IJIREEICE

ISSN (Online) 2321-2004
ISSN (Print) 2321- 5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

NFTPCOS-18

National Conference on Future Technologies in Power Control and Communication Systems

College of Engineering Perumon, Kollam, Kerala

Vol. 1, Special Issue 2, March 2018

High Efficiency DC-DC Converter for Low Voltage PV Sources

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Abstract: As far as renewable energy is concerned solar photovoltaic means of energy production plays a major role. Since sun's energy is available in abundant not completely its source is utilized by the photovoltaic cells. So, efficiency of the energy conversion scheme should be high. Hence a high-efficiency dc–dc converter is proposed for low-voltage photovoltaic sources. The proposed converter boosts up the DC voltage with high voltage gain and high efficiency. The proposed converter uses a transformer-less adjustable voltage quadrupler dc–dc converter with high-voltage transfer gain and reduced semiconductor voltage stress is proposed with an input-parallel output-series configuration for providing a much higher voltage gain without adopting an extreme large duty cycle.

Keywords: DC-DC converter, Photovoltaic (PV), Quadrupler.

I. INTRODUCTION

Conventional photovoltaic (PV) generation system is sourced from several serially connected PV module strings, which provides a sufficiently high voltage which can be converted to electricity through the PV inverter. If there are one or more solar panels which are connected in series is shaded, changes in output characteristics called shading will occur. The decrease of conventional energy sources and the environmental pollution led to the research and utilization renewable energy, such as solar energy, wind energy. This paper proposes the design and implementation approach of a PV module micro inverter. The inverter structure is a two-stage system. The first stage is a high step-up high-efficiency DC-DC converter with maximum power point tracking control. The DC-DC converter raises the input low voltage to a high voltage level, and the maximum power point tracking as well as system starting check control are also achieved in this stage. The second stage is a full-bridge inverter. The DC-AC inverter transforms DC voltage from the first stage into sinusoidal voltage waveform for grid connection.

II. BLOCK DIAGRAM AND THE PROPOSED CONVERTER OPERATION

There are two stages in the proposed system. The first stage is the DC-DC converter which releases the maximum solar power from the PV panel and thus provides a high voltage DC for the second stage. The second stage is the inverter stage. In this stage, each of the two switches is being modulated individually so that no problem of overshoot happens. Thus the proposed converter can achieve high efficiency and reliability.

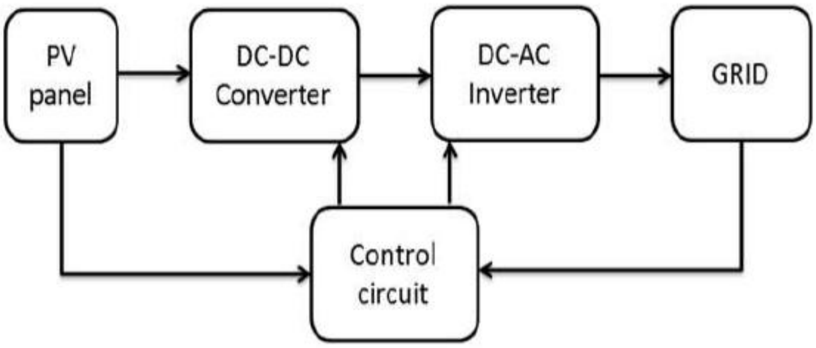

Fig. 1.Block diagram of the proposed system.

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The proposed topology is basically formed from a two-phase interleaved boost converter in which two more capacitors and two more diodes are added so that during the energy transfer period partial inductor stored energy is stored in one capacitor and partial inductor stored energy together with the other capacitor store energy is transferred to the output to achieve much higher voltage gain.

The proposed converter possesses the drawback of existence of pulsating output period. Furthermore, as the main objective is to obtain high voltage gain and such characteristic can only be achieved when the duty cycle is greater than 0.5 and in continuous conduction mode (CCM). Basically, the operating principle of the proposed converter can be classified into four operation modes.

