PV Integrated SEPIC Converter Using Maximum Power Point Tracking for Ac Loads

K. Mohanraj, B.Yokesh Kiran

Abstract--- A PV integrated SEPIC converter where it able traceout the maximum power point (MPP) of a photovoltaic (PV) source and it can able to generates a sine output for AC loads and grid connected application. It is double stage topology where it traces and finds out the maximum power point of PV source using P&O algorithm.To enable connection with the PV model,where it needs the regulation and compact are increased with a double stage that traces outthe Maximum power inPV source, the input of PV system is DC voltage where its boostwith the help of SEPIC converter and it able to generate a regulated sine outputusing single orthree phase inverterfor a standalone systemin AC loads and grid connected applications. In proposed system in order to get the maximum power point in photovoltaic input where it is compared with sinusoidal pulse width modulation in order to get voltage and current. A converter is SEPIC converter and the PV panel is controlled by a sinusoidal pulse width modulation using PI controller where it helps to controlling the duty cycle ratio of SEPICconverter. A hardware prototype of PV integrated SEPIC converter for a standalone system that operates at 70W PV module system and delivering sine output voltage of 110V rms, with 50Hz frequency and the output simulations are presented.

Keywords--- Photovoltaic(PV),Maximum Power Point Tracking(MPPT),SEPIC Converter.

I. INTRODUCTION

Capacitor control conditioners carry out control change by electronic switching exchange of capacitors in between the data control source of the system and the heap. SEPIC converters are mostly utilized for dc-dc converter. The important advantage for SEPIC converter is that it has a non-inverting output (output voltage has the same similar polarity as the input voltage). SEPIC converter is essentially boost converter and is same as the classical buck-boost converter. Making of regulating examine, control frameworks, topologies capacity issues and purpose of SEPIC converters are mostly used on project where it is dc-dc converter.

The most specific part of SEPIC converter where it has one mosfet switch which plays a major role in the model and impelling high power voltageshowed up diversely in connection to standard dc-dc converters. SEPIC converter where it normally same as classical buck boost converter in proposed system where SEPIC converter act as only boost converter. In order to get PV voltage increased.PV module is integrated with SEPIC converter where it is able to maximize the output of PV voltage and it is given to inverter where it converts dc voltage to ac voltage. Thegenerated sine output is given to ac load or to grid connected applications.

The SEPIC converter and SPWM where it has capable of performing maximum power point tracking of separate independent PV model. By using SPWMwhere the PV voltage is compared and referenced by carrier frequency signal inorder to get gating signal where it helps to trace out the maximum point in PV system. The first block is an PV integrated with SEPIC converter where it traces out maximum power that boostinput voltage and the second stage of block is a single phase inverter or three phase inverter where it is the conversion stage dc-acand it's given to ac load.AC load where it can be induction motor or any other ac load applications .In proposed system where the output voltage is given to induction motor or different ac loads.In proposed system where it operates at 70W PV module system where it is operated by PIC microcontroller in hardware prototype and delivering sine output voltage of 110V in single phase inverter with 50Hz frequency.

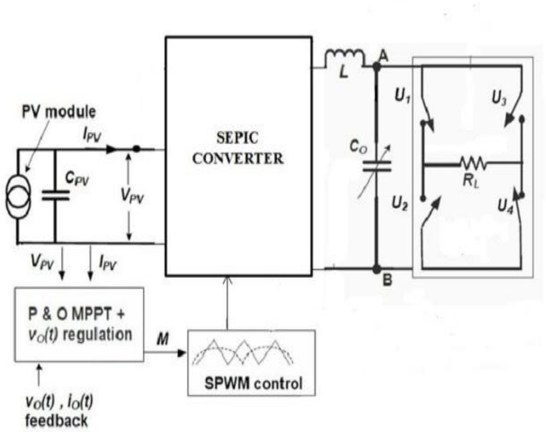

Fig.1.PV Module Integrated Inverter with SEPIC Converter.

II. WORKING PRINCIPLE OF SYSTEM

The main aim of stage of processing is converting PV output to AC. The input of controller is dc output of PV panel where it is send to SEPIC converter where it boosts the PV output voltage and where it finds and trace out the maximum power point extraction in PV panel, the first block is boosting up the voltage and second block is send to inverter for conversion ofdc to ac voltage.

