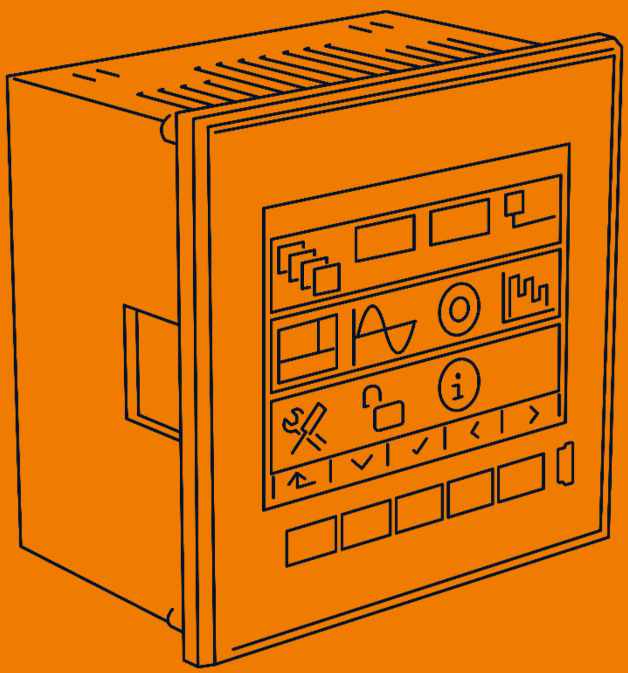
wöhner



MIEZ Poweranalyzer

ALLES MIT SPANNUNG

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Contents

1 General

Measurement and analysis

- Three voltage measurement inputs, star/delta/Arron circuit
- Three/four current measuring inputs for current transformers with rated current second outputs of 5/1 A or 0.1 A
- 10/12-period evaluation cycle (200 ms at 50/60 Hz)
- Continuous (uninterrupted) measurement of voltage and current
- Evaluation of harmonic components up to the 50th order
- Display of the mean values of all evaluated variables with registration of the minimum and maximum values in the fixed/sliding window
- Built-in energy meter:
  - Four-quadrant electricity meter for active and reactive energies at three tariffs
  - Single-phase and three-phase energy values
  - Maximum of the recorded average active power value (maximum demand)
- Built-in thermometer
- Fault current inputs

Communication

- USB 2.0 communication interface for fast data acquisition, configuration and firmware upgrades
- Remote communications interface (Ethernet)
- Proprietary protocol with free data acquisition software (Wöhner ServiceTool)
- MODBUS RTU/TCP protocols for easy integration with third-party SCADA software
- Integrated web server

Data logging functions

- Battery-buffered real-time clock (RTC)
- Recording interval from 0.2 seconds up to 1 hour
- High memory capacity for programmable recording of aggregated measured values
- Automated reading of energy meters at preselected time intervals

Inputs and outputs

- Digital outputs
- 0 – 20 mA_{DC} analog inputs
- Pt100 temperature sensor input

Design

- Plastic housing 96x96 mm for panel mounting
- TFT LCD colour graphic display, 5 keys

2 Installation

2.1 Meaning of the symbols used on the unit


Warning - Read operating instructions!

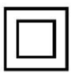

AC - Alternating Voltage


DC - Direct Voltage


The CE marking guarantees compliance with European directives and regulations.


The appliance must not be disposed of with normal unsorted municipal waste.


Basic insulation of the unit (protection class I)


Double or reinforced insulation of the unit (protection class II)

2.2 Physical arrangement

The unit is built into a plastic housing designed for installation in a distribution panel. Normally this panel is part of a control cabinet door - in this case the installation must be done in such a way that the control cabinet door can be closed under all operating conditions. In any case, it must be ensured that only the front panel of the unit is accessible to laypersons. Therefore, if the switchgear is located in an area accessible to non-professionals, the door or panel of the switchgear must only be openable with a tool, or the door must be locked.

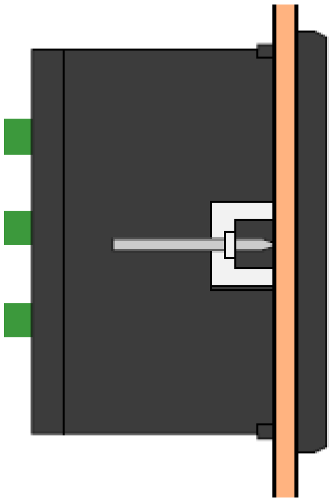


Figure 1: Panel mounting

The installation position of the unit must be secured with locks.
There should be sufficient natural air circulation in the distribution box and no other heat-generating appliances should be installed near the unit.

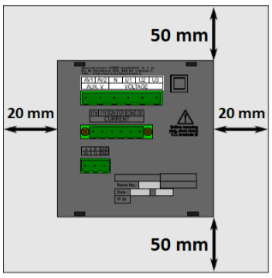


Figure 2: Spacing around the unit

In particular, no other instrumentation that gives off heat should be installed under the unit, otherwise an incorrect temperature value may be measured.

2.3 Connecting the device

2.3.1 Power supply

The supply voltage (in the range specified in the technical data) is connected to terminals **AV1** (no. 9) and **AV2** (no. 10) via a disconnecting device (switch - see circuit diagram). This must be close to the unit and easily accessible to the operator. The disconnecting device must be marked as such. A two-pole miniature circuit breaker with tripping characteristic C and a rated current of 1 A is suitable as a disconnecting device. However, its function and working positions must be clearly marked.
When operating on a DC supply voltage, the connection polarity is basically arbitrary; however, to achieve maximum electromagnetic compatibility, the earthed pole should be connected to terminal **AV2**.

Recommended line type:	H07V-U (CY)
Recommended minimum conductor cross-section:	1.5 mm^2
Maximum conductor cross-section:	2.5 mm^2

2.3.2 Measured voltages

The measured phase voltages are connected to the terminals U1 (12), U2 (13) and U3 (14); the common terminal to be connected to the neutral conductor is marked N (11; this is not used in the delta (3-D) and the Aron circuit (A)). It is advisable to fuse the voltage measurement lines with 1 A fuses, for example. The measured voltages can also be connected via instrument voltage transformers.

Recommended line type:	H07V-U (CY)
Recommended minimum conductor cross-section:	1.5 mm^2
Maximum conductor cross-section:	2.5 mm^2

2.3.3 Measured currents

The units are designed exclusively for indirect current measurement via external current transformers. The correct current signal polarity (terminals S1 and S2) must be observed. You can check the polarity using the phase effective powers on the meter display (of course only if the energy transfer direction is known).
The current transformer ratio must be set - see example below.
In the case of the Aron circuit (A), terminals I2 remain free.

2.3.3.1 Current-based current input meters (models "X/5A")

The current signals of encoder current transformers with 5 A or 1 A must be connected to terminal pairs I11, I12, I21, I22, I31, I32, I41, I42 (no. 1 - 8). Recommended line type:

H05V-U (CY)

Recommended minimum conductor cross-section:

- "X/5A" meters: 2.5 mm²

Maximum conductor cross-section: 2.5 mm²

2.3.4 Other inputs and outputs

Connecting fault current inputs, other inputs, outputs and communication connections is described in the relevant chapters below.

3 Commissioning

3.1 Setup

When the power is switched on, the unit briefly displays the manufacturer's logo. Then one of the actual data screens - for example, the one with the conductor-neutral voltages - is displayed:

At this time, the meter parameters that are required to perform proper measurements with the meter must be set up (called the installation group):

- Connection mode (direct measurement or measurement via measuring voltage transformer)
- Circuit type (star, delta, Aron)
- Current transformer and voltage transformer ratios and their multipliers (if used)
- Nominal voltage $\mathbf{U_{NOM}}$ and nominal frequency $\mathbf{f_{NOM}I_{NOM}}$, $\mathbf{P_{NOM}}$) (not mandatory, but recommended)

3.1.1 Installation setup for the electrical measured variables

For correct data evaluation, all group parameters of the installation setup must be set.

- **Connection mode** defines whether the voltage signals are connected directly or via voltage transformers.
- **Circuit type** must be set according to the network configuration - star (or **Y**) or delta (**D** if no zero-voltage potential is connected). Usually all three phases are connected. Therefore, select **3-Y** or **3-D**. Set 3-A for the Aron circuit. Set **1-Y** for a single-phase circuit.
- **Current transformers (CTN, CTRCM):** The current transformer ratios must be specified here, and for the "via VT" connection mode, the VT voltage transformer ratio must also be specified.
  The current transformer CT applies to the currents I1, I2 and I3. If the fourth current input or fault current inputs are used, the corresponding **CT_N/CT_{RCM}** transformer ratios must also be set.
  Current transformer ratios can be set in the form .../5 A or .../1 A.
  The voltage transformer ratio VT must be set in the form nominal primary voltage/ nominal secondary voltage. For higher primary voltage values, the U multiplier must also be used.
- **I** and **U multipliers** - you can change any current or voltage transformer ratio with these parameters. For example, to achieve higher accuracy when using overload current transformers, you can increase the number of turns of the measured conductor through the transformer. In this case you have to set the multiplier. For example, if 2 turns are used, set the multiplier to 1/2 = 0.5.
  For the standard connection with 1 turn, the multiplier must be set to 1.
  The **CT_N** and **CT_{RCM}** current transformer ratios have their additional **I_N** and **I_{RCM} multipliers**.
  Instead of the IRCM multiplier, the RCT type, 0/20 mA or 4/20 mA, can be set - see the chapter "RCM" below.
- **Nominal frequency f_{NOM}** - this parameter must be set to either 50 or 60 Hz in accordance with the nominal frequency of the measuring network and optionally to "DC-500" (= Fixscan mode).
- **Nominal voltage U_{NOM}, nominal current I_{NOM}, nominal power P_{NOM}** - For the display of quantities as a percentage of nominal value, alarm operation, detection of voltage events and other functions, it is necessary to also enter the (primary) nominal voltage **U_{NOM}**, nominal current **I_{NOM}** and three-phase nominal apparent power (input power) of the connected load **P_{NOM}** (in kVA). Although correct setup does not affect the

measuring operation of the unit, it is strongly recommended that at least the nominal voltage **U**NOM is set correctly.

The correct setting of **I**NOM and **P**NOM is not critical and only affects the percentage representation of powers and currents as well as the statistical processing of the measured values within the software. If the respective nominal value of the measured network node is not defined, it is recommended to set its values to, for example, the nominal power of the transformer of the power source or to the maximum power assumed according to the current transformer ratios, etc.

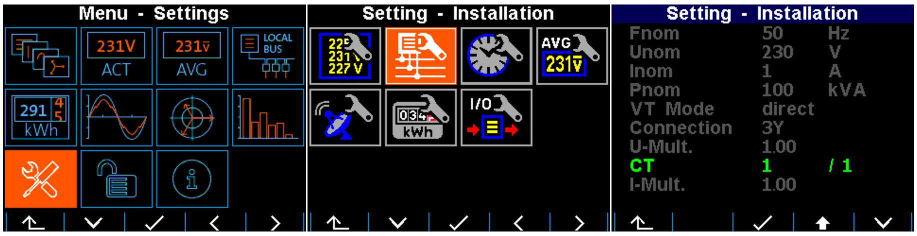
UNOM is displayed in the form of the phase or mains voltage.

3.1.1.1 Example of a setup

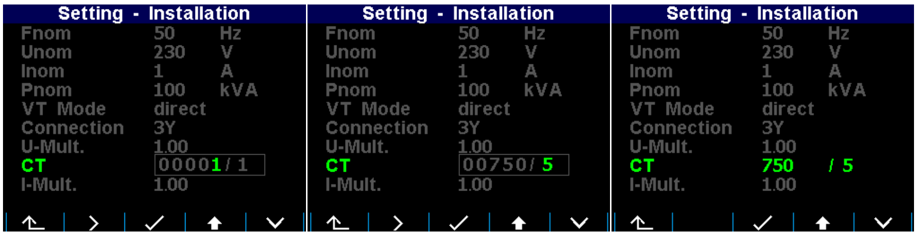
The following example explains how to set the current transformer ratio:

Assume that the transformer ratio of the current transformers used for inputs L1 to L3 is 750/5 A. To edit the parameters, press ▤ , navigate to the **settings** with the > and < buttons and select the parameter with ✓ . From the **Setting** screen, select **Measurement**. The **Measurement** screen appears.

In this screen, navigate down to the Current Transformer Ratio (CT) parameter and select it with ✓ .



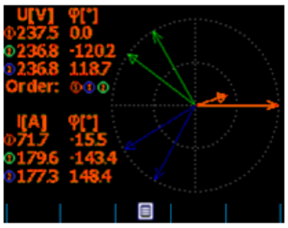
Now you can enter the new parameter value: Use the button > to move from one digit to another and set each digit to its target value using the ↑ and ∨ buttons. Press the button ✓ to finish. The parameter is now set. You can set other parameters in the same way.



When all parameters of the group are set correctly, return to a live data screen by pressing ↰ (Escape) and confirm saving the changes by pressing ✓ .

Now you can use the ↑ and ∨ buttons to navigate through the displayed actual values and check whether they correspond to reality.

! **For a proper check of the current transformer connections, you can use the phasor diagram screen.**



After checking the measured quantities, other parameters (for the real-time clock, for averaging, for remote communication, etc.) can be set.

4 Detailed description

4.1 Basic functions

The meters evaluate all common electrical quantities such as line voltages, phase voltages, currents, active, reactive and apparent powers, power factors, voltage and current total distortion factors, harmonics, active and reactive energy, average maximum powers, frequency, etc. In addition, a built-in sensor measures the temperature. With these meters, the second temperature can be measured with an external Pt100 sensor.
The meters are equipped with inputs for connecting three voltage signals, four current signals (for connecting external current transformers with a nominal secondary signal of 5/1 AAC) and a separate input for an AC/DC power supply. These can be used in both low and high voltage networks.
The meters have a four-quadrant electricity meter for three different tariffs for active and reactive energies and for recording the maximum average power (maximum demand). Models with advanced features can store all results for the current and last month, and a separate archive specifically for automated meter readings records the current status at preset intervals.
The meter can also be used for residual current monitoring.
The meters are equipped with a battery-backed Real-Time Clock (RTC) and a high-capacity "flash" memory for recording measured data and events.
The USB 2.0 type communication link can be used for setting the meter and transferring recorded data. Ethernet communication interfaces are available for remote access. The unit also has an integrated web server.
Basic specifications of the meter can be set via the integrated keypad and display. With the Wöhner ServiceTool, which is included as standard, you can set the meter and transfer recorded data via any available communication link. In addition to setting the measuring device, the Wöhner ServiceTool allows you to display, view and archive measured curves in the form of graphs and also offers many other functions.

4.2 Use and setup

4.2.1 Data area – Status bar – Tool bar

The screen of the meter consists of two parts: a data area and an area for the status bar or tool bar.

After switching on the meter, the status bar appears below the data area according to the default settings. The status bar contains the following information:

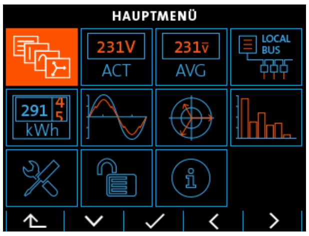
-  Warning displays A1 and A2. The two symbols next to the bell symbol indicate the current status of the warning displays; the first symbol - A1 - is switched on in this example, while A2 is just switched off. This information only appears if either the A1 or A2 alarm output function is set in the I/O management settings (see below).
-  digital I/O state. The meter in the example is equipped with four bidirectional inputs (DI)/outputs (DO), with either input DI3 or output DO3 active in each case.
- 

Local time (hours: minutes)

When one of the buttons is pressed, the status bar is replaced by the toolbar. The toolbar determines the function of the respective buttons and changes dynamically depending on the context. If no entries are made via the buttons for a longer period of time, the toolbar is replaced by the status bar.
In special cases, a flashing warnimng symbol may appear in the upper right corner of the data area, indicating one of the following cases:

-  Frequency measurement not yet completed or out of range. In these cases, the signals are acquired using the preset nominal frequency $\mathbf{f_{NOM}}$ and the measured values may be erroneous. Check the parameter setting for $\mathbf{f_{NOM}}$.
-  At least one of the voltage or current inputs is overloaded.

4.2.2 Main menu



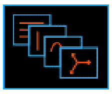
By pressing the ▇▤▇ button, the Main Menu screen appears. Use the ▇>▇ and ▇<▇ buttons to navigate through the menu and either select a desired action with the ▇✓▇ button or return to the previous menu via ▇⬑▇ (Escape).

All other buttons - other than ▇▤▇ - are contextual and variable.

Note that the button ▇▤▇ is accessible from almost any screen, which is helpful for quick orientation.

In the next chapters, individual options of the main menu are described.

4.2.3 Main data group



This screen data group can be configured by the user. You can select the data screens that interest you most and place them in this group for quick access. To setup his function, use the programme ServiceTool -DAQ.

4.2.4 Actual value and mean value data groups

Actual and average values of the measured data are displayed in numerical form in each group. A detailed description of the display of the actual values can be found in the following chapter *Display of the evaluation and averaging of actual values*.

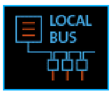
All values are provided with a designation of the measurand and a unit of measurement.

An exception is the U/I/P/Q Summary screen - no unit of measurement is shown here, only a multiplier **k/M/G**.

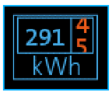
The last line contains the actual values of the voltage unbalance **u2** [%] and the frequency **f** [Hz].

The second exception is the I/O actual data screen. A detailed description can be found in the chapter *Representation of the I/O actual data*.

4.2.5 Local bus



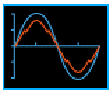
4.2.6 Energy meter



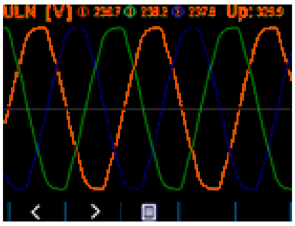
In this data group you can check the active and reactive energies recorded in all quadrants. Next, the maximum values of the average three-phase active power appear, including their time stamps - so-called maximum demands. For details, see the chapter Integrated Energy Meter.

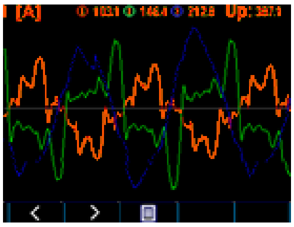
In addition, there is the actual state table of the pulse counters. A detailed description can be found in the chapter *Representation of the I/O actual data*

4.2.7 Oscillograms



This group contains the actual waveforms of all measured voltages and currents. Use the buttons and to switch between the voltage and current screens. Also displayed are the rms values of the voltages/currents and the maximum of their peak values Up and Ap, respectively.





4.2.8 Phasor diagram

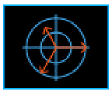
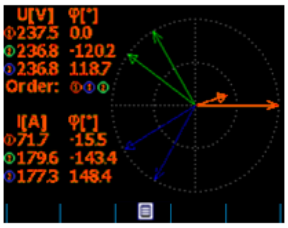
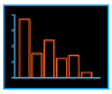


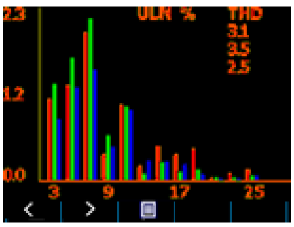
Diagram with fundamental-frequency phasors for voltage and current.
The voltage phasor angles φ are absolute values, the current phasor angles are shown relative to the corresponding voltage phasor (Δφ).
The phase sequence can also be checked here (representation as 1-2-3 or 1-3-2).

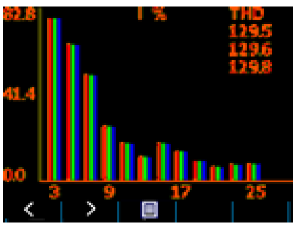


4.2.8 Harmonics and total distortion factors



Histogram of the actual harmonics of voltage and current signals, expressed as percentage of the fundamental component.
Only the odd-numbered components from 3rd to 25th are displayed; to see the full harmonic spectrum, use the programme ServiceTool -DAQ.
In the upper right corner, the values of the total distortion factors of the individual phases are shown.



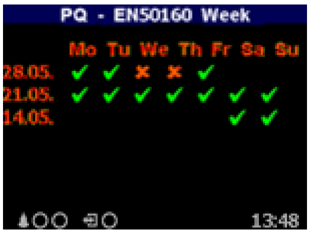


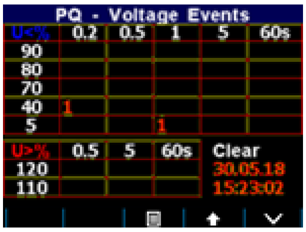
4.2.9 Power quality and voltage events

This data group is only available if the corresponding firmware module is activated.

The first screen shows a "calendar" of the power quality evaluation according to the EN 50160 standard. Each day is marked either with ✓ or ✗ , depending on whether the power quality during the day complied with the standard or not.

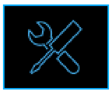
Next is the Voltage Events (VE) table. The events are sorted according to the size and duration of the individual voltage dips, swells and interruptions. In the table you can query the number of individual events that have been registered since the last deletion. You can delete the CE table in the PQ setup screen.





Detailed information on the evaluation of the power quality (PQ evaluation) and the voltage events can be analysed after downloading into the ServiceTool programme.

4.2.11 Device setup (parameters)



In this group, most of the presettable parameters can be viewed and edited. Other parameters can only be accessed via the communication link with the ServiceTool - DAQ programme.

When one of the setting windows is opened, a meter automatically switches back to the current data display if no key is pressed for approx. 1 minute.

The following chapters explain the meaning of certain parameter groups.

4.2.11.1 Display setup

- **Contrast** Adjustable in the range 0 – 100 %
- **Brightness** The set brightness level is activated as soon as a key is pressed. If no key is pressed for approx. 5 minutes, the brightness is automatically reduced to lower the power dissipation of the meter and extend the life of the display.
- **Language** In addition to the German original version, other language versions can also be selected.
- **Display update cycle** Current values of the update period. For details, see the chapter *Displaying the evaluation and aggregation of actual values*.
- **Display resolution** The format of the current and average data groups can be set to 3 or 4 significant digits.

4.2.11.2 Installation setup

All parameters of this group are explained in the chapter *Installation setup for the electrical measured variables* above in the section "Commissioning".

4.2.11.3 Remote communication setup

The communication parameters for different interface types differ from each other:

Ethernet interface:

- **DHCP** Activation of dynamic IP address assignment
- **IP address** Internet Protocol address
- **Subnet mask** Subnet mask
- **Standard Gateway** Standard Gateway
- **Port** Communication interface for communication with the KMB protocol (default: 2101)
- **Web port** Communication interface for communication with the web server (80)
- **Modbus port** Communication interface for communication with the Modbus protocol (502)

For more information, see the chapter *Computer-controlled operation* below.

