

AQ-S214

Alarm and Indication device

Instruction manual



Table of contents

1 Document information	4
1.1 Version 2 revision notes	4
1.2 Version 1 revision notes	6
1.3 Safety information	7
1.4 Abbreviations	8
2 General	10
3 Device user interface	11
3.1 Panel structure	11
3.1.1 Local panel structure	11
3.2 Mimic and main menu	12
3.2.1 Basic configuration	12
3.2.2 Navigation in the main configuration menus	13
3.3 General menu	13
3.4 Control menu	17
3.5 Communication menu	31
3.6 Monitoring menu	33
3.7 Configuring user levels and their passwords	37
4 Functions	40
4.1 Functions included in AQ-S214	40
4.2 General menu	40
4.3 Alarming function	42
4.4 Control functions	51
4.4.1 Setting group selection	51
4.4.2 Object control and monitoring	59
4.4.3 Indicator object monitoring	68
4.4.4 Milliampere output control	69
4.4.5 Programmable control switch	71
4.4.6 Analog input scaling curves	72
4.4.7 Logical outputs	74
4.4.8 Logical inputs	75
4.5 Monitoring functions	77
4.5.1 Disturbance recorder (DR)	77
4.5.2 Event logger	87
4.5.3 Measurement recorder	88
5 Communication	94
5.1 Connections menu	94
5.2 Time synchronization	96
5.2.1 Internal	96
5.2.2 NTP	97
5.3 Communication protocols	98
5.3.1 IEC 61850	98
5.3.1.1 GOOSE	99
5.3.2 Modbus/TCP and Modbus/RTU	101
5.3.3 IEC 103	102
5.3.4 IEC 101/104	102
5.3.5 SPA	105
5.3.6 DNP3	105
5.3.7 Modbus I/O	108
5.4 Analog fault registers	108
5.5 Real-time measurements to communication	109
6 Connections and application examples	112

6.1 Connections of AQ-S214.....	112
7 Construction and installation	115
7.1 Construction.....	115
7.2 CPU module	117
7.3 Option cards.....	120
7.3.1 Digital input module (optional).....	120
7.3.2 Digital output module (optional)	123
7.3.3 RTD input module (optional)	124
7.3.4 Serial RS-232 communication module (optional).....	125
7.3.5 LC or RJ45 100 Mbps Ethernet communication module (optional)	127
7.3.6 Double ST 100 Mbps Ethernet communication module (optional).....	128
7.3.7 Double RJ45 10/100 Mbps Ethernet communication module (optional).....	130
7.4 Dimensions and installation.....	131
8 Technical data	134
8.1 Hardware.....	134
8.1.1 CPU & Power supply	134
8.1.1.1 Auxiliary voltage.....	134
8.1.1.2 CPU communication ports.....	135
8.1.1.3 CPU digital inputs	136
8.1.1.4 CPU digital outputs.....	136
8.1.2 Option cards	137
8.1.2.1 Digital input module.....	137
8.1.2.2 Digital output module.....	138
8.1.2.3 RTD input module.....	139
8.1.2.4 RS-232 & serial fiber communication module.....	139
8.1.2.5 Double LC 100 Mbps Ethernet communication module	140
8.1.2.6 Double ST 100 Mbps Ethernet communication module	140
8.1.3 Display	141
8.2 Functions.....	141
8.2.1 Control functions	141
8.2.1.1 Setting group selection	141
8.2.1.2 Object control and monitoring.....	141
8.2.1.3 Indicator object monitoring	142
8.2.2 Monitoring functions	142
8.2.2.1 Disturbance recorder.....	142
8.2.2.2 Event logger	143
8.3 Tests and environmental	143
9 Ordering information	146
10 Contact and reference information.....	148

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

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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	<ul style="list-style-type: none"> - 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	<ul style="list-style-type: none"> - Added description for LED test and button test. - 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	<ul style="list-style-type: none"> - 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. - Improved and updated device user interface display images. - AQ-S214 Functions included list Added: Indicator objects. - 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 parameter descriptions to General menu Device user interface chapter. - Added new parameter descriptions to Monitoring menu device user interface chapter. - 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	<ul style="list-style-type: none"> - Increased the consistency in terminology - Various image upgrades - Visual update to the order codes
Revision	2.05
Date	22.6.2021
Changes	<ul style="list-style-type: none"> - 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	<ul style="list-style-type: none"> - Improved descriptions generally in many chapters. - Improved readability of a lot of drawings and images. - Order codes have been revised. - 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	
Revision	2.08
Date	8.9.2022

Changes	<ul style="list-style-type: none"> - 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.
Revision	2.09
Date	14.3.2023
Changes	<ul style="list-style-type: none"> - 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 the maximum and minimum allowed tracking frequencies to the settings table of the "Frequency tracking and scaling" chapter (under "Measurements"). - Added the RTD function description and its technical data.

1.2 Version 1 revision notes

Table. 1.2 - 2. Version 1 revision notes

Revision	1.00
Date	30.1.2013
Changes	<ul style="list-style-type: none"> • The first revision for AQ-S214.
Revision	1.01
Date	22.11.2013
Changes	<ul style="list-style-type: none"> • Additions to the HMI structure and the digital input module chapters.
Revision	1.02
Date	2.2.2015
Changes	<ul style="list-style-type: none"> • Added the RTD & mA input module, the double LC 100Mb Ethernet card module, and the serial RS-232 & serial fiber module hardware descriptions. • Added the object control and monitoring function description and its technical data.
Revision	1.03
Date	11.3.2015
Changes	<ul style="list-style-type: none"> • Alarms description revised.
Revision	1.04
Date	30.8.2016

Changes	<ul style="list-style-type: none"> Added the password set-up guide (previously only in the AQtivate 200 user guide).
Revision	1.05
Date	10.2.2017
Changes	<ul style="list-style-type: none"> Added the programmable control switch and the indicator object descriptions. Order code updated.
Revision	1.06
Date	13.3.2017
Changes	<ul style="list-style-type: none"> Alarming function description revised as the CTRL button now clears all alarms.
Revision	1.07
Date	20.12.2017
Changes	<ul style="list-style-type: none"> Event lists revised on several functions. RTD & mA card description improved. Ring-lug CT card option description added. Order code revised.
Revision	1.08
Date	18.1.2019
Changes	<ul style="list-style-type: none"> 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 contains four (4) types of special messages to call the reader's attention to useful information as follows:



NOTICE!

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



CAUTION!

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



WARNING!

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



DANGER!

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

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

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

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-S214 alarm and indication unit is a member of the AQ 200 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-S214 alarm and indication unit. For other AQ 200 and AQ 250 series products please consult their respective device manuals.

AQ-S214 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 LED display and event list. There are up to six (6) option card slots available for additional I/O or communication cards for more comprehensive monitoring and control applications. AQ-S214 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

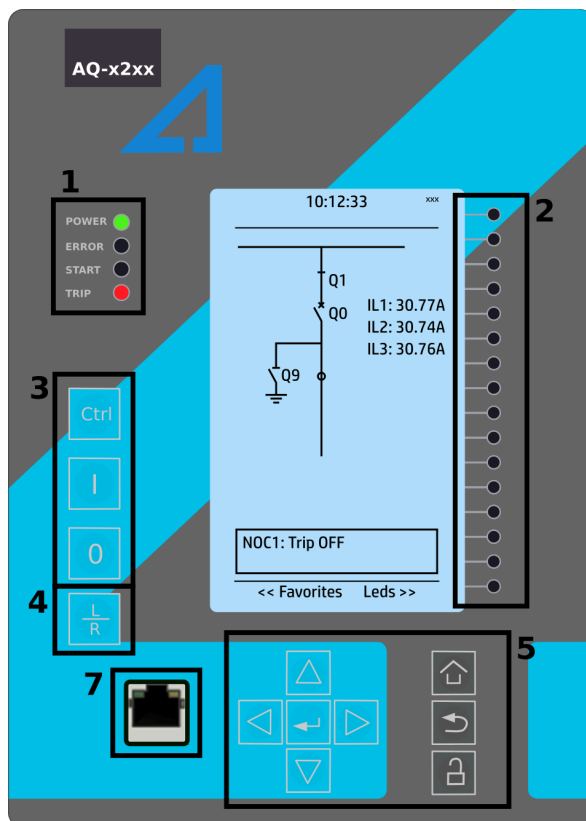
3.1 Panel structure

The user interface section of an AQ 200 or AQ 250 series device is divided into two user interface sections: one for the hardware and the other for the software. You can access the software interface either through the front panel or through the AQtivate 200 freeware software suite.

3.1.1 Local panel structure

The front panel of AQ 200 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 - 1. Local panel structure.



1. Four (4) default LEDs: "Power", "Error", "Start" (configurable) and "Trip" (configurable).
2. Sixteen (16) freely configurable LEDs 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 **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 and the **Enter** button in the middle, as well as the **Home**, the **Back** and the password activation buttons.
6. 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 right side of the display. Their activation and color (green or yellow) are based on the settings the user has put in place in the software.

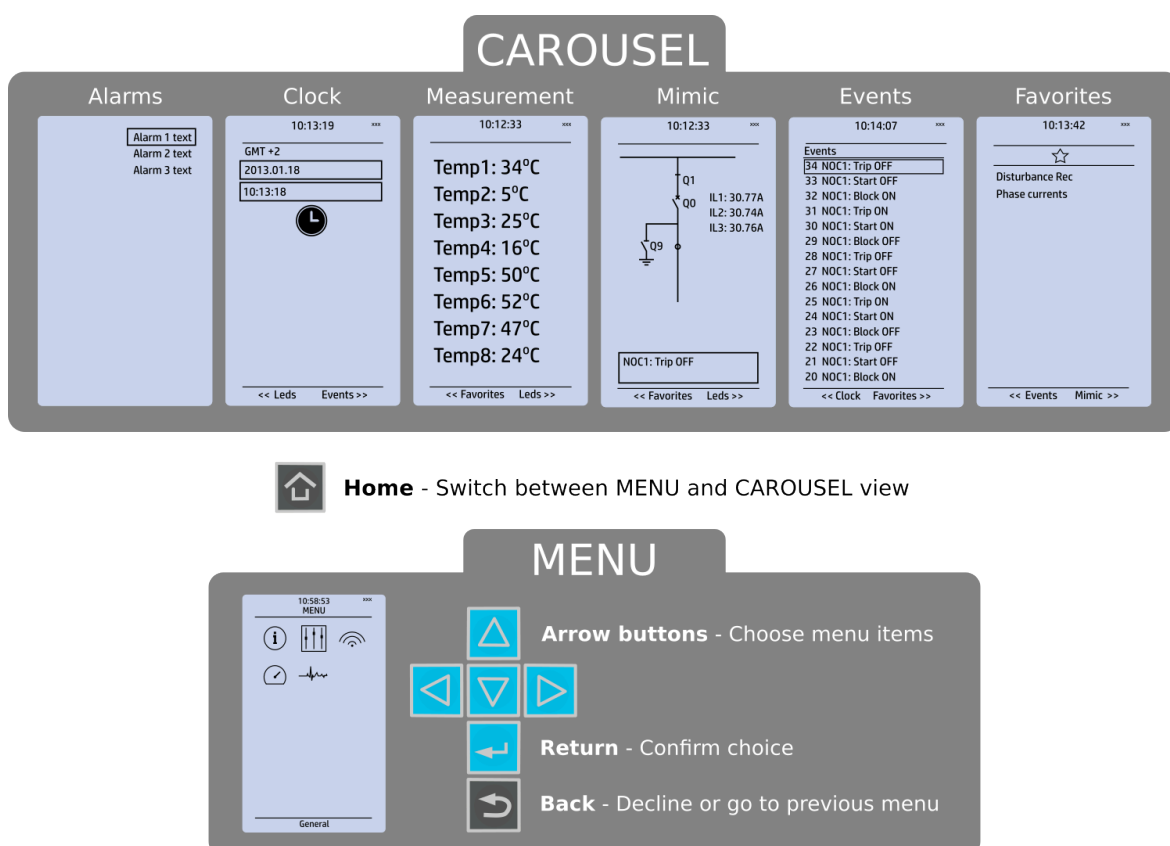
Holding the I (object control) button down for five seconds brings up the button test menu. It displays all the physical buttons on the front panel. Pressing any of the listed buttons marks them as tested. When all buttons are marked as having been tested, the device will return back to the default view.

3.2 Mimic and main menu

3.2.1 Basic configuration

The user interface is divided into six (6) quick displays: "Alarms", "Clock", "Measurement", "Mimic", "Events" and "Favorites". The default quick display (as presented in the image below) is the mimic view; you can move through these menus by pressing the left and right arrow buttons. Please note that the available quick display carousel view might be different if you have changed the view with AQtivate's Carousel Designer tool.

Figure. 3.2.1 - 2. Basic navigation for AQ-S214.



The **Home** button switches between the quick display carousel and the main display with the five (5) main configuration menus. The AQ-S214 alarm and indication device has the following five configuration menus: *General*, *Control*, *Communication*, *Transducers* and *Monitoring*. You can switch between these menus by using the four navigational arrow keys and confirming your selection with the **Enter** button in the middle. Please note that the menu's name appears at the bottom of the display when selected. The **Back** button takes you back one step. If you hold it down for three seconds, it takes you back to the main menu. You can also use it to reset the alarm LEDs the user has set. The password activation button (with the padlock icon) takes you to the password menu where you can enter the passwords for the various user levels (User, Operator, Configurator, and Super-user).

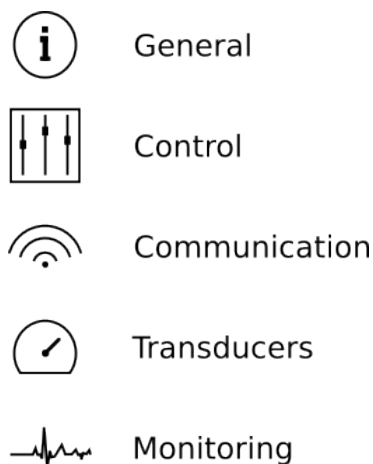
3.2.2 Navigation in the main configuration menus

All the settings in this device have been divided into the following five (5) main configuration menus:

- General
- Control
- Communication
- Transducers
- Monitoring.

They are presented in the image below.

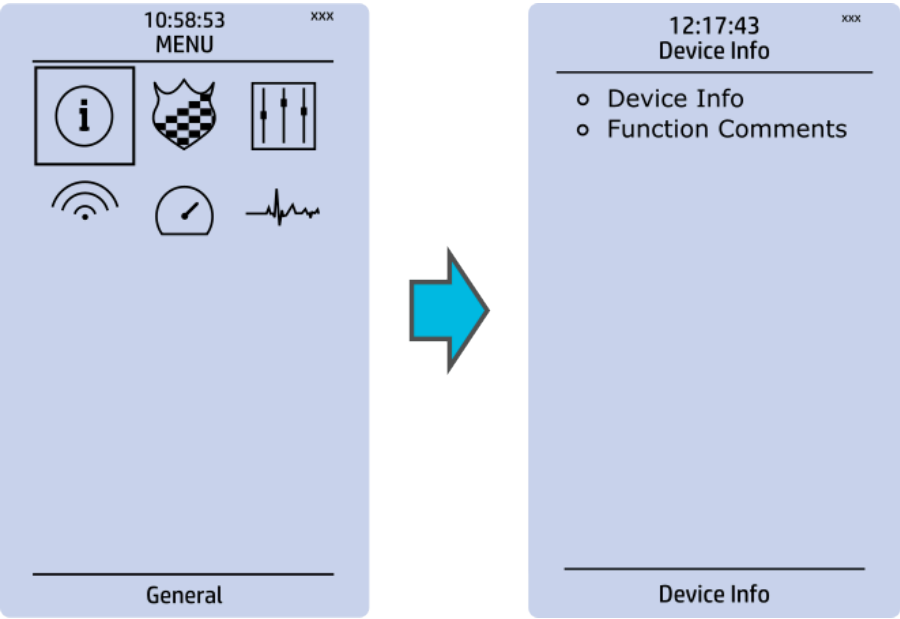
Figure. 3.2.2 - 3. Main configuration menus.



3.3 General menu

The *General* main menu is divided into two submenus: the *Device info* tab presents the information of the device, while the *Function comments* tab allows you to view all comments you have added to the functions.

Figure. 3.3 - 4. General menu structure.



Device info

Figure. 3.3 - 5. Device info.

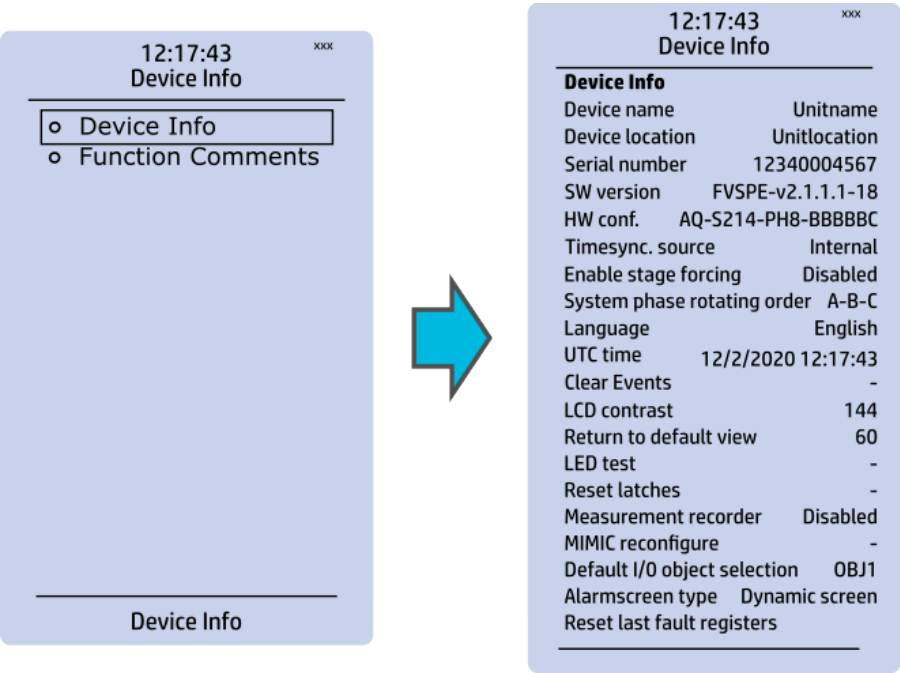


Table. 3.3 - 3. Parameters and indications in the *General* menu.

Name	Range	Step	Default	Description
Device name	-	-	Unitname	The file name uses these fields when loading the .aq5 configuration file from the AQ-200 unit.
Device location	-	-	Unitlocation	

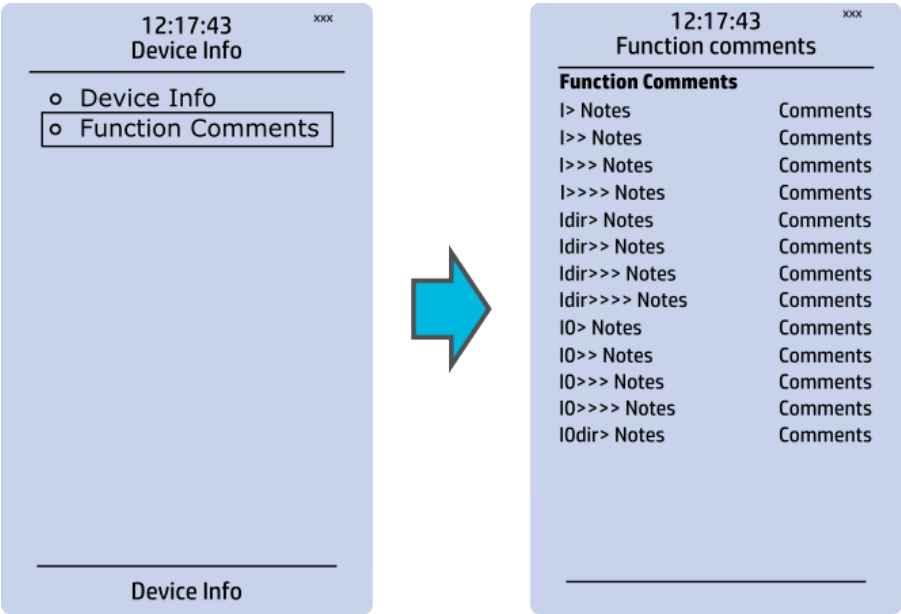
Name	Range	Step	Default	Description
Serial number	-	-	-	Displays the unit's unique serial number. The serial number is also printed on the sticker located on the side of the unit.
Firmware version	-	-	-	Displays the software version (firmware) used by the unit. Upgradable by the user if a newer version is available.
Hardware configuration	-	-	-	Displays the hardware configuration of the unit. The hardware configuration is also printed on the sticker located on the side of the unit.
Time synchronization source	0: Internal 1: External NTP 2: External Serial 3: IRIG-B	-	0: Internal	If an external clock time synchronization source is available, the type is defined with this parameter. In the internal mode there is no external Timesync source. IRIG-B requires a serial fiber communication option card.
Enable stage forcing	0: Disabled 1: Enabled	-	0: 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>Status force to</i> parameter.
System phase rotating order	0: A-B-C 1: A-C-B	-	0: A-B-C	Allows the user to switch the expected order in which the phase measurements are wired to the unit.
Language	0: User defined 1: English 2: Finnish 3: Swedish 4: Spanish 5: French 6: German 7: Russian 8: Ukrainian	-	1: 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 200 setting tool, AQtivate follows the value set into this parameter.
Clear events	0: - 1: Clear	-	0: -	Clears the event history recorded in the AQ-200 device.
LCD Contrast	0...255	1	120	Changes the contrast of the LCD display.
Return to default view	0...3600 s	10 s	0 s	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	0: - 1: Activated	-	0: -	When activated, all LEDs are lit up. LEDs with multiple possible colors blink each color.
Reset latches	0: - 1: Reset	-	0: -	Resets the latched signals in the logic and the matrix. When a reset command is given, the parameter automatically returns back to "-".
Measurement recorder	0: Disabled 1: Enabled	-	0: Disabled	Enables the measurement recorder tool, further configured in <i>Tools</i> → <i>Misc</i> → <i>Measurement recorder</i> .

Name	Range	Step	Default	Description
Reconfigure mimic	0: - 1: Reconfigure	-	0: -	Reloads the mimic to the unit.
Alarm screen type	0: Dynamic screen 1: Fixed screen	-	0: Dynamic screen	Changes the type of alarm view if such is added to the device's carousel view.

Function comments

Function comments displays notes of each function that has been activated in the Protection, Control and Monitoring menu. Function notes can be edited by the user.

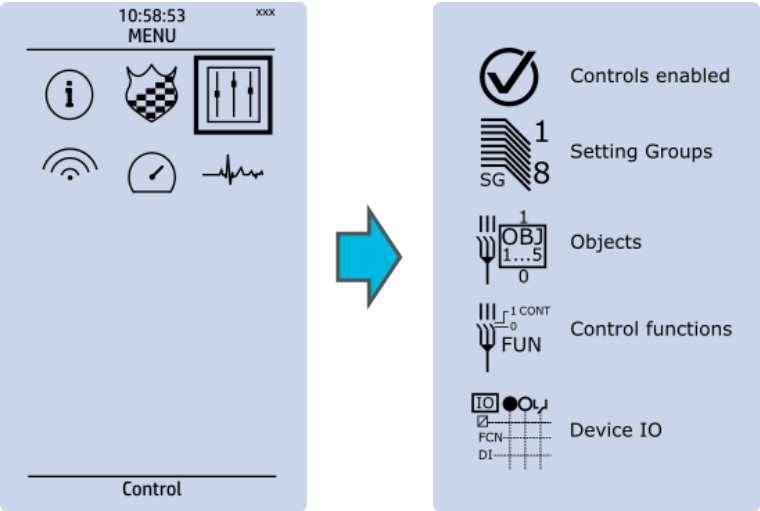
Figure. 3.3 - 6. Function comments.



3.4 Control menu

Main menu

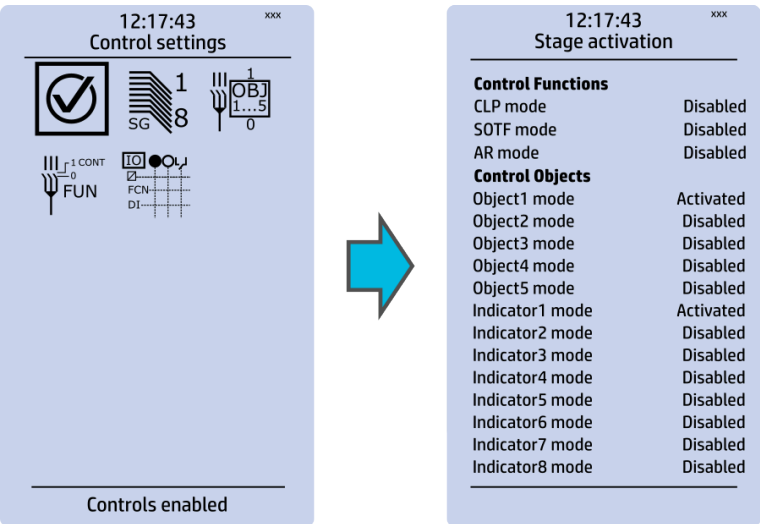
Figure. 3.4 - 7. Main menu structure.



The *Control* main menu includes submenus (see the image above) for enabling the various control functions and objects (*Controls enabled*), for enabling and controlling the setting groups (*Setting groups*), for configuring the objects (*Objects*), for setting the various control functions (*Control functions*), and for configuring the inputs and outputs (*Device I/O*). The available control functions depend on the model of the device in use.

Controls enabled

Figure. 3.4 - 8. Controls enabled submenu.

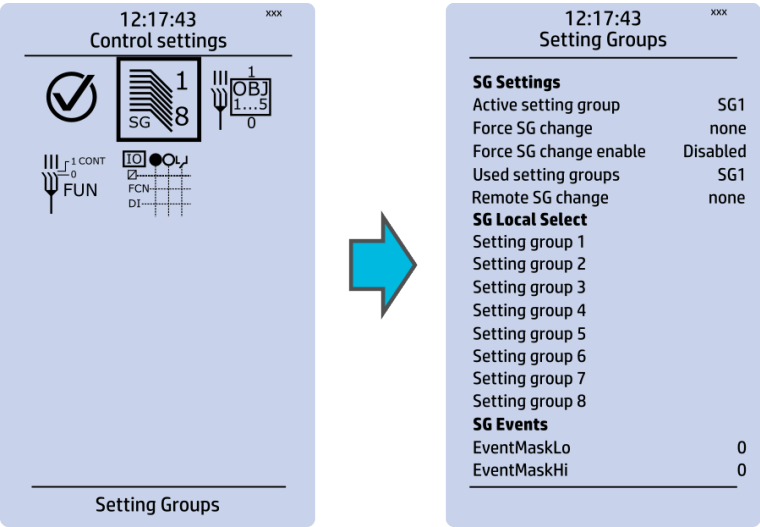


You can activate the selected control functions in the *Controls enabled* submenu. By default all the control functions are disabled. All activated functions can be viewed in the *Control functions* submenu (see the section "Control functions" below for more information).

In this submenu you can also activate and disable controllable objects. As with control functions, all objects are disabled by default. All activated objects can be viewed in the *Objects* submenu (see the section "Objects" below for more information).

Setting groups

Figure. 3.4 - 9. Setting groups submenu.

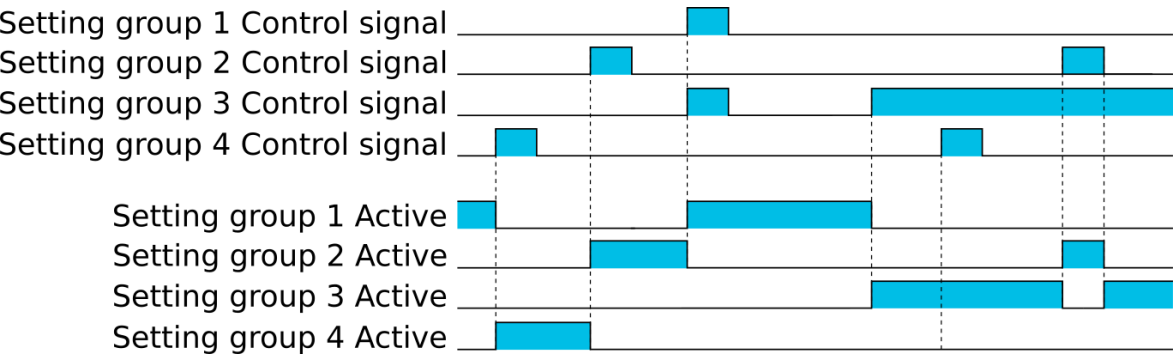


The *Setting groups* submenu displays all the information related to setting group changing, such as the following:

- **Active setting group:** displays the current active setting group (SG1...SG8).
- **Force setting group change:** this setting allows the activation of a setting group at will (please note that Force SG change enable must be "Enabled").
- **Used setting groups:** this setting allows the activation of setting groups SG1...SG8 (only one group is active by default).
- **SG local select:** selects the local control for the different setting groups (can use digital inputs, logical inputs or outputs, RTDs, object status information as well as stage starts, trips or blocks).
- **Remote setting group change:** When enabled it is possible to change the setting group manually through SCADA.
- **SG events:** event masking for setting groups (masks are OFF by default; please note that only masked events are recorded into the event history).

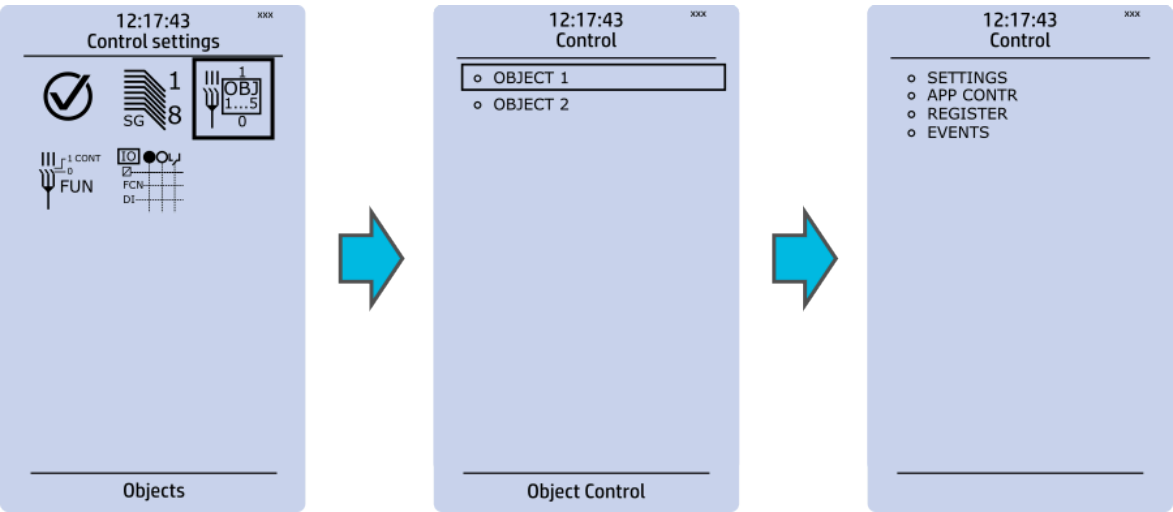
Setting group 1 (SG1) has the highest priority, while Setting group 8 (SG8) has the lowest priority. Setting groups can be controlled with pulses or with both pulses and static signals (see the image below).

Figure. 3.4 - 10. Example of setting group (SG) changing.



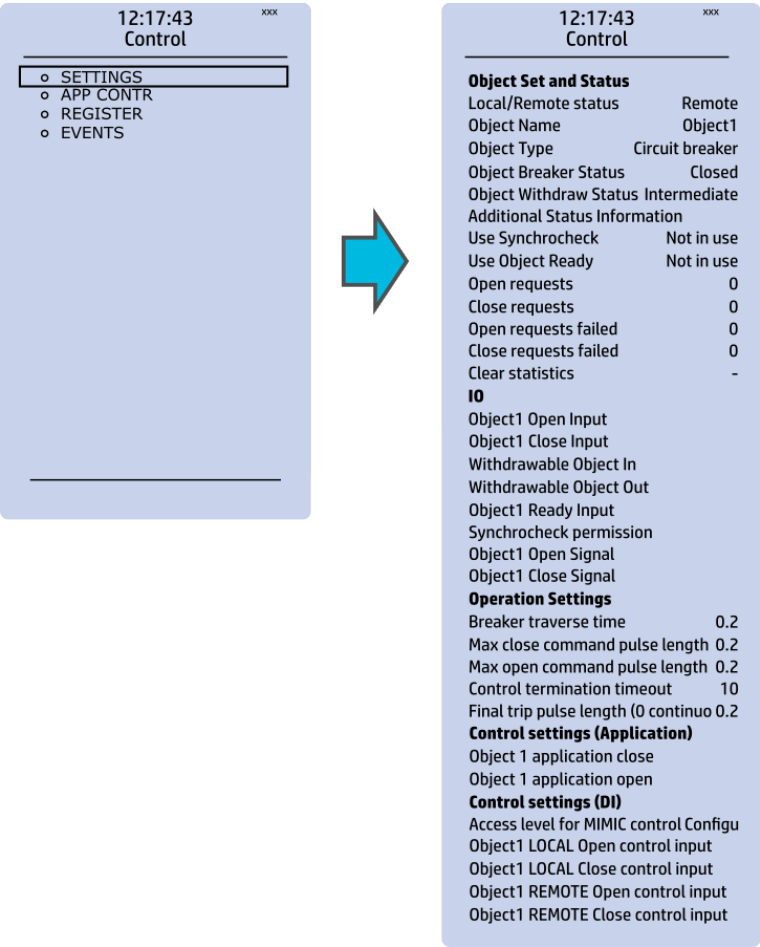
Objects

Figure. 3.4 - 11. Objects submenu.



Each activated object is visible in the *Objects* submenu. By default all objects are disabled unless specifically activated in the *Controls* → *Controls enabled* submenu. Each active object has four sections in their submenus: "Settings", "Application control" ("App contr"), "Registers" and "Events". These are described in further detail below.

Figure. 3.4 - 12. Settings section.



OBJECT SET AND STATUS

- **Local/Remote status:** control access may be set to Local or Remote (Local by default; please note that when local control is enabled, the object cannot be controlled through the bus and vice versa).
- **Object name:** the name of the object (objects are named "ObjectX" by default).
- **Object type:** selects the type of the object from Grounding disconnecter, Motor-controlled disconnecter, Circuit breaker and Withdrawable circuit breaker (Circuit breaker by default).
- **Object x status:** the status can be Bad, Closed, Open and Intermediate. The status "Intermediate" is the phase between "Open" and "Closed" where both status inputs are 0. The status "Bad" occurs when both status inputs of the object/cart are 1.
- **Additional status information:** gives feedback from the object on whether the opening and closing are allowed or blocked, whether the object is ready, and whether the synchronization status is ok.
- **Use synchrocheck and Use Object ready:** closing the object is forbidden when the sides are not synchronized or when the object is not ready to be closed.
- **Open requests and Close requests:** displays the statistics, i.e. the number of Open and Close requests.
- **Open requests failed and Close requests failed:** displays the statistics of Open and Close request failures. A request is considered to have failed when the object does not change its status as a result of that request.
- **Clear statistics:** statistics can be cleared by choosing "Clear statistics" and then "Clear".

