



## **MRU3-2 – Voltage relay with evaluation of Symmetrical components**

**(September 2008)**

**Manual MRU3-2 (Revision New)**

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# 1. Introduction and application

The MRU3-2 is a relay for voltage supervision with universal application, it protects the three-phase network against voltage unbalance or earth faults in isolated networks. Beside the pure rms value measurement of the line voltage the MRU3-2 evaluates the symmetrical components (positive-, negative- and zero sequence system). By evaluating these components relay MRU3-2 can detect the phase sequence, voltage unbalance and earth-faults.

## Important:

For additional common data of all MR-relays please refer to technical description "MR - Digital Multifunctional Relays".

# 2. Features and characteristics

- Microprocessor technology with watchdog,
- digital filtering of the measured values by using discrete Fourier analysis to suppress higher harmonics and d.c. components induced by faults or system operations,
- analog low pass filter,
- two parameter sets,
- voltage supervision each with two step under-/ and overvoltage detection,
- voltage supervision for each phase separately
- completely independent time settings for voltage supervision
- separate tripping elements for over- and under-voltage and positive sequence system
- overvoltage detection in negative- and zero sequence system,
- display of measuring values of the line voltages and system voltages  $U_0$ ,  $U_1$  and  $U_2$  as rms values (zero , positive- and negative sequence system)  
alternatively connection and measurement of the phase-to-neutral or phase-to-phase voltage
- display of the phase sequence,
- display of all measuring values and setting parameters for normal operation as well as tripping via a alphanumeric display and LEDs,
- display of measuring values as primary quantities,
- tripping memory for all line voltages and the voltages of the symmetrical components,
- storage and display of tripping values in a fault memory (voltage-failure safe),
- recording of up to eight fault occurrences with time stamp
- for blocking the individual functions by the external blocking input, parameters can be set according to requirement,
- suppression of indication after an activation (LED flash),
- free assignment for output relays,
- display of date and time,
- in compliance with VDE 0435, part 303 and IEC 255,
- mains frequency is adjustable to 50 Hz or 60 Hz or variable from 40 - 70 Hz,
- RS485 interface for communication with master systems
- serial data exchange via RS485 interface possible; alternatively with SEG RS485 Pro-Open Data Protocol or Modbus Protocol.

# 3. Design

## 3.1 Connections

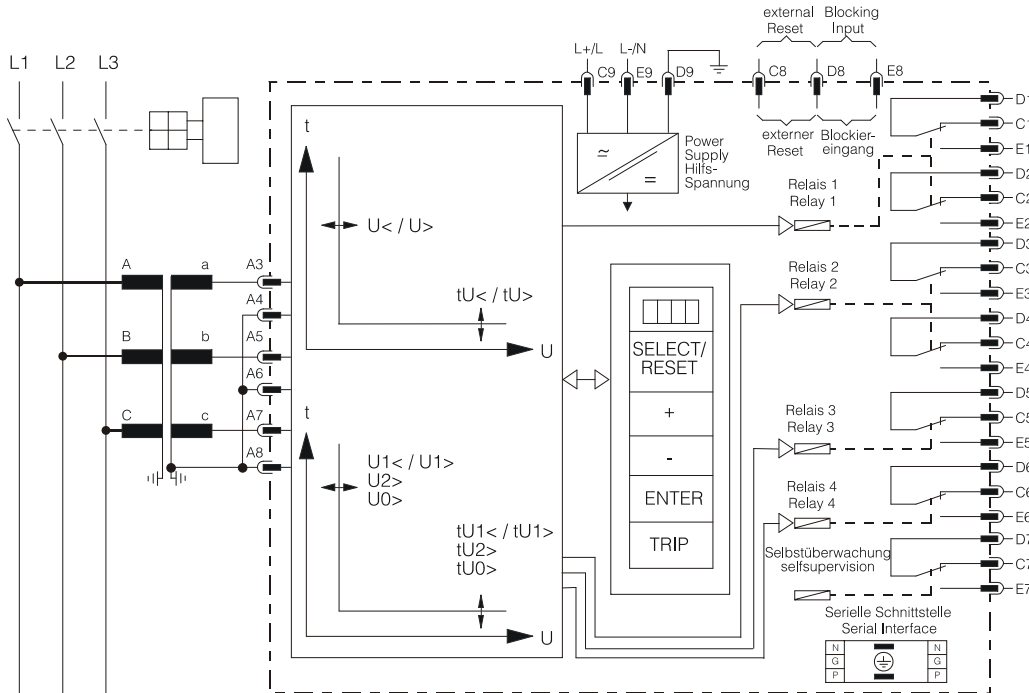


Figure 3.1: Star connection of the voltage transformers

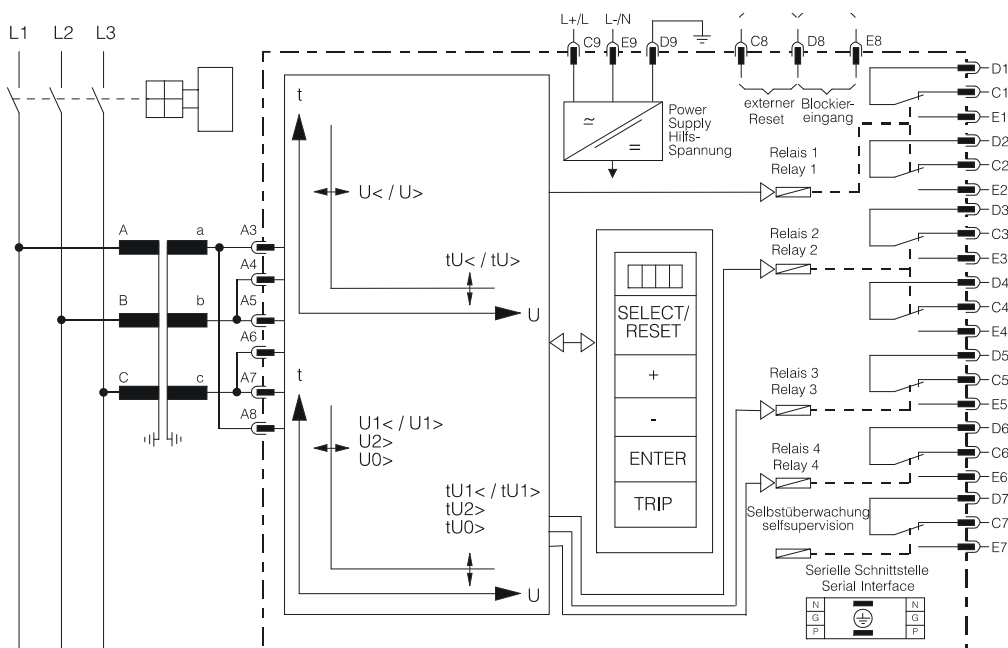


Figure 3.2: Delta connection of the voltage transformers

**Attention!**

If the input transformers are connected in delta circuit no detection of zero phase sequence (U0) is possible.

### 3.1.1 Analog input circuits

The analog input voltages are galvanic ally decoupled by the input transformers of the device, then filtered and finally fed to the analog digital converter. Depending upon the demands the MRU3-2 can be connected directly to the mains or via external voltage transformers in star- or delta connection. The priority should be given to the star connection, because of the ability to detect a zero sequence system.

### 3.1.2 Blocking input

When the voltage, which must be in the admissible range of the auxiliary voltage, is connected to terminals D8/E8, the following tripping functions are blocked undelayed:

- Under voltage  $U</U<<$
- Over voltage  $U>/U>>$
- positive sequence system undervoltage  $U1<$
- positive sequence system overvoltage  $U1>$
- negative sequence system overvoltage  $U2>$
- zero sequence system overvoltage  $U0>$

Blocking can be freely selected via the allocation mode. (refer to chapter 5.9).

Input D8 is the ground (L- or N) for blocking and the external reset. The blocked functions are again released undelayed when the auxiliary voltage is disconnected from the terminals D8/E8.

The above mentioned functions remain blocked for 2 s after the supply voltage had been applied.

### 3.1.3 External reset input

Refer to chapter 5.9.2

### 3.1.4 Output relays

The MRU3-2 is equipped with 5 output relays.

- Relay 1; C1, D1, E1 and C2, D2, E2
- Relay 2; C3, D3, E3 and C4, D4, E4
- Relay 3; C5, D5, E5
- Relay 4; C6, D6, E6
- Relay 5; Signal self-supervision (internal failure of the unit ) C7, D7, E7

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

### 3.1.5 Fault recorder

The MRU3-2 has a fault value recorder which re-cords the measured analog values as instantaneous values.

The instantaneous values

UL1; UL2; UL3 for star connection or U12; U23; U31 for delta connection are scanned at a raster of 1.25 ms (at 50 Hz) and 1.041 ms (at 60 Hz) and saved in a cyclic buffer.

#### Storage division

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

#### No writing over

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

#### Writing over

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

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

Memory space 6 to 4 is occupied.

