RELION® 605 SERIES

Feeder Protection and control / Feeder Protection
REF601 / REJ601
Product Guide

Contents

1. Description

REF601/REJ601 is a dedicated feeder protection relay, intended for the protection of utility substations and industrial power systems, in primary and secondary distribution networks. REF601/REJ601 is a member of ABB Relion® product family and part of its 605 series.

The relay provides an optimized composition of protection, monitoring, and control functionality in one unit, with the best performance usability in its class and are based on ABB's in-depth knowledge of protection and numerical technology.

2. Standard configurations

REF601/REJ601 offers pre-configured functionality which facilitates easy and fast commissioning of switchgear.

To emphasize the simplicity of relay's usage, only application specific parameters needs to set within the relay's intended area of application. The standard signal configuration can be altered by LHMI (local human-machine interface) and using signal matrix in PCM600.

The relay is available in four alternative application configurations, as indicated in Table 2.

Table 1. Standard variants

Description	Relay type
Feeder protection and control with sensor	REF601
Feeder protection and control with conventional current transformer	REF601
Feeder protection with sensor	REJ601
Feeder protection with conventional current transformer	REJ601

Table 2. Supported functions

Functionality	Related products		REJ601 / REF601	REJ601 / REF601	REJ601 / REF601	REF601
	ANSI	IEC	B	C	D	F
Protection						
Non-directional overcurrent protection, low-set stage	51	3I >	●	●	●	●
Non-directional overcurrent protection, high-set stage	50-1	3I >>	●	●	●	●
Non-directional overcurrent protection, instantaneous stage	50-2	3I >>>	●	●	●	●
Earth-fault protection, low-set stage	51N	Io>	●	●	●	●
Earth-fault protection, high-set stage	50N-1	Io>>	●	●	●	●
Non-directional earth-fault protection, instantaneous stage	50N-2	Io>>>	●	●	●	●
Three-phase thermal protection for feeders, cables and distribution transformers	49	3Ith>	-	●	●	●
Phase discontinuity protection	46PD	I_2/I_1>	-	●	●	●
Negative-sequence overcurrent protection	46	I_2>	-	-	●	●
Under current protection	37	3I<	-	●	●	●
Circuit breaker failure protection	51BF/51NBF	3I>/Io>BF	-	●	●	●
Three phase transformer inrush detectors	68	3I2f>	●	●	●	●
Cold load pick up (working along with breaker status and current value)	62CLD	CLP	-	-	-	●
Master trip	86	Master Trip	●	●	●	●
Two setting group			●	●	●	●
Control (Functionality available in REF601)						
Breaker control functionality	I <-> O CB	I <-> O CB	●	●	●	●
Auto-reclosing	79	O -> I	-	-	●	●
Logic gates and timers			-	-	-	●

Table 2. Supported functions, continue

Functionality	Related products		REJ601 / REF601	REJ601 / REF601	REJ601 / REF601	REF601
	ANSI	IEC	B	C	D	F
Condition monitoring						
Trip circuit supervision	TCM	TCS	●	●	●	●
Breaker operation counter			-	-	-	●
Breaker travel time			-	-	-	●
Breaker inactive time			-	-	-	●
Accumulated currents power (Iyt), phase A, B, C			-	-	-	●
Measurement						
Three-phase current measurement	3I	3I	●	●	●	●
Residual current measurement	In	Io	●	●	●	●
Negative phase sequence current	I_2	I_2	-	-	●	●
Thermal level	ϑ	ϑ	-	●	●	●
Operation counter	-	-	●	●	●	●
Demand values - Maximum and minimum current	-	-	●	●	●	●
Disturbance recorder	RDRE	DR	-	-	-	●
Other						
AND, OR, NOT gates	-	-	-	-	-	●
Time delay ON, Time delay OFF	-	-	-	-	-	●

● = Included

The relay is delivered from the factory with default configuration as indicated in the functional diagram for binary inputs, binary outputs, function to function connection and alarm LEDs.

The configuration can be altered by LHMI (local human-machine interface) and using signal matrix in PCM600 if needed.

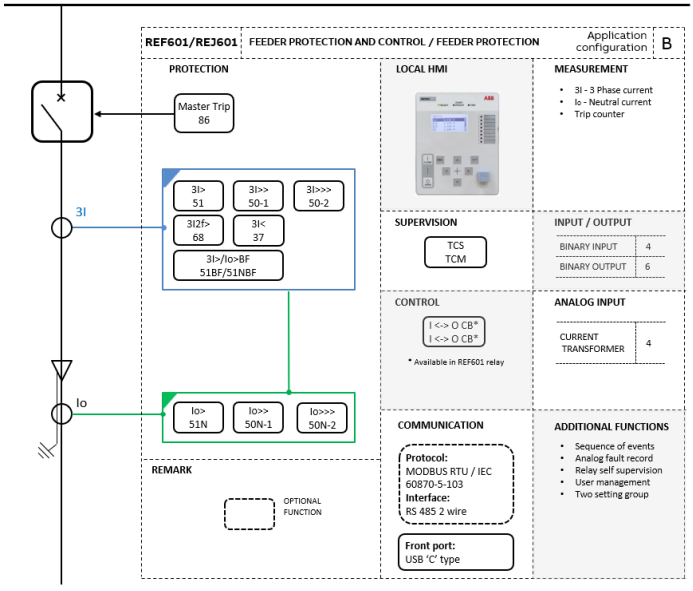

Figure 1. Functionality overview for REJ601/REF601 standard configuration B with current transformer inputs

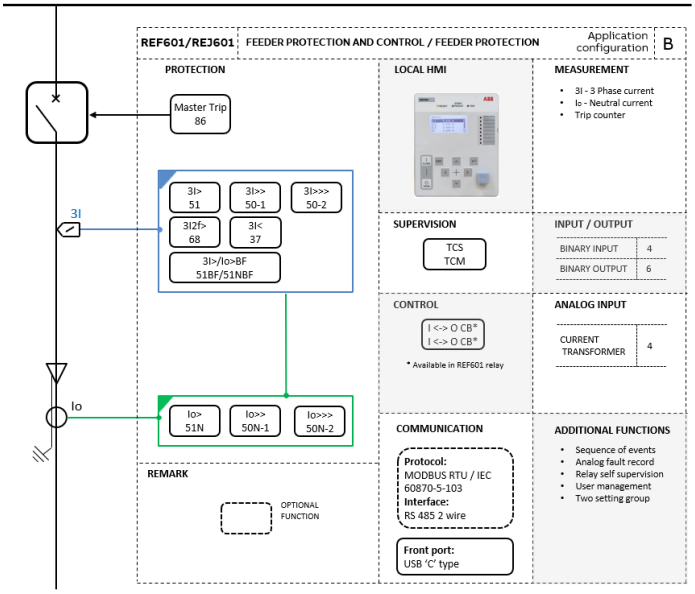

Figure 2. Functionality overview for REJ601/REF601 standard configuration C with sensor inputs

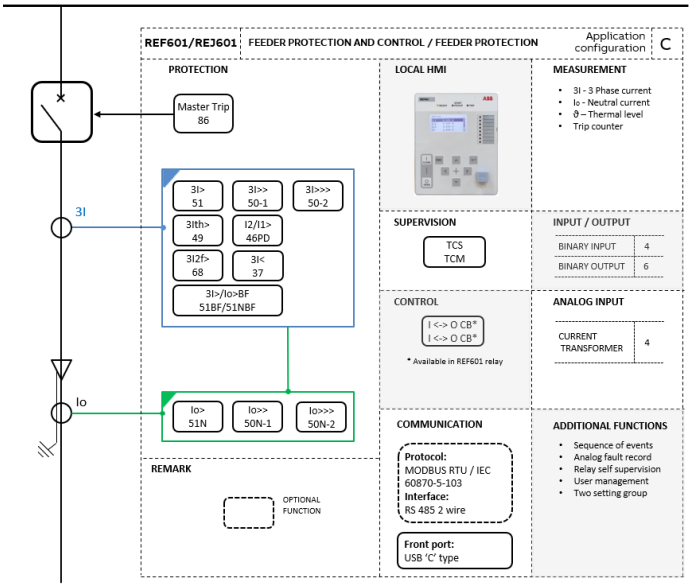

Figure 3. Functionality overview for REJ601/REF601 standard configuration C with current transformer inputs

