

AQ-S254

Alarm and Indication device

Instruction manual



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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.

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1 Document information

1.1 Version 2 revision notes

Table. 1.1 - 1. Version 2 revision notes

Revision	2.00
Date	6.6.2019
Changes	- New more consistent look. - Improved descriptions generally in many chapters. - Improved readability of a lot of drawings and images. - Updated protection functions included in every manual. - Every protection relay type now has connection drawing, application example drawing with function block diagram and application example with wiring. - Added General-menu description.
Revision	2.01
Date	6.11.2019
Changes	- Added description for LED test and button test. - Added display sleep timer description. - Complete rewrite of every chapter. - Improvements to many drawings and formula images. - Order codes revised. - Added double ST 100 Mbps Ethernet communication module and Double RJ45 10/100 Mbps Ethernet communication module descriptions
Revision	2.02
Date	7.7.2020
Changes	- A number of image descriptions improved.
Revision	2.03
Date	27.8.2020

Changes	- Terminology consistency improved (e.g. binary inputs are now always called digital inputs). - Tech data modified to be more informative about what type of measurement inputs are used (phase currents/voltages, residual currents/voltages), what component of that measurement is available (RMS, TRMS, peak-to-peak) and possible calculated measurement values (powers, impedances, angles etc.). - Improvements to many drawings and formula images. - Event read mode parameter added to Modbus description. - Added inches to Dimensions and installation chapter. - Added raising frames, wall mounting bracket, combiflex frame to order code. - Added logical input and logical output function descriptions. - Additions to Abbreviations chapter. - Added button test description to Local panel structure chapter. - Added note to Configuring user levels and passwords chapter that AQ-250 frame units generate a time-stamped event from locking and unlocking user levels. - Added note to Configuring user levels and passwords chapter that user level with a password automatically locks itself after 30 minutes of inactivity. - Added more "Tripped stage" indications and fault types to Measurement value recorder function. - Updated: Digital input activation and release threshold setting ranges and added drop-off delay setting.
Revision	2.04
Date	8.6.2021
Changes	- Increased the consistency in terminology - Various image upgrades - Visual update to the order codes
Revision	2.05
Date	22.6.2021
Changes	- Fixed phase current measurement continuous thermal withstand from 30A to 20A. - Fixed lots of timing errors written to registers table. "Prefault" is -200 ms from Start event, "Pretrigger" is -20 ms from trip (or start if fault doesn't progress to trip), "Fault" is start (or trip if fault doesn't progress to trip). - Added event history technical data
Revision	2.06
Date	21.6.2022
Changes	- Improved descriptions generally in many chapters. - Improved readability of a lot of drawings and images. - Order codes have been revised. - Added LN mode parameters to all functions (On, Blocked, Test, Test/Blocked, Off). - Added color themes parameter description. - Improved color sleep mode description. - Improved alarm function color behavior description and images. - Added operation time with different measurement values vs setting ratio in instant operation mode to non-directional overcurrent function description. - Added 30 s pretriggering time for disturbance recorder (AQ-250 devices only). - Added new trip detections and fault types to measurement value recorder. - Added user description parameter descriptions for digital inputs, digital outputs, logical inputs, logical outputs and GOOSE inputs. - Added spare part codes and compatibilities to option cards.
Revision	2.07

Date	7.7.2022
Changes	- Fixed number of logical inputs. - Added common signals function description. - Added PTP time synchronization description. - Added Modbus Gateway description. - Added alarm view carousel designer setting descriptions.
Revision	2.08
Date	8.9.2022
Changes	- Added stage forcing parameter to function descriptions. - Fixes to "Real time signals to comm" description. - Added "Ethernet port" parameter description to IEC61850, IEC104 and Modbus TCP descriptions. - Removed "Measurement update interval" settings from Modbus description. No longer in use. - Renamed "System integration" chapter to "Communication" and restructured the chapters to be closer to how they are in the menus. - Added "Event logger" chapter. - Added more descriptions to new IEC 61850 ed2 GOOSE parameters. - Added "Condition monitoring / CB wear" description to object description. - Added "User button" description. - Added logical device and logical node mode descriptions.
Revision	2.09
Date	14.3.2023
Changes	- Updated the Arcteq logo on the cover page and refined the manual's visual look. - Added the "Safety information" chapter and changed the notes throughout the document accordingly. - Changed the "IED user interface" chapter's title to "Device user interface" and replaced all 'IED' terms with 'device' or 'unit'. - Updated the rated values for the change-over CPU digital outputs in "Technical data". - Added double ethernet port configuration parameters to "Connections menu" chapter. - Added event overload detection description to "Event logger" chapter.
Revision	2.10
Date	19.6.2023
Changes	
Revision	2.11
Date	29.11.2023
Changes	- Added spring lock cage options for connectors. See the "Ordering information" chapter. - Updated the contact address for technical support in the "Contact and reference information" chapter.
Revision	2.12
Date	January 2024
Changes	- Added Chinese and Kazakh languages as language options in "General menu".
Revision	2.13

Date	September 2024
Changes	- Corrected the number of devices that fit a 19 in rack in the "Dimensions and installation" chapter.
Revision	2.14
Date	June 2025
Changes	- Increased phase current measurement range. See the current measurement section in the Technical data chapter. - Updated the product and packaging weights. - Added new "User access control" description. - Added "High-speed and high-current output" option card description. - Added "Milliampere input module (4x mA in & 1x mA out)" option card description. - Added "Double SFP Ethernet & IRIg-B communication module" option card description. - Order code table updated.
Revision	2.15
Date	January 2026
Changes	- Updated the Connections images.
Revision	2.16
Date	June 2026
Changes	- General improvements to descriptions. - IEC61850 integration time description improved. - Added CBW abrasion (SCBR) calculation description. - Added measurements to Programmable stages. - Added OPCUA communication protocol.
Revision	2.17
Date	October 2026
Changes	- Added Integration time chapter. - Added a list to explain which measurements are affected by deadband settings to IEC61850, IEC101/104 and DNP3 chapters. - Added permission list for each user level in User access control chapter.

1.2 Version 1 revision notes

Table. 1.2 - 2. Version 1 revision notes

Revision	1.00
Date	15.1.2018
Changes	• The first revision for AQ-S254.
Revision	1.01
Date	18.1.2019
Changes	• Added the HMI display technical data.

1.3 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 may contain 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 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.

1.4 Abbreviations

AI	– Analog input
AR	– Auto-recloser
ASDU	– Application service data unit
AVR	– Automatic voltage regulator
BCD	– Binary-coded decimal
CB	– Circuit breaker
CBFP	– Circuit breaker failure protection
CLPU	– Cold load pick-up
CPU	– Central processing unit
CT	– Current transformer
CTM	– Current transformer module
CTS	– Current transformer supervision
DG	– Distributed generation
DHCP	– Dynamic Host Configuration Protocol
DI	– Digital input
DO	– Digital output
DOL	– Direct-on-line
DR	– Disturbance recorder
DT	– Definite time
FF	– Fundamental frequency
FFT	– Fast Fourier transform
FTP	– File Transfer Protocol
GI	– General interrogation
HMI	– Human-machine interface
HR	– Holding register
HV	– High voltage
HW	– Hardware
IDMT	– Inverse definite minimum time
IGBT	– Insulated-gate bipolar transistor

I/O – Input and output

IRIG-B – Inter-range instruction group, timecode B

LCD – Liquid-crystal display

LED – Light emitting diode

LV – Low voltage

NC – Normally closed

NO – Normally open

NTP – Network Time Protocol

RMS – Root mean square

RSTP – Rapid Spanning Tree Protocol

RTD – Resistance temperature detector

RTU – Remote terminal unit

SCADA – Supervisory control and data acquisition

SG – Setting group

SOTF – Switch-on-to-fault

SW – Software

THD – Total harmonic distortion

TRMS – True root mean square

VT – Voltage transformer

VTM – Voltage transformer module

VTS – Voltage transformer supervision

2 General

The AQ-S254 alarm and indication unit is a member of the AQ 250 product line. The hardware and software are modular: the hardware modules are assembled and configured according to the application's I/O requirements and the software determines the available functions. This manual describes the specific application of the AQ-S254 alarm and indication unit. For other AQ 200 and AQ 250 series products please consult their respective device manuals.

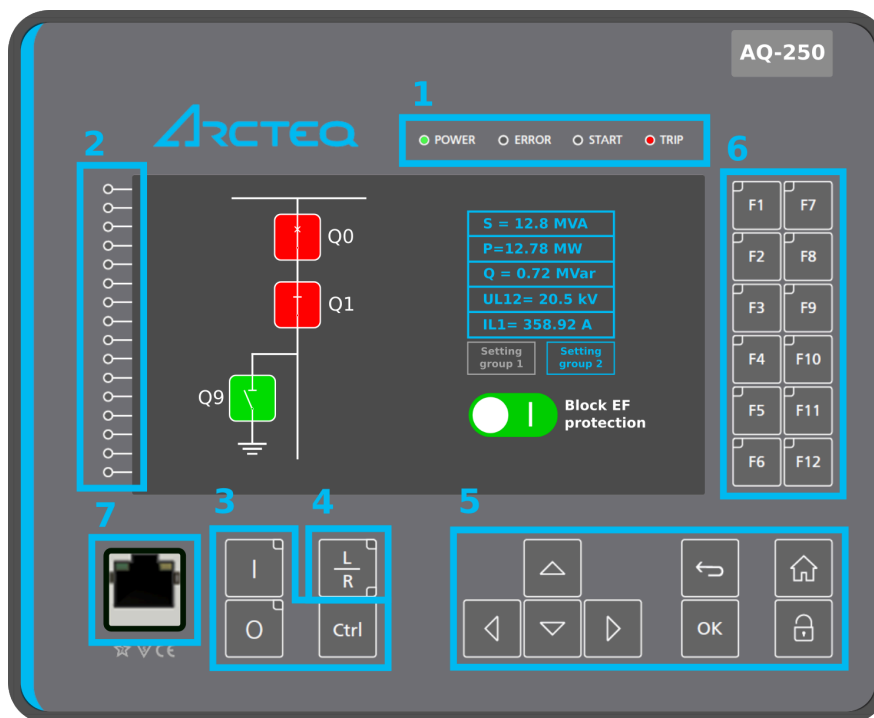
AQ-S254 may be applied as a substation alarm sounder, a substation general I/O extension unit or in any other application that requires extended I/O capabilities. The local indications are visualized conveniently through the freely programmable alarm display and event list. There are up to fourteen (14) option card slots available for additional I/O or communication cards for more comprehensive monitoring and control applications. AQ-S254 can be connected to a substation automation system by using various standard communication protocols, including the IEC 61850 substation communication standard.

3 Device user interface

3.1 Local panel structure

The front panel of AQ-250 series devices have multiple LEDs, control buttons and a local RJ-45 Ethernet port for configuration. Each unit is also equipped with an RS-485 serial interface and an RJ-45 Ethernet interface on the back of the device.

Figure. 3.1 - 1. Local panel structure.



1. Four (4) default LEDs: "Power", "Error", "Start" (configurable) and "Trip" (configurable).
2. Sixteen (16) freely configurable LEDs (red, orange, green) with programmable legend texts.
3. Three (3) object control buttons: Choose the controllable object with the Ctrl button and control the breaker or other object with the I and the O buttons.
4. The L/R button switches between the local and the remote control modes.
5. Eight (8) buttons for device local programming: the four navigation arrows, the Back and the OK buttons, the Home and the password activation buttons).
6. Twelve (12) freely configurable function buttons (F1...F12). Each button has a freely configurable LED (red, orange, green).
7. One (1) RJ-45 Ethernet port for device configuration.

When the unit is powered on, the green "Power" LED is lit. When the red "Error" LED is lit, the device has an internal (hardware or software) error that affects the operation of the unit. The activation of the yellow "Start" LED and the red "Trip" LED are based on the setting the user has put in place in the software.

The sixteen freely configurable LEDs are located on the left side of the display. Their activation and color (green, orange, red) are based on the settings the user has put in place in the software.

The view in the screen is freely configurable. Virtual switches and buttons can be added which can be used to change the setting groups or control the device's general logic locally or remotely. The status of the object (circuit breaker, disconnecter) can be displayed on the screen. All measured and calculated values regardless of the magnitude category (current, voltage, power, energy, frequency, etc.) can be shown on the screen.

Holding the I (Object Control) button for five seconds opens the "Button Test" menu. This menu displays all physical buttons on the device's front panel. Pressing a button marks it as tested. Once all buttons have been tested, the device automatically performs an LED test and displays its internal voltage. Press the OK button to exit the LED test and return to normal operation.

4 Functions

4.1 Functions included in AQ-S254

The AQ-S254 alarm and indication device includes the following functions as well as the number of stages in those functions.

Table. 4.1 - 3. Alarming functions of AQ-S254.

Name	IEC	ANSI	Description
ALARM	-	-	Alarming function (128 alarms)
PGS (1...10)	PGx>/<	99	Programmable stage

Table. 4.1 - 4. Control functions of AQ-S254.

Name	IEC	ANSI	Description
SGS	-	-	Setting group selection (8 setting groups available)
OBJ	-	-	Object control and monitoring (10 objects available)
CIN	-	-	Indicator object monitoring (20 indicators available)

Table. 4.1 - 5. Transducer functions of AQ-S254.

Name	IEC	ANSI	Description
RTD (1...16)	-	-	RTD alarms (Resistance temperature detector)

Table. 4.1 - 6. Monitoring functions of AQ-S214.

Name	IEC	ANSI	Description
DR	-	-	Disturbance recorder

4.2 General menu

The *General* menu consists of basic settings and indications of the device. Additionally, the all activated functions and their status are displayed in the *Protection*, *Control* and *Monitor* profiles.

Table. 4.2 - 7. The *General* menu read-only parameters

Name	Description
Serial number	The unique serial number identification of the unit.

Name	Description
Firmware version	The firmware software version of the unit.
Hardware configuration	The order code identification of the unit.
System phase rotating order at the moment	The selected system phase rotating order. Can be changed with parameter "System phase rotating order".
UTC time	The UTC time value which the device's clock uses.

Table. 4.2 - 8. Parameters and indications in the *General* menu.

Name	Range	Default	Description
Device name	-	Unitname	The file name uses these fields when loading the .aqs configuration file from the device.
Device location	-	Unitlocation	
Enable stage forcing	- Disabled - Enabled	Disabled	When this parameter is enabled it is possible for the user to force the protection, control and monitoring functions to different statuses like START and TRIP. This is done in the function's <i>Info</i> page with the <i>Force status to</i> parameter.
Allow setting of device mode	- Prohibited - From HMI/setting tool only - Allowed	Prohibited	Allows global mode to be modified from setting tool, HMI and IEC61850. Prohibited: Cannot be changed. From HMI/setting tool only: Can only be changed from the setting tool or HMI Allowed: Can be changed from the setting tool, HMI, and IEC 61850 client.
Allow setting of individual LN mode	- Prohibited - From HMI/setting tool only - Allowed	Prohibited	Allow local modes to be modified from setting tool, HMI and IEC61850. Prohibited: Cannot be changed. From HMI/setting tool only: Can only be changed from the setting tool or HMI Allowed: Can be changed from the setting tool, HMI, and IEC 61850 client.
System phase rotating order	- A-B-C - A-C-B	A-B-C	Allows the user to switch the expected order in which the phase measurements are wired to the unit.
Language	- User defined - English - Finnish - Chinese - Spanish - French - German - Russian - Ukrainian - Kazakh	English	Changes the language of the parameter descriptions in the HMI. If the language has been set to "Other" in the settings of the AQtivate setting tool, AQtivate follows the value set into this parameter.

Name	Range	Default	Description
AQtivate ethernet port	- All - COM A - Double Ethernet card	All	If the device has a double Ethernet option card it is possible to choose which ports are available for connecting with AQtivate software.
Clear events	- - Clear	-	Clears the event history recorded in the device.
Display brightness	0...8	4	Changes the display brightness. Brightness level 0 turns the display off.
Display sleep timeout	0...3600s	0s	If no buttons are pressed after a set time, the display changes the brightness to whatever is set on the "Display sleep brightness" parameter. If set to 0 s, this feature is not in use. When the device is in sleep mode, all button actions are disabled. Pressing any of the buttons on the front panel will wake up the display, which enables the buttons again.
Display sleep brightness	0...8	0	Defines the brightness of the display when the set display sleep timeout has elapsed. The brightness level "0" turns the display off.
Return to default view	0...3600s	0s	If the user navigates to a menu and gives no input after a period of time defined with this parameter, the unit automatically returns to the default view. If set to 0 s, this feature is not in use.
LED test	- - Activated	-	When activated, all LEDs are lit up. LEDs with multiple possible colors blink each color.
HMI restart	- - Restart	-	When activated, display restarts.
Display color theme	- Light theme - Dark theme	Light theme	Defines the color theme used in the HMI.
Reset latches	- - Reset	-	Resets the latched signals in the logic and the matrix. When a reset command is given, the parameter automatically returns back to "-".
Measurement recorder	- Disabled - Enabled	Disabled	Enables the measurement recorder tool, further configured in <i>Tools</i> → <i>Misc</i> → <i>Measurement recorder</i> .
Clear active alarms	- Disabled - Enabled	Disabled	Enables the clearing of those alarms that still have an activation signal on. If an alarm is cleared while its activation signal is active, the alarm will go to the "active cleared" status.
I/O default object selection	- OBJ1 - OBJ2 - OBJ3 - OBJ4 - OBJ5 - OBJ6 - OBJ7 - OBJ8 - OBJ9 - OBJ10	OBJ1	"I" and "O" push buttons on the front panel of the device have an indication LED. This parameter defines which objects' status push buttons follow when lighting up the LEDs.

Name	Range	Default	Description
Device Mode	- On - Blocked - Test - Test/Blocked - Off	On	Set mode of device block. This parameter is visible only when <i>Allow setting of device mode</i> is enabled in <i>General</i> menu.
Reconfigure mimic	- - Reconfigure	-	Reloads the mimic to the unit.

Table. 4.2 - 9. General menu logical inputs.

Name	Description
Reset last fault registers	Signal set to this point can be used for resetting latest recorded fault register.
Reset latches	Signals set to this point can be used for resetting latched signals. An alternative to using the "Back" button on the front panel of the device.
Ph.Rotating Logic control 0=A-B-C, 1=A-C-B	Signals set to this point can be used for switching the expected phase rotating order.

4.3 Alarming function

Figure. 4.3 - 2. Front panel view



The alarming unit has 128 alarms the user can set. The user defines each alarm description and activating signal. These settings are done in the *Alarm settings* menu (*Control* → *Device I/O* → *Alarm settings*).

The alarming unit generates events with time stamps into the event history and the alarm statuses are shown on the device's display. The alarm statuses can also be read in the remote terminal unit (RTU).

Alarm descriptions

The user-edited alarm text is displayed in the *Alarm* view in the HMI when the alarm has been activated. The user can update the descriptions in the settings (*Commands* → *Write to relay* → *Parameters or Commands* → *Write changes*).

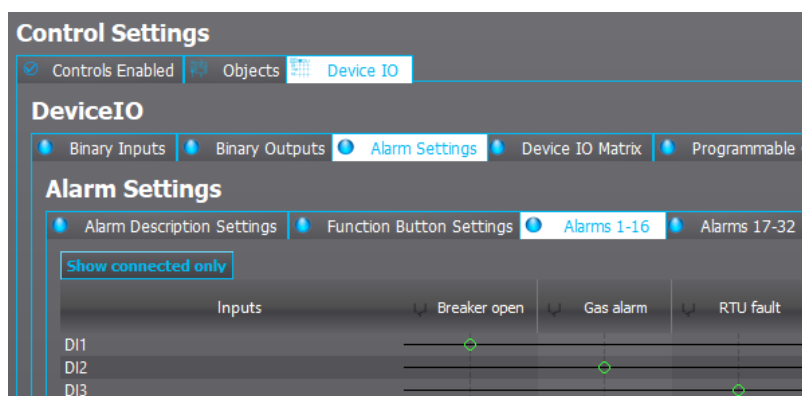
Table. 4.3 - 10. Alarm user description.

Name	Range	Default	Description
User editable description Alarm x	1...31 characters	Alarm x	Description of the alarm. This description is used in several menu types for easier identification.

Assigning alarm activation signals

Alarm activation signals are divided into eight tabs in groups of 16. The user can assign a digital input, a logic signal or a GOOSE message into each of the alarms. When any of the alarms have been activated by the assigned signal, the alarm appears in the *Alarms* view in the device's HMI.

Figure. 4.3 - 3. Digital inputs assigned as alarm activating signals.

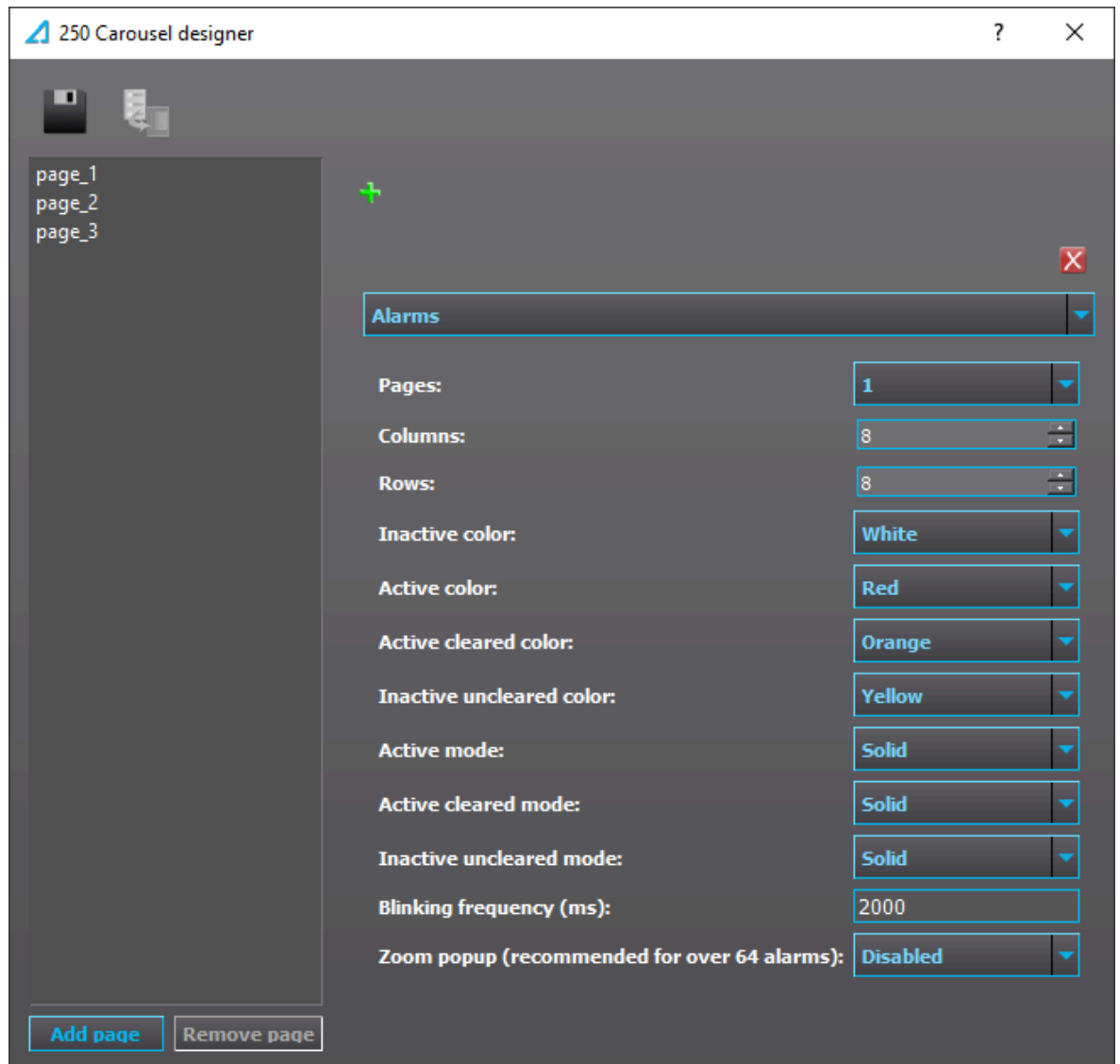


The user can assign signals into alarms by clicking on the matrix. When the matrix is done, it must be sent to the device for the changes to take effect (*Commands* → *Write to relay* → *Logic*).

If the alarm signal's ON state has been checked in the *Event Mask*, an ALARM ON event is recorded with a time stamp into the event history. These alarms are also reported in the communication protocol if one is in use.

Changing the look of the *Alarms* view

Figure. 4.3 - 4. Carousel designer view of the *Alarms* view settings.



Changing the look of the *Alarms* views is done in Carousel designer. Carousel designer is found in *Tools* → *Carousel designer*.

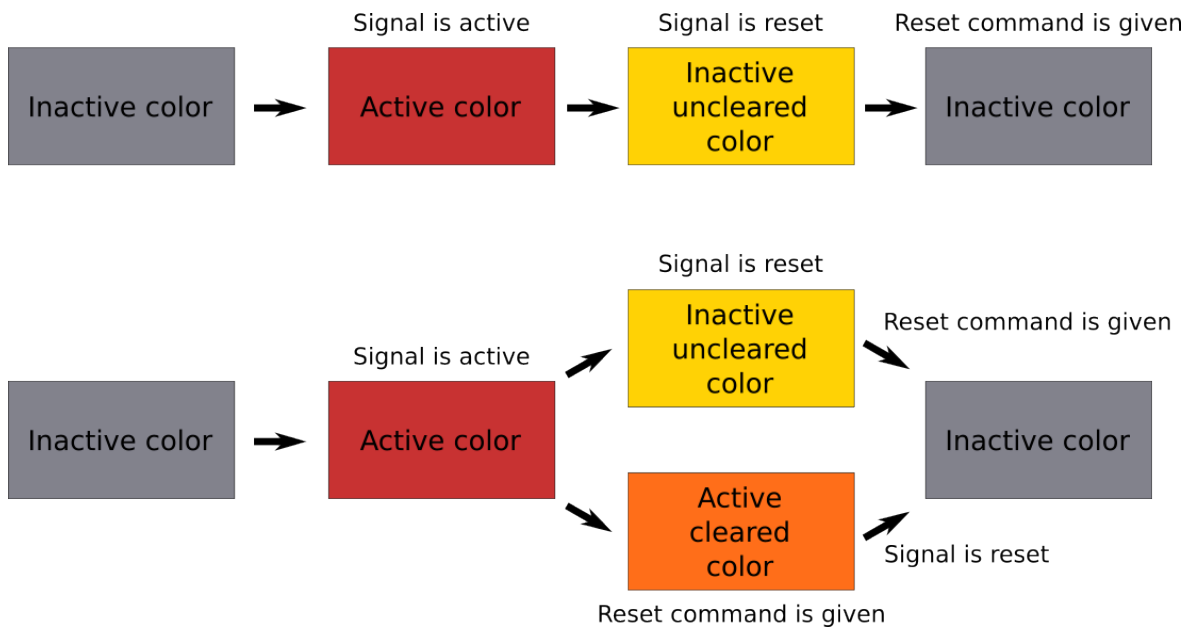
The column and row settings allow the user to define the size, shape and number of alarms displayed in the *Alarms* view. Any number of alarms between 1 and 128 can be displayed. The color displayed in different states of the alarm can be gray, red, green, yellow, orange, or blue.

Table. 4.3 - 11. Alarm view settings

Parameter	Description
Pages	Number of pages used. Pages can be scrolled with left and right arrow buttons. Each page used as many columns and rows as is defined with following two parameters.
Columns	Number of columns used per page.
Rows	Number of rows used per page.

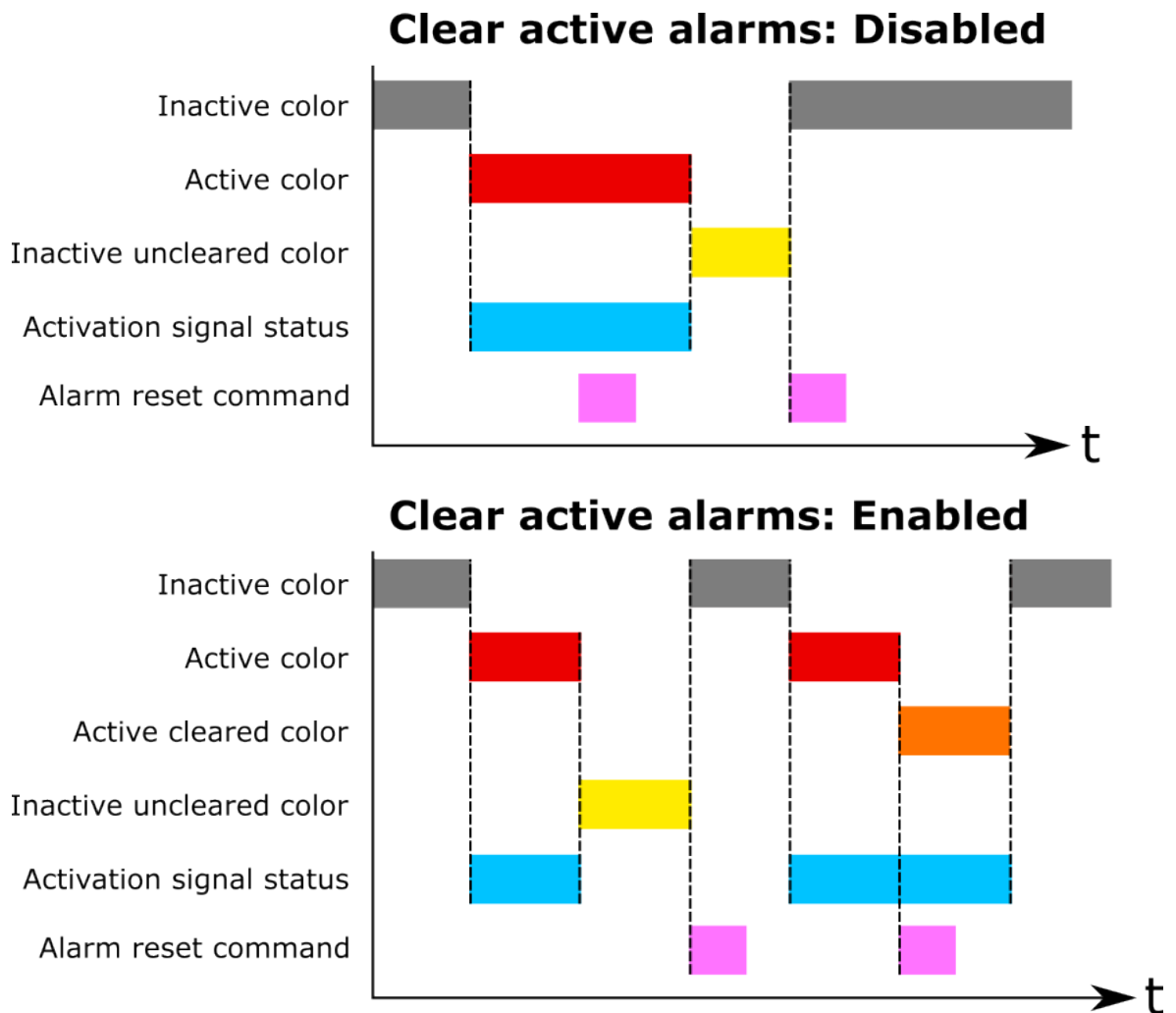
Parameter	Description
Inactive color.	Color displayed for an alarm that hasn't been activated.
Active color.	Color displayed for an alarm that has a signal currently active.
Active cleared color.	Color displayed for an alarm that has a signal currently active AND it has been acknowledged with "Reset command". If "Reset command" is given the alarm will return to "Inactive color" when the activating signal is reset too.
Inactive uncleared color.	Color displayed for an alarm that had a signal active in the past but hasn't been acknowledged with "Reset command" yet. After "Reset command" is given the alarm will return to "Inactive color".
Active / Active cleared / Inactive uncleared mode	Selection between solid and blinking modes. If blinking mode is selected the color of alarm will alternate between its color and inactive color.
Blinking frequency	Sets how frequently blinking states switch colors.
Zoom pop-up	When enabled pressing up arrow button will zoom alarm boxes. Zoomed alarm can then be selected with up, down, left and right arrow buttons. Press back-button to exit zoomed view.

Figure. 4.3 - 5. Alarm color behaviour with active alarm clearing enabled and disabled.



By default active alarms cannot be cleared. This can be changed by setting *Clear active alarms* to *Enabled* at *General* → *Device info* menu. When enabled the alarms otherwise change color just the same way as with default settings but it is also possible to clear an alarm while the activation signal is still active. If alarm is cleared when signal is active, color will change to what has been set to *Active cleared color* in Carousel designer (orange by default).

Figure. 4.3 - 6. Comparison between clear active alarms disabled and enabled.



Alarm zooming

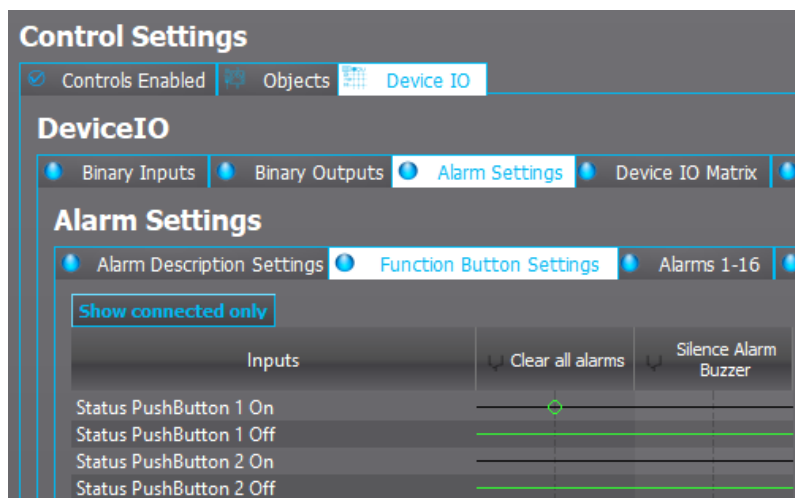
If *Zoom popup* parameter is enabled in *Carousel designer* menu it is possible to enlarge alarms by pressing the up-arrow button. Once in zoomed mode direction arrows up, down, left and right can be used for choosing the alarm. Use Back-button to exit zoomed mode.

Figure. 4.3 - 7. Alarm 1 is zoomed

Alarm 1 20/06/2022 12:32:05.842	Alarm 2	Alarm 3	Alarm 4	Alarm 5	Alarm 6	Alarm 7	Alarm 8
Alarm 10	Alarm 11	Alarm 12	Alarm 13	Alarm 14	Alarm 15	Alarm 16	Alarm 17
Alarm 18	Alarm 19	Alarm 20	Alarm 21	Alarm 22	Alarm 23	Alarm 24	Alarm 25
Alarm 26	Alarm 27	Alarm 28	Alarm 29	Alarm 30	Alarm 31	Alarm 32	Alarm 33
Alarm 34	Alarm 35	Alarm 36	Alarm 37	Alarm 38	Alarm 39	Alarm 40	Alarm 41
Alarm 42	Alarm 43	Alarm 44	Alarm 45	Alarm 46	Alarm 47	Alarm 48	Alarm 49
Alarm 50	Alarm 51	Alarm 52	Alarm 53	Alarm 54	Alarm 55	Alarm 56	Alarm 57
Alarm 58	Alarm 59	Alarm 60	Alarm 61	Alarm 62	Alarm 63	Alarm 64	Alarm 65
Alarm 66	Alarm 67	Alarm 68	Alarm 69	Alarm 70	Alarm 71	Alarm 72	Alarm 73
Alarm 74	Alarm 75	Alarm 76	Alarm 77	Alarm 78	Alarm 79	Alarm 80	Alarm 81
Alarm 82	Alarm 83	Alarm 84	Alarm 85	Alarm 86	Alarm 87	Alarm 88	Alarm 89
Alarm 90	Alarm 91	Alarm 92	Alarm 93	Alarm 94	Alarm 95	Alarm 96	Alarm 97
Alarm 98	Alarm 99	Alarm 100	Alarm 101	Alarm 102	Alarm 103	Alarm 104	Alarm 105
Alarm 106	Alarm 107	Alarm 108	Alarm 109	Alarm 110	Alarm 111	Alarm 112	Alarm 113
Alarm 114	Alarm 115	Alarm 116	Alarm 117	Alarm 118	Alarm 119	Alarm 120	Alarm 121
Alarm 122	Alarm 123	Alarm 124	Alarm 125	Alarm 126	Alarm 127	Alarm 128	

Clearing activated alarms

Figure. 4.3 - 8. Setting up the button for clearing alarms.



