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MODELLING AND SIMULATION OF GRID INTEGRATED SOLAR PV SYSTEM THROUGH BOOST CONVERTER AND INVERTER

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ABSTRACT: Integration of solar photovoltaic (PV) resources into distribution networks changes the normally expected network behaviour by injecting real power into the point of connection. Depending on the characteristics and setup of the PV inverter, reactive power could also be injected into the network. With random variations in load and PV output throughout the day, the behaviour of distribution network needs to be studied so that any unexpected operational behaviour of the network arising from PV integration can be avoided. The primary objective of this paper is to model PV system and to obtain results of its outcome. By getting these outcomes, modelled PV system is then implemented to the standard bus system. The second major objective is to analyse the impacts of high PV penetration level on various parameters of distribution system. Analysis had been done in terms of voltage deviation from nominal value. The PV system model is developed and simulated using MATLAB/Simulink software.

I. INTRODUCTION

The search for energy sources other than fossil fuels is no longer a luxury with the world energy demand increasing at an exponential rate. The fossil fuels offer a temporary solution to this energy crisis. The fossil fuels cause the emission of carbon dioxide and other greenhouse gases, which are harmful to the environment. This has paved the way for research on renewable energy technology and other researches in the fields of power electronics and hence, the cost of utilizing the renewable energy is at an ever decreasing rate. One such source of renewable energy, the Sun, offers unlimited energy for harnessing and for this very reason, Photovoltaic (PV) systems consisting of PV modules, for generating environmental friendly power are gaining more and more recognition with each passing day.

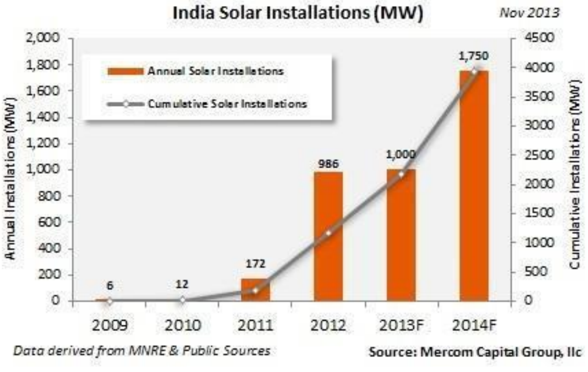

Fig.1 Total Solar installation in India till 2014

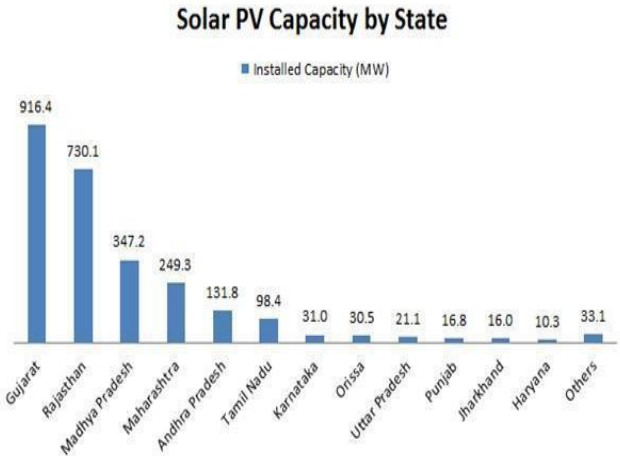

Fig. 2 State wise Solar PV capacity in India

From the fig 1 we can also see rapid growth of solar installations in India. Till 2009, solar installation was only 6MW, which increased up to 1750MW till 2014. Now, fig.2 shows state wise solar installed capacity in India. From fig. 1 we can see that solar PV capacity is increasing day by day. As grid connected solar capacity is increasing day by day, its impacts on transmission and distribution system should be analyzed.

