Advanced Analysis and Design to Know Functionality of Photovoltaic Connected By Grid System

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Abstract— This research paper shows the proposed methodology, sun radiation is provided to the Photovoltaic module, which creates the electrical force that is then created with the aid of the P&O, MPPT and boost converter to keep the input side voltage of the inverter constant for SP. Two separate PWM strategy is then used to generate the control signals for the three-stage inverter. The inverter is connected to the resistive load along with an inverter type L-C in which the harmonics are used to decrease from the inverter output. Inverter is operated by both SPWM and SVPWM modulation techniques and evaluated both the inverters' THD along with the filter output voltage at that point find that SVPWM strategy has less THD when compared with SPWM. And shows that the SVPWM approach is highly competent than the SPWM modulation of the sinusoidal pulse duration

Keywords: Photovoltaic, Grid System

I. INTRODUCTION

Every day the requirement of power is incrementing very rapidly. To satisfy the interest the customary age framework isn't sufficient on the grounds that the contribution of conventional force age are restricted like non-renewable energy source. Due to this the interest is attempt to satisfy by sustainable power source assets like sun based vitality, wind vitality and so forth these assets are complimentary and therefore no expense is incurred for the fuel. As of late energy from sun is broadly utilized for generating power in the whole world. The energy from sun is widely available all over, liberated from cost and medium, no fluid is needed to consume the fuel, condition benevolent, boundless measure of assets. The different nation utilized the sunlight based capacity to satisfy the heap request. So as to handle the current vitality emergency one needs to build up a proficient way in which force must be removed from the approaching sun based radiation. The force transformation components have been extraordinarily decreased in size in the previous scarcely any years. The improvement in power gadgets and material science has helped architects to come up exceptionally little yet incredible frameworks to withstand the powerful interest .But the hindrance of these frameworks is the expanded force thickness. Pattern has set in for the utilization of multi-input converter units that can viably deal with the voltage fluctuations. In any case, because of high creation cost and the low effectiveness of the frameworks they can barely contend in the serious markets as a prime force age source.

The sun based (PV) module is utilized for generating power from sun that is comprising of solar cell (SC). A SC is developed by doping of Si as well as Ge material. At a point when the sun beams falls on the solar panel (SP) the photon discover the vitality structure beams and built up a photograph current. As a result of this the SP resembles a current source. To accomplish the greatest force from the SC the maximum power point tracking (MPPT) methods are utilized. These strategies are because that the illumination of sun is differing in nature. Today the exploration is proceeding to discover the best method to accomplish the ultimate power from SP. These strategies increment the productivity of SP and are helpful in the field of sustainable power source assets [3], [8]. The inverter is utilized for changing over the SP power to AC power for supplying it to the grid. Various techniques of modulation are utilized for changing control of inverter to acquire less THD yield. The significant two strategies are SPWM which is sinusoidal pulse width modulation while the other is SVPWM which is space vector pulse width modulation.

II. MOTIVATION AND OBJECTIVE OF RESEARCH

The solar power generation is very important for meets the loads. But solar radiation is time varying is depend upon the temperature, irradiation, material by which panel is design and the future power generation is totally depend upon the solar energy. Because of this many researchers are given concept and algorithms to achieve the maximum power. The challenges of this field and new research area is motivates behind the projects.

The objective of proposed system is by using modified P&O MPPT technique achieve maximum power output from the PV module connected to grid. Design PV system connected with boost converter and 3-level inverter. Then by using control algorithm and modulation techniques SPWM, to converts the dc power generated by PV module to ac power by inverter with less THD and feed the power to the load. Parameters, THD of load supplied voltage and current. Objective of proposed system is as follows:-

- Used Modified P&O MPPT to get maximum power form PV array.
- By using 3 level inverter reduced harmonics at output end of inverter.
- Supplied PV power to grid using control scheme.

III. WORKING AND MODELLING OF SOLAR CELL

A. *Working of Solar Cell*

The solar cell is a device which converts the sun radiation into electricity. This solar cell made up of Silicon and Germanium material and doping is also present in these material. Solar cell having photon and when the sun radiation is hit on the cell then the photons are finding extra energy. With the help of this energy the photons moves valence band to conduction band. Because the movement of photons a current is start flowing in cell with reverse direction of current. Solar cell is operated as controlled current sources device.

