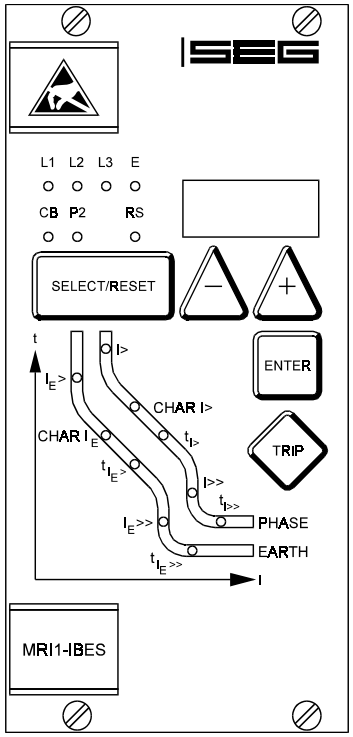
MRI1-IBES - Time overcurrent relay with circuit breaker failure protection and two parameter sets



Contents

This technical manual is valid for software version D34-1.00 and D84-1.00 for Modbus Protocol onwards.

Important:
For additional common data of all *MR*-relays please refer to manual "*MR* - Digital Multifunctional relays".

1 Introduction and application

The *MRI1* 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 *MRI1* which are implemented in only one device are summarized as follows:
- Independent (Definite) time overcurrent relay.
- Inverse time overcurrent relay with selectable characteristics.
- Two-element (low and high set) earth fault protection with definite or inverse time characteristics.

Furthermore, the relay *MRI1* can be employed as a back-up protection for distance and differential protective relays.

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

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
- Selectable protective functions between:
  definite time overcurrent relay and
  inverse time overcurrent relay
- Selectable inverse time characteristics according to BS 142 and IEC 255-4:
  Normal Inverse
  Very Inverse
  Extremely Inverse
- Reset setting for inverse time characteristics selectable
- High set overcurrent unit with instantaneous or definite time function.
- Two-element (low and high set) overcurrent relay for both phase and earth faults.
- Numerical display of setting values, actual measured values and their active, reactive components, memorized fault data, etc.
- Storing of trip values and times, memorized data of 8 fault occurrences
- Switching over between 2 parameter sets via binary input
- C.B. failure protection
- Withdrawable modules with automatic short circuit of C.T. inputs when modules are withdrawn.
- Blocking e.g. of protection functions (e.g. for selective fault detection through minor overcurrent protection units after unsuccessful AR).
- Free assignment of output relays
- Relay assignment and blocking function separately adjustable for both parameter sets
- 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)

3 Design

3.1 Connections

Phase and earth current measuring:

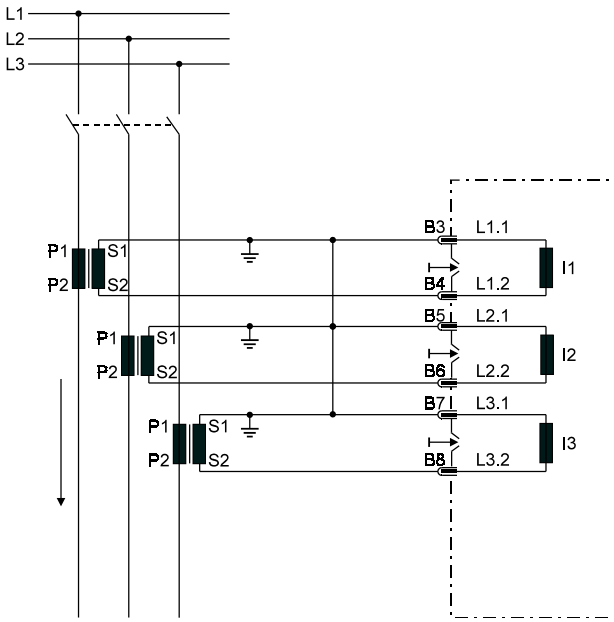


Figure 3.1: Measuring of the phase currents for over-current- and short-circuit protection (I>,I>>)

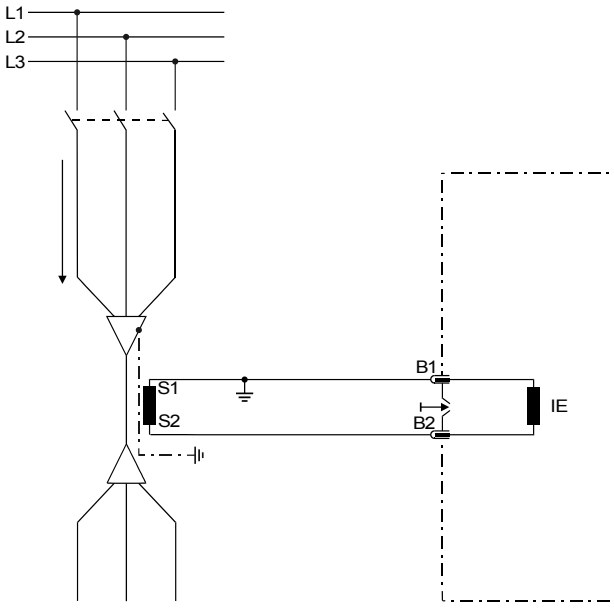


Figure 3.2: Earth-fault measuring by means of ring-core C.T. (I_E)

