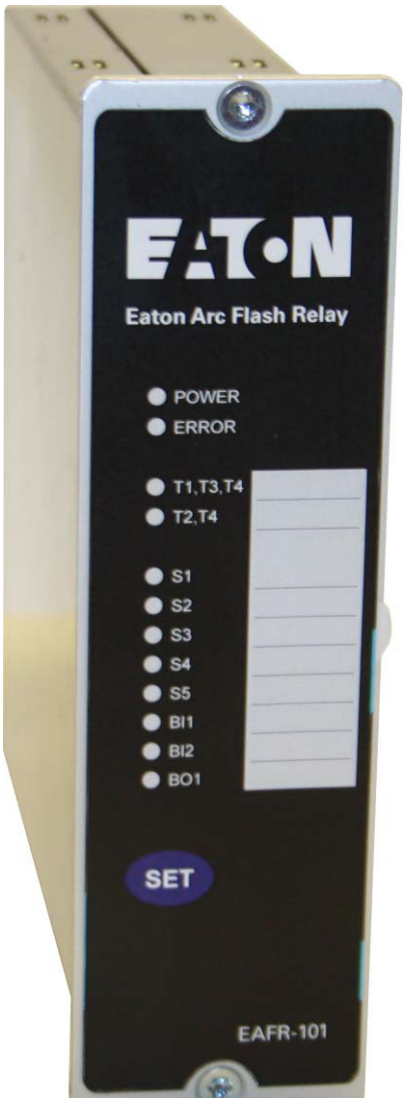
MN026004EN

EAFR-101 Arc Point Sensor Relay User Manual



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Contents

1. Introduction

Read these instructions carefully and inspect the equipment to become familiar with it before trying to install, operate, service, or maintain it.

Electrical equipment should be installed, operated, serviced, and maintained only by qualified personnel. Local safety regulations should be followed. No responsibility is assumed by Eaton for any consequences arising out of the use of this material.

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1.1 Abbreviations

CB	–	Circuit breaker
CBFP	–	Circuit breaker failure protection
EMC	–	Electromagnetic compatibility
EPROM	–	Erasable programmable read only memory
HW	–	Hardware
LED	–	Light emitting diode
LV	–	Low voltage
ms	–	Millisecond
MV	–	Medium voltage
NC	–	Normally closed
NO	–	Normally open
PMSG	-	Permanent magnet synchronous generator
Rx	-	Receiver
SF	-	System failure
SW	-	Software
Tx	-	Transceiver
uP	-	Microprocessor

2. General

The Eaton Arc Flash Relay 101 (EAFR-101) is a sophisticated micro-processor based arc flash protection relay including complete self-supervision functionality. It is designed to minimize the damage caused by an arcing fault (arc flash) by sensing light from the point sensor and tripping the circuit breaker sourcing the fault current. The EAFR-101 complete system self-supervision function provides the highest level of dependability by continuously monitoring all internal system functions along with external connections.

The EAFR-101 is designed according to the latest protection relay standards and is therefore suitable for installations in rough environments, such as utility, traditional or renewable power plants, off shore, marine, oil and gas, mining, steel, or any other heavy industry applications. It is also well suited for commercial and institutional electrical systems. The EAFR-101 is suitable for either medium voltage or low voltage switchgear and motor control center applications in both new and retrofit installations.

2.1 EAFR-101 Features

The EAFR-101 is a multipurpose arc flash protection relay that can receive light from four different channels of light point sensors and can be applied for variety of applications. The EAFR-101 can be used as a stand-alone relay or as part of a more complex arc protection system through the binary bus. The EAFR-101 comes in 2 mounting styles. EAFR-101 is a vertical panel or door mounted package and the EAFR-101D is a horizontal DIN rail package.

Main features of EAFR-101:

- (110 to 220) Vac / (125-250) Vdc auxiliary power supply;
- Four arc point sensor channels (S1, S2, S3, and S4);
- Two binary inputs (BI1 and BI2) nominal voltage of 24 Vdc;
- Three normally open trip relay outputs with direct trip circuit rated contacts (T1, T2, and T4);
- One normally open (EAFR-101, EAFR-101D) or normally closed (EAFR-101B, EAFR-101DB) electronic lock-out trip relay with direct trip circuit rated contacts (T3);
- One 24 Vdc binary output (BO1);
- One system failure relay, form C output (SF);
- 11 indication LEDs; and
- One push-button (SET).

Figure 1. The EAFR-101 Arc Protection Unit.

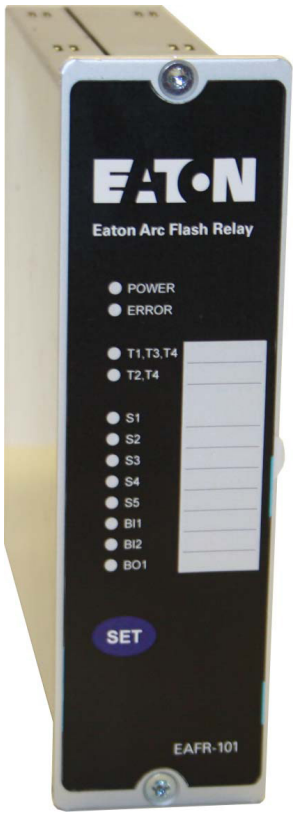
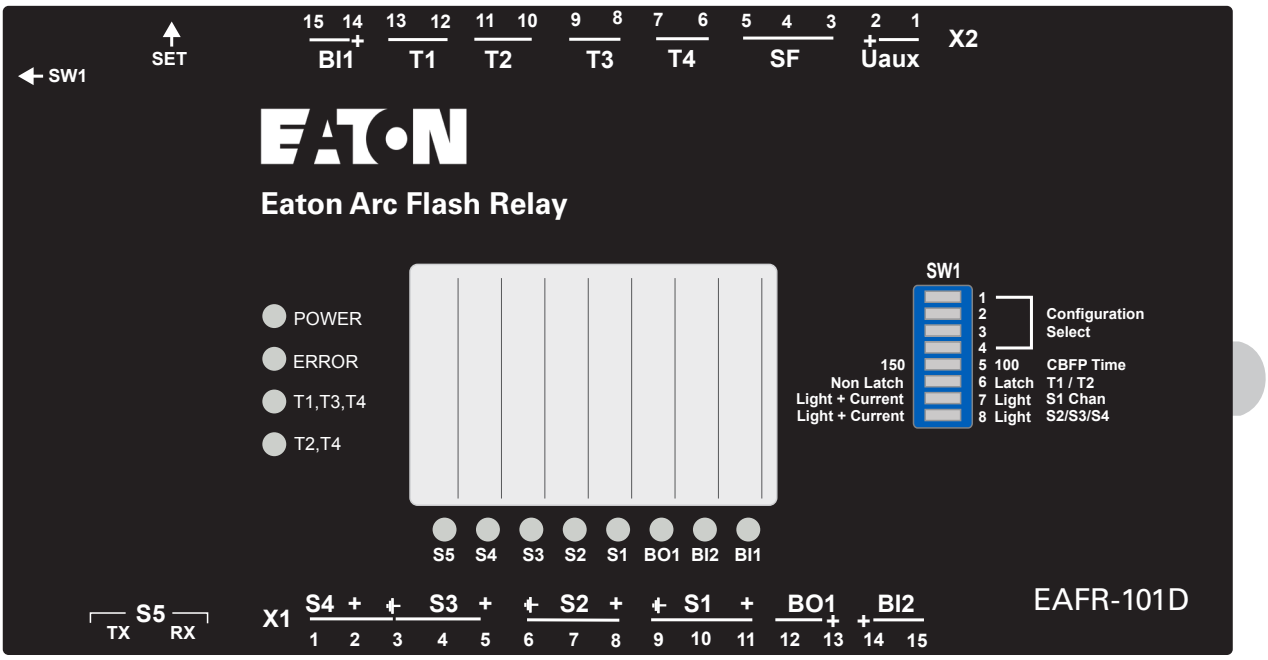


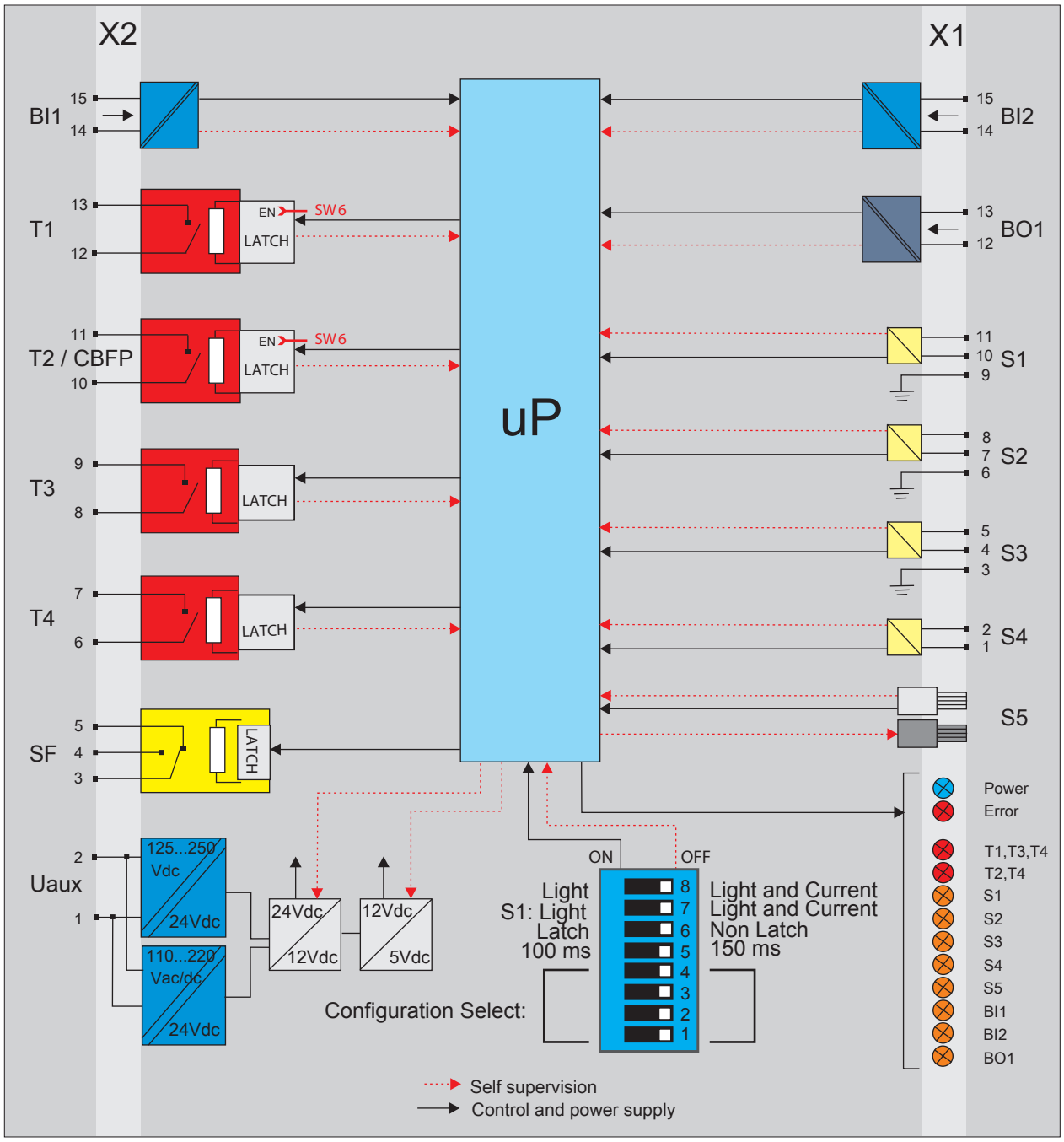
Figure 2. The EAFR-101D Arc Protection Relay.



2.2 Simplified Block Diagram

The EAFR-101 simplified block diagram (see Figure 3) shows the main components of the EAFR-101 relay.

