DANEO 400

User Manual

Manual Version: DANEO400.ENU.1

Contents

1 Preface

1.1 About this manual

This manual provides information on how to use *DANEO 400*, the different measurement systems supported and the methods of connecting to the substation communication network and controlling *DANEO 400*. The acquisition and analysis with *DANEO Control* are explained in detail. The web interface is presented. *DANEO 400* hardware is addressed including the technical data. Software license information is also included.

This manual includes the following chapters:

- **Safety instructions**

  Safety instructions and rules to properly operate the device.
- **DANEO 400 overview**

  Information about the designated use and key features of the product.
- **Connections and interfaces**

  Descriptions of connections and interfaces between *DANEO 400* and the substation network, as well as the different options to control *DANEO 400*.
- **DANEO Control**

  Information about the different functional parts of the application and main commands. Detailed description of the procedures to use *DANEO Control*.
- **Web interface**

  Description of *DANEO 400* web interface.
- **DANEO 400 hardware**

  Description of the hardware by functional blocks and the I/O interface.
- **Technical data**

  Information about the technical characteristics and performance of *DANEO 400* hardware components, as well as the CE conformity, EMC, and certified safety standards.
- **Open source software license information**

  License information for *DANEO Control* software and *DANEO 400* embedded firmware.

1.2 Documentation overview

The *DANEO 400* documentation comprises the Quick Start Guide, the User Manual, and the *DANEO Control* Help.

Quick Start Guide

The Quick Start Guide is delivered in printed format and provides the steps to set up the test interface and install *DANEO Control*. Brief safety instructions and technical data are also included.

User Manual

The User Manual is delivered in PDF format on the CD-ROM. For detailed information, check the previous section.

DANEO Control Help

DANEO Control Help covers the main features and user tasks and can be opened from *DANEO Control*.

2 Safety instructions

Before operating *DANEO 400*, carefully read the following safety instructions. Only operate (or even turn on) *DANEO 400* after you have read this User Manual including the "Technical data" chapter and fully understood the instructions herein.

2.1 For your safety

DANEO 400 may only be operated by trained personnel. Any maloperation can result in damage to property or persons. The binary/analog I/O terminals of *DANEO 400* can conduct life-hazardous voltages.

2.2 Rules for use

- *DANEO 400* must be used only when in a technically sound condition. Its use must be in accordance with the safety regulations for the specific job site and application. Always be aware of the dangers of high voltages. Pay attention to the information provided in *DANEO 400* documentation.
- The instructions provided in this User Manual and associated *DANEO 400* documentation are considered part of the rules governing proper usage.

2.2.1 Orderly practices and procedures

- Keep the *DANEO 400* Quick Start Guide, which contains printed safety instructions, available on site where *DANEO 400* is used.
- Personnel assigned to using *DANEO 400* must have read the *DANEO 400* Quick Start Guide and fully understood the instructions therein.
- Do not carry out any modifications, extensions, or adaptations at *DANEO 400*.

2.2.2 Operator qualifications

- Installation and configuration of *DANEO 400* should only be carried out by authorized and qualified personnel.
- Personnel receiving training, instruction, direction, or education on *DANEO 400* should remain under the constant supervision of an experienced operator while working with the equipment.

2.2.3 Safe operation procedures

- Before wiring the terminals, verify that the conducting parts are de-energized. The terminal connectors have hazardous live parts.
- Do not operate *DANEO 400* under wet or moist conditions (condensation).
- Do not operate *DANEO 400* when explosive gas or vapors are present.
- When setting up *DANEO 400*, make sure that the ventilation holes on the rear of the device remain unobstructed.
- Do not open *DANEO 400*. There are no user serviceable parts inside. If *DANEO 400* is opened by unauthorized personnel, all guarantees are invalidated.
- *DANEO 400* is designed to measure signals that are Measurement Category I, II, III, and IV, as described in the IEC 60664. The 10 measurement inputs are only functional isolated from each other (4 mm creepage distance). Never mix signals from different measurement categories!

- If *DANEO 400* seems to be functioning improperly, please contact the “OMICRON Service Centers” on page 75.

3 DANEO 400 overview

3.1 Designated use

DANEO 400 is a hybrid measurement and recording device to be used in protection, automation, and control systems for the electrical power industry.

The system is designed to record and analyze all conventional signals (such as secondary voltages and current and hard wired binary signals) and messages on the communication network of the power utility automation system.

Typical applications are in factory acceptance tests (FAT), site acceptance tests (SAT), commissioning, and troubleshooting.

DANEO 400 is a portable device for temporary use. It is not designed to perform mission critical operational tasks in 24/7 applications.

The device is intended for commercial use operated by trained personnel and is not suited for private use.

3.2 Key features

Key features of *DANEO 400* are:

- Recording and analyzing any traffic on the substation communication network
- Distributed recording with multiple units
- Time synchronized measurements
- Portable measurement system
- Unattended operation mode
- Remote control over TCP/IP network
- Time synchronization using the IEEE 1588 precision time protocol
- Aggregated and time-aligned presentation of results
- Generated network traffic does not impair the substation automation system operation

DANEO 400 hardware main features are:

- Analog inputs for voltages and currents
- Hard-wired binary I/Os
- Ethernet interfaces with Power over Ethernet (PoE)
- USB interfaces (host and device port)
- EtherCAT ports for extension devices
- IEC 61850 GOOSE
- IEC 61850 Sampled Values (9-2LE @ 80SPC)

DANEO Control software main features are:

- Online observation of selected signals from the substation automation system
- Use of configuration information in IEC 61850 SCL format for easy identification of traffic, communication verification, and setup of signals for recording
- Making the power utility communication accessible and visible in an easy-to-understand manner for the power systems engineer
- Setup of trigger conditions and scope of data for recording
- Recording of events and measurements of the substation automation system
- Collecting recordings from the individual devices in a measurement system
- Analyzing data in the collected recordings
- Exporting data in PCAP or COMTRADE format for further investigation in other tools

3.3 Distributed system

DANEO 400 was inherently designed to be used in a measurement system comprised of multiple devices distributed in different locations over arbitrary distances. The options for controlling *DANEO 400* were made in a way so that remote access is possible. *DANEO Control* software is designed to control multiple devices from one place and to collect the acquired data from all devices of the measurement system for a coordinated analysis.

3.4 Hybrid measurement

DANEO 400 combines the classical signals in a protection and automation system with digitized signals conveyed over communication networks. *DANEO 400* acquires classical secondary voltages and currents and hard-wired binary signals as well as traffic from the power utility communication network. The information from both worlds is recorded and presented together, revealing the coordination between each other.

4 Connections and interfaces

The following figure shows *DANEO 400* with the interfaces located on the front panel.

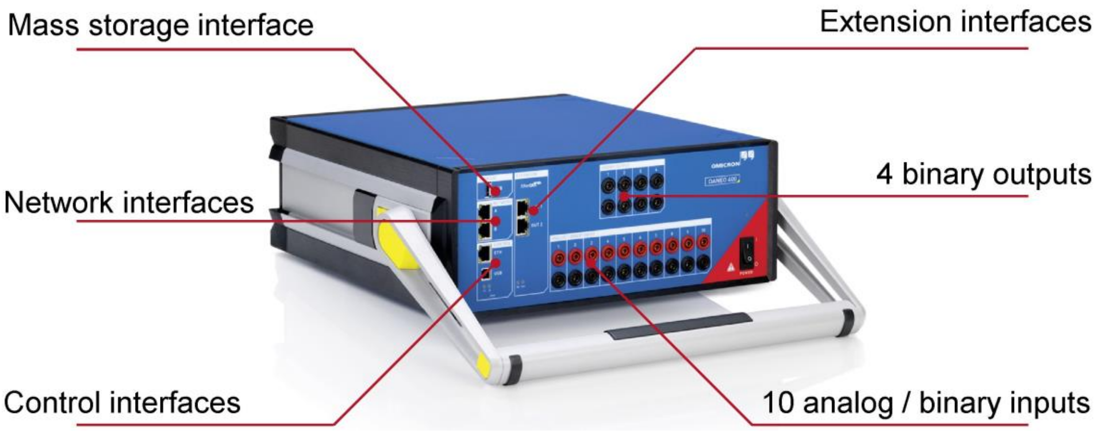


Figure 1: *DANEO 400* connections and interfaces

There is only one interface on the rear panel: the socket for the power supply.

4.1 Ethernet ports

DANEO 400 has three Ethernet ports. Two of them are in the group NETWORK and are labelled A and B. These ports will be referred as the “process ports” in the following.

A third Ethernet port is in the group CONTROL and is labelled ETH. This port will be referred as the “control port” in the following.

4.1.1 Network interfaces (A, B) – Process ports

The process ports are primarily intended for capturing traffic from the “process”, in our case the communication network of the power utility automation system. The two ports can be either individually used or they can be combined to form a tap (see below 4.3.1).

When the process ports are used individually, the captured traffic flows “one-way” into the port. If required, *DANEO 400* can be also controlled through one of the ports A or B.

When the process ports are combined to form a tap, the traffic received on port A is transmitted from port B and vice-versa. For capturing, it can still be selected from which of the two ports the incoming traffic is to be captured. In tap mode is not possible to control *DANEO 400* through one of the process ports.

4.1.2 Control port (ETH)

The control port is primarily intended to control *DANEO 400* via a network connection. In addition, you can also use the ETH port for capturing traffic, even when the port is actually used for controlling *DANEO 400*.

The process ports A and B are supported by dedicated hardware and have a higher performance than the control port ETH. When capturing traffic with high bandwidth or high packet rate (for example, multiple SV streams) it is preferred to use the process ports.

4.2 USB control port

DANEO 400 can also be controlled via the USB port that is also located in the CONTROL group on the front panel.

The control via the USB port is a convenient option when the controlling PC is located close enough to *DANEO 400*. The control connection is immediately established and no setting of an IP address is required. Additionally, an Ethernet port otherwise required for the control becomes available for capturing traffic or connecting a PTP clock for time synchronization.

4.3 Capturing network traffic

4.3.1 Taps and mirror ports

In Ethernet networks, there is a significant difference between multicast traffic and unicast traffic. Multicast is used, for example, for GOOSE and Sampled Values. Unless dedicated filters are set up, the Ethernet switches will replicate all such received traffic and forward it to all connected links. So any device can receive GOOSE and Sampled Values without further efforts.

With unicast traffic, the circumstances are different. IP traffic, which is used for example for the IEC 61850 client/server communication, is of this kind. The communication is performed between devices explicitly addressing each other. The data packets are forwarded as unicast traffic and that means that the corresponding Ethernet packets are only forwarded on those links that actually establish the path between the involved end points (for example, the client and the server). This exclusive forwarding is the achievement of the Ethernet switch. Without special precautions, a capture device like *DANEO 400*, connected to an arbitrary port on an Ethernet switch, will not receive the packets to be analyzed.

There are two means of accessing unicast traffic: mirror ports and taps.

- A tap is a device that is inserted into a network link and that replicates the traffic going over the link to additional monitor ports, from where it can be received for further processing.
- A mirror port can be typically found on managed Ethernet switches and such a port can be configured to replicate the traffic from other specified ports on the switch, similar as if a tap was used. The configuration of such a port requires access rights to administer the switch and possibly dedicated software for administering the switch. The setup, the exact behavior, and the performance of such mirror ports vary between different models of switches.

As mentioned on section 4.1.1, *DANEO 400* can operate itself as a tap when the process ports A and B are configured accordingly.

4.4 Examples of network connection options

Due to the multiplicity of process ports, control ports, and usage options for the individual ports, there are a huge number of possible connections. Each of these options may be suited in certain applications and several options may similarly serve an application.

In the following, a number of examples with a short explanation of the typical use are provided. For further reference, the connection options are labelled CO01, CO02, and so on.

Used symbols

The following figure shows the meaning of symbols used to exemplify the network connection options.

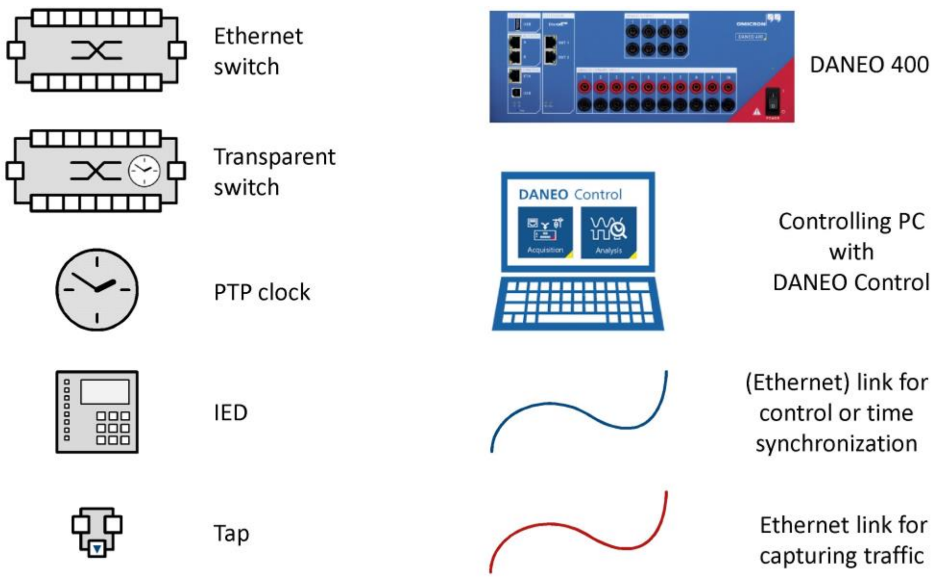


Figure 2: Symbols used to exemplify different network connection options

Single *DANEO 400* with implicit synchronization

The acquisition of network traffic at different ports of the one *DANEO 400* unit is time aligned, that is, the time stamps assigned to packets captured from different ports represent the exact relative timing. When the absolute time of the capture is of no relevance and the relative timing between packets needs to be evaluated, simple connection options without synchronizing to absolute time can be used.

CO01 - Control via ETH, capturing on A and B

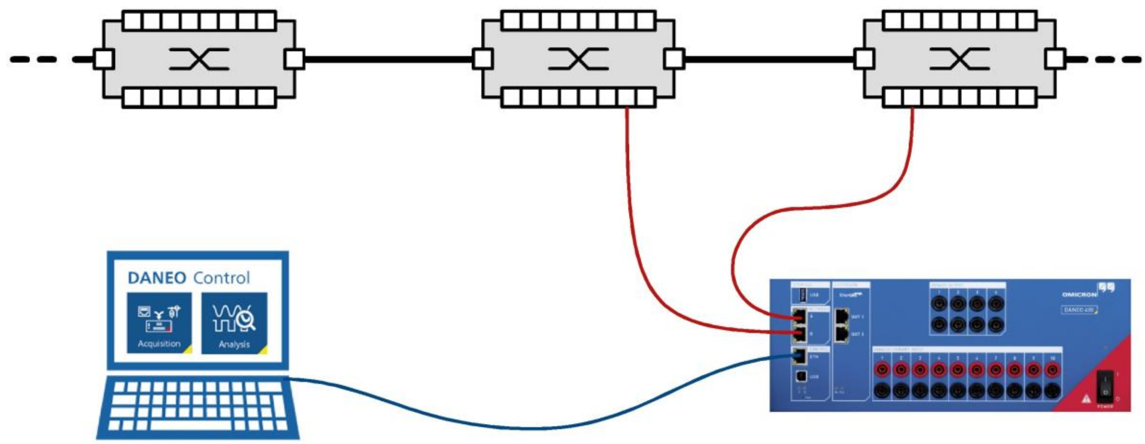


Figure 3: CO01 – All Ethernet ports are used in the primarily intended way. The unit is controlled via the ETH control port; two streams of traffic are captured via the process ports A and B.

Even in a local network, considerable distances can be spanned by such a configuration. As the length of an Ethernet segment can be up to 100 m, the two locations where the data are captured from can be up to approximately 200 m apart, if *DANEO 400* can be conveniently located at the middle between the capture locations and if Ethernet cables of sufficient length are available.

