Technical Documentation

Capacitor-Bank Protection-Relay

KSR-Z

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Revision history

Date	Name	Revision	Change
07.11.11	Le	01	Initial document release
04.11.15	ChP	02	Password description corrected.
10.11.15	ChP	03	Earth fault protection and natural unbalance compensation descriptions corrected. List of metering values updated.
18.07.18	SO	04	Content correction

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Section 1: Overview

KSR-Z Capacitor Bank protection device has been designed to protect the capacitors from overload, over voltage and unbalance with the advanced and flexible microprocessor technology.

A wide range of protection elements are supplemented by advanced features such as control, metering, data storage, fault recorder, remote communications, supervision and self monitoring features.

An HMI LCD display on the front of the device gives user-friendly access to read the measurements, view and edit relay settings and operational annunciation's. The backlit provides a good visibility even in the poor room illumination. Four context soft keys facilitate easy and flexible parameterisation through LCD display without the need of manual.

An interface is provided at the rear side of the device for remote communications via RS485 with MODBUS protocol.

Section 2: Protection Function and Other Features

2.1 Introduction

KSR-Z device accepts 4 current inputs and 3 voltage inputs.

A full range “Fast Fourier Transformation” is performed on the input data of all channels (3 Voltage channels, 4 Current channels). Thus provides information about the harmonic contents which distort the sine waveform of the current and voltage channels up to 51 order.

Current inputs are available with two options either 1A input or 5A input.

Current $I_{L1}I_{L2}I_{L3}$ inputs used to achieve overload protection, while I_{UB} achieves unbalance protection. Current measurements are derived from these inputs.

Voltage $V_{L1}V_{L2}V_{L3}$ inputs used to achieve over voltage and under voltage protection. Voltage measurements are derived from these inputs.

2.2 Protection Elements

2.2.1 Overload and Unbalance protection

Current $I_{L1}I_{L2}I_{L3}$ and I_{UB} elements provide Overload and Unbalance protection respectively. Each element is pre-programmed to have two independent stages (Alarm and Trip) for current setting and DTL (definite time lag) characteristic or trip characteristic as described in section 3 and Appendix B. For Overload protection the current can be monitored as follows:

OL = current as trms value

OL_{th}= current as thermal damped value

OL_f= current as fundamental value (Only ground wave 50 or 60 Hz)

Samples of the current input signals are taken at a frequency of 6,4 kHz. This enables KSR-Z to act as a True RMS measuring device (TRMS) over a wide frequency range.

2.2.2 Overvoltage and Undervoltage Protection

Voltage $V_{L1}V_{L2}V_{L3}$ elements provide Over-voltage and Under-voltage. Each element can is pre-programmed to have two independent stages (Alarm and Trip) for current setting and DTL (definite time lag) characteristic or trip characteristic as described in section 3 and Appendix B.

Samples of the voltage input signals are taken at a frequency of 6,4 kHz. This enables KSR-Z to act as a True RMS measuring device (TRMS) over a wide frequency range.

2.2.3 Voltage asymmetric protection

The KSR-Z is monitoring the deviation between all line voltages. For the monitoring function it's possible to adjust an allowed deviation from 1% -99.99%. To calculate the Voltage asymmetry the IEEE formula is used:

$$PVUR = \frac{\text{max voltage deviation from the avg. phase voltage}}{\text{Avg. phase voltage}} * 100$$

2.2.4 Earth fault protection

The KSR-Z calculates the earth fault current as the RMS value of the vector sum from the three currents $I_{L1}I_{L2}I_{L3}$. All values are taken from the fundamental wave. **EF** is compared with two adjustable thresholds**, EF trip** and **EF alarm.** For each threshold it's adjustable to use an adjustable time delay or select a trip characteristic.

2.2.5 Protection against repetitive overload and over voltage

To avoid damages of the capacitors due to repetitive overload or over voltage which is to short to be detected by the normal monitoring functions, the KSR-Z has an additionally timer to detect such repetitive events. If an adjusted threshold is exceeded, the time for the threshold violation is stored and subtracted from the delay time respective the trip characteristic to get an alarm or trip event if this violation occurs multiple during a critical time frame. To switch off this additional timer set "T-RESET" to "0" in the protection settings.

2.2.6 Hysteresis of threshold values

For the adjusted alarm thresholds the KSR-Z uses depending on the trigger a pickup respectively a dropout ratio. In case of monitoring a value "greater than", the device triggers an alarm at the adjusted value and go back to normal at value * 0,97. For the monitoring of values "less than", the function works vice versa (value * 1,03).

2.2.7 Output contacts

KSR-Z relays are available with two types of output contacts

- two change over contacts
- four normally open contacts

Output contacts are user programmable to operate from protection characteristic, DTL for different protection functions and relay self-monitoring feature (watchdog). These output contacts are shown in de-energized state in the drawing under section 5.

Under normal mode of operation, output contacts remain energized for the adjusted time delay or trip characteristic for T-OFF or for the duration of fault detected by the protection function. Alternatively, outputs can be programmed to operate as latching contacts, if required. It is also possible to invert the operation of the output contacts.

The factory settings of the relays are shown on the table under point 3.3.4

2.3 Other features

2.3.1 Natural unbalance compensation

The KSR-Z contains the function "natural unbalance compensation". This function allows to measure and store the natural unbalance current (I_{nuc}) at the protected capacitor banks. The value of the natural unbalance current depends on production tolerances of the used capacitors. The unbalance current is measured in the star point connection of two stages. This current can be compensated in amplitude and phase angle to zero, to detect further changes in phase angle and absolute value. During the normal operation the KSR-Z subtracts the stored I_{nuc} value from the current I_n. The result of this operation should be "0". In case of variations of this result it is possible to set a threshold between 0.01A and 50kA to trigger an alarm.

Attention: The natural unbalance compensation is only possible with a voltage signal between L1 – N and a current signal at current channel 1. This signals are needed get the information of the phase angle and absolute value.

