ARCTEQ®
RELAYABLE POWER

AQ-103

Arc flash protection unit

Instruction manual

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1. Document information

Revision	1.00
Date	September 2020
Changes	- The first revision of the manual.
Revision	1.01
Date	December 2020
Changes	- updated the Modbus map

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-103 device is a sophisticated microprocessor-based arc flash protection unit with fourteen (14) arc sensor channels. Optionally it can also have one (1) fiber optic sensor channel. 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-103 provides the highest level of dependability as it continuously monitors all internal system functions.

The AQ-103 device is designed according to the latest protection relay standards and it is therefore suitable for installations in rough environments. These include utilities and power plants (both traditional and renewable), various heavy industry applications (oil, gas, mining, steel, etc.) as well as commercial and institutional electrical systems. AQ-103 is suitable for MV and LV switchgears as well as for motor control center applications in both new and retrofitted installations.

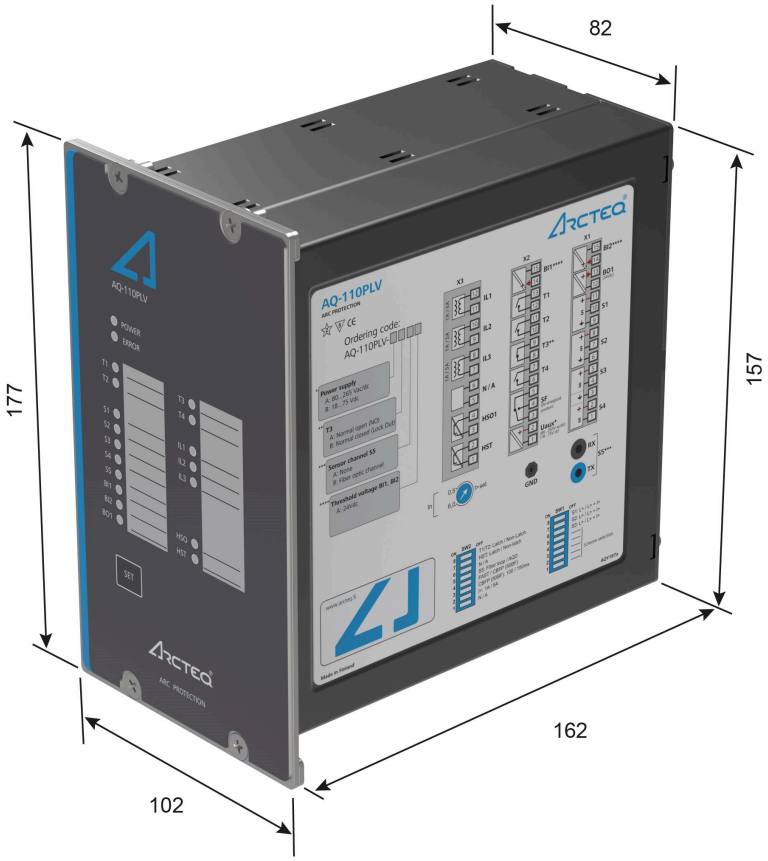
3.1. Dimensions and installation

AQ-103 can be either door-mounted or panel-mounted in a standard 19 inch rack. The unit's dimensions are as follows:

- Height: 177 mm (7.00")
- Width: 102 mm (4.02")
- Depth: 162 mm (6.38").

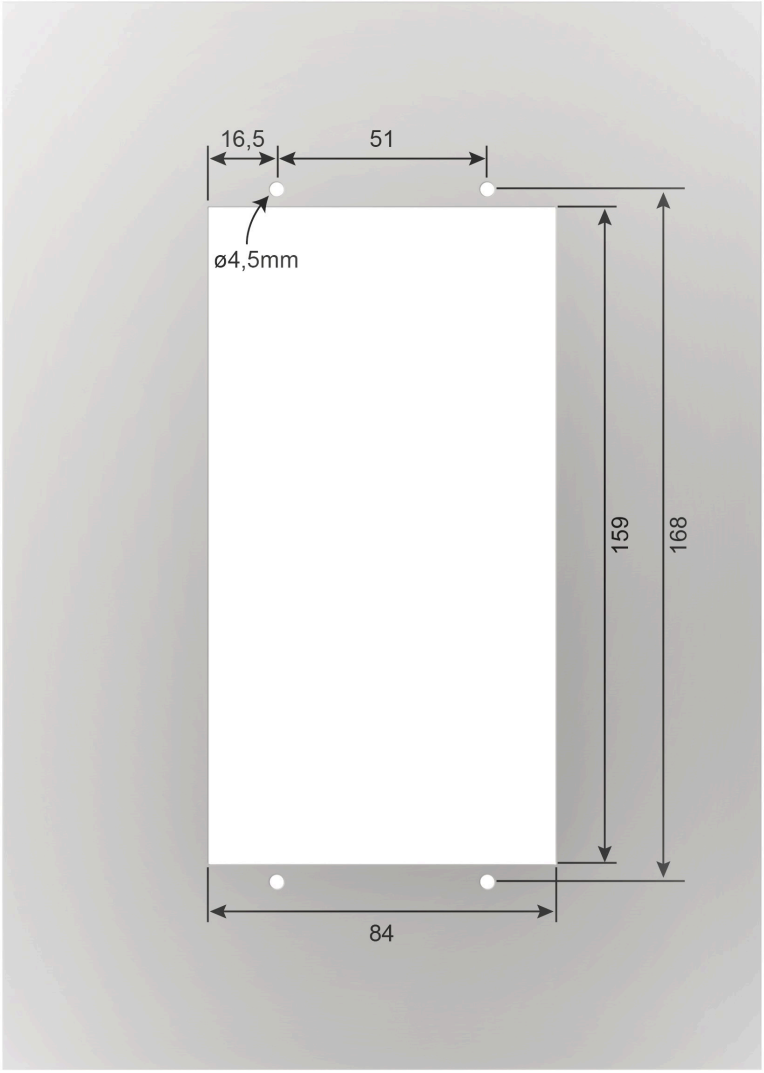
The figure below presents a side view of the device and gives the dimensions in more detail. While the image is of the AQ-110PLV device, the measurements are the same for AQ-103 and AQ-103LV. Please note that all values are given in millimeters.

Figure. 3.1. - 1. Dimensions of the device.



The image below presents the dimensions of the cut-put need for mounting the unit on a panel.

Figure. 3.1. - 2. Cut-out for panel-mounting a unit.



The following image illustrates how the unit is installed into a cut-out:

Figure. 3.1. - 3. Installing a unit into a cut-out.

3.2. Wiring

Please note that while the wiring diagrams in the images below refer to AQ-103LV, they also apply to AQ-103.

Figure. 3.2. - 4. Wiring diagram for AQ-103.

