Mitigation of Power Quality Issues In Grid Connected PV Systems

Abstract— **Priorities for renewable energy resources grew rapidly due to environmental concerns and energy requirements. Solar photovoltaic energy is by now one of the world's most common and renewable energy choices. Inverter is the basic portion of grid-connected PV network. As PV is connected to the grid through an inverter, with certain critical terms such as total harmonic distortion, galvanic isolation, anti-islanding discovery and voltage, the frequency ranges for continuous operation must be within certain limits as per theory.. The power quality problems that occur when the PV system is connected to the grid have been established. We'll get a dip in the output voltage so we'll go with LCL filter to reduce the dip. And the system's output is contrasted with L filter and LCL filter. We intend to remove the harmonics which is a major problem in a grid-connected PV system in future work. The simulation was carried out using MATLAB. First SIMULINK program for modeling the photovoltaic cell. MPPT interfacing is then done with a boost converter and resistive load, and finally with an inverter connected to the 3-phase grid. All the simulations were performed in MATLAB's SIMULINK program.**

Keywords—power quality,PV module, capacitors, inverters, converters, filters, controllers, grid.

I. INTRODUCTION

World's existing energy needs are largely fuelled by traditional energy supplies. Some resources on earth are minimal. Day by day, the atmosphere is polluted by CO2 emissions, global warming and other pollutions. Solar energy has more prominence than others among all renewable energy options, as it serves as the best alternative to conventional energy due to its availability. Technical advancement in the solar energy system makes implementation simple in different applications. Solar photovoltaic (PV) system is used mainly to transform solar energy into electrical energy, although it can be used both for small-scale and large-scale power generation. The cost of solar photovoltaic is decreasing due to the progress in the semiconductor technology. The large improvement in power electronics also helps to produce high-efficiency electricity and allows power to be supplied directly to the grid [1],[3]. Grid connection is important because the PV power is better used and more energy is collected. Eviting the use of batteries in grid-connected PV systems with less maintenance has become cost-effective. As the PV module generates normally low voltage, a boost converter is needed to increase this DC voltage to a higher amplitude [2].

Obviously the world vitality requests can't be make my customary source .Taking into record the developing populace it is essential to discover as supportable wellspring of intensity. In such manner sustainable power source presents one of a kind potential. Sunlight based power is a significant of the sustainable power source blend on the planet today yet a few factor have restricted it's across the board use and reception. establishment of PV exhibit .That has rendered it uncompetitive is the vitality showcase. So need of the our own

is more examination into making sun powered less expensive demonstrating and recreation of PV clusters is done to evaluate its attributes hitter and concentrate most extreme power conceivable.The I-V and P-V qualities of a PV exhibit for changing barometrical condition empower as to improve plan interfacing of a synchronous boost converter with PV cluster goes about as impedance coordinating gadget and make it conceivable to get ideal power from it.

- The objectives are Development of a PV module comprising single diodes associated in parallel with voltage controlled opposition for high performance.
- Development of MPPT controller by utilizing boost converter.
- Identify the power quality issues that occur when solar panel is connected to the grid

The research presented on this paper aims to help develop the degree of penetration of PV structures within the electric powered culture. This goal can be achieved by accurately comparing the PV system's output without overestimating or underestimating its effect on the electric network. In doing this research, attention should be given to the impacts of the fluctuating production power of PV systems. The primary motive behind this consideration is the intermittent nature of the output produced from these structures any other vital element that can help to increase the penetration level of photovoltaic systems is to investigate the suitability of various strategies that could improve the efficiency of the photovoltaic system and mitigate its negative impacts, particularly due to fluctuations in power. The key goals of the studies can therefore be summarized as follows:

Develop a methodology that takes into account the variations within the strength of the PV output when evaluating the impact of putting massive PV structures on the overall performance of distribution networks prior to putting these structures in. With the aid of overlaying the subsequent variables, the approach used in this form of look will provide a reasonable evaluation of the viable effects:

- Estimating the output power profile of the PV system using long historical time-collection data on irradiance and temperature as a result, the imagined profile would hold statistics on the gift variations within the machine's output intensity and can therefore be used in sequential simulations.
- Consideration of the actual data of the electrical group in the study with a view to providing sensible effects on the overall community results.Utilizing the long historical time series facts of the output power generated from the PV system correctly via decreasing its length at the same time as maintaining the useful records it incorporates.
- Making use of statistical evaluation with a purpose to identify the periods all through which there may be high chance of undesirable overall performance of the electrical community.