I/O

- An object has both **Open input** and **Close input** signals which are used for indicating the status of the breaker on the HMI and in SCADA. Status can be indicated by any of the following: digital inputs, logical inputs or outputs.
- A withdrawable object has both **In** and **Out** inputs. The status can be indicated by any of the following: digital inputs, logical inputs or outputs.
- Both **Object ready** and **Synchrocheck permission** have status inputs. If either one is used, the input(s) must be active for the device to be able to give the "Object Close" command.
- **Object open** and **Object close** signals define which digital output is controlled.

OPERATION SETTINGS

- **Breaker traverse time:** determines how long a gap there can be between a status change from "Open" to "Closed" before an intermediate status is reported by the function.
- **Max close/open command pulse length:** defines the maximum length of "Open" and "Close" commands. If the status has changed before the maximum pulse length has elapsed, the pulse is cut short.
- **Control termination timeout:** If the status of the object does not change during the set time, an "Open/Close request failed" event is recorded.
- After the set delay, if the controlled object does not respond accordingly, the procedure is terminated and a fail message is issued.

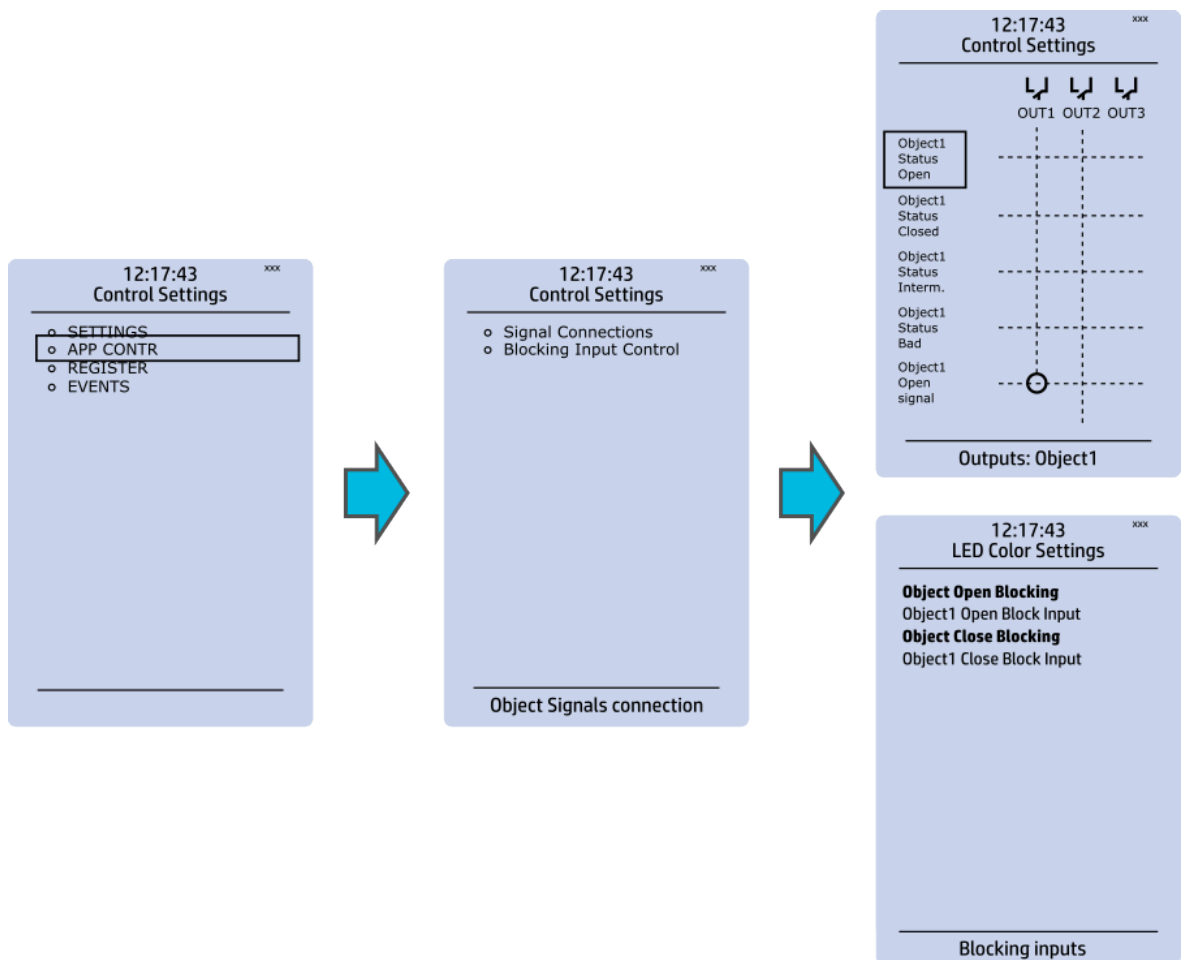
CONTROL SETTINGS (APPLICATION)

- **Object application close and Object application open:** a signal set to these points can be used to open and close the object. Controlling the object through this point does not follow the local/remote status of the device.

CONTROL SETTINGS (DI)

- **Access level for MIMIC control:** determines the access level required to control the MIMIC (each level has its own password). By default, the access level is set to "Configurator".
- You can use digital inputs to control the object locally or remotely. Remote controlling via the bus is configured on the protocol level.

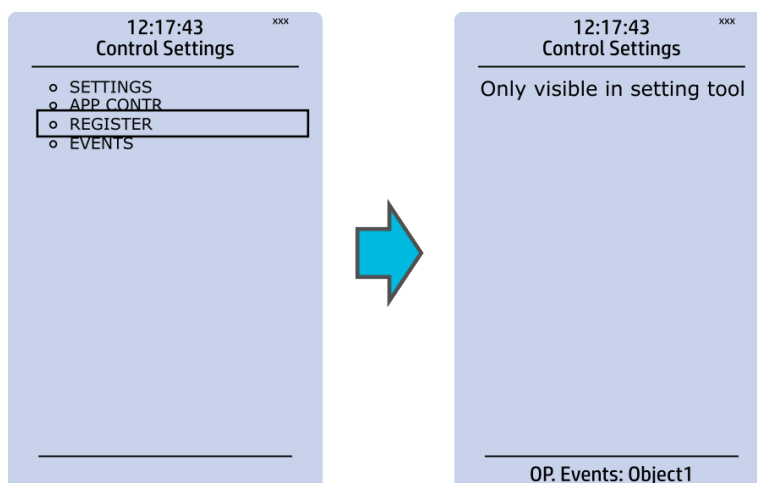
Figure. 3.4 - 13. Application control section.



You can connect object statuses directly to specific physical outputs in the "Signal connections" subsection (*Control* → *Application control*). A status can be connected to output relays, as well as to user-configurable LEDs. A connection to an output can be either latched ("x|") or non-latched ("x").

Object blocking is done in the "Blocking input control" subsection. It can be done by any of the following: digital inputs, logical inputs or outputs, object status information as well as stage starts, trips or blocks.

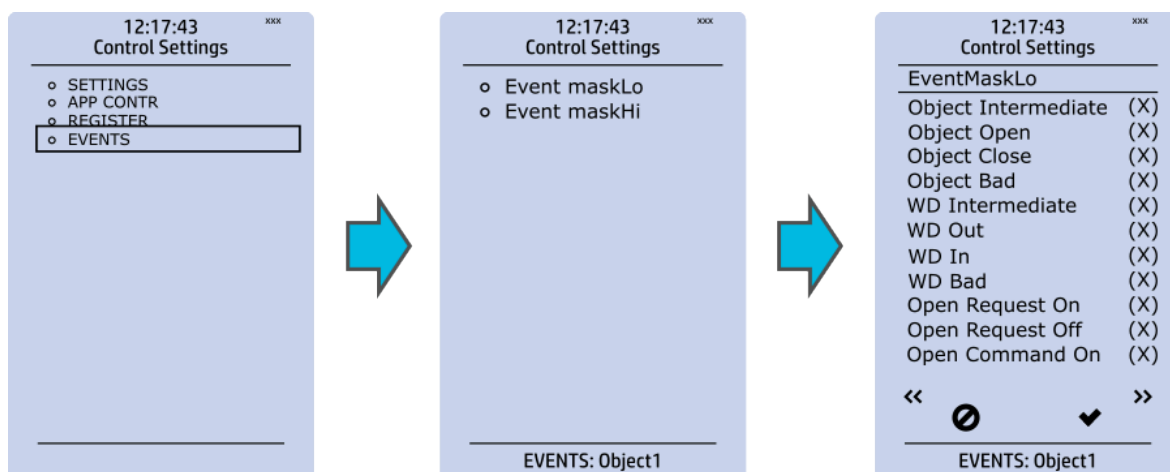
Figure. 3.4 - 14. Registers section.



The "Registers" section stores the function's specific fault data. There are twelve (12) registers, and each of them includes data such as opening and closing times, command types and request failures. The data included in the register depend on the protection function. You can clear the the operation register by choosing "Clear registers" → "Clear".

Please note that the content of the *Registers* section is not available in the HMI. It can only be accessed via the AQtivate setting tool.

Figure. 3.4 - 15. Events section.

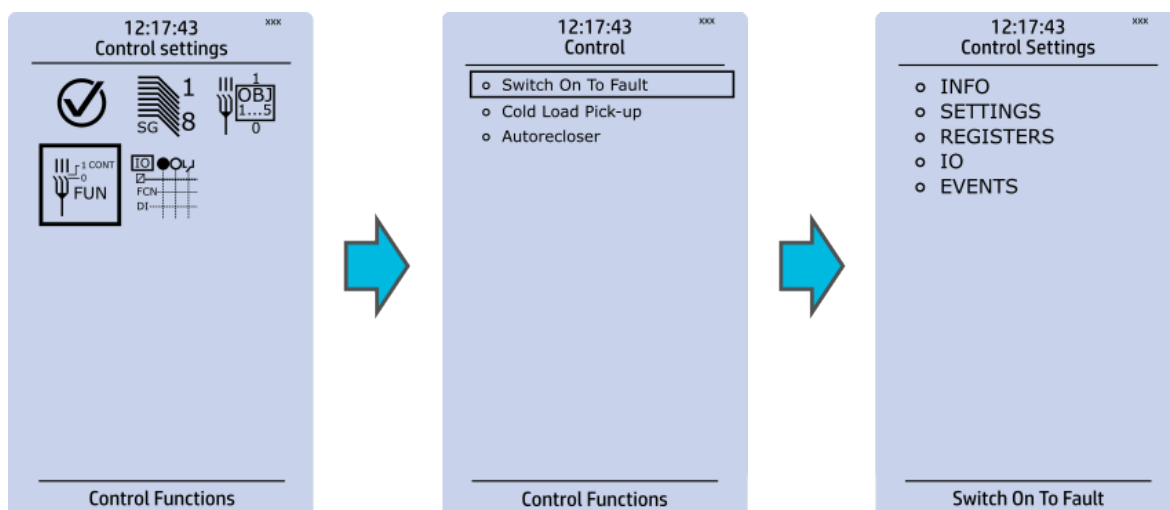


You can mask on and mask off events related to an object's stage in "Event mask". By default all events are masked off. You can activate the desired events by masking them ("x"). Please remember to save your maskings by confirming the changes with the check mark icon. If you want to cancel the changes, select the strike-through circle to do so. Only masked events are recorded to the event history (which can be accessed in the "Events" view in the user view section).

Control functions

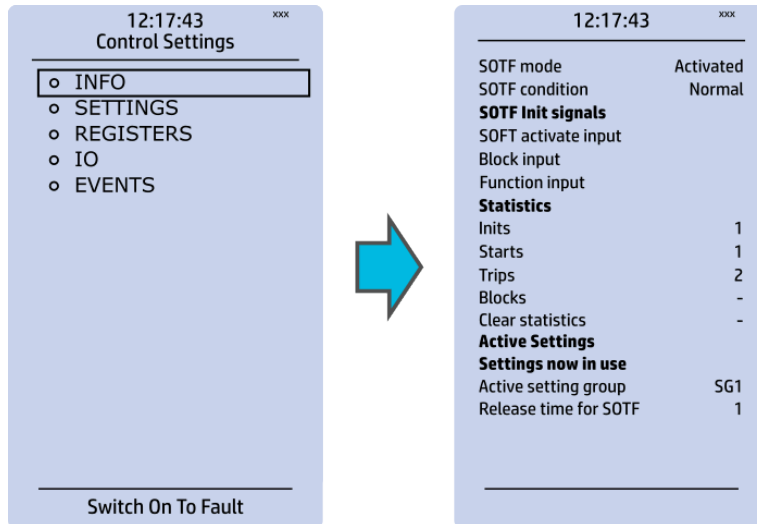
Once a control function has been activated in the *Controls* → *Controls enabled* submenu, its own submenu can be opened. In the image series below, the user has activated three control functions. The user accesses the list of activated control stages through the "Control functions" module, and selects the control function for further inspection.

Figure. 3.4 - 16. Control functions submenu.



Each control function that has been activated is listed in the *Control functions* submenu (see the middle image above). This submenu includes the following sections: "Info", "Settings", "Registers", "I/O" and "Events". The text below describes these in further detail.

Figure. 3.4 - 17. Info section.

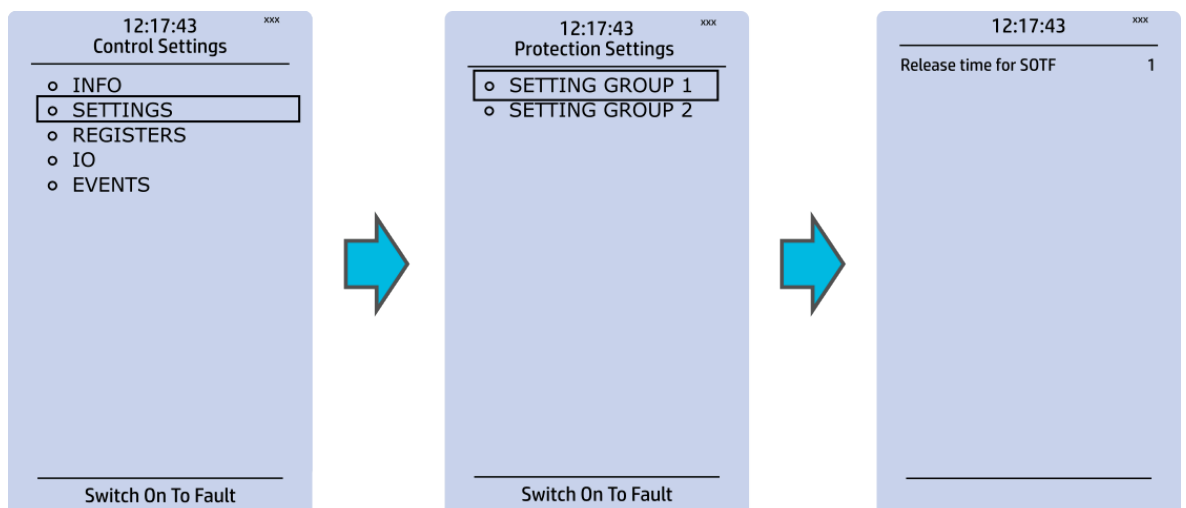


The "Info" section offers many details concerning the function and its status:

- **Function condition**: indicates the stage's condition which can be Normal, Start, Trip, or Blocked.
- **Measured magnitude**: In some functions it is possible to choose the monitored magnitude between Peak-to-peak, TRMS, or RMS (the default is RMS; the available magnitudes depend on the function).
- **Statistics**: indicates the number of function starts, trips and blocks (can be cleared through "Clear statistics" → "Clear").
- **Measurements**: displays the measurements carried out by the function.
- **Active settings**: displays the setting group that is currently in use and its settings (other setting groups can be set in the "Settings" section).

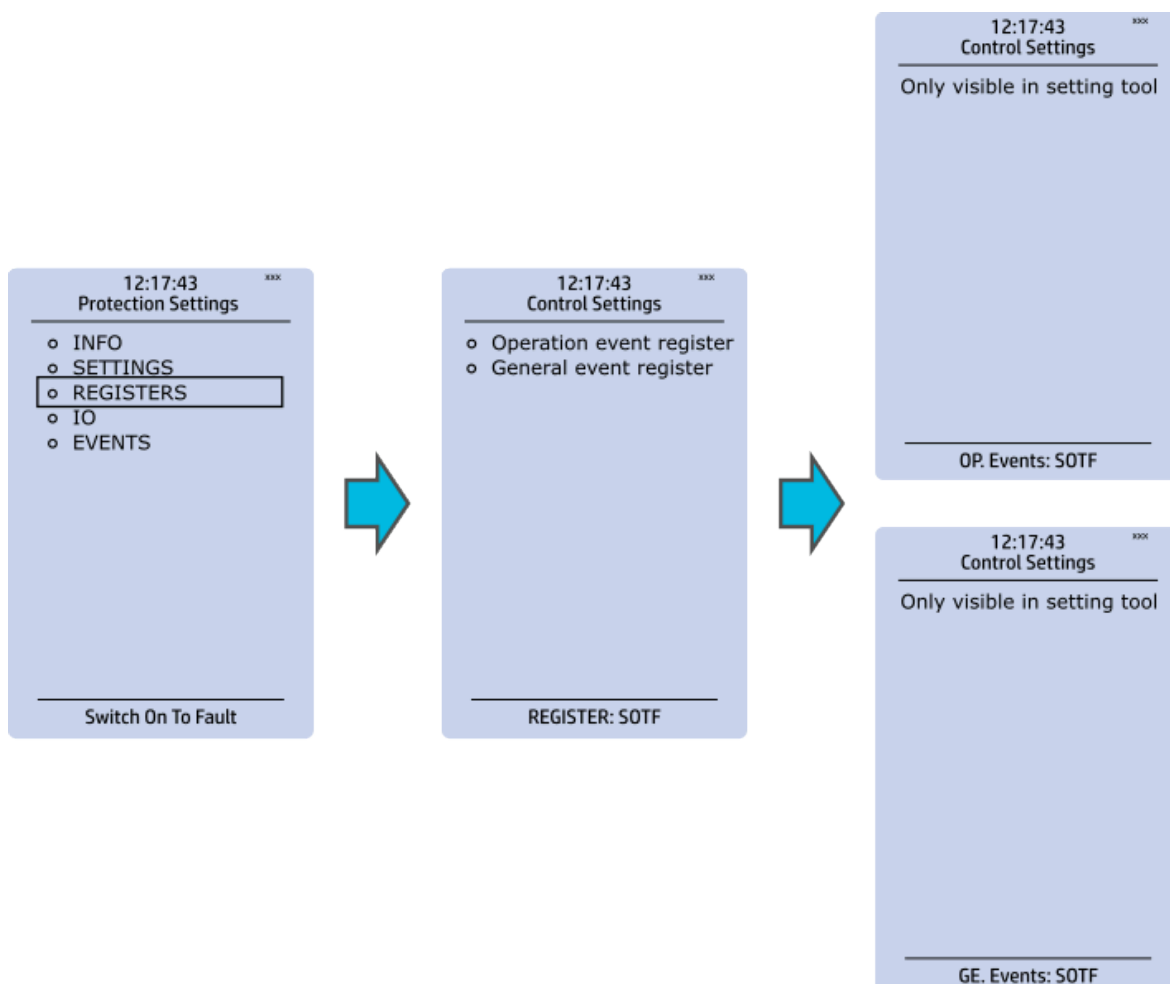
While the function is activated and disabled in the *Control* → *Controls enabled* submenu, you can disable the function through the "Info" section (the [function name] mode at the top of the section).

Figure. 3.4 - 18. Settings section.



The stage settings vary depending on which control function they are a part of. By default only one setting group of the eight available setting groups is activated. You can enable more groups in the *Control → Setting groups* menu, although they are set here in the "Settings" section.

Figure. 3.4 - 19. Registers section.

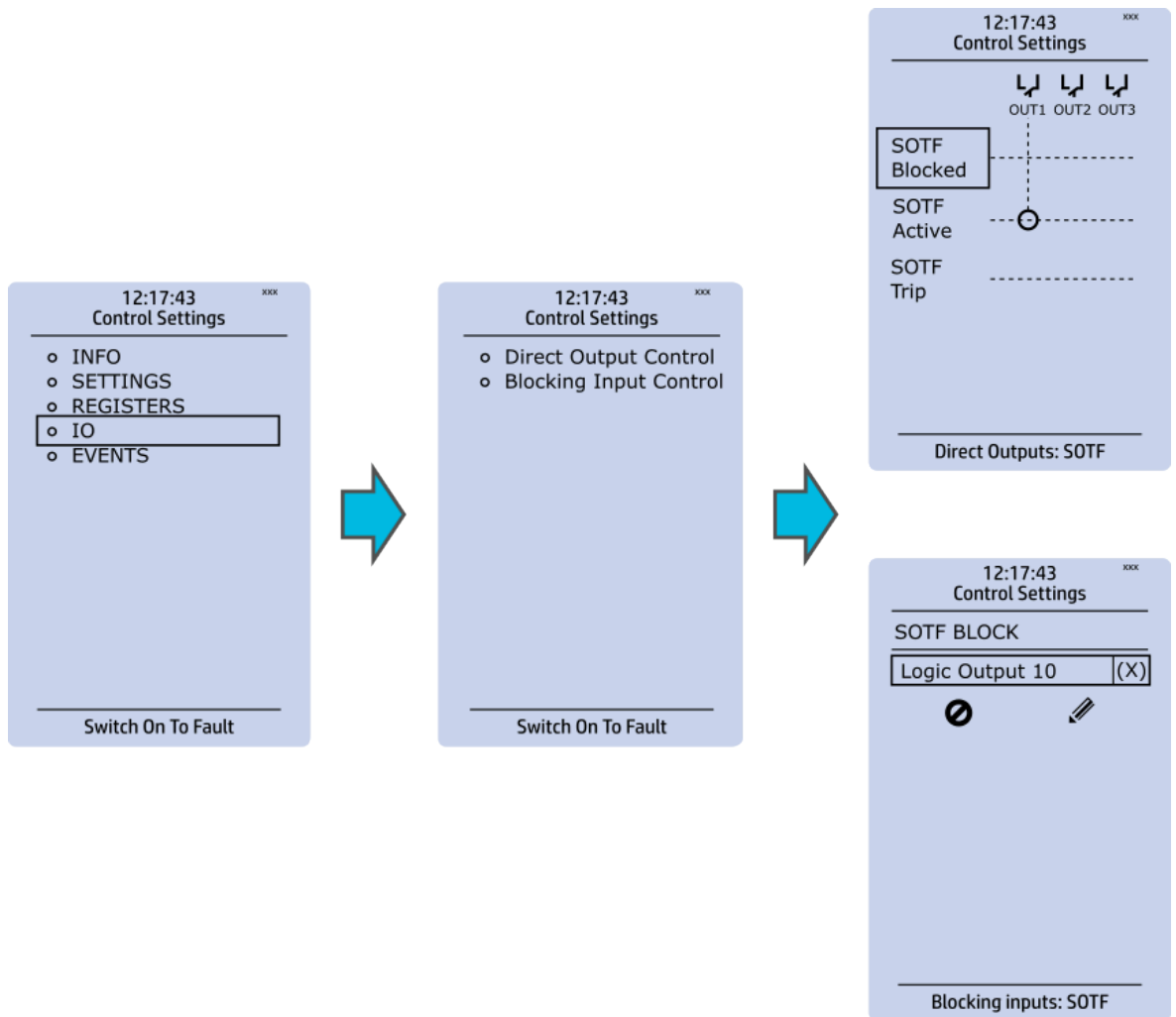


Please note that the content of the "Registers" section is not available in the HMI. It can only be accessed via the AQtivate setting tool. Stored in the "Registers" section you can find both "Operation event register" and "General event register".

"Operation event register" stores the function's specific operation data. There are twelve (12) registers, and each of them includes data like the pre-fault value, the fault value, the time stamp and the active group during the trigger. Data included in the register depend on the control function. You can clear the the operation register by choosing "Clear registers" → "Clear".

"General event register" stores the event generated by the stage. These general event registers cannot be cleared.

Figure. 3.4 - 20. I/O section.



The "I/O" section is divided into two subsections: "Direct output control" and "Blocking input control".

In "Direct output control" you can connect the stage's signals to physical outputs, either to an output relay or an LED (START or TRIP LEDs or one of the 16 user configurable LEDs). If the stage is blocked internally (by a digital input or another signal), you can configure an output to indicate the stage that is blocked. A connection to an output can be either latched ("x|") or non-latched ("x").

"Blocking input control" allows you to block stages. The blocking can be done by using any of the following:

- digital inputs.
- logical inputs or outputs.
- the START, TRIP or BLOCKED information of another protection stage.
- object status information.

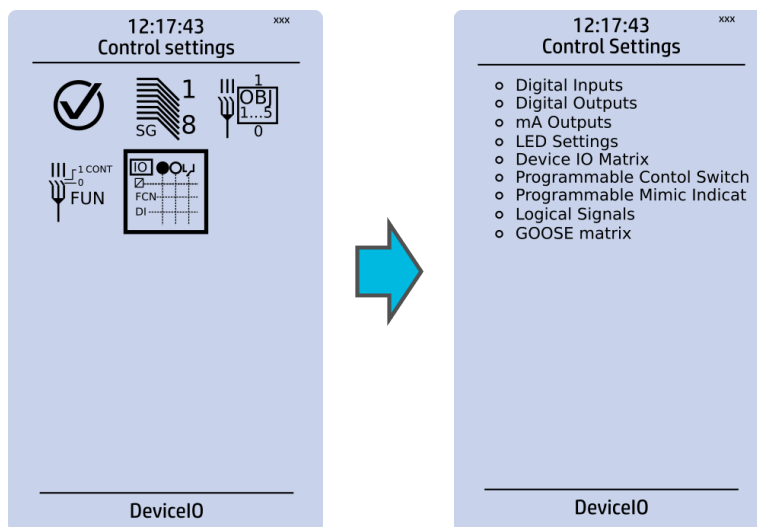
Figure. 3.4 - 21. Events section.



You can mask on and mask off events related to an object's stage in "Event mask". By default all events are masked off. You can activate the desired events by masking them ("x"). Please remember to save your maskings by confirming the changes with the check mark icon. If you want to cancel the changes, select the strike-through circle to do so. Only masked events are recorded to the event history (which can be accessed in the "Events" view in the user view section).

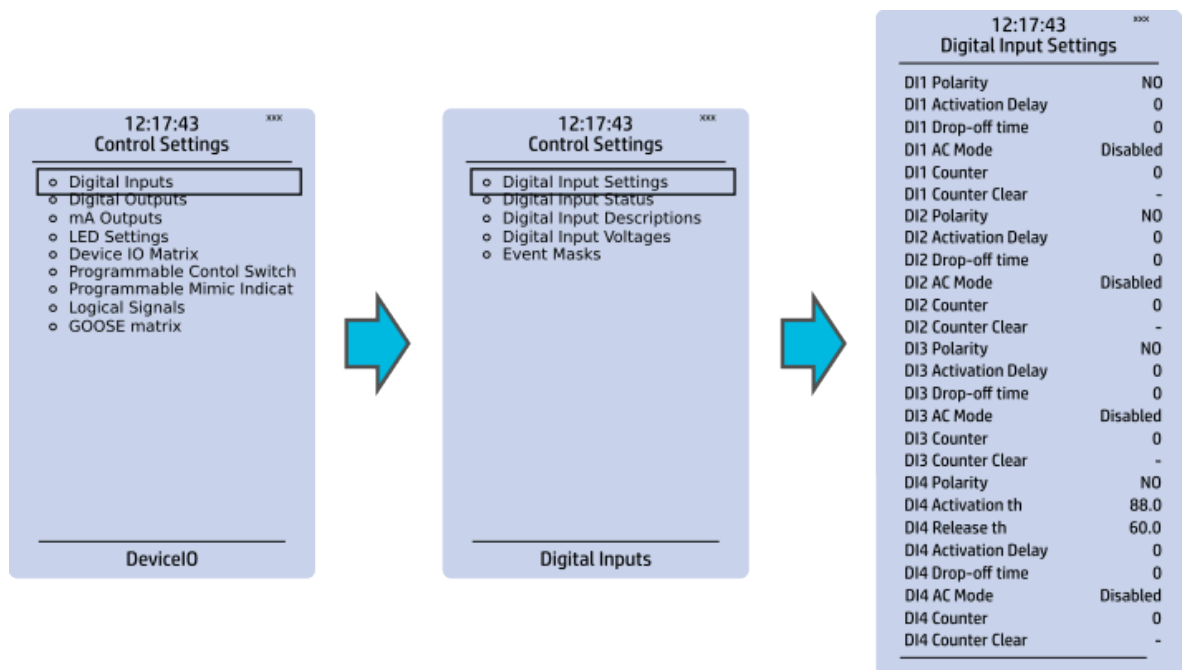
Device I/O

Figure. 3.4 - 22. Device I/O submenu.



The *Device I/O* submenu is divided into the following nine sections: "Digital inputs", "Digital outputs", "mA Outputs", "LED settings", "Device I/O matrix", "Programmable control switch", "Programmable Mimic Indicator", "Logic signals" and "GOOSE matrix". Please note that digital inputs, logic outputs, protection stage status signals (START, TRIP, BLOCKED, etc.) as well as object status signals can be connected to an output relay or to LEDs in the "Device I/O matrix" section.

Figure. 3.4 - 23. Digital input section.

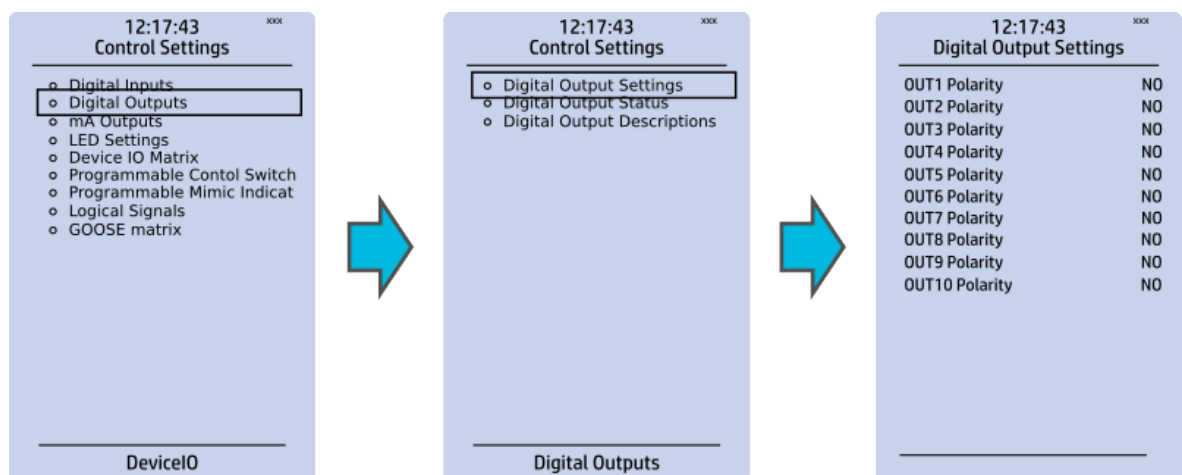


All settings related to digital inputs can be found in the "Digital inputs" section.

The "Digital inputs settings" subsection includes various settings for the inputs: the polarity selection determines whether the input is Normal Open (NO) or Normal Closed (NC) as well as the activation threshold voltage (16...200 V AC/DC, step 0.1 V) and release threshold voltage (10...200 V AC/DC, step 0.1 V) for each available input. There is also a setting to determine the wanted activation and release delay (0...1800 s, step 1 ms). Digital input activation and release threshold follow the measured peak value. The activation time of an input is 5...10 ms. The release time with DC is 5...10 ms, while with AC it is less than 25 ms. The first three digital inputs don't have activation and release threshold voltage settings as these have already been defined when the unit was ordered.


Digital input statuses can be checked from the corresponding subsection ("Digital input status"). The "Digital input descriptions" subsection displays the texts the user has written for each digital input. In the "Event masks" subsection you can determine which events are masked –and therefore recorded into the event history– and which are not.

Figure. 3.4 - 24. Digital outputs section.



All settings related to digital outputs can be found in the "Digital outputs" section.

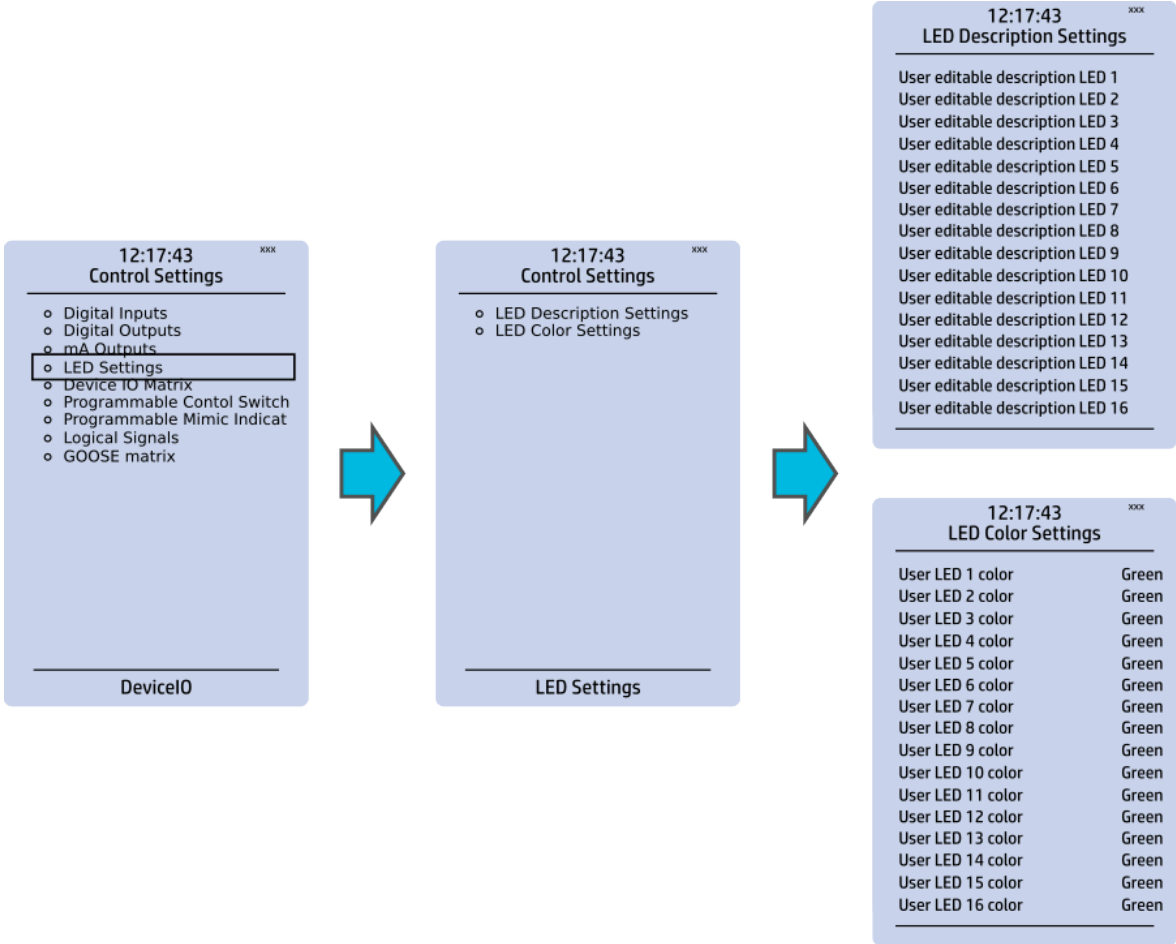
The "Digital outputs settings" subsection lets you select the polarity for each output; they can be either Normal Open (NO) or Normal Closed (NC). The default polarity is Normal Open. The operational delay of an output contact is approximately 5 ms. You can view the digital output statuses in the corresponding subsection ("Digital output status"). The "Digital output descriptions" subsection allows you to configure the description text for each output. All name changes affect the matrices as well as input–output selection lists.



