ARCTEQ®
RELAYABLE POWER

AQ-102LV

Arc flash protection unit

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1. Manual revision notes

Revision	1.00
Date	September 2020
Changes	- The first revision of the manual.

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-102LV fiber optic loop 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-102LV provides the highest level of dependability as it continuously monitors all internal system functions as well as all external connections.

The AQ-102LV 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. While AQ-102LV is suitable for MV use, it is designed for LV switchgears and for motor control center applications in both new and retrofitted installations.

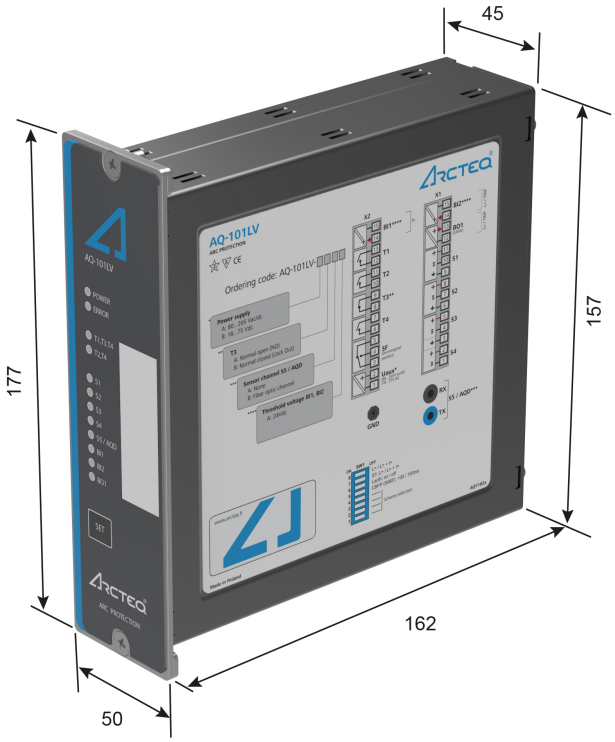
3.1. Dimensions and installation

AQ-102LV 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: 50 mm (1.97")
- Depth: 162 mm (6.38").

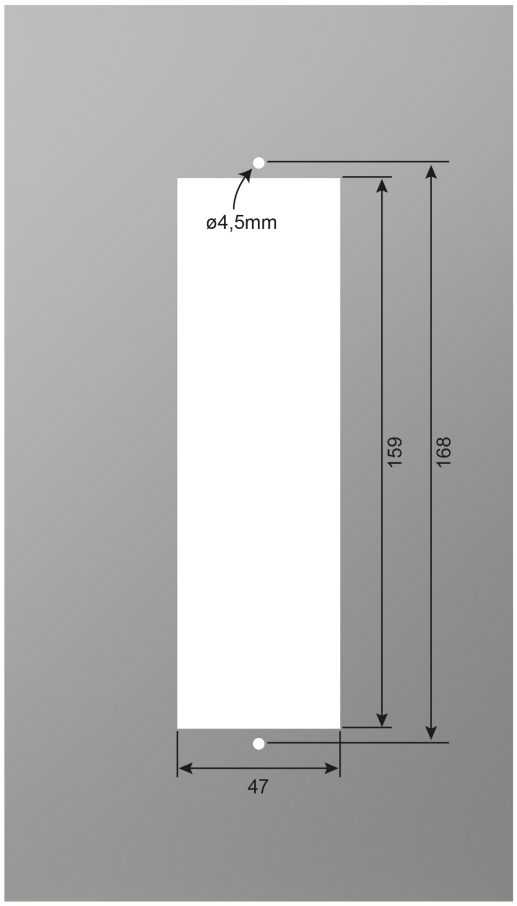
The figure below presents a side view of the device and gives the dimensions in more detail. Please note that all values are given in millimeters.

