ARCTEQ®
PART OF ENSTO GROUP

AQ-S391

Bay control device

Instruction manual

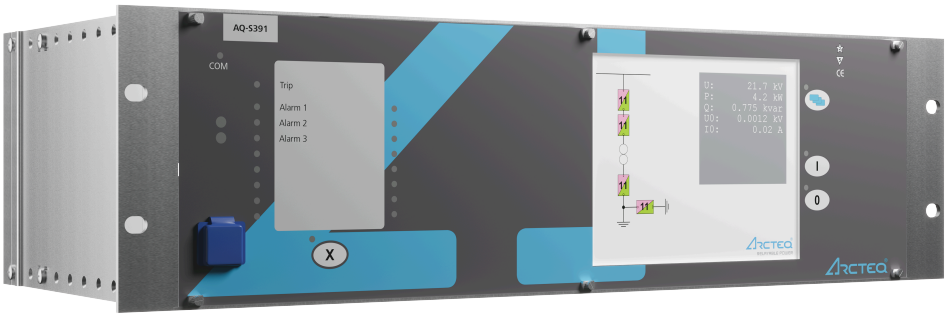

Table of contents

Disclaimer

Please read these instructions carefully before using the equipment or taking any other actions with respect to the equipment. Only trained and qualified persons are allowed to perform installation, operation, service or maintenance of the equipment. Such qualified persons have the responsibility to take all appropriate measures, including e.g. use of authentication, encryption, anti-virus programs, safe switching programs etc. necessary to ensure a safe and secure environment and usability of the equipment. The warranty granted to the equipment remains in force only provided that the instructions contained in this document have been strictly complied with.

Nothing contained in this document shall increase the liability or extend the warranty obligations of the manufacturer Arcteq Relays Ltd. The manufacturer expressly disclaims any and all liability for any damages and/or losses caused due to a failure to comply with the instructions contained herein or caused by persons who do not fulfil the aforementioned requirements. Furthermore, the manufacturer shall not be liable for possible errors in this document.

Please note that you must always comply with applicable local legislation and regulations. The manufacturer gives no warranties that the content of this document is in all respects in line with local laws and regulations and assumes no liability for such possible deviations.

You are advised to notify the manufacturer in case you become aware of any errors in this document or of defects in the equipment.

The manufacturer reserves the right to update or amend this document at any time.

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1 Document information

Table. 1 - 1. History of Revision 1.

Revision	1.00
Date	August 2011
Changes	• The first revision of the manual.
Revision	**1.01**
Date	January 2012
Changes	• HW construction and application drawing revised.
Revision	**1.02**
Date	May 2012
Changes	• Synchrocheck chapter revised. • Voltage measurement module revised. • Description for the CPU module added. • Description for the binary input module revised. • IRIG-B information added. • Ordering information and type designation updated. • Technical data revised.
Revision	**1.03**
Date	July 2012
Changes	• Synchrocheck parameters updated.
Revision	**1.04**
Date	October 2015
Changes	• Updated parameters.
Revision	**1.05**
Date	October 2019
Changes	• The "Construction and installation" chapter updated.
Revision	**1.06**
Date	June 2020
Changes	• Added redundant power supply, possibility to remove display.
Revision	**1.07**
Date	January 2021
Changes	• Removed statement that binary input modules are capable of IRIG-B.

Table. 1 - 2. History of Revision 2.

Revision	2.00
Date	February 2023
Changes	• Updated the Arcteq logo on the cover. • An overall visual update for the manual's layout and design. • Added the "Safety information" chapter. • Added the "Abbreviations" chapter. • Added the previously separate documents "AQ 300 Operator's manual" and "AQ 300 Web server description" into the "IED user interface" chapter. • Added the respective funtion block's setting parameters to the "Circuit breaker control function" and the "Disconnector control function" chapters. • Various images updated. • Updated contact and reference information.

2 Safety information

This document contains important instructions that should be saved for future use. Read the document carefully before installing, operating, servicing, or maintaining this equipment. Please read and follow all the instructions carefully to prevent accidents, injury and damage to property.

Additionally, this document contains four (4) types of special messages to call the reader's attention to useful information as follows:

NOTICE!
"Notice" messages indicate relevant factors and conditions to the the concept discussed in the text, as well as to other relevant advice.

CAUTION!
"Caution" messages indicate a potentially hazardous situation which, if not avoided, **could** result in minor or moderate personal injury, in equipment/property damage, or software corruption.

WARNING!
"Warning" messages indicate a potentially hazardous situation which, if not avoided, **could** result in death or serious personal injury as well as serious damage to equipment/property.

DANGER!
"Danger" messages indicate an imminently hazardous situation which, if not avoided, **will** result in death or serious personal injury.

These symbols are added throughout the document to ensure all users' personal safety and to avoid unintentional damage to the equipment or connected devices.

Please note that although these warnings relate to direct damage to personnel and/or equipment, it should be understood that operating damaged equipment may also lead to further, indirect damage to personnel and/or equipment. Therefore, we expect any user to fully comply with these special messages.

3 Abbreviations

AC
: alternating current

AVR
: automatic voltage regulator

CB
: circuit breaker

CBFP
: circuit breaker failure protection

CPU
: central processing unit

CT
: current transformer

CTS
: current transformer supervision

CVT
: capacitive voltage transformer

DC
: direct current

DI
: digital input(s)

DLD
: dead line detection

DO
: digital output(s)

EFT
: electronic fast transients

EMC
: electromagnetic compatibility

EOB
: Ethernet Overboard

ESD
: electrostatic discharge

HMI
: human—machine interface

IDMT
: inverse definite minimum time

IED
: intelligent electronic device

IO
: inputs and outputs

LCD
: liquid-crystal display

LED
: light-emitting diode

NC
: normally closed

NO
: normally open

NTP
: Network Time Protocol

RF
: radio frequency

RCA
: relay characteristic angle

RMS
: root mean square

SCADA
: supervisory control and data acquisition

SDRAM
: synchronous dynamic random access memory

SLD
: single-line diagram

SOTF
: switch-on-to-fault

TMS
: time multiplier setting

VT
: voltage transformer

VTS
: voltage transformer supervision

4 General

The AQ S391 bay control IED is a member of the AQ-300 product line. The AQ-300 protection product line in respect of hardware and software is a modular device. The hardware modules are assembled and configured according to the application IO requirements and the software determines the available functions. This manual describes the specific application of the AQ S391 bay control IED. . All generic AQ 300 series features such as color touch screen HMI but can be manufactured also without any displays. Wide range of communication protocols including IEC 61850, DNP3, IEC101, IEC103 and IEC104 are available in this device as well.

5 IED user interface

5.1 Front panel

The figure below presents the front panel structure for AQ-300 series units, while the table below the image describes the functions of the front panel's various elements.

Figure. 5.1 - 1. AQ-300 front panel structure.

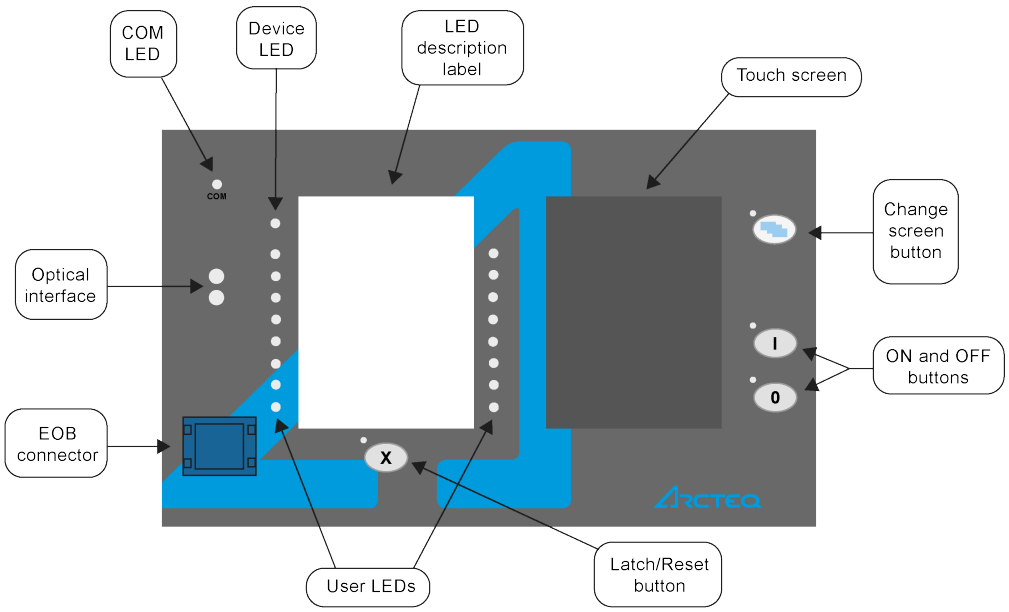


Table. 5.1 - 3. Elements of the front panel.

Function	Description
Device LED	One (1) three-colored circular LED. • Green = normal operation • Yellow = warning state • Red = alarm state
COM LED	One (1) yellow circular LED, which indicates the EOB communication link and activity.
User LEDs	Three-colored circular LEDs. Their number depends on the relay model.
LED description label	A changable label with LED functionality descriptions.
Optical interface	(for factory usage)
EOB connector	Ethernet Overboard communication interface. It attains an isolated and non-galvanic Ethernet connection with the help of a magnetic EOB device. The EOB device has an RJ-45 type connector which supports 10Base-T Ethernet connection to the user's computer.
Touch screen	The main screen, a 3.5" (320 x 240 pixels) portrait-oriented TFT display with a resistive touch screen interface. Optionally, the touch screen can be 5.7" and landscape-oriented.

Function	Description
Operation buttons	The device has four (4) capacitive operational buttons: • "X" (below the LED label) latches and resets the LEDs. • The button with a blue icon (top right) changes the touch screen menus. • "ON" and "OFF" (bottom right). Pushing a button causes an audible buzzer pressure feedback. All four buttons also have an LED off their top-left corner to indicate their status.

5.2 LED assignment

5.3 Touch screen

The touch screen comes with a variety of powerful features, including the ability to make customized menus. It also supports single-line diagrams (SLD). The touch screen can be accessed and controlled remotely via the device's web interface. For more information on the remote user interface, please refer to "The embedded web server" chapter below.

The image below depicts the main screen of the front panel as well as the "ON", "OFF" and "Change screen" buttons.

Figure. 5.3 - 2. The main menu and three operation buttons.

The touch screen is the main control where you can enable functions and input values.

The "Change screen" button changes the menu shown on the main display. The menus are in the following order by default: the main menu, the parameter menu, the online measurement menu, the events menu, and the system settings menu. You can also add a number of customized menus which can be created with EuroCAP software. Pushing the button moves the displayed menu by one, in a cycle.

The operation buttons can be used to define certain functions on customer-defined menus. For example, you can set up these buttons to turn a circuit breaker on or off, or to increment and decrement the position of a transformer's tap changer. For more information, please refer to the "Custom user-defined menus" chapter.

Main menu

The main menu is the first one shown when the device is turned on. It displays general information such as the device and station names, the current time, and language options (when available).

Figure. 5.3 - 3. Lock status indicator, as displayed in the main menu.

The **lock status indicator** shows whether a password is required to unlock the device before parameters or settings can be changed. By default, the device is not password-protected. However, is such a functionality is needed, you can set the password application via the web interface.

NOTICE!
The password cannot be set with the touch screen.

When a device is protected by a password, push the lock icon. This brings up a password input screen (see the image below) where you can enter the password. When the password is entered correctly, the lock status indicator on the main menu becomes unlocked, as does the menu in question. The device can be unlocked from any of the menus.

Figure. 5.3 - 4. The password input screen.

NOTICE!
The lock icon is displayed even when the device has no password!

Parameter menu

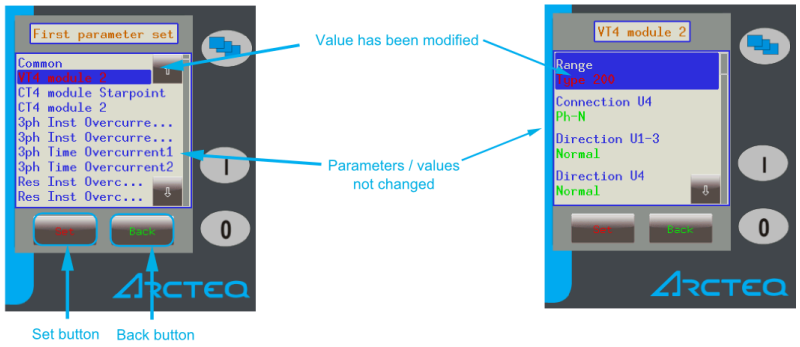
In the parameters menu (below) you can view, set and edit certain parameters within the device. You can also choose which of the parameter sets the device uses.

The parameter set that is currently active has a red box around it (see the figure below). When you want to edit or activate a parameter set, touching its name to select and highlight it and then press the "Edit" or "Activate" button.

Figure. 5.3 - 5. The parameter set menu.

The Activate button activated the selected parameter set, which the device will now use. Depending on the device's configuration, the "Activate" button may not be available. The Edit button takes you to another screen where you can choose which function blocks the parameter set uses. Please note that when there is only one parameter set, the device takes you immediately to the parameter set edit screen (below).

Figure. 5.3 - 6. The parameter set edit screen (left) and the function block screen (right).



Normally, the various function blocks appear blue. However, if any value has been changed within a function block, its listing appears red to notify the user. This also happens in the function block screen, where unmodified parameter values appear green but modified values appear red.

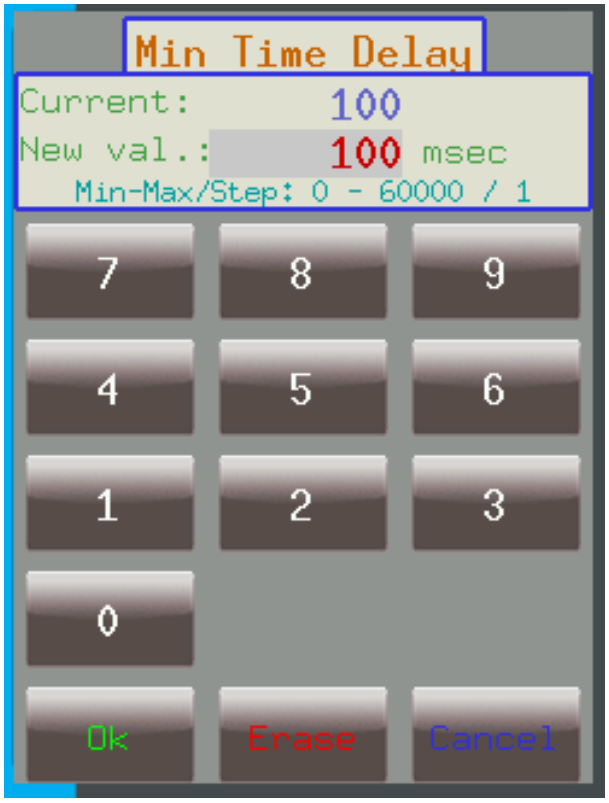
The Set button brings up a screen where you can modify a value. If there is a lock icon instead of the "Set" button, the device must first be unlocked. The Back button returns you to the previous screen.

Within all function blocks, the parameter values can have one of the following four types of input:

- Integer
  A whole number, entered with the number pad.

- Floating-point number
  A number with a decimal point, entered with the number pad. Please note that the pad has the decimal point available only when the value can be entered as a floating-point number!
- List item
  The parameter lists thr available options as a list, and the user selects the desired option from them.
- Checkbox
  The user can enable and disable the parameter as a whole.

Figure. 5.3 - 7. Editing the parameter values.



The new parameter value is put in the "New value" field. The "Current value" field shows the parameter value that is currently in use. The "Min–Max/Step" field shows the range within which the parameter's value can be modified, as well as the step with which the value can be incremented or decremented. For example, in the image above, the range is between 1 000 and 10 000 with a step value of 1. This means that the value can be 1 001, 1 002, 1 003,...,9 999, 10 0000. If the step value were 5, the field would only accept values such as 1 005, 1 010, 1 015, and so on.

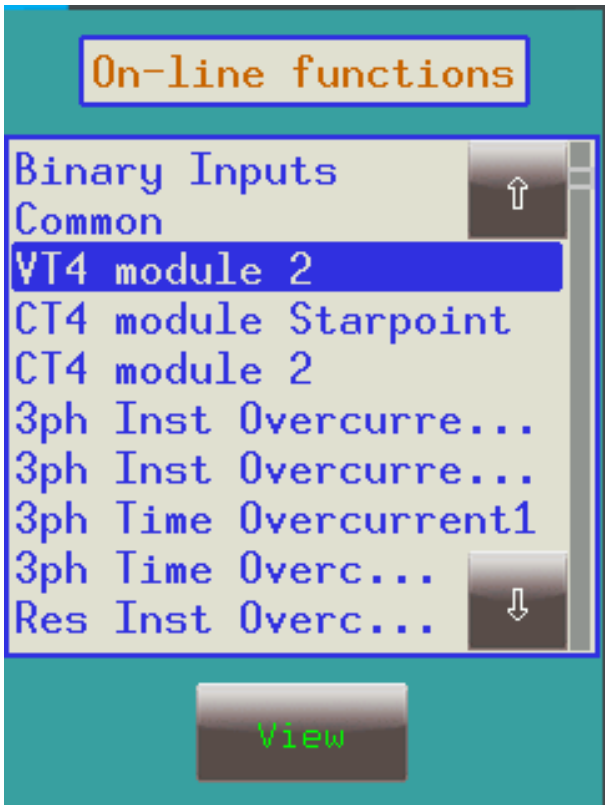
The OK button confirms the value in the "New value" field and returns the user to the previous screen. The Cancel button deletes a single digit from the "New value" field. The Erase button discards any changes to the current parameter and returns the user to the previous menu item.

CAUTION!
Make sure that only one person edits the parameters at any one time, either in the touch screen or in the web interface! Simultaneous editing leads to confusion as to what the values of a parameter set actually are.

Online measurement menu

The online measurement menu displays real-time data depending on what is connected to the device. When you have selected a specific function block from the online functions list, clicking the **View button** takes you to a new window that displays the parameters and their current values. The image below shows the values of VT4 module 2: the voltages and angles for channels U1 and U2.

Figure. 5.3 - 8. Online measurement menu.

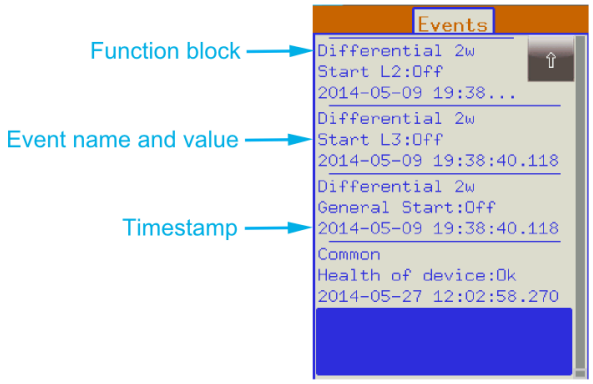


Events menu

The events menu displays a list of events that have occurred within and in relation to the device. This menu screen is continuously updated. If the scrollbar on the right is at the bottom, the screen shifts as a new event occurs. However, if the scrollbar is not on the bottom, the screen stays in place even when a new event occurs. This allows you to take a closer look at the events.

The first row of an event displays the function block's name, the second row displays the event's name and value, and the third row displays the event's time stamp (see the image below).

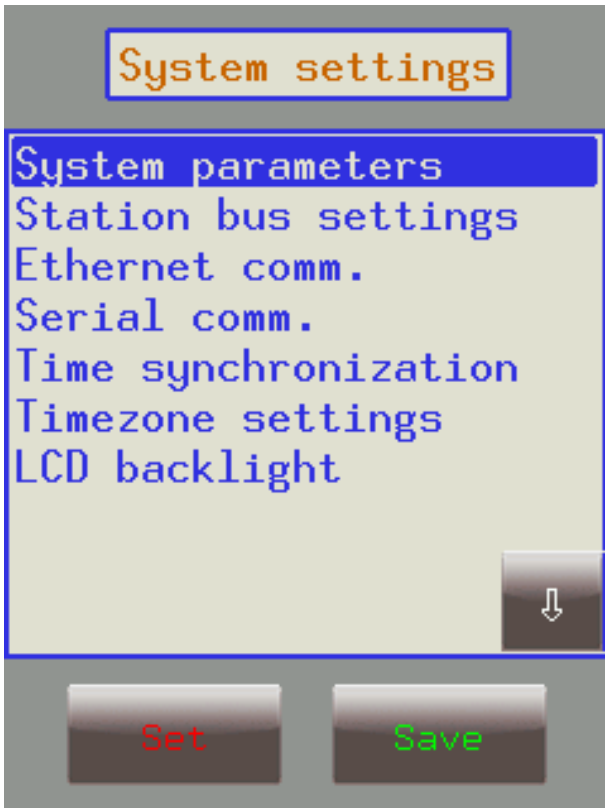
Figure. 5.3 - 9. Event structure.



NOTICE!
The events menu does not display the whole event log, only the first few hundred items in the log!

System settings menu

Figure. 5.3 - 10. System settings menu.



In the system settings menu you can set certain parameter values that are related to the device itself (as opposed to its protection functions and operations). The menu works similarly to the parameters menu and the same properties apply.

Table. 5.3 - 4. The system settings.

