

Feeder Protection REF601 IEC

Product Guide



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1. Description

REF601 is a dedicated feeder protection relay, intended for the protection, measurement and supervision of utility substations and industrial power systems.

Engineered from the ground up, the relay is inspired by and is compatible with the Rogowski coil sensor 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.

The low-set stages for overcurrent and earth-fault protection are equipped with selectable Definite-time (DT) and Inverse-Definite Minimum Time (IDMT) characteristics. 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.

The table below indicates the protection functions available in the relay.

2. Protection Functions

REF601 offers three-stage overcurrent and two-stage earth-fault protection functions. The transformer inrush detector function is incorporated to prevent unwarranted trippings.

Protection	IEC Code	ANSI Code
Three-phase non-directional overcurrent, low-set stage	3I >	51
Three-phase non-directional overcurrent, high-set stage	3I >>	50 / 51
Three-phase non-directional overcurrent, very high-set stage	3I >>>	50
Non-directional earth-fault, low-set stage	I ₀ >	51N
Non-directional earth-fault, high-set stage	I ₀ >>	50N/51N
Three phase transformer inrush detector	3I _{2f} >	68

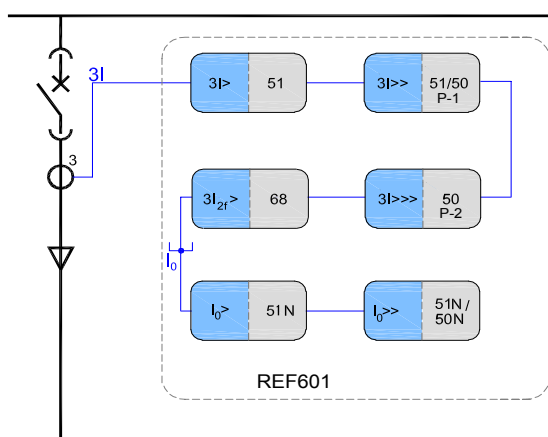


Fig. 1 Protection function overview of feeder protection REF601 with earth current measurement by internal calculation

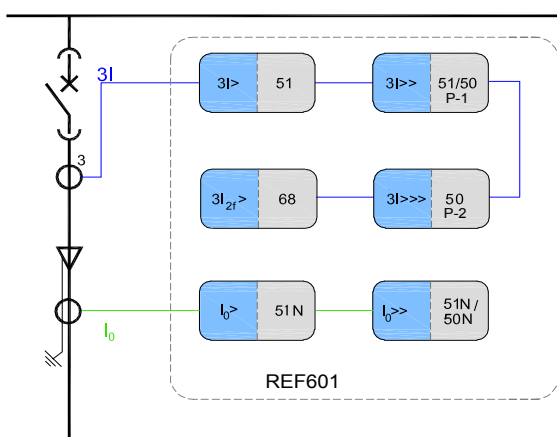


Fig. 2 Protection function overview of feeder protection REF601 with earth current measurement by external CBCT

3. 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 incoming and outgoing feeders in isolated neutral, resonant earthed, solidly earthed and resistively earthed power systems.

The relay is well-matched for mounting on the 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.

4. Sensor technology

Sensors based on alternative principles have been introduced as successors to instrument transformers in order to obtain equipment size reduction, performance improvement and better standardization. ABB's offering of two sensors, KECA and KEVCR; 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 the 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.

5. Control

The relay offers control of one circuit breaker with dedicated push-buttons for opening and closing. It includes two binary inputs and two outputs for remote breaker control.

6. Measurement

The relay continuously measures phase currents and earth current. Earth current can be measured either by internal calculation or by external core balance current transformer input. Although the sensor eliminates the need for providing CT's with various ratio's, the relay has provision for selecting either of the four nominal primary currents. Thus allowing setting to be done in terms of selected nominal primary current and gives a sense of continuity with legacy products. 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. 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.

7. Event log

To collect sequence-of-events (SoE) information, the relay incorporates a non-volatile memory to store five event logs. Each event log includes a snapshot of Analog values, 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 pre- and 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.

8. Recorded data

The relay stores 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 the user interface on the relay front panel and can be uploaded for subsequent fault analysis.

9. 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.

10. 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.

11. Inputs and outputs

The relay is equipped with three Rogowski sensor inputs. The relay has an additional earth-current input suitable for a 1A core-balanced current transformer which is normally used in applications requiring sensitive earth-fault protection.