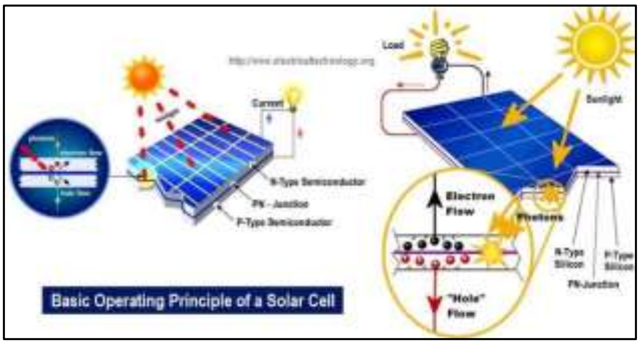


Fig. 2.1: Working of solar cell

The figure 2.1 shows the basic operating principle of solar cell. The photons and electrons are also display with their position and the movement or flow of electron and holes pairs are also indicates in figure. When we connect load across the solar cell then the current is start flowing through load and solar cell.

IV. SIMULATION

A. *Modelling of Proposed System*

In our presented system of a GC PV model for standard roof-top solar-powered establishing is demonstrated in as shown in Fig. 6.1. The device is unruffled of PV panel consisting of PV system arrays (make of Sun Power SPR-305-WHT), the DC to DC boosting conversation designed for improving the PV voltage to the position that is sufficient meant for inverter in order to generate an optimum output, a 3-phase VSI interconnected in between DC-link capacitance (which in turn functions like a momentary power storing area to offer VSI having a constant movement of electricity) and then L-C filtration system to protect against harmonics coming within the UG. The conventional PV voltage is usually 274 Vdc for a solar irradiance of thousand W/m2, which usually creates a 500 Vdc through DC to DC boost conversion after which transformed down into AC voltage by means of a 3 tier VSI close to 20 kV by using a step-up transformer to input to UG.

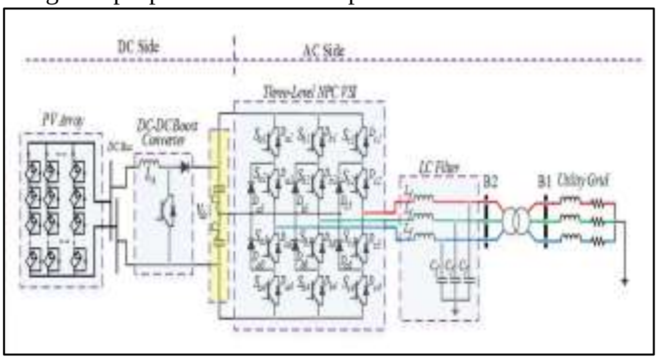


Fig. 6.1: Diagram of three-level PV grid associated inverter [8]

B. *PV System Modeling*

Fig. 6.2 shows the electrical equivalent circuitry diagram of PV cluster using the corrected two-diodes modeling arrangement. The output current (IPV) of the PV array system is given by Eq. 6.1. VPV is the output voltage of PV array, Rs, and Rsh are the series and shunt resistance of the concerned PV cells. Ns and Np are the number of series and parallel cells respectively [10]. The parameters of two-diodes system of photo diode-current (Iph), flooded currents (Is1, Is2), series and shunt resistances (Rs, Rsh), and ideality two-diode factors (a1, a2) are arranged as in Fig 6.2

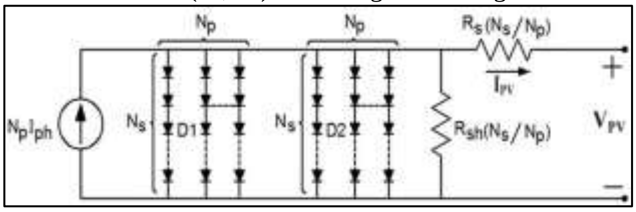


Fig. 6.2: Equivalent circuit model of single-diode for PV array [9]

where:

I_{s1} = saturation current of diode D1,
I_{s2} = saturation current of diode D2,
V_T = thermal voltage (VT =Ns KT/q),
K = Boltzmann constant,
T = temperature in degrees K,
q = electric charge (1.6 * 10-19 C)
a_1 =ideality factor of diode D1,
a_2 = ideality factor of diode D2,

C. *Modeling for DC-DC Boost Converter*

The input and output associations of the DC-DC boost converter displayed in Fig.3, The DC-DC boost converter factors can be calculated using Eqs. (2:5) [11-18].