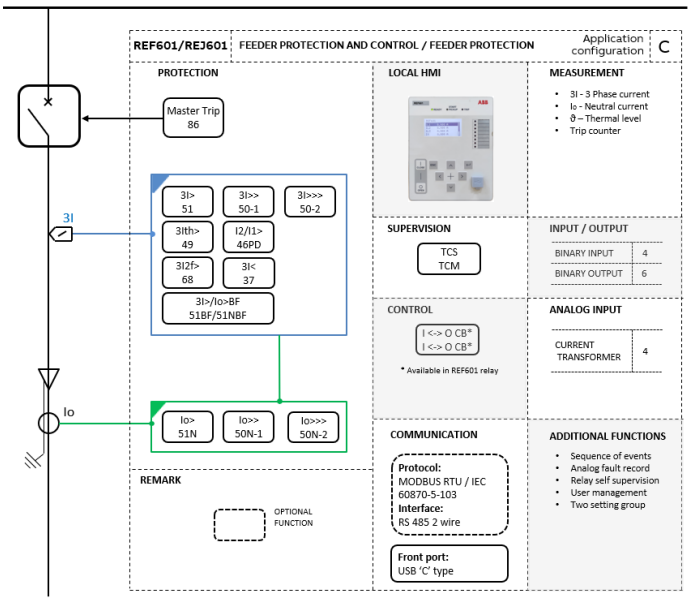

Figure 4. Functionality overview for REJ601/REF601 standard configuration C with sensor inputs

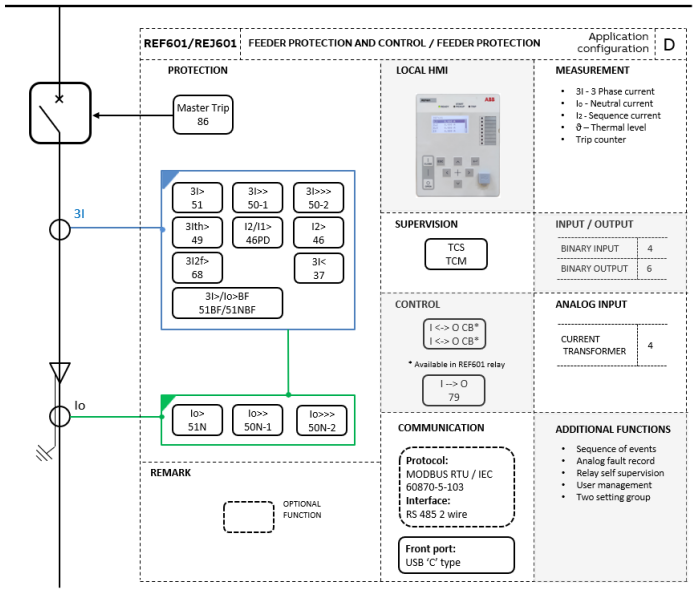

Figure 5. Functionality overview for REJ601/REF601 standard configuration D with current transformer inputs

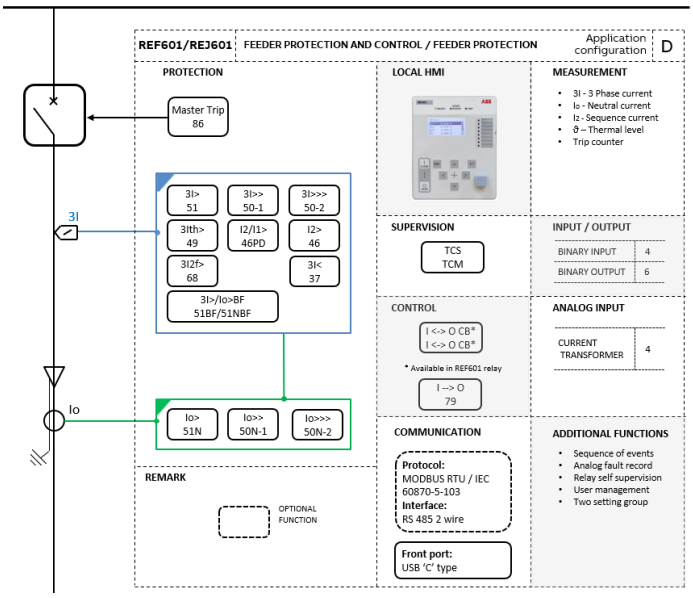

Figure 6. Functionality overview for REJ601/REF601 standard configuration D with sensor inputs

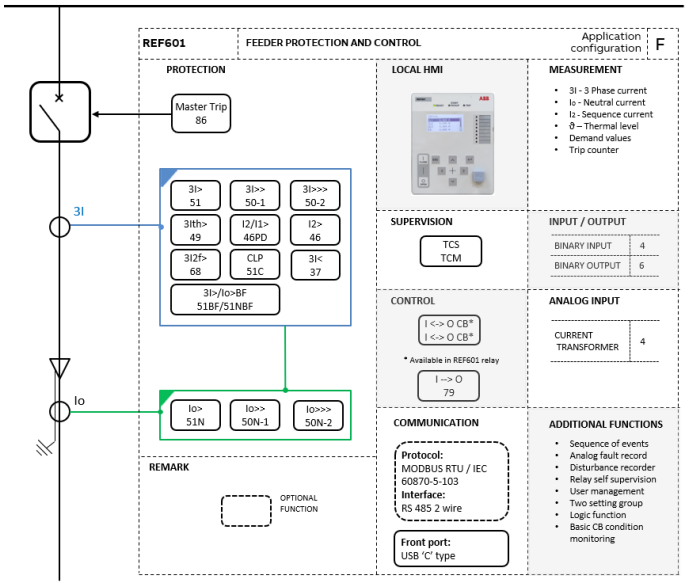

Figure 7. Functionality overview for REF601 standard configuration F with current transformer inputs

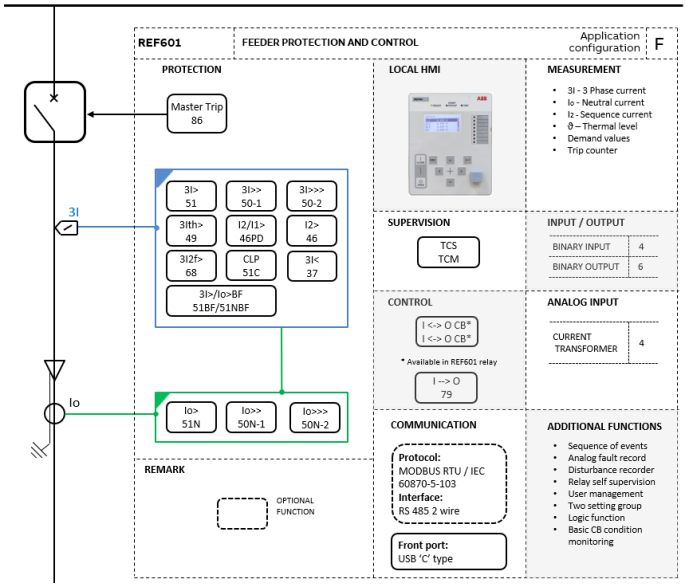

Figure 8. Functionality overview for REF601 standard configuration F with sensor inputs

3. Protection functions
REF601/REJ601 offers three-stage three phase overcurrent and three-stage earth-fault protection functions. The transformer inrush detector function is incorporated to prevent unwanted tripping's due to energizing of transformers.

The low-set stage for overcurrent and earth-fault protection are equipped with selectable characteristics – Definite time (DT) and Inverse definite minimum time (IDMT).

The relay features standard IDMT characteristics according to IEC 60255-3 and ANSI C37.112, Normal Inverse (NI), Very Inverse (VI), Extremely Inverse (EI), Long-time Inverse (LI) respective Moderate inverse, Normal Inverse, Very inverse, Extremely inverse and a special characteristic RI inverse (RI) for better co-ordination with rest of the network.

Further relay offers thermal overload protection for feeder, cable and transformer, negative phase sequence protection, phase discontinuity protection, under current protection and circuit breaker failure protection. Relay also has feature of auto-reclose function for overhead line feeders.

Cold load pick up function ensures stabilization of protection by blocking or raising settings when circuit breaker is re-closed after short period of opening with load configuration such that heavy load current during re-closing.

4. Application
The REF601/REJ601 is a protection relay aimed at protection and control of incoming and outgoing feeders in MV distribution substations. The relay can be applied for the short-circuit, over current and earth-fault protection of overhead lines and cable feeders of distribution and sub-distribution network.

The inrush current stabilization function allows the relay to be used as main protection of distribution transformers. The relay with application configuration B offers, non-directional over current and earth-fault protection. 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. Application comprises of additional under current protection functionality.

The application configuration C additionally offers thermal overload protection for feeders, cables and transformers, phase discontinuity protection and circuit breaker failure protection.

The application configuration D provides functionality with incorporation of negative phase sequence protection and multi shot auto-reclose functionality making relay suitable for overhead line feeders.

The application configuration F provides functionality with cold-load pick up, logical gates and timers, breaker condition monitoring, demand values for current measurement and disturbance recorder functionality.

5. Optimized for limited space
With its compact size and unique technical features, REF601 / REJ601 is an ideal relay for retrofits, compact switchgears and switchgear with limited space. The relay has small mounting depth and does not have any loose mounting accessories, while the press-fit mounting arrangement makes it suitable for quick and easy installation on switchgear.

6. Control
The relay offers control of one circuit breaker via front panel HMI or by means of remote control for opening and closing. It includes two dedicated outputs for breaker control. The breaker control in via remote is possible through optional MODBUS or IEC 60870-5-103 communication.

