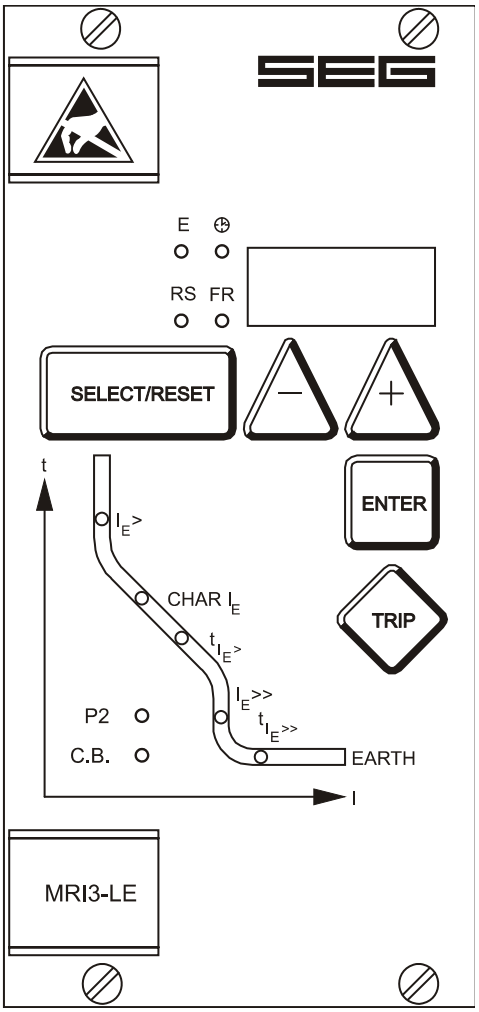
WOODWARD



MRI3-LE – Digital multifunctional relay for earth fault protection

(January 2010)
Manual MRI3-LE (Revision New)

Contents

1. Introduction and application

The MRI3-LE digital multifunctional relay is a universal earth fault protection device intended for use in low voltage and medium-voltage systems

- Independent (Definite) time earth overcurrent and earth short circuit relay,
- two-element (low and high set) with definite or inverse time characteristics,

Important:
For additional common data of all MR-relays please refer to manual "MR - Digital Multifunctional relays". On the last page 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 frequence harmonics and DC components induced by faults or system operations,
- two parameter sets,
- selectable protective functions between:
  - definite time earth overcurrent relay and
  - inverse time earth 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,
- numerical display of setting values, actual measured values, memorized fault data, etc.,
- display of measuring values as primary quantities,
- withdrawable modules with automatic short circuiter of C.T. inputs when modules are withdrawn,
- circuit breaker failure protection,
- storage of trip values and switching-off time (tCBFP) of 5 fault occurences (fail-safe of voltage),
- recording of up to eight fault occurences with time stamp,
- free assignment of output relays
- serial data exchange via RS485 or RS232 interface possible; with Modbus Protocol,
- suppression of indication after an activation (LED flash),
- display of date and time

3. Design

3.1 Connections

Earth current measuring:

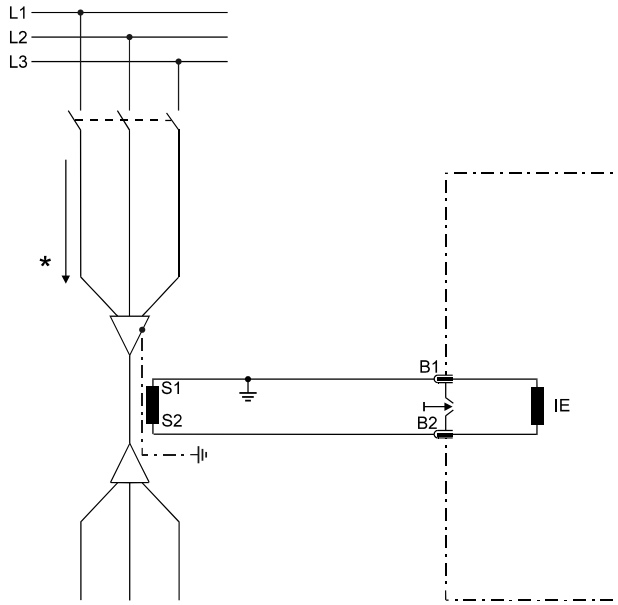


Figure 3.1: Earth-fault measuring by means of ring-core C.T. (IE)

3.1.1 Analog input circuits

The protection unit receives the analog input signal of the eath current IE (B1-B2
The constantly detected current measuring values are galvanically decoupled, filtered and finally fed to the analog/digital converter.

