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IRIPROX-ER

Current Differential Relay

IRIPro

IRIPro

IRIPro

Series

Catalog

C&S electric

CE

PMD Division

contents

1) Introduction

IRIPROX-3ER offers a compact 3 Phase High impedance current differential protection.

IRIPROX-3ER protective relays are numeric relays that provides protection and monitoring with reliable and fast protection solution in a single unit with programmable digital outputs.

2) Application

The IRIPROX-3ER relays have been designed for protection and monitoring for generators/transfoemers.

3) Hardware

- Measures True RMS with DFT Filter
- CT Inputs
- Bright LCD Display
- 3 Push Button on the Front for HMI
- Front USB Communication
- LEDs for Annunciation

4) Protection Features

- Single Phase / Three Phase High impedance Current Differential
- In-built Harmonic / Inrush Blocking

5) Protection Function Description

Relay Latching

Relay can be configured to Latch /Unlatch depending on configuration.
(Latching is possible in presence of Auxiliary supply voltage only)

Reset Delay

This parameter introduces a delay in opening of relay contacts, when the current goes below the drop out value for current differential. This parameter will not work when manual reset mode is selected.

Inrush Blocking

Relay is equipped with in-built facility of Inrush blocking to avoid nuisance tripping and stable operations.

Calculation of the tripping current and the stabilizing resistance

Prior to setting the relay, the stabilizing resistance R_{sr}, as well as the tripping current I_{set} must be calculated. For the correct setting, the knee-point voltage in the magnetizing circuit of the CT is of special importance. In order to obtain a sufficient differential current for tripping on account of internal faults, the knee-point voltage U_{kn} of the transformer should be twice as high as the maximum expected stabilizing voltage U_S in case of faults from outside the protection zone. From this results the following calculation:

$U_{kn} = 2 \times U_S = 2 x I_{f,sek} \times (R_S + R_L)$

Explanation:

U_{kn} knee-point voltage of the magnetizing circuit of the transformer

U_s maximum stabilizing voltage in case of external faults

$I_{f,sek}$ maximum expected fault current (secondary-side) in case of external faults

R_S secondary resistance of the transformer

R_L Resistance of the connection line between CT and relay

The tripping current of the relay is then calculated, as follows:

$$Id \geq \frac{Ukn}{2x\ Rsr}$$

Explanation:

Rsr stabilizing resistance

The strength of the stabilizing resistance must be selected in a way to ensure that the tripping current is within the setting range (5% to 82.5% of I_N).

When the pick-up value is exceeded, nearly an immediate tripping is initiated. With 30 ms the tripping time is approx. five times as high as the tripping value. In case of lower currents, the tripping time is slightly higher (about 100ms), in order to reach a stabilization of the protective function against external faults

Calculation of the knee-point voltage

If the knee-point voltage is not indicated by the manufacturer, as is the case in our example, the approximate value can be calculated, as follows:

$$U_{kn} = \left(\frac{S \times I_{IU}}{I_N}\right) = \left(\frac{2.5 \times 10}{1}\right) = 25V$$

Explanation

S : Output of the CT

Kiu : Over current factor of the CT

In : Secondary side rated current of the transformer

Calculation of the active resistance

The relevant resistance in the differential circuit add upto a total circle resistance :

$$R_{circuit} = \left(\frac{U_{kn}}{2 \times I_{set}} \right) = R_{sr} + 2 \times R_L + R_s + R_r$$

Explanation

R_{kreis} Total resistance in the differential circuit
R_{sr} Stabilizing resistance
R_L Resistance of the connection line between CT & relay
R_s Secondary resistance of the transformer (0.7Ω)
R_r Relay input resistance (= 0.02Ω)
I_d Tripping current

The individual resistance values are :

$2 \times R_L$ = 150 mΩ 20m, 2.5mm^2 Cu

$2 \times R_L + R_r + R_s = 0.87\Omega$

Therefore the following is valid

$$R_{kreis} = \left(\frac{25kV}{2 \times 0.2A} \right) = 62.5\Omega$$

Calculation of the stabilising resistance

The stabilizing resistance is calculated from above ratios as follows:

$$R_s = S_{r\,circuit} - (2 \times R_L + R_s + R_r)$$
$$= R_{circuit} - 0.87\Omega$$
$$= 61.6\Omega$$

In operational mode $\leq I_d$, the output requirement P_N is as follows:

$$P_N < I^2 \times Rsr = 0.2^2 A^2 \times 61.6\,\Omega \leq 2.47\,W$$

In this case, P_N represents the minimum output required (pure current-heat losses). A considerably increased output PF is required in the event of a fault.

