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Quasi Single Stage Inverter

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Abstract: For the growing electricity demand solar energy has vital role. Power electronic device has important role for converting dc power extracted from sun light to suitable available form of energy such as ac power. The roof top solar P V are found in everywhere because of its available amount of power in an easy manner. The proposed system deals a single stage inverter for efficient ac-dc operation without line frequency transformer. It also overcomes the drawbacks of conventional inverter system. The proposed system can operate in both boost and buck mode by adjusting the control pulses. The system is analysed by using MATLAB/SIMULINK model.

Keywords: Renewable energy, MO SFET, Pulse Width Modulation (PWM), DC-AC inverter

I. INTRODUCTION

Renewable energy source has important role in energy extraction among that most commonly available or used form of energy is from sunlight. So the roof top solar PV are found in everywhere for energy extraction. An inverter is necessary for making the available PV source of energy to grid connected application. Several inverter topologies are existed to perform the function based on the available amount of power. Central inverter topology is used to transform high DC power (more than 10KW) to ac power suitable for grid. But it has certain drawback such as DC wiring cost, power loss due to voltage drop, system output reduce s due to partial shading etc. These can be overcome by string inverters. Compared to central inverter they have better MPPT capability but they also have poor flexibility at partial shading. Multi MPPT inverter is the modified form of string inverter. Later module integrated inverter is used for power rating less than 300W [7].The advantage of inverter is there is no dc cabling requirement and mismatch losses [4], [6].

Multistage power conversion system mostly used in grid connected application. They utilise two stages, DC-DC conversion stage for boosting the solar PV array voltage and track maximum power from PV array. Then it is followed by DC-AC inverter, which is the second stage. The first stage operates as boost or buck boost type converter. The drawbacks of such system are larger size, lower reliability, higher part count and cost [2], [9]. Single stage topology can overcome these drawbacks [8]. Single stage buck type inverter s require several series connected modules also input dc voltage is less than peak value of output voltage so they are inadequate for power conversion.VSI perform voltage buck operation and CSI inverter perform voltage boost operation. Current source inverter requires bulky inductor in dc side [3]. In VSI inverter topologies, transformers are used to perform voltage boosting. Full bridge inverter is a VSI topology. They lower the output of dc power source. To solve this problem line frequency transformers are used [5]. The structure increases system volume, weight, cost also reduces system power density. Because of this two stage structure mostly used in grid connected application. To overcome the drawbacks of conventional topologies proposed system introduce a single stage buck boost inverter. They perform voltage buck and boost operation in a single stage inverter [1]. They have compact structure, improved power density, efficiency without utilising line frequency transformer and additional passive network elements.

II. PROPOSED SYSTEM

The proposed systems replace the line frequency transformer to an AC- AC module to perform voltage boost function. Here the DC source connected to a voltage source inverter followed by AC-AC module. They perform voltage buck and boost operation b y utilising single power conversion.

Hence they can be called it as a quasi single stage inverter. The system share inductor and capacitor in DC-AC and AC-AC units. Hence they do not require additional passive elements.Fig.1shows the circuit diagram of proposed inverter.

