Reference Manual

Capacitor-Bank Protection-Relay

KSR

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Revision history

Date	Name	Revision	Change
26.05.04	CE	01	initial document release
15.12.04	CE	02	new firmware (V1.05)
21.03.05	ATh	03	new firmware (V1.06)
11.04.06	ATh	04	new firmware (V1.8.1)
14.03.07	ATh	05	general additions
04.04.07	ATh	06	new firmware (V1.12.x)
09.10.08	Le	07	new firmware (V1.14.x)
17.06.09	Le	08	add fault recorder
28.05.10	Le	09	new firmware (V1.16.x)
27.08.10	Le	10	add option –E
27.09.11	MR	11	new Document
09.12.15	RH	12	correct Password
17.07.18	SO	13	correct contents
29.01.24	Ja	14	Adaptation of technical data according to UL

Contents

1. Overview

KSR 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 LCD display on the front of the device gives user-friendly access to read the measurements, view and edit relay settings and operational annunciations. The backlit provides a good visibility even in the poor room illumination. Four context soft keys facilitate easy and flexible parameterization 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.

2. Protection Function and Other Features

2.1 Introduction

KSR 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.

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 can be programmed to have two independent stages for current setting and DTL (definite time lag) characteristic as described in section 3.

Samples of the current input signals are taken at a frequency of 12.8 kHz. This enables KSR to act as a True RMS measuring device (TRMS) over a wide frequency range.

The KSR relay comes with an automatic damping function of the current inputs inputs. This damping function is used to avoid accidental deployments.
The damping function works as an exponential curve. For every new measurement it took 10% of the former measurement. Depending on the ratio between signal level on the input and adjusted threshold, it can result some delay before starting the real delay time.
The real delay time is only starting when the adjusted threshold is exceeded.

2.2.2 Overvoltage and Undervoltage Protection

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

Samples of the voltage input signals are taken at a frequency of 12.8 kHz. This enables KSR to act as a True RMS measuring device (TRMS) over a wide frequency range.

2.2.3 Hysteresis of threshold values

For the adjusted alarm thresholds, the KSR 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).

2.2.4 Output contacts

KSR 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 4.

Under normal mode of operation, output contacts remain energized for at least 100ms 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.

2.3 Further features

2.3.1 Natural unbalance compensation

The KSR 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. During the normal operation the KSR 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 limit between 0.01A and 50kA to trigger an alarm.

2.3.2 Metering functions

The KSR 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 V_{L1-N}, V_{L2-N}, V_{L3-N}
$V_{Line\ to\ Line}$	TRMS Voltages V_{L1-L2}, V_{L2-L3}, V_{L3-L1}
I	TRMS Current I_{L1}, I_{L2}, I_{L3}, I_{UB}
If	RMS values of fundamental waves of currents (without harmonics)
Harmonics	Order of (2-63) for current and voltages
THD	THD – factors for voltages ($V_{Line\ to\ Neutral}$) and all 4 currents
Ith	exponentially damped current values to simulate thermal measurement[1]
T	ambient temperature

2.3.3 Alarm system

The KSR allows the programming of the output relays to produce alarms or trips. The alarm or trip system works with two separate facilities:

- The output relays can be programmed separately. Each relay implements an inversion feature as well as a hold state in which the user must manually reset the relay after activating alarm or trip has become

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

inactive again. The relays receive signals to “activate themselves” from one or more of the 32 configurable alarms. Depending on its inversion setting, the relay closes or opens on activation.

- A maximum of 32 alarms or trips can be assigned. Each of them continuously compares a value to an assigned limit. If a selectable alarm or trip condition is true (value>limit or value<limit), a delay timer is started. After the selected delay time is over, the alarm or trip sends the activation signals to all output relays, which are programmed as “targets” for this alarm or trip. A second, configurable timeout delay can be set for the time between the reset of the alarm condition and the transmission of the deactivation signals to the output relays. Additional to the adjustable delay times, the KSR contains an separate dropout respectively pickup ratio to avoid a hunting of the alarm condition. This function works depending on the adjusted trigger. For a trigger "greater than" the alarm condition is not is true at the adjusted limit and untrue at adjusted limit * 0.97. For trigger "less than" the function works vice versa. A graphical display message can be used to show the alarms in the LCD of the device. This message can be programmed either with manually or automatically reset. The alarm display message is treated as if it was another output relay (so it can simply be selected as target for an alarm). Also it is possible to store for each alarm event date and time for activating and deactivating the alarm.