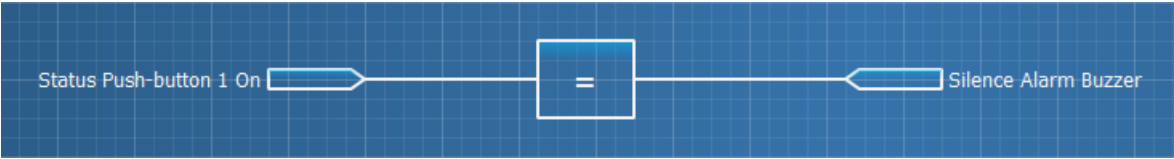
The button used for clearing alarms is defined in *Control* → *Device I/O* → *Alarm settings* → *Function Button Settings*. Please notice that the function button mode should be set to PRESS RELEASE mode in *Control* → *Device I/O* → *User-button settings*.

Buzzer activation and deactivation

The device doesn't have an integrated buzzer. However, if an alarming buzzer is needed it is possible to connect an external buzzer. It is activated by one of the output relays of the device. The user can set up the buzzer control by connecting the ALARM BUZZER signal to an output (*Control* → *Device I/O* → *Device IO Matrix*). Whenever an alarm is activated the ALARM BUZZER signal will also activate and the output contact can be controlled.

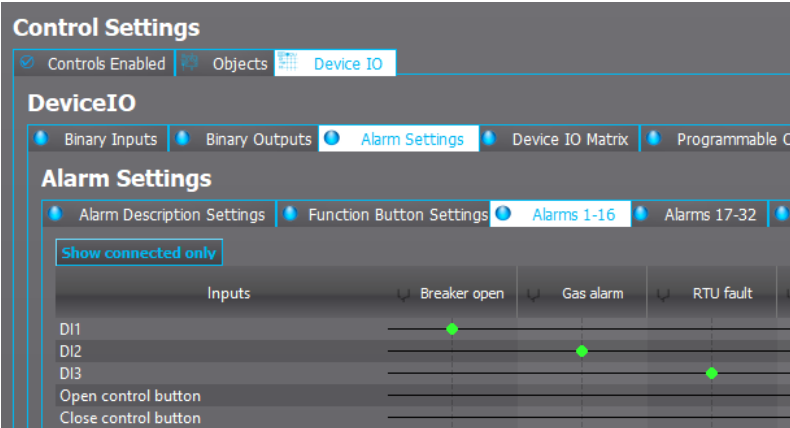
The user can silence the alarm buzzer by connecting a digital input or some other binary signal in the logic to SILENCE ALARM BUZZER in the logic.

Figure. 4.3 - 9. Silence alarm buzzer logic connection.



Clearing latched alarms

Figure. 4.3 - 10. Latched signals as dots.



Latched signals are represented by filled markers in the matrix.

If a latched signals is connected to an alarm, the alarm unit requires the user to push the **Back** button in the unit's front panel before the latched signal can be cleared. Using latched signals is generally not advised in order to keep alarm clearing simple.

Events

The alarm function generates events from the status changes in the monitored signals. The user can select which event messages are stored in the main event buffer: ON, OFF, or both.

Table. 4.3 - 12. Event messages.

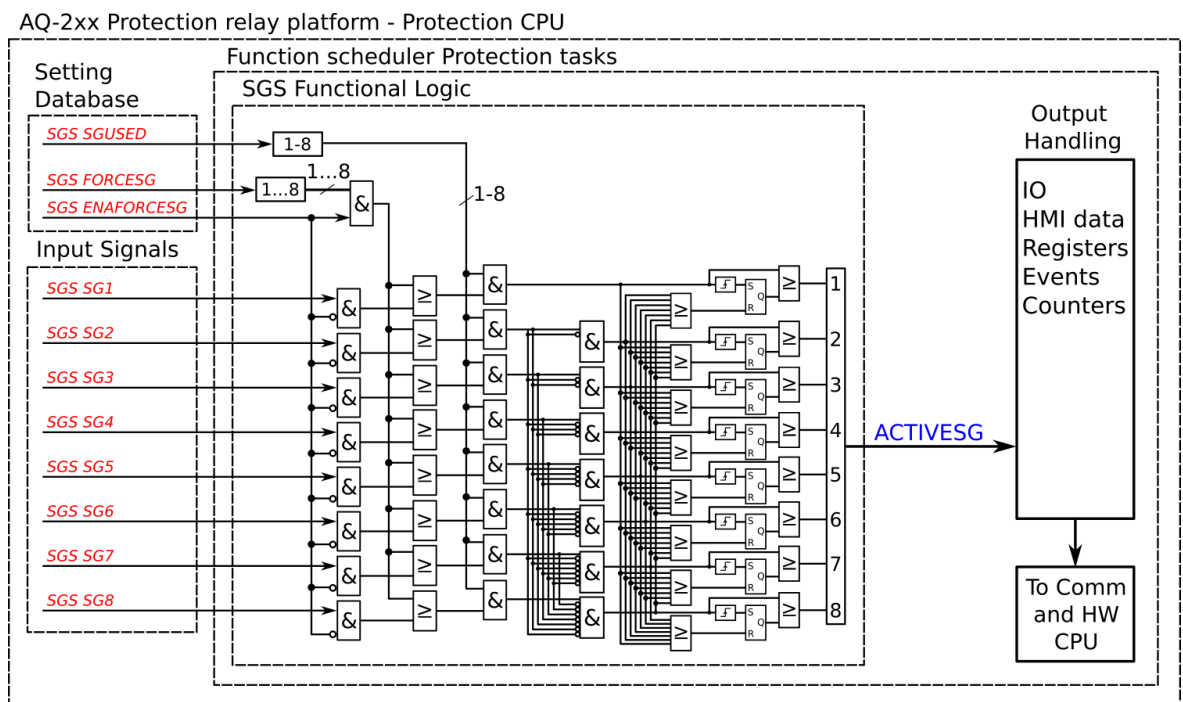
Event block name	Event name
ALARM1	Alarm 1...32 ON/OFF
ALARM2	Alarm 33...64 ON/OFF
ALARM3	Alarm 65...96 ON/OFF
ALARM4	Alarm 97...128 ON/OFF

4.4 Control functions

4.4.1 Setting group selection

All device types support up to eight (8) separate setting groups. The Setting group selection function block controls the availability and selection of the setting groups. By default, only Setting group 1 (SG1) is active and therefore the selection logic is idle. When more than one setting group is enabled, the setting group selector logic takes control of the setting group activations based on the logic and conditions the user has programmed.

Figure. 4.4.1 - 11. Simplified function block diagram of the setting group selection function.

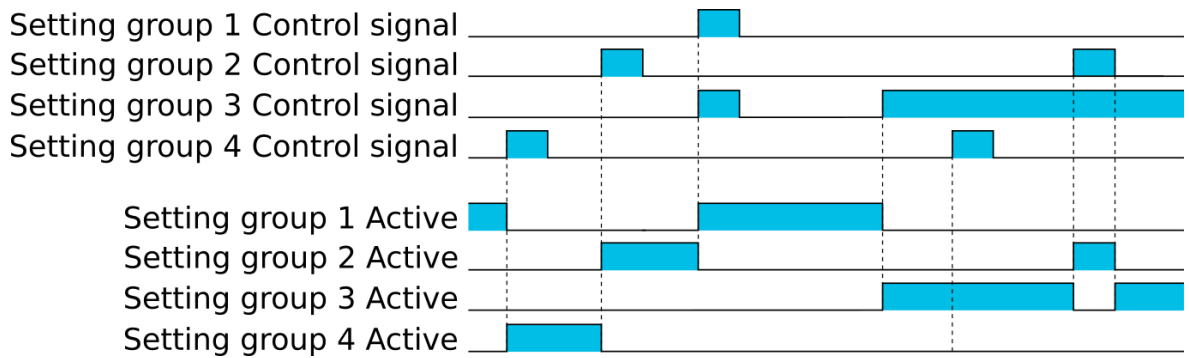


Setting group selection can be applied to each of the setting groups individually by activating one of the various internal logic inputs and connected digital inputs. The user can also force any of the setting groups on when the "Force SG change" setting is enabled by giving the wanted quantity of setting groups as a number in the communication bus or in the local HMI, or by selecting the wanted setting group from *Control* → *Setting groups*. When the forcing parameter is enabled, the automatic control of the local device is overridden and the full control of the setting groups is given to the user until the "Force SG change" is disabled again.

Setting groups can be controlled either by pulses or by signal levels. The setting group controller block gives setting groups priority values for situations when more than one setting group is controlled at the same time: the request from a higher-priority setting group is taken into use.

Setting groups follow a hierarchy in which setting group 1 has the highest priority, setting group 2 has second highest priority etc. If a static activation signal is given for two setting groups, the setting group with higher priority will be active. If setting groups are controlled by pulses, the setting group activated by pulse will stay active until another setting groups receives an activation signal.

Figure. 4.4.1 - 12. Example sequences of group changing (control with pulse only, or with both pulses and static signals).



Settings and signals

The settings of the setting group control function include the active setting group selection, the forced setting group selection, the enabling (or disabling) of the forced change, the selection of the number of active setting groups in the application, as well as the selection of the setting group changed remotely. If the setting group is forced to change, the corresponding setting group must be enabled and the force change must be enabled. Then, the setting group can be set from communications or from HMI to any available group. If the setting group control is applied with static signals right after the "Force SG" parameter is released, the application takes control of the setting group selection.

Table. 4.4.1 - 13. Settings of the setting group selection function.

Name	Range	Default	Description
Active setting group	• SG1 • SG2 • SG3 • SG4 • SG5 • SG6 • SG7 • SG8	SG1	Displays which setting group is active.
Force setting group	• None • SG1 • SG2 • SG3 • SG4 • SG5 • SG6 • SG7 • SG8	None	The selection of the overriding setting group. After "Force SG change" is enabled, any of the configured setting groups in the device can be overridden. This control is always based on the pulse operating mode. It also requires that the selected setting group is specifically controlled to ON after "Force SG" is disabled. If there are no other controls, the last set setting group remains active.
Force setting group change	• Disabled • Enabled	Disabled	The selection of whether the setting group forcing is enabled or disabled. This setting has to be active before the setting group can be changed remotely or from a local HMI. This parameter overrides the local control of the setting groups and it remains on until the user disables it.

Name	Range	Default	Description
Used setting groups	• SG1 • SG1...2 • SG1...3 • SG1...4 • SG1...5 • SG1...6 • SG1...7 • SG1...8	SG1	The selection of the activated setting groups in the application. Newly-enabled setting groups use default parameter values.
Remote setting group change	• None • SG1 • SG2 • SG3 • SG4 • SG5 • SG6 • SG7 • SG8	None	This parameter can be controlled through SCADA to change the setting group remotely. Please note that if a higher priority setting group is being controlled by a signal, a lower priority setting group cannot be activated with this parameter.

Table. 4.4.1 - 14. Signals of the setting group selection function.

Name	Description
Setting group 1	The selection of Setting group 1 ("SG1"). Has the highest priority input in setting group control. Can be controlled with pulses or static signals. If static signal control is applied, no other SG requests will be processed.
Setting group 2	The selection of Setting group 2 ("SG2"). Has the second highest priority input in setting group control. Can be controlled with pulses or static signals. If static signal control is applied, no requests with a lower priority than SG1 will be processed.
Setting group 3	The selection of Setting group 3 ("SG3"). Has the third highest priority input in setting group control. Can be controlled with pulses or static signals. If static signal control is applied, no requests with a lower priority than SG1 and SG2 will be processed.
Setting group 4	The selection of Setting group 4 ("SG4"). Has the fourth highest priority input in setting group control. Can be controlled with pulses or static signals. If static signal control is applied, no requests with a lower priority than SG1, SG2 and SG3 will be processed.
Setting group 5	The selection of Setting group 5 ("SG5"). Has the fourth lowest priority input in setting group control. Can be controlled with pulses or static signals. If static signal control is applied, SG6, SG7 and SG8 requests will not be processed.
Setting group 6	The selection of Setting group 6 ("SG6"). Has the third lowest priority input in setting group control. Can be controlled with pulses or static signals. If static signal control is applied, SG7 and SG8 requests will not be processed.
Setting group 7	The selection of Setting group 7 ("SG7"). Has the second lowest priority input in setting group control. Can be controlled with pulses or static signals. If static signal control is applied, only SG8 requests will not be processed.
Setting group 8	The selection of Setting group 8 ("SG8"). Has the lowest priority input in setting group control. Can be controlled with pulses or static signals. If static signal control is applied, all other SG requests will be processed regardless of the signal status of this setting group.

Events

The setting group selection function block (abbreviated "SGS" in event block names) generates events from the status changes in the events listed below. The user can select which event messages are stored in the main event buffer: ON, OFF, or both. The events triggered by the function are recorded with a time stamp.

Table. 4.4.1 - 15. Event messages.

Event block name	Event names
SGS	SG2...8 Enabled/Disabled
SGS	SG1...8 Request ON/OFF
SGS	Remote Change SG Request ON/OFF
SGS	Local Change SG Request ON/OFF
SGS	Force Change SG ON/OFF
SGS	SG Request Fail Not configured SG ON/OFF
SGS	Force Request Fail Force ON/OFF
SGS	SG Req. Fail Lower priority Request ON/OFF
SGS	SG1...8 Active ON/OFF

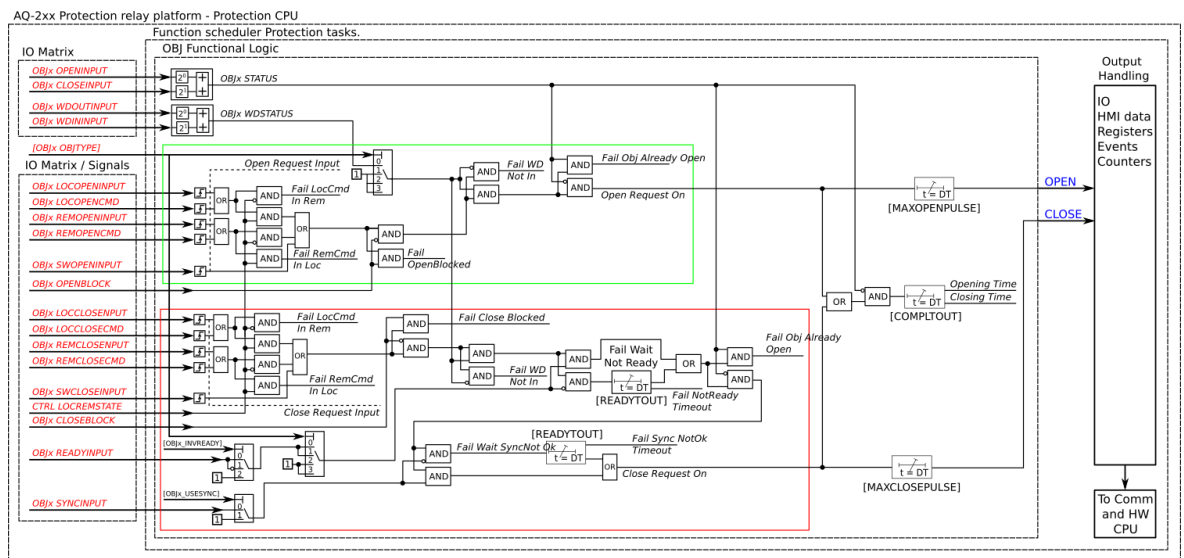
4.4.2 Object control and monitoring

The object control and monitoring function takes care of both for circuit breakers and disconnectors. The monitoring and controlling are based on the statuses of the device's configured digital inputs and outputs. The number of controllable and monitored objects in each device depends on the device type and amount of digital inputs. One controllable object requires a minimum of two (2) output contacts. The status monitoring of one monitored object usually requires two (2) digital inputs. Alternatively, object status monitoring can be performed with a single digital input: the input's active state and its zero state (switched to 1 with a NOT gate in the Logic editor).

An object can be controlled manually or automatically. Manual control can be done by local control, or by remote control. Local manual control can be done by devices front panel (HMI) or by external push buttons connected to devices digital inputs. Manual remote control can be done through one of the various communication protocols available (Modbus, IEC101/103/104 etc.). The function supports the modes "Direct control" and "Select before execute" while controlled remotely. Automatic controlling can be done with functions like auto-reclosing function (ANSI 79).

The main outputs of the function are the OBJECT OPEN and OBJECT CLOSE control signals. Additionally, the function reports the monitored object's status and applied operations. The setting parameters are static inputs for the function, which can only be changed by the user in the function's setup phase.

Figure. 4.4.2 - 13. Simplified function block diagram of the object control and monitoring function.



Settings

The following parameters help the user to define the object. The operation of the function varies based on these settings and the selected object type. The selected object type determines how much control is needed and which setting parameters are required to meet those needs.

Table. 4.4.2 - 16. Object settings and status parameters.

Name	Range	Default	Description
Local/Remote status	- Local - Remote	Remote	Displays the status of the device's "local/remote" switch. Local controls cannot override the open and close commands while device is in "Remote" status. The remote controls cannot override the open and close commands while device is in "Local" status.
Object status force to	- Normal - Openreq On - Closereq On - Opensignal On - Closesignal On - WaitNoRdy On - WaitNoSnc On - NotrdyFail On - NosyncFail On - Opentout On - Clotout On - OpenreqUSR On - CloreqUSR On	Normal	Force the status of the function. Visible only when <i>Enable stage forcing</i> parameter is enabled in <i>General</i> menu.
OBJ LN mode	- On - Blocked - Test - Test/Blocked - Off	On	Set mode of OBJ block. This parameter is visible only when <i>Allow setting of individual LN mode</i> is enabled in <i>General</i> menu.

Name	Range	Default	Description
OBJ LN behaviour	- On - Blocked - Test - Test/Blocked - Off	-	Displays the mode of OBJ block. This parameter is visible only when <i>Allow setting of individual LN mode</i> is enabled in <i>General</i> menu.
Object name	-	Objectx	The user-set name of the object, at maximum 32 characters long.
Object type	- Withdrawable circuit breaker - Circuit breaker - Disconnecter (MC) - Disconnecter (GND)	Circuit breaker	The selection of the object type. This selection defines the number of required digital inputs for the monitored object. This affects the symbol displayed in the HMI and the monitoring of the circuit breaker. It also affects whether the withdrawable cart is in/out status is monitored. See the next table ("Object types") for a more detailed look at which functionalities each of the object types have.
Objectx Breaker status	- Intermediate - Open - Closed - Bad	-	Displays the status of breaker. Intermediate is displayed when neither of the status signals (open or close) are active. Bad status is displayed when both status signals (open and close) are active.
Objectx Withdraw status	- WDIntermediate - WDCartOut - WDCart In - WDBad - Not in use	-	Displays the status of circuit breaker cart. WDIntermediate is displayed when neither of the status signals (in or out) are active. WDBad status is displayed when both status signals (in and out) are active. If the selected object type is not set to "Withdrawable circuit breaker", this setting displays the "No in use" option.
Additional status information	- Open Blocked - Open Allowed - Close Blocked - Close Allowed - Object Ready - Object Not Ready - Sync Ok - Sync Not Ok	-	Displays additional information about the status of the object.
Use Synchrocheck	- Not in use - Synchrocheck in use	Not in use	Selects whether the "Synchrocheck" condition is in use for the circuit breaker close command. If "In use" is selected the input chosen to "Sync.check status in" has to be active to be able to close circuit breaker. Synchrocheck status can be either an internal signal generated by synchrocheck function or digital input activation with an external synchrocheck device.
Use Object ready	- Ready High - Ready Low - Not in use	Not in use	Selects whether the "Object ready" condition is in use for the circuit breaker close command. If in use the signal connected to "Object ready status In" has to be high or low to be able to close the breaker (depending on "Ready High or Low" selection).
Open requests	$0 \dots 2^{32} - 1$	-	Displays the number of successful "Open" requests.
Close requests	$0 \dots 2^{32} - 1$	-	Displays the number of successful "Close" requests.

Name	Range	Default	Description
Open requests failed	$0 \dots 2^{32} - 1$	-	Displays the number of failed "Open" requests.
Close requests failed	$0 \dots 2^{32} - 1$	-	Displays the number of failed "Close" requests.
Clear statistics	- - Clear	-	Clears the request statistics, setting them back to zero (0). Automatically returns to "-" after the clearing is finished.

Table. 4.4.2 - 17. Object types.

Name	Functionalities	Description
Withdrawable circuit breaker	Breaker cart position Circuit breaker position Circuit breaker control Object ready check before closing breaker Synchrochecking before closing breaker Interlocks	The monitor and control configuration of the withdrawable circuit breaker.
Circuit breaker	Position indication Control Object ready check before closing breaker Synchrochecking before closing breaker Interlocks	The monitor and control configuration of the circuit breaker.
Disconnecter (MC)	Position indication Control	The position monitoring and control of the disconnector.
Disconnecter (GND)	Position indication	The position indication of the earth switch.

Table. 4.4.2 - 18. I/O.

Signal	Range	Description
Objectx Open Status In	Digital input or other logical signal selected by the user (SWx)	A link to a physical digital input. The monitored object's OPEN status. "1" refers to the active open state of the monitored object.
Objectx Close Status In		A link to a physical digital input. The monitored object's CLOSE status. "1" refers to the active close state of the monitored object.
Withdrw.CartIn.Status In		A link to a physical digital input. The monitored withdrawable object's position is IN. "1" means that the withdrawable object cart is in.
Withdrw.CartOut.Status In		A link to a physical digital input. The monitored withdrawable object's position is OUT. "1" means that the withdrawable object cart is pulled out.

Signal	Range	Description
Objectx Ready status In		A link to a physical digital input. Indicates that status of the monitored object. "1" means that the object is ready and the spring is charged for a close command.
Sync.Check status In		A link to a physical digital input or a synchrocheck function. "1" means that the synchrocheck conditions are met and the object can be closed.
Objectx Open Command	OUT1...OUTx	The physical "Open" command pulse to the device's output relay.
Objectx Close Command		The physical "Close" command pulse to the device's output relay.

Table. 4.4.2 - 19. Operation settings.

Name	Range	Step	Default	Description
Breaker traverse time	0.02...500.00 s	0.02 s	0.2 s	Determines the maximum time between open and close statuses when the breaker switches. If this set time is exceeded and both open and closed status inputs are active, the status "Bad" is activated in the "Objectx Breaker status" setting. If neither of the status inputs are active after this delay, the status "Intermediate" is activated.
Sync wait timeout	0.02...500.00 s	0.02 s	0.2 s	If synchrocheck is used, the object will wait for a "synchrocheck ok" signal before giving the closing command. This parameter will cancel the command if synchronization is not achieved on time.
Maximum Close command pulse length	0.02...500.00 s	0.02 s	0.2 s	Determines the maximum length for a Close pulse from the output relay to the controlled object. If the object operates faster than this set time, the control pulse is reset and a status change is detected.
Maximum Open command pulse length	0.02...500.00 s	0.02 s	0.2 s	Determines the maximum length for a Open pulse from the output relay to the controlled object. If the object operates faster than this set time, the control pulse is reset and a status change is detected.
Control termination timeout	0.02...500.00 s	0.02 s	10 s	Determines the control pulse termination timeout. If the object has not changed its status in this given time the function will issue error event and the control is ended. This parameter is common for both open and close commands.
Final trip pulse length	0.00...500.00 s	0.02 s	0.2 s	Determines the length of the final trip pulse length. When the object has executed the final trip, this signal activates. If set to 0 s, the signal is continuous. If auto-recloser function controls the object, "final trip" signal is activated only when there are no automatic reclosings expected after opening the breaker.

Table. 4.4.2 - 20. Control settings (DI and Application).

Signal	Range	Description
Access level for MIMIC control	• User • Operator • Configurator • Super user	Defines what level of access is required for MIMIC control. The default is the "Configurator" level.
Objectx LOCAL Close control input	Digital input or other logical signal selected by the user	The local Close command from a physical digital input (e.g. a push button).
Objectx LOCAL Open control input		The local Open command from a physical digital input (e.g. a push button).
Objectx REMOTE Close control input		The remote Close command from a physical digital input (e.g. RTU).
Objectx REMOTE Open control input		The remote Open command from a physical digital input (e.g. RTU).
Objectx Application Close		The Close command from the application. Can be any logical signal.
Objectx Application Open		The Close command from the application. Can be any logical signal.

Blocking and interlocking

The interlocking and blocking conditions can be set for each controllable object, with Open and Close set separately. Blocking and interlocking can be based on any of the following: other object statuses, a software function or a digital input.

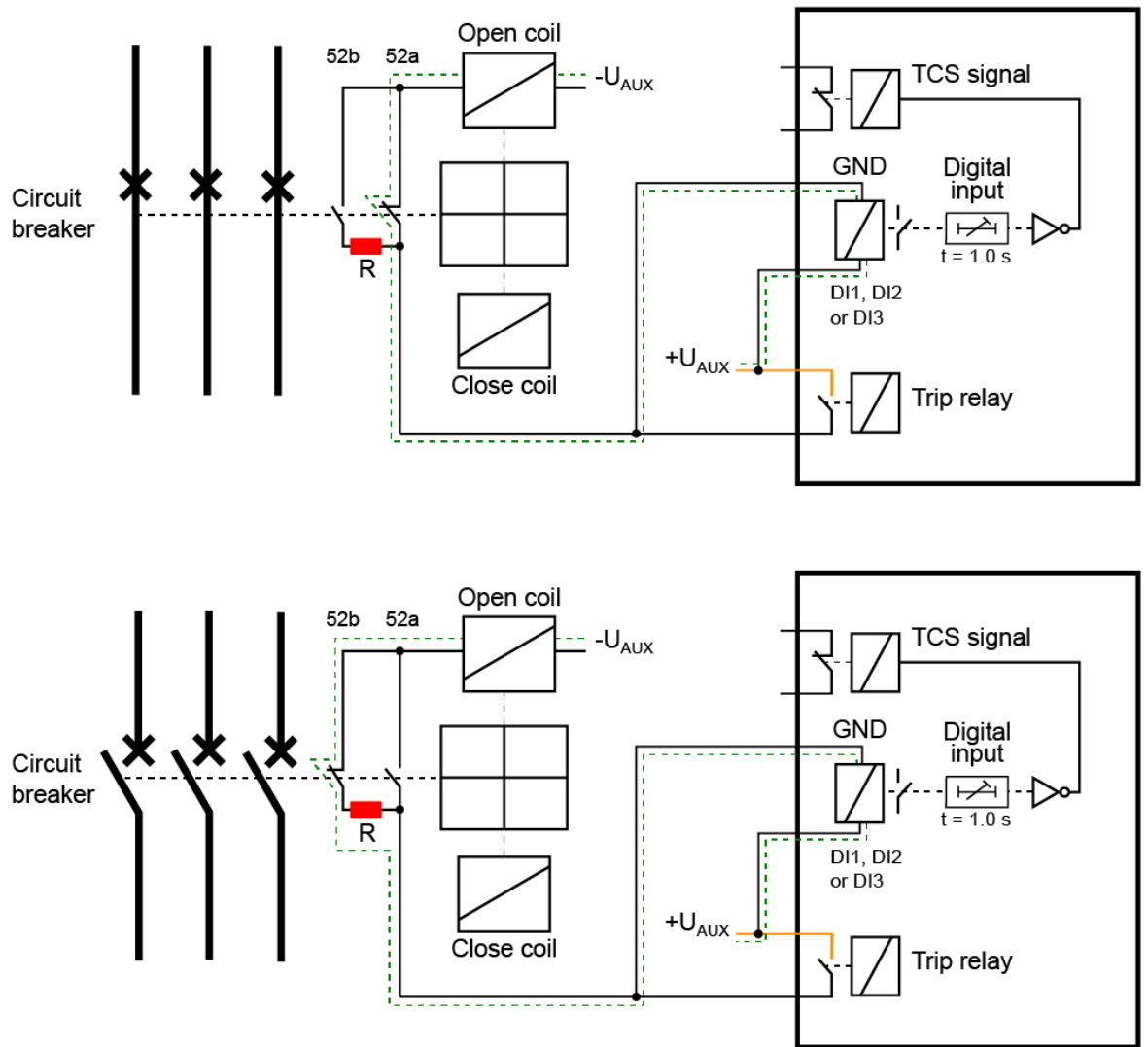
In order for the blocking signal to be received on time, it has to reach the function 5 ms before the control command.

Trip circuit supervision

Trip circuit supervision monitors the wiring from auxiliary power supply, through the device's digital output, and all the way to the open coil of the breaker. It is recommended to supervise the health of the trip circuit when breaker is closed.

The figure below presents an application scheme for trip circuit supervision with one digital input and a non-latched trip output. With this connection the current keeps flowing to the open coil of the breaker via the breaker's closing auxiliary contacts (52b) even after the circuit breaker is opened. This requires a resistor which reduces the current: this way the coil is not energized and the relay output does not need to cut off the coil's inductive current.

Figure. 4.4.2 - 14. Trip circuit supervision with one DI and one non-latched trip output.



Note that the digital input that monitors the circuit is normally closed, and the same applies to the alarm relay if one is used. For monitoring and especially trip circuit supervision purposes it is recommended to use a normally closed contact to confirm the wiring's condition. An active digital input generates a less than 2 mA current to the circuit, which is usually small enough not to make the breaker's open coil operate.

When the trip relay is controlled and the circuit breaker is opening, the digital input is shorted by the trip contact as long as the breaker opens. Normally, this takes about 100 ms if the relay is non-latched. A one second activation delay should, therefore, be added to the digital input. An activation delay that is slightly longer than the circuit breaker's operations time should be enough. When circuit breaker failure protection (CBFP) is used, adding its operation time to the digital input activation time is useful. The whole digital input activation time is, therefore, $t_{DI} = t_{CB} + t_{IEDrelease} + t_{CBFP}$.

Figure. 4.4.2 - 15. Trip circuit supervision with high-speed output. High-speed outputs have an internal input for trip circuit supervision.

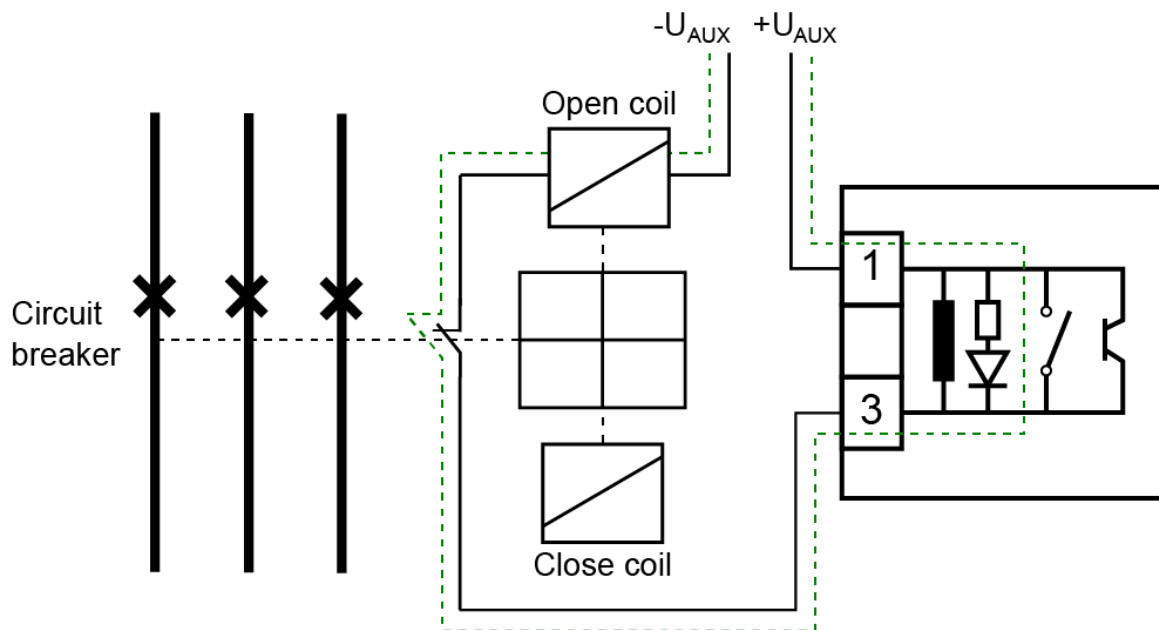


Table. 4.4.2 - 21. Trip circuit supervision settings (Control → Objects → Object X → APP CONTR → Condition monitoring).

Name	Range	Default	Description
ObjectX Trip circuit supervision	- Disabled - Enabled	Disabled	Enables the trip circuit supervision function.
ObjectX TCS Alarm activation delay	0.02...500.00 s	0.20 s	Time delay before TCS alarm is activated.
Object1 TCS input	-	-	Defines the supervised digital input, high-speed output or other signal.

Events and registers

The object control and monitoring function (abbreviated "OBJ" in event block names) generates events and registers from the status changes in the events listed below. The user can select which event messages are stored in the main event buffer: ON, OFF, or both. The events triggered by the function are recorded with a time stamp.

The function also provides a resettable cumulative counter for OPEN, CLOSE, OPEN FAILED, and CLOSE FAILED events.

Table. 4.4.2 - 22. Event messages of the OBJ function.

Event block name	Description
OBJX	Object Intermediate
OBJX	Object Open
OBJX	Object Close

Event block name	Description
OBJX	Object Bad
OBJX	WD Intermediate
OBJX	WD Out
OBJX	WD in
OBJX	WD Bad
OBJX	Open Request ON/OFF
OBJX	Open Command ON/OFF
OBJX	Close Request ON/OFF
OBJX	Close Command ON/OFF
OBJX	Open Blocked ON/OFF
OBJX	Close Blocked ON/OFF
OBJX	Object Ready
OBJX	Object Not Ready
OBJX	Sync Ok
OBJX	Sync Not Ok
OBJX	Open Command Fail
OBJX	Close Command Fail
OBJX	Final trip ON/OFF
OBJX	Contact Abrasion Alarm ON/OFF
OBJX	Switch Operating Time Exceeded ON/OFF
OBJX	XCBR Loc ON/OFF
OBJX	XSWI Loc ON/OFF
OBJX	OBJX Cond monitoring alarm 1 ON/OFF
OBJX	OBJX Cond monitoring alarm 2 ON/OFF
OBJX	OBJX Trip Circuit Supervision ON/OFF

The function registers its operation into the last twelve (12) time-stamped registers. The table below presents the structure of the function's register content.

Table. 4.4.2 - 23. Register content.

