Review on Design Optimization and Topologies of PV Micro-Inverter

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Abstract - *Nowadays, the use of renewable energy sources is increasing day by day considering the environmental issues. The Solar Photovoltaic (PV) system is expanding rapidly due to its pollution-free, clean and unlimited nature. The microinverter is a device that converts Direct Current (DC) from the output of a photovoltaic solar panel into an Alternating Current (AC) connected to a grid. Micro-inverter is placed behind every panel in the solar photovoltaic system as it is an effective solution for the photovoltaic system. To obtain high-quality output, high reliability, and reduce switching losses modulation techniques (PWM & HPWM) are reviewed. The string inverter and centralized inverter are compared based on Maximum Power Point Tracking (MPPT). In this paper, various topologies of flyback inverters and optimization techniques suggested for microinverter are reviewed.*

Key Words*: *Interleaved flyback inverter, MPPT, BCM, DCM.

1.INTRODUCTION

Renewable energy can be replaced by the natural process during a short period and can be replaced and reused multiple times. Wind energy, solar energy, hydroelectric and geothermal are some examples of renewable energy sources. Solar energy is one of the best sources to generate electricity. The DC output of the PV solar panel is converted into AC using an inverter. Many researchers have been provided proposed varieties of research in recent publications to improve reliability, compactness, efficiency, and cost of the micro-inverter topology.

In the flyback inverter active clamp circuit is used for eliminating the switching loss, drive loss, and conduction loss [1]. For controlling the flyback inverter as well as for MPPT only a current detection sensor is used [2]. BCM is mostly used in this topology because of its higher efficiency and wider switching frequency [3]. A two-stage micro-inverter topology is expounding to achieve high efficiency, good output voltage and current waveform smart grid support capabilities, and higher reliability [4]. The concept MPP-tracking at the substring level for AC modules are used to improve the AC module technology. Meanwhile, reduce mismatching losses and achieve high efficiency [5]. Microinverter with PV Current Decoupling (PVCD) strategy without large electrolytic capacitors is used to improve MPPT performance [6].

An optimal control method, a multi-objective Pareto optimization routine, reliability-oriented design method, DC to DC converters optimization technique, and some control strategies and modulation techniques are studied. For grid-connected PV micro-inverter to improve its reliability and efficiency. for detection of abnormal faults, islanding protection, and maximum power point tracking DSP TMS320LF2407A is used. An effective PWM method for the reduction of switching losses in a full-bridge inverter is proposed. This method has some drawbacks, to overcome this HPWM method is capable to produce high-quality output and reduce switching losses. The control method for reconfigurable working of PV micro-inverter in both grid-connected and island mode is discussed to demonstrate the suggested control configuration will possible without any dangerous transient.

Inverter Topology:

In the flyback inverter a novel method of control of active clamp circuit is used for eliminating the switching loss, drive loss, and conduction loss. These losses occur because of a switch, which is turned ON and OFF with a hard switching. Furthermore, the voltage spike occurred due to resonance between the leakage inductance of the transformer and the output capacitance across the main switch. For reducing the voltage spike, a snubber circuit is used in the proposed topology [1].

In flyback inverter power is directly converted DC-AC, hence DC-DC converter is not required. When this architecture is applied to a problem, an AC Photovoltaic Module System can create a tiny amount of electric power, around 200W per square meter under ideal weather circumstances. MPPT technique is used in flyback inverters to utilize the PV module efficiently. The traditional MPPT method necessitates the use of at least two PV module output current and voltage detection sensors, as well as a somewhat sophisticated control scheme. But in this topology, to improve MPPT, only the output current of PV modules is necessary. So, for controlling the flyback inverter and MPPT only one current detection sensor is used [2].

A flyback inverter is an effective solution for PV AC module application. In this architecture, BCM is recommended over DCM and CCM Because of its better power density, higher efficiency, and wider switching frequency. To get the accurate mathematical model between the output current I_{out} and the reference current I_{ref} [3].

The topology of a two-stage micro-inverter is expounding to achieve high efficiency, superior output voltage and current waveform, smart grid support capabilities, and higher reliability. And also, two microinverter are designed to obtain peak efficiency and meet grid code requirements [4].

To improve AC technology, the notion of substring level MPP-Tracking for AC modules is adopted. It allows to reduce mismatching losses and achieve high efficiency by using an HF-link LC resonant converter and a power balancer. A topology comparison reveals two concepts: a single-stage converter with a power balancer and a two-stage topology with three paralleled DC to DC converters with a complete bridge Pulse Width Module (PWM). A systematic comparison of single input and multi-input AC module topology hence the given result a power balancer and HF-link resonant converter are a more attractive approach and it may achieve comparable efficiency of 94.5% [5].

