

AQ-110x

Arc sensor device with overcurrent

Instruction manual

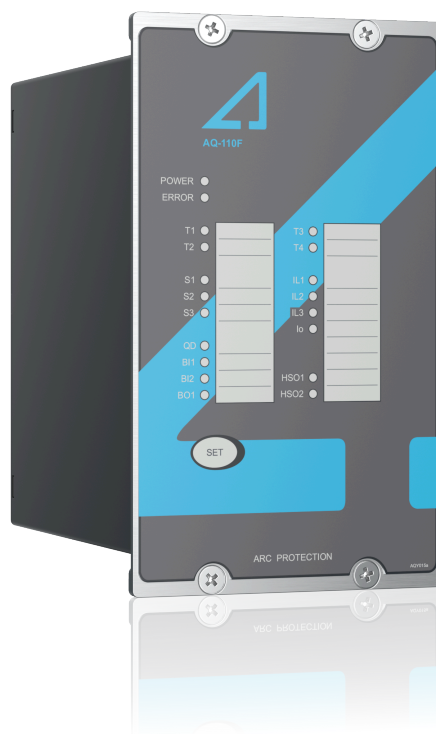


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Disclaimer

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

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1 Document information

Table. 1 - 1. History of Revision 1.

Revision	1.00
Date	October 2010
Changes	- The first revision of the manual.
Revision	1.01
Date	July 2011
Changes	<ul style="list-style-type: none"> - Sensor chapter revised (fiber pictures and point sensor connections). - Standard Arc Scheme chapter revised (e.g. scheme 0a added). - DIP switch definition updated (e.g. HSO latch/non-latch). - LED description revised (current channels LEDs will not blink during the auto-configuration). - Partly AQ-110F information added. - Dimensions and installation chapter, the depth of the unit is changed from 170 mm to 175 mm. - Casing and dimensions section, the unit size and the size with package have been added.
Revision	1.02
Date	April 2012
Changes	- The AQ-SAS TM chapter removed from the manual.
Revision	1.03
Date	July 2012
Changes	<ul style="list-style-type: none"> - Scheme select DIP switch settings chapter added. - The point sensor max. wiring length is up to 200 meters. - System self-supervision chapter revised.
Revision	1.04
Date	May 2019
Changes	<ul style="list-style-type: none"> - Moved the scheme selection content to DIP switch settings, refer to Chapter 3.5. - Technical data updated. - Added an application example, refer to Chapter 6.
Revision	1.05
Date	November 2019
Changes	- Added information to the "Technical data" chapter.

Table. 1 - 2. History of Revision 2.

Revision	2.00
Date	October 2020

Changes	<ul style="list-style-type: none"> - Content completely rewritten to improve grammar and readability. - The "Available logic schemes" chapter updated. - The AQ-02 point sensor chapter added to the "Arc sensors" chapter, and AQ-02's technical data added to the "Technical data" chapter. - The sensor-unit type dependency list updated. - The original "Connecting sensors" chapter moved to the AQ-0x instruction booklet, and replaced with a summary of how to connect point sensors. A summary of connecting fiber sensors also added to the chapter. - All technical data checked and updated where necessary. - Ordering information updated. - Images updated where necessary.
Revision	2.01
Date	November 2021
Changes	<ul style="list-style-type: none"> - Panel cut-out installation image added. - Dimension measurements updated. - Replaced "one fifths" with "1 A or 5 A secondary nominal can be selected" in the "Unit features" chapter. - Wiring diagram, simplified block diagram, DIP switch diagram & application image(s) updated. - Push button image added. - End covering description added to AQ-07, removed from AQ-08. - Cut-and-slice text removed all fiber descriptions. - Connections image updated. - The test plan example updated. - The Main-Tie-Main application example image updated. - The HSO chapter updated. - All table layouts unified in "Technical data". - The IP classification of point sensors updated. - The AWG value updated. - "Disturbance tests" table reformatted. - Order code images updated (separated the codes for AQ-110P and AQ-110F). - The number for Arcteq's technical support added to the reference information.
Revision	2.02
Date	January 2023
Changes	<ul style="list-style-type: none"> - Updated the Arcteq logo on the cover. - Updated the distance between the flash and the sensor in the "Testing the operation time" chapter. - Unified terminology used throughout the manual (e.g. unit and device means the same thing. Now all AQ 100 series relays are called "devices"). - Improved many existing drawings. - Rearranged topics into a more logical order. - Added connection drawings to input and output descriptions under "Connections" chapter. - Added hyperlinks to chapters. (e.g. "See Device features chapter for more information") - Listed more features in Device features chapter. - T3 is now considered to be normally open by default and normally closed as an order option. - Added information about binary output pulse messages. - Many tables have been simplified and made easier to read. - Scheme matrixes and simplified logic diagrams have been made more detailed in "Available schemes" chapter.
Revision	2.03
Date	April 2023

Changes	<ul style="list-style-type: none">- Small changes to visual style.- Small improvements to descriptions.
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2 Safety information

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

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



NOTICE!

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



CAUTION!

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



WARNING!

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



DANGER!

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

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

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

3 Abbreviations

AQD	– arc quenching device
BI	– binary input
BO	– binary output
CB	– circuit breaker
CBFP	– circuit breaker failure protection
CT	– current transformer
EPROM	– erasable, programmable read-only memory
HSO	– high-speed output
LED	– light emitting diode
LV	– low-voltage
MV	– medium-voltage
NC	– normally closed
NO	– normally open
PCB	– printed circuit board
RF	– radio frequency
Rx	– receiver
SAS	– standard arc scheme
SF	– system failure
Tx	– transceiver
μP	– microprocessor

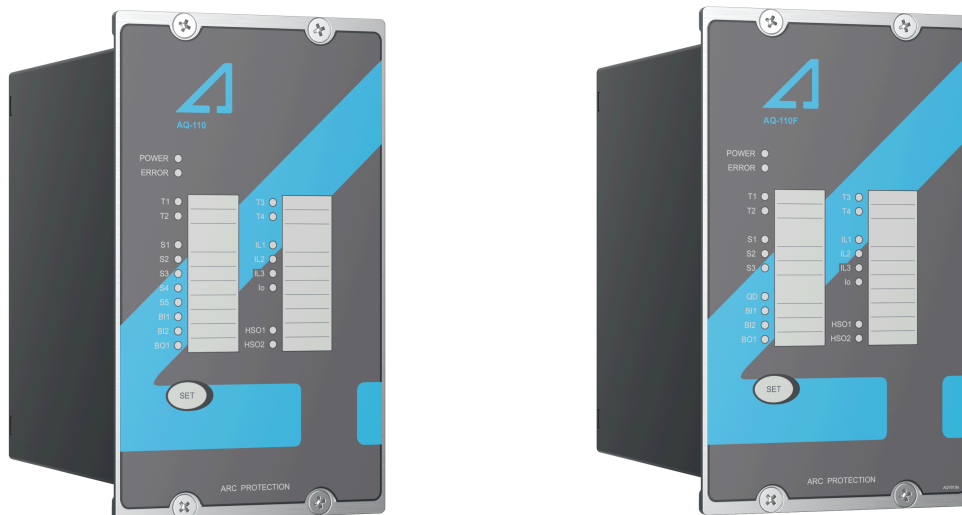
4 General

The AQ-110P is a sophisticated microprocessor-based arc flash protection device with point sensor channels and an optional fiber loop sensor channel. The AQ-110F is a sophisticated microprocessor-based arc flash protection device with fiber loop sensor channels. The devices are designed to minimize the damage caused by an arc fault. This is done by tripping the circuit breaker which supplies current to the fault when sensors detect arc light.

AQ-110 devices have three phase current measurement channels and one residual current measurement channel. Device can be set to require overcurrent to trip the circuit breaker when arc flash is detected.

The device includes a complete system self-supervision functionality which provides the highest level of dependability as it continuously monitors all internal system functions as well as all external connections.

Figure. 4 - 1. Arc protection devices AQ-110P (left) and AQ-110F (right).



The AQ-110P and AQ-110F are designed according to the latest protection relay standards and are therefore suitable for installations in rough environments. These include utilities and power plants (both traditional and renewable), various heavy industry applications (off-shore, marine, oil, gas, mining, steel, etc.) as well as commercial and institutional electrical systems. Both devices are suitable for MV and LV switchgears as well as for motor control center applications in both new and retrofitted installations.

5 Device features

AQ-110P and AQ-110F are arc flash protection devices which can be applied to a variety of applications. Both can be used on their own as a stand-alone device, or they can be a part of a more complex arc protection system by using binary inputs and outputs to connect multiple AQ 100 series devices together.

The AQ-110P supports four (4) arc sensing point sensor channels as well as one (1) optional fiber sensor channel for arc detection or arc quencher control. The AQ-110F supports three (3) arc sensing fiber sensor channels as well as one (1) optional fiber channel for arc quencher control. All other features are the same in both variants.

The following list presents the main features of the AQ-110P device:

- 92...265 V AC/DC auxiliary power supply or 18...72 V DC auxiliary power supply (optional)
- three (3) phase current inputs; 1 A or 5 A secondary nominal can be selected
- one (1) residual current inputs; 1 A or 5 A secondary nominal can be selected
- two (2) trimmers for configuring overcurrent function trip levels
- four (4) arc flash point sensor channels, max. three (3) point sensors per channel
- one (1) fiber loop sensor channel for arc flash detection or AQ-1000 arc quenching device control (optional)
- two (2) binary inputs with nominal operation voltage of 24 V DC
- two (2) high-speed semiconductor outputs
- four (4) trip relay outputs
- one (1) binary output (with internal 24 V DC power supply)
- one (1) system failure output (change-over)
- twenty (20) indication LEDs
- sixteen (16) DIP switches for logic configuration
- one (1) push button.

The following list presents the main features of the AQ-110F device:

- 92...265 V AC/DC auxiliary power supply or 18...72 V DC auxiliary power supply (optional)
- three (3) phase current inputs; 1 A or 5 A secondary nominal can be selected
- one (1) residual current inputs; 1 A or 5 A secondary nominal can be selected
- two (2) trimmers for configuring overcurrent function trip levels
- three (3) fiber loop sensor channels for arc flash detection
- one (1) fiber connector for AQ-1000 arc quenching device control (optional)
- two (2) binary inputs with nominal operation voltage of 24 V DC
- two (2) high-speed semiconductor outputs
- four (4) trip relay outputs
- one (1) binary output (with internal 24 V DC power supply)
- one (1) system failure output (change-over)
- nineteen (19) indication LEDs
- sixteen (16) DIP switches for logic configuration
- one (1) push button.

6 Connections

The figures below depict the connections of AQ-110P and AQ-110F. Please note that the SF relay is in the de-energized position; also note that the device has been halved for the image to allow for space for all connector explanations.

Figure. 6 - 2. Rear terminals of AQ-110P.

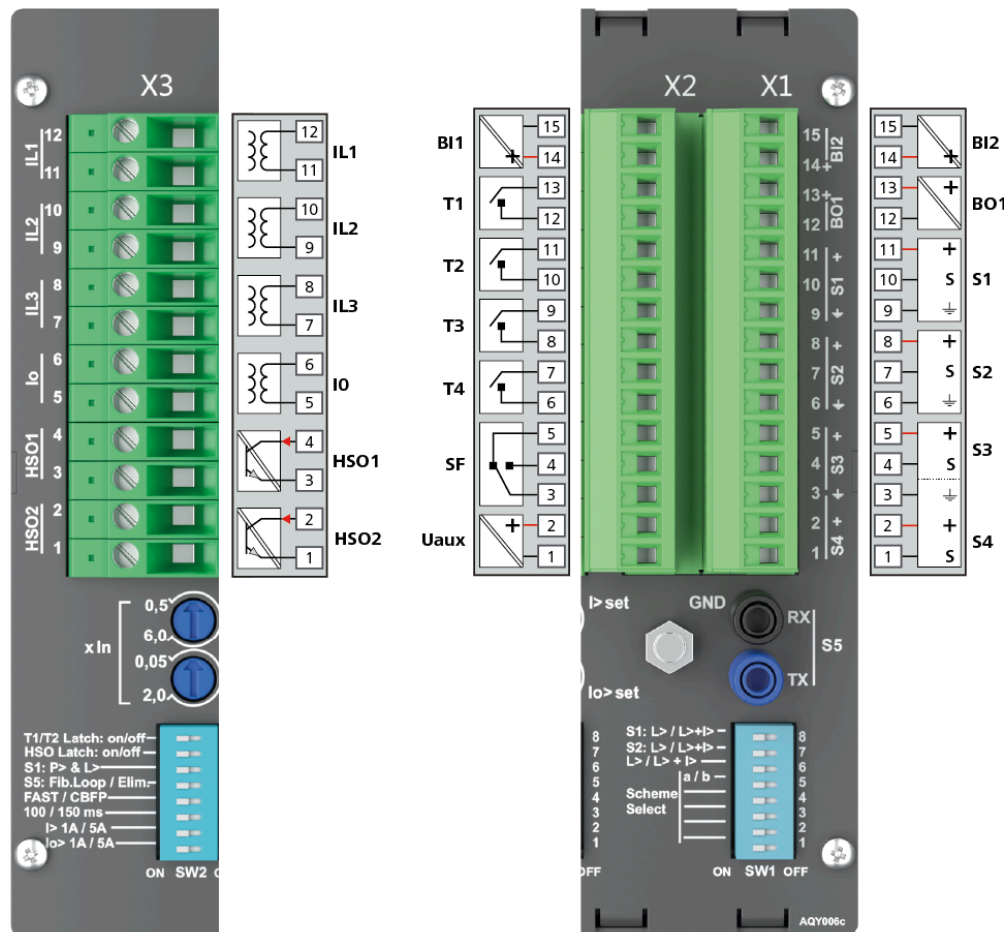
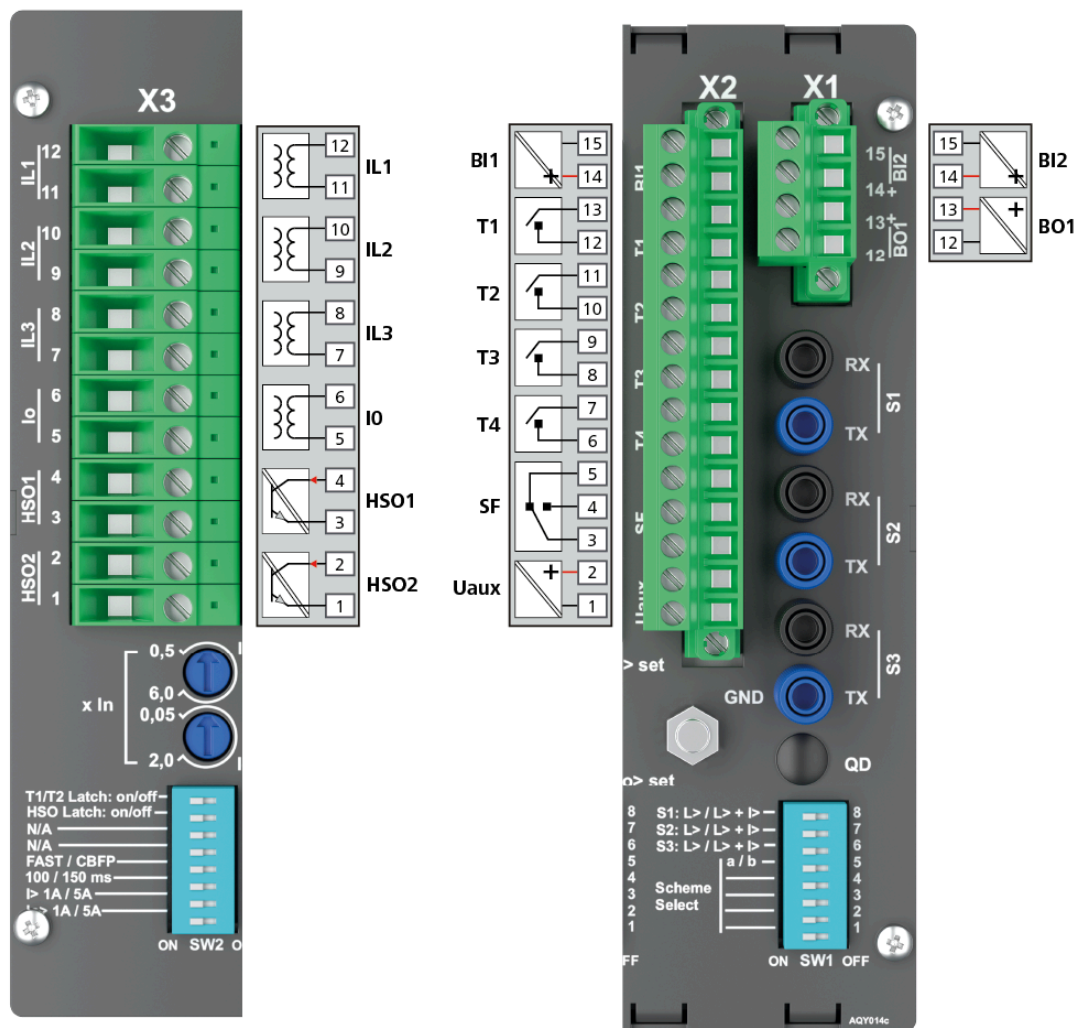


Figure. 6 - 3. Rear terminals of AQ-110F.



6.1 Simplified block diagram

The figures below presents the main components that can be found in the AQ-110x devices (AQ-110P and AQ-110F).

Figure. 6.1 - 4. Simplified block diagram of AQ-110P.