Figure 3. EAFR-101 Simplified Block Diagram.



3. Operation and Configuration

3.1 LED Indicator Functions

TThe EAFR-101 contains 11 indication LEDs. A user definable text pocket can be slid in under the label for identifying each LED function (except Power and Error LEDs). LEDs are located at the front plate of the relay for clear viewing without a need for opening doors.

During power up, the relay performs a LED test. All LEDs are turned on for two seconds and then off. Only the blue Power LED will remain ON. After powered up, the relay goes into protection mode in 50 ms even while the LED test is being performed. During normal operation only the blue power LED is ON.

The point sensor LEDs are off during the inactive condition. If a point arc sensor is activated, the corresponding sensor channel LED will turn on if the activation is longer than 1.5 ms. The sensor LED activation function is latched (steady light). To clear the LED, the "Set" button should be pressed.

In case of a loose sensor wire or configuration mismatch (new sensor attached without running auto-configuration system setup [see Section 3.3.1) situation, the corresponding LED for that point sensor will start flashing and the Error LED will activate.

The Binary I/O LEDs are indicating the I/O-line status. If any of the lines become active for more than 1.5 ms, the corresponding LED will turn on (latch).

In a trip situation, the corresponding trip LED will turn on. Trip outputs are controlled by the dipswitch settings (see Section 3.5).

All activation and trip indication LEDs are latched, even if the dipswitch setting is in the non-latched mode. They have to be cleared by pushing the "Set" button.

LED indications are stored in non-volatile EPROM memory for identifying the trip information in case the auxiliary power is lost. When re-powering the relay after power supply loss, the actual LED status can be visualized from the front of the relay.

3.2 LED Operation Quick Guide

Table 1. LED Operation Quick Guide.

LED	Off	Steady On	Blinking	Action if Abnormal
POWER - Blue	Auxiliary supply disconnected.	Auxiliary power connected.	N/A	Check the power source.
ERROR - Red	System healthy.	System failure.	Configuration mismatch. Protection partly operational.	Verify system condition. See Sections 11: Troubleshooting Guide and 5: System Self-supervision.
T1, T2, T4 - Red	Normal status.	Trip relays T1, T2, T4 activated.	N/A	Check the reason for trip. Clear the fault and reset indications by pushing SET button.
T3 - Red	Normal status.	Trip relay T3 activated.	N/A	Check the reason for trip. Clear the fault and reset indications by pushing SET button.
S1 - Amber	Normal status.	Sensor channel 1 activated by light information	Sensor channel 1 has loose connection or the system set-up was not performed. Also activated by pressure information.	Check why the sensor activated, check the sensor wire connection, or perform the system set-up (see Section 3.3.1: Auto-Configuration (System Setup).
S2 - Amber	Normal status.	Sensor channel 2 activated by light information.	Sensor channel 2 has loose connection or system set-up not performed. Also activated by pressure information.	Check why the sensor activated, or check the sensor wire connection, or perform system set-up (see Section 3.3.1: Auto-Configuration (System Setup).
S3 - Amber	Normal status.	Sensor channel 3 activated by light information.	Sensor channel 3 has loose connection or system set-up not performed. Also activated by pressure information.	Check why the sensor activated, or check the sensor wire connection, or perform system set-up (see Section 3.3.1: Auto-Configuration (System Setup).
S4 - Amber	Normal status.	Sensor channel 4 activated by light information	Sensor channel 4 has loose connection or system set-up not performed. Also activated by pressure information.	Check why the sensor activated, check the sensor wire connection, or perform system set-up (see Section 3.3.1: Auto-Configuration (System Setup).
S5 - Amber	Normal status			
BI1 - Amber	Normal status.	Binary input 1 activated.	Binary input 1 has loose connection.	Check the binary input wiring.
BI2 - Amber	Normal status.	Binary input 2 activated.	Binary input 2 has loose connection.	Check the binary input wiring.
BO1 - Amber	Normal status.	Binary Output activated.	N/A	N/A

3.3 Push-button Description

The EAFR-101 contains one single push-button (SET) that can be used for all operational functions of the relay. The push-button is used to initialize the auto-configuration of the system (see Section 3.3.1) and for resetting the indicators and latched output relays.

3.3.1 Auto Configuration (System Setup)

When all sensors and binary lines have been connected, an auto-configuration procedure must be executed. The initialization sequence is performed by pressing the "Set" button for two seconds. The EAFR-101 sensor LEDs and BI1/BI2 LEDs start blinking. The relay scans these inputs to see if they are connected and when an input is detected, the corresponding LEDs are illuminated to mark that a connection was found. The inputs without connection continue blinking during the remaining three seconds. After five seconds, all LEDs are turned off. During this system setup, the dip-switch setting are also stored in non-volatile memory.

All sensor inputs will remain operational even when they are not auto-configured. The auto-configuration is only used for self-supervision purposes.

Note: To redo auto-configuration for a relay containing less connections (binary inputs/outputs or sensors) than in a previously memorized set-up, a dip-switch (anyone) must be moved back and forth prior to performing auto-configuration. The timeout allowing a new configuration is one minute. Reconfiguration with more connections is allowed without moving a dip-switch.

3.4 Reset

All LED indications and latched trip relays are reset by pressing the "SET" button for one second. Otherwise, the latched trip relays will remain activated until auxiliary power is disconnected. All LED indications will remain active until reset is performed by the operator, even when auxiliary power supply is disconnected (see Section 3.6: Non-volatile Memory).

3.5 Dipswitch Settings

EAFR-101 functionality, such as tripping logic, is configured using dipswitch settings. Different trip configurations can be easily programmed by selecting the appropriate dip-switch positions. This gives users the flexibility to change settings dependent on the application. Tripping may be selected based on arc light only or arc light and current thresholds (or other tripping criteria such as under-voltage, or similar). Current threshold or other tripping criteria may be applied to binary input BI1 for blocking a trip caused by natural light sources. Also, the CBFP configuration may be enabled using the dipswitches. Dipswitches are located at the back of the relay for easy access (see Figure 4: EAFR-101 Dipswitch SW1 and Table 2: EAFR-101 Dipswitch Setting Selection for details of settings).

Figure 4. EAFR-101 Dipswitch SW1 and EAFR-101D Dipswitch SW1.

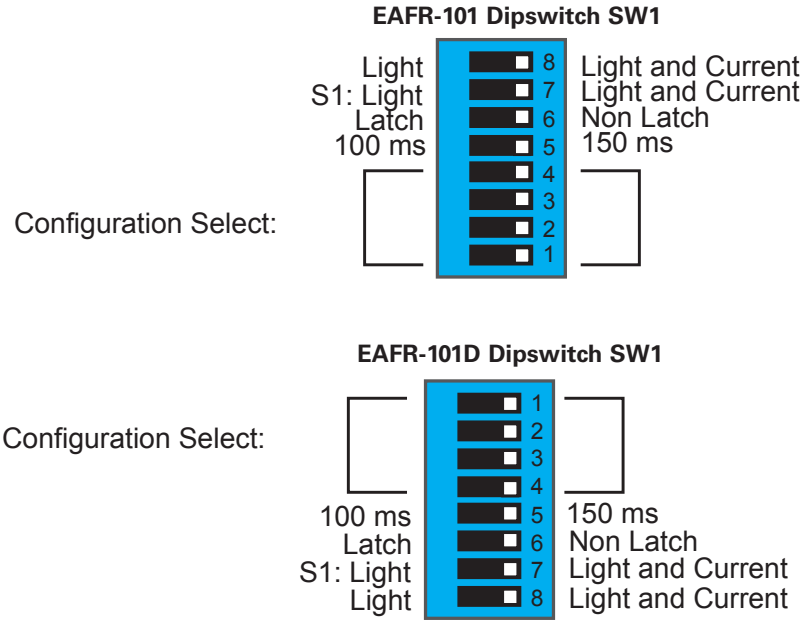
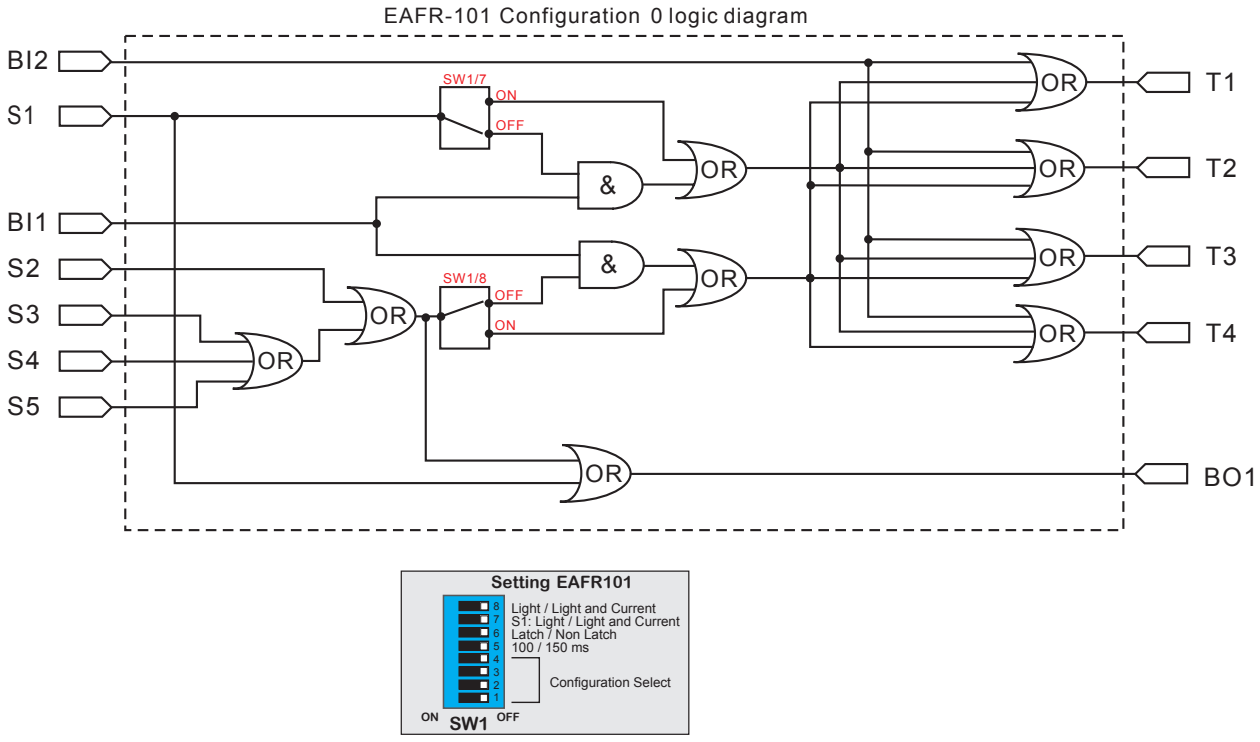


Table 2. EAFR-101 Dipswitch Setting Selection.

Dipswitch	Function Selection	ON (Left Position)	OFF (Right Position)
8	Point sensor channels S2, S3, S4 trip criteria.	Trip on light only. (L)	Trip on light and over-current. (L+C) Both signals are required simultaneously to trip.
7 S1	Point sensor channel S1 trip criteria.	Trip on light only. (L)	Trip on light and over-current. (L+C) Both signals are required simultaneously to trip.
6	Latch or non-latch for trip relays T1 and T2.	T1 and T2 operate as latched.	T1 and T2 operate as non-latched.
		Note: Trip relays T3 and T4 are always latched. Binary output BO1 function is always non-latched.	
5	CBFP time setting.	CBFP time is set to 100 ms.	CBFP time is set to 150 ms.
4 Configuration Select	Configuration selection.	Refer to Sections 3.5.10 and 6.	Refer to Sections 3.5.1 and 6.
3 Configuration Select	Configuration selection.	Refer to Sections 3.5.1 and 6.	Refer to Sections 3.5.1 and 6.
2 Configuration Select	Configuration selection.	Refer to Sections 3.5.1 and 6.	Refer to Sections 3.5.1 and 6.
1 Configuration Select	Configuration selection.	Refer to Sections 3.5.10 and 6.	Refer to Sections 3.5.1 and 6.

