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NEMO 332

Network Analyzer and Monitor

Operating manual

Version 1.0

Contents

1 General Description

Network monitor NEMO 332 (hereinafter referred to as NEMO) is a programmable registration measuring device for measuring the three-phase distribution systems. It is designed for measurements in substations, switch cabinet, low voltage distribution networks or directly by customers.

1.1 Characteristic Features

Connection and Measurement

- four voltage inputs
- up to 8x4 (I_1, I_2, I_3, I_n) current inputs for connecting a number of current probes SPQ-I
- an input for Pt100 thermometer or 4-20mA current loop input (optional)
- power supply:
  - separated from measuring voltage, range $85 - 480\,V_{AC}$ or $80 - 680\,V_{DC}$
  - internal battery (for a limited time to cover loss of power supply)
  - via USB interface (when setting up the device and downloading)
- 128 samples per period, voltage inputs and current inputs up to 4 currents are read continuously without any gaps, when measuring more than 4 currents inputs are read discontinuously (multiplexed)
- evaluates the measured values as frequency, power, power factor and harmonic components and THD of voltages and currents to the order of 63

Registration of Measured Data

- built-in real-time clock with battery backup.
- "flash" memory with a capacity of 512 megabytes to record the measured data
- aggregation interval from 200 milliseconds to 24 hours
- voltage events recording (short-term / voltage dips and interruptions)

Transfer and Evaluation of Recorded Data

- USB communication interface for data transmission, device configuration and firmware upgrade
- wireless communication: WiFi (optional), GPRS or HSDPA (optional)
- visualization and setup program ENVIS

1.2 Types and Accessories

Measuring set is available in several configurations according to the customer requirements[1]. It usually consists of the main analyzer unit and several optional accessories as follows:

Table 1: Instrument types

Type	Description
NEMO 332-0	without current inputs
NEMO 332-1	1 input for SPQ-I series current probe
NEMO 332-2	2 inputs for SPQ-I series current probe
NEMO 332-4	4 inputs for SPQ-I series current probe
NEMO 332-8	8 inputs for SPQ-I series current probe

Table 2: Standard accessories

Type	Description
XSMF-419	voltage cable with built-in fuse, 8 pcs
USB A/miniB	USB communication cable, 1 pc
XKK 1001	croco clip, 8 pcs
SPQ-UX	jumper, 2 pcs

Table 3: The basic types of current probes

Type	Description
SPQ-I3000-3JRF1	current probe with three sensors JRF1 to 3000A
SPQ-I3000-4JRF1	current probe with four sensors JRF1 to 3000A
SPQ-I1000-3JRF1	current probe with three sensors JRF1 to 1000A
SPQ-I1000-4JRF1	current probe with four sensors JRF1 to 1000A

Table 4: Optional accessories

Type	Description
SPQ-T	temperature sensor Pt100

Figure 1: Voltage cable (XSMF-419), USB cable, Jumper (SPQ-UX), Croco-Clip (XKK-1001)

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

1.3 Ordering diagram

NEMO 332 - 1 A W N

Instrument Type
NEMO 332 = Portable Network Monitor

Current Inputs
1 = 1 input for SPQ-I current probe (up to 4 currents)
2 = 2 inputs for SPQ-I current probes (up to 8 currents)
4 = 4 inputs for SPQ-I current probes (up to 1 currents)
8 = 8 inputs for SPQ-I current probes (up to 32 currents)

Analog Inputs
N = Without inputs
A = 0(4) - 20 mA current loop input, 2 logical inputs
T = Input for temperature sensor, 2 logical inputs

Wireless Communication Interface 1
N = Without communication interface
W = Wi-Fi with integrated antenna
X = Wi-Fi, SMA-M connector for external antenna

Wireless Communication Interface 2
N = Without communication interface

Current probe options

SPQ - I3000 - 4 JRF1

Current Probe Type
SPQ - Probe for NEMO class instruments

Current Ranges
I10000 = Inom 10000A/3000A/1000A/300A
I3000 = Inom 3000A/1000A/300A/100A
I1000 = Inom 1000A/300A/100A/30A
I300 = Inom 300A/100A/30A/10A

Number of Current Sensors
3 = Three sensors
4 = Four sensors

Current Sensor Type
JRF1 = J&D rogowski coil (Ø12mm), length 40cm (Ø12,7cm)
JRF2 = J&D rogowski coil (Ø12mm), length 60cm (Ø19,1cm)
JRF3 = J&D rogowski coil (Ø12mm), length 100cm (Ø32,0cm)
MFC0 = Algodue rogowski coil (Ø8,3mm), length 25cm (Ø8,0cm)
MFC1 = Algodue rogowski coil (Ø8,3mm), length 40cm (Ø12,7cm)
MFC2 = Algodue rogowski coil (Ø8,3mm), length 60cm (Ø19,1cm)
MFC3 = Algodue rogowski coil (Ø8,3mm), length 100cm (Ø32,0cm)
JCLA = J&D clamp-on CT, max. conductor Ø13mm, (only I300 available)

2 Operating the Analyzer

2.1 Safety Requirements when using NEMO

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. It is recommended to always use protective gloves.

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!

2.2 Connecting cables

Correct procedure of cable connection:

- Verify, that you are connecting cable to correct connector.
- In good light conditions, check cable and connectors optically and turn them co-axially properly to each other.
- Plug the cable gently onto the connector.
- While pushing slightly, turn cable until its groove snaps to its counterpart on connector.
- Now push the cable stronger towards the connector (without any further turning) until it is completely plugged in.

Procedure of cable disconnection:

- Take the plug and pull it straight from the connector without any turning. Stronger force might be necessary — it is not a bug.

2.3 Preparation Prior to Measurement

Before the measurement is started it is necessary to configure the instrument appropriately. This setting is always done by PC with a supplied program ENVIS.Daq[2].

[2] Before first use the ENVIS must be installed in the PC. Detailed description can be found in The ENVIS User Guide.

2.3.1 Configuring NEMO on a PC

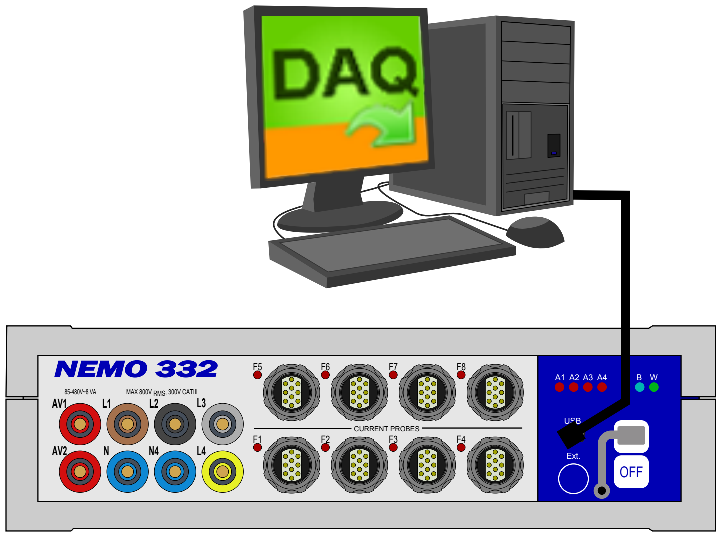


Figure 2: Connecting NEMO to a Computer

A connection form with typical parameters is shown in Figure 2. Connect NEMO to the computer via USB cable[3]. The connection through the USB interface should also supply enough power to the analyzer. No additional auxiliary voltage is required. Supply voltage is indicated by the LED B glowing green. Than the unit is ready to be adjusted. We can now set-up a desired operation. This setting will erase all previously archived data in internal memory of the instrument. So before writing new configuration to the device make sure to backup the last measured archive.

1. Run the ENVIS.Daq.
2. Open the main window (Figure 3).
3. Choose the type of communication interface and its other related parameters. Because the device driver creates a virtual PC COM port select the appropriate COM port (in our case).
4. Press the 'Connect' button.