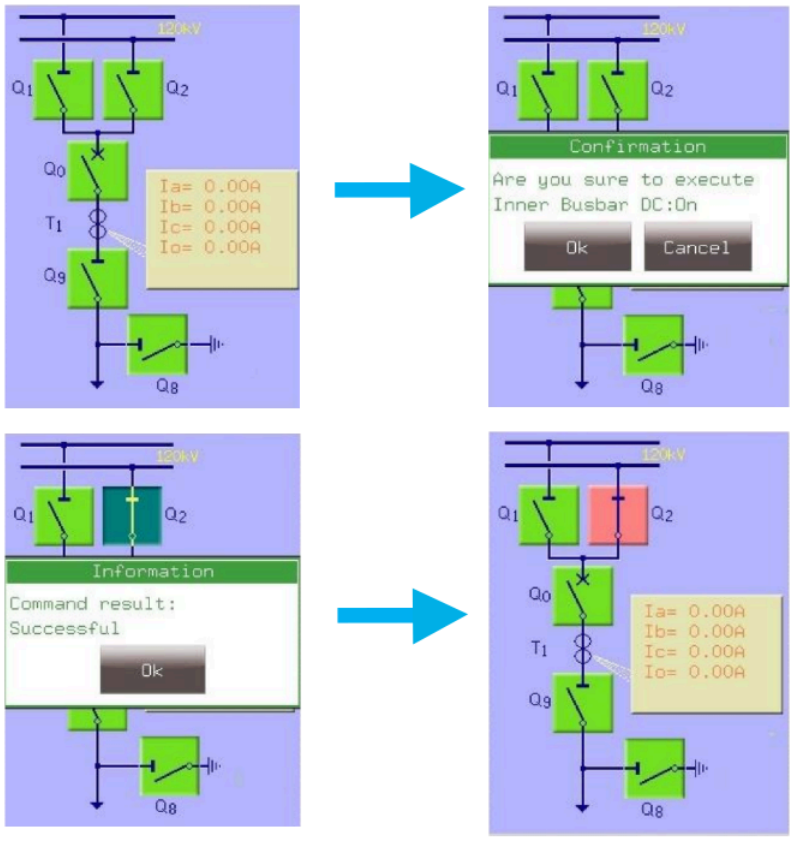
Setting	Description
System parameters and station bus settings (IP address, netmask, default gateway, DNS servers)	Please contact your local network administrator for further information about these settings.
Ethernet communication (IEC 61850 enabled, IEC 104 enabled)	Enables or disables the IEC 61850 and IEC 104 communication protocols.
Serial communication	Selects which serial protocol the device uses. The "Serial baudrate" field sets the baudrate to a specific amount. Please note that this and link address only apply to legacy protocols!
Time synchronization	When time synchronization via NTP server addresses is enabled, the device uses Network Time Protocol to synchronize time with one of the servers. The device also supports other, non-NTP time synchronization methods, such as pin and serial.
Time zone settings	"GMT offset" defines the positive or negative offset for Greenwich Mean Time. "Use DST" and "DST start/stop" define the daylight savings time setting. As DST is different in each country, set these as appropriate.
LCD backlight	Changes the brightness of the touch screen's back illumination.

Custom user-defined menus

You can add menus based on your application needs with the help of the AQtivate 300 software. You can also set up the operation buttons "I" and "0" to perform specific functions.

For example, let us say we have the following network depicted in the top-left image in the figure below as a single-line drawing. We have set the operation buttons to function as "ON" and "OFF", and now we would like to switch the line disconnecter Q2 on.

Figure. 5.3 - 11. Turning on Q2.



(1) First, we press Q2 on the touch screen to highlight the object. This causes Q2 to start blinking for a short while; if an action is not performed within this time, the object deselects on its own. So, while Q2 is highlighted and blinking, we press the "I" button (configured to function as an "ON" button) to turn it on. (2) A window pops up to confirm we want to do this action; again, we have a shirt time to give an answer (in this case, to press "Yes") before the requested operation is automatically cancelled. (3) Another window pops up to state that the operation was successful. (4) After acknowledging this window, the display is updated as appropriate, with the Q2 line disconnector in the "ON" position.

Just as the online measurement and events menus, this menu is also updated continuously. Therefore, any kind of change in the states or in the measured parameters are shown and updated accordingly. If there is an error with an operation, the device signals the user of this with an error pop-up window that includes the error code and the reason for the error.

5.4 The embedded web server

Introduction

This product offers the ability to remotely monitor and modify various parameters and settings within the device. You can access the front panel and choose other options with the help of a web browser. With the user-friendly interface, you can easily manage the device. Password protection is available to grant certain priviledges and access to special functions.

You can perform the following actions with the embedded web server:

- modify user parameters
- check the event list and disturbance records
- manage the password
- display the measured data and the generated binary information
- perform commands

- provide remote or local firmware updgrades
- perform administrative tasks.

System requirements

In order to access the device interface you need a compatible web browser as well as an Ethernet connection. It is recommended that the screen resolution is at least 1024 x 768 so that the screen can display data properly.

You can use any of the following web browsers:

- Microsoft Internet Explorer, version 7.0 or higher
- Mozilla Firefox, version 1.5 or higher **(version 3.0 or higher recommended!)**
- Apple Safari, version 2.0.4 or higher
- Google Chrome, version 1.0 or higher
- Opera, version 9.25 or higher

You must also enable JavaScript within your browser. For security reasons the device is only allowed a limited number of connections over the network.

To access the device via a web browser write the correct IP address on the browser's address bar. You can find the device's IP address on the main menu of the device's touch screen.

5.4.1 Ethernet connections

Properties of the Ethernet connection

An AQ-300 unit has five (5) Ethernet ports built into the device, allowing it to be connected to IP/ Ethernet-based networks. The unit has the following Ethernet ports available (the first is located in the front panel, the others on the rear side of the CPU unit):

- Ethernet over board (EOB) 10Base-T user interface
- Station Bus (100Base-FX Ethernet)
- Redundant Station Bus (100Base-FX Ethernet)
- Process Bus (100Base-FX Ethernet, in preparation)
- 10/100Base-Tx port via the RJ45 connector

There are three different types of interfaces for the communication ports:

- The EOB interface is attachable to the device's front panel by a proprietary magnetic connector. The connector box ends in a RJ45 8/8 plug, and the interface is a 10Base-T full duplex interface.
- The 100Base-FX Ethernet interface is of type ST, which offers 1 300 nm/MM for a 50 µm/125 µm (or, 62.5 µm/125 µm) fiber.
- The 10/100Base-Tx Ethernet interface is an RJ45 8/8 plug.

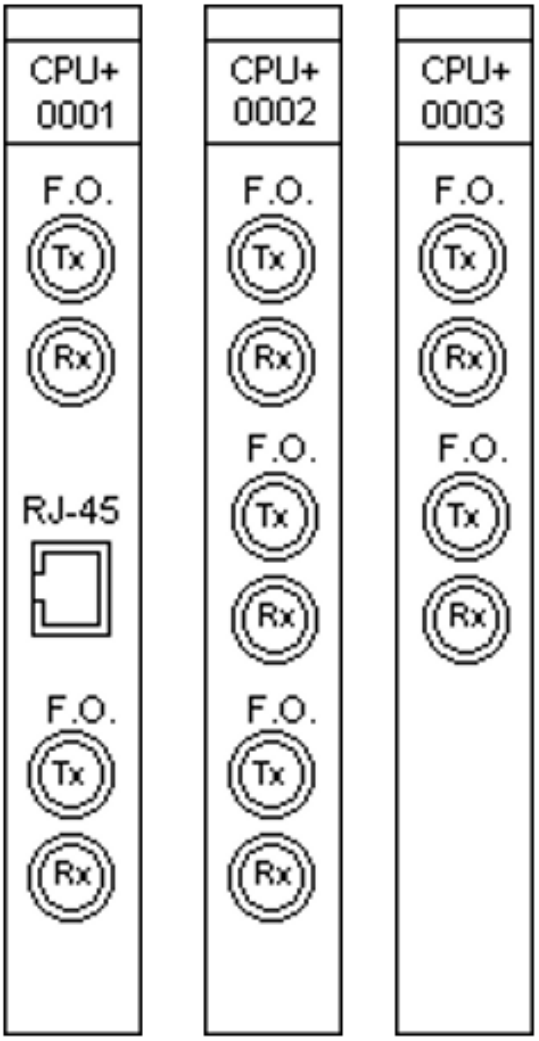
The following table catalogues the different Ethernet communication versions available for the different AQ-300 CPU versions.

Table. 5.4.1 - 5. The available Ethernet communication in different CPU versions.

CPU version	EOB	Station Bus	Redundant Station Bus	Process Bus	RJ45	Legacy port/protocol
CPU+0001	Yes	Yes	No	Prep	Yes	No
CPU+0002	Yes	Yes	Yes	Prep	No	No
CPU+0003	Yes	Yes	Yes	No	No	No

The diagram below depicts the three (3) different CPU versions and their structures:

Figure. 5.4.1 - 12. The three CPU versions.



Settings needed for Ethernet connection

The AQ-300 devices can only be accessed over Ethernet-based communication protocols. This is why it is very important for the network to be set up correctly before accessing the device.

IP settings

The device operates with fixed IPv4 addressing. At the moment dynamically assigned IP addresses are not supported. We recommend using the private address range as defined in RFC 1918. All addresses must be in the same network range. Additionally, the computer should be set to use fixed IP settings.

You can connect to a stand-alone device by plugging the EOB cable into your computer or by using the RJ45 connector at the back of the device (this requires a crossover UTP cable). When you want to connect the device to a station or corporate network, contact the system administrator for all the required information: an available IP address, the gateway address, the netmask, the DNS and NTP server addresses.

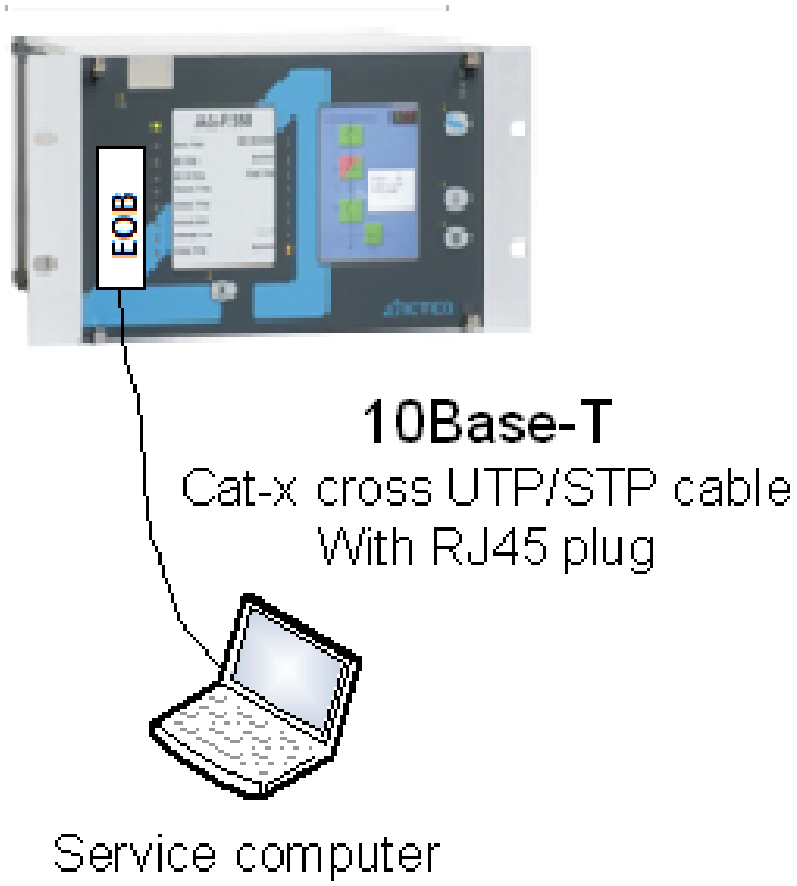
Web browser settings

Make sure that your browser does NOT use a proxy server while accessing an AQ-300 device. However, if there is a proxy server in your network, contact the system administrator and have them add an exception.

EOB connection

Attach the magnetic EOB connector to the front panel of the device; the magnets assure that the adapter is in the correct position. Next, connect the other end of the cable to a computer's RJ45 port (see the figure below).

Figure. 5.4.1 - 13. Using the EOB connection.

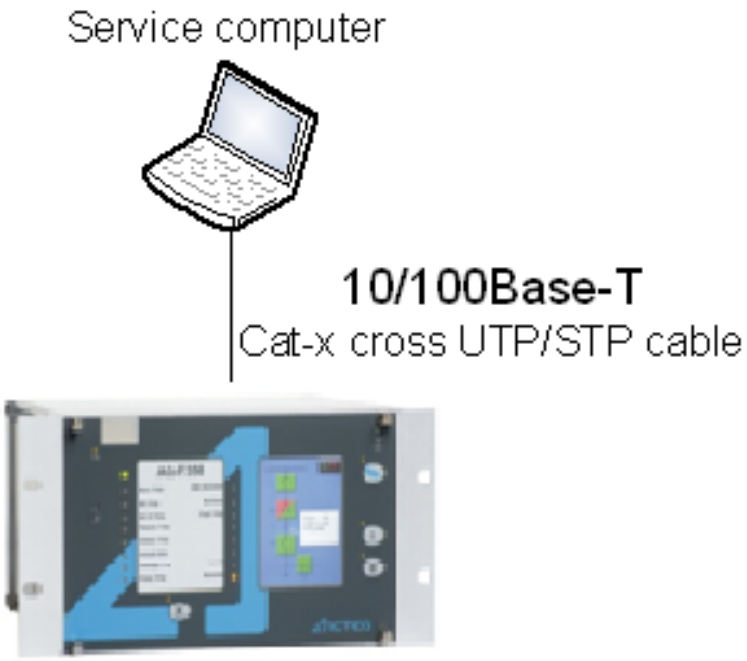


Please note that the RJ45 connector can also be connected to an Ethernet switch. When this is the case, all the network's IEDs with client functionalities (e.g. a computer) have access to the device.

RJ45 connection

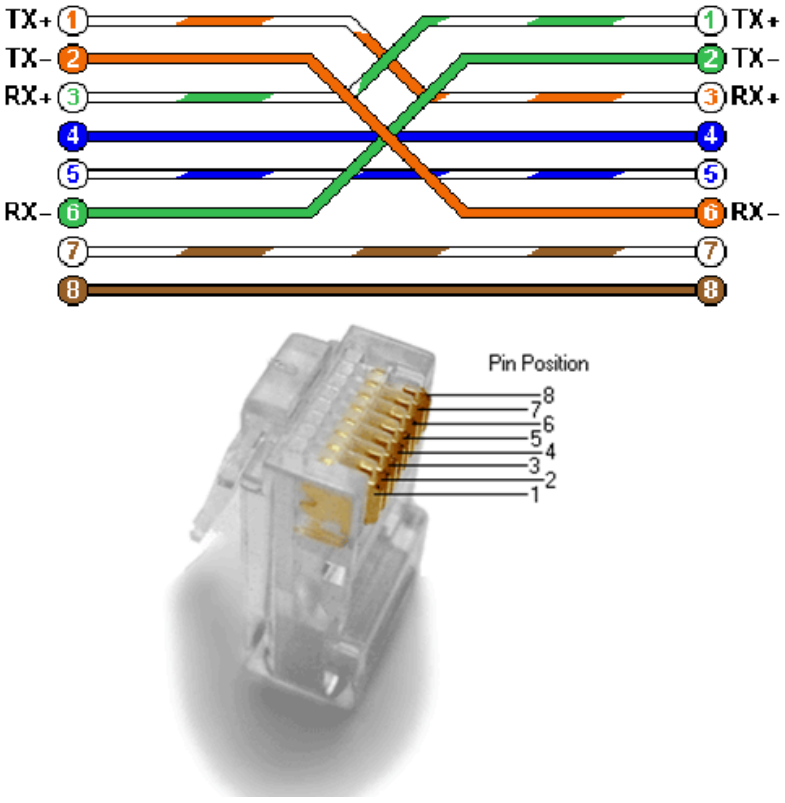
As seen in the beginning of this chapter, the CPU version "+0001" also has an integrated RJ4 port. When using a UTP crossover cable with RJ45 connectors at both ends, you can connect the device directly to a computer (see the figure below).

Figure. 5.4.1 - 14. Using the RJ45 connection.



The crossover cable's pinout has been depicted in the diagram below:

Figure. 5.4.1 - 15. The pinout of the crossover cable.

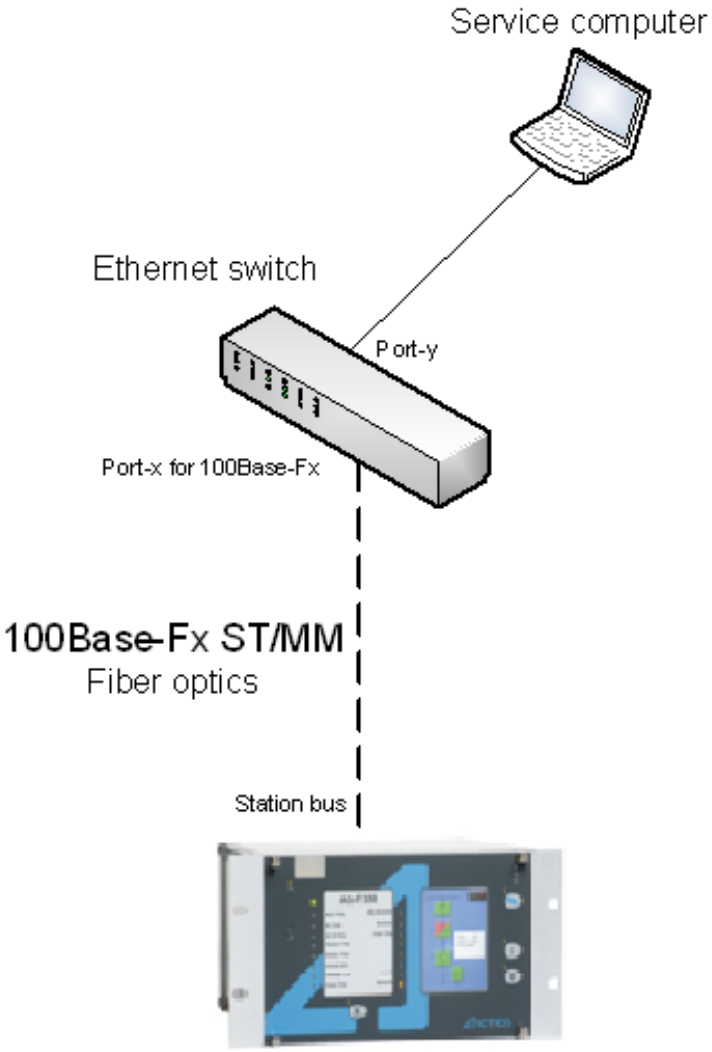


Please note that the cable's RJ45 connector can also be connected to an Ethernet switch. When this is the case, all the network's IEDs with client functionalities (e.g. a computer) have access to the device.

ST-type fiber optic connection

The ST-type fiber optic connector of the 100Base-FX Ethernet provides a connection to an Ethernet switch with an identical fiber optic input. When using this connection, all the network's IEDs with client functionalities (e.g. a computer) have access to the device (see the figure below).

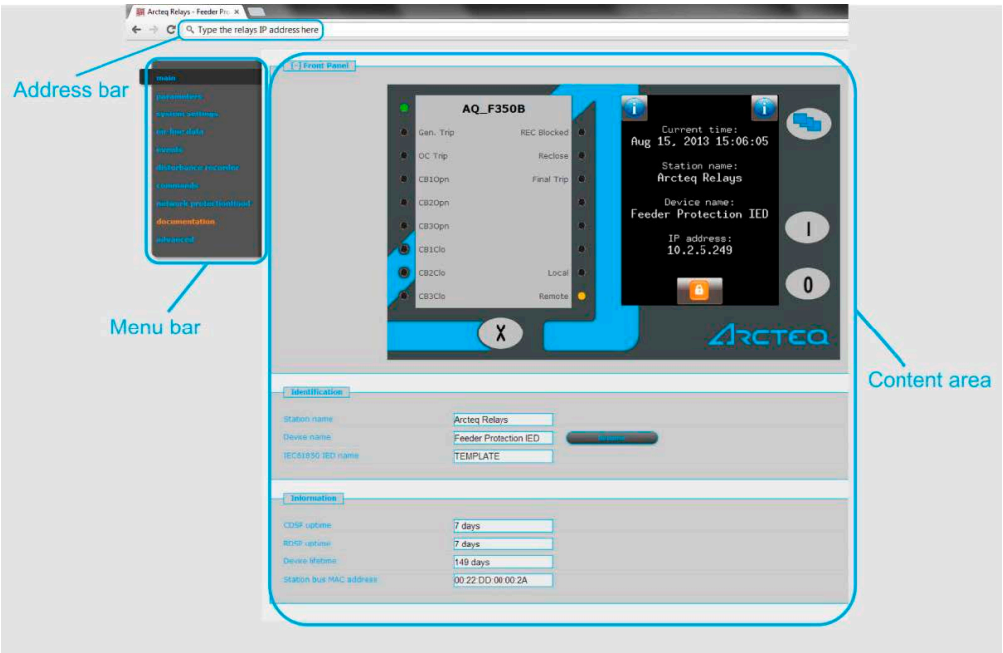
Figure. 5.4.1 - 16. Using the ST-type fiber optic connection to connect computers via an optical Ethernet switch.



5.4.2 Getting started

Make sure you are connected to your AQ-300 device and that you have JavaScript enabled within your web browser. Type the IP address of the device into your browser's address bar to access its embedded web server (see the image below).

Figure. 5.4.2 - 17. Web server elements.



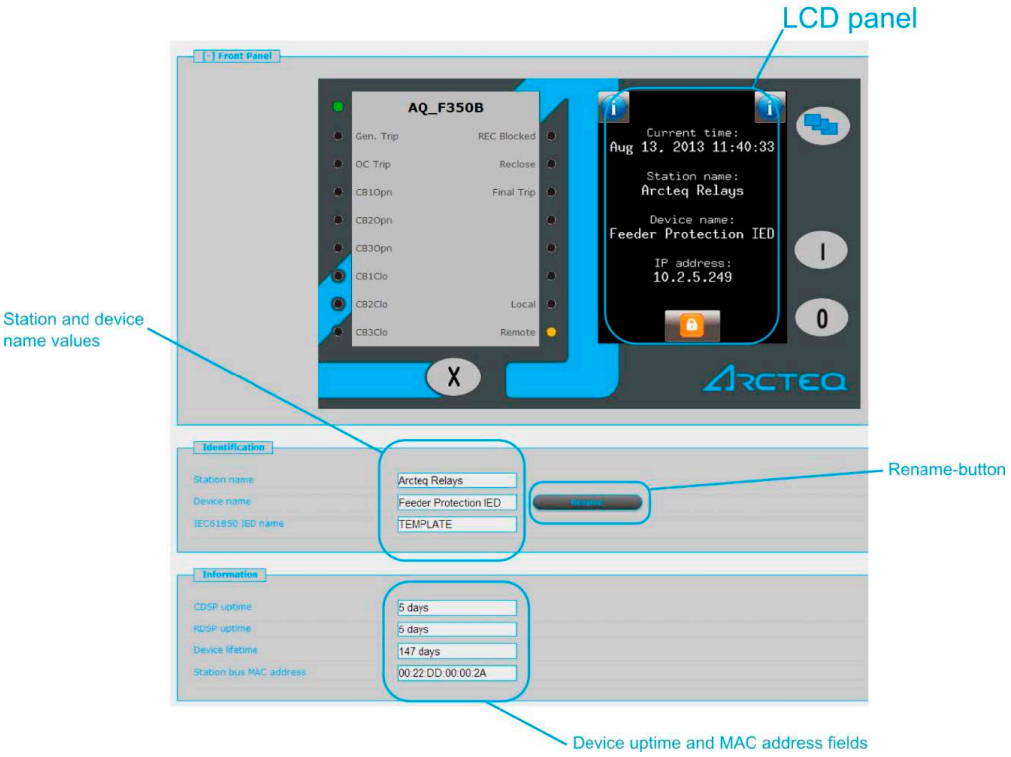
The menu that is currently selected is highlighted in black (in the image above, the main menu is selected). If the content area is too long to fit the browser window, you can scroll down; the menu bar will always be visible as it follows the user.

