



Relion® 605 series

# Feeder protection and control REF601 Product Guide

Power and productivity  
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Feeder Protection	1MDB07207-YN
REF601	
Product version: 2.0	

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<b>REF601</b>	
<b>Product version: 2.0</b>	<b>Issued: 2012-03-27</b>
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## 1. Description

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

The relay uses the Rogowski coil sensors for current measurement. The new feeder protection relay is designed to unleash the advantages of current sensors for protection and control in medium voltage applications.

## 2. Relay functions

REF601 offers pre-configured functionality which facilitates easy and fast commissioning of switchgear. To emphasize the relay's simplicity of usage, only application specific parameters need to be set within the relay's intended area of application.

The settings can be changed by LHMI (local human-machine interface) or through optional communication interface MODBUS master with setting capability.

The relay offers protection, control, measurement and condition monitoring functionality.

Table 1. Supported functions of REF601

Functionality	IEC	ANSI
<b>Protection</b>		
Non-directional overcurrent protection, low-set stage	3I>	51
Non-directional overcurrent protection, high-set stage	3I>>	50-1
Non-directional overcurrent protection, very high-set stage	3I>>>	50-2
Earth-fault protection, low-set stage	Io>	51N
Earth-fault protection, high-set stage	Io>>	50N
Three phase transformer inrush detector	3I <sub>2f</sub> >	68
<b>Control</b>		
Circuit-breaker control	I <-> O CB	I <-> O CB
<b>Condition monitoring</b>		
Trip circuit supervision	TCS	TCM
<b>Measurement</b>		
Three-phase current measurement	3I	3I
Residual current measurement	Io	In

### 3. Protection functions

REF601 offers three-stage phase segregated overcurrent and two-stage earth-fault protection functions. The transformer inrush detector function is incorporated to prevent unwanted trippings due to energizing of transformers.

The low-set stages 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 – Normal Inverse (NI), Very Inverse (VI), Extremely Inverse (EI), Long-time Inverse (LI) and a special characteristic RI inverse (RI) for better co-ordination with rest of the network protection.

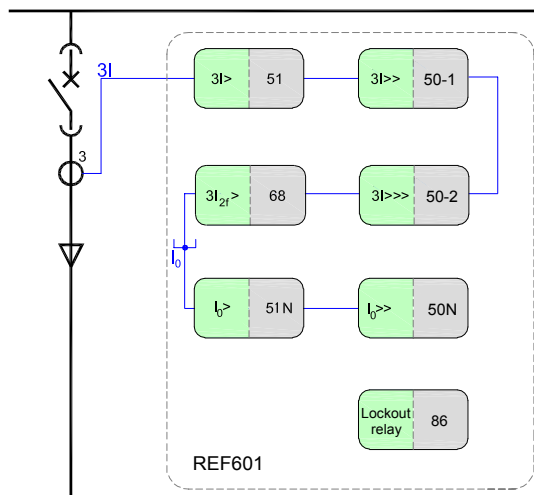


Figure 1. Protection function overview of REF601 with earth current measurement by internal calculation

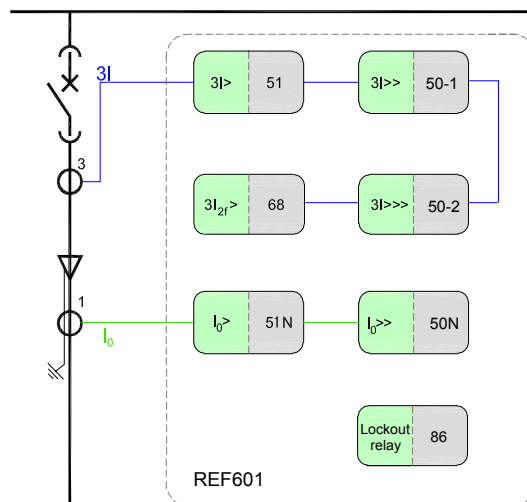


Figure 2. Protection function overview of REF601 with earth current measurement by external core-balance current transformer

### 4. Application

The REF601 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 relay is well-matched for mounting on the ABB circuit breakers VD4 & HD4. Along with sensors, it will be a part of ABB's offering of integrated apparatus. 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 panels too.

### 5. 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 employ 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

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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.

## 6. Control

The relay offers control of one circuit breaker with dedicated push-buttons and guidance on local HMI for opening and closing. It includes two dedicated outputs for breaker control. The breaker control is also possible through optional MODBUS 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 the most loaded phase current in primary terms (Amps) and the earth current in terms of nominal value of CT. The values measured can be accessed locally via the user interface on the relay or remotely via the communication interface of the relay.

