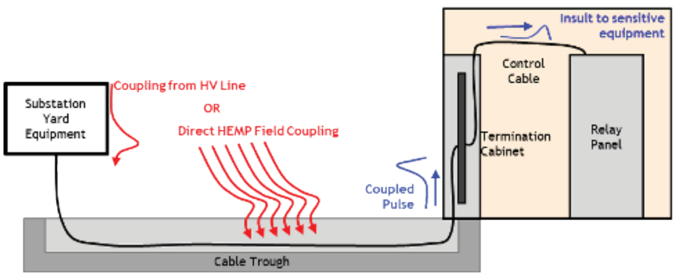
HYBRID SYSTEM-COMPONENT MODEL DEVELOPMENT FOR LOW-COST HEMP TESTING

This project will create a methodology for modeling components or structures in an electrical system. These models will be used for relating system level events to insults arriving at specific pieces of critical equipment. This will be particularly useful for assessing high-altitude electromagnetic pulse events on the grid by directly relating the coupling of large systems or circuits to individual devices. The goal is to predict what areas of the grid are truly vulnerable and where mitigation technology is needed.

THE CHALLENGE



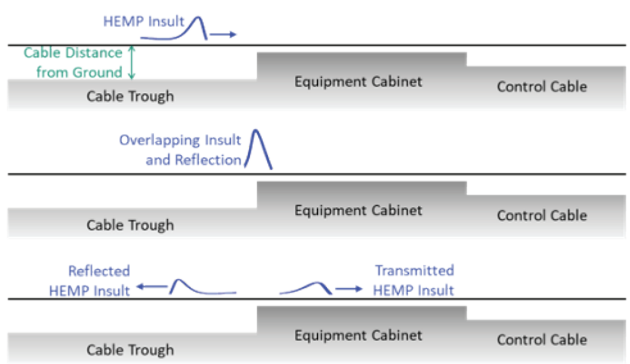
Example EMP propagation in an electric substation.

This project will enable more accurate assessments of the vulnerability of energy and critical infrastructure to electromagnetic pulses (EMP). This is done by accurately predicting how electromagnetic pulse transients spread through generation and substation systems. This work will support current EMP vulnerability knowledge by allowing existing component-level tests to be viewed in the context of a system during a pulse event. Additionally, this work will support future vulnerability assessment efforts. Pioneering this type of research and development directly complements research activities by DOE, DHS, the NRC, and other government agencies. Specifically, this research aligns with Executive Order 13865 – Coordinating National Resilience to Electromagnetic Pulses. The outcome of this project will be critical for energy sector owners, operators, manufacturers, and regulators.

APPROACH

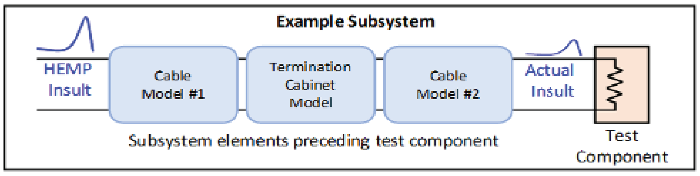
This project proposes to define a methodology for predicting attacks at components from HEMP coupling in a system. Current methods that assess vulnerability of power systems equipment only rely on applying insults directly to the component input while they are disconnected from the system. Methods produced in this work will enable the generation of Xyce-compatible circuit models. Ultimatley, representing the system to which a test component is connected that can be used to predict the actual insult expected to arrive at sensitive equipment and determine whether a vulnerability exists.

In addition, time domain implementations of the models will be developed using lumped element and transmission line analysis of equipment and transitional wiring structures. This is meant to represent reflection and absorption that will affect the EMP pulse as it proceeds to the component under test. This work will focus on development and demonstration of the methodology for generating the circuit models on critical system elements, while defining the approach to broader analysis for future work.



Time-domain representation of pulse behavior.

EXPECTED RESULTS



Subsystem representation with modeled elements.

The primary outcome of this project will establish the methodology for circuit model generation. This initial technique will focus on typical installations and features in an electrical installation on the power grid, including typical wire and cable installation configurations and transitional elements like termination cabinets and circuit breaker panels. A few select cases of equipment will be selected for demonstration of the methodology via development of the circuit model and experimental validation. Experimental responses of the equipment to conducted EMP will be used to further refine the modeling approach. The combined modeling demonstration and experimental validation will serve as a proof of concept for the methodology, and will lay out initial planning for follow-on activities to expand model development for broader use. Finally, a SAND report will be delivered by the completion of this one-year project.

EXPECTED IMPACT OF THIS RESEARCH

Successful completion of this project will enable more cost-effective and accurate vulnerability assessments of electrical systems by integrating component-level failure thresholds and vulnerability into system-level analysis. This will directly impact the ability to determine the true vulnerability of a system without resorting to costly system-level tests. This capability directly impacts DOE, NNSA, and DHS missions under Executive Order 13865 – Coordinating National Resilience to Electromagnetic Pulses. Developing technologies to maintain the US national electric infrastructure security during a HEMP event will prodvide the technology basis to protect other national infrastructures as well. Completion of this research will enable mitigation and informed response to threats by ensuring the US domestic infrastructure is capable of withstanding nuclear HEMP detonations. Implementing science and technoloy solutions will support the accomplishment of these goals; therefore, increasing National Security by preserving critical energy infrastructure.

RESILIENT ENERGY SYSTEMS

Sandia's investment in this project is part of its Resilient Energy Systems portfolio of projects, coordinated R&D that addresses the resiliency of the nation's energy systems. The ability to relate system and component level vulnerabilities via modeling supports the understanding of the energy grid vulnerability as a whole and is vital to provide effective planning of mitigation technologies and techniques. This work will develop the tools needed to perform that assessment and to construct models and functions that allow for predictive action to increase grid resilience.

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