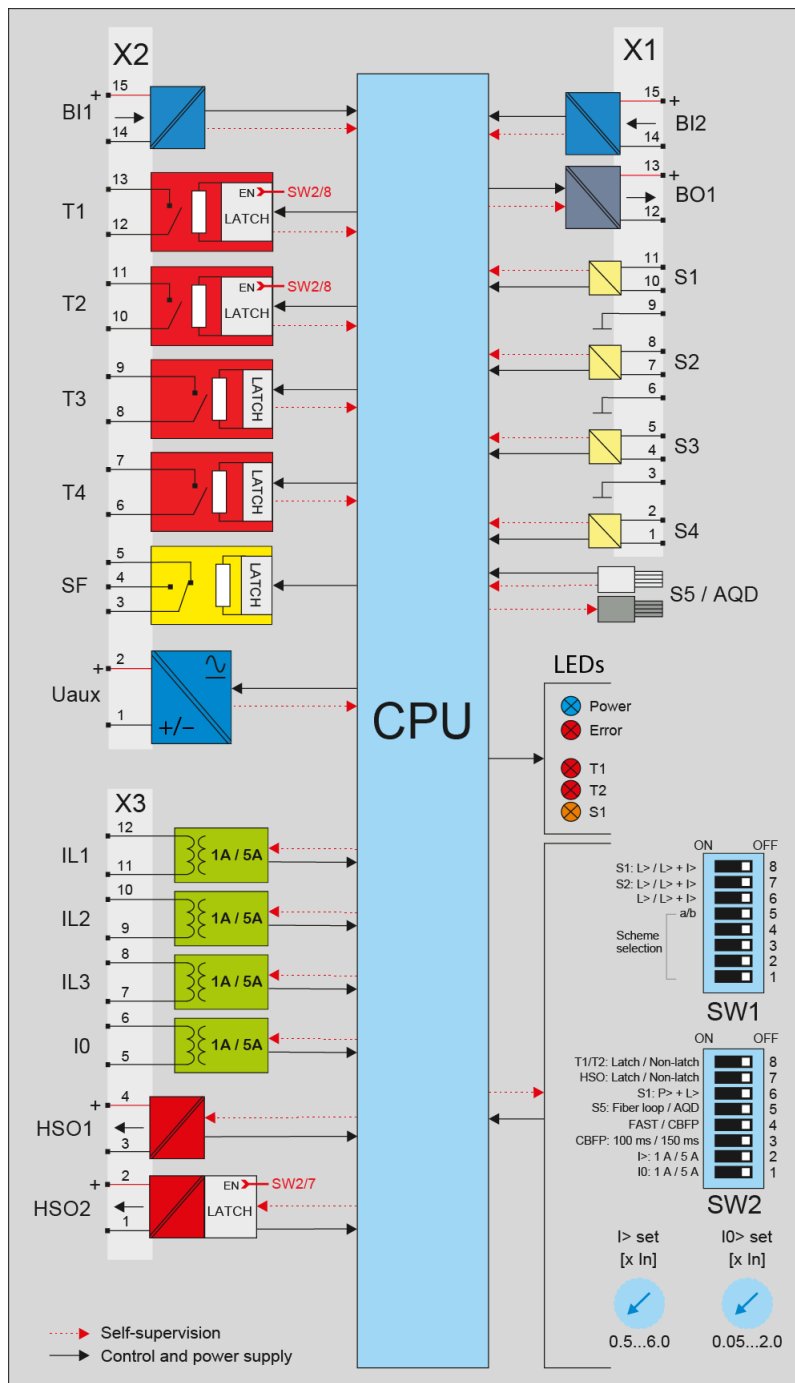
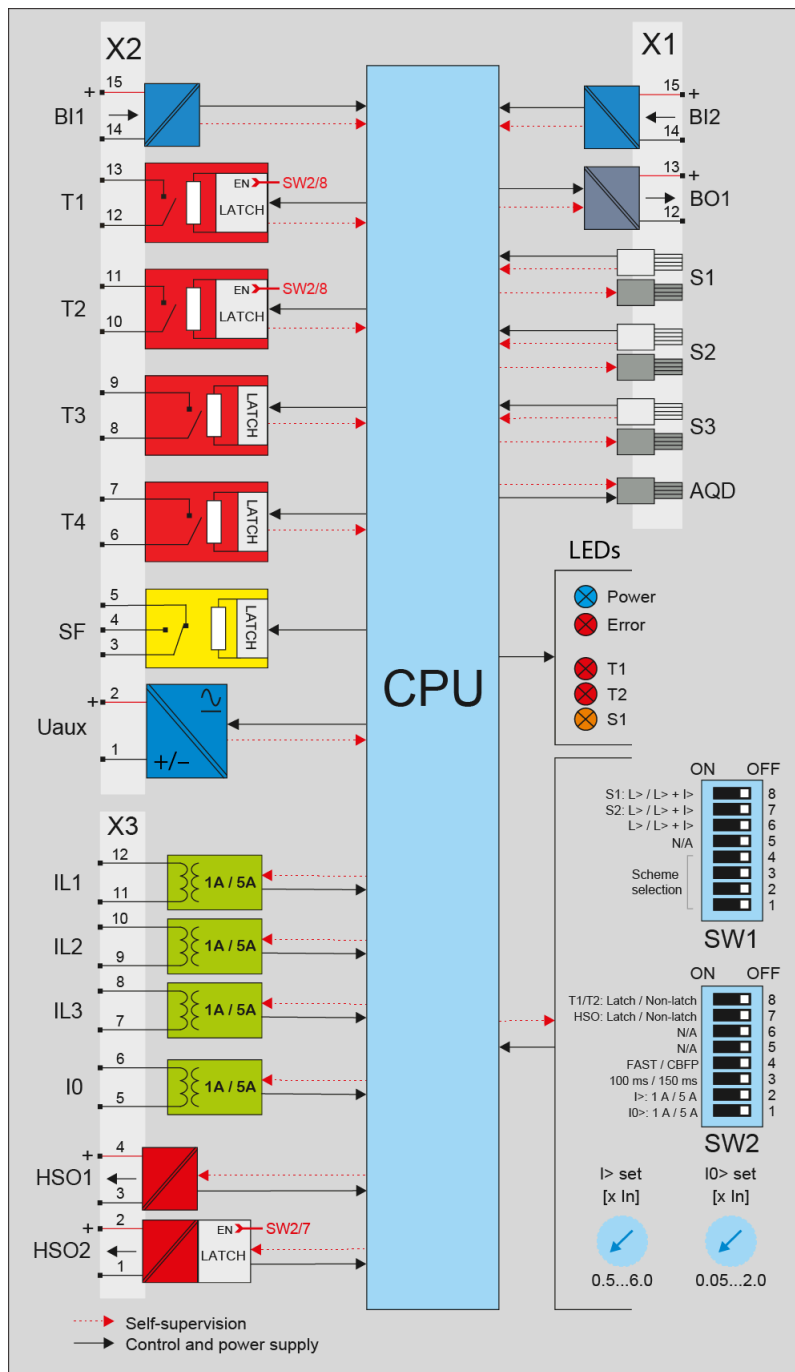


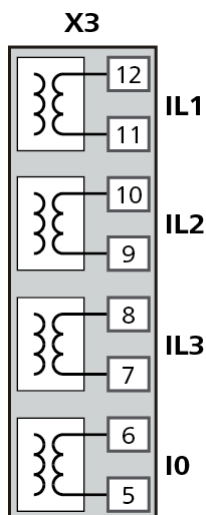
Figure. 6.1 - 5. Simplified block diagram of AQ-110F.



6.2 Inputs

6.2.1 Current measurement inputs

Figure. 6.2.1 - 6. Current measurement connections



This device contains four (4) CT inputs for measuring the three phase currents and the residual current. Both the phase current and the residual current inputs can be configured to a nominal current of 1 A or 5 A with the DIP switches (for more information, please refer to the [DIP switch settings](#) chapter).

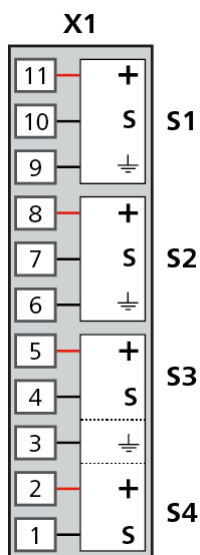
The [Current threshold settings](#) chapter describes the setting of current threshold levels in more detail.

This device includes a current transformer supervision function. See [System self-supervision](#) chapter for more information.

6.2.2 Arc sensor channels

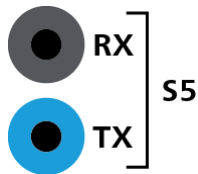
AQ-110P

Figure. 6.2.2 - 7. Arc point sensor connections available in AQ-110P.



AQ-110P has four (4) arc point sensor channels: S1, S2, S3 and S4. Up to three (3) arc point sensors can be connected to each channel. When the arc protection system has been set up, point sensor connections are constantly monitored. In case of sensor fault or disconnection, the device will go into Error mode. See [System self-supervision](#) chapter for more information.

Figure. 6.2.2 - 8. Optional fiber loop channel connection available in AQ-110P.



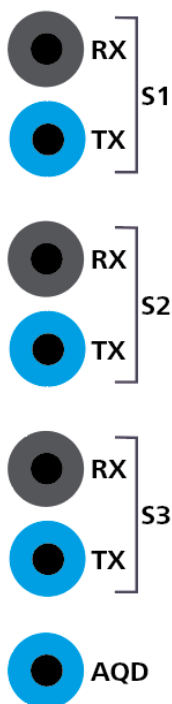
S5 is the optional fiber loop sensor channel with a transmitter (Tx) terminal and a receiver (Rx) terminal. The function of S5 is controlled with the DIP switches (please refer to the [DIP switch settings](#) chapter for more information). When S5 is configured as a fiber loop arc sensor channel, one of its ends is connected to "Tx" and the other to "Rx". This sensor loop is then continuously monitored by a test light pulse that travels through the loop. If a discontinuity is detected, the device goes into Error mode. See [System self-supervision](#) chapter for more information.

Alternatively, S5 can be configured to control the arc quenching device (AQD). Device sends a test light pulse continuously to the arc quenching device to supervise the fiber connection. If the arc quenching device doesn't receive the test pulses the device will go into Error mode.

For more information on sensors, please refer to the [Arc sensors](#) chapter as well as to the AQ-0x instruction booklet which can be found on Arcteq's website (<https://www.arcteq.fi/downloads/>). For more information on AQ-1000 arc quenching device (AQD) please refer to the AQ-1000 Instruction manual.

AQ-110F

Figure. 6.2.2 - 9. Sensor connections available in AQ-110F.



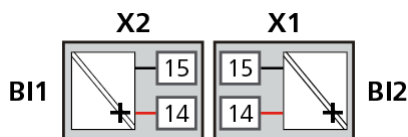
AQ-110F has three (3) fiber loop arc sensor channels: S1, S2 and S3. Each channel has a transmitter (Tx) terminal and a receiver (Rx) terminal. These sensor loops are continuously monitored by a test light pulse that travels through the loop. If a discontinuity is detected, the device goes into Error mode. See [System self-supervision](#) chapter for more information.

AQ-110F can be ordered with an additional transmitter (Tx) terminal for arc quenching device (AQD) control. Device sends a test light pulse continuously to the arc quenching device to supervise the fiber connection. If the arc quenching device doesn't receive the test pulses the device will go into Error mode.

For more information on sensors, please refer to the [Arc sensors](#) chapter as well as to the AQ-0x instruction booklet which can be found on Arcteq's website (<https://www.arcteq.fi/downloads/>). For more information on AQ-1000 arc quenching device (AQD) please refer to the AQ-1000 Instruction manual.

6.2.3 Binary inputs

Figure. 6.2.3 - 10. Binary input connections



This device contains two (2) binary inputs. Typically, the binary inputs are used for receiving arc light signals, master trip commands or overcurrent signals. Function of binary inputs are configured using DIP switches. For more information, please refer to the [DIP switch settings](#) chapter.

Please note that when this device receives an overcurrent signal from a non-AQ 100 series device, the actual operating time depends on the operating time of the that device. Therefore, the total operating time cannot be specified in the technical data.

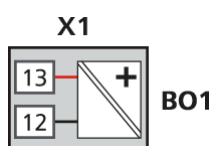
The binary inputs are activated when a connected DC signal reaches the specified nominal voltage level of the corresponding input. The nominal voltage level for this device is 24 VDC. Please note that the actual activation threshold of the binary input is at a lower voltage than the specified nominal voltage value (see [Technical Data](#) chapter).

AQ 100 series devices monitor health of wiring between binary inputs and binary outputs. If binary input loses connection to any of the configured binary outputs, the device will go into Error mode. See [System self-supervision](#) chapter for more information.

6.3 Outputs

6.3.1 Binary outputs

Figure. 6.3.1 - 11. Binary output connection



The device has one (1) binary output: BO1. AQ 100 series binary outputs have an internal 24 VDC power supply. This binary output is used for sending overcurrent, light detection, master trip and other signals to other AQ 100 series devices in the same system. The binary output function can be configured with the DIP switches. For more information on the configuration, please refer to the [DIP switch settings](#) chapter.

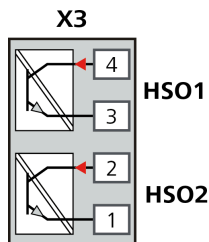
AQ 100 series device's binary outputs send out a short pulse every second. Binary inputs of the receiving AQ 100 series devices use these pulses to count the number of connected binary outputs. See [System self-supervision](#) chapter for more information.

**NOTICE!**

Please note that the binary outputs are polarity-sensitive.

6.3.2 High-speed output(s)

Figure. 6.3.2 - 12. The high-speed output's direction of rotation.



The device contains two (2) high-speed semiconductor outputs, namely HSO1 and HSO2. These outputs can be used as heavy-duty signaling outputs. Due to their high current-carrying capacity, HSO1 and HSO2 can send overcurrent or light information to a maximum of twenty (20) pieces of AQ 100 series devices without a need for signal amplifiers. The operation of these high-speed outputs depends on the DIP switch settings (for more information, please refer to the [DIP switch settings](#) chapter).

AQ 100 series device's high-speed outputs send out a short pulse every second. Binary inputs of the receiving AQ 100 series devices use these pulses to count the number of connected high-speed outputs. See [System self-supervision](#) chapter for more information.

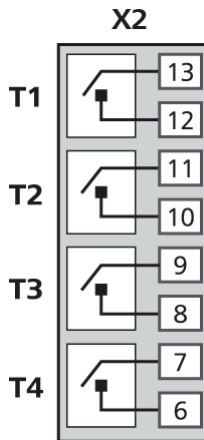
The output's direction of rotation is as follows: the signal goes in the even pin and out from the odd pin (see the image below, as detailed in the device's side sticker).

**NOTICE!**

The high-speed outputs are polarity-sensitive.

6.3.3 Trip relays

Figure. 6.3.3 - 13. Trip relay connections



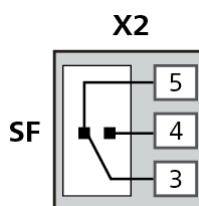
This device has four (4) normally open trip relay outputs. Trip relays T1 and T2 are used for tripping circuit breakers. T4 is generally used for tripping one additional disconnecting device, or as a trip alarm (local or remote) monitoring and alarming system.

T3 can alternatively be ordered as a normally closed trip relay (electronic lock-out relay). Once opened by fault detection it holds its open position until it receives a manual reset command or until auxiliary power supply is lost. When re-applying the auxiliary power supply, the electronic lock-out relay returns to the same position it had prior to the power loss. This normally closed relay output can also be used for tripping contactor-controlled devices.

T3 and T4 are always latching relays. Trip relays T1 and T2 can be set as latching relays by setting DIP switch SW2:8 ("T1/T2: Latching / Non-latching") to "Latching" position. Latched relays can be reset by pressing the "SET" button.

6.3.4 System failure relay

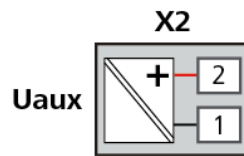
Figure. 6.3.4 - 14. System failure relay connection (de-energized position)



The system failure (SF) relay is of the change-over type (NO/NC) and it is energized when the device is in a healthy condition and powered on. Whenever the device detects a system error or the auxiliary power supply is disconnected, the SF relay changes its state. The state stays this way until the device returns to a healthy condition. See the [System self-supervision](#) chapter for more information.

6.4 Auxiliary voltage

Figure. 6.4 - 15. Auxiliary power supply connection



The auxiliary power supply voltage is 92....265 V AC/DC. Alternatively, the optional auxiliary power supply can be of 18...72 V DC. This choice must be specified when ordering.

7 Arc sensors

The AQ 100 series provides arc light point sensors and arc light fiber optic loop sensors. These sensors can be used with different devices and different switchgear types according to specific application requirements.

Arc light point sensors are typically installed in metal-clad compartments, and they provide a quick and accurate location of the fault area. Arc light fiber loop sensors typically cover a wider protected area with one fiber, when there is no need to pinpoint the exact location for a fault.

7.1 Arc light point sensor AQ-01

AQ-01 is an arc light point sensor with a light-sensitive photodiode element activated by arc light. The AQ-01 sensors should be mounted in the switchgear cubicles in such a way that the light-sensitive part covers the protected area as completely as possible. While multiple sensors can be installed, in most cases one sensor per closed metal-clad compartment is sufficient. In open spaces (such as a busbar section) the sensors should be mounted no more than two meters apart.

The default light intensity threshold for an AQ-01 sensor is 8,000 lux. Depending on the demand of the application, light point sensors can be ordered with 25,000 lux or 50,000 lux thresholds. Its detection radius is 180 degrees.

Figure. 7.1 - 16. The AQ-01 light sensor.