To maintain the measurement accuracy of the overall protection system, the sensor calibration constants available on the rating plate of sensors can be programmed to the relay.

## 8. Event log

To collect sequence-of-events (SoE) information, the relay incorporates a non-volatile memory with a capacity of storing 100 events with associated time stamps with resolution of 1 milli second. 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 analog values for two trip events in non-volatile memory. The fault recording is triggered by the trip signal of protection function. A sample of analog value is recorded for every power frequency cycle. Fifteen such samples are recorded, five before the trip and ten after the trip event. These records enable the user to analyze the two most recent power system events. Each record includes the current values for three phases and earth current.

The relay records the number of phase and earth fault trip events into dedicated trip counters. These trip counters can not 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. 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 relay HMI and trip outputs.

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### 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. 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. The password is a combination of different navigation keys.

### 13. Inputs and outputs

The relay is equipped with three Rogowski sensor inputs. The relay has an additional earth-current input suitable for a 1A which can be connected to core-balanced current transformer /split core current transformer.

Relay binary input/output overview:

- Two binary inputs one for remote-trip and one for remote-reset
- One normally open trip output, with trip circuit supervision functionality
- One normally-closed trip output
- Two signalling outputs one for phased over-current fault and one for earth fault
- One breaker close output
- Unit ready / IRF output
- LED indication for Ready/IRF, Protection start, protection trip, Phase fault and Earth fault trip, Trip circuit fault

### 14. Communication

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

### 15. Application warning

In case the relay REF601 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

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## 16. Technical data

Table 2. Dimensions

Description	Value	
Width	frame	130.0 mm
	case	121.5 mm
Height	frame	160.0 mm
	case	151.5 mm
Depth	case	102.0 mm (92 + 10 mm)
Weight	relay	1.2 kg

Table 3. Power supply

Description	Value
U <sub>aux</sub> nominal	24...240 V AC, 50 and 60 Hz
	24...240 V DC
U <sub>aux</sub> variation	85...110% of U <sub>aux</sub> (20.4...264 V AC)
	70...120% of U <sub>aux</sub> (16.8...288 V DC)
Burden of auxiliary voltage supply under quiescent (P <sub>q</sub> )/operating condition	< 12.0 VA
Ripple in the DC auxiliary voltage	Max 12% of the DC value (at frequency of 100 Hz)
Maximum interruption time in auxiliary DC voltage without resetting the relay	50 ms at U <sub>aux</sub> rated

Table 4. Energizing inputs

Description		Value
Rated frequency		50/60 Hz ± 5 Hz
Phase sensor inputs	Input type:	Rogowski coil sensor
	Rated transformation ratio, K <sub>ra</sub>	250A / 0.15V at 50Hz
		250A / 0.18V at 60Hz
Earth current input	Linear current measurement	4A - 25 kA
	Input type	Current transformer
	Rated current, I <sub>n</sub>	1A
	Linear current measurement	0.5- 12.5 x I <sub>n</sub>
	Thermal withstand capability:	
	• Continuously	4 A
	• For 1 sec	100 A
	Dynamic current withstand:	
	• Half-wave value	250 A
Input impedance		< 100 m Ω

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Table 5. Binary input

Description	Value
Rated voltage	24...240 V AC / DC
Operating range	85...110% of $U_{aux}$ for AC and 70...120% of $U_{aux}$ for DC
Current drain	2...20 mA
Power consumption / input	< 0.5 W
Input sensing time	100 ms

Table 6. Double-pole power output relay with TCS function (Trip 2 output - Normally open, pulsed contact)

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
Trip-circuit supervision (TCS):	
• Control voltage range	48...250 V AC / DC
• Current drain through the supervision circuit	~ 1.5 mA
• Minimum voltage over the TCS contact	20V AC / DC (15...20 V)

Table 7. Single-pole power output relay (Trip 1 output - Normally closed, pulsed contact)

Description	Value
Rated voltage	240 V AC / DC
Continuous contact carry	8A
Make and carry for 3.0 s	15 A
Make and carry for 0.5 s	30 A
Breaking capacity when the control-circuit time constant $L/R < 40$ ms, at 35/220 V DC	5A / 0.2 A
Minimum contact load	100 mA at 24 V AC / DC
Pulse duration of contact operation	200 msec



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Table 8. Single-pole signal and IRF output relay (O/C and E/F Trip, Unit ready, Breaker close)