II. IMPACTS OF PV SYSTEMS ON GRID

Grid-linked PV systems are usually set up to decorate electrical network output by reducing resistance losses and improving the network's voltage profile. This is not always the case, however, as these systems can inflict some terrible effects on the society, particularly if their stage of penetration is excessive. These poor impacts include energy and voltage fluctuation disorders, harmonic distortion, shielding system breakdown and feeders overloading and undercarging.

Studying the potential effects of PV systems on the electrical environment is rapidly becoming a critical problem and is attracting tons of attention from every researcher and electrical utility. The primary explanation for the importance of this difficulty is that proper evaluation of such impacts, as well as providing feasible solutions to operational problems that might rise due to the implementation of photovoltaic systems, is considered a first-rate contribution towards facilitating the enormous use of these structures.

III. POTENTIAL PROBLEMS ASSOCIATED WITH GRID CONNECTED PV SYSTEM

Given all the advantages that PV structures are bringing to electric powered utilities, these systems can trigger some operational problems. One of the key factors causing these problems is the variability in the output power of PV systems due to the changes in the sun's irradiance due to cloud motion. These variations trigger various operational problems and make the photovoltaic production intensity forecast a hard task. Furthermore, the high costs of such systems limit the feasible solutions that can be pursued by electric powered utilities in order to minimize the extent of the operational issues that could occur due to these fluctuations.

Despite the substantial increase in the deployment of these systems, the negative impacts of grid-connected PV systems on network operation have not received much attention until recently.The work done in this area can be classified under three main categories:

- Impacts on the generation side,
- Impacts on the transmission and sub-transmission networks
- Impacts on the distribution networks.

A. Impact on Generation Side

Intense fluctuations in the output energy of large PV systems may have an effect on the technology in electric powered utilities. This is in particular due to the truth that the utilities ought to comply with those fluctuations which will catch up on any rise and fall inside the generation of PV structures. Subsequently, the generating units which might be scheduled to operate in the course of the technology duration of PV systems must have ramping rate capabilities that are suitable for the fluctuations of those systems.Moreover, the power fluctuations from the PV device make it difficult to expect the output strength of those structures,
and for that reason, to do not forget them when scheduling the producing units in the network.

In general, the generation side of an electric utility can be affected by the PV system if the penetration level of the PV system is comparable to the size of the generating units. However, systems with such large sizes are not expected to be widely installed in the near future due to the high cost of PV systems. Thus, studying the impacts on the generation side does not seem to be crucial at the time being.

B. Impacts on the Transmission and Sub-Transmission Networks

PV systems might cause problems in the transmission and sub-transmission networks if their sizes are large enough to affect these networks. The problems arise mainly due to power fluctuations of these systems which might lead to:

- power swings in lines,
- power reversal,
- over and under loading in some lines, and
- unacceptable voltage fluctuations in some cases.

During fault conditions, because of the presence of PV units, rotors of some of the traditional generators present in the network can swing to higher magnitudes. In addition, voltage failure may occur at very high PV systems penetration rates. Thus, at the moment, researching the effect of PV systems on transmission and sub-transmission networks does not seem necessary to electrical utilities.

Impacts on Distribution Networks

At present, the impact of photovoltaic systems on the overall performance of distribution networks is one of the main issues faced by electric powered utilities. This is because the dimensions and location of the deployed PV systems especially affect certain networks. The operational problems given by PV structures are similar to those imposed by dispensed generators which generate constant active energy, such as diesel generators and fuel cells. These problems occur especially because of the installation of turbines on the patron side in a feeder built for unidirectional power glide.