Figure 3: Start screen of ENVIS.Daq

The program reads the settings from the connected device and displays it in the summary window (Figure 4).

[3]When the instrument is connected for the first time it is necessary to provide a proper USB driver. This driver can be found in the ENVIS installation directory and on the KMB DVD.

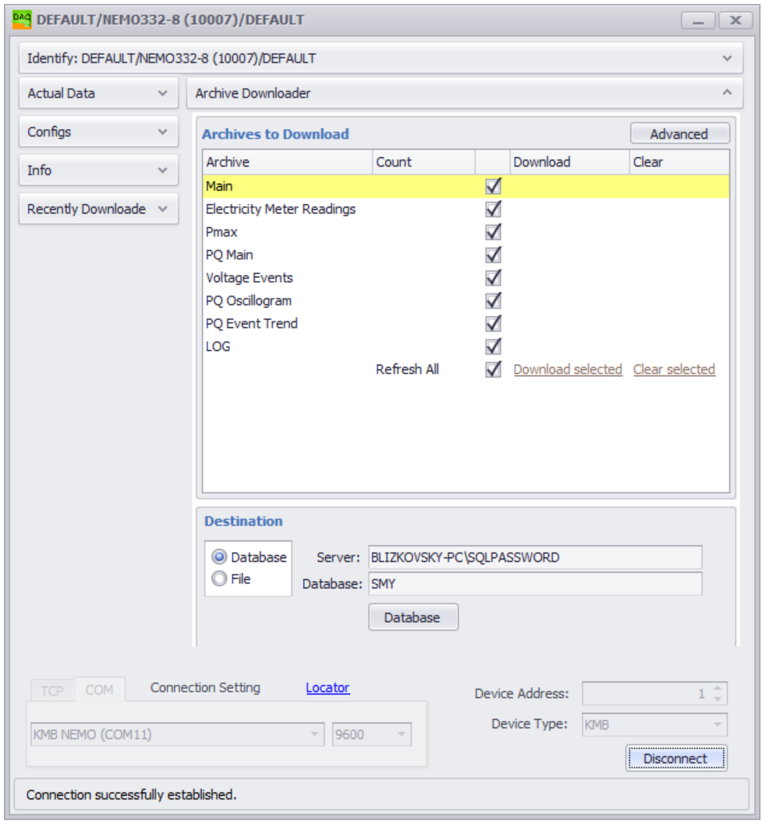


Figure 4: ENVIS.Daq - connected instrument

Category 'Instrument Settings' includes a number of parameters, which are arranged in tabs according to its relation. User can configure the following in the individual tabs:

2.3.2 Identify

- *Object* - is a number or name of object (generally a text string) , where the measurement was performed. 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 (eg. name of the transformer in the building). In our case "DEFAULT". This is again a text string of maximum length of 32 characters which can be adjusted later.
- Other informative parameters of this tab group indicate the type of connected device (model, serial number, etc.) and they can not be changed.

2.3.3 Configs

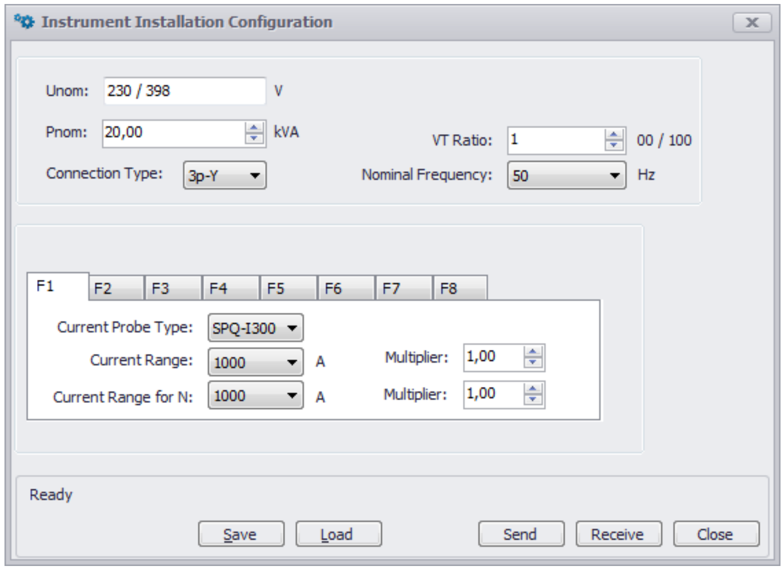


Figure 5: ENVIS.Daq - Install configuration window

Install (see fig. 5)

- *Nominal Frequency* - This parameter should be set according to the nominal network frequency measured at 50 or 60 Hz.
- U_{NOM} , P_{NOM} – Rated voltage and rated power. To be able to view the voltage output as a percentage of nominal value and the detection of voltage events, it is necessary to specify a nominal (primary) voltage $\mathrm{U_{NOM}}$ and the nominal three-phase power (power) $\mathrm{P_{NOM}}$. Although the setting for $\mathrm{U_{NOM}}$ and $\mathrm{P_{NOM}}$ has no effect on the device measuring functionality, we recommend to set at least the $\mathrm{P_{NOM}}$ correctly. Proper setting of $\mathrm{P_{NOM}}$ is a critical issue as it affects the displayed relative values of power and current and some of the data interpretation functions in ENVIS software. The setting can moreover be adjusted later. If the value of $\mathrm{P_{NOM}}$ at the measured point can not be determined, we recommend to set the value according to the nominal power supply of the transformer, or to estimate this value as the maximal expected. $\mathrm{U_{NOM}}$ value is displayed in the format as phase/line voltage for convenience.
- *VT Ratio* - must be set accordingly to the used method of voltage measurement and used transformer.
- *Connection type* -
  - *3p-Y* - configuration for measuring in 3ph 4 wire systems
  - *4p-Y* - configuration for measuring in 3ph 5 wire systems
  - *3p-D* - configuration formeasuring in 3ph 3 wire systems, without neutral
  - *Aron* - configuration for measuring in Aron connection networks
- *Current range* - specifies range of used current probe. Each probe (F1-F8) is configured individualy.
- *Multiplier* - multiplies measured value of current. Appropriate for situations where measured wire is going through current sensor multiple times in order to reach higher sensitivity. I.e.: Set multiplier to 0.5 in situatuin where wire is going through current sensor 2 times.

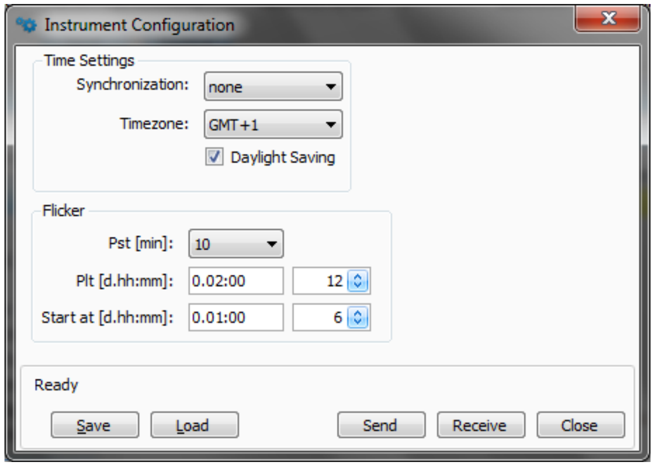


Figure 6: ENVIS.Daq - General configuration window

General (see fig. 6)

- *Time Settings*
  - *Timezone* - Time zone must be set according to the local requirements. The setting is important for correct interpretation of local time, which also determines the actual allocation of tariff zones of the meter.
  - *Synchronization* - This parameter determines how the device synchronizes its time.
  - *Daylight Saving* - This parameter can be set to automatically switch of the local time according to the season (eg. summer or winter time).