3.1.2 Output relays

The MRI3-LE is equipped with 2 output relays. 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

All trip and alarm relays are working current relays.

3.2 Relay output contacts

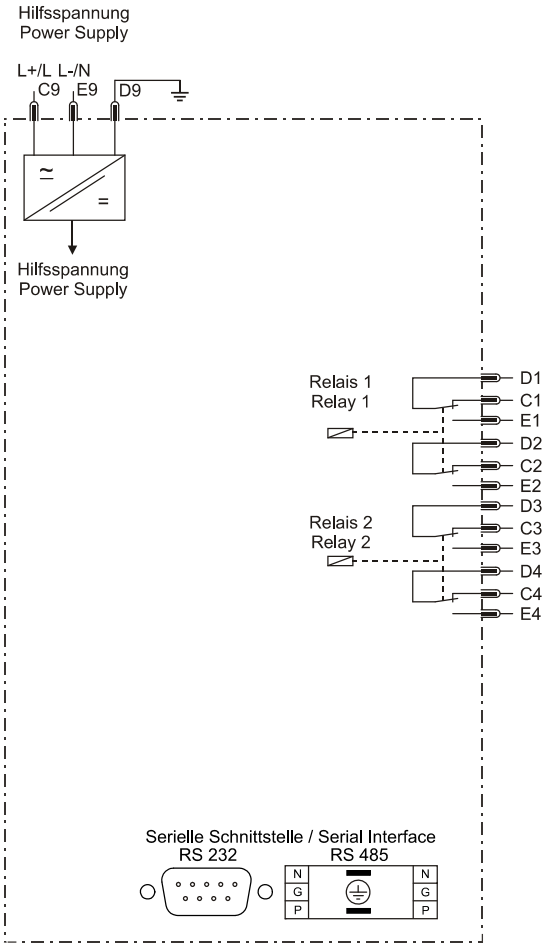


Figure 3.2: Relay out put contacts, power supply and communication outputs

3.2.1 Fault recorder

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

i_E,

is 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

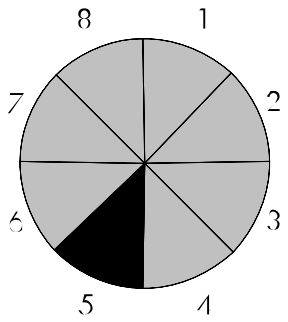


Figure 3.5: Division of the memory into 8 segments, for example

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.

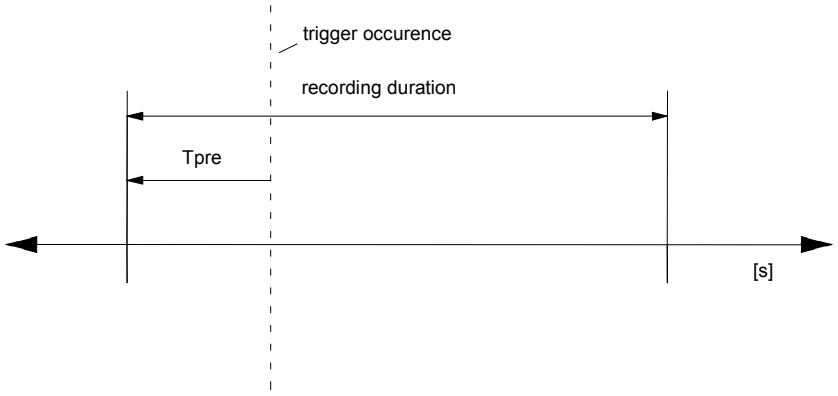


Figure 3.62: Recording scheme of the fault recorder with pre-trigger time

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

Via the interface RS485 or RS232 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.

Front plate

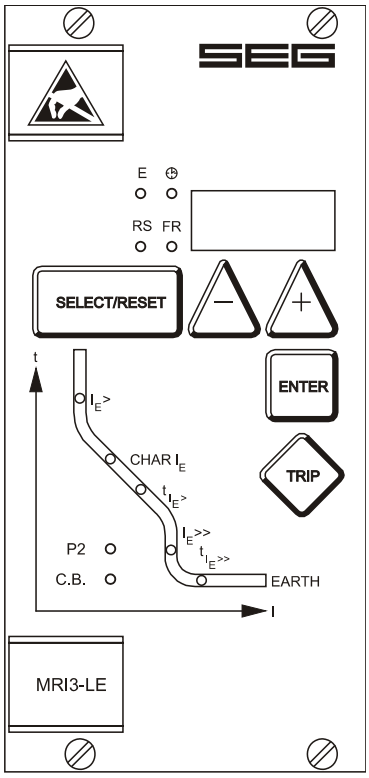


Figure 3.3: Front plate MRI3-LE

3.3 LEDs

The LEDs left from the display are partially bi-colored, the green indicating measuring, and the red fault indication.
. 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 earth-fault relay indicate the corresponding menu point selected.
The LED labeled with the letters FR is a light 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 transformer 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).