Note: Section 3.5.1 shows EAFR-101 internal logic and dipswitch selections. For input and output, descriptions refer to chapter 6.

Figure 5. EAFR-101 Configuration Selection 0.



3.5.1 Configuration Select Dipswitch Settings

This section describes the available configurations that are available using the Configuration Select 1 through 4 dip-switches.

3.5.1.1 Configuration Selection 0

The EAFR-101 logic Configuration 0 can be not only applied as stand-alone arc protection relay, but also widely used as non-selective outgoing feeder compartment protection. Dependent on this configuration, the user can select either light only mode or arc light + over-current mode to trip all circuit breakers. The detailed instruction is described in EAFR Standard Arc Configurations booklet.

Table 3. General Trip Logic for the EAFR-101 Standard Arc Configuration 0.

Tripping Signals Fault Location	T1	T2	T3	T4	BO1
S1	x	x	x	x	x
S2	x	x	x	x	x
S3 and S4	x	x	x	x	x
BI1	x	x	x	x	
BI2	x	x	x	x	

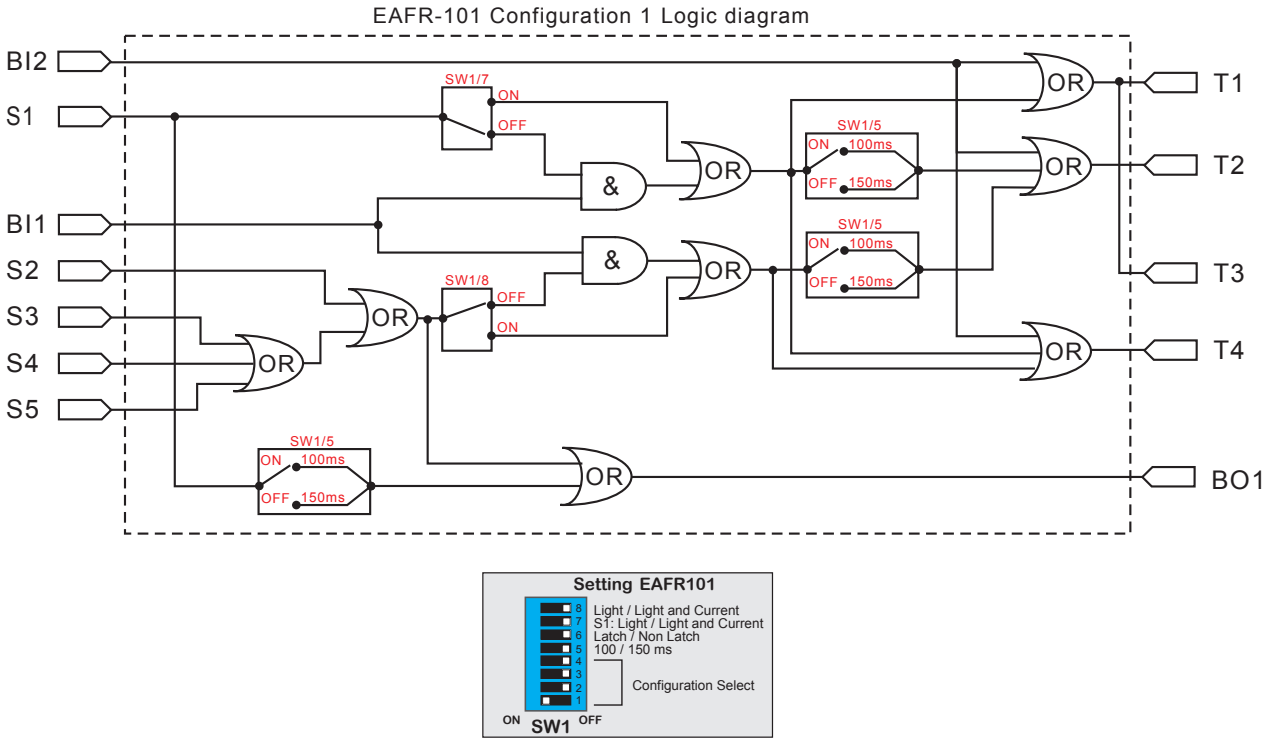
3.5.1.2 Configuration Selection 1

The EAFR-101 logic Configuration 1 is mainly utilized in selective arc protection solutions. The point sensor S1 monitors the outgoing feeder cable compartment. The point sensor S2 monitors the corresponding feeder breaker compartment and busbar compartment. Trip contact T1 is responsible for tripping circuit breaker of the outgoing feeder. The detailed instruction is described in EAFR Standard Arc Configurations booklet.

Table 4. General Trip Logic for the EAFR-101 Standard Arc Configuration 1.

Tripping Signals Fault Location	T1	T2	T3	T4	BO1
S1	x		x	x	
S2				x	x
S3 and S4				x	x
BI1	x		x	x	
BI2	x	x	x	x	

Figure 6. EAFR-101 Configuration Selection 1.



3.6 Non-volatile Memory

All critical system data, including dipswitch settings and auto-configuration file described in Section 3.3.1, are stored in EPROM non-volatile memory to ensure correct operation and full self-supervision, even if auxiliary power is temporarily lost.

Also, all LED indications described in Section 3.1 are stored in non-volatile memory in order to provide quick recovery of the system status indication, even if auxiliary power is temporarily lost. This feature is especially important if auxiliary power is lost after tripping.

Non-volatile memory does not require a power supply to maintain information and will retain settings and indications permanently without power.

4. Arc Sensors

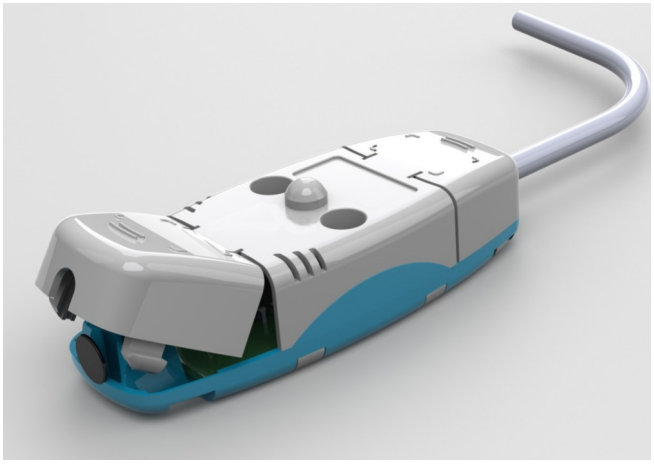
The EAFR-101 relay series provides the use of point arc light sensors to be utilized in different switchgear types, according to the specific application requirements. Arc light point sensors are typically installed in metal clad compartments, providing quick accurate location of the faulted area.

4.1 Arc Light Point Sensor EAFR-01

The EAFR-01 is an arc light point sensor with a light sensitive photodiode element activated by receiving arc light. The EAFR-01 arc sensors should be mounted in the switchgear cubicles in such a way that the light sensitive part can receive light from the protected area. Typically, one sensor per closed metal clad compartment is used. In open spaces, such as the busbar section, arc sensors should be mounted at a maximum of two meters (6.56 ft) apart.

The fixed light sensitivity of the EAFR-01-A sensor is 8000 Lux. The sensor does not require any user settings. The point sensor's light detection radius is 180 degrees. Other point sensors are available with different Lux sensitivities, EAFR-01-B at 25,000 Lux and EAFR-01-C at 50,000 Lux.

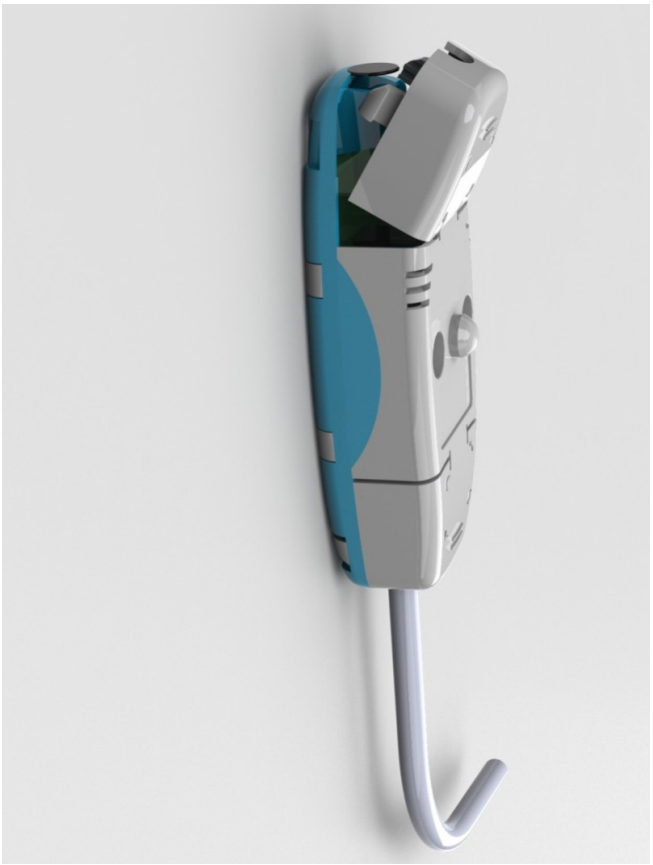
Figure 7. EAFR-01 Arc Light Point Sensor.



4.1.1 EAFR-01 Installation and Wiring

The EAFR-01 point sensor can be installed either on or through the compartment wall. An example of on the wall mounting is seen in Figure 8. The EAFR-01 is fixed against the wall using two screws. The same screw pattern is utilized in a through wall mounting arrangement. In this arrangement the unit is turned around and the point of the eye of the photodiode sensor protrudes through a small hole cut in the wall. The point of the sensor now faces the compartment to be protected. This allows for the body of the sensor and cabling to be located outside the compartment. For both types of installation, two screws are attached from the back side of the sensor. No external mounting plates are needed.

Figure 8. EAFR-01 Point Sensor Mounted to the Compartment Wall.

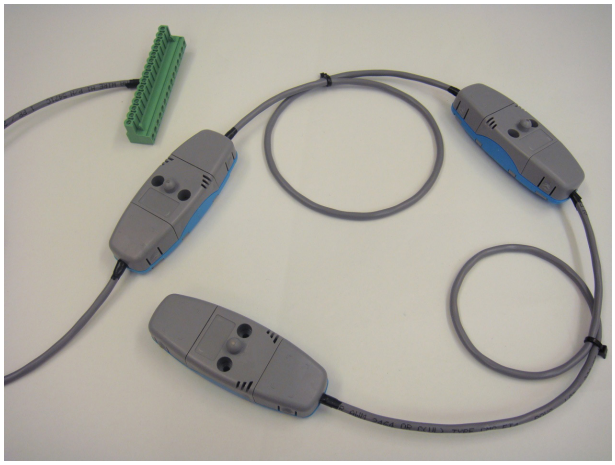


The cable to be used for wiring to the sensor should be a shielded, twisted pair cable. Table 5 lists several cables that can be used. Equivalent cable styles are acceptable to be used for the dielectric and temperature requirements of the application. Cable connectors are located beneath the covers that can be conveniently detached for fastening the sensor wires. The cover will be attached after installing the wires. Cable connectors are located at both ends of the sensor for series connecting a maximum of three sensors in one line (see Figure 9).

Table 5. 100 Ω Compatible Cables.

Manufacturer	Part No.	Atten. dB/100 at 1 Mhz	Data AWG	Cable Diameter mm (in.)	Temperature Rating °C (°F)	Voltage Rating
Belden	3074F	0.34	18	11.68 (0.46)	-40/+75 (-40/+167)	600 V
Belden	9841	0.60	24	5.89 (0.23)	-30/+80 (-22/+176)	300 V
Belden	89841	0.60	24	5.13 (0.20)	-70/+200 (-94/+392)	300 V

Figure 9. Cables Connected to the EAFR-01 with the Covers Closed.



