

High-Tech Range

IRI1- (Overcurrent, Short-circuit and Earth Fault Relay)



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1. Introduction

The application of powerful microprocessors opens a new chapter for power protection systems. Because of their capabilities to process the measuring values digitally and to perform arithmetical and logical operations, the digital protective relays are superior to the traditional analogue devices. In addition, the digital protective relays offer some additional advantages such as very low power consumption, adaptability, possibilities for self-supervision, flexible construction, selection of relay characteristics etc.

The development of microprocessor-based protective relays and their introduction into the market are stimulated by the trend nowadays to replace analogue with digital protective equipment.

The superiority of digital protective relays to the traditional systems is enhanced by the MR relay family which has the following characteristics :

- Integration of multiple protective functions into one compact housing
- High measuring accuracy due to digital processing of measuring values
- Digital relay setting with very wide setting ranges and the fine setting steps
- User-friendly setting procedure by means of DIP-switches
- Operation reliability due to continuous self-supervision

The digital time relay IRI1 was designed as a universal over-current relay for application to medium voltage networks.

A similar protection relay with extended functions, the MRI1-digital multifunctional relay is also available. It additionally provides an alpha-numeric display for the indication of measuring values and faults. Furthermore, the MRI1 allows data exchange via serial interface and directional determination of the fault.

2. Application

The digital over-current time relay IRI1 is a universal protection device for low and medium voltage networks. It is used in radial networks and combines the following functions in one unit :

- Independent (Definite) time over-current relay
- Inverse definite minimum time over-current relay with following selectable characteristics :
- Normal inverse
- Very inverse
- Extremely inverse
- Integrated independent and dependent over-current time protection for the earth fault detection.

Furthermore, the device, providing the above functions, can be employed as back-up protection for differential and distance protection relays.

3. Characteristic and features

- Digital processing of the sampled measuring values
- Digital filtering of the measured values by using discrete Fourier analysis to suppress the high frequency harmonics and transient d.c. components during short circuit
- Selectable protective functions between : definite time over-current relay and inverse time over-current relay
- Selectable inverse time characteristics according to BS 142 and IEC 255-4 :
 - normal inverse
 - very inverse
 - extremely inverse
- Independent stage for the fast tripping of short circuit (protection)
- Two-stage over-current time protection for phase current
- One-stage over-current time protection for earthfault current
- Extremely wide setting ranges and fine steps for current and time settings
- Continuous self-supervision of software and hardware
- Wide operating ranges of the supply voltage (AC/DC)
- Plug-in technology with self-shorting c.t. circuits

4. Versions

3 Phase over current with high set and 1 earth fault with highset.

IRI1-3I-EI	3 phase over current and 1 phase earth fault without high set
IRI1-EO	Earth fault relay with high set
IRI1-3I-EI (N1 MODEL)	3 Phase overcurrent with high set and 1 E/F with high set.

5. Design

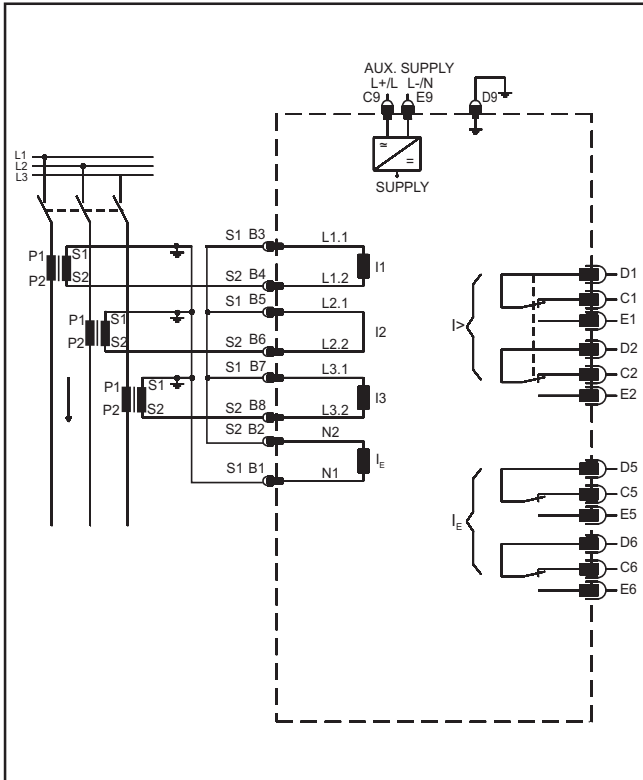
5.1 Connection

In the following the IRI1 functional description always refers to the version IRI-3I-EO. With a few exceptions (no earth-fault detection for the IRI-3O & IRI1-3I) all functions are valid for the other units.