7. Measurement
The relay continuously measures phase currents and earth current. Earth current can be measured using external core balance current transformer or can be calculated internally.

During service, the default view of display shows all thee phase current and earth current in primary terms (Amps). The values measured can be accessed locally via the user interface on the relay or remotely via the communication interface of the relay.

The relay continuously measures negative sequence current, thermal level and counter values if these functions are supported as per application configurations.

The relay also calculates the demand values of the current over user selectable pre-set time frame.

8. Event log
To collect sequence – of – events (SoE) information, the relay incorporates a non-volatile memory with a capacity of storing 250 events with associated time stamps with resolution of 1 ms. Event log includes trip circuit supervision status, protection operation status, binary I/O status and relay fault code. The event logs are stored sequentially, the most recent being first and so on. The non-volatile memory retains its data also in case the relay temporarily loses its auxiliary supply.

The event log facilitates detailed post-fault analysis 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.

9. Recorded data

The relay stores fault records of analogue values for last twenty trip events in non-volatile memory. The fault recording is triggered by the trip signal of protection function. Each fault record includes the current values for three phases and earth current of five different instances along with time stamp. These records enable the user to analyze the five most recent power system events.
The relay records the number of phase and earth fault trip events into dedicated trip counters. These trip counters cannot be reset by the user and are stored in non-volatile memory.

The recorded information can be accessed locally via user interface on the relay front panel and can be uploaded for subsequent fault analysis.

10. Disturbance recorder

The relay is provided with disturbance recorder featuring up to 4 analog and 16 digital channels. The analog channels are set to record current waveforms. The triggering of disturbance record can be done through external or internal relay signals like protection start, trip, and remote trip etc. There is provision of manual triggering of the recording.

The recorded information is stored in COMTRADE format with date and time stamping in a non-volatile memory and can be uploaded from front USB port for subsequent fault analysis.

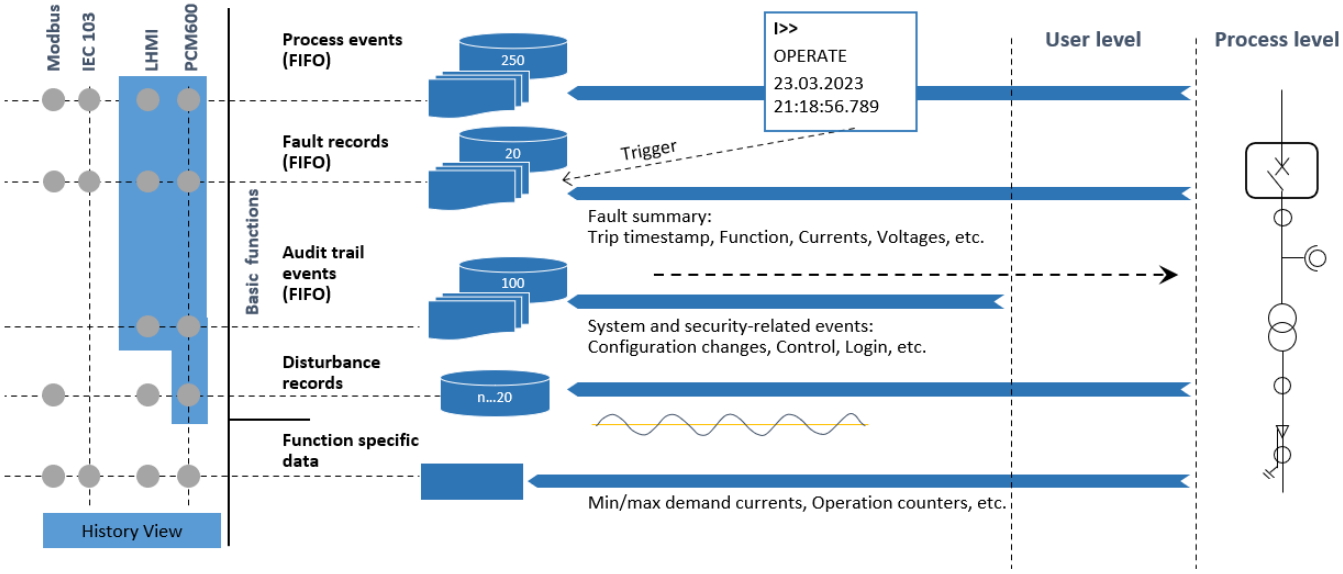

Figure 9: Recording and event capability overview

11. Self-supervision and test function

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.

The relay supports a built-in test mode which enables user to test the protection functions, relay HMI and binary outputs.

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. Condition monitoring

The condition monitoring function of relay continuously monitors the condition of circuit breaker. The monitoring comprises of breaker travel time, breaker inactive time, accumulated currents power for each phases and breaker trip counter.

14. Access control and cybersecurity

Cybersecurity measures are implemented to secure safe operation of the protection and control functions. The relay supports these measures with configuration hardening capabilities, encrypted communication, security event logging and user access control.

To protect the relay from unauthorized access and to maintain the integrity of information, the relay is armed with a three level, role-based user authentication system with individual password for the operator, engineer and administrator level. There is availability of 2 different password protection, one which is a combination of different navigation keys which is default one and other with Alpha-numeric password. User can select either of password depending on their requirement.

15. Local HMI

Local HMI of relay contains LCD display, LED indicators and navigation keys. The measurement, recorded data, events, setting can be viewed in display. The relay has three fixed LED indications on LHMI for ready / IRF, protection start and protection trip. Relay has eight freely configurable LED indications which can be configured for various internal and external signals like phase fault trip, earth fault trip and trip circuit fault indications etc. Display supports built in multiple languages.

16. Inputs and outputs

The relay with conventional CT variant is equipped with four 1A and 5A analog current inputs, three for phase current and one for earth current measurement.

As an alternate option, the relay with sensor variant is equipped with three Rogowski sensor inputs along with an additional earth-current input suitable for a 1A which can be connected to core-balanced current transformer /spit core current transformer. More details of sensor provided in "Section 15 - Sensor technology".

The relay has four binary inputs. The binary inputs can be configured for various functions like Blocking, Protection reset, Breaker position, Breaker control and trip circuit supervision. In turn these signals can be mapped at binary output and LEDs for indications. Individual input can be configured either as "Inverted" or "Non Inverted".

The relay has six output contacts, two power outputs and four signaling outputs. The output contacts can be configured for different functions like routing of protection start / trip signals, external trip /open, external close command, trip circuit supervision status etc. One dedicated output contact is available for Unit ready / IRF status indication.

17. Sensor technology

Sensors based on Rogowski coil principle have been introduced in order to get benefit of improved performance like saturation of conventional current transformer and equipment size reduction. ABB is offering two types of sensors - KECA and KEVCR which employs the Rogowski coil principle for measurement of current. Albeit this principle is far from new, now it is possible to exploit the advantages of sensor with the advent of numerical relays like REF601.

Rogowski coil is a toroidal coil without an iron core, placed around the primary conductor in the same way as the secondary winding in a current transformer. However, the output signal from Rogowski coil is not current, but a voltage. Due to absence of ferromagnetic core, the sensor is linear up to the highest currents.

The wide measurement range of sensors with high accuracy eliminates the need for high variants of conventional instrument transformers, resulting in simplified engineering, logistics and reduced inventory. The low level voltage signals and integrated secondary cables contribute to easy and fast installation with enhanced safety.

All binary input and output contacts are pre-con-figured according to default configuration, however can be easily reconfigured by using the LHMI menu.

18. Communication

The relay is available with optional communication feature with Modbus RTU protocol or IEC 60870-5-103 on RS-485 bus with two wire connection. This allows relay to connect to control and monitoring system through serial communication for remote monitoring.

19. Application warning

In case the relay REF601 / REJ601 is supplied with UPS step-wave or square-wave, an interposing transformer is needed to keep the supply voltage (peak voltage) below the upper limit of the relay.

