Reference Manual

POWER-ANALYZER

EMM5

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28.02.06	ATh	06	features of new software (V1.8.x)
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01.06.10	Le	08	Features of new software (V1.12.x)
01.02.11	Le	09	Add option –E
19.04.16	RH	10	Voltage measurement
17.07.18	SO	11	Content correction

Contents

1 Overview

The EMM5 power analyzer has been designed to provide a great variety of information from the power distribution system it supervises. It contains a powerful measurement system which is able to provide high-precision values from 3-phase systems.

A big liquid crystal display with backlight provides a good visibility even in poor light conditions.

Four adaptive soft-keys provide easy and intuitive usage also in complex situations.

A basic set of standard values (currents, voltages and powers) is calculated from the measured input data. These are then used to calculate further values such as power factors and others. A full list can be found in the “Measurement system” chapter. Nearly all calculated values are true RMS (TRMS) values, which means that they are correct even if the waveform is not a sine function.

A full range “Fast Fourier Transformation” is performed on the input data from all channels (3 voltage channels, 4 current channels). This provides information about the harmonic contents which distort the sine waveforms of currents and voltages.
The following options are available for EMM5:

Relay outputs: For external alarm signal can be used each relay by one or more alarm.

Impulse outputs: These allow to trigger external counters for active and reactive energy.

Modbus RTU Interface: This enables an easy connection to a bus system.

Data Logger: This option offers in addition to the Data Logger function a Modbus RTU Interface and a digital input. The additional functions, such as for example, the additional counters and the event recorder are described in more details in the appropriate menu.

Important information!

If the sign aside appears besides a text passage in the manual the reader is strongly advised to read the corresponding information as it may be very important for usage of the EMM5.

It can contain safety advice or other information for the correct handling of the device. If the information is disregarded, the device may be inoperable or even damaged!

2 Measurement system

The EMM5 is designed to acquire all necessary data to provide full information in a 3-phase power distribution system. This requires the measurement of the three voltages L1/2/3 versus the N connector and the three currents in L1/L2/L3. Additionally, the current in N can be measured or, if desired, it can also be calculated from the data for I1/I2/I3 (but this will be less accurate due to calculation and rounding errors).

The EMM5 provides separate input terminals for device supply and measurement, so the measurement inputs are completely independent. Of course, measurement and supply may be connected to the same power grid.

For the most measurement values, minimum and maximum is stored and they are available for the user if necessary.

2.1 Data collection

The waveforms of the signals (=voltage or current) on the 6 (7 with N-current) input channels are sampled by the data collection logic of the EMM5. This supplies the software with enough information to calculate all the values.

The sampling of the input signal needs to be synchronized to the input signal, so the EMM5 needs at least one input signal for the voltage L1-N to be able to do calculations. If this voltage is too small or even disconnected, the device will not be able to do any measurements. This mechanism is also used to provide the frequency reading.

The data collection circuitry for the voltage channels uses the four terminals L1, L2, L3 and N which have to be connected in accordance to the connection diagram. As a minimum, the L1/L2/L3 terminals have to be connected while N can be left floating. In this case, N is artificially generated inside the device by three resistors. Connection of the N-terminal overrides this high-impedance resistor circuit. The voltages can be connected directly (with respect to the maximum rating) or via transformers. The voltage transformer factor can be set in the EMM5.

The three (four with N) current inputs use two terminals each, labelled “K” and “L”. The neutral current can be measured, but if necessary it can also be calculated with the other 3 currents. Current transformers have to be used for the measurement. The current transformer factors can be set in the EMM5. Each channel is additionally equipped with an input filter. This protects the system from being damaged by transients with high frequencies like voltage spikes and is mainly used to ensure proper sampling, synchronisation and measurement in presence of high frequency harmonics.

Always make sure, you don’t exceed the maximum ratings of voltage and current channels. The ratings and a connection diagram are available on the labels on the back side of the device.

2.2 Measurement values

The measurement system uses the information from the data collection system to calculate the values of the power grid.

Values, which are directly calculated from the raw input data:

- ULN : TRMS values for the voltages L1-N, L2-N, L3-N
- ULL : TRMS values for the voltages L1-L2, L2-L3, L3-L1
- I : TRMS values for the currents L1, L2, L3, (N)
- If : RMS values for the current fundamentals L1, L2, L3, (N)
- P : TRMS active power P for L1, L2, L3 and sum L1+L2+L3
- Q :TRMS reactive power Q for L1, L2, L3 and sum L1+L2+L3
- Harmonics (in percent of fundamental wave) for all currents and voltages
- phi : Angle between fundamental waves of current and voltage of a phase (L1, L2, L3)
- cp : cos-φ for fundamental waves of L1, L2, L3
- f : Frequency of voltage L1-N

From these, further calculations are possible:

- THD-U : THD for each voltage channel from the harmonics 1-62
- THD-I : THD for each current channel from the harmonics 1-62
- Pth / Ith : Exponentially damped values for currents and active powers which resemble the behaviour of thermal measurement
- S : TRMS apparent powers S from P and Q of each phase and for power sums
- pf : Power factor as the absolute quotient P/S for each phase. It includes the influence of harmonics, because it is calculated from TRMS values P and S. If the harmonic-free information is needed, use the fundamental cp values! The power factor is unsigned!