Example: The fault current is: IF,prim = 13.1 kA

If one neglects the transformer saturation, the following peak voltage U_P occurs:

$$U_p = \left(\frac{I_{F,prim}}{n} \right) (R_{sr} + 2 \times R_L + R_s + R_r)$$

$$U_p = \left(\frac{13100A \times 1}{100} \right) \times (62.5\Omega) = 8187.5V$$

If one considers the transformer saturation, a short- term peak voltage USS occurs, as shown in the following calculation:

$$U_{ss} = 2 \times (2 \times U_{KN} \times (U_P - U_{KN}))^{+0.5} \leq 3kV$$

$$U_{ss} = 2 \times (2 \times 25V \times (8187.5V - 25V))^{+0.5}$$

$$U_{ss} = 1.28\ kV$$

$$P_r = \left(\frac{U_{ss}^2}{R_{sr}} \right) = \frac{1280^2\ V^2}{61.6\Omega} \quad 26.6kW$$

The calculation of P_N and P_F must be effected in any case, in order to get the exact power range of the stabilizing resistor.

Take over of power by the resistor in the event of a fault PF creates a short-term peak value.

Example of Calculation Transformer

An IRIPROX-ER protection relay is used for the earth fault protection of a 1.6 MVA transformer (11000/415V), 6%.
The following CTs are used in the rigidly earthed star point.

Transformer ratio	2500/1A
Class	X
Resistance Rs	8 Ω
Knee point voltage	250V

The relay is situated about 20 meter away from the CTs and is connected with a 2.5 square mm cable.
Calculation of the stabilizing voltage
The primary side fault current $I_{F,PRIM}$ is :

$$I_{F,prim} = \left(\frac{1600000\ VA}{\sqrt{3} \times 415\ V \times 6\%} \right) = 37.1\ kA$$

Line resistance R_L (2.5 square mm $\simeq$ 7.46 / Ωkm)

$$R_L = 20\ m \times \left(\frac{7.46\ \Omega}{1000\ m} \right) = 0.15\ \Omega$$

Additional resistance R_r (Ca 0.02 Ω)

From this results the stabilizing voltage for

$$U_S = \left(\frac{I_{F,prim}}{n} \right) \times (2 \times R_L + R_s + R_r)$$

$$U_S = \left(\frac{37100A \times 1}{2500} \right) \times (2 \times 0.15\ \Omega + 8\Omega + 0.01\Omega)$$

$$U_S = 123.5$$

Since the knee-point voltage shall be
$U_{kn} = 2 \times U_S$ (2 x 123.5V = 247 V)
the above transformer with U_{kn} = 250 V can be used.
Calculation of the set current and the stabilizing resistance (sample value)
The rating for the set current of 20% is calculated:
$I_d = 20\ \% \times I_N = 0.2 \times 1\ A = 0.2\ A$
From this results the stabilizing resistance for

$$R_{circuit} = \left(\frac{Us}{I_d} \right) \simeq Rsr \Rightarrow \left(\frac{123.5V}{0.2A} \right) = 617.5\ \Omega$$

In the event of a fault, the stabilizing resistance must withstand a secondary-side false current of:

$$I_{F,prim} = \left(\frac{1600000\ VA}{\sqrt{3} \times 415\ V \times 6\% \times 2500} \right) = 14.84A$$

The calculation of the short-term peak voltages provides the following result:

$$U_s = \left(\frac{37.1\ kA \times 1}{2500} \right) \times (8\ \Omega + 2 \times 0.15\ \Omega) = 8187.5V$$

$$+ 0.02\ \Omega + 615\ \Omega = 9.25\ kV$$

Thus the ratio

$$U_{ss} = 2 \times (2 \times U_{KN} \times (U_P - U_{KN}))^{+0.5} \leq 3kV$$

$$U_{ss} = 2 \times (2 \times 250V \times (9250V - 250V))^{+0.5}$$

$$U_{ss} = 4.24\ kV$$

is not reached and the calculation must be repeated with a higher set current.