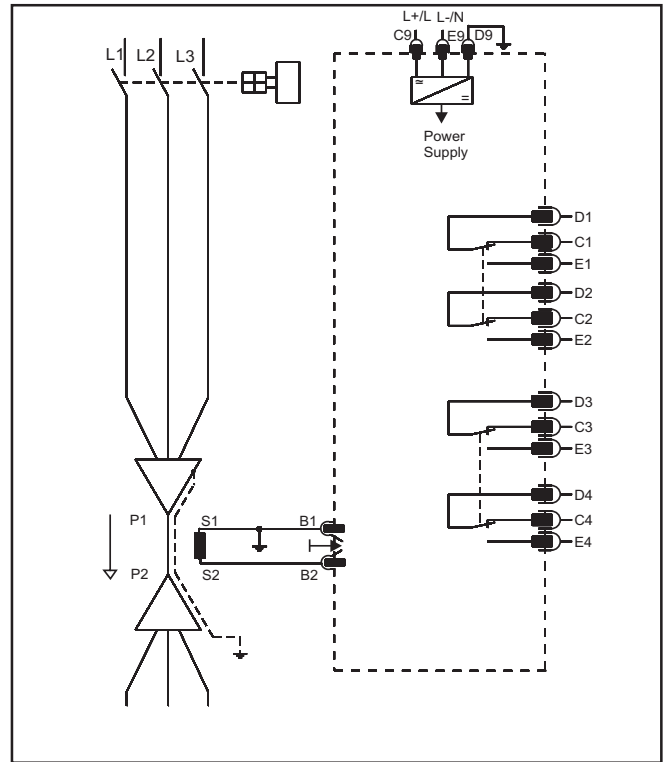
5.1.1 Analog input

The analog input signal of the conductor currents IL1 (B3-B4), IL2 (B5-B6), IL3 (B7-B8) and the total current IE (B1-B2) are fed to the protective device via separate input transformers.

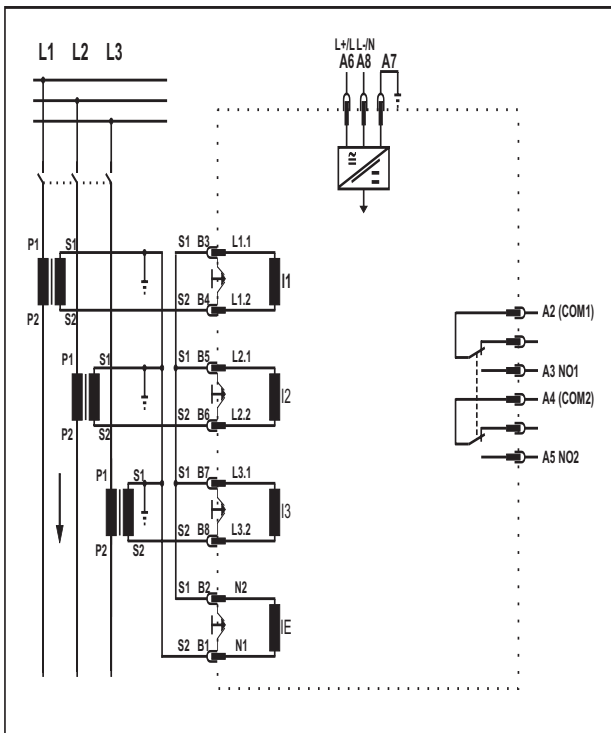
The continuously measured current values are galvanically isolated, analog filtered and finally fed to the analog/digital converter.