These include shielding relays breakdown, voltage control problems, opposite electricity flow, as well as overloading or underloading a few feeders. Different problems arise due to the use of interfacing electronics which lead to harmonic distortion and parallel and series resonances when a massive range of inverters is mounted in a certain place.

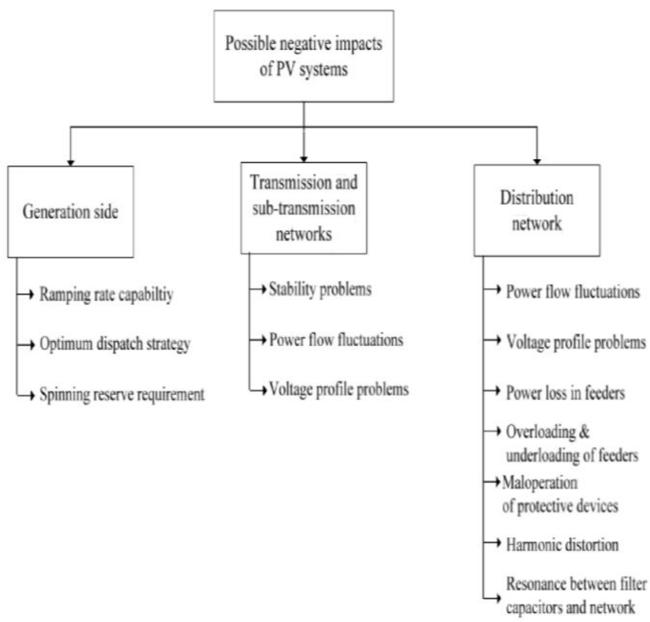

Fig. 1. Impacts of PV system on electric grid

IV. SIMULATION

This section deals with the Simulink modeling of different components in a PV network connected to a grid..

- Mathematical modelling of PV module
- The Simulink model of DC-DC Boost converter, the algorithm used for MPPT (i.e. perturb & observe).
- Simulink model of inverter.

A. Modelling of PV System

A cell is usually often modelled by a current supply and a parallel inverted diode. The PV cell has its own sequence and resistance to shunting. Series resistance is attributable to the diode resistance (most material) & metal contact resistance while parallel resistance reflects the recombination of the lep ton hole before t reaches the charge.

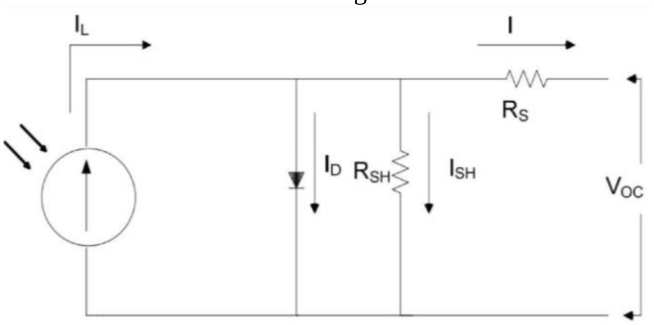

Fig. 2. Single Diode Model of a PV cell

A current supply (I) is considered in combination with a diode and the series resistance (Rs). The parallel shunt resistance (Rsh) is extremely high, has a marginal effect and can be ignored. The electrical phenomenon array output current is also given by

$$I = I_{SC} - I_d \quad (1)$$

$$I_d = I_o(eqV_d/kT-1) \quad (2)$$

Where Io is the present of the inverse diode saturation, the alphabet's letter is that we will use 2 diode model, but during this project our area of study is prohibited for the single diode model. The shunt resistance is also extremely strong, and our work can neglect it. The lep ton value, contagion is that the voltage around the diode, k is Ludwig Boltzmann constant (1.38 * 10-19 J / K) and T is the junction temperature in Kelvin (K).

$$I = Isc - Io(eqVd/kT-1) \quad (3)$$

$$I = Isc - Io(eq((V_1)) \quad (4)$$

where, I is that the solar cell current, V is that the PV cell voltage, T is that the temperature (in Kelvin) and n is that the diode quality issue so as to model the solar battery accurately.