Memory space 5 is currently being written in

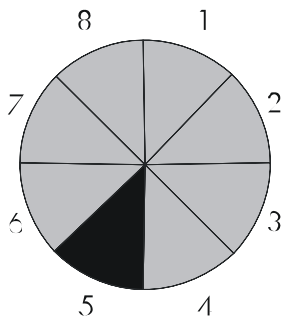


Figure 3.3: Division of the memory into 8 segments, for example



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

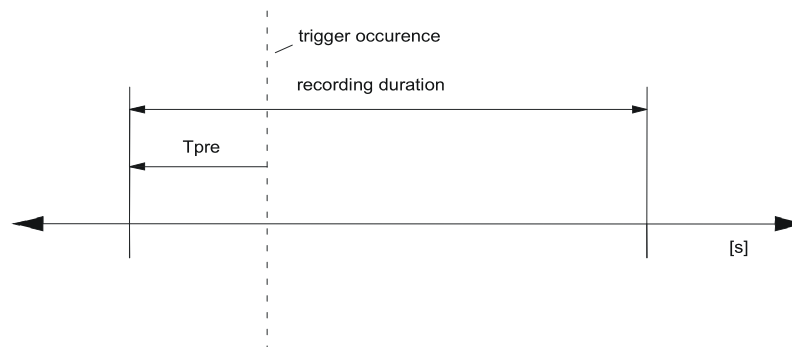


Figure 3.4: Basic set-up of the fault recorder

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

### 3.1.6 Parameter settings

#### System parameters

$U_{\text{prim}}/U_{\text{sek}}$	Primary/secondary measured value display of the voltage transformers
D/Y	Selection of switching groups
$f_N$	Rated frequency
LED-Flash	Suppression of LED flashing after activation
P2/FR	Parameter switch/external trigger for the fault recorder

#### Protection parameters

1/3	1-phase or 3-phase U</U> tripping
U<	Pickup value for under voltage
$t_{U<}$	Trip value for under voltage low set element
U<<	Pickup value for under voltage
$t_{U<<}$	Trip value for under voltage high set element
U>	Pickup value for overvoltage
$t_{U>}$	Trip value for overvoltage low set element
U>>	Pickup value for overvoltage
$t_{U>>}$	Trip value for overvoltage high set element
U1<	Pick-up value for under voltage in positive-phase sequence system
$t_{U1<}$	Trip value for under voltage in positive phase sequence system
U1>	Pick-up value for overvoltage in positive phase sequence system
$t_{U1>}$	Trip value for overvoltage in positive phase sequence system
U2>	Pick-up value for overvoltage in negative phase sequence system
$t_{U2>}$	Trip value for overvoltage in negative phase sequence system
U0>	Pick-up value for overvoltage in zero phase sequence system
$t_{U0>}$	Trip value for overvoltage in zero-phase sequence system

**Parameters for the fault recorder**

FR	Number of disturbance events
FR	Trigger events
FR	Pre-trigger time $T_{vor}$

## Date and time

Year	Y = 00
Month	M = 04
Day	D = 18
Hour	h = 07
Minute	m = 59
Second	s = 23

**Additional functions**

Blocking function  
Relay configuration  
Fault memory

**3.2 Display**

The display is used for indicating all setting- and measuring values. The actual measuring values as also the fault values can be indicated. In faultless operation the indicated value of the normal operation can be called by pressing the <SELECT> and <ENTER> pushbuttons.

After tripping the display changes into the tripping mode from where fault data can be called.

**3.3 LEDs**

LEDs L1, L2, L3, U1 and U2 left from the display are two-colored and indicate the measured quantities; green for measuring values and red for fault indication.

LED U0 lights yellow which normally indicates (relay not tripped) that the measuring value of the zero sequence system and in case of tripping the tripping value of the zero sequence system is shown in the display.

The LED marked with the letters RS lights up during setting of the slave address for the serial interface (RS 485) of the unit.

The LED marked with "FR" lights up during parameter setting at the fault recorder. When LED • lights up, date and time are displayed. LED "PS" indicates the phase sequence.

The 9 LEDs below the <SELECT/RESET> pushbutton signalize the parameter of the individual tripping elements. In case of tripping they indicate, together with the upper LEDs, the respective kind of fault.

A permanent red light indicates tripping. When the tripping delay has not elapsed the LEDs of the corresponding combination (at pickup) are flashing.

If one of the limit values is exceeded for only a short time before the set tripping delay is not expired, the corresponding LED combination flashes. This flashing is shorter than for warning. This pickup warning signal can be switched off with a reset. This activation signal can be shut-down with the "Reset" key (refer to chapter 5.9.2) or suppressed by the FLASH/NO\_FLASH function. The active parameter set is indicated by LED "P2". LED D/Y lights up during parameter setting for the interlinking of the input voltage CTs.

### 3.4 Front plate

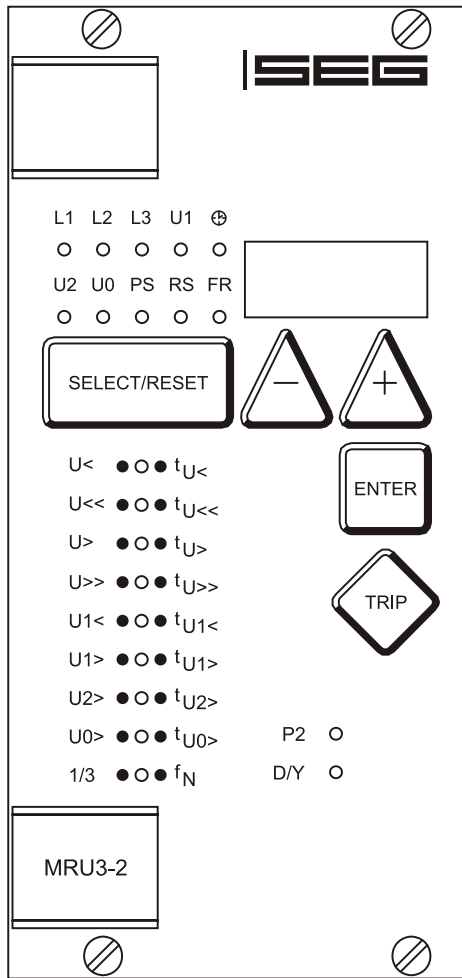


Figure 3.5: Front plate MRU3-2

## 4. Working principle

### 4.1 Analog circuits

The input voltages are galvanically insulated by the input transformers. 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 with a sampling frequency of  $16 \times f_N$ , namely, a sampling rate of 1.25 ms for every measuring quantity, at 50 Hz.

### 4.2 Digital circuits

The essential part of the MRU3-2 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 voltage in order to detect a possible fault situation in the protected object.

For the calculation of the voltage value an efficient digital filter based on the Fourier Transformation (DFFT - Discrete Fast Fourier Transformation) is applied to suppress high frequency harmonics and d.c. components caused by fault-induced transients or other system disturbances. The microprocessor continuously compares the measured values with the preset thresholds stored in the parameter memory (EEPROM). If a fault occurs an alarm is given and after the set tripping 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 Selection of star or delta connection

All six connections of the input voltage transformers are led to screw terminals. The nominal voltage of the device is equal to the nominal voltage of the input transformers. Dependent on the application the input transformers can be connected in either delta or star. The connection for the phase-to-phase voltage is the delta connection. In star connection the measuring voltage is reduced by  $1/\sqrt{3}$ . During parameter setting the connection configuration either Y or  $\Delta$  has to be adjusted.

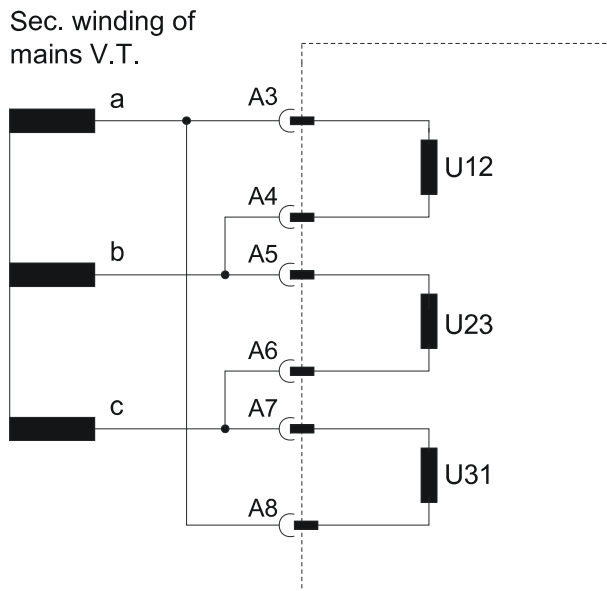


Figure 4.1: Input v.t.s in delta connection (D)

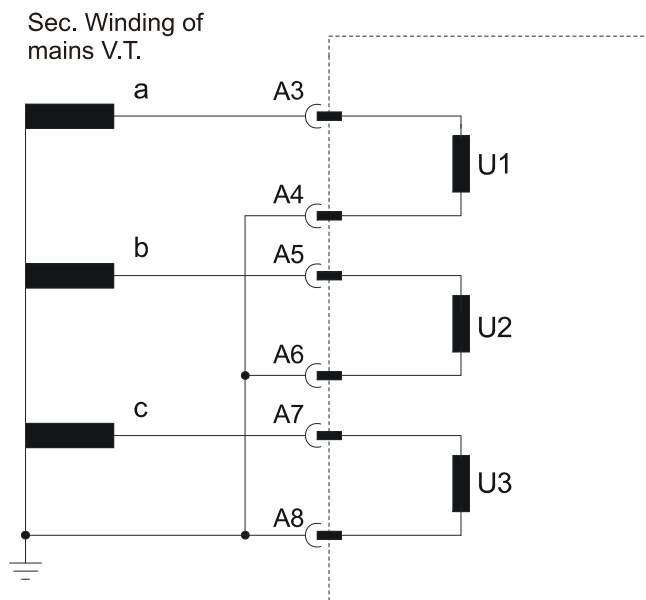


Figure 4.2: Input v.t.s in star connection (Y)

## 4.4 Voltage supervision

### 4.4.1 1-phase/3-phase supervision

The voltage relay MRU3-2 protects electrical generation systems, consumers and appliances in general against over- and/or under voltage. The re-lay is equipped with an independent, 2-step over- ( $U>$ ,  $U>>$ ) and under voltage supervision ( $U<$ ,  $U<<$ ) with separately adjustable tripping values and de-lay times. Voltage measuring is 3-phase. In this process there is a continuous comparison of the line conductor voltages in case of a delta connection and of the phase voltages in case of a star connection with the preset limit values.