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



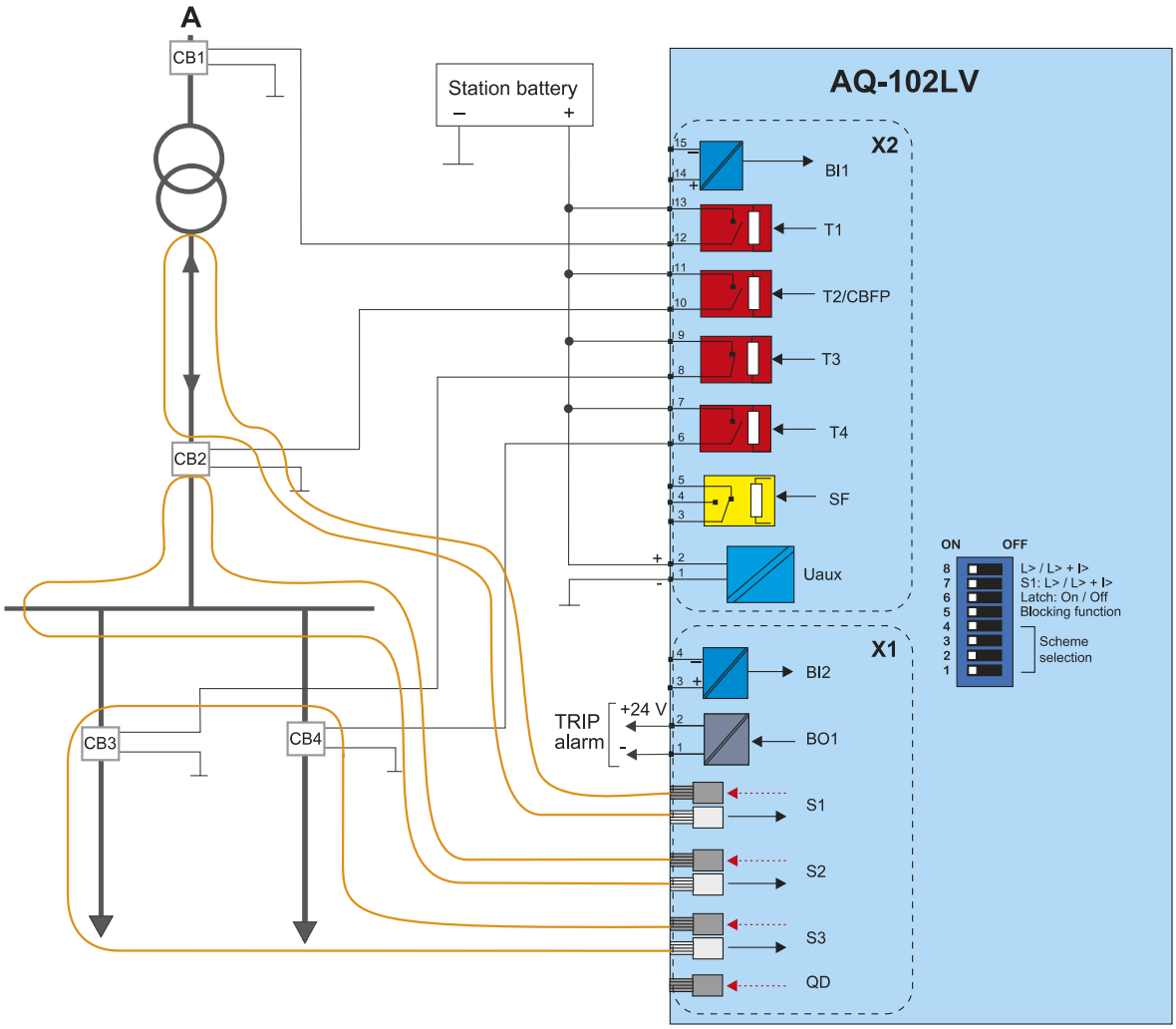
The image below presents the dimensions of the cut-out needed for mounting the unit on a panel.

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



3.2. Wiring

Figure. 3.2. - 3. Wiring diagram for AQ-102LV.



