecting to an external input or output module, for example RIO600, increases the number of binary inputs and outputs utilizable in the IED configuration. In this case, the external inputs and outputs are connected to the IED via IEC 61850 GOOSE to reach fast reaction times between the IED and RIO600 information. The needed binary input and output connections between the IED and RIO600 units can be configured in a PCM600 tool and then utilized in the IED configuration.

Table 3. Input/output overview table

Conf.	Analog channels				Binary channels	
	CT	VT	Combi sensor	RTD/mA	BI	BO
A	4	5	-	-	24(32)[1)]	14(18)[1)]
				-	24(32)[2)]	14(17)[2)]
				(6/2)[3)]	24	14
B	1	-	3[4)]	-	16(24)[1)]	14(18)[1)]
				-	16(24)[2)]	14(17)[2)]
				(6/2)[3)]	16	14

1) With optional BIO0005 module
2) With optional BIO0007 module
3) With optional RTD0003 module
4) Combi sensor inputs for three-phase currents and voltages

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 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 exchange signals with other IEDs using the IEC 61860 protocol.

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. The IED also 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 redundant Ethernet solution, the IED offers a fibre-optic communication module providing two optical and one galvanic Ethernet network interfaces. Alternatively, the IED features a galvanic communication module with two galvanic and one optical Ethernet network interfaces or three galvanic interfaces. The third Ethernet interface provides connectivity for any other Ethernet devices to an IEC 61850 station bus inside in a switchgear bay. The redundant solution can be applied to the Ethernet-based IEC 61850, Modbus and DNP3 protocols.

Ethernet network redundancy can be achieved using the high-availability seamless redundancy (HSR) protocol or the parallel redundancy protocol (PRP) or a with self-healing ring using RSTP in managed switches. Ethernet redundancy can be applied to all Ethernet-based IEC 61850, Modbus and DNP3 protocols.

The IEC 61850 standard specifies network redundancy which improves the system availability for the substation communication. The network redundancy is based on two complementary protocols defined in the IEC 62439-3 standard: PRP and HSR protocols. Both the protocols are able to overcome a failure of a link or switch with a zero switch-over time. In both the protocols, each network node has two identical Ethernet ports dedicated for one network connection. The protocols rely on the duplication of all transmitted information and provide a zero switch-over time if the links or switches fail, thus fulfilling all the stringent real-time requirements of substation automation.

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

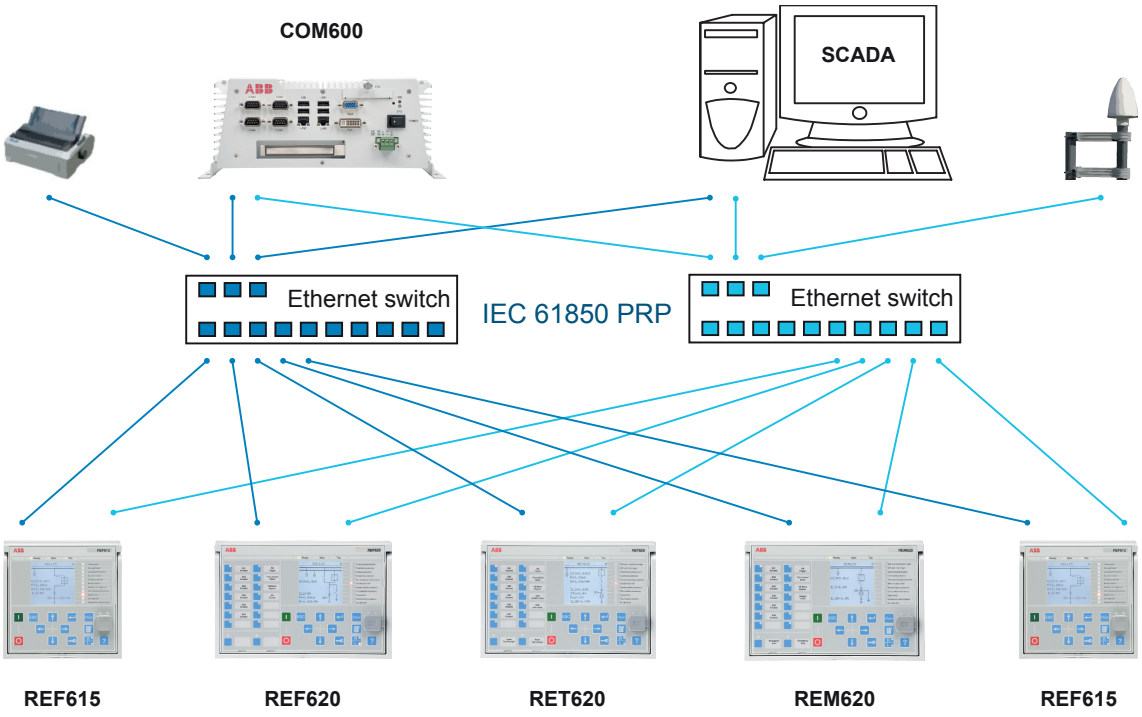

Figure 9. Parallel redundancy protocol (PRP) solution

HSR applies the PRP principle of parallel operation to a single ring. For each message sent, the node sends two frames, one through each port. Both the frames circulate in opposite directions over the ring. Every node forwards the frames it receives from one port to another to reach the next node. When the originating sender node receives the frame it sent, the sender node discards the frame to avoid loops. The HSR ring with 620 series IEDs supports the connection of up to thirty IEDs. If more than 30 IEDs are to be connected, it is recommended to split the network into several rings to guarantee the performance for real-time applications.

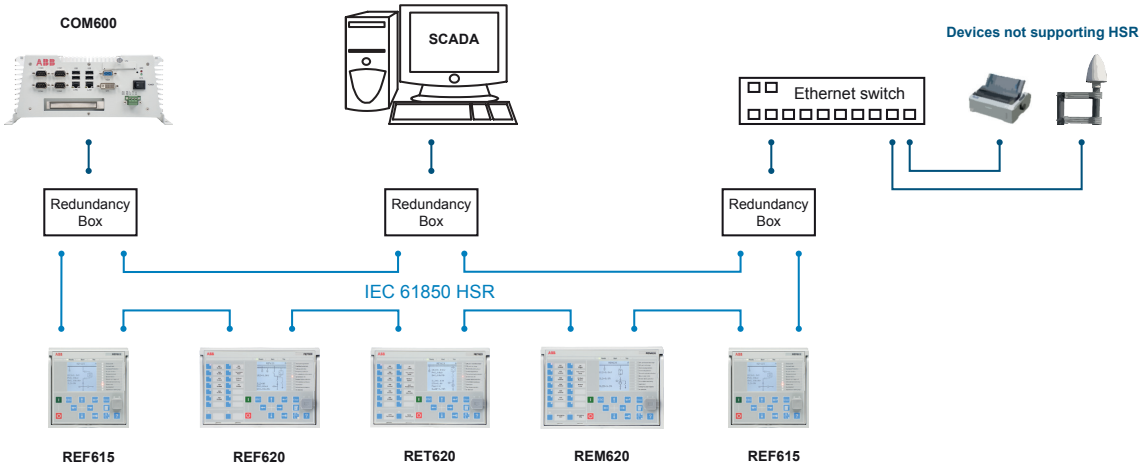

Figure 10. High availability seamless redundancy (HSR) solution

The choice between the HSR and PRP redundancy protocols depends on the required functionality, cost and complexity.