The high flexibility of this alarm system is achieved due to the following points:

1. One alarm or trip can cause the activation of one or more output relays.
2. One relay can be activated from more than one alarm or trip. If two or more alarms use the same relay as output, a logical OR condition is used: one active alarm or trip suffices to cause the relay to switch. Both, relays and alarms, are invertible in their function.

2.3.4 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 V DC. See details at chapter 2.3.5.8.

2.3.5 Fault recorder

If the KSR is equipped with the integrated fault recorder, it is possible to store each triggered Alarm event. The integrated fault recorder of the KSR provides 64 memory cells. Each of them stores one Event (ON/OFF). Each event is stored with the following information:

- **RECORD:** Indicates in, which place of the memory the alarm is stored.
- **ALARM XX:** Shows which alarm was triggered **ON:** Alarm active
  OFF: Alarm inactive
- **DATE:** Date of the alarm event.
- **TIME:** Time of the alarm event.

  Date and time can be set under „setup parameter“.
- **LIMIT:** Which limit was exceeded.
- **EXT-VAL:** **Shows the maximum limit exceedance in the moment of the alarm event.**

Button „⇒“ is used to visit the next page.

Seite 2:

- **RECORD:** Indicates in which part of the memory the alarm is stored.
- **ALARM XX:** Shows which alarm was triggered **ON:** Alarm active
  OFF: Alarm inactive
- Value in the moment of the alarm event

U (in Volt)		**I** (in Ampere)	
L12	**0.00**	**1**	**0.0**
L23	**0.00**	**2**	**0.0**
L31	**0.00**	**3**	**0.0**
		UB	**0.0**

Button „⇒“ is used to visit the next page.

Seite 3:

- **RECORD:** Indicates in which part of the memory the alarm is stored.
- **ALARM XX:** Shows which alarm was triggered **ON:** Alarm active
  OFF: Alarm inactive
- **DELAY:** Time Delay from exceeding the adjusted level to activate an alarm.
- **RELAY:** What happens in case of an alarm (display alarm / activate relay / etc.).

2.3.6 Usage

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 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.

2.3.6.1 Main menu

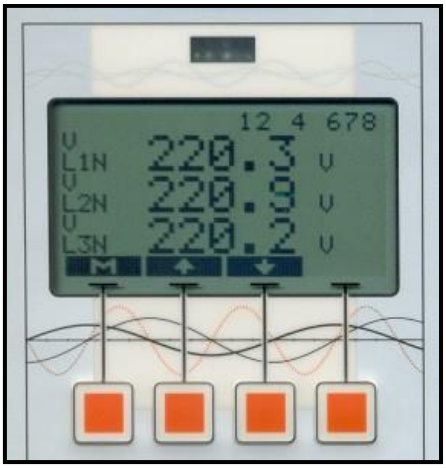
In the main menu, one can choose between the following possibilities:

- measurement = display measured values
- harmonics = display harmonics
- setup = device setup sub-menu
- device info = display device information
- reset alarms = reset all relays, configured with “manual reset”
- 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.

2.3.6.2 Menu “measurement”

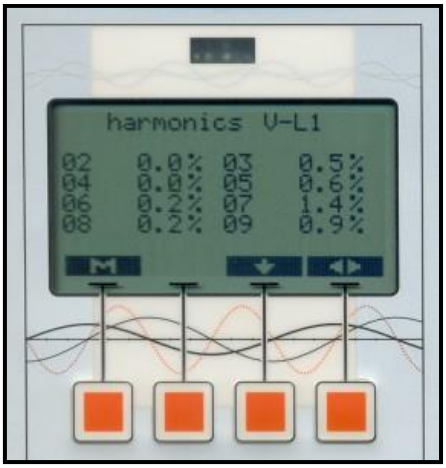


This menu holds nearly all the measured values. Each value is displayed together with its name (VLN, Ith,...) and its origin (L1, L2, L3, N). The units of the measured values are also displayed. Use keys „↑“ and „↓“ to select from the variety of measured values.