Relay binary input/output overview:

- Four binary inputs for Remote-trip, Remote-reset, Remote-close, Remote-open
- Two trip outputs with pulsed operation, one normally-closed & one normally-open
- Two signalling outputs, one for phase over-current trip and one for earth fault trip
- One breaker close output
- Unit ready / IRF output
- LED indication for Ready/IRF, Protection start, Protection trip, Phase fault and Earth fault trip

12. Communication

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

13. Technical data

Dimensions

Width	frame	130.0 mm,
	case	121.5 mm
Height	frame	160.0 mm,
	case	151.5 mm
Depth	case	92 mm, 101 mm with terminal
Weight	relay	1.2 kg

Power Supply

U_{aux} nominal	24...240 V AC, 50 Hz 24...240 V DC
U_{aux} variation	85...110% of U_n (20.4...264 V AC) 70...120% of U_n (16.8...288 V DC)
Burden of auxiliary voltage supply under quiescent (P_q)/operating condition	< 5.0 VA
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

Energizing inputs

Rated frequency		50 Hz $\pm$ 5 Hz
Phase current inputs	Input type	Rogowski coil sensor
	Rated transformation ratio, K_{ra}	250A / 0.15V at 50Hz 250A / 0.18V at 60Hz
	Linear current measurement range	8 A - 25 kA
Earth current input	Input type	Current Transformer
	Rated current, I_n	1 A
	Burden at rated current	< 0.1 VA
	Linear current measuring range	0.05 x I_n - 5.0 x I_n
	Thermal withstand capability:	
	• Continuously • For 1 s	5 A 100 A
	Dynamic current withstand:	
	• Half-wave value	250 A

Binary inputs

Rated voltage	24...240 V AC / DC
Operating range	85...110% of Un for AC 70...120% of Un for DC
Current drain	2...20 mA
Power consumption/input	<0.5 W
Input sensing time	100 msec

Output relays

Trip1 output (Normally closed, pulsed contact)	
Rated voltage	240 V AC / DC
Continuous contact carry	8 A at 240V AC
Make and carry for 3.0 s	15 A at 24V DC
Make and carry 0.5 s	30 A at 24V DC
Breaking capacity when the control-circuit time constant L/R<40 ms, at 35 / 220 V DC	5 A/ 0.2 A
Minimum contact load	100 mA at 24 V AC / DC
Pulse duration of contact operation	200 msec

Trip2 output (Normally open, pulsed contact)	
Rated voltage	240 V AC / DC
Continuous carry	6 A at 240V AC
Make and carry for 3.0 s	8 A at 24V DC
Make and carry 0.5 s	10 A at 24V DC
Breaking capacity when the control-circuit time constant L/R<40 ms at 30 / 220 V DC	4 A/0.15 A
Minimum contact load	100 mA at 24 V AC / DC
Pulse duration of contact operation	200 msec

Signal output (O/C, E/F Trip, Unit ready, Breaker close)	
Rated voltage	240 V AC / DC
Continuous contact carry	6 A at 240V AC
Make and carry for 3.0 s	8 A at 24V DC
Make and carry 0.5 s	10 A at 24V DC
Breaking capacity when the control-circuit time constant L/R<40 ms at 30 / 220 V DC	4 A/0.15 A
Minimum contact load	100 mA at 24 V AC / DC

Protection functions

Three-phase non-directional overcurrent protection

Low-set stage I >	Setting range of pick-up current	0.2...1 x I _n in step of 0.025, infinite
	Setting range of time multiplier 'k'	0.1...1.6, in step of 0.1
	Operate time at DT mode 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
	Inverse time characteristics	IEC 60255-3: Normal inverse, Extremely inverse, Very inverse, Long time inverse Special curves: RI inverse time
	Accuracy of pick-up current	± 5% of set value
	Accuracy of operate time DMT and RI characteristic IDMT characteristic	± 5% of set value or ± 30 msec class E(5) or ± 30 msec
	Reset ratio	IDMT : 0.96 and DT : 0.98
High-set stage I >>	Setting range of pick-up current	1.0...2.75 x I _n in step of 0.25, infinite
	Operation mode	Definite time
	Operate time t >>	0.1...0.45 in step of 0.05
	Accuracy of pick-up current	± 5% of set value
	Accuracy of operate time	± 5% of set value or ± 30 msec
	Reset ratio	0.98
Very High-set stage I >>>	Setting range of pick-up current	2.0...15 x I _n in step of 1.0, infinite
	Operation mode	Instantaneous
	Operate time t >>>	30 msec
	Accuracy of pick-up current	± 5% of set value
	Accuracy of operate time	± 15 msec
	Reset ratio	0.98

