



MRI3 – Digital multifunctional relay for overcurrent protection

Manual MRI3 (Revision A)

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1. Introduction and application

The MRI3 digital multifunctional relay is a universal time overcurrent and earth fault protection device intended for use in medium-voltage systems, either with an isolated/compensated neutral point or for networks with a solidly earthed/resistance-earthed neutral point.

The protective functions of MRI3 which are implemented in only one device are summarized as follows:

- Independent (Definite) time overcurrent relay,
- inverse time overcurrent relay with selectable characteristics,
- integrated determination of fault direction for application to doubly infeed lines or meshed systems,
- two-element (low and high set) earth fault protection with definite or inverse time characteristics,
- integrated determination of earth fault direction for application to power system networks with isolated or arc suppressing coil (Peterson coil) neutral earthing. (ER/XR-relay type),
- integrated determination of earth short-circuit fault direction in systems with solidly-earthed neutral point or in resistance-earthed systems (SR-relay type).

Furthermore, the relay MRI3 can be employed as a back-up protection for distance and differential protective relays.

A similar, but simplified version of overcurrent relay IRI1 with reduced functions without display and serial interface is also available.

Important:

For additional common data of all MR-relays please refer to manual "MR - Digital Multifunctional relays". On page 66 of this manual you can find the valid software versions.

2. Features and characteristics

- Digital filtering of the measured values by using discrete Fourier analysis to suppress the high frequency harmonics and DC components induced by faults or system operations,
- two parameter sets,
- selectable protective functions between:
 - definite time overcurrent relay and
 - inverse time overcurrent relay,
- selectable inverse time characteristics according to IEC 255-4:
 - Normal Inverse (Type A)
 - Very Inverse (Type B)
 - Extremely Inverse (Type C)
 - Special characteristics,
- reset setting for inverse time characteristics selectable,
- high set overcurrent unit with instantaneous or de-finite time function,
- two-element (low and high set) overcurrent relay both for phase and earth faults,
- directional feature for application to the doubly in-fed lines or meshed systems,
- earth fault directional feature selectable for either isolated or compensated networks,
- sensitive earth fault current measuring with or without directional feature (X and XR-relay type),
- determination of earth short-circuit fault direction for systems with solidly-earthed or resistance-earthed neutral point,
- numerical display of setting values, actual measured values and their active, reactive components, memorized fault data, etc.,
- display of measuring values as primary quantities,
- withdrawable modules with automatic short circuiters of C.T. inputs when modules are withdrawn,
- blocking e.g. of high set element (e.g. for selective fault detection through minor overcurrent protection units after unsuccessful AR),
- relay characteristic angle for phase current directional feature selectable,
- circuit breaker failure protection,
- storage of trip values and switching-off time (tCBFP) of 5 fault occurrences (fail-safe of voltage),
- recording of up to eight fault occurrences with time stamp,
- free assignment of output relays
- serial data exchange via RS485 interface possible; alternatively with SEG RS485 Pro-Open Data Protocol or Modbus Protocol,
- suppression of indication after an activation (LED flash),
- display of date and time

3. Design

3.1 Connections

Phase and earth current measuring:

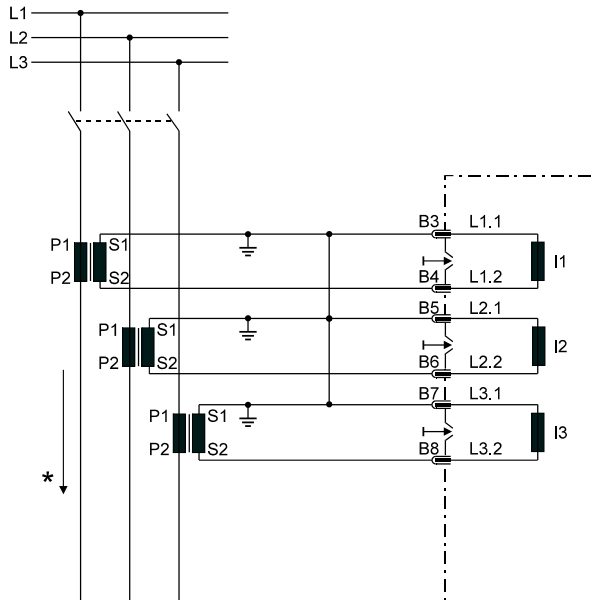


Figure 3.1: Measuring of the phase currents for over-current- and short-circuit protection ($I>$, $I>>$)

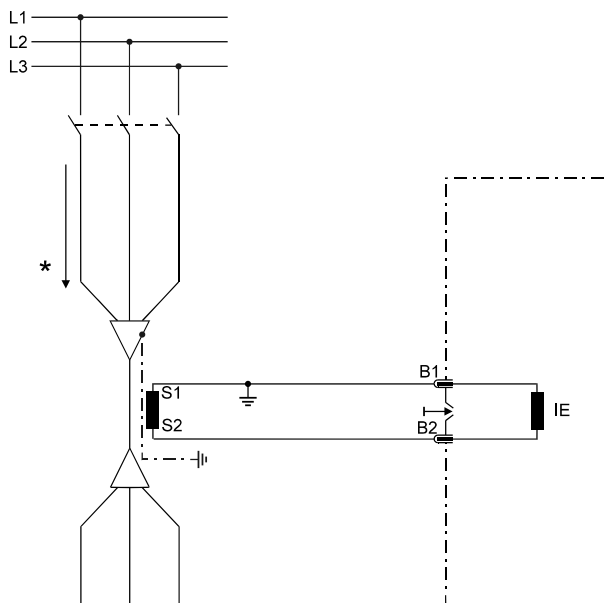


Figure 3.2: Earth-fault measuring by means of ring-core C.T. (IE)

When phase- and earth-fault current measuring are combined, the connection has to be realized as per Figure 3.1 and Figure 3.2 or Figure 3.3.

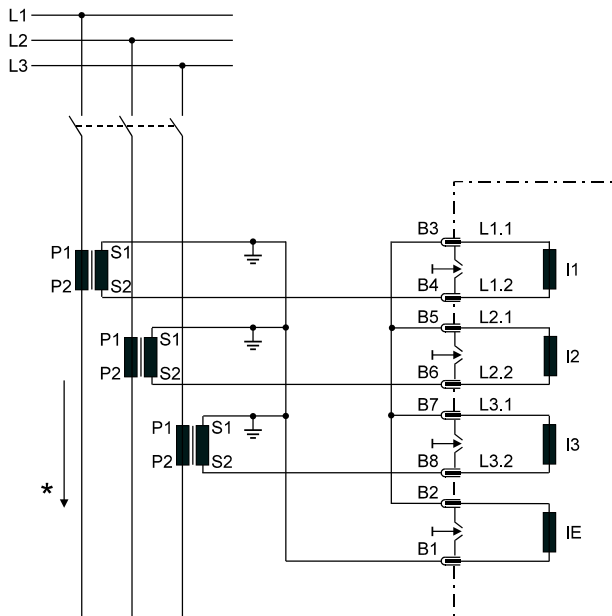


Figure 3.3: Phase current measuring and earth-current detection by means of Holmgreen-circuit.

This connection can be used with three existing phase current transformers when combined phase and earth-current measuring is required.

Disadvantage of holmgreen-circuit:

At saturation of one or more C.Ts the relay detects seeming an earth current.

* This arrow shows the current flow in forward direction, for this LED →← lights up green

Voltage measuring for the directional detection:

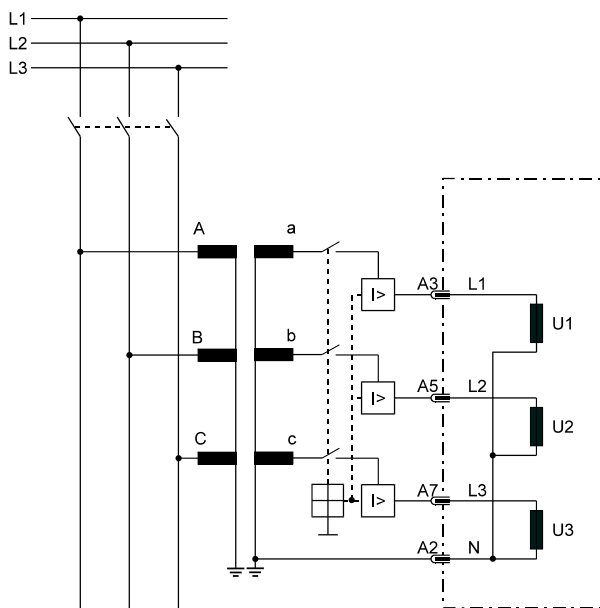


Figure 3.4: Measuring of the phase voltages for the directional detection at overcurrent, short-circuit or earth-fault protection ($I>$, $I>>$, $IE>$ and $IE>>$).

For details on the connection of ER/XR-unit type c.t.s, see para 4.5.

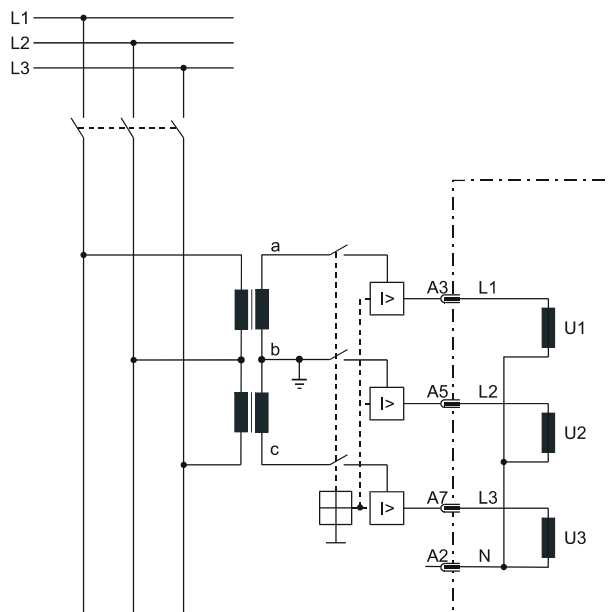


Figure 3.5: Voltage transformer in V-connection for the directional detection at overcurrent and short-circuit protection.

The V-connection cannot be applied at earth fault directional feature.

3.1.1 Analog input circuits

The protection unit receives the analog input signals of the phase currents IL1 (B3-B4), IL2 (B5-B6), IL3 (B7-B8) and the current IE (B1-B2), phase voltages U1 (A3), U2 (A5), U3 (A7) with A2 as star point, each via separate input transformers.

The constantly detected current measuring values are galvanically decoupled, filtered and finally fed to the analog/digital converter.

For the unit type with earth fault directional features (ER/XR-relay type) the residual voltage UE in the secondary circuit of the voltage transformers is internally formed.

In case no directional feature for the phase current path is necessary the residual voltage from the open delta winding can directly be connected to A3 and A2.

See Chapter 4.5 for voltage transformer connections on isolated/compensated systems.

3.1.2 Output relays

The MRI3 is equipped with 5 output relays. Apart from the relay for self-supervision, all protective functions can be optionally assigned:

- Relay 1: C1, D1, E1 and C2, D2, E2
- Relay 2: C3, D3, E3 and C4, D4, E4
- Relay 3: C5, D5, E5
- Relay 4: C6, D6, E6
- Relay 5: Self-supervision C7, D7, E7

All trip and alarm relays are working current relays, the relay for self supervision is an idle current relay.

3.1.3 Blocking input

The blocking functions adjusted before will be blocked if an auxiliary voltage is connected to (terminals) D8/E8. (See chapter 5.7.1)

3.1.4 External reset input

Please refer to chapter 5.10.

3.2 Relay output contacts

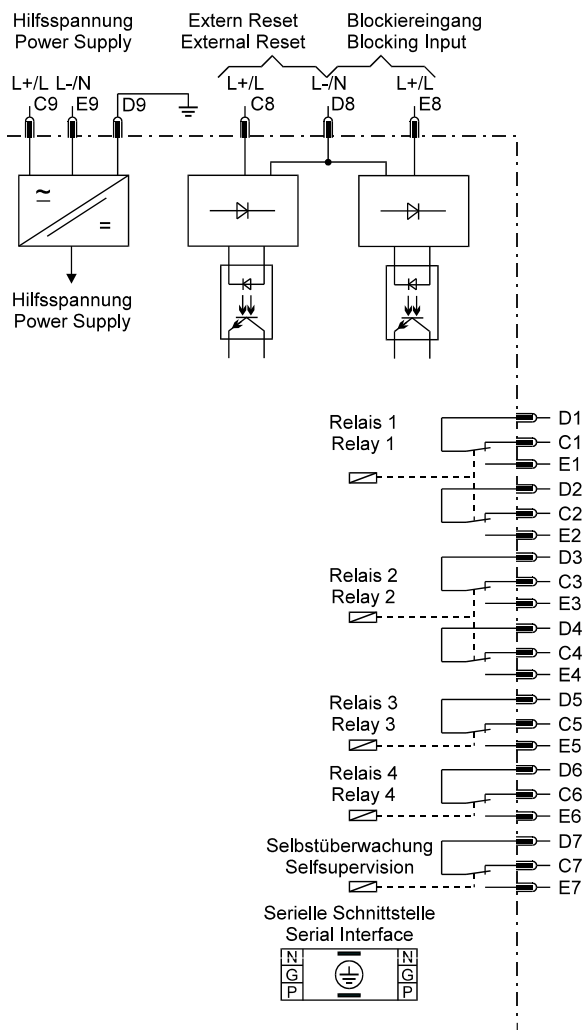


Figure 3.6:

3.2.1 Fault recorder

The MRI3 is equipped with a disturbance value recorder which records the measured analogue values as momentary values. The momentary values

$$iL1, iL2, iL3, i_E,$$

are scanned within a grid 1.25 ms (with 50 Hz) or 1.041 ms (with 60 Hz) and filed in a circulating storage. The max. storage capacity amounts to 16 s (with 50 Hz) or 13.33 s (with 60 Hz).

Storage division

Independent of the recording time, the entire storage capacity can be divided into several cases of disturbance with a shorter recording time each. In addition, the deletion behaviour of the fault recorder can be influenced.

No writing over

If 2, 4 or 8 recordings are chosen, the complete memory is divided into the relevant number of partial segments. If this max. number of fault event has been exceeded, the fault recorder block any further recordings in order to prevent that the stored data are written over. After the data have been read and deleted, the recorder to ready again for further action.

Writing over

If 1, 3 or 7 recordings are chosen, the relevant number of partial segments is reserved in the complete memory. If the memory is full, a new recording will always write over the oldest one.

The memory part of the fault recorder is designed as circulating storage. In this example 7 fault records can be stored (written over).

Memory space 6 to 4 is occupied.
Memory space 5 is currently being written in

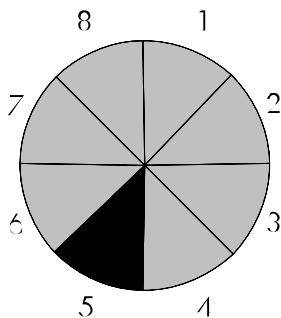


Figure 3.7: Division of the memory into 8 segments, for example

Since memory spaces 6, 7 and 8 are occupied, this example shows that the memory has been assigned more than eight recordings. This means that No. 6 is the oldest fault recording and No. 4 the most recent one.

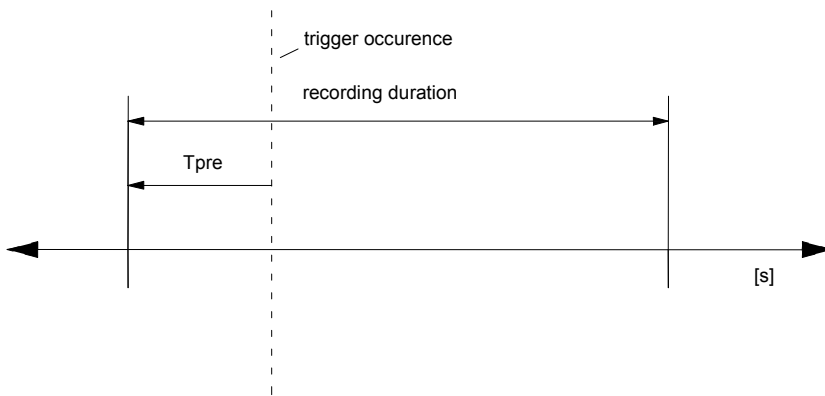


Figure 3.8: Recording scheme of the fault recorder with pre-trigger time

Each memory segment has a specified storage time which permits setting of a time prior to the trigger event.

Via the interface RS485 the data can be read and processed by means of a PC with HTL/PL-Soft4. The data is graphically edited and displayed. Binary tracks are recorded as well, e.g. activation and trip.

3.2.2 Parameter settings (see chapter 5)

System parameter

Relay type MRI3-	I	IE IX	IRE IRX	IR	IER IXR	IRER IRXR	ER XR	EX	ISR	IRSR	SR
Display of measuring values as primary quantities (I_{prim} phase)	X	X	X	X	X	X			X	X	
Display of earth current as primary quantities (I_{prim} earth)		X	X		X	X	X	X	X	X	X
Display of residual voltage UE as primary quantity ($U_{\text{prim}}/U_{\text{sec}}$)					X	X	X				
3pha/e-n/1:1					X	X	X				
50/60 Hz	X	X	X	X	X	X	X	X	X	X	X
LED-Flash	X	X	X	X	X	X	X	X	X	X	X
RS 485 slave address	X	X	X	X	X	X	X	X	X	X	X
Baud-Rate ¹⁾	X	X	X	X	X	X	X	X	X	X	X
Parity-Check ¹⁾	X	X	X	X	X	X	X	X	X	X	X
Adjustment of the clock: Y = year; M = month; D = day; h = hour; m = minute; s = sec.	X	X	X	X	X	X	X	X	X	X	X

Table 3.1: System parameters of the different relay types

¹⁾ Only devices with Modbus-Protocol

Protection parameter

Relay type MRI3-	I	IE IX	IRE IRX	IR	IER IXR	IRER IRXR	ER XR	EX	ISR	IRSR	SR
2 parameter sets	X	X	X	X	X	X	X	X	X	X	X
I>	X	X	X	X	X	X			X	X	
CHAR I>	X	X	X	X	X	X			X	X	
tI>	X	X	X	X	X	X			X	X	
0s /60s ²⁾	X	X	X	X	X	X			X	X	
I>>	X	X	X	X	X	X			X	X	
tI>>	X	X	X	X	X	X			X	X	
RCA			X	X		X				X	
U _E					X	X	X				
I _{E>}		X	X		X	X	X	X	X	X	X
warn/trip		X	X		X	X	X	X			
CHAR I _E		X	X					X	X	X	X
t _{I_E}		X	X		X	X	X	X	X	X	X
0s / 60s ³⁾		X	X					X	X	X	X
I _{E>>}		X	X		X	X	X	X	X	X	X
t _{I_{E>>}}		X	X		X	X	X	X	X	X	X
sin/cos					X	X	X				
sol/resi									X	X	X
tCBFP	X	X	X	X	X	X	X	X	X	X	X
Block/Trip	X	X	X	X	X	X	X	X	X	X	X

Table 3.2: Protection parameters of the different relay types.