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

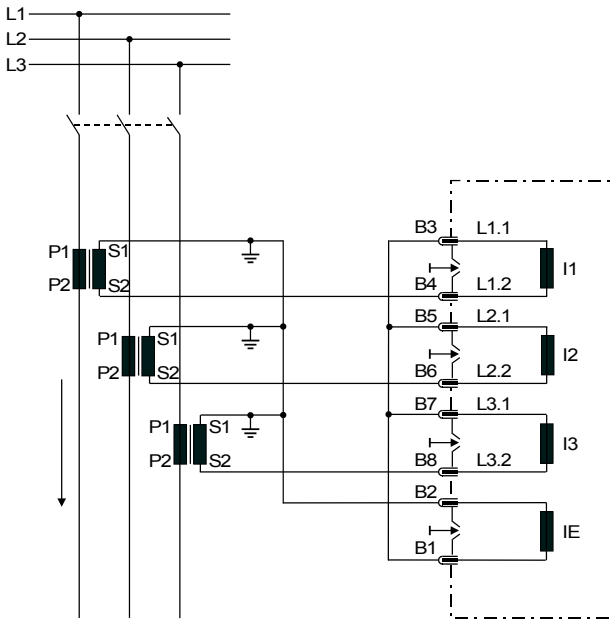


Figure 3.3: Phase current measuring and earth-current detection by means of Holmgreen-circuit.

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.

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), each via separate input transformers.

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

3.1.2 Output relays of *MRI1-IBES* relays

Two relays are equipped with two change-over contacts and three relays with each one change-over contact for alarm. 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
- 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 5.3.18 and 5.3.1)

3.1.4 External reset input

Please refer to chapter 5.6 and chapter 5.3.1

3.2 Relay output contacts

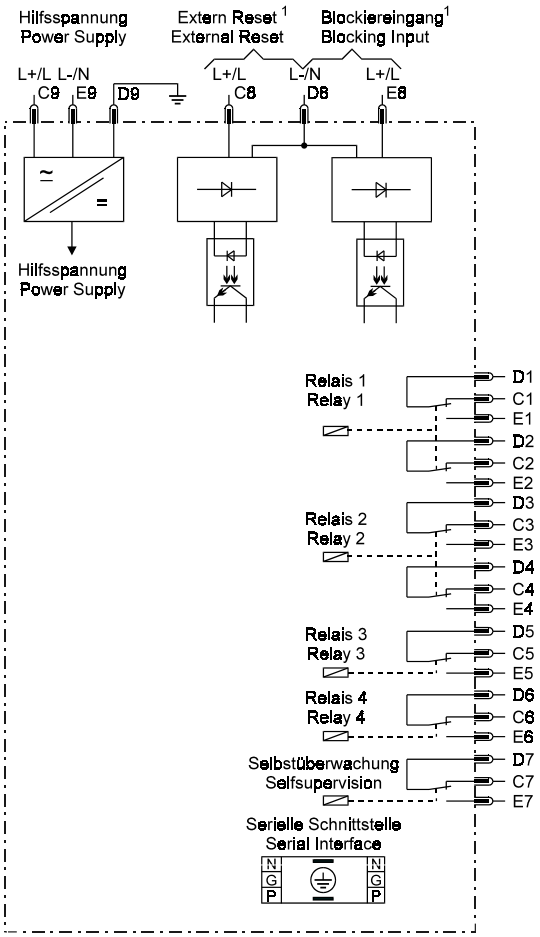


Figure 3.4

[1] alternatively parameter switch

To prevent that the C.B. trip coil circuit is interrupted by the *MRI1* first, i.e. before interruption by the C.B. auxiliary contact, a dwell time is fixed.
This setting ensures that the *MRI1* remains latched for 200 ms after the fault current is interrupted.

3.2.1 Parameter settings

Relay type MRI1-	IBS	IBES	BES
Parameter switch	X	X	X
I>	X	X	
CHAR I>	X	X	
$t_{I>}$	X	X	
0s /60s[1)]	X	X	
I>>	X	X	
$t_{I>>}$	X	X	
$I_{E>}$		X	X
WARN/TRIP		X	X
CHAR I_E		X	X
$t_{IE>}$		X	X
0s / 60s[2)]		X	X
$I_{E>>}$		X	X
$t_{IE>>}$		X	X
t_{CBFP}	X	X	X
50/60 Hz	X	X	X
LED Flash	X	X	X
RS485 / Slave	X	X	X
Baud Rate [3)]	X	X	X
Parity Check [3)]	X	X	X
Blocking mode	X	X	X
Assignment of the output relays	X	X	X

Table 3.1: Parameters of the different relay types

[1)] RESET-Setting for inverse time tripping characteristics in phase current path
[2)] RESET-Setting for inverse time tripping characteristics in earth current path
[3)] only Modbus Protocol

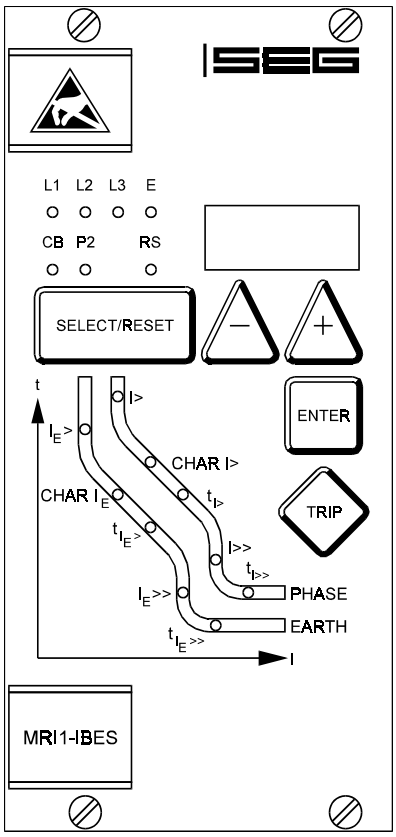


*Figure 3.5: Front panel **MRI1-IBES***

3.3 LEDs

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

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.

