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Single-Phase Transformer less Photovoltaic Inverter for Grid Connected System

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ABSTRACT: Single phase transformer less inverters are widely being adopted for grid connected PV systems due to their high efficiency, lower cost and high power density. However, leakage current is the main concern in these inverters which needs to be addressed carefully. Moreover, PV inverters should also be capable of injecting a definite amount of reactive power into the grid as prescribed by the international regulations. In this paper, an improved common mode voltage clamped topology with modified modulation strategy is proposed. The proposed topology offers low loss ac side decoupling, complete elimination of leakage current via clamping and reactive power generation capability. The proposed modulation technique facilitates the flow of current in order to generate zero voltage state during negative power flow.

KEYWORDS: Single-Phase Transformer, Photovoltaic Inverter, Grid Connected System

I. INTRODUCTION

The increasing power demand due to rising population along with depletion of conventional fuel sources has highlighted the importance and need of distributed power generation by renewable energy sources. Various benefits of solar photovoltaic (PV) system have led to diverse schemes for local generation of power. The main objective of a designer is to enhance the fidelity and efficiency, which is causing a tough competition among the power generating industries. Their supreme need is to supply uninterrupted power to the end users along with fast payback of the capital cost. The later issue is tackled by increasing the reliability of the system and optimizing peak power from the solar PV energy. Despite of non-linear characteristics of a solar PV array, researchers have tried to overcome the issue of extracting maximum power. Various techniques have been implemented by researchers which have been extensively reported in the literature. The most universally accepted perturb and observe (P&O) method involves continuous perturbation to the DC-DC converter till it reaches the peak power. The incremental conductance (I&C) method is another commonly used method which compares the instantaneous conductance of the array and provides continuous perturbation till MPP is reached.

II. LITERATURE SURVEY

1. PV STRING PER-MODULE MAXIMUM POWER POINT ENABLING CONVERTERS: G.R. Walker (2011): Many grid connected PV installations consist of a single series string of PV modules and a single DCAC inverter. This efficiency of this topology can be enhanced with additional low power, low cost per panel converter

modules. Most current flows directly in the series string which ensures high efficiency. However parallel Cuk or buck-boost DC-DC converters connected across each adjacent pair of modules now support any desired current difference between series connected PV modules. Each converter “shuffles” the desired difference in PV module currents between two modules and so on up the string. Spice simulations show that even with poor efficiency, these modules can make a significant improvement to the overall power which can be recovered from partially shaded PV strings.

2. Design and Analysis of a Grid-Connected Photovoltaic Power System: J. Kishore Kumar, V. Lakshmi Devi & CH. Rajesh Kumar (2012)-

A grid-connected photovoltaic (PV) power system with high voltage gain is proposed, and the steady-state model analysis and the control strategy of the system are presented in this paper. For a typical PV array, the output voltage is

relatively low, and a high voltage gain is obligatory to realize the grid-connected function. The proposed PV system employs a ZVT-interleaved boost converter with winding-coupled inductors and active-clamp circuits as the first power-processing stage, which can boost a low voltage of the PV array up to a high dc-bus voltage. Two compensation units are added to perform in the system control loops to achieve the low total harmonic distortion and fast dynamic response of the output current. Furthermore, a simple maximum-power-point-tracking method based on power balance is applied in the PV system to reduce the system complexity and cost with a high performance. At last, a 2-kW prototype has been built and tested to verify the theoretical analysis of the paper.

3. Topologies of Single-Phase Inverters for Small Distributed Power Generators: An Overview: Yaosuo Xue, Liuchen Chang (2004)-

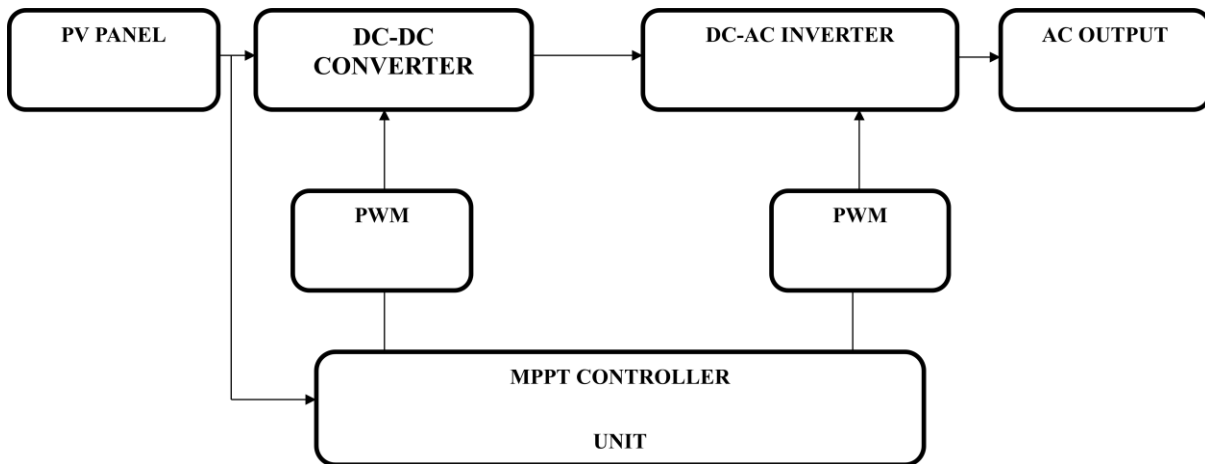
This paper presents an overview of single-phase inverters developed for small distributed power generators. The functions of inverters in distributed power generation (DG) systems include dc-ac conversion, output power quality assurance, various protection mechanisms, and system controls. Unique requirements for small distributed power generation systems include low cost, high efficiency and tolerance for an extremely wide range of input voltage variations. These requirements have driven the inverter development toward simpler topologies and structures, lower component counts, and tighter modular design. Both single-stage and multiple-stage inverters have been developed for power conversion in DG systems. Single-stage inverters offer simple structure and low cost, but suffer from a limited range of input voltage variations and are often characterized by compromised system performance.

