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Operating Manual for

POWER ANALYSER & METER ARTIQ 144

Complete version 2.0

The complete and most actual version of this manual is available online at http://www.KMB.cz/

Contents

1 General Description

The ARTIQ 144 is specially designed for monitoring of energy and power quality in advanced power systems and smart grids. It is intended to be used mostly for DIN rail mounting. This display-less design with multiple communication options is suitable for a wide spectrum of automation tasks in modern buildings, distributed power generation, remote supervision of the infrastructure and also remote load management. Absence of local panel controls (display and keyboard) limits possibilities for hostile user interaction. For advanced protection, the configuration of ARTIQ 144 can be also locked by a pin.

It is equipped with four voltage inputs and four current inputs for external through-hole or clamp-on current sensors for direct measuring up to 2400 A nominal current. It uses standard RS485 serial communication. Additional peripherals such as WiFi, USB or Ethernet modules can be optionally assembled. There are three LED diodes for device status indication and programmable alarm monitoring.

1.1 Version 2.0 improvements

- advanced calibration and higher precision
- optional six-quadrant meter - differentiates reactive energy through the direction of active power flow.
- improved, more precise and continuous measurement of harmonic phasors (amplitude, phase)
- advanced time synchronization options: NMEA, PPS, PPM, power frequency lock
- special rugged current inputs X/100 mA
-
- optional expansion modules USB, WiFi and ZigBee possible
- modular firmware - Power Quality, ModBus Master, Ethernet-Serial (only for instruments, which have booth interfaces) and General Oscillogram modules
- *PQ module*: power quality analysis according to EN 50160 ed. 3.
  - voltage and current measurement class S according to IEC 61000-4-30 ed. 3
  - inter-harmonics (IEC 61000-4-30 ed. 3, 61000-4-7 ed. 2)
  - flicker severity indices (P_{inst}, P_{st} a P_{lt} class F3 as defined in IEC 61000-4-15 ed. 2)
  - voltage interruptions, dips and swells
- *RCS module*: measurement, analysis and recording of the mains signaling voltage signals

1.2 Characteristic features

Connection and Measurement

- up to four measuring voltage inputs (L_1, L_2, L_3, L_4) towards input N
- up to four inputs current sensors (I_1, I_2, I_3, I_4)
- current input options

  -
  - special wire-through (Pxxx) or split-core (Sxxx) current probes for direct measurement - defined by actual type for $I_{nom} = 5\,A\,..\,600\,A$ (table 1).
  - option X/100mA for indirect measurement with special curerent transformers (nominal secondary current up to 100 mA)
  -
  - option NOCT measures only voltages, does not have any current inputs. It is possible to use it as a smart transducer and relay, with memory, to analyse frequency, voltage, harmonics, unbalance and voltage quality (with PQ module).

- two digital inputs (option D)
- single relay or impulse output (option R or I)
- features can be upgraded via external I/O modules (with ModBus Master module)
- power supply:
  - option U: $75 \div 510\,V_{AC}$ or $85 \div 350\,V_{DC}$
  - option L: $24 \div 48\,V_{AC}$ or $20 \div 75\,V_{DC}$
  - option S: $12 \div 24\,V_{AC}$ or $9 \div 36\,V_{DC}$
- 128 samples per period, voltage and current inputs are read continuously without any gaps
- 63 voltage and current harmonics
- evaluation of all usual three-phase and single-phase quantities such as powers (active, reactive, apparent, distortion, fundamental), power factors, harmonics and THD of voltages and currents etc.

Registration of Measured Data

- built-in real-time clock with battery backup
- flash memory to record the measured data with a capacity of 512 MB
- aggregation interval from 200 milliseconds to 24 hours
- records voltage outages

Transfer and Evaluation of Recorded Data

- ENVIS software suite available free of charge for configuration and data analysis
- system service ENVIS.Online for live data recording.
- primary RS-485 interface for data transmission, device configuration and firmware upgrade
- can be equipped with Ethernet (option E), secondary RS-485 (option B), M-Bus (option M), USB (option U, W, Z), WiFi or ZigBee (option Z).

Supported Firmware Modules

- Power Quality (PQ) — extends the measured quantities for inter-harmonics, flicker and selective voltmeter, archive options for PQ main and PQ events archive, so as that the instrument can serve as a fully compatible PQI-S - class S power quality analyzer.
- General Oscillogram (GO) — Adds a feature that allows recording of raw signal samples.
- Ripple Control Signal (RCS) — Allows archiving of ripple control signals (RCS, HDO) data-grams and theirs voltage levels.

1.3 Types and accessories

The ARTIQ 144 is available in several configurations according to the customer requirements[1]. See the ordering scheme on figure 1.

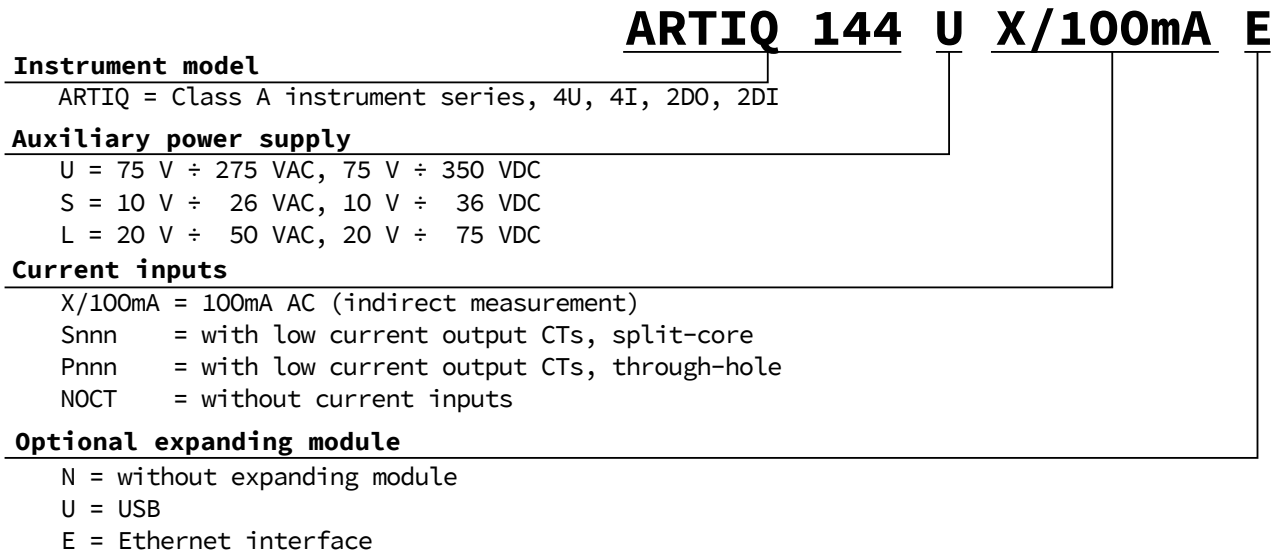


Figure 1: Schematics of the ARTIQ 144 ordering options and variants. It includes special codes for proper current and voltage rating options.

In table 1 there are dimensions and weights of Sxxx and Pxxx current sensors for special current input variants. Parameter d is inner diameter for a measured conductor. Parameters x, y, z are external dimensions and g is weight of a sensor.

[1]Complete and most up to date list of optional and other accessories are available on request from the device vendor.

Table 1: Physical dimensions of special, supplied current sensors for **devices with Sxxx** options. See chapter 2.2.3.

Option	Model	Inom [A]	d [mm]	Connection	Dimmension [mm]
S005	JC10F	5A	10mm	Terminal	50×23×26
S015	JC10F	15A	10mm	Terminal	50×23×26
S025	JC10F	25A	10mm	Terminal	50×23×26
S035	JC10F	35A	10mm	Terminal	50×23×26
S050	JC10F	50A	10mm	Terminal	50×23×26
S075	JC16F	75A	16mm	Terminal	55×30×31
S100	JC16F	100A	16mm	Terminal	55×30×31
S150	JC24F	150A	24mm	Terminal	75×45×34
S200	JC24F	200A	24mm	Terminal	75×45×34
S250	JC24F	250A	24mm	Terminal	75×45×34
S300	JC36S-3	300A	36mm	Terminal	91×57×41
S400	JC36S-3	400A	36mm	Terminal	91×57×41
S500	JC36S-3	500A	36mm	Terminal	91×57×41
S600	JC36S-3	600A	36mm	Terminal	91×57×41

Table 2: Physical dimensions of special, supplied current sensors for **devices with Pxxx** options. See chapter 2.2.3.

Option	Model	Inom [A]	d [mm]	Connection	Dimmension [mm]
P005	JP3W	5A	7	Wire	27×24×11
P015	JP3W	15A	7	Wire	27×24×11
P025	JP5W	25A	13	Wire	41×37×14
P035	JP5W	35A	13	Wire	41×37×14
P050	JP5W	50A	13	Wire	41×37×14
P075	JP5W	75A	13	Wire	41×37×14
P100	JP5W	100A	13	Wire	41×37×14
P150	JP5W	150A	13	Wire	41×37×14
P200	JP6W	200A	19	Wire	51×49×20
P250	JP6W	250A	19	Wire	51×49×20
P300	JP6W	300A	19	Wire	51×49×20

Table 3: Selected parameters for **option X/100mA** for indirect measurement with special types of supplied 100mA CTs. See chapter 2.2.3.

Split-Core Model	Inom [A]	d [mm]	Connection	Dimmension [mm]	Overvoltage Category
JS17F – Inom/100mA	050, 100 125, 150	17	Terminal	64×33×34	600V CAT III
JS17S – Inom/100mA	200	17	Terminal	64×33×34	600V CAT III
JS24F – Inom/100mA	200	24	Terminal	75×45×34	600V CAT III
JS24S – Inom/100mA	250, 300	24	Terminal	75×45×34	600V CAT III
JS36S – Inom/100mA	300, 400 500, 600	36	Terminal	91×57×40	600V CAT III
JSC-01 – Inom/100mA	250, 400	38×32	Wire	93×92×39	600V CAT III
JSC-02 – Inom/100mA	400, 600, 800 1000, 1200	73×62	Wire	128×124×39	600V CAT III
JSC-03 – Inom/100mA	800, 1000, 1200 1600, 2000, 2400	141×62	Wire	196×124×39	600V CAT III

2 Operating the Meter

2.1 Safety requirements when using ARTIQ 144

Warning ! When working with the instrument it is necessary to perform all necessary measures for the protection of persons and property against injury and electric shock.

- The device must be operated by a person with all required qualifications for such work and this person must know in detail the operation principles of the equipment listed in this description!
- When the device is being connected to the parts which are under dangerous voltage it is necessary to comply with all the necessary measures to protect users and equipment against injury with electrical shock.
- Person, performing the installation or maintenance of the instrument must be equipped with and must use personal protective clothing and tools.
- If the analyzer is used in a manner not specified by the manufacturer, the protection provided by the analyzer may be impaired.
- If the analyzer or its accessories appear to be impaired or not functioning properly, do not use it and send it in for repair.

2.2 Installation of the instrument

Natural air circulation should be provided inside the distribution board cabinet, and in the instrument's neighborhood, especially underneath the instrument, no other instrumentation that is source of heat should be installed or the temperature value measured may be false. A connection wire's maximum cross section area is $2.5\,mm^2$ in case of all screw terminals.