Additional values by numeric integration:

For active powers P-L1, P-L2, P-L3 and P-sum, an energy accumulator is available, which separately counts the amount of energy for import and export direction (in kWh). The same counter is available for the reactive power readings Q-L1, Q-L2, Q-L3 and Q-sum. These are accumulated separately for inductive and capacitive reactive power. For devices with

integrated data logger (option –DM) are also counter for a second tariff available. The switchover can be done via the built-in clock or the digital input.

Active power values are signed values! The signs have to be interpreted as follows: A positive sign shows power flow in one direction, a negative sign in the other. So, positive active power can be interpreted as active power import, the negative active power as active power export.[1] Reactive power values are signed values, too! The signs are automatically interpreted as inductive or capacitive. The user of the EMM5 will always see a "ind" or "cap" mark with reactive values, so he never needs to worry about interpretation of signs with any reactive value.

3 Alarm system

The unique alarm-system of the EMM5 was designed to provide maximum flexibility. It consists of 32 user-configurable alarms. Each of them continuously compares one of the measured values to an assigned limit and, if necessary, triggers the alarm. Each of the alarms provides the following features:

- Alarm source can be any measured value, with exclusion of work counters and single harmonics
- Configurable limit value for each alarm
- Trigger condition selectable (value>limit or value<limit)
- Alarm-specific turn-on-delay[2]
- Alarm-specific turn-off-delay[3]
- Alarm storage in the event recorder (optional)
- An alarm-specific set of output relays and the possibility to display an alarm message

[1] The precise definition is: If the current, measured on terminal K with respect to terminal L, is in phase with the corresponding voltage, the active power will be positive and defined as “energy import”.

[2] This provides a delay between the recognition of the alarm state and the activation of the alarm outputs (relays and display message).

[3] The function is similar to the turn-on-delay but it is used for insertion of a delay time between the alarm condition becoming false and the signal to all target relays to reset being sent.

This alarm system reaches its maximum flexibility by these features:

- **Multi-source alarm**

One single output relay, if available for alarms, can be triggered by any of the 32 alarms. More than one alarm can be used to trigger the same relay. In this case, only one of the alarms is sufficient to activate the relay (logical OR).

As each alarm first handles the necessary delay times before sending the activation signal to the relay, different delay times from all the alarms, which are sourcing a relay, are handled correctly!

- **Multi-target alarm**

One alarm can trigger a configurable set of relays. This includes the activation of more than one output relay.

3.1 Alarm display

If any alarm is configured to display an alarm message, the following contents will be shown whenever the alarm is triggered. The display message has to be quitted manually.

An alarm message offers the following information:

- In the right top corner of the display, the status of all assembled relays is displayed. A dark number on bright ground shows a relay which is deactivated, the reverse display (bright number on dark ground) shows an activated relay.
- The message “ALARM #xx” in the centre of the display shows the number of the active alarm. The number appears instead of “xx” in this example.
- The active value of the measurement which is the source of this alarm.

If more than one alarm message is active, the user can switch between them by pressing key “+”.

The right key can be used to confirm the alarm message. After confirmation, this alarm message will not reappear until the alarm has become inactive and active again. The confirmation disables only the alarm message. If any output relays are configured for the same alarm they are **not** influenced by the confirmation.

After confirmation the display shows the next active alarm or, if there are no more active alarms, resumes work at the same point where it left before the alarm occurred. Each alarm message has to be confirmed separately.

The alarm message is displayed after the turn-on-delay time for the alarm. If the alarm condition becomes false again, the alarm message is deactivated after expiration of the turn-off-delay time.

To enhance visibility and to make recognition of the alarm easier, the backlight of the display is toggled between full brightness and reduced brightness, which resembles a blinking signal light.

4 User Interface

The EMM5 user interface uses a combination of a graphical LC display with automatic backlight and four multi-function softkeys. The action, a key performs, depends on the actual context and is given by small icons at the bottom of the display. This means a much more easy and intuitive usage of the device, even in complex situations.

After the supply voltage is connected to the device, it will take a short time to power up and initialise itself. During this time, the display remains empty. After the power-up-procedures have been completed, an entry-screen is displayed. The keys on the left and the right (icon is a capital “M”) will proceed to main menu.

If, after waiting for some seconds of set-up-time, the display does not show the introduction screen or is fully dark, it is possible that the display contrast is not set properly. The user would not be able to navigate to the display contrast set-up menu in this case, so an additional possibility to set the contrast is included in the introduction screen: press one of the two keys in the middle repeatedly to change contrast. If no change can be seen, try the other key. The value is automatically saved for the next start.