Name	Description
Date and time	dd.mm.yyyy hh:mm:ss.mss

Name	Description
Event	Event name
Recorded Object opening time	Time difference between the object receiving an "Open" command and the object receiving the "Open" status.
Recorded Object closing time	Time difference between the object receiving a "Close" command and object receiving the "Closed" status.
Object status	The status of the object.
WD status	The status of the withdrawable circuit breaker.
Open fail	The cause of an "Open" command's failure.
Close fail	The cause of a "Close" command's failure.
Open command	The source of an "Open" command.
Close command	The source of an "Open" command.
General status	The general status of the function.

4.4.3 Indicator object monitoring

The indicator object monitoring function takes care of the status monitoring of disconnectors. The function's sole purpose is indication and does not therefore have any control functionality. To control circuit breakers and/or disconnectors, please use the Object control and monitoring function. The monitoring is based on the statuses of the configured device's digital inputs. The number of monitored indicators in a device depends on the device type and available inputs. The status monitoring of one monitored object usually requires two (2) digital inputs. Alternatively, object status monitoring can be performed with a single digital input: the input's active state and its zero state (switched to 1 with a NOT gate in the Logic editor).

The outputs of the function are the monitored indicator statuses (Open, Close, Intermediate and Bad). The setting parameters are static inputs for the function, which can only be changed by the use in the function's setup phase.

The inputs of the function are the binary status indications. The function generates general time stamped ON/OFF events to the common event buffer from each of the following signals: OPEN, CLOSE, BAD and INTERMEDIATE event signals. The time stamp resolution is 1 ms.

Settings

Function uses available hardware and software digital signal statuses. These input signals are also setting parameters for the function.

Table. 4.4.3 - 24. Indicator status.

Name	Range	Default	Description
Indicator name ("Ind. Name")	-	IndX	The user-set name of the object, at maximum 32 characters long.

Name	Range	Default	Description
IndicatorX Object status ("Ind.X Object Status")	- Intermediate - Open - Closed - Bad	-	Displays the status of the indicator object. Intermediate status is displayed when neither of the status conditions (open or close) are active. Bad status is displayed when both of the status conditions (open and close) are active.

Table. 4.4.3 - 25. Indicator I/O.

Signal	Range	Description
IndicatorX Open input ("Ind.X Open Status In")	Digital input or other logical signal selected by the user (SWx)	A link to a physical digital input. The monitored indicator's OPEN status. "1" refers to the active "Open" state of the monitored indicator.
IndicatorX Close input ("Ind.X Close Status In")	Digital input or other logical signal selected by the user (SWx)	A link to a physical digital input. The monitored indicator's CLOSE status. "1" refers to the active "Close" state of the monitored indicator.

Events

The indicator object monitoring function (abbreviated "CIN" in event block names) generates events from the status changes in the events listed below. The user can select which event messages are stored in the main event buffer: ON, OFF, or both. The events triggered by the function are recorded with a time stamp.

Table. 4.4.3 - 26. Event messages (instances 1-20).

Event block name	Event names
CIN1...20	Intermediate
CIN1...20	Open
CIN1...20	Close
CIN1...20	Bad

4.4.4 Milliampere output control

The milliamp current loop is the prevailing process control signal in many industries. It is an ideal method of transferring process information because a current does not change as it travels from a transmitter to a receiver. It is also much more simple and cost-effective.

The benefits of 4...20 mA loops:

- the dominant standard in many industries
- the simplest option to connect and configure
- uses less wiring and connections than other signals, thus greatly reducing initial setup costs
- good for travelling long distances, as current does not degrade over long connections like voltage does

- less sensitive to background electrical noise
- detects a fault in the system incredibly easily since 4 mA is equal to 0 % output.

Milliampere (mA) outputs

The device supports up to two (2) independent mA option cards. Each card has four (4) mA output channels and one (1) mA input channel. If the device has an mA option card, enable mA outputs at *Control* → *Device IO* → *mA outputs*. The outputs are activated in groups of two: channels 1 and 2 are activated together, as are channels 3 and 4.

Table. 4.4.4 - 27. Main settings (output channels).

Name		Range	Default	Description
mA option card 1	Enable mA output channels 1 and 2	• Disabled • Enabled	Disabled	Enables and disables the outputs of the mA output card 1.
	Enable mA output channels 3 and 4			
mA option card 2	Enable mA output channels 5 and 6	• Disabled • Enabled	Disabled	Enables and disables the outputs of the mA output card 2.
	Enable mA output channels 7 and 8			

Table. 4.4.4 - 28. Settings for mA output channels.

Name	Range	Step	Default	Description
Enable mA output channel	• Disabled • Enabled	-	Disabled	Enables and disables the selected mA output channel. If the channel is disabled, the channel settings are hidden.
Magnitude selection for mA output channel	• Currents • Voltages • Powers • Impedance and admittance • Other	-	Currents	Defines the measurement category that is used for mA output control.
Magnitude of mA output channel	(dependent on the measurement category selection)	-	(dependent on the measurement category selection)	Defines the measurement magnitude used for mA output control. The available measurements depend on the selection of the "Magnitude selection for mA output channel" parameter.
Input value 1	$-10^7 \dots 10^7$	0.001	0	The first input point in the mA output control curve.
Scaled mA output value 1	0.0000...24.0000mA	0.0001mA	0mA	The mA output value when the measured value is equal to or less than Input value 1.
Input value 2	$-10^7 \dots 10^7$	0.001	1	The second input point in the mA output control curve.

Name	Range	Step	Default	Description
Scaled mA output value 2	0.0000...24.0000mA	0.0001mA	0mA	The mA output value when the measured value is equal to or greater than Input value 2.

Figure. 4.4.4 - 16. Example of the effects of mA output channel settings.

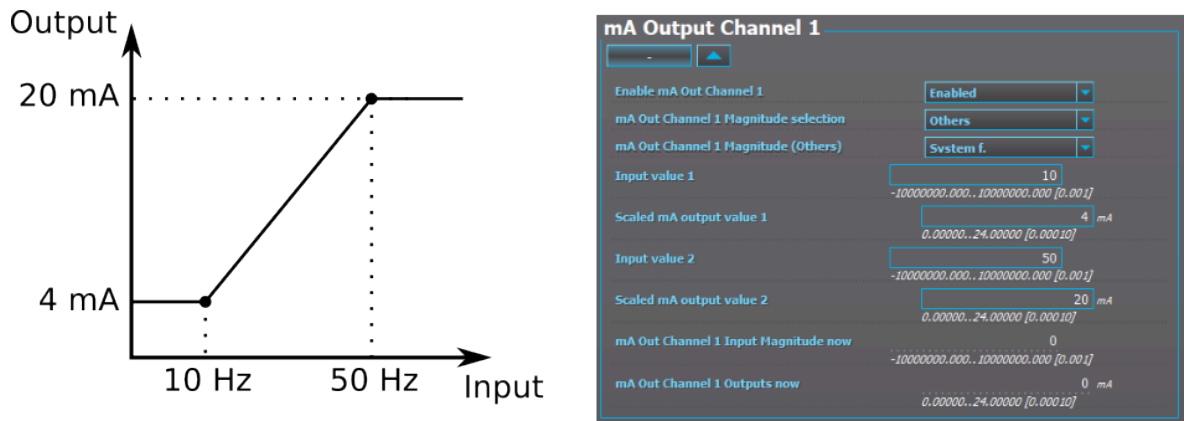


Table. 4.4.4 - 29. Hardware indications.

Name	Range	Description
Hardware in mA output channels 1...4	- None - Slot A - Slot B - Slot C - Slot D - Slot E - Slot F - Slot G - Slot H - Slot I - Slot J - Slot K - Slot L - Slot M - Slot N - Too many cards installed	Indicates the option card slot where the mA output card is located.
Hardware in mA output channels 5...8		

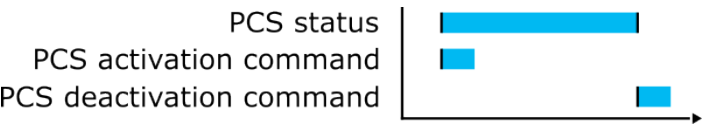
Table. 4.4.4 - 30. Measurement values reported by mA output cards.

Name	Range	Step	Description
mA in Channel 1	0.0000...24.0000mA	0.0001mA	Displays the measured mA value of the selected input channel.
mA in Channel 2			
mA Out Channel Input Magnitude now	$-10^7 \dots 10^7$	0.001	Displays the input value of the selected mA output channel at that moment.
mA Out Channel Outputs now	0.0000...24.0000mA	0.0001mA	Displays the output value of the selected mA output channel at that moment.

4.4.5 Programmable control switch

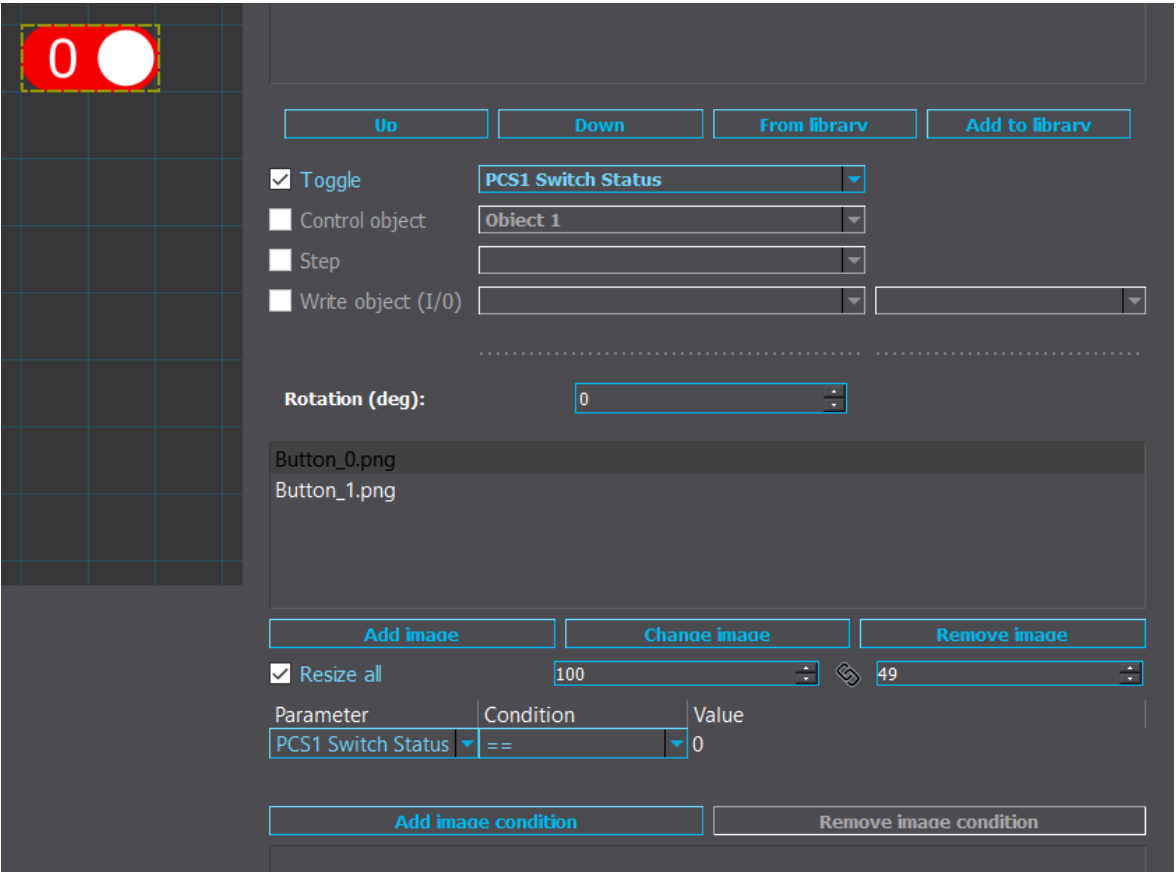
The programmable control switch is a control function that controls its binary output signal. This output signal can be controlled locally from the device's mimic or remotely from the RTU. The main purpose of programmable control switches is to block or enable function and to change function properties by changing the setting group. However, this binary signal can also be used for any number of other purposes, just like all other binary signals. Once a programmable control switch has been activated or disabled, it remains in that state until given a new command to switch to the opposite state (see the image below). The switch cannot be controlled by an auxiliary input, such as digital inputs or logic signals; it can only be controlled locally (mimic) or remotely (RTU).

Figure. 4.4.5 - 17. When a PCS has been controlled "ON" or "OFF", the PCS will keep its state.



Setting up a switch in the mimic editor

Figure. 4.4.5 - 18. Programmable control switch setup in the mimic editor.



When an item has been added to the mimic, a collection of toggleable buttons can be found from the library with the "From library" button. To make an item a "programmable control switch", select one of the programmable switches (PCS1...5 Switch status) from the "Toggle" dropdown menu. After this select one of the images in the item ("Button_0.png" and "Button_1.png" in the example image above) and then choose the corresponding programmable control switch as the image condition. In the example image "Button_0.png" is displayed when "PCS1 Switch Status == 0". Set the other image (in this case "Button_1.png") to "PCS1 Switch Status == 1". When this is done, the image displayed by the item will follow the status of the programmable control switch.

If more than five toggleable switches are needed, logical inputs can also be set for the same purpose. The only difference is that the status of logical inputs are set to zero when the processor is rebooted, whereas programmable control switches keep the status.

Settings.

These settings can be accessed at *Control → Device I/O → Programmable control switch*.

Table. 4.4.5 - 31. Settings.

Name	Range	Default	Description
Switch name	-	Switchx	The user-settable name of the selected switch. The name can be up to 32 characters long.
Access level for Mimic control	- User - Operator - Configurator - Super user	Configurator	Determines which access level is required to be able to control the programmable control switch via the Mimic.

Events

The programmable control switch function (abbreviated "PCS" in event block names) generates events from the status changes in the events listed below. The user can select which event messages are stored in the main event buffer: ON, OFF, or both. The events triggered by the function are recorded with a time stamp. The function offers five (5) independent switches. The function's output signals can be used for direct I/O controlling and user logic programming.

Table. 4.4.5 - 32. Event messages.

Event block name	Event names
PCS	Switch 1 ON/OFF
PCS	Switch 2 ON/OFF
PCS	Switch 3 ON/OFF
PCS	Switch 4 ON/OFF
PCS	Switch 5 ON/OFF

4.4.6 Function buttons

AQ 250 devices have twelve (12) physical function buttons in the front panel of the device. The main purpose of function buttons is to block or enable functions and to change function properties by changing the setting group. However, this binary signal can also be used for any number of other purposes, just like all other binary signals.

Function buttons have two operation modes: "Press release" and "Toggle On/Off". In "Press release" mode the button status is active while the button is pressed down. In "Toggle On/Off" mode the button status toggles between "On" and "Off". Each button has a user configurable LED at the top left corner of the button. The LED can be configured to activate red, orange or green color from button status or any other logical binary signal.

General button settings and LED activation settings can be set at *Control* → *Device IO* → *Function Button Settings*.



NOTICE!

The status of the function button outputs can only be controlled from the front panel i.e. can't be controlled remotely. Therefore it is recommended to use "a virtual button" (programmable control switches or logical inputs) if a toggleable signal must be controlled both locally and remotely.

Table. 4.4.6 - 33. User button settings

Name	Range	Step	Default	Description
Access level for function buttons	- User - Operator - Configurator - Super user	-	Operator	Determines which access level is required to be able to control the buttons.
Consider Local/ Remote switch for push-buttons	- No - Yes	-	No	When set to "Yes", the buttons can be operated only when the "L/R" button has been set to "Local" mode .
User editable description button 1...12	-	-	BTN1...12	Description of the button. If "Function button" view has been added to the "Carousel design", these descriptions are used for the buttons.
Function button 1...12 mode	Press release Toggle On/Off	-	Press release	Defines the operation mode of the button. In "Press release" mode the button signal is active while the button is pressed down. In "Toggle On/Off" mode the button signal changes status between "On" and "Off" each time the button is pressed.

Table. 4.4.6 - 34. Function button output signals

Signal name	Description
Status Function Button 1...12 ON/OFF	"On" and "Off" status of each button

4.4.7 Analog input scaling curves

Sometimes when measuring with RTD inputs, milliampere inputs and digital inputs the measurement might be inaccurate because the signal coming from the source is inaccurate. One common example of this is tap changer location indication signal not changing linearly from step to step. If the output difference between the steps are not equal to each other, measuring the incoming signal accurately is not enough. "Analog input scaling curves" menu can be used to take these inaccuracies into account.

Analog input scaling curve settings can be found at *Measurement → AI(mA, DI volt) scaling* menu.

Currently following measurements can be scaled with analog input scaling curves:

- RTD inputs and mA inputs in "RTD & mA input" option cards
- mA inputs in "4x mA output & 1x mA input" option cards
- mA input in "4x mA input & 1x mA output" option cards
- Digital input voltages

Table. 4.4.7 - 35. Main settings (input channel).

Name	Range	Step	Default	Description
Analog input scaling	• Disabled • Activated	-	Disabled	Enables and disables the input.
Scaling curve 1...10	• Disabled • Activated	-	Disabled	Enables and disables the scaling curve and the input measurement.
Curve 1...10 input signal select	• S7 mA Input • S8 mA Input • S15 mA Input • S16 mA Input • DI1...DI20 Voltage • RTD S1...S16 Resistance • mA In 1 (I card 1) • mA In 2 (I card 2) • mA In 1 (T card 1) • mA In 2 (T card 1) • mA In 3 (T card 1) • mA In 4 (T card 1) • mA In 1 (T card 2) • mA In 2 (T card 2) • mA In 3 (T card 2) • mA In 4 (T card 2)	-	S7 mA Input	Defines the measurement used by scaling curve.

Name	Range	Step	Default	Description
Curve 1...10 input signal filtering	- No - Yes	-	No	Enables calculation of the average of received signal.
Curve 1...10 input signal filter time constant	0.005...3800.000 s	0.005 s	1 s	Time constant for input signal filtering. This parameter is visible when "Curve 1...4 input signal filtering" has been set to "Yes".
Curve 1...10 input signal out of range set	- No - Yes	-	No	Enables out of range signals. If input signal is out of minimum and maximum limits, "ASC1...4 input out of range" signal is activated.
Curve1...10 input minimum	-1 000 000.00...1 000 000.00	0.00001	0	Defines the minimum input of the curve. If input is below the set limit, "ASC1...4 input out of range" is activated.
Curve 1...10 input	-1 000 000.00...1 000 000.00	0.00001	-	Displays the input measurement received by the curve.
Curve1...10 input maximum	-1 000 000.00...1 000 000.00	0.00001	0	Defines the maximum input of the curve. If input is above the set limit, "ASC1...4 input out of range" is activated.
Curve1...10 output	-1 000 000.00...1 000 000.00	0.00001	-	Displays the output of the curve.

The input signal filtering parameter calculates the average of received signals according to the set time constant. This is why rapid changes and disturbances (such as fast spikes) are smothered. The Nyquist rate states that the filter time constant must be at least double the period time of the disturbance process signal. For example, the value for the filter time constant is 2 seconds for a 1 second period time of a disturbance oscillation.

$$H(s) = \frac{Wc}{s+Wc} = \frac{1}{1+s/Wc}$$

When the curve signal is out of range, it activates the "ASC1...10 input out of range" signal, which can be used inside logic or with other functions of the device. The signal can be assigned directly to an output relay or to an LED in the I/O matrix. The "Out of range" signal is activated, when the measured signal falls below the set input minimum limit, or when it exceeds the input maximum limit.

If for some reason the input signal is lost, the value is fixed to the last actual measured cycle value. The value does not go down to the minimum if it has been something else at the time of the signal breaking.

Table. 4.4.7 - 36. Output settings and indications.

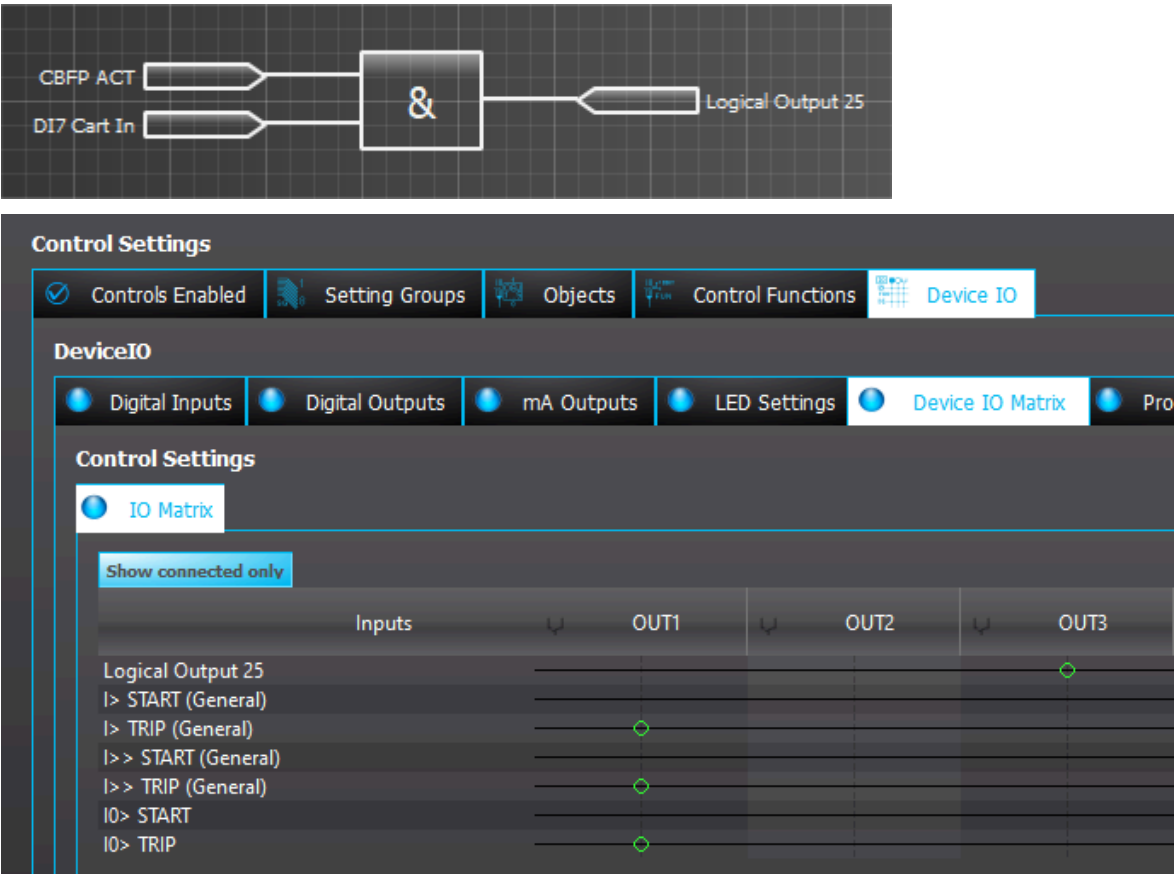
Name	Range	Step	Default	Description
Curve 1...10 update cycle	5...10 000ms	5ms	150ms	Defines the length of the input measurement update cycle. If the user wants a fast operation, this setting should be fairly low.

Name	Range	Step	Default	Description
Scaled value handling	- Floating point - Integer out (Floor) - Integer (Ceiling) - Integer (Nearest)	-	Floating point	Rounds the milliampere signal output as selected.
Input value 1	0...4000	0.000 01	0	The measured input value at Curve Point 1.
Scaled output value 1	$-10^7 \dots 10^7$	0.000 01	0	Scales the measured milliampere signal at Point 1.
Input value 2	0...4000	0.000 01	1	The measured input value at Curve Point 2.
Scaled output value 2	$-10^7 \dots 10^7$	0.000 01	0	Scales the measured milliampere signal at Point 2.
Add curvepoint 3...20	- Not used - Used	-	Not used	Allows the user to create their own curve with up to twenty (20) curve points, instead of using a linear curve between two points.

4.4.8 Logical outputs

Logical outputs are used for sending binary signals out from a logic that has been built in the logic editor. Logical signals can be used for blocking functions, changing setting groups, controlling digital outputs, activating LEDs, etc. The status of logical outputs can also be reported to a SCADA system. 64 logical outputs are available. The figure below presents a logic output example where a signal from the circuit breaker failure protection function controls the digital output relay number 3 ("OUT3") when the circuit breaker's cart status is "In".

Figure. 4.4.8 - 19. Logic output example. Logical output is connected to an output relay in matrix.



Logical output descriptions

Logical outputs can be given a description. The user defined description are displayed in most of the menus:

- logic editor
- matrix
- block settings
- event history
- disturbance recordings
- etc.

Table. 4.4.8 - 37. Logical output user description.

Name	Range	Default	Description
User editable description LO1...64	1...31 characters	Logical output 1...64	Description of the logical output. This description is used in several menu types for easier identification.



NOTICE!

After editing user descriptions the event history will start to use the new description only after resetting the HMI. HMI can be reset from *General* → *Device info* → *HMI restart*.

Events

The logical outputs (abbreviated "LOGIC" in event block names) generates events from the status changes in the events listed below. The user can select which event messages are stored in the main event buffer: ON, OFF, or both. The events triggered by the function are recorded with a time stamp. The function's output signals can be used for direct I/O controlling and user logic programming.

Table. 4.4.8 - 38. Event messages.

Event block name	Event names
LOGIC1	Logical out 1...32 ON/OFF
LOGIC3	Logical out 33...64 ON/OFF

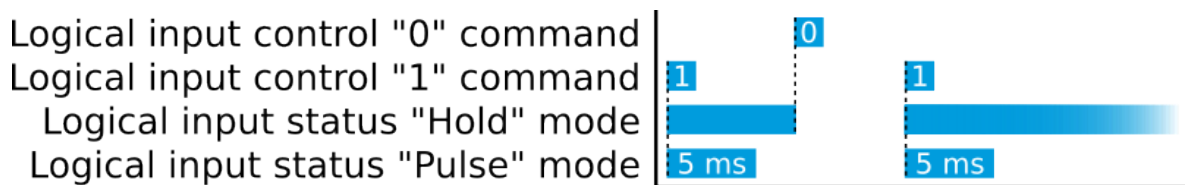
4.4.9 Logical inputs

Logical inputs are binary signals that a user can control manually to change the behavior of the device or to give direct control commands. Logical inputs can be controlled with a virtual switch built in the mimic and from a SCADA system. Logical inputs are volatile signals: their status will always return to "0" when the device is rebooted. 32 logical inputs are available.

Logical inputs have two modes available: Hold and Pulse. When a logical input which has been set to "Hold" mode is controlled to "1", the input will switch to status "1" and it stays in that status until it is given a control command to go to status "0" or until the device is rebooted. When a logical input which has been set to "Pulse" mode is controlled to "1", the input will switch to status "1" and return back to "0" after 5 ms.

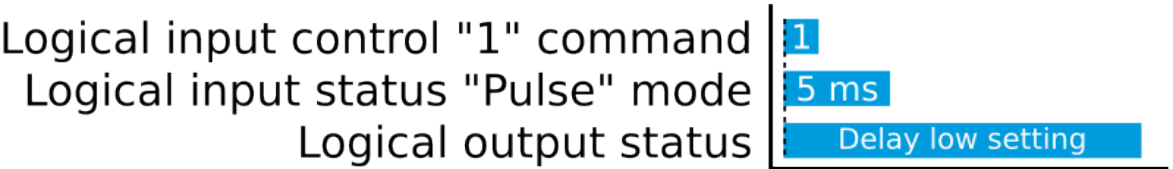
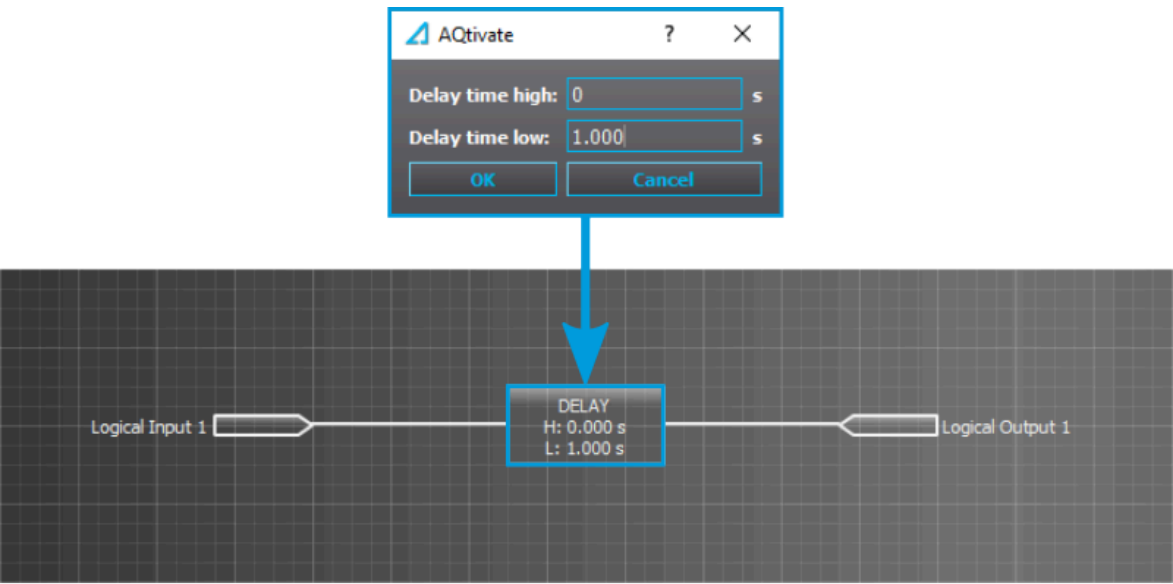
The figure below presents the operation of a logical input in Hold mode and in Pulse mode.

Figure. 4.4.9 - 20. Operation of logical input in "Hold" and "Pulse" modes.



A logical input pulse can also be extended by connecting a DELAY-low gate to a logical output, as has been done in the example figure below.

Figure. 4.4.9 - 21. Extending a logical input pulse.



Logical input descriptions

Logical inputs can be given a description. The user defined description are displayed in most of the menus:

- logic editor
- matrix
- block settings
- event history
- disturbance recordings
- etc.

Table. 4.4.9 - 39. Logical input user description.

Name	Range	Default	Description
User editable description LI1...32	1...31 characters	Logical input 1...32	Description of the logical input. This description is used in several menu types for easier identification.

NOTICE!

After editing user descriptions the event history will start to use the new description only after resetting the HMI. HMI can be reset from *General* → *Device info* → *HMI restart*.

Events

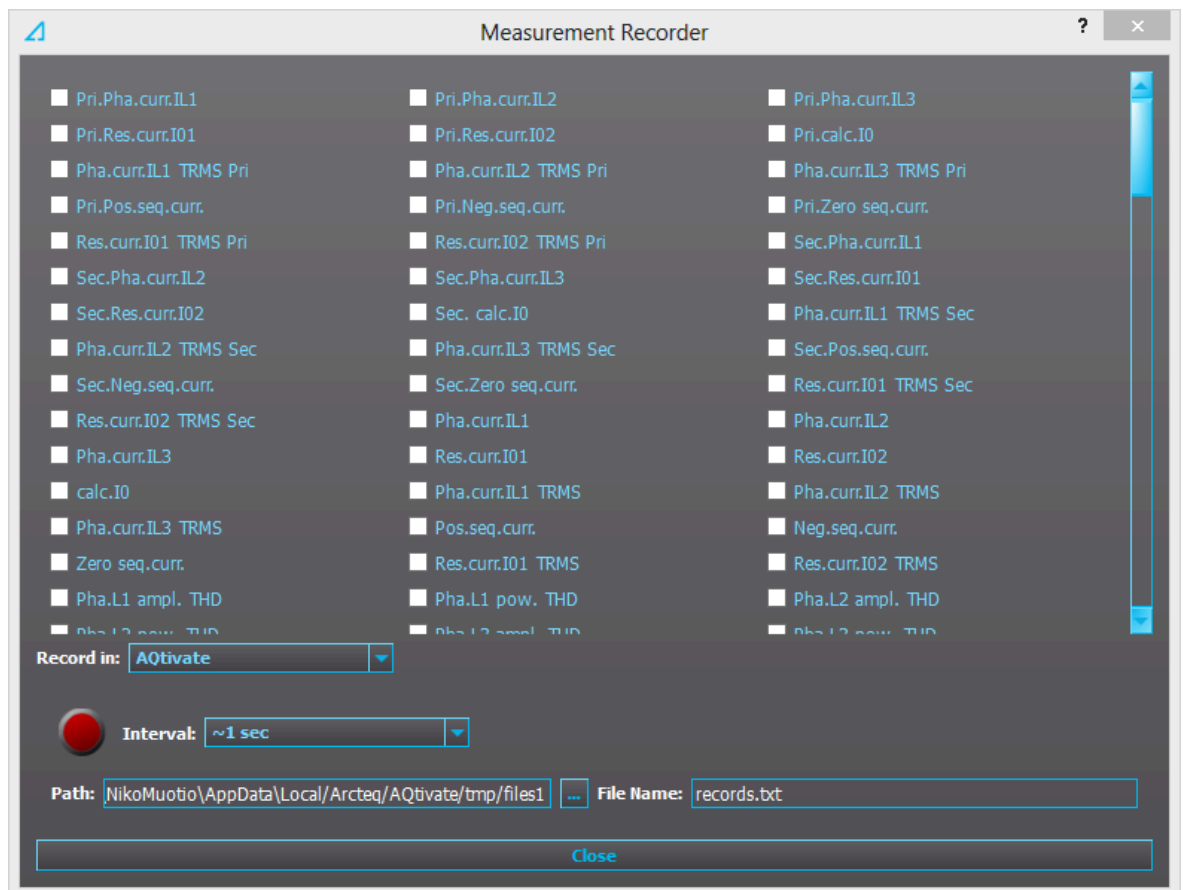
The logical outputs (abbreviated "LOGIC" in event block names) generates events from the status changes in the events listed below. The user can select which event messages are stored in the main event buffer: ON, OFF, or both. The events triggered by the function are recorded with a time stamp. The function's output signals can be used for direct I/O controlling and user logic programming.

Table. 4.4.9 - 40. Event messages.

Event block name	Event names
LOGIC2	Logical in 1...32 ON/OFF

4.5 Monitoring functions

4.5.1 Measurement recorder



Measurements can be recorded to a file with the measurement recorder. The chosen measurements are recorded at selected intervals. In the "Measurement recorder" window, the measurements the user wants to be recorded can be selected by checking their respective check boxes. In order for the measurement recorder to activate, a connection to a device must be established via the setting tool software and its Live Edit mode must be enabled (see the setting tool manual for more information). Navigate to the measurement recorder through *Tools* → *Miscellaneous tools* → *Measurement recorder*. The recording interval can be changed from the "Interval" drop-down menu. From the "Record in" drop-down menu the user can also choose whether the measurements are recorded in the setting tool or in the device.

If the recording is done in the setting tool, both the setting tool software and its Live Edit mode have to be activated. The user can change the recording file location by editing the "Path" field. File names can also be changed with the "File name" field. Hitting the "Record" button (the big red circle) starts the recorder. Please note that closing the "Measurement recorder" window does not stop the recording; that can only be done by hitting the "Stop" button (the big blue circle).

4.5.2 Event logger

Event logger records status changes of protection functions, digital inputs, logical signals etc. Events are recorded with a timestamp. The time stamp resolution is 1 ms. Up to 15 000 events can be stored at once. When 15 000 events have been recorded, the event history will begin to remove the oldest events to make room for new events. You can find more information about event masks in the selected function's "Events" tab. Event masks determine what is recorded into the event history; they are configured in each function's individual settings in the *Protection*, *Control* and *Monitoring* menu. Event history is accessible with PC setting tool (*Tools* → *Events and Logs* → *Event history*) and from the device HMI if "Events" view has been configured with Carousel designer in PC setting tool.