²⁾ Reset setting for inverse time characteristics in phase current path

³⁾ Reset setting for inverse time characteristics in earth current path

Parameter for the fault recorder

Relay type MRI3-	I	IE IX	IRE IRX	IR	IER IXR	IRER IRXR	ER XR	E X	ISR	IRSR	SR
Number of fault events	X	X	X	X	X	X	X	X	X	X	X
Trigger events	X	X	X	X	X	X	X	X	X	X	X
Pre-trigger time (Tpre)	X	X	X	X	X	X	X	X	X	X	X

Table 3.3: Parameters for the fault recorder of the different relay types

Additional parameters

Relay type MRI3-	I	IE IX	IRE IRX	IR	IER IXR	IRER IRXR	ER XR	E X	ISR	IRSR	SR
Blocking mode ¹⁾	X	X	X	X	X	X	X	X	X	X	X
Relay parameterizing	X	X	X	X	X	X	X	X	X	X	X
Fault recorder	X	X	X	X	X	X	X	X	X	X	X

Table 3.4: Additional parameters of the different relay types

¹⁾ For 2 parameter sets (separately for each parameter set)

Front plates

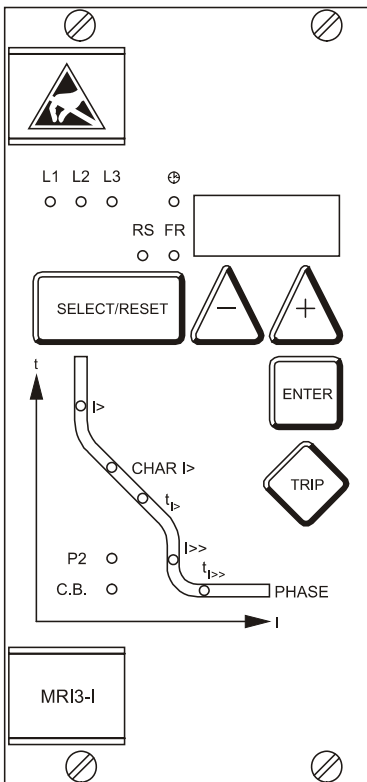


Figure 3.9: Front plate MRI3-I

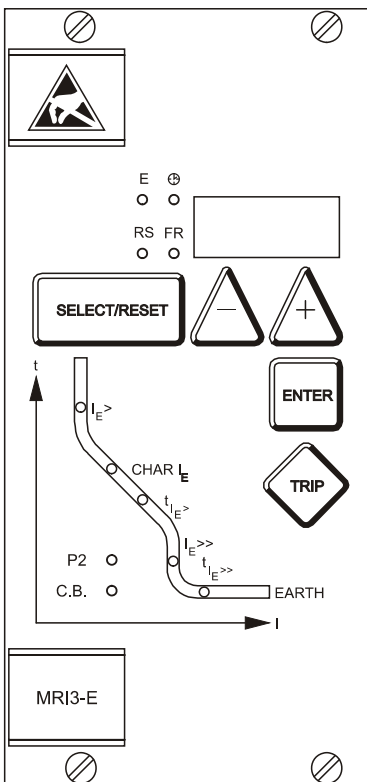


Figure 3.10: Front plate MRI3-E/X

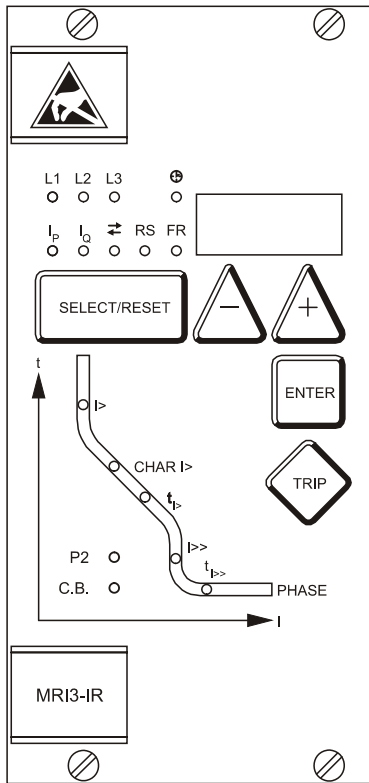


Figure 3.11: Front plate MRI3-IR

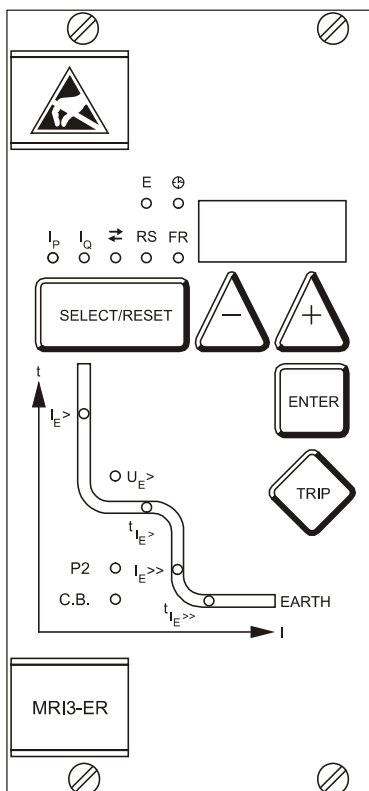


Figure 3.12: Front plate MRI3-ER/XR

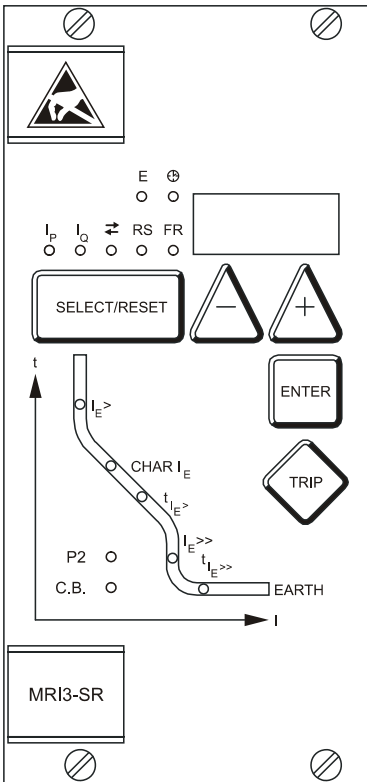


Figure 3.13: Front plate MRI3-SR

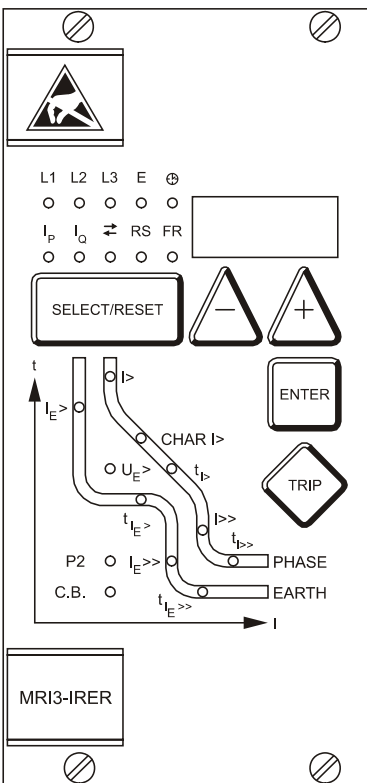


Figure 3.14: Front plate MRI3-IRER/IRXR and MRI3-IER/IXR

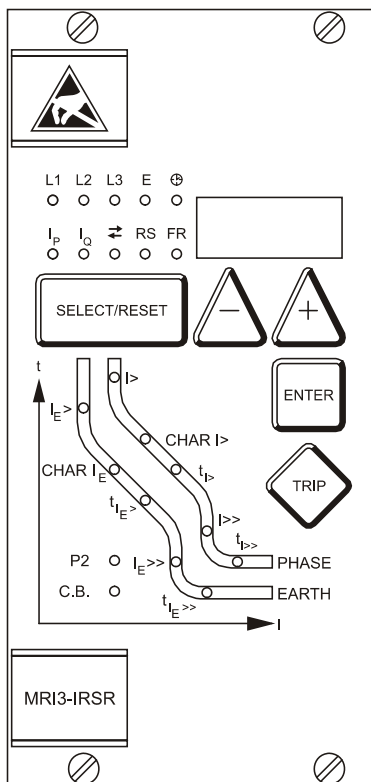


Figure 3.15: Front plate MRI3-IRSR; MRI3-IRE/IRX, MRI3-IRYR and MRI3-ISR

3.3 LEDs

The LEDs left from the display are partially bi-colored, the green indicating measuring, and the red fault indication.

MRI3 with directional feature have a LED (green- and red arrow) for the directional display. At pickup/trip and parameter setting the green LED lights up to indicate the forward direction, the red LED indicates the backward direction.

The LED marked with letters RS lights up during setting of the slave address of the device for serial data communication.

The LEDs arranged at the characteristic points on the setting curves support the comfortable setting menu selection. In accordance with the display 5 LEDs for phase fault overcurrent relay and 5 LEDs for earth-fault relay indicate the corresponding menu point selected.

The LED labeled with the letters LR is alight while the fault recorder is being adjusted.

4. Working principle

4.1 Analog circuits

The incoming currents from the main current transformers on the protected object are converted to voltage signals in proportion to the currents via the input transformers and burden. 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. The analog signals are sampled at 50 Hz (60 Hz) with a sampling frequency of 800 Hz (960 Hz), namely, a sampling rate of 1.25 ms (1.04 ms) for every measuring quantity. (16 scans per period).

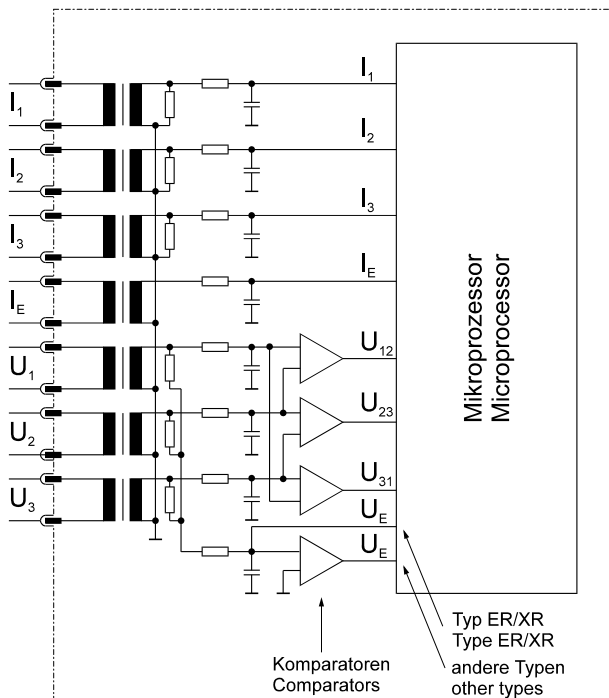


Figure 4.1: Block diagram

4.2 Digital circuits

The essential part of the MRI3 relay is a powerful microcontroller. All of the operations, from the analog digital conversion to the relay trip decision, are carried out by the microcontroller digitally. The relay program is located in an EPROM (Electrically-Programmable-Read-Only-Memory). With this program the CPU of the microcontroller calculates the three phase currents and ground current in order to detect a possible fault situation in the protected object.

For the calculation of the current value an efficient digital filter based on the Fourier Transformation (DFFT - Discrete Fast Fourier Transformation) is applied to suppress high frequency harmonics and DC components caused by fault-induced transients or other system disturbances.

The calculated actual current values are compared with the relay settings. If a phase current exceeds the pickup value, an alarm is given and after the set trip delay has elapsed, the corresponding trip relay is activated.

The relay setting values for all parameters are stored in a parameter memory (EEPROM - Electrically Erasable Programmable Read-only Memory), so that the actual relay settings cannot be lost, even if the power supply is interrupted.

The microprocessor is supervised by a built-in "watch-dog" timer. In case of a failure the watchdog timer re-sets the microprocessor and gives an alarm signal, via the output relay "self supervision".

4.3 Directional feature

A built-in directional element in MRI3 is available for application to doubly infeeded lines or to ring networks.

The measuring principle for determining the direction is based on phase angle measurement and therefore also on coincidence time measurement between current and voltage. Since the necessary phase voltage for determining the direction is frequently not available in the event of a fault, whichever line-to-line voltage follows the faulty phase by 90° is used as the reference voltage for the phase current. The characteristic angle at which the greatest measuring sensitivity is achieved can be set to precede the reference voltage in the range from 15° to 83°.

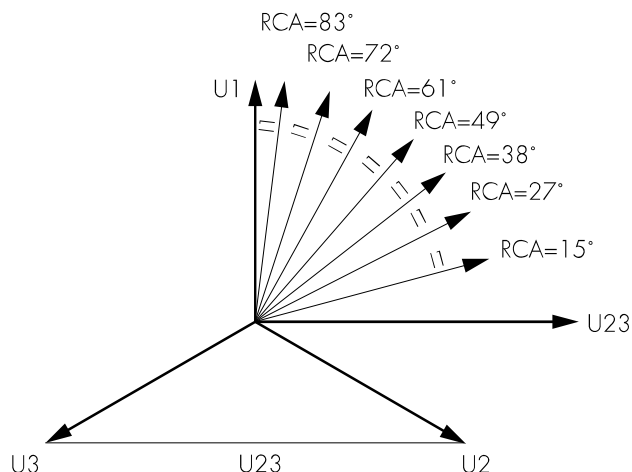


Figure 4.2: Relay characteristic angle

The TRIP region of the directional element is determined by rotating the phasor on the maximum sensitivity angle for ±90°, so that a reliable direction decision can be achieved in all faulty cases.

4.3.1 Reversal in direction during the activation phase

Reversal of the current direction during the activation phase can lead to hyper functions. This mainly applies to installations where parallel connected lines are monitored by current relays with directional feature. For this reason the directional determination for the phase current is shown in a time window; this applies to all SR versions. In case of activation due to a fault, a timer is started and measures the time in the determined direction for max. 1 s. This timer runs backwards at half speed if, during the activation phase, a fault causes reversal of the direction. Only when the timer is at zero again, the MRI3 recognizes the reversal in direction. The switch-over time is max. 2 s. The activation delays $t_{l>}$ and $t_{l>>}$ are not affected by the delayed recognition of direction.

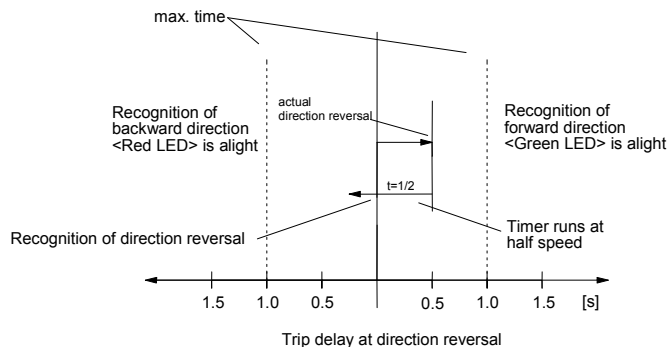


Figure 4.3: Recording scheme of the fault recorder with lead time

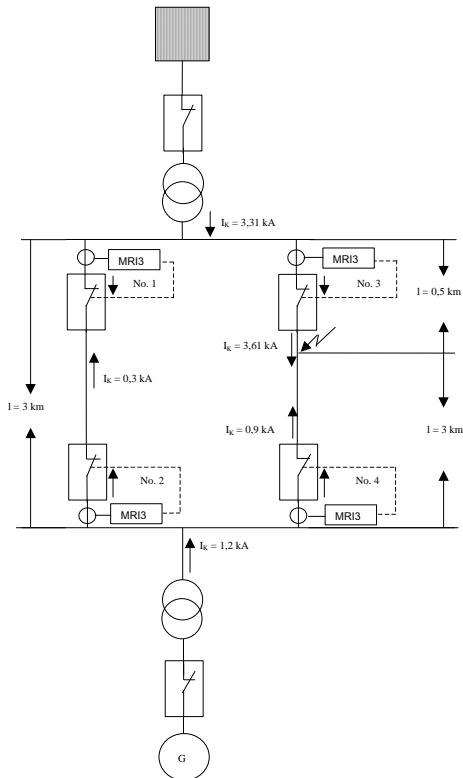


Figure 4.4

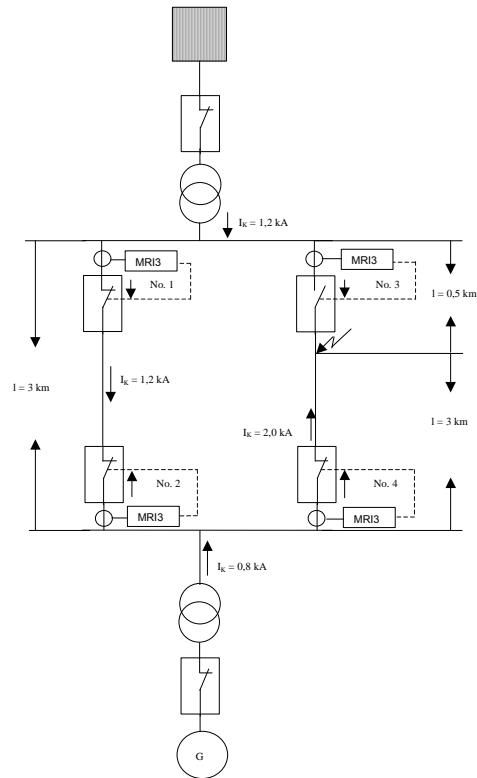


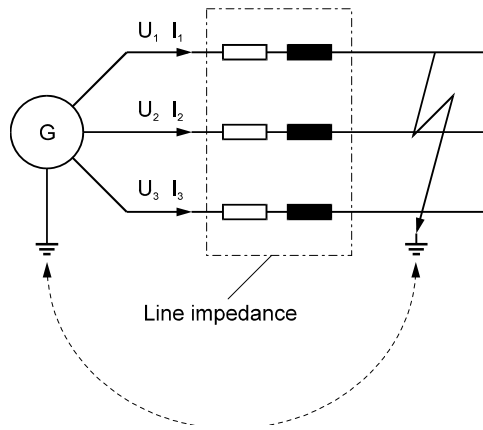
Figure 4.5

Example:

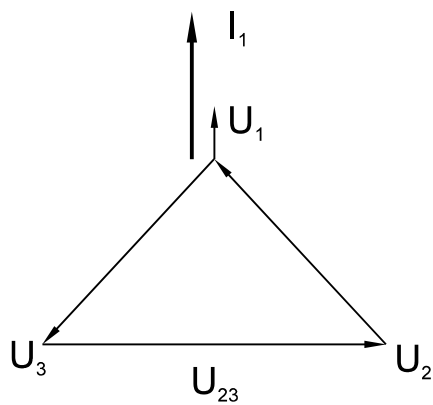
Figure 4.4 and Figure 4.5 illustrate a possible fault situation with a reversal in direction in the fault-free line. The current transformers used have a primary current of 250 A. The switch point for the $I>$ stage is 0.25 kA and for the $I>>$ stage 1 kA. All devices have the same setting and will, if set to "Forward", recognize the direction in relation to the forward direction of the line. The critical point here is the MRI3 No. 1. Using delay action in directional recognition, it is possible to prevent shut-down of the fault-free line.