Calculation of the set current and the stabilizing resistance (actual value)

The rating for the set current of 40% is calculated again:

$$I_d = 40\% \times I_n = 0.4 \times 1A = 0.4A$$

From the results the stabilizing resistance for :

$$R_{circuit} = \left(\frac{U_s}{I_d} \right) \simeq R_{sr} \Rightarrow \left(\frac{123.5V}{0.4A} \right) = 308.75\ \Omega$$

Thus, the requirement of the short-term peak voltage is met

$$U_p = \left(\frac{37.1\ kA \times 1}{2500} \right) \times 8 + 2 \times 0.15\ \Omega + 0.02\ \Omega + 308.75\ \Omega = 4.7kV$$

$$U_{ss} = 2 \times (2 \times 250V \times (4700V \times 250V))^{+0.5}$$

$$= 298$$

Since the requirement is met, the set values and the resulting resistance values can be accepted.

The calculation of the output requirement for the stabilizing resistance can be carried out similar to the calculation on page 4

6) Fault Recording (Model dependent)

IRIPROX-ER relays records last 5 faults in its non volatile memory with it's time stamp. Each record has the following information:

Fault Format

Id1 / Id2 / Id3	:	Fault Current Amplitude (model based)
FLT	:	Fault Type
TIME	:	HH:MM:SEC:mSEC
DATE	:	DD/MM/YY

The user can view the fault record / various parameters via the front USB interface software.

Output Contact

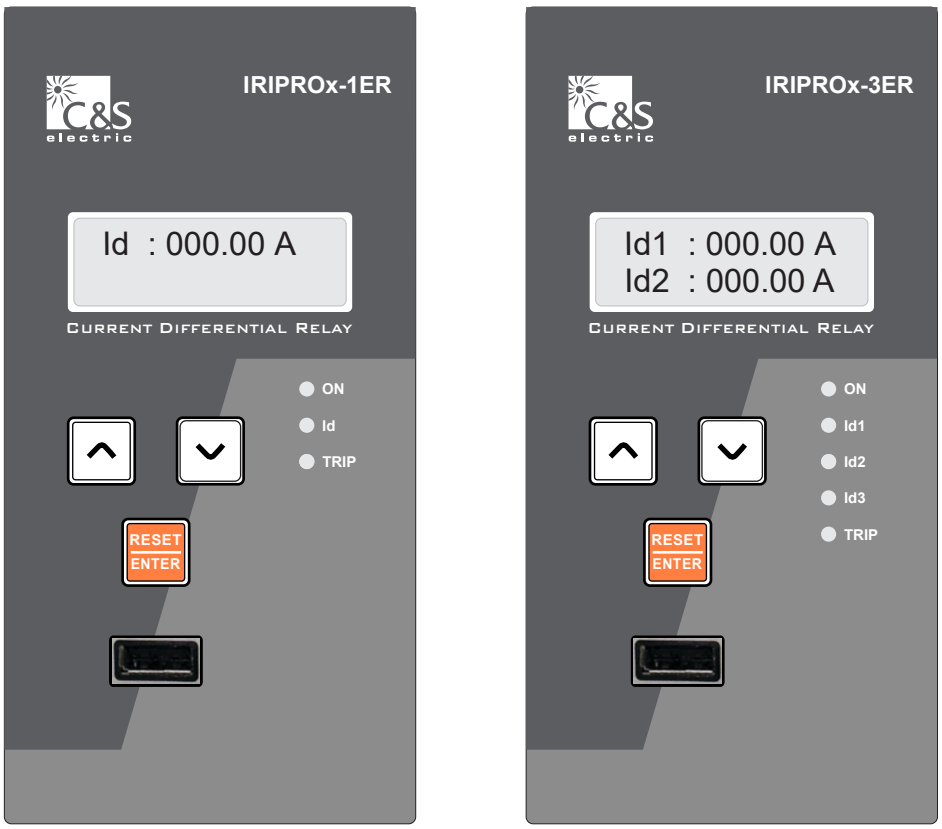
No. of Digital Outputs	:	3 (DO1, DO2, DO3)
Type of Outputs	:	Relay
Programmable (DO Assignment)	:	Yes
Relay Reset Type	:	Programmable (Auto/Manual)

7) Human Machine Interface

It comprises of bright LCD display

- Two push switches for setting values of normal tripping characteristics and other operations for local access.
- One RESET/ENTER push switch.
- LEDs for phase availability & fault annunciation

Keys	Manual Key
RESET ENTER	is used to manual reset (after pressing for 3 sec) and also works as ENTER key.
^	is used to scroll in backward direction.
v	is used to scroll in forward direction.



