

AQ-101 (AQ-101D)

Arc flash protection unit

Instruction manual

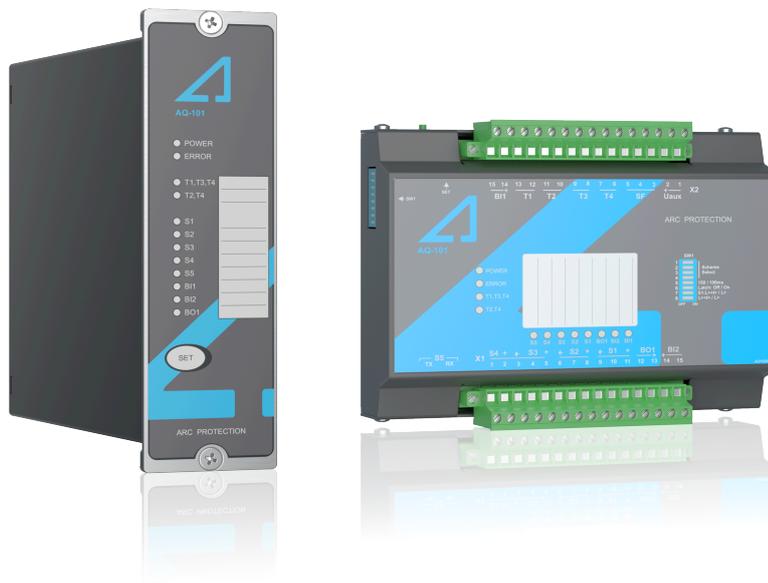


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1 Document information

Table. 1 - 1. History of Revision 1.

Revision	1.00
Date	October 2010
Changes	- The first revision of the manual.
Revision	1.01
Date	June 2011
Changes	- Sensor chapter revised. - DIP switch definition updated. - "Dimensions and installation" chapter edited: the depth of the unit is changed from 170 mm to 175 mm.
Revision	1.02
Date	May 2012
Changes	- One selective scheme and the non-selective scheme are updated. - DIP switch definition is changed to scheme selection. - AQ-101 DIN rail version added.
Revision	1.03
Date	November 2012
Changes	- AQ-101 simplified block diagram revised: the name of the BI2 on X1 connector is corrected.

Table. 1 - 2. History of Revision 2.

Revision	2.00
Date	October 2020
Changes	- 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-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 image added.- Dimension measurements updated.- 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 in all fiber descriptions removed.- Connections image updated.- The test plan example 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.- The number for Arcteq's technical support added to the reference information.
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2 Abbreviations

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

QD – quenching device

RF – radio frequency

Rx – receiver

SAS – standard arc scheme

SF – system failure

Tx – transceiver

μP - microprocessor

3 General

The AQ-101 (AQ-101D) point sensor device is a sophisticated microprocessor-based arc flash protection unit that includes complete self-supervision. The device is designed to minimize the damage caused by an arcing fault (arc flash) by tripping the circuit breaker which supplies current to the fault. The complete system self-supervision functionality of AQ-101 (AQ-101D) provides the highest level of dependability as it continuously monitors all internal system functions as well as all external connections.

The AQ-101 (AQ-101D) device is designed according to the latest protection relay standards and is 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. AQ-101 (and AQ-101D) is suitable for MV and LV switchgears as well as for motor control center applications in both new and retrofitted installations.

3.1 Unit features

AQ-101 is a multipurpose arc flash protection unit and can be applied to a variety of applications. It can be used on its own as a stand-alone unit, or it can be a part of a more complex arc protection system through a binary bus.

The following list presents the main features of the unit:

- 92...265 V AC/DC auxiliary power supply or 18...72 V DC auxiliary power supply (optional)
- four (4) arc point sensor channels
- one (1) fiber loop channel (optional)
- two (2) binary inputs with nominal operation voltage of 24, 110, or 220 V DC
- three (3) normally open trip relay outputs
- one (1) normally open trip relay output or one (1) normally closed trip relay output (electronic lock-out)
- one (1) binary output (24 V DC)
- one (1) system failure output
- twelve (12) indication LEDs
- one (1) push button.

AQ-101 comes in two variants. The AQ-101 variant is door and panel-mounted, while the AQ-101D variant is mounted on a DIN rail.

Figure. 3.1 - 1. Arc protection units AQ-101 (left) and AQ-101D (right).



3.2 Dimensions and installation

AQ-101 can be either door-mounted or panel-mounted in a standard 19 inch rack. The unit's dimensions (without cards) are as follows:

- Height: 157 mm (6.18 in)
- Width: 50 mm (1.97 in)
- Depth: 160 mm (6.30 in).

The dimensions of the AQ-101D variant are as follows:

- Height: 109 mm (4.29 in)
- Width: 145 mm (5.71 in)
- Depth: 34 mm (1.34 in).

The figure below presents the dimension of the unit visually. It also shows the dimensions of the cut-out (bottom-left) required when mounting the unit on a panel.

Figure. 3.2 - 2. Dimensions of the device and its cut-out panel.

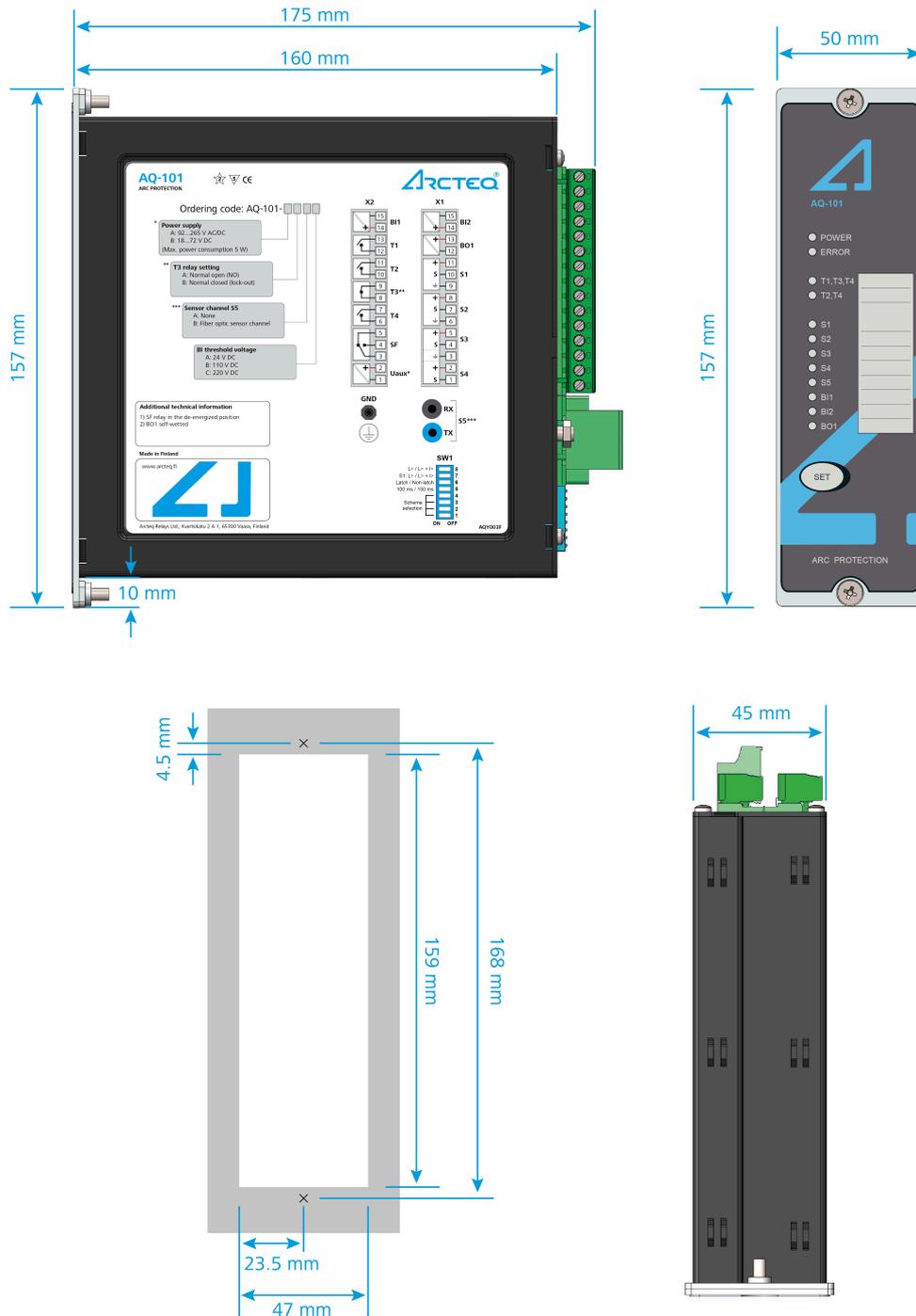
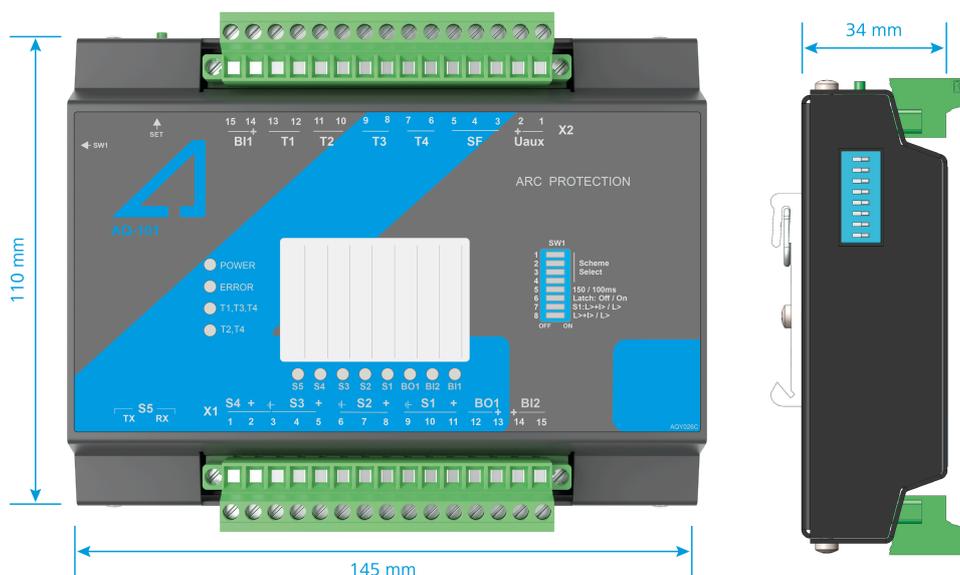