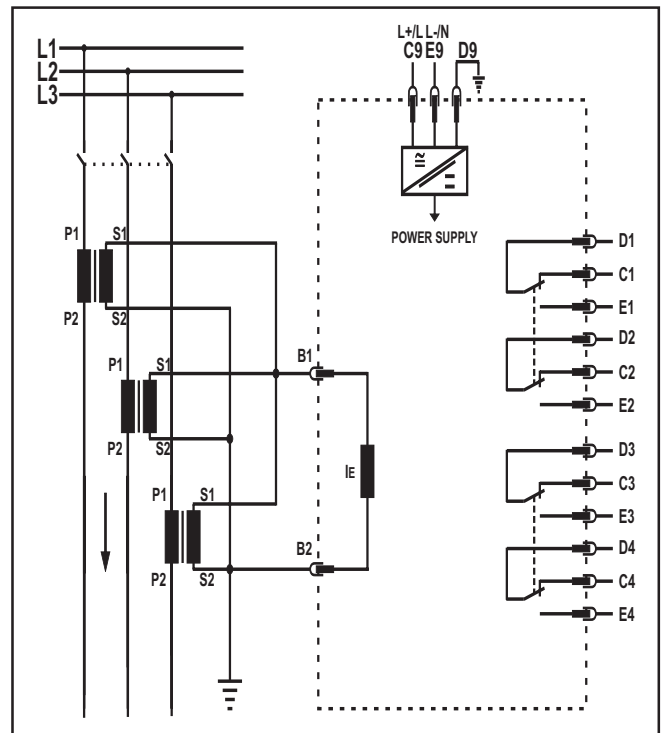
Circuit Diagram IRI1-3I-EI



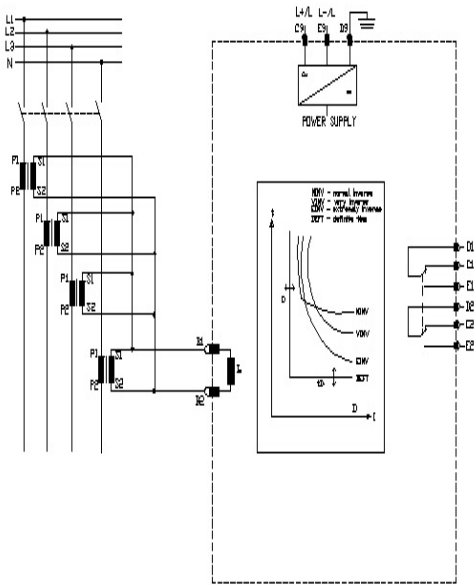
Circuit Diagram IRI1-EO for CBCT Application



Circuit Diagram IRI1-3I-EI (N1 MODEL)



IRI-EO in Holmgreen Circuit



Residual connection method of 3 phases 4 wire system

5.2.1 LEDs

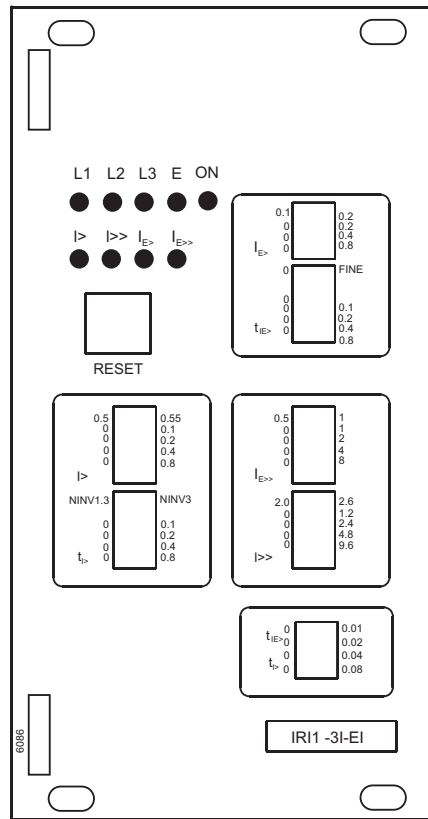
On the front panel there are 8 LEDs (9 LEDs in case of 3I-EI). Their functions are indicated by the appropriate inscriptions above them. LED ON indicates the readiness for service, the other 7 LEDs are used for the fault display and indicate the type of fault and the repetitive phases.

5.2.2 DIP - switches

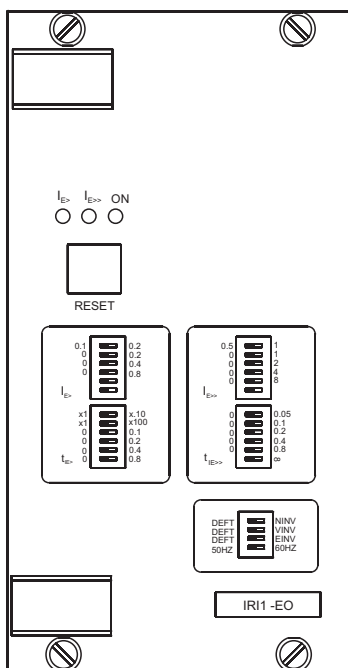
The 7 sets of DIP - switches on the front plate serve to adjust the tripping values, times, characteristics and mains frequency.

5.2.3 RESET - pushbutton

Push - button RESET is used for acknowledgment and reset after fault clearance.



Front plate IRI1-3I-EI



Front plate IRI1-EO

6. Working Principles

6.1 Analog circuits

The incoming currents from the main current transformers on the protected objects are converted to voltage signals in proportion to the currents via the input transducers and shunt resistors. The noise signals caused by inductive and capacitive coupling are suppressed by an analog R-C filter circuit. The analog voltage signals are fed to the A/D-converter of the microprocessor and transformed to digital signals through Sample and Hold circuits. All the processing is carried out on these digitized values. The measuring values are detected with a sampling frequency of 800 Hz, a sampling rate of 1.25 ms for each measurement (at 50 Hz).

6.2 Digital circuits

The protective device is equipped with an efficient microprocessor which is the main processing unit. It digitally carries out all of the operations, from the digitization of the measuring values to the protective tripping.

The relay program is located in an EPROM (Read-Only-Memory). With this program the microprocessor processes the voltages at the analog inputs and calculates the fundamental components of the current. For the calculation of the current value an efficient digital filter based on the Fourier Transformation (DEFT-Discrete Fast Fourier Transformation) is applied to suppress high frequency harmonics and d.c. components during a short circuit.

The calculated actual current values are continuously compared with the set value which is adjusted using the DIP - switches. When activated, the over-current tripping time is determined according to the selected characteristic curve. When the calculated time delay has elapsed, a tripping command is given.