NOTICE!

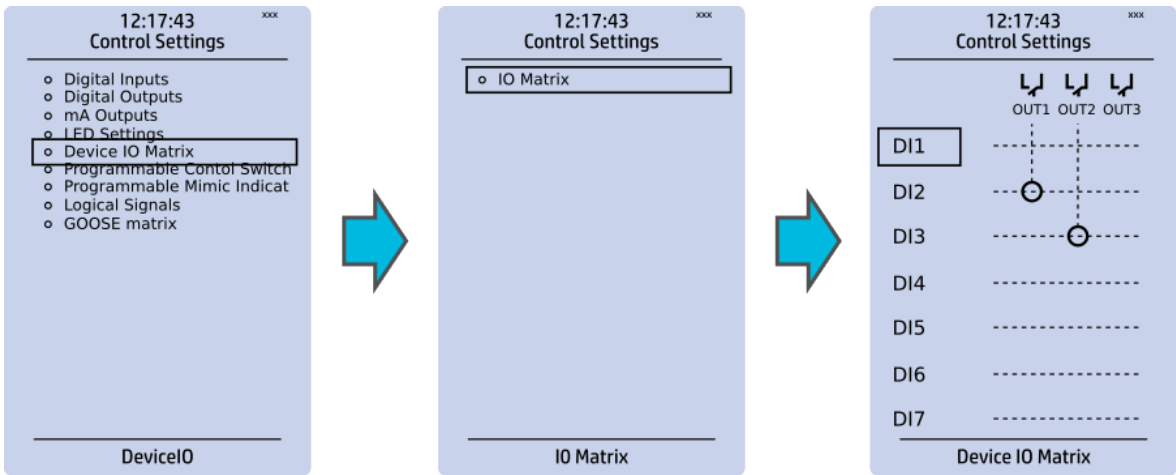
An NC signal goes to the default position (NO) if the device loses the auxiliary voltage or if the system is fully reset. However, an NC signal does not open during voltage or during System full reset. An NC output signal does not open during a Communication or Protection reset.

Figure. 3.4 - 25. LED settings section.



The "LED settings" section allows you to modify the individual label text attached to an LED ("LED description settings"); that label is visible in the LED quick displays and the matrices. You can also modify the color of the LED ("LED color settings") between green and yellow; by default all LEDs are green.

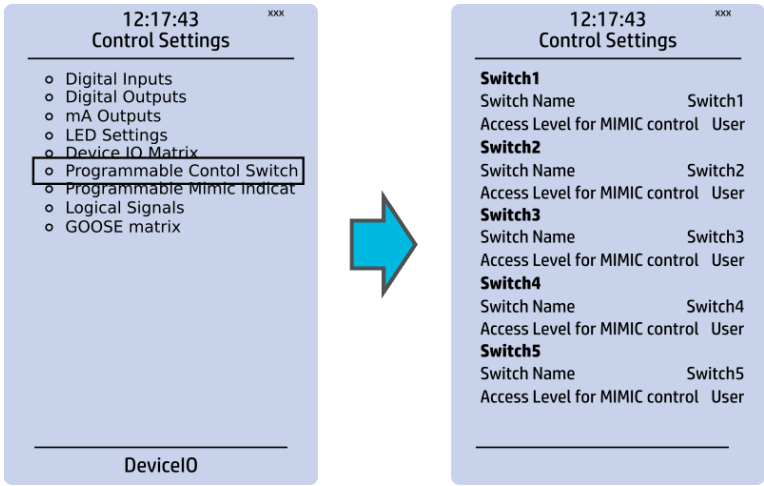
Figure. 3.4 - 26. Device I/O matrix section.



Through the "Device I/O matrix" section you can connect digital inputs, logical outputs, protection stage status signals (START, TRIP, BLOCKED, etc.), object status signals and many other binary signals to output relays, or to LEDs configured by the used. A connection can be latched ("|x|") or non-latched ("x"). Please note that a non-latched output is deactivated immediately when the triggering signal is disabled, while a latched signal stays active until the triggering signal deactivates and the latched function is manually cleared.

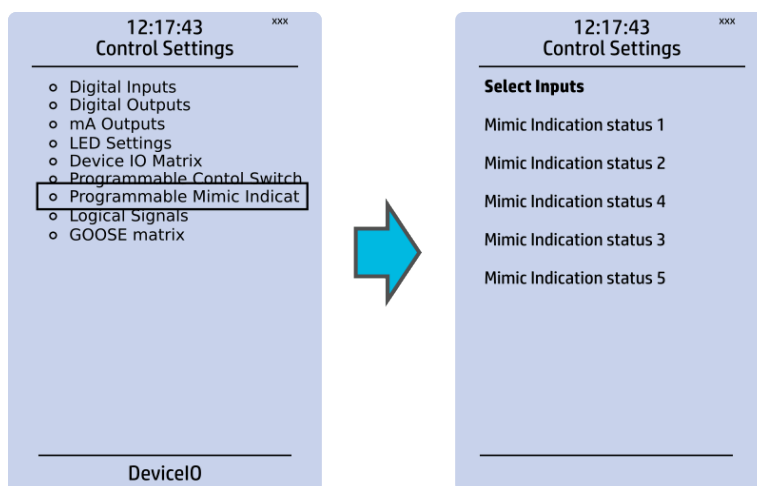
You can clear latched signals by entering the mimic display and the pressing the **Back** button on the panel.

Figure. 3.4 - 27. Programmable control switch section.



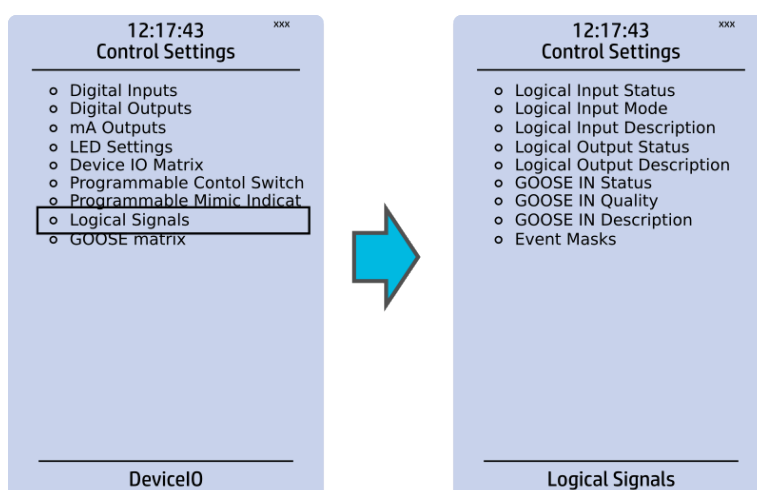
Programmable control switches (PCSs) are switches that can be used to control signals while in the mimic view. These signals can be used in a variety of situations, such as for controlling the logic program, for function blocking, etc. You can name each switch and set the access level to determine who can control the switch.

Figure. 3.4 - 28. Programmable mimic indicators section.



Programmable mimic indicators can be placed into the mimic to display a text based on the status of a given binary signal (digital input, logical signal, status of function start/tripped/blocked signals etc.). When configuring the mimic with the AQtivate 200 setting tool, it is possible to set a text to be shown when an input signal is ON and a separate text for when the signal is OFF.

Figure. 3.4 - 29. Logical signals section.



All AQ 200 series units have the following types of logical signals:

- 32 logical input signal status bits; the status of a bit is either 0 or 1.
- 32 logical output signal status bits; the status of a bit is either 0 or 1.
- 64 GOOSE input signal status bits; the status of a bit is either 0 or 1.
- 64 quality bits for GOOSE input signals; the status of a bit is either 0 or 1.

Logical input signals can be used when building a logic with the AQtivate 200 setting tool. The status of a logical input signal can be changed either from the mimic or through SCADA. By default logical inputs use "Hold" mode in which the status changes from 0 to 1 and from 1 to 0 only through user input. The mode of each input can be changed to "Pulse" in which a logical input's status changes from 0 to 1 through user input and then immediately back to 0.

Logical output signals can be used as the end result of a logic that has been built in the AQtivate 200 setting tool. The end result can then be connected to a digital output or a LED in the matrix, block functions and much more.

GOOSE inputs are mainly used for controlling purposes and in conjunction with the IEC 61850 communication protocol. There are 64 GOOSE inputs signal status bits, and their status can be either 0 or 1. "GOOSE IN quality" checks the quality of a GOOSE input message. There are 64 GOOSE input quality signals, and their status can be either 0 ("Good" or "Valid") or 1 ("Bad" or "Invalid"). Logical outputs can be used when building a programmable logic. Activating a logic gate does not create an event but when a logical output is connected to a logic gate it is possible to create an event from the gate's activation. All logical inputs and outputs have both ON and OFF events, and they can be masked on when necessary (they are masked off by default).

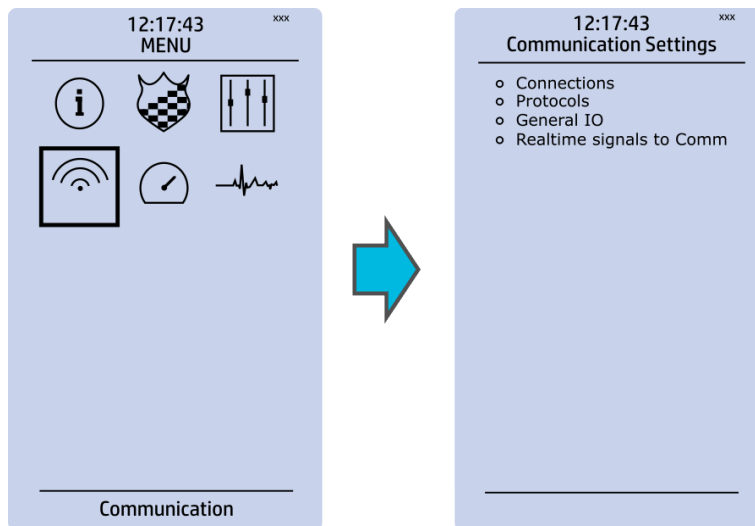


NOTICE!

Please refer to the "[Communication](#)" chapter for a more detailed description of the use of logical signals.

3.5 Communication menu

Figure. 3.5 - 30. Communication menu.

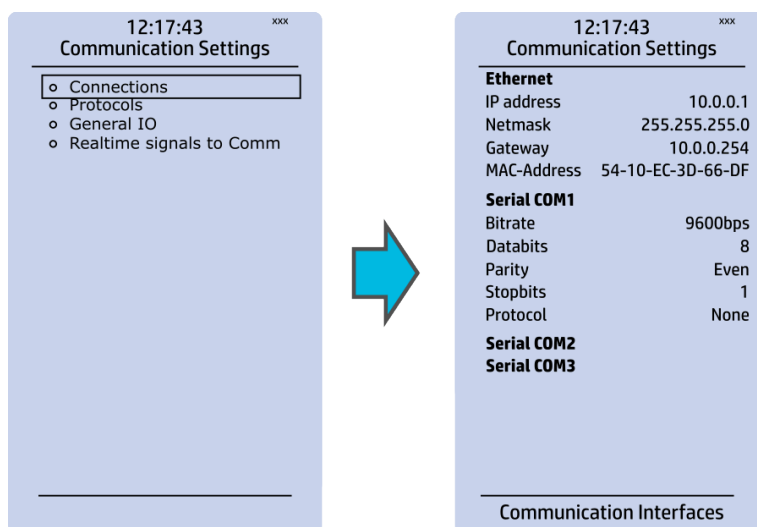


The *Communication* main menu includes four submenus (as seen in the figure above): *Connections*, *Protocols*, *General IO* and *Realtime signals to Comm*. All devices can be configured through the Ethernet connection in the back panel with the AQtivate 200 setting tool software. Connecting to AQtivate requires knowing the IP address of your device: this can be found in the *Communication* → *Connections* submenu. As a standard, the devices support the following communication protocols:

- NTP
- IEC 61850
- Modbus/TCP
- Modbus/RTU
- IEC-103
- IEC -101/104
- SPA
- DNP3
- ModbusIO.

Connections

Figure. 3.5 - 31. View of the Connections submenu.



The *Connections* submenu offers the following bits of information and settings:

ETHERNET

This section defines the IP settings for the Ethernet port in the back panel of the unit.

- IP address: the IP address of the device which can be set by the user (the default IP address depends on the device).
- Network: the network subnet mask is entered here.
- Gateway: the gateway is configured only when communicating with devices in a separate subnet.
- MAC-Address: The unique MAC address of the device, which is not configurable by the user.

SERIAL COM

This section defines the basic settings of the RS-485 port in the back panel of the unit.

- Bitrate: displays the bitrate of the RS-485 serial communication interface (9600 bps as standard, although it can be changed to 19,200 bps or to 38,400 bps if an external device supports the faster speed).
- Databits, Parity and Stopbits: these can be set according to the connected external devices.
- Protocol: by default the device does not have any serial protocol activated, although IEC 103, Modbus I/O and Modbus/RTU can be used for communication.



NOTICE!

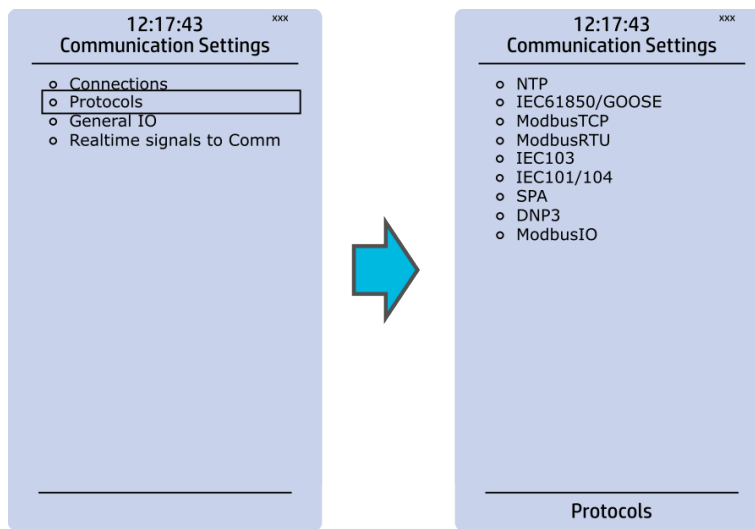
When communicating with a device via the front Ethernet port connection, the IP address is always 192.168.66.9.

SERIAL COM1 & COM2

SERIAL COM1 and SERIAL COM2 are reserved for serial communication option cards. They have the same settings as the RS-485 port.

Protocols

Figure. 3.5 - 32. View of the Protocols submenu.



The *Protocols* submenu offers access to the various communication protocol configuration menus. Some of the communication protocols use serial communication and some use Ethernet communication. Serial communication protocols can be used either with the RS-485 port that is in AQ 200 series units by default, or with a serial communication option card. Ethernet communication protocols can be used either with the RJ-45 port in the back of the unit or with an Ethernet communication option card.

The communication protocols are:

- NTP: this protocol is used for time synchronization over Ethernet, and can be used simultaneously with Ethernet-based communication protocols.
- IEC 61850: an Ethernet-based communication protocol.
- Modbus/TCP: an Ethernet-based communication protocol.
- Modbus/RTU: a serial communication protocol.
- IEC-103: a serial communication protocol.
- IEC-101/104: since the standards IEC 60870-5-101 and IEC 60870-5-104 are closely related, the IEC-101 protocol uses serial communication on the physical layer, whereas the IEC-104 protocol uses Ethernet communication.
- SPA: a serial communication protocol.
- DNP3: supports both serial and Ethernet communication.
- ModbusIO: used for connecting external devices like ADAM RTD measurement units.



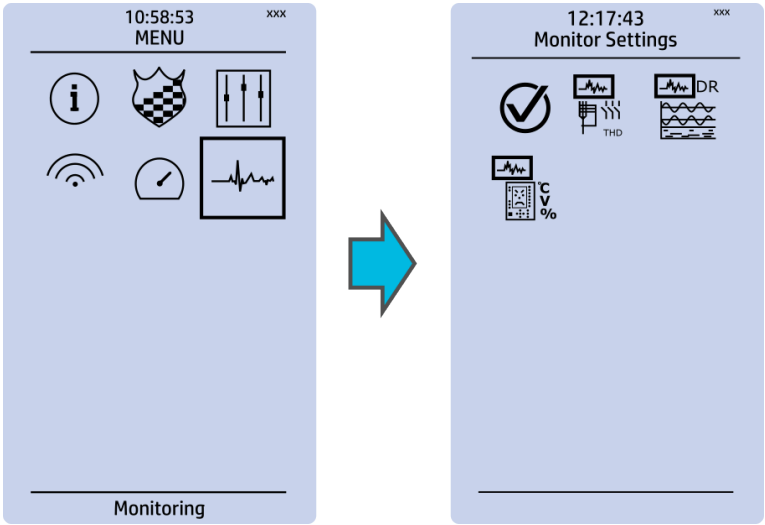
NOTICE!

Please refer to the "[Communication](#)" chapter for a more detailed text on the various communication options.

3.6 Monitoring menu

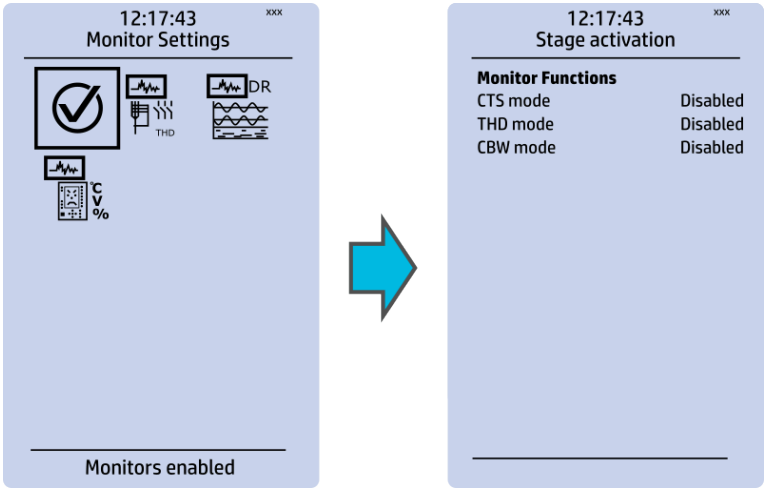
The *Monitoring* main menu includes submenus (see the image below) for enabling the various monitoring functions (*Monitors enabled*), setting the various monitoring functions (*Monitor functions*), controlling the disturbance recorder (*Disturbance REC*) and accessing the device diagnostics (*Device diagnostics*). The available monitoring functions depend on the type of the device in use.

Figure. 3.6 - 33. Monitoring menu view.



Monitors enabled

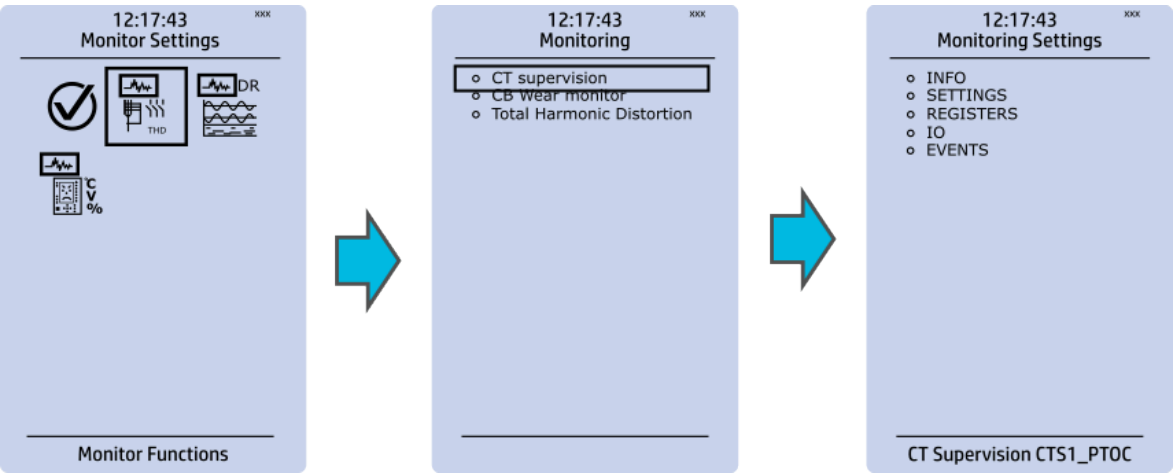
Figure. 3.6 - 34. Monitors enabled submenu.



You can activate the selected monitor functions in the *Monitors enabled* submenu. By default all the control functions are disabled. All activated functions can be viewed in the *Monitor functions* submenu (see the section "Monitor functions" below for more information).

Monitor functions

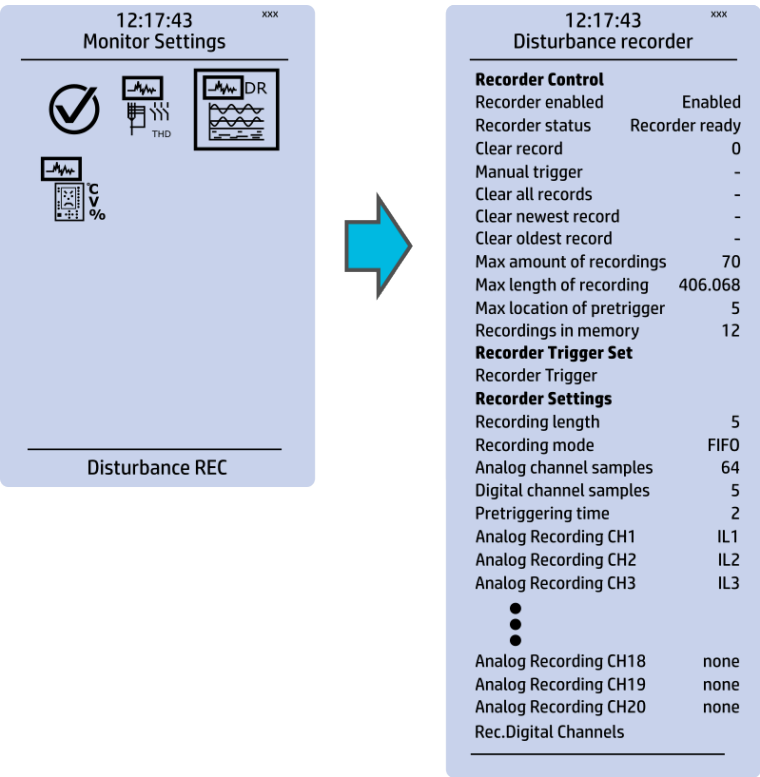
Figure. 3.6 - 35. Monitor function view.



Configuring monitor functions is very similar to configuring protection and control stages. They, too, have the five sections that display information ("Info"), set the parameters ("Settings"), show the inputs and outputs ("I/O") and present the events and registers ("Events" and "Registers").

Disturbance recorder

Figure. 3.6 - 36. Disturbance recorder settings.



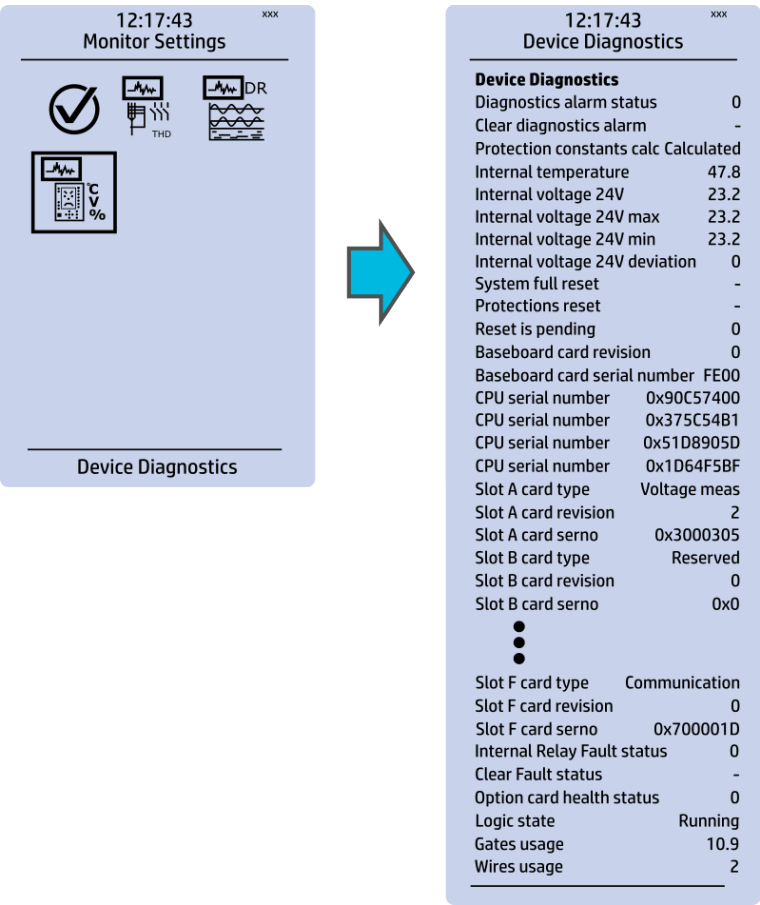
The *Disturbance recorder* submenu has the following settings:

- "Recorder enabled" enables or disables the recorder.
- "Recorder status" indicates the status of the recorder.
- "Clear record" records the chosen record in the memory.

- "Manual trigger" triggers the recorder when set to "Clear". Goes back to "-" when afterwards.
- "Clear all records", "Clear newest record" and "Clear oldest record" allows the clearing of all, the latest, or the oldest recording.
- "Max. amount of recordings" displays the maximum number of recordings; depends on the number of channels, the sample rate and the length of the file.
- "Max. length of recording" displays the maximum length of a single recording; depends on the number of chosen channels and the sample rate.
- "Recordings in memory" displays the number of recordings currently in the disturbance recorder's memory.
- "Recorder trigger" shows which signals or other states has been selected to trigger the recording (digital input, logical input or output, signals of a stage, object position, etc.); by default nothing triggers the recorder.
- "Recording length" displays the length of a single recording and can be set between 0.1...1,800.0 seconds.
- "Recording mode" can be selected to replace the oldest recording ("FIFO") or to keep the old recordings ("FILO").
- "Analog channel samples" determines the sample rate of analog channels, and it can be selected to be 8/16/32/62 samples per cycle.
- "Digital channel samples" displays the sample rate in a digital channel; this is a fixed 5 ms.
- "Pretriggering time" can be selected between 0.1...15.0 s.
- The device can record up to 20 (20) analog channels that can be selected from the twenty (20) available channels. Every measured current or voltage signal can be selected to be recorded.
- Enabling "Auto. get recordings" allows the device to automatically upload recordings to the designated FTP folder (which, in turn, allows any FTP client to read the recordings from the device's memory).
- "Rec. digital channels" is a long list of the possible digital channels that can be recorded (including primary and secondary amplitudes and currents, calculated signals, TRMS values, sequence components, inputs and outputs, etc.).

Device diagnostics


Figure. 3.6 - 37. Device diagnostics submenu.



The *Device Diagnostics* submenu gives a detailed feedback of the device's current condition. It also shows whether option cards have been installed correctly without problems. If you see something out of the ordinary in the *Device diagnostics* submenu and cannot reset it, please contact the closest representative of the manufacturer or the manufacturer of the device itself.

3.7 Configuring user levels and their passwords

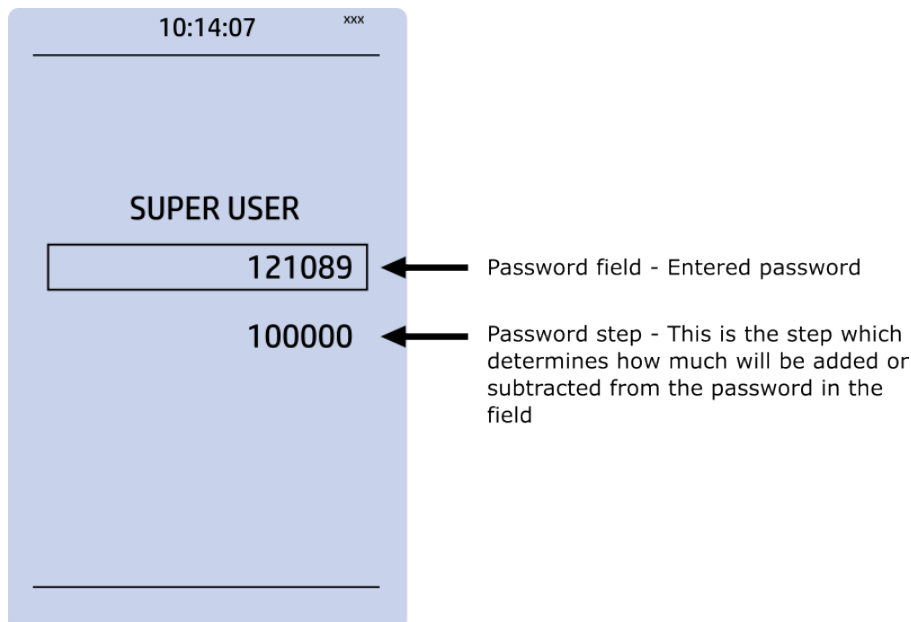
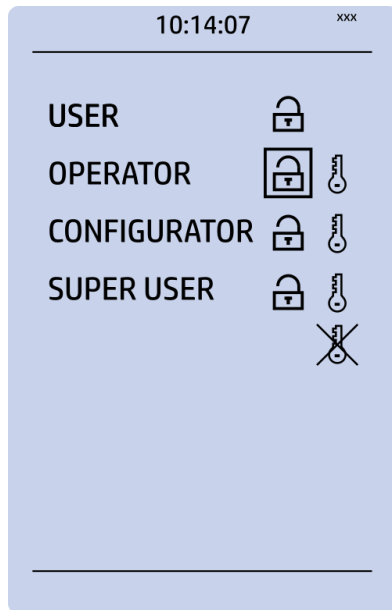
As a factory default, no user level is locked with a password in a device. In order to activate the different user levels, click the **Lock** button in the device's HMI and set the desired passwords for the different user levels.



NOTICE!
Passwords can only be set locally in an HMI.

A number of stars are displayed in the upper right corner of the HMI; these indicate the current user level. The different user levels and their star indicators are as follows (also, see the image below for the HMI view):

- Super user (***)
- Configurator (**)
- Operator (*)
- User (-)



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. Please note that in order to do this the user level whose password is being changed must be unlocked.

As mentioned above, the access level of the different user levels is indicated by the number of stars. The required access level to change a parameter is indicated with a star (*) symbol if such is required. As a general rule the access levels are divided as follows:

- *User*: Can view any menus and settings but cannot change any settings, nor operate breakers or other equipment.
- *Operator*: Can view any menus and settings but cannot change any settings BUT can operate breakers and other equipment.
- *Configurator*: Can change most settings such as basic protection pick-up levels or time delays, breaker control functions, signal descriptions etc. and can operate breakers and other equipment.
- *Super user*: Can change any setting and can operate breakers and other equipment.



NOTICE!

Any user level with a password automatically locks itself after half an hour (30 minutes) of inactivity.

4 Functions

4.1 Functions included in AQ-S214

The AQ-S214 alarm and indication device includes the following functions as well as the number of stages in those functions.

Table. 4.1 - 4. Alarming functions of AQ-S214.

Name	IEC	ANSI	Description
ALARM	-	-	Alarming function (64 alarms)

Table. 4.1 - 5. Control functions of AQ-S214.

Name	IEC	ANSI	Description
SGS	-	-	Setting group selection
OBJ	-	-	Object control and monitoring (10 objects available)
CIN	-	-	Indicator object monitoring (5 indicators available)
PCS	-	-	Programmable control switch
mA output	-	-	Milliampere output control

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

Name	IEC	ANSI	Description
RTD (1...16)	-	-	RTD alarms (Resistance temperature detector)
PGS (10)	PGx>/<	99	Programmable stage

Table. 4.1 - 7. 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 - 8. The *General* menu read-only parameters

Name	Description
Serial number	The unique serial number identification of the unit.
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 - 9. Parameters and indications in the *General* menu.

Name	Range	Default	Description
Device name	-	Unitname	The file name uses these fields when loading the .aqg configuration file from the AQ-200 unit.
Device location	-	Unitlocation	
Time synchronization source	0: Internal 1: External NTP 2: External Serial 3: IRIG-B	0: Internal	If an external clock time synchronization source is available, the type is defined with this parameter. In the internal mode there is no external Timesync source. IRIG-B requires a serial fiber communication option card.
Enable stage forcing	0: Disabled 1: Enabled	0: 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.
System phase rotating order	0: A-B-C 1: A-C-B	0: A-B-C	Allows the user to switch the expected order in which the phase measurements are wired to the unit.
Language	0: User defined 1: English 2: Finnish 3: Swedish 4: Spanish 5: French 6: German 7: Russian 8: Ukrainian	1: 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.
AQtivate ethernet port	1: All 2: COM A 3: Double Ethernet card	1: 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	0: - 1: Clear	0: -	Clears the event history recorded in the AQ-200 device.
LCD Contrast	0...255	120	Changes the contrast of the LCD display.

Name	Range	Default	Description
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	0: - 1: Activated	0: -	When activated, all LEDs are lit up. LEDs with multiple possible colors blink each color.
Reset latches	0: - 1: Reset	0: -	Resets the latched signals in the logic and the matrix. When a reset command is given, the parameter automatically returns back to "-".
Measurement recorder	0: Disabled 1: Enabled	0: Disabled	Enables the measurement recorder tool, further configured in <i>Tools</i> → <i>Misc</i> → <i>Measurement recorder</i> .
I/O default object selection	0: OBJ1 1: OBJ2 2: OBJ3 3: OBJ4 4: OBJ5 5: OBJ6 6: OBJ7 7: OBJ8 8: OBJ9 9: OBJ10	0: 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.
Reconfigure mimic	0: - 1: Reconfigure	0: -	Reloads the mimic to the unit.
Alarm screen type	0: Dynamic screen 1: Fixed screen	0: Dynamic screen	Changes the type of alarm view if such is added to the device's carousel view.

Table. 4.2 - 10. General menu logical inputs.

Name	Description
Reset last fault registers	Signal set to this point can be used for resetting latest recorded fault register.