Manuscript received June 10, 2019 .

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The figure 1 shows the circuit diagram of PV module integrated with SEPIC.

Because of the advantages of two stage topology, we proposed ona PV model connectedwith SEPIC converterthat tracks the MPP. In first stage of block where PV output is boosted up and second stage is boosted output voltage where the boosted and converted AC voltages 110 V in rms, 50Hz frequency .The applied output voltage is used in ac loads and grid connected applications. Proposed system used only for AC loads or grid application where it can be connected directly from the output.

III. PROJECT DESCRIPTION

The SEPIC converter device is primarily based schemes accessibleuntil extent and lots of the proposals with standard converters are 2 level solutions. Because of the obliviousbenefits of 2 level topology, wetend topropose a PV model connectedSEPICand SPWM where it primarily traces out the MPP and it is maximized the power by SEPIC which is the first level and inverts the PV supply voltage to 110Vrms using single phase inverter, at 50Hz frequency of sinevoltage. Most of the schemes accessible in literature are grid connected applications

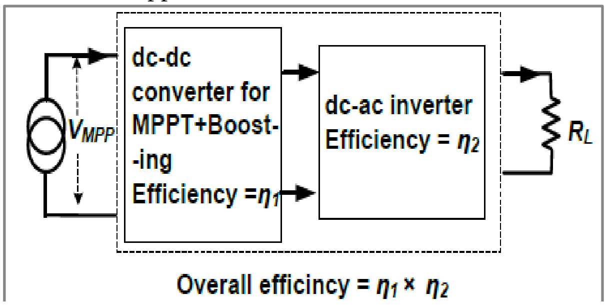

Fig.2: Two Level Solutions for Conversion, Boosting and Inversion

In Fig.2 explains the two level solutions where the first level of block is tracing out maximum power and input of PV is increased by SEPIC in second level of block where its inversion process which may be single phase or three phase inverter and delivering the sine output.

IV. SEPIC CONVERTER AND MPPT ALGORITHM

SEPIC converter where it is normally same as classical buck boost converter.It has non-inverting output (output voltage has the same similar polarity as the input voltage) .SEPIC converter where it normally has two modes of operations.In proposed system we use continuous mode of operation.

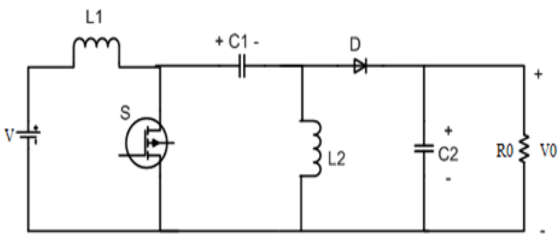

Fig.3: Circuit Diagram of SEPIC

In Fig.3shows the circuit diagram of a SEPIC converter when the current through inductor L_1 is continuous, it will be in a mode of continuous conduction.SEPIC converter exchanges energy between the inductor and capacitor where it converts from one voltage form to another voltage.With the help of switch S_1 where it helps to control exchanged energy.The switch is generally used is MOSFET where it has high impedance and low voltage than the bipolar junction transistor.

When switch$S_1$is closed,inductorL_1 will store the energy as the current through it increases.Voltage drop across L_1 is equal to the input voltage.Diode is opened.L_2 charged by capacitor C_1.C_2 discharges through the load and gives the output.The switch S_1 is open and diode is closed.Inductor L_1 where current decreases and charging capacitor C_1.The current through inductor L_2decreases and charges capacitor C_2.Capacitor C_2 provides the output at load.In the SEPIC converter, when the switch S is ON, the inductor L_1 gets charged from the input sourceV_{in} and inductor L_2 gets charged from the discharging capacitor C_1. This makes the diode D to be in reverse biased condition and the capacitor C_2will supply power to the load. When the switch S made OFF, the inductor L_2 dischargesthrough the diode which makes it to conduct and the capacitors are charged from the inductors