4.2.11.4 Setting the time

- **Date** and **time** Local date and time
- **Time zone** The time zone should be set during installation according to the location of the meter. A correct setting is essential for the correct interpretation of the local time.
- **Daylight saving time changeover** This option controls the automatic changeover of the local time between winter and summer time
- **Time synchronisation** Since the built-in real time clock (RTC) has limited accuracy in independent operation, the RTC time can be kept synchronised with an external precision time reference by this option. The RTC can be synchronised by:
  - **Pulses per second/minute (PPS/PPM)** In this case, a digital input is used for time synchronisation with an external source. The meter sets the RTC to the next second or minute as soon as a synchronisation pulse is detected. Accepted are seconds, minutes, quarter-hour or hourly synchronisation pulses.
  - **NMEA message** If a meter is equipped with the RS-485 remote communication interface, an external (usually GPS-based) time signal receiver can be connected. The receiver must be set to send the "ZDA" or

"RMC" message (NMEA 0183 protocol). The communication interface must be set accordingly (usually 4800 Bd, 8 bits, 1 stop bit).

- **NTP Server** This option can be used when a meter is equipped with an Ethernet communication link and an NTP server is available on the network.
- **Mains frequency** For this option, the nominal frequency parameter $\mathbf{f_{NOM}}$ must be set correctly. Otherwise, the synchronisation will not work.

! **When editing parameters for the clock, it must be considered that this also affects internal data archives: When changing date or time, <u>all archives are deleted</u>!**

4.2.11.5 Mean value processing setup

In this parameter group, the mean value processing for the measured variables of the **U/I**, the **P/Q/S** and - - of the **RCM** group can be set. A detailed explanation can be found below in the chapter *Mean value evaluation*.

4.2.11.6 Built-in energy meter setup

In this group, the parameters regarding the acquisition of electrical energy data and the processing of the maximum active power demand (MD) can be set. A detailed parameter description can be found below in the chapter *Integrated energy meter*.

4.2.11.7 Mains quality and input/output setup

Only overviews of parameters are available. Use the ServiceTool -DAQ programme to edit them.

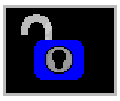
You can only delete the voltage event table in the group Power Quality Setup.

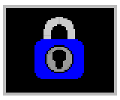
4.2.12 Device lock

The meter can be locked to protect against unauthorised changes or access. You can lock the unit in two ways:

- Directly from the control panel
- Via communication with the ServiceTool -DAQ programme using the so-called *user management facility* (see below).

The current lock status is indicated in the main menu by its associated symbol:





- **Unlocked** Any person with physical access to the control panel can set and configure all parameters in the unit, delete archives and other persistent data or reset counters without restriction.
- **Locked** A password (PIN) is required before a configuration change can be requested.

! **<u>Exception:</u> You can change the group parameters of the display setting even when the meter is locked! These are the only parameters that can be changed at any time.**

4.2.12.1 Locking from the control panel

To lock the meter, simply switch the lock from to in the **Menu Lock** window. Then exit the window with the button and confirm the saving the changed state.

4.2.12.2 Unlocking from the control panel

To unlock the meter, switch the status "Locked" from to by entering a PIN in **Menu → Lock**.

If the meter has been locked from the control panel, the value of this PIN is fixed and corresponds to the last four digits of the meter's serial number. This serial number can be found in the device screen under **Menu → Info → Serial number**.

If the meter has been locked via the user administration, you need the PIN set in the administration (see below).

Then exit the **Lock** window with the key and confirm the saving the changed state.

! **Note that unlocking the Locked state via user administration from the control panel is only <u>temporarily</u> effective and the meter automatically switches back to the locked state approx. 15 minutes after the last key was pressed. To unlock the meter permanently, use the user administration.**

4.2.12.3 Locking/unlocking via user administration

User management allows you to use more complex and sophisticated functions to control the meter not only via the control panel but also via all communication interfaces.

By selecting **Menu → Locks**, you can check whether the lock is used by user administration – and if so, at least one additional parameter *User* is displayed.

In this case, the PIN described in the previous chapter is not applicable and the PIN defined in the user administration is required for unlocking. In addition, further users can be defined with their private PINs.

So, if you want to change something from the control panel, you have to:

1. select the user (in our example Peter) and
2. enter the PIN corresponding to that user registered in the user management facility.

For details, see Application Note No. 004: *Users, Passwords and PINs*.

! **If the PIN is lost, request an alternative PIN from the manufacturer via the manufacturer's website www.woehner.de.**

4.2.13 Device information

- **Model and serial number** Hardware model and serial number of the device
- **Version of device hardware, firmware** and **bootloader** Specification of the device hardware and firmware.
- **Object number** Specification of the network node to be measured (preset by the programme ServiceTool-DAQ for data recognition).
- **Vbatt** Voltage of backup battery (if installed)
- **Error code** Indicates any problem with the hardware or setup of the device. In the normal state, 0 is displayed. If an error is detected, a number appears here that is formed as the sum of the binary weights of the errors. The following table shows an overview of the errors and the recommended actions:

Table 1 Device errors

Error no. (weighting)	Error	Action
1	RAM memory error	Set the unit (preferably with the ServiceTool if possible) to the default setting; if the error reoccurs, send the unit to a service centre for repair.
2	Device setup error	Set the unit (preferably with the ServiceTool if possible) to the default setting; if the error occurs again, send the unit to a service centre for repair.
4	Calibration error	The unit needs to be recalibrated - send it to a service centre.
8	Error in the radio communication module (Wifi/Zigbee)	Send the unit to a service centre.
16	RTC error	Set the current values for the date and time in the Time Setting window (or better with the ServiceTool, if possible); if the error occurs again, check the built-in backup battery; otherwise send the unit to a service centre.
128	Archive data error	Delete all archives with the ServiceTool; if the error occurs again, send the unit to a service centre for repair.
256	Flash memory error	Send the unit to a service centre.

4.3 Functional description

4.3.1 Measurement method

The measurement consists of three processes that are carried out continuously and simultaneously: Frequency measurement, sampling of voltage and current signals and evaluation of the quantities from the sampled signals.

4.3.1.1 Method for measuring the voltage fundamental frequency

The voltage fundamental frequency is measured at the voltage signal U1. It is continuously measured and evaluated every 10 seconds.

The fundamental frequency output is the ratio of the number of integral mains cycles counted during the 10-second time interval divided by the total duration of the integral cycles.

If the frequency value is outside the measuring range, this condition is signalled by a flashing display F in the upper right corner of the current data window.

4.3.1.2 Voltage and current measurement methods

Both the voltage and current signals are continuously evaluated in accordance with the IEC 61000-4-30 standard, edition 2. The uniform evaluation interval, a measuring cycle, is a ten or twelve (the latter value applies for f_{NOM} = 60 Hz) mains cycles long period (i.e. 200 ms at a frequency equal to the preset f_{NOM}), which is used as the basis for all other calculations.

The sampling of all voltage and current signals together is done with a frequency of 128/96 samples per mains cycle. The sampling rate is adjusted according to the frequency measured at one of the voltage inputs **U1**, **U2** and **U3**. If the measured frequency at at least one of these inputs is in the measurable range, this value is used for the subsequent signal sampling. If the measured frequency is outside this range, the preset value (f_{NOM}) is used and the measured values may not be correct.

If the measuring range for a voltage or current is exceeded, the unit signals this by displaying the symbol > in the upper right corner of the current data window.

RMS values of voltages and currents are calculated from the sampled signals from the measurement cycle using the formulae below (examples for phase no. 1):

Phase voltage (r.m.s. value): $U|1 = \sqrt{\frac{1}{n}\sum_{i=1}^{n} \quad U1i^2}$

Mains voltage (r.m.s. value): $U|12 = \sqrt{\frac{1}{n}\sum_{i=1}^{n} \quad (U1i - U2i)^2}$

Current (r.m.s. value): $I1 = \sqrt{\frac{1}{n}\sum_{i=1}^{n} \quad I1i^2}$

where:	i	sample index
	N	number of samples per measuring cycle (1280/1152)

Ui1, Ii1 sampled voltage and current values

Sum of the phase currents: $\sum|I = I_1 + I_2 + I_3$

The data for the longer measurements is aggregated from these measurement cycles. The long-term interval starts after the RTC tick occurs at the beginning of the next measuring cycle time interval. This principle makes it possible to configure other intervals of up to 2 hours in length for data recording.

The measured phase voltages U1 to U3 correspond to the potential between the terminals VOLTAGE/U1 to U3 and the terminal VOLTAGE/N.

! **The impedance of the voltage inputs is in the order of MΩ. If no signal is present (e.g. if a protective fuse has blown), a parasitic voltage of several tens of volts can build up at the measuring voltage inputs due to the parasitic impedance of the mains input. In such a case, the unit may display voltages that differ from zero!**

Three current signals - I_1, I_2 and I_3- are measured at the star connection (Y, 3Y). Another current is measured from samples of directly measured values as the negative vector sum of the current vectors I_1, I_2 and I_3 (Kirchhoff's rule). The calculated current is referred to as $\mathbf{I_{NC}}$.

If a device is equipped with four current inputs, the fourth current I_4 is also measured. Then another current, called $\mathbf{I_{PEC}}$, is calculated as the negative vector sum of the current vectors I_1, I_2, I_3 und I_4.

On the Aron circuit (3A), the current I_2 is not measured, but calculated as the negative vector sum of the current vectors I_1 and I_3.

4.3.1.3 Evaluation methods for harmonics and total distortion factor

The entire spectrum of the harmonic components and the total distortion factor are evaluated discontinuously - periodically every second of a 10 or 12 mains cycles long signal according to IEC 61000-4-7 edition 2 as harmonic subgroups (H_{sg}).

The following quantities are evaluated:

Harmonic components of voltage and current up to the 50th order: Uih_1, Iih_1

(i .... order of the harmonic component)

Absolute angle of the voltage phasor of the harmonic component: φUih_1

Angle of the harmonic current phasor relative to phasor Ufh1: φIih_1

Relative angle between the corresponding voltage and current phasors: $\Delta\varphi i_1$

Total voltage distortion factor: $THD_{U1} = \frac{1}{U1h1}\sqrt{\sum_{i=2}^{40} \quad Uih1^2} * 100\%$

Total current distortion factor: $THD_{I1} = \frac{1}{I1h_1}\sqrt{\sum_{i=2}^{40} \quad Iih_1^2} * 100\%$

4.3.1.4 Evaluation procedure for power, power factor and unbalance

The power and power factor values are calculated continuously from the sampled signals according to the formulas below. The formulas apply to the basic circuit type Y (star).

Active power: $P_1 = \sum_{k=1}^{40} \quad U_{k,1}{}^{*}I_{k,1}{}^{*}cos\Delta\varphi_{k,1}$

Reactive power: $Q_1 = \sum_{k=1}^{40} \quad U_{k,1}{}^{*}I_{k,1}{}^{*}sin\Delta\varphi_{k,1}$

where

k harmonic order, only odd components

$U_{k,1}$, $I_{k,1}$ the kth harmonic components of voltage and current (phase 1)

$\Delta\varphi_{k,1}$ angle between the k-th harmonic components Uk,1, Ik,1 (phase 1)

(these harmonic components of U and I are evaluated from each measuring cycle).

Apparent power: $S_1 = U_1 * I_1$

Distortion power: $D_1 = \sqrt{S_1^2 - P_1^2 - Q_1^2}$

Power factor: $PF_1 = \frac{|P_1|}{S_1}$

Three-phase active power: $\sum P = P_1 + P_2 + P_3$

Three-phase reactive power: $\sum Q = Q_1 + Q_2 + Q_3$

Three-phase apparent power: $\sum S = S_1 + S_2 + S_3$

Three-phase distortion power: $3D = \sqrt{3S^2 - 3P^2 - 3Q^2}$

Three-phase power factor: $\sum PF = \frac{|\sum P|}{\sum S}$

Magnitudes of the fundamental component:

Power factor of the fundamental: $cos\Delta\varphi_1$ (or $\tan\Delta\varphi_1$, $\Delta\varphi_1$)

Fundamental active power: $Pfh_1 = Ufh_1 * Ifh_1 * cos\Delta\varphi_1$

Fundamental reactive power: $Qfh_1 = Ufh_1 * Ifh_1 * sin\Delta\varphi_1$

Fundamental three-phase active power: $\sum Pfh = Pfh_1 + Pfh_2 + Pfh_3$

Fundamental three-phase reactive power: $\sum Qfh = Qfh_1 + Qfh_2 + Qfh_3$

Fundamental three-phase power factor: $\sum cos\Delta\varphi = cos(arctg(\frac{\sum Qfh}{\sum Pfh}))$

Power and power factors of the fundamental component (cos φ) are evaluated in 4 quadrants according to the standard IEC 62053 - 23, Annex C:

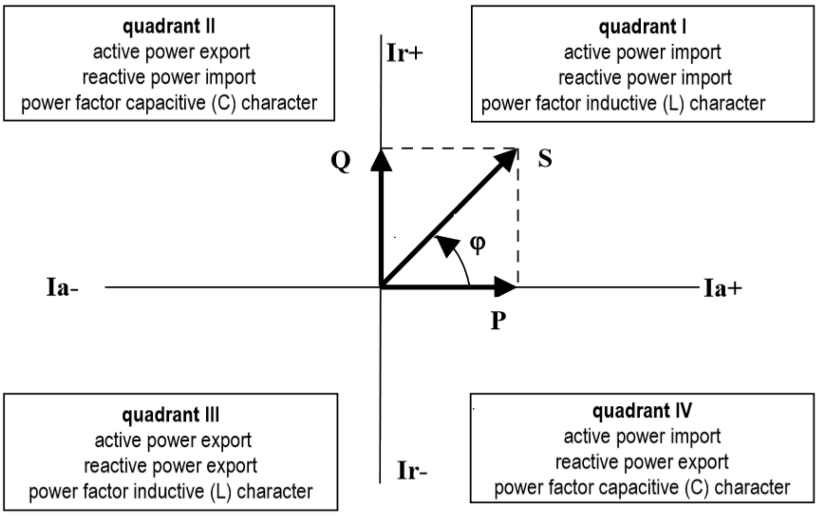


Figure 4: Detection of current consumption or current feed-in and property of the reactive power according to the phase difference:

To specify the quadrant unambiguously, the power factor of the fundamental component - cos φ - is given two flags, as expressed in the graph:

- *A sign* (**+** or **–**) indicating the polarity of the active power and
- *a letter* (**L** or **C**) indicating the power factor property (the polarity of the reactive power relative to the active power)

The evaluation of the voltage and current unbalance is based on the negative/positive sequences of the voltage and current fundamental components:

Voltage unbalance: $$unb_U = \frac{voltagenegativesequence}{voltagepositivesequence} * 100\%$$

Current unbalance: $$unb_I = \frac{currentnegativesequence}{currentpositivesequence} * 100\%$$

Angle of the current with negative sequence: φnsI

All angle values are expressed in degrees, in the value range [-180.0 to +179.9].

4.3.1.5 Temperature

Both the indoor temperature ***Ti*** and the outdoor temperature ***Te*** are measured and updated approx. every 10 seconds.

4.3.1.6 The "Fixscan" mode

The meter is primarily designed for measurements in distribution networks with a nominal frequency of 50 or 60 Hz. The sampling, processing and aggregation of a measurement signal when setting the parameter f_{NOM} to one of these two values is described above and complies with the standards specified in technical parameters.

However, there are other applications, for example:

- Networks with f_{NOM} = 400 Hz

- Networks with variable frequency, e.g. at the output of frequency converters

The Fixscan mode is used for measuring in these networks.

4.3.1.6.1 Function

The Fixscan mode is activated by setting the parameter f_{NOM} to "DC-500". The device then works as follows:

- The U and I signals are sampled with the fixed sampling frequency of 6400 Hz.
- The measured quantity is evaluated with a fixed interval every 200 ms.
- The DC component of the voltage is also evaluated (the DC component of the current is not measured).
- The selection of measured quantities is limited according to the following table; other variables such as harmonic components, total distortion factors or unbalances are not measured in this mode.
- The measurement uncertainties are defined by a separate table (see technical parameters).

The frequency of the measurement signal can be in the range of 0 - 500 Hz.

! **Because of the fixed evaluation window (200 ms), a systematic error can occur in the form of an incomplete number of evaluated waves, especially with low-frequency signals!**

The temperature and analogue inputs are measured as in the standard mode. Similarly, the energy is calculated in a standard way by integrating the corresponding power.

Table 2 Overview of the quantities measured in the *Fixscan mode*

Symbol	Quantity	Evaluation method
f	Frequency of the voltage	Digital filtering of the voltage signal + zero-crossing-based period duration measurement
U1	Phase-to-neutral AC voltage (RMS value)	$U1 = \sqrt{\frac{1}{1280} \sum_{i=1}^{1280} Ui1^2}$
Udc1	Phase-to-neutral DC voltage (DC component of the signal)	$Udc1 = \frac{1}{1280} \sum_{i=1}^{1280} Ui1$
U12	Line voltage (RMS value)	$U12 = \sqrt{\frac{1}{1280} \sum_{i=1}^{1280} (Ui1 - Ui2)^2}$
I1	Alternating current (RMS value)	$I1 = \sqrt{\frac{1}{1280} \sum_{i=1}^{1280} Ii1^2}$
P1	Active power	$P1 = \frac{1}{1280} \sum_{i=1}^{1280} Ui1 * Ii1$
Q1	Reactive power	$Q1 = \sqrt{S1^2 - P1^2}$
S1	Apparent power	$S1 = U1 * I1$
PF1	Power factor	$PF1 = \frac{\lvert P1 \rvert}{S1}$

4.3.2 Measurement evaluation and aggregation

As described above, the measured values are evaluated according to IEC 61000-4-30 edition 2 by processing continuous (gapless) and 10 or 12 mains cycles long intervals (measuring cycles).

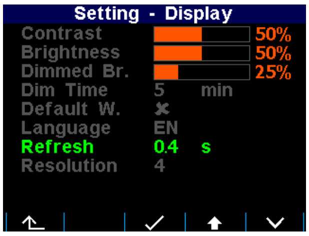
Values for display and recording are derived from a further aggregation of the actual values from this evaluation.

4.3.2.1 Actual value-evaluation and -aggregation

The actual values (instantaneous values) of measured quantities that can be read on the meter's display are evaluated as the mean value of the integral number of measuring cycle values per display update cycle.

The display update cycle can be preset in the range of 2 - 20 measuring cycles, which corresponds to an update cycle duration of approximately 0.4 - 4 seconds.

The maximum (marked as ↑) and minimum (↓) of the measurement cycle values registered during the display update cycle interval are also displayed.



Exceptions:

- Frequency - the value is updated at each frequency measurement cycle (see above)
- Harmonic components, total distortion factor and unbalance - the last measuring cycle values are displayed here (without averaging).
- Temperature - the value is updated with each temperature measurement cycle (see above)

Actual values read from a measuring device via a communication link for monitoring purposes are only evaluated from one - the last - measuring cycle.

! **Due to the special nature of the quantity, neither the maximum nor the minimum of cosφ are evaluated. Similarly, because of a special measurement procedure, these extreme values are not evaluated for the values for frequency, harmonics, total distortion factors and temperature.**

4.3.2.2 Mean value evaluation

Mean values of all basic variables are calculated from the measuring cycle values. The following parameters can be set to control the type of averaging:

- For averaging, one of the following options can be selected:
  - Fixed window
  - Moving window
- Averaging period in the range of 0.2 seconds to 1 hour

If **Fixed Window** is set as the averaging method, the values are calculated from fixed block intervals. The values are updated at the end of each interval. The start times of the intervals are synchronised to the next whole time (for example, if the averaging period is set to 15 minutes, the averages are updated four times per hour at the times xx:00, xx:15, xx:30 and xx:45).

If moving window is set, the exponential moving average is evaluated.

The mean value processing can be set independently for so-called **U/I** group, **P/Q/S** group and optionally **RCM** group sizes. The following table lists the processed sizes of all groups.

Table 3 Mean value groups

Mean value group	Averaged quantities
"U/I"	U_{LL}, U_{LN}, I, f, T
"P/Q/S"	P, Q, S, PF, Pfh, Qfh, cosφ
"RCM"	IΔ (Fault currents)

! **After setting the averaging parameters, the evaluation of the mean values starts again. Until the first averaging window has expired, the averages are temporarily unavailable.**

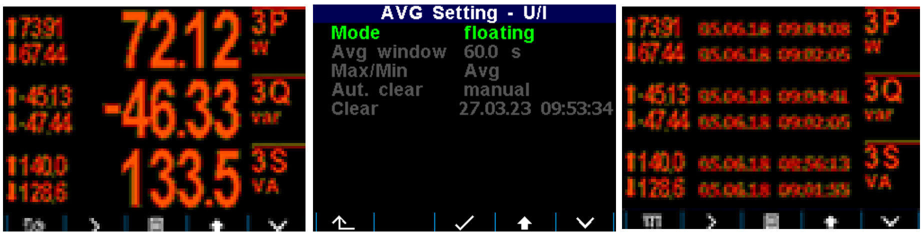
! **The aforementioned preset averaging parameters apply to so-called standard averages. A separate parameter is used for the maximum power demand MD in the electricity meter group (see below).**

4.3.2.2.1 Maximum and minimum mean values

The maximum and minimum mean values are stored in the meter's memory along with the date and time of their occurrence.

The maximum and minimum values are displayed on the left side of the mean value window, with the maximum value marked with the symbol ↑ and the minimum value marked with the symbol ↓.

To view their timestamps, press the button .



The registered maximum and minimum values can be deleted manually or automatic deletion can be set.

To delete the values manually, navigate to the appropriate averaging group setup screen and select Delete. The date of the last deletion can also be queried in this screen.

To activate the automatic deletion of maximum/maximum values, set the time period for automatic deletion.

! **Only the respective group (U/I, P/Q/S or RCM) of the maximum or minimum mean values is affected by the individual deletion process! Each group must be deleted or set individually.**

! **After deleting registered maximum or minimum mean values, the evaluation of the respective mean values starts anew. Afterwards, both the mean values and their registered maximum or minimum mean values are temporarily unavailable until the new averaging window has expired.**

4.3.2.3 Aggregation of recorded values

All measured and evaluated data can optionally be archived in the meter's memory. The recording period can be preset over a wide range and aggregated data is archived.
The shortest aggregation interval is 0.2 s, the longest configurable interval is 2 hours. If an aggregation interval of less than 1 minute is selected, the evaluation is aggregated according to the number of cycles at the actual frequency. For intervals longer than one minute, aggregation is performed according to a tick of the real-time clock.
If necessary, not only the mean value but also the minimum and maximum values can be stored over the aggregation interval.

4.3.3 Built-in energy meter

For measurements of electrical energy, an independent unit - the electricity meter - is implemented in the measuring devices. The energy quantities are evaluated in accordance with the IEC 62053-24 standard: Active energy from the entire harmonic spectrum and reactive energy only from the fundamental component.
In addition to the electrical energy, the maximum active power demand values are recorded in the unit.