The following relay setting applies:

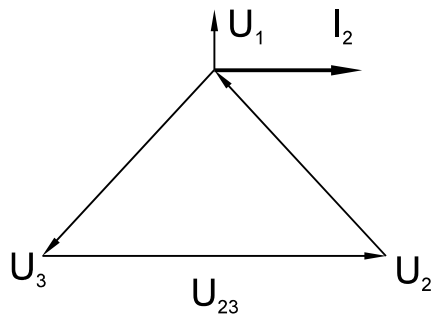
$I>$	1.00 x I_n
CHAR $I>$	DEFT (inverse)
	trip delay
$tI>(V)$	10s
	Trip delay in forward direction
$tI>(R)$	EXIT (no trip) Delay in backward direction
$I>>$	4.00 x I_n
$tI>>(V)$	0.1 s
$tI>>(R)$	EXIT



If line impedance and internal resistance of the generator is only ohmic:



If line impedance and internal resistance of the generator is only inductive:



The maximum sensitivity angle corresponds to the R/L component.

The TRIP region of the directional element is determined by rotating the phasor on the maximum sensitivity angle for $\pm 90^\circ$, so that a reliable direction decision can be achieved in all faulty cases.

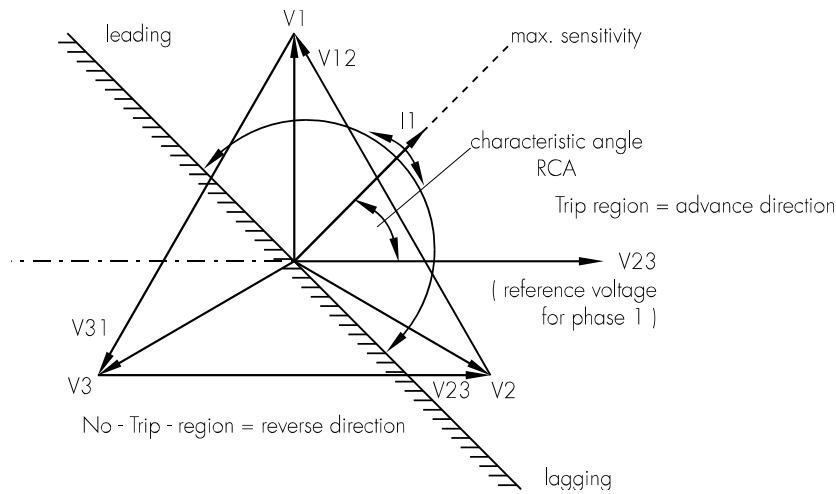


Figure 4.6: TRIP/NO-TRIP region for directional element in MRI3. In this case the forward direction is defined as TRIP region and the backward direction as NO-TRIP region.

By means of accurate hardware design and by using an efficient directional algorithm a high sensitivity for the voltage sensing circuit and a high accuracy for phase angle measurement are achieved so that a correct directional decision can be made even by close three-phase faults. As an addition, to avoid maloperations due to disturbances, at least 2 periods (40 ms at 50 Hz) are evaluated.

For the MRI3-overcurrent relays with directional feature different time delays or time multipliers can be set for forward and backward faults (ref. to chapter 5.4.3).

If the trip delay for backward faults is set longer than the one for forward faults, the protective relay works as a "backup"-relay for the other lines on the same busbar. This means that the relay can clear a fault in the backward direction with a longer time delay in case of refusal of the relay or the circuit breaker on the faulted line.

If the trip delay for backward faults is set out of range (on the display "EXIT"), the relay will not trip in case of backward faults.

The assignment of the output relays can be used to select in which direction the failure is to be indicated (refer also to Chapter 5.7.1). It is possible to indicate the activation and/or the tripping for each tripping direction via the output relays.

4.4 Earth fault protection

4.4.1 Generator stator earth fault protection

With the generator neutral point earthed as shown in Figure 4.7 the MRI3 picks up only to phase earth faults between the generator and the location of the current transformers supplying the relay. Earth faults beyond the current transformers, i.e. on the consumer or line side, will not be detected.

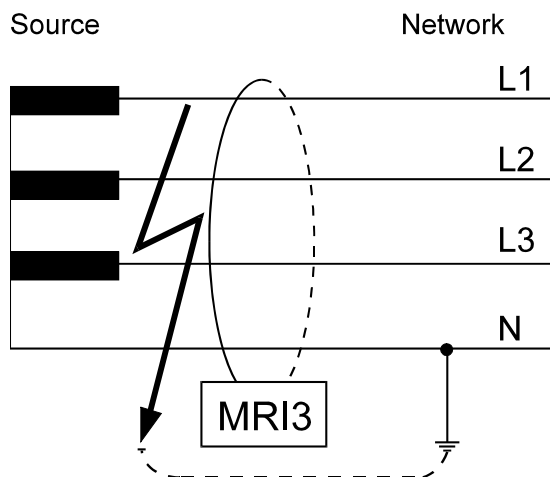


Figure 4.7: Generator stator earth fault protection

4.4.2 System earth fault protection

With the generator neutral point earthed as shown in Figure 4.8, the MRI3 picks up only to earth faults in the power system connected to the generator. It does not pick up to earth faults on the generator terminals or in generator stator.

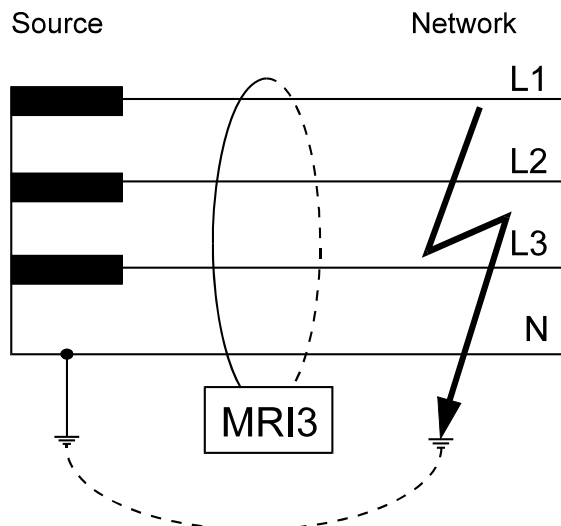


Figure 4.8: System earth fault protection

4.5 Earth-fault directional feature (ER/XR-relay type)

A built-in earth-fault directional element is available for applications to power networks with isolated or with arc suppressing coil compensated neutral point.

For earth-fault direction detection it is mainly the question to evaluate the power flow direction in zero sequence system. Both the residual voltage and neutral (residual) current on the protected line are evaluated to ensure a correct direction decision.

In isolated or compensated systems, measurement of reactive or active power is decisive for earth-fault detection. It is therefore necessary to set the ER/XR-relay type to measure according to $\sin \varphi$ or $\cos \varphi$ methods, depending on the neutral-point connection method.

The residual voltage U_E required for determining earth fault direction can be measured in three different ways, depending on the voltage transformer connections.

(refer to Table 4.1: Connection of the voltage transformers). Total current can be measured by connecting the unit either to a ring core C.T. or to current transformers in a Holmgreen circuit. However, maximum sensitivity is achieved if the MRI1 protective device is connected to a ring core C. T. (see Figure 3.2).

The pick-up values $I_{E>}$ and $I_{E>>}$ (active or reactive current component for $\cos \varphi$ or $\sin \varphi$ method) for ER-relay types can be adjusted from 0.01 to $0.45 \times I_N$. For relay type MRI3-XR these pick-up values can be adjusted from 0.1 to $4.5\% I_N$.

Adjust-ment pos-sibility	Application	Voltage trans-former connections	Measured voltage at earth fault	Correction fac-tor for residual voltage
„3pha“	3-phase voltage transformer con-nected to terminals A3, A5, A7, A2 (MRI3-IRER; MRI3-IER; MRI3-ER/XR)		$\sqrt{3} \times U_N = 3 \times U_{1N}$	$K = 1/3$
„e-n“	e-n winding con-nected to terminals A3, A2 (MRI3-IER; MRI3-ER/XR)		$U_N = \sqrt{3} \times U_{1N}$	$K = 1/\sqrt{3}$
„1:1“	Neutral-point vol-tage(=residual vol-tage) terminals A3, A2 (MRI3-IER; MRI3-ER/XR)		$U_{1N} = U_{NE}$	$K = 1$

Table 4.1: Connection of the voltage transformers

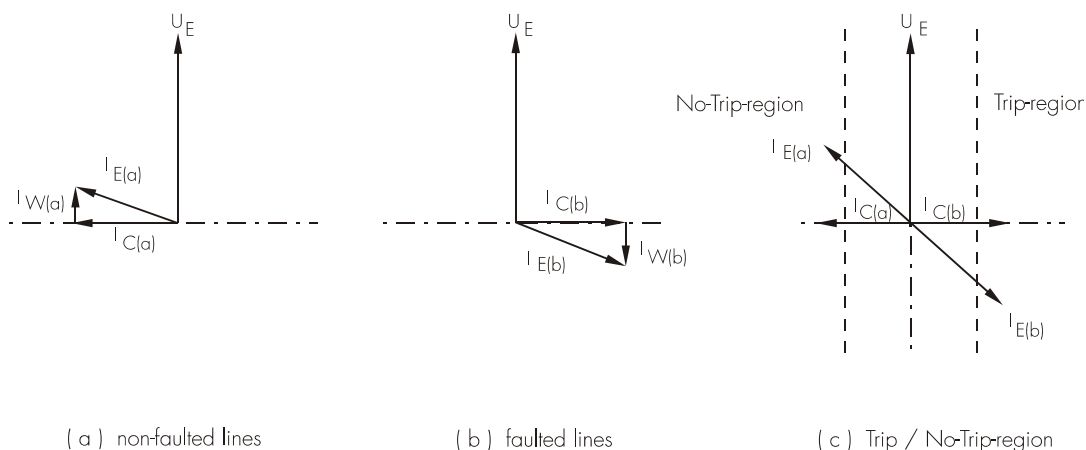


Figure 4.9: Phase position between the residual voltage and zero sequence current for faulted and non-faulted lines in case of isolated systems ($\sin \varphi$)

- U_E - residual voltage
- I_E - zero sequence current
- I_C - capacitive component of zero sequence current
- I_W - resistive component of zero sequence current

By calculating the reactive current component ($\sin \varphi$ adjustment) and then comparing the phase angle in relation to the residual voltage U_E , the ER/XR-relay type determines whether the line to be protected is earth-faulted.

On non-earth-faulted lines, the capacitive component $I_C(a)$ of the total current precedes the residual voltage by an angle of 90° . In case of a faulty line the capacity current $I_C(b)$ lags behind the residual voltage at 90° .

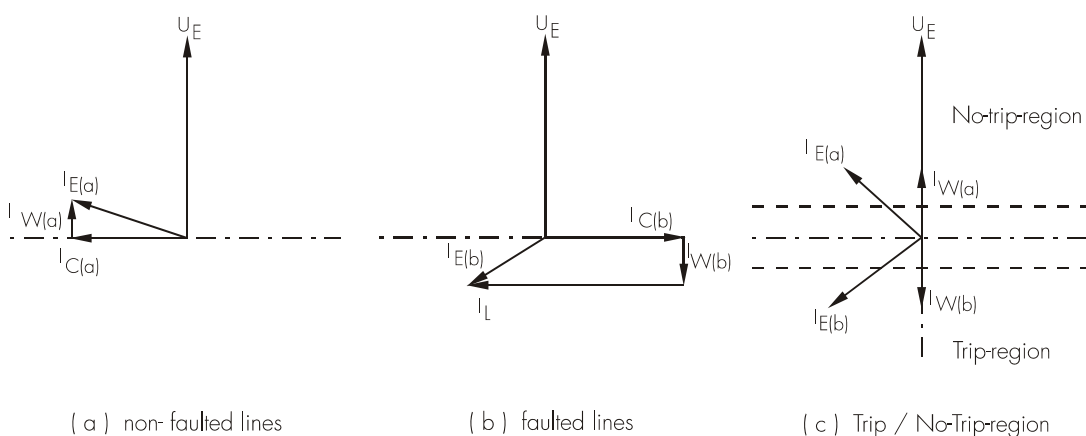


Figure 4.10: Phase position between the residual voltage and zero sequence current for faulted and non-faulted lines in case of compensated systems ($\cos \varphi$)

- U_E - residual voltage
- I_E - zero sequence current
- I_L - inductive component of zero sequence current (caused by Petersen coil)
- I_C - capacitive component of zero sequence current
- I_W - resistive component of zero sequence current

In compensated mains the earth fault direction cannot be determined from the reactive current components because the reactive part of the earth current depends upon the compensation level of the mains. The ohmic component of the total current (calculated by $\cos \varphi$ adjustment) is used in order to determine the direction. The resistive component in the non-faulted line is in phase with the residual voltage, while the resistive component in the faulted line is opposite in phase with the residual voltage.

By means of an efficient digital filter harmonics and fault transients in the fault current are suppressed. Thus, the uneven harmonics which, for instance, are caused an electric arc fault, do not impair the protective function.

4.6 Determining earth short-circuit fault direction (SR/YR-relay type)

The SR-relay type is used in solidly-earthed or resistance-earthed systems for determining earth short-circuit fault direction. The measuring principle for determining the direction is based on phase angle measurement and therefore also on the coincidence-time measurement between earth current and zero sequence voltage.

The zero sequence voltage U_0 required for determining the earth short-circuit fault direction is generated internally in the secondary circuit of the voltage transformers. With SR/ISR-relay types the zero sequence voltage U_0 can be measured directly at the open delta winding (e-n). Connection A3/A2.

4.6.1 Directly – earthed system

Most faults in a characteristic angle are predominantly inductive in character. The characteristic angle between current and voltage at which the greatest measuring sensitivity is achieved has therefore been selected to precede zero sequence voltage U_0 by 110° .

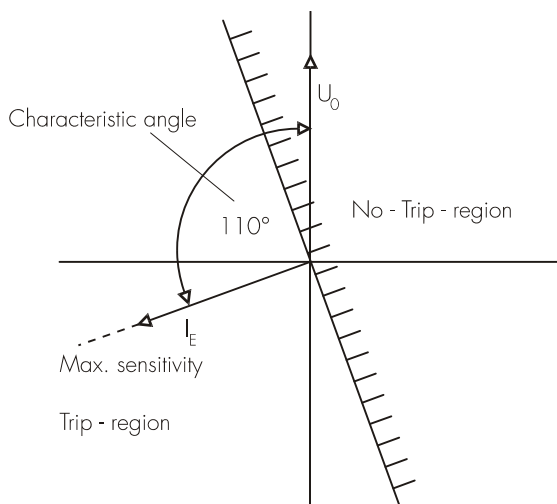


Figure 4.11: Characteristic angle in solidly earthed-systems (SOLI)

4.6.2 Resistance – earthed system

Most faults in a resistance-earthed system are pre-dominantly ohmic in character, with a small inductive part. The characteristic angle for these types of system has therefore been set at $+170^\circ$ in relation to the zero sequence voltage U_0 (see Figure 4.12).

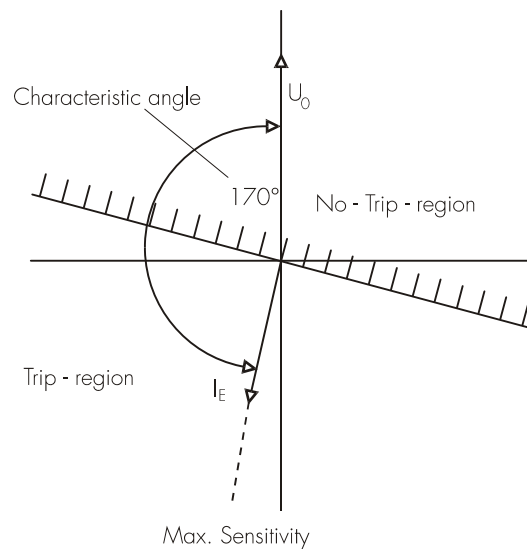


Figure 4.12: Characteristic angle in resistance-earthed systems (RESI)

The pickup range of the directional element is set by turning the current indicator at the characteristic angle through $\pm 90^\circ$, to ensure reliable determination of the direction.