$$V_0(CCM) = V\frac{D}{1-D} \quad \text{Eqn(1)}$$

$$V_0(DCM) = D\,V\sqrt{\frac{R\,T_S}{2\,L_{eq}}} \quad \text{Eqn(2)}$$

Where

$$\text{occurs for } \frac{2\,L_{eq}}{(1-D)^2}R\,T_S < 1$$

$$\text{Duty cycle} = \frac{V_o + V_D}{V_{IN} + V_o + V_D} \quad \text{Eqn(3)}$$

A Maximum power point where its principle to obtain the extreme power point extraction under every condition.Its basically used in wind turbine and PV panel. The major aim of MPPT is to extraction of the maximum power from a PV model by working them operate at desired voltage (maximum power point). MPPT verifies out the output of PV model, with the help of battery that can be the most suitable for PV. The supply power to a load, where the battery can be connected directly to PV model and MPPT .It is mainly used for power extraction in renewable energy

MPPT is most effective under these conditions:

It can be worked in all the weather condition and it is more easy to operate and control. PV modelgenerally used at cold temperature and MPPT is used to extract the maximum power available from sunlight or PV rays. When battery is completely discharged: MPPT can extracted more current and charge the battery if the state of charge in the battery is lowers. MPPT technique is used in this project is pertub and observe method.

MPPT are generally used in typically is an electronic power converters.

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This Electronic power converter where it provides filter, regulate to control the voltage and current. In proposed system where we are using Pertub and Observe method. In P&O method where we can measure the power from the PV array by using controller technique to adjust or vary the voltage from PV array for few amount. When power is no longer changes or increases where further measurement is done. From this method we can finalize the oscillation of output power result. P&O is most commonly and mainly used for easy implementation where it has accurate and has high efficiency with hill climbing strategy is used.

V. SINUSOIDAL PULSE WIDTH MODULATION

In proposed system Sinusoidal Pulse Width Modulation (SPWM) is generally used as it is simple and is easily implemented to reduce and limit the minimum number of distortion and increasing the output voltage. During the zero crossing of $V_o(t)$, which is used to minimize the number of distortion where the output capacitor C_o is changed with a ranges of values. It is able to encoding the transmission signal to form pulsing signal and it is applied.Where fig 4explains the sinusoidal pulse width modulation method.The perturb and observe (P&O) algorithm is incorporated to obtain the MPP at all times during the operation. The module’s point of operation is changed by varying the modulation index M = VM / VT. When M is increased, the control pulse of the SPWM will provide a pulse such that the power extracted from the PV will always be the maximum.