4.3.3.1 Processing of the electrical energy values

The measured values of electrical energy are recorded separately in four quadrants: consumed active energy (**EP**) (**+**, import), supplied active energy (-, export), reactive energy (**EQ**) inductive (**L**) and reactive energy capacitive (**C**). Both single-phase and three-phase energies are processed.
Furthermore, three-phase energies are evaluated in three predefined tariff zones (time of use). The current tariff can be controlled either by a current RTC time based on a preset tariff zone table with a resolution of one hour or by an external signal via a digital input.
The storage capacity of the internal energy meters is so large that no memory overflow can occur during the entire service life of the meter. 9 digits can be displayed on the meter display. Therefore, after exceeding an energy value of 999999999 kWh/kvarh, the display format automatically switches to MWh/Mvarh and then to GWh/Gvarh.
The electricity meter data can be archived periodically with a preset registration interval in the unit's memory and analysed later after downloading to a PC.

4.3.3.1.1 Standard display of the energy values

The energy data of the energy meter is in a separate group of screens that can be accessed from the main menu.

By default, the so-called **2Q branch** is displayed (in the overview on the left). The 1st screen shows the current three-phase energy values registered for all tariff zones since the last reset until now (**ΣT**):

- **3EP+** imported active energy
- **3EP** exported active energy
- **3EQL** imported reactive energy (inductive**, L**)
- **3EQC** exported reactive energy (capacitive, **C**)

By scrolling down, the energy values of individual phases can also be queried.

Navigating to the right takes you to the **4Q/T** branch. This plot shows individual reactive energy values registered during the import and export of active power, which can be particularly useful for monitoring renewable energy sources. Example:

- **3EQL+** registered when the three-phase active power 3P is positive (+ = import)
- **3EQL-** registered when the three-phase active power 3P is negative (- = export)

By scrolling down, you can check these energies registered in the individual tariff zones **T1**, **T2** and **T3**.

Finally, in the right branch **4Q/**L you can scroll through the energies of the individual phases **L1, L2** and **L3** (for all three tariff zones).

The tariff zones can be set via a communication link with the ServiceTool -DAQ programme.

The energy meters can be deleted either manually or from a remote PC. Manual deletion can be accessed via the **Delete** option in the electricity meter setup screen. There you can also check the time and date of the previous reset.

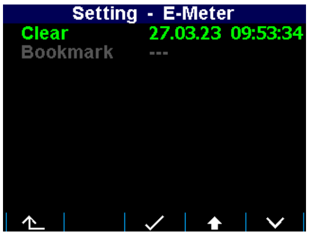
4.3.3.1.2 Customisable energy screen

The ServiceTool -DAQ programme allows you to add a special user-configurable energy meter screen to the main data group. In this screen you can not only select energies that interest you, but also a processing period.

For the processing period, you can choose from the following options:

- **Current** Energies registered since the last reset
- **This month/week** Energies registered during the current month/week
- **Last month/last week** Energies registered during the last month/last week
- **User def.** Energies registered since a defined date and time (= bookmarks)

For example, if you are interested in the imported three-phase active energy registered since 11 am on 5 June 2018, create such a custom screen in the ServiceTool -DAQ programme, select the evaluation period to be used as a bookmark and set its date and time. The desired screen then appears in the main data group.



!

When you set the processing period, note that the energies evaluated in this screen are calculated using values stored in the electricity meter archive. If such a data set is not stored in the archive, the evaluated energies may be incorrect. To obtain correct values, the registration of the electricity meter archive must be set accordingly and the archive must be filled with sufficient data depth. Care must be taken whenever deleting the electricity meter archive!

4.3.3.1.3 Aggregation of recorded energy values

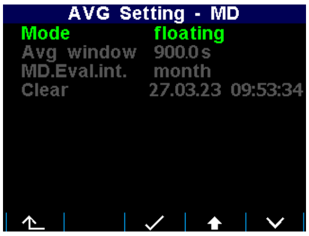
All electricity meter readings can optionally be archived in a separate archive. Use the ServiceTool -DAQ programme to set up the electricity meter archive.

With the recording duration, you can set how often the electricity meter reading is stored in the memory. The minimum recording time is 1 minute. The electricity meter history can later be downloaded to a PC and analysed.

The current tariff can be controlled either by the current local time using the tariff zone table or via a digital input. When the table is selected, a daily schedule can be set for 3 different tariff selections with hourly resolution.
When the digital input is selected, the selected digital input indicates the current tariff. Here, the open state means tariff 1 and the closed state means tariff 2. Tariff 3 is not used in this case.

4.3.3.2 Processing of the maximum demand

From the momentary measured values of all active powers, the measuring device determines their average values per preset time period with the help of a preset procedure for averaging. These quantities are referred to as actual demand values (AD). It should be noted that the actual demand values are processed individually and their averaging method and period can be preset to standard average values ($\mathbf{P_{AVG}}$) independently of each other. Their maximum values, which they have reached since the last reset or during the MD evaluation interval, are called maximum demand values (**MD**).



Parameters that determine the processing of the maximum demand values can be set in the **Setting - AVG - MD** screen. By default, the centre method is set to Floating Window.
The demand registered since the last reset is simply marked as MD. The demand values registered during the MD evaluation interval are marked with the corresponding additional index X - see below.
The MD evaluation interval can be set in the range from 1 day to 1 year.
The maximum demand values are stored together with their time stamps. They can be deleted independently of the maximum and minimum standard mean values. The time and date of the last reset can be queried in the MD setting screen.

! **After setting the MD averaging parameters or deleting the registered MD values, the evaluation of the demand values starts again. Until the first averaging window has expired, the demand values are temporarily unavailable.**

4.3.3.2.1 MD processing, last demand and estimated demand in the window

When the maximum demand averaging mode is set to Fixed Window, the **AD** evaluation differs from that with the floating window. The auxiliary-energy buffer is cleared at the beginning of each averaging window and starts counting from zero. The average power, which is calculated from the energy registered in the buffer divided by the length of the averaging window, thus periodically drops to zero, then rises and only reaches the actual average power at the end of the averaging interval.
Then other demand values can be useful:

- **LD** last demand value = value of actual demand **AD** (actual demand = average active power) at the end of the previous averaging window. The value is displayed together with its timestamp, which corresponds to the end of the window.
- **ED** estimated demand value = estimated value of the actual demand **AD** (actual demand = average active power) that should be reached at the end of the current averaging window.

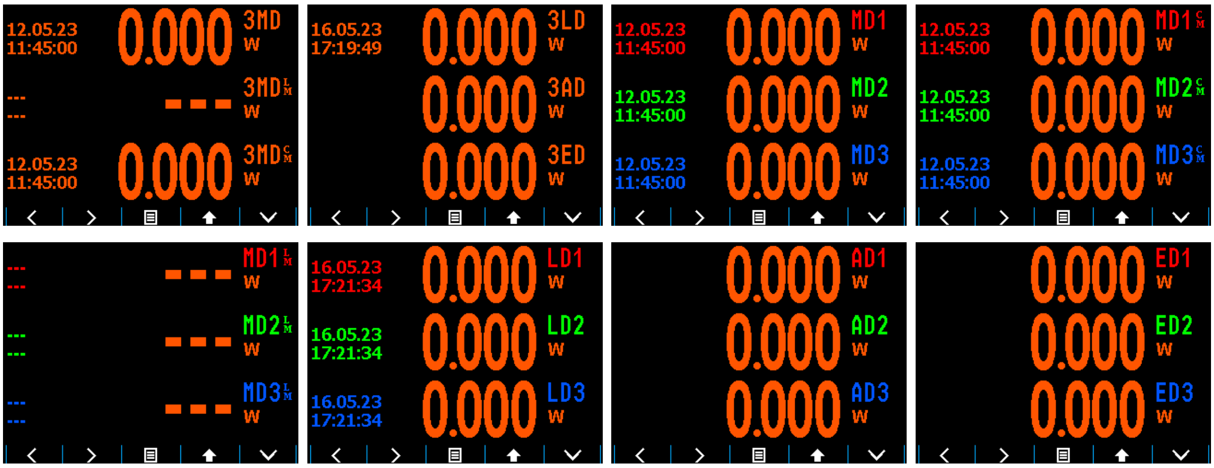
! **If the maximum demand averaging mode is set to the floating window, the LD and ED values are irrelevant (they only contain copies of the AD sizes).**

4.3.3.2.2 Representation of the maximum demand

If you are in the electricity meter energy window, you can switch down to the maximum demand windows.

The first branch consists of only two screens and contains three-phase values:

- **3MD** Maximum demand = Maximum of **3AD** reached since last reset.
- **3MD$_{LX}$**, **3MD$_{CX}$** Maxima of the **3AD** values reached since the last (**L**) and the current (**C**) evaluation interval. The index "X" depends on the preset value for the MD evaluation interval: D = day, W = week, M = month, Q = quarter, Y = year.
- **3AD, 3LD, 3ED** current/last/estimated demand



Scroll down to access the single-phase branch of the maximum demand values. Here you can query the demand values for individual phases.

5 Residual current monitoring (RCM)

The RCM can trigger early warnings in case of measured grid disturbances.
The measuring instruments measure AC and pulsating DC fault currents according to the RCM specification type A as defined in the IEC 62020 standard. No directional sensitivity for the fault currents is implemented.

5.1 Measuring transducers for RCM

All measuring devices are designed for indirect connection, which is why the use of a current transformer is required. For RCM, however, a special residual current transformer (RCT) must be used. The following parameters are required for an appropriate RCT selection:

- **In** ... Rated current = maximum primary current of the RCT. The **In** value of the RCT must be greater than the tripping current of the upstream circuit breaker (= maximum continuous phase current of the monitored network). If this is not specified, the RCT's Rated Continuous Thermal Current (**Icth**) can be used instead.

Normally, the size of the RCT and its window depends on the **In** value - check this also so that the cable used matches it.

- **RCT ratio** (for example 600/1)
- **IΔn** primary operating fault current. This defines the range of primary residual currents that can be measured with defined accuracy and used for reliable indication of exceeding a residual current threshold. Then the following applies:
  - The desired residual current threshold must fit within the **IΔn** range of the RCT.
  - The desired residual current threshold divided by the RCT ratio must fit within the residual current range of the meter.
- **RRCMMAX** maximum load = maximum impedance of the shunt connected to the RCT output. This must be greater than the fault current input impedance of the measuring device.

5.1.1 Electrical safety

The residual current measurement inputs are not galvanically isolated from the unit's internal circuitry, so that only signals with safe voltage can be connected.

! **The insulation of the RCT used must meet the requirements of the IEC61010-1 standard regarding double insulation according to CAT III for the existing mains voltage!**

5.1.2 Standard RCTs with AC current output

These RCTs are commonly used. The corresponding **CT_{RCM}** ratio in the form xxx/1 must be set in the *Installation* parameter group.
However, it must be taken into account that in certain cases a possible overcurrent at the RCT output can be dangerous for the input of the meter.

5.1.2.1 Overcurrent protection

In contrast to standard current inputs, the residual current inputs are dimensioned to measure residual current in the milliamp range (see technical data), i.e. currents that are several orders of magnitude lower. Therefore, they are generally less overcurrent resistant than the standard current inputs.
Therefore, check the possible worst-case conditions in the network and calculate the maximum possible fault currents at the RCT output - both continuous and dynamic currents. Then compare them with the maximum permissible static and dynamic currents of the encoder inputs, which can be found in the technical data.
Special care must be taken during RCT installation. If, for example, only two current conductors of a three-phase cable are accidentally installed in the RCT, the RCT can deliver a false fault current at its output in a magnitude which can correspond to that of the rated phase current of the mains at maximum!

Example:

- Rated primary phase current: 120 A
- RCT ratio: 600/1
- Incorrect primary fault current (only 2 phase currents measured): 120 A
- Incorrect secondary fault current: 120/600 = 0,2 A

! **If the RCT is powerful enough to generate such a false secondary fault current for a prolonged period of time and its value exceeds the maximum allowable current of the unit input, it is strongly recommended to check the RCT output current before connecting it to the unit!**

!

Never use standard current transformers with 5 A secondary rated current for the RCM! A possible overcurrent can damage the fault current input of the meter!

5.1.3 Special RCTs with DC current output

In addition to standard RCTs, RCTs with an output current loop of 4-20 mA DC can also be used. In such a case, instead of the CTRCM ratio, the primary fault current values corresponding to 20 mA are set in the Installation parameter group (see below).
In this case, there can be no current overload of the meter inputs.

5.2 Connection of the RCM inputs

If this is also not prescribed, we recommend connecting the S1 signal (or "k") of a standard RCT to terminal **IΔ11/IΔ21** and the S2 signal ("l") to terminal **IΔ12/IΔ22** if a standard RCT is used.
When using a special RCT with DC current loop output, connect the positive pole (+) to terminal **IΔ11/IΔ21** and the negative pole (-) to terminal **IΔ12/IΔ22**.

Recommended line type:	H05V-U (CY)
Recommended minimum cross-section:	0.5 mm^2
Maximum cross-section:	1.5 mm^2

!

Check the measured fault currents immediately after the RCT connection - if any of them is higher than the maximum permissible current of the input (specified in the technical data), disconnect the RCT immediately, otherwise the meter may be damaged!!!
The fault currents are marked with IΔ and can be checked on the meter display. If one of the RCM inputs is overloaded, the symbol  in the upper right corner of the display flashes.

Then set the CTRCM ratio in the Installation Setting parameter group.

!

The RCM inputs are neither isolated from the unit's internal circuitry nor from each other! As the terminals IΔ12 and IΔ22 are internally connected to each other, you must not connect signals with different potential here!

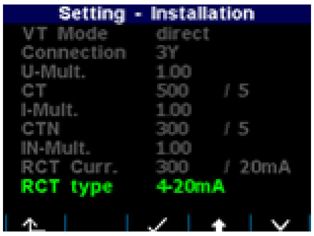
!

One of the outputs of each RCT can optionally be earthed via PE - in this case, always earth the output connected to the IΔ12/IΔ22 terminal(s)!
Take this earthing into account if one of the residual current inputs is used for the RCM and at the same time the other for a 20 mA DC current loop measurement, or if a temperature input is also connected, in order to avoid possible short circuits!

! **The maximum cable length is 3 metres! Otherwise, the EMC immunity of the unit may be impaired.**

5.3 RCM setup and display

If a standard RCT with AC current output is used, set its **CT_{RCM} ratio** in the *Installation* parameter group. Optionally, you can also use the **I_{RCM} multiplier**.



If an RCT with DC output current loop 4/20 mA or 0/20 mA is used, first switch the **RCT type** accordingly by editing the **I_{RCM} multiplier**. Then enter the RCT primary current corresponding to the 20 mA DC output (in milliamps - in the example above, a transformer ratio of 300 mA/20 mA is set). The value corresponding to the current 0 or 4 mA cannot be set - it is automatically assumed to be zero.

Only rms values of residual currents are available. The fault currents are marked **IΔ1** and **IΔ2**.

The residual current values can not only be monitored and archived, but also the exceeding of a preset level can be reported with the help of a corresponding I/O management - see the corresponding chapter below.

! **If the RCT is set to 0-20 mA or 4-20 mA type, the fault current value is marked as overloaded and the symbol flashes in the upper right corner of the display as soon as the primary fault current exceeds the value corresponding to the secondary current of 20 mA, indicating a possible RCT overload.**

! **If the RCT is set to 4-20 mA type, the fault current is marked as possibly incorrect and the symbol flashes in the upper right corner of the display as soon as the secondary RCT current drops below 3.8 mA, indicating an incorrect connection or a possibly damaged RCT.**

! **As soon as a residual current input is used as an analogue input (AI) and a corresponding action is defined in the I/O management (see below), residual current monitoring at the corresponding input is suppressed and the corresponding IΔ value is no longer available!**

5.4 Tips and notes

- Never route the protective earth conductor (PE) with live conductors through an RCT; only **all current-carrying conductors** can be passed through here. The only exception is when the fault current is monitored by a single protective conductor measurement - then this must be **the only conductor** that is passed through.
- Never run a shielded cable through the RCT.
- Install the RCT on a straight section of cable and far enough away from bends. Centre the cable as precisely as possible in the RCT window. Otherwise, incorrect residual currents may occur.
- To achieve higher immunity to false fault currents due to asymmetrical installation, especially with low fault currents to be measured, use an RCT with a larger window diameter than required.
- Take into account natural leakage currents caused by long cables (stray capacitance), capacitive filters, surge arresters, etc., especially if many single-phase devices connected to the PE line (for safety or other reasons) are installed in the monitored network. These can cause faults in the residual current display.

6 Inputs and outputs

The panel meter is equipped with a combination of outputs and inputs. The following I/O types are available:

- Semiconductor digital outputs - **Dox**
- Digital (semiconductor) signal inputs - **Dix**
- Analogue inputs, usually in the range 0 - 20 mA DC - **Aix**
- Temperature inputs, usually for a Pt100 sensor - **TE**

The power analysers have 1 digital input or output. In addition, they have 1 residual current input which - if not used for residual current measurement - can be used as a 0-20 mA DC or 4-20 mA DC current loop analogue input. Instead of a second input, the power analysers have a Pt100 temperature sensor input for an external temperature measurement (TE).
In addition, all unit models have two "alarm" lights **A1** and **A2** for signalling various states, which can be regarded as further special digital outputs. The function of these lights can be set in the same way as for the standard digital outputs.
The operating behaviour of the digital outputs can be programmed as:

- *Standard output* a simple two-point controller or a defined status display
- *Pulse output* transmitting electricity meter (DO type outputs only)

- *Time synchronisation output* for transmission of second or minute pulses

Digital inputs can be used

- for status monitoring (closing a contact, etc.)
- as pulse or frequency counter (see description below)
- as input variable of a condition for the I/O device (see description below)

The current status of both the alarm lights and the digital I/Os can be checked in the status bar (see above).

6.1 Connecting the inputs and outputs

The I/O connector is located in the lower right corner.

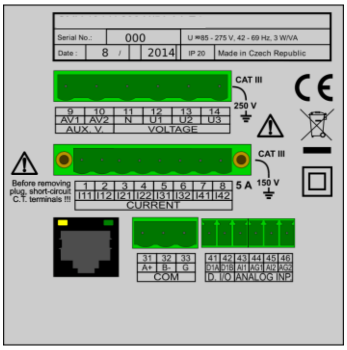


Figure 5: Power Analyser 37010 - Connectors

Inputs and outputs are connected to terminals on the back of a meter according to the following tables.

Table 4: Power analyser 37010 - I/O connection

Termi-nal no.	Signal	Notes
41, 42	D1A, D1B DO1 Digital output or DI1 Digital input	- the input or output is unipolar. Output is unipolar. - D1B of output "DO" is positive (+). - D1B of input "DI" is negative (-). - The digital I/O system is isolated from the unit's internal circuitry. Recommended line type: H05V-U (CY) Recom. minimum cross-section: 0.5 mm^2 Maximum cross-section: 1.5 mm^2 1.5 mm^2

43, 44	IΔ11, IΔ12 IΔ1 residual current input or AI1 Analogue 20 mA current loop input	- For the fault current, IΔx1 is S1 (k). - For the 20-mA current loop, IΔx1 is positive (+). - The inputs are not isolated from the unit's internal circuitry!!! - The same signal (voltage level) or potential-free signal can only be connected to terminals IΔ12, IΔ22 or T-! Recommended line type: H05V-U (CY) Recom. minimum cross-section: 0.5 mm² Maximum cross-section: 1.5mm²

6.1.1 Connection of the digital output (DO)

The output is formed by a semiconductor switching device (DO). The maximum permissible voltages and load currents according to the technical data must be observed.

6.1.2 Connection of the digital input (DI)

The input assumes that a voltage signal of suitable magnitude is present (see technical data).
If the voltage exceeds the specified level, the input is activated (= value 1).
Common 12 or 24 V DC/AC signals can be connected directly. If you need to connect a voltage signal whose magnitude exceeds the maximum digital input voltage, an appropriately dimensioned external limiting resistor must be used.
The digital input is isolated from the unit's internal circuitry.

6.1.3 Connecting the analogue inputs

If no residual currents are measured, the residual current inputs can optionally be used as 0-20 mA DC or 4-20 mA DC current loop analogue inputs.
Check that the signal source can work with the impedance of the input specified in the technical data.
Connect the positive signal (+) to terminal **IΔ11** and the negative signal (-) to terminal **IΔ12**.
Then set the input parameters - see chapter I/O Setup below.

! **The residual current input and the external temperature input are neither isolated from the unit's internal circuitry nor from each other! As the terminals IΔ12 and T- are internally connected to each other, you must not connect signals with different potential here!**

!

The maximum cable length is 3 metres. Otherwise, immunity to electromagnetic interference may be negatively affected!

!

As soon as an analogue input mode (AI mode) is activated in the I/O management (see below), the residual current monitoring at the corresponding input is suppressed and the corresponding IΔ value is no longer available!

6.1.4 Connection of an external Pt100 temperature sensor

The power analyser can be used to measure an external temperature **T_E**. The corresponding input of this model is designed for connection to a Pt100 resistance temperature sensor. Connect the sensor to terminals no. 45 (**T+**) and 46 (**T-**). As the sensor is only connected via a two-wire line, you must ensure that the loop impedance of the sensor cable is as low as possible (every 0.39 Ohm means an additional measurement error of 1ºC).

!

If a signal is connected to inputs IΔ11 - IΔ12 at the same time, note that terminal IΔ12 is internally connected to terminal T-. So only signals isolated from each other or signals with the same common pole potential can be connected!

6.2 I/O management

The possibilities for processing the inputs and outputs are very diverse and it would be quite complicated to set them via the control panel. Therefore, you can only make these settings on a PC connected via a communication link using the ServiceTool -DAQ programme.