LED *CB* indicates trip of the C.B. failure protection.
LED P2 indicates that parameter set 2 is activated.

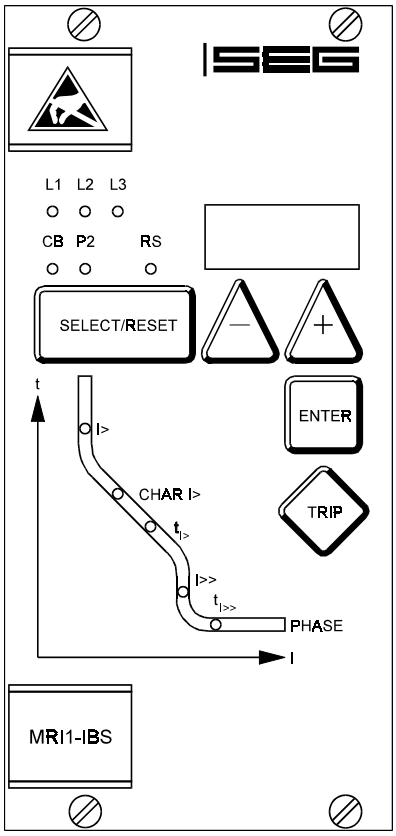


*Figure 3.6: Front panel **MRI1-IBS***

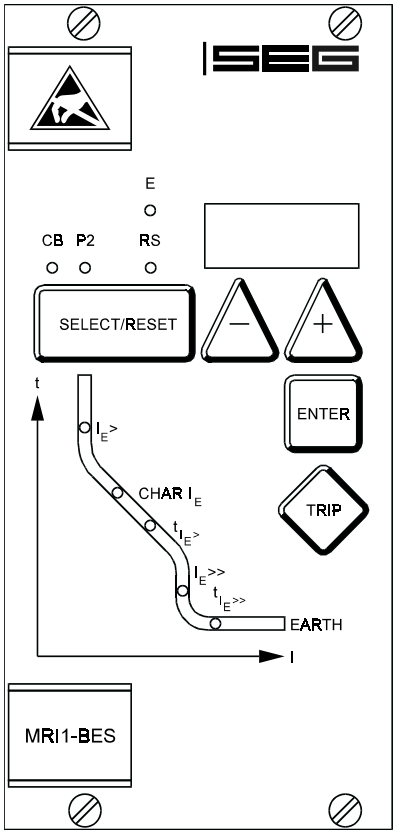


*Figure 3.7: Front panel **MRI1-BES***

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 periode).

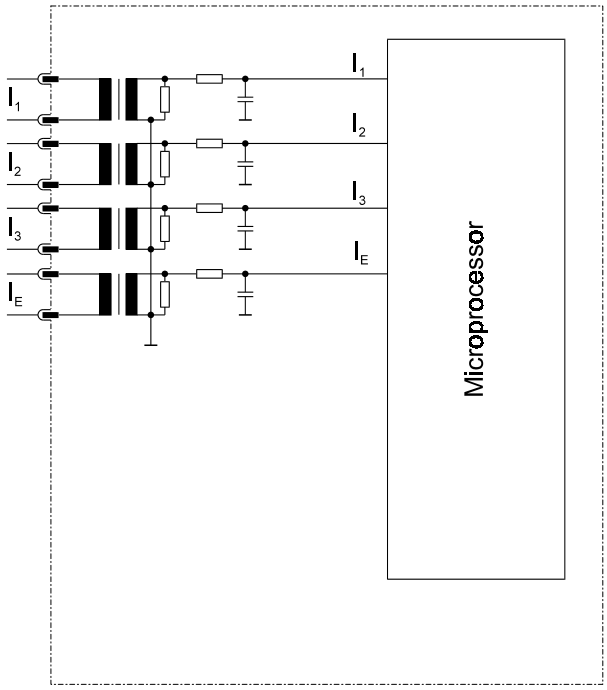


Figure 4.1: Block diagram

4.2 Digital circuits

The essential part of the *MRI1* 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 "watchdog" timer. In case of a failure the watchdog timer resets 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 4.2 the *MRI1* 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.

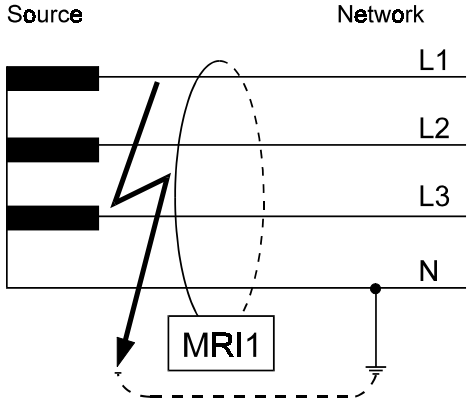


Figure 4.2: Generator stator earth fault protection

4.3.2 System earth fault protection

With the generator neutral point earthed as shown in figure 4.3, the *MRI1* picks up only at earth faults in the power system connected to the generator. It does not pick up at earth faults on the generator terminals or in generator stator.