The self-healing Ethernet ring solution enables a cost-efficient communication ring controlled by a managed switch with standard Rapid Spanning Tree I Protocol (RSTP) support. The managed switch controls the consistency of the loop, routes the data and corrects the data flow in case of a communication switch-over. 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 620 series IEDs. If more than 30 IEDs are to be connected, it is recommended to split the network into several rings. The self-healing Ethernet ring solution avoids single point of failure concerns and improves the reliability of the communication.

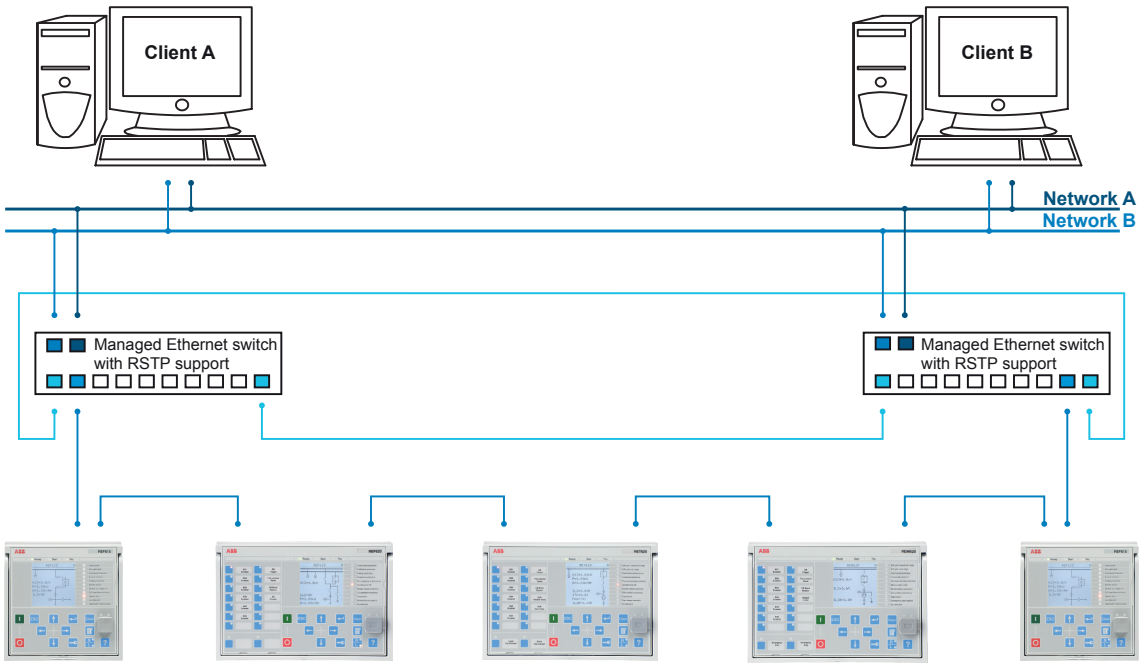

Figure 11. Self-healing Ethernet ring solution

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. Further, IEC 60870-5-103 can be used at the same time with the IEC 61850 protocol.

DNP3 supports both serial and TCP modes for connection to one master. Further, changing of the active setting group is supported. DNP3 can also be used at the same time with the IEC 61850 protocol.

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

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

Ethernet-based:
- SNTP (Simple Network Time Protocol)

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

In addition, the IED supports time synchronization via the following serial communication protocols:
- Modbus
- DNP3
- IEC 60870-5-103

Table 4. 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 5. Dimensions

Description	Value	
Width	Frame	262.2 mm
	Case	246 mm
Height	Frame	177 mm, 4U
	Case	160 mm
Depth		201 mm
Weight	Complete IED	max. 5.0 kg
	Plug-in unit only	max. 2.9 kg

Table 6. 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)/<19.0 W (max) AC <13.0 W (nominal)/<21.0 W (max)	DC <12.0 W (nominal)/<19.0 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 7. 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	4 A	20 A
	• For 1 s	100 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	240 V AC	
	• For 10 s	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 8. Energizing inputs (sensors)

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 9. Binary inputs

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

Table 10. RTD/mA measurement

Description		Value	
RTD inputs	Supported RTD sensors	100 Ω platinum 250 Ω platinum 100 Ω nickel 120 Ω nickel 250 Ω nickel 10 Ω copper	TCR 0.00385 (DIN 43760) TCR 0.00385 TCR 0.00618 (DIN 43760) TCR 0.00618 TCR 0.00618 TCR 0.00427
	Supported resistance range	0...2 kΩ	
	Maximum lead resistance (three-wire measurement)	25 Ω per lead	
	Isolation	2 kV (inputs to protective earth)	
	Response time	<4 s	
	RTD/resistance sensing current	Maximum 0.33 mA rms	
	Operation accuracy	Resistance	Temperature
		± 2.0% or ±1 Ω	±1°C 10 Ω copper: ±2°C
mA inputs	Supported current range	0…20 mA	
	Current input impedance	44 Ω ± 0.1%	
	Operation accuracy	±0.5% or ±0.01 mA	

Table 11. Signal output with high make and carry

Description	Value [1]
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

1) X100: SO1
X105: SO1, SO2, when any of the IEDs is equipped with BIO0005.
X110: SO1, SO2 when REF620 or RET620 is equipped with BIO0005
X115: SO1, SO2 when REF620 or REM620 is equipped with BIO0005

Table 12. Signal outputs and IRF output

Description	Value [1]
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

1) X100: IRF,SO2
X105: SO3, SO4, when any of the IEDs is equipped with BIO0005
X110: SO3, SO4, when REF620 or RET620 is equipped with BIO0005
X115:SO3, SO4, when REF620 or REM620 is equipped with BIO0005

Table 13. Double-pole power outputs with TCS function X100: PO3 and PO4

Description	Value [1]
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 monitoring (TCS):	
• Control voltage range	20...250 V AC/DC
• Current drain through the monitoring circuit	~1.5 mA
• Minimum voltage over the TCS contact	20 V AC/DC (15...20 V)

1) PSM0003: PO3, PSM0004: PO3, PSM0003: PO4 and PSM0004: PO4.