3.3. Unit features

AQ-102LV 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:

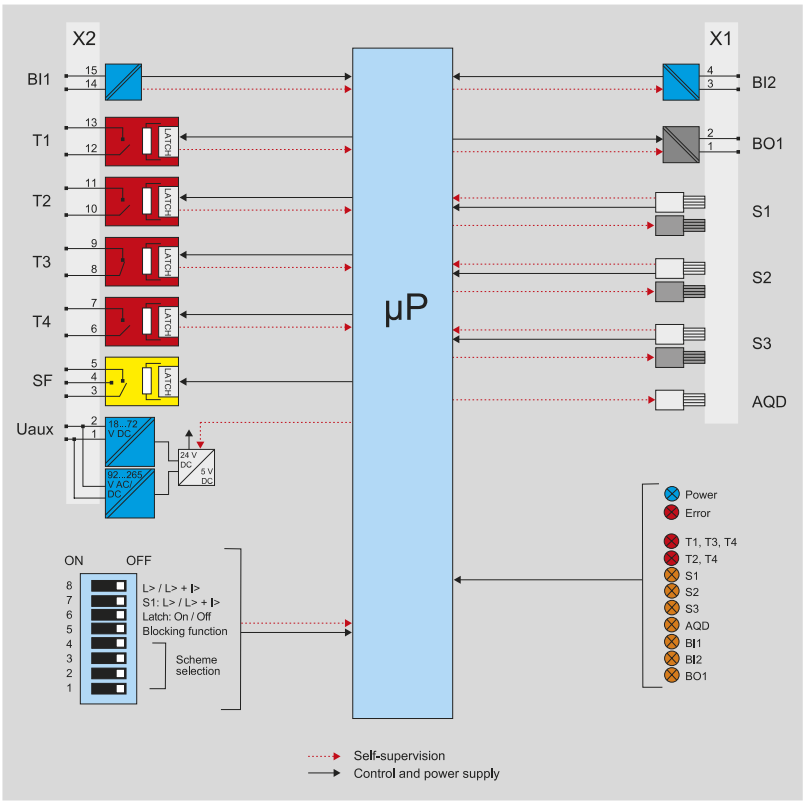
- 92…265 V AC/DC auxiliary power supply or 18…72 V DC auxiliary power supply (optional)
- three (3) fiber loop channels
- two (2) binary inputs with nominal operation voltage of 24 V DC
- three (3) normally open trip relay outputs
- one (1) normally open trip relay output or one (1) normally closed trip relay output (electronic lock-out)
- one (1) binary output (24 V DC)
- one (1) system failure output
- eleven (11) indication LEDs
- one (1) push-button.

Figure. 3.3. - 4. Arc protection unit AQ-102LV.

3.4. Simplified block diagram

The figure below presents the main components of the AQ-102LV unit.

Figure. 3.4. - 5. Simplified block diagram of AQ-102LV.



4. Operation and configuration

4.1. LED indicator functions

The AQ-102LV unit has eleven (11) 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 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.

Table. 4.2. - 1. LED operations AQ-102LV.

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 in question 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–S3 (amber)	Normal status.	The fiber sensor channel has activated.	The fiber sensor has dropped off or a system setup has not been performed.	Check the sensor continuity or perform a system setup (see the "System setup" chapter); or, check what activated the sensor.
AQD (amber)	Normal status.	The AQD channel has been activated.	The fiber connection to the quenching system has dropped off or a system setup has not been performed.	Check the fiber connection and/or the system configuration.
BI1–BI2 (amber)	Normal status.	The binary input has been activated.	The binary input has a loose connection.	Check the binary input wiring.
BO1 (amber)	Normal status.	The binary output has been activated.	N/A	-

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, which allows for more flexibility when changing the settings depending on the application. Tripping can be based on arc ligh 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.

Figure. 4.4. - 6. DIP switch diagram.

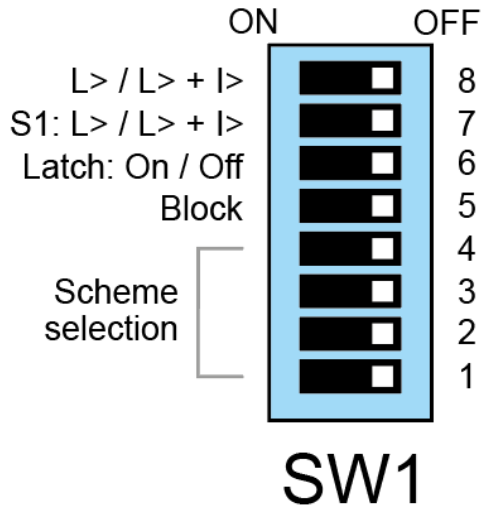


Table. 4.4. - 2. DIP switch settings.