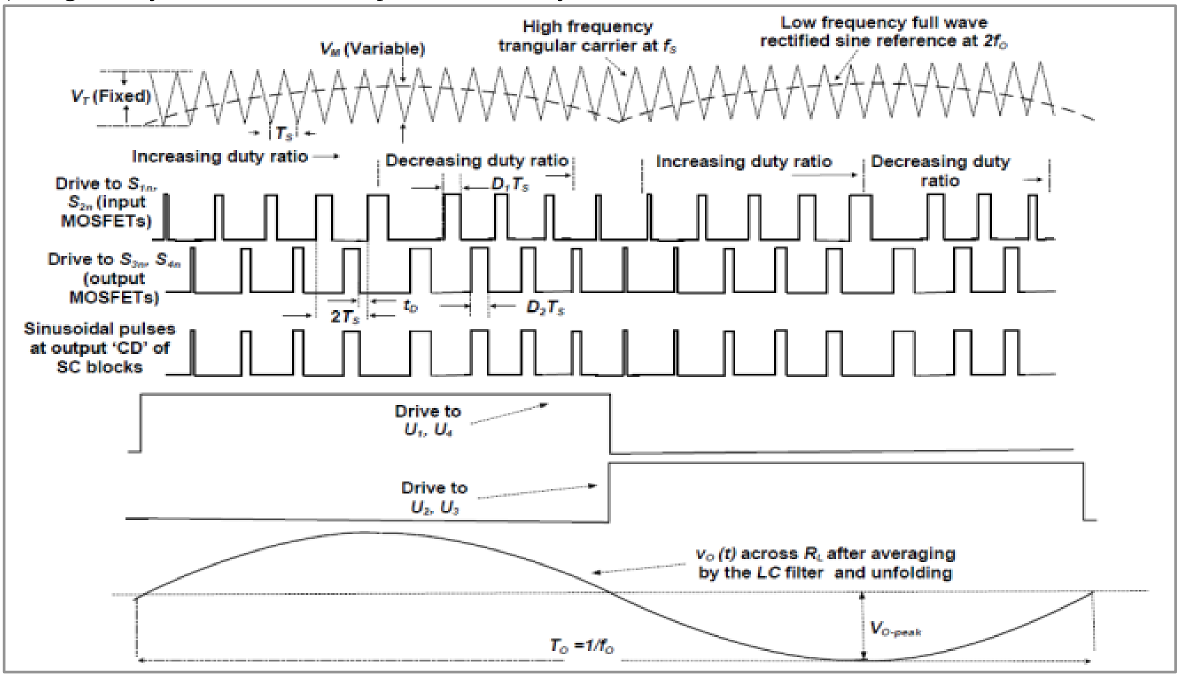

Fig.4: Sinusoidal PWM Method

VI. VOLTAGE REGULATION OF OUTPUT

PV integrated SEPIC converter for grid connected or ac loads are as from the literature survey. In PV integrated SEPIC where it has the main advantage is having less switch in converter where it reduces a switching loss in the system.The output of PV where it obtained with perturb and observe technique and using SPWM. By sending the carrier frequency where it is compared with the input voltage and by using MPPT algorithm where we can able to trace out the maximum power in PV panel. In grid connected system where it has most important advantage where the output voltage $V_o(t)$ is regulated easily since inverter are tied to grid.Grid where its acts as sink where it absorbs all sine output from the inverter .IN PV integrated SEPIC converter for AC loads where it has following conditions(a) if $V_o(t)$output is maximum and the output of PV is also maximum only at the fixed conditions.(b)if $V_o(t)$ ismaximum while during load decreases its at condition of fixed generation. These conditions are viewed in literature review and it is used n proposed system .We know that wide varied voltagesupply cannot load and particularlyhigh voltage so its necessary to managethe $V_o(t)$ of upper limit.

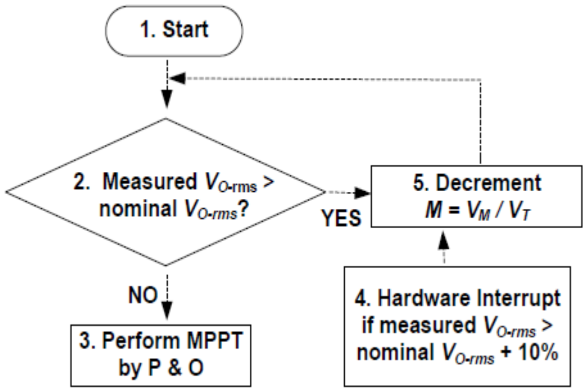

Fig. 5: Flowchart for MPPT

By controlling the modulation index, the MPP of the PV panel can be obtained and can achieve the output voltage regulation. The value of the RMSfor the output sine wave is made to be in the range of +10% of the nominal value. TheFig.5displays the flowchart of MPPT wherethe block 1 carries out the initializations.