4.1 Main menu

The main menu is the central point of the device's menu navigation. It shows the following items:

- **MEASUREMENT:** This submenu contains the measured values
- **AUTO-ROLL:** Measurement display with automatic switching to the next value
- **HARMONICS:** This submenu shows the single harmonics for the input channels (voltages L1-N, L2-N, L3-N and currents I-1, I-2, I-3, I-N)
- **WORK:** This submenu contains the work counters
- **SETUP:** The device setup can be found inside this menu
- **DEVICE INFO:** This submenu displays some information about the device
- **EVENTRECORDER:** Contains all stored alarm including timestamp and grid data. (The event recorder is available in devices with the option –DM only)

KEYS:

The user can navigate through the menu entries by use of the "⇑ "and "⇓” keys. On the top left side a tiny arrow shows which item is actually selected. By pressing "⇒", one can enter the selected submenu.

Whenever a capital "M" is used as key symbol in any submenu, pressing the key will switch straight to the main menu.

4.2 Measurement

This menu contains all measured values. The values are organised in several pages, which can be displayed on the LCD. With the right key the user can additionally select between the active value ("TRMS"), minimum ("MIN") and maximum ("MAX"). For some measurement values the MIN / MAX selection is not possible.

The navigation through the values is quite easy: You can use the "⇑" and "⇓" keys to select the different pages. Press one of the keys repeatedly to see all the values. If the last page is reached, the EMM5 continues with the first page.

Each value is displayed with its name (ULL, ULN, I, ...), its origin (L1, L2, L3, N) and the unit (V, A,...).

In addition to the measurement display, shows the EMM54 the rotation field of the system. The indicator for this is in the row and shows "↻" for a clockwise rotation field and "↺" for anti clockwise rotation field. The rotation field can also be used as an alarm source.

The EMM5 features an auto range-function: If a certain value becomes too big, the display automatically switches the unit prefixes. For example: If the voltage exceeds 1000V, the display switches to 1.00 kV.

In the top right corner of the display, the status of all assembled output relays is shown. The relays are represented by numbers. A dark number on bright ground shows a deactivated relay, a bright number on dark ground shows an activated relay.

Devices with option –DM shows in the upper left corner the currently used tariff. The digital input is indicated by a "D", the active or inactive state is indicated as with output relays.

Use the "M"-key to switch back to the main menu at any time.

4.3 Auto-roll

This menu also contains all measured values. The values are organised in several "pages", which can be displayed on the LCD. This menu has a timer-controlled auto-roll mechanism. **Every 10 seconds the display is automatically switched to the next page.** Additionally the keys "⇑" and "⇓" keys can be used to select the different pages.

4.4 Harmonics

The EMM5 calculates harmonics for the seven input channels (U-L1, U-L2, U-L3, I-L1, I-L2, I-L3, I-N). Harmonics are displayed regarding EN 61000-2-4 from the fundamental wave (1st harmonic) up to the 62nd harmonic. The harmonics are given in percent, each harmonic is standardized to the TRMS value. The harmonics are displayed in two columns:

odd harmonics on the left side, even harmonics on the right. The numbers before the harmonic value gives the order of the harmonic (01 = fundamental wave).

KEYS:

- Left key (“M”) switches back to main menu
- “⇓” - key scrolls the list of harmonics down to the harmonics of higher order
- “⇑” - key scrolls the list back to the top (lower harmonics)
- Right key (“⇔”) switches between the seven data sources (4 currents and 3 voltages)

If the harmonic display quotes "NOT AVAILABLE", the current or voltage, which sources the harmonic calculation is below a certain limit or even not present. This makes the FFT calculation of the harmonics very inaccurate or impossible.

The contents of the harmonic menu occupy a great amount of memory in the device, so no minimum / maximum values are stored for the harmonics. Single harmonics, as displayed in this menu, cannot be the source of alarms. Harmonic alarms should use the THD as source, which contains information of all harmonics of one source in one single value.

4.5 Work

This submenu contains the work accumulators. These accumulators count certain amounts of electrical energy given by the elapsed time of the powers.

The work counters are programmed to integrate the powers for L1, L2, L3 and power sum in a separate accumulator each. They are further divided:

- Active work is accumulated separately for import and export energy flow direction
- Reactive work is accumulated separately for inductive and capacitive reactive power

The display can show one of four different pages, which are: WP-IMP, WP-EXP, WQ-IND, WQ-CAP. Each page contains four work counters for L1, L2, L3 and sum(L1+L2+L3). For the counting of two tariffs, have devices with integrated data logger (option –DM) additional counters.

These are also divided among four pages (WP-IMP-2, WP-EXP-2, WQ-IND-2 and WQ-KAP-2) and include also for counters for L1, L2, L3 and sum (L1+L2+L3).

KEYS:

- Left key (“M”) switches back to main menu
- Right key (“⇔”) switches between the four different work accumulator pages

It is important to mention, that, even if the lowest counter is labelled "sum", it must not show the sum of the above counters for L1, L2 and L3. This merely indicates that this work counter accumulates the power sum, which is calculated as arithmetic sum of the powers of the three phases. Because the powers of the phases can be of different nature (imp. /exp. or índ. /cap.), which are mathematically represented by positive and negative values, the powers can even add up to zero. This would result in the sum-power-accumulator not running at all even if the single-phase accumulators are counting!

4.6 Setup

The “SETUP”-menu contains all settings, which can be performed by the user of the EMM5 to adjust it to certain ambient circumstances. Because there are many possible settings, the “setup”-menu is divided into more submenus to provide easy and logical access to all the set-up possibilities.