8) Communication

The unit has:

Front USB port for direct connection to a PC

The entire setting, Fault is available on 'A to A' type USB (female) interface with saving & printing option.

9) Setting Ranges

Common Setting (These are the settings common for all protections)

Parameter	Display	Setting Range		Step Size	Default Setting
		Min.	Max.		
Phase CT ratio	P-CTR	1	9999	1	1
Frequency *	Freq	50Hz	60Hz	1	50Hz
Reset Delay	R_dly	0	20 Sec	0.1 Sec	0 Sec
Fault popup	FltPop	Enable	Disable	1	Enable

Measurement Accuracy

Quantity	Range	Frequency Range	Accuracy
Current *	1-20 x Ip	50/60 Hz	±2%

Differential Current

Parameter	Range	Step size	Tolerances
Id>	5 - 90% x In	1%	±3% of set value
td	0.02 - 150 sec	0.01 sec	± 20 msec

DO Assignment

Parameter	Display	DO Assign
Current differential	Id>	DO1 / DO2 / DO3
Self supervision	SlfSup	DO1 / DO2 / DO3

Auxiliary Supply

Auxiliary voltage range	18-300V DC / 60-280V AC
Power consumption	Quiescent approx. 3W, Operating <7W

Front (USB) Communication

Protocol	CSE proprietary protocol: available with PC software
Cable required for interface	USB cable type (A to A)

* : Frequency setting is available only in IRIPROx-1ER model

Measuring Input

Rated Data	Rated current Ip :1A or 5A Rated frequency Fn : 50/60 Hz (only available in IRIPROx-1ER)
Drop out to Pickup Ratio	>96%
DC Current Carrying Capacity	8A@30VDC / 0.3A@110VDC/ 0.2A@220VDC
Power consumption in current circuit	At Ip=1A 0.2 VA At Ip=5A 0.4 VA
Thermal withstand capacity in current circuit	Dynamic current withstand for 1 Sec : 100 x Ip for 10 Sec : 30 x Ip continuously : 4 x Ip
Protection-Front Panel	IP-54
Weight	Approx. 700 gms

Trip Contact Rating

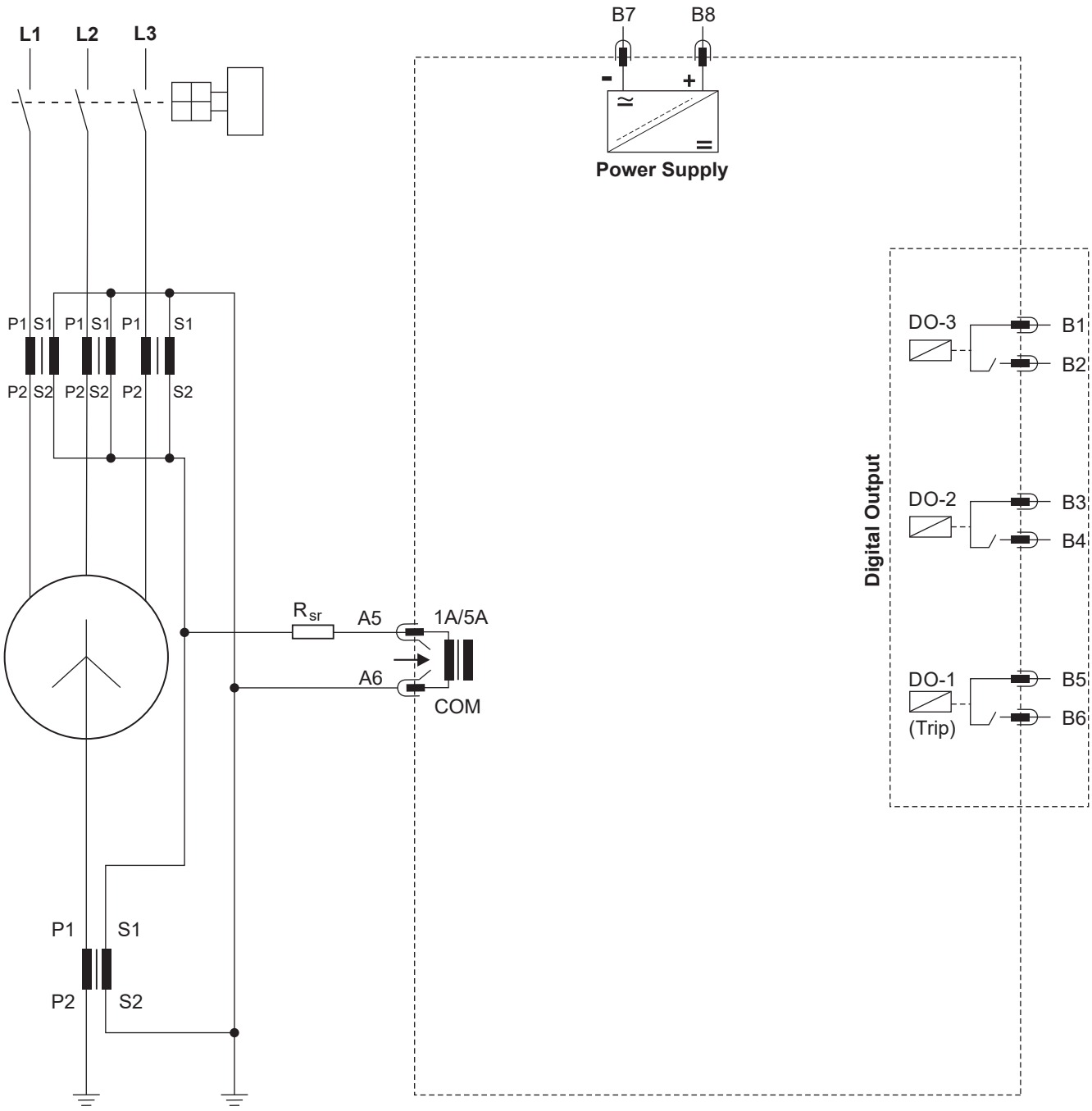
Mechanical Life	Min. 10,000,000 operations (at 36,000 operation/Hr.)
Di-electric Strength (Initial)	
between Contacts of the same polarity	1000 VAC, 50/60Hz for 1 minute
between Contacts & Coil	4000 VAC, 50/60Hz for 1 minute
Surge withstand capacity	
between Contacts & Coil	10,000 V (1.2 x 50 us)
Contact current rating (trip)	8A
Switching voltage	250VAC
Output contact type	Ag Alloy + gold plating (Cd free)