Event overload detection

Continuous generation of a high number of nuisance events may have adverse effects on the operation and communication capabilities of the device. A high number of nuisance events may end up being generated due to mistakes in configuration and/or installation. For example, mistakes in logic configuration or RTD sensor wiring, in conjunction with suitable event mask settings may generate an excessive number of unintended events. Event overload detector looks for a condition where over 200 events are being generated inside one (1) second window (more than 1 event every 5 milliseconds on average). If such a condition is detected, further events are blocked and an IRF (Internal Relay Fault-message) is issued. The event blocking is released and the IRF can be cleared after 5 seconds if the overload condition has been corrected. Other device operations, such as protection and communication, remain available even during the event overload condition.

4.5.3 Disturbance recorder (DR)

The disturbance recorder is a high-capacity (64 MB permanent flash memory) and fully digital recorder integrated to the protection relay. The maximum sample rate of the recorder's analog channels is 64 samples per cycle. Up to 20 analog recording channels and 96 digital channels are supported. Maximum capacity of recordings is 100.

The recorder provides an effective tool to analyze the performance of the power system during network disturbance situations. The recorder's output is in general COMTRADE format and it is compatible with most recording viewers and injection devices. The files are based on the IEEE standard C37.111-1999. Captured recordings can be injected as playback with secondary testing tools that support the COMTRADE file format. Playback of files might help to analyze the fault, or can be simply used for educational purposes.

Analog and digital recording channels

Table. 4.5.3 - 41. Analog recording channels.

Signal	Description
IL1	Phase current I_{L1}
IL2	Phase current I_{L2}
IL3	Phase current I_{L3}

Signal	Description
I01c	Residual current I ₀₁ coarse*
I01f	Residual current I ₀₁ fine*
I02c	Residual current I ₀₂ coarse*
I02f	Residual current I ₀₂ fine*
IL1"	Phase current I _{L1} (CT card 2)
IL2"	Phase current I _{L2} (CT card 2)
IL3"	Phase current I _{L3} (CT card 2)
I01"c	Residual current I ₀₁ coarse* (CT card 2)
I01"f	Residual current I ₀₁ fine* (CT card 2)
I02"c	Residual current I ₀₂ coarse* (CT card 2)
I02"f	Residual current I ₀₂ fine* (CT card 2)
U1(2)VT1	Line-to-neutral U _{L1} or line-to-line voltage U _{L12} (VT card 1)
U2(3)VT1	Line-to-neutral U _{L2} or line-to-line voltage U _{L23} (VT card 1)
U3(1)VT1	Line-to-neutral U _{L3} or line-to-line voltage U _{L31} (VT card 1)
U0(ss)VT1	Zero sequence voltage U ₀ or synchrocheck voltage U _{SS} (VT card 1)
F tracked 1	Tracked frequency of reference 1
F tracked 2	Tracked frequency of reference 2
F tracked 3	Tracked frequency of reference 3
ISup	Current measurement module voltage supply supervision (CT card 1)
ISup"	Current measurement module voltage supply supervision (CT card 2)
USup	Voltage measurement module voltage supply supervision (VT card 1)
IL1'''	Phase current I _{L1} (CT card 3)
IL2'''	Phase current I _{L2} (CT card 3)
IL3'''	Phase current I _{L3} (CT card 3)
I01'''c	Residual current I ₀₁ coarse* (CT card 3)
I01'''f	Residual current I ₀₁ fine* (CT card 3)
I02'''c	Residual current I ₀₂ coarse* (CT card 3)
I02'''f	Residual current I ₀₂ fine* (CT card 3)
ISup_3	Current measurement module voltage supply supervision (CT card 3)
UL1(2)VT2	Line-to-neutral U _{L1} or line-to-line voltage U _{L12} (VT card 2)

Signal	Description
UL2(3)VT2	Line-to-neutral U_{L2} or line-to-line voltage U_{L23} (VT card 2)
UL3(1)VT2	Line-to-neutral U_{L3} or line-to-line voltage U_{L31} (VT card 2)
U0(SS)VT2	Zero sequence voltage U_0 or synchrocheck voltage U_{SS} (VT card 2)
USup_2	Voltage measurement module voltage supply supervision (VT card 2)

***NOTE:** There are two signals for each residual current channel in the disturbance recorder: coarse and fine. A coarse signal is capable of sampling in the full range of the current channel but suffers a loss of accuracy at very low currents. A fine signal is capable of sampling at very low currents and with high accuracy but cuts off at higher currents. Table below lists performance of both channels with fine and coarse gain.

Table. 4.5.3 - 42. Residual current channel performance with coarse or residual gain.

Channel	Coarse gain range	Fine gain range	Fine gain peak
I01	0...150 A	0...10 A	15 A
I02	0...75 A	0...5 A	8 A

Recording settings and triggering

Disturbance recorder can be triggered manually or automatically by using the dedicated triggers. Every signal listed in "Digital recording channels" can be selected to trigger the recorder.

The number of analog and digital channels together with the sample rate and the time setting affect the recording size. See calculation examples below in the section titled "Estimating the maximum length of total recording time". The recording size affects how many recordings can be stored at a time, but the number can't exceed 100 recordings.

Table. 4.5.3 - 43. Recorder control settings.

Name	Range	Description
Recorder enabled	- Enabled - Disabled	Enables and disables the disturbance recorder function.
Recorder status	- Recorder ready - Recording triggered - Recording and storing - Storing recording - Recorder full - Wrong config	Indicates the status of recorder. "Wrong config" is activated if: "Pre-triggering time" is longer than "Max length of recording" setting "Max amount of recordings" is "1" and "Recording mode" is "FIFO". "1ms" digital channel sample rate is selected when analog channel sample rate is 8 or 16 s/c.
Clear record	0...2 ³² -1	Clears selected recording. If "1" is inserted, first recording will be cleared from memory. If "10" is inserted, tenth (10th) recording will be cleared from memory.

Name	Range	Description
Manual trigger	- - Trig	Triggers disturbance recording manually. This parameter will return back to "-" automatically.
Clear all records	- - Clear	Clears all disturbance recordings.
Clear newest record	- - Clear	Clears the newest stored disturbance recording.
Clear oldest record	- - Clear	Clears the oldest stored disturbance recording.
Max. number of recordings	0...100	Displays the maximum number of recordings that can be stored in the device's memory with settings currently in use. The maximum number of recordings can go up to 100.
Max. length of a recording	0.000...1800.000s	Displays the maximum length of a single recording.
Max. location of the pre-trigger	0.000...1800.000s	Displays the highest pre-triggering time that can be set with the settings currently in use.
Recordings in memory	0...100	Displays how many recordings are stored in the memory.

Table. 4.5.3 - 44. Recorder trigger setting.

Name	Description
Recorder trigger	Selects the trigger input(s). Clicking the "Edit" button brings up a pop-up window, and checking the boxes enable the selected triggers.

Table. 4.5.3 - 45. Recorder settings.

Name	Range	Default	Description
Recording length	0.100...1800.000s	1s	Sets the length of a recording.
Recording mode	- FIFO - Keep olds	FIFO	Selects what happens when the memory is full. "FIFO" (= first in, first out) replaces the oldest stored recording with the latest one. "Keep olds" does not accept new recordings.
Analog channel samples	64s/c 32s/c 16s/c 8s/c	64s/c	Selects the sample rate of the disturbance recorder in samples per cycle. The samples are saved from the measured wave according to this setting.

Name	Range	Default	Description
Digital channel samples	5 ms 1 ms	5 ms	The fixed sample rate of the recorded digital channels. Recorded digital channels can be chosen with "Recorder digital channels" below. NOTE: 1 ms sample rate can't be used when analog channel sample rate is 8 or 16 s/c.
Pretriggering time	0.2...30.0s	0.2s	Sets the recording length before the trigger.
Analog recording CH1...CH20	0...8 freely selectable channels	-	Selects the analog channel for recording. Please see the list of all available analog channels in the section titled "Analog and digital recording channels".
Automatically get recordings	- Disabled - Enabled	Disabled	Enables and disables the automatic transfer of recordings. The recordings are taken from the device's protection CPU and transferred to the device's FTP directory in the communication CPU; the FTP client then automatically loads the recordings from the device and transfers them further to the SCADA system. Please note that when this setting is enabled, all new disturbance recordings will be pushed to the FTP server of the device. Up to six (6) recordings can be stored in the FTP at once. Once those six recordings have been retrieved and removed, more recordings will then be pushed to the FTP. When a recording has been sent to the FTP server of the device, it is no longer accessible through setting tools <i>Disturbance recorder</i> → <i>Get DR files</i> command.
Recorder digital channels	0...96 freely selectable channels	-	Selects the digital channel for recording. Please see the list of all available digital channels in the section titled "Analog and digital recording channels".

NOTICE!

The disturbance recorder is not ready unless the "Max. length of a recording" parameter is showing some value other than zero. At least one trigger input has to be selected in the "Recorder Trigger" setting to fulfill this term.

NOTICE!

When writing new disturbance recorder settings to the device, any existing recordings in the device memory will be deleted.

Estimating the maximum length of total recording time

Once the disturbance recorder's settings have been made and loaded to the device, the device automatically calculates and displays the total length of recordings. However, if the user wishes to confirm this calculation, they can do so with the following formula. Please note that the formula assumes there are no other files in the FTP that share the 64 MB space.

$$\frac{\text{Total sample reserve}}{(f_n * (Ch_{an} + 1) * SR) + (200 \text{ Hz} * Ch_{dig})}$$

Where:

- total sample reserve = the number of samples available in the FTP when no other files are saved; calculated by dividing the total number of available bytes by 4 bytes (=the size of one sample); e.g. 64 306 588 bytes/4 bytes = 16 076 647 samples.

- f_n = the nominal frequency (Hz).
- Ch_{an} = the number of analog channels recorded; "+ 1" stands for the time stamp for each recorded sample.
- SR = the selected sample rate (s/c).
- 200 Hz = the rate at which digital channels are always recorded, i.e. 5 ms.
- Ch_{dig} = the number of digital channels recorded.

For example, let us say the nominal frequency is 50 Hz, the selected sample rate is 64 s/c, nine (9) analog channels and two (2) digital channels record. The calculation is as follows:

$$\frac{16\,076\,647 \text{ samples}}{(50 \text{ Hz} * (9 + 1) * 64) + (200 \text{ Hz} * 2)} \approx 496 \text{ s}$$

Therefore, the maximum recording length in our example is approximately 496 seconds.

Application example

This chapter presents an application example of how to set the disturbance recorder and analyze its output. The recorder is configured by using the setting tool software or device HMI, and the results are analyzed with the AQviewer software (is automatically downloaded and installed with AQtivate). Registered users can download the latest tools from the Arcteq website (arcteq.fi/downloads/).

In this example, we want the recordings to be made according to the following specifications:

- the recording length is 6.0 s
- the sample rate is 64 s/c (therefore, with a 50 Hz system frequency a sample is taken every 312.5 μ s)
- the analog channels 1...8 are used
- digital channels are tracked every 5 ms
- the first activation of the overcurrent stage trip ($I > \text{TRIP}$) triggers the recorder
- the pre-triggering time is 5 (ie. how long is recorded before the $I > \text{TRIP}$ signal) and the post-triggering time is 1 s

The image below shows how these settings are placed in the setting tool.

Figure. 4.5.3 - 22. Disturbance recorder settings.

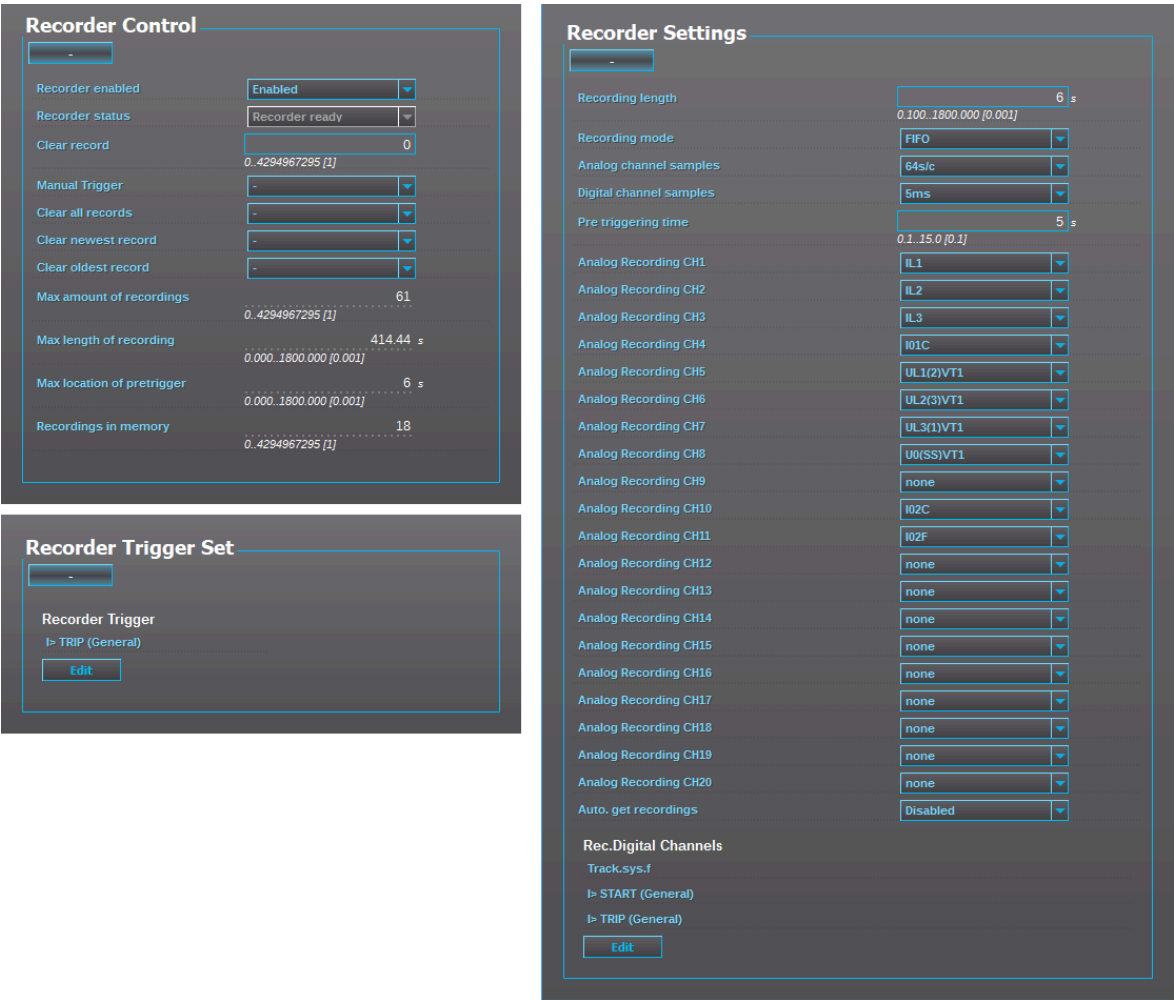
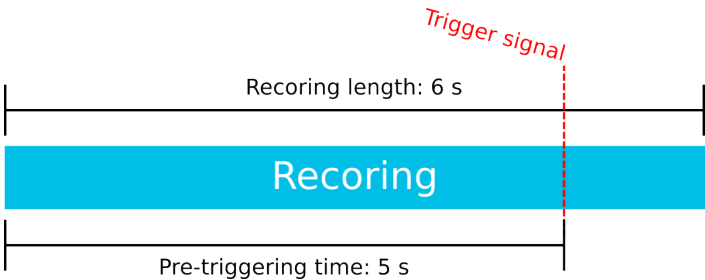
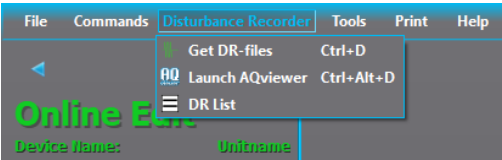


Figure. 4.5.3 - 23. Effects of recording length and pre-triggering time signals. This example is based on the settings shown above.



When there is at least one recording in the device's memory, that recording can be analyzed by using the AQviewer software (see the image below). However, the recording must first be made accessible to AQviewer. The user can read it from the device's memory (*Disturbance recorder* → *Get DR-files*). Alternatively, the user can load the recordings individually (*Disturbance recorder* → *DR List*) from a folder in the PC's hard disk drive; the exact location of the folder is described in *Tools* → *Settings* → *DR path*.



The user can also launch the AQviewer software from the *Disturbance recorder* menu. AQviewer software instructions can be found in AQtivate Instruction manual (<https://www.arcteq.com/documents-and-software/>).

Events

The disturbance recorder function (abbreviated "DR" in event block names) generates events and registers from the status changes in the events listed below. Events cannot be masked off. The events triggered by the function are recorded with a time stamp.

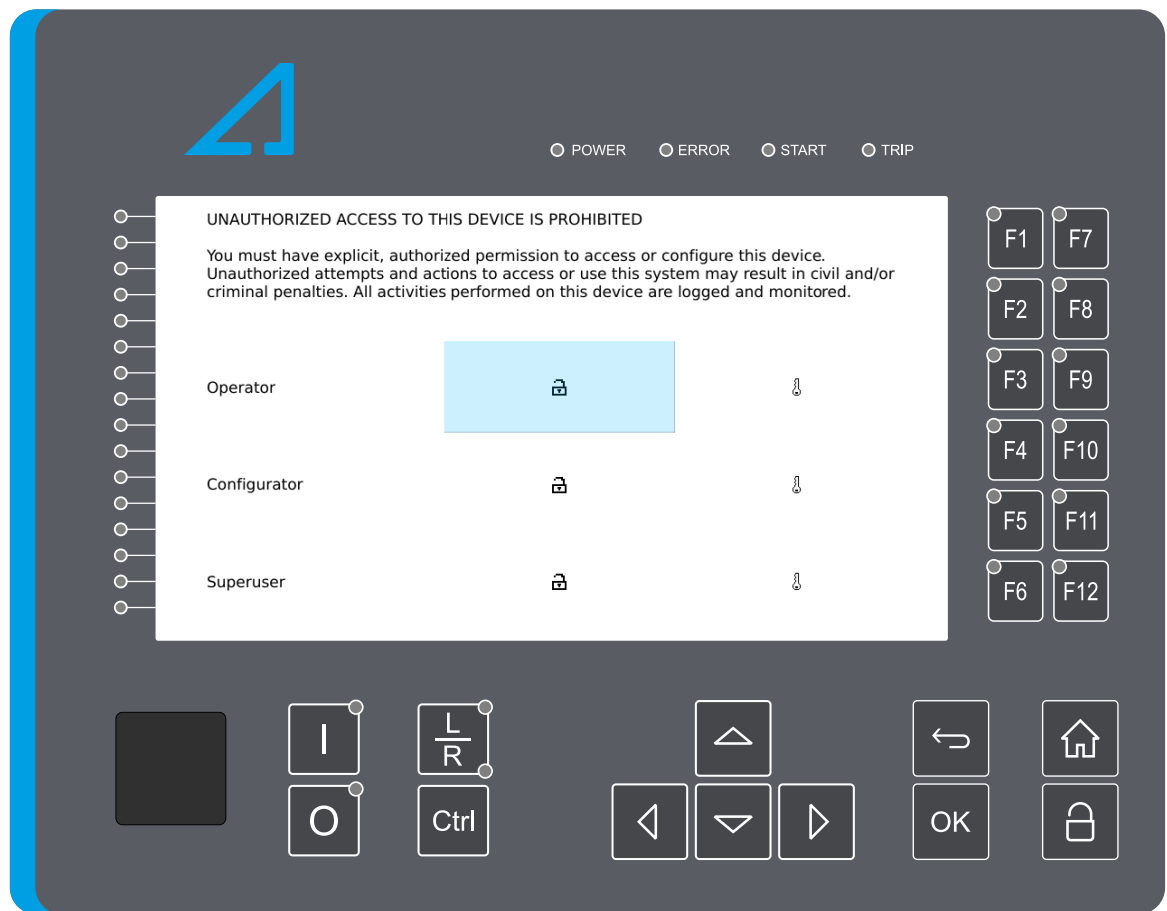
Table. 4.5.3 - 46. Event messages.

Event block name	Event names
DR1	Recorder triggered ON/OFF
DR1	Recorder memory cleared
DR1	Oldest record cleared
DR1	Recorder memory full ON/OFF
DR1	Recording ON/OFF
DR1	Storing recording ON/OFF
DR1	Newest record cleared

4.5.4 User access control

As a factory default, no user level is locked with a password in a device. In order to activate the different user levels, push the **Lock** button on the device's front panel and set the desired passwords for the user levels.

Figure. 4.5.4 - 24. User access control view.

**NOTICE!**

Passwords can only be set locally in an HMI.

You can set a new password for a user level by selecting the key icon next to the user level's name. After this you can lock the user level by pressing the Return key while the lock is selected. If you need to change the password, you can select the key icon again and give a new password. To remove the password, set the password to "0" (zero). Please note that in order to do this the user level whose password is being changed must be unlocked.

As a general rule, access levels are divided into four categories:

- **User:** Can view all menus and settings but cannot modify settings or operate breakers or other equipment.
- **Operator:** Can view all menus and settings and operate breakers and other equipment, but cannot modify settings.
- **Configurator:** Can modify most settings, such as protection pickup levels, time delays, breaker control functions, and signal descriptions. Can also operate breakers and other equipment.
- **Super User:** Has full access to all settings and can operate breakers and other equipment.

The **User** access level provides the following permissions:

- Download the aqs file from the device.
- Download disturbance recordings.
- Read events.
- Retrieve the default IEC 61850 configuration file (.cid) from the device.
- Limited parameter writing permissions.

The **Operator** access level includes all **User** permissions, plus:

- All rights as "User" user level.
- Can operate circuit breakers, disconnectors and other equipment.

The **Configurator** access level includes all **Operator** permissions, plus:

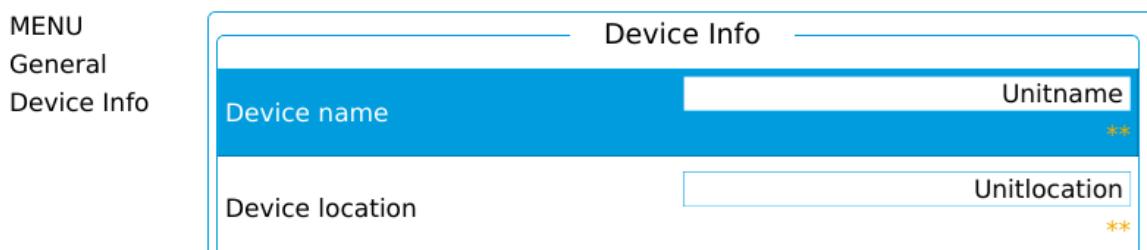
- Configure logic, disturbance recorder, mimic diagrams, communications, alarms, measurement recorder, and timers.
- Read and clear the device log.
- Upload user language files.
- Set the device time and time zone.
- Modify most parameters. Critical settings, such as enabling or disabling protection functions, remain restricted.

The **Super User** access level includes all **Configurator** permissions, plus:

- Full read and write access to all parameters.
- Upgrade device firmware.
- Execute scripts on the device.
- Perform a factory reset.
- Clear event history.
- Upload security file (certificate, key, etc.).

When configuring the device parameters, the required user level is displayed below the parameter.

Figure. 4.5.4 - 25. Required user level is displayed below the parameter in HMI view.



Within the AQtivate configuration software, users can choose whether the required user level is displayed together with the parameter. The user level can be opened in the *Commands* → *Login* menu. Currently open user level is displayed in the top bar of the software.

Advanced user access control settings

More detailed settings for user access can be found from *Monitoring* → *User Access Control* menu.

Table. 4.5.4 - 47. UAC settings.

Name	Range	Default	Description
Enable user group - Operator	• Enabled • Disabled	Enabled	Enables or disables "Operator" user group.
Enable user group - Configurator	• Enabled • Disabled	Enabled	Enables or disables "Configurator" user group.
Minimum password length	0...128	1	Sets the minimum character length for passwords.

Name	Range	Default	Description
Number of fail attempts before lock	0...1000	3	Sets the number of failed attempts allowed before locking the user level.
Lock period after max fail attempts	0...86400000 s	0 s	Wait time after locking a user level.
HMI session period before logout	5...86400 s	900 s	Time delay for logging out in the HMI. Timer will start the countdown when there are no front panel button presses.
Setting tool session period before logout	5...86400 s	900 s	Time delay for logging out in the setting tool. Timer will start the countdown when there are no key presses or mouse movement.

Table. 4.5.4 - 48. UAC management.

Name	Range	Default	Description
Enable UAC management	- Enabled - Disabled	Disabled	If UAC has been enabled, the function will set default passwords for the user levels, if no passwords have been set. The function will also monitor if the passwords have been expired.
Enable default passwords	- Enabled - Disabled	Disabled	If enabled, user levels will use the default passwords, if no passwords have been set. The default passwords are: - Operator: Oper17 - Configurator: Conf12 - Super user: Supr98
Password change interval - Operator	0...1000 day(s)	0 day(s)	Required interval for changing passwords. If the password hasn't been changed on time, "Password expired" parameter will change to "True", diagnostic alarm will be activated and an entry to the audit log will be added.
Password change interval - Configurator	0...1000 day(s)	0 day(s)	
Password change interval - Superuser	0...1000 day(s)	0 day(s)	
Password expired - Operator	- False - True	-	If the password hasn't been changed before the "password change interval" has expired, this parameter will change to "True"
Password expired - Configurator	- False - True	-	
Password expired - Superuser	- False - True	-	

Name	Range	Default	Description
Default password unchanged - Operator	- False - True	-	Indicates if the user level is using the default password or a user configured password.
Default password unchanged - Configurator	- False - True	-	
Default password unchanged - Superuser	- False - True	-	
Password last changed - Operator	DD/MM/YYYY HH:mm:ss	-	Timestamp of the last time the password has been changed for the user level.
Password last changed - Configurator	DD/MM/YYYY HH:mm:ss	-	
Password last changed - Superuser	DD/MM/YYYY HH:mm:ss	-	

5 Communication

5.1 Connections menu

"Connections" menu is found under "Communication" menu. It contains all basic settings of the default back panel ethernet port and RS-485 serial port as well as settings of communication option cards.

Table. 5.1 - 49. Ethernet settings.

Name	Range	Description
IP address	0.0.0.0...255.255.255.255	Set IP address of the ethernet port in the back of the device.
Netmask	0.0.0.0...255.255.255.255	Set netmask of the ethernet port in the back of the device.
Gateway	0.0.0.0...255.255.255.255	Set gateway of the ethernet port in the back of the device.
MAC-Address	00-00-00-00-00-00...FF-FF-FF-FF-FF-FF	Indication of MAC address of the device.
Storm Protection	- Disable - Enable	When enabled, the Storm protection functionality of the internal switch in the device is enabled. This functionality aims to protect the device from excess ethernet traffic caused by storm situation. When enabled, the packet rate allowed to pass through on the ingress port towards the device, is limited to 150 packets per second. Multicast packets are also included in the packet limit.
Double Ethernet card mode	- Switch - HSR - PRP	If the device has a double ethernet option card it is possible to choose its mode.
COM A and Ethernet option card connection	- Block all - Allow both directions - Allow COM A to option card - Allow option card to COM A	If the device has ethernet option card it is possible to determine the allowed direction of data.
Double Ethernet link events	- Disable - Enable	Disables or enables "Double Ethernet Link A down" and "Double Ethernet Link B down" logic signals and events.
Double Ethernet PRP ports	- AB - BA	LanA and LanB port assignment for communication cards that support PRP.

Table. 5.1 - 50. Ethernet security settings.

Name	Description
Enable back Ethernet port	Enable/Disable back panel Ethernet port communication.
Enable front Ethernet port	Enable/Disable front panel Ethernet port communication.

Name	Description
Enable SSH from front Ethernet port	Enable/Disable front panel Ethernet port SSH.
Enable FTP	Enable/Disable FTP server.
Enable discovery messages	Enable/Disable discovery messages. Discovery messages enable <i>Tools</i> → <i>Device list</i> menu in AQtivate setting tool to find all of the devices in the network.
Enable script running	Enable/Disable running scripts with <i>Tools</i> → <i>Run script</i> in AQtivate setting tool.
Enable HMI view buttons	Enable/Disable HMI button presses in the "HMI View" (<i>Tools</i> → <i>Misc</i> → <i>HMI View</i> in AQtivate).

Virtual Ethernet enables the device to be connected to multiple different networks simultaneously via one physical Ethernet connection. Virtual Ethernet has its own separate IP address and network configurations. All Ethernet-based protocol servers listen for client connections on the IP addresses of both the physical Ethernet and the Virtual Ethernet.

Table. 5.1 - 51. Virtual Ethernet settings.

Name	Description
Enable virtual adapter (No / Yes)	Enable virtual adapter. Off by default.
IP address	Set IP address of the virtual adapter.
Netmask	Set netmask of the virtual adapter.
Gateway	Set gateway of the virtual adapter.

Table. 5.1 - 52. Ethernet Option Card settings.

Name	Range	Default	Description
Ethernet card type	- None - SFP - RJ45	Ready only	Indicates the ethernet card type.
Card mode	- COM A IP - Single virtual IP - Dual virtual IP	COM A IP	
Rate limit	- No limit 12.5Mb/1Mb 30Mb/2Mb	No limit	Set the rate limit of communication.
Clock synchronization mode	- IRIG-B - PTP	IRIG-B	Clock synchronization mode selection. See "Time synchronization" chapter for more information.
Card status	- Port1 link ok - Port2 link ok	Read only	Shows if the connection in the two ports are healthy or not.
Port 1 dropped packet count	0...4294967295	Read only	Counts the number of dropped packets in port 1

Name	Range	Default	Description
Port 2 dropped packet count	0...4294967295	Read only	Counts the number of dropped packets in port 2
Enable port 1	- No - Yes	No	Port enable/disable.
Port 1 SFP module status	- Module present - Module supported - Module problem	Read only	Shows the port 1 SFP module status (if applicable).
Port1 virtual Ethernet adapter IP address	0.0.0.0...255.255.255.255	10.15.1.0	Set the IP address of the virtual Ethernet adapter.
Port1 virtual Ethernet adapter netmask	0.0.0.0...255.255.255.255	255.255.255.0	Set the netmask of the virtual Ethernet adapter.
Port1 virtual Ethernet adapter gateway	0.0.0.0...255.255.255.255	10.15.1.254	Set the gateway of the virtual Ethernet adapter.
Port1 virtual Ethernet adapter MAC address	00-00-00-00-00-00...FF-FF-FF-FF-FF-FF	Read only	Indication of MAC address of the virtual Ethernet adapter.
Port 1 allowed protocols	- IEC61850 - GOOSE - ModbusTCP - IEC104 - DNP TCP - FTP - OPC UA - NTP - LPM communication - Settingtool communication - PTP	None	This parameter is used for selecting the protocols port 1 is allowed to use.
Port 1 link status events	- Enable - Disable	Enable	If this parameter is enabled, port 1 link status events are recorded to the device event history.
Port 2 SFP module status	- Error - OK	Read only	Shows the port 2 SFP module status (if applicable).
Port 2 link status events	- Enable - Disable	Enable	If this parameter is enabled, port 2 link status events are recorded to the device event history.

The device is equipped with an RS-485 serial port. In the software it is identified as "Serial COM1" port.

Table. 5.1 - 53. Serial COM1 settings.

Name	Range	Description
Bitrate	9600bps 19200bps 38400bps	Bitrate used by RS-485 port.
Databits	7...8	Databits used by RS-485 port.
Parity	- None - Even - Odd	Paritybits used by RS-485 port.
Stopbits	1...2	Stopbits used by RS-485 port.
Protocol	- None - ModbusRTU - ModbusIO - IEC103 - SPA - DNP3 - IEC101	Communication protocol used by RS-485 port.

The device supports communication option card type that has serial fiber ports (Serial COM2) an RS-232 port (Serial COM3).

Table. 5.1 - 54. Serial COM2 settings.

Name	Range	Description
Bitrate	9600bps 19200bps 38400bps	Bitrate used by serial fiber channels.
Databits	7...8	Databits used by serial fiber channels.
Parity	- None - Even - Odd	Paritybits used by serial fiber channels.
Stopbits	1...2	Stopbits used by serial fiber channels.
Protocol	- None - ModbusRTU - ModbusIO - IEC103 - SPA - DNP3 - IEC101	Communication protocol used by serial fiber channels.
Echo	- Off - On	Enable or disable echo.
Idle Light	- Off - On	Idle light behaviour.

Table. 5.1 - 55. Serial COM3 settings.

Name	Range	Description
Bitrate	9600bps 19200bps 38400bps	Bitrate used by RS-232 port.
Databits	7...8	Databits used by RS-232 port.
Parity	- None - Even - Odd	Paritybits used by RS-232 port.
Stopbits	1...2	Stopbits used by RS-232 port.
Protocol	- None - ModbusRTU - ModbusIO - IEC103 - SPA - DNP3 - IEC101	Communication protocol used by RS-232 port.

5.2 Time synchronization

Time synchronization source can be selected with "Time synchronization" parameter at *Communication* → *Synchronization* → *General*.

Table. 5.2 - 56. General time synchronization source settings.

Name	Range	Description
Time synchronization source	- Internal - External NTP - External serial - IRIG-B - PTP	Selection of time synchronization source.

5.2.1 Internal

If no external time synchronization source is available the mode should be set to "internal". This means that the device clock runs completely on its own. Time can be set to the device with AQtivate setting tool with *Commands* → *Sync Time* command or in the clock view from the HMI. When using *Sync time* command AQtivate sets the time to device the connected computer is currently using. Please note that the clock doesn't run when the device is powered off.

5.2.2 NTP

When enabled, the NTP (Network Time Protocol) service can use external time sources to synchronize the device's system time. The NTP client service uses an Ethernet connection to connect to the NTP time server. NTP can be enabled by setting the primary time server and the secondary time server parameters to the address of the system's NTP time source(s).

Table. 5.2.2 - 57. Server settings.

Name	Range	Description
Primary time server address	0.0.0.0...255.255.255.255	Defines the address of the primary NTP server. Setting this parameter at "0.0.0.0" means that the server is not in use.
Secondary time server address	0.0.0.0...255.255.255.255	Defines the address of the secondary (or backup) NTP server. Setting this parameter at "0.0.0.0" means that the server is not in use.
NTP version	3...4	Defines the NTP version used.
NTP timesync events	• Enable • Disable	Enables "NTP Sync time acquired" event recording.

Table. 5.2.2 - 58. Status.

Name	Range	Description
NTP quality for events	• No sync • Synchronized	Displays the status of the NTP time synchronization at the moment. NOTE: This indication is not valid if another time synchronization method is used (external serial).
NTP-processed message count	0...4294967295	Displays the number of messages processed by the NTP protocol.

Additionally, the time zone of the device can be set by connecting to the device and the selecting the time zone at *Commands* → *Set time zone* in AQtivate setting tool.

5.2.3 PTP

The device supports IEEE 1588v2 precision time protocol synchronization in accordance with the PTP profiles defined in IEEE C37.238-2011/2017 and IEC 61850-9-3 (2016). The device can be configured to operate as a master, as a slave or in an automatic mode where the role is selected dynamically.

In typical operation the device functions as an ordinary clock and is configured either in slave mode or in auto mode. In both cases the device synchronizes to an external Grandmaster and does not normally act as a time source when a higher-priority clock is available. This is common in networks where a GPS-synchronized Grandmaster is present.

When operating in auto mode the device participates in the Best Master Clock Algorithm (BMCA) continuously comparing its clock quality with other PTP devices in the network. Based on this evaluation it automatically assumes the appropriate role—either master or slave.

