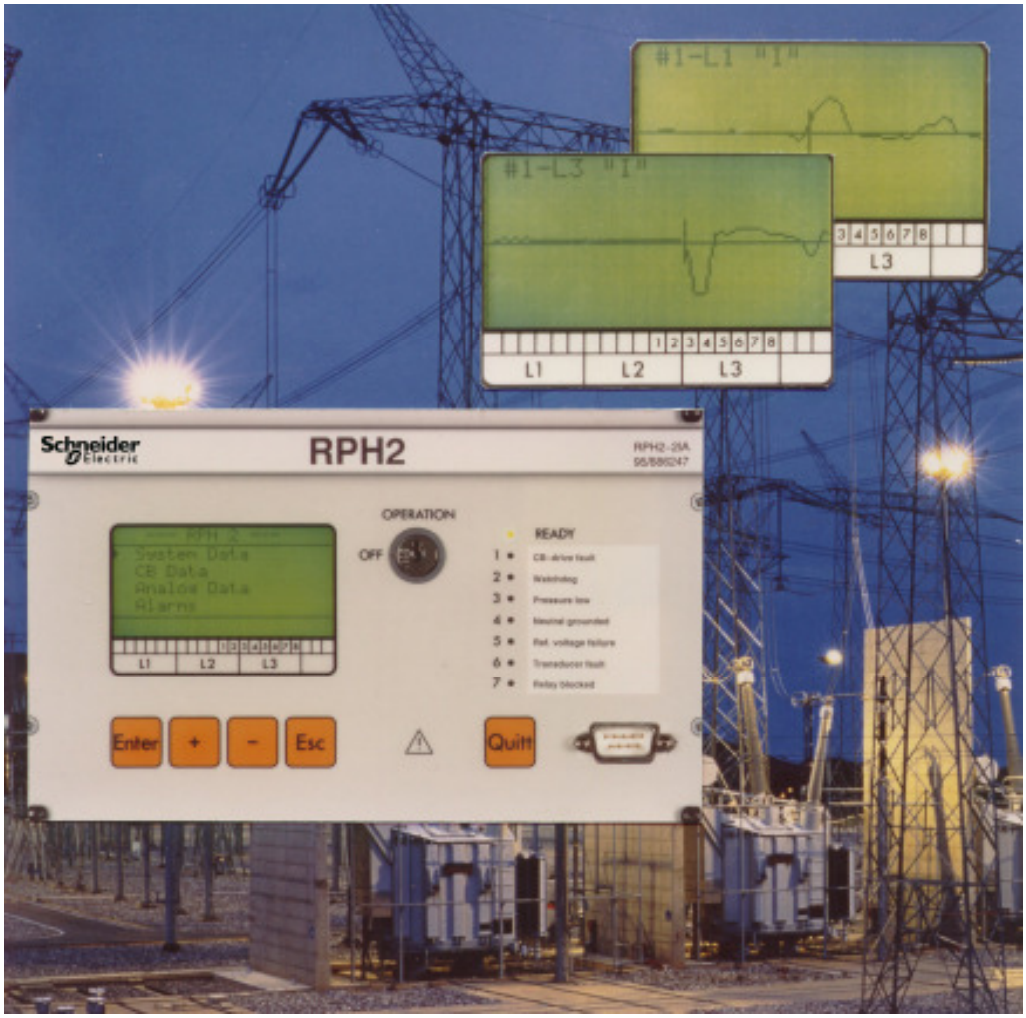
# Point-on-Wave Controller
# Series RPH2

## Service Manual

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Schneider Electric

# RPH2 Service Manual

## CONTENTS

# 1. IN GENERAL

## 1.1. Handling of electronic equipment

A person can cause an electronic potential of many thousands of volts.
When this potential is discharged into appliances with semiconductor components, serious damage can occur which is not immediately evident, but can still impair operational reliability.

The electronic switching circuit of the RPH2 Point-on-Wave Controller from Schneider Electric Energy Austria AG, Leonding meets all the requirements concerning electromagnetic compatibility in accordance with the EN 50 081-1/1992 and EN 50 082-2/1995.

Care is necessary only if the plug-in unit is pulled out of the casing. Take care not to touch the plug contact on the back! For storing and transporting loose plug-in units, we recommend a conductive fail packaging.

As soon as the plug-in unit is properly installed in the casing, no safety measures are necessary at all.

## 1.2. Unpacking

Despite the general robust construction of the Point-on-Wave Controller, it must be handled with care before installation. Before accepting the Point-on-Wave Controller it should be checked for damage which could have originated during transportation. If you have cause for complaint, please refer to the transport company and notify a person responsible at Schneider Electric.

## 1.3. Storage

If the Point-on-Wave Controller is not to be installed immediately upon receipt, it should be stored in a place which is free of dust and moisture, in its original packaging. If a moisture-absorption bag is in the packaging, leave it as it is. The effectiveness of the drying agent is impaired if the non-protected bag is subjected to the surrounding conditions.
Before the Point-on-Wave Controller is placed in the box again, warm the drying bag slightly in order to regenerate the drying agent.

Storage temperature: -40 °C to +70 °C

## 1.4. Installation

The RPH2 Point-on-Wave Controller can either be installed in a switchboard or a suitable frame with the provided material (panel cut-out see diagram 58.001.115).

We suggest the control room or the relays room as the most favourable installation site. Installation in a heated outdoor control cubicle is also possible. Installation directly in the operating mechanism of a circuit breaker is not provided for (please contact Schneider Electric regarding this).
The position should be well lit in order to make inspections easier.

Wiring is carried out according to the wiring diagram which is enclosed with every Point-on-Wave Controller. Take care to earth the housing appropriately.

## 1.5. Technical data

| | | |
|---|---|---|
| supply voltage | Nominal: | 48 V - 250 VDC |
| (= CB trip coil voltage): | Operative range: | 35 V - 300 VDC |
| special power supply for 48 V -44 % ANSI-Standard available | | |
| power consumption: | | < 20 W |
| | | |
| reference voltage (L1/N): | Nominal: | 100/√3 V; 220/√3 V AC |
| | Operative range: | 15 V -105 VAC; 30 V - 250 VAC |
| rated frequency: | | 16 2/3 / 50 / 60 Hz ±10 % |
| power consumption of measuring inputs: | | < 2 VA |
| | | |
| maximum permissible current of CB trip coil: | | 14.5 A/ phase for 1 sec. |
| minimum command time: | | 100 ms |
| polarity of command impulse: | | positive (negative on request) |
| resolution of time setting: | | 0.1 ms |
| accuracy of switching times over temperature range -55 °C to +55 °C | | ±0.3 ms |
| | | |
| current inputs: | | 1 A and 5 A |
| rated short time current: | | 100 x In / 1 s |
| accuracy of current measurement | | ±10% (0.5 In ... 4 In) |
| | | |
| measurement control voltage | | internal |
| input temperature measurement: | | 4...20 mA of Pt 100 |
| input pressure measurement: | | 4...20 mA of pressure sensor |
| accuracy of measurement by RPH2: | | |
| control voltage | | ±3% |
| ambient temperature | | ±3% |
| hydraulic pressure | | ±3% |
| | | |
| signalling inputs: | | potential free contacts required |
| (e.g. CB or neutral ground disconnector position, CB aux. contacts, external reset) | | |
| | | |
| indication outputs: | | potential free contacts |
| contact rating | | 24-250 V AC/DC ± 25 %, max. 70 VA/ max. 3 A |
| | | |
| communication port: | | RS 232, DC decoupled |

# 2. INTRODUCTION

## 2.1. Using the handbook

This handbook will guide the user through the setting-up procedure for the Point-on-Wave Controller.
It explains the additional functions of this appliance, and how they are selected and used. In addition, some examples of its usage are given, the theory behind it examined and explained, and which circuit breaker and main data are absolutely necessary for operation.
The handbook shows the complete list of all menu points with cross-references to the chapter with the accompanying descriptions. The menu point order for the individual modules is shown on this list as well.
Notes on checking and commissioning are given in the last chapter.

## 2.2. Models available, Assembly

The RPH2 is available in 2 basic models:

- RPH2-1xx: for one switching function (closing or opening alternatively)
- RPH2-2xx: for 2 switching functions
  channel 1 for closing, channel 2 for opening
  (only when using the given switching programs)

The 7 alarm LED's are active, however there is only one alarm contact (Alarm 1) available. In addition, there is an alarm contact "Device not ready".

The RPH2 Point-on-Wave Controller is assembled in a modular system. The function can be extended through the combination of various modules. Extending the function at a later date is only possible by the manufacturer.

The casing is a standard 19 inch sub-rack, with half width for one device or alternatively with full width for 2 devices. After removing the 4 external screws of the front panel, the plug-in unit on the grip rail can be removed from the housing. Safety notes see 1.1.

## 2.3. Additional modules

### 2.3.1. Signal module: Option S

This module offers 6 alarm outputs (alarm 2 to alarm 7) and 6 optoelectronic coupler inputs. Inputs 1-3 serve as circuit breaker monitors via its auxiliary contacts. With this the pole operating times can be measured. Resolution 0.1 ms.
Input 4 serves as an input for a remote-reset. Inputs 5 and 6 are not in use at present. A further input is used for synchronizing with a radio clock. It can be switched in parallel with other Point-on-Wave Controllers.

### 2.3.2. Current measurement module: Option I

With this the phase currents during the switching process can be recorded and graphically displayed. Data from the last 4 switching operations (curves, amplitudes) are stored in a non volatile memory and can be analysed on the display. Primary values are shown after feeding in the current transformer ratios.

### 2.3.3. Analogue module: Option A

Independent of the breaking system and the kind of operating mechanism, the operating times of a circuit breaker change in dependence on certain service parameters:

With reduced control voltage at the circuit breaker coil there is less energy available to change the electrical control commands into a mechanical action. The operating time extends itself. (Valid for all types of operations.)

By altering the hydraulic pressure on hydraulic drives, the energy available to carry out the switching movement changes.

The ambient temperature is the most complex parameter of influence. The electrical resistance of the trip coils, the oil viscosity and the pressure of the SF6 gas are dependent on the temperature. In addition, changes of length in the driving linkage and the porcelains occur. All these parameters influence the operating time in different ways.

In the extreme, each of these 3 parameters can alter the operating time by some milliseconds. The RPH2 with option A is in the position to compensate these operating time alterations.
There are inputs available for the measurements acquired when measuring the control voltage, pressure and temperature for the compensation of pole operating times.

The control voltage is measured directly in the RPH2 at the input terminals for the auxiliary voltage. There are no external measuring devices necessary.
For measuring pressure and temperature, external sensors with integrated transducer banks (2 conductor constructions, auxiliary voltage 24 VDC) and standard output signal (4...20 mA) are necessary. The supply for the transducer bank is effected by the RPH2. Up to 8 RPH2's can be switched in parallel on one temperature sensor. When measuring pressure, an individual transducer is necessary for each circuit breaker (option A1) or each circuit breaker pole (option A3). The measuring range of the measuring instruments depends on the requirements and can be simply parameterized in the RPH2.

Three types of this additional module are available:

#### *2.3.3.1. Option **A0***

Measuring and compensation of control voltage and temperature (for springloaded drives)

*2.3.3.2. Option **A1***

Same design as 2.3.3.1, however with additional measurement and compensation for hydraulic pressure (for hydraulic drives which have a mutual pressure generation for all three poles).

*2.3.3.3. Option **A3***

Like 2.3.3.2, however for circuit breakers which have pressure generation per pole.

*2.3.3.4. List of available models*

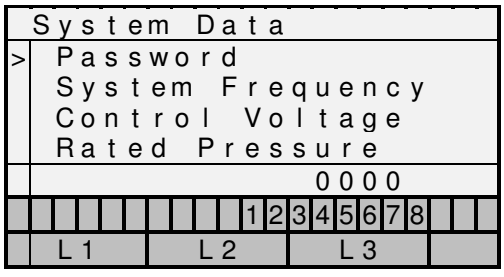
| | | | | |
|---|---|---|---|---|
| RPH2-1 | RPH2-1S | RPH2-1I | RPH2-1A0 | RPH2-1A1 |
| RPH2-2 | RPH2-2S | RPH2-2I | RPH2-2A0 | RPH2-2A1 |
| RPH2-1A3 | RPH2-1SI | RPH2-1SA0 | RPH2-1SA1 | RPH2-1SA3 |
| RPH2-2A3 | RPH2-2SI | RPH2-2SA0 | RPH2-2SA1 | RPH2-2SA3 |
| RPH2-1SIA0 | RPH2-1SIA1 | RPH2-1SIA3 | | |
| RPH2-2SIA0 | RPH2-2SIA1 | RPH2-2SIA3 | | |

## 2.4. Elements on the front of the device

The device identification is located on the right side of the grip rail. The top line shows the model variation code and the serial number is located on the line beneath.
**With any queries or questions please state both numbers.**

### 2.4.1. Graphic display

To show the adjusted and measured values.
The top line shows each active menu point. Underneath four menu lines appear. The last line (under the drawn line) is the status line. The feed in or measured values appear here.
The digits which are pressed into the front panel underneath the display indicate the positions for setting the alarms.




*2.4.1.1 Setting Contrast of LC-Display*

Turn key-operated switch to „OFF“.
Press the [Enter] button and hold it.
Turn the key-operated switch to „OPERATION“.
The contrast changes within its limits from dark to light.
When the optimal contrast for your requirements is reached, release the [Enter] button.

**Note:** The whole contrast-range of the display is adjustable. Therefore the display becomes nearly transparent or dark respectively for a moment. The selected contrast is stored in a non-volatile memory.

## 2.4.2. Key-operated switch

*2.4.2.1. Position "OFF"*

The RPH2 is blocked. No switching operation is possible. The green LED "READY" is extinguished and the alarm contact "Device not Ready" (-X6: 12/13) closes.

*2.4.2.2. Position "OPERATION"*

After switching to this position the device carries out an internal test. After the averaging of the analogue measured values (pressure, temperature, control voltage) is completed (it takes approx. 20 sec.) and no failure is present, the device switches to "OPERATION" and the green LED "READY" lights up. The alarm contact "Device not ready" (-X6: 12/13) opens.

## 2.4.3. LED indicators

*2.4.3.1.LED "READY" (green)*

| **Status** | **Function** |
|---|---|
| Steady light | The device is ready for operation |
| Dark | Key-operated switch in "OFF" position<br>Averaging of analogue measured values is still not completed (see 1.2) Voltage reference is missing or frequency is not in the permitted range (±10 %)<br>The device has identified an internal failure. |
| Blinking | The password is activated, the device can be parameterized. All functions are active. |

*2.4.3.2.LED 1 to 7 (red)*

To show the parameterized alarms. The LED's are assigned to the alarm relays 1 to 7. Next to the LED's is a window in which the user's message texts can be placed. For a withdrawn cassette, the input tag with the texts is inserted from the top behind the front. As insert use a sheet of paper 41 mm x 90 mm.

| **Status** | **Function** |
|---|---|
| Steady light | An alarm has occurred. The LED remains alight until the alarm is active (regardless of whether the "Quitt" button has been pressed). As long as the LED is alight, the affiliated output relay is also activated. |

| Status | Function |
|---|---|
| Blinking | An alarm has occurred which is marked as „Reset obligatory“<br>After pressing the "Quitt" button two possibilities arise:<br>**1)** The LED extinguishes, i.e. the alarm was no longer active when reseted, the output relay is released.<br>**2)** The indicator switches over to permanent light, i.e. the alarm is still active, the output relay remains energized. |

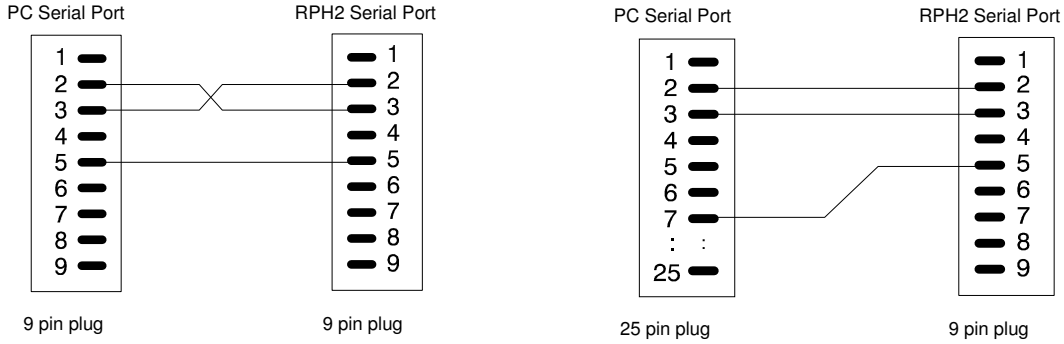
As long as the LED is alight or blinks, the affiliated output relay is energized.

### 2.4.4. Keys

| | |
|---|---|
| **[Enter]** | Menu point open / confirm |
| **[+]** | Cursor up / increase value |
| **[-]** | Cursor down / decrease value |
| **[Esc]** | Leave menu point / break-off action |
| **[Quitt]** | Acknowledge alarm / alter current scale (together with [+] or [-]) |

### 2.4.5. Serial interface

To connect the RPH2 to a computer via a standard interface cable.
Pinning of connection cable (Nullmodem Cable):




## 2.5. Menu system

The user surface is organized in several master menu points, each with linked sub-menu points. For their part, the sub-menus can contain further sub-menus. The last line (under the drawn line) is the status line. Adjusted or measured values are shown here.
The menu structure depends on the RPH2 configuration, e.g. with a device without a current measuring module (option I) menu points are not available which are connected with his function. There are menu cells which can only be read and others where an alteration to the setting can be carried out.

**Changes are only possible after the password has been activated.**

After feeding the auxiliary voltage, the first four lines of the master menu (1st plane) appear on the display. Move the menu cursor (black triangle on the left side of the

display) up and down using the [+] an[-] keys. The first four lines of the 2nd plane are shown after pressing [Enter]. Analogues are also valid for the 3rd plane. The menu cursor is moved again using [+] or [-]. The contents of the cells are shown in the status line. If a value is to be altered, move the menu cursor to the desired plane and line. After pressing [Enter], a blinking cursor appears under the first status line position. Change this position using [+] or [-]. [Enter] moves the cursor right to the next position.

With [Esc] the input mode can be left at any time without storing the changes made.

After feeding in the last position the message

Accept: YES - NO

appears in the status line.