In some configurations the language that is currently displayed can be changed; to do this, click one of the other available languages represented by flags, located at the top of the touch screen. The page automatically refreshes in the chosen language. Please note that changing the display language only affects the local browser, NOT other browser or the language of the touch screen.

5.4.3 Menu items

Main menu

Figure. 5.4.3 - 18. The main menu and its elements.



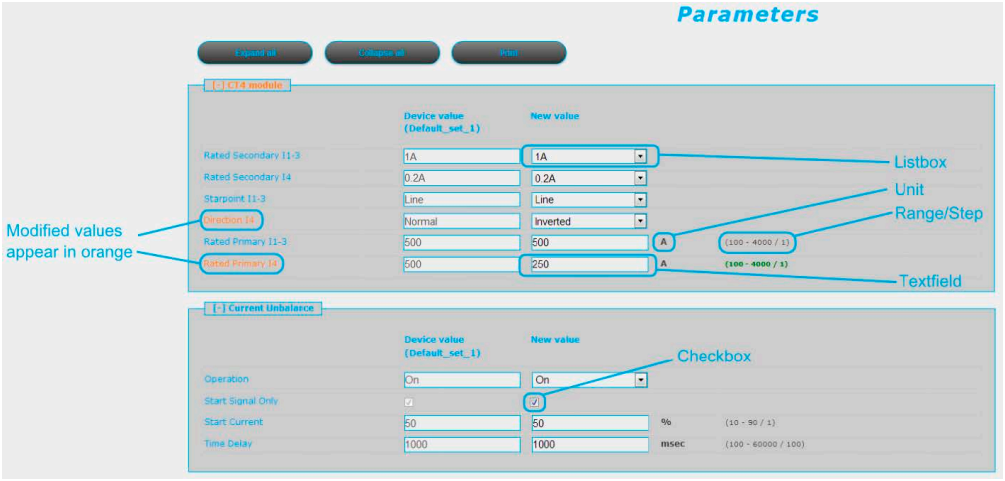
In the main menu you can control the device's front panel. The image of a touch screen (located on the right) behaves the same way as the actual touch screen. For more information on the touch screen, please refer to the "Touch screen" subchapter in the "IED user interface" main chapter.

In the "Identification" section of the view, you can change the station name and the device name. Type the desired name in the relevant field and click the **Rename** button.

The "Information" section shows additional information about the device. The uptime fields show how much time has passed since the device was last powered on. The "Station bus MAC address" displays the network card's MAC address, which is a uniwue identification number assigned by Arcteq (the address range assigned by the IEEE authority). Please note that these fields are read-only and cannot be modified!

Parameters menu

Figure. 5.4.3 - 19. The parameters menu and its elements.



You can view and change various parameters and variables in this menu. You can manage the different parameter sets by resetting, renaming, exporting and importing them. You can also apply a password for importing, exporting and setting.

All parameters are part of specific function blocks. You can expand and collapse the individual function block information boxes by clicking the [+] and [–] signs in front of its name. You can also use the button at the top to expand all function blocks, collapse them all, or print out a printer-friendly layout of the function blocks (opens in a new browser window).

The parameter sheet has the following general layout

- The first column contains the name of the parameter. In multilingual devices changing the language also changes this name.
- The second column displays the current values of the selected parameter set stored in the device. Changing the parameter does NOT activate it, it only loads to the fields.
- The third column is used to give parameters user-desired values. When changed, the color changes to blue to draw attention to the change. The expected value range and step are located to the right of the parameter line.

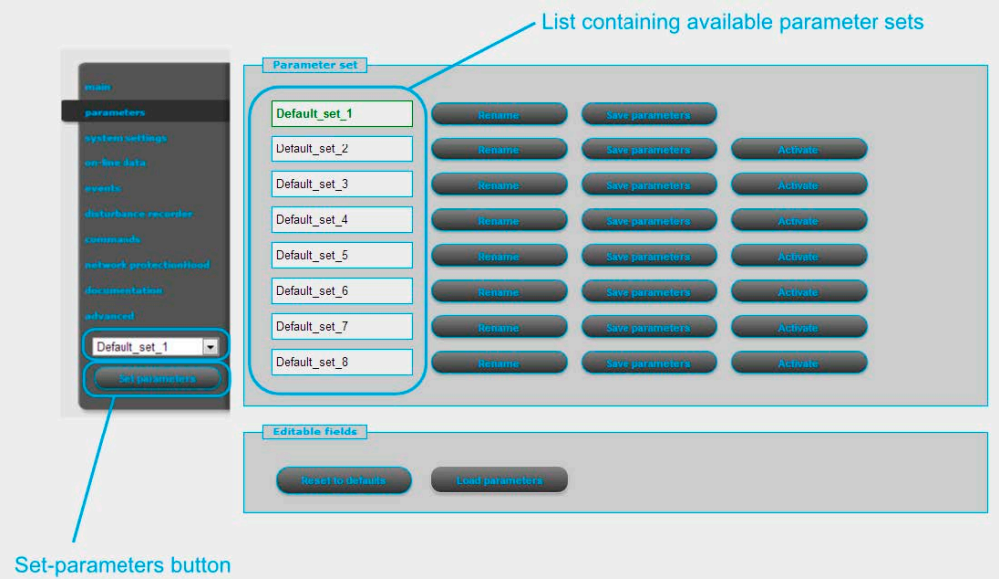
The parameter values are displayed in text fields, checkboxes, or listboxes. All of these can be modified; the name of the parameter whose value has been modifed appears in orange, as does the name of the function block (see the image above). When modifying *text fields*, please be mindful of the parameter range and step, although the device does alert the user when an improper value is entered. The new value is displayed in red. *Checkboxes* (Boolean parameter type) enable and disable certain functions and properties; a ticked checkbox means that the parameter is enabled. *Listboxes* (enumerated parameter type)open a drop-down menu with a number of predetermined values. When a value that is not the default is selected, both the letters and the box outline become red.

NOTICE!
A parameter line has the unit between the new value textfield and the range/step information when applicable. Some parameters do not have units!

The parameter values are checked for changes when you navigate away from the parameter page or when you try to load another parameter set. A pop-up window notifies you if you have made changes and try to leave the page without saving them. Clicking Cancel returns you to the parameter page, whereas clicking OK ignores the changes.

In the "Parameter set" section of the page there are options for managing the parameter sets. The section lists all the available parameter sets, and each can be manipulated with the buttons located on the right of the line.

Figure. 5.4.3 - 20. Managing multiple parameter sets.



With the Activate button, you can enable the selected parameter set. The device will now use the values from this set. The Rename button, unsurprisingly, renames the selected parameter set. The names can include alphanumeric characters, spaces, dashes and underscores. Please note that two or more parameter sets CANNOT share the same name! The Save parameters button saves the selected parameter set in a separate file, which can be loaded into the device at any time.

The Set parameters button (located below the menu bar on the left) overwrites the selected parameter set with the values that are on the screen. Note that this only modifies the values of the selected set; to have the device use these values you must also activate the set! You can also set a password that is required before overwriting can be done.

The "Editable fields" section has two buttons. The Reset to defaults button replaces the values on the screen with the factory default settings. With the Load parameters button you can import values from a parameter set file. These values must be saved after loading by pressing the Set parameters button.

NOTICE!
These buttons and functions only appear if the device is configured to have more than one parameter set. The available buttons and functions depend on the configuration.

System settings menu

In the system settings menu you can adjust the miscellaneous device settings. This menu can also be password protected. The text fields, checkboxes and listboxes function the same as in the parameter menu. The column structure is also the same.

The Set settings button (located below the menu bar on the left) enabled the device to use the values displayed on the screen at the time the button was clicked. Please note that if the device's IP address has changed, the device must first be accessed through the new IP address.

Figure. 5.4.3 - 21. The system settings menu.

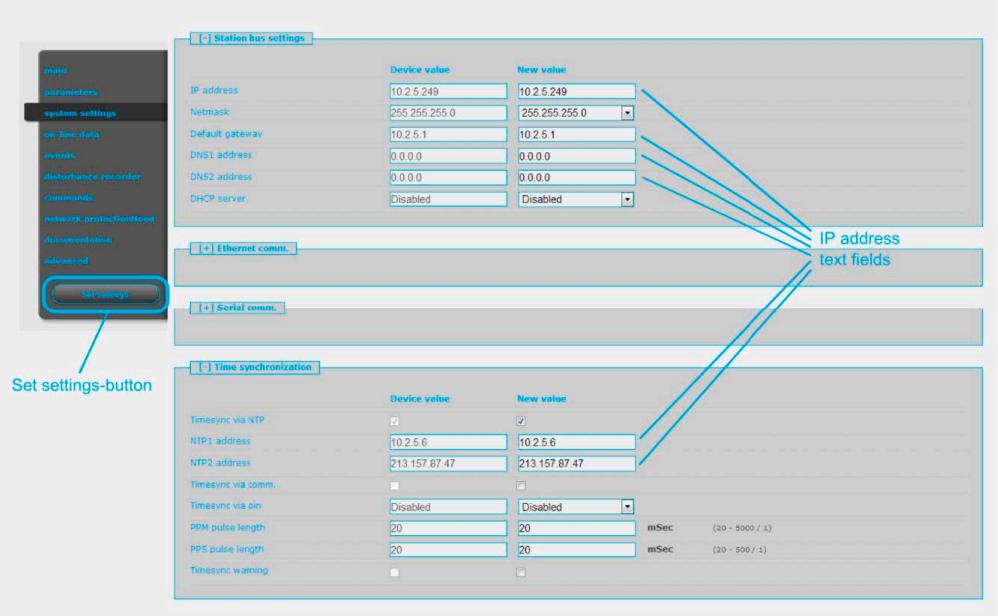


Table. 5.4.3 - 6. The system setting sections and their content.

Section name	Description
Safe settings	If enabled, the device asks you to confirm the saving of new settings by pressing the "I" (ON) button on the device's front panel. Pressing "0" (OFF) discards the changes. This selection must be made within 300 seconds.
Power system frequency	Sets the power system frequency. By default it is 50 Hz, can be changed to 60 Hz. **CAUTION!** Changing this parameter initiates a system restart!
Station bus settings	Contains the settings for IPv4-based communication (IP address, mask, gateway, DNS address). The DHCP server function can be switched on with a combo-box. **CAUTION!** Uncontrolled use of the DHCP server function can cause serious communication failures!
Ethernet communication	The device can communicate using several Ethernet-based protocols at the same time. Only IEC 61850 is licensed, other protocols are available by default. You can adjust the T0 time of GOOSE messaging with the GOOSE repeat rate combo-box.
Serial communication	Contains the physical parameters for serial communication (only one protocol can be selected!). Note that serial communication requires a proper CPU card!
Time synchronization	Contains the settings for a broad range of time synchronzation protocols (NTP, serial communication, pulse inputs). If the "Time sync warning" parameter is enabled and the device is not synchronized, an alarm is raised (that is, the "Status" LED becomes yellow).
Time zone settings	Contains the settings to offset GMT and to define daylight savings time.

Section name	Description
LCD backlight	Contain the parameters to control the LCD panel's behaviour. The light switches off after its set timeout. The "Backlight group" parameter is useful when you have two or more devices close to each other: touching one switches on all devices that have been configured to belong to the same group.

Online data menu

Figure. 5.4.3 - 22. The online data menu.

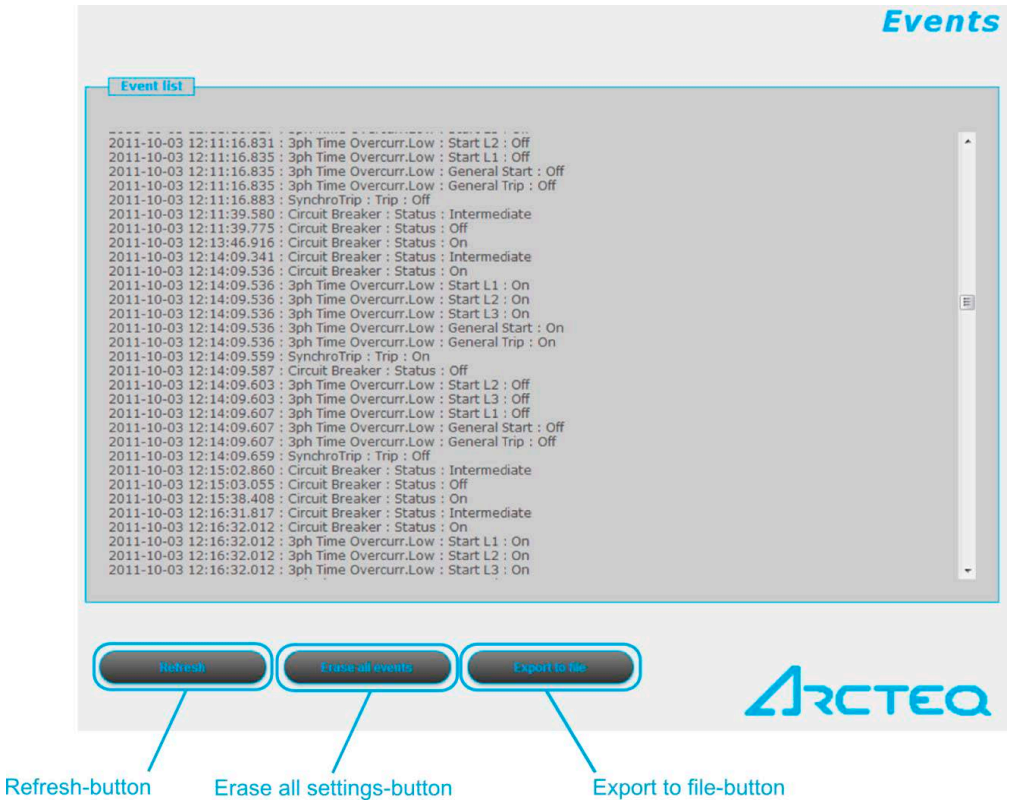
This menu displays the data measured by the device. Each block has their own section, and these sections can be expanded and collapsed individually as needed with the [+] and [–] signs in front of their names. The values on screen are updated every second, which may cause older systems to slow down or halt the browser altogether. All data is strictly read-only, and cannot be modified. If there is a counter on the page, next to it will be a button that resets it.

Binary data is displayed as a checkbox (for example, the "SystemWarning" parameter in the first section in the image above), whereas enumerated data is presented as text information. If you are using a browser compatible with HTML5, analogue measurements are drawn as vectors.

Events menu

This page displays the events that have occured in the device. The events are listed in the following format: [local time] : [function block] : [channel] : [new value].

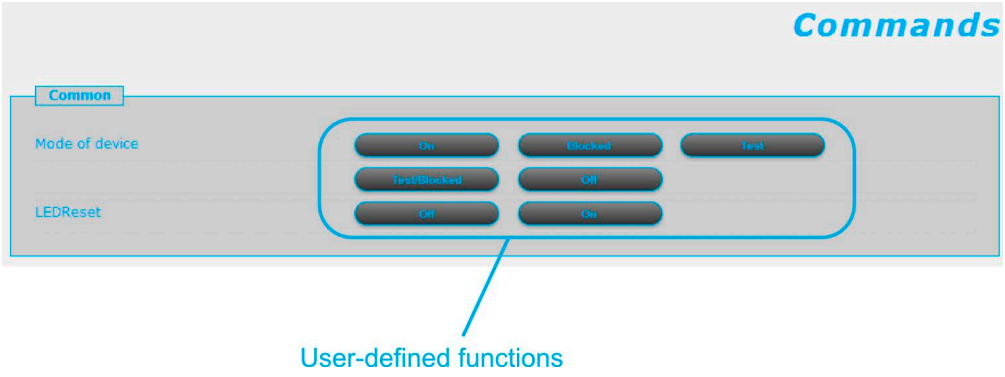
Figure. 5.4.3 - 23. Elements of the events menu.



With the **Refresh** button you can refresh the list displaying the events, the **Erase all events** button clears the list on the screen, and the **Export to file** button downloads the events and saves them as a .txt file.

Commands menu

Figure. 5.4.3 - 24. The commands menu.

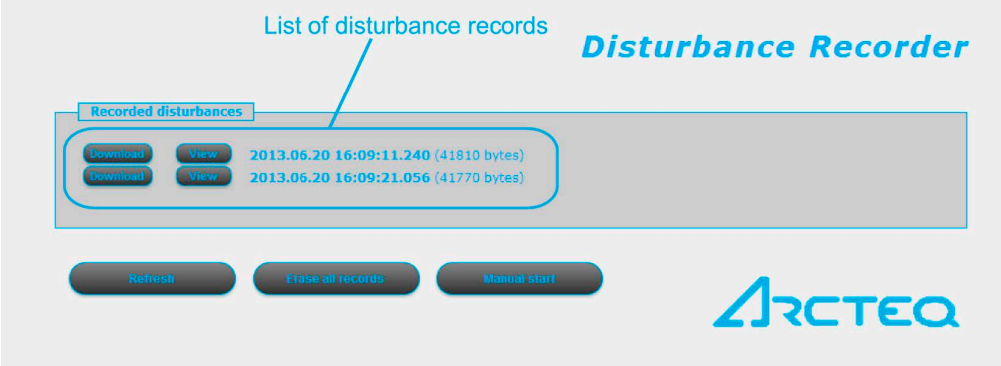


In the commands menu you can instruct the processor to carry out customized, user-defined commands. You can use the various mode buttons (**On**, **Blocked**, **Test**, **Test/Blocked**, **Off**) and LED buttons (**On**, **Off**) to define functions. A status update is always generated with a command, regardless of whether the command was successful or not. If the command was unsuccessful, the device gives the reason for the error.

Disturbance recorder

This page displays a list of the disturbance records that the device has recorded.

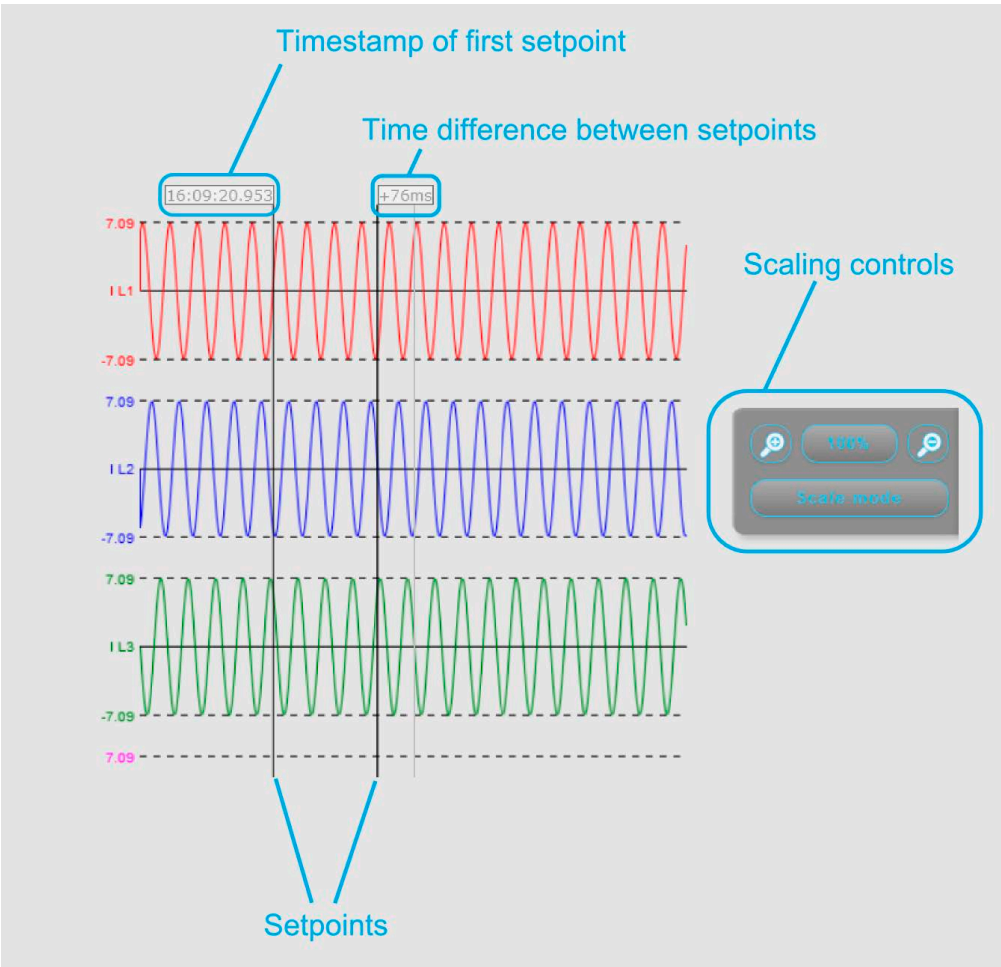
Figure. 5.4.3 - 25. Disturbance recorder.



The "Recorded disturbances" section lists all disturbance records. You can refresh the list with the **Refresh** button to display any new disturbance records that have occurred after the page was opened or refreshed last. You can also clear the list with the **Erase all records** button. Additionally, you can create a disturbance record manually by clicking the **Manual start** button.

There is one one record per line. You can download the chosen record by clicking the **Download** button on its line; the device downloads you a COMTRADE file which you can then open with any supporting software for further evaluation. You can also click the **View** button to open a new browser window which then displays a simple preview of the disturbance record (see the image below).