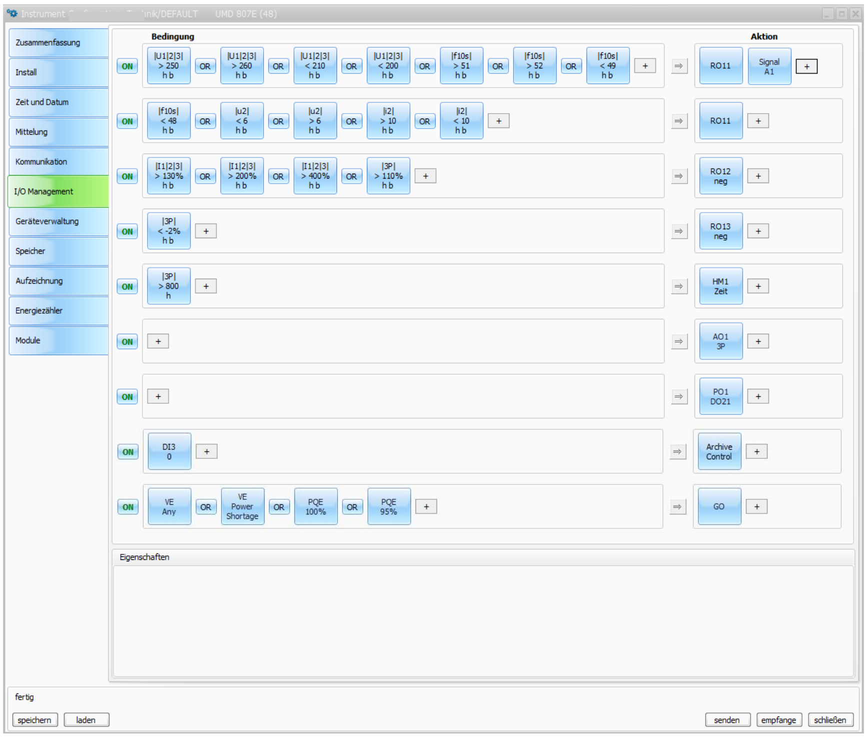


Figure 6: Example of setting up I/O management in the ServiceTool -Daq programme

For I/O setup, use Configure → I/O-Management. The entire I/O setup consists of so-called clauses. Individual clauses are listed in the I/O management screen.
Each clause consists of the following elements:

- ON *Clause switch* - When ON, the clause is active, i.e. the *clause condition* (if set) is evaluated and if the result is "true" (= logic 1), the *clause action* (or *actions*) is processed. By clicking on the switch, you can switch it to OFF - the clause processing is then suppressed and has no effect.
- *Clause condition* - a logical expression. If the result of the expression is true (= logical 1), the clause action is executed. If the result is false (= logical 0), the action is not executed (= suppressed).

The clause condition may

- be empty - in this case the corresponding clause action is executed permanently (an empty condition returns a true result)
- be formed by only one condition element (for example, the magnitude condition)
- be formed by combining two or more conditional elements, which are to be connected with the operators OR and AND (see clause no. 2 in the example above)

- *Clause action* - with the actions you can set various functions that usually refer to the inputs and outputs of the meter. Typical actions are, for example, digital output control or analogue input processing.

! **The symbol + is not a condition, operator or action - this button allows you to add conditions or actions to the clause. Even if no I/O action is set, the "I/O Management" folder contains an empty Template clause with the buttons + prepared for new clause definitions.**

To add a new clause, click the button + in the Action field (= right) of an empty clause template. Select the desired action from the pop-up menu. You can add either one or up to two actions to the same clause.

Optionally, you can also add one or more conditions with the corresponding button + in the "Condition" field (= left). If multiple conditions have been added, you will need to set the logical operators OR/AND - just click on them to toggle the relevant value.

! **When designing the conditional expression, make sure that the AND operator has a higher priority - first the sub-expressions connected with the AND operators are evaluated and only then the rest of the expression with the OR operators.**

To remove an action or condition from a clause, click on it and press the *Delete* button in the Condition/Action field (or press the *Delete* key).
To temporarily disable or enable a clause, press the ON/OFF clause switch. In the OFF state, the clause operation is suppressed but remains in the facility and is available for future use.

6.2.1 I/O actions

6.2.1.1 Digital output

In combination with a suitable condition (see description of the size value condition below), you can use this action to create a simple two-point controller or a display. This type of action is called standard output.
Add the Digital Output action and set:

- Desired digital output
- *Polarity* Select Direct, if the output is to be switched on with a true result of the corresponding clause condition and vice versa.
- *Control* If this element is set to 1, the output state simply follows the result value of the condition. If it is set to ↑, the output temporarily turns on or off for the preset *pulse width* (depending on the polarity setting) only when the condition result *changes from false (0) to true (1)*.

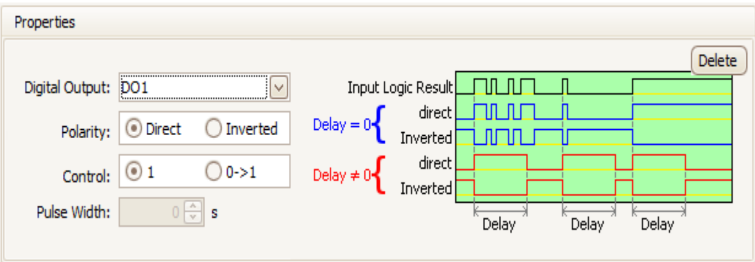


Figure 7: I/O Setup - Standard Digital Output Action Properties

! **For simple "manual" control of a digital output, add the default digital output action without condition (an "empty" condition permanently returns the result "true" (=1)). Then set the desired polarity and send the setup to the meter.**

6.2.1.2 Alarm light (A)

Alarm lights A1 and A2 can be set in the same way as the digital outputs (see above) and are used to indicate various events on the meter display.

6.2.1.3 Pulse output (PO)

All digital outputs or alarm lights can be set as a transmitting electricity meter. The frequency of the generated pulses can be adjusted depending on the values of the measured electrical energy by the built-in electricity meter unit.

The following parameters must be set for the pulse output:

!

- Target *digital output*
- Target energy quantity here the transmitted energy must be selected (for explanation of energies see description of electricity meter).
- Number of pulses per kWh/kvarh/kVAh

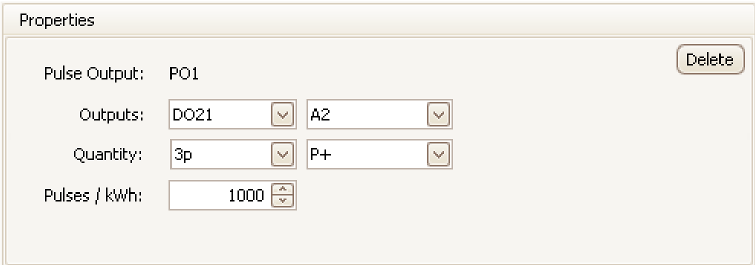


Figure 8: I/O Setup - Pulse Output Action Properties

!

You can also set one of the alarm lights (A1, A2) as a pulse output and then check the pulse function on the meter display at the same time.

6.2.1.4 Pulse switch

The pulse switch function is used to control switches or contactors that require two signals: one to switch on and the second to switch off.

Select the digital outputs for switching on and off and set the switching pulse width. Next, add a condition for the pulse switch action.

Figure 9: I/O device - Pulse switch

If a change of condition occurs after the set-up, a pulse of fixed duration appears

- at the output set to On when changing from "false" to "true”
- at the output set to off when changing from "true" to "false”

6.2.1.5 Frequency Counter (FC)

Each digital input can be used to monitor a variable depending on the frequency of the input pulses. For example, flow meters or anemometers with pulse output (often of the "S0 type") can be connected and the unit can measure and record a flow or wind speed. So although this quantity is called a counter, it is in fact a frequency-controlled quantity.

Select an empty clause and add the Frequency Counter action. In the Properties field you can set the following:

- *Name* of the size (for example *Vwind*)
- *Unit* of the quantity (*m/s*)
- Transmission ratio in one of two formats:
  - Either *Hz/unit* Frequency of the input pulses in Hertz, which corresponds to a unit
  - or *units/Hz* Value of the quantity (in the set units) for the case that the input pulse frequency is 1 Hz

Figure 10: I/O Setup - FC Action Properties

If the name is not defined, the size is specified with its general name FCxx (where xx is the index of the associated digital input).

6.2.1.6 Pulse Counter (PC)

Similarly, counters of incoming pulses can be checked for all digital inputs. The counters usually reflect the amount of a medium that has passed through since the counter was last reset.

Add the *Pulse Counter* action and set:

- *Name* of the counter (for example *Barrel1*)
- *Unit* of the quantity (*hl*)
- Transmission ratio in one of two formats:
  - Either *pulse/unit* Number of input pulses corresponding to one unit
  - or *units/pulse* Value of the quantity (in the set units) corresponding to a pulse

Figure 11: I/O Setup - PC Action Properties

If the name is not defined, the quantity is given its general name *PCxx* (where xx is the index of the associated digital input).

6.2.1.7 Analogue Input (AI)

The following must be specified for each analogue input:

- *Analogue input number*
- Displayed quantity *Name*
- Displayed quantity *Unit*
- Input type and *conversion ratio* Select either "10 V" or "20 mA" as the input type and the values of the displayed quantity for 10 V/20 mA or 0 V/4 (0) mA.

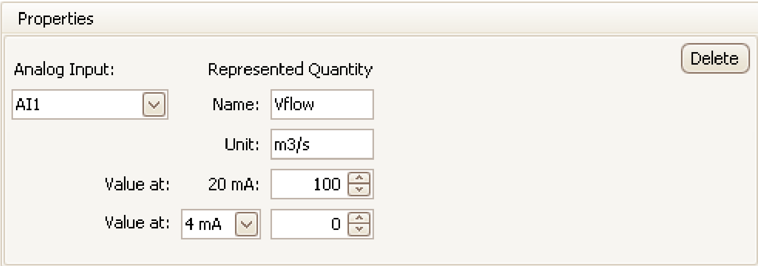


Figure 12: I/O Setup - Analogue Input Properties

! **If an analogue input can also measure residual currents, the corresponding residual current IΔ is measured by default at the input using the CTRCM ratio specified in the "Installation" parameter group. However, once the analogue input action is defined in the I/O block setup, fault current monitoring on this input is suppressed and the corresponding IΔ value is no longer available because the input is now used for a 20 mA current loop signal.**

6.2.1.8 Sending a message

This action can be used to transmit a simple message to a selected communication interface. The message must be entered in hexadecimal form.

The message is sent as soon as the corresponding condition changes from "false" to "true".

The Repeat option allows you to set multiple transmissions of the message.

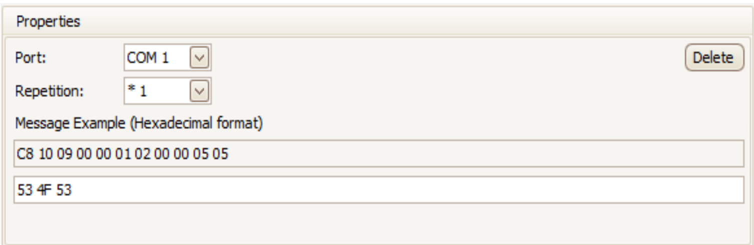


Figure 13: I/O Setup – Sending a message

6.2.1.9 Sending an e-mail

This function is similar to that of the previous action. In addition to the message, you can also set its subject - both in text format.

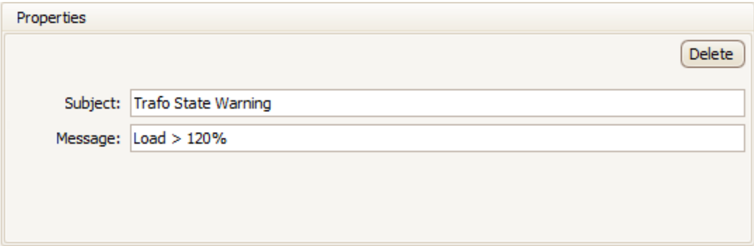


Figure 14: I/O Setup - Send e-mail

In addition, the receiver must be specified in the *Communication* setup folder. Activate the E-mail option and set the e-mail parameters according to Application Note No. 003: *E-mail use for status notifications.*

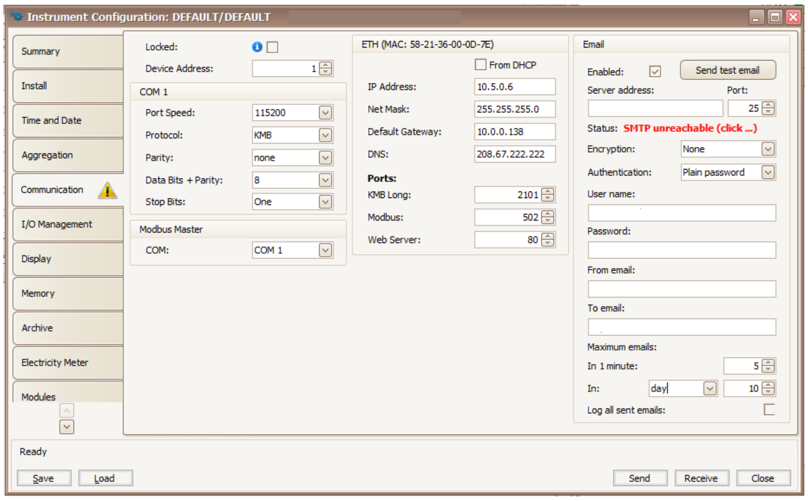


Figure 15: Example of setting up communication for the "Send e-mail" action

6.2.1.10 Hour Meter (HM)

The hour counter can be used to measure the duration of some events. Add the hour counter and enter its name - for example HX2:

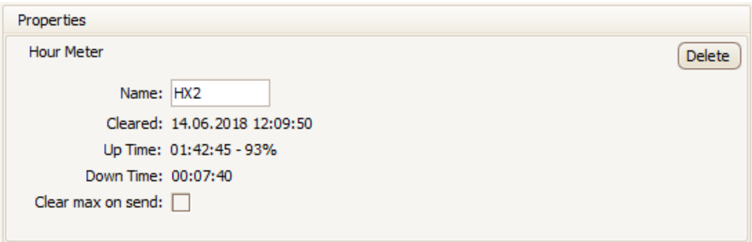
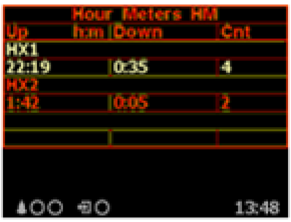


Figure 16: I/O setup - hour counter

Then add a condition for the event, e.g. to check the time of a power overload, add the Measured Quantity condition and set a power threshold for it (see condition setting below). After that, the hour counter starts counting. It contains three counters:

- ***Up*** The period since the last reset where the condition was fulfilled (= "true")

- **Down** The period since the last reset where the condition was not fulfilled (= "false").
- ***Cnt*** Number of changes of the condition from "false" to "true" since the last reset.



Up to 4 hour meters can be defined.

To query the status of the hour counters on a meter display, you must add the hour counter screen to the main data group using the ServiceTool -DAQ programme. You can then scroll to the screen and check the measured data.

In the example you see two hour-meters, i.e. HM1, named HX1, and HM2, named HX2. The duration of the u*p*- and d*own*-counters is expressed in the *hours:minutes* format.

! **The only way to clear an hour meter is to select the hour meter setup icon in the ServiceTool -DAQ programme, activate the *Clear on Send* option and send the setting to the meter. The time and date of the reset are registered simultaneously and can be checked by reading the setting from the unit.**

6.2.1.10 Time synchronisation

Meters with built-in real time clock (RTC) can be used with this action to synchronise the time of other meters.

Select the digital output to which the synchronisation pulse is to be sent and select "PPS" or "PPM" as the transmission duration. The synchronisation pulse width is fixed at 200 ms.

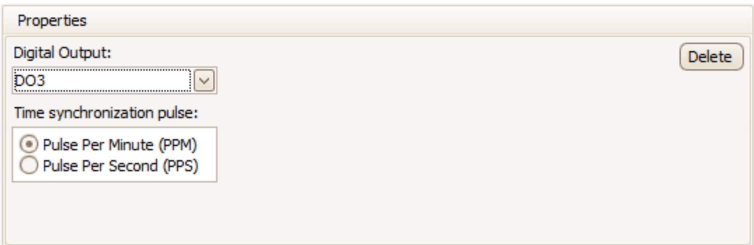


Figure 17: I/O Setup - Time Synchronisation Output

6.2.1.11 Archiving modes

With this action you can control the recording of measured data in the archive of the meter. You can set one of two operating modes:

- *Continuous* The data recording runs if the corresponding condition is true and is stopped if it is false.
- *Duration* Data recording starts as soon as the corresponding condition changes from "false" to "true"; after the time period defined in the Duration field has

elapsed, the recording is stopped and then waits for the next change of the condition from "false" to "true".

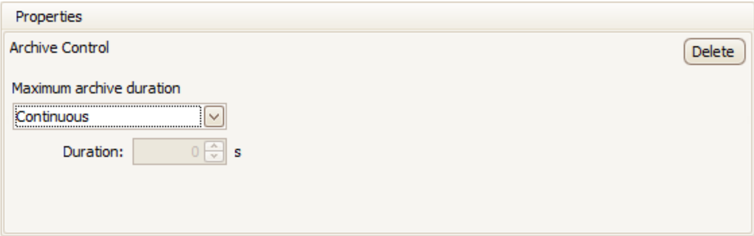


Figure 18: I/O setup - archive control

If no archive control action is set, the recording runs permanently.

6.2.1.12 Oscillogram – general setup

This action is only available if the corresponding firmware module is installed. It allows you to record the courses of measured voltages and currents in graphical form.

In the set-up screen you can set the following:

- Voltage and current signals to be recorded
- Sampling rate of the recording
- Duration of the recording before (pre-trigger) and after (post-trigger) the change of the trigger condition from "false" to "true".

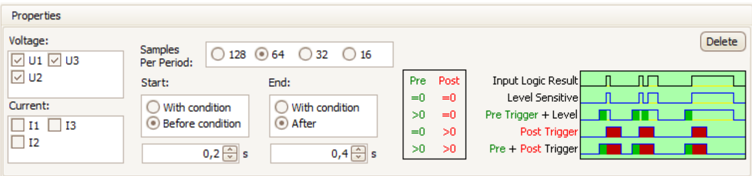


Figure 19: I/O Setup - General oscillogram

Subsequently, the oscillograms are recorded as soon as the corresponding condition changes from "false" to "true", or the recording can be controlled by the value of the condition - see application note *Firmware Module General Oscillogram*.

! **Usually, the unit state condition "VE - All" is optimal for triggering the oscillogram recording. Refer to the unit status condition below.**

! **Make sure that there is enough space reserved in the memory settings folder for oscillogram recording! Otherwise, no records will be created!**

6.2.1.13 Variables

This action allows you to create more complex conditions in a clause than can be created in it with only basic conditions.

The value of the variable is evaluated against the condition defined in the clause using the parameters below. It can then be used in logical expressions of conditions in any other clause.

Add the action and select its name Var x, where x is the number from 1 to 16. Then set:

- *Polarity* This determines whether the direct or inverted result of the condition defined in the clause is used for variable evaluation.
- *Control* This determines whether the variable is the controlled state value (1, "level-controlled") or the change-controlled state value (0→1, "slope-controlled").
- *Pulse width* If the variable is slope-controlled (control = 0→1), this option sets the time period for which the variable remains "true" after it has been set to this value; then it automatically changes back to "false".
- *Remaining* Once the variable changes to "true", this option causes this value to be retained until it is manually reset to "false".
- *Reset on send* If the variable remains "true" because of the option *Remaining*, it is possible to force it to reset to "false" by activating this option and sending it to the unit.

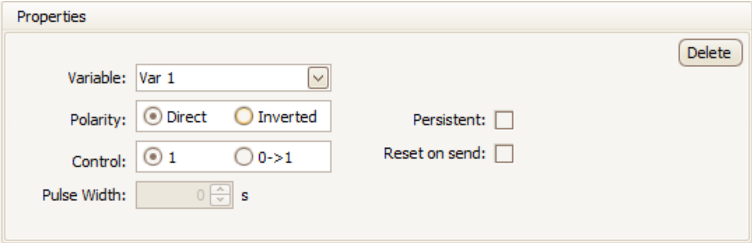


Figure 20: I/O setup - variable

Now enter the condition for this action, e.g.:

Figure 21: I/O Setup - Example Condition for the "Variable" Action

Subsequently, the variable is controlled by the condition and can easily be used in other clauses as another condition *Var1* - see chapter *I/O conditions* below.

! **During the initialisation of the I/O block after switching on or restarting the meter, all variables (except those that remain true due to the "Remaining" option) are set to false. After each step of the I/O block evaluation, the variable values are saved and used in the next step. See chapter "I/O block processing".**

6.2.2 I/O conditions

6.2.2.1 Digital input condition

Click the button  in the condition part of the target clause and select the *Digital Input* option. You must then set the following:

- Desired *digital input*
- *1/0/0<->1/1<->0/0<->1* State (= level-controlled mode) or change of state (= slope-controlled mode) of the digital input, which assumes the state *true* (logic 1).

If a change of state is set and the digital input retains the same value as in the previous I/O block evaluation cycle, the result of the condition is "false".

- *Block time* Minimum duration of the stable state of the digital input (only relevant for level-controlled mode). If this is not zero, fast changes of the input signal are "filtered" and a new state of the condition result only occurs if the signal lasts for at least the set block time. This setting is indicated by the character "b" in the condition symbol.

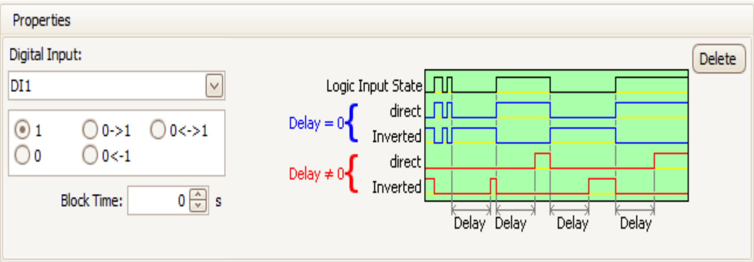


Figure 22: I/O Setup - Digital Input Condition Properties

6.2.2.2 Condition for measured quantity

Values of the most important measured quantities can be used as a condition in the clauses for the I/O facility. The value of the selected variable is compared with the preset limit value and receives either the result "true" (1) or "false" (0). The following parameters must be set for this:

- *Amplitude and phase* Desired control variable (single-phase or three-phase or an AND/OR combination of them)
- *Actual or mean value* Desired value of the control variable
- *Abs* Tick whether the absolute value of the control variable is to be evaluated (only relevant for bipolar variables).
- *Rule* Defines the polarity of the deviation between the control variable and the preset limit value for the result "true" of the condition
- *Limit value* Limit value of the control variable - either in base units or as a percentage of the nominal value (UNOM/INOM/PNOM).
- *Hysteresis* Defines the insensitivity range of the condition state evaluation

- *Block time* Defines the minimum continuous duration of the corresponding value of the control variable until the result of the condition changes

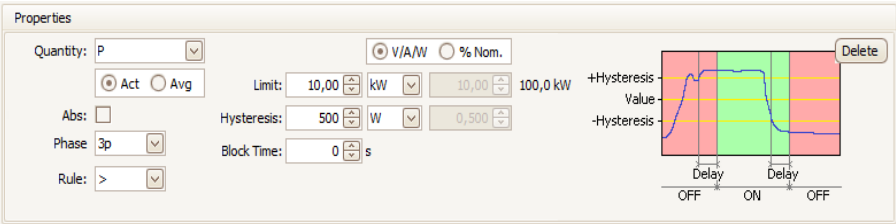


Figure 23: I/O Setup - properties of the measured variable condition

6.2.2.3 Device status condition

The condition can be configured to monitor various events that mainly affect the power quality (voltage events, power outages, rapid voltage changes, etc.). or affect some state changes of the meter.

Select the desired event and - if applicable - check the phases to be evaluated.