CO02 – Control via ETH over network, capturing on A and B

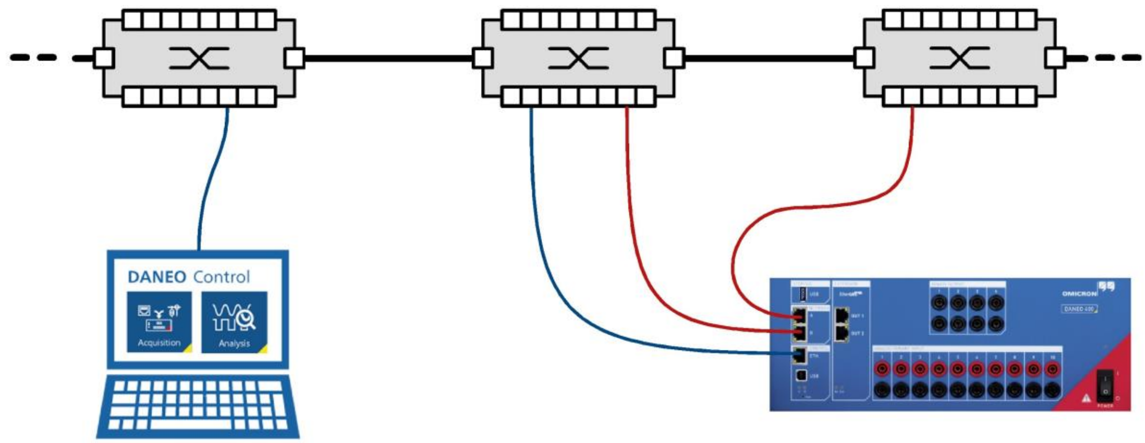


Figure 4: CO02 – The PC with the control SW is not directly connected to *DANEO 400*. The control traffic is also forwarded through the network, so the controlling PC can be located independently of *DANEO 400*. This is a “remote control” scenario that also works when the network connection is established over a WAN.

CO03 – Control via USB, capturing on A, B, and ETH

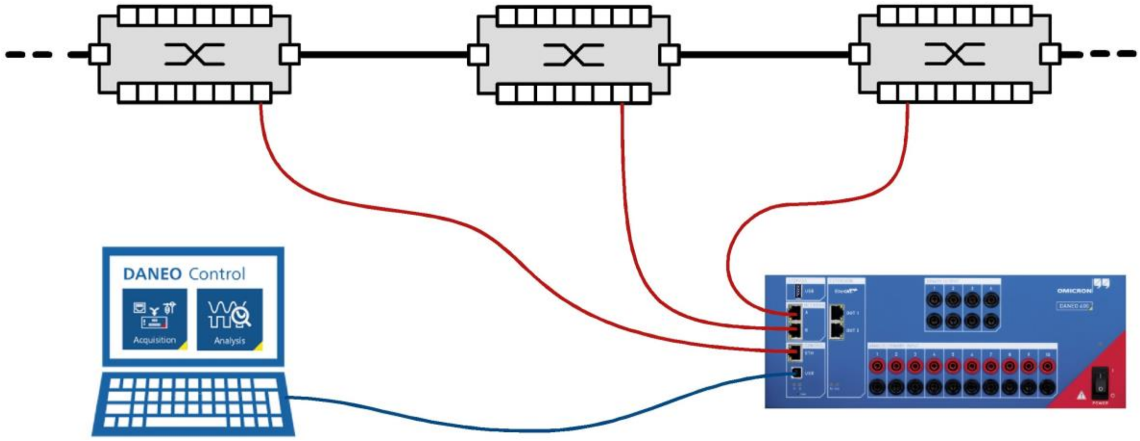


Figure 5: CO03 – By using the USB port for controlling *DANEO 400*, the ETH port becomes available as a third port for traffic capturing.

In configurations as shown above, it is not recommended to enable the tap mode of *DANEO 400*. Depending on the features and the configuration of the Ethernet switches, either a loop with potentially circulating packets will be established or a spanning tree (STP) algorithm will disable a network link.

CO04 – Tapping a trunk link

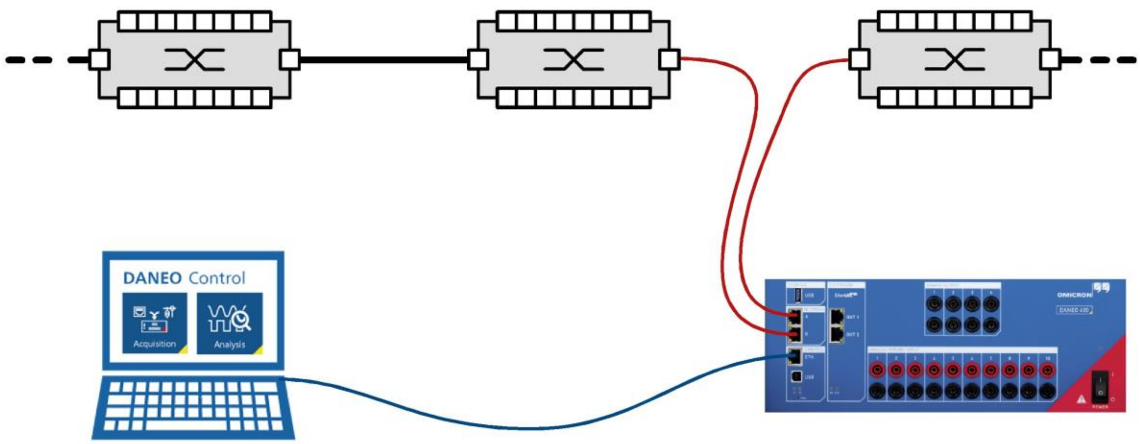


Figure 6: CO04 – The Ethernet ports A and B are configured as a tap. *DANEO 400* is inserted into the link between switches and can capture all traffic exchanged over this link.

CO05 – Tapping an edge link

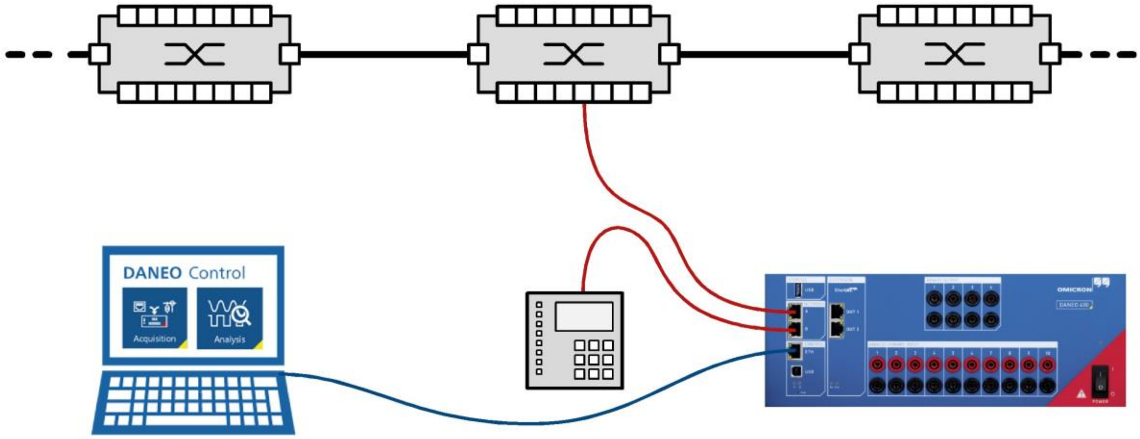


Figure 7: CO05 – The Ethernet ports A and B are configured as a tap. *DANEO 400* is inserted into the link between switches and an end device (IED) and can capture all traffic of this IED.

CO06 – Capturing using an external tap

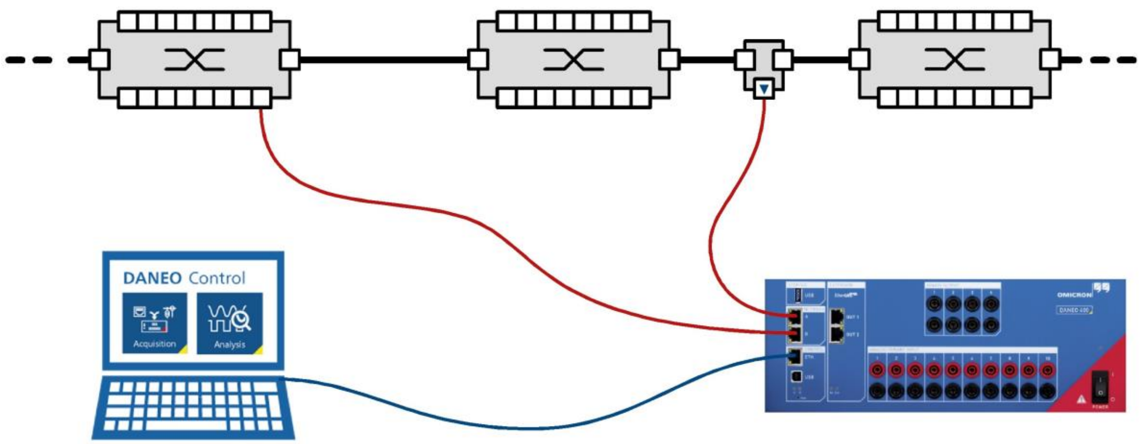


Figure 8: CO06 – Port A gets all traffic from the trunk link between the switches at the right delivered by an external tap. Port B captures traffic from a port on another switch. It obtains either multicast traffic if it is a normal port or the configured traffic if it is a mirror port.

Single *DANEO 400* with explicit synchronization

To time stamp the captured data with accurate absolute time, *DANEO 400* needs to be time synchronized, that is connected to a PTP clock. The following scenarios can also be part of a measurement system with multiple *DANEO 400* devices.

CO07 – Time synchronized capturing using an external tap

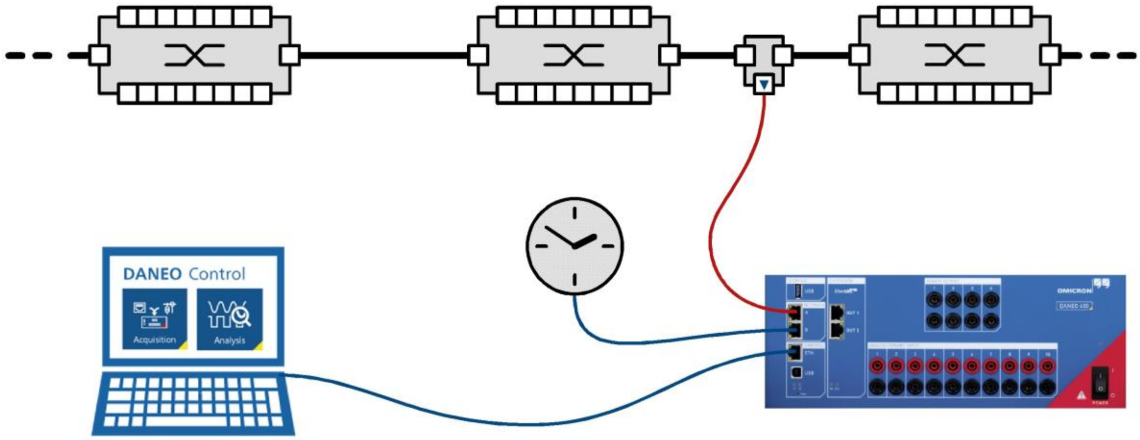


Figure 9: CO07 – Port A gets all traffic from the trunk link delivered by an external tap. Port B establishes a point-to-point connection to a PTP clock for time synchronization.

CO08 – Time synchronized capturing using tap mode

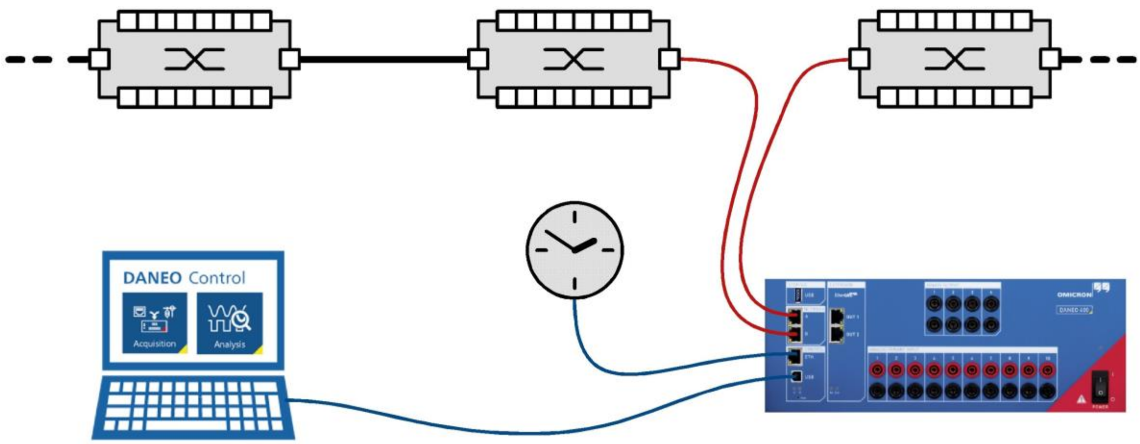


Figure 10: CO08 – The Ethernet ports A and B are configured as a tap. The ETH port is used to connect to the PTP clock. The control is performed via USB.

CO09 – Time synchronized capturing using tap mode

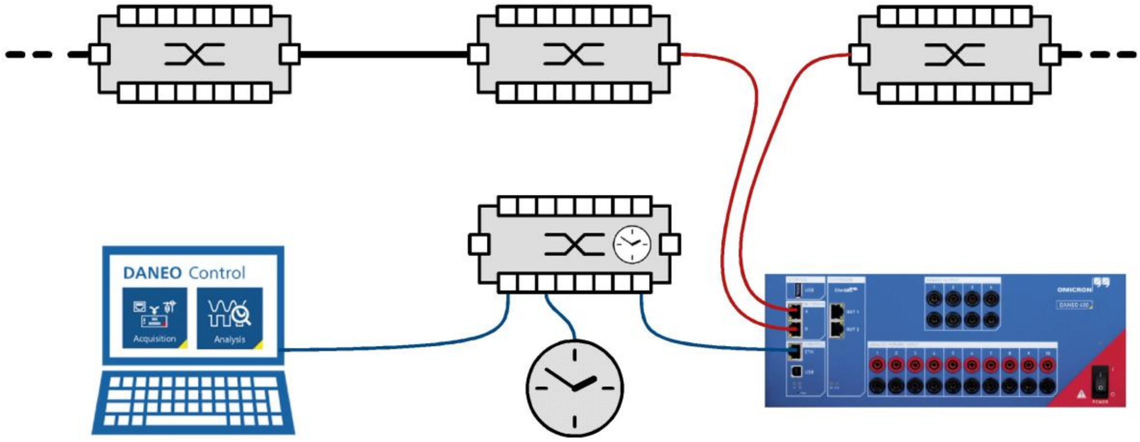


Figure 11: CO09 – Both, control and time synchronization, are performed over the ETH port. To connect the controlling PC and the PTP clock, a PTP capable switch (transparent switch) has to be used.

CO10 – Time synchronized capturing with control over the network

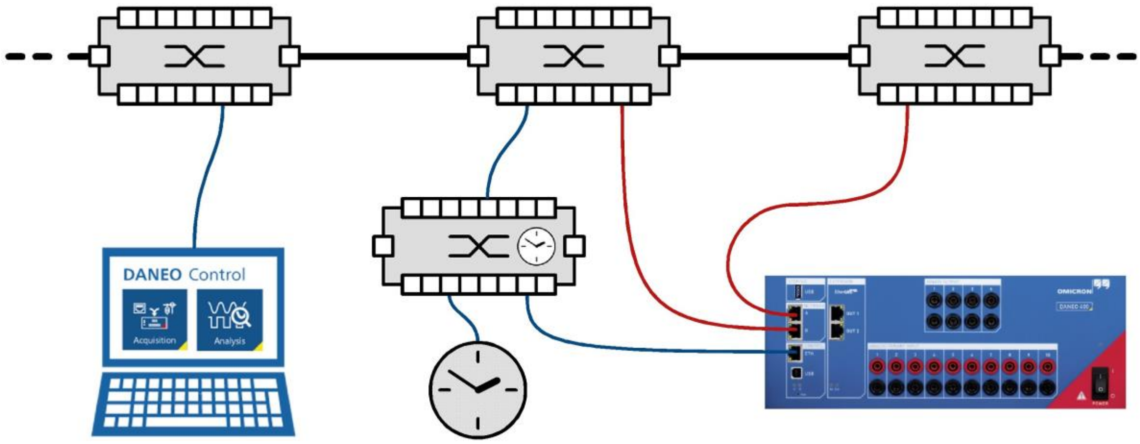


Figure 12: CO10 – *DANEO 400* is controlled over the network. Again, a transparent switch is needed to provide control and time synchronization to the ETH port.