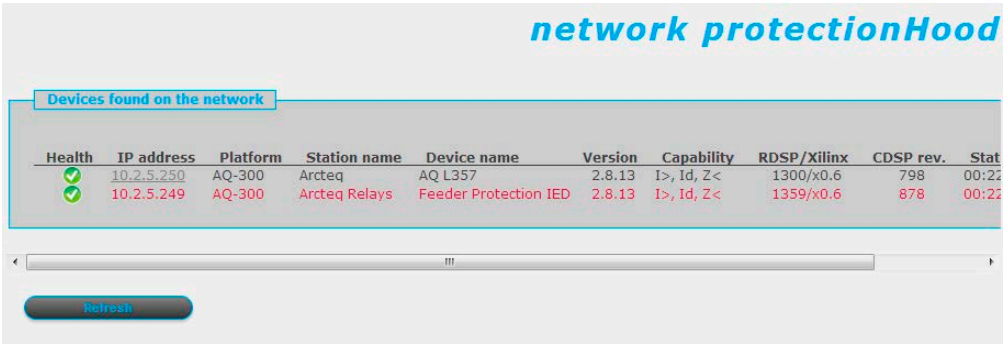
Figure. 5.4.3 - 26. Example of a disturbance record preview.



You can set a setpoint by clicking anywhere on the graph, and the positioning the cursor to a desired second point. The preview then displays the timestamp of the first setpoint, and the time difference between the two setpoints. You can also scale the time axis with the scaling controls (the plus and minus magnifying glasses), or by clicking the Scale mode button to switch between standard and scaled modes. The scaled mode stretches the Y axis of all recorded values.

Network protectionHood

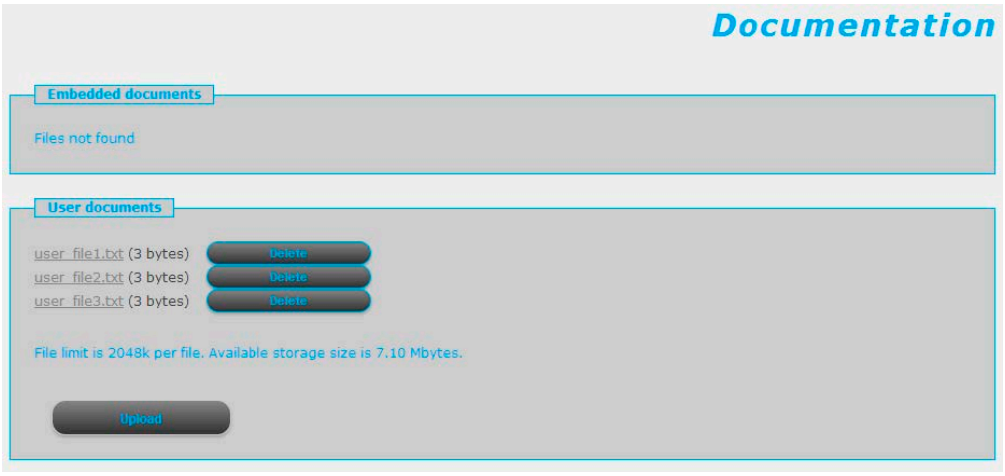
Figure. 5.4.3 - 27. The network protectionHood menu.



This page shows all other devices that are located in the same network with the AQ-300 unit. The page identifies compatible devices and displays information about them, such as their IP address and version. The device that is currently accessed is highlighted in red in the list. You are redirected to other devices by clicking their corresponding links. The Refresh button scans the network for connected devices.

Documentation

Figure. 5.4.3 - 28. The documentation menu.

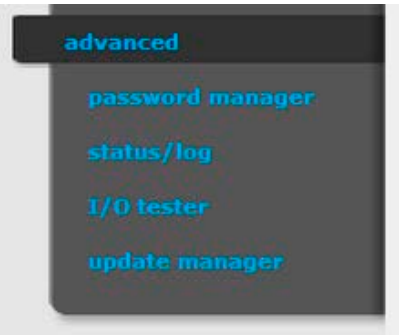


This page displays the documentation files on the device. You can upload other documents and files on the device, which are then saved and can be accessed later. One file can be up to 2048K , and there is storage for up to 8 MB of documentation.

The "Embedded documentation" section displays all the documents that have been preloaded into the device. You cannot delete these. The "User documents" section lists all the files the user has uploaded into the device, and you can delete them with the Delete button. You can upload a selected file with the Upload button. Please ensure that the file size is below the limit and that you have enough storage left before commencing the upload.

Advanced

Figure. 5.4.3 - 29. The Advanced menu.

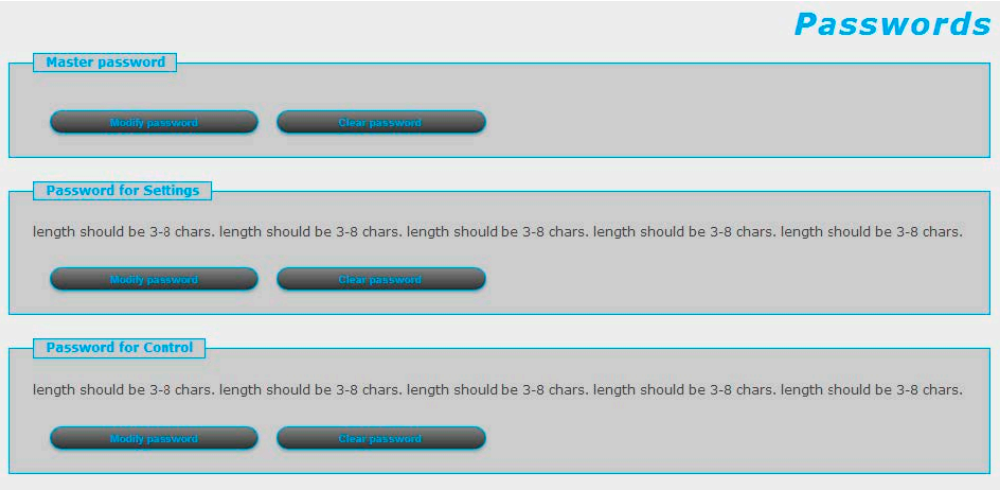


This menu displays the additional, more advanced options. You can set a password request before a user is allowed access to these options.

Password manager

You can modify and clear the three available passwords. The *master password* is used for accessing the Advanced menu. The *password for settings* is required when a user wants to set parameters or settings, or wants to clear counters in the Online data menu. The *password for control* is required when executing commands in the Commands menu. If no password has been created, you can create one with the Modify password button.

Figure. 5.4.3 - 30. Password manager.



Status/log

The Status/log submenu displays information from various logs. The log files are primarily meant for the manufacturer, but a user can also view them.

Figure. 5.4.3 - 31. Status/log.

The Get report button generates a .zip file that has all of the log files archived together. The files have valuable information and they can help in analyzing errors and malfunctions; see the table below for the different log types and their contents.

Table. 5.4.3 - 7. Log types.

Log name	Description
Relay CPU	Displays the logged events that are connected to the relay's CPU.
SPORT	Displays the log file from the SPORT communication interface.
System startup	Displays the events that have occurred when the system was started up.
Serial Comm	Displays the log file from the serial communication interface.
LCD display	Displays the log file about the events that have occurred with the LCD display.
IEC 61850	Displays the log file from the IEC 61850 communication interface.
Access	Displays information about the users who have accessed the device remotely through the embedded web browser interface.
Error	Displays the errors that have occurred with the remote user interface.

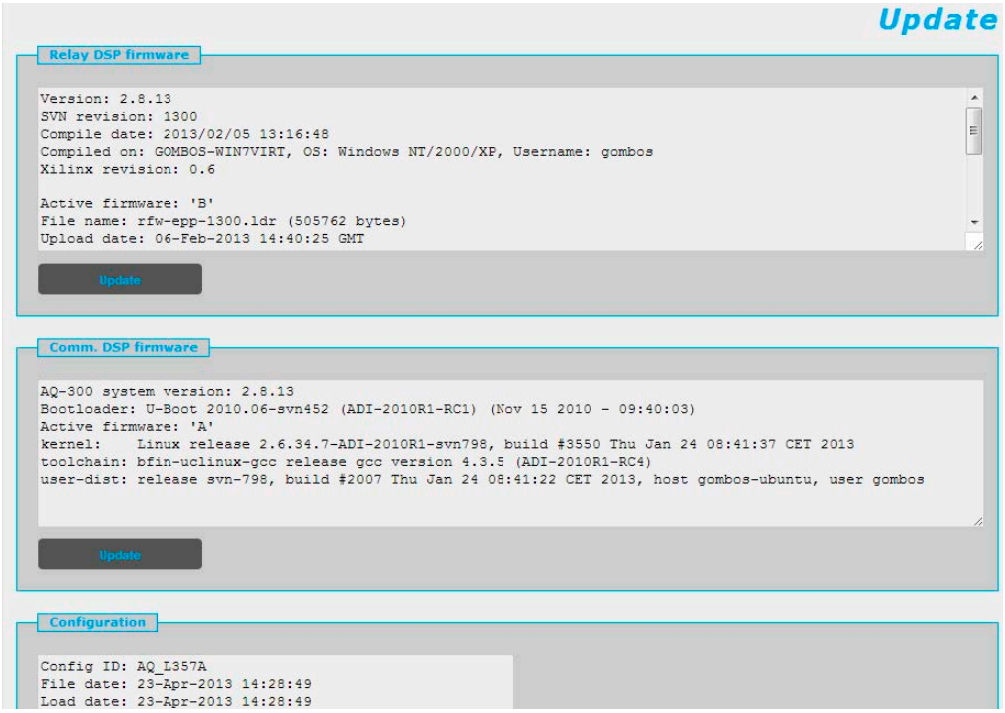
NOTICE!
All log files are in English, regardless of your language selection!

Update manager

When a new version of the firmware is available, it can be updated in this submenu. Click the Update button of the correct section to select the new firmware file and upload it into the device. Please make sure that you are updating the right firmware; for example, do not attempt to update the "Relay DSP firmware" section with a "Comm. DSP firmware" file!

This page also displays information about the firmware currently in use as well as of the configuration of the device.

Figure. 5.4.3 - 32. Update manager.



5.4.4 Troubleshooting

Some browsers have a tendency to handle and cache various JavaScript function improperly, and this may cause anomalies and errors in the interface. If you notice improper functionalities, try to clear both the browser history and cache, and refresh the web page.

If this does not clear the problem, please contact Arcteq for further instructions.

6 Application

The AQ S391 bay control IED is suitable to various types of control and monitoring applications in extra-high voltage, high voltage and medium voltage applications. The modular hardware construction offers required options for different kind of bay configurations in terms of type and quantity of analogue and digital signals. The versatile programmable software logic allows for extensive customization of provided standard configurations.

The IED may be applied to single or double breaker arrangements both in single or double busbar configurations. Control and monitoring of full diameter of one and half circuit breaker arrangement can be realized with a single IED as well.

Motorized switching devices can be controlled from remote control system through communication or locally using the HMI. Synchrocheck function is provided for safe closing of circuit breakers.

7 Main characteristics of the AQ-S391 bay control system

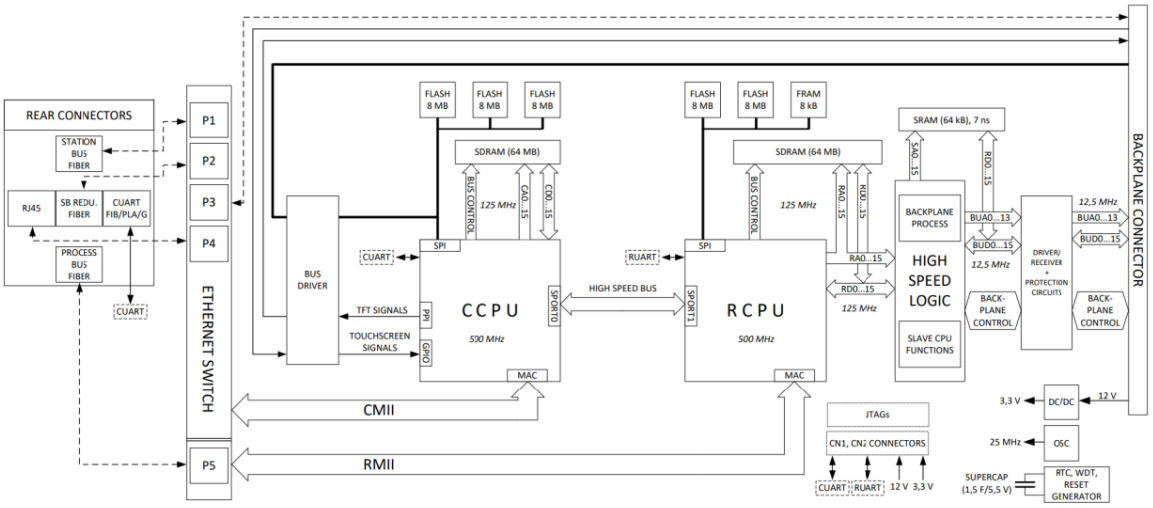
List of the main characteristics

- Flexible and modular hardware construction allowing for multiple sets of current and voltage measurement modules, digital input and output modules and mA input modules
- Flexible software adaptation to different busbar and interlocking schemes using programmable logic functions
- Configurable MIMIC display
- Touch screen (TFT) colour display
- Local and remote control and/or status indication of up to 12 controllable objects
- Direct control mode or select before execute control mode
- CT supervision (CTS)
- Dead line detection features (DLD)
- Voltage transformer supervision (VTS)
- Synchrocheck and synchroswitch function over multiple circuit breakers
- Optional redundant power supply (80-300Vac/dc or 48Vdc)
- Programmable disturbance recorder for up to 100 records stored in non-volatile memory
- Event recorder for up to 10000 latest events stored in non-volatile memory
- IED time synchronization (e.g. SNTP or IRIG-B)
- Wide range of communication protocols, including IEC 61850
- IED self supervision functionality

System design

The AQ-300 protection device family is a scalable hardware platform to adapt to different applications. Data exchange is performed via a 32-bit high-speed digital non-multiplexed parallel bus with the help of a backplane module. Each module is identified by its location and there is no difference between module slots in terms of functionality. The only restriction is the position of the CPU module because it is limited to the “CPU” position. The built-in self-supervisory function minimizes the risk of device malfunctions.

Figure. 7 - 33. CPU block diagram.



8 Software setup

8.1 Functions included in AQ-S391

In this chapter are presented the control and monitoring functions, listed in the table below. The function blocks are described in detail in following chapters.

Table. 8.1 - 8. Available control and monitoring functions

Name	IEC	ANSI	Description
CB Control	-	-	Circuit breaker control
DS Control	-	-	Disconnector control
DLD	-	-	Dead line detection
VTS	-	60	Voltage transformer supervision
CTS	-		Current transformer supervision
SYN25	SYNC	25	Synchro-check function Δf, ΔU, Δφ
DREC	-	-	Disturbance recorder

8.2 Control, monitoring and measurements

8.2.1 Circuit breaker control function

Application

The circuit breaker control block can be used to integrate the circuit breaker control of the AQ 300 device into the station control system and to apply active scheme screens of the local LCD of the device.

Mode of operation

The circuit breaker control block receives remote commands from the SCADA system and local commands from the local LCD of the device, performs the prescribed checking and transmits the commands to the circuit breaker. It processes the status signals received from the circuit breaker and offers them to the status display of the local LCD and to the SCADA system.

Main features:

- Local (LCD of the device) and Remote (SCADA) operation modes can be enabled or disabled individually.
- The signals and commands of the synchro check / synchro switch function block can beintegrated into the operation of the function block.
- Interlocking functions can be programmed by the user applying the inputs “EnaOff” and“EnaOn”, using the graphic equation editor.
- Programmed conditions can be used to temporarily disable the operation of the functionblock using the graphic equation editor.
- The function block supports the control models prescribed by the IEC 61850 standard.

- All necessary timing tasks are performed within the function block:
    - Time limitation to execute a command
    - Command pulse duration
    - Filtering the intermediate state of the circuit breaker
    - Checking the synchro check and synchro switch times
    - Controlling the individual steps of the manual commands
- Sending trip and close commands to the circuit breaker (to becombined with the tripcommands of the protection functions and with the close command of the automaticreclosing function; the protection functions and the automatic reclosing function directlygives commands to the CB). The combination is made graphically using the graphicequation editor
- Operation counter
- Event reporting

Available internal status variable and command channel

To generate an active scheme on the local LCD, there is an internal status variableindicating the state of the circuit breaker. Different graphic symbols can be assigned to thevalues. (See AQtivate 300 software instructions for more details).

Table. 8.2.1 - 9. Status variable of the circuit breaker control.

Status variable	Title	Explanation
CB1Pol_stVal_Ist_	Status	0: Intermediate 1: Off 2: On 3: Bad

The available control channel to be selected is:

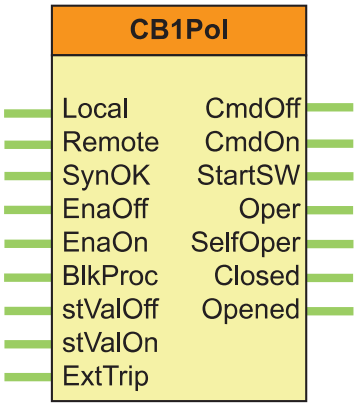
Table. 8.2.1 - 10. Command channel of the circuit breaker control.

Command channel	Title	Explanation
CB1Pol_Oper_Con_	Operation	On Off

Using this channel, the pushbuttons on the front panel of the device can be assigned toclose or open the circuit breaker. These are the “Local commands”.

The symbol of the function block in the AQtivate 300 software

Figure. 8.2.1 - 34. Function block symbol of circuit breaker control.



The binary input and output status signals of the circuit breaker control are listed in tables below.

Table. 8.2.1 - 11. The binary input status signals of the circuit breaker control.

Binary status signal	Title	Explanation
CB1Pol_Local_GrO_	Local	If this input is active, the circuit breaker can be controlled using the local LCD of the device.
CB1Pol_Remote_GrO_	Remote	If this input is active, the circuit breaker can be controlled via remote communication channels of the SCADA system.
CB1Pol_SynOK_GrO_	SynOK	This input indicates if the synchron state of the voltage vectors at both sides of the circuit breaker enables the closing command. This signal is usually generated by the synchro check/ synchro switch function. If this function is not available, set the input to logic true.
CB1Pol_EnaOff_GrO_	EnaOff	The active state of this input enables the opening of the circuit breaker. The state is usually generated by the interlocking conditions defined by the user.
CB1Pol_EnaOn_GrO_	EnaOn	The active state of this input enables the closing of the circuit breaker. The state is usually generated by the interlocking conditions defined by the user.
CB1Pol_BlkProc_GrO_	BlkProc	The active state of this input blocks the operation of the circuit breaker. The conditions are defined by the user.
CB1Pol_stValOff_GrO_	stValOff	Off state of the circuit breaker.
CB1Pol_stValOn_GrO_	stValOn	On state of the circuit breaker.
CB1Pol_ExtTrip_GrO_	ExtTrip	External trip command for the circuit breaker (e.g. from protection). This signal is considered when evaluating uninteded operation.

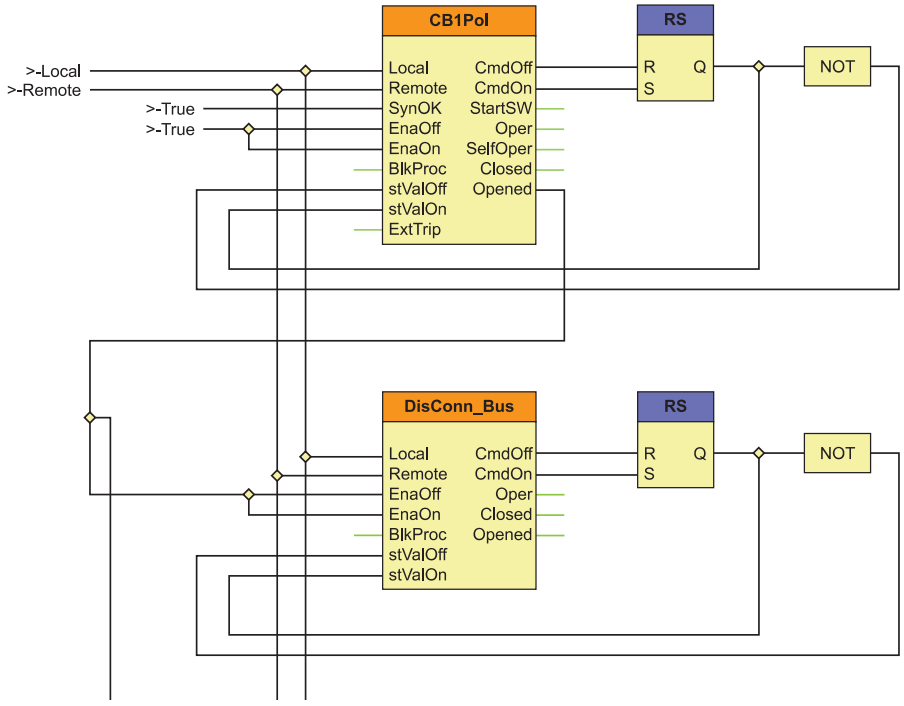
Table. 8.2.1 - 12. The binary output status signals of the circuit breaker control.

Binary status signal	Title	Explanation
CB1Pol_CmdOff_Grl_	Off Command	Off command impulse, the duration of which is defined by the parameter "Pulse length".
CB1Pol_CmdOn_Grl_	On Command	On command impulse, the duration of which is defined by the parameter "Pulse length".
CB1Pol_StartSW_Grl_	Start Synchroswitch	If the synchrocheck/synchroswitch function is applied and the synchron state conditions are not valid for the time defined by the parameter "Max.SynChk time", then this output triggers the synchroswitch function (see synchrocheck/ synchroswitch function block description).
CB1Pol_Oper_Grl_	CB Operated	An impulse with a duration of 150 ms at any operation of the circuit breaker.
CB1Pol_SelfOper_Grl_	Unintended Oper	This output is logic true if the status of the circuit breaker has changed without detected command from the SCADA system or on the input "Ext trip".
CB1Pol_Opened_Grl_	Opened	The filtered status signal for opened state of the circuit breaker.
CB1Pol_Closed_Grl_	Closed	The filtered status signal for closed state of the circuit breaker.

