SCHWEITZER ENGINEERING LABORATORIES, INC.
WHITE PAPER

Electromagnetic Pulse Effects, Industry Standards, and Solutions

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Introduction

An electromagnetic pulse (EMP), or a transient electromagnetic disturbance, creates a burst of electromagnetic energy that spreads over a range of frequencies and can damage or disrupt the function of electronic equipment. This white paper provides an overview of the various EMP threat categories, the effects of EMP on protection and control systems, and a selection of electromagnetic compatibility (EMC) standards for protective relays and other intelligent electronic devices (IEDs). The paper also discusses how protection and control enclosures mitigate potential EMP impacts, and it provides alternative design considerations to minimize or mitigate the effects of EMP.

The Threat

The following are two categories of EMP threats:

- High-altitude electromagnetic pulse (HEMP), such as a nuclear burst at a very high altitude.
- Intentional electromagnetic interference (IEMI) caused by repeatable pulses directed by antennas, with a much smaller intensity and area affected.

EMP Effects on Protection and Control Systems

EMP can result in strong electric and magnetic fields, causing voltages and currents to be induced on conductors. EMP can disrupt or damage electrical or electronic equipment, with simultaneous effects over a wide area.

EMP effects are similar to any harsh electromagnetic event found in power systems, such as lightning strikes, radio frequency interference (RFI), high-voltage surge events, and so on. However, the effects can have greater severity and can occur at various frequencies. EMP-induced currents and the resulting voltages on conductors connecting equipment in the substation yard to the control enclosure are a concern.

Standards for Relays and Other IEDs

Standards used by the power industry for protection and control IEDs are typically more severe than commercial or industrial equipment standards. Asset owners should consider the criticality of the asset, specify the appropriate severity levels listed in the standards, and select products that meet or exceed the standards.

The following are existing standards related to EMP for protective relays:

- IEC 60255-26 Edition 3.0, Measuring Relays and Protection Equipment – Part 26: Electromagnetic Compatibility Requirements. This standard and its predecessor standards establish requirements for the EMC of protective relays.
- IEC 61000-6-6, Electromagnetic Compatibility – Part 6-6: Generic Standards – HEMP Immunity for Indoor Equipment. This standard establishes HEMP immunity requirements for generic electrical and electronic equipment installed indoors. Various immunity levels are specified and applied based upon the degree of radio frequency shielding provided by the equipment enclosure.
- MIL-STD-188-125-1, High-Altitude Electromagnetic Pulse Protection for Ground-Based C41 Facilities Performing Critical, Time-Urgent Missions – Part 1: Fixed Facilities. This facility standard is approved for use by the United States Department of Defense, and it contains technical requirements and design objectives for HEMP protection of fixed and transportable systems and facilities.

SEL relays are designed and tested to industry EMC standards for protective relays. Depending on the application specifics, including equipment location and cable installation practices, devices meeting existing standards for protective relays can meet or exceed many of the electromagnetic immunity requirements established by IEC 61000-6-6.

To learn more about how SEL designs quality and reliability into our products, including type testing, margin testing, product validation, and certification methods, visit https://www.selinc.com/SELquality/DesigningQuality.

Impact of Using Protection and Control Enclosures

SEL designs and manufactures control enclosures and IEDs that are hardened to protect against traditional electromagnetic effects. SEL control enclosures provide conductive metallic barriers that, when properly grounded, attenuate electromagnetic fields. Both the conductive chassis enclosing the IEDs and the closed cabinets surrounding them provide additional shielding. Note that SEL has not specifically designed an enclosure to comply with MIL-STD-188-125-1.

Alternative Protection and Control System Designs

A significant threat to substation control room equipment is EMP-induced current on conductors from the switchyard. These conductors can run for long distances before entering the control room and can be in close proximity to electronic protection and control devices, if not directly connected to the relays. To avoid induced voltages entering the relay, many utilities are identifying ways to minimize wiring between the substation yard and the control enclosure. SEL provides several solutions for this, including fiber-optic transceivers and remote contact I/O modules.

Conclusions

Asset owners concerned about EMP and other more common electromagnetic events should specify substation-hardened relays, controllers, and computers (not commercial or industrial platforms). Control enclosures compliant with MIL-STD-188-125-1 are expensive and require specialized tests. Existing control enclosure designs, such as those created by SEL, provide substantial shielding without added expense. It is helpful to reduce the electrical points of entry using alternatives such as fiber optics.

SEL is committed to providing equipment that meets applicable standards today and in the future. To learn more about SEL solutions, including protective relays, controllers, computers, fiber-optic transceivers, remote contact I/O modules, and control enclosures, visit http://www.selinc.com or contact a local sales and support engineer by calling +1.509.332.1890.

BIOGRAPHY

Lee Underwood received a B.S. in Electrical Engineering from the University of Virginia in Charlottesville in 1990. From 1990 to 1996, Lee worked as a design and systems engineer for Duke Power Oconee Nuclear Station, with emphasis on dc power systems, medium- and low-voltage switchgear, and protective relaying. In 1996, he joined Duke/Fluor-Daniel and participated in the design and construction of electrical systems for coal-fired power plants. He joined Schweitzer Engineering Laboratories, Inc. as a field application engineer in 2004, and he is currently a Research and Development director. Lee is a member of the IEEE Power Engineering Society and a registered professional engineer.

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