An AQ-01 is installed either inside or outside the compartment wall. When mounting inside the wall, the sensor is placed on the wall with the colored side against the wall and then fixed to the wall with two screws. When mounting outside the wall the sensor is placed on the wall with the grey side against the wall and the eye is pushed into the drilled compartment hole and then fixed to the wall with two screws from the back of the sensor. No external mounting plates are needed regardless of the mounting type; however, mounting brackets can be used if so desired.

Up to three (3) sensors can be connected in series (with the exception of AQ-103 which can take only one point sensor per channel). Installing a connection cable is simple as each end of the sensor has a detachable cover over the cable connectors. Please remember to reattach the cover once the wires have been installed.



NOTICE!

The AQ-01 point sensor does not come with a connection cable!

7.2 Arc light and pressure point sensor AQ-02

AQ-02 is an arc light and pressure point sensor that comes with arc light detection and ambient pressure detection. AQ-02 point sensor activates when both light and pressure are detected. The AQ-02 sensors should be mounted in the switchgear cubicles in such a way that the light-sensitive part covers the protected area as completely as possible. While multiple sensors can be installed, in most cases one sensor per closed metal-clad compartment is sufficient. The AQ-02 sensors cannot be installed in open spaces.

The default light intensity threshold for an AQ-02 sensor is 8,000 lux. Depending on the demand of the application, AQ-02 can also be ordered with 25,000 lux or 50,000 lux thresholds. Its detection radius is 180 degrees. The pressure threshold is fixed at 0.2 bar above ambient pressure.

Figure. 7.2 - 17. AQ-02 arc light and pressure point sensor.



An AQ-02 can only be installed inside the compartment wall as not to block pressure detection located next to "the eye". The sensor is placed on the wall (with the colored side against the wall), and then fixed to the wall with two screws. No external mounting plates are needed regardless of the mounting type; however, mounting brackets can be used if so desired.

Up to three (3) sensors can be connected in series (with the exception of AQ-103 which can take only one point sensor per channel). Installing a connection cable is simple as each end of the sensor has a detachable cover over the cable connectors. Please remember to reattach the cover once the wires have been installed.



NOTICE!

The AQ-02 point sensor does not come with a connection cable!

7.3 Arc light fiber optic loop sensor AQ-06

AQ-06 is an arc light fiber optic loop sensor, which is a plastic fiber optic cable. Fiber sensors are distributed through the protected switchgear cells. The fixed light intensity threshold of an AQ-06 sensor is 8,000 lux. The sensor's detection radius is 360 degrees.

AQ-06 sensors can be ordered in pre-manufactured lengths of 3...40 meters (3 m, 5 m, 10 m, 15 m, 20 m, 25 m, 30 m, 35 m, 40 m).

7.4 Arc light fiber optic loop sensor AQ-07

AQ-07 is an arc light fiber optic loop sensor, which is a robust fiber optic cable with a practically unlimited bending radius. The sensor contains hundreds of glass fiber drains covered by a plastic tube, thus making it extremely strong and durable. Fiber sensors are distributed through the protected switchgear cells.

AQ-07 sensors can be ordered in pre-manufactured lengths of 3...50 meters (3 m, 5 m, 10 m, 15 m, 20 m, 25 m, 30 m, 35 m, 40 m, 45 m, 50 m).

The fixed light intensity threshold of an AQ-07 sensor is 8,000 lux. The sensor's detection radius is 360 degrees.

If necessary, the ends of an AQ-07 cable can be ordered with heat shrinking tubing to avoid light detection outside the protected zone. The covered area can be one (1) or two (2) meters by default; if other lengths are required, please consult the Arcteq sales team. You can find the [Contact and reference information](#) page at the end of this manual.

7.5 Arc light fiber optic loop sensor AQ-08

AQ-08 is an arc light fiber optic loop sensor. It is designed to withstand temperatures up to 125 °C, which makes it suitable for e.g. wind turbine windings. AQ-08 is a robust fiber optic cable with a practically unlimited bending radius. The sensor contains hundreds of glass fiber drains that are covered by a plastic tube, thus making it extremely strong and durable. Fiber sensors are distributed through the protected switchgear cells.

AQ-08 sensors can be ordered in pre-manufactured lengths of 3...15 meters (3 m, 5 m, 10 m, 15 m).

The fixed light intensity threshold of an AQ-08 sensor is 8,000 lux. The sensor's detection radius is 360 degrees.

7.6 Sensor dependencies

Compatibility of arc sensor types depend on the hardware available in the AQ 100 series device. The table below describes those dependencies.

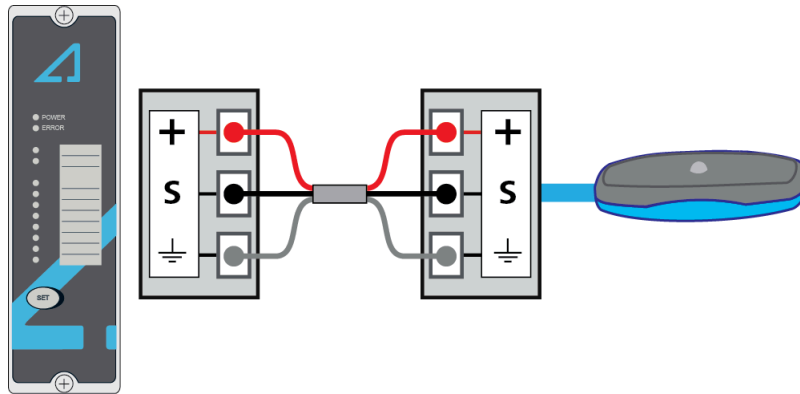
Table. 7.6 - 3. Sensor dependencies.

	Point sensors (AQ-01 & AQ-02)	Fiber loops (AQ-06, AQ-07 & AQ-08)
AQ-101	Yes	Order option
AQ-101D	Yes	Order option
AQ-101S	Yes	No
AQ-102	No	Yes
AQ-103	Yes	Order option
AQ-110P	Yes	Order option
AQ-110F	No	Yes

7.7 Connecting sensors

7.7.1 Point sensors

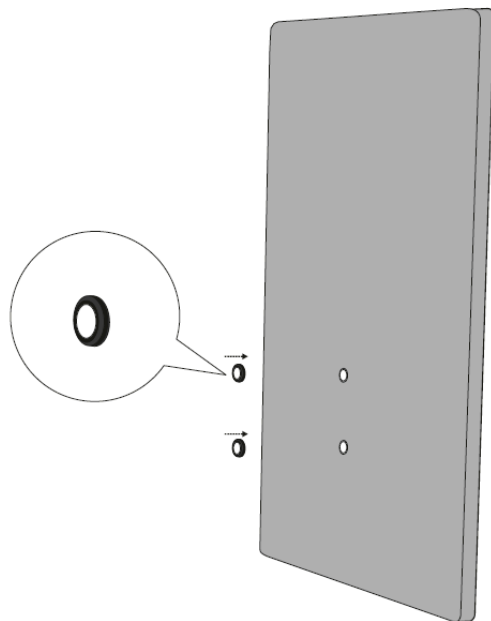
Figure. 7.7.1 - 18. Wiring diagram of point sensors.



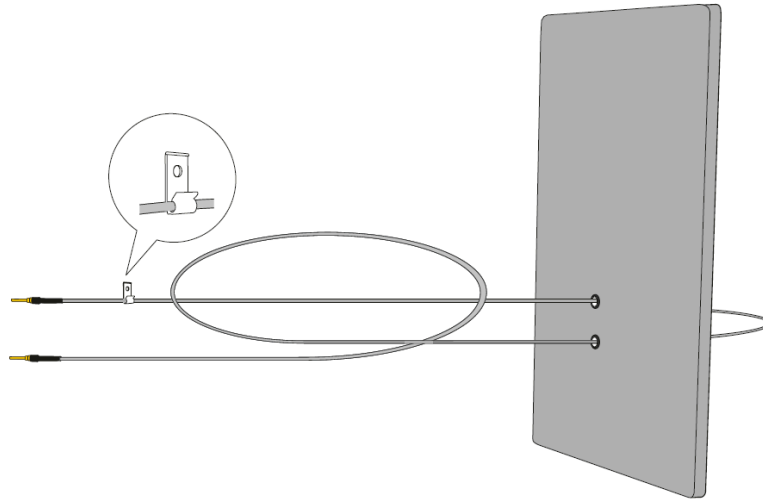
1. Open the sensor covers and detach the connectors.
2. Attach the cable to the connector and to the arc protection device.
3. Reattach the connectors to the sensor.
4. Run the auto-configuration procedure. See [System setup](#) for more details.

7.7.2 Fiber loop sensors

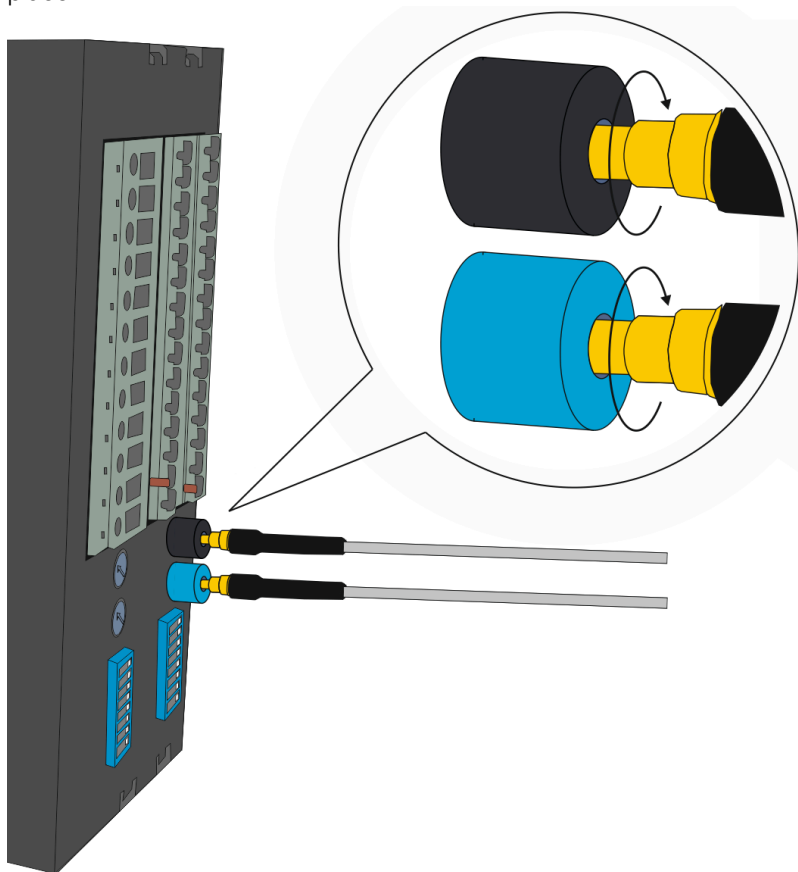
1. Drill holes on the wall for the sensor cable to enter the protected compartment.
2. Install protective covers in the holes to ensure the sensor cable remains unharmed by rough edges.



3. Run the sensor cable through the holes and along the protected area. Fasten it to the compartment walls with cable clips or some other appropriate anchoring method.



4. Turn the black and blue receiver ("Rx") and transceiver ("Tx") screws counter-clockwise and plug in the sensor cable terminals. Then turn the screws clockwise to secure the terminals in their place.



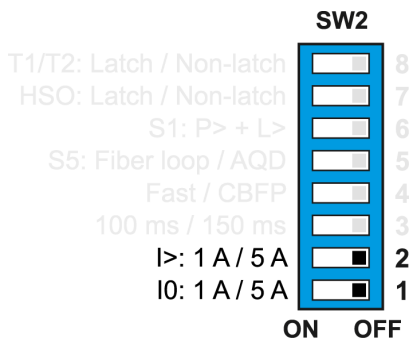
8 Operation and configuration

8.1 Current threshold settings

The AQ-110x devices have four (4) current measurement inputs: three (3) measure phase currents and one (1) measures the residual current. Both the phase and residual current measurements can be used as an additional trip criteria in an arc protection system to avoid trips caused by natural light sources. When an arc sensor channel has been set to "Light and overcurrent" mode, overcurrent and light must be detected simultaneously for the device to trip.

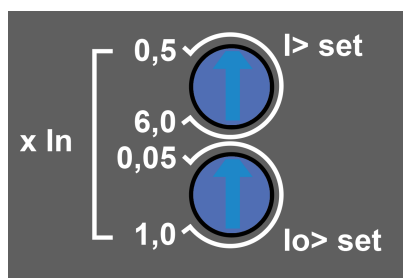
Depending on the selected logic scheme the device can also send overcurrent indication signals with binary outputs or high-speed outputs to external devices.

Figure. 8.1 - 19. DIP switches for defining nominal current.



DIP switches SW2:1 and SW2:2 can be used for selecting either 1 A or 5 A nominal current for phase current measurement and residual current measurement. The set points are set by using the trimmers (see the image below). The setting range for the phase overcurrent stage is $0.5...6 \times I_n$. The setting range for the residual overcurrent stage is $0.05...1 \times I_n$.

Figure. 8.1 - 20. Overcurrent setting trimmers.



The threshold for phase overcurrent is typically set to 50 % above the highest load current. The residual overcurrent is typically set to very sensitive. You can get an accurate setting by injecting the desired set current into the phase and residual current inputs of the device and by simultaneously adjusting the trimmers until the phase and residual current indicator LEDs are lit. You can fine-tune the current threshold setting by adjusting the trimmers and switching between lit and unlit LEDs.

8.2 DIP switch settings

The DIP switches are used to easily configure various tripping logics and other functionalities for the device. Both AQ-110 variants contain two switch groups, SW1 and SW2. They are located at the back of the device. The figure below presents the numbering of the two switch groups, and the tables below that give a detailed description of the settings for both switch groups.

Protection logic can be defined by selecting a logic scheme with DIP switches SW1:1 to SW1:5. The scheme selection is based on binary arithmetic. Logic schemes are described in the next chapter.

Tripping can be set with DIP switches to require either just arc light or both arc light and overcurrent simultaneously. Adding overcurrent criteria ensures the device trips when an arc fault occurs but not when a strong natural light source hits the light sensor (e.g. sunlight). Device can detect overcurrent by measuring phase currents and residual current or by receiving overcurrent signal from an external device (mainly another AQ-110P or AQ-110F device) which is connected to a binary input.

CBFP (circuit breaker failure protection) function can be enabled with DIP switch SW2:4. CBFP time delay (100 ms or 150 ms) can be set with DIP switch SW2:3. CBFP logic depends on the selected logic scheme. See [Circuit breaker failure protection](#) chapter for more information.

Figure. 8.2 - 21. DIP switch diagram for AQ-110P (above) and AQ-110F (below).

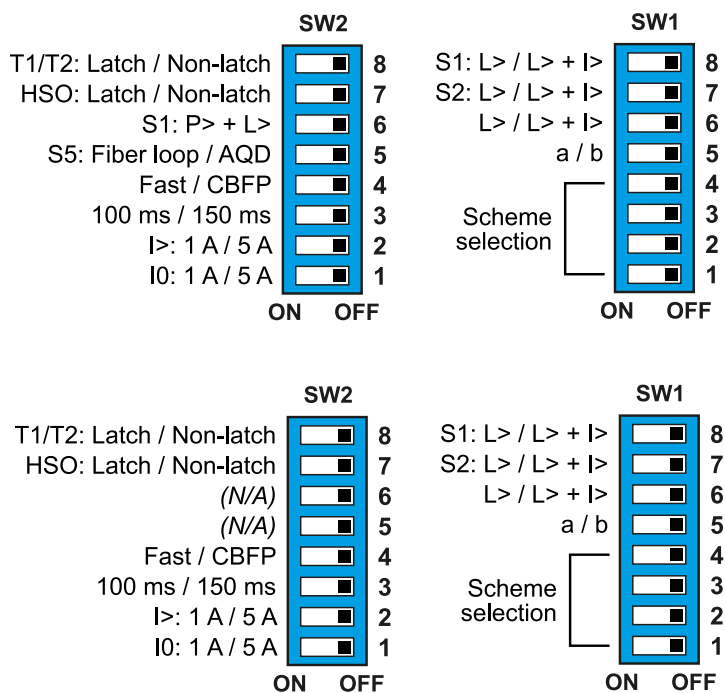


Table. 8.2 - 4. DIP switch settings for SW1 group.

Switch	Function selection	ON (left position)	OFF (right position)
8	The tripping criterion for the S1 point sensor channel. (AQ-110P) The tripping criterion for the S1 fiber loop channel. (AQ-110F)	Tripping on light only (L>).	Light detection only trips if overcurrent is also detected at the same time (L> + I>)

Switch	Function selection	ON (left position)	OFF (right position)
7	The tripping criterion for the S2 point sensor channel. (AQ-110P) The tripping criterion for the S2 fiber loop channel. (AQ-110F)		
6	The tripping criterion for the S3 fiber loop channel. (AQ-110F) The tripping criterion for the S3 and S4 (point sensors) and S5 (fiber loop) channels. (AQ-110P)		
5	Selects the logic scheme. Please refer to the Available logic schemes chapter.	Switch 1: 1	Switch 1: 0
4-1		Switch 2: 2 Switch 3: 4 Switch 4: 8 Switch 5: a	Switch 2: 0 Switch 3: 0 Switch 4: 0 Switch 5: b

Table. 8.2 - 5. DIP switch settings for SW2 group.