The ARTIQ 144 is primarily intended for DIN-rail mounting. Dimensions of the instrument are on figure 2. There are also positions marked with dash dot lines of holes for wall-mounting with three screws.

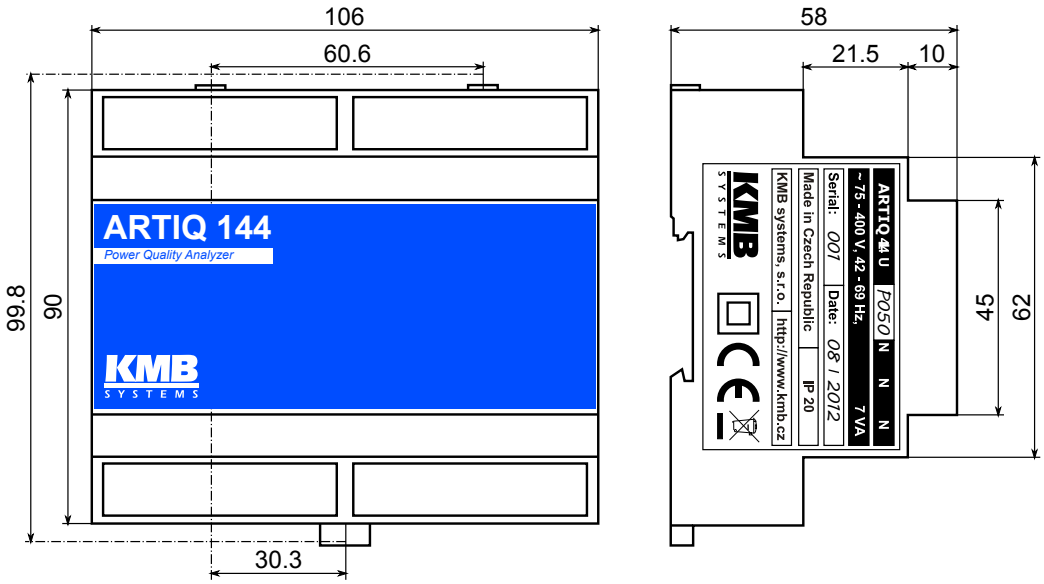


Figure 2: Dimensions of the ARTIQ 144 .

2.2.1 Supply voltage

Power supply voltage (options in ch. 5) must be connected to the terminals X1 and X2 via a circuit breaking device (power switch – see installation diagram on figure 3). It has to be located left to the instrument and reachable by the operator. The circuit breaking device must be identified as the equipment power disconnection switch. A circuit breaker of the nominal value $1\,A$ is a convenient circuit breaking device, its function and position has to be clearly identified (symbols '0' and 'I' acc. to IEC EN 61010-1). Internal power supply is galvanically isolated from internal circuits.

2.2.2 Measured voltage

The measured voltages are connected to the terminals L1, L2, L3 and L4. The common terminal to connect the neutral wire to being identified as N - with delta or Aaron connections it remains unused. Terminal L4 can be optionally used to measure potential of one line voltage or the PE against N terminal. All voltage measurement inputs are connected with internal circuits over high impedance.

It is suitable to protect the voltage lines measured for example with 1A fuses of the required rating. Measured voltages can also be connected via instrument voltage transformers. A connection cable maximum cross section area is $2.5\,mm^2$.

2.2.3 Measured currents

For proper current measuring the current sensors must be installed with correct orientation and polarity. Figure 3 illustrates such connection of through-hole current transformers in LV network. Intended direction of power flow is from left (source) to right (load). It is highly recommended to verify correctness of wiring and polarity of currents with phasor diagram in Actual Data window ot the ENVIS.Daq application.

The current inputs are directly connected with internal circuits. To ground the measuring CT user can use L terminals if required. Inputs l_i and k_i are connected through shunt resistors.

Warning !: Connection of unsupported type of current transformer such as the common type with 5A or 1A secondary to an instrument is strictly forbidden! The instrument can be seriously damaged!

Warning !: Do not connect the current input signals with neither ground nor other potential! Otherwise, measurement accuracy can be affected or the instrument can be damaged!

Always use only correctly rated (mA secondary output) measurement current transformers which were originally supplied with the actual instrument. A connection cable maximum cross section area is $1.5\,mm^2$.

2.2.4 Communication peripherals

All peripherals stated below are galvanically isolated from the rest of the instrument and from each other.

Ethernet interface (optional) 10Base-T Ethernet interface with RJ-45 connector described *ETH* is situated on a top panel of the device. Ethernet interface can be used as substitution for the primary RS-485 for connection of the device to LAN and for easy connection of remote control PC.

RS-485 Serial Line serves usually as a remote communication for reading of actual data, archive downloading and device configuration. Serial RS-485 line uses terminals *A*, *B* with shielding at terminal *G* of *COM1* block (fig. 6). The final points of the communication line must be properly terminated with resistance.

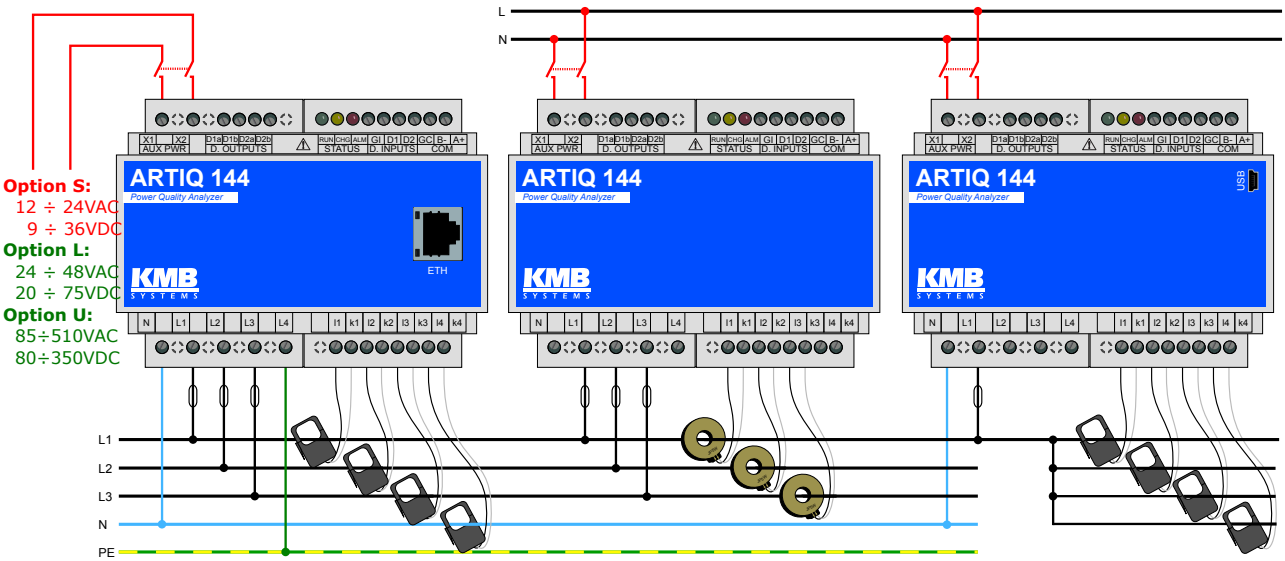


Figure 3: An example of typical installation of ARTIQ 144 instrument in a low voltage network — left to right: with low voltage supply voltage (possible DC, AC including battery backed UPS setups); with supply from measured network. Typical connection options for voltage measurements: star, delta and four single phase feeders. Option E for Ethernet port remote communication, option U for local USB communication port (all instruments provide RS485 serial line).

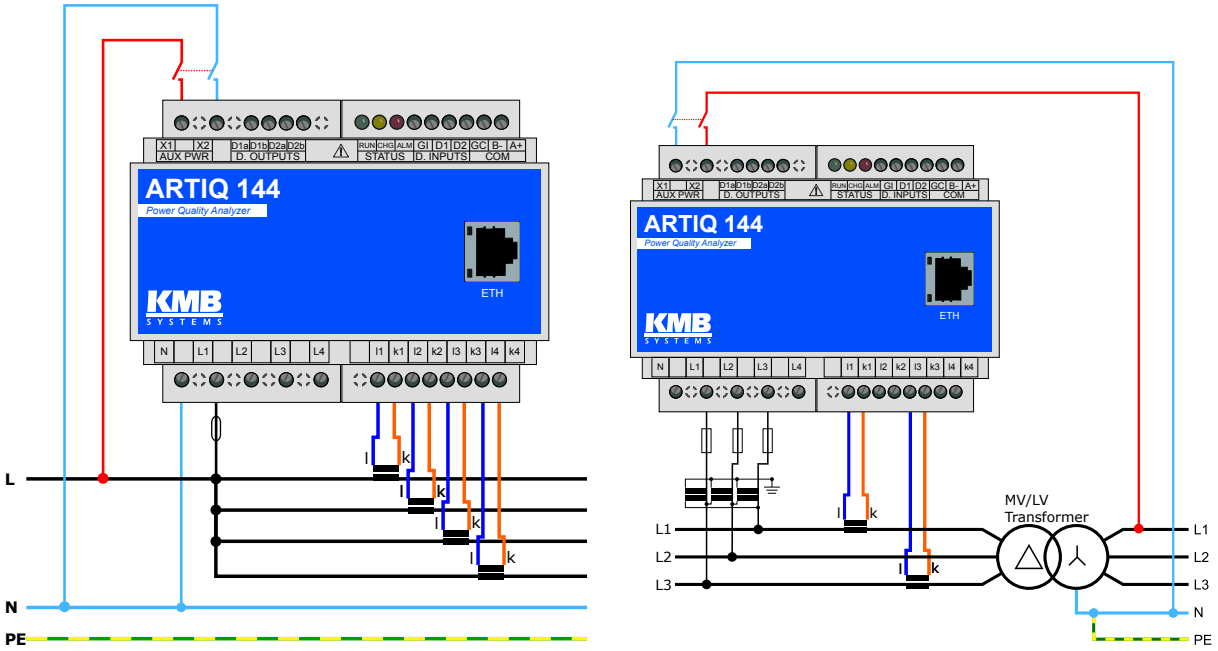


Figure 4: Special cases of connection for ARTIQ 144 instrument: single phase three wire connection in LV network and Aron connection. .