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.

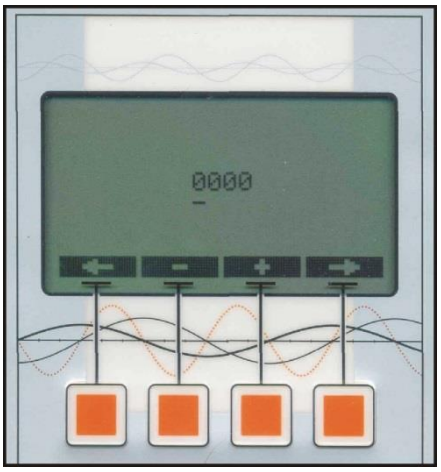
2.3.6.3 Menu “harmonics”



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 limit or even not present. This makes the FFT calculation of the harmonics very inaccurate or impossible.

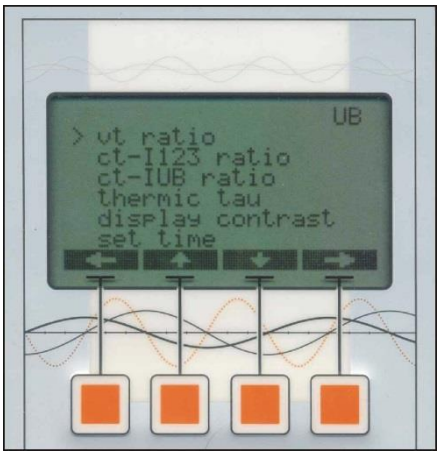
2.3.6.4 Menu “setup”



The „setup“-menu is protected from unauthorized usage by means of a password. The password is fixed („2402“). 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 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.

2.3.6.5 Menu “setup->parameter”



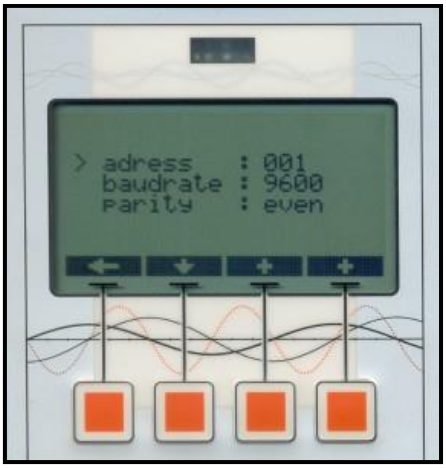
System parameters:

- „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)
- „thermic tau“ - time constant for calculation of Ith[2]
- „display contrast“ - display contrast setting
- "set time" – time and date for the integrated data storage
- „set UB comp.“ – measure and store the value for the natural unbalance
- „clear UB comp.“ – clear the stored value for the natural unbalance (Appears only when UB current is set)

Top right you can see if the UB current is set or not. If the UB current is set, the UB sign is marked in black.

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

2.3.6.6 Menu “setup->modbus”

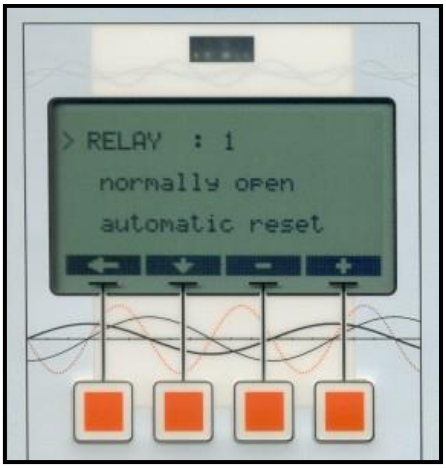


This menu contains all MODBUS settings:

- 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 Modbus.