Configuration examples

Example 1

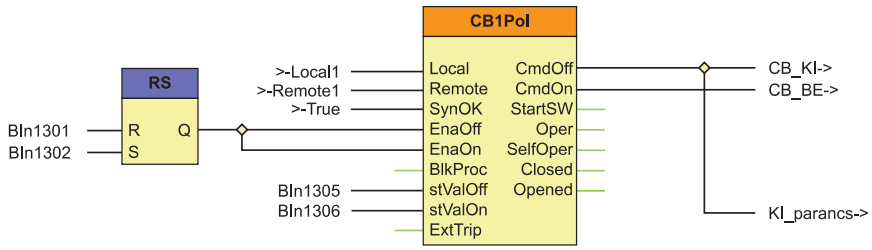
Figure. 8.2.1 - 35. Simulation of the circuit breaker (and disconnectors; detail).



In the Figure above the local/remote selection is made by another function block (Common). In VB1Pol, synchro check is not applied, the input “SynOK” is programmed for constant “True”. The circuit breaker can be switched any time, no interlocking is needed, the “EnaOff” and “EnaOn” are programmed for constant “True”. (However, note the similar DisConn_Bus function block in the Figure above.) The function block does not need to be blocked; the “BlkProc” input is not connected. The CB is simulated by an RS flip-flop, the status inputs are connected to the simulated signals.

Example 2

Figure. 8.2.1 - 36. A simple application.



In the figure above the local/remote selection is made by another function block (Common). In VB1Pol, synchro check is not applied, the input “SynOK” is programmed for constant “True”. Interlocking is applied; the “EnaOff” and “EnaOn” are programmed with external binary input signals. The function block does not need to be blocked; the “BlkProc” input is not connected. The CB status inputs are connected to the binary input signals. The commands are directed to another graphic page (to be “OR”-ed with the signals of the protection and automatic reclosing functions).

Setting parameters

Table. 8.2.1 - 13. Setting parameters of the circuit breaker control function.

Parameter	Setting value, range, and step	Description
ControlModel	Direct normal Direct enhanced SBO enhanced	Direct normal: only command transmission. The default setting value is Direct normal. Direct enhanced: command transmission with status check and command supervision SBO enhanced: Select Before Operate (select before execute) mode with status check and command supervision.
Max operating time	10...20,000 ms	The tImeout for signaling a failed operation. The default is 1,000 ms.
Pulse length	50...30,000 ms	Control pulse duration. The default is 100 ms.
Max.Intermediate time	20...30,000 ms	Waiting time, at expiry intermediate state of the disconnector is reported. The default is 100 ms.
Max.SynChk time	10...5,000 ms	Length of the time period to wait for the conditions of the synchronous state. After expiry of this time, the synchroswitch procedure is initiated (see synchrocheck/synchroswitch function description). The default is 1,000 ms.

Parameter	Setting value, range, and step	Description
Max.SynSW time	0...60,000 ms	Length of the time period to wait for the synchroswitch pulse (see synchrocheck/synchroswitch function description). After this time the function resets and no switching is performed. The default time is 0 ms. (If this parameter is set to "0", then the synchroswitch is not activated.)
SBO Timeout	1,000...20,000 ms	Duration of the waiting time between object selection and command selection. At timeout no command is performed. The default time is 5,000 ms.

8.2.2 Disconnector control function

Application

The disconnector control block can be used to integrate the disconnector control of the AQ 300 device into the station control system and to apply active scheme screens of the local LCD of the device.

Mode of operation

The disconnector control block receives remote commands from the SCADA system and local commands from the local LCD of the device, performs the prescribed checking and transmits the commands to the disconnector. It processes the status signals received from the disconnector and offers them to the status display of the local LCD and to the SCADA system.

Main features:

- Local (LCD of the device) and Remote (SCADA) operation modes can be enabled or disabled individually.
- Interlocking functions can be programmed by the user applying the inputs “EnaOff” and “EnaOn”, using the graphic equation editor.
- Programmed conditions can be used to temporarily disable the operation of the function block using the graphic equation editor.
- The function block supports the control models prescribed by the IEC 61850 standard.
- All necessary timing tasks are performed within the function block:
    - Time limitation to execute a command
    - Command pulse duration
    - Filtering the intermediate state of the disconnector
    - Controlling the individual steps of the manual commands
- Trip and close commands to the disconnector
- Operation counter
- Event reporting

Available internal status variable and command channel

To generate an active scheme on the local LCD, there is an internal status variableindicating the state of the circuit breaker. Different graphic symbols can be assigned to thevalues. (See AQtivate 300 software instructions for more details).

Table. 8.2.2 - 14. Status variable of the circuit breaker control.

Status variable	Title	Explanation
DisConn I_stVal_Ist_	Status	0: Intermediate 1: Off 2: On 3: Bad

The available control channel to be selected is:

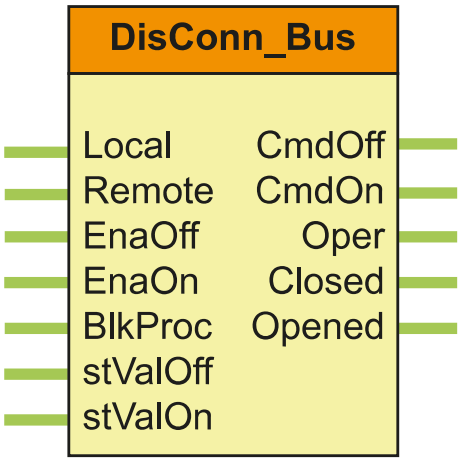
Table. 8.2.2 - 15. Command channel of the circuit breaker control.

Command channel	Title	Explanation
DisConn _Oper_Con_	Operation	On Off

Using this channel, the pushbuttons on the front panel of the device can be assigned toclose or open the disconnector. These are the “Local commands”.

The symbol of the function block in the AQtivate 300 software

Figure. 8.2.2 - 37. The symbol of the function block.



The binary input and output status signals of the disconnector control are listed in tables below.

Table. 8.2.2 - 16. The binary input status signals of the circuit breaker control.

Binary status signal	Title	Explanation
DisConn_Local_GrO_	Local	If this input is active, the disconnector can be controlled using the local LCD of the device.
DisConn_Remote_GrO_	Remote	If this input is active, the disconnector can be controlled via remote communication channels of the SCADA system.

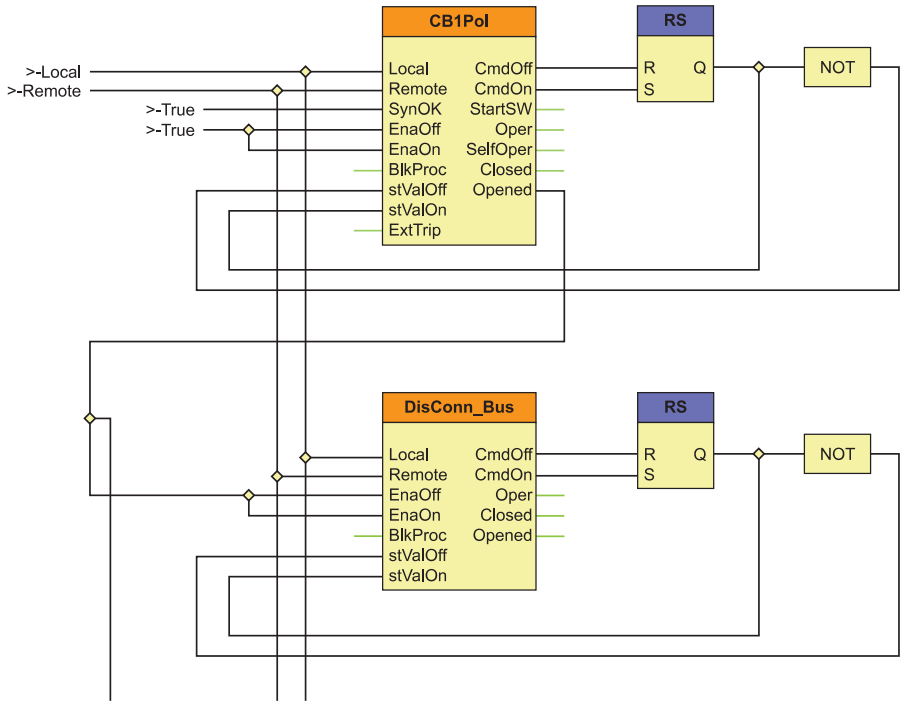
Binary status signal	Title	Explanation
DisConn_EnaOff_GrO_	EnaOff	The active state of this input enables the opening of the disconnector. The state is usually generated by the interlocking conditions defined by the user.
DisConn_EnaOn_GrO_	EnaOn	The active state of this input enables the closing of the disconnector. The state is usually generated by the interlocking conditions defined by the user.
DisConn_BlkProc_GrO_	BlkProc	The active state of this input blocks the operation of the disconnector. The conditions are defined graphically by the user.
DisConn_stValOff_GrO_	stValOff	Off state of the disconnector.
DisConn_stValOn_GrO_	stValOn	On state of the disconnector.

Table. 8.2.2 - 17. The binary output status signals of the circuit breaker control.

Binary status signal	Title	Explanation
CB1Pol_CmdOff_Grl_	Off Command	Off command impulse, the duration of which is defined by the parameter "Pulse length".
CB1Pol_CmdOn_Grl_	On Command	On command impulse, the duration of which is defined by the parameter "Pulse length".
CB1Pol_StartSW_Grl_	Start Synchroswitch	If the synchrocheck/synchroswitch function is applied and the synchron state conditions are not valid for the time defined by the parameter "Max.SynChk time", then this output triggers the synchroswitch function (see synchrocheck/ synchroswitch function block description).
CB1Pol_Oper_Grl_	CB Operated	An impulse with a duration of 150 ms at any operation of the circuit breaker.
CB1Pol_SelfOper_Grl_	Unintended Oper	This output is logic true if the status of the circuit breaker has changed without detected command from the SCADA system or on the input "Ext trip".
CB1Pol_Opened_Grl_	Opened	The filtered status signal for opened state of the circuit breaker.
CB1Pol_Closed_Grl_	Closed	The filtered status signal for closed state of the circuit breaker.

Configuration example

Figure. 8.2.2 - 38. Simulation of the disconnector (and circuit breaker; detail).



In the Figure above the local/remote selection is made by another function block (Common). The disconnector cannot be switched any time: interlocking is needed; the “EnaOff” and “EnaOn” are programmed for the “Opened” state of the circuit breaker. The function block does not need to be blocked; the “BlkProc” input is not connected. The disconnector is simulated by an RS flip-flop, the status inputs are connected to the simulated signals.

Setting parameters

Table. 8.2.2 - 18. Setting parameters of the circuit breaker control function.

Parameter	Setting value, range, and step	Description
ControlModel	Direct normal Direct enhanced SBO enhanced	Direct normal: only command transmission. The default setting value is Direct normal. Direct enhanced: command transmission with status check and command supervision SBO enhanced: Select Before Operate (select before execute) mode with status check and command supervision.
Max operating time	10...20,000 ms	The tImeout for signaling a failed operation. The default is 1,000 ms.
Pulse length	50...30,000 ms	Control pulse duration. The default is 100 ms.
Max.Intermediate time	20...30,000 ms	Waiting time, at expiry intermediate state of the disconnector is reported. The default is 100 ms.

Parameter	Setting value, range, and step	Description
Max.SynChk time	10...5,000 ms	Length of the time period to wait for the conditions of the synchronous state. After expiry of this time, the synchroswitch procedure is initiated (see synchrocheck/synchroswitch function description). The default is 1,000 ms.
Max.SynSW time	0...60,000 ms	Length of the time period to wait for the synchroswitch pulse (see synchrocheck/synchroswitch function description). After this time the function resets and no switching is performed. The default time is 0 ms. (If this parameter is set to "0", then the synchroswitch is not activated.)
SBO Timeout	1,000...20,000 ms	Duration of the waiting time between object selection and command selection. At timeout no command is performed. The default time is 5,000 ms.

8.2.3 Dead line detection (DLD)

The “Dead Line Detection” (DLD) function generates a signal indicating the dead or live state of the line. Additional signals are generated to indicate if the phase voltages and phase currents are above the pre-defined limits.

The task of the “Dead Line Detection” (DLD) function is to decide the Dead line/Live line state.

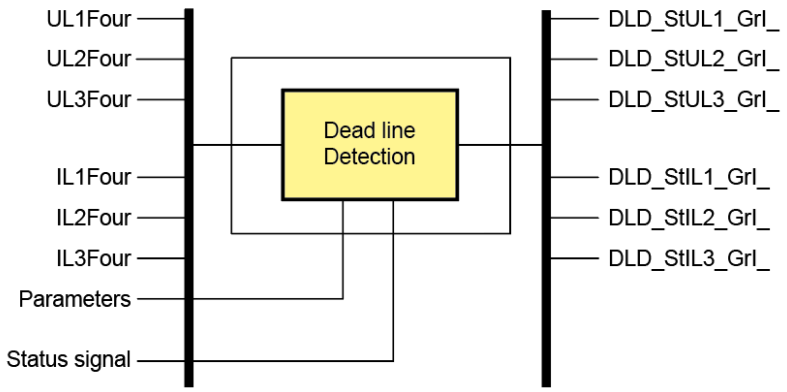
Criteria of “Dead line” state: all three phase voltages are below the voltage setting value AND all three currents are below the current setting value.

Criteria of “Live line” state: all three phase voltages are above the voltage setting value.

Dead line detection function is used in the voltage transformer supervision function also as an additional condition.

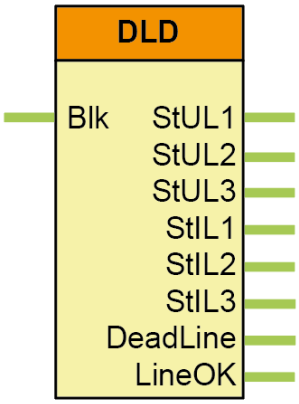
In the figure below is presented the operating logic of the dead line detection function.

Figure. 8.2.3 - 39. Principal scheme of the dead line detection function.



The function block of the dead line detection function is shown in figure bellow. This block shows all binary input and output status signals that are applicable in the AQtivate 300 software.

Figure. 8.2.3 - 40. The function block of the dead line detection function.



The binary input and output status signals of the dead line detection function are listed in tables below.

Table. 8.2.3 - 19. The binary input status signals.

Binary status signal	Explanation
DLD_Blk_GrO_	Output status defined by the user to disable the dead line detection function.

Table. 8.2.3 - 20. The binary output status signals.

Binary output signal	Signal title	Explanation
DLD function		
DLD_StUL1_Grl_	Start UL1	The voltage of phase L1 is above the setting limit
DLD_StUL2_Grl_	Start UL2	The voltage of phase L2 is above the setting limit
DLD_StUL3_Grl_	Start UL3	The voltage of phase L3 is above the setting limit
DLD_StIL1_Grl_	Start IL1	The current of phase L1 is above the setting limit
DLD_StIL2_Grl_	Start IL2	The current of phase L2 is above the setting limit
DLD_StIL3_Grl_	Start IL3	The current of phase L3 is above the setting limit
DLD_DeadLine_Grl_	DeadLine condition	The requirements of "DeadLine condition" are fulfilled
DLD_LineOK_Grl_	LineOK condition	The requirements of "Live line condition" (LineOK) are fulfilled

Table. 8.2.3 - 21. Setting parameters of the dead line detection function.

Parameter	Setting value/ range	Step	Default	Description
Operation	On Off	-	On	Operating mode selection for the function. Operation can be either disabled "Off" or enabled "On".
Min. operate voltage	10…100 %	1 %	60 %	Minimum voltage threshold for detecting the live line status. All measured phase to ground voltages have to be under this setting level.

Parameter	Setting value/ range	Step	Default	Description
Min. operate current	8…100 %	1 %	10 %	Minimum current threshold for detecting the dead line status. If all the phase to ground voltages are under the setting "Min. operate voltage" and also all the phase currents are under the "Min. operate current" setting the line status is considered "Dead".

8.2.4 Voltage transformer supervision (VTS)

The voltage transformer supervision function generates a signal to indicate an error in the voltage transformer secondary circuit. This signal can serve, for example, a warning, indicating disturbances in the measurement, or it can disable the operation of the distance protection function if appropriate measured voltage signals are not available for a distance decision.

The voltage transformer supervision function is designed to detect faulty asymmetrical states of the voltage transformer circuit caused, for example, by a broken conductor in the secondary circuit. The voltage transformer supervision function can be used for either tripping or alarming purposes.

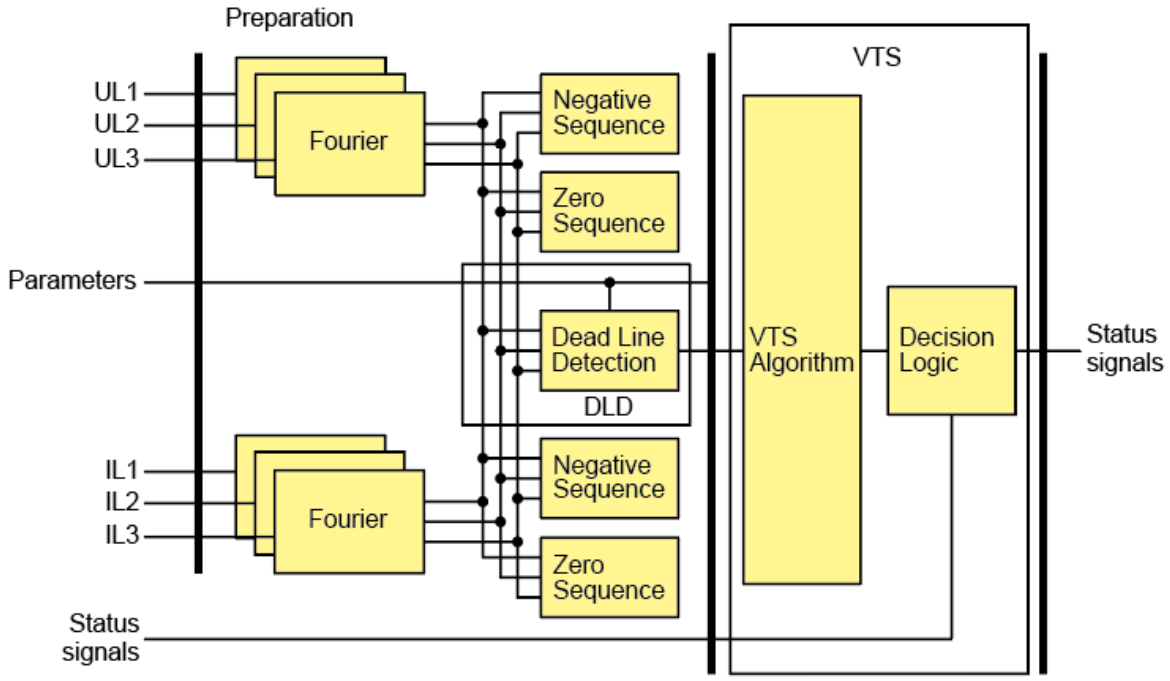
The voltage transformer supervision function can be used in three different modes of application:

- Zero sequence detection (for typical applications in systems with grounded neutral): “VT failure” signal is generated if the residual voltage (3Uo) is above the preset voltage value AND the residual current (3Io) is below the preset current value.
- Negative sequence detection (for typical applications in systems with isolated or resonant grounded (Petersen) neutral): “VT failure” signal is generated if the negative sequence voltage component (U2) is above the preset voltage value AND the negative sequence current component (I2) is below the preset current value.
- Special application: “VT failure” signal is generated if the residual voltage (3Uo) is above the preset voltage value AND the residual current (3Io) AND the negative sequence current component (I2) are below the preset current values.

The voltage transformer supervision function can be triggered if “Live line” status is detected for at least 200 ms. The purpose of this delay is to avoid mal-operation at line energizing if the poles of the circuit breaker make contact with a time delay. The function is set to be inactive if “Dead line” status is detected. If the conditions specified by the selected mode of operation are fulfilled then the voltage transformer supervision function is triggered and the operation signal is generated. When the conditions for operation are no longer fulfilled, the resetting of the function depends on the mode of operation of the primary circuit:

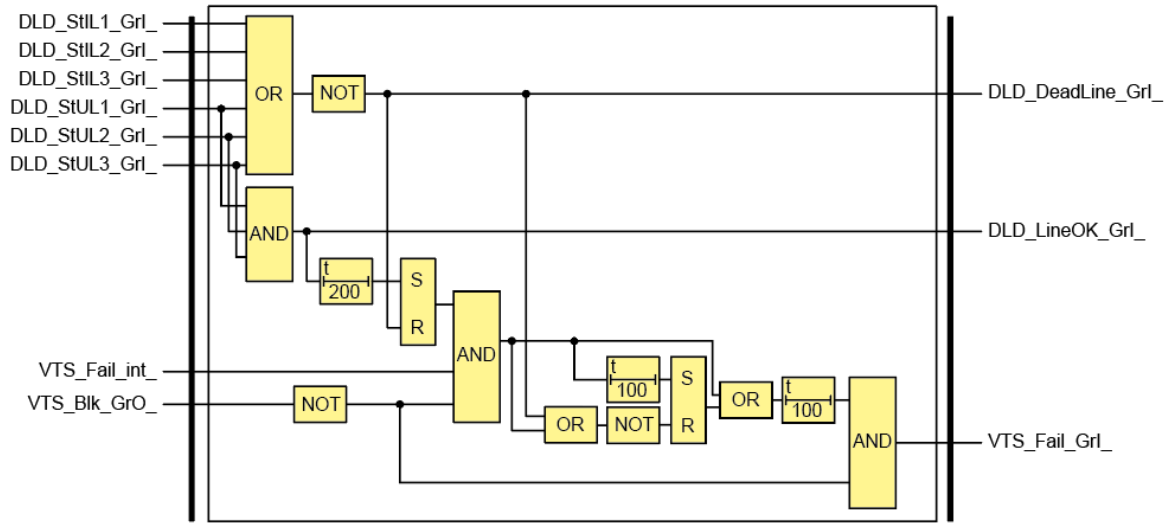
- If the “Live line” state is valid, then the function resets after approx. 200 ms of time delay.
- If the “Dead line” state is started and the “VTS Failure” signal has been continuous for at least 100 ms, then the “VTS failure” signal does not reset; it is generated continuously even when the line is in a disconnected state. Thus, the “VTS Failure” signal remains active at reclosing.
- If the “Dead line” state is started and the “VTS Failure” signal has not been continuous for at least 100 ms, then the “VTS failure” signal resets.