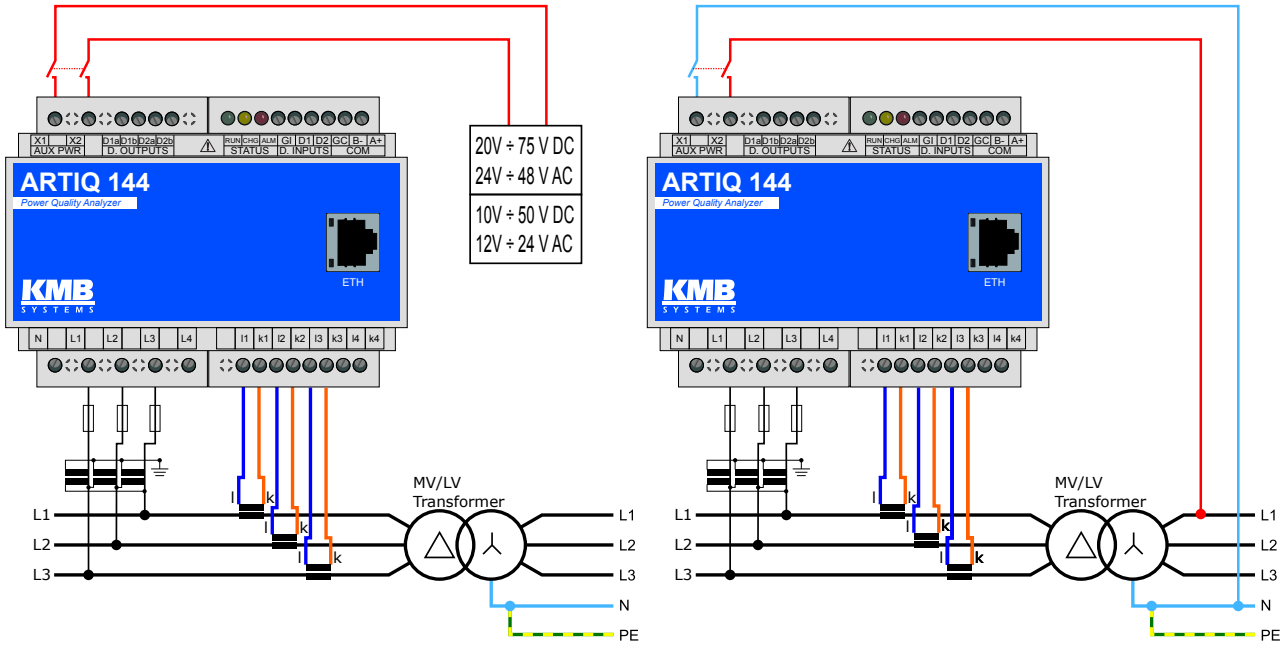


Figure 5: Example of typical connection of ARTIQ 144 with indirect measurement via voltage transformers. Option L on left side is supplied from a backup power supply. Option U on the right side is supplied from L1 of the LV network.

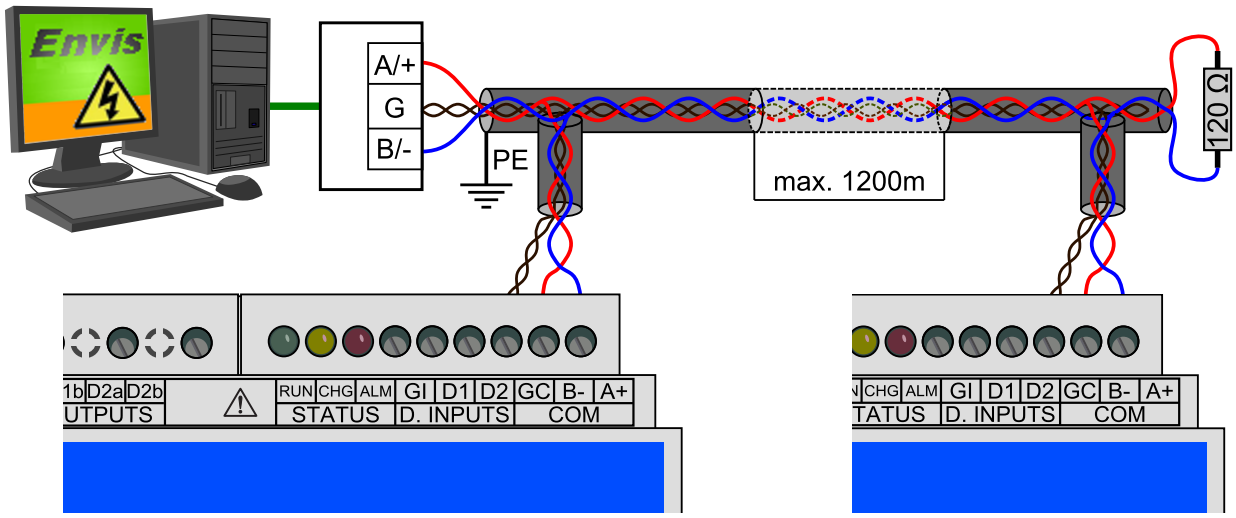


Figure 6: Typical wiring of the RS-485 communication line terminals in ARTIQ 144 or optional M-Bus (right).

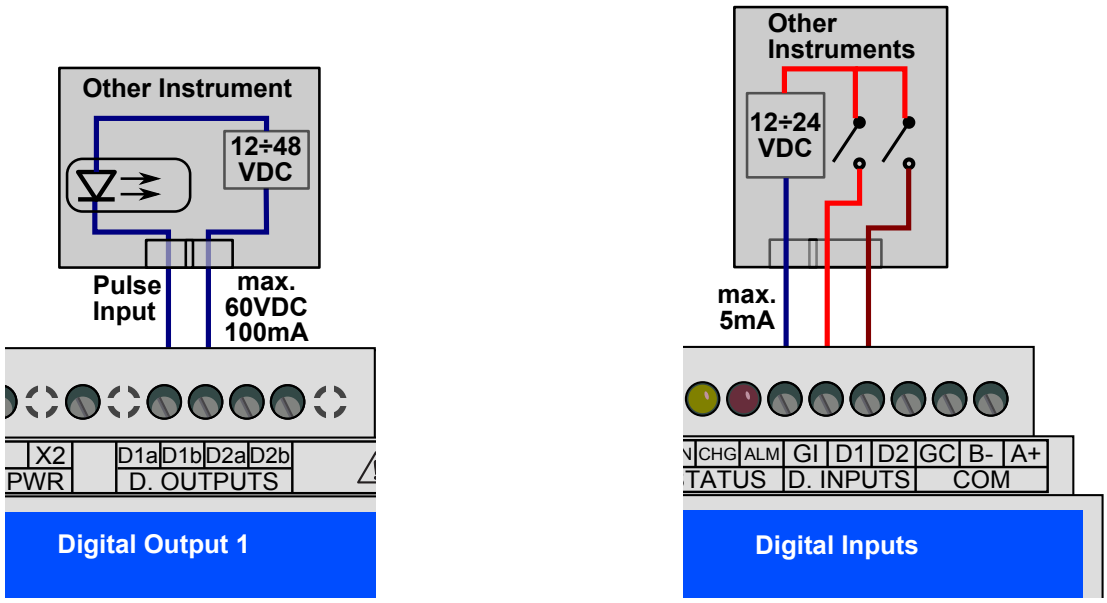


Figure 7: An example of wiring connection for inputs and outputs in ARTIQ 144 .

2.2.5 Outputs and inputs

Digital Inputs DI1 and DI2, sensitive to voltage, are using three terminals in *COM2/DI* block — *G* is common terminal, *B/1* is first and *A/2* is second digital input. Voltage lower than 3 V applied between *G* and digital input *B/1* or *A/2* is evaluated as inactive state, voltage greater than 10 V is evaluated as active state. On fig. 7 right there is a sample schema for connection of two external switches in series with voltage source of $24\,V_{DC}$.

Digital Outputs DO1 and DO2 are connected through terminals *O+* and *O-*. There must be an external voltage source in series ($24\,V_{DC}$ is recommended). In case of solid state based DO outputs an external voltage supply polarity must comply with terminal poles (see fig. 7).

2.3 Detailed configuration of ARTIQ 144 on a PC

To begin a measurement it is recommended to configure the ARTIQ 144 instrument appropriately. This setting is done by PC with an ENVIS.Daq[2] application.

Warning! This setting will erase all previously archived data in memory of the instrument. Before writing new configuration to the device make sure to backup the last measured archive.

1. Turn on the instrument. Supply voltage will be indicated by the blinking green LED (PWR).
2. Connect the ARTIQ 144 to a computer via USB[3], RS-485 or Ethernet interface. Now the unit is ready to be configured.

[2]The ENVIS.Daq application is used for configuration of the instrument. This software is available for download form WWW.KMB.CZ as a part of ENVIS installation package or as a standalone application. Detailed description can be found in The ENVIS User Guide.

[3]If a USB instrument is connected to the PC for the first time it is necessary to install its driver in Windows. You can find the actual driver for our instruments online on the the WWW.KMB.CZ website. It is also located in the driver folder of ENVIS software installation folder, for example in: *'C:\Program Files (x86)\KMB systems\ENVIS 1.2\driver'*

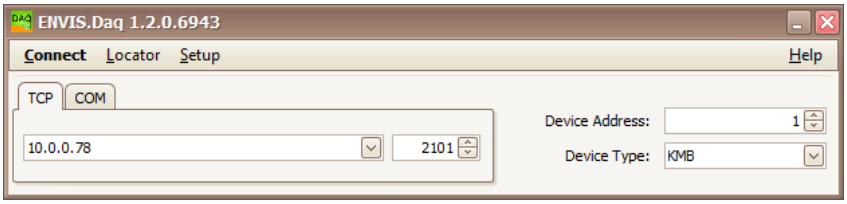


Figure 8: Main window of the ENVIS.Daq application - enter communication type, choose its parameters and click *Connect* to continue.

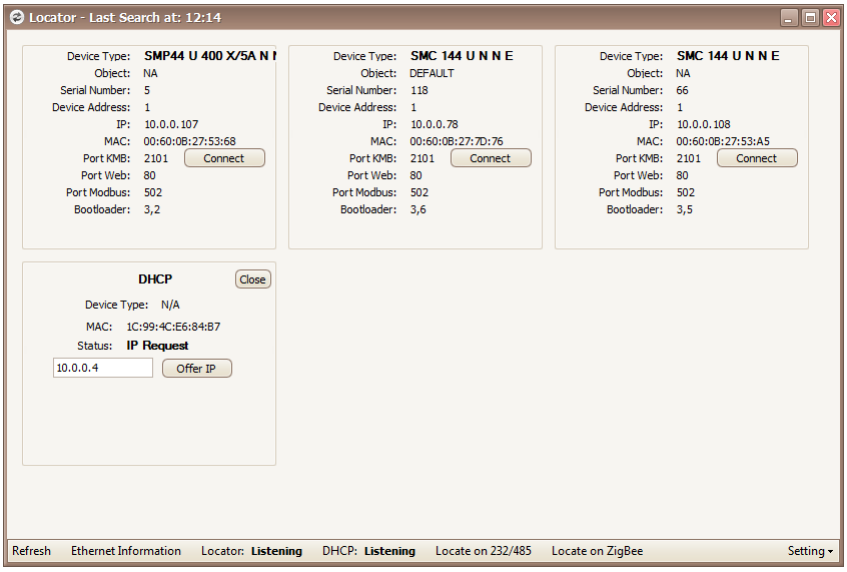


Figure 9: Window of *Locator* tool - provides automatic discovery of the supported instruments in a local network.