Non-directional earth-fault protection

Low-set stage $I_o >$	Nominal value of earth current	1 A
	Measurement range	0.05...5 x I_n
	Setting range for External earth fault measurement	0.05...1 x I_n in step of 0.05, infinite
	Setting range for Internal earth fault measurement	0.20...1 x I_n in step of 0.05, infinite
	Setting range of time multiplier 'k'	0.1...1.6, in step of 0.1
	Operate time at DT mode to >	0.1...1.6 sec insteps of 0.1 for B=1 0.5...8.0 sec insteps of 0.5 for B=5
	Inverse time characteristics	IEC 60255-3: Normal inverse, Extremely inverse, Very inverse, Long time inverse Special curves: RI inverse time
	Accuracy of pick-up current	± 5% of set value for ext. measurement ± 15% of set value for int. measurement
	Accuracy of operate time : DMT and RI characteristic IDMT characteristic	For external measurement ± 5% of set value or ± 30 msec class E(5) or ± 30 msec For internal measurement ± 10% of set value or ± 30 msec class E(7.5) or ± 30 msec
	Reset ratio	IDMT : 0.96 and DMT : 0.98
High-set stage $I_o >>$	Setting range	0.5...4.0 x I_n in step of 0.25, infinite
	Operation mode	Definite time
	Operate time to >>	0.00...0.75 in step of 0.05
	Accuracy of pick-up current	± 5% of set value for ext. measurement ± 15% of set value for int. measurement
	Accuracy of operate time	± 5% of set value or ± 30 msec for int. measurement, ± 10% of set value or ± 30 msec for ext. measurement Note : 45 msec for setting of 0.00 msec
	Reset ratio	0.98

Transformer inrush detection

Inrush threshold value	0.2...20 x I_n
Ratio Setting	30%...50%

Degree of protection of flush-mounted relay

Front side	IP 42
Sides with connection terminal	IP 20

Environmental conditions and tests

Environmental conditions	
Operating temperature range	-25...+70°C (continuous)
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

Cold test	IEC 60068-2-1	Test Ad (working) : -25 ± 3°C for 16 hours, gradual Test Ab (storing) : -25 ± 3°C for 4 days, gradual
Dry heat test	IEC 60068-2-2	Test Bd (working) : +70 ± 2°C for 16 hours, gradual A.H. = 20 g/m = R.H. 50% a 35°C, 1°C/min Test Bb (storing) : +85 ± 2°C for 4 days, gradual
Damp heat, Steady state	IEC 60068-2-3 (replaced by : IEC 60068-2-78)	Test Cab (storing/working) : 40°C ± 2°C, 4 days R.H. controlled [93±3%]
Damp Heat, Cyclic	IEC 60068-2-30	Test Db (working): 93% humidity, 2 Cycles, From 25±3°C to 55±2°C

Mechanical tests

Vibration response test	IEC 60255-21-1	Class 2: 10 to 150Hz freq range, Cross-over freq.: 58 Hz Peak displac. (f<fco): 0.075mm Peak accel. (f>fco): 1gn No. of sweep cycles in each axis: 1
Vibration endurance test	IEC 60255-21-1	Class 2: 10 to 150Hz freq range, Constant acceleration: 2 gn No. sweep cycles in each axis: 20

Environmental tests

Shock test	IEC60255-21-2 (based on IEC60068-2-27 test Ea and IEC60068-2-29 test Eb)	Shock response test: Class2. Peak acceleration (A) 10gn, Duration of the pulse (D) 11ms, 3 pulses in each direction Shock withstand test: Class2. Peak acceleration (A) 30gn, Duration of the pulse (D) 11ms, 3 pulses in each direction
Bump test	IEC60255-21-2 (based on IEC60068-2-27 test Ea and IEC60068-2-29 test Eb)	Class2. Peak acceleration (A) 20gn, Duration of the pulse (D) 16ms, 1000 pulses in each direction

Electrical Insulation and mechanical construction tests

Power-Frequency withstand Voltage (Insulation test voltage)	IEC 60255-5	Level 2, 50Hz, 1min:- 2 kVrms (CM)
Lightening Impulse Voltage	IEC 60255-5	Level 3, 1.2/50µs, 500Ω, source Z, 0.5J source energy, - 5kVp (CM)
Insulation resistance	IEC 60255-5	500Vdc (CM) test voltage: >100MΩ
Protective bonding resistance	IEC 60255-27	< 0.1 Ω (60 sec)

