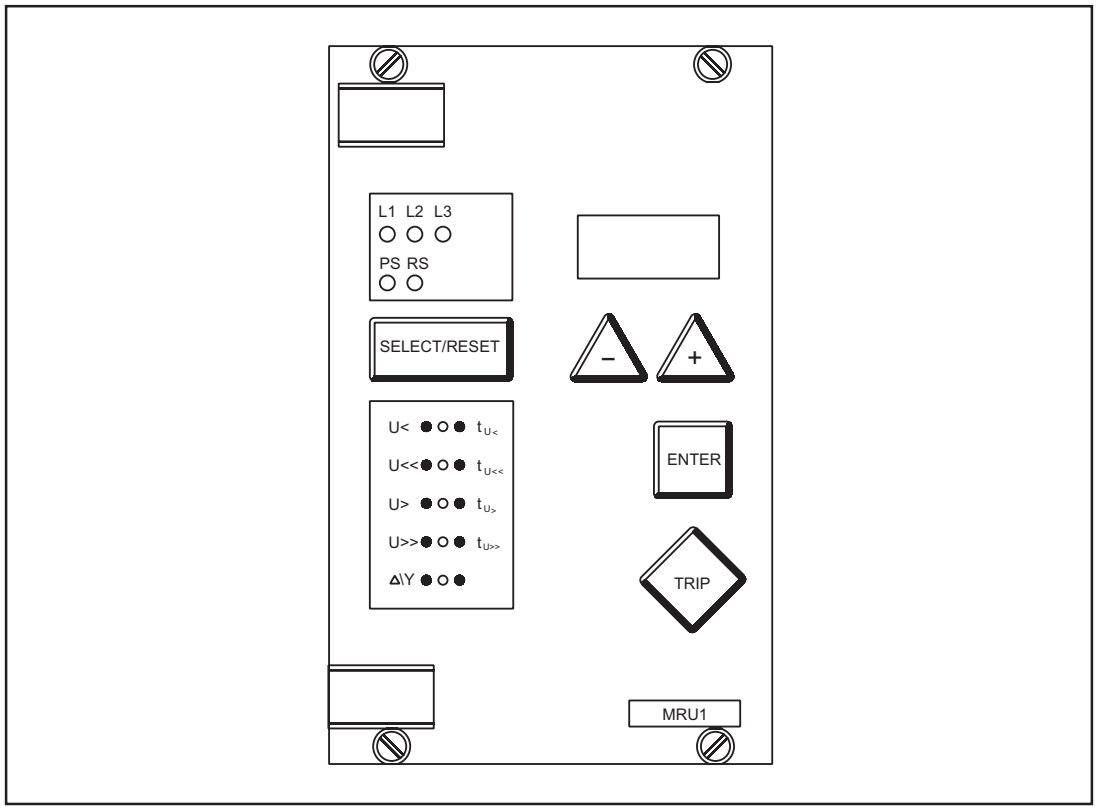
High-Tech Range

MRU1-1- AC Voltage Relay



C&S Electric Limited

(Protection & Control Division)

Contents

1. Introduction and application

The voltage supervision relay MRU1-1/3 protects electrical power generators, consumers or operating components generally against over- or undervoltages.

Among other applications the relay can be used:

- for detection of over- or undervoltages in power generating plants and energy supply systems
- to protect generators against critical overvoltages in case of defective voltage regulators
- as undervoltage protection for motors
- as generator stator earth fault protection
- as over- and undervoltage protection with evaluating the symmetrical components (*MRU1-2*, detailed information on this type can be found in the relevant technical description)

There is also a similar protection relay IRU1 available in a more simpler design, i.e. with less function, without display and without serial interface.

2. Features and characteristics

- Microprocessor technology and watchdog
- Digital filtering of the measured values by using discrete Fourier analysis to suppress the high frequency harmonics and d.c. components induced by faults or system operations
- Voltage supervision with two step under-/ and over-voltage detection
- Completely independent time settings for voltage supervision
- Display of all measuring values and setting parameters for normal operation via an alphanumerical display and LEDs, actual measured values and their active, reactive components, stored fault data, etc.
- Storage and display of tripping values
- In compliance with VDE 0435, part 303 and IEC 255