The available submenus are:

- **PARAMETER:** This menu provides the possibility to set certain system parameters
- **ALARM:** This submenu contains the settings for the 32 alarms
- **TARIFF SETUP (optional):** This submenu contains the settings for the tariff switch over.
- **IMPULSE (optional):** This submenu contains the settings for the impulse outputs
- **MODBUS (optional):** This submenu contains the settings for the Modbus interface
- **MEAS. VAL. STOR. (optional):** This submenu contains the settings for the measured data storage.
- **LOAD DEFAULTS:** This item resets the settings of the EMM5 to default values. *All settings, which have been changed manually are lost.*
- **RESET MIN/MAX:** This item resets the min/max values
- **RESET WORK:** This item resets the work counters to 0

KEYS:

Select a submenu with the arrow-keys ("⇓" and "⇑") and enter it by pressing the “⇒” - key.

PASSWORD:

To enter the “SETUP”-Menu, a password is needed. The fixed password is “2402”.

4.6.1 Input of numerical values

Inside the “SETUP”-menu and its submenus, the user will at certain points encounter the problem to enter numerical values. Whenever the EMM5 prompts for the input of a value, the routine will be the same:

A preset-value will be displayed with the first (highest) digit underlined by a “_”. This digit can now be changed by use of the keys which are labelled with “+” and “-“ signs. If no change can be encountered while pressing one of these buttons, the value may be at its minimum or maximum, so just try the other key or change to the next, smaller digit by use of the “⇒” key. After changing, the next digit will be also underlined and can now be altered just like the first one. To store the value, proceed to the least significant digit on the right side. Press the “⇒” key once more, and the new value will be saved and used.

At any time the user can go back to the last menu without changing the value by pressing the “⇐” key.

4.6.2 Parameter

Select one of the submenu entries with the arrow-keys (“⇓” and “⇑”) and activate it by pressing the “⇒” key:

- **PT RATIO:** This sets up the device to work with a voltage measurement transformer. Enter the transformer ratio. The range is 1-4000. If no transformer is used and the EMM5 is directly connected for voltage measurement, enter factor 1.
- **CT RATIO:** This sets up the device to work with current measurement transformers. Enter the transformer ratio (e. g. 1000/5 = 200). The range is 1-10000. Current transformers always have to be used!

  This setting only applies to current channels L1, L2, and L3!
- **CT-N RATIO:** This sets up the device to work with a current measurement transformer for the N current. Enter the transformer ratio (e. g. 1000/5 = 200). The range is 1-10000. If this channel is connected, a current transformer has to be used!

  This setting only applies to current channel N!
- **THERMIC TAU:** This sets the damping time constant for the Ith and Pth values. The time constant is given in seconds (default value is 300 seconds = 5 min). The entered value is the time constant of the exponential damping function.
- **CALC/MEAS IN:** Here the measurement method of the I-N current can be selected.
- **DISPLAY CONTRAST:** Here the display contrast can be adjusted by repeated use of the “+” and “-” keys.
- **TIME & DATE (optional):** Setting of date and time. Important for Tariff switch over and event-recorder.

4.6.3 Alarm

This submenu contains all settings, which have to be performed in order to use the EMM5 alarm system. The menu contains a set of different settings, between which the user can select with the "⇓" key.

- **ALARM:** Move the ">" to this line and use "+" and "-" to select one of the 32 alarms. Each alarm compares one source value to a limit and, if the trigger condition is met, activates the outputs.
- **SOURCE:** Use the "+" and "-" keys to select the appropriate source for the alarm. This is the value which is compared to the limit by the alarm system.
- **TRIGGER:** Use the "⇔" key to select the condition under which the alarm is considered to be active. Possible values are "VAL>LIMIT" (alarm if selected source value is bigger than limit) and "VAL<LIMIT" (alarm if selected source value is smaller than limit). For the source values which are of reactive nature (reactive power, cp) the display shows "+ind" or "+cap" for the trigger setting. This has to be interpreted as "more inductive than limit" or "more capacitive than limit".
- **LIMIT:** The limit value can be set here. Press the "⇒" key to enter a value.
- **T-ON / T-OFF:** Use these items to enter delay times for activation and deactivation of alarm relays in a range of 0-600 seconds with steps of 10 ms.
- **OUTPUT:** Here you can choose to which of the relays an activation signal will be sent once the alarm is active and the on-delay time is over. The alarm message display can also be selected here. In the following submenu "+" and "-" select the different alarm outputs and the "⇔" key chooses, whether the relay or display message will be activated on alarm or not.

Some of the alarm settings may not get active until the alarm menu is leaved because at that time, a great part of the entered values is given to the alarm subsystem for execution. This is done to inhibit the alarm subsystem from executing weird intermediate settings while the user enters an new alarm setup.

Example of use:

This sample alarm setting is used to signal the total energy flow direction to an external device by use of two alarm relays. The following specifications have to be met:

- Relay 1 signals energy import, relay 2 signals energy export. The relays may not be closed at the same time; a delay of up to 1 second at switchover point is suitable.
- The measurement needs to have a “dead area” around P=0. In the range [20W export; 20W import] none of the relays should be closed to prevent spurious switching at zero.

