SOFTWARE-DEFINED ELECTRICITY

NATO Innovation Hub Challenge Abstract

Our NATO Innovation Hub Challenge Solution

In this abstract, we describe how the use of our patented technology, called Software-Defined Electricity (SDE), solves this challenge. SDE delivers unprecedented control of electricity using an innovative computing power electronics to assist in detecting, protecting, mitigating, and recovering from an Electro-Magnetic Pulse (EMP), sun flare, or similar disruptive events.

3DFS

3DFS is a private research engineering group with decades of research into electricity, its behavior, and the widespread effects from abnormal energy events like EMP and Solar Flares. Our company also has expertise in power sensing and controls.

Introduction to Software Defined Electricity

SDE is an edge, model-based computing power electronics system. It is a valuable tool in the detection, prevention of EMP damage, mitigation and recovery from EMP and Solar Flare scenarios outside the initial blast zone. It can be used to protect land, air, and maritime assets.

Instead of traditional electricity measurement, SDE relies on proprietary Real-Time electricity modeling. Through intelligent sensing, error free data is acquired on 26 electrical parameters (i.e. current, voltage harmonics, active power, reactive power, etc.) in 24-bit resolution every 6 nanoseconds. All input timing is synchronized and immediately fed into a model for deep real time power flow analysis to determine what corrective action is required.

3DFS power electronics operate at the microsecond level based on Real-Time electricity modeling. The Flash Energy Storage System (FESS) is a transistor-based injection/consumption energy storage system that responds each microsecond based on the real time need.

The speed and precision of the power electronics is critical because it minimizes the amount of energy required to make corrections, resulting in a true 98%+ efficient solution.

The in-market SDE power controller, VectorQ2, corrects energy used in power circuits with up to 60 kW of load. The VectorQ2 includes dynamic, non-degrading class B lightning protection (which is a mini EMP). It consumes an average of 70W with a maximum power consumption of 120W. The size and weight of the VectorQ2 is shown in Figure 1 below.

Figure 1: VectorQ2 Dimension and Weight

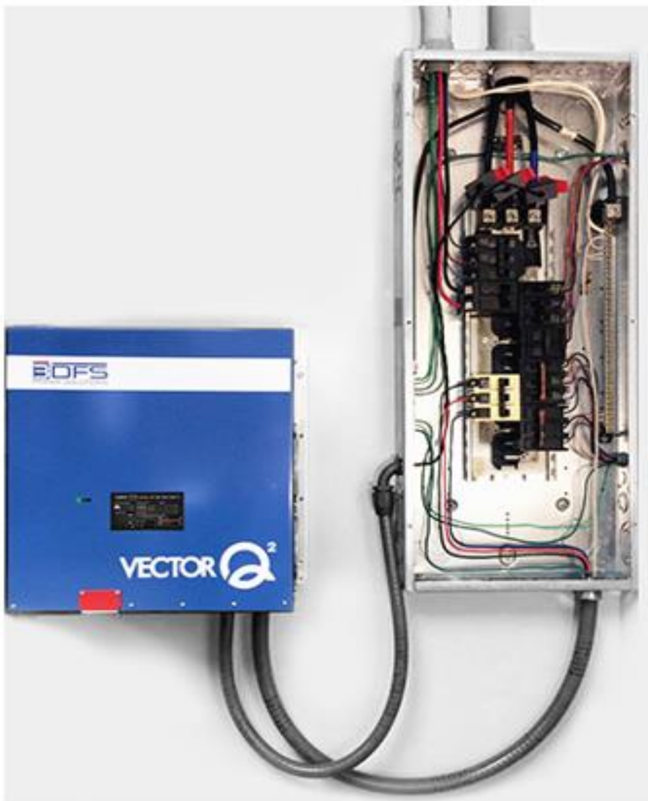
PHONE
+01 919 973 6244
+01 919 807 1884

WEBSITE
power@3dfs.com
www.3DFS.com

ADDRESS
1911 NC-902
Pittsboro, NC 27312
United States

The VectorQ2 is simply installed on a spare breaker with a typical install time of less than 30 minutes. A VectorQ2 installed on a circuit panel is shown in Figure 2 below. Being a simple “plug and play” device, it does not require any specialized training for installation. The VectorQ2’s small footprint and light weight allows for installation in existing electrical infrastructure.

Installation of VectorQ2
Power Controller



VectorQ Series Power Controllers are installed in parallel with the network (3 CTs, 3 pole breaker, Neutral, Ground), within 30 minutes.