3. Design

3.1 Connections

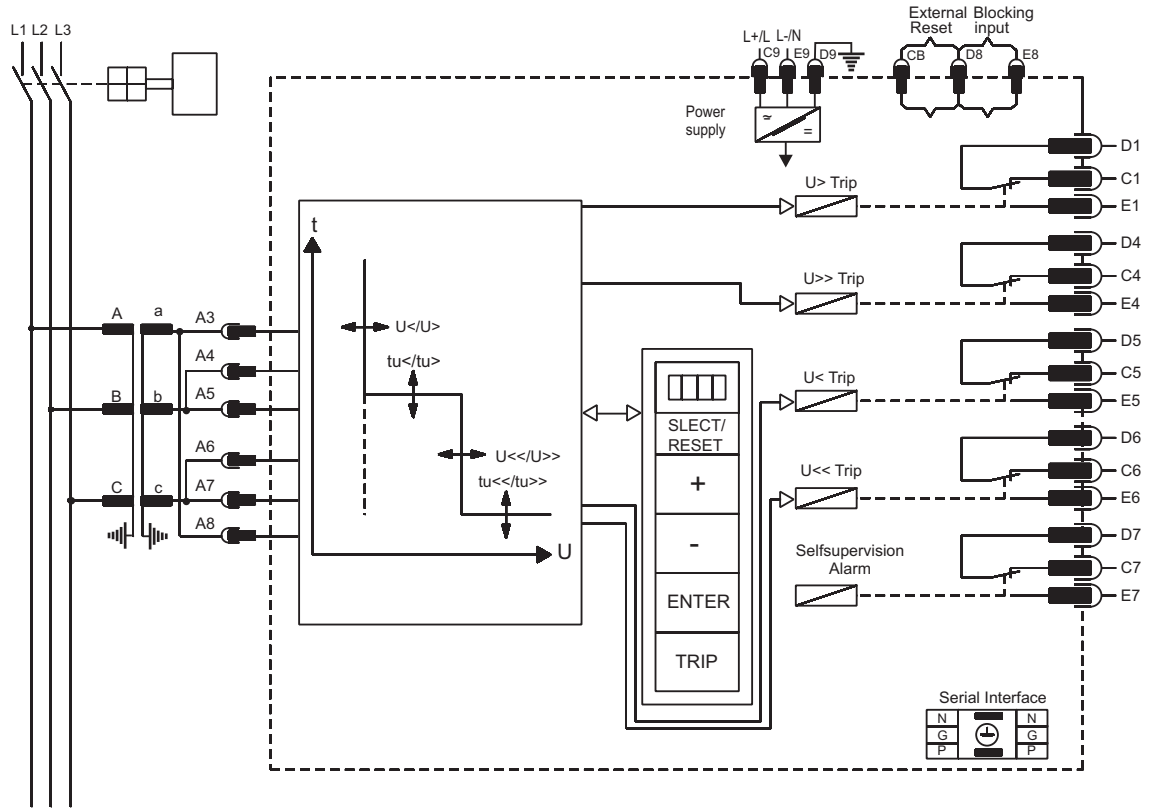


Fig.3.1: Connection of the MRU1-1/3 to phase-to-phase voltage

Hint: Connection of phase-to-neutral voltage is possible too.

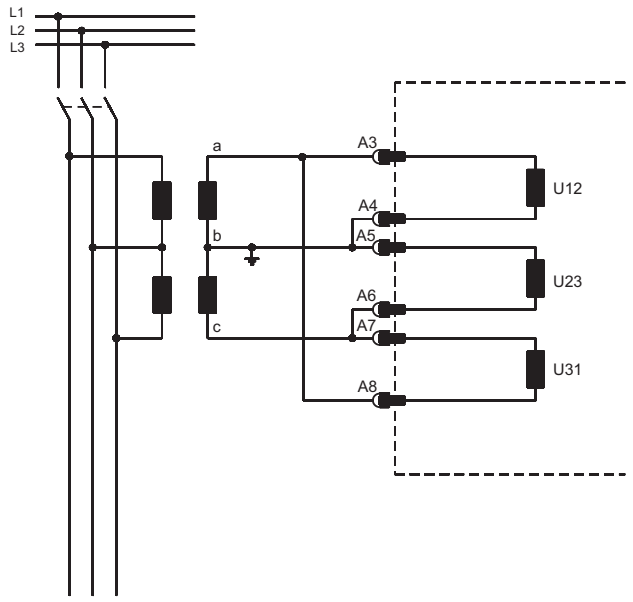


Fig 3.2: Voltage transfomer in V-connection

3.1.1 Analog input circuits

The external wiring of the measuring circuits are shown in the connection diagram. The analog input voltages are galvanically decoupled by the input transformers of the device, then filtered and finally fed to the analog digital converter. The measuring circuits can be connected in star or delta connection.