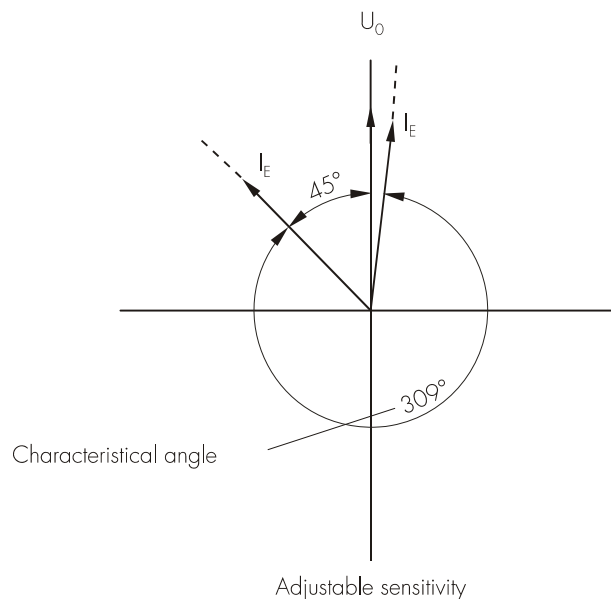


Figure 4.13: Adjustable characteristic angle of 45° to 309°

For all other applications the characteristic angle between 45° and 309° is free selectable

4.6.3 Connection possibilities of the voltage transformers for SR relay types

Application	Voltage transformer connections
3-phase voltage transformer connected to terminals A3, A5, A7, A2 (MRI3-IRSR; MRI3-ISR; MRI3-SR)	
e-n winding connected to terminals A3, A2 (MRI3-ISR; MRI3-SR)	
Neutral-point voltage (=residual voltage) terminals A3, A2 (MRI3-ISR; MRI3-SR)	

4.7 Demand 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 overcurrent

function: $K1 = 2$

Inverse time overcurrent function: $K1 = 20$

High-set function: $K1 = 1.2 - 1.5$

$K1$ = Current factor related to set value

Moreover, the current transformers have to be rated according to the maximum expected short circuit current in the network or in the protected objects.

The low power consumption in the current circuit of MRI3, namely $<0.2 \text{ VA}$, has a positive effect on the selection of current transformers. It implies that, if an electromechanical relay is replaced by MRI3, a high accuracy limit factor is automatically obtained by using the same current transformer.

5. Operation and settings

5.1 Display

Function	Display shows	Pressed push button	Corresponding LED
Normal operation	WW		
Measured operating values	Actual measured values (related to I_N ; $U_E^{1)}$ (XR-type related to % I_N)	<SELECT/RESET> one time for each	L1, L2, L3, E, U_E , I_E (I_P/I_Q in reference to directional feature)
Measuring range overflow	max.	<SELECT/RESET>	L1, L2, L3, E
Setting values: phase (I >; CHAR I >; $t_{I>}$; $I>>$; $t_{I>>}$) earth (I_E >; CHAR I_E >; $t_{I_E>}$; $I_E>>$; $t_{I_E>>}$; U_E >)	Current settings Trip delay characteristics	<SELECT/RESET> one time for each parameter	I >; CHAR I >; $t_{I>}$; $I>>$; $t_{I>>}$; LED $\rightarrow\leftarrow$ I_E >; CHAR I_E >; $t_{I_E>}$; $I_E>>$; $t_{I_E>>}$; U_E >
Current display as second rated repetition current I_{prim} (phase)/ I_{prim} (earth)	SEK (0.001-50.0kA=prim)	<SELECT/RESET><+><->	L1, L2, L3, E
Parameter switch/external triggering of the fault recorder	SET1, SET2, B_S2, R_S2, B_FR, R_FR, S2_FR	<SELECT/RESET><+><->	P2
LED blinking after activation	FLSH, NOFL	<SELECT/RESET><+><->	
Characteristics	DEFT, NINV, VINV, EINV, LINV, RINV	<SELECT/RESET><+><->	CHAR I >
Characteristics	DEFT, NINV, VINV, EINV, LINV, RINV, RXIDG	<SELECT/RESET><+><->	CHAR I_E >
Reset setting (only available at inverse time characteristics)	0s/60s	<SELECT/RESET><+><->	I > + CHAR I > + $t_{I>}$ I_E > + CHAR I_E > + $t_{I_E>}$
Relay characteristic angle for phase current directional feature	RCA in Grad ($^{\circ}$)	<SELECT/RESET><+><->	LED $\rightarrow\leftarrow$ (green)
Warning or trip at earth fault measuring (E- and ER/XR-types)	TRIP WARN	<SELECT/RESET><+><->	I_E >
Measured method of the residual voltage $U_E^{1)}$	3 PHA; E-N; 1:1	<SELECT/RESET><+><->	U_E >
Residual voltage setting	Voltage in Volt	<SELECT/RESET><+><->	U_E >
Changeover of isolated (sin φ) or compensated (cos φ) networks (for ER/XR-type)	SIN	<SELECT/RESET><+><->	
Changeover of solidly/resistance earthed networks (SR-type)	SOLI RESI	<SELECT/RESET><+><->	
Switch failure protection	ICBFP	<SELECT/RESET> <+><->	
Tripping protection switch failure protection	CBFP	After fault tripping	
Nominal frequency	f = 50/f = 60	<+> <-><SELECT/RESET>	
Blocking of function	EXIT	<+> until max. setting value	LED of blocked parameter
Slave address of serial interface	1-32	<+> <-><SELECT/RESET>	RS
Baud-Rate 2)	1200-9600	<SELECT/RESET> <+><->	RS
Parity-Check 2)	even odd no	<SELECT/RESET> <+><->	RS
Recorded fault data	Tripping currents and other fault data	<SELECT/RESET> one time for each phase	L1, L2, L3, E I >, $I>>$, I_E >, $I_E>>$, U_E >
Save parameter?	SAV?	<ENTER>	
Delete failure memory	Wait	<-> <SELECT/RESET>	
Enquiry failure memory	FLT1; FLT2.....	<-><+>	L1, L2, L3, E I >, $I>>$, I_E >, $I_E>>$,
Trigger signal for the fault recorder	TEST, P_UP, A_PI, TRIP	<SELECT/RESET> <+><->	FR
Number of fault occurrences	S = 2, S = 4, S = 8	<SELECT/RESET> <+><->	FR
Display of date and time	Y = 99, M = 10, D = 1, h = 12, m = 2, s = 12	<SELECT/RESET> <+><->	⊕
Change over the blocking function	PR_B, TR_B	<ENTER> and <TRIP>; <+><->	I >, $I>>$, I_E >, $I_E>>$ or $t_{I>}$, $t_{I>>}$, $t_{I_E>}$, $t_{I_E>>}$
Blocking of the protection function	BLOC, NO_B	<+> <-><SELECT/RESET>	I >, $I>>$, I_E >, $I_E>>$

Function	Display shows	Pressed push button	Corresponding LED
Save parameter!	SAV!	<ENTER> for about 3 s	
Software Version	1. part (e. g D01-) 2. part (e.g. 8.00)	<TRIP> one time for each part	
Manual trip	TRI?	<TRIP>three times	
Inquire password	PSW?	<TRIP><ENTER>	
Relay tripped	TRIP	<TRIP> or after fault tripping	
Secret password input	„XXXX“	<+><-> <ENTER> <SELECT/RESET>	
System reset	WW	<SELECT/RESET> for about 3 s	

Table 5.1: possible indication messages on the display

- 1) refer to 4.4
2) only Modbus

5.2 Setting procedure

After push button <SELECT/RESET> has been pressed, always the next measuring value is indicated. Firstly the operating measuring values are indicated and then the setting parameters. By pressing the <ENTER> push button the setting values can directly be called up and changed. Before parameter setting can be started the relevant password must be entered (refer to chapter 4.4 of the "MR Digital Multifunctional Relay" description).

5.3 System parameter

5.3.1 Display of measuring values as primary quantities (I_{prim} phase)

With this parameter it is possible to show the indication as primary measuring value. For this purpose the parameter must be set to be equal with the rated primary CT current. If the parameter is set to "SEK", the measuring value is shown as a multiple of the rated secondary CT current.

Example:

The current transformer used is of 1500/5 A. The flowing current is 1380 A. The parameter is set to 1500 A and on the display "1380 A" are shown. If the parameter is set to "SEK", the value shown on the display is "0.92" x In.

Note:

The pick-up value is set to a multiple of the rated secondary CT current.

5.3.2 Display of earth current as primary quantity (I_{prim} earth)

The parameter of this function is to be set in the same way as that described under 5.3.1. If the parameter is not set to "SEK", to relay types MRI3-X and MRI3-XR it applies too, that the measuring value is shown as primary current in ampere. Apart from that the indication refers to % of I_N .

5.3.3 Display of residual voltage U_E as primary quantity ($U_{\text{prim}}/U_{\text{sec}}$)

The residual voltage can be shown as primary measuring value. For this parameter the transformation ratio of the VT has to be set accordingly. If the parameter is set to "SEK", the measuring value is shown as rated secondary voltage.

Example:

The voltage transformer used is of 10 kV/100 V. The transformation ratio is 100 and this value has to be set accordingly. If still the rated secondary voltage should be shown, the parameter is to be set to 1.

5.3.4 Voltage transformer connection for residual voltage measuring (3pha/e-n/1:1)

Depending on the connection of the voltage transformer of ER/XR-relay types three possibilities of the residual voltage measurement can be chosen (see chapter 4.5).

5.3.5 Nominal frequency

The adapted FFT-algorithm requires the nominal frequency as a parameter for correct digital sampling and filtering of the input currents.

By pressing <SELECT> the display shows "f=50" or "f=60". The desired nominal frequency can be adjusted by <+> or <-> and then stored with <ENTER>.

5.3.6 Display of the activation storage (FLSH/NOFL)

If after an activation the existing current drops again below the pickup value, e.g. I>, without a trip has been initiated, LED I> signals that an activation has occurred by flashing fast. The LED keeps flashing until it is reset again (push button <RESET>). Flashing can be suppressed when the parameter is set to NOFL.

5.3.7 Parameter switch/external triggering of the fault recorder

By means of the parameter-change-over switches it is possible to activate two different parameter sets. Switching over of the parameter sets can either be done by means of software or via the external inputs RESET or blocking input. Alternatively, the external inputs can be used for Reset or blocking of the triggering of the fault recorder.

Software-parameter	Blocking input used as	RESET input use as
SET1	Blocking input	RESET Input
SET2	Blocking input	RESET Input
B_S2	Parameter switch	RESET Input
R_S2	Blocking input	Parameter switch
B_FR	Ext. Triggering of the FR	Reset input
R_FR	Blocking input	Ext. Trigger for FR
S2_FR	Parameter switch	Ext. Trigger for FR

With the settings SET1 or SET2 the parameter set is activated by software. Terminals C8/D8 and D8/E8 are then available as external reset input or blocking input.

With the setting B_S2 the blocking input (D8, E8) is used as parameter-set change-over switch. With the setting R_S2 the reset input (D8, E8) is used as parameter-set change-over switch. With the setting B_FR the fault recorder is activated immediately by using the blocking input. On the front plate the LED FR will then light up for the duration of the recording. With the setting R_FR the fault recorder is activated via the reset input. With the setting S2_FR parameter set 2 can be activated via the blocking input and/or the fault recorder via the reset input. The relevant function is then activated by applying the auxiliary voltage to one of the external inputs.

Important note:

When functioning as parameter change over facility, the external input RESET is not available for resetting. When using the external input BLOCKING the protection functions must be deactivated by software blocking separately (refer to chapter 5.7.1).

5.4 Parameter protection

5.4.1 Pickup current for phase overcurrent element (I_s)

The setting value for this parameter that appears on the display is related to the nominal current (I_N) of the relay. This means: pickup current (I_s) = displayed value x nominal current (I_N) e.g. displayed value = 1.25 then, I_s = 1.25 x I_N.

5.4.2 Time current characteristics for phase overcurrent element (CHAR I_s)

By setting this parameter, one of the following 6 messages appears on the display:

DEFT - Definite Time
 NINV - Normal Inverse
 VINV - Very Inverse
 EINV - Extremely Inverse
 RINV - RI-Inverse
 LINV - Long Time Inverse

Anyone of these four characteristics can be changed by using <+> <->-push buttons, and can be stored by using <ENTER>-push button.

5.4.3 Trip delay or time factor for phase overcurrent element (tl_s)

Usually, after the characteristic is changed, the time delay or the time multiplier should be changed accordingly. In order to avoid an unsuitable arrangement of relay modes due to carelessness of the operator, the following precautions are taken:

If, through a new setting, another relay characteristic other than the old one has been chosen (e.g. from DEFT to NINV), but the time delay setting has not been changed despite the warning from the flashing LED, the relay will be set to the most sensitive time setting value of the selected characteristics after five minutes warning of flashing LED tl_s>. The most sensitive time setting value means the fastest tripping for the selected relay characteristic. If a definite time characteristic has been selected, the display shows the trip delay in seconds. When selecting an inverse time characteristic, the time multiplier appears on the display. Both settings can be changed by push-buttons <+><->. When the time delay or the time multiplier is set out of range (Text "EXIT" appears on the display), the low set element of the overcurrent relay is blocked. The "WARN"-relay will not be blocked.

For the MRI3-version with directional feature, the different trip time delays or the time multipliers can be chosen for forward and backward faults.

By setting the trip delay, the actual set value for forward faults appears on the display first and the LED under the arrows is a light green. It can be changed with push button <+> <-> and then stored with push button <ENTER>. After that, the actual trip delay (or time factor) for backward faults appears on the display by pressing push button <SELECT> and the LED under the arrows is a light red.

Usually this set value should be set longer than the one for forward faults, so that the relay obtains its selectivity during forward faults. If the time delays are set equally for both forward and backward faults, the relay trips in both cases with the same time delay, namely without directional feature.

Note:

When selecting dependent tripping characteristics at relays with directional phase current detection, attention must be paid that a clear directional detection will be assured only after expiry of 40 ms.

5.4.4 Reset setting for all tripping characteristics in the phase current path

To ensure tripping, even with recurring fault pulses shorter than the set trip delay, the reset mode for inverse time tripping characteristics can be switched over. If the adjustment t_{RST} is set at 60 s, the tripping time is only reset after 60 s faultless condition. This function is not available if t_{RST} is set to 0. With fault current cease the trip delay is reset immediately and started again at recurring fault current.

5.4.5 Current setting for high set element ($I_{>>}$)

The current setting value of this parameter appearing on the display is related to the rated current of the relay.

This means: $I_{>>} = \text{displayed value} \times I_N$.

When the current setting for high set element is set out of range (on display appears "EXIT"), the high set element of the overcurrent relay is blocked.

The high set element can be blocked via terminals E8/D8 if the corresponding blocking parameter is set to bloc (refer to chapter 5.7.1).

5.4.6 Trip delay for high set element ($t_{I_{>>}}$)

Independent from the chosen tripping characteristic for $I_{>}$, the high set element $I_{>>}$ has always a definite-time tripping characteristic. An indication value in seconds appears on the display.

The setting procedure for forward- or backward faults, described in chapter 5.4.3, is also valid for the tripping time of the high set element.

5.4.7 Relay characteristic angle RCA

The characteristic angle for directional feature in the phase current path can be set by parameter RCA to 15°, 27°, 38°, 49°, 61°, 72° or 83°, leading to the respective reference voltage (see chapter 4.3).

5.4.8 Pickup value for residual voltage UE (ER/XR-relay type)

Regardless of the preset earth current, an earth fault is only identified if the residual voltage exceeds the set reference value. This value is indicated in volt.

5.4.9 Pickup current for earth fault element ($I_{E>}$)

(Similar to chapter 5.4.1)

The pickup value of YR, X and XR-relay type relates to % I_N .

5.4.10 WARN/TRIP changeover (all earth fault-relay type)

A detected earth fault can be parameterized as follows. After delay time.

- a) "warn" only the alarm relay trips
- b) "trip" the trip relay trips and tripping values are stored.

5.4.11 Time current characteristics for earth fault element (CHAR I_E) (not for ER/XR-relay type)

By setting this parameter, one of the following 7 messages appears on the display:

DEFT	-	Definite Time (independent overcurrent time protection)
NINV	-	Normal inverse (Type A)
VINV	-	Very inverse (Type B)
EINV	-	Extremely inverse (Type C)
RINV		RI-Inverse
LINV		Long Time Inverse
RXID		Special characteristic

Anyone of these four characteristics can be chosen by using <+> <->-pushbuttons, and can be stored by using <ENTER>-pushbutton.

5.4.12 Trip delay or time multiplier for earth fault element (t_{IE>>})

(Similar to chapter 5.4.3)

5.4.13 Reset mode for inverse time tripping in earth current path

(Similar to chapter 5.4.4)

5.4.14 Current setting for high set element of earth fault supervision (I_{E>>})

(Similar to chapter 5.4.5)

The pickup value of YR, X and XR-relay type relates to % I_N.

5.4.15 Trip delay for high set element of earth fault supervision (t_{IE>>})

(Similar to chapter 5.4.6)

5.4.16 COS/SIN Measurement (ER/XR-relay type)

Depending on the neutral earthing connection of the protected system the directional element of the earth fault relay must be preset to cos φ or sin φ measurement.

By pressing <SELECT> the display shows "COS" resp. "SIN". The desired measuring principle can be selected by <+> or <-> and must be entered with password.

