TRANSTECTOR

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White Paper

Positive Train Control

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Surge Protection Solutions for Positive Train Control

Abstract

To ensure the safety of trains, passengers and track workers as well as guarantee uninterrupted traffic flow, the US Rail Safety Improvement Act of 2008 mandates the adoption of a Positive Train Control (PTC) system by December 2015 by any mainline rail corridor sharing freight and passenger operations.

PTC's predictive technology will enforce any required action to communication signals from wayside systems if missed or misinterpreted by the train operator. This includes acceleration, braking or stopping of the locomotive.

PTC consists of a complex set of advanced technologies, which need to be adequately protected from surge anomalies to ensure their proper functioning. This paper discusses the new demands that are placed upon surge protectors to qualify for use in PTC systems.

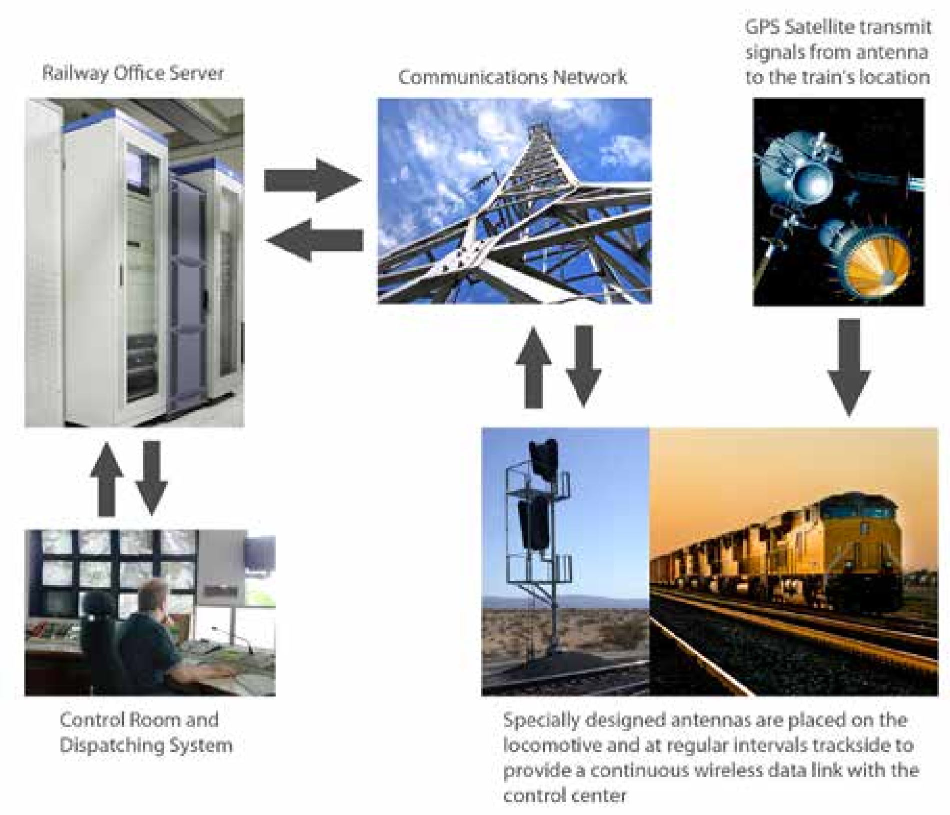
Introduction

The US Rail and Safety Improvement Act of 2008 is a federal mandate that affects railroad mainlines, which operate regularly scheduled commuter or intercity passenger services. This new safety law was developed in response to a fatal collision between a passenger and a freight train. The Federal Railroad Administration (FRA) estimates that PTC will impact 80,000 route miles as well as 19,000 locomotives and will require 50,000 new wayside interface units (WIU's), updated or new back office servers, communication gateways and modifications at virtually every dispatching office. The cost to the industry is currently estimated at $10 B.

