WOODWARD

MRD1-T – Transformer Differential Protection System

Manual MRD1-T (Revision A)

Contents

1. Preface and Application

MRD1 is a modular system to protect electrical apparatus and it is used for complex applications in the energy distribution, primarily designed for transformer, generator, motor or line protection; additionally it can be integrated into automation systems. Due to its modular design, the MRD1 can be adapted to individual applications without problem, with all implemented functions remaining combined in one single device. All vacant rack places in the basic unit can optionally be used for modules according to requirements. The modules provide the necessary measuring inputs e.g. for two-winding or three-winding transformers as well as increase the number of output relays or digital inputs according to requirements.

The high-performance digital technique of data calculation makes complex mathematical algorithm for measured value processing possible for the MRD1 as well as utilization of the trip decision resulting from the individual protection functions. The MRD1 software is also of modular structure. Each protection function is allocated to a special program segment and so it is possible to subsequently add further functions.

All essential parameters, measuring data or values calculated from these can be called off and are shown locally on the display. The MRD1 is equipped with an Event Recorder which stores all system signals, protection activations or trip events. When trips occur a Fault Recorder records all fault data measured at the instant of the trip. Data of both recorders is provided with a time stamp and can be called off either at the display or interface.

At present the following versions of MRD1 are available :

- MRD1-T2 Transformer differential protection for two-winding transformers
- MRD1-T3 Transformer differential protection for three-winding transformers
- MRD1-G Differential protection for generators and motors

2. Features and Benefits

Basic Unit

Standard equipment

- Modular design with automatic short circuiting CT-inputs
- Signal and data processing in a separate digital signal processor (32 samples per cycle)
- Digital filtering of measured quantities
- Three possibilities of parameter setting and data calling:
  1) keyboard and display
  2) RS232 interface at the front (lap top)
  3) RS485 interface for integration into control systems at the rear
- Safety interlocking preventing parameter setting via different ways at the same time
- extensive internal plausibility check of modified parameters
- Event Recorder for recording system messages
- Fault Recorder for recording measured fault data
- Four programmable independent parameter sets
- Non-volatile memory for parameter sets, events and fault data
- Indication of measured operational values and resulting quantities
- Wide-ranging automatic self-tests
- Small relay size
- Indication of relay functions optically or via separate self supervision relay
- Three possibilities for relay resetting
- All data interfaces galvanical isolated
- Rated frequency selectable: 50 Hz/60 Hz
- Parameter setting protected by pass-word

Functions which can be programmed by the user :

- Protection and system parameters
- Latched position or minimal signal duration for each of the output re-lays

Transformer differential protection

- Stabilization against transformer inrush and CT saturation
- Adaption to vector groups and trans-formation ratio by means of software without additional interposing CTs
- Compensation of tap changer position
- Waveform recognition technique with a special Fourier algorithm (inrush element)
- No complete blocking of differential element but only reduced sensitivity
- Independent High Set differential element for heavy faults

3. Design

This chapter informs briefly about operation elements and indication elements of the MRD1. Name and position of the individual modules are also described. In chapter 5 operating of the relay and type specific functions are explained in more detail.

Note
Front view and rear view illustrations of the MRD1 as well as connection diagrams can be found at the end of the manual.

3.1 Relay front

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Display in Home Position

3.1.1 Display

The MRD1 is provided with a 16-digit, double-line
liquid crystal display (LCD), which is of alphanumerical design for an easy dialog. The figure above shows the basic status of the display. Dependent on the mode selected, the following data can be shown on the display:

- Date / Time / Relay type (Home Position)
- Measured operational data
- Measured fault data
- System parameters and protection parameters
- System signals and fault signals

3.1.2 LED's

Additionally to the display there are max. 15 LED's at the front, indicating each of the operational status in the MRD1. All LED's are two-colored (red/green) and arranged in two groups:

System and relay status indications
The 15 system indications are arranged underneath the alphanumerical display. They are allocated to a certain function and show:

- Operational voltage available
- Trip
- OFFLINE TEST mode active
- Edit mode active
- Displayed parameter is modified but has not been stored yet
- Switch status of the 5 (optionally 10) output relays
- Display of the relay function (self-test)

3.1.3 Push-buttons

All necessary MRD1 adjustments and inquiries can be carried out from the front of the relay by pressing the respective push-button (9 in total). Individual function of these push-buttons is explained in chapter Operating.

3.1.4 Parameter interface RS232

At the left of the relay front there is a 9-pole, D-SUB plug-and-socket connector for temporary laptop connection. At this connection a serial interface RS-232 is provided. A standard IBM™ compatible PC or portable notebook can be connected to this PC interface. To connected MRD1 and PC a 1:1 modem-cable with 9-pole plug-and-socket is used. By using Woodward software HTLSOFT 3, which is Windows™ compatible, MRD1 parameters can comfortably be set. Additionally all measured operational and fault data can be read out of the relay integrated non-volatile memories.

3.2 Master module

The master module is fitted right in the middle and contains compo entries for data processing, the main processor and the following connections:

3.2.1 Interface RS485

Interface RS485 at the rear of the relay is a permanent connection between the MRD1 and the host computer. This interface operates at a constant transmission ratio of 9600 Baud if Woodward interface recorder "RS485pro" is used. Via RS485 interface all measured operational and fault data as well as operational status indications can be read out - identical to RS232 inter-face. Remote setting of parameters is also possible from the control station. The 8-pole plug-and-socket connector contains all necessary connections for this interface.

3.3 Basic module and additional module

Plug-in units 1 and 3 are intended for individual applications and at our works they are equipped with modules for measuring value detection in compliance with the relay function. (see folding page)

Important Note

The MRD1 must only be dismantled or opened by authorized staff.
Removal of live modules entail severe danger for the person(s) involved because there can no sufficient protection against accidental contact be guaranteed as soon as the relay has been opened. Furthermore there is the risk of the modules being damaged by electrostatic discharge (ESD/EGB) when handled improperly.

Identical modules must not be exchanged between different MRD1 basic versions.

Calibration of every MRD1 is done at work with regard to the specific features of that relay. A random change of modules would lead to unreliable operation of the relay because the compatibility of the relay components among each other would be in disorder and could not be guaranteed any longer.
Any modification jobs on the MRD1, for instance, exchange of modules or software additions, are only allowed to be done at our works or by authorized agents.

3.3.1 Basic module NT 6I (MRD1-G, MRD1-T2 and MRD1-T3)

For generator, motor and transformer differential protection, module NT-61 is plugged into the first space.

Measuring inputs
The module consists of six current measuring channels which are used for measuring the three conductor currents of each winding. The CT start point must be formed outside the relay since all 12 CT connections are wired separately on terminals. In addition to other measuring or protection devices the MRD1 can be looped in to existing CT lines, assumed the CT being able to carry the total burden.

Apart from further connections for voltage supply of the relay, the module is also provided with a digital input for remote resetting as well as connection facilities for the five output relays. Four of these are free to be used acc. to requirement, the fifth is assigned for Selftest Relay.

Input RESET
If a voltage is applied to terminals of the RESET input (C8-D8), the MRD1 is reset to its basic status. By this procedure possible alarms and trip signals are cancelled.
The voltage applied for resetting must be within the permissible high-range (see technical data), although it must not necessarily be identical with the latter.

The input is galvanical isolated from the relay electronics. Contact D8 is also the neutral or minus for the blocking input.

Blocking Input
If a voltage is applied to the terminals of the blocking input (D8-E8), all protection functions assigned to the output relays are blocked. Terminal D8 is also the neutral or minus for the reset input.

Alarm relays
Potential free outputs of the five alarm relays provided are at terminals C, D and E, series 1 to 7. Exact allocation can be taken from the connection diagram. Relay 5 is permanently assigned to Selftest Relay. Function allocation of the remaining relays is free and can be defined when programming (see chapter 5). Two of these four relays are provided with two changeover contacts each and the other two with one changeover contact each.

3.3.2 Additional module 3I (MRD1 T3)

Module 3I is used for three-winding transformers and applied to rack place 3. By this module the number of measuring channels is increased by three currents for the tertiary winding of the transformer and it provides also five additional output relays.

4. Working principle

In this chapter the individual functions and working principle of the MRD1 are described.

4.1 Protective functions

4.1.1 Transformer differential protection

	Term	Explanation
ID	Bias current	This is the current flowing from the input side into the object to be protected, having a respective output current available at the output side. This current is representing the normal load and the load at external faults.
Id	Differential current	The current resulting from the difference of incoming and outgoing conductor currents when these were converted at one transformer side. In other words: The differential current is the component at the transformer input current which has no related output current.
Ia	Pickup current	If the differential current exceeds the pickup current, the relay trips.
	Fault current due to operational conditions	This kind of fault current is the component of the measured differential current which, however, is not caused by a fault of the object to be protected but is of systematic nature
	Stabilisation	Under this heading all measures are compiled which stabilise the differential relay against nuisance tripping. Stabilising always means the pickup current is raised and by this the differential relay becomes more insensitive, but is never completely blocked.
I_S	Stabilising current	This current develops from the bias current and represents the extent of stabilising measures necessary as result of the fundamental analysis. Parameters of the stabilising characteristic can be set.
m	Harmonic stabilising factor	This factor, derived from the analysis of the harmonic frequency, is apart from I_S the second stabilising factor and in case of rush and saturation by following a special characteristic makes the differential relay stable against tripping errors.
d[Id]	Characteristic Offset	The characteristic curve is raised up by the value d[Id] immediately after a harmonic stabilisation factor “m” is measured to be greater than zero. This is to give a basic stabilisation after detection of inrush or ct-saturation during external fault by means of harmonic measurement.
	Pickup characteristic	In this characteristic both stabilising quantities (stabilising current and stabilising factor) are brought together and from this the pickup current is defined necessary for the operational condition of the object to be protected at that instant.

Table 4.1: Term definitions

General idealized view
Differential protection is a strict selective object protection and is based on the current measuring principle at the input and output side of the object being protected. Dependent on the earthing method used, the neutral can also be included in measuring and balance.
The area between input and output CTs of the object is classed as protection zone supervised by the MRD1. Included in the protection zone are also CTs and CT connection wire to the relay.

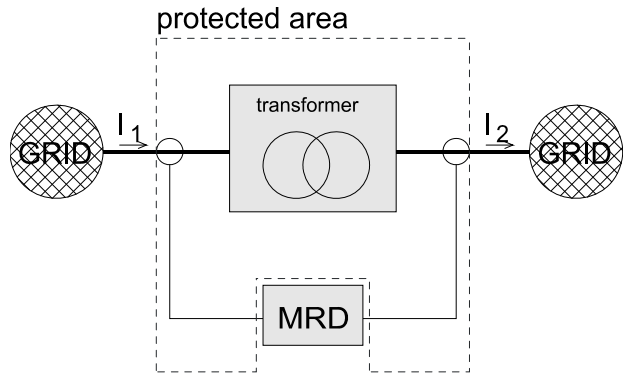


Figure 4.1: Definition of protection zone

The relay checks constantly if the in-coming currents of the input side are met by respective outgoing currents at the output side. If the balance of the conductor currents shows a difference, this may suggest a fault within the protection zone. Especially where transformers are concerned it is necessary that all conductor currents are converted to one reference transformer side according to their transformation voltage ratio and to their vector group so that quantities and phases can be compared.

To distinguish between faults occurring within (internally) or outside (externally) of the protection zone is the main purpose of the differential protection because at internal faults the differential protection relay must trip, but not so at external faults.

Examples:

External fault
During a short circuit occurring at the right grid, the complete short circuit current flows through the transformer. The difference between incoming and outgoing currents of all transformer terminals is small (in ideal cases = zero) I_1-I_2 = 0. The differential protection relay does not trip. (Switching off in such cases probably to be realized by an over current relay).

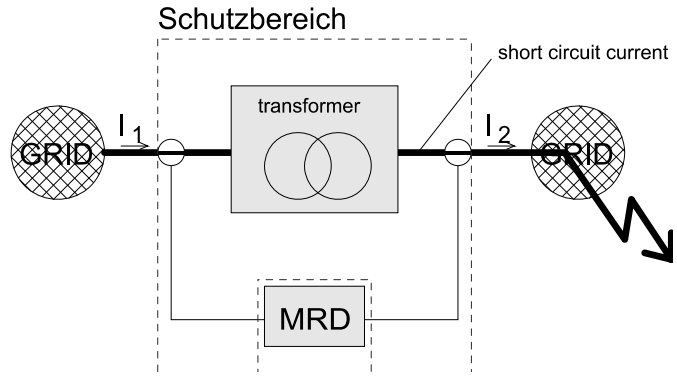


Figure 4.2: External fault

Internal fault
When an internal fault occurs the cur-rent balance is different. Dependent on the kind of fault a deficit in the total of incoming currents can be ob-served. A winding short circuit, for instance, can be fed from both sides, even if with different intensity. But this short circuit does not go through the transformer, it is fed from both grids into the transformer. So there-fore the current balance shows a difference.

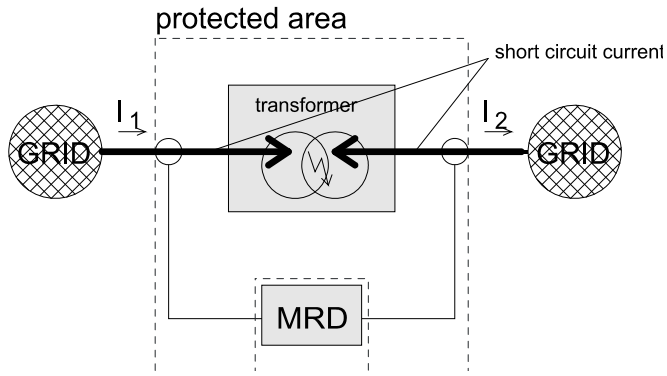


Figure 4.3: Internal fault (example of a short circuit fed from two sides)

Due to the chosen direction of the reference arrow, current I_2 flows here in negative direction.

The differential relays detects a cur-rent difference of I_1-I_2 = Id and trips when Id has exceeded the set threshold.

Stabilizing
At first approximation this idealized view applies to stationary states only. In reality other effects, especially dynamic processes, may cause the established current difference to rise, even if there is no internal fault. In such cases a simple static differential relay would mistakenly trip and to prevent this stabilizing measures have to be taken. Possible sources of measuring errors are systematic and can be duly taken into account. Especial measures for detecting switching actions (inrush), CT saturation or to counteract errors caused by transformer tap changer position switches are here referred to. Stabilizing the MRD1 means always an action to make the relay more insensitive. By the MRD1 two independent stabilizing quantities are calculated from the fundamental oscillation and harmonic analysis (see following paragraphs).

