Mitigation Of Power Quality Issues Due To Grid Connected PV Systems

***Abstract*— The interest of renewable resources has been expanding quickly because of the ecological concerns and need of energy. Solar photovoltaic energy is as of now a standout amongst the most prominent and sustainable power resource on the earth. Inverter is the basic segment in grid associated PV system. At the point when PV is connected to grid through inverter some significant terms like total harmonic distortion, galvanic isolation, antiislanding discovery and voltage, frequency ranges for continuous activity must be in determined limits as per principles. This paper reviews state of part of discussion about various components in grid connected photovoltaic systems. The power quality issues that occur when PV system is connected to grid was identified. We will get a dip in the output voltage so we go with LCL filter so that the dip can be reduced. And the output comparison of the system with L filter and LCL filter is done. In the future work we are planning to eliminate the harmonics that is a major issue in a grid connected PV system. The simulation was done by using MATLAB. First SIMULINK software is used to model the photovoltaic cell. Then MPPT interfacing is done with a boost converter and resistive load and finally through an inverter connected to the 3 phase grid. All simulations have been done in SIMULINK software of MATLAB.**

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

I. Introduction

The current energy need of world is mostly fed by the conventional energy resources. These resources are limited on the earth. The environment is polluted by CO2 emission, global warming and other pollutions day by day. Among all renewable energy resources the solar energy has more attention than others, as it act as a best alternative to conventional energy because of its availability. Technical development in solar energy system makes it easy to implement in various application. Solar photovoltaic (PV) system is mainly used to change solar energy into electrical energy, as it can be used for small scale as well as large scale power generation. Due to the improvement in the semiconductor technology the cost of the solar photovoltaic is reducing. Also the wide improvement in power electronics helps to generate electricity at high efficiency and makes it possible to supply power straight to the grid [1],[3]. Grid connection is needed because there is better utilization of PV power and more energy is harvested. Avoiding the usage of batteries in grid connected PV system has become cost effective with less maintenance. As the PV module normally generates low voltage, so a boost converter is needed to rise 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.One of the serious issue is the moderately costlier 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 bitter 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 intention of the research provided on this paper is to assist growing the penetration degree of PV structures within the electric powered community. This goal may be performed by using correctly comparing the performance of the PV system without overestimating or underestimating its impacts on the electrical network. Upon acting this analysis, the impacts of the fluctuating output power of PV systems should be taken into consideration. the primary motive in the back of this consideration is the intermittent nature of the output generated from these structures any other vital element that can help growing the penetration level of PV systems is to investigate the suitability of various strategies which could improve the performance of the PV system and mitigate its bad impacts, in particular because of strength fluctuations. Therefore, the main targets of the studies may be summarized as follows:

To develop a technique that considers the fluctuations inside the PV output strength while analyzing the affects of putting in huge PV structures on the overall performance of distribution networks prior to putting in these structures. The method utilized in this type of look at can offer correct evaluation of the viable affects with the aid of overlaying the subsequent factors:

- Estimating the profile of the output power of the PV machine using long historic time collection information of irradiance and temperature as a result, the envisioned profile will keep statistics about the fluctuations gift within the output strength of the machine, and for this reason, can be utilized in the chronological simulations.
- Considering the actual data of the electrical community in the analysis with a purpose to offer sensible effects about the overall performance of the community.
- 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 typically established to decorate the performance of the electrical network by decreasing the strength losses and enhancing the voltage profile of the network. However, this isn't constantly the case as these systems may impose several terrible affects at the community, in particular if their penetration stage is excessive. Such bad impacts encompass energy and voltage fluctuation troubles, harmonic distortion, malfunctioning of shielding devices and overloading and underloading of feeders.

Studying the possible influences of PV systems on the electric community is presently turning into a vital issue and is receiving loads of attention from each researchers and electric utilities. The primary reason for the significance of this difficulty is that correct assessment of these impacts, as well as supplying feasible answers for the operational troubles that might rise-up because of installing PV systems, is considered a first-rate contribution in the direction of facilitating the huge use of those structures.

III. POTENTIAL PROBLEMS ASSOCIATED WITH GRID CONNECTED PV SYSTEM

In spite of all the advantages introduced by PV structures to electric powered utilities, these systems may cause some operational troubles. One of the main factors that result in such problems is the fluctuations of the output power of PV systems because of the variations within the sun irradiance because of the motion of clouds. Such fluctuations cause numerous operational issues and make the output strength forecast of PV systems a hard venture. Further, the excessive cost of those systems limits the feasible solutions that can be followed by means of electric powered utilities to reduce the severity of the operational problems that could get up because of these fluctuations.