10) Model Selection Table

Particular Details	IRIPROX-1ER	IRIPROX-3ER
PROTECTION		
Current differential protection	Single Phase	Threee Phase
Digital Output	3	3
CT Input	1	3
RECORD		
Fault record / Trip history	5	5
DISPLAY / HMI	LCD-12x2	LCD-12x2
LEDs	3	5
Setting	Fine setting with keypad	Fine setting with keypad
COMMUNICATION		
USB port for PC/Laptop communication	✓	✓
MOUNTING TYPE	Vertical	Vertical
Frequency	50/60Hz	50Hz

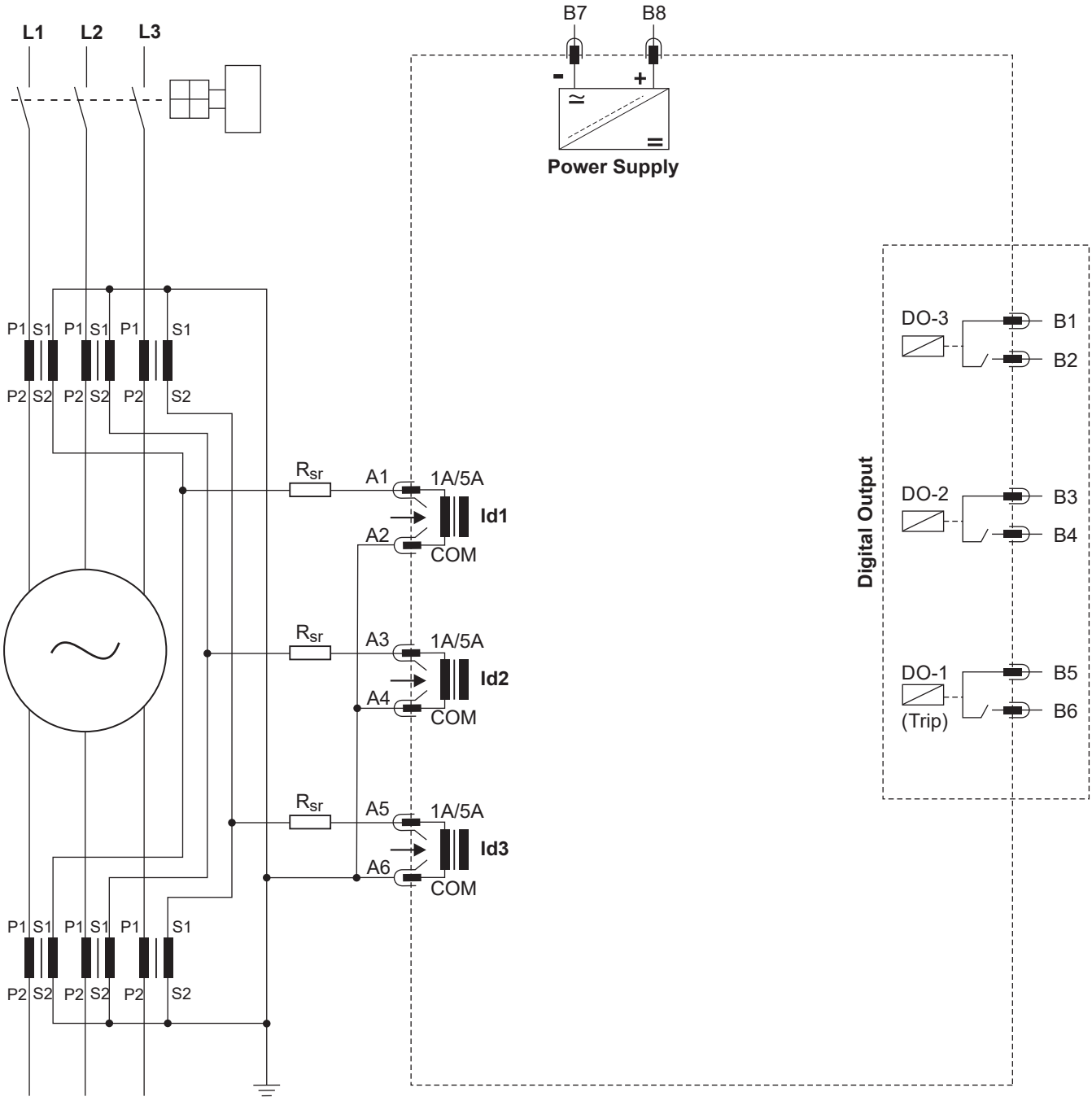