6.3 Power supply

For the 24 V (nominal voltage) unit it is possible to select an auxiliary voltage range from 16 V to 90 V and for the 110 V (nominal voltage) unit an auxiliary voltage from 80 V to 250 V (a.c./d.c.).

6.4 Demands imposed on the main current transformers

The current transformers have to be rated in such a way, that a saturation should not occur within the following operating current ranges : Independent time over-current function $K1 = 2$

Inverse time over-current function $K1 = 20$

High-set function $K1 = 1.2 - 1.5$

$K1 =$ Current factor related to set value with the current transformer not yet operating in the saturation range.

Moreover, the current transformers have to be rated according to the maximum expected short circuit currents of the network or the object to be protected.

The lower consumption of the IRI1, i.e. 0.2 VA, has a positive effect on the rating of the current transformers. It implies that, if an electromechanical relay is replaced by IRI1, a high accuracy limit factor is automatically obtained by using the same current transformer.


7. Operation and Settings

7.1 Layout of operating elements

All DIP-switches required for the setting of parameters are located on the front panel (see fig. "front panel").

7.2 Setting of parameters by DIP-switches

For a better comprehension of the different DIP-switch positions, it was agreed that

1.  DIP-switch is turned off (Off position)

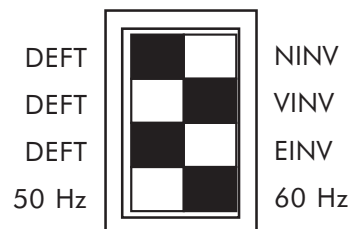
 DIP-switch is turned on (On position)

2. Contrary to the DIP-switches on the IRI1 front panel the examples given here are numbered. Position On is equally marked.

7.2.1 Setting of the tripping characteristic for phase-overcurrent and earth fault stage

The following tripping characteristics can be adjusted :

- Independent tripping curve : DEFT (definite) adjusted :
- dependent tripping curve :
 - NINV (normal inverse)
 - VINV (very inverse)
 - EINV (extremely inverse)



For characteristic selection in IRI-31-EI refer 7.5.5.

By setting DIP-switch (not 50/60 Hz) to the On position it is possible to select one of the three dependent tripping curves. If an independent over-current tripping is required, all three of the DIP-switches must be set to position DEFT. In case of an invalid setting of the DIP-switches, for example if several switches are simultaneously set to On position, an independent tripping characteristic with the smallest possible tripping values and times is automatically selected. This ensures that the object to be protected cannot be overloaded under any circumstances. Setting ranges and characteristics are detailed in chapter 10.

Please Note :

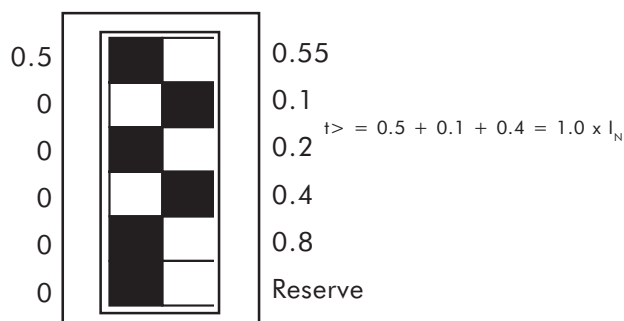
The IR11-2O-EO unit type provides identical dependent tripping characteristics for phase overcurrent and earth overcurrent stages i.e. if NINV characteristics is selected it is applicable for both O/C + E/F.

7.2.2 Setting of response value $I>$ for phase-over-current

With the aid of DIP-switch set $I>$ it is possible to adjust the response value for phase-over-current tripping in the range $0.5 - 2.5 \times I_N$. The tripping value is calculated from the sum of the individual settings of all the DIP-switches.

Example :

A tripping value of $1.0 \times I_N$ is required. Therefore switches 2 and 4 are switched on.



7.2.3 Setting of tripping time ($t_{I>}$) for phase-over-current

With the aid of DIP-switch set $t_{I>}$ it is possible to select the tripping time for the phase-over-current in the range $0.1 - 150$ s. There are four switches available to adjust the set value switch (3, 4, 5 & 6) and two switches (switch 1 & 2) to select the multiplication factor.

The set value is calculated from the sum of the individual factors (switch 3-6) multiplied by the set multiplication factor (switch 1 or 2). 1, 10 and 100 are possible as multiplication factors. If the switches 1 and 2 are both set On, the setting is invalid and gives an automatic multiplication factor of 1. If all the switches 3 - 6 are set to the Off position, the tripping time is equal to the relay operating time (approx. 30 ms).

Note: The multiplication factor (switch 1 and 2) must be set to 1 for dependent tripping characteristics.

7.2.4 Setting of response value ($I>>$) for phase-short-circuit

With the aid of DIP-switch set $I>>$ it is possible to adjust the response value for the fast tripping of phase-short-circuit in the range from $2.0 - 33.5 \times I_N$.