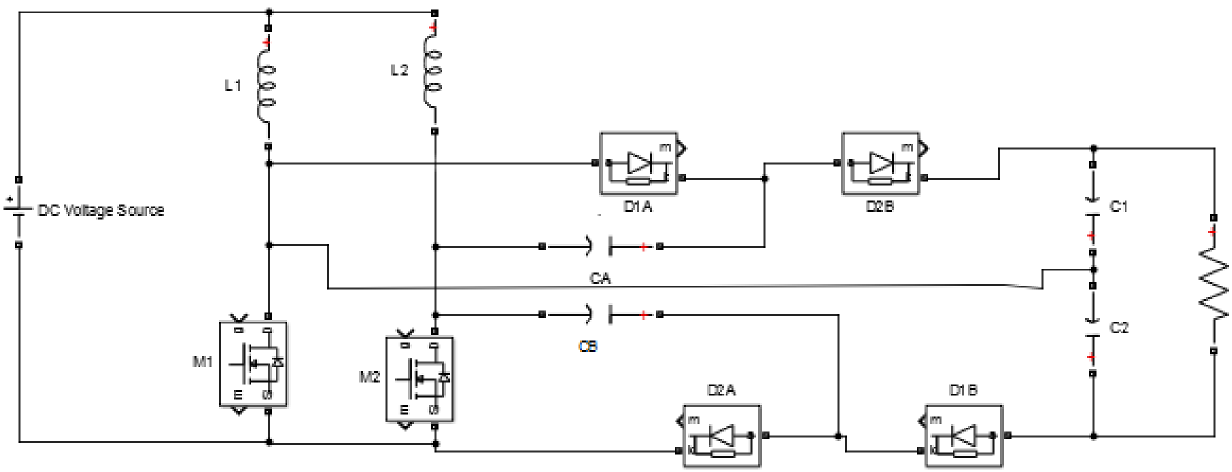

Fig.2. Proposed converter

Mode 1 ($t0 \leq t < t1$): For mode 1, switches S1 and S2 are turned ON, D1A, D1B, D2A, and D2B OFF. Both i_{L1} and i_{L2} are increasing to store energy in L1 and L2. The voltages across diodes D1a and D2a are clamped to capacitor voltage V_{CA} and V_{CB}, respectively. Also, the load power is supplied from capacitors C1 and C2 in Fig. 3 (a).

Mode 2 ($t1 \leq t < t2$): For this operating mode, switch S1 remains conducting and S2 is turned OFF. Diodes D2a and D2b become conducting. It can be seen that part of stored energy in inductor L2 as well as the stored energy of CA is now released to output capacitor C1 and load and part of stored energy in inductor L2 is stored in CB. In this mode, capacitor voltage V_{C1} is equal to V_{CB} plus V_{CA}. Thus, i_{L1} still increases continuously and i_{L2} decreases linearly in Fig. 3 (b).

Mode 3 ($t2 \leq t < t3$): For this operation mode, both S1 and S2 are turned ON. The corresponding equivalent circuit turns out to be the same as mode 1.

Mode 4 ($t3 \leq t < t4$)*:* For this operating mode, switch S2 remains conducting and S1 is turned OFF. Diodes D1a and D1b become conducting. It can be seen that the part of stored energy in inductor L1 as well as the stored energy of CB is now passed to the output capacitor C2 and load. Whereas a part of stored energy in inductor L1 is stored in CA. In this mode, the output capacitor voltage V_{C2} is equal to V_{CB} plus V_{CA}. Thus, iL2 still increases continuously and i_{L1} decreases linearly in Fig. 3 (c).