Figure. 8.2.4 - 41. Operation logic of the voltage transformer supervision and dead line detection.



The voltage transformer supervision logic operates through decision logic presented in the following figure.

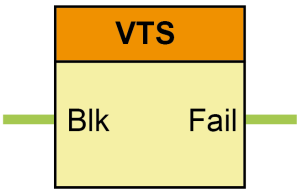
Figure. 8.2.4 - 42. Decision logic of the voltage transformer supervision function.



NOTICE!
For the operation of the voltage transformer supervision function the " Dead line detection function" must be operable as well: it must be enabled by binary parameter.

The function block of voltage transformer supervision function is shown in figure below. This block shows all binary input and output status signals that are applicable in the graphic equation editor.

Figure. 8.2.4 - 43. The function block of the voltage transformer supervision function.



The binary input and output status signals of voltage transformer supervision function are listed in tables below.

Table. 8.2.4 - 22. The binary input and output signals of the VTS function.

Binary status signal	Title	Explanation
VTS_Blk_GrO_	-	Output status defined by the user to disable the voltage transformer supervision function
VTS_Fail_GrI_	VT Failure	Failure status signal of the VTS function

Table. 8.2.4 - 23. Setting parameters of the VTS function.

Parameter	Setting value/ range	Step	Default	Description
Operation	Off Neg. Sequence Zero sequence Special	-	Neg. Sequence	Operating mode selection for the function. Operation can be either disabled "Off" or enabled with criteria "Neg. Sequence", "Zero sequence" or "Special".
Start URes	5…50 %	1 %	30 %	Residual voltage setting limit.
Start IRes	10…50 %	1 %	10 %	Residual current setting limit.
Start UNeg	5…50 %	1 %	10 %	Negative sequence voltage setting limit.
Start INeg	10…50 %	1 %	10 %	Negative sequence current setting limit.

8.2.5 Synchrocheck (dV/da/df; 25)

Several problems can occur in the power system if the circuit breaker closes and connects two systems operating asynchronously. The high current surge can cause damage in the interconnecting elements, the accelerating forces can overstress the shafts of rotating machines or the actions taken by the protective system can result in the eventual isolation of parts of the power system.

To prevent such problems, this function checks if the systems to be interconnected are operating synchronously. If yes, then the close command is transmitted to the circuit breaker. In case of asynchronous operation, the close command is delayed to wait for the appropriate vector position of the voltage vectors on both sides of the circuit breaker. If the conditions for safe closing cannot be fulfilled within an expected time, then closing is declined.

NOTICE!
For capacitive reference voltage measurement, the voltage measurement card can be ordered with <50 mVA burden special input.

The conditions for safe closing are as follows:

- The difference of the voltage magnitudes is below the set limit.
- The difference of the frequencies is below the set limit.
- The angle difference between the voltages on both sides of the circuit breaker is within the set limit.

The function processes both automatic reclosing and manual close commands.

The limits for automatic reclosing and manual close commands can be set independently of each other.

The function compares the voltage of the line and the voltage of one of the busbar sections (Bus1 or Bus2). The bus selection is made automatically based on a binary input signal defined by the user.

For the reference of the synchrocheck any phase-to-ground or phase-to-phase voltage can be selected.

The function processes the signals of the voltage transformer supervision function and enables the close command only in case of plausible voltages.

The synchrocheck function monitors three modes of conditions:

- Energizing check:
    - Dead bus, live line
    - Live bus, dead line
    - Any Energizing case (including Dead bus, dead line)
- Synchro check (Live line, live bus)
- Synchro switch (Live line, live bus)

If the conditions for “Energizing check” and “Synchro check” are fulfilled, then the function generates the release command, and in case of a manual or automatic close request, the close command is generated.

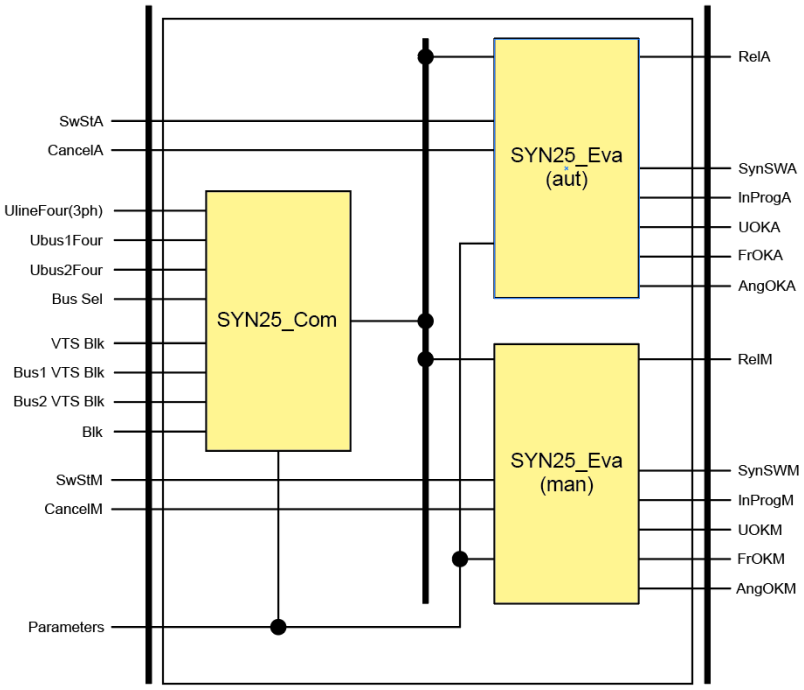
If the conditions for energizing and synchronous operation are not met when the close request is received, then synchronous switching is attempted within the set time-out. In this case, the rotating vectors must fulfill the conditions for safe switching within the set waiting time: at the moment the contacts of the circuit breaker are closed, the voltage vectors must match each other with appropriate accuracy. For this mode of operation, the expected operating time of the circuit breaker must be set as a parameter value, to generate the close command in advance taking the relative vector rotation into consideration.

Started closing procedure can be interrupted by a cancel command defined by the user.

In “bypass” operation mode, the function generates the release signals and simply transmits the close command.

In the following figure is presented the operating logic of the synchrocheck function.

Figure. 8.2.5 - 44. Operation logic of the synchrocheck function.



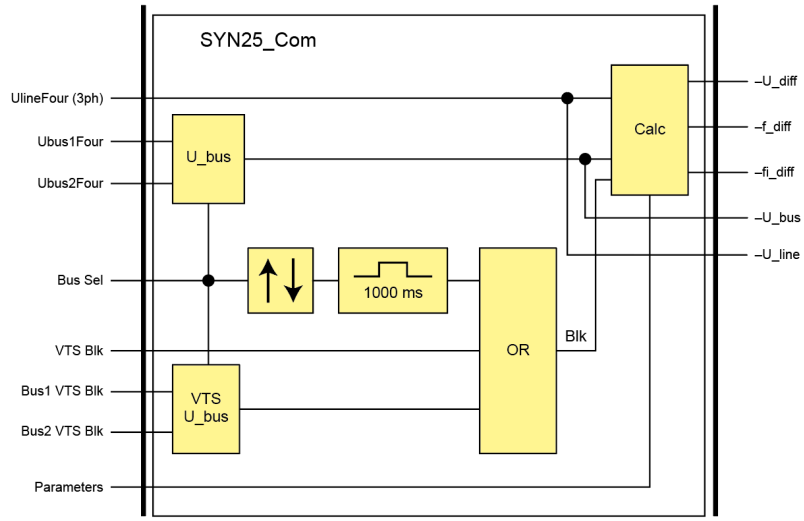
The synchro check/synchro switch function contains two kinds of software blocks:

- SYN25_Com = a common block for manual switching and automatic switching.
- SYN25_EVA = an evaluation block, duplicated for manual switching and for automatic switching.

The SYN25_Com block selects the appropriate voltages for processing and calculates the voltage difference, the frequency difference and the phase angle difference between the selected voltages. The magnitude of the selected voltages is passed for further evaluation.

These values are further processed by the evaluation software blocks. The function is disabled if the binary input (Block) signal is TRUE. The activation of voltage transformer supervision function of the line voltage blocks the operation (VTS Block). The activation of voltage transformer supervision function of the selected bus section blocks the operation (VTS Bus1 Block or VTS Bus2 Block).

Figure. 8.2.5 - 45. Synchrocheck common difference calculation function structure.

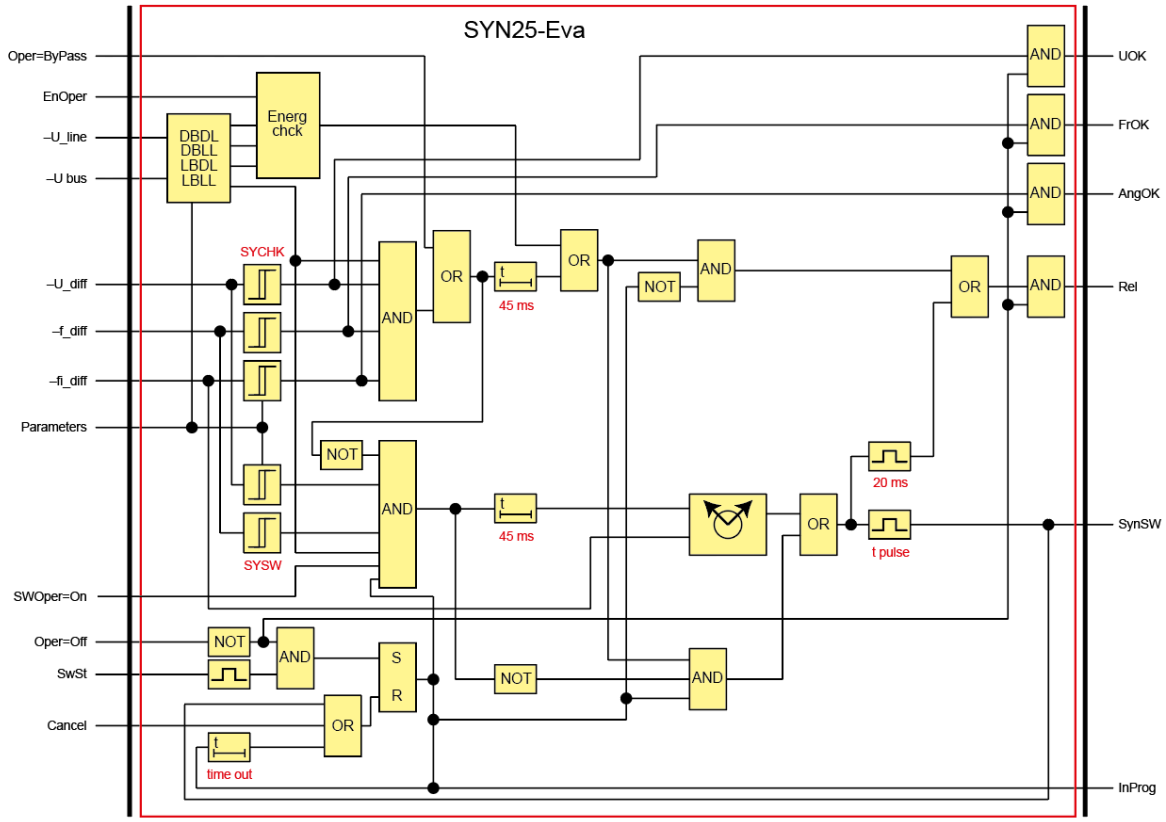


If the active bus section changes the function is dynamically blocked for 1000ms and no release signal or switching command is generated. The processed line voltage is selected based on the preset parameter (Voltage select). The choice is: L1-N, L2-N, L3-N, L1-L2,L2-L3 or L3-L1. The parameter value must match the input voltages received from the bus sections. The active bus section is selected by the input signal (Bus select). If this signal is logic TRUE, then the voltage of Bus2 is selected for evaluation.

The software block SYN25_Eva is applied separately for automatic and manual commands. This separation allows the application to use different parameter values for the two modes of operation.

The structure of the evaluation software block is shown in the following figure.

Figure. 8.2.5 - 46. Synchrocheck evaluation function structure.



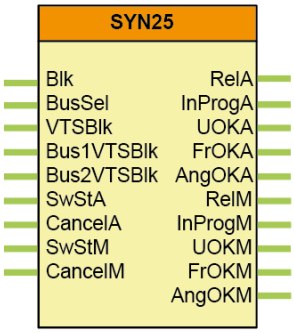
This evaluation software block is used for two purposes: for the automatic reclosing command (the signal names have the suffix “A”) and for the manual close request (the signal names have the suffix “M”). As the first step, based on the selected line voltage and bus voltage, the state of the required switching is decided (Dead bus-Dead line, Dead bus-Live line, Live bus-Dead line or Live bus- Live line). The parameters for decision are (U Live) and (U Dead). The parameters (Energizing Auto/Manual) enable the operation individually. The choice is: (Off, DeadBus LiveLine, LiveBus DeadLine, Any energ case). In simple energizing modes, no further checking is needed. This mode selection is bypassed if the parameter (Operation Auto/Manual) is set to “ByPass”. In this case the command is transmitted without any further checking.

First, the function tries switching with synchro check. This is possible if: the voltage difference is within the defined limits (Udiff SynChk Auto/Manual)) the frequency difference is within the defined limits (FrDiff SynChk Auto) and the phase angle difference is within the defined limits (MaxPhaseDiff Auto/Manual)).

If the conditions are fulfilled for at least 45 ms, then the function generates a release output signal (Release Auto/Manual).If the conditions for synchro check operation are not fulfilled and a close request is received as the input signal (SySwitch Auto/Manual), then synchro switching is attempted. This is possible if: the voltage difference is within the defined limits (Udiff SynSW Auto /Manual)) the frequency difference is within the defined limits (FrDiff SynSW Auto).

These parameters are independent of those for the synchro check function. If the conditions for synchro check are not fulfilled and the conditions for synchro switch are OK, then the relative rotation of the voltage vectors is monitored. The command is generated before the synchronous position, taking the breaker closing time into consideration (Breaker Time).The pulse duration is defined by the parameter (Close Pulse). In case of slow rotation and if the vectors are for long time near-opposite vector positions, no switching is possible, therefore the waiting time is limited by the preset parameter (Max.Switch Time).

Figure. 8.2.5 - 47. The function block of the synchrocheck/synchroswitch function.



The progress is indicated by the output status signal (SynInProgr Auto/Manual). The started command can be canceled using the input signal (Cancel Auto/Manual).

The binary input and output status signals of the dead line detection function are listed in tables below.

Table. 8.2.5 - 24. The binary input signals.

Binary status signal	Title	Explanation
SYN25_BusSel_GrO_	Bus Select	If this signal is logic TRUE, then the voltage of Bus2 is selected for evaluation.
SYN25_VTSBlk_GrO_	VTS Block	Blocking signal of the voltage transformer supervision function evaluating the line voltage.
SYN25_Bus1VTSBlk_GrO_	VTS Bus1 Block	Blocking signal of the voltage transformer supervision function evaluating the Bus1 voltage.
SYN25_Bus2VTSBlk_GrO_	VTS Bus2 Block	Blocking signal of the voltage transformer supervision function evaluating the Bus2 voltage.
SYN25_SwStA_GrO_	SySwitch Auto	Switching request signal initiated by the automatic reclosing function.
SYN25_CancelA_GrO_	Cancel Auto	Signal to interrupt (cancel) the automatic switching procedure.
SYN25_Blk_GrO_	Block	Blocking signal of the function.
SYN25_SwStM_GrO_	SySwitch Manual	Switching request signal initiated by manual closing.

Binary status signal	Title	Explanation
SYN25_CancelM_GrO_	Cancel Manual	Signal to interrupt (cancel) the manual switching procedure.

Table. 8.2.5 - 25. The binary output signals.

Binary status signal	Title	Explanation
SYN25_RelA_Grl_	Release Auto	Releasing the close command initiated by the automatic reclosing function.
SYN25_InProgA_Grl_	SynInProgr Auto	Switching procedure is in progress, initiated by the automatic reclosing function.
SYN25_UOKA_Grl_	Udiff OK Auto	The voltage difference is appropriate for automatic closing command.
SYN25_FrOKA_Grl_	FreqDiff OK Auto	The frequency difference is appropriate for automatic closing command, evaluated for synchrocheck.
SYN25_AngOKA_Grl_	Angle OK Auto	The angle difference is appropriate for automatic closing request.
SYN25_RelM_Grl_	Release Man	Releasing the close command initiated by manual closing request.
SYN25_InProgM_Grl_	SynInProgr Man	Switching procedure is in progress, initiated by the manual closing command.
SYN25_UOKM_Grl_	Udiff OK Man	The voltage difference is appropriate for automatic closing command.
SYN25_FrOKM_Grl_	FreqDiff OK Man	The frequency difference is appropriate for manual closing command, evaluated for synchrocheck.
SYN25_AngOKM_Grl_	Angle OK Man	The angle difference is appropriate for manual closing command.

Table. 8.2.5 - 26. Setting parameters.

Parameter	Setting value/ range	Step	Default	Description
Voltage select	L1-N L2-N L3-N L1-L2 L2-L3 L3-L1	-	L1-N	Reference voltage selection. The function will monitor the selected voltage for magnitude, frequency and angle differences.
U Live	60…110 %	1 %	70 %	Voltage setting limit for "Live Line" detection. When measured voltage is above the setting value the line is considered "Live".
U Dead	10…60 %	1 %	30 %	Voltage setting limit for "Dead line" detection. When measured voltage is below the setting value the line is considered "Dead".

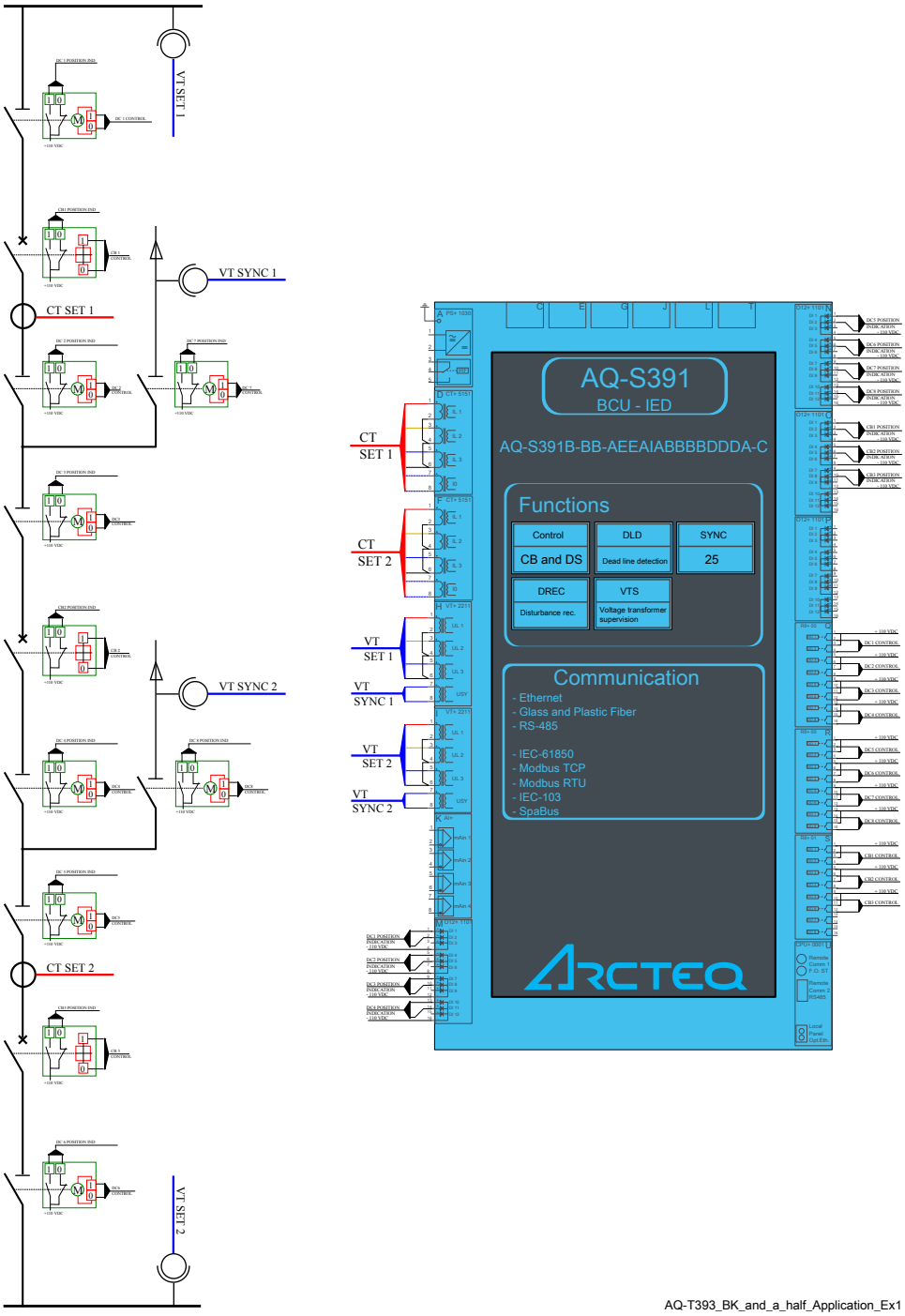
Parameter	Setting value/ range	Step	Default	Description
Breaker Time	0…500 ms	1 ms	80 ms	Breaker operating time at closing. This parameter is used for the synchroswitch closing command compensation and it describes the breaker travel time from open position to closed position from the close command.
Close Pulse	10…60 000 ms	1 ms	1 000 ms	Close command pulse length. This setting defines the duration of close command from the IED to the circuit breaker.
Max Switch Time	100…60 000 ms	1 ms	2 000 ms	Maximum allowed switching time. In case synchrocheck conditions are not fulfilled and the rotation of the networks is slow this parameter defines the maximum waiting time after which the close command is failed.
Operation Auto	On Off ByPass	-	On	Operation mode for automatic switching. Selection can be automatic switching off, on or bypassed. If the Operation Auto is set to "Off" automatic switch checking is disabled. If selection is "ByPass" Automatic switching is enabled with bypassing the bus and line energization status checking. When the selection is "On" also the energization status of bus and line are checked before processing the command.
SynSW Auto	On Off	-	On	Automatic synchroswitching selection. Selection may be enabled "On" or disabled "Off".
Energizing Auto	Off DeadBus LiveLine LiveBus DeadLine Any energ case	-	DeadBus LiveLine	Energizing mode of automatic synchroswitching. Selections consist of the monitoring of the energization status of the bus and line. If the operation is wanted to be LiveBus LiveLine or DeadBus DeadLine, the selection is "Any energ case".
Udiff SynChk Auto	5…30 %	1 %	10 %	Voltage difference checking of the automatic synchrocheck mode. If the measured voltage difference is below this setting the condition applies.
Udiff SynSW Auto	5…30 %	1 %	10 %	Voltage difference checking of the automatic synchroswitch mode. If the measured voltage difference is below this setting the condition applies.
MaxPhasediff Auto	5…80 deg	1 deg	20 deg	Phase difference checking of the automatic synchroswitch mode. If the measured phase difference is below this setting the condition applies.
FrDiff SynChk Auto	0.02…0.50 Hz	0.01 Hz	0.02 Hz	Frequency difference checking of the automatic synchrocheck mode. If the measured phase difference is below this setting the condition applies.
FrDiff SynSW Auto	0.10…1.00 Hz	0.01 Hz	0.2 Hz	Frequency difference checking of the automatic synchroswitch mode. If the measured phase difference is below this setting the condition applies.
Operation Man	On Off ByPass	-	On	Operation mode for manual switching. Selection can be manual switching off, on or bypassed. If the Operation Man is set to "Off" manual switch checking is disabled. If selection is "ByPass" manual switching is enabled with bypassing the bus and line energization status checking. When the selection is "On" also the energization status of bus and line are checked before processing the command.