The tripping value is calculated as described in 7.2.2.

7.2.5 Setting of the tripping time ($t_{I>>}$) for tripping of phase-short circuit protection

With the aid of DIP-switch $t_{I>>}$ it is possible to adjust the tripping period $t_{I>>}$ for the fast tripping of phase -short circuit protection in the range from 0.05 - 1.55 s. The setting time is calculated from the sum of the individual factors of all the DIP - switches switched on. If all the switches are in the Off position, the tripping time is equal to the relay operating time (approx. 30 ms).

Please Note :

If switch $t_{I>>}$ is set, the fast tripping of short-circuit protection is inhibited, independent of other switch settings.

Independent of the selected tripping characteristic of the over-current stage $I>>$, the tripping period for the fast tripping short-circuit stage $I>$ is always definite.

7.2.6 Setting of response value (I_E) for earth-fault stage

See setting procedure as described in paragraph 7.2.2.

7.2.7 Setting of the tripping time ($t_{IE>}$) for earth-fault stage

See setting procedure as described in paragraph 7.2.3.

7.2.8 Setting of response value ($I_{E>>}$) for earth-fault high set stage

See setting procedure as described in paragraph 7.2.2.

7.2.9 Setting of the tripping time ($t_{IE>>}$) for earth-fault high set stage

See setting procedure as described in paragraph 7.2.3.

7.2.10 Setting of normal frequency

The nominal frequency can be adjusted to 50 or 60 Hz by means of DIP-switches on the front panel.

7.3 Indication of faults

For the fault indication the IR11 front panel provides 8/9 LEDs with the following functions :

- LED L1 : fault in phase L1
- LED L2 : fault in phase L2
- LED L3 : fault in phase L3
- LED E : earth-fault
- LED $I>$: serves to indicate tripping from a phase over-current
- LED $I>>$: serves to indicate tripping from a phase-short-current
- LED IE : serves to indicate tripping from a earth fault
- LED $IE>>$: serves to indicate tripping from earth fault high set stage
- ON : power ON indication.

7.4 Reset

7.4.1 Reset by pressing push-button <RESET>

When the push-button <RESET> is pressed, the device immediately reset and the LEDs extinguish.

7.4.2 Reset by each new energization

At each new energization, the unit returns to its initial position and the LEDs indicate the fault now present.

7.5 Calculation of the setting values

7.5.1 Phase-over-current stage (I>)

The main criterion for the setting of the over-current response value is the normal maximum operating current which is therefore adjusted to about 20% for power line, about 50 % for transformers and motors, above the maximum expected load currents. The delay of the trip signal is selected according to the selectivity and time grading, and the system overload capacity of the protected object.

7.5.2 Fast tripping short circuit protection (I>>)

The fast tripping short-circuit protection is normally set to act for near-by faults. The time delay for I>> is always independent of the fault current.

7.5.3 Dependent over-current time protection

Apart from the selection of the tripping characteristics, the response value for the phase-current is also adjustable.

7.5.4 Phase-over-current stage (I>)

The starting current is determined according to the maximum expected load current. For example :

Current transformer ratio : 400/5 A

Maximum expected load current : 300 A

Overload coefficient : 1.2 (assumed)

Starting current setting : $I_S = (300 / 400) \times 1.2 = 0.9 \times I_N$

7.5.5 Time multiplier setting

The time multiplier setting for inverse time over-current is a scale factor for the selected characteristics. The characteristics for two adjacent relays should have a time interval of about 0.3 - 0.4 s.

7.5.6 Fast tripping short circuit protection (I>>)

The high-set current setting is set as a multiplier of the nominal current. The time delay is always independent to the fault current.

7.5.7 IRI1-3I-EI

Short Circuit Protection : The Current setting range is from $2 \times I_n$ to $20.6 \times I_n$.

8. Housing

The IRI1 can be supplied in an individual housing for flush-mounting or as a plug-in module for installation in a 19" mounting rack according to DIN 41494. Both versions have plug-in connections.

8.1 Flush mounting

The individual housing of the IRI1 is constructed for flush-mounting. The dimensions of the mounting frame correspond to the requirements of DIN 43700 (76 x 142 mm). The cut-out for panel mounting is 68.7 x 136.5 mm.

The front panel of the IRI1 is covered with a transparent, sealable flap (IP54).

For case dimensions and cut-out refer to "technical data". The individual housing is fixed with the supplied clasps from the rear of the panel.

8.2 Rack mounting

The IRI1 is in general suitable for installation in a modular carrier according to DIN 41494. The installation dimensions are : 12 TE; 3 HE. According to requirements, The IRI1-devices can be delivered mounted in 19" racks.