3.1.2 Blocking input

When required to inhibit functions of the relay, the auxiliary voltage has to be switched to D8/E8. Please refer to chapter 4.4.

3.1.3 Reset input

Please refer to chapter 5.4.

3.1.4 Output relays

The *MRU1* has 5 output relays each with one changeover contact.

- Tripping by overvoltage U>; C1, D1, E1
- Tripping by overvoltage U>>; C4, D4, E4
- Tripping by undervoltage U<; C5, D5, E5
- Tripping by undervoltage U<<; C6, D6, E6
- Indication self supervision (internal fault of the unit) C7, D7, E7

All trip and alarm relays are normally open relays, the relay for self supervision is a normally closed relay.

3.2 Display

Function	Display shows	Pressed pushbutton	Corresponding LED
Normal operation	CSE		
Measured operating values	actual measured value	<SELECT/RESET> one time for each value	L1, L2, L3,
Setting values: star/delta adjustment	Y/ DELT	<SELECT/RESET><+><->	Δ/Y
undervoltage (low set) trip delay of low set element	setting value in volt setting value in seconds	<SELECT/RESET><+><-> one time for each value	U< $t_{U<}$
undervoltage (high set) trip delay of high set element	setting value in volt setting value in seconds	<SELECT/RESET><+><-> one time for each value	U<< $t_{U<<}$
overvoltage (low set) trip delay of low set element	setting value in volt setting value in seconds	<SELECT/RESET><+><-> one time for each value	U> $t_{U>}$
overvoltage (high set) trip delay of high set element	setting value in volt setting value in seconds	<SELECT/RESET><+><-> one time for each value	U>> $t_{U>>}$
Function blockade	EXIT	<+> until max. setting value <-> until min. setting value	LED of blocked parameter
Slave address of serial interface	1 - 32	<SELECT/RESET> <+><->	RS
Recorded fault data: star—connection: U1, U2, U3, U12, U23, U31 delta-connection: U12, U23, U31	tripping values in Volt tripping values in Volt	<SELECT/RESET><+><-> one time for each phase <SELECT/RESET><+><-> one time for each phase	L1, L2, L3, U<, U<<, U>, U>> L1, L2, L3, U<, U<<, U>, U>>
Save parameter?	SAV?	<ENTER>	
Save parameter!	SAV!	<ENTER> for about 3 s	
Software version	First part (e.g. D02-) Sec. 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	CSE	<SELECT/RESET> for about 3 s	

Table 3.1: possible indication messages on the display

3.3 Front plate

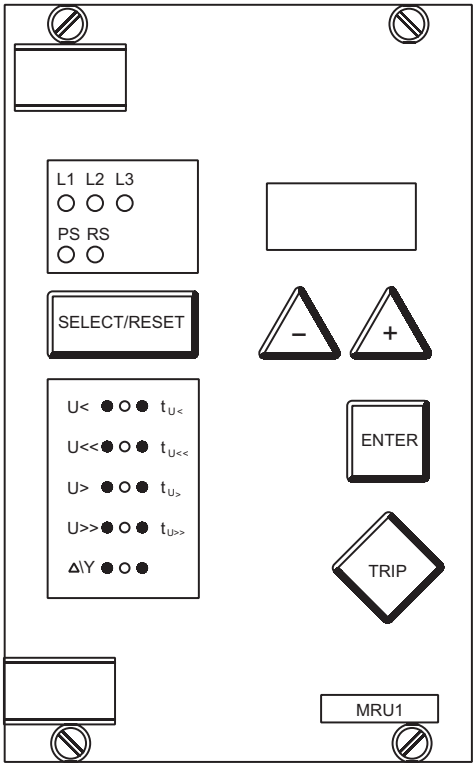


Fig. 3.3: Front plate MRU1-1

3.4 LEDs

All LEDs (except LED RS) are two-coloured. The LEDs on the left side, next to the alphanumerical display light up green during measuring and red after tripping.

The LEDs beyond the push button <SELECT/RESET> are lit green during setting and inquiry procedure of the setting values which are printed on the left side next to the LEDs. The LEDs will light up red after activation of the setting values next to their right side.

The LED marked with letters RS lights up during setting of the slave address of the device for serial data communication (RS485).

4. Working principle

4.1 Analog circuits

The input voltages are galvanically decoupled by the input transformers. The noise signals caused by inductive and capacitive coupling are supressed 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 x 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 MRU1 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 voltages 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 occures an alarm is given and after the set trip delay has elapsed, the corresponding trip relay is activated.