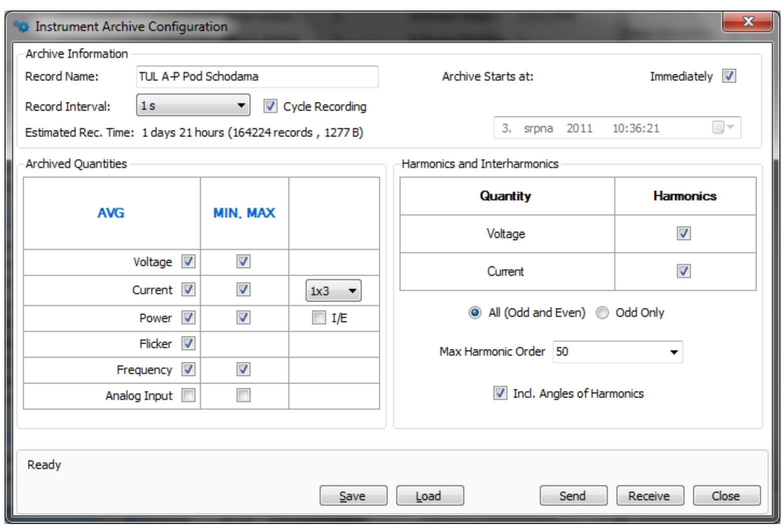


Figure 7: ENVIS.Daq - Archive configuration window

Archive (see fig. 7) this settings determines the set of quantities which are being recorded:

- *Record Name* – Naming the records helps to distinguish different records in the measured object (eg, using the id marking of the measured transformer). This is again a text string of maximum length of 32 characters. The records are stored in a database or in the file while using this identifier.

- *Record Interval* – this (aggregation) interval of the recording determines the frequency of entry into the archives of readings in the range of 1 second up to 24 hours.
- *Cycle Recording* – With this switch you can determine the behavior of the device when closing the main archive. If this option is activated, the memory capacity of the archive of the main unit stops recording data in the archive until the instrument is reconfigured. Otherwise, the record continues with the new measured values overwriting the oldest values first (FIFO). The main archive than contains the "latest" data of a total length corresponding to the capacity of the main archive.
- *Recording Start Time , Immediately* - determines whether to begin recording immediately after the instrument is powered on or only after the preset amount of time has passed. This time value can be set in the appropriate box.
- *Archived Quantities* - In this section you can choose the set of quantities that you want to record. Selection is made by checking required quantities in *AVG* column. Record will then contain average values for the time equal to *Record Interval.* If you want to record the maximum and minimum values of the measuring cycle (see explanation below) during the recording interval, check the appropriate box in column MIN MAX. At the current it can be determined how many current probes will be recorded. The powers in column Import/Export determines whether to store import and export resp. inductive or reactive load sums separately. Under Harmonics section operator can choose to record harmonic voltages and currents. Due to the large volume of data you can enter only a limited range of selected major harmonic components.
- The dialog also shows the estimated capacity of the main archive with the actual configuration (Estimated Record Time).

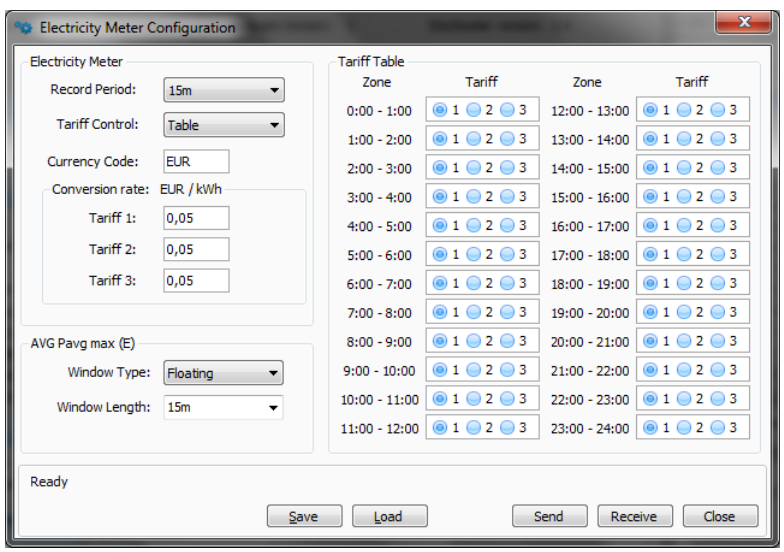


Figure 8: ENVIS.Daq - Electricity meter configuration window

Electricity Meter (see fig. 8) for measuring the electrical energy NEMO use standalone functional unit, so called electricity meter. In addition to electric energy, this unit records the maximum and average active powers. Electric energy is only recorded for the first four currents (Feeder F1).

- *Record Period* – the period of recording of the meter status (automatic meter reading).
- *Tariff* Control – set tariff control.
- *Tariff Table* – This table can set a daily tariffs for three different prices per hour. Energy will be registered separately for each tariff.

- *Window Type, Window Length* – Method of averaging of the average active power $P_{AVGMAX(E)}$. You can choose a fixed window (Fixed), a floating window (Floating). In addition, you can set the length of averaging window.

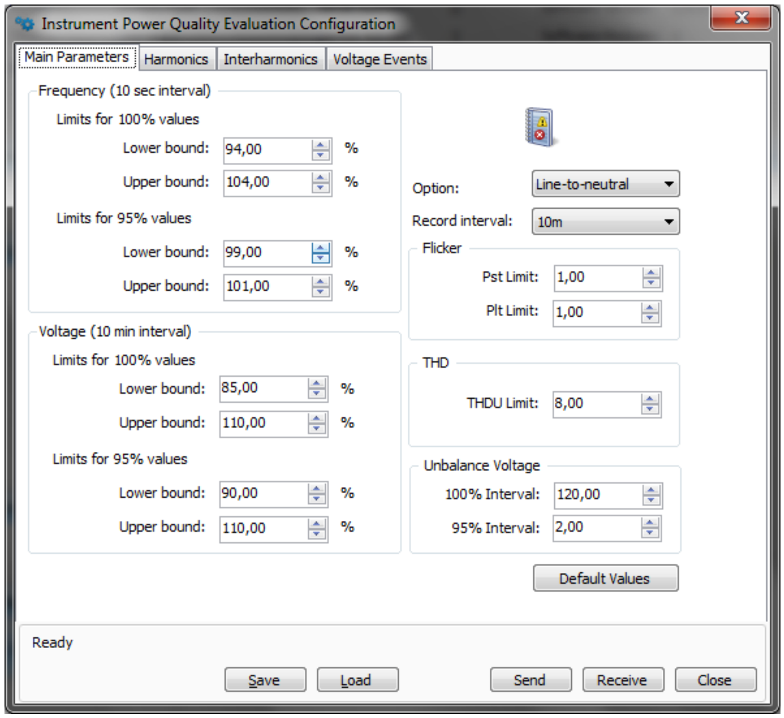


Figure 9: ENVIS.Daq - PQ Setting window

PQ Settings (see fig. 9) In this window you can set the parameters for recording of the voltage events:

- *Dip / Swell / Interruption Threshold* - the threshold of detection drop / surge / power outage (in percent of U_{NOM}).
- *Hysteresis* - Hysteresis of event detection as start/end.

To commit changes in any of the above parameters it is required to send these new values to the instrument using the Send button. Settings can also be backed up into the file for later use with the 'Save' button.

Figure 10: ENVIS.Daq - Settings window of time

It is recommended to check the status of the internal clock in the device. In the 'Info' tab open the 'Instrument Time' window (Figure 10). The program reads the current time set in your device and will display it. It also displays the difference to the actual PC time (Time Difference). If the time in the instrument varies significantly, it can be adjusted by selecting the 'Set Time from the PC' option.

The necessary crucial device settings is than done - disconnect the communication cable and NEMO is ready to be connected to the measured device.