$$I_{PV} = N_P I_{PH} - N_P I_{S1}\left[EXP\left(\frac{1.0}{a_1}\left(\frac{V_{PV}}{N_S}+\frac{I_{PV}R_S}{N_P}\right)\right)-1\right] - N_P I_{S2}\left[EXP\left(\frac{1.0}{a_2}\left(\frac{V_{PV}}{N_S}+\frac{I_{PV}R_S}{N_P}\right)\right)-1\right] - \frac{1}{R_{SH}}\left(\frac{V_{PV}}{N_S}+\frac{I_{PV}R_S}{N_P}\right) \quad (6.1)$$

$$V_{DC} = \frac{V_{PV}}{1-D} \quad (6.2)$$

$$L_{BOOST} = \frac{V_{PV}(V_{DC}-V_{PV})}{\Delta I_{LBOSST}} \quad (6.3)$$

$$C_B = \frac{\Delta I_L}{8 f_s \Delta V_{PV}} \quad (6.4)$$

$$C_{DC} = \frac{P_{PV}}{2.0 w_g V_{DC} \Delta V_{DC}} \quad (6.5)$$

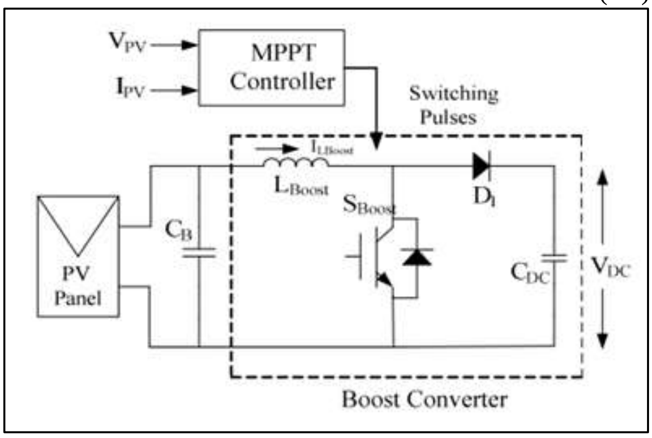


Fig. 6.3: DC-DC boost converter

D. Filter for Power

The UG user interface is made up of filtration systems in order to decrease the harmonics produced in the inverter and also to reduce the effects of surges originating from one of the UG [12]. Unit of electrical power filter system taken into account in this important model is demonstrated in Fig.6.4 that's a 3-phase second order low-pass passive filter. The filter is mounted along at the output of 3-phase VSI.

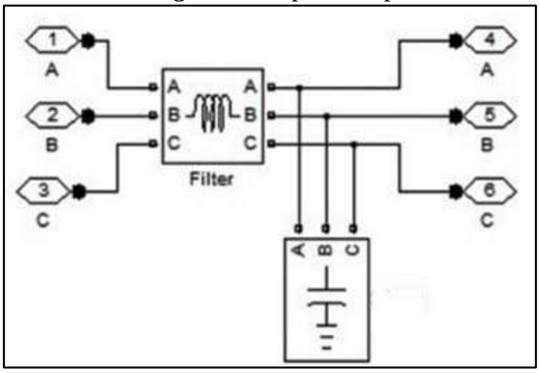


Fig. 6.4: LC low pass power filter used at the output terminals of PV inverter [12].

`The assortment of the capacitance is usually an alternative between the reactive power provided by a capacitance at the primary frequency and inductance. The raising of capacitor capacity can decrease the performance for the inverter, whereas minimizing capacitor value of LC filtration system can boost the inductor as well as voltage drop throughout networking system. More often than not the reactive power associated with capacitor value is recommended lower than 15 percent of the graded inverter power efficiency. In this kind of model, the reactive power is selected by 10% of the graded power associated with the inverter [13-15].

$$C_f = \frac{0.1 * P_{PV}}{3 * w_g V_g^2} \quad (6.6)$$

The choices of the inductor in the filter, Lf relies on the filter's resonance frequency that could be more than or comparable to thye 1/10 of grid frequency in order to avoid resonance with the grid network. Therefore, the filter inductance as shown in equation 6.6:

$$L_f \leq \frac{1}{100 * w_g^2 C_f} \quad (6.7)$$

E. MPPT Controller

Fig.6.5 demonstrates the flow-diagram of MPPT P&O improved protocol [14-15]. The flow-diagram demonstrate the fact that each and every sample duration, the MPP could be monitored by evaluating the variations in power, voltage and load importance regarding zero to obtain the appropriate track for excitation the PV array voltage, to track down the MPP promptly in which Vpv, equates to Vmpp at MPP. When the MPP is got, the process in the PV array is preserved at this time except if there exists a swap in ΔP, which shows a difference in solar radiation or weather scenario. The algo minimizes or accelerates Vpv to track the latest MPP [14-16]. This kind of approach gives a considerably better monitoring of the MPP underneath swift swapping atmospheric circumstances in comparison with the classic P&O approach. Maximum power point is expression is given below:

dP/dV=0 , where P= V*I

d(V*I)/dV = I + V*dI/dV = 0

dI/dV = -I/V

The integral regulator minimizes the error i.e.