Figure. 3.2 - 3. Dimensions of the DIN rail variant of the device.



The following image illustrates how a unit is installed into a cut-out. Please note that as AQ-101 is narrower than the unit in the image, they are connected to the cut-out panel by a single screw on both the top and the bottom of the front panel instead of the two depicted below.

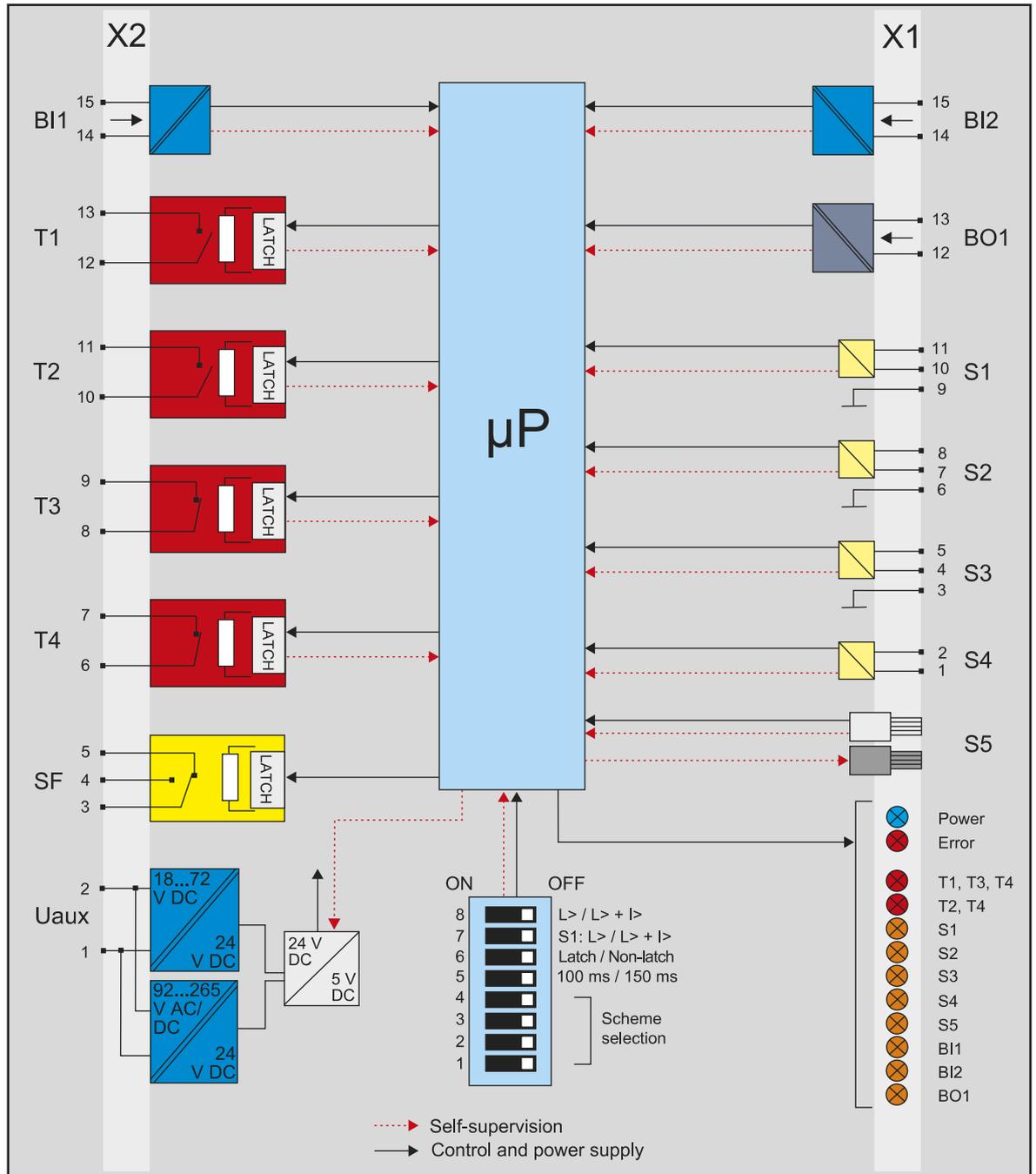
Figure. 3.2 - 4. Installing a unit into a cut-out.



3.3 Simplified block diagram

The figure below presents the main components that can be found in both the AQ-101 unit and the AQ-101D variant.

Figure. 3.3 - 5. Simplified block diagram of AQ-101 and AQ-101D.



NOTE!

