

Mpmp Tracking For Interleaved Boost Converter

N.Beaulah¹, N.Gurusakthi²

^{1&2}Final year M.E., Power Electronics & Drives, Sri Sai Ram Engineering College, Chennai, India

Abstract

A single-phase grid connected transformerless photovoltaic (PV) inverter for residential application is presented. The inverter is derived from a boost cascaded with buck converter along with a line frequency unfolding circuit. Due to its novel operating modes, high efficiency can be achieved because there is only one switch operating at high frequency at a time, and the converter allows the use of Power MOSFET and ultra-fast reverse recovery diode. The only loss is due to conduction voltage drop, which can be minimized with the use of low on-drop power devices, such as thyristors or slow-speed insulated gate bipolar transistor (IGBT). Thus, interleaved multiple phase's structure is proposed to have small equivalent inductance, meanwhile the ripple can be decreased, and the inductor size can be reduced. IGBT is used in the unfolding circuit because it can be easily turned ON and OFF with gating control. An interleaved-boost-cascaded-with-buck (IBCB) converter is proposed to increase the resonant pole frequency by the use of a smaller inductor value, which improves both control and stability. Finally, the simulation results indicate that the efficiency of the proposed solution is around 2% higher than the conventional solution. Individual parameters were designed and validated with MATLAB SIMULINK.

Keywords— Photovoltaic (PV), inverter, Grid-tied, High efficiency

1. Introduction

Photovoltaic (PV) power supplied to the utility grid is gaining more and more attention nowadays [1]–[3]. Numerous inverter circuits and control schemes can be used for PV power conditioning system (PCS). For residential PV power generation systems, single-phase utility interactive inverters are of particular interest [4]–[5]. This type of application normally requires a power level lower than 5 kW [6], [7] and a high input voltage stack that provides a dc voltage around 400V. However, depending on the characteristics of the PV panels, the total output voltage from the PV panels varies greatly due to different temperature, irradiation conditions, and shading and clouding effects. Thus, the input voltage of a residential PV inverter can vary widely, for example, from 200 to 500V, and can be quite different from the desirable 400-V level. Therefore, a dc–dc converter with either step-up function

or step-down function or even both step-up and step-down functions is needed before the dc–ac inverter stage. Such a dc–dc converter in conjunction with a dc–ac inverter arrangement has been widely used in the state-of-the-art PV PCS.

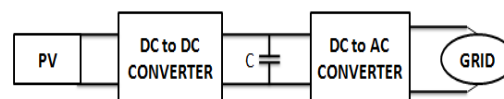


Fig 1. Conventional two-stage PV

Fig. 1 shows the block diagram of the PV PCS which has two-stage high-frequency power conversion in cascaded configuration with dc link in the middle [8]. The major drawbacks are limitation of input-voltage range and/or requirement of two input sources [9]. With recent changes in electric code that allows ungrounded PV panels, it is possible to replace the isolated dc–dc with non isolated or transformerless dc–dc [10]. Without the transformer, the dc–dc stage will be more reliable and cost effective [11]. If the dc–dc stage can produce a rectified sinusoidal output, then the dc–ac stage only needs to operate in line frequency by simply determining the polarity of the dc–dc output.

In this paper, a boost–buck-type dc–dc converter is proposed as the first stage with regulated output inductor current, and a full-bridge unfolding circuit with 50- or 60-Hz line frequency is applied to the dc–ac stage, which will unfold the rectified sinusoid current regulated by the dc–ac stage into a pure sinusoidal current. Since the circuit runs either in boost or buck mode, its first stage can be very efficient if the low conduction voltage drop power MOSFET and ultrafast reverse recovery diode are used. For the second stage, because the unfolding circuit only operates at the line frequency and switches at zero voltage and current, the switching loss can be omitted. The only loss is due to the conduction voltage drop, which can be minimized with the use of low on-drop power devices, such as thyristors or slow-speed insulated gate bipolar transistor (IGBT).

In this version, IGBT is used in the unfolding circuit because it can be easily turned ON and OFF with gating control. Since only the boost dc–dc converter or buck dc–dc converter operates with high-frequency switching all the

time in the proposed system, the efficiency is improved [12]. Also, because there is only one high-frequency power processing stage in this complete PCS, the reliability can be greatly enhanced [13]. Finally an interleaved-boost-cascaded-with-buck (IBCB) converter is proposed to increase the resonant pole frequency by the use of a smaller boost inductor value, which improves both control and stability.

2. Proposed System Module Description

A. Module 1-Block Diagram

The unfolding circuit only operates at the line frequency and switches at zero voltage and current, the switching loss can be omitted. The only loss is due to the conduction voltage drop, which can be minimized with the use of low on-drop power devices, such as insulated gate bipolar transistor (IGBT). IGBT is used in the unfolding circuit because it can be easily turned ON and OFF with gating control. An interleaved-boost cascaded- with-buck (IBCB) converter is proposed to increase the resonant pole frequency by the use of a smaller boost inductor value, which improves both control and stability. By using interleaved multiphase structure ripple can be decreased, and inductor size can be reduced. Efficiency is 2% higher than the conventional solution.