5.4.17 SOLI/RESI changeover (SR/YR-relay type)

Depending on the method of neutral-point connection of the system to be protected, the directional element for the earth-current circuit must be set to "SOLI" (= solidly earthed) or "RESI" = (resistance earthed).

5.4.18 Block/Trip – time

The block/trip time serves for detection of a c.b. failure protection by rear interlocking. It is activated by setting the blocking input D8/E8 and by setting the parameter to TR_B. After the set block/trip time has expired, the relay can be tripped if the excitation of a protective function has been applied the delay time of which has expired and the blocking function is still active. If the parameter PR_B is set, the individual protection stages are blocked (refer to Chapter 5.7.1).

5.4.19 Circuit breaker failure protection tCBFP

The CB failure protection is based on supervision of phase currents during tripping events. Only after tripping this protective function becomes active. The test criterion is whether all phase currents are dropped to $<1\% \times I_N$ within t_{CBFP} (Circuit Breaker Failure Protection - adjustable between 0.1 - 2.0 s). If not all of the phase currents have dropped to $<1\% \times I_N$ within this time, CB failure is detected and the related relay activated. The CB failure protection function is deactivated again as soon as the phase currents have dropped to $<1\% \times I_N$ within t_{CBFP} .

5.4.20 Adjustment of the slave address

Pressing push buttons <+> and <-> the slave address can be set in the range of 1-32.

5.4.21 Setting of Baud-rate (applies for Modbus Protocol only)

Different transmission rates (Baud rate) can be set for data transmission via Modbus protocol. The rate can be changed by push buttons <+> and <-> and saved by pressing <ENTER>.

5.4.22 Setting of parity (applies for Modbus Protocol only)

The following three parity settings are possible :

- "even" = even
- "odd" = odd
- "no" = no parity check

The setting can be changed by push buttons <+> and <-> and saved by pressing <ENTER>.

5.5 Fault recorder

5.5.1 Adjustment of the fault recorder

The MRI3 is equipped with a fault recorder (see chapter 0). Three parameters can be determined.

5.5.2 Number of the fault recordings

The max. recording time is 16 s at 50 Hz or 13.33 s at 60 Hz.

The number of max. recordings requested has to be determined in advance. There is a choice of (1)* 2, (3)* 4 or (7)* 8 recordings and dependent on this the duration of the individual fault recordings is defined, i.e.

(1)* 2 recordings for a duration of 8 s (with 50 Hz) (6.66 s with 60 Hz)

(3)* 4 recordings for a duration of 4 s (with 50 Hz) (3.33 s with 60 Hz)

(7)* 8 recordings for a duration of 2 s (with 50 Hz) (1.66 s with 60 Hz)

* is written over at new trigger signal

5.5.3 5.5.3 Adjustment of trigger occurrences

There is a choice between four different occurrences:

P_UP (PickUP)	Storage is initiated after recognition of a general activation
TRIP	Storage is initiated after a trip has occurred
A_PI (After Pickup)	Storage is initiated after the last activation threshold was fallen short of.
TEST	Storing is activated by simultaneous actuation of the keys <+> and <->. During the recording time the display shows "Test".

5.5.4 Pre-trigger time (T_{pre})

By the time T_{pre} it is determined which period of time prior to the trigger occurrence should be stored as well. It is possible to adjust a time between 0.05s and 8s. With keys <+> and <-> the values can be changed and with <ENTER> be saved.

5.6 Adjustment of the clock

When adjusting the date and time, LED ☉ lights up. The adjustment method is as follows:

Date:	Year	Y=00
	Month	M=00
	Day	D=00
Time:	Hour	h=00
	Minute	m=00
	Second	s=00

The clock starts with the set date and time as soon as the supply voltage is switched on. The time is safe-guarded against short-term voltage failures (min. 6 minutes).

Note:

The window for parameter setting of the clock is located behind the measured value display. The parameter window can be accessed via the <SELECT/RESET> key.

5.7 Additional functions

5.7.1 Blocking the protection functions and assignment of the output relays

Blocking of the protective functions:

The MRI3-IHE is equipped with a blocking function that can be parameterized arbitrary. Connecting supply voltage to terminals D8/E8 blocking of those functions which were selected by the user takes place.

It is possible to choose between two types of protective blocking:

1. Blocking of the individual protection stages. The excitation of the blocked protection stage is blocked.
2. Blocking of the individual tripping stages. The individual protection stages are excited and the set tripping time expires. Tripping only takes place when:
 - a) the voltage at the blocking input D8/E8 is reduced;
 - b) the voltage at the blocking input D8/E8 is applied, the tripping time and the blocking time have expired. (refer to Chapter 5.4.8)

Parameter setting is to be carried out as follows:

- After the <ENTER> and <TRIP> keys have been actuated simultaneously, the display shows the text "PR_B" (the protection stages are blocked) or "TR_B" (the tripping stages are blocked).
- The settings can be changed by actuating the keys <+> or <->. In this procedure, the LEDs l>; l>>; lE>; lE>> are simultaneously alight in case of protective blocking "PR_B" and LEDs tl>; tl>>; tIE>; tIE>> simultaneously emit light in case of trip blocking "TR_B".
- Actuation of the <ENTER> key with a one-time en-try of the password will store the set function.
- After this actuate the <SELECT/RESET> key to call up the first blockable protection function.
- The display will show the text "BLOC" (the respective function is blocked) or "NO_B" (the respective function is not blocked).
- Actuation of the <ENTER> key will store the set function.
- By pressing the <SELECT/RESET> pushbutton, all further protective function that can be blocked are called one after the other.
- After selection of the last blocking function renewed pressing of the <SELECT/RESET> pushbutton switches to the assignment mode of the output relays.

Blockade function		Display	LED/Color
Blocking of the protection stage		PR_B	I>; I>>; I_E>; I_E>>
Blocking of the trip function		TR_B	t_I>; t_I>>; t_I_E>; t_I_E>>
I>	Overcurrent	NO_B	I> yellow
I>>	Short circuit	BLOC	I>> yellow
I_E>	Earth current 1 st element	NO_B	I_E> yellow
I_E>>	Earth current 2 nd element	NO_B	I_E>> yellow
t_CBF	Circuit breaker failure protection	NO_B	CB green

Table 5.2: Default settings of both parameter sets

Assignment of the output relays:

Unit MRI3 has five output relays. The fifth output relay is provided as permanent alarm relay for self supervision is normally on. Output relays 1 - 4 are normally off and can be assigned as alarm or tripping relays to the current functions which can either be done by using the push buttons on the front plate or via serial interface RS485. The assignment of the output relays is similar to the setting of parameters, however, only in the assignment mode. The assignment mode can be reached only via the blocking mode.

By pressing push button <SELECT/RESET> in blocking mode again, the assignment mode is selected.

The relays are assigned as follows: LEDs I>, I>>, I_E>, I_E>> are two-colored and light up green when the output relays are assigned as alarm relays and red as tripping relays.

In addition, the LED →← also lights up with each adjustment. Green means forward and red backward direction.

Definition:

Alarm relays are activated at pickup.

Tripping relays are only activated after elapse of the tripping delay.

After the assignment mode has been activated, first LED I> lights up green. Now one or several of the four output relays can be assigned to current element I> as alarm relays. At the same time the selected alarm relays for frequency element 1 are indicated on the display. Indication "1 ___" means that output relay 1 is assigned to this current element. When the display shows "___", no alarm relay is assigned to this current element. The assignment of output relays 1 - 4 to the current elements can be changed by pressing <+> and <-> push buttons. The selected assignment can be stored by pressing push button <ENTER> and subsequent input of the password. By pressing push button <SELECT/RESET>, LED I> lights up red. The output relays can now be assigned to this current element as tripping relays.

Relays 1 - 4 are selected in the same way as described before. By repeatedly pressing of the <SELECT/RESET> push button and assignment of the relays all elements can be assigned separately to the relays. The assignment mode can be terminated at any time by pressing the <SELECT/RESET> push button for some time (abt. 3 s).

Note:

- The function of jumper J2 described in general description "MR Digital Multifunctional Relays" has no function. For relays without assignment mode this jumper is used for parameter setting of alarm relays (activation at pickup or tripping).
- A form is attached to this description where the setting requested by the customer can be filled-in. This form is prepared for fax transmission and can be used for your own reference as well as for telephone queries.

Relay function		Output relays				Display-indication	Lighted LED
		1	2	3	4		
I> (V)	alarm		X			_ 2 _ _	I>; →← green
tI> (V)	tripping	X				1 _ _ _	tI>; →← grün
I> (R)	alarm		X			_ 2 _ _	I>; →← red
tI> (R)	tripping	X				1 _ _ _	tI>; →← red
I>> (V)	alarm			X		_ _ 3 _	I>>; →← green
tI>> (V)	tripping	X				1 _ _ _	tI>>; →← green
I>> (R)	alarm			X		_ _ 3 _	I>>; →← red
tI>> (R)	tripping	X				1 _ _ _	tI>>; →← red
IE> (V)	alarm				X	_ _ _ 4	IE>; →← green
tIE> (V)	tripping	X				1 _ _ _	tIE>; →← green
IE> (R)	alarm				X	_ _ _ 4	IE>; →← red
tIE> (R)	tripping	X				1 _ _ _	tIE>; →← red
IE>> (V)	alarm				X	_ _ _ 4	IE>>; →← green
tIE>> (V)	tripping	X				1 _ _ _	tIE>>; →← green
IE>> (R)	alarm				X	_ _ _ 4	IE>>; →← red
tIE>> (R)	tripping	X				1 _ _ _	tIE>>; →← red
tCBFP	tripping					_ _ _ _	C.B.; red

(V) = forward direction;
(R) = backward direction

This way, a tripping relay can be set for each activation and tripping direction.

Table 5.3: Example of assignment matrix of the output relays (default settings).

5.8 Setting value calculation

5.8.1 Definite time overcurrent element

Low set element (I>)

The pickup current setting is determined by the load capacity of the protected object and by the smallest fault current within the operating range. The pickup current is usually selected about 20% for power lines, about 50% for transformers and motors above the maximum expected load currents.

The delay of the trip signal is selected with consideration to the demand on the selectivity according to system time grading and overload capacity of the protected object.

High set element (I>>)

The high set element is normally set to act for near-by faults. A very good protective reach can be achieved if the impedance of the protected object results in a well-defined fault current. In case of a line-transformer combination the setting values of the high set element can even be set for the fault inside the transformer.

The time delay for high set element is always independent to the fault current.

5.8.2 Inverse time overcurrent element

Beside the selection of the time current characteristic one set value each for the phase current path and earth current path is adjusted.

Low set element I>

The pickup 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:

$$I_s = (300/400) \times 1.2 = 0.9 \times I_N$$

Time multiplier setting

The time multiplier setting for inverse time overcurrent 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.

High set element I>>

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

5.9 Indication of measuring and fault values

5.9.1 Indication of measuring values

The following measuring quantities can be indicated on the display during normal service:

- Apparent current in phase 1 (LED L1 green),
- active current in Phase 1 (LED L1 and IP green),*
- reactive current in Phase 1 (LED L1 and IQ green),*
- apparent current in phase 2 (LED L2 green),
- active current in Phase 2 (LED L2 and IP green),*
- reactive current in Phase 2 (LED L2 and IQ green),*
- apparent current in phase 3 (LED L3 green),
- active current in Phase 3 (LED L3 and IP green),*
- reactive current in Phase 3 (LED L3 and IQ green),*
- apparent earth current (LED E green),
- active earth current (LED E and IP green),*
- reactive earth current (LED E and IQ green),*
- residual voltage UR (LED UE) only at ER/XR-relay type,
- angle between IE and UE (only ER/XR)
- (LED E green, LED IE> yellow and LED UE> yellow).

* only in case that the directional option is built in.

The indicated current measuring values refer to rated current. (For MRI3-XR/X relays the indicated measuring values refer to % of I_N)

5.9.2 Units of the measuring values displayed

The measuring values can optionally be shown in the display as a multiple of the "sec" rated value (xIn) or as primary current (A). According to this the units of the display change as follows:

Phase current:

Indication as	Range	Unit
Secondary current	.000 – 40.0	x In
Active portion I _P	±.00 – 40	x In
Reactive portion I _Q	±.00 – 40.	x In
Primary current	.000 – 999.	A
	k000 – k999	kA*
	1k00 – 9k99	kA
	10k0 – 99k0	kA
	100k – 999k	kA
	1M00 – 2M00	MA
Active portion I _P	±.00 – ±999	A
	±k00 – ±k99	kA*
	±1k0 – ±9k9	kA
	±10k – ±99k	kA
	±M10 – ±M99	MA
	±1M0 – ±2M0	MA
Reactive portion I _Q	±.00 – ±999	A
	±k00 – ±k99	kA*
	±1k0 – ±9k9	kA
	±10k – ±99k	kA
	±M10 – ±M99	MA
	±1M0 – ±2M0	MA

*rated current transformer >2kA

Earth current (sensitive):

Indication as	Range	Unit
Secondary current	.000 – 15.0	x In
Active portion I _P	±.00 – 15	x In
Reactive portion I _Q (X/XR types)	±.00 – 15	x In
Primary earth current	00m0 – 99m9	mA*
	100m – 999m	mA*
	.000 – 999.	A
	k000 – k999	kA*
	1k00 – 9k99	kA
Active portion I _P	±00m - ±99m	mA*
	±.10 – ±999	A
	±k00 – ±k99	kA**
	±1k0 – ±9k9	kA
Reactive portion I _Q	±00m - ±99m	mA*
	±.00 – ±999	A
	±k00 – ±k99	kA**
	±1k0 – ±9k9	kA

* rated current transformer 0.019kA

** rated current transformer 20kA

Earth current (normal):

Indication as	Range	Unit
Secondary current	.000 – 15.0	x In
Active portion I _P	±.00 – 15	x In
Reactive portion I _Q (E/SR/ER types)	±.00 – 15	x In
Primary earth current	.000 – 999.	A
	k000 – k999	kA*
	1k00 – 9k99	kA
	10k0 – 99k0	kA
	100k – 999k	kA
1M00 – 2M00	MA	
Active portion I _P	±.00 – ±999	A
	±k00 – ±k99	kA*
	±1k0 – ±9k9	kA
	±10k – ±99k	kA
	±M10 – ±M99	MA
	±1M0 – ±2M0	MA
Reactive portion I _Q	±.00 – ±999	A
	±k00 – ±k99	kA*
	±1k0 – ±9k9	kA
	±10k – ±99k	kA
	±M10 – ±M99	MA
	±1M0 – ±2M0	MA

* rated current transformer >2kA

Earth voltage:

Indication	Range	Unit
Sec. voltage	000V – 999V	V
Primary voltage	.000 – 999 V	kV
	1K00 – 9K99	kV
	10K0 – 99K9	kV
	100K – 999K	kV
	1M00 – 3M00	MV

5.9.3 Indication of fault data

All faults detected by the relay are indicated on the front plate optically. For this purpose, the four LEDs (L1, L2, L3, E) and the four function LEDs (I>, I>>, IE>, IE>> und →←) are equipped at MRI3. Not only fault messages are transmitted, the display also indicates the tripped protection function. If, for example an overcurrent occurs, first the corresponding LEDs will light up. LED I> lights up at the same time. After tripping the LEDs are lit permanently.

5.9.4 Fault memory

When the relay is energized or trips, all fault data and times are stored in a non-volatile memory manner. The MRI3 is provided with a fault value recorder for max. five fault occurrences. In the event of additional trip-pings always the oldest data set is written over.

For fault indication not only the trip values are recorded but also the status of LEDs. Fault values are indicated when push buttons <-> or <+> are pressed during normal measuring value indication.

- Normal measuring values are selected by pressing the <SELECT/RESET> button.
- When then the <-> button is pressed, the latest fault data set is shown. By repeated pressing the <-> button the last but one fault data set is shown etc. For indication of fault data sets abbreviations FLT1, FLT2, FLT3, ... are displayed (FLT1 means the latest fault data set recorded). At the same time the parameter set active at the occurrence is shown.
- By pressing <SELECT/RESET> the fault measuring values can be scrolled.
- By pressing <+> it can be scrolled back to a more recent fault data set. At first FLT8, FLT7, ... are al-ways displayed. When fault recording is indicated (FLT1 etc), the LEDs flash in compliance with the stored trip information, i.e. those LEDs which showed a continuous light when the fault occurred are now blinking to indicate that it is not a current fault. LEDs which were blinking during trip conditions, (element had picked up) just briefly flash.
- If the relay is still in trip condition and not yet reset (TRIP is still displayed), no measuring values can be shown.
- To delete the trip store, the push button combination <SELECT/RESET> and <-> has to be pressed for about 3s. The display shows "wait".

Recorded fault values:

Value displayed	relevant LED
Phase currents L1, L2, L3 in I/In	L1, L2, L3
Earth current I_E in I/I_{EN} (%)	E
C.B. switching time in s ¹⁾	CB
Expired tripping time of I> in % of $t_{I>}^{>2)}$	I>
Expired tripping time of $I_{E>}$ in % of $t_{I_{E>}}^{>2)}$	$I_{E>}$
Time stamp	
Date: Y = 99	⊕
M = 04	⊕
D = 20	⊕
Time: h = 11	⊕
m = 59	⊕
s = 13	⊕

Table 5.4

- 1) C.B. tripping time:
Time between energizing of the trip output relay and switching of the C.B. (current < 1% I_N).
- 2) Expired tripping time:
Time between pickup and release of the low set element.
This value is only displayed for I> and $I_{E>}$.

5.10 Reset

Unit MRI3 has the following three possibilities to reset the display of the unit as well as the output relay at jumper position J3=ON.

Manual Reset

- Pressing the push button <SELECT/RESET> for some time (about 3 s)

Electrical Reset

- Through applying auxiliary voltage to C8/D8

Software Reset

- The software reset has the same effect as the <SELECT/RESET> push button (see also communication protocol of RS485 interface).

The display can only be reset when the pickup is not present anymore (otherwise "TRIP" remains in display). During resetting of the display the parameters are not affected.

5.10.1 Erasure of fault storage

The fault storage is erased by pressing the key combination <SELECT/RESET> and <-> for about 3 s. At the display "Wait" appears.