4.3 Alarming function

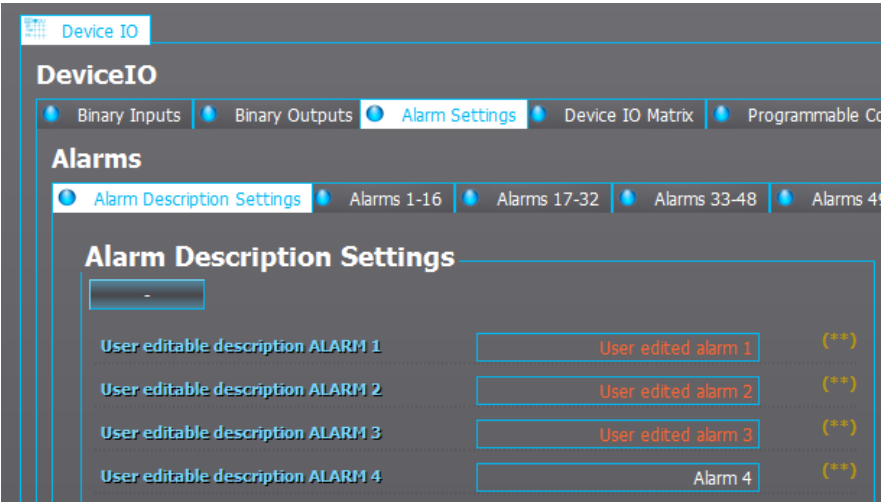
Signal alarming is the main feature of AQ-S214 Alarming devices. The alarming unit has 64 alarms the user can set. The user defines each alarm description and activating signal. These settings are controlled in the *Alarm settings* menu (*Control* → *Device I/O* → *Alarm settings*).

The alarming unit generates events with time stamps into the event history and the alarm statuses can be reported to the remote terminal unit (RTU).

The alarm display has two different modes: dynamic and fixed screen. The fixed screen always lists 1 to 16 alarm texts on the display. The dynamic screen starts with an empty display and fills up the list as alarms are activated. Switching between these modes can be done in the *General* menu.

Alarm descriptions

Figure. 4.3 - 38. User-edited 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 settings*).

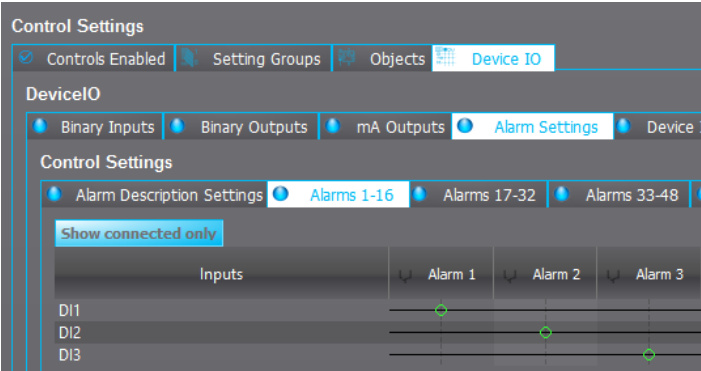
Assigning digital inputs into alarms

The setting of alarms is divided into four tabs in groups of 16. The user can assign a digital input or a logic output into each of the alarms. When any of the alarms has been activated by the assigned signal, the alarm appears in the *Alarms* menu in the device's HMI.

Figure. 4.3 - 39. Assigning alarms.



Figure. 4.3 - 40. Digital inputs assigned as alarm activating signals.



The user can assign digital inputs or logical outputs 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*).

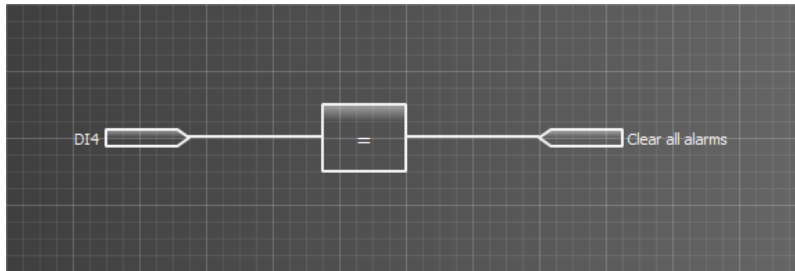
When the signal assigned into an alarm (digital input or logical output) activates, the alarm text is displayed in the *Alarms* view in the device's HMI. Active alarms are displayed in the *Alarms* display with a continuously lit LED. A deactivated alarm text is displayed until the alarm has been cleared in the HMI. This kind of alarm is displayed with a blinking LED in the *Alarms* display.

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.

Clearing activated alarms

The user can clear all alarms by pressing the **Ctrl** button located in the device front panel. Please note that the signal will not be cleared if the alarm that has activated it is still active.

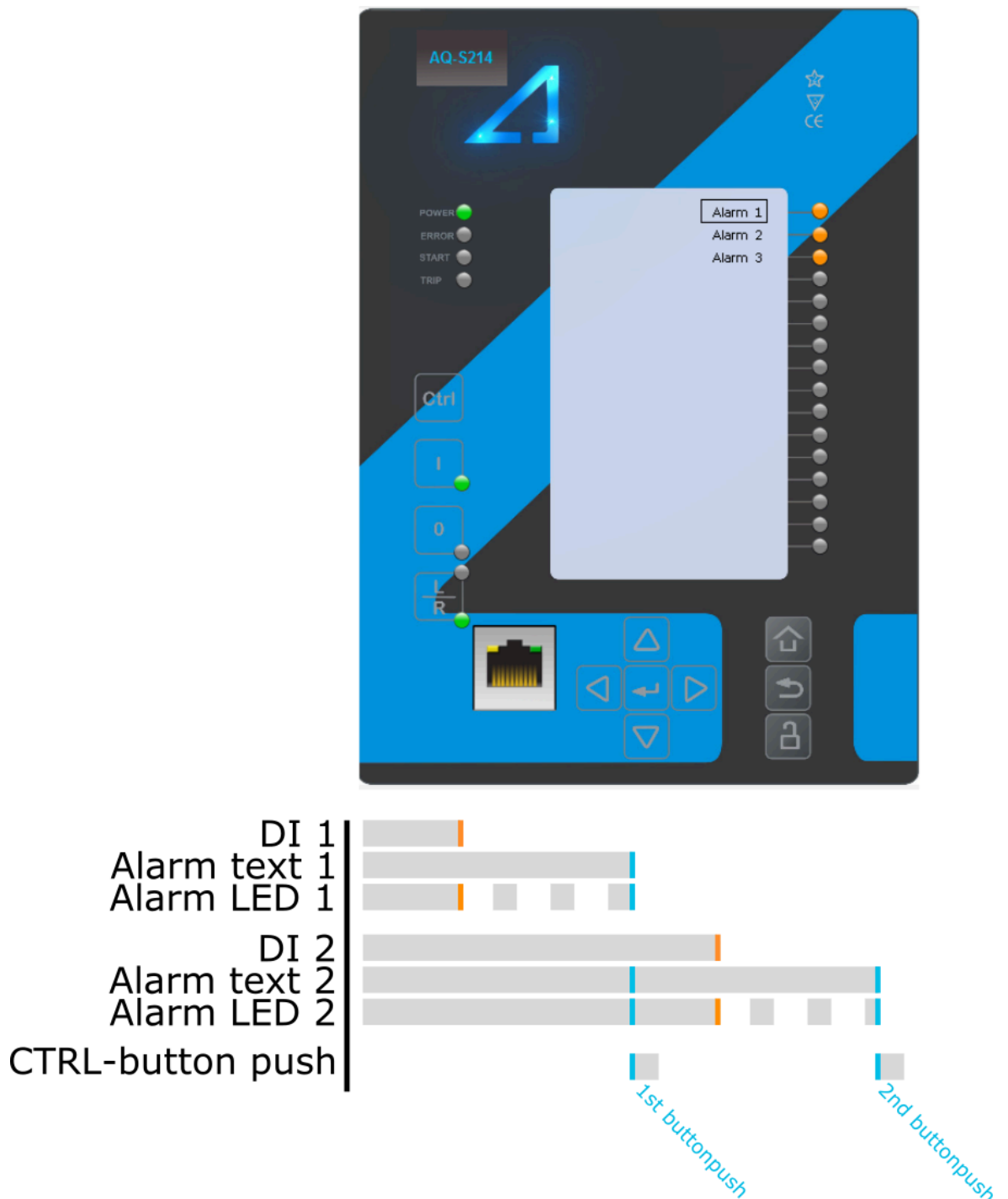
Alarms can be also cleared by using the CLEAR ALL ALARMS signal. In the image below a physical push button activates Digital Input 4 which is connected to CLEAR ALL ALARMS.



After doing this in the logic editor, click Save and then update logic (*Commands* → *Write to relay* → *Logic*).

Example of an alarm activation and clearing situation

Figure. 4.3 - 41. Example situation of an alarm text and LED activation/clearing.



In this example Digital Inputs 1 and 2 activate Alarm Texts 1 and 2. The LEDs next to the texts are also lit up as long as the digital inputs are on. When Digital Input 1 is deactivated the alarm text is still displayed but the LED will start blinking to indicate that the digital input is deactivated. The first push of the **Ctrl** button clears Alarm Text 1 and its corresponding LED. Alarm Text 2 and its corresponding LED are not affected because Digital Input 2 is not yet deactivated. By the time the **Ctrl** button is pushed a second time Digital Input 2 is deactivated and Alarm Text 2 is also cleared alongside its alarm LED.

Clearing an individual alarm

An individual activated alarm can be cleared by choosing the alarm in the *Alarm* view and by pressing the **Enter** button in the device front panel which leads to a menu with commands.

Table. 4.3 - 11. Available commands when an alarm has been selected in the *Alarm* view.

Command	Description
Clear	Clears the selected alarm (if the activating signal is off).
Clear all	Clears all alarms.
Mute buzzer	Mutes the buzzer.
Back	Goes back to the <i>Alarms</i> view.

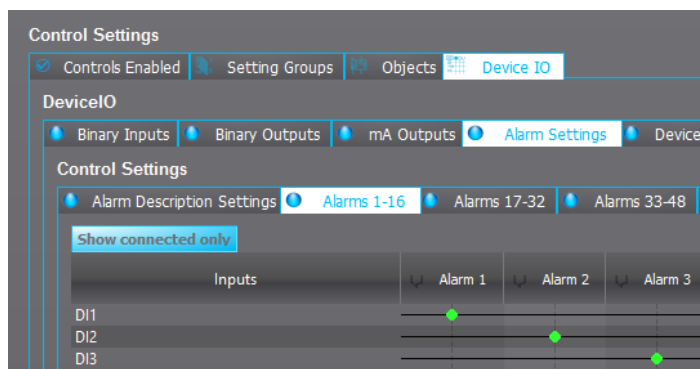
Buzzer activation and deactivation

AQ-S214 and AQ-S254 Alarming devices do not 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 pressing the **Back** button located in the device panel, or by connecting a digital input or some other binary signal in the logic to SILENCE ALARM BUZZER.

Clearing latched signals

Figure. 4.3 - 42. Latched signals as dots.



Latched signals are represented by filled green circles in the matrix, whereas connected but unlatched signals are unfilled green circles.

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

Events and registers

The alarm function generates events and registers 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 ON
ALARM1	Alarm 1 OFF
ALARM1	Alarm 2 ON
ALARM1	Alarm 2 OFF
ALARM1	Alarm 3 ON
ALARM1	Alarm 3 OFF
ALARM1	Alarm 4 ON
ALARM1	Alarm 4 OFF
ALARM1	Alarm 5 ON
ALARM1	Alarm 5 OFF
ALARM1	Alarm 6 ON
ALARM1	Alarm 6 OFF
ALARM1	Alarm 7 ON
ALARM1	Alarm 7 OFF
ALARM1	Alarm 8 ON
ALARM1	Alarm 8 OFF
ALARM1	Alarm 9 ON
ALARM1	Alarm 9 OFF
ALARM1	Alarm 10 ON
ALARM1	Alarm 10 OFF
ALARM1	Alarm 11 ON
ALARM1	Alarm 11 OFF
ALARM1	Alarm 12 ON
ALARM1	Alarm 12 OFF
ALARM1	Alarm 13 ON
ALARM1	Alarm 13 OFF
ALARM1	Alarm 14 ON
ALARM1	Alarm 14 OFF
ALARM1	Alarm 15 ON
ALARM1	Alarm 15 OFF

Event block name	Event name
ALARM1	Alarm 16 ON
ALARM1	Alarm 16 OFF
ALARM1	Alarm 17 ON
ALARM1	Alarm 17 OFF
ALARM1	Alarm 18 ON
ALARM1	Alarm 18 OFF
ALARM1	Alarm 19 ON
ALARM1	Alarm 19 OFF
ALARM1	Alarm 20 ON
ALARM1	Alarm 20 OFF
ALARM1	Alarm 21 ON
ALARM1	Alarm 21 OFF
ALARM1	Alarm 22 ON
ALARM1	Alarm 22 OFF
ALARM1	Alarm 23 ON
ALARM1	Alarm 23 OFF
ALARM1	Alarm 24 ON
ALARM1	Alarm 24 OFF
ALARM1	Alarm 25 ON
ALARM1	Alarm 25 OFF
ALARM1	Alarm 26 ON
ALARM1	Alarm 26 OFF
ALARM1	Alarm 27 ON
ALARM1	Alarm 27 OFF
ALARM1	Alarm 28 ON
ALARM1	Alarm 28 OFF
ALARM1	Alarm 29 ON
ALARM1	Alarm 29 OFF
ALARM1	Alarm 30 ON
ALARM1	Alarm 30 OFF
ALARM1	Alarm 31 ON

Event block name	Event name
ALARM1	Alarm 31 OFF
ALARM1	Alarm 32 ON
ALARM1	Alarm 32 OFF
ALARM2	Alarm 33 ON
ALARM2	Alarm 33 OFF
ALARM2	Alarm 34 ON
ALARM2	Alarm 34 OFF
ALARM2	Alarm 35 ON
ALARM2	Alarm 35 OFF
ALARM2	Alarm 36 ON
ALARM2	Alarm 36 OFF
ALARM2	Alarm 37 ON
ALARM2	Alarm 37 OFF
ALARM2	Alarm 38 ON
ALARM2	Alarm 38 OFF
ALARM2	Alarm 39 ON
ALARM2	Alarm 39 OFF
ALARM2	Alarm 40 ON
ALARM2	Alarm 40 OFF
ALARM2	Alarm 41 ON
ALARM2	Alarm 41 OFF
ALARM2	Alarm 42 ON
ALARM2	Alarm 42 OFF
ALARM2	Alarm 43 ON
ALARM2	Alarm 43 OFF
ALARM2	Alarm 44 ON
ALARM2	Alarm 44 OFF
ALARM2	Alarm 45 ON
ALARM2	Alarm 45 OFF
ALARM2	Alarm 46 ON
ALARM2	Alarm 46 OFF

Event block name	Event name
ALARM2	Alarm 47 ON
ALARM2	Alarm 47 OFF
ALARM2	Alarm 48 ON
ALARM2	Alarm 48 OFF
ALARM2	Alarm 49 ON
ALARM2	Alarm 49 OFF
ALARM2	Alarm 50 ON
ALARM2	Alarm 50 OFF
ALARM2	Alarm 51 ON
ALARM2	Alarm 51 OFF
ALARM2	Alarm 52 ON
ALARM2	Alarm 52 OFF
ALARM2	Alarm 53 ON
ALARM2	Alarm 53 OFF
ALARM2	Alarm 54 ON
ALARM2	Alarm 54 OFF
ALARM2	Alarm 55 ON
ALARM2	Alarm 55 OFF
ALARM2	Alarm 56 ON
ALARM2	Alarm 56 OFF
ALARM2	Alarm 57 ON
ALARM2	Alarm 57 OFF
ALARM2	Alarm 58 ON
ALARM2	Alarm 58 OFF
ALARM2	Alarm 59 ON
ALARM2	Alarm 59 OFF
ALARM2	Alarm 60 ON
ALARM2	Alarm 60 OFF
ALARM2	Alarm 61 ON
ALARM2	Alarm 61 OFF
ALARM2	Alarm 62 ON

Event block name	Event name
ALARM2	Alarm 62 OFF
ALARM2	Alarm 63 ON
ALARM2	Alarm 63 OFF
ALARM2	Alarm 64 ON
ALARM2	Alarm 64 OFF

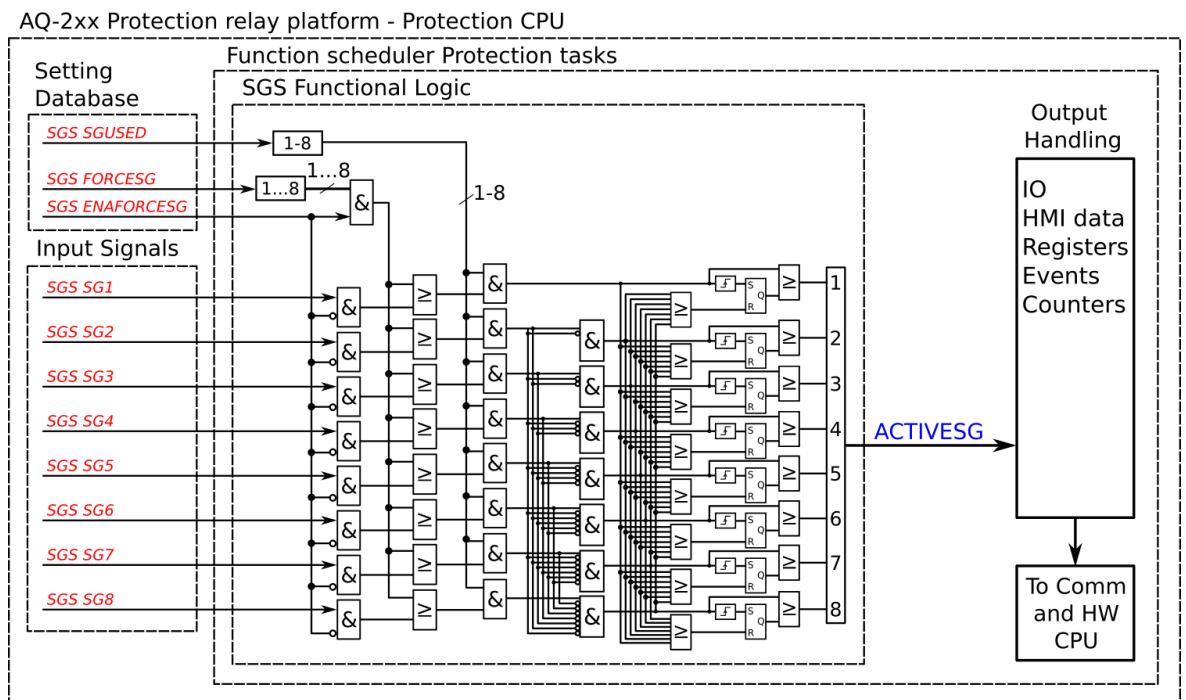
4.4 Control functions

4.4.1 Setting group selection

All relay 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.

The following figure presents a simplified function block diagram of the setting group selection function.

Figure. 4.4.1 - 43. Simplified function block diagram of the setting group selection function.

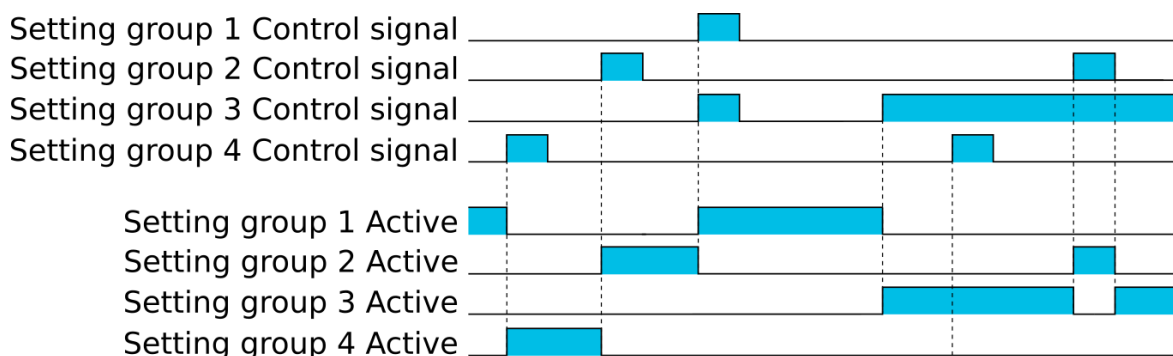


Setting group selection can be applied to each of the setting groups individually by activating one of the various internal logic inputs and connected digital inputs. The user can also force any of the setting groups on when the "Force SG change" setting is enabled by giving the wanted quantity of setting 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 - 44. 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	0: SG1 1: SG2 2: SG3 3: SG4 4: SG5 5: SG6 6: SG7 7: SG8	SG1	Displays which setting group is active.
Force setting group	0: None 1: SG1 2: SG2 3: SG3 4: SG4 5: SG5 6: SG6 7: SG7 8: SG8	0: None	The selection of the overriding setting group. After "Force SG change" is enabled, any of the configured setting groups in the relay 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.

Name	Range	Default	Description
Force setting group change	0: Disabled 1: Enabled	0: 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.
Used setting groups	0: SG1 1: SG1...2 2: SG1...3 3: SG1...4 4: SG1...5 5: SG1...6 6: SG1...7 7: SG1...8	0: SG1	The selection of the activated setting groups in the application. Newly-enabled setting groups use default parameter values.
Remote setting group change	0: None 1: SG1 2: SG2 3: SG3 4: SG4 5: SG5 6: SG6 7: SG7 8: SG8	0: 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.

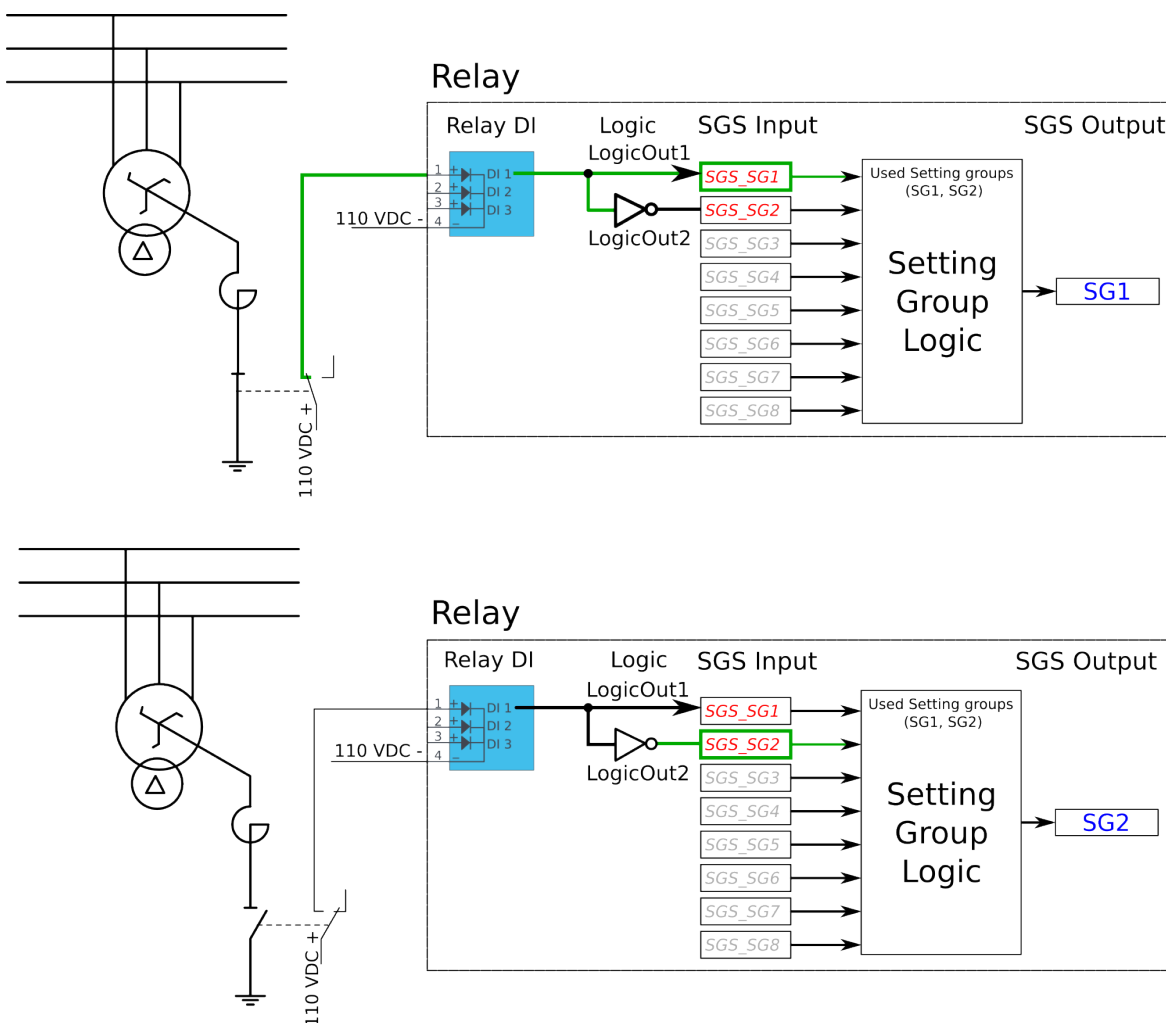
Name	Description
Setting group 7	The selection of Setting group 7 ("SG7"). Has the second lowest priority input in setting group control. Can be controlled with pulses or static signals. If static signal control is applied, only SG8 requests will not be processed.
Setting group 8	The selection of Setting 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.

Example applications for setting group control

This chapter presents some of the most common applications for setting group changing requirements.

A Petersen coil compensated network usually uses directional sensitive earth fault protection. The user needs to control its characteristics between varmetric and wattmetric; the selection is based on whether the Petersen coil is connected when the network is compensated, or whether it is open when the network is unearthed.

Figure. 4.4.1 - 45. Setting group control – one-wire connection from Petersen coil status.



Depending on the application's requirements, the setting group control can be applied either with a one-wire connection or with a two-wire connection by monitoring the state of the Petersen coil connection.

When the connection is done with one wire, the setting group change logic can be applied as shown in the figure above. The status of the Petersen coil controls whether Setting group 1 is active. If the coil is disconnected, Setting group 2 is active. This way, if the wire is broken for some reason, the setting group is always controlled to SG2.

Figure. 4.4.1 - 46. Setting group control – two-wire connection from Petersen coil status.

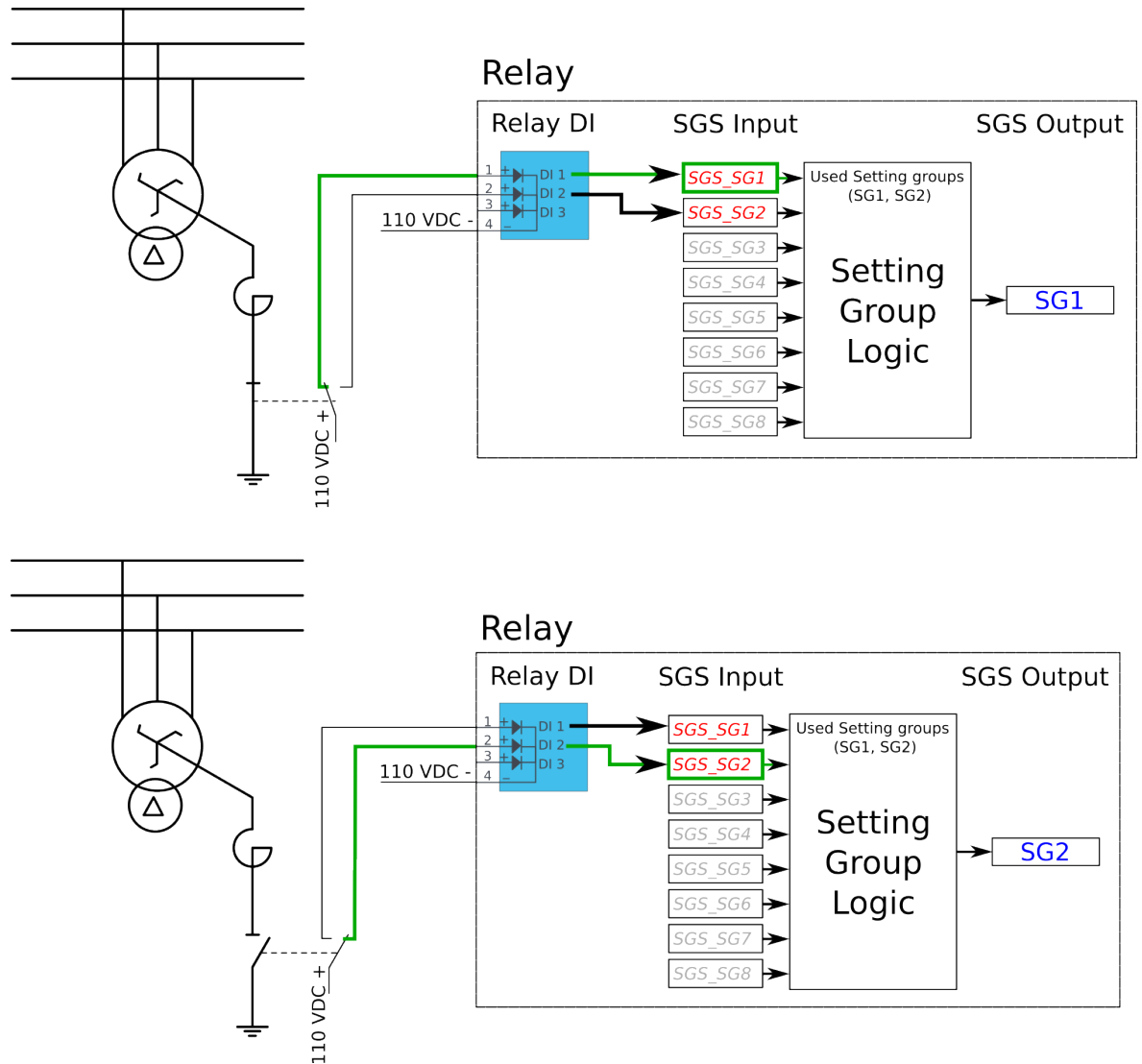
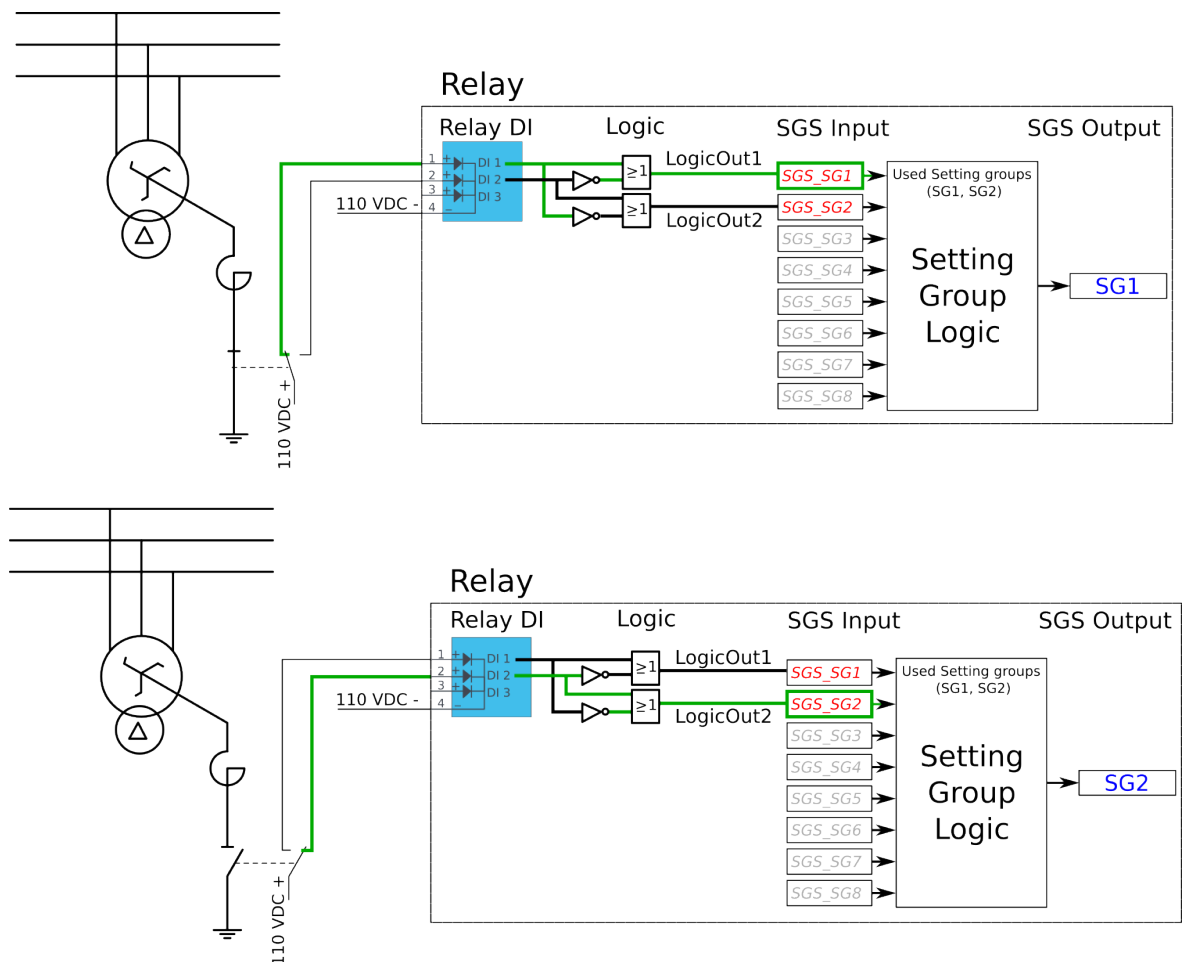


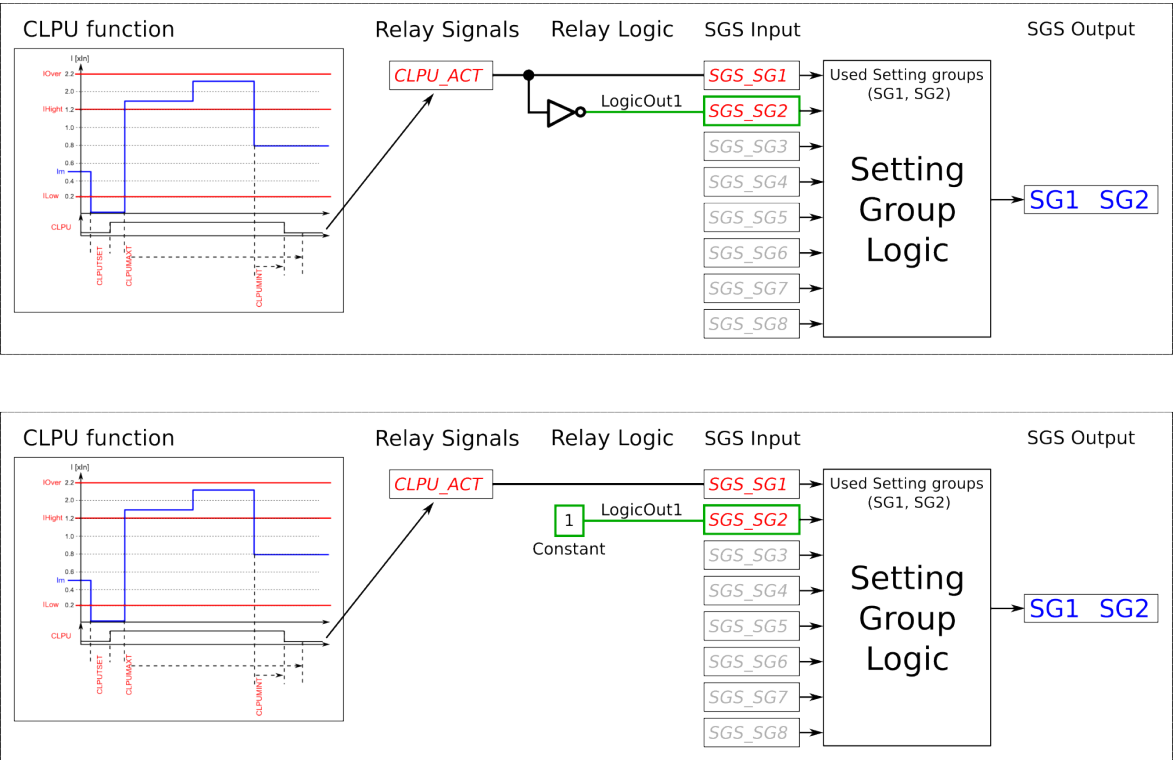
Figure. 4.4.1 - 47. Setting group control – two-wire connection from Petersen coil status with additional logic.