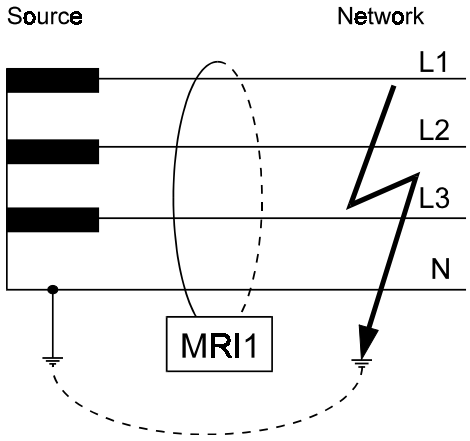


Figure 4.3: System earth fault protection

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 *MRI1*, namely <0,2 VA, has a positive effect on the selection of current transformers. It implies that, if an electromechanical relay is replaced by *MRI1*, a high accuracy limit factor is automatically obtained by using the same current transformer.

5 Operation and setting

5.1 Display

Function	Display shows	Pressed push button	Corresponding LED
Normal operation	SEG		
Measured operating values	Actual measured values	<SELECT/RESET> one time for each value	L1, L2, L3, E
Measuring range overflow	max.	<SELECT/RESET>	L1, L2, L3, E
Parameter switch	SET1, SET2, BLOC, RST	<SELECT/RESET> <+><->	P2
Setting values: phase (I>; CHAR I>; $t_{I>}$; I>>; $t_{I>>}$) 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 >; CHAR I>; $t_{I>}$; I>>; $t_{I>>}$; $I_{E>}$;CHAR I_E; $t_{IE>}$;$I_{E>>}$; $t_{IE>>}$;
Reset setting (only available at inverse time characteristics)	0s / 60s	<SELECT/RESET> <+><->	I>; CHAR I>; $t_{I>}$ $I_{E>}$; CHAR $I_{E>}$; $t_{IE>}$
Warning or Trip at earth fault measuring	trip warn	<SELECT/RESET> <+><->	$I_{E>}$
Time delay of circuit breaker failure protection	Trip delay	<SELECT/RESET> <+><->	CB
System reset	SEG	<SELECT/RESET> for about 3 s	
Nominal frequency	f=50 / f=60	<SELECT/RESET><+><->	
Switch-over LED-Flash No LED-Flash	FLSH NOFL	<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 [1)]	1200-9600	<SELECT/RESET> <+><->	RS
Parity Check [1)] System reset	even, odd, no	<SELECT/RESET> <+><-><SELECT/RESET> for about 3 s	RS
Recorded fault data	Tripping currents and other fault data	<SELECT/RESET> one time for each phase	L1, L2, L3, E I>, I>>, $I_{E>}$, $I_{E>>}$
Enquiry fault memory	FLT1; FLT2....	<+><->	L1, L2, L3, E I>, I>>, I_E>, I_E>> t_I>, t_{IE}>
Delete fault memory	wait	<->; <SELECT/RESET> s	
Save parameter?	SAV?	<ENTER>	
Save parameter!	SAV!	<ENTER> for about 3 s	
Software version	First part (e.g. D01-) Sec. 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	<SELECT/RESET> <+><-><ENTER>	
Circuit breaker failure protection	CBFP	After fault tripping	

[1)] *only Modbus Protocol*

Table 5.1: Possible indication messages on the display

5.2 Fault memory

When the relay is energized or trips, all fault data and times are stored in a non-volatile memory manner. The *MRI1-IBES* is provided with a fault value recorder for max. 8 fault occurrences. In the event of additional trippings 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).
- 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 always 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 occured 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]	C.B.
Expired tripping time of I> in % of $t_{I>}$ [2]	I>
Expired tripping time of $I_{E>}$ in % of $t_{IE>}$ [2]	$I_{E>}$

[1] C.B. switching time:
Time between energizing of the trip output relay and switching of the C.B. (current = 0).

[2] Expired tripping time:
Time between pickup and release of the low set element. This value is only displayed for I> and $I_{E>}$.

5.3 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. By pressing the <SELECT/RESET> push button firstly all parameters of parameter set 1 are set and thereafter those of parameter set 2. The setting procedure is indicated by LED P2.

5.3.1 Parameter switch

By means of a change over facility, two different parameter sets can be activated. This change over procedure can be realized either by software or by using the external inputs RESET or BLOCKING:

Software-parameter	Blocking input used as	RESET input used as
SET1	Blocking input	RESET input
SET2	Blocking input	RESET input
BLOC	Parameter set change over	RESET input
RST	Blocking input	Parameter set change over

When settings SET1 or SET2 are used, the parameter set is activated by software. Terminals C8/D8 and D8/E8 are then available as external inputs for RESET or BLOCKING:

The setting BLOCK results in the use of BLOCKING input (D8, E8) for the change over procedure and the setting RST is for the use of RESET input (C8, D8) for this procedure. When aux. voltage is applied to one of these two external inputs, then it is changed over from parameter set 1 to parameter set 2. When parameter set 2 is active, LED P2 lights up. If the aux. voltage is disconnected, it is automatically changed to parameter set 1 again.