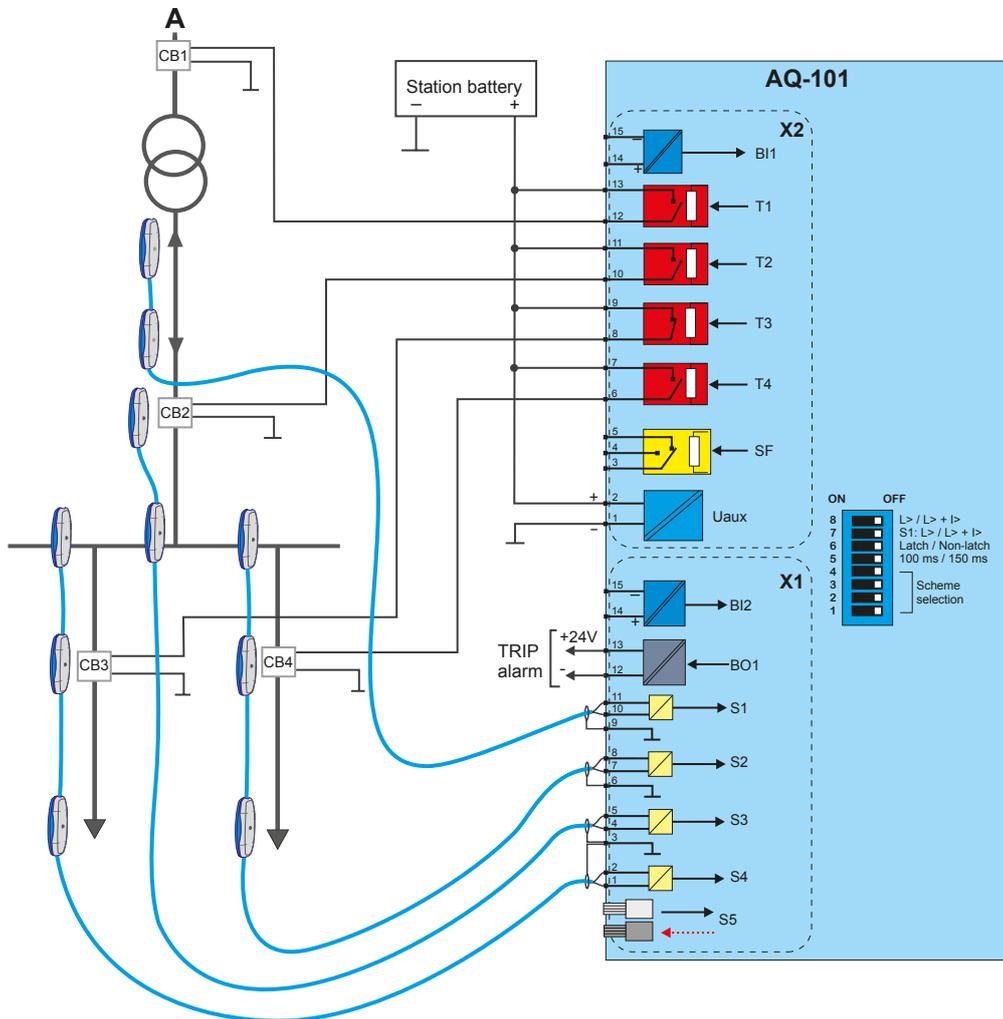


Please note that the latching (or non-latching) of trip relays T1 and T2 is determined with the DIP switch (SW1:6). The trip relays T3 and T4 are always latched.

The binary output BO1 is always non-latched!

3.4 Wiring

Figure. 3.4 - 6. Wiring diagram for AQ-101 and AQ-101D.



4 Operation and configuration

4.1 LED indicator functions

Both the AQ-101 and its AQ-101D variant have twelve (12) indication LEDs. 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. The LEDs are on the unit's front panel to allow for a clear view without a separate need to open doors.

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

The LEDs of inactive sensors are off. If an arc sensor is activated for longer than 1.5 ms, its corresponding LED turns on. The activation function of the sensor LEDs is latched when the LED's light is not blinking.

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 for longer than 1.5 ms, the corresponding LED turns on (that is, they become latched). This also happens when a trip situation occurs. The trip outputs are controlled with DIP switch settings. All activation 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 if auxiliary power is lost. When the unit 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.

4.2 LED operations guide

The table below describes the function of each indicator LED in detail.

Table. 4.2 - 3. LED operations of AQ-101 and AQ-101D.

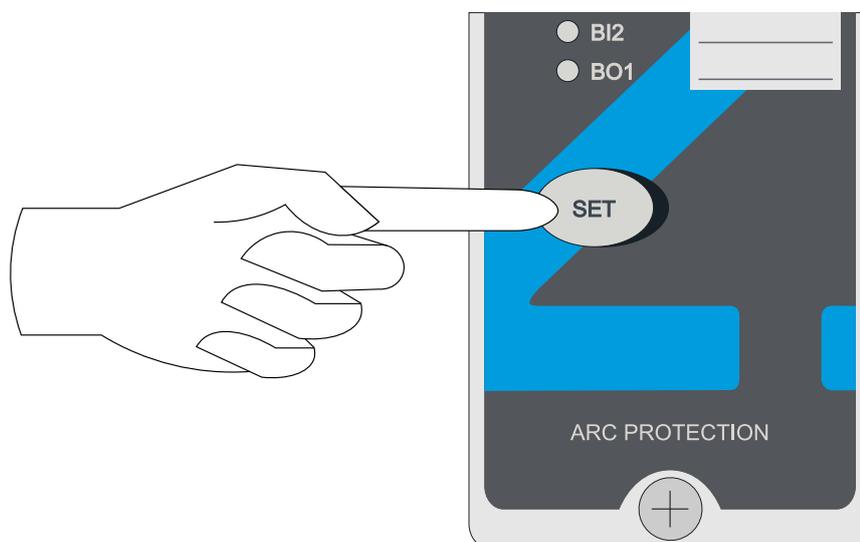
LED name (color)	Light off	Steady light	Blinking light	Action if abnormal
POWER (blue)	The auxiliary power supply is disconnected.	The auxiliary power supply is connected.	(N/A)	Check the power supply.
ERROR (red)	The system is healthy.	A system failure has occurred.	A configuration mismatch has been 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—S4 (amber)	Normal status.	Light information has activated the sensor channel.	There is a loose connection or a system setup has not been performed; <u>or</u> , pressure information has activated the sensor channel in question (when using an AQ-02 point sensor).	Check the sensor wire connection or perform a system setup (see the "System setup" chapter); <u>or</u> , check what activated the sensor.
S5 (amber)	Normal status.	The fiber sensor channel has been activated.	There is a loose fiber sensor connection or a system setup has not been performed.	Check the sensor wire continuity or perform a system setup (see the "System setup" chapter); <u>or</u> , check what activated the sensor.
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)	—

4.3 Push button (SET)

The unit contains one push button, **SET**, and it can be used for all operational functions. The push button is used for setting up the system (also known as auto-configuration), for resetting the indicator LEDs and the latched output relays, as well as for checking the input connection.

Figure. 4.3 - 7. The "SET" push button on the device's front panel.



4.3.1 System setup (auto-configuration)

After all sensors and binary lines 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 LEDs to start blinking. The unit scans these inputs to see if they are connected; when an input is detected, the corresponding LED lights up to mark 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 during this sequence.

All sensor inputs remain operational even when they have not been auto-configured. System setup is only used for self-supervision purposes.

Please note that to reconfigure a unit with fewer connections (BI/BO or 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. After this, you must wait one minute before you begin the new auto-configuration sequence.

You can reconfigure a unit with more connections at any time without the wait and without having to move one of the DIP switches.

4.3.2 Reset

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

Unless the button is pressed, the latched trip relays remain active until the auxiliary power is disconnected. All LED indications also remain active even when the auxiliary power supply is disconnected unless the button is pressed. Please refer to the "Non-volatile memory" chapter for more information.

4.3.3 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 and binary input channels start blinking while the "Power" LED is already blinking. The LEDs blink as many times as there are connected sensors and binary output channels from other units.

4.4 DIP switch settings

The DIP switches are used to configure the unit's tripping logic and other functionalities. The various trip schemes can be programmed easily by selecting the appropriate DIP switch positions, which allows for more flexibility when changing the settings depending on the application. However, the most convenient way to set the unit or a more complex arc protection system is to use Standard Arc Schemes (SAS).

Tripping can be based on arc light only, or on both arc light and current thresholds, or on other tripping criteria (such as undervoltage, etc.). Current threshold and other tripping criteria can also be applied to BI1 to block tripping caused by natural light sources. The CBFP (circuit breaker failure protection) scheme can also be enabled with the DIP switches. The DIP switch's pins 1...4 are used for selecting schemes, and their numbering is based on binary arithmetic.

The DIP switches are located at the back of the unit for easy access. The figure below presents the DIP switch numbering, and the table below that gives a detailed description of the settings.

NOTE!



Please note that while the pin numbers and their functions are the same for both AQ-101 and AQ-101D, in the DIN rail variant of the unit the pins are "upside down" (that is, Pin 1 is at the top of the DIP switch when normally Pin 8 is at the top)!

Figure. 4.4 - 8. DIP switch diagram.

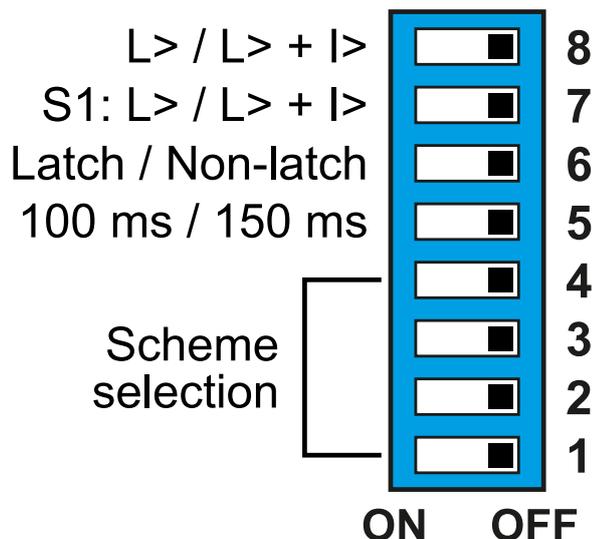


Table. 4.4 - 4. DIP switch settings.