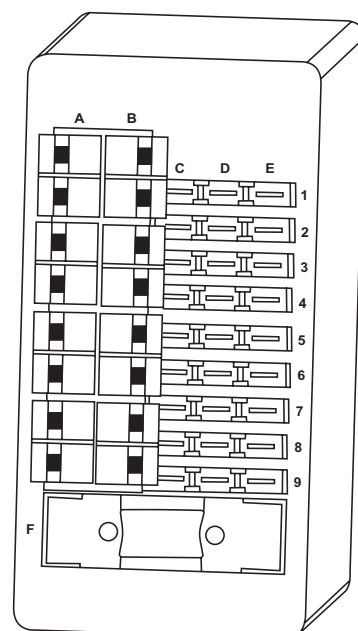
8.3 Terminal

The IRI1-plug-in module has a very compact plug-and socket connector. This connector consists of up to 27 terminals of 5 A and 15 terminals of 20 A.

The current terminals are equipped with self-closing contacts. Thus, the IRI1-module can be unplugged even with current flowing, without endangering the current transformers connected.

The measuring circuits of IRI1 (terminal connector series A and B) are connected through spade terminals with dimensions of 6.3 mm x 0.8 mm, for cables, max. 6 mm². By using 2.8 mm x 0.8 mm spade terminals, a bridge connection between different poles is possible.

The following figure shows the terminals back of IRI1



9. Test and Maintenance

The measuring input circuits are of completely static design and the relay functions are entirely digital, so that the IRI1 has no requirement for maintenance.

10. Technical Data

10.1 Measuring input

Rated data : Rated current I_N 1 A or 5 A
 Rated frequency F_N 50/60 Hz adjustable (IRI1-3I-EI) is available only in 50 Hz version)

Power consumption in current circuit : at $I_N = 1$ A 0.2 VA
 at $I_N = 5$ A 0.1 VA

Thermal withstand capability in current circuit : dynamic current withstand (half-wave) 250 x I_N
 for 1 s 100 x I_N
 for 10 s 30 x I_N
 continuously 4 x I_N

10.2 Auxiliary voltage

Rated auxiliary voltage U_H : 24 V working range 16-90 V AC/DC
 110 V working range 80-250 V AC/DC
 Power consumption : at 24 V quiescent approx. 3 W operating approx. 6 W
 at 110 V quiescent approx. 3 W operating approx. 6 W

10.3 General data

Dropout ratio : >97%
 Returning time : 30 ms
 Time lag error class index E : + 10 ms
 Minimum operating time : 30 ms
 Transient overreach at instantaneous operation : 5 %

10.4 Setting ranges and steps

10.4.1 Independent time over-current, earth fault and short circuit protection

		Setting Range	Step	Tolerances
I>	Is ti>	0.5 - 2.05 x I_N	0.05 x I_N	± 5% from set value
		x 1 : 0.1 - 1.5s	0.1 s	± 3% or ± 10 ms
		x 10 : 1.0 - 1.5s	1.0 s	± 3% or ± 10 ms
		x 100 : 10 - 150s	10 s	± 3% or ± 10 ms
I>>	I ti>>	2.0 - 33.5 x I_N	0.5 I_N	± 5% from set value
		0.05 - 1.55 s	0.05 s	± 3% or ± 10 ms
I _E	Is t _{IE}	0.1 - 1.6 x I_N	0.1 x I_N	± 5% from set value
		x 1 : 0.1 - 1.5 s	0.1 s	± 3% or ± 10 ms
		x 10 : 1.0 - 15 s	1.0 s	± 3% or ± 10 ms
		x100 : 10 -150 s	10 s	± 3% or ± 10 ms
I _E >> IRI1 - EO only	I _E >> t _{IE} >	0.5 - 16 x I_N	0.5 x I_N	± 5% of set value
		0.05 - 1.55 s	0.05 s	± 3% or ± 10 ms

For short circuit protection setting range of IRI1-3I-EI please refer 10.4.3.

10.4.2 Dependent time over-current, earth fault and short circuit protection

Tripping characteristics according to IEC 255-4 or BS 142

Normal Inverse $t = \frac{0.14}{(I/I_s)^{0.02-1}}$ $tI > [s]$

Very Inverse $t = \frac{13.5}{(I/I_s)-1}$ $tI > [s]$

Extremely Inverse $t = \frac{80}{(I/I_s)^2-1}$ $tI > [s]$

Where t = tripping time $tI >$ = time multiplier

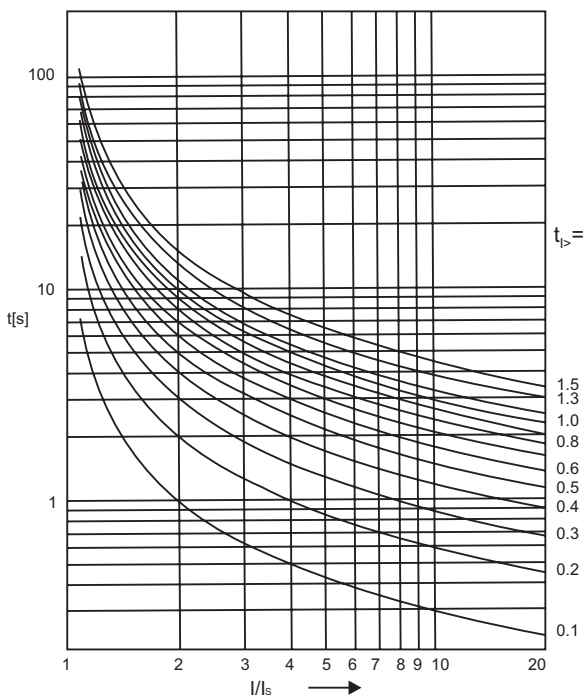
I = fault current I_s = setting value of the current