4.1.2 EAFR-01 Point Sensor Technical Data

Table 6. EAFR-01 Point Sensors Technical Data.

Light Intensity Threshold	8,000 Lux/25,000 Lux/50,000 Lux
Detection Radius	180 Degrees
Mechanical Protection	IP 64
Sensor Wiring Arrangement	Two Wires and Shield
Sensor Cable Specification	Shielded Twisted Pair 0.75 mm2 (0.03 in.2)
Maximum Sensor Cable Length per Sensor Channel	200 m (656 ft)
Operating Temperature	-20 to 85°C (-4 to 185°F)

4.2 Sensor Type Dependencies

Different sensor types can be utilized in different arc flash protection relays of the EAFR series. Table 7 describes the dependencies.

Table 7. Arc Sensor Dependencies.

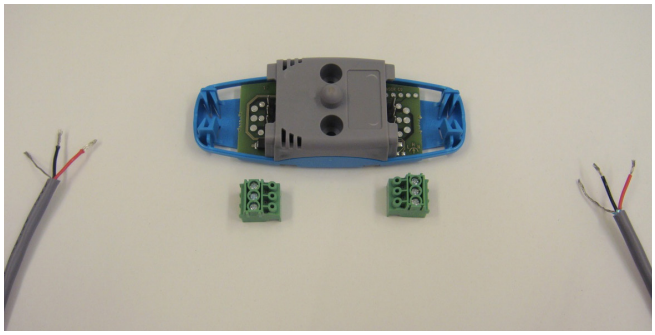
	EAFR-01	EAFR-06	EAFR-07	EAFR-08
EAFR-101	Yes	No	No	No
EAFR-102	No	Yes	Yes	Yes
EAFR-110P	Yes	No	No	No
EAFR-110F	No	Yes	Yes	Yes

4.3 Sensor Connection

4.3.1 Arc Light Point Sensor EAFR-01 Connection

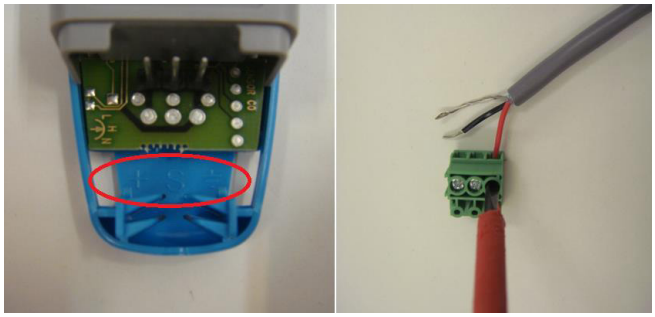
1. Open the sensor side-covers, then detach the plug-gable connectors from the sensor PCB, and prepare the twisted shielded pair cable connecting (see Figure 10).

Figure 10. EAFR-01 Sensor Connection.



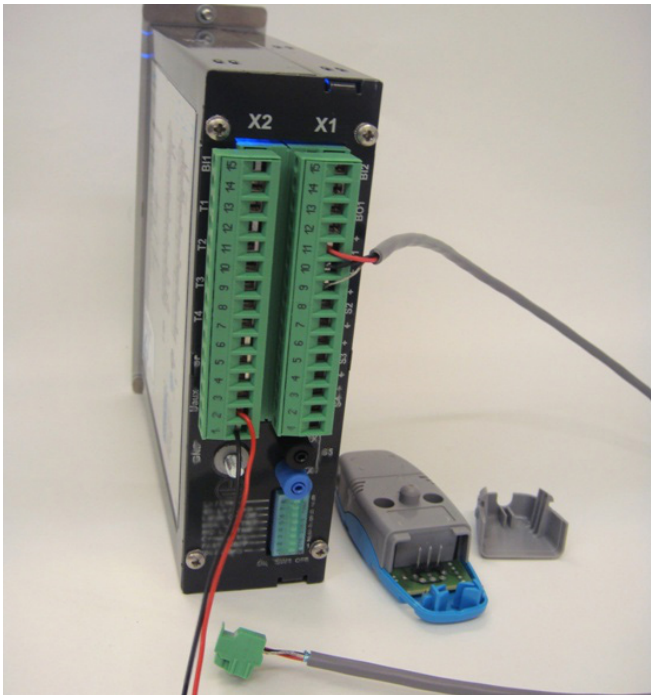
2. Before connecting the cable to the connector, make sure that the connecting order is correct (+, signal, and shield). The appropriate pin information is shown on the blue bottom part of the sensor. Plug the wires into the connectors and fasten them by using a screw driver (see Figure 11).

Figure 11. Location of the PIN Information and Securing the Cable.



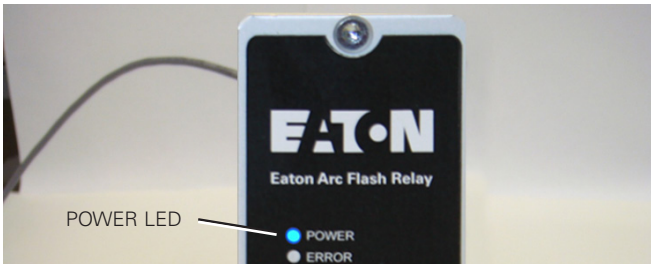
3. Connect the other end of the cable to a sensor channel on the EAFR-101 or EAFR-110P relay (see Figure 12).

Figure 12. EAFR-101 Sensor.



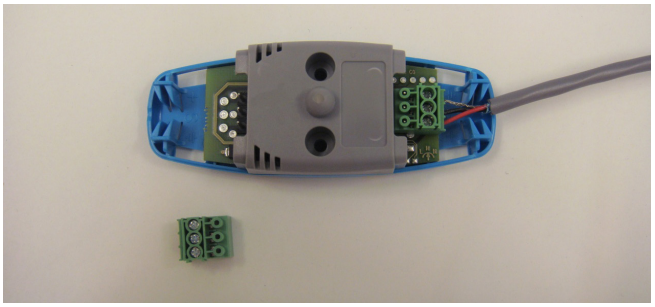
4. Check the front panel of the relay, only the POWER LED turns on at this moment (see Figure 13).

Figure 13. EAFR-01 Sensor Connection.



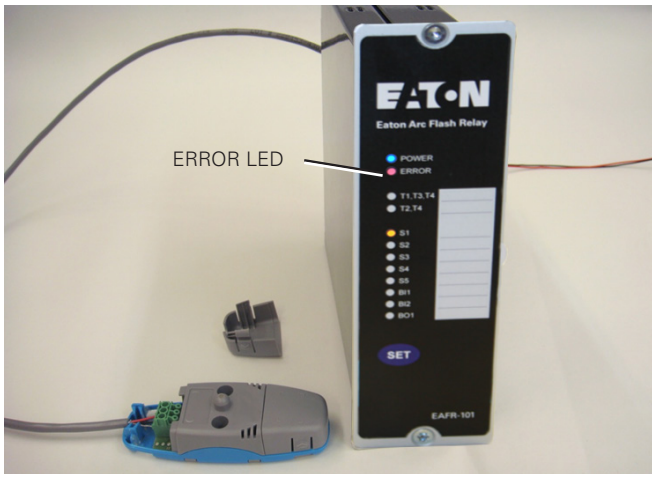
5. Attach the connector back to the sensor PCB (see Figure 14).

Figure 14. EAFR-01 Sensor Connection - Step 5.



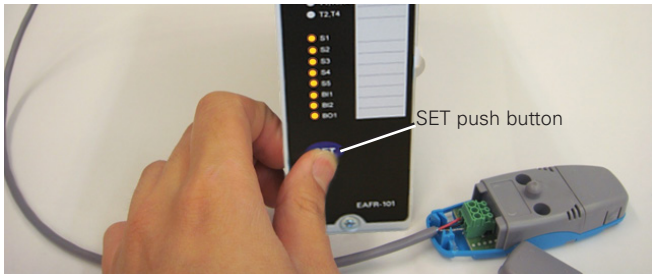
6. After connecting the sensor to the relay, the ERROR LED illuminates and the appropriate sensor channel LED starts to blink (e.g. S1 LED) (see Figure 15).

Figure 15. EAFR-01 Sensor Connection - Step 6.



7. Press and hold the SET push button on the front panel for two seconds in order to run the system auto-configuration setting (see Figure 16). The relay memorizes the sensor amount and binary input lines connected (if any).

Figure 16. EAFR-01 Sensor Connection Step 7.

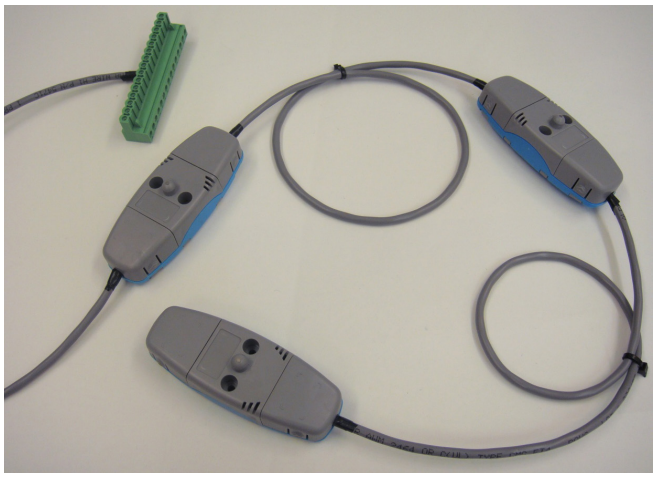


8. After completing the system auto-configuration setting the Error LED should be reset and then close both end side-covers of the point sensors (see Figure 17).

Figure 17. EAFR-01 Sensor Connection Step 8.

9. A maximum amount of three arc sensors can be daisy-chained to the same sensor input on the EAFR-101 relay (see Figure 18).

Figure 18. EAFR-01 Sensor Connection Step 9.



The Auto Configuration is a part of the Self Supervision Function which ensures that all connections and sensors are fully functional and ready to operate at all times.

5. System Self-supervision

The EAFR-101 includes an extensive self-supervision feature. Self-supervision includes both internal functions and external connections. The self-supervision module monitors power supply, hardware and software malfunctions, and binary input connection and sensor problems. Dipswitch settings are also supervised by comparing the actual value with stored non-volatile memory data (see Section 3.3.1: Auto Configuration [System Setup]).

In a healthy condition, the POWER LED is on and the System Failure (SF) relay is energized. If the self-supervision function detects a faulty condition or the power supply fails, the self-supervision relay is released and the ERROR LED is illuminated.

If a sensor failure occurs, the relay will go into the ERROR mode. The ERROR LED will turn on, the SF relay will de-energize, and the corresponding faulty sensor channel LED will start blinking. In this situation, the relay is still in protection mode, but with the faulty sensor channel blocked. If the error is resolved, the relay will automatically clear the SF-status. This means that the SF relay will energize and the ERROR LED will turn off. If one or more of the sensors are disconnected, the healthy sensors remain in use and the relay remains operational. The EAFR-101 will remain in Error mode until the disconnected sensors are repaired.

If a dipswitch setting is changed after the auto-configuration function (see Section 3.3.1: Auto Configuration) has been executed, the relay will go into SF alarm mode. The configured (stored) setting is however still valid and the relay is still operational.

6. Application Examples

The EAFR-101 may be applied to a variety of power switchgear and control gear layouts and technologies. Some typical applications are described in this section. Please consult your nearest Eaton representative for a solution to your particular application.