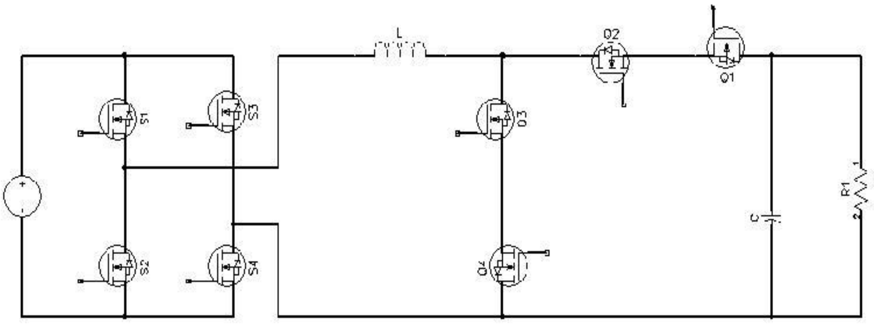

Fig. 1 Circuit diagram of proposed inverter

III. PRINCIPLE OF OPERATION

Proposed inverter can be operated in both boost and buck mode of operation. SPWM (sinusoidal pulse width modulation) is the control strategy used to switching the system. The DC power which is from PV panel or DC source directly given to the full bridge inverter to get an AC output voltage. In boost mode the AC-AC unit required for boosting operation, where as in buck mode there is no need of high frequency AC-AC module. The equivalent circuit of buck mode of operation is shown in fig.2.

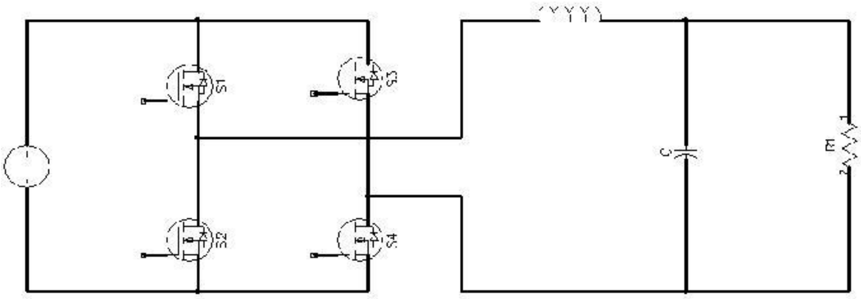

Fig. 2 Circuit diagram of proposed inverter in buck mode

Frontend VSI has four switches S_1, S_2, S_3, and S_4.They are operated in complementary fashion. During positive half cycle S_1 and S_4 will be operated and in negative half cycle S_3 and S_4 will be operated. Two switches in same leg will not be operated simultaneously in order to avoid dead shot. The bridge output voltage can be expressed as,

$$V_o = mV_i sin\omega t \quad (1)$$

Where ‘m’ is the modulation ratio.

In buck mode m is used to step down the voltage. In buck mode of operation, the inverted voltage is passed through the AC-AC module. But there is no boosting operation happened. In buck mode the switches Q_1 and Q_2 are always on while Q_3, Q_4 switch in line frequency. There is no high frequency pulse required for switching operation. The output voltage of AC-AC module can be represented as,

$$V_o = \frac{mV_i sin\omega t}{d} \quad (2)$$

As can be seen, the output voltage can be modulated1 with two parameters modulation ratio ’m’ and duty ratio d’. Where d’ is the duty ratio of Q_1 for positive half cycle and Q_2 for negative half cycle.

$$d' = 1 - d \quad (3)$$

Where d is the duty ratio of Q_3 in positive half cycle and Q_4 in negative half cycle.

When input voltage is high the system operated in buck mode. The switches Q_1 and Q_2 become turn on always by setting d’=1.When input voltage is low to get the desired output voltage the system operated in boost mode by setting m=1 and d’ is adjusted to boost the voltage. SPWM signals are produced by sinusoidal signal with carrier signal. The switches of full bridge inverter operated by using SPWM signals, the same modulation scheme is used in AC-AC module in boosting operation.

The voltage gain can be expressed a s,

$$\frac{V_o}{V_i} = \frac{sin\omega t}{d} \quad (4)$$

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STIMULATION RESULTS

The proposed system has been simulated in MATLAB/SIMULINK model [10]. For the 100V input dc voltage system gives an output of 200Vac in boost mode of operation. The dc-ac and ac-ac units share the inductor and capacitor having the specification 1 mH and 20uF respectively.