CO11 – Time synchronized with PTP over the network

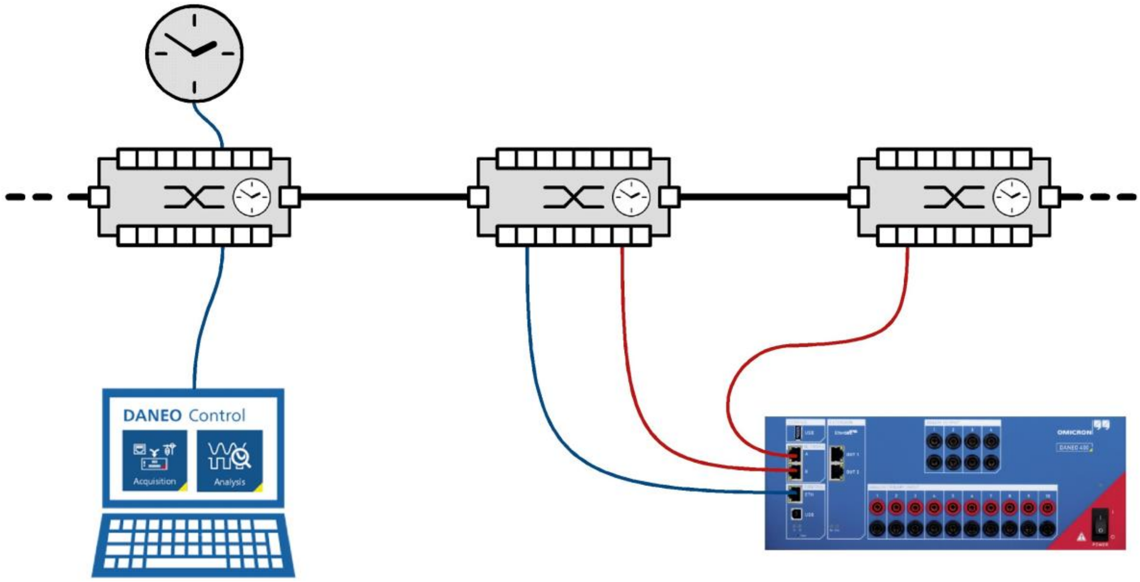


Figure 13: CO11 – When the communication network is equipped with transparent switches and a PTP clock, *DANEO 400* can use this infrastructure for time synchronization.

Multiple *DANEO 400* devices in a measurement system

To make useful capturing, *DANEO 400* devices have to be time synchronized. The absolute time of the capture is of relevance.

CO12 – Measurement system time synchronized with PTP over the network

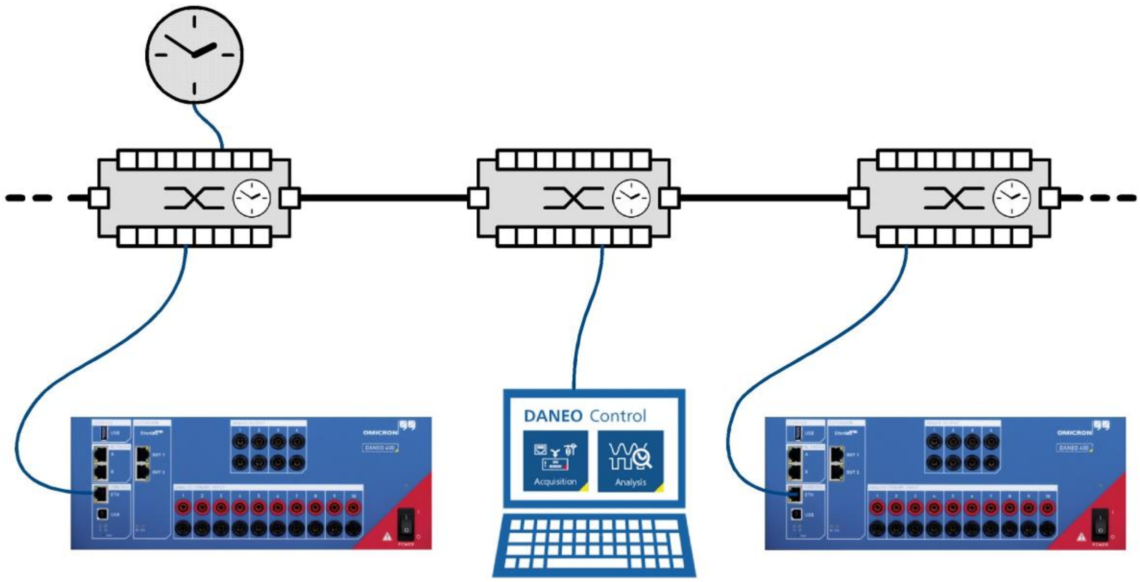


Figure 14: CO12 – With a PTP infrastructure on the communication network, time synchronization of multiple *DANEO 400* devices is most easily established. No links for capturing traffic are shown in this figure.

CO13 – WAN scenario with complete PTP infrastructure

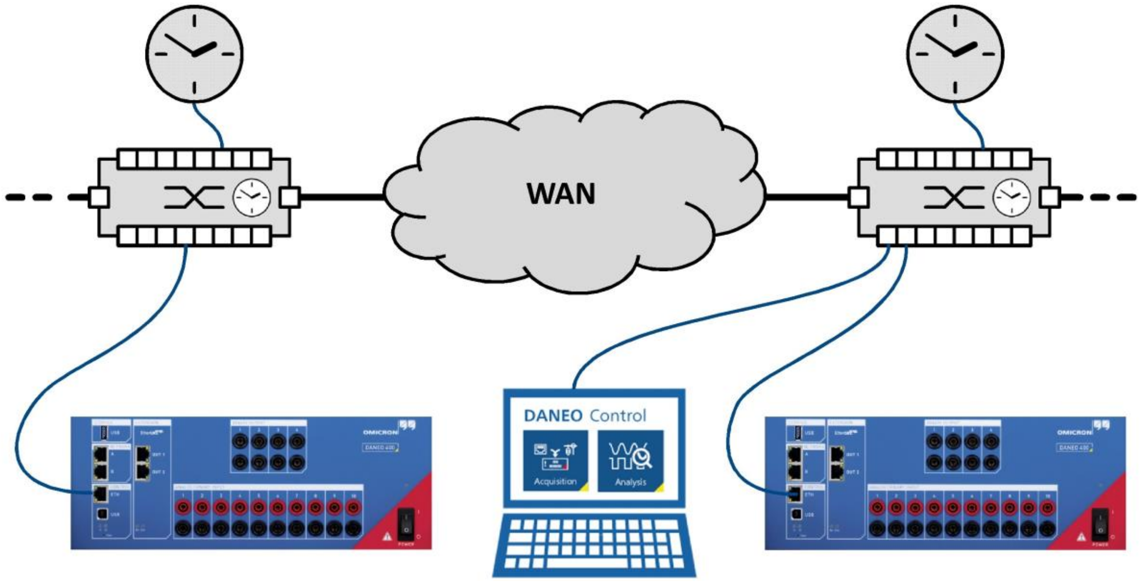


Figure 15: CO13 – With a PTP infrastructure present in all involved locations, time synchronization in a WAN scenario is most easily established. No links for capturing traffic are shown in this figure.

CO14 – WAN scenario with incomplete PTP infrastructure

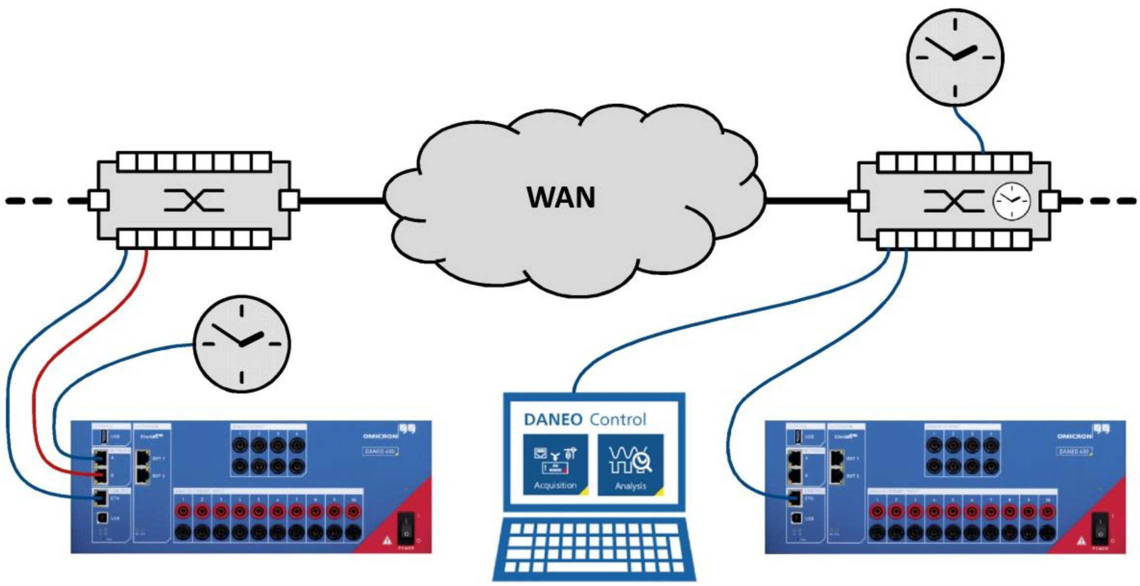


Figure 16: CO14 – Even if the PTP infrastructure is not present in some locations, time synchronization can be established locally by using one of the options shown above in CO07 to CO10. *DANEO 400* on the left captures traffic via port B. The kind of traffic obtainable depends in the port configuration at the switch (normal or mirror port); an external tap can also be used to capture traffic from a distinct network link.

4.5 Storage interface

This is an USB host port for connecting an external mass storage device, such as an external hard disk or a flash drive.

The setting to save recordings on this external mass storage is made in the **Recording** section (**Storage**) of *DANEO Control*.

4.6 Extension Interfaces

Accessories for *DANEO 400* can be connected to these ports when available.

4.7 Binary outputs

These are four potential free relay contacts. The contacts can be activated by a post-trigger action to signal the detection of a trigger condition, for example to trigger other devices.

The settings are made in the **Recording** section (**Post-trigger**) of *DANEO Control*.

4.8 Analog/binary inputs

These are ten inputs that can be either used as analog or binary inputs.

The configurations are made in **Measurement System** section (**Inputs**) of *DANEO Control*.

5 DANEO Control

This chapter introduces you *DANEO Control*, each functional section, and instructions to operate the application. Important topics are configuring the acquisition, recording, observing, and analyzing recordings.

DANEO Control is divided into two major workspaces: **Acquisition** and **Analysis**. The following figure shows the home screen.

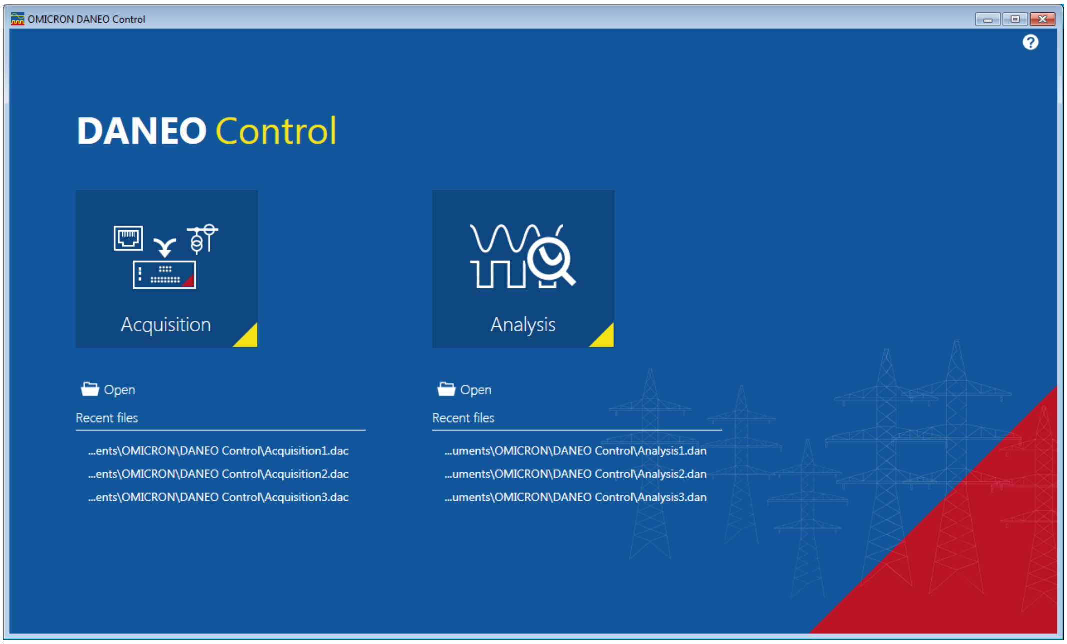


Figure 17: *DANEO Control* home screen

Acquisition

Create a new or open an existing *DANEO* Acquisition file (.dac). Within the acquisition, the measurement system is configured and recordings can be performed. When you open a .dac file that contains devices in the measurement system, the application tries to reconnect automatically.

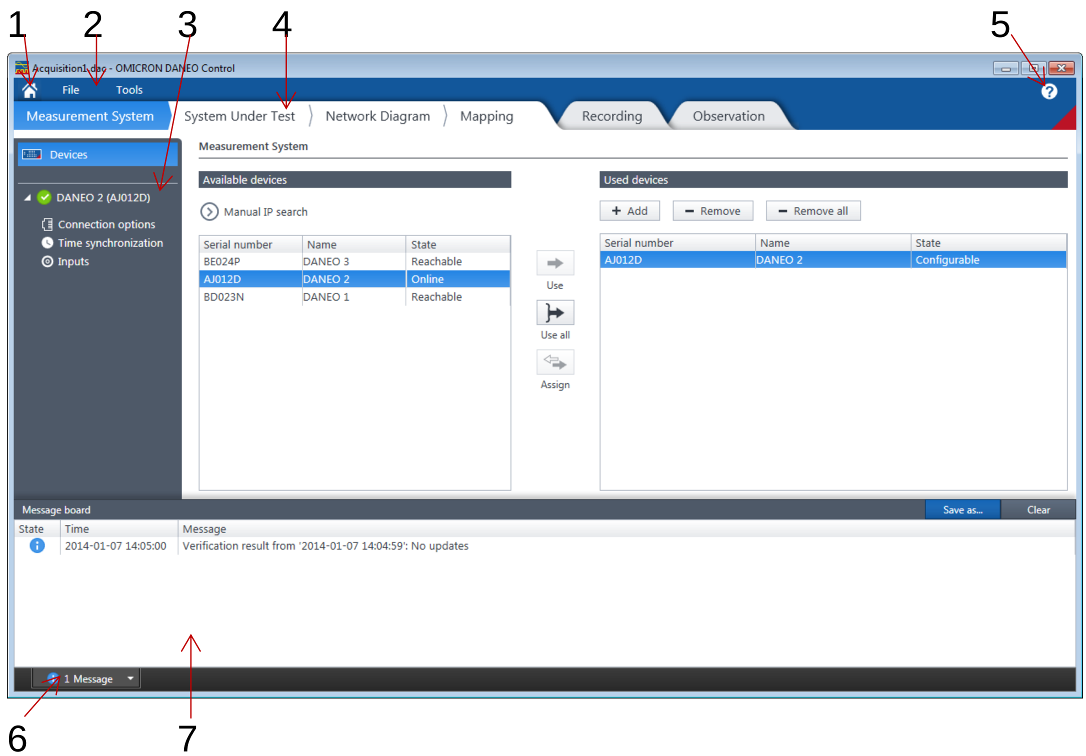
Only one file can be opened per instance of the application. You cannot open the same file on multiple instances.

Analysis

Create a new or open an existing *DANEO* Analysis file (.dan). You can analyze recordings located on reachable devices or on a local hard disk.