Figure 2: Installation of VectorQ2 in a Circuit Panel

PHONE
+01 919 973 6244
+01 919 807 1884

WEBSITE
power@3dfs.com
www.3DFS.com

ADDRESS
1911 NC-902
Pittsboro, NC 27312
United States

SDE is a fully enclosed system added on top of existing infrastructure to optimize power flow. It does not require any redesign of the power network. Once activated, no matter how aggressively the power is consumed within the circuit, the power quality remains ideal. SDE automatically balances power flow across all phases. It corrects both harmonics up to the 23rd to under 2%, and power factor to unity. The result of this is improved efficiency, performance, and reduced maintenance for all electrical equipment and generators connected to the VectorQ protected electrical network.

Using 3DFS SDE for EMP Detection

EMP travels in waves. In oceans preceding a tsunami, shore water recedes significantly back before the inrush. A similar phenomenon is true with EMP in power networks providing an unmistakable signature that triggers an instant reaction. For EMP in particular, if not detected in time, devastation is inevitable, making time the most precious resource. The sooner it is detected, the more time there is to react, making sensing the most important aspect of prevention or mitigation.

SDE operates on the principle of oversampling the inputs to extract the maximum amount of information on the power flow to provide the most amount of time possible to react and provide correction to any energy event. This detection and correction can be seen in Figure 3 below showing 7 cycle period of three phase power initially without SDE VectorQ2 correction (Vector Q2 Off) and then with SDE VectorQ2 correction (VectorQ2 On).

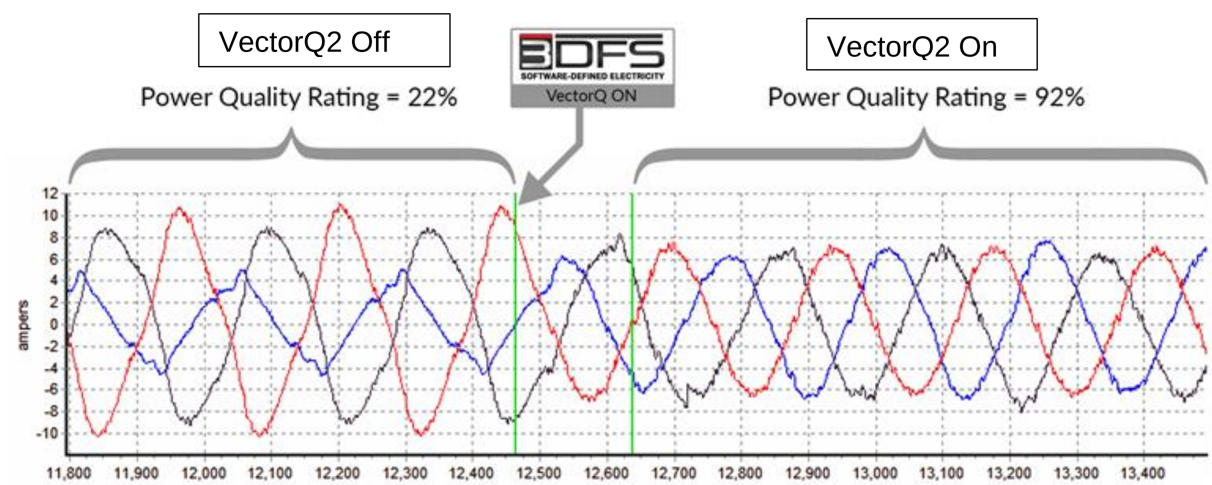


Figure 3: SDE VectorQ2 Detection and Correction of Energy Events

PHONE
+01 919 973 6244
+01 919 807 1884

WEBSITE
power@3dfs.com
www.3DFS.com

ADDRESS
1911 NC-902
Pittsboro, NC 27312
United States

With the SDE VectorQ2 turned on and detection and correction performed there is an improvement in Power Quality Rating from 22% to 92%. This means that most of the energy being used after correction is being used to perform useful work instead of generating heat, the main by-product of poor power quality. In this real example, energy savings will be within a range of 17% to 44%.

EMP Damage Prevention

EMP damage prevention of electrical assets depends on the strength and proximity to initial EMP blast zone. Outside that blast zone, the level of protection depends on the quality of preventative and protective measures that are in place.

SDE uses the FESS for dynamic surge protection. The inductive portion of the FESS is contained in an enclosed unit within the power controller that is oil, water and air cooled. When any abnormal energy event surges are detected, the system dynamically shunts the excess energy into the FESS and fully runs all cooling systems to absorb the energy and emit it as heat. Real-Time electricity modeling continues to track the surge throughout its duration, and SDE resumes its normal correction activity after the event. The level of surge protection is maintained and does not degrade over time or after events, ensuring continuous protection of the network and assets. This dynamic shunting provided by SDE prevents the destruction of semiconductors and electronic components.