Specifications of PV Module

Rated power	Pm (W)	200
Open circuit Voltage	Voc (V)	32.9
Maximum power voltage	Vmp (V)	26.3
Short circuit current	Isc(A)	8.21
Maximum power current	Imp(A)	7.61
Module efficiency	η(%)	16.22-16.47
Power tolerance	W	-0/+4.99

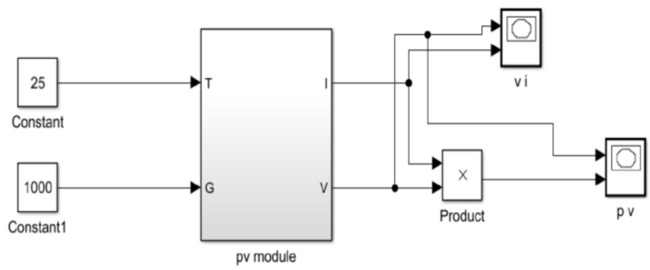

Fig. 3. Masked Simulink model of PV Panel

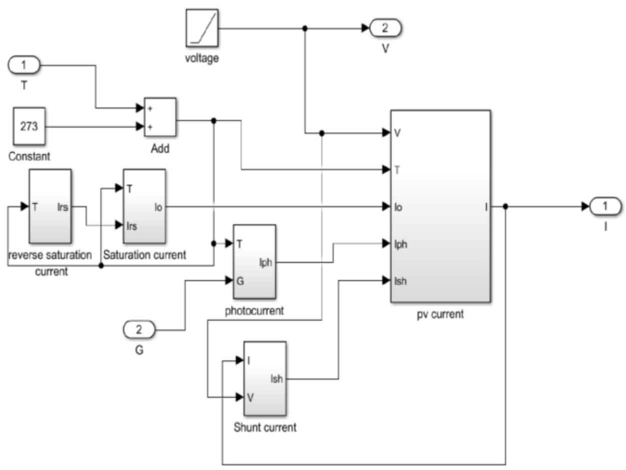

Fig. 4. Simulation of I_{ph} andI_{sh}

Step 1: Setting the input parameters.
Step 2: Calculating the short circuit current.
Step 3: Calculating the saturation current and reverse saturation current.
Step 4: Creating subsystems.
Step 5: Creating overall PV module

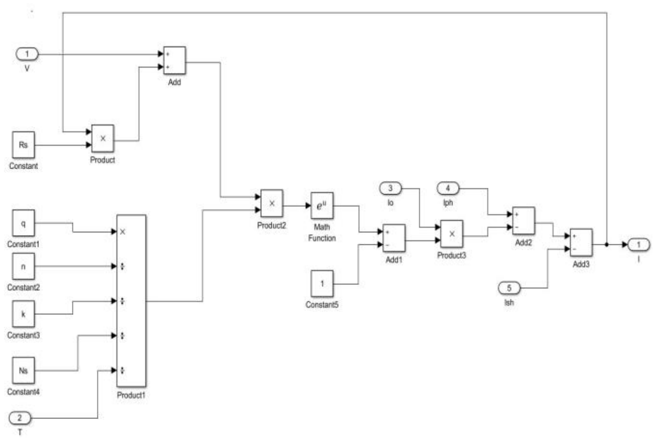

Fig. 5. Simulation of PV Current

The performance for ideal conditions of the PV array is given in the figure 5.1 below which can only be solved iteratively. Typical curve is shown in the graph below.

Table. 1. Sensitivity parameters

Conversion Efficiency	Shift to higher currents
Temperature	Low open circuit voltage and high short circuit current. Shift of MPP to a lower level is the overall output.