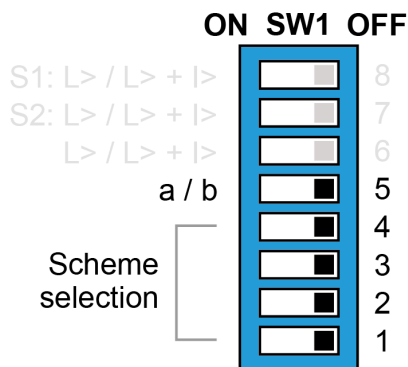
Switch	Function selection	ON (left position)	OFF (right position)
8	Enables or disables T1 and T2 latching.	T1 and T2 operate as latching relay outputs.	T1 and T2 latching is disabled.
7	Enables or disables HSO2 high-speed output latching.	HSO2 operates as a latching output.	HSO2 latching is disabled.
6	The tripping criterion for the S1 sensor channel.	Tripping on pressure only (P>).	Tripping on light only (L>).
5	The selection between the fiber loop function and the arc quenching device (AQD) control.	The S5 fiber sensor channel operates as the fiber loop sensor function.	The S5 fiber sensor channel operates as the arc quenching device (AQD) control. The Tx terminal of S5 sends a test pulse signal to the quenching system.
4	Enable or disable CBFP time delay.	CBFP time delay is not used.	Depending on the selected scheme, some outputs (trip contacts and the binary output) activate after a time delay if the fault is not cleared on time. Check the logic scheme diagram for more information.
3	The setting for the CBFP time.	The CBFP time is set to 100 ms.	The CBFP time is set to 150 ms.
2	The nominal current selection for the phase currents IL1, IL2 and IL3.	The nominal current is 1 A.	The nominal current is 5 A.
1	The nominal current selection for the residual current IO.	The nominal current is 1 A.	The nominal current is 5 A.

8.3 Available logic schemes

The schemes described below are the most commonly used ones for AQ-110P and AQ-110F devices. However, additional schemes are also available; please contact your nearest Arcteq representative for more information on those schemes. The schemes are configured using the first DIP switch group (SW1) and its switches numbered 1...4 ("Scheme selection") and 5 ("a or b"). The scheme selection is based on binary arithmetic:

- Switch 1: 1
- Switch 2: 2
- Switch 3: 4
- Switch 4: 8
- Switch 5: a or b

Figure. 8.3 - 22. DIP switches used for selecting the logic scheme.

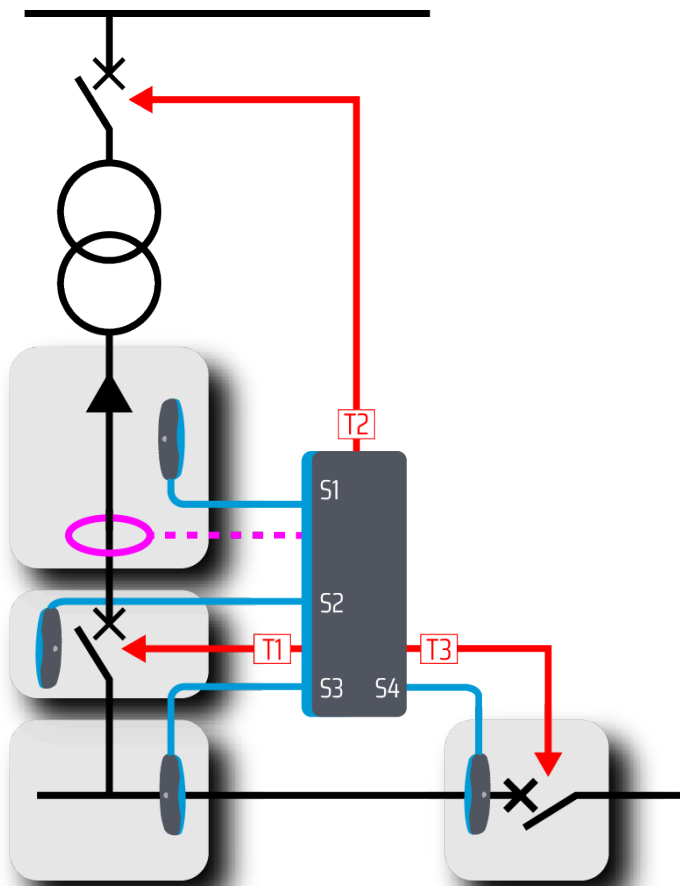


AQ 100 series arc protection devices can be used as a stand-alone device or as a part of a more complex arc protection system with multiple AQ 100 series devices. The most convenient way to set the device to a more complex arc protection system is to use Standard Arc Schemes (SAS). For detailed instructions on each of the available Standard Arc Schemes please refer to the AQ-SAS™ booklet (can be found at arcteq.fi/downloads/).

8.3.1 SS:0a Selective arc protection

The logic scheme SS:0a is designed for selective incomer arc protection. It can be used for substations with one or more incomers. This logic scheme is a modified version of [SS:2a](#). The only difference is that S1 channel doesn't activate BO1 pulse signal but does activate the arc quenching device control (AQD) signal.

Figure. 8.3.1 - 23. Example application with AQ-110 (SS:1a).



If a fault is detected in the incomer cable compartment (S1), circuit breakers on both sides of the transformer will be tripped with T1 and T2. If the fault isn't cleared on time, T3 will trip the tie breaker (if applicable) and HSO2 sends master trip signal to the outgoing feeder protection devices after CBFP time delay.

If a fault is detected in the incomer circuit breaker compartment (S2), circuit breakers on both sides of the transformer (T1-T2), tie breaker (T3) and all outgoing feeders (HSO2) will be tripped. If a fault is detected in the busbar compartment (S3) or in the tie breaker compartment (S4) the incomer (T1), tie breaker (T3) and all outgoing feeders (HSO2) will be tripped. If the fault isn't cleared on time, T2 will trip the incomer HV side circuit breaker.

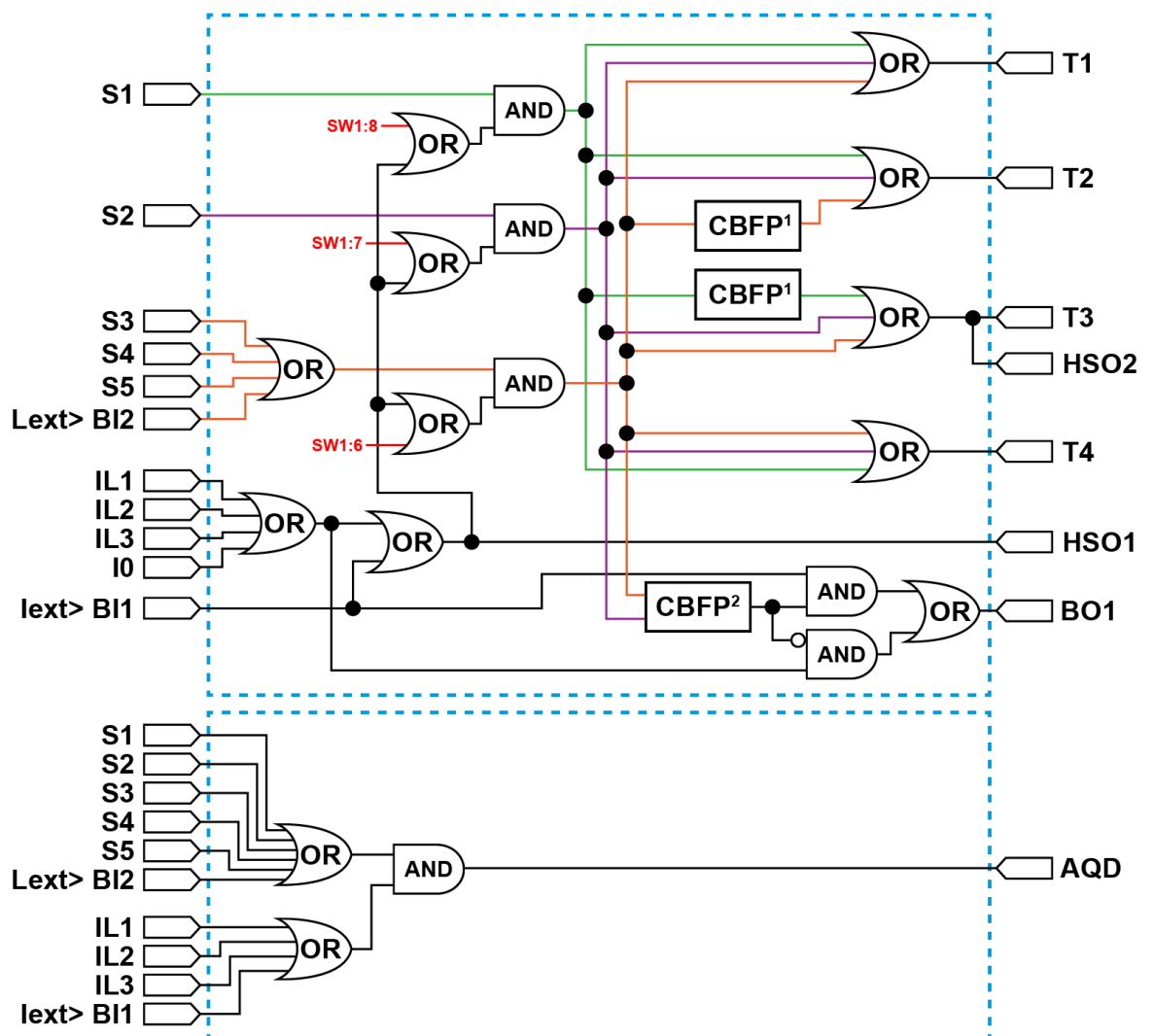
The overcurrent signal is sent with HSO1 to the outgoing feeder devices. The binary output BO1 is responsible for sending overcurrent information to an AQ-110 device at another incoming feeder.

Figure. 8.3.1 - 24. The trip logic matrix of SS:0a.

SS:0a		OUTPUTS								
INPUTS	S1	T1	T2	T3	T4	BO1	BO1 pulse	HSO1	HSO2	AQD
	S1	x^1	x^1	CBFP ¹	x^1				CBFP ¹	x^2
	S2	x^1	x^1	x^1	x^1		CBFP ³		x^1	x^2
	S3,S4,S5	x^1	CBFP ¹	x^1	x^1		CBFP ³		x^1	x^2
	Lext> (BI1 pulse)	x^1	CBFP ¹	x^1	x^1		CBFP ³		x^1	x^2
	Lext> (BI2)	x^1	CBFP ¹	x^1	x^1		CBFP ³		x^1	x^2
	Lext> (BI1)							x		
	I> (phase currents)					x^4		x		
	Io> (residual current)					x^4		x		

1. Activates only if channel has been set to light only mode or if any overcurrent signal (I>, Io> or Lext>) is ON.
2. Activates only if phase overcurrent signal (I>) or external overcurrent signal (Lext>) is ON.
3. Activates only if external overcurrent (Lext>) is ON.
4. Activates only if BO1 pulse signals are not active.

Figure. 8.3.1 - 25. Simplified logic diagram of SS:0a.

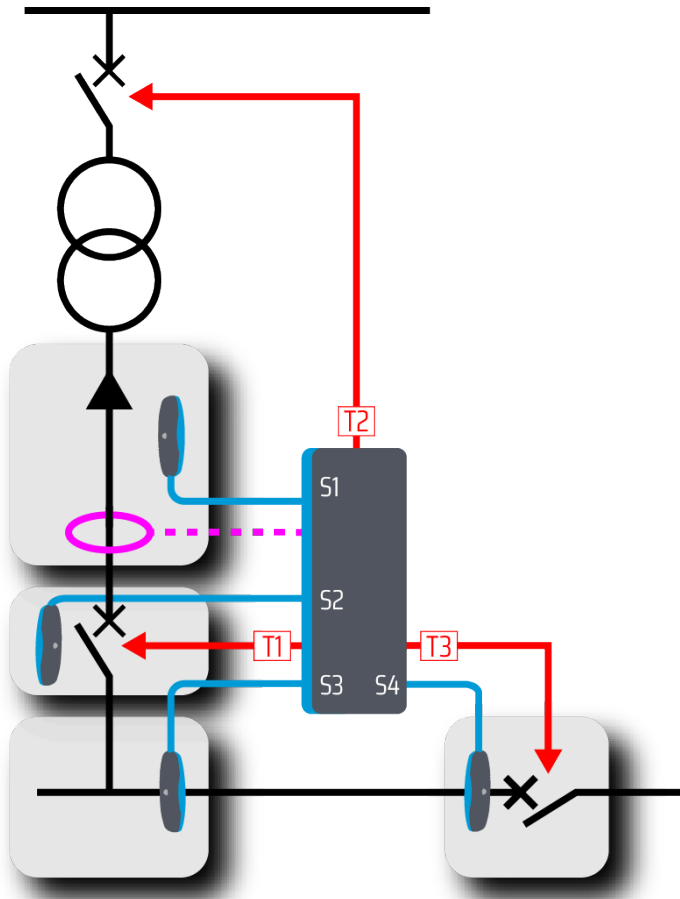


1. Signal is activated instantly if "Fast / CBFP" DIP-switch is set to FAST mode.
2. Signal is NOT activated if "Fast / CBFP" DIP-switch is set to FAST mode.

8.3.2 SS:1a Selective arc protection

The logic scheme SS:1a is designed for selective incomer arc protection. It can be used for substations with one or more incomers. This logic scheme is a modified version of [SS:2a](#). The only difference is that the arc quenching device control (AQD) activation also allows external current signal.

Figure. 8.3.2 - 26. Example application with AQ-110 (SS:1a).



If a fault is detected in the incomer cable compartment (S1), circuit breakers on both sides of the transformer will be tripped with T1 and T2. If the fault isn't cleared on time, T3 will trip the tie breaker (if applicable) and HSO2 sends master trip signal to the outgoing feeder protection devices after CBFP time delay.

If a fault is detected in the incomer circuit breaker compartment (S2), circuit breakers on both sides of the transformer (T1-T2), tie breaker (T3) and all outgoing feeders (HSO2) will be tripped. If a fault is detected in the busbar compartment (S3) or in the tie breaker compartment (S4) the incomer (T1), tie breaker (T3) and all outgoing feeders (HSO2) will be tripped. If the fault isn't cleared on time, T2 will trip the incomer HV side circuit breaker.

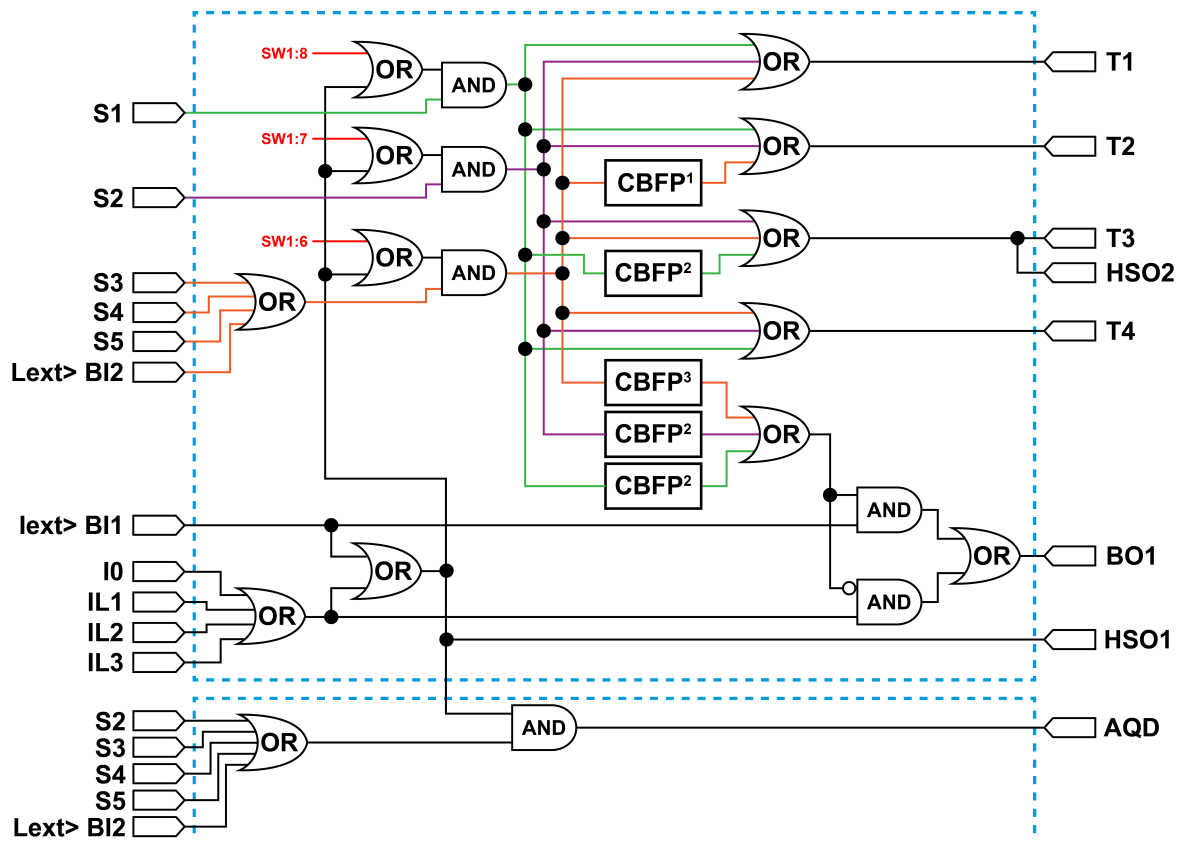
The overcurrent signal is sent with HSO1 to the outgoing feeder devices. The binary output BO1 is responsible for sending overcurrent information to an AQ-110 device at another incoming feeder.

Figure. 8.3.2 - 27. The trip logic matrix of SS:1a.