5.1 Acquisition

This section describes the necessary steps to create and configure a measurement system, configure the system under test, place devices and IEDs onto a substation network diagram, map GOOSE and Sampled Values streams to devices inputs, record, and observe signals.



1	Takes you to the home screen. The file closes and the application disconnects from the device.
2	**Menu** bar: Provides options for saving files, open the **Options** dialog to select/assign application default values, update firmware and license, and run a device diagnosis.
3	**Navigation** pane: To navigate within each view of the **Acquisition** workspace.
4	**Navigation** toolbar: To switch between different views.
5	To open the **Help** or the **About** dialog.
6	Expands/collapses the **Message** board.
7	**Message** board: To track the most important events, which are classed by colors. The contents can be saved to a file or cleared.

5.1.1 Signal pool concept

The central point of the Acquisition is the **Signal pool**, which receives selected inputs in the form of hard wired signals or mapped signals. The selected signals work as the **Signal pool** output for recording and observation as shown by the following figure.

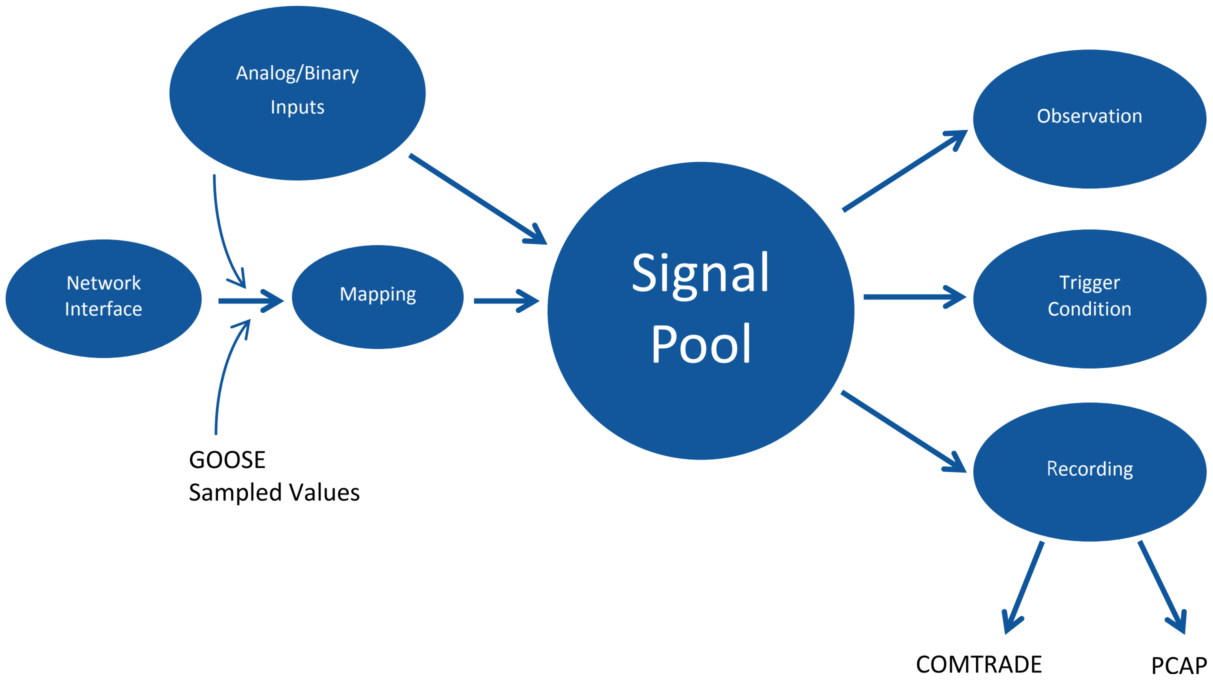


Figure 18: Signal pool concept

5.1.2 Measurement system

To create the measurement system, navigate to **Devices**. You can use existing physical devices that appear in the **Available devices** section, or create offline devices in the **Used devices** section, and later assign them to physical devices.

By using offline devices it is possible to prepare your measurement system already in the office.

When you are working with online devices and you change the configuration, the application displays a popup containing the **Apply** button, so that your changes can be applied immediately.

Understanding the devices states

Icon	State	The device is…
	Offline	Unavailable, for example, due to a network issue, disconnected from the network, or switched-off; disappears from the **Available devices** table. If it is already part of the measurement system, it can be configured offline.
	Locked by another user	The device is used by another user. Therefore, the device can be configured, but the configuration is not applied until the user who has locked the device stops using the device.
	Configurable	Successfully connected and synchronized; can be configured.
	Armed	Waiting for the trigger condition to start recording.
	Recording	The device is currently recording.
	Issue	Some issue has occurred. Refer to the information provided in the yellow issue bar.

Using available devices

For the following procedures, work in the **Available devices** section.

To use available devices for measuring:

1. Click the appropriate device.
2. Click **Use** to use the selected device, or click **Use all** to use all devices. The devices used in the measurement system appear in the **Used devices** section. The application automatically tries to connect to all devices.

Manual IP search

This function is especially useful in WAN scenarios, where a *DANEO 400* cannot be found by OMFIND. But also in LAN scenarios, there may be segregated broadcast domains set up or special filters set that prohibit the propagation of the OMFIND packets.

In such cases, an assigned IP address has to be configured for a port on *DANEO 400* prior to including it into a measurement system with *DANEO Control*.

There are different ways to do this:

- Connect to *DANEO 400* via the USB control port and configure the IP address of an Ethernet port with *DANEO Control* software.

- Connect to *DANEO 400* locally via an Ethernet port and configure the IP address of an Ethernet port with *DANEO Control* software.
- Connect to *DANEO 400* locally via an Ethernet port, locate the device in the OMICRON Device Browser and configure the IP address of the Ethernet port using the function **Set Network Configuration** from the context menu.

Adding and removing devices

For the following procedures, work in the **Used devices** section.

To manually add an offline device, click **Add**.

To remove a device, select the appropriate device, and then click **Remove**.

Assigning offline devices to physical devices

Associate used devices with physical devices. This is mainly important for manually added devices.

Devices that were added via the **Available devices** table are automatically re-connected as soon as they appear on the network and do not need to be associated any more. An associated device obtains the settings of the preconfigured used device.

To associate devices:

1. In the **Used devices** table, click the appropriate offline device.
2. In the **Available devices** table, click the appropriate physical device.
3. Click **Assign**. The physical device appears in the **Used devices** table.
4. (Optional) In the **Used devices** table, click the device name, and then changed it (limited to 30 characters).

Configuring the connection options

You can configure the control-traffic limit, the network, and the control ports. The device can be controlled by means of the USB or the ETH control port. When both control ports are connected, the USB port has priority. The device can switch between control ports in real time (a time lag may occur).

To configure the connection options:

1. In the **Navigation** pane, expand the device.
2. Click **Connection options**.
3. Select appropriate values for **Bandwidth** and **Maximum packet size** of the control traffic.
4. If you want to use the TAP mode, select **TAP**. From the drop-down list, choose the appropriate bit rate.
5. For network and control ports, from the **IP assignment**, choose how the device gets the IP address:
   - **Disabled:** No IP address is assigned.
   - **DHCP:** The DHCP server assigns the IP address automatically.
   - **Static:** You must enter the IP address manually.

Typically, an IP address is only assigned to one port that is intended to be used for controlling *DANEO 400*.

Assigning IP addresses of the same subnet to more than one port of *DANEO 400* has to be done with care. Depending on the network topology, this may lead to a condition where the control of *DANEO 400* is interrupted.

When a port has an IP address assigned, it can be “pinged” (it will reply to an ICMP echo request). This may as well be used for timing measurements.

Configuring the time synchronization

The device can use two possible time sources: a network PTP master clock for time synchronization or the internal device clock. The PTP is designed for applications that require high time accuracies. If you have a distributed measurement system with multiple devices you have to make sure that all devices are time synchronized over PTP.

To configure the time synchronization:

1. In the **Navigation** pane, expand the device.
2. Click **Time synchronization**.

To use PTP as time source:

1. Make sure that there is a PTP master clock in the network.
2. Select PTP.
3. Choose the port that connects to the network to obtain the time synchronization.
   Note: If the process ports (A and B) are in TAP mode and you choose any of these as the PTP communication port, the PTP cannot determine the cable length. In this case, you must enter the cable length (from the device port to the master clock) in **Cable length**.
4. Enter the VLAN ID and priority.

   PTP The device is not PTP time synchronized or is using the internal clock

   PTP The device is PTP time synchronized

   The **PTP details** provide read-only information about the state of the current selected port and the time synchronization clock.

To use the internal clock as time source:

1. Select **Internal clock**.
2. Click **Apply PC time**.

Configuring the inputs

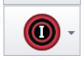
In the **Inputs** section, you configure the physical connections of the device. Each input can be configured either as voltage, current, or binary input. It is not possible to disable inputs.

To configure the inputs:

1. In the **Navigation** pane, expand the device.
2. Click **Inputs**.
3. In the **Analog settings**, choose the sampling frequency (10 kHz or 40 kHz) and enter the nominal frequency (15 Hz…70 Hz).

4. In the **Binary settings**, enter the debounce and deglitch time for all binary inputs (0 … 500 ms).
5. Select the input type, which can be an analog or binary input, see details below.
6. Assign a descriptive name to the input.
7. An analog input can be configured for measuring voltages or for measuring currents:

 Analog voltage input

 Analog current input

Choose a range that covers the maximum expected voltage at the input. The range refers to the RMS value of a sinusoidal voltage. For further details, refer to section “Technical data” on page 63.
The conversion factor is for the correct calculation of the primary quantities from the measured voltage. See the examples below on how to derive the conversion factors.

8. For binary inputs, choose the binary input type:

 Potential sensing for externally “wetted” contacts

 Internally “wetted” for sensing potential free (“dry”) contacts

9. For a potential sensing input, choose the appropriate voltage range and threshold.
10. Configure the phase systems by choosing their type and entering a name. The type “None” means that the phase system is not used. The phase systems are filled up automatically by using the voltage and current inputs from left to right (input numbers 1 to 10).

Calculating conversion factors

All quantities for observation, recording, and analysis are treated as primary quantities within *DANEO 400* and *DANEO Control*. At the analog inputs of *DANEO 400*, only voltages are measured, which are a proportional “image” of the primary quantities. Depending on the instrument transformers and/or sensors used, these voltages cannot even be always called secondary quantities in the classical sense.
To convert the measured voltages U_m into the corresponding primary quantity Q_p, the conversion factor k has to be set correctly (the letter Q is not to be confused with reactive power in this context).
The conversion factor is the ratio of the primary quantity to the measured voltage at the analog inputs:

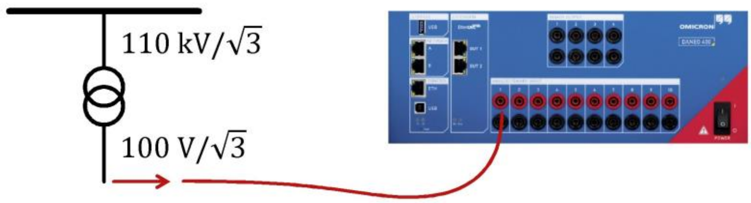
$$k = \frac{Q_p}{U_m}$$

Or, in other words, the measured voltage U_m is to be multiplied by the conversion factor k to obtain the primary quantity Q:

$$Q_p = k \cdot U_m$$

For an input configured as a voltage input, the conversion factor is a dimensionless number, in the user interface displayed with the “unit” $\mathrm{V/V}$.
For an input configured as a current input, the conversion factor is a conductance, in the user interface displayed with the unit $\mathrm{A/V}$.

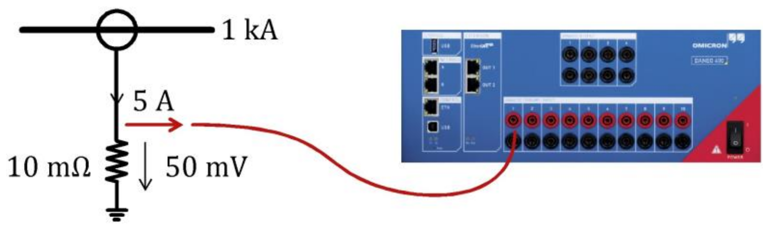
Voltage input: The instrument transformer is rated $U_{p,nom} = 110\ \mathrm{kV}/\sqrt{3}$ for the primary voltage and $U_{s,nom} = 100\ \mathrm{V}/\sqrt{3}$ for the secondary voltage.



The primary quantity is the primary voltage: $Q_p = U_p$.
The secondary voltage is measured with *DANEO 400*: $U_m = U_s$.
At nominal primary voltage we get:

$$k = \frac{Q_p}{U_m} = \frac{U_{p,nom}}{U_{s,nom}} = \frac{110\ \mathrm{kV}/\sqrt{3}}{100\ \mathrm{V}/\sqrt{3}} = \frac{110\ \mathrm{kV}}{100\ \mathrm{V}} = 1.1\ \mathrm{kV/V}$$

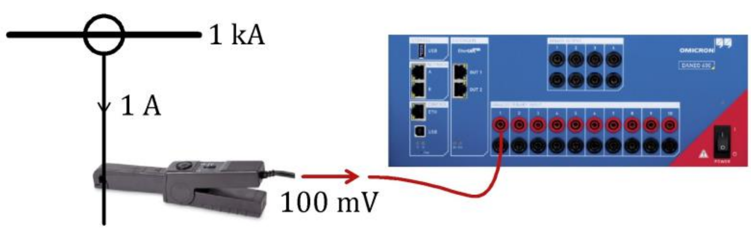
Current input: The instrument transformer is rated $I_{p,nom} = 1\ \mathrm{kA}$ for the primary current and $I_{s,nom} = 5\ \mathrm{A}$ for the secondary current. The secondary circuit is terminated by a shunt with the value $R_S = 10\ \mathrm{m\Omega}$.



The primary quantity is the primary current: $Q_p = I_p$.
The voltage across the shunt is measured with *DANEO 400*: $U_m = I_s \cdot R_S$.
At nominal primary current we get:

$$k = \frac{Q_p}{U_m} = \frac{I_{p,nom}}{I_{s,nom} \cdot R_S} = \frac{1\ \mathrm{kA}}{5\ \mathrm{A} \cdot 10\ \mathrm{m\Omega}} = \frac{1\ \mathrm{kA}}{50\ \mathrm{mV}} = 20\ \mathrm{kA/V}$$

Current input: The instrument transformer is rated $I_{p,nom} = 1\ \mathrm{kA}$ for the primary current and $I_{s,nom} = 1\ \mathrm{A}$ for the secondary current. The secondary current is sensed with a current clamp with voltage output and the transfer ratio $r_C = 100\ \mathrm{mV/A}$.



The primary quantity is the primary current: $Q_p = I_p$.
The output voltage of the current clamp measured with *DANEO 400*: $U_m = I_s \cdot r_C$.

At nominal primary current we get:

$$k = \frac{Q_p}{U_m} = \frac{I_{p,nom}}{I_{s,nom} \cdot r_C} = \frac{1\ \text{kA}}{1\ \text{A} \cdot 100\ \text{mV/A}} = \frac{1\ \text{kA}}{100\ \text{mV}} = 10\ \text{kA/V}$$

5.1.3 System under test

In **System Under Test**, you create the substation system. Therefore, load an SCL file including the GOOSE and Sampled Values or manually add an IED. Only selected IEDs are used for testing.

The GOOSE and Sampled Values of the loaded substation system can be verified against the network. For further details, refer to section “IEC 61850 SCL verification” on page 35.

Loading SCL files

Loading an SCL file imports the GOOSE and Sampled Values configurations of IEDs.

To load an SCL file, in the **System Under Test** section, click **Load SCL file**.

Note: The following SCL file extensions are supported: .scd, .icd, .cid, .iid, .sed, .xml.

The following table shows possible issues while loading an SCL file.

Issues while loading an SCL file	Result
The SCL file contains IEDs already included in the system under test, but with different settings.	Choose whether to replace the existing IEDs by the imported IEDs.
The SCL file contains the same IED twice.	Only the first IED is parsed and loaded.

Manually adding, selecting, and removing IEDs

To manually add an IED:

1. On the **Navigation** pane, click **IEDs**.
2. In the **System Under Test** section, click **Add**. The newly created IED appears in the **Loaded IEDs** table.