4. A Soft-Switched DC/DC Converter for Fuel Cell Vehicle Applications: Gui-Jia Su, Donald J. Adams, Fang Z. Peng (2002):

Fuel cell-powered electric vehicles (FCPEV) require an energy storage device to start up the fuel cells and to store the energy captured during regenerative braking. Low-voltage (12 V) batteries are preferred as the storage device to maintain compatibility with the majority of today’s automobile loads. A dc/dc converter is therefore needed to interface the low-voltage batteries with the fuel cell-powered higher-voltage dc bus system (255 V ~ 425 V), transferring energy in either direction as required. This paper presents a soft-switched, isolated bi-directional dc/dc converter developed at Oak Ridge National Laboratory for FCPEV applications. The converter employs dual half-bridges interconnected with an isolation transformer to minimize the number of switching devices and their associated gate drive requirements. Snubber capacitors including the parasitic capacitance of the switching devices and the transformer leakage inductance are utilized to achieve zero-voltage switching (ZVS). Therefore, no extra resonant components are required for ZVS, further reducing component count. The inherent soft-switching capability and the low component count of the converter allows high power density, efficient power conversion, and compact packaging. A prototype rated at 1.6 kW was built and successfully tested. Experimental results confirmed soft-switching operation and an average model based analysis.

III. METHODS

PROPOSED BLOCK DIAGRAM:



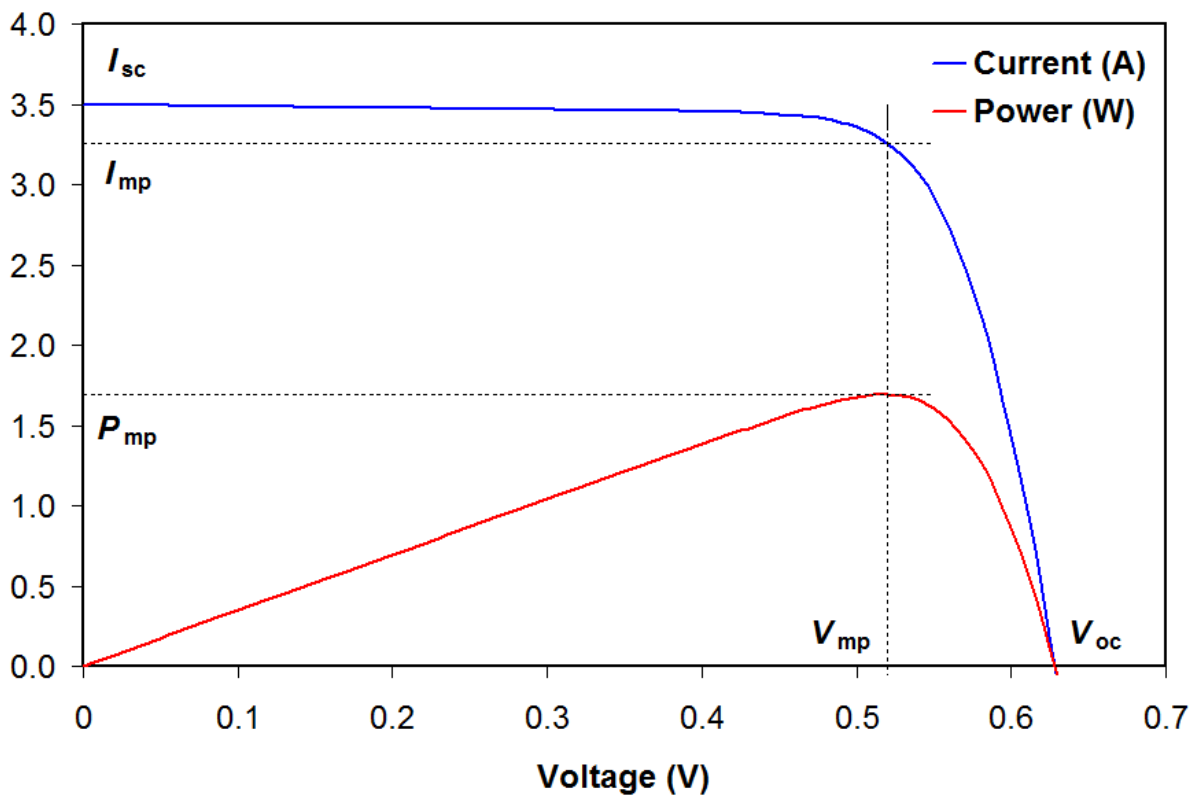
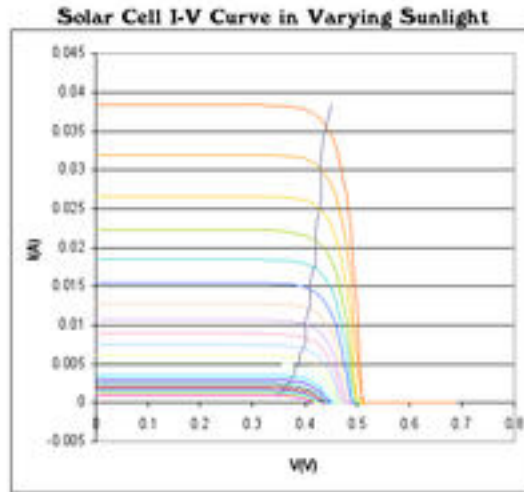
A solar panel (photovoltaic module or photovoltaic panel) is a packaged interconnected assembly of solar cells, also known as photovoltaic cells. The solar panel is used as a component in a larger photovoltaic system to offer electricity for commercial and residential applications. Because a single solar panel can only produce a limited amount of power, many installations contain several panels. This is known as a photovoltaic array. A photovoltaic installation typically includes an array of solar panels, an inverter, batteries and interconnection wiring.

