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Three Phase Single Stage Boost Inverter With Coupled Inductor For Renewable Energy Sources

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***Abstract*: A wind-solar hybrid system is a reliable alternative energy source because it uses solar energy combined with wind energy to create a stand-alone energy source that is both dependable and consistent. Renewable power systems as distributed generation units often experience big changes in the inverter input voltage due to fluctuations of Wind energy resources. However, when a very high boost gain is demanded, the duty cycle may come to its extreme and large duty cycles causes serious reverse-recovery problems. This paper proposes a three phase single stage boost Inverter with space vector modulation, by introducing hybrid system containing Permanent magnet Synchronous Generator(PMSG) along with Photovoltaic cell. The MaximumPower Point Tracker (MPPT) including coupled inductor into the three phase bridge inverter can realize a high boost gain and output a stable ac voltage. The single-stage operation of the converter may lead to improved reliability and higherefficiency.**

***Index Terms:* Space vector modulation, Boost inverter, Bridge inverter, MPPT, PV cell, shoot-through zero state, PMSG.**

I. INTRODUCTION

The increasing number of renewable energy sources and distributed generators requires new strategies for the operation and management of the electricity grid in order to maintain or even to improve the power supply reliability and quality. In addition, liberation of the grids leads to new management structures, in which trading of energy and power management structures, in which trading of energy and power is becoming increasingly important. The power-electronic technology plays an important role in distribution generation and in integration of renewable energy sources into the electrical grid, and it is widely used and rapidly expanding as these applications become more integrated with the grid-based systems. Wind is an abundant source of energy that will never run out. It is world's fastest growing energy source which is available free. Its maintenance and running cost is low[1].

The Permanent Magnet Synchronous Generator (**PMSG**) the design [2] can be even more simplified. A Voltage source inverter (VSI) proposed in [3] is able to overcome the problems in conventional VSI and conventional current source inverter. It can provide a wide range of obtainable voltage and has been applied to renewable power generation systems [4]–[7]. K. Nishida, T. Ahmed show some advantages of QZSIs over conventional ZSI, such as lower voltage/current stress of impedance network and lower switch voltage stress. Nevertheless, they do not overcome the limits of conventional ZSI described earlier.

II. PROPOSED BOOST INVERTER:

Figure 1 shows the conventional two-stage power conversion for wind power generation. Here wind turbine is fed to the PMSG and the boost inverter is fed to the load side, space vector pulse width modulation used to get the better controlling of wind turbine as well as to get improved modulation index operation.

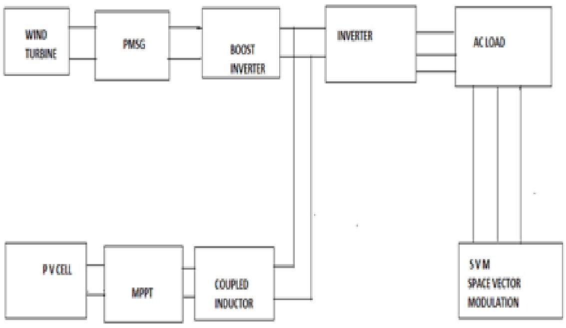


Fig.1.boost inverter with space vector modulation

Permanent magnet synchronous generator: A Permanent magnet synchronous machine is an ac rotating machine whose speed under steady state condition is proportional to the frequency of the current in its armature. Because the rotor speed is proportional to the frequency of excitation, synchronous motors can be used in situations where constant speed drive is required.

Topology Analysis of SL Z-Source Inverter:

As illustrated in Fig. 2, the proposed SL Z-source inverter consists of four inductors ($L1$, $L2$, $L3$, and $L4$), two capacitors ($C1$ and $C2$), and six diodes ($D1$, $D2$, $D3$, $D4$, $D5$, and $D6$).

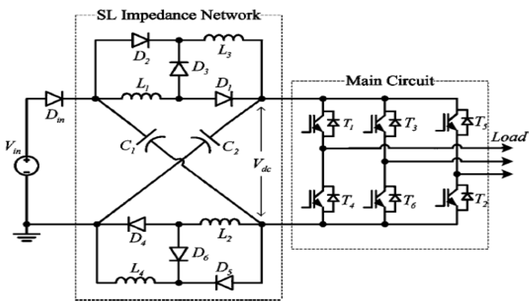


Fig.2.Topology of proposed SL Z-source inverter

The combination of $L1$–$L3$–$D1$–$D3$–$D5$ and the combination of $L2$–$L4$–$D2$–$D4$–$D6$ performs the function of the top SL cell and the bottom SL cell, respectively. Both of these two SL cells are used to store and transfer the energy from the capacitors to the dc bus under the switching action of the main circuit.