✓ : **Available in this model**

11) Connection Diagram



The IRIPROx-1ER has a Single phase differential current supervision with adjustable pick-up value

11) Connection Diagram



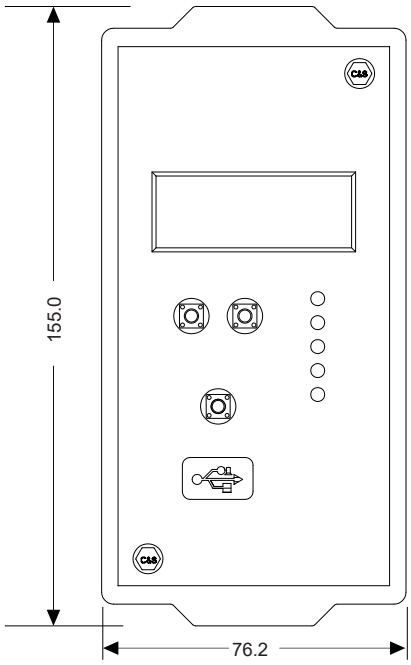
The IRIPROx-3ER has a Three phase differential current supervision with adjustable pick-up value

12) Back Terminal view of the Relay

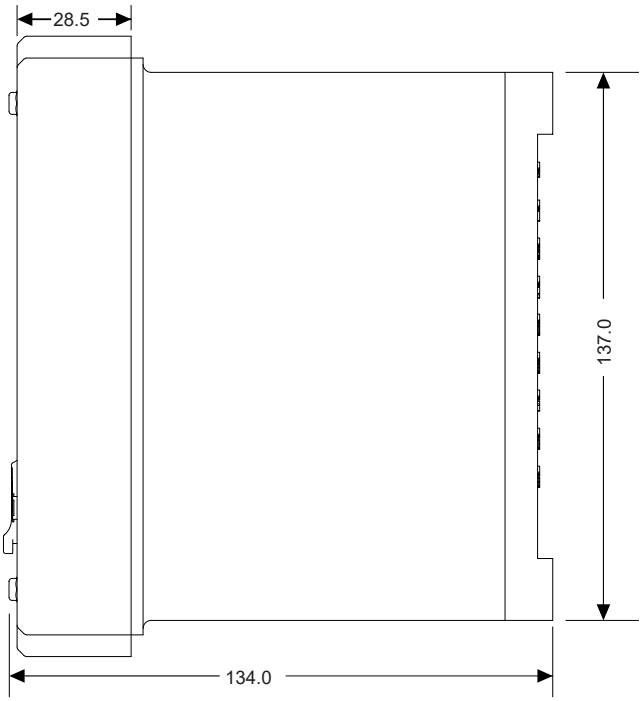
(All the dimensions are in mm, Gen. Tol. : ±1.0 mm)

