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Development of Low Power Micro Inverter for Use In House Hold Applications

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Abstract: The paper presents the design of a single phase low power solar micro inverter that can be used in homes for low power applications. The basic idea behind this research is to make most use of solar energy in operating smaller loads. This would help save energy and use it efficiently for the larger loads. The design is completely transformer-free and would thus help in reducing losses due to use of transformers in such designs. Multi-level boosting techniques are used for boosting the DC voltage to a desired level.
Keywords: solar micro inverter; transformer-less; low power; DC converter; multilevel boost converter;

I. 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).

II. 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. 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]. 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.

III. 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

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to filter out the 50Hz frequency output from the inverter circuit.

IV. 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 (MBC) 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. The equations are stated below.

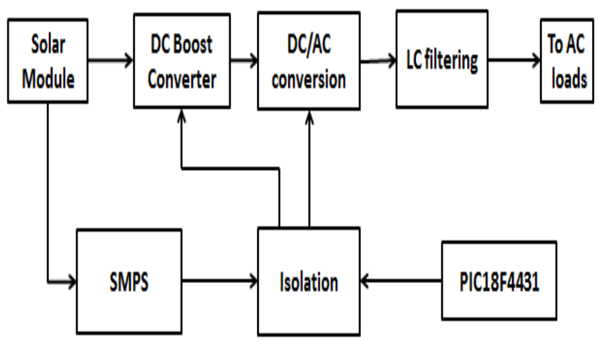

Fig 1: Proposed model of Micro inverter

The transfer function of the conventional boost converter is:

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

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

$$V_{(out)} = \frac{V*N}{1-D} \qquad (2)$$

The inductor and capacitor values are calculated as below

$$L_{(opt)} = \frac{5*R*(1-D)^2}{N^2} D\,T(s) \qquad (3)$$

$$C_{(opt)} = \frac{D}{\Delta V(C)*f(s)*R} V_{(out)} \qquad (4)$$

The current in the inductor is given by the equation

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$$I_L = \frac{(N)^2 * V}{(1-D) * R} \qquad (5)$$

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.

V. SIMULATION

The simulation of the proposed model was carried out in Power Simulator (PSIM). The software is a very simple and easy tool to work with power electronic circuits. The output gain required for the converter is very high where the voltage has to be boosted from 12V dc to 315V dc. Such a high gain cannot be obtained by using a single stage of MBC. Thus a cascade of two MBC stages has been used to meet the requirements. The first stage has two boosting levels whereas the second stage comprises of three boost levels. The values of the other components have been calculated by using the equations mentioned. Fig. 3 shows the DC-DC boost converter output. The higher voltage gain of the MBC boosts the voltage to 315 V DC. The output voltage response is observed to be slow. Thus a controller circuitry is used with the converter circuitry to improve upon the response. Fig. 4 shows the output response with the controller circuitry applied. The response is seen to be faster than the response without the controller circuitry. Switching frequency of 100 kHz is used for the MOSFETs.

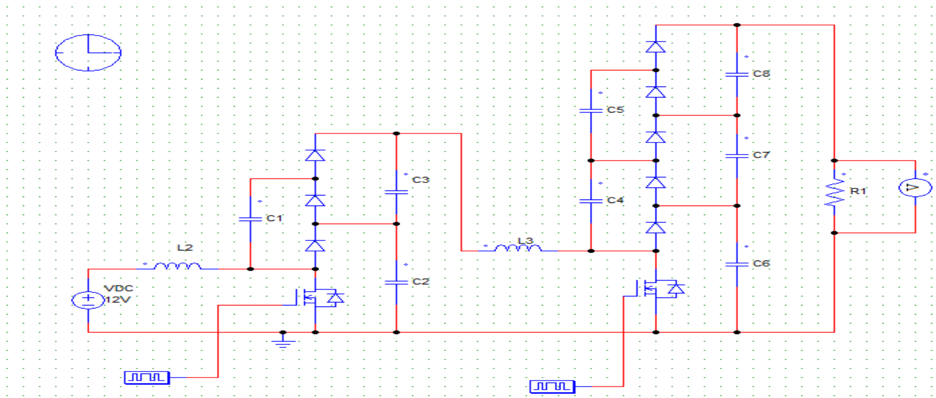

Fig 2: DC-DC boost converter

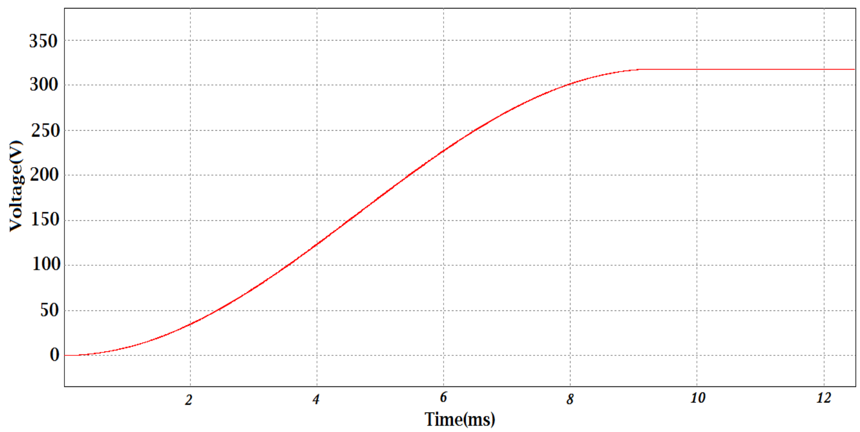

Fig. 3: Boost converter output without the controller

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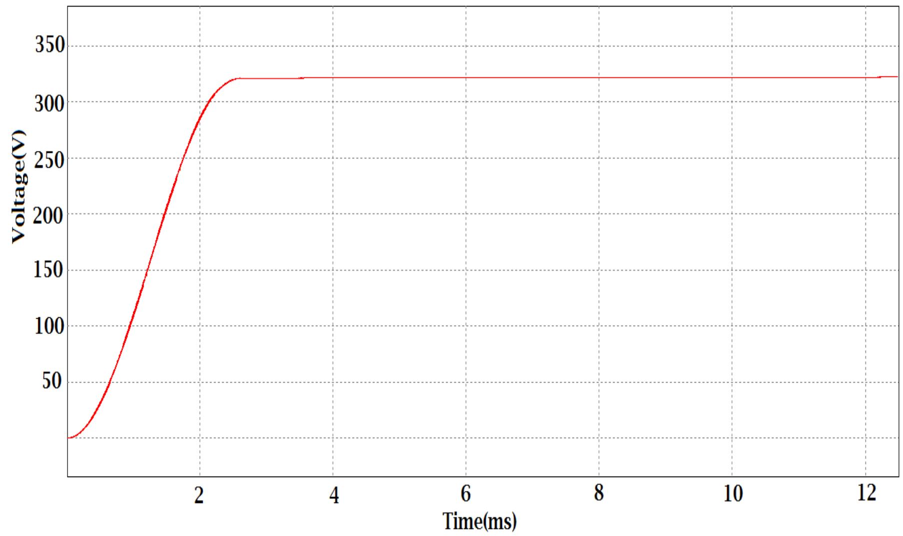

VI. CONCLUSION

The converter was modeled for a low power solar home system. The output response has been shown both with and without the controller circuitry. The output response is faster when employing the control circuitry. The designed model is light in weight since there is no transformer in the circuitry. Also the losses are reduced which makes the converter more efficient.

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