III. Photovoltaic Systems:

In order to transfer energy from Photo Voltaic cell arrays into utility grids, PCS converter systems have to fulfill the following three requirements:

1) To convert the dc voltage into ac voltage
2) To boost the voltage, if the PV array voltage is lower than the grid voltage
3) To insure maximum power utilization of the PV modular.

In the system shown in Fig. 3(a), a transformer at line frequency is utilized to boost the voltage after the dc–ac inverter. a high frequency dc-dc converter is used to boost the voltage to a constant value as shown in Fig. 3(b).

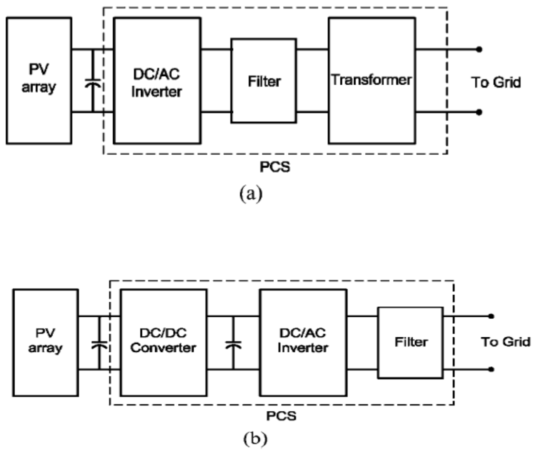


Fig.3.Traditional PV systems: (a) dc–ac with step-up transformer and (b) dc–ac with dc–dc boost.

PRINCIPLE OF MPPT:

Maximum power point tracker (or MPPT) is a high efficiency DC to DC converter that presents an optimal electrical load to a solar panel or array and produces a voltage suitable for the load. Maximum power point trackers utilize some type of control circuit or logic to search for this point and thus to allow the converter circuit to extract The error is fed into a proportional integrator (PI) type controller, which controls the duty cycle of the dc-dc converters. For the fuel cell system, the inductor reference current is calculated using a look-up table. The input of the look-up table is difference between required power and summation of the power generated by the turbine and photovoltaic array. The difference between this reference current and the measured inductor current is fed to the PI controller to minimize the error.

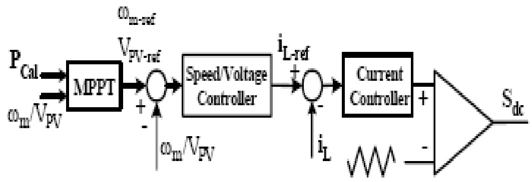


Fig.4. Point Tracking of Wind and Photovoltaic Sources

Space Vector PWM:

The space vector PWM (SVM) method is an advanced, computation-intensive PWM method and is possibly the best method among the all PWM techniques for variable-frequency drive application. Because of its superior performance characteristics, it has been finding wide spread application in recent years. Space vector modulation (SVM) is an algorithm for the control of pulse width modulation (PWM). There are various variations of SVM that result in different quality and computational requirements. One active area of development is in the reduction of total harmonic distortion (THD) created by the rapid switching inherent to these algorithms. As illustrated in Fig.3, there are eight possible combinations of on and off patterns for the three upper power switches. The on and off states of the lower power devices are opposite to the upper one and so are easily determined once the states of the upper power transistors are determined.Fig.4 shows Six out of these eight topologies produce a nonzero output voltage and are known as non-zero switching states and the remaining two topologies produce zero output voltage and are known as zero switching states.

The desired three phase voltages at the Output of the inverter could be represented by an equivalent vector **V** rotating in the counter clock wise direction as shown in Fig.6 (a). The magnitude of this vector is related to the magnitude of the output voltage (Fig.6 (b)) and the time this vector takes to complete one revolution is the same as the fundamental time period of the output voltage.