The input is confirmed with [Enter]. The new value is stored and the menu cursor appears. [Esc] enables the input procedure to be repeated.

**After completing the input, turn the key-operated switch to "OFF" and then to "OPERATION" or start the selftest via the menu. After the selftest the data in the system is accepted.**

The following pages show a list of all the available menu points. The cross-references to the chapter with the detailed function description are in the column "Chapt.".
The column "Module" shows with which model variation this menu is available.
The following coding system applies:

| | |
|---|---|
| -1 | RPH2 with one switching function |
| -2 | RPH2 with two switching functions |
| Ax | Analogue module in all models with module A |
| A1 | Analogue module, e.g. Option 1 |
| I | Current measuring module Option I |
| S | Signal module Option S |

Menu points without a particular task are available on all models.

## 2.5.1. Menu structure

| Chapter | Module | Level 1 | Level 2 | Level 3 |
|---|---|---|---|---|
| **5.1** | | **System Data** | | |
| 5.1.1 | | | Password | |
| 5.1.2 | | | System Frequency | |
| 5.1.3 | Ax | | Control Voltage | |
| 5.1.4 | Ax | | Rated Pressure | |
| 5.1.5. | | | Switching Program | |
| 5.1.5.1 | | | | User Program |
| 5.1.6 | -1 | | Function CH1 | |
| 5.1.7 | | | Language | |
| 5.1.8 | | | Time/Date | |
| 5.1.9 | | | New Password | |
| 5.1.10 | | | Selftest Start | |
| 5.1.11 | | | Selftest Interval | |
| | | | | |
| **5.2** | | **CB Data** | | |
| 5.2.1 | | | Operating Time CH1 | |
| 5.2.2 | | | Operating Time CH2 | |
| 5.2.3 | | | Arcing Time CH1 | |
| 5.2.4 | | | Arcing Time CH2 | |
| 5.2.5 | S | | Aux.Timeshift CH1 | |
| 5.2.6 | S | | Aux.Timeshift CH2 | |
| 5.2.7 | SAx | | Adaptive Control -> | |
| 5.2.7.1 | SAx | | | Weighting Factor |
| 5.2.7.2 | SAx | | | Adaptive Times CH1 |
| 5.2.7.3 | SAx | | | Adaptive Times CH2 |
| 5.2.7.4 | SAx | | | Reset Adaptive Times |
| 5.2.8 | Ax | | Compensation | |
| 5.2.9 | Ax | | kU1 Voltage CH1 | |
| 5.2.10 | A1,A3 | | kP1 Pressure CH1 | |
| 5.2.11 | Ax | | Temp. Comp. CH1 | |
| 5.2.12 | Ax | | Table Temp. CH1 -> | |
| 5.2.12.1 | Ax | | | Delta_t xx°C |
| 5.2.13 | Ax | | kU2 Voltage CH2 | |
| 5.2.14 | A1,A3 | | kP2 Pressure CH2 | |
| 5.2.15 | Ax | | Temp. Comp. CH2 | |
| 5.2.16 | Ax | | Table Temp. CH2 -> | |
| 5.2.16.1 | Ax | | | Delta_t xx°C |
| **5.3** | | **Analogue Data** | | |
| 5.3.1 | | | Thresholds | |
| 5.3.1.1 | I | | | Current max (peak) |
| 5.3.1.2 | Ax | | | Control Voltage max |
| 5.3.1.3 | Ax | | | Control Voltage min |
| 5.3.1.4 | Ax | | | Temperature max |
| 5.3.1.5 | Ax | | | Temperature min |
| 5.3.1.6 | A1,A3 | | | Pressure max |
| 5.3.1.7 | A1,A3 | | | Pressure min |
| 5.3.2 | I | | Rated Curr. prim | |
| 5.3.3 | I | | Rated Curr. sec | |

| Chapter | Module | Level 1 | Level 2 | Level 3 |
|---|---|---|---|---|
| | | **Analogue Data (contin.)** | | |
| 5.3.4 | Ax | | Actual Contr. Voltage | |
| 5.3.5 | Ax | | Temperature | |
| 5.3.5.1 | Ax | | | Value at 4 mA |
| 5.3.5.2 | Ax | | | Value at 20 mA |
| 5.3.6 | A1,A3 | | Pressure | |
| 5.3.6.1 | A1,A3 | | | Value at 4 mA |
| 5.3.6.2 | A1,A3 | | | Value at 20 mA |
| **5.4** | | **Alarms** | | |
| 5.4.1 | | | Reset obligatory | |
| 5.4.2 | | | Lock-out | |
| 5.4.3 | | | Alarm List | |
| 5.4.3.1 | | | | Lock-out |
| 5.4.3.2 | | | | Frequency min |
| 5.4.3.3 | | | | Frequency max |
| 5.4.3.4 | I | | | Current max (peak) |
| 5.4.3.5 | | | | Ref. Voltage Failure |
| 5.4.3.6 | S | | | RTC Impulse Failure |
| 5.4.3.7 | | | | Neutral intermediate |
| 5.4.3.8 | | | | Neutral grounded |
| 5.4.3.9 | | | | Neutral isolated |
| 5.4.3.10 | | | | Selftest ERROR |
| 5.4.3.11 | | | | Selftest CH1 ERROR |
| 5.4.3.12 | -2 | | | Selftest CH2 ERROR |
| 5.4.3.13 | | | | Command Time CH1 min |
| 5.4.3.14 | -2 | | | Command Time CH2 min |
| 5.4.3.15 | S | | | Operating Time min |
| 5.4.3.16 | S | | | Operating Time max |
| 5.4.3.17 | S | | | Drive Mech. Failure |
| 5.4.3.18 | | | | Archive Full |
| 5.4.3.19 | | | | Archive Failure |
| 5.4.3.20 | Ax | | | Control Voltage min |
| 5.4.3.21 | Ax | | | Control Voltage max |
| 5.4.3.22 | Ax | | | Temperature min |
| 5.4.3.23 | Ax | | | Temperature max |
| 5.4.3.24 | Ax | | | Temp. Transd. Fault |
| 5.4.3.25 | A1,A3 | | | Pressure min |
| 5.4.2.26 | A1,A3 | | | Pressure max |
| 5.4.3.27 | A1,A3 | | | Pressure Transd. Fault |
| **5.5** | | **Measurement** | | |
| 5.5.1 | I | | Current Graphs | |
| 5.5.2 | | | Measured Times | |
| 5.5.2.1 | | | | Command OUT |
| 5.5.2.2 | S | | | CB Signal received |
| 5.5.2.3 | Ax | | | Calculated Op. Time |
| 5.5.2.4 | S | | | Measured Op. Time |
| 5.5.3 | | | Frequency | |
| 5.5.4 | I | | Current (RMS) | |
| 5.5.5 | Ax | | Control Voltage | |

| Chapter | Module | Level 1 | Level 2 | Level 3 |
|---|---|---|---|---|
| | | **Measurement (contin.)** | | |
| 5.5.6 | Ax | | Temperature | |
| 5.5.7 | Ax | | Temperature f. Comp | |
| 5.5.8 | Ax | | Additional Op. Times | |
| 5.5.8.1 | Ax | | | Voltage CH1 |
| 5.5.8.2 | Ax | | | Voltage CH 2 |
| 5.5.8.3 | Ax | | | Temperature CH1 |
| 5.5.8.4 | Ax | | | Temperature CH2 |
| 5.5.8.5 | A1,A3 | | | Pressure CH1 |
| 5.5.8.6 | A1,A3 | | | Pressure CH2 |
| 5.5.9 | A3 | | Pressure (L1/L2/L3) | |
| 5.5.10 | A1 | | Pressure (L1) | |
| **5.6** | | **Aux. Functions** | | |
| 5.6.1 | S | | Alarm Output | |
| 5.6.2 | S | | Alarm Input | |
| 5.6.3 | | | Error Type | |
| **5.7** | | **Switching Archive** | | |

# 3. APPLICATION NOTES

## 3.1. General Description of the Functions

The RPH2 Point-on-Wave Controller is a three-phase control device for circuit breakers with single pole drives. It can be used for both the energizing and de-energizing of high voltage devices.

### 3.1.1. Synchronized switching

*3.1.1.1. Closing*

Energizing of transformers, reactors and capacitors is normally effected three-pole - for all 3 phases simultaneously. In doing this the point on wave is left up to chance. If closing is carried out in this manner, high inrush currents with high DC components are unavoidable. When energizing capacitors additional high switching surges can occur. The results are unwanted operation of protection devices and repercussions on machines and network.

The inrush currents and switching surges can be reduced to an acceptable rate by installing closing resistors at the circuit breaker. The costs for such closing resistors are very high, due to the mechanical expenditure. Besides, the necessarily high energetic absorbtivity of the resistor material sets relatively restricted limits of practicability.

By selecting a suitable switching time the physical causes of these high inrush currents can be counteracted. This possibility is effected through synchronized switching with the RPH2. This enables the three poles of a circuit breaker to be controlled independently.

*3.1.1.2. Opening*

The de-energizing of shunt reactors is a critical process liable to generate re-ignitions between circuit breaker contacts. This means very high stress for the insulation of both the shunt reactor and the circuit breaker.

If the contact separation takes place a sufficient amount of time before the current zero crossing through suitable circuit breaker control, to ensure a gap capable of withstanding the transient recovery voltage at interruption.

### 3.1.2. Circuit breaker

The mechanical closing time of the circuit breaker is defined as the time between the electrical command to the operating coil and touching of the main contacts.

On the other hand, the opening time is the time between the electrical command and the separation of the main contacts. The operating times of circuit breakers, independent of the breaking system and the type of operating mechanism, changes in dependence on certain service parameters:

- With reduced control voltage at the operating coil there is less energy available to change the electrical control commands into a mechanical action. The operating time extends itself. (Valid for all types of operating drives.)

- By altering the hydraulic pressure on hydraulic drives, the energy available to carry out the switching movement changes.

- The ambient temperature is the most complex parameter of influence. The electrical resistance of the operating coils, the oil viscosity and the pressure of the SF6 gas are all dependent on the temperature. Moreover, there is expansion of operating rods and porcelains. All these parameters influence the operating time in different ways.

In the extreme, each of these 3 parameters can alter the operating time by some milliseconds. The RPH2 is in the position to compensate these operating time variations.

### 3.1.3. RPH2 structure

The outstanding features of the RPH2 are:

- Microprocessor control with a switching command time resolution of 0,1 ms.

- Large graphic display to show the adjusted and measured values ( in German, English and French or user defined language)

- Easy setting via keypad or PC interface.

- Analogue module for measuring control voltage, pressure and temperature, for the compensation of changes in operating time.

- Current measuring function for the graphic display of the line currents during switching.
- Extensive alarm functions
- Two switching functions (CLOSING and OPENING) with one device are possible.
- Switching programs with fixed switching times for the most frequent applications.
- A free program is available for special user-defined applications (e.g. switching unloaded lines).
- Extensive archive function. The most important data for the last 1000 operations are stored in a non-volatile memory and are available for diagnostic purposes.
- Comfortable PC software for setting and read-out archive data. All data can be stored and printed out. If the user cannot find sufficiency with the three languages mentioned previously, then the display can be translated into the user's national language using PC software.
- Compact housing for flush mounting.

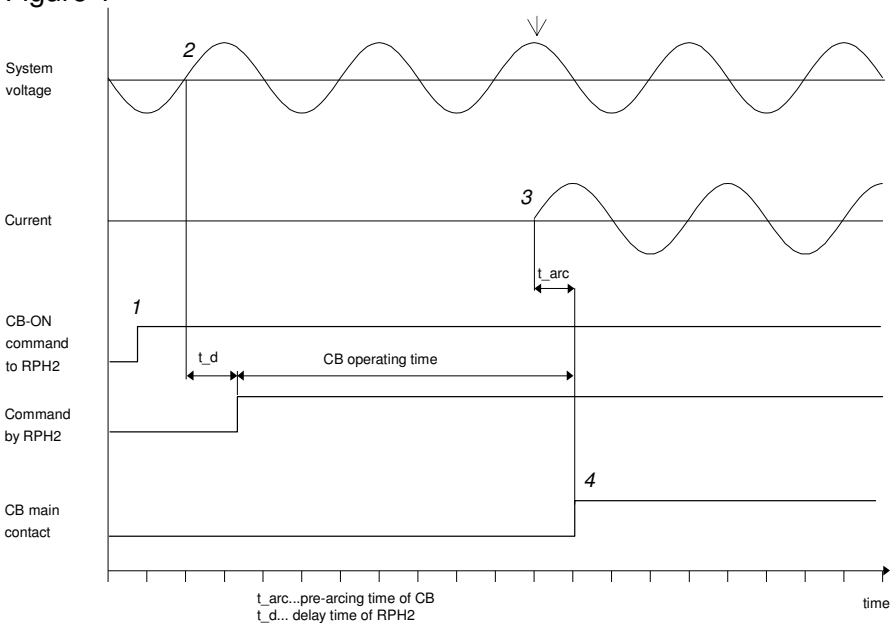
### 3.1.4. Function of the RPH2

The phase-synchronous trigger-signal is taken from the network voltage (phase L1). The trigger-signal is based on the voltage-zeros of the reference voltage.
The network voltage is also used as a reference for circuit opening. The amount of phase shift between current and voltage is almost always +90°el. or -90°el. (A deviation of ±1°el. creates a variation of ±0,06 ms of the switching point.)
The controller's mode of operation shown below. The diagrams are only single-phased and shown without transient effects which may possibly occur.

#### *3.1.4.1. Energizing of an inductive load in the voltage maximum (Fig. 1)*

At any point on wave whatever, the control impulse is given to the RPH2 (1). The next voltage zero crossing is the internal synchronizing impulse (2). Depending on the given operating time for the respective pole, a time delay t_d is calculated so that current starts at the required time (3). Through the unavoidable pre-arcing in the circuit breaker pole the current begins before actually touching the contacts. Contact touching happens at the pre-arcing time after the voltage maximum (optimum switching time). The required pre-arcing time t_arc is separately adjustable for all three phases. The two other phases are controlled in the same (independent) manner.

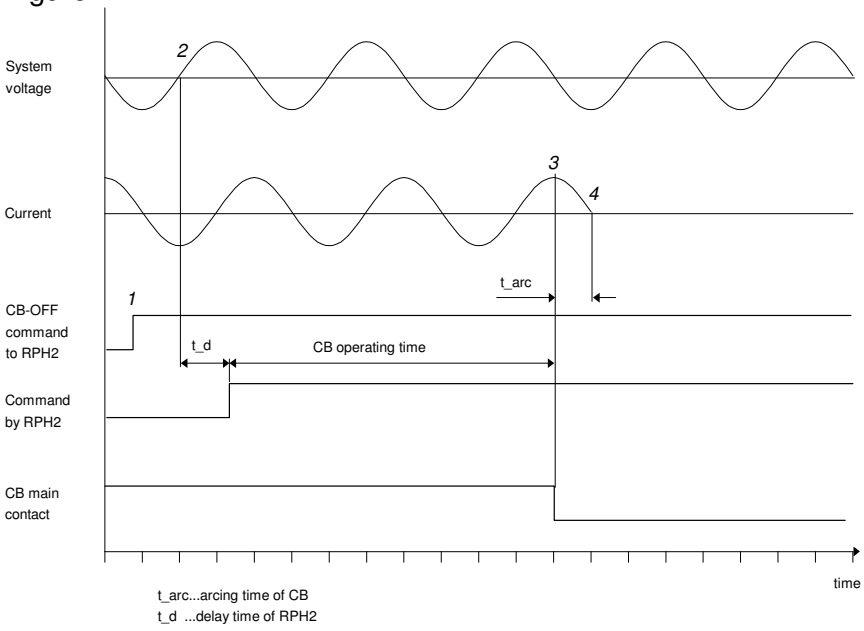
Figure 1




*3.1.4.2. Breaking of an inductive current*

At any point on wave whatever, the control impulse is given to the RPH2 (1). The next voltage zero crossing is the internal synchronizing impulse (2). Depending on the given operating time for the respective pole, a time delay t_d is calculated so that contact separation occurs at the required time (3). In the time between contact separation and the following current zero crossing, the contacts have separated so far that after the current breaking in the zero crossing (4),an adequate contact gap exists to withstand the transient recovery voltage. The required arcing time t_arc is separately adjustable for all three phases. The two other phases are controlled in the same (independent) manner.

Figure 2



Whether the system neutral is grounded or isolated, the RPH2 registers the signal contacts of the neutral earthingswitch and automatically selects the correct switching time.

*3.1.4.3. Switching program*

The RPH2 already has several preconfigured switching programs for various uses. The treatment of the system neutral of the network is automatically taken into consideration.
The trigger point for the switching times is the beginning of the period that is determinated by the zero crossing of the voltage L1-N (reference voltage). The given delay times in table 1 are given in milliseconds after the trigger point. They show the moment where current flow begins or ends (point (4) in figures 1 and 2). The RPH2 automatically takes pre-arcing and breaking times into account.

The following programs are available:

- Transformer (transformer, transformer bank, three-core reactor)
- Reactor (reactor group)
- Capacitor bank
- Free program

The following table is based on a phase sequence of the network of
L1= reference L2= reference - 120° L3= reference - 240°

Table 1: Delay times of the various switching programs.

| Switching programs | Neutral | Operation | Delay time | | |
|---|---|---|---|---|---|
| | | | L1 | L2 | L3 |
| **Transformer** | GROUNDED | CLOSING | 5 (4.2) | 10 (8.3) | 10 (8.3) |
| | | OPENING | 5 (4.2) | 1.7 (1.4) | 8.3 (6.9) |
| | ISOLATED | CLOSING | 5 (4.2) | 0 | 0 |
| | | OPENING | 5 (4.2) | 10 (8.3) | 10 (8.3) |
| **Reactor** | GROUNDED | CLOSING | 5 (4.2) | 1.7 (1.4) | 8.3 (6.9) |
| | | OPENING | 5 (4.2) | 1.7 (1.4) | 8.3 (6.9) |
| | ISOLATED | CLOSING | 5 (4.2) | 0 | 0 |
| | | OPENING | 5 (4.2) | 10 (8.3) | 10 (8.3) |
| **Capacitor** | GROUNDED | CLOSING | 0 | 6.7 (5.6) | 3.3 (2.8) |
| | | OPENING | 5 (4.2) | 1.7 (1.4) | 8.3 (6.9) |
| | ISOLATED | CLOSING | 10 (8.3) | 5 (4.2) | 5 (4.2) |
| | | OPENING | 5 (4.2) | 10 (8.3) | 10 (8.3) |

Values in () for 60 Hz.
The free program enables the user to select whatever switching time for both switching functions (if available) and for both types of neutral treatment.

