Application Note

Arc Flash
Design Tool

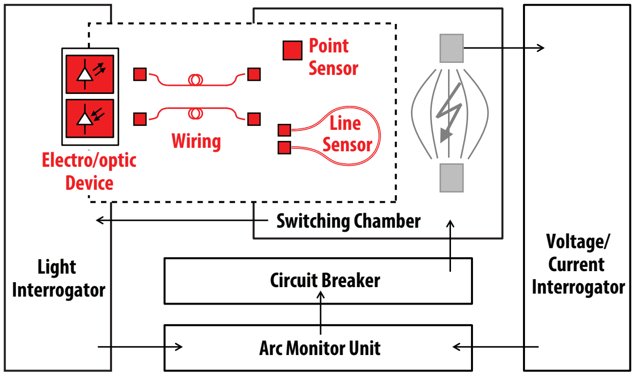
Introduction

Controlled arc flash events have many applications, for example, electric welding, steel-making, satellite engines, and illumination. Uncontrolled arc flashes become dangerous and risky, especially when they occur within the power grid, where they might damage not only expensive and critical electric equipment, but they might also injure people.

One of the main components of an electric power grid is called the switchgears. The components of a switchgear consist of a combination of electrical disconnect switches, fuses, or circuit breakers, and they allow isolating, controlling, and protecting electrical equipment.

Figure 1 shows an arc flash detection system.

Figure 1: Block Diagram of an Arc Flash Detection System



There are two different options in the arc flash detection system. The first one is the point sensor, which can be distributed along the different compartments of the switchgear.

The second option is a single optical sensor called the line sensor and covers one or more of those compartments.

The difference between a point sensor and a line sensor is the area of capturing light. The point sensor captures light only in small area, and the line sensor captures light in a relative large area.

The line sensor consists of an optical fiber, which can be configured as a loop. The optical fiber captures the light and guides it to the receiver.

Purpose

The purpose of this application note is to enhance understanding of the Arc Flash Detection Systems Design Tool calculator. The calculator can be found at the following link, under the Downloads tab:

https://www.broadcom.com/products/fiber-optic-modules-components/industrial/optical-fiber-sensors/arc-flash/afbr-s10tr001z

The tool has been created to support customers with the design of systems for optical arc flash detection.

The calculations included in these sheets are based on Broadcom best knowledge, no warranty or liability is given on the results.

This document guides you step-by-step through the arc flash calculator to help you achieve the best solution for your application.

For an arc flash detection system, you need the analog fiber optic transceiver (AFBR-S10TR001Z), either a line sensor (AFBR-TUS500Z) or point sensor (AFBR-S10PS010Z or AFBR-S10PS011Z), duplex connectors (AFBR-4536xZ), and polymer optical fiber or POF cable (AFBR-HUD500Z). There are different connector options, depending on your setup. Instead of the transceiver, it is also possible to use a versatile link based sensor receiver (AFBR-S10Rx021Z/031Z) separately. But in this case, the transceiver is used to perform the calculations and is therefore also referred to. All products that can be used for the arc flash detection are listed in Table 1.

Table 1: Related Parts

Part Number	Description
AFBR-S10TR001Z	Analog Fiber Optic Transceiver
AFBR-TUS500Z	Line Sensor
AFBR-S10PS010Z/011Z	Point Sensor
AFBR-4536xZ	Versatile Link Duplex Connectors
AFBR-HUD500Z	POF Duplex Fiber
AFBR-4536EZ	Versatile Link Duplex Bulkhead
AFBR-S10RX021Z/031Z	Analog Receiver with Versatile Link Connector
HFBR-4531Z	Versatile Link Simplex Connector
HFBR-4505Z	Versatile Link Simplex Bulkhead

The approach to calculate such arc flash detection systems is explained in the following sections of this document.

Arc Flash Characteristics

Some constants are listed at the tool, which represents an arc flash. With a luminance of the arc flash of E_V = 5000 lx, the distance to the lux meter of one meter, the result is an arc flash luminous flux L_V of 6.28×10^4 lm.