The Control option allows you to set the way in which the appearance of an event is evaluated:

- **1** If an event has **occurred** (i.e. has arisen during the current assessment cycle or has persisted since the last one), the result of the condition becomes **true**, otherwise **false**.
- **0→1** If an event has **occurred** (i.e. has not persisted) during the current evaluation cycle, the result of the condition becomes **true**; if no events have arisen (i.e. none have occurred or have only lasted), it becomes **false**.

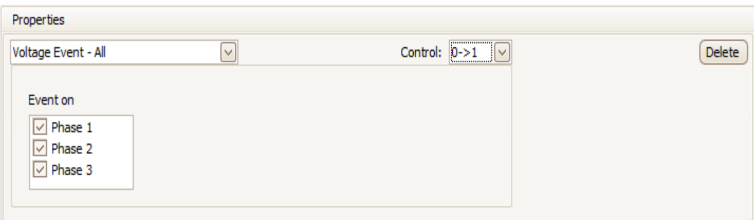


Figure 24: I/O Setup - Unit State Condition Properties

! **If the control input field is set to "0→1", all events on all set phases are evaluated individually and independently of each other. For example, if an interruption on phase L1 has lasted for the entire evaluation cycle and a rise on phase L2 has occurred at the same time, the result of the condition is "true".**

For more details, see the application note Firmware Module General Oscillogram.

6.2.2.4 RCM condition

Units equipped with a Residual Current Monitoring (RCM) input can be used with this condition to indicate network isolation status faults.
Add the condition and check the RCM currents *IΔx* to be monitored. Then set the residual current limit value, the polarity of the deviation, the evaluation of the actual and average value of the current, the hysteresis and the delay.

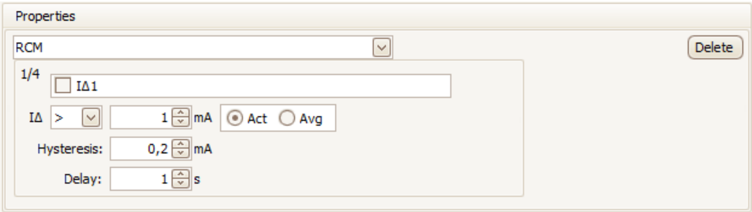


Figure 25: I/O Setup - RCM Condition Properties

Up to four of these different conditions can be created and used.

! **Do not forget to set the residual current monitoring ratio CT_{RCM} in the parameter group Installation setting!**

6.2.2.5 Time condition

This condition can be used as a single timer.

- *Time* Date and time since when the result of the condition either becomes "true" forever or starts pulsating.
- *Level/Pulse* For Level, the condition becomes "true" forever after the specified date and time have elapsed; for Pulse, the condition becomes true periodically (for one I/O block evaluation cycle).

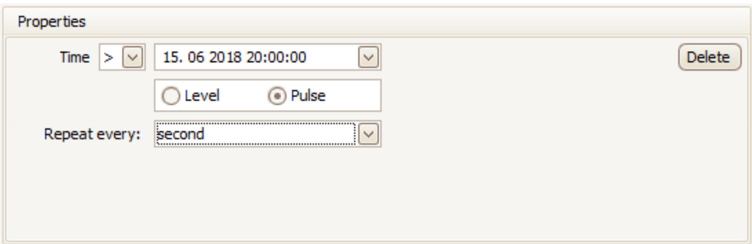
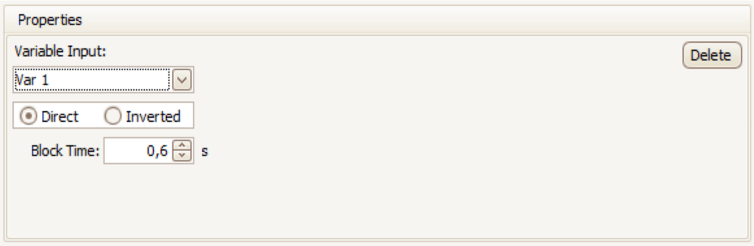


Figure 26: I/O Setup - Time Condition Properties

6.2.2.6 Variable condition

When a variable action is defined (see description above), it can be used in the same way as other basic conditions.
Setup is similar to the digital input condition - specify the variable number, polarity and block time.



Figue 27: I/O Setup - Variable Condition Properties

6.3 I/O actual data display

6.3.1 Digital and analogue I/O

At the end of the actual data branch, the digital I/O actual status screen and, if set, the analogue I/O status screen can be listed.

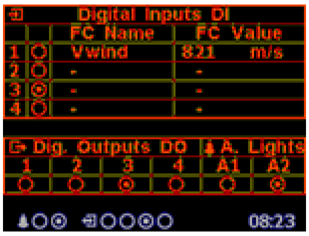


Figure 28: Example of a digital I/O actual state screen

Der digitale I/O-Istzustandsbildschirm zeigt den aktue|Status of all inputs and outputs:

-  Off state (or inactive) The input voltage is below the defined threshold or the output is open.
-  On state (or active: The input voltage is above the defined threshold or the output is closed.)

If a digital input frequency counter processing is set, its name (*Vwind* in the example) and the actual value (*8.21 m/s*) are also displayed in the corresponding line. Otherwise, only a hyphen is displayed.

If analogue-quantity processing is also set, the analogue I/O actual data screen is displayed in the branch (otherwise it is skipped):

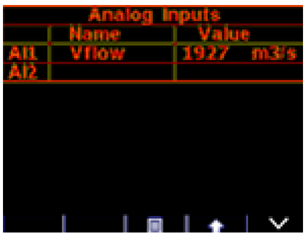
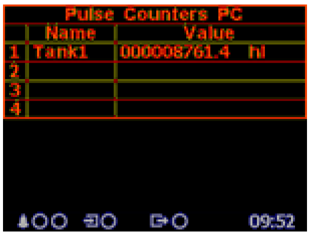


Figure 29: Example of an analogue I/O actual data screen

The displayed reading of the analogue input refers to the actual input current or the actual input voltage on the corresponding analogue input according to the set ratio. In the example, the displayed variable Vflow has an actual value of *19.27 m3/s*.

6.3.2 Pulse counter



If at least one pulse counter action is used in the I/O device, the pulse counter screen can be listed in the electricity meter branch.

The table shows the set pulse counters (PC) corresponding to the digital inputs (DI). The current pulse counter value, which is recalculated to preset the pulse counter size units, is displayed in the corresponding line with its name and unit (shortened to 6/4 characters).

6.4 I/O block processing

The I/O block is processed periodically in each measuring cycle (i.e. 200 ms at 50 Hz) so that it defines the shortest reaction time of all set actions.

The evaluation takes place in the following order:

1. **Conditions** of the clauses that are not switched off are evaluated in the order in which they are listed - from top to bottom.

By default, the individual conditions are evaluated from left to right. However, expressions linked with the AND operator are always evaluated first, followed by expressions linked with the OR operator.

If a variable is used in a condition, values from the previous I/O block evaluation cycle are used. In the first evaluation cycle (after switching on or restarting the meter), the value of all variables is "false", except for the value that remains "true" due to the option Remaining.

2. **Variable type actions** (from clauses that are not switched off) are evaluated from top to bottom (the variables receive new values).
3. Steps 1 and 2 are executed again with the new variable values (the conditions and variable values are updated).
4. All **actions** (of the clauses that are not switched off) except variable type actions are evaluated and executed from top to bottom using updated conditions.
5. The updated values of the **variables** are saved for the next step of the I/O block evaluation.

6.4.1 Digital inputs

6.4.1.1 Digital input filters

The digital inputs are read during each measuring cycle (with a period of 0.2 ms). To suppress interference, the signal is digitally filtered (by firmware). The default cut-off frequency of the filter is preset to 100 Hz.

The filter cut-off frequency can be set in the Advanced parameters. The parameter Minimum pulse width of the DI filter defines the minimum pulse or pause width in milliseconds. For example, if a cut-off frequency of 100 Hz is desired, set the parameter to 50 ms (pulse width 50 ms + pause width 50 ms = 100 ms). Pulses and pauses shorter than the set limit value are filtered out.

! **It is not recommended to increase the cut-off frequency too far. Otherwise, interference peaks can cause incorrect measurements. If, on the other hand, the maximum output frequency of a sensor connected to the unit is less than 100 Hz, it is useful to lower the cut-off frequency to the corresponding value.**

6.4.1.2 Digital input as frequency- and pulse-counter

The function of the frequency counter is based on measuring the time span between the last two pulses. After starting the unit, the quantity is set to zero until at least two pulses arrive.

The pulse counters have a capacity of 2^{32} - 1 pulses. Then an overflow occurs and the counter starts counting again from zero. In the event of a power failure, the counter content is retained.

6.4.2 Digital outputs

The digital outputs are processed and updated after each measuring cycle, i.e. usually every 200 ms.

The only exception are the outputs set to pulse function.

6.4.2.1 Pulse outputs

After the pulse function mode has been set, the unit evaluates the measured electrical energy every 200 milliseconds. If the increase in the detected electrical power is higher than or equal to the "power per pulse" quantity, the unit sends one or two pulses. The mentioned description shows that the flow of the pulse transmission is +/- 200 ms.

The pulse width and the minimum pulse gap are 50/50 ms (according to the definition for the so-called S0 output); the maximum frequency is 10 pulses per second.

7 Local bus

Local Bus is a proprietary bus that combines signals for communication, synchronisation and power supply of external modules. The basic electrical parameters of a maximum of 20 additional three-phase feeders, i.e. 60 currents, can be measured via the Local Bus interface using up to five 37100 current expansion modules.
The Power Analyser 37010 automatically detects the connected modules and then carries out their configuration. The current values of the measured variables are available immediately after connection. In addition, user configurations of newly recognised modules can be made. To clearly identify the modules in the settings, their serial numbers are used.

The data flow of the local bus system is controlled by a master - in our case the power analyser 37010. The power extension modules 37100 respond to the requests of the master - they act as slaves.

7.1 Connection

A Poweranalyser 37010 with power supply option S (i.e. with an auxiliary power supply in the range of 12 - 24 V DC) is used for these applications.

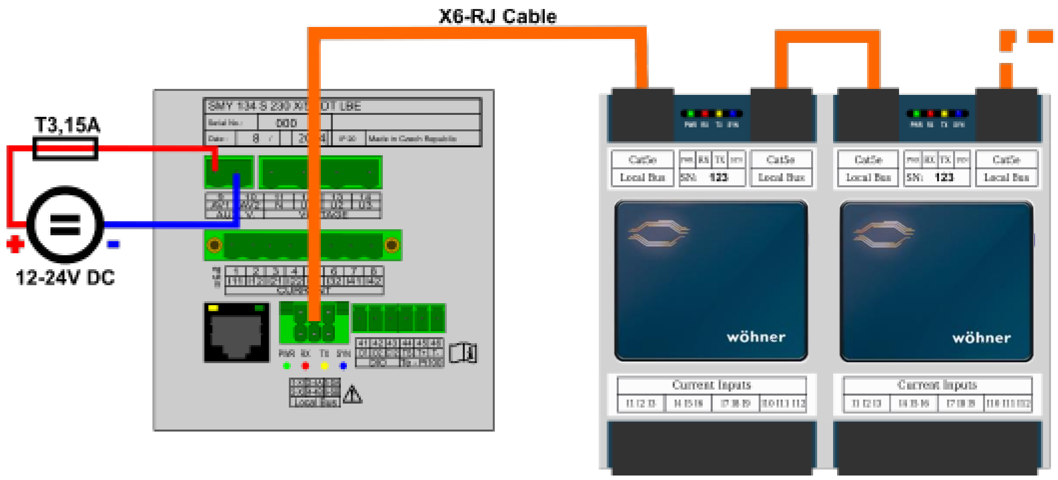


Figure 30: Measurement of multiple feeders via Local Bus

The device supply terminals AV1 / AV2 are internally connected to the terminals of the Local Bus interface X1 / X2. Therefore, the auxiliary voltage for the power extension modules 37100 is automatically provided after the unit is switched on.

!

An external fuse with a maximum rating of T3.15 A (T = slow blow) must be installed between the output of the 12-24 V DC power supply and the input of the unit supply. Optionally, the fuse can be dispensed with, provided the 12 - 24 V DC power supply can be limited to an output current of approx. 3 A. Otherwise, the unit may be damaged in the event of a short circuit of the local bus.

For connection to the 37100 current expansion modules, the units are equipped with a 6-pin DFMC connector - see central connector in the bottom row on the figure 7.2.

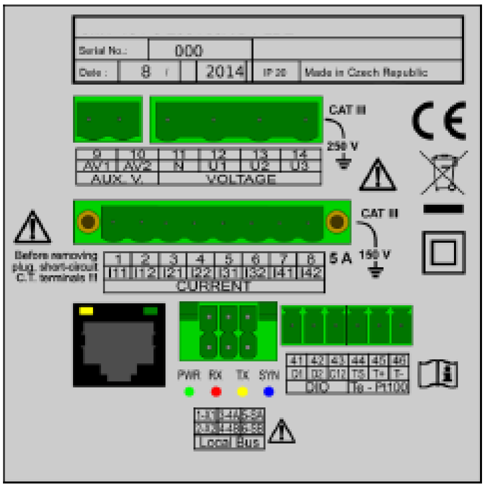


Figure 31: Poweranalyser 37010 with Local Bus Interface - Connections

The 37100 power extension modules are equipped with two RJ connectors that enable the Local Bus system to be set up. A special X6-RJ cable of appropriate length is required for the connection between the master (Poweranalyser 37010) and the first power extension module 37100.

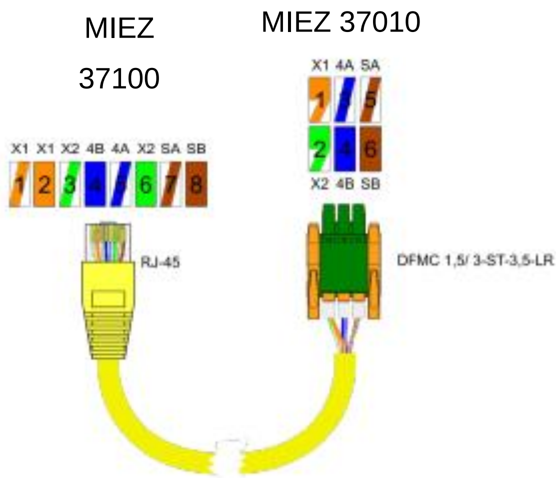


Figure 32: X6 RJ cable for Local Bus

Recommended cable: UTP CAT5e 8xAWG24

Pin wiring standard: DFMC side: 1=X1, 2=X2, 3=4A, 4=4B, 5=SA, 5=SB

RJ-45 side: TIA/EIA-568-B (1+2=X1, 3+6=X2, 5=4A, 4=4B, 7=SA, 8=SB)

RJ-RJ cables of the appropriate length must be used to connect the 37100 power extension modules to each other. The instructions in the operating manual of the power extension modules 37100 must be followed.

MIEZ 37100 MIEZ 37100

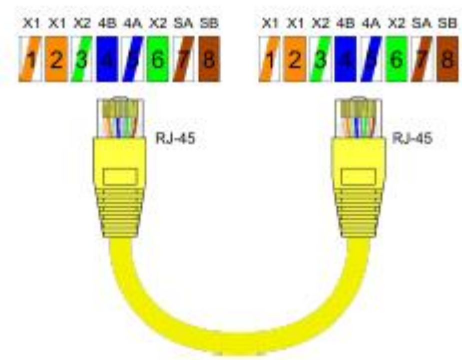


Figure 33: RJ-RJ cable for Local Bus

! **The maximum length of the Local Bus (i.e. the distance between the Master and the last installed Power Extension Module 37100) should not exceed 15 metres. Otherwise, reliability in operation may be impaired.**

Cables in common lengths can be supplied with the units - ask your dealer.

The correct connection of the 37100 power extension modules to the master can be checked by their LED indicators - the PWR indicator must light up, all others must flash.

7.2 LED displays - local bus

PWR-green lights up when supply voltage is present on the bus

SYN-blue flashes synchronously with the synchronisation pulse every ten periods of the mains frequency (or twelve periods at 60Hz mains frequency).

TX-yellow flashes when data is sent to the bus

RX-red flashes when data is received from the bus

7.3 Start-up

Connect the Power Analyser 37010 to the computer via one of the communication interfaces. Start the ServiceTool Daq application, select the selected interface and connect to the unit - a window similar to the following example should appear:

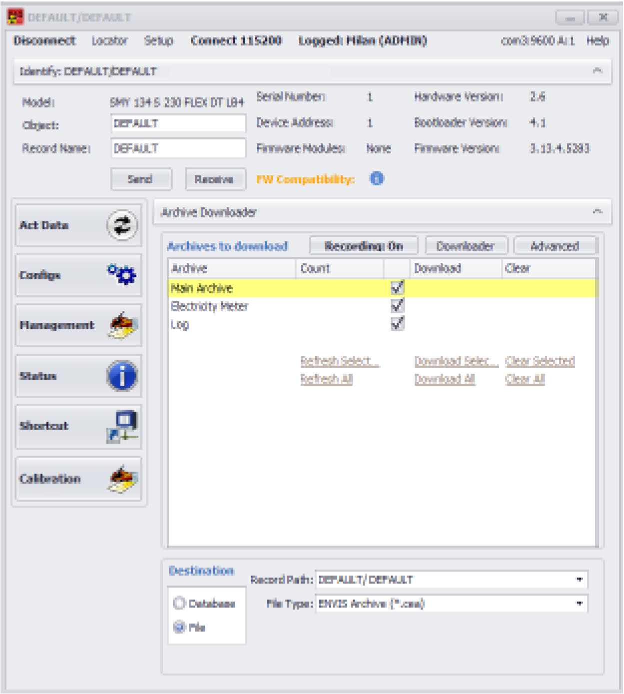


Figure 34: ServiceTool-Daq - Connected Instrument Main Window

Press the Configs button. A new window appears with tabs for the sub-settings. Select the Local Bus tab:

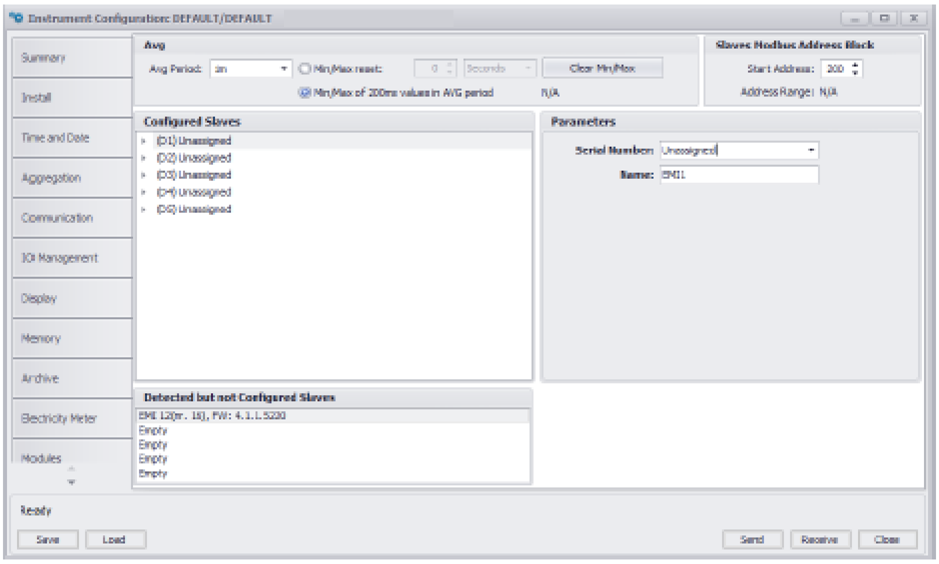


Figure 35: ServiceTool-Daq - Local Bus Config, Nothing Configured

If the slaves (power extension modules 37100) are properly connected to the Local Bus, they should appear in the Detected but not Configured Slaves block - in this case it is the power extension module 37100 with serial number XXX.

If no slave has been detected (Empty in all five rows), check the Local Bus displays again both on the master and on all slaves. If they are OK, press Receive. - then the status of the local bus is updated.

Once a slave has been recognised, you must configure it. Select the first slave in the *Configure Slaves* block, i.e. the slave marked as *D1*, and then select the serial number of the first non-configured slave - number XXX - in the *Parameters* block.