Electromagnetic Compatibility Tests

Emission Test (For test site measurements,)	IEC 60255-25	30...230MHz: 40dB (µV/m) quasi peak at 10m distance 230...1000MHz: 47dB (µV/m) quasi peak at 10m distance
Power supply Emission	IEC 60255-25	0.15...0.5MHz: 79dB (µV/m) quasi peak 66dB (µV/m) average 0.5...30MHz: 73dB (µV/m) quasi peak 60dB (µV/m) average

Conducted Immunity and Power unit tests

Electrostatic Discharge	IEC 60255-22-2	Level 3, 5/30ns pulse, 5 discharges: ±6kVp contact ±8kVp air
Fast Low Energy Transient (EFT) (Including functional earth port)	IEC 60255-22-4	5/50ns pulse, 2.5 kHz, ±4kVp,

Conducted Immunity and Power unit tests

Slow High Energy Transient (Surge 1.2/50µs Voltage pulse)	IEC 61000-4-5 IEC 60255-22-5	1.2/50µs pulse ±4kVp (L-Gnd) ±2kVp (L-L)
Radio-Frequency disturbance (Including functional earth port)	IEC 60255-22-6	Level 3, 0.15...80MHz, step 1%, AM 80% @ 1kHz,,: 10Vrms/unmod (CM), Spot freq 27MHz 68Mhz
Voltage Dips, Short Interruptions (ac)	IEC 61000-4-11	100% (10ms and 30ms), 70% and 40%
Voltage Variation immunity tests (ac)	IEC 61000-4-11	Voltage Test level 70%
Damped Oscillatory Waves (HFD)	IEC 61000-4-12	Level 3 1 MHz , 10 transients: ± 2.5kVp (CM) , ± 1kVp (DM)
Ripple Voltage	IEC 60255-11 IEC 61000-4-17	Level 3: 10% Un 50, 300 Hz ripple freq.
Voltage Drop, Supply Interruption and voltage variations on d.c. input power port (immunity tests)	IEC 61000-4-29	100% @ 10ms and 100ms
Power Frequency Immunity Test	IEC 60255-22-7	Class A : CM: 300Vrms DM: 150Vrms

Radiated Immunity Tests

Radio-Frequency Electromagnetic Field (Amplitude modulated)	IEC 60255-22-3	80...1000MHz, AM 80% @ 1kHz, horizontal and vertical polarization: - 10V/m Spot freq: 80, 160, 450, 900MHz, AM 80% @ 1kHz
Radio-Frequency Electromagnetic Field from digital radio telephones (Pulse Modul.)	IEC 60255-22-3	Level 4, 900 ± 5MHz, PWM 100% @ 200Hz, 50% D.C.: - 10V/m (10s Dwell time)

Magnetic immunity tests

Power-Frequency Magnetic Field	IEC 61000-4-8	Level 5, X-Y-Z axis : -100A/m continuously -1000A/m short time
Pulse Magnetic Field	IEC 61000-4-9	Level 5, 5 positive and 5 negative, 8/20µs pulses every 10s:- 1000 A/m

Contact tests

Make and carry	IEC 60255-23 (Replaced by IEC61810-2, Ed.1.0)	Signaling : 10A@24VDC for 0.5s and 8A@24VDC for 3s Tripping : 30A@24V DC for 0.5S and 15A@24VDC for 3S
Breaking capacity for d.c., L/R ≤ 40 ms	IEC 60255-23	Signaling: 0.15A@220VDC and 4.5A @30VDC Tripping: 0.2A@220VDC and 5.5A@35VDC
Make and Break capacity for resistive load	IEC 60255-23	Signaling: 6A @240V ac Tripping: 8A@240V ac
Mechanical durability	IEC 60255-6	10,000 operations ; tripping and signaling contacts

EMC compliance

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

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	
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Data communication (optional)