To select IEDs for testing, select the **Used** check box either in the **System Under Test** section or in the **Navigation** pane. The selected IEDs are included in a subset that is used for all subsequent tasks concerning IEDs.

When you clear an IED check box, the IED is no longer used for testing, but its GOOSE and Sampled Values remain persisted.

To remove IEDs, in the **System Under Test** section, select the IEDs, and then click **Remove**. You can use **Ctrl** and **Shift** for multiple selections.

When you remove an IED, its GOOSE and Sampled Values are deleted and removed from all views.

Configuring an IED

You must configure a newly added IED before it can be used. You can also use this section to change an existing IED, and see or remove its GOOSE and Samples Values.

To configure an IED:

1. In the **Navigation** pane, click the appropriate IED.
2. In the **Properties** section, enter/change the IED properties. The IED name must be unique in the System Under Test.
3. If there are unnecessary GOOSE or Sampled Values, select them, and click **Remove**.

IEC 61850 SCL verification

In the verification, you can check which imported GOOSE and Sampled Values streams really exist on the network. The devices sniff the network, search, and verify the GOOSE and Sampled Values. The following figure shows an example of the SCL verification with results.

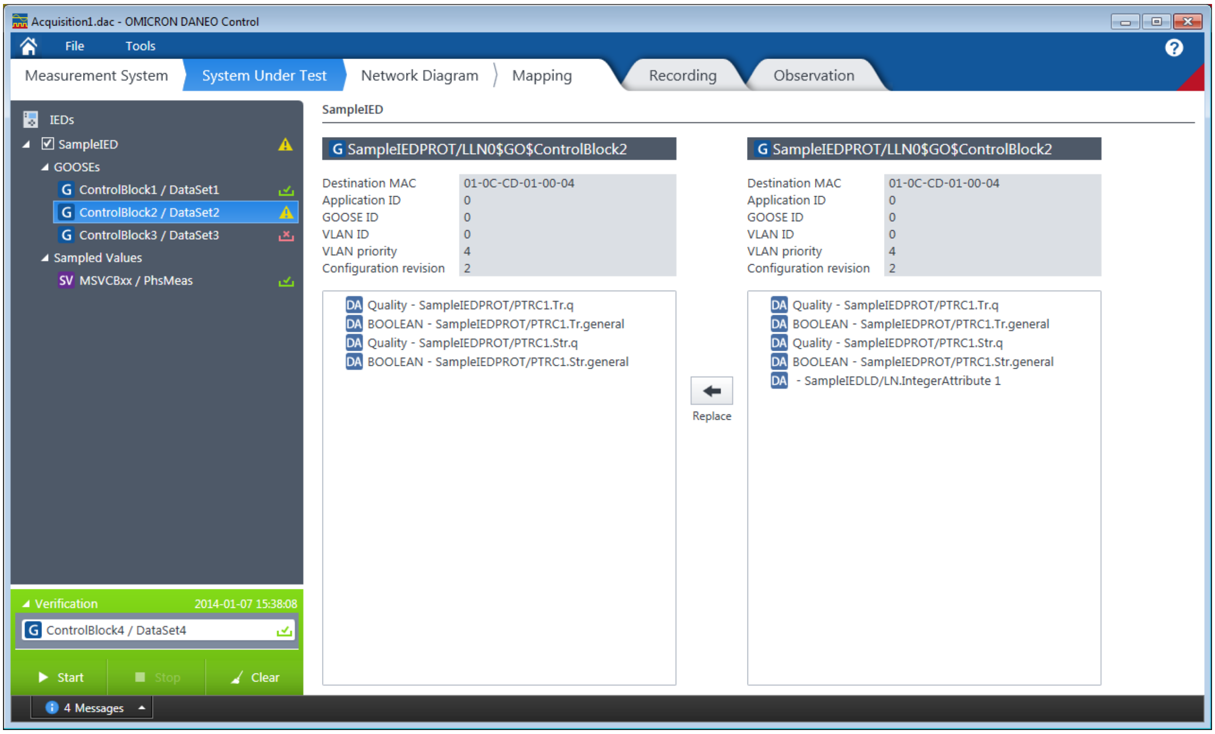


Figure 19: IEC 61850 SCL verification

The discovered GOOSE and SV streams are compared to the definitions loaded from the SCL file(s). If a discovered GOOSE or SV stream can be related to a loaded definition, a verification result will be given. If a GOOSE or SV stream is entirely unrelated to the loaded definitions, it will be presented as an orphan.

The verification results are updated in real time and classed by means of three different icons.

	Found	The control block reference (GOOSE) or SVID (SV), the data set, and the header match.
	Found with differences	The control block reference (GOOSE) or SVID (SV) match, but not the data set or header.
	Not found	The control block reference (GOOSE) or SVID (SV) was not found.

To start the verification, in the **Navigation** pane, click **Start**. To clear the verification results and any unassociated orphans, click **Clear**.

Issues during the verification	Result
GOOSE or SV streams were found with differences.	In the **System Under Test** section, for comparison purposes, the GOOSE or SV streams found with differences are placed to the right of the GOOSE or SV streams loaded from the SCL file. GOOSE or SV streams loaded from the SCL file can be replaced entirely by the GOOSE or SV streams found with differences.
GOOSE or SV streams were found, but do not match any GOOSE or SV streams loaded from the SCL file.	This GOOSE or SV stream is an orphan and can be associated with an IED.

Associating an orphan with an IED

When you select an orphan in the **Verification** section of the **Navigation** pane, the orphan details are displayed. The orphan can be associated with an IED. In this case, from the **IEDs** list, select the target IED, and then click . There, you can also associate the orphan to a new IED by clicking .

Tip: The orphan can also be dragged from the **Verification** section directly onto the appropriate IED in the **Navigation** pane.

5.1.4 Network diagram

In **Network Diagram**, you can import the substation network diagram and place the devices and the IEDs onto the diagram. The diagram can be useful for orientation while working in the substation.

Importing and adjusting a network diagram

Click **Import diagram** and choose a .jpeg or .png file. To adjust the diagram size to the **Network Diagram** area, click **Zoom to fit**. To adjust the diagram to a different size, move the **Zoom** slider.

Placing and adjusting devices and IEDs

From the **Navigation** pane, drag devices and IEDs (items) to where you want them in the network diagram. To adjust the item's size, move the **ItemSize** slider. When you point an item, you enable the option to remove the item.

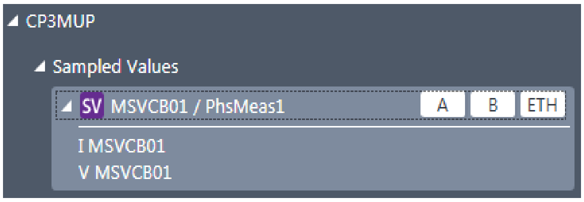
Tip: Double-click a device or an IED in the diagram to navigate directly to its configuration in the **Measurement System** or **System Under Test**.

5.1.5 Mapping

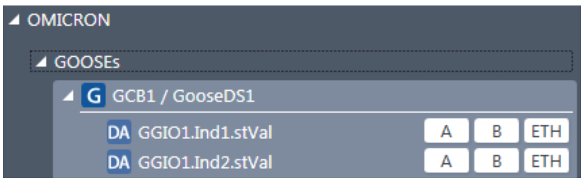
In **Mapping**, you can map voltages, currents, and binary values, which are encapsulated in Sampled Values and GOOSE as well as hard-wired inputs and phase systems to specific devices. This way, you build up a signal pool for every device.

Mapping signals to a device

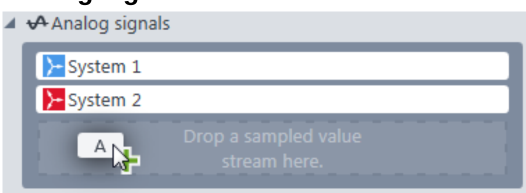
1. In the **Navigation** pane, expand “IED” > Sampled Values until you see ports A, B, ETH.

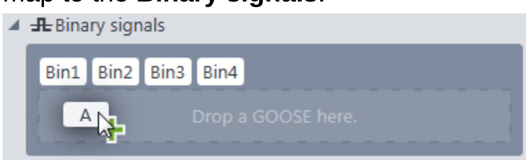
   You get the currents and voltages of every “IED”.
2. In the **Navigation** pane, expand “IED” > GOOSE until you see ports A, B, ETH.

   You get the binary signals of every “IED”.
   Note: The device needs to know on which port (A, B, or ETH) the GOOSE or Sampled Value streams can be read.
3. In the **Devices** section, choose the device.
4. From the **Navigation** pane, drag the port of the Sampled Value that you want to map to the **Analog signals**.

   The voltage and current (phase system) appear. You can now combine a voltage and current to generate a power system.
5. From the **Navigation** pane, drag the port of the GOOSE data attribute (DA) that you want to map to the **Binary signals**.

Note: Each device can hold up to three Sampled Value streams.

Tip: Instead of dragging the port, double-click the port to map the signal in a quicker way.

By repeating the above procedure for all desired signals, you map the analog and binary signals to the selected ports of every device.

Remapping signals

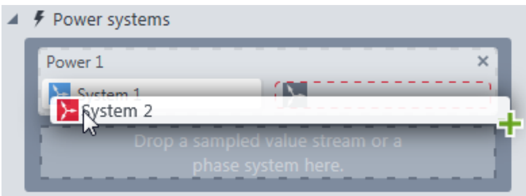
To remap signals, which are currently mapped to devices, you must first delete those signals from the **Signal pool**. You can only remap a Sampled Value when its voltage and current are both deleted. This way, the port becomes available again and you can map the signal to a different device.

Creating power systems

To create a valid power system, you must combine a current system and a voltage system. You can create power systems from mapped and hard-wired phase systems.

To create a power system:

1. From the **Analog signals**, drag the voltage system to the **Power systems**. An incomplete power system appears.
2. From the **Analog signals**, drag the current system to the incomplete power system created in step 1.



The power system is now complete and valid.

Tip: Create a power system by dragging a Sampled Value directly onto **Power systems**.

Understanding the Properties section

The **Properties** section displays the properties of the signal selected in the **Signal pool**. This section is read-only for analog signals and power systems. For mapped binary signals, you can define the **Comparator** to evaluate the GOOSE value.

Evaluating whether a binary signal is true or false

Every GOOSE has at least one attribute subject to a logical comparison. You can configure the GOOSE's attributes comparator in **Properties** > **Comparator**. The binary signal is considered true if the result of the comparison of all selected attributes is true.

Tip: Map the same GOOSE data attribute multiple times to create several binary inputs with different conditions of the same payload.

To evaluate whether a binary signal is true or false:

1. In the **Comparator** section, clear the **Inverted** check box.
2. Select the attributes for comparison.
3. Configure the comparator of the selected attributes.
   The logical conjunction (AND) of the result of each individual comparison defines whether the binary signal is true of false.

To invert the result of each comparator, select the **Inverted** check box. This procedure is useful when dealing with negative logic.

As shown in the following figure, the binary signal "Gin1" is true if the Boolean attribute value is true.

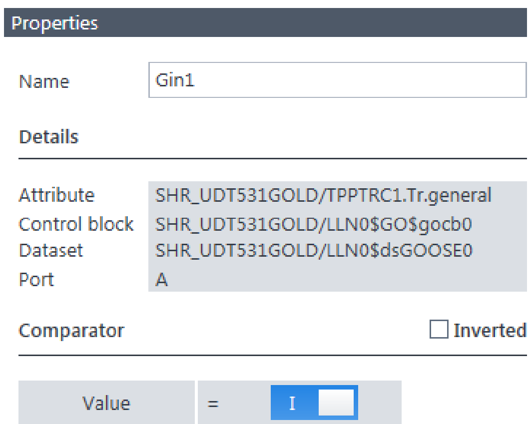


Figure 20: Example of a mapped binary input signal

5.1.6 Recording

In **Recording**, you select for each device the signals and the network traffic per port for recording, set trigger conditions and post-trigger actions, and define the storage location on the device to save the recording files. Finally, you can arm the devices with the trigger conditions or start the recordings immediately.

Understanding the Recording overview

The **Recording overview** on the **Recording** section (**Overview**) provides a summary of the configured recording. When you click a link, you are directed to the corresponding section within the device.

You can control the recording simultaneously or individually per device. The following buttons are used to operate all devices simultaneously.

Arm	Wait for the trigger condition to become true
Record	Start the recording immediately
Stop	Stop the armed state or the recording

Note: To operate each device independently, use the individual buttons per device.

Selecting signals

In the **Signals** section you can add available signals to the recording pool. There is no difference between mapped or hard-wired signals. When you add signals of a phase system to the recording pool, all phases are added by default.

To add signals to the recording pool, from **Available signals**, drag the appropriate signal to the **Signals** section.

To remove signals from the recording pool, select the signals, and then click **Remove**. You can use **Ctrl** and **Shift** for multiple selections.

Tip: Instead of dragging the signal, double-click the signal to add it in a quicker way.

Selecting and filtering network traffic

In the **Traffic** section you can record Ethernet packets (traffic) captured on a certain port (A, B, or ETH) to a PCAP file. The traffic can be filtered based on the options you choose in the filter details. When you enable recording traffic on a port the default criteria is to record traffic that contains only mapped GOOSE and Sampled Values—the traffic selection is based on the destination MAC address. If you want to record IPv4 traffic you can define a source IP address filter. Additionally, you can also define generic Ethertypes in the filter to record any kind of other traffic.

All	All traffic on the respective port is recorded.
Mapped	Only traffic from mapped GOOSE or Sampled Values is recorded.
SCL	Only traffic that belongs to IEDs in the system under test is recorded.

Used IEDs	Only traffic that belongs to the used IEDs in the system under test is recorded.
Custom	Only traffic whose destination MAC address, source IP address, and/or Ethertype have been entered manually is recorded.
None	No traffic is recorded.

Note: Choosing "All" may produce a high amount of data, especially when recording Sampled Values. Choosing "All" for generic Ethertypes will overrule all other filter settings.

Example

You want to record on a PCAP file the traffic containing:

- GOOSE mapped to "DANEO 1"
- GOOSE captured on port A
- Sampled Values from used IEDs
- Traffic containing the sender IP address "10.10.5.33"

To meet the above requirements:

1. Enable recording on port A

2. In the **GOOSE destination addresses**, choose "Mapped"
3. In the **Sampled Value destination addresses**, choose "Used IEDs"
4. In the **IP host addresses**, choose "Custom"
5. Enter "10.10.5.33" in the appropriate field, and click + and if required delete other existing IP addresses in the list.

The result is a group of MAC addresses and one IP address that reveal the desired traffic as shown below.

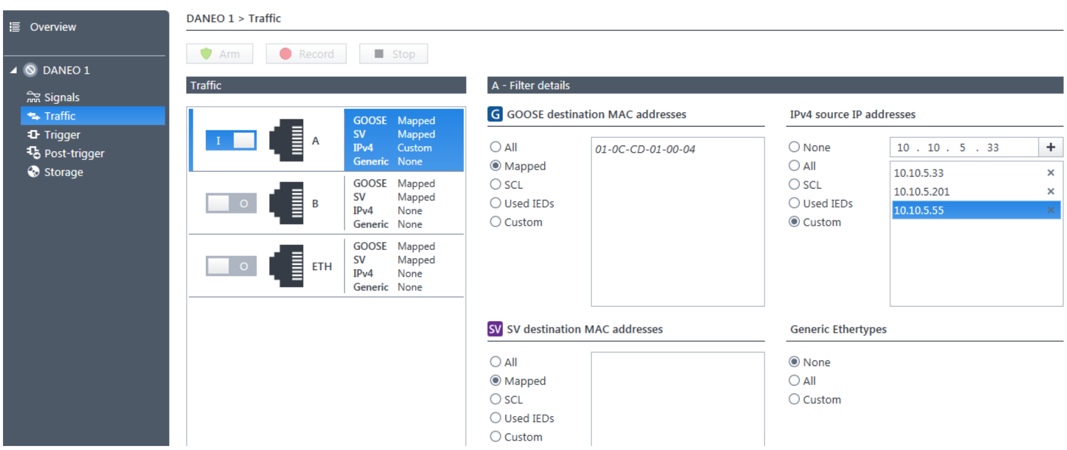


Figure 21: Traffic recording configuration (Filter details)

Understanding and configuring the trigger settings

The trigger settings comprise a pre-trigger time, a post-trigger time, a lockout period, and a re-arming option.