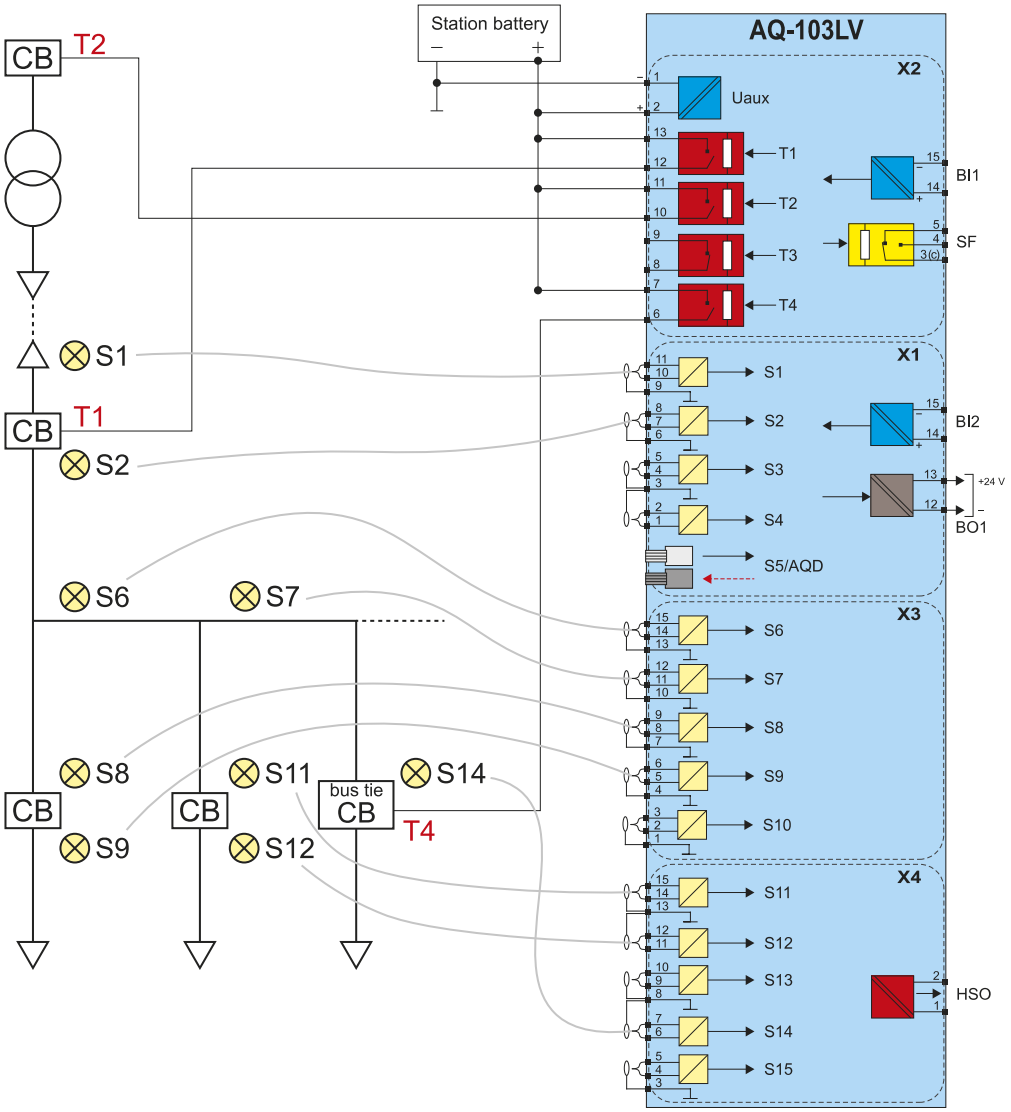
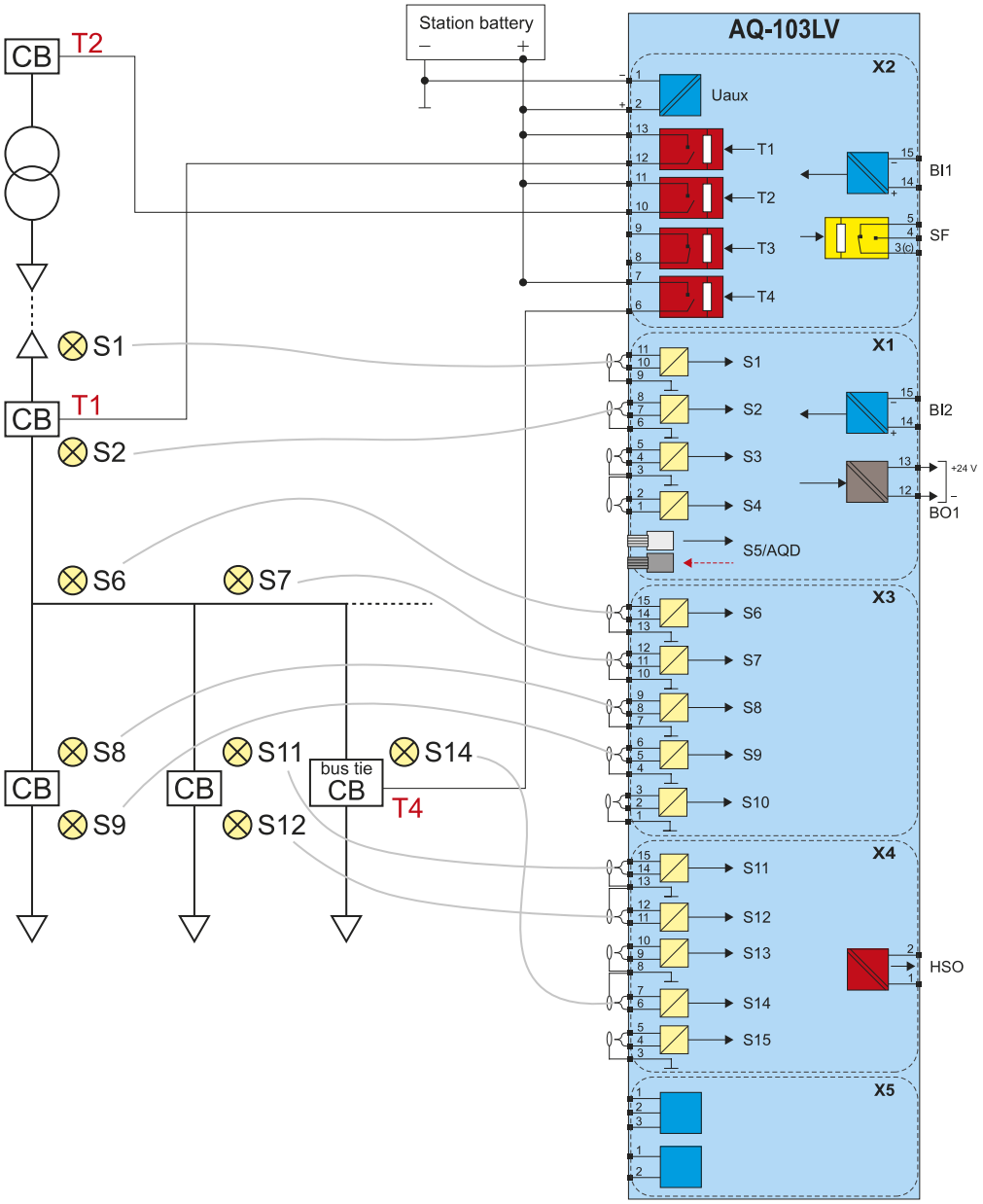


Figure. 3.2. - 5. Wiring diagram for the Modbus variant of AQ-103.