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When the condition in the algorithm is not satisfied, the RMS output voltage which is measured will be sent to the block 3. If the RMS output voltage which is measured is less than the RMS nominal voltage value, the standard power tracking method of pertub and observe algorithm is done which is given in block 3. During any point of the operation, the RMS output voltage value which is measured exceeds the RMS output voltage nominal value by about 10%, the hardware circuit will interrupt which makes the Modulation index to decremented. The output RMS voltage that is decreased will cause it to be just below the RMSnominal voltage value, when it is given to the P&O tracking algorithm in the block 3.Thus the pertub and observe algorithm is performed.

VII. MATLAB/SIMULINK RESULTS

A simulation design of the proposed is implemented in MATLAB SIMULINK. The obtained output waveform were shown in the following figures. The Fig 5 explains the simulation of proposed system with single phase inverter using SEPIC integrated with PV panel. In Fig 6 explains the simulation of 3phase inverter using SEPIC integrated with PV panel usinginduction motor as AC load. In Fig 7shows simulation ofthe output waveform of PV panel which is V_{pv} =70V.InFig 8 describes simulation result of the output waveform of SEPIC where it boost up the PV voltage to 85V.Fig 9shows the output waveform of single phase inverter where we gets ac voltage 110V.Fig 10 shows the output waveform of 3phase inverter using proposed system for induction motor. In Fig 11show the output waveform of induction motor with rotor speed 600rpm and stator current0.5.p.u.