Point Sensor

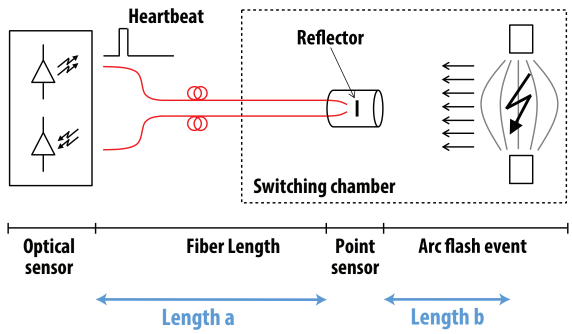
If you want to design an arc flash detection tool with a point sensor, you must calculate your system with following tabs:

- Point Sensor (inputs)
- Point Sensor (calculations)
- Point Sensor (output)

Input Explanation

The structure is illustrated in Figure 2. The main components are the optical sensor, the fiber length, the arc flash, and the point sensor inside a switching chamber.

Figure 2: Optical Point Sensor Block Diagram



There are two options that can be calculated:

1. Distance between the arc flash and the point sensor.

   In this case, you must know the fiber length that you are using in your system. The wanted variable is the distance between the arc flash event and the point sensor, in order to find the maximum acceptable location of the point sensor. The length of the fiber from capturing point to photodiode must be known.

2. Length of the fiber.

   In this case, the wanted variable is the length of the fiber from the optical sensor to the point sensor. The distance from arc flash event to the point sensor is fixed and must be known.

In the *Point Sensor (inputs)* tab, all necessary information has to be collected. Further components of the system, for example, the number of the bulkheads and the detection threshold of the application, must be known for the calculation. In this tab, you can choose which option you want to calculate. Either you choose option 2 to calculate the distance between the arc flash and the point sensor or you choose option 2 to calculate the length of the fiber. Depending on which option you choose, the fiber length or the distance from arc flash event to point sensor must be filled in. The heartbeat peak power is determined in the data sheet for the transceiver. (See Table 2 and Document References.)

Table 2: AFBR-S10TR001Z Transmitter Electrical Optical Characteristics

Characteristic	Min.	Typ.	Max.	Unit
Peak Launch End Power (IFDC = 10 mA)	–11	–6	–3	dBm
Peak Launch End Power (IFDC = 30 mA)	–6	–1	2	dBm

Calculation

The *Point Sensor (calculations)* tab illustrates the calculation procedure.

There are three different cases for the calculation:

- Case 1: Calculates the distance between arc flash event and point sensor. According to Figure 2, *length a* must be known and *length b* is searched.
- Case 2: Calculates fiber length as a function out of Vout arc flash. According to Figure 2, *length a* is the wanted variable and *length b* is known.
- Case 3: Calculates fiber length as a function of Vout heartbeat. The difference between case 2 and case 3 is just the evaluation function.

The calculator uses tick marks for numbering the measurement steps. It calculates all necessary variables to determine the correct distances.

Example Calculation Output

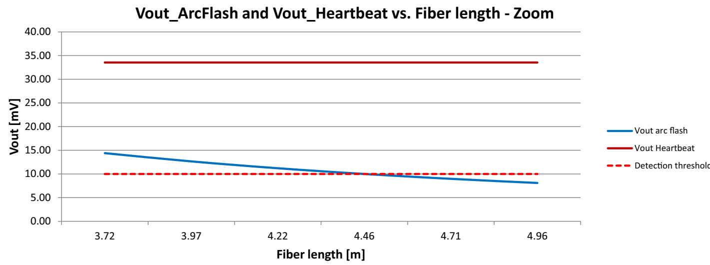
The result of the calculation is figured at the *Point Sensor (output)* tab. An example that illustrates the maximum fiber length is shown.

The following are the adjusted parameters:

- Number of bulkheads: 1
- Detection threshold: 10 mV
- Heartbeat peak power: –6 mV
- Fiber length (capturing point to photodiode): 0.5m

The outcome is shown in the following graph. This setup results in a maximum fiber length of 4.45m.