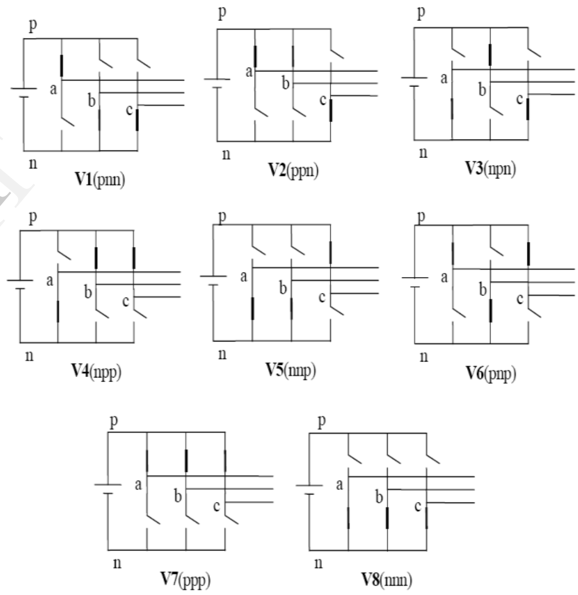


Fig.5 Eight switching state topologies of a voltage source inverter

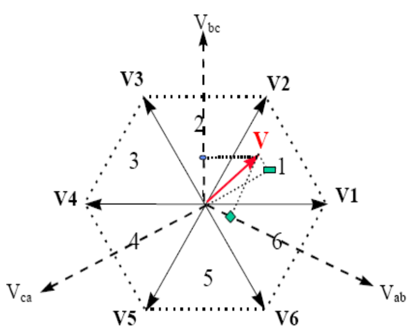


Fig.6 (a). Output voltage vector in the α, β plane.

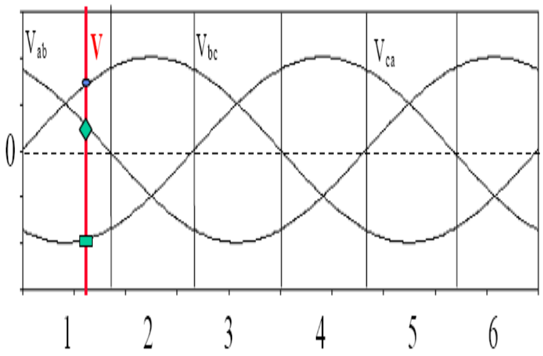


Fig.6 (b). Output line voltages in time domain.

IV. Simulation Results:

Simulation has been performed to confirm the previous analysis. Figure7 shows the simulation waveforms of single stage inverter connected to wind energy.

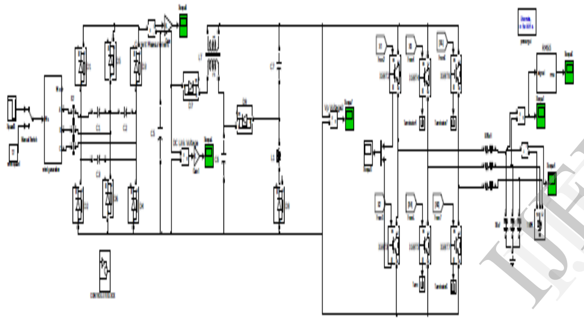
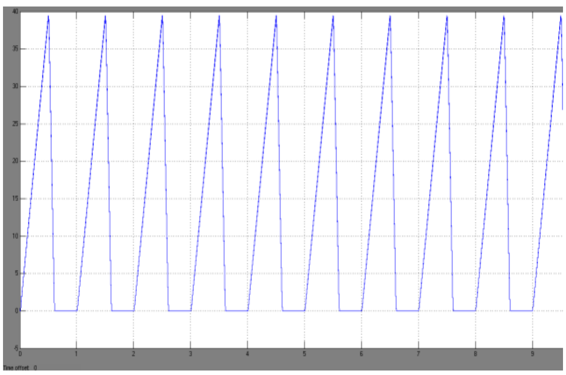
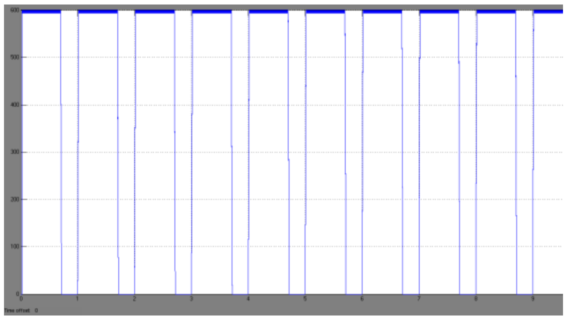


Fig.7. Boost inverter with coupled inductor

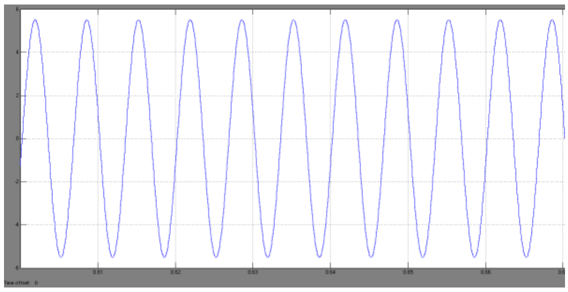
Figure 8 shows the wave forms of the boost inverter connected to a wind turbine model.



