Feeder Protection REF615

Product Guide

Contents

1. Description

REF615 is a dedicated feeder protection relay designed for the protection, measurement and supervision of utility substations and industrial power systems. Re-engineered from the ground up, the relay has been guided by the IEC 61850 standard for communication and interoperability of substation automation devices.

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

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

The 615 series relays support a range of communication protocols including IEC 61850 with GOOSE messaging and Modbus®.

2. Standard configurations

The feeder protection relay REF615 is available with four alternative standard configurations. The table below indicates the functions supported by the different relay configurations.

Standard configuration functionality	Overcurrent and directional earth-fault protection		Overcurrent and non-directional earth-fault protection	
	Std. conf. A	Std. conf. B	Std. conf. C	Std. conf. D
Protection				
Three-phase non-directional overcurrent, low-set stage	•	•	•	•
Three-phase non-directional overcurrent, high-set stage, instance 1	•	•	•	•
Three-phase non-directional overcurrent, high-set stage, instance 2	•	•	•	•
Three-phase non-directional overcurrent, instantaneous stage	•	•	•	•
Directional earth-fault, low-set stage, instance 1	•	•	-	-
Directional earth-fault, low-set stage, instance 2	•	•	-	-
Directional earth-fault, high-set stage	•	•	-	-
Non-directional earth-fault, high-set stage (cross country earth-fault)	•	•	-	-
Transient/intermittent earth-fault	•	•	-	-
Non-directional earth-fault, low-set stage	-	-	•	•
Non-directional earth-fault, high-set stage	-	-	•	•
Non-directional earth-fault, instantaneous stage	-	-	•	•

Protection, continued

Non-directional sensitive earth-fault	-	-	•	•
Negative-sequence overcurrent, instance 1	•	•	•	•
Negative-sequence overcurrent, instance 2	•	•	•	•
Phase discontinuity	•	•	•	•
Thermal overload	•	•	•	•
Circuit breaker failure protection	•	•	•	•
Three-phase inrush current detection	•	•	•	•
Arc protection with three sensors	o	o	o	o
Control				
Circuit breaker control with basic interlocking [1)]	•	•	•	•
Circuit breaker control with extended interlocking [2)]	-	•	-	•
Auto-reclosing of one circuit breaker	o	o	o	o
Supervision and Monitoring				
Circuit breaker condition monitoring	-	•	-	•
Trip-circuit supervision of two trip circuits	•	•	•	•
Measurement				
Transient disturbance recorder	•	•	•	•
Three-phase current measurement	•	•	•	•
Current sequence components	•	•	•	•
Residual current measurement	•	•	•	•
Residual voltage measurement	•	•	-	-

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

1) Basic interlocking functionality: Closing of the circuit breaker can be enabled by a binary input signal. The actual interlocking scheme is implemented outside the relay. The binary input serves as a “master interlocking input” and when energized it will enable circuit breaker closing.

2) Extended interlocking functionality: The circuit breaker interlocking scheme is implemented in the relay configuration, based on primary equipment position information (via binary inputs) and the logical functions available. The signal matrrix tool of PCM600 can be used for modifying the interlocking scheme to suit your application.

3. Protection functions

The relay offers overcurrent and thermal overload protection, directional and nondirectional earth-fault protection, sensitive earth-fault protection, phase discontinuity protection, transient/intermittent earth-fault protection and three-pole multi-shot auto-reclose functions for overhead line feeders.