(dI/dV + I/V)

Regulator output = Duty cycle correction

F. Grid-Connected Control System

The PLL is employed to synchronizing the inverter together with the grid, by which it can take the voltage from the grid and provides the frequency as well as, phase angle associated with the voltage from the grid appropriately maybe even with the warping in the voltage from the grid [18]. Voltage regulator provides command current (Id)* in order to progression of its current regulator by establishing DC electric voltage (Vdc)*. The current regulator is composed of PI controllers for both of those id as well as, iq currents. The command current (Id)* is pulled via voltage regulator which is likened together with the grid current (Id).

The evaluated signal (ΔI_d) is analyzed via the PI controller for lessening the miscalculation and generating the adding-signal with the built-up voltage computing signal (Vd) in order to assess with ωL to develop (Vd)*. Additionally, the command current (Iq)* tends to zero in order to boost the PF of the inverter near unity. The signal (ΔIq) is produced by using the PI controller to generate the adding signal with the produced voltage (Vq) as well as, ωL to generate (Vq)* command. The results of the PI controllers are analyzed by using hysteresis band to overcome the errors amongst upper/lower limit. The d_{q0}, is modified for the 3-phase to PWM.

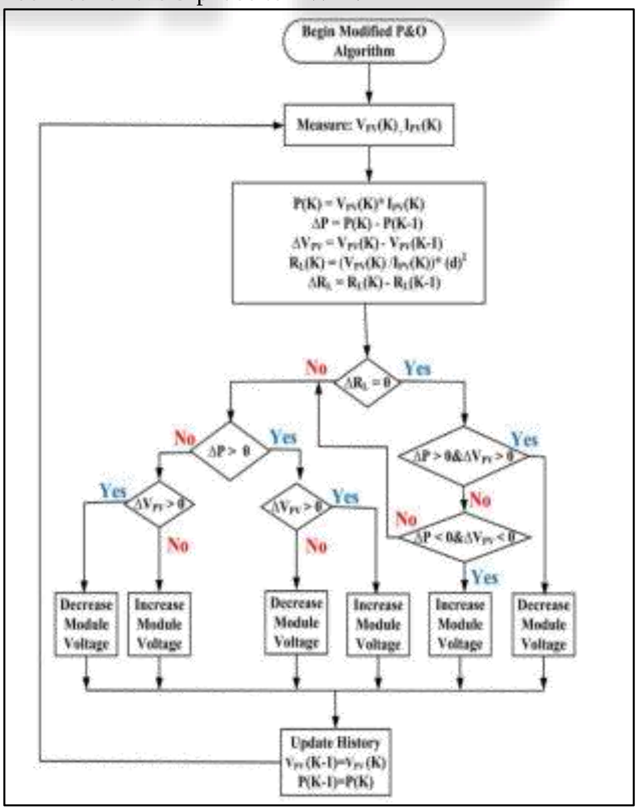


Fig. 6.5: Flowchart of the MPPT algorithm

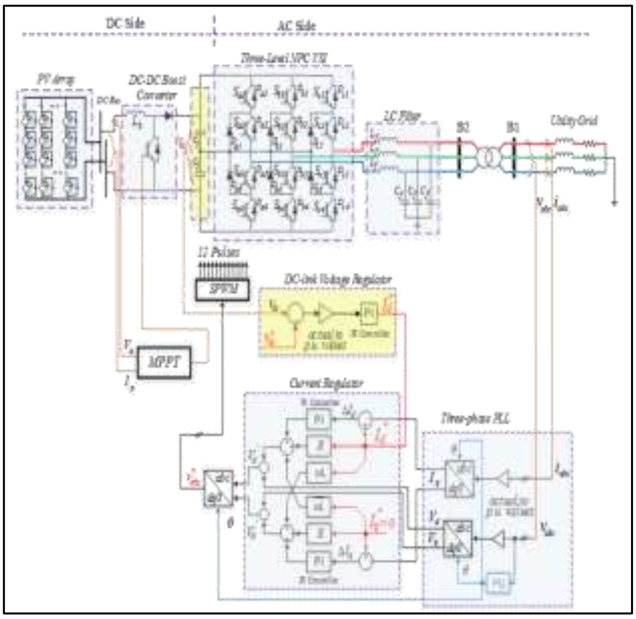
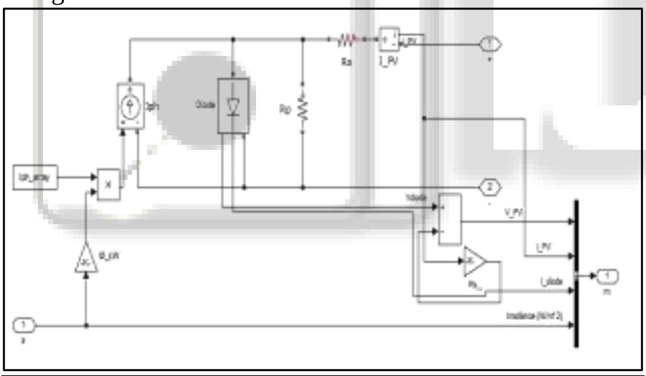