2.4 WiFi Configuration (optional module)

To configure wireless network connection use *WiFi* item in configuration options of ENVIS.Daq application. The configuration panel will open (as shown in figure 11).

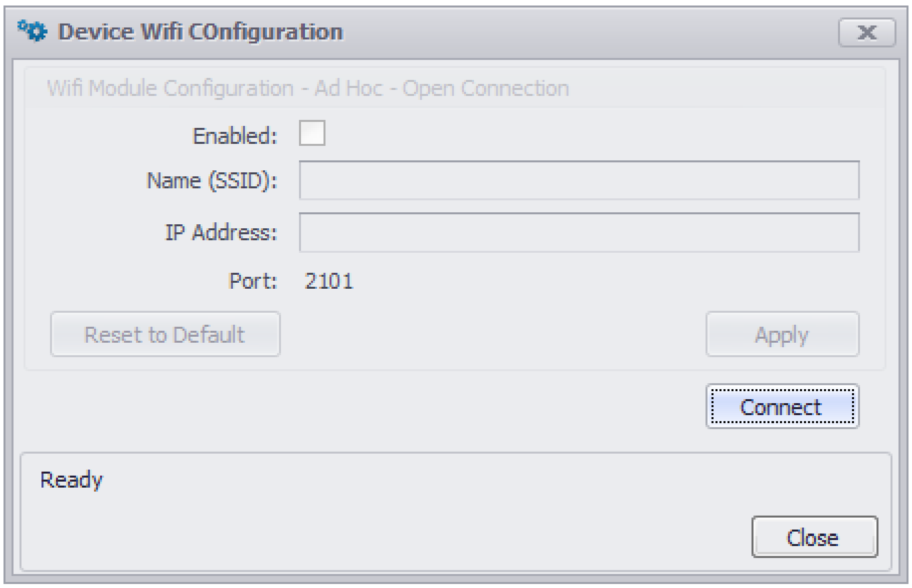


Figure 11: ENVIS.Daq - connection to WiFi module in configuration panel.

Press *Connect* to connect with the embedded WiFi module of NEMO analyzer.

Here you can enable or disable WiFi configure SSID of broadcasted wireless network and IP address of instrument. These parameters must be saved into the instrument by clicking the *Apply* button. Figure 12 shows an example of such configuration.

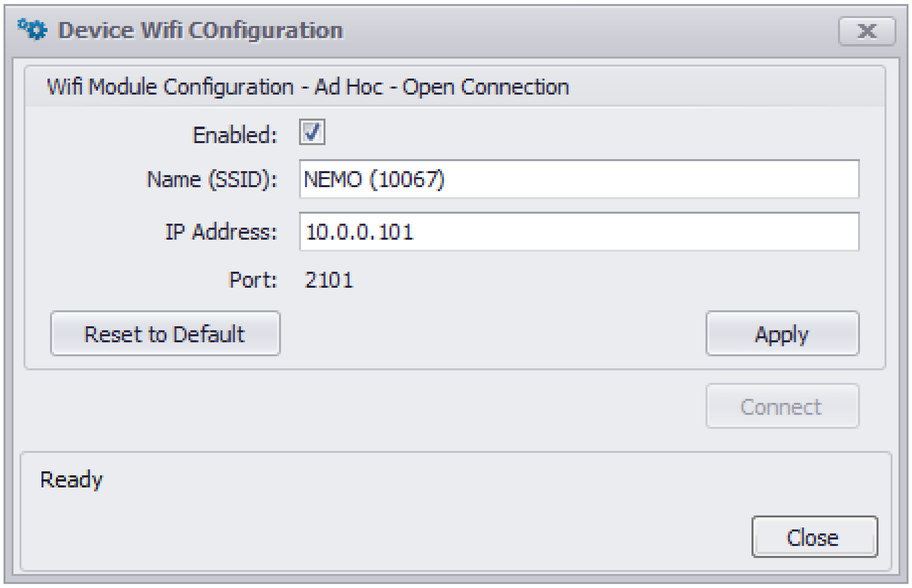


Figure 12: ENVIS.Daq - example of a WiFi network configuration.

If for example we have configured the instrument according to the figure 12 we can than connect it with a PC in the following way:

- Look up available WiFi networks in the PC/laptop and connect to the NEMO (10067).
- Configure PC/laptop wireless network adapter with a fixed IP address — IP address 10.0.0.1 and sub-net mask 255.255.255.0 for example.

PC and the analyzer are now connected in the so called AdHoc mode. Connection to this network is indicated by a blue LED (W) light. You can run the ENVIS.Daq tool, fill in the appropriate credentials and (in *Connection Configuration* chose *TCP*, set IP address 10.0.0.101, port 2101 and *Device Type* KMB). *Connect* button connects the ENVIS.Daq application to the analyzer.

2.5 Installation

Connection of measured voltage input and power supply is carried through cable with safety banana plugs for connecting croco clips.

For current measurements the flexible current probes of SPQ-I series are generally used and it plugs directly into the device.

2.5.1 Measurement of Three-phase 5-wire Grids

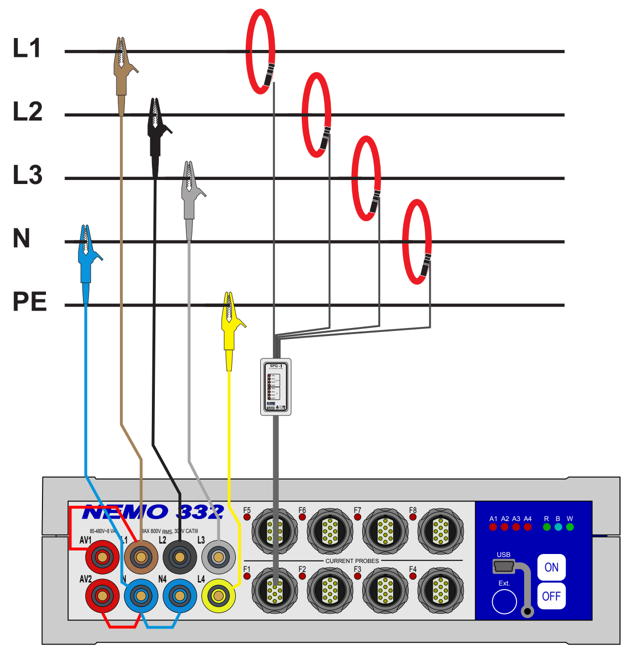


Figure 13: Connecting an instrument to 5-wire network (see also picture 19)

Connection Voltage wires are terminated by safety banana plugs for connecting croco clips that connects directly to the parts under voltage. If possible, connect the measured and supply voltage croco clips to the protective elements. To measure the unprotected circuits wires are secured with 1 A fuses with breaking capability of 1500 A @ 500 V. Example of 5-wire connection of the instrument is in picture 13.

When installing the cable to the measuring point it is recommended to use proper insulated gloves and other applicable protection. When connecting you must proceed as follows:

1. The device is connected to all the voltage and supply cables. When powering from measured voltage signals is required, we connect auxiliary power supply with L1 and N by jumpers SPQ-UX as in picture 13. It is necessary to pay attention to the maximum supply voltage according to the technical parameters set out below! In the opposite case, use separate voltage cables XSMF-419 with corresponding color.

2. If you want to record the currents, power or power factor, connect proper SPQ-I series probes into ports on NEMO - F1, F2, ... according to the number of used current probes.

3. Now connect the voltage and power supplycables with croco clips to the measured device. First, prepare croco clips in one hand in the order in which we will attach them to the measurements. Make sure to grab them so that you can not touch any of the conductive parts.

   In case of usage of an auxilliary power supply voltage, firstly connect this voltage to the red terminals. After connecting the two power supply cables, the LED light B should be green.

   Then connect the neutral conductor N (light blue). Use the empty hand to manipulate with the croco clip and connect it to the N wire of the transformer. Gradually connect other line clips, it is necessary to keep the assignment of appropriate voltage inputs. The croco clip L1 (brown) must be connected to phase 1, croco clip L2 (black) on the phase 2, croco clip L3 (black) on phase 3 and croco clip L4 (yellow) on measured voltage 4.