3.3. Unit features

AQ-103 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 the binary bus. AQ-103 comes in the two variants, with or without RS-485 Modbus communication.

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 (optional)
- fourteen (14) arc point channels
- one (1) fiber loop sensor channel or AQ-1000 control (optional)
- two (2) binary inputs with a nominal operation voltage of 24 V DC
- one (1) high-speed semiconductor trip output
- three (3) normally open trip relay outputs
- one (1) normally open trip relay or one (1) normally closed trip relay output (electronic lock-out)

- one (1) binary output (24 V DC)
- one (1) system failure output
- twenty-five (25) indication LEDs
- one (1) push-button.

Figure. 3.3. - 6. Arc protection unit AQ-103.

3.4. Simplified block diagram

The figures below present the main components of the AQ-103 variants (the basic unit and the Modbus unit).

Figure. 3.4. - 7. Simplified block diagram of AQ-103.

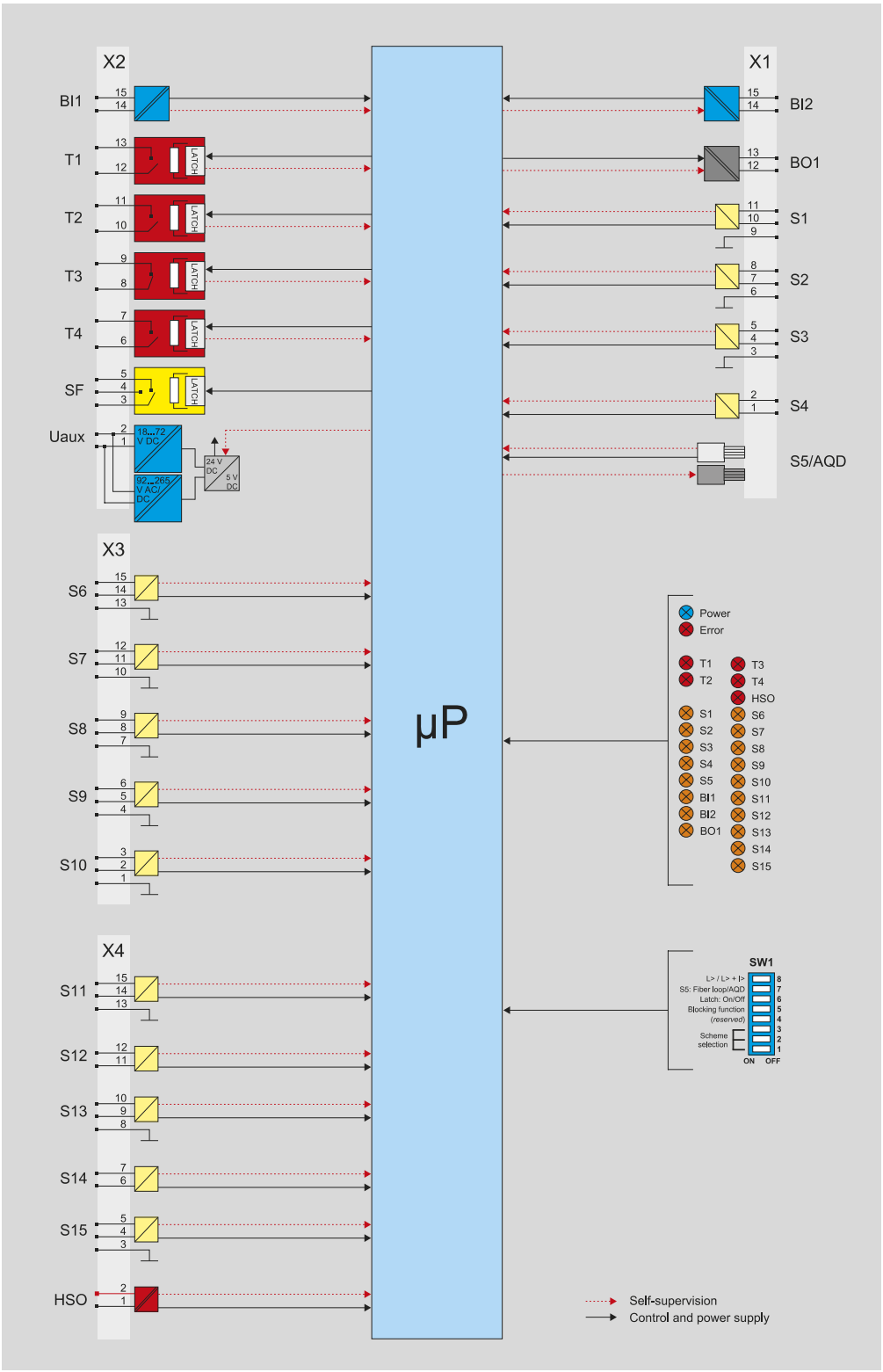
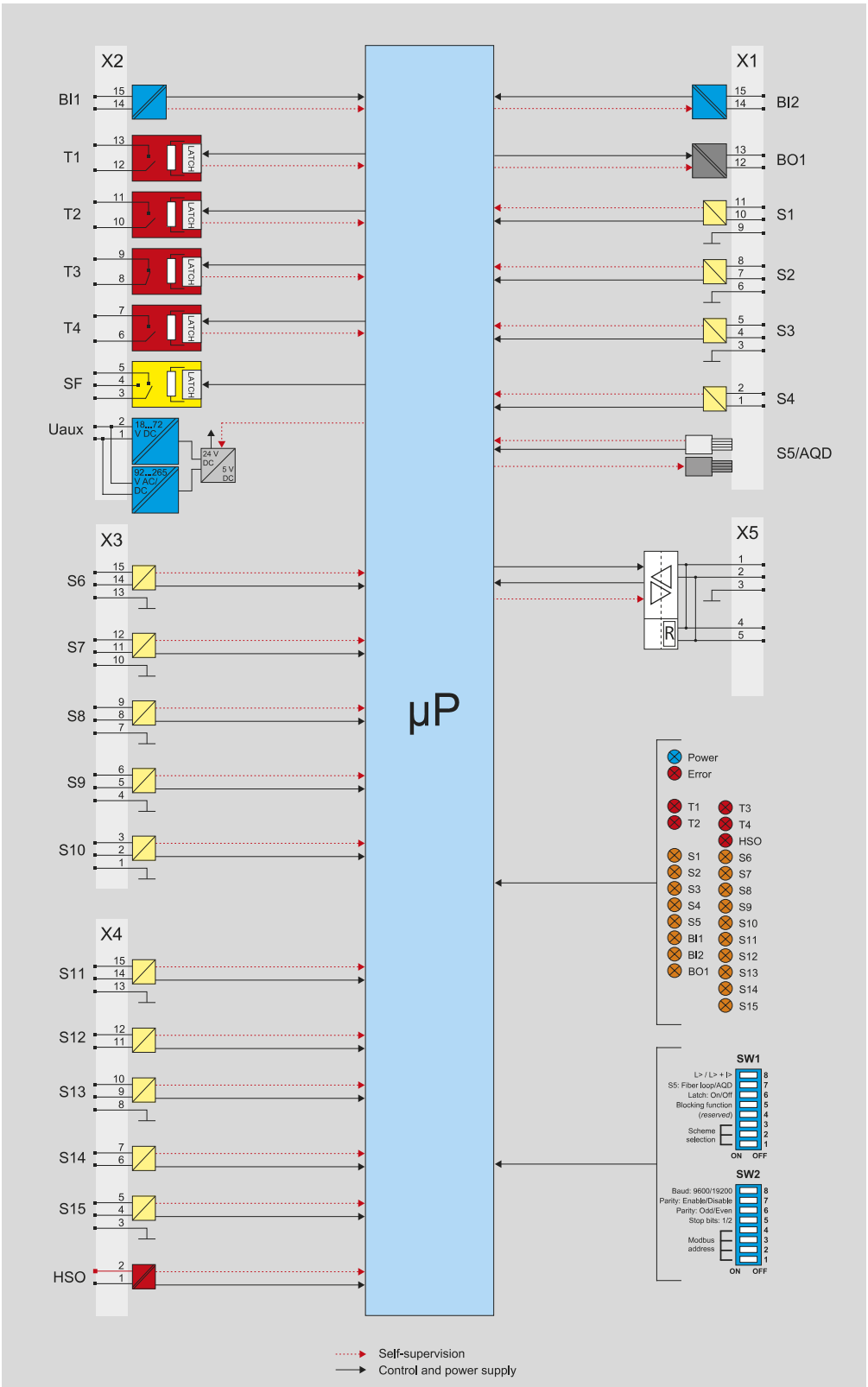