Fundamental analysis
Distortion factors for differential current measuring are:
- Measuring errors of angle and value of the CTs used
- Poor adjustment of rated CT data to rated transformer data
- Effects caused by no-load currents
- Adverse effects caused by tap changer position

By these factors a fault current is caused which mainly depends on the biasing current. This fault current is being measured as a differential current, although a transformer fault must not necessarily have occurred. When the pickup current is set at a very sensitive value, each of these static factors can cause unintended trippings. With increasing bias current the pickup current has to be corrected upwardly. The following pickup characteristic (exact characteristic) gives an de-tailed study of the individual fault factors and the resulting fault current. In fig. 4 the expected fault current versus tripping characteristic is shown.

If a real fault occurs, the measured differential current exceeds the biasing current caused by operational conditions. Therefore the pickup characteristic must exceed the biasing cur-rent characteristic by the required sensitivity value. The exact course can be approximated by a simplified characteristic consisting of two linear sections (I and II). The higher the characteristic begins, the higher the permissible differential current. If the characteristic begins at a very low point this means maximum sensitivity. If the pickup characteristic is below the biasing characteristic, systematic effects can cause unintended trips.

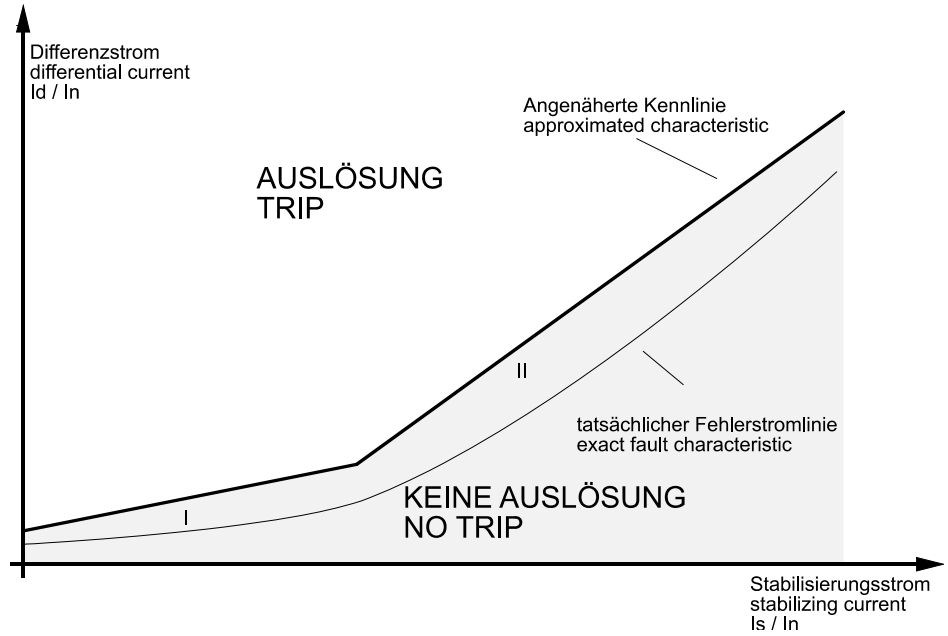


Figure 4.4: Typical pickup characteristic (without considering transient processes)

Calculation of the differential current and stabilizing current resulting from the fundamental oscillation of the input and output currents (current of the negative and positive phase sequence system) produces a point on the characteristic. If this point is within the tripping range, the output relay picks up.

Harmonic analysis

The analysis of harmonics allows detection of special processes in the grid, which also distort ascertained differential current values.

These factors are:

- Inrushes
- Over excitation of the transformer by overvoltage or under frequency
- CT saturation at very high current load caused by:

- severe faults (external short circuit at high load)
- start-up phases of big motor-operated drives
- magnetizing currents of unloaded transformers
- faults within the zone to be protected
  (short circuits)

We will explain the harmonic oscillation analysis more detailed by taking the example "CT saturation": In unsterilized transformer differential protection systems instabilities can arise which may have grave consequences because the CT core is saturated due to transient processes. In this state the CTs, arranged at either side of the zone to be protected, do not portray the "right" secondary cur-rent (when compared to the primary side). Through this constellation the differential protection relay detects at the secondary side of the CTs a differential current Id' which does, however, not exist at the primary side and this may cause unintended tripping.

In figure 4.5 core saturation due to short circuit current is illustrated.
Short circuit currents often contain a DC component. The high primary current arising during this kind of fault generates a magnetic B induction, causing saturation of the iron core.

The iron core keeps this high induction until the primary current has reached zero. During the time the core is saturated, the secondary current is not in compliance with the primary current, but becomes zero. During the time the core is not saturated, the CT induces a current which does not represent the real current for the entire cycle duration, its effective value is far too low.

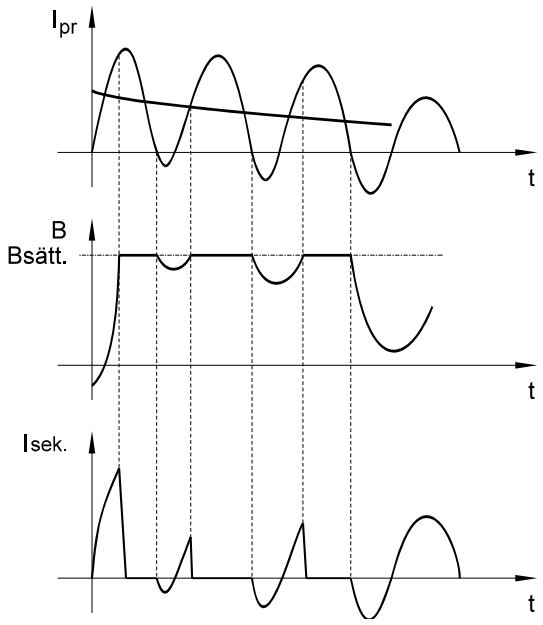


Figure 4.5: Core saturation of a CT
a) primary current with DC component
b) induction in the core
c) secondary current

Different saturation of CTs belonging to one protection zone generate differential current $I_{d'}$ causing some unstabilitzed relay to trip.
For the harmonic analysis the MRD1 exploits the second, fourth and fifth harmonic.

Important Note.
For perfect functioning of the rush stabilization system it is essential that the MRD-T is connected in the correct phase sequence, i.e. that there is a positive rotating field. Refer also to page 11.

Trip characteristic
The MRD1 identifies such factors by using the harmonic analysis and calculates a second dynamic stabilizing quantity, i.e. stabilizing factor m. Harmonic analysis makes also detection of an inrush and transformer saturation caused by overvoltage possible and are added to the calculation of the stabilizing factor. The MRD1 ascertains stabilizing factor m for the
present situation with the effect of further lifting the complete characteristic. Calculation of m is defined and cannot be adjusted.
m and I_S each stabilize the relay entirely separate from each other, but never have a complete blocking effect. Both stabilizing quantities together define the pickup value in the trip characteristic.

A basic stabilization is performed by the parameter d[Id]. For all cases m>0 (rush current, single sided ct-saturation and external faults) the characteristic curve is raised up for the minimum amount of d(Id). Another additional raising is performed for raising m (more servery rush, more severe ct-saturation).

The additionally adjustable parameter Idiff high set (Idiff >>) is a high current differential element. This setting value is not subjected to stabilization and specifies the highest permissible differential current. This parameter defines characteristic sector III.

Tripping procedure
The protection program permanently checks the measurements that the DSP (digital signal processor) delivers. When the DSP gives a new differential current the protection task checks whether it lies within the tripping limits. If this is the case the MRD1 is internally energized. Tripping occurs when the calculated difference current is consecutively three times within the tripping limits. To prevent the energized state from being reset too quickly, a hysteresis of 75 % is programmed. This means that a newly calculated difference current must be smaller than 75 % of the present characteristic trip value in order for the energized condition to be reset. The total tripping time of the Relay is below 35 ms.

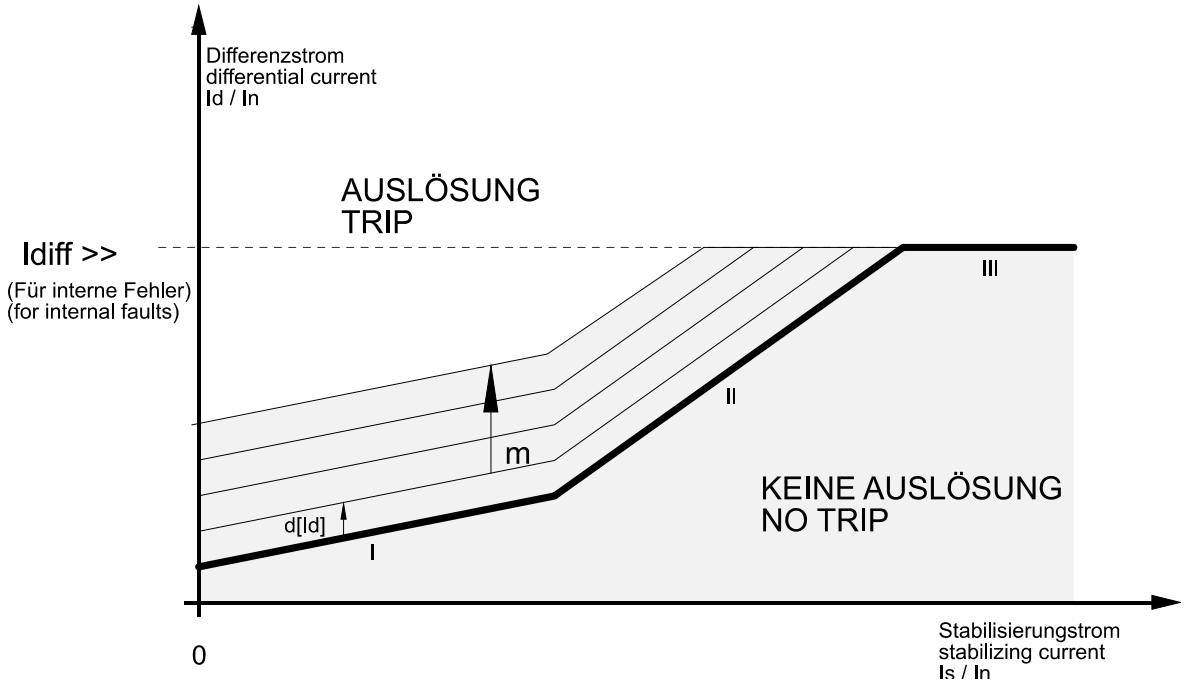


Figure 4.6: Dynamic stabilized trip characteristic (pick-up value).

4.2 Analogue measured value detection

4.2.1 Current measuring

For measuring the relevant currents there is a separate transducer for each of the existing measured quantities. This transducer provides galvanical isolation to the relay electronics. Adjustment to transformer vector group and to the main CT rated currents is realized via the software. The input signal is transmitted by internal CTs up to 64 times rated current linear. To achieve an utmost accuracy there are two current measuring ranges, changeover of which is automatically.
Each channel has its own sample-and-hold circuit. All channels are scanned simultaneously.

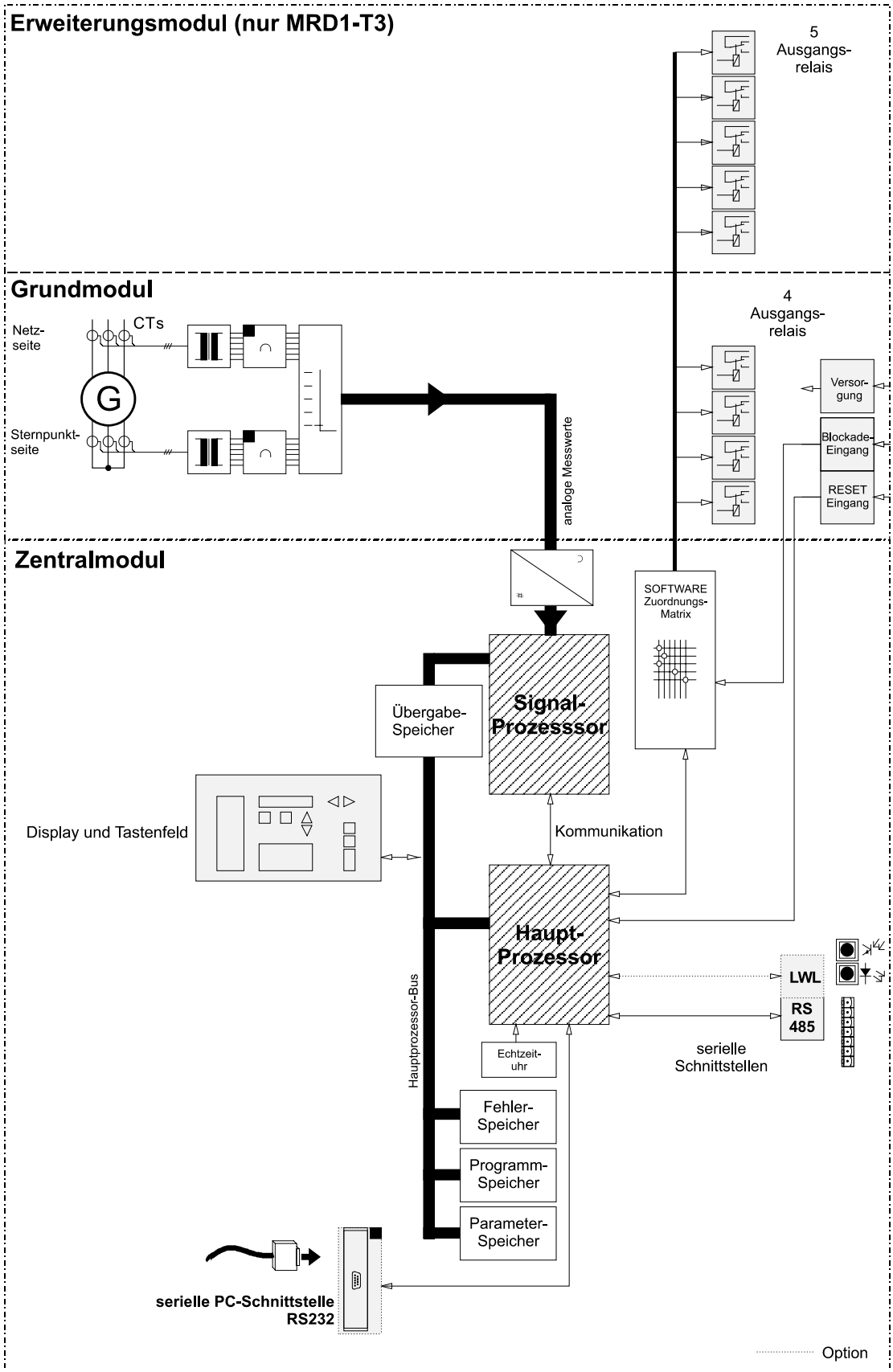
4.3 Digital signal processor

The digital signal processor (DSP) in the MRD1 is mainly used for processing measured values by controlling and monitoring data entry from the different measuring channels. In addition all input signals are digitally Fourier filtered. Among other values this processor calculates RMS values and analyses harmonics by processing sampled data and stores digitalized signal sequences to the memory. Apart from data management and processing the DSP keeps performing wide-ranging selftests.

