PGR-8800 Arc Flash Relay

Introduction

Arc-Flash – an unexpected sudden release of intense heat and light energy produced by electricity traveling through air, usually caused by breakdown of isolation or accidental contact between live conductors. The Littelfuse PGR-8800 Arc Flash Relay detects the arc optically and disconnects the power source within less than 1 millisecond - preventing serious damage, loss of essential services and – most importantly - injury or loss of life.

Figure 1 – Unmitigated Arc Fault in an electrical switchboard

History

The Littlefuse PGR-8800 started life as the SELCO D1000 Arc Protection relay. The SELCO's experience with arc flash protection and the D1000 were major drivers in the acquisition of SELCO A/S of Denmark. Arc flash protection was actually a fairly new area for SELCO who's revenue was mainly driven by engine controls, generator controls and industrial alarm systems. Arc flash only started in 2005 with the D0910 Arc flash relay. The D0910 has since become a standard component in wind turbines manufactured by Spanish Gamesa and the D0910 is now the bestselling Littelfuse Selco product.

The decision to initiate the development of the PGR-8800 came about from a desired to provide longer term protection of the D0910 revenue stream. There was also a desire to optimize the production cost of the sensors and increase the overall safety of the product (e.g. with optical loop-back check of the sensors, surveillance of the trip circuit etc.).

Team & Methodology

The design process started out with a number of surveys to map the future requirements of key OEM customers (e.g. Spanish Gamesa). Following the surveys analysis of competing product were made to map both differences in pricing and technical features. At SELCO we were always aiming to do unique and special products so we engaged into cooperation with the Danish Technical University (DTU) to analyze the spectral composition of high voltage arc faults in relation to the arcs lifecycle. The analysis produced a through report that became the foundation of the requirement specification for the SELCO D1000.

At SELCO we quickly realized that the development of mechanics, optics, electronics and software were a significant task. The existing R&D department had only 3 engineers so we went out to recruit 2 additional HW+SW developers. We aimed to get the best of the best so we ended up headhunting engineers that were already in positions at e.g. Nokia.

The design and development of the D1000 made for a very interesting project. The project did not only include electronics and software – it also included design of mechanics (3D printed sensor enclosures), tiny solar cells and specialized fiber optics. The project was made even more challenging by aggressive restraints on cost, time, resources and quality. The high demands to the functionality of the product lead to the decision of using a real time operating system under the IAR C-based software. Requirement for data storage, connectivity and future expansion lead to the development of a standardized ARM based hardware platform that has since be reused for other products (e.g. a CAN1939 industrial engine controller).

Following the acquisition by Littelfuse, the D1000 became the PGR-8800. Littelfuse recognized the PGR-8800 to be a high potential product and the team grew quickly to include colleagues from Startco in Saskatoon Canada and Littelfuse in Chicago. This gave the PGR-8800 a huge boost with regard to marketing, sales and certification. The PGR-8800 has now become a true star. The combined effort of Littelfuse associates worldwide has made the PGR-8800 a well proven high potential product. The PGR-8800 has already saved lives and prevented collateral damage for millions of dollars.