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 5.3.21).

5.3.2 Pickup current for phase overcurrent element (I>)

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 (Is) = displayed value x nominal current (I_N)e.g. displayed value = 1.25 then, Is = 1.25 x IN.

5.3.3 Time current characteristics for phase overcurrent element (CHAR I>)

By setting this parameter, one of the following 4 messages appears on the display:

DEFT - Definite Time
NINV - Normal Inverse
VINV - Very Inverse
EINV - Extremely Inverse

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

5.3.4 Trip delay or time multiplier for phase overcurrent element ($t_{I>}$)

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:

After the characteristic setting, the setting process turns to the time delay setting automatically. The LED tI> is going to flash yellow to remind the operator to change the time delay setting accordingly. After pressing the <SELECT>-push button, the present time delay setting value is shown on the display. The new setting value can then be changed by using <+> <-> -push buttons.

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>. The most sensitive time setting value means the fastest tripping for the selected relay characteristic. 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.

5.3.5 Reset setting for inverse time 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 tRST is set at 60s, the tripping time is only reset after 60s 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.

5.3.6 Current setting for high set element (I>>)

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

This means: I>> = 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 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 5.3.21).

5.3.7 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.

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

(Similar to chapter 5.3.2)

5.3.9 WARN/TRIP changeover

A detected earth fault can be parameterized as follows:
a) "warn" only the alarm relay trips
b) "TRIP" the trip relay trips and tripping values are stored.

5.3.10 Time current characteristics for earth fault element

(Similar to chapter 5.3.3)

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

(Similar to chapter 5.3.4)

5.3.12 Reset mode for inverse time tripping in earth current path

(Similar to chapter 5.3.5)

5.3.13 Current setting for high set element of earth fault supervision (I_E>>)

(Similar to chapter 5.3.6)

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

(Similar to chapter 5.3.7)

5.3.15 Circuit breaker failure protection t_{CBFP}

The C.B. failure protection is based on supervision of the phase currents during tripping of the relay. This protective function becomes only active after tripping and it is then checked whether all phase currents have dropped to <1% x I_N within time t_{CBFP} (Circuit Breaker Failure Protection). Should not all phase currents have dropped within this time (t_{CBFP} can be adjusted from 0.1 - 2.0 s), the protection device diagnoses C.B. failure and the respective assigned relay is activated. The C.B. failure protection function is deactivated again, when all phase currents drop to <1% x I_N within $t_{CBFP.}$

5.3.16 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>.

5.3.17 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 occured 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.

5.3.18 Adjustment of the slave address

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

5.3.19 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>.

5.3.20 Setting of parity (applies for Modbus Protocol only)

The following three parity settings are possible:

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

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

5.3.21 Blocking the protection functions and assignment of the output relays

Blocking the protection functions:
The blocking function of the *MRI1* can be set according to requirement. By applying the aux. voltage to D8/E8, the functions chosen by the user are blocked (Please refer to chapter 5.3.1). Setting of the parameter should be done as follows:

- When pressing push buttons <ENTER> and <TRIP> at the same time, message "BLOC" is displayed (i.e. the respective function is blocked) or "NO_B" (i.e. the respective function is not blocked). The LED allocated to the first protection function I> lights red.
- By pressing push buttons <+> <-> the value displayed can be changed.
- The changed value is stored by pressing <ENTER> and entering the password.
- By pressing the <SELECT/RESET> push button, any further protection function which can be blocked is displayed.
- After setting of the last blocking function of parameter set 1, it will be switched over to the blocking functions of parameter set 2.
- Thereafter the blocking menu is left by pressing <SELECT/RESET> again and it will be switched to the assignment mode.

Function		Display	LED/Colour (P2)
I>	Overcurrent (Low set)	NO_B	I> yellow
I>>	Overcurrent (High set)	BLOC	I>> yellow
$I_{E>}$	Earth current 1. element	NO_B	$I_{E>}$ yellow
$I_{E>>}$	Earth current 2. element	NO_B	$I_{E>>}$ yellow
CBFP	Circuit breaker failure protec.	NO_B	CB yellow

Table 5.2: Default settings of blocking functions

Assignment of the output relays:
Unit *MRI1* has five output relays. The fifth output relay, 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. The assignment can be set separately for each parameter set. This 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-coloured and light up **green** when the output relays are assigned as **alarm relays** and **red** 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> of parameter set 1 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 $t_{I>}$ 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. After that, the same procedure for parameter set 2 takes place. 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 telefax transmission and can be used for your own reference as well as for telephone queries.

Relay function		Output relays								Display-indication	Lighted LED (P2)
		1		2		3		4			
Parameter set		Set 1	Set 2	Set1	Set 2	Set 1	Set 2	Set 1	Set 2	Set 1/set 2	Set 1/set 2
I>	alarm					X	X			_ _ 3 _	I>: green
	tripping	X	X							1 _ _ _	$t_{I>}$: red
I>>	alarm					X	X			_ _ 3 _	I>>: green
	tripping	X	X							1 _ _ _	$t_{I>>}$: red
$I_{E>}$	alarm					X	X			_ _ 3 _	$I_{E>}$: green
	tripping			X	X					_ 2 _ _	$t_{IE>}$: red
$I_{E>>}$	alarm					X	X			_ _ 3 _	$I_{E>>}$: green
	tripping			X	X					_ 2 _ _	$t_{IE>>}$: red
CBFP	tripping							X	X	_ _ _ 4	CB

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

5.4 Setting value calculation

5.4.1 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.