2.3.2 Metering functions

The KSR-Z metering features provide continuous measurement of Currents and Voltages which are connected as analogue inputs. The signal processor calculates different values from these inputs.

$V_{Line\ to\ Neutral}$	TRMS Voltages $\mathbf{V_{L1-N}}$, $\mathbf{V_{L2-N}}$, $\mathbf{V_{L3-N}}$
$V_{Line\ to\ Line}$	TRMS Voltages $\mathbf{V_{L1-L2}}$, $\mathbf{V_{L2-L3}}$, $\mathbf{V_{L3-L1}}$
THD	THD – factors for voltages ($\mathbf{V_{Line\ to\ Neutral}}$) and currents ($\mathbf{I_{L1}}$, $\mathbf{I_{L2}}$, $\mathbf{I_{L3}}$, $\mathbf{I_{UB}}$)
I	TRMS Current $\mathbf{I_{L1}}$, $\mathbf{I_{L2}}$, $\mathbf{I_{L3}}$, $\mathbf{I_{UB}}$
If	RMS values of fundamental waves of currents $\mathbf{I_{L1}}$, $\mathbf{I_{L2}}$, $\mathbf{I_{L3}}$ and $\mathbf{I_{UB}}$ (without harmonics)
I UC4	Unbalanced current compensated value $\mathbf{I_{UC4}}$
I EF	Earth fault current actual value $\mathbf{I_{EF}}$ and compensated value $\mathbf{I_{EF-cp}}$
Ith	exponentially damped current values of $\mathbf{I_{L1}}$, $\mathbf{I_{L2}}$, $\mathbf{I_{L3}}$ and $\mathbf{I_{UB}}$ to simulate thermal measurement[1]
T	ambient temperature
Harmonics	Order of (3-51) for current and voltages (only **ODD harmonic orders)**

[1] Please check Appendix A for detailed explaination of thermal damping function.

2.4 Digital Input

Each trip or alarm can be blocked via the DI. This input is detected as active, when there is a voltage between 50 - 132 VDC. The sensing of the DI can be changed to low active as well. See details at the table at item 3.3.4.

2.5 Trip characteristic

With the KSR-Z it is possible to select a adjustable delay time or one of 10 tripping characteristics. For the characteristics please check appendix B.

Following trip characteristics are available:

U1 = U.S. Moderately inverse
U2 = U.S. Inverse
U3 = U.S. Very inverse
U4 = U.S. Extremely inverse
U5 = U.S. Short-time inverse

C1 = I.E.C. Class A – Standard inverse
C2 = I.E.C. Class B – Very inverse
C3 = I.E.C. Class C – Extremely inverse
C4 = I.E.C. Long-time inverse
C5 = I.E.C. Short-time inverse

Section 3: Usage and Main menu

The device provides 4 keys to the user to accept any inputs. The keys are numbered key 1... key 4 from left to right. The actual function of a certain key changes due to the actual context. The keys function is indicated by small pictograms in the bottom line of the display.

After turning on the supply power, the KSR-Z automatically starts with displaying values of the measurement menu. The key, which is labelled with capital letters „M“ can be used to switch to the main menu.

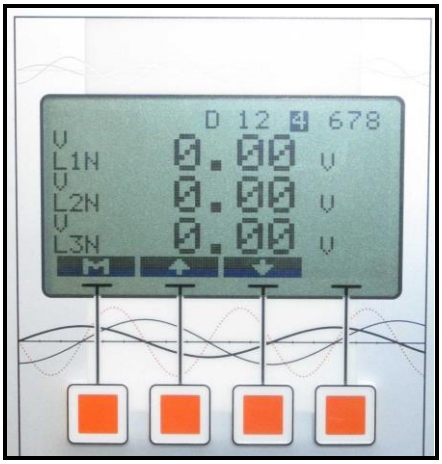
In the main menu, one can choose between the following possibilities:

3. Main menu
    - 3.1. measurement = display measured values
    - 3.2. harmonics = display harmonics
    - 3.3. setup = device setup sub-menu
    - 3.4. device info = display device information
    - 3.5. reset alarms = reset all relays, configured with “manual reset”
    - 3.6. fault recorder = displays all recorded alarms with time stamp and grid data's

Use the keys „↑“ and „↓“ to place the desired entry next to the tiny arrow („>“) on the left side. Press the „→“ - key to activate the selected entry.

Whenever a capital “M” is used as key symbol in any sub-menu, pressing the key will switch straight to the main menu.

3.1 Menu “measurement”

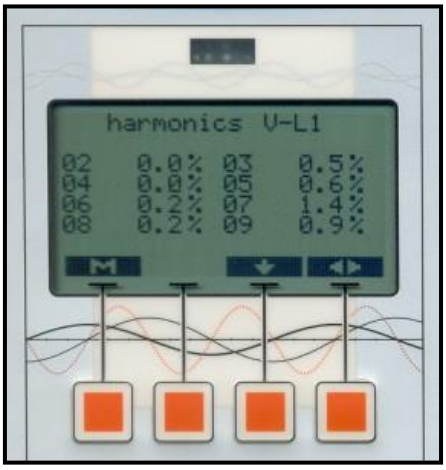


This menu holds nearly all the measured values. Each value is displayed together with its name (VLN, Ith,...) and its origin (L1, L2, L3, N). The units of the measured values are also displayed. Use keys „↑“ and „↓“ to select from the variety of measured values.

In the top line the actual state of the assembled relays is shown with the backlit on each number. A dark number on bright ground represents an inactive relay. Inverse display (bright number on dark ground) indicates an activated relay.

The „M“ - key switches back to the main menu.