To accomplish these needs, the following set-up can be used:

- Define the following alarm: ALARM=01, SOURCE=P-sum, TRIGGER=VAL>LIMIT;

  LIMIT=+20.00W, T-ON=01,000sec, T-OFF=00,500sec, OUTPUT=1
- Define the following alarm: ALARM=02, SOURCE=P-sum, TRIGGER=VAL<LIMIT;

  LIMIT=-20.00W, T-ON=01,000sec, T-OFF=00,500sec, OUTPUT=2

This will have the following effects:

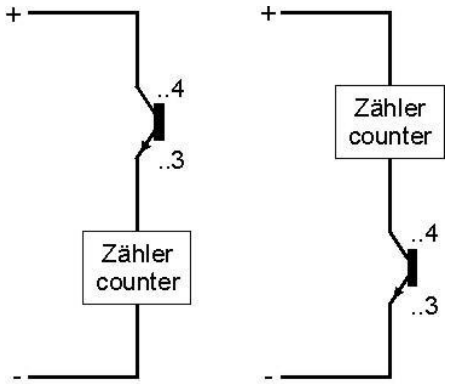
- Relay 1 will close if P-sum > +20W, relay 2 will close when P-sum < -20W. This setting contains the dead zone of ±20W.
- The on-delay of 1sec and off-delay of 0.5 sec for both relays prohibits them from being closed at the same time. After change of sign, the old (to be switched off) relay will wait for 0,5 seconds before turning off, while the new (to be turned on) relay will wait 1 second until it closes. Because both delay times start at the same moment, the new relay will close 0,5 sec after the old relay opened.
- The delay set-up provides some security against spurious relay switches, because every change in power flow direction has to persist for at least 0,5sec and has to exceed +/- 20W to cause a relay to close.

4.6.4 Tariff Setup (optional)

This menu item is visibly only when the unit is equipped with the optional data logger (option –DM). The switch over can be made by time or digital input. Switch over via time requires the start and end time for tariff 2. If the tariff switch over shall be in sync on multiple devices, this can done using the digital input. For the digital input can be determined whether the signal is high or low switched.

4.6.5 Impulse (optional)

This menu item can only be seen, if the device is equipped with the optional impulse outputs. These 4 transistor outputs (galvanic isolation by optocouplers) are dedicated to the counters. With these outputs e. g. external counters can be driven. The following schematic shows the correct connection:



The following impulse outputs are available at the referring connectors:

- Active power sum import (clamp 13/14)
- Active power sum export (clamp 23/24)
- Reactive power sum inductive (clamp 33/34)
- Reactive power sum capacitive (clamp 43/44)

In the menu the amount of pulses can be set for the dedicated impulse outputs. Select one pulse output with the "⇓" and "⇑"-keys and after pushing "⇒" the value can be adjusted. The range is between 1 and 10000 pulses/Mwh or Mvarh. The adjusted value should be selected in the way, that 4 pulses per second are not permanently exceeded. Short term exceeding is possible, because too many accumulated pulses are stored. But durable you have to ensure, that the storage can be executed completely.

Worked sample:

P = 1,050 MW, 10000 pulses / MWh:

→ produces 1,050 MW * 10000 pulses / MWh = 10500 pulses / hour

→ produces (10500 pulses / hour) / (3600 sec / h) = 2,92 pulses / sec → setting allowed

Important: If you use two tariffs (option – DM) is to be noted that the output pulse always exits the currently used tariff.

4.6.6 Modbus (optional)

This menu item can only be seen, if the device is equipped with the optional Modbus interface. Select one item by the "⇓" and "⇑"-keys and set it with the "+"-key.

In this menu item the following settings can be done:

- **ADDRESS:** valid range is between 1 and 247.
- **BAUDRATE**: selectable range is between 1200 and 38400.
- **PARITY**: the following settings can be selected: even (8 data bits/1 stop bit), odd (8 data bits/1 stop bit), no (8 data bits/2 stop bits).

The settings for baud rate and parity must be the same for all bus devices. The address must be unique for each device.

4.6.7 MEAS. VAL. STOR. (optional)

This menu item is visibly only when the unit is equipped with the optional data logger (option –DM). Within the set time interval, is formed from the detected values a mean value. If the interval is set to 0 min, the data logging is off. The recording intervals can be synchronized via the digital input (DI) if necessary. For the DI can be adjusted if the synchronization is done via a positive edge (HIGH) or negative edge (LOW). When synchronization via the DI, the time interval to be terminated since this time will be used to monitor the synchronization. The monitoring of DI will be set in the alarm menu, as is source “Sy.-DI” is used. For reading out the memory, an additional data cable (UMS9) and the read out software is necessary.

4.6.8 Load defaults

In this submenu all parameters and alarm settings can be reset to standard values. *All settings are lost!*

4.6.9 Reset min/max

In this submenu minima and maxima of the measurement values can be reset. *All available minima and maxima are reset simultaneously!*

4.6.10 Reset work

In this submenu all counters can be set to 0. *All available counters are set to 0 simultaneously!*

4.6.11 Clear Datalogger

In this menu, all values stored in the memory will erased.