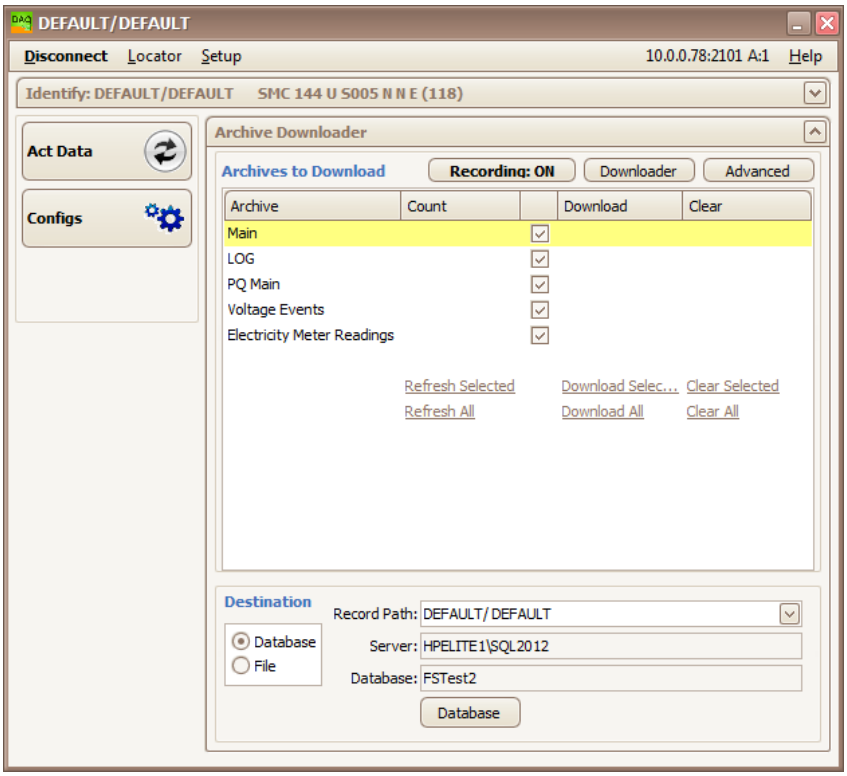


Figure 10: ENVIS.Daq application connected to the instrument.

3. Run ENVIS.Daq application and pick the appropriate tab for the given communication line.

4. Fill in communication line parameters. A connection form with typical parameters is shown in figure 8.

   (a) USB: choose the correct virtual communication port from the list

   (b) RS485: Immediatelly after power up the green LED is fast blinking (once per 400 ms). For the first 10 seconds after power-up, device can always communicate with fixed baud rate 9600 bps and is listening on address 250. If ARTIQ 144 does not receive any command until the interval expires, its communication port is reconfigured to the user defined parameters. During start the ARTIQ 144 is also listening on its own address — if same baud rate as default is set, it is possible to connect to the device immediately after power-up. Otherwise, user has to wait 10 seconds before connecting with his own baud rate. End of start interval is indicated by slowly blinking green LED (once per 2 s). Select the correct serial port from a list and set up communication line baud rate.

   (c) Ethernet: enter correct IP address and port (default: 2101). If you do not know the right values you can use *Locator*[4] (fig. 9).

   (d) Edit an address of the instrument (Default: 1)

   (e) Enter the device type: KMB

5. Press the *Connect* button or the *ENTER* key. application will attempt to connect to the instrument. In

[4]Locator is a tool for automatic look-up of the instruments in a local network or on a serial line. Caution: it contains special functions such as an embedded DHCP server, which can severely interfere with the normal operation of Ethernet network. It also might need a customization of your PC firewall to work correctly.

case of successful connection it reads the configuration from the instrument and displays new window with summary information (figure 10).

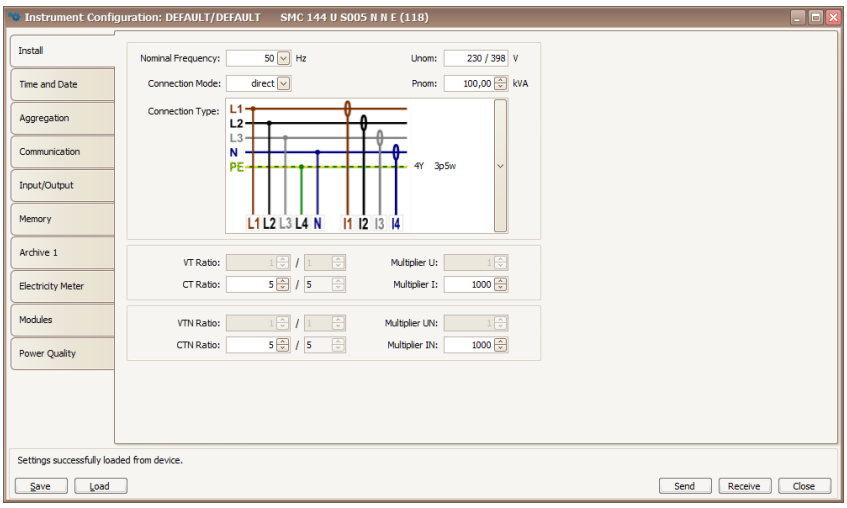
6. Press the *Settings* button in left column. New window with actual instrument settings will be opened.

Category *Instrument Settings* includes sub-categories, sorted and grouped in various tabs. Changes in configuration are only performed in the windows application. To the instrument they are sent with a *Send* button. With button *Receive* user can re-read the stored configuration from a device. This will effectively cancel all the local modification in the application. Unwritten changes in configuration on each tab is signalized by an exclamation sign. Buttons *Save* and *Load* provide a possibility to archive the actual settings to a file.

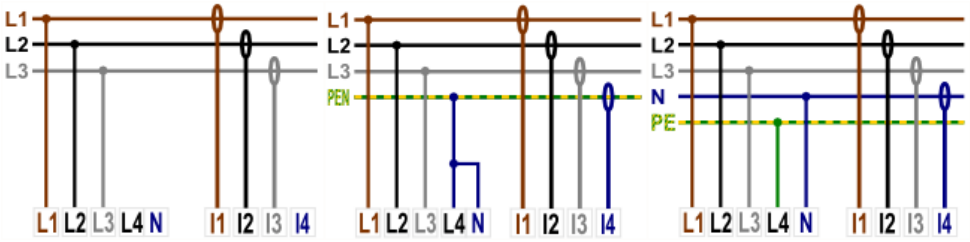
For correct operation an appropriate configuration of at least *Installation* and *Time and Date* tab is crucial.

2.3.1 Installation (fig.11)

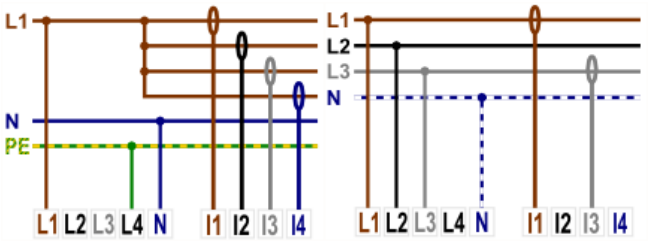
- *Nominal Frequency* - defines the nominal network frequency measured at 50 or 60 Hz. It also influences, how power quality indice are evaluated.
- *Connection Mode* - the way of connection of the instrument to the measured voltage — either direct voltage measurement or via voltage transformers (usually in a HV network).
- *Connection Type* - type of measured network according to the actual connection - three-phase star, three-phase delta or Aron connection. Supported connections schema are in fig. 11b, 11c and 11d for illustration.
- U_{NOM}, P_{NOM} (rated voltage and power) — correct configuration of these values influences relative values used on display and in condition evaluation (alarms, PQ evaluation, IO, ENVIS data processing).
  - U_{NOM} is a nominal (primary) voltage of the measured network
  - P_{NOM} is a nominal power given by the system transformer or used protection device.
- *VT Ratio, VTN Ratio* - sets the conversion ratio of voltage inputs for *Connection Mode: via VT* measurement. Must be set accordingly to the primary and secondary rating of the measuring voltage transformer (transfer ratio). 'VTN' designates the optional fourth voltage input, available with some *Connection Types*.
  - nominal primary voltage: default value for 'via VT' option is 22 000 V.
  - nominal secondary voltage: default value is 100 V (other common values are 110, 120, 230V)
- *CT Ratio, CTN Ratio* - sets the conversion ratio of current input. 'CTN' designates the fourth input, usually a neutral wire.
  -
  - For ARTIQ 144 options X/100mA and X/20mA a nominal primary and nominal secondary current of the supplied transformer is used. Default value is 100 A/100 mA resp. 20 mA.
  - For ARTIQ 144 options Sxxx and Pxxx **the factory default value corresponds to range of specific current input variant stated after slash** (for example *Range I: 50 / 50* for S050 or P050 option) and shouldn't be changed under normal conditions!
- *Multiplier U*: this parameter is usually not necessary. Default value is 1. In special cases it can be used to correct the ratio of measured voltage.



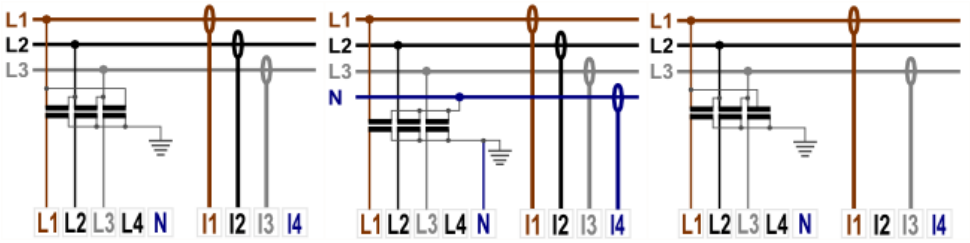
(a) Configuration of basic installation parameters in ENVIS.Daq.



(b) Typical instrument connection types for direct measurement (in LV networks).



(c) Special instrument connection types for direct measurement (in LV networks).



(d) Instrument connection types for indirect measurement — to be connected via VT (in HV networks).

Figure 11: ENVIS.Daq - configuration of the device installation.

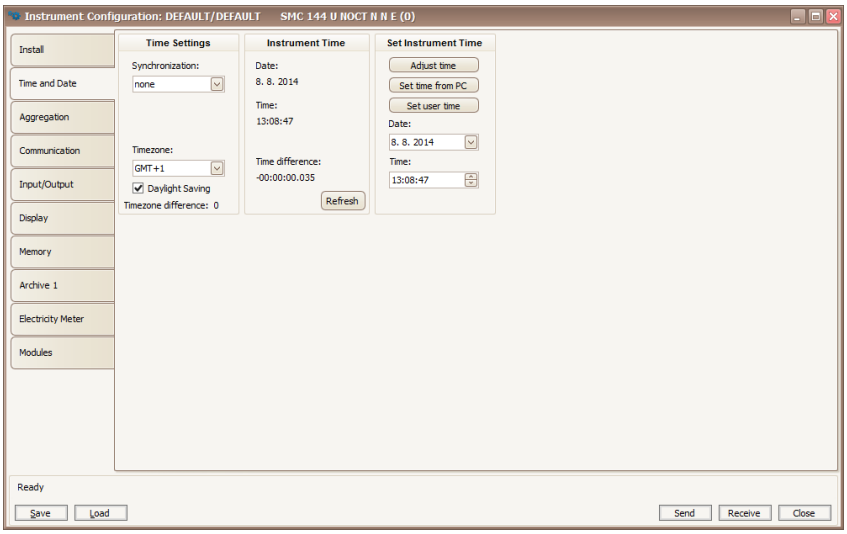


Figure 12: ENVIS.Daq - configuration of date and time options.

- *Multiplier I* - this parameter is usually not nescessry. Default value is 1.
  - in case of direct current measurement (fig. 3) leave the *Multiplier I* in its default value:1.
  - in case of indirect current measurements with nonstandard conversion ratio (multiple loops of measured wire through the measuring transformer etc) specify the new ratio as a fraction[5] to which you need to multiply the original conversion ratio to get the real measured value of current.

2.3.2 Date and time (fig. 12)

This tab contains configurations related to the instrument internal time and date settings.