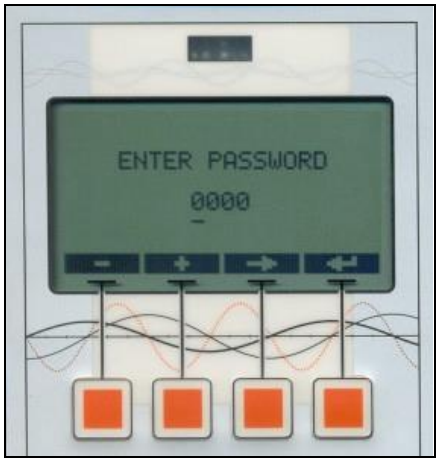
3.2 Menu “harmonics”



All harmonics are normalized to 100% of the fundamental harmonic. Key “↔“ selects the data source (voltages, currents), “↑“ and “↓“ move the display to higher and lower harmonics. The index, which is shown with each harmonic, specifies its order. The fundamental harmonic (index 01) is not shown as it is always 100%.

If the harmonic display quotes “not available”, the current or voltage, which sources the harmonic calculation is below a certain threshold or even not present. This makes the FFT calculation of the harmonics very inaccurate or impossible.

3.3 Menu “setup”

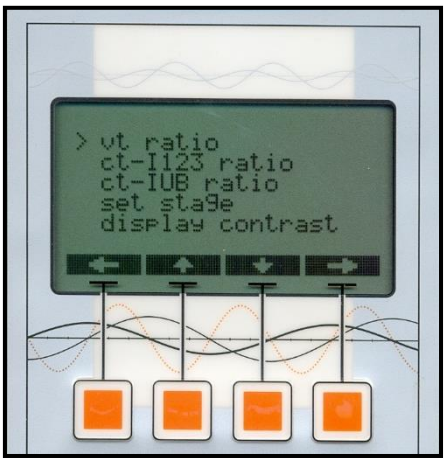


In factory settings the “setup” menu is protected by a password: 2402. If another password or no protection is required, please check point 3.3.5. This submenu allows to set an individual password.

Because of the huge amount of setup possibilities, a set of submenus is used.

At certain points the user will be confronted with the need to enter numeric values. The KSR-Z will prompt with the old or a default value. One digit of this value will be marked with a “_“ below it. Now this digit can be changed with the „+“ and „-“ keys. „→“ will switch to the next digit which can then be altered as described. After you have reached the last digit, press the right button once more and the new value will be used by the device.

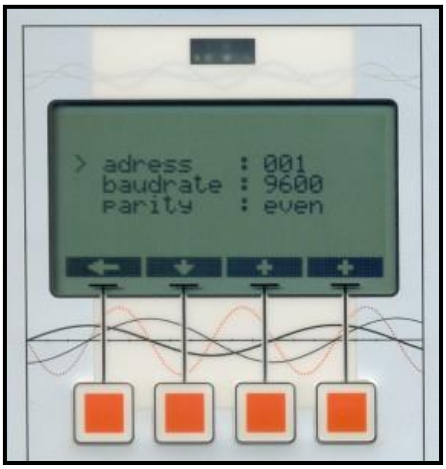
3.3.1 Menu “setup->parameter”



System parameters:

- „vt ratio“ - ratio of a VT
- „ct-I123 ratio“ - ratio of CT for L1, L2 L3
- „ct-Iub ratio“ - ratio of a CT for current 4 (unbalance current)
- “set stage” – stage is shown in the display in case of an trip / alarm
- „display contrast“ - display contrast setting
- “DI high active” – adjusts the behaviour of digital input (sensing for high or low signal)
- "set time" – time and date for the integrated data storage

3.3.2 Menu “setup->modbus”

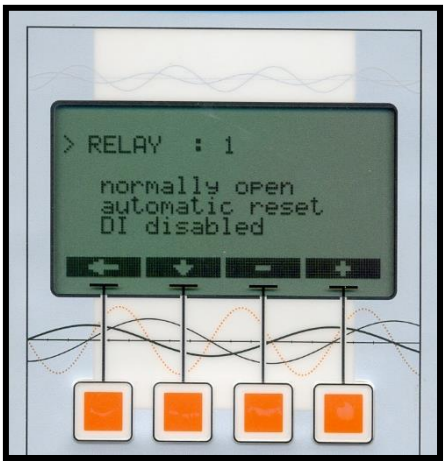


This menu contains all MODBUS settings:

- address - modbus slave address of the device
- baudrate - data transfer speed over serial RS485 connection
- parity - parity setting for serial connection

For details consult the separate technical documentation for KSR-Z Modbus.

3.3.3 Menu “setup->relay”



Setup for the relays:

- „normally open ↔ normally closed“ - this selects the relay inversion. If one chooses „normally open“, the relay will be open in inactive state and it will close on activation. “normally closed” inverts this behaviour.

- „automatic reset ↔ manual reset“ - If a relay is set to “manual reset”, it will stay activated once it has been triggered by an alarm or trip, even if the alarm or trip is inactive again (hold state). If “automatic reset” is used, the relay will fall back to inactive state automatically once the activating alarms or trips have become inactive again.

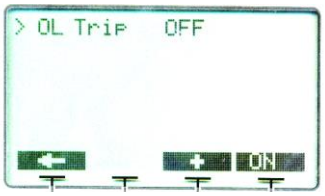
- „DI disabled ↔ DI enabled“ – If adjusted “DI enabled” a relay can be blocked via the digital input to avoid accidentally trips

3.3.4 Menu “setup->protection settings”

The following table gives an overview about the available alarms / trips in KSR-Z which are factory set:

Protection setting:	Monitored values:	Operated Relay	Relay N/C	Store in FR	Blocked by DI	Display message	Display Auto reset	Display Man. reset
OL Alarm	TRMS current L1, L2, L3	Relay 1	√	√	√	√	√	
OL Trip		Relay 4	√	√	√	√		√
UL Alarm	TRMS current L1, L2, L3	Relay 2	√	√	√	√	√	
UL Trip		Relay 4	√	√	√	√		√
OL th Alarm	Thermal damped current L1, L2, L3	Relay 1	√	√	√	√	√	
OL th Trip		Relay 4	√	√	√	√		√
OL f Alarm	Fundamental current L1, L2, L3	Relay 1	√	√	√	√	√	
OL f Trip		Relay 4	√	√	√	√		√
UB Alarm	Current channel 4	Relay 2	√	√	√	√	√	
UB Trip		Relay 4	√	√	√	√		√
EF Alarm	Calculated earth fault current	Relay 8	√	√	√	√	√	
EF Trip		Relay 4	√	√	√	√		√
VA Alarm	Voltage asymmetry between all phases	Relay 7	√	√	√	√	√	
VA Trip		Relay 4	√	√	√	√		√
OV Alarm	TRMS voltage L1-L2, L2-L3, L1-L3	Relay 7	√	√	√	√	√	
OV Trip		Relay 4	√	√	√	√		√
UV Alarm	TRMS voltage L1-L2, L2-L3, L1-L3	Relay 7	√	√	√	√	√	
UV Trip		Relay 4	√	√	√	√		√

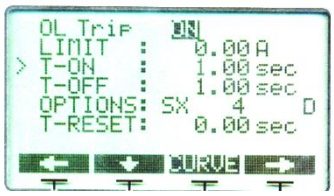
The procedure to enable an protection setting is equal for all available alarms. On the following page please find the exemplary procedure for OL trip:

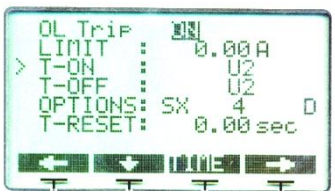


Select protection setting by pushing + and enable it by pushing “ON”.

Before the protection setting is enabled, the allowed threshold must be adjusted.

Use the ↓ button to enter the remaining settings. To open a input mask us the ⇨ button.





With the KSR-Z it is possible to select a adjustable delay time or one of 10 tripping characteristics by pushing “CURVE” respective “TIME”: For the characteristics please check appendix B.
Following trip characteristics are available:
U1 = U.S. Moderately inverse
U2 = U.S. Inverse
U3 = U.S. Very inverse
U4 = U.S. Extremely inverse
U5 = U.S. Short-time inverse
C1 = I.E.C. Class A – Standard inverse
C2 = I.E.C. Class B – Very inverse
C3 = I.E.C. Class C – Extremely inverse
C4 = I.E.C. Long-time inverse
C5 = I.E.C. Short-time inverse

“OPTION” indicates which action shall follows to the protection setting in case off exceeding the adjusted threshold. In the table above all this options are listed in factory settings. If necessary of course they can be adapted.

Following options are possible
Figures: 1 – 7 = Relay 1 – 7
D = Display message
S = stored in fault recorder
X = Event blocked by DI

“T-RESET” additional timer to protect the capacitor bank against repetitive over voltage or over current events. For further information’s check point 2.2.5

For the settings UB Alarm / UB Trip and EF Alarm / EF Trip it’s possible to compensate the natural unbalance respective natural EF current. The proceed is shown below:

Natural unbalance compensation

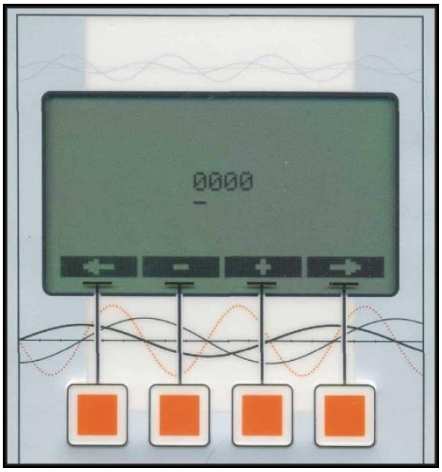
Select item “UB COMP” and set the compensation by pushing the ⇨ button. To reset “UB COMP” the procedure is equal.

For Olth Alarm / Olth Trip it’s necessary to adjust an value for tau. Over the adjusted tau the thermal damping is calculated. For further information check Appendix A

Thermal Tau

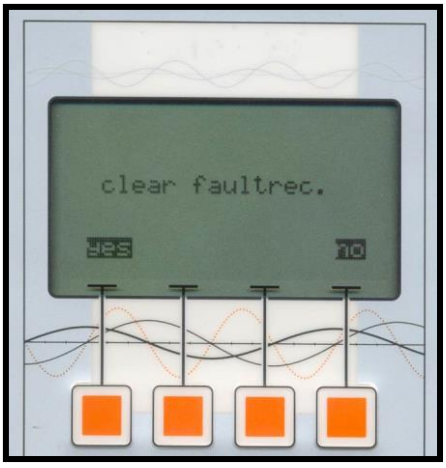
Select item “TAU” and open the input mask by pushing the I button. Enter the value and confirm by pushing ⇨ button.

3.3.5 Menu “setup ->set password”



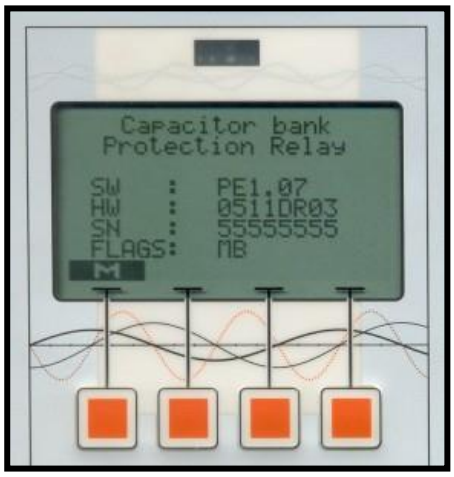
This submenu allows to change password from factory setting (**2402**) to customer requirement. If no password protection is required, adjust the password to **0000 ➔ no password is required**.

3.3.6 Menu "setup -> clear faultrecorder"



This function allows to delete the content of the storage cells from the fault recorder.