4.4 Digital main processor

The main processors is the highest control element within the MRD1 and processes the actual protection program which interprets data obtained by the DSP and so refers to the operational status of the object to be protected and to the own device. Special protection mechanism enable the MRD1 to detect problems in the own hardware. All communication between MRD1 and the outside world is also controlled by the main processor. This does not only mean control of indications or handling of key inputs but also harmonizing the different data interfaces as well as control of output relays.

4.5 Block diagram



4.6 General functions

4.6.1 Event-Recorder

The MRD1 is provided with an event recorder for recording events in a chronological order and then stores them on a non-volatile memory. Any data entry has a time stamp so that time of the event can always be traced back. Data can be called off either via keys and display or data interfaces.
Important events, such as trippings, are not only recorded in the memory but also shown on the display. Pure informative events are stored in the recorder only and are not displayed.

More details on calling off events and further information on the event recorder can be found in chapter 5.

The system messages are listed in chapter 9.1.

4.6.2 Fault-Recorder

At each tripping of the relays, the fault recorder records all measured data and resulting quantities. Any tripping event is automatically numbered consecutively in the recorder. Additionally to the measured data the following details are also stored: the cause for tripping, serial number of the incident as well as date and time at the instant of tripping.

The MRD1 is able to record several incidents in a FIFO memory. The longest stored data is overwritten when a new incident occurs. Complete data of altogether 10 incidents can always be called off.
More information on storage capacity and calling off recorder data via keyboard can be found in chapter 5.

4.6.3 -test relay

The self-test relay (relay 5) is energized during normal operation of the MRD1 and deenergized in the following events:

- failure of aux. voltage
- failure of internal partial power supply
- processor failure detected by the internal watchdog
- detection of an internal fault by software routines
- when protection function of the out-put relays is decoupled in OFFLINE TEST mode
- when the default parameterset was loaded and the device automatically switched in OFFLINE TEST mode
- During power on initialisation
- self-test of the output relays is performed

4.6.4 Self-test

By pressing the TEST key several menu guided special test routines can be started in the MRD1 for internal test purposes. Some tests disable the transformer protection. These tests are locked by password.
The following tests and information can be performed/is available:

Test/Inquiry	Description	Password requested	Protection-function
Software version number	Number of version and date of software are inquired	no	remains active
LED-Test	all LED's light-up red f. 2s all LED's light up green f.2s	no	remains active
Test of output relays	Sequence in one-second interval: self-test relay deenergizes all other relays deenergize all relays energize one after the other (with LED) relays return to actual position self-test relay energizes	yes	inactive during the test
Memory test	Test of software and memory by checking the program check sum	no	remains active

4.6.5 Output relay settings

Reset time of the output relays:

With the exception of the self-supervision relay, all existing output relays are assigned to the differential current element. It is possible to define a proper reset time for each individual relay. For this period - from the moment of tripping - the relay remains in trip condition even if the cause for the tripping does no more exist.

Note:
If the time for which the relay has been energized exceeds the adjusted reset time, the relay will release instantaneously after trip condition is cancelled. This is particularly important for relay tests (test of the reset time) where the test current is not switched off immediately with tripping.

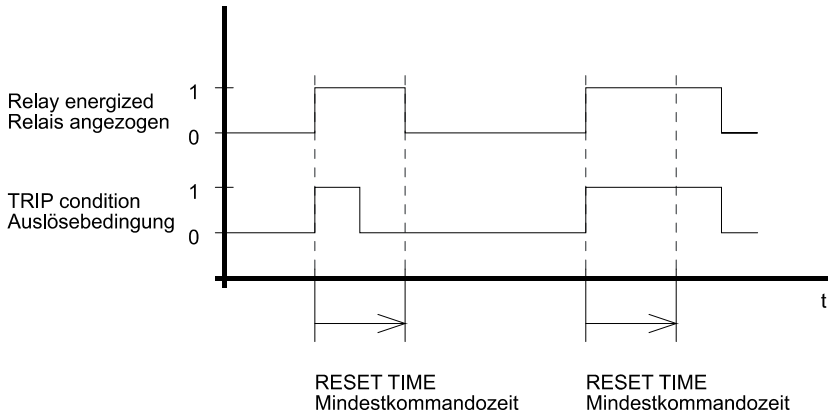


Figure 4.7.: Reset time

If a relay is to remain self-holding after tripping, the reset time has to be set to „exit“. Setting as per customer’s requirements can be noted down in the „selection“ line.

	Relay									
	Basic equipment					**(Only MRD1-T3)**				
	1	2	3	4	5	6	7	8	9	10
Function	I_{diff} I_{diff} >>	I_{diff} I_{diff} >>	I_{diff} I_{diff} >>	I_{diff} I_{diff} >>	ST	I_{diff} I_{diff} >>	I_{diff} I_{diff} >>	I_{diff} I_{diff} >>	I_{diff} I_{diff} >>	I_{diff} I_{diff} >>
Pre-adjustment (in s)	0,20	0,20	0,20	0,20	•	0,20	0,20	0,20	0,20	0,20
Custom					•					

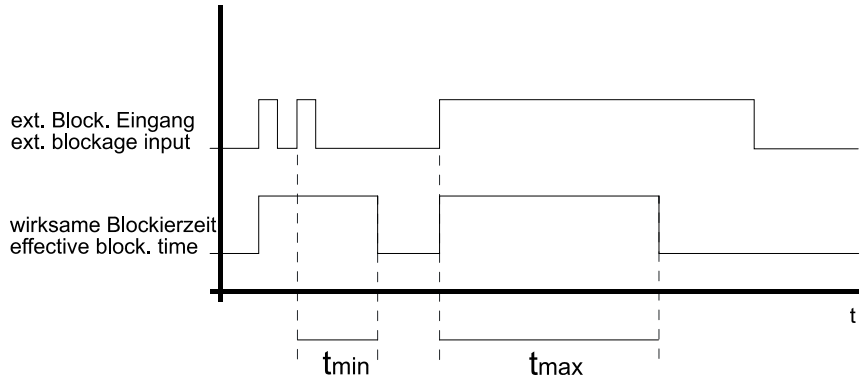
Setting range: 0 -...1,00 s or exit (=latching- contact until a DEVICE RESET is performed)
ST=Self-Test relay
• = no selection

4.6.6 Parameterizing blocking

Blocking of protective function

The MRD1 offers a configurable blocking function. When applying a voltage to terminals D8-E8 all protective functions are blocked that are configured for blocking. In case of active blocking the output relays don’t act, but the device shows the fictive trip by means of Trip-LED.

A minimum hold time can be set for the blocking. During this time, starting from the begin of external blocking, all protective functions are blocked, also in case the external blocking may was released. In case of longer continuous external blocking the blocking can be stopped after a maximum hold time t_{max} for enabling the relay to trip in case of ongoing faults.



Note:
Repeated impulse at the blocking time within t_{min} restart the hold times.

Assignment of functions to output relays

The MRD1 offers 5 output relays. Relay number 5 is preassigned to the selftest function of the relay and is working with zero-signal current principle. Output relays 1 – 4, and 6 – 10 are open-circuit relays and can be assigned to internal logic functions.

5. Operation

5.1 General

5.1.1 Data organization

Data and settings in the MRD1 are sub-divided into 4 groups and each of those are allocated to one menu key or key combination. Related parameters or measuring data of one group are combined on individual pages. General settings can be made on the SYSTEM parameter page. Test routines are also on separate pages.

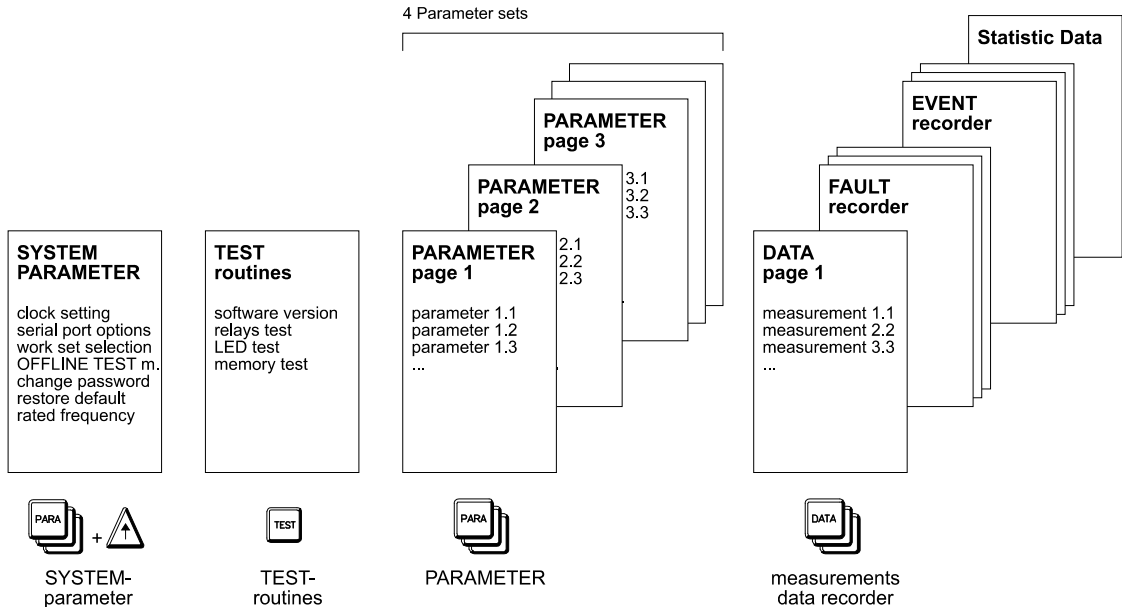


Figure 5.1: Data organization

5.1.2 Parameter sets

MRD1 has access to four independent parameter sets. Each of these data sets comprises a complete parameter set which makes individual setting of the MRD1 possible. If required by the operational procedure several different settings can be stored and then called off when needed.
Data of SYSTEM parameters (e.g. rated frequency, slave address, date, time etc.) are not filled in the four parameter sets, they do always apply.

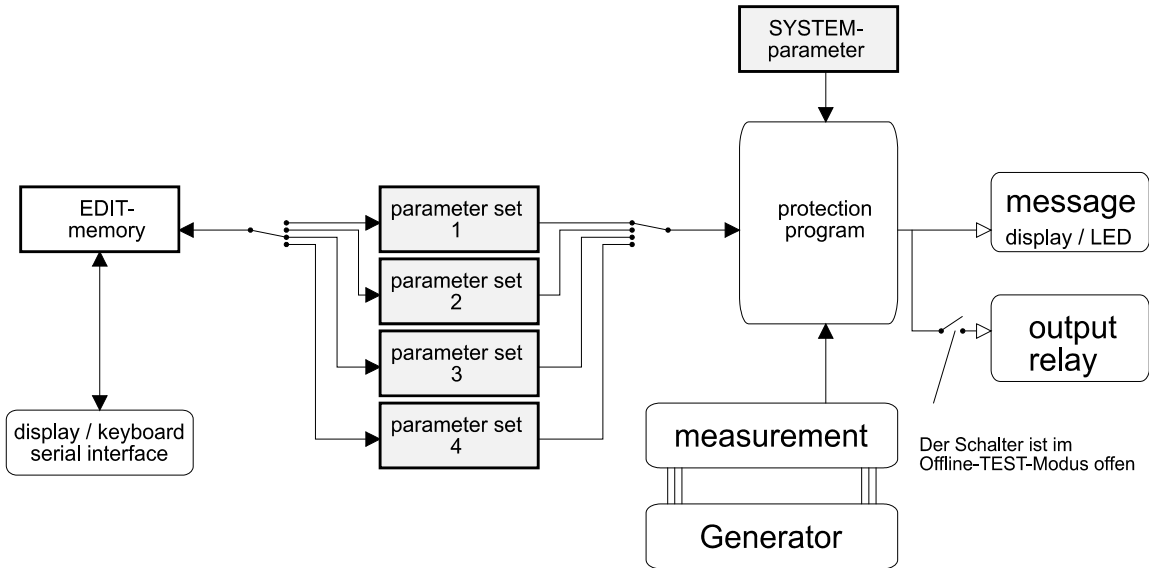
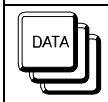
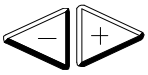
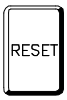


Figure 5.2: Parameter sets, principle

For processing the selected set is loaded into the EDIT memory (switch: Set to Edit). After parameters have been changed, the EDIT memory is completely restored in the parameter set memory. All changes are then jointly read-in.
Another switch (Work Set) defines on which of the data sets the protection program is based. All switches are adjusted via software.

OFFLINE TEST mode is specified in chapter 5.1.6.