4. We will install the current measuring sensors. While connecting it is necessary to keep the order of current inputs corresponding to the setup. The current sensor connected to the L1 input current (current probes)

must be connected to phase 1 etc. Current input labeled L4 is primarily designed to measure current in the neutral conductor but can be used otherwise.

Make sure the orientation of current probes is kept correct - the arrow shows the direction of expected positive energy transfer (from the assumed source to the load — see picture [fig:Current-probe-assembly]). When the sensor is closed the lock must be placed as far as possible from the measured conductor. In this position accuracy is the best (optimal axially symmetrical position usually can't be achieved).

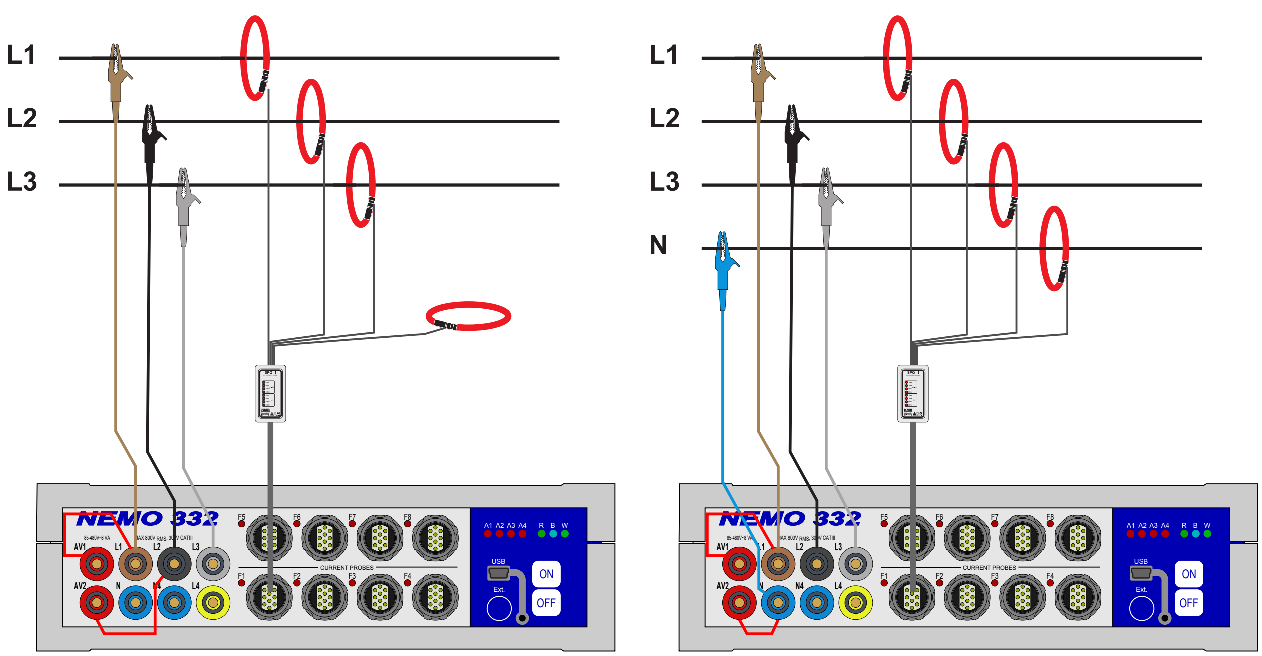
5. Now we can press ON button to start recording. When you start recording, the LED R lights green. At this point the correspondence between the configuration and connected CT's is tested. The device number and type of currently connected sensors is checked. After the scan, LED R flashes green if no discrepancy between the setting of the installation of the device and the actually connected set. Otherwise the LED R flashes red and you must fix either the configuration of the instrument or repair the physical connection.

Disconnection After recording for the required time period the device should be disconnected from the measured point. Recorded data should be transferred to computer. Disconnecting the device must follow the same principles as the connection. The respective tasks should be performed in reverse order:

1. Press OFF to turn off the record. LED R stops flashing, data logging is completed.
2. Carefully disconnect current measuring transducers from the measured appliance.
3. Disconnect voltage and power supply cables. First, disconnect the croco-clips connected to the lines. The N croco-clips should be disconnected as a last one.

   You can now click the button OFF to completely shut instrument down. Transfer the data to a computer using appropriate cable and software.

2.5.2 Measurement of Three-phase 4-wire Grids



(a) Připojení ke 3-vodičové síti (b) Připojení ke 4-vodičové síti

Figure 14: Connecting the 3-wire (b) and 4-wire (a) network (see also picture 19)

In case of connection illustrated in picture 14, maximal power supply voltage must be kept in mind. For possibility of measuring higher voltages, connection of power supply inputs to separate auxiliary voltage is needed.

2.5.3 Measurement of Three-phase 3-wire Grids

Connection from picture 14 can be used to connect to the transformer connected as delta or in isolated systems. Phase voltages, currents and power factor are then evaluated against an artificial neutral voltage, which is created on a voltage divider inside the unit.

In case of connection illustrated in picture 14, maximal power supply voltage must be kept in mind. Instrument measures only phases L1, L2 and L3. Making a connection/disconnection is the same as in the above connection, only the conductor N is missing and its device input remains disconnected.

Phase voltages, currents and power factor are then evaluated against an artificial neutral voltage, which is created on a voltage divider inside the unit.

Please note, that in this case, instrument is powered through the jumpers SPQ-UX from the line voltage. It is crucial to not exceed the maximal power supply voltage (see 4). For possibility of measuring a higher voltages, connection of the power supply inputs to a separate auxiliary voltage is needed.

2.6 Transferring Measured Data to PC

As with setting phase the device should be first connected to the computer where the program ENVIS.Daq runs. Select the appropriate port and press the *Connect* button. Next, press the button Refresh All. This will load and display the actual status of each archive:

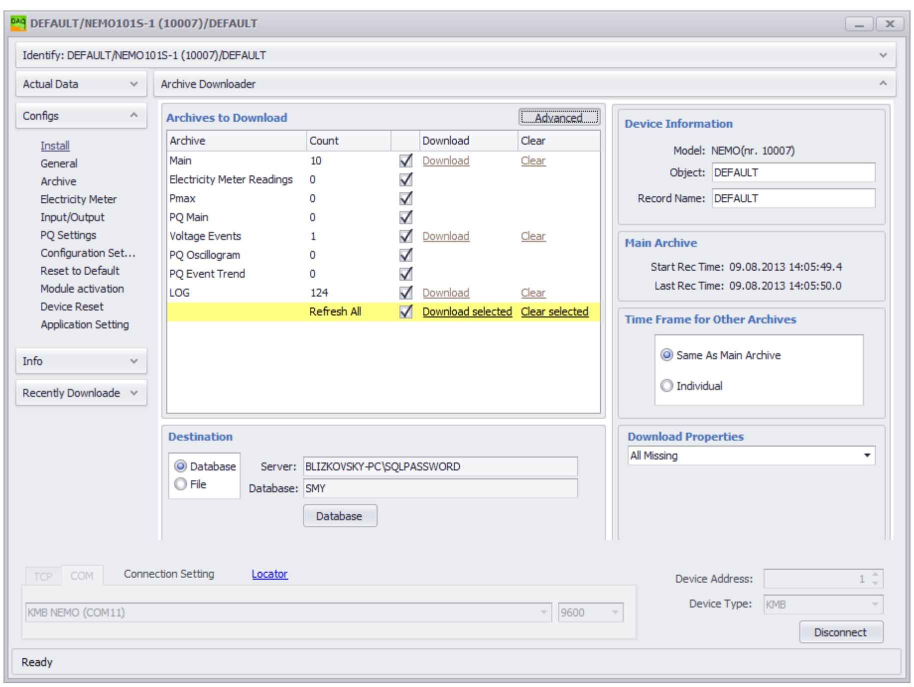


Figure 15: Download window records program ENVIS.Daq

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. In the actual version this can be database or file (several formats). The CEA file data can be imported into the database and vice versa. The check boxes in *Archives to Download* determines which specific archive(s) you want to download. The actual download will start by the download button - after confirming the program starts transferring the data. Progress of the data acquisition is displayed in a window. After complete transmission the window will close automatically. Data can be than viewed in the ENVIS Program.

