

## Abstract:

Due to the rapid advancement of power electronics converter technology and commercialization of DC based loads, DC Microgrids (DCMGs) are becoming a focus of interest due to its reduced capital cost, simple control requirement, higher efficiency and flexibility. Conventionally, individual unidirectional/bidirectional two port DC-DC converters are used to integrate individual energy sources to the DCMG system. In recent days, a new architecture of connecting different RE sources to the load has come up, where the conventional two port converters are replaced by a single power-electronic converter with multiple ports. Multiport converter (MPC) based configuration can achieve better power density, higher reliability, compact structure compare to the conventional two port converter based DCMG system. Further the centralized control scheme of MPC reduces the control complexity and number of communication links.

In this thesis, the characteristics of various available MPC topologies are discussed and based on their feature the Triple active bridge (TAB) based topologies are identified to be the most promising candidate for the MPC implementation in case of DCMG application. First a decoupled controller design technique is proposed for a Triple active half bridge MPC system and then a full bridge current fed TAB (CF-TAB) is taken up for study to derive a generalized frequency domain steady-state mode which is independent of the transformer voltage profile, modulation scheme and active bridge structure (both for VF/CF TAB). It is further used to formulate a state space model of the full bridge CF-TAB converter considering all control variables which makes it generic for the entire range of operating modes and modulation strategies. Further, a detailed small signal model of the converter is formulated which finally reduces to ac equivalent circuits for each of the three active bridges. A general method for decoupling these equivalent circuits is also proposed which significantly simplifies the individual controller design. Considering the fact that, full bridge active bridges can not integrate low voltage storage devices to the DC bus duty to their duty ratio limitation, a high gain non-isolated bidirectional converter is proposed for storage integration. The proposed converter can serve as a separate two port converter or as one of the port in MPC with high conversion ratio. It can achieve minimum voltage stress of only one third of the DC bus voltage on all the capacitors and switching devices for the entire range of operation. Further a generalized high gain MPC system is proposed for DCMG application which can include four different power sources together to supply the variable DC load. The overall control scheme for the proposed high gain MPC system is also proposed considering the power flow management of DCMG system.

The performance of the proposed topologies and their control schemes are validated using the experimental results obtained from the developed laboratory prototype against the analytical predictions.

**Keywords:** Bidirectional, DC Microgrid, Multiport Converters (MPC), Triple Active Bridge (TAB) Converters, Converter Modelling, Decoupled Controller Design, High Gain DC-DC converter topology, Isolated high gain MPC, Power management strategy