The Power of an Arc Fault

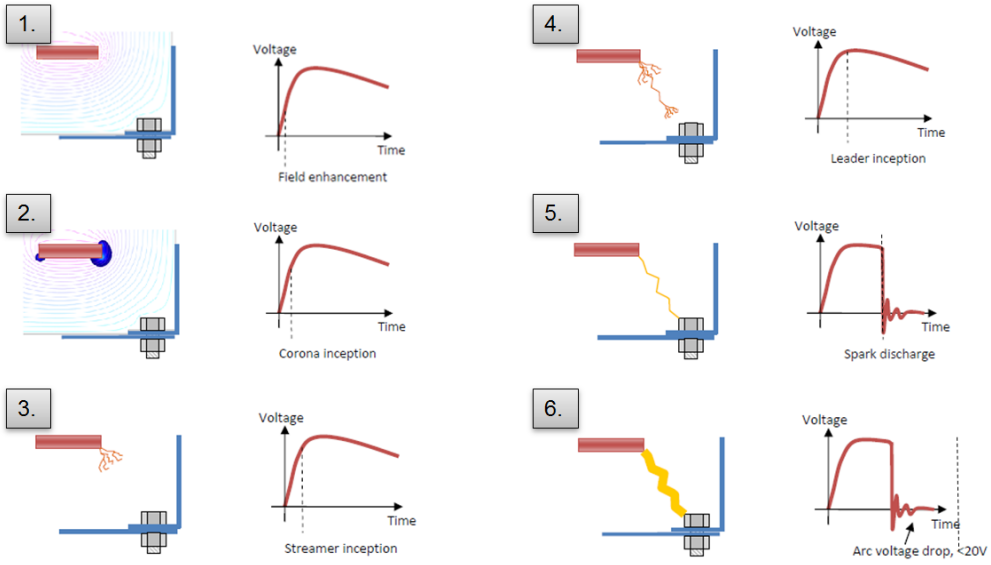


Figure 2 – The lifecycle of an Arc Fault

The lifecycle of an arc fault starts with the build-up of an electrical field between a conductor and ground (or another conductor). As the voltage increases corona will start to form. Following further increase of the voltage streamers will start originating from the conductor and short-circuit will occur once the streamer reaches ground. (the isolation breaks down) This is when the actual arc fault occurs.

The Power of an Arc Fault

A phase-to-phase fault within a 480 V system with 20,000 ampere of fault current provides 9,600,000 watts of power. Imagine that there is no arc protection and the fault lasts for 200 milliseconds. The resulting energy would be 1,920,000 Joules. TNT releases approximately 2,175 Joules/gram when detonated, so this arc flash would approximately correspond to the detonation of 883 grams of TNT. One stick of dynamite contains approximately 1,000 grams of TNT.

The formula is as follows:

Energy = (voltage x current) x duration = (480 V x 20,000 A) x 200 ms =1,920,000 J

The formula clearly shows that the destruction depends on power over time, which is in fact the formula for energy. The main task of the PGR-8800 is to quickly detect the release of power and limit its lifespan.

The Consequences of an Arc Fault

There are typically no serious consequences if the arc fault is mitigated with 35 milliseconds. An unmitigated arc fault can cause a very powerful explosion with fire, shrapnel, excessive heat and a very powerful pressure wave. An arc fault can easily kill or cause serious injury.

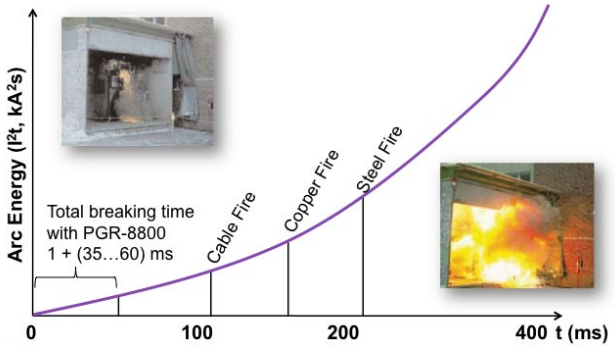


Figure 3 – Consequence vs. trip time

Applications

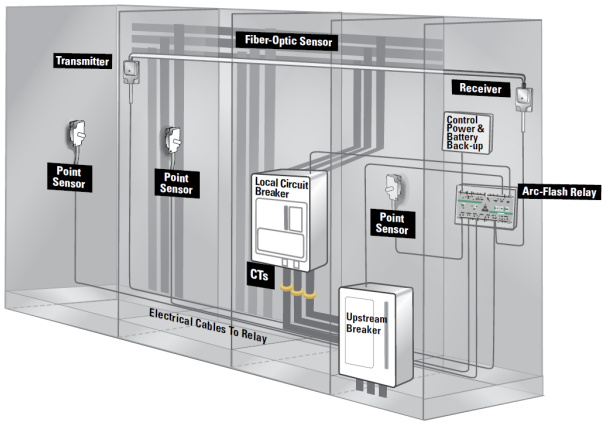


Figure 4 – Electrical switchboard with PGR-8800 Arc Flash Protection

Chemcial Processing

Electrical Switchgear

Transformer stations
National Power Grid

Mining

Cement & Aggregate

Offshore

Arc Flash protection is applicable in industries and applications where high energy (high current) is applied. This can be utilities, petro-chemical, mining, offshore, win-turbines etc. Arc Flash protection helps fulfil NPFA regulation for protection against injury or loss of life as well as protection against loss of essential services and collateral damage.