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

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

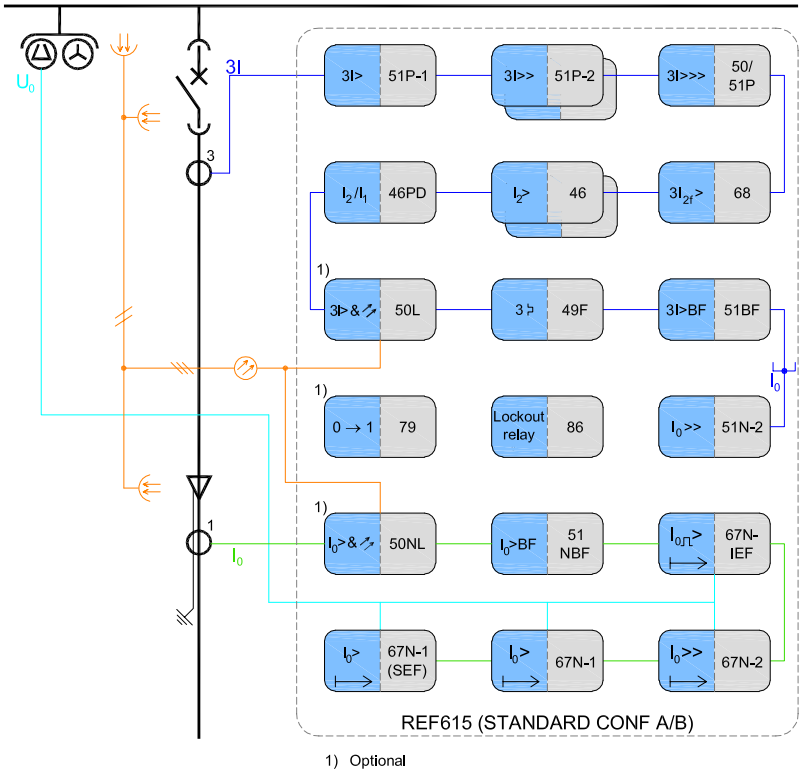

Fig. 1 Protection function overview of standard configuration A and B

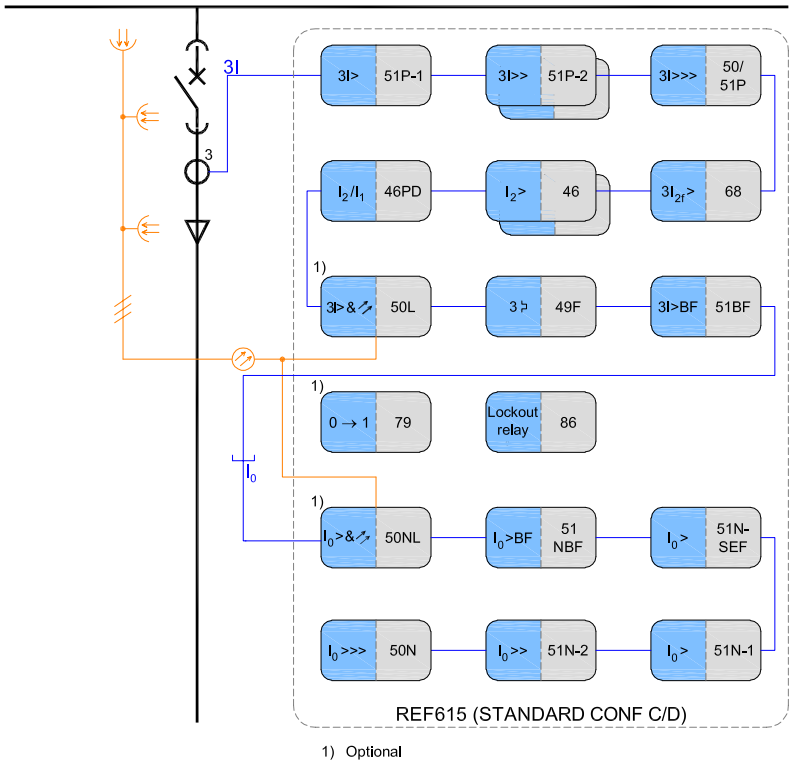

Fig. 2 Protection function overview of standard configuration C and D

4. Application

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

The standard configurations A and B offer directional earth-fault protection, if the outgoing feeder includes phase current transformers, a core-balance current transformer and residual voltage measurement. The residual current calculated from the phase currents can be used for double (cross country) earth-fault protection. The relay further features transient/intermittent earth-fault protection. The standard configurations C and D offer non-directional earth-fault protection for outgoing feeders including phase current trans-

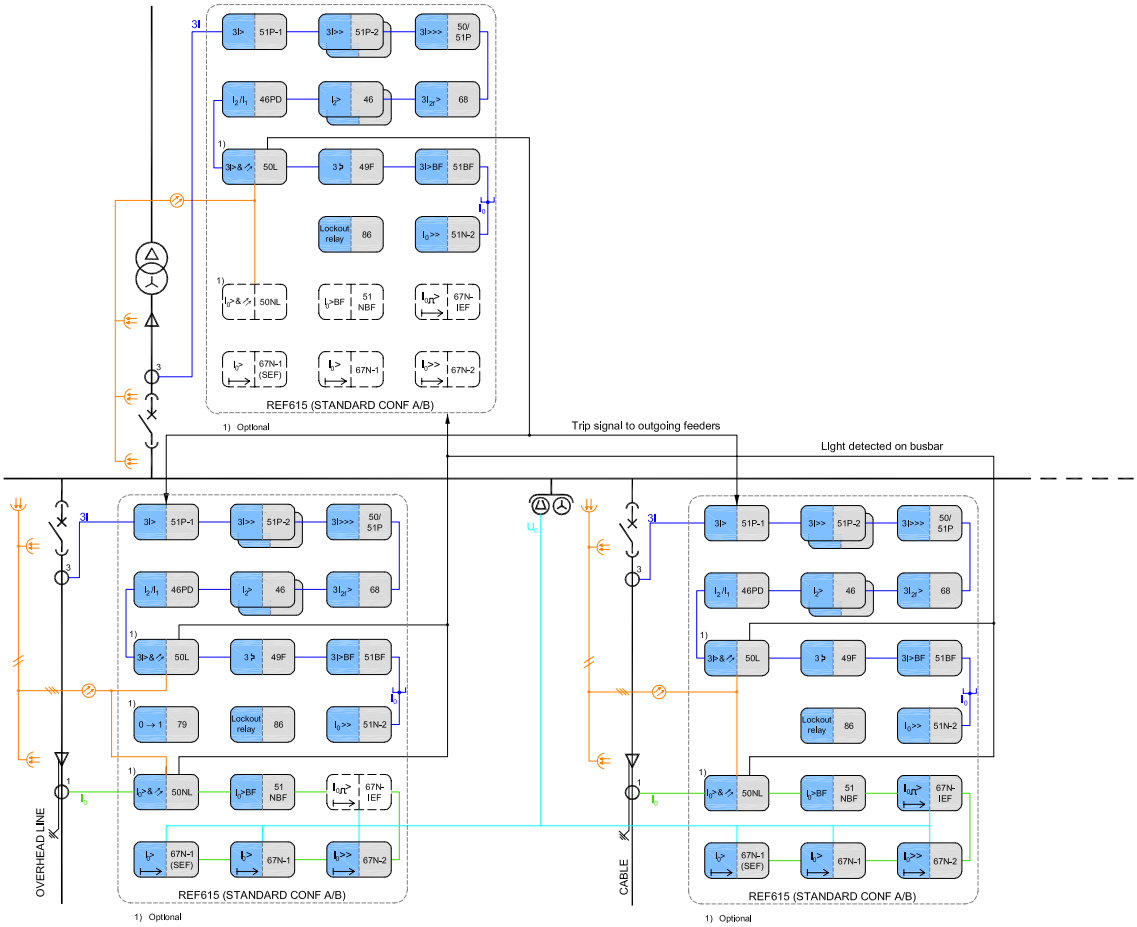

Fig. 3 Substation O/C and E/F protection using the standard configuration A or B with relevant options. In the incoming feeder bay, the protection functions not used are uncoloured and indicated with a dashed block outline. The relays are equipped with optional arc protection functions, enabling fast and selective arc protection throughout the switchgear.

formers. The residual current for the earth-fault protection is derived from the phase currents. When applicable, the core-balance current transformers can be used for measuring the residual current, especially when sensitive earth-fault protection is required.