2.3.6.7 Menu “setup->relay”

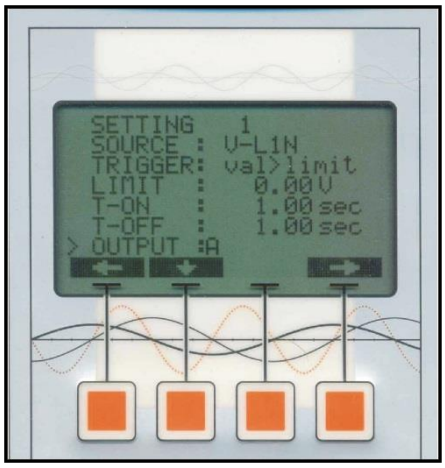


Setup for the relays:

- „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.

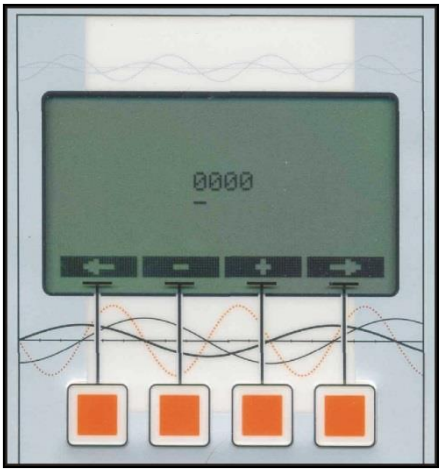
- „automatic reset ↔ manual reset“ - If a relay is set to “manual reset”, it will stay activated once it has been triggered by an alarm or trip, even if the alarm or trip is inactive again (hold state). If “automatic reset” is used, the relay will fall back to inactive state automatically once the activating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

2.3.6.8 Menu “setup->protection settings”



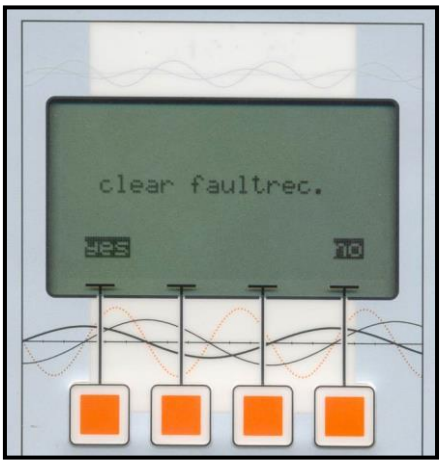
- SOURCE : this selects the data source
- TRIGGER : trigger condition
- LIMIT : selection of the limit value
- T-ON : turn-on delay time (0 – 600s)
- T-OFF : turn-off delay time (0 – 600s)
- OUTPUT : selection of the relays, which shall be activated if alarm condition is true and after T-ON is over. The alarm display feature can be selected here too, as if it was another relay output. For each display alarm a display message can be adjusted, it is possible to select the following messages: UB alarm or trip, OV alarm or trip, UV alarm or trip, OL alarm or trip. The setting for automatic or manual reset works the same as with output relays. Also it can be adjusted if a alarm is stored in the fault recorder and if the alarm is disabled when the DI is active.

2.3.6.9 Menu “setup ->set password”



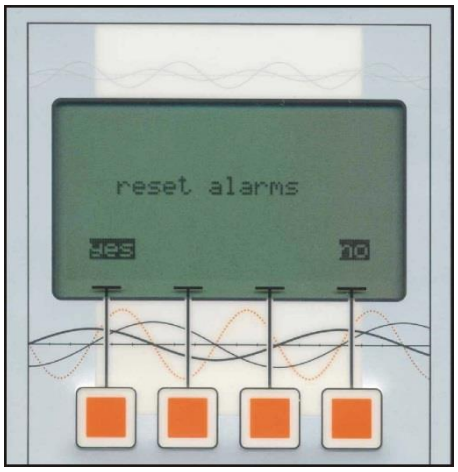
This submenu allows to change password from factory setting (2402) to customer requirement.