Figure. 3.4. - 8. Simplified block diagram of the AQ-103 Modbus variant.



4. Operation and configuration

4.1. LED indicator functions

Both variants of the AQ-103 unit have twenty-five (25) 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 sheet located in the transparent pockets 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 are turned on for two seconds and then turned 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 (includes both variants).

Table. 4.2. - 1. LED operations of AQ-103 (both variants).

LED name (color)	Off	Steady light	Blinking	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 occured.	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.

LED name (color)	Off	Steady light	Blinking	Action if abnormal
S1–S4, S6–S15 (amber)	Normal status.	Light information has activated the sensor channel.	There is a sensor channel discontinuity, or a system setup has not been performed; or, pressure information has activated the sensor channel.	Check sensor continuity or perform a system setup (see the "System setup (auto-configuration)" chapter); or, check what activated the sensor.
S5 (amber) (optional)	Normal status.	The fiber sensor channel has been activated. Or, if the unit has AQD control configured to this sensor channel, an arc flash has activated the channel.	There is a fiber sensor discontinuity, or a system setup has not been performed.	Check sensor continuity or perform a system setup (see the "System setup (auto-configuration)" chapter); or, 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 outpus has been activated.	N/A	-
HSO (red)	Normal status.	The high-speed output has been activated.	N/A	Check the activated output, clear the fault, and reset the indicator LEDs with the push-button.

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.

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 setting 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. 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, on both arc light and current thresholds. The different tripping criteria can also be applied to BI1 to block tripping caused by natural light sources.

The basic variant only contains one DIP switch (SW1), while the Modbus variant also has a second DIP switch (SW2). You can find the DIP switch(es) at the back of the unit for easy access. The scheme selection number is based on binary arithmetic. The Modbus address is selected with Pins 1 through 4 of the SW2 DIP switch. The address always begins with 20. For example, when Pin 1 is in the left position (ON), the address is “21”. When Pin 4 is ON, the address is “28”.

The figure below presents the two DIP switches, and the table below them gives a detailed description of the settings for both switch groups.

Figure. 4.4. - 9. DIP switch diagrams.

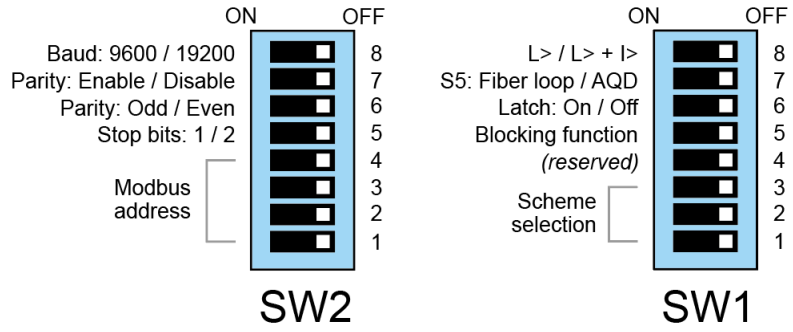


Table. 4.4. - 2. DIP switch settings for SW1.

Pin number (name)	Function selection	ON (left position)	Off (right position)
8 (L> or L> + I>)	Selects the tripping criteria used by all sensor channels.	Tripping on light only (L>).	Tripping on light (L>) and overcurrent (I>). Both are required to occur simultaneously to trigger tripping.
7 (S5: Fiber loop or AQD)	Selects how the sensor channel S5 is used.	The channel operates as the fiber loop sensor function.	The channel operates as the arc quenching system control. The Tx terminal of S5 sends a test pulse signal to the quenching system.

Pin number (name)	Function selection	ON (left position)	Off (right position)
6 (Latch: On or Off)	Selects whether the trip relays are latched or not.	The trip relays operate as latched.	The trip relays operate as non-latched.
5 (Blocking function)	Selects whether the outputs are blocked.	The outputs (T1–T4, HSO and BO1) are blocked.	Normal operation.
4 *(reserved)*	*(Reserved for future use.)*	-	-
3–1 (Scheme selection)	Selects the logic scheme.	Please refer to the "Scheme selection" chapter.	Please refer to the "Scheme selection" chapter.

Table. 4.4. - 3. DIP switch settings for SW2.