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	4A / 0.15 A
Minimum contact load	100 mA at 24 V AC / DC

Table 9. Degree of protection of relay

Description	Value
Front side	IP 43
Side with terminal connector	IP 20

Table 10. Environmental conditions

Description	Value
Operating temperature range	-25...+55°C
Short-time service temperature range	-25...+70°C (<16 h)
Relative humidity	< 93%, non-condensing
Atmospheric pressure	86...106 kPa
Altitude	up to 2000 m
Transport and storage temperature range	-40...+85°C

Table 11. Environmental tests

Description	Type test value	Reference
Dry heat test (humidity < 50% )  • Working • Storing	• 96 h at +70°C • 96 h at +85°C	IEC 60068-2-2 IEC 60068-2-48
Dry cold test  • Working • Storing	• 96 h at -25°C • 96 h at -40°C	IEC 60068-2-1 IEC 60068-2-48
Damp heat test, cyclic	• 2 cycles at +25°C...+55°C humidity > 93%	IEC 60068-2-30
Damp heat test, steady state	• 96 h at +40°C, humidity > 93%	IEC 60068-2-78

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Table 12. Electromagnetic compatibility tests

Description	Type test value	Reference
1 MHz burst disturbance test:		IEC 61000-4-12 IEC 60255-22-1, class III
<ul style="list-style-type: none"> <li>• Common mode</li> <li>• Differential mode</li> </ul>	2.5 kV, 1MHz, 400 pulses/sec 1.0 kV, 1MHz, 400 pulses/sec	
Electrostatic discharge test:		IEC 60255-22-2, class III IEC 61000-4-2
<ul style="list-style-type: none"> <li>• Contact discharge</li> <li>• Air discharge</li> </ul>	6 kV, 150 pF/330 $\Omega$ 8 kV, 150 pF/330 $\Omega$	
Radio frequency, electro-magnetic field immunity test:		IEC 60255-22-3, class III IEC 61000-4-3
	10 V/m f=80-1000 MHz 10 V/m f=80, 160, 450, 900 MHz	
Fast transient disturbance tests:		IEC 60255-22-4, class A IEC 61000-4-4
<ul style="list-style-type: none"> <li>• All ports</li> </ul>	4 kV, 5.0 kHz	
Surge immunity test:		IEC 60255-22-5 IEC 61000-4-5
<ul style="list-style-type: none"> <li>• Common mode</li> <li>• Differential mode</li> </ul>	1.0 kV, 1.2/50 $\mu$ s 0.5 kV, 1.2/50 $\mu$ s	
Immunity to conducted disturbance induced by RF:		IEC 61000-4-8
<ul style="list-style-type: none"> <li>• Continuous</li> <li>• Short duration ( 1 sec )</li> </ul>	100 A/m 1000 A/m	
Conducted radio frequency interfere tests:		IEC 60255-22-6, class III IEC 61000-4-6
	10 V f=150 KHz...80 Mhz	
Pulse magnetic field immunity tests:		IEC 61000-4-9
	1000 A/m, 6.4/16 $\mu$ s	

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**Table 13. Electromagnetic compatibility tests, continued**

Description	Type test value	Reference
Emission tests:		IEC 60255-25 EN 55011-CISPR II
• Conducted 150 kHz-0.5 MHz 0.5 MHz-30 MHz	< 66 dB ( $\mu$ V/m) < 60 dB ( $\mu$ V/m)	
• Radiated 30-230 MHz 230-1000 MHz	< 40 dB ( $\mu$ V/m) < 47 dB ( $\mu$ V/m)	

**Table 14. Insulation tests**

Description	Type test value	Reference
Dielectric test		IEC 60255-5 IEC 60255-27
• Test voltage	2 kV, 50 Hz, 1 min	
Impulse voltage test		IEC 60255-5 IEC 60255-27
• Test voltage	5 kV, 1.2/50 $\mu$ s, 0.5 J	
Insulation resistance test		IEC 60255-5 IEC 60255-27
• Isolation resistance	> 100 M $\Omega$ at 500 V DC	

**Table 15. Mechanical tests**

Description	Type test value	Reference
Vibration tests		IEC 60255-21-1, class II
• Response	10...150 Hz, 0.035 mm / 1.0 g, 1 sweep / axis	
• Endurance / Withstand	10...150 Hz, 2.0 g, 20 sweeps / axis	
Shock tests		IEC 60255-21-2, class II
• Response	10 g, 3 pulses in each direction	
• Endurance / Withstand	30 g, 3 pulses in each direction	
Bump tests		IEC 60255-21-2, class II
	20 g, 1000 bumps in each direction	