		Setting Range	Step	Tolerances
$I >$	I_s $tI >$	0.5 - 2.05 x I_N 0.1 - 1.5	0.05 x I_N 0.1	± 5% from set value ± 5% for NINV and VINV ± 7.5% for EINV at 10 xIs
$I >>$	I $tI >>$	2.0 - 33.5 x I_N 0.05 - 1.55 s	0.5 X I_N 0.05 s	± 5% from set value ± 3% or ± 10 ms
I_E	I_s t_{IE}	0.1 - 1.6 x I_N 0.1 - 1.5	0.1 x I_N 0.1	± 5% from set value ± 5% for NINV and VINV ± 7.5% for EINV at 10 xIs
$I_E >>$ IRI1 - EO only	$I_E >>$ $t_{IE} >$	0.5 - 16 x I_N 0.05 - 1.55 s	0.5 x I_N 0.05 s	± 5% of set value ± 3% or ± 10 ms

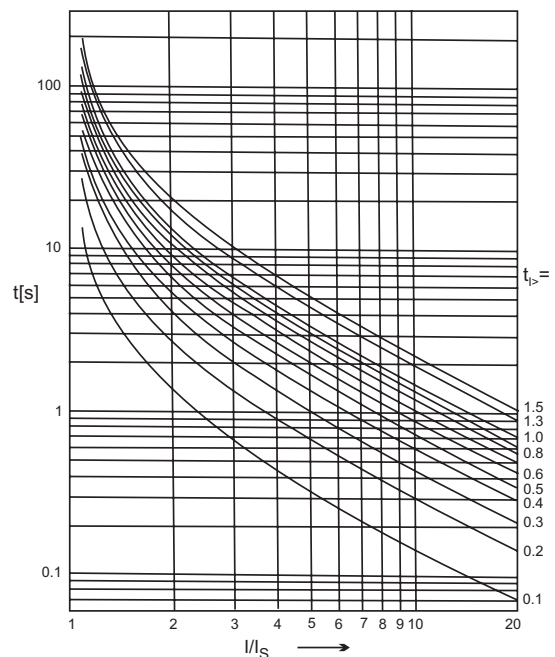
10.4.3 Setting only for IRI1-3I-EI(N1 MODEL)

		Setting Range	Step	Tolerances
$I >>$	$I >>$	2.0 - 20.6 x I_N	0.6 x I_N	± 5% from set value
$I_E >>$	$I_E >>$	0.5 - 16.0 x I_N	0.5 x I_N	± 5% from set value

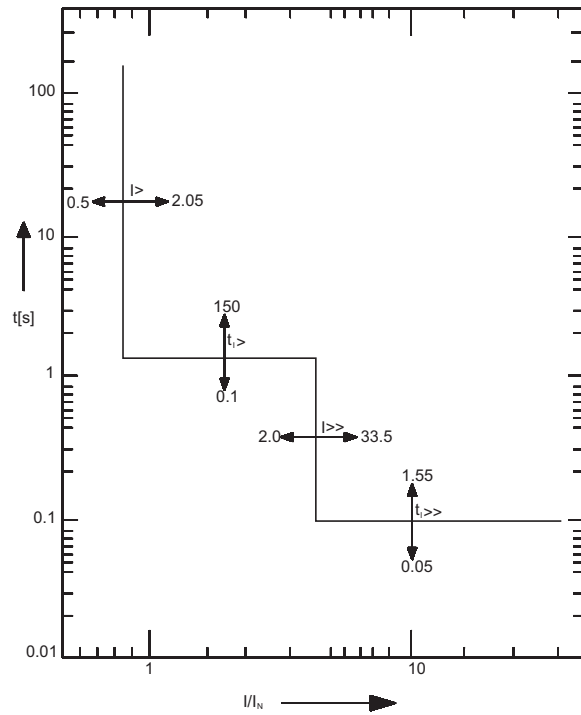
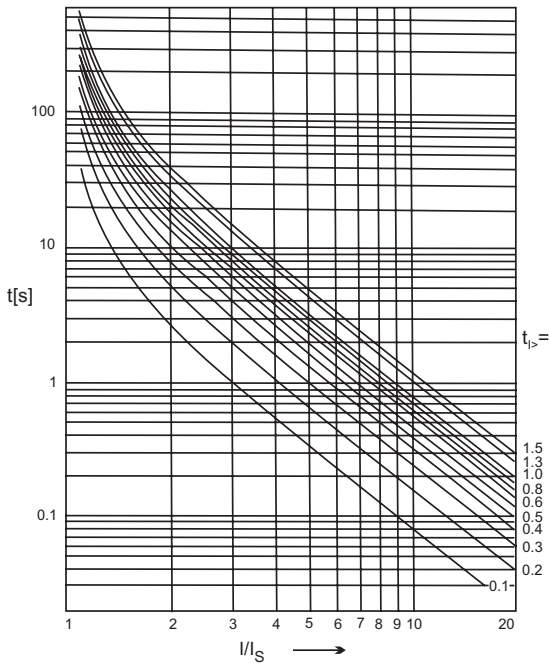
10.5 Tripping characteristics



