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Mobile STATCOM
A Multi Tool for Transmission Operations, Construction and Rapid Restoration

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SUMMARY

The rapid evolution of the grid requires the need for new and innovative technologies to operate, construct, and maintain electrical service. Traditional equipment and techniques are not timely or efficient, nor do they maintain reliability during replacement or upgrade of transmission. The deployment of temporary and mobile support for fast voltage mitigation and regulation is necessary. Development of power electronics designed to apply voltage source converters in a multilevel modular converter configuration will provide the technology needed to reduce size and weight for a mobile solution. Non-traditional deployments of Flexible AC Transmission (FACT's) devices are economical and reduce the time needed for construction or maintenance.

KEYWORDS

STATCOM, Capacitors, Reactors, Mobiles, Voltage Mitigation

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Changes to the transmission system have traditionally been slow and incremental as load growth and development was methodical and predictable. Environmental regulatory changes and new generation incentives have sparked rapid and profound changes to utility transmission systems. The development of the new generation market coupled with economic incentives to install renewables, has profoundly changed the way transmission systems operate. Dispatch of generation and system operation is based on market signals and managed by newly formed Regional Transmission System Operators (TSO); leaving transmission system owners to fend for themselves to provide reactive support and to maintain voltage regulation.

The nature of the new grid development upsets traditional planning criterion as the changes are not in the addional five to ten year planning cycle. Traditional generation plants are closing and addition of renewable generation sites are constructed in the span of 18 months or less. The new generation location creates problems since it is not replacing traditional generation in the same location or size. To maintain the voltage stability regulation and tolerance is difficult since generation now is typically remote to the load centers. Installation and upgrading of new infrastructure is necessary to make the generation meet the load. New transmission lines, reconductoring of transmission lines and installation of shunt capacitors or reactors are some of the projects required to make the grid function properly again. The problem is how do you make the transmission transformation and still provide reliability and quality of service?

The updating or construction of transmission assets can create overloads and contingencies that can cause the power system to be stressed. To reconductor transmission lines the remaining transmission lines can become overloaded and cause voltage violations at specific load levels and contingencies. Construction has to start and stop based on load levels to prevent overloads and voltage violations. The transition of the grid is less reliable and not efficient due to the extra length of time. Constructing the grid with temporary structures and lines temporarily disconnected facilitates a critical vulnerability to normal weather disturbances. The installation of FACT's devices can provide the necessary transient and steady state voltage support but would only be needed during the construction or transition stages until the permanent transmission work is completed. A permanent or traditional FACTS deployment for example of an SVC or STATCOM is not cost effective or reasonable. System operators need a flexible tool. An effective solution is the development of mobile FACTS devices.

Study of multiple Dominion Energy construction projects predicts road blocks for normal operation at higher load levels. Frequent sources of voltage violations were noted and observed. An example of a line reconductoring project was studied. Area PSSE studies based on load level increases show voltage violations for N-1 contingencies. At larger load levels fault induced delayed recovery voltage (FIDRV) violations became more profound. Without additional FACTS support the only alternative would be to only perform construction during light load periods dragging a line rebuild out to possible 30 months. With the mobile STATCOM the line construction project can be a continuous process culminating in significant savings and enhanced reliability. You want to reduce the time needed that the system is broken apart for construction. Figure 1 below shows the basic fault case near peak load with a critical transmission line out of service. A FIDVR condition occurs that may cause an area voltage collapse. The worst case bus is mitigated with a +- 50 MVAR STATCOM