4.7 Device info

This menu simply shows some information about the EMM5 device:

- SW: software version e. g. 1.09.2

- HW: hardware revision number e. g. 0511R06
- SN: serial number of the device e. g. 7777777
- FLAGS: options of the device e. g. –MB for option Modbus

4.8 Event History

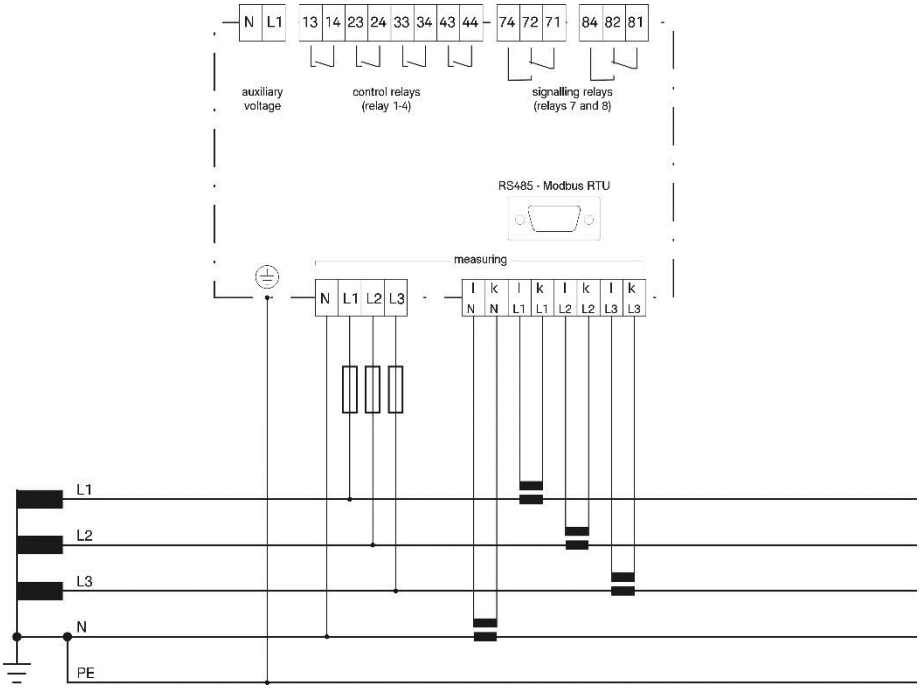
If the EMM54 is equipped with a data logger (option –DM), it's possible to store occurring alarms with time stamp. The event recorder consists of 64 memory cells. Each event (occurrence and drop out the alarm) is stored in a separate memory cell. Are all storage cells full, the recording starts again at memory cell one. As additional information will be stored the values listed in the following table.

<table>
<tr><td>Page 1</td><td></td><td>Page 2</td><td></td><td></td><td>Page 3</td><td></td></tr>
<tr><td>Record 1-64</td><td colspan="6">Indicates in which memory cell the event is stored.</td></tr>
<tr><td>Alarm 1-32</td><td colspan="6">Indicates which setting was triggered or deactivated</td></tr>
<tr><td>Source</td><td>Show the supervised value</td><td>V</td><td>I</td><td></td><td>Delay</td><td>Time Delay from exceeding the adjusted level to activate an alarm</td></tr>
<tr><td>Date</td><td>Date of event</td><td>L12</td><td>L1</td><td rowspan="4">Value during Alarm condition</td><td>Output</td><td rowspan="2">Which relays respectively which action has followed to the event</td></tr>
<tr><td>Time</td><td>Time of event</td><td>L23</td><td>L2</td><td rowspan="3"></td></tr>
<tr><td>Limit</td><td>Shows the adjusted limit</td><td>L31</td><td>L3</td></tr>
<tr><td>Ext-Val</td><td>Shows the maximum exceeding during the delay time</td><td></td><td>I UB</td><td></td></tr>
</table>