3.4 Menu “device info”

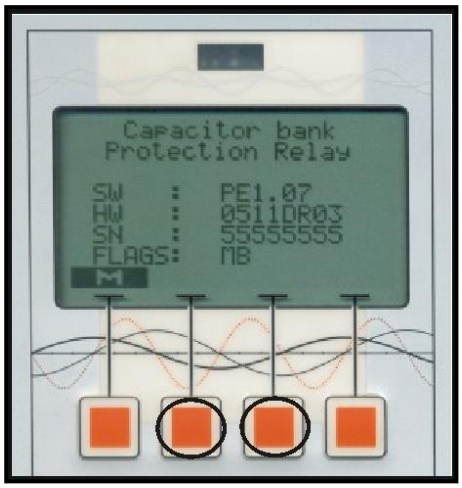


This menu shows information about the device :

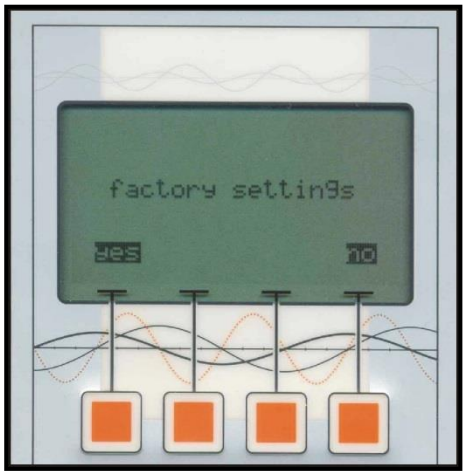
- SW = software version
- HW = hardware revision number
- SN = serial number of the device
- FLAGS = options of the device

The „M“ - key will switch back to the main menu.

To reset the KSR-Z to factory settings, press button 2 & 3 simultaneous.

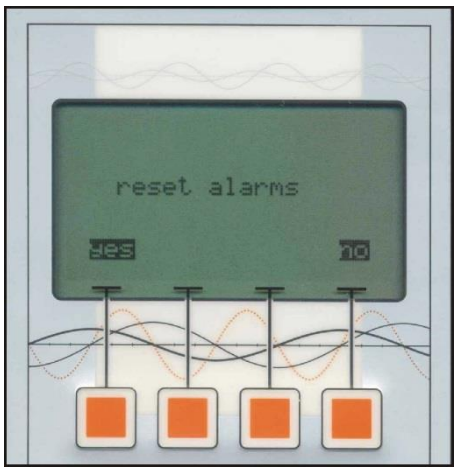


After pressing the buttons the display reading below should appear.



This sets all relay settings, parameters, alarm or trip settings to factory setting.

3.5 Menu “reset alarms”

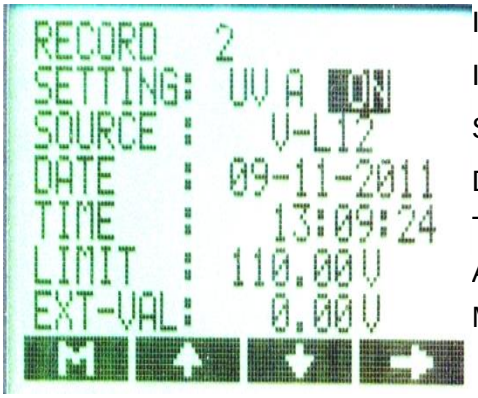


This resets all relays, which are configured with the “manual reset” setting. By selection of this menu entry, the relays are set back to inactive state. A new alarm or trip will re-activate the hold state for the relay.

3.6 Menu “fault recorder”

The KSR-Z is equipped with a integrated fault recorder. With this fault recorder it’s possible to store each triggered Alarm / Trip event. The fault recorder of the KSR-Z provides 64 memory cells. Each of them stores one Event (ON/OFF). For each event the following data's are stored:

Page 1



Indicates in which memory cell the event is stored.

Indicates the setting and whether an ON or OFF event

Show the supervised value

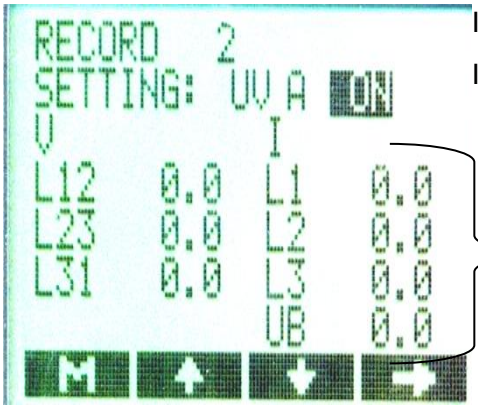
Date of event

Time of event

Adjusted threshold

Maximum exceeding during the delay time

Page 2



Indicates in which memory cell the event is stored.

Indicates the setting and whether an ON or OFF event

Max. Values for current and voltage during the trip / alarm event is stored

Page 3

Indicates in which memory cell the event is stored.

Indicates the setting and whether an ON or OFF event

Adjusted time delay or time depending on trip characteristic

Action followed to the event: Figures: 1 – 7 = Relay 1 – 7

D = Display message

S = stored in fault recorder

X = Event blocked by DI

Section 4: Technical Specifications

4.1 General

Performance data according to IEC and VDE standards.