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Table 16. Product safety

Description	Type test value
LV directive	2006/95/IEC
Standard	EN 60255-27 (2005) EN 60255-1 (2009)

Table 17. EMC compliance

Description	Type test value
EMC directive	2004/108/IEC
Standard	EN 50263 (2000) EN 60255-26 (2007)

Table 18. RoHS compliance

Description
Complies with RoHS directive 2002/95/IEC

Table 19. Data communication (Optional)

Description	Type test value
Protocol	MODBUS RTU
Communication port	RS485, 2 wire

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## 17. Protection functions

Table 20. Low-set phase overcurrent protection, stage I> / 51

Parameter	Value (Range)
Setting range of pick-up current 'I >'	0.2...1.0 x I <sub>n</sub> in steps 0.025, infinite
Operation accuracy	± 5.0% of set value
Operate time delay (DMT) 't >'	0.1...1.6 sec in steps of 0.1 for B=1 0.5...8.0 sec in steps of 0.5 for B=5
Operation time accuracy	± 5.0% of set value or ± 30 msec
Operating curve type	IEC 60255-3: Normal inverse, Very inverse, Extremely inverse, Long-time inverse Special curves: RI inverse
Time multiplier setting 'k'	0.1...1.6, in steps of 0.1
Operation time accuracy	
IEC characteristics	class E(5) or ± 30 msec
RI characteristics	± 5.0% of set value or ± 30 msec
Reset ratio	IDMT : 0.96 and DT : 0.98

Table 21. High-set phase overcurrent protection, stage I>> / 50-1

Parameter	Value (Range)
Setting range of pick-up current 'I >>'	1.0...2.75 x I <sub>n</sub> in steps 0.25, infinite
Operation accuracy	± 5.0% of set value
Operation mode	Definite time
Operate time delay (DMT) 't >>'	0.1...0.45 sec in steps of 0.05
Operation time accuracy	± 5.0% of set value or ± 30 msec
Reset ratio	0.98

Table 22. Very High-set phase overcurrent protection, stage I>>> / 50-2

Parameter	Value (Range)
Setting range of pick-up current 'I >>>'	2.0...15.0 x I <sub>n</sub> in steps 1.0, infinite
Operation accuracy	± 5.0% of set value
Operation mode	Instantaneous
Operate time 't >>>'	0.05 sec
Operation time accuracy	± 15 msec
Reset ratio	0.98

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Table 23. Low-set earth-fault protection, stage  $I_0 > / 51N$

Parameter	Value (Range)
Nominal value of earth current	1 A
Measurement range	0.05...5 x $I_n$
Setting range of pick-up current ' $I_0 >$ '	External earth measurement : 0.05...0.1 x $I_n$ in steps 0.05, infinite Internal earth measurement : 0.2...1.0 x $I_n$ in steps 0.05, infinite
Operation accuracy	External earth measurement : $\pm 5.0\%$ of set value Internal earth measurement : $\pm 15.0\%$ of set value
Operate time delay (DMT) ' $t_0 >$ '	0.1...1.6 sec in steps of 0.1 for B=1 0.5...8.0 sec in steps of 0.5 for B=5
Operation time accuracy	External earth measurement : $\pm 5.0\%$ of set value or $\pm 30$ msec Internal earth measurement : $\pm 10.0\%$ of set value or $\pm 30$ msec
Operating curve type	IEC 60255-3: Normal inverse, Very inverse, Extremely inverse, Long-time inverse Special curves: RI inverse
Time multiplier setting 'k'	0.1...1.6, in steps of 0.1
Operation time accuracy	
IEC characteristics	External earth measurement : class E(5) or $\pm 30$ msec
RI characteristics	External earth measurement : class E(7.5) or $\pm 30$ msec
IEC characteristics	Internal earth measurement : $\pm 5.0\%$ of set value or $\pm 30$ msec
RI characteristics	Internal earth measurement : $\pm 10.0\%$ of set value or $\pm 30$ msec
Reset ratio	IDMT : 0.96 and DT : 0.98