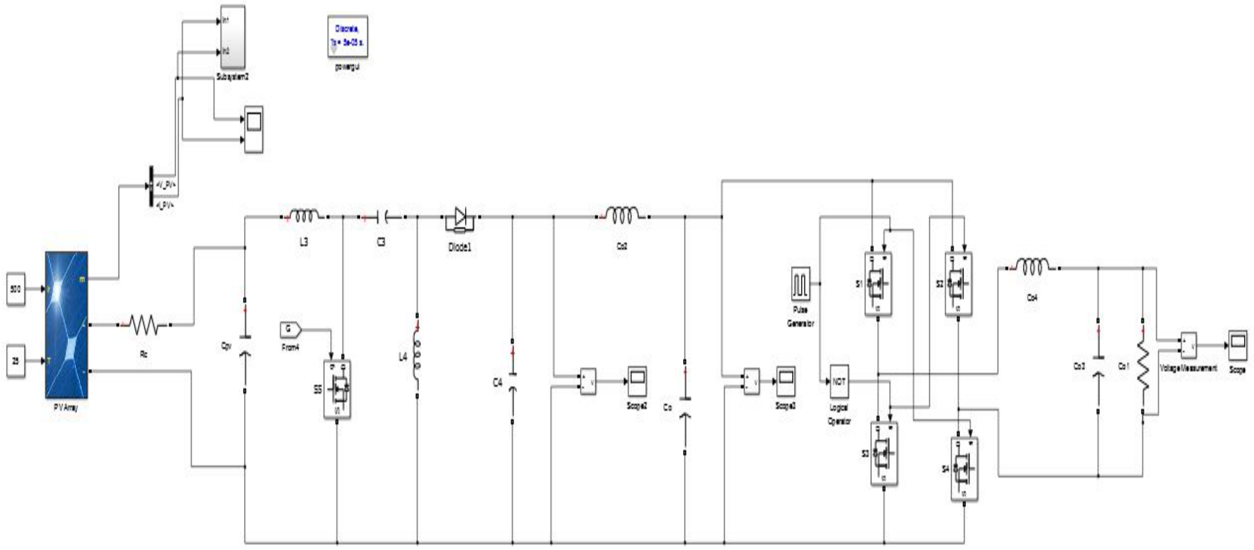

Fig.6: Simulation of Proposed System

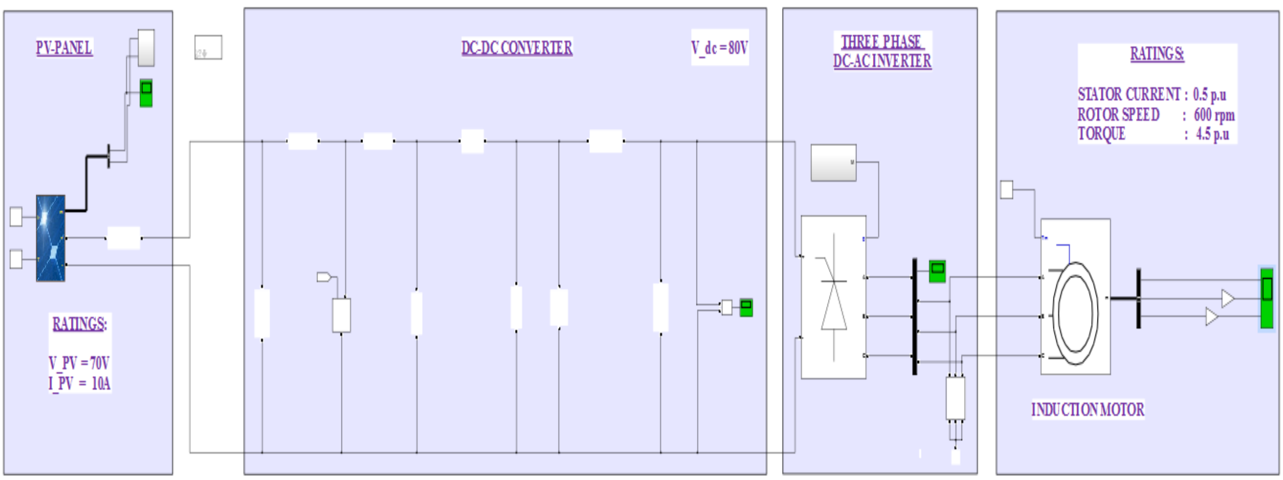

Fig.7: Simulation of Proposed System with InductionMotor

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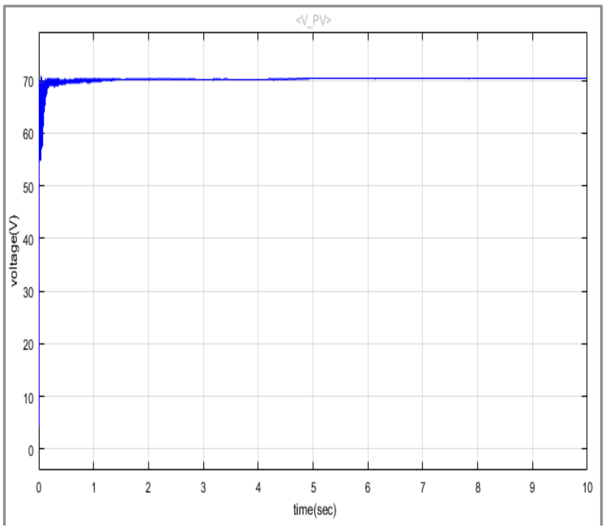