6.1 MV or LV Application with Current and Light Condition

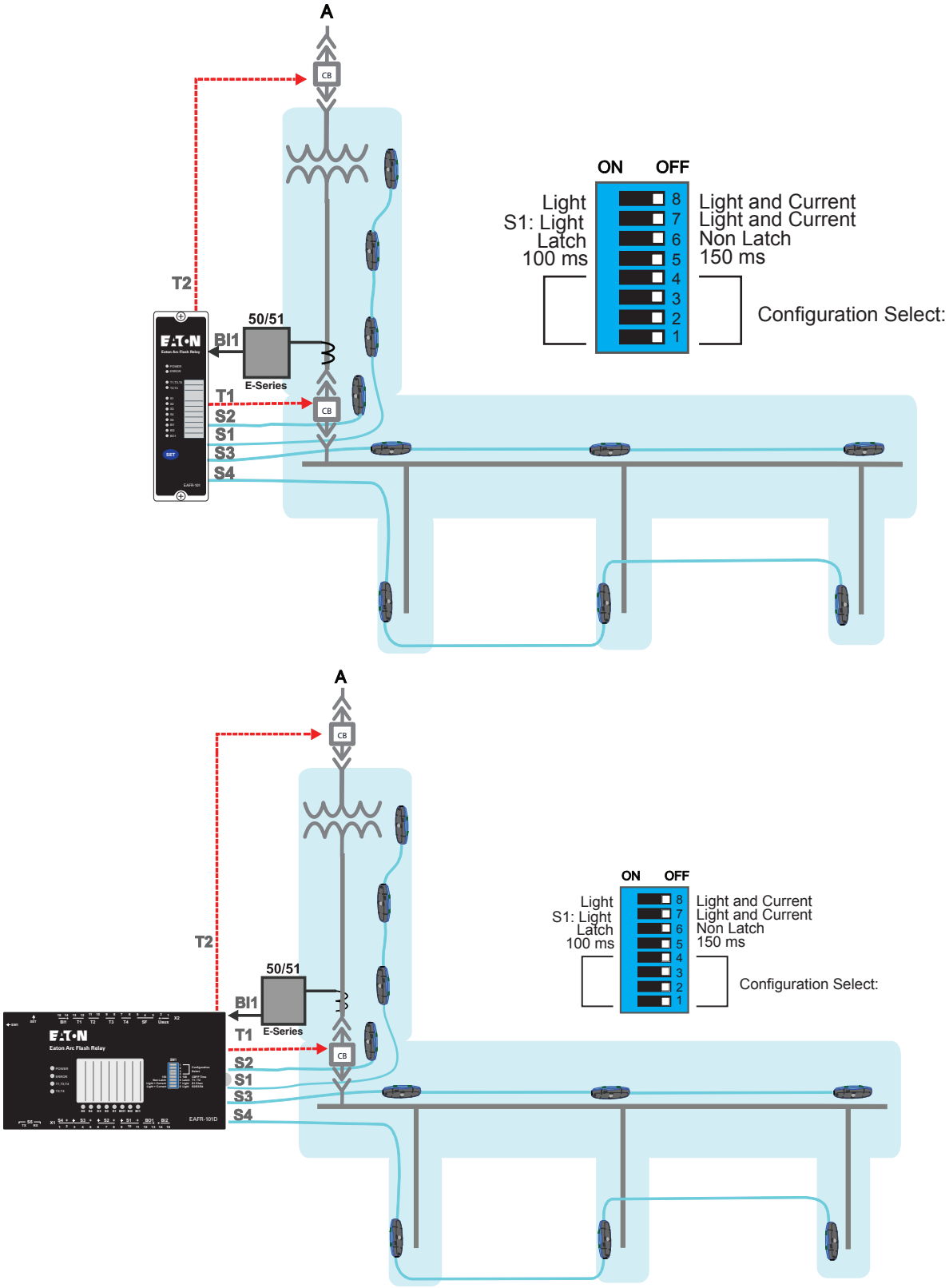
The EAFR-101 may be applied requiring both over-current and arc light conditions for trip. In this application, tripping is performed only if both conditions are fulfilled simultaneously. Typically, the over-current condition is obtained from an EAFR-110 relay and the trip relay will be activated in 7 ms. The over-current condition may also be monitored by non-Eaton products (e.g.: generic feeder protection relay) and the total operation time is then dependent on device feeding the over-current signal to the EAFR-101.

The sensor channel S1 can be set to operate on arc light only, even if other channels operate on both conditions of arc light and over-current.

Figure 19 shows an example of a system applying both over-current and arc light for tripping from the sensor channels S2, S3, and S4 activations and arc light only from sensor channel S1 activation. The S1 channel is monitoring the transformer feeder bus duct above the current monitoring point. a maximum three arc light point sensors type EAFR-01 can be connected to each sensor channel.

The current monitoring signal is in this application coming from an external over-current relay.

Figure 19. LV or MV Application by EAFR-101 and EAFR-101D.



6.2 Wind Power Application Example (Light Only Condition)

The EAFR-101 may be applied using arc light only as the tripping criteria.

The example in Figure 20 shows a typical wind power scheme where a permanent magnet synchronous generator (PMSG) is applied with a converter cabinet and LV/MV transformer.

The EAFR-101 is equipped with four point sensor channels and each channel may have up to three sensors (type EAFR01) connected in series allowing for up to 12 point sensors. In this application, three sensor channels with three sensors in each channel are utilized. In the event of arc light in any of the compartments containing a sensor, the EAFR-101 relay will execute a trip to all three circuit breakers in 7 ms thus clearing the arc fault in total time of 7 ms + CB opening time. Additionally, an electronic lock-out relay (T3) is utilized to provide the lock-out function ensuring the fault is recognized and corrected prior to putting the generator back into service (safety loop).

Figure 20. Typical Wind Power Applications by EAFR-101 and EAFR-101D.

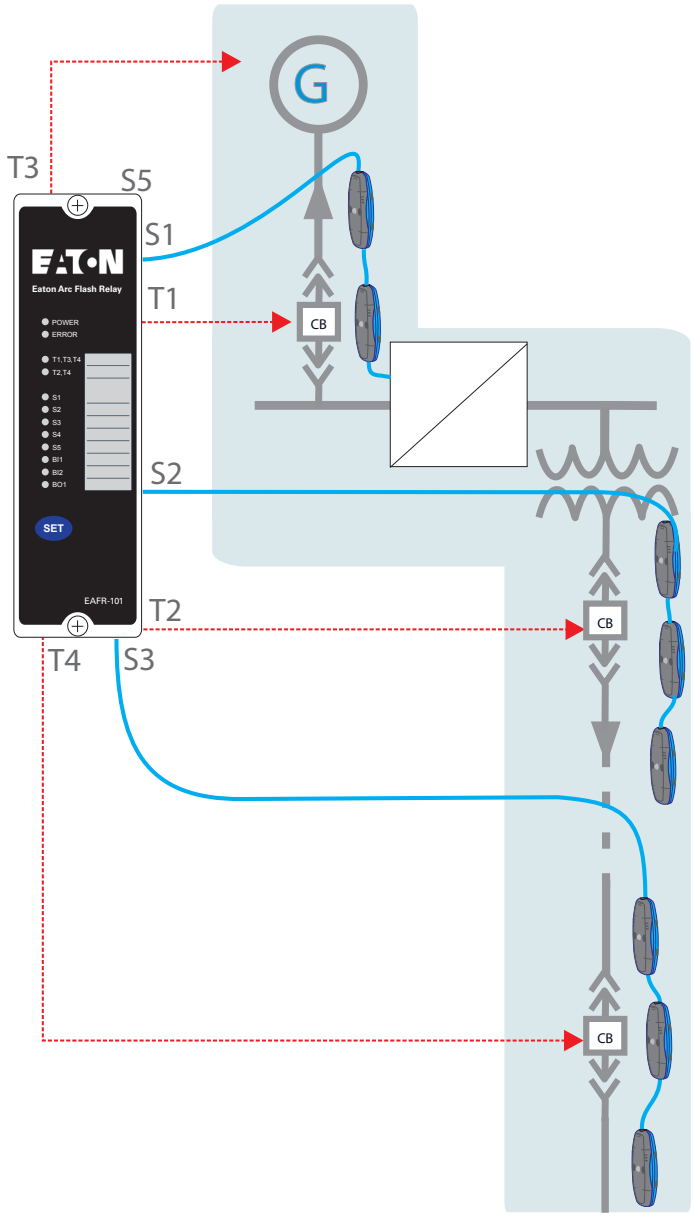
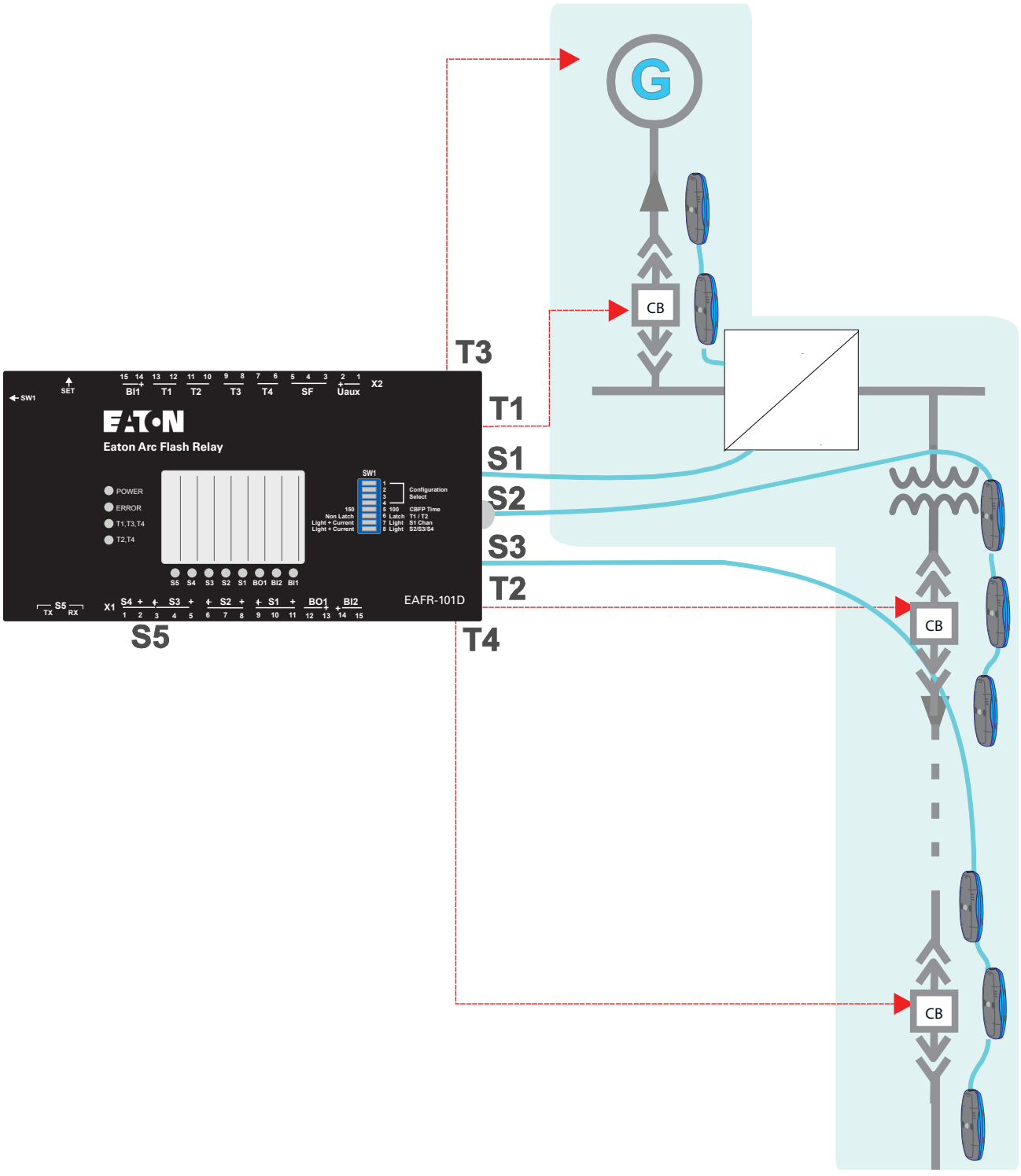


Figure 20. Typical Wind Power Applications by EAFR-101 and EAFR-101D (Continued).