Pin number (name)	Function selection	ON (left position)	OFF (right position)
8 (L> or 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> or 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 or 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.

Pin number (name)	Function selection	ON (left position)	OFF (right position)
5 (Blocking function)	Selects between the blocking function and the current signal.	The blocking function is selected. All trip signals (T1…T4) and the quencher control (AQD) are blocked.	The current signal is selected.
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.

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").

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

SS:0			OUTPUTS				
			T1	T2	T3	T4	BO1
INPUTS	BI2[1]	S1					x
		S2					x
		S3					x
		BI1					
	BI2[2]	S1	x	x	x	x	x
		S2	x	x	x	x	x
		S3	x	x	x	x	x
	BI1		x	x	x	x	

1) If the blocking function (SW1: 5) is ON, the activation of BI2 block all trip output signals.

2) If the blocking function (SW1: 5) is OFF, the binary input BI2 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>).

SS:1

SS:1			OUTPUTS				
			T1	T2	T3	T4	BO1
INPUTS	BI1[1]	S1					x
		S2					x
		S3					x
		BI1					x[3]
	BI1[2]	S1	x	x		x	x
		S2	x	x	x	x	x
		S3	x		x	x	x
	BI1		x		x	x	

1) If the blocking function (SW1: 5) is ON, the activation of BI1 block all trip output signals.

2) If the blocking function (SW1: 5) is OFF, 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>).

3) Only available when the unit's configuration includes the light-only setting (i.e. when "L>" has been selected for the DIP switch SW1: 6).

SS:2

SS:2			OUTPUTS				
			T1	T2	T3	T4	BO1
INPUTS	BI2[1]	S1					x
		S2					x
		S3					x
	BI2[2]	S1	x	x	x	x	x
		S2	x	x	x	x	x
		S3	x	x	x	x	x

1) If the blocking function (SW1: 5) is ON, the activation of BI2 block all trip output signals.

2) If the blocking function (SW1: 5) is OFF, the binary input BI2 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>).

NOTE!

In this scheme, the binary input BI1 is used as the input for the device reset.

SS:3

SS:3			OUTPUTS				
			T1	T2	T3	T4	BO1
INPUTS	BI2[1]	S1					x
		S2					x
		S3					x
		BI1					
	BI2[2]	S1	x	x			x
		S2	x	x	x		x
		S3				x	x
	BI1		x	x	x	x	

1) If the blocking function (SW1: 5) is ON, the activation of BI2 block all trip output signals.

2) If the blocking function (SW1: 5) is OFF, the binary input BI2 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>).

SS:4

SS:4			OUTPUTS				
			T1	T2	T3	T4	BO1
INPUTS	BI1[1]	S1					x
		S2					x
		S3					x
		BI1					x[3]
	BI1[2]	S1	x	x			x
		S2	x	x	x		x
		S3	x			x	x
		BI2	x		x	x	x

1) If the blocking function (SW1: 5) is ON, the activation of BI1 block all trip output signals.

2) If the blocking function (SW1: 5) is OFF, 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>).

3) Only available when the unit's configuration includes the light-only setting (i.e. when "L>" has been selected for the DIP switch SW1: 6).

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.

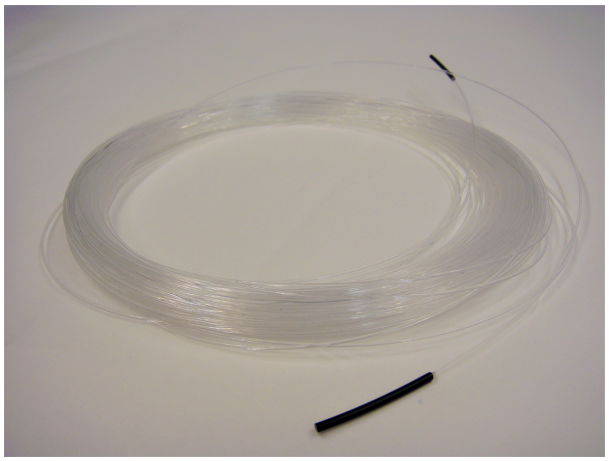
5.1. Arc light fiber optic loop sensor AQ-06

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. 5.1. - 7. AQ-06 sensor with covered ends.