Pin number (name)	Function selection	ON (left position)	Off (right position)
8 (Baud: 9600 or 19200)	Selects the baud rate used by Modbus.	The baud rate is 9600.	The baud rate is 19200.
7 (Parity: Enable or Disable)	Selects whether the parity bit is enabled or not.	The parity bit is enabled.	The parity bit is disabled.
6 (Parity: Odd or Even)	Selects whether the parity makes the string's total number odd or even.	The total number is odd.	The total number is even.
5 (Stop bits: 1 or 2)	Selects the number of stop bits used to indicate the end of data transmission.	One (1) stop bit is used.	Two (2) stop bits are used.
4–1 (Modbus address)	Defines the Modbus address.	Pin 1: 1 Pin 2: 2 Pin 3: 4 Pin 4: 8	Pin 1: 0 Pin 2: 0 Pin 3: 0 Pin 4: 0

4.4.1. Scheme selection

This chapter describes the schemes available for both variants of the unit. The schemes are configured using the first DIP switch (SW1) and its pins 1…3 ("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

Below you can see descriptions of all the logic schemes available to the AQ-103 unit. The basic logic is the same in all the logic schemes: BO1 and BI2 are always tripped by light (L>), whereas BI1 is always tripped by overcurrent (I>). Regardless of the selected logic scheme, BO1 activates whenever the sensors S1–S4, S5, S6–S15 or BI2 activates. You can select between light-only tripping and light-and-overcurrent tripping with DIP switch 1 (SW1: 8). This selection affects all trip relays (T1–T4) as well as the high-speed output (HSO). This is also true of the DIP switch that determines latching (SW1: 6).

The current value always comes into the 103LV unit through BI1 and with the help of an external current measuring device. Please note that there must not be any pulses within the HSO channel. Additionally, synchronization output comes from BO1, while the input goes into BI1. BI2 trips T1–T4 as well as AQD in all logic schemes. If BI2 is ON but the tripping criteria selected with the DIP switch is not both light and current, only tripping can occur. BO1 sends a latched signal when something trips, and both it and its LED stay on for ten (10) seconds if nothing tripped.

SS:0

All sensors trip all trip relays (T1–T4) as well as the high-speed output (HSO) and the AQD control. When the blocking function is selected, it prevents all tripping activations apart from LED activations.

SS:0			OUTPUTS						
			T1	T2	T3	T4	BO1	HSO	AQD
INPUTS	BI1[1] Sync input current	S1	x	x	x	x	x	x	x^2
		S2	x	x	x	x	x	x	x^2
		S3	x	x	x	x	x	x	x^2
		S4	x	x	x	x	x	x	x^2
		S5	x	x	x	x	x	x	
		S6	x	x	x	x	x	x	x^2
		S7	x	x	x	x	x	x	x^2
		S8	x	x	x	x	x	x	x^2
		S9	x	x	x	x	x	x	x^2
		S10	x	x	x	x	x	x	x^2
		S11	x	x	x	x	x	x	x^2
		S12	x	x	x	x	x	x	x^2
		S13	x	x	x	x	x	x	x^2
		S14	x	x	x	x	x	x	x^2
		S15	x	x	x	x	x	x	x^2

1) The binary input BI1 can be used to receive an external ***current*** signal. The tripping criterion can be selected to be light only (L>) or both light and current (L> + I>). When the current input function (SW1: 8) is OFF, the relay must receive both current and light signals simultaneously to be able to trip.

2) The AQD output does not work without a current signal, even when the relay is in the light-only mode (SW1: 8 is ON).

SS:1

The sensors S1 and S2 do not activate the AQD control. All sensors trip all trip relays (T1–T4) as well as the high-speed output (HSO). When the blocking function is selected, it prevents all tripping activations apart from LED activations.

SS:1			OUTPUTS						
			T1	T2	T3	T4	BO1	HSO	AQD
INPUTS	BI1[1] Sync input current	S1	x	x	x	x	x	x	
		S2	x	x	x	x	x	x	
		S3	x	x	x	x	x	x	x[2]
		S4	x	x	x	x	x	x	x[2]
		S5	x	x	x	x	x	x	
		S6	x	x	x	x	x	x	x[2]
		S7	x	x	x	x	x	x	x[2]
		S8	x	x	x	x	x	x	x[2]
		S9	x	x	x	x	x	x	x[2]
		S10	x	x	x	x	x	x	x[2]
		S11	x	x	x	x	x	x	x[2]
		S12	x	x	x	x	x	x	x[2]
		S13	x	x	x	x	x	x	x[2]
		S14	x	x	x	x	x	x	x[2]
		S15	x	x	x	x	x	x	x[2]

1) The binary input BI1 can be used to receive an external *current* signal. The tripping criterion can be selected to be light only (L>) or both light and current (L> + I>). When the current input function (SW1: 8) is OFF, the relay must receive both current and light signals simultaneously to be able to trip.

2) The AQD output does not work without a current signal, even when the relay is in the light-only mode (SW1: 8 is ON).

SS:2

The sensors S1 and S2 do not activate the AQD control, but they do control the input (with T1) and the first circuit breaker (with T2). The sensor S14 always monitors the bus coupler circuit breaker and it controls the trip relays T1, T3, and T4 (which is the main input of the other side of the bus coupler circuit breaker). S14 also monitors the AQD control. The rest of the sensors control T1 and T3 as well as the AQD control. All sensors can also trip the high-speed output (HSO). When the blocking function is selected, it prevents all tripping activations apart from LED activations.

SS:2			OUTPUTS						
			T1	T2	T3	T4	BO1	HSO	AQD
INPUTS	BI1[1] Sync input current	S1	x	x			x	x	
		S2	x	x			x	x	
		S3	x		x		x	x	x[2]
		S4	x		x		x	x	x[2]
		S5	x		x		x	x	
		S6	x		x		x	x	x[2]
		S7	x		x		x	x	x[2]
		S8	x		x		x	x	x[2]
		S9	x		x		x	x	x[2]
		S10	x		x		x	x	x[2]
		S11	x		x		x	x	x[2]
		S12	x		x		x	x	x[2]
		S13	x		x		x	x	x[2]
		S14	x		x	x	x	x	x[2]
		S15	x		x		x	x	x[2]

1) The binary input BI1 can be used to receive an external *current* signal. The tripping criterion can be selected to be light only (L>) or both light and current (L> + I>). When the current input function (SW1: 8) is OFF, the relay must receive both current and light signals simultaneously to be able to trip.

2) The AQD output does not work without a current signal, even when the relay is in the light-only mode (SW1: 8 is ON).

SS:3

The sensors S1 and S2 do not activate the AQD control, but they do control the trip relay T4 and the high-speed output (HSO). The sensor S11 controls the trip relay T1, S12 controls T2, and S13 controls T3. The remaining sensors control T4 as well as the high-speed output (HSO). All sensors (except S1 and S2) can activate the AQD control. When the blocking function is selected, it prevents all tripping activations apart from LED activations.