5.4.2 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: 400/5A
Maximum expected load current: 300A
Overload coefficient: 1.2 (assumed)
Starting current setting:
Is = (300/400) x 1.2 = 0.9 x 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.

5.5 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)
- Apparent current in phase 2 (LED L2 green)
- Apparent current in phase 3 (LED L3 green)
- Apparent earth current (LED E green)

The indicated current measuring values refer to nominal current.

5.6 Reset

Unit *MRI1* 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 (please refer to chapter 3.1.5)

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.

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 "ISEG" 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 and LEDs should then be activated and the self supervision alarm relay (watchdog) be deactivated one after another with a time interval of
3 second. Thereafter, reset 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
- Test leads and tools

6.4.2 Example of test circuit

For testing *MRI1-IBES* 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 *MRI1-IBES* relay under test.

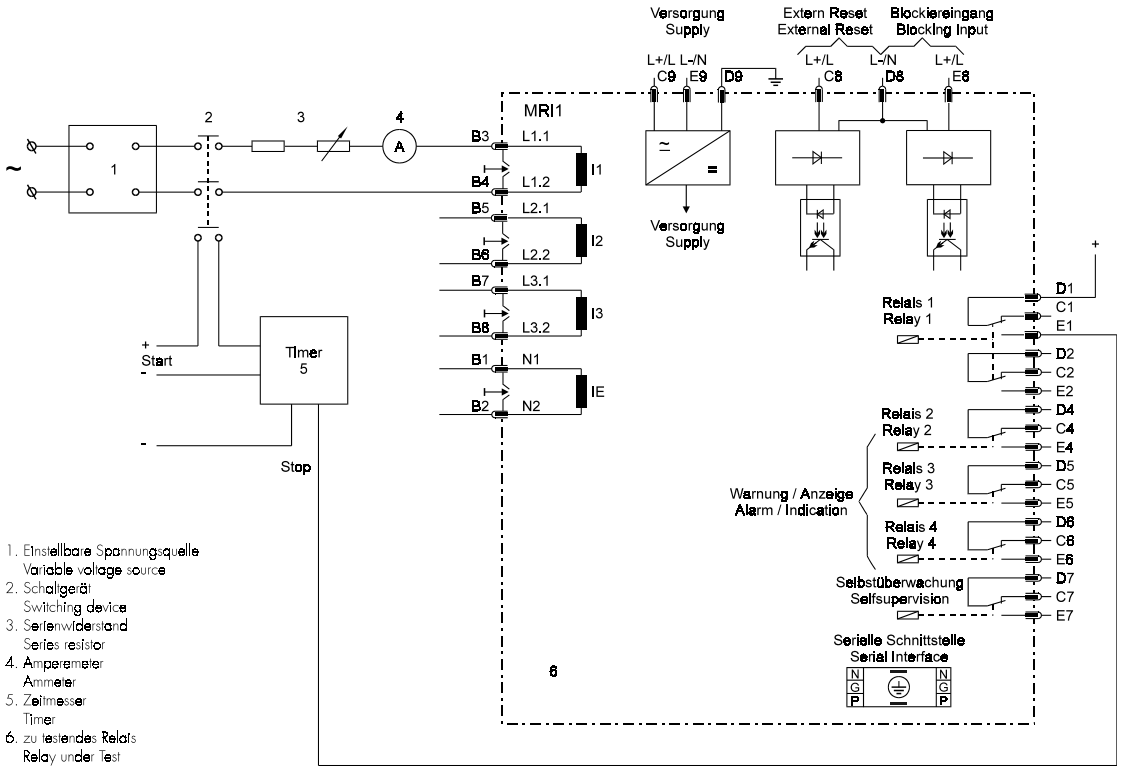


Figure 6.1: Test circuit

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 In = 5A, for example, a secondary current injection of 1A should be indicated on the display with about 0.2 (0.2 x In). 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 % In. By using an RMS-metering instrument, a greater deviation may be observed if the test current contains harmonics. Because the *MRI1* 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 % In.
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 ±3% of measuring value).

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 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>>. Inject the current instantaneously and check that the alarm output relay I>> (contact terminals D5/E5) 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 form 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 x 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 Checking the external blocking and reset functions

The external blocking input inhibits e. g. the function of the high set element of the phase current. To test the blocking function apply auxiliary supply voltage to the external blocking input of the relay (terminals E8/D8). The time delay $t_{I>}$ 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 and alarm for the high 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.

6.4.8 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 (see section 6.4.5) 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 *MRI1* 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 *MRI1* 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.