5.2. 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. 5.2. - 8. AQ-07 sensor with covered ends.

5.3. 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. 5.3. - 9. AQ-08 sensor with covered ends and terminals.

5.4. 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. 5.4. - 3. Low-voltage sensor—unit dependencies.

	AQ-01	AQ-02	AQ-06	AQ-07	AQ-08
AQ-101LV	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-101DLV	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-102LV	No	No	Yes	Yes	Yes
AQ-103LV	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-110PLV	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-110FLV	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)

5.5. Connecting sensors

How to connect point sensors

Open the sensor covers and detach the connectors. Attach the cable to the connector and to the unit, and reattach the connectors to the sensor. Next, run the auto-configuration procedure, and (once 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

Drill holes on the compartment wall and cover the sharp edges. Run the fiber through the holes and fasten it to the protected area. 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 if the placing requires 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. 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, 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.

7. Connections

Figure. 7. - 10. Rear terminals of AQ-102LV.

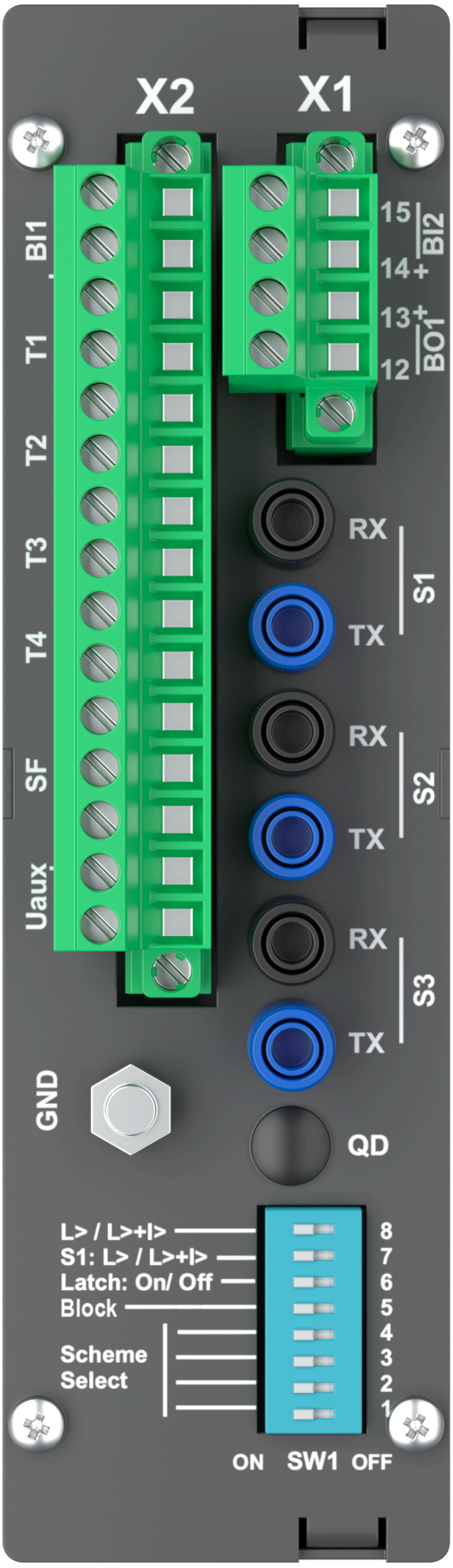
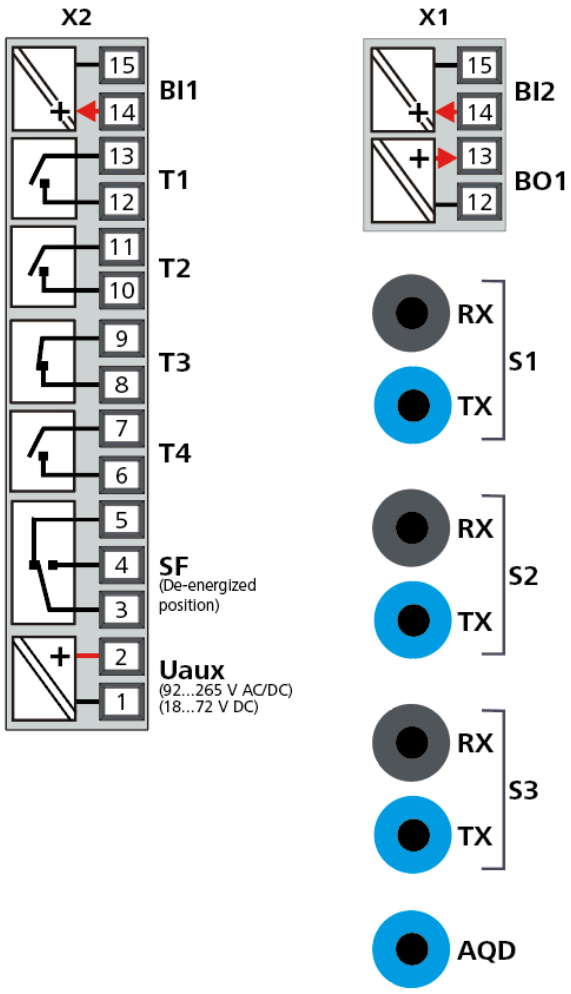


