DESIGN OF LOW POWER SOLAR MICRO INVERTER FOR HOME APPLICATIONS

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Abstract: This paper presents the design of a low power solar micro inverter for a home system capable of running AC loads (25-30W). The inverter is designed to have a transformer-less body thus making the micro inverter light in weight and more efficient. The proposed DC converter stage uses low loss components to further reduce the losses. Opto-coupler isolation is used for both the inverter and DC converter stage. High frequency PWM pulses are produced using a micro controller.

Keywords: micro inverter, DC-DC converter, multilevel boost converter

1. INTRODUCTION

A Solar PV inverter is an electrical device that changes the direct current (DC) electricity, which is produced by Solar PV panels, into alternating current (AC). A solar PV inverter can be classified into (i) string inverter (ii) Central inverter and (iii) Micro inverter. String inverter is connected to all the solar panels in one string of wide arrangement of solar panels. All the power from the inverters is then summed up at one point and then supplied either to a grid or for residential purpose. Central inverter is a bigger inverter. The output from each solar panel in the arrangement is given to the solar inverter. A micro inverter converts direct current (DC) from a single solar panel to alternating current (AC).
2. LITERATURE SURVEY
The present use of micro inverters is mostly restricted to commercial production of electricity to be supplied to the electrical grid. Using these inverters in residential areas is costly because these inverters are costly themselves. Experts in the field of solar energy have estimated that the demand for micro inverters would quadruple by the end of 2017. According to records, every year our nation suffers a huge loss due to shortage of electricity. Although most of the nation has a sufficient supply of electricity, however there are areas which are still deficit of electricity. Some areas have supply for only few hours in the day.

Taking into the rural scenario into account a solar inverter was built which gives 220V AC output at a frequency of 50Hz. The DC/DC converter is designed which uses transformer to boost the voltage from 12V DC to 312 V DC [1].

A multilevel boost converter was modeled and designed so as to take an insight on this [2]. Comparisons to other topologies show that the designed controller was the preferred model for the photovoltaic applications. Some of the advantages of multilevel DC – DC converter compared to traditional topologies are low harmonic distortion, low voltage stress, low EMI noise, and High efficiency. A comparison between IGBTs and MOSFETs was made in [3] and it was found that MOSFET is the preferred device that is to be used for designing the micro inverter.

The micro inverters have a great flexibility over the conventional string or central inverters [4]. Mounting of solar panels in micro inverters is very easy and have the independence of orienting the panels in the desired direction with each panel being oriented in its own direction.

Though the conventional micro inverters are single stage inverters, the two stage inverters show a comparatively higher efficiency and reliability over the single stage inverters [7]. The comparison of the solar panels in PV inverters shows that, the solar panels that are used with micro inverters are capable of yielding a higher power over the others [8].

3. PROPOSED MODEL
Block diagram of the proposed model for the micro inverter is shown in Fig. 1. The solar module is the source to both, the DC boost Converter and the Switched Mode Power Supply, SMPS. The DC boost requires an isolation circuitry here since the voltage boost is achieved using semiconductor devices and other passive devices.
Thus opto-coupler isolation is provided to both, the DC-DC boost and DC-AC inversion stages. A microcontroller (PIC18F4431) is used to provide the PWM pulses. Finally a low pass filter is used to filter out the 50Hz frequency output from the inverter circuit.

4. **DC-DC BOOST CONVERTER**

The low level voltage from the solar panel (12V) is boosted to a high level (approx. 312V) using the boost converter. Since the design is to be a transformer-less one, the voltage boost is achieved with the help of semiconductor devices (MOSFETs). The conversion requires a high voltage gain. A conventional dc chopper is inefficient to provide a high voltage gain. Thus a more complex circuitry is used for the purpose.

A multilevel boost converter provides a high voltage gain. Although a high gain is possible with this topology, the number of diodes and passive elements increases in order to obtain a very high gain as required for this application. Thus a conventional boost converter is used along with the multilevel inverter to serve the purpose. The equations are stated below.

The transfer function of the conventional boost converter is:

$$ V_{(out)} = \frac{V}{1 - D} $$

(1)

For the multilevel converter the transfer function can be calculated as:

$$ V_{(out)} = \frac{V \cdot N}{1 - D} $$

(2)

The inductor and capacitor values are calculated as below

$$ L_{(opt)} = \frac{5 \cdot R \cdot (1 - D)^2}{N^2} D \cdot T(s) $$

(3)

$$ C_{(opt)} = \frac{D}{\Delta V(C) \cdot f(s) \cdot R} V_{(out)} $$

(4)
Where \( V \) is the input voltage, \( D \) is the duty cycle, \( R \) is the output load, \( T(s) \) is the switching period and \( N \) is the number of levels of the multilevel converter.

5. SIMULATION

The simulation of the proposed model was carried out in Power Simulator (PSIM). Firstly a transformer based boost converter circuit is simulated and the output is presented (Fig 2 and Fig. 3).

Fig 2: Boost converter with transformer

Fig. 3: Output with transformer based design

Fig. 4 shows the DC-DC boost converter design for the micro inverter application. The Multi Boost Converter, MBC, is designed with 3 stages which forms a three level boost inverter. A conventional dc boost circuit is attached to the output of the three level converter. The three level converter boosts the voltage to 120V DC. The boost converter at the output of the three level converter boosts the voltage to above 312V. This configuration makes use of two MOSFETs which are operated at a frequency of 100 kHz.
Fig. 4: Boost converter without transformer

Fig. 5: Output with transformer-less design
6. CONCLUSION
The converter was modeled for a low power solar panel (12V, 2.5A, 30Watts). The boost converter model with transformer based design and transformer less design was simulated. The simulation results show that the proposed model shows very close characteristics to the transformer based model. The designed model is light in weight since there is no transformer in the circuitry.

7. FUTURE SCOPE
A control circuitry to control the output voltage of the DC-DC boost converter could be designed in future. This would make the output stable. Also a topology could be thought of to take care of the partially shaded condition of the solar panel.

8. ACKNOWLEDGEMENT
I wish to thank Dr. V. N. Shet, Principal, Goa College of Engineering, for his constant encouragement and support. I am very grateful to Dr. H. G. Virani, Head of Electronics and Telecommunications Department, for allowing me to pursue the project.

REFERENCES