5.1.3 Key function

Key Function	short actuated	long actuated (2s)
	a) from HOME POSITION: View active parameter set (VIEW mode) b) leaf to next PARA page	from HOME POSITION: ❶ select one of the four parameter sets to edit (EDIT-mode)
	from HOME POSITION: ❶ select SYSTEM-parameter page	•
	a) from HOME POSITION: View DATA pages b) leaf to next DATA page	•
	select the selftest routines page	•
	scrolling up/down single step	scrolling up/down fast
	a) ❶ change value. single step b) move cursor	❶ change value, fast
	a) confirm selection (YES) b) toggle setting in EDIT mode (yes/no; on/off)	finish working in EDIT mode, perform parameter plausibility check and save (if check passed) all modifications
	a) reject selection (NO) b) cancel modification c) clear message	a) From HOME POSITION DEVICE RESET b) From Sub-Menu back to home position

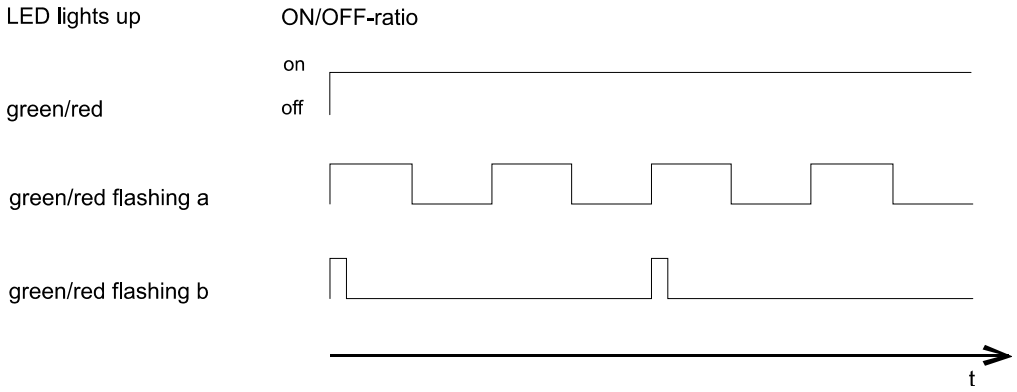
Note
In the following paragraphs key symbols are mainly used when explaining an operational procedure. Keys with the term "long" on them have to be pressed for about 2s for actuating the function. If there is nothing stated, the respective key has only to be pressed briefly.

```
Woodward▪▪▪▪29.10.08
MRD1▪▪▪▪▪▪▪▪▪15:40:47
```

Figure 5.3:Display in HOME POSITION

5.1.4 LED's

LED's arranged at the relay front can light up in different colors and can also either show permanent light or flash in different frequencies.



Meaning of the LED-signals

LED name	LED lights up	Meaning
POWER	green	Device OK
	red flashing a	FAULT of an internal supply
	Off	Device OFF
TRIP	Off	Normal
	red	Trip
	red flashing a	Energized
TEST	Off	Normal
	red flashing a	OFFLINE-TEST-mode active
EDIT	Off	Normal, VIEW mode
	Red	EDIT mode after password access
MODIFIED	Off	Normal
	Red	EDIT mode: parameter modified
Relay	Off	Relays off
	Red	Relays energized
	Green	Relay-test
	red flashing b	Relay off after energizing (until DEVICE RESET)
	red flashing a	Relay blocked
SELFTEST	Green	Protection o.k. (selftest relay on)
	Red	System initialisation (after power on)
	red flashing a	OFFLINE TEST mode / Relay-TEST. no protection, only messages
	Off	Internal fault. no protection

5.1.5 VIEW mode / EDIT mode

There are two modes for selecting PARAMETER pages:
A short press on the PARA-key activates the VIEW-mode. The EDIT-mode can be selected by pressing the PARA-key for approx. 2 s (long press).

- VIEW mode (viewing)
  On pressing the key this mode only allows viewing the active parameters
- EDIT mode (processing)
  Unlike in mode VIEW, in EDIT mode one of the four parameter sets can be selected. That parameter set is then copied automatically into the EDIT memory and can be viewed there. At the first attempt of changing a parameter, the password is requested. After entering the password (LED EDIT lights up if the password was correct), the parameter can be changed. For any further change of parameter(s) the password is not requested again. In case the user does not know the password, the password entering mode can be cancelled and still parameter sets be viewed but as explained above, they cannot be changed.

It is not necessary to acknowledge any change separately by pressing the ENTER key since at first everything is processed in the EDIT memory only. Each of the changes can be cancelled again. LED MODIFIED indicates that the parameter displayed was changed. If it should be set back to the initial value, only brief actuation of key RESET (cancel function) is needed. If the process is closed (with: ENTER, long), all the changes can be rejected again or be accepted. (Checkback: ARE YOU SURE?). Before the parameter set is finally stored an internal plausibility check is performed to ensure that all settings are conclusive. If the check routine detects a irresolute combination of settings, the user will be informed and the settings are not stored. e.g. an unsuitable combination of trans-former rated current (which is calculated from rated voltage and power capacity setting) an the setting CT primary rated current.

The protection program executed in the MRD1 at the time is not effected by this procedure. Values of the active parameter sets filed in the PARAMETER memory are still being used until the complete EDIT memory is recopied into the respective PARAMETER memory. Only then all changes made taking effect together in the protection program.

Note

If during processing the aux. voltage fails, the complete EDIT memory is erased. After aux. voltage has returned, the protection program starts with those settings which were stored in the PARAMETER memory before the last processing operations. By this it is ensured that the protection program does not work with incompletely changed data or meaningless data.

If due to the continuously running check-sum test data error or loss of parameter memory is noted during start-up of the relay or during operation, a default parameter is loaded automatically. In such case the relay changes to the Offline mode (see next chapter) and the self-supervision relay de-energizes.

The EDIT-mode is left automatically if there is no input longer than 10 minutes (time out). Changed parameters will not be stored.

5.1.6 OFFLINE-TEST mode

For testing a parameter set the OFFLINE TEST mode can be activated. In this mode all output relays are being switched off. Now it can be changed over to another parameter set for testing without risking nuisance trip-ping. If the parameter set causes tripping, alarms are only shown on the MRD1 display or indicated via LED's. The OFFLINE TEST mode is enabled or disabled on the SYSTEM SETTING page.

The OFFLINE TEST mode is indicated by:
- Self-supervision relay deenergizes
  (to inform the control system about the missing protection function)
- Self-supervision LED flashes red (= no protection)
- LED TEST flashes red (= TEST mode active)

Important Notes

To prevent an unintended trip the OFFLINE TEST mode is activated as de-fault setting on first commissioning. When the MRD1 recognizes a damaged parameter memory the default settings are loaded automatically and the Offline mode is activated (with selftest relay deenergized).

During OFFLINE TEST mode the transformer is not protected by the MRD1. Although a failure could be detected during this mode, the MRD1 would not initiate a trip of the transformer.

In order to prevent dangerous conditions, the transformer must either have a sufficient backup protection or has to be switched off.

After an intended OFFLINE TEST this mode must be disabled so that protection is ensured again.

5.1.7 Reset (DEVICE RESET)

System messages in the display can be cancelled with a short press on the RESET key. The message is not removed at all but stored in the EVENT-memory. A trip will also cause a message which is also to be cancelled with a short RESET press. After this all measured and calculated values can be recalled from the fault recorder. All output relays and LED's (if set to self-holding contact) will remain in energized position until a DEVICE RESET is initiated to the MRD1 by a long RESET press from home position.
The DEVICE RESET can also be initiated by the external reset input or via serial interface.

Info-messages do not need to be reset manually. They extinguish automatically after 5 s.

5.1.8 Enter password

The MRD1 calls for a password if parameters are intended to be changed in the memory or other important functions to be activated. Nearly all data can be called off by the user without entering a password, but for changing any data, the password is required. Some test functions can only be started after the password has been entered (see chapter 5.5).
If a password is required this is indicated on the display. The password consists of four digits and key combination  has to be actuated.

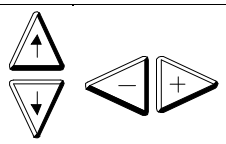
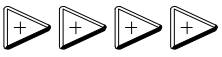
Display	Process	Key
PASSWORD	request to enter password	
PASSWORD? XX	entering password with every keypress a further □ will appear in the display	
PASSWORD CORRECT ❶	password correct. LED EDIT on	
PASSWORD WRONG NO ACCESS ❶	password incorrect LED EDIT remains off	

Table 5.1: Procedure for entering a password

Message appears for app. 2 s

Note
Any process started can be stopped at any time by pressing key RESET:

The password entered at our works consists of key sequence 
It is advisable to change this password immediately to an individual one.

LED EDIT indicates if the password entered is correct. In this state changes on MRD1 settings can be made. When changing over to another function in some cases the password has to be entered again.
Also after storing or cancelling, editing authority becomes invalid. Hence it is very important that the relay is only left after LED EDIT has extinguished to prevent unauthorized change of settings.

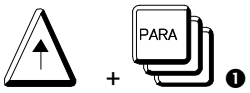
5.1.9 Password forgotten

Important
In case the password has been forgotten our works have to be contacted to inquire about the measures for regaining access.

5.2 SYSTEM settings

5.2.1 Selection

On this page the general functions are shown which are not stored in the four parameter sets. They are stored separately and always apply, irrespectively of the parameter set selected. The SYSTEM SETTINGS can only be selected from Home Display.

page select	Display
 ❶	SYSTEM SETTINGS

❶ Starting at Home Display: press UP and hold, press PARA in addition to, release both

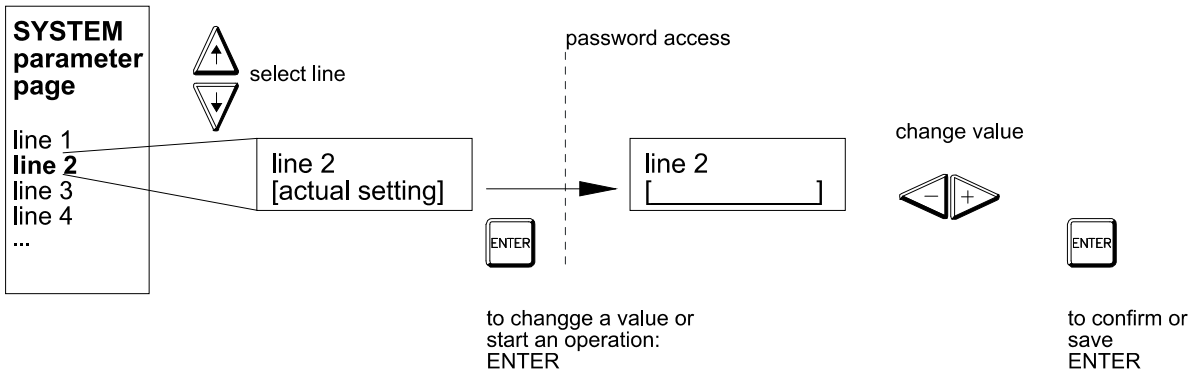


Figure 5.4.: System settings, principle

Note:
To change any setting or start an operation:

- Select parameter or option with UP/DOWN
- Press ENTER
- Enter password if requested
- If necessary: select setting with the ± keys.
  On setting date/time the arrow keys (up/down) are used to scroll to the next value.
- Press ENTER to get new value valid.

5.2.2 Overview

Key	Existing lines	Settings	Range	Default	Actual setting
scroll 	-----SYSTEM----- ---SETTINGS-----	Headline			
	CHANGE DATE/TIME	change time and date	see 5.2.3		
	RATED FREQUENCY Fn= .. Hz	rated frequency in Hz	50 Hz 60 Hz	50 Hz	
	COMMUNICATION MODE = ...	select serial port	Disable ❶ RS232 RS485 CAN	RS485	
	SLAVE ADDRESS RS485	Slave-address of RS485-interface	1-32	1	
	GROUP ADDRESS CONFIG:	A...F Group selection t Time-/Date setting via master	ABCDEFt ❷	. . . . t	
	EDIT PARA-SET VIA SP	programming via interface	Enable disable ❶	disable	
	SELECT PARA SET VIA SP	parameter set switch over via interface	Enable disable ❶	disable	
	OFFLINE TEST.....	activate Offline-TEST-Mode	Enable disable ❶	enable	
	SELECT WORK-SET SET (1) [ACTIVE]	select active parameter set	1 ... 4	1	
	PASSWORD CHANGEROUTINE	change password	see 5.2.4		
	RESTORE DEFAULT SETTINGS	clear all parameter sets and set to default **The device switches to OFFLINE TEST mode automatically!**			
	CLEAR EVENT RECORDER	clear event recorder			
	CLEAR FAULT RECORDER	clear fault recorder			

Table 5.2: SYSTEM settings page, overview

❶ Select with cursor and ENTER

❷ To change any setting or start an operation press ENTER while shown in display.

5.2.3 Time/Date

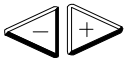
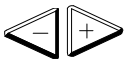
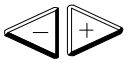
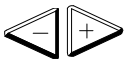
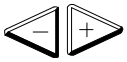
Key	Display	Remark	Change value	Setting range
	CHANGE TIME / DATE	Headline	•	Password input
scroll 	DATE: 01.01.___ TIME: 00:00:25	change year		1980-2099
	DATE: 01.__.1996 TIME: 00:00:25	change month		1-12
	DATE: __.01.1996 TIME: 00:00:25	change day		1-31 (depends on year/month)
	DATE: 30.01.1996 TIME: __:00:25	change hours		0-23
	DATE: 30.01.1996 TIME: 12:__:25	change minutes		0-59
	DATE: 30.01.1996 TIME: 12:00:__	change seconds		0-59
		accept settings and start new time/date	•	•
		cancel settings and re-store old time/date	•	•

Table 5.3: Date /time-setting

• No selection possible

Note
Both arrow keys have the same function for this setting procedure. Both move the cursor always to the next digit group. After reaching the SECOND column, it is switched back to YEAR again. Digits for the year and month have to be entered before digit(s) for the day to enable the MRD1 to carry out correct calculation of intercalary days as well as the max. days in a month. The internal clock does not stop during the setting procedure so that when cancelled by RESET key the actual time is not changed. After pressing ENTER the modified time becomes valid.

Date/time setting may be synchronized via serial interface (see setting "GROUP ADDRESS").

5.2.4 Password change

The password in the MRD1 can be changed at any time. For changing a password it is necessary to know the present one. To rule out any typing errors, the password has to be entered twice. If the entries are not identical, the password is not changed and the previous one still applies. (Please see table below).