Table 14. Signal/trip output with high make and carry and with TCS function

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, at 48/110/220 V DC (two contacts connected in series)	1A/0.25A/0.15A
Minimum contact load	100 mA at 24 V AC/DC

Table 15. Single-pole power output relays X100: PO1 and PO2

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	5 A/3 A/1 A
Minimum contact load	100 mA at 24 V AC/DC

Table 16. High-speed output HSO

Description	Value [1)]
Rated voltage	250 V AC/DC
Continuous contact carry	6 A
Make and carry for 3.0 s	15 A
Make and carry for 0.5 s	30 A
Breaking capacity when the control-circuit time constant L/R < 40 ms, at 48/110/220 V DC	5 A/3 A/1 A
Start	1 ms
Reset	20 ms, resistive load

1) X105: HSO1, HSO2 HSO3, when any of the IEDs is equipped with BIO0007

Table 17. 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 18. 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 19. 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 20. 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 21. Degree of protection of flush-mounted IED

Description	Value
Front side	IP 54

Table 22. 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 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	
Voltage dips and short interruptions:	30%/10 ms 60%/100 ms 60%/1000 ms >95%/5000 ms	IEC 61000-4-11

Table 23. Electromagnetic compatibility tests, continued

Description	Type test value	Reference
Conducted common mode disturbances:	15 Hz...150 kHz Test level 3 (10/1/10 V rms)	IEC 61000-4-16
Emission tests: • Conducted 0.15-0.50 MHz 0.5-30 MHz • Radiated 30-230 MHz 230-1000 MHz	 < 79 dB(µV) quasi peak < 66 dB(µV) average < 73 dB(µV) quasi peak < 60 dB(µV) average < 40 dB(µV/m) quasi peak, measured at 10 m distance < 47 dB(µV/m) quasi peak, measured at 10 m distance	EN 55011, class A IEC 60255-25

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 MΏ, 500 V DC	IEC 60255-5 and IEC 60255-27
Protective bonding resistance	<0.1 Ώ, 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. 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 27. Product safety

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

Table 28. EMC compliance

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

Table 29. RoHS compliance

Description
Complies with RoHS directive 2002/95/EC

Protection functions

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

Characteristic		Value		
Operation accuracy		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
	PHIPTOC: 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 31. 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, see Operation characteristics table

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

Characteristic		Value		
Operation accuracy	DPHLPDOC	Depending on the frequency of the current/voltage measured: f_n ±2 Hz		
		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*	38 ms	43 ms	46 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 33. 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 34. 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 35. 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, see Operation characteristics table

Table 36. 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 37. 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 38. 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 x 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 39. Admittance-based earth-fault protection (EFPADM) main settings

Parameter	Function	Value (Range)	Step
Voltage start value	EFPADM	0.01...2.00 xUn	0.01
Directional mode	EFPADM	1=Non-directional 2=Forward 3=Reverse	
Operation mode	EFPADM	1=Yo 2=Go 3=Bo 4=Yo, Go 5=Yo, Bo 6=Go, Bo 7=Yo, Go, Bo	
Operate delay time	EFPADM	60...200000 ms	10
Circle radius	EFPADM	0.05...500.00 mS	0.01
Circle conductance	EFPADM	-500.00...500.00 mS	0.01
Circle susceptance	EFPADM	-500.00...500.00 mS	0.01
Conductance forward	EFPADM	-500.00...500.00 mS	0.01
Conductance reverse	EFPADM	-500.00...500.00 mS	0.01
Conductance tilt Ang	EFPADM	-30...30 deg	1
Susceptance forward	EFPADM	-500.00...500.00 mS	0.01
Susceptance reverse	EFPADM	-500.00...500.00 mS	0.01
Susceptance tilt Ang	EFPADM	-30...30 deg	1

Table 40. 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 41. Wattmetric based earth-fault protection (WPWDE) main settings

Parameter	Function	Value (Range)	Step
Directional mode	WPWDE	2=Forward 3=Reverse	
Current start value	WPWDE	0.010...5.000 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 42. 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 43. 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 44. 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 45. HAEFPTOC main settings

Parameter	Function	Value (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 46. 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*	22 ms	24 ms	25 ms
	I_{Fault} = 10 x set *Start value*	14 ms	16 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 47. 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, see Operation characteristics table

Table 48. 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 49. 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 50. 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 51. 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 52. 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)]	U_{Fault} = 0.9 x set *Start value*	Minimum	Typical	Maximum
		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 53. 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, see Operation characteristics table

Table 54. 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 55. 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, see Operation characteristics table

Table 56. 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 57. 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 58. 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 59. 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 60. 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 61. Frequency protection (FRPFRQ) main settings

Parameter	Function	Value (Range)	Step
Operation mode	FRPFRQ	1=Freq< 2=Freq> 3=df/dt 4=Freq< + df/dt 5=Freq> + df/dt 6=Freq< OR df/dt 7=Freq> OR df/dt	
Start value Freq>	FRPFRQ	0.9000...1.2000 xFn	0.0001
Start value Freq<	FRPFRQ	0.8000...1.1000 xFn	0.0001
Start value df/dt	FRPFRQ	-0.200...0.200 xFn /s	0.005
Operate Tm Freq	FRPFRQ	80...200000 ms	10
Operate Tm df/dt	FRPFRQ	120...200000 ms	10

Table 62. 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 63. 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 64. Phase undercurrent protection (PHPTUC)

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

Table 65. Phase undercurrent protection (PHPTUC) main settings

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

Table 66. 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
Retardation time	< 20 ms

Table 67. 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 68. 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 69. 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 70. 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)]	12 ms[3)] 7 ms[4)]	14 ms[3)] 8 ms[4)]	16 ms[3)] 11 ms[4)]
	Operation mode = "Light only"[2)]	9 ms[3)] 4 ms[4)]	10 ms[3)] 6 ms[4)]	12 ms[3)] 6 ms[4)]
Reset time		< 40 ms[3)] < 55 ms[4)]		
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
3) Normal power output
4) High-speed output

Table 71. 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 72. High impedance fault detection (PHIZ) main settings

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

Table 73. Operation characteristics

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

Control functions

Table 74. Autoreclosing (DARREC)

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

Table 75. 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 76. Synchronism and energizing check (SECRSYN) main settings

Parameter	Function	Value (Range)	Step
Live dead mode	SECRSYN	-1=Off 1=Both Dead 2=Live L, Dead B 3=Dead L, Live B 4=Dead Bus, L Any 5=Dead L, Bus Any 6=One Live, Dead 7=Not Both Live	
Difference voltage	SECRSYN	0.01...0.50 xUn	0.01
Difference frequency	SECRSYN	0.001...0.100 xFn	0.001
Difference angle	SECRSYN	5...90 deg	1
Synchrocheck mode	SECRSYN	1=Off 2=Synchronous 3=Asynchronous	
Control mode	SECRSYN	1=Continuous 2=Command	
Dead line value	SECRSYN	0.1...0.8 xUn	0.1
Live line value	SECRSYN	0.2...1.0 xUn	0.1
Close pulse	SECRSYN	200...60000 ms	10
Max energizing V	SECRSYN	0.50...1.15 xUn	0.01
Phase shift	SECRSYN	-180...180 deg	1
Minimum Syn time	SECRSYN	0...60000 ms	10
Maximum Syn time	SECRSYN	100...6000000 ms	10
Energizing time	SECRSYN	100...60000 ms	10
Closing time of CB	SECRSYN	40...250 ms	10

Table 77. Load shedding (LSHDPFRQ)

Characteristic		Value
Operation accuracy	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<	< 80 ms
	df/dt	< 120 ms
Reset time		< 150 ms
Operate time accuracy		±1.0% of the set value or ±30 ms