Using SDE and the FESS method, SDE products can be specifically engineered to meet the level of EMP protection required for assets (buildings, bases, power plants, etc.) at any scale as well as entire power networks. SDE products can be adapted and installed into terrestrial vehicles, planes, ships and submarines.

EMP Mitigation

SDE is a detection and control tool that definitively delivers the capability of reacting at the speeds required to mitigate damage from all energy events. SDE must be integrated into the power network presently in place to improve the precision and response time.

By incorporating SDE within power networks, the capacity of the grid infrastructure and assets is increased by reducing the electrical energy waste that is naturally present in AC power flow. This energy waste reduction extends to the backup power systems as well, which are generally smaller than the main power supply and are more susceptible

PHONE
+01 919 973 6244
+01 919 807 1884

WEBSITE
power@3dfs.com
www.3DFS.com

ADDRESS
1911 NC-902
Pittsboro, NC 27312
United States

to instability related to the effects of poor power quality. SDE increases the reliability of the assets and infrastructure before, during and after abnormal electrical events.

EMP Recovery

There are two main tasks that have to be incorporated in an EMP recovery plan. The first is evaluation of the electrical equipment/assets after the blast, and the second is the prevention of further damage to the surviving equipment/infrastructure.

In any recovery effort, the first step is to understand what the current status is and extent of damage. SDE VectorQ2 provides this information for all electrical equipment connected/protected by the VectorQ2. The VectorQ2 accomplishes this task by the constant comparison of each electrical equipment's electronic baseline signature and current measured signature. Deviation from this baseline indicates degradation of that piece of equipment. Examples of electronic equipment baseline signatures as measured by SDE VectorQ2 are shown below in Figure 4.

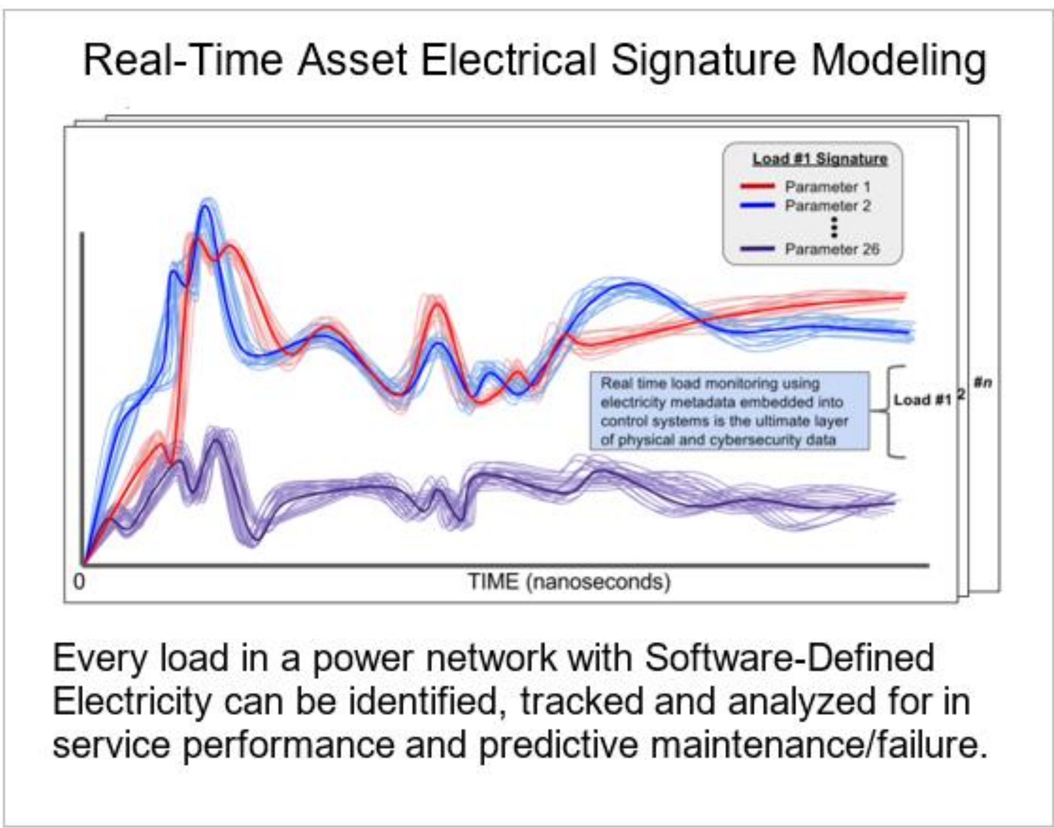
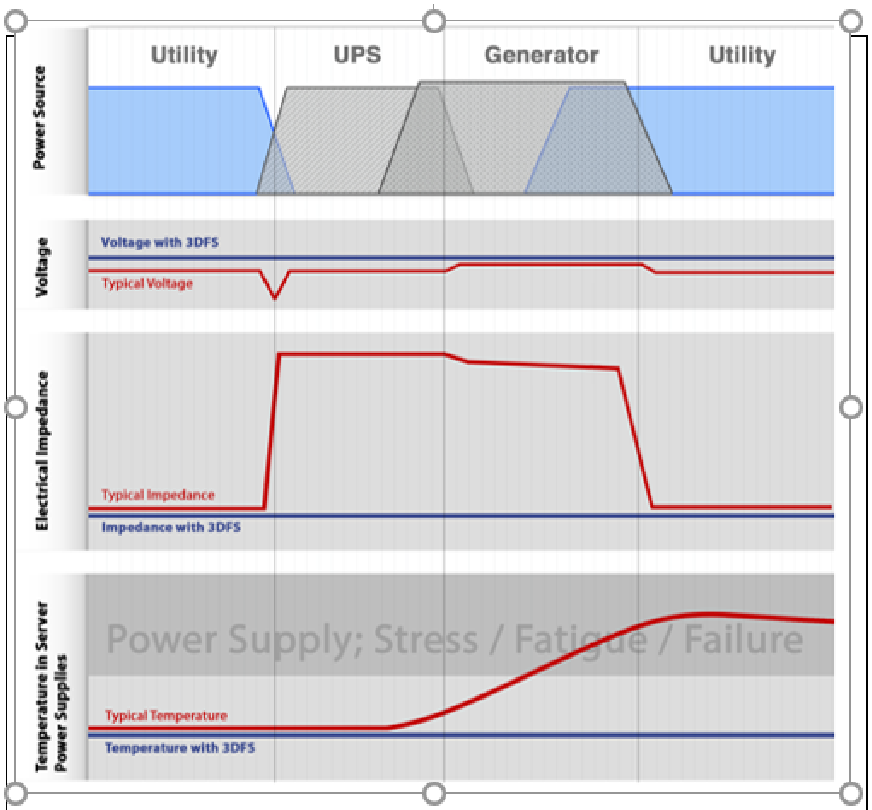


