Abstract—As far as renewable energy is concerned solar energy production plays a major role. Though sun’s energy is abundant not completely its source is utilized by the photovoltaic cells. So, efficiency of the energy conversion scheme system should be high. So 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.

I. INTRODUCTION

Photovoltaic (PV) generation system is sourced from serially connected PV module, which provides a 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 microinverter 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 increases 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 an H-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 [1]. Thus the proposed converter can achieve high efficiency and reliability.

Fig. 1. Block diagram of the proposed system

The proposed topology is basically formed from an interleaved boost converter in which two more capacitors and two more diodes are being added so that during the energy transfer period inductor stored energy is stored in one capacitor and inductor stored energy together with the other capacitor store energy is transferred to the output to achieve a higher voltage gain[2].
High efficiency DC DC converter with fast dynamic response for low voltage photovoltaic sources by Woo Young Choi et. al. [1] proposes a fast output voltage control and reduces the switching power losses and thus increases the efficiency of the system.

A novel transformer-less adjustable voltage quadrupler dc–dc converter with high-voltage transfer gain and reduced semiconductor voltage stress is proposed by Ching-Tsai Pan et.al. [3] in which the topology used is input-parallel output-series configuration for providing a higher voltage gain without adopting large duty cycle. The proposed converter can not only achieve high step-up voltage gain but also with reduced component count and can reduce the voltage stress of both switches and diodes.

Efficient Transformerless MOSFET Inverter for Grid-Tied Photovoltaic System by Monirul Islam et.al. [6] proposes a unipolar sinusoidal pulse width modulation (SPWM) full-bridge transformerless photovoltaic (PV) inverter. The paper explains that it can achieve high efficiency by using latest super-junction metal oxide semiconductor field effect transistor (MOSFET) together with silicon carbide (SiC) diodes. The added clamping branch clamps the freewheeling voltage at the half of dc input voltage during the freewheeling period. As a result, the common mode (CM) voltage kept constant during the whole grid period that reduces the leakage current significantly. In addition, dead time is not necessary for main power switches at both the high frequency commutation and the grid zero crossing instant, results low current distortion at output.

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.

**Mode 1 (t0 ≤ t < t1):** For mode 1, switches S1 and S2 are turned ON, D1A, D1B, D2A, and D2B OFF. Both iL1 and iL2 are increasing to store energy in L1 and L2. The voltages across diodes D1a and D2a are clamped to capacitor voltage VCA and VCB, respectively. Also, the load power is supplied from capacitors C1 and C2 in Fig. 3 (a).

**Mode 2 (t1 ≤ 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 Vc1 is equal to V cb plus VCA. Thus, iL1 still increases continuously and iL2 decreases linearly in Fig. 3 (b).

**Mode 3 (t2 ≤ 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 \((t_3 \leq t < t_4)\): 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 \(C_B\) is now passed to the output capacitor \(C_2\) and load. Whereas a part of stored energy in inductor L1 is stored in \(C_A\). In this mode, the output capacitor voltage \(V_{C_2}\) is equal to \(V_{C_B}\) plus \(V_{C_A}\). Thus, \(i_{L_2}\) still increases continuously and \(i_{L_1}\) decreases linearly in Fig. 3 (c).

![Fig. 3. Equivalent circuit of the proposed converter](image)

(a) Mode 1 & 3  (b) Mode 2  (c) Mode 4

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. 4. Waveforms of the proposed converter](image)
Fig. 5. Simulink model of the proposed microinverter

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

A detailed analysis and modelling of a microinverter for a photovoltaic system 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 quadrupler circuit and the inverter are the main two stages of the system. The output voltage of the PV panel is given as the input to the converter and this voltage is stepped up by using the dc dc converter which is the quadrupler circuit. The simulation results of the system were verified in SIMULINK/MATLAB. Boost converter output voltage was obtained as 400V. Also a voltage of 230V was obtained for the inverter. The system is however capable of working in single phase grid connected systems.

REFERENCES


[3] Ching-Tsai Pan, Member, IEEE, Chen-Feng Chiang, and Chia-Chi Chu, Member, IEEE, “A Novel Transformer-less Adaptable Voltage Quadrupler DC Converter with Low Switch Voltage Stress” IEEE transactions on power electronics, vol. 29, no. 9, september 2014