Pre-trigger	Represents the recording time before the trigger condition becomes true. The recorded data is stored in a buffer in the device. When you select Maximum, the whole data of the buffer will be stored into the recording. Otherwise, you can enter a value between 0 … 10 s to limit the pre-trigger duration and reduce the amount of data in the recording.
Post-trigger	Represents the recording time after the trigger condition has been met. When you select **Unlimited**, the record spans through the maximum allowed period, which is limited by the available space of used storage. Otherwise, you can enter a value to limit the post-trigger duration.
Lockout	Represents the sleep time-period after the post-trigger period as elapsed and before the re-arming of the device.
Re-arming	Offers the option to re-arm the device after a recording. When you select **Unlimited**, the device shall re-arm infinite times. Otherwise, you can enter the number of times that the device shall re-arm.

After configuring the trigger settings, the application shows the estimated recording file size. This estimated size excludes the traffic recordings configured in the **Traffic** section.

Note: The trigger settings are user desired values, which may not be fulfilled due to limited storage space and the trigger occurrence.

Creating trigger conditions

In **Trigger**, you can create the trigger condition to start the recording. The trigger condition can be based on a time stamp, on a binary or analog input measurement, or a combination of any of these conditions. By combining several conditions you form a logical operation with a single output, which is the trigger condition. The available logical operators are AND, OR, NAND, and NOR.

To configure the trigger condition:

1. From the **Available signals**, drag the appropriate signal to the **Trigger condition** section. A block representing a condition for the signal appears.
2. Configure the condition. The resulting condition determines the trigger right away if there are no further conditions to combine.
   When you add multiple conditions to create the trigger condition, each one creates a new condition-block. All blocks are then combined through a logical operator.
3. Drag the new signal to the ⊞ that appears next to the already inserted block. A logical operator appears.
4. In the logical operator, choose the logical operation. Continue this procedure if you need to add further conditions.

Tip: Instead of dragging the signal, double-click the signal to add it to the trigger condition in a quicker way. The new condition-block appends to the next available input of a logical operator.

Configuring the post-trigger action

With the **post-trigger action**, you can configure what the device outputs when the recording has finished.

Possible actions are sending a GOOSE message or setting a binary output to a certain value.

The GOOSE message can be used as a trigger input for another device.

To send a GOOSE message, select the appropriate port(s) and configure the GOOSE details. Ports A and B cannot be used when they are in TAP mode.

To set a binary output to a certain level, select the binary output. The selected binary outputs are set to true. When you select **Inverted**, the value is inverted (negative logic).

Storage location

In the **Storage**, you can define the location where to store the recording files. In addition to the device's internal disk, you can also use external storage devices such as USB flash drives or external HDDs.

When you click a disk in the **Drives** section, the disk details and recording files on the disk become available in the **Details** and the **Recording** sections, respectively.

To define the default storage disk, click the appropriate disk, and then click **Use storage as default**. The default disk is used whenever it is connected and available; otherwise the internal disk is used.

To safely remove a disk, click the appropriate disk, and then click **Safely remove disk**.

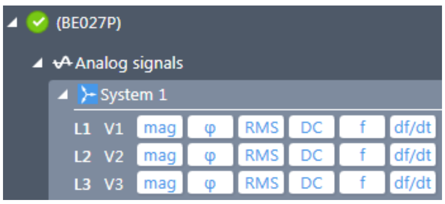
5.1.7 Observation

In the **Observation**, you can observe hard-wired and mapped analog/binary signals, as well as traffic. The following table shows the available measurements and their parameters.

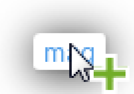
Measurements	Signal parameters
Analog signals	Magnitude, phase, RMS, DC, frequency, and frequency change. In a phase system there are also magnitude and phase of the symmetric components (zero, positive, and negative). Independent signals (not in a phase system) appear in **Not in a phase system**.
Power systems	Active, apparent, reactive power, and cos(φ).
Binary signals	All defined binary signals.
Traffic per port	Packets/s and Bytes/s for each port (A, B, and ETH).

Adding signals for observation

In the **Navigation** pane, you need to expand the devices to see the signals available for observation.



To observe a signal, drag it to the **Observation** pane.



You can also double-click it. A graph and the value (right side) at the current instant appear. The graphs are refreshed every 1 second.

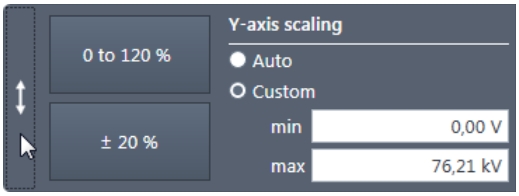
Configuring the Observation pane

You can adjust the visible time and zoom level by using the respective sliders at the top.

Tip: With multiple signals already visible in the **Observation** pane, you can now drag them to other positions.

Y-axis scaling

To adjust the Y-axis range, click the Y-axis button (left of the graph). The **Y-axis scaling** dialog opens and you can click the buttons to set the custom value. When the button unit is percentage, the resulting values are derived from the nominal value.



When you select **Auto**, the range is calculated automatically based on the measured values.

Note: Binary changes with durations lower than 100 ms are recorded, but not visualized in the binary observation diagram.

5.1.8 Tools

From the **Tools** menu, you can access the following dialogs: **Options**, **Firmware update**, **License update**, and **Diagnosis**.

Options dialog

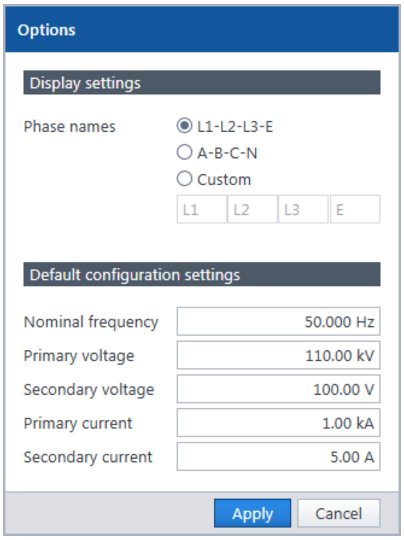


Figure 22: Options dialog

The options are saved as user-preferred settings and are re-used whenever the same user opens *DANEO Control* again.

Display settings

Choose your preferred phase names. Changes take effect immediately.

Default configuration settings

To enter default frequency, voltage, and current names. Voltages and currents in the primary and secondary are used as a conversion factor in *DANEO 400* analog inputs. For example, a primary voltage of 110.00 kV and a secondary voltage of 100.00 V create a factor of 1.10 kV/V.

Note: Changes made in this dialog will take effect only for newly created acquisition files.

Firmware update

The firmware update can be performed only for used devices that are either configurable, in recovery mode, or require a firmware update. An ongoing verification/sniffing, observation, recording, or just being armed will prevent the device from being upgraded.

A firmware update is required if the major software version has changed. Minor software versions are compatible and do not require a firmware update.

In case a firmware update is required, no other actions can be performed.

To manually update the firmware, click **Tools** > **Firmware update**.

By default, the firmware update that came with the last installation is used for the actual firmware update and the corresponding version is displayed. You can use a local firmware image by clearing the **Default image** check box and browsing the custom image path.

During the firmware update, you may also need to update the slaves. A slave can be either the internal slave or an external extension device. The slave is automatically rebooted without the need for rebooting the device. In case a slave update is required only (represented again through an issue), the slave update is performed as a single step.

A step-based progress is displayed (finished or error). The following figure shows the firmware update progress.

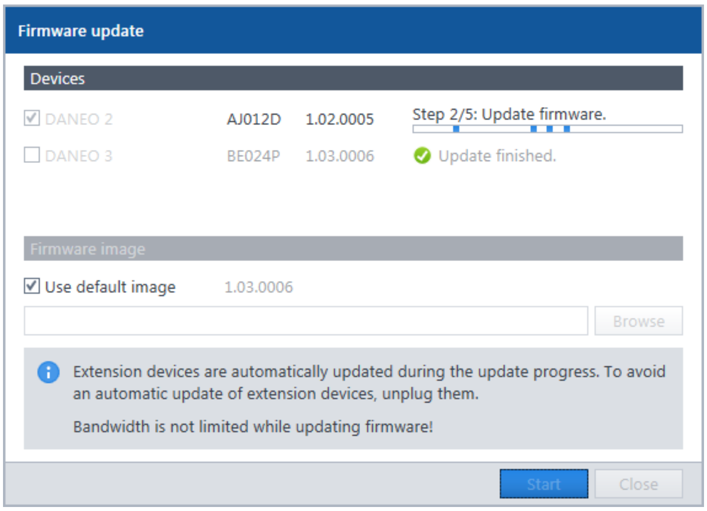


Figure 23: Firmware update progress

The whole firmware update may take up to two minutes including reboot and slave updates.

Important:

- During the firmware update, the bandwidth is not limited.
- Extension devices are automatically updated during the firmware update process if needed. To avoid an automatic update, unplug the extension devices.

License update

There are two licenses for a *DANEO 400* device. With the basic license you can measure and record conventional (analog and binary) signals. With the standard license you can additionally measure and record traffic from power utility communication networks and you get the IEC 61850 capabilities.

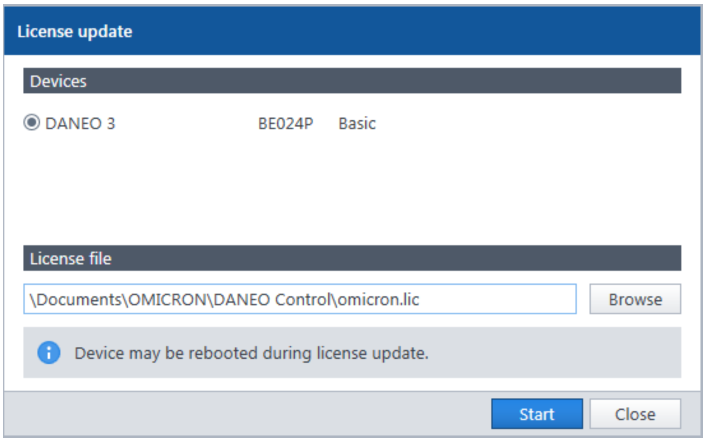


Figure 24: License update

A license update is used to add IEC 61850 and network capabilities to a device with a basic license. Licenses are associated with the serial number of a device, so you can use a license file only for the device it is meant for. Because of that, you can only select one device at a time for license update.

The license update has restrictions similar to the firmware update (configurable, not being armed, etc.). As with the firmware update, all other actions are blocked during a license update.

If the license file is invalid, *DANEO 400* will report an error and is reverted to basic license.

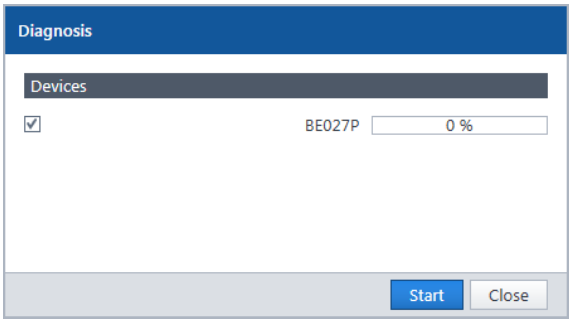
Note: The device may be rebooted during the license update.

Diagnosis

Devices in the measurement system can be subject to a diagnosis. When the diagnosis is complete, you can save the diagnosis or send it to the technical support. The diagnosis cannot be started if the device is offline, locked by another user, armed, or in recording state. In these situations, you can save or send the PC log file.

To run the diagnosis:

1. Click **Tools** > **Diagnosis**.
2. Select the devices, and click **Start**.

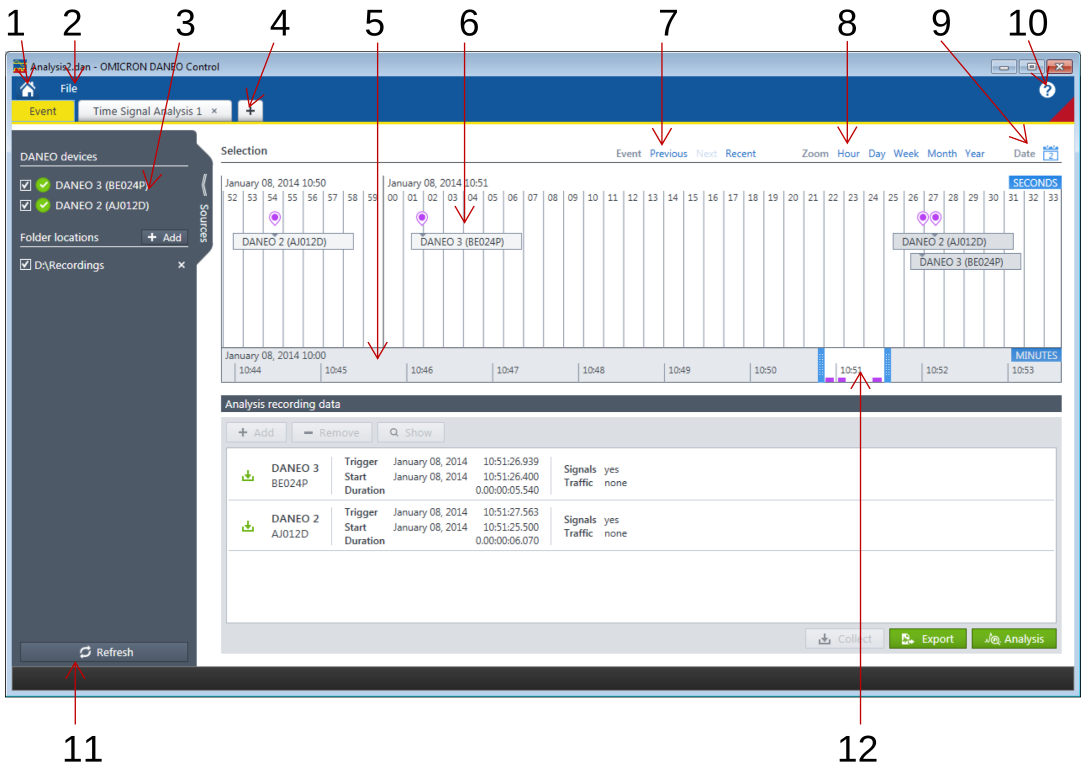
   Once the diagnosis has completed, you can:

   a. Choose your region, and click **Send** to send the diagnosis via email.
   Note: Your default email client (for example Microsoft Outlook) will open containing the files attached for the technical support. You may get an error message if your email client is not supported or you do not have an email client at all.

   b. Click **Save** to save the diagnosis file to your computer.
3. Click **Close**.

5.2 Analysis

In the **Analysis** workspace, you can access the **Event** view and add **Time Signal Analysis** or **Propagation Delay** views to run multiple analyses. You can analyze recordings located either on a reachable device or on a defined folder location on your local hard disk.



1	Takes you to the home screen.
2	**Menu** bar: Provides options for saving files.
3	**Sources** pane: To select devices from the list of reachable devices and define folder locations containing the recordings.
4	Add a new **Time Signal Analysis** or **Propagation Delay** view.
5	Timeline.
6	The bar represents a recording. The pin indicates the trigger instant.
7	**Event:** To navigate to previous, next, or most recent event.
8	**Zoom:** Changes the zoom to hour, day, week, month, or year view if there are events spread throughout such time span.
9	To place the timeline at the selected day. You can only select days where events have occurred.

10	To open the Help or the **About** dialog.
11	To refresh the recordings from the defined sources.
12	Sliding window to focus the diagram view to a specific time range.

5.2.1 Collecting recordings of an event

Finding events—navigating on the timeline

In the **Event** view you can search and select recordings to analyze. Online devices appear automatically in the list of reachable devices within the **Sources** pane.

To see recordings from certain devices, expand the **Sources** pane, and clear the undesired devices.

A pin on the diagram indicates the trigger instant of a recording event. When you click the pin or increase the zoom, each recording is displayed as a bar on a timeline.

Data sources

To add and remove folders from local or external discs containing recordings, from the **Sources** pane, click **Add**. The list of folders remains unchanged even after restarting the application or starting a new analysis.

Collecting the recordings

Recordings (or whole events) can be added to the **Analysis recording data** section, a list of all recordings you intend to analyze.