PTC is designed to provide another level of railroad safety by eliminating the element of human error in responding to communication signals sent by wayside systems. The technology is capable of accelerating, braking or stopping the train and thus prevents train-to-train collisions, over-speed derailments and injuries or casualties to roadway workers.

Currently, multiple PTC projects in varying stages of development are underway. A PTC system requires four components: GPS satellite data, locomotive based (onboard) equipment, dispatching office and wayside interface units (WIU's).

Although PTC systems must operate through temporary losses of GPS coverage, the system's reliability can be significantly impacted by delayed or lost messages. To avoid such disruptions, a constant 220 MHz data radio transfer between each component is required. In addition, both control centers and wayside equipment (WIUs) must be properly grounded and protected from surges. The newer, highly sensitive digital equipment used in the PTC systems demand new, advanced surge protection technologies to ensure long-term operation.



Developments in Surge Protection Technologies

In the past the rail and transit industry has mainly relied upon simple surge protection technologies primarily consisting of only one component – spark gaps, gas tubes or metal oxide varistors (MOVs). PTC related highly sensitive electronic equipment, however, requires a more advanced approach to surge protection.

Surge protectors have traditionally fallen into two categories: voltage limiting and voltage switching. Voltage limiting devices rely on the Zener effect and are exemplified by MOVs and silicon avalanche diodes (SAD).

Voltage switching devices rely on an ionization effect typical of both gas discharge tubes (GDT) and spark gap arresters. Switching devices are frequently used in the rail signaling industry primarily because of their "normally open" characteristics. It is common, however, to find devices that have suffered carbonization between electrodes which can lead to shorting. In addition their relatively slow operation and higher let-through voltage can lead to damage, poor performance and a premature end of life of electronic equipment.

Research over the past decade has led to a hybrid design taking advantage of the best operating characteristics of voltage limiting and voltage switching devices, resulting in state-of-the-art two-stage protection products.

While the medical, telecommunication and broadcast industries have been using hybrid surge protection systems for years, the rail and transit industry believed to be adequately protected by single component protectors like spark gaps.

Two-stage devices used for panel and signal protection incorporate the latest generation of high surge capacity SAD components in parallel with rugged GDT and MOV components to provide a robust, fast-acting diversion path designed to protect sensitive electronic equipment. The SAD portion of a hybrid suppressor responds significantly faster than any single component MOV, GDT or spark gap arrestor. In less than a nanosecond it immediately clamps the voltage spike that would otherwise damage the signaling and communications electronics. During a surge event, the surge current instantaneously flows through the SAD element, causing a slight rise in voltage that triggers the additional GDT or MOV element to “fire” and provide a virtual short circuit to completely shunt all remaining surge energy away from the protected equipment. These hybrid suppressors are capable of deflecting an extremely high amount of surge current while still maintaining a low enough residual voltage throughout the surge event to sufficiently protect the equipment.

Hybrid Signal Protectors

Properly designed hybrid devices used for signal protection have consistently performed well in an open circuit condition. If an extremely high surge event (>20 kA) occurs the SAD element will be driven into failure, briefly shorting all available current and causing the series fuse element to open. Further surge will be deflected by the GDT portion of the suppressor additionally present in the circuit. If the subsequent events are of sufficient magnitude (again >20 kA), the wire leads of the GDT element may vaporize and leave the two-stage suppressor in a completely open state with no leakage or short circuit evident to the signaling circuit.

AC Panel Protectors

For AC panel board protection MOV devices have been the overwhelming choice of most rail and transit systems, despite its degradation characteristic. After each instance of an MOV “firing” and diverting surge energy to ground, degradation follows and eventually results in failure and the need to replace the surge protector. In contrast, hybrid devices utilizing SADs in conjunction with MOVs react quicker and degrade at a much slower rate, substantially extending the life of the unit.