6. Relay testing and commissioning

The test instructions following below help to verify the protection relay performance before or during commissioning of the protection system. To avoid a relay damage and to ensure a correct relay operation, be sure that:

- The auxiliary power supply rating corresponds to the auxiliary voltage on site.
- The rated current and rated voltage of the relay correspond to the plant data on site.
- The current transformer circuits and voltage transformer circuits are connected to the relay correctly.
- All signal circuits and output relay circuits are connected correctly.

6.1 Power-On

NOTE!

Prior to switch on the auxiliary power supply, be sure that the auxiliary supply voltage corresponds with the rated data on the type plate.

Switch on the auxiliary power supply to the relay and check that the message "WW" appears on the display and the self supervision alarm relay (watchdog) is energized (Contact terminals D7 and E7 closed).

6.2 Testing the output relays and LEDs

NOTE!

Prior to commencing this test, interrupt the trip circuit to the circuit breaker if tripping is not desired. By pressing the push button <TRIP> once, the display shows the first part of the software version of the relay (e.g. "D08-"). By pressing the push button <TRIP> twice, the display shows the second part of the software version of the relay (e.g. "4.01"). The software version should be quoted in all correspondence. Pressing the <TRIP> button once more, the display shows "PSW?". Please enter the correct password to proceed with the test. The message "TRI?" will follow. Confirm this message by pressing the push button <TRIP> again. All output relays should then be activated and the self supervision alarm relay (watchdog) be deactivated one after another with a time interval of 3 second and all LEDs with a delay of 0.5 seconds, with the self-supervision relay dropping. Thereafter, re-set all output relays back to their normal positions by pressing the push button <SELECT/RESET> (about 3 s).

6.3 Checking the set values

By repeatedly pressing the push button <SELECT>, all relay set values may be checked. Set value modification can be done with the push button <+><-> and <ENTER>. For detailed information about that, please refer to chapter 5.

For a correct relay operation, be sure that the frequency set value ($f=50/60$) has been selected according to your system frequency (50 or 60 Hz).

6.4 Secondary injection test

6.4.1 Test equipment

- Voltmeter, Ammeter with class 1 or better,
- auxiliary power supply with the voltage corresponding to the rated data on the type plate,
- single-phase current supply unit (adjustable from
- 0 to $\geq 4 \times I_n$),
- single-phase voltage supply unit (adjustable from 0 to $\geq 1.2 \times U_n$)
(Only for relays with directional feature),
- timer to measure the operating time
(Accuracy class $\leq \pm 10$ ms),
- switching device and
- test leads and tools.

6.4.2 Example of test circuit for MRI3 relays without directional feature

For testing MRI3 relays without directional feature, only current input signals are required. Figure 6.1 shows a simple example of a single phase test circuit with adjustable current energizing the MRI3 relay under test.

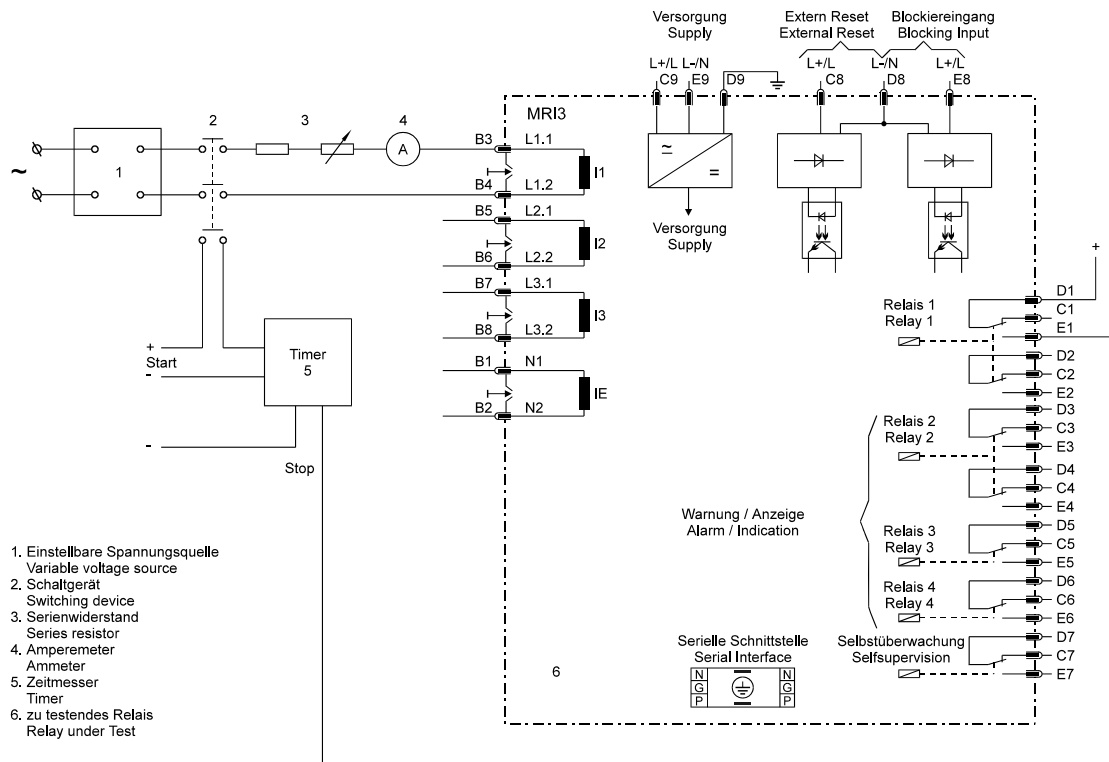


Figure 6.1: Test circuit

6.4.3 Checking the input circuits and measured values

Inject a current, which is less than the relay pickup current set values, in phase 1 (terminals B3-B4), and check the measured current on the display by pressing the push button <SELECT>. For a relay with rated current $I_n = 5A$, for example, a secondary current injection of 1A should be indicated on the display with about 0.2 ($0.2 \times I_n$). When parameter $I_{prim} = „SEK“$ is set, the indication is $0.2 \times I_n$ and at „5“ the indication is 1.00 [A]. The current can be also injected into the other current input circuits (Phase 2: terminals B5-B6, Phase 3: terminals B7-B8). Compare the displayed current value with the reading of the ammeter. The deviation must not exceed 3% or 1% I_n . By using an RMS-metering instrument, a greater deviation may be observed if the test current contains harmonics. Because the MRI3 relay measures only the fundamental component of the input signals, the harmonics will be rejected by the internal DFFT-digital filter. Whereas the RMS-metering instrument measures the RMS-value of the input signals.

6.4.4 Checking the operating and resetting values of the relay

Inject a current which is less than the relay set values in phase 1 of the relay and gradually increase the current until the relay starts, i.e. at the moment when the LED I> and L1 light up or the alarm output relay I> is activated. Read the operating current indicated by the ammeter. The deviation must not exceed 3% of the set operating value or 1% I_n .

Furthermore, gradually decrease the current until the relay resets, i.e. the alarm output relay I> is disengaged. Check that the resetting current is smaller than 0.97 times the operating current. Repeat the test on phase 2, phase 3 and earth current input circuits in the same manner. (Accuracy of earth current measuring $\pm 3\%$ of measuring value or 0.1% of I_n for E-type; 0.01% of I_n for X-type).

6.4.5 Checking the relay operating time

To check the relay operating time, a timer must be connected to the trip output relay contact. The timer should be started simultaneously with the current injection in the current input circuit and stopped by the trip relay contact. Set the current to a value corresponding to twice the operating value and inject the current instantaneously. The operating time measured by the timer should have a deviation of less than 3% of the set value or ± 10 ms (DEFT). Accuracy for inverse time characteristics refer to IEC 255-3.

Repeat the test on the other phases or with the inverse time characteristics in the similar manner. In case of inverse time characteristics the injected current should be selected according to the characteristic curve, e.g. two times I_S . The tripping time may be read from the characteristic curve diagram or calculated with the equations given under "technical data".

Please observe that during the secondary injection test the test current must be very stable, not deviating more than 1%. Otherwise the test results may be wrong.

6.4.6 Checking the high set element of the relay

Set a current above the set operating value of I>>. Inject the current instantaneously and check that the alarm output relay I>> operates. Check the tripping time of the high set element according chapter 6.4.5.

Check the accuracy of the operating current setting by gradually increasing the injected current until the I>> element picks up. Read the current value from the ammeter and compare with the desired setting.

Repeat the entire test on other phases and earth current input circuits in the same manner.

Note !

Where test currents $> 4 \times I_n$ are used, the thermal withstand capability of the current paths has to be considered (see technical data, chapter 7.1).

6.4.7 Example of a test circuit for MRI3 relay with directional feature

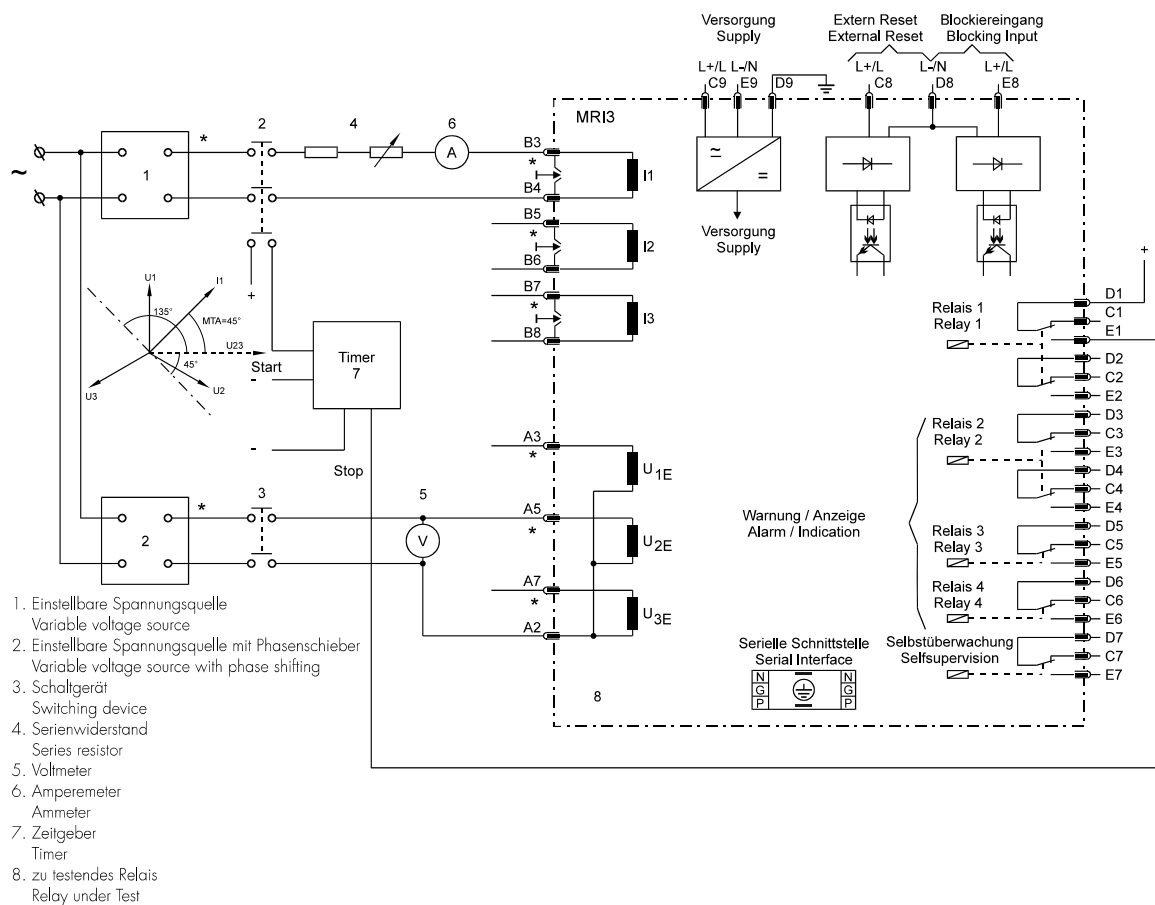


Figure 6.2: Test circuit

For testing relays with directional feature, current and voltage input signals with adjustable phase shifting are required. Figure 6.2 shows an example of a single phase test circuit with adjustable voltage and current energizing the MRI3 relay under test.

For testing a relay with directional feature, one of the input energizing quantity (voltage) shall be applied to the relay with a constant value within its effective range. The other input energizing quantity (current) and phase angle shall be appropriately varied.

MRI3 is a three phase directional time overcurrent relay with relay connection angle of 0°. The relay input currents and their corresponding reference voltages are shown in Table 6.1 (also refer to 4.3):

If the single phase test circuit as illustrated in Figure 6.2 is applied to test the directional feature of the relay and the current source is connected to phase 1 current input (B3/B4), then the voltage source should be connected to relay terminals A5/A7.

In order to test the directional feature, all thresholds should first be set to “EXIT”. Then a test voltage equivalent to the rated voltage is connected to terminals A5/A7 and a current of $1 \times I_n$ is impressed upon the current inputs B3/B4.

It is now possible to read and check all measured values in accordance with Table 6.1. If the phase position is changed, the values I_Q and I_P change. If the angle is changed by 90°, for example, the measured value for current input I1 must be 1.0 for I_P and ± 0.0 for I_Q .

Determining the change in direction

The angle of greatest sensitivity for determining the phase direction is adjustable between 15° and 83°. Consequently, the greatest sensitivity is achieved with setting 49° if the input current leads the input voltage by 49°. This setting results in a tripping range in forward direction of 139° leading to 41° lagging if the marginal regions are neglected on account of lack in measuring precision.

Current input	Terminals	Reference voltage	Terminals	Display		
				Phase	IP	IQ
	S2/S1		L/N			
I1	B3/B4	U23	A5/A7	1.00 ±3%	±0.0 ±3% In	+1.0 ±3% In
I2	B5/B6	U31	A3/A7	1.00 ±3%	±0.0 ±3% In	+1.0 ±3% In
I3	B7/B8	U12	A3/A5	1.00 ±3%	±0.0 ±3% In	+1.0 ±3% In
E*	B1/B2	U1	A3/A2	1.00 ±5%	+1.0 ±5% In	±0.0 ±5% In

Table 6.1: Input currents and corresponding on the conductor voltages

* Only SR-Types

In order to check this, the following parameters should be set:

Parameter	Setting
I>	0,5 x In
tI> (V)	EXIT
tI> (R)	EXIT
IE>	0,5 x In
tIE> (V)	EXIT
tIE> (R)	EXIT

Table 6.2

for relay assignment:

Parameter	Relay
I> Alarm (V)	<u> 2 </u>
I> Alarm (R)	<u> 3 </u>
IE> Alarm (V)	<u> 2 </u>
IE> Alarm (R)	<u> 3 </u>

Table 6.3

A test current of 1 x In is impressed upon the current input I1. The voltage source is to be connected as provided for in Table 6.1. With an angle setting of 49° leading, relay 2 must respond and LED →← lights up green. If the angle is now changed beyond the marginal regions, the LED →← changes from green to red. Relay 2 drops and relay 3 responds. This test must be repeated for current inputs I2 and I3.

In order to determine the direction in the earth current circuit (SR version) refer to Figure 4.11 with the characteristic angle in the rigid grid (SOLI) and to Figure 4.12 with the characteristic angle in the grid with resistance earthing (RESI).

To check the trip delays for forward and backward direction they have to be set differently, because there's only one trip relay for both directions.

Great care must be taken to connect the test current and test voltage to the relay in correct polarity. In Figure 6.2 the relay and test source polarity are indicated by a * mark near the terminals. The markings indicate that the relay will trip in its maximum sensitive angle when the voltage drop from the marked end to the non-marked end in the voltage input circuit has 49° phase angle lagging the current flowing from the marked end to the non-marked in the current input circuit. Of course, regardless of polarity, the current level must be above the pickup value.

6.4.8 Test circuit earth fault directional feature

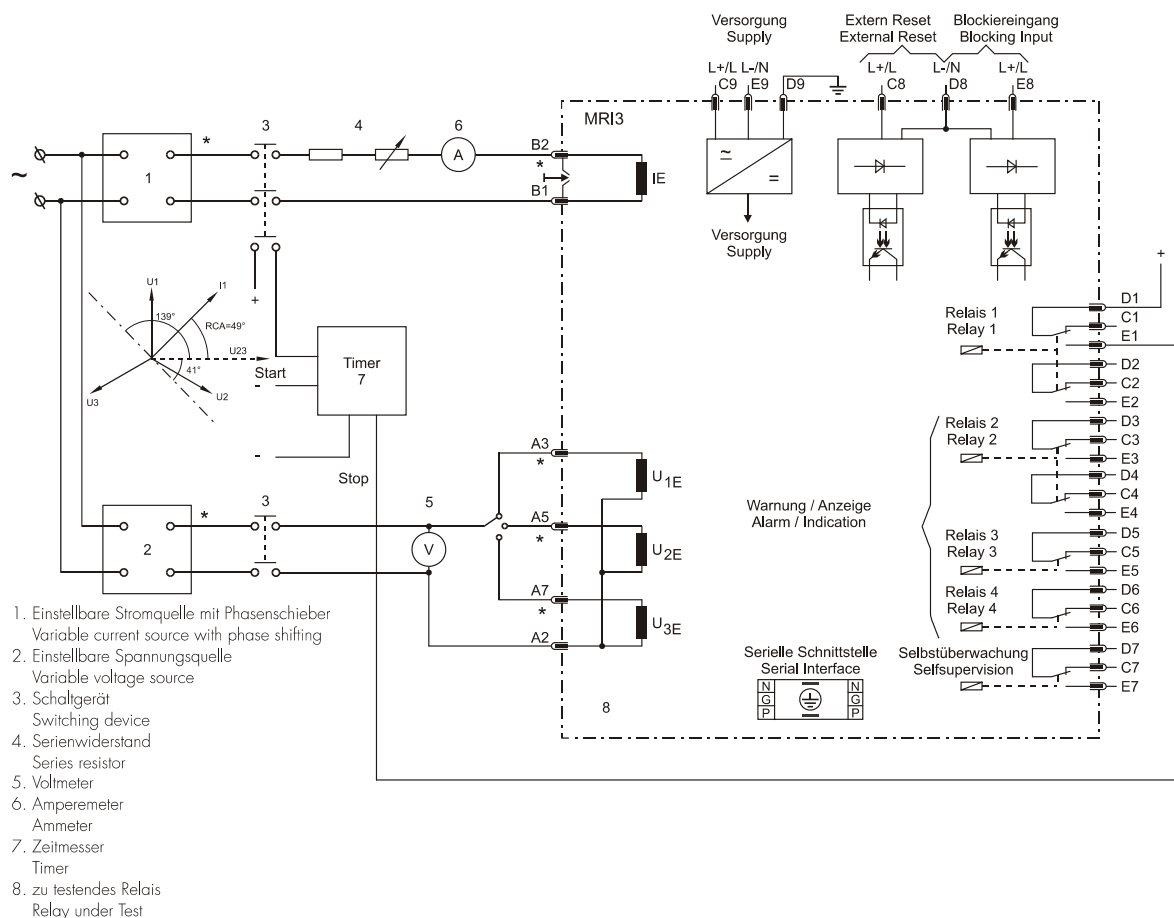


Figure 6.3: Test circuit

For testing relays with earth fault directional feature, current and voltage input signals with adjustable phase shifting are required. Figure 6.3 shows an example of a single phase test circuit with adjustable voltage and current energizing the MRI3 relay under test.