When the device is explicitly configured in master mode it behaves as a pre-master if a GPS-synchronized Grandmaster is present. In this condition it advertises its clock properties but does not take over the Grandmaster role unless the higher-priority clock becomes unavailable.

To ensure redundancy at least one device often a protection relay is typically assigned a higher priority or explicitly set to master to act as a backup Grandmaster. If the GPS-synchronized master becomes unavailable this device takes over seamlessly and continuous time distribution.

If the device becomes a Grandmaster either because it is explicitly configured as master or because BMCA selects it in auto mode it provides the reference time for other devices. In this state the device is not synchronized to GPS and the time source relies solely on its internal oscillator. This ensures continued synchronization within the network even when the GPS-based master is lost although the absolute accuracy depends on the internal clock stability.

Settings

Select PTP as the time synchronization source from *Communication* → *Synchronization* → *General* menu.

The following settings are available in *Communication* → *Synchronization* → *PTP* menu.

Table. 5.2.3 - 59. PTP time synchronization settings.

Name	Range	Description
Power profile	- None - IEEE C37-238-2011 - IEC61850-9-3 - IEEE C37-238-2017	Defines used power profile.
Role	- Auto (Default) - Master - Slave	In Auto mode, the device can take both the role of a clock source and clock consumer. In Master mode the device is forced to consider itself to be a clock source. In Slave mode the device is forced to be a clock consumer.
Mechanism	- P2P (Default) - E2E	Delay measurement mechanism used. Peer-to-peer can utilize the PTP enabled switches as transparent or boundary clocks while End-to-end must be used if non-PTP enabled switches are found in the network.
Domain number	0...255	PTP devices can be set to belong to a grouping called domain. Devices in same domain is primarily being synchronized together.
Log announce interval		Mean time interval between successive announce messages.
Log delayReq interval		The minimum permitted mean time interval between successive Delay_Req messages
Log sync interval		Mean time interval between successive sync messages
Sync receipt timeout		Number of sync intervals that must pass without receipt of an sync message before the occurrence of the event SYNC_RECEIPT_TIMEOUT_EXPIRES
Announce receipt timeout		Number of announce intervals that must pass without receipt of an announce message before the occurrence of the event ANNOUNCE_RECEIPT_TIMEOUT_EXPIRES
Clock class		The traceability, synchronization state and expected performance of the time or frequency distributed by the Grandmaster PTP Instance
Clock accuracy		The expected accuracy of a PTP Instance when it is the Grandmaster PTP Instance, or in the event it becomes the Grandmaster PTP Instance

Name	Range	Description
Priority 1		Priority setting used in the execution of the best master clock algorithm. Lower values take precedence
Priority 2		Priority setting used in the execution of the best master clock algorithm. Lower values take precedence
VLAN enable	- Disabled - Enabled	Enable VLAN header for PTP communication
VLAN priority	0...7	Priority setting for VLAN
VLAN ID	0...4095	VLAN identification setting
Reconfigure PTP	- - Reconfigure	Parameter to trig reconfiguration of the PTP application

Status indications

The following status indications are available in *Communication* → *Synchronization* → *PTP* menu.

Table. 5.2.3 - 60. PTP status indications

Name	Description
State	State of the PTP application (Master, Slave, Listening).
Best master	Identification of best master in network. Id consist of MAC address plus id number.
Last receive	Time when last synchronization frame was received.
Message sent	Diagnostic message counter.
Message receive	Diagnostic message counter.
PTP timesource	Diagnostic number describing the current time source.

5.3 Communication protocols

The following chapters will describe all available communication protocols. The device includes an RJ-45 ethernet port and an RS-485 serial port, which are able to use communication protocols. See other options for communication ports under "[Construction and installation](#)".

5.3.1 IEC 61850

The user can enable the IEC 61850 protocol in device models that support this protocol at *Communication* → *Protocols* → *IEC61850*. The device supports both Edition 1 and 2 of IEC 61850. The following services are supported by the device:

- Up to eight (8) data sets
- Report Control Blocks (both buffered and unbuffered reporting)
- Control ('Direct operate with normal security', 'Select before operate with normal security, 'Direct with enhanced security' and 'Select before operate with enhanced security' control sequences)
- Disturbance recording file transfer

- GOOSE
- Time synchronization

The device's current IEC 61850 setup can be viewed and edited with the IEC61850 tool (*Tools* → *Communication* → *IEC 61850*).

Settings

The general setting parameters for the IEC 61850 protocol are visible both in AQtivate and in the local HMI. The settings are described in the table below.

Table. 5.3.1 - 61. General settings.

Name	Range	Step	Default	Description
Enable IEC 61850	• Disabled • Enabled	-	Disabled	Enables and disables the IEC 61850 communication protocol.
Reconfigure IEC 61850	• - • Reconfigure	-	-	Reconfigures IEC 61850 settings.
IEC61850 edition	• Ed1 • Ed2	-	-	Displays the IEC61850 edition used by the device. Edition can be chosen by loading a new CID file at <i>Tools</i> → <i>Communication</i> → <i>IEC 61850</i> with <i>Open</i> button.
Control Authority switch	• Remote Control • Station Level Control	-	Remote Control	The device can be set to allow object control via IEC 61850 only from clients that are of category Station level control. This would mean that other Remote control clients would not be allowed to control. In Remote control mode all IEC 61850 clients of both remote and station level category are allowed to control objects.
Ethernet port	• All • COM A • Double ethernet card	-	All	Determines which ports use IEC61850. Parameter is visible if double ethernet option card is found in the device.
Configure GOOSE Subscriber from CID file allowed	• Disabled • Allowed	-	Disabled	In edition 2 of IEC 61850 GOOSE subscriber configuration is a part of the CID file. Determines if it is possible to import published GOOSE settings of another device with a CID file and set them to GOOSE input at <i>Tools</i> → <i>Communication</i> → <i>IEC 61850</i> → <i>GOOSE subscriptions</i> .
General deadband	0.1...10.0 %	0.1 %	2 %	General reporting deadband.
Active energy deadband	0.1...1000.0 kWh	0.1 kWh	2 kWh	Reporting deadband for active energy related measurements.
Reactive energy deadband	0.1...1000.0 kVar	0.1 kVar	2 kVar	Reporting deadband for reactive energy related measurements.
Active power deadband	0.1...1000.0 kW	0.1 kW	2 kW	Reporting deadband for active power related measurements.

Name	Range	Step	Default	Description
Reactive power deadband	0.1...1000.0 kVar	0.1 kVar	2 kVar	Reporting deadband for reactive power related measurements.
Apparent power deadband	0.1...1000.0 kVA	0.1 kVA	2 kVA	Reporting deadband for apparent power related measurements.
Power factor deadband	0.01...0.99	0.01	0.05	Reporting deadband for power factor related measurements.
Frequency deadband	0.01...1.00 Hz	0.01 Hz	0.1 Hz	Reporting deadband for frequency related measurements.
Current deadband	0.01...50.00 A	0.01 A	5 A	Reporting deadband for current related measurements.
Residual current deadband	0.01...50.00 A	0.01 A	0.2 A	Reporting deadband for residual current related measurements.
Voltage deadband	0.01...5000.00 V	0.01 V	200 V	Reporting deadband for voltage related measurements.
Residual voltage deadband	0.01...5000.00 V	0.01 V	200 V	Reporting deadband for residual voltage measurement.
Angle measurement deadband	0.1...5.0 deg	0.1 deg	1 deg	Reporting deadband for angle related measurements.
mA deadband	0.01...5.00 mA	0.01 mA	0.10 mA	Reporting deadband for mA related measurements.
Integration time	0...10 000 ms	1 ms	0 ms	Determines the integration time of the protocol. If this parameter is set to "0 ms", no integration time is in use. See chapter " Integration time " for more information.
GOOSE Ethernet port	- All - COM A - Double ethernet card	-	All	Determines which ports can use GOOSE communication. Visible if double ethernet option card is found in the device.

For more information on the IEC 61850 communication protocol support, please refer to the conformance statement documents (<https://www.arcteq.com/documents-and-software/> → AQ 200 series → Resources).

Deadband settings

Deadband settings define the minimum change in a measured value required before a new report is generated. They are used to reduce communication load and filter out insignificant measurement variations.

The measurement deadband settings have been split into categories like this:

- General deadband
 - Analog scaling curves
 - THD measurements (current and voltage)
 - Fault impedance and distance (distance protection function)
 - Fault location and reactance (fault locator function)
 - RTD measurements
 - Object abrasion calculations
 - Synchronizer and synchrocheck angle, frequency and angle values
 - Automatic voltage regulator function voltage values
- Power factor deadband
 - Single-phase and three-phase power factors
 - Single-phase and three-phase cos phi values
- Active energy deadband
 - Single-phase and three-phase exported energy
 - Single-phase and three-phase imported energy
 - Single-phase and three-phase energy balance (Import/Export)
- Reactive energy deadband
 - Single-phase and three-phase exported energy
 - Single-phase and three-phase imported energy
 - Single-phase and three-phase energy balance (Import/Export)
- Reactive power deadband
 - Single-phase and three-phase reactive energy
 - Reactive energy demand
- Active power deadband
 - Single-phase and three-phase active energy
 - Active energy demand
- Residual current deadband
 - Residual current measurements (primary)
- Residual voltage deadband
 - Residual voltage measurements (primary)
- Voltage deadband
 - Phase-to-phase voltage (primary)
 - Phase-to-neutral voltages (primary)
 - U4 channel voltage
- mA deadband
 - mA input card measurement values
- Angle measurement deadband
 - Phase current angles
 - Phase-to-phase and phase-to-neutral voltage angles
 - Neutral voltage angle
 - Angle of the latest fault impedances (distance protection)
- Current deadband
 - Phase currents (primary)
 - Phase reactive and resistive current (primary and secondary)
 - Residual current resistive and reactive current (primary and secondary)
- Frequency deadband
 - All three frequency references
 - Synchronizer frequency references
 - Phase current demand

5.3.1.1 Logical device mode and logical node mode

Every protection block has its own behavior (LNBeh). This behavior is determined using a combination of the protection block's mode (LNMod) and the device's mode (LDMod).

In IEC68150 mode,

- LNMod can be reported and controlled through Mod data object in all logical nodes.
- LNBeh can be reported through Beh data object in all logical nodes.
- LDMod is only visible through logical node zero's Mod data object (LLN0.Mod).

Mode and behavior values

There are 5 values defined for mode and behavior: On, Blocked, Test, Test / Blocked and Off.

Table. 5.3.1.1 - 62. Behavior descriptions.

LNBeh	On	Blocked	Test	Test / Blocked	Off
Function working	Yes	Yes	Yes	Yes	No
Data quality	Relevant to data	Relevant to data	q.test = True	q.test = True	q.validity = Invalid
Output to process	Yes	No	Yes	No	No
Accept normal control	Yes	Yes	No	No	No
Accept test control	No	No	Yes	Yes	No

The communication services for the **data object Mod** do not care about the status of the LNBeh. Mod will always accept commands with **q.test = False**.

Data objects Mod, Beh and Health will always have **q.validity = Good**. Regardless of the status of LNBeh, the quality test attribute of Mod, Beh and Health shall be **q.test = False**.

Behavior determination

The values for LDMod and LNMod are settable by the user by using HMI, setting tool, or IEC 61850 client. The value for LNBeh are then determined using following rules.

- If either LDMod or LNMod is Off, LNBeh is Off.
- Otherwise,
 - If either LDMod or LNMod is set to either "Test" or "Test / Blocked" mode, LNBeh is in Test mode.
 - If either LDMod or LNMod is set to either "Blocked" or "Test / Blocked" mode, LNBeh is in Blocked mode.
 - If LNBeh still doesn't have anything, LNBeh is "On".

All the possible combinations are laid out in the following table.

Table. 5.3.1.1 - 63. All possible logical device and logical node combinations.

LDMod	LNMod	LNBeh
Off	Off	Off

LDMod	LNMod	LNBeh
	Test / Blocked	Off
	Test	Off
	Blocked	Off
	On	Off
Test / Blocked	Off	Off
	Test / Blocked	Test / Blocked
	Test	Test / Blocked
	Blocked	Test / Blocked
	On	Test / Blocked
Test	Off	Off
	Test / Blocked	Test / Blocked
	Test	Test
	Blocked	Test / Blocked
	On	Test
Blocked	Off	Off
	Test / Blocked	Test / Blocked
	Test	Test / Blocked
	Blocked	Blocked
	On	Blocked
On	Off	Off
	Test / Blocked	Test / Blocked
	Test	Test
	Blocked	Blocked
	On	On

Processing of incoming data in different behaviors

This part only applies to incoming data with quality information.

The table below gives the functional processing of the data in different behavior states **as defined by the standard**. Logical nodes should process receiving data according to their quality information:

- Processed as valid - Reacts according to the quality.
- Processed as invalid - Reacts as if the quality of the data had been invalid.
- Processed as questionable - The application decides how to consider the status value.
- Not processed - Do not belong to communication services, no quality bit can be evaluated.

Table. 5.3.1.1 - 64. Processing of incoming data in different behaviors as defined by the standard.

	On	Blocked	Test	Test / Blocked	Off
q.validity = Good q.test = False	Processed as valid	Processed as valid	Processed as valid	Processed as valid	Not processed
q.validity = Questionable q.test = False	Processed as questionable	Processed as questionable	Processed as questionable	Processed as questionable	Not processed
q.validity = Good q.test = True	Processed as invalid	Processed as invalid	Processed as valid	Processed as valid	Not processed
q.validity = Questionable q.test = True	Processed as invalid	Processed as invalid	Processed as questionable	Processed as questionable	Not processed
q.validity = Invalid q.test = True/ False	Processed as invalid	Processed as invalid	Processed as invalid	Processed as invalid	Not processed

Arcteq's implementation treats "Processed as questionable" and "Processed as invalid" in the same way with "Not processed". Only "Processed as valid" is passed to the application.

Table. 5.3.1.1 - 65. Arcteq's implementation of processing of incoming data in different behaviors.

	On	Blocked	Test	Test / Blocked	Off
q.validity = Good q.test = False	Processed as valid	Processed as valid	Processed as valid	Processed as valid	
q.validity = Questionable q.test = False					
q.validity = Good q.test = True			Processed as valid	Processed as valid	
q.validity = Questionable q.test = True					
q.validity = Invalid q.test = True/False					

Using mode and behavior

Enabling LDMOD and LNMOD changing can be done at *General* → *Device info*.

Table. 5.3.1.1 - 66. Parameters to allow changing of LNMod and LDMoD.

Name	Range	Default	Description
Allow setting of device mode	- Prohibited - From HMI/setting tool only - Allowed	Prohibited	Allows global mode to be modified from setting tool, HMI and IEC61850. Prohibited: Cannot be changed. From HMI/setting tool only: Can only be changed from the setting tool or HMI. Allowed: Can be changed from the setting tool, HMI, and IEC 61850 client.
Allow setting of individual LN mode	- Prohibited - From HMI/setting tool only - Allowed	Prohibited	Allow local modes to be modified from setting tool, HMI and IEC61850. This parameter is visible only when "Allow setting of device mode" is enabled. Prohibited: Cannot be changed. From HMI/setting tool only: Can only be changed from the setting tool or HMI Allowed: Can be changed from the setting tool, HMI, and IEC 61850 client.

When enabled it is possible to change LDMoD at *Communication* → *Protocols* → *IEC61850*.

Table. 5.3.1.1 - 67. Parameter for changing logical device mode.

Name	Range	Default	Description
Allow setting of device mode	- On - Blocked - Test - Test/Blocked - Off	On	Set mode of logical device. This parameter is visible only when <i>Allow setting of device mode</i> is enabled in <i>General</i> menu.

Each protection, control and monitoring function has its own logical node mode which can be changed individually. This parameter is found in the functions *Info*-menu. Each function also reports its behavior. Behavior of the function is influenced by the status of the device mode setting and the functions mode setting.

Table. 5.3.1.1 - 68. LNMod parameters.

Name	Range	Default	Description
LN mode	- On - Blocked - Test - Test/Blocked - Off	On	Set mode of function logical node. This parameter is visible only when <i>Allow setting of individual LN mode</i> is enabled in <i>General</i> menu.
LN behavior	- On - Blocked - Test - Test/Blocked - Off	On	Displays the mode of the function logical node. This parameter is visible only when <i>Allow setting of individual LN mode</i> is enabled in <i>General</i> menu.

5.3.1.2 GOOSE

Arcteq devices support both GOOSE publisher and GOOSE subscriber. GOOSE subscriber is enabled with the "GOOSE subscriber enable" parameter at *Communication* → *Protocols* → *IEC 61850/GOOSE*. The GOOSE inputs are configured using either the local HMI or the AQtivate software.

There are up to 64 GOOSE inputs available for use. Each of the GOOSE inputs also has a corresponding input quality signal which can also be used in internal logic. The quality is good, when the input quality status is "low" (that is, when the quality is marked as "0"). The value of the input quality can switch on as a result of a GOOSE time-out or a configuration error, for example. The status and quality of the various logical input signals can be viewed at the *GOOSE IN status* and *GOOSE IN quality* tabs at *Control* → *Device I/O* → *Logical signals*.

General GOOSE setting

The table below presents general settings for GOOSE publisher.

Table. 5.3.1.2 - 69. General GOOSE publisher settings.

Name	Range	Description
GOOSE control block 1 simulation bit	- Disabled (Default) - Enabled	The publisher will publish frames with simulation bit active if enabled. For GOOSE simulation testing purposes.
GOOSE control block 2 simulation bit		

The table below presents general settings for GOOSE subscriber

Table. 5.3.1.2 - 70. General GOOSE subscriber settings.

Name	Range	Description
GOOSE subscriber enable	- Disabled (Default) - Enabled	Enables or disables GOOSE subscribing for the device.
Not used GOOSE input Quality	- Bad quality (1) - Good quality (0)	Defines what state should GOOSE input quality signal to be in the logic if the input has been set as "disabled".
Subscriber checks GoCRef	- No (Default) - Yes	When subscriber sees GOOSE frame it checks APPID and Conf. Rev but can also check if GoCRef or SqNum match.
Subscriber checks SqNum		

Name	Range	Description
Subscriber process simulation messages	- No (Default) - Yes	Subscriber can be set to process frames which are published with simulation bit high if enabled. The subscriber can still subscribe to non-simulated frames from a publisher until that a simulated frame is received from a publisher. From that point on, only simulated frames are accepted from that publisher. For other publishers, non-simulated frames are accepted normally (given no simulated frame is received from that publisher). This behavior ends when the setting is set back to No.

GOOSE input settings

The table below presents the different settings available for all 64 GOOSE inputs.

These settings can be found from *Communication* → *Protocols* → *IEC61850/GOOSE* → *GOOSE Input Settings*.

Table. 5.3.1.2 - 71. GOOSE input settings.

Name	Range	Description
In use	- No (Default) - Yes	Enables and disables the GOOSE input in question.
Application ID ("AppID")	0×0...0×3FFF	Defines the application ID that will be matched with the publisher's GOOSE control block.
Configuration revision ("ConfRev")	1...2 ³² -1	Defines the configuration revision that will be matched with the publisher's GOOSE control block.
Data index ("DataIdx")	0...99	Defines the data index of the value in the matched published frame. It is the status of the GOOSE input.
NextIdx is quality	- No (Default) - Yes	Selects whether or not the next received input is the quality bit of the GOOSE input.
Data type	- Boolean (Default) - Integer - Unsigned - Floating point	Selects the data type of the GOOSE input.
Control block reference	-	GOOSE subscriber can be set to check the GCB reference of the published GOOSE frame. This setting is automatically filled when Ed2 GOOSE configuration is done by importing cid file of the publisher.

GOOSE input descriptions

Each of the GOOSE inputs can be given a description. The user defined description are displayed in most of the menus:

- logic editor
- matrix

- block settings
- event history
- disturbance recordings
- etc.

These settings can be found from *Control* → *Device IO* → *Logical Signals* → *GOOSE IN Description*.

Table. 5.3.1.2 - 72. GOOSE input user description.

Name	Range	Default	Description
User editable description GI x	1...31 characters	GOOSE IN x	Description of the GOOSE input. This description is used in several menu types for easier identification.

GOOSE input values

Each of the GOOSE subscriber inputs (1...64) have indications listed in the following table. These indications can be found from *Communication* → *Protocols* → *IEC61850/GOOSE* → *GOOSE input values*.

Table. 5.3.1.2 - 73. GOOSE input indications

Name	Range	Description
Subscription status	• Not Active • Active	When active correct data received and passed to application.
Processing simulation message	• False • True	When true subscriber is processing simulation frames for this input (and rejecting non-simulated frames).
Needs commissioning	• False • True	When true configuration doesn't match the received frame (goCBRef, confRev).
Last received state number	0...4294967295	Status number (stNum) of the last data passed to application.
GOOSE IN X boolean value	0...1	GOOSE input 1...64 boolean value.
GOOSE IN X analog value	-3.4E+38...3.4E+38	GOOSE input 1...64 analog value.
GOOSE IN X quality	• Old data • Failure • Oscillatory • Bad reference • Out of range • Overflow • Invalid • Reserved/Questionable • Operator blocked • Test • Substituted • Inaccurate • Inconsistent	GOOSE input quality indication.

Name	Range	Description
GOOSE IN X time	DD/MM/YYYY HH:MM:SS	Time when publisher sent GOOSE frame.
GOOSE IN X time fraction	0...4294967295 μ s	Microseconds of the publisher GOOSE frame.

GOOSE events

GOOSE signals generate events from status changes. The user can select which event messages are stored in the main event buffer: ON, OFF, or both. The events triggered by the function are recorded with a time stamp and with process data values. The time stamp resolution is 1 ms.

Table. 5.3.1.2 - 74. GOOSE event

Event block name	Event name	Description
GOOSE1...GOOSE2	GOOSE IN 1...64 ON/OFF	Status change of GOOSE input.
GOOSE3...GOOSE4	GOOSE IN 1...64 quality Bad/Good	Status change of GOOSE inputs quality.
GOOSE5...GOOSE6	GOOSE Subscription status 1...64 Active/Not active	When active correct data received and passed to application.
GOOSE7...GOOSE8	GOOSE Processing simulated messages 1...64 True/False	When true subscriber is processing simulation frames for this input (and rejecting non-simulated frames).
GOOSE9...GOOSE10	GOOSE Subscription needs commissioning 1...64 True/False	When true configuration doesn't match the received frame (goCBRef, confRev).

Setting the publisher

The configuration of the GOOSE publisher is done using the IEC 61850 tool in AQtivate (*Tools* → *Communication* → *IEC 61850*). Refer to *AQtivate-200 Instruction manual* for more information on how to set up GOOSE publisher.

5.3.2 Modbus TCP and Modbus RTU

The device supports both Modbus TCP and Modbus RTU communication. Modbus TCP uses the Ethernet connection to communicate with Modbus TCP clients. Modbus RTU is a serial protocol that can be selected for the available serial ports.

The user can enable the Modbus TCP protocol at *Communication* → *Protocols* → *Modbus TCP*. The user can enable the Modbus RTU protocol at *Communication* → *Connections*.

The following Modbus function types are supported:

- Read multiple holding registers (function code 3)
- Write single holding register (function code 6)
- Write multiple holding registers (function code 16)
- Read/Write multiple registers (function code 23)

The following data can be accessed using both Modbus TCP and Modbus RTU:

- Device measurements

- Device I/O
- Commands
- Events
- Time

Once the configuration file has been loaded, the user can access the Modbus map of the device via the AQtivate software (*Tools → Communication → Modbus Map*). Please note that holding registers start from 1. Some masters might begin numbering holding register from 0 instead of 1; this will cause an offset of 1 between the device and the master. Modbus map can be edited with Modbus Configurator (*Tools → Communication → Modbus Configurator*).

Table. 5.3.2 - 75. Modbus TCP settings.

Parameter	Range	Description
Enable Modbus TCP	• Disabled • Enabled	Enables and disables the Modbus TCP on the Ethernet port.
IP port	0...65 535	Defines the IP port used by Modbus TCP. The standard port (and the default setting) is 502.
Ethernet port	• All • COM A • Double Ethernet card	Defines which ethernet ports are available for Modbus connection. Visible if any double ethernet option card is installed in the device.
Event read mode	• Get oldest available • Continue previous connection • New events only	Get oldest event possible (Default) Continue with the event idx from previous connection Get only new events from connection time and forward.

Table. 5.3.2 - 76. Modbus RTU settings.

Parameter	Range	Description
Slave address	1...247	Defines the Modbus RTU slave address for the unit.

Reading events

Modbus protocol does not support time-stamped events by standard definition. This means that every vendor must come up with their own definition how to transfer events from the device to the client. Events can be read from HR17...HR22 holding registers. HR17 contains the event-code, HR18...20 contains the time-stamp in UTC, HR21 contains a sequential index and HR22 is reserved for future expansion. See the Modbus Map for more information. The event-codes and their meaning can be found from Event list (*Tools → Events and Logs → Event list* in setting tool). The event-code in HR17 is 0 if no new events can be found in the device event-buffer. Every time HR17 is read from client the event in event-buffer is consumed and on following read operation the next un-read event information can be found from event registers. HR11...HR16 registers contains a back-up of last read event. This is because some users want to double-check that no events were lost

5.3.3 IEC 103

IEC 103 is the shortened form of the international standard IEC 60870-5-103. The device is able to run as a secondary (slave) station. The IEC 103 protocol can be selected for the serial ports that are available in the device. A primary (master) station can then communicate with the device and receive information by polling from the slave device. The transfer of disturbance recordings is not supported.

The user can enable the IEC 103 protocol at *Communication* → *Connections*.

NOTE: Once the configuration file has been loaded, the IEC 103 map of the device can be found in the AQtivate software (*Tools* → *IEC 103 map*).

Table. 5.3.3 - 77. IEC 103 settings.

Name	Range	Step	Default	Description
Slave address	1...254	1	1	Defines the IEC 103 slave address for the unit.
Measurement interval	0...60 000 ms	1 ms	2000 ms	Defines the interval for the measurements update.

The following table presents the setting parameters for the IEC 103 protocol.

5.3.4 IEC 101/104

The standards IEC 60870-5-101 and IEC 60870-5-104 are closely related. Both are derived from the IEC 60870-5 standard. On the physical layer the IEC 101 protocol uses serial communication whereas the IEC 104 protocol uses Ethernet communication. The IEC 101/104 implementation works as a slave in the unbalanced mode.

For detailed information please refer to the IEC 101/104 interoperability document (<https://www.arcteq.com/documents-and-software/> → AQ-200 series → Resources → "AQ-200 IEC101 & IEC104 interoperability").

The user can enable the IEC104 protocol at *Communication* → *Protocols* → *IEC101/104*. The user can enable the IEC101 protocol at *Communication* → *Connections*.

IEC 101 settings

Table. 5.3.4 - 78. IEC 101 settings.

Name	Range	Step	Default	Description
Common address of ASDU	0...65 534	1	1	Defines the common address of the application service data unit (ASDU) for the IEC 101 communication protocol.
Common address of ASDU size	1...2	1	2	Defines the size of the common address of ASDU.
Link layer address	0...65 534	1	1	Defines the address for the link layer.
Link layer address size	1...2	1	2	Defines the address size of the link layer.

Name	Range	Step	Default	Description
Information object address size	2...3	1	3	Defines the address size of the information object.
Cause of transmission size	1...2	1	2	Defines the cause of transmission size.

IEC101/104 measurement scaling coefficients

Table. 5.3.4 - 79. Measurement scaling coefficient settings.

Name	Range	Default	Description
General scaling coef.	- No scaling 1/10 1/100 1/1000 1/10000 1/100000 1/1000000 10 100 1000 10000 100000 1000000	No scaling	Optional scaling factor for IEC101/IEC104 communication. Values from 1/10 to 1/1,000,000 apply a division to the measurement. Values from 10 to 1,000,000 apply a multiplication to the measurement.
Active energy scaling coef.			
Reactive energy scaling coef.			
Active power scaling coef.			
Reactive power scaling coef.			
Apparent power scaling coef.			
Power factor scaling coef.			
Frequency scaling coef.			
Current scaling coef.			
Residual current scaling coef.			
Voltage scaling coef.			
Residual voltage scaling coef.			
Angle measurement scaling coef.			
mA scaling coef.			

IEC101/104 deadband settings

Table. 5.3.4 - 80. Analog change deadband settings.

Name	Range	Step	Default	Description
General deadband	0.1...10.0%	0.1%	2%	Determines the general data reporting deadband settings.

Name	Range	Step	Default	Description
Active energy deadband	0.1...1000.0kWh	0.1kWh	2kWh	Determines the data reporting deadband settings for this measurement.
Reactive energy deadband	0.1...1000.0kVar	0.1kVar	2kVar	
Active power deadband	0.1...1000.0kW	0.1kW	2kW	
Reactive power deadband	0.1...1000.0kVar	0.1kVar	2kVar	
Apparent power deadband	0.1...1000.0kVA	0.1kVA	2kVA	
Power factor deadband	0.01...0.99	0.01	0.05	
Frequency deadband	0.01...1.00Hz	0.01Hz	0.1Hz	
Current deadband	0.01...50.00A	0.01A	5A	
Residual current deadband	0.01...50.00A	0.01A	0.2A	
Voltage deadband	0.01...5000.00V	0.01V	200V	
Residual voltage deadband	0.01...5000.00V	0.01V	200V	
Angle measurement deadband	0.1...5.0deg	0.1deg	1deg	
mA measurement deadband	0.01...5.00 mA	0.01 mA	0.10 mA	
Integration time	0...10 000ms	1ms	-	Determines the integration time of the protocol. If this parameter is set to "0 ms", no integration time is in use. See chapter " Integration time " for more information.

Deadband settings

Deadband settings define the minimum change in a measured value required before a new report is generated. They are used to reduce communication load and filter out insignificant measurement variations.

The measurement deadband settings have been split into categories like this:

- General deadband
 - Analog scaling curves
 - Fault impedance and distance (distance protection function)
 - Fault location and reactance (fault locator function)
 - RTD measurements
 - Automatic voltage regulator function voltage values
- Power factor deadband
 - Single-phase and three-phase power factors
 - Single-phase and three-phase cos phi values
- Active energy deadband
 - Single-phase and three-phase exported energy
 - Single-phase and three-phase imported energy
- Reactive energy deadband
 - Single-phase and three-phase exported energy
 - Single-phase and three-phase imported energy
- Reactive power deadband
 - Single-phase and three-phase reactive energy
 - Reactive energy demand
- Active power deadband
 - Single-phase and three-phase active energy
 - Active energy demand
- Residual current deadband
 - Residual current measurements (primary)
- Residual voltage deadband
 - Residual voltage measurements (primary)
- Voltage deadband
 - Phase-to-phase voltage (primary)
 - Phase-to-neutral voltages (primary)
 - U4 channel voltage (primary)
- mA deadband
 - mA input card measurement values
- Angle measurement deadband
 - Phase current angles
 - Phase-to-phase and phase-to-neutral voltage angles
 - Neutral voltage angle
- Current deadband
 - Phase currents (primary)
 - Current demand measurements
- Frequency deadband
 - Frequency reference used by the device

5.3.5 SPA

The device can act as a SPA slave. SPA can be selected as the communication protocol for the RS-485 port (Serial COM1). When the device has a serial option card, the SPA protocol can also be selected as the communication protocol for the serial fiber (Serial COM2) ports or RS-232 (Serial COM3) port. Please refer to the chapter "[Construction and installation](#)" in the device manual to see the connections for these modules.

The data transfer rate of SPA is 9600 bps, but it can also be set to 19 200 bps or 38 400 bps. As a slave the device sends data on demand or by sequenced polling. The available data can be measurements, circuit breaker states, function starts, function trips, etc. The full SPA signal map can be found in AQtivate (*Tools* → *SPA map*).

The SPA event addresses can be found at *Tools* → *Events and logs* → *Event list*.

The user can enable the SPA protocol at *Communication* → *Connections*.

Table. 5.3.5 - 81. SPA setting parameters.

Name	Range	Description
SPA address	1...899	SPA slave address.
UTC time sync	- Disabled - Enabled	Determines if UTC time is used when synchronizing time. When disabled it is assumed time synchronization uses local time. If enabled it is assumed that UTC time is used. When UTC time is used the timezone must be set at <i>Commands</i> → <i>Set time zone</i> .



NOTICE!

To access SPA map and event list, an .aqc configuration file should be downloaded from the device.

5.3.6 DNP3

DNP3 is a protocol standard which is controlled by the DNP Users Group (www.dnp.org). The implementation of a DNP3 slave is compliant with the DNP3 subset (level) 2, but it also contains some functionalities of the higher levels. For detailed information please refer to the DNP3 Device Profile document (<https://www.arcteq.com/documents-and-software/> → AQ-200 series → Resources).

The user can enable the DNP3 TCP protocol at *Communication* → *Protocols* → *DNP3*. The user can enable the DNP3 serial protocol at *Communication* → *Connections*.

General settings

The following table describes the DNP3 setting parameters.

Table. 5.3.6 - 82. Settings.

Name	Range	Step	Default	Description
Enable DNP3 TCP	- Disabled - Enabled	-	Disabled	Enables and disables the DNP3 TCP communication protocol when the Ethernet port is used for DNP3. If a serial port is used, the DNP3 protocol can be enabled from <i>Communication</i> → <i>DNP3</i> .
IP port	0...65 535	1	20 000	Defines the IP port used by the protocol.
Ethernet port	- All - COM A - Double Ethernet card	-	All	Defines which ethernet ports are available for Modbus connection. Visible if any double ethernet option card is installed in the device.

Name	Range	Step	Default	Description
Slave address	1...65 519	1	1	Defines the DNP3 slave address of the unit.
Master address	1...65 534	1	2	Defines the address for the allowed master.
Link layer time-out	0...60 000ms	1ms	0ms	Defines the length of the time-out for the link layer.
Link layer retries	1...20	1	1	Defines the number of retries for the link layer.
Diagnostic - Error counter	0...2 ³² -1	1	-	Counts the total number of errors in received and sent messages.
Diagnostic - Transmitted messages	0...2 ³² -1	1	-	Counts the total number of transmitted messages.
Diagnostic - Received messages	0...2 ³² -1	1	-	Counts the total number of received messages.

Default variations

Table. 5.3.6 - 83. Default variations.

Name	Range	Default	Description
Group 1 variation (BI)	- Var 1 - Var 2	Var 1	Selects the variation of the binary signal.
Group 2 variation (BI change)	- Var 1 - Var 2	Var 2	Selects the variation of the binary signal change.
Group 3 variation (DBI)	- Var 1 - Var 2	Var 1	Selects the variation of the double point signal.
Group 4 variation (DBI change)	- Var 1 - Var 2	Var 2	Selects the variation of the double point signal.
Group 20 variation (CNTR)	- Var 1 - Var 2 - Var 5 - Var 6	Var 1	Selects the variation of the control signal.
Group 22 variation (CNTR change)	- Var 1 - Var 2 - Var 5 - Var 6	Var 5	Selects the variation of the control signal change.

Name	Range	Default	Description
Group 30 variation (AI)	• Var 1 • Var 2 • Var 3 • Var 4 • Var 5	Var 5	Selects the variation of the analog signal.
Group 32 variation (AI change)	• Var 1 • Var 2 • Var 3 • Var 4 • Var 5 • Var 7	Var 5	Selects the variation of the analog signal change.

DNP3 measurement scaling coefficients

Table. 5.3.6 - 84. Measurement scaling coefficient settings.