The negative impacts of Grid-connected PV systems on the network operation did not receive much attention until lately, after the noticeable increase in installation of these systems. 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, rotors of some of the conventional generators present in the network might swing at higher magnitudes due to the existence of PV units. Moreover, at very high penetration levels of PV systems, voltage collapse might occur.Hence, studying the impact of PV systems on transmission and sub-transmission networks does not seem to be important for electric utilities at the time being.

C. *Impacts on Distribution Networks*

The impacts of PV systems at the overall performance of distribution networks are currently one of the main issues for electric powered utilities. That is because the dimensions and place of the set up PV systems especially have an effect on these networks. The operational problems delivered by PV structures are much like those imposed via dispensed generators that produce constant active energy, such as diesel generators and fuel cells. These problems rise up particularly because of the installation of turbines at the patron side in a feeder designed for unidirectional power glide.

They include malfunctioning of protecting relays, voltage regulation problems, opposite electricity flow, as well as overloading or underloading of a few feeders. Different issues arise because of using interfacing electronics that lead to harmonic distortion and parallel and series resonances if a massive range of inverters are installed in a certain location.

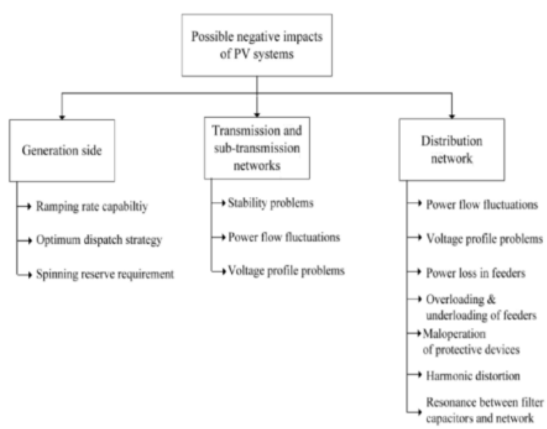

Fig. 1. Impacts of PV system on electric grid

IV. SIMULATION

This portion deals with the Simulink modelling of various components in a grid connected PV system.

- 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

Generally a cell are often modelled by a current supply and an inverted diode connected in parallel thereto. The PV cell has its own series and shunt resistance. Series resistance is because of the diode resistance(of the majority material) & resistance of metal contacts whereas parallel resistance represents the lep ton hole recombination before t reaches the load.

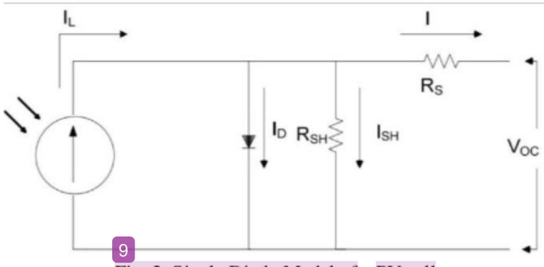

Fig. 2. Single Diode Model of a PV cell

A current supply (I) in conjunction with a diode and series resistance (Rs) is taken into account. The shunt resistance (Rsh) in parallel is extremely high, includes a negligible result and may be neglected. The output current from the electrical phenomenon array are often given by

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

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

where Io is that the reverse saturation current of the diode, letter of the alphabet is that we will use 2 diode model, however during this project our scope of study is proscribed to the only diode model. Also, the shunt resistance is extremely high and may be neglected throughout the course of our study. The lep ton charge, contagion is that the voltage across the diode, k is Ludwig Boltzmann constant (1.38 * 10-19 J/K) and T is that the junction temperature in Kelvin (K).