Protocol : Modbus RTU	
Communication port : RS485 4-wire	

14. Terminal diagram

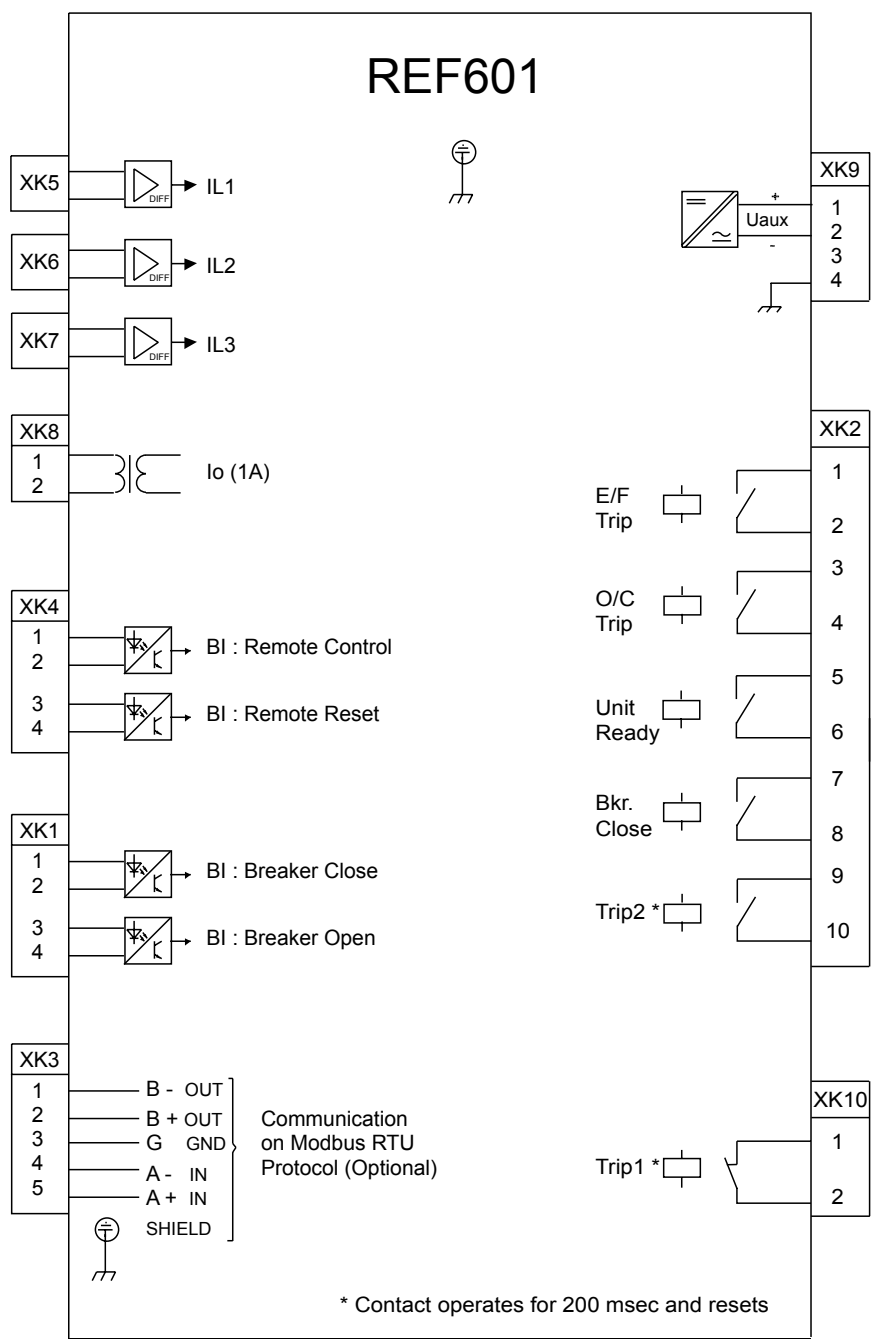


Fig. 3 Terminal diagram of REF601 relay

15. Mounting and dimension

By means of in-built press-fit mechanism, without the use of mounting accessories, the REF601 can be easily flush mounted.

Panel cut-out for flush mounting:

- Height: 154 ± 1 mm
- Width: 124 ± 1 mm

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

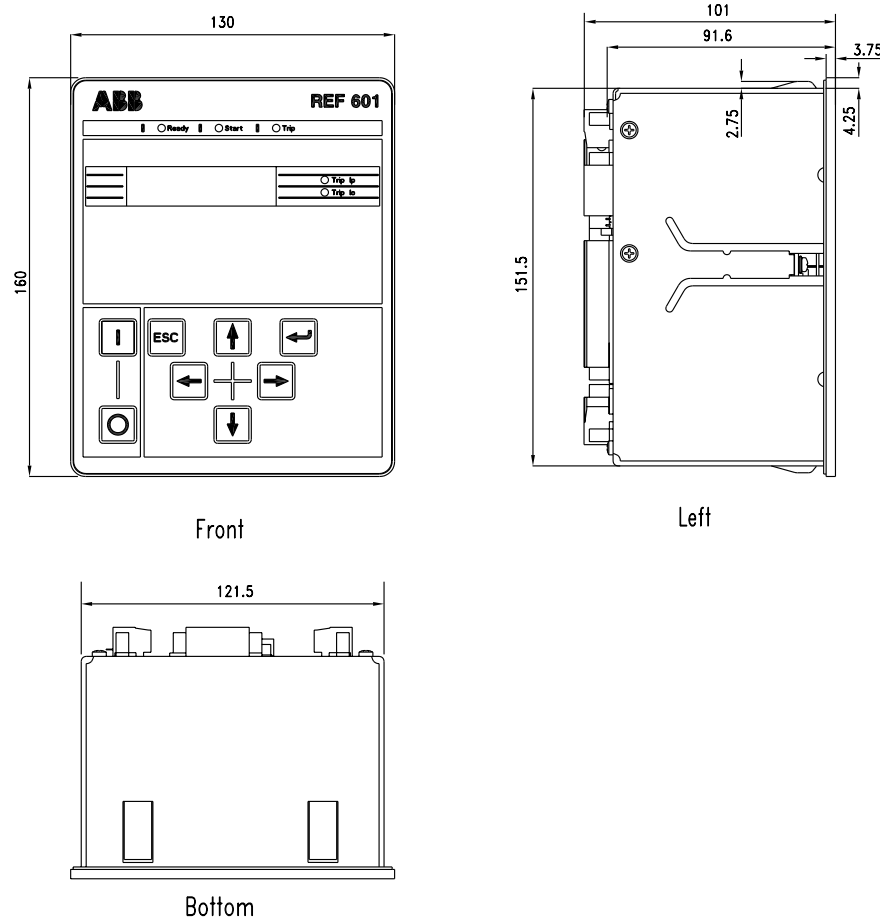


Fig. 4 Mechanical dimension of REF601 relay

16. 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 the hardware and software modules of the relay.

Use the ordering key information in Fig. 5 to generate the order number when ordering complete protection relays.

REF601 B A A 4 6 A A 1 X A

#	DESCRIPTION	
1	Relay type	
	REF601	REF601
2	Standard	
	IEC	B
3,4	Analog input / output	
	3 sensor and ground CT	AA
5,6	Binary input / output	
	4BI + 6 BO	46

REF601 B A A 4 6 A A 1 X A

#	DESCRIPTION	
7	Serial communication	
	with RS485	A
	None	N
8	Communication protocol	
	MODBUS RTU	A
	None	N
9	Power supply	
	24...240V AC	1
10	Vacant digit	
	Vaccant	X
11	Version	
	Version 1.0	A

Example code: REF601 B A A 4 6 A A 1 X A

Your ordering code:

Digit (#)1234567891011

Code

Figure 5: Ordering key for complete relays

17. Accessories and ordering data

Compatible Sensors	
Item	Order No.
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

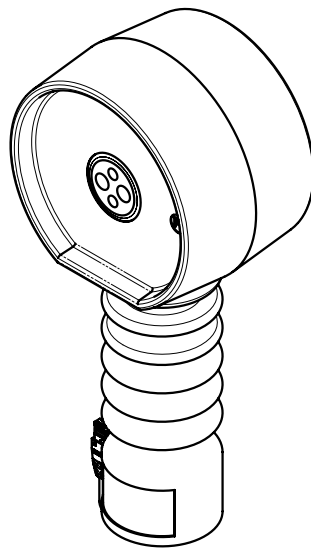


Fig. 6 Outline view of KEVCR Sensor

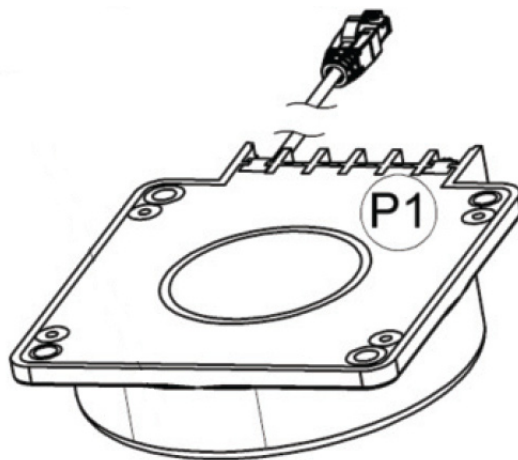


Fig. 7 Outline view of KECA Sensor



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