Reverse Saturation Current	Flatter curve by higher leakage
Serial Resistance	Lower voltage by higher losses

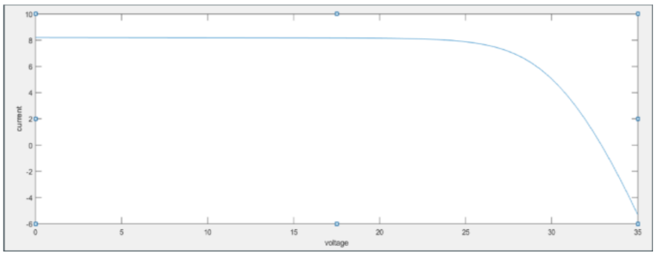

Fig. 6. Output of the PV array for ideal condition

The curve for PV and VI is shown in the fig. Photovoltaic characteristics for 6 different irradiation ranges are shown in Fig. 6 and 7 respectively. It could be discovered that the PV output power is also increased, just as the increase in irradiation is multiplied. It can be inferred that even though the improvements in irradiation influence the PV output current in particular, the greater energy factor is also increased.

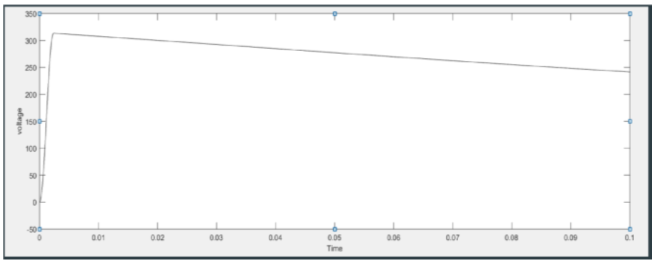

Fig. 7. PV curve

By the Fig. 7. It can be shown that temperature variations directly affect the voltage of the PV output. When the temperature increases the voltage falls significantly. But the temperature rises from 25 ° C to 50 ° C, and naturally the voltage fell larger. As a result, the voltage exchange as temperature increase is huge than contemporary commerce. In addition, the maximum output electricity matches the relation, so it has very small alternates. Thus it can be inferred that the temperature changes directly affect the PV output voltage, while the irradiation changes primarily affect the existing PV output.

B. Simulink Model of DC-DC Boost converter, the algorithm used for MPPT

Maximum power point tracking (MPPT) is an algorithm used in photovoltaic (PV) inverters to continuously adjust the impedance measured by the solar array to keep the PV system operating at or near the peak power point of the PV panel under various conditions, such as increasing solar irradiance, temperature, and charge. The algorithms regulate the voltage to ensure that the device is running on the current voltage curve at "full power point" (or peak voltage), as shown below. Usually MPPT algorithms are used in PV device controller designs. The algorithms account for factors such as variable irradiance (sunlight) & temperature to ensure the maximum power is provided at all times by the PV system.

Boost Converter

The main drawback to a Buck-like system is that the switch should be at the PV panel output, and if it is thereon it transfers power but if no output to the PV panel occurs it means that the operating function remains close to the electrical circuit voltage which is a loss. Such issue is not present in boost system mechanism during a boost system the Load matching is completed by varied input facet resistance by sterilizing the Duty magnitude relationship that basically allows a DC-DC device to be called a pursuit. Another reason in using a Boost regulator given the fact that it is a lower power than its predecessors is that this DCDC tool is mostly used to feed a load or a system with a higher demand for voltage, thus justifying its name.

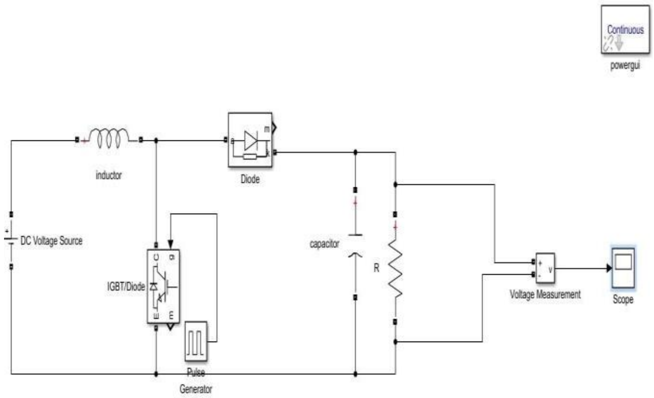

Fig. 8. Simulink model of DC to DC converter

The fig. 8. shows the Simulink model of a boost converter which consist of an inductor, switch(IGBT), a capacitor and a diode.