The images above depict a two-wire connection from the Petersen coil: the two images at the top show a direct connection, while the two images on the bottom include additional logic. With a two-wire connection the state of the Petersen coil can be monitored more securely. The additional logic ensures that a single wire loss will not affect the correct setting group selection.

The application-controlled setting group change can also be applied entirely from the relay's internal logics. For example, the setting group change can be based on the cold load pick-up function (see the image below).

Figure. 4.4.1 - 48. Entirely application-controlled setting group change with the cold load pick-up function.



In these examples the cold load pick-up function's output is used for the automatic setting group change. Similarly to this application, any combination of the signals available in the relay's database can be programmed to be used in the setting group selection logic.

As all these examples show, setting group selection with application control has to be built fully before they can be used for setting group control. The setting group does not change back to SG1 unless it is controlled back to SG1 by this application; this explains the inverted signal NOT as well as the use of logics in setting group control. One could also have SG2 be the primary SG, while the ON signal would be controlled by the higher priority SG1; this way the setting group would automatically return to SG2 after the automatic control is over.

Events

The setting group selection function block (abbreviated "SGS" in event block names) generates events from its controlling status, its applied input signals, enabling and disabling of setting groups, as well as unsuccessful control changes. The function does not have a register.

Table. 4.4.1 - 15. Event messages.

Event block name	Event names
SGS	SG2 Enabled
SGS	SG2 Disabled
SGS	SG3 Enabled
SGS	SG3 Disabled
SGS	SG4 Enabled
SGS	SG4 Disabled

Event block name	Event names
SGS	SG5 Enabled
SGS	SG5 Disabled
SGS	SG6 Enabled
SGS	SG6 Disabled
SGS	SG7 Enabled
SGS	SG7 Disabled
SGS	SG8 Enabled
SGS	SG8 Disabled
SGS	SG1 Request ON
SGS	SG1 Request OFF
SGS	SG2 Request ON
SGS	SG2 Request OFF
SGS	SG3 Request ON
SGS	SG3 Request OFF
SGS	SG4 Request ON
SGS	SG4 Request OFF
SGS	SG5 Request ON
SGS	SG5 Request OFF
SGS	SG6 Request ON
SGS	SG6 Request OFF
SGS	SG7 Request ON
SGS	SG7 Request OFF
SGS	SG8 Request ON
SGS	SG8 Request OFF
SGS	Remote Change SG Request ON
SGS	Remote Change SG Request OFF
SGS	Local Change SG Request ON
SGS	Local Change SG Request OFF
SGS	Force Change SG ON
SGS	Force Change SG OFF
SGS	SG Request Fail Not configured SG ON

Event block name	Event names
SGS	SG Request Fail Not configured SG OFF
SGS	Force Request Fail Force ON
SGS	Force Request Fail Force OFF
SGS	SG Req. Fail Lower priority Request ON
SGS	SG Req. Fail Lower priority Request OFF
SGS	SG1 Active ON
SGS	SG1 Active OFF
SGS	SG2 Active ON
SGS	SG2 Active OFF
SGS	SG3 Active ON
SGS	SG3 Active OFF
SGS	SG4 Active ON
SGS	SG4 Active OFF
SGS	SG5 Active ON
SGS	SG5 Active OFF
SGS	SG6 Active ON
SGS	SG6 Active OFF
SGS	SG7 Active ON
SGS	SG7 Active OFF
SGS	SG8 Active ON
SGS	SG8 Active 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 relay's configured digital inputs and outputs. The number of controllable and monitored objects in each relay 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 relays front panel (HMI) or by external push buttons connected to relays 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).

Object control consists of the following:

- control logic
- control monitor
- output handler.

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.

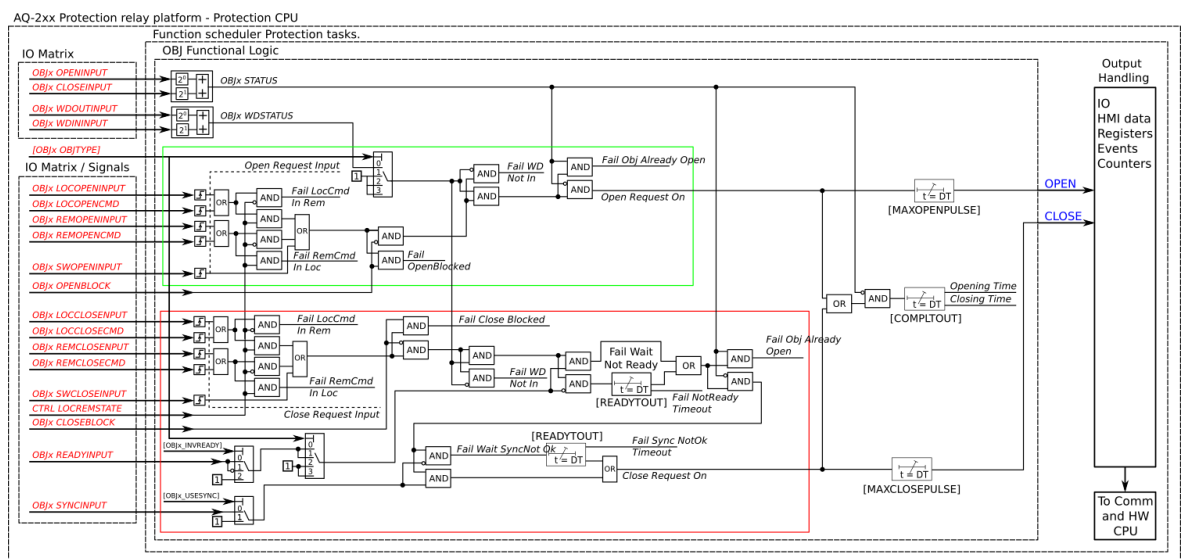
The inputs for the function are the following:

- digital input status indications (the OPEN and CLOSE status signals)
- blockings (if applicable)
- the OBJECT READY and SYNCHROCHECK monitor signals (if applicable).
- Withdrawable cart IN and OUT status signals (if applicable).

The function generates general time stamped ON/OFF events to the common event buffer from each of the two (2) output signals as well as several operational event signals. The time stamp resolution is 1 ms. The function also provides a resettable cumulative counter for OPEN, CLOSE, OPEN FAILED, and CLOSE FAILED events.

The following figure presents a simplified function block diagram of the object control and monitoring function.

Figure. 4.4.2 - 49. 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	0: Local 1: Remote	1: Remote	Displays the status of the relay'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	0: Normal 1: Openreq On 2: Closereq On 3: Opensignal On 4: Closesignal On 5: WaitNoRdy On 6: WaitNoSnc On 7: NotrdyFail On 8: NosyncFail On 9: Opentout On 10: Clotout On 11: OpenreqUSR On 12: CloreqUSR On	0: Normal	Force the status of the function. Visible only when <i>Enable stage forcing</i> parameter is enabled in <i>General</i> menu.
Object name	-	Objectx	The user-set name of the object, at maximum 32 characters long.
Object type	0: Withdrawable circuit breaker 1: Circuit breaker 2: Disconnecter (MC) 3: Disconnecter (GND)	1: 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	0: Intermediate 1: Open 2: Closed 3: 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	0: WDIntermediate 1: WDCartOut 2: WDCart In 3: WDBad 4: 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.

Name	Range	Default	Description
Additional status information	0: Open Blocked 1: Open Allowed 2: Close Blocked 3: Close Allowed 4: Object Ready 5: Object Not Ready 6: Sync Ok 7: Sync Not Ok	-	Displays additional information about the status of the object.
Use Synchrocheck	0: Not in use 1: Synchrocheck in use	0: 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	0: Ready High 1: Ready Low 2: Not in use	2: 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...2 ³² -1	-	Displays the number of successful "Open" requests.
Close requests	0...2 ³² -1	-	Displays the number of successful "Close" requests.
Open requests failed	0...2 ³² -1	-	Displays the number of failed "Open" requests.
Close requests failed	0...2 ³² -1	-	Displays the number of failed "Close" requests.
Clear statistics	0: - 1: Clear	0: -	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.

Name	Functionalities	Description
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 input ("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 input ("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.
WD Object In ("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.
WD Object Out ("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.
Object Ready (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.
Syncrocheck permission ("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 ("Objectx Open Command")	OUT1...OUTx	The physical "Open" command pulse to the device's output relay.
Objectx Close command ("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.
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).

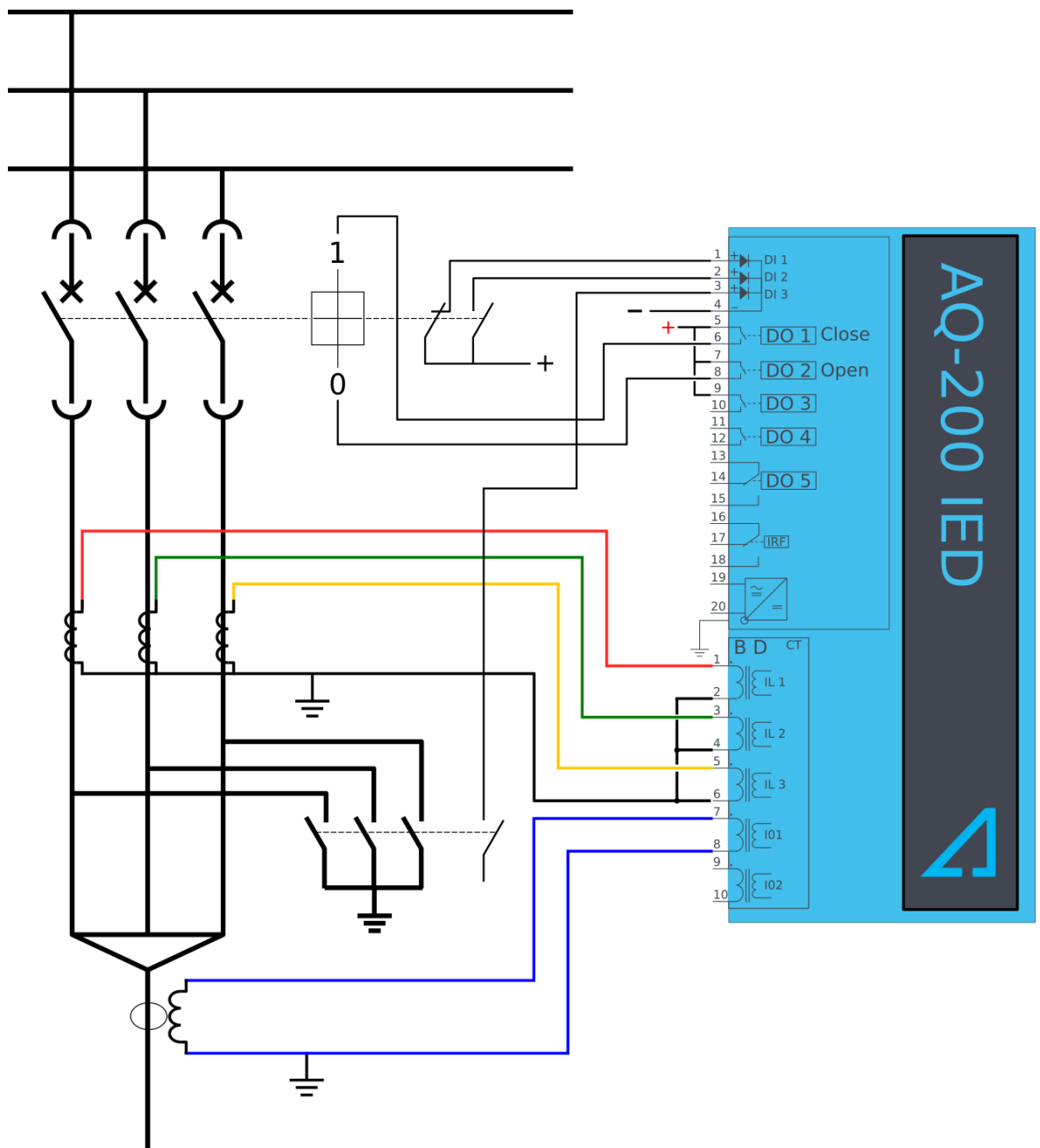
Signal	Range	Description
Access level for MIMIC control	0: User 1: Operator 2: Configurator 3: Super user	Defines what level of access is required for MIMIC control. The default is the "Configurator" level.
Objectx LOCAL Close control input	Digital input or other logical signal selected by the user	The 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.

The image below presents an example of an interlock application, where the closed earthing switch interlocks the circuit breaker close command.

Figure. 4.4.2 - 50. Example of an interlock application.



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

Events and registers

The object control and monitoring function (abbreviated "OBJ" in event block names) generates events and registers from the status changes in monitored signals as well as control command fails and operations. The user can select which event messages are stored in the main event buffer: ON, OFF, or both.

The function registers its operation into the last twelve (12) time-stamped registers. The events triggered by the function are recorded with a time stamp and with process data values.

Table. 4.4.2 - 21. Event messages of the OBJ function instances 1 – 10.

Event block name	Description
OBJ1...OBJ10	Object Intermediate
OBJ1...OBJ10	Object Open
OBJ1...OBJ10	Object Close
OBJ1...OBJ10	Object Bad
OBJ1...OBJ10	WD Intermediate
OBJ1...OBJ10	WD Out
OBJ1...OBJ10	WD in
OBJ1...OBJ10	WD Bad
OBJ1...OBJ10	Open Request On
OBJ1...OBJ10	Open Request Off
OBJ1...OBJ10	Open Command On
OBJ1...OBJ10	Open Command Off
OBJ1...OBJ10	Close Request On
OBJ1...OBJ10	Close Request Off
OBJ1...OBJ10	Close Command On
OBJ1...OBJ10	Close Command Off
OBJ1...OBJ10	Open Blocked On
OBJ1...OBJ10	Open Blocked Off
OBJ1...OBJ10	Close Blocked On
OBJ1...OBJ10	Close Blocked Off
OBJ1...OBJ10	Object Ready
OBJ1...OBJ10	Object Not Ready
OBJ1...OBJ10	Sync Ok
OBJ1...OBJ10	Sync Not Ok

Event block name	Description
OBJ1...OBJ10	Open Command Fail
OBJ1...OBJ10	Close Command Fail
OBJ1...OBJ10	Final trip On
OBJ1...OBJ10	Final trip Off
OBJ1...OBJ10	Contact Abrasion Alarm On
OBJ1...OBJ10	Contact Abrasion Alarm Off
OBJ1...OBJ10	Switch Operating Time Exceeded On
OBJ1...OBJ10	Switch Operating Time Exceeded Off
OBJ1...OBJ10	XCBR Loc On
OBJ1...OBJ10	XCBR Loc Off
OBJ1...OBJ10	XSWI Loc On
OBJ1...OBJ10	XSWI LOC Off

Table. 4.4.2 - 22. Register content.

Name	Description
Date and time	dd.mm.yyyy hh:mm:ss.mss
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 relay's digital inputs. The number of monitored indicators in a relay 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 - 23. Indicator status.

Name	Range	Default	Description
Indicator name ("Ind. Name")	-	IndX	The user-set name of the object, at maximum 32 characters long.
IndicatorX Object status ("Ind.X Object Status")	0: Intermediate 1: Open 2: Closed 3: 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 - 24. 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 monitored signals, including the continuous status indications. The user can select which event messages are stored in the main event buffer: ON, OFF, or both.

Table. 4.4.3 - 25. Event messages (instances 1 – 5).

Event block name	Event names
CIN1...5	Intermediate
CIN1...5	Open
CIN1...5	Close
CIN1...5	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

AQ-200 series 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.

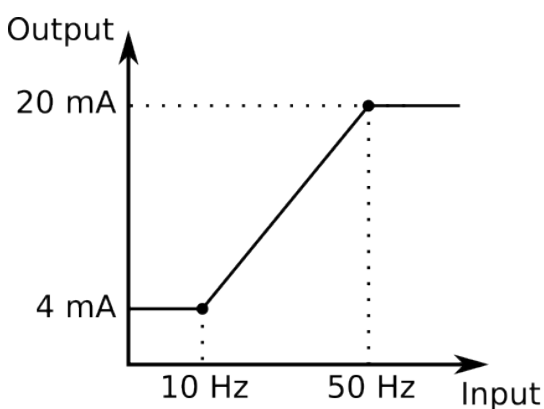
Table. 4.4.4 - 26. Main settings (output channels).

Name		Range	Default	Description
mA option card 1	Enable mA output channels 1 and 2	0: Disabled 1: Enabled	0: 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	0: Disabled 1: Enabled	0: Disabled	Enables and disables the outputs of the mA output card 2.
	Enable mA output channels 7 and 8			

Table. 4.4.4 - 27. Settings for mA output channels.

Name	Range	Step	Default	Description
Enable mA output channel	0: Disabled 1: Enabled	-	0: 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	0: Currents 1: Voltages 2: Powers 3: Impedance and admittance 4: Other	-	0: 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.
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 - 51. Example of the effects of mA output channel settings.



mA Output Channel 1

Enable mA Out Channel 1:

mA Out Channel 1 Magnitude selection:

mA Out Channel 1 Magnitude (Others):

Input value 1: -100000000.000...100000000.000 [0.001]

Scaled mA output value 1: 0.00000...24.00000 [0.00010] mA

Input value 2: -100000000.000...100000000.000 [0.001]

Scaled mA output value 2: 0.00000...24.00000 [0.00010] mA

mA Out Channel 1 Input Magnitude now: -100000000.000...100000000.000 [0.001]

mA Out Channel 1 Outputs now: 0.00000...24.00000 [0.00010] mA

Table. 4.4.4 - 28. Hardware indications.

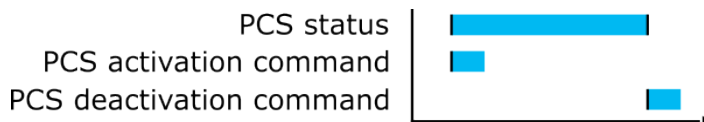
Name	Range	Step	Description
Hardware in mA output channels 1...4	0: None	-	Indicates the option card slot where the mA output card is located.
Hardware in mA output channels 5...8	1: Slot A		
	2: Slot B		
	3: Slot C		
	4: Slot D		
	5: Slot E		
	6: Slot F		

Table. 4.4.4 - 29. 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 relay's mimic (displayed as a box in the 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).



Settings.

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

Table. 4.4.5 - 30. 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	0: User 1: Operator 2: Configurator 3: Super user	2: 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 status changes. The user can select which event messages are stored in the main event buffer: ON, OFF, or both. The function offers five (5) independent switches.

Table. 4.4.5 - 31. Event messages.

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

4.4.6 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 "mA output & mA input" option cards
- Digital input voltages

Table. 4.4.6 - 32. Main settings (input channel).

Name	Range	Step	Default	Description
Analog input scaling	0: Disabled 1: Activated	-	0: Disabled	Enables and disables the input.
Scaling curve 1...4	0: Disabled 1: Activated	-	0: Disabled	Enables and disables the scaling curve and the input measurement.
Curve 1...4 input signal select	0: S7 mA Input 1: S8 mA Input 2: S15 mA Input 3: S16 mA Input 4: DI1 Voltage ... 23: DI20 Voltage 24: RTD S1 Resistance ... 39: RTD S16 Resistance 40: mA In 1 (I card 1) 41: mA In 2 (I card 2)	-	0: S7 mA Input	Defines the measurement used by scaling curve.
Curve 1...4 input signal filtering	0: No 1: Yes	-	0: No	Enables calculation of the average of received signal.
Curve 1...4 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...4 input signal out of range set	0: No 1: Yes	-	0: 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...4 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...4 input	-1 000 000.00...1 000 000.00	0.00001	-	Displays the input measurement received by the curve.
Curve1...4 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...4 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...4 input out of range" signal, which can be used inside logic or with other relay functions. 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.

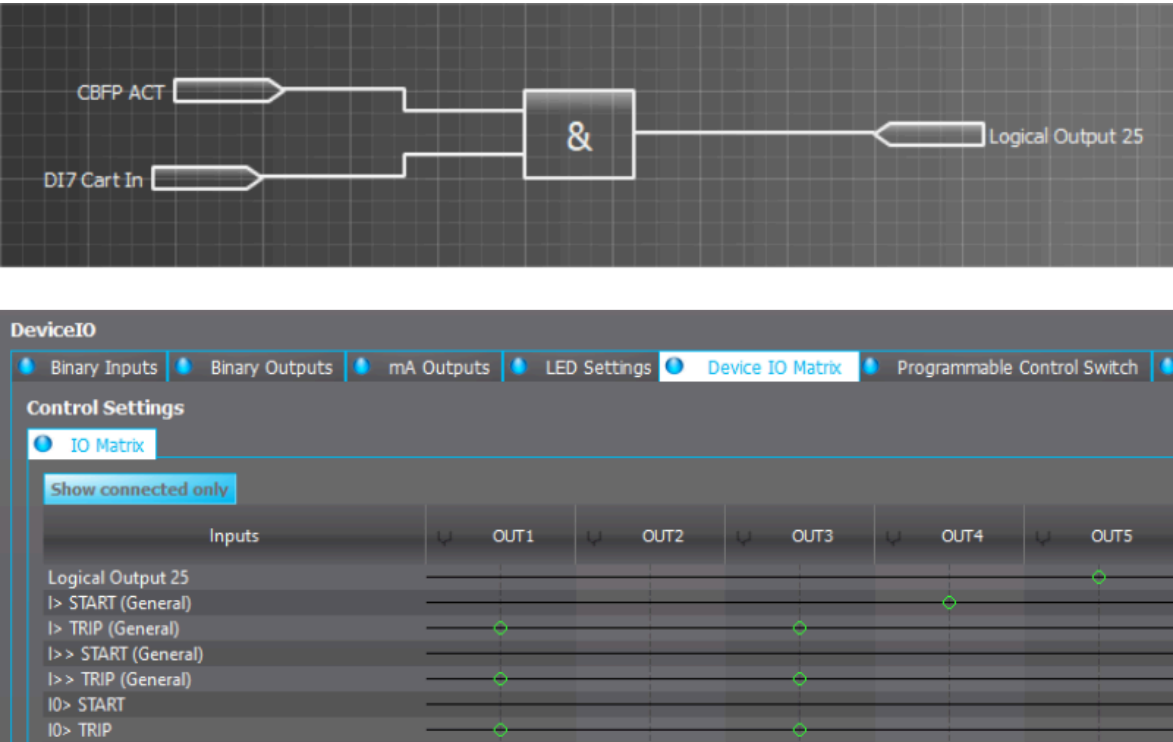
Table. 4.4.6 - 33. Output settings and indications.

Name	Range	Step	Default	Description
Curve 1...4 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.
Scaled value handling	0: Floating point 1: Integer out (Floor) 2: Integer (Ceiling) 3: Integer (Nearest)	-	0: 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 ...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 ...10 ⁷	0.000 01	0	Scales the measured milliampere signal at Point 2.
Add curvepoint 3...20	0: Not used 1: Used	-	0: 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.

4.4.7 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. 32 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 5 ("OUT5") when the circuit breaker's cart status is "In".

Figure. 4.4.7 - 52. 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
-
-
- etc.

Table. 4.4.7 - 34. Logical output user description.

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

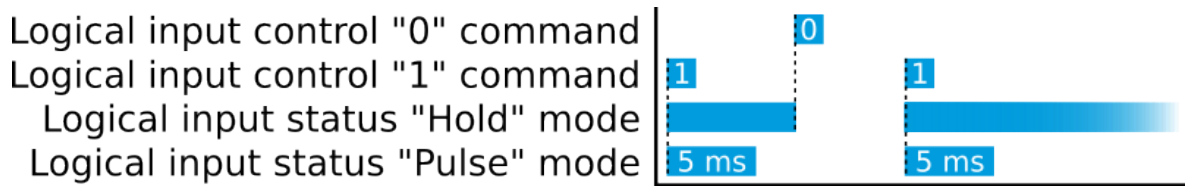
4.4.8 Logical inputs

Logical inputs are binary signals that a user can control manually to change the behavior of the AQ-200 unit 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 AQ-200 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.

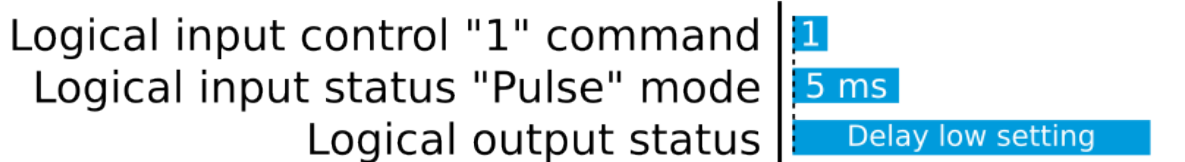
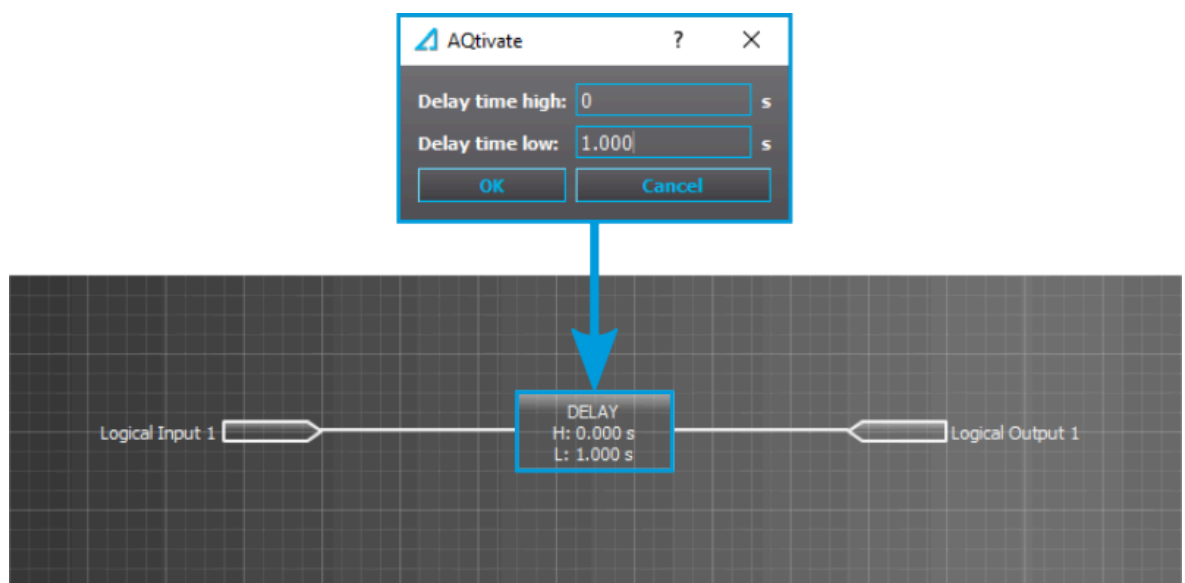
The figure below presents the operation of a logical input in Hold mode and in Pulse mode.

Figure. 4.4.8 - 53. 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. 4.4.8 - 54. 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
-
-
- etc.

Table. 4.4.8 - 35. Logical input user description.

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

4.5 Monitoring functions

4.5.1 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. The recorder also supports 95 digital channels simultaneously with the twenty (20) measured analog channels. Maximum capacity of recordings is 100.

The recorder provides a great 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 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

Up to 20 analog recording channels and 95 digital channels are supported.

Table. 4.5.1 - 36. Analog recording channels.

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

Signal	Description
I02"f	Residual current I ₀₂ fine* (CT card 2)
U1(2)VT1	Line-to-neutral U _{L1} or line-to-line voltage U ₁₂ (VT card 1)
U2(3)VT1	Line-to-neutral U _{L2} or line-to-line voltage U ₂₃ (VT card 1)
U3(1)VT1	Line-to-neutral U _{L3} or line-to-line voltage U ₃₁ (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 2)
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 ₁₂ (VT card 2)
UL2(3)VT2	Line-to-neutral U _{L2} or line-to-line voltage U ₂₃ (VT card 2)
UL3(1)VT2	Line-to-neutral U _{L3} or line-to-line voltage U ₃₁ (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. 4.5.1 - 37. 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

Table. 4.5.1 - 38. Digital recording channels – Measurements.

Signal	Description	Signal	Description
Currents			
Pri.Pha.curr.ILx	Primary phase current ILx (IL1, IL2, IL3)	Pha.curr.ILx TRMS Pri	Primary phase current TRMS (IL1, IL2, IL3)
Pha.angle ILx	Phase angle ILx (IL1, IL2, IL3)	Pos./Neg./Zero seq.curr.	Positive/Negative/Zero sequence current
Pha.curr.ILx	Phase current ILx (IL1, IL2, IL3)	Sec.Pos./Neg./Zero seq.curr.	Secondary positive/negative/zero sequence current
Sec.Pha.curr.ILx	Secondary phase current ILx (IL1, IL2, IL3)	Pri.Pos./Neg./Zero seq.curr.	Primary positive/negative/zero sequence current
Pri.Res.curr.I0x	Primary residual current I0x (I01, I02)	Pos./Neg./Zero seq.curr.angle	Positive/Negative/Zero sequence current angle
Res.curr.angle I0x	Residual current angle I0x (I01, I02)	Res.curr.I0x TRMS	Residual current TRMS I0x (I01, I02)
Res.curr.I0x	Residual current I0x (I01, I02)	Res.curr.I0x TRMS Sec	Secondary residual current TRMS I0x (I01, I02)
Sec.Res.curr.I0x	Secondary residual current I0x (I01, I02)	Res.curr.I0x TRMS Pri	Primary residual current TRMS I0x (I01, I02)
Pri.cal.I0	Primary calculated I0	Pha.Lx ampl. THD	Phase Lx amplitude THD (L1, L2, L3)
Sec.calc.I0	Secondary calculated I0	Pha.Lx pow. THD	Phase Lx power THD (L1, L2, L3)
calc.I0	Calculated I0	Res.I0x ampl. THD	Residual I0x amplitude THD (I01, I02)
calc.I0 Pha.angle	Calculated I0 phase angle	Res.I0x pow. THD	Residual I0x power THD (I01, I02)
Pha.curr.ILx TRMS	Phase current TRMS ILx (IL1, IL2, IL3)	P-P curr.ILx	Phase-to-phase current ILx (IL1, IL2, IL3)
Pha.curr.ILx TRMS Sec	Secondary phase current TRMS (IL1, IL2, IL3)	P-P curr.I0x	Phase-to-phase current I0x (I01, I02)
Voltages			

Signal	Description	Signal	Description
Ux Volt p.u.	Ux voltage in per-unit values (U1, U2, U3, U4)	System volt ULxx mag	Magnitude of the system voltage ULxx (UL12, UL23, UL31)
Ux Volt pri	Primary Ux voltage (U1, U2, U3, U4)	System volt ULxx mag(kV)	Magnitude of the system voltage ULxx in kilovolts (UL12, UL23, UL31)
Ux Volt sec	Secondary Ux voltage (U1, U2, U3, U4)	System volt ULxx ang	Angle of the system voltage ULxx (UL12, UL23, UL31)
Ux Volt TRMS p.u.	Ux voltage TRMS in per-unit values (U1, U2, U3, U4)	System volt ULx mag	Magnitude of the system voltage ULx (U1, U2, U3, U4)
Ux Volt TRMS pri	Primary Ux voltage TRMS (U1, U2, U3, U4)	System volt ULx mag(kV)	Magnitude of the system voltage ULx in kilovolts (U1, U2, U3, U4)
Ux Volt TRMS sec	Secondary Ux voltage TRMS (U1, U2, U3, U4)	System volt ULx ang	Angle of the system voltage ULx (U1, U2, U3, U4)
Pos./Neg./Zero seq.Volt.p.u.	Positive/Negative/Zero sequence voltage in per-unit values	System volt U0 mag	Magnitude of the system voltage U0
Pos./Neg./Zero seq.Volt.pri	Primary positive/negative/zero sequence voltage	System volt U0 mag(kV)	Magnitude of the system voltage U0 in kilovolts
Pos./Neg./Zero seq.Volt.sec	Secondary positive/negative/zero sequence voltage	System volt U0 mag(%)	Magnitude of the system voltage U0 in percentages
Ux Angle	Ux angle (U1, U2, U3, U4)	System volt U0 ang	Angle of the system voltage U0
Pos./Neg./Zero Seq volt.Angle	Positive/Negative/Zero sequence voltage angle	Ux Angle difference	Ux angle difference (U1, U2, U3)
Resistive and reactive currents			
ILx Resistive Current p.u.	ILx resistive current in per-unit values (IL1, IL2, IL3)	Pos.seq. Resistive Current Pri.	Primary positive sequence resistive current
ILx Reactive Current p.u.	ILx reactive current in per-unit values (IL1, IL2, IL3)	Pos.seq. Reactive Current Pri.	Primary positive sequence reactive current
Pos.Seq. Resistive Current p.u.	Positive sequence resistive current in per-unit values	I0x Residual Resistive Current Pri.	Primary residual resistive current I0x (I01, I02)
Pos.Seq. Reactive Current p.u.	Positive sequence reactive current in per-unit values	I0x Residual Reactive Current Pri.	Primary residual reactive current I0x (I01, I02)

Signal	Description	Signal	Description
I0x Residual Resistive Current p.u.	I0x residual resistive current in per-unit values (I01, I02)	ILx Resistive Current Sec.	Secondary resistive current ILx (IL1, IL2, IL3)
I0x Residual Reactive Current p.u.	I0x residual ractive current in per-unit values (I01, I02)	ILx Reactive Current Sec.	Secondary reactive current ILx (IL1, IL2, IL3)
ILx Resistive Current Pri.	Primary resistive current ILx (IL1, IL2, IL3)	I0x Residual Resistive Current Sec.	Secondary residual resistive current I0x (I01, I02)
ILx Reactive Current Pri.	Primary reactive current ILx (IL1, IL2, IL3)	I0x Residual Reactive Current Sec.	Secondary residual reactive current I0x (I01, I02)
Power, GYB, frequency			
Lx PF	Lx power factor (L1, L2, L3)	Curve x Input	Input of Curve x (1, 2, 3, 4)
POW1 3PH Apparent power (S)	Three-phase apparent power	Curve x Output	Output of Curve x (1, 2, 3, 4)
POW1 3PH Apparent power (S MVA)	Three-phase apparent power in megavolt-amperes	Enablebasedfunctions(VT1)	Enable frequency-based functions
POW1 3PH Active power (P)	Three-phase active power	Track.sys.f.	Tracked system frequency
POW1 3PH Active power (P MW)	Three-phase active power in megawatts	Sampl.f. used	Used sample frequency
POW1 3PH Reactive power (Q)	Three-phase reactive power	Tr f CH x	Tracked frequency (channels A, B, C)
POW1 3PH Reactive power (Q MVar)	Three-phase reactive power in megavars	Alg f Fast	Fast frequency algorithm
POW1 3PH Tan(phi)	Three-phase tangent phi	Alg f avg	Average frequency algorithm
POW1 3PH Cos(phi)	Three-phase cosine phi	Frequency based protections blocked	When true ("1"), all frequency-based protections are blocked.
3PH PF	Three-phase power factor	f atm. Protections (when not measurable returns to nominal)	Frequency at the moment. If the system nominal is set to 50 Hz, this will show "50 Hz".
Neutral conductance G (Pri)	Primary neutral conductance	f atm. Display (when not measurable is 0 Hz)	Frequency at the moment. If the frequency is not measurable, this will show "0 Hz".
Neutral susceptance B (Pri)	Primary neutral susceptance	f meas qlty	Quality of tracked frequency

Signal	Description	Signal	Description
Neutral admittance Y (Pri)	Primary neutral admittance	f meas from	Indicates which of the three voltage or current channel frequencies is used by the relay.
Neutral admittance Y (Ang)	Neutral admittance angle	SS1.meas.frqs	Synchrocheck – the measured frequency from voltage channel 1
I01 Resistive component (Pri)	Primary resistive component I01	SS2.meas.frqs	Synchrocheck – the measured frequency from voltage channel 2
I01 Capacitive component (Pri)	Primary capacitive component I01	Enable f based functions	Status of this signal is active when frequency-based protection functions are enabled.