With the MRU3-2 the highest voltage is always evaluated for overvoltage supervision and the lowest voltage for under voltage supervision.

A distinction is made between 1-phase and 3-phase tripping. (1/3 – Parameter)

With 1-phase tripping the voltages are evaluated as follows:

$U</U<</U</U>>$ : Activation cum tripping takes place if at least one phase has fallen short of the tripping value.

With 3-phase tripping the voltages are evaluated as follows:

$U<$ : Activation cum tripping takes place if **all three phases** have fallen short of the tripping value.

$U<<$ : Activation cum tripping takes place if **one phase** has fallen short of the tripping value.

$U>$ : Activation cum tripping takes place if **all three phases** have exceeded the tripping value.

$U>>$  Activation cum tripping takes place if **one phase** has exceeded the tripping value.

### 4.4.2 Principle of the voltage unbalance protection

The principle of this procedure is to detect faults which affect an asymmetry of the voltage vector.

A single-phase line interruption can for instance cause voltage unbalance in the mains which does not guarantee that the voltage will be zero in the faulty phase. Especially in higher impedance networks the missing phase can partly be rebuilt through running engines or transformers. A pure undervoltage protection cannot detect this condition, however, the rebuilt phase does not coincide with its old position in amount and phase. So an asymmetrical voltage vector system is formed.

In a compensated or isolated grid a single-phase earth fault will hardly cause a significant earth current. Because, however, the faulty phase takes on the earth potential the entire voltage vector system is shifted by the amount of the faulty phase and does not rotate anymore around the initial star point (earth). The relative position of the voltage vectors between each other is hereby not changed. Also this vector system is not symmetrical anymore in relation to the earth potential.

The MRU3-2 can detect such asymmetry.

### 4.4.3 Measuring principle

Any rotating three-phase system (original system) can be replaced by three symmetrical systems acc. to the method of the "symmetrical components", a positive sequence system, a negative sequence system and a zero sequence system.

#### Positive sequence system $U_1$ :

The rms value of the positive sequence system represents the component of the original system which is symmetrical and rotates in the positive direction acc. to its definition. A pure symmetrical voltage vector system consists only of its positive sequence system.

The residual voltage in the positive sequence system is calculated by:

$$U_1 = 1/3 | ( U_1 + a^1 U_2 + a^2 U_3 ) |$$

#### Negative sequence system $U_2$ :

The rms value of the negative sequence system describes the component of the vector system which rotates in negative direction. The rotating field, which rotates in the mathematical sense in the negative direction (so-called "left rotating field"), consists only of a negative sequence system. A measure for the size of the asymmetry of the original system represents the residual voltage in the negative sequence system.

The residual voltage in the negative sequence system is calculated as follows:

$$U_2 = 1/3 | ( U_1 + a^2 U_2 + a^1 U_3 ) |$$

#### Zero sequence system $U_0$ :

The zero sequence system describes the displacement of the vector star point from the reference star point. This reference star point is generally the earth potential.

The residual voltage in the zero sequence system is calculated as:

$$U_0 = 1/3 | ( U_1 + U_2 + U_3 ) |$$

#### Used variables:

(complex vectors are underlined>)

$U_1$	rms value vector of phase voltage L1
$U_2$	rms value vector of phase voltage L2
$U_3$	rms value vector of phase voltage L3
$U_0$	rms value of the zero sequence system
$U_1$	rms value of the negative sequence system
$U_2$	rms value of the positive sequence system
$a^1$	= $e^{i120^\circ}$ rotation operator for 120°
$a^2$	= $e^{i240^\circ}$ rotation operator for 240°

#### Explanation:

$a^2 U_2$  means:

Rotate the voltage vector  $U_2$  by 240° in positive direction (to the left).

#### 4.4.4 Negative sequence system of a symmetrical voltage system

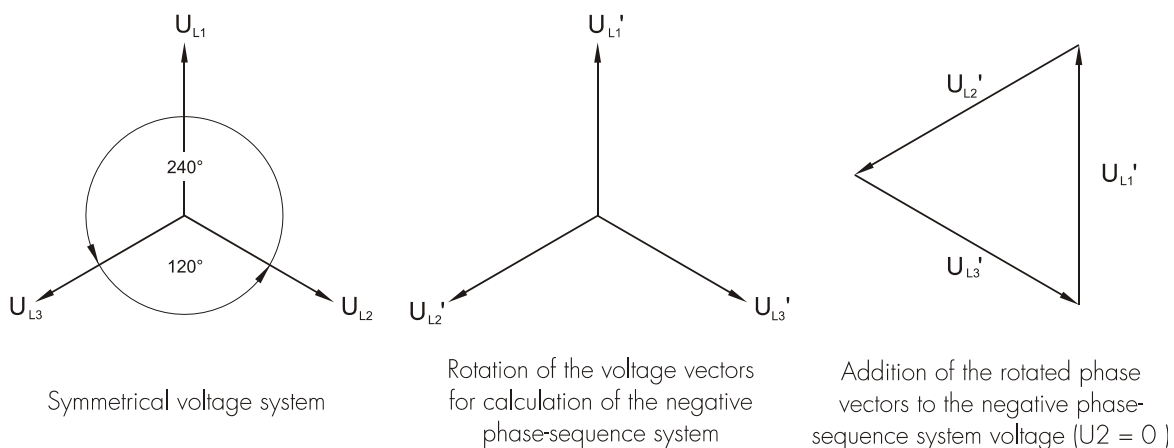


Figure 4.3: Graphical determination of the negative sequence system in a symmetrical system

Figure 4.3 shows a symmetrical vector system. As indicated in the calculation the MRU3-2 forms the negative sequence system. For this it rotates per software both voltage vectors  $U_2$  by  $240^\circ$  and  $U_3$  by  $120^\circ$  and adds them. Acc. to definition the result of the vector must be multiplied by  $1/3$ . In this example the sum equals zero. Conclusion: the source system is symmetrical.

#### 4.4.5 System with voltage unbalance

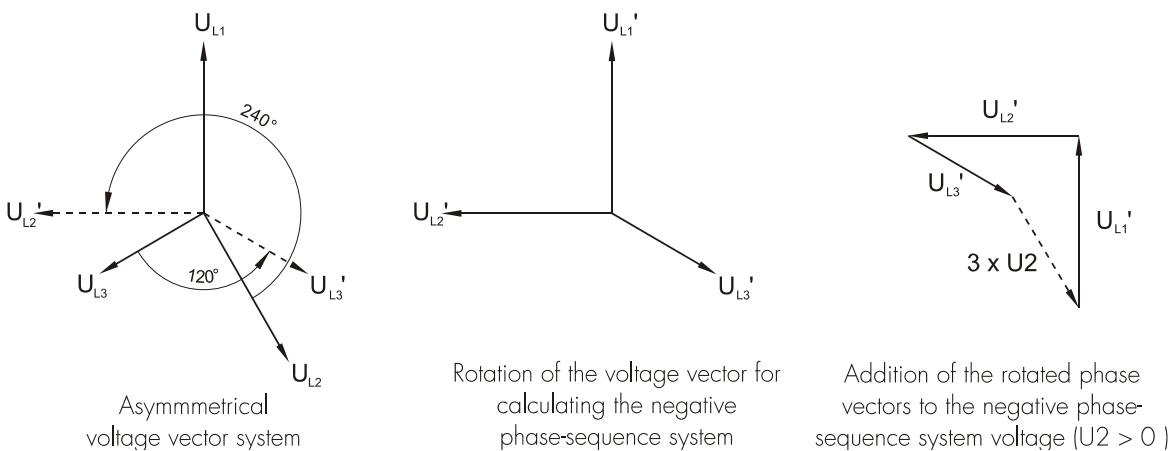


Figure 4.4: Graphical determination of the negative sequence system in an asymmetrical system

Figure 4.4 shows the voltage vectors of an asymmetrical grid. A residual negative sequence system voltage, which is not zero, is calculated in this example. Should this residual voltage exceed the set threshold, which is indicated as rms value, the relay trips after the preselected time delay. For the exact rotation of the current vectors by  $120^\circ$  or  $240^\circ$  the system frequency has to be precisely adjusted.



### 4.4.6 Zero sequence system

To decide whether a vector system is symmetrically, the point, the symmetry has to refer to, is always to be mentioned. Usually this point is the earth potential.

When an earth fault occurs in an isolated or compensated grid, it does not influence the relative position of the three voltage vectors to each other, mains operation can be maintained. The vector peak of the missing phase is forced on the earth potential. For an observer who takes the earth potential as reference, the star point shifts by the amount of the missing phase. For him the voltage vector system is not anymore symmetrical. The exact measure of the shifting results from replacing this system in symmetrical components in the developed zero sequence system.

**Note:**

Shall the relay evaluate the zero sequence system it is absolutely necessary that the voltage transformers and the MRU3-2 are wired in star connection. The star points must be earthed; furthermore the MRU2-2 must be set to Y-connection. In delta connection no zero sequence system evaluation is possible and thus no earth fault detection.

When only the phase-to-phase voltages are measured, the vector star point is not known, thus also the position of the star point in regard to the earth potential cannot be defined.