To add a recording for analysis, select the recording from the timeline, and then click **Add**. The recording appears in the **Analysis recording data**.

To remove a recording, click the appropriate recording from the **Analysis recording data** list, and then click **Remove**.

To show a recording in the timeline, select the recording from the **Analysis recording data** list, and then click **Show**.

Before the actual analysis, you have to load all recordings to your local computer. If the loading is successful, the recording's icon shows green. If an error occurs, the respective recording's icon shows red. To load recordings to your computer, click **Collect**. You can now export signals and recorded traffic or start the analysis.

If you add or remove recordings while you are analyzing, the **Time Signal Analysis** and **Propagation Delay** views will dynamically add/remove the according signals and remove deserted diagrams.

COMTRADE and PCAP export

The instantaneous and binary signals of loaded recordings can be exported in COMTRADE 1999 format. You can also specify the signals to be exported, the sampling frequency, the COMTRADE format, and the save path.

There is the possibility to directly open the exported file in an application associated to .cfg files, such as the OMICRON application *TransView*. These applications are not included in *DANEO Control* and have to be installed separately. For example, in case *TransView* is not found, the COMTRADE file is exported correctly and an error message is displayed.

Recorded traffic can be exported by the captured ports (A, B, ETH) and is saved in PCAP format. One file per selected port is generated.

Creating an analysis

You can create multiple time signal analysis and propagation delay views and therefore run multiple analyses.

To create a new analysis, on the **Event** view, click **Analysis**, and then click **Time Signal Analysis** or **Propagation Delay**.

5.2.2 Time signal analysis

The list of devices and their recorded signals appear in the **Navigation** pane. By drag and drop or through double click, the signals are displayed in different types of diagrams.

Available diagrams:

- Instantaneous signals: Instantaneous, cursor, and calculation
- RMS, DC: The according value as time diagram, cursor, and calculation
- Phasor: Magnitude and phase time diagram, cursor, and calculation
- df/dt: f, df/dt cursor, and calculation
- Binary: Binary trace, and GOOSE packets for a mapped binary signal
- Traffic: Byte/s, packets/s, cursor, and calculation

The following figure shows an example of a time signal analysis displaying analog and binary signals.

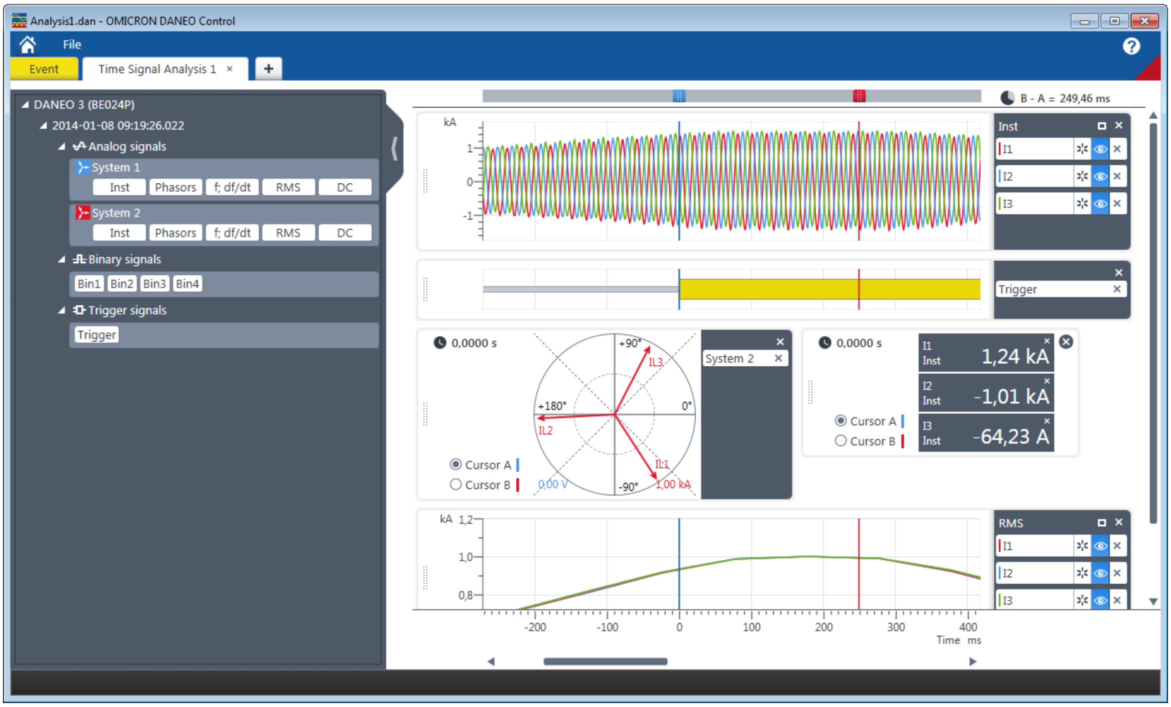


Figure 25: Example of a time signal analysis

The cursor diagram shows the signal's values and/or components at the selected cursor's position. The calculation diagram can additionally perform basic calculation operations (addition, subtraction, division, multiplication) based on the cursor position values.

The GOOSE packets diagram is available for mapped binary signals from GOOSE. It displays information about the GOOSE packet that caused the current state of the binary signal at the selected cursor.

All signals can be removed from a diagram or copied via drag and drop into a new diagram. Where applicable, they can also be copied into another already existing diagram.

A visible analog signal can be highlighted or hidden. All diagrams can be zoomed and optimized in their X- and Y-axis range.

5.2.3 Propagation delay analysis

You can create a propagation delay analysis from loaded recordings containing at least two PCAP files or traffic recorded on two ports of the same device. This type of analysis enables you to create histograms showing the propagation delay of packets between two different locations in the network.

The following figure shows an example of a propagation delay analysis displaying a propagation delay histogram.

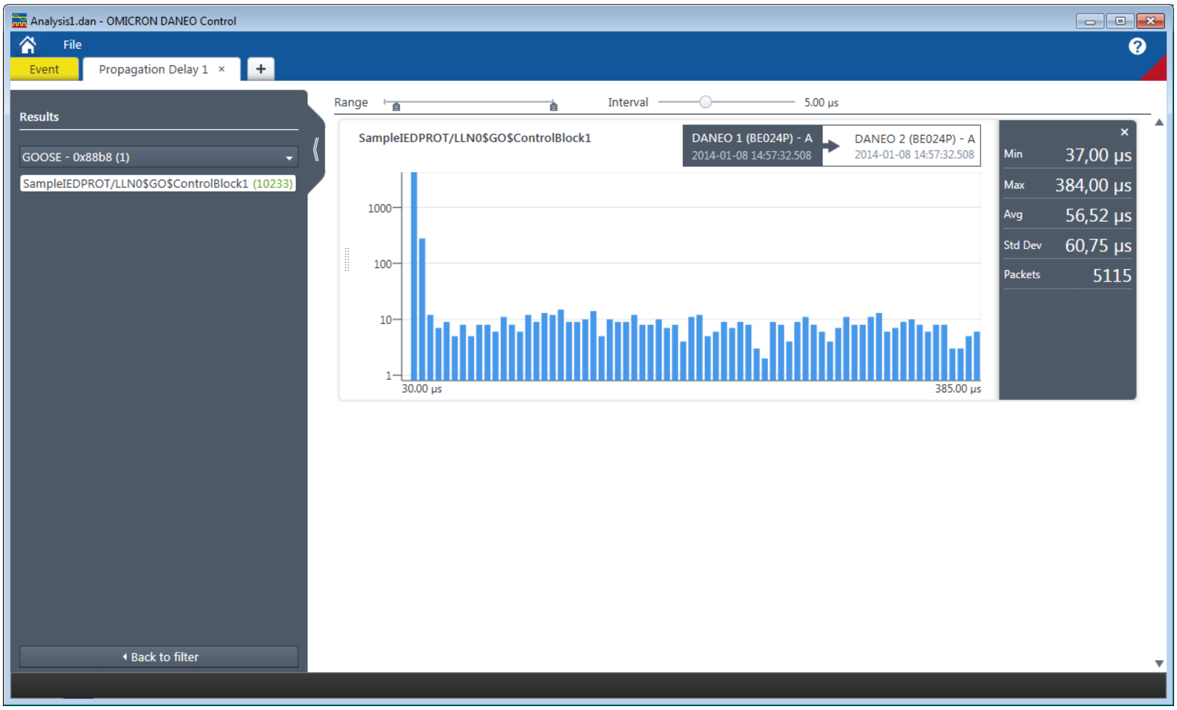


Figure 26: Propagation delay histogram showing the propagation delay of packets between two different locations captured by two different *DANEO 400* units

There are various filter options available. You can filter for a subset of all loaded recordings, for source and/or destination MAC address, for GOOSE, sampled values, and generic Ethertypes found at least in one of the PCAP files.

Applying the filter leads to the **Results** view where you can further specify the traffic you are interested, for example double click or drag a particular GOOSE.

When creating a propagation analysis, you have to choose which location is the reference and which one is the investigated. The propagation analysis generates a histogram of the packet delay in relation to the reference recording.

6 Web interface

DANEO 400 hosts a web server for providing status information and configuration via a web interface. With the web interface it is also possible to observe or capture network traffic and browse the recordings on the device.

6.1 Homepage

The *DANEO 400* homepage in the figure below is displayed when connecting to *DANEO 400* with a browser by specifying the device's IP address or URL.

Clicking *DANEO 400* logo in the upper left corner redirects to the homepage.

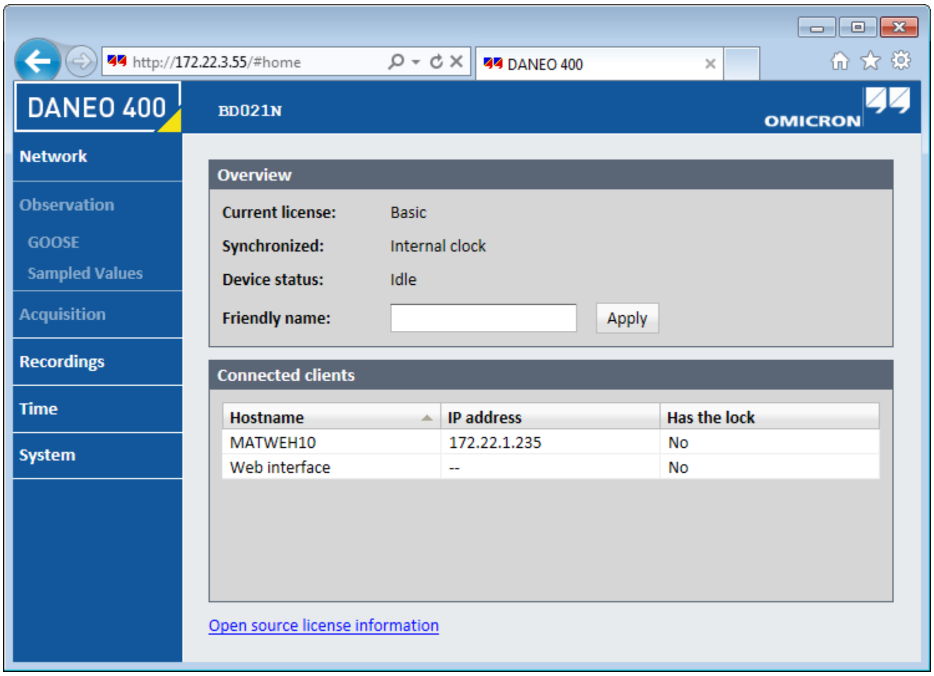


Figure 27: Homepage of *DANEO 400* web interface

6.1.1 Overview and connected clients

The overview section shows general information about the device. You can also set the device name. There are five possible device statuses:

Idle: The device is ready for configuration.

Running: The device is sniffing the network or recording, afterwards it continues in the running status. When the device is running, the **Acquisition** > **Stop** button is available to change the device status to Idle.

Sniffing: The device is sniffing the network (GOOSE, SV).

Armed: The device is waiting for the trigger condition in order to start the recording (sub-status of Running).

Recording: The device is recording.

The **Connected clients** section shows the list of clients using the device, their IP address, and whether they are locking the device. The table shows one entry for each client connected to *DANEO Control*. Clients connected through the web interface appear only once as “Web interface”.

6.2 Network

6.2.1 Network interfaces

The **Network** section provides similar options as for the **Connection options** in *DANEO Control*. For further details, refer to section “Configuring the connection options” on page 29. In the **Network** section of the web interface there is no information about USB connection, but you can find information about the MAC address of the Ethernet ports.

6.3 Observation

The **Observation** section provides traffic observation in two forms, packets per second and bytes per second. Select the Ethernet port to see its traffic statistic in the corresponding diagram.

6.3.1 GOOSE and Sampled Values

The **GOOSE** and **Sampled Values** sections provide options for sniffing the network. When you click a found GOOSE or Sampled Value stream, its **Details** list appears to the right. The found GOOSE or Sampled Value stream can be used in **Acquisition** for configuring the recording filter.

Searching GOOSE and Sampled Values

You can search a GOOSE or Sampled Value stream by entering its destination or source MAC address or part of it.

You can also search a GOOSE by the control block and dataset reference, and Sampled Values by their SVID.

6.4 Acquisition

In **Acquisition**, you can configure and perform recordings. A time trigger condition can be defined to arm the device for recording and the storage location can be selected.

In the **Filters** section, you select the ports for recording and configure their traffic filters. A filter can include GOOSE and SV destination MAC addresses, IPv4 source IP addresses, and other traffic Ethertypes.

When you select **Custom**, you can add custom addresses or add the sniffed GOOSE or Sampled Values from **Observation**.

The filter options in the web interface slightly differ from the filter options in *DANEO Control*. The web interface has the option to select **None** for GOOSE and SV, which excludes this kind of traffic from the recording.

Note: An icon appears in the **Trigger condition** section to indicate that the time in the device is different of the time in the computer.

6.5 Recordings

In the **Recordings** section you can browse, delete, and download recordings from the device to the computer.

6.6 Time

The **Time** section is similar to *DANEO Control*. Refer to section “Configuring the time synchronization” on page 30 to understand its functionality.

6.7 System

6.7.1 Status

Some general information about *DANEO 400* system:

- Product name
- Serial number
- Host name
- Kernel
- Uptime
- Diagnosis (**Start** > **Download**)
- Firmware version

To understand the diagnosis, refer to section “Diagnosis” on page 50.

6.7.2 Licenses information

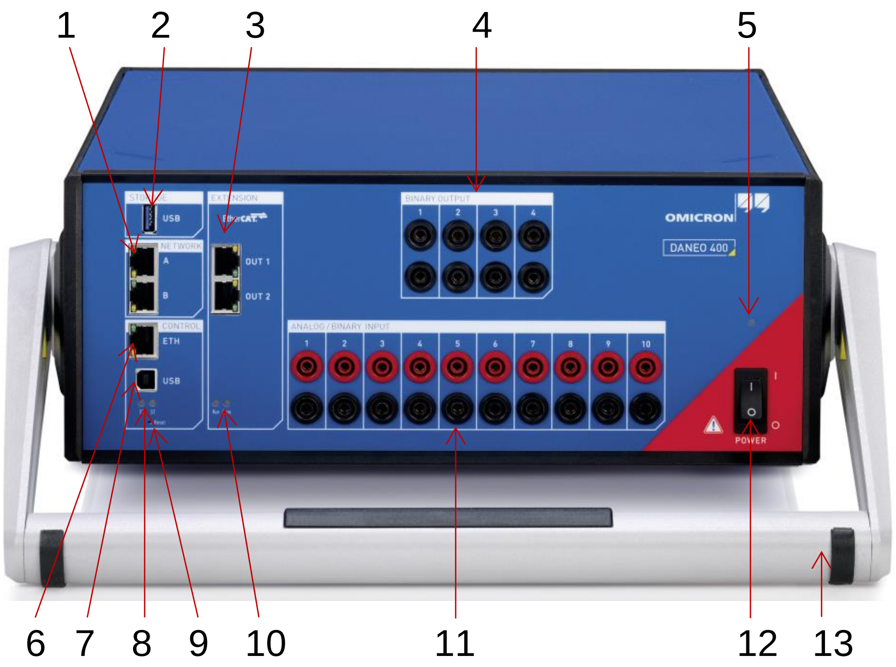
Open source license information is displayed to view copyright and license information regarding open source products used in *DANEO 400* software.

