Abstract

The focus of the thesis is on control of frequency and active power sharing in converter dominated standalone power systems. This thesis aims to present stability analysis of inverter based microgrids, development of control schemes that can achieve better stability, active power sharing and other benefits like ease of analysis and implementation.

For inverter dominated microgrids, there are different levels of hierarchical control for achieving desired operation. One of the key requirement of microgrid operation is the accurate power sharing among the various sources which is implemented using primary level of control based on droop philosophy. Droop control suffers from lower stability margins specially in inverter dominated system. This thesis presents stability analysis and control design for microgrids operating in droop control mode with focus on the low frequency oscillations (LFOs) arising due to the droop control.

The work starts with designing a power system stabilizer (PSS) for stability improvement of a droop-controlled inverter-based autonomous microgrid. The stabilizer is designed as a lead compensator to nullify the lag associated with the droop controller of grid forming inverters. The proposed stabilizer provides sufficient damping to the LFO even at higher value of droop gains which are usually unstable otherwise. The PSS designed in this thesis is a generalized one and a step-by-step method to select the PSS parameters is also presented in this thesis.

This thesis then proposes a modified decentralised droop controller for inverter-based autonomous photovoltaics (PV) microgrids which offers three key benefits, i.e. improves active power sharing, enhances system stability, and performs the secondary control action by nullifying the frequency deviation by using only one auxiliary signal in the control loop. The proposed controller modifies the conventional droop mechanism

in transient as well as in steady state by adding an auxiliary control signal in the power control loop of the inverters. With the proposed modification, frequency is restored within 1.8 sec from the instant of load change and 75% increase in damping ratio in LFO is achieved.

This thesis also proposes a new modelling approach for studying LFOs in a droop controlled autonomous microgrid. A transfer function based closed loop small signal model of inverter-based autonomous microgrid is developed to study power sharing among the various inverters. This model uses the concept of dynamic power flow through network to find the power output of each source following load perturbations in a system. The proposed approach helps to reduce computation time and complexity with acceptable accuracy. The computation time reduces to 7 seconds from 9 minutes with the proposed modelling approach.

Following this, an application of impedance based modelling approach to identify suitable locations for design and expansion of an inverter-based autonomous AC microgrid is presented. The objective is to find out ideal location for placement of additional components which can include new inverter-based sources, microgrid damping controller, etc., ensuring sufficient stability margins. These objectives are achieved by first identifying the weakest and the strongest nodes in the system with respect to the system stability and then observing the effects of choosing various nodes for design and expansion on overall system stability. With the given approach, stability of the system can be enhanced in terms of damping ratios with the placement of new stabilizer, new grid forming inverter and new grid following inverter, from 0.47% to 29.26%, 10.3% to 29.3% and 1.1% to 9.9% respectively.

Finally, in order to improve the performance of microgrid which consists of both static and rotating sources, this thesis presents a performance comparison of different droop schemes in AC microgrids where both rotating machine-based source (diesel engine generator) and static inverter-based sources are present. Choice of appropriate scheme for droop control by evaluating transient performance is suggested keeping the system stability in view so that a sustainable operation of the microgrid is obtained without losing its stability.