Table. 4.5.1 - 39. Digital recording channels – Binary signals.

Signal	Description	Signal	Description
Dlx	Digital input 1...11	Timer x Output	Output of Timer 1...10
Open/close control buttons	Active if buttons I or O in the unit's front panel are pressed.	Internal Relay Fault active	If the unit has an internal fault, this signal is active.
Status PushButton x On	Status of Push Button 1...12 is ON	(Protection, control and monitoring event signals)	(see the individual function description for the specific outputs)
Status PushButton x Off	Status of Push Button 1...12 is OFF	Always True/False	"Always false" is always "0". Always true is always "1".
Forced SG in use	Stage forcing in use	OUTx	Output contact statuses
SGx Active	Setting group 1...8 active	GOOSE INx	GOOSE input 1...64
Double Ethernet LinkA down	Double ethernet communication card link A connection is down.	GOOSE INx quality	Quality of GOOSE input 1...64
Double Ethernet LinkB down	Double ethernet communication card link B connection is down.	Logical Input x	Logical input 1...32
MBIO ModA Ch x Invalid	Channel 1...8 of MBIO Mod A is invalid	Logical Output x	Logical output 1...64
MBIO ModB Ch x Invalid	Channel 1...8 of MBIO Mod B is invalid	NTP sync alarm	If NTP time synchronization is lost, this signal will be active.
MBIO ModB Ch x Invalid	Channel 1...8 of MBIO Mod C is invalid	Ph.Rotating Logic control 0=A-B-C, 1=A-C-B	Phase rotating order at the moment. If true ("1") the phase order is reversed.



NOTICE!

Digital channels are measured every 5 ms.

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 device has a maximum limit of 100 for the number of recordings. Even when the recordings are very small, their number cannot exceed 100. 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".

Table. 4.5.1 - 40. Recorder control settings.

Name	Range	Step	Default	Description
Recorder enabled	0: Enabled 1: Disabled	-	0: Enabled	Enables and disables the disturbance recorder function.
Recorder status	0: Recorder ready 1: Recording triggered 2: Recording and storing 3: Storing recording 4: Recorder full 5: Wrong config	-	-	Indicates the status of recorder.
Clear record+	0...2 ³² -1	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.
Manual trigger	0: - 1: Trig	-	0: -	Triggers disturbance recording manually. This parameter will return back to "-" automatically.
Clear all records	0: - 1: Clear	-	0: -	Clears all disturbance recordings.
Clear newest record	0: - 1: Clear	-	0: -	Clears the newest stored disturbance recording.
Clear oldest record	0: - 1: Clear	-	0: -	Clears the oldest stored disturbance recording.
Max. number of recordings	0...100	1	-	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	0.001s	-	Displays the maximum length of a single recording.
Max. location of the pre-trigger	0.000...1800.000s	0.001s	-	Displays the highest pre-triggering time that can be set with the settings currently in use.
Recordings in memory	0...100	1	-	Displays how many recordings are stored in the memory.

Table. 4.5.1 - 41. 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. 4.5.1 - 42. Recorder settings.

Name	Range	Step	Default	Description
Recording length	0.100...1800.000s	0.01s	1s	Sets the length of a recording.
Recording mode	0: FIFO 1: Keep olds	-	0: 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	0: 64s/c 1: 32s/c 2: 16s/c 3: 8s/c	-	0: 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.
Digital channel samples	5ms (fixed)	-	5 ms(fixed)	The fixed sample rate of the recorded digital channels.
Pretriggering time	0.2...15.0s	0.1s	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	0: Disabled 1: Enabled	-	0: Disabled	Enables and disables the automatic transfer of recordings. The recordings are taken from the relay's protection CPU and transferred to the relay's FTP directory in the communication CPU; the FTP client then automatically loads the recordings from the relay 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 relay. 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 relay, it is no longer accessible through setting tools <i>Disturbance recorder</i> → <i>Get DR files</i> command.
Recorder digital channels	0...95 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.

Estimating the maximum length of total recording time

Once the disturbance recorder's settings have been made and loaded to the relay, 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 relay 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 µs)
- the analog channels 1...8 are used
- digital channels are tracked every 5 ms
- the first activation of the overcurrent stage trip (I > TRIP) triggers the recorder
- the pre-triggering time is 5 (ie. how long is recorded before the I > TRIP signal) and the post-triggering time is 1 s

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

Figure. 4.5.1 - 55. Disturbance recorder settings.

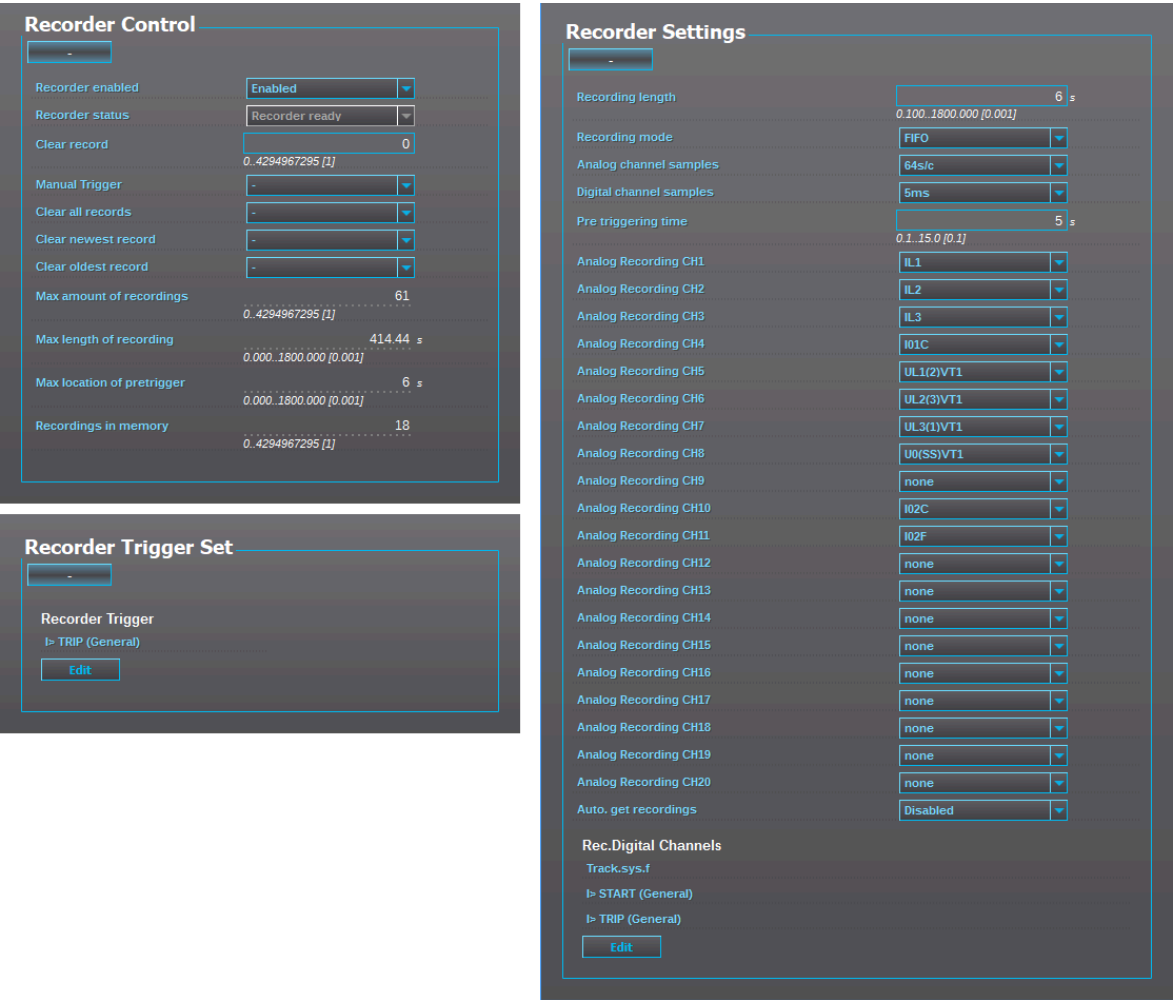
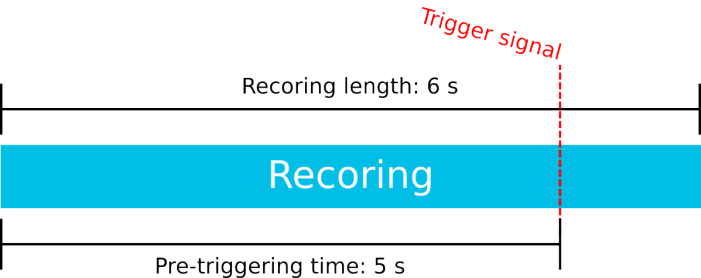
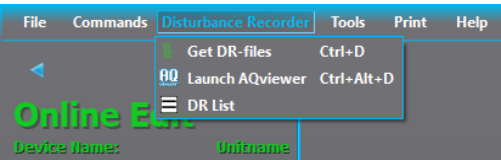


Figure. 4.5.1 - 56. Effects of recording length and pre-triggering time signals. This example is based on the settings shown above.



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 200 Instruction manual (arcteq.fi/downloads/).

Events

The disturbance recorder function (abbreviated "DR" in event block names) generates events and registers from the status changes of the function: the recorder generates an event each time it is triggered (manually or by dedicated signals). Events cannot be masked off. The user can select which event messages are stored in the main event buffer: ON, OFF, or both.

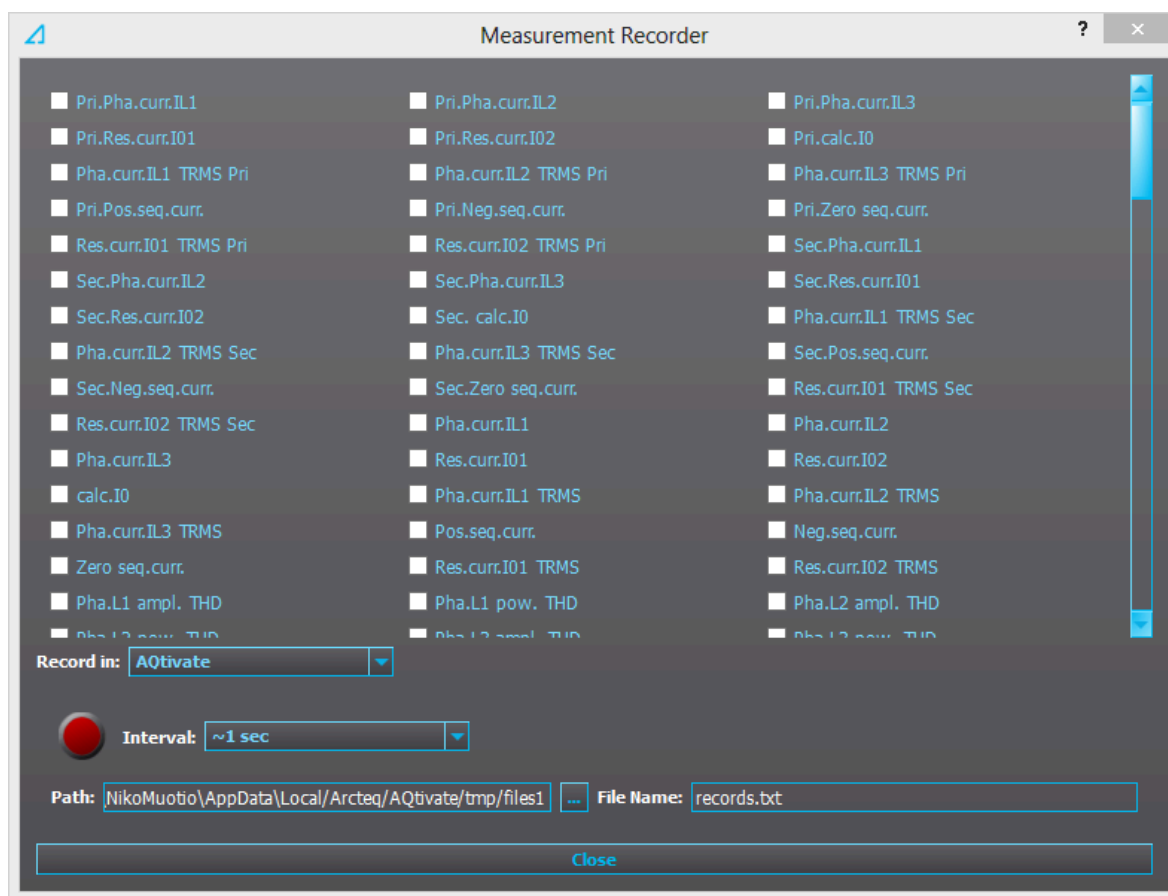
Table. 4.5.1 - 43. Event messages.

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

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.

4.5.3 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 relay must be established via the setting tool software and its Live Edit mode must be enabled (see the AQtivate 200 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 relay.

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).

If the recording is done in the relay, only the recording interval needs to be set before recording can be started. The setting tool estimates the maximum recording time, which depends on the recording interval. When the measurement recorder is running, the measurements can be viewed in graph form with the AQtivate PRO software (see the image below).

Figure. 4.5.3 - 57. Measurement recorder values viewed with AQtivate PRO.



Table. 4.5.3 - 44. Available analog signals.

Current measurements	P-P Curr.I" L3	L1 Imp.React.Ind.E.Mvarh
Pri.Pha.Curr.IL1	P-P Curr.I" 01	L1 Imp.React.Ind.E.kvarh
Pri.Pha.Curr.IL2	P-P Curr.I" 02	L1 Exp/Imp React.Ind.E.bal.Mvarh
Pri.Pha.Curr.IL3	Pha.angle I" L1	L1 Exp/Imp React.Ind.E.bal.kvarh
Pri.Res.Curr.I01	Pha.angle I" L2	L2 Exp.Active Energy MWh
Pri.Res.Curr.I02	Pha.angle I" L3	L2 Exp.Active Energy kWh
Pri.Calc.I0	Res.Curr.angle I" 01	L2 Imp.Active Energy MWh
Pha.Curr.IL1 TRMS Pri	Res.Curr.angle I" 02	L2 Imp.Active Energy kWh
Pha.Curr.IL2 TRMS Pri	Calc.I" 0.angle	L2 Exp/Imp Act. E balance MWh
Pha.Curr.IL3 TRMS Pri	I" Pos.Seq.Curr.angle	L2 Exp/Imp Act. E balance kWh
Pri.Pos.Seq.Curr.	I" Neg.Seq.Curr.angle	L2 Exp.React.Cap.E.Mvarh
Pri.Neg.Seq.Curr.	I" Zero.Seq.Curr.angle	L2 Exp.React.Cap.E.kvarh
Pri.Zero.Seq.Curr.	Voltage measurements	L2 Imp.React.Cap.E.Mvarh
Res.Curr.I01 TRMS Pri	U1Volt Pri	L2 Imp.React.Cap.E.kvarh
Res.Curr.I02 TRMS Pri	U2Volt Pri	L2 Exp/Imp React.Cap.E.bal.Mvarh
Sec.Pha.Curr.IL1	U3Volt Pri	L2 Exp/Imp React.Cap.E.bal.kvarh
Sec.Pha.Curr.IL2	U4Volt Pri	L2 Exp.React.Ind.E.Mvarh

Sec.Pha.Curr.IL3	U1Volt Pri TRMS	L2 Exp.React.Ind.E.kvarh
Sec.Res.Curr.I01	U2Volt Pri TRMS	L2 Imp.React.Ind.E.Mvarh
Sec.Res.Curr.I02	U3Volt Pri TRMS	L2 Imp.React.Ind.E.kvarh
Sec.Calc.I0	U4Volt Pri TRMS	L2 Exp/Imp React.Ind.E.bal.Mvarh
Pha.Curr.IL1 TRMS Sec	Pos.Seq.Volt.Pri	L2 Exp/Imp React.Ind.E.bal.kvarh
Pha.Curr.IL2 TRMS Sec	Neg.Seq.Volt.Pri	L3 Exp.Active Energy MWh
Pha.Curr.IL3 TRMS Sec	Zero.Seq.Volt.Pri	L3 Exp.Active Energy kWh
Sec.Pos.Seq.Curr.	U1Volt Sec	L3 Imp.Active Energy MWh
Sec.Neg.Seq.Curr.	U2Volt Sec	L3 Imp.Active Energy kWh
Sec.Zero.Seq.Curr.	U3Volt Sec	L3 Exp/Imp Act. E balance MWh
Res.Curr.I01 TRMS Sec	U4Volt Sec	L3 Exp/Imp Act. E balance kWh
Res.Curr.I02 TRMS Sec	U1Volt Sec TRMS	L3 Exp.React.Cap.E.Mvarh
Pha.Curr.IL1	U2Volt Sec TRMS	L3 Exp.React.Cap.E.kvarh
Pha.Curr.IL2	U3Volt Sec TRMS	L3 Imp.React.Cap.E.Mvarh
Pha.Curr.IL3	U4Volt Sec TRMS	L3 Imp.React.Cap.E.kvarh
Res.Curr.I01	Pos.Seq.Volt.Sec	L3 Exp/Imp React.Cap.E.bal.Mvarh
Res.Curr.I02	Neg.Seq.Volt.Sec	L3 Exp/Imp React.Cap.E.bal.kvarh
Calc.I0	Zero.Seq.Volt.Sec	L3 Exp.React.Ind.E.Mvarh
Pha.Curr.IL1 TRMS	U1Volt p.u.	L3 Exp.React.Ind.E.kvarh
Pha.Curr.IL2 TRMS	U2Volt p.u.	L3 Imp.React.Ind.E.Mvarh
Pha.Curr.IL3 TRMS	U3Volt p.u.	L3 Imp.React.Ind.E.kvarh
Pos.Seq.Curr.	U4Volt p.u.	L3 Exp/Imp React.Ind.E.bal.Mvarh
Neg.Seq.Curr.	U1Volt TRMS p.u.	L3 Exp/Imp React.Ind.E.bal.kvarh
Zero.Seq.Curr.	U2Volt TRMS p.u.	Exp.Active Energy MWh
Res.Curr.I01 TRMS	U3Volt p.u.	Exp.Active Energy kWh
Res.Curr.I02 TRMS	U4Volt p.u.	Imp.Active Energy MWh
Pha.L1 ampl. THD	Pos.Seq.Volt. p.u.	Imp.Active Energy kWh
Pha.L2 ampl. THD	Neg.Seq.Volt. p.u.	Exp/Imp Act. E balance MWh
Pha.L3 ampl. THD	Zero.Seq.Volt. p.u.	Exp/Imp Act. E balance kWh
Pha.L1 pow. THD	U1Volt Angle	Exp.React.Cap.E.Mvarh
Pha.L2 pow. THD	U2Volt Angle	Exp.React.Cap.E.kvarh
Pha.L3 pow. THD	U3Volt Angle	Imp.React.Cap.E.Mvarh

Res.I01 ampl. THD	U4Volt Angle	Imp.React.Cap.E.kvarh
Res.I01 pow. THD	Pos.Seq.Volt. Angle	Exp/Imp React.Cap.E.bal.Mvarh
Res.I02 ampl. THD	Neg.Seq.Volt. Angle	Exp/Imp React.Cap.E.bal.kvarh
Res.I02 pow. THD	Zero.Seq.Volt. Angle	Exp.React.Ind.E.Mvarh
P-P Curr.IL1	System Volt UL12 mag	Exp.React.Ind.E.kvarh
P-P Curr.IL2	System Volt UL12 mag (kV)	Imp.React.Ind.E.Mvarh
P-P Curr.IL3	System Volt UL23 mag	Imp.React.Ind.E.kvarh
P-P Curr.I01	System Volt UL23 mag (kV)	Exp/Imp React.Ind.E.bal.Mvarh
P-P Curr.I02	System Volt UL31 mag	Exp/Imp React.Ind.E.bal.kvarh
Pha.angle IL1	System Volt UL31 mag (kV)	Other measurements
Pha.angle IL2	System Volt UL1 mag	TM> Trip expect mode
Pha.angle IL3	System Volt UL1 mag (kV)	TM> Time to 100% T
Res.Curr.angle I01	System Volt UL2 mag	TM> Reference T curr.
Res.Curr.angle I02	System Volt UL2 mag (kV)	TM> Active meas curr.
Calc.I0.angle	System Volt UL3 mag	TM> T est.with act. curr.
Pos.Seq.Curr.angle	System Volt UL3 mag (kV)	TM> T at the moment
Neg.Seq.Curr.angle	System Volt U0 mag	TM> Max.Temp.Rise All.
Zero.Seq.Curr.angle	System Volt U0 mag (kV)	TM> Temp.Rise atm.
Pri.Pha.Curr.I"L1	System Volt U1 mag	TM> Hot Spot estimate
Pri.Pha.Curr.I"L2	System Volt U1 mag (kV)	TM> Hot Spot Max. All
Pri.Pha.Curr.I"L3	System Volt U2 mag	TM> Used k for amb.temp
Pri.Res.Curr.I"01	System Volt U2 mag (kV)	TM> Trip delay remaining
Pri.Res.Curr.I"02	System Volt U3 mag	TM> Alarm 1 time to rel.
Pri.Calc.I"0	System Volt U3 mag (kV)	TM> Alarm 2 time to rel.
Pha.Curr.I"L1 TRMS Pri	System Volt U4 mag	TM> Inhibit time to rel.
Pha.Curr.I"L2 TRMS Pri	System Volt U4 mag (kV)	TM> Trip time to rel.
Pha.Curr.I"L3 TRMS Pri	System Volt UL12 ang	S1 Measurement
I" Pri.Pos.Seq.Curr.	System Volt UL23 ang	S2 Measurement
I" Pri.Neg.Seq.Curr.	System Volt UL31 ang	S3 Measurement
I" Pri.Zero.Seq.Curr.	System Volt UL1 ang	S4 Measurement
Res.Curr.I"01 TRMS Pri	System Volt UL2 ang	S5 Measurement
Res.Curr.I"02 TRMS Pri	System Volt UL3 ang	S6 Measurement

Sec.Pha.Curr.I" L1	System Volt U0 ang	S7 Measurement
Sec.Pha.Curr.I" L2	System Volt U1 ang	S8 Measurement
Sec.Pha.Curr.I" L3	System Volt U2 ang	S9 Measurement
Sec.Res.Curr.I" 01	System Volt U3 ang	S10 Measurement
Sec.Res.Curr.I" 02	System Volt U4 ang	S11 Measurement
Sec.Calc.I" 0	Power measurements	S12 Measurement
Pha.Curr.I" L1 TRMS Sec	L1 Apparent Power (S)	Sys.meas.frqs
Pha.Curr.I" L2 TRMS Sec	L1 Active Power (P)	f atm.
Pha.Curr.I" L3 TRMS Sec	L1 Reactive Power (Q)	f meas from
I" Sec.Pos.Seq.Curr.	L1 Tan(phi)	SS1.meas.frqs
I" Sec.Neg.Seq.Curr.	L1 Cos(phi)	SS1f meas from
I" Sec.Zero.Seq.Curr.	L2 Apparent Power (S)	SS2 meas.frqs
Res.Curr.I" 01 TRMS Sec	L2 Active Power (P)	SS2f meas from
Res.Curr.I" 02 TRMS Sec	L2 Reactive Power (Q)	L1 Bias current
Pha.Curr.I" L1	L2 Tan(phi)	L1 Diff current
Pha.Curr.I" L2	L2 Cos(phi)	L1 Char current
Pha.Curr.I" L3	L3 Apparent Power (S)	L2 Bias current
Res.Curr.I" 01	L3 Active Power (P)	L2 Diff current
Res.Curr.I" 02	L3 Reactive Power (Q)	L2 Char current
Calc.I" 0	L3 Tan(phi)	L3 Bias current
Pha.Curr.I" L1 TRMS	L3 Cos(phi)	L3 Diff current
Pha.Curr.I" L2 TRMS	3PH Apparent Power (S)	L3 Char current
Pha.Curr.I" L3 TRMS	3PH Active Power (P)	HV I0d> Bias current
I" Pos.Seq.Curr.	3PH Reactive Power (Q)	HV I0d> Diff current
I" Neg.Seq.Curr.	3PH Tan(phi)	HV I0d> Char current
I" Zero.Seq.Curr.	3PH Cos(phi)	LV I0d> Bias current
Res.Curr.I" 01 TRMS	Energy measurements	LV I0d> Diff current
Res.Curr.I" 02 TRMS	L1 Exp.Active Energy MWh	LV I0d> Char current
Pha.IL"1 ampl. THD	L1 Exp.Active Energy kWh	Curve1 Input
Pha.IL"2 ampl. THD	L1 Imp.Active Energy MWh	Curve1 Output
Pha.IL"3 ampl. THD	L1 Imp.Active Energy kWh	Curve2 Input
Pha.IL"1 pow. THD	L1 Exp/Imp Act. E balance MWh	Curve2 Output

Pha.IL"2 pow. THD	L1 Exp/Imp Act. E balance kWh	Curve3 Input
Pha.IL"3 pow. THD	L1 Exp.React.Cap.E.Mvarh	Curve3 Output
Res.I"01 ampl. THD	L1 Exp.React.Cap.E.kvarh	Curve4 Input
Res.I"01 pow. THD	L1 Imp.React.Cap.E.Mvarh	Curve4 Output
Res.I"02 ampl. THD	L1 Imp.React.Cap.E.kvarh	Control mode
Res.I"02 pow. THD	L1 Exp/Imp React.Cap.E.bal.Mvarh	Motor status
P-P Curr.I"L1	L1 Exp/Imp React.Cap.E.bal.kvarh	Active setting group
P-P Curr.I"L2	L1 Exp.React.Ind.E.Mvarh	
	L1 Exp.React.Ind.E.kvarh	

5 Communication

5.1 Connections menu

"Connections" menu is found under "Communication" menu. It contains all basic settings of ethernet port and RS-485 serial port included with every AQ-200 device as well as settings of communication option cards.

Table. 5.1 - 45. 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 AQ-200 series device.
Netmask	0.0.0.0...255.255.255.255	Set netmask of the ethernet port in the back of the AQ-200 series device.
Gateway	0.0.0.0...255.255.255.255	Set gateway of the ethernet port in the back of the AQ-200 series device.
MAC-Address	00-00-00-00-00-00...FF-FF-FF-FF-FF-FF	Indication of MAC address of the AQ-200 series device.
Storm Protection	1: Disable 2: Enable	
Double Ethernet card mode	1: Switch 2: HSR 3: PRP	If the device has a double ethernet option card it is possible to choose its mode.
COM A and Ethernet option card connection	1: Block all 2: Allow both directions 3: Allow COM A to option card 4: 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	1: Disable 2: Enable	Disables or enables "Double Ethernet Link A down" and "Double Ethernet Link B down" logic signals and events.
Double Ethernet PRP ports	1: AB 2: BA	LanA and LanB port assignment for communication cards that support PRP.

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 - 46. 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.

Name	Description
Netmask	Set netmask of the virtual adapter.
Gateway	Set gateway of the virtual adapter.

AQ-200 series devices are always equipped with an RS-485 serial port. In the software it is identified as "Serial COM1" port.

Table. 5.1 - 47. Serial COM1 settings.

Name	Range	Description
Bitrate	0: 9600bps 1: 19200bps 2: 38400bps	Bitrate used by RS-485 port.
Databits	7...8	Databits used by RS-485 port.
Parity	0: None 1: Even 2: Odd	Paritybits used by RS-485 port.
Stopbits	1...2	Stopbits used by RS-485 port.
Protocol	0: None 1: ModbusRTU 2: ModbusIO 3: IEC103 4: SPA 5: DNP3 6: IEC101	Communication protocol used by RS-485 port.

AQ-200 series supports communication option card type that has serial fiber ports (Serial COM2) an RS-232 port (Serial COM3).

Table. 5.1 - 48. Serial COM2 settings.

Name	Range	Description
Bitrate	0: 9600bps 1: 19200bps 2: 38400bps	Bitrate used by serial fiber channels.
Databits	7...8	Databits used by serial fiber channels.
Parity	0: None 1: Even 2: Odd	Paritybits used by serial fiber channels.
Stopbits	1...2	Stopbits used by serial fiber channels.
Protocol	0: None 1: ModbusRTU 2: ModbusIO 3: IEC103 4: SPA 5: DNP3 6: IEC101	Communication protocol used by serial fiber channels.

Name	Range	Description
Echo	0: Off 1: On	Enable or disable echo.
Idle Light	0: Off 1: On	Idle light behaviour.

Table. 5.1 - 49. Serial COM3 settings.

Name	Range	Description
Bitrate	0: 9600bps 1: 19200bps 2: 38400bps	Bitrate used by RS-232 port.
Databits	7...8	Databits used by RS-232 port.
Parity	0: None 1: Even 2: Odd	Paritybits used by RS-232 port.
Stopbits	1...2	Stopbits used by RS-232 port.
Protocol	0: None 1: ModbusRTU 2: ModbusIO 3: IEC103 4: SPA 5: DNP3 6: IEC101	Communication protocol used by RS-232 port.

5.2 Time synchronization

Time synchronization source can be selected with "Time synchronization" parameter in the "General" menu.

Table. 5.2 - 50. General time synchronization source settings.

Name	Range	Description
Time synchronization source	0: Internal 1: External NTP 2: External serial 3: IRIG-B 4: 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 AQ-200 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 - 51. 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.

Table. 5.2.2 - 52. Client settings.

Name	Range	Description
IP address	0.0.0.0...255.255.255.255	Defines the address of the NTP client. NOTE: This address must be different than the general IP address of the device.
Netmask	0.0.0.0...255.255.255.255	Defines the client's netmask.
Gateway	0.0.0.0...255.255.255.255	Defines the client's gateway.
MAC address	00-00-00-00-00-00...FF-FF-FF-FF-FF-FF	Displays the MAC address of the client.
Network status	0: Running 1: IP error 2: NM error 3: GW error	Displays the status or possible errors of the NTP (client) settings.

Table. 5.2.2 - 53. Status.

Name	Range	Description
NTP quality for events	0: No sync 1: 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.



NOTICE!

A unique IP address must be reserved for the NTP client. The relay's IP address cannot be used.

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

5.3 Communication protocols

5.3.1 IEC 61850

The user can enable the IEC 61850 protocol in device models that support this protocol at *Communication* → *Protocols* → *IEC61850*. AQ-21x frame units support Edition 1 of IEC 61850. AQ-25x frame units support both Edition 1 and 2 of IEC 61850. The following services are supported by IEC 61850 in Arcteq devices:

- Up to six data sets (predefined data sets can be edited with the IEC 61850 tool in AQtivate)
- 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 - 54. General settings.

Name	Range	Step	Default	Description
Enable IEC 61850	0: Disabled 1: Enabled	-	0: Disabled	Enables and disables the IEC 61850 communication protocol.
Reconfigure IEC 61850	0: - 1: Reconfigure	-	0: -	Reconfigures IEC 61850 settings.
IP port	0...65 535	1	102	Defines the IP port used by the IEC 61850 protocol. The standard (and default) port is 102.
Control Authority switch	0: Remote Control 1: Station Level Control	-	0: 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	0: All 1: COM A 2: Double ethernet card	-	0: All	Determines which ports use IEC61850. Parameter is visible if double ethernet option card is found in the device.
General deadband	0.1...10.0 %	0.1 %	2 %	Determines the general data reporting deadband settings.
Active energy deadband	0.1...1000.0 kWh	0.1 kWh	2 kWh	Determines the data reporting deadband settings for this measurement.

Name	Range	Step	Default	Description
Reactive energy deadband	0.1...1000.0 kVar	0.1 kVar	2 kVar	Determines the data reporting deadband settings for this measurement.
Active power deadband	0.1...1000.0 kW	0.1 kW	2 kW	Determines the data reporting deadband settings for this measurement.
Reactive power deadband	0.1...1000.0 kVar	0.1 kVar	2 kVar	Determines the data reporting deadband settings for this measurement.
Apparent power deadband	0.1...1000.0 kVA	0.1 kVA	2 kVA	Determines the data reporting deadband settings for this measurement.
Power factor deadband	0.01...0.99	0.01	0.05	Determines the data reporting deadband settings for this measurement.
Frequency deadband	0.01...1.00 Hz	0.01 Hz	0.1 Hz	Determines the data reporting deadband settings for this measurement.
Current deadband	0.01...50.00 A	0.01 A	5 A	Determines the data reporting deadband settings for this measurement.
Residual current deadband	0.01...50.00 A	0.01 A	0.2 A	Determines the data reporting deadband settings for this measurement.
Voltage deadband	0.01...5000.00 V	0.01 V	200 V	Determines the data reporting deadband settings for this measurement.
Residual voltage deadband	0.01...5000.00 V	0.01 V	200 V	Determines the data reporting deadband settings for this measurement.
Angle measurement deadband	0.1...5.0 deg	0.1 deg	1 deg	Determines the data reporting deadband settings for this measurement.
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.
GOOSE Ethernet port	0: All 1: COM A 2: Double ethernet card	-	0: 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 (www.arcteq.fi/downloads/ → AQ 200 series → Resources).

5.3.1.1 GOOSE

Arcteq relays 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*.

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*.