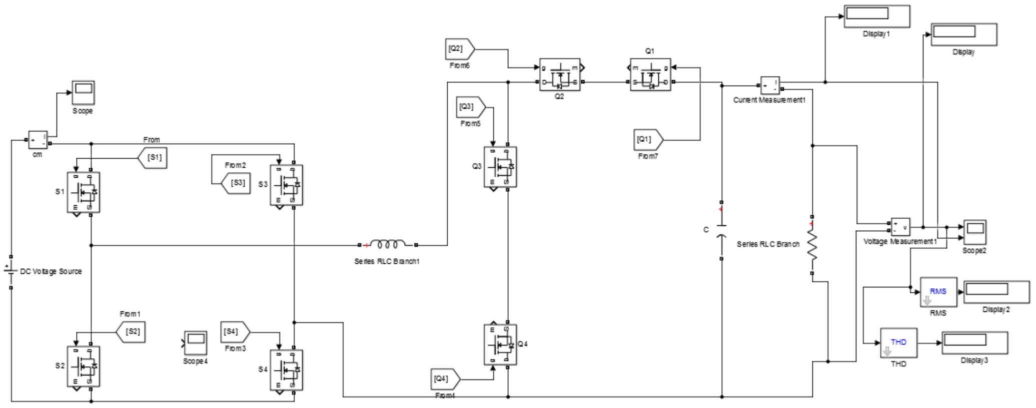

Fig. 3 Simulated view of proposed inverter

SPWM signals of 20 KHz are used to give control pulses. Full bridge circuit consist of four switches operated using SPWM signals, which is shown in fig.4.

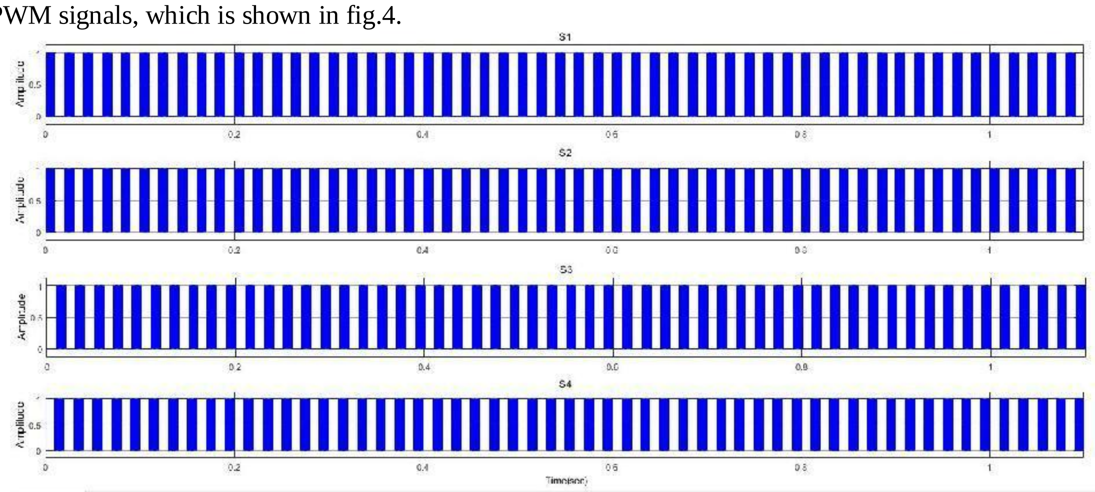

Fig. 4 Waveform shows pulses given for full bridge

Fig.5 shows the waveform of pulses for the switches of ac-ac module in boosts and buck mode of operation. In boost mode positive half cycle Q_2 and Q_4 are turn on and Q_1 and Q_3 are switch with high frequency pulses, where as in negative half cycle Q_1 and Q_3 are on Q_2 and Q_4in high frequency pulses.

In buck mode of operation Q_1 and Q_2 are always on Q_3 and Q_4 switch with line frequency pulses.Q_4 switch in positive half cycle and Q_3 switch in negative half cycle.