Normal inverse



Very inverse



Definite time overcurrent relay

Extremely inverse

10.6 Output Relays

Number of relays

- : 2 in IR11-2O-EO and IR11-EO
- 1 in IR11-3I-EI

Contacts

- : 2 change-over contacts each for trip relay I> and I>>
- 2 change-over contacts for I_E>
- 2 change-over contacts for I_E>>

Max. breaking capacity

- : 1250 VA/150 W resistive
- 500 VA/90 W inductive

Max. breaking voltage

- : 400 V AC, 125 V DC

Max. continuous current

- : 5 A

Max. making current (16 ms)

- : 20 A

10.7 System data

Design standard

- : VDE 04335, part 303, IEC 255-4, BS 142

Specified ambient service

Temperature range

- for storage
- for operation

- : -40°C to + 85°C
- : -20°C to + 70°C

Environmental protection class F as per DIN 40040 and per DIN IEC 68, part 2.3

- : Relative humidity 95 % at 40°C for 56 days

Isolation test voltage, inputs and outputs between themselves and to the relay frame as per VDE 0435, part 303

- : 2.5 kV (eff.) / 50 Hz, 1 min.

Impulse test voltage, inputs and outputs between themselves and to the relay frame as per VDE IEC 0435, part 303

- : 2.5 kV (eff.) / 50 Hz, 1 min.

High frequency interference test voltage, inputs and outputs between themselves and to the relay frame as per DIN IEC 255, part 22-1

- : 2.5 kV / 1 MHz

Electrical fast transient (Burst) test as per DIN VDE 0843, part 4

- : 4 kV / 2.5 kHz, 15 ms

Radio interference suppression test as per DIN VDE 57 871

- : Limit value class B

Electrostatic discharge (ESD) test as per DIN VDE 0843 part 2

- : 8 kV

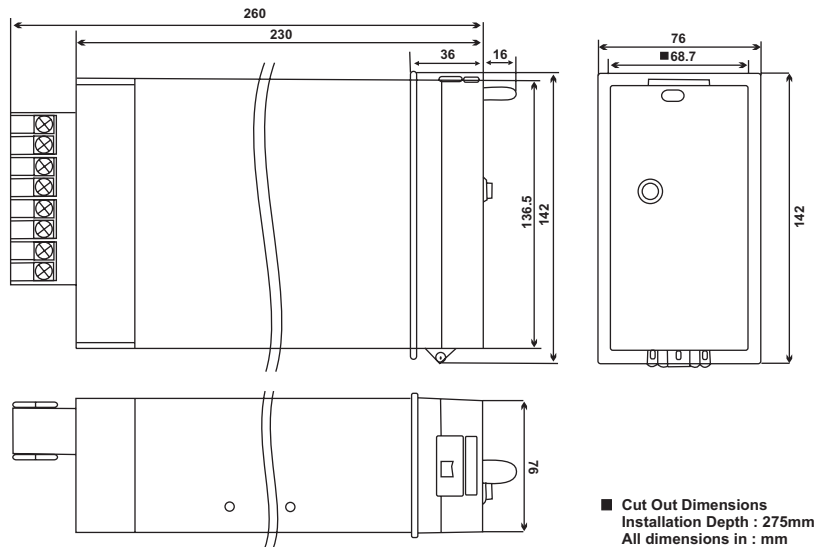
Radiated electromagnetic field test as per VDE 0843 part 2

- : 10 V/m

10.8 Mechanical tests

- Shock : As per DIN IEC 41 B (CO) 38 : class 1
- Vibration : As per DIN IEC 41 B (CO) 35 : class 1
- Protection-front panel : IP 54
- Protection-rear panel : IP 00
- Weight : Approx. 1.5 kg

10.9 Dimensional Drawing



11. Order form

Microprocessor Over-current + Earth Fault Protection Relay		IRI1				
3 O/C with high Set and 1 E/F with high Set	3I-EI	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1 E/F with high Set	EO	-	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Rated current (O/C Element)		1	5			
Rated current (E/F Element)			1	5		
Auxiliary voltage (AC/DC)					L	
24 V (16 to 90 V)					H	
110 V (80 to 250 V)						D
Housing Flush						A
19" rack						

* Data subject to change without notice



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