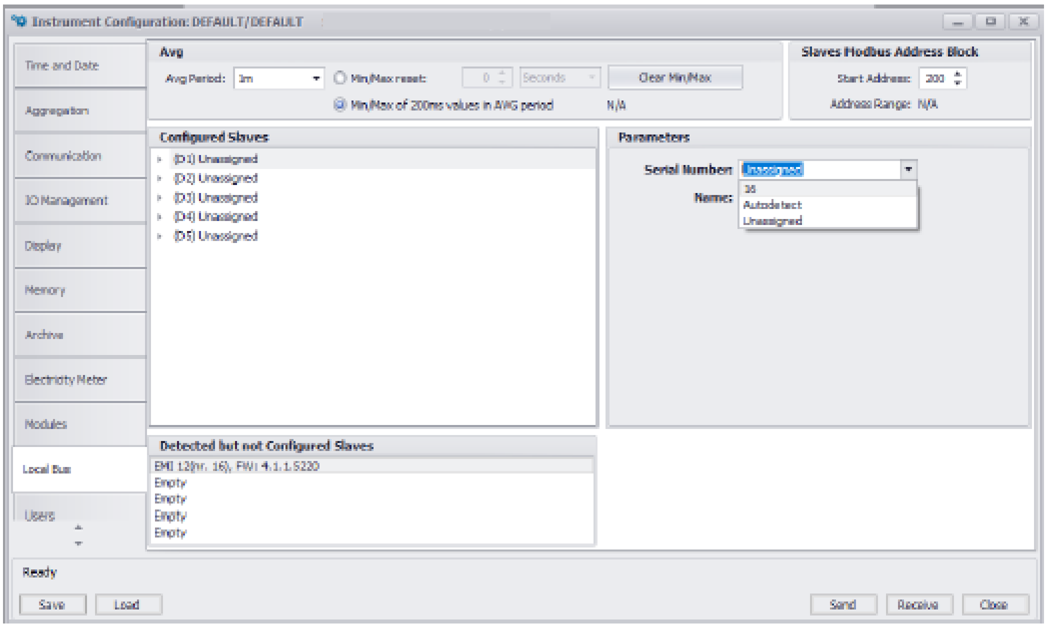


Figure 36: ServiceTool-Daq - Local Bus Config, Configuring of a Slave, Step 1

After selection, the slave with serial number XXX appears in the *Configured Slaves* block as slave D1:

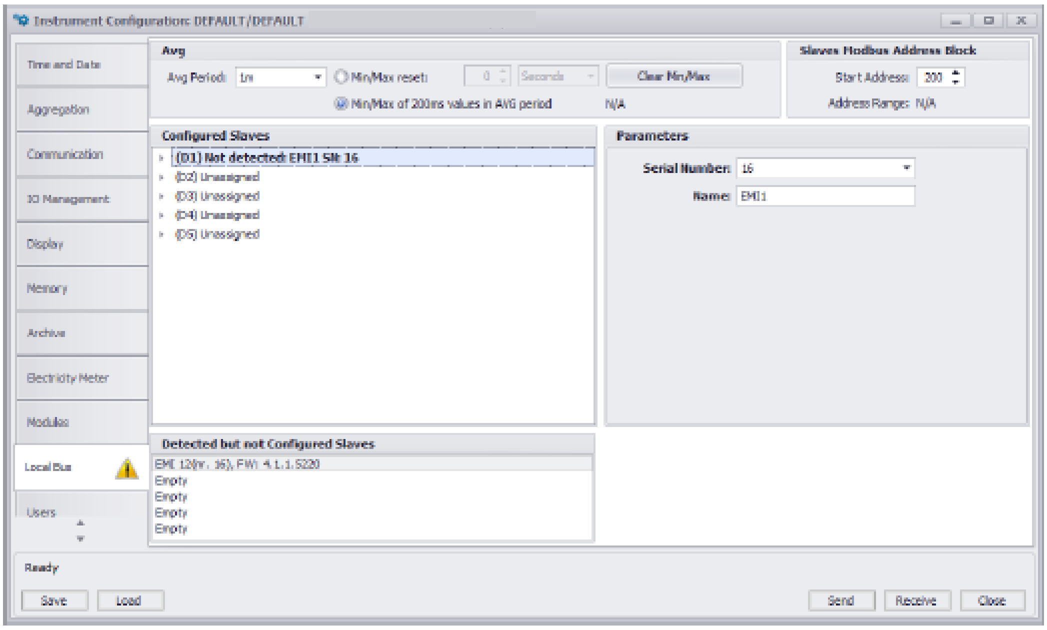


Figure 37: ServiceTool-Daq - Local Bus Config, Configuring of a Slave, Step 2

Now you have to send the setting to the master - press Send and then Receive. The master processes the setting and returns the new status:

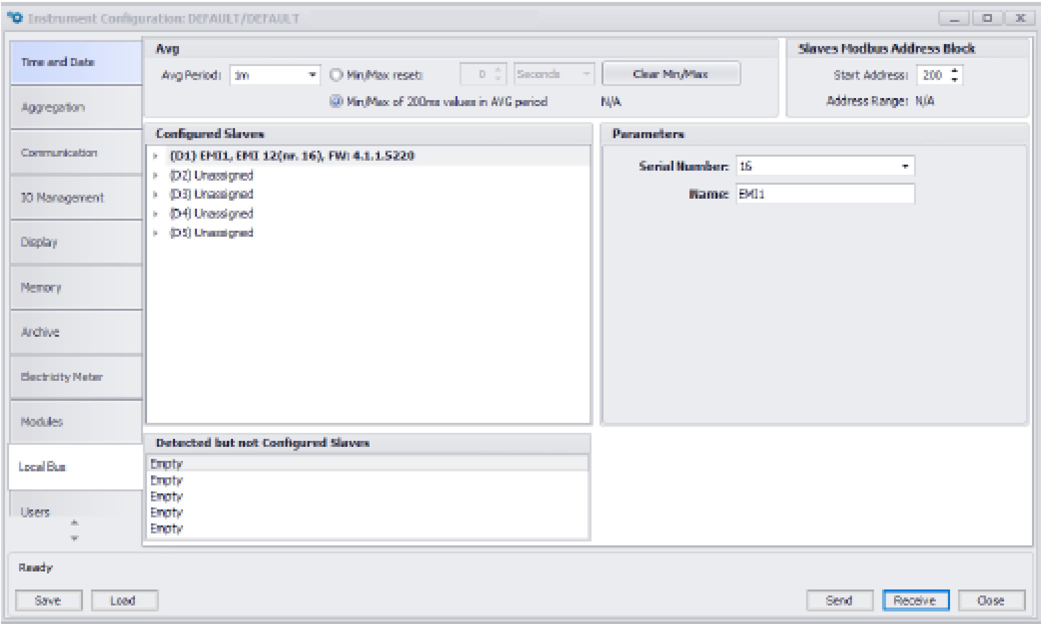


Figure 38: ServiceTool-Daq - Local Bus Config, Configuring of a Slave, Step 3

Note that slave D1 in the Configured Slaves block now contains more detailed information. At the same time, the slave has disappeared from the *Detected but not Configured Slaves* block.

By default, it is assigned the name EMI 1. For easier orientation in the measurement data, you can freely name the slave in the *Parameters* block as follows:

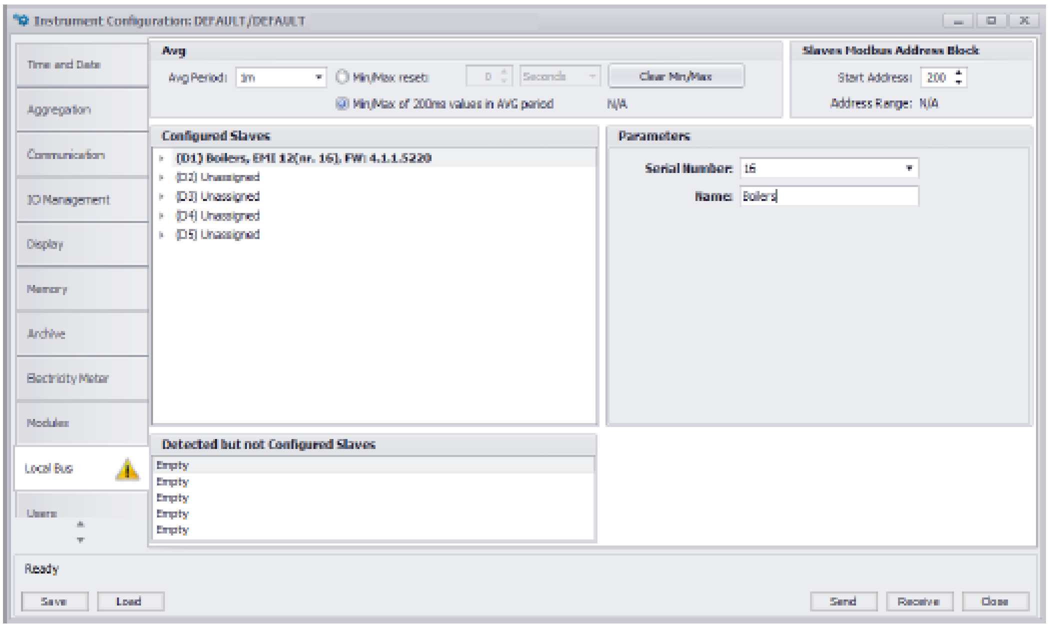


Figure 39: ServiceTool-Daq - Local Bus Config, Configuring of a Slave, Step 4

Now the slave is renamed *Boilers*. In addition to the name, the following information is displayed for each configured slave:

- Slave type and serial number (EMI 12(no. 16))
- Firmware no. of slave (FW: 4,1,1,5220)

Next, the feed of the slave must be set. Click on the triangle in front of slave D1 and select feed F1:

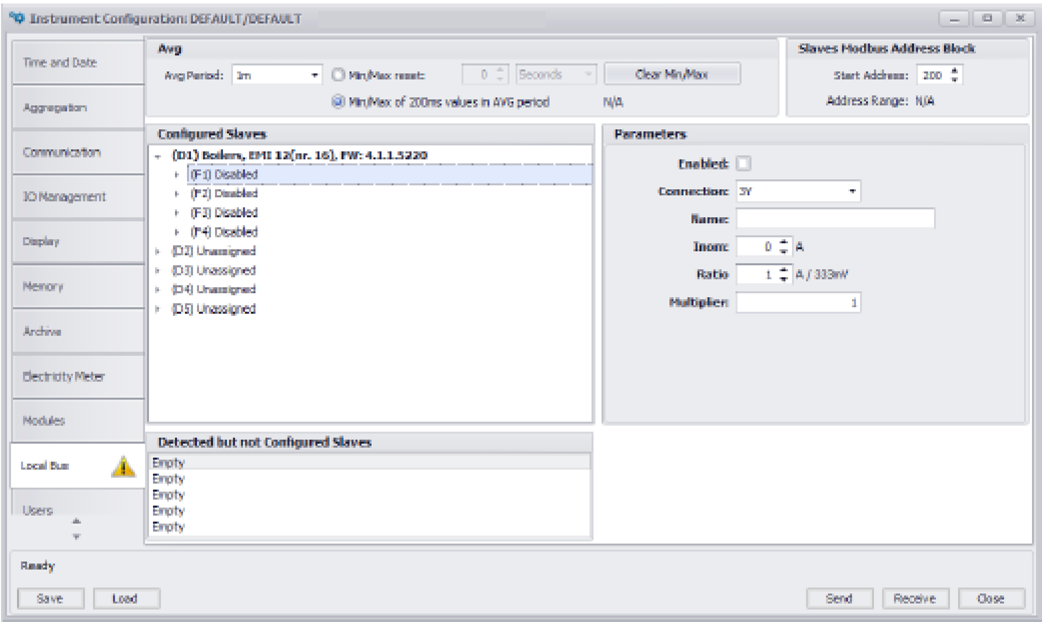


Figure 40: ServiceTool-Daq - Local Bus Config, Configuring of a Slave, Step 5

As you can see, all feeds and measurements are disabled by default. To start a measurement, each feed must first be activated in the *Parameters* block - check the corresponding box.

Then set the other parameters of the feed (see below for the overview of the parameters), as in the following example:

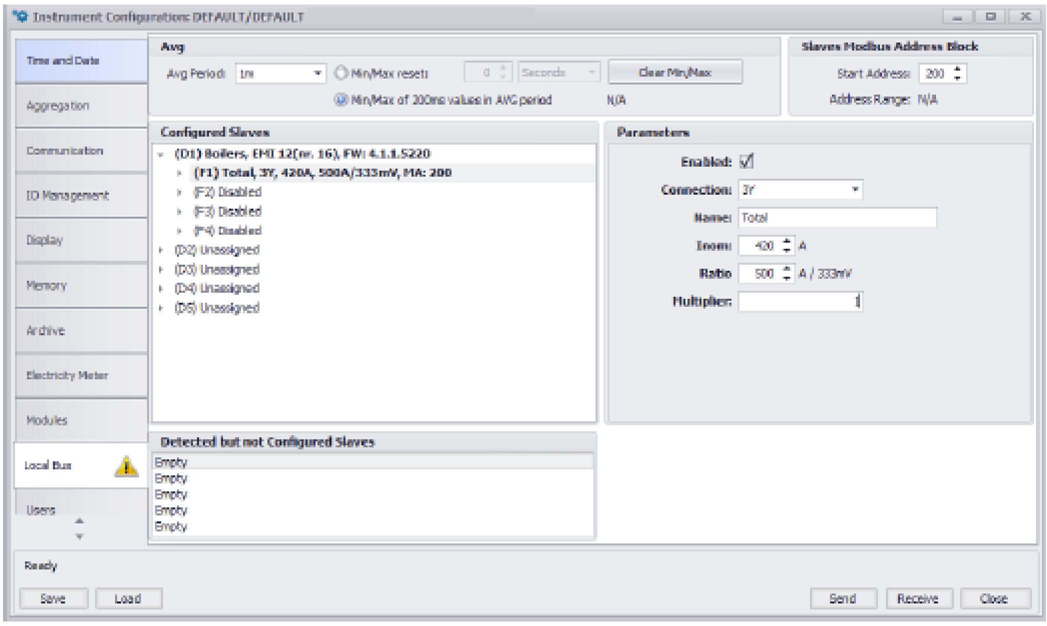


Figure 41: ServiceTool-Daq - Local Bus Config, Configuring of a Slave, Step 6

In three-phase networks (connection types 3Y, 3D or 3A), the phase currents of the individual feeds must be connected to the current expansion modules 37100 with the correct polarity and sequence (L1 - L2 - L3), i.e. according to the sequence of the phase voltage of the master (power analyser 37010). Otherwise, the determined power values and power factors will be falsified.

!

To keep order during installation, it is recommended to reconnect the power inputs if they do not match the order of the voltages. If this is difficult or impossible, you can solve the problem of the so-called "channel setting" - see detailed description below.

In the example shown, the most common connection type 3Y is selected. If you want to set a different type, you will find a detailed description below in the parameter overview.

You can also set other feeds of the slave in the same way. Then send the setting with *Send* and read it with *Receive*. This can look like this:

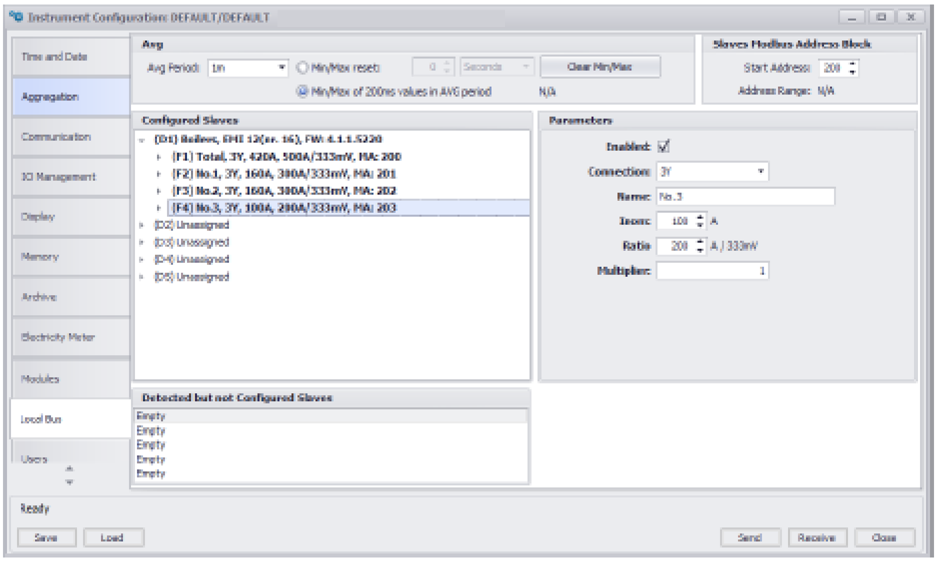


Figure 42: ServiceTool-Daq - Local Bus Config, Configuring of a Slave, Step 7

Other slaves can set them similarly when they have been recognised.

7.3.1 Local bus parameter overview

The *Local Bus* tab window consists of five blocks:

7.3.1.1 „Averaging“ block

- **AVG Period** Averaging Depth
- **Reset Min/Max** Method for resetting the registered minima and maxima

7.3.1.2 "Slaves Modbus Address Block" block

- **Start Address** If the data of the power extension modules 37100 are to be read by a third-party device/PC, any suitable interface of the master (power analyser 37010) that supports the Modbus protocol can be used. With the Start Address, you can set the Modbus address of the data block of the first feed from the first configured current expansion module 37100 (= slave). The data blocks of the next feeds can be read from consecutive addresses.
  For example, the data block of the first feed of the first current expansion module 37100 may start at address 200; the next feeds of the same module at 201, 202, and 203; the first feed of the second module at address 204, and so on.
  If the data of the current expansion modules 37100 are only shown on the display of the master and/or in the Wöhner ServiceTool, the value of this parameter is not relevant.

7.3.1.3 Configured slaves block

Contains the tree structure of the already set (= configured) modules.
On the top level, there are five positions for up to five current expansion modules 37100, identified as D1 to D5. After the first installation, the modules are not yet configured - therefore the positions are specified as *Unassigned*.
As soon as one of the *detected slaves* is converted to a *configured slave* by selecting its serial number in the *Parameters* block, it appears in the *Configured Slaves* block. Now you can set its *name* - it also appears in this block. Then send the settings with the new name to the master using the *Send* button and read them back using the *Receive* button. The information then appears behind the name of the slave:

- Slave type (model)
- Serial number
- Firmware version

Under each slave there are four positions for three-phase feeds, marked F1 to F4 (to display these, click on the triangle in front of the respective position). As long as they are not activated, they are marked as *Disabled*. Consequently, the slave does not measure the feeds.
After selecting a feed, you can set the following:

- **Enable** (or Disable) the feed-in
  Activates/deactivates the selected feed or channel. If a feed (or a channel) is deactivated, no measurement is performed. Deactivate the feed (or channel) when not in use.
- **Name**
  Sets the name of the slave, feed or channel. It is mainly used for easier orientation in the measurement data.
- **Connection type**
  Sets the connection type of the selected feed. Available three-phase connection types: Star (**3Y**), Triangle (**3D**) and Aron (**3A**).
  It is also possible to use the **3*1Y** mode, which allows the measurement of three independent single-phase currents.
  Feeder F4 can also be used to measure the neutral currents of feeders 1 to 3. In this case, select the **3*In** mode.
- **Inom**
  Sets the nominal current of the selected feed **(3Y**, **3D**, **3A, 3*In**) or channel (**3*1Y)**.
- **CT ratio**
  Sets the transformation ratio of the current transformers of the selected feed or channel.

- **Current multiplier**
  Sets the current multiplier of the selected feeder or channel (to correct the measured value, e.g. in case of current transformers with multiple windings). The default value is 1.

These parameters, including the Modbus Address (MA) of the respective data block (see setting in the *Slaves Modbus Address Block*), appear in the line of the corresponding feed in the *Configured Slaves* block.

Depending on the connection type, you can use other feed options. Three "channels" CH1 to CH3 appear when you click on the triangle in front of the feed:

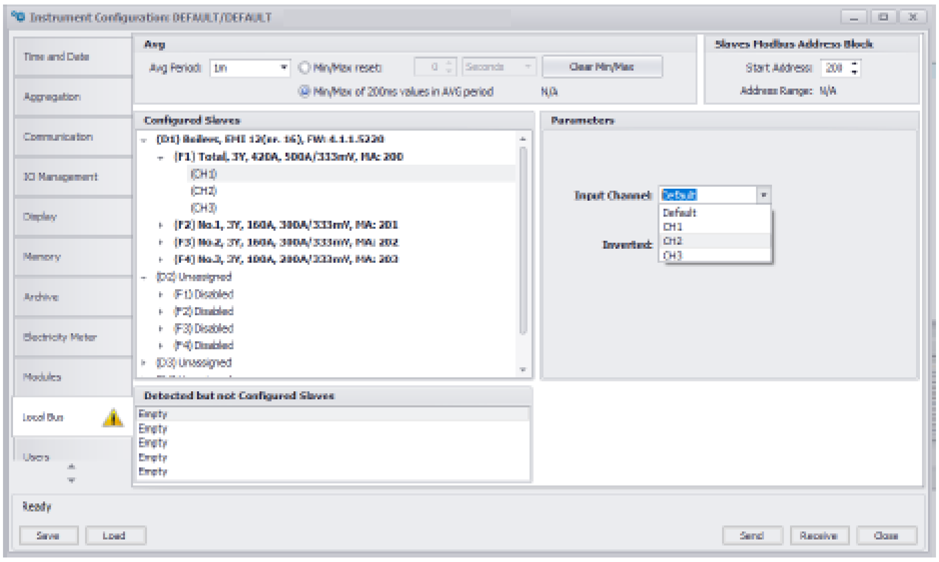


Figure 43: ServiceTool-Daq - Local Bus Config, Feeder Channel Option

The channels correspond to the feed-in currents. After selecting a current channel, you can:

- Change the phase sequence of the currents. For example, if the current inputs of phases L1 and L2 were accidentally connected incorrectly to the 37100 current expansion module, you can switch them to the correct position without having to reconnect them using the setting shown below.
- If the current input L3 is connected with opposite polarity, this can be easily corrected by activating the Inverted check box (see below).

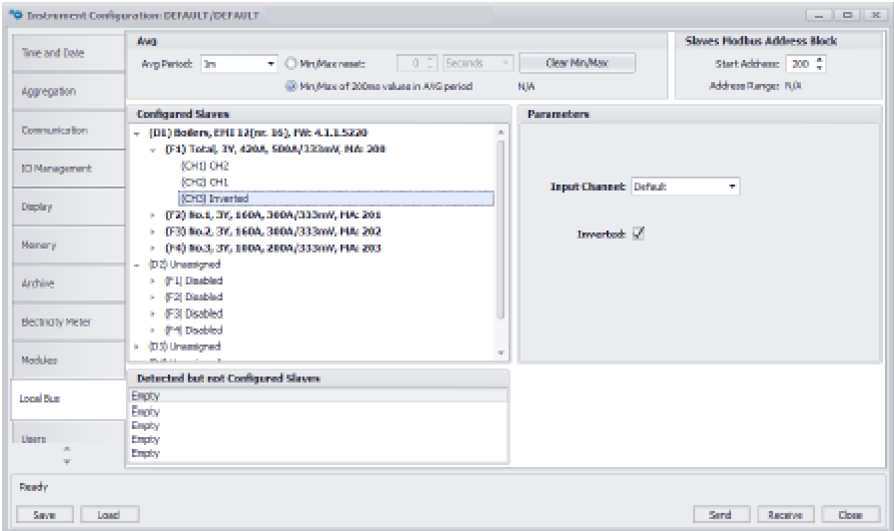


Figure 44: ServiceTool-Daq - Local Bus Config, Feeder Channel Change

If single-phase currents are connected to the feeder, the feeder connection type must be set to **3*1Y** mode. Then the setting of the feed is different:

- The name of the feeder does not exist, but you can define the *name* of the individual channels (currents) - *Light1*, *Light2* and *Wallsocket* in the example below.
- For each channel (= current), the so-called *assigned voltage* (of the master) must be set. It determines the reference voltage channel of the master that is used to evaluate the power and the power factor of the channel. For example, if the currents of channels CH1 (*Light1*) and CH2 (*Light2*) are fed by voltage L1, their assigned voltages must be set accordingly; the assigned voltage of channel CH3 (W*allsocket)* is set to L2, as the channel is supplied by this voltage.

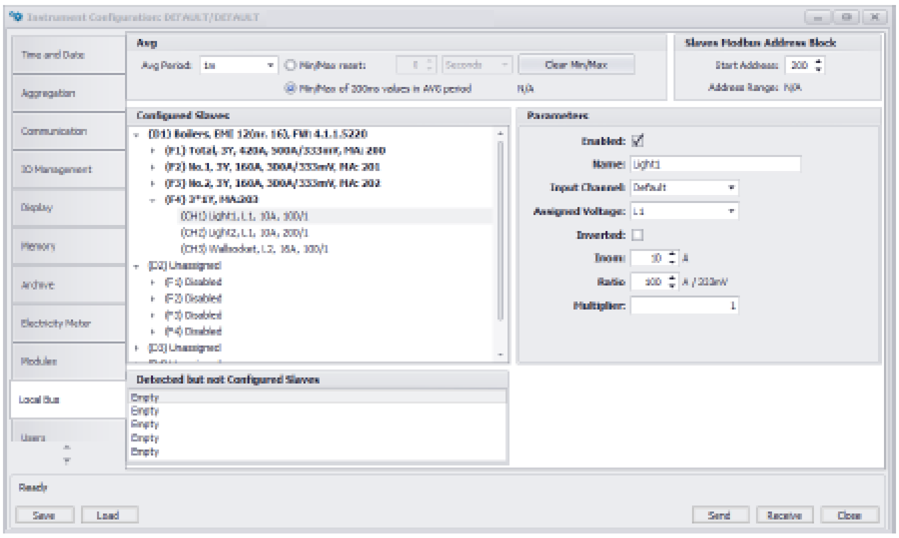


Figure 45: ServiceTool-Daq - Local Bus Config, Single Phase Channels

7.3.1.4 Detected but not configured slaves block

Contains a list of recognised modules that are not yet prepared for use (*not configured*)
Each slave occupies one line and reflects its type, serial number and firmware version.
If less than a maximum of five slaves have been detected, the remaining lines are reported as *Empty*.