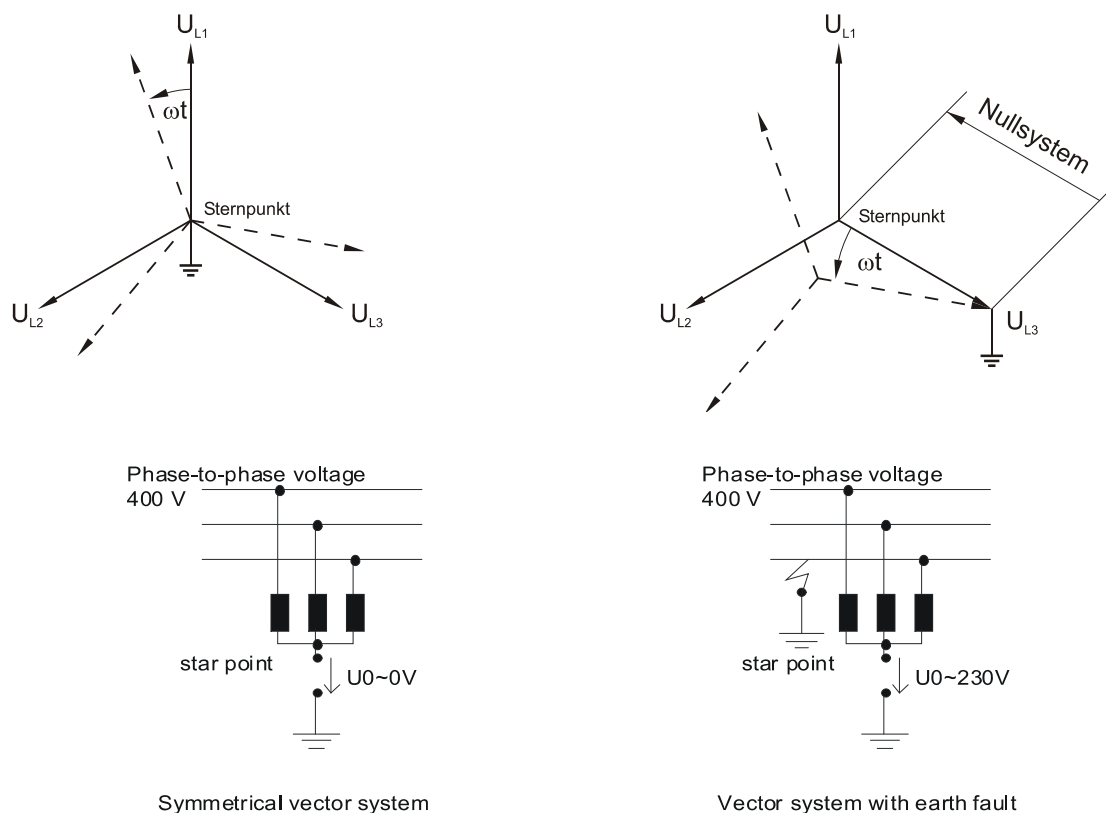


Figure 4.5: Zero point shifting after earth fault in the isolated grid

## 5. Operations and settings

### 5.1 Display

Function	Display shows	Pressed pushbutton	Corresponding LED
Normal operation	SEG		
Measured operating values	Actual measured value	<SELECT/RESET> one time for each value	L1, L2, L3, U1, U2, U0
Phasenfolge	123; 321		PS
Transformer ratio of the CT's	(SEK) 1.01-6500=prim	<SELECT/RESET><+><->	L1, L2, L3
Setting values Star/delta connection	Y/DELTA	<SELECT/RESET><+><->	D/Y
Mains frequency	f = 50 Hz, f = 60 Hz v = 50 Hz, v = 60 Hz	<SELECT/RESET><+><->	f <sub>N</sub>
Parameter switch/external trigger for the fault recorder	SET1, SET2, B_S2, R_S2, B_FR, R_FR, S2_FR	<SELECT/RESET><+><->	P2
Switch-over LED flash No LED flash	FLSH NOFL	<SELECT/RESET><+><->	
U</U> 1-phase/3-phase tripping	U</U>1/U</U>3	<SELECT/RESET><+><->	1/3
undervoltage (low set) tripping delay of low set element	Setting value in volt Setting value in seconds	<SELECT/RESET><+><-> one time for each value	U< t <sub>U&lt;</sub>
undervoltage (high set) tripping delay of high set element	Setting value in volt Setting value in seconds	<SELECT/RESET><+><-> one time for each value	U<< t <sub>U&lt;&lt;</sub>
overvoltage (low set) tripping delay of low set element	Setting value in volt Setting value in seconds	<SELECT/RESET><+><-> one time for each value	U> t <sub>U&gt;</sub>
overvoltage (high set) tripping delay of high set element	Setting value in volt Setting value in seconds	<SELECT/RESET><+><-> one time for each value	U>> t <sub>U&gt;&gt;</sub>
positive-phase sequence system undervoltage U1<; trip delay t <sub>U1&lt;</sub>	Setting value in volt Setting value in seconds	<SELECT/RESET><+><-> one time for each value	U1< t <sub>U1&lt;</sub>
positive-phase sequence system overvoltage U1>; trip delay t <sub>U1&gt;</sub>	Setting value in volt Setting value in seconds	<SELECT/RESET><+><-> one time for each value	U1> t <sub>U1&gt;</sub>
negative-phase sequence system overvoltage U2>; trip delay t <sub>U2&gt;</sub>	Setting value in volt Setting value in seconds	<SELECT/RESET><+><-> one time for each value	U2> t <sub>U2&gt;</sub>
zero-phase sequence system U0> trip delay t <sub>U0&gt;</sub>	Setting value in volt Setting value in seconds	<SELECT/RESET><+><-> one time for each value	U0> t <sub>U0&gt;</sub>
Function blocking	EXIT	<+> until max. setting <-> until min. setting	LED of blocked parameter
Slave adresse of serial interface	1 - 32	<SELECT/RESET><+><->	RS
Baud-Rate <sup>1)</sup>	1200-9600	<SELECT/RESET><+><->	RS
Parity-Check <sup>1)</sup>	even odd no	<SELECT/RESET><+><->	RS
Recorded fault data: Star-connection: L1, L2, L3 Symmetrical components: U1, U2, U0	Tripping values in volt	<SELECT/RESET><+><-> one time for each phase	L1, L2, L3; U1, U2, U0, U<, U<<, U>, U>>,

Function	Display shows	Pressed pushbutton	Corresponding LED
Delta-connection: L1/L2, L2/L3, L3/L1 symmetrical components: U1, U2			U1<, U1>, U2>, U0>
	Tripping values in volt	<SELECT/RESET><+><-> one time for each phase	L1, L2, L3, U1, U2, U<, U><, U>, U>>, U1<, U1>, U2>
Save parameter?	SAV?	<ENTER>	
Save parameter!	SAV!	<ENTER> for about 3 s	
Delete failure memory	wait	<-> <SELECT/RESET>	
Enquiry failure memory	FLT1; FLT2.....	<-><+>	L1, L2, L3 U<, U<<, U>, U>>
Trigger signal for the fault recorder	TEST, P_UP, A_PI, TRIP	<SELECT/RESET> <+><->	FR
Function	Display shows	Pressed pushbutton	Corresponding LED
Number of fault occurrences	S = 2, S = 4, S = 8	<SELECT/RESET> <+><->	FR
Display of date and time	Y = 99, M = 10, D = 1, h = 12, m = 2, s = 12	<SELECT/RESET> <+><->	□
Software version	First part (e. g. D02-) Second part (e. g. 6.01)	<TRIP> one time for each part	
Manual trip	TRI?	<TRIP> three times	
Inquire password	PSW?	<SELECT/RESET>/<+>/<->/<ENTER>	
Relay tripped	TRIP	<TRIP> or fault tripping	
Secret password input	XXXX	<SELECT/RESET>/<+>/<->/<ENTER>	
System reset	SEG	<SELECT/RESET> for about 3 s	

1) only Modbus

Table 5.1: Possible indication messages on the display

## 5.2 Setting procedure

In this paragraph the settings for all relay parameters are described in detail. For parameter setting a password has to be entered first (please refer to 4.4 of description "MR-Digital Multifunctional Relays").

## 5.3 System parameter

### 5.3.1 Display of residual voltage UE as primary quantity ( $U_{\text{prim}}/U_{\text{sec}}$ )

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

#### Example:

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

### 5.3.2 D/Y – Switch - over

Depending on the mains voltage conditions, the input voltage transformers can be operated in delta or Y connection. Changeovers are effected via the <+> and the <-> keys and stored with <ENTER>.

### 5.3.3 Setting of nominal voltage

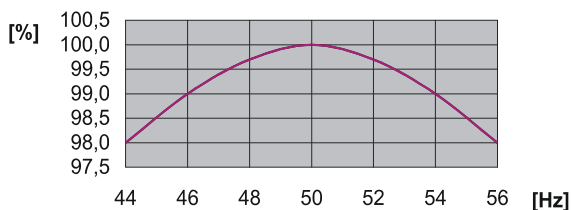
For proper functioning it is necessary to first adjust the rated frequency (50 or 60 Hz). It can be selected between „f = 50 Hz“, „f = 60 Hz“ or „v = 50 Hz“, „v = 60 Hz“.

The difference lies in the method of voltage measuring.

With the setting "v = 50 Hz" or "v = 60 Hz" voltage measuring is independent of the existing frequency. This means, the voltage value can be correctly measured between 40 Hz and 70 Hz without adverse effects from the frequency.