4.2 Digital circuits

The essential part of the MRI3-LE 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 sup-press 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 Earth fault protection

4.3.1 Generator stator earth fault protection

With the generator neutral point earthed as shown in Figure 4.1 the MRI3-LE 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.

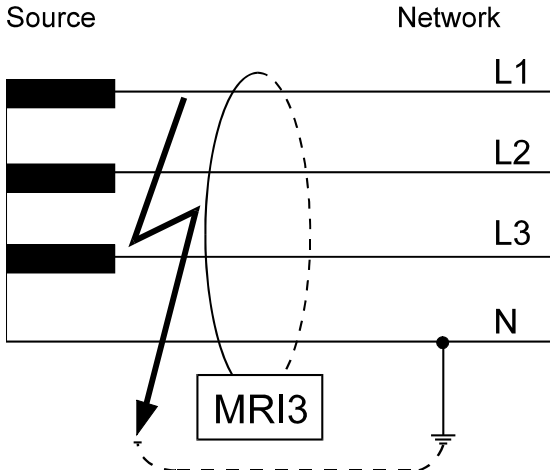


Figure 4.1: Generator stator earth fault protection

4.3.2 System earth fault protection

With the generator neutral point earthed as shown in Figure 4.2, the MRI3-LE 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.

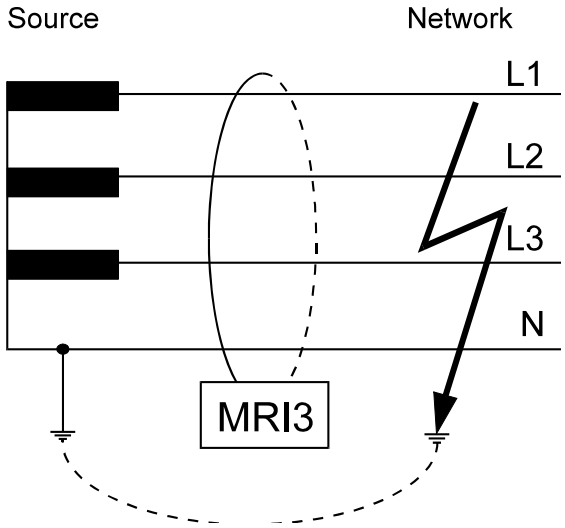


Figure 4.2: System earth fault protection

4.4 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 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	SEG		
Measured operating value	Actual measured value	<SELECT/RESET> one time for each	E,
Measuring range overflow	max.	<SELECT/RESET>	E
Setting values: earth (I_E>; CHAR I_E; t_{IE}>; I_E>>; t_{IE}>>)	Current settings Trip delay characteristics	<SELECT/RESET> one time for each parameter	$I_{E>}$; CHAR I_E>; t_{IE}>; I_E>>; t_{IE}>>
Current display as second rated repetition current I_{prim} (earth)	SEK (0.001-50.0kA=prim)	<SELECT/RESET><+><->	E
Parameter switch	SET1, SET2	<SELECT/RESET><+><->	P2
LED blinking after activation	FLSH, NOFL	<SELECT/RESET><+><->	
Characteristics	DEFT, NINV, VINV, EINV, LINV, RINV, RXIDG	<SELECT/RESET><+><->	CHAR IE>
Reset setting	0s/60s	<SELECT/RESET><+><->	I_E> + CHAR I_E + t_{IE}>
Warning or trip at earth fault measuring	TRIP WARN	<SELECT/RESET><+><->	I_E>
Switch failure protection	tCBFP	<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	1200-9600	<SELECT/RESET> <+><->	RS
Parity-Check	even odd no	<SELECT/RESET> <+><->	RS
Recorded fault data	Tripping currents and other fault data	<SELECT/RESET> one time for each phase	E; I_E>, I_E>>,
Save parameter?	SAV?	<ENTER>	
Delete failure memory	Wait	<-> <SELECT/RESET>	
Enquiry failure memory	FLT1; FLT2.....	<-><+>	E; 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 = 10, M = 01, D = 13, h = 16, m = 2, s = 12	<SELECT/RESET> <+><->	◷
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	SEG	<SELECT/RESET> for about 3 s	

Table 5.1: possible indication messages on the display

[1)] refer to 4.3

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 4.3 of the "MR Digital Multifunctional Relay" description).