SS:3			OUTPUTS						
			T1	T2	T3	T4	BO1	HSO	AQD
INPUTS	BI1[1] Sync input current	S1					x	x	
		S2					x	x	
		S3					x	x	
		S4					x	x	
		S5					x	x	
		S6					x	x	
		S7					x	x	
		S8					x	x	
		S9					x	x	
		S10					x	x	
		S11	x						
		S12		x					
		S13			x				
		S14				x			
		S15					x	x	

1) The binary input BI1 can be used to receive an external *current* signal. The tripping criterion can be selected to be light only (L>) or both light and current (L> + I>). When the current input function (SW1: 8) is OFF, the relay must receive both current and light signals simultaneously to be able to trip.

The AQD output is not available with this scheme! If AQ-103 must be used for the AQD output, another scheme should be selected for the incomer relay.

SS:4

SS:4				OUTPUTS						
				T1	T2	T3	T4	BO1	HSO	AQD
INPUTS	BI2 Master trip (MT)	BI1[1] Sync input current	S1	(MT)	(MT)	(MT)	(MT)	x	x	
			S2	(MT)	(MT)	(MT)	(MT)	x	x	
			S3	(MT)	(MT)	(MT)	(MT)	x	x	
			S4	(MT)	(MT)	(MT)	(MT)	x	x	
			S5	(MT)	(MT)	(MT)	(MT)	x	x	
			S6	(MT)	(MT)	(MT)	(MT)	x	x	
			S7	(MT)	(MT)	(MT)	(MT)	x	x	
			S8	(MT)	(MT)	(MT)	(MT)	x	x	
			S9	(MT)	(MT)	(MT)	(MT)	x	x	
			S10	(MT)	(MT)	(MT)	(MT)	x	x	
			S11	x						
			S12		x					
			S13			x				
			S14				x			
			S15	(MT)	(MT)	(MT)	(MT)	x	x	

1) The binary input BI1 can be used to receive an external *current* signal. The tripping criterion can be selected to be light only (L>) or both light and current (L> + I>). When the current input function (SW1: 8) is OFF, the relay must receive both current and light signals simultaneously to be able to trip.

The AQD output is not available with this scheme! If AQ-103 must be used for the AQD output, another scheme should be selected for the incomer relay.

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. - 10. 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. - 11. 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.

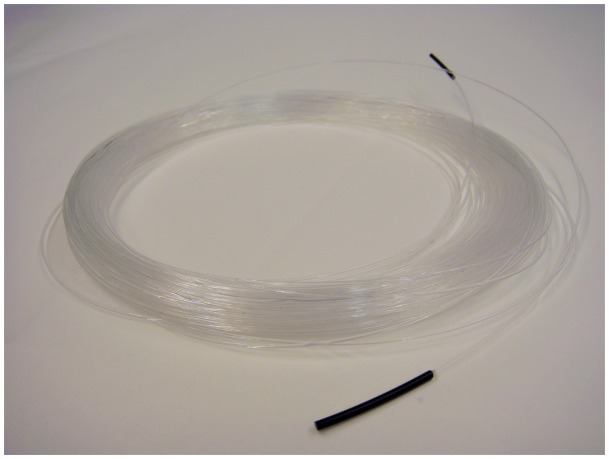
5.3. Arc light fiber optic loop sensor AQ-06

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). It is not recommended to cut or splice the cable on-site. However, if cutting or splicing is necessary due to the cable breaking, please contact your nearest Arcteq representative for instructions.

When requested, the ends of an AQ-06 cable can be covered with black rubber to avoid light detection outside the protected zone (see the figure below). The covered area can be as large or small as necessary. For more information, please consult your nearest Arcteq representative.

Figure. 5.3. - 12. AQ-06 sensor with covered ends.



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). It is not recommended to cut or splice the cable on-site. However, if cutting or splicing is necessary due to the cable breaking, please contact your nearest Arcteq representative for instructions.

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.

When requested, the ends of an AQ-07 cable can be covered with black rubber to avoid light detection outside the protected zone (see the figure below). The covered area can be as large or small as necessary. For more information, please consult your nearest Arcteq representative.

Figure. 5.4. - 13. AQ-07 sensor with covered ends.

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 ºC, 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). It is not recommended to cut or splice the cable on-site. However, if cutting or splicing is necessary due to the cable breaking, please contact your nearest Arcteq representative for instructions.

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.

When requested, the ends of an AQ-08 cable can be covered with black rubber to avoid light detection outside the protected zone (see the figure below). The covered area can be as large or small as necessary. For more information, please consult your nearest Arcteq representative.

Figure. 5.5. - 14. AQ-08 sensor with covered ends and terminals.

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. - 4. Medium-voltage 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-01	AQ-02	AQ-06	AQ-07	AQ-08
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.

Please note that AQ-07 and AQ-08 glass fibers can be covered with additional tubing, if the fiber sensor's placing requires the blocking of unwanted light activation.

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

6. Modbus communication

Modbus polling rate

The recommended maximum polling rate for the Modbus protocol is twice per second (2/s). The device also works with higher polling rates; however, unless there is a pressing reason to exceed the recommended rate, it is strongly advised to stay below the recommended maximum polling rate.

Modbus map

Figure. 6. - 15. The Modbus map.

Register name	Reg. address	BIT 16	BIT 15	BIT 14	BIT 13	BIT 12	BIT 11	BIT 10	BIT 9
Installed sensors	0 (40001)	-	S15	S14	S13	S12	S11	S10	S9
Sensor activations	1 (40002)	-	S15	S14	S13	S12	S11	S10	S9
I/O activations	2 (40003)	-	-	-	-	-	-	AQD	HSO1
DIP switch settings	3 (40004)	SW2:8	SW2:7	SW2:6	SW2:5	SW2:4	SW2:3	SW2:2	SW2:1
Serial number	4-5 (40005)	SN32	SN31	SN30	SN29	SN28	SN27	SN26	SN25
		SN16	SN15	SN14	SN13	SN12	SN11	SN10	SN9
Latched sensor activations	6 (40007)	-	S15	S14	S13	S12	S11	S10	S9
Latched I/O activations	7 (40008)	-	-	-	-	-	-	AQD	HSO1
Clear latched signals	10 (40011)	-	-	-	-	-	-	-	-

Register name	Reg. address	BIT 8	BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1
Installed sensors	0 (40001)	S8	S7	S6	S5	S4	S3	S2	S1
Sensor activations	1 (40002)	S8	S7	S6	S5	S4	S3	S2	S1
I/O activations	2 (40003)	SF	T4	T3	T2	T1	BO1	BI2	BI1
DIP switch settings	3 (40004)	SW1: 8	SW1:7	SW1: 6	SW1: 5	SW1: 4	SW1: 3	SW1: 2	SW1: 1
Serial number	4-5 (40005)	SN24	SN23	SN22	SN21	SN20	SN19	SN18	SN17
		SN8	SN7	SN6	SN5	SN4	SN3	SN2	SN1
Latched sensor activations	6 (40007)	S8	S7	S6	S5	S4	S3	S2	S1
Latched I/O activations	7 (40008)	SF	T4	T3	T2	T1	BO1	BI2	BI1
Clear latched signals	10 (40011)	-	-	-	-	-	-	-	-

7. System self-supervision

Both variants of this unit have an extensive self-supervision feature. This always includes internal functions and occasionally external functions. 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, enegizing 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.