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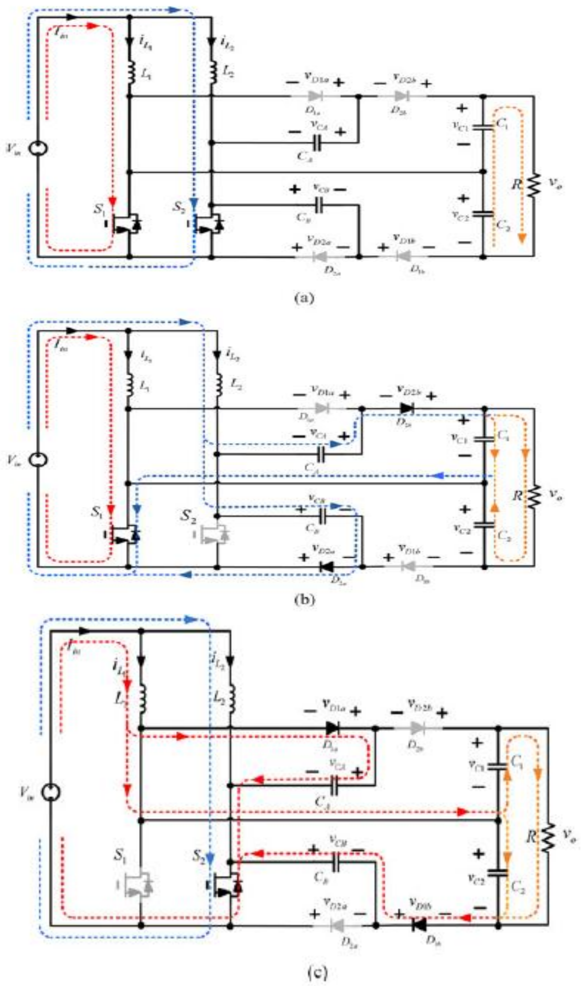

fig. 3. equivalent circuit of the proposed converter (a) mode 1&3 (b) mode 2 (c) mode 4

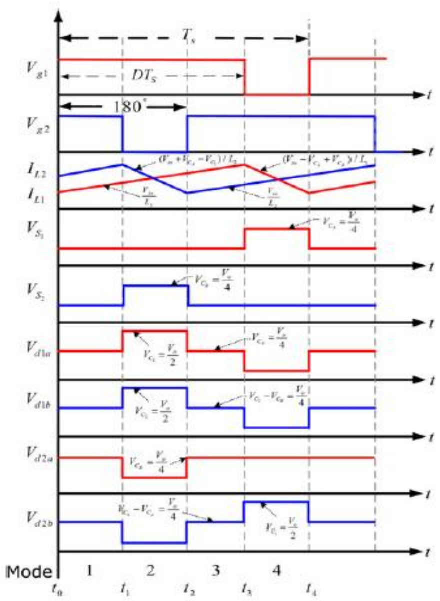

Fig. 4. Waveforms of the proposed converter

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III. SIMULATION DIAGRAM OF THE MICROINVERTER

The proposed microinverter system is simulated in MATLAB to check its performance and its simulink model is been shown. The PV voltage is taken as 22V and the output of the dc – dc converter was obtained as 400V. The output of the dc-dc converter with and without closed loop control is shown