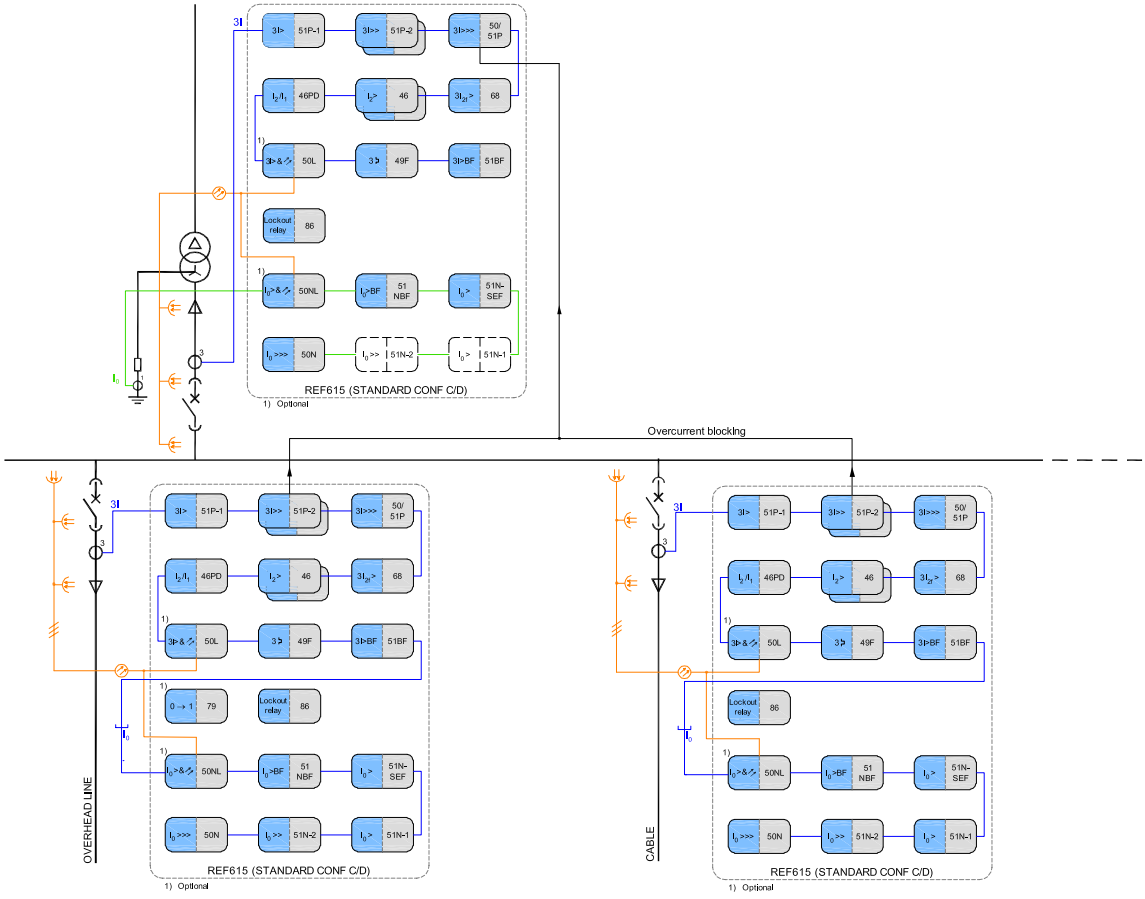

Fig. 4 Substation O/C and E/F protection using the standard configuration C or D with relevant options. In the incoming feeder bay the unemployed protection functions are uncoloured and indicated with a dashed block outline. The busbar protection is based on the interlocking principle, where the start of the O/C protection of the outgoing feeder sends a blocking signal to the instantaneous O/C stage of the incoming feeder. In the absence of the blocking signal, the O/C protection of the incoming feeder will clear the internal switchgear (busbar) fault.

5. Control

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

6. Measurement

The relay continuously measures the phase currents, the symmetrical components of the currents and the residual current. If the relay includes directional earth-fault protection, it also measures the residual voltage. In addition, the relay calculates the maximum demand value over a user-selectable pre-set time frames, the thermal overload of the protected object, and the phase unbalance value based on the ratio between the negative sequence and positive sequence current.

The values measured can be accessed locally via the user interface on the relay front panel or remotely via the communication interface of the relay. The values can also be accessed locally or remotely using the web-browser based user interface.

7. Disturbance recorder

The relay is provided with a disturbance recorder featuring up to 12 analog and 64 binary signal channels. The analog channels can be set to record either the waveform or the trend of the currents and voltage measured.

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

By default, the binary channels are set to record external or internal relay signals, e.g. the start or trip signals of the relay stages, or external blocking or control signals. Binary relay signals such as a protection start or trip signal, or an external relay control signal over a binary input can be set to trigger the recording. The recorded information is stored in a non-volatile memory and can be uploaded for subsequent fault analysis.

8. Event log

To collect sequence-of-events (SoE) information, the relay incorporates a non-volatile memory with a capacity of storing 50 event codes with associated time stamps. The non-volatile memory retains its data also in case the relay temporarily loses its auxiliary supply. The event log facilitates detailed pre- and post-fault analyses of feeder faults and disturbances.

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

9. Recorded data

The relay has the capacity to store the records of four fault events. The records enable the user to analyze the four most recent power system events. Each record includes the current and voltage values, the start times of the protection blocks, time stamp, etc. The fault recording can be triggered by the

start signal or the trip signal of a protection block, or by both. The available measurement modes include DFT, RMS and peak-to-peak. In addition, the maximum demand current with time stamp is separately recorded. By default, the records are stored in a non-volatile memory.

10. Circuit-breaker monitoring

The condition monitoring functions of the relay constantly monitors the performance and the condition of the circuit breaker. The monitoring comprises the spring charging time, SF6 gas pressure, the travel-time and the inactivity time of the circuit breaker.

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

11. 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.

12. Self-supervision

The relay's built-in self-supervision system continuously monitors the state of the relay hardware and the operation of the relay software. Any fault or malfunction detected will be used for alerting the operator. A permanent relay fault will block the protection functions of the relay to prevent incorrect relay operation.

13. Access control

To protect the relay from unauthorized access and to maintain information integrity, the relay 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.

14. Inputs and outputs

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

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

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

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

Relay analog input and binary input/output overview:
- Four current inputs
- One optional voltage input (for directional E/F protections applications)
- Three binary inputs with U_0 measurement and four binary inputs without U_0 measurement
- Two heavy-duty output relays with normally-open contact
- Two changeover signal-output contacts
- Two double-pole power-output contacts with trip-circuit supervision
- One dedicated IRF output contact

I/O extension module:
- Seven binary control inputs
- Three signaling-output contacts

Optional I/O extension module:
- Six binary control inputs
- Three signaling-output contacts

15. Communication

The relay supports two different communication protocols: IEC 61850 and Modbus®. Operational information and controls are available through these protocols. However, some communication functionality, for example, horizontal communication between the relays, is only enabled by the IEC 61850 communication protocol.