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

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

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

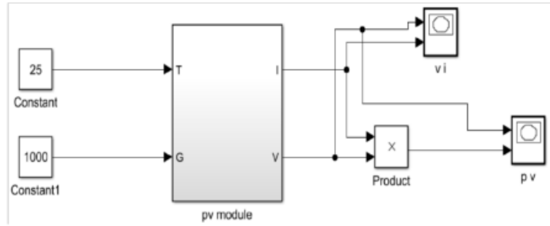

Fig. 3. Masked Simulink model of PV Panel

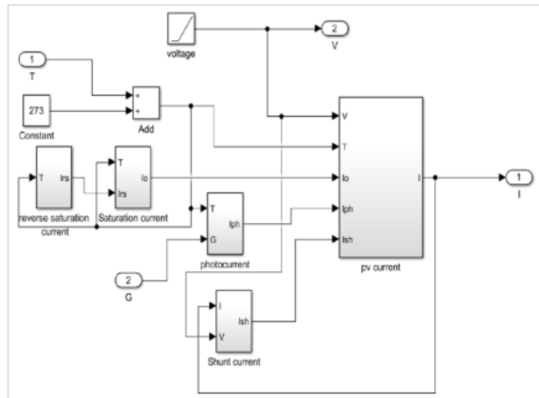

Fig. 4. Simulation of I_{ph} andI_{sh}

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

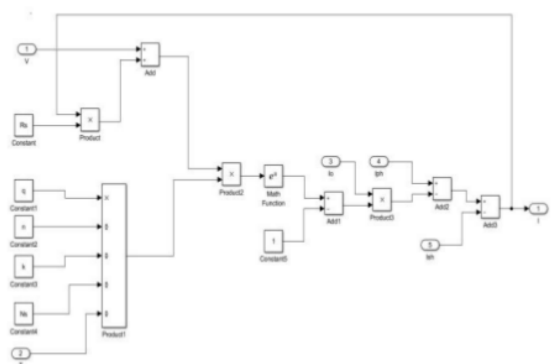
Fig. 5. Simulation of PV Current

The output of the PV array for ideal conditions is given in the below figure 5.1 which can only be solved iteratively. The below graph shows the typical curve.

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

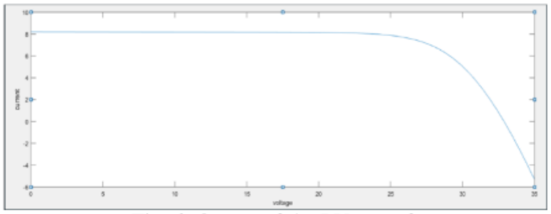

Fig. 6. Output of the PV array for ideal condition

The PV curve and the VI curve are shown in the fig. 6 and 7 respectively.P-V photovoltaic characteristic for 6 different irradiation ranges is proven in Fig.6.. It could be discovered that even as the irradiation change is multiplied, the PV output power is likewise extended. It can be conclude that even as the irradiation changes especially affect the PV output current, therefore the most energy factor is increased.

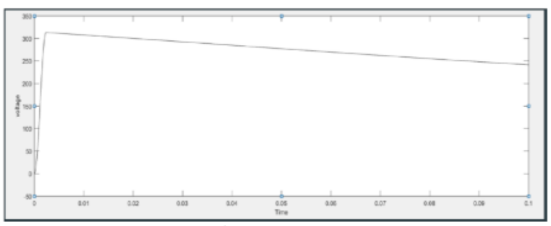

Fig. 7. PV curve

From the Fig. 7. it may be visible that the temperature modifications specially affect the PV output voltage. When the temperature rises, the voltage fell sharply. But the temperature rises from 25°C to 50°C, voltage fell greater obviously. As an end result, the voltage exchange is massive than the contemporary trade as the rise of temperature. The maximum output electricity meets additionally the connection, so its alternate is very small. Therefore, it can be conclude that the temperature adjustments specifically have an effect on the PV output voltage, while the irradiation adjustments mainly have an effect on the PV output present day.

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

Maximum power point tracking (MPPT) an algorithm implemented in photovoltaic (PV) inverters to continuously adjust the impedance seen by the solar array to keep the PV system operating at, or close to, the peak power point of the PV panel under varying conditions, like changing solar irradiance, temperature, and load.Engineers developing solar inverters implement MPPT algorithms to maximize the power generated by PV systems. The algorithms control the voltage to ensure that the system operates at "maximum power point" (or peak voltage) on the power voltage curve, as shown below. MPPT algorithms are typically used in the controller designs for PV systems.The algorithms account for factors such as variable irradiance (sunlight) and temperature to ensure that the PV system generates maximum power at all times.

Boost Converter

The major disadvantage of a Buck kind device is that the switch may be at the output of PV panel therefore once it's thereon transfers power however once off no output to the PV panel happens which suggests the operative purpose remains close to the electrical circuit voltage that is a loss. This issue isn't there in boost device mechanism during a boost device the Load matching is completed by varied the resistance of the input facet by sterilization the Duty magnitude relation that a DC-DC device is needed essentially this can be referred to as pursuit. Another purpose of employing a Boost regulator in spite of the actual fact that it's a lower potency than its counterparts is that this DCDC device are often wont to feed a load or a system with higher voltage demand so justifying its name.