Warning ! manipulation with the time configuration erases all instrument archives and related registers.

Instrument Time panel displays actual time and date in the instrument and an absolute difference to the actual time in PC. When this tab is opened for the first time the instrument time is immediately read and is periodically actualized. Button *Refresh* rereads the instrument time again.

Time Setup panel provides controls for actual modification of the time in instrument.

- *Set Time from PC* — sets the instrument time according to the clock in PC
- *Set user Time* — sets the instrument time to the manually given value
- *Adjust Time* — aligns the instrument time to the PC time without erasing instrument memory. Adjustment to the desired value is achieved in a way that:
  - to move time forwards it skips required number of archives
  - to move time backwards it waits with the creation of next archive until the instrument reaches the time given in setup.

[5] If, for example, primary CT with ratio 100/5 is used, set multiplier to $\frac{100}{5} = 20$. Another example, when *Multiplier I* can be used, is winding more than one loop of measured conductor through current transformer for sensitivity extension (and range reduction). For example for 4 loops *Multiplier I* should be set to $\frac{1}{4} = 0.25$.

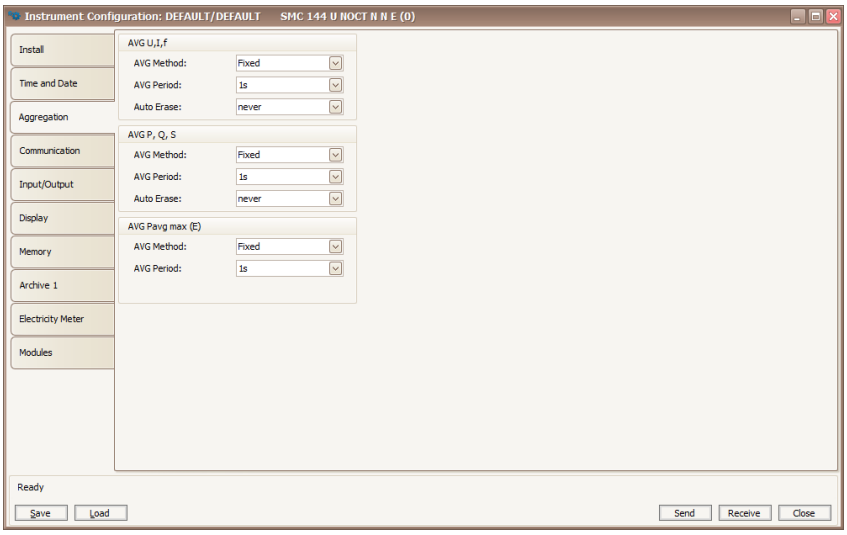


Figure 13: ENVIS.Daq - aggregation configuration defines how instrument evaluates average, minimum and maximum actual values for display and communication.

Calendar Configuration defines ways of interpretation and display of time tags in instrument and in its archives:

- *Synchronization* — defines how each instrument synchronizes its time. Methods supported include:
  - pulse per second and pulse per minute (PPS, PPM) on a digital input,
  - NMEA protocol on a communication line - the comm port must be configured,
  - NTP protocol over Ethernet - IP address of the time server must be filled
  - and a network frequency lock.
  - It is also possible to disable this function.
- *Time Zone* — must be set according to the local requirements. The configuration is important for correct interpretation of the local time for tariff, for remote communication etc.
- *Summer Time* — if set the calendar automatically adjusts itself to the change of the local time according to the season.

2.3.3 Aggregation (averaging, fig. 13)

This configuration influences algorithms used for calculation of special ModBus registers of the aggregated values. In instruments with graphical display it also influences how aggregated (AVG) values are displayed. Parameters are defined separately for primary quantities - voltages, currents and frequency, for derived quantities and specially for PavgMax. Correctly configured aggregation in an istrument allows in connection with ENVIS software to evaluate quarter-hour or hour maximal demand (power).

2.3.4 Communication (fig. 14)

Device is always equipped with at least one RS 485 port (COM1) for parametrization and data acquisition. Optionally it can be equipped with secondary RS485 port (COM2) or with Ethernet (ETH) interface.

- *Instrument Address* - assign unique address to each instrument on the same serial line.

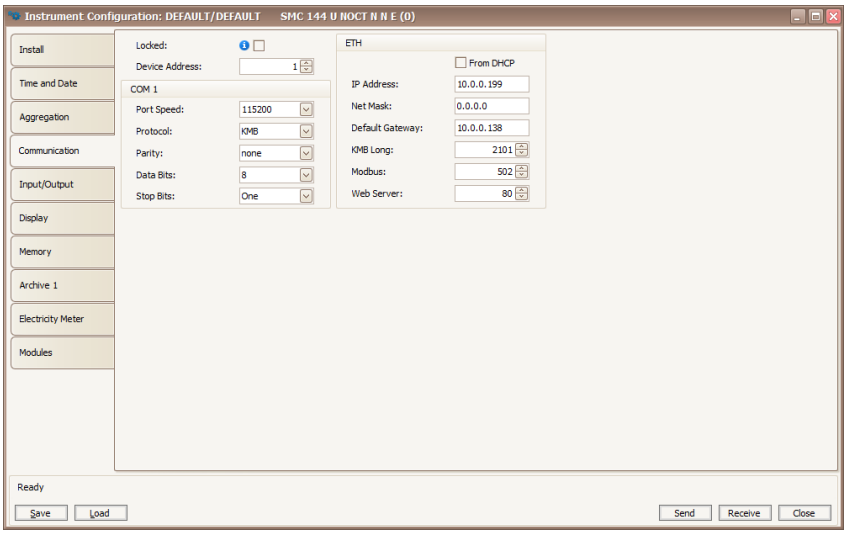


Figure 14: ENVIS.Daq - setting up communication line options.

COM1, COM2

- *Communication Speed* — speed (baud rate) of the communication line. Default value is 9600 bps.
- *Communication Protocol* — to be chosen between KMB protocol and ModBus RTU.
- *Parity* — odd, even or none. Defines behavior of the parity bit control settings.
- *Data bits* — defines number of data bits.
- *Stop bits* — defines number of re-synchronization bits after each sent character.

ETH

- *IP address* — to be specified by user or assigned via the local DHCP server.
- *Network Mask* — setting of the network mask.
- *Gateway* — setting of network gateway.
- TCP Ports — each port can be individually assigned a special TCP port. Default values are:
  - *KMB Long protocol:* 2101,
  - *ModBus TCP protocol:* 502,
  - *Web server:* 80.

2.3.5 Inputs & Outputs (fig. 15)

ARTIQ 144 is assembled with two alarm leds A1 and A2 and optionally (options R, I) with one relay or SSR output O1.

- output controll logic can be programmed into the instrument

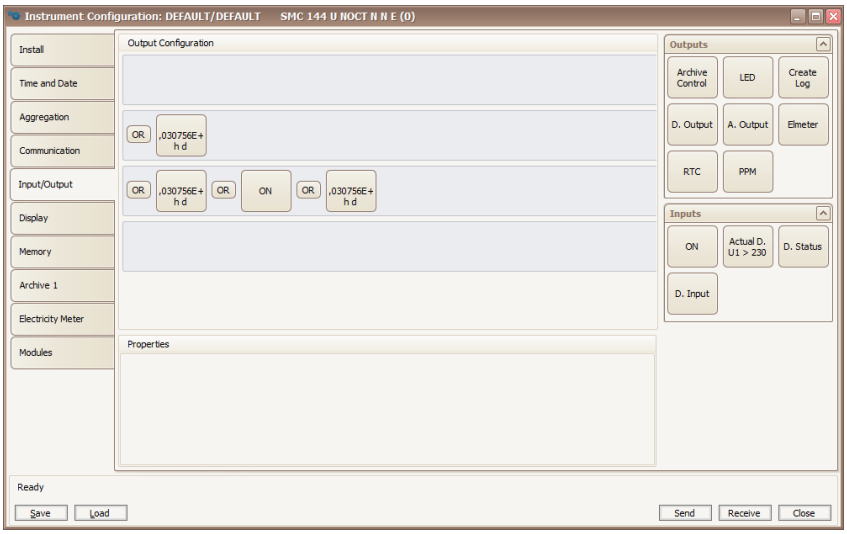


Figure 15: ENVIS.Daq - nastavení chování programovatelných vstupů a výstupů.

- any output can be configured to provide meter pulse output. In such cases the control quantity can be either active or reactive energy in each quadrant. It is nescessary to correctly configure number of pulses per kWh or kvarh.

2.3.6 Memory Assignments (fig. 16)

In this config tab it is possible to partition the internal memory among different archives with the slider control or by editing the apropriate value. The capacity of the new allocations is displayed right to the slider control. Sizes of some archives are fixed and can not be modified. Allocation for the main archive is automatically adjusted according to the remaining space and user requirements for another data such as meter readings, voltage events, oscillograms etc.

2.3.7 Main archive configuration (Archiv 1, fig. 17)

Archive configuration options split into archive properties panel and puantity selection list panel.

- *Record Name* – naming the measurements helps users to identify them correctly during evaluation. For example the transformer or circuit breaker ID could be a good descriptor. Record name is a string of up to 32 charactetrs.
- *Archive Start:*
  - *Immediately* - starts recording immediately after the instrument is turned on;
  - *Digital input* - saves records only when the digital input state is active;
  - *Preset time* - starts recording only after the given date and time.
- *Record Interval* – this aggregation interval defines the frequency of creation of the main archive readings. valid value is between 200 milliseconds (10/12 periods) and 2 hours.

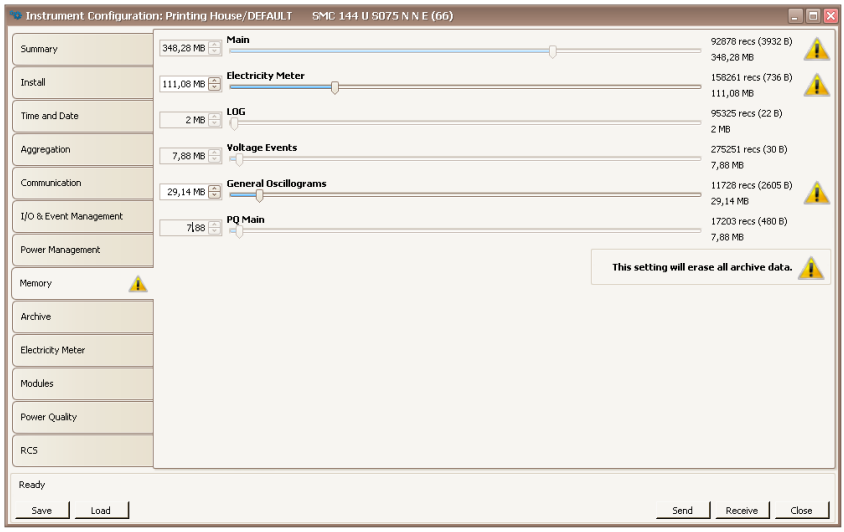


Figure 16: ENVIS.Daq - memory partitioning for each separate archive/data type.