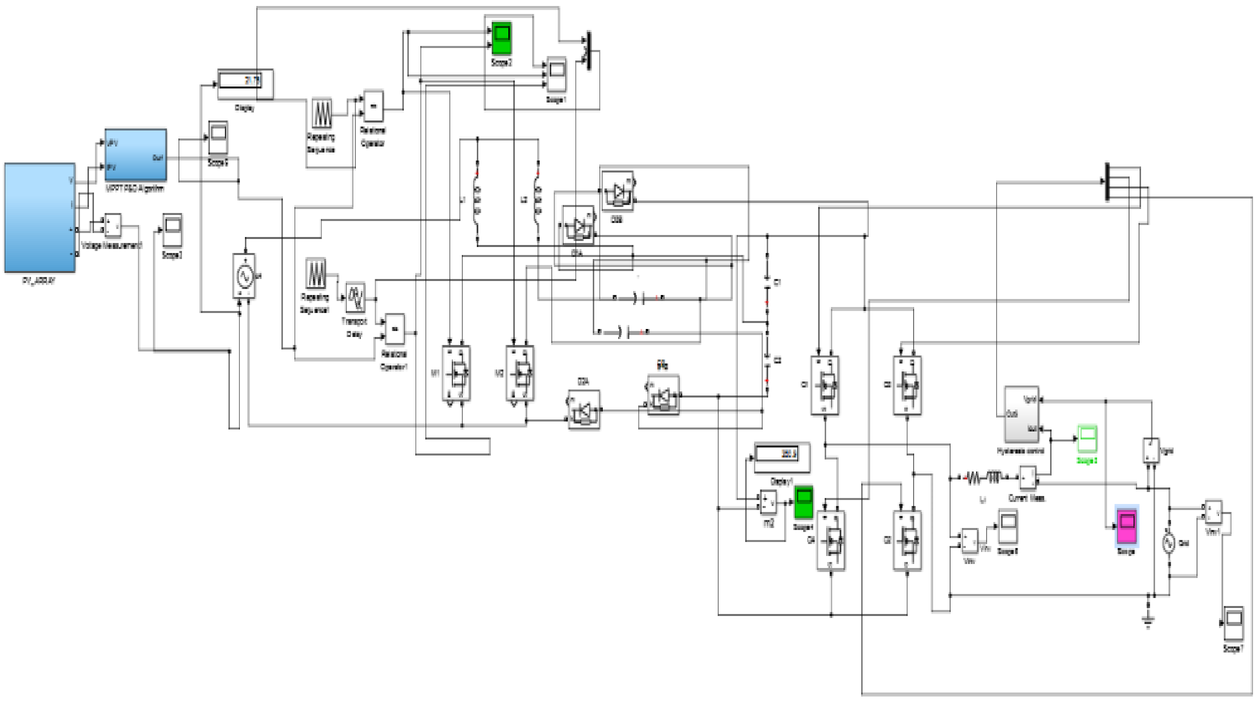
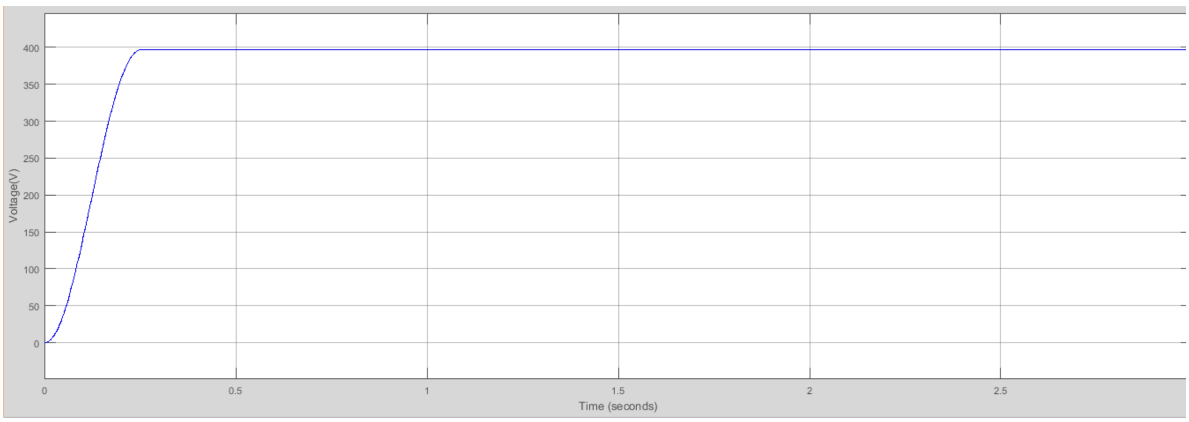
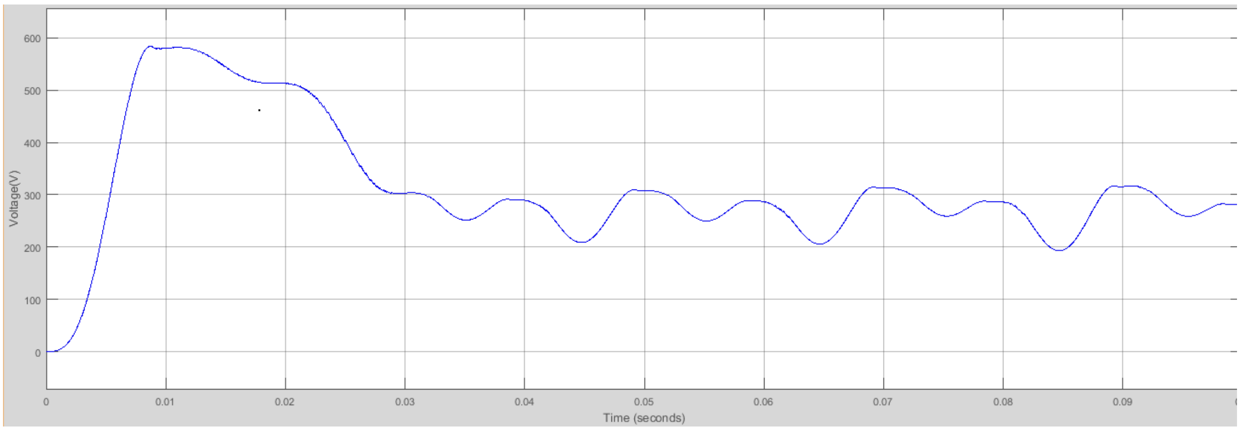