SS:1a		OUTPUTS								
INPUTS	S1	T1	T2 ³	T3	T4	BO1	BO1 pulse ⁴	HSO1	HSO2	AQD
	S1	x ¹	x ¹	CBFP ¹	x ¹		CBFP ⁵		CBFP ¹	
	S2	x ¹	x ¹	x ¹	x ¹		CBFP ¹		x ¹	x ²
	S3,S4,S5	x ¹	CBFP ¹	x ¹	x ¹		CBFP ¹		x ¹	x ²
	Lext> (BI1 pulse)	x ¹	CBFP ¹	x ¹	x ¹		CBFP ¹		x ¹	x ²
	Lext> (BI2)	x ¹	CBFP ¹	x ¹	x ¹		CBFP ¹		x ¹	x ²
	lext> (BI1)							x		
	I> (phase currents)					x ⁶		x		
	lo> (residual current)					x ⁶		x		

1. Activates only if channel has been set to light only mode or if any overcurrent signal (I>, lo> or lext>) is ON.
2. Activates only if any of the overcurrent signals (I>, lo> or lext>) are ON.
3. T2 uses CBFP regardless of SW2/4 DIP switch status.
4. Activates only if external overcurrent signal (lext>) is ON.
5. Delay time is 200 ms if SW2/3 is OFF. Delay time is 300 ms if SW 2/3 is ON.
6. Activates only if BO1 pulse signals are not active.

Figure. 8.3.2 - 28. Simplified logic diagram of SS:1a.

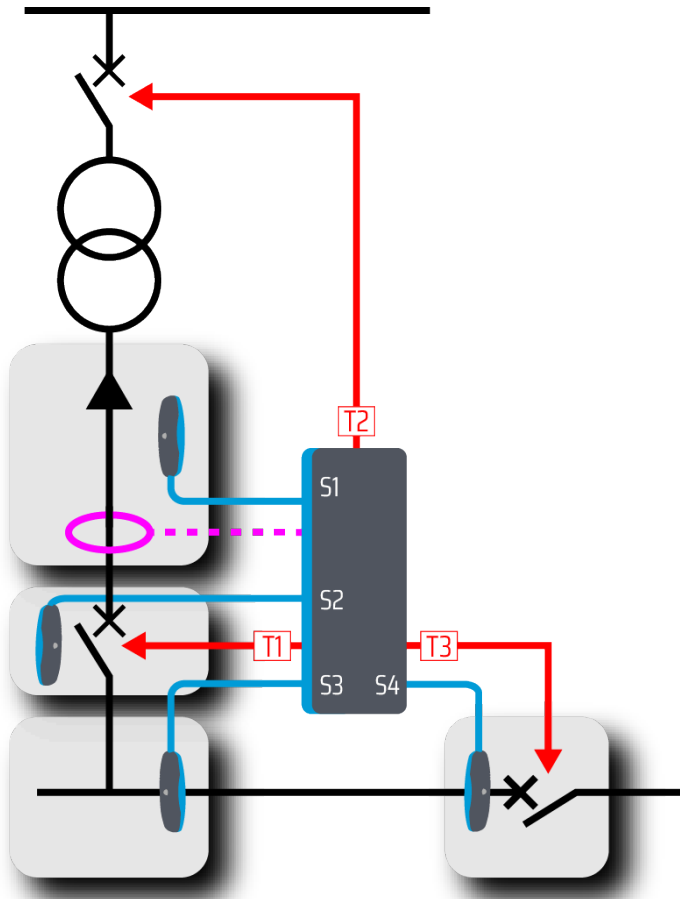


1. Signal is NOT activated if "Fast / CBFP" DIP-switch is set to FAST mode.
2. Signal is activated instantly if "Fast / CBFP" DIP-switch is set to FAST mode.
3. Signal is activated instantly if "Fast / CBFP" DIP-switch is set to FAST position. "100 / 150 ms" DIP-switch can be used for choosing 200 ms or 300 ms time delay.

8.3.3 SS:1b Selective arc protection

The logic scheme SS:1b is designed for selective incomer arc protection. It can be used for substations with one or more incomers. This logic scheme is a modified version of [SS:1a](#). In SS:1b the high-speed output HSO1 acts as an additional alarm contact or a master trip signal.

Figure. 8.3.3 - 29. Example application with AQ-110 (SS:1b).



If a fault is detected in the incomer cable compartment (S1), circuit breakers on both sides of the transformer will be tripped with T1 and T2. If the fault isn't cleared on time, T3 will trip the tie breaker (if applicable) and HSO2 sends master trip signal to the outgoing feeder protection devices after CBFP time delay.

If a fault is detected in the incomer circuit breaker compartment (S2), circuit breakers on both sides of the transformer (T1-T2), tie breaker (T3) and all outgoing feeders (HSO2) will be tripped. If a fault is detected in the busbar compartment (S3) or in the tie breaker compartment (S4) the incomer (T1), tie breaker (T3) and all outgoing feeders (HSO2) will be tripped. If the fault isn't cleared on time, T2 will trip the incomer HV side circuit breaker.

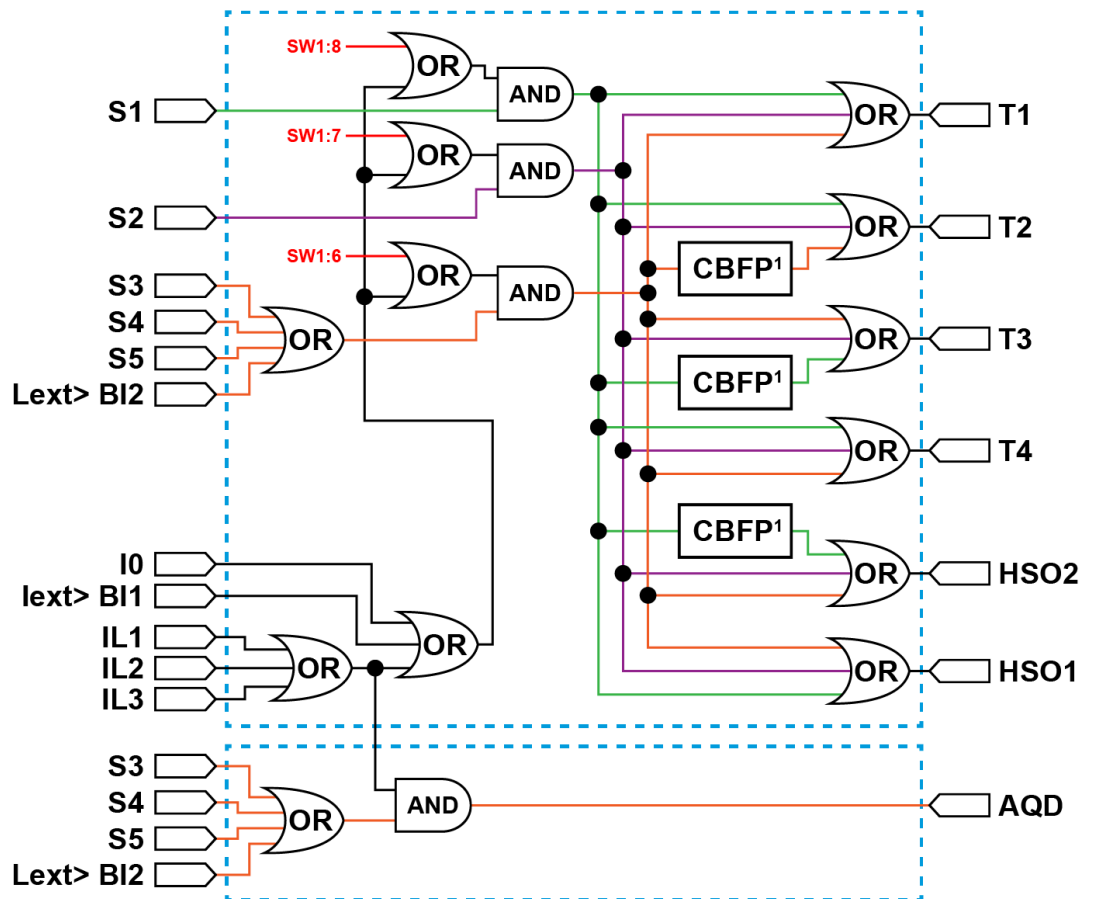
The overcurrent signal is sent with HSO1 to the outgoing feeder devices. The binary output BO1 is responsible for sending overcurrent information to an AQ-110 device at another incoming feeder.

Figure. 8.3.3 - 30. The trip logic matrix of SS:1b.

SS:1b		OUTPUTS							
		T1	T2	T3	T4	BO1	HSO1	HSO2	AQD
INPUTS	S1	x ¹	x ¹	CBFP ¹	x ¹		x ¹	CBFP ¹	
	S2	x ¹	x ¹	x ¹	x ¹		x ¹	x ¹	
	S3,S4,S5	x ¹	CBFP ¹	x ¹	x ¹		x ¹	x ¹	x ²
	Lext> (BI2)	x ¹	CBFP ¹	x ¹	x ¹		x ¹	x ¹	x ²
	l<ext> (BI1)								
	l> (phase currents)								
	lo> (residual current)								

1. Activates only if channel has been set to light only mode or if any overcurrent signal (l>, lo> or l>t>) is ON.
2. Activates only if phase overcurrent signal (l>) is ON.
3. No activation if "Fast / CBFP" DIP-switch has been set to FAST mode. Activates only if DIP-switch has been set to light only mode or if any overcurrent signal (l>, lo> or l>t>) is ON.

Figure. 8.3.3 - 31. Simplified logic diagram of SS:1b.

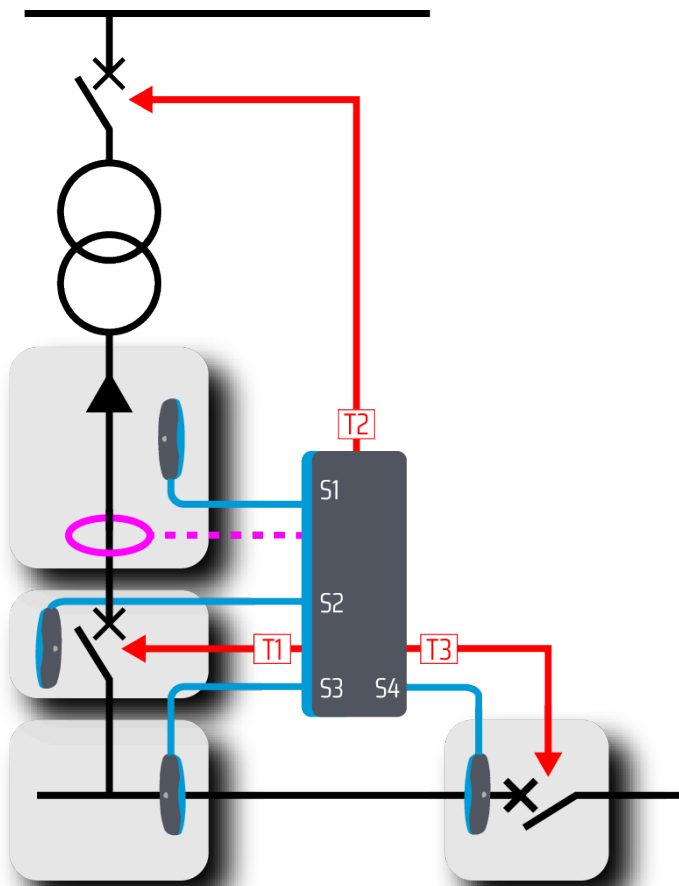


1. Signal is NOT activated if "Fast / CBFP" DIP-switch is set to FAST mode.

8.3.4 SS:2a Selective arc protection (recommended)

The logic scheme SS:2a is designed for selective incomer arc protection. It can be used for substations with one or more incomers.

Figure. 8.3.4 - 32. Example application with AQ-110 (SS:2a).



If a fault is detected in the incomer cable compartment (S1), circuit breakers on both sides of the transformer will be tripped with T1 and T2. If the fault isn't cleared on time, T3 will trip the tie breaker (if applicable) and HSO2 sends master trip signal to the outgoing feeder protection devices after CBFP time delay.

If a fault is detected in the incomer circuit breaker compartment (S2), circuit breakers on both sides of the transformer (T1-T2), tie breaker (T3) and all outgoing feeders (HSO2) will be tripped. If a fault is detected in the busbar compartment (S3) or in the tie breaker compartment (S4) the incomer (T1), tie breaker (T3) and all outgoing feeders (HSO2) will be tripped. If the fault isn't cleared on time, T2 will trip the incomer HV side circuit breaker.

The overcurrent signal is sent with HSO1 to the outgoing feeder devices. The binary output BO1 is responsible for sending overcurrent information to an AQ-110 device at another incoming feeder.

You can find a more detailed description of this scheme in the AQ-SASTM booklet.

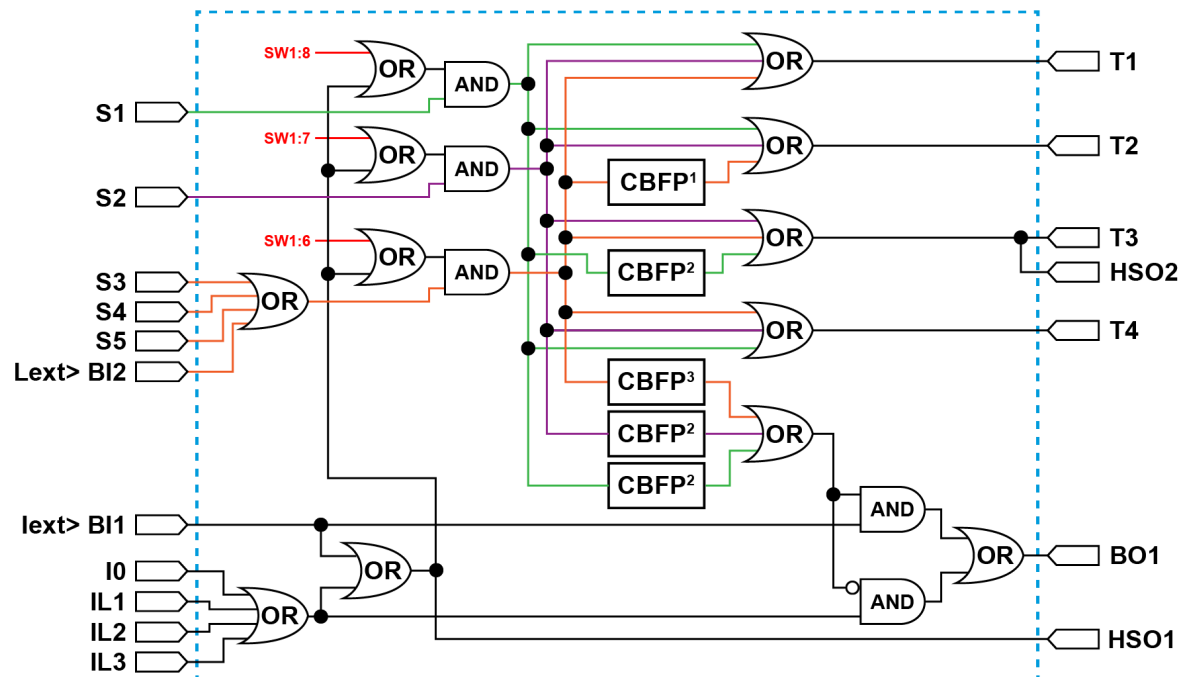
Figure. 8.3.4 - 33. Simplified trip logic matrix of SS:2a.

SS:2a		OUTPUTS								
INPUTS	S1	T1	T2 ³	T3	T4	BO1	BO1 pulse ⁴	HSO1	HSO2	AQD
	S1	x ¹	x ¹	CBFP ¹	x ¹		CBFP ⁵		CBFP ¹	
	S2	x ¹	x ¹	x ¹	x ¹		CBFP ¹		x ¹	x ²
	S3,S4,S5	x ¹	CBFP ¹	x ¹	x ¹		CBFP ¹		x ¹	x ²
	lext> (BI1 pulse)	x ¹	CBFP ¹	x ¹	x ¹		CBFP ¹		x ¹	x ²
	lext> (BI2)	x ¹	CBFP ¹	x ¹	x ¹		CBFP ¹		x ¹	x ²
	lext> (BI1)							x		
	I> (phase currents)					x ⁶		x		
	lo> (residual current)					x ⁶		x		

1. Activates only if channel has been set to light only mode or if any overcurrent signal (I>, lo> or lext>) is ON.
2. Activates only if phase overcurrent signal (I>) is ON.
3. T2 uses CBFP regardless of "Fast / CBFP" DIP-switch status.
4. Activates only if external overcurrent signal (lext>) is ON.
5. Delay time is 200 ms when "100 / 150 ms" DIP-switch is OFF, 300 ms when it is ON.
6. Activates only if BO1 pulse signals are not active.

CBFP signals are NOT activated if "Fast / CBFP" DIP-switch is set to FAST mode.

Figure. 8.3.4 - 34. Simplified logic diagram of SS:2a.