Fig.8: Output Waveform ofPV Panel

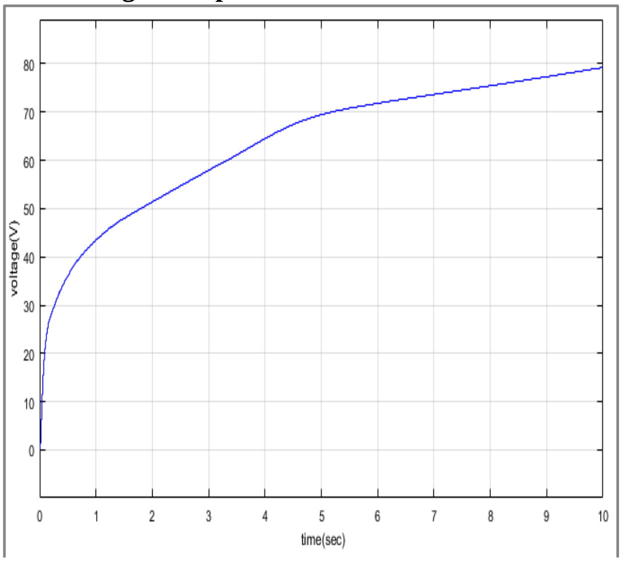

Fig.9: Voltage Waveform for SEPIC Converter

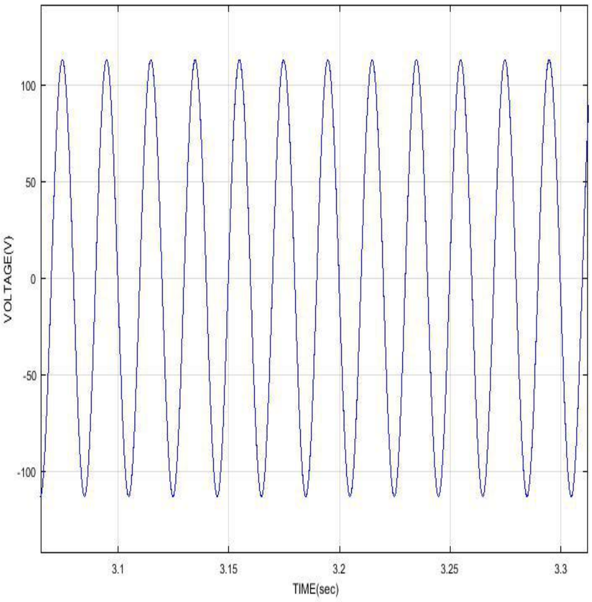

Fig.10:Output Waveform of Inverter

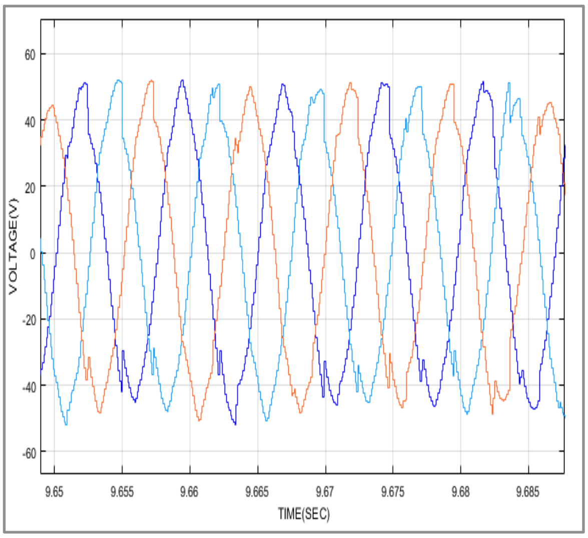

Fig.11: Inverter Output Voltage Waveform for 3Phase Inverter.

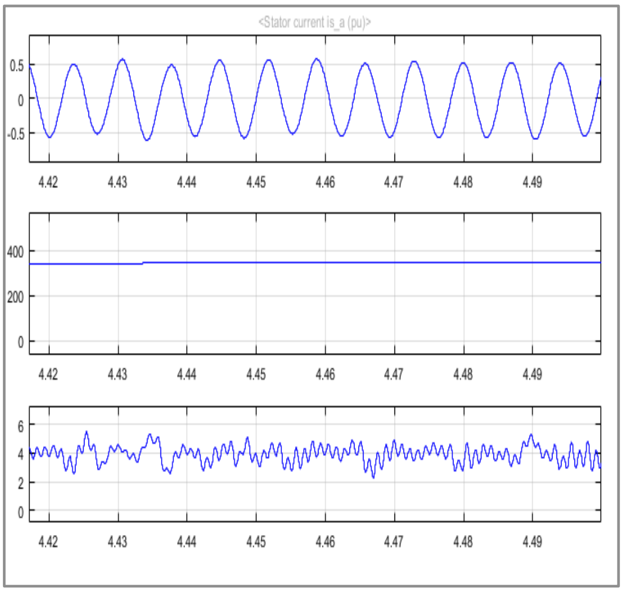

Fig.12: Motor Output Waveform.

VIII. CONCLUSION

In proposed system where it discussedSEPIC converter and double stage(a) PV is integrated with SEPIC and inverter which may be either single phase inverter or three phase inverter.(b) It is a double stage topology technique.(c)the first stage is tracking boosting the converter outputand second stage isinversion process from inverter with high efficiency. (d) load and intensity of PV model illumination is respected to the output voltage and it has the capable abilityfor standalone operation. (e) It hasdone with both the single phase inverter and three phase inverter with interconnecting with PV for AC loads. For 70W,50Hz PV source where we can get the sine wave output of 110V for single phase inverter.For 70W,50Hz PV source for three phase inverter connecting with induction motor where we get stator current 0.5p.u,torque 4.5p.u and rotor speed 600rpm.