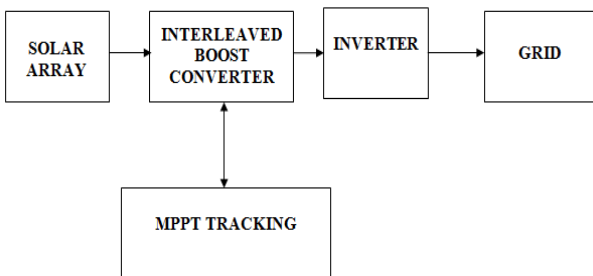


Fig 2 Block diagram

Solar Array:

Solar arrays are used to generate electricity. When sunlight strikes a PV cell, the photons of the absorbed sunlight dislodge the electrons from the atoms of the cell. The free electrons then move through the cell, creating and filling in holes in the cell. It is this movement of electrons and holes that generates electricity.

The physical process in which a PV cell converts sunlight into electricity is known as the photovoltaic effect. These

arrays are connected in series with interleaved boost converter to obtain desired voltage.

Interleaved Boost Converter

An interleaved-boost-cascaded-with-buck (IBCB) converter is proposed to increase the resonant pole frequency by the use of a smaller boost inductor value, which improves both control and stability. By the use of interleaved boost converter ripples can be reduced.

Mpvt Tracking

MPPT is a technique that grid tie inverters, solar battery chargers and similar devices used to get the maximum possible power from one or more solar panels. The objective of MPPT algorithm is to adjust the DC-DC control variables so that the PV array operates at the maximum power point. MPPT electronic circuitry is used to ensure that maximum amount of generated power is transferred to the grid.

Advantages

Summarizing, the advantages of interleaved boost cascaded with buck converter are listed as following.

- A multiphase interleaved boost stage is proposed to increase the resonant pole frequency by the use of smaller inductor value, which improves both control and stability.
- Low weight and small size.
- Ripple can be decreased.
- Inductor size can be reduced.
- Efficiency of the proposed solution is around 2% higher than the conventional solution.

B .Module 2-Circuit Model Pv Array Model

Output obtained from the single solar cell is increased and combined together to form a PV array. The photovoltaic array can be simulated with an equivalent circuit model based on the photovoltaic model.

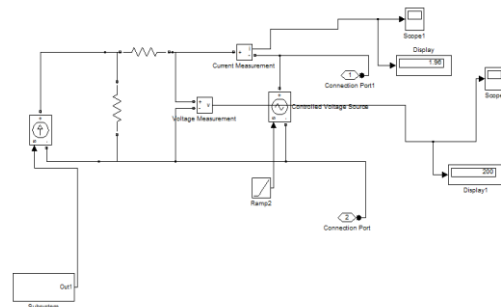


Fig .3 Simulation diagram of PV Module

The sub system is modelled by the following equation I_m is given by

$$I_m = I_{PV} - I_O [\exp(V+R_S I/V_t * a) - 1]$$

C. Design Calculation

Calculation for Solar Input

$G=600,$ $K_V= 0.123,$ $V_{OCN}=32.9,$
 $I_{PVN}=8.214,$ $a=1.3,$ $G_N=8.5$

$k=1.3807*10^{(-23)},$ $N_S=54,q=1.602*10^{(-19)}$
 $K_i=0.0032,$ $I_{scn} = 8.21,$ $T_n = 200,$ $R_s=0.221.$

Input current=1.96A

Input voltage=200V

Input power = Input current*Input voltage
 =1.96*200 =392W

Calculation of Interleaved Boost Converter

Output current=1.96A

Output voltage=196V

Output power = Output current*Output voltage
 =1.96*196=384.16W

3. Simulation Results

Solar Array Input Parameters

Solar input current is 1.96A and input voltage is 200V which are generated by the PV subsystem .

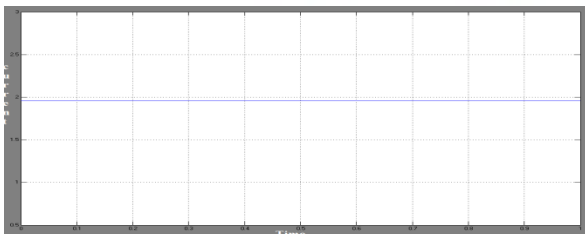


Fig.4 Current versus Time

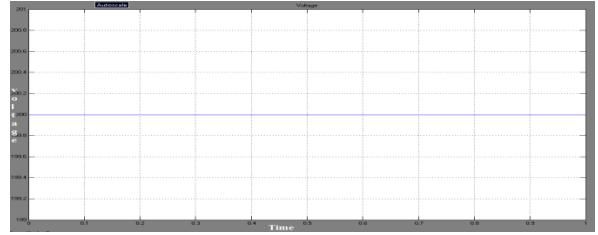


Fig.5. Voltage versus Time

392W input power which is also generated by the PV subsystem. This curve is drawn between Power and Time .It reaches the constant output power.