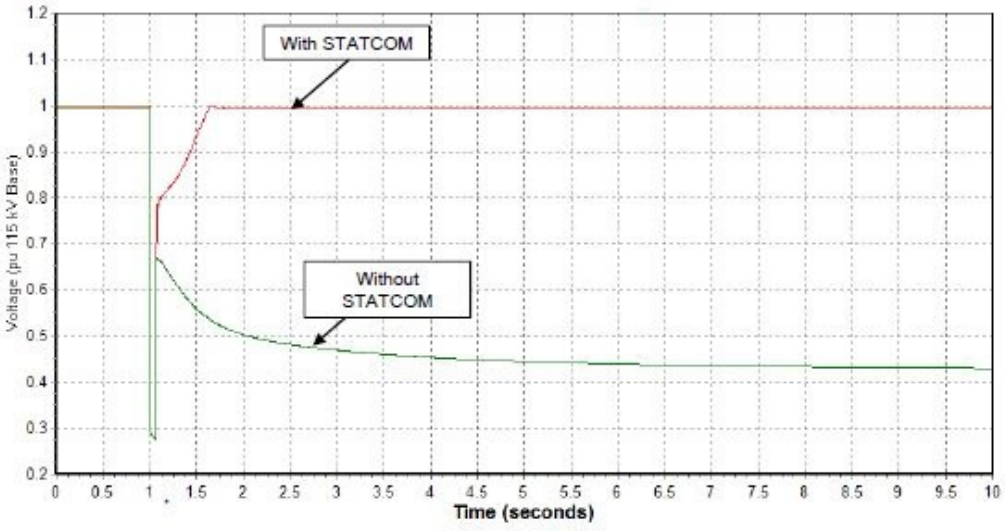

Figure 1 Worst Case Fault Before and After STATCOM Installation

Additional simulations were performed for N-1 and the results in Figure 2 show multiple stations with voltage below 90 % of nominal rating beyond the 2.5 second recover time. Multiple voltage violations are observed.

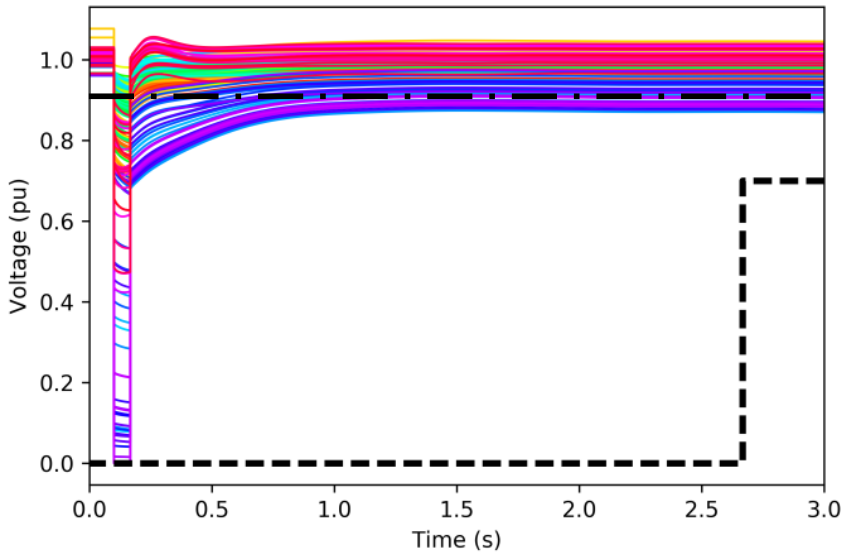

Figure 2 Uncompensated Substation Voltages after a Fault

The installation of a +- 50 MVAR STATCOM mitigates the substation voltage violations Figure 3 for the worst case N-1 conditions.