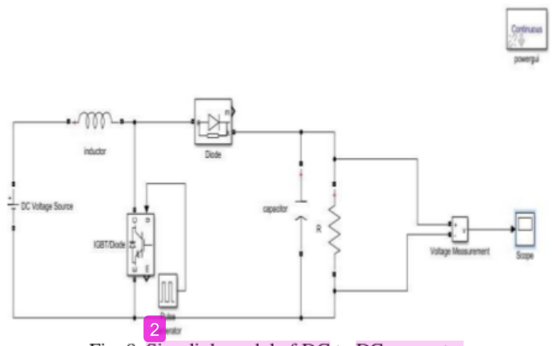

Fig. 8. Simulink model of DC to DC converter

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

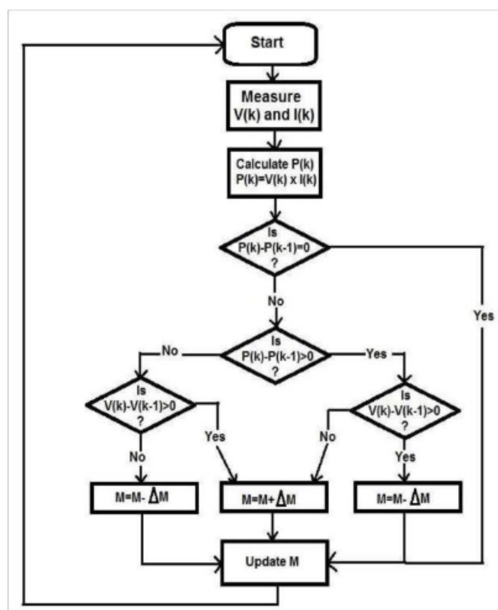

Fig. 9. Flowchart of P&O algorithm

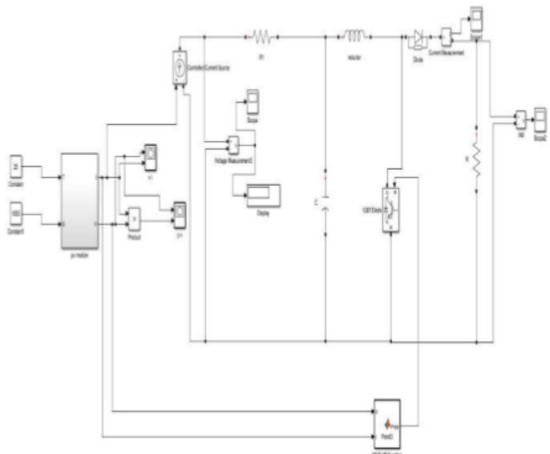

Fig. 10. Simulink model of PV cell with MPPT

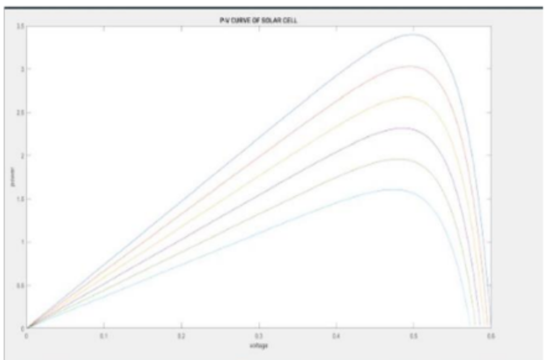

Fig. 11. Converter output characteristics

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 electrical converter, or electrical converter, or electronic equipment that changes electricity (DC) to electrical energy (AC). The input voltage, output voltage and frequency, and overall power handling rely upon the look of the particular device or electronic equipment. The electrical converter doesn't turn out any power; the ability is provided by the DC supply.A power electrical converter are often entirely electronic or is also a mixture of mechanical effects (such as a rotary apparatus) and electronic electronic equipment.Static inverters don't use moving elements within the conversion method.

For the 120° degree conduction mode, every thyristor conducts for 120° of a cycle. Like a hundred and eighty° mode, 120° conduction mode inverter additionally requires six steps, each of 60° length for completing one cycle output voltage (AC).For this inverter too, a desk giving the sequence of firing the six thyristor is ready as shown in the table1. In this table, proven that even conducts for 120° and for the next 60° neither S1 nor S4 conducts. Now S4 is became on at ωt=180° is similarly conducts for a hundred and twenty°,i.e. from ωt=one