Table. 5.3.1.1 - 55. GOOSE input settings.

Name	Range	Description
In use	0: No (Default) 1: Yes	Enables and disables the GOOSE input in question.
Application ID ("AppID")	0x0...0x3FFF	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	0: No (Default) 1: Yes	Selects whether or not the next received input is the quality bit of the GOOSE input.

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
-
-
- etc.

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

Table. 5.3.1.1 - 56. 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 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. 5.3.1.1 - 57. 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.

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 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 relay 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 relay and the master. Modbus map can be edited with Modbus Configurator (*Tools* → *Communication* → *Modbus Configurator*).

Table. 5.3.2 - 58. Modbus/TCP settings.

Parameter	Range	Description
Enable Modbus/TCP	0: Disabled 1: 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.
Event read mode	0: Get oldest available 1: Continue previous connection 2: New events only	0: Get oldest event possible (Default) 1: Continue with the event idx from previous connection 2: Get only new events from connection time and forward.

Table. 5.3.2 - 59. 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. In AQ-200 series devices 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 AQ-200 series units are 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 AQ-200 device and receive information by polling from the slave device. The transfer of disturbance recordings is not supported.

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

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

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.

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 (www.arcteq.fi/downloads/ → AQ-200 series → Resources → "AQ-200 IEC101 & IEC104 interoperability").

IEC 101 settings

Table. 5.3.4 - 60. 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.
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.

IEC 104 settings

Table. 5.3.4 - 61. IEC 104 settings.

Name	Range	Step	Default	Description
IEC 104 enable	0: Disabled 1: Enabled	-	0: Disabled	Enables and disables the IEC 104 communication protocol.
IP port	0...65 535	1	2404	Defines the IP port used by the protocol.
Common address of ASDU	0...65 534	1	1	Defines the common address of the application service data unit (ASDU) for the IEC 104 communication protocol.
APDU timeout (t1)	0...3600 s	1 s	0 s	The maximum amount of time the slave waits for a transmitted Application Protocol Data Unit (APDU) to be confirmed as received by the master.
Idle timeout (t3)	0...3600 s	1 s	0 s	The slave outstation can use a test fram to determine if the channel is still available after a prolonged period of communications inactivity. Test frame is sent at an interval specified here.

Measurement scaling coefficients

The measurement scaling coefficients are available for the following measurements, in addition to the general measurement scaling coefficient:

Table. 5.3.4 - 62. Measurements with scaling coefficient settings.

Name	Range
Active energy	0: No scaling 1: 1/10 2: 1/100 3: 1/1000 4: 1/10 000 5: 1/100 000 6: 1/1 000 000 7: 10 8: 100 9: 1000 10: 10 000 11: 100 000 12: 1 000 000
Reactive energy	
Active power	
Reactive power	
Apparent power	
Power factor	
Frequency	
Current	
Residual current	
Voltage	
Residual voltage	
Angle	

Deadband settings.

Table. 5.3.4 - 63. 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	

Name	Range	Step	Default	Description
Residual voltage deadband	0.01...5000.00V	0.01V	200V	
Angle measurement deadband	0.1...5.0deg	0.1deg	1deg	
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.

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*.

Table. 5.3.5 - 64. SPA setting parameters.

Name	Range	Description
SPA address	1...899	SPA slave address.
UTC time sync	0: Disabled 1: 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 relay.

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 (www.arcteq.fi/downloads/ → AQ-200 series → Resources).

Settings

The following table describes the DNP3 setting parameters.

Table. 5.3.6 - 65. Settings.

Name	Range	Step	Default	Description
Enable DNP3 TCP	0: Disabled 1: Enabled	-	0: 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.
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 - 66. Default variations.

Name	Range	Default	Description
Group 1 variation (BI)	0: Var 1 1: Var 2	0: Var 1	Selects the variation of the binary signal.
Group 2 variation (BI change)	0: Var 1 1: Var 2	1: Var 2	Selects the variation of the binary signal change.
Group 3 variation (DBI)	0: Var 1 1: Var 2	0: Var 1	Selects the variation of the double point signal.
Group 4 variation (DBI change)	0: Var 1 1: Var 2	1: Var 2	Selects the variation of the double point signal.
Group 20 variation (CNTR)	0: Var 1 1: Var 2 2: Var 5 3: Var 6	0: Var 1	Selects the variation of the control signal.

Name	Range	Default	Description
Group 22 variation (CNTR change)	0: Var 1 1: Var 2 2: Var 5 3: Var 6	2: Var 5	Selects the variation of the control signal change.
Group 30 variation (AI)	0: Var 1 1: Var 2 2: Var 3 3: Var 4 4: Var 5	4: Var 5	Selects the variation of the analog signal.
Group 32 variation (AI change)	0: Var 1 1: Var 2 2: Var 3 3: Var 4 4: Var 5 5: Var 7	4: Var 5	Selects the variation of the analog signal change.

Setting the analog change deadbands

Table. 5.3.6 - 67. 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	
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.

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 - 68. 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	0: ADAM-4018+ 1: 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 - 69. Channel settings.

Name	Range	Step	Default	Description
Thermocouple type	0: +/- 20mA 1: 4...20mA 2: Type J 3: Type K 4: Type T 5: Type E 6: Type R 7: Type S	-	1: 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	0: Invalid 1: OK	-	-	Displays the input status of the selected channel.

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 - 70. 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	-	0: 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 Real-time measurements to communication

With the *Real-time signals to communication* menu the user can report measurements to SCADA in a faster interval. The real measurement update delay depends on the used communication protocol and equipment used. Up to ten (10) magnitudes can be selected. The recorded value can be either a per-unit value or a primary value (set by the user).

Measurable values

Function block uses analog current and voltage measurement values. The relay uses these values as the basis when it calculates the primary and secondary values of currents, voltages, powers, impedances and other values.

Table. 5.5 - 71. Available measured values.

Signals	Description
Currents	
IL1 (ff), IL2 (ff), IL3 (ff), IO1 (ff), IO2 (ff)	Fundamental frequency (RMS) current measurement values of phase currents and residual currents.
IL1 (TRMS), IL2 (TRMS), IL3 (TRMS), IO1 (TRMS), IO2 (TRMS)	TRMS current measurement values of phase currents and residual currents.
IL1, IL2, IL3, IO1, IO2 & 2 nd h., 3 rd h., 4 th h., 5 th h., 7 th h., 9 th h., 11 th h., 13 th h., 15 th h., 17 th h., 19 th h.	Magnitudes of the phase current components: 2 nd harmonic, 3 rd harmonic, 4 th harmonic, 5 th harmonic 7 th , harmonic 9 th , harmonic 11 th , harmonic 13 th , harmonic 15 th , harmonic 17 th , harmonic 19 th harmonic current.
I1, I2, IOZ	Positive sequence current, negative sequence current and zero sequence current.
IOCalcMag	Residual current calculated from phase currents.

Signals	Description
IL1Ang, IL2Ang, IL3Ang, I01Ang, I02Ang, I0CalcAng I1Ang, I2Ang	Angles of each measured current.
Voltages	
UL1Mag, UL2Mag, UL3Mag, UL12Mag, UL23Mag, UL31Mag, U0Mag, U0CalcMag	Magnitudes of phase voltages, phase-to-phase voltages and residual voltages.
U1 Pos.seq V mag, U2 Neg.seq V mag	Positive and negative sequence voltages.
UL1Ang, UL2Ang, UL3Ang, UL12Ang, UL23Ang, UL31Ang, U0Ang, U0CalcAng	Angles of phase voltages, phase-to-phase voltages and residual voltages.
U1 Pos.seq V Ang, U2 Neg.seq V Ang	Positive and negative sequence angles.
Powers	
S3PH P3PH Q3PH	Three-phase apparent, active and reactive power.
SL1, SL2, SL3, PL1, PL2, PL3, QL1, QL2, QL3	Phase apparent, active and reactive powers.
tanfi3PH tanfiL1 tanfiL2 tanfiL3	Tan (ϕ) of three-phase powers and phase powers.
cosfi3PH cosfiL1 cosfiL2 cosfiL3	Cos (ϕ) of three-phase powers and phase powers.
Impedances and admittances	
RL12, RL23, RL31 XL12, XL23, XL31 RL1, RL2, RL3 XL1, XL2, XL3 Z12, Z23, Z31 ZL1, ZL2, ZL3	Phase-to-phase and phase-to-neutral resistances, reactances and impedances.
Z12Ang, Z23Ang, Z31Ang, ZL1Ang, ZL2Ang, ZL3Ang	Phase-to-phase and phase-to-neutral impedance angles.
Rseq, Xseq, Zseq RseqAng, XseqAng, ZseqAng	Positive sequence resistance, reactance and impedance values and angles.
GL1, GL2, GL3, G0 BL1, BL2, BL3, B0 YL1, YL2, YL3, Y0	Conductances, susceptances and admittances.
YL1angle, YL2angle, YL3angle, Y0angle	Admittance angles.

Signals	Description
Others	
System f.	Used tracking frequency at the moment.
Ref f1	Reference frequency 1.
Ref f2	Reference frequency 2.
M thermal T	Motor thermal temperature.
F thermal T	Feeder thermal temperature.
T thermal T	Transformer thermal temperature.
RTD meas 1...16	RTD measurement channels 1...16.
Ext RTD meas 1...8	External RTD measurement channels 1...8 (ADAM module).

Settings

Table. 5.5 - 72. Settings.

Name	Range	Step	Default	Description
Measurement value recorder mode	0: Disabled 1: Activated	-	0: Disabled	Activates and disables the real-time signals to communication.
Scale current values to primary	0: No 1: Yes	-	0: No	Selects whether or not values are scaled to primary.
Slot X magnitude selection	0: Currents 1: Voltages 2: Powers 3: Impedance (ZRX) and admittance (YGB) 4: Others	-	0: 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-S214

Figure. 6.1 - 58. AQ-S214 variant without add-on modules.

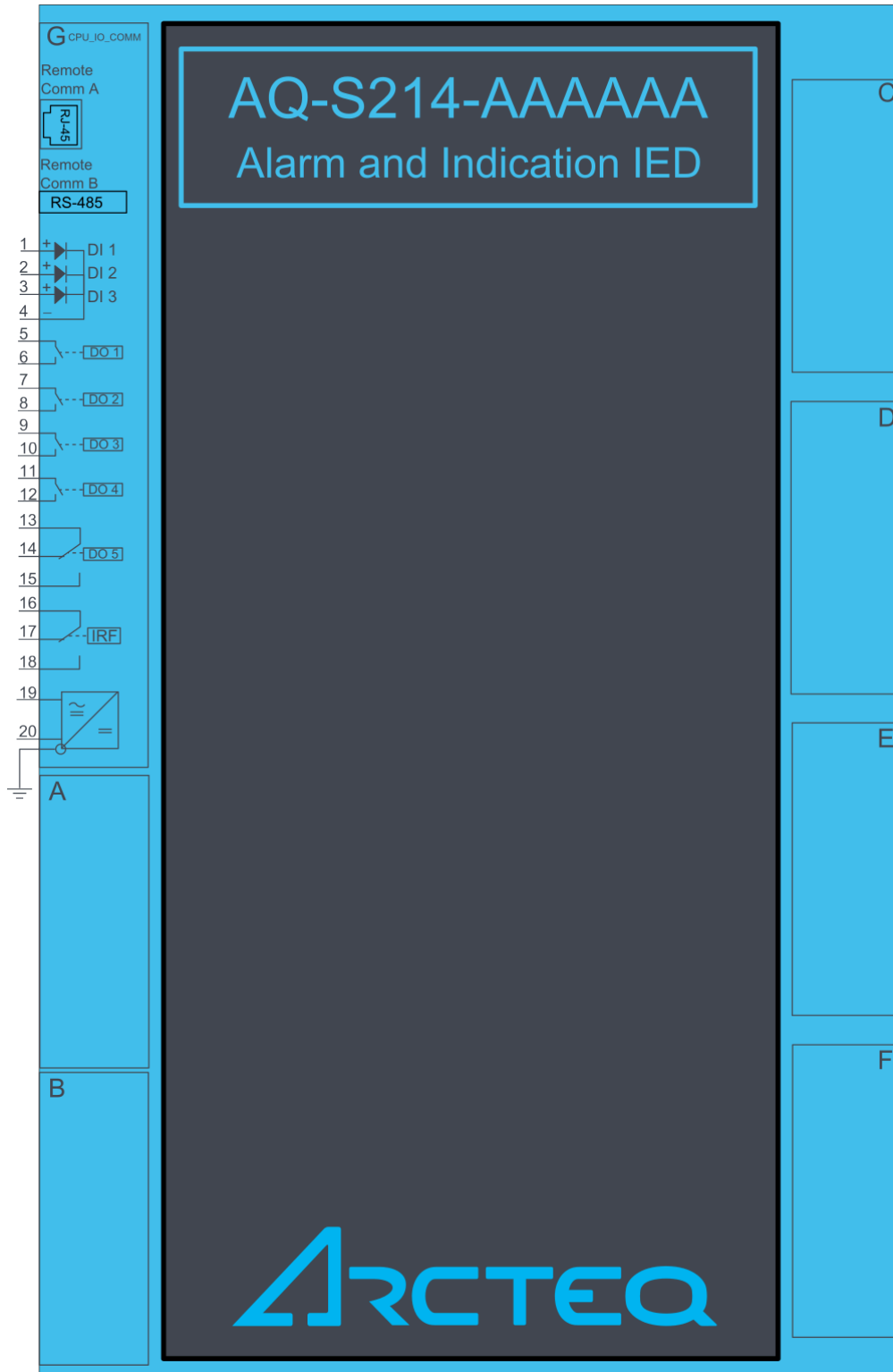


Figure. 6.1 - 59. AQ-S214 variant with digital input and output modules.

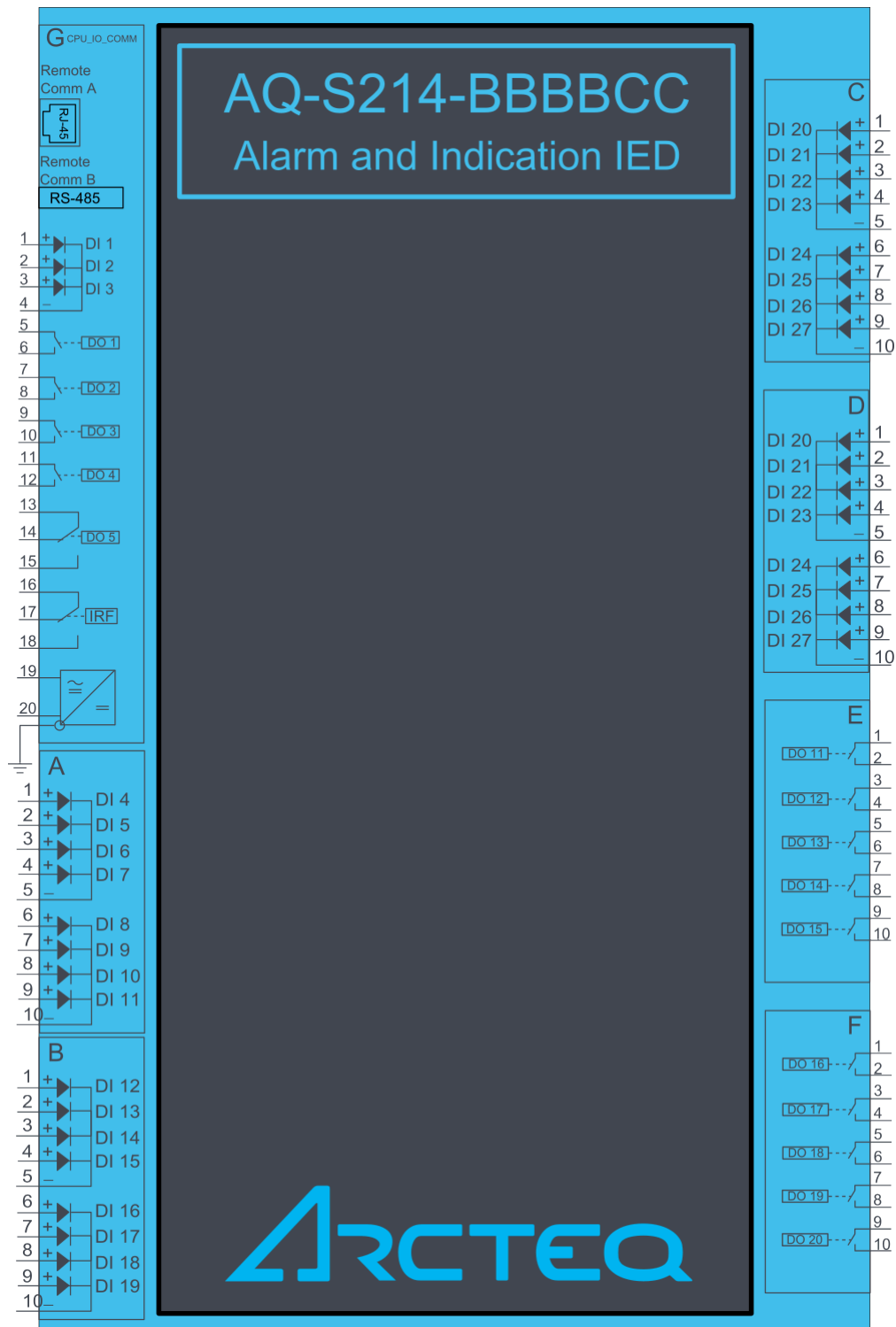
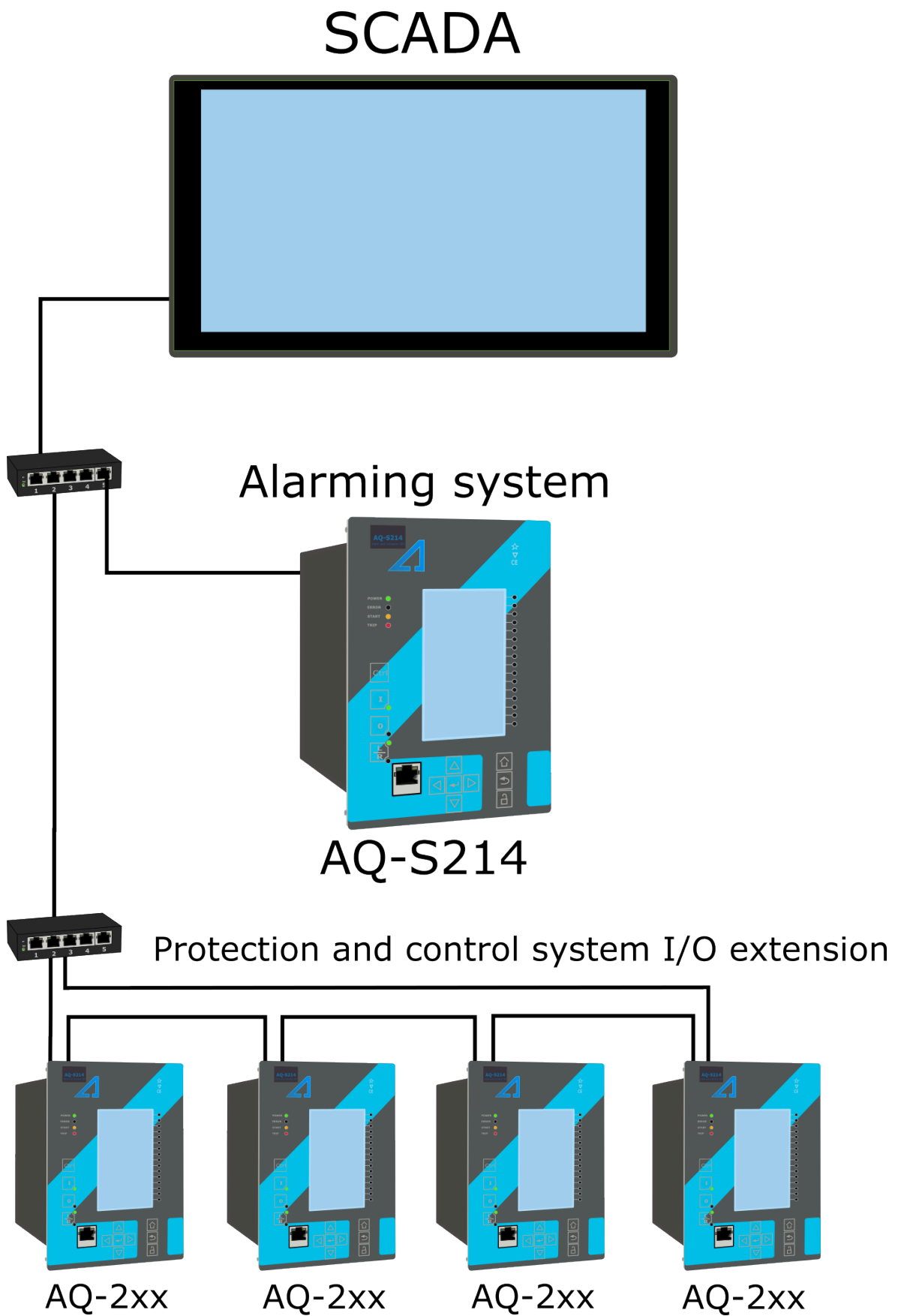


Figure. 6.1 - 60. AQ-S214 application example.



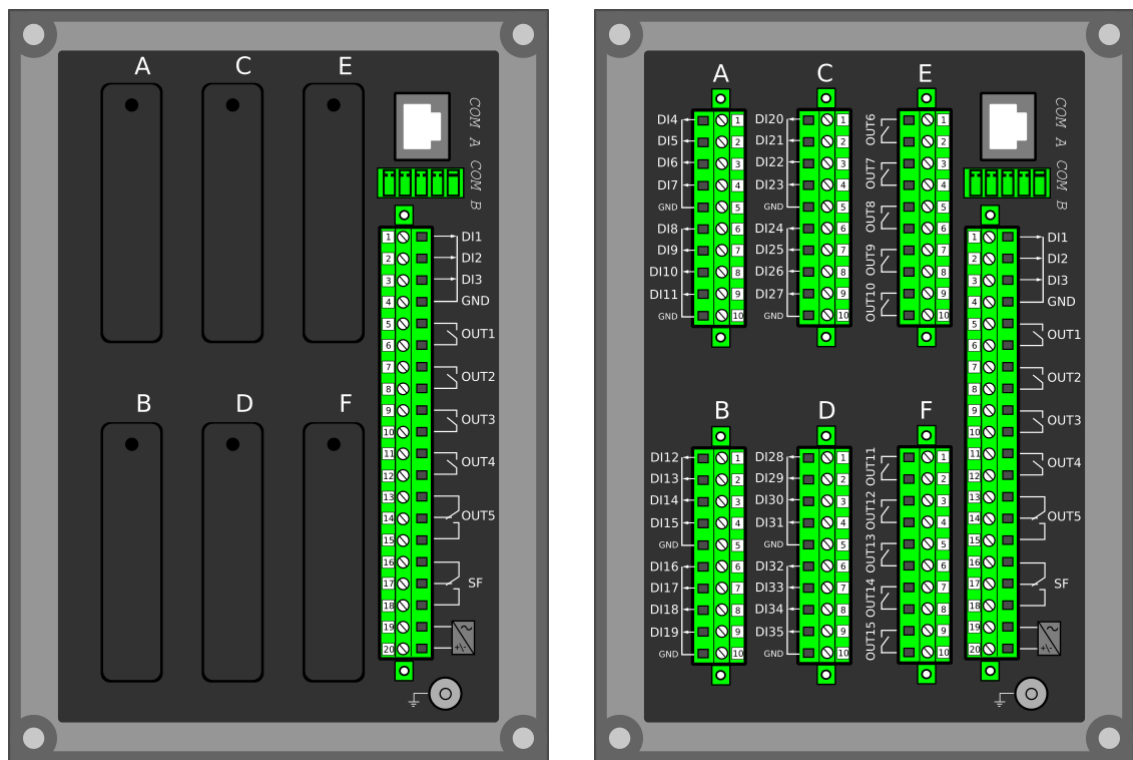
7 Construction and installation

7.1 Construction

AQ-X214 is a member of the modular and scalable AQ-200 series, and it includes six (6) 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-X214-XXXXXXX-AAAAAA, on the left) and the fully optioned model (AQ-X214-XXXXXXX-BBBBCC, on the right).

Figure. 7.1 - 61. Modular construction of AQ-X214.



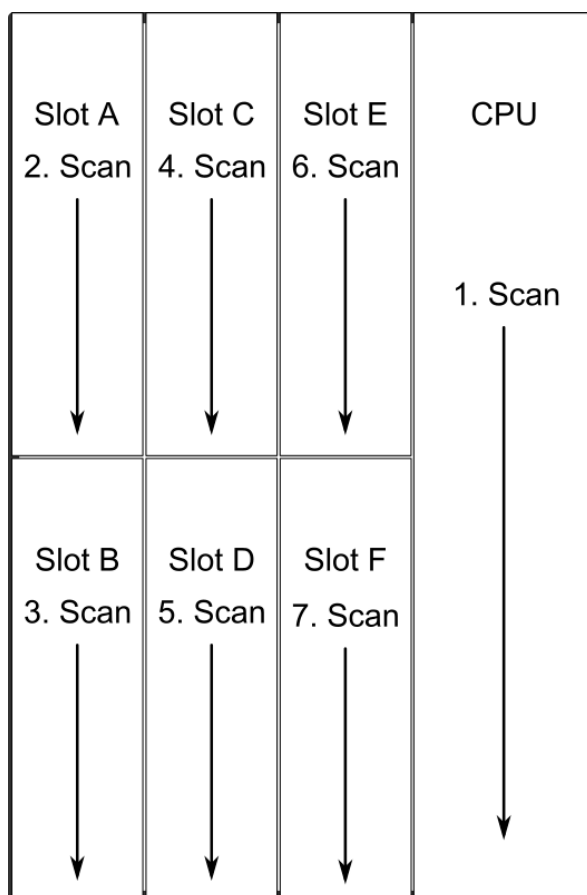
The modular structure of AQ-X214 allows for scalable solutions for different application requirements. In non-standard configurations Slots A, B, C, D, E and F accept all available add-on modules, such as digital I/O modules and other special modules. The only difference between the slots affecting device scalability is that Slots E and F 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, Slot D, Slot E, Slot F. 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 - 62. AQ-X214 hardware scanning and I/O naming principles.



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. Scan
A similar operation to Scan 3 (checks which designations have been reserved by modules in previous slots and numbers the new ones accordingly).

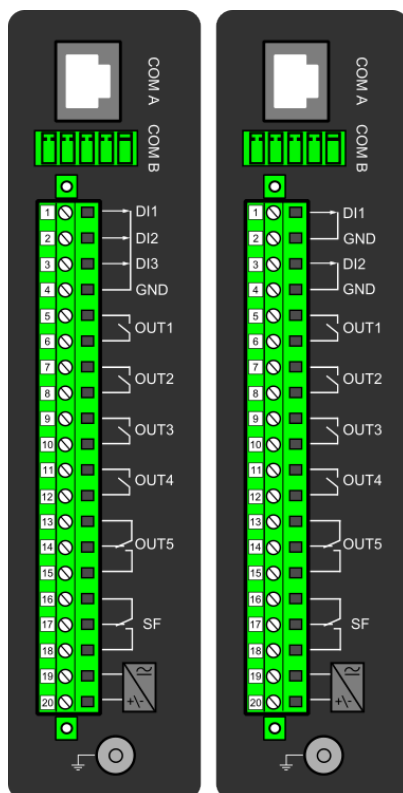
5. Scan
A similar operation to Scan 3 (checks which designations have been reserved by modules in previous slots and numbers the new ones accordingly).
6. Scan
A similar operation to Scan 3 (checks which designations have been reserved by modules in previous slots and numbers the new ones accordingly).
7. Scan
A similar operation to Scan 3 (checks which designations have been reserved by modules in previous slots and numbers the new ones accordingly).

Thus far this chapter has only explained the installation of I/O add-on cards to the option module slots. This is because all other module types are treated in a same way. For example, when an additional communication port is installed into the upper port of the communication module, its designation is Communication port 3 or higher, as Communication ports 1 and 2 already exist in the CPU module (which is scanned, and thus designated, first). After a communication port is detected, it is added into the device's communication space and its corresponding settings are enabled.

The fully optioned example case of AQ-X214-XXXXXXX-BBBBCC (the first image pair, on the right) has a total of 35 digital input channels available: three (DI1...DI3) in the CPU module, and the rest in Slots A...D in groups of eight. It also has a total of 15 digital output channels available: five (DO1...DO5) in the CPU module, and the rest in Slots E...F in groups of five. These same principles apply to all non-standard configurations in the AQ-X214 devices.

7.2 CPU module

Figure. 7.2 - 63. CPU module.



Module connectors

Table. 7.2 - 73. Module connector descriptions.

Connector	Description	
COM A	Communication port A, or the RJ-45 port. Used for the setting tool connection and for IEC 61850, Modbus/TCP, IEC 104, DNP3 and station bus communications.	
COM B	Communication port B, or the RS-485 port. Used for the SCADA communications for the following protocols: Modbus/RTU, Modbus I/O, SPA, DNP3, IEC 101 and IEC 103. The pins have the following designations: Pin 1 = DATA +, Pin 2 = DATA -, Pin 3 = GND, Pins 4 & 5 = Terminator resistor enabled by shorting.	
	Model with 3 digital inputs	Model with 2 digital inputs
X 1	Digital input 1, nominal threshold voltage 24 V, 110 V or 220 V.	Digital input 1, nominal threshold voltage 24 V, 110 V or 220 V.
X 2	Digital input 2, nominal threshold voltage 24 V, 110 V or 220 V.	GND for digital input 1.
X 3	Digital input 3, nominal threshold voltage 24 V, 110 V or 220 V.	Digital input 2, nominal threshold voltage 24 V, 110 V or 220 V.
X 4	Common GND for digital inputs 1, 2 and 3.	GND for digital input 2.
X 5:6	Output relay 1, with a normally open (NO) contact.	
X 7:8	Output relay 2, with a normally open (NO) contact.	
X 9:10	Output relay 3, with a normally open (NO) contact.	
X 11:12	Output relay 4, with a normally open (NO) contact.	
X 13:14:15	Output relay 5, with a changeover contact.	
X 16:17:18	System fault's output 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.	
X 19:20	Power supply IN. Either 80...265 VAC/DC (model A; order code "H") or 18...75 DC (model B; order code "L"). Positive side (+) to Pin 20.	
GND	The relay's earthing connector.	

By default, the CPU module (combining the CPU, the I/O and the power supply) is included in all AQ-200 devices to provide two standard communication ports and the relay's basic digital I/O. The module can be ordered to include 2 or 3 digital inputs.

The current consumption of the digital inputs is 2 mA when activated, while 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, and their pick-up and release delays as well as their NO/NC selection can be set with software. The digital output controls are also set by the user with software. By default, the 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.

The auxiliary voltage is defined in the ordering code: the available power supply models available are A (80...265 VAC/DC) and B (18...75 DC). For further details, please refer to the "Auxiliary voltage" chapter in the "Technical data" section of this document.

Digital input settings

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

Table. 7.2 - 74. Digital input settings.

Name	Range	Step	Default	Description
Dlx Polarity	0: NO (Normally open) 1: NC (Normally closed)	-	0: 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	0: Disabled 1: Enabled	-	0: Disabled	Selects whether or not a 30-ms deactivation delay is added to account for alternating current.

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
-
-
- etc.

Table. 7.2 - 75. 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.

Scanning cycle

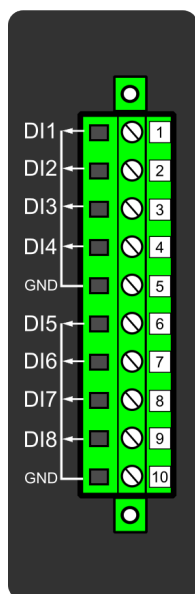
All digital inputs are scanned in a 5 ms cycle, meaning that the state of an input is updated every 0...5 milliseconds. When an input is used internally in the device (either in setting group change or logic), it takes additional 0...5 milliseconds to operate. Theoretically, therefore, it takes 0...10 milliseconds to change the 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 (T1...Tx), 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.

Please note that 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 - 64. Digital input module (DI8) with eight add-on digital inputs.



Connector	Description (x = the number of digital inputs in other modules that precede 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.

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 relay settings.

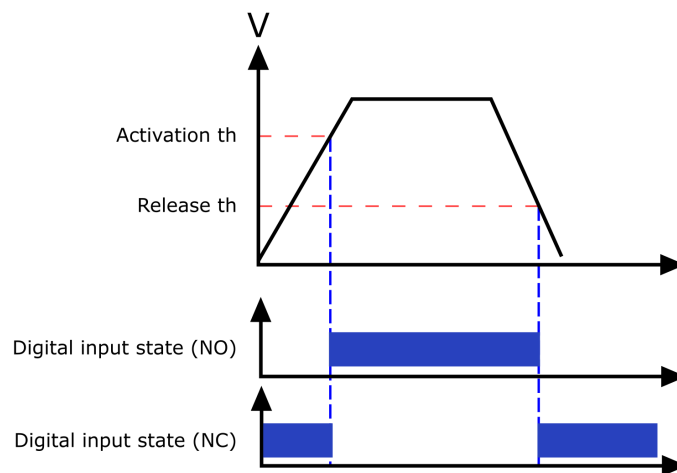
Table. 7.3.1 - 76. Digital input settings of DI8 module.

Name	Range	Step	Default	Description
Dlx Polarity	0: NO (Normally open) 1: NC (Normally closed)	-	0: 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.
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	0: Disabled 1: Enabled	-	0: 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.
Dlx Clear counter	0: - 1: Clear	-	0: -	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 - 65. 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
-
-
- etc.

Table. 7.3.1 - 77. Digital input 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.

Digital input voltage measurements

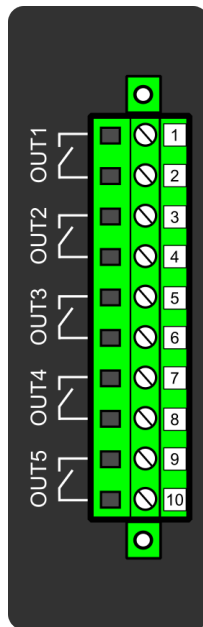
Digital input option card channels measure voltage on each channel. The measured voltage can be seen at *Control* → *Device IO* → *Digital inputs* → *Digital input voltages*.

Table. 7.3.1 - 78. Digital input channel voltage measurement.

Name	Range	Step	Description
DIx 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 - 66. Digital output module (DO5) with five add-on digital outputs.



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) 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. The user can set the digital output controls with software. All digital outputs are scanned in 5 ms program cycles, and their contacts are mechanical in type. The rated voltage of the NO/NC outputs is 250 VAC/DC.

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 output module" in the "Technical data" section of this document.

