HVDC Grid Hardening against Geomagnetic Disturbance (GMD)

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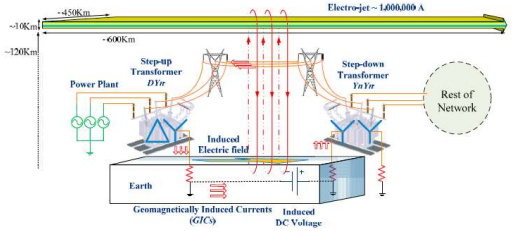
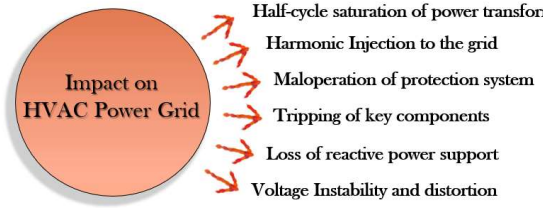
Introduction

Geomagnetic Disturbance (GMD) is a natural phenomenon initiated by solar activity. Solar coronal holes and coronal mass ejections (CMEs) are the two main categories of solar activity that drive solar magnetic disturbances on the Earth.

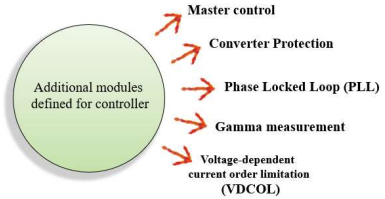


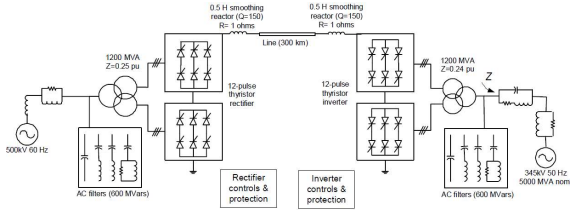
-At higher operating voltages , the average length of each line increases and the average circuit resistance decreases. These trends result in larger GIC flows in the higher voltage portions of the network, given the same geo-electric field conditions.

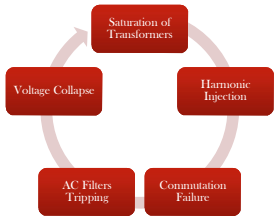


HVDC Grid Model

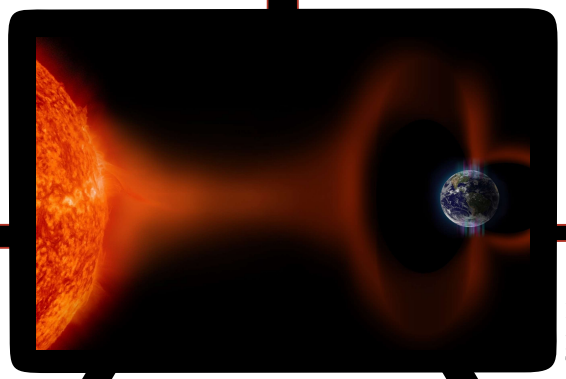
- GMD in HVDC grid was simulated with latest version of EMTP with accurate models of different types of transformers, frequency dependent transmission lines.
- Bipolar, Line Commutated Converter topology (12-pulse, 2X1GW, 500kV-2KA, 50/60Hz) was employed in GMD study for HVDC







Storm impacts on HVDC grid

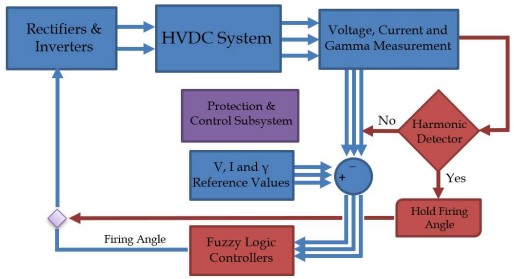


Improvements on Converter Controller

- Up to now, all studies carried out in this topic have focused on storms impact On Bulk AC power system and risk analysis to minimize its vulnerability.

- Our studies show possibility of maloperation of converters due to commutation failure in switches and bridge short circuit. Detection of harmonics and preventing increase of firing angle in inverters, provides enough deionization time for switches to release stored energy.

- Fuzzy logic algorithm has been used instead of conventional PI controllers to respond faster when severe voltage and current changes happen.



Research Objective

★ Comprehensive study of influence of GMD on power system, and evaluation of existing challenges in forecasting, modeling, and risk assessment of key components of power grid.

★ Investigation on geographical features, especially latitude and coastlines, and power system structure of New England, and their impact on HVDC grid.

★ Clarifying potential factors affecting HVAC power system which have deteriorating impact on one of HVDC systems planned by Eversource.

★ Identifying practical mitigating methods for avoiding or reducing entrance of GICs into the New England HVDC power grid.

Highlighted results

Proposed algorithm with fast harmonic detection and reactive power support control prevents tripping HVDC link due to injected even and odd harmonics during power Transformer half-cycle saturation.

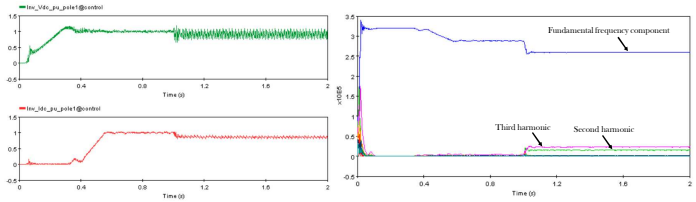


Figure description: DC system has been programmed to start within 0.4 sec. Right: Harmonic injection has been applied at 1ms (V3/V1=7.5%, V2/V1=5.8% and total THDv= 9.5%. Left: HVDC link voltage (green) and current (red) waveform.

References

[1] Randy Horton, and et al,"A Test Case for the Calculation of Geomagnetically Induced Currents", IEEE Transactions on Power Delivery, OCT. 2012.

[2] Innocent Oketch, "Commutation Failure Prevention for HVDC", Master's thesis, Chalmers University, 2016.