Table 78. Load shedding (LSHDPFRQ) main settings

Parameter	Function	Value (Range)	Step
Load shed mode	LSHDPFRQ	Freq< Freq< AND df/dt Freq< OR df/dt	-
Restore mode	LSHDPFRQ	Disabled Auto Manual	-
Start value Freq	LSHDPFRQ	0.800...1.200 x Fn	0.001
Start value df/dt	LSHDPFRQ	-0.200...-0.005 x Fn	0.005
Operate Tm Freq	LSHDPFRQ	80...200000 ms	10
Operate Tm df/dt	LSHDPFRQ	120...200000 ms	10
Restore start Val	LSHDPFRQ	0.800...1.200 x Fn	0.001
Restore delay time	LSHDPFRQ	80...200000 ms	10

Measurement functions

Table 79. 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 80. 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 81. 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 82. 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 83. 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 84. 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 85. 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 86. Frequency measurement (FMMXU)

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

Supervision functions

Table 87. Current circuit supervision (CCRDIF)

Characteristic	Value
Operate time[1)]	< 30 ms

1) Including the delay of the output contact

Table 88. Current circuit supervision (CCRDIF) main settings

Parameter	Function	Value (Range)	Step
Start value	CCRDIF	0.05...0.20 x I_n	0.01
Maximum operate current	CCRDIF	1.00...5.00 x I_n	0.01

Table 89. 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 supports process information and status monitoring from the IED's local HMI via its display and indication/alarm LEDs. The local LHMI also enables control operations for the equipment connected and controlled by the IED, either via display or via manual push buttons available on the local HMI.

LCD display offers front-panel user interface functionality with menu navigation and menu views. In addition, the display includes a user-configurable two-page single-line diagram (SLD) with a position indication for the associated primary equipment and primary measurements from the process. The SLD can be modified according to user requirements by using Graphical Display Editor in PCM600.

The local HMI also includes 11 programmable LEDs. These LEDs can be configured to show alarms and indications as needed by PCM600 graphical configuration tool. The LEDs include two separately controllable colors, red and green, making one LED able to indicate better the different states of the monitored object.

The IED also includes 16 configurable manual push buttons, which can freely be configured by the PCM600 graphical configuration tool. These buttons can be configured to control the IED's internal features e.g. changing setting group, trigger disturbance recordings and changing operation modes for functions or to control IED external equipment, e.g. opening or closing the equipment, via IED binary outputs. These buttons also include a small indication LED for each button. This LED is freely configurable, making it possible to use push button LEDs to indicate button activities or as additional indication/alarm LEDs in addition to the 11 programmable LEDs.

The local HMI includes a push button (L/R) for the 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 remotely. 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 the IEDs are in the local mode during maintenance work and that the circuit breakers cannot be operated remotely from the network control center.

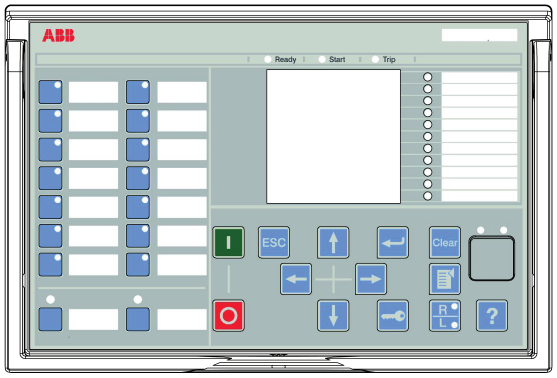

Figure 12. Example of the LHMI

21. Mounting methods

By means of appropriate mounting accessories, the standard IED case for the 620 series IED can be flush-mounted, semi-flush-mounted or wall-mounted.

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

Mounting methods:

- Flush mounting
- Semi-flush mounting
- Rack mounting
- Wall mounting
- Mounting to a 19" equipment frame

Panel cut-out for flush mounting:

- Height: 162 ± 1 mm
- Width: 248 ± 1 mm

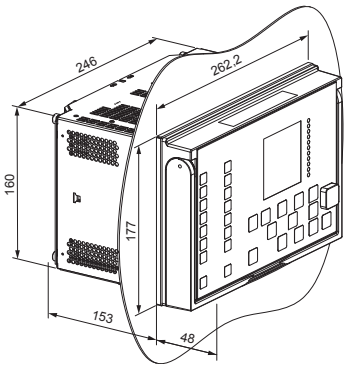

Figure 13. Flush mounting

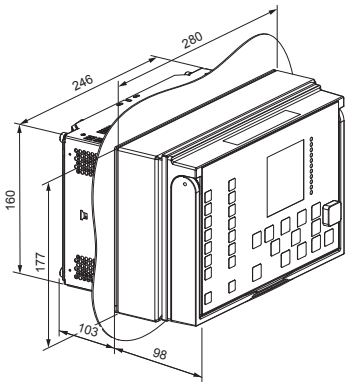

Figure 14. Semi-flush mounting

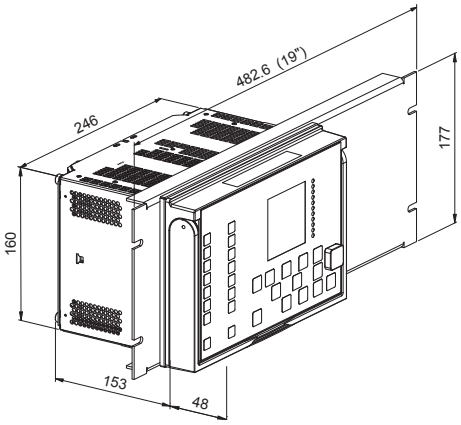

Figure 15. Rack mounting

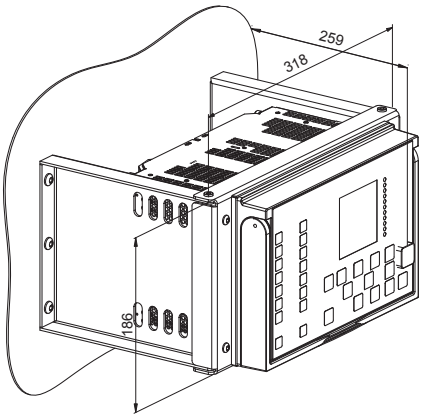

Figure 16. Wall mounting

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.

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

#	Description	
1	**IED**	
	620 series IED (including case)	N
2	**Standard**	
	IEC	B
	CN	C
3	**Main application**	
	Feeder protection and control	F
4	**Functional application**	
	Example configuration	N
5-6	**Analog inputs and outputs**	
	4I (I_0 1/5 A) + 5U + 24BI + 14BO	AA
	4I (I_0 0,2/1 A) + 5U + 24BI + 14BO	AB
	Sensors (3I + 3U) + 1CT + 16BI + 14BO	AC
7-8	**Optional board**	
	Optional I/Os 8BI+ 4BO	AA
	Optional RTDs 6RTD in + 2mA in	AB
	Optional Fast I/Os 8BI + 3HSO	AC
	No optional board	NN
9 - 10	**Communication modules (Serial)**	
	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) + Serial RS-485 connector, RS-232/485 D-Sub 9 connector + 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) with HSR/PRP	BD
	Serial glass fibre (ST) + Ethernet 100Base-TX and -FX (2 x RJ-45 + 1 x LC) with HSR/PRP	BC
	Serial glass fibre (ST) + Ethernet 100Base-TX and -FX (1 x RJ-45 + 2 x LC) with HSR/PRP	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) with HSR/PRP	NC
	Ethernet 100Base-TX (3 x RJ-45) with HSR/PRP	ND
	Ethernet 100Base-TX and -FX (1 x RJ-45 + 2 x LC) with HSR/PRP	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.