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

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

4.3 Voltage supervision

The voltage relay *MRU1-1* has its application in protection of generators, consumers and other electrical equipment against over-/and undervoltage.

The relay is equipped with two step independent three-phase overvoltage (U>, U>>) and undervoltage (U<, U<<) function with completely separate time and voltage settings.

In delta connection the phase-to-phase voltages and in star connection the phase-to-neutral voltages are continuously compared with the preset thresholds.

For the overvoltage supervision the highest voltage of each phase is decisive for energizing and for the undervoltage supervision the lowest.

4.3.1 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 Δ has to be adjusted.

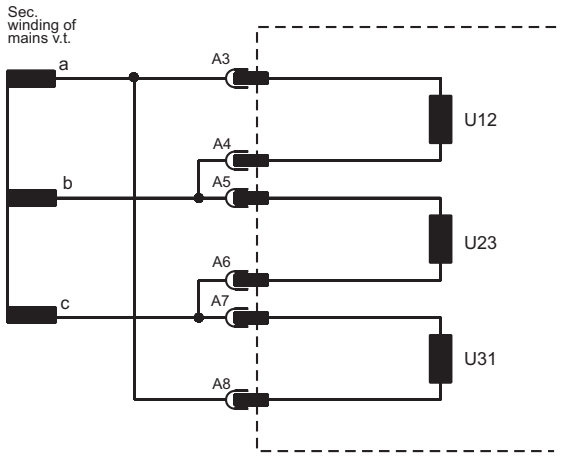


Fig. 4.1: Input v.t.s in delta connection (Δ)

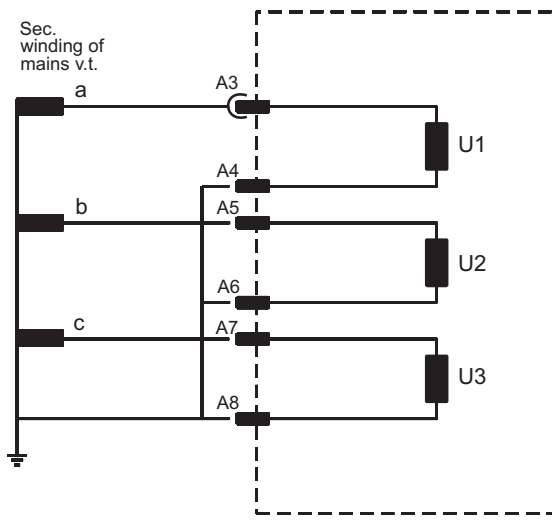


Fig. 4.2: Input v.t.s in star connection (Y)

4.4 Blocking function

Nr.	Dynamic Behaviour	U</<<	U>/>>
1	voltage to external blocking input is applied	blocked	released
2	blocking input is released	released	released
3	supply voltage is switched on	released	released
4	3ph measuring volt. is suddenly applied	released	released
5	one or several measuring voltages are switched off suddenly (phase failure)	released	released

Table 4.1: Dynamic behaviour of MRU1 functions:

5. Operation and settings

5.1 Adjustable parameters

The following parameters can be set by the user himself:

U< - threshold for undervoltage
$t_{U<}$ - trip delay for undervoltage
U<< - threshold for undervoltage
$t_{U<<}$ - trip delay for undervoltage
U> - threshold for overvoltage
$t_{U>}$ - trip delay for overvoltage
U>> - threshold for overvoltage
$t_{U>>}$ - trip delay for overvoltage
Δ/Y - input transformer connection
RS - Slave address of the serial interface
50/60/Vari nominal frequency; Vari = variable sampling rate, dependent on actual measured frequency

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").

5.2.1 Parameter setting of over- and undervoltage supervision

The setting procedure is guided by two coloured 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 are lit red.

Measuring of residual voltage

When the *MRU1-1* 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. Undervoltage 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.

Thresholds of the voltage supervision

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

The undervoltage supervision (U< and U<<) as well as the overvoltage supervision (U> and U>>) can be deactivated by setting the threshold to "EXIT".

Trip delay of voltage supervision

During setting of the trip delays $t_U<$, $t_U<<$, $t_U>$ and $t_U>>$ the display shows the value directly in seconds.The trip 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 trip delay to "EXIT" the value is infinit meaning only warning no tripping.

5.2.2 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.

5.3 Indication of measuring values

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

5.4 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

The display can only be reset when the pickup is not present anymore (otherwise "TRIP" remains in display).