5.3 System parameter

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

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 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>.

5.3.3 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.

5.3.4 Parameter switch/ for parameter set change

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 this parameter.

5.4 Parameter protection

5.4.1 Pickup current for earth phase overcurrent element (I_E>)

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

5.4.2 Time current characteristics for earth overcurrent element (CHAR IE)

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
RXID Special characteristic

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 earth overcurrent element (tI_E>)

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 tI_E>. 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 charges 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 earth overcurrent relay is blocked. The "WARN"-relay will not be blocked.

5.4.4 Reset setting for all tripping characteristics in the earth 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 tRST is set at 60 s, the tripping time is only reset after 60 s faultless condition. This function is not available if tRST 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 of earth fault supervision (I_E>>)

The current setting value of this parameter appearing on the display is related to the rated current of the relay.
This means: I_E>> = displayed value x 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 earth overcurrent relay is blocked.

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

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

5.4.7 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% x 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%xIN 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% x I_N within t_{CBFP}

5.4.8 Adjustment of the slave address

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

5.4.9 Setting of Baud-rate

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>.

5.4.10 Setting of parity

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-LE is equipped with a fault recorder (see chapter3.2.1). 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 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 (Tpre)

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 function

Assignment of the output relays:
Unit MRI3-LE has two output relays. The two ouitput relays 1 - 2 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.after the <ENTER> and <TRIP> keys have been actuated simultaneously, the display

shows the text "_ 2 _ _" and the LED I_E> light up.

The relays are assigned as follows: LEDs IE>, IE>> light up when the output relays are assigned as alarm relays and the LEDs tI_E> and tI_E>> as tripping relays.

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_E> lights up. Now one or several of the four output relays can be assigned to current element I_E> as alarm relays. At the same time the selected alarm relays for earth overcurrent element 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 cur-rent element. The assignment of output relays 1 - 2 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 tI_E> lights up. The output relays can now be assigned to this current element as tripping relays.

Relays 1 - 2 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		
IE>	alarm		X			_ 2 _ _	I_E>
tIE>	tripping	X				1 _ _ _	t_{IE}>
IE>>	alarm		X			_ 2 _ _	I_E>>
tIE>>	tripping	X				1 _ _ _	t_{IE}>>
tCBFP	tripping					_ _ _ _	C.B.; red

Table 5.2: Example of assignment matrix of the output relays (default settings).

5.8 Indication of measuring and fault values

5.8.1 Indication of measuring values

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

- Apparent earth current (LED E green),
-

The indicated current measuring values refer to rated current. 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:

Earth current:

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

* rated current transformer >2kA

5.8.2 Indication of fault data

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

5.8.3 Fault memory

When the relay is energized or trips, all fault data and times are stored in a non-volatile memory manner. The MRI3-LE 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 blinking to indicate that it is not a current fault. LEDs which were blinking 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**
Earth current I_E in I/I_En	E
C.B. switching time in s [1)]	CB
Expired tripping time of I_E> in % of t_{IE}> [2)]	$I_{E>}$
Time stamp	
Date: Y = 10	🕒
M = 01	🕒
D = 14	🕒
Time: h = 15	🕒
m = 12	🕒
s = 04	🕒

Table 5.3

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 displayed for I_E>.

5.9 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)

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.

5.9.1 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 corresponds to the plant data on site.
- The current transformer circuits and voltage trans-former 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 "SEG" 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 ≥ 4 x In),
- timer to measure the operating time
- (Accuracy class ≤±10 ms),
- switching device and
- test leads and tools.

6.4.2 Example of test circuit for MRI3-LE relays

For testing MRI3 relays, 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.