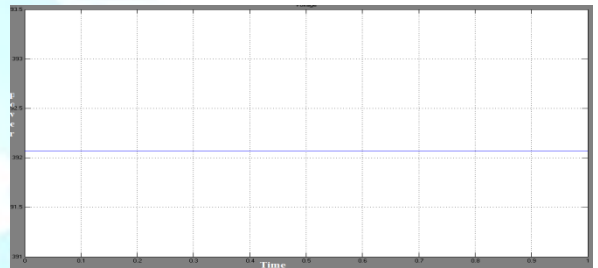


Fig.6. Power versus Time

Open Loop Circuit

The open loop circuit implemented in MATLAB simulation. Solar energy is used as a source which is connected to the interleaved boost converter to increase the resonant pole frequency by the use of smaller inductor value, which improves both control and stability due to which Ripple can be decreased. Finally, Efficiency can be increased 2% higher than the conventional method.

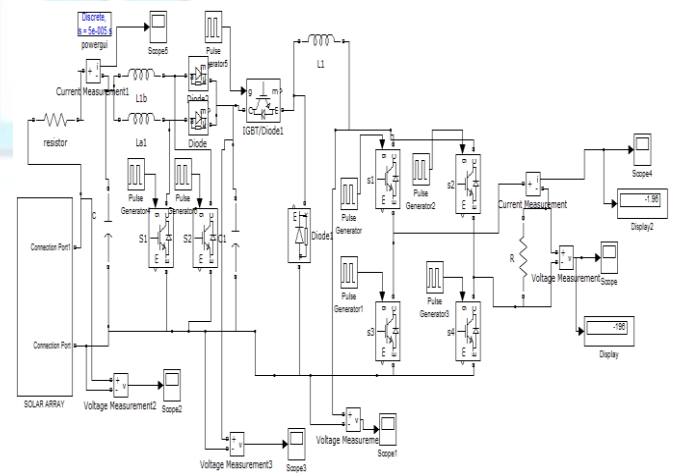


Fig 7. Interleaved Boost Cascaded with Buck PV Inverter

1.96A of load current and 196V load voltage is obtained.

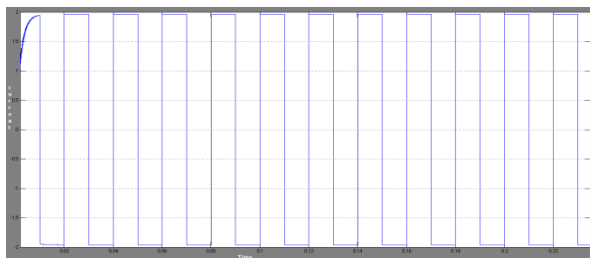


Fig 8. Current versus Time

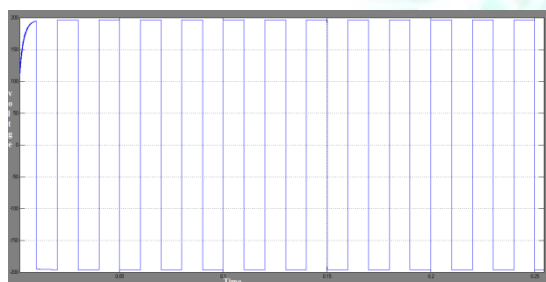


Fig 9. Voltage versus Time

384.16W output power is obtained. Ripples can be reduced by the use of interleaved boost converter.

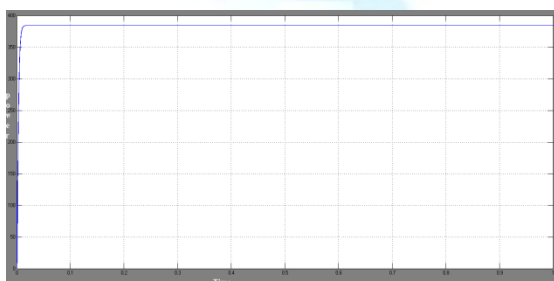


Fig 10. Power versus Time

4. Conclusion

In this paper highly efficient residential PV inverter based on boost cascaded with buck converter along with on unfolding circuit has been presented. An interleaved boost converter is proposed to increase the resonant pole frequency by the use of smaller inductor value which improves both control and stability. By the use of interleaved boost converter ripples can be reduced. Finally the simulation results indicate that the efficiency of proposed solution is around 2% higher than the conventional solution.

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Authors Biography



N.Beulah received her B.E .degree in Electrical & Electronics engineering from Karpaga Vinayaga College of Engineering & Technology (Affiliated to Anna University-Chennai), in 2010 and currently pursuing M.E (Power Electronics & Drives) from Sri Sai Ram

Engineering College (Affiliated to Anna University), Chennai. Her area of interest includes Renewable Energy and Power Electronics



N.Gurusakthi received his B.E .degree in Electrical & Electronics engineering from Syed Ammal Engineering College (Affiliated to Anna University-Chennai), in 2008 and currently pursuing M.E (Power Electronics & Drives)from Sri Sai Ram Engineering

College (Affiliated to Anna University, Chennai).His area of interest includes Renewable Energy and Power Electronics.



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