The IEC 61850 communication implementation supports all monitoring and control functions. Additionally, parameter setting and disturbance file records can be accessed using the IEC 61850-8-1 protocol. Further, the relay can send and receive binary signals from other relays (so called horizontal communication) using the IEC61850-8-1 GOOSE profile, where the highest performance class with a total transmission time of 3 ms is supported. The relay can simultaneously report events to five different clients on the station bus.

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

Modbus implementation supports RTU, ASCII and TCP modes. Besides standard Modbus functionality, the relay supports retrieval of time-stamped events, uploading of disturbance files and storing of the latest fault records. If a Modbus TCP connection is used, five clients can be connected to the relay simultaneously.

When the relay uses the RS-485 bus for the Modbus RTU/ASCII 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 relay supports the following time synchronization method with a time-stamping resolution of +/-1 ms:

Ethernet based:
- SNTP

With special time synchronization wiring:
- IRIG-B

Supported communication interfaces and protocols

	100BASE-TX RJ45	100BASE-FX LC	RS-485 +IRIG-B
IEC 61850-8-1	•	•	-
MODBUS RTU/ASCII	-	-	•
MODBUS TCP	•	•	-

• = Supported

16. Technical data

Dimensions

Width	frame case	177 mm, 164 mm
Height	frame case	177 (4U) 160 mm
Depth	case	155 mm
Weight	relay spare unit	3.5 kg 1.8 kg

Power Supply

Type:	Type 1	Type 2
U_{aux} nominal	100, 110, 120, 220, 240 V AC, 50 and 60 Hz 48, 60, 110, 125, 220, 250 V DC	24, 30, 48, 60 V DC
U_{aux} variation	38...110% of U_n (38...264 V AC) 80...120% of U_n (38.4...300 V DC)	50...120% x U_n (12...72 V DC)
Start-up threshold		19.2 V DC (24 V DC * 80%)
Burden of auxiliary voltage supply under quiescent (Pq)/operating condition	<8.4 W/13 W	
Ripple in the DC auxiliary voltage	Max 12% of the DC value (at frequency of 100 Hz)	
Maximum interruption time in the auxiliary DC voltage without resetting the relay	50 ms at U_{aux} rated	
Fuse type	T4 A/250 V	

Energizing inputs

Rated frequency		50/60 Hz ± 5 Hz	
Current inputs	Rated current, I_n	0.2/1 A [1]	1/5 A [2]
	Thermal withstand capability: • Continuously • For 1 s • For 10 s	 4 A 100 A 25 A	 20 A 500 A 100 A
	Dynamic current withstand: • Half-wave value	 250 A	 1250 A
	Input impedance	<100 mΩ	<20 mΩ
Voltage input	Rated voltage	100 V/ 110 V/ 115 V/ 120 V (Parametrization)	
	Voltage withstand: • Continuous • For 10 s	 2 x Un (240 V) 3 x Un (360 V)	
	Burden at rated voltage	<0.05 VA	

1) Residual current
2) Phase currents

Binary inputs

Operating range	±20 % of the rated voltage
Rated voltage	24...250 V DC
Current drain	2...18 mA
Power consumption/input	<0.9 W
Threshold voltage	18...176 V DC

Signal outputs

Rated voltage	250 V AC/DC
Continuous carry	5 A
Make and carry for 3.0 s	8 A
Make and carry 0.5 s	10 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

IRF relay change over - type signal output relay	
Rated voltage	250 V AC/DC
Continuous contact carry	5 A
Make and carry for 3.0 s	8 A
Make and carry 0.5 s	10 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

Heavy-duty output relays

Double-pole power relay with trip-circuit supervision function	
Rated voltage	250 V AC/DC
Continuous contact carry	8 A
Make and carry for 3.0 s	15 A
Make and carry 0.5 s	30 A
Breaking capacity when the control-circuit time constant L/R<40 ms, at 48/110/220 V DC (two contacts connected in series)	5 A/3 A/1 A
Minimum contact load	100 mA at 24 V AC/DC
Trip-circuit supervision: • Control voltage range • Current drain through the supervision circuit • Minimum voltage over the TCS contact	 20...250 V AC/DC ~1.5 m/A 20 V AC/DC (15...20 V)

Single-pole power output relays	
Rated voltage	250 V AC/DC
Continuous contact carry	8 A
Make and carry for 3.0 s	15 A
Make and carry 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

Lens sensor and optic fiber for arc protection

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

Degree of protection of flush-mounted relay

Front side	IP 54
Top of the relay	IP 40
Rear side, connection terminals	IP 20

Environmental conditions and tests

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

Environmental tests	
Dry heat test (humidity <50%)	According to IEC 60068-2-2 Test values: • 96 h at +55°C • 16 h at +85°C
Cold test	According to IEC 60068-2-1 Test values: • 96 h at -25°C • 16 h at -40°C
Damp heat test, cyclic	According to IEC 60068-2-30 Test values: • 6 cycles at +25…55°C, humidity 93…95%
Storage test	According to IEC 60068-2-48 Test values: • 96 h at -40°C • 96 h at +85°C

Electromagnetic compatibility tests

The EMC immunity test level meets the requirements listed below:	
1 MHz burst disturbance test, class III: • Common mode • Differential mode	According to IEC 61000-4-18 and IEC 60255-22-1, level 3 2.5 kV 1.0 kV
Electrostatic discharge test • Contact discharge • Air discharge	According to IEC 61000-4-2, IEC 60255-22-2, level 3 6 kV 8 kV

(continued)