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 *MRI1*, this interval can be substantially longer. This is because:

- the *MRI1* 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 *MRI1* relays enable supervision the relay functions during service.
- the combined TRIP test function of the *MRI1* 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	1A or 5A
	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 %
Returning time :	30 ms
Time lag error class index E:	± 10 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

7.3.1 Time overcurrent protection

	Setting range	Step	Tolerance
I>	0.2...4.0 x I_N	0.01, 0.02, 0.05; 0.1 x I_N	±3 % from set value or min. ±1 % In
tI>	0.03 - 260 s (definite time)	0.01; 0.02; 0.1; 0.2; 0.5; 1.0; 2.0; 5.0 10.0; 20.0 s	±3 % or ±10 ms
	0.05 - 10 (inverse time)	0.01; 0.02; 0.05; 0.1; 0.2	±5 % for NINV and VINV ±7.5 % for NINVand EINV
I>>	0,5...40 x IN	0.02; 0.05; 0.1; 0.2; 0.5; 1.0 x I_N	±3 % from set value or min. ±1 % In
$t_{I>>}$	0.03...10 s	0.01 s; 0.02 s; 0.05 s, 0.1, 0.2 s	±3 % or ±10 ms

7.3.2 Earth fault protection

	Setting range	Step	Tolerance
I_E>	0.01...2.0 x I_N	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_{IE}>	0.04 - 260 s (definite time)	0.01; 0.02; 0.05; 0.1; 0.2; 0.5; 1.0; 2.0; 5.0 s	±3 % or ±15 ms
	0.06 - 10 (inverse time)	0.01; 0.02	±5 % for NINV and VINV ±7.5 % for NINVand EINV
I_E>>	0.01...15 x I_N	0.01; 0.02; 0.05; 0.1; 0.2; 0.5 x I_N	±5 % from set value or min. ±1 % In
I_{IE}>>	0.04...10 s	0.01 s; 0.02 s; 0.05 s, 0.1, 0.2 s	±3 % or ±15 ms

7.3.3 Inverse time overcurrent protection relay

According to IEC 255-4 or BS 142

Normal Inverse $$t = \frac{0{,}14}{\left(\frac{I}{Is}\right)^{0{,}02} - 1} t_I > [s]$$

Very Inverse $$t = \frac{13{,}5}{\left(\frac{I}{Is}\right) - 1} t_I > [s]$$

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

Where: t = tripping time
$t_{I>}$ = time multiplier
I = fault current
Is = Starting current

7.3.4 Circuit breaker failure protection

	Setting range	Step	Tolerance
t_{CBFP}	0.1…2 s (EXIT)	0.01 s; 0.02 s; 0.05 s	±3 % or 15 ms

7.3.5 Interface parameter

Function	Parameter	Modbus-Protocol	RS485 Open Data Protocol
RS	Slave-Address	1 - 32	1 - 32
RS	Baud-Rate*	1200, 2400, 4800, 9600	9600 (fixed)
RS	Parity*	even, odd, no	„even Parity" (fixed)