Fig. 6.6: System configuration of PV GC system

G. Modelling Of PV Module

The modelling of PV module is done by Matlab software. The designing is of PV module is done by Sim power system toolbox of Matlab. Basically we create the equivalent diagram of single solar cell and set the value of parallel and series resistance to achieve the desired output voltage.



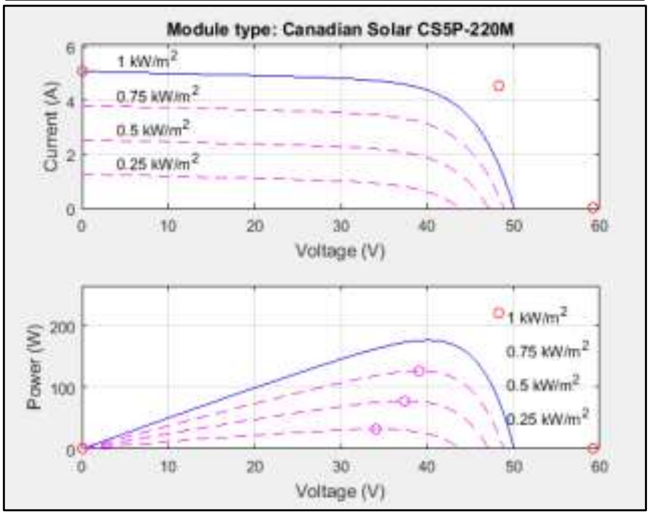


Fig. 6.8: I-V and P-V curve of solar module

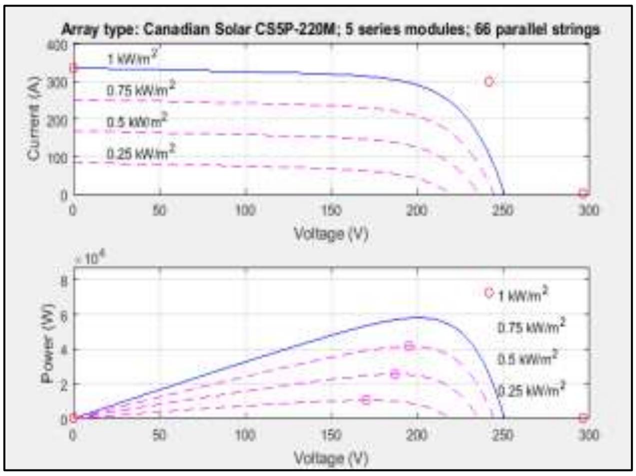


Fig. 6.9: I-V and P-V curve of solar array

Parameters	Values
Open circuit voltage (Voc)	59.2618 volt
Isc	5.09261 amp
Vmp	48.316 volt
Imp	4.5476 amp
Rs	0.2408 ohm
Rp	235.76 ohm
Isat	$5.31*10^{-7}$
Iph	5.098 amp
Quality factor Q_d	1.5
Series connected module per string	5
Numbers of cell per module	96
Numbers of Parallel string	66

Table 6.1: Parameters of PV module

H. Boost Converter Simulink Model

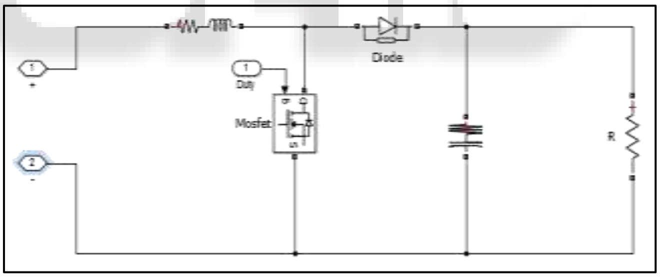


Fig. 6.12: Design of boost converter in SIMULINK

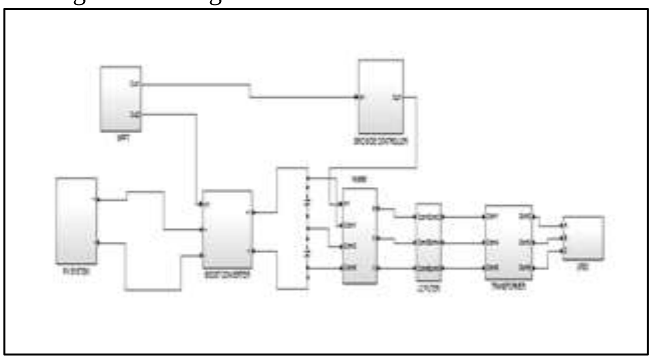


Fig. 6.13: SIMULINK model of proposed system.