## 3.2. Switching of Transformers and Reactors

For this switching task select the program "Transformer" in the menu [System Data] [Switching Program]. The switching times are specified as seen in table 1.

For transformers with primary windings in delta connection the program for isolated neutral must be used (short circuit the terminals -X6:8 with -X8:11 of the RPH2).

### 3.2.1. Closing

*3.2.1.1. Networks with grounded Neutral*

Circuit breaker closing takes place in the voltage peak in order to prevent transient processes. With earthed-neutral networks the obvious thing to do would be to switch offset the three phases L1, L2 and L3 in their respective voltage peak, i.e. timewise each one about a third of the period. Due to the mutual coupling of the individual phases (via the iron core in three-core transformers or via the low-voltage winding in transformer banks) this switching sequence did not have the desired effect. The first phase L1 is closed in the voltage peak (a quarter period after the voltage zero crossing of the reference voltage L1-N). Because the first phase is laid to nominal voltage, the flux in the relevant core rises also to its nominal value. This flux closes via both the remaining, non-generated cores, to each a half. If closing of the two remaining phases occurs a quarter period after the first, current flow can start immediately and without transient process (switching sequence L1-L2+L3).

*3.2.1.2. Networks with isolated Neutral*

With an isolated neutral, closing of one phase makes no sense. Two phases must be closed first (L2 and L3) and the obvious thing to do would be to select for the switching time the voltage peak of the phase to phase voltage (i.e. zero crossing of the reference voltage L1-N). Switching on the third phase occurs about a quarter period later, at the peak of voltage L1 (switching sequence L2+L3-L1).

### 3.2.2. Opening

For switching off transformers and three leg reactors with the RPH2, please read point 3.3.2 "Switching off Reactor Groups".

### 3.2.3. Data on circuit breaker required

The following data on the circuit breaker are absolutely necessary to operate the RPH2:

The mechanical closing and/or opening operating time of the three circuit breaker poles (see 3.1.2 for definition). Accuracy about ±0,1 ms.

*3.2.3.1. Closing*

For closing at the correct time, the pre-arcing time of the breaker at the closing voltage (see table 2) according to the phases and the treatment of the system neutral.

Table 2: Closing Voltage (Un= system voltage (rms.))

| Phase | Neutral Grounded | Neutral Isolated |
|---|---|---|
| L1 | √(2/3)*Un | 1.5*√(2/3)*Un |
| L2 | ½*√2*Un | ½*√2*Un |
| L3 | ½*√2*Un | ½*√2*Un |

If the exact value cannot be obtained from the breaker manufacturer, the optimum closing time can be determined through switching tests with oscillographical measurements of the inrush currents. For RPH2 with option I, the inrush currents are directly shown by the device (curve course and peak value). For the tests it is advisable

to begin with an assumed pre-arcing time of 3 ms at √(2/3)*Un, 2.5 ms at ½*√2*Un and 4.5 ms at 1.5*√(2/3)*Un.

*3.2.3.2. Opening*

Data of the optimum arcing time in order to guarantee a sure current breaking in the next zero crossing.
See 3.3.3 for further information

### 3.2.4. Necessary Switching Time Accuracy

With regard to the accuracy of the switching time, closing in the voltage peak is not so critical. By closing at 1 ms before or after the peak, the voltage still amounts to 95 % of the peak value, at 2 ms at least 81 % (valid for 50 Hz).
Therefore an accuracy of ±2 ms at 50 Hz or 60 Hz is sufficient.

See 3.3.4 for opening values

## 3.3. Switching of Reactor Groups

For this switching task select the program "Reactor" in the menu [System Data] [Switching Program]. The switching times are specified as seen in table 1.
If the RPH2 is only to be used for opening, then this program can also be used to switch three core reactors (switching moments are identical to the transformer program).

### 3.3.1. Closing

*3.3.1.1. Networks with grounded Neutral*

Closing takes place in the voltage peak in order to prevent transient processes. With grounded neutral networks the three phases L1, L2 and L3 are closed in their respective voltage peak, i.e. timewise each one offset about a third of the period, as there is no coupling between the phases (switching sequence L2-L1-L3).

*3.3.1.2. Networks with isolated Neutral*

Closing runs according to the same principles as in the program for transformers (see 3.2.1.2).

### 3.3.2. Opening

Breaking of small inductive currents, as is with reactors, can lead to high switching surges if current chopping or restriking in the circuit breaker occurs.
Contact separation should take place a sufficient time before current zero crossing so that after current breaking the contact gap is great enough to withstand the recovery voltage. The switching times given in table 1, indicate the moment of current breaking. The necessary arcing window is taken into account by the RPH2 through the arcing time.

### 3.3.3. Data on circuit breaker required

The following data on the circuit breaker are absolutely necessary to operate the RPH2:

The mechanical closing and/or opening operating time of the three circuit breaker poles (see 3.1.2 for definition). Accuracy about ±0,1 ms.

*3.3.3.1. Closing*

The pre-arcing times of the circuit breaker must be known.

- Pre-arcing time of the breaker in the voltage peak: equal value for all three phases with grounded neutral or for phase L1 with isolated neutral.
- Pre-arcing time with partial voltage: for phases L2 and L3 with isolated neutral (see table 2)

*3.3.3.2. Opening*

The optimum arcing time input determines the arcing window for a secure current breaking, free from restrikes, in the next zero crossing. The value is given by the breaker manufacturer.

In order not to come into conflict with unavoidable operating time tolerances, contact separation should begin 1,5 ms after zero crossing at the earliest, i.e. do not select an arcing time of longer than 8,5 ms (6,8 ms at 60 Hz). About a quarter period as arcing time is regarded as standard time.

### 3.3.4. Necessary Switching Time Accuracy

For circuit breaker closing, point 3.2.4 applies (standard value ±2 ms).

For circuit breaker opening, the breaker should achieve an operating time accuracy of ±1,5 ms.

## 3.4. Switching of unloaded Capacitors

For this switching task select the program "Capacitor" in the menu [System Data] [Switching Program]. The switching times are specified as seen in table 1.

### 3.4.1. Closing

High inrush currents and high voltage surges can occur with the random switching of capacitors, especially if switching takes place in the voltage peak. The effects of parallel switching of capacitors is particularly serious. Particularly high voltage surges can occur, due to reflections at the end of radial networks.

*3.4.1.1. Networks with grounded Neutral*

Closing takes place in the voltage zero crossing of the related phase-to earth voltage, i.e. all phases offset one third of the period (switching sequence L1-L3-L2).

*3.4.1.2. Networks with isolated Neutral*

As a unipolar switching makes no sense, two phases are simultaneously closed in the voltage zero crossing of their phase to phase voltage. The third phase follows a quarter period later (switching sequence L2+L3-L1).

### 3.4.2. Opening

In general, breaking of capacitive currents represents no problem for modern circuit breakers. If the RPH2 is used for the synchronized switching of capacitor banks, then the same applies as in 3.3.2, i.e. contact separation in sufficient time before voltage zero crossing.

### 3.4.3. Data on circuit breaker required

The following data on the circuit breaker are absolutely necessary to operate the RPH2:

The mechanical closing and/or opening operating time of the three poles (see 3.1.2 for definition). Accuracy about ±0,1 ms.

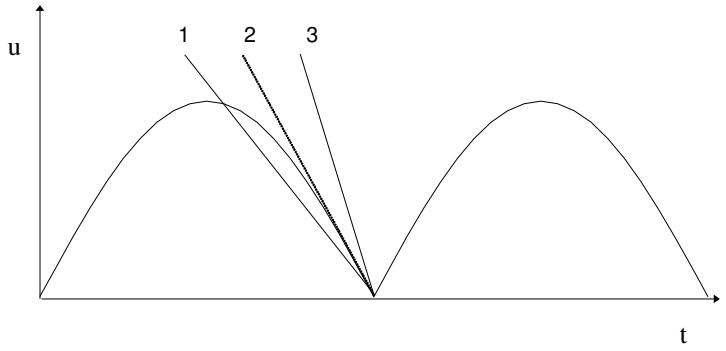
In order to achieve the necessary accuracy when closing in the voltage zero crossing, the rate of fall of the withstand voltage ($dU_d/dt$) of the breaker should be greater than the rate of change of the gap voltage at voltage zero (dU/dt). Figure 3 shows three possible cases.

1 The rate of fall of the breakers withstand voltage ($dU_d/dt$) is less than the rate of fall of the system voltage (dU/dt). $dU_d/dt < dU/dt$, $k<1$.
The breaker can be used for this application if $dU_d/dt > 0.8*dU/dt$. In this case please contact the manufacturer of the breaker for calculation of the pre-arcing times.

2 The rate of fall of the breakers withstand voltage ($dU_d/dt$) is equal to the rate of fall of the system voltage (dU/dt). $dU_d/dt = dU/dt$, $k=1$.

3 The rate of fall of the breakers withstand voltage ($dU_d/dt$) is greater than the rate of fall of the system voltage (dU/dt). $dU_d/dt > dU/dt$, $k>1$.

Figure 3

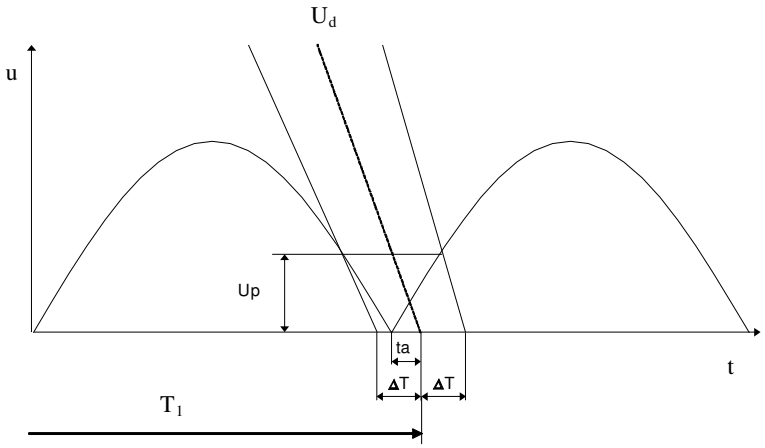



1 interrupter dielectric strength lower than dU/dt of system voltage
2 interrupter dielectric strength equal dU/dt of system voltage
3 interrupter dielectric strength greater than dU/dt of system

However, some pre-arcing may be inevitable due to variations in the closing time and the spread in dielectric withstand. To minimise energizing transients, the closing should aim at an instant, $t_d$, after the voltage zero (the RPH2 takes this into account through a given arcing time). If data is not available from the breaker manufacturer, the pre-arcing time can be approximated. Modern breakers have closing contact speeds of typical 5 m/s and a dielectric strength of more than 20 kV/mm. That results in a fall rate ($dU_d/dt$) of more than 100 kV/ms.

Figure 4 shows the voltage across the open contact gap and the withstand voltage fall with varying closing times. The arcing time $t_a$ is calculated so that the withstand voltage is approx. the same value as the upper and lower operating time tolerance.

Figure 4




voltage across the open contact gap and withstand voltage fall with varying closing time $T_1 \pm \Delta T$

The RPH2 arcing time setting can be calculated according to the following formulas. Take note of the differing arcing times with isolated neutrals. The calculations must be verified by switching tests.

Note: The system voltage in the following formulas is related to one interrupting chamber of the circuit breaker, take care in case of breakers with multiple interrupting chambers!
The voltage across one interrupting chamber is calculated as follows where "m" is the number of interrupting chambers of one pole:

$$Un = U_{system} \cdot \frac{1.05^{m-1}}{m}$$ Un... Voltage for one interrupting chamber

| | |
|---|---|
| $U_n$ [kV] | system voltage (rms) for one interrupting chamber |
| $u' = U_n \cdot \sqrt{\frac{2}{3}}$ [kV] | peak value, neutral grounded, for all poles |
| $u' = U_n \cdot \frac{\sqrt{2}}{2}$ [kV] | peak value, neutral isolated, for the two first poles L2 and L3 |
| $u' = 1.5 \cdot U_n \cdot \sqrt{\frac{2}{3}}$ [kV] | peak value, neutral isolated, for the last pole L1 |
| $\frac{dU}{dt} = u' \cdot \omega \cdot \frac{1}{1000}$ [kV/ms] | rate of fall of system voltage |
| $\frac{dU_d}{dt}$ [kV/ms] | rate of fall of CB withstand voltage |
| $\frac{\left(\frac{dU_d}{dt}\right)}{\left(\frac{dU}{dt}\right)} = k$ [p.u.] | see figure 3 |
| $\Delta T$ [ms] | variation of CB closing time |
| $t_a = \frac{\sin(\omega \cdot \frac{\Delta T}{1000})}{\omega \cdot k} \cdot 1000$ [ms] | prearcing time set to RPH2 |
| $U_p = \sin(\omega \cdot \frac{\Delta T}{1000}) \cdot u$ [kV] | prearcing voltage |

The following example demonstrates the calculation for the pre-arcing time for each pole with various system neutral treatments.

Example:

| | |
|---|---|
| $U_n = 145$ [kV] | system voltage (rms) |
| $u' = 118.4$ [kV] | peak value, neutral grounded, for all poles |
| $u' = 102.5$ [kV] | peak value, neutral isolated, for the two first poles L2 and L3 |
| $u' = 177.6$ [kV] | peak value, neutral isolated, for the last pole L1 |
| $\frac{dU}{dt} = 37.2$ [kV / ms] | rate of fall of system voltage, neutral grounded |
| $\frac{dU}{dt} = 32.2$ [kV / ms] | rate of fall of system voltage, neutral isolated (for the two first poles L2 and L3) |
| $\frac{dU}{dt} = 55.8$ [kV / ms] | rate of fall of system voltage, neutral isolated (for the last pole L1) |
| $\frac{dU_d}{dt} = 100$ [kV / ms] | rate of fall of CB withstand voltage |
| $k = 2.7$ [p.u.] | neutral grounded, for L1, L2, L3 |
| $k = 3.1$ [p.u.] | neutral isolated, for L2, L3 |
| $k = 1.8$ [p.u.] | neutral isolated, for L1 |
| $\Delta T = \pm 1$ [ms] | variation of CB closing time |
| ta = 0.4 [ms] | neutral grounded, prearcing time set to RPH2 for all poles |
| ta = 0.3 [ms] | neutral isolated, prearcing time set to RPH2 for poles L2 and L3 |
| ta = 0.5 [ms] | neutral isolated, prearcing time set to RPH2 for pole L1 |

### 3.4.4 Necessary Switching Time Accuracy

Capacitor energizing places the greatest demands on the breaker in reference to operating time constancy. Every variation from the required switching time leads to a higher withstand voltage value which causes greater surges and inrush currents. Closing time variation should amount to ± 1 ms at the most. When this accuracy cannot be maintained under all conditions, we recommend the use of the analogue module option A to correct the operating time influences.

For opening, the switch should reach a operating time accuracy of ± 1,5 ms.

## 3.5 Switching (closing) of uncharged Lines

Uncharged high voltage lines are to be fundamentally treated like capacitors. Due to the inter-phase coupling the switching moments are not the same as for capacitor banks. The RPH2 can also be used for auto-reclosing of uncompensated lines equipped with inductive potential transformers. During the auto-reclose dead-time the trapped charges on the line must be fully discharged by the inductive potential transformers!

Whether the system neutral is earthed or isolated does not effect the switching moments.

The RPH2 must be set to the [User Program] with the following settings (see also 5.1.5.1).

For [T_C1 Neutral isolated] and for [T_C1 Neutral grounded] the same values must be set:

50 Hz:
L1 = 0 ms
L2 = 7.3 ms
L3 = 13.3 ms

60 Hz:
L1 = 0 ms
L2 = 6.1 ms
L3 = 11.1 ms

# 4 FUNCTIONS OF THE ADDITIONAL MODULES

## 4.1 Signal Module: Option S

### 4.1.1 Alarm outputs

The module offers additional outlets (alarm 2 to 7). Each alarm contact corresponds with the associated indicator-LED (LED 2 to 7) at the front. The allocation of the alarm functions to the output contacts is user-defined. Many alarm functions can be laid to one output. The procedure is described in chapter 5.

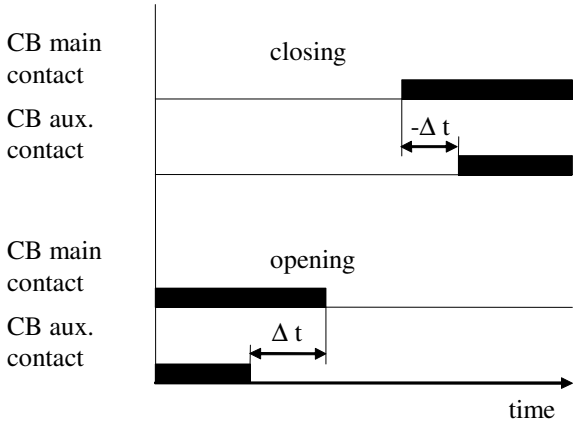
### 4.1.2 Opto coupler inputs

Opto coupler inputs with pre-defined functions are available.

*4.1.2.1 Measuring the operating time*

Three inputs serve to measure the operating time of the three poles via their auxiliary contacts. (Resolution 0,5 ms). The circuit breaker auxiliary contacts signalling (contact 52a) works with an internal RPH2 voltage (48 VDC), i.e. potential-free contacts are necessary. The necessary wiring is to be carried out according to the accompanying wiring diagram.