With the setting "f" = 50/60 Hz the measured voltage value is influenced by the frequency. (see Table 5.2)

Declination of measuring value at 50Hz



Declination of measuring value at 60Hz

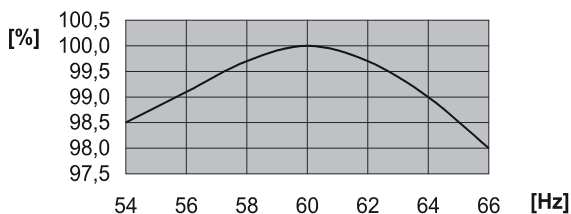


Figure 5.1: Impairment of voltage measuring

This difference in settings is required for the fault recorder. If the fault recorder is to be used, the setting must be f = 50 Hz or f = 60 Hz.

At 50 Hz or 60 Hz the fault recorder determines 16 measured values per period. With the setting "v = 50 Hz" or "v = 60 Hz" 16 measured values of the presently measured frequency would always be determined. The disturbance recorder would not indicate any frequency changes and thus render incorrect measuring results.

Setting	v = 50	f = 50	v = 60	f = 60
Rated frequency	50 Hz	50 Hz	60 Hz	60 Hz
Influence on voltage measurement	none	0,5..1%/Hz (refer to table 5.1)	none	0,5..1%/Hz (refer to table 5.1)
Fault recorder	Recording distorted**	Recording correct**	Recording distorted**	Recording correct**
Influence on all other functions	none	none	none	none

Table 5.2: Deviation of measured value at 50 Hz or 60 Hz

\* Setting is important for correct recording of fault recorder

\*\* Sample rate is variably adjusted to the momentarily measured frequency. 16 samples are always measured in one period.

\*\*\* Sample rate setting is fixed to 50 Hz or 60 Hz. 16 samples per 20 ms or 16.67 ms are always measured.

### 5.3.4 Display of the activation storage

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

### 5.3.5 Parameter set change-over switch/external trigger for fault recorder

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

Software-parameter	Blocking input used as	RESET input used as
SET1	Blocking input	RESET input
SET2	Blocking input	RESET input
B_S2	Parameter switch	RESET input
R_S2	Blocking input	Parameter switch
B_FR	External triggering for the fault recorder	Reset input
R_FR	Blocking input	External triggering for the fault recorder
S2_FR	Parameter switch	External triggering for the fault recorder

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

With the setting B\_S2 the blocking input (D8, E8) is used as parameter-set change-over switch.

With the setting R\_S2 the reset input (D8, E8) is used as parameter-set change-over switch. With the setting B\_FR the fault recorder is activated immediately by using the blocking input. On the front plate the LED FR will then light up for the duration of the recording. With the setting R\_FR the fault recorder is activated via the reset input.

With the setting S2\_FR parameter set 2 can be activated via the blocking input and/or the fault recorder via the reset input.

The relevant function is then activated by applying the auxiliary voltage to one of the external inputs.

#### Important note:

When functioning as parameter change over facility, the external input RESET is not available for resetting. When using the external input BLOCKING the protection functions must be deactivated by software blocking separately (refer to chapter 5.9.1).

## 5.4 Protection parameters

### 5.4.1 1-phase or 3-phase U</U>-tripping

Switching-over of the parameter permits selection between 1-phase and 3-phase tripping of the U</U> steps. Keys <+> or <-> are used to change the value and <ENTER> to store it.

#### Note

When the MRU3-2 is to be used for measuring the residual voltage in systems with isolated or compensated neutral or as generator earth fault protection, the measuring voltage has to be applied to terminals

A3-A4. Under voltage functions U< and U<< have to be set to "EXIT" and overvoltage functions U> and U>> have to be adjusted to the required pickup values.

The frequency must be set to 50 or 60 Hz. The parameter 1-phase or 3-phase tripping must be set to U<>1 (1-phase tripping).

### 5.4.2 Parameter setting of over- and under voltage supervision

The setting procedure is guided by two colored LEDs. During setting of the voltage thresholds the LEDs U<, U<<, U> and U>> are lit green. During setting of the trip delays  $t_{U>}$ ,  $t_{U>>}$ ,  $t_{U<}$  and  $t_{U<<}$  the according LEDs light up red.

#### Thresholds of the voltage supervision

During setting of the threshold U>, U>>, U< and U<< the displays shows the voltages directly in volt. The thresholds can be changed by the <+> <-> push buttons and stored with <ENTER>.

The under voltage supervision (U< and U<<) as well as the overvoltage supervision (U> and U>>) can be de-activated by setting the threshold to "EXIT".

#### Tripping delay of voltage supervision

During setting of the tripping delays  $t_{U<}$ ,  $t_{U<<}$ ,  $t_{U>}$  and  $t_{U>>}$  the display shows the value directly in seconds. The tripping delay is changed via the push button <+> and <-> in the range of 0,04 s to 50 s and can be stored with the push button <ENTER>.

When setting the tripping delay to "EXIT" the value is infinite meaning only warning, no tripping.

### 5.4.3 Positive sequence system voltage (U1<, U1>)

Rms values and tripping delays can be set in the similar manner as described for the normal under-/over voltage settings. Both elements can be blocked or set as alarm stages.

### 5.4.4 Negative sequence system overvoltage (U2>)

This parameter determines the threshold for the rms value of the negative sequence system. As described in 5.4.2, the entire stage can be blocked or set as alarm element.

### 5.4.5 Zero sequence system overvoltage (U0>)

The threshold for the rms value of the zero sequence system can be set with this parameter. Also here it is possible, as described in chapter 5.4.2, to block the entire element or to set it only as alarm element.

### 5.4.6 Adjustment of the slave address

By pressing push buttons <+> and <-> the slave address can be set in the range of 1 - 32. During this adjustment the LED RS lights up.

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

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

## 5.4.8 Setting of parity (applies for Modbus-Protocol only)

The following three parity settings are possible :

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

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

## 5.5 Parameter for the fault recorder

### 5.5.1 Adjustment of the fault recorder

The MRU3-2 is equipped with a fault recorder (refer to chapter 3.1.5). Three parameters can be determined.

### 5.5.2 Number of the fault recordings

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

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

(1)\* 2 recordings for adoration of 8 s (with 50 Hz) (6.66 s with 60 Hz)

(3)\* 4 recordings for adoration of 4 s (with 50 Hz) (3.33 s with 60 Hz)

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

\* is written over when a new trigger signal arrives

#### Caution:

If the fault recorder is used, the frequency should be set to  $f = 50$  Hz or  $f = 60$  Hz (refer to chapter 5.3.3).

### 5.5.3 Adjustment of trigger occurrences

There is a choice between four different occurrences:

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

### 5.5.4 Pre-trigger time (Tvor)

By the time  $T_{pre}$  it is determined which period of time prior to the trigger occurrence should be stored as well. It is possible to adjust a time between 0.05s and the max. recording interval (2, 4 and 8s at 50 Hz and 1.33; 3.33 and 6.66 s at 60 Hz). With keys <+> and <-> the values can be changed and with <ENTER> be saved.

## 5.6 Date and time

### 5.6.1 Adjustment of the clock

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

Date :	Year	Y=00
	Month	M=01
	Day	D=01

Time :	Hour	h=00
	Minute	m=00
	Second	s=00

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

**Note:**

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



## 5.7 Indication of measuring values

### 5.7.1 Measuring indication

In normal operation the following measuring values can be displayed.

- Voltages (LED L1, L2, L3 green)
- In star connection all phase-to-neutral voltages
- In delta connection all phase-to-phase voltages
- Phase sequence (LED PS yellow)

### 5.7.2 Unit of the measuring values displayed

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

Indication as	Range	Unit
Sec. voltage	000V - 999V	V
Primary voltage	.00V – 999V	V
	1k00 – 9k99	kV
	10k0 – 99k0	kV
	100k – 999k	kV
	1M00 – 3M00	MV

Table 5.3: Units of the display

### 5.7.3 Indication in faultless condition

In normal operation the display always shows SEG. After pressing the pushbutton <SELECT/RESET> the display switches cyclically to the next value. After the measuring values had been indicated the setting parameters are displayed. Hereby the LEDs in the upper section signalize which measured value is indicated, the LEDs in the lower section signalize which setting parameter is indicated on the display. Longer actuating the pushbutton resets the relay and the display changes into normal operation (SEG).

### 5.7.4 Indication after pickup / tripping

In tripped condition "TRIP" appears on the display and the LEDs of the operating measuring data light up red together with the LEDs of the tripping parameter (U0: yellow). All operating data, which were measured at the moment of tripping, can now be called one after another by pressing pushbutton <SELECT/RESET>. (Refer to chapter 5.8). By pressing the <-> key, the fault memory can be retrieved. If in this condition setting parameters are to be indicated, pushbutton <ENTER> has to be pressed.

The graphic below shows again the difference between the different display modes.

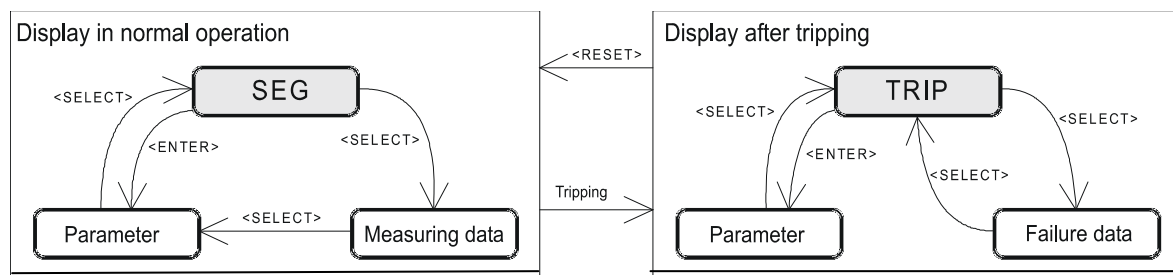


Figure 5.2: Switching over of the display in dependence of the operating mode.