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

#	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
	IEC 61850 + IEC 60870-5-103(for serial + Ethernet communication modules)	G
	IEC 61850 + DNP3(for Ethernet or serial + Ethernet communication modules)	H
12	**Language**	
	English	1
	English and Chinese	2
13	**Front panel**	
	Large LCD with Single Line Diagram - IEC	B
	Large LCD with Single Line Diagram - CN	D
14	**Option 1**	
	Arc protection (requires a communication module, cannot be combined with communication module options BN or BB)	B
	None	N
15	**Option 2**	
	None	N
16	**Power supply**	
	Power supply 48-250 VDC, 100-240 VAC	1
	Power supply 24-60 VDC	2
17 - 18	**Reserved**	
	Product version 2.0	XF

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

Your ordering code:

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

Figure 17. Ordering key for complete IEDs

24. Accessories and ordering data

Table 90. 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 91. Mounting accessories

Item	Order number
Semi-flush mounting kit	2RCA030573A0001
Wall mounting kit	2RCA030894A0001
19" Mounting panel kit	2RCA031135A0001

25. Tools

The IED is delivered as a pre-configured unit including the example configuration. 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 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. Furthermore, the Connectivity Packages for the 620 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 it enables multiple updates of the additional HMI language, thus offering flexible means for possible future language updates.

Table 92. Tools

Configuration and setting tools	Version
PCM600	2.5 or later
Web-browser based user interface	IE 7.0, IE 8.0 or IE 9.0
REF620 Connectivity Package	2.0

Table 93. Supported functions

Function	WebHMI	PCM600
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	●	-
Online monitoring	-	●