Name	Range	Default	Description
General scaling coef.	• No scaling • 1/10 • 1/100 • 1/1000 • 1/10000 • 1/100000 • 1/1000000 • 10 • 100 • 1000 • 10000 • 100000 • 1000000	No scaling	Optional scaling factor for SPA communication. Values from 1/10 to 1/1,000,000 apply a division to the measurement. Values from 10 to 1,000,000 apply a multiplication to the measurement.
Active energy scaling coef.			
Reactive energy scaling coef.			
Active power scaling coef.			
Reactive power scaling coef.			
Apparent power scaling coef.			
Power factor scaling coef.			
Frequency scaling coef.			
Current scaling coef.			
Residual current scaling coef.			
Voltage scaling coef.			
Residual voltage scaling coef.			
Angle measurement scaling coef.			
mA scaling coef.			

DNP3 deadband settings

Table. 5.3.6 - 85. Analog change deadband settings.

Name	Range	Step	Default	Description
General deadband	0.1...10.0%	0.1%	2%	Determines the general data reporting deadband settings.
Active energy deadband	0.1...1000.0kWh	0.1kWh	2kWh	Determines the data reporting deadband settings for this measurement.
Reactive energy deadband	0.1...1000.0kVar	0.1kVar	2kVar	
Active power deadband	0.1...1000.0kW	0.1kW	2kW	
Reactive power deadband	0.1...1000.0kVar	0.1kVar	2kVar	
Apparent power deadband	0.1...1000.0kVA	0.1kVA	2kVA	
Power factor deadband	0.01...0.99	0.01	0.05	
Frequency deadband	0.01...1.00Hz	0.01Hz	0.1Hz	
Current deadband	0.01...50.00A	0.01A	5A	
Residual current deadband	0.01...50.00A	0.01A	0.2A	
Voltage deadband	0.01...5000.00V	0.01V	200V	
Residual voltage deadband	0.01...5000.00V	0.01V	200V	
Angle measurement deadband	0.1...5.0deg	0.1deg	1deg	
mA deadband	0.01...5.00 mA	0.01 mA	0.10 mA	
Integration time	0...10 000ms	1ms	0ms	Determines the integration time of the protocol. If this parameter is set to "0 ms", no integration time is in use. See chapter " Integration time " for more information.

Deadband settings

Deadband settings define the minimum change in a measured value required before a new report is generated. They are used to reduce communication load and filter out insignificant measurement variations.

The measurement deadband settings have been split into categories like this:

- General deadband
 - Measurements not covered by other deadband categories
 - Fault impedance and distance (distance protection function)
 - Fault location and reactance (fault locator function)
 - RTD measurements
- Power factor deadband
 - Single-phase and three-phase power factors
 - Single-phase and three-phase cos phi values
- Active energy deadband
 - Single-phase and three-phase exported energy
 - Single-phase and three-phase imported energy
- Reactive energy deadband
 - Single-phase and three-phase exported energy
 - Single-phase and three-phase imported energy
- Reactive power deadband
 - Single-phase and three-phase reactive energy
 - Reactive energy demand
- Active power deadband
 - Single-phase and three-phase active energy
 - Active energy demand
- Residual current deadband
 - Residual current measurements (primary)
- Residual voltage deadband
 - Residual voltage measurement (primary)
- Voltage deadband
 - Phase-to-phase voltage (primary)
 - Phase-to-neutral voltages (primary)
 - U3 channel voltage (primary)
 - U4 channel voltage (primary)
- mA deadband
 - mA input card measurement values
- Angle measurement deadband
 - Phase current angles
 - Phase-to-phase and phase-to-neutral voltage angles
 - Neutral voltage angle
- Current deadband
 - Phase currents (primary)
 - Phase current demand
- Frequency deadband
 - Frequency reference used by the device.

5.3.7 Modbus I/O

The Modbus I/O protocol can be selected to communicate on the available serial ports. The Modbus I/O is actually a Modbus/RTU master implementation that is dedicated to communicating with serial Modbus/RTU slaves such as RTD input modules. Up to three (3) Modbus/RTU slaves can be connected to the same bus polled by the Modbus I/O implementation. These are named I/O Module A, I/O Module B and I/O Module C. Each of the modules can be configured using parameters in the following two tables.

Table. 5.3.7 - 86. Module settings.

Name	Range	Description
I/O module X address	0...247	Defines the Modbus unit address for the selected I/O Module (A, B, or C). If this setting is set to "0", the selected module is not in use.
Module x type	- ADAM-4018+ - ADAM-4015	Selects the module type.
Channels in use	Channel 0...Channel 7 (or None)	Selects the number of channels to be used by the module.

Table. 5.3.7 - 87. Channel settings.

Name	Range	Step	Default	Description
Thermocouple type	+/- 20mA 4...20mA - Type J - Type K - Type T - Type E - Type R - Type S	-	4...20mA	Selects the thermocouple or the mA input connected to the I/O module. Types J, K, T and E are nickel-alloy thermocouples, while Types R and S are platinum/rhodium-alloy thermocouples.
Input value	-101.0...2000.0	0.1	-	Displays the input value of the selected channel.
Input status	- Invalid - OK	-	-	Displays the input status of the selected channel.

5.3.8 OPCUA

Table. 5.3.8 - 88. OPCUA settings.

Name	Range	Step	Default	Description
OPCUA mode	- Disabled - Enabled	-	Disabled	Enables or disables the OPCUA protocol.
OPCUA reconfigure	- - Reconfigure	-	-	Reconfigures the OPCUA and takes the settings configured in <i>Tools</i> → <i>Communication</i> → <i>OPCUA</i> into use.

Name	Range	Step	Default	Description
OPCUA Flat struct enable	- Disabled - Enabled	-	Disabled	

Flat structure option

By default, some data points are represented as nested structures.

For example, I3MMXU1.A.phsA.cVal is a structured value containing:

- mag
 - f (basic value)
 - i (basic value, typically not mapped)
- ang
 - f (basic value)
 - i (basic value, typically not mapped)

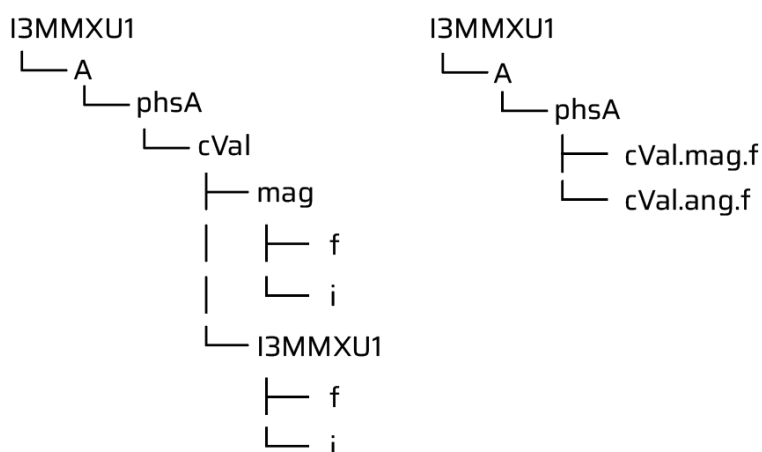
When **Flat Structure** is enabled, the server applies two changes:

1. Removes members that do not contain mapped data (for example, i).
2. Flattens nested structures into individual data points.

Using the previous example, instead of exposing cVal as a structured node, the server exposes the following data points directly under phsA:

- cVal.mag.f
- cVal.ang.f

Figure. 5.3.8 - 26. Nested structure (left) and flat structure (right) comparison.



5.3.9 Integration time

When integration time is not used, measurement values are updated only when the change exceeds the configured deadband. If the deadband is set too low, measurements may be reported too frequently, creating unnecessary traffic. If the deadband is configured too high, the measurement may almost never update. When integration time is used, large changes are still reported quickly, but smaller changes are accumulated over time and eventually reported even if the deadband is not very sensitive.

With integration time enabled, the following parameters determine when a measurement is reported:

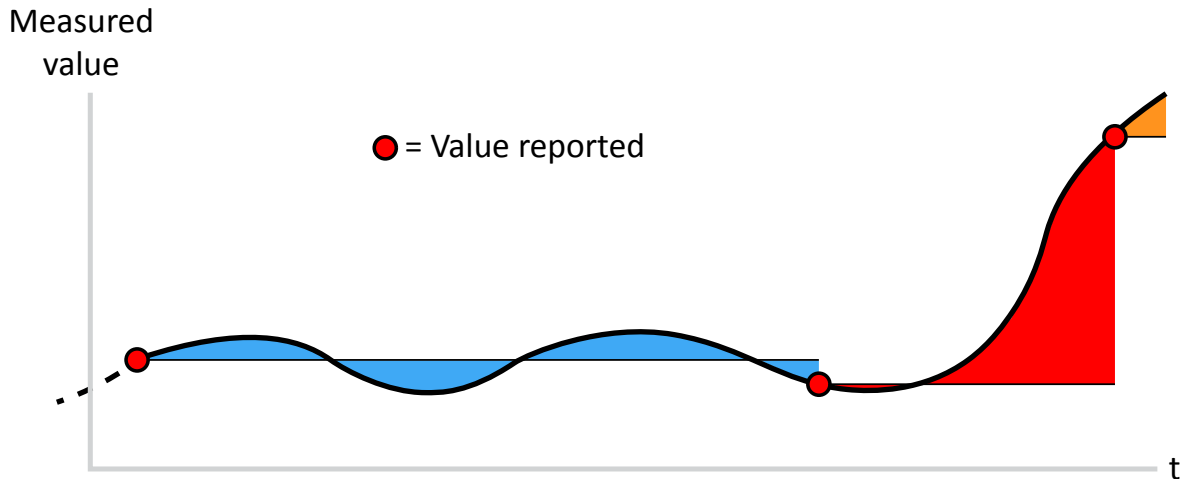
- deadband setting of the measurement
- integration time setting
- latest reported measurement value
- measured value.

An integrated value is calculated over time using these parameters. Once this integrated value exceeds the deadband, a new measurement update is sent.

Figure. 5.3.9 - 27. Integration time formula.

$$\text{Integrated value} = |\text{Measured value} - \text{Latest reported value}| * \left(\frac{t}{\text{Integration time}} \right)$$

Figure. 5.3.9 - 28. Example graph showing how integration time affects measurement reporting. Small changes take longer to increase the integrated value over the deadband setting (blue area). Big changes meet the deadband criteria faster (red area).



The time it takes for a value to be updated with the configured settings can be roughly estimated with the following formula:

Figure. 5.3.9 - 29. Measurement reporting delay when integration time is used.

$$t = \frac{\text{Deadband setting} * \text{Integration time setting}}{|\text{Measured value} - \text{Latest reported value}|}$$

If the latest reported value was 5.00 A and the measurement rises up to 6.00 A and stays stable, and the deadband setting for current is 2 A and the integration time setting is 1 s, we get the following result:

Figure. 5.3.9 - 30. Calculation example for estimating reporting time when integration time is in use.

$$t = \frac{2A * 1s}{|6A - 5A|} = 2s$$

5.4 Analog fault registers

At *Communication* → *General I/O* → *Analog fault registers* the user can set up to twelve (12) channels to record the measured value when a protection function starts or trips. These values can be read in two ways: locally from this same menu, or through a communication protocol if one is in use.

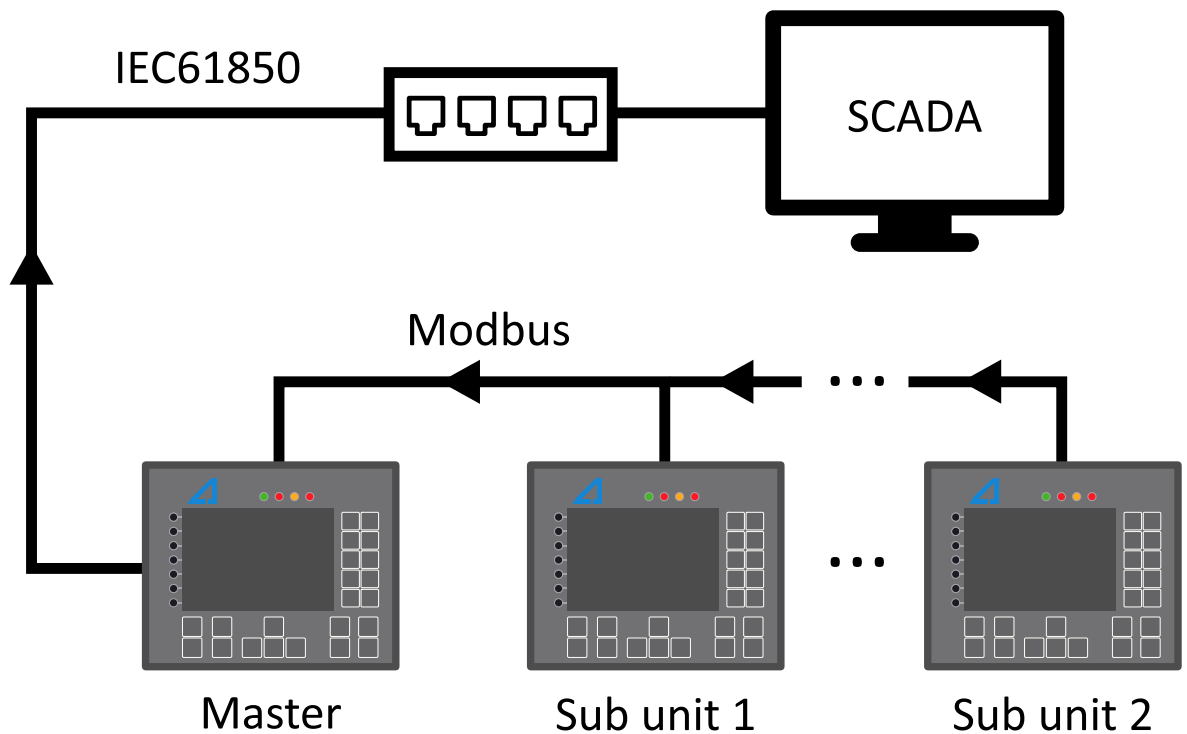
The following table presents the setting parameters available for the 12 channels.

Table. 5.4 - 89. Fault register settings.

Name	Range	Step	Default	Description
Select record source	Not in use I>, I>>, I>>>, I>>>> (IL1, IL2, IL3) Id>, Id>>, Id>>>, Id>>>> (IL1, IL2, IL3) IO>, IO>>, IO>>>, IO>>>> (IO) IOd>, IOd>>, IOd>>>, IOd>>>> (IO) FLX (Fault locator)	-	Not in use	Selects the protection function and its stage to be used as the source for the fault register recording. The user can choose between non-directional overcurrent, directional overcurrent, non-directional earth fault, directional earth fault, and fault locator functions.
Select record trigger	• TRIP signal • START signal • START and TRIP signals	-	TRIP signal	Selects what triggers the fault register recording: the selected function's TRIP signal, its START signal, or either one.
Recorded fault value	- 1000 000.00...1 000 000.00	0.01	-	Displays the recorded measurement value at the time of the selected fault register trigger.

5.5 Modbus Gateway

Figure. 5.5 - 31. Example setup of Modbus Gateway application.



The device can be setup as a Modbus Gateway (i.e. master). Modbus Gateway device can import messages (measurements, status signals etc.) from external Arcteq and third-party devices. RS-485 serial communication port. Up to 32 sub units can be connected to a master unit. These messages can then be used for controlling logic in the master device, display the status in user created mimic. Binary signals can be reported forward to SCADA with IEC61850, IEC101, IEC103, IEC104, Modbus, DNP3 or SPA.

Modbus Gateway and its basic settings can be found from *Communication* → *Modbus Gateway*. General settings-menu displays the health of connection to each sub unit.

Table. 5.5 - 90. General settings

Name	Range	Description
Modbus Gateway mode	- Disabled (Default) - Enabled	Enables or disables Modbus Gateway.
Modbus Gateway reconfigure	- Reconfigure	Setting this parameter to "Reconfigure" takes new settings into use. Parameter returns back to "-" automatically.
Quality of Modbus Sub unit 1...32	- OK - Old data - Data questionable - Modbus error - Send fail - Receive fail	Quality of each connected sub unit.

Imported signals

Modbus Gateway supports importing of measurements, bits, double bits, counters and integer signals. Up to 128 signals can be imported of each signal type with the exception of double bits (32).

Table. 5.5 - 91. Imported signals

Name	Range
Imported measurement 1-128	-3.4E+38...3.4E+38
Imported bit signal 1-128	0...1
Imported double bit data 1-32	0...3
Imported counter data 1-128	0...4294967295
Imported integer signal 1-128	-2147483648...2147483647

To assign the signals use Modbus Gateway editor (*Tools* → *Communication* → *Modbus Gateway*). Detailed description of this tool can be found in *AQtivate Instruction manual* (<https://www.arcteq.com/documents-and-software/>).

All imported signals can be given a description. The description will be displayed in most of menus with the signal (logic editor, matrix, block settings etc.).

Table. 5.5 - 92. Imported signal user description.

Name	Range	Default	Description
Describe measurement x	1...31 characters	Acq. Meas x	User settable description for the signal. This description is used in several menu types for easier identification.
Describe bit signal x		Acq. Bit x	
Describe double bit signal x		Acq. Binary x	
Describe counter signal x		Acq. Counter x	
Describe integer signal x		Acq. Integer x	

Events

The Modbus Gateway generates events the status changes in imported bits and double bits. The user can select which event messages are stored in the main event buffer: ON, OFF, or both.

Table. 5.5 - 93. Event messages

Event block name	Event names
MGWB1	Bit 1...Bit 32 (ON, OFF)

Event block name	Event names
MGWB2	Bit 33...Bit 64 (ON, OFF)
MGWB3	Bit 65...Bit 96 (ON, OFF)
MGWB4	Bit 97...Bit 128 (ON, OFF)
MGWD1	Double Bit 1... Double bit 16 (ON/ON, OFF/OFF, ON/OFF, OFF/ON)
MGWD2	Double Bit 17... Double bit 32 (ON/ON, OFF/OFF, ON/OFF, OFF/ON)

5.6 Realtime signals to Comm

The Real-time signals to communication menu allows selected measurements to be reported to the SCADA system at a faster update rate. This feature is primarily intended for use with Fast Modbus.

Up to eight (8) measurement magnitudes can be selected for reporting. Each reported value can be transmitted either as a per-unit value or as a primary value, as configured by the user.

Settings

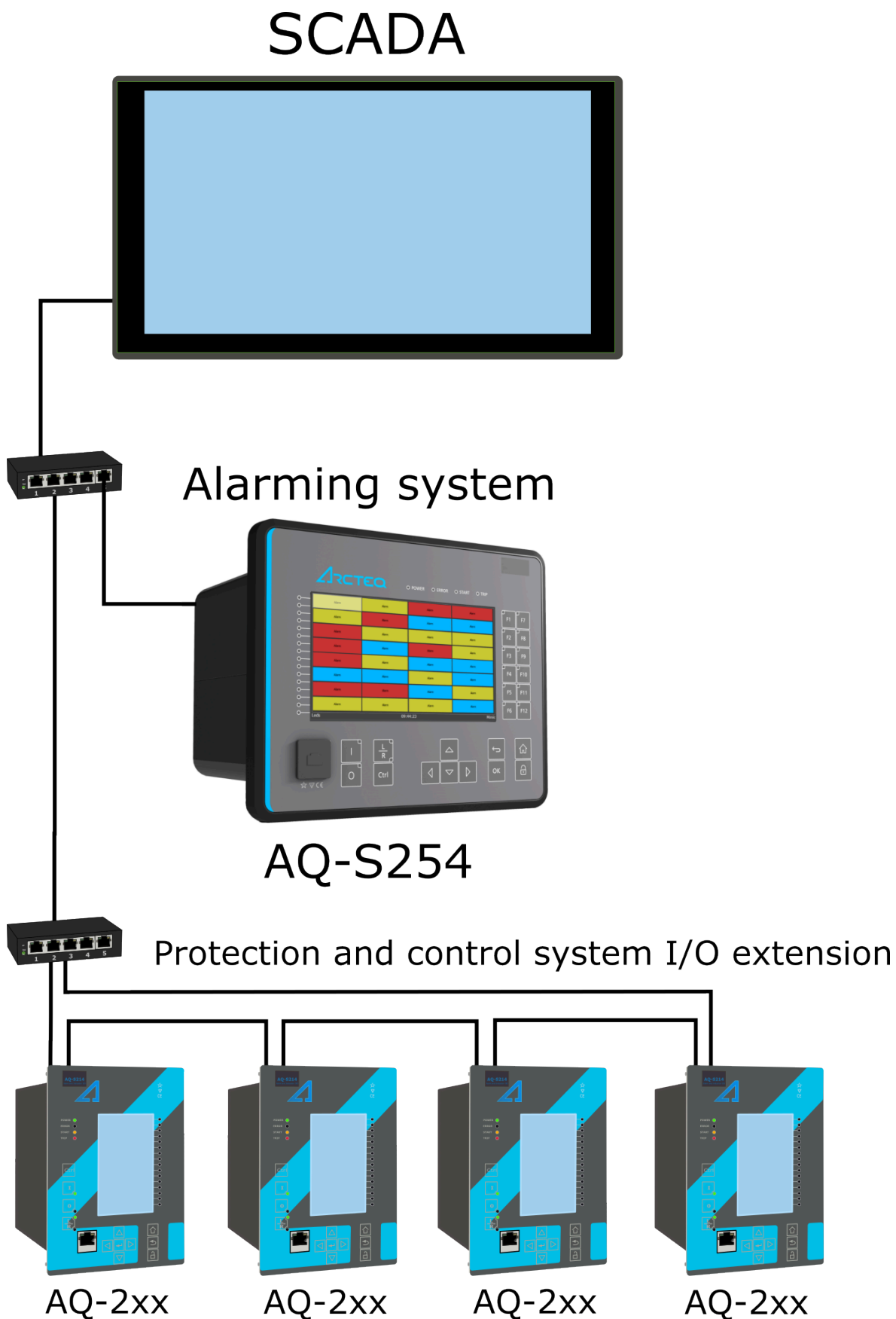
Table. 5.6 - 94. Settings.

Name	Range	Step	Default	Description
Measurement value recorder mode	- Disabled - Activated	-	Disabled	Activates and disables the real-time signals to communication.
Scale current values to primary	- No - Yes	-	No	Selects whether or not values are scaled to primary.
Slot X magnitude selection	- Currents - Voltages - Powers - Impedance (ZRX) and admittance (YGB) - Others	-	Currents	Selects the measured magnitude category of the chosen slot.
Slot X magnitude	Described in table above ("Available measured values")	-	-	Selects the magnitude in the previously selected category.
Magnitude X	-10 000 000.000...10 000 000.000	0.001	-	Displays the measured value of the selected magnitude of the selected slot. The unit depends on the selected magnitude (either amperes, volts, or per-unit values).

6 Connections and application examples

6.1 Connections of AQ-S254

Figure. 6.1 - 32. AQ-S254 application example.



7 Construction and installation

7.1 Construction

AQ-X254 is a member of the modular and scalable AQ-200 series, and it includes 14 configurable and modular add-on card slots. As a standard configuration the device includes the CPU module (which consists of the CPU, a number of inputs and outputs, and the power supply).

The images below present the modules of both the non-optioned model (AQ-X254-XXXXXXX-AAAAAAAAAAAAAAAA) and the almost fully optioned model (AQ-X254-XXXXXXX-BBBBBBBBBBBBCAJ).

Figure. 7.1 - 33. Modular construction of AQ-X254-XXXXXXX-AAAAAAAAAAAAAAAA

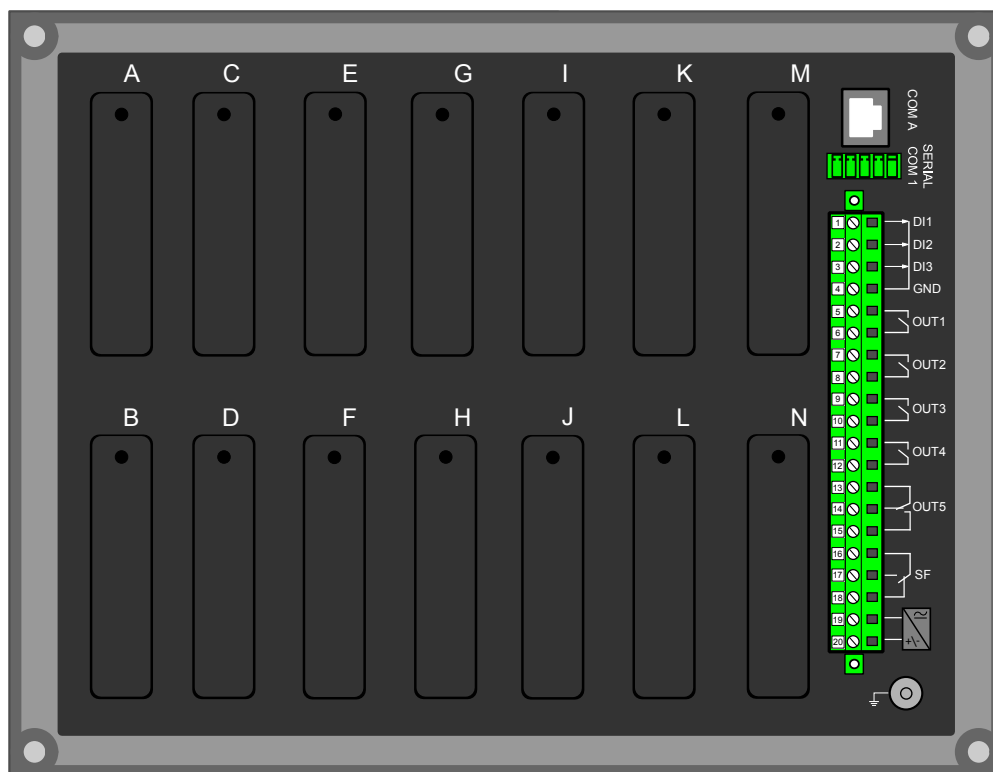
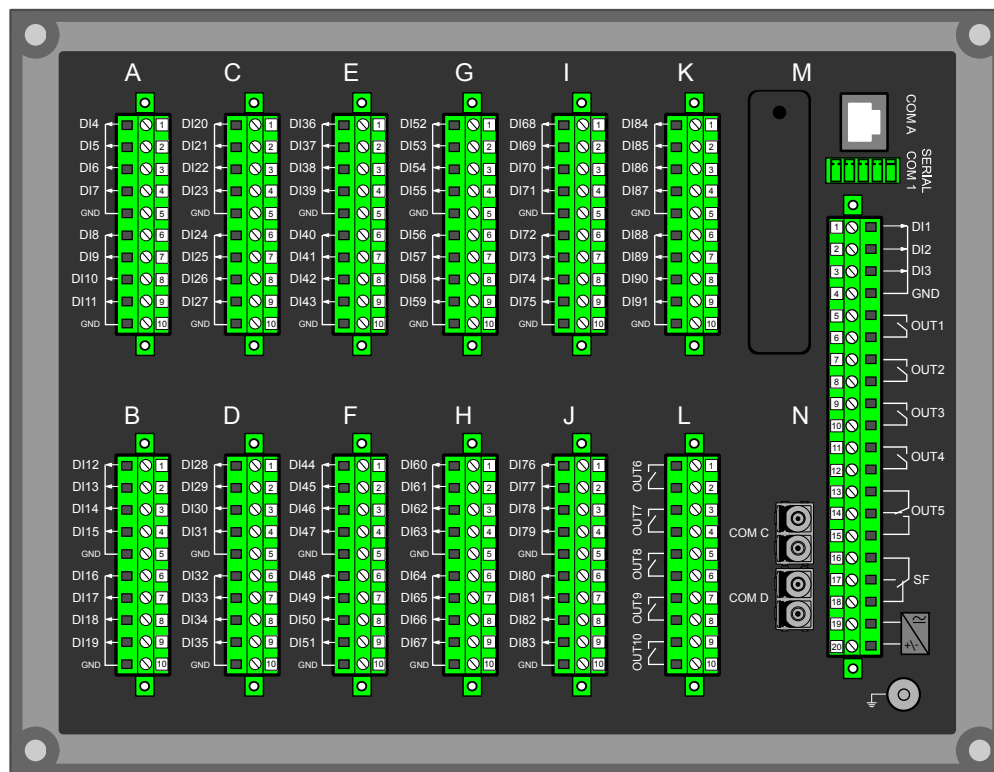


Figure. 7.1 - 34. Modular construction of AQ-X254-XXXXXXX-BBBBBBBBBBBBCAJ



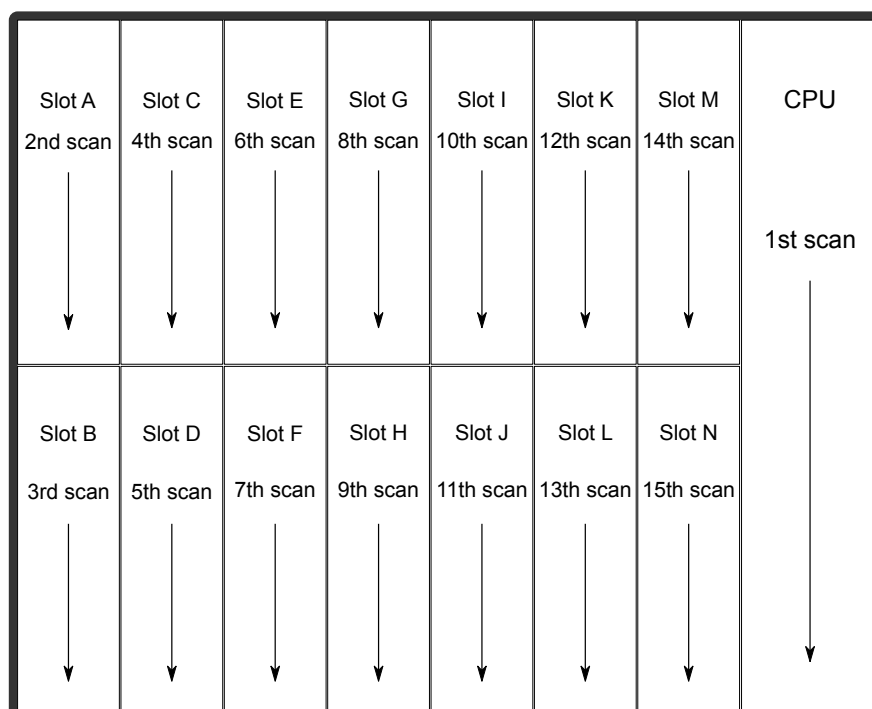
The modular structure of AQ-X254 allows for scalable solutions for different application requirements. In non-standard configurations Slots A to N accept all available add-on modules, such as digital I/O modules and other special modules. The only difference between the slots affecting device scalability is that Slots M and N also support communication options.

Start-up scan searches for modules according to their type designation code. If the module content is not what the device expects, the device issues a hardware configuration error message. In field upgrades, therefore, add-on modules must be ordered from Arcteq Relays Ltd. or its representative who can then provide the module with its corresponding unlocking code to allow the device to operate correctly once the hardware configuration has been upgraded.

When an I/O module is inserted into the device, the module location affects the naming of the I/O. The I/O scanning order in the start-up sequence is as follows: the CPU module I/O, Slot A, Slot B, Slot C, and so on. This means that the digital input channels DI1, DI2 and DI3 as well as the digital output channels OUT1, OUT2, OUT3, OUT4 and OUT5 are always located in the CPU module. If additional I/O cards are installed, their location and card type affect the I/O naming.

The figure below presents the start-up hardware scan order of the device as well as the I/O naming principles.

Figure. 7.1 - 35. Hardware scanning and IO naming principle in AQ-X254 devices.

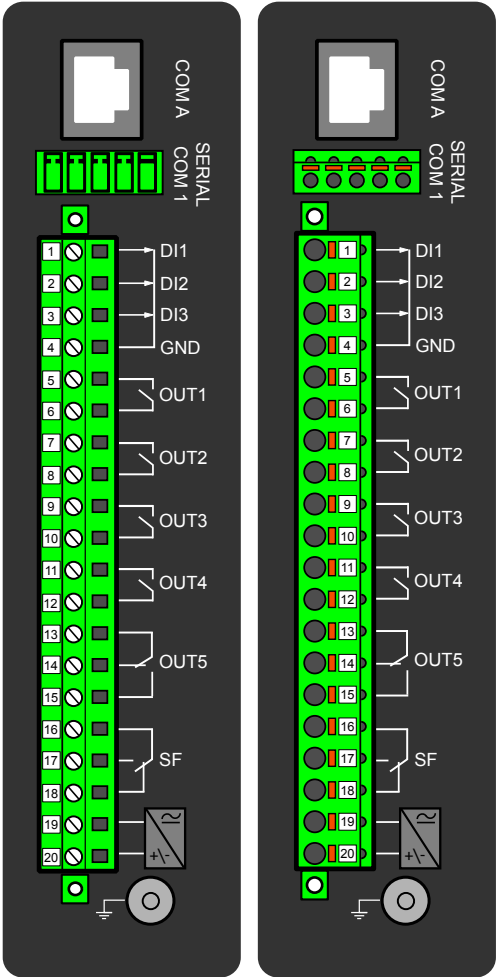


1. Scan
The start-up system; detects and self-tests the CPU module, voltages, communication and the I/O; finds and assigns "DI1", "DI2", "DI3", "OUT1", "OUT2", "OUT3", "OUT4" and "OUT5".
2. Scan
Scans Slot A, and moves to the next slot if Slot A is empty. If the scan finds an 8DI module (that is, a module with eight digital inputs), it reserves the designations "DI4", "DI5", "DI6", "DI7", "DI8", "DI9", "DI10" and "DI11" to this slot. If the scan finds a DO5 module (that is, a module with five digital outputs), it reserves the designations "OUT6", "OUT7", "OUT8", "OUT9" and "OUT10" to this slot. The I/O is then added if the type designation code (e.g. AQ-P215-PH0AAAA-BBC) matches with the existing modules in the device. If the code and the modules do not match, the device issues an alarm. An alarm is also issued if the device expects to find a module here but does not find one.
3. Scan
Scans Slot B, and moves to the next slot if Slot B is empty. If the scan finds an 8DI module, it reserves the designations "DI4", "DI5", "DI6", "DI7", "DI8", "DI9", "DI10" and "DI11" to this slot. If Slot A also has an 8DI module (and therefore has already reserved these designations), the device reserves the designations "DI12", "DI13", "DI14", "DI15", "DI16", "DI17", "DI18" and "DI19" to this slot. If the scan finds a 5DO module, it reserves the designations "OUT6", "OUT7", "OUT8", "OUT9" and "OUT10" to this slot. Again, if Slot A also has a 5DO and has therefore already reserved these designations, the device reserves the designations "OUT11", "OUT12", "OUT13", "OUT14" and "OUT15" to this slot.
4. – 15. Scan
A similar operation to Scan 3 (checks which designations have been reserved by modules in previous slots and numbers the new ones accordingly).

The almost fully optioned example case of AQ-X254-XXXXXXX-BBBBBBBBBBBBCAJ (the first image pair, on the right) has a total of 91 digital input channels available: three (DI1...DI3) in the CPU module, and the rest in Slots A...K in groups of eight. It also has a total of 10 digital output channels available: five (DO1...DO5) in the CPU module, and five (DO6...DO10) in Slot L.

7.2 CPU module

Figure. 7.2 - 36. CPU module can be equipped with standard screw terminals or spring cage terminals for connection.



Connector	Description
COM A	Communication port A, or the RJ-45 port. Used for the setting tool connection and for SCADA communication.
COM B	Communication port B, or the RS-485 port. Used for SCADA communication. The pins have the following designations: - Pin 1 = DATA + - Pin 2 = DATA - - Pin 3 = GND - Pins 4 & 5 = Terminator resistor enabled by shorting.
X1-1	Digital input 1, nominal threshold voltage 24 V, 110 V or 220 V.
X1-2	Digital input 2, nominal threshold voltage 24 V, 110 V or 220 V.
X1-3	Digital input 3, nominal threshold voltage 24 V, 110 V or 220 V.
X1-4	Common GND for digital inputs 1, 2 and 3.
X1-5:6	Output relay 1, with a normally open (NO) contact.

