ABSTRACT

Modern overhead power distribution networks (OPDNs) that are increasingly incorporating microgrids based on renewable energy units and energy storage devices (ESDs) are facing many challenges with the age-old infrastructure to withstand the impact of high impact low probability (HILP) events and facilitate a resilient power supply to the end customers. While the grid codes are emerging to channel the inherent capabilities of the microgrids in aiding the OPDNs during circumstances requiring so, there is a strong need for developing converter/microgrid level control algorithms and network level frameworks for compliance with these grid codes.

In this thesis, various algorithms are developed to achieve the self-healing operation of the OPDNs during HILP events by considering the support from microgrids. Firstly, a distributed control strategy based on the direct current bus signaling method with virtual resistance-based voltage drop compensation, state-of-charge control, and demand side management is developed for a direct current (DC) microgrid. Secondly, extending the distributed control to a grid-connected microgrid, an algorithm based on extreme voltage tracking is developed for achieving adaptive dynamic voltage support (DVS) during voltage fault ride-through (VFRT) operation of the microgrid adhering to the IEEE 1547:2018 standard. The role of microgrid ESD in facilitating the adaptive DVS operation is studied and a sizing methodology is developed. Thirdly, a novel resiliency framework is proposed for an OPDN to assess its resiliency status through appropriate metrics, quantification of the composite resiliency considering the interaction among the metrics, enabling the existing feasible networks to supply critical loads and enhancing the resiliency through system hardening approaches. Fourthly, an algorithm for the self-healing operation of the OPDN is proposed that utilizes the resiliency framework for network reconfiguration and mobile microgrids with a seamless control strategy for network support.

The proposed algorithms and control strategies are validated through real-time digital simulation studies on the CIGRE test network and field network data of CESC Limited, Kolkata using the RTDS simulator, thereby affirming their applicability in real-time.

Keywords: *Dynamic voltage support, IEEE 1547:2018 standard, Microgrid, Overhead power distribution network, Real-time digital simulation, Resiliency framework, self-healing.*