Product

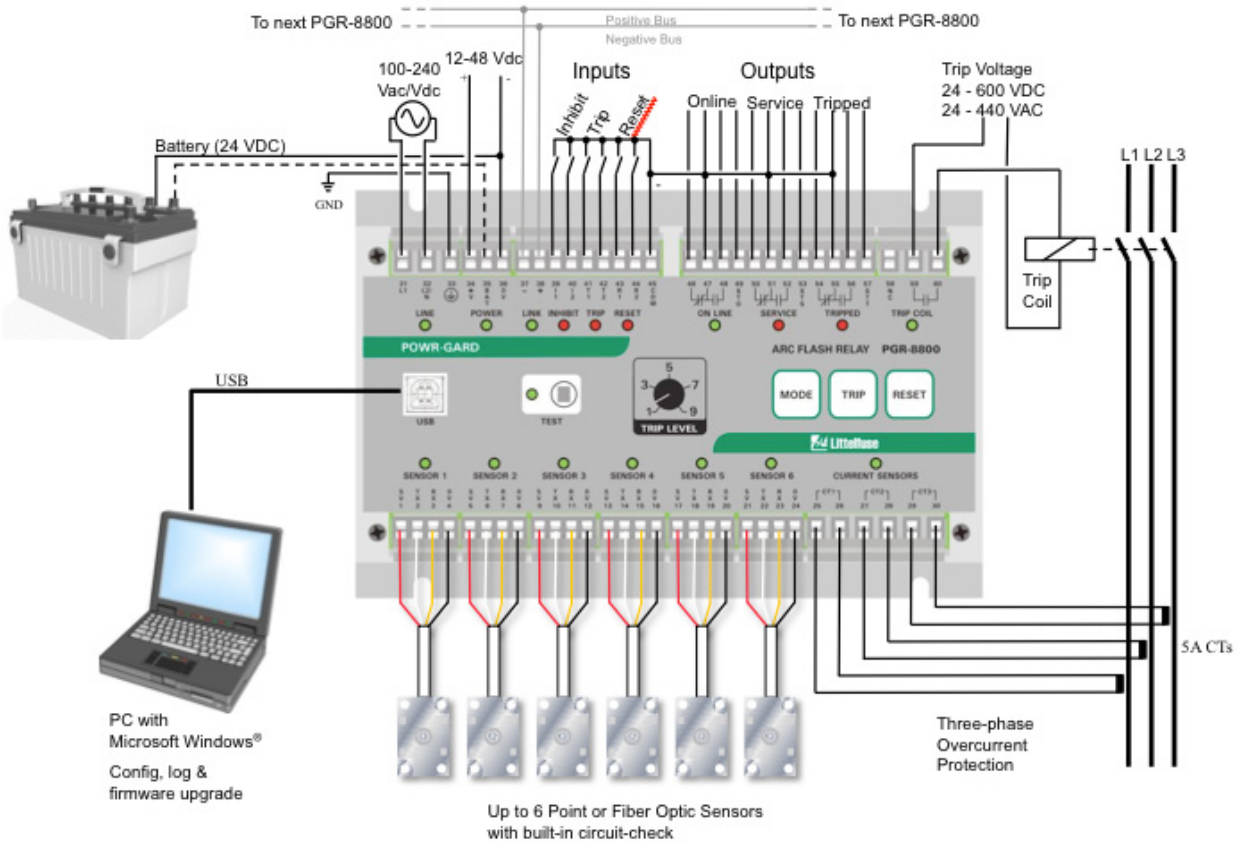
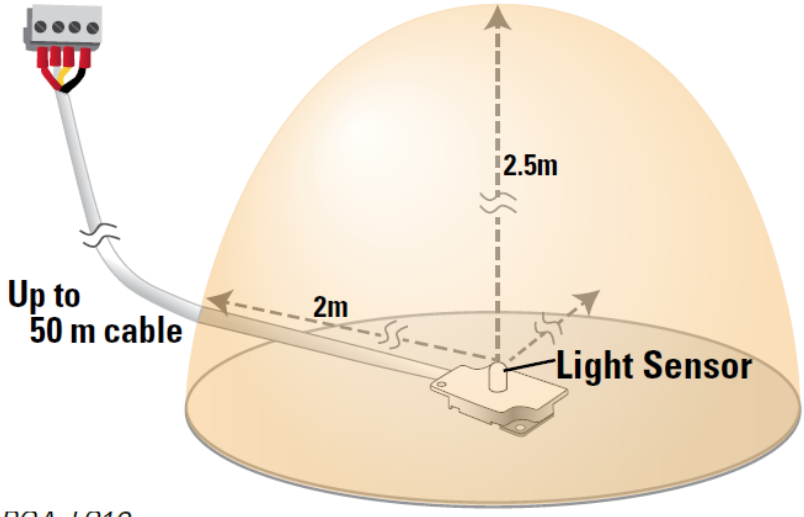