These are the recommended transformer characteristics:

- Nominal Power: 20 VA
- Secondary voltage: in the range 30...150 V AC

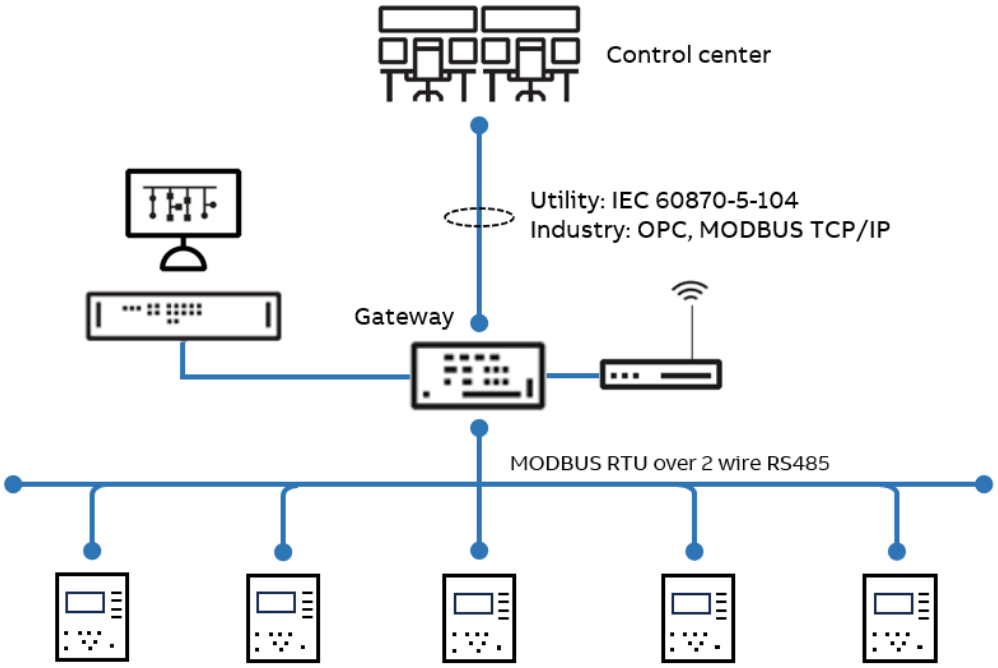

Figure 10: Communication example using REF601 relays

Table 3. Relay input / output overview

Relay type	Analog channels		Binary channels	
	CT	Sensor	Binary input	Binary output
REF601 sensor variant	1	3	4	6
REJ601 CT variant	4	-	4	6
REF601 CT variant	4	-	4	6

20. Technical data

Table 4. Relay input / output overview

Description	Value	
Width	Frame	130.0 mm
	Case	121.5 mm
Height	Frame	160.0 mm
	Case	151.5 mm
Depth	CT variant	151.4 mm
	Sensor variant	101.5 mm
Weight	CT variant	1.45 kg
	Sensor variant	1.25 kg

Table 5. Power supply

Description	Value
Nominal auxiliary voltage U_n	24…240 V AC, 50 and 60 Hz
	24…240 V DC
Auxiliary voltage variation	85…110% of U_n (20.4…264 V AC)
	80…120% of U_n (19.2…288 V DC)
Burden of auxiliary voltage supply under quiescent (Pq)/ operating condition	DC <3.5 W, AC < 5.0 VA
Maximum interruption time in auxiliary DC voltage without resetting the relay	50 ms at U_n
Ripple in the DC auxiliary voltage	Max 15% of the DC value (at frequency of 100 Hz)

Table 6. Energizing inputs (Conventional CT variant)

Description		Value
Rated frequency		50/60 Hz
Current inputs	Rated current, I_n	1/5 A
	Thermal withstand capability:	
	• Continuous	20 A
	• For 1 s	500 A
	Dynamic current withstand:	
	• Half-wave value	1250 A
	Input impedance	<20 mΩ

Table 7. Energizing inputs (Sensor variant)

Description		Value		
Rated frequency		50/60 Hz ± 5 Hz		
Phase sensor inputs	Input type	Rogowski coil sensor		
Phase sensor inputs	Rated current, I_n	80 A	240 A	250 A
	Base value, I_r	12.8, 25.6, 80, 400, 750, 1000, 1250, 1500, 1750	40, 80, 250, 1250, 1750, 2000, 2500, 3000, 3500	40, 80, 250, 1250, 1750, 2000, 2500, 3000, 3500
	Rated transformation ratio, Kra	50Hz: 80A / 0.15V 60Hz: 80A / 0.18V	50Hz: 240A / 0.15V 60Hz: 240A / 0.18V	50Hz: 250A / 0.15V 60Hz: 250A / 0.18V
Earth current inputs	Input type	Current transformer		
	Rated current, I_n	1 A		
	Thermal withstand capability:			
	• Continuous	4 A		
	• For 1 s	100 A		
	Dynamic current withstand:			
	• Half-wave value	250 A		
	Input impedance	<100 mΩ		

Table 8. Binary input

Description	Value
Rated voltage	24…240 V AC, 50 and 60 Hz
	24…240 V DC
Operating range	85…110% of U_n (20.4…264 V AC)
	80…120% of U_n (19.2…288 V DC)
Current drain	2…20 mA
Power consumption per input	< 0.5 W
Input sensing time	25 ms
Trip-circuit supervision (TCS): (BI2) Control voltage range Current drain through the supervision circuit Minimum voltage over the TCS contact	 48...250 V AC / DC ~ 1.5 mA 20V AC / DC (15...20 V)

Table 9. Double-pole power output (XK2:BO1, BO2)

Description	Value
Rated voltage	240 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

Table 10. Signal output and IRF output (XK2:BO3, BO4, BO5, BO6)

Description	Value
Rated voltage	240 V AC / DC
Continuous contact carry	6 A
Make and carry for 3.0 s	8 A
Make and carry for 0.5 s	10 A
Breaking capacity when the control-circuit time constant L/R<40 ms, at 35/220 V DC	4 A / 0.15 A
Minimum contact load	100 mA at 24 V AC/DC

Table 11. Serial interface (available as ordering option)

Type	Connector
RS485	3 pin connector, 1 = A, 2=B, 3=GND

Table 12. USB interface

Type	Location	Connector	Rate
USB, type C	Front	USB 2.0 and USB 3.0 compatible	240 Mbits/s (max.)

Table 13. Degree of protection of relay

Description	Value
Front side	IP 54
Rear, side and terminal	IP 20

Table 14. Environmental conditions

Description	Value
Operating temperature range	-25...+70ºC (continuous)
Short-time service temperature range	-40...+85ºC
Relative humidity	Up to 95%, non-condensing
Atmospheric pressure	86...106 kPa
Altitude	Up to 2000 m
Transport and storage temperature range	- 40...+85ºC

Table 15. Electromagnetic compatibility tests

Description	Type test value	Value
Slow Damped Oscillatory Waves Test (Burst disturbance test)	1 MHz and 100 kHz	IEC 61000-4-18
• Common mode	2.5 kV	IEC 60255-26
• Differential mode	1.0 kV	
Fast Damped Oscillatory Waves Test (Burst disturbance test)	3 MHz, 10 MHz and 30 MHz	IEC 61000-4-18
• Common mode	2.0 kV	IEC 60255-26
Electrostatic discharge test		IEC 61000-4-2
• Contact discharge	6 kV	IEC 60255-26
• Air discharge	8 kV	
Radiated radiofrequency electromagnetic field test	f = 80 MHz...6 GHz	IEC 61000-4-3
	10 V/m (rms), AM 80%, 1kHZ	IEC 60255-26
	f = 80...2700 MHz	IEEE C37.90.2-2004
	10 V/m	
	f = 900 MHz	
	10 V/m (rms)	
	f = 1.85 GHz	
Conducted disturbance induced by radio frequency fields test	f = 150 kHz...80 MHz, AM 80%, 1 kHz 10 V (rms)	IEC 60255-26 IEC 61000-4-6
Fast transient disturbance test		IEC 61000-4-4
• Communication	4 kV	IEC 60255-26
• Other ports	4 kV	
Surge immunity test		IEC 61000-4-5
• Communication / Shielded cables	1 kV, line-to-earth	IEC 60255-26
• Other ports	2 kV, line-to-line; 4 kV line to earth	
Power frequency (50 Hz) magnetic field immunity test		
• Continuous	100 A/m	IEC 61000-4-8
• 1...3 s	1000 A/m	IEC 60255-26
Pulse magnetic field immunity test	1000 A/m	IEC 61000-4-9
	6.4/16 µs	
Damped oscillatory magnetic field immunity test		IEC 61000-4-10
• 2 s	100 A/m	
• 100 kHz	40 transients/s	
• 1 MHz	400 transients/s	
Voltage dips and short interruptions	0%/50 ms Criterion A	IEC 61000-4-11
	40%/200 ms Criterion C	IEC 61000-4-29
	70%/500 ms Criterion C	IEC 60255-26
	0%/5000 ms Criterion C	
Power frequency immunity test	Binary inputs only	IEC 61000-4-16
• Common mode	300 V rms	IEC 60255-26, class A
• Differential mode	150 V rms	
Ripple on DC input power port test	15 % of rated DC value	IEC 60255-26 IEC 61000-4-17

Table 15. Electromagnetic compatibility tests, continue

Description	Type test value	Value
Gradual shutdown/start-up test	Shut-down ramp 60s Power off 5 min Start-up ramp 60s	IEC 60255-26
Emission tests		IEC 60255-26
• Conducted		CISPR 32, class A
0.15. 0.50 MHz	<79 dB (µV) quasi peak	
	<66 dB (µV) average	
0.5...30 MHz	<73 dB (µV) quasi peak	
	<60 dB (µV) average	
Emission tests		
• Radiated		IEC 60255-26
30...230 MHz	<40 dB (µV/m) quasi peak, measured at 10 m distance	CISPR 11, class A
230...1000 MHz	<47 dB (µV/m) quasi peak, measured at 10 m distance	