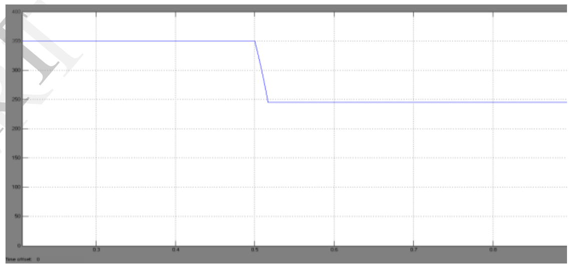
(a)



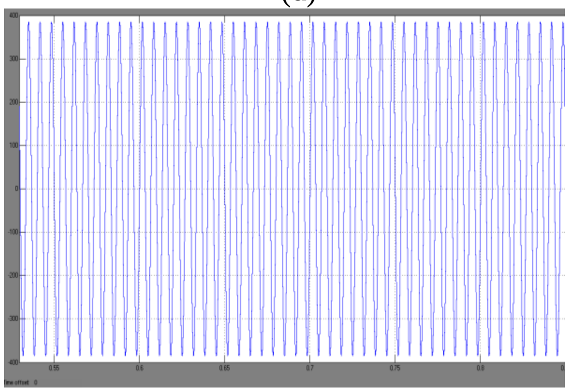
(b)



(c)



(d)



(e)

Fig.8. Simulation waveforms

By using space vector modulation the results Waveform distortion of the ac output voltage caused by dead time is essentially avoided. Fig.8 shows the simulation waveforms. It is clear that the bus voltage is stepped up to 400V, indicating a successful boost inverting operation of the converter. In this case, the modulation index was set to 0.96, the shoot-through duty cycle was set to 0.355, and the switching frequency was 6 kHz. The shoot-through zero state was inserted in every traditional open-zero state, achieving an equivalent switching frequency of 18 kHz viewed from the Impedance network. Fig.8(c) illustrates that the output phase voltage is constant during input voltage transient.

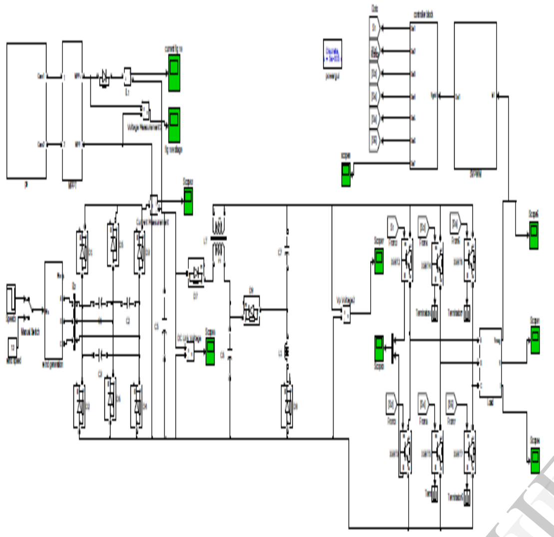


Fig.9. proposed system model configuration

A prototype, as shown in Fig.9, has been constructed. The same parameters as the simulation were used. Fig. 10 shows the modified results. When the input voltage is low, as shown in Fig. 10(a) and (c), the shoot-through zero state was regulated to boost the amplitude of bus voltage to about 400V, enough to output the desired ac voltage. Fig. 10(e) shows a constant output phase voltage when input voltage varies from 350 to 250V. The waveforms are consistent with the simulation results. By controlling the shoot-through duty cycle By introducing the Space vector modulation the desired output voltage can be obtained even when the input voltage is at a low level.