Please refer to section “Open Source Software License Information” on page 71.

7 DANEO 400 hardware

The *DANEO 400* hardware interface is located at the front and rear panels of the device.

7.1 Front panel



1	Ethernet network process ports
2	USB 3.0 device port to connect external storage devices
3	EtherCAT output ports for extension devices, such as binary I/O extension box, capable of powering devices with PoE+ (~25 W each port)
4	Binary outputs
5	Power-status LED
6	Ethernet network control port
7	USB 2.0 host control port
8	General device status LEDs
9	Reset button
10	EtherCAT communication status LEDs
11	Analog/binary inputs
12	Power switch
13	Handle

The two general device status LEDs (S1, S2) are indicating the following different device states:

Orange LED (S1)	**Green LED (S2)**	**Device state**
Off	Off	Rebooted
On	Off	Booting (RLK or OLK)
Off	Blinking	Recovery mode
Off	On	Normal mode (idle or running, ECAT LEDs indicate RUN state)
Blinking	On	Armed
On	On	Recording
Blinking	Blinking	Error (runtime error until stop)

The two EtherCAT communication status LEDs (Run, Error) are defined by the EtherCAT standard. The Run LED indicates the current state of the EtherCAT state machine (“Off” is idle state; “Blinking” is pre-operation state, “On” is operation state). The Error LED indicates different error codes defined by the standard (“Off” is no error).

7.2 Rear panel

On the rear panel you find the power socket and the power fuse.

7.3 Flexible housing

The housing of *DANEO 400* is very flexible. It can be configured for different working positions by rotating and moving the device handle.

For placing *DANEO 400* on the floor, the handle can be used as floor stand as shown in the figure below. If the handle is not required (for example to stack multiple devices) you can easily stash it to the rear side of *DANEO 400*.

Figure 28: *DANEO 400* flexible housing

8 Technical data

8.1 Guaranteed values

- The values are valid for the period of one year after factory calibration, within 23 °C ±5 °C at nominal value and after a warm-up time greater than 25 min.
- The given input/output accuracy values relate to the range limit value (% of range limit value).

8.2 Power supply

Main power supply	
Connection	Connector according to IEC 60320
Voltage, single phase nominal voltage operational range	 100 ... 240 V AC 85 ... 264 V AC
Power fuse	T 12.5 AH 250 V (5 x 20 mm) "Schurter", order number 0001.2515
Nominal current	10 A
Frequency nominal frequency operational range	 50/60 Hz 45 ... 65 Hz
Overvoltage category	II

8.3 Analog measurement inputs

Analog inputs: ANALOG INPUT 1...10	
Number of analog measurement inputs	10
Measurement ranges (RMS value of the sinusoidal shaped input signal)	10 mV, 100 mV, 1 V, 10 V, 100 V, 600 V
Crest factor	1.75
Sampling frequency	10 kHz 40 kHz
Input impedance	(1 MΩ ±2%) || (170 pF ±50 pF)
Measurement category	CAT II / 600 V CAT III / 300 V CAT IV / 150 V
Temperature drift	<25 ppm/K

8.3.1 Magnitude accuracy

The maximum measurement error is specified in the unit percent (%).

The error composed by two parts, the first one referring to the actual reading and the second one referring to the measurement range.

Maximum error				
Sampling frequency	10 kHz / 40 kHz	10 kHz / 40 kHz	10 kHz	40 kHz
Frequency range	DC	10 Hz ... 1 kHz	1 kHz ... 4 kHz	1 kHz ... 10 kHz
10 mV	0.08 + 0.5	0.20 + 0.3	0.20 + 0.3	0.20 + 0.3
100 mV	0.08 + 0.07	0.08 + 0.05	0.16 + 0.04	0.16 + 0.04
1 V	0.08 + 0.02	0.08 + 0.02	0.16 + 0.04	0.16 + 0.04
10 V	0.08 + 0.02	0.08 + 0.02	0.16 + 0.04	0.16 + 0.04
100 V	0.08 + 0.02	0.08 + 0.02	0.16 + 0.04	0.16 + 0.04
600 V	0.08 + 0.02	0.08 + 0.02	0.16 + 0.04	0.16 + 0.04

8.3.2 Phase and frequency accuracy

The phase and frequency accuracy are specified for signal levels above 10% of the range and sinusoidal signals.

Accuracy of frequency and phase measurements			
Sample frequency	Frequency range	Maximum error	
		Frequency measurement	Phase measurement
10 kHz	15 Hz … 70 Hz	0.01%	0.1º
40 kHz	15 Hz … 70 Hz		

The phase and frequency accuracy are not guaranteed for the 10mV range.

8.4 Binary inputs

Binary inputs: BINARY INPUT 1...10	
Number of binary inputs	10
Trigger criteria	Potential-free or DC-voltage compared to threshold voltage
Sampling frequency	10 kHz
Time resolution	100 µs
Max. measuring time	unlimited
Debounce time	0 … 500 ms (refer to “Debouncing input signals” below)
Deglitch time	0 … 500 ms (refer to “Deglitching input signals” below)
Configuration	Binary inputs can be configured. Refer to *DANEO Control* Help.
Connection	4 mm/0.16 " banana sockets on the front panel
Insulation	10 galvanic insulated binary inputs. Functional isolation between with 4 mm creepage between channels. Reinforced insulation from all SELV interfaces and from power supply.

Data for potential-free operation	
Trigger criteria	Logical 0: R > 80 kΩ Logical 1: R < 20 kΩ
Input impedance	(125 kΩ ± 20%) || (170 pF ±50 pF)

Deglitching input signals

In order to suppress short spurious pulses a deglitching algorithm could be configured. The deglitch process results in an additional dead time and introduces a signal delay. In order to be detected as a valid signal level, the level of an input signal must have a constant value at least during the deglitch time. The figure below illustrates the deglitch function.

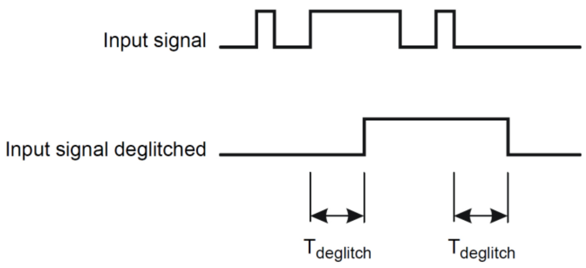


Figure 29: Signal curve, deglitching input signals

Debouncing input signals

For input signals with a bouncing characteristic, a debounce function can be configured. This means that the first change of the input signal causes the debounced input signal to be changed and then be kept on this signal value for the duration of the debounce time.

The debounce function is placed after the deglitch function described above and both are realized by the firmware of *DANEO 400* and are calculated in real time.

The figure below illustrates the debounce function. On the right-hand side of the figure, the debounce time is too short. As a result, the debounced signal rises to “high” once again, even while the input signal is still bouncing and does not drop to low level until the expiry of another period $T_{debounce}$.

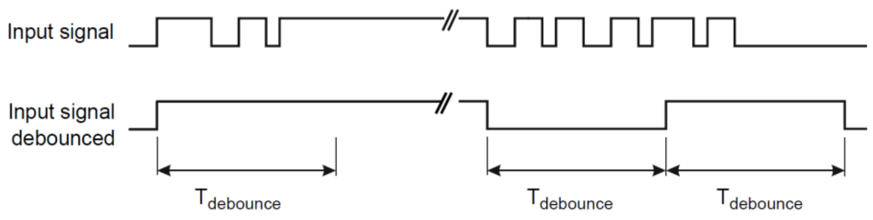


Figure 30: Signal curve, debounce input signals

8.5 Binary outputs

Binary output relays: BINARY OUTPUT 1...4	
Number of binary outputs	4
AC loading	V_{max}=300 V AC; I_{max}=8 A; S_{max}=2000 VA
DC loading	V_{max}=300 V DC; I_{max}=8 A; P_{max}=50 W (refer to load limit curve)
Switch-on current	15 A (max. 4 s at 10 % duty-cycle)
Electrical lifetime	100000 switching cycles at 230 V AC / 8 A and ohmic load
Pickup time	Approx. 6 ms
Fall back time	Approx. 3 ms
Bounce time	Approx. 0.5 ms
Connectors	4 mm/0.16 " banana sockets
Insulation	Reinforced insulation from all SELV interfaces and from power supply

The diagram below shows the load limit curve for DC voltages. For AC voltages, a maximum power of 2000 VA is achieved.

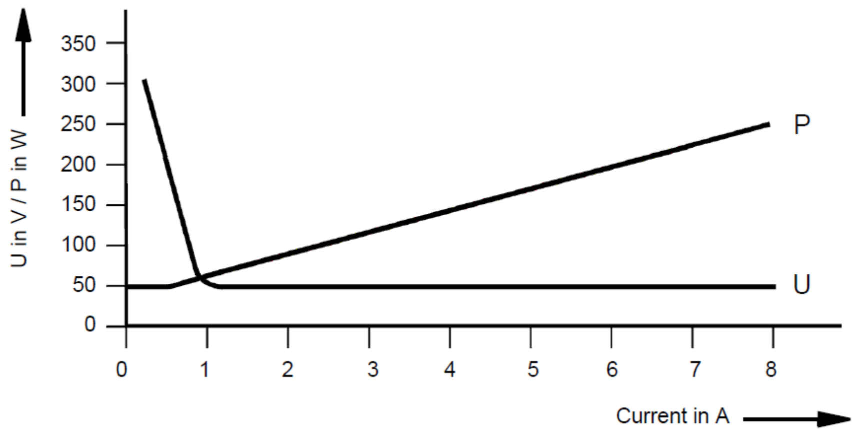


Figure 31: Load limit curve for relays on the binary outputs with DC voltages

8.6 Ethernet ports

All Ethernet ports support Power over Ethernet (PoE) according to IEEE 802.3af and IEEE 802.3at. The accumulated output power of all PoE ports is limited to 75 W.

8.6.1 Control and network ports

Ethernet ports ETH1 and ETH2	
Type	10/100/1000Base-TX
Connector	RJ45
Cable type	LAN cable of category 5 (CAT5) or better
Status indication	Green LED: physical link present Yellow LED: traffic on interface
Power over Ethernet (PoE)	IEEE 802.3af (PoE) and IEEE 802.3at (PoE+) compliant

8.6.2 Extension ports

Extension ports OUT1 and OUT2	
Type	10/100Base-TX
Connector	RJ45
Cable type	LAN cable of category 5 (CAT5) or better
Status indication	Green LED: physical link present Yellow LED: traffic on interface
Power over Ethernet (PoE)	IEEE 802.3af (PoE) and IEEE 802.3at (PoE+) compliant

8.7 USB

8.7.1 Control port

USB control port	
USB type	USB 2.0 high speed (480 Mbit/s) USB 1.1 compatible (12 Mbit/s)
USB connector	USB type B
USB cable	2 m USB 2.0 high speed type A-B

8.7.2 Storage port

USB storage port	
USB type	USB 3.0 ultra speed (5 Gbit/s)
USB connector	USB type A
Output current	Up to 900 mA

8.8 Environmental conditions

Climate	
Operating temperature	0 °C ... +50 °C
Storage and transportation	-25 °C ... +70 °C
Maximum altitude Operating Non-operating	 4000 m 15000 m
Humidity	5 % … 95 % relative humidity; no condensation

8.9 Mechanical data

Size, weight, and protection	
Mass	Approx. 7.0 kg
Dimensions W x H x D without handle	450 x 145 x 390 mm
Ingress protection	IP20 according to EN 60529

8.10 Cleaning

To clean *DANEO 400*, use a cloth dampened with isopropanol alcohol or water. Prior to cleaning, always unplug all connectors so that all hazardous life parts are disconnected and the device is turned off.

8.11 Safety standards, electromagnetic compatibility, certificates

CE conformity and requirements	
CE	The product adheres to the specifications of the guidelines of the council of the European Community for meeting the requirements of the member states regarding the electromagnetic compatibility (EMC) Directive 2004/108/EC and the low voltage Directive 2006/95/EC.
EMC	
Emission	
Europe	EN 61326-1; EN 61000-6-4; EN 61000-3-2/3
International	IEC 61326-1; IEC 61000-6-4; IEC 61000-3-2/3
USA	FCC Subpart B of Part 15 Class A
Immunity	
Europe	EN 61326-1; EN 61000-6-2; EN 61000-4-2/3/4/5/6/11
International	IEC 61326-1; IEC 61000-6-2; IEC 61000-4-2/3/4/5/6/11

Certified safety standards	
Europe	EN 61010-1
International	IEC 61010-1
USA	UL 61010-1
Canada	CAN/CSA-C22.2 No 61010-1-04

9 Open source software license information

Parts of *DANEO Control* software are under OMICRON license, other parts are under open source software licenses.

DANEO 400 contains the following open source components:

Open source component	License type
boost	MIT
boot-format	GPLv2
buildbot-slave	GPL2
busybox	GPL2
calibrator	BSD
calimero_avahi	LGPL2
calimero_omflite	Proprietary
cppcms	Commercial
dhcp	BSD
e2fsprogs	GPL2
ecatmaster	Proprietary
ethtool	GPL2
expat	MIT
fcgi	MIT
glibc	LGPL
hdparm	BSD
hydra	Proprietary
ics9fg104_ctrl	Proprietary
iproute2	GPL
libarchive	BSD
libconfigpp	LGPL2
libdaemon	LGPL2
libgtest	NEWBSD
liblog4cpp	LGPL
libpcap	BSD
libpcre	BSD
libusbstring	LGPL2
lighttpd	BSD
lm_sensors	GPL2

logagent	Proprietary
maio	GPL2
mtd-utils	GPL2
ncurses	MIT
net-snmp	BSD
nose	LGPL
omippc_kernel	GPL2
omippc_pwr_fail	GPL2
openresolv	BSD
openssh	BSD
openssl	BSD
otpid	Proprietary
pita	Proprietary
procps	GPL2
protobuf	BSD
ptpdoo	Proprietary
pv	Artistic2
pyro	MIT
python	PSF
rt-tests	GPL2
subscomm	Proprietary
sval_sim	Proprietary
tcpdump	BSD
tron_firmware_binaries	Proprietary
tron_uboot	GPL2
tsil	Proprietary
twisted	MIT
usbcontrol	Proprietary
util-linux	libblkid/COPYING
vim	Charityware
watchdog_kicker	Proprietary
zlib	BSD
zope.interface	ZPL2.1

You can find the corresponding license information file “DANEO400LicenseInformation.txt” in the Application Folder of the installed software, for example:

C:\Program Files\OMICRON\DANEO Control\OpenSource. Additionally, the license information can be displayed by launching *DANEO 400* web interface and clicking the License Information hyperlink on the system page.

DANEO Control software contains the following open source components:

Open source component	**License type**
Enterprise Library	MS-PL
Boost C++ Libraries	Boost
Resource Description Framework (RDF)	Apache 2.0
Google Protocol Buffers (protobuf)	BSD3
pugixml XML parser for C++	MIT
Log4cpp C++ classes for flexible logging	LGPL 2.1
WinPCAP	BSD
protobuf-net	Apache 2.0

You can find the corresponding license information file "DANEOControlSoftwareLicenseInformation.txt" in the Application Folder of the installed software, for example: C:\Program Files\OMICRON\DANEO Control\OpenSource. Additionally, the license information can be displayed in the *DANEO Control* Copyright dialog (Click ? > About > Third Party Licenses).

The open source code is available on the Internet via www.omicron.at/opensource.

Glossary

CID	Configured IED Description
DHCP	Dynamic Host Configuration Protocol
GOOSE	Generic Object Oriented Substation Event
ICD	IED Capability Description
IED	Intelligent Electronic Device
IID	Instantiated IED Description
IP	Internet Protocol
LD	Logical Device
MAC address	Media Access Control address
OMFIND	Protocol for finding devices on an Ethernet network
PoE	Power over Ethernet (IEEE 802.3at)
PTP	Precision Time Protocol (IEEE 1588, IEEE C27.238)
SCL	Substation Configuration Language
SELV	Safety Extra Low Voltage
STP	Spanning Tree Protocol
SV	Sampled Values
URL	Uniform Resource Locator
VLAN	Virtual Local Area Network
XML	Extensible Markup Language

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