Table 16. Safety related tests

Description	Type test value	Value
Overvoltage category	III	IEC 60255-27
Pollution degree	3	IEC 60255-27
Insulation class	Class I	IEC 60255-27
Leakage current	Evaluated / tested	IEC 60255-27
Clearance and creepage	Evaluated	IEC 60255-27
Accessible parts test	Tested	IEC 60255-27
IP rating	IP 54, Front side IP20, Rear and Side	IEC 60255-27 IEC 60529
Dielectric tests	2 kV, 50 Hz, 1 min 500 V, 50 Hz, 1 min for communication / shielded cables	IEC 60255-27
Impulse voltage test	5 kV, 1.2/50 µs, 0.5 J 1 kV, 1.2/50 µs, 0.5 J for communication / shielded cables	IEC 60255-27 IEEE C37.90-2005
Insulation resistance measurements	>1 MΩ, 500 V DC	IEC 60255-27
Protective bonding resistance	<0.1 Ω, 20 A, 60 s	IEC 60255-27
Maximum temperature of parts and materials	Tested	IEC 60255-27
Flammability of insulating materials, components and fire enclosures	Evaluated / Tested	IEC 60255-27
Reverse polarity and slow ramp test	Tested	IEC 60255-27
Resistance to mechanical stress test	IK 06	IEC 60255-27
Marking durability test	Tested	IEC 60255-27
Thermal short time test	Tested (See chapter Energizing inputs for test values)	IEC 60255-27
Output relay, make and carry tests	Tested	IEC 60255-27 IEC 60255-1
Single-fault condition	Tested	IEC 60255-27

Table 17. Mechanical tests

Description	Type test value	Value
Vibration tests (sinusoidal)	Class 2	IEC 60255-21-1
Shock and bump test	Class 2	IEC 60255-21-2
Seismic test	Class 2	IEC 60255-21-3

Table 18. Environmental tests

Description	Type test value	Value
Dry heat test	• 96 h at +70°C	IEC 60068-2-2
	• 16 h at +85°C	IEC 60255-1
Dry cold test	• 96 h at -25°C	IEC 60068-2-1
	• 16 h at -40°C	IEC 60255-1
Damp heat cyclic test	• 6 cycles (12 h + 12 h) at +25…+55°C, humidity >93%	IEC 60068-2-30 IEC 60255-1
Damp heat steady state test	10 days at + 40°C, humidity 93%	IEC 600068-2-78 IEC 60255-1
Change of temperature test	• 5 cycles (3 h + 3 h) at -25...+55°C	IEC60068-2-14 IEC 60255-1
Storage test	• 96 h at -40°C	IEC 60068-2-1
	• 96 h at +85°C	IEC 60068-2-2

Table 19. Product safety

Description	Value
LV directive	EMC Directive 2014/30/EU Low Voltage Directive 2014/35/EU RoHS Directive 2011/65/EU RoHS Directive 2015/863/EU amending Annex II WEEE directive 2012/19/EU
Standard	EN 60255-27 EN 60255-1

Table 20. EMC compliance

Description	Value
EMC directive	2014/30/EU
Standard	EN 60255-26

Table 21. RoHS compliance

Description	Value
Complies with RoHS Directive 2011/65/EU and the amended EU Directive 2015/863/EU	

Protection functions

Table 22. Three phase non-directional overcurrent protection main settings

Parameter	Function	Value (Range)	Step
Start value	Low-set overcurrent (I> / 51)		
	• CT variant	0.05…2.50 x I_n	0.001
	• Sensor variant	0.10…2.50 x I_n	0.001
	High-set overcurrent (I>> / 50-1)		
	• CT variant	0.20…25.0 x I_n	0.001
	• Sensor variant	0.20…20.0 x I_n	0.001
	Instantaneous overcurrent (I>>>/50-2)		
	• CT variant	0.20…25.0 x I_n	0.001
	• Sensor variant	0.20…20.0 x I_n	0.001
Time multiplier	Low-set overcurrent (I> / 51)	0.02…1.6	0.01
Operate delay time	Low-set overcurrent (I> / 51)	0.040…64.0 sec	0.01
	High-set overcurrent (I>> / 50-1)	0.040…64.0 sec	0.01
	Instantaneous overcurrent (I>>>/50-2)	0.030…64.0 sec	0.01
Operation curve type	Low-set overcurrent (I> / 51)	Definite time or inverse time IEC 60255-3: Normal inverse, Very inverse, Extremely inverse, Long-time inverse ANSI C37.112: Moderate inverse, Normal Inverse, Very inverse, Extremely inverse Special curves: RI inverse	
	High-set overcurrent (I>> / 50-1)	Definite time or Instantaneous	
	Instantaneous overcurrent (I>>>/50-2)	Definite time or Instantaneous	
Start value multiplier	Low-set overcurrent (I> / 51)	0.8…10.0	0.1
	High-set overcurrent (I>> / 50-1)	0.8…10.0	0.1
	Instantaneous overcurrent (I>>>/50-2)	0.8…10.0	0.1

Table 23. Three phase non-directional overcurrent protection accuracy

Description	Function	Value		
Operation accuracy	Low-set overcurrent (I> / 51)	Depending on the frequency of the current measured: fn ±2 Hz		
	• CT variant	±1.5% of the set value or ±0.004*I_n		
	• Sensor variant	±4% of the set value or ±0.020*I_n		
	High-set overcurrent (I>> / 50-1)			
	• CT variant	±1.5% of the set value or ±0.004*I_n		
	• Sensor variant	±2% of the set value or ±0.020*I_n		
	Instantaneous overcurrent (I>>> / 50-2)			
	• CT variant	±1.5% of the set value or ±0.004*I_n		
	• Sensor variant	±2% of the set value or ±0.020*I_n		
Start time [1) 2)]		Minimum	Typical	Maximum
	Instantaneous overcurrent (I>>> / 50-2)			
	• I_{Fault} = 2 × set *Start value*	25 ms	20 ms	38 ms
	• I_{Fault} = 10 × set *Start value*	15 ms	19 ms	25 ms
	Low-set overcurrent (I> / 51) and High-set overcurrent (I>> / 50-1)			
	• I_{Fault} = 2 × set *Start value*	25 ms	29 ms	34 ms
Reset time		Typically 40 ms		
Reset ratio	• CT variant	Typically 0.92 to 0.98		
	• Sensor variant	Typically 0.92 to 0.98		
Operate time accuracy in definite time mode		± 1.0% of the set value or ±40 ms		
Operate time accuracy in inverse time mode [3) 4)]	• CT variant	± 5.0% of the set value or ±50 ms		
	• Sensor variant	± 5.0% of the set value or ±50 ms		

1) Measurement mode = default (depends on the stage), current before fault = 0.0 × I_n, f_n = 50 Hz, fault current in one phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact (SO)
3) Maximum Start value = 2.5 × In, Start value multiples in the range of 1.2...20 for CT Variant
4) Maximum Start value = 2.5 × In, Start value multiples in the range of 2...20 for Sensor Variant

Table 24. Three phase non-directional earth-fault protection main settings

Parameter	Function	Value (Range)	Step
Start value	Low-set earth-fault (Io> / 51N)		
	• External measurement	0.01…2.00 x I_n	0.001
	• Internal measurement	0.10…2.00 x I_n	0.001
	High-set earth-fault (Io>> / 50N-1)		
	• External measurement	0.05…12.5 x I_n	0.001
	• Internal measurement	0.50…12.5 x I_n	0.001
	Instantaneous earth-fault (Io>>>/50N-2)		
	• External measurement	0.05…12.5 x I_n	0.001
	• Internal measurement	0.50…12.5 x I_n	0.001
Time multiplier	Low-set earth-fault (Io> / 51N)	0.02…1.6	0.01
Operate delay time	Low-set earth-fault (Io> / 51N)	0.040…64.0 sec	0.01
	High-set earth-fault (Io>> / 50N-1)	0.040…64.0 sec	0.01
	Instantaneous earth-fault (Io>>>/50N-2)	0.040…64.0 sec	0.01
Operation curve type	Low-set earth-fault (Io> / 51N)	Definite time or inverse time IEC 60255-3: Normal inverse, Very inverse, Extremely inverse, Long-time inverse ANSI C37.112: Moderate inverse, Normal Inverse, Very inverse, Extremely inverse Special curves: RI inverse	
	High-set earth-fault (Io>> / 50N-1)	Definite time or Instantaneous	
	Instantaneous earth-fault (Io>>>/50N-2)	Definite time or Instantaneous	
Start value multiplier	Low-set earth-fault (Io> / 51N)	0.8…10.0	0.1
	High-set earth-fault (Io>> / 50N-1)	0.8…10.0	0.1
	Instantaneous earth-fault (Io>>>/50N-2)	0.8…10.0	0.1