V. RESULTS

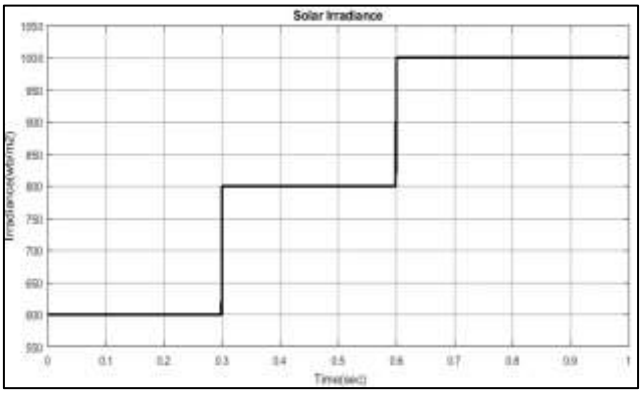


Fig. 6.14: Input solar radiation

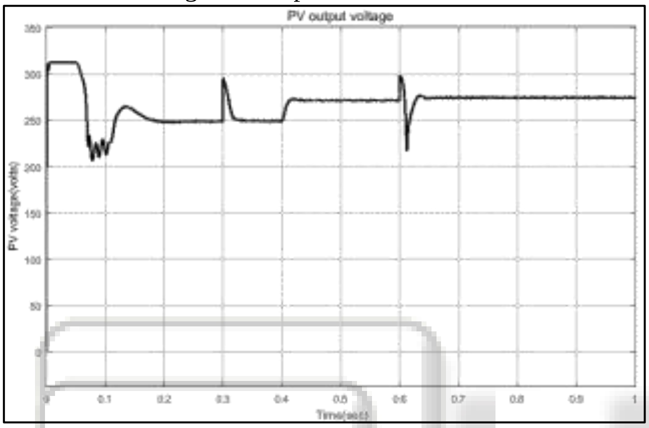


Fig. 6.15: Solar output voltage

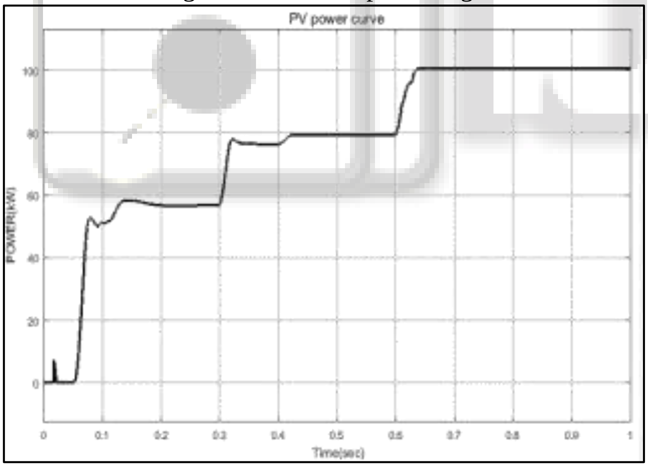


Fig. 6.16: solar power generated

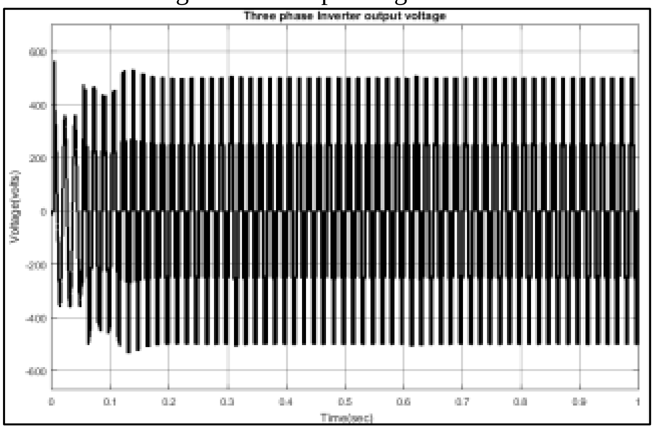


Fig. 6.17: Inverter output voltage.