Table 24. High-set earth-fault protection, stage  $I_0 >> / 50N$

Parameter	Value (Range)
Setting range of pick-up current ' $I_0 >>$ '	0.5...4.0 x $I_n$ in steps 0.25, infinite
Operation accuracy	External earth measurement : $\pm 5.0\%$ of set value Internal earth measurement : $\pm 15.0\%$ of set value
Operation mode	Definite time
Operate time delay (DMT) ' $t_0 >>$ '	0.00...0.75 sec in steps of 0.05
Operation time accuracy	External earth measurement : $\pm 5.0\%$ of set value or $\pm 30$ msec Internal earth measurement : $\pm 10.0\%$ of set value or $\pm 30$ msec For setting 0.00 msec : 45 msec
Reset ratio	0.98

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Table 25. Transformer inrush detector

Parameter	Value (Range)
Inrush threshold value	0.2...20 x I <sub>n</sub>
Ratio Setting	30%...50%

### 18. Dimensions and mounting

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

The panel cut-out for flush mouting:

- Height :  $151.5 \pm 1$  mm
- Width :  $121.5 \pm 1$  mm
- Thickness of panel : 2.0 - 3.0 mm

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

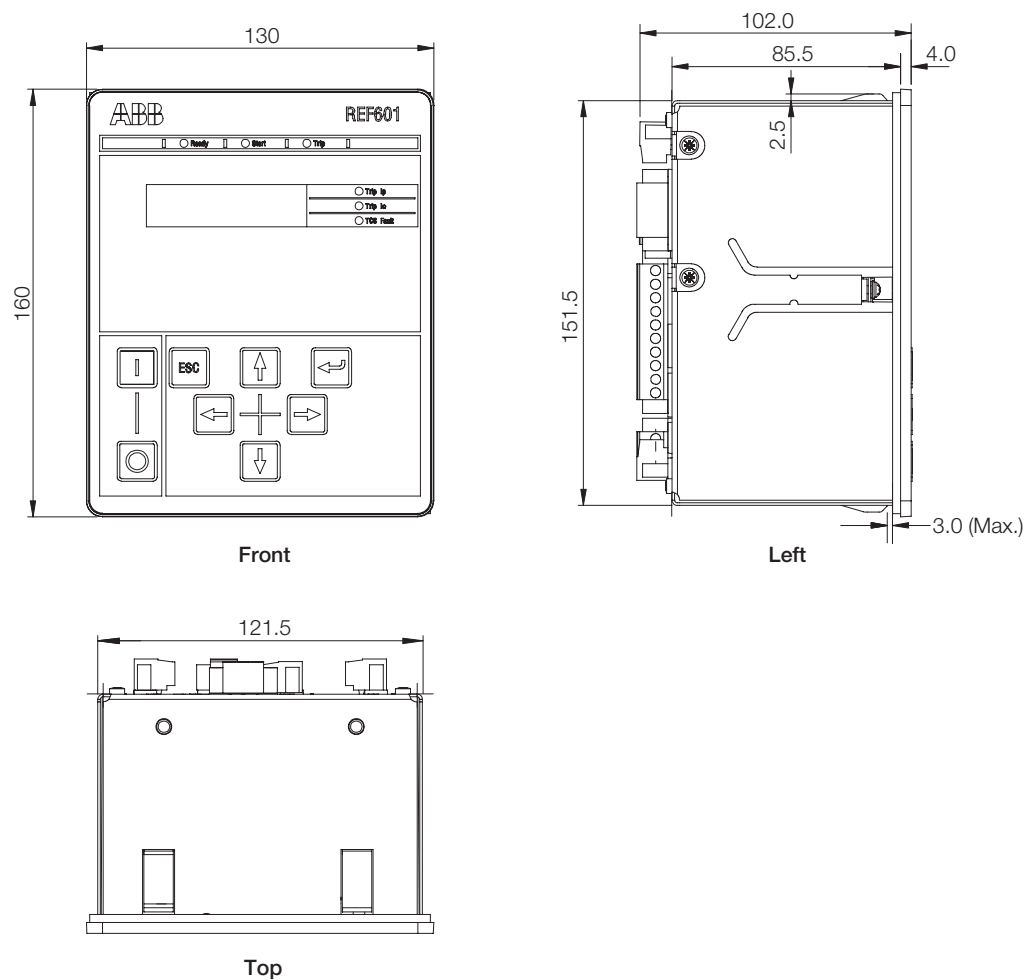


Figure 3. Dimension of REF601 - Flush mounting



Use the ordering key information in Fig. 4 to generate the order number when ordering complete protection relays.

Use the ordering key information in Fig. 4 to generate the order number when ordering complete protection relays.