During resetting of the display the parameters are not affected.

6. Relay testing and commissioning

The 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

Switch on the auxiliary power supply to the relay and check that the message "CSE" 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 undervoltage condition has been detected after power-on, because no input 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 undervoltage functions. After that, press the <SELECT/RESET> for app. 3 s to reset the LEDs and "TRIP" message.
- The undervoltage 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 undervoltage functions and press the <SELECT/RESET> push button for app. 3 s to reset the LEDs and "TRIP" message.

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 output 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 5.

As relay input energizing quantities, three phase voltages should be applied to MRU1 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 input 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 *MRU1* 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).

6.4 Secondary injection test

6.4.1 Test equipment

- Voltmeter
- 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 $\geq 2 \times U_N$)
- Timer to measure the operating time
- Switching device
- Test leads and tools

6.4.2 Example of test circuit

For testing of the *MRU1* relay, a three phase voltage source is required. Figure 6.1 shows an example of a three-phase test circuit energizing the *MRU1* relay during test. The three phase voltages are applied to the relay in Y-connection.

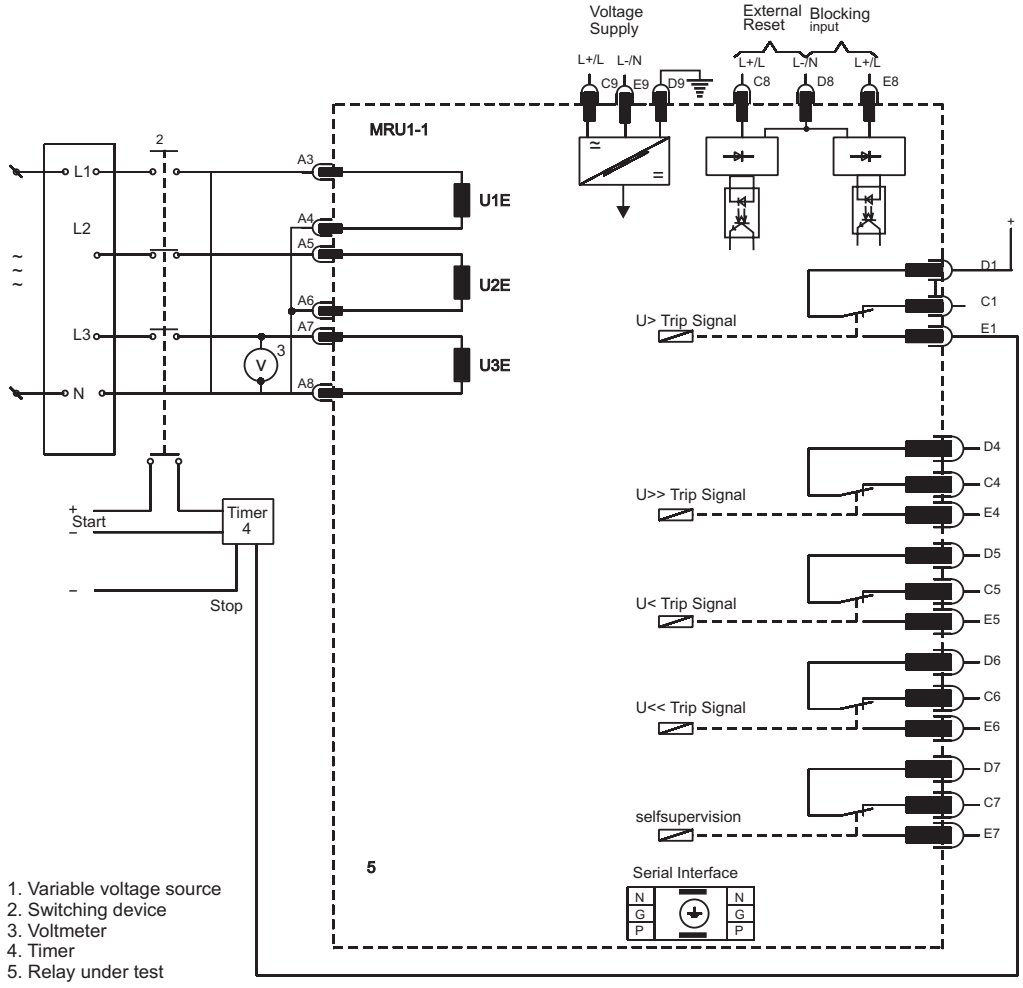


Fig. 6.1: Test circuit

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

Delta-connection:

- 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 Checking the operating and resetting values of the over/undervoltage 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 undervoltage).