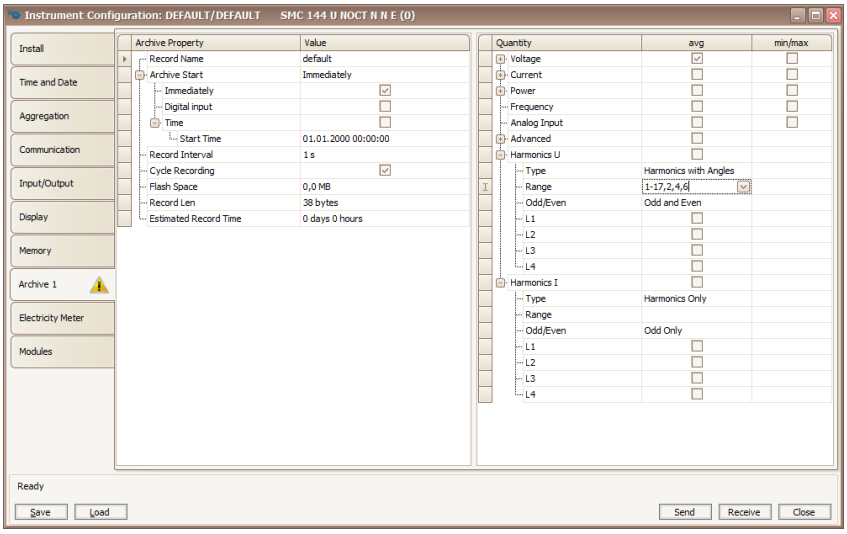


Figure 17: ENVIS.Daq - configuration of the recorded quantities for the main archive.

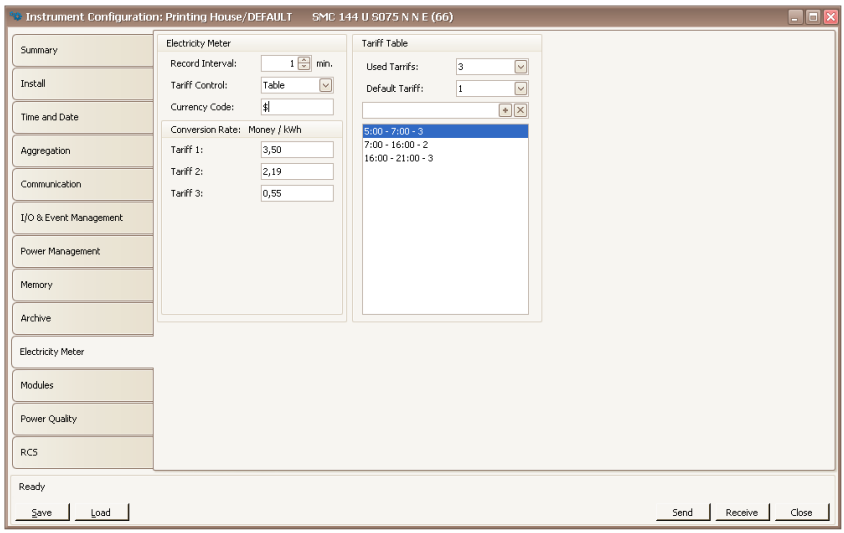


Figure 18: ENVIS.Daq - electricity meter configuration panel - tarrifs, prices, etc.

- *Cycle Recording* – this switch defines what happens when main archive is fully recorded. When active, the archive continues to overwrite archives in a cyclic manner (FIFO). When disabled the recording stops and the oldest measured data is kept.
- *Flash Space* — total memory space assigned for the archive data.
- *Record Len* — actual length of the configured record.
- *Estimated Record Time* - this provides estimation of the overal capacity of the archive at the actual configuration. It is updated only after the configuration is written into the instrument and read back.
- *Quantities* — in this section user can choose quantities which should be recorded. required values should be enabled in the *avg* and/or *min/max* column .
  - *Power*: in the *I/E* line user can choose to separately evaluate and record consumed and generated active power resp. the inductive and capacitive reactive power.
  - *Harmonics* - user choses which data should be recorded in regard to harmonics.

2.3.8 Electricity meter (fig. 18)

ARTIQ 144 can be used as a standalone energy meter and register for submetering applications to record four-quadrant active and reactive energies (watt- and var-hour meter).

- *Record Interval:* period of creation of the automated meter readings in memory.
- *Tariff Control* - tariffs can be controlled by user defined tarrif table or by state of the input.
- *Tariff Table* - this panel configures number of tariffs, number of measured wires and tim based table of tariffs.
- *Currency Code* - name of currency is used for reporting and energy audits.
- *Conversion rate:* - defines prices (rates) for energy 1 kWh for each tariff per unit of currency.

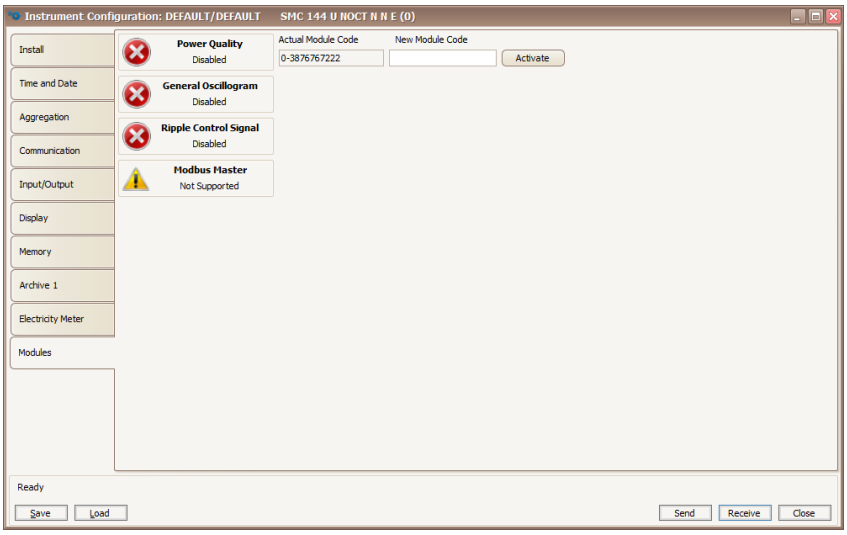


Figure 19: ENVIS.Daq - activation and deactivation of the supported special firmware options.

Firmware Modules (fig. 19) This tabs allows the user to activate or deactivate optional firmware modules by providing a valid activation code. State of each supported module is indicated.

2.4 Measurement ID configuration

This configuration can be performed in the main ENVIS.Daq window on an *Identification* panel. it is crucial for correct identification and categorization of the archived data.

- *Object* - Is a number or name of object (generally a text string), where was performed the measurement. This is a basic identification element, that will organize the measurement archive in a database record of the ENVIS program. In our case (object name is "DEFAULT") it was retrieved directly from the instrument. It can later be adjusted manually.

- *Record Name* - The individual records in the measured object can be distinguished by their name (name of the transformer in the building). In that case "DEFAULT". This is again a text string of maximum length of 32 characters which can be adjusted later.

To write the new values for *Object* and *Record Name* push the *Set* button in the *Identification* panel. Other informative parameters of this tab group do indicate the type of connected device (model, serial number, firmware and hardware versions etc.) and they can not be changed.

2.5 Downloading data to PC

Connect the instrument to the PC and run ENVIS.Daq application (fig. 8). Select the appropriate communication option (as described in section 2.3) and connect to the instrument. In the next screen press *Refresh All* (fig. 10). This will load and display the actual status of each supported archive.

Device Information section contains editable description and name under which the actual record is stored. *Time Frame for Other Archives* tab allows you to limit the date ranges of all archives by the time interval of the main archive. In the *Destination* section the actual storage can be selected - either to the SQL database or to

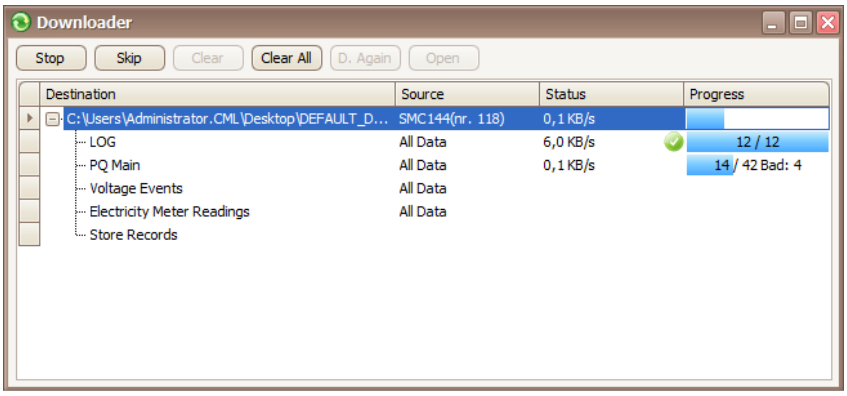


Figure 20: A window providing information about the download progress.

the file (CEA, XLS, PQDIF file formats). The check boxes in *Archives to Download* determines which specific archive(s) you want to download.

The actual download will start by pressing the *Download All* button. Progress of the data acquisition is displayed in a window as in figure 20. After complete transmission the window will close automatically. Data can be than viewed in the ENVIS application. user can open the downloaded file directly from ENVIS.Daq: in *Downloaded Files* panel in the left column of the main window there is a list of recently downloaded files.

2.6 Energy meter readings

ARTIQ 144 has an embedded three phase, four-quadrant energy meter with automatic meter reading functions and tariff (Time-of-Use, TOU). The instrument registers active and reactive energy separately (EP+, EP-). For reactive energy it measures — capacitive EQC and inductive EQL for four-quadrant meter resp. reactive EQC+, EQC- and EQL+, EQL- separately for active power demanded and supplied for six-quadrant meter. According to the configuration of meter (ch. 18) readings are shuffled to the respective tariffs. It automatically provides summaries per phase. For star connections and single phase measurements it can also register energy for each phase separately.

Meter data readings can be downloaded and analyzed in ENVIS or via the standard ModBus protool in any other system.

2.7 Embedded Webserver

All of instruments with Ethernet communication option are equipped with a native embedded webserver. Over this feature all important actual main measurements, registers and instrument setting can be viewed with a standard web browser with support for HTML5. It requires to set properly the instrument remote communication parameters and to connect it to the network. Then in the web browser enter an appropriate IP address of the instrument and information from the instrument appears.

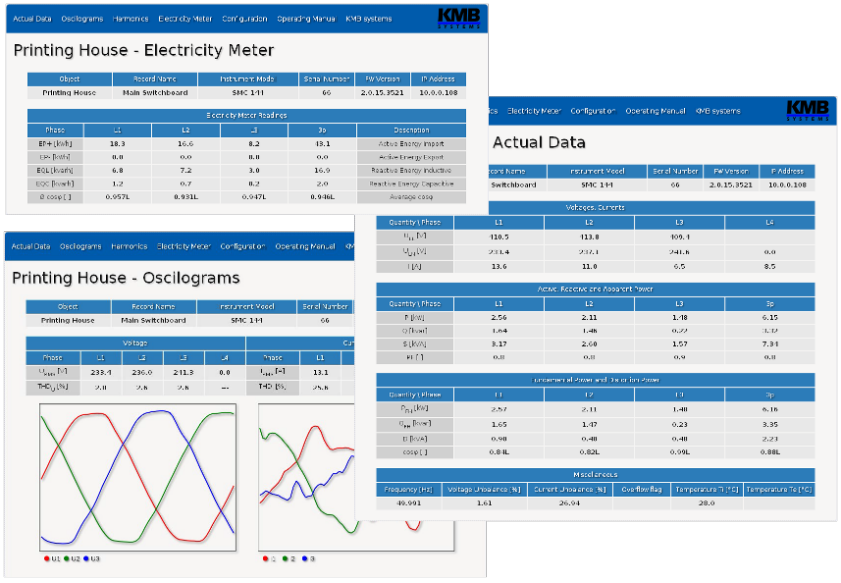


Figure 21: Sample pages of the embedded web server - actual data, electricity meter, oscilograms.