Radio frequency interference tests: • Conducted, common mode • Radiated, amplitude-modulated • Radiated, pulse-modulated	 According to IEC 61000-4-6 and IEC 60255-22-6, level 3 10 V (emf), f = 150 kHz...80 MHz According to IEC 61000-4-3 and IEC 60255-22-3, level 3 10 V/m (rms), f=80...1000 MHz and f=1.4...2.7 GHz According to the ENV 50204 and IEC 60255-22-3,level 3 10 V/m, f=900 MHz
Fast transient disturbance tests: • Signal outputs, binary inputs, IRF • Other ports	According to IEC 61000-4-4 and IEC 60255-22-4, class B 2 kV 4 kV
Surge immunity test: • Binary inputs • Communication • Other ports	According to IEC 61000-4-5 and IEC 60255-22-5, level 4/3 2 kV, line-to-earth, 1kV, line-to-line 1 kV, line-to-earth 4 kV, line-to-earth, 2 kV, line-to-line
Power frequency (50 Hz) magnetic field: • Continuous	According to IEC 61000-4-8, level 5 300 A/m
Power frequency immunity test: • Common mode • Differential mode	According to IEC 60255-22-7, class A 300 V rms 150 V rms
Voltage dips and short interruptions	According to IEC 61000-4-11 30%/10 ms 60%/100 ms 60%/1000 ms >95%/5000 ms
Electromagnetic emission tests: • Conducted, RF emission (mains terminal) 0.15...0.50 MHz 0.5...30 MHz • Radiated RF emission 0...230 MHz 230...1000 MHz	According to the EN 55011, class A and IEC60255-25 < 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

Insulation and mechanical tests

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

Mechanical tests	
Vibration tests (sinusoidal)	According to IEC 60255-21-1, class 2
Shock and bump test	According to IEC 60255-21-2, class 2

EMC compliance

Complies with the EMC directive 2004/108/EC	
Standards	EN 50263 (2000), EN 60255-26 (2007)

Product safety

Complies with the LV directive 2006/95/EC	
Standards	EN 60255-27 (2005), EN 60255-6 (1994)

RoHS compliance

Complies with the RoHS directive 2002/95/EC

Data communication for front interface

Front interface: • TCP/IP protocol • Standard CAT 5 Ethernet cable • 10 MBits/s

Protection functions

Three-phase non-directional overcurrent protection (PHxPTOC)

Operation accuracy	Depending on the frequency of the current measured: f_n ±2Hz			
	PHLPTOC	±1.5% of the set value or ±0.002 x I_n		
	PHHPTOC and PHIPTOC	±1.5% of set value or ±0.002 x I_n (at currents in the range of 0.1…10 x I_n) ±5.0% of the set value (at currents in the range of 10…40 x I_n)		
Start time [1) 2)]		Minimum	Typical	Maximum
	PHIPTOC: I_{Fault} = 2 x set *Start value*	16 ms	19 ms	23 ms
	I_{Fault} = 10 x set *Start value*	11 ms	12 ms	14 ms
	PHHPTOC and PHLPTOC: I_{Fault} = 2 x set *Start value*	22 ms	24 ms	25 ms
Reset time		< 40 ms		
Reset ratio		Typical 0.96		
Retardation time		< 30 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms [3)]		
Suppression of harmonics		RMS: No suppression DFT: -50dB at f = n x f_n, where n = 2, 3, 4, 5,… Peak-to-Peak: No suppression P-to-P+backup: No suppression		

1) *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) Maximum *Start value* = 2.5 x In, *Start value* multiples in range of 1.5 to 20

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	0.10...40.00 x I_n	0.01
Time multiplier	PHLPTOC	0.8...10.0	0.05
	PHHPTOC	0.05...15.00	0.05
Operate delay time	PHLPTOC	40...200000 ms	10
	PHHPTOC	40...200000 ms	10
	PHIPTOC	40...200000 ms	10
Operating curve type [1)]	PHLPTOC	Definite or inverse time Curve type: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19	
	PHHPTOC	Definite or inverse time Curve type: 1, 3, 5, 9, 10, 12, 15, 17	
	PHIPTOC	Definite time	

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

Non-directional EF protection (EFxPTOC)

Operation accuracy	Depending on the frequency of the current measured: f_n ±2Hz			
	EFLPTOC	±1.5% of the set value or ±0.002 x I_n		
	EFHPTOC and EFIPTOC	±1.5% of set value or ±0.002 x I_n (at currents in the range of 0.1…10 x I_n) ±5.0% of the set value (at currents in the range of 10…40 x I_n)		
Start time [1) 2)]		Minimum	Typical	Maximum
	EFIPTOC: I_{Fault} = 2 x set *Start value*	16 ms	19 ms	23 ms
	I_{Fault} = 10 x set *Start value*	11 ms	12 ms	14 ms
	EFHPTOC and EFLPTOC: I_{Fault} = 2 x set *Start value*	22 ms	24 ms	25 ms
Reset time		< 40 ms		
Reset ratio		Typical 0.96		
Retardation time		< 30 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms [3)]		
Suppression of harmonics		RMS: No suppression DFT: -50dB at f = n x f_n, where n = 2, 3, 4, 5,… Peak-to-Peak: No suppression		

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

Non-directional EF protection (EFxPTOC) main settings

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

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

Directional EF protection (DEFxPDEF)

Operation accuracy	Depending on the frequency of the current measured: f_n ±2Hz			
	DEFLPDEF	Current: ±1.5% of the set value or ±0.002 x I_n Voltage: ±1.5% of the set value or ±0.002 x U_n Phase angle: ±2°		
	DEFHPDEF	Current: ±2% of the set value or ±0.003 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 ±0.01 x U_n Phase angle: ±2°		
Start time [1) 2)]		Minimum	Typical	Maximum
	DEFHPDEF and 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: -50dB at f = n x f_n, where n = 2, 3, 4, 5,… Peak-to-Peak: No suppression		

1) Set *Operate delay time* = 0,06 s, *Operate curve type* = IEC definite time, *Measurement mode* = default (depends on stage), current before fault = 0.0 x In, fn = 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 In, *Start value* multiples in range of 1.5 to 20

Directional EF protection (DEFxPDEF) main settings

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

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

Transient/intermittent earth-fault protection (INTRPTEF)

Operation accuracy (U0 criteria with transient protection)	Depending on the frequency of the current measured: f_n = ±2Hz
	±1.5% of the set value or ±0.002 x U_n
Operate time accuracy	±1.0% of the set value or ±20 ms
Suppression of harmonics	DFT: -50dB at f = n x f_n, where n = 2, 3, 4, 5

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

Parameter	Function	Value (Range)	Step
Directional mode	INTRPTEF	1=Non-directional 2=Forward 3=Reverse	
Operate delay time	INTRPTEF	40...1200000 ms	10
Voltage start value (voltage start value for transient EF)	INTRPTEF	0.01...0.50 x U_n	0.01
Operation mode	INTRPTEF	1=Intermittent EF 2=Transient EF	
Peak counter limit (Min requirement for peak counter before start in IEF mode)	INTRPTEF	2...20	