Figure 5




To compensate the time shift between the main contacts and the auxiliary contacts of the breaker poles, the possibility exists to feed in a compensation time in order to maintain the operating time as real value on the display and in the archives. Figure 5 shows the correlation as an example. If the auxiliary contact closes after the main contact then the compensation time value. Δt is negative, if the auxiliary contact opens before the main contact then a positive value results. If no possibility exists to measure the time shift of the auxiliary contacts, this value can also be determined via the RPH2 within the time release limits.
Conditions:

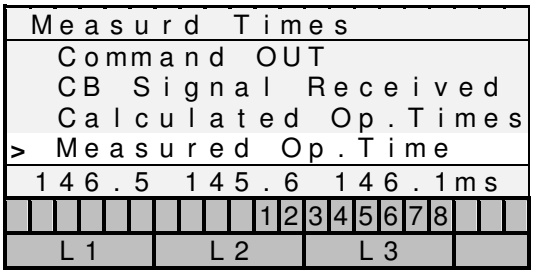
- The pole operating times given by the manufacturer are correctly fed in (see 5.1 and 5.2)

- The environmental conditions correspond approx. to the conditions when measuring the pole operating times in the factory. With strong deviations in the environmental conditions, the pole operating times must be measured again on site.
- The RPH2 compensating function is deactivated (see 5.6).
- The circuit breaker can be operated repeatedly without load (with opened busbar disconnector.

Operate the circuit breaker via the RPH2 with channel 1.

Check that password is active (flashing READY LED).
Change to the menu [Measurement] / [Measured Times].
In the menu [Measured Op. Times] (Figure 6) the measured pole operating times appear in the status line, including the main contact/auxiliary contact time shift.

Figure 6




**Pole operating times:**

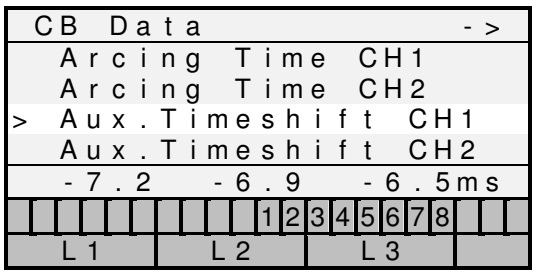
L1 = 139.3 ms
L2 = 138.7 ms
L3 = 139.6 ms

The value for " Aux. Timeshift CH1" for every pole is calculated with:

**[Aux. Timeshift CH1] = [Pole operating time] - [Measured Op. Time]**

The input values in figure 7 are calculated with the values form figure 6 and the values of the pole operating times shown on the right side in figure 6.
Feed in the determined values under [CB Data] / [Aux. Timeshift CH1] (figure 7)

Figure 7




For RPH2 with software version J006.x a new function for easy setting of the values for Aux. Timeshift is available, see 5.5.2.4.

Check in all cases that the measured operating time corresponds with actual operating times of the circuit breaker. This is essential for using the function of the adaptive control!
For devices with two switching functions (RPH2-2), repeat the procedure for the second switching channel too.

#### *4.1.2.2 Remote reset*

An input for remote reset is available. A potential-free contact (closer) is necessary as control device. Drive takes place with the RPH2 intern 48 VDC voltage.

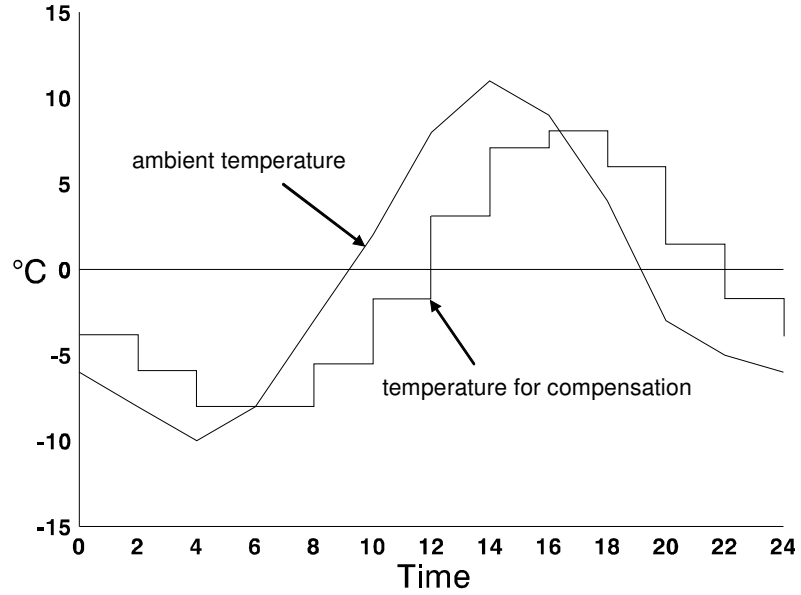
#### *4.1.2.3 Real time clock synchronization*

A further input is for synchronizing with a radio clock. It can be parallel switched with other synchronized control devices. A potential-free contact is necessary.

## 4.2 Analogue Module: Option A

With this module the influence of environmental parameters on the pole operating time can be compensated. External sensors are necessary for pressure and temperature measurement. Control voltage, pressure and temperature are continually measured. The voltage and pressure values are immediately available for the calculation of compensation times. The shown vales in the menus [Measured value/Control voltage] and [Measured value/Pressure] are the basic calculating factors.
An average value formation is carried out for temperature compensation.
Update takes place every two hours. The stored temperature value is compared with the measured value and the stored temperature is compensated by half the difference (figure 8). In the menu [Measured value/Temperature] the actual measured temperature is shown, in the menu [Measured value/Temperature f. Comp.] the average is shown which is effective for compensation.

Figure 8




In the menu [Measured value/Compensation] each of the actual additional times are shown. After the key-operated switch is turned form "OFF" to "OPERATION", the RPH2 carries out an automatic check and all analogue measured values for compensation are set at the actual measured value.

### 4.2.1 Control Voltage Compensation

Measuring the control voltage is done internally in the RPH2 and no additional equipment is necessary. The RPH2 calculates the additional times for operating time compensation according to a function with an open parameter. By fixing these parameters the compensation function can be suited to the character of the power switch. Calculation for opening and closing takes place separately. The parameter kU1 works for switching channel 1, kU2 for switching channel 2 (only for devices with 2 switching functions). If a zero value is fed in for a parameter, then no additional times are calculated and the compensation function concerned is blocked. Fixing the compensation parameters takes place through calculation or with the assistance of the accompanying PC Software.

Two breaker characteristic measured points are required to calculate the compensation function:

- One point with nominal conditions (value 1): measured pole operating time (of one pole) with rated voltage, rated pressure and rated temperature. In general that is the manufacturer value for pole operating time.
- A second point with deviation conditions (value 2): measured pole operating time of the same pole with rated pressure, rated temperature and reduced control voltage.

Figure 9 shows an example of a circuit breaker opening:

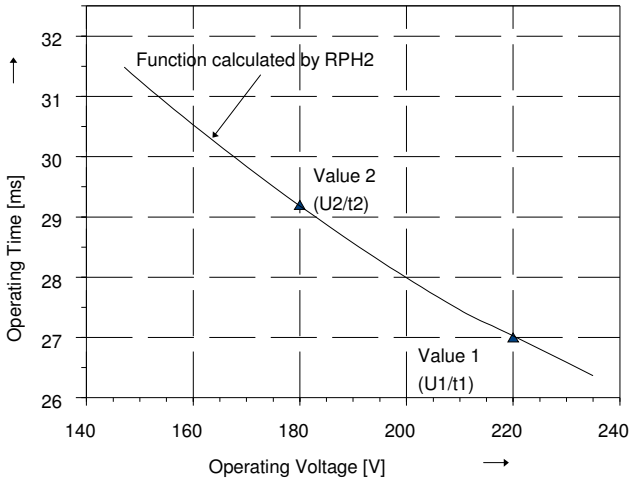
Value 1 (with nominal conditions):

| | | | |
|---|---|---|---|
| $U_1$ | = | 220 VDC | Rated control voltage |
| $t_1$ | = | 27.0 ms | Pole operating time with nominal conditions |

Value 2:

| | | | |
|---|---|---|---|
| $U_2$ | = | 180 VDC | Reduced control voltage |
| $t_2$ | = | 29.2 ms | Pole operating time with control voltage $U_2$ |

Figure 9



The compensation parameter kU can be calculated using the following formula:

Value 1:

$U_1$ [V] rated control voltage

$t_1$ [ms] CB operating time at nominal conditions

Value 2:

$U_2$ [V] reduced control voltage

$t_2$ [ms] CB operating time with $U_2$

$$kU = \frac{(t_2 - t_1) \cdot 100}{(\frac{U_1}{U_2} - 1) \cdot t_1}$$ drive mechanism parameter

The input from above results in a compensation parameter kU = 36.6

With RPH2's with two switching functions, the calculation for kU1 and kU2 is to be carried out separately for both switching channels and the values stored in the RPH2.

### 4.2.2 Temperature Compensation

An external sensor with integrated transducer (2 conductors, auxiliary voltage 24 VDC) and standard output signal (4 ... 20 mA) is necessary for measuring the temperature. The transducer supply is effected through the RPH2. Up to eight RPH2's can be parallel switched to one temperature transducer. See the connection plan 58.010.111-xx also.

The RPH2 calculates the additional times for operating time compensation according to a piecewise linear function with one control point every 10 °C in the range of -50 °C and +50 °C. So all kinds of temperature functions of the circuit breaker (from linear to exponential) can be set to the RPH2. The measured values can be entered in the table in figure 10. The line Delta_t = 0 ms defines the nominal operating time of the circuit breaker under normal conditions. The values of Delta_t at different ambient temperatures are the differences of the measured operating times to the nominal operating time. The 11 values of Delta_t(T) (T = -50 °C to +50 °C) must be set to the RPH2.

In the example in figure 11 the procedure is shown. The measured values are marked by squares. Connect the points by lines end eventually extend the lines to the extremes (dotted line in the example). Evaluate the values of Delta_t(T) at the control points (-50 °C to +50 °C) so to get the 11 values for Delta_t(T) shown in the table in figure 11.

By using the PC software "RPH2- Tool" also an exponential function with one open parameter can be calculated. Especially for circuit breakers with spring drive mechanism this option will be useful.

Figure 10

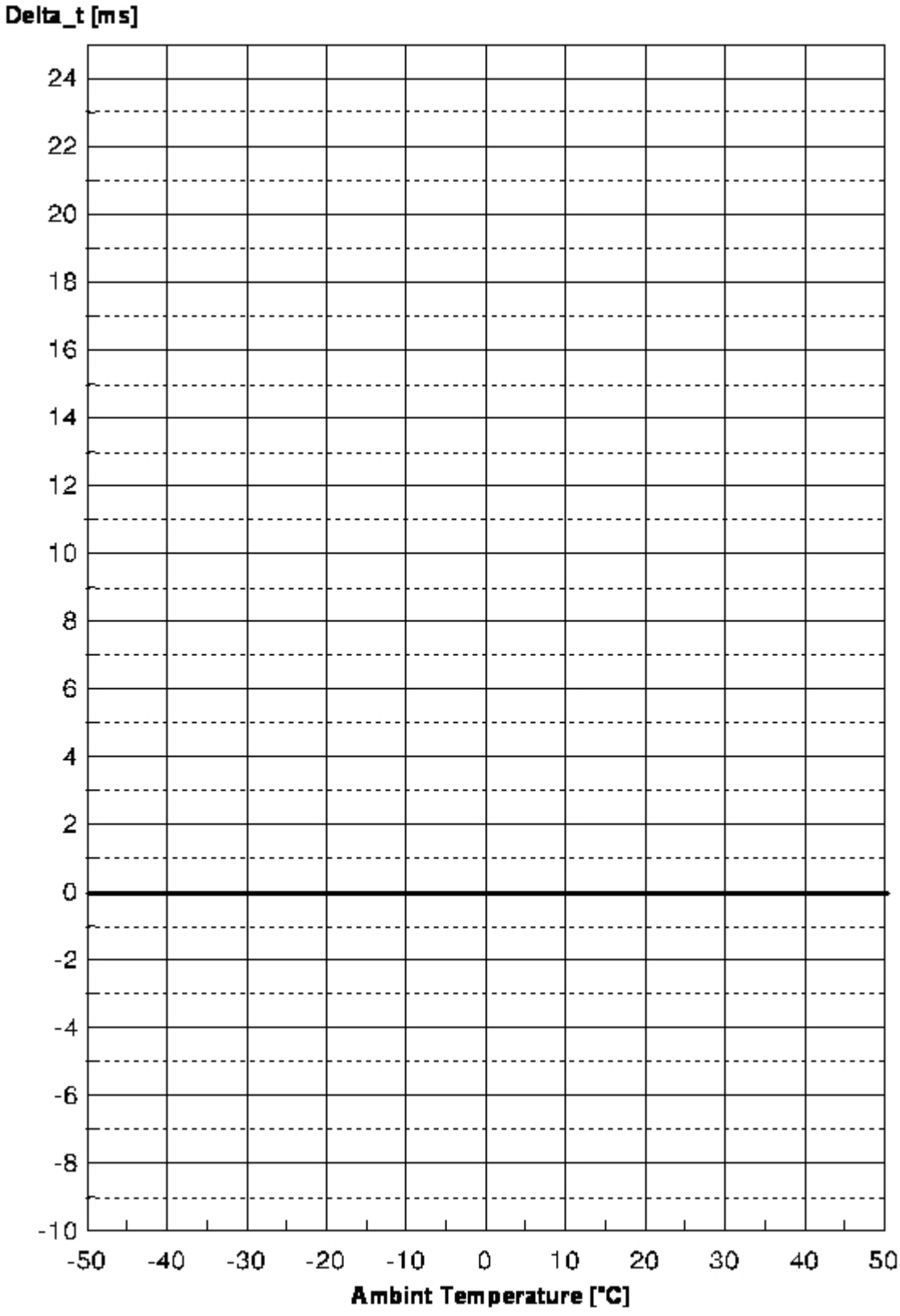
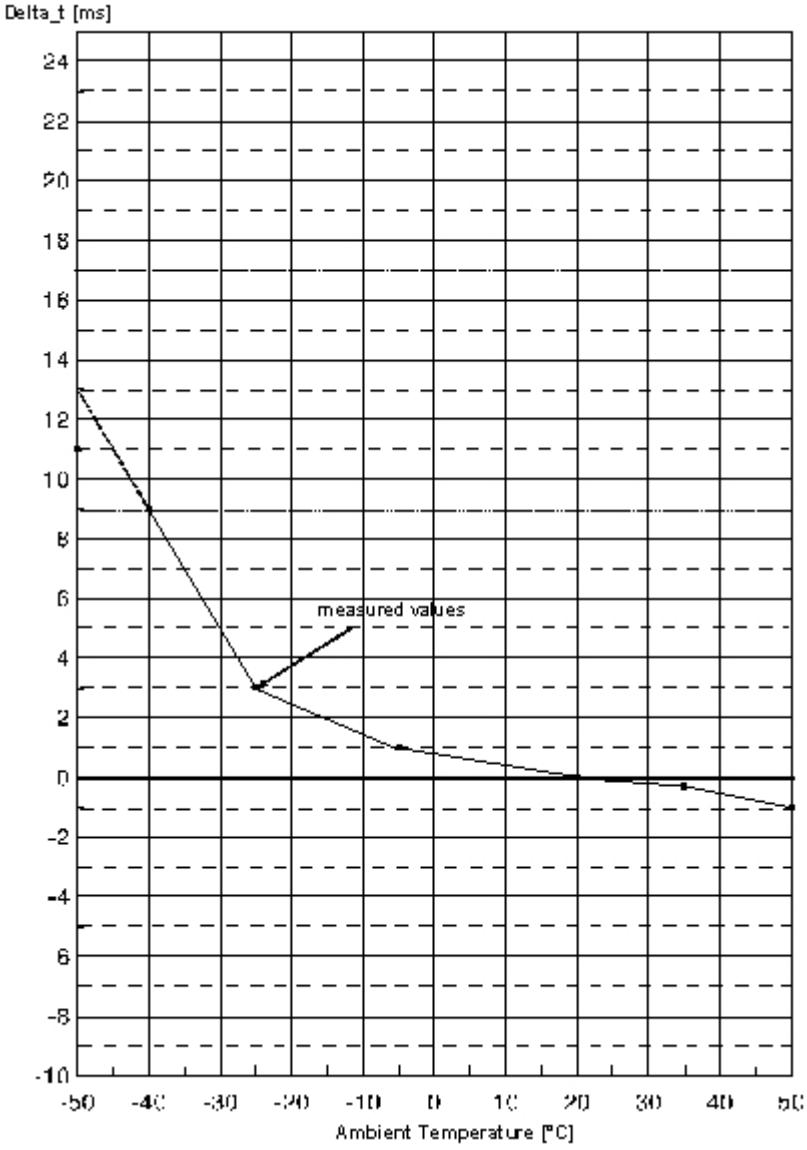

Delta_t [ms]
24
22
20
18
16
14
12
10
8
6
4
2
0
-2
-4
-6
-8
-10
-50
-40
-30
-20
-10
0
10
20
30
40
50
Ambint Temperature [°C]

Figure 11




| Temperature | Delta_t |
|---|---|
| -50 °C | 13.0 ms |
| -40 °C | 9.0 ms |
| -30 °C | 5.0 ms |
| -20 °C | 2.5 ms |
| -10 °C | 1.6 ms |
| 0 °C | 0.8 ms |
| +10 °C | 0.4 ms |
| +20 °C | 0.0 ms |
| +30 °C | -0.2 ms |
| +40 °C | -0.4 ms |
| +50 °C | -1.0 ms |

With RPH2's with two switching functions, the evaluation of Delta_t(T) has to be carried out separately for both switching channels and the values stored in the RPH2.

### 4.2.3 Hydraulic Pressure Compensation

There are two module models available for measuring pressure:

- Option A1: for breakers with a mutual hydraulic system for all three poles
- Option A3: for breakers with separate hydraulic systems for each pole

One (Option A1) or three (Option A3) external sensors with integrated transducer (2 conductors, auxiliary voltage 24 VDC) and standard output signal (4 ... 20 mA) are necessary for measuring hydraulic pressure. The transducer supply is effected through the RPH2.

The RPH2 calculates the additional times for operating time compensation according to a function with one open parameter. By fixing this parameter, the compensation function can be suited to the character of the circuit breaker. Calculation for opening and closing takes place separately. The parameter kP1 works for switching channel 1, kP2 for switching channel 2 (only for devices with 2 switching functions). For the model with option A3 with pressure measuring per pole only a compensation parameter for each of the three poles is fed in. If a zero value is fed in for a parameter, then no additional times are calculated and the compensation function concerned is blocked. Fixing the compensation parameters takes place through calculation or with the assistance of the accompanying PC Software.

