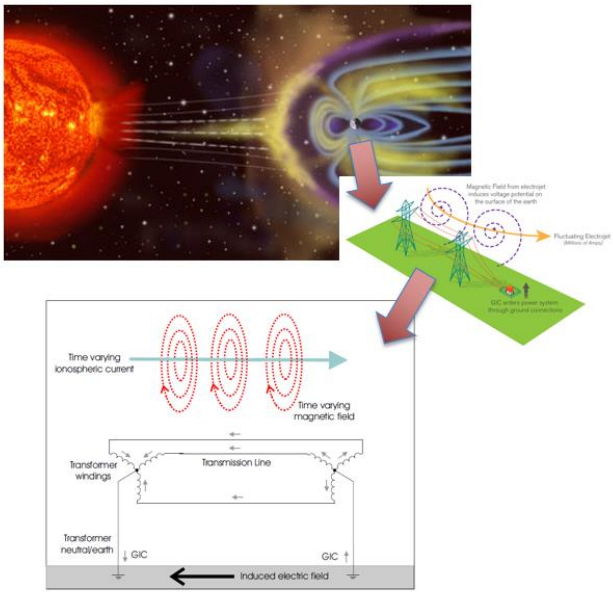
HVDC Grid Hardening against Geomagnetic Disturbance (GMD)

Dr. Yang Cao, Tohid Shahsavarian

Brief Description



Geomagnetic disturbances (GMDs) as most affective portion of solar activities on earth magnetic field have received much attention in recent decades due to their extensive impact on different type of installations and interconnected systems like pipelines, telecommunication system, especially power transmission grid. DC currents as a consequence of induced voltage, despite of having lower magnitude with respect to transmitted AC current in grid, can easily create a flux offset in HV power transformers which drives the core into half-cycle saturation as a crucial factor in tripping these key components or cause of disturbances in grid. Increase in fundamental component of the exciting current leads to increase in reactive loading, which cause voltage depression and collapse in bulk power system. Injected harmonic current, reactive power losses due to unintended isolation of required components such as capacitor banks, and protection system maloperation during GMD jeopardize network stability. Despite the challenges, modeling of complex phenomenon like GMD to assess its impact on large-scale power system would provide better understanding of problem to find out reliable solution for its mitigation. Most studies conducted on GMD vulnerability analysis at different regions susceptible to these solar storms aim HVAC network and evaluate reliability of components and their interaction with these disturbances. So, this project has been defined to evaluate performance of HVDC grid and provide reasonable solution for its hardening against this phenomena through comprehensive transient analysis on simulated grid.

Current Studies

To date, comprehensive studies on GMD impacts on US power grids has been carried out. Since, majority of researches and projects are defined to predict, categorize and analyze different scenarios of solar storms on HVAC grids, additional investigations for evaluating vulnerability of this event on HVDC grid has been done. Like HVAC systems, occurrence of GMD and induced currents would endanger normal operation of key components of HVDC systems. On the other hand, adverse consequence of any failures or disturbances in each AC or DC side could affect other side of the grid. Disturbances like voltage collapse or harmonics which affect the voltage signal, could give rise to commutation failure of valves. Although different filters are used to maintain operating voltage level in a stable and constant value, loss of VAR supports would affect performance of these components too. Commutation failure of valve group injects more harmonic components. In addition to AC voltage stresses on the transformer's windings, converter transformers are subjected to DC voltage stresses, as well as, half cycle saturation which endangers normal operation of transformers. Converters' control system as most important part of HVDC system and responsible to provide optimum performance of rectifier and

inverter in both side of HVDC grid would be affected by voltage distortion and extra commutation failure stress.

Modeling of interconnected HVAC/HVDC network by including all susceptible components, and assessing various probable scenarios will be efficient way to prioritize susceptibility of components in implemented grid and finding practical and optimal solution to avoid or mitigate flowing geomagnetic induced current to the grid. To this end, HVAC/HVDC network considering complete converters control system for planned HVDC network of Eversource has been implemented. Performance of HVAC system has been verified based on existing researches, and operation of HVDC system is examined.