3 Functional description

3.1 Instrument construction

Figure 22: Description of the ARTIQ 144 instrument.

1. Input connector for auxiliary power supply voltage
2. Galvanically isolated digital relay or impulse output (optional)
3. Green instrument status LED
4. Two red configurable alarm LED
5. Primary communication RS-485 interface
6. Secondary RS-485 of M-Bus interface (optional) or two digital inputs (optional)
7. RJ-45 Ethernet connector (optional)
8. Current inputs for externally connected current sensors
9. Voltage inputs for four measured voltages

3.2 Control

device has no control buttons. It simply works while connected to proper auxiliary voltage (see Technical specifications). Communication using ENVIS software on your PC, which is the only way, how to control device, was described in chapter 2.

3.2.1 Machine status

can be in one of three basic states indicated by green LED. Function of green LED in conjunction with 10 seconds power-up interval and fixed baud rate communication was previously described in 2.3.

3.2.2 LED codes

LED "PWR" (green) - device status:

- ● (off) power supply voltage is not present, measurement is stopped
- ◐ (slow blinking once per 2 s) normal operation, ready for connection
- ◐ (fast blinking once per 400 ms) device is awaiting commands in fixed baud rate (see 2.3)

LED "A1" and "A2" (red) - configurable/alarm LEDs:

- ● (off) configurable (e.g. alarm off)
- ● (on) configurable (e.g. alarm on)

-  (blinking) configurable (e.g. electricity meter pulse output)

"PWR", "A1" and "A2" LEDs while firmware upgrade is in progress:

-  erasing main program memory
-  receiving new firmware

4 The Method of Measurement and Evaluation of Individual Variables

Measurement includes three continuously performed processes: frequency evaluation, sampling voltage and current signals and evaluation of these sampled data.

Frequency of the fundamental harmonic voltage component is continuously measured and evaluated every 10 seconds. The measured signal is a line voltage of first phase signal modified with a low pass filter. Frequency is assessed as a percentage of the number of full cycles of the network established within each 10 seconds and the cumulative duration of full cycles.

Voltages and currents are evaluated continuously without gaps. Basic evaluation interval is 10/12 cycles of the network ($\sim 200\,ms$ for both $50\,Hz$ or $60\,Hz$ network). All channels are sampled at the frequency of 128 samples per network cycle. Sampling is controlled by the measured frequency in channel U_1. If the value of the frequency is in measurable range it also controls the sampling — sampling is automatically adjusted to the frequency change. Otherwise, the sampling runs according to the preset nominal frequency ($50\,Hz$ or $60\,Hz$). RMS voltage and currents are evaluated from the sampled values for the measuring cycle according to equations:

4.1 Basic quantities (RMS)

Line-to-Neutral and Line-to-Line voltages, currents:

$$U_1 = \sqrt{\frac{1}{n}\sum_{i=1}^{n} U_{1i}^2},\ U_{12} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(U_{1i} - U_{2i})^2},\ I_1 = \sqrt{\frac{1}{n}\sum_{i=1}^{n} I_{1i}^2}$$

where: i..... sample index
n..... number of samples per cycle of measurement (128)
$U_{1,i}$, $U_{2,i}$, $I_{1,i}$ ..... individual samples of voltage and current

4.2 Powers and power factor (PF)

Active and reactive power (single phase, three phase)[6]:

$$P_1 = \frac{1}{n}\sum_{i=1}^{n} U_{1i} \times I_{1i},\ 3P = P_1 + P_2 + P_3$$

$$Q_1 = \sum_{k=1}^{N} U_{1,k} \times I_{1,k} \times \sin \triangle\varphi_{1,k},\ 3Q = Q_1 + Q_2 + Q_3$$

[6]The equations are valid for a three phase star connection.

where: k ..... index of the order of each harmonic
N ..... highest harmonic (63)
$U_{1,k}$, $I_{1,k}$ ..... k-th harmonic of voltage and current (1^{st} phase)
$\Delta\varphi_{1,k}$ ..... angle between $U_{1,k}$, $I_{1,k}$ (1^{st} phase)

Apparent and Distortion power (per phase, three phase):

$$S_1 = U_1 \times I_1,\ 3S = S_1 + S_2 + S_3$$

$$D_1 = \sqrt{S_1^2 - P_1^2 - Q_1^2},\ 3D = \sqrt{3S^2 - 3P^2 - 3Q^2}$$

Power factor (per phase, three phase):

$$PF_1 = \frac{|P_1|}{S_1},\ 3PF = \frac{|3P|}{3S}$$

4.3 Harmonic distortion of voltages and currents

is continuously evaluated by FFT up to 63rd harmonic. The calculation is performed by using a rectangular window of each measurement cycle. Following parameters are evaluated from the harmonic analysis:

Fundamental (1^{st}) harmonic of voltage and current:

$$Ufh_1,\ Ifh_1$$

The absolute angle of the fundamental harmonic voltage and current phasors:

$$\varphi U_1,\ \varphi I_1$$

The angle between the corresponding phasors of the fundamental harmonic components of voltage and current:

$$\triangle\varphi_1$$

The angle between a voltage and the corresponding current phasors of the i-th order:

$$\triangle\varphi_i$$

Total harmonic distortion of voltage and current (as defined in 61000-4-30):

$$THDU = \frac{\sqrt{\sum_{i=2}^{40} Uh_i^2}}{Uh_1} \times 100,\ \ THD\text{–}R_U = \frac{\sqrt{\sum_{i=2}^{max} Uh_i^2}}{U} \times 100\,[\%]$$

$$THDI = \frac{\sqrt{\sum_{i=2}^{40} Ih_i^2}}{Ih_1} \times 100,\ \ THD\text{–}R_I = \frac{\sqrt{\sum_{i=2}^{max} Ih_i^2}}{I} \times 100\,[\%]$$

where: U ..... voltage TRMS (line-to-neutral or line-to-line)
I ..... current TRMS
i ..... order of the respective harmonic component
Uh_i, Ih_i ..... i-th harmonic of voltage and current

Power factor (of the fundamental harmonic components):

$$\cos \triangle\varphi_1$$

$$3cos\triangle\varphi = cos\left(\arctan\left(\frac{3Qfh}{3Pfh}\right)\right)$$

Reactive and reactive power of the fundamental harmonic component:

$$Pfh_1 = Ufh_1 \times Ifh_1 \times cos\triangle\varphi_1,\ 3Pfh = Pfh_1 + Pfh_2 + Pfh_3$$

$$Qfh_1 = Ufh_1 \times Ifh_1 \times sin\triangle\varphi_1,\ 3Qfh = Qfh_1 + Qfh_2 + Qfh_3$$

4.4 Symmetrical components

Voltage, current unbalance and negative sequence current is evaluated as a decomposition to the positive and negative sequence of fundamental harmonic:

$$unb_U = \frac{negative\_sequence\_component}{positive\_sequence\_component} \times 100\%$$

$$unb_I = \frac{negative\_sequence\_component}{positive\_sequence\_component} \times 100\%$$

$$\varphi nsl$$

4.5 Aggregation and recording

Values are aggregated and stored in the archive in instrument memory according to the settings of the recording interval. By default all average values are recorded. Additionally extreme (maximum and minimum) values in each aggregation interval can be also recorded.

Aggregation of each interval starts at the beginning of the cycle (determined by RTC tick), following the expiration of the previous time interval as required by the standards - 61000-4-30 for class S. If all the available memory capacity for main archive is used than the archivation stops or restarts according to the Main Archive configuration. If *Cyclic Recording* is not selected, the instrument stops recording until it is reconfigured (and thus erased) by user or software. Otherwise the recording continues with the new measured values overwriting the oldest values in memory (FIFO). The device contains the "latest" set of records, which corresponds to the memory capacity of the actual device and configuration.

5 Technical Specifications

5.1 Basic Parameters

Auxiliary Voltage			
	model „U“	**model „L“**	**model „S“**
AC aux. voltage range, f: 40 ÷ 450 Hz	85 ÷ 275 VAC	20 ÷ 50 VAC	10 ÷ 26 VAC
DC aux. voltage range	80 ÷ 350 VDC	20 ÷ 75 VDC	10 ÷ 36 VDC
power supply	10 VA / 5 W		
overvoltage category	III		
pollution degree	2		
connection	isolated, polarity free		

Other Specifications	
operational temperature	- 20 to 60°C
storage temperature	- 40 to 80°C
operational and storage humidity	< 95 % - non-condensable environment
EMC – immunity	EN 61000 – 4 - 2 (6 kV / 8 kV) EN 61000 – 4 - 3 (10 V/m up to 1 GHz, 3 V/m up to 3 GHz) EN 61000 – 4 - 4 (4 kV / 2 kV) EN 61000 – 4 - 5 (4 kV / 2 kV) EN 61000 – 4 - 6 (10 V) EN 61000 – 4 - 11 (250 periods)
EMC – emissions	EN 55011, class A EN 55022, class A (not for home use)
communication ports	RS-485, optional USB, Ethernet, M-bus
communication protocols	KMB, Modbus RTU and TCP, web server, DHCP, NTP
accuracy of RTC	+/- 1 seconds per day
capacity of RTC backup battery	> 5 years (without supply voltage applied)
protection class front panel whole instrument	 IP 40 IP 20
dimensions front panel whole instrument	 106 x 45 mm 106 x 90 x 58 mm
weight	max. 0.3 kg

5.2 Measured Quantities

Measured Quantities – Voltage	
Frequency	
f_{NOM}– nominal frequency	50 / 60 Hz
measuring range	40 ÷ 70 Hz
uncertainty	± 10 mHz
Voltage	
voltage input option	**standard variant („230“)**
U_{NOM} (U_{DIN})– rated voltage	50 ÷ 550 VAC
measuring range line-to-line	3 ÷ 850 VAC
measuring range line-to-neutral	5 ÷ 1470 VAC
intrinsic uncertainty (t_A=23±2ºC)	+/- 0.05 % of rdg ± +/- 0.01 % of rng
temperature drift	+/- 0.03 % of rdg ± +/- 0.01 % of rng / 10 ºC
measurement category	300V CAT III
permanent overload	1300 VAC (UL–N)
peak overload, 1 second	2210 VAC (UL–N)
burden power (impedance)	< 0.1 VA (Ri = 3.9 MΩ)
Voltrage Unbalance	
measuring range	0 ÷ 10 %
measuring uncertainty	± 0.15 %
THDU	
measuring range	0 ÷ 20 %
measuring uncertainty	± 0.1 %
Harmonics (up to 127th order)	
reference conditions	other harmonics up to 200 % of class 3 acc. to IEC 61000–2-4 ed.2
measuring range	10 ÷ 100 % of class 3 acc. to IEC 61000–2-4 ed.2
measuring uncertainty	the levels of class I acc. to IEC 61000–4-7 ed.2

Mains Signalling Voltage (with optional firmware module „RCS“ only)	
measuring range	0 ÷ 20 % U_{NOM}
frequency range	100 ÷ 6000 Hz
measuring uncertainty	the levels of class I acc. to IEC 61000–4-7 ed.2