Pin number (name)	Function selection	ON (left position)	OFF (right position)
8 (L> <u>or</u> L> + I>)	The tripping criterion for the S2, S3, S4 (sensor) and S5 (fiber) channels.	Tripping on light only (L>).	Tripping on light and overcurrent (L> + I>), both of which are required to occur simultaneously to trigger tripping.
7 (S1: L> <u>or</u> L> + I>)	The tripping criterion for the S1 sensor channel.	Tripping on light only (L>).	Tripping on light and overcurrent (L> + I>), both of which are required to occur simultaneously to trigger tripping.
6 (Latch <u>or</u> Non-latch)	Latching or non-latching for the T1 and T2 trip relays.	T1 and T2 operate as latched.	T1 and T2 operate as non-latched.
5 (100 ms <u>or</u> 150 ms)	The setting for the CBFP time.	The CBFP time is set to 100 ms.	The CBFP time is set to 150 ms.
4 (scheme select)	Scheme selection.	Please refer to the "Scheme selection" and "Application examples" chapters.	Please refer to the "Scheme selection" and "Application examples" chapters.
3 (scheme select)	Scheme selection.	Please refer to the "Scheme selection" and "Application examples" chapters.	Please refer to the "Scheme selection" and "Application examples" chapters.
2 (scheme select)	Scheme selection.	Please refer to the "Scheme selection" and "Application examples" chapters.	Please refer to the "Scheme selection" and "Application examples" chapters.
1 (scheme select)	Scheme selection.	Please refer to the "Scheme selection" and "Application examples" chapters.	Please refer to the "Scheme selection" and "Application examples" chapters.

NOTE!



The T3 and T4 trip relays are always latched. The BO1 binary output function is always non-latched.

4.4.1 Scheme selection

This chapter describes the schemes that are available to this unit. The schemes are configured using the DIP switches numbered 1...4 ("Scheme selection"). For detailed instructions on each of the available schemes please refer to the AQ-SAS™ booklet (can be found at arcteq.fi/downloads/). Please note that there are four booklets: two are for schemes based on IEC standards (MV and LV versions) and the other two for schemes based on ANSI standards (MV and LV versions).

4.4.2 Available logic schemes

The schemes described below are the most important ones for this unit. However, additional schemes are also available; please contact your nearest Arcteq representative for more information on those schemes.

SS:0

The logic scheme SS:0 can be applied as a stand-alone arc protection scheme, but it can also be used for protecting non-selective outgoing feeder compartments. Depending on the purpose you can choose between the two tripping modes to trip all the circuit breakers: the light-only mode L>, or the light and overcurrent mode L> + I>.

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

Figure. 4.4.2 - 9. The logic diagram of SS:0.

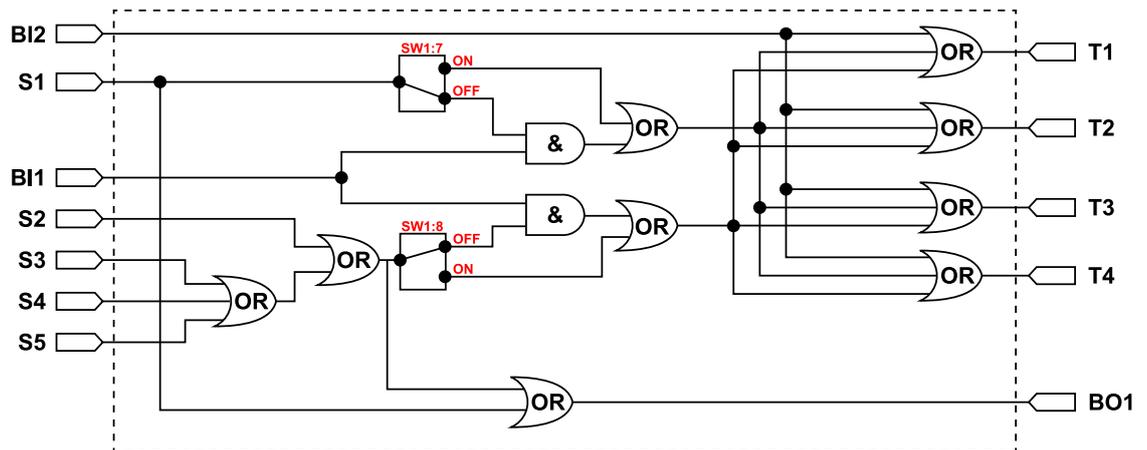


Figure. 4.4.2 - 10. The DIP switch settings for SS:0.

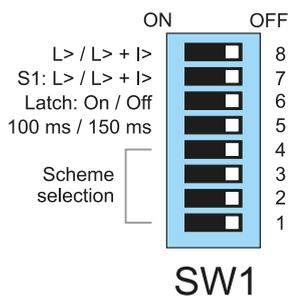


Figure. 4.4.2 - 11. The trip logic matrix for SS:0.

SS:0		OUTPUTS				
		T1	T2	T3	T4	BO1
INPUTS	S1	x	x	x	x	x
	S2	x	x	x	x	x
	S3	x	x	x	x	x
	S4	x	x	x	x	x
	S5	x	x	x	x	x
	BI1	x	x	x	x	
	BI2	x	x	x	x	

SS:1

The logic scheme SS:1 is mainly used in selective arc protection solutions. The fiber sensor S1 monitors the outgoing feeder cable compartment. The fiber sensor S2 monitors the corresponding feeder breaker compartment as well as the busbar compartment. The trip contact T1 is responsible for tripping the circuit breaker of the outgoing feeder.

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

Figure. 4.4.2 - 12. The logic diagram of SS:1.

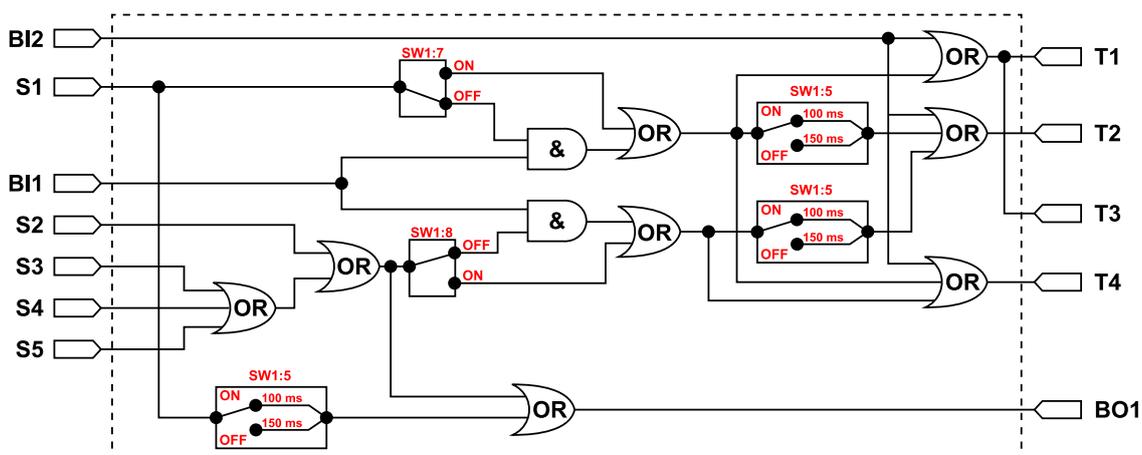


Figure. 4.4.2 - 13. The DIP switch settings for SS:1.

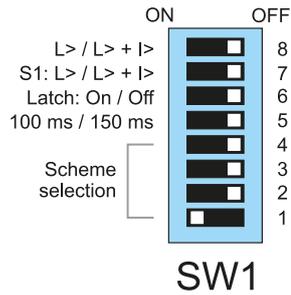


Figure. 4.4.2 - 14. The trip logic matrix for SS:1.

SS:1		OUTPUTS				
		T1	T2	T3	T4	BO1
INPUTS	S1	x		x	x	
	S2				x	x
	S3				x	x
	S4				x	x
	S5				x	x
	BI1	x		x	x	
	BI2	x	x	x	x	

4.5 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 unit 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.

5 Arc sensors

The AQ-100 series provides different types of arc sensors to be used with different units and different switchgear types according to specific application requirements. There are two types of sensors: arc light point sensors and arc light fiber optic loop sensors.

Arc light point sensors are typically installed in metal-clad compartments, and they provide a quick and accurate location of the faulted 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.

5.1 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. Only one sensor should be used per one closed metal-clad compartment. 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, the default threshold can also be set to 25,000 lux or 50,000 lux. An arc light sensor does not require further settings by the user. Its detection radius is 180 degrees.

Figure. 5.1 - 15. The AQ-01 light sensor.



An AQ-01 is installed either on the compartment wall or through the wall. When wall-mounting, the unit is placed on the wall (with the gray side against the wall) and then fixed to the wall with two screws from the back of the sensor. Through-the-wall mounting is similar: the unit is placed on the wall (with the blue side against the wall and the eye is pushed into the drilled compartment hole for protection) 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. 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.