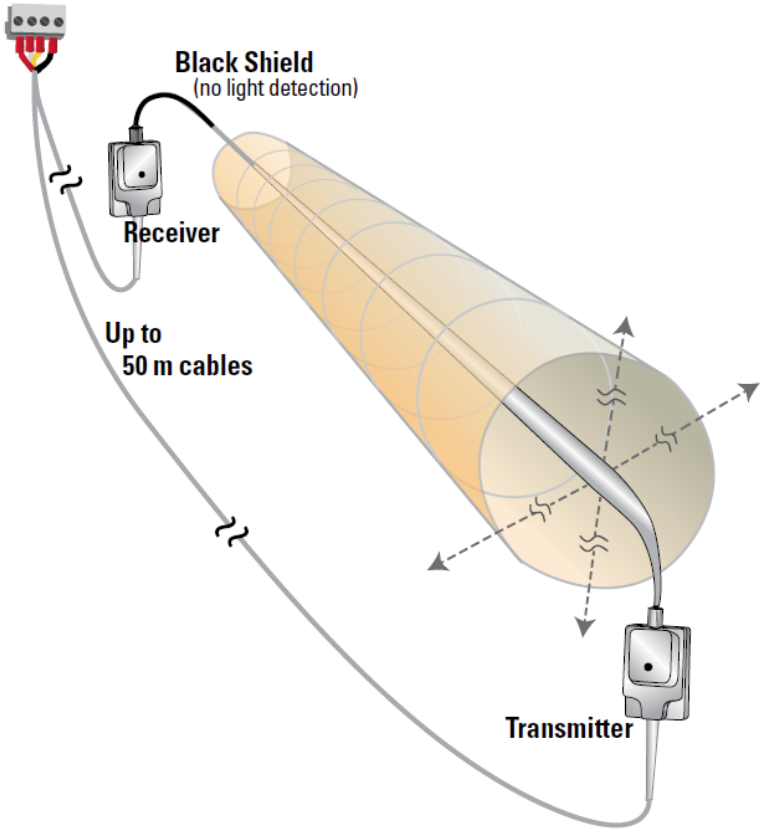
Figure 5 – The Littelfuse PGR-8800 with six optical point sensors and three CTs

The Littelfuse PGR-8800 is a microprocessor-based Arc Flash relay that limits arc fault damage by detecting the light from an arc flash and rapidly tripping. Phase-current-transformer inputs are provided for current-constrained arc-flash protection and, when so equipped, a programmable definite-time overcurrent function can be enabled. An optical sensor on the PGR-8800 and adjustable trip level reduce the chance of nuisance tripping by setting a threshold for ambient light. Sensors, inputs, and connections are monitored to ensure fail-safe operation. A secondary solid-state trip circuit provides a redundant trip path. A USB port is used for configuration and access to event logs and graphs.

The PGR-8800 features an ARM architecture and the software monitoring the sensors and controlling the main trip path was developed with IAR C and is based on an RTOS scheduling system. The PGR-8800 features USB for easy configuration through a web browser.



PGA-LS10:
Detection Range of a 3 kA Arcing Fault



PGA-LS20: Detection Range of 8 m
PGA-LS25: Detection Range of 5 m

Figure 6 – The Littelfuse PGA point and fiber sensors

Case Study

Shortly after deciding to test the PGR-8800 in production, a customer experienced a serious arc fault. The PGR-8800 really saved the day…

Case Study

"Had this relay not been there, they were looking at $800,000 to $1 million of cost.."

—Tim Deschamp, Evans Enterprises, USA

Littelfuse Arc-Flash Relay Saves Plant from Catastrophic Damage

Tim Deschamp from Evans Enterprises was working with a customer to help them resolve a critical issue with an electrical hazard in their furnace control room. An earlier arc-flash analysis had determined that one 480-volt cabinet, which was fed from a 3500 kVA transformer, exceeded an arc-flash Hazard Risk Category 4 (HRC 4).

To be able to work on the cabinet or lower required PPE, Deschamp needed to lower the HRC. He selected the PGR-8800 Arc-Flash Relay from Littelfuse, which could be easily retrofitted into the existing cabinet and didn't have the maintenance problems that he had experienced with other relay manufacturers. After the relay was installed, an engineering firm rerated the cabinet's arc flash hazard rating from HRC 4 to a HRC 2, a level easily approachable using 8 cal/cm² PPE.

$1 Million Savings

Just one week after the PGR-8800 was installed, the plant experienced an arc-flash incident. "Had this relay not been there, they were looking at between $800,000 and $1 million of cost, considering downtime and equipment replacement," Deschamp said. "Besides the lead-time for delivery and the installation, they would have had to cut a hole in the outside wall of the plant to install it." Instead, the entire cost to the end-user was only $6,000, which included replacing a few insulators and a portion of the bus bar. The plant was back up and running within 24 hours. Immediately after the incident, the customer requested that Deschamp install Littelfuse PGR-8800 Arc-Flash relays in all of their larger electrical cabinets.