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REFERENCES

1. P.K.Peter and V.Agarwal, "Photovoltaic Module-Integrated Stand-alone Single-Stage Switched Capacitor Inverter with Maximum Power Point Tracking," in *IEEE Transactions on Power Electronics*, vol. 32, no. 5, pp. 3571-3584, May 2017,
2. M.D. Seeman, S.R. Sanders, “Analysis and optimisation of switched capacitor dc-dc converters”, *IEEE Transactions on Power Electronics*”,vol.23, no.2, pp. 841-851, March 2008.
3. A. Ioinovici, C.K. Tse, H.S. Chung, “ Comments on ‘Design and analysis of switched apacitor based step up resonant converters’”, *IEEE Transactions on circuits and systems*, vol 53, no. 6, pp.1403, 2006.
4. J. Liu, Z. Chen, Z. Du, “A new design of power supplies for pocket computer systems”, *IEEE Transactions on Industrial Electronics*, vol 45, issue 2, pp. 228-235, April 1998.
5. C. K. Cheng, S. C. Tan, C. K. Tse, A. Ioinovici, “On the energy efficiency of switched capacitor converters”, *IEEE Transactions on power electronics*, vol. 28, no. 2, pp.862-876, Feb 2013.
6. G. V. Pique, H. J. Bergveld, E. Alarcon, “Survey and benchmark of fully integrated switching power converters: Switched capacitor versus inductive approach”, *IEEE Transactions on power electronics*, vol. 28, no. 9, pp.4156-4167, Sept. 2013.
7. F. Zhang, L. Du, F. Z. Peng, “A new design method for high power high efficiency switched capacitor dc-dc converters”, *IEEE Transactions on power electronics*, vol. 23, no. 2, pp.832-840, Mar 2008.
8. A. Kushnerov, “High efficiency self adjusting switched capacitor dc-dc converter with binary resolution” M.S thesis, Dept. of Elect. Eng. And Computer Science, Ben Gurion University of Negev, Beer-Sheva, 2009, pp. 94.
9. Y.K.Ramadass, A.PChandrakasan, “Voltage scalable switched capacitor dc-dc converter for ultra low power on chip applications”, *IEEE Power Electronics Specialists Conference*, June 2007, pp. 2353-2359.
10. T. B. Lazzarin, R. L. Anderson, G. B. Martins, I. Barbi, “A 600W switched capacitor ac-ac converter for 220V / 110V and 110V / 220V applications, *“IEEE Transactions on power electronics*, vol. 27, no. 12, pp.4821-4826, Dec.2012.
11. P. M. Lin, L. O. Chau, “Topological generation and analysis of voltage multiplier circuits”, *IEEE Transactions on circuits and systems,* vol. cas-24, no. 10 , pp. 517-530, Oct. 1997.
12. O. Mak, A. Ioinovici, “Switched capacitor inverter with high power density and enhanced regulation capability”, *IEEE Transactions on circuits and systems-I*: Fundamental theory and applications, vol. 45, no. 4 , pp. 336- 346, Apr. 1998.
13. Y. H. Chang, “Design and analysis of power CMOS gate based switched capacitor boost dc-ac inverter”, *IEEE Transactions on circuits and systems-I*: Regular papers, vol. 51, no. 10 , pp. 1998-2016, Oct. 2004.
14. Y. H. Chang, “Design and analysis of multistage multiphase switched capacitor boost dc-ac inverter”, *IEEE Transactions on circuits and systems-I*: Regular papers, vol. 58, no. 1 , pp. 205-218, Jan. 2011.
15. K. Zou, M. J. Scott, J. Wang, “Switched capacitor cell based voltage multipliers and dc-ac inverters”, *IEEE Transactions on Industry applications*, vol. 48, no. 5 , pp. 1598-1609, Oct. 2012.
16. K. Ishimatsu, I. Oota, F. Ueno, “A dc-ac converter using a voltage equational type switched capacitor transformer”, *13th annual applied power electronics conference and exposition*, vol. 2, pp. 603-606,Mar 1998.
17. H. Patangia, E. Dervishi, “A switched capacitor inverter for driving a highly capacitive load”, *IEEE International conference on industrial technology*”,pp. 525-529,Feb 2004.
18. Y. Ye, K. W. E. Cheng, J. Liu, K. Ding, “A step up switched capacitor multilevel inverter with self voltage balancing”, *IEEE Transactions on industrial electronics*, vol. 61, no. 12 , pp. 6672-6680, Dec. 2014
19. J. Liu, K. W. E. Cheng, Y. Ye, “A cascaded multilevel inverter based on switched capacitor for high frequency ac power distribution system”, *IEEE Transactions on power electronics*, vol. 29, no. 8, pp.4219-4230, Aug. 2014.
20. Y. Hinago, H. Koizumi, “A switched capacitor inverter using series / parallel conversion with inductive load”, *IEEE Transactions on industrial electronics*, vol. 59, no. 2,pp. 878-887, Feb. 2012.

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