Negative phase-sequence current protection (NSPTOC)

Operation accuracy		Depending on the frequency of the current measured: f_n = ±2Hz		
		±1.5% of the set value or ±0.002 x I_n		
Start time [1) 2)]		Minimum	Typical	Maximum
	I_{Fault} = 2 x set *Start value* I_{Fault} = 10 x set *Start value*	22 ms 14 ms	24 ms 16 ms	25 ms 17 ms
Reset time		< 40 ms		
Reset ratio		Typical 0.96		
Retardation time		< 35 ms		
Operate time accuracy in definite time mode		±1.0% of the set value or ±20 ms		
Operate time accuracy in inverse time mode		±5.0% of the theoretical value or ±20 ms [3)]		
Suppression of harmonics		DFT: -50dB at f = n x f_n, where n = 2, 3, 4, 5,…		

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

Negative phase-sequence current protection (NSPTOC) main settings

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

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

Phase discontinuity protection (PDNSPTOC)

Operation accuracy	Depending on the frequency of the current measured: fn ±2Hz
	±2% of the set value
Start time	< 70 ms
Reset time	< 40 ms
Reset ratio	Typical 0.96
Retardation time	< 35 ms
Operate time accuracy in definite time mode	±1.0% of the set value or ±20 ms
Suppression of harmonics	DFT: -50dB at f = n x fn, where n = 2, 3, 4, 5,…

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 In	0.01

Circuit breaker failure protection (CCBRBRF)

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

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

Three-phase thermal overload (T1PTTR)

Operation accuracy	Depending on the frequency of the current measured: fn ±2Hz
	Current measurement: ±0.5% or ±0.002 x I_n (at currents in the range of 0.01…4.00 x I_n)
Operate time accuracy	±2.0% or ±0.50 s

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
Sensor available (External temperature sensor available)	T1PTTR	0=False 1=True	
Initial temperature (Temperature raise above ambient temperature at startup)	T1PTTR	-50.0...100.0 °C	0.1

Three-phase inrush current detection (INRPHAR)

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

Three-phase inrush current 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

Arc protection (ARCSARC)

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

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

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	

Operating characteristics

Parameter	Values (Range)
Operating curve type	1=ANSI Ext. inv. 2=ANSI Very. inv. 3=ANSI Norm. inv. 4=ANSI Mod inv. 5=ANSI Def. Time 6=L.T.E. inv. 7=L.T.V. inv. 8=L.T. inv. 9=IEC Norm. inv. 10=IEC Very inv. 11=IEC inv. 12=IEC Ext. inv. 13=IEC S.T. inv. 14=IEC L.T. inv 15=IEC Def. Time 17=Programmable 18=RI type 19=RD type

Control functions

Autoreclosure (DARREC)

Operation accuracy	±1.0% of the set value or ±20 ms

17. Display options

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

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

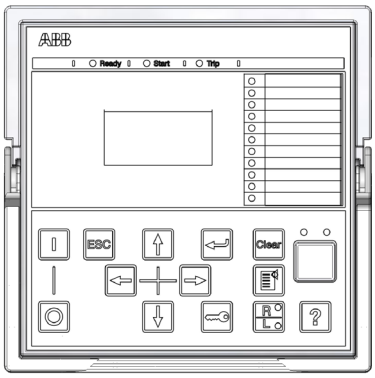

Fig. 5 Small display

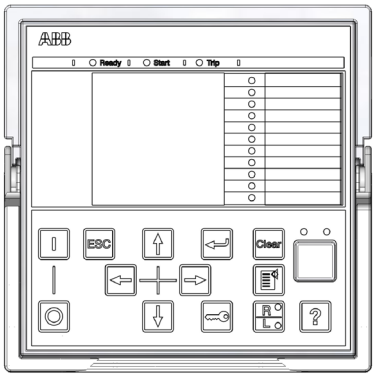

Fig. 6 Large display

Display options

Small display		
Character size [1]	**Rows in the view**	**Characters per row**
Small, mono-spaced (6x12 pixels)	5	20
Large, variable width (13x14 pixels)	4	8 or more [1]
Large display		
Character size [1]	**Rows in the view**	**Characters per row**
Small, mono-spaced (6x12 pixels)	10	20
Large, variable width (13x14pixels)	8	8 or more [1]

1) Depending on the selected language

18. Mounting methods

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

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

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

Mounting methods:

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

Panel cut-out for flush mounting:

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

19. Relay case and relay plug-in unit

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

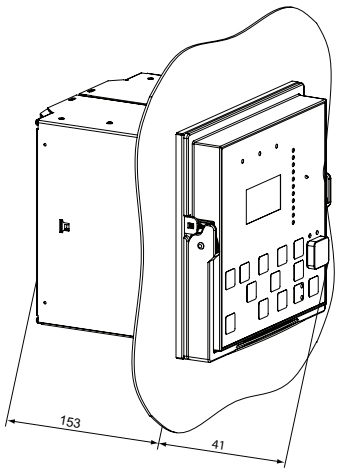

Fig. 7 Flush mounting

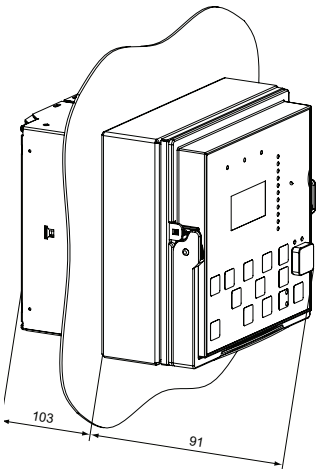

Fig. 8 Semi-flush mounting

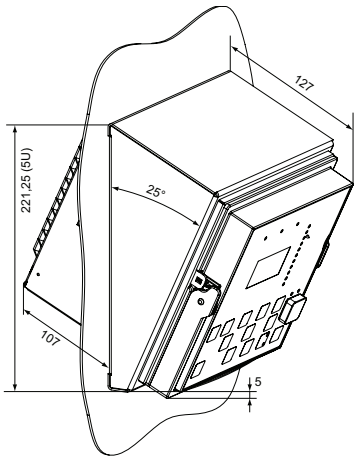

Fig. 9 Semi-flush with a 25° tilt

20. Selection and ordering data

The relay type and serial number label identifies the protection relay. 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 hardware and software modules of the relay.