Two measuring points of the switching characteristic analogue for 4.2.1 are required to calculate the equalising curve:

- One point with rated conditions (value 1): measured pole operating time (of one pole) with rated voltage, rated pressure and rated temperature. In general that is the manufacturer value for pole operating time.
- A second point with deviation conditions (value 2): measured pole operating time of the same pole with rated control voltage, rated temperature and reduced hydraulic pressure.

Example:

Value 1 (with nominal conditions):

| | | | |
|---|---|---|---|
| $P_1$ | = | 265 bar | Rated pressure |
| $t_1$ | = | 110.5 ms | Pole operating time with nominal conditions |

Value 2:

| | | | |
|---|---|---|---|
| $P_2$ | = | 200 bar | Reduced pressure |
| $t_2$ | = | 127.7 ms | Pole operating time with pressure $P_2$ |

The compensation parameters kP can be calculated using the following formula.

Value 1:

$P_1$ [V] rated hydraulic pressure

$t_1$ [ms] CB operating time at nominal conditions

Value 2:

$P_2$ [V] reduced hydraulic pressure

$t_2$ [ms] CB operating time with $P_2$

$$kP = \frac{(t_2 - t_1) \cdot 100}{(\frac{P_1}{P_2} - 1) \cdot t_1}$$ drive mechanism parameter

The input from above results in a compensation parameter kP = 47.9.

With RPH2's with two switching functions, the calculation for kP1 and kP2 is to be carried out separately for both switching channels and the values stored in the RPH2.

### 4.2.4 Specifications for the external sensors

For measuring pressure and temperature, external sensors with integrated transducer are necessary which are not part of the delivery.

The integrated transducers must meet the following requirements:

Auxiliary voltage 24 VDC (supplied by the RPH2)
2 conductor system
Output signal 4 mA to 20 mA

Such transducers can be obtained from many manufacturers. The measuring range of the sensors adjust itself to the respective requirements.
However, unnecessarily large measuring ranges reduce the measuring accuracy of the RPH2. The RPH2 measuring input is adapted to the measuring range of the sensor through parameterisation.

Transducer installation is carried out according to the manufacturer's guidelines. Likewise, the connection cables to the RPH2 must be selected according to the manufacturer's information. If no information is available, we recommend a shielded two-wire cable per transducer, or at least a twisted pair of wires.

### 4.2.5 Adaptive Control

RPH2 with analogue module **A** and signal module **S** provide the additional feature of an adaptive control to compensate the long time drift in operating time of the CB drive. The actual operating times of the poles are measured by the signal module. A weighting factor in the range of 0 to 0.5, step 0.05 (0 = function is disabled) is used for controlling this function. A fraction (depending on the weighting factor) of the time difference between the operating time of the last operation and the operation before is added to the actual operating time. Additional operating times due to compensation functions are not taken into consideration, so the pure long time drift of the drive mechanism is compensated. The additional adaptive times are displayed and a function is available to reset these times.

The compensation of the time shift between the main contacts and the auxiliary contacts of the breaker poles must be done very exactly to avoid errors in measuring of the actual operating times.

- Time deviations of the measured values greater than 10 ms are not considered. (no operation of the CB or incorrect measurement of operating times).
- Additional adaptive time is limited to 1 ms from one operation to the next.
- If the operating time corrected by adaptive control has drifted away from the pre-set operating times for more than
  ±5 ms for opening
  ±10 ms for closing
  the alarm "Drive mech. Failure" is generated.

The value of the weighting factor depends on the type of drive mechanism. We propose a value of 0.25 to 0.30 for all types of mechanism.

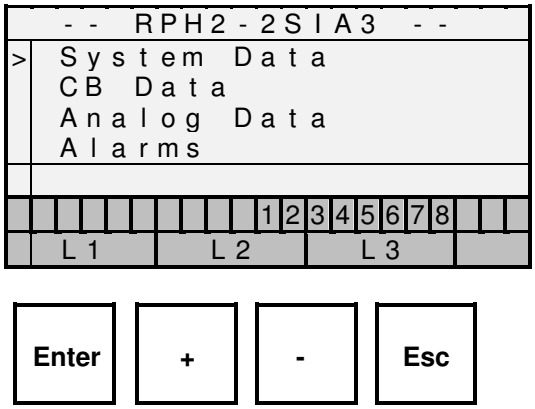
## 4.3 Current Module Option I

A current measuring module is available to make the switching of large transformers and reactors easy when putting the RPH2 Point-on-Wave Controller into operation. With this the inrush current can be recorded and graphically displayed during the switching process. Data for the last 4 switching operations are stored in a non-volatile memory and can be analysed on the display. Primary values are shown after feeding in the current transformer current ratio.

For every phase there is an input for each 1 A and 5 A available. Because the current inputs have a short time withstand of 100 xIn, current measurement can be carried out over a measuring core as well as a protection core of the current transformer.

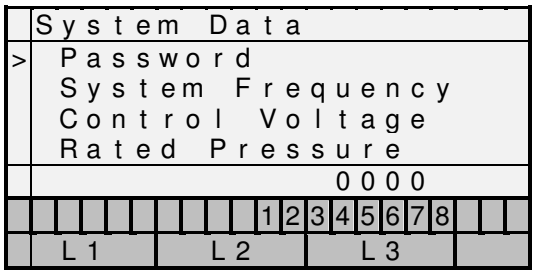
# 5 RPH2 MENUE SYSTEM

## 5.1 System data




### 5.1.1 Password

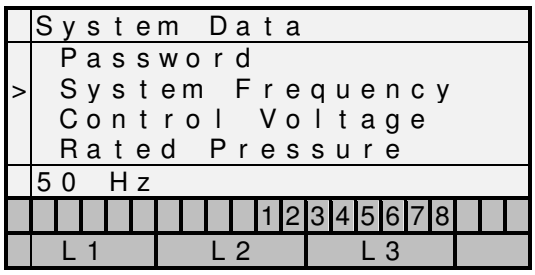
The factory-setting of the-password is "0000". To activate the password you must change to the submenu [System Data/Password]. The actual status (‘active’ or ‘off’) is shown in the bottom-left corner of the display. Type in the correct password and confirm the assumption by pressing the ‘Enter’-button (see chapter 2.5). The display shows ‘active’ and the green LED ‘ready’ starts blinking if the password is correct (see chapter 2.4.3.1).
The password will be deactivated automatically if no button is pressed for more than 90 seconds.




### 5.1.2 System Frequency

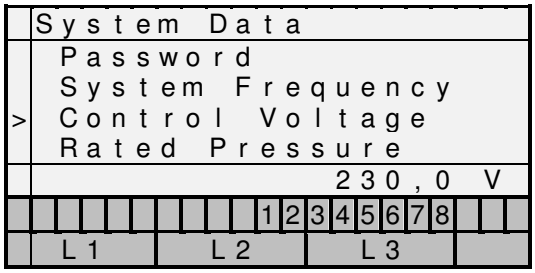
After activating this function by pressing the ‘Enter’-button you can choose any item of the list by pressing the ‘+’- or the ‘-’-button (see chapter 2.5).

Available items: 50 Hz, 60 Hz, 16 2/3 Hz



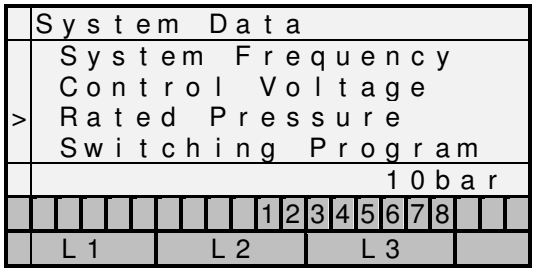

### 5.1.3 Control Voltage

Type in the rated voltage of your CB-coil (available only for modules RPH2-xxA0, RPH2-xxA1, RPH2-xxA3).
This value acts as base for the calculation of the additional compensation value of the mechanical operating time of the CB.




### 5.1.4 Rated Pressure

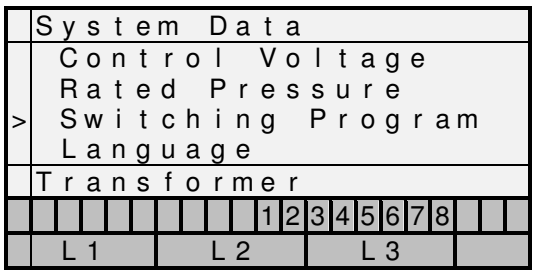
Type in the value of the rated pressure of the hydraulic system of your CB-drive (available only for module RPH2-xxA1, RPH2-xxA3). This value acts as base for the calculation of the compensation value of the operating time of the CB.




### 5.1.5 Switching Program

Select the suitable switching program by pressing the '+'- or '-'-button:

- transformer
- shunt reactor
- capacitor bank
- user program



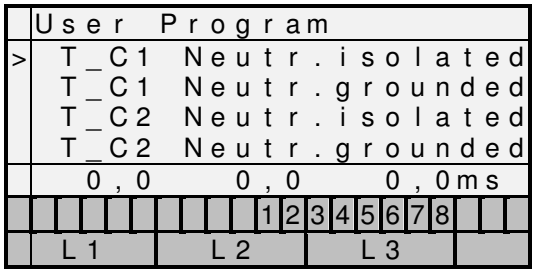

*5.1.5.1 User Program*

You can define your own switching moments for each phase by selecting the 'User Program'.

**Note:** If you select 'user program' you have to select the rated frequency first (see chapter 5.2).

Adjustable switching moments:

T_C1 Neutral isolated:
Type in the switching moments of the three phases L1/L2/L3 for channel 1 with isolated neutral.




T_C1 Neutral grounded:
Type in the switching moments of the three phases L1/L2/L3 for channel 1 with grounded neutral.

The following two submenus are available only for module RPH2-2xx (module with two switching channels):

T_C2 Neutral isolated:
Type in the switching moments of the three phases L1/L2/L3 for channel 2 with isolated neutral.

T_C2 Neutral grounded:
Type in the switching moments of the three phases L1/L2/L3 for channel 2 with grounded neutral.

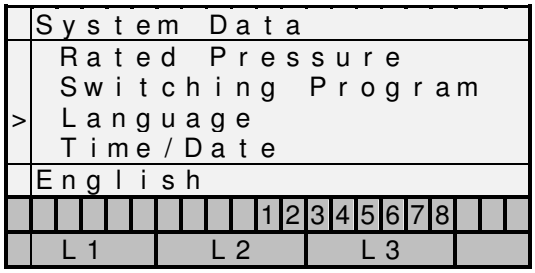
### 5.1.6 Function Channel 1

For the module RPH2-1xxx you have to select whether if you use the RPH2 for closing or opening of the CB.

### 5.1.7 Language

Select your preferred language.
Available languages:

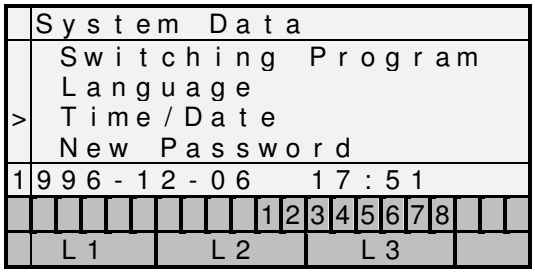
- German
- English
- French
- User language




**Note:** You can load the menutext in any language with the RPH-Tool (PC-based software). If there any problems with the loaded language file you can return to the English menus: Turn the key-operated switch to "OFF", press the "Quitt" button and meanwhile return the key-operated switch back to "OPERATION".

### 5.1.8 Time / Date

Type in the actual date and time. The format for date and time is:
”YYYY-MM-DD HH:MM”.

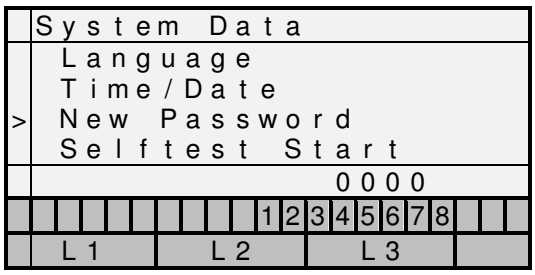



**Note:** Type in only correct values for date and time.

**Note:** There are no problems with a date after 2000-01-01.

### 5.1.9 New Password

If you want to change the actual password simply type in the new password.
Possible values are all numbers between ‘0000’ and ‘9999’.

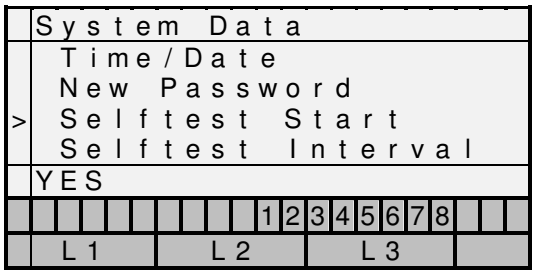



**Note:** If you have forgotten the selected password, you can ask for a temporary password (call your local Schneider Electric representative)

### 5.1.10 Selftest Start

You can activate the selftest-facility by pressing the ‘Enter’-button.

The selftest-facility checks the internal function of the module and the switching outputs.

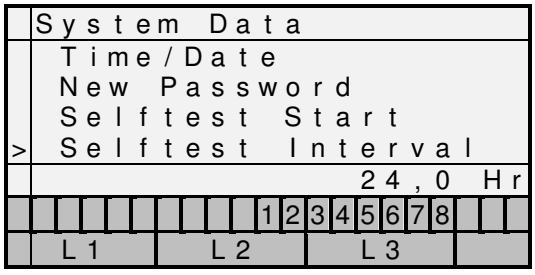



**Note:** You can activate the selftest with the key-operated-switch too (see chapter 2.4.2).

### 5.1.11 Selftest Interval

Type in the desired interval between the automatic selftests.

The possible range is from 0,0 hours (shortest interval is 0,1 hour = 6 minutes) to 500 hours. Choosing a value of 0,0 hours deactivates the automatic selftest-facility.




In the menu [Aux. Functions][Error Type] the type errors are displayed (see 5.6.3).

## 5.2 CB Data

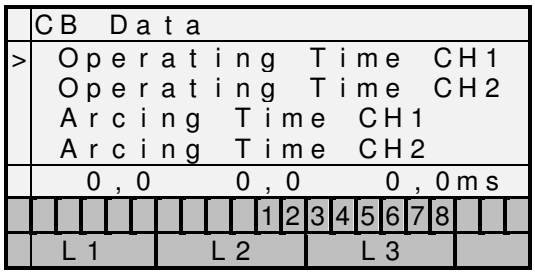
### 5.2.1 Operating Time CH1

Type in the operating time for each phase at the rated voltage, rated pressure and a temperature of 20 °C for switching channel 1.

The permissible range is from 0,0 ms (minimum value is 0,1 ms) to 200 ms.

The switching function (closing or opening) for module RPH2-1xx depends on the selection made in the submenu ‘Function Channel 1’. (see chapter 5.1.6).

Module RPH2-2xx uses channel 1 for closing of the CB.




**Note 1:** The value of the operating time for each phase of the CB depends on the type and manufacturer of the CB. This value is part of the CB-documentation delivered with your CB.

**Note 2:** The difference between 2 phases should be less than one period (20 ms for 50 Hz).

**Note 3:** For single-phase-CBs the values for all three phases **must** be the same.

### 5.2.2 Operating Time CH2

Type in the operating time for each phase at the rated voltage, rated pressure and a temperature of 20 °C for switching channel 2. Channel 2 always is used for opening.

The permissible range is from 0,0 ms (minimum value is 0,1 ms) to 200 ms.

This submenu is available only for module RPH2-2xxx.

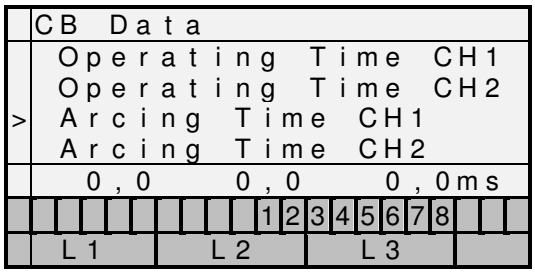
### 5.2.3 Arcing Time CH1

Type in the arcing time for each phase of the CB (see chapter 3.2 to 3.4).

The permissible range is from 0,0 ms (minimum value is 0,1 ms) to 50 ms.

Closing: Pre-arcing time of the CB. The closing of the main-contact happens **after** the chosen switching moment.

Opening: Arcing time of the CB. The opening of the main-contact happens **before** the zero-crossing of the current.



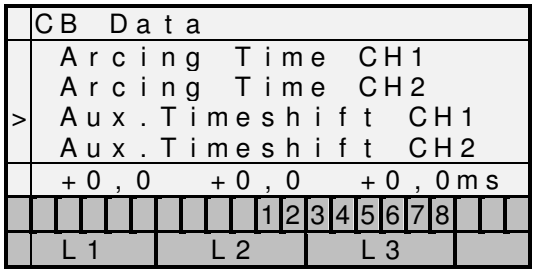

### 5.2.4 Arcing Time CH2

This submenu is available only for module RPH2-2xxx. It works as for channel 1 except that channel 2 always is used for opening.

### 5.2.5 Auxiliary Timeshift CH1

This value is used for compensating the time lag between the main-contact and the auxiliary-contact of the CB (see chapter 4.1.2.1).

The permissible range is from -25,5 ms to +25,5 ms.




This submenu is available only with module RPH2-xxS.

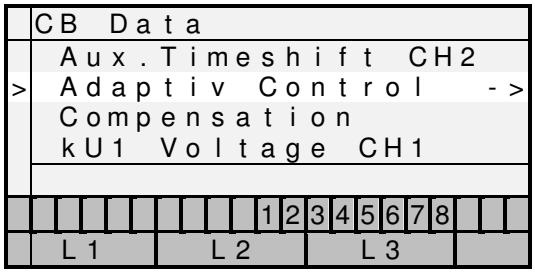
For RPH2 with software version J006_x a new function for setting is available, see 5.5.2.4.

### 5.2.6 Auxiliary Timeshift CH2

This submenu is available only for module RPH2-2xxx. It works as for channel 1 except that channel 2 always is used for opening.

### 5.2.7 Adaptive Control

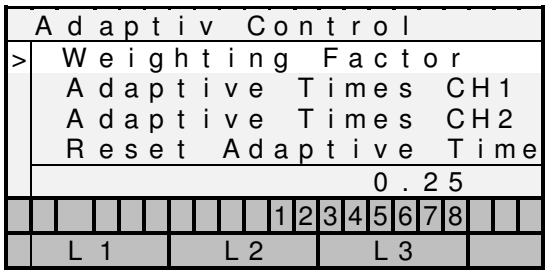
This menu opens a submenu for controlling the this function (see also 4.2.5)



This submenu and the following menus are available only with module RPH2-xSAx.