2.3.6.10 Menu "setup -> clear faultrecorder"



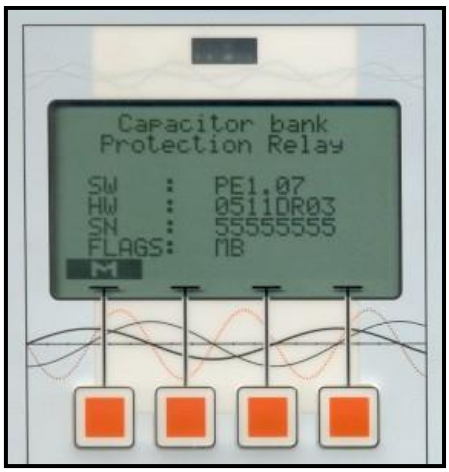
This function allows to delete the content of the storage cells from the fault recorder.

2.3.6.11 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.

2.3.6.12 Menu “device info”

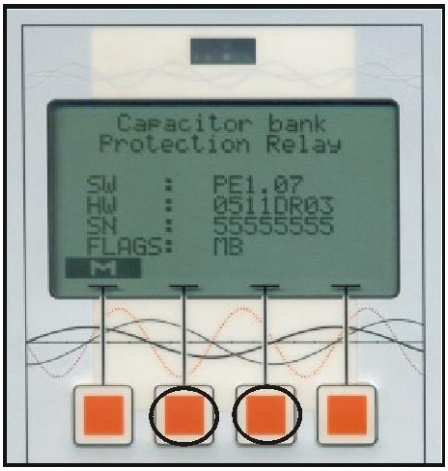


This menu shows information about the device :

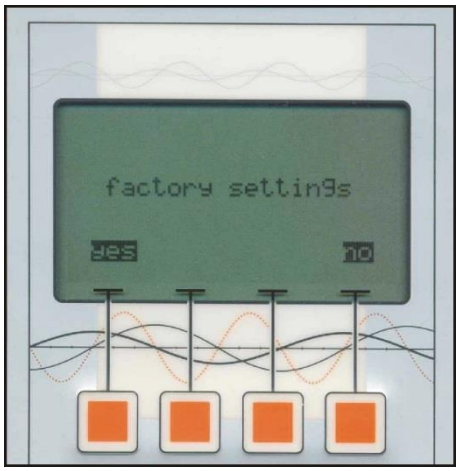
- SW = software version
- HW = hardware revision number
- SN = serial number of the device
- FLAGS = options of the device

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

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



After pressing the buttons the display reading below should appear.



This resets all relay settings, parameters, alarm or trip settings and impulse settings to standard values.

3. Technical Specifications

3.1 General

Performance data according to IEC and VDE standards.

3.2 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

3.3 Auxiliary Supply

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

3.4 Temperature Measuring

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

3.5 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%
	Harmonics (Voltage 2 – 63)	0 - 100%
	Harmonics (Current 2 – 63)	0 - 100%

3.6 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

3.7 Connections

Connections (at the rear side)	Aux. Supply	Screw type terminals max. 2.5sqmm
	Current and Voltage inputs	Screw type terminals max. 2.5sqmm
	Output Contacts	Screw type terminals max. 2.5sqmm
	Temperature sensor	Plug in type