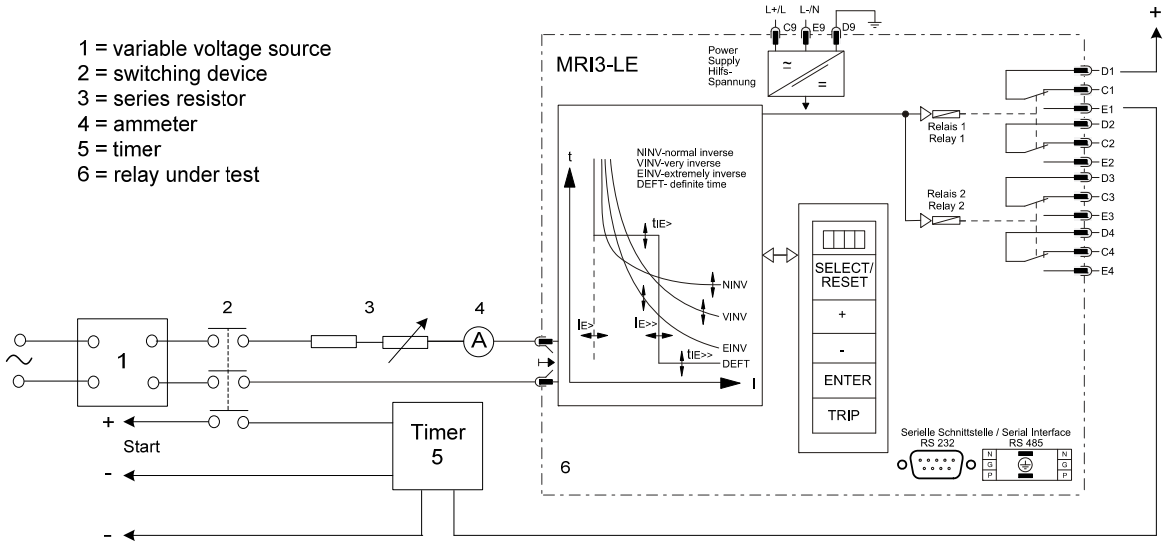


Figure 6.1: Test circuit

6.4.3 Checking the input circuit and measured values

Inject a current, which is less than the relay pickup current set values, in earth path (terminals B1-B2), and check the measured current on the display by pressing the push button <SELECT>. For a relay with rated current In = 5A, for example, a secondary current injection of 1A should be indicated on the display with about 0.2 (0.2 x In). When parameter IE_{prim} = „SEK“ is set, the indication is 0.2 x In and at „5“ the indication is 1.00 [A]. Compare the displayed current value with the reading of the ammeter. The deviation must not exceed 3% or 1% In. By using an RMS-metering instrument, a greater deviation may be observed if the test current contains harmonics. Because the MRI3-LE 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 earth path of the relay and gradually increase the current until the relay starts, i.e. at the moment when the LED IE> and E light up or the

alarm output relay I_E> is activated. Read the operating current indicated by the ammeter. The deviation must not exceed 3% of the set operating value or 0.1% In.
Furthermore, gradually decrease the current until the relay resets, i.e. the alarm output relay I_E> is disengaged. Check that the resetting current is smaller than 0.97 times the operating current.

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 ±15 ms (DEFT). Accuracy for inverse time characteristics refer to IEC 255-3.
Repeat the test 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 Is. The tripping time may be red 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_E>>. Inject the current instantaneously and check that the alarm output relay I_E>> 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_E>> element picks up. Read the current value form the ammeter and compare with the desired setting.
Note !
Where test currents >4 x I_N are used, the thermal with-stand capability of the current paths has to be considered (see technical data, chapter 7.1).

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 should be injected to the relay through the current 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.

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 relay, 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-LE, this interval can be substantially longer.

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 circuit

Rated data:	Nominal current I_N	1 A or 5 A
	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
Thermal withstand capability in current circuit:	dynamic current withstand	
	(half-wave)	250 x I_N
	for 1 s	100 x I_N
	for 10 s	30 x I_N
	continuously	4 x I_N

7.2 Common data

Dropout to pickup ratio:	>97%
Dropout to pickup ratio for phase current in range 0.2 x I_N to 0.5 x I_N:	= 100 %
Returning time:	30 ms
Minimum operating time:	30 ms
Transient overreach at instantaneous operation:	≤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_{Eprim}	(SEK) 0.001...50.0KA	0.001; 0.002; 0.005; 0.01; 0.02; 0.05; 0.1; 0.2	

7.3.1 Earth fault protection

	Setting range	Step	Tolerance
$I_E>$	0.01...2.0 x I_N (EXIT)	0.001; 0.002; 0.005; 0.01; 0.02; 0.05 xI_N 0.01; 0.02; 0.05; 0.1; 0.2; 0.5; 1.0; 2.0;	±5% from set value or ±0.3% I_N
$t_{IE}>$	0.03...260 s (EXIT) (definite time) 0.05...10 (EXIT) (inverse time)	5.0; 10; 20 s 0.01; 0.02; 0.05; 0.1; 0.2	±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)	0.001; 0.002; 0.005, 0.01; 0.02; 0.05; 0.1; 0.2; 0.5 xI_N	±5% from set value or ±0.3% I_N
$t_{IE}>>$	0.03...10 s (EXIT)	0.01; 0.02; 0.05 s; 0.1 s; 0.2 s	±3% or ±15 ms