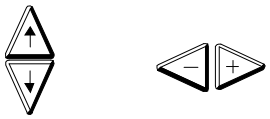
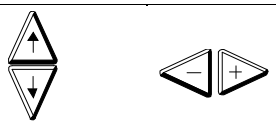
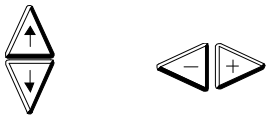
Display	Step	Key
PASSWORD CHANGE ROUTINE	Password change with ENTER	
TO CHANGE OPTION PASSWORD?	Request to enter old password	
TYPE YOUR NEW PASSWORD!	Enter new password	
TYPE AGAIN NEW PASSWORD	Enter new password again	
PASSWORD CHANGED	❶ changing done	
2 SIFF NEW PSW TRY AGAIN	❶ The new password wouldn't be typed 2 times identically Try again	

Table 5.4: Password change, procedure

❶ message appears for app. 2 s

5.3 PARAMETER-pages

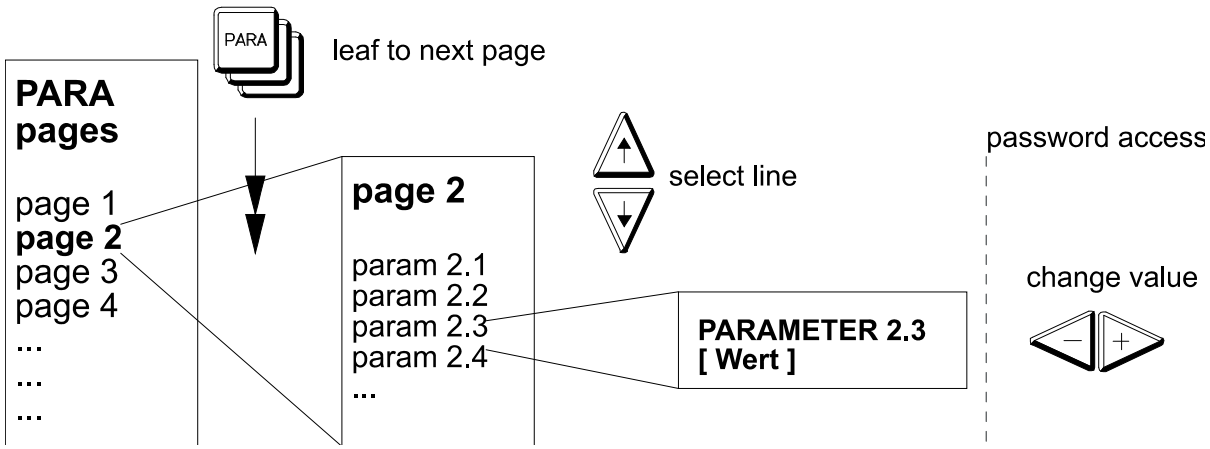
5.3.1 Selection

This table gives an overview about all pages of a parameter set and the parameters belonging to.

Select PARAMETER-pages in VIEW- or EDIT mode

Key	Display	Remark	
PARA short	VIEW PARAMETER SET (1) [ACTIVE]	VIEW active parameter set	continued at 5.3.2.
PARA long	LOAD SET TO EDIT SET (1) [ACTIVE]	EDIT mode select one of the four parameter sets to view or edit confirm with ENTER	− + ENTER
	EDIT PARAMETER SET (2) [IDLE]	e.g. set 2 was loaded and is now ready for editing	continued at 5.3.2.

Table 5.5.: Parameter pages, organization



Possibilities after modifying a parameter:

- Keep modifications and scroll to next line (up/down)
- Keep modifications and leaf to next page (PARA short)
- Cancel modification of the displayed value (RESET short)
- Finish working, accept all modifications and store (ENTER long)
- Finish working and refuse all modifications, no store (RESET long)

5.3.2 Overview

Key	Pages Headline		Parameter	see
leaf to next page	VIEW PARAMETER SET (1) [ACTIVE] or EDIT PARAMETER SET (1) [ACTIVE]	Parameter pages	active parameter ready for viewing (e.g. set 1) selected set ready for viewing and editing (e.g. set 2)	5.3.1
	***GENERATOR**** ****RATINGS*****	Data of protected device for all windings W 1 W 2 W 3	Rated power Rated voltage CT primary current Connection group Phase shift tap ratio CT connection	5.3.3
	PROTECTION ****SETTINGS****	parameter of differential-protection	Difference current at Is=0 × In Difference current at Is=2 × In Difference current at Is=10 × In max. Difference current Idiff>> d[Id] Offset in case of harmonics	5.3.4
	FUNCTION INPUT *LOGIC SETTINGS	Parameter of output relays	Reset time or self-holding of the output relay	5.3.5
	OUTPUT RELAY ***SETTINGS****	Parameter of logic functions	Assignment of protective and logic functions (AND-logic)	5.3.6
	*EXTERN BLOCKING ****SETTINGS****	Parameter of external blocking		5.3.7

Table 5.6: Parameter pages, overview

On the first attempt to change a set-ting with the ± keys in a edit session the password is asked. To view only parameter set-tings the PARA key is used to leaf to the next page and the UP/DOWN keys are used to select the parameter.

5.3.3 Transformer ratings

Key	Display	Parameter	Available in *MRD1-* T2	Available in *MRD1-* T3	Select	Setting range (• no selection)	Default	Parameter setting 1	2	3	4
	TRANSFORMERR* ****RATTINGS*****	Headline	×	×	none	•	•	•	•	•	•
	POWER CAPACITY SnW1= ...kVA	rated apparent power of winding 1(High-voltage-side)	×	×	◁ ▷	10 kVA - 800 MVA	17.3 MVA				
	POWER CAPACITY SnW2= ...kVA	corresponding to winding 2		×	◁ ▷	10 kVA - 800 MVA	17.3 MVA				
	POWER CAPACITY SnW3= ...kVA	corresponding to winding 3		×	◁ ▷	10 kVA - 800 MVA	17.3 MVA				
	POWER CAPACITY UnW1= ... kV	rated voltage of winding 1 (phase to phase voltage on high-voltage-side)	×	×	◁ ▷	100 V....800 kV	20 kVA				
	POWER CAPACITY UnW2= ... kV	corresponding to winding 2	×	×	◁ ▷	100 V....800 kV	6.6 kV				
	POWER CAPACITY UnW3= ... kV	corresponding to winding 3		×	◁ ▷	100 V....800 kV	6.6 kV				
	CT PRIMARY W1 In= ... A	rated primary current of phase CT winding 1	×	×	◁ ▷	1.....50.000 A	500 A				
	CT PRIMARY W2 In= ... A	corresponding to winding 2	×	×	◁ ▷	1.....50.000 A	1500 A				
	CT PRIMARY W3 In= ... A	corresponding to winding 3		×	◁ ▷	1.....50.000 A	1500 A				
	CONNECTION SYST. WINDING 1=	connection system of winding 1	×	×	◁ ▷	wye, delta, zigzag, wye+n, zigzag+n	wye + n				
	CONNECTION SYST. WINDING 2=	corresponding to winding 2	×	×	◁ ▷	wye, delta, zigzag, wye+n, zigzag+n	wye + n				
	PHASE SHIFT WINDING 2=	phase shift in winding 2 in ×30° in relation to winding 1	×	×	◁ ▷	0-11	0				

Key	Display	Parameter	Available in *MRD1-* T2	T3	Select	Setting range (• no selection)	Default	Parameter setting 1	2	3	4
	CONNECTION SYST. WINDING 3=	connection system in winding 3		×	◁ ▷	wye, delta, zigzag, wye+n, zigzag+ n	wye + n				
	PHASE SHIFT WINDING 3=	phase shift in winding 3 in ×30° in relation to winding 1		×	◁ ▷	0-11	0				
	RATIO CHANGE TAP WINDING 3= .... %	voltage displacement by transformer tap changer in winding 1	×	×	◁ ▷	- 20 %...+ 20 %	0,0				
	W1 CT CONNECTION	Winding 1 CT connection in normal polarity (like connection diagram) or inverted (reverse polarity) ❶	×	×	◁ ▷	normal, inverted	normal				
	W2 CT CONNECTION	corresponding to winding 2 ❶	×	×	◁ ▷	normal, inverted	normal				
	W3 CT CONNECTION	corresponding to winding 3 ❶		×	◁ ▷	normal, inverted	normal				

NOTE: The Parameter must be set to inverted polarity, if the direction of current flow in the secondary circuit is reverse to the input terminals of MRD1 according to the connection diagram (Chapter 10).

5.3.4 Protection parameters

Differential protection

The tripping characteristic of the MRD1 can be set with four parameters:

Idiff0: Error caused by no load current and error of the CTs
Idiff2: Additional error by tap and linear error of the CTs (linear range of the CTs)
Idiff10: Additional error by saturation of the CTs
Idiff>>: maximum permitted difference current
d[Id]: raise up of characteristic curve by offset in case of characteristic harmonics

In: Transformer nominal current

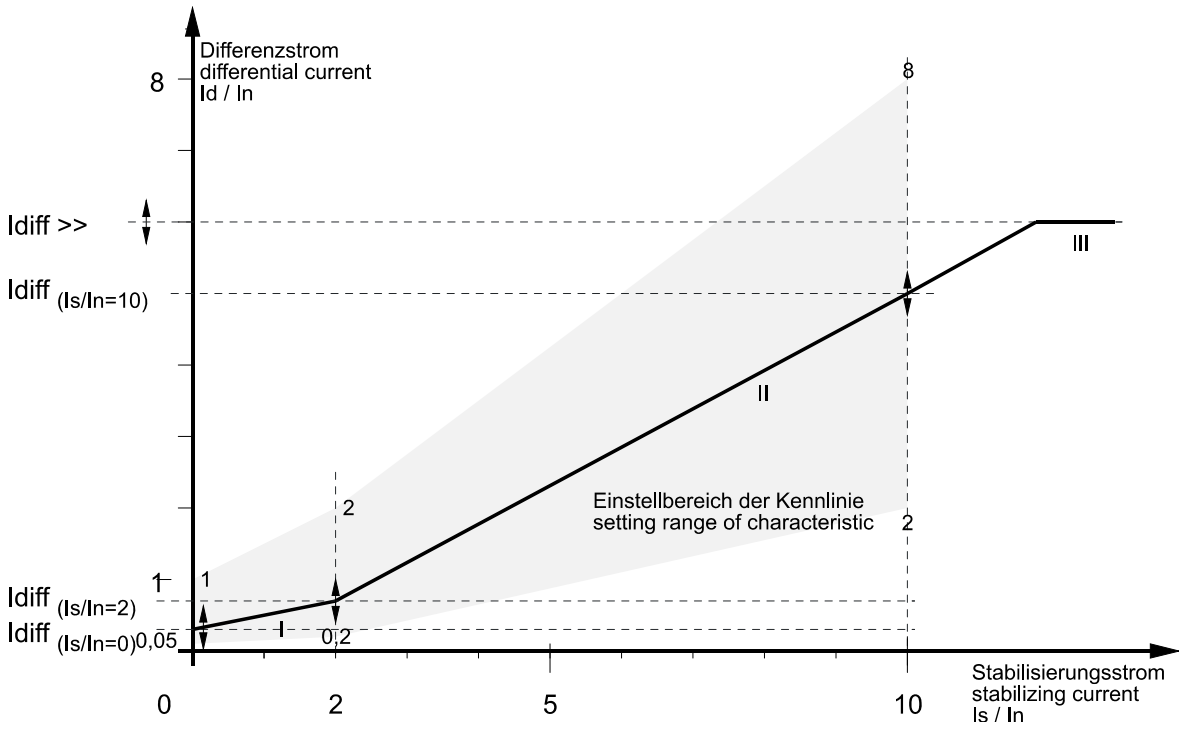


Figure 5.5: Possible setting range of the characteristic

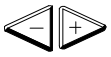
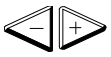
Key	Display	Parameters of the characteristic	Select	Setting range (• no selection)	Default	Parameter setting 1	2	3	4
	***PROTECTION*** ****SETTINGS****	Headline	none	•	•	•	•	•	•
	Idiff (Is=0xIn) = x.xx xIn	differential current Idiff at stabilising current Is/In=0 (see picture) ❷		0.1...0.5 × In ❶	0.5				
	Idiff (Is=2xIn) = x.xx xIn	corresponding to Is/In=2 ❷		0.2...1 × In ❶	1.0				
	Idiff (Is=10xIn) = x.xx xIn	corresponding to Is/In=10 ❷		2.0...8.0 × In	8.0				
	Idiff (High Set) Idiff>>= xx.xxIn	maximum permitted differential current		2.0...20.0 × In	20.0				
	OFFSET VALUE **d[Id]= x.x xIn*	Offset of characteristic curve from static basic characteristic curve		0.0...8.0	2.0				

Table 5.7: Adjustable protection parameter

❶To get no negative slope in the characteristic part I the setting Idiff (Is=2) must not be less then the setting Idiff (Is=0). The MRD1 will check the inputs on this must.

❷ In = Transformer nominal current

5.3.5 Relay-settings

Key	Display	Setting	Select	Setting range (• no selection)	Default	Parameter setting 1	2	3	4
	**OUTPUT RELAY** ****SETTINGS****	headline	none	•		•	•	•	•
	RELAY 1 TO LOG. AB----------	Assignment of relay 1 to logic functions A...P, OR-logic	 [↵]	ABC....P	AB....				
	RELAY 2 TO LOG. AB----------	corresponding to relay 2	 [↵]	ABC....P	AB....				
	RELAY 3 TO LOG. AB----------	corresponding to relay 3	 [↵]	ABC....P	AB....				
	RELAY 4 TO LOG. AB----------	corresponding to relay 4	 [↵]	ABC....P	AB....				
Only MRD 1-T3	RELAY 6 TO LOG. AB----------	corresponding to relay 6	 [↵]	ABC....P	AB....				
	RELAY 7 TO LOG. AB----------	corresponding to relay 7	 [↵]	ABC....P	AB....				
	RELAY 8 TO LOG. AB----------	corresponding to relay 8	 [↵]	ABC....P	AB....				
	RELAY 9 TO LOG. AB----------	corresponding to relay 9	 [↵]	ABC....P	AB....				
	RELAY 10 TO LOG. AB----------	corresponding to relay 10	 [↵]	ABC....P	AB....				
	REL1 RESET TIME T(rst)= ... s	minimun Reset time /latching time for relay 1		0.00 .... 1.00s / exit ❶	0.2 s				

Key	Display	Setting	Select	Setting range (• no selection)	De-fault	Parameter setting 1	2	3	4
	REL2 RESET TIME t(rst)= ... s	corresponding to relay 2		0.00 .... 1.00s / exit ❶	0.2 s				
	REL3 RESET TIME t(rst)= ... s	corresponding to relay 3		0.00 .... 1.00s / exit ❶	0.2 s				
	REL4 RESET TIME t(rst)= ... s	corresponding to relay 4		0.00 .... 1.00s / exit ❶	0.2 s				
Only MRD 1-T3	REL6 RESET TIME t(rst)= ... s	corresponding to relay 6 (If equipped)		0.00 .... 1.00s / exit ❶	0.2 s				
	REL7 RESET TIME t(rst)= ... s	corresponding to relay 7 (If equipped)		0.00 .... 1.00s / exit ❶	0.2 s				
	REL8 RESET TIME t(rst)= ... s	corresponding to relay 8 (If equipped)		0.00 .... 1.00s / exit ❶	0.2 s				
	REL9 RESET TIME t(rst)= ... s	corresponding to relay 9 (If equipped)		0.00 .... 1.00s / exit ❶	0.2 s				
	REL10 RESET TIME t(rst)= ... s	corresponding to relay 10 (If equipped)		0.00 .... 1.00s / exit ❶	0.2 s				