● = Supported

26. Connection diagrams

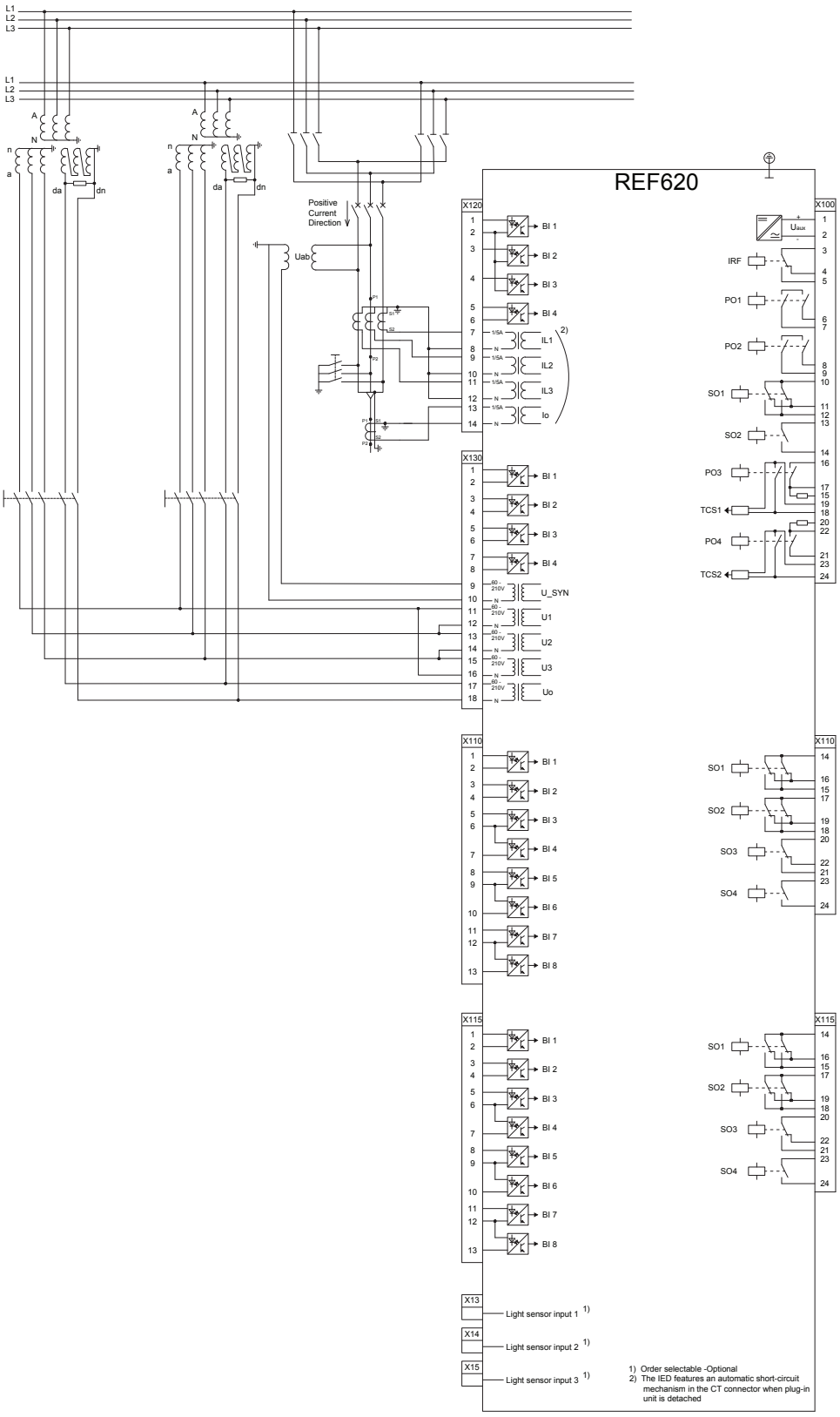

Figure 18. Connection diagram for the configuration with CTs and VTs

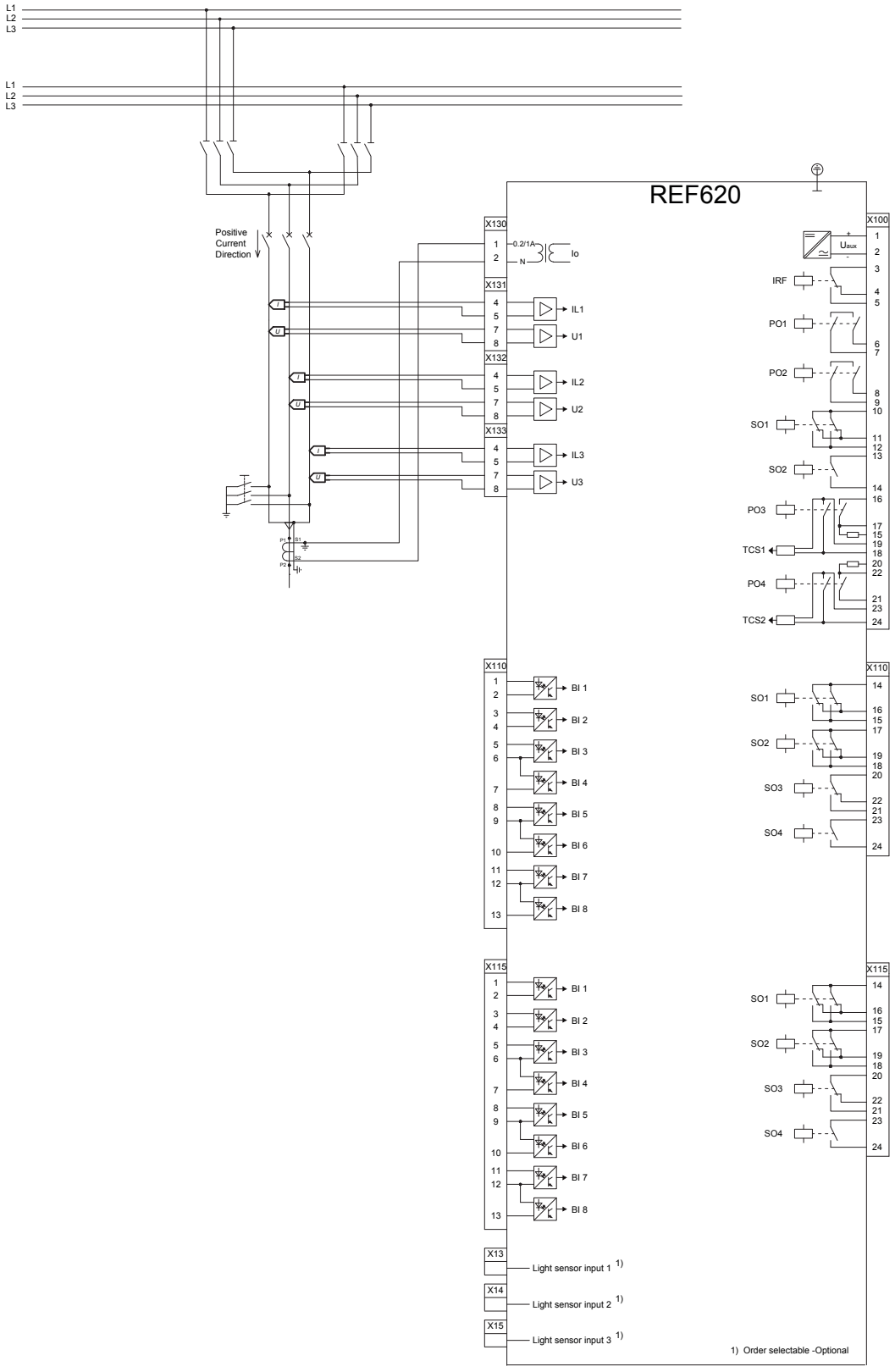

Figure 19. Connection diagram for the configuration with sensors

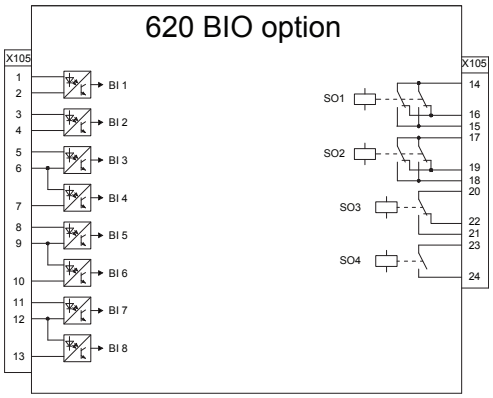

Figure 20. Optional BIO0005 module (slot X105)

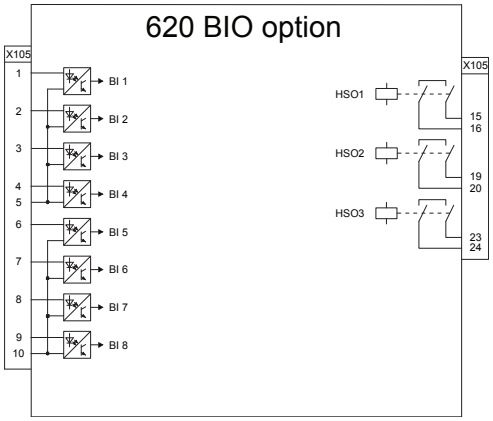

Figure 21. Optional BIO0007 module for fast outputs (slot X105)

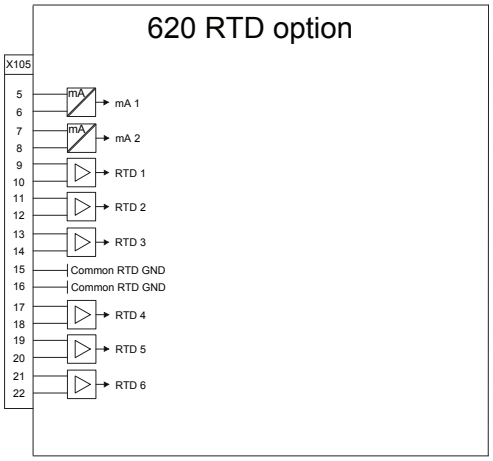

Figure 22. Optional RTD0003 module (slot X105)

27. 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 620 series is based on the same technology as the 615 series, and it has been verified to include the same excellent IEC 61850 performance as the 615 and 630 series.

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”.

28. References

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

You will find the latest relevant information on the REF620 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.

29. Functions, codes and symbols

Table 94. REF620 functions, codes and symbols

Function	IEC 61850	IEC 60617	IEC-ANSI
Protection			
Three-phase non-directional overcurrent protection, low stage, instance 1	PHLPTOC1	3I> (1)	51P-1 (1)
Three-phase non-directional overcurrent protection, high stage, instance 1	PHHPTOC1	3I>> (1)	51P-2 (1)
Three-phase non-directional overcurrent protection, high stage, instance 2	PHHPTOC2	3I>> (2)	51P-2 (2)
Three-phase non-directional overcurrent protection, instantaneous stage, instance 1	PHIPTOC1	3I>>> (1)	50P/51P (1)
Three-phase directional overcurrent protection, low stage, instance 1	DPHLPDOC1	3I> -> (1)	67-1 (1)
Three-phase directional overcurrent protection, low stage, instance 2	DPHLPDOC2	3I> -> (2)	67-1 (2)
Three-phase directional overcurrent protection, high stage, instance 1	DPHHPDOC1	3I>> -> (1)	67-2 (1)
Three-phase directional overcurrent protection, high stage, instance 2	DPHHPDOC2	3I>> -> (2)	67-2 (2)
Non-directional earth-fault protection, low stage, instance 1	EFLPTOC1	Io> (1)	51N-1 (1)
Non-directional earth-fault protection, low stage, instance 2	EFLPTOC2	Io> (2)	51N-1 (2)
Non-directional earth-fault protection, high stage, instance 1	EFHPTOC1	Io>> (1)	51N-2 (1)
Non-directional earth-fault protection, instantaneous stage, instance 1	EFIPTOC1	Io>>> (1)	50N/51N (1)
Directional earth-fault protection, low stage, instance 1	DEFLPDEF1	Io> -> (1)	67N-1 (1)
Directional earth-fault protection, low stage, instance 2	DEFLPDEF2	Io> -> (2)	67N-1 (2)
Directional earth-fault protection, low stage, instance 3	DEFLPDEF3	Io> -> (3)	67N-1 (3)
Directional earth-fault protection, high stage	DEFHPDEF1	Io>> -> (1)	67N-2 (1)
Admittance based earth-fault protection, instance 1	EFPADM1	Yo> -> (1)	21YN (1)
Admittance based earth-fault protection, instance 2	EFPADM2	Yo> -> (2)	21YN (2)
Admittance based earth-fault protection, instance 3	EFPADM3	Yo> -> (3)	21YN (3)
Wattmetric based earth-fault protection, instance 1	WPWDE1	Po> -> (1)	32N (1)
Wattmetric based earth-fault protection, instance 2	WPWDE2	Po> -> (2)	32N (2)
Wattmetric based earth-fault protection, instance 3	WPWDE3	Po> -> (3)	32N (3)
Transient / intermittent earth-fault protection	INTRPTEF1	Io> -> IEF (1)	67NIEF (1)
Harmonics based earth-fault protection	HAEFPTOC1	Io>HA (1)	51NHA (1)
Negative-sequence overcurrent protection, instance 1	NSPTOC1	I2> (1)	46 (1)
Negative-sequence overcurrent protection, instance 2	NSPTOC2	I2> (2)	46 (2)
Phase discontinuity protection	PDNSPTOC1	I2/I1> (1)	46PD (1)
Residual overvoltage protection, instance 1	ROVPTOV1	Uo> (1)	59G (1)