Figure. 7. - 11. Connections of the AQ-102LV (with SF in de-energized position).



7.1. Outputs

7.1.1. 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.

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

7.1.3. 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.

7.2. Inputs

7.2.1. Arc sensor channels

AQ-102LV has three (3) fiber optic loop sensor channels: S1, S2, S3 and S4. Each channel has a transceiver (Tx) and a receiver (Rx). When the fiber optic loop sensor is connected to the unit, one of its ends is connected to "Tx" and the other to "Rx", both located at the rear of the unit. 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.

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/).

7.2.2. 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. The nominal threshold level for this unit is 24 VDC. The actual activation of the binary input occurs at 80 % of the specified nominal threshold value (i.e. 19 V DC).

7.3. 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.

8. 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.

8.1. 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.

8.2. 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 BO2 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 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.

8.3. 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.

8.4. 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-102 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 xxx 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-102 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.

8.5. Test plan example

Date:	
Substation:	
Switchgear:	
AQ-102 serial number:	

Preconditions	**Light-only**	**Light + current**	**Comments**
Sensor channel 1 setting			
Sensor channel 2 setting			
Sensor channel 3 setting			
Master trip binary input in use (Yes / No):			
Circuit breaker failure protection (CBFP) in use (Yes / No):			

Object activated	**LED indication**	**T1, T2, T3, T4 active**	**BO1 active**	
Fiber sensor channel 1				
Fiber sensor channel 2				
Fiber sensor channel 3				
BIN 1				
BIN 2				

Tested by :	
Approved by:	

9. Troubleshooting

Table. 9. - 4. Troubleshooting guide for AQ-102.

Problem	Possible solution(s)
The sensor does not activate during testing.	Check the sensor connection (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).

10. Technical data

10.1. Protection

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.

10.2. Outputs

10.2.1. Trip relays

Number of trip relays	4 NO or 3 NO + 1 NC
Voltage withstand	250 V AC/DC
Carry: - continuous carry - 3 s make and carry - 0.5 s make and carry	 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.

10.2.2. Binary output(s)

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

10.2.3. System failure relay

Number of SF relays	1
Rated voltage	250 V AC/DC
Carry: - continuous carry - 3 s make and carry - 0.5 s make and carry	 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.

10.3. Binary inputs

Nominal threshold voltage	24 VDC

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

10.4. 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

10.5. Sensors

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…+85 ºC

10.6. 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

10.7. 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

10.8. 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.