3.8 Interface

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

3.9 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

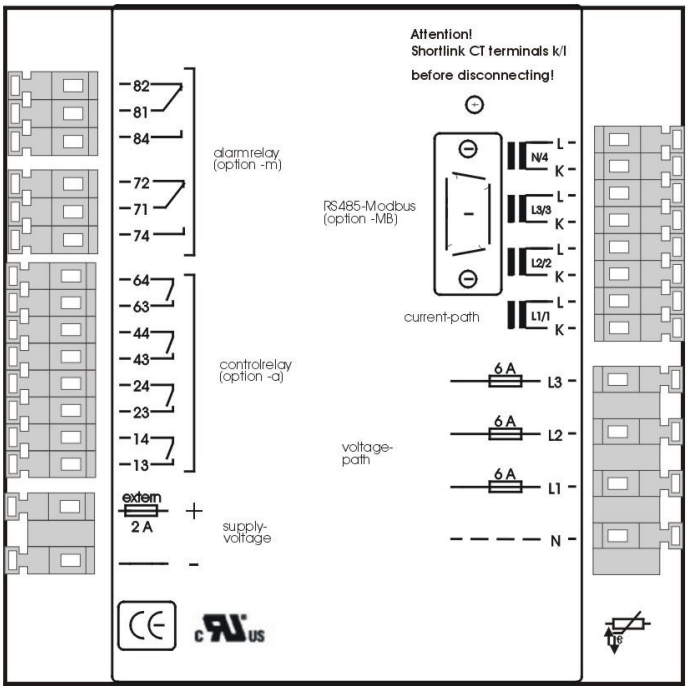
Ambient conditions according to UL approval	Ambient temperature: 0 - 40°C Environment: Pollution degree 2 Installation location: Door installation

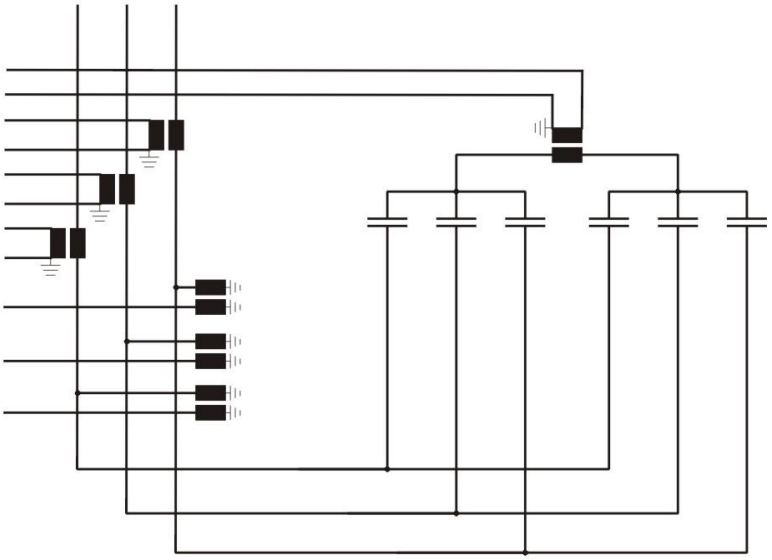
3.10 Standards

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)