NOTE!

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

5.2 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. 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. Only one sensor should be used per one closed metal-clad compartment. 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, the default threshold can also be set to 25,000 lux or 50,000 lux. An arc light sensor does not require further settings by the user. Its detection radius is 180 degrees. The pressure threshold is fixed at 0.2 bar above ambient pressure.

Figure. 5.2 - 16. AQ-02 arc light and pressure point sensor.



An AQ-02 can only be installed on the compartment wall as not to block pressure detection located next to "the eye". The unit placed on the wall (with the gray 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. 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.

5.3 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 does not require further settings by the user. 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).

5.4 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 does not require further settings by the user. The sensor's detection radius is 360 degrees.

If necessary, the ends of an AQ-07 cable can be covered with black rubber 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.

5.5 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 does not require further settings by the user. The sensor's detection radius is 360 degrees.

5.6 Sensor—unit dependencies

Different sensor types can be used with different arc flash protection units of the AQ-100 series. The table below describes those dependencies.

Table. 5.6 - 5. Sensor—unit dependencies.

	AQ-01	AQ-02	AQ-06	AQ-07	AQ-08
AQ-101	Yes	Yes	Yes (when the unit is equipped with the fiber option)	Yes (when the unit is equipped with the fiber option)	Yes (when the unit is equipped with the fiber option)
AQ-101D	Yes	Yes	Yes (when the unit is equipped with the fiber option)	Yes (when the unit is equipped with the fiber option)	Yes (when the unit is equipped with the fiber option)
AQ-101S	Yes	Yes	No	No	No
AQ-102	No	No	Yes	Yes	Yes
AQ-103	Yes	Yes	Yes (when the unit is equipped with the fiber option)	Yes (when the unit is equipped with the fiber option)	Yes (when the unit is equipped with the fiber option)
AQ-110P	Yes	Yes	Yes (when the unit is equipped with the fiber option)	Yes (when the unit is equipped with the fiber option)	Yes (when the unit is equipped with the fiber option)
AQ-110F	No	No	Yes (when the unit is equipped with the fiber option)	Yes (when the unit is equipped with the fiber option)	Yes (when the unit is equipped with the fiber option)

5.7 Connecting sensors

How to connect point sensors

1. Open the sensor covers and detach the connectors.
2. Attach the cable to the connector and to the unit.
3. Reattach the connectors to the sensor.
4. Run the auto-configuration procedure.
5. Once the auto-configuration has been successfully completed, put the sensor covers back in place.

For more detailed instructions, please refer to the "Connecting sensors" chapter in the AQ-0x instruction booklet (arcteq.fi/downloads).

How to connect fiber sensors

1. Drill holes on the compartment wall and cover any sharp edges.
2. Run the fiber through the holes and fasten it to the protected area.
3. Connect the sensor terminals into the Tx and Rx slots at the back of the unit.

The placement of the fiber sensor may require blocking of unwanted light activation. The AQ-07 glass fiber can be ordered with end covers to conceal one (1) or two (2) meters of the fiber on each end. Please refer to the "Arc light fiber optic loop sensor AQ-07" chapter for more information.

6 System self-supervision

All AQ-101 and AQ-102 variants (that is, both LV and MV) have an extensive self-supervision feature, including both internal functions and external connections. The self-supervision module monitors the power supply, hardware and software malfunctions, as well as problems with the binary input connection(s) and sensor(s). Additionally, the module supervises the DIP switch settings by comparing actual values with the data stored in the non-volatile memory.

When the unit's condition is healthy, 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.

If a sensor failure occurs, the unit 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 unit is still in the protection mode, although the faulty sensor channel is blocked. If the error is resolved, the unit 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 unit remains operational accordingly. However, the unit remains in Error mode until the disconnected sensors are repaired.

The unit goes into SF alarm 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 unit is still operational.

7 Application examples

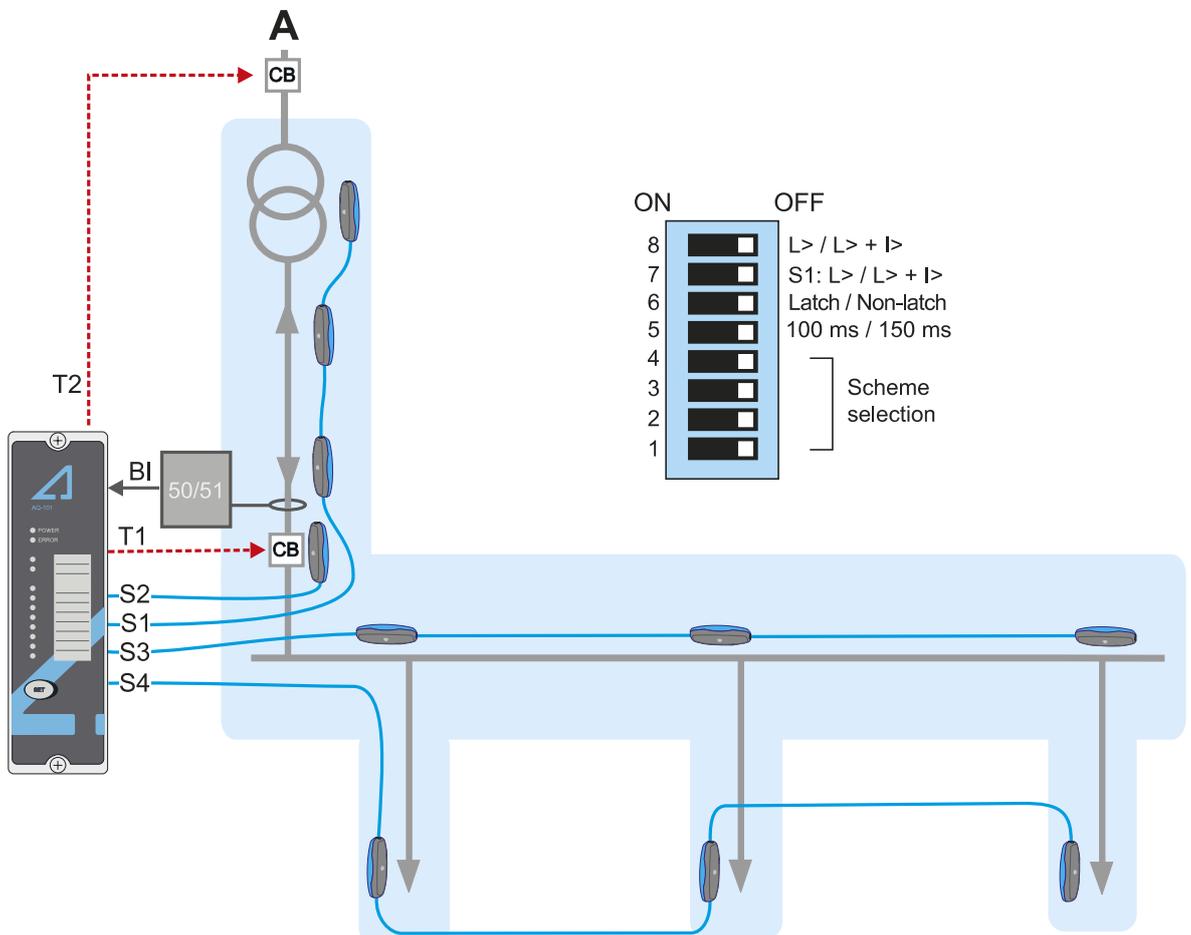
This unit can be applied to a variety of power switchgear and controlgear layouts and technologies. This chapter describes some of the most typical applications. Please consult the AQ-SAS™ booklet (can be found at arcteq.fi/downloads/) or your nearest Arcteq representative for a solution to your particular application.

7.1 Application with overcurrent and arc light conditions (LV and MV)

AQ-101 and AQ-101D can be used for applications that require tripping from both overcurrent (I>) and arc light (L>), where tripping is performed only when both conditions occur simultaneously. Typically, the overcurrent condition is obtained from an AQ-110 unit, activating the trip relay in 7 ms. The I> condition can also be monitored by non-Arcteq products (such as a generic feeder protection relay); however, the total operating time cannot be guaranteed to be 7 ms, as that is dependent on the device feeding the I> signal to the AQ-101 (or AQ-101D) unit. Please note that the S1 sensor channel can be set to operate solely on the light condition, even if other channels are set to operate on both conditions.