6.3 Circuit Breaker Failure Protection (CBFP)

The EAFR-101 includes a selective circuit breaker failure function which can be enabled by dipswitch setting (see Section 3.5: Dipswitch Settings). When enabled, the breaker failure function activates when the tripped breaker fails to operate. The breaker failure function is activated if the EAFR-101 detects the presence of light after a set operating time. When EAFR-101 is set to operate on light and current, both parameters must persist to activate CBFP. Breaker failure can be set to operate either on 100 ms or 150 ms delay (Section 3.5: Dipswitch Settings).

7. Connections

7.1 Outputs

7.1.1 Trip Relays T1 and T2

The EAFR-101 relay has integrated trip relays T1 and T2 for tripping of the circuit breakers. The T1 and T2 relays are normally open type (NO).

7.1.2 Trip Relays T3 and T4

The T3 relay output may act either as an electronic lock-out relay or as a trip relay. This option must be specified when ordering. When the T3 is factory configured as electronic lock-out relay, it is normally open type (NO) and will hold its position until manual reset command or until auxiliary power supply is lost. When re-applying the auxiliary power supply, the electronic lock-out relay will return to the contact condition prior to loosing the auxiliary power. This NC relay output can be used for tripping contactor controlled devices.

Alternately, the T3 relay can be ordered as normally closed (NC) type relay EAFR-101B, EAFR-101DB.

The T3 relay follows the operation of T1 and activates whenever T1 is activated.

Trip relay T4 is a common trip relay that operates anytime the T1 or T2 relay operates and can be used either for tripping one more disconnecting device or for trip alarm to local or remote monitoring and alarming system.

7.1.3 Binary Output BO1

One binary output is available (+24 Vdc). The binary output function can be configured using dipswitches (see Section 3.5: Dipswitch Settings).

Note: The binary output is polarity sensitive (see Section 8: Wiring Diagram).

Figure 21. EAFR-101 Terminals at Rear Plate and EAFR-101D Connections.

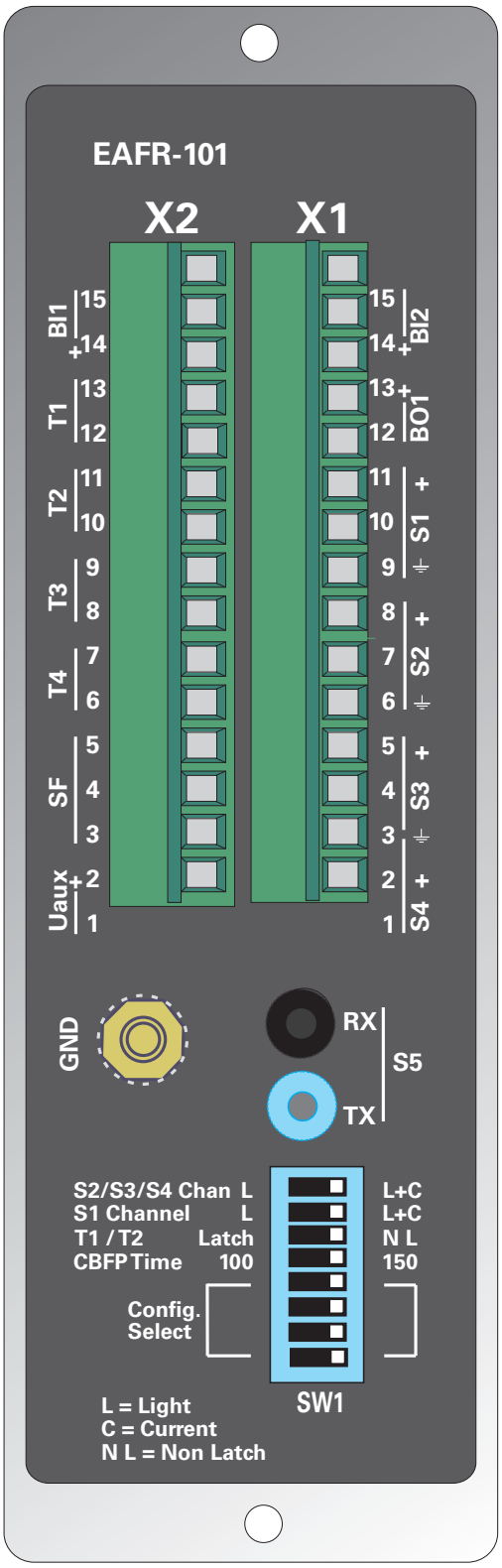
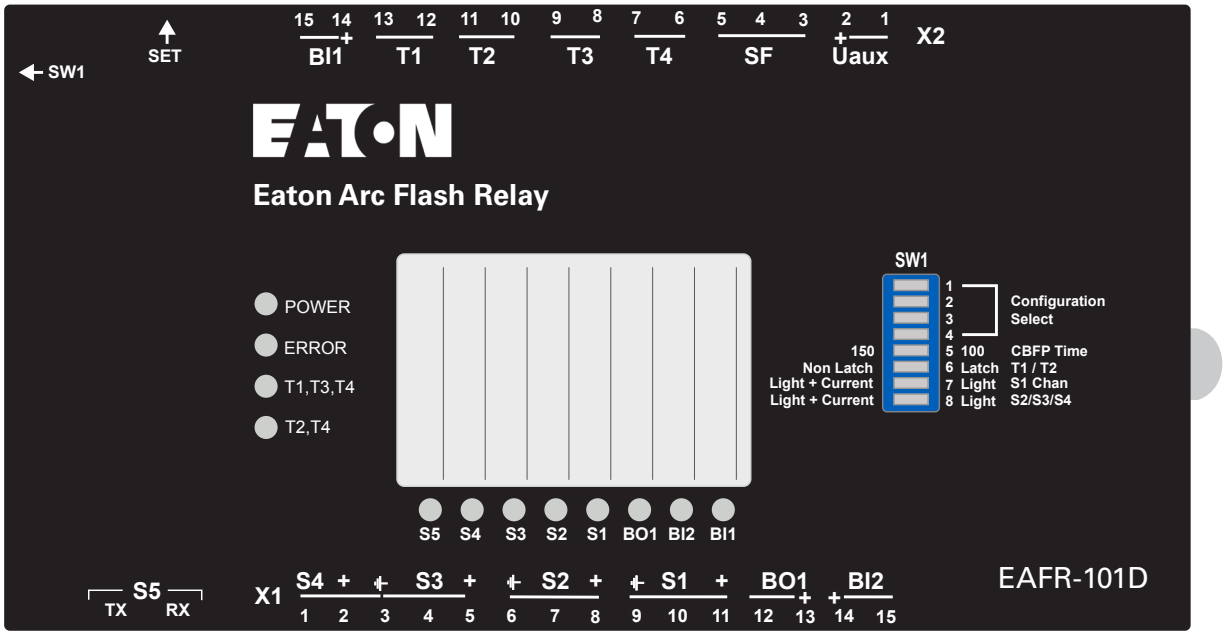


Figure 20. EAFR-101 Terminals at Rear Plate and EAFR-101D Connections. (Continued).



7.1.4 System Failure Relay SF

The system failure (SF) relay is a form C type (NO/NC) and is energized in the healthy condition. Whenever the EAFR-101 detects a system error or disconnection of the auxiliary power supply, the contact changes its state. The state of the SF relay remains the same until the relay returns to a healthy condition and the SF relay is again energized.

7.2 Inputs

7.2.1 Arc Sensor Channels S1, S2, and S3

EAFR-101 has four arc point sensor channels. Maximum three arc point sensors (type EAFR-01) may be connected to each channel.

For details on sensors, refer to Section 4: Arc Sensors.

7.2.2 Binary Inputs BI1 and BI2

The EAFR-101 contains two binary inputs. The BI1 is always reserved for second trip criteria signal. In the most typical application, the EAFR-101 is receiving over-current information from the Eaton EAFR-110 device. Over-current information may come also from a non-Eaton device (e.g.: an upstream protection relay). Alternately, any other signal (such as under-voltage, or similar) can be used as second trip criteria along with light information.

Note: When the EAFR-101 receives an over-current signal from a non-Eaton device, the actual operation time depends on the operation time of the external device and so total operational time cannot be specified or guaranteed.

BI2 can be used for receiving a trip signal or arc light signal. The BI2 can be used for receiving a trip signal or arc light signal. The function of the BI2 is configured using dip-switches (see Section 3.5: Dipswitch Settings).

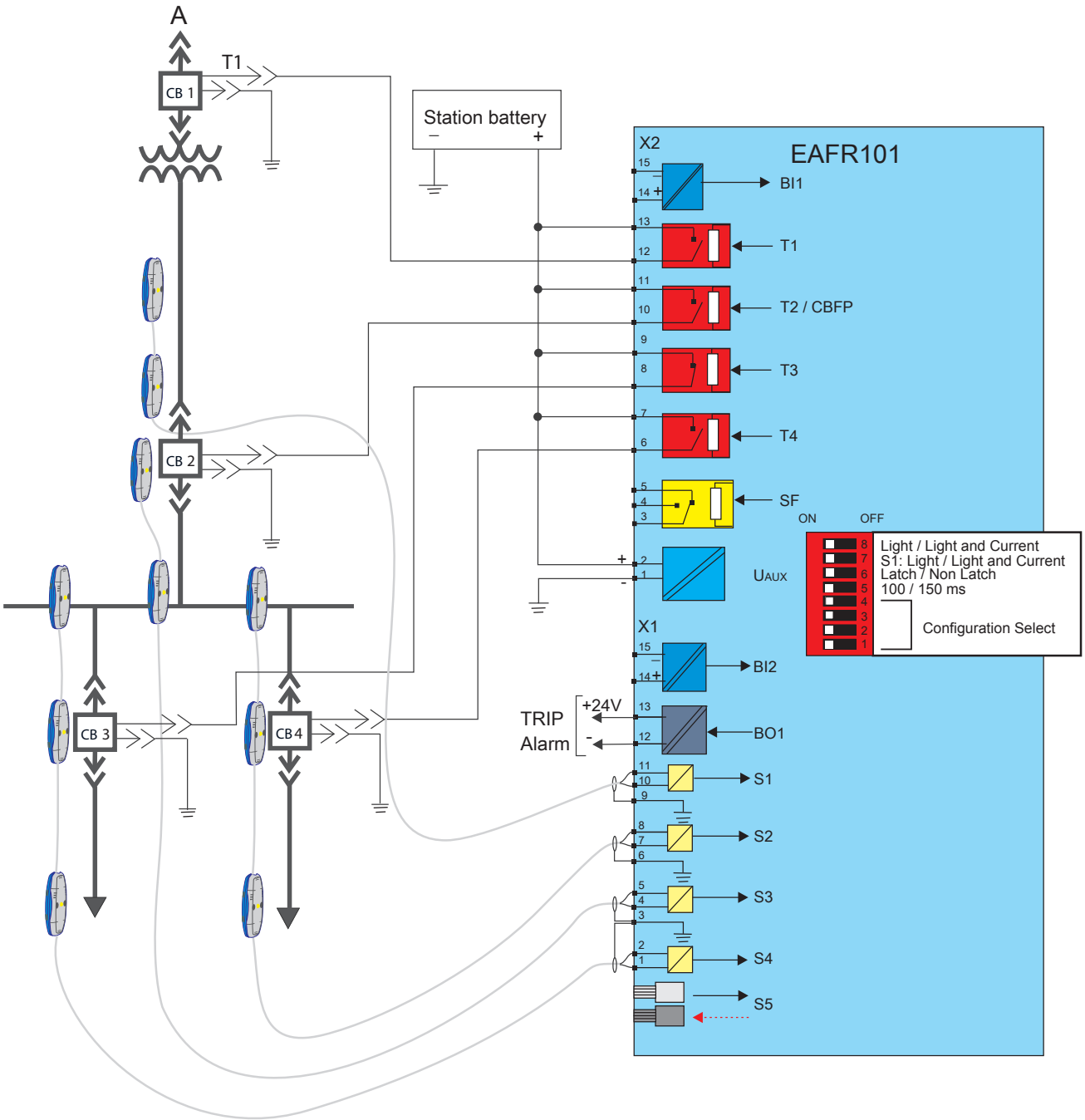
The inputs are activated by connecting a dc signal exceeding the specified nominal threshold level of the corresponding input. The nominal threshold level is 24 Vdc. The actual activation of the binary input occurs at 80% of the specified nominal threshold value (i.e.: 19 Vdc).