PV micro-inverter with PV Current Decoupling (PVCD) Strategy is used to improve MPPT performance using long lifetime film capacitors due to the reliability of PV micro-inverter increases and also MPPT increases [6].

Design and implementation-

Comparison between string inverter-based configuration and micro-inverter-based configuration is shown to identify the reliability, cost-effectiveness, safety, and also longer lifetime configuration. Microinverter-based configuration is most effective [7].

For high-quality output and reduced switching losses, PWM and HPWM method with random switching method is proposed to overcome unequal switching loss problem in power switches [8][9]. Also, the reconfiguration control technique for PV micro-inverter working in both grid-connected and island modes is presented to demonstrate the suggested control configuration will be possible without hazardous transients for micro-inverter. A multiloop linear PI control system is employed in a reconfigurable control strategy. Linear inner and outer PI control loops regulate the system state variables [10]. In addition, novel grid-connected boost-half bridge PV micro-inverter system and associated control implementations are also described, to achieving low cost, simple control, high efficiency, and high reliability. higher conversion efficiency is obtained by the quasi sinusoidal PWM method. Plugin repetitive current control method is used to regulate the grid current [11].

A 200 W Photovoltaic micro-inverter implemented to increase the input voltage to a level that can be efficiently transformed to electricity and also Prototype circuit with 20V-40V and 220Vac/200W input range and output range respectively is proposed. For abnormal fault detection, islanding protection, and MPPT, Digital Signal Processor (DSP) TMS320LF2407A is used [12].

Design and Optimization:

An optimal control method for grid-connected PV micro-inverter to improve efficiency at light load conditions. BCM is used to improve efficiency and DCM is used to limit switching losses. Switching frequency in DCM is constant, switching losses play a more significant role in overall power losses at light load conditions. Switching frequency in DCM will be restricted by the cut-off region. Switching frequency reduces directly according to the value of output power P_o [13].

To evaluate the performance aspects affecting annual degradation, volume, and cost, a multi-objective Pareto optimization technique is proposed. It can be optimized by a two-stage PV micro-inverter. For thermal aspect modelling, the functioning concept of the inverter stage in BCM is first investigated. Second, a system-level electro-thermal model for the PV micro-inverter is developed, resulting in a significant increase in dependability while keeping low cost and volume [14].

To attain high reliability, this work uses a reliability-oriented design strategy for a grid-connected PV micro-inverter. Each type of component is given a reliability target for the microinverter system as a whole. The electro-thermal modelling, lifetime modelling, and Monte Carlo analysis for different HEMTs and aluminium electrolytic capacitors are all part of the design process for switches and dc-link capacitors. The overall reliability target for the micro-inverter system can be met if component-level reliability is achieved [15].

This research focuses on the performance and physical dimensions of the DC/DC converter, as well as an efficient approach for tracking maximum power point and load regulation. For this purpose, a special architecture and design of a highly durable, rugged, stable, and compact system has been presented. This implementation minimised losses through power components, allowing magnetic circuits to be smaller and lighter for high-frequency operation. Introducing impedance matching for effective power harvesting and electrically isolating the PV from the load to safeguard it [16].

With a heavy load, the conduction losses of the power MOSFET and diode, as well as the core and copper losses of the transformer, are the most significant losses for the interleaved fly-back micro-inverter. With a light load, the gate driving loss, power MOSFET turn-off loss, and transformer core loss are the most common losses. For this, a novel control method combining 2 Phase DCM and 1 Phase control is presented. This control technique can achieve great efficiency [17].

This work presents an optimal control technique for the interleaved fly-back based micro-inverter in order to enhance its efficiency across the whole operating range. Because of ZCS (Zero Current Switching) feature of the DCM and BCM, turn-on switching losses and diode reserve recovery losses are significantly reduced. [18].

3. CONCLUSIONS

After studying the papers related to the solar inverter it is concluded that,

1. A flyback inverter is an appealing choice for photovoltaic AC module applications, and it should be efficient enough to meet the needs of the customer.
2. The topology of single and multi-input AC modules is systematically compared.
3. Pulse Width Modulation (PWM) and Hybrid Pulse Width Modulation (HPWM) with random switching methods are investigated for full-bridge inverters, to obtain high reliability, cost-effectiveness, and safety.
4. The reconfigurable control scheme for the photovoltaic (PV) micro-inverter is reviewed.
5. Grid-connected micro-inverter topology is discussed in this review study. The efficiency and reliability analysis method with PV micro-inverters connected to the grid is also summarized.

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