Table 5.8: Reset time of the output relays

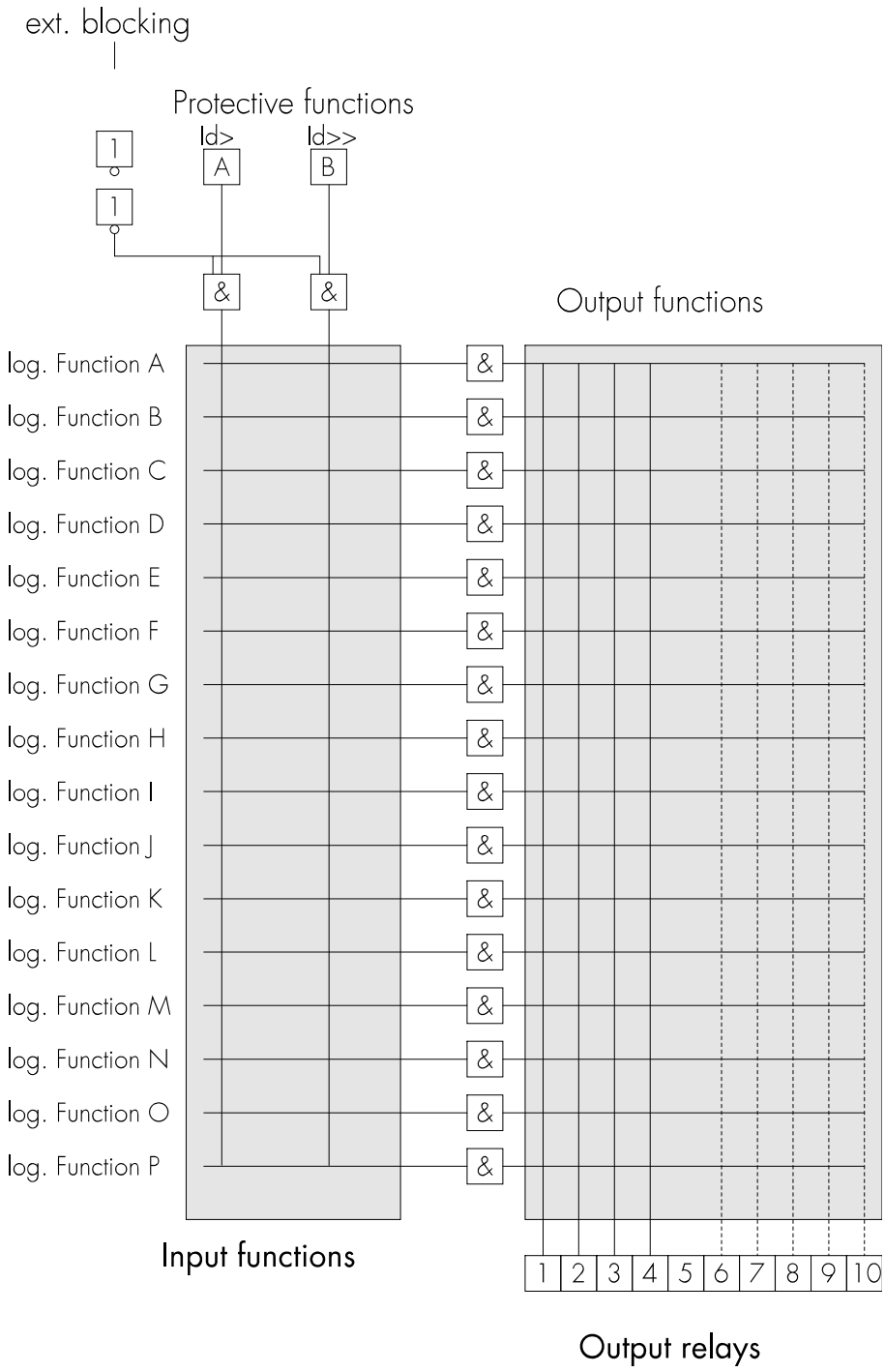
❶ The reset time is the minimum time the relay keeps energized after a trip. If the time is set to exit the output relay is configurated as a latching contact.
The relay keeps energized after a trip until the MRD1 is RESETed. (DEVICE RESET)

5.3.6 Setting of logic functions

Taste	Display	Setting	Select	Setting range (• no selection)	Default	Parameter setting 1	2	3	4
	FUNCTION INPUT *LOGIC SETTINGS*	Header line							
	(F) INPUT LOGIC A TO FUNCT: A-	Assignment of logic functions A to protective functions (here: protective function A = Id>)		A…B	A_				
	(F) INPUT LOGIC B TO FUNCT: -B	Assignment of logic functions B to protective functions (here: protective function B=Id>>)		A…B	_B				
	(F) INPUT LOGIC C TO FUNCT: AB	Assignment of logic functions C to protective functions (here: protective function A and B)		A…B	__				
	...	Assignment of logic functions P to protective functions (here: no protective function)		A…B	__				

Note
For MRD1 there is the following definition:
Protective function A: Differential protection Id> (Low Set)
Protective function B: Id> (High Set)

Scheme:


ext. blocking
Protective functions
Id>
Id>>
A
B
1
1
&
&
Output functions
log. Function A
log. Function B
log. Function C
log. Function D
log. Function E
log. Function F
log. Function G
log. Function H
log. Function I
log. Function J
log. Function K
log. Function L
log. Function M
log. Function N
log. Function O
log. Function P
Input functions
1 2 3 4 5 6 7 8 9 10
Output relays

5.3.7 Blocking Setting

Key	Display	Setting	Select	Setting range (• no selection)	Default	Parameter setting			
						1	2	3	4
	EXTERN BLOCKING* ***SETTINGS****	Header Line							
	EXTERN BLOCK TO* FUNCTION = AB**	Blocking of protective functions (here: protective function A and B)		--,AB	AB				
	EXT. MIN BL-TIME t-min = 0.1 s	Min hold time of blocking «exit»:no min. hold time		0.0 ... 60.0 exit	0.1s				
	EXT. MAX BL-TIME t-max = 2.0s	Max. blocking time when continuing blocking signal «exit»: latched as long as signal holds		0.1 ... 60.0 exit	2.0s				

5.3.8 Validity check

The MRD1 is provided with a special parameter checking facility as protection against wrong settings. However, to prevent that the actual setting range is too much restricted , this facility can only protect against gross setting errors. Before they are stored, changed settings are checked for their mutual validity. The procedure is such that firstly the parameters are compared to the calculated rated currents I_N (per winding) of the component, which result from the rated apparent power and rated voltage. Thereafter interrelation of the parameters is checked.
If there is a discrepancy when setting parameters via the keyboard, either the MRD1 does not allow the respective value to be further changed or refers to the inconsistent value

by issuing a clear text message when trying to store the parameter. In this case the EDIT mode is not left and the value can be corrected.
When setting parameters via an inter-face, validity errors are indicated by a special telegram message.

A setting is not regarded to be valid if one of the following conditions are not met :

- CT mismatch for each winding
  $1/4 \times I_N < I_{WPN} < 2 \times I_N$

- CT transformation ratio at MRD1 rated current $I_{WPN} \geq 5$ A

- Relation of voltage levels
  For three-winding transformers (MRD1-T3)
  $U_{N\ Winding\ 1} \times U_{N\ Winding\ 2} \times U_{N\ Winding\ 3}$

  For two-winding transformers (MRD1-T2)
  $U_{N\ Winding\ 1} \times U_{N\ Winding\ 2}$

- Tripping characteristic
  Id(IS=0) ≤ Id(IS=2)
  i.e. gradient $_{Sector\ I} \times 0$
  and
  gradient $_{Sector\ I} \leq$ gradient $_{Sector\ II}$

- Ext. Blockage
  $t_{min} > t_{max}$
  minimum hold time is greater than maximum hold time

Abbreviations :

S_N	set rated vector power
U_N	set rated component voltage (phase-to-phase voltage)
I_N	rated component current ($I_N = S_N/\sqrt{3} \times U_N$)) calculated from U_N and S_N
I_{WPN}	set rated CT primary current
Gradient	characteristic gradient in the respective linear sector (see chapter 5.3.4)

5.4 DATA pages

5.4.1 Selection

All measured, calculated and stored data can be recalled on the data pages

Key	Display
DATA	--DATA READING-- ---PROCEDURE---

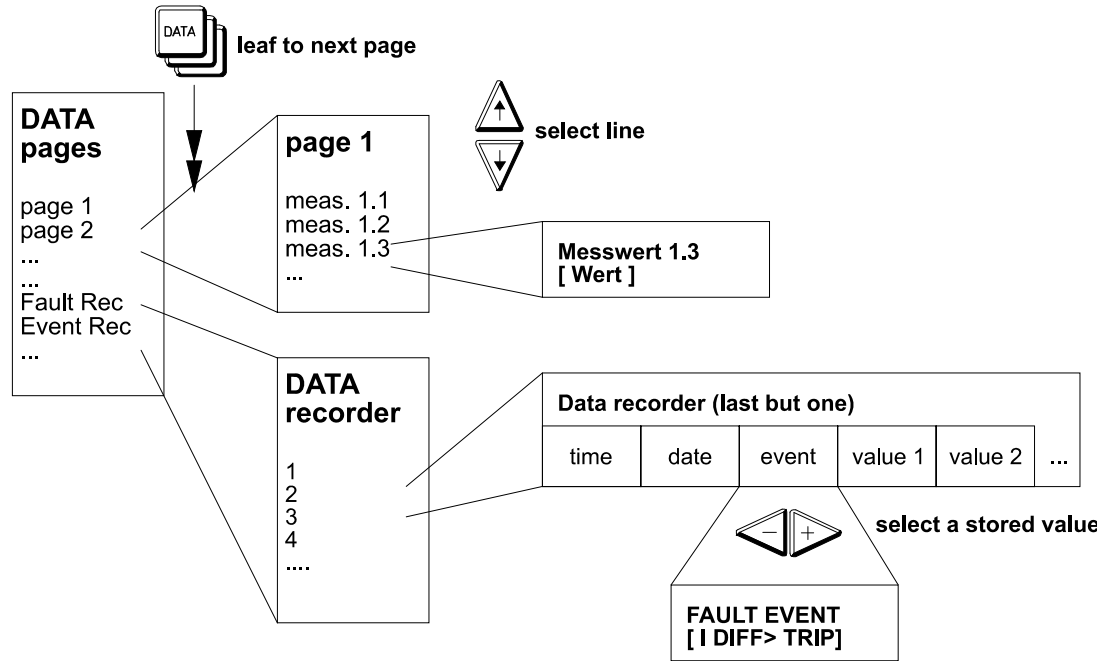


Figure 5.6.: Data pages, organisation

5.4.2 Overview

Key	Page Headline	Data	
leaf to next page 	--DATA READING-- ---PROCEDURE----	Data pages selected	
	OPERATIONAL* **MEASURED DATA*		Actual measurements and calculated data	Phase current (L1 L2 L3) Differential current Stabilising current Is (fundamental oscillation analysis) Stabilising factor m (harmonic analysis)
	FAULT RECORDER ******DATA******		Recall stored trip data	Trip message, date/time, measurements calculated measurements
	EVENT RECORDER ******DATA******		Recall event messages	Message text date/time
	STATISTIC* ******DATA******		Recall statistic data	Operating hours Trip counter Alarm counter

Table 5.9: Data pages, overview

5.4.3 Measured and calculated data

Key	Display	Data
scroll 	OPERATIONAL MEASURED DATA	Headline
	MEASURED CURRENT IW1 L1 ....A	Actual measuring value of the phase current L1 of winding 1 in A
	MEASURED CURRENT IW1 L2 ....A	corresponding to L2
	MEASURED CURRENT IW1 L3 ....A	corresponding to L3
...	etc.	Phase current in A (all phases, all windings) calculated difference current (Idiff) ❶ calculated stabilising current (Irestr) ❶ calculated stab. factor (harm restr.)

Table 5.10: Operational measured data

❶ related to the transformer nominal current

5.4.4 FAULT Recorder

Key	Display	Value		
scroll 	*FAULT RECORDER** ******DATA******		Headline	
	FAULT RECORDER REGISTER (0)	 see below	Record 0 (last trip)	Trip number date/time trip reason, all stored data
	FAULT RECORDER REGISTER (1)		Record 1 (last trip but one)	Trip number date/time trip reason, all stored data
	for all existing registers		Record n in chrono-logical order	Trip number date/time trip reason, all stored data

Table 5.11: Fault-Recorder

The display shows „END OF DATA“ at the end of the list or if no trips are stored.

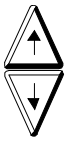
Key	Display	Value
next value 	FAULT RECORDER REGISTER (0)	Headline of the last trip (e.g.)
	FAULT NUMBER Nr. XXXX	Trip number
	FAULT EVENT XXXXX XXXXX	Reason of the trip
	FAULT DATE xx.xx.xx	Date of trip
	FAULT TIME xx:xx:xx:xxx	Time of trip
	FAULT CURRENT W1 L1: xxx A	Current L1 of winding 1 in A
	etc.	corresponding for all stored data

Table 5.12: Data of a fault recorder

5.4.5 EVENT-Recorder

Key	Display	Value		
Scroll 	*EVENT RECORDER* ******DATA******		headline	
	EVENT Nr: 0	 see below	Event 0	event message date/time of the last event
	EVENT Nr: 1		Event 1	event message date/time of the last trip but one (previous)
	corresponding to all stored events		Event n	event message date/time in chronological order

Table 5.13: Event-Recorder

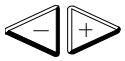
Key	Display	Value	
next value 	EVENT NUMBER (1)	Event number and event message	e.g. last event
	EVENT DATE: 01.01.90	Date of event	
	EVENT TIME: 12:23:34,123	Time of event	

Table 5.14: Message and time/date

5.4.6 Statistic data

Key	Display	Value
next value 	***STATISTIC**** ******DATA******	Headline
	TOTAL RUN TIME ... h	MRD1 Operating hours
	TOTAL NUMBER OF TRIPS: ...	Trip counter
	TOTAL NUMBER OF ALARMS: ...	Alarm counter

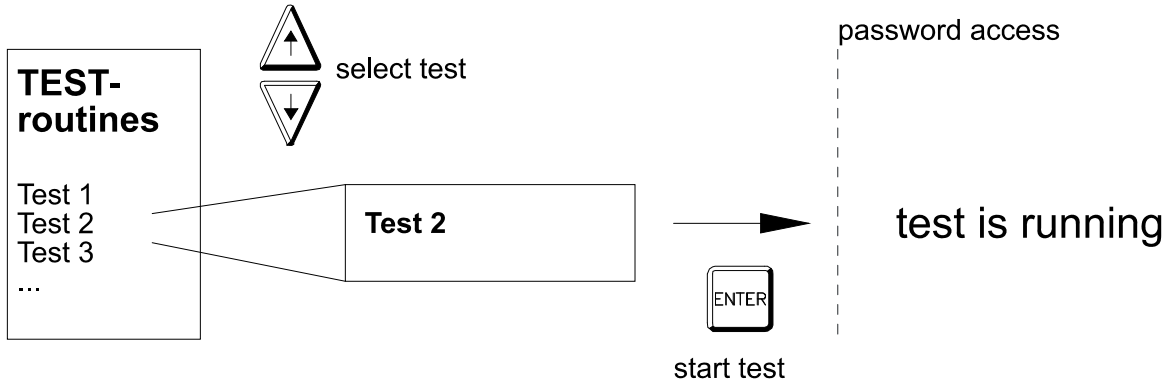
Table 5.15: Statistic data

Note
This statistic counters can not be resetted.