The figure below presents an example system (for both LV and MV) that applies both I> and L> for tripping from the S2, S3 and S4 sensor channels, while the S1 sensor channel is set to only activate on the light condition. S1 monitors the transformer feeder's bus duct located above the current monitoring point. A maximum of three arc light point sensors (AQ-01 or AQ-02) can be connected to each sensor channel. In this application, the current monitoring signal comes from an external overcurrent relay, although it could also come from an AQ-110 unit. An overcurrent relay (50/51) monitors the I> condition.

Figure. 7.1 - 17. Connections of the I> and L> application for AQ-101.



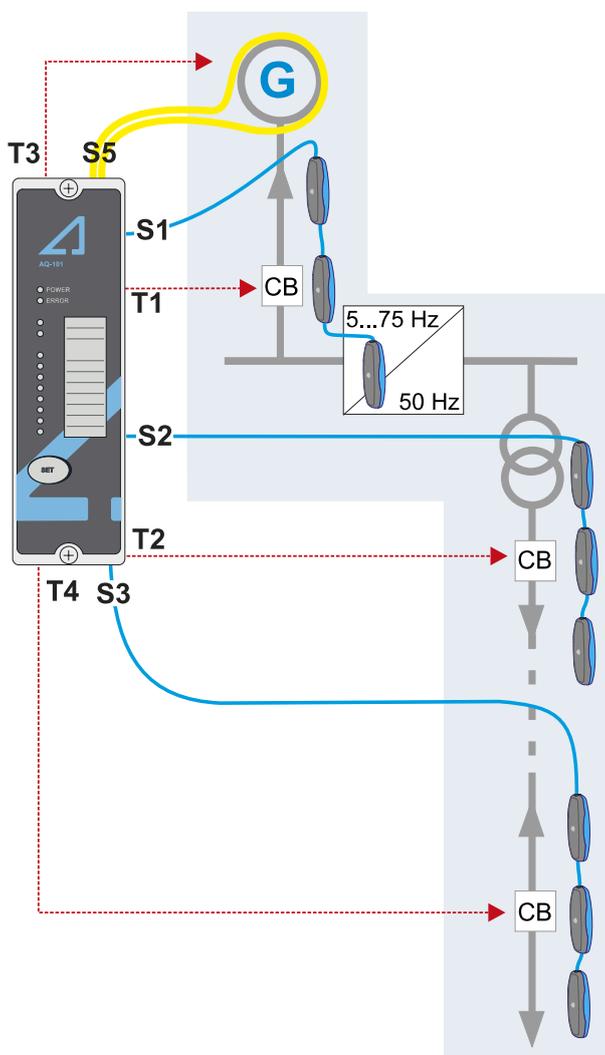
7.2 Wind power application (light only)

AQ-101 and AQ-101D can be applied by using arc light as the only tripping criterion. This example application describes a typical wind power scheme, where a permanent magnet synchronous generator is applied with a converter cabinet and an MV/LV transformer.

As described in the "Unit features" chapter, AQ-101 and AQ-101D have four point sensor channels (each of which can have up to three sensors) and one optional fiber optic loop sensor channel. This example application uses three of the point sensor channels, each with three sensors. The application also uses the optional fiber loop sensor channel to monitor the generator windings and terminations.

If arc light occurs in any of the compartments containing a sensor, the unit executes a trip to all three circuit breakers in 7 ms. Thus, the total operating time for the unit to clear the arc fault is 7 ms and the time it takes for the circuit breaker to open. Additionally, the application uses the electronic lock-out relay T3 to provide a safety loop: it ensures that the fault is recognized and corrected before the generator is put back into service.

Figure. 7.2 - 18. The wind power application's wiring diagram for AQ-101.



7.3 Circuit breaker failure protection

All AQ-101 variants include a selective circuit breaker failure (CBFP) function, which can be enabled through the DIP switch settings (please refer to the "DIP switch settings" chapter for more information). When enabled, the CBFP function activates when the tripped breaker fails to operate, or if the unit detects the presence of light after a set operating time. Please note that if the unit 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 (again, please refer to the "DIP switch settings" chapter for more information).

8 Connections

The figures below depict the connections of AQ-101 and AQ-101D. Please note that the SF relay is in the de-energized position.

Figure. 8 - 19. Rear terminals of AQ-101.

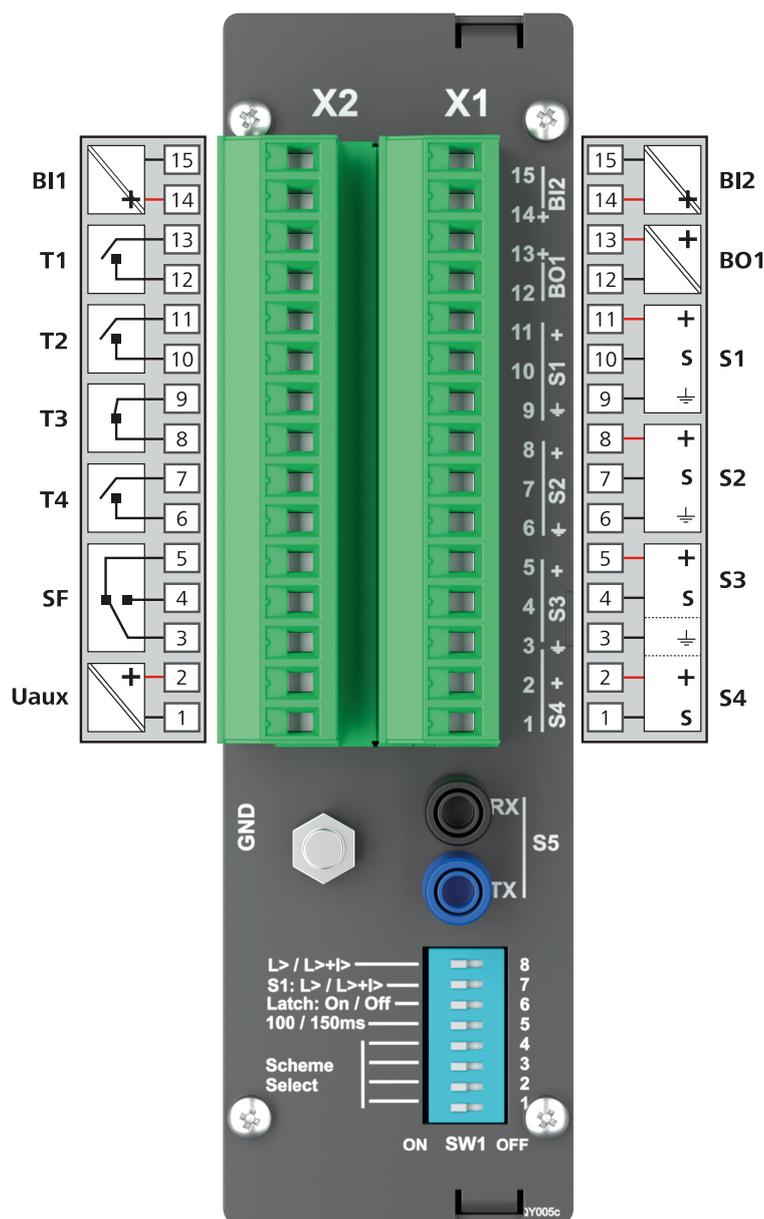
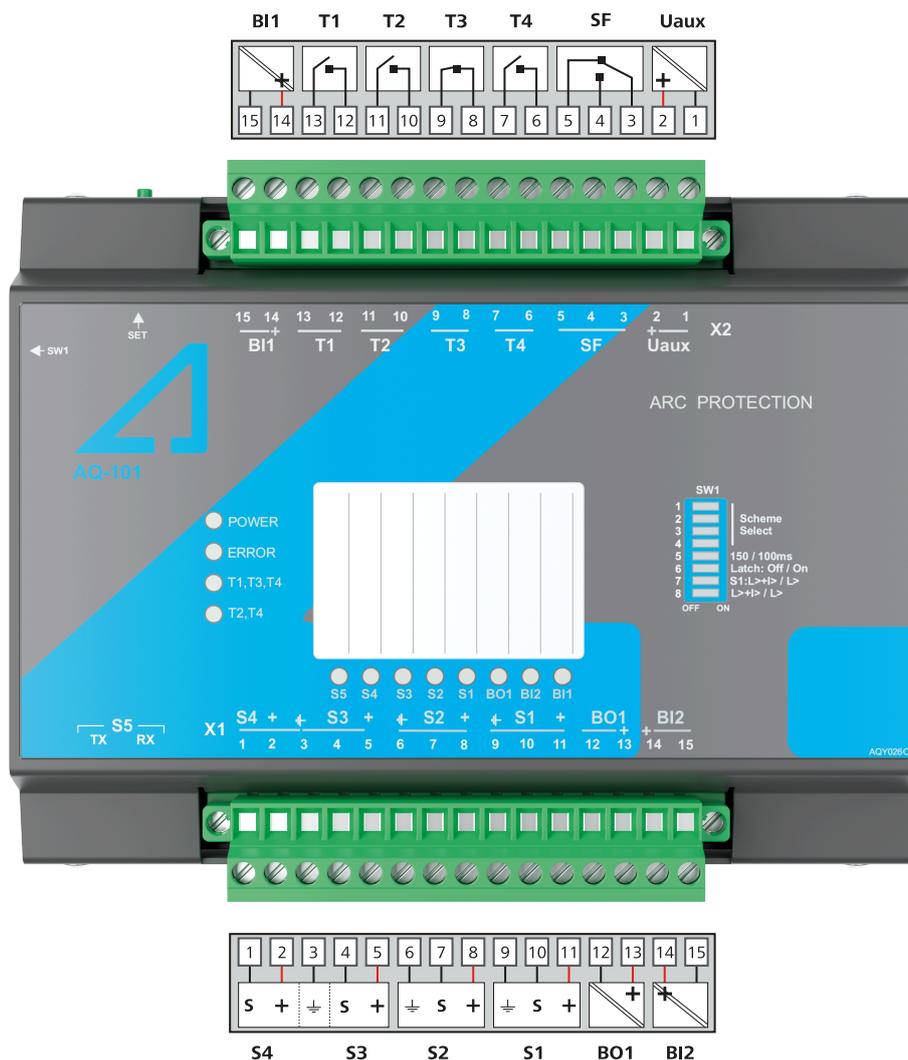