Connector	Description
X1-7:8	Output relay 2, with a normally open (NO) contact.
X1-9:10	Output relay 3, with a normally open (NO) contact.
X1-11:12	Output relay 4, with a normally open (NO) contact.
X1-13:14:15	Signaling relay 5, with a changeover contact. Not to be used in trip coil control.
X1-16:17:18	System fault's signaling relay, with a changeover contact. Pins 16 and 17 are closed when the unit has a system fault or is powered OFF. Pins 16 and 18 are closed when the unit is powered ON and there is no system fault.
X1-19:20	Power supply IN. Either 88...265 VAC/DC (model A; order code "H") or 18...72 DC (model B; order code "L"). Positive side (+) to Pin 20.
GND	The device's earthing connector.

By default, the CPU module (combining the CPU, the I/O and the power supply) includes two standard communication ports and the device's basic digital I/O.

The digital output controls can be set by the user with software. Digital outputs are controlled in 5 ms program cycles. All output contacts are mechanical. The rated voltage of the NO/NC outputs is 250 VAC/DC.

Digital inputs

The current consumption of the digital inputs is 2 mA when activated. The range of the operating voltage is 24 V/110 V/220 V depending on the ordered hardware. All digital inputs are scanned in 5 ms program cycles.

The settings described in the table below can be found at *Control* → *Device I/O* → *Digital input settings* in the device settings.

Table. 7.2 - 95. Digital input settings.

Name	Range	Step	Default	Description
Dlx Polarity	- NO (Normally open) - NC (Normally closed)	-	NO	Selects whether the status of the digital input is 1 or 0 when the input is energized.
Dlx Activation delay	0.000...1800.000 s	0.001 s	0.000 s	Defines the delay for the status change from 0 to 1.
Dlx Drop-off time	0.000...1800.000 s	0.001 s	0.000 s	Defines the delay for the status change from 1 to 0.
Dlx AC mode	- Disabled - Enabled	-	Disabled	Selects whether or not a 30-ms deactivation delay is added to account for alternating current.

Digital outputs

The digital output controls can be set by the user with software. Digital outputs are controlled in 5 ms program cycles. All output contacts are mechanical. The rated voltage of the NO/NC outputs is 250 VAC/DC.

Table. 7.2 - 96. Digital output settings.

Name	Range	Description
Out x Polarity	• NO • NC	Determines the normal status of the output relay. Digital outputs are configured as “normally open” relays by default. Each output can be changed to “normally closed” using the “OUTx Polarity” parameter. Please note that this change is implemented in software only. If the device is powered off, the outputs will revert to an open state and return to the configured polarity once power is restored. If a truly “normally closed” contact is required, use the changeover relay OUT5 available in the CPU module of the device. An NC output signal does not open during a Communication or Protection reset.

Digital input and output descriptions

CPU card digital inputs and outputs can be given a description. The user defined description are displayed in most of the menus:

- logic editor
- matrix
- block settings
- event history
- disturbance recordings
- etc.

Table. 7.2 - 97. Digital input and output user description.

Name	Range	Default	Description
User editable description DIx	1...31 characters	DIx	Description of the digital input. This description is used in several menu types for easier identification.
User editable description OUTx		OUTx	Description of the digital output. This description is used in several menu types for easier identification.



NOTICE!

After editing user descriptions the event history will start to use the new description only after resetting the HMI. HMI can be reset from *General* → *Device info* → *HMI restart*.

Scanning cycle

All digital inputs are scanned in a 5 ms cycle, meaning that the state of an input is updated every 0...5 milliseconds. When an input is used internally in the device (either in setting group change or logic), it takes additional 0...5 milliseconds to operate. Theoretically, therefore, it takes 0...10 milliseconds to change the setting group when a digital input is used for group control or a similar function. In practice, however, the delay is between 2...8 milliseconds about 95 % of the time. When a digital input is connected directly to a digital output (OUT1...OUTx), it takes an additional 5 ms round. Therefore, when a digital input controls a digital output internally, it takes 0...15 milliseconds in theory and 2...13 milliseconds in practice.



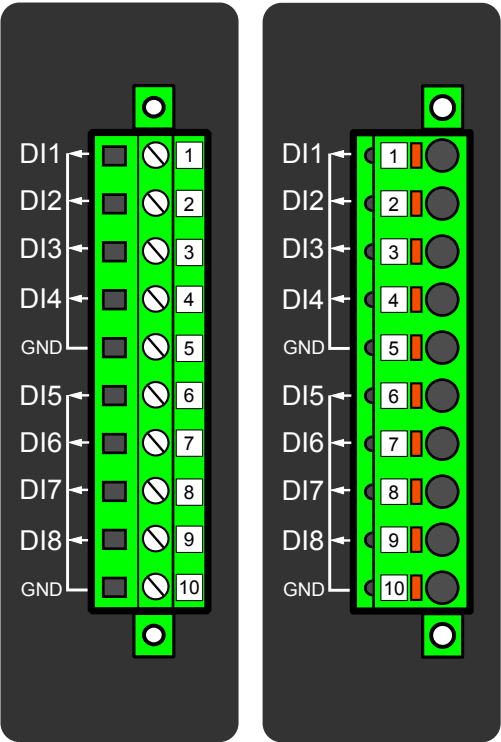
NOTICE!

The mechanical delay of the relay is not included in these approximations!

7.3 Option cards

7.3.1 Digital input module (optional)

Figure. 7.3.1 - 37. Digital input module (DI8) with eight add-on digital inputs. Can be equipped with standard screw terminals or spring cage terminals for connection.



Connector	Description (x = the number of digital inputs in other modules that preceed this one in the configuration)
X 1	DIx + 1
X 2	DIx + 2
X 3	DIx + 3
X 4	DIx + 4
X 5	Common earthing for the first four digital inputs.
X 6	DIx + 5
X 7	DIx + 6
X 8	DIx + 7
X 9	DIx + 8
X 10	Common earthing for the other four digital inputs.

The DI8 module is an add-on module with eight (8) galvanically isolated digital inputs. This module can be ordered directly to be installed into the device in the factory, or it can be upgraded in the field after the device's original installation when required. The properties of the inputs in this module are the same as those of the inputs in the main processor module. The current consumption of the digital inputs is 2 mA when activated, while the range of the operating voltage is from 0...265 VAC/DC. The activation and release thresholds are set in the software and the resolution is 1 V. All digital inputs are scanned in 5 ms program cycles, and their pick-up and release delays as well as their NO/NC selection can be set with software.

For the naming convention of the digital inputs provided by this module please refer to the chapter titled "[Construction and installation](#)".

For technical details please refer to the chapter titled "[Digital input module](#)" in the "Technical data" section of this document.

The hardware configuration code of this module is "B". For more information, please refer to the "[Ordering information](#)" chapter of this document.

Setting up the activation and release delays

The settings described in the table below can be found at *Control* → *Device I/O* → *Digital input settings* in the device settings.

Table. 7.3.1 - 98. Digital input settings of DI8 module.

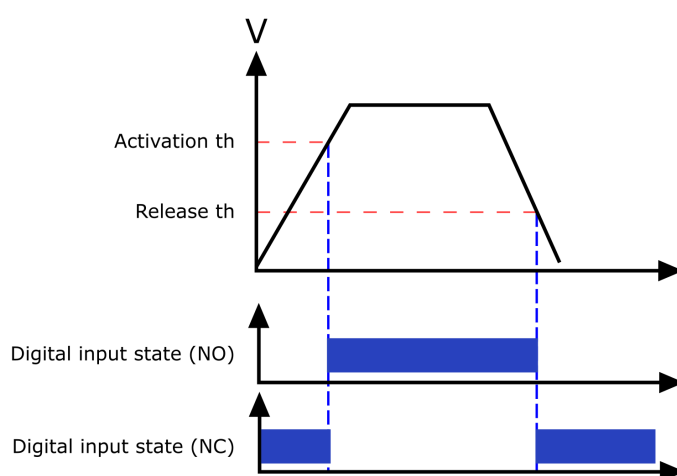
Name	Range	Step	Default	Description
Dlx Polarity	- NO (Normally open) - NC (Normally closed)	-	NO	Selects whether the status of the digital input is 1 or 0 when the input is energized.
Dlx Activation threshold	16.0...200.0 V	0.1 V	88 V	Defines the activation threshold for the digital input. When "NO" is the selected polarity, the measured voltage exceeding this setting activates the input. When "NC" is the selected polarity, the measured voltage exceeding this setting deactivates the input.
Dlx Release threshold	10.0...200.0 V	0.1 V	60V	Defines the release threshold for the digital input. When "NO" is the selected polarity, the measured voltage below this setting deactivates the input. When "NC" is the selected polarity, the measured voltage below this setting activates the input.
Dlx Activation delay	0.000...1800.000 s	0.001 s	0.000 s	Defines the delay when the status changes from 0 to 1. Not visible when DI has been set to AC mode with "Dlx AC mode" parameter.
Dlx Drop-off time	0.000...1800.000 s	0.001 s	0.000 s	Defines the delay when the status changes from 1 to 0.
Dlx AC Mode	- Disabled - Enabled	-	Disabled	Selects whether or not a 30-ms deactivation delay is added to take the alternating current into account. The "Dlx Release threshold" parameter is hidden and forced to 10 % of the set "Dlx Activation threshold" parameter.
Dlx Counter	0...2 ³² -1	1	0	Displays the number of times the digital input has changed its status from 0 to 1.

Name	Range	Step	Default	Description
Dlx Clear counter	- - Clear	-	-	Resets the Dlx counter value to zero.

The user can set the activation threshold individually for each digital input. When the activation and release thresholds have been set properly, they will result in the digital input states to be activated and released reliably. The selection of the normal state between normally open (NO) and normally closed (NC) defines whether or not the digital input is considered activated when the digital input channel is energized.

The diagram below depicts the digital input states when the input channels are energized and de-energized.

Figure. 7.3.1 - 38. Digital input state when energizing and de-energizing the digital input channels.



Digital input descriptions

Option card inputs can be given a description. The user defined description are displayed in most of the menus:

- logic editor
- matrix
- block settings
- event history
- disturbance recordings
- etc.

Table. 7.3.1 - 99. Digital input user description.

Name	Range	Default	Description
User editable description Dlx	1...31 characters	Dlx	Description of the digital input. This description is used in several menu types for easier identification.



NOTICE!

After editing user descriptions the event history will start to use the new description only after resetting the HMI. HMI can be reset from *General* → *Device info* → *HMI restart*.

Digital input voltage measurements

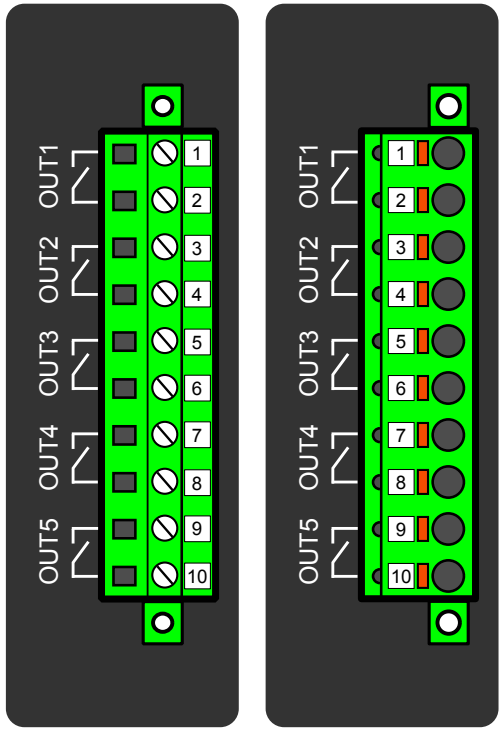
Digital input option card channels measure voltage on each channel. The measured voltage can be seen at *Control* → *Device IO* → *Digital inputs* → *Digital input voltages*.

Table. 7.3.1 - 100. Digital input channel voltage measurement.

Name	Range	Step	Description
Dlx Voltage now	0.000...275.000 V	0.001 V	Voltage measurement of a digital input channel.

7.3.2 Digital output module (optional)

Figure. 7.3.2 - 39. Digital output module (DO5) with five add-on digital outputs. Can be equipped with standard screw terminals or spring cage terminals for connection.



Connector	Description
X 1-2	OUTx + 1 (1 st and 2 nd pole NO)
X 3-4	OUTx + 2 (1 st and 2 nd pole NO)
X 5-6	OUTx + 3 (1 st and 2 nd pole NO)
X 7-8	OUTx + 4 (1 st and 2 nd pole NO)
X 9-10	OUTx + 5 (1 st and 2 nd pole NO)

The DO5 module is an add-on module with five (5) mechanical type digital outputs. This module can be ordered directly to be installed into the device in the factory, or it can be upgraded in the field after the device's original installation when required. The properties of the outputs in this module are the same as those of the outputs in the main processor module. Output control logic is user configurable. All digital outputs are controlled in 5 ms program cycles. The rated voltage of the outputs is 250 VAC/DC.

For the naming convention of the digital outputs provided by this module please refer to the chapter titled "[Construction and installation](#)".

For technical details please refer to the chapter titled "[Digital output module](#)" in the "Technical data" section of this document.

The hardware configuration code of this module is "C". For more information, please refer to the "[Ordering information](#)" chapter of this document.

Digital output settings

The parameters described in the table below can be found at *Control → Device I/O → Digital Outputs → Digital Output Settings* in the device settings.

Table. 7.3.2 - 101. Digital output user description.

Name	Range	Default	Description
OUTx Polarity	- NO - NC	NO	Digital outputs are configured as "normally open" relays by default. Each output can be changed to "normally closed" using the "OUTx Polarity" parameter. Please note that this change is implemented in software only. If the device is powered off, the outputs will revert to an open state and return to the configured polarity once power is restored. If a truly "normally closed" contact is required, use the changeover relay OUT5 available in the CPU module of the device.

Digital output descriptions

Option card outputs can be given a description. The user defined description are displayed in most of the menus:

- logic editor
- matrix
- block settings
- event history
- disturbance recordings
- etc.

The parameters described in the table below can be found at *Control → Device I/O → Digital Outputs → Digital Output Descriptions* in the device settings.

Table. 7.3.2 - 102. Digital output user description.

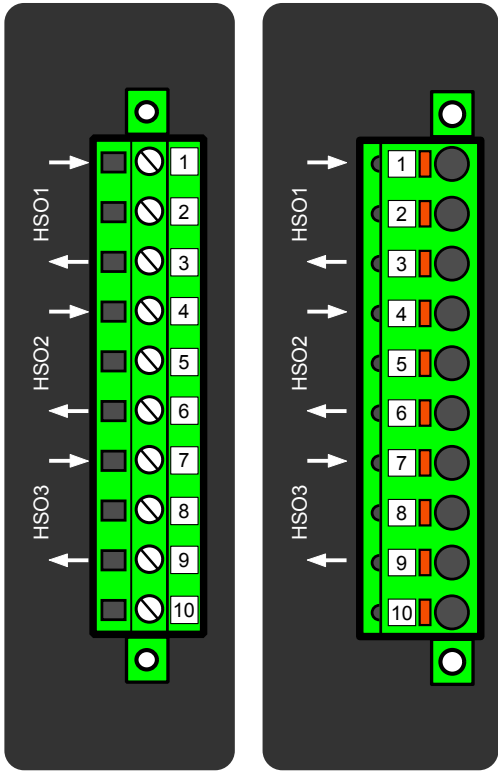
Name	Range	Default	Description
User editable description OUTx	1...31 characters	OUTx	Description of the digital output. This description is used in several menu types for easier identification.



NOTICE!
After editing user descriptions the event history will start to use the new description only after resetting the HMI. HMI can be reset from *General* → *Device info* → *HMI restart*.

7.3.3 High-speed and high-current output module (optional)

Figure. 7.3.3 - 40. High-speed and high-current output module with three add-on high-speed outputs. Can be equipped with standard screw terminals or spring cage terminals for connection.



Connector	Description
X 1	HSOx + 1 in
X 2	N/A
X 3	HSOx + 1 out
X 4	HSOx + 2 in
X 5	N/A
X 6	HSOx + 2 out
X 7	HSOx + 3 in
X 8	N/A
X 9	HSOx + 3 out
X 10	N/A

The high-speed and high-current module is an add-on module with three (3) hybrid outputs consisting of a semiconductor and a relay connected in parallel. This module can be ordered directly to be installed into the device in the factory, or it can be upgraded in the field after the device's original installation when required. Output control logic is user configurable. All high-speed outputs are controlled in 1 ms program cycles.

For technical details please refer to the chapter titled "[High-speed output module](#)" in the "Technical data" section of this document.

The hardware configuration code of this module is "R". For more information, please refer to the "[Ordering information](#)" chapter of this document.

HSO Input Settings menu

The parameters described in the table below can be found at *Control → Device I/O → HSO Inputs → HSO Input Settings* in the device settings.

Table. 7.3.3 - 103. HSO input parameters.

Name	Range	Step	Default	Description
HSO1...9 TCS Polarity	NC (Normally closed)	-	NC	The inputs on high-speed output cards are normally closed contacts, meaning they remain in the closed state under normal conditions and indicate '0' when the circuit is energized.
HSO1...9 TCS Drop-off time	0.000...1800.000 s	0.001 s	0.200 s	Defines the delay when the status changes from 0 to 1.
HSO1...9 TCS AC Mode	- Disabled - Enabled	-	Disabled	Selects whether or not a 30 ms deactivation delay is added to take the alternating current into account. The "Dlx Release threshold" parameter is hidden and forced to 10 % of the set "Dlx Activation threshold" parameter.
HSO1...9 TCS Counter	0...4294967295	1	0	Displays the number of times the input has changed its status from 0 to 1.
HSO1...9 TCS Clear counter	- - Clear	-	-	Resets the input activation counter value to zero.

HSO Output Settings menu

The parameters described in the table below can be found at *Control → Device I/O → HSO Outputs → HSO Output Settings* in the device settings.

Table. 7.3.3 - 104. HSO output parameters.

Name	Range	Step	Default	Description
HSO1...9 Polarity	- NO - NC	-	NO	The inputs on high-speed output cards are normally closed contacts, meaning they remain in the closed state under normal conditions and indicate '0' when the circuit is energized.

HSO output and input descriptions

Option card outputs and inputs can be given a description. The user defined description are displayed in most of the menus:

- logic editor
- matrix
- block settings
- event history
- disturbance recordings
- etc.

Table. 7.3.3 - 105. HSO input and output user description.

Name	Range	Default	Description
User editable description HSOx	1...31 characters	HSOx	Description of the high-speed output. This description is used in several menu types for easier identification.
User editable description HSO1...9 TCS	1...31 characters	HSO1...9 TCS	Description of the high-speed output. This description is used in several menu types for easier identification.

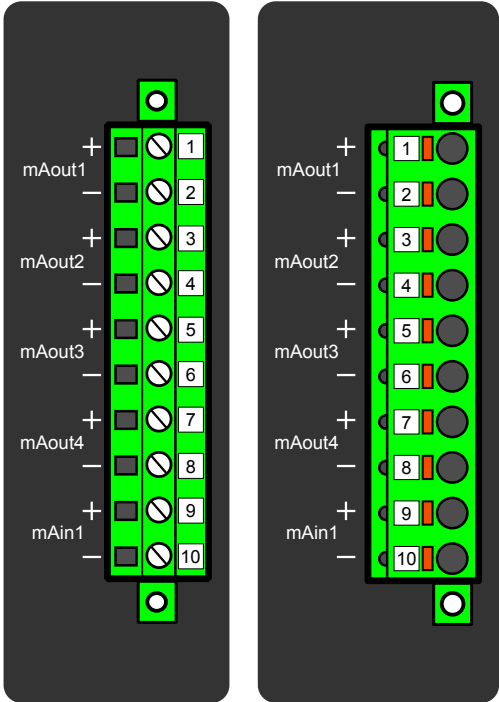


NOTICE!

After editing user descriptions the event history will start to use the new description only after resetting the HMI. HMI can be reset from *General* → *Device info* → *HMI restart*.

7.3.4 Milliampere output module (4x mA out & 1x mA in) (optional)

Figure. 7.3.4 - 41. Milliampere output (mA) I/O module connections. Can be equipped with standard screw terminals or spring cage terminals for connection.



Connector	Description
Pin 1	mA OUT 1 + connector (0...24 mA)
Pin 2	mA OUT 1 – connector (0...24 mA)
Pin 3	mA OUT 2 + connector (0...24 mA)
Pin 4	mA OUT 2 – connector (0...24 mA)
Pin 5	mA OUT 3 + connector (0...24 mA)
Pin 6	mA OUT 3 – connector (0...24 mA)
Pin 7	mA OUT 4 + connector (0...24 mA)
Pin 8	mA OUT 4 – connector (0...24 mA)
Pin 9	mA IN 1 + connector (0...33 mA)
Pin 10	mA IN 1 – connector (0...33 mA)

The milliampere output (mA) I/O module is an add-on module with four (4) mA outputs and one (1) mA input. Both the outputs and the input are in two galvanically isolated groups, with one pin for the positive (+) connector and one pin for the negative (–) connector.

This module can be ordered directly to be installed into the device in the factory, or it can be upgraded in the field after the device's original installation when required.

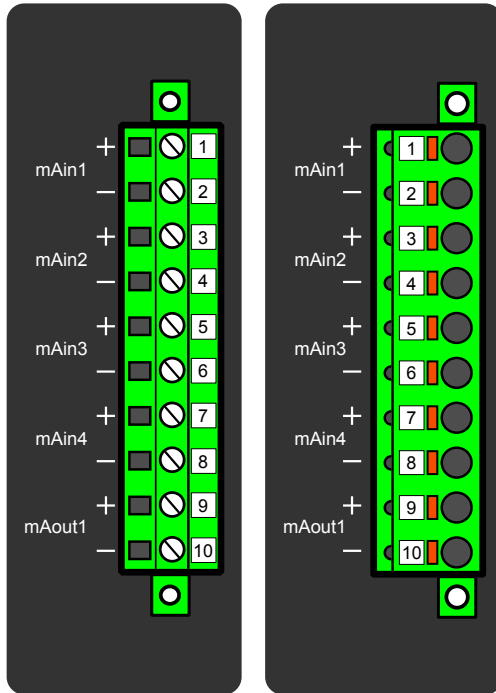
The user sets the mA I/O with the mA outputs control function. This can be done at *Control* → *Device I/O* → *mA outputs* in the device configuration settings.

For further information please refer to the chapter titled "[Milliampere output module \(4 x mA out & 1 x mA in\)](#)" in the "Technical data" section of this manual.

The hardware configuration code of this module is "I". For more information, please refer to the "[Ordering information](#)" chapter of this document.

7.3.5 Milliampere input module (4x mA in & 1x mA out) (optional)

Figure. 7.3.5 - 42. Milliampere input (mA) I/O module connections. Can be equipped with standard screw terminals or spring cage terminals for connection.



Connector	Description
Pin 1	mA IN 1 + connector (0...24 mA)
Pin 2	mA IN 1 – connector (0...24 mA)
Pin 3	mA IN 2 + connector (0...24 mA)
Pin 4	mA IN 2 – connector (0...24 mA)
Pin 5	mA IN 3 + connector (0...24 mA)
Pin 6	mA IN 3 – connector (0...24 mA)
Pin 7	mA IN 4 + connector (0...24 mA)
Pin 8	mA IN 4 – connector (0...24 mA)
Pin 9	mA OUT 1 + connector (0...33 mA)
Pin 10	mA OUT 1 – connector (0...33 mA)

The milliampere input (mA) I/O module is an add-on module with four (4) mA inputs and one (1) mA output. Both the inputs and the output are in two galvanically isolated groups, with one pin for the positive (+) connector and one pin for the negative (–) connector.

This module can be ordered directly to be installed into the device in the factory, or it can be upgraded in the field after the device's original installation when required.

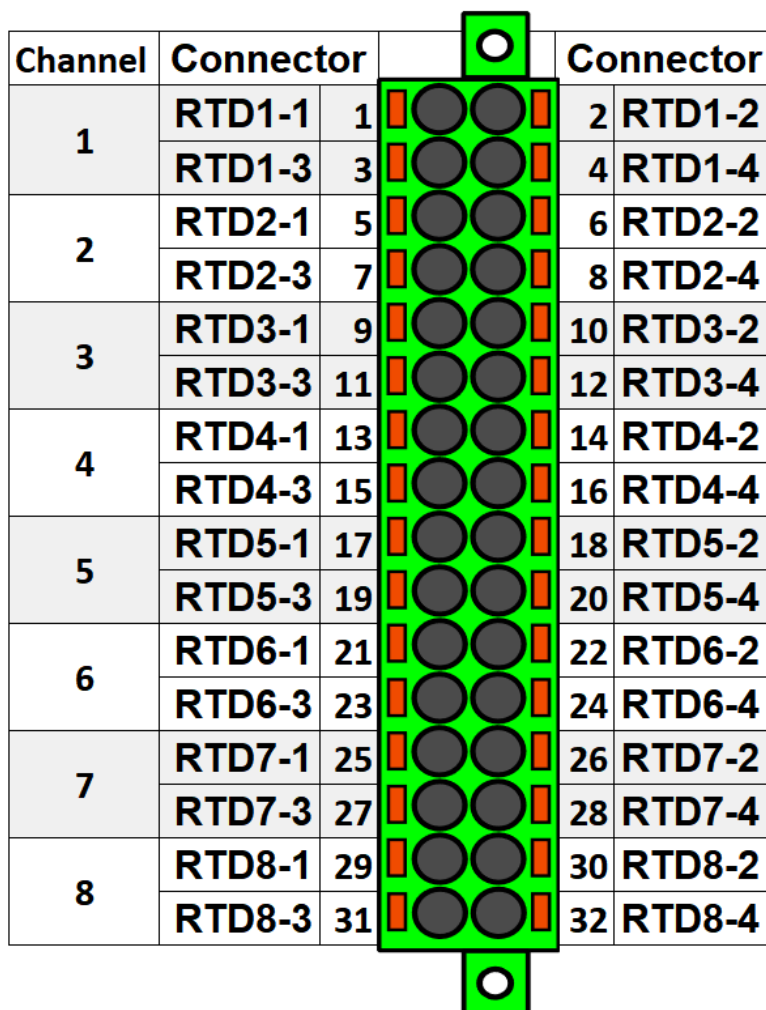
The user sets the mA I/O with the mA output control function. This can be done at *Control* → *Device I/O* → *mA outputs* in the device configuration settings.

For further information please refer to the chapter titled "[Milliampere input module \(1x mA out & 4x mA in\)](#)" in the "Technical data" section of this manual.

The hardware configuration code of this module is "T". For more information, please refer to the "[Ordering information](#)" chapter of this document.

7.3.6 RTD input module (optional)

Figure. 7.3.6 - 43. RTD input module connectors.

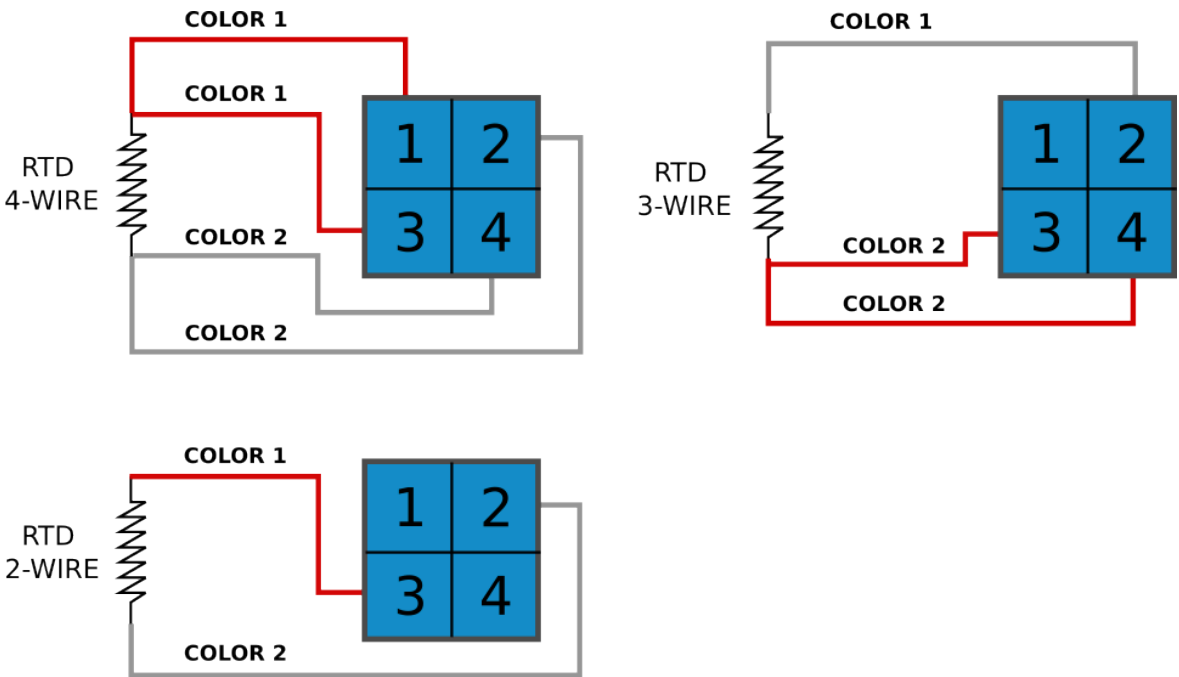


The RTD input module is an add-on module with eight (8) RTD input channels. Each input supports 2-wire, 3-wire and 4-wire RTD sensors. The sensor type can be selected with software for two groups, four channels each. The card supports Pt100 and Pt1000 sensors.

For further information please refer to the chapter titled "[RTD input module](#)" in the "Technical data" section of this manual.

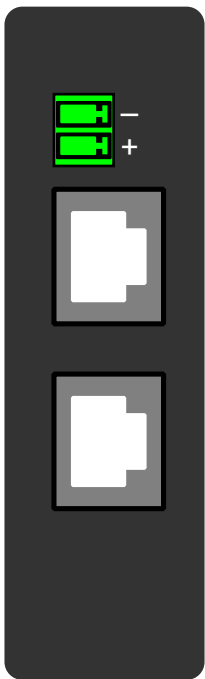
The hardware configuration code of this module is "F". For more information, please refer to the "[Ordering information](#)" chapter of this document.

Figure. 7.3.6 - 44. RTD sensor connection types.



7.3.7 Double RJ45 Ethernet & IRIG-B communication module (optional)

Figure. 7.3.7 - 45. Double RJ-45 10/100 Mbps Ethernet communication module.



Connector	Description
Two-pin connector	IRIG-B input
RJ-45 connectors	- Two Ethernet ports - RJ-45 connectors 10BASE-T and 100BASE-TX

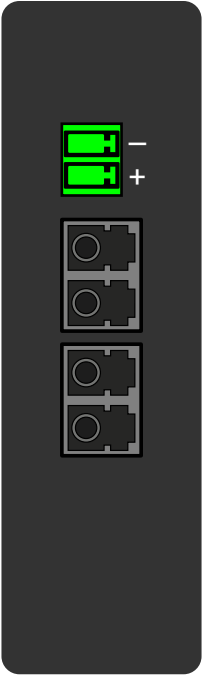
This option card supports daisy chain configurations.

For further information please refer to the chapter titled "[Double RJ45 Ethernet & IRIG-B communication module](#)" in the "Technical data" section of this manual.

The hardware configuration code of this module is "G". For more information, please refer to the "[Ordering information](#)" chapter of this document.

7.3.8 Double SFP Ethernet & IRIG-B communication module (optional)

Figure. 7.3.8 - 46. Double SFP 100 Mbps Ethernet communication module.



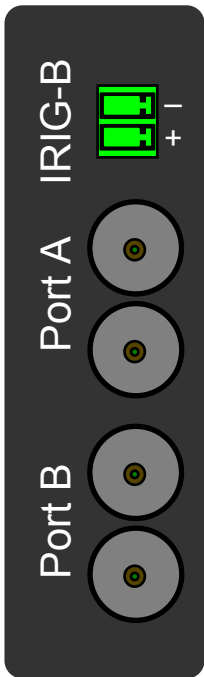
Connector	Description
Two-pin connector	IRIG-B input
SFP slots	- Two SFP slots - Compatible SFP modules available as accessories

For further information please refer to the chapter titled "[Double SFP Ethernet & IRIG-B communication module](#)" in the "Technical data" section of this manual.

The hardware configuration code of this module is "Q". For more information, please refer to the "[Ordering information](#)" chapter of this document.

7.3.9 Double ST 100 Ethernet & IRIG-B communication module (optional)

Figure. 7.3.9 - 47. Double ST 100 Mbps Ethernet communication module connectors.



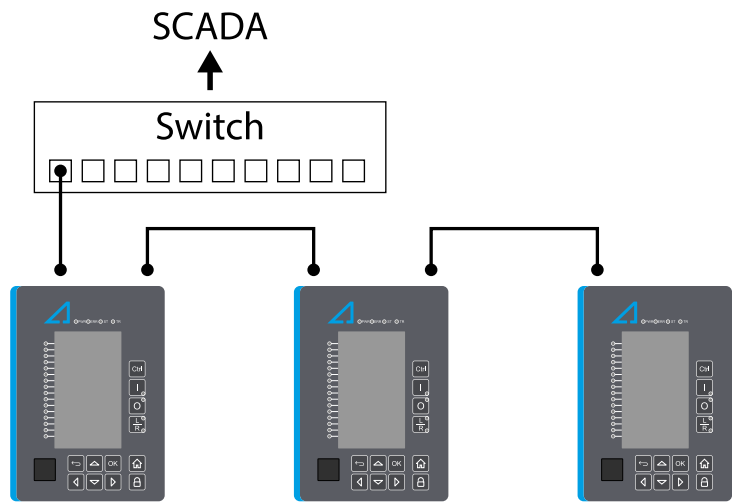
Connector	Description
Two-pin connector	• IRIG-B input
ST connectors	• Duplex ST connectors • 62.5/125 μm or 50/125 μm multimode fiber • Transmitter wavelength: 1260...1360 nm (nominal: 1310 nm) • Receiver wavelength: 1100...1600 nm • 100BASE-FX • Up to 2 km

This option cards supports redundant ring configuration and multidrop configurations. Please note that each ring can only contain AQ 250 series devices, and any third party devices must be connected to a separate ring.

For further information please refer to the chapter titled "[Double ST Ethernet & IRIG-B communication module](#)" in the "Technical data" section of this manual.

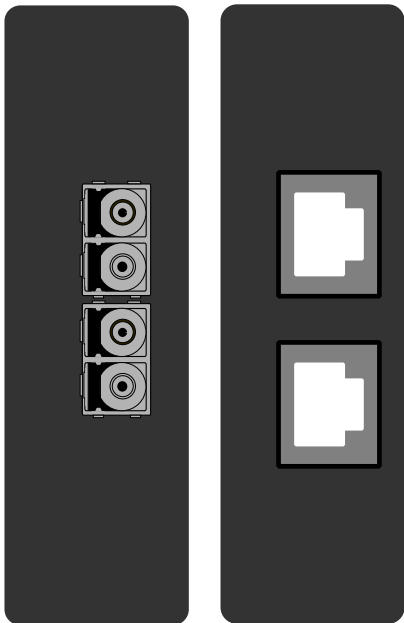
The hardware configuration code of this module is "H". For more information, please refer to the "[Ordering information](#)" chapter of this document.

