Spring 2016 Seminar Series

HYBRID AC—MULTI TERMINAL DC GRIDS: MODELING, ANALYSIS, AND CONTROL

FRIDAY FEBRUARY 19, 2016

11:00 AM – HEC 101

A sub-sea DC grid is envisaged to share the diverse renewable energy resources across different geographical regions (e.g. UK, Scandinavia and continental Europe; parts of North America). In this talk, a comprehensive modelling, analysis and control design framework aimed at evaluating the impact and potential benefits of DC grids on the surrounding AC networks will be proposed.

A generic averaged model for asymmetric bipole multi-terminal DC (MTDC) grid with the provision of metallic return network and a cascaded pi-section approximation of DC cables will be proposed to enable easy integration with the multi-machine AC system models for planning studies. The averaged model developed in Matlab/SIMULINK will be validated against a detailed switched model in EMTDC/PSCAD environment. Modal analysis will be presented to understand the root-cause of the temporal behavior of a hybrid AC-MTDC grid. Next, the concept of droop control for autonomous power sharing in MTDC grids will be presented and a novel adaptive droop control strategy will be proposed for appropriate power sharing taking into account the available headroom in each converter station. Impact of the droop constant on system stability will be presented and the advantages of the proposed technique in avoiding possible overloading will be established through extensive simulation studies.

The autonomous power sharing control will be modified with a frequency droop control loop to minimize the deviation from nominal AC system frequency and share the burden of frequency support among the converter stations of the MTDC grid. The sensitivity of the system eigen-values to changes in control parameters (e.g. droop coefficients) will be established through modal analysis. It will be shown that appropriate droop control loop for the MTDC grid converters could be effective in reducing the deviation from nominal AC system frequency. An analytical formulation for the post-disturbance steady state operating condition will be presented which corresponds with the simulation results for both AC side (generation load imbalance) and DC side (change of power reference or outage of a converter) disturbances. In this context the concept of `Inertial Coupling Matrix` will be proposed to develop insight into the system interactions.

Finally, a laboratory setup that can potentially analyze and validate the concepts and do future research on this topic will be elaborated.

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Nilanjan Ray Chaudhuri received his Ph.D. degree from Imperial College London, London, UK in 2011 in Power Systems. From 2005-2007, he worked in General Electric (GE) John F. Welch Technology Center as Edison Engineer. He came back to GE and worked in GE Global Research Center, NY, USA as a Lead Engineer during 2011-2014. Presently, he is an Assistant Professor with North Dakota State University (NDSU), Fargo, ND, USA. He is a member of the IEEE, IEEE PES, and Sigma Xi. He holds 4 US patents and 1 European Patent. Dr. Ray Chaudhuri is the lead author of the book Multi-terminal Direct Current Grids: Modeling, Analysis, and Control (Wiley/IEEE Press, 2014), and an Associate Editor of the IEEE TRANSACTIONS ON POWER DELIVERY. He received the National Science Foundation CAREER Award in 2016.