Figure 4: SDE VectorQ2 Baseline Electronic Signature Example

The second task is to prevent further damage to electrical equipment, power sources, and infrastructure. It is probable that backup power supplies will be utilized during the recovery period. These power sources include generators, inverters operating off of batteries storage systems, and other alternative energy sources. These energy sources are typically smaller that the electrical grid and can't supply constant power at the same power quality level normally provided by the electrical grid. This can cause additional stress on the electrical equipment. An example of this is shown in Figure 5 below which shows how variance of electrical system impedance and voltage can impact of server power supply temperature/reliability.



Backup generation does not deliver the same power quality as the main source and causes stress on both the infrastructure and assets unless protected by 3DFS Software-Defined Electricity

Figure 5: Effect of Variance in Impedance/Voltage on Server Power Supply

PHONE
+01 919 973 6244
+01 919 807 1884

WEBSITE
power@3dfs.com
www.3DFS.com

ADDRESS
1911 NC-902
Pittsboro, NC 27312
United States

Improve Society Resilience

SDE provides an automated layer of intelligence in the power network delivering optimal power flow while maintaining complete asset and infrastructure awareness and power correction. This layer improves the overall performance of the grid by preventing power fluctuation from affecting operations and generation. Distributed installation of SDE devices protects electrical equipment from all abnormal energy events, not just major ones. As more SDE devices are installed into the infrastructure, buildings, and houses, the grid will become more resilient and stabile. Abnormal energy events including EMPs, are constantly anticipated, examined, and corrected automatically in an easy to install, plug and play solution.

As the power quality of the grid improves through SDE, so will the efficiency of the operating equipment and power generation plants. This will reduce energy consumption and CO_2 footprint. SDE further solves the major interconnection problems related to incorporating alternative energy resources in power networks.

Conclusion

SDE is a viable solution to protect against abnormal energy events including EMP, Solar Flares and many others. It is installed easily within 30 minutes, provides instant verification, self-reports internal problems, has no maintenance except for periodic cleaning, and requires no software updates for the life of the machine.

This new innovative technology provides invaluable information on power flow within grids and networks. It is a non-invasive way to acquire preventative maintenance information on all connected electrical equipment for accurate real time asset assessment and management.

The SDE solution is scalable and can be customized for maximum EMP protection in onshore or offshore assets. It is presently being designed, manufactured and commercialized within the United States. The current production facility has the capacity to ramp up to 10,000 units per week for rapid deployment.

Contact: Mike Gaffney
Senior Engineer, 3DFS Maritime Division
Senior Engineer, Navis Energy Management Solutions
mgaffney@navisenergy.com