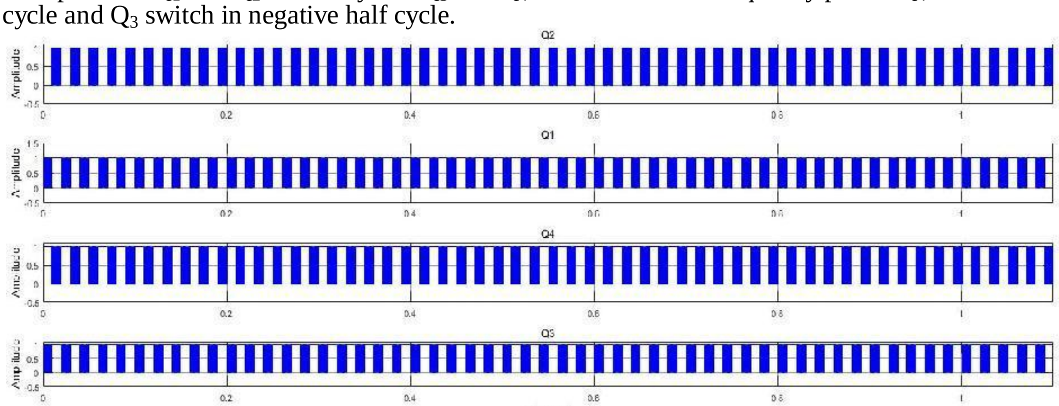

Fig.5 Waveform shows the pulses given for switches in boost mode

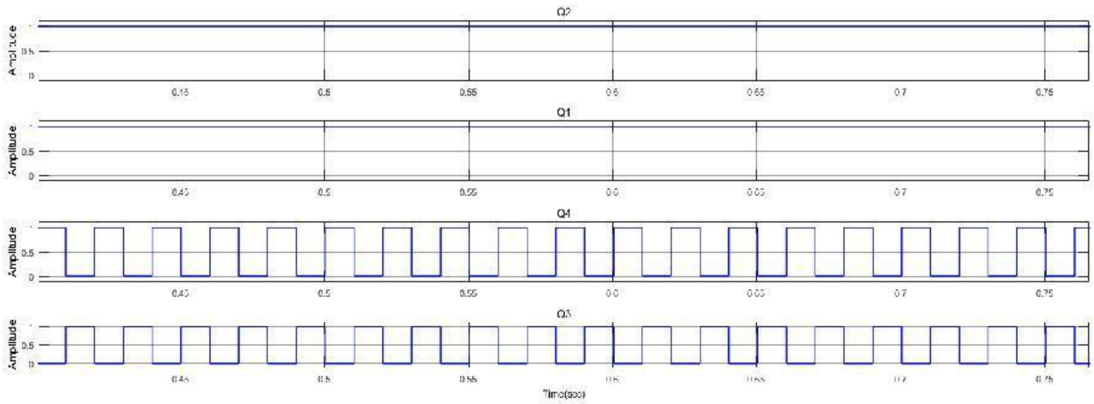

Fig. 6 Waveform shows the pulses given for switches in buck mode

Fig.7 shows the output voltage of 2 00V ac for 100V dc source voltage in boost mode of operation. For 200V dc input the system gives 100V ac output in buck mode which is shown in fig.8.