7.3.2 CBFP Circuit breaker failure protection protection

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

7.3.3 Interface parameter

Function	Parameter	Modbus-Protocol	
RS	Slave-Adresse	1 - 32	
RS	Baud-Rate*	1200, 2400, 4800, 9600	
RS	Parität*	even, odd, no	

7.3.4 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

7.3.5 Inverse time overcurrent protection relay

According to IEC 255-4 or BS 142

Normal Inverse (Type A)

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

Very Inverse (Type B)

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

Extremely Inverse (Type C)

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

Long Time Inverse

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

RI-Inverse Time

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

RXIDG – characteristic

$$t = \left(5.8 - 1.3 \cdot \ell n\left(\frac{I}{Is}\right)\right) \cdot t_{I>}[s]$$

Where:	t	=	tripping time
	tI>	=	time multiplier
	I	=	fault current
	Is	=	Starting current
	ℓn	=	natural logarithm

7.4 Inverse time characteristics

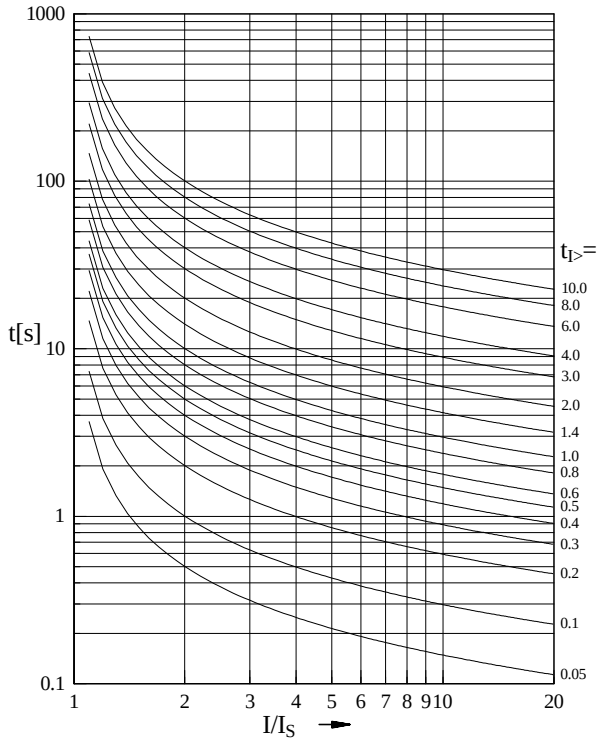


Figure 7.1: Normal Inverse (Type A)

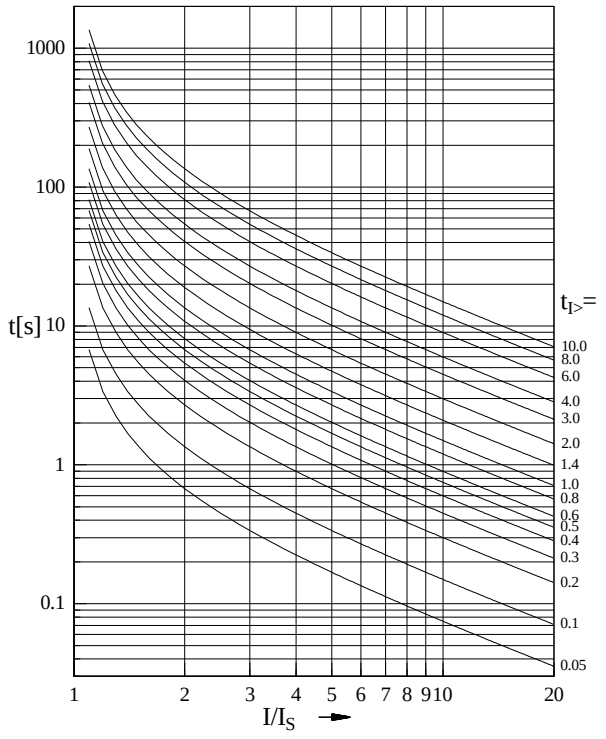


Figure 7.2: Very Inverse (Type B)