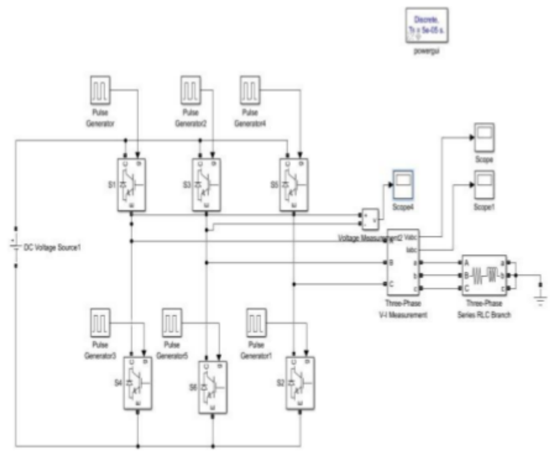

Fig. 12. Simulink model of an inverter

hundred eighty° to at ωt=300°. this means that for 60° c language from ωt=120° to ωt=a hundred and eighty°, collection linked transfer S1, S4 do not conduct. At ωt=three hundred°, S4 is grew to become off, then 60° c programming language elapses before S1 is turned on again at ωt=360°, inside the second row, S3 is became on at ωt=one hundred twenty° as in 180° mode inverter. Now S3 conducts for a hundred and twenty°, then 60° c language elapses during which neither S3 nor S6 conducts. At ωt=300°, S6 is grew to become on, it conducts for one hundred twenty° after which 60° interval elapses and then S3 is grew to become on again. The third row is also completed is in addition. This desk show that S6, S1 must be gated for step I; S1, S2 for step II ; S2 ,S3 for step III and so on. The series of firing the six thyristor is the same as for the a hundred and eighty mode inverter. at some point of each step, simplest two thyristors conducts for this inverter one from the upper group and one from the decrease organization; but in 180° mode inverter, three thyristors conduct in every step.
The output characteristics of the inverter is illustrated in the fig. 13.

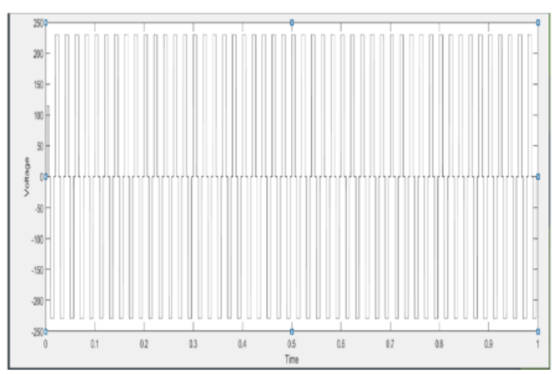

Fig. 13. Output characteristics of inverter

D. Overall System

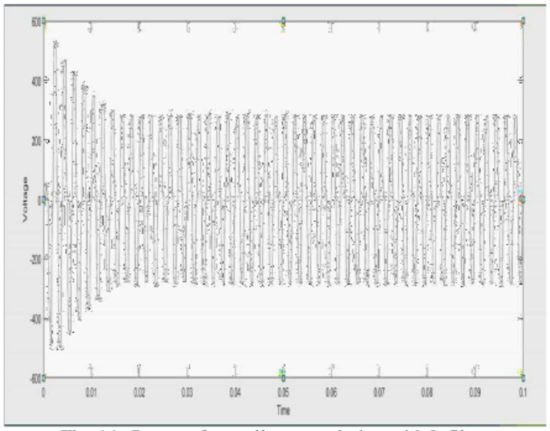

Fig. 14. Output of overall system design with L filter

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

V. CONCLUSION

The undertaking procedure rearranged piecewise straight model for a PV cluster. In this work we have picked the BP SX 150 sun powered board as the power source and recreated its I-V and P-V attributes. The last re-enactment of PV-cluster alongside MPPT and an impedance coordinating gadget.

A boost converter was utilized to execute the MPPT calculation as a result of its better proficiency in the fragmentary open-circuit voltage MPPT calculation. At the point when there is change in the sun based illumination the most extreme power point changes and in this manner the required obligation cycle for the activity of the model additionally changes. In any case, on the off chance that consistent obligation cycle is utilized, at that point greatest power point can't be followed and therefore the framework is less effective.

The different waveforms were gotten by utilizing the plot system in MATLAB. There is a little loss of intensity from the sun based board side to the lift converter yield side. This can ascribed to the exchanging misfortunes and the misfortunes in the inductor and capacitor of the boost converter.

The parameters of the inverter model like the inductance, the dc gain (kv) and time consistent (television) significantly influence the framework elements at the exchanging time and ought to be picked appropriately to acquire a stable intermittent conduct. At the point when rather than PV, DC source is associated the voltage waveform is very like the reference voltage however both current and voltage has some consonant substance in them. Subsequent to associating the PV module the harmonic substance in current and voltage expanded and the yield of the PV was additionally influenced impressively.

The MPPT calculation utilized was partial open circuit voltage calculation. The yield of the boost converter is an added advantage to the general extension that demonstrations like an inverter hardware. A discrete PWM generator was utilized to give activating sign to the inverter. Mat lab and Simulink have been utilized for different plots and esteem estimations.

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