Flowchart For Perturb & Observe Algorithm

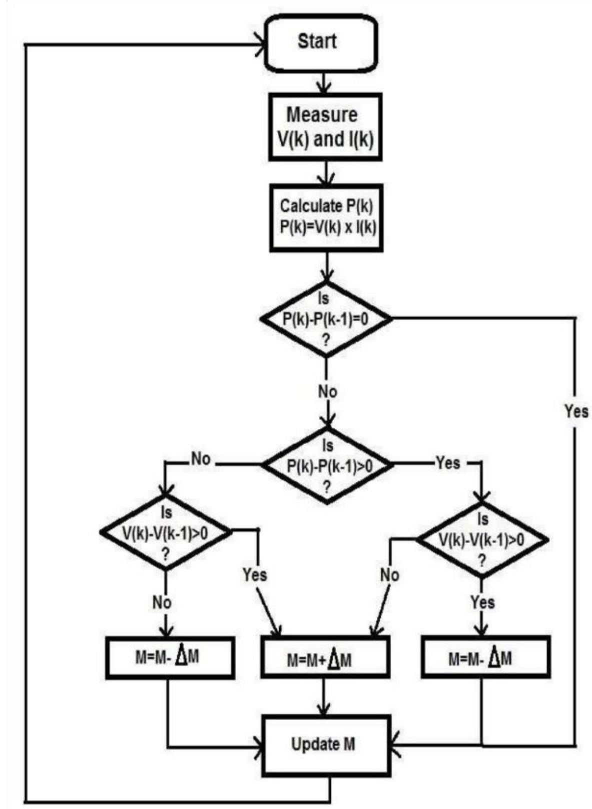

Fig. 9. Flowchart of P&O algorithm

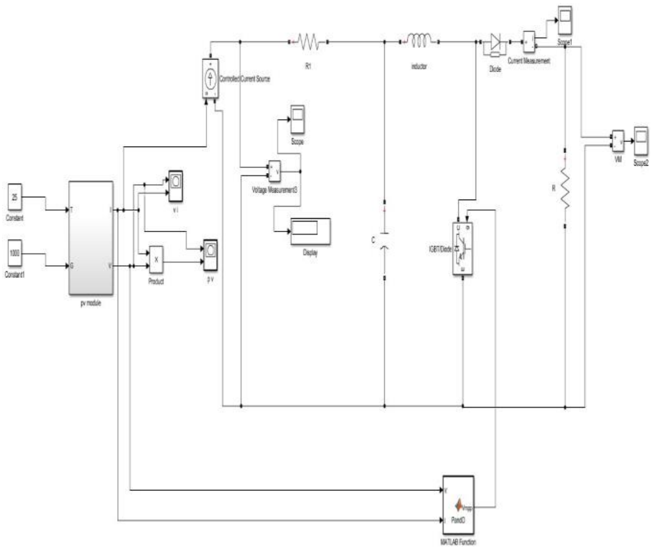

Fig. 10. Simulink model of PV cell with MPPT

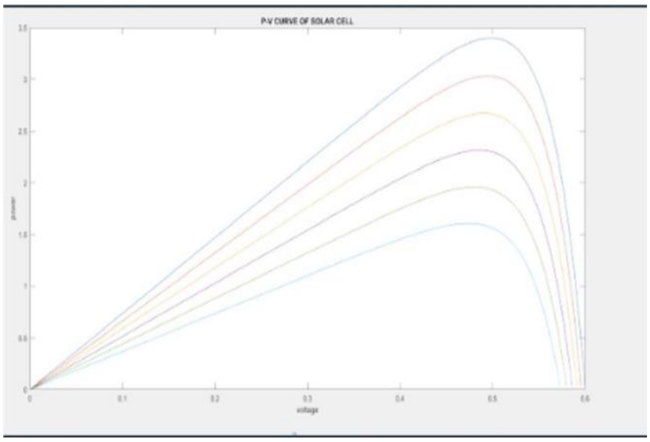

Fig. 11. Converter output characteristics

The output characteristics of the converter is shown in fig. 9. The proposed boost converters with proper controller gives better voltage law, overshoot discount and improves the converter overall performance as compared to the conventional converters. This efficiently provides a way to satisfy the objective of DC-DC converter to keep a regular output voltage on the load area. The proposed circuit is easy, smooth to apprehend and may be implemented with no extra additives thereby preserving size and price of producing the converter inside considerable range.

C. Simulation of Inverter

A power converter or electrical converter, or electronic equipment that converts electricity (DC) into electrical power (AC). Input voltage, output voltage and frequency, and overall power handling depend on the look of the system or electronic equipment in question. The electrical converter turns out to be no electricity; the energy is provided by the DC supply. A electricity electrical converter is either fully electronic or is often a combination of mechanical effects (such as a rotary device) and electronic electronic equipment.

Each thyristor conducts for 120 ° of a cycle for the 120 ° degree conduction mode. As a hundred and eighty ° mode, the 120 ° conductive inverter mode additionally requires six steps, each 60 ° in duration, to complete one cycle output voltage (AC). For this inverter too, a desk providing the six thyristor firing sequence is ready as shown in table 1. In this table, shown that neither S1 nor S4 conducts even for 120 ° and for the next 60 °.