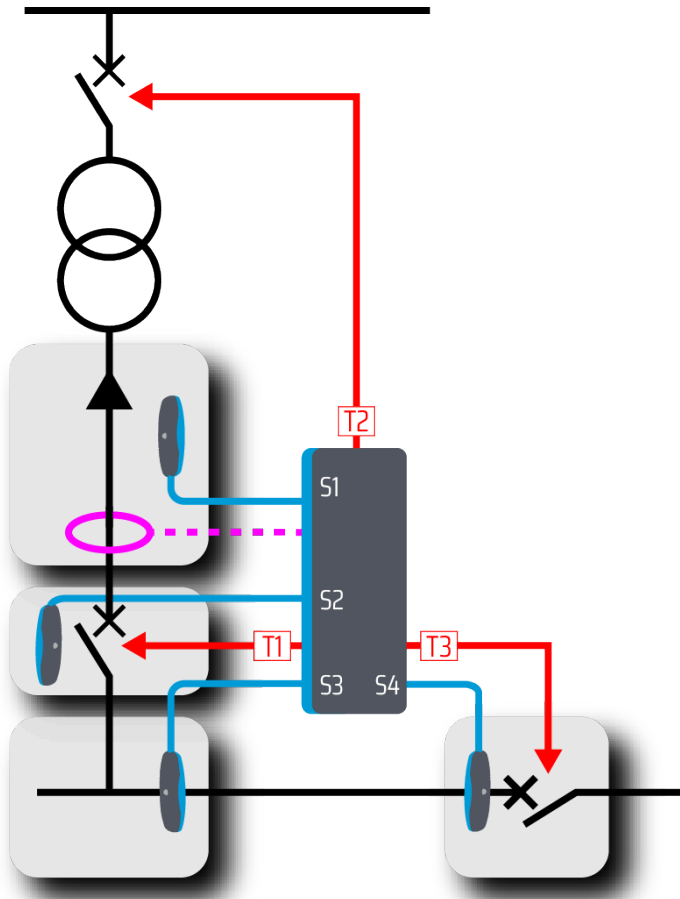


1. Signal is delayed regardless of "Fast / CBFP" DIP-switch setting.
2. Signal is activated instantly if "Fast / CBFP" DIP-switch is set to FAST position.
3. Signal is activated instantly if "Fast / CBFP" DIP-switch is set to FAST position. "100 / 150 ms" DIP-switch can be used for choosing 200 ms or 300 ms time delay "Fast / CBFP" DIP-switch is set to CBFP mode.

8.3.5 SS:2b Selective arc protection

The logic scheme SS:2b is designed for selective incomer arc protection. It can be used for substations with one or more incomers. The logic scheme SS:2b is a modification of [SS:2a](#). In SS:2b the high-speed output HSO1 acts as an additional alarm contact or a master trip signal.

Figure. 8.3.5 - 35. Example application with AQ-110 (SS:2b).



If a fault is detected in the incomer cable compartment (S1), circuit breakers on both sides of the transformer will be tripped with T1 and T2. If the fault isn't cleared on time, T3 will trip the tie breaker (if applicable) and HSO2 sends master trip signal to the outgoing feeder protection devices after CBFP time delay.

If a fault is detected in the incomer circuit breaker compartment (S2), circuit breakers on both sides of the transformer (T1-T2), tie breaker (T3) and all outgoing feeders (HSO2) will be tripped. If a fault is detected in the busbar compartment (S3) or in the tie breaker compartment (S4) the incomer (T1), tie breaker (T3) and all outgoing feeders (HSO2) will be tripped. If the fault isn't cleared on time, T2 will trip the incomer HV side circuit breaker.

The binary output BO1 is responsible for sending overcurrent information to an AQ-110 device at another incoming feeder.

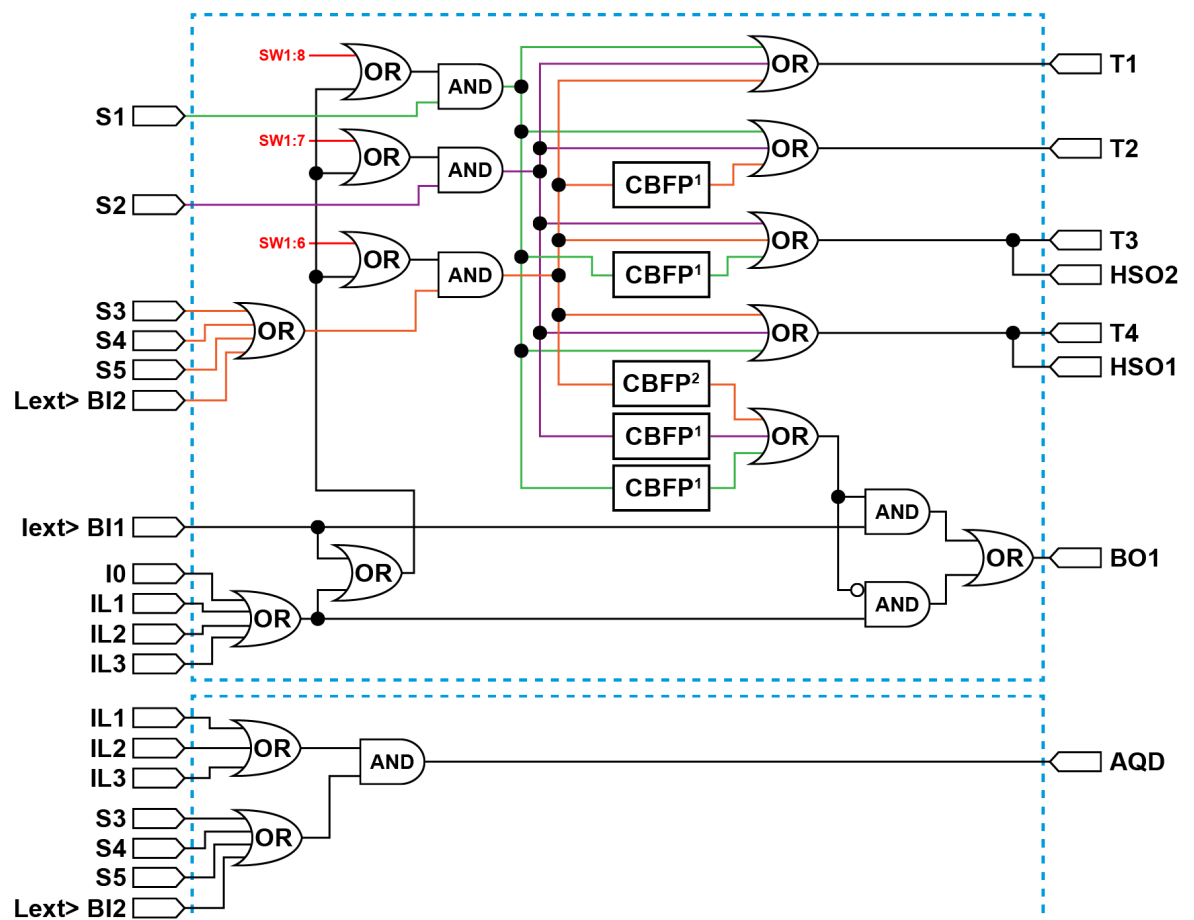
Figure. 8.3.5 - 36. The trip logic matrix of SS:2b.

SS:2b		OUTPUTS								
INPUTS	S1	T1	T2	T3	T4	BO1	BO1 pulse ³	HSO1	HSO2	AQD
	S1	x ¹	x ¹	CBFP ¹	x ¹		CBFP ⁴	x ¹	CBFP ¹	
	S2	x ¹	x ¹	x ¹	x ¹		CBFP ¹	x ¹	x ¹	x ²
	S3,S4,S5	x ¹	CBFP ¹	x ¹	x ¹		CBFP ¹	x ¹	x ¹	x ²
	Lext> (BI1 pulse)	x ¹	CBFP ¹	x ¹	x ¹		CBFP ¹	x ¹	x ¹	x ²
	Lext> (BI2)	x ¹	CBFP ¹	x ¹	x ¹		CBFP ¹	x ¹	x ¹	x ²
	Lext> (BI1)									
	I> (phase currents)					x ⁵				
	Io> (residual current)					x ⁵				

1. Activates only if channel has been set to light only mode or if any overcurrent signal (I>, Io> or Lext>) is ON.
2. Activates only if phase overcurrent signal (I>) is ON.
3. Activates only if external overcurrent signal (Lext>) is ON.
4. Delay time is 200 ms if SW2/3 is OFF. Delay time is 300 ms if SW 2/3 is ON.
5. Activates only if CBFP signals are not active.

CBFP signals are NOT activated if SW2/4 is set to FAST mode.

Figure. 8.3.5 - 37. Simplified logic diagram of SS:2b.



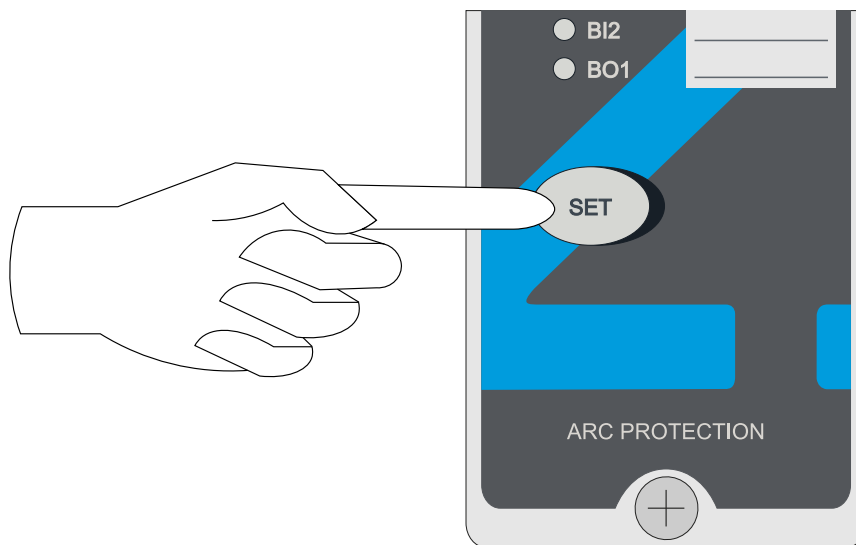
1. Signal is activated instantly if "Fast / CBFP" DIP-switch is set to FAST position.
2. Signal is activated instantly if "Fast / CBFP" DIP-switch is set to FAST position. NOTE: "100 / 150 ms" DIP-switch can be used for choosing 200 ms or 300 ms time delay when "Fast / CBFP" is set to CBFP mode.

8.4 Push button (SET)

The device contains one push button, **SET**, and it can be used for all operational functions. The push button is used for:

1. Setting up the system (also known as auto-configuration)
2. Resetting the indicator LEDs
3. Resetting latched outputs
4. Checking the input connections

Figure. 8.4 - 38. The "SET" push button on the device's front panel.



8.4.1 System setup (auto-configuration)

After DIP switches have been set to correct position and all sensors, binary inputs and binary outputs have been connected, a system setup procedure (also known as auto-configuration) must be performed. The sequence is initialized by pressing the **SET** push button for two seconds. This causes the sensor and binary I/O LEDs to start blinking. The device scans these inputs to see if they are connected; when an input is detected, the corresponding LED lights up to indicate that a connection was found. All inputs that are not connected continue to blink for three more seconds. Then, all LEDs are turned off. Additionally, the DIP switch settings are stored in the non-volatile memory after this sequence.

All arc sensors are operational even when they have not been auto-configured. System setup is only used for self-supervision purposes.

Please note that to reconfigure a device with fewer connections (BI/BO or arc sensors) than in the previously memorized setup, one of the DIP switches must be moved back and forth once before the system setup procedure is carried out. You can reconfigure a device with more connections at any time without having to move one of the DIP switches.

8.4.2 Reset

All LED indications and latched trip relays can be reset by pressing the **SET** push button.

8.4.3 Input connection check

After the system setup (auto-configuration) procedure is completed, you can verify the connectivity of all sensors and binary input channels by pressing the **SET** push button three (3) times within two (2) seconds. The LEDs of the corresponding sensors, binary input channels and the "Power" LED start blinking. The LEDs blink as many times as there are connected sensors and binary output channels from other devices.

8.5 Circuit breaker failure protection

The circuit breaker failure protection function is used for detecting a failure to open the breaker when tripping command has been given by the arc protection relay. The CBFP function activates when the arc protection relay detects the presence of fault for a set duration (100 ms or 150 ms). In case of circuit breaker failure the arc protection relay will send a trip signal to the next available breaker. Please note that if the device is set to operate on both arc light and overcurrent, both conditions must persist to activate the CBFP function. The CBFP function can be set to operate either on a 100-ms or a 150-ms delay (please refer to the [DIP switch settings](#) chapter for more information). The operation logic of CBFP function depends on the chosen logic scheme (see Scheme selection chapter for more information).

8.6 LED indicator functions

The AQ-110P device has twenty (20) indication LEDs and the AQ-110F device has nineteen (19) indication LEDs on the device's front panel.. Apart from the "Power" and "Error" LEDs, the user can write their own identifications for each of the remaining LEDs on the text insert located in the transparent pocket next to the LEDs.

When the device is powered up, it performs an LED test. All LEDs turn on for two (2) seconds and then turn off; only the blue "Power" LED stays on.

When the device operates normally, only the blue "Power" LED is lit.

All current measuring channels (that is, IL1, IL2, IL3 and I0) have their own indication LEDs. When any channel measurement exceeds the set threshold value for longer than 1.5 ms, its corresponding LED turns on. In an open CT condition both the corresponding current channel indicator LED and the "Error" LED are blinking.

If an arc sensor is activated, its corresponding LED turns on. Activated arc sensor LEDs will stay on until user has reset them with "SET" push button.

If there is a loose sensor wire or if the self-supervision function detects a configuration mismatch (that is, a new sensor has been attached but the auto-configuration system setup has not been run), the corresponding LED starts flashing and the "Error" LED activates.

The binary I/O LEDs indicate the status of the input and output lines. If any of the lines become active, the corresponding LED turns on. All light channel and trip indication LEDs are latched, even if the DIP switch settings are in the non-latched mode.

All LED indications are stored in the non-volatile memory (EPROM) to help identify the necessary trip information even after auxiliary power is lost. When the device is re-powered after a power supply loss, the front panel shows the status of all LEDs.

You can clear the LEDs by pushing the **SET** button.

8.7 LED operations guide

The table below describes the function of each indicator LED in detail. Please note that the S4 and S5 sensor channels are not in use in the AQ-110F variant.

Table. 8.7 - 6. LED operations of AQ-110P and AQ-110F.

LED name (color)	Light off	Steady light	Blinking light	Action if abnormal
POWER (blue)	The auxiliary power supply is disconnected.	The auxiliary power supply is connected.	(N/A)	Check the power supply.
ERROR (red)	The system is healthy.	A system failure has occurred.	A configuration mismatch has been detected. Protection is partially operational.	Verify the system condition (see the System self-supervision and Troubleshooting chapters).
T1–T4 (red)	Normal status.	The trip relay has activated.	(N/A)	Check what caused the trip, clear the fault and reset the indicator LEDs with the push button.
S1–S3 (amber)	Normal status.	Light information has activated the sensor channel.	There is a sensor channel discontinuity or a system setup has not been performed.	Check the sensor continuity or perform a system setup (see the System setup chapter); or , check what activated the sensor.
S4 (amber) NB! Only in AQ-110P!	Normal status.	Light information has activated the sensor channel.	There is a sensor channel discontinuity or a system setup has not been performed.	Check the sensor continuity or perform a system setup (see the System setup chapter); or , check what activated the sensor.
S5 (amber) NB! Only in AQ-110P!	Normal status.	Light information has activated the fiber sensor channel. Or , if the device has AQD control configured to this fiber channel, an arc flash has activated the channel.	There is a fiber discontinuity or a system setup has not been performed.	Check the sensor continuity or perform a system setup (see the System setup chapter); or , check what activated the sensor.
AQD (amber) NB! Only in AQ-110F!	Normal status.	AQD (arc quenching device) has been given a trip signal.	The fiber connection to the AQD (arc quenching device) has dropped off or a system setup has not been performed.	Check the fiber connection and/or the system configuration.
BI1–BI2 (amber)	Normal status.	The binary input has been activated.	The binary input has a loose connection.	Check the binary input wiring.
BO1 (amber)	Normal status.	The binary output has been activated.	(N/A)	—

LED name (color)	Light off	Steady light	Blinking light	Action if abnormal
IL1–IL3 (amber)	Normal status (the actual current is below the set threshold).	The measured current is above the set threshold.	There is an open CT connection in the channel.	Check the set current thresholds, or check the CT wiring.
I0 (amber)	Normal status (the actual current is below the set threshold).	The measured residual current is above the set threshold.	(N/A)	Check the threshold set for residual current.
HSO1–HSO2 (amber)	Normal status.	The high-speed output has been activated.	(N/A)	Check what activated the output, clear the fault and reset the indicator LEDs with the push button.

8.8 Non-volatile memory

All critical system data (such as DIP switch settings and the system setup file) are stored in the non-volatile memory (EPROM) to ensure accurate operation and full self-supervision even if auxiliary power is lost temporarily.

Additionally, all LED indications are stored in the non-volatile memory to provide a quick recovery of the system status indication. This feature is especially important if tripping causes the device to lose its auxiliary power.

The non-volatile memory does not require a power supply to maintain the information and it retains the settings and the indications permanently without power.

9 System self-supervision

AQ 100 series devices have an extensive self-supervision function, including both internal functions and external connections. The self-supervision function monitors the following:

- power supply
- hardware
- software
- binary input connection(s)
- sensor connection(s)
- DIP switch settings
- current transformer supervision

When the device's condition is healthy and is powered on, the "Power" LED is lit and the system failure (SF) relay is energized. If the self-supervision function detects a faulty condition or if the power supply fails, the SF relay is released and the "Error" LED becomes lit.

Point sensor connection monitoring

If a point sensor failure occurs, the device will go into Error mode. The "Error" LED turns on, the SF relay releases, and the LED of the corresponding faulty sensor channel starts blinking. In this situation the device is still operational, although the faulty sensor channel is blocked. If the error is resolved, the device automatically clears the system failure status, energizing the SF relay and turning off the "Error" LED. If one or more of the sensors are disconnected, the healthy sensors remain in use and the device remains operational accordingly. However, the device remains in Error mode until the sensors are connected again.

Fiber loop connection monitoring

Fiber loop channel(s) is monitored by a test light pulse that travels through the loop. If a discontinuity is detected, the "Error" LED turns on, the SF relay releases, and the LED of the corresponding faulty sensor channel starts blinking. If the error is resolved, the device automatically clears the system failure status, energizing the SF relay and turning off the "Error" LED. The device remains in Error mode until the sensors are connected again.