For testing a relay with earth fault directional feature, one of the input energizing quantity (voltage) shall be applied to the relay with a constant value within its effective range. The other input energizing quantity (current) and phase angle shall be appropriately varied.

With the aid of phase angle indicated on the display the correct function of the relay can be checked (ER-relay type).

Parameters $I_{E>}$ and $I_{E>>}$ should be set to EXIT.

The following measured values are shown:

Measured value	LED
Earth current	E, $I_{E>}$
Active share	E, I_P
Reactive share	E, I_Q
Earth voltage	E, $U_{E>}$
Angle	E, $I_{E>}, U_{E>}$

Table 6.4

6.4.9 Checking the external blocking and reset functions

By means of the external blocking input, it is possible to block all protective functions. To give an example, the blocking function of the phase current high set element is described.

This can be tested by first setting the parameter for the phase current high set element to „BLOC“ and then connecting the auxiliary voltage to terminals E8/D8.

The phase current low set element $I_{>}$ should be set to EXIT for this test. Inject a test current which could cause a high set ($I_{>>}$) tripping. Observe that there is no trip of any assigned output relay of the high set or low set element.

Remove the auxiliary supply voltage from the blocking input. Inject a test current to trip the relay (message „TRIP“ on the display). Interrupt the test current and apply auxiliary supply voltage to the external reset input of the relay (terminals C8/D8). The display and LED indications should be reset immediately.

6.4.10 Testing the external blocking with Block/Trip function

In order to simplify things, the short-circuit stage is to be tested here as described in Chapter 5.7.1. For this purpose, the parameter for the Block/Trip function must be set to "TR_B" (first value in the blocking menu of the protection functions Chapter 5.7.1. The appertaining Block/Trip time should be longer than the set tripping time $t_{I>>}$ (see chapter 5.4.18). Here, too, a current is impressed which should make the short-circuit stage trip. After the Block/Trip time has expired, tripping will take place. Tripping takes place when:

- the blocking input has been set
- a tripping stage has been excited
- the appertaining tripping time has expired
- the Block/trip time has expired

If the Block/Trip time is set shorter than the tripping time, tripping will only take place after the tripping time has expired.

6.4.11 Test of the CB failure protection

For testing the tripping time a test current of about 2 times the rated current to be injected. The timer is started upon tripping of the relay of a protection function ($I_{>}$, $I_{>>}$, $I_{E>}$, $I_{E>>}$) and stopped as soon as the relay for the CB failure protection has picked up. Message "CBFP" is displayed. The tripping time ascertained by the timer should not deviate more than 1% or, at short trip delay, less than ± 10 ms from the set tripping time.

Alternatively, the timer can be started when the aux. voltage and the test current are injected simultaneously. The timer stops when the corresponding output relay for circuit breaker failure protection trips.

In this case the previously measured tripping delay has to be subtracted from the total tripping time measured.

6.5 Primary injection test

Generally, a primary injection test could be carried out in the similar manner as the secondary injection test described above. With the difference that the protected power system should be, in this case, connected to the installed relays under test "on line", and the test currents and voltages should be injected to the relay through the current and voltage transformers with the primary side energized. Since the cost and potential hazards are very high for such a test, primary injection tests are usually limited to very important protective relays in the power system.

Because of its powerful combined indicating and measuring functions, the MRI3 relay may be tested in the manner of a primary injection test without extra expenditure and time consumption. In actual service, for example, the measured current values on the MRI3 relay display may be compared phase by phase with the current indications of the ammeter of the switchboard to verify that the relay works and measures correctly. In case of a MRI3 relay with directional feature, the active and reactive parts of the measured currents may be checked and the actual power factor may be calculated and compared it with the $\cos\phi$ -meter indication on the switchboard to verify that the relay is connected to the power system with the correct polarity.

6.6 Maintenance

Maintenance testing is generally done on site at regular intervals. These intervals vary among users depending on many factors: e.g. the type of protective relays employed; the importance of the primary equipment being protected; the user's past experience with the re-lay, etc. For electromechanical or static relays, maintenance testing will be performed at least once a year according to the experiences. For digital relays like MRI3, this interval can be substantially longer. This is because:

- The MRI3 relays are equipped with very wide self-supervision functions, so that many faults in the relay can be detected and signalized during service. Important: The self-supervision output relay must be connected to a central alarm panel!
- The combined measuring functions of MRI3 relays enable supervision the relay functions during service.
- The combined TRIP test function of the MRI3 relay allows to test the relay output circuits.

A testing interval of two years for maintenance will, therefore, be recommended.

During a maintenance test, the relay functions including the operating values and relay tripping characteristics as well as the operating times should be tested.

7. Technical data

7.1 Measuring input circuits

Rated data:	Nominal current I_N	1 A or 5 A
	Nominal voltage U_N	100 V, 230 V, 400 V
	Nominal frequency f_N	50 Hz; 60 Hz adjustable
Power consumption in current circuit:	at $I_N = 1$ A	0.2 VA
	at $I_N = 5$ A	0.1 VA
Power consumption in voltage circuit:		<1 VA
Thermal withstand capability in current circuit:	dynamic current withstand (half-wave)	$250 \times I_N$
	for 1 s	$100 \times I_N$
	for 10 s	$30 \times I_N$
	continuously	$4 \times I_N$
Thermal withstand in voltage circuit:	continuously	$1.5 \times U_N$

7.2 Common data

Dropout to pickup ratio:	>97%
Dropout to pickup ratio for phase current in range $0.2 \times I_N$ to $0.5 \times I_N$:	= 100 %
Returning time:	30 ms
Time lag error class index E:	± 10 ms
Minimum operating time:	30 ms
Transient overreach at instantaneous operation:	$\leq 5\%$
Influences on the current measurement	
Auxiliary voltage:	in the range of $0.8 < U_H/U_{HN} < 1.2$ no additional influences can be measured
Frequency:	in the range of $0.9 < f/f_N < 1.1$; $< 0.2\%$ / Hz
Harmonics:	up to 20% of the third harmonic; $< 0.08\%$ per percent of the third harmonic up to 20% of the fifth harmonic; $< 0.07\%$ per percent of the fifth harmonic
Influences on delay times:	no additional influences can be measured

7.3 Setting ranges and steps

System parameter

	Setting range	Step	Tolerance
I_{prim} I_{Eprim}	(SEK) 0.001...50.0KA	0.001; 0.002; 0.005; 0.01; 0.02; 0.05; 0.1; 0.2	
$U_{E>}$ ($U_{prim}/$ U_{SEK})	(SEK) 1.01...6500	0.01; 0.02; 0.05; 0.1; 0.2; 0.5; 1; 2; 5; 10; 20; 50	

7.3.1 Time overcurrent protection (I-Type)

	Setting range	Step	Tolerance
$I>$	0.2...4.0 x I_N (EXIT)	0.01; 0.02; 0.05; 0.1 x I_N	±3% from set value or min. ±2 % I_N
$t_{I>}$	0.03 - 260 s (EXIT) (definite time) 0.05 - 10 (EXIT) (inverse time)	0.01; 0.02; 0.05; 0.1; 0.2; 0.5; 1.0; 2.0; 5.0; 10 s; 20 s 0.01; 0.02; 0.05; 0.1; 0.2	±3% or ±10 ms ±3% of the measuring value of the current or ±20 ms (see EN60255-3)
$I>>$	0.5...40 x I_N (EXIT)	0.02; 0.05; 0.1; 0.2; 0.5; 1.0 x I_N	±3% from set value or min. ±2% I_N
$t_{I>>}$	0.03...10 s (EXIT)	0.01 s; 0.02 s; 0.05 s; 0.1 s; 0.2 s	±3% or ±10 ms

7.3.2 Earth fault protection (SR/YR-Type)

	Setting range	Step	Tolerance
$I_{E>}$	0.01...2.0 x I_N (EXIT) (SR)	0.001; 0.002; 0.005; 0.01; 0.02; 0.05 x I_N	±5% from set value or ±0.3% I_N
$t_{I_{E>}}$	0.1...20 % I_N (EXIT)(YR) 0.03...260 s (EXIT) (definite time) 0.05...10 (EXIT) (inverse time)	0.01%; 0.02%; 0.05% I_N 0.01; 0.02; 0.05; 0.1; 0.2; 0.5; 1.0; 2.0; 5.0; 10; 20 s 0.01; 0.02; 0.05; 0.1; 0.2	±0.3% I_N (SR); ±0.03% I_N (YR) ±3% or ±15 ms ±3% of the measuring value of the current or ±20 ms (see EN60255-3)
$I_{E>>}$	0.01...15 x I_N (EXIT) (SR)	0.001; 0.002; 0.005, 0.01; 0.02; 0.05; 0.1; 0.2; 0.5 x I_N	±5% from set value
$t_{I_{E>>}}$	0.1...150 % I_N (EXIT)(YR) 0.03...10 s (EXIT)	0.01%; 0.02%; 0.05% I_N 0.01 s; 0.02 s; 0.05 s; 0.1 s; 0.2s	±0.3% I_N (SR); ±0.03% I_N (YR) ±3% or ±15 ms

7.3.3 Earth fault protection (E/X-Type)

	Setting range	Step	Tolerance
$I_{E>}$	0.01...2.0 x I_N (EXIT)(E)	0.001; 0.002; 0.005; 0.01; 0.02; 0.05 x I_N	±5% from set value or
$t_{I_{E>}}$	0.1...20 % I_N (EXIT)(X) 0.03...260 s (EXIT) (definite time) 0.05...10 (EXIT) (inverse time)	0.01%; 0.02%; 0.05% I_N 0.01; 0.02; 0.05; 0.1; 0.2; 0.5; 1.0; 2.0; 5.0; 10; 20 s 0.01; 0.02; 0.05; 0.1; 0.2	±0.3% I_N (E); ±0.03% I_N (X) ±3% or ±15 ms ±3% of the measuring value of the current or ±20 ms (see EN60255-3)
$I_{E>>}$	0.01...15.0 x I_N (EXIT)(E)	0.001; 0.002; 0.005, 0.01; 0.02; 0.05; 0.1; 0.2; 0.5 x I_N	±5% from set value or
$t_{I_{E>>}}$	0.1...150 % I_N (EXIT)(X) 0.03...10 s (EXIT)	0.01%; 0.02%; 0.05% I_N 0.01; 0.02; 0.05 s; 0.1 s; 0.2 s	±0.3% I_N (E); ±0.03% I_N (X) ±3% or ±15 ms

7.3.4 Earth fault protection (ER/XR-Type)

	Setting range	Step	Tolerance
$I_{E>}$	0.01...0.45 x I_N (EXIT) (ER)	0.001; 0.002; 0.005; 0.01 x I_N	±5% from set value or
$t_{E>}$	0.1...4.5% I_N (EXIT) (XR) 0.05...260 s (EXIT)	0.01%; 0.02%; 0.05%; 0.1% I_N 0.01; 0.02; 0.05; 0.1; 0.2; 0.5; 1.0; 2.0; 5.0; 10; 20 s	±0.3% I_N (ER); ±0,03% I_N (XR) ±3% or ±15 ms
$I_{E>>}$	0.01...0.45 x I_N (EXIT) (ER)	0.001; 0.002; 0.005; 0.01 x I_N	±5% from set value or
$t_{E>>}$	0.1...4.5% I_N (EXIT) (XR) 0.05...10 s (EXIT)	0.01%; 0.02%; 0.05%; 0.1% I_N 0.01; 0.02; 0.05 s; 0.1 s; 0.2 s	±0,3% I_N (ER); ±0,03% I_N (XR) ±3% or ±15 ms
$U_{E>}$	$U_N = 100$ V: 3 PHA/e-n: 1 - 70 V 1:1: 1 - 120 V $U_N = 230$ V: 3 PHA/e-n: 2 - 160 V 1:1: 2 - 300 V $U_N = 400$ V: 3 PHA/e-n: 5 - 300 V 1:1: 5 - 500 V	1 V 1 V 2 V 2 V 5 V 5 V	±5% from set value or <0,5% U_N

7.3.5 Block/Trip – time

Block/Trip	0.1...2.0 s; EXIT	0.01; 0.02; 0.05; 0.1 s	±1% or ±10 ms
------------	-------------------	-------------------------	---------------

7.3.6 Switch failure protection

t_{CBFP}	0.1...2.0 s; EXIT	0.01; 0.02; 0.05; 0.1 s	±1% or ±10 ms
------------	-------------------	-------------------------	---------------

7.3.7 Interface parameter

Function	Parameter	Modbus-Protocol	RS485 Open Data Protocol
RS	Slave-Adresse	1 - 32	1 - 32
RS	Baud-Rate*	1200, 2400, 4800, 9600	9600 (fest)
RS	Parität*	even, odd, no	„even Parity“ (fest)

*only Modbus Protocol

7.3.8 Parameter for the fault recorder

Function	Parameter	Adjustment example
FR	Number of recordings	(1)* 2 x 8 s; (3)* 4 x 4 s; (7)* 8 x 2 s (50 Hz) (1)* 2 x 6.66 s, (3)* 4 x 3.33 s, (7)* 8 x 1.66 s
FR	Saving of the recording at the occurrence	P_UP; TRIP; A_PI; TEST
FR	Pre-trigger time	0.05 s – 8.00 s

* is written over at new trigger signal

7.3.9 Inverse time overcurrent protection relay

According to IEC 255-4 or BS 142

Normal Inverse (Type A)

$$t = \frac{0.14}{\left(\frac{I}{I_s}\right)^{0.02} - 1} \cdot t_l > [s]$$

Very Inverse (Type B)

$$t = \frac{13.5}{\left(\frac{I}{I_s}\right) - 1} \cdot t_l > [s]$$

Extremely Inverse (Type C)

$$t = \frac{80}{\left(\frac{I}{I_s}\right)^2 - 1} \cdot t_l > [s]$$

Long Time Inverse

$$t = \frac{120}{\left(\frac{I}{I_s}\right) - 1} \cdot t_l > [s]$$

RI-Inverse Time

$$t = \frac{1}{0.339 - \frac{0.236}{\left(\frac{I}{I_s}\right)}} \cdot t_l > [s]$$

*RXIDG – characteristic

$$t = \left(5.8 - 1.3 \cdot \ln\left(\frac{I}{I_s}\right)\right) \cdot t_l > [s]$$

Where:

t	=	tripping time
t _l	=	time multiplier
I	=	fault current
I _s	=	Starting current
=	=	natural logarithm

*only for earth current

7.3.10 Direction unit for phase overcurrent relay

Directional sensitivity for voltage input circuit:	$<0.025\% U_N$ (phase-to-phase voltage) at $I = 1 \times I_N$
Connection angle:	90°
Characteristic angle:	$15^\circ, 27^\circ, 38^\circ, 49^\circ, 61^\circ, 72^\circ, 83^\circ$
Effective angle:	$\pm 78^\circ$ related to relay characteristic angle at U_N

7.3.11 Determination of earth fault direction (MRI3-ER/XR)

Measurement of active current component for compensated systems:	$I_E \times \cos \varphi$
Measurement of reactive current component for isolated systems:	$I_E \times \sin \varphi$
Angle measuring accuracy at rated voltage:	$\pm 3^\circ$ at $I_E \times \cos \varphi$ or $I_E \times \sin \varphi > 5\% I_E$

7.3.12 Determination of earth fault direction (MRI3-SR/YR)

Characteristic angle:	"SOLI" setting - 110° "RESI" setting - 170°
Effective angle:	$45^\circ - 309^\circ$ in 5.625° - steps $\pm 70^\circ$ related to relay characteristic angle at $U_N/\sqrt{3}$
Residual voltage sensitivity:	$<0.2\% U_N$ at $I = 0.1 \times I_N$

7.4 Inverse time characteristics

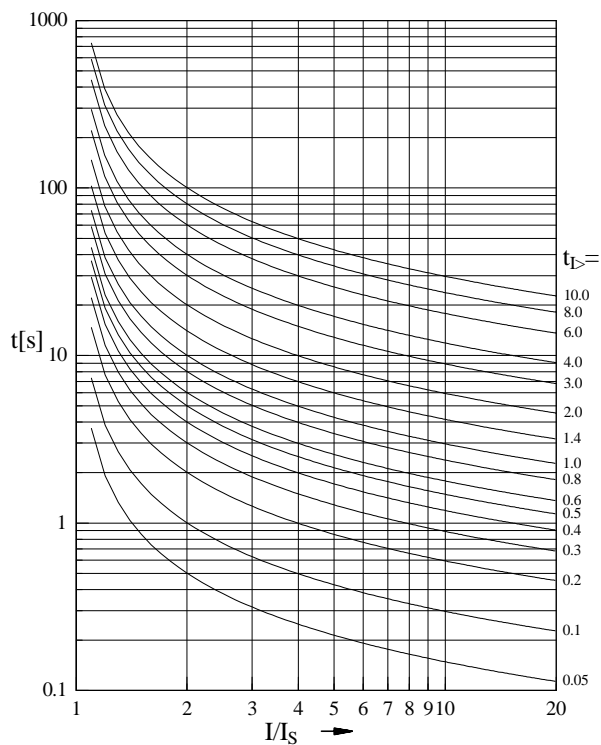


Figure 7.1: Normal Inverse (Type A)