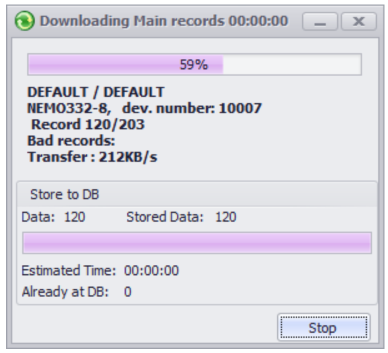


Figure 16: A window providing information about the download.

3 Functional Description

3.1 Instrument Construction

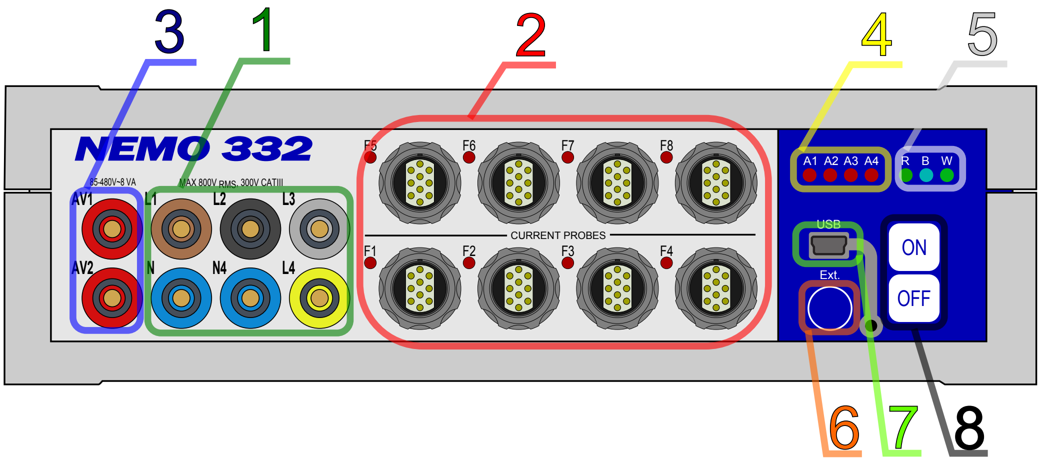


Figure 17: Description of NEMO front panel

1. Inputs for voltage measurement
2. Inputs for connection of SPQ-I current probes
3. Input of power supply voltage 85 ÷ 480 VAC
4. 4 configurable alarm LEDs
5. Status LEDs
6. Connector for external Pt100 temperature sensor
7. Connector for USB cable
8. Control buttons

3.2 Design of Current Sensors

Figure 18: Current probe SPQ-series with three JRF sensors.

Correct polarity must be observed while connecting current sensors. The arrow on the current sensor must show the direction of the nominal power flow, that is from the power source to point of consumption.

After locking up the sensor lock, adjust the sensor position on measured conductor in order that the lock is as far of the conductor as possible – in such position the measurement accuracy is the best.

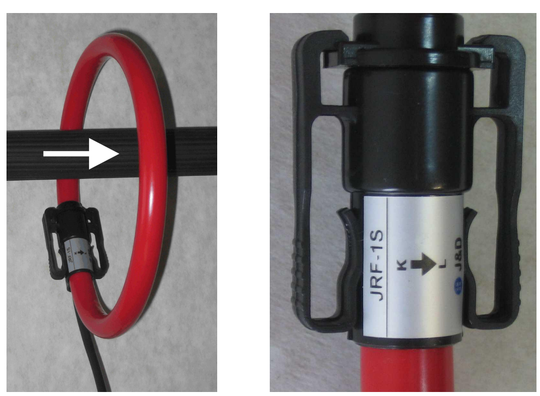


Figure 19: Current probe assembly illustration and detail of current direction indicator.

3.3 Control

NEMO device has two buttons which are used to turn the device on / off and to start / stop each recording.

3.3.1 Machine Status

While powered by battery, the instrument can be in one of three states illustrated below. The state can be changed by pressing one of a control buttons. When the instrument is connected by USB A/miniB cable with

PC or when auxiliary voltage is connected, the device automatically turns on and it is impossible to get it into standby mode by pressing a button. In this state, the internal battery is being recharged and an operator can only pause or resume recording. This feature allows to resume recording after power fails longer than 10 minute interval. After 10 minutes of running power by the battery (while it continues measuring and recording) the instrument automatically switches to the standby mode. When a button is pressed or voltage is connected it switches on and returns to the last state before shutdown. Recording restarts approximately 12 seconds after voltage recovery.

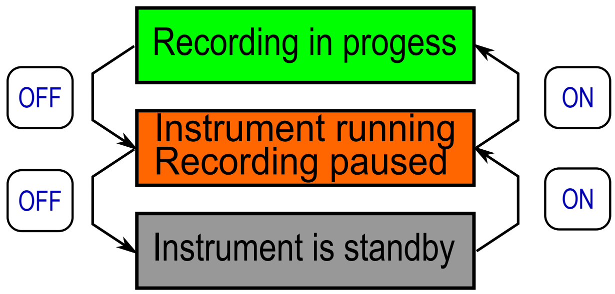


Figure 20: Instrument statuses and function of buttons

3.3.2 LED Codes

LED "R" (Record) - record state:

- (blue) stand-by, measuring and recording offline
- (green) initialization of configuration
- (blinking green) recording started, the instrument setup matches the actual connection
- (blinking red) record is running, instrument setup does not match the actual connection (the data may be invalid)

LED "B" (Battery) - power supply status:

- (off) instrument is turned off
- (blue) battery is fully charged, power supply is connected
- (blinking blue) battery is fully charged, power supply is not connected
- (green) battery charge is normal, power supply is connected
- (blinking green)battery charge is normal, power supply is not connected
- (yellow) low battery warning, battery is charging but instrument won't turn on when turned off
- (blinking yellow žlutá) low battery warning, power supply is not connected and instrument won't turn on when turned off
- (red) battery level is low, power supply is connected
- (blinking red) battery level is low, power supply is not connected

- (blinking red - double flash) battery level is critical, instrument will turn of soon

LED "W" (WiFi) - status of wireless connection:

- (off) WiFi module is down or unpopulated
- (green) connection established
- (blinking green) initialization

Other LEDs:

- LED A1 ÷ A4 is fully configurable alarm and it can be programmed in the 'Output Settings' section of the ENVIS.Daq program
- LED F1 ÷ F8 on the multiplexer unit indicates that the respective feeder is being measured.
- LED on SPQ-I current probe indicates the current range configured.

3.4 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.

3.4.1 Frequency of the Fundamental Harmonic Voltage Component

Frequency of the fundamental harmonic of voltage signal is continuously measured and evaluated every 10 seconds. The measured signal is a logic sum of line voltage signals 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.