*5.2.7.1 Weighting Factor*

This factor defines the friction of time difference added to the operating time.




The permissible range is from 0.00 to 0.50 (step 0.05).
A value of 0.00 disables this function.

*5.2.7.2 Adaptive Times CH1*

Here the adaptive times for each pole related to switching channel 1 are displayed.

*5.2.7.3 Adaptive Times CH2*

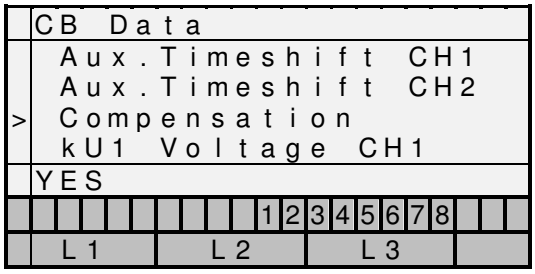
Here the adaptive times for each pole related to switching channel 2 are displayed.

*5.2.7.4 Reset Adaptive Times*

This function allows to reset the additional times due to adaptive control to zero. After this, the RPH2 operates with the pre-set pole operating times.

### 5.2.8 Compensation

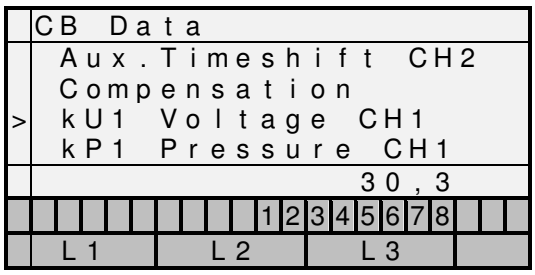
If you select 'NO' all compensation functions are blocked.
If you select 'YES' compensation is active (for description see chapter 4.2)




### 5.2.9 kU1 Voltage CH1

Type in the calculated value for compensation of changes of the control voltage (see chapter 4.2.1).

The permissible range is from 0,0 to 150,0.




This submenu is available only with modules RPH2-xxA0, RPH2-xxxA1, RPH2-xxxA3.

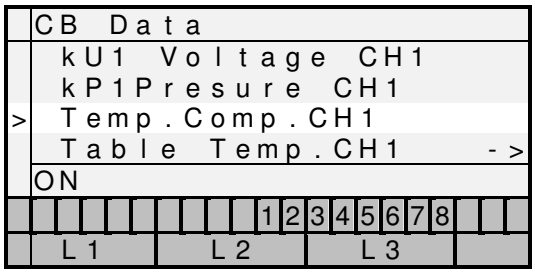
### 5.2.10 kP1 Pressure CH1

same as 5.2.9, but for pressure compensation for channel 1.

This submenu is available only with modules RPH2-xxxA1, RPH2-xxxA3.

### 5.2.11 Temperature Compensation CH1

This submenu enables or disables the temperature compensation.



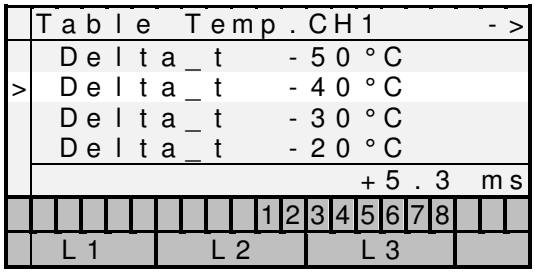

This submenu is available only with modules RPH2-xxA0, RPH2-xxxA1, RPH2-xxxA3.

### 5.2.12 Table Temp. CH1

This menu opens a submenu for setting the values for temperature compensation.

*5.2.12.1 Delta_t xx°C*

Here the 11 values of Delta_t(T) for defining the temperature compensation function can be entered to the RPH2 (see also 4.2.2).




The permissible range for Delta_t is from -10.0 ms to +25.0 ms.

### 5.2.13 kU2 Voltage CH2

same as 5.2.9, but for control voltage compensation for channel 2.

This submenu is available only with modules RPH2-xxA0, RPH2-xxxA1, RPH2-xxxA3.

### 5.2.14 kP2 Pressure CH2

same as 5.2.10, but for temperature compensation for channel 2.

This submenu is available only with modules RPH2-xxxA1, RPH2-xxxA3.

### 5.2.15 Temperature Compensation CH2

same as 5.2.11, but for temperature compensation for channel 2.

This submenu is available only with modules RPH2-xxA0, RPH2-xxxA1, RPH2-xxxA3.

### 5.2.16 Table Temp. CH1

same as 5.2.12, but for temperature compensation for channel 2.

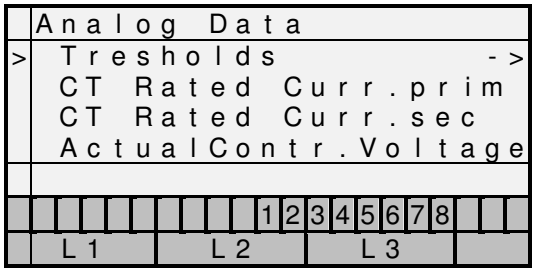
*5.2.16.1 Delta t xx°C*

same as 5.2.12.1, but for temperature compensation for channel 2.

## 5.3 Analogue Data

### 5.3.1 Thresholds

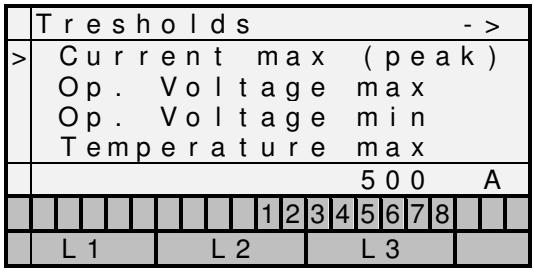
The following submenus are depending on the configuration of the RPH 2 obtained. Exceeding of limit-settings cause an alarm, if set (see chapter 5.4).




*5.3.1.1 Current max.*

Type in the allowed maximum value (peak-value) of the current during the switching operation. If the current during a switching operation exceeds this limit an alarm is generated.

The permissible range is from 0 A to 9999 A.

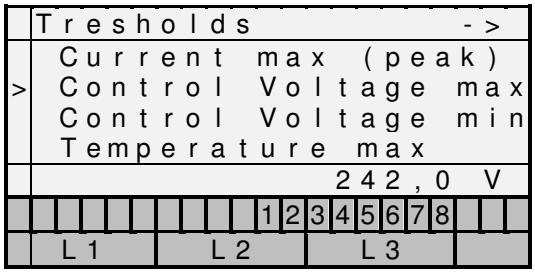



This submenu is only available for module RPH2-xxI.

*5.3.1.2 Control Voltage max.*

Type in the upper limit for the control voltage. If the measured value of the control voltage becomes higher than the limit an alarm is generated.

The permissible range is from 35 V to 300 V.

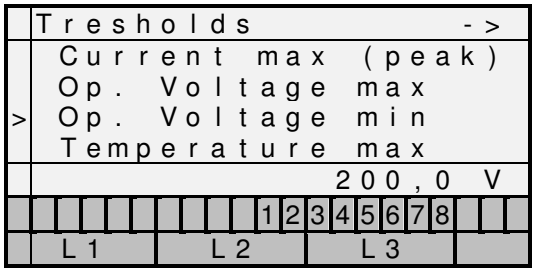



This submenu is available only with modules RPH2-xxA0, RPH2-xxA1, RPH2-xxA3.

*5.3.1.3 Control Voltage min.*

Type in the lower limit for the control voltage. If the measured value of the control voltage becomes lower than the limit an alarm is generated.

The permissible range is from 35 V to 300 V.

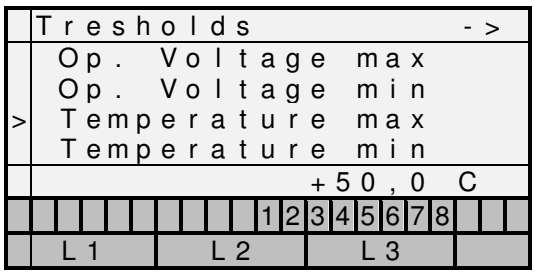



This submenu is available only with modules RPH2-xxA0, RPH2-xxA1, RPH2-xxA3.

*5.3.1.4 Temperature max.*

Type in the upper limit for the ambient temperature of the CB. If the measured value of the temperature becomes higher than the limit an alarm is generated.

The permissible range is from -100° C to +100° C.

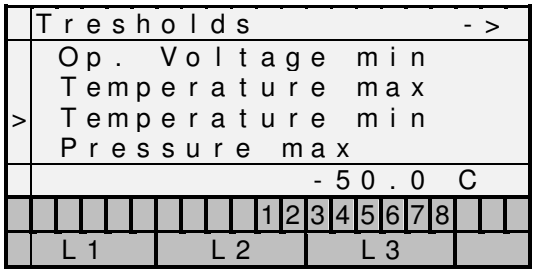



This submenu is available only with modules RPH2-xxA0, RPH2-xxA1, RPH2-xxA3.

*5.3.1.5 Temperature min.*

Type in the lower limit of the ambient temperature of the CB. If the measured value of the temperature becomes lower than the limit an alarm is generated.

The permissible range is from -100° C to +100° C.

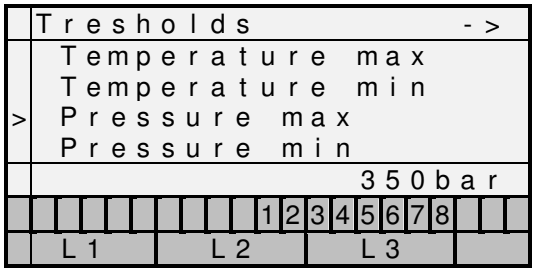



This submenu is available only for module RPH2-xxA0, RPH2-xxA1, RPH2-xxA3.

*5.3.1.6 Pressure max.*

Type in the upper limit of the hydraulic pressure of the CB. If the measured value of the temperature becomes higher than the limit an alarm is generated.

The permissible range is from 0 bar to 1000 bar.

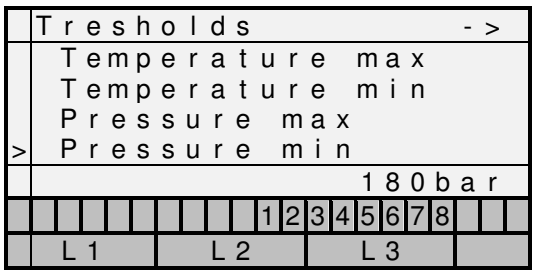



This submenu is available only with modules RPH2-xxA1, RPH2-xxA3.

*5.3.1.7 Pressure min.*

Type in the lower limit of the hydraulic pressure of the CB. If the measured value of the temperature becomes lower than the limit an alarm is generated.

The permissible range is from 0 bar to 1000 bar.

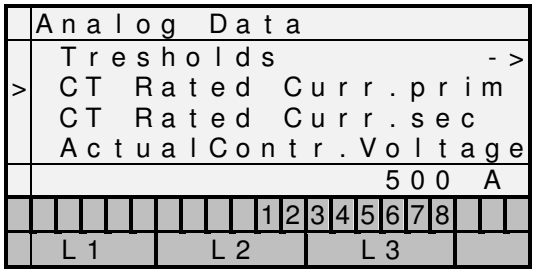



This submenu is available only with modules RPH2-xxA1, RPH2-xxA3.

### 5.3.2 CT Rated Current prim

Type in the rated primary current of your current transducer.

The permissible range is from 0 A to 5000 A.

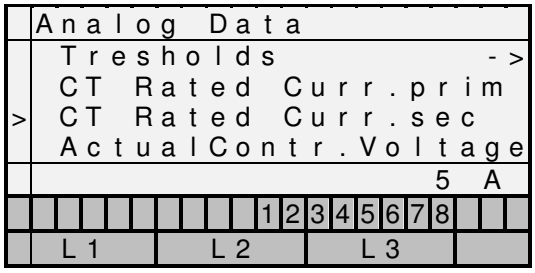



This submenu is available only with module RPH2-xxI.

### 5.3.3 CT Rated Current sec

Type in the rated secondary current of your current transducer.

Permissible values are 1 A and 5 A.



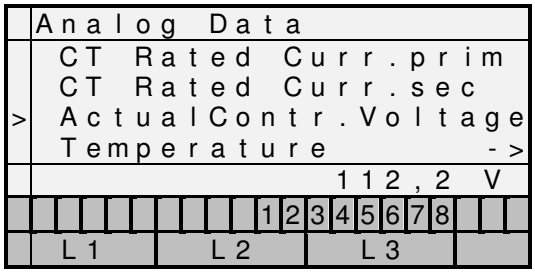

This submenu is available only for module RPH2-xxI.

**Note:** The current transformer has to be connected to the correct terminal of the RPH2 (1 A or 5 A, see wiring diagram).

### 5.3.4 Actual Control Voltage

Type in the measured value of the actual control voltage. This input calibrates the internal voltage measurement. This value acts as base for the calculation of compensation of the switching moment.

The permissible range is from 35 V to 300 V.



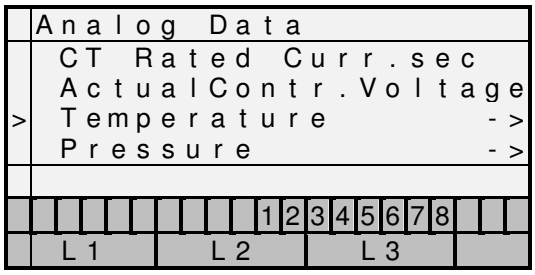

This submenu is available only with modules RPH2-xxA0, RPH2-xxA1, RPH2-xxA3.

Determine the correct value:
Measure the actual value of the control voltage on terminal -X6:10 and -X6:11 with an calibrated voltmeter and type in this value.
Type in the determined value.

Note:This input calibrates the voltage measurement function. The correct input of this value is **absolutely necessary**. You cannot calibrate the RPH2 with the PC-software 'RPH-Tool'.
In the Normal-Mode (Ready-LED is steady-light) the measured voltage is displayed.
After calibrating the voltage measurement check the correct function by monitoring the display.

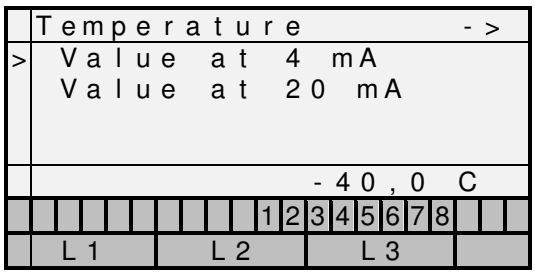
### 5.3.5 Temperature

The following submenus are available only with modules RPH2-xxA0, RPH2-xxA1, RPH2-xxA3.
In this submenu the temperature transducer is calibrated.



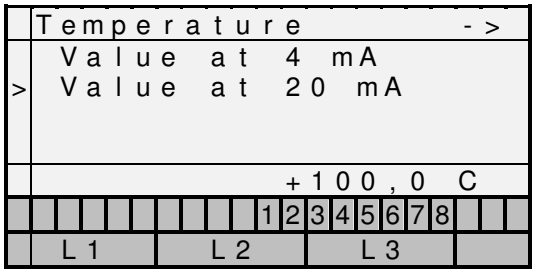

*5.3.5.1 Value at 4 mA*

Type in the rated value of the temperature transducer at an output current of 4 mA. This information is part of the documentation of the temperature transducer.



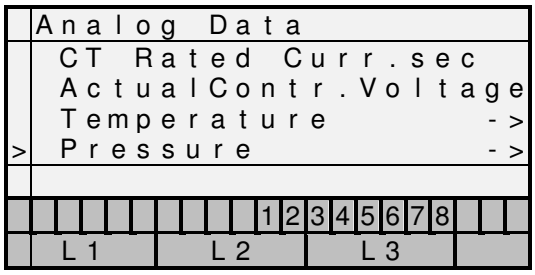

*5.3.5.2 Value at 20 mA*

Type in the rated value of the temperature transducer at an output current of 20 mA. This information is part of the documentation of the temperature transducer.



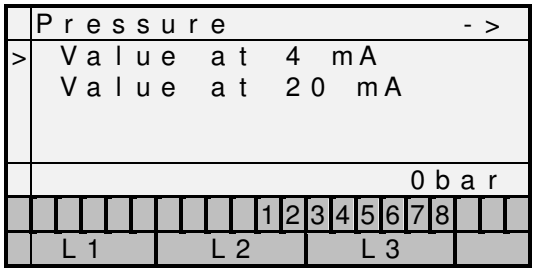

## 5.3.6 Pressure

These submenus are available only with modules RPH2-xxA1, RPH2-xxA3.
In the following submenus the pressure transducer can be calibrated.



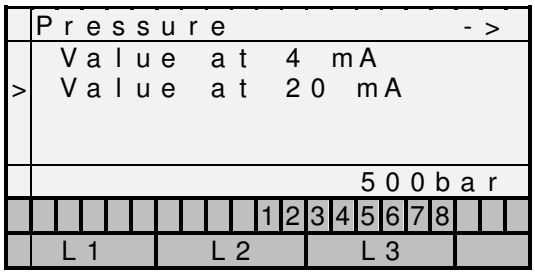

*5.3.6.1 Value at 4 mA*

Type in the rated value of the pressure transducer at an output current of 4 mA. This information is part of the documentation of the pressure transducer.



*5.3.6.2 Value at 20 mA*

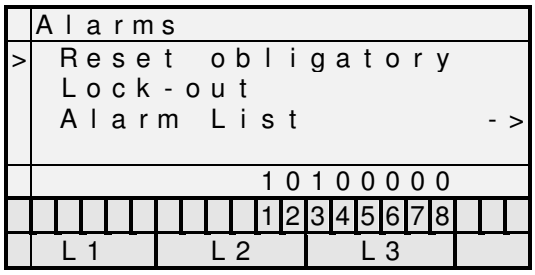
Type in the rated value of the pressure transducer at an output current of 20 mA. This information is part of the documentation of the pressure transducer.