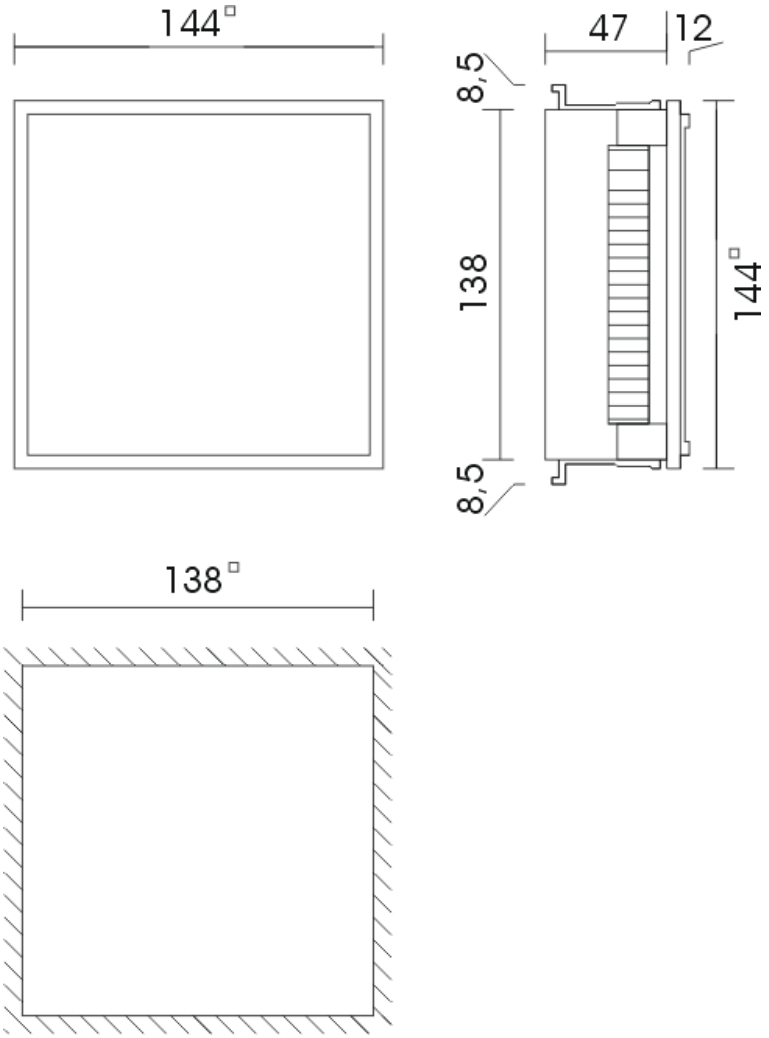
4. Drawings

4.1 Connection diagram



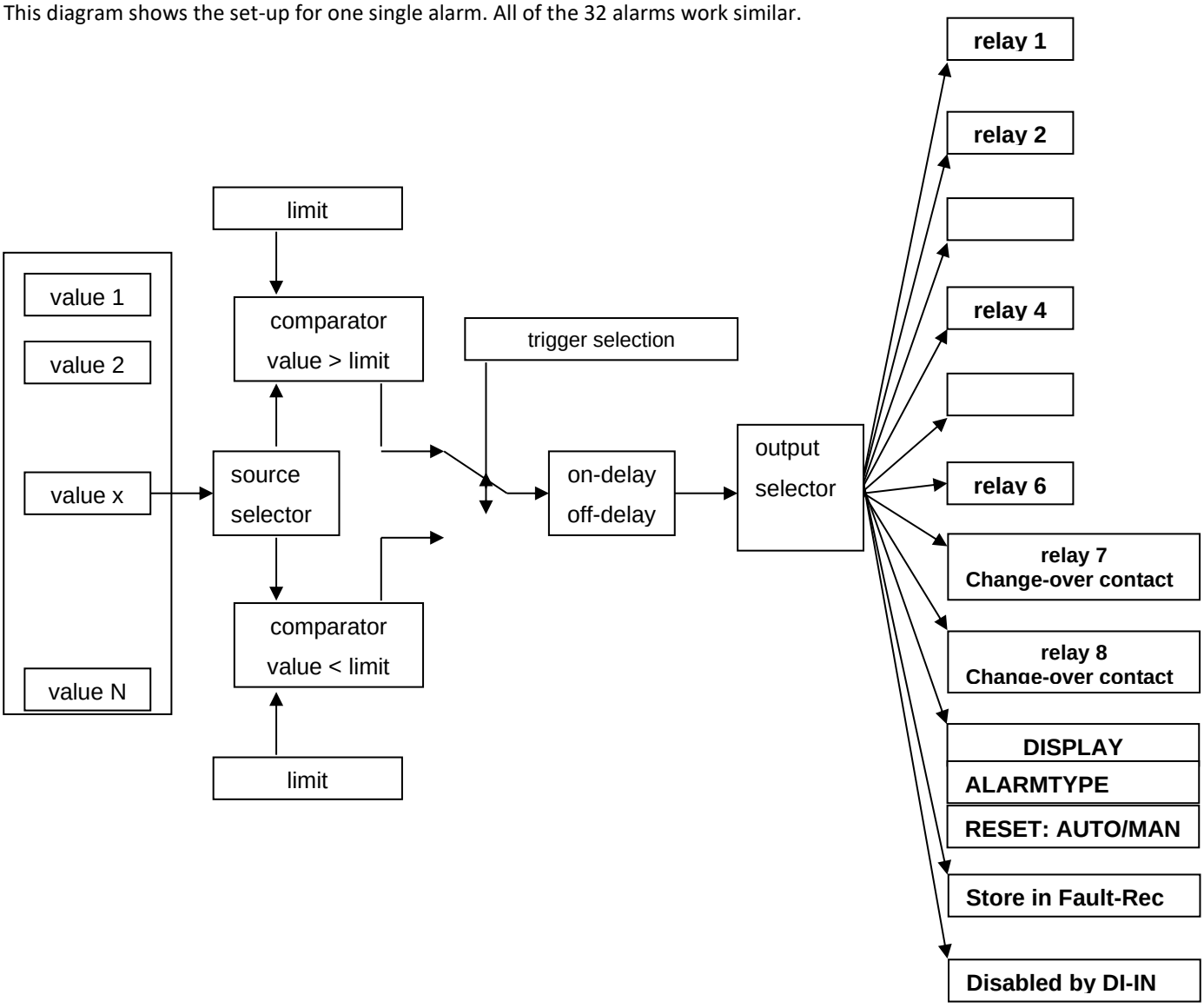


4.2 Dimensions



4.3 Diagram

This diagram shows the set-up for one single alarm. All of the 32 alarms work similar.



5. Applications

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

6. Commissioning Guide

6.1 Test

Before putting the KSR 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 and output relays for example the relay should be checked. This is also applicable for the voltage setting.

6.2 Installation

The KSR 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 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.