Table 94. REF620 functions, codes and symbols, continued

Function	IEC 61850	IEC 60617	IEC-ANSI
Residual overvoltage protection, instance 2	ROVPTOV2	Uo> (2)	59G (2)
Residual overvoltage protection, instance 3	ROVPTOV3	Uo> (3)	59G (3)
Three-phase undervoltage protection, instance 1	PHPTUV1	3U< (1)	27 (1)
Three-phase undervoltage protection, instance 2	PHPTUV2	3U< (2)	27 (2)
Three-phase undervoltage protection, instance 3	PHPTUV3	3U< (3)	27 (3)
Three-phase overvoltage protection, instance 1	PHPTOV1	3U> (1)	59 (1)
Three-phase overvoltage protection, instance 2	PHPTOV2	3U> (2)	59 (2)
Three-phase overvoltage protection, instance 3	PHPTOV3	3U> (3)	59 (3)
Positive-sequence undervoltage protection, instance 1	PSPTUV1	U1< (1)	47U+ (1)
Positive-sequence undervoltage protection, instance 2	PSPTUV2	U1< (2)	47U+ (2)
Negative-sequence overvoltage protection, instance 1	NSPTOV1	U2> (1)	47O- (1)
Negative-sequence overvoltage protection, instance 2	NSPTOV2	U2> (2)	47O- (2)
Frequency protection, instance 1	FRPFRQ1	f>/f<,df/dt (1)	81 (1)
Frequency protection, instance 2	FRPFRQ2	f>/f<,df/dt (2)	81 (2)
Frequency protection, instance 3	FRPFRQ3	f>/f<,df/dt (3)	81 (3)
Frequency protection, instance 4	FRPFRQ4	f>/f<,df/dt (4)	81 (4)
Frequency protection, instance 5	FRPFRQ5	f>/f<,df/dt (5)	81 (5)
Frequency protection, instance 6	FRPFRQ6	f>/f<,df/dt (6)	81 (6)
Three-phase thermal protection for feeders, cables and distribution transformers	T1PTTR1	3Ith>F (1)	49F (1)
Loss of phase (undercurrent), instance 1	PHPTUC1	3I< (1)	37F (1)
Circuit breaker failure protection, instance 1	CCBRBRF1	3I>/Io>BF (1)	51BF/51NBF (1)
Circuit breaker failure protection, instance 2	CCBRBRF2	3I>/Io>BF (2)	51BF/51NBF (2)
Three-phase inrush detector	INRPHAR1	3I2f> (1)	68 (1)
Master trip, instance 1	TRPPTRC1	Master Trip (1)	94/86 (1)
Master trip, instance 2	TRPPTRC2	Master Trip (2)	94/86 (2)
Arc protection, instance 1	ARCSARC1	ARC (1)	50L/50NL (1)
Arc protection, instance 2	ARCSARC2	ARC (2)	50L/50NL (2)
Arc protection, instance 3	ARCSARC3	ARC (3)	50L/50NL (3)
High impedance fault detection	PHIZ1	PHIZ (1)	PHIZ (1)
Multipurpose analog protection, instance 1	MAPGAPC1	MAP (1)	MAP (1)
Multipurpose analog protection, instance 2	MAPGAPC2	MAP (2)	MAP (2)
Multipurpose analog protection, instance 3	MAPGAPC3	MAP (3)	MAP (3)
Multipurpose analog protection, instance 4	MAPGAPC4	MAP (4)	MAP (4)
Multipurpose analog protection, instance 5	MAPGAPC5	MAP (5)	MAP (5)
Multipurpose analog protection, instance 6	MAPGAPC6	MAP (6)	MAP (6)
Multipurpose analog protection, instance 7	MAPGAPC7	MAP (7)	MAP (7)
Multipurpose analog protection, instance 8	MAPGAPC8	MAP (8)	MAP (8)

Table 94. REF620 functions, codes and symbols, continued

Function	IEC 61850	IEC 60617	IEC-ANSI
Multipurpose analog protection, instance 9	MAPGAPC9	MAP (9)	MAP (9)
Multipurpose analog protection, instance 10	MAPGAPC10	MAP (10)	MAP (10)
Multipurpose analog protection, instance 11	MAPGAPC11	MAP (11)	MAP (11)
Multipurpose analog protection, instance 12	MAPGAPC12	MAP (12)	MAP (12)
Control			
Circuit-breaker control, instance 1	CBXCBR1	I <-> O CB (1)	I <-> O CB (1)
Circuit-breaker control, instance 2	CBXCBR2	I <-> O CB (2)	I <-> O CB (2)
Disconnector control, instance 1	DCXSWI1	I <-> O DCC (1)	I <-> O DCC (1)
Disconnector control, instance 2	DCXSWI2	I <-> O DCC (2)	I <-> O DCC (2)
Earthing switch control, instance 1	ESXSWI1	I <-> O ESC (1)	I <-> O ESC (1)
Disconnector control, instance 3	DCXSWI3	I <-> O DCC (3)	I <-> O DCC (3)
Disconnector control, instance 4	DCXSWI4	I <-> O DCC (4)	I <-> O DCC (4)
Earthing switch control, instance 2	ESXSWI2	I <-> O ESC (2)	I <-> O ESC (2)
Disconnector position indication, instance 1	DCSXSWI1	I <-> O DC (1)	I <-> O DC (1)
Disconnector position indication, instance 2	DCSXSWI2	I <-> O DC (2)	I <-> O DC (2)
Earthing switch position indication, instance 1	ESSXSWI1	I <-> O ES (1)	I <-> O ES (1)
Disconnector position indication, instance 3	DCSXSWI3	I <-> O DC (3)	I <-> O DC (3)
Disconnector position indication, instance 4	DCSXSWI4	I <-> O DC (4)	I <-> O DC (4)
Earthing switch position indication, instance 2	ESSXSWI2	I <-> O ES (2)	I <-> O ES (2)
Auto-reclosing, instance 1	DARREC1	O -> I (1)	79 (1)
Auto-reclosing, instance 2	DARREC2	O -> I (2)	79 (2)
Synchronism and energizing check	SECRSYN1	SYNC (1)	25 (1)
Load shedding and restoration, instance 1	LSHDPFRQ1	UFLS/R (1)	81LSH (1)
Load shedding and restoration, instance 2	LSHDPFRQ2	UFLS/R (2)	81LSH (2)
Load shedding and restoration, instance 3	LSHDPFRQ3	UFLS/R (3)	81LSH (3)
Load shedding and restoration, instance 4	LSHDPFRQ4	UFLS/R (4)	81LSH (4)
Load shedding and restoration, instance 5	LSHDPFRQ5	UFLS/R (5)	81LSH (5)
Load shedding and restoration, instance 6	LSHDPFRQ6	UFLS/R (6)	81LSH (6)
Condition monitoring			
Circuit-breaker condition monitoring, instance 1	SSCBR1	CBCM (1)	52CM (1)
Circuit-breaker condition monitoring, instance 2	SSCBR2	CBCM (2)	52CM (2)
Trip circuit supervision, instance 1	TCSSCBR1	TCS (1)	TCM (1)
Trip circuit supervision, instance 2	TCSSCBR2	TCS (2)	TCM (2)
Current circuit supervision, instance 1	CCRDIF1	MCS 3I (1)	CSM 3I (1)
Fuse failure supervision	SEQRFUF1	FUSEF (1)	60 (1)
Measurement			
Three-phase current measurement, instance 1	CMMXU1	3I (1)	3I (1)
Sequence current measurement, instance 1	CSMSQI1	I1, I2, I0 (1)	I1, I2, I0 (1)