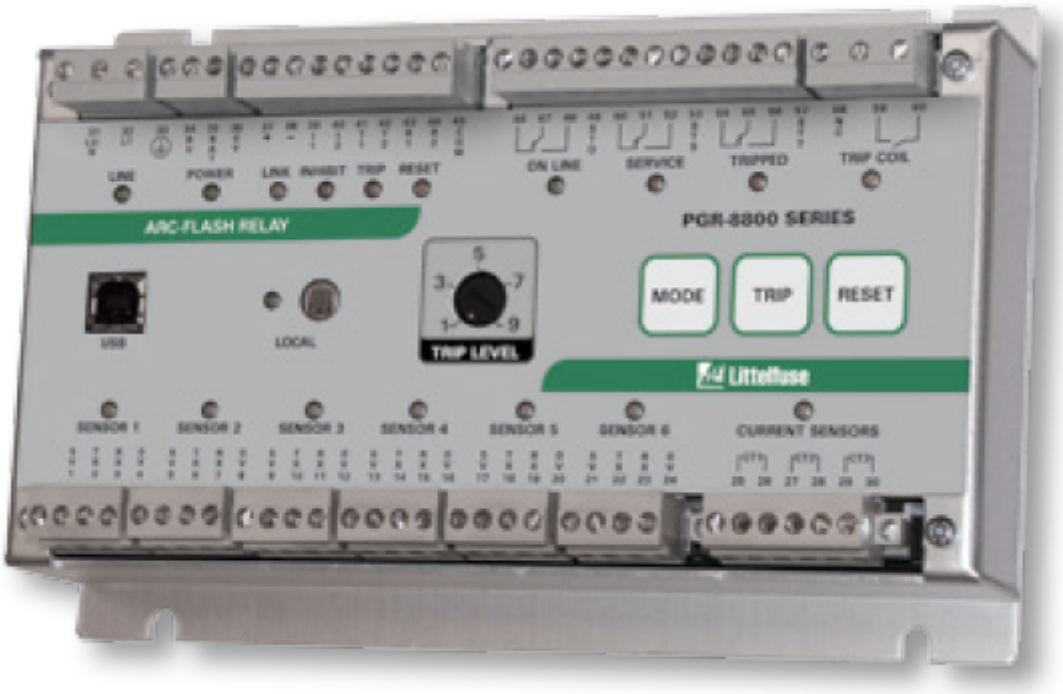
Summary

This is an example of how a minimal investment of just a few thousand dollars can save tremendous costs in lost equipment, downtime and production, not to mention the risk of employee injury or fatality. This customer was fortunate with his timing, but a proactive strategy is recommended when it comes to protecting critical assets and employee safety. An arc-flash relay is an integral component of an arc-flash protection scheme that can minimize damage and save money, time and lives.

To read the full story and for more information on the PGR-8800 Arc-Flash Relay, visit **Littelfuse.com/ArcFlash.**

Design

The PGR-8800 is designed for installation in the back of an electrical switchboard or on a DIN rail mount. The PGR-8800 has already be brand labeled for a number of OEM customers, including Mexican CFE and a major Indian corporation.



Mathematical Modelling

Many customers are uncertain about the placement of the light sensors inside the application (see the Application section of this document). We are currently giving the customers a set of general rules:

1. Place the point sensor on the ceiling of the switchboard compartment, looking down. Do not place the point sensor on the bottom looking up, as dust may settle on the sensor blocking it view.
2. Two point sensors per switchboard compartment it typically enough. Install more if the view through the compartment is blocked by large components, such as circuit breakers.

3. Use the fiber sensor to monitor horizontal busbars (e.g. along the top of the switchboard).
4. Standard sensitivity of the sensors are 20,000 Lux. The intensity of an arc is typically much higher.

Despite the above recommendation – and despite that the intensity of the arc is normally so high that even sensors in abjuring compartments will trip – some customers are still asking for a mathematical model of sensor coverage.. We can currently only give a general idea on the range and viewing angle of the two sensors (see figure 6 earlier in this document). It would be an advantage if we could provide some kind of mathematical model that could provide more certainty to the customers while they are figuring out where to place the sensors.

References

More information on the Littelfuse Web site at:

http://www.littelfuse.com/search-results.aspx?dsNav=Ntk:All|PGR%2f-8800|1|,N:1401246&both=true

Videos available at Youtube:

http://www.youtube.com/results?search_query=pgr-8800&sm=3

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