Figure 3: Results of Example Calculation (Point Sensor)



Line Sensor

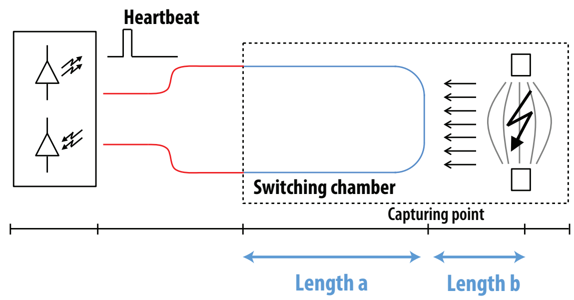
In order to use a line sensor for the detection of an arc flash, refer to the following tabs in the tool:

- Line Sensor (inputs)
- Line Sensor (calculations)
- Line Sensor (output)

Input Explanation

The setup of the Arc Flash Detection with a line sensor is illustrated in Figure 4. The main components are a switching chamber with the line sensor inside the POF and the optical sensor.

Figure 4: Line Sensor Block Diagram



There are two options that can be calculated:

1. Distance between the arc flash and the line sensor.

   In this case, you must know the fiber length that you are using in your system. The wanted variable is the distance between the arc flash event and the capturing point of the line sensor, in order to find the maximum acceptable location of the line sensor. The length of the fiber from the capturing point to the photodiode must be known.

2. Length of the line sensor.

   In this case, the wanted variable is the distance from the capturing point to the end of the line sensor. The distance from the arc flash event to the capturing point is fixed and must be known.

In the *Line Sensor (inputs)* tab, the requirements must be filled in. The important parameters are the number of bulkheads and the length of the POF. The detection threshold value and heartbeat peak power are determined in the data sheet of the transceiver. (See Table 2 and Document References.) The length of the illuminated line sensor and the number of the line sensor loops inside the chamber must be entered.

In this tab, you can choose your calculating option. Either you choose option 1 to calculate the distance between the arc flash event and the line sensor, or you select option 2 to calculate the length of the line sensor. Depending on the selected calculation option, the length of the line sensor or the distance from the arc flash to the line sensor must be filled in.

Calculation

In the *Line Sensor (calculation)* tab, all used parameters are listed. The parameters marked in yellow are variable parameters from the input tab.

There are three different cases for the calculation:

- Case 1: Calculates the distance between the arc flash event and the line sensor. According to Figure 4, *length a* must be known and *length b* is searched.
- Case 2: Calculates the fiber length as a function of Vout arc flash. According to Figure 4, *length a* is the wanted variable and *length b* is known.
- Case 3: Calculates the fiber length as a function of Vout Heartbeat. The difference between case 2 and case 3 is just the evaluation function.

The calculator uses tick marks for numbering the measurements steps. It calculates all necessary variables to determine the correct distances.

Example Calculation Output

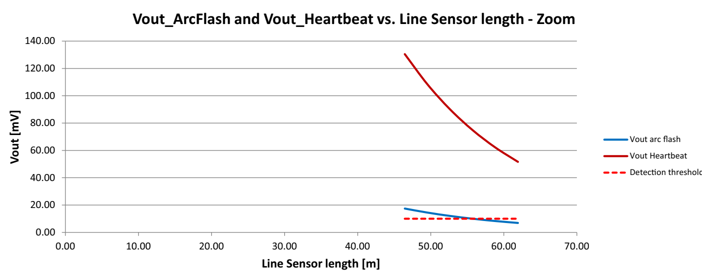
The result of the calculation is shown at the *Line Sensor (output)* tab. An example is shown that illustrates the maximum line sensor length.

The following are the adjusted parameters:

- Number of bulkheads: 1
- Length of *black jacket* POF: 5m
- Detection threshold: 10 mV
- Heartbeat peak power: –6 mV
- Length of illuminated line sensor: 0.50m
- Distance from arc flash to line sensor: 0.2m
- Number of line sensor loops: 1

The outcome is shown in the following graph. This setup results in a maximum line sensor length of 55m.

Figure 5: Results of Example Calculation (Line Sensor)



Document References

- *Fiber Optic Sensor Systems for Arc Flash Detection White Paper*

  https://docs.broadcom.com/doc/AV02-4503EN
- *Design Tool for Arc Flash Detection* (under Downloads tab)

  https://www.broadcom.com/products/fiber-optic-modules-components/industrial/optical-fiber-sensors/arc-flash/afbr-s10tr001z

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