## 5.4 Alarms

### 5.4.1 Reset Obligatory

In this submenu you can select which alarm outputs (and the according LED on the front panel of the RPH2) are to be acknowledged. Alarm-outputs which are marked as reset obligatory are displayed on the front panel and activated (closed) until you press the 'Quitt'-button, regardless whether the alarm is still active or already gone.
Example:




In the example mentioned above the alarms 1 and 3 are marked with the function "Reset obligatory" (must be acknowledged).

Reset Obligatory (Setting "1"):

| | | |
|---|---|---|
| Alarm is active | -> | LED is blinking, alarm-output active |
| Alarm is acknowledged | -> | LED has steady-light, alarm-output active |
| Alarm off | -> | LED off, alarm-output not active |
| respectively: | | |
| Alarm is active | -> | LED is blinking, alarm-output active |
| Alarm off | -> | LED is blinking, alarm-output active |
| Alarm is acknowledged | -> | LED off, alarm-output not active |

Alarm is not reset obligatory (Setting "0"):

| | | |
|---|---|---|
| Alarm is active | -> | LED has steady-light, alarm-output active |
| Alarm off | -> | LED off, alarm-output not active |

**Note:** With the function "reset obligatory" you can change an alarm-message from the type pulse type to a steady alarm type (see 5.4.3).

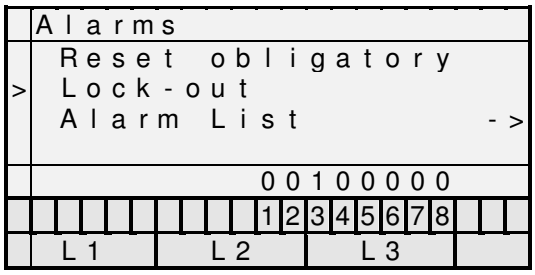
### 5.4.2 Lock-Out

Here you can mark each of the 7 alarm outputs to produce a blocking of the device in case of the corresponding alarm occurs.
That means:
No switching operation is possible, the green LED is dark and the contact "Device not ready" (-X6:12/13) is closed.

Some actions or alarms cause a lock out in any case, also without activating the responding alarm (green LED dark, contact -X6:12-13 is closed):

- Keyswitch is "OFF"
- Relay starting up
- Reference voltage is missing
- Frequency not in permitted range
- Neutral earthing switch in intermediate position

Example:

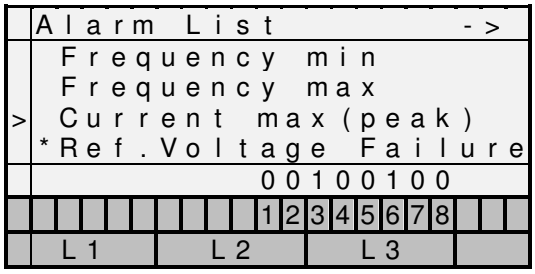



In the example mentioned above the activating of alarm 3 blocks the RPH2. No operation is possible, as long as the alarm is active. The output contact "Device not ready" (-X6:12/13) is closed.

### 5.4.3 Alarm List

The following submenus are depending on the configuration of the RPH2. Each internal alarm (message) can be assigned to up to 7 alarm-outputs. The assignment is made through the setting of a ‘1’ at the corresponding display-unit.

Example:



In the example mentioned above the alarm-message ‘Current max. (peak)’ is assigned to alarm-output 3 and alarm-output 6.

The asterisk (‘*’) at the position ‘Ref. Voltage Failure’ in the picture above indicates that the fault ‘Ref. Voltage Failure’ is pending, that means the reference voltage is missing.

Pulse-alarm:
If an alarm-message is a pulse, this alarm-message is active only for a period of 0,5 seconds. If this alarm-message is assigned to an alarm-output which is marked as ‘reset obligatory’, the alarm-output remains active until this alarm is acknowledged.

**Note:** The assignment of an alarm-message to the alarm-output number 8 has no effect.

#### *5.4.3.1 Lock-out*

This is only a summary alarm. It is generated by other alarms which cause a blocking of the relay. It is active when the device is blocked (see 5.4.2). The alarm itself causes no blocking of the device!

#### *5.4.3.2 Frequency min*

The reference voltage (phase L1) is monitored permanently. If the lower limit of the frequency is reached, an alarm-message ‘Frequency min.’ is generated.

Limits:

| Rated Frequency | Lower Limit |
|---|---|
| 50 Hz | 45 Hz |
| 60 Hz | 54 Hz |
| 16 2/3 Hz | 15 Hz |

**Note:** The monitoring of the frequency is active only if the reference voltage is connected to the device. If the reference voltage is missing, no alarm ‘Frequency min.’ is generated.

#### *5.4.3.3 Frequency max.*

The reference voltage is monitored permanently on phase L1. If the upper limit of the frequency is reached, an alarm-message ‘Frequency max.’ is generated.

Limits:

| Rated Frequency | Upper Limit |
|---|---|
| 50 Hz | 55 Hz |
| 60 Hz | 66 Hz |
| 16 2/3 Hz | 18,26 Hz |

**Note:** The monitoring of the frequency is active only, if the reference voltage is connected to the device. If the reference voltage is missing, no alarm ‘Frequency min.’ is generated.

#### *5.4.3.4 Current max. (peak)*

This alarm-message is generated if the setting of the current maximum (peak value) is reached or exceeded during a switching operation in one or more phases (thresholds see 5.3.1.1)

The peak-value of the current is monitored, not the RMS-value.

This alarm-message is a pulse (see chapter 5.4.3. Pulse-alarm).

This alarm-message is available only for module RPH2-xxI.

#### *5.4.3.5 Reference Voltage Failure*

This alarm-message is generated if the reference voltage is missing for more than 2 seconds.

**Note:** This alarm-message blocks the RPH2 in any case, regardless whether the alarm is set for blocking or not (see chapter 5.4.2).

#### *5.4.3.6 RTC Impulse Failure*

This alarm-message is generated if the minute-pulse is missing.

#### *5.4.3.7 Neutral intermediate*

This alarm-message is generated if the position of the 'Neutral-switch' is not defined.

**Note:** This alarm-message blocks the RPH2 in any case, regardless whether the alarm is set for blocking or not (see chapter 5.4.2).

#### *5.4.3.8 Neutral grounded*

This message indicates, that the 'Neutral-switch' is in position 'grounded'. If the position 'grounded' is indicated, the RPH2 uses the parameter-set 'Neutral grounded'.

**Note:** This message is not an alarm-message but may be helpful for supervising

#### *5.4.3.9 Neutral isolated*

This message indicates, that the 'Neutral-switch' is in position 'isolated'. If the position 'isolated' is indicated, the RPH2 uses the parameter-set 'Neutral isolated' (see 5.4.3.8).

#### *5.4.3.10 Selftest ERROR*

This alarm-message is generated when the automatic selftest discovers an internal error (output circuit is not working correct).

This alarm-message is a pulse (see chapter 5.4.3. Pulse-alarm).

**Note:** This alarm-message blocks the RPH2 in any case, regardless whether the alarm is set for blocking or not (see chapter 5.4.2).

#### *5.4.3.11 Selftest CH1 ERROR*

This alarm-message is the detailed message from 5.4.3.10 related to channel 1.

This alarm-message is a pulse (see chapter 5.4.3. Pulse-alarm).

*5.4.3.12 Selftest CH2 ERROR*

This alarm-message is the detailed message from 5.4.3.10 related to channel 2.

This alarm-message is a pulse (see chapter 5.4.3. Pulse-alarm).

This alarm-message is available only for module RPH2-2xx.

*5.4.3.13 Command Time CH1 min*

This alarm-message is generated when the command time for channel 1 (the function of channel 1 is depending on configuration of the RPH2 and the 'Function Channel 1' - chapter 5.1.6) is to short, i. e. perhaps not all three phase are switched within this time.

The alarm is generated if the duration of the command impulse is less than 100 ms.

This alarm-message is a pulse (see chapter 5.4.3. Pulse-alarm).

*5.4.3.14 Command Time CH2 min*

This alarm-message is generated when the command time for channel 2 (opening) is to short.

The alarm is generated if the duration of the command impulse is less than 100 ms.

This alarm-message is a pulse (see chapter 5.4.3. Pulse-alarm).

This alarm-message is available only for module RPH2-2xx .

*5.4.3.15 Operating Time min*

This alarm-message is generated when the measured operating time differs more than 2 ms of the calculated operation time (measured time is shorter).

This alarm-message is a pulse (see chapter 5.4.3. Pulse-alarm).

This alarm-message is available only for module RPH2-xxS.

*5.4.3.16 Operating Time max.*

This alarm-message is generated when the measured operating time differs more than 2 ms of the calculated operation time (measured time is longer).

This alarm-message is a pulse (see chapter 5.4.3. Pulse-alarm).

This alarm-message is available only for module RPH2-xxS.

*5.4.3.17 Drive mech. Failure*

This alarm-message is generated when:

- The monitoring of the CB-position is undefined.
- The operating time corrected by adaptive control has drifted away for more than 5 ms for opening and 10 ms for closing from the pre-set operating times (only with adaptive control, see 4.2.5).

This alarm-message is a pulse (see chapter 5.4.3. Pulse-alarm).

This alarm-message is available only for module RPH2-xxS.

*5.4.3.18 Archive Full*

This alarm-message indicates that the archive is nearly full.

This alarm-message is a pulse (see chapter 5.4.3. Pulse-alarm).

**Note:** The archive is capable to store 1000 switching operations. When the 900th switching operation is stored in the archive the alarm-message is generated. Each switching operation following generates an alarm-message until the archive is read by the PC-Software RPH-Tool,

*5.4.3.19 Archive Failure*

This alarm-message is generated, when storing data into the archive fails.

This alarm-message is a pulse (see chapter 5.4.3. Pulse-alarm).

*5.4.3.20 Control Voltage min*

This alarm-message indicates that the lower limit of the control voltage is reached (see chapter 5.3.1.3 ‘Control Voltage min.).

This alarm-message is available only with modules RPH2-xxA0, RPH2-xxA1, RPH2-xxA3.

*5.4.3.21 Control Voltage max.*

This alarm-message indicates that the upper limit of the control voltage is reached (see chapter 5.3.1.2 ‘Control Voltage max.).

This alarm-message is available only with modules RPH2-xxA0, RPH2-xxA1, RPH2-xxA3.

*5.4.3.22 Temperature min*

This alarm-message indicates that the lower limit of the ambient temperature is reached (see chapter 5.3.1.5 ‘Temperature min.).

This alarm-message is available only with modules RPH2-xxA0, RPH2-xxA1 or RPH2-xxA3.

*5.4.3.23 Temperature max.*

This alarm-message indicates that the upper limit of the ambient temperature is reached (see chapter 5.3.1.4 ‘Temperature max.).

This alarm-message is available only with modules RPH2-xxA0, RPH2-xxA1 or RPH2-xxA3.

*5.4.3.24 Temp. Transducer Fault*

This alarm-message indicates an error of the temperature transducer (cable or sensor), i. e. the temperature measurement is not working.

This alarm-message is available only with modules RPH2-xxA0, RPH2-xxA1 or RPH2-xxA3.

*5.4.3.25 Pressure min*

This alarm-message indicates that the lower limit of the hydraulic pressure is reached (see chapter 5.3.1.7 ‘Pressure min.).

This alarm-message is available only for module RPH2-xxA1 or RPH2-xxA3.

*5.4.3.26 Pressure max.*

This alarm-message indicates that the upper limit of the hydraulic pressure is reached (see chapter 5.3.1.6 ‘Pressure max.).

This alarm-message is available only with modules RPH2-xxA1 or RPH2-xxA3.

*5.4.3.27 Press. Transducer Fault*

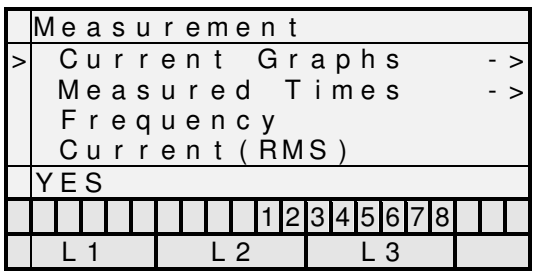
This alarm-message indicates an error of the pressure transducer (cable or sensor), i. e. the pressure measurement is not working.

This alarm-message is available only with modules RPH2-xxA1 or RPH2-xxA3.

# 5.5 Measurement

## 5.5.1 Current Graphs

In this submenu you can display the current curves of the last 4 switching operations for each phase (L1, L2, L3), as well as the maximum currents (peak value).

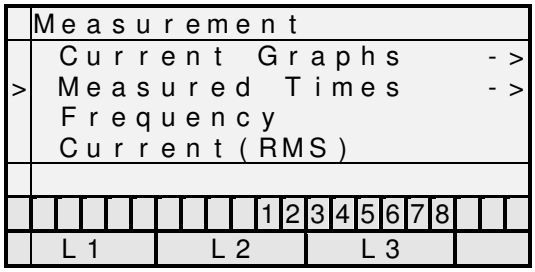


Pressing the ‘Enter’-button activates the Graph-mode. Repeatedly pressing the ‘Enter’-button allows to go through the last 4 switching operations. Pressing the ‘+’- or ‘-’-button changes from phase L1 to phase L2 to phase L3 to the peak values of the current of each phase. When a graph is displayed, the amplification factor of the graph can be changed. Pressing the [Quitt] and [+] button at the same time increases the amplification, [Quitt] and [-] button decreases the amplification.

This submenu is available only for module RPH2-xxI.

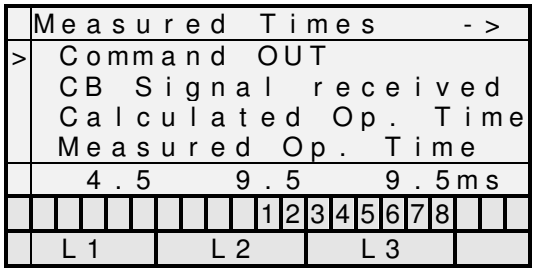
### 5.5.2 Measured Times

The measured times of the last switching operation are displayed in this submenu. The values available are depending on the configuration of the RPH2.




*5.5.2.1 Command OUT*

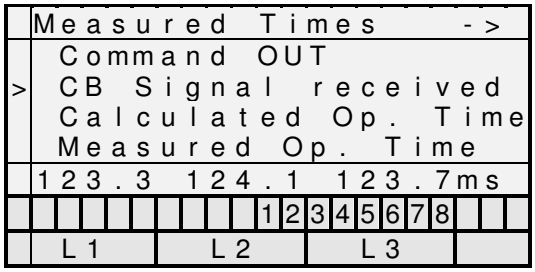
This submenu shows the measured time from the zero-crossing of the reference voltage (phase L1) until the command is executed.




**Note:** The resolution of the time measurement is 0.1 ms.

*5.5.2.2 CB Signal received*

This submenu shows the measured time from the zero-crossing of the reference voltage (phase L1) until the auxiliary-contacts of the CB are switched.

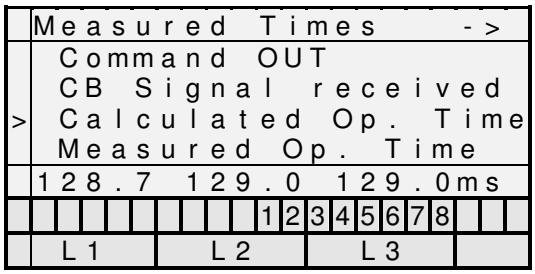


This submenu is available only with module RPH2-xxxS.

**Note:** The resolution of the time measurement is 0.1 ms.

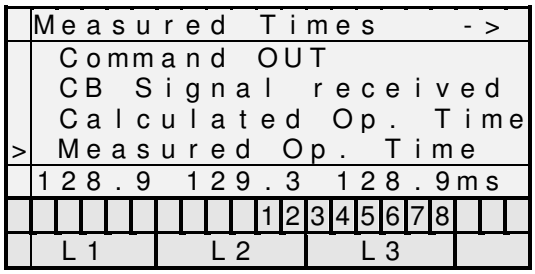
### *5.5.2.3 Calculated Operating Time*

This submenu shows the calculated operating time according to the measured service conditions (temperature, pressure, control voltage). If the compensation facility is not active, the set values of "Operating Time CH1" (see 5.2.1).and "Operating Time CH2" (see 5.2.2) are displayed.




### *5.5.2.4 Measured Operating Time*

This submenu shows the measured operating times, assuming that the values for "Aux. Timeshift CH1/CH2" (see 5.2.5, 5.2.6 and 4.1.2.1) have been determined correctly.




This submenu is available only with module RPH2-xxxS.

Note: The resolution of the time measurement is 0.1 ms.

For RPH2 with software version J006.x a new function for easy setting of the values for Aux. Timeshift is available:

After a switching operation of the circuit breaker position the cursor in the menu “Measured Op. Time” and press the “ENTER” button repeatedly to initialize the automatic setting procedure.

The cursor will first move to the value L1 of the bottom display line, then to L2 and L3. At last the message “OK: YES_NO” is displayed.

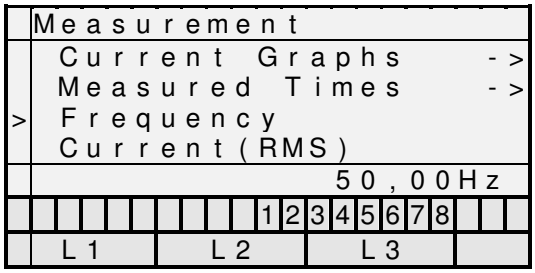
Press “ENTER” once again and the settings in the appropriate “Aux. Time shift CHx” are automatically set to values necessary for correct operation.

For devices with two switching functions (RPH2-2), repeat the procedure for the second switching channel too.

### 5.5.3 Frequency

This submenu shows the actual frequency of the reference voltage.

The resolution of the frequency measurement is 0,05 Hz.

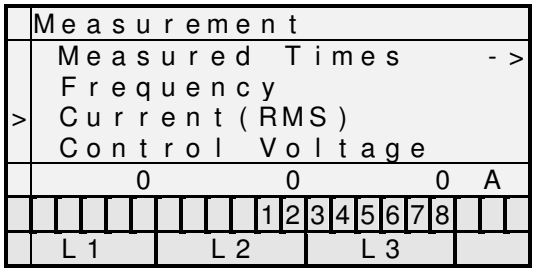



The switching moments (switching programs) are permanently corrected according to the measured frequency.