7.3.2 Autodetect option

The *Autodetect* option can simplify the configuration of the slaves. It allows configured slaves to be automatically arranged in the desired order.
The master constantly monitors the Local Bus. As soon as the master detects a new slave, it normally only lists the slave in the *Detected but not Configured Slaves* block and waits for the next commands.
However, if any position in the *Configured Slaves* block is set to *Autodetect* mode, when a new slave is detected, it is automatically paired with the first position that is currently in *Autodetect* mode. The slave takes this position and is thus configured. At the same time, the *Autodetect* mode of this position is cancelled.
The procedure works as follows:

1. Disconnect all slaves from the master by unplugging the Local Bus cable. Read the new status of the master by pressing the *Receive* button - then the message *Empty* (no slave detected at the moment) appears in all five lines of the block *Detected but not Configured Slaves*.
2. Select positions D1 to D5 in the *Configured Slaves* block step by step and activate the *Autodetect* mode (see below). Then send these settings to the master (*Send*) and read out the current status (*Receive*). The situation should look like this:

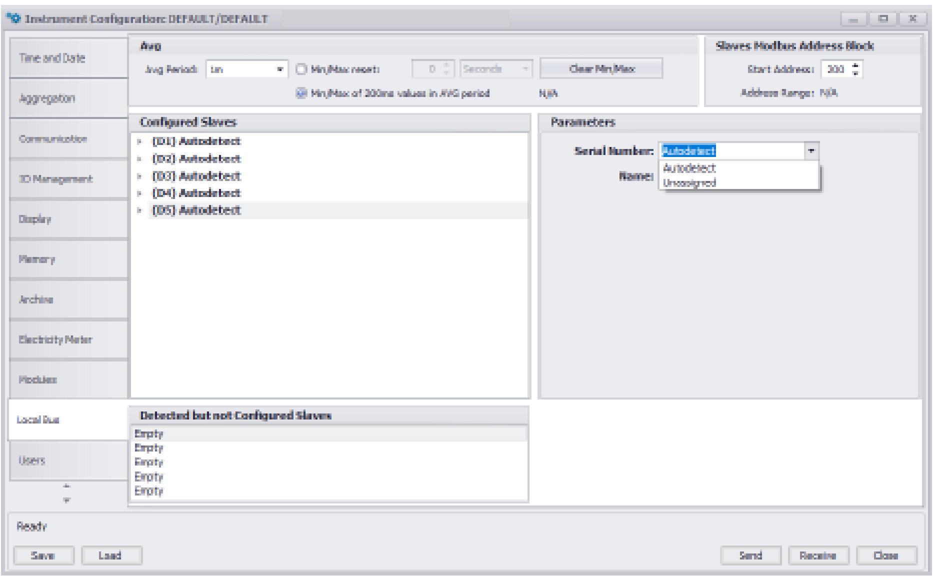


Figure 46: ServiceTool-Daq - Local Bus Config, Autodetect Mode, Step 1

3. Now connect the slave that is to take the position D1 in the list to the Local Bus and check the corresponding LED displays.
4. Read out the new status of the master with the *Receive* button.

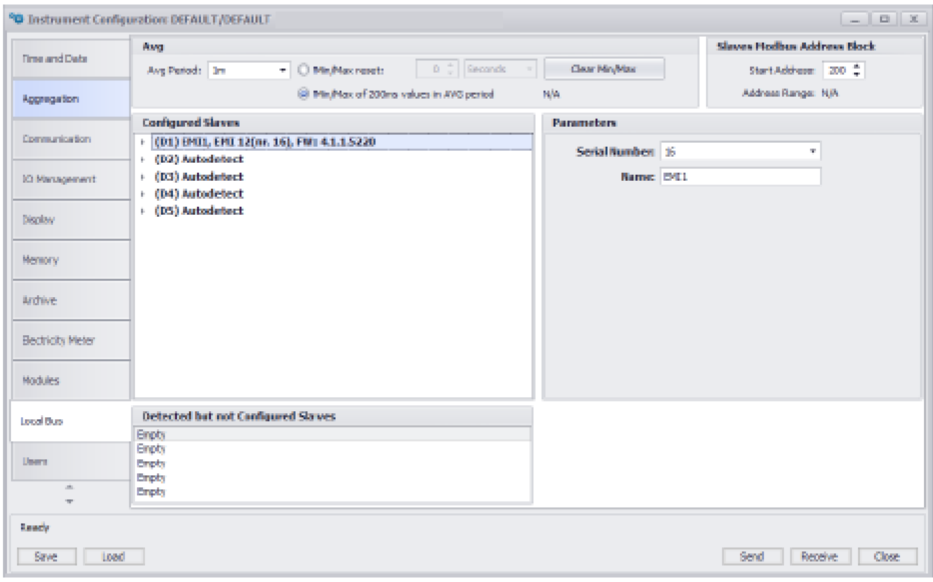


Figure 47: ServiceTool-Daq - Local Bus Config, Autodetect Mode, Step 2

5. Repeat steps 3 and 4 until all slaves have been added.

Reading out the new status of the master after connecting each slave (as described in step 3) is not necessary. You can simply connect the slaves one after the other and check the status of the master with the *Receive* button at the end.
After all slaves have been added to the *Configured Slaves* block, set all necessary parameters of all slaves and send these settings to the master with the *Send* button.

7.4 Display of the measurement data

7.4.1 ServiceTool DAQ application

Click on the *EMI Act* tab in the current data window. On the panel you can check the current data of the individual 37100 power extension modules. The feeds are arranged from top to bottom in the order of the *Configured Slaves* block.

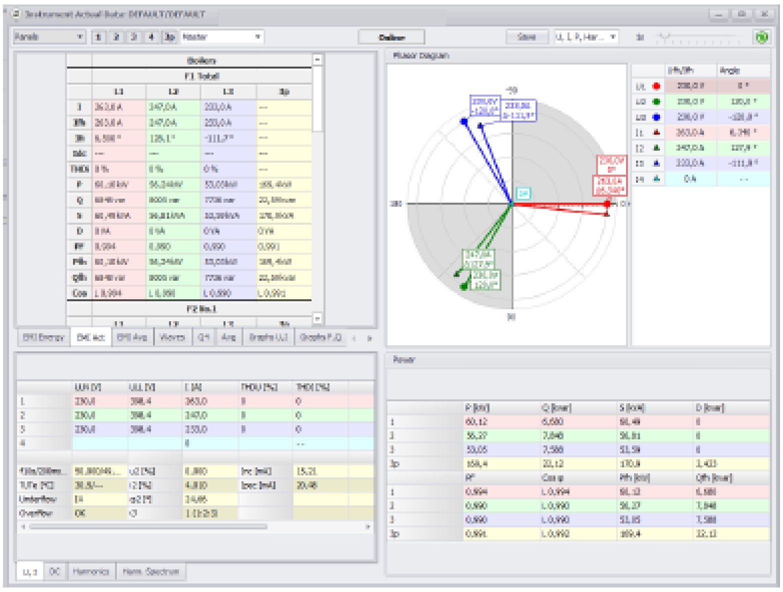


Figure 48: ServiceTool-Daq - Actual Data of Local Bus Module

If several modules are installed, their data is arranged in the columns to the right of the previous module. In the same way, you can check the average values of the measured variables in the *EMI Avg* tab. In addition to the average values, you can also check their recorded minima and maxima. The selection is made with the button in the upper left corner of the tab.

Finally, the corresponding energies are entered in the *EMI Energy* tab.

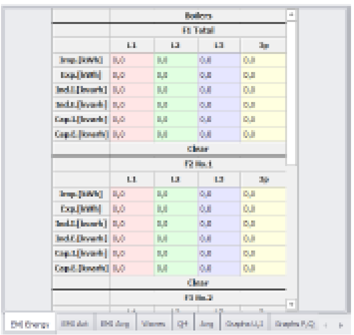


Figure 49: ServiceTool-Daq - Energies of Local Bus Module

The energy meters are processed and secured in the power extension modules 37100. Below the respective feed-in data is the *Clear* button, which can be used to clear the feed-in counters individually.

To check the measuring function of the current expansion modules 37100 already during installation, not only the data columns of the configured modules but also those of the detected modules are displayed.

7.4.2 Device display

Power analysers 37010 equipped with the Local Bus interface have a special icon in the main menu. This allows you to check actual, average and energy data of the modules connected to the Local Bus.

Any of the screens described below can be inserted between the user screens - see above chapter Main Data Group.

7.4.2.1 Local bus actual & average values

The actual/average values of the variables, measured in numerical form by the modules connected to the Local Bus, are arranged in the groups.

Screens with current data are shown below:

Figure 50: Actual values of the Local Bus modules on the display

On the first screen there is a list with the data groups of the measured variables. It consists of two parts:

- Data grouped by quantities ...

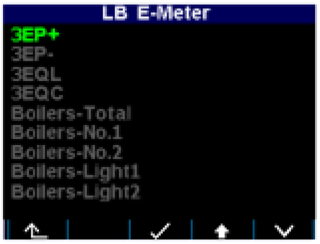
  I, I_{NC}, I_{PEC}, I_{DC}, THDi, P, Q, S, D und PF. Each of these groups contains the values of the selected measured variable of all modules connected to the Local Bus.
- Data grouped by feed ...

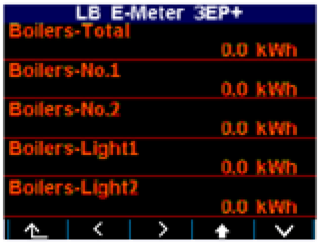
  These groups are labelled with the names of the feeds (in our example Boilers-Total) and each group contains a summary of the values of all measured variables of the selected feed.

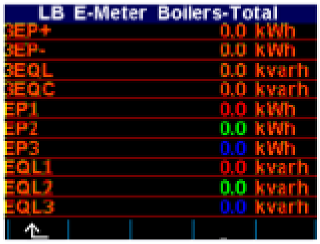
You can navigate through the average-data screens in the same way. They contain average values of the Local Bus modules, which are aggregated in the same way as the average values of the master unit itself.

7.4.2.2 Local bus energy data

Each of the modules connected to a Local Bus also evaluates the energy meters. Their current values are arranged in the same way as the actual and average values described above.







To delete the energy meters of the individual feeders, use the ServiceTool-DAQ application.

8 Computer-controlled operation

Monitoring of the currently measured values and the unit setup can be done not only via control panel, but also via a local or remote computer connected to the unit via a communication link. Such operation is not only more convenient, but also allows you to use all the unit's options, such as setting the inputs/outputs or setting up and monitoring histories recorded in the unit's internal memory, which is not possible from the unit's control panel.
The following chapters describe the communication connections only from the aspect of the software and the integrated web server.

8.1 Communication links

8.1.1 Local communication links

The meter is equipped with a USB 2.0 serial interface on the front panel. This interface can be used to set the unit parameters and transfer data to a portable computer. To do this, the unit must be connected to the PC using the appropriate communication cable (type USB-A - mini B, see list of optional accessories).
Considering that the unit is also equipped with a remote communication link, the communication link described is referred to as *Local*.

8.1.2 Long-distance communication links

The unit is equipped with a remote communication link and Ethernet interface to enable it to be operated from a remote computer. Subsequently, remote adjustment of the unit and transfer of current or recorded data can be performed from this computer.
The cable for the remote communication connection is to be provided by the customer.
One or more units can be connected to the remote PC via this connection. Each unit must have a properly set up remote communication address and protocol. These specifications can be set manually or by computer via a local communication link in the ServiceTool.
The remote communication link is always isolated from the unit's internal electronics.

8.1.2.1 Ethernet interface (IEEE802.3)

The unit can be connected directly to a local computer network (LAN) via this interface. The meter is equipped with a corresponding RJ-45 connector with eight signals (according to ISO 8877), where one physical layer corresponds to 100 BASE-T.
The type and maximum length of the required cable must comply with IEEE 802.3.
Each unit must have a different IP address, which is preset during installation. The address can be set from the control panel or with the ServiceTool-DAQ. You can use the *Locator* function to determine the current IP address.
In addition, you can set the DHCP function for dynamic IP address assignment.

8.2 Communication protocols

The parameters of the remote communication connection must be set according to the chapter *Setting the remote communication* - see above.

8.2.1 KMB communication protocol

This manufacturer-specific protocol is used for communication with the ServiceTool.

8.2.2 Modbus RTU communication protocol

For easier integration of the unit into the user's programme, the unit is additionally equipped with the Modbus RTU communication protocol. A detailed description of the communication settings can be found in a corresponding manual.

8.3 Integrated web server

The 37010 panel meter is equipped with an integrated web server so that all essential measured values as well as the unit settings can be viewed with a standard web browser. To do this, it is necessary to set the remote communication parameters of the unit correctly and connect the unit to the network. Then enter the corresponding IP address of the unit in the web browser, and the information about the unit appears.

9 Firmware extension modules

The standard firmware contains specific modules with additional functions. In order to use the modules, they must first be activated. For an activation code, please contact the manufacturer of your device or our sales department directly.

9.1 Power quality module PQ S

Units with activated PQ S module measure power quality according to EN 50160. This enables the use of certain functions in the power analyser that are required for monitoring power quality: Flicker, inter-harmonics and voltage events as defined in EN 50160, IEC EN 61000-4-30, -4-7 and -4-15. In addition, this module activates the secondary archive - the PQ main archive that contains aggregated values in the desired interval. The module also adds an archive of voltage events that contains start and end times as well as extreme values of all recorded voltage fluctuations.

Netzqualität

PQ-Spannungsereignisse

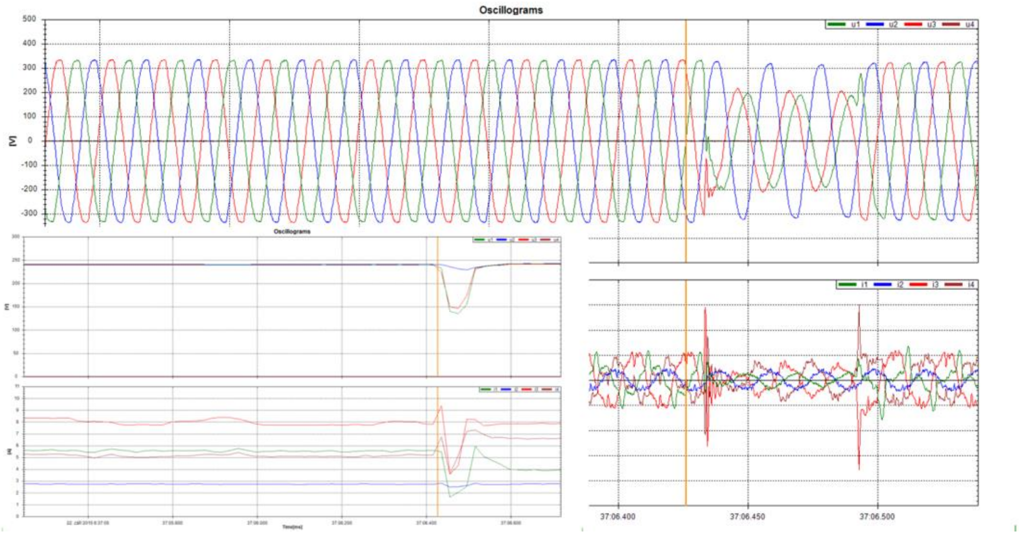
Zeit					
Startzeit	Dauer[s]	Datensatzzeit	Phase	Typ	Max[V]
11.04.2017 13:33:08	20h 9m	12.04.2017 09:42:21	3p: 2 3	Spannungsunterbrechung	0,375
12.04.2017 09:42:21	150ms	12.04.2017 09:42:21	3p: 1	Überspannung	298,2
14.04.2017 18:47:23	80ms	14.04.2017 18:47:23	3p: 3	Unterspannung	196,3
15.04.2017 06:15:56	50ms	15.04.2017 06:15:56	3p: 3	Unterspannung	204,3
17.04.2017 08:27:01	60ms	17.04.2017 08:27:01	3p: 1	Unterspannung	197,2
19.04.2017 14:09:30	11s 580ms	19.04.2017 14:09:42	3p: 2 3	Unterspannung	67,29
19.04.2017 14:09:42	20ms	19.04.2017 14:09:42	3p: 3	Unterspannung	168,2
20.04.2017 06:16:15	113ms	20.04.2017 06:16:15	3p: 1 2 3	Unterspannung	179,6
21.04.2017 06:44:45	110ms	21.04.2017 06:44:45	3p: 2 3	Unterspannung	189,0
25.04.2017 04:56:13	100ms	25.04.2017 04:56:13	3p: 1	Unterspannung	197,8
03.05.2017 13:26:26	9s 883ms	03.05.2017 13:26:36	3p: 2 3	Unterspannung	61,21
03.05.2017 13:26:36	50ms	03.05.2017 13:26:36	3p: 3	Unterspannung	64,63
03.05.2017 13:26:37	20ms	03.05.2017 13:26:37	3p: 3	Unterspannung	194,0
03.05.2017 13:26:37	20ms	03.05.2017 13:26:37	3p: 3	Unterspannung	200,9

PQ Hauptarchiv

Zeit	U			Frequenz	Oberwellen			Oberwellen/Uh							
					THDU			U1							
Datensatzzeit	U1[V]	U2[V]	U3[V]	f[Hz]	THDU1[%]	THDU2[%]	THDU3[%]	h,1[V]	h,2[mV]	h,3[mV]	h,4[mV]	h,5[V]	h,6[mV]	h,7[V]	h,8[mV]
17.04.2017 00:10:00	228,1	226,5	227,5	49,98	2,096	2,087	1,883	228,0	97,74	895,5	31,18	3,998	111,2	1,915	41,28
17.04.2017 00:20:00	228,6	227,0	228,3	50,01	2,039	2,041	1,823	228,5	97,96	873,2	30,34	3,900	100,9	1,845	39,08
17.04.2017 00:30:00	228,8	227,1	228,3	50,03	2,009	2,009	1,798	228,8	99,23	874,6	29,35	3,834	77,70	1,825	47,39

9.2 Module "General Oscillogram"

This module extends the possibility to record detailed oscillographic events in the internal memory.
For more details, see the application note *Firmware Module General Oscillogram*.



10 Connection examples

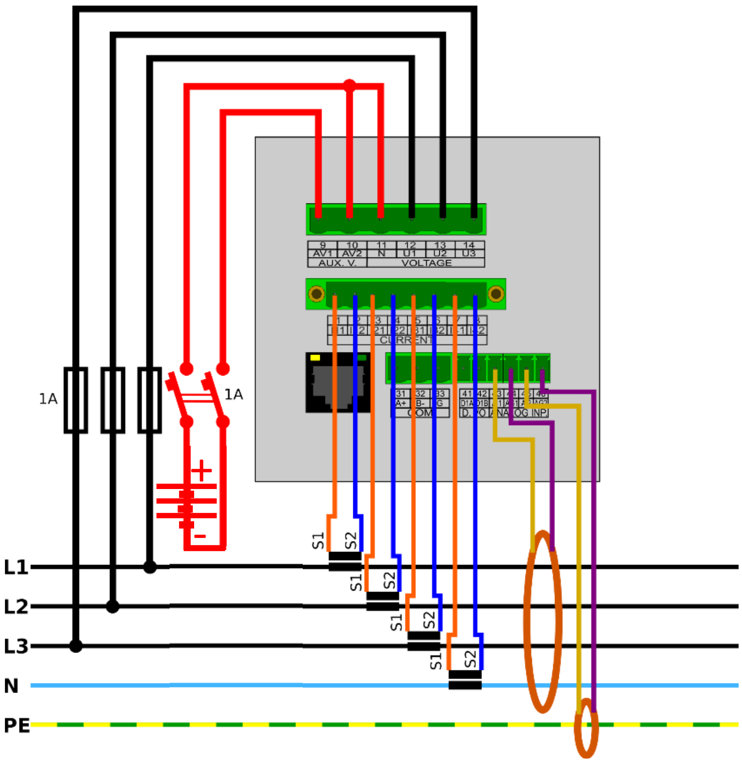


Figure 51: Connection using current transformers with 5A rated output and fault current monitoring