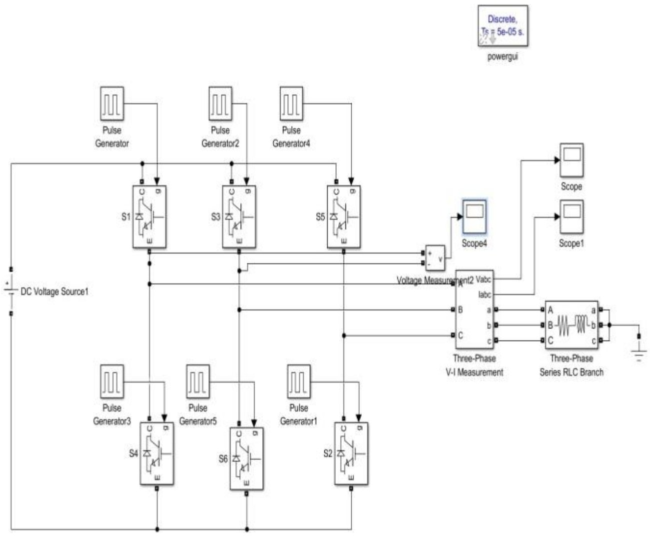

Fig. 12. Simulink model of an inverter

Now S4 is turned on for a hundred and twenty °, i.e. at a range of 180 ° is similarly performed. Between one hundred and eighty degrees to one hundred and three hundred degrees. This means that for the 60 ° c language from t=120 ° to t=100 and 80 °, the related transition S1, S4 does not take place. At a distance of three hundred degrees S4 is increased to become off, then the programming language of 60 degrees c elapses until S1 is switched on again at a distance of 360 degrees, within the second row S3 is switched on at a distance of one hundred and twenty degrees as in 180 degrees inverter mode.Now S3 conducts language for one hundred and twenty degrees, then 60 degrees c elapses during which neither S3 nor S6 conducts.At a ωt=300 ° , S6 has grown to become on, it conducts for a hundred and twenty °, during which the interval of 60 ° has elapsed, and then S3 has grown again. In addition, the third row is also completed. This desk indicates that for step I, step I, step I, step II, step II, step II, step II, step III, and so on, S6, S1 must be gated. The six thyristor firing sequence is the same as for the inverter in hundred and eighty mode. At some point in each step, the simplest two thyristors conduct one from the upper group and one from the decreasing organization for this inverter; but in 180 ° inverter mode, three thyristors conduct in each step.