Binary input connection monitoring

During system setup (auto-configuration) AQ 100 series device checks how many AQ 100 device binary outputs or high-speed outputs have been connected to binary inputs. Each AQ 100 series device binary output and high-speed output constantly sends a short pulse every second which the receiving binary input uses to count the number of connected devices. If any of the outputs are disconnected after the system setup, the binary input will detect the mismatch and the device will go into Error mode and the binary input LED will blink. If the error is resolved, the device automatically clears the system failure status, energizing the SF relay and turning off the "Error" LED.

DIP switch setting monitoring

The device goes into Error mode, if a DIP switch setting is changed after the system setup procedure has been performed. However, the configured (stored) settings are still valid and the device is still operational.

Current transformer supervision

In AQ 100 series devices with current measurements the self-supervision function also monitors the three phase current transformer circuit. If the current flow exceeds $0.2 \times I_n$ in any of the phases, the device assumes that the switchgear is energized and the function monitors the phases for an open connection. If at least one of the phases remains above $0.2 \times I_n$ while at least one of the others are at zero, the device issues an open CT alarm: the SF relay is released, the "Error" LED is turned on and the LED of the faulty phase(s) starts blinking.

10 Wiring example

Figure. 10 - 39. Example wiring diagram for AQ-110P.

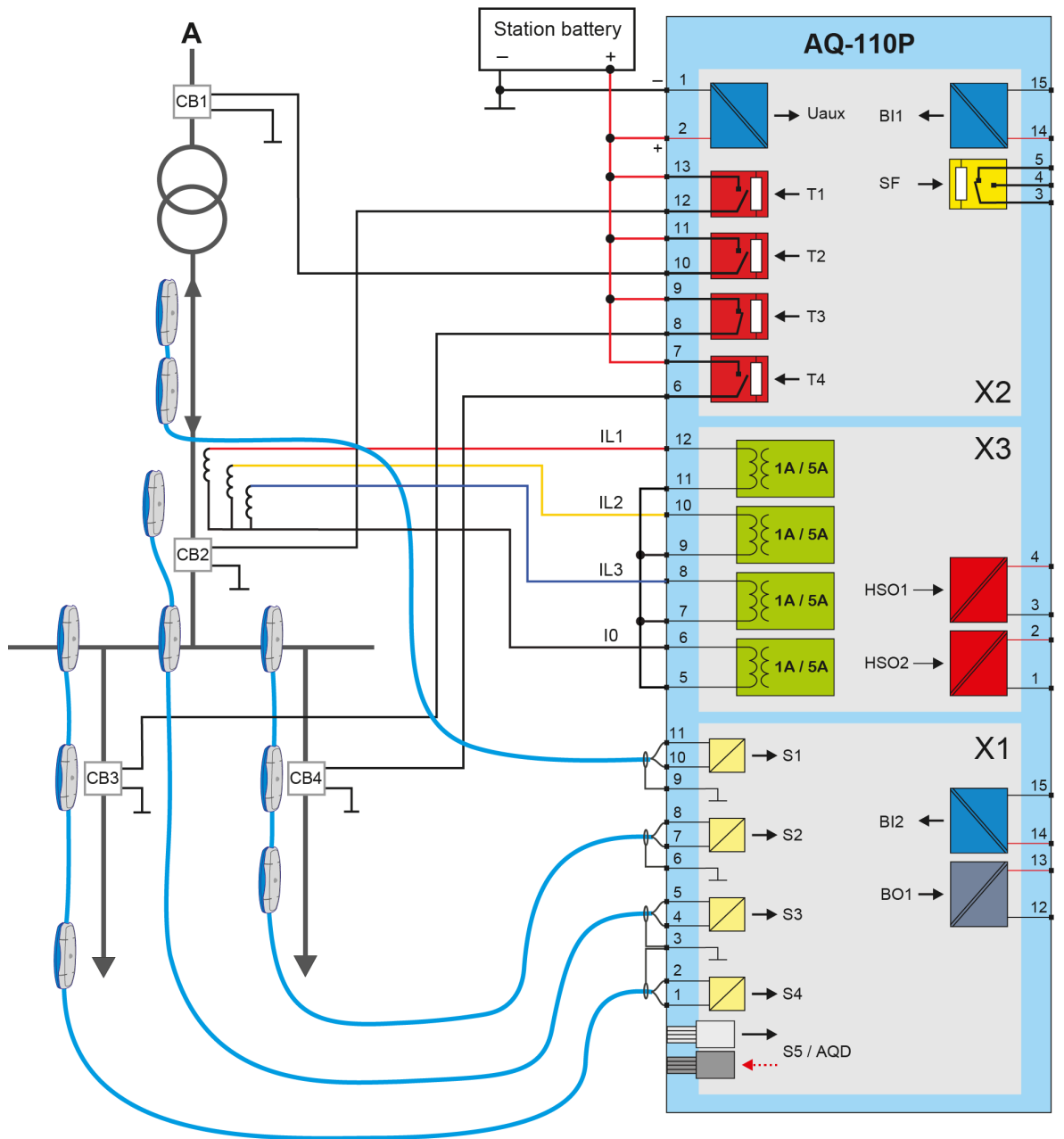
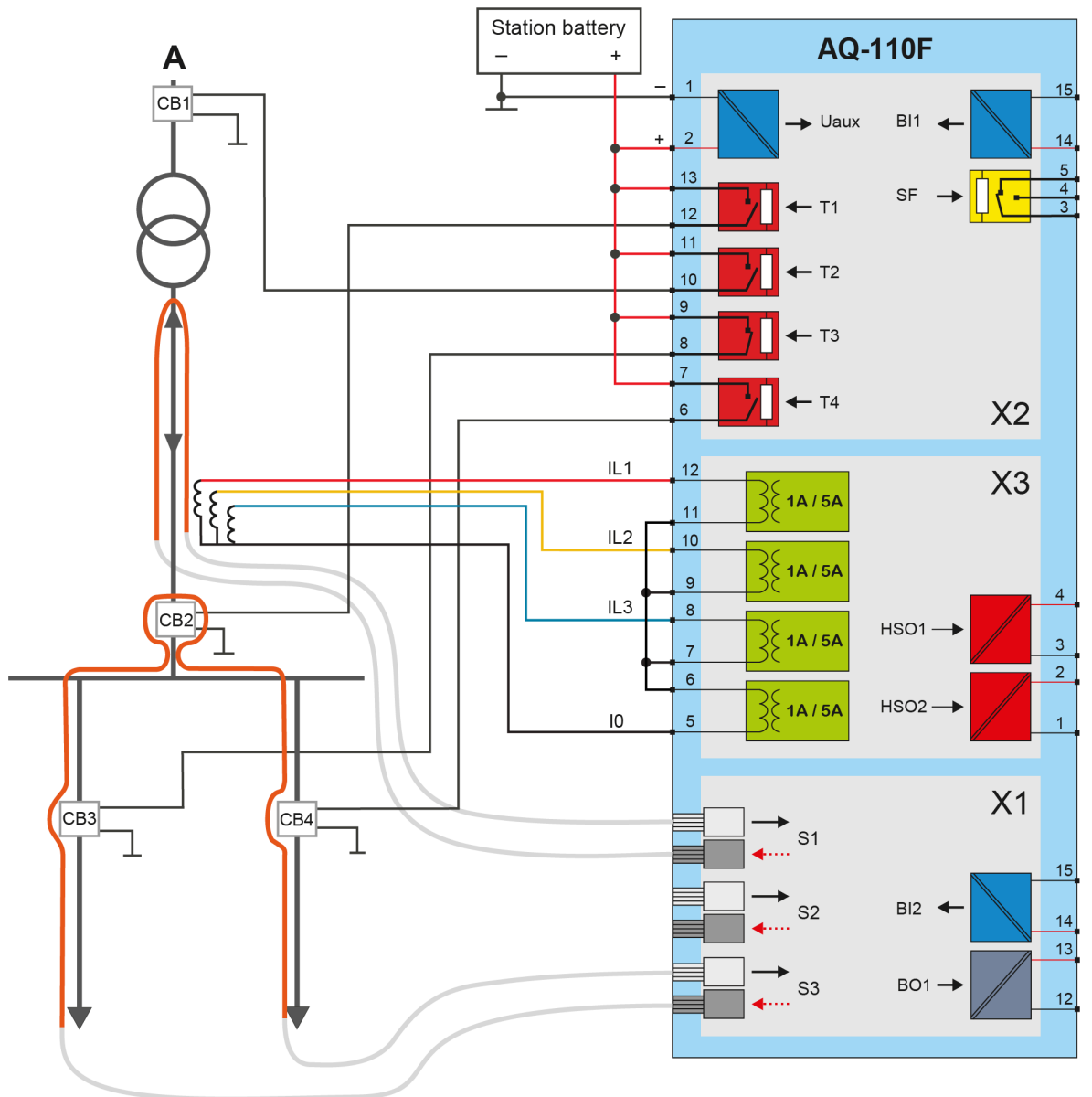


Figure. 10 - 40. Example wiring diagram for AQ-110F.



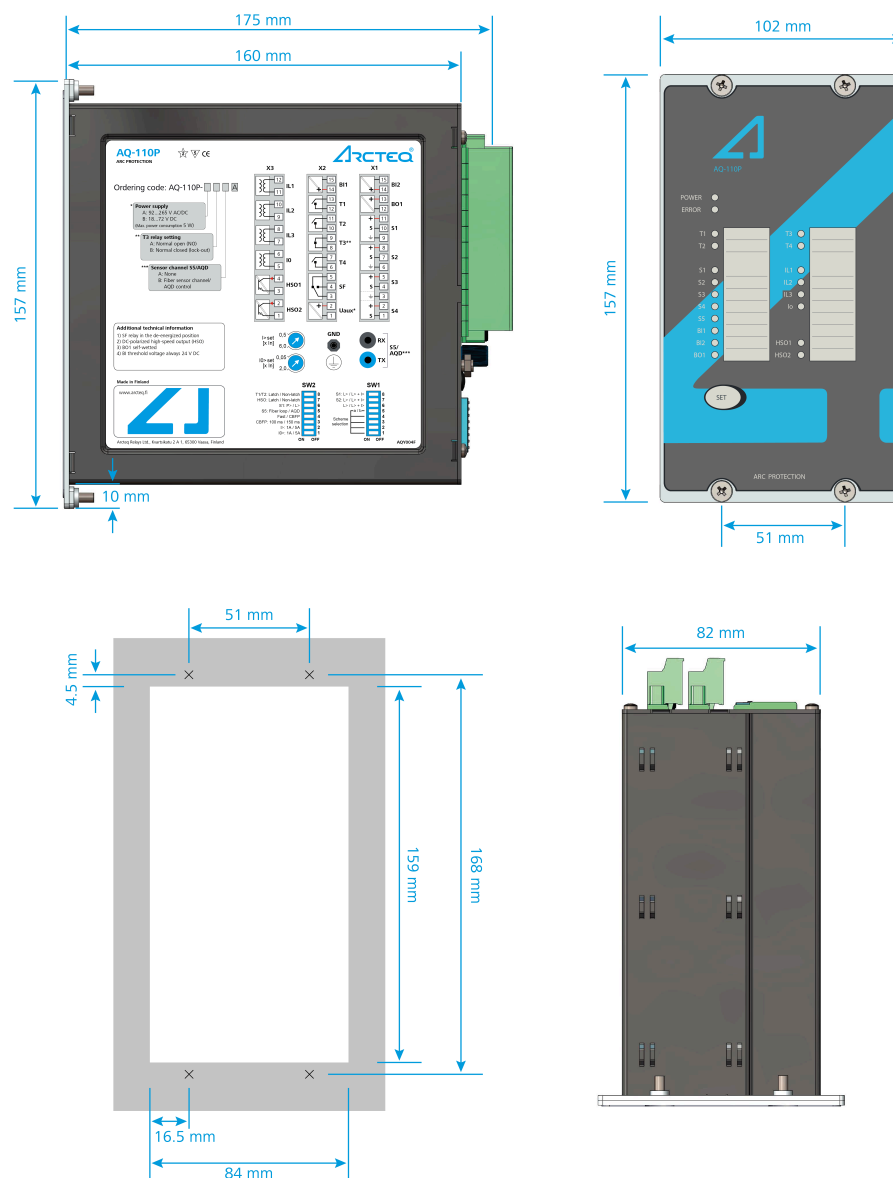
11 Dimensions and installation

AQ-110x can be either door-mounted or panel-mounted in a standard 19 inch rack. The device's dimensions (without PCBs) are as follows:

- Height: 157 mm (6.18 in)
- Width: 102 mm (4.02 in)
- Depth: 160 mm (6.30 in).

The figure below presents the dimension of the device visually. It also shows the dimensions of the cut-out (bottom-left) required when mounting the device on a panel. While the image is of the AQ-110P device, the measurements are the same for AQ-110F as well.

Figure. 11 - 41. Dimensions of the device.



The following figure presents how to install an AQ-110x device into a cut-out.

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Figure. 11 - 42. Installing a device into a cut-out.



12 Testing

It is recommended that the device is tested prior to substation energizing. Testing is carried out by simulating an arc light for each sensor and verifying that the correct trip contact(s) tripped and that the correct indicator LED(s) turned on.

Any strong camera flash works well to simulate arc light. Please note that small LED lights like smartphone flashes are not strong enough to activate a point sensor or a fiber loop. Having a self-timer helps with the testing process because it can be connected to the test kit. Any strong flashlight works to test non-latched signals and the CBFP function. Before testing please check that the equipment used has a fully charged battery.

12.1 Testing the light-only mode

1. Check that the DIP switch settings are positioned according to your application.
2. Activate the camera flash within 30 cm (12 inches) of the sensor that is being tested.
3. Verify that the indicator LED of the corresponding sensor channel is lit.
4. Verify the activation(s) of the relay output(s) by checking the circuit breaker's status, or by monitoring the trip contact's status. The circuit breaker should open, or the contacts operate. Please note that you achieve the best test results when you operate the circuit breaker while testing.
5. Verify that the indicator LED(s) of the corresponding relay output(s) is lit.
6. If you are using the BO1 binary output and/or one or both of the high-speed outputs, verify their signal activation either through the status change of the relevant input, or by measuring the signal output voltage. Please note that BO1 is of the non-latched type.
7. If you are using the BO1 binary output and/or one or both of the high-speed outputs, also verify that their corresponding LED is lit.
8. Press the **SET** push button to reset all indications and latches.
9. If you are using the BI2 binary input as the master trip, activate it and verify that the trip has occurred by repeating the steps 4 and 5.
10. Press the **SET** push button to reset all indications and latches.
11. Repeat the steps 1 through 10 for all sensors.

12.2 Testing the light and current mode

1. Check that the DIP switch settings are positioned according to your application.
2. Activate the following two things simultaneously: the camera flash within 30 cm (12 inches) of the sensor that is being tested, and the binary input used for the overcurrent condition (I>).
3. Verify that the indicator LED of the corresponding sensor channel is lit.
4. Verify that the indicator LED of the binary input is lit.
5. Verify the activation(s) of the relay output(s) by checking the circuit breaker's status, or by monitoring the trip contact's status. The circuit breaker should open, or the contacts operate. Please note that you achieve the best test results when you operate the circuit breaker while testing.
6. Verify that the indicator LED(s) of the corresponding relay output(s) is lit.
7. If you are using the BO1 binary output or a high-speed output (HSO1 and/or HSO2), verify the signal activation either through the status change of the relevant input, or by measuring the signal output voltage.
8. If you are using the BO1 binary output or a high-speed output (HSO1 and/or HSO2), also verify that the corresponding LED is lit. Please note that BO1 is of the non-latched type.
9. Activate the camera flash within 30 cm (12 inches) of the sensor but do not activate the binary input used for the overcurrent condition (I>).
10. Verify that no trip has occurred and only the indicator LED of the sensor activation is lit.

11. If you are using the BO1 signal and have configured it to send light information, verify that it is activated.
12. Press the **SET** push button to reset all indications and latches.
13. If you are using a binary input as the master trip, activate it and verify that the trip has occurred by repeating the steps 5 and 6.
14. Press the **SET** push button to reset all indications and latches.
15. Repeat the steps 1 through 12 for all sensors.

12.3 Testing the CBFP function

The circuit breaker failure protection (CBFP) function is tested by taking the light signal and the additional trip criterion signal (if applicable) and leaving them active for longer than the set CBFP time (that is, 100 or 150 ms). Check that the correct outputs activated after the set delay time.

12.4 Testing the operation time

An operation time test is not required at commissioning as it is performed by the manufacturer both as a type test and as a routine production test. If you want to have more information of these tests, please refer to the routine test reports sent with the AQ-110 device and/or consult your nearest Arcteq representative for the type test reports.

However, if it is deemed necessary, you can conduct an on-site timing test with the following instructions.

1. Use a calibrated relay test set.
2. Connect one of the test set's outputs to a strong camera flash to initialize the flash and to configure the set's timer to start simultaneously with the flash.
3. Connect one of the AQ-110 device's trip outputs (T1, T2, T3, T4) or high-speed outputs (HSO1, HSO2) to a test set input and configure the input to stop the timer.
4. Place the camera flash within 30 cm (12 inches) of the sensor.
5. Initiate the flash and the timer by using the test set output.
6. Read the measured time between the simulated arc light and the operation of the trip contact.
7. Subtract the digital input delay of the test set from the final measured time (if applicable). For specific test instructions, please consult the manufacturer of the relay test set.