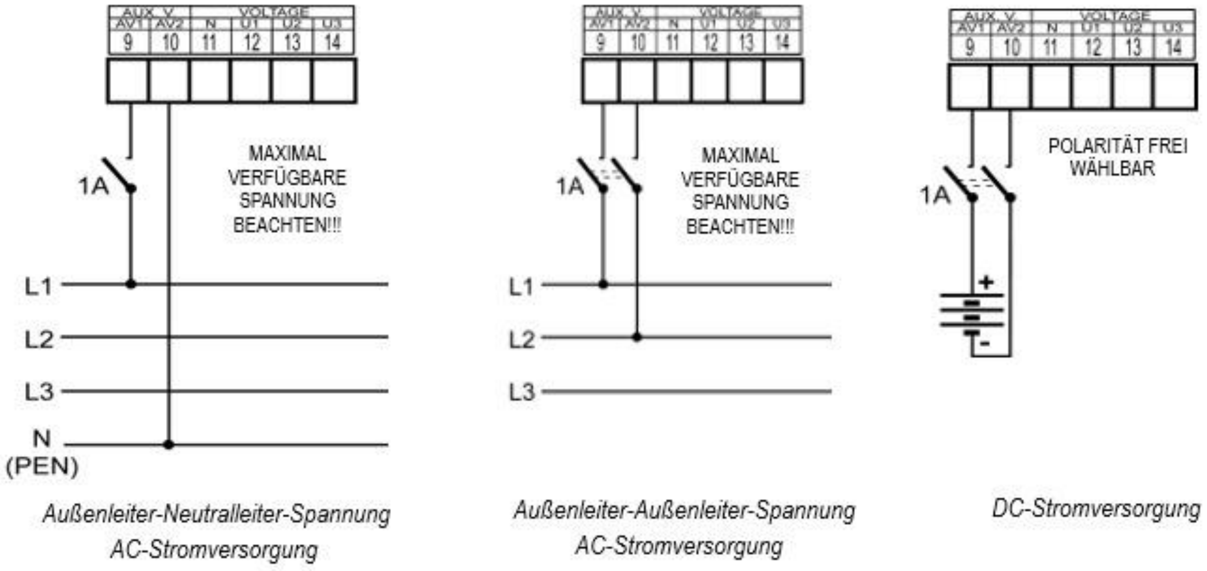


Figure 52: Power supply options

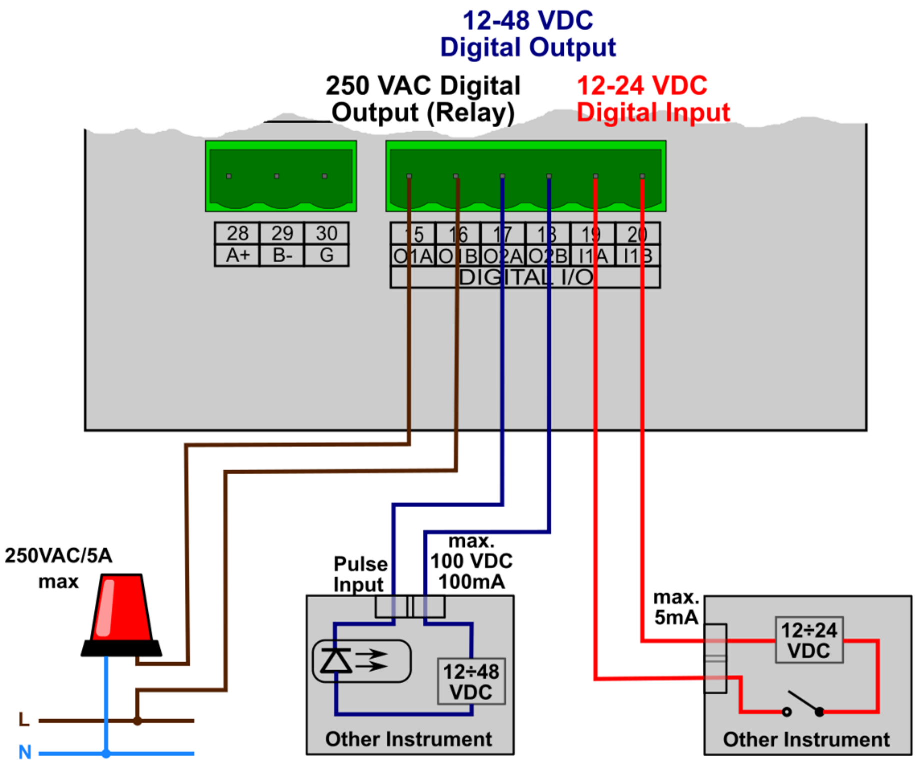


Figure 53: Digital I/O connection example

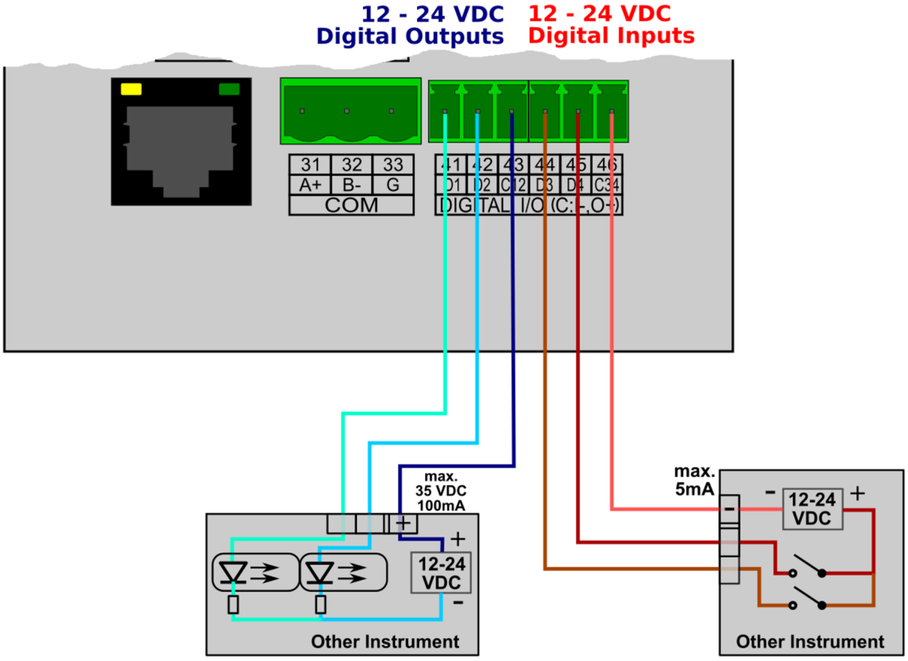


Figure 54: Digital I/O connection example

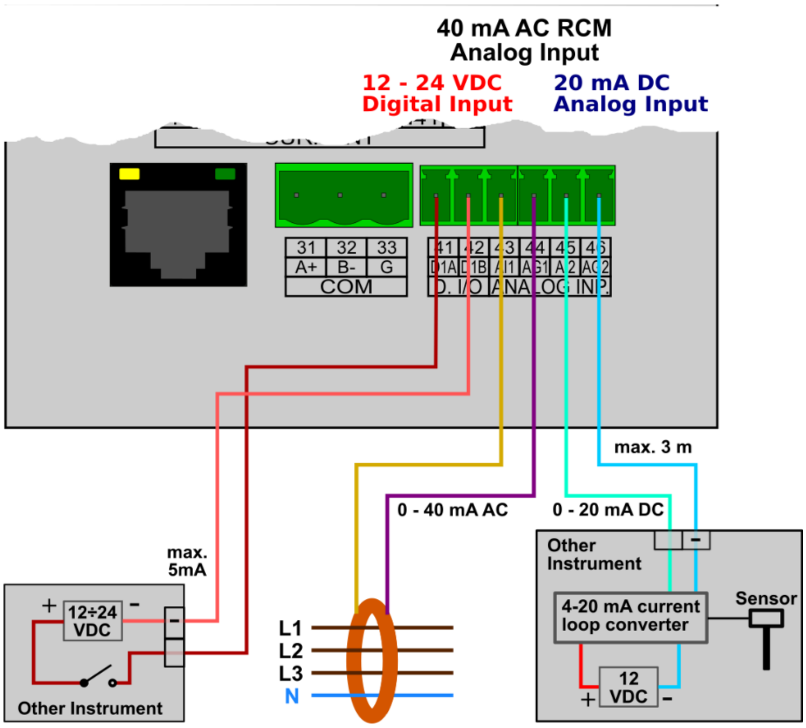


Figure 55: I/O connection example: 1x digital input, 1x RCM, 1x 20 mA analogue input

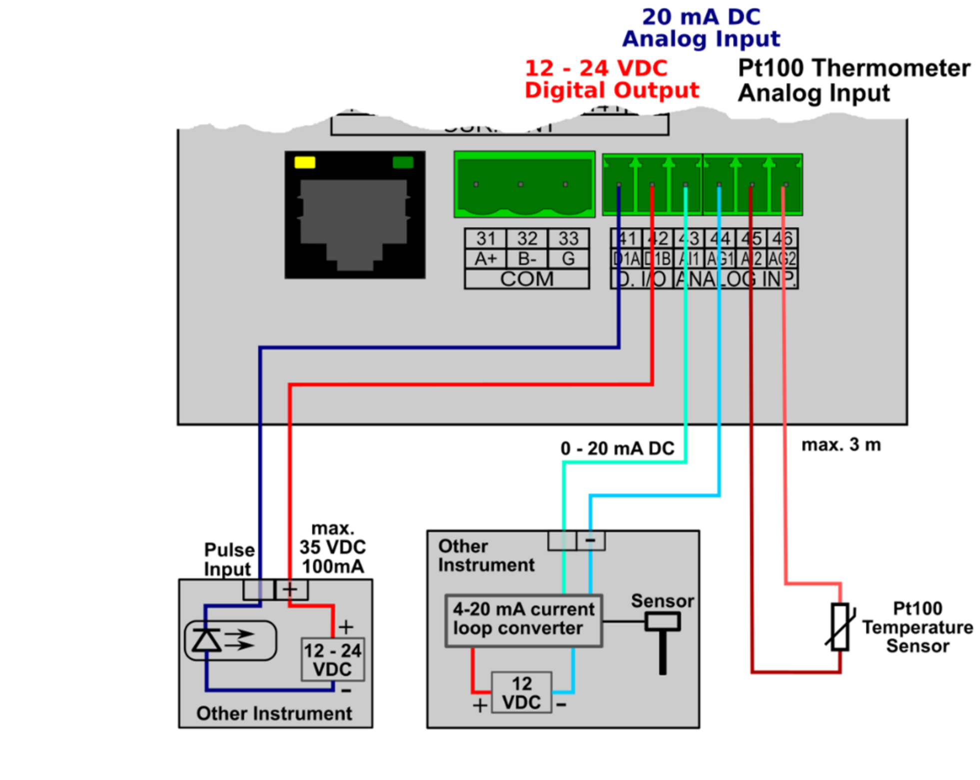


Figure 56: I/O connection example: 1x digital input, 1x RCM, 1x Pt100 thermometer

Figure 57: RS-485 wiring of the communication link

Table 5: Numbering of the terminals - measuring and power supply inputs

Signal	Terminal no.
AV1	9
AV2	10
U1	12
U2	13
U3	14
N	11
I11	1
I12	2
I21	3
I22	4
I31	5
I32	6
I41	7
I42	8

Table 6: Numbering of the terminals - I/O

Signal	Terminal no.
D1A	41
D1B	42
IΔ11	43
IΔ12	44
T+	45
T-	46

11 Technical data

Accuracy classes* specified in IEC 61557-12	
Voltage:	Cl. 0.1
Current:	Cl. 0.1
Frequency:	Cl. 0.02
Active power:	Cl. 0.2
Reactive power:	Cl. 0.5
Apparent power:	Cl. 0.2
Harmonics:	Cl. 2
Power factor:	Cl. 0.5
cos phi:	Cl. 0.5
Active work:	Cl. 0.2
Reactive work:	Cl. 0.5
Apparent work:	Cl. 0.2

* Measurement uncertainties under certain ambient conditions are listed separately for the following measurands.

Device characteristics according to IEC 61557-12	
Power quality assessment function	PQI-S
Classification according to Par. 4,3 **Direct voltage connection** **Voltage connection via VT**	 SD SS
Temperature according to par. 4,5,2,2	K55

Relative humidity and altitude according to par. 4,5,2,3	< 95 % - non-condensing conditions < 3000 m
Active power/energy function performance class	0.5

Functional characteristics in accordance with IEC 61000-4-30 edition 2				
Function	Class	Uncertainty	Measuring range	Notes
Frequency	A	± 10 mHz	40 – 70 Hz	
Magnitude at supply	S	± 0,1 % U_{din}	20 – 120 % U_{din}	
Flicker	S	± 5 % of reading or ±0.05	0.4 – 10	2, 4)
Dips and swells	S	± 0.5 % U_{din}, ± 1 cycle	5 – 120 % U_{din}	2)
Interruptions	S	± 1 cycle	unlimited	2)
Unbalance	S	± 0.3 %	0.5 – 10 %	
Voltage harmonics and interharmonics	S	Twice as high as class II according to IEC 61000-4-7 edition 2	10 - 100 % of class 3, according to IEC 61000-2-4 edition 2, up to the 50th order	1)
Line signal voltage	S	Twice as high as class II according to IEC 61000-4-7 edition 2	0 – 20 % U_{din} f_{Msv}: 100 - 3000 Hz	1, 3)

Notes: 1) according to IEC 61000-4-7 edition 2

2) with optional firmware module "PQ S”

3) with optional firmware module "RCS”

4) Class F3 according to IEC 61000-4-15 edition 2.0

Measured variables - Voltage *)	
Frequency	
f_{NOM}– Nominal frequency	50/60 Hz
Measuring range	40 – 70 Hz
Uncertainty of measurement	± 10 mHz
Voltage	
Model	„230“
U_{NOM} (U_{DIN}) - Rated voltage (phase-to-neutral, U_{L-N})	180 – 250 V_{AC}
Crest factor @U_{Nom}	2.1
Measuring range U_{L-N}	6 – 375 V_{AC}
Measuring range U_{L-L}	8 – 660 V_{AC}
Uncertainty of measurement (tA=23±2°C)	+/- 0.05 % of reading +/- 0.02 % of reading
Temperature drift	+/- 0.03 % of reading +/- 0.01 % of reading/10 °C
Measurement category	300 V CAT III
Permanent overload	600 V_{DC}
Peak overload ($U_{L–N}$/1 s)	1200 V_{DC}
Burden (rated power) **Impedance**	< 0.025 VA Ri = 3.6 MΩ
Voltage unbalance	
Measuring range	0 – 10 %
Uncertainty of measurement	± 0.3
Harmonics and interharmonics (up to the 50th order or the 40th order at 60 Hz)	
Reference conditions	Other harmonics up to 200 % of class 3 according to IEC 61000-2-4 issue 2,
Measuring range	10 - 100 % of class 3 according to IEC 61000-2-4 edition 2,
Uncertainty of measurement	Twice as much as class II according to IEC 61000-4-7 issue 2,
THDU	
Measuring range	0 – 20 %
Uncertainty of measurement	± 0.5

Note *): The quantities and their measurement uncertainties apply to f_{NOM} = 50/60 Hz. For f_{NOM} = DC - 500 Hz ("Fixscan" mode) see separate table below.

Measured variables - current *)	
Model	„X/5A “
INOM (IB) – Rated current	1/5 AAC
Crest factor @I_{Nom}	Default: 2.0
Measuring range Default	0.005 - 7 AAC
Uncertainty of measurement (tA = 23±2°C)	+/- 0.05 % of reading +/- 0.02 % of reading
Temperature drift	+/- 0.03 % of reading +/- 0.01 % of reading/10 °C
Measurement category	150V CAT III
Permanent overload	7.5 AAC
Peak overload - for 1 second, max. repetition frequency > 5 minutes	70 AAC
Burden power (impedance)	< 0.5 VA (Ri < 10 mΩ)
Current unbalance	
Measuring range	0 – 100 %
Uncertainty of measurement	± 1 % of reading or ± 0.5
Harmonics and interharmonics (up to the 50th order or the 40th order at 60 Hz)	
Reference conditions	Other harmonics up to 1000 % of class 3 according to IEC 61000-2-4 edition 2
Measuring range	500 % of class 3 according to IEC 61000-2-4 edition 2,
Uncertainty of measurement	Ih <= 10 % INOM: ± 1 % INOM Ih > 10 % INOM: ± 1 % of reading
THDI	
Measuring range	0 – 200 %
Uncertainty of measurement	THDI <= 100 %: ± 0.6 THDI > 100 %: ± 0.6 % of reading value

Note *): The quantities and their measurement uncertainties apply to f_{NOM} = 50/60 Hz. For f_{NOM} = DC - 500 Hz ("Fixscan" mode) see separate table below.

Measured quantities - power, power factor, energy *)	
Active/reactive power, power factor (PF), cos φ (P_{NOM} = U_{NOM} x I_{NOM})	
Reference conditions "A": **Ambient temperature (t_A)** **U, I** **for active power, PF, cos φ** **for reactive power**	 23 ± 2 °C U = 80 – 120 % U_{NOM}, I = 1 – 120 % I_{NOM} PF = 1.00 PF = 0.00
Active / reactive power uncertainty	± 0.5 % of reading ± 0.005 % P_{NOM}
PF and cos φ uncertainty	± 0.005
Reference conditions "B”: **Ambient temperature (t_A)** **U, I** **for active power, PF, cos φ** **for reactive power**	 23 ± 2 °C U = 80 – 120 % U_{NOM}, I = 1 – 120 % I_{NOM} PF <= 0.87 PF <= 0.87
Active / reactive power uncertainty	± 1 % of reading ± 0.01 % P_{NOM}
PF and cos φ uncertainty	± 0.005
Temperature drift of the power readings	+/- 0.05 % of reading +/- 0.02 % P_{NOM} /10 °C
Energy	
Measuring range	Corresponds to the U and I measuring ranges Four-quadrant energy meter for active and reactive energies

Note *): The quantities and their measurement uncertainties apply to f_{NOM} = 50/60 Hz. For f_{NOM} = DC - 500 Hz ("Fixscan" mode) see separate table below.

"FIXSCAN" mode - measurement uncertainties f_{NOM} set to "DC-500” Frequency range: 350 – 450 Hz	
Frequency	
Uncertainty of measurement	± 0.1 Hz
Voltage	
Uncertainty of measurement	+/- 0.2 % of reading +/- 0.1 % of reading
Current	
Uncertainty of measurement	+/- 0.2 % of reading +/- 0.1 % of reading
Active/reactive power, power factor (PF), cos φ (P_{NOM} = U_{NOM} x I_{NOM})	
Reference conditions "A": **U, I** **for active power, PF, cos φ** **for reactive power**	 U = 80 – 120 % U_{NOM}, I = 1 – 120 % I_{NOM} PF = 1.00 PF = 0.00
Active / reactive power uncertainty	± 0.5 % of reading ± 0.01 % P_{NOM}
PF and cos φ uncertainty	± 0.01
Reference conditions "B”: **U, I** **for active power, PF, cos φ** **for reactive power**	 U = 80 – 120 % U_{NOM}, I = 1 – 120 % I_{NOM} PF >= 0.5 PF <= 0.87
Active / reactive power uncertainty	± 2 % of reading ± 0.1 % P_{NOM}
PF and cos φ uncertainty	± 0.02

Measuring devices auxiliary power supply	
Model	“L “
Nominal auxiliary voltage range	23 – 68 VAC
Auxiliary voltage range **AC: f = 40 – 100 Hz;** **DC:**	 20 – 50 VAC 20 – 75 VDC
Power	8 VA/4 W
Overvoltage cat.	III
Degree of contamination	2
Connection	isolated, polarity-free

Measured variables - temperature	
TI - (internal sensor, measured value is influenced by the power loss of the unit)	
Measuring range	- 40 – 80 °C
Uncertainty of measurement	± 2 ºC
TE - External Pt100 temperature sensor input	
Measuring range	- 50 – 150 º
Uncertainty of measurement	± 2 ºC
Notes	- The external temperature input is neither isolated from the unit's internal circuitry nor from the residual current input. - As the terminals T- and IΔ12 are internally connected to each other, you must not connect signals with different potential here! - The maximum connection cable length is 3 metres! Otherwise, the EMC immunity of the unit may be impaired.

Residual current/analogue inputs		
Operating mode	RCM	20 mA DC
Measuring range	0.01 - 40 mAAC	0.02 - 22 mADC
Residual operating current IΔn Setting range	0.1 - 30 mAAC	–
Intrinsic measurement uncertainty (tA = 23±2 °C)	+/- 0.1 % of reading +/- 0.02 % of reading	
Temperature drift	+/- 0.03 % of reading + +/- 0.01 % of reading/10°C	
Permanent overload	1 AAC	
Peak overload	6 AAC/200 ms, repetition delay > 5 Sekunden 60 AAC/20 ms, repetition delay > 1 minute	
Burden power (impedance)	< 0.007 VA (Ri = 4 Ω)	
Notes	- The measurement inputs are not isolated from the unit's internal circuitry, from each other or from the external temperature input. - As the terminals IΔ12 and IΔ12 (or T-) are internally connected to each other, you must not connect signals with different potential here!	

	- The maximum connection cable length is 3 metres! Otherwise, the EMC immunity of the unit may be impaired. RCM mode: - The inputs are only intended for indirect connection - a suitable residual current transformer (RCT) must be used. - The insulation of the RCT used must meet the requirements of the IEC61010-1 standard regarding double insulation according to CATIII for the existing mains voltage. - Measurement of alternating and pulsating DC fault currents according to the RCM specification type A as defined in the standard IEC 62020 No directional sensitivity of the residual currents is evaluated.

Examples for residual current transformers							
Manufacturer	Type	In [A]	Window size [mm] Window size [mm] Window size [mm]	RCT ratio/20 mADC	IΔn [A]	RRCMMAX [Ω]	Notes
PQ Plus	RCM-CT	n.s. *)	D 20 – 120	600/1	0.02 – 20	180	Solid core
Bender	W	n.s. *)	D 20 – 210	600/1	10	180	Solid core
Bender	WS	n.s. *)	20 x 30 – 80 x 120	600/1	10	180	Split core
Bender	WF	n.s. *)	L 170 – 1800	600/1	0.1 – 20	68	Rogowski transducer, split core
MBS	DACT	n.s. *)	D 20 – 120	600/1	0.02 – 20	180	Solid core

Doepke	DCTRA	200 – 300	D 35 – 70	20 mADC	0.03	300	Solid core, 20 mADC current loop output
IME	TD	65 – 630	D 28 – 310	700/1	0.03 – 1 (IΔn min.)	n.s. *)	Solid core
J&D	BCT	100 – 600	D 30 – 80	127/1	10	10	Solid core

n.s. *): unspecified

Characteristics of other residual current transformers on request

Digital outputs and digital inputs	
"D" outputs (semiconductor/opto-MOS outputs)	
Type	Opto-MOS, unipolar
Nominal load	35 V_{DC}, 100 mA
Dynamic parameters (pulse output): **- Pulse duration** **- Pause duration** **- Maximum frequency**	S0-compatible 50 ms >= 50 ms 10 Hz
Digital inputs	
Type	opto-isolated, unipolar
Maximum voltage	35 V_{DC}
Voltage for "logical" 0/1	< 3 V_{DC}/ > 10 V_{DC}
Input current	3 mA at 10 V/13 mA at 24 V/20 mA at 35 V
Dynamic parameters *): **- Pulse/pause duration** **- Maximum frequency**	 >= 0.5 / 0.5 ms 1 kHz

Note *): Limit values according to the design of the unit hardware. For the actual maximum frequency of the input signal, see chapter Digital input filter.

Other technical data	
Operating temperature:	-20 to 60 °C
Storage temperature:	-40 to 80 °C

Rel. humidity during operation and storage	< 95 % - non-condensing environment
EMC interference immunity	EN 61000 – 4 – 2 (4 kV/8 kV) EN 61000 - 4 - 3 (10 V/m to 1 GHz) EN 61000 – 4 – 4 (2 kV) EN 61000 – 4 – 5 (2 kV) EN 61000 – 4 – 6 (3 V) EN 61000 - 4 - 11 (5 periods)
EMC interference emissions	EN 55011, Class A EN 55022, Class A (not for home use)
Protection class (according to IEC 61140)	II
RTC (Real-Time-Clock) **Accuracy** **Backup battery capacity**	 +/- 2 seconds per day > 5 years (without supply voltage applied)
Communication interfaces	USB 2.0 Ethernet 100 Base-T,
Communication protocols	Modbus RTU and TCP WEB server, JSON, DHCP, SNTP
Sampling frequency at 50 Hz (60 Hz)	25.6 kHz (23.04 kHz)
Display	TFT LCD colour display, 3.5" diagonal, 320 x 240 pixels
Protection class (according to IEC 60529) **Front panel** **Back wall**	 IP 40 (IP 54 with cover foil) IP 20
Dimensions **Front panel** **Installation depth** **Installation cut-out**	 96 x 96 mm 80 mm 92^{+1} x 92^{+1} mm
Mass	max. 0.3 kg

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