6.4.5 Checking the relay operating time of the over/undervoltage functions

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

6.4.6 Checking the external blocking and reset functions

The external blocking input inhibits undervoltage 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 injection test

Generally, a primary injection test could be carried out in the similar manner as the secondary injection test described above. With the difference that the protected power system should be, in this case, connected to the installed relays under test "on line", and the test voltages should be injected to the relay through the voltage transformers with the primary side ener- gized. 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 *MRU1* 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 *MRU1* 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 relays like *MRU1*, this interval can be substantially longer. This is because:

- the *MRU1* relays are equipped with very wide self-supervision functions, so that many faults in the relay can be detected and signalised during service. Important: The self-supervision output relay must be connected to a central alarm panel!
- the combined measuring functions of MRU1 relays enable supervision the relay functions during service.
- the combined TRIP test function of the *MRU1* 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	
Thermal withstand in voltage circuit	:	continuously	2 x U_N

7.2 Common data

Dropout to pickup ratio	:	for U>/U>> : >97 %;	for U</U<< : <103 %
Dropout time	:	30 ms	
Time lag error class index E	:	±10 ms	
Minimum operating time	:	30 ms	
Max. allowed interruption of the auxiliarxy supply without effecting the function of the device	:	50 ms	

Influences on voltage measuring:

Aux. voltage	:	in the range 0.8 <U_H /U_{HN} <1.2 no additional influences to be measured
Frequency	:	in the range 0.8 <f / f_N <1.4 (for f_N = 50 Hz) <0.15 % / Hz
Harmonics	:	up to 20 % of the 3rd harmonic <0.1 % per percent of the 3rd harmonic up to 20 % of the 5th harmonic <0.05 % per percent of the 5th harmonic

7.3 Setting ranges and steps

Function	Parameter		Steps	Tolerance
U</<<	U</<<	U_N = 100 V: 2...200 V (EXIT) U_N = 230 V: 2...460 V (EXIT) U_N = 400 V: 4...800 V (EXIT)	1 V 1 V 2 V	±1 % of set value or < 0.3 % U_N
	$t_{U<}$ $t_{U<<}$	0.04...50 s (EXIT)	0.02; 0.05; 0.1; 0.2; 0.5; 1.0	±1 % or ± 15 ms
U>/>>	U>/>>	U_N = 100 V: 2...200 V (EXIT) U_N = 230 V: 2...460 V (EXIT) U_N = 400 V: 4...800 V (EXIT)	1 V 1 V 2 V	±1 % of set value or < 0.3 % U_N
	$t_{U>}$ $t_{U>>}$	0.04...50 s (EXIT)	0.02; 0.05; 0.1; 0.2; 0.5; 1.0	±1% or ±15 ms

8. Order form

AC voltage relay	***MRU1***					
Standard incl. measuring of the negatve, positive and zero-sequence components		**1** **2**				
Rated voltage	100 V 230 V 400 V		**1** **2** **4**			
Auxiliary voltage	24 V (16 to 60 V AC/16 to 80 V DC) 110 V (50 to 270 V AC/70 to 360 V DC)			**L** **H**		
Serial interface RS485					**R**	
Housing (12TE)	19" rack Flush mounting					**A** **D**

Technical data subject to change without notice!

Setting list *MRU1-1*

Project: _____

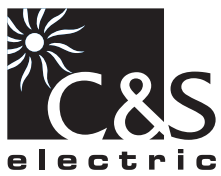
Function group: = _____ Location: + _____ Relay code: _____

Relay functions: _____ Password: _____

Date: _____

Function		Unit	Default settings	Actual settings
Δ/Y	input transformer connection		Y	
U<	pickup value for undervoltage element (low set)	V	90/210/360*	
t_U <	tripping delay for undervoltage element	s	0.04	
U<<	pickup value for undervoltage element (high set)	V	80/190/320*	
t_U <<	tripping delay for undervoltage element	s	0.04	
U>	pickup value for overvoltage element (low set)	V	110/250/440*	
t_U >	tripping delay for overvoltage element	s	0.04	
U>>	pickup value for overvoltage element (high set)	V	120/270/480*	
t_U >>	tripping delay for overvoltage element	s	0.04	
f_N	rated frequency	Hz	50	
RS	Slave address of the serial interface		1	

* thresholds dependent on rated voltage 100 V / 230 V / 400 V



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