Solar panels use light energy (photons) from the sun to generate electricity through the photovoltaic effect. The structural (load carrying) member of a module can either be the top layer (superstrate) or the back layer (substrate). The majority of modules use wafer-based crystalline silicon cells or a thin-film cell based on cadmium telluride or silicon. Crystalline silicon, which is commonly used in the wafer form in photovoltaic (PV) modules, is derived from silicon, a commonly used semi-conductor. In order to use the cells in practical applications, they must be: connected electrically to one another and to the rest of the system protected from mechanical damage during manufacture, transport, installation and use (in particular against hail impact, wind and snow loads). This is especially important for wafer-based silicon cells which are brittle. protected from moisture, which corrodes metal contacts and interconnects, (and for thin-film cells the transparent conductive oxidelayer) thus decreasing performance and lifetime. Most modules are usually rigid, but there are some flexible modules available, based on thin-film cells.

IV. RESULT ANALYSIS

Maximum power point tracking (MPPT) is a technique that grid connected inverters, solar battery chargers and similar devices use to get the maximum possible power from one or more photovoltaic devices, typically solar panels,^[1] though optical power transmission systems can benefit from similar technology.^[2] Solar cells have a complex relationship between solar irradiation, temperature and total resistance that produces a non-linear output efficiency which can be analyzed based on the I-V curve. It is the purpose of the MPPT system to sample the output of the cells and apply the proper resistance (load) to obtain maximum power for any given environmental conditions.^[citation needed] MPPT devices are typically integrated into an electric power converter system that provides voltage or current conversion, filtering, and regulation for driving various loads, including power grids, batteries, or motors.

I-V curve



Solar cell I-V curves where a line intersects the knee of the curves where the maximum power point is located. Photovoltaic cells have a complex relationship between their operating environment and the maximum power they can produce. The fill factor, abbreviated FF, is a parameter which characterizes the non-linear electrical behavior of the solar cell. Fill factor is defined as the ratio of the maximum power from the solar cell to the product of Open Circuit Voltage V_{oc} and Short-Circuit Current I_{sc} . In tabulated data it is often used to estimate the maximum power that a cell can provide with an optimal load under given conditions, $P=FF*V_{oc}*I_{sc}$. For most purposes, FF, V_{oc} , and I_{sc} are enough information to give a useful approximate model of the electrical behavior of a photovoltaic cell under typical conditions.

V. CONCLUSION

In this project, an alternative inverter topology is proposed for the PV system connected to the single-phase grid under the safety regulation. The main principle of operation of this topology depends on decoupling the DC link from the AC side during the zero voltage levels of inverter output voltage. The proposed inverter topology has the advantages of using a single DC link capacitor, eliminating the possible resonance due to the junction capacitors and oscillations in the common mode voltage of improved. It keeps the common mode voltage constant while providing almost the same efficiency. The use of single DC link capacitor eliminates possible voltage unbalance with the existence of two or more capacitors and it reduces the failure probability of more electrolytic capacitors used in the system. Also, this proposed inverter topology is fully compatible with the standard switching enabling the use of PWM ports of digital signal processors.

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