SHAZAM: A TECHNIQUE FOR SELF-HEALING AND HIGH RESILIENCE OF POWER-ELECTRONICS SOURCED NETWORKED MICROGRIDS

SHAZAM is a technique for controlling power system line and load relays to enable power systems with geographically dispersed power electronics-based sources to be self-healing following major disruptions, without the need for high-speed networked communications.

THE CHALLENGE

Self-healing power systems (SHePS) can be extremely resilient after disruptions. However, most SHePS techniques today require the use of high-speed networked communications (HSNCs), which increases costs, can reduce resilience and reliability, creates certain cybersecurity risks, and hinders scalability. Furthermore, many commonly used power-system protection and restoration techniques were developed for rotating generation and may not work well with power electronics-based sources (PEBSs) and solid-state transformers. To address part of DoE's national security mission to invest in protections against cyber and physical attacks on U.S. energy infrastructure, SHAZAM will enable power systems that are resilient from natural disasters, or intentional attacks such as high-altitude EMP (HEMP) bursts and certain classes of cyberattacks, without using HSNCs. SHAZAM will provide self-healing capabilities that result in reduction of outage time and diminished negative consequences of these events, ultimately reducing the risk posed by these events.

APPROACH

SHAZAM is a holistic approach combining aspects of inverter controls, power system planning, and power system protection and restoration. The controls of the PEBSs are configured according to a set of rules that provide automatic overload protection, and the loads' smart meters and line relays include specific functions such as "undervoltage load shedding" (UVLS). Load shedding is sequenced based on load criticality. This approach does have some challenges:

1. Increased number of breaker operations, reducing their lifetimes.
2. Need to prevent accidental mesh formation or thermal overload of conductors
3. Need to detect series faults (open circuits) or malfunctioning relays which may be a dominant failure mode during a deliberate attack.

This project will address the above obstacles via cutting-edge approaches including:

1. Expansion of standard relaying funtions using machine learning (ML), reinforcement learning (RL), or non-standard distributed spiking computation algorithms to improve speed and selectivity.
2. Application of statistical relaying to series faults and accidental mesh formation
3. Use of voltage modulation to prevent thermal overload of microgrid components.

EXPECTED RESULTS

The SHAZAM project will result in the following deliverables:

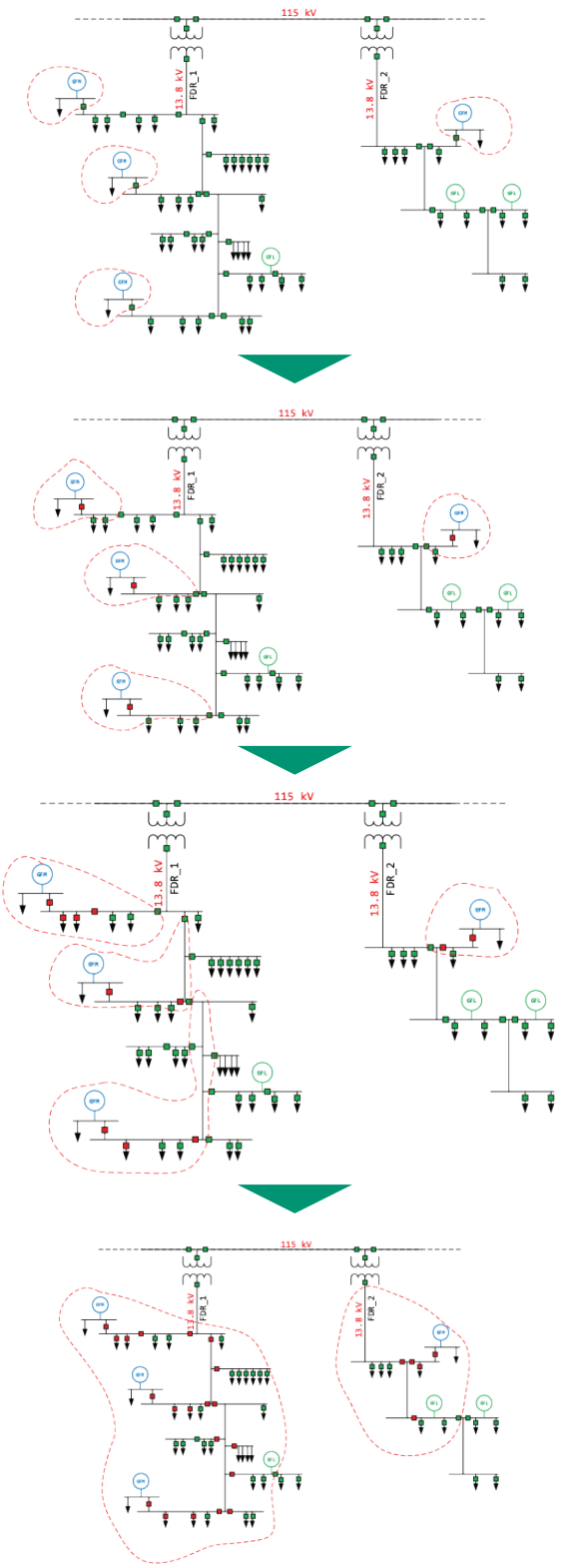
1. Patent applications on three new protection and restoration tools
2. Simulation models for all of the relevant components
3. Reports documenting the SHAZAM method and theoretical and simulation-based demonstration of its effectiveness

EXPECTED IMPACT OF THIS RESEARCH

SHAZAM will enable the creation of PEBS-based power systems that can spontaneously disassemble and reassemble themselves such that during major disruptions, all loads for which there is sufficient generation capacity and an intact source-load path will be energized in a relatively short period of time, without using HSNCs. This can be achieved using existing commercially-available hardware. SHAZAM will positively impact national security by reducing the risk posed by attacks to the power system. Implementing SHAZAM will inhibit widespread blackout. The only way to cause a long-term widespread blackout would be to physcially damage all sources or paths between each source and load.

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. Sandia's Strategic Direction and Priorities includes these priorities: (#4) invent and demonstrate pathfinder systems to address threats; and (#6) unleash the power of Sandia. This project does both things. The SHAZAM concept is a pathfinder system both figuratively and literally. It leverages Sandia's expertise in machine learning, adaptive protection, power system optimization, and computer "digital twin" simulation of systems. We are unleashing the power of Sandia through interdisciplinary collaboration. We are building a strong partnership with NMSU. We believe this concept has excellent potential for technology transfer, unleashing the power of Sandia-developed ideas into industrial practice.



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