8. Connections

Figure. 8. - 16. Rear terminals of the AQ-103(LV) basic variant.

Figure. 8. - 17. Connections of the AQ-103(LV) basic variant (with SF in de-energized position).

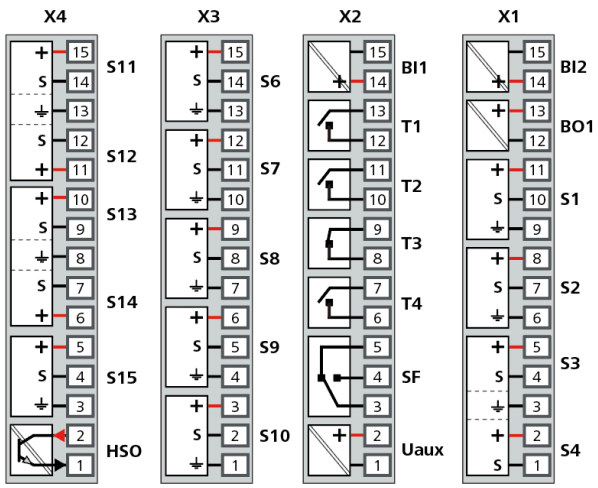
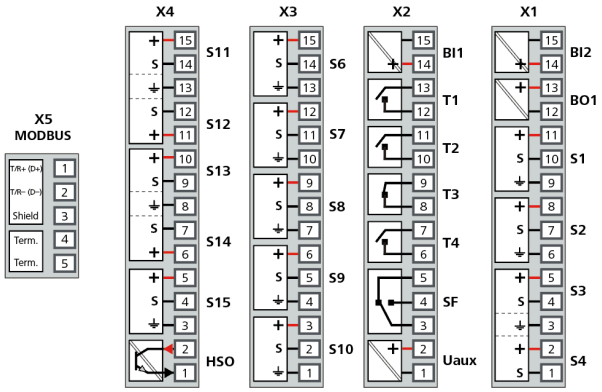


Figure. 8. - 18. Rear terminals of AQ-103(LV) Modbus variant.

Figure. 8. - 19. Connections of the AQ-103(LV) Modbus variant (with SF in de-energized position).



8.1. Outputs

8.1.1. Trip relays

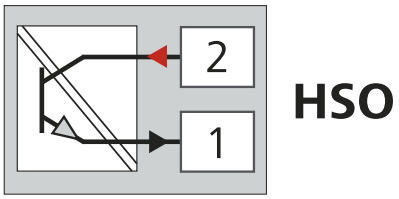
This unit has four (4) integrated trip relays for tripping circuit breakers according to the scheme selection. Their type is normally open (NO). Optionally, T3 can be selected as normally closed (NC).

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 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.

8.1.2. High-speed output(s)

The unit contains one (1) high-speed semiconductor output, abbreviated HSO. 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 unit's side sticker).

Figure. 8.1.2. - 20. The high-speed output's direction of rotation.



HSO can be used either for direct tripping of a circuit breaker, or as a heavy-duty signaling output. Due to its high current-carrying capacity, HSO can supply current or light information to a maximum of twenty (20) pieces of AQ-100 series units without a need for signal amplifiers. The operation of the high-speed output depends on the DIP switch settings (for more information, please refer to the “DIP switch settings” chapter).

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

8.1.3. 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 ouput is polarity-sensitive (see the "Wiring" chapter for more information).

8.1.4. 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

The unit can have fifteen (15) sensor channels: fourteen (14) point sensor channels are included by default, and you can opt to have S5 be a fiber optic loop channel. Please note that unlike other AQ-100 series units, AQ-103 and AQ-103LV can only have one sensor in each sensor channel!

S5 can be configured to function as a fiber optic loop sensor channel or as a control for the arc quenching system. The function of S5 in controlled with the SW1 DIP switch (please refer to the “DIP switch settings” chapter for more information). When S5 is configured as a fiber optic loop sensor channel, one end of the sensor is connected to the unit’s transceiver (Tx) terminal and the other to the receiver (Rx) terminal. This sensor loop is then continuously monitored by a 60-µs 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.

Alternatively, S5 can be configured to control the arc quenching system. Similarly, the unit sends a continuous light pulse to the arc quenching system for self-supervision purposes.

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

Both AQ-103 variants contain two (2) binary inputs, BI1 and BI2.

The function of the binary inputs is selected with the DIP switches according to the SAS application used (for more information, please refer to the "DIP switch settings" chapter in this manual). Typically, the binary inputs are used for receiving arc light information from AQ-101 and AQ-102 units as well as for receiving overcurrent information from AQ-110 units.

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 V DC. Please note that the threshold value must be chosen and specified when ordering the unit. The actual activation of the binary input occurs at 80 % of the specified nominal threshold value (i.e. 19, 88, and 176 V DC, respectively).

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.

A high-quality camera flash (Canon Speedlite 430EX or equivalent) is used to simulate arc light. You can use a flashlight (Mini Maglite 2 CELL AAA or equivalent) 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 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.

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 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. If you are using the BO2 binary input, verify its correct operations by activating the input.
10. Activate the camera flash within 30 cm (12 inches) of the point sensor unit but do not activate the binary input used for the overcurrent condition (I>).
11. Verify that no trip has occured and only the indicator LED of the sensor activation is lit.

12. If you are using the BOUT 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 4 and 5.
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 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-103(LV) 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 camera flash (Canon xx or equivalent) to initialize the flash and to configure the set's timer to start simultaneously with the flash.
3. Connect one of the AQ-110 unit's trip outputs (T1, T2, T3, T4) or high-speed outputs (HSO [HSO1] ja HST [HSO2]) 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.

9.4. Test plan example

Date:	
Substation:	
Switchgear:	
AQ-103 serial number:	

Tested by: _____
Approved by: _____

Preconditions	**Light only**	**Light + current**	**Additional notes**
Sensor channel settings			

Object activated	**LED indication**	**T1,T2,T3,T4, HSO1, AQD active**	**BO1 active**	**Additional notes**
Sensor channel 1				
Sensor channel 2				
Sensor channel 3				
Sensor channel 4				
Sensor channel 5				
Sensor channel 6				
Sensor channel 7				
Sensor channel 8				
Sensor channel 9				
Sensor channel 10				
Sensor channel 11				
Sensor channel 12				
Sensor channel 13				
Sensor channel 14				
Sensor channel 15 **or** Quenching device				
BIN 1				
BIN 2				

10. Troubleshooting

Table. 10. - 5. Troubleshooting guide for AQ-103 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). or 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).
The system gives an alarm that cannot be cleared or installed.	Check that each sensor channel only has one sensor connected to it.