Parameter	Setting value/ range	Step	Default	Description
SynSW Man	On Off	-	On	Manual synchroswitching selection. Selection may be enabled "On" or disabled "Off".
Energizing Man	Off Deadbus LiveLine LiveBus DeadLine Any energ case	-	DeadBus LiveLine	Energizing mode of manual synchroswitching. Selections consist of the monitoring of the energization status of the bus and line. If the operation is wanted to be LiveBus LiveLine or DeadBus DeadLine the selection is "Any energ case".
Udiff SynChk Man	5…30 %	1 %	10 %	Voltage difference checking of the manual synchrocheck mode. If the measured voltage difference is below this setting the condition applies.
Udiff SynSW Man	5…30 %	1 %	10 %	Voltage difference checking of the manual synchroswitch mode. If the measured voltage difference is below this setting the condition applies.
MaxPhaseDiff Man	5…80 deg	1 deg	20 deg	Phase difference checking of the manual synchroswitch mode. If the measured phase difference is below this setting the condition applies.
FrDiff SynChk Man	0.02…0.50 Hz	0.01 Hz	0.02 Hz	Frequency difference checking of the manual synchroswitch mode. If the measured phase difference is below this setting the condition applies.
FrDiff SynSW Man	0.10…1.00 Hz	0.01 Hz	0.2 Hz	Frequency difference checking of the manual synchroswitch mode. If the measured phase difference is below this setting the condition applies.

9 Application examples

One and a half circuit breaker configuration

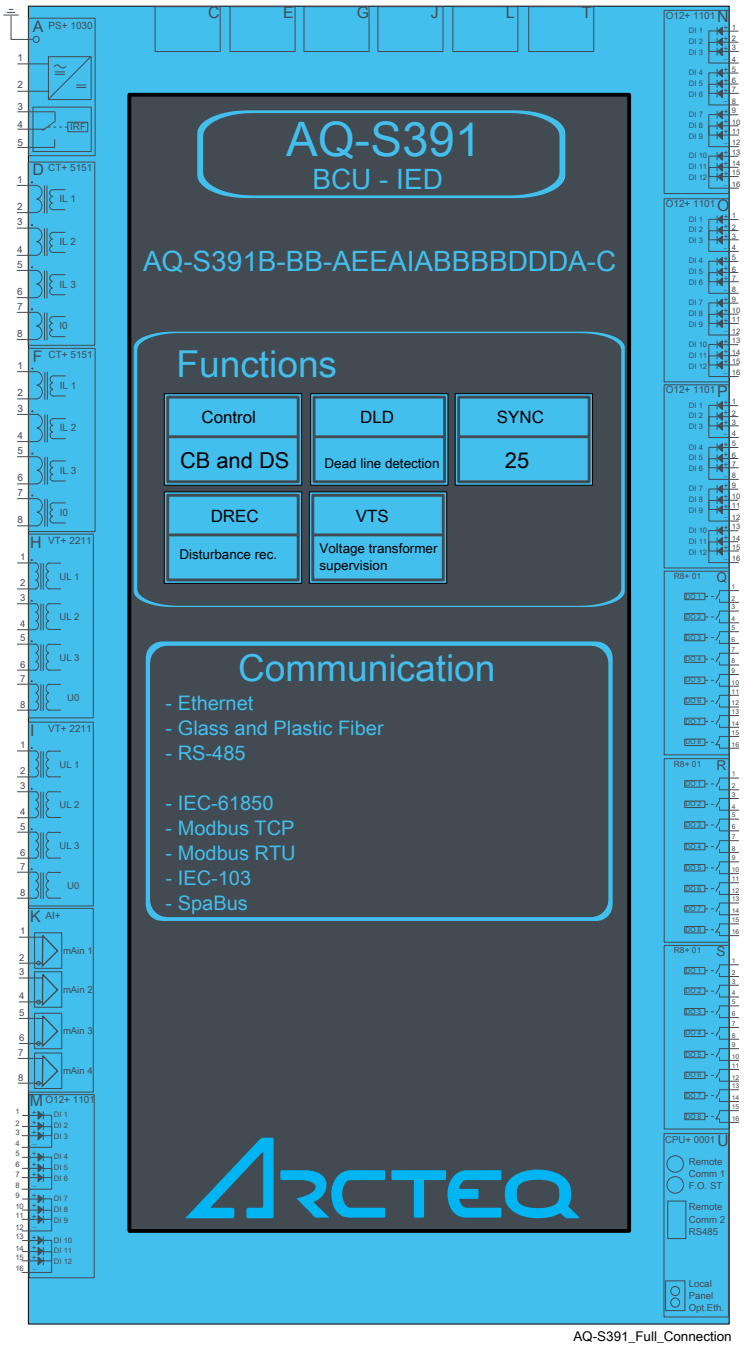
Figure. 9 - 48. Application example of a one-and-a-half circuit breaker configuration.



AQ-T393_BK_and_a_half_Application_Ex1

IED IO positions in one and a half circuit breaker configuration

Figure. 9 - 49. Application example of the IO positions in a one-and-a-half circuit breaker configuration.



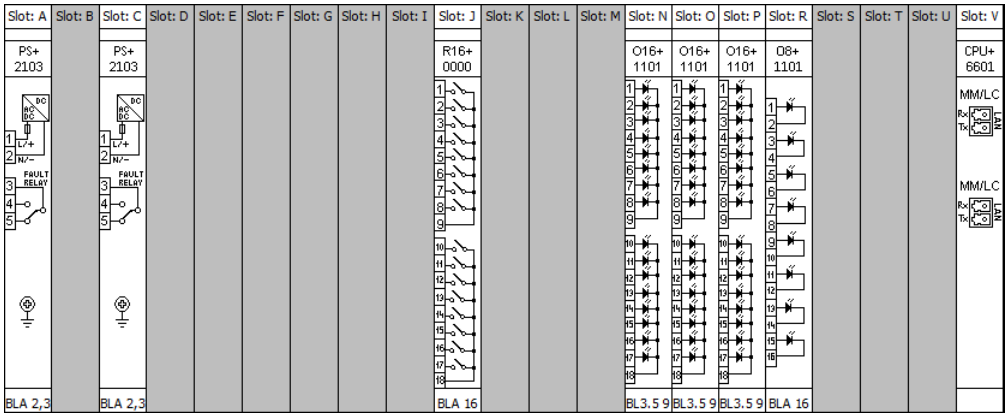
AQ-S391_Full_Connection

10 Construction and installation

10.1 Construction

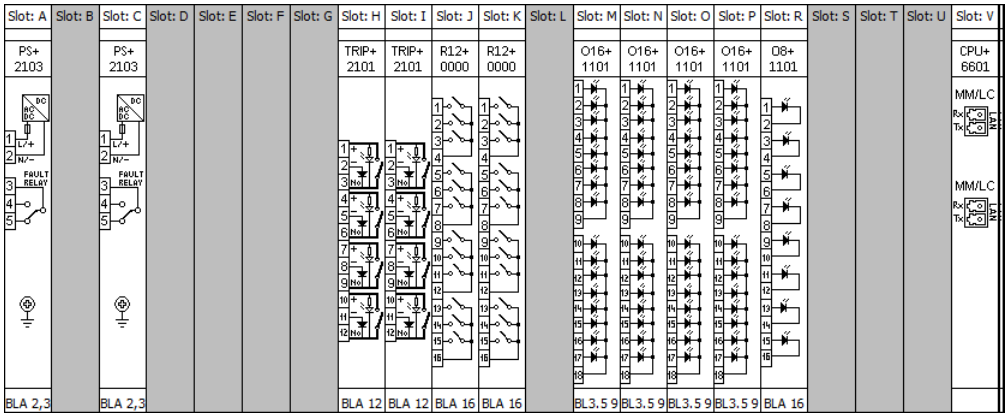
The AQ-S391 bay control IED consists of hardware modules. Due to modular structure optional positions for the slots can be user defined in the ordering of the IED to include I/O modules and other types of additional modules. An example module arrangement configuration of AQ-S391 is shown in the figure below. Visit https://configurator.arcteq.fi/ to see all of the available options.

Figure. 10.1 - 50. An example module arrangement configuration for the AQ-S391 IED.



Example above presents a simple hardware configuration with redundant power supplies (PS+2103), signaling binary outputs (R16+0000), binary input cards (O16+1101 and O8+1101) and 100Base-FX Ethernet MM/LC communication card (CPU+6601).

Figure. 10.1 - 51. An example module arrangement configuration for the AQ-S391 IED.

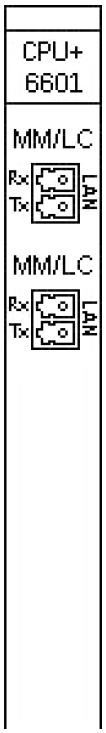


Example above presents a simple hardware configuration with redundant power supplies (PS+2103), trip contacts (TRIP+101), signaling binary outputs (R12+0000), binary input cards (O16+1101 and O8+1101) and 100Base-FX Ethernet MM/LC communication card (CPU+6601).

Following chapters describe the cards in more detail.

10.2 CPU module

Figure. 10.2 - 52. Communication card with 100Base-FX Ethernet MM/LC 1300 nm, 50/62.5/125 µm connector, (up to 2 km) fiber.



The CPU module contains all the protection, control and communication functions of the AQ-300 device. Dual 500 MHz high-performance Analog Devices Blackfin processors separate relay functions (RDSP) from communication and HMI functions (CDSP). Reliable communication between processors is performed via high-speed synchronous serial internal bus (SPORT). Each processor has its own operative memory such as SDRAM and non-volatile flash memories for configuration, parameter and firmware storage. The firmwares are stored in a dedicated flash memory independent from the disturbance recorder and event storage. CDSP's operating system (uClinux) utilizes a robust JFFS flash file system, which enables fail-safe operation and the storage of disturbance record files, configuration and parameters.

The RDSP core runs at 500 MHz and its external bus speed is 125 MHz. The backplane data speed is limited to approx. 20 MHz, which is more than enough for module data throughput. An additional logic element (CPLD and SRAM) is used as a bridge between the RDSP and the backplane. The CPLD collects analogue samples from CT/VT modules and also controls signaling outputs and inputs.

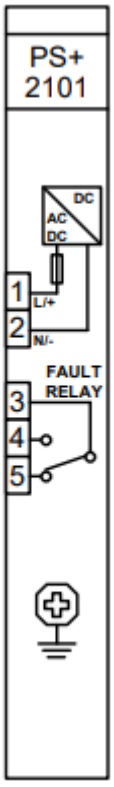
After power-up the RDSP processor starts up with the previously saved configuration and parameters. Generally, the power-up procedure for the RDSP and relay functions takes only a few seconds. That is to say, it is ready to trip within this time. CDSP's start-up procedure is longer because its operating system needs time to build its file system, initializing user applications such as HMI functions and the IEC 61850 software stack.

HMI and communication tasks

- Embedded WEB-server:
    - Firmware upgrade possibility
    - Modification of user parameters
    - Events list and disturbance records
    - Password management
    - Online data measurement
    - Commands
    - Administrative tasks
- Front panel TFT display handling: the interactive menu set is available throughthe TFT and the touchscreen interface
- User keys: capacitive touch keys on front panel
- The built-in 5-port Ethernet switch allows AQ-300 to connect to IP/Ethernet-based networks. The following Ethernet ports are available:
    - Station bus (100Base-FX Ethernet) SBW
    - Redundant station bus (100Base-FX Ethernet)SBR
    - Process bus (100Base-FX Ethernet)
    - EOB or EOB2 (Ethernet Over Board) or RJ-45 Ethernet user interface onfront panel
    - Optional 10/100Base-T port via RJ-45 connector
- PRP/HSR seamless redundancy for Ethernet networking (100Base-FXEthernet)
- Other communication:
    - RS422/RS485 interfaces (galvanic interface to support legacy or otherserial protocols, ASIF)
    - Plasticor glass fiber interfaces to support legacy protocols, ASIF
    - Proprietary process bus communication controller on COM+ module
    - Telecommunication interfaces: G.703, IEEE C37.94

10.3 Power supply module

Figure. 10.3 - 53. Power supply module connections.



The power supply module converts primary AC and/or DC voltage to required system voltages. In most applications, one power supply module is sufficient to provide the required power to the system. Redundant power supply modules extend system availability in case of the outage of any power source.

NOTICE!
Depending on the hardware configuration, the power consumption of the devices can be different. We reserve the right to make the decision about which PS+ module must be used. For most applications where the power consumption does not reach 30 W we use one of our 4HP wide PS+ modules.

Table. 10.3 - 27. Hardware data.

Module type	PS+ 2101
Nominal voltage	110 V DC / 220 V DC
Input voltage range	88…264 V DC 88…250 V AC
Nominal power	20 W
Input voltage interruption time (at nominal load)	Min. 100 ms in the specified input voltage range
Internal fuse	3.15 A / 250 V
Connector type	Power connector: - Receptacle: Weidmüller SLA 2/90 - Plug: Weidmüller BLA 2/180 Fault relay connector: Receptacle: Weidmüller 3/90 Plug: Weidmüller BLA 3/180

Main features:

- Fault relay contacts (NC and NO): device fault contact and also assignable to user functions. All the three relay contact points are accessible to users.
- Redundant applications (nominal power and reliability can be increased byusing parallel power supplies)
- On-board self-supervisory circuits: temperature and voltage monitors
- Short-circuit-protected outputs
- Efficiency: > 70 %, power consumption = nominal power / efficiency
- Passive heatsink
- Early power failure indication signals to the CPU the possibility of power outage, thus the CPU has enough time to save the necessary data to non-volatile memory
- Inrush current (until 0.1 s): < 10 A for all types excluding PS+4401 which has <21 A inrush current
- Common features for internal fuses:
    - 5 mm x 20 mm (0.20" x 0.79")
    - TT characteristics (very inverse time-lag)
    - 35 A at 250 V AC rated breaking capacity
- Recommended external protection: miniature circuit breaker, 6 A (C char.)

10.4 Binary input module(s)

The inputs are galvanic isolated and the module converts high-voltage signals to the voltage level and format of the internal circuits.

Table. 10.4 - 28. Hardware data for the different O8 module types.

Module type	O8+2401	O8+4801	O8+1101	O8+2201
Number of channels	8	8	8	8
Time synchronization	Configured via AQtivate 300	Configured via AQtivate 300	Configured via AQtivate 300	Configured via AQtivate 300
Rated voltage	24 V	48 V	110 V	220 V
Thermal withstand voltage	72 V	100 V	250 V	320 V
Clamp voltage	Falling 0.64 Un Rising 0.8 Un	Falling 0.64 Un Rising 0.8 Un	Falling 0.64 Un Rising 0.8 Un	Falling 0.64 Un Rising 0.8 Un
Grounding groups	Independent	Independent	Independent	Independent
Connector type	Receptacle: Weidmüller SLA 16/90 Plug: Weidmüller BLA 16/180			

Table. 10.4 - 29. Hardware data for the different O12 module types.

Module type	O12+2401	O12+4801	O12+1101	O12+2201
Number of channels	12	12	12	12
Time synchronization	Configured via AQtivate 300	Configured via AQtivate 300	Configured via AQtivate 300	Configured via AQtivate 300
Rated voltage	24 V	48 V	110 V	220 V
Thermal withstand voltage	72 V	100 V	250 V	320 V
Clamp voltage	Falling 0.64 Un Rising 0.8 Un	Falling 0.64 Un Rising 0.8 Un	Falling 0.64 Un Rising 0.8 Un	Falling 0.64 Un Rising 0.8 Un
Grounding groups	4×3 (common ground)	4×3 (common ground)	4×3 (common ground)	4×3 (common ground)
Connector type	Receptacle: Weidmüller SLA 16/90 Plug: Weidmüller BLA 16/180			

Table. 10.4 - 30. Hardware data for the different O16 module types.

Module type	O16+2401	O16+4801	O16+1101	O16+2201
Number of channels	16	16	16	16

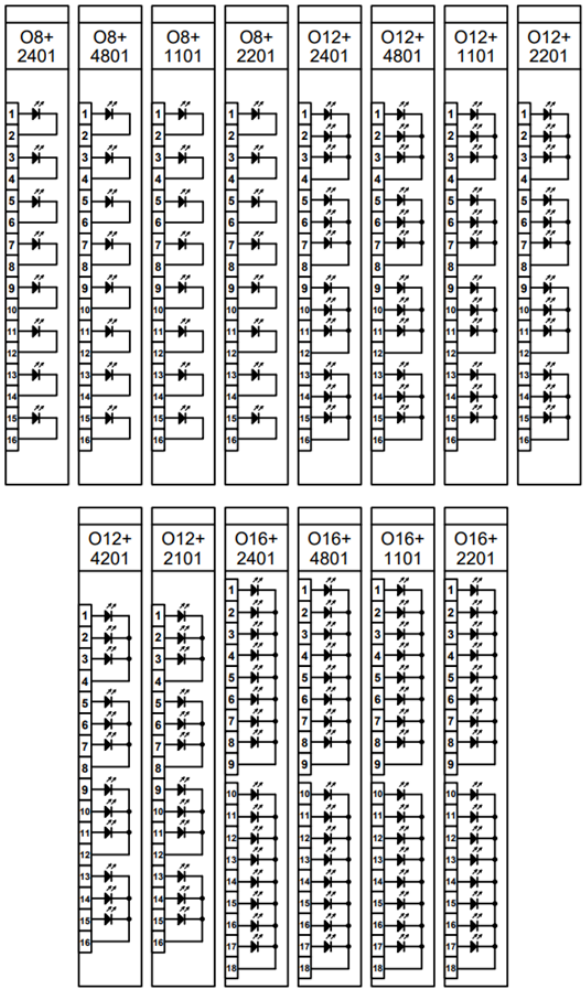
Module type	O16+2401	O16+4801	O16+1101	O16+2201
Time synchronization	Configured via AQtivate 300	Configured via AQtivate 300	Configured via AQtivate 300	Configured via AQtivate 300
Rated voltage	24 V	48 V	110 V	220 V
Thermal withstand voltage	72 V	100 V	250 V	320 V
Clamp voltage	Falling 0.64 Un Rising 0.8 Un	Falling 0.64 Un Rising 0.8 Un	Falling 0.64 Un Rising 0.8 Un	Falling 0.64 Un Rising 0.8 Un
Grounding groups	2×8 (common ground)	2×8 (common ground)	2×8 (common ground)	2×8 (common ground)
Connector type	Receptacle: Weidmüller SLA 16/90 Plug: Weidmüller BLA 16/180			

Thermal withstand voltage: continuous with 60 % of the input channels are energized.

Main features:

- Digitally filtered per channel
- Current drain:
    - max. 1.6 mA per channel at 220 V DC
    - max. 1.8 mA per channel at 110 V DC
    - max. 2 mA per channel at 48 V DC
    - max. 3 mA per channel at 24 V DC
- In such applications where the input voltage is 60 V the modules with 48 V rated voltage can be used.
- Input voltage type can be either DC or AC voltage. If AC voltage is used make sure that the type and the parameters of the binary inputs are configured properly in AQtivate 300 tool.

Figure. 10.4 - 54. Binary input modules.



10.5 Binary output module(s)

The signaling module has 4, 8, 12 or 16 relay outputs with dry contacts.

Table. 10.5 - 31. Hardware data for the R4 module type.

Module type	R4+01
Rated voltage	250 V AC/DC
Continuous carry	8 A
Contact version	4 NO
Grounding groups	4 independent
Connector type	Receptacle: Weidmüller SLA 12/90 Plug: Weidmüller BLA 12/180

Table. 10.5 - 32. Hardware data for the different R8 module types.

Module type	R8+00	R8+80	R8+C0
Rated voltage	250 V AC/DC	250 V AC/DC	250 V AC/DC
Continuous carry	8 A	8 A	8 A
Contact version	8 NO	7 NO 1 NC (channel 8)	6 NO 2 NC (channels 7 and 8)
Grounding groups	4 independent	8 independent	8 independent
Connector type	Receptacle: Weidmüller SLA 16/90 Plug: Weidmüller BLA 16/180		

NOTICE!
Please note that module R8+C0 is a special module, and it is available only for special configurations.

Table. 10.5 - 33. Hardware data for the different R12 module types.

Module type	R12+0000	R12+4000
Rated voltage	250 V AC/DC	250 V AC/DC
Continuous carry	8 A	8 A
Contact version	12 NO	11 NO 1 NC (channel 12)
Grounding groups	4×3 (common)	4×3 (common)
Connector type	Receptacle: Weidmüller SLA 16/90 Plug: Weidmüller BLA 16/180	

Table. 10.5 - 34. Hardware data for the different R16 module types.