Installation concerns surrounding AC panel protection units have also surfaced over the past several years. AREMA Committee 38 recently investigated intermittent AC breaker tripping issues and found that they were directly related to surge protection devices installed via sub-breakers at the main AC supply panel. These sub-breaker fed surge protectors react to the presence of long duration man made surges causing the intermittent breaker to trip. When the breaker that feeds the surge suppressor has opened, the suppressor is disconnected and unable to protect the equipment. This now allows surge energy to enter the AC panel board, traveling through the battery charger and into the vital S&C equipment, damaging the equipment and causing operational downtime.

To properly protect the equipment from surge energy on the AC power side, a safe disconnecting means should be incorporated. During fault current it will open and allow surge current to pass through effectively deflecting the surge. Many fuse manufacturers produce “surge rated” fuses that will operate in this fashion. Utilizing these fuses as the safety disconnect device for surge suppression will limit the intermittent breaker trip issue and reduce the failure of signal & communications equipment.

Regardless of the application, whether it is AC panel protection or signal protection, improved installation techniques as outlined in AREMA committee 38's findings will only be effective if the protector itself provides a high level of suppression.

The metal skin of a bungalow effectively acts as a Faraday cage, and can carry current from lightning EMF fields to the ground rods. Since lightning or utility created surges cannot be stopped from entering the bungalow on the incoming AC power feed it is important to apply protection at this particular location as first line of defense. To perform effectively, it must turn on quickly and protect even under abnormal conditions. In addition it must be installed properly with the lead length between the unit and the power source as short as possible, because for every increase in lead length between the AC power protector and the incoming feed, the turn on voltage of the unit increases as well. It is important to follow the manufacturer's installation guidelines and provide a good ground source to divert the surge energy away from the electrical equipment. Recent observations at several railroad installations, however, identified many multi-location bonds to the skin of the bungalow. This ultimately leads to ground loop currents along with the resulting equipment malfunctions and failures. Therefore it is recommended that each piece of equipment is tied directly to one ground bar instead of daisy chaining them.

RF Protection for Radios and GPS Equipment

The rail and transit industry has been using gas tube coaxial connect RF protectors for years despite the existence of a better protection technology. Although inexpensive, gas tubes perform inconsistently and degrade over time until eventual failure. Unfortunately these devices do not indicate when they have reached their saturation point and most maintainers replace RF protectors only when the equipment is damaged. The new, sophisticated and expensive radio and GPS equipment used in PTC, however, require reliable protection to effectively ensure the safe operation of the railroad at all times.

PTC related equipment utilizing a coaxial cable to transfer information, should be safeguarded through RF protectors with "filter" technology. The filter unit provides a quicker reaction and lower throughput energy since it is always on, utilizing in series conductors. Gas tubes on the other hand require a period of time for the gas to ionize resulting in a higher turn on rate and possible damage to radio and GPS equipment in the meantime. In addition, as mentioned before these gas tubes also degrade over time. Filtering units will not degrade and require little or no servicing unless a catastrophic incident occurs causing system wide damage.

Single-Point Grounding

Whenever RF protectors are used in an enclosure that also contains equipment that is grounded on the incoming AC side, referencing each piece of equipment to the earth at different points can be detrimental to equipment, as well as safety. Since the earth is a very poor conductor, steady state and momentary voltage differences exist in the soil. If the equipment includes high-speed communication interfaces, with each one connecting to the earth at different points, these voltage differences can cause ground loop currents (IG), which pose a safety threat and could lead to equipment downtime.

To protect PTC's inherent objective of reliably safeguarding railroads, using a single-point grounding system is recommended.

Conclusion

Positive Train Control promises a new level of safety and efficiency for U.S. railroads. To deliver on its promise, reliable data transfer must occur. One component of ensuring the uninterrupted data transfer is surge protection, which has to meet new demands as the components of PTC continue to advance in sensitivity and complexity. Several new technologies are available to effectively and reliably protect from surges and thus contribute to the PTC goal of preventing collisions, derailments and consequently injuries and casualties to roadway workers as well as costly disruptions to traffic flow.