12.5 Test plan example

Basic data	
Date:	
Substation:	
Switchgear:	
Serial number:	



Preconditions	Additional notes
Trip mode (channel 1): ___ L> ___ L> + I>	
Trip mode (channels 2, 3, 4): ___ L> ___ L> + I>	
BI master trip in use: ___ Yes ___ No	
CBFP in use: ___ Yes ___ No	
CBFP time setting: ___ 100 ms ___ 150 ms	

Object activated	LED active	T1, T2, T3, T4 active	BO1 active	Additional notes
Sensor channel 1	S1			
	S2			
	S3			
Sensor channel 2	S1			
	S2			
	S3			
Sensor channel 3	S1			
	S2			
	S3			
Sensor channel 4	S1			
	S2			
	S3			
Fiber sensor channel				
Binary inputs	BI1			
	BI2			
Phase current (IL1, IL2, IL3)				
Residual current (IO)				

Involved personnel	
Tested by:	
Approved by:	

13 Troubleshooting

Table. 13 - 7. Troubleshooting guide for AQ-110x variants.

Problem	Possible solution(s)
The sensor does not activate during testing.	Check the sensor's cable wiring. <u>or</u> Check the testing equipment, especially the camera flash intensity (see the Testing chapter for more information).
The trip relay does not operate even when the sensor is activated.	Tripping might require overcurrent signal simultaneously with light signal. Check the DIP switch settings (see the DIP switch settings chapter for more information).
The current measurement's indicator LED is continuously lit.	Check the set current threshold (see the Current threshold settings chapter for more information).
The current measurement's indicator LED is blinking.	Check that the connections of the three phase currents are correct (see the System self-supervision for more information).

14 Technical data

14.1 Mounting and installation

Table. 14.1 - 8. Technical data for relay mounting and installation (AQ-110P).

Panel: - material - thickness (min...max)	metal 1.0...5.0 mm (0.04...0.20 in)
Panel mounting: - screw type - key size - tightening torque (min...max)	ISO 14581 M4x12, galvanized Torx T20 1.5...2.0 N·m (13.3...17.7 lbf·in)
Grounding: - nut type - key size - tightening torque (min...max)	DIN934-M5 galvanized 8 2.5...3.0 N·m (22.1...26.6 lbf·in)
Connectors X1 and X2: - connector type - wire cross section (min...max) - minimum stripping length - screw tightening torque (min...max)	Phoenix Contact MSTB 2,5/15-ST-5,08 BD:1-15 0.2...2.5 mm ² (24...13 AWG) 7 mm (0.28 in) 0.5...0.6 N·m (4.4...5.3 lbf·in)
Connector X3: - wire cross section (min...max) - minimum stripping length - screw tightening torque (min...max)	0.5...6.0 mm ² (20...9 AWG) 14 mm (0.55 in) 0.5...0.6 N·m (4.4...5.3 lbf·in)
Fiber connectors: - nut tightening torque	light finger tightening

Table. 14.1 - 9. Technical data for relay mounting and installation (AQ-110F).

Panel: - material - thickness (min...max)	metal 1.0...5.0 mm (0.04...0.20 in)
Panel mounting: - screw type - key size - tightening torque (min...max)	ISO 14581 M4x12, galvanized Torx T20 1.5...2.0 N·m (13.3...17.7 lbf·in)
Grounding: - nut type - key size - tightening torque (min...max)	DIN934-M5 galvanized 8 2.5...3.0 N·m (22.1...26.6 lbf·in)
Connector X1: - connector type - wire cross section (min...max) - minimum stripping length - screw tightening torque (min...max)	Phoenix Contact FRONT-MSTB 2,5/4-STF-5,08 0.34...2.5 mm ² (24...12 AWG) 10 mm (0.39 in) 0.5...0.6 N·m (4.4...5.3 lbf·in)

Connector X2: - connector type - wire cross section (min...max) - minimum stripping length - screw tightening torque (min...max)	Phoenix Contact FRONT-MSTB 2,5/15-STF-5,08 0.34...2.5 mm ² (24...12 AWG) 10 mm (0.39 in) 0.5...0.6 N·m (4.4...5.3 lbf·in)
Connector X3: - wire cross section (min...max) - minimum stripping length - screw tightening torque (min...max)	0.5...6.0 mm ² (20...9 AWG) 14 mm (0.55 in) 0.5...0.6 N·m (4.4...5.3 lbf·in)
Fiber connectors: - nut tightening torque	light finger tightening

14.2 Operating times

Table. 14.2 - 10. Technical data for relay operating times.

Trip time using HSO	2 ms*
Trip time using mechanical trip relays	7 ms*
Reset time: - light stage - overcurrent stage	1 ms 50 ms

*) The total trip time when using both the arc light (L>) or phase/residual overcurrent (I>) from this device and the arc light (L>) from an AQ-101 variant or an AQ-102 device.

14.3 Auxiliary voltage

Table. 14.3 - 11. Technical data for the relay auxiliary voltage (Uaux).

Auxiliary power supply	92...265 V AC/DC 18...72 V DC (optional)
Maximum power consumption	5 W, < 10 mΩ
Standby current	90 mA
Start-up inrush current	<150 ms (110 V DC) <600 ms (24 V DC)

14.4 Current measuring circuits

Table. 14.4 - 12. Technical data for the current measurement circuits (IL1, IL2, IL3, IO).

Nominal current	1 A <u>or</u> 5 A
Rated frequency	2...1,000 Hz
Number of inputs	3 (phase) + 1 (residual)

Thermal withstand: - continuous - 10 s - 1 s	30 A 100 A 500 A
Overcurrent setting range: - phase overcurrent - residual overcurrent	$0.5 \dots 6.0 \times I_N$ $0.05 \dots 2.00 \times I_N$
Measurement accuracy	10 %
Rated AC burden (VA)	10 mΩ (input resistance)
Power consumption of current input circuit	< 10 mΩ

14.5 Binary inputs

Table. 14.5 - 13. Technical data for the binary inputs (BI1, BI2).

Nominal threshold voltage	24 V DC
Threshold: - pick-up - drip-off	Approximately 16 V DC Approximately 15 V DC
Rated current	3 mA
Number of inputs	2

14.6 Trip relays

Table. 14.6 - 14. Technical data for the trip relays (T1, T2, T3, T4).

Number of trip relays	4 NO <u>or</u> 3 NO + 1 NC
Voltage withstand	250 V AC/DC
Carry: - continuous carry - make-and-carry for 3 s - make-and-carry for 0.5 s	5 A 16 A 30 A
Breaking capacity DC*	40 W (0.36 A at 110 V DC)
Contact material	AgNi 90/10

*) When the time constant $L/R = 40$ ms.

14.7 High-speed output(s)

Table. 14.7 - 15. Technical data for the high-speed outputs (HSO1, HSO2).

Number of outputs	2
Rated voltage	250 V DC

Carry: - continuous carry - make-and-carry for 3 s - make-and-carry for 0.5 s	2 A 6 A 15 A
Breaking capacity DC*	1 A/110 W
Contact material	Semiconductor

*) When the time constant L/R = 40 ms.

14.8 Binary output(s)

Table. 14.8 - 16. Technical data for the binary output (BO1).

Number of outputs	1
Rated voltage	+24 V DC (internal power supply)
Rated current (max.)	20 mA

14.9 System failure relay

Table. 14.9 - 17. Technical data for the system failure relay (SF).

Number of SF relays	1
Rated voltage	250 V AC/DC
Carry: - continuous carry - make-and-carry for 3 s - make-and-carry for 0.5 s	5 A 16 A 30 A
Breaking capacity DC*	40 W (0.36 A at 110 V DC)
Contact material	AgNi 90/10

*) When the time constant L/R = 40 ms.

14.10 Point sensors

AQ-01 point sensor

Table. 14.10 - 18. Technical data for the AQ-01 light point sensor.

Light intensity threshold	8,000 lux 25,000 lux 50,000 lux
Detection radius	180°
Mechanical protection	IP 20

Sensor cable specification	Shielded twisted pair 0.75 mm ² (AWG: 18)
Maximum sensor cable length (per channel)	200 m
Operating temperature	−20...+85 °C

AQ-02 point sensor

Table. 14.10 - 19. Technical data for the AQ-02 light and pressure point sensor.

Light intensity threshold	8,000 lux 25,000 lux 50,000 lux
Pressure threshold (fixed)	0.2 bar above ambient pressure
Pressure measuring accuracy	±1.8 % (of full scale)
Detection radius	180°
Mechanical protection	IP 20
Sensor cable specification	Shielded twisted pair 0.75 mm ² (AWG: 18)
Maximum sensor cable length (per channel)	200 m
Operating temperature	−20...+85 °C

14.11 Fiber optic loop sensors

AQ-06 fiber optic loop sensor

Table. 14.11 - 20. Technical data for the AQ-06 fiber optic loop sensor.

Material	Plastic fiber
Light intensity threshold	8,000 lux
Cable length (min...max)	3...40 m
Cable diameter	1.0 mm
Detection radius	360°
Bending radius	5 cm
Operating temperature	−40...+85 °C

AQ-07 fiber optic loop sensor

Table. 14.11 - 21. Technical data for the AQ-07 fiber optic loop sensor.

Material	Covered glass fiber
----------	---------------------

Light intensity threshold	8,000 lux
Cable length (min...max)	3...50 m
Cable diameter	1.2 mm
Detection radius	360°
Bending radius	1 cm
Operating temperature	−40...+85 °C

AQ-08 fiber optic loop sensor

Table. 14.11 - 22. Technical data for the AQ-08 fiber optic loop sensor.

Material	Covered glass fiber
Light intensity threshold	8,000 lux
Cable length (min...max)	3...15 m
Cable diameter	1.2 mm
Detection radius	360°
Bending radius	1 cm
Operating temperature	−40...+125 °C

14.12 Disturbance tests

Table. 14.12 - 23. Technical data for the disturbance tests.

Electromagnetic compatibility test	CE-approved and tested according to EN 50081-2 and EN 50082-2
Conducted emission (EN 55011, class A)	0.15...30.00 Hz
Radiated emission (EN 55011, class A)	30.00...1,000.00 MHz
Electrostatic discharge immunity (IEC 244-222 and EN 61000-4-2, level 4)	Air discharge: 15 kV Contact discharge: 8 kV
Electrical fast transients (EN 61000-4-4, class III & IEC 801-4, level 4)	Power supply input: 4 kV, 5/50 ns Other inputs and outputs: 4 kV, 5/50 ns
Surge immunity (EN 61000-4-5, level 4)	Between wires: 2 kV, 1.2/50 µs Between wire and earth: 4 kV, 1.2/50 µs
RF electromagnetic field (EN 61000-4-3, level 3)	f = 80...1,000 MHz, 10 V/m
Conducted RF field (EN 61000-4-6, level 3)	f = 150 kHz...80 MHz, 10 V/m

14.13 Voltage tests

Table. 14.13 - 24. Technical data for the voltage tests.

Insulation test voltage (IEC 60255-5)	2 kV, 50 Hz, 1 min
Impulse test voltage (IEC 60255-5)	5 kV, 1.2/50 μ s, 0.5 J

14.14 Mechanical tests

Table. 14.14 - 25. Technical data for the mechanical tests.

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

14.15 Environmental conditions

Table. 14.15 - 26. Technical data for the environmental conditions.

Specified ambient service temperature	−35...+70 °C
Transportation and storage temperature	−40...+70 °C
Relative humidity	Up to 97 %
Altitude	Up to 2,000 m above sea level

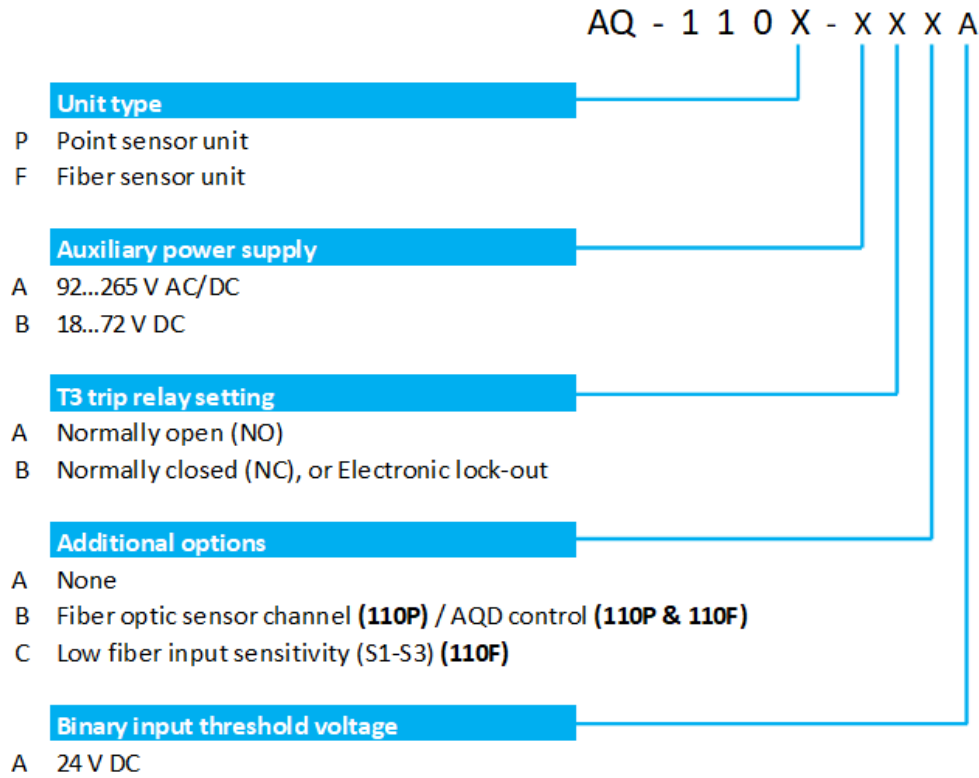
14.16 Casing

Table. 14.16 - 27. Technical data for the device casing.

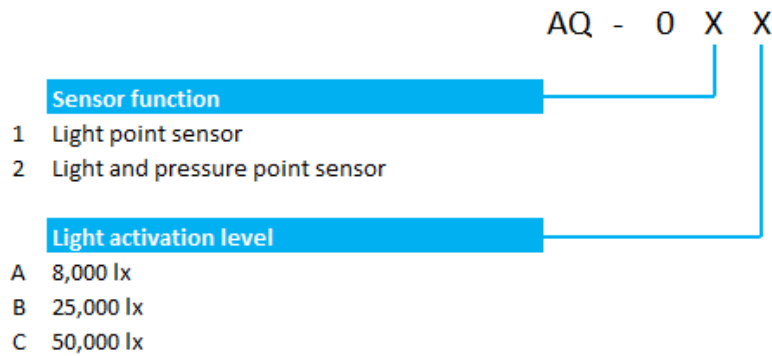
Protection: - front - back	IP 52 IP 20
Device dimensions (W × H × D)	102 × 177 × 161 mm
Weight	1.2 kg

15 Ordering information

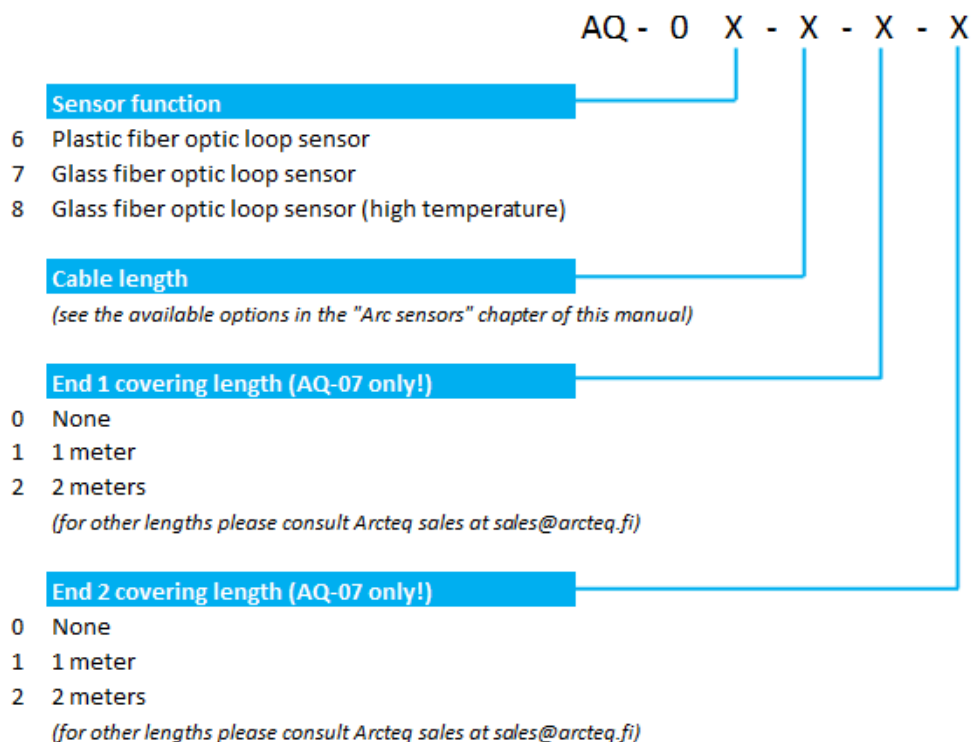
AQ-110x current measurement and arc sensing device



AQ-0x point sensors



AQ-0x fiber optic loop sensors



Accessories

Order code	Description	Note	Manufacturer
AQX006	Wall mounting bracket	For AQ-103 and AQ-110x variants (MV and LV).	Arcteq Ltd.
AQX016	Wall mounting bracket	For AQ-101, AQ-101S and AQ-102 devices (MV and LV).	Arcteq Ltd.

16 Contact and reference information

Manufacturer

Arcteq Relays Ltd.

Visiting and postal address

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Contacts

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