3.4.2 Voltages and Currents

Voltage signals are evaluated continuously without gaps. Basic evaluation interval is ten cycles of the network (200 ms at 50 Hz). This evaluation forms the basis for all further calculations. When connecting a single current feeder the measured currents are evaluated continuously. If multiple feeders are evaluated at once than the current and power measurement is multiplexed. Evaluation of each feeder lasts two measuring cycles and they are evaluated one by one. All channels are sampled at the frequency of 128 samples per network cycle. Sampling is controlled by the measured frequency at the L_1, L_2 and L_3. If the value of the frequency is in measurable range it also controls the sampling. It is automatically adjusted to the frequency change. Otherwise, the sampling runs according to the preset nominal frequency (50 or 60 Hz). RMS voltage and currents are evaluated from the sampled values for the measuring cycle according to equations (examples given for the stage no. 1):

Line-to-Neutral voltage (RMS):

$$U_1 = \sqrt{\frac{1}{n}\sum_{i=1}^{n} U_{i1}^2}$$

Line-to-Line voltage (RMS):

$$U_{12} = \sqrt{\frac{1}{n}\sum_{i=1}^{n} (U_{i1} - U_{i2})^2}$$

Current (RMS):

$$I_2 = \sqrt{\frac{1}{n}\sum_{i=1}^{n} I_{i1}^2}$$

where: i............................sample index
n...........................number of samples per cycle of measurement (1280)
U_{i1},U_{i2}..............individual samples of voltage and current

3.4.3 Powers and Power Factor (PF)

Powers and power factors are evaluated by the following relations. The formula apply to the star type of connection.

Active power:

$$P_1 = \frac{1}{n}\sum_{i=1}^{n} U_{i1} \times I_{i1}$$

Reactive power:

$$Q_1 = \sum_{k=1}^{N} U_{k,1} \times I_{k,1} \times \sin\triangle\varphi_{k,1}$$

where: k...................index of the order of each harmonic
N.................order of highest harmonic (25)
$U_{k,1}$, $I_{k,1}$.....k-th harmonic of voltage and current (Phase #1)
$\Delta\varphi_{k,1}$..........angle between k-th harmonic component $U_{k,1}$,$I_{k,1}$(Phase No.2)
(Harmonics of U and I are evaluated for each measurement cycle)

Apparent power:

$$S_1 = U_1 \times I_1$$

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:

$$3P = P_1 + P_2 + P_3$$

Three-phase reactive power:

$$3Q = Q_1 + Q_2 + Q_3$$

Three-phase apparent power:

$$3S = S_1 + S_2 + S_3$$

Three-phase distortion power:

$$3D = \sqrt{3S^2 - 3P^2 - 3Q^2}$$

Three-phase power factor:

$$3PF = \frac{|3P|}{3S}$$

3.4.4 Harmonic Distortion

Using Fourier transform the instrument evaluates harmonic distortion of voltages and currents. The calculation is performed by using a rectangular window of each measurement cycle. Following parameters are evaluated from the harmonic analysis:

Fundamental(= 1st) harmonic phase voltage:

$$Ufh_1$$

Fundamental(= 1st) harmonic current:

$$Ifh_1$$

The absolute angle of the phasors of the fundamental harmonic voltage components:

$$\varphi U_1$$

Phasor shift of the fundamental harmonic current phasors to Ufh1:

$$\varphi I_1$$

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

$$\triangle\varphi_1$$

Harmonic voltages and currents in the order of 50 (i .... is order of the harmonic):

$$Uih_1, Iih_1$$

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

$$\triangle\varphi_1$$

Total harmonic distortion of voltage:

$$THD_{U1} = \frac{1}{U1h_1}\sqrt{\sum_{i=2}^{50} Uih_1^2} \times 100\%$$

Total harmonic distortion of current:

$$THD_{I1} = \frac{1}{I1h_1}\sqrt{\sum_{i=2}^{50} Iih_1^2} \times 100\%$$

Power factor (of the fundamental harmonic components):

$$\cos\triangle\varphi_1$$

Active power of the fundamental harmonic component:

$$Pfh_1 = Ufh_1 \times Ifh_1 \times cos\triangle\varphi_1$$

Reactive power of the fundamental harmonic component:

$$Qfh_1 = Ufh_1 \times Ifh_1 \times sin\triangle\varphi_1$$

Three-phase active power of the fundamental harmonic components:

$$3Pfh = Pfh_1 + Pfh_2 + Pfh_3$$

Three-phase reactive power of fundamental harmonic components:

$$3Qfh = Qfh_1 + Qfh_2 + Qfh_3$$

Three-phase power factor of the fundamental harmonic components:

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

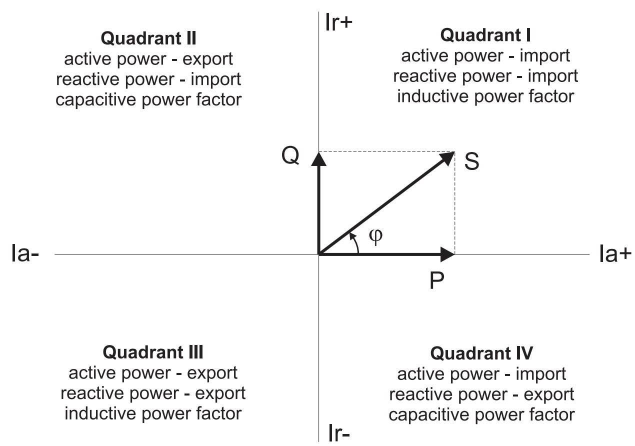


Figure 21: Identification of demand, supply and PF profile according to the phase angle (IEC 60375)

Power and power factors of the fundamental harmonic component (cos φ) are evaluated in 4 quadrants in accordance with IEC 60375, see Fig. 21

Voltage and current unbalances are evaluated on the basis of positive and negative sequence components of fundamental harmonic:

Voltage unbalance:

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

Current unbalance:

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

Negative sequence current:

$$\varphi nsl$$

3.4.5 Evaluation of Voltage Events

For the detection of voltage events (short-term dips/swells, interruptions) and its registration the instrument evaluates effective value of voltage every half period ($U_{(1/2)}$) in accordance with IEC 61000-4-30 ed.2. Additionally it can also define other conditions to trigger the recording of events. Each event can be recorded at several levels of detail: The PQ Event records time when the event occurred, its duration and an achieved extreme true RMS half period value. The PQ Trend archive stores the half cycle RMS value for line voltages and currents during the event - within limited shorter pre-triger and longer post-trigger memory. The PQ Oscilogram is the most detailed archive of the quantities at the trigger time. They record the samples of the actual trigger with greatest detail for shorter time period. All the archives are being filled on the first-in first-out basis.

3.4.6 Aggregation and Recording

Values are aggregated and stored in the archive in instrument memory according to the settings of the recording interval. Aggregated (average) values are recorded by default for all selected parameters. Maximum/minimum values can be separately selected to be recorded. This feature is off by default to save free storage space.

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. If all the available memory capacity for main archive is used than the archive creation 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.

4 Technical Specifications

Measured Quantities	
Voltage	
measured voltages	L1, L2, L3, L4
measurement method	continuous (gap-less), in compliance with IEC 61000-4-30 ed. 2
measuring range phase / line	 3÷800 V_{AC}/ 5÷1380 V_{AC}
input impedance	15 MΩ
measurement uncertainty	± 0.1 % of rdg ±0.1 V
temperature drift	±0.05 % of rdg ± 0.1 V / 10°C
$U_{NOM}(U_{DIN})$ - nominal voltage phase / line to fulfill class S of IEC 61000-4-30 ed. 2 for over-voltage class III over-voltage class IV	 100 ÷ 1000 V_{AC} 100 ÷ 600 V_{AC}
peak overload	1200 V_{AC}/ 1 minute
supply voltage	85 ÷ 480 V_{AC} / 42 ÷ 70 Hz, 100 ÷ 600 V_{AC}
Flicker	
measuring range	0.4 ÷10
measurement uncertainty	according to IEC 61000-4-15
Voltage Dips / Swells	
△U measurement uncertainty	± 0.5 % U_{NOM}
Voltage interruptions	
interruption duration measurement uncertainty	± 1 cycle
Voltage unbalance	
measuring range	0 ÷ 5 %
measurement uncertainty	±0.15 % of rdg or ±0.15 %
Voltage Harmonics, Interharmonics	
reference conditions	other harmonics up to 200 % of class 3 of IEC 61000–2-4 ed.2
measuring range	10 ÷ 100 % of class 3 of IEC 61000-2-4 ed.2
measurement uncertainty	twice the levels of class II acc. to IEC 61000–4-7 ed.2
THDU	
measuring range	0 ÷ 20 %
measurement uncertainty	± 0.3 %
Frequency	
f_{NOM}- nominal frequency	50 / 60 Hz
measuring range	42,5 ÷57,5 Hz / 51 ÷ 69 Hz
measurement uncertainty	±10 mHz