13) Dimensional Details

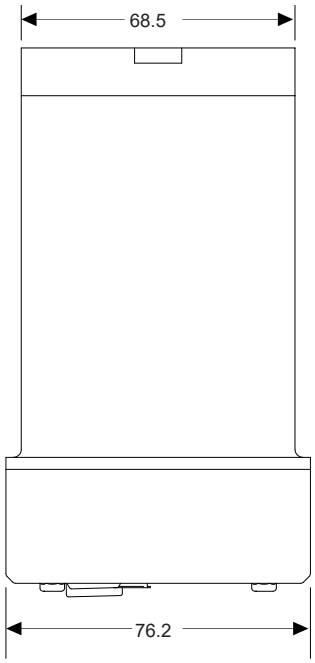
Front View

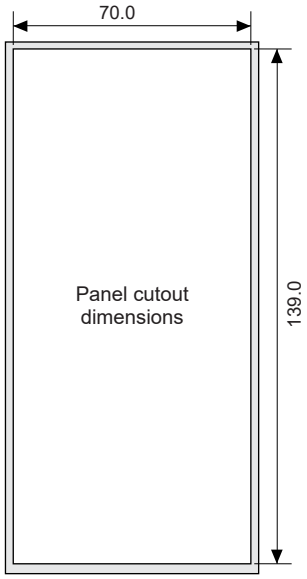


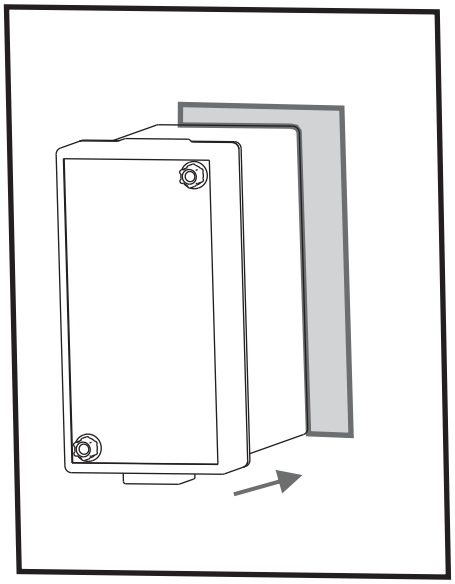
Side View



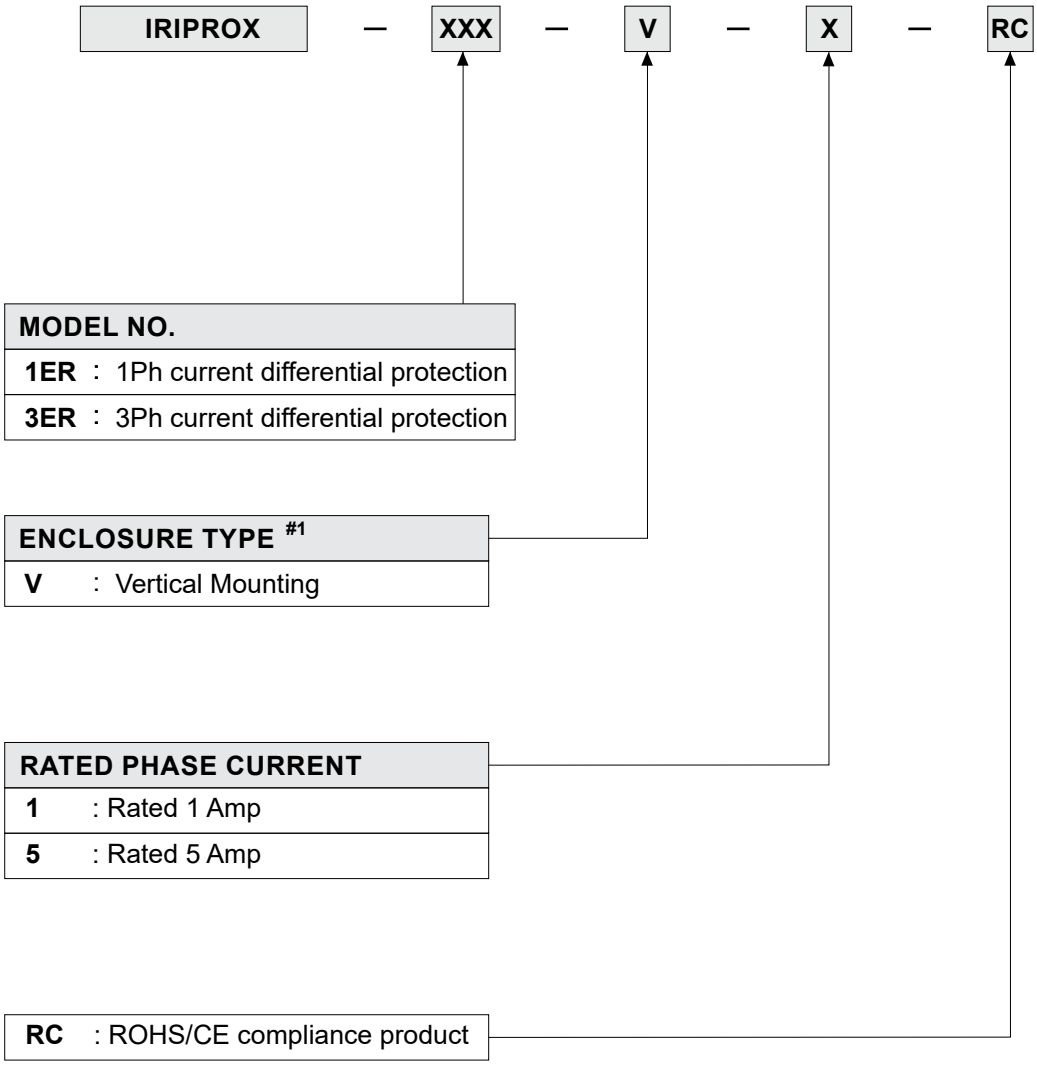
Top View







14) Ordering Information



NOTE :
#1) Refer Dimension detail / Panel cutout dimension (S.No. 12).

Revision Number

S.No.	Rev.No.	Details	Date
01	01	Change in ordering information and included one more conn diagram for single phase	12.08.22
02	02	Include back terminal view of relay on page 14.	30.06.23
03	03	Removed Earth terminal point shown near B7, B8 (Power supply) terminal from the conn diagrams.	04.07.23
04	04	Include ROHS/CE compliance option in ordering information on page-16	22.11.23
05	05	Include Frequency detail in common setting on page 10 & in model selection on page 11	01.04.25

NOTE

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For further information, please contact:

C&S Electric Ltd.
(Protection & Measurement Devices)