Table 94. REF620 functions, codes and symbols, continued

Function	IEC 61850	IEC 60617	IEC-ANSI
Residual current measurement, instance 1	RESCMMXU1	Io (1)	In (1)
Three-phase voltage measurement	VMMXU1	3U (1)	3V (1)
Residual voltage measurement	RESVMMXU1	Uo (1)	Vn (1)
Sequence voltage measurement	VSMSQI1	U1, U2, U0 (1)	V1, V2, V0 (1)
Three-phase power and energy measurement	PEMMXU1	P, E (1)	P, E (1)
Frequency measurement	FMMXU1	f (1)	f (1)
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)
Voltage unbalance	VSQVUB1	PQUUB (1)	PQVUB (1)
Other			
Minimum pulse timer (2 pcs), instance 1	TPGAPC1	TP (1)	TP (1)
Minimum pulse timer (2 pcs), instance 2	TPGAPC2	TP (2)	TP (2)
Minimum pulse timer (2 pcs), instance 3	TPGAPC3	TP (3)	TP (3)
Minimum pulse timer (2 pcs), instance 4	TPGAPC4	TP (4)	TP (4)
Minimum pulse timer (2 pcs, second resolution), instance 1	TPSGAPC1	TPS (1)	TPS (1)
Minimum pulse timer (2 pcs, second resolution), instance 2	TPSGAPC2	TPS (2)	TPS (2)
Minimum pulse timer (2 pcs, minute resolution), instance 1	TPMGAPC1	TPM (1)	TPM (1)
Minimum pulse timer (2 pcs, minute resolution), instance 2	TPMGAPC2	TPM (2)	TPM (2)
Pulse timer (8 pcs), instance 1	PTGAPC1	PT (1)	PT (1)
Pulse timer (8 pcs), instance 2	PTGAPC2	PT (2)	PT (2)
Time delay off (8 pcs), instance 1	TOFGAPC1	TOF (1)	TOF (1)
Time delay off (8 pcs), instance 2	TOFGAPC2	TOF (2)	TOF (2)
Time delay off (8 pcs), instance 3	TOFGAPC3	TOF (3)	TOF (3)
Time delay off (8 pcs), instance 4	TOFGAPC4	TOF (4)	TOF (4)
Time delay on (8 pcs), instance 1	TONGAPC1	TON (1)	TON (1)
Time delay on (8 pcs), instance 2	TONGAPC2	TON (2)	TON (2)
Time delay on (8 pcs), instance 3	TONGAPC3	TON (3)	TON (3)
Time delay on (8 pcs), instance 4	TONGAPC4	TON (4)	TON (4)
Set reset (8 pcs), instance 1	SRGAPC1	SR (1)	SR (1)
Set reset (8 pcs), instance 2	SRGAPC2	SR (2)	SR (2)
Set reset (8 pcs), instance 3	SRGAPC3	SR (3)	SR (3)
Set reset (8 pcs), instance 4	SRGAPC4	SR (4)	SR (4)
Move (8 pcs), instance 1	MVGAPC1	MV (1)	MV (1)

Table 94. REF620 functions, codes and symbols, continued

Function	IEC 61850	IEC 60617	IEC-ANSI
Move (8 pcs), instance 2	MVGAPC2	MV (2)	MV (2)
Move (8 pcs), instance 3	MVGAPC3	MV (3)	MV (3)
Move (8 pcs), instance 4	MVGAPC4	MV (4)	MV (4)
Generic control points, instance 1	SPCGGIO1	SPCGGIO (1)	SPCGGIO (1)
Generic control points, instance 2	SPCGGIO2	SPCGGIO (2)	SPCGGIO (2)
Generic control points, instance 3	SPCGGIO3	SPCGGIO (3)	SPCGGIO (3)
Remote Generic control points	SPCRGGIO1	SPCRGGIO (1)	SPCRGGIO (1)
Local Generic control points	SPCLGGIO1	SPCLGGIO (1)	SPCLGGIO (1)
Generic Up-Down Counters, instance 1	UDFCNT1	UDCNT (1)	UDCNT (1)
Generic Up-Down Counters, instance 2	UDFCNT2	UDCNT (2)	UDCNT (2)
Generic Up-Down Counters, instance 3	UDFCNT3	UDCNT (3)	UDCNT (3)
Generic Up-Down Counters, instance 4	UDFCNT4	UDCNT (4)	UDCNT (4)
Generic Up-Down Counters, instance 5	UDFCNT5	UDCNT (5)	UDCNT (5)
Generic Up-Down Counters, instance 6	UDFCNT6	UDCNT (6)	UDCNT (6)
Generic Up-Down Counters, instance 7	UDFCNT7	UDCNT (7)	UDCNT (7)
Generic Up-Down Counters, instance 8	UDFCNT8	UDCNT (8)	UDCNT (8)
Generic Up-Down Counters, instance 9	UDFCNT9	UDCNT (9)	UDCNT (9)
Generic Up-Down Counters, instance 10	UDFCNT10	UDCNT (10)	UDCNT (10)
Generic Up-Down Counters, instance 11	UDFCNT11	UDCNT (11)	UDCNT (11)
Generic Up-Down Counters, instance 12	UDFCNT12	UDCNT (12)	UDCNT (12)
Programmable buttons(16 buttons)	FKEYGGIO1	FKEY (1)	FKEY (1)
Logging functions			
Disturbance recorder	RDRE1	DR (1)	DFR (1)
Fault recorder	FLTMSTA1	FR (1)	FR (1)
Sequence event recorder	SER1	SER (1)	SER (1)
Load profile	LDPMSTA1	LOADPROF (1)	LOADPROF (1)

30. Document revision history

Document revision/date	Product version	History
A/2013-05-07	2.0	First release

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