Table 25. Three phase non-directional earth-fault protection accuracy

Description	Function	Value		
Operation accuracy	Low-set earth-fault (Io> / 51N), High-set earth-fault (Io>> / 50N-1) and Instantaneous earth-fault (Io>>>/50N-2)	Depending on the frequency of the current measured: fn ±2 Hz		
	• External measurement (CT)	±1.5% of the set value or ±0.004*I_n		
	• Internal measurement (Sensor)	±4% of the set value or ±0.03*I_n		
	• Internal measurement (CT)	±1.5% of the set value or ±0.004*I_n		
Start time [1) 2)]		Minimum	Typical	Maximum
	Instantaneous earth-fault (Io>>> / 50N-2)			
	• I_{Fault} = 2 × set *Start value*	29 ms	34 ms	38 ms
	• I_{Fault} = 10 × set *Start value*	15 ms	19 ms	25 ms
	Low-set earth-fault (Io> / 51N) and High-set earth-fault (Io>> / 50N-1)			
	• I_{Fault} = 2 × set *Start value*	29 ms	34 ms	39 ms
Reset time		Typically 40 ms		
Reset ratio	• CT variant	Typically 0.92 to 0.98		
	• Sensor variant	Typically 0.92 to 0.98		
Operate time accuracy in definite time mode	• External measurement	± 1.0% of the set value or ±40 ms		
	• Internal measurement	± 1.0% of the set value or ±40 ms		
Operate time accuracy in inverse time mode[3) 4)]	• CT variant	± 5.0% of the set value or ±50 ms		
	• Sensor variant	± 5.0% of the set value or ±50 ms		

1) Measurement mode = default (depends on the stage), current before fault = 0.0 × I_n, f_n = 50 Hz, fault current in one phase with nominal frequency injected from random phase angle, results based on statistical distribution of 1000 measurements
2) Includes the delay of the signal output contact (SO)
3) Maximum Start value = 2.5 × In, Start value multiples in the range of 1.2...20 for CT Variant
4) Maximum Start value = 2.5 × In, Start value multiples in the range of 2...20 for Sensor Variant

Table 26. Negative sequence overcurrent protection main settings

Parameter	Function	Value (Range)	Step
Start value	Negative sequence protection, I2> / 46	0.10…1.50 x I_n	0.01
Time multiplier		0.02…1.6	0.01
Operate delay time		0.1…300 s	0.1
Operation curve type		Definite time or inverse time IEC 60255-3: Normal inverse, Very inverse, Extremely inverse, Long-time inverse ANSI C37.112: Moderate inverse, Normal Inverse, Very inverse, Extremely inverse Special curves: RI inverse	
Start value multiplier		0.8…10.0	0.1

Table 27. Negative sequence overcurrent protection accuracy

Description	Function	Value		
Operation accuracy	NPS, I2> / 46 • Current transformer • Sensor	Depending on the frequency of the current measured: fn ±2 Hz ±1.5% of the set value or ±0.004*I_n ±2% of the set value or ±0.02*I_n		
Start time [1) 2)]		Minimum	Typical	Maximum
	NPS, I2> / 46 • I_{Fault} = 2 × set *Start value* • I_{Fault} = 10 × set *Start value*	 40 ms 20 ms	 46 ms 26 ms	 50 ms 28 ms
Reset time		Typically 40 ms		
Reset ratio	• CT variant • Sensor variant	Typically 0.92 to 0.98 Typically 0.92 to 0.98		
Operate time accuracy in definite time mode		± 1.0% of the set value or ±40 ms		
Operate time accuracy in inverse time mode		± 5.0% of the set value or ±50 ms		

Table 28. Phase discontinuity protection main settings

Parameter	Function	Value (Range)	Step
Start value	PDN, I2/I1> / 46PD	10…100 %	1
Operate delay time	PDN, I2/I1> / 46PD	0.1…64 s	0.1

Table 29. Phase discontinuity protection accuracy

Description	Function	Value
Operation accuracy	PDN, I2/I1> / 46PD • Current transformer • Sensor	Depending on the frequency of the current measured: fn ±2 Hz ±2.5% of the set value ±5.0% of the set value
Start time		Typically 72 ms
Reset time		Typically 40 ms
Reset ratio	• CT variant • Sensor variant	Typically 0.92 to 0.99 Typically 0.92 to 0.99
Operate time accuracy		± 1.0% of the set value or ±30 ms

Table 30. Under current protection main settings

Parameter	Function	Value (Range)	Step
Start value	PTUC 3I< / 37	0.12…0.80 x I_n	0.01
Operate delay time	PTUC 3I< / 37	0.4…30 s	0.1

Table 31. Under current protection accuracy

Description	Function	Value
Operation accuracy	PTUC 3I< / 37 • Current transformer • Sensor	Depending on the frequency of the current measured: fn ±2 Hz ±3.0% of the set value or ±0.004*I_n ±3.0% of the set value or ±0.01*I_n
Start time		Typically 40 ms
Reset time		Typically 40 ms
Reset ratio		Typically 0.100 to 0.104
Operate time accuracy		± 1.0% of the set value or ±30 ms

Table 32. Three-phase thermal protection for feeders, cables and distribution transformers main settings

Parameter	Function	Value (Range)	Step
Env Tmp Set	TOL 3Ith>F / 49F	-50…100 ° C	1.0
CurRef Stat	TOL 3Ith>F / 49F	0.05...4.00 x I_n	0.01
Temp Rise	TOL 3Ith>F / 49F	0.0...200 ° C	0.1
Time Const	TOL 3Ith>F / 49F	60...60000 s	1.0
Max Temp	TOL 3Ith>F / 49F	20.0...200 ° C	0.1
Alm Val	TOL 3Ith>F / 49F	20.0...150 ° C	0.1
ReCls Tmp	TOL 3Ith>F / 49F	20.0...150 ° C	0.1
Cur Mult	TOL 3Ith>F / 49F	1...5	1.0
Initial Tmp	TOL 3Ith>F / 49F	-50…100 ° C	0.1

Table 33. Three-phase thermal protection for feeders, cables and distribution transformers accuracy

Description	Function	Value
Operation accuracy	TOL 3Ith>F / 49F • Current transformer • Sensor	Depending on the frequency of the current measured: fn ±2 Hz ±1.5% of the set value or ±0.004*I_n ±5.0% of the set value or ±0.02*I_n
Operate time accuracy		± 10.0% of the set value or ±0.5 s

Table 34. Cold load pick up function main settings

Parameter	Function	Value (Range)	Step
Auto Ini	CLP / 62CLD	0 = Disable; 1= Enable	
DeEnerg Tm	CLP / 62CLD	1…180 min	1.0
CLP Dur	CLP / 62CLD	0.04...3600 s	0.001
Min Cur Lvl	CLP / 62CLD	0.05…1.00 x I_n	0.01

Table 35. Cold load pick up function main accuracy

Description	Function	Value
Operation accuracy	CLP / 62CLD • Current transformer • Sensor	Depending on the frequency of the current measured: fn ±2 Hz ±5.0% of the set value or ±0.002*I_n ±5.0% of the set value or ±0.02*I_n
Operate time accuracy		± 1.0% of the set value or ± 60 ms

Table 36. Three phase Inrush detection main settings

Parameter	Function	Value (Range)	Step
Inrush threshold value	Inrush 3I2f> / 68 • Current transformer • Sensor	 0.20...25.0 x I_n 0.20...20.0 x I_n	0.01
Start value	Inrush 3I2f> / 68	05…50%	5%

Table 37. Three phase Inrush detection accuracy

Description	Function	Value
Operation accuracy	Inrush 3I2f> / 68 • Current transformer • Sensor	Depending on the frequency of the current measured: fn ±2 Hz ±1.5% of the set value or ±0.02*I_n ±5.0% of the set value or ±0.02*I_n
Reset time		± 40 ms
Reset ratio	• CT variant • Sensor variant	Typically 0.96 Typically 0.94
Operate time accuracy		± 55 ms

Table 38. Circuit breaker failure protection main settings

Parameter	Function	Value (Range)	Step
Earth Type	CBFP 3I>/Io>BF / 51/51NBF	1 = External; 2= Internal	
Icbfp	CBFP 3I>/Io>BF / 51/51NBF	0.2…2.0 x I_n	0.10
Iocbfp	CBFP 3I>/Io>BF / 51/51NBF	0.1…2.0 x I_n	0.10
t Retrip	CBFP 3I>/Io>BF / 51/51NBF	0.06...0.50 s	0.01
t Backup	CBFP 3I>/Io>BF / 51/51NBF	0.06...0.50 s	0.01

Table 39. Circuit breaker failure protection accuracy

Description	Function	Value
Operation accuracy	CBFP 3I>/Io>BF / 51/51NBF • Current transformer • Sensor	Depending on the frequency of the current measured: fn ±2 Hz ±1.5% of the set value or ±0.002*I_n ±5.0% of the set value or ±0.02*I_n
Reset time		± 40 ms
Operate time accuracy		± 1.0 % of the set value or ± 40 ms