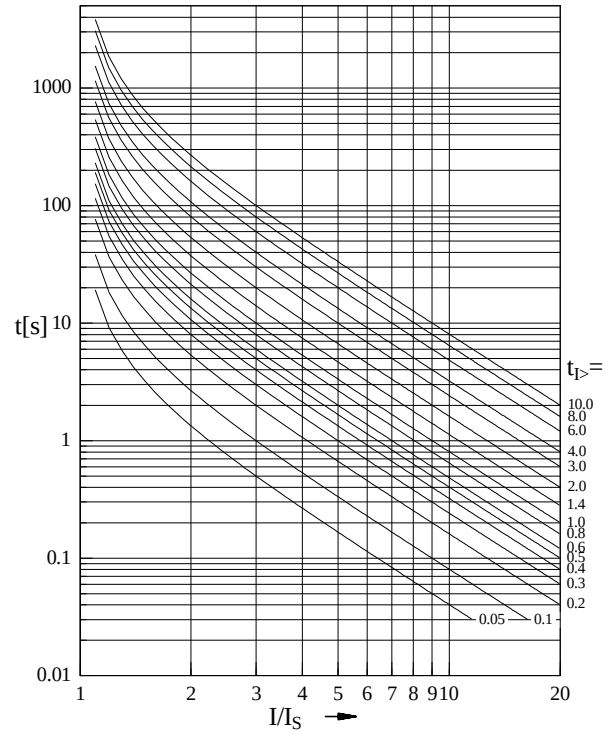


Figure 7.3: Extremely Inverse (Type C)