* only Modbus Protocol

7.4 Inverse time characteristics

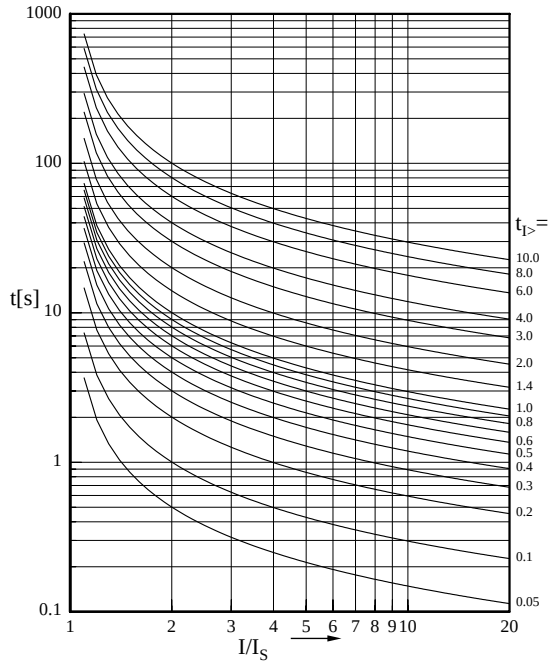


Figure 7.1: Normal Inverse

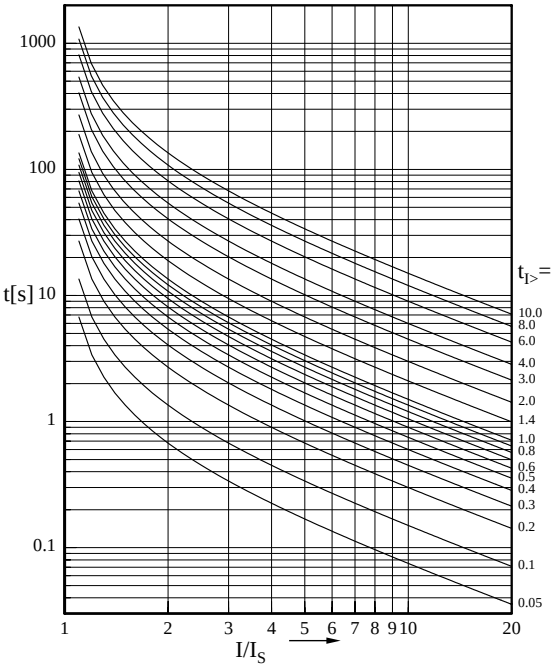


Figure 7.3: Very Inverse

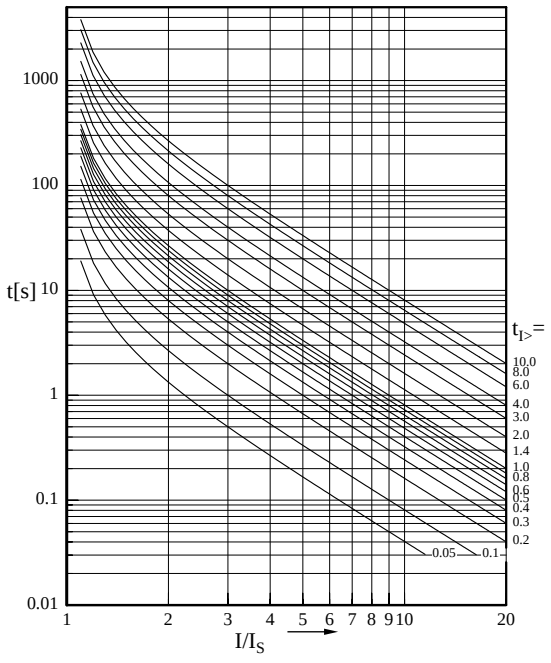


Figure 7.2: Extremely Inverse

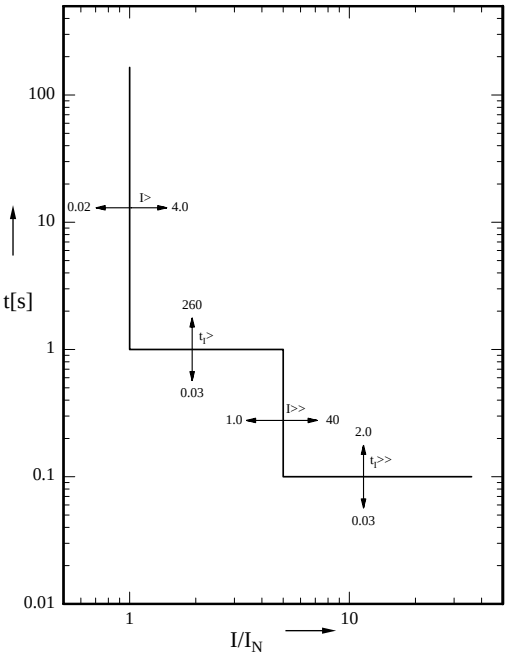


Figure 7.4 Definite time overcurrent relay

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 relay	***MRI1-***	**I**		**B**				**S**	
3-phase measuring I>, I>>									
Rated current	1 A		**1**						
	5 A		**5**						
Earth current measuring					**E**				
Rated current in earth path	1 A					**1**			
	5 A					**5**			
Housing (12TE)	19"-rack						**A**		
	Flush mounting						**D**		
Relay assignment separately adjustable for both para. sets									
RS485	Alternatively with Modbus Proto-col								**-M**

Setting list *MRI1-IBES*

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: _____

Relay type MRI1-	IBS	IBES	BES	Default settings Set 1/Set 2	Possibility of switching over between two parameter sets	Actual settings Set 1	Actual settings Set 2
Parameter set	X	X	X	SET1	NO		
I>	X	X		0.2 x I_N	YES		
CHAR I>	X	X		DEFT	YES		
$t_{I>}$	X	X		0.03 s	YES		
0s /60s[1)]	X	X		0 s	YES		
I>>	X	X		1.0 x I_N	YES		
$t_{I>>}$	X	X		0.03 s	YES		
$I_{E>}$		X	X	0.01 x I_N	YES		
WARN/TRIP		X	X	TRIP	YES		
CHAR I_E		X	X	DEFT	YES		
$t_{IE>}$		X	X	0.04 s	YES		
0s /60s[1)]		X	X	0 s	YES		
$I_{E>>}$		X	X	0.01 x I_N	YES		
$t_{IE>>}$		X	X	0.04 s	YES		
t_{CBFP}	X	X	X	0.2 s	YES		
50/60 Hz	X	X	X	50 Hz	NO		
FLASH/NOFL	X	X	X	FLASH	NO		
RS485 / Slave	X	X	X	1	NO		
Assignment of blocking functions	X	X	X	see below	YES		
Assignment of relays	X	X	X	see below	YES		

Table 8.1: Setting of the protective funtions

[1)] RESET-mode for phase currents at inverse time characteristic
[2)] RESET-mode for earth currents at inverse time characteristic

Setting of code jumpers

Code jumper	J1		J2		J3	
	Default setting	Actual setting	Default setting	Actual setting	Default setting	Actual setting
Plugged			not used			
Not plugged	X				X	

Assignment of the output relays:

Function	Relay 1				Relay 2				Relay 3				Relay 4			
	Default setting		Actual setting		Default setting		Actual setting		Default setting		Actual setting		Default setting		Actual setting	
Parameter set	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
I> alarm									X	X						
I> tripping	X	X														
I>> alarm									X	X						
I>> tripping	X	X														
IE> alarm									X	X						
IE> tripping					X	X										
IE>> alarm									X	X						
IE>> tripping					X	X										
CBFP tripping													X	X		

Assignment of the blocking function:

	Default setting				Actual setting			
Function	Blocking		No blocking		Blocking		No blocking	
Parameter set	Set 1	Set 2	Set 1	Set 2	Set 1	Set 2	Set 1	Set 2
I>			X	X				
I>>	X	X						
$I_{E>}$			X	X				
$I_{E>>}$			X	X				
CBFP			X	X				

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