C-60, Wing-A, Phase-II, Noida-201 305, Dist: Gautam Budh Nagar (U.P) INDIA
Phone : +91-120-38748 00 / 01 Fax: +91-120-3874802

Technical Question or After-sales Service

Customer Center Quick Response Service, Excellent Technical Support

1800 572 2012

Branch Address

Branch	Phone	Fax	E-mail
Ahmedabad	+91-79-615651 22/23/24	+91-79-61565130	cspc.ahemdabad@cselectric.co.in
Bangalore	+91-80-305703 72/73, 30570347	+91-2558-4839	bangalore@cselectric.co.in
Bhubaneswar	+91-674-2507265	+91-674 2507265	bhubaneswar@cselectric.co.in
Chennai	+91-44-33534501,33534521-23	----	chennaiteam@cselectric.co.in
Cochin	+91-484-3071717	+91-484-3071716	----
Delhi	+91-11-338490 00/10/11	+91-11-30838826	sales.pmd@cselectric.co.in
Hyderabad	+91-40-485340 80/82	----	hyderabad@cselectric.co.in
Kolkata	+91-33-392121 19-21	----	----
Mumbai	+91-22-241147 27/28	----	mumbaiteam@cselectric.co.in
Pune:	+91-20-242505 18/19	+91-20-30283244	pune@cselectric.co.in

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