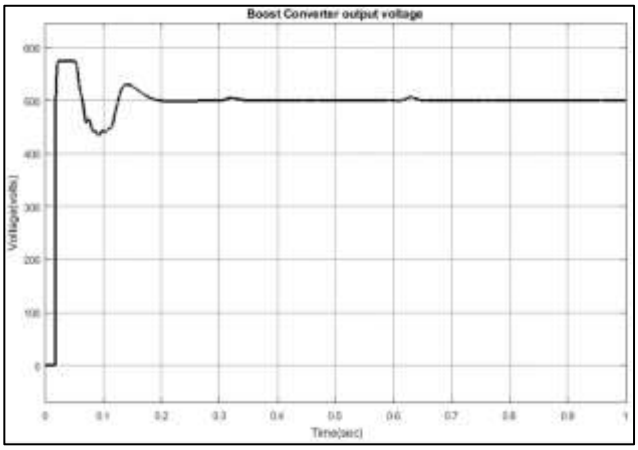


Fig. 6.18: boost converter output voltage

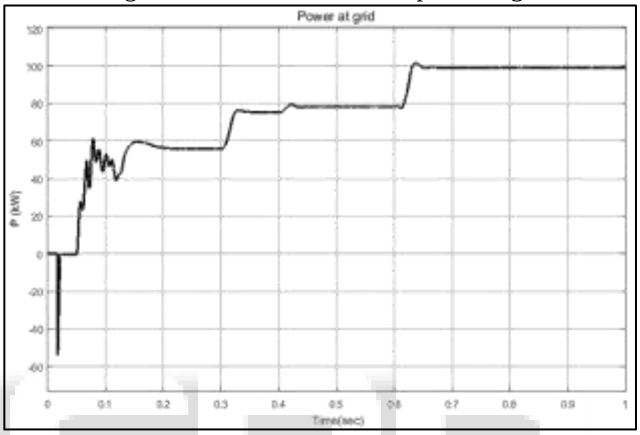


Fig. 6.19: Power at grid

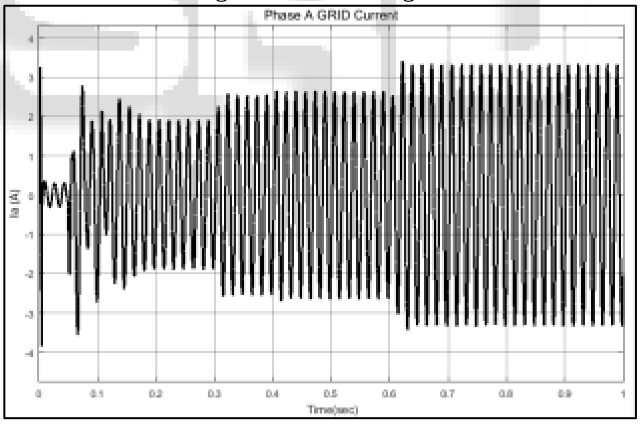


Fig. 6.20: Phase a grid current

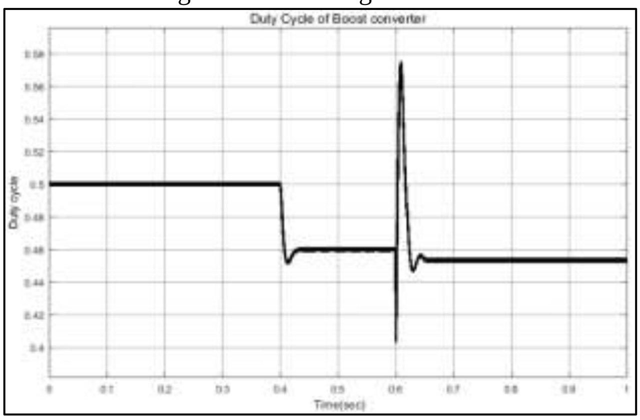


Fig. 6.21: Duty cycle of boost converter

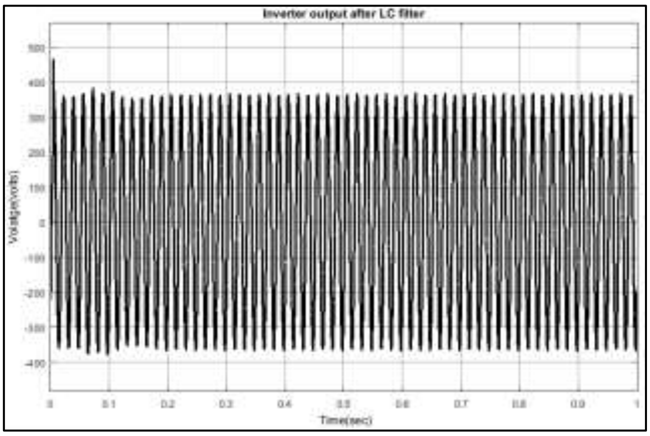


Fig. 6.22: Inverter output voltage

Solar parameters
Quantity of cell/ module—90
Amount of strings in parallel--60
Maximum Photovoltaic output voltage at 1000wb/m^2—274 volts
Minimum volatge at 600 wb/ m^2—250 volts
Maximum power at 1000 wb/ m^2—100 kw
Minimum power at 600 wb/ m^2—57 kw
Boost converter
L=5mH
C=1000microF
Transformer rating
VA-100e3
f=50Hz
260v/25kv

Irradiation (W/m2)	PV Voltage (volts)	PV Power (kWatts)	Boost voltage (volts)	Duty cycle
400	249	37.6	500	0.475
600	267	58	500	0.462
800	271	79.38	500	0.455
1000	274	100	500	0.432

Table 6.2: Results at Different Irradiance

VI. Conclusion

This research paper shows the presented framework radiation from sun is given to the Photovoltaic module that creates the electric force which is then with the assistance of P&O, MPPT and boost converter produce the utmost power for SP keeping the input side voltage of the inverter constant. Thereafter two diverse strategy of PWM is utilized to create the control signals for the three stage inverter. The inverter is connected with the resistive load along with a L-C ype filter in between which is utilized to diminish the harmonics from output of the inverter. Inverter is controlled by both the techniques of modulation SPWM as well as SVPWM and evaluated the THD of both the inverters along with the voltage of filter output at that point find that SVPWM strategy having less THD when contrasted with SPWM.

Thus it is clear than SVPWM method is highly competent than sinusoidal pulse width modulation SPWM.

References

[1] M.G. Villalva, J.R. Gazoli ,E. Ruppert F," Comprehensive approach to modeling and simulation of photovoltaic arrays", IEEE Transactions on Power Electronics,2009vol.25, no. 5, pp. 1198--1208,ISSN 0885-8993.