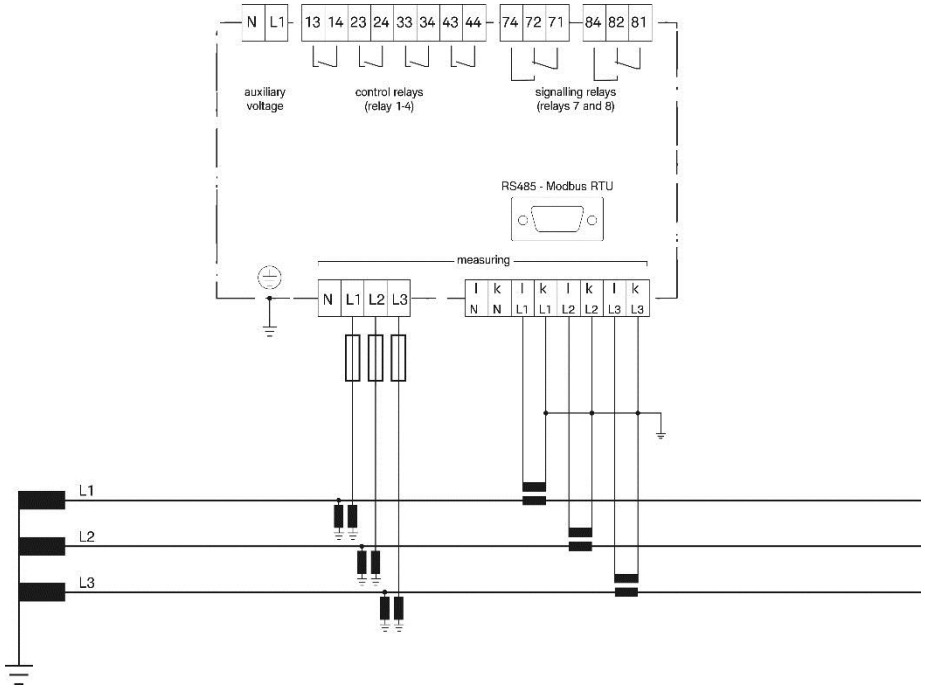
5 Connection diagrams

The EMM5 can be used in power systems with or without the neutral conductor. Below measurements in systems with L1/L2/L3 and N (PEN) are called four-wire measurement. Measurements in systems without N are called three-wire measurement.

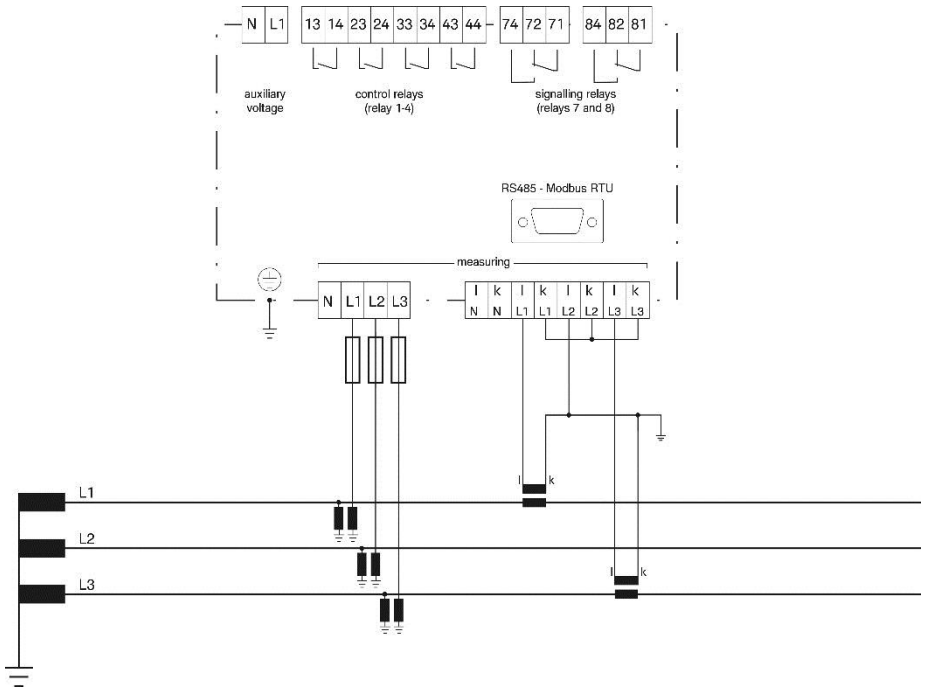
5.1 3-phase measurement with neutral conductor and four current transformers (four-wire measurement)



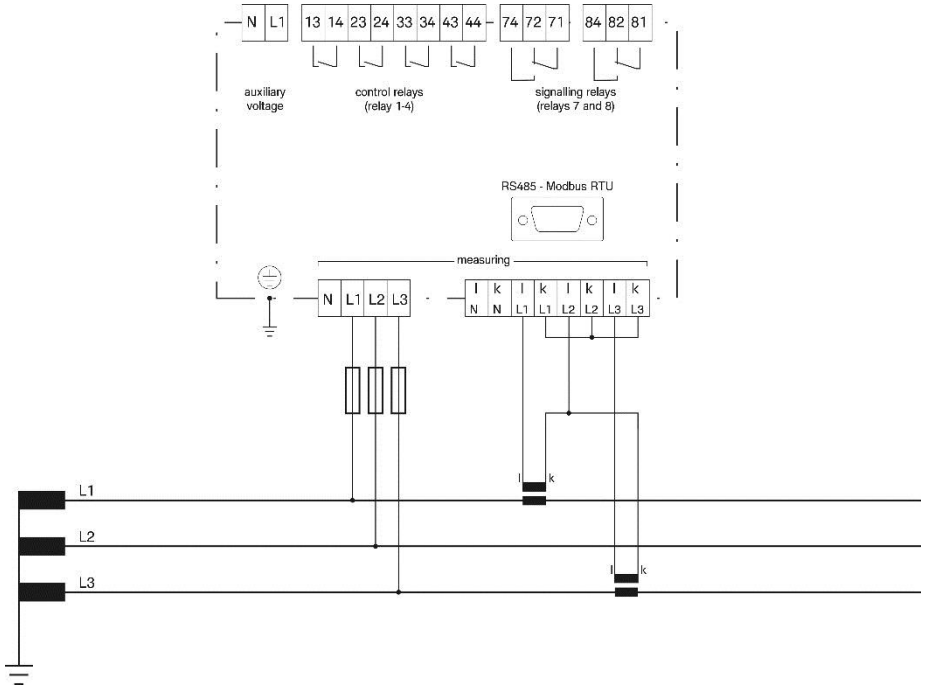
5.2 3-phase measurement without neutral conductor with three current- and three voltage transformers (three-wire measurement)