REF601 B A 4 2 6 B A 1 X E

REF601 B A 4 2 6 B A 1 X E

**Your ordering code:**

[illegible]

Figure 4. Ordering key for complete relay

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## 20. Accessories and ordering data

Table 26. 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 : 1VL5400052V0101

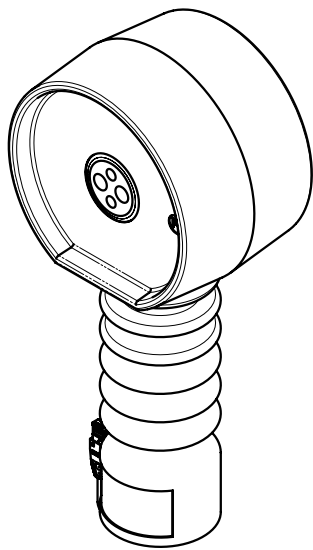


Figure 5. Outline view of KEVCR sensor

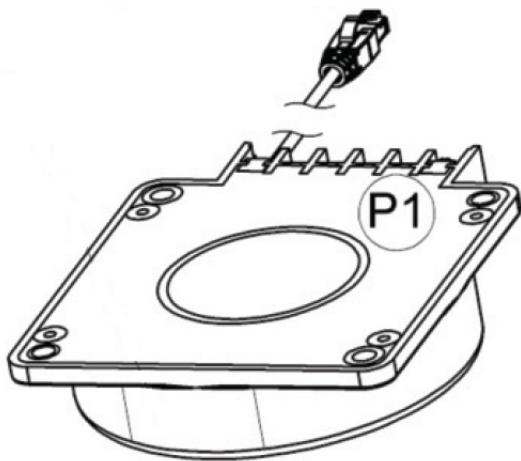


Figure 6. Outline view of KECA sensor

## 21. Terminal diagram

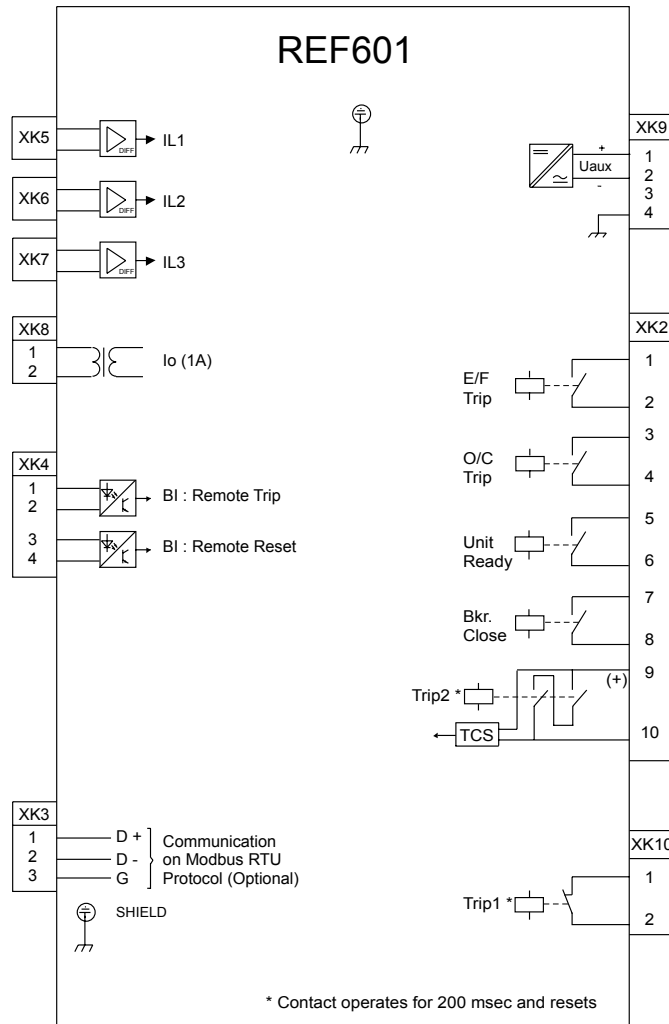


Figure 7. Terminal diagram of REF601

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## 22. References

The [www.abb.com/substationautomation](http://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 REF601 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, operator manual, and so on. 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.

## 23. Document revision history

<b>Document revision/date</b>	<b>Product version</b>	<b>History</b>
A/2009-03-20	1.0	First release
B/2009-08-21	1.0 SP	Content updated to correspond to the service pack release
C/2010-09-30	1.0 SP2	Content updated to correspond to the service pack release
D/2011-04-21	1.0 SP2	Content updated
E/2012-04-04	2.0	Content updated to correspond to the product version



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