Figure. 8 - 20. Connections of AQ-101D.



8.1 Outputs

8.1.1 Trip relays

This unit has two (2) integrated trip relays for tripping circuit breakers, namely T1 and T2. Their type is normally open (NO).

T3 can function either as an electronic lock-out relay or as a trip relay. When T3 is configured as an electronic lock-out relay, its type is normally closed (NC) and it holds its 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 contact condition it had prior to the power loss. This normally closed relay output can also be used for tripping contactor-controlled devices. If the application so requires, T3 can also be ordered as normally open (NO) from the factory. This choice is specified when ordering this unit.

T4 is a common trip relay that operates whenever T1 or T2 operates. It can be used either for tripping one additional disconnecting device, or as a trip alarm in a (local or remote) monitoring and alarming system.

8.1.2 Binary outputs

The unit has one (1) binary output: BO1 (+24 VDC). 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.

Please note that the binary output is polarity-sensitive (see the "Wiring" chapter for more information).

8.1.3 System failure relay

The system failure (SF) relay is of the change-over type (NO/NC) and it is energized when the unit is in a healthy condition. Whenever the unit detects a system error or a disconnection between the auxiliary power supply and the contacts, the SF relay changes its state. The state stays this way until the unit returns to a healthy condition and the SF relay is energized again.

8.2 Inputs

8.2.1 Arc sensor channels

Both AQ-101 and AQ-101D have four (4) arc point sensor channels: S1, S2, S3 and S4. You can connect a maximum of three (3) arc point sensors to each channel.

S5 is the optional fiber optic loop sensor channel with a transceiver (Tx) terminal and a receiver (Rx) terminal. When the fiber optic loop sensor is connected to the unit, 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 unit goes into Error mode and activates the "Error" LED and the SF relay output.

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/>).

8.2.2 Binary inputs

This unit contains two (2) binary inputs.

BI1 is always reserved for the signal from the secondary trip criterion. Typically, the unit receives overcurrent information from an AQ-110x unit, although such information can also come from a non-Arcteq device (such as an upstream protection relay). Alternatively, any other signal (such as undervoltage) can be used as a secondary trip criterion along with light information.

Please note that when this unit receives an overcurrent signal from a non-Arcteq device, the actual operating time depends on the operating time of the third-party device. Therefore, the total operating time cannot be specified nor guaranteed.

BI2 can be used for receiving a trip signal or an arc light signal. The function of the BI2 is configured using the DIP switches. For more information, please refer to the "DIP switch settings" chapter in this manual.

The binary inputs are activated when a connected DC signal exceeds the specified nominal threshold level of the corresponding input. There are three (3) different nominal threshold levels available: 24, 110, or 220 VDC. Please note that the threshold value must be chosen and specified when ordering the unit. Please note that the actual activation of the binary input occurs earlier than the specified nominal threshold value (see Chapter 11.4, "Technical Data").

8.3 Auxiliary voltage

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.

9 Testing

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

Any high-quality camera with an interchangeable lens works well to simulate arc light. 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.

9.1 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, verify its 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, also verify that the "BO1" 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.

9.2 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 unit that is being tested, and the BI1 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 BI1 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, verify its 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.
8. If you are using the BO1 binary output, also verify that the "BO1" LED is lit.
9. If you are using the BI2 binary input, verify its correct operations by activating the input.
10. Activate the camera flash within 30 cm (12 inches) of the sensor unit but do not activate the binary input used for the overcurrent condition ($I >$).
11. Verify that no trip has occurred and only the indicator LED of the sensor activation is lit.
12. If you are using the BO1 signal and have configured it to send light information, verify that it is activated.

13. Press the **SET** push button to reset all indications and latches.
14. 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 5 and 6.
15. Press the **SET** push button to reset all indications and latches.
16. Repeat the steps 1 through 15 for all sensors.

9.3 Testing the CBFP function

The circuit breaker failure protection (CBFP) function is tested by taking the light signal and the secondary trip criterion signal (if applicable) and leaving them active for longer than the set CBFP time (that is, 100 or 150 ms). The T2 trip relay and the BO1 binary output must be active after the set time delay has passed to confirm the CBFP function operates correctly.

9.4 Testing the unit 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-101 unit 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-101 unit's trip outputs (T1, T2, T3, T4) to a test set input and configure the input to stop the timer.
4. Place the camera flash within 20 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.

9.5 Test plan example



Basic data	
Date:	
Substation:	
Switchgear:	
Serial number:	

Preconditions		Additional notes
Trip mode (channel 1):	<input type="checkbox"/> L> <input type="checkbox"/> L> + I>	
Trip mode (channels 2, 3, 4):	<input type="checkbox"/> L> <input type="checkbox"/> L> + I>	
BI master trip in use:	<input type="checkbox"/> Yes <input type="checkbox"/> No	
CBFP in use:	<input type="checkbox"/> Yes <input type="checkbox"/> No	
CBFP time setting:	<input type="checkbox"/> 100 ms <input type="checkbox"/> 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			

Involved personnel	
Tested by:	
Approved by:	

10 Troubleshooting

Table. 10 - 6. Troubleshooting guide for AQ-101 variants.

Problem	Possible solution(s)
The sensor does not activate during testing.	Check the sensor's cable wiring (see the "Arc sensors" chapter for more information). <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.	Check the DIP switch settings (see the "DIP switch settings" chapter for more information).

11 Technical data

11.1 Mounting and installation

Table. 11.1 - 7. Technical data for relay mounting and installation (AQ-101 & AQ-101LV).

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)
Fiber connectors: - nut tightening torque	light finger tightening

Table. 11.1 - 8. Technical data for relay mounting and installation (AQ-101D & AQ-101DLV).

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 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)
Fiber connectors: - nut tightening torque	light finger tightening

11.2 Operating times

Table. 11.2 - 9. Technical data for relay operating times.

Trip time using mechanical trip relays	7 ms*
Reset time (arc light stage)	2 ms

*) The total trip time when using both the arc light (L>) or phase/residual overcurrent (I>) from an AQ-110 unit and the arc light (L>) from this unit.

11.3 Auxiliary voltage

Table. 11.3 - 10. Technical data for the relay auxiliary voltage (Uaux).

Auxiliary power supply	92...265 V AC/DC 18...72 V DC (optional)
Maximum interruption	100 ms
Maximum power consumption	5 W, < 10 mΩ
Standby current	90 mA

11.4 Binary inputs

Table. 11.4 - 11. Technical data for the relay binary inputs (BI1, BI2).

Nominal threshold voltage	24 V DC <u>or</u> 110 V DC <u>or</u> 220 V DC
Rated current	3 mA
Number of inputs	2

11.5 Trip relays

Table. 11.5 - 12. 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.

11.6 Binary output(s)

Table. 11.6 - 13. Technical data for the relay binary output (BO1).

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

11.7 System failure relay

Table. 11.7 - 14. 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.