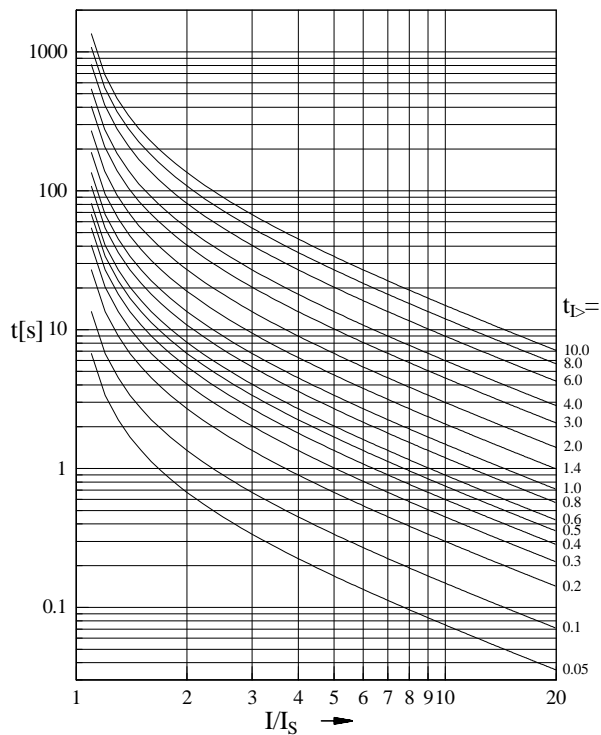


Figure 7.2: Very Inverse (Type B)

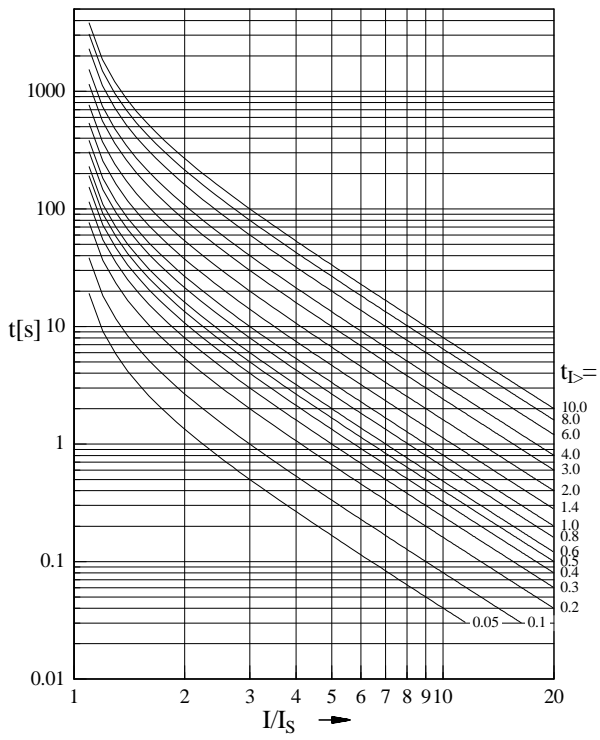


Figure 7.3: Extremely Inverse (Type C)

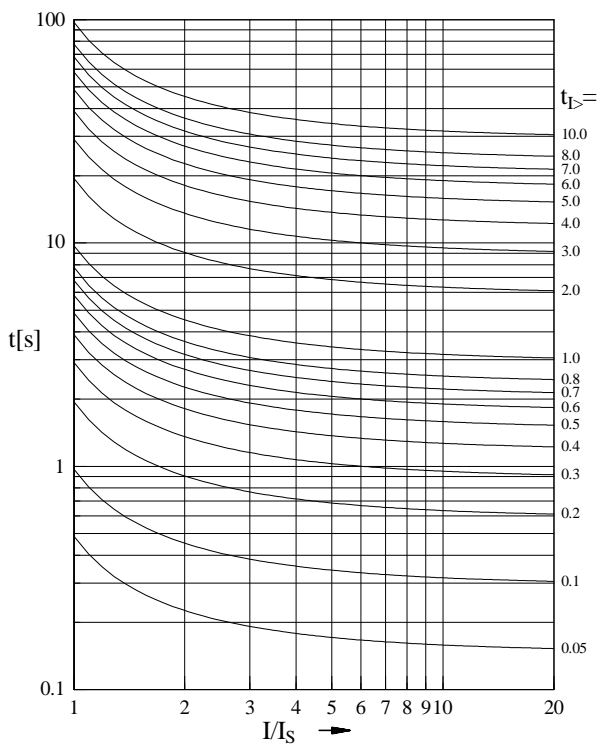


Figure 7.4: RI-Inverse

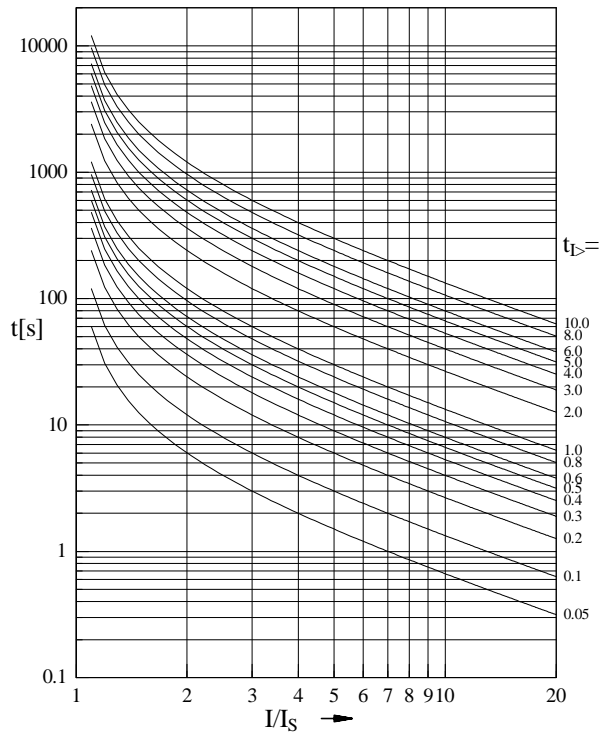


Figure 7.5: Long Time Inverse

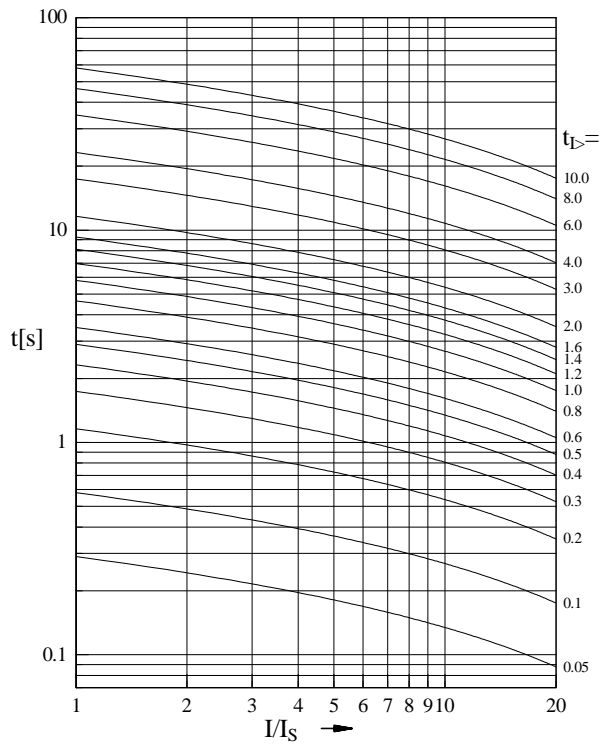


Figure 7.6: RXIDG-characteristic

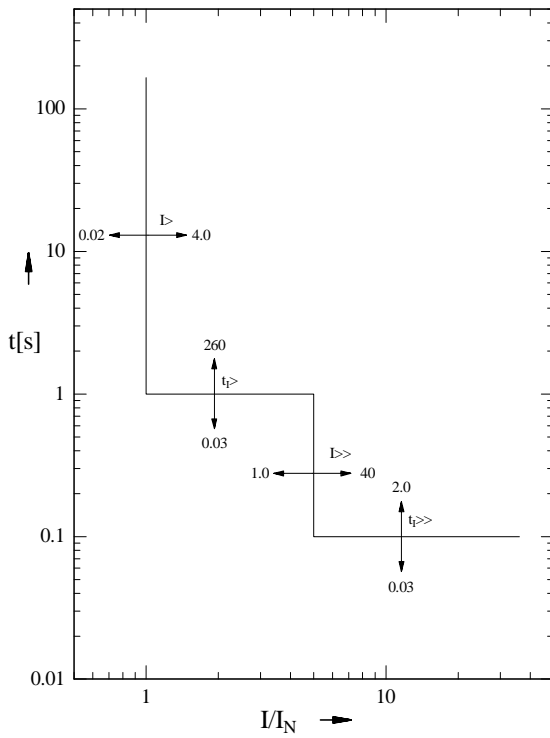


Figure 7.7: Definite time overcurrent relay

7.5 Output contacts

Number of relays:	dependent on relay type
Contacts:	2 change-over contacts for trip relay 1 change-over contact for alarm relays

Technical data subject to change without notice!

8. Order form

Time overcurrent-/ Earth fault current relay		MRI3-						
3-phase current >, >> Rated current ³		none 1 A 5 A	* I1 I5					
Phase fault directional feature Rated voltage ²		none 100 V 230 V 400 V	* R1 R2 R4					
Earth current measuring				*				
Rated current ³	Standard	none		E1				
		1 A		E5				
	sensitive	5 A		X1				
		1 A		X5				
		5 A		S1				
		* ¹ solid grounded	1 A		S5			
		* ¹ solid grounded	5 A		Y1			
sensitive	1 A		Y5					
		5 A						
Directional feature in earth path Rated voltage ² in earth circuit		none 100 V 230 V 400 V		*	R1 R2 R4			
Housing (12TE)		19"- Flush mounting				A D		
Communication protocol RS485 Pro Open Data; Modbus RTU							* -M	

- * Leave box empty if option is not desired (no extra charge)
- ¹ Only in connection with directional detection in the earth current path
- ² Both rated voltages must be the same!
- ³ At least one of these versions must be chosen

Setting list MRI3

Note !

All settings must be checked at site and should the occasion arise, adjusted to the object / item to be protected.

Project: _____ Woodward job.-no.: _____

Function group: = _____ Location: + _____ Relay code: - _____

Relay functions: _____ Password: _____

Date: _____

Adjustment of the parameter

Systemparameter

Relay type MRI3-	I	IE IX	IRE IRX	IR	IER IXR	IRER IRXR	ER XR	E X	ISR IYR	IRSR IRYR	SR YR	Default settings	Actual settings
I_{prim} (phase)	X	X	X	X	X	X			X	X		SEK	
I_{prim} (earth)		X	X		X	X	X	X	X	X	X	SEK	
U_{prim}/U_{sek} (earth)					X	X	X					SEK	
1:1/3pha / e-n					X	X	X					3pha	
50/60 Hz	X	X	X	X	X	X	X	X	X	X	X	50Hz	
Indication Pickup	X	X	X	X	X	X	X	X	X	X	X	FLSH	
Parameter switch/external triggering for the fault recorder	X	X	X	X	X	X	X	X	X	X	X	SET1	

Protection parameter

Relay type MRI3-	I	IE IX	IRE IRX	IR	IER IXR	IRER IRXR	ER XR	E X	ISR	IRSR	SR	Default settings		Actual settings	
												Set 1/Set 2	Set 1/	Set 2	
2 parameter sets	X	X	X	X	X	X	X	X	X	X	X	Set 1/Set 2	Set 1/	Set 2	
$I_{>}$	X	X	X	X	X	X			X	X		$0.2 \times I_N$			
CHAR $I_{>}$	X	X	X	X	X	X			X	X		DEFT			
$t_{I>(V)} / t_{I>(R)}$	X	X	X	X	X	X			X	X		0.03s			
0s/60s (phase)	X	X	X	X	X	X			X	X		0s			
$I_{>>}$	X	X	X	X	X	X			X	X		$1.0 \times I_N$			
$t_{I>>(V)} / t_{I>>(R)}$	X	X	X	X	X	X			X	X		0.03s			
RCA			X	X		X				X		49°			
$U_{E>}$					X	X	X					1V/2V/5V			
$I_{E>}$		X	X		X	X	X	X	X	X	X	$0.01 \times I_n$ (E) 0.1 % (X, YR)			
trip/warn		X	X		X	X	X	X	X	X	X	Trip			
CHAR I_E		X	X					X	X	X	X	DEFT			
$t_{IE>(V)} / t_{IE>(R)}$		X	X		X	X	X	X	X	X	X	0.05s (ER/XR) 0.04s others			
0s/60s (phase)		X	X					X	X	X	X	0s			
$I_{E>>}$		X	X		X	X	X	X	X	X	X	$0.01 \times I_n$ (E) 0.1 % (X, YR)			
$t_{IE>>(V)} / t_{IE>>(R)}$		X	X		X	X	X	X	X	X	X	0.05s (ER/XR) 0.04s others			
SIN/COS					X	X	X					SIN			
SOLI/RESI									X	X	X	SOLI			
Block/Trip - time	X	X	X	X	X	X	X	X	X	X	X	EXIT			
t_{CBFP}	X	X	X	X	X	X	X	X	X	X	X	EXIT			
RS485/Slave	X	X	X	X	X	X	X	X	X	X	X	1			
Baud-Rate*	X	X	X	X	X	X	X	X	X	X	X	9600			
Parity-Check*	X	X	X	X	X	X	X	X	X	X	X	even			

*only Modbus Protocol

Fault recorder

Function		Unit	Default settings	Actual settings
FR	Number of recordings		4	
FR	Saving of the recording at the occurrence		TRIP	
FR	Time prior to trigger impulse	s	0,05	
⌚	Year settings	Year	Y = 00	
⌚	Month settings	Month	M=00	
⌚	Day settings	Day	D=00	
⌚	Setting of the hours	Hours	h=00	
⌚	Setting of the minutes	Minutes	m=00	
⌚	Settings of the seconds	Seconds	s=00	

Setting of code jumpers

Code jumper	J1		J2		J3	
	Default settings	Actual settings	Default settings	Actual settings	Default setting	Actual settings
Plugged						
No plugged	X		No function	X		

Code jumper	Low/High-range for reset input		Low/High-range for blockage input	
	Default settings	Actual settings	Default settings	Actual settings
Low=plugged	X		X	
High=no plugged				

Assignment of the output relays:

Function	Relay 1		Relay 2		Relay 3		Relays 4	
	Default setting	Actual setting	Default setting	Actual setting	Default setting	Actual setting	Default setting	Actual setting
I _{>} alarm (V)			X					
t _{I>} tripping (V)	X							
I _{>} alarm (R)*			X					
t _{I>} tripping (R)*	X							
I _{>>} alarm (V)					X			
t _{I>>} tripping (V)	X							
I _{>>} alarm (R)*					X			
t _{I>>} tripping (R)*	X							
I _{E>} alarm (V)							X	
t _{I E>} tripping (V)	X							
I _{E>} alarm (R)*							X	
t _{I E>} tripping (R)*	X							
I _{E>>} alarm (V)							X	
t _{I E>>} tripping (V)	X							
I _{E>>} alarm (R)*							X	
t _{I E>>} tripping (R)*	X							
t _{CBFP} tripping								

* only relays with directional function

Assignment of the blocking function:

Parameter set	Default setting		Actual setting	
	Set 1	Set 2	Set 1	Set 2
Blocking th protection function PR_B	PR_B	PR_B		
Blocking the trip step TR_B				

Parameter set	Default setting				Actual setting			
	Blocking		No blocking		Blocking		No blocking	
	Set 1	Set 2	Set 1	Set 2	Set 1	Set 2	Set 1	Set 2
I>			X	X				
I>>	X	X						
IE>			X	X				
IE>>			X	X				
tCBFP			X	X				

This technical manual is valid for
Software version:

D01-9.03 (MRI3-ER; -IER; -IRER)
D20-3.03 (MRI3-XR; -IXR; -IRXR)
D24-2.03 (MRI3-X; -IX; -IXR)
D00-9.04 (MRI3; I; E; IE; -IR; SR; -IRE; -ISR; -IRSR)
D18-9.00 (MRI3; -IRYR; -IYR; -YR)

Modbus version number:

D51-2.12 (MRI3-ER-M; -IER-M; -IRER-M)
D70-2.12 (MRI3-XR-M; -IXR-M; -IRXR-M)
D74-2.12 (MRI3-X-M; -IX-M; -IXR-M)
D50-2.12 (MRI3-M; I-M; E-M; IE-M; -IR-M; SR-M; -IRE-M;
-ISR-M; -IRSR-M)
D68-2.00 (MRI3-M; IRYR-M; IYR-M; YR-M)

**Woodward Kempen GmbH**

Krefelder Weg 47 · D – 47906 Kempen (Germany)
Postfach 10 07 55 (P.O.Box) · D – 47884 Kempen (Germany)
Phone: +49 (0) 21 52 145 1

Internet

www.woodward.com

Sales

Phone: +49 (0) 21 52 145 216 or 342 · Telefax: +49 (0) 21 52 145 354
e-mail: salesEMEA_PGD@woodward.com

Service

Phone: +49 (0) 21 52 145 614 · Telefax: +49 (0) 21 52 145 455
e-mail: SupportEMEA_PGD@woodward.com