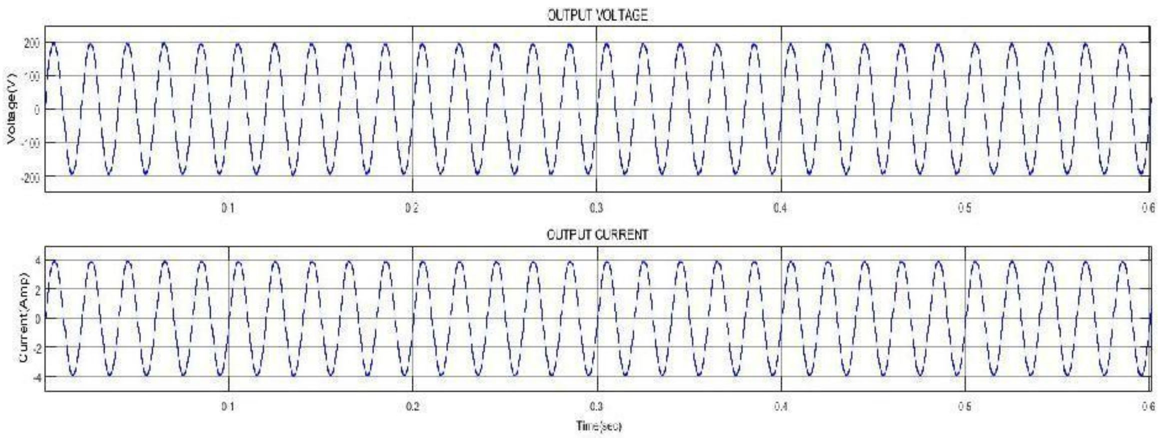

Fig. 7 Waveform shows output voltage and current of inverter in boost mode

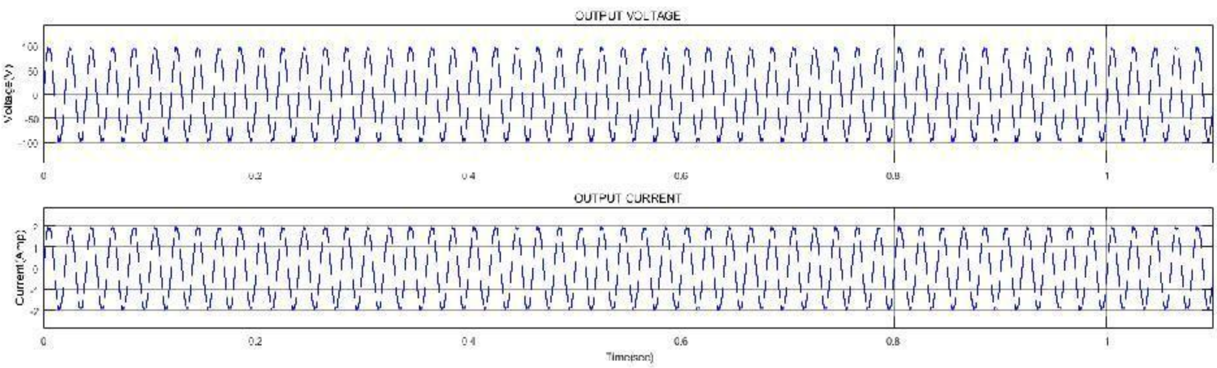

Fig. 8 Waveform shows output voltage and current of inverter in buck mode

Fig.9 shows the total harmonic distortion level of proposed inverter. FFT analysis shows that only 5th order harmonics exist compared to other harmonics level. The harmonic level of proposed inverter is 2.98%, which is less than standard acceptance level.

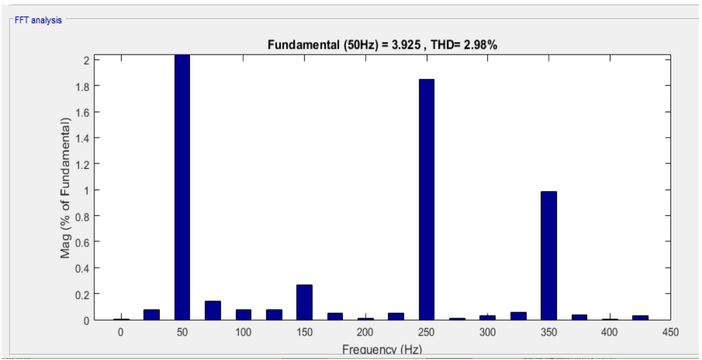

Fig. 9 Harmonic level of proposed inverter

CONCLUSION

The proposed inverter operated in both boost and buck mode which is validated from the simulation results. The system performs voltage boost function without introducing line frequency transformer and other passive components. By adjusting the modulation parameter the system output voltage can be modified. Also, the system harmonic level less than 5% which is the standard acceptance level. The system offered compact structure, improved power density and efficiency without utilising transformer and other passive components.

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