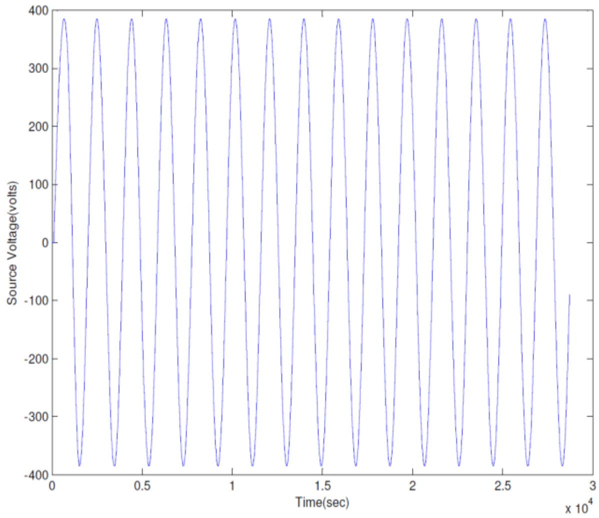


Fig.10 (a) Source voltage magnitude versus time

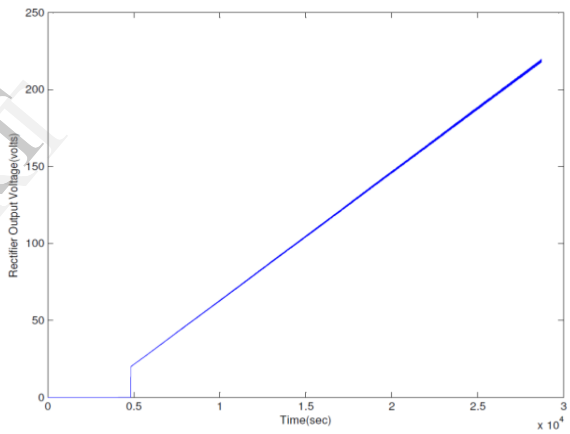


Fig.10 (b) Rectifier output current versus time

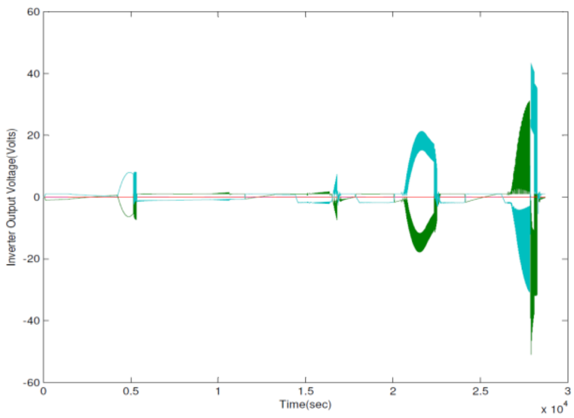


Fig.10(c) Inverter output voltage versus time

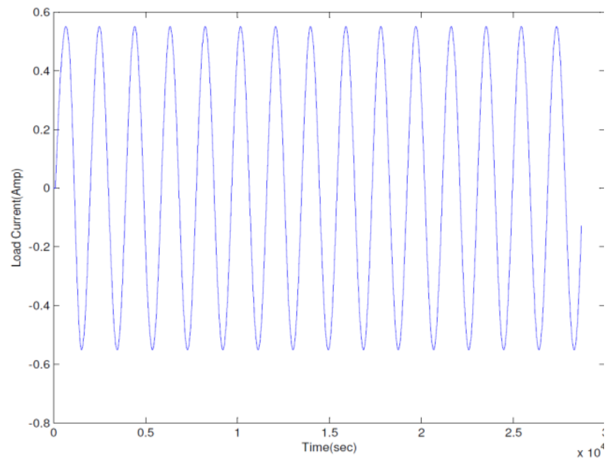


Fig.10(d) Load current magnitude versus time

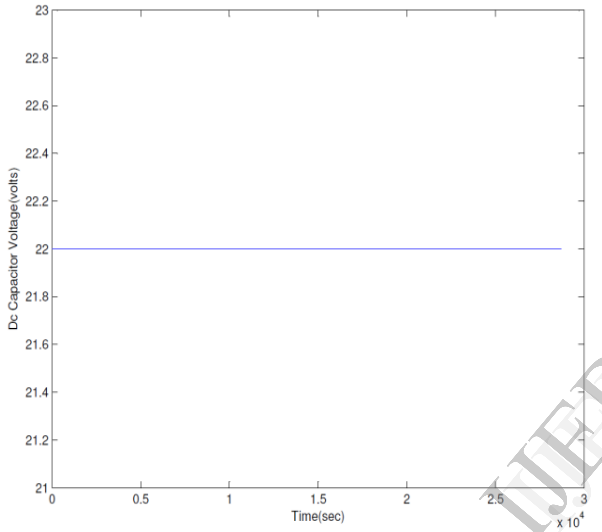


Fig.10 (e) Dc capacitor voltage versus time

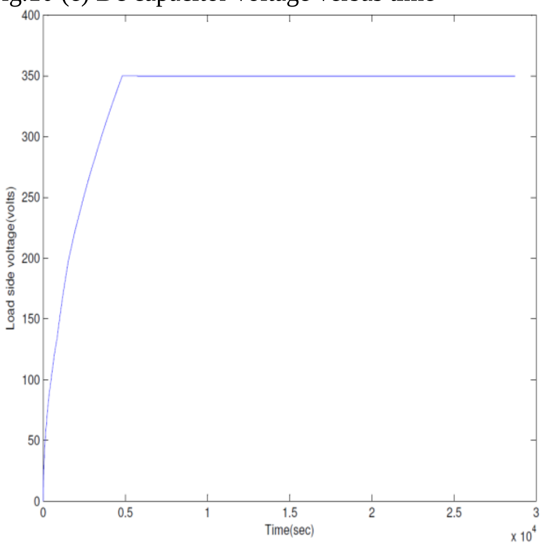


Fig.10(f) Load side voltage magnitude versus time

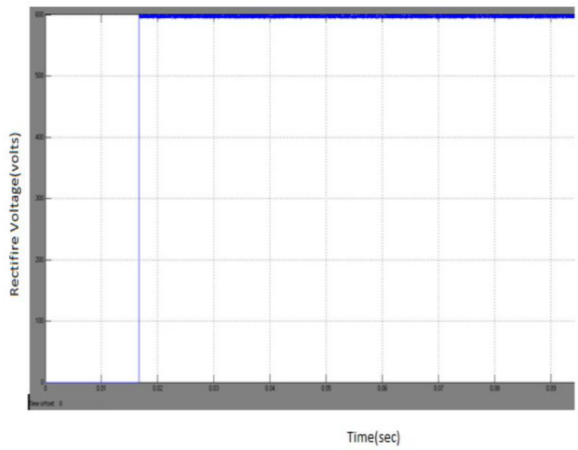


Fig.10 (g) Rectifier voltage versus time

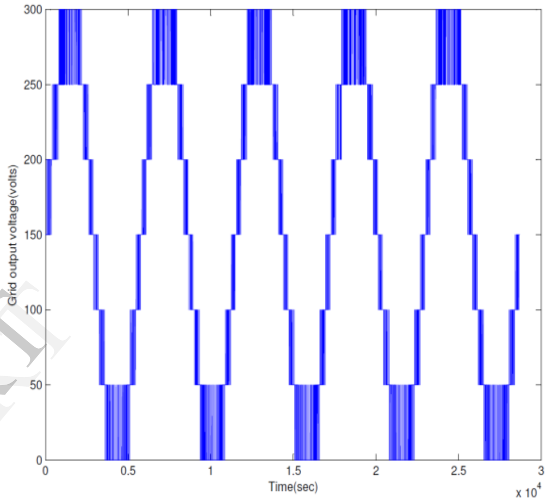


Fig.10 (h) Grid output voltage versus time

V. CONCLUSION

This paper has presented a novel single-stage boost inverter with Space Vector PWM, which exhibits several merits.

a) Shoot-through states, which are forbidden in conventional VSIs, are utilized to store and transfer energy within the impedance network to boost the amplitude of the bus voltage. Waveform distortion of the ac output voltage caused by dead time is essentially avoided.

b) The reduction of total harmonic distortion (THD) created by the rapid switching inherent to these algorithms by using space vector PWM technique.

C) To ensure maximum power utilization of the system by using PV modular.

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BIOGRAPHY

Shaik Baji received his B.Tech Degree in Electrical & Electronics Engineering from chalapathi institute of engineering, Guntur India in 2011 currently he is pursuing M.tech in Aditya Institute of Technology & Management, Tekkali, Srikakulam, India. His research interests include Network theory, Control systems, Power electronics.

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Mr. S.Nagaraju obtained the B.Tech. Degree in EEE from CR REDDY College of Engineering, ELURU, 1998, M.Tech Degree in Energetics from NIT, CALICUT in 2000. He has more than 08 Years of industrial Experience and 05 Years of Teaching Experience. Currently he is working as a Associate Professor in the Department of Electrical & Electronics Engineering, Aditya Institute of Technology And Management, Tekkali, Srikakulam District, Andhra Pradesh. His research interests are power system and its protection and power electronics. He has published two papers in power electronics area.