10.9. Environmental conditions

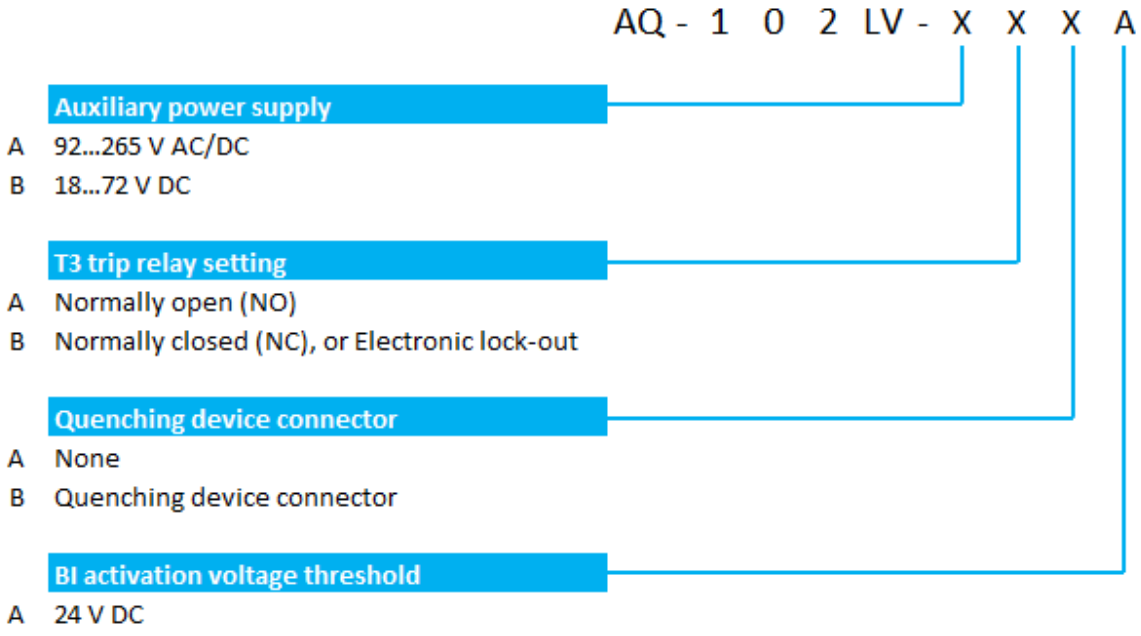
Specified ambient service temperature	–35…+70 ºC
Transportation and storage temperature	–40…+70 ºC
Relative humidity	Up to 97 %
Altitude	Up to 2,000 m above sea level

10.10. Casing and packaging

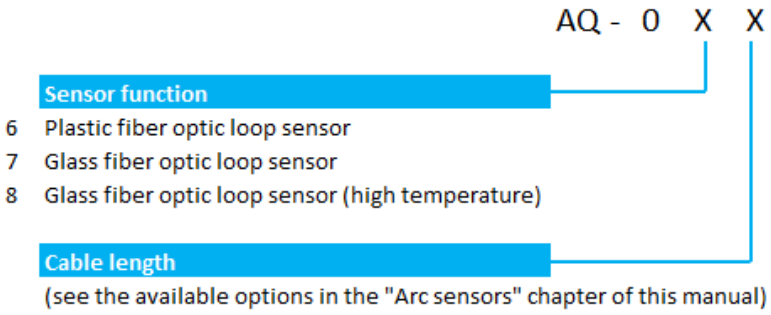
Protection: - front - back	 IP 50 IP 20
Dimensions (W × H × D): - device - package	 45 × 164 × 157 mm
Weight	0.7 kg 1.0 kg (with package)

11. Ordering information

AQ-102LV fiber optic loop sensor unit



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.
AQX100	Wall bracket	For AQ-103 and AQ-110x variants (MV and LV).	Arcteq Ltd.

12. Contact and reference information

Manufacturer

Arcteq Relays Ltd.

Visiting and postal address

Kvartsikatu 2 A 1

65300 Vaasa, Finland

Contacts

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