Use the ordering key information in Fig. 10 to generate the order number when ordering complete protection relays.

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

#	DESCRIPTION	
1	**Relay**	
	615 series relay (including case)	**H**
2	**Standard**	
	IEC	**B**
3	**Main application**	
	Feeder protection	**F**

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

#	DESCRIPTION				
4	**Functional application** [1]				
	Standard configuration	**A**	**B**	**C**	**D**
5-6	**Analog inputs**				
	4 I + U_0 (I_0 1/5 A)	**AA**	**AA**		
	4 I + U_0 (I_0 0.2/1 A)	**AB**	**AB**		
	4 I (I_0 1/5 A)			**AC**	**AC**
	4 I (I_0 0.2/1 A)			**AD**	**AD**
7-8	**Binary inputs/outputs**				
	3 BI + 6 BO	**AA**			
	4 BI + 6 BO			**AB**	
	10 BI + 9 BO		**AC**		
	11 BI + 9 BO				**AD**
	16 BI + 12BO		**AE**		
	17 BI + 12 BO				**AF**

[1] The selected standard configuration defines the required and optional hardware. Select the correct digits from the standard configuration column A, B, C or D.

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

#	DESCRIPTION				
9	**Communication serial**				
	RS485	**A**	**A**		
	None			**N**	**N**
10	**Communication Ethernet**				
	Ethernet 100BaseFX (LC)		**A**	**A**	
	Ethernet 100BaseTX (RJ45)		**B**	**B**	
	None	**N**			**N**
11	**Communication protocol** [1)]				
	IEC 61850			**A**	**A**
	Modbus	**B**		**B**	
	IEC 61850 and Modbus		**C**	**C**	

[1)] The selected communication module (digit 9-10) specifies the available communication protocols. Select your protocol from the relevant column.

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

#	DESCRIPTION	
12	**Language**	
	English	**1**
13	**Front panel**	
	Small LCD	**A**
	Large LCD	**B**
14	**Option 1**	
	Reclosing	**A**
	Arc protection [1)]	**B**
	Arc protection and reclosing [1)]	**C**
	None	**N**
15	**Option 2**	
	None	**N**
16	**Power supply**	
	48...250 V DC, 100...240 V AC	**1**
	24...60 V DC	**2**
17	**Vacant digit**	
	Vacant	**X**
18	**Version**	
	Version 1.1	**B**

[1)] The arc protection hardware is located on the communication module (digit 9-10). Thus a communication module is always required to enable arc protection.

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

Your ordering code:

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

Fig. 10 Ordering key for complete relays

21. Accessories and ordering data

Cables

Item	Order nr
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

Mounting accessories

Item	Order nr
Semi-flush mounting kit	1MRS050696
Wall mounting kit	1MRS050697
Inclined semi-flush mounting kit	1MRS050831
19 ” rack mounting kit with cutout for one relay	1MRS050694
19 ” rack mounting kit with cutout for two relays	1MRS050695
Mounting kit for RTXP 18 (4U Combiflex)	1MRS051010
Mounting kit for 4U high Combiflex equipment frame	1MRS050779

Test switches

Item	Order nr
Mounting kit for 19” rack, single relay, including test switch RTXP 18	1MRS050783

22. Tools

The relay is delivered as a pre-configured unit. The default parameter setting values can be changed from the front-panel user interface, the web-browser based user interface (WebHMI) or the PCM600 tool in combination with the relay specific connectivity package.

PCM600 offers extensive relay configuration functions such as relay signal configuration using the signal matrix tool, and IEC 61850 communication configuration including horizontal relay-to-relay communication, GOOSE.

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

Tools

Configuration, setting and SA system tools	Version
PCM600	2.0 SP1 or later
Web-browser based user interface	IE 7.0 or later
REF615 Connectivity Package	1.2 or later
Station Automation Series COM600	3.2 or later
MicroSCADA Pro	9.2 SP1 or later