[2] M.G. Villalva, J.R. Gazoli, E. Ruppert F, "Modeling and circuit-based simulation of photovoltaic arrays", Brazilian Journal of Power Electronics,2009 vol.14, no.1 ,pp.35--45, ISSN 1414-8862.
[3] Mummadi Veerachary, "Control of TI-SEPIC Converter for Optimal Utilization of PV Power", IICPE, 2010 New Delhi.
[4] R.Sridhar, Dr.Jeevananathan, N.ThamizhSelvan, SaikatBanerjee, “ModelingofPVArray and Performance Enhancement by MPPT Algorithm", International Journal of Computer Applications (0975 – 8887) Volume7– No.5, September2010.
[5] Hairul Nissah Zainudin, Saad Mekhilef, “Comparison Study of Maximum Power Point Tracker Techniques for PV Systems”, Cairo University, Egypt, December19-21, 2010, Paper ID278.
[6] KatherineA .Kimand Philip T. Krein,“Photovoltaic Converter Module Configurations for.
[7] Maximum PowerPoint Operation”, University of Illinois Urbana-Champaign Urbana, IL.
[8] Huan-Liang Tsai,Ci-Siang Tu,and Yi-Jie Su, “Development of Generalized Photovoltaic Model Using MATLAB/ SIMULINK ”,Proceedings of the World Congresson Engineering and Computer Science2008 WCECS2008, October22.
[9] Arun Kumar Verma, Bhim Singhand S.C Kaushik, “AnIsolated Solar Power Generation using Boost Converter and Boost Inverter,” in Proc. National Conference on Recent AdvancesinComputationalTechniqueinElectricalEngineerin, SLITE,Longowal(India).
[10] Athimulam Kalirasu, Subharensu Sekar Dash, “Simulation of Closed Loop Controlled Boost ConverterforSolarInstallation”,Serbian Journal of Electrical EngineeringVol.7,No.1, May2010, 121-130. M.Berrera, A.Dolara, R.FarandaandS.Leva, “Experimentaltestof sevenwidely-adopted.
[11] P.S Revankar, W.Z. Gandhare and A.G. Thosar Government College of Engineering, Aurangabad, “Maximum Power Point Tracking for PV Systems Using MATLAB/SIMULINK”,2010 Second International Conference on Machine Learning and Computing.
[12] Ramos Hernanz, JA.,Campayo Martín,J.J.ZamoraBelver,I.,LarrañagaLesaka,J.,Zulueta Guerrero, E. Puelles Pérez,E.,” Modeling of Photovoltaic Module”, International Conference on Renewable Energies and Power Quality