4.2 Current and Voltage Input

AC Current Input	Rating	1A or 5A (exact rating to be specified during order)
	Continuous Overload	20% Continuous
	Short term overload	50A for 1sec
	Short term overload Option –E	200A for 1sec
	Burden	<100 mOhm (1A type) < 30 mOhm (5A type)
	CT ratio (Max)	1:10000
AC Voltage Input	Rating	55/95V to 318/550V
	Frequency	45 – 65 Hz
	VT Ratio (Max)	1:4000
	Burden	min. 3 MOhm

4.3 Auxiliary Supply

Supply Voltage	Nominal rating	110V DC (other voltages on request)
	Operating range	80 – 132V DC
	Power Consumption	10VA

4.4 Temperature Measuring

Temperature (on the rear side)	Probe / Sensor type	NTC
	Range	30°C – 50°C

4.5 Settings

Settings (Note: Settings are done corresponding to the primary values)	$V_{Line\ to\ Neutral}$	55 – 318V +/- 0.5%
	$V_{Line\ to\ Line}$	95 – 550V +/- 0.5%
	I_{L1}, I_{L2}, I_{L3}, I_{UB}	0.02 - 1.0A +/- 0.5% (1A type) 0.05 - 5.0A +/- 0.5% (5A type)
	Frequency	45 – 65 Hz +/- 0.1%

4.6 Output Contacts

Contact Details	Changeover contacts	2 Nos. (programmable)
	Normally open contacts	4 Nos. (programmable)
	Current rating	5A continuous
	Make and Carry	5A for 4s, duty factor 10%
	Break	30Vdc, 3.0A, ohmic load 30Vdc, 2.0A, inductive load 100Vdc, 0.2A, ohmic load 250Vac, 5.0A ohmic load
	Minimum number of operation	> 100000
	Minimum recommended load	5 V / 1mA

4.7 Connections

Connections (at the rear side)	Aux. Supply	Screw type terminals max. 6sqmm rigid, 4spmm flexible
	Current and Voltage inputs	Screw type terminals max. 6sqmm rigid, 4spmm flexible
	Output Contacts	Screw type terminals max. 6sqmm rigid, 4spmm flexible
	Temperature sensor	Plug in type

4.8 Interface

Interface	User Interface (Local)	An HMI LCD Display
	Remote Interface	RS485 with MODBUS protocol

4.9 Environmental Withstand

Ambient Temperature	Operating range	0°C … +70°C
	Storage range	-20°C … +85°C

Humidity	Operating range	0% to 95% without moisture condensation

Overvoltage Category	Standards	II, pollution degree 3 (DIN VDE 0110 Teil 1 / IEC 60664-1)

Protection Class	Front	IP 52
	Rear	IP 20

Housing	Case	Instrument casing
	Colour	RAL 7037 dusty grey

Dimensions	H x W x D	144 x 144 x 59 mm
	Cutout	138+0.5 x 138+0.5 mm

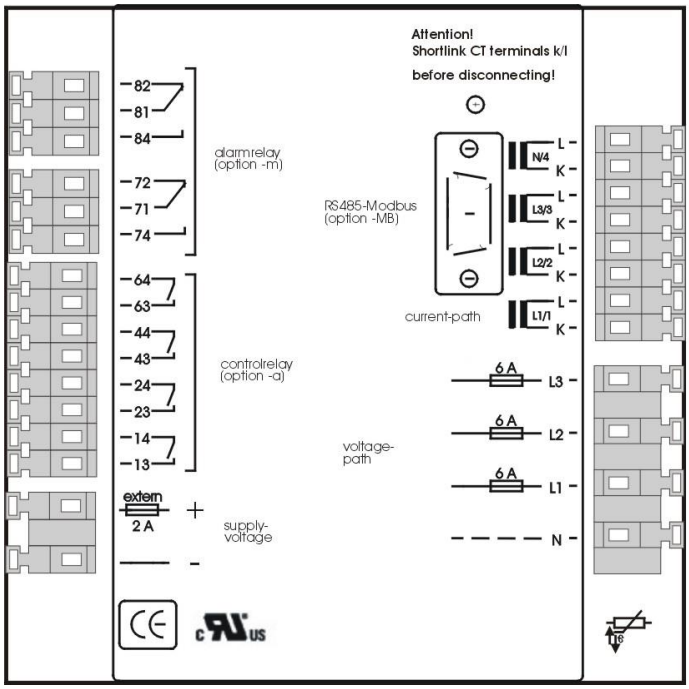
Weight	Complete case	650 g

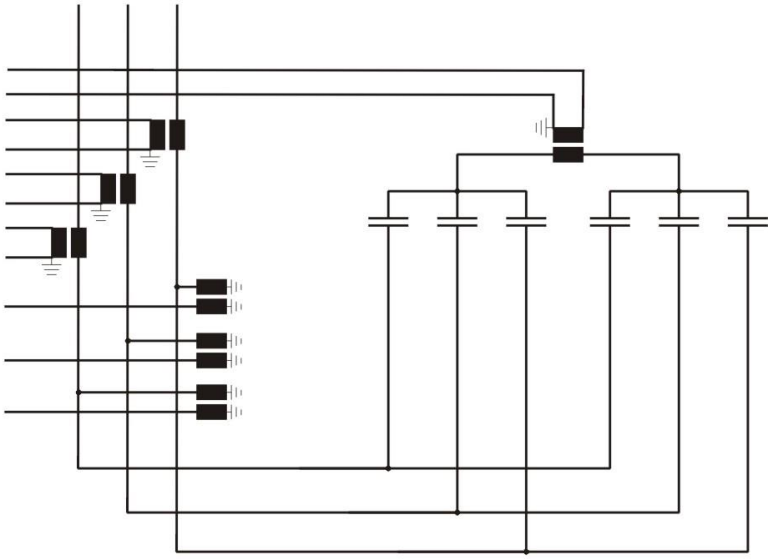
4.10 Standards

Standards	IEC / DIN	DIN VDE 0110 Teil 1 (IEC 60664-1:1992) VDE 0411 Teil 1 (DIN EN 61010-1 / IEC 61010-1:2001) VDE 0843 Teil 20 (DIN EN 61326 / IEC 61326:1997 + A1:1998 + A2:2000)