7.3 Auxiliary Voltage

The auxiliary power supply voltage is (110-220) Vac / (125-250) Vdc. After powering up the relay, protection is active and operational within 50 ms.

8. Wiring Diagram

Figure 22. Wiring Diagram of the EAFR-101 Relay.



9. Dimensions and Installation

The EAFR-101 is either door mounted or panel mounted in standard, 19 in. (482.6 mm) rack (height of 4U and 1/8 of a unit wide).

Figure 23. EAFR-101 Dimensions in Millimeters (In.) (Side View).

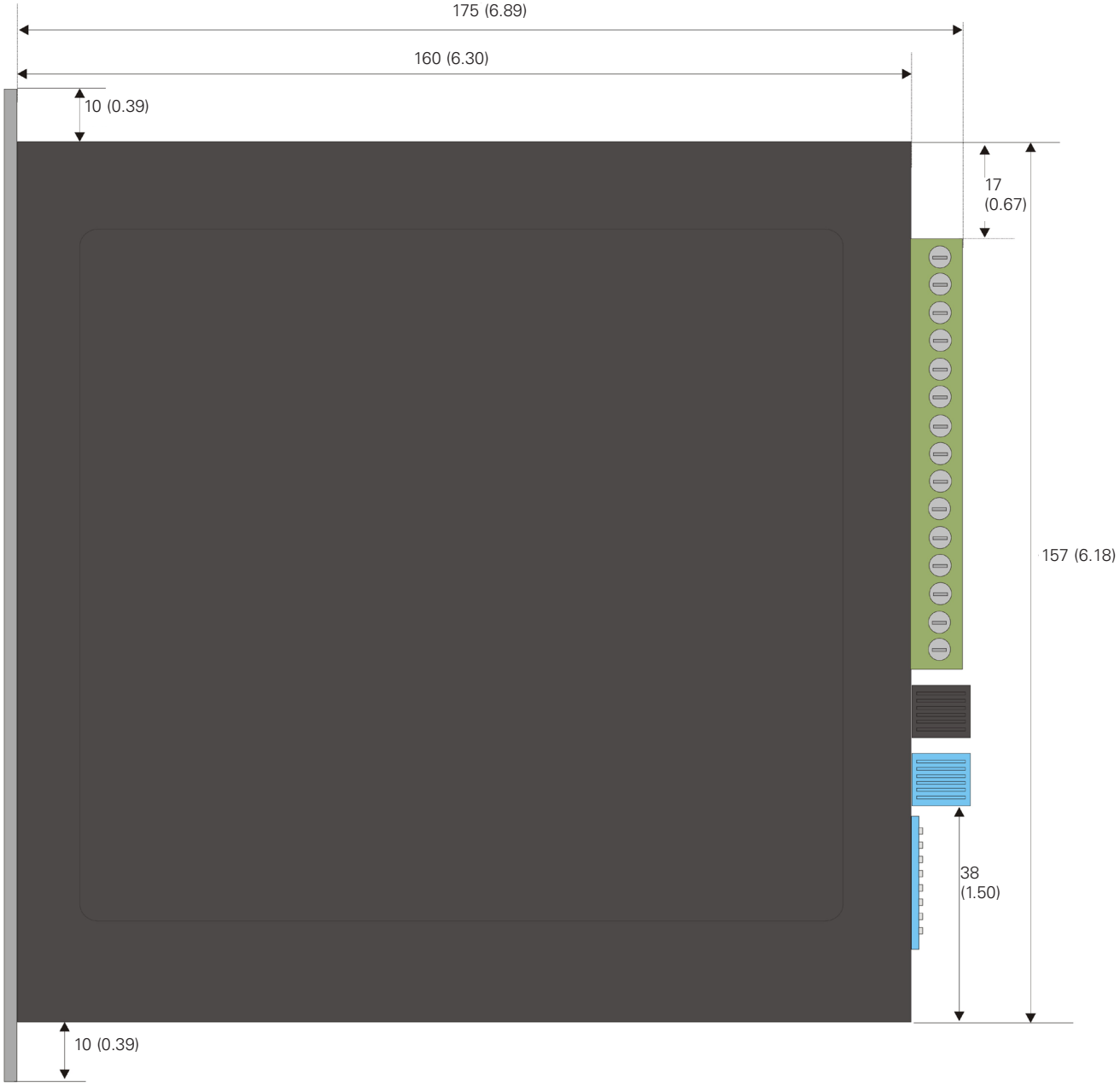


Figure 23 EAFR-101 and EAFR-101D (Dimensions in mm [in.]) - Side View (Continued).

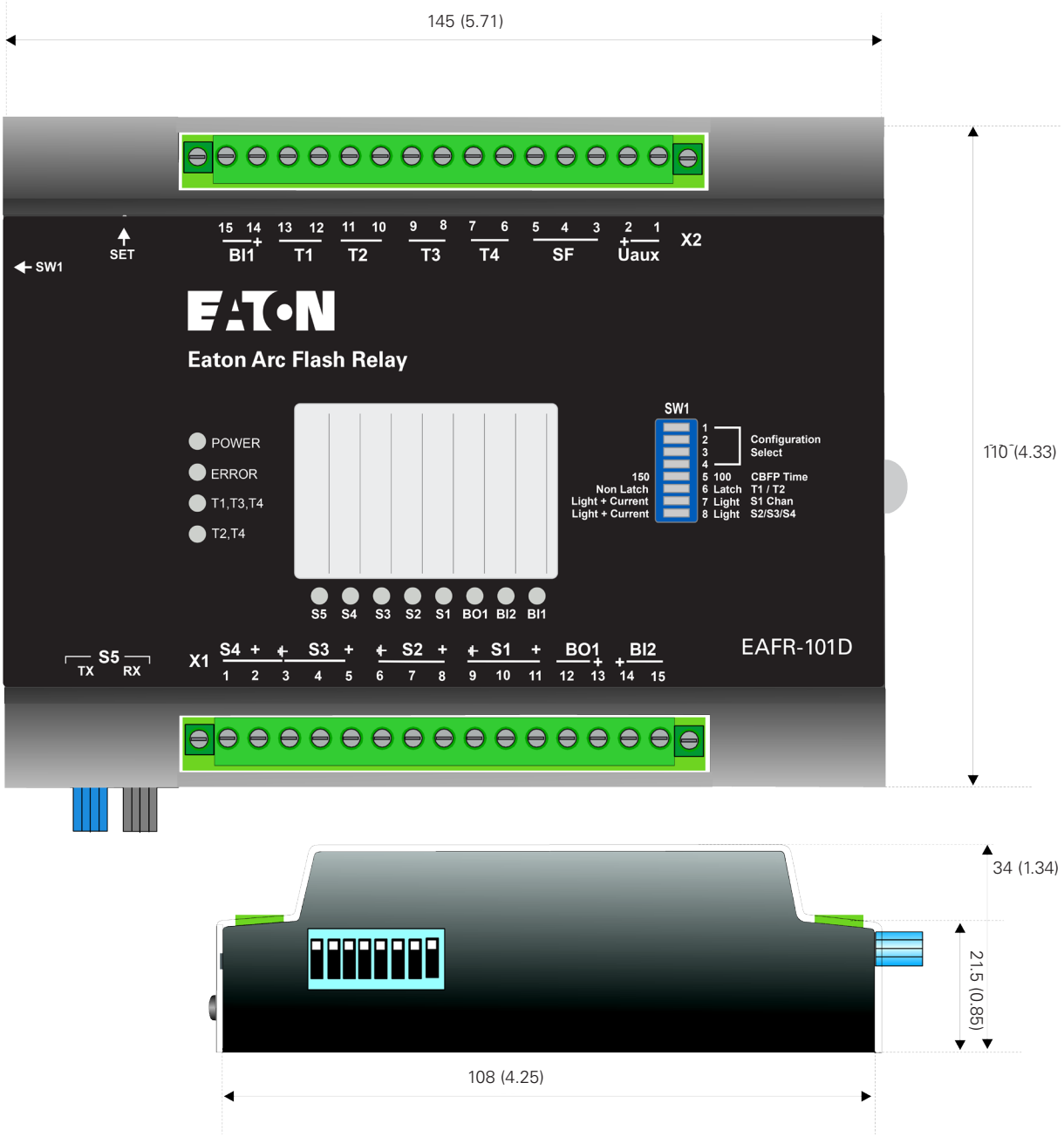
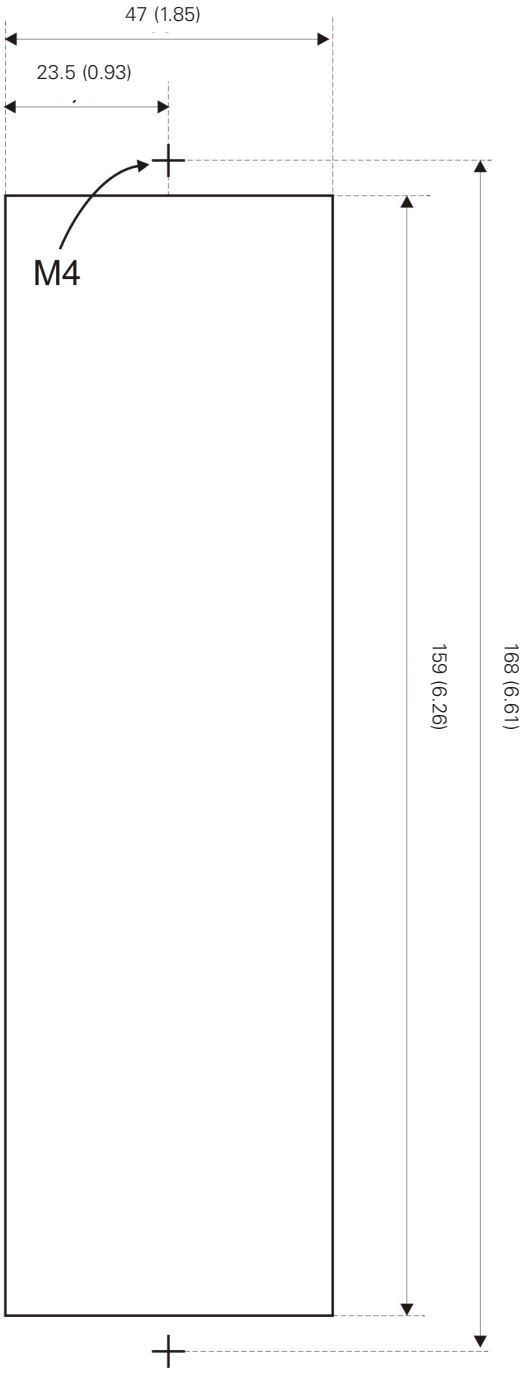


Figure 24. EAFR-101 Cut Out for Panel Mounting (mm [in.]).



10. Testing

It is recommended that the EAFR-101 relay be tested prior to substation energizing. Testing is carried out by simulating arc light to each sensor and verifying the tripping and LED indication. For arc light simulation, a superior camera flash type is used: Canon Speedlite® 430EX or equivalent. For testing of non-latched signals and the CBFP function, use a Mini Maglite® 2 Cell AAA or equivalent type of flashlight. Check that the camera flash or flashlight has fully charged battery(ies) when testing.

10.1 Carrying Out Testing in the Light Only Mode

1. Check that the dipswitch setting positions are in accordance to your application.
2. Activate the camera flash within 20 cm (7.87 in.) of the EAFR-01 to be used.
3. Verify that the corresponding sensor channel indication LED status is changed to ON.
4. Verify the relay output(s) activation(s) by checking the circuit breaker status or by monitoring trip contact status. The circuit breaker should open or contacts operate.