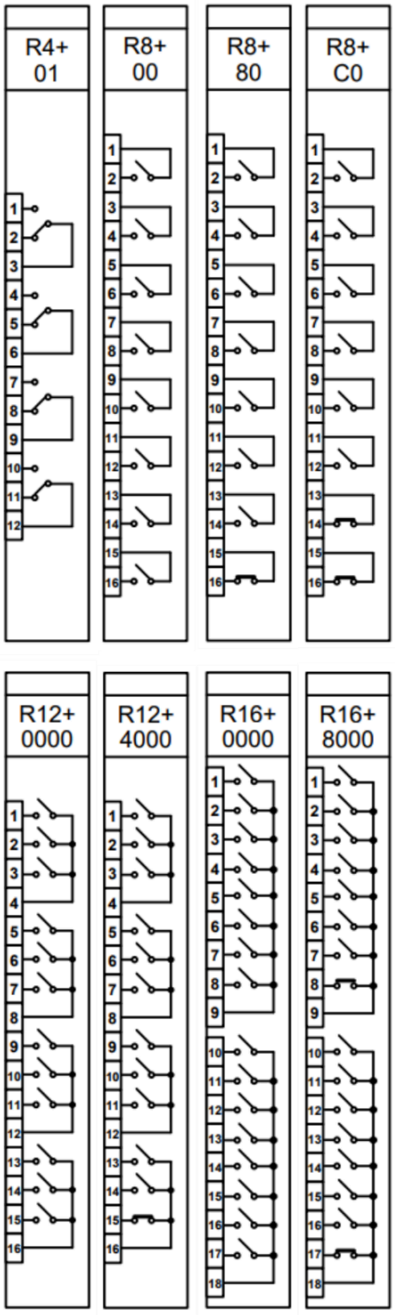
Module type	R16+0000	R16+8000
Rated voltage	250 V AC/DC	250 V AC/DC
Continuous carry	8 A	8 A
Contact version	16 NO	15 NO 1 NC (channel 16)
Grounding groups	2×8 (common)	2×8 (common)
Connector type	Receptacle: 2 × Weidmüller SL 3.5/9/90 Plug: 2 × Weidmüller BL 3.5/9/180	

Main features (according to IEC 61255-26):

- Maximum switching voltage: 400 V AC
- Breaking capacity (L/R = 40 ms):
- at 220 V DC: 0.2 A
- at 110 V DC: 0.3 A

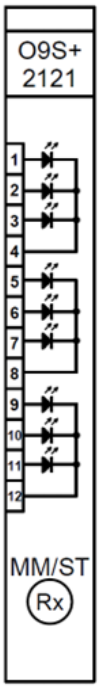
- Breaking capacity max.: 2000 VA
- Short time carrying capacity: 1 s, 35 A
- Limiting making current, max. 4 s: 15 A (df = 10 %)
- Initial dielectric strength between open contacts, 1 min: 1000 VRMS
- Mechanical endurance: 10 × 106 cycles
- Circuit closing capability: typically 10 ms, maximally 22 ms, with SSR 0.5 ms
- Bounce time: typically 6,5 ms, maximally 10 ms, with SSR 0.5 ms
- Minimal switching requirement: 5 V.

Figure. 10.5 - 55. Binary output modules.



10.6 9DI + BNC IRIG-B

Figure. 10.6 - 56. The O9S+2121 module.



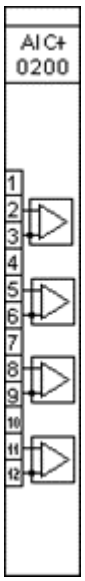
The inputs are galvanic isolated and the module converts high-voltage signals to the voltage level and format of the internal circuits. This module is also used as an external IRIG-B synchronization (IRIG-B000, unmodulated), PPM or PPS input. Dedicated synchronization input is used for this purpose.

Main features for binary inputs:

- Digitally filtered per channel
- Current drain:
    - max. 1.6 mA per channel at 220 V DC
    - max. 1.8 mA per channel at 110 V DC
    - max. 2 mA per channel at 48 V DC
    - max. 3 mA per channel at 24 V DC
- In such applications where the input voltage is 60 V the modules with 48 V rated voltage can be used.
- Input voltage type can be either DC or AC voltage. If AC voltage is used make sure that the type and the parameters of the binary inputs are configured properly in AQtivate300 tool.

10.7 Milliampere module

Figure. 10.7 - 57. The milliampere (mA) input module AIC +0200.



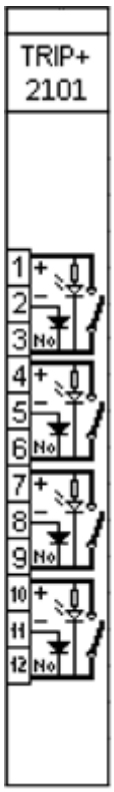
The analog input module accepts transducers current outputs. The AIC module can measure unipolar and bipolar current values in wide ranges.

Main features:

- Number of channels: 4
- Measurement method: 2 wire inputs with optional 15V excitation
- Relative accuracy: ± 0.5 % ± 1 digit
- Measurement ranges: ± 20 mA (typical 0-20, 4-20 mA), Rload = 56 Ω

10.8 Tripping module

Figure. 10.8 - 58. The tripping module TRIP+ 2101.



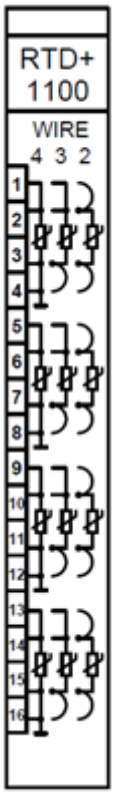
The tripping module applies direct control of a circuit breaker. The module provides fast operation and is rated for heavy duty controlling.

The main characteristics of the trip module:

- 4 independent tripping circuits.
- High-speed operation.
- Rated voltage: 110 V, 220 V DC.
- Continuous carry: 8 A.
- Making capacity: 0.5 s, 30 A.
- Breaking capacity (L/R = 40 ms) at 220 V DC: 4A.
- Trip circuit supervision for each trip contact.

10.9 RTD module

Figure. 10.9 - 59. The RTD +1100 module.



The RTD+1100 module is used to measure the temperature through the variation of resistance of temperature detectors.

If 2-wire wiring is used you have to make sure that the value of RA and RD resistors are set correctly in the “parameters” menu of the web server.

Figure. 10.9 - 60. 2-wire RTD wiring.

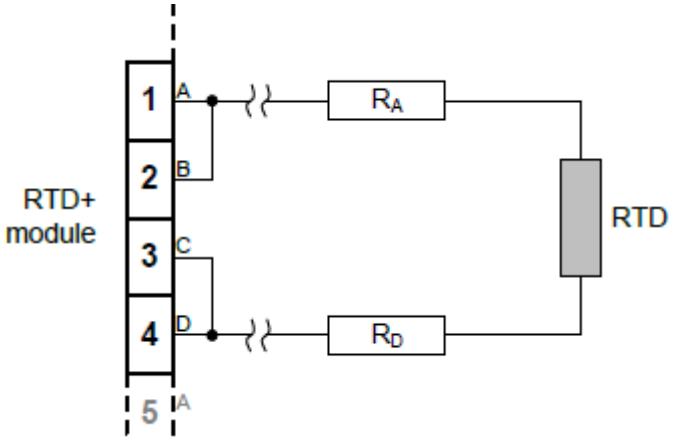


Figure. 10.9 - 61. 3-wire RTD wiring.

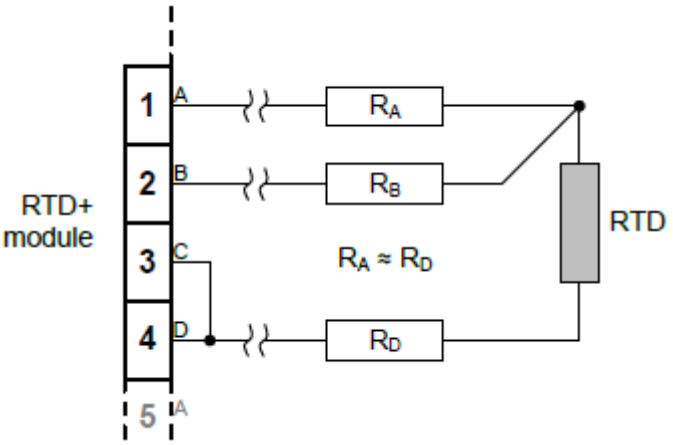


Figure. 10.9 - 62. 4-wire RTD wiring.

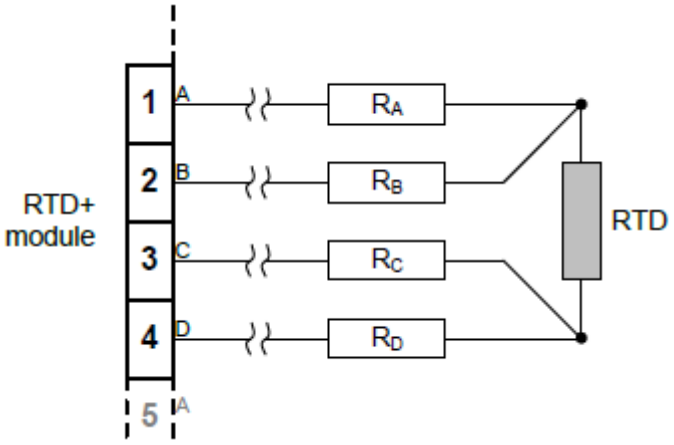
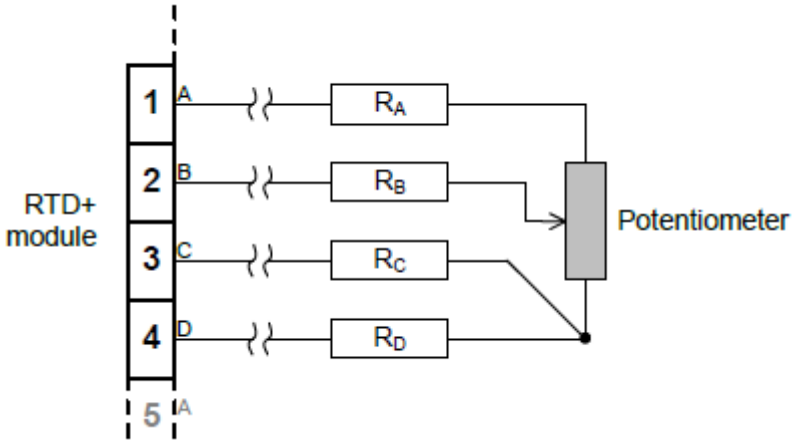


Figure. 10.9 - 63. 4-wire RTD wiring. of potentiometer.



10.10 Voltage measurement module

Figure. 10.10 - 64. The voltage measurement module VT+ 2211.

For voltage related functions (over- /under -voltage, directional functions, distance function,power functions) or disturbance recorder functionality this module is needed. This module also has capability for frequency measurement.

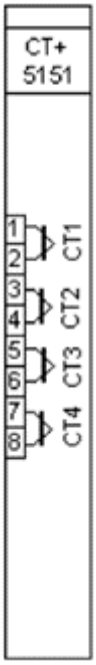
For capacitive voltage measurement of the synchrocheck reference, the voltage measurement module can be ordered with reduced burden in channel VT4. In this module the burden is < 50 mVA.

The main characteristics of the voltage measurement module:

- Number of channels: 4.
- Rated frequency: 50 Hz, 60 Hz.
- Selectable rated voltage (Un): 100/√3, 100 V, 200/√3, 200 V by parameter.
- Voltage measuring range: 0.05 Un – 1.2 Un.
- Continuous voltage withstand: 250 V.
- Power consumption of voltage input: ≤1 VA at 200 V (with special CVT module the burden is < 50 mVA for VT4 channel).
- Relative accuracy: ±0.5 %.
- Frequency measurement range: ±0.01 % at Ux 25 % of rated voltage.
- Measurement of phase angle: 0.5º Ux 25 % of rated voltage.

10.11 Current measurement module

Figure. 10.11 - 65. Connector allocation of the current measurement module.



Current measurement module is used for measuring current transformer output current. Module includes three phase current inputs and one zero sequence current input. The nominal rated current of the input can be selected with a software parameter either 1 A or 5 A.

The main chracteristics of the current measurement module:

- Number of channels: 4.
- Rated frequency: 50 Hz, 60 Hz.
- Electronic iron-core flux compensation.
- Low consumption: ≤0.1 VA at rated current.
- Current measuring range: 35 x In.
- Selectable rated current 1 A/5 A by parameter.
- Thermal withstand:
    - 20 A (continuously)
    - 500 A (for 1 s)
    - 1200 A (for 10 ms)
- Relative accuracy: ±0.5 %.
- Measurement of phase angle: 0.5º, Ix 10 % rated current.

10.12 Installation and dimensions

Figure. 10.12 - 66. Dimensions of AQ-x39x IED.

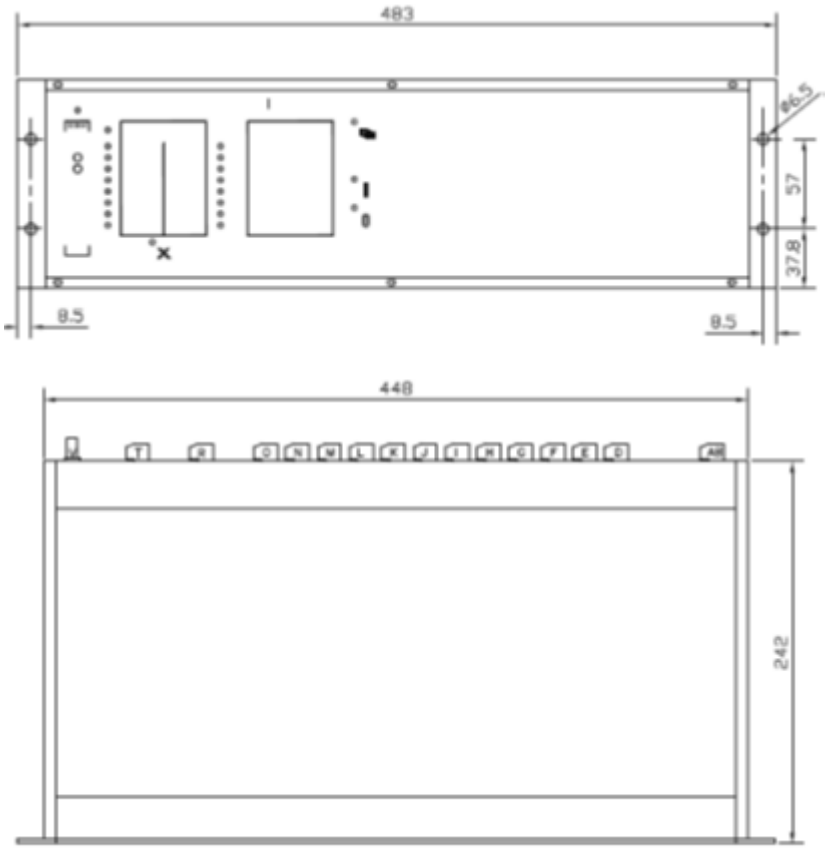
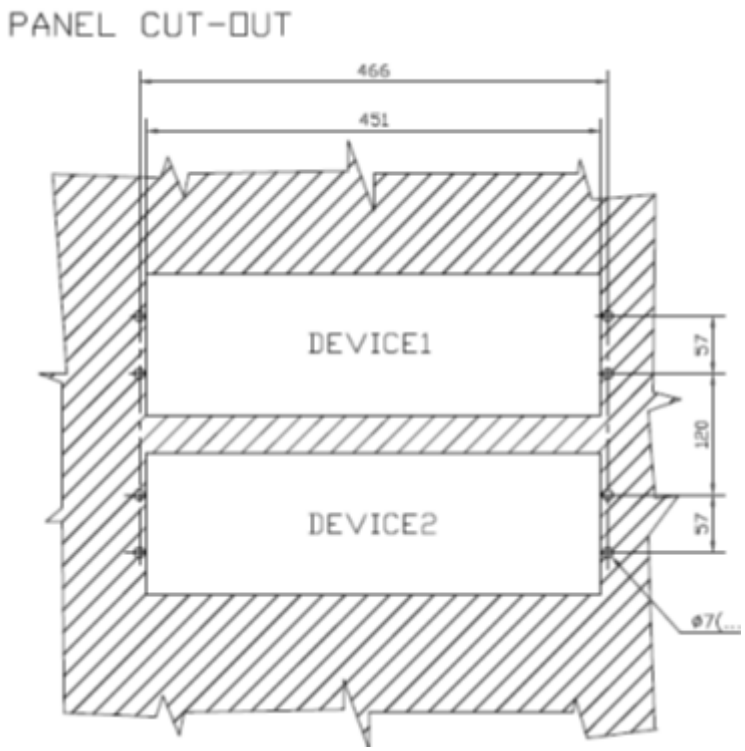


Figure. 10.12 - 67. Panel cut-out and spacing of AQ-x39x IED.



11 Technical data

11.1 Control functions

Circuit breaker control function

Operation time inaccuracy	±5 % or ±15 ms, whichever is greater

Disconnector control function

Operation time inaccuracy	±5 % or ±15 ms, whichever is greater

Synchroncheck function du/df (25)

Rated Voltage Un	100/200V, setting parameter
Voltage effective range	10-110 % of Un
Voltage inaccuracy	±1% of Un
Frequency effective range	47.5 – 52.5 Hz
Frequency inaccuracy	±10mHz
Phase angle inaccuracy	±3 °
Operate time inaccuracy	±3ms
Reset time	<50ms
Reset ratio	0.95

11.2 Monitoring functions

Current transformer supervision function CTS

Pick-up starting inaccuracy at In	<2%
Minimum operation time	70ms
Reset ratio	0.95

Voltage transformer supervision function VTS

Pick-up voltage inaccuracy	1 %
Operation time inaccuracy	<20 ms
Reset ratio	0.95

Dead line detectioin (DLD)

Pick-up voltage inaccuracy	1%
Operation time inaccuracy	<20ms
Reset ratio	0.95

11.3 Hardware

Power supply module

Input voltage	80-255VAC 90-300VDC
Nominal voltage	110VDC/220VDC
Maximum interruption	100ms
Maximum power consumption	30W

Current measurement module

Nominal current	1/5A (parameter settable) 0.2A (ordering option)
Number of channels per module	4
Rated frequency	50Hz 60Hz (ordering option)
Burden	<0.1VA at rated current
Thermal withstand	20A (continuous) 500A (for 1s) 1200A (for 10ms)
Current measurement range	0-50xIn
Power consumption at rated current	0.01 VA with 1A rated current 0.25 VA with 5A rated current
Phase angle accuracy at Ix ≥ 10% ± 1 digit	≤ 0.5 º
Relative accuracy [%] ± 1 digit	± 1 (> 0.5In) with 1A rated current ± 1 (> 0.4In) with 5A rated current

Voltage measurement module

Rated voltage Un	100/√3, 100V, 200/√3, 200V (parameter settable)
Number of channels per module	4
Rated frequency	50Hz 60Hz (ordering option)
Burden	<1VA at 200V

Voltage withstand	250V (continuous) 275VAC/350VDC (1s)
Voltage measurement range	0.05-1.2xUn
Power consumption	0.61VA at 200V 0.2 VA at 100V
Relative accuracy	±0.5 % (>0.6Un)
Frequency measurement range	±0.01 % at Ux ≥ 25% of rated voltage
Phase angle accuracy	≤ 0.5 º at Ux ≥ 25% of rated voltage

Binary input module

Rated voltage Un	110 or 220Vdc (ordering option)
Number of inputs per module	12 (in groups of 3)
Current drain	approx. 2mA per channel
Breaking capacity	0.2A (L/R=40ms, 220Vdc)

Binary output module

Rated voltage Un	250Vac/dc
Number of outputs per module	7 (NO) + 1(NC)
Continuous carry	8A
Breaking capacity	0.2A (L/R=40ms, 220Vdc)

High speed trip module

Rated voltage Un	110/220VDC
Max. withstand voltage	242V DC
Number of outputs per module	4
Continuous carry	8A
Making capacity	30A (0.5s)
Breaking capacity	4A (L/R=40ms, 220Vdc)

Milliampere input module

Number of channels	4
Measurement method	2 wire inputs with optional 15V excitation
Relative accuracy	± 0.5 % ± 1 digit

Measurement ranges	± 20 mA (typical 0-20, 4-20 mA) Rload = 56 Ω

11.4 Tests and environmental conditions

Disturbance tests

EMC test	CE approved and tested according to EN 50081-2, EN 50082-2
Emission - Conducted (EN 55011 class A) - Emitted (EN 55011 class A)	0.15 - 30MHz 30 - 1 000MHz
Immunity	
- Static discharge (ESD) (According to IEC244-22-2 and EN61000-4-2, class III)	Air discharge 8kV Contact discharge 6kV
- Fast transients (EFT) (According to EN61000-4-4, class III and IEC801-4, level 4)	Power supply input 4kV, 5/50ns other inputs and outputs 4kV, 5/50ns
- Surge (According to EN61000-4-5 [09/96], level 4)	Between wires 2 kV / 1.2/50µs Between wire and earth 4 kV / 1.2/50µs
- RF electromagnetic field test (According. to EN 61000-4-3, class III)	f = 80….1000 MHz 10V /m
- Conducted RF field (According. to EN 61000-4-6, class III)	f = 150 kHz….80 MHz 10V

Voltage tests

Insulation test voltage acc- to IEC 60255-5	2 kV, 50Hz, 1min
Impulse test voltage acc- to IEC 60255-5	5 kV, 1.2/50us, 0.5J

Mechanical tests

Vibration test	2 ... 13.2 Hz ±3.5mm 13.2 ... 100Hz, ±1.0g
Shock/Bump test acc. to IEC 60255-21-2	20g, 1000 bumps/dir.

Casing and package

Protection degree (front)	IP 54 (with optional cover)
Weight	5kg net (AQ-x35x devices) 6kg net (AQ-x39x devices) 6kg with package (AQ-x35x devices) 7kg with package (AQ-x39x devices)

Environmental conditions

Specified ambient service temp. range	-10…+55°C
Transport and storage temp. range	-40…+70°C
IED lifetime	> 20 years

12 Ordering information

Visit https://configurator.arcteq.fi/ to build a hardware configuration, define an ordering code and get a module layout image.

13 Contact and reference information

Manufacturer

Arcteq Relays Ltd.

Visiting and postal address

Kvartsikatu 2 A 1

65300 Vaasa, Finland

Contacts

Phone:	+358 10 3221 370
Website:	arcteq.fi
Technical support:	support.arcteq.fi +358 10 3221 388 (EET 9:00 – 17.00)
E-mail (sales):	sales@arcteq.fi