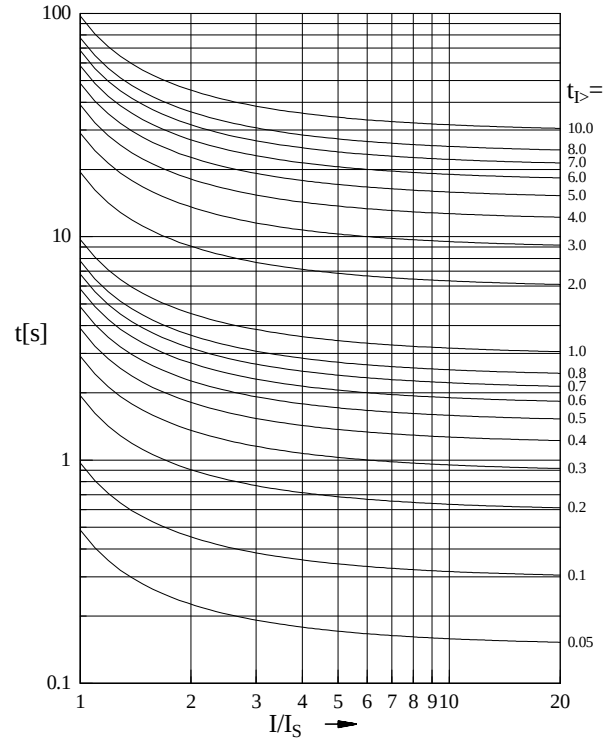


Figure 7.4: RI-Inverse

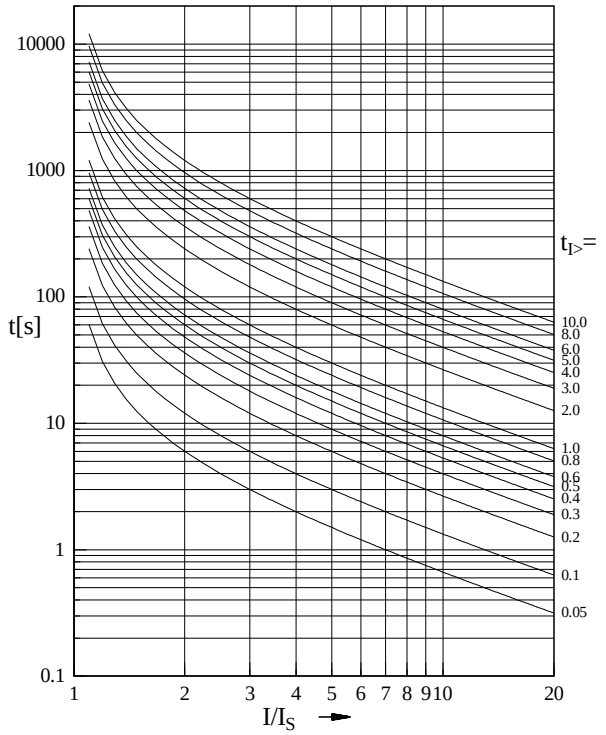


Figure 7.5: Long Time Inverse

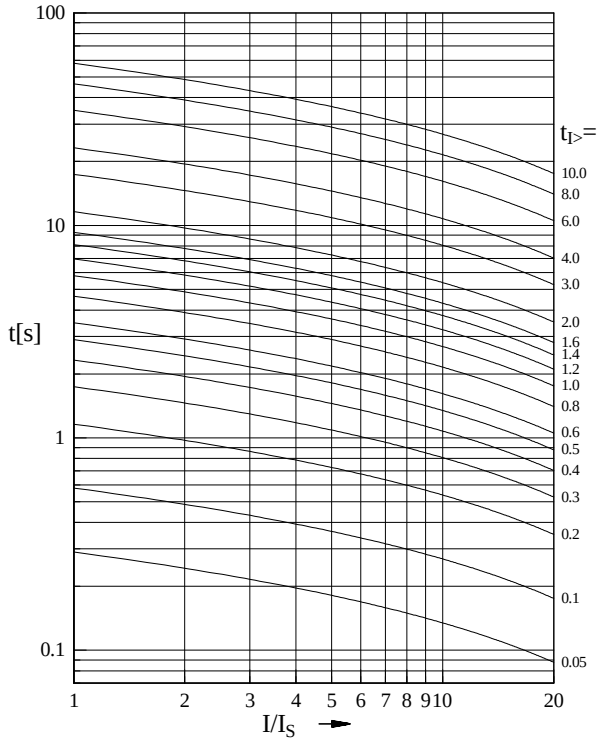


Figure 7.6: RXIDG-characteristic

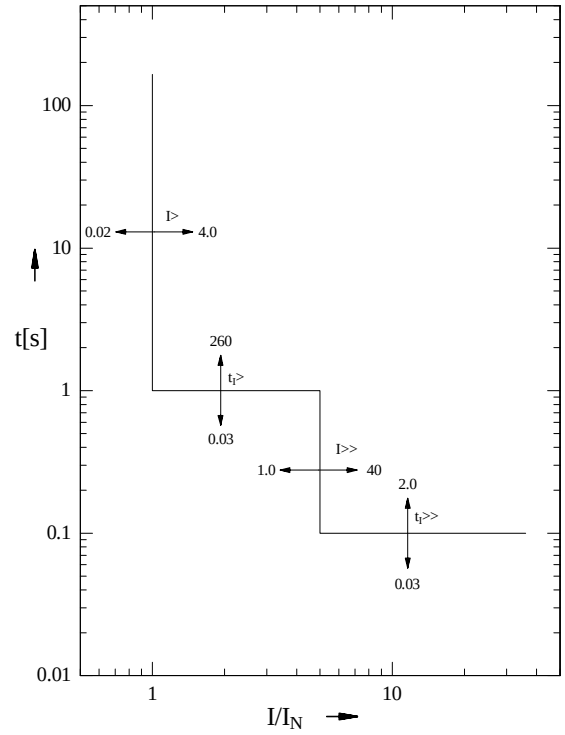


Figure 7.7: Definite time overcurrent relay

7.5 Output contacts

Number of relays:
Contacts: 2 change-over contacts

Technical data subject to change without notice!

8. Order form

Time overcurrent-/ Earth fault current relay	***MRI3***		**D**	**M**
Earth current measuring	Rated current[1] Standard			
	1 A	**LE1**		
	5 A	**LE5**		
Housing (12TE)	Flush mounting			
Communication protocol Modbus RTU				

[1] At least one of these versions must be chosen

Setting list MRI3-LE

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

Project: _____ SEG job.-no.: _____

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

Relay functions: _____ Password: _____

Date: _____

Adjustment of the parameter

Systemparameter

Relay type MRI3-LE	Default settings	Actual settings
I_{prim} (earth)	SEK	
50/60 Hz	50Hz	
Indication Pickup	FLSH	
Parameter switch/external triggering for the fault recorder	SET1	

Protection parameter

Relay type MRI3-LE	Default settings	Actual settings	
2 parameter sets	Set 1/Set 2	Set 1/	Set 2
I_E>	0.01 xI_n		
trip/warn	Trip		
CHAR I_E	DEFT		
t_{IE}>	0.04s		
0s/60s	0s		
I_E>>	0.01 xI_n		
t_{IE}>>	0.04s		
t_{CBFP}	EXIT		
RS485 / RS232/Slave	1		
Baud-Rate	9600		
Parity-Check	even		

Fault recorder

Function		Unit	Default set-tings	Actual settings
FR	Number of recordings		4	
FR	Saving of the recording at the occur-rence		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		

Assignment of the output relays:

Function	Relay 1		Relay 2					
	Default setting	Actual setting	Default setting	Actual setting				
I_E> Alarm		X						
t_{IE}> Tripping	X							
I_E>> Alarm		X						
t_{IE}>> Tripping	X							
t_{CBFP} Tripping								

This technical manual is valid for

Software version:
Modbus version number: D88-1.00

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