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

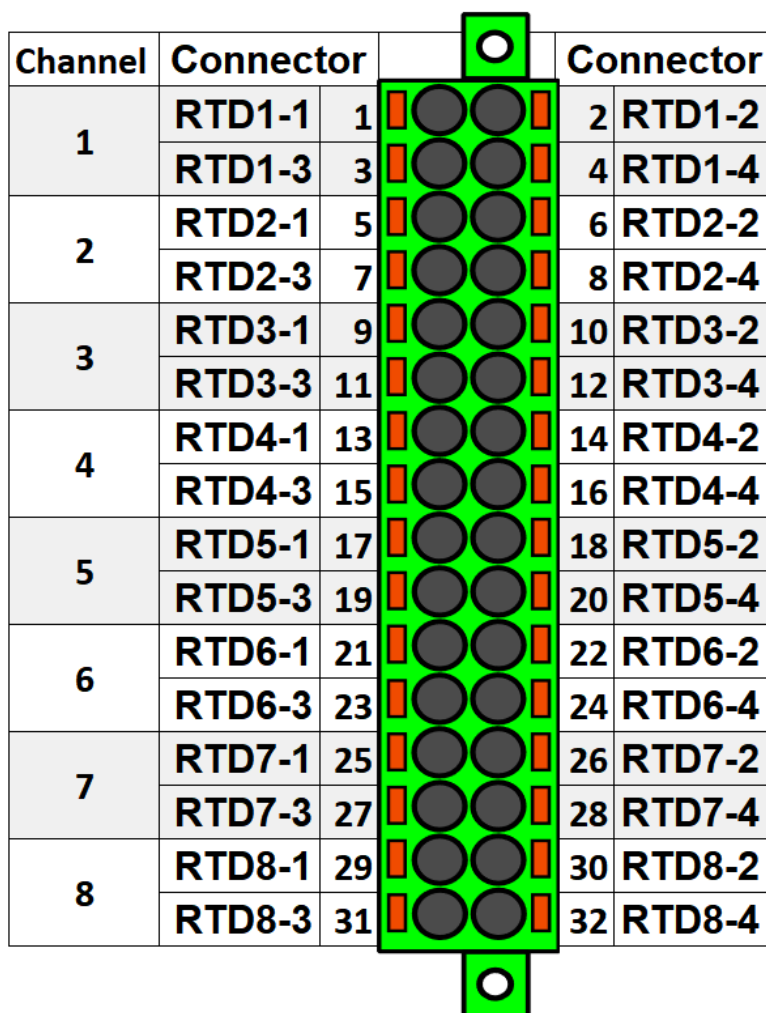
- block settings
-
-
- etc.

Table. 7.3.2 - 79. 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.

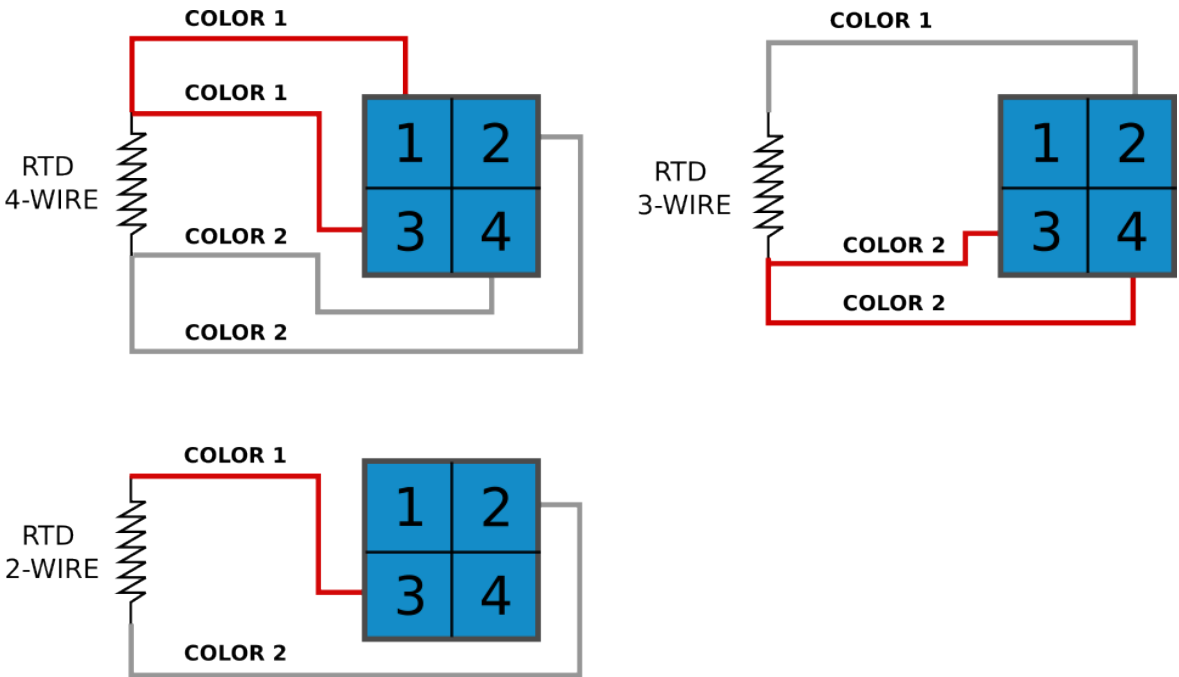
7.3.3 RTD input module (optional)

Figure. 7.3.3 - 67. RTD input module connectors.



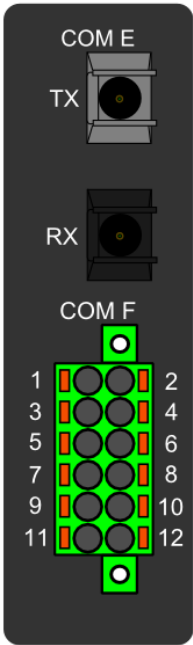
The RTD input module is an add-on module with eight (8) RTD input channels. Each input supports 2-wire, 3-wire and 4-wire RTD sensors. The sensor type can be selected with software for two groups, four channels each. The card supports Pt100 and Pt1000 sensors

Figure. 7.3.3 - 68. RTD sensor connection types.



7.3.4 Serial RS-232 communication module (optional)

Figure. 7.3.4 - 69. Serial RS-232 module connectors.



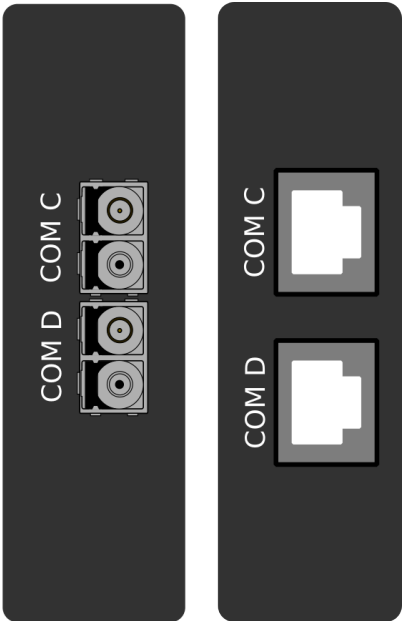
Connector	Name	Description
COM E	Serial fiber (GG/PP/GP/PG)	<ul style="list-style-type: none">Serial-based communicationsWavelength 660 nmCompatible with 50/125 μm, 62.5/125 μm, 100/140 μm, and 200 μm Plastic-Clad Silica (PCS) fiberCompatible with ST connectors

Connector	Name	Description
COM F – Pin 1	+24 V input	Optional external auxiliary voltage for serial fiber
COM F – Pin 2	GND	Optional external auxiliary voltage for serial fiber
COM F – Pin 3	-	-
COM F – Pin 4	-	-
COM F – Pin 5	RS-232 RTS	Serial based communications
COM F – Pin 6	RS-232 GND	Serial based communications
COM F – Pin 7	RS-232 TX	Serial based communications
COM F – Pin 8	RS-232 RX	Serial based communications
COM F – Pin 9	-	-
COM F – Pin 10	+3.3 V output (spare)	Spare power source for external equipment (45 mA)
COM F – Pin 11	Clock sync input	Clock synchronization input
COM F – Pin 12	Clock sync GND	Clock synchronization input

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

7.3.5 LC or RJ45 100 Mbps Ethernet communication module (optional)

Figure. 7.3.5 - 70. LC and RJ45 100 Mbps Ethernet module connectors.

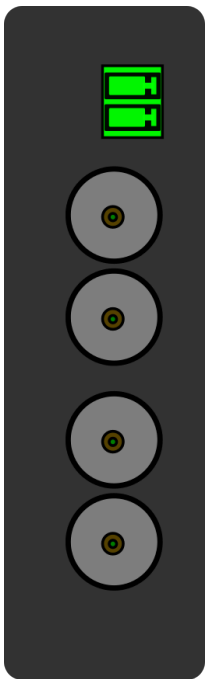


Connector	Description (LC ports)	Description (RJ45)
COM C:	<ul style="list-style-type: none">• Communication port C, 100 MbpsLC fiber connector.• 62.5/125 μm or 50/125 μm multimode (glass).• Wavelength 1300 nm.	<ul style="list-style-type: none">• RJ-45 connectors• 10BASE-T and 100BASE-TX
COM D:	<ul style="list-style-type: none">• Communication port D, 100 Mbps LC fiber connector.• 62.5/125 μm or 50/125 μm multimode (glass).• Wavelength 1300 nm.	<ul style="list-style-type: none">• RJ-45 connectors• 10BASE-T and 100BASE-TX

Both cards support both HSR and PRP protocols.

7.3.6 Double ST 100 Mbps Ethernet communication module (optional)

Figure. 7.3.6 - 71. Double ST 100 Mbps Ethernet communication module connectors.



Connector	Description
Two-pin connector	<ul style="list-style-type: none"> IRIG-B input
ST connectors	<ul style="list-style-type: none"> 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-200 series devices, and any third party devices must be connected to a separate ring.

For other redundancy options, please refer to the option card "LC 100 Mbps Ethernet communication module".

The images below present two example configurations: the first displays a ring configuration (note how the third party devices are connected in a separate ring), while the second displays a multidrop configuration.

Figure. 7.3.6 - 72. Example of a ring configuration.

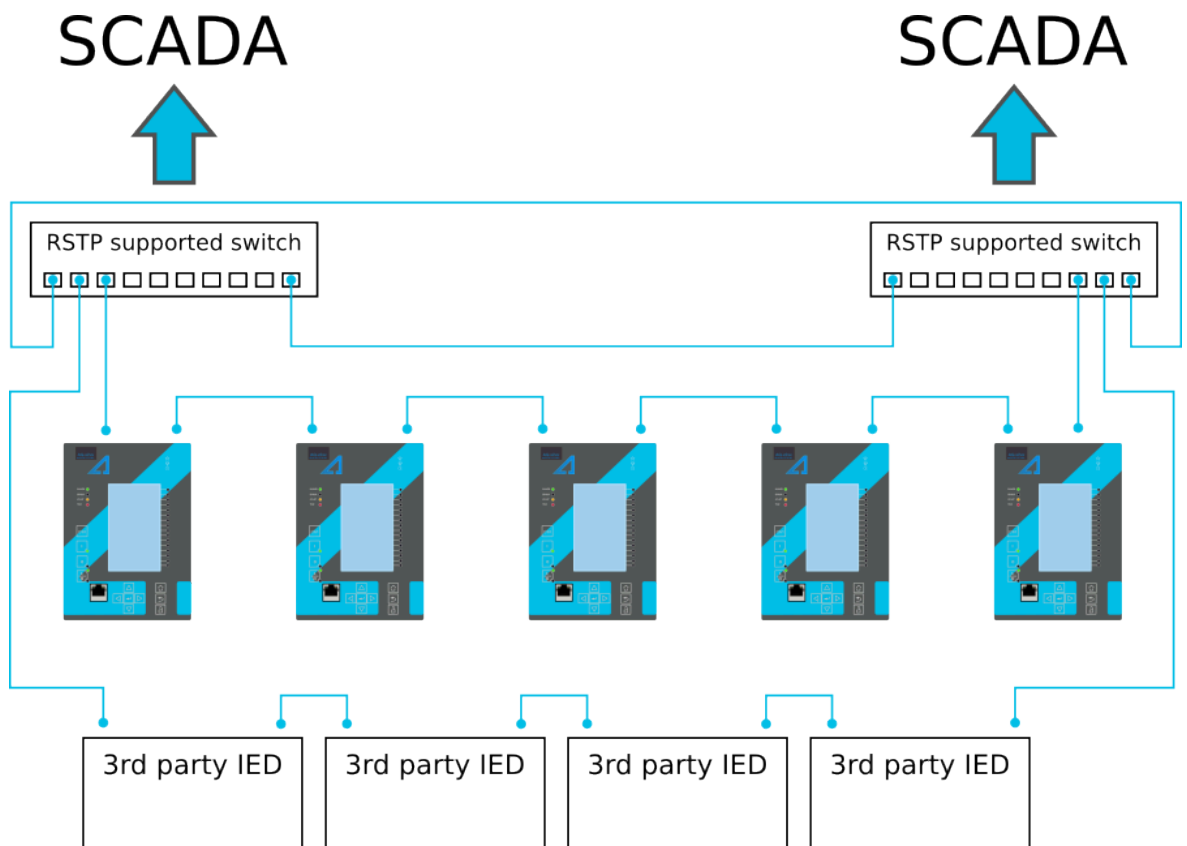
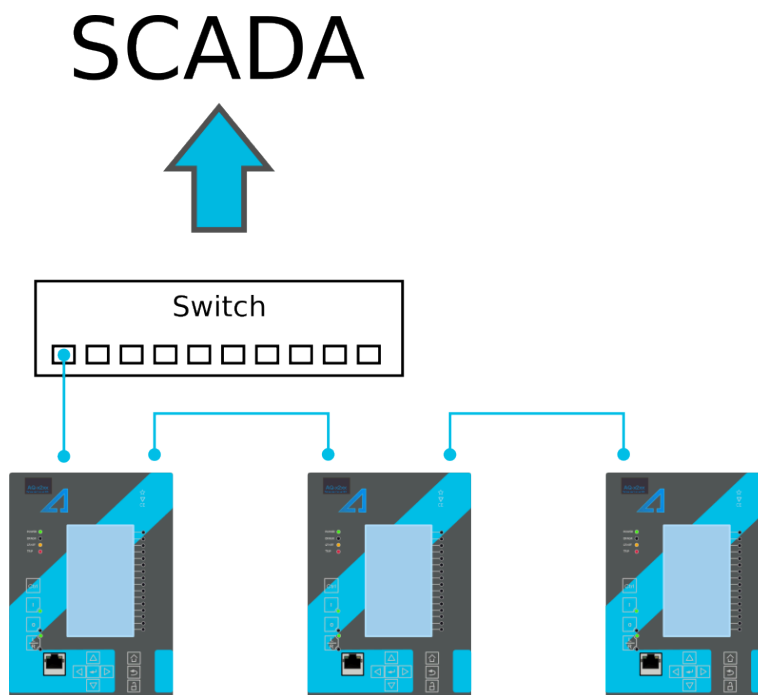
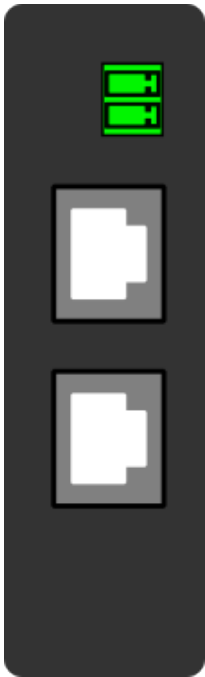


Figure. 7.3.6 - 73. Example of a multidrop configuration.



7.3.7 Double RJ45 10/100 Mbps Ethernet communication module (optional)

Figure. 7.3.7 - 74. Double RJ-45 10/100 Mbps Ethernet communication module.

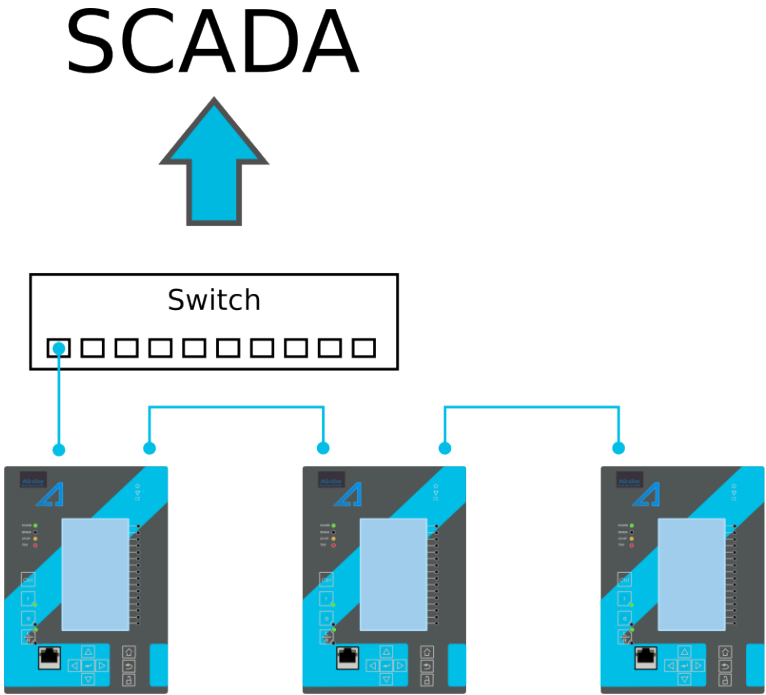


Connector	Description
Two-pin connector	<ul style="list-style-type: none">• IRIG-B input
RJ-45 connectors	<ul style="list-style-type: none">• Two Ethernet ports• RJ-45 connectors• 10BASE-T and 100BASE-TX

This option card supports multidrop configurations.

For other redundancy options, please refer to the option card "LC 100 Mbps Ethernet communication module".

Figure. 7.3.7 - 75. Example of a multidrop configuration.



7.4 Dimensions and installation

{{Default-Series}}. 7.4 - 1.

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. When installing to a rack, the device takes a quarter ($\frac{1}{4}$) of the rack's width, meaning that a total of four devices can be installed to the same rack next to one another.

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 - 76. Device dimensions.

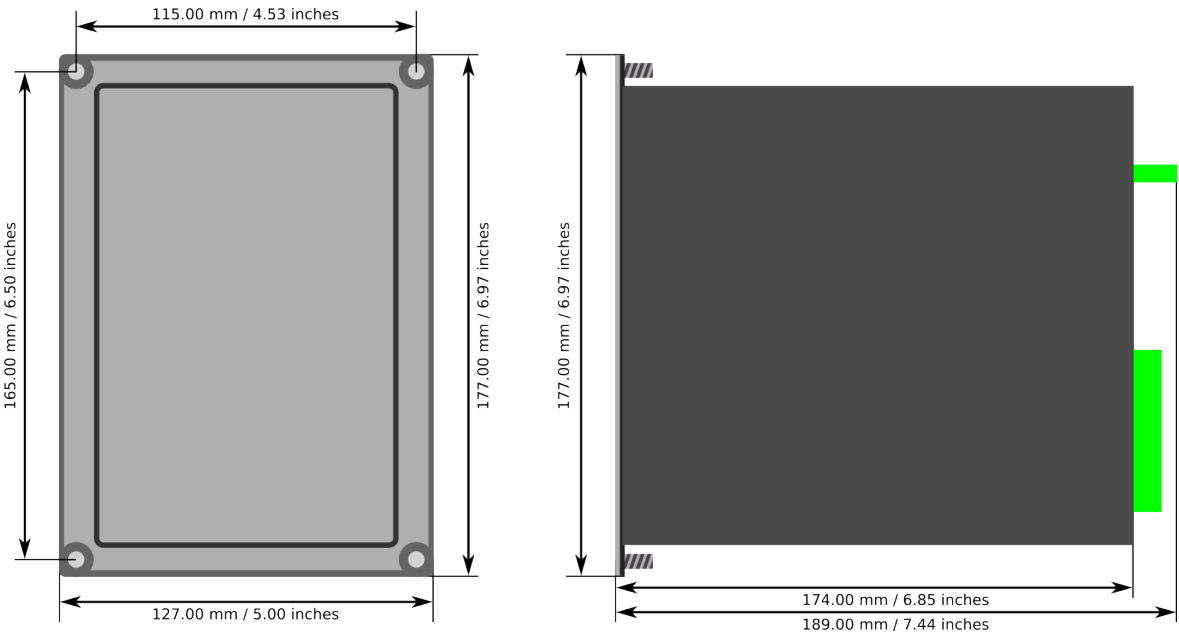


Figure. 7.4 - 77. Device installation.

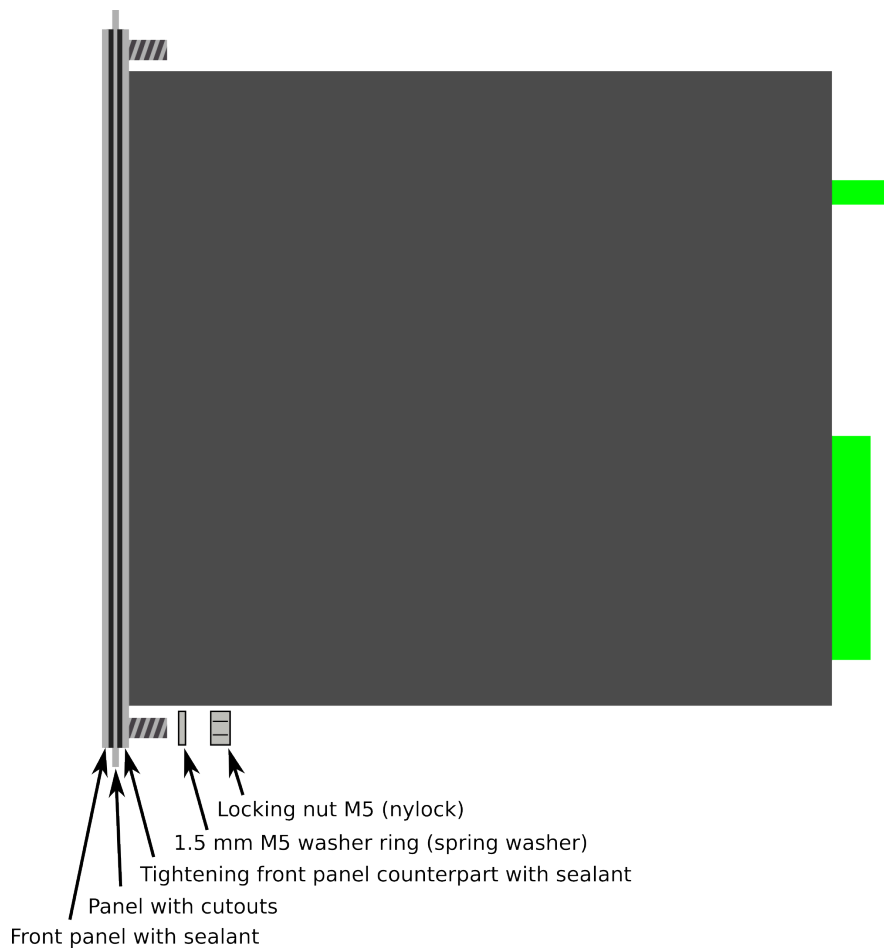
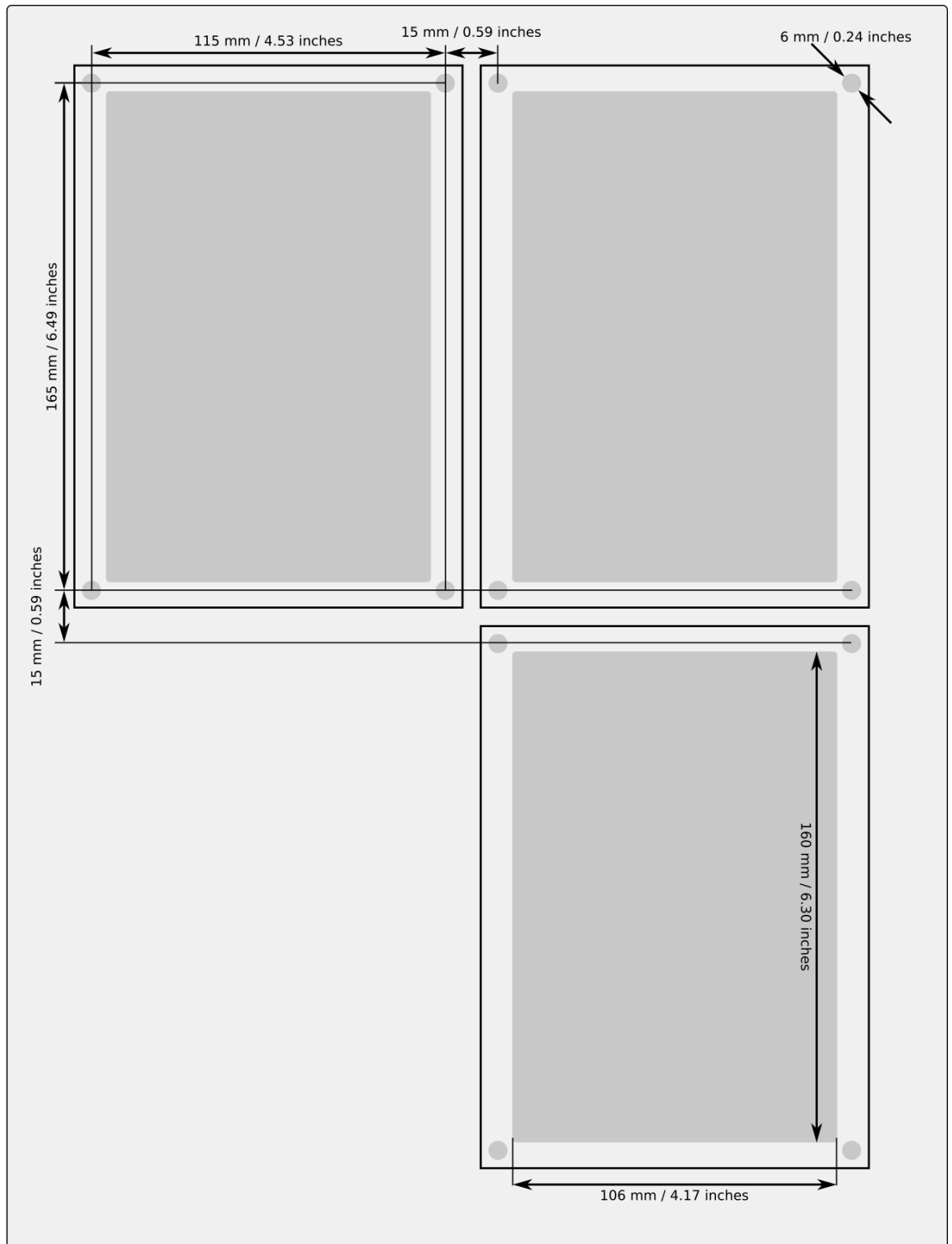


Figure. 7.4 - 78. Panel cutout dimensions and device spacing.



8 Technical data

8.1 Hardware

8.1.1 CPU & Power supply

Table. 8.1.1 - 80. General information for the CPU module.

General information	
Spare part code	#SP-200-CPU
Compatibility	AQ-200 series models

8.1.1.1 Auxiliary voltage

Table. 8.1.1.1 - 81. Power supply model A

Rated values	
Rated auxiliary voltage	80...265 V (AC/DC)
Power consumption	< 7 W < 15 W
Maximum permitted interrupt time	< 60 ms with 110 VDC
DC ripple	< 15 %
Terminal block connection	
Terminal block	Phoenix Contact MSTB 2,5/5-ST-5,08
Solid or stranded wire Maximum wire diameter	2.5 mm ²
Other	
Minimum recommended fuse rating	MCB C2

Table. 8.1.1.1 - 82. Power supply model B

Rated values	
Rated auxiliary voltage	18...72 VDC
Power consumption	< 7 W < 15 W
Maximum permitted interrupt time	< 90 ms with 24 VDC
DC ripple	< 15 %

Terminal block connection	
Terminal block	Phoenix Contact MSTB 2,5/5-ST-5,08
Solid or stranded wire Maximum wire diameter	2.5 mm ²
Other	
Minimum recommended fuse rating	MCB C2

8.1.1.2 CPU communication ports

Table. 8.1.1.2 - 83. Front panel local communication port.

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

Table. 8.1.1.2 - 84. Rear panel system communication port A.

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

Table. 8.1.1.2 - 85. 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 - 86. 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
Terminal block connection	
Terminal block	Phoenix Contact MSTB 2,5/5-ST-5,08
Solid or stranded wire Maximum wire diameter	2.5 mm ²

8.1.1.4 CPU digital outputs

Table. 8.1.1.4 - 87. 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
Terminal block connection	
Terminal block	Phoenix Contact MSTB 2,5/5-ST-5,08
Solid or stranded wire Maximum wire diameter	2.5 mm ²

Table. 8.1.1.4 - 88. 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
Terminal block connection	
Terminal block	Phoenix Contact MSTB 2,5/5-ST-5,08
Solid or stranded wire Maximum wire diameter	2.5 mm ²

8.1.2 Option cards

8.1.2.1 Digital input module

Table. 8.1.2.1 - 89. Technical data for the digital input module.

General information

Spare part code	#SP-200-DI8
Compatibility	AQ-200 series models
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	
Terminal block	Phoenix Contact MSTB 2,5/5-ST-5,08
Solid or stranded wire Maximum wire diameter	2.5 mm ²

8.1.2.2 Digital output module

Table. 8.1.2.2 - 90. Technical data for the digital output module.

General information	
Spare part code	#SP-200-DO5
Compatibility	AQ-200 series models
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	
Terminal block	Phoenix Contact MSTB 2,5/5-ST-5,08
Solid or stranded wire Maximum wire diameter	2.5 mm ²

8.1.2.3 RTD input module

Table. 8.1.2.3 - 91. Technical data for the RTD input module.

General information	
Spare part code	#SP-2xx-RTD
Compatibility	AQ-200 series & AQ-250 series models
Channels 1-8	
2/3/4-wire RTD	
Pt100 or Pt1000	

8.1.2.4 RS-232 & serial fiber communication module

Table. 8.1.2.4 - 92. Technical data for the RS-232 & serial fiber communication module.

General information	
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-200 series & AQ-250 series models
Ports	
RS-232	
Serial fiber (GG/PP/GP/PG)	
Serial port wavelength	
660 nm	
Cable type	
1 mm plastic fiber	

8.1.2.5 Double LC 100 Mbps Ethernet communication module

Table. 8.1.2.5 - 93. Technical data for the double LC 100 Mbps Ethernet communication module.

General information	
Spare part code	#SP-2XX-2XLC
Compatibility	AQ-200 series & AQ-250 series models
Protocols	
Protocols	HSR and PRP
Ports	
Quantity of fiber ports	2
Communication port C & D	LC fiber connector Wavelength 1300 nm
Fiber cable	50/125 µm or 62.5/125 µm multimode (glass)

8.1.2.6 Double ST 100 Mbps Ethernet communication module

Table. 8.1.2.6 - 94. Technical data for the double ST 100 Mbps Ethernet communication module.

General information	
Spare part code	#SP-2XX-2XST
Compatibility	AQ-200 series & AQ-250 series models
Dimensions	74 mm X 179 mm
Ports	ST connectors (2) and IRIG-B connector (1)
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
Transmitter wavelength	1260...1360 nm (nominal: 1310 nm)
Receiver wavelength	1100...1600 nm
Maximum distance	2 km
IRIG-B Connector	
Connector type	Phoenix Contact MC 1,5/ 2-ST-3,5 BD:1-2

8.1.3 Display

Table. 8.1.3 - 95. Technical data for the HMI LCD display.

General information	
Spare part code	#SP-200-DISP
Compatibility	AQ-200 series models
Dimensions and resolution	
Number of dots/resolution	320 x 160
Size	84.78 × 49.90 mm (3.34 × 1.96 in)
Display	
Type of display	LCD
Color	Monochrome

8.2 Functions

8.2.1 Control functions

8.2.1.1 Setting group selection

Table. 8.2.1.1 - 96. 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 digital 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 - 97. 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)
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.

8.2.1.3 Indicator object monitoring

Table. 8.2.1.3 - 98. Technical data for the indicator object monitoring function.

General	
Number of objects	5
Supported object types	Disconnecter (GND)
Signals	
Input signals	Digital inputs Software signals

8.2.2 Monitoring functions

8.2.2.1 Disturbance recorder

Table. 8.2.2.1 - 99. Technical data for the disturbance recorder function.

Recorded values	
Recorder analog channels	0...20 channels Freely selectable

Recorder digital channels	0...95 channels Freely selectable analog and binary signals 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

8.2.2.2 Event logger

Table. 8.2.2.2 - 100. Technical data for the event logger function.

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

8.3 Tests and environmental

Electrical environment compatibility

Table. 8.3 - 101. 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
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 - 102. Voltage tests.

Dielectric voltage test	
EN 60255-27, IEC 60255-5, EN 60255-1	2 kV (AC), 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 - 103. Mechanical tests.

Vibration test	
EN 60255-1, EN 60255-27, IEC 60255-21-1 Class 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 Class 1	20 g, 1 000 bumps/direction.

Table. 8.3 - 104. 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 - 105. 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 - 106. Dimensions and weight.

Without packaging (net)	
Dimensions	Height: 117 mm (4U) Width: 127 mm (1¼ rack) Depth: 174 mm (no cards & connectors)
Weight	1.5 kg
With packaging (gross)	
Dimensions	Height: 170 mm Width: 242 mm Depth: 219 mm
Weight	2 kg

9 Ordering information

		AQ - S 2 1 4 - P X 8 A A X A - X X X X X													
Model															
S	Alarm and Indication IED														
Device size															
1	1/4 of 19" rack														
Analog measurement															
4	No analog measurements														
Mounting															
P	Panel mounting														
Auxiliary voltage															
H	80...265 VAC/DC														
L	18...72 VDC														
Measurement accuracy class															
8	N/A														
Terminals															
A	N/A														
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														
D	2 Digital inputs, 24 V nominal threshold														
E	2 Digital inputs, 110 V nominal threshold														
F	2 Digital inputs, 220 V nominal threshold														
Reserved for future use															
A	N/A														
Slots A, B, C, D, E, F (6 pcs)															
A	Empty														
B	8 Digital inputs														
C	5 Output relays **														
F	2 x mA input - 8 x RTD input **														
G	2 x RJ45 100Mb Ethernet & IRIG-B *														
H	2 x ST 100Mb Ethernet & IRIG-B *														
J	Double LC 100Mb Ethernet (HSR, PRP redundant protocols) *														
K	Double RJ45 100Mb Ethernet (HSR, PRP redundant protocols) *														
L	RS-232 - Serial fiber (Plastic-Plastic) *														
M	RS-232 - Serial fiber (Plastic-Glass) *														
N	RS-232 - Serial fiber (Glass-Plastic) *														
O	RS-232 - Serial fiber (Glass-Glass) *														

* One card at most per IED

** Two cards at most per IED

Accessories

Order code	Description	Note	Manufacturer
ADAM-4015-CE	External 6-channel 2 or 3 wires RTD Input module, pre-configured	Requires an external power module	Advanced Co. Ltd.

ADAM-4018+-BE	External 8-ch Thermocouple mA Input module, pre-configured	Requires an external power module	Advanced Co. Ltd.
AQX033	Raising frame 87 mm		Arcmaq Ltd.
AQX070	Raising frame 40 mm		Arcmaq Ltd.
AQX069	Combiflex frame		Arcmaq Ltd.
AQX097	Wall mounting bracket		Arcmaq Ltd.

10 Contact and reference information

Manufacturer

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Visiting and postal address

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Contacts

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