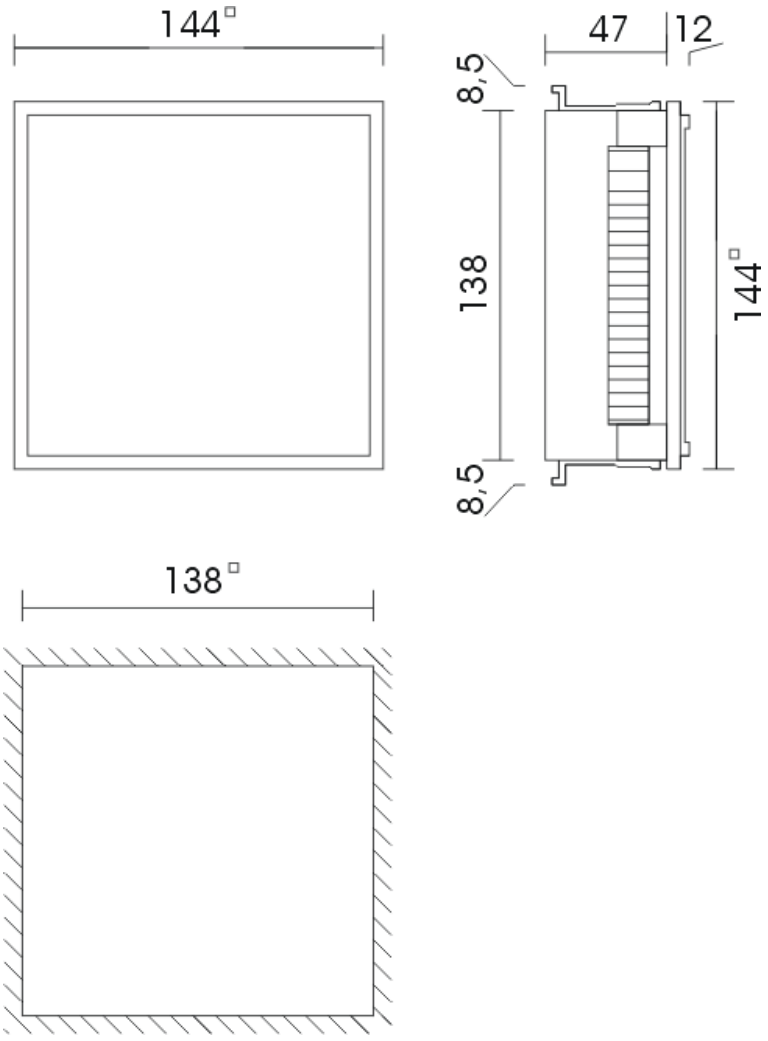
Section 5: Drawings

5.1 Connection diagram



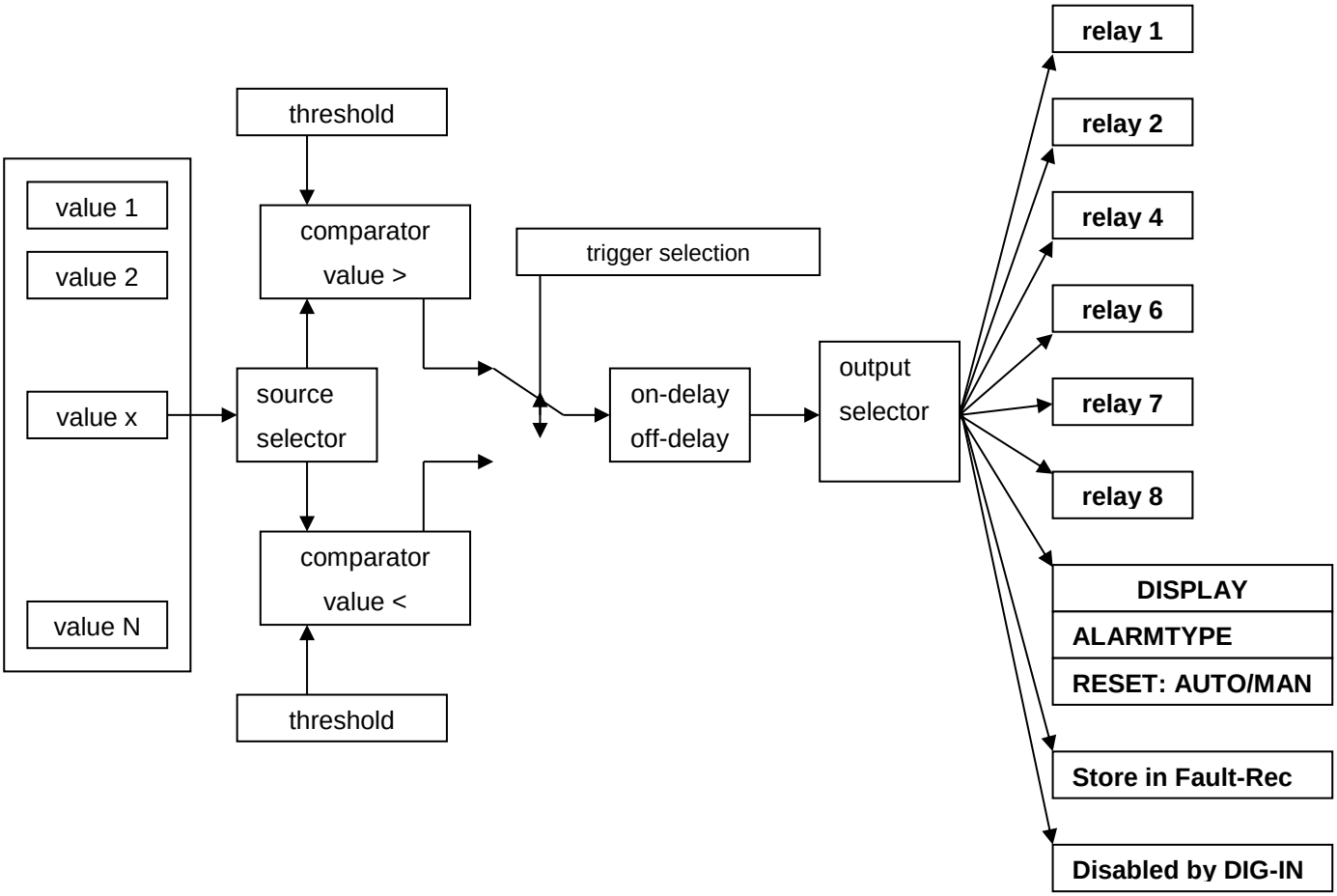


5.2 Dimensions



5.3 Diagram

This diagram shows the set-up for one single alarm. All protection settings work similar.