**Note:** The measurement of the frequency works only when the reference voltage is connected. If the reference voltage is missing the rated frequency is displayed instead.

### 5.5.4 Current (RMS)

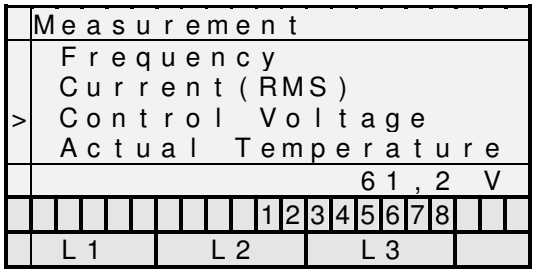
This submenu shows the actual measured line current per phase.




This submenu is available only with module RPH2-xxI.

### 5.5.5 Control Voltage

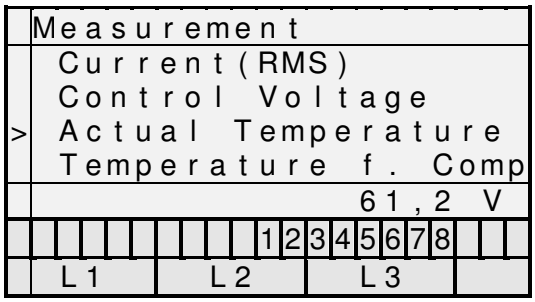
This submenu shows the actual measured control voltage.




This submenu is available only with modules RPH2-xxA0, RPH2-xxA1, RPH2-xxA3.

### 5.5.6 Actual Temperature

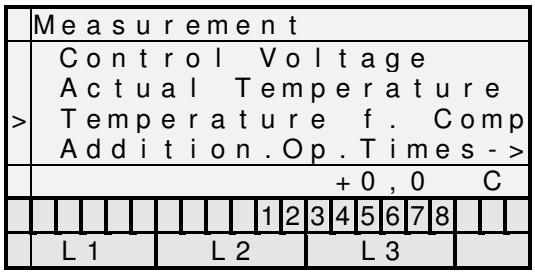
This submenu shows the actual measured ambient temperature.




This submenu is available only with modules RPH2-xxA0, RPH2-xxA1, RPH2-xxA3.

### 5.5.7 Temperature for Compensation

This submenu shows the averaged environmental temperature (see chapter 4.2)



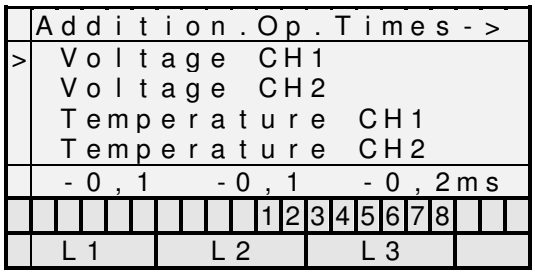

This submenu is available only with modules RPH2-xxA0, RPH2-xxA1, RPH2-xxA3.

### 5.5.8 Additional Operating Times

The following submenus show the calculated additional times according to the service conditions and the configuration of the RPH2.

#### *5.5.8.1 Voltage CH1*

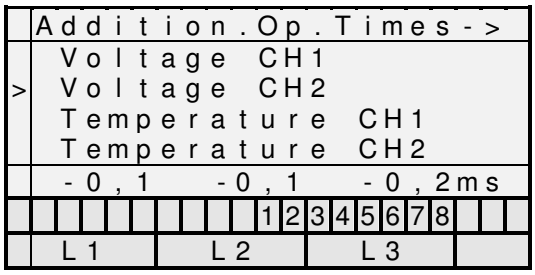
This submenu shows the compensation value for channel 1 for the actual control voltage per phase.




This submenu is available only with modules RPH2-xxxA0, RPH2-xxxA1, RPH2-xxxA3.

*5.5.8.2 Voltage CH2*

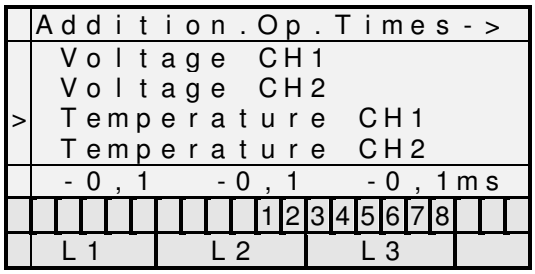
This submenu shows the compensation value for channel 2 for the actual control voltage per phase.




This submenu is available only with modules RPH2-xxxA0, RPH2-xxxA1, RPH2-xxxA3.

*5.5.8.3 Temperature CH1*

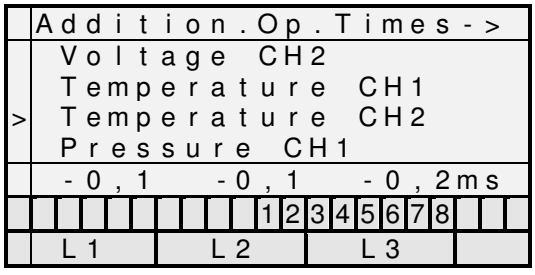
This submenu shows the compensation value for the environmental temperature measured for channel 1 per phase.




This submenu is available only with modules RPH2-xxxA0, RPH2-xxxA1, RPH2-xxxA3.

*5.5.8.4 Temperature CH2*

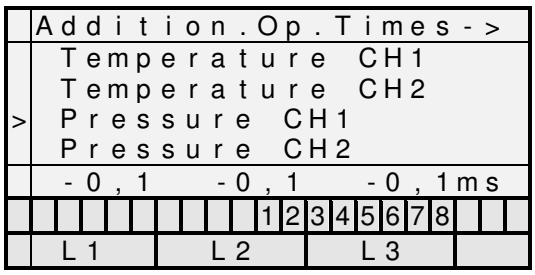
This submenu shows the compensation value for the environmental temperature measured for channel 2 per phase.




This submenu is available only with modules RPH2-xxxA0, RPH2-xxxA1, RPH2-xxxA3.

*5.5.8.5 Pressure CH1*

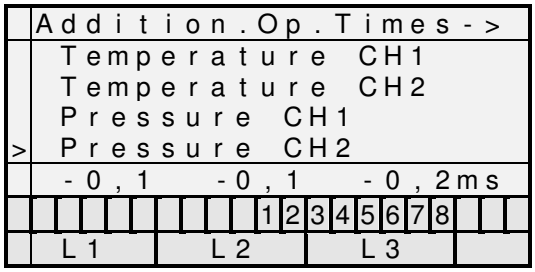
This submenu shows the compensation value for the actual hydraulic pressure measured for channel 1 per phase.




This submenu is available only with modules RPH2-xxxA1, RPH2-xxxA3.

*5.5.8.6 Pressure CH2*

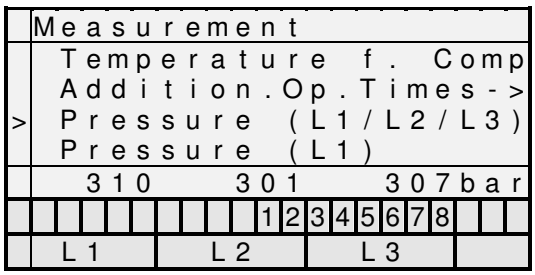
This submenu shows the compensation value for the actual hydraulic pressure measured for channel 2 per phase.




This submenu is available only with modules RPH2-xxxA1, RPH2-xxxA3.

### 5.5.9 Pressure (L1/L2/L3)

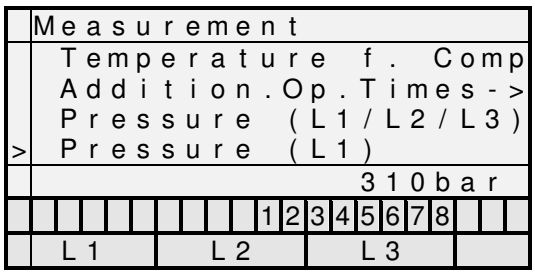
This submenu shows the actual measured hydraulic pressure per phase (L1, L2, L3).




This submenu is available only with module RPH2-xxxA3.

### 5.5.10 Pressure (L1)

This submenu shows the actual measured hydraulic pressure.




This submenu is available only with module RPH2-xxxA1.

## 5.6 Auxiliary functions

### 5.6.1 Alarm Input

This submenu is for testing only. It shows the inputs (auxiliary contacts and position of the neutral earthing switch) of the alarm-board (only available for module RPH2-xxS).

### 5.6.2 Alarm Output

This submenu is for testing only. You can set the alarm-outputs individually by typing a '1' at the according position of the pattern shown on the display (only available for module RPH2-xxS).

### 5.6.3 Error Type

If an internal fault is detected (selftest interval > 0 h), error flags are displayed in this menu.

| | |
|---|---|
| Error type 1: | the switching command on input -x8:1 or -x8:6 is still bending |
| Error type 2-4: | CH1 phase L1 is defective |
| Error type 5-7: | CH1 phase L2 is defective |
| Error type 8-10 | CH1 phase L3 is defective |
| Error type 11-13: | CH2 phase L1 is defective |
| Error type 14-16: | CH2 phase L2 is defective |
| Error type 17-19: | CH2 phase L3 is defective |

If an error code appears, please contact the manufacturer.

## 5.7 Switching archive

This submenu shows the result of the last 8 switching operations.

**List of messages:**

- Switching OK
- NOT Switched (no operation of the breaker)
- Command Time min (command impulse to short (<100 ms))

In the statusline the date and the time of the operation is displayed.

Ahead of the messages a reference to the archive entries is shown:
"n" last operation
"n-1" operation before
etc.

# 6 COMMISSIONING

## 6.1 Commissioning preliminaries

Before initial operation of a RPH2 Point-on-Wave Controller, time should be taken in order to become familiar with operation of the device and, if a portable PC is available, with the parameterization software also.

**NOTE:** After the RPH2 is connected to the supply voltage the first time, or after a self test, it will last about 20 seconds until the green LED is illuminated and the relay is ready for operation (see also 2.4.2.2). If the green LED stays dark, please check at first the proper connection of the reference voltage and the neutral earthing switch

### 6.1.1 Settings

*6.1.1.1 Factory Settings*

Depending on the model, all values for CB-Data, compensation and all thresholds for the alarms are set to '0', except:

| | |
|---|---|
| System Frequency: | 50 Hz |
| Control Voltage: | 125 V |
| Switching Program: | Transformer |
| Function Cannel 1: | CB closing |
| Selftest Interval: | 24 h |
| CT Rated Current | |
| primary: | 1 A |
| secondary: | 1 A |

Alarms:

| | |
|---|---|
| Ref. Voltage Failure -> | Alarm1 |
| Neutral intermediate -> | Alarm2 |

All other alarm functions are inactive.

*6.1.1.2 Necessary Settings*

Before the RPH2 is ready to operate, all relevant settings must be completed. These data must be set before the first operation (depending on the model):

- System frequency (5.1.2)
- Control voltage (5.1.3)
- Rated pressure (5.1.4)
- Switching program (5.1.5)
- Function channel 1 (5.1.6)
- Operating times of each pole (5.2.1, 5.2.2)
- Arcing Times (5.2.3, 5.2.4)
- All data for compensation and adaptive control (5.2.7....5.2.16)
- Actual control voltage (5.3.4)
- Ratings of external transducers (5.3.5, 5.3.6)

All other parameters are not essential for operation.

To evaluate the necessary data, use the configuration checklist shown on the last pages of this service manual.

### 6.1.2 Inspection

Check whether the external wiring corresponds to the relevant RPH2 wiring diagram. Particularly whether the reference voltage and the neutral earthing switch position signals are wired. If a switching of the neutral is not intended, then it is necessary to short circuit the relevant input terminals of the RPH2 (-X6:8 with -X8:11 for neutral isolated or -X6:8 with -X8:12 for neutral grounded).

Make sure that the case is properly earthed. If external sensors are necessary, they are to be installed according to the manufacturer's information. Check whether the plug-in unit is sitting firmly and the fixing screws are tightened.

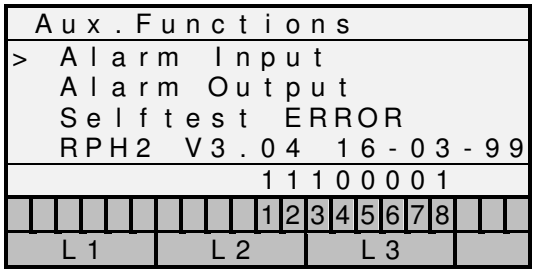
Measure the actual RPH2 control voltage with a multimeter. This value (depending on the model) is required for parameterization (5.3.4).
Check the 48 V field voltage between the terminals -X6:8 and-X6:11 (ground).
Measure the voltage at the inputs of the external transducers (approx. 24 VDC).

Compare the displayed values on the RPH2 for control voltage, hydraulic pressure and ambient temperature (only models RPH2-xxA) with the externally measured ones.

Verify the connections of the voltage and current transformer circuits (current only for model RPH2-xI) to the correct terminals (100/√3V or 220/√3V, 1A or 5A) of the RPH2.

The two functions of the menu [Aux. Functions] maybe helpful by testing the external connections:

The proper connection of the CB's auxiliary contacts to the RPH2 (only model RPH2-Sxx) can easily be checked by the function [Aux. Functions][Alarm Input]. When the circuit breaker is in the closed position you must see three '1' at the first positions in the status line.




When the breaker is in the open position, three '0' will be displayed.
If the remote reset input is activated, at the fourth position a '1' must be displayed.
By using the function [Aux. Functions][Alarm Output] you can activate individually each alarm relay by typing a '1' at the according position of the pattern. So the external wiring of the alarm circuits can be checked on correct function.

### 6.1.3 First operation

When all inspections are done, operate the dead circuit breaker via the RPH2. On Point-on-Wave-Controllers with option S check, if the measured operating times are correct, otherwise adjust the values for [Aux.Timeshift] according to 4.1.2.1. Prove that the command impulse to the RPH2 is of sufficient length.

For the first load switchings, we recommend using an oscillograph to measure the currents of the three phases together with the reference voltage, in order to verify that the unit is working correctly. It is helpful if the three relayed drive commands can also be recorded on additional oscillograph traces.

By using a RPH2 with the option I the currents during switching can be displayed and analysed (see 5.5.1).

If the results are not satisfactory you must adapt the pole operating times and/ or the arcing times to achieve the optimal function.

# Configuration Checklist RPH2

**System Data**

System Frequency O 16 2/3 Hz O 50 Hz O 60 Hz

Control Voltage (48V...250V) .....V

Rated Pressure .....bar

Switching program: O Transformer O Shunt Reactor O Capacitor Bank

O User Program

| Point on Wave | L1 | L2 | L3 | |
|---|---|---|---|---|
| T_C1 Neutral isolated | | | | ms |
| T_C1 Neutral grounded | | | | ms |
| T_C2 Neutral isolated | | | | ms |
| T_C2 Neutral grounded | | | | ms |

Function Channel 1 O CB Close O CB Open (RPH2-1xx only)

Language O German O English O French
O Free language .....

Selftest Interval .....Hours

**CB Data:**

| CB Data | L1 | L2 | L3 | |
|---|---|---|---|---|
| Operating Time CH1 | | | | ms |
| Operating Time CH2 | | | | ms |
| Arcing Time CH1 | | | | ms |
| Arcing Time CH2 | | | | ms |
| Aux.Timeshift CH1 | | | | ms |
| Aux.Timeshift CH2 | | | | ms |

Adaptive Control Weighting Factor .....

Compensation O Yes O No

kU1 Voltage CH1 .....

kP1 Pressure CH1 .....

kU2 Voltage CH2 .....

kP2 Pressure CH2 .....

# Configuration Checklist RPH2

Temperature Compensation:
Switching Channel 1

| Temperature | Delta_t |
|---|---|
| +50 °C | ms |
| +40 °C | ms |
| +30 °C | ms |
| +20 °C | ms |
| +10 °C | ms |
| 0 °C | ms |
| -10 °C | ms |
| -20 °C | ms |
| -30 °C | ms |
| -40 °C | ms |
| -50 °C | ms |

Switching Channel 2

| Temperature | Delta_t |
|---|---|
| +50 °C | ms |
| +40 °C | ms |
| +30 °C | ms |
| +20 °C | ms |
| +10 °C | ms |
| 0 °C | ms |
| -10 °C | ms |
| -20 °C | ms |
| -30 °C | ms |
| -40 °C | ms |
| -50 °C | ms |

**Analogue Data:**

Thresholds:

Current max. (peak) ..... A

Control Voltage max ..... V

Control Voltage min ..... V

Temperature max ..... °C

Temperature min ..... °C

Pressure min ..... bar

Pressure max ..... bar

Actual Control Voltage ..... V (to be measured and set at site)

CT rated current prim. ..... A

CT rated current sec. O 1A O 5A

Temperature:

Value at 4 mA ..... °C

Value at 20 mA ..... °C

Pressure:

Value at 4 mA ..... bar

Value at 20 mA ..... bar

# Configuration Checklist RPH2

**Alarms:**

| Alarmtext | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| **Alarm Functions** | | | | | | | |
| Reset Obligatory | | | | | | | |
| Lock-out | | | | | | | |
| **Alarm List** | | | | | | | |
| Lock-out | | | | | | | |
| Frequency min | | | | | | | |
| Frequency max | | | | | | | |
| Current max | | | | | | | |
| Ref.Voltage Failure | | | | | | | |
| RTC Impulse Failure | | | | | | | |
| Neutral Intermediate | | | | | | | |
| Neutral Grounded | | | | | | | |
| Neutral Isolated | | | | | | | |
| Selftest ERROR | | | | | | | |
| Selftest CH1 ERROR | | | | | | | |
| Selftest CH2 ERROR | | | | | | | |
| Command Time CH1 min | | | | | | | |
| Command Time CH2 min | | | | | | | |
| Operating Time min | | | | | | | |
| Operating Time max | | | | | | | |
| Drive Mech.Failure | | | | | | | |
| Archive Full | | | | | | | |
| Archive Failure | | | | | | | |
| Control Voltage min | | | | | | | |
| Control Voltage max | | | | | | | |
| Temperature min | | | | | | | |
| Temperature max | | | | | | | |
| Temp. Transducer Fault | | | | | | | |
| Pressure min | | | | | | | |
| Pressure max | | | | | | | |
| Press. Transducer Fault | | | | | | | |