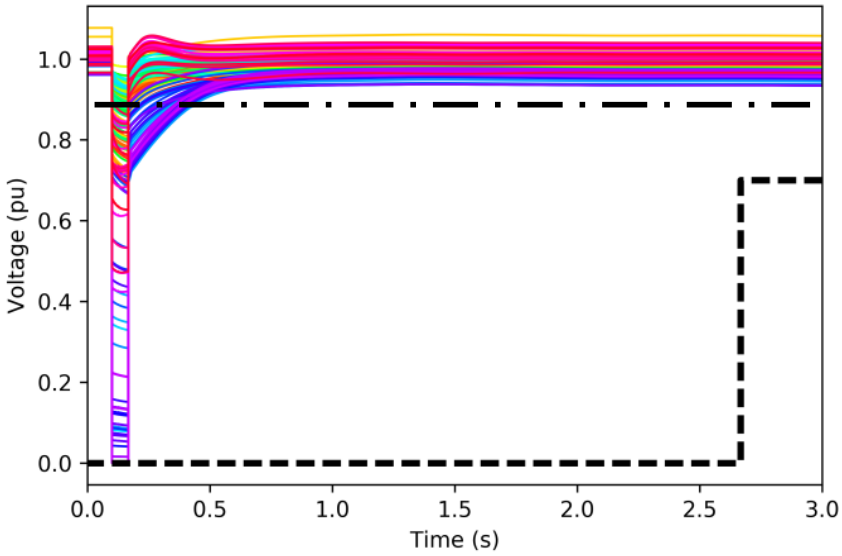

Figure 3Compensated Substation Voltages after a Fault

The need for fast reactive compensation is clear and present. The development of the voltage source converter (VSC) Modular Multilevel Converter (MMC) makes a mobile STATCOM possible. Smaller size and smaller package than traditional capacitor banks or shunt reactors. The challenge was to adapt the proven design of permanently installed STATCOMs in a substation control house, to a mobile concept. The requirement involved multiple engineering disciplines of mechanical, civil and electrical engineering. Design of a mobile STATCOM requires separating component equipment in to logical practical blocks that can be connected with temporary power and control cables. The Mobile STATCOM system was designed to be fully relocatable in a comparably short duration. The main trailer contains the STATCOM valves or submodules, Protection with Control and the Cooling System. The second trailer contains arm reactors. The third trailer contains all required auxiliary equipment such as auxiliary transformer, batteries, AC and DC distribution panels and storage. The heat exchanger is connected using stainless steel hose allowing for flexible location and orientation. All other equipment is designed to be temporary and relocatable for rapid deployment.

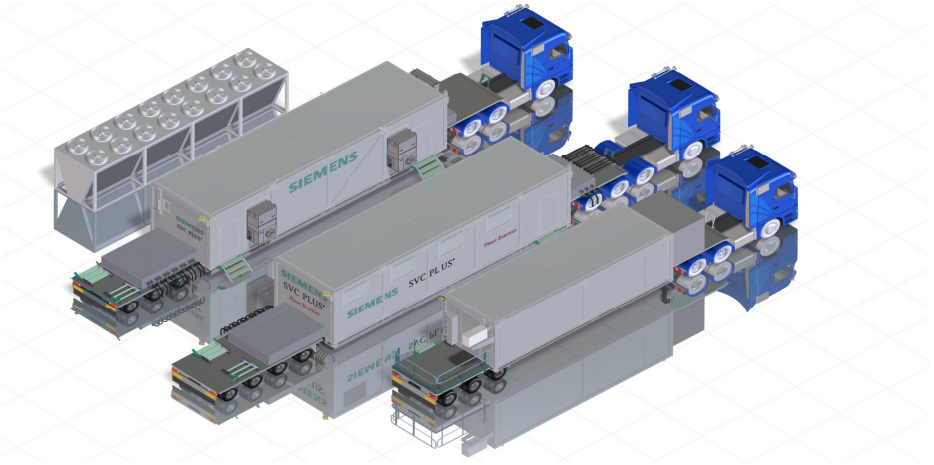

Figure 4 STATCOM Trailers and Components

The mobile STATCOM therefore can be relocated to any substation or temporary connection in a specific transmission system. The use of underground cables in this over ground application makes easy of location and fit possible. Laying the cable in temporary toughs is standard for mobiles applications. Future changes of the transmission system for example increase of harmonic contents are not an issue. The mobile STATCOM is designed to withstand the maximum harmonic planning levels in the transmission network and is therefore very robust.

The protection and control can allow for operation of remote devices such as shunt capacitors and or reactors which not only help coordinate steady state control but also help to extend the size and range of the STATCOM. In addition, the STATCOM has most of its reactive power output range available during system fault conditions (e.g. N-1). The control has standard features such as mitigation for power oscillation dampening (POD) , voltage balancing and hunting control to prevent interactions.

The Dominion Energy design provides for connection at 230 KV and 115 KV with a dual voltage transformer that can be switched manual. Connection to the transmission grid can be done using a traditional breaker or mobile breaker configuration on a bus or line. The only limit for design is the imagination of the engineer.