Section 6: Applications

The KSR-Z Capacitor Bank protection device is constructed with a compact case and intended for the protection of capacitor banks. Some applications for the KSR-Z are for example:

- Detection of over load
- Detection of over voltage
- Detection of under voltage
- Capacitor over load harmonic protection
- Capacitor stage unbalance protection
- Out-of-balance detection at doublestar- and H-circuits
- Unsymmetrical protection
- Protection against repetitive overload events
- Earth fault detection
- Voltage asymmetric monitoring

Section 7: Commissioning Guide

7.1 Test

Before putting the KSR-Z in normal service the device should be tested for the correct function. This will be done at site by using a secondary injection test kit. After keeping the required current, on delay time / trip characteristics and output relays for example the relay should be checked. This is also applicable for the voltage setting.

7.2 Installation

The KSR-Z device is packed in a separate carton inside an outer packaging. Open the carton carefully and unpack the device. Also remove the manual included inside the carton. After unpacking the device make a visual inspection to confirm the KSR-Z is all right.

Check that the measurement voltage, supply voltage and current transformer ratings comply with the ratings given on the back of the device.

7.3 Connection

The dimensions of the case and the necessary cut-out in the control panel are given in the manual. Mount the device in the control panel by means of the two mounting clamps included in the carton.

The screw type terminal blocks to connect the KSR-Z device are mounted on the left and right side on the back. The optional connection for the Modbus via RS485 is also mounted on the back.

The case of the KSR-Z must be grounded to meet protective equipment grounding requirements. This ground connection is an absolute requirement for a proper operation.

Connect the supply voltage to the terminal block for the external power supply on the left side of the back. For this connection a minimum cross section of 1.5mm^2 is required.

Connect the voltage measurement inputs L1, L2, L3, (N) on the right side with your voltage. Please don’t exceed the maximum voltage. For this connection a minimum cross section of 1.5mm^2 is required.

Connect the current measurement inputs on the right side to the referring current measurement transformers (remove short circuit link after connecting!). For this connection a minimum cross section of 2.5mm^2 is required.

Connect the alarm relay outputs on the left side with the referring wiring of the system.

Connect the optional communication interface via RS485 on the backside of the KSR-Z if required.

7.4 Preparation

After the KSR-Z device has been installed and connected as described in 6.2 and 6.3 the commissioning procedure can begin.

Before turning on the supply voltage, the following items should be checked:

- device connected to protective ground?
- nominal voltage of the system complies with nominal voltage of the device?
- current transformer connections, grounding and phase sequence correct ?
- short circuit link of the current transformer removed?

After all checks have been made the supply voltage may be turned on. After voltage has been applied, the KSR-Z device starts immediately.

Section 8: Maintenance

There is no maintenance necessary for the KSR-Z if you comply with the operating conditions. It is advisable to accomplish a functional test of the device once a year in connection with the regular examination of the system. This functional test should include the checking of all main functions and all outputs.

Section 9: Appendix

Appendix A

Explanations of the Current damping function for Ith. Ith is a exponentially damped current value to simulate thermal measurement. The formula and the drawings below shall help to understand the Ith function. The drawing below shows cold curve.

Formula: $t = -\tau \ln(1-y)$

t = time elapsing until Ie is arrived after applying current at current channel

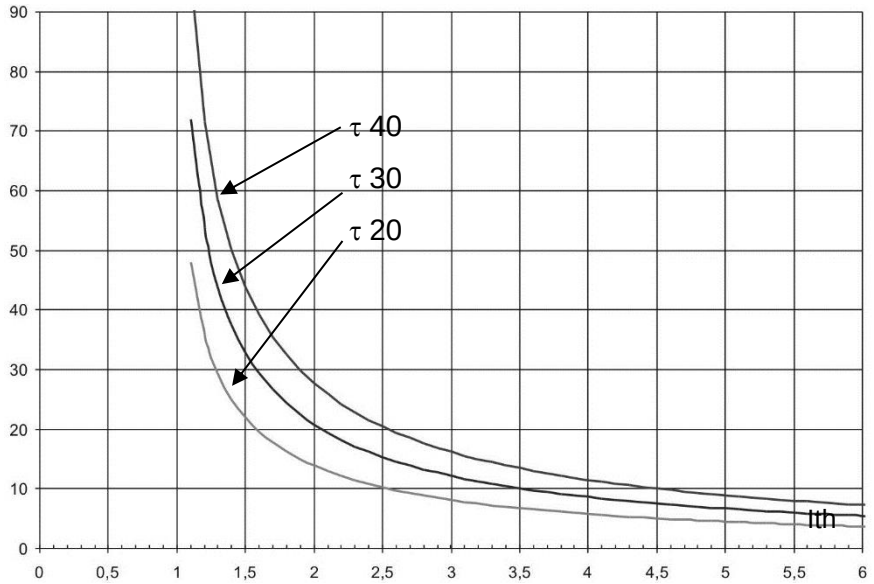
τ = adjusted thermic tau (see referring setting)

y = Ie / I

Ie = adjusted threshold

I = applied current

t [s]



Multiple of alarmthreshold

The drawings stated above shows the relation between the ratio of exceeding the adjusted threshold and the time before Ith has the same value as applied at the current channel. Also the function of the adjustable value for thermic tau (τ) can be seen.

Appendix B tripping characteristics