5.5 TEST-routines page (Self-test)

5.5.1 Page selection

Page select	Display
	*INTERNAL TEST** ****ROUTINES****



5.5.2 Overview

Key	Test		Description	execute
scroll 	*INTERNAL TEST** ****ROUTINES****		Headline	
	VERSION:xxx-x.xx DATE: XX.XX.XX		Display of version and date of the software	only display
	LED FUNCTION SELF TEST	Test	Test of the LED's: all LED's will be illuminated green and red for two seconds (no password needed)	ENTER
	OUTPUT RELAY SELFTEST	Test	Test of the output relays: IMPORTANT: all relays will be energised in a 1 s interval. The self test relay keeps off for the duration of the test. After the test all relays will be set to the state before.	ENTER ❶
	PROGRAMM DATA CHECKSUM TEST	Test	Memory/program test: This routine will test the memory and the program by calculating a checksum.	ENTER

Table 5.16: Implemented test routines

❶ NOTE: Password is needed, because the protection function is disabled during the test!

5.6 Parameter programming help

This chapter is a step by step help how to enter the first specific settings into the MRD1 by key-board. For more information about the parameter and its set-ting ranges see chapters: PARAMETER-pages and SYSTEM settings.

	Step	Key
1	select PARAMETER-page in EDIT-mode	PARA long
2	if necessary: select the set No. to edit	− +
3	confirm selection (set will be loaded in EDIT memory)	ENTER
4	leaf to first parameter page	PARA
5	scroll to the first line of this page (first parameter)	
6	if necessary: change displayed value	− +
		on first modification: enter password
		For bit-wise parameter like system-parameter “Group Address” press [□] shortly
7	scroll to next line (second parameter)	there is no need to confirm the modification of step 6 with a separately ENTER press.
8	if necessary: change displayed value	repeat step 6 and 7 as long as needed
9	leaf to next page	PARA continue at step 5

Other operations	Key
finish working and store all modifications (EDIT-memory will be copied back to parameter memory)	ENTER long
abandon working and refuse all modifications (no storing)	RESET long
cancel modification on the displayed parameter and reset to old value. (if LED MODIFIED illuminated)	RESET short
edit another parameter set	finish with ENTER long or RESET long and continue on step 1

Note
There is no need to confirm any modification by pressing ENTER. All modifications are temporarily stored in the edit memory when scrolling with up/down keys. When pressing ENTER long all modifications in the edit memory will be stored in the parameter set memory after an ensurance request.

6. Relay Tests

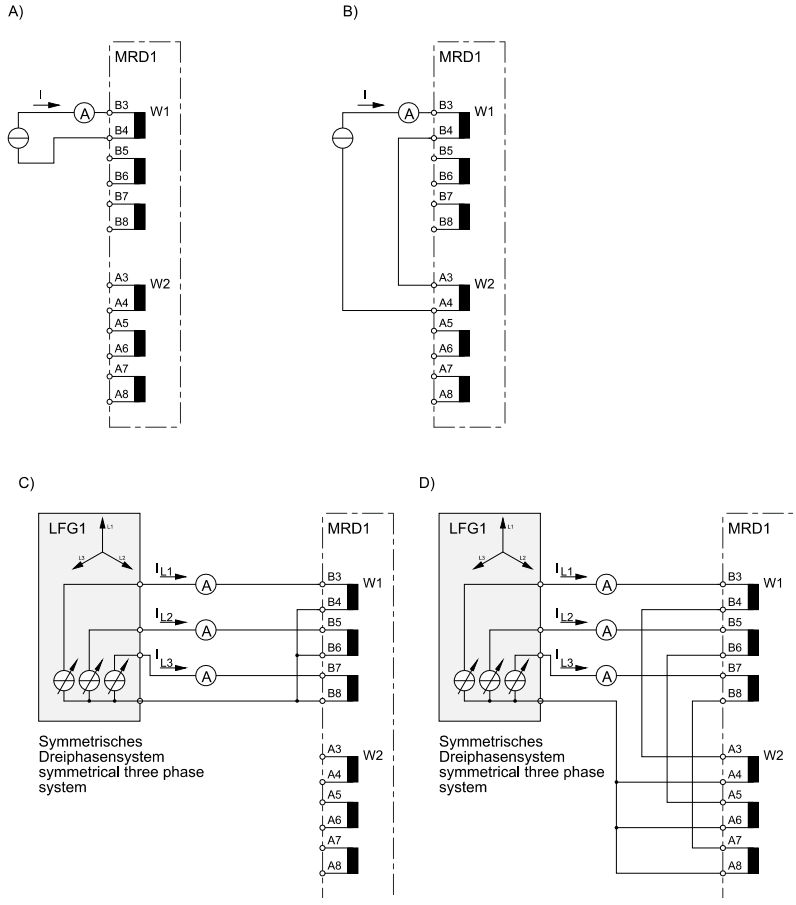
For testing the MRD1 the following has to be taken into account:
The test current source must supply a current free of harmonics. Should this not be the case, measuring errors may result from this if the reference am-meter used is an RMS instrument (which is common practice).

Test circuits for differential current I_{diff} and stabilizing current I_s:

The rated value indication for differential current and stabilizing current can be gathered from the following table. Test current I should be in compliance with the transformer nominal current.

	A	B	C	D
I_{diff}	2/3 × I	0	1× In	0
I_s	0	2/3 × I	0	1 × In

Value indications dependent on the test circuit used



NOTE for relay tests:

- Stated accuracies apply to rated values
- Currents must be free of harmonics
- When a three-phase connection is used for the test, the current must form a symmetric system
- Parameters W1 CT connection and W2 CT connection must be in normal position
- Rated data parameters must be adjusted for a transformer of vector group Yy0
- The settings of the primary nominal current of the CTs and the nominal voltages for all windings must be the equal (transmission ratio 1:1).
- LFG = Woodward-Power Function Generator

7. Commissioning

7.1 Check list

Check	Remark	ok.
Safety Measures	Observe relevant safety regulations	
Aux. voltage range	Prior to connection it has to be checked whether existing aux. voltage is within the permissible range for MRD1	
Rated system data	Secondary currents of CTs provided in the system have to be in compliance with rated currents of the MRD1 (1 A or 5A) in the respective winding	
Connection	Check MRD1 for correct connection in the switchboard	
Entry of rated system data	Has all rated system data correctly been programmed ? Are the indices of the vector group setting Are the CTs connected normal or revers	
Setting of parameters for protection	Have all parameters for protection correctly been programmed ?	
Reset time	Are the reset times set to all output relays?	
Selection of work parameter set	Has the right parameter set been selected as working set?	
Protection function	Does LED SELF-TEST light up green and is Selftest relay energised ?	
Device tests	Selftest routines - Lamptest - Test of the output relays - Checksum test - Test of the working parameter set in OFFLINE TEST mode	

7.2 CT connection

The right polarity of the CT is very important and so when the MRD1 is initially connected this has to be checked carefully. Reverse polarity at even one CT only is likely to cause trip errors. Whether connection of the MRD1 is correct can roughly be seen from the differential current indication, provided the object to be protected operates trouble free. To check the correct CT connection, firstly the MRD1 should be operated at the object to be protected in OFFLINE TEST mode.

Important Note:
In this operational mode, the object to be protected must have a sufficient back-up protection. Furthermore it is assumed that the supervised component is not faulty and all parameters are correct. When in OFFLINE TEST mode it is ensured that a CT with perhaps reverse polarity does not cause an unintended trip.

Now the supervised component can be switched on while observing and interpreting the differential current indication. Interpretation of the indicated value is always subject to local conditions (operation related fault current) and can here only be described generally. The test circuits described in chapter 6 can be of help for fault identification.

The following table can be considered as reference when checking the connection. The stated values are based on symmetrical load $I=I_{L1}=I_{L2}=I_{L3}$. Where loads are involved which are not 100 % symmetrical, the observed values may deviate from the table. All figures are to be understood as approximate values and are a multiple of the load current.

Case		Differential current I_{diff} / I_n	Through current I_s / I_n
1	All CTs are correctly connected	0	1
2	One CT connect. with rev. polarity	1.33	0.66
3	Two CTs connect. with rev. polarity	2.0	0
4	Three CTs connect. with rev. polarity	2.0	0

Table 7.1: Recommended values for differential current and stabilizing current indication at the MRD1 with assumed faultless components and different numbers of CTs connected

1) Correct connection :
All CTs are correctly connected. This case is identical to that where all CTs are wrongly connected or the direction of energy flow is reverse. But changes at the CT connection are not necessary.

2) One CT wrongly connected
In this case the current balance is out of place. There is about 1/3 x I through current missing and the MRD1 recognizes 2/3 x I differential current instead. Input and output currents in the phase with wrong polarity are interpreted by the MRD1 that way as if 1/3 x I each flow into the faulty phase. Thus the resulting differential current is 2/3 x I.

3/4) Two or three CTs wrongly connected
In these two cases the indication does not distinguish between two or three CTs wrongly connected because of the internal calculation. If three CTs are wrongly connected, the respective fault can be eliminated by changing parameter "CT Connection" without having to change the wiring.

For locating all other faults either the complete CT wiring has to be checked after disconnection of the component or the reversed connections to be traced by means of a suitable test current source.

8. Technical Data

8.1 MRD - Transformer Differential Protection Relay

Common data

Rated frequency:	50 Hz, 60 Hz
Display:	LED and LCD-Display (2 x 16 digits)

Voltage supply

Aux. voltage ranges	Range	Rated voltage	Range
DC	L	24 V	19-40 V
	M	48/60 V	38-72 V
	H	110/125/220 V	88-264 V
AC	on request		

Power consumption	stand-by	13 VA
	maximum	16 VA

Permissible interruption of the auxiliary voltage supply: max. 50 ms (at rated voltage)

Input CT
a) Phase current CT

Rated current I_N	1 A or 5 A
Power consumption in current path:	at I_N: < 0.1 VA

Thermal withstand capability in current circuit:
250 x I_N (VDE 435, T303),
dynamical current withstand (half-wave)
100 x I_N for 1 s
30 x I_N for 10 s
4 x I_N continuously (VDE 435, T303)

linear range	Low-Range	0.05...2 x I_N
	High-Range	2...64 x I_N

Range setting	automatical
Resolution	12 Bit per range
Failure	< 0.1 % at I_N < 0.1 % at 64 x I_N

Accuracy (related to the measured value)	0.05xI_N	<2%
	1xI_N	<1%
	15xI_N	<2%

Operating time	25-30 ms
CT requirements:	recommended min. requirements to exposit device accuracy 5P20

Function- and signal inputs

Digital inputs

Thermal withstand capability	max. 310 V DC, 265 V AC
Coupling	galvanically isolated with common return wire
High-level	U > 18 V DC/AC
Low-level	U < 12 V DC/AC

Reset and blocking input

Thermal withstand capability	max. 310 V DC, 265 V AC
Coupling	galvanically isolated with common return wire (D8)
High-level	U > 18 V DC/AC function activated
Low-level	U < 12 V DC/AC Function not activated

Communication serial interface RS232C

Data transmission rate	9600 Baud
Connection	9-pin D-sub plug
Insulation voltages	DIN 19244 part 3 (IEC 870-3):

RS485

Data transmission rate	9600 Baud
Connection	plugged terminals (RXT/TXD-P, RXT/TXD-N, Signal Ground, PE)
Insulation voltages	DIN 19244 part 3 (IEC 870-3):

Output relay

Contact class	IIB DIN VDE 435 part 120
max. breaking voltage:	250 VAC/300 VDC
max. closing power:	1500 VA (250 V)
max. breaking power:	11 VA (220 VDC) at L/R = 40 ms
max. rating making current:	6 A
Short circuit current:	20A / 16 ms
Rated inrush current load:	64A
Returning time:	20 ms (without minimum operating time!)
Contact material:	AgCdO
Contact life span:	electrical: $2x10^5$ switching points at 220V AC/6A mechanical: $30x10^6$ switching points
Rated insulation voltage:	600 VAC (450V DC/380 VAC) (VDE 435, T303) Air- and creeping distance VDE 0160
Insulation coordination:	pollution degree 3 for terminals, pollution degree 2 for the electronic

Temperature range for

Operation:	-5°C to +55°C (within class 3K3)
Transport:	-25°C to +70°C (class 1K4)
Storage:	-25°C to +70°C(class 2K3)

Insulation test voltage, inputs and outputs between themselves and to the relay frame as per IEC 255-5:	2.0 kV (RMS)/50 Hz; 1 min.
Impulse test voltage, inputs and outputs between themselves and to the relay frame as per IEC 255-5:	5 kV; 1.2/50 □s, 0.5 J
High frequency interference test voltage, inputs and outputs between themselves and to the relay frame as per IEC 255-22-1:	2.5 kV/1 MHz
Electrical discharge (ESD) test as per VDE 0843, part 2 IEC 77B(CO)21; IEC 255-22-2:	8 kV
Electrical fast transient (Burst) test as per DIN VDE 0843, part 4 IEC 77B(CO)22; IEC 255-22-4:	4 kV/2.5 kHz, 15 ms
Radio interference suppression test as per EN 55011:	limit value class B
Radiated electromagnetic field test as per ENV 50140:	electric field strength: 10 V/m
Power frequency magnetic field immunity test	100 A/m continuous
IEC 1000-4-8 (EN 61000-4-8):	1000 A/m 3 s
Surge immunity test (asymmetrical / symmetrical) IEC 1000-4-5 (EN 6100-4-5):	4 kV