Measured Quantities – Current, Temperature			
Current			
current input option	**„Pxxx“**	**„Sxxx“**	**„X/100mA“**
I_{NOM} (I_B) – rated (basic) current	xxx AAC	xxx AAC	0.1 AAC
measuring range	0.0005 ÷ 2 xxx AAC	0.0005 ÷ 2 xxx AAC	0.00005 ÷ 0.2 AAC
intrinsic uncertainty (t_A=23 ±2 ºC)	+/- 0.05 % of rdg ± +/- 0.01 % of rng		
temperature drift	+/- 0.03 % of rdg ± +/- 0.01 % of rng / 10 ºC		
measurement category	150V CAT III	600V CAT III	600V CAT III
permanent overload	3 x I_{NOM}	3 x I_{NOM}	0.3 AAC
peak overload 1 second, maximum repetition frequency > 5 minutes	I_{NOM}<35A: 20xI_{NOM} I_{NOM}=35÷100A:10xI_{NOM} I_{NOM}>100 A: 5xI_{NOM}	I_{NOM}<35A: 20xI_{NOM} I_{NOM}=35÷100A:10xI_{NOM} I_{NOM}>100 A: 5xI_{NOM}	1 AAC
burden power (impedance)	<0.05 VA (Ri=0.2÷25 Ω)	<0.05 VA (Ri=0.2÷25 Ω)	< 0.005 VA (Ri < 0.5 Ω)
Current Unbalance			
measuring range	0 ÷ 100 %		
measuring uncertainty	± 0.15 %		
Harmonics & Interharmonics (up to 50th order)			
reference conditions	other harmonics up to 1000 % of class 3 acc. to IEC 61000–2-4 ed.2		
measuring range	500 % of class 3 acc. to IEC 61000–2-4 ed.2		
measuring uncertainty	Ih <= 10 % I_{NOM} : ± 0.1 % I_{NOM}		
	Ih > 10 % I_{NOM} : ± 0.5 % of rdg		
THDI			
measuring range	0 ÷ 200 %		
measuring uncertainty	THDI <= 100 % : ± 0.1 %		
	THDI > 100 % : ± 0.1 % of rdg		
Temperature (internal sensor, measured value affected by the instrument power dissipation)			
measuring range	- 40 ÷ 80°C		
measuring uncertainty	± 2 ºC		

Measured Quantities – Power, Power Factor, Energy	
Active / Reactive Power, Power Factor (PF), cos φ ($P_{NOM} = U_{NOM} \times I_{NOM}$)	
reference conditions “A” : ambient temperature (t_A) U, I for active power, PF, cos φ for reactive power	 23 ± 2 ºC U = 80 ÷ 120 % U_{NOM}, I = 1 ÷ 120 % I_{NOM} PF = 1.00 PF = 0.00
act. / react. power uncertainty	± 0.1 % of rdg ± 0.005 % P_{NOM}
PF & 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 ºC U = 80 ÷ 120 % U_{NOM}, I = 2 ÷ 120 % I_{NOM} PF >= 0.5 PF <= 0.87
act. / react. power uncertainty	± 0.2 % of rdg ± 0.005 % P_{NOM}
PF & cos φ uncertainty	± 0.005
temperature drift of powers	± 0.05 % od rdg ± 0.02 % P_{NOM} / 10 ºC
Energy	
measuring range	6 „quadrants“, corresponds to U & I measuring ranges
active energy uncertainty	class 0.2S acc. to EN 62053 – 22
reactive energy uncertainty	class 2 acc. to EN 62053 – 23

5.3 Inputs and Outputs

Digital Outputs & Digital Inputs	
Two Digital Outputs	
type	Opto-MOS relay, bipolar
load rating	100 $V_{AC/DC}$, 100 $mA_{rms/DC}$
Two Digital Inputs	
type	optoisolated, unipolar
maximum voltage	30 V_{DC}
voltage for “logical 1“	> 10 V_{DC}
voltage for “logical 0“	< 3 V_{DC}
input current	3 mA @ 10V / 8 mA @ 24V

5.4 Power Quality and Energy Management

5.4.1 IEC 61000-4-30, 61000-4-15, 61000-4-7:

Function characteristics according to IEC 61000-4-30 ed.2				
Function	Class	Uncertainty	Measuring range	Notes
frequency	A	± 10 mHz	40 ÷ 70 Hz	
magnitude of the supply	A	± 0.1 % Udin	10 ÷ 150 % Udin	
flicker	A	± 5 % of value or ± 0,05	0.2 ÷ 20	2, 4)
dips and swells	A	± 0.1 % Udin, ± 1 cycle	5 ÷ 150 % Udin	2)
interruptions	A	± 1 cycle	unlimited	2)
unbalance	A	± 0.15 %	0.5 ÷ 10 %	
voltage harmonics & interharmonics	A	the levels of class I acc. IEC 61000–4-7 ed.2	10 ÷ 200 % of class 3, 50h acc. IEC 61000–2-4 ed.2	1)
mains signalling voltage	A	the levels of class I acc. IEC 61000–4-7 ed.2	0 ÷ 20 % Udin	1, 3)

1) … according to IEC 61000-4-7 ed. 2.0

2) … with optional firmware module „PQ A“

3) … with optional firmware module „RCS“

4) … class F1 according to IEC 61000-4-15 ed. 2.0

5.4.2 EN 50160

Power Quality acc. to EN 50160 (with optional firmware module „PQ A“ only)	
evaluation period	weekly
Interharmonics (up to 127th order)	
reference conditions	other harmonics up to 200 % of class 3 acc. to IEC 61000–2-4 ed.2
measuring range	10 ÷ 100 % of class 3 acc. to IEC 61000–2-4 ed.2
measuring uncertainty	the levels of class I acc. to IEC 61000–4-7 ed.2
Flicker (with optional firmware module „PQ A“ only)	
measuring range	0.2 ÷ 10
measuring uncertainty	± 5 % of rdg (acc. to IEC 61000–4-15)
Voltage Dips & Swells (with optional firmware module „PQ A“ only)	
measuring uncertainty	+/- 0.05 % of rng
Voltage Interruptions (with optional firmware module „PQ A“ only)	
measuring uncertainty	+/- 0.1 % of rng
duration measuring uncertainty	± 1 cycle
Mains Signalling Voltage	
evaluation period	3s interval

5.5 IEC 61557-12: Classification of the power monitoring instrument

Instrument characteristics according to IEC 61557-12	
power quality assessment function	PQI-A
classification according to par. 4.3 direct voltage connection voltage connection via VT	 SD SS
temperature according to par. 4.5.2.2	K55
humidity + altitude according to par. 4.5.2.3	< 95 % - noncondensation conditions < 3000 m
active power/energy function performance class	0.2

Function characteristics according to IEC 61557-12 Model **„Pxxx“, „Sxxx“** or **„X/100mA“** with **„xxx/100mA“** CTs, I_{NOM} = xxx A, U_{NOM} = 230 V				
Symbol	Function	Class	Measuring range	Notes
P	total effective power	0.1	0 ÷ (4800 * I_{NOM}) W	
Q_A, Q_V	total reactive power	1	0 ÷ (4800 * I_{NOM}) var	
S_A, S_V	total apparent power	0.2	0 ÷ (4800 * I_{NOM}) VA	
E_a	total active energy	0.2	0 ÷ (4800 * I_{NOM}) Wh	
E_{rA}, E_{rV}	total reactive energy	2	0 ÷ (4800 * I_{NOM}) varh	
E_{apA}, E_{apV}	total apparent energy	0.2	0 ÷ (4800 * I_{NOM}) VAh	
f	frequency	0.02	40 ÷ 70 Hz	
I	phase current	0.05	0.01 ÷ 2 * I_{NOM} A_{AC}	
I_N	neutral current measured	0.2	0.002 ÷ 2 * I_{NOM} A_{AC}	
I_{Nc}	neutral current calculated	–	–	
U_{LN}	line-to-neutral voltage	0.05	40 ÷ 280 V_{AC}	
U_{LL}	line-to-line voltage	0.05	70 ÷ 480 V_{AC}	
PF_A, PF_V	power factor	0.5	0 ÷ 1	
P_{st}, P_{lt}	flicker	2	0.4 ÷ 10	2)
U_{dip}	voltage dips	0.1	10 ÷ 230 V_{AC}	2)
U_{swl}	voltage swells	0.1	230 ÷ 280 V_{AC}	2)
U_{tr}	transients overvoltage	–	–	
U_{int}	voltage interruption	0.1	0 ÷ 10 V_{AC}	2)
U_{nba}	voltage unbalance (amp.)	0.2	0 ÷ 10 %	
U_{nb}	voltage unbalance (ph.&amp.)	0.2	0 ÷ 10 %	
U_h	voltage harmonics	1	up to 50th order	1)
THD_u	voltage total harmonic distortion (rel. to fund.)	1	0 ÷ 20 %	1)
$THD\text{-}R_u$	voltage total harmonic distortion (rel. to RMS)	1	0 ÷ 20 %	1)
I_h	current harmonics	1	up to 50th order	1)
THD_i	current total harmonic distortion (rel. to fund.)	1	0 ÷ 200 %	1)
$THD\text{-}R_i$	voltage total harmonic distortion (rel. to RMS)	1	0 ÷ 200 %	1)
M_{SV}	mains signalling voltage	1	0 ÷ 46 V_{AC}	1)

1) … according to IEC 61000-4-7

2) … with optional firmware module „PQ S“

3) … with optional firmware module „RCS“

6 Maintenance, Service, Warranty

Maintenance: the ARTIQ 144 power analyzer does not require any maintenance during its operation. For reliable operation it is only necessary to meet the operating conditions specified and not expose the instrument to violent handling and contact with water or chemicals which could cause mechanical damage.

The lithium cell built in the instrument can backup a real time circuit for more than 5 years without power supply, at average temperature $20^{\circ}C$ and load current in the instrument less than $10\,\mu A$. If the cell is empty, it is necessary to ship the instrument to the manufacturer for battery replacement.

Service: in the case of failure or a breakdown of the product, you should contact the supplier at their address:

KMB Systems, s. r. o.
Tř. dr. M. Horákové 559
460 05 Liberec 7
Czech Republic
Tel. 485 130 314, Fax 482 739 957
E-mail: kmb@kmb.cz, Web: `www.kmb.cz`

The product must be in proper packaging to prevent damage during transit. A description of the problem or its symptoms must be delivered together with the product.

If a warranty repair is claimed, the warranty certificate must be sent in. In case of an out-of-warranty repair you have to enclose an order for the repair.

Warranty certificate: warranty period of 24 months from the date of purchase is provided for the instrument, however, no longer than 30 months from the day of dispatch from the manufacturer. Problems in the warranty period, provably because of faulty workmanship, design or inconvenient material, will be repaired free of charge by the manufacturer or an authorized servicing organization.

The warranty ceases even within the warranty period if the user makes unauthorized modifications or changes to the instrument, connects it to out-of-range quantities, if the instrument is damaged due to ineligible or improper handling by the user, or when it is operated in contradiction with the technical specifications presented.

Type of product:	ARTIQ 144	Serial number:	.....
Date of dispatch:	.....	Final quality inspection:	.....
		Manufacturer's seal:	.....
Date of purchase:	.....	Supplier's seal:	.....