## 5.7.5 Indication of the phase sequence

The indication refers to the designation of the volt-age input terminals. The sequence can be "123" or "321". Which phase sequence is the correct one depends upon the given case of application. But in any case the assignment has to be met which phase sequence shall correspond to the positive sequence system.

Display "123" means that the connected rotating field has the positive sequence system of unit MRU3-2 and thus is considered as correct. If these voltages are additionally symmetrical, there will be no negative sequence system and the positive sequence system has the same rms value as the phase voltages.

If the phase sequence "321" is indicated the assignment could be wrong. This has to be checked whether the applied voltages show a wrong phase sequence or whether there is a fault in the connection. When "???" is indicated the unit signalizes that no clear measurement of the phase sequence is possible.

## 5.8 Fault memory

When the relay is energized or is energized or trips, all fault data and times are stored in a non-volatile memory manner. Events will be recorded at pick-up of the relay and faults when the relay trips. Any further faults which occur during this tripping will also be recorded, when the time difference between the fault is >300 ms. The MRU3-2 is provided with a fault value recorder for max. five fault occurrences. In the event of additional trip-pings always the oldest data set is written over. For fault indication not only the trip values are re-corded but also the status of LEDs. Fault values are indicated when push buttons <-> or <+> are pressed during normal measuring value indication.

- Normal measuring values are selected by pressing the <SELECT/RESET> button.
- When then the <-> button is pressed, the latest fault data set is shown. By repeated pressing the <-> button the last but one fault data set is shown etc. For indication of fault data sets abbreviations FLT1, FLT2, FLT3, ... are displayed (FLT1 means the latest fault data set recorded). At the same time the parameter set active at the occurrence is shown.
- By pressing <SELECT/RESET> the fault measuring values can be scrolled.
- By pressing <+> it can be scrolled back to a more recent fault data set. At first FLT8, FLT7, are 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 occurred are now blinking to indicate that it is not a current fault. LEDs which were blinking during trip conditions, (element had picked up) just briefly flash.
- If the relay is still in trip condition and not yet reset (TRIP is still displayed), no measuring values can be shown.
- To delete the trip store, the push button combination <SELECT/RESET> and <->, has to be pressed for about 3s. The display shows "wait".5

Measuring	Displayed values	Corresponding LED
Voltage	L1; L2; L3; star L1/L2; L2/L3; L3/L1; delta	L1; L2; L3
Time stamp		
Date	Y = 99 M = 03 D = 10	⊕ ⊕ ⊕
Time	h = 17 m = 21 s = 14	⊕ ⊕ ⊕
Symmetrical components	Voltage: positive-phase sequence ; negative-phase sequence; zero-phase sequence	U1; U2; U0
Phase sequence	123: positive sequence; 132: negative sequence	PS

Table 5.4: Recorded fault data

## 5.9 Additional Funktion

### 5.9.1 Setting procedure for blocking the protection functions

The blocking function of the MRU3-2 can be set according to requirement. By applying the aux. voltage to D8/E8, the functions chosen by the user are blocked. 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 U< 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.
- Thereafter the menu is left by pressing <SELECT/RESET> again.
- If the <SELECT/RESET> key is actuated again, the blocking menu is left and the assignment mode is accessed<sup>^</sup>.

Function	Description	Display	LED
U<	Under voltage step 1	BLOC	green
U<<	Under voltage step 2	BLOC	green
U>	Overvoltage step 1	NO_B	green
U>>	Overvoltage step 2	NO_B	green
U1<	Under voltage step in positive-phase sequence system	BLOC	green
U1>	Overvoltage step in positive-phase sequence system	BLOC	green
U2>	Overvoltage step in negative-phase sequence system	BLOC	green
U0>	Overvoltage step in zero-phase sequence system	BLOC	green

Table 5.5: Blocking function for two parameter sets

#### Assignment of the output relays:

Unit MRU3-2 has five output relays. The fifth out-put relay is provided as permanent alarm relay for self supervision is normally on. Output relays 1 - 4 are normally off and can be assigned as alarm or tripping relays to the voltage functions which can either be done by using the push buttons on the front plate or via serial interface RS485.

The assignment of the output relays is similar to the setting of parameters, however, only in the assignment mode. The assignment mode can be reached only via the blocking mode. By pressing push button <SELECT/RESET> in blocking mode again, the assignment mode is selected.

The relays are assigned as follows: LEDs U<, U<<, U>, U>>, U1>, U1<, U2> and U0>are two-colored and light green when the output relays are assigned as alarm relays and  $t_{U<}$ ,  $t_{U<<}$ ,  $t_{U>}$ ,  $t_{U>>}$ ,  $t_{U1<}$ ,  $t_{U1>}$ ,  $t_{U2>}$ , and  $t_{U0>}$ .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 U< lights up green. Now one or several of the four output relays can be assigned to under volt-age element U< as alarm relays. At the same time the selected alarm relays for under voltage element 1 are indicated on the display. Indication "1\_ \_ \_" means that output relay 1 is assigned to this under voltage element. When the display shows " \_ \_ \_ \_", no alarm relay is assigned to this under voltage 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 U< lights up red. The output relays can now be assigned to this voltage element as tripping relays. Relays 1 - 4 are selected in the same way as de-scribed before. By repeatedly pressing of the <SELECT/RESET> push button and assignment of the relays all elements can be assigned separately to the relays. The assignment mode can be terminated at any time by pressing the <SELECT/RESET> push button for some time (abt. 3 s).

**Note:**

- The function of jumper J2 described in general description "MR Digital Multifunctional Relays" does not apply for MRU3-2. 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.

## 5.9.2 Reset

All relays have the following three possibilities to reset the display of the unit as well as the output relay at jumper position J3=ON.

**Manual Reset**

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

**Electrical Reset**

- Through applying auxiliary voltage to C8/D8 Software Reset
- The software reset has the same effect as the <SELECT/RESET> push button (see also communication protocol of RS485 interface)

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

### 5.9.3 Erasure of fault storage

To delete the trip store, the push button combination <SELECT/RESET> and <->, has to be pressed for about 3s. The display shows "wait".

Relay function	Output relays				Display-Indication	Corresponding LED
	1	2	3	4		
U< Alarm tU< Tripping	X				---- 1 _ _ _	U<; green tU< red
U<< Alarm tU<< Tripping	X				---- 1 _ _ _	U<< green tU<< red
U> Alarm tU> Tripping	X				---- 1 _ _ _	U> green tU> red
U>> Alarm tU>> Tripping	X				---- 1 _ _ _	U>> green tU>> red
U1< Alarm tU1< Tripping		X			---- _ 2 _ _	U1< green tU1< red
U1> Alarm tU1> Tripping		X			---- _ 2 _ _	U1> green tU1> red
U2> Alarm tU2> Tripping			X		---- _ _ 3 _	U2> green tU2> red
U0> Alarm tU0> Tripping				X	---- _ _ _ 4	U0> green tU0> red

Table 5.6: Example of assignment matrix of the output relay (defaults settings)

## 6. Relay testing and commissioning

The following test instructions should 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 frequency and rated voltage of the relay correspond to the plant data on site.
- The 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 to the rated data on the type plate.

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

It may happen that the relay is tripped because of under-voltage condition after power-on. (The message "TRIP" on the display and LED L1, L2, L3 and U< light up red). An under voltage condition has been detected after power-on, because no in-put voltages are applied to the relay. In this case:

- Press the push button <ENTER>, thus entering into the setting mode. Now set the parameters U< and U<< to "EXIT" to block the under voltage functions. After that, press the <SELECT/RESET> for app. 3 s to reset the LEDs and "TRIP" message.
- The under voltage tripping after power on can also be eliminated by applying three phase rated voltages after power-on and reset the LED and "TRIP" message.
- Apply auxiliary voltage to the external blocking input (Terminals E8/D8) to inhibit the under voltage functions (refer to 6.5) and press the <SELECT/RESET> for app. 3 s to Reset the LEDs and "TRIP" message.

Refer to chapter 5.9.1

### 6.2 Testing the output relays

#### 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 out-put relays should then be activated and the self supervision alarm relay (watchdog) be deenergized one after another with a time interval of 1 second. Thereafter, reset all output relays back to their normal positions by pressing the push button <SELECT/RESET>.

## 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 4.3 of the description "MR – Digital multifunctional re-lays". As relay input energizing quantities, three phase voltages should be applied to MRU3-2 relay input circuits. Depending on the system conditions and the voltage transformer used, three voltages can be connected to the relay input circuits with either star or delta connection. In case of a star connection the phase-to-neutral voltage will be applied to the voltage input circuits, while the phase-to-phase voltages will be connected to the voltage input circuits in case of a delta connection. The voltage in-put connection must be set as a parameter, and should correspond with the actual voltage input connection:

Star connection:           Phase-to-neutral voltages will be measured and evaluated.  
Delta connection:        Phase-to-phase voltages will be measured and evaluated.

### **NOTE!**

For MRU3-2 relay used for earth fault protection be sure that the frequency set value ( $f=50/60$ ) has been selected correctly according to your system frequency (50 or 60 Hz).

This also applies when using the disturbance recorder (refer to Chapter 5.3.3).

