Abstract

There has been increasing interest in dc microgrids since beginning of the first decade of 21^{st} century. This is also witnessed by the quantum of work contributed by the community, many pilot projects around the globe, and many special issues of learned journals dedicated to the topic. Multi-converter dc distribution systems or dc microgrids are treated as one of the key enabling technologies, among many, towards the development of modern smart grids. DC distribution systems offer inherent benefits of higher power transfer capacity of lines, no reactive power and frequency control requirements, and avoidance of multiple power conversions when the source is dc, resulting in simple control structures, higher efficiency, and cost effectiveness. However, tightly regulated Point-of-load Converters (POLCs) in a multi-converter dc distribution system having cascaded structure, behave as Constant Power Loads (CPLs) when control bandwidth of load converter is sufficiently higher than that of feeder converter, and introduces a destabilizing effect into the system. This destabilizing effect of CPLs due to their negative impedance characteristics, may lead to reduced system damping, significant oscillations in the dc bus voltage, and sometimes voltage collapse. The linear control techniques, providing operating point dependent performance, are insufficient to stabilize a system with high penetration of CPLs, and fails to ensure required performance and large signal stability, in the presence of CPLs and uncertainty. Therefore, the application of robust nonlinear control techniques to stabilize the power electronic converters in multi-converter cascaded dc distributed system or dc microgrids under high penetration of CPLs, is one of the ways to address the issue.

This thesis addresses the mitigation of the destabilizing effects introduced by CPLs in different non-isolated dc/dc converters and Photo-voltaic (PV) based islanded dc microgrid using robust non-linear Sliding Mode Control (SMC) approach. Novel sliding mode controllers are proposed to mitigate negative impedance instabilities in dc/dc boost, buck, buck-boost, bidirectional buck-boost converters and islanded dc microgrid. In each case, the condition for large-signal stability of the converter feeding a CPL is established. SMC based nonlinear control scheme for an islanded dc microgrid feeding CPL dominated load is proposed to mitigate the destabilizing effect of CPL and to ensure system stability in various operating conditions. A limit on CPL power is also established to ensure the system stability. For all proposed solutions, simulation studies and experimental results are provided to validate the effectiveness of the proposed sliding mode controllers.

...