11.8 Sensors

AQ-01 point sensor

Table. 11.8 - 15. 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. 11.8 - 16. 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

AQ-06 fiber optic loop sensor

Table. 11.8 - 17. 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. 11.8 - 18. 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. 11.8 - 19. 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

11.9 Disturbance tests

Table. 11.9 - 20. 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 μ s Between wire and earth: 4 kV, 1.2/50 μ s
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

11.10 Voltage tests

Table. 11.10 - 21. 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

11.11 Mechanical tests

Table. 11.11 - 22. 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.

11.12 Environmental conditions

Table. 11.12 - 23. 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

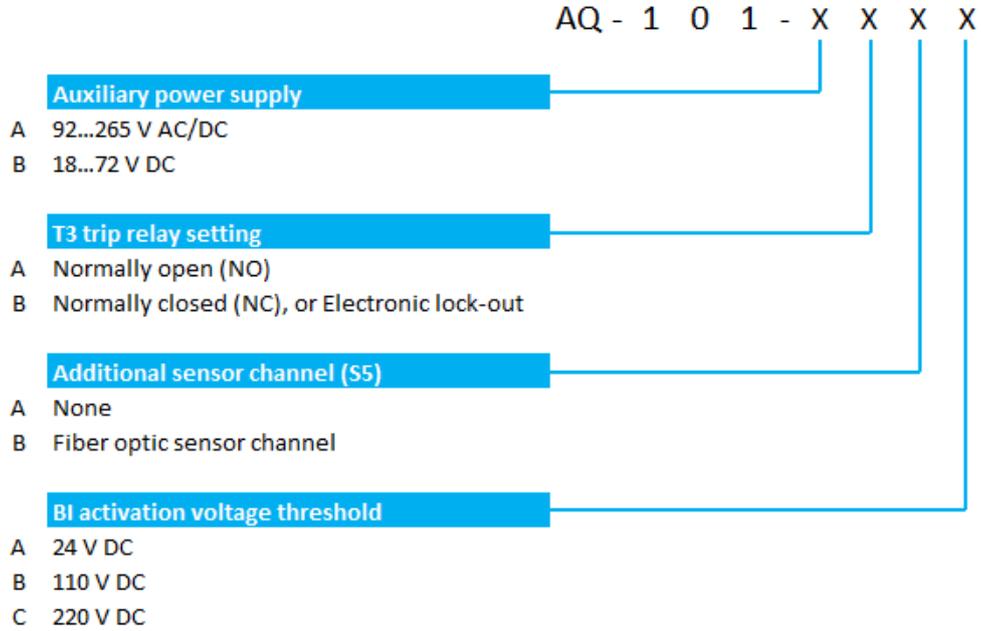
11.13 Casing

Table. 11.13 - 24. Technical data for the device casing.

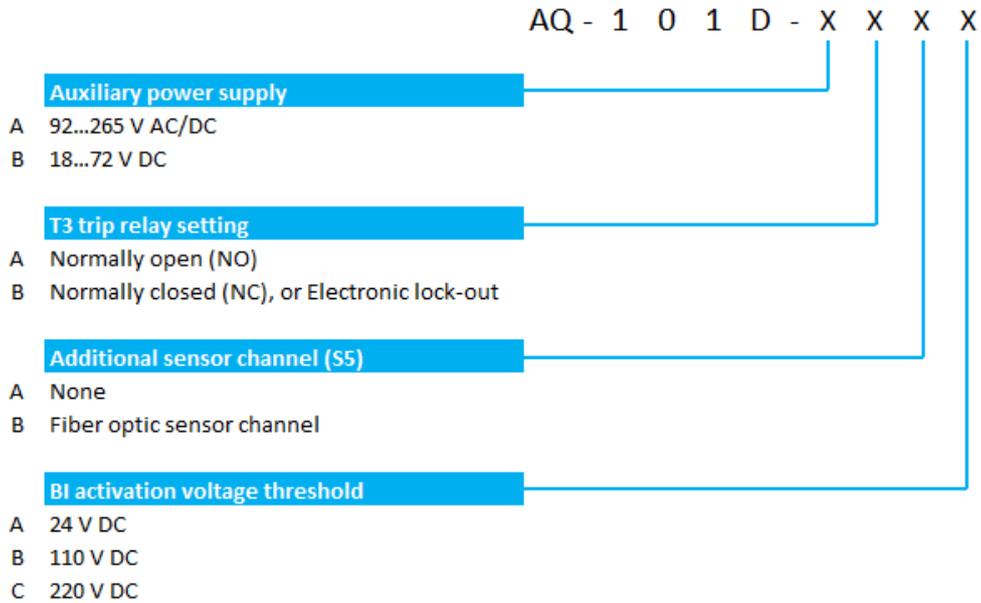
Protection: - front - back	IP 50 IP 20
Device dimensions (W \times H \times D)	50 \times 157 \times 160 mm 145 \times 109 \times 34 mm (the DIN rail variant)
Weight	0.7 kg

12 Ordering information

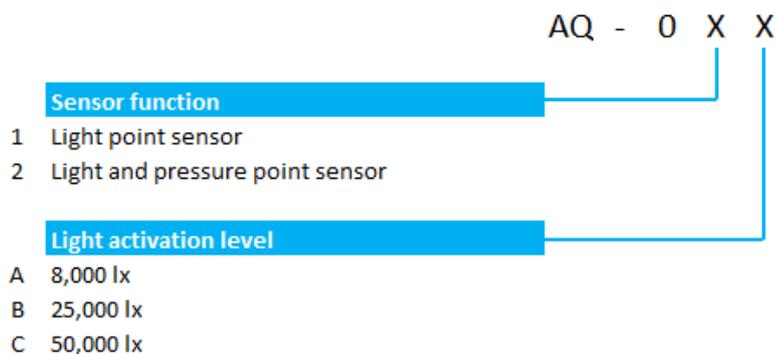
AQ-101 point sensor unit (panel mounted)



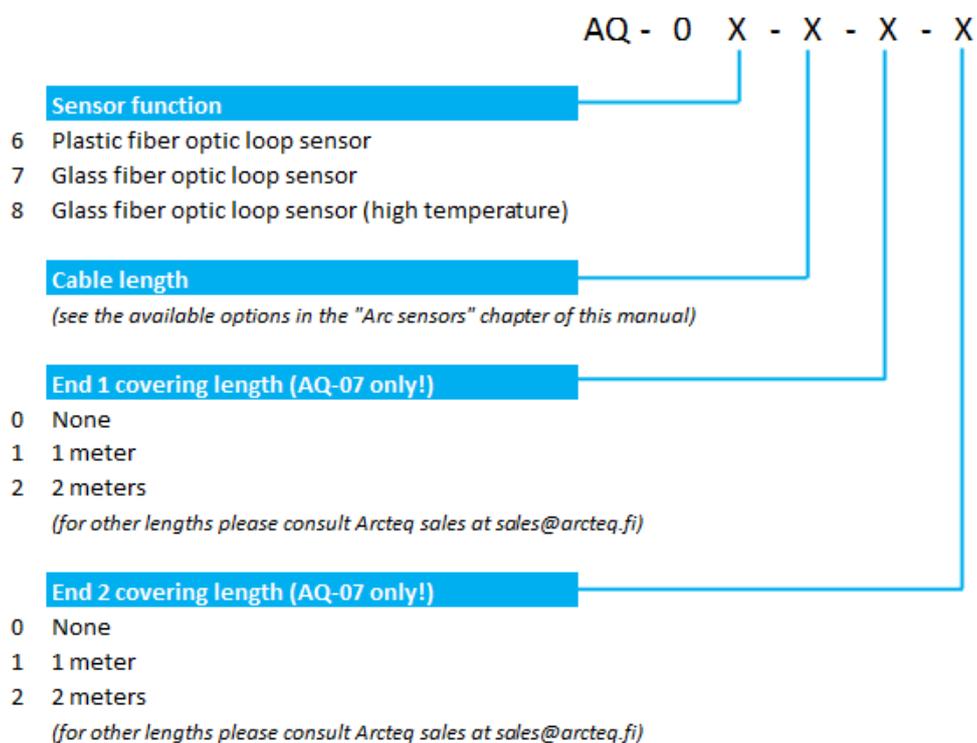
AQ-101D point sensor unit (DIN rail mounted)



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 units (MV and LV).	Arcteq Ltd.

13 Contact and reference information

Manufacturer

Arcteq Relays Ltd.

Visiting and postal address

Kvartsikatu 2 A 1

65300 Vaasa, Finland

Contacts

Phone:	+358 10 3221 370
Website:	arcteq.fi
Technical support:	https://arcteq.fi/support-landing/
	+358 10 3221 388 (EET 8:00 – 16.00)
E-mail (sales):	sales@arcteq.fi