## 6.4 Secondary injection test

### 6.4.1 Test equipment

- Voltmeter with class 1 or better
- Auxiliary power supply with the voltage corresponding to the rated data on the type plate
- Three-phase voltage supply unit with frequency regulation (Voltage: adjustable from 0 to  $2 \times U_N$ )
- Timer to measure the operating time (Accuracy class  $\pm 10$  ms)
- Switching device
- Test leads and tools

### 6.4.2 Example of the test circuit

For testing of the MRU3-2 relay, a three phase voltage source is required. Figure 6.1 shows an example of a three-phase test circuit energizing the MRU3-2 relay during test. The three phase voltages are applied to the relay in Y-connection.

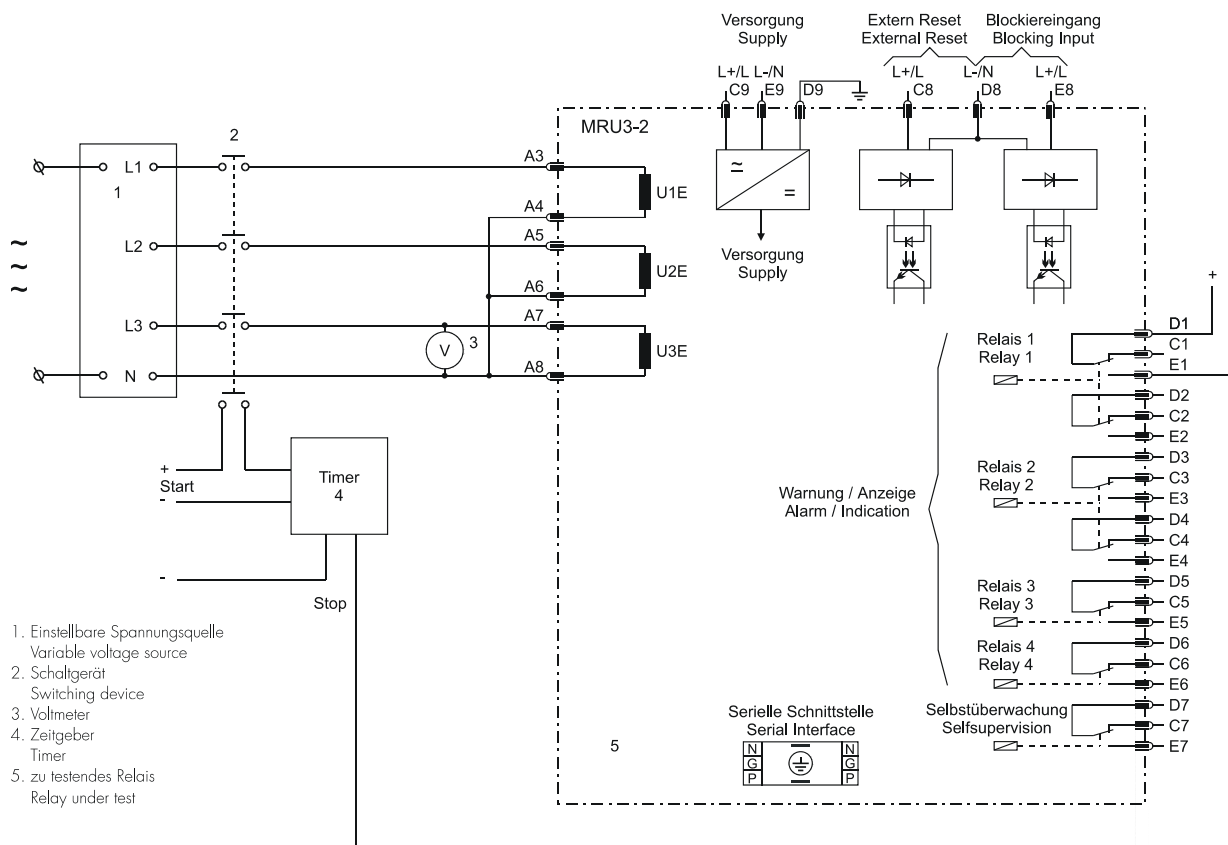


Figure 6.1: 3-phase test circuit



### 6.4.3 Checking the input circuits and measuring functions

Apply three voltages of rated value to the voltage input circuits (terminals A3 - A8) of the relay. Check the measured voltages, frequency and vector surge on the display by pressing the push button <SELECT/RESET> repeatedly.

The voltages are indicated on the display in volts, at

Y-connection:

- Phase-to-neutral voltages: LED L1, L2, L3
- Phase-to-phase voltages: LED L1+L2, L2+L3, L3+L1

Change the voltages around the rated value and check the measured voltages on the display. Compare the voltage displayed with the reading at voltmeter. The deviation for the voltage must not exceed 1%.

By using an RMS-metering instrument, a greater deviation may be observed if the test voltages contains harmonics. Because the MRU1 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 Test of the symmetrical components values

The following tests describe basically the indicating values and voltages of the symmetrical components with which the measuring functions of the MRU3-2 can be tested. If simultaneously the tripping function is to be tested, the corresponding parameter must be set between the rated voltage and the theoretical value accept to the table.

#### Symmetrical measuring voltage system

For this test the relay has to be correctly connected with all of the three phases and the star point. If the measuring voltage system is symmetrical, the unit should indicate the following measuring values:

measuring value	indication
L1, L2, L3	$U_N$
U1	$\approx U_N$
U2	$\approx 0$
U0	$\approx$

Table 6.1: Indication at normal rotating field (symmetrical)

The deviation must not exceed some Volts. Exact data cannot be given here because this depends upon the actual symmetry of the test voltage system. By an exactly symmetrical system the data must be precisely within the tolerance of the unit. Also a deviation of the mains frequency from the set frequency can lead to errors in the measurements. In this case it is better to set the system frequency to "v = 50 Hz" or "v = 60 Hz".

#### Wrong phase sequence

For this test two phases must be reversed to the MRU3-2. The third phase and the star point N are connected as usual. The theoretical indicating values are:

measuring value	indication
L1, L2, L3	$U_N$
U1	$\approx 0$
U2	$\approx U_N$
U0	$\approx 0$

Table 6.2: Indication during simulated left rotating field

### Phase failure

The MRU3-2 is now to be connected with the two phases L2 and L3 and with the neutral conductor. The two phases must be assigned correctly. The measuring input of phase L1 is connected with the star point of the relay in order to prevent interference voltages at the input. (This simulation is realistic because in a real case of failure other relays in parallel or the voltage transformer itself would cause this "pull down" effect).

The test can basically be carried out with any phase. The result of the measurement differs only in the indicating values for the phase voltages L1-L3.

Measuring value	indication
L1	0
L2, L3	$U_N$
U1	$\approx 2/3 \times U_N$
U2	$\approx 1/3 \times U_N$
U0	$\approx 1/3 \times U_N$

Table 6.3: Indication at phase failure

### Earthfault

For this test all conductors L1-L3 have to be correctly connected. The star point N from the mains is not connected. Instead the star point of the MRU3-2 is connected with phase L1. This type of connection simulates an earthfault of phase L1.

Measuring value	Indication
L1	0
L2, L3	$\sqrt{3} U_N \times$
U1	$\approx U_N$
U2	$\approx 0$
U0	$\approx U_N$

Table 6.4: Indication at earthfault

### 6.4.5 Checking the operating and resetting values of the over/under voltage functions

Apply three voltages with the rated value and gradually increase (decrease) the voltages until the relay starts, i.e. at the moment when the LED U> (or U<) lights up or the voltage alarm output relay (contact terminals D4/E4) is activated. Read the operating voltage indicated by the voltmeter. The deviation must not exceed 1% of the set operating value.

Furthermore, gradually decrease (increase) the voltages until the relay resets, i.e. the voltage alarm output relay is disengaged. Check that the dropout to pickup ratio is greater than 0.97 (for overvoltage function) or smaller than 1.03 (for under voltage).

### 6.4.6 Checking the relay operating time of the over/under voltage functions

To check the relay's operating time, a timer must be connected to the trip output relay contact (Contact terminals D1/E1).

It must be ensured that the respective output relay is assigned to the function to be tested. (refer to chapter 5.9.1).

The timer should be started simultaneously with the voltage change from sound condition to a faulty condition and stopped by the trip relay contact. The operating time measured by timer should have a deviation about 3% of the set value or < 20 ms.

### 6.4.7 Checking the external blocking and reset functions

The external blocking input blocks the selected voltage functions.

Care must be taken that these terminals are also assigned the blocking function (refer to chapter 5.9.1). The external blocking input inhibits under-voltage functions. To test the blocking function apply auxiliary supply voltage to the external blocking input of the relay (terminals E8/D8). Inject a test voltage which could cause tripping for the functions above mentioned. Observe that there is no trip and alarm.

Remove the auxiliary supply voltage from the blocking input. Apply test voltages to trip the relay (message „TRIP“ on the display). Return the test voltages to the sound condition 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.

## 6.5 Primary 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 voltages should be injected to the relay through the 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 MRU3 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 voltage values on the MRU3-2 relay display may be compared phase by phase with the concerned indications of the instruments 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 re-lays like MRU3-2, this interval can be substantially longer. This is because

- The MR- 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 MR-relays enable supervision the relay functions during service.
- The combined TRIP test function of the MR-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 times should be tested.