Note: A best practice is to operate the circuit breaker during testing.

5. Verify that the corresponding relay output(s) LED(s) indication status is changed to ON.
6. If the binary output (BO1) signal is utilized, verify the BO1 signal activation by the status change of the relevant input where the binary output signal is connected, or by measuring the signal output voltage.

Note: The BO1 signal is a non-latched type.

7. If a binary output signal is utilized, verify that the BO1 LED is illuminated.
8. Press the SET push-button to reset all indications and latches.
9. If a binary input BI2 is utilized as master trip to activate the corresponding binary input, verify that the trip has occurred by repeating Steps 4 and 5.
10. Press the SET push-button to reset all indications and latches.
11. Repeat the testing procedure for all sensors.

10.2 Carrying Out Testing in Light and Current Mode

1. Check that the dipswitch setting positions are in accordance with your application.
2. Activate the camera flash within 20 cm (7.87 in.) of the EAFR-01 to be used.
3. Verify that the sensor channel indication LED status is changed to ON.
4. Verify that the binary input BI1 indication LED status is changed to ON.
5. Verify the relay output(s) activation(s) by checking the circuit breaker status or by monitoring trip contact status.

Note: A best practice is to operate circuit breaker at testing. The circuit breaker should open or contacts operate.

6. Verify that the corresponding relay output(s) LED(s) indication status is changed to ON.
7. If the binary output (BO1) signal is utilized, verify the BO1 signal activation by the status change of the relevant input where the binary output signal is connected, or by measuring the signal output voltage.
8. If the binary output signal is utilized, verify that BO1 LED is illuminated.

Note: The BO1 signal is a non-latched type.

9. If another binary input BI2 is in use, verify correct operation by activating the input.
10. Activate the camera flash within 20 cm (7.87 in.) of the EAFR-01 to be used and do not activate the binary input BI1 used for over-current condition.
11. Verify that no trip has occurred and only the sensor activation indication LED is ON.
12. Verify that the BOUT signal is activated (if in use and configured to send light information).
13. Press the SET push-button to reset all indications and latches.
14. If the binary input BI2 is utilized for master trip to activate the BI2, verify that a trip has occurred by repeating Steps 4 and 5.
15. Press the SET push-button to reset all indications and latches.
16. Repeat the testing procedure for all sensors.

10.3 Testing the CBFP Function

The circuit breaker failure function is tested by leaving light signal and second trip criteria signal (e.g. over-current), if applicable, active for above the set CBFP time of either 100 or 150 ms. The trip relay T2 and binary output BO1 should be active after the set time delay.

10.4 Testing the Arc Flash Protection Unit Operation Time

The EAFR-101 operation time test is not required at commissioning as it is performed by Eaton as a type test and routine production test. Refer to the routine test reports sent with EAFR-101 relay and consult your nearest Eaton representative for type test reports.

However, if it is deemed necessary, a site timing test may be conducted using the following instructions.

1. Use a calibrated relay test set.
2. Connect an output from the relay test set to the camera flash (Metz® 20B1 or equivalent input) for initializing the flash and configure a relay test set timer to be started simultaneously with flash.
3. Connect the EAFR-101 trip output T1, T2, T3, or T4 to the relay test set input and configure the input to stop the timer.
4. Place camera flash to a maximum 20 cm (8 in.) distance of the EAFR-01 or EAFR fiber sensor.
5. Initiate the flash and timer using the relay test set output.
6. Read the measured time between simulated arc and trip contact operation.
7. Subtract the digital input delay of the relay test set from the final measured time if applicable. For specific test instructions consult the manufacturer of the relay test set.

10.5 Test Plan Example

Date:

Substation:

Switchgear:

EAFR-101 Serial Number:

Preconditions	Light Only	Light + Current	Remarks
Sensor Channel 1 Setting			
Sensor Channel 2,3,4 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, and T4 Active	BO1 Active
Sensor Channel 1	Sensor 1			
	Sensor 2			
	Sensor 3			
Sensor Channel 2	Sensor 1			
	Sensor 2			
	Sensor 3			
Sensor Channel 3	Sensor 1			
	Sensor 2			
	Sensor 3			
Sensor Channel 4	Sensor 1			
	Sensor 2			
	Sensor 3			
BIN 1				
BIN 2				

Tested by:

Approved by:

11. Troubleshooting Guide

Table 8. Troubleshooting Guide.

Problem	Check	Cross Reference
Sensor does not activate when testing.	Sensor cable wiring	Section 4 of this manual
	Camera (or other test equipment) flash intensity	Section 10 of this manual
Trip relay(s) does not operate even if sensor is activated.	Dipswitch settings	Section 3.5 of this manual

12. Technical Data

12.1 Protection

Trip time using mechanical trip relays.	7 ms*
Reset time (arc light stage).	2 ms
Protection operational after power up.	88 ms

* = Total trip time using arc light or phase/residual over-current from EAFR-110 and arc light.

12.2 Auxiliary Voltage

Vaux	(110-220) Vac / (125-250) Vdc ±20%
Maximum Interruption	100 ms
Maximum Power Consumption	5 W
Standby Current	90 mA

12.3 Trip Relays T1, T2, T3, and T4

Number	3 NO + 1 NC or 4 NO
Rated Voltage	250 Vac/dc
Continuous Carry	5 A
Make and Carry for 0.5 s	30 A
Make and Carry for 3 s	16 A
Breaking Capacity DC, When Time Constant L/R=40 ms	40 W; 0.36 A at 110 Vdc
Contact Material	AgNi 90/10

12.4 Binary Output BO1

Rated Voltage	+24 Vdc
Rated Current	20 mA (max)
Number of Outputs	1

12.5 Binary Inputs BI1 and BI2

Rated Voltage	+24 Vdc
Rated Current	3 mA
Number of Inputs	2

12.6 Disturbance Tests

EMC Test	CE approved and tested according to EN 50081-2, EN 50082-2
Emission	
- Conducted (EN 55011 Class A)	0.15 - 30 MHz
- Emitted (EN 55011 Class A)	30 - 1,000 MHz
Immunity	
- Static Discharge (ESD) (According to IEC244-22-2 and EN61000-4-2, severity Class 4)	Air discharge 15 kV Contact discharge 8 kV
- Fast Transients (EFT) (According to EN61000-4-4, Class III and IEC801-4, Level 4)	Power supply input 4 kV, 5/50 ns Other inputs and outputs 4 kV, 5/50 ns
- Surge (According to EN61000-4-5 [09/96], Level 4)	Between wires 2 kV / 1.2/50 µs Between wire and earth 4 kV / 1.2/50 µs
- RF Electromagnetic Field Test (According. to EN 61000-4-3, Class III)	f = 80 ... 1,000 MHz 10 V/m
- Conducted RF Field (According. to EN 61000-4-6, Class III)	f = 150 kHz ... 80 MHz 10 V

12.7 Voltage Tests

Insulation Test Voltage Acc - to IEC 60255-5	2 kV, 50 Hz, 1 min
Impulse Test Voltage Acc - to IEC 60255-5	5 kV, 1.2/50 us, 0.5 J

12.8 Mechanical Tests

Vibration Test	2 ... 13.2 Hz ± 3.5 mm (0.14 in.) 13.2 ... 100 Hz, ± 1.0 g (0.04 oz)
Shock/Bump Test Acc. to IEC 60255-21-2	20 g, 1,000 bumps/dir.

12.9 Casing and Package

Protection Degree (Front)	IP 50
Protection Degree (Back)	IP 20
Dimensions - W x H x D mm (W x H x D in.)	45 x 164 x 157 mm (1.77 x 6.46 x 6.81 in.)
Weight	0.7 kg (24.69 oz) 1.0 kg (35.27 oz) (with package)

12.10 Environmental Conditions

Specified Ambient Service Temp. Range	-35 to 70°C (-31 to 158°F)
Transport and Storage Temp. Range	-35 to 70°C (-31 to 158°F)
Relative Humidity	Up to 97%

13. Ordering Codes

Eaton Catalog Number	Eaton Style Number	Part Number Description
EAFR-110P	65C2010G01	Current, point sensor unit
EAFR-110F	65C2010G02	Current, fiber loop sensor unit
EAFR-101	65C2010G03	Point Sensor unit
EAFR-101D	65C2010G04	Point Sensor unit, DIN Rail mounted
EAFR-102	65C2010G06	Fiber loop sensor unit
EAFR-110PB	65C2010G07	Current, point sensor unit, NC Trip Relay
EAFR-110FB	65C2010G08	Current, fiber loop sensor unit, NC Trip Relay
EAFR-101B	65C2010G09	Point Sensor unit, NC Trip Relay
EAFR-101DB	65C2010G10	Point Sensor unit, DIN Rail mounted, NC Trip Relay
EAFR-102B	65C2010G11	Fiber loop sensor unit, NC Trip Relay
EAFR-01-A	65C2011G01	Arc light point Sensor - 8,000 Lux
EAFR-01-B	65C2011G02	Arc light point Sensor - 25,000 Lux
EAFR-01-C	65C2011G03	Arc light point Sensor - 50,000 Lux
EAFR-06-10	65C2013G01	Arc light plastic fiber sensor - 10 m (32.81 ft)
EAFR-06-15	65C2013G02	Arc light plastic fiber sensor - 15 m (49.21 ft)
EAFR-06-20	65C2013G03	Arc light plastic fiber sensor - 20 m (65.62 ft)
EAFR-06-25	65C2013G04	Arc light plastic fiber sensor - 25 m (82.02 ft)
EAFR-06-30	65C2013G05	Arc light plastic fiber sensor - 30 m (93.43ft)
EAFR-06-35	65C2013G06	Arc light plastic fiber sensor - 35 m (114.83 ft)
EAFR-06-40	65C2013G07	Arc light plastic fiber sensor - 40 m (131.23 ft)
EAFR-07-10	65C2014G01	Arc light glass fiber sensor - 10 m (32.81 ft)
EAFR-07-15	65C2014G02	Arc light glass fiber sensor - 15 m (49.21 ft)
EAFR-07-20	65C2014G03	Arc light glass fiber sensor - 20 m (65.62 ft)
EAFR-07-25	65C2014G04	Arc light glass fiber sensor - 25 m (82.02 ft)
EAFR-07-30	65C2014G05	Arc light glass fiber sensor - 30 m (93.43ft)
EAFR-07-35	65C2014G06	Arc light glass fiber sensor - 35 m (114.83 ft)
EAFR-07-40	65C2014G07	Arc light glass fiber sensor - 40 m (131.23 ft)
EAFR-07-45	65C2014G08	Arc light glass fiber sensor - 45 m (147.64 ft)
EAFR-07-50	65C2014G09	Arc light glass fiber sensor - 50 m (164.05 ft)
EAFR-08-10	65C2015G01	Arc light glass fiber sensor (High Temperature) - 10 m (32.81 ft)
EAFR-08-15	65C2015G02	Arc light glass fiber sensor (High Temperature) - 15 m (49.21 ft)
EAFR-08-20	65C2015G03	Arc light glass fiber sensor (High Temperature) - 20 m (65.62 ft)
EAFR-08-25	65C2015G04	Arc light glass fiber sensor (High Temperature) - 25 m (82.02 ft)
EAFR-08-30	65C2015G05	Arc light glass fiber sensor (High Temperature) - 30 m (93.43ft)
EAFR-08-35	65C2015G06	Arc light glass fiber sensor (High Temperature) - 35 m (114.83 ft)
EAFR-08-40	65C2015G07	Arc light glass fiber sensor (High Temperature) - 40 m (131.23 ft)
EAFR-08-45	65C2015G08	Arc light glass fiber sensor (High Temperature) - 45 m (147.64 ft)
EAFR-08-50	65C2015G09	Arc light glass fiber sensor (High Temperature) - 50 m (164.05 ft)

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Printed in USA
Publication No. MN026004EN / TBG1261
February 2016