Figure. 7.3.9 - 48. Example of a multidrop configuration.



7.3.10 Double LC or RJ45 (HSR/PRP) Ethernet communication module (optional)

Figure. 7.3.10 - 49. LC and RJ45 100 Mbps Ethernet module connectors.



Card type	Description
LC ports	• Communication port D, 100 Mbps LC fiber connector. • 62.5/125 μm or 50/125 μm multimode (glass). • Wavelength 1300 nm. • HSR and PRP protocols supported.
RJ45	• RJ-45 connectors. • 10BASE-T and 100BASE-TX. • HSR and PRP protocols supported.

For further information please refer to the chapters titled "[Double LC \(HSR/PRP\) Ethernet communication module](#)" and "[Double RJ45 \(HSR/PRP\) Ethernet communication module](#)" in the "Technical data" section of this manual.

The hardware configuration codes of these modules are "J" (Double LC 100Mb Ethernet) and "K" (Double RJ45 100Mb Ethernet). For more information, please refer to the "[Ordering information](#)" chapter of this document.

7.3.11 Serial RS-232 communication module (optional)

Figure. 7.3.11 - 50. Serial RS-232 module connectors.

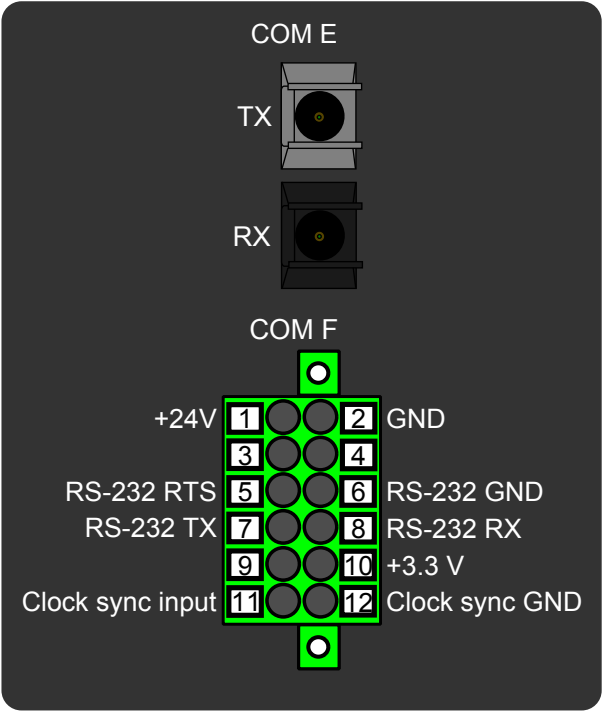


Table. 7.3.11 - 106. Module connections.

Connector	Pin	Name	Description
COM E	-	Serial fiber	- Serial-based communications - Port options: - Glass/glass - Plastic/plastic - Glass/plastic - Plastic/glass - Wavelength 660 nm - Compatible with 50/125 μm, 62.5/125 μm, 100/140 μm, and 200 μm Plastic-Clad Silica (PCS) fiber - Compatible with ST connectors
COM F	1	+24 V input	Optional external auxiliary voltage for serial fiber.
	2	GND	
	3	-	Not in use.
	4		

Connector	Pin	Name	Description
	5	RS-232 RTS	Serial based communications.
	6	RS-232 GND	
	7	RS-232 TX	
	8	RS-232 RX	
	9	-	Not in use.
	10	+3.3 V output (spare)	Spare power source for external equipment (45 mA).
	11	Clock sync input	Clock synchronization input (supports IRIG-B).
	12	Clock sync GND	

The option card includes two serial communication interfaces: COM E is a serial fiber interface with glass/glass, plastic/plastic, glass/plastic and plastic/glass options, COM F is an RS-232 interface.

For further information please refer to the chapter titled "[RS-232 & serial fiber communication module](#)" in the "Technical data" section of this manual.

The hardware configuration codes of these modules are "L", "M", "N" and "O". For more information, please refer to the "[Ordering information](#)" chapter of this document.

7.4 Dimensions and installation

The device can be installed either to a standard 19" rack or to a switchgear panel with cutouts. The desired installation type is defined in the order code.

The figures below describe the device dimensions (first figure), the device installation (second), and the panel cutout dimensions and device spacing (third).

Figure. 7.4 - 51. Device dimensions.

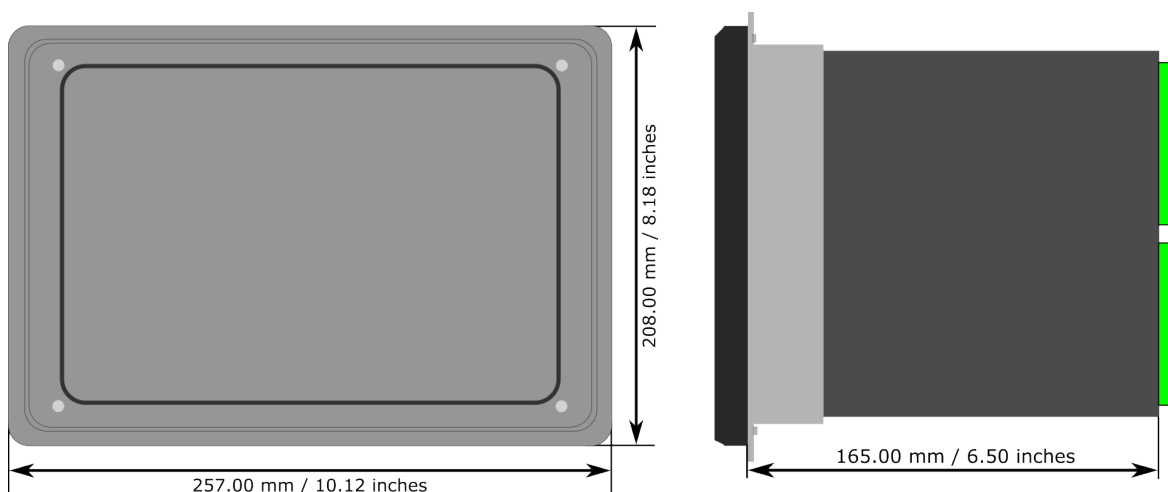


Figure. 7.4 - 52. Device installation.

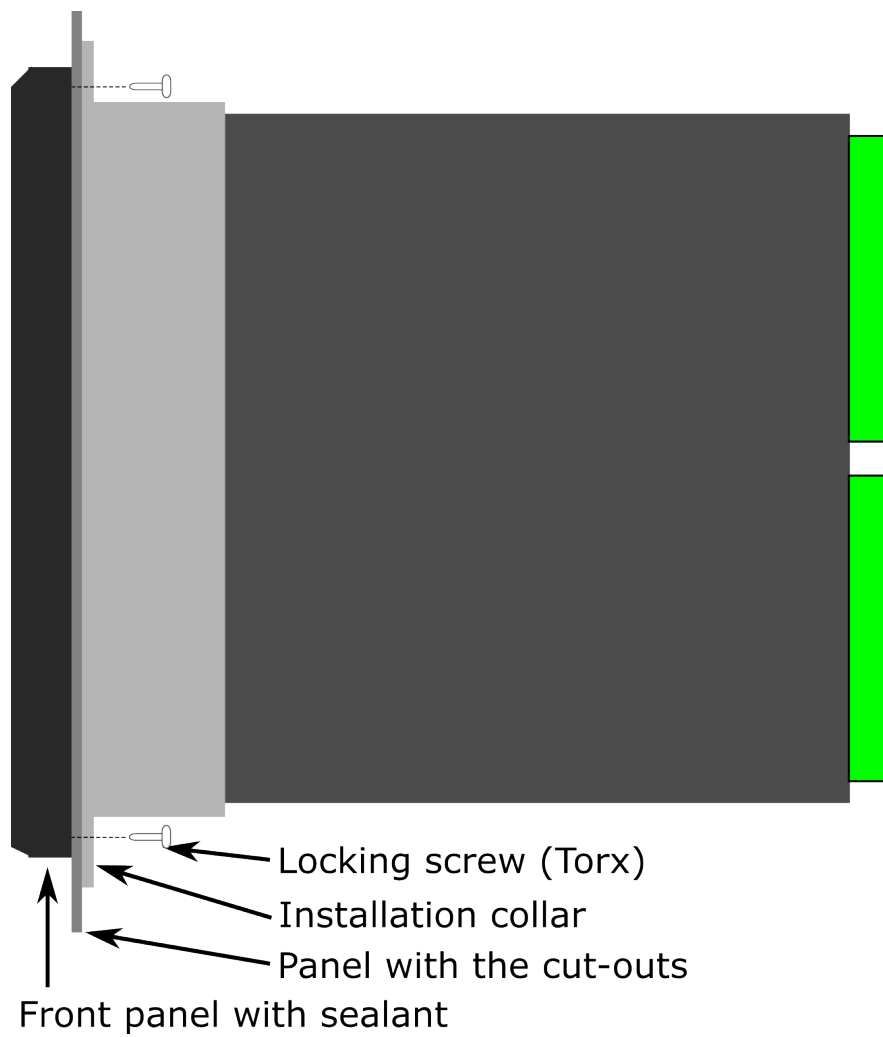
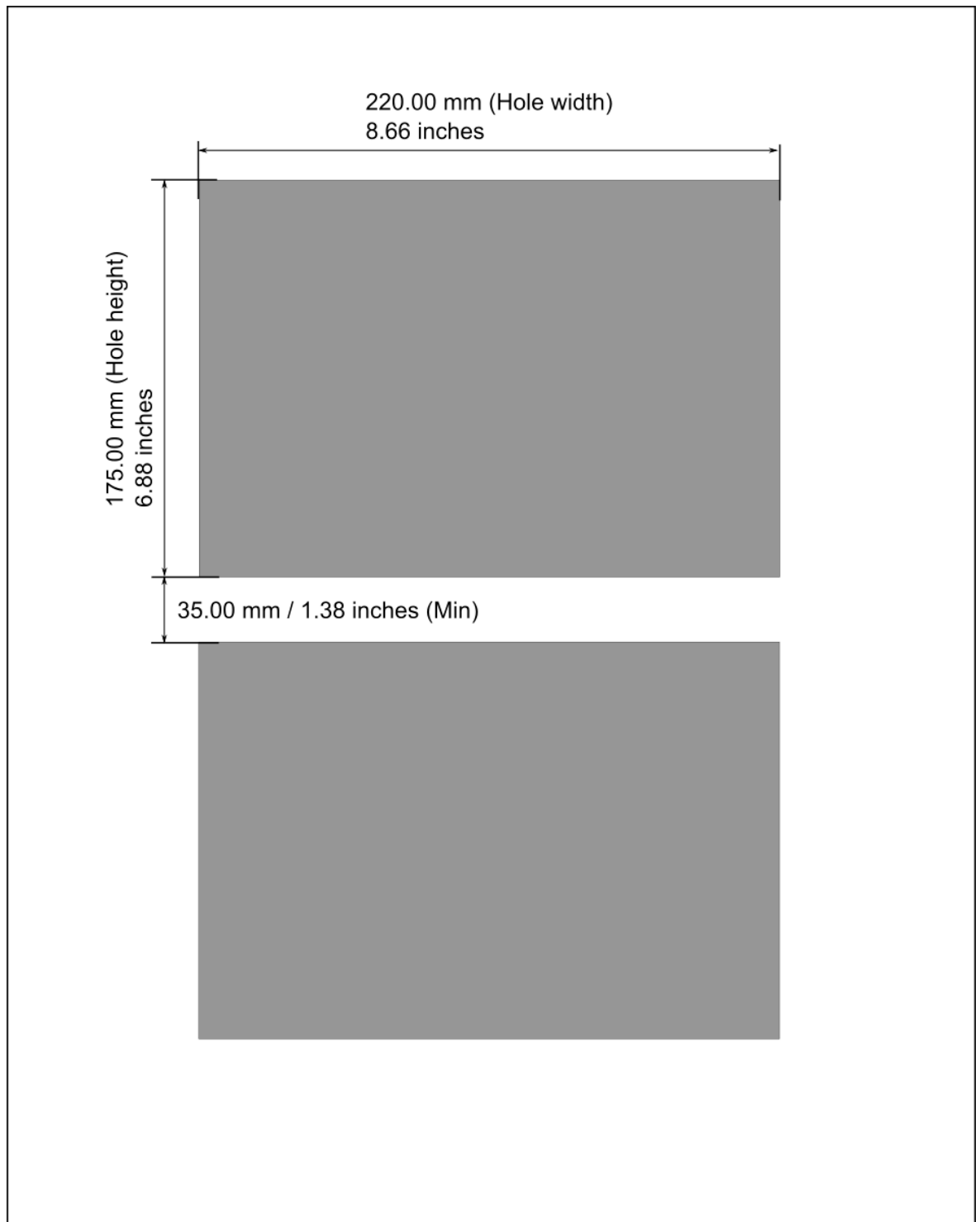


Figure. 7.4 - 53. Panel cut-out and spacing of the devices.



8 Technical data

8.1 Hardware

8.1.1 CPU & Power supply

Table. 8.1.1 - 107. General information for the CPU module.

General information	
Spare part code	#SP-250-CPU
Compatibility	AQ 210 series AQ 250 series AQ-ONE
Terminal block connection	
Solid or stranded wire Nominal cross section	2.5 mm ²
RS-485 serial terminal block connection	
Maximum cross section (solid or stranded wire)	1.5 mm ²

8.1.1.1 Auxiliary voltage

Table. 8.1.1.1 - 108. Power supply model A

Rated values	
Rated auxiliary voltage	88...265 V (AC/DC)
Power consumption	< 20 W (no option cards) < 40 W (maximum number of option cards)
Maximum permitted interrupt time	< 40 ms with 110 VDC
DC ripple	< 15 %
Other	
Minimum recommended fuse rating	MCB C2

Table. 8.1.1.1 - 109. Power supply model B

Rated values	
Rated auxiliary voltage	18...72 VDC
Power consumption	< 20 W (no option cards) < 40 W (maximum number of option cards)

Maximum permitted interrupt time	< 40 ms with 24 VDC
DC ripple	< 15 %
Other	
Minimum recommended fuse rating	MCB C2

8.1.1.2 CPU communication ports

Table. 8.1.1.2 - 110. Front panel local communication port.

Port	
Port media	Copper Ethernet RJ-45
Number of ports	1
Port protocols	PC-protocols FTP
Features	
Data transfer rate	100 MB/s
System integration	Can't be used for system protocols, only for local programming

Table. 8.1.1.2 - 111. Rear panel system communication port A.

Port	
Port media	Copper Ethernet RJ-45
Number of ports	1
Features	
Port protocols	IEC 61850 (1st edition) IEC61850 (2nd edition) IEC 104 Modbus/TCP DNP3 FTP
Data transfer rate	100 MB/s
System integration	Can be used for system protocols and for local programming

Table. 8.1.1.2 - 112. Rear panel system communication port B.

Port	
Port media	Copper RS-485
Number of ports	1

Features	
Port protocols	Modbus/RTU IEC 103 IEC 101 DNP3 SPA
Data transfer rate	65 580 kB/s
System integration	Can be used for system protocols

8.1.1.3 CPU digital inputs

Table. 8.1.1.3 - 113. CPU model-isolated digital inputs, with thresholds defined by order code.

Rated values	
Rated auxiliary voltage	265 V (AC/DC)
Nominal voltage	Order code defined: 24, 110, 220 V (AC/DC)
Pick-up threshold Release threshold	Order code defined: 19, 90, 170 V Order code defined: 14, 65, 132 V
Scanning rate	5 ms
Settings	
Pick-up delay	Software settable: 0...1800 s
Polarity	Software settable: Normally On/Normally Off
Current drain	2 mA

8.1.1.4 CPU digital outputs

Table. 8.1.1.4 - 114. Digital outputs (Normally Open)

Rated values	
Rated auxiliary voltage	265 V (AC/DC)
Continuous carry	5 A
Make and carry 0.5 s Make and carry 3 s	30 A 15 A
Breaking capacity, DC (L/R = 40 ms) at 48 VDC at 110 VDC at 220 VDC	1 A 0.4 A 0.2 A
Control rate	5 ms
Settings	

Polarity	Software settable: Normally Open / Normally Closed
----------	--

Table. 8.1.1.4 - 115. Digital outputs (Change-Over)

Rated values	
Rated auxiliary voltage	265 V (AC/DC)
Continuous carry	2.5 A
Make and carry 0.5 s Make and carry 3 s	30 A 15 A
Breaking capacity, DC (L/R = 40 ms) at 48 VDC at 110 VDC at 220 VDC	1 A 0.3 A 0.15 A
Control rate	5 ms
Settings	
Polarity	Software settable: Normally Open / Normally Closed

**CAUTION!**

Please note, that signaling relay 5 and system fault's signaling relay are designed only for signaling purposes, and are not to be used in trip coil control.

8.1.2 Option cards

8.1.2.1 Digital input module

Table. 8.1.2.1 - 116. Technical data for the digital input module.

Spare part code	#SP-250-DI8
Compatibility	AQ 210 series models AQ 250 series models AQ-ONE
Rated values	
Rated auxiliary voltage	5...265 V (AC/DC)
Current drain	2 mA
Scanning rate Activation/release delay	5 ms 5...11 ms
Settings	
Pick-up threshold Release threshold	Software settable: 16...200 V, setting step 1 V Software settable: 10...200 V, setting step 1 V
Pick-up delay	Software settable: 0...1800 s

Drop-off delay	Software settable: 0...1800 s
Polarity	Software settable: Normally On/Normally Off
Terminal block connection	
Solid or stranded wire Nominal cross section	2.5 mm ²

8.1.2.2 Digital output module

Table. 8.1.2.2 - 117. Technical data for the digital output module.

Spare part code	#SP-250-DO5
Compatibility	AQ 210 series models AQ 250 series models AQ-ONE
Rated values	
Rated auxiliary voltage	265 V (AC/DC)
Continuous carry	5 A
Make and carry 0.5 s Make and carry 3 s	30 A 15 A
Breaking capacity, DC (L/R = 40 ms) at 48 VDC at 110 VDC at 220 VDC	1 A 0.4 A 0.2 A
Control rate	5 ms
Settings	
Polarity	Software settable: Normally On/Normally Off
Terminal block connection	
Maximum cross section (solid or stranded wire)	2.5 mm ²

8.1.2.3 High-speed and high-current output module

Table. 8.1.2.3 - 118. Technical data for the high-speed and high-current output module.

Spare part code	#SP-250-HSO
Compatibility	AQ 250 series models AQ-ONE
High-speed output rated values	
Rated auxiliary voltage	265 V (AC/DC)
Continuous carry	10 A

Make and carry 0.5 s Make and carry 3 s	30 A 15 A
Breaking capacity, DC (L/R = 40 ms) at 48 VDC at 110 VDC at 220 VDC	10 A
Control rate	1 ms
Operating time	Typically under 4 ms
Trip Circuit Supervision input rated values	
Rated auxiliary voltage	265 V (AC/DC)
Nominal voltage	Order code defined: 24, 110, 220 V (AC/DC)
Pick-up threshold	Order code defined: 19, 90, 170 V
Release threshold	Order code defined: 14, 65, 132 V
Scanning rate	5 ms
High-speed output settings	
Polarity	Software settable: Normally On/Normally Off
Trip Circuit Supervision input settings	
Release delay	Software settable: 0.000...1800.000 s
Polarity	Normally Closed
Current drain	2 mA
Terminal block connection	
Maximum cross section (solid or stranded wire)	2.5 mm ²

8.1.2.4 Milliampere output module (4 x mA out & 1 x mA in)

Table. 8.1.2.4 - 119. Technical data for the milliampere output module.

Spare part code	#SP-2XX-MA
Compatibility	AQ 210 series models AQ 250 series models AQ-ONE
Signals	
Output magnitudes Input magnitudes	4 × mA output signal (DC) 1 × mA input signal (DC)
mA input	

Range (hardware) Range (measurement) Inaccuracy	0...33 mA 0...24 mA ±0.1 mA
Update cycle Response time at 5 ms cycle Update cycle time inaccuracy	5...10 000 ms, setting step 5 ms ~ 15 ms (13...18 ms) Max. +20 ms above the set cycle
mA input scaling range Output scaling range	0...4000 mA -1 000 000.0000...1 000 000.0000, setting step 0.0001
mA output	
Inaccuracy at 0...24 mA	±0.01 mA
Response time at 5 ms cycle [fixed]	< 5 ms
mA output scaling range Source signal scaling range	0...24 mA, setting step 0.001 mA -1 000 000.000...1 000 000.0000, setting step 0.0001
Terminal block connection	
Maximum cross section (solid or stranded wire)	2.5 mm ²

8.1.2.5 Milliampere input module (1x mA out & 4x mA in)

Table. 8.1.2.5 - 120. Technical data for the milliampere input module.

Spare part code	#SP-250-MAIN
Compatibility	AQ 250 series models AQ-ONE
Signals	
Input magnitudes Output magnitudes	4 × mA input signal (DC) 1 × mA output signal (DC)
mA input	
Range (hardware) Range (measurement) Inaccuracy	0...33 mA 0...24 mA ±0.1 mA
Update cycle Response time at 5 ms cycle Update cycle time inaccuracy	5...10 000 ms, setting step 5 ms ~ 15 ms (13...18 ms) Max. +20 ms above the set cycle
mA input scaling range Output scaling range	0...4000 mA -1 000 000.0000...1 000 000.0000, setting step 0.0001
mA output	
Inaccuracy at 0...24 mA	±0.01 mA
Response time at 5 ms cycle [fixed]	< 5 ms

mA output scaling range	0...24 mA, setting step 0.001 mA
Source signal scaling range	-1 000 000.000...1 000 000.0000, setting step 0.0001
Terminal block connection	
Maximum cross section (solid or stranded wire)	2.5 mm ²

8.1.2.6 RTD input module

Table. 8.1.2.6 - 121. Technical data for the RTD input module.

Spare part code	#SP-2xx-RTD
Compatibility	AQ 210 series models AQ 250 series models AQ-ONE
Channels 1-8	
2/3/4-wire RTD	
Pt100 or Pt1000	
Terminal block connection	
Maximum cross section (solid or stranded wire)	1.5 mm ²

8.1.2.7 Double RJ-45 Ethernet & IRIG-B communication module

Table. 8.1.2.7 - 122. Technical data for the double RJ-45 Ethernet communication module.

Spare part code	#SP-2XX-ETH-RJ45
Compatibility	AQ 210 series models AQ 250 series models AQ-ONE
Ethernet connector features	
Protocols	IEC 61850 IEC 104 Modbus/TCP DNP3 FTP
Data transfer rate	100 MB/s
System integration	Can be used for system protocols and for local programming
Number of ports	2
Communication ports	Copper Ethernet RJ-45
IRIG-B Connector	
Maximum cross section (solid or stranded wire)	1.5 mm ²

8.1.2.8 Double SFP Ethernet & IRIg-B communication module

Table. 8.1.2.8 - 123. Technical data for the double SFP Ethernet communication module.

Spare part code	#SP-250-ETH-SFP
Compatibility	AQ 250 series models AQ-ONE
Ethernet connector features	
Protocols	IEC 61850 IEC 104 Modbus/TCP DNP3 FTP
Data transfer rate	100 MB/s
System integration	Can be used for system protocols and for local programming
Number of ports	2
Communication ports	SFP
IRIG-B Connector	
Maximum cross section (solid or stranded wire)	1.5 mm ²

8.1.2.9 Double ST Ethernet & IRIg-B communication module

Table. 8.1.2.9 - 124. Technical data for the double ST 100 Mbps Ethernet communication module.

Spare part code	#SP-2XX-2XST
Compatibility	AQ 210 series models AQ 250 series models AQ-ONE
Protocols	
Protocols	IEC61850 DNP/TCP Modbus/TCP IEC104 FTP
ST connectors	
Connector type	Duplex ST connectors 62.5/125 µm or 50/125 µm multimode fiber 100BASE-FX
Number of connectors	2
Transmitter wavelength	1260...1360 nm (nominal: 1310 nm)

Receiver wavelength	1100...1600 nm
Maximum distance	2 km
Data transfer rate	100 MB/s
IRIG-B Connector	
Maximum cross section (solid or stranded wire)	1.5 mm ²

8.1.2.10 Double LC (HSR/PRP) Ethernet communication module

Table. 8.1.2.10 - 125. Technical data for the double LC 100 Mbps Ethernet communication module.

Spare part code	#SP-2XX-2LC(HSR/PRP)
Compatibility	AQ 210 series models AQ 250 series models AQ-ONE
Protocols	
Protocols	IEC 61850 IEC 104 Modbus/TCP DNP3 FTP
Redundancy	HSR and PRP
Data transfer rate	100 MB/s
System integration	Can be used for system protocols and for local programming
Ports	
Number of fiber ports	2
Communication port	LC fiber connector Wavelength 1300 nm
Fiber cable	50/125 µm or 62.5/125 µm multimode (glass)

8.1.2.11 Double RJ-45 (HSR/PRP) Ethernet communication module

Table. 8.1.2.11 - 126. Technical data for the double RJ-45 100 Mbps Ethernet communication module.

Spare part code	#SP-2XX-2RJ45(HSR/PRP)
Compatibility	AQ 210 series models AQ 250 series models AQ-ONE
Features	

Protocols	IEC 61850 IEC 104 Modbus/TCP DNP3 FTP
Redundancy	HSR and PRP
Data transfer rate	100 MB/s
System integration	Can be used for system protocols and for local programming
Ports	
Number of ports	2
Communication port	Copper Ethernet RJ-45

8.1.2.12 RS-232 & serial fiber communication module

Table. 8.1.2.12 - 127. Technical data for the RS-232 & serial fiber communication module.

PP Spare part code	#SP-2XX-232PP
PG Spare part code	#SP-2XX-232PG
GP Spare part code	#SP-2XX-232GP
GG Spare part code	#SP-2XX-232GG
Compatibility	AQ 210 series models AQ 250 series models AQ-ONE
Serial fiber connections	
Connection types	• Plastic - Plastic • Plastic - Glass • Glass - Plastic • Glass - Glass
Wavelength (plastic)	660 nm
Wavelength (glass)	820 nm
Cable type	1 mm plastic fiber
RS-232 terminal block connections	
Maximum cross section (solid or stranded wire)	1.5 mm ²

8.1.3 Display

Table. 8.1.3 - 128. Technical data for the HMI TFT display.

General information

Spare part code	#SP-200-DISP
Compatibility	AQ-250 series models
Dimensions and resolution	
Number of dots/resolution	800 x 480
Size	154.08 × 85.92 mm (6.06 × 3.38 in)
Display	
Type of display	TFT
Color	RGB color

8.2 Functions

8.2.1 Control functions

8.2.1.1 Setting group selection

Table. 8.2.1.1 - 129. Technical data for the setting group selection function.

Settings and control modes	
Setting groups	8 independent, control-prioritized setting groups
Control scale	Common for all installed functions which support setting groups
Control mode	
Local	Any binary signal available in the device
Remote	Force change overrule of local controls either from the setting tool, HMI or SCADA
Operation time	
Reaction time	<5 ms from receiving the control signal

8.2.1.2 Object control and monitoring

Table. 8.2.1.2 - 130. Technical data for the object control and monitoring function.

General	
Number of objects	10
Supported object types	Circuit breaker Circuit breaker with withdrawable cart Disconnecter (MC) Disconnecter (GND) Custom object image
Signals	

Input signals	Digital inputs Software signals
Output signals	Close command output Open command output
Operation time	
Breaker traverse time setting	0.02...500.00 s, setting step 0.02 s
Max. close/open command pulse length	0.02...500.00 s, setting step 0.02 s
Control termination time out setting	0.02...500.00 s, setting step 0.02 s
Inaccuracy: - Definite time operating time	±0.5 % or ±10 ms
Breaker control operation time	
External object control time	<75 ms
Object control during auto-reclosing	See the technical sheet for the auto-reclosing function.

Table. 8.2.1.2 - 131. Technical data for the circuit breaker wear monitoring function.

Pick-up	
Breaker characteristics settings: - Nominal breaking current - Maximum breaking current - Operations with nominal current - Operations with maximum breaking current	0.00...100.00 kA, setting step 0.001 kA 0.00...100.00 kA, setting step 0.001 kA 0...200 000 operations, setting step 1 operation 0...200 000 operations, setting step 1 operation
Pick-up setting for Alarm 1 and Alarm 2	0...200 000 operations, setting step 1 operation
Inaccuracy	
Inaccuracy for current/operations counter: - Current measurement element - Operation counter	$0.1 \times I_N > I < 2 \times I_N \pm 0.2 \%$ of the measured current, rest 0.5 % ±0.5 % of operations deducted

8.2.1.3 Indicator object monitoring

Table. 8.2.1.3 - 132. Technical data for the indicator object monitoring function.

General	
Number of objects	20
Supported object types	Disconnecter (GND) Custom object image
Signals	
Input signals	Digital inputs Software signals

8.2.2 Monitoring functions

8.2.2.1 Event logger

Table. 8.2.2.1 - 133. Technical data for the event logger function.

General information	
Event history capacity	15 000 events
Event timestamp resolution	1 ms

8.2.2.2 Disturbance recorder

Table. 8.2.2.2 - 134. Technical data for the disturbance recorder function.

Recorded values	
Recorder analog channels	0...20 channels Freely selectable
Recorder digital channels	0...96 channels Freely selectable analog and binary signals 1 ms or 5 ms sample rate (FFT)
Performance	
Sample rate	8, 16, 32 or 64 samples/cycle
Recording length	0.000...1800.000 s, setting step 0.001 s The maximum length is determined by the chosen signals.
Number of recordings	0...100, 60 MB of shared flash memory reserved The maximum number of recordings according to the chosen signals and operation time setting combined

8.3 Tests and environmental

Electrical environment compatibility

Table. 8.3 - 135. Disturbance tests.

All tests	CE-approved and tested according to EN 60255-26
Emissions	
Conducted emissions: EN 60255-26 Ch. 5.2, CISPR 22	150 kHz...30 MHz
Radiated emissions: EN 60255-26 Ch. 5.1, CISPR 11	30...1 000 MHz
Immunity	

Electrostatic discharge (ESD): EN 60255-26, IEC 61000-4-2	Air discharge 15 kV Contact discharge 8 kV
Electrical fast transients (EFT): EN 60255-26, IEC 61000-4-4	Power supply input 4 kV, 5/50 ns, 5 kHz Other inputs and outputs 4 kV, 5/50 ns, 5 kHz NOTE: Shielded cable required for ethernet communication
Surge: EN 60255-26, IEC 61000-4-5	Between wires: 2 kV, 1.2/50 μ s Between wire and earth: 4 kV, 1.2/50 μ s
Radiated RF electromagnetic field: EN 60255-26, IEC 61000-4-3	f = 80...1 000 MHz, 10 V/m
Conducted RF field: EN 60255-26, IEC 61000-4-6	f = 150 kHz...80 MHz, 10 V (RMS)

Table. 8.3 - 136. Voltage tests.

Dielectric voltage test	
EN 60255-27, IEC 60255-5, EN 60255-1	2 kV, 50 Hz, 1 min
Impulse voltage test	
EN 60255-27, IEC 60255-5	5 kV, 1.2/50 μ s, 0.5 J

Physical environment compatibility

Table. 8.3 - 137. Mechanical tests.

Vibration test	
EN 60255-1, EN 60255-27, IEC 60255-21-1	2...13.2 Hz, $\pm$ 3.5 mm 13.2...100 Hz, $\pm$ 1.0 g
Shock and bump test	
EN 60255-1, EN 60255-27, IEC 60255-21-2	20 g, 1 000 bumps/dir.

Table. 8.3 - 138. Environmental tests.

Damp heat (cyclic)	
EN 60255-1, IEC 60068-2-30	Operational: +25...+55 °C, 93...97 % (RH), 12+12h
Dry heat	
EN 60255-1, IEC 60068-2-2	Storage: +70 °C, 16 h Operational: +55 °C, 16 h
Cold test	
EN 60255-1, IEC 60068-2-1	Storage: -40 °C, 16 h Operational: -20 °C, 16 h

Table. 8.3 - 139. Environmental conditions.

IP classes	
Casing protection class	IP54 (front) IP21 (rear)
Temperature ranges	
Ambient service temperature range	−35...+70 °C
Transport and storage temperature range	−40...+70 °C
Other	
Altitude	<2000 m
Overvoltage category	III
Pollution degree	2

Casing and package

Table. 8.3 - 140. Dimensions and weight.

Without packaging (net)	
Dimensions	Height: 208 mm Width: 257 mm (½ rack) Depth: 165 mm (no cards or connectors)
Weight	Appr. 3.4 kg
With packaging (gross)	
Dimensions	Height: 250 mm Width: 343 mm Depth: 256 mm
Weight	Appr. 4 kg

9 Ordering information

	AQ - S 2 5 4 A - P X 8 A A X A - X X X X X X X X X X X X X X X X
Model	
S Alarm and indication IED	
Device size	
5 1/2 of 19" rack	
Analog measurement	
4 No analog measurements	
Functionality package	
A Standard	
Mounting	
P Panel mounting	
Auxiliary voltage	
H 88...265 VAC/DC	
L 18...72 VDC	
Measurement accuracy	
8 N/A	
Terminals	
A Standard I/O terminals	
C Spring cage I/O terminals	
Reserved for future use	
A N/A	
Digital inputs on power supply module	
A 3 Digital inputs, 24 V nominal threshold	
B 3 Digital inputs, 110 V nominal threshold	
C 3 Digital inputs, 220 V nominal threshold	
Reserved for future use	
A N/A	
Slots A, B, C, D, E, F, G, H, I, J, K, L, M, N (14 pcs)	
A Empty	
B 8 Digital inputs	
C 5 Output relays (max. 6 pcs)	
F 8 x RTD input (max. 2 pcs)	
G 2 x RJ45 100Mb Ethernet & IRIg-B (max. 1 pcs) *	
H 2 x ST 100Mb Ethernet & IRIg-B (max. 1 pcs) *	
I 4 x mA outputs - 1 x mA input (max. 2 pcs)	
J Double LC 100Mb Ethernet (HSR, PRP redundant protocols) (max. 1 pcs) *	
K Double RJ45 100Mb Ethernet (HSR, PRP redundant protocols) (max. 1 pcs) *	
L RS-232 - Serial fiber (Plastic-Plastic) (max. 1 pcs) *	
M RS-232 - Serial fiber (Plastic-Glass) (max. 1 pcs) *	
N RS-232 - Serial fiber (Glass-Plastic) (max. 1 pcs) *	
O RS-232 - Serial fiber (Glass-Glass) (max. 1 pcs) *	
Q 2 x SFP 100Mb Ethernet & IRIg-B (max. 4 pcs) **	
R 3 x High-speed high current output (max. 3 pcs)	
T 4 x mA inputs - 1 x mA output (max. 2 pcs)	

* Can only be applied to the two last slots.

** Can only be applied to the four last slots. Requires an SFP adapter. See "Accessories" list.

Accessories

Order code	Description	Note
AX007	External 6-channel 2 or 3 wires RTD Input module, pre-configured	Requires an external 24 VDC supply.
AX008	External 8-ch Thermocouple mA Input module, pre-configured	Requires an external 24 VDC supply.
AX020	SFP module LC 2 km multi-mode	2 km multi-mode fiber (1310 nm)
AX021	SFP module LC 40 km single-mode	40 km single-mode fiber (1310 nm)

AX022	SFP module LC 120 km single-mode	120 km single-mode fiber (1550 nm)
AX013	AQ 250 series raising frame 120mm	-
AQX014	AQ 250 series raising frame 40mm	-
AQX015	AQ 250 series wall mounting bracket	-

10 Contact and reference information

Manufacturer

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