Abstract

Due to increased penetration of renewable energy sources (RES), the distribution network is constantly changing and moving away from the conventional form. Various distributed generators (DGs) require voltage source converters to share power between the renewable source and the grid. The conventional control approach for these VSCs generally do not take the grid condition into consideration. In a low voltage distribution network, the grid strength may be very weak due to low SCR combined with low X/R ratio. It is also necessary for the controller to take account of this variation in grid intensity in order to provide a satisfactory operation. In addition, small-scale power systems commonly known as microgrids are required for electrification for remote areas where the grid is not available. Microgrid systems with hybrid distributed generations (DGs) (mainly RES) are therefore gaining popularity due to environmental emission concerns and increased fuel costs. Power-sharing between various DGs needs to be maintained by a stable and reliable active distribution network. Another grid scenario is called the Open Phase scenario, where one phase out of three phases is disconnected from the primary side of the Distribution Transformer (DT). This results in a sharp decline in the secondary side of the DT, where low-end users are connected. If the operation continues during the open phase fault, there may be a permanent power outage due to the operation of the system beyond the overcurrent limit of the distribution lines. The goal of this study is to establish control schemes that can resolve different issues related to grid connectivity related to a low voltage active distribution network.

First, a weak grid operating condition for VSCs is taken into account in this thesis. A PLL less controller has been proposed that gives satisfactory control in weak grid scenarios over the varying grid condition such as swag, swell & frequency variation. The controllers proposed in this thesis emphasize not only the dynamic performance in terms of settling time, overshoots and undershoots, but also on the ease of implementation in real time, the reduction of control efforts and the reduction of the number of parameters to be tuned. The proposed PLL less control algorithm uses instantaneous samples of voltage sensor readings.

The second state where the complete absence of a grid is taken into account which is known as an autonomous or islanded condition. In the case of low-voltage islanded grid conditions, the main objective is to maintain stable voltage and frequency throughout its network for the smooth operation of distributed loads. The other objective is to maintain a proportionate distribution of power between multiple sources connected by voltage source converters (VSCs). A decentralized fast terminal sliding mode control strategy for active power sharing between parallel VSCs has been proposed in this case. A detailed mathematical model based on Lyapunov's stability theory-based study is designed to establish the operating stability of the proposed controller. However, the chattering issue with this controller remains an issue. To overcome the problem of chattering, this thesis further presents a decentralized adaptive droop-based control for active power sharing between parallel inverters in autonomous microgrids. A dynamic droop coefficient is designed to achieve improved transient performance during dynamic loading.

In the third and final scenario, the impact of the open phase fault on the power supply of end consumers connected to the low voltage side of DT is presented. The open phase condition at a voltage level (11 kV) will result in a continuous voltage sag at low voltage (LV) voltage (400 V) which may be detrimental to various types of loads, especially constant power loads. The

grid-connected photovoltaic (PV) with battery energy storage (BESS) system has been used for a number of demand-related issues. This study explores the use of grid-connected PV with BESS in the event of an open phase fault in the distribution system. The usefulness of the proposed configuration is demonstrated with the voltage restoration in all phases at the LV level during an open phase fault at the MV level, with MATLAB simulation as well as real-time experimental results obtained for selected possible loading conditions have been presented.

The presentation will be done online in Microsoft meeting.