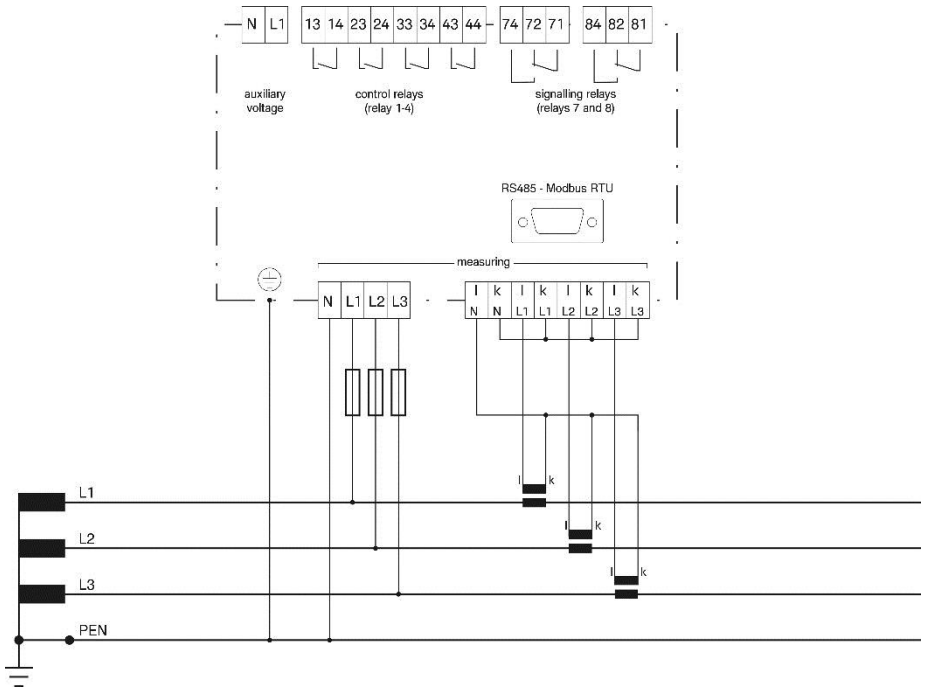
5.3 3-phase measurement with two current- and three voltage transformers (three-wire measurement)



5.4 3-phase measurement with two current transformers (three-wire measurement)



5.5 3-phase measurement with three current transformers and measured neutral conductor current (four-wire measurement)



6 Technical data

Auxiliary voltage	207 - 253V, 45 - 65Hz, max. fuse 6A
Voltage measuring	L-N 50V .. 289V, L-L 90V .. 500V, 45 – 65Hz, PT-ratio 1 - 4000
Current measuring	0 – 5A, sensitivity 50mA, power consumption < 1VA CT necessary, CT-ratio 1 - 10000 overload 20% continuous, 50A for 1 sec.
Current measuring option -E	200 A for 1 sec.
Relay outputs (optional)	6 n/o, with common point, max. fuse 6A 4 n/o, voltfree, max. fuse 6A 2 c/o, voltfree, max. fuse 6A breaking capacity: 250V AC / 5A, 30V DC / 5A (ohmic) 110V DC / 0,4A (ohmic), 110V DC / 0,3A (inductive)
Impulse outputs (optional)	transistor outputs, galvanic isolation by optocoupler switching voltage max. 250V DC, switching current max. 100mA switching frequency max. 4Hz, $t_{ON} \geq 50ms$ / $t_{OFF} \geq 50ms$
Digital Input	On request
Fan control	temperature measurement on rear side of device programming of relay outputs for fan control possible
Interface (optional)	RS485 Modbus-RTU (slave)
Ambient temperature	operation: 0°C ... +70°C, storage: -20°C ... +85°C
Humidity	0% - 95%, without moisture condensation
Overvoltage class	II, pollution degree 3 (DIN VDE 0110, Teil 1 / IEC 60664-1)
Standards	DIN VDE 0110 Teil 1 (IEC 60664-1:1992) VDE 0411 Teil 1 (DIN EN 61010-1 / IEC 61010-1:2001) VDE 0843 Teil 20 (DIN EN 61326 / IEC 61326:1997 + A1:1998 + A2:2000)
Conformity and listing	CE, UL, cUL
Terminals	cage clamp, max. 2,5mm^2
Casing	front: instrument casing plastic (UL94-VO), rear: metal
Protection class	front: IP 54, rear: IP 20
Weight	ca. 0,65 kg
Dimensions	144 x 144 x 58mm (H x W x D), cutout $138^{+0,5}$ x $138^{+0,5}$ mm