Control functions

Table 40. Auto reclosing main settings

Parameter	Function	Value (Range)	Step
Auto reclose initialization mode	Auto reclosing O -> I / 79	1 = Trip, 2 = Gen. start and trip	
Type of CB ready signal available, 'CB ready'		1 = OCO, 2 = CO	
Number of Auto reclose shots, 'Shot' (0 = Auto-reclose not in use)		0…4	
Activate t		0.1…5 s	0.1
Auto reclose pulse time, 'Pulse tp'		0.2…20 s	0.1
Dead time for first auto reclose shot, 'Cycle t1'		0.2…300 s	0.01
Dead time for second auto reclose shot, 'Cycle t2'		0.2…300 s	0.01
Dead time for third auto reclose shot, 'Cycle t3'		0.2…300 s	0.01
Dead time for fourth auto reclose shot, 'Cycle t4'		0.2…300 s	0.01
Reclaim time, 'Reclaim tr'		1…300 s	1.00
Auto reclosure block time, 'Block tb'		1…300 s	1.00

Table 41. Auto reclosing main accuracy

Description	Function	Value
Operate time accuracy	Auto reclosing O -> I / 79	± 1.0 % of the set value or ± 50 ms

Measurement functions

Table 42. Three-phase current measurement

Description	Function	Value
Operation accuracy	Three-phase current measurement	Depending on the frequency of the current measured: fn ±5 Hz
	• Current transformer	± 0.6% or ± 0.002*I_n for frequency 50 Hz, ± 1.5% or ±0.007*I_n for frequency ±5 Hz (in the range of 0.05…12xIn)
	• Sensor	± 5.0% or ± 0.02*I_n

Table 43. Residual current measurement

Description	Function	Value
Operation accuracy	Residual current measurement	Depending on the frequency of the current measured: fn ±2 Hz
	• Current transformer	± 0.6% or ± 0.002*I_n for frequency 50 Hz, ± 1.5% or ±0.007*I_n for frequency ±5 Hz (in the range of 0.01…3xIn)
	• Sensor	± 5.0% or ± 0.02*I_n

Condition monitoring functions

Table 44. Circuit-breaker condition monitoring

Description	Function	Value
Operation accuracy	Circuit breaker condition monitoring	Depending on the frequency of the current measured: fn ±2 Hz
	• Current transformer	± 1.5% or ±0.002*I_n for frequency ±5 Hz (in the range of 0.05…12xIn)
	• Sensor	± 5.0% or ± 0.02*I_n
Operate time accuracy		± 1.0 % of the set value or ± 40 ms

21. Local HMI

The relay is available with 5-line display providing more user-friendly front panel interface. The LCD display offers front-panel user interface functionality with menu navigation and menu views.

Relay six navigation buttons, three number fixed LEDs for Ready, Protection Start and Protection Trip indication, eight programmable LED indications. Through front C type USD port, it is possible to connect relay with PC with PCM600 software. Relay having control function support (REF601, REM601) has a setting for local/remote operation of the relay which can be defined from either the LHMI or PCM600. When the relay is in the local mode, it can be operated only by using the local front panel user interface. When the relay is in the remote mode, it can execute commands sent from a remote location. Depending on the relay configuration, the selection of the local/remote mode can be made via a binary input. This feature facilitates, for example, the use of an external switch at the substation to ensure that all relays are in the local mode during maintenance work and that the circuit breakers cannot be operated remotely from the network control center.

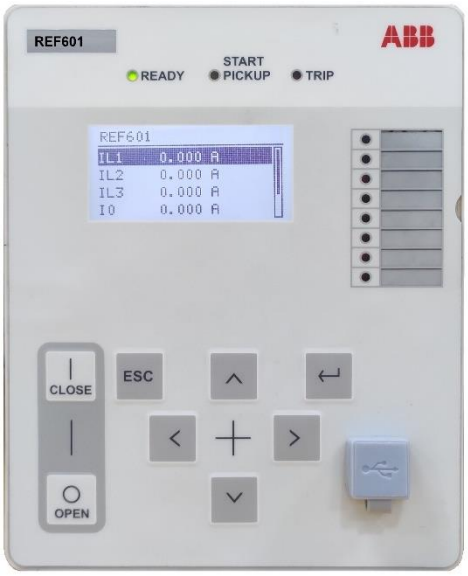

Figure 11. Relay local HMI

Table 45. HMI display

Character size	Rows in the view	Character per row
LCD display of relay	5	20

22. Dimension and mounting

The REF601/ REJ601 have been equipped with in-built press-fit mechanism. Without using any additional mounting accessories, the REF601/REJ601 can be easily flush mounted on the panel.

With appropriate mounting accessories the REF601/ REJ601 can be mounted on the circuit breakers type VD4 / HD4.

The panel cut-out for flush mounting:

- Height: 151.5 ± 0.5 mm
- Width: 121.5 ± 0.5 mm
- Thickness of panel: 2.0 – 3.0 mm

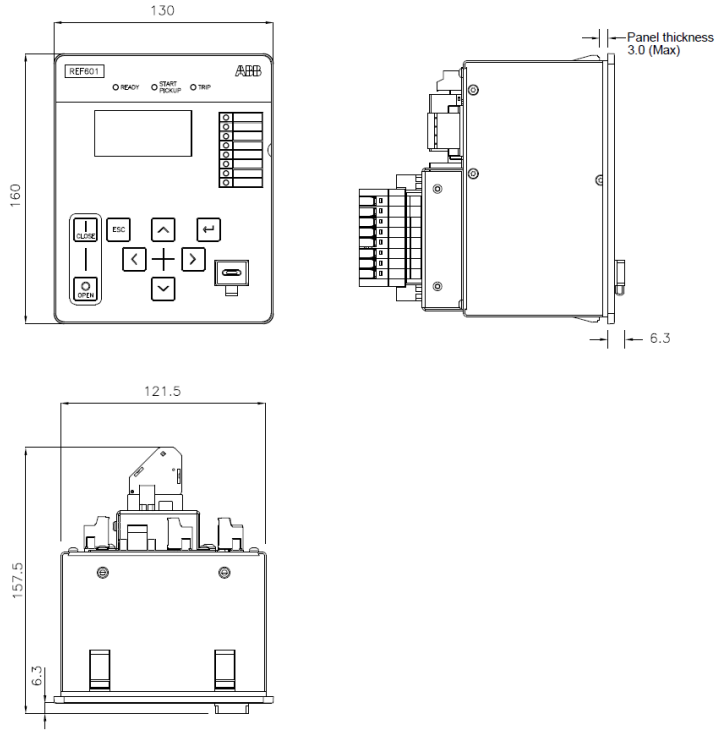

Figure 12: Dimension of relay – Flush mounting CT variant

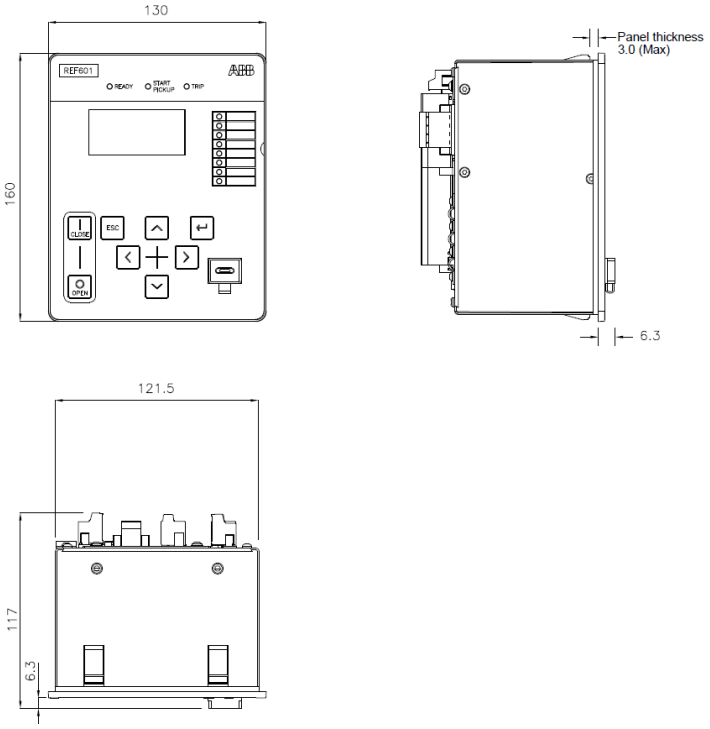

Figure 13: Dimension of relay – Flush mounting Sensor variant

23. Selection and ordering data

The relay type and serial number label identifies the protection relay. An order number label is placed on the side of the relay. The order number consists of a string of codes generated from hardware and software modules of relay.

The serial number and order number label is placed on side of relay.

Use the ordering key information in Figure 15 to generate the order number when ordering complete protection relay.

