Abstract

Photovoltaic (PV) inverter is one of the most important components of the PV power generation system. Key requirements for grid-connected solar photovoltaic inverters are power quality, efficiency, reliability, cost of implementation, etc. Current research focuses on the development of different topologies for inverters to achieve the above-mentioned figures of merit to support the grid with a limited number of components. This thesis is an attempt to develop such PV inverter topology for large-scale solar PV applications (multi-Mega-Watt scale). A single dc-source-based high-resolution multilevel inverter topology with the appropriate blend of switches is developed to address most of the practical constraints of central inverters for PV applications.

The cost of converter systems rises in relation to the number of levels, as more output voltage levels are achieved in literature at the cost of more dc sources, power devices, and associated components, as well as complex control techniques. The symmetric and asymmetric multilevel inverter requires isolated dc sources and a significant number of switches to get high power quality. Asymmetrical *Cascaded H-Bridge Multilevel Inverter* (CHBMLI) can enhance power quality using an equal number of switches (similar number of switches used in symmetrical CHBMLI) but with a trade-off in modularity. Asymmetrical cascaded bridge multilevel converters use voltage sources of different magnitudes and diversified power rating to generate higher number of levels. However, the availability of sources of different ratings feeding the bridges is a limitation. This thesis overcomes such a limitation by utilizing the concept of capacitor voltage balancing using the *Level Doubling Network* (LDN) principle in the space-vector plane. The ratio of asymmetry for multiple LDN-based topology is optimized to remove the auxiliary dc sources by having justified trade-off with number of levels. With this motivation, a topology is developed with the capability to generate 43 levels at the output line voltage by using only 12 switches per phase. This topology does not require isolated auxiliary power supplies to develop such a high-resolution output voltage. The thesis has progressed further to propose a two-stage high-resolution

multilevel inverter solution to double the inverter utilization as well as to increase efficiency in grid connected solar PV applications. Reactive power handling and fault-blocking capability of the system are also studied. Moreover, all the main bridges of the three phases are merged with the help of isolation transformers and fed by a common PV array to reduce capacitor requirement and to avoid unbalanced current injection into the grid during partial shading. This topology will be useful for applications, where the isolation transformers are unavoidable to boost the output voltage. However, a transformer increases the cost, volume, and weight of the system, and may not be a compulsory requirement for every installation. With this motivation, an alternative solution is also developed to remove the isolation transformers by replacing the main bridges by a three-phase *T-Type Neutral Point Clamped* (TNPC) converter. The major issue of this hybrid topology is the capacitor balancing of NPC with LDN operation. To solve this issue an additional circuitry is added for capacitor balancing. Worst case power handled by this additional converter is negligible compared to the power handling capability of the entire converter. Hence, a full-capacity transformer is replaced by a non-isolated dc-dc converter of fractional rating. Implementation cost and running cost (losses) are substantially reduced. In line of that work, the above-mentioned hybrid inverter topology is tested for grid-connected operation. A dc-dc converter is customized in this work, which is normally required for two-stage operation of solar PV inverter. This converter topology reduces the size and losses of filter inductors due to high-resolution inverter output voltage in addition to restricting the leakage current well below the relevant standards. A multilevel inverter prototype is being developed in the laboratory to demonstrate all of the converter topologies under research. All simulations are done using MATLAB/Simulink and dSpace micro lab box is used for all controller implementations.
Key Words:- Multilevel Inverter, Level Doubling Network (LDN) , T-Type neutral point clamped (TNPC) , Asymmetric Multilevel Inverter, Photovoltaic Inverter, Grid connected systems, transformerless inverter.