6.3 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 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 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 if required.

6.4 Preparation

After the KSR 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 device starts immediately.

7. Maintenance

There is no maintenance necessary for the KSR 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.

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

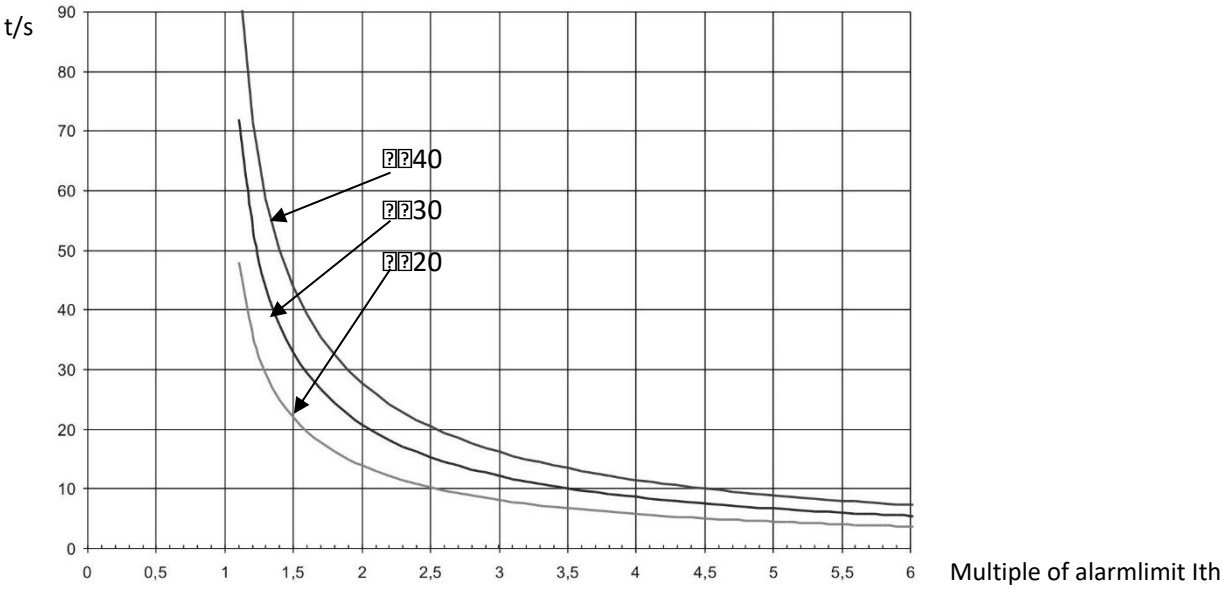
t = time elapsing until Ie is arrived after applying current at current channel

□□□□adjusted thermic tau (see referring setting)

y =Ie/I

Ie = adjusted threshold

I = applied current



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 (□□□can be seen.