Example code			REF601	B	F4	46	D	B	1	N	K
#	**Description**										
1	**Relay type**										
	Feeder protection with control	**REF601**									
	Feeder protection	REJ601									
2	**Standard**										
	ANSI	A									
	IEC	**B**									
	Chinese	C									
	CEI	J									
3,4	**Analog input / output**										
	3 sensor and ground current input	A4									
	Phase and Earth current input – 1 & 5A	**F4**									
5,6	**Binary input / output**										
	4 BI + 6 BO	**46**									
7	**Serial communication**										
	MODBUS RTU and IEC60870-5-103 with RS485 two wire	**D**									
	None	N									
8	**Application configuration**										
	Configuration B	B									
	Configuration C	C									
	Configuration D	D									
	Configuration F	**F**									
9	**Power supply**										
	24...240V AC / DC	**1**									
10	**Configuration**										
	Disconnecting Ring lug terminals with CT shorting	B									
	Disconnecting Screw terminals with CT shorting or Sensor	**N**									
11	**Version**										
	Product version 2.5	K									

Example order code: REF601 B F4 46 DF 1 N K

Your ordering code:

Digit (#)	**1-6**	**7**	**8 9**	**10 11**	**12**	**13**	**14**	**15**	**16**
Code									

Figure 14: Ordering key for complete relay

24. Accessories and ordering data

Table 46. Accessories

Item	Order number
RE_601 communication card	CIM601BNNNNBANXH

Table 47. Compatible sensors

Item	Order number
KEVCR for integrated circuit-breakers type VD4/HD4	KEVCR24OC2R0101, 630A KEVCR24AC2R0102, 1250A
KECA for other applications where relay is panel mounted. For more information please refer to the catalogue reference no. 1VLC000584.	KECA 250 B1 KECA 80 C85, KECA 80 D85

Figure 15: Outline view of KEVCR and KECA sensor

25. Tools

The protection relay is delivered with the correct protection and control functionality included but if needed configuration can be changed to fit in the needed application. The default parameter setting values can be changed from the LHMI or Protection and Control IED Manager PCM600 in combination with the relay-specific connectivity package.

PCM600 offers extensive relay configuration functions and setting parameterization.

The relay connectivity package is a collection of software and specific relay information which enables system products and tools to connect and interact with the protection relay. The connectivity packages reduce the risk of errors in system integration, minimizing device configuration and setup times.

Table 48. Tools

Item	Order number
PCM600	2.13 or later
Relay connectivity package	2.5 or later

Table 49. Supported functions by PCM600

Function	PCM600
Relay parameter setting	●
Saving of relay parameter settings in the relay	●
Signal monitoring	●
Disturbance recorder handling	●
Alarm LED viewing	●
Access control management	●
Relay signal configuration (Signal Matrix)	●
Saving of relay parameter settings in the tool	●
XRIO parameter export/import	●
Event viewing	●
Saving of event data on the user's PC	●

● = Supported

26. Terminal diagram

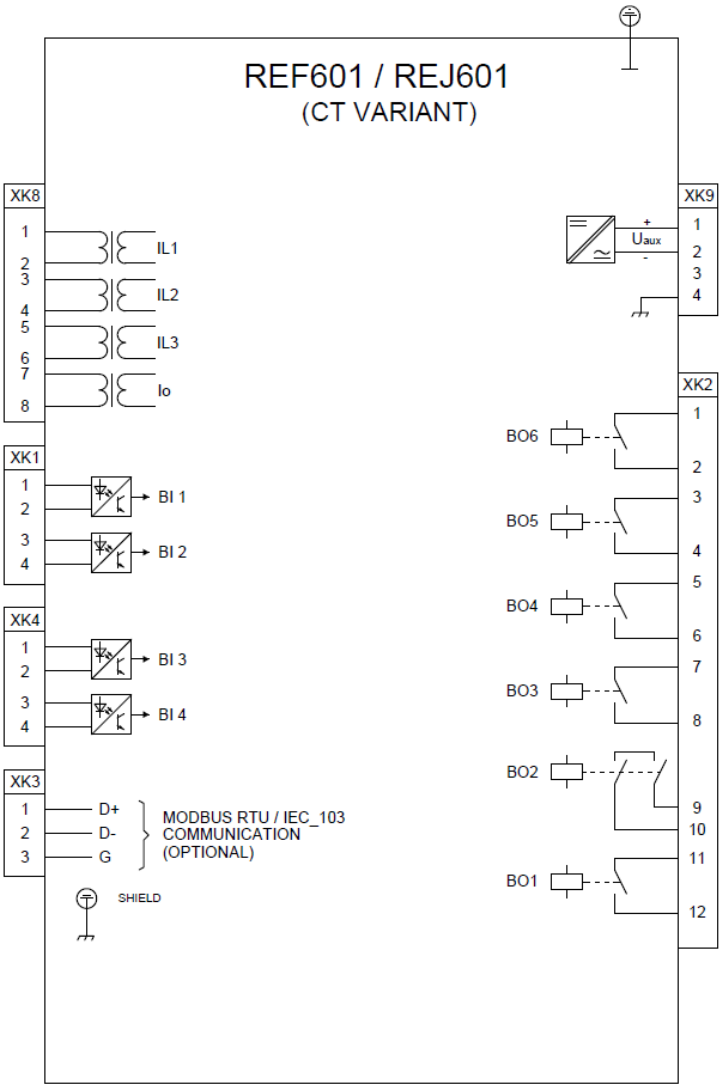

Figure 16: Terminal diagram of REF601/REJ601 for CT variant

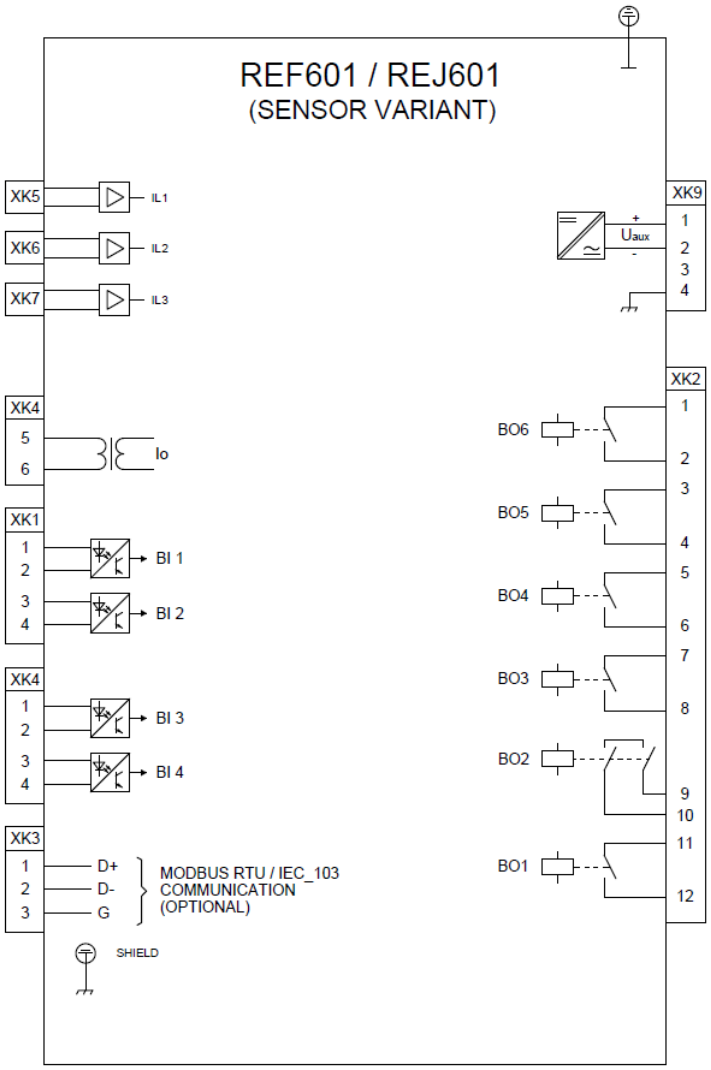

Figure 17: Terminal diagram of REF601/REJ601 for Sensor variant

27. Certificates

Certificates can be found on the product page.

28. References

The www.abb.com/substationautomation portal provides information on the entire range of distribution automation products and services.

The latest relevant information on the REF601 / REJ601 protection and control relay is found on the product page. Scroll down the page to find and download the related documentation.

29. Document revision history

Table 50. Accessories

Document revision	Product version	History
A/2012-08-15	2.1	REF601/REJ601 with CT release
B/2013-03-28	2.2	Common version for REF601 /REJ601 CT and REF601 Sensor variant
C/2014-03-31	2.2 FP1	Content updated to include features of additional functions
D/2024-06-08	2.5	Content updated to include features of additional functions of new release

ABB India Limited
Distribution Solutions
Digital Substation Products
Maneja Works, Maneja,
Vadodara, Gujarat
India 390 011

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1MDB07212-YN D