STUDY OF GRID CONNECTED PV SYSTEM BASED ON CURRENT SOURCE INVERTER

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ABSTRACT

Current Source Inverter (CSI) topology is fast acceptance as aggressive substitute for grid interface of renewable energy systems due to its exclusive and advantageous features. Merits of CSI over the more popular Voltage Source Inverter (VSI) topology have been discussed on by a number of researchers. However, there is a lack of quality work in modeling and control of CSI topology interfacing renewable energy resources to the grid. To improve the study focusing on application of CSI for renewable energy interface, this paper develops a multilevel structure based on CSI for three-phase grid-connected.

Keywords- Photovoltaic (PV) Cell, Current Source Inverter (CSI), Voltage Source Inverter (VSI).

I. INTRODUCTION

In recent years, there has been an appreciable interest in the utilization of Photovoltaic (PV) systems due to concerns about environmental issues associated with use of fossil fuels, rising fuel cost and energy security. Despite this high interest, not a significant number of grid-connected PV systems are visible at present as compared to traditional energy sources such as oil, gas, coal, nuclear, hydro, and wind. PV systems of single or double digit megawatt capacities have been connected to the grid mainly at sub-transmission voltage levels. At the distribution level, the PV systems mainly consist of roof top installations with capacities of few kilowatts which are unlikely to have any significant impact on the existing power system. With the growing interest in solar energy and national policies designed in favor of green energy, it is expected that there will be significant increase in large size PV plants, which can have significant impact on the existing power grid. For successful operation of large-scale grid-connected PV systems, a robust and cost-effective PV inverter solution is required.
1.1 Structure of a Typical Photovoltaic (PV) System

A PV array consists of a number of PV modules. The inverter in a PV system is employed to transform the DC-voltage generated from a PV module to a three-phase AC voltage. The inverter is usually interfaced to the utility grid through a transformer. The output quantity of an inverter is pulsed and contains switching harmonics a filter is essential at the AC terminal of the inverter, where it is interfaced to the grid. The blocks of a PV system shown, in fig.1.

![Fig.1: The blocks of a PV system](image)

The present inverter technology has been introduced, which is based on processing the power produced by individual strings or individual modules. The present technology offers improved performance compared to the past technology.

1.2 Classification of Inverter Topologies

Inverter topology is classified on the basis of number of power processing stages.

![Fig 2: (a) Single power processing stage, (b) Dual power processing stage, (c) Dual power processing stage with a common DC-AC inverter](image)
The inverter employed in single-stage conversion must be designed to handle a peak power of twice the nominal power. A dual-stage topology the tasks are divided between the DC-DC converter and DC-AC converter. Maximum power point tracking is performed by the DC-DC converter and current control task is performed by the DC-AC converter. Fig. 2(c) is the solution for multi-string technology. The DC-DC converters take care of MPPT and are connected to the DC-link of a common DC-AC inverter which takes care of the grid interfacing.

1.3 CSI-based Topology Compared to VSI-based Topology for Photovoltaic (PV) Application

The CSI topology offers numerous advantages over the VSI topology from the view points of short-circuit current limiting, harmonics, and losses. CSI has high reliability due to inherent short-circuit current protection capability. VSI offers some advantages over CSI topology in terms of efficiency, and ease of control. The control scheme and pulse width modulation techniques for VSI topology are more established and more thoroughly investigated when compared to those for CSI.

![Fig.3: a single-stage grid interface for PV based on a CSI using 3 RBIGBTs, 3 normal IGBTs and 3 diodes](image)

A diagram for the topology adopted is shown in Fig.3. The justification behind is mixed-switch design is that in CSI most of the switching stress is handled by the positive or upper switch group. Though RB-IGBT has reverse blocking capability, the IGBT in series with diode has better switching behavior than the RB-IGBT; therefore, RB-IGBT switches can be used in the negative switch group or lower group. This has resulted in lower number of semiconductor devices, which in turn, results in lower switching losses as compared to the commonly used CSI topology. One major advantage of using RB-IGBT in CSI is that it eliminates the requirement of series diodes, which are normally employed to reduce voltage stress in conventional IGBTs in a current source inverter, and their associated conduction losses. The upper and lower devices of each leg in a VSI cannot be gated simultaneously as shoot through can destroy the devices. In a CSI, shoot-through is a valid state and is used for magnitude control of fundamental component of AC-side current. Combining RB-IGBTs, IGBTs, and diodes has proposed a multi-converter topology that connects multiple independently controlled renewable energy sources to the same grid. The analysis is further extended to evaluate the installed power. It was found that CSI based on RB-IGBT has lower installed power compared to VSI and CSI based on conventional IGBTs and diodes. Any experimental or simulation analysis for transient performance of the CSI based on RB-IGBT. RB-IGBT has resulted in a less loss structure which used to be a major concern for opting to use current source converter topology. Still, there are some disadvantages which make CSI not considered so preferred by PV system manufacturers.
One major drawback of the control method is that it does not allow the PV inverter to operate in standalone mode. In addition, with the evolution of RB-IGBT switches, use of series diodes and the corresponding losses can be eliminated. However, producing a strong inverter solution may not ensure successful operation of a PV system. Along with the inverter, other issues such as harmonics in the current injected into the grid, high power rating of PV system, low switching frequency, reduced sensor requirements need to be addressed. To address such concerns, a multilevel structure for CSI-based PV system is proposed in this paper.

1.4 Multilevel Inverter Topologies

By increasing the number of levels in a given topology, the output voltages in the case of VSI, and output currents in the case of CSI, assume stair case waveforms with increased number of steps. This results in closer to reduced switch-sinusoidal AC quantity waveforms with reduced Total Harmonic Distortion (THD) at switching frequency. The operation of a multilevel inverter at a low switching frequency results in lower switching losses and a higher power transfer capability. For their advantageous features, multilevel inverters have been adopted in Distributed Generation (DG) application area. The topology proposed is a three-phase 5-level CSI that uses only two intermediate DC-link inductors and a single DC current source. A multi-modular structure based on CSI for superconducting magnetic energy storage system. Control algorithms for multilevel CSI structures are not fully investigated as opposed to the case of VSI-based multilevel topologies.

II. CONCLUSION

CSI offers numerous advantages; it is not a widely used topology for interfacing renewable energy sources as compared to VSI. To make CSI as competitive as VSI, a fair amount of research has been carried out in the field of current control, switching strategy, suppression of harmonics, damping of oscillations, and efficient energy storage. A few research works has been focused on modeling, design, analysis, and multilevel structure of CSI-based PV systems. With numerous advantageous features of CSI, the research can be extended to design a multi-module, multilevel converter system that will contribute towards injecting clean sinusoidal current with lower switching loss and accommodating high power.
III. REFERENCES