Measured Quantities - Current Measurement with the SPQ-I series Rogowski Current Sensors	
Current	
number of inputs - NEMO 332 - 1 - NEMO 332 - 2 - NEMO 332 - 4 - NEMO 332 - 8	 1 x 4 (1 feeder/4 currents) 2 x 4 (2 feeders/8 currents) 4x 4 (4 feeders/16 currents) 8 x 4 (8 feeders/32 currents)
measurement method - 1 feeder measurement only (3 ÷ 4 sensors) - n feeders meas. (n = 2 ÷ 8)	 continuous (gap-less) multiplexed, feeder by feeder, duty 20 cycles measurement / ((n-1)*2 +1) x 20 cycles pause
measuring range - SPQ-I3000 line sensors - SPQ-I1000 line sensors	 1. range "3000" : 0 ÷ 3300 A_{AC} 2. range "1000" : 0 ÷ 1100 A_{AC} 3. range "300" : 0 ÷ 330 A_{AC} 4. range "100" : 0 ÷ 110 A_{AC} 1. range "1000" : 0 ÷ 1100 A_{AC} 2. range "300" : 0 ÷ 330 A_{AC} 3. range "100" : 0 ÷ 110 A_{AC} 4. range "30" : 0 ÷ 33 A_{AC}
I_{NOM} - nominal current	0.1 ÷ 1.0 % of rng
measurement uncertainty (room temperature, conductor at the center of flexible loop)	±0.3 % of rdg ±0.06 % of rng
temperature drift	±0.05 % of rdg ±0.05 % of rng / 10 °C
loop position influence	max 2 % of rdg
external field influence - SPQ-I-JRF line (shielded)	 max 1.5 % of rng
phase uncertainty 5 ÷100 % of meas. range 1 ÷5 % of meas. range 0.1 ÷ 1 % of meas. range	 ±0.1° ±0.2° ±2°
peak overloaded	undefined
Current Unbalance	
measuring range measurement uncertainty	0 ÷ 5 % ± 0.15 % of rdg or ± 0.15 %
Current Harmonics, Interharmonics	
measuring range	0 ÷ 100 % of I_{NOM}
measurement uncertainty $I_h \leq$ 10 % of I_{NOM} I_h > 10 % of I_{NOM}	 ± 0.5 % of I_{NOM} ± 5 % of rdg
THDI	
measuring range	0 ÷ 200 %
measurement uncertainty	± 0.3 % of rdg ± 0.3 %

Measured Quantities – Power & Power Factor Measurement with the SPQ-I series Rogowski Current Sensors	
Active / Reactive Power, Power Factor, cos φ	
reference conditions “A”: U & I reference conditions active p.,PF,cos φ ref. cond. reactive power ref. condition	 U >= 5% of meas. range, I >= 5% of meas. range PF = 1.00 PF = 0.00
active / reactive power measurement uncertainty	±1.0 % of rdg ±0.5 % of rng *)
power factor, cos φ measurement uncertainty	±0.01 *)
reference conditions “B”: U & I reference conditions active p.,PF,cos φ ref.cond. reactive power ref. condition	 U ≥ 5 % of meas. range, I ≥ 5 % of meas. range PF ≥ 0.5 PF ≤ 0.87
active / reactive power measurement uncertainty	± 2.0 % of rdg ± 1 % of rng *)
power factor, cos φ measurement uncertainty	± 0.02 *)

*...room temperature, conductor at the center of flexible loop, no electromagnetic field

Measured Quantities - Others	
IEC 61000-4-30 ed. 2 Classification	
class	S
Power Quality	
evaluation method	weekly, according EN 50160
Pt100 Temperature Sensor Analog Input	
measuring range	- 50 ÷ 150 ˚C
measurement uncertainty	± 1 ˚C (two-wire connection, loop impedance non-compensated)

Other Specifications	
voltage inputs power (impedance)	< 0.1 VA (15 MΩ)
current inputs power (impedance)	undefined
aux. power supply voltage (power) - standard aux. v. input	85 ÷ 480 V_{AC} / 40 ÷ 70 Hz (8 VA) 80 ÷ 680 V_{DC} (8 W)
over-voltage class / pollution degree - max altitude 2000 m - max. altitude 5000 m	according to EN 61010 - 1 ed.2 max 600 V CAT IV*, power supply: 300 V CAT III / 2 max 300 V CAT III*, power supply: 300 V CAT II / 2 *...depending on current sensors
operational temperature	- 25 to 60 ˚C
storage temperature	- 40 to 85 ˚C
operational and storage humidity	< 95 % - non-condensable environment
EMC – immunity	EN 61000 - 4 - 2 (4kV / 8kV) EN 61000 - 4 - 3 (10 V/m up 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 – emissions	EN 55011, class A EN 55022, class A (not for home use)
RTC - accuracy - backup battery capacity	± 2 seconds per day > 5 years (without supply voltage applied)
rechargable battery - full recharge time - capacity (instrument running) - auto power-off - recharge cycles	< 4 hours > 4 hours 10 minutes > 1000
communication port - standard - additional (optional)	USB 2.0 WLAN - IEEE 802.11 b, g, GSM/GPRS, HSDPA

Design	
protection class	IP 40
dimensions	250 x 210 x 70 mm
weight	1 kg
transport case dimensions	460 x 365 x 110 mm
standard voltage measurement set weight (instrument+voltage cables+case)	4.2 kg
current measurement set dimensions / weight (8 x current sensors+case)	475 x 380 x 170 mm / 3 kg

SPQ-I Line Rogowski Current Sensors Design	
number of measured currents - SPQ-IXXX-3xxx line - SPQ-IXXX-4xxx line	 3 4
operating voltage	max. 600 V_{AC}
over-voltage cat. / pollution degree,	
- JRF series sensors	600 V CAT III / 2 - acc. IEC EN 61010-1, double insulation
- MFC series sensors	600 V CAT IV / 2 - acc. IEC EN 61010-1, double insulation
safety	
operating and storage temperature	- 20 to 85 ˚C
operating and storage humidity	< 95% - non-condensation conditions
protection rating	IP 41, indoor use only
sensor length / diameter SPQ-IXXX-JRF1 SPQ-IXXX-JRF2 SPQ-IXXX-JRF3 SPQ-IXXX-MFC0 SPQ-IXXX-MFC1 SPQ-IXXX-MFC2 SPQ-IXXX-MFC3	 400 / 12 mm 600 / 12 mm 1000 / 12 mm 250 / 8 mm 400 / 8 mm 600 / 8 mm 1000 / 8 mm
minimum bending diameter	35 mm
cable length	200 cm
mass - SPQ-IXXX-3JRF1 - SPQ-IXXX-4JRF1	 0.55 kg 0.65 kg

5 Maintenance, service, warranty

Maintenance

The analyzer NEMO 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 voltage cables are protected by 6.3 x 32 mm type fuses of T 1A / 500V rating; their breaking capability is 10 kA/250V, resp. 1500A/500V (Omega, model GT632210). They can be easily replaced after removing the fuse holder or unscrewing the voltage cable probes, respectively. A spare fuses are supplied with the product.

The lithium cell built in the instrument can backup the memory and real time circuit for more than 5 years without power supply, at average temperature 20°C and load current in the instrument less than 10 µA. 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:	....	Serial number:	....
Date of dispatch:	....	Final quality inspection:	....
		Manufacturer's seal:	....
Date of purchase:	....	Supplier's seal:	....