Fig.5. Simulink model of the proposed microinverter



(a)



(b)

Fig. 6. Output voltage of the DC DC converter (a) with closed loop control (b) without closed loop control

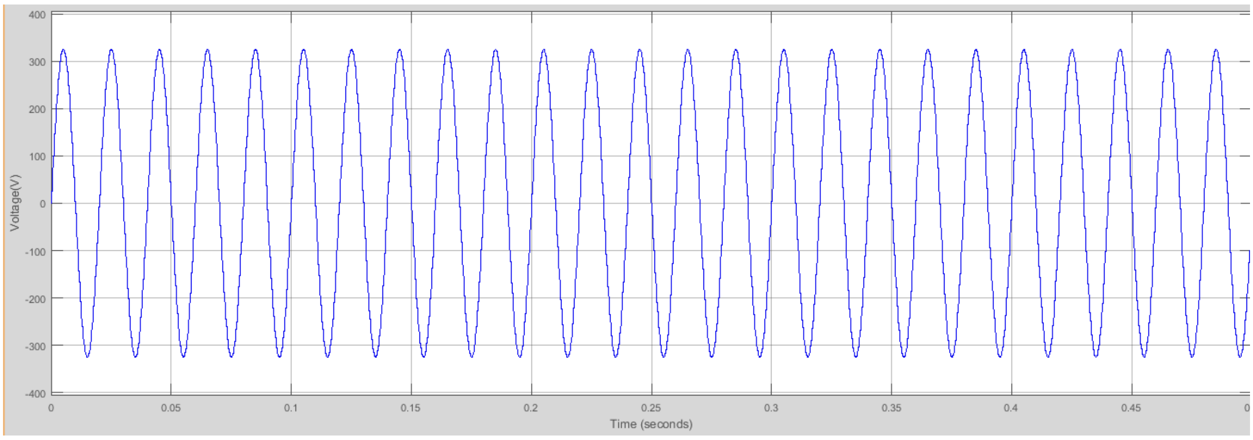


Fig. 7. Output voltage of the microinverter

IV. CONCLUSION

A microinverter for grid connection has been implemented in this paper. For better PV conversion a high efficiency, high gain DC-DC converter has been proposed. The simulation results of the system were verified in SIMULINK/MATLAB. The system is however capable of working in single phase grid connected systems.

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