Mechanical test:

Shock:	Class 1 as per DIN IEC 255 T 21-2
Vibration:	Class 1 as per DIN IEC 255 T 21-1
Degree of protection:	Front IP40
Overvoltage class:	III
Setting ranges:	s. tables chapter 5 and 10

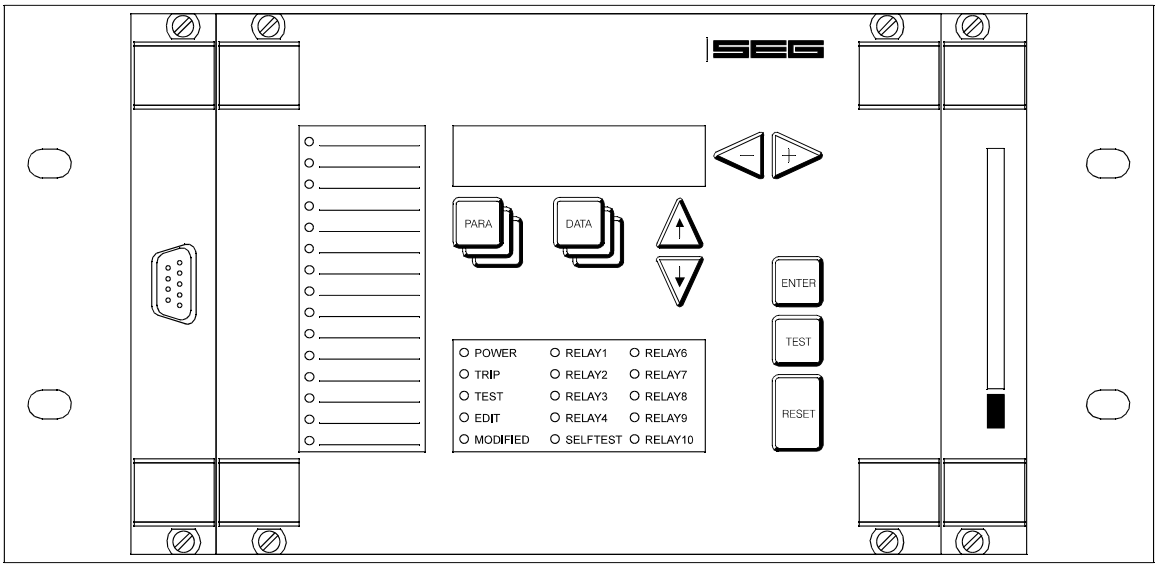
9. Tables/Connection diagrams

9.1 Possible event messages

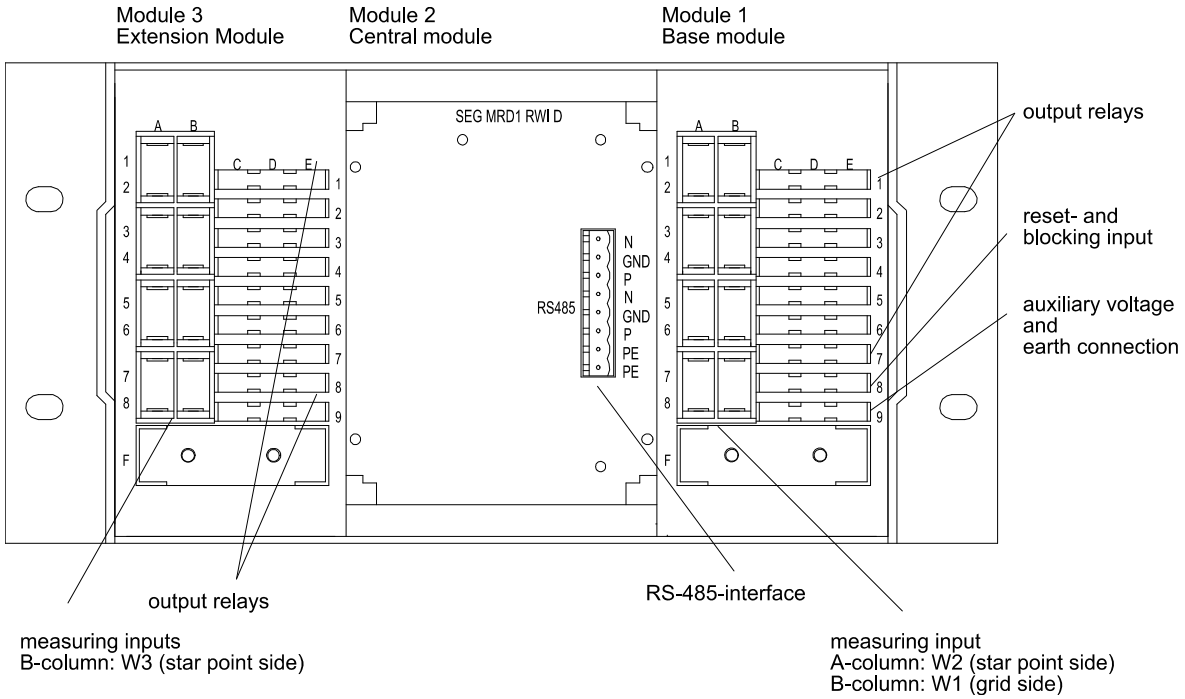
Display	Event
change to pset x	Parameterset x is selected to active working set
UART paramet. on	Parameter setting via interface is active
UART paramet. off	Parameter setting via interface is not permitted
deflt. para. load	Default parameter settings reloaded
manual reset	Manual DEVICE RESET is performed
external reset	External DEVICE RESET is performed
ser. port reset	Software DEVICE RESET is performed
ext. block begin	Blocking feature activated by external input
ext. block end	End of blocking
Idiff> tripped	Difference current trip
Idiff> released	Difference current trip released
Idiff>> tripped	Difference current high-set trip
Idiff>> released	Difference current high-set trip released
relays operated	Change output relay state (except Selftest relay)
ST-relay energ.	Selftest relay is energised
ST-relay release	Selftest supervision relay is de-energised
LED-Test done	Lamp test is finished
relay-test done	Test of the output is finished
self-test done	Self-test is finished
offline mode en	Offline-Test-Mode is active
offline mode dis	Offline-Test-Mode is not active
fault rec clear	Fault recorder is cleared
event rec clear	Event recorder is cleared
System start	System start/device initialisation
old time setting	Time/date setting was changed (old time)
new time setting	Time/date setting was changed (new time)

9.2 View

Front plate:



Rear panel



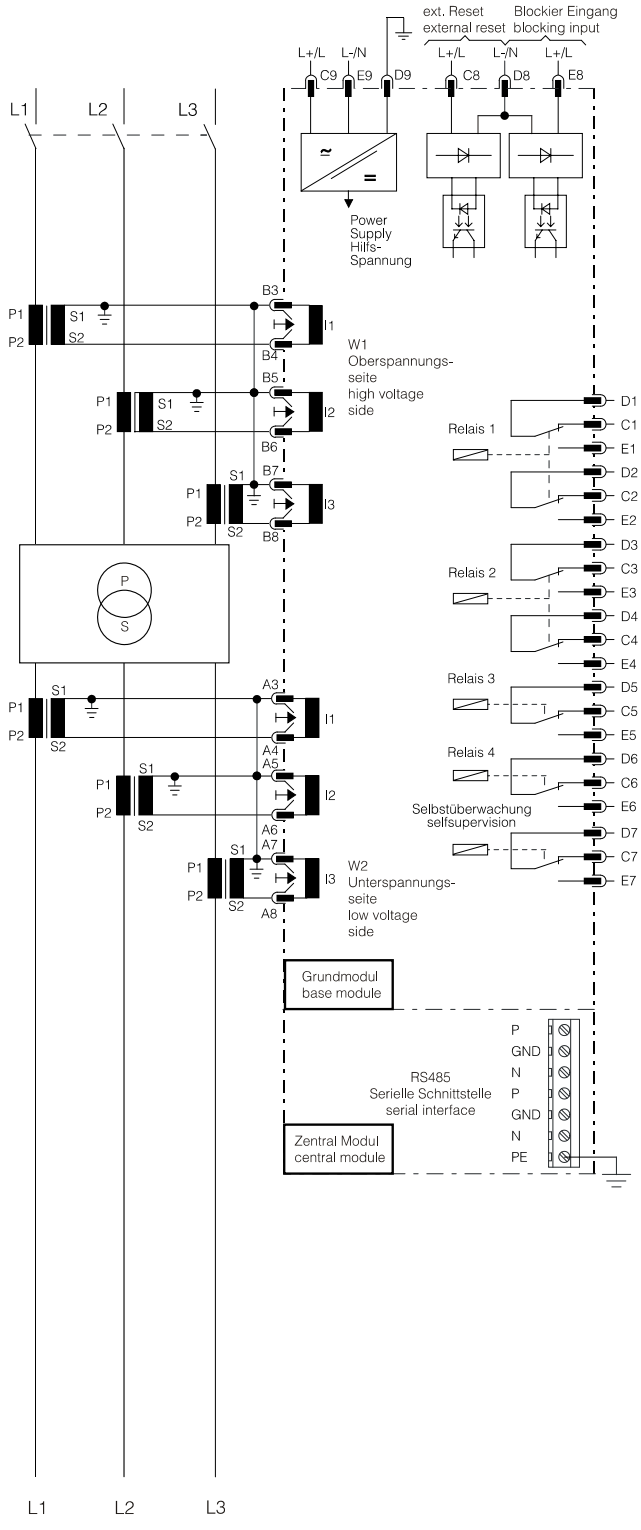


Table 9.1.: Connection diagram MRD1-T2 (2-winding transformer)

The System W1 is assigned to the high voltage side.

Important Note.
For perfect functioning of the rush stabilization system it is essential that the MRD-T is connected in the correct phase sequence, i.e. that there is a positive rotating field. Refer also to page 11.

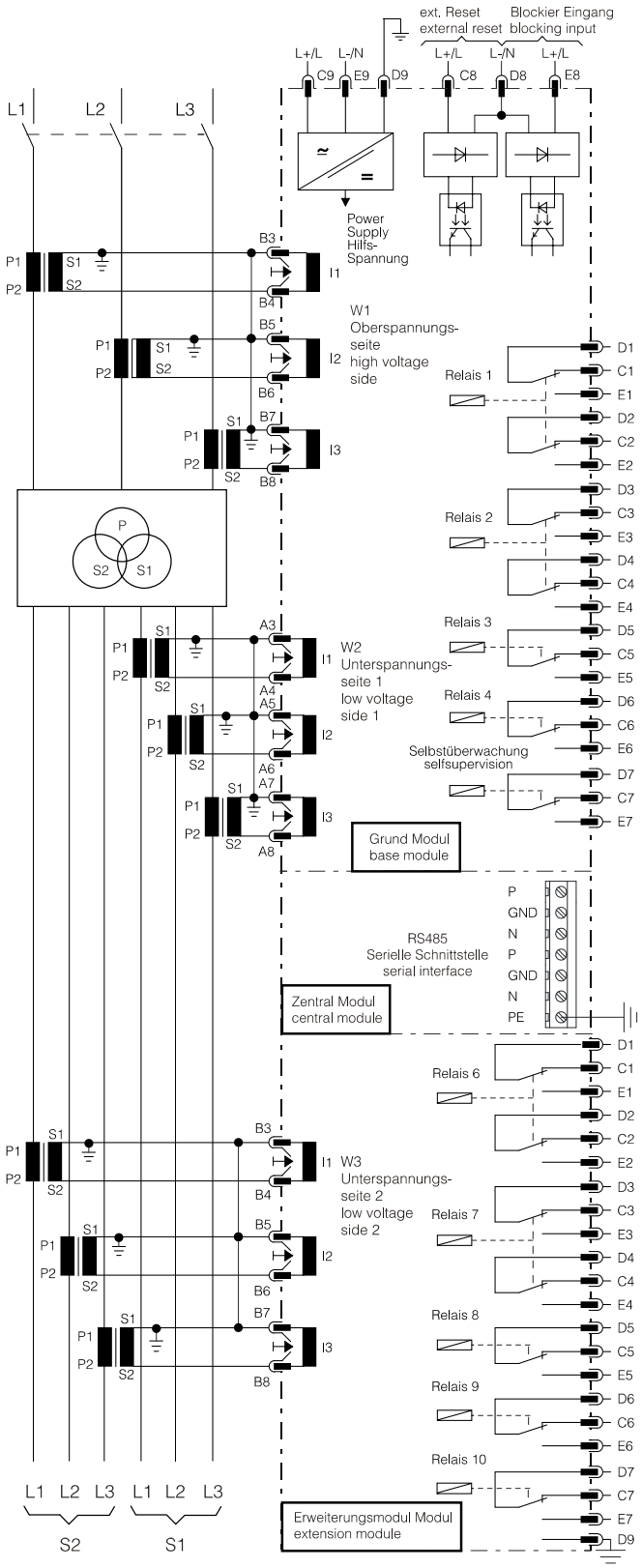


Figure 9.1.: Connection diagram MRD1-T3 (3-winding transformer)

The System W1 is assigned to the high voltage side. If the voltages in the systems W2 and W3 are different, the system W3 must be assigned to the lower volt-age level.

Technical data subject to change without notice!

10. Order form

Transformer – differential protection relay			***MRD1-***						**A**
2 winding transformers				**T2**					
3 winding transformers				**T3**					
Rated current	primary	1 A			**1**				
		5 A			**5**				
	secondary	1 A				**1**			
		5 A				**5**			
	tertiary	1 A	Information only required for T3 type				**1**		
		5 A					**5**		
DC-auxiliary voltage 24 V (19 to 40 V DC)								**L**	
48 V/60 V (38 to 72 V DC)								**M**	
110 V/125 V/220 V (88 to 264 V DC)								**H**	
Housing (42TE) additional MRD1-T2-HTL-3F42 for T2+G resp. MRD1-T3-HTL-3F42 for T3 available ❶									

❶ necessary rack for the single components

Note
Normally the MRD1 is provided with one type of current transformer only (1A or 5A). Equipment with two CTs of different current ratings in one relay only on request.

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