## 7. Technical Data

### 7.1 Measuring input circuits

Rated data:	Nominal voltage	$U_N$	100 V, 230 V, 400 V
	Nominal frequency	$f_N$	40 - 70 Hz
Power consumption in voltage circuit:	< 1 VA per phase at $U_N$		
Thermal withstand in voltage circuit:	continuously		$2 \times U_N$

### 7.2 Common data

Dropout to pickup ratio:	$U>/U>> : >98\%$	$U</U<< : < 102\%$
Dropout time:	40 ms	
Time lag error class index E:	$\pm 10$ ms	
Minimum operating time:	40 ms	
Max. allowed interruption of the auxiliary supply without effecting the function of the device:	50 ms	
Weight:	approx. 1.5 kg	
Mounting position:	any	
Influences:		
Frequency influence on voltage measuring circuit:	$0.9 f_N < f < 1.1 f_N, \leq 2 \% / \text{Hz}$ bei 50/60 Hz	
Voltage influence on frequency measuring circuit:	$0.5 U_N < U < 1.5 U_N$ , no influence	
Temperature influence: -	20 °C ... 70 °C, < 1 %	
Auxiliary voltage influence:	no influence within the admissible range	

## 7.3 Setting ranges and steps

Function	Parameter	Setting range	Step	Pickup tolerance
Transformer ratio	$U_{\text{prim}}/U_{\text{sek}}$	(sek) 1.01...6500	0.01; 0.02; 0.05; 0.1; 0.2; 0.5; 1.0; 2.0; 5.0; 10; 20; 50	
Switch group	D/Y	D = DELT/Y = Y		
Rated frequency	$f_N$	$f = 50/f = 60/v = 50/v = 60$		
LED blinking at pick-up		FLSH/NOFL		
Parameter switch/ext. Triggering for the fault recorder	P2 2	SET1/SET2/B_S2/R_S 2/B_FR/R_FR/S2FR		
1/3-phase tripping	1/3	$U_{<} > 1$ ; $U_{<} > 3$		
$U_{<}$	$U_{<}$ ; $U_{<<}$ $U_{1<}$  $t_{U_{<}}$ ; $t_{U_{<<}}$ ; $t_{U_{1<}}$	$U_N = 100$ V: 2...200 V (EXIT) $U_N = 230$ V: 2...460 V (EXIT) $U_N = 400$ V: 4...800 V (EXIT) 0.04...50 s (EXIT)	1 V  1 V  2 V 0.01; 0.02; 0.05; 0.1; 0.2; 0.5; 1.0; 2.0 s	$\pm 1\%$ of set value or $< 0,3\% U_N$   $\pm 1\%$ oder +15 ms/-35 ms
$U_{>}$	$U_{>}$ , $U_{>>}$ , $U_{1>}$ ,  $t_{U_{>}}$ , $t_{U_{1>}}$ , $t_{U_{1>>}}$	$U_N = 100$ V: 2...200 V (EXIT) $U_N = 230$ V: 2...460 V (EXIT) $U_N = 400$ V: 4...800 V (EXIT) 0,04...50 s (EXIT)	1 V  1 V  2 V 0.01; 0.02; 0.05; 0.1; 0.2; 0.5; 1.0; 2.0 s	$\pm 1\%$ of set value or $< 0.3\% U_N$   $\pm 1\%$ or +15 ms/-35 ms
$U_{0>}$	$U_{2>}$ , $U_{0>}$  $t_{U_{2>}}$ , $t_{U_{0>}}$	$U_N = 100$ V: 2...100 V (EXIT) $U_N = 230$ V: 2...230 V (EXIT) $U_N = 400$ V: 4...400 V (EXIT) 0.04...50 s (EXIT)	1 V  1 V  2 V 0.01; 0.02; 0.05; 0.1; 0.2; 0.5; 1.0; 2.0 s	$\pm 1\%$ of set value or $< 0,3\% U_N$   $\pm 1\%$ or +15 ms/-35 ms

### 7.3.1 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

### 7.3.2 Parameter for the fault recorder

Function	Parameter	Adjustment example
FR	Number of recordings	(1)*2 x 8 s; (3)*4 x 4 s; (7)*8 x 2 s (50 Hz) (1)*2 x 6.66 s, (3)*4 x 6.66 s, (7)*8 x 1.66 s (60 Hz)
FR	Savings of the recording at the occurrence	P_UP; TRIP; A_PI; TEST
FR	Pre-trigger-time	0.05 s – 8.00 s

\* is written over when a new trigger signal arrives

### 7.4 Output relays

	Trip relays/change-over contacts	Alarm relay/change-over contacts
MRU3	2/2	3/1



## 8. Order form

<b>Mains decoupling relay</b>		<b>MRU3-</b>			
Standard		1			
incl. measuring of the positive phase-sequence, negative phase-sequence and zero phase- sequence system component		2			
Rated voltage	100 V		1		
	230 V		2		
	400 V		4		
Housing (12TE)	19"- rack			A	
	Flash mounting			D	
RS 485	Alternatively with Modbus protocol				-M

**Technical data subject to change without notice!**

## Setting list MRU3-2

Project: \_\_\_\_\_ SEG-Job.-No.: \_\_\_\_\_

Function group:= \_\_\_\_\_ Location:+ \_\_\_\_\_ Relay code: - \_\_\_\_\_

Relay functions: \_\_\_\_\_ Password: \_\_\_\_\_

Date: \_\_\_\_\_

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

### Setting of the parameters

#### System parameter

Function		Einheit	Default settings	Actual settings
$U_{\text{prim}}/U_{\text{sek}}$	Voltage transformer ratio		sek	
D/Y	Input voltage correction dependent on the connection of the input transformer		DELTA	
$f_N$	Rated frequency	Hz	f = 50 Hz	
LED Flash	LED – Display of the activation storage		FLSH	
P2/FR	Parameter switch/ext. triggering for the fault recorder		SET1	

## Protection parameter

Function		Unit	Default setting Set 1/Set 2	Actualsetting Set1/Set2
1/3	1-phase/3-phase tripping		U<>1	
U<	Pickup value for under voltage element	V	90/210/360*	
t <sub>U&lt;</sub>	Tripping delay for under voltage element	s	0.04	
U<<	Pickup value for under voltage element	V	80/190/320*	
t <sub>U&lt;&lt;</sub>	Tripping delay for under voltage element	s	0.04	
U>	Pickup value for overvoltage element	V	110/250/440*	
t <sub>U&gt;</sub>	Tripping delay for overvoltage element	s	0.04	
U>>	Pickup value for overvoltage element	V	120/270/480*	
t <sub>U&gt;&gt;</sub>	Tripping delay for overvoltage element	s	0.04	
U1<	Pickup value for under voltage in positive-phase sequence system	V	90/210/360*	
t <sub>U1&lt;</sub>	Trip value for under voltage in positive-phase sequence system	s	0.04	
U1>	Pickup value for overvoltage in positive-phase sequence system	V	110/250/440*	
t <sub>U1&gt;</sub>	Trip value for overvoltage in positive-phase sequence system	s	0,04	
U2>	Pickup value for overvoltage in negative-phase sequence system	V	50/115/200*	
t <sub>U2&gt;</sub>	Trip value for overvoltage in negative-phase sequence system	s	0.04	
U0>	Pickup value for overvoltage in zero-phase sequence system	V	30/70/120*	
t <sub>U0&gt;</sub>	Trip value for overvoltage in zero-phase sequence system	s	0.04	
RS	Slave address of the serial interface		1	
RS**	Baud-Rate		9600	
RS**	Parity-Check		even	

\* thresholds dependent on rated voltage 100 V/230 V/400 V      \*\*only Modbus

## Fault recorder

Function		Unit	Default setting	Actual setting
FR	Number of recordings		4	
FR	Saving of the recording at the occurrence		TRIP	
FR	Time prior to trigger impulse	s	0,05	
Uhr	Year setting	year	Y=00	
Uhr	Month setting	month	M=01	
Uhr	Day setting	day	D=01	
Uhr	Setting of the hour	hour	h=00	
Uhr	Setting of the minute	minute	m=00	
Uhr	Setting of the second	second	s=00	

## Blocking function

Parameter set	Default setting				Actuala setting			
	Blocking		Not blocking		Blocking		Not blocking	
	Set 1	Set 2	Set 1	Set 2	Set 1	Set 2	Set 1	Set 2
U<	X	X						
U<<	X	X						
U>			X	X				
U>>			X	X				
U1<	X	X						
U1>	X	X						
U2>	X	X						
U0>	X	X						

## Assignment of the output relays

Funktion	Relay 1		Relay 2		Relay 3		Relay 4	
	Default settings	Actual settings	Default settings	Actual settings	Default settings	Actual settings	Default settings	Actual settings
U< alarm								
t <sub>U&lt;</sub> tripping	X							
U<< alarm								
t <sub>U&lt;&lt;</sub> tripping	X							
U> alarm								
t <sub>U&gt;</sub> tripping	X							
U>> alarm								
t <sub>U&gt;&gt;</sub> tripping	X							
U1< alarm								
t <sub>U1&lt;</sub> tripping			X					
U1> alarm								
t <sub>U1&gt;</sub> tripping			X					
U2> alarm								
t <sub>U2&gt;</sub> tripping					X			
U0> alarm								
t <sub>U0&gt;</sub> tripping							X	

**Setting of code jumpers**

Code jumper	J1		J2		J3	
	Default settings	Actual settings	Default settings	Actual settings	Default settings	Actual settings
Plugged						
Not plugged	X		No function		X	

Code jumper	Low/High-range for reset input		Low/High-range for blockage input	
	Default settings	Actual settings	Default settings	Actual settings
Low=plugged	X		X	
High=not plugged				

This technical manual is valid for

For software-Version number: D06-7.01 (MRU3-1)  
D07-8.01 (MRU3-2)

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