11. Technical data

11.1. Protection

Trip time using HSO	2 ms
Trip time using mechanical trip relays	7 ms
Reset time (light stage)	1 ms

11.2. Outputs

11.2.1. Trip relays

Number of trip relays	4 NO or 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.

11.2.2. Binary output(s)

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

11.2.3. High-speed output(s)

Number of outputs	1
Rated voltage	250 VDC
Carry: - continuous - 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.

11.2.4. System failure relay

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.

11.3. Binary inputs

Nominal threshold voltage	24 VDC
Threshold: - pick-up - drop-off	 ≥ 15 VDC ≤ 14 VDC
Rated current	3 mA
Number of inputs	2

11.4. Auxiliary voltage

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

11.5. Sensors

AQ-01 point sensor

Light intensity threshold	8,000 lux 25,000 lux 50,000 lux
Detection radius	180º
Mechanical protection of the whole sensor Mechanical protection for the active light detection part of the sensor	IP 20 IP 60
Sensor cable specification	Shielded twisted pair 0.75 mm^2 (AWG: 20)
Maximum sensor cable length (per channel)	200 m
Operating temperature	–20…+85 ºC

AQ-02 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	180º

Mechanical protection for the whole sensor Mechanical protection for the active light detection part of the sensor Mechanical protection for the active pressure detection part of the sensor	IP 20 IP 60 IP 40
Sensor cable specification	Shielded twisted pair 0.75 mm^2 (AWG: 20)
Maximum sensor cable length (per channel)	200 m
Operating temperature	–20…+85 ºC

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	360º
Bending radius	5 cm
Operating temperature	–40…+85 ºC

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	360º
Bending radius	1 cm
Operating temperature	–40…+85 ºC

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	360º
Bending radius	1 cm
Operating temperature	–40…+125 ºC

11.6. Disturbance tests

Electromagentic compatibility test	
CE-approved and tested according to EN 50081-2 and EN 50082-2	
Emission	
Conducted (EN 55011, class A)	0.15…30.00 Hz

Radiated (EN 55011, class A)	30…1,000 MHz
Immunity	
Electrostatic discharge (IEC 244-22-2 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 (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

11.7. 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 µs, 0.5 J

11.8. Mechanical tests

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

11.9. Environmental conditions

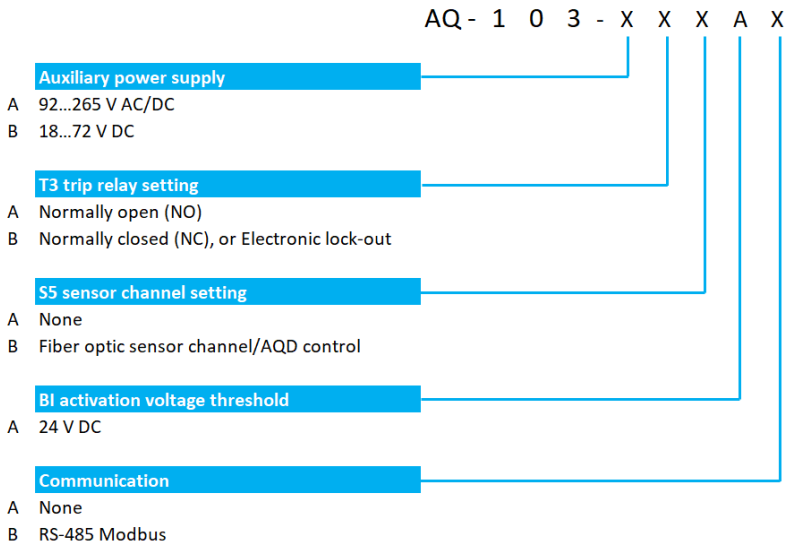
Specified ambient service temperature	–35…+70 ºC
Transportation and storage temperature	–40…+70 ºC
Relative humidity	Up to 97 %
Altitude	Up to 2,000 m above sea level

11.10. Casing and packaging

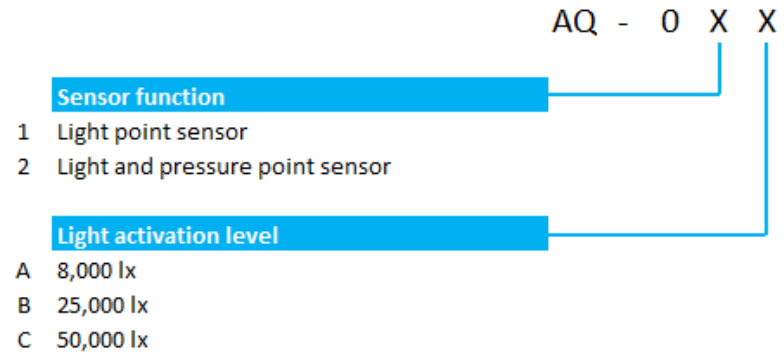
Protection: - front - back	 IP 52 IP 20
Dimensions (W × H × D): - device - package	 102 × 177 × 162 mm 230 × 120 × 210 mm
Weight	1.2 kg 1.5 kg (with package)

12. Ordering information

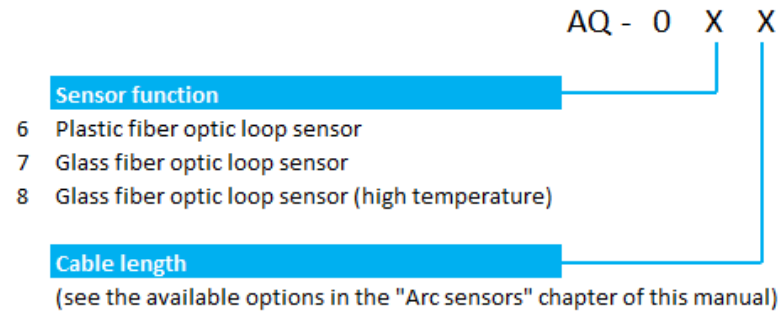
AQ-103 arc flash protection unit



AQ-0x point sensors



AQ-0x fiber optic loop sensors



Accessories

Order code	Description	Note	Manufacturer
AQX099	Wall bracket	For AQ-101, AQ-101S and AQ-102 units (MV and LV).	Arcteq Ltd.

Order code	Description	Note	Manufacturer
AQX100	Wall bracket	For AQ-103 and AQ-110x variants (MV and LV).	Arcteq Ltd.

13. Contact and reference information

Manufacturer

Arcteq Relays Ltd.

Visiting and postal address

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Contacts

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