Tool function overview

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

• = Supported

23. Terminal diagrams

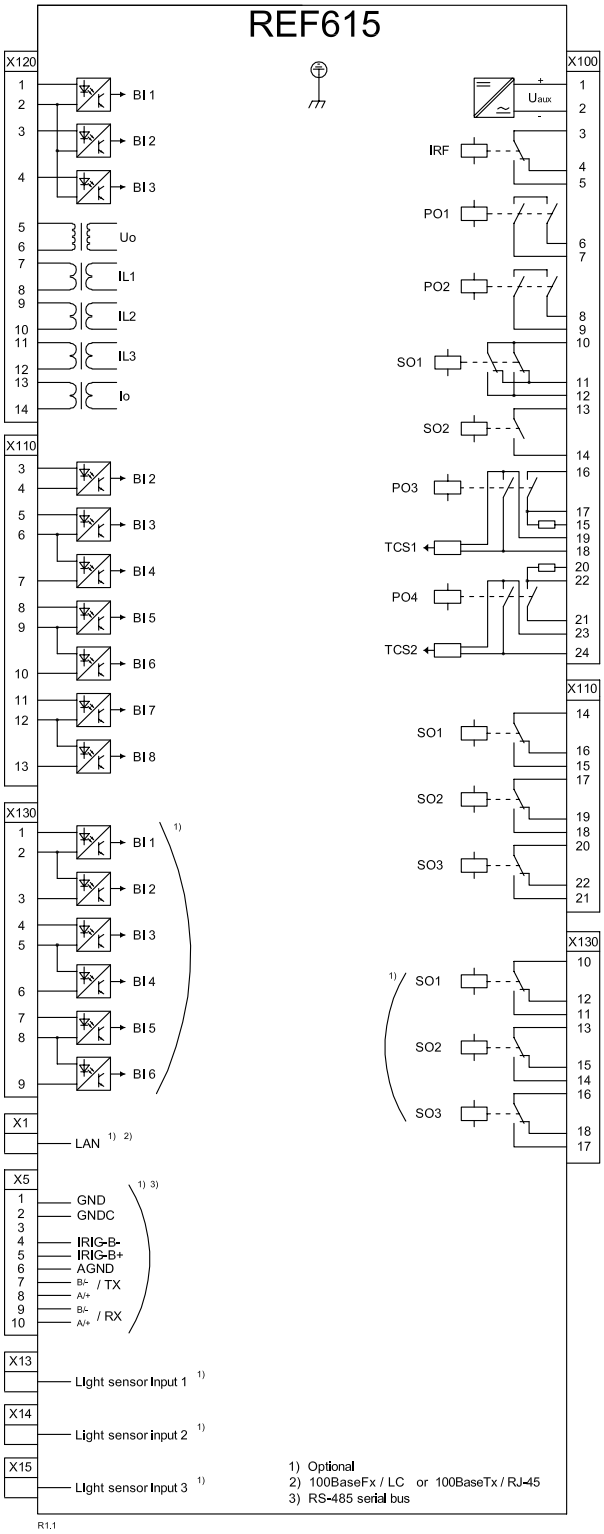

Fig. 11: Terminal diagram of standard configuration B

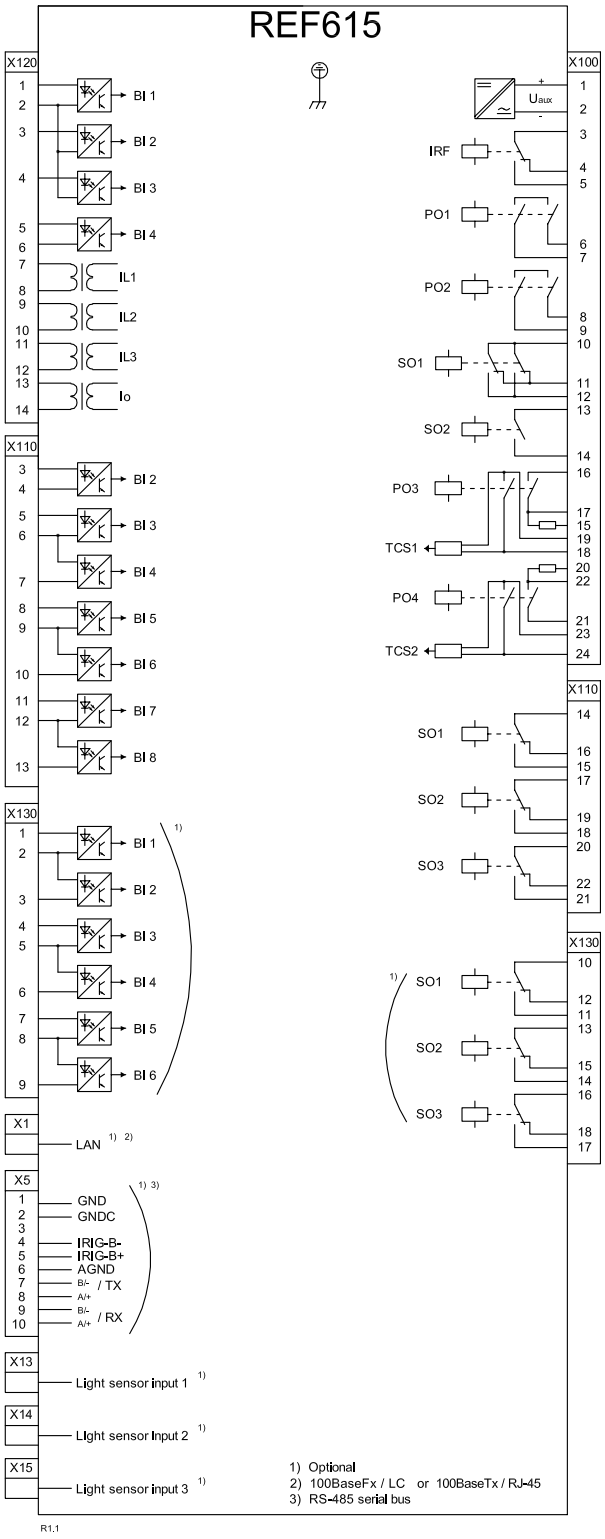

Fig. 12: Terminal diagram of standard configuration D

24. Certificates

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

25. References

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

You will find the latest relevant information on the REF615 protection relay on the product page.

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

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

Fig. 13 Product page

26. Functions, codes and symbols

REF615 functions, codes and symbols

Functions	IEC 61850	IEC 60617	ANSI
Protection functions			
Three-phase non-directional overcurrent, low-set stage	PHLPTOC	3I>	51P-1
Three-phase non-directional overcurrent, high-set stage	PHHPTOC	3I>>	51P-2
Three-phase non-directional overcurrent,instantaneous stage	PHIPTOC	3I>>>	50P/51P
Directional earth-fault, low-set stage	DEFLPDEF	I_0>→	67N-1
Directional earth-fault, high-set stage	DEFHPDEF	I_0>>→	67N-2
Transient/intermittent earth-fault	INTRPTEF	I_0>→ IEF	67N-IEF
Non-directional earth-fault, low-set stage (SEF)	EFLPTOC	I_0>	51N-1
Non-directional earth-fault, low-set stage	EFLPTOC	I_0>	51N-1
Non-directional earth-fault, high-set stage	EFHPTOC	I_0>>	51N-2
Non-directional earth-fault, instantaneous stage	EFIPTOC	I_0>>>	50N/51N
Negative-sequence overcurrent	NSPTOC	I_2>	46
Phase discontinuity	PDNSPTOC	I_2/I_1>	46PD
Thermal overload	T1PTTR	$3I_{th}$>	49F
Circuit breaker failure protection	CCBRBRF	3I>/I_0>BF	51BF/51NBF
Three-phase inrush current detector	INRPHAR	3I2f>	68
Arc protection	ARCSARC	ARC	50L/50NL
Control functions			
Circuit-breaker control	CBXCBR	I ↔ O CB	
Autoreclosing	DARREC	O→ I	79
Measurement functions			
Three-phase current	CMMXU	3I	3I
Current sequence components	CSMSQI	I_1,I_2 ,I_0	I_1,I_2,I_0
Residual current	RESCMMXU	I_0	I_N
Residual voltage	RESVMMXU	U_0	V_N
Disturbance recorder function			
Transient disturbance recorder	RDRE		
CB conditioning monitoring function			
Circuit-breaker condition monitoring	SSCBR	CBCM	CBCM
Supervision function			
Trip-circuit supervision	TCSSCBR	TCS	TCM

1MRS756379 C

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