The inverter performance properties are shown in the fig. 13. 13.

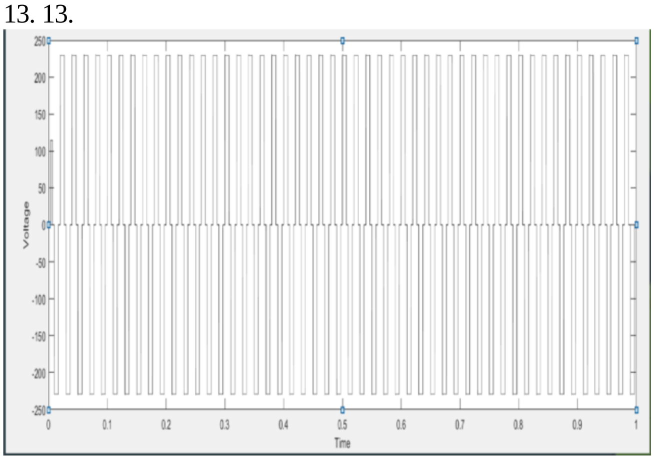

Fig. 13. Output characteristics of inverter

D. Overall System

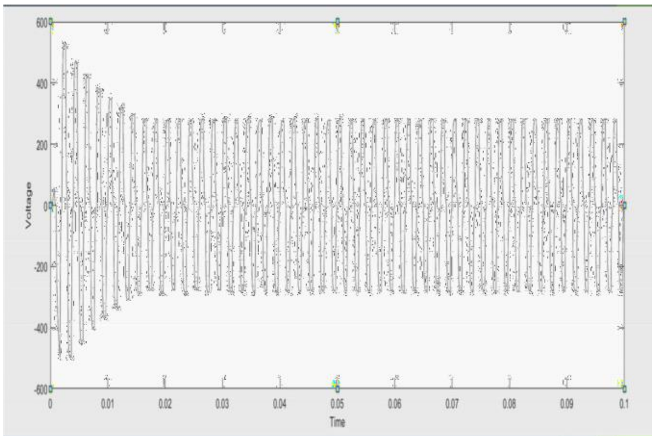

Fig. 14. Output of overall system design with L filter

The overall system output with L filter is shown in the fig. 14.

V. CONCLUSION

For a PV cluster, the undertaking procedure rearranged a piece-wise straight pattern. For this work we selected the BP SX 150 sun driven board as the power source and recreated the characteristics of its I-V and P-V. The last PV-cluster re-enactment alongside MPPT and a supporting impedance gadget.

As a result of its enhanced ability to measure the fragmentary open-circuit voltage MPPT, a boost converter was used to perform the MPPT calculation. The most severe power point changes at the point where there is change in the sun-based illumination and thus the necessary obligation period for the model's operation additionally changes. In any case, on the off chance of using a consistent bond cycle, the greatest power point at that point can not be followed and the system is therefore less efficient.

The different waveforms were obtained by the use of MATLAB's plot method. On the sun-based board side to the lift converter yield side, there is a bit of loss of power. That can be traced to the boost converter's swap mishaps and misfortunes in the inductor and condenser.

Inverter model parameters such as inductance, dc gain (kv) and time consistent (television) have a major effect on the frame elements at the time of exchange and should be chosen correctly to acquire a stable intermittent behaviour. The voltage waveform is very similar to the reference voltage at the point where DC source is associated rather than PV, but both current and voltage have some consonant substance in them. After the interaction of the PV module the harmonic substance increased in current and voltage and the PV yield was further impressively affected.

The calculation of MPPT used was partial measurement of the open circuit voltage. The boost converter yield is an added benefit to the general extension which demonstrates like a hardware inverter. A discrete generator of PWM has been used to give the inverter the activating symbol. Matlab and Simulink were used for different estimates of plots.

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