II. PV TECHNOLOGIES AND INDIAN ELECTRICITY SCENARIO

Solar cells also called photovoltaic cells, convert sunlight directly into electricity. PV cell gets its name from the process of converting light (photons) to electricity (voltage), which is called the PV effect. According to the Photovoltaic effect, which was discovered in 1839 by Edmund Becquerel, who was French scientist, energy form sun can be converted to electric energy. The first silicon solar cell was demonstrated 50 years ago which was in operating condition. There is a large improvisation in solar technologies in past 20 years with best confirmed 24% efficiency. Today, thousands of solar PV systems are used to power thousands of peoples' homes and business places. The solar panels are mounted at a fixed angle facing south, or they can be mounted on a tracking device which follows the sun to allow solar panels to capture the most sunlight and to obtain maximum power.

WORKING PRINCIPLE OF PV CELL

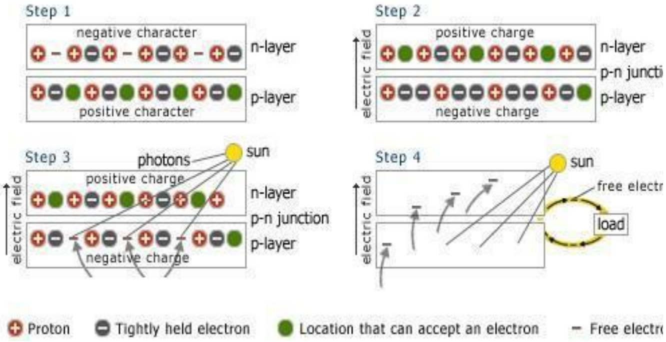

Fig.3. Working Principle of solar cell

Photovoltaic energy is the conversion of solar energy into electrical energy. The technology used to convert solar energy directly into electrical energy is called solar cell, PV cell or photovoltaic cell. A photovoltaic cell is generally made from silicon alloys and it is static device (non-mechanical). When enough solar energy is absorbed by the semiconductor material (generally silicon), electrons are dislodged from the material's atoms. Special treatment of the material surface during manufacturing makes the front surface of the cell more receptive to free electrons, so the electrons naturally migrate to the surface.

CELL, MODULE AND ARRAY

The photovoltaic cell or solar cell is known as the basic building block of a solar system. The size of the individual photovoltaic cell varies in the range of 1cm to 10cm (1/2inches to 4inches). Usually one cell produces 1 to 2 watts which is not enough for any system.

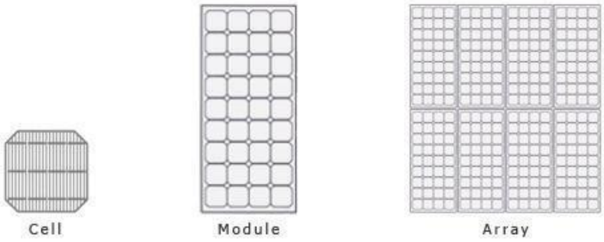

Fig. 4 Cell, Module and Array

Cells are electrically series and or parallel connected into a package weather tight module to increase power output. These modules can be further connected in series and parallel to form an array for the further increase of the power. The term array refers to the entire generating plant, whether it is made up of one or several thousand modules. The number of modules connected together in an array depends on the amount of power output needed. The photovoltaic array performance is dependent upon sunlight and weather conditions. Climate changes (e.g., clouds, fog, and rain) have a significant effect on the amount of solar energy received by a photovoltaic array and due to that on the performance of the PV array.

GRID CONNECTED PV SYSTEM

A grid connected PV system is shown in figure. These systems have become very popular because of their applications in distributed generation and for effectively using the PV array Power. These grid connected systems can be designed with battery or without battery storage. Excess power, not required by the load connected to the system, can be directly fed into the grid which is considered to be an infinite source or sink of power [6].

The system consists of the following:

- Solar panels: These are mounted on the roof or in open spaces. The electric power produced by these systems is DC.□ □
- Batteries: To store DC energy generated by the solar panels and to supply MPPT.□ □
- Charge controller: It is used to prevent overcharging the battery.□
- DC-DC converter: This is used for converting one level of DC voltage (unregulated) to another level of DC voltage (regulated).The basic DC-DC converters are buck, boost and buck boost converter [1][2].□ □
- MPPT: It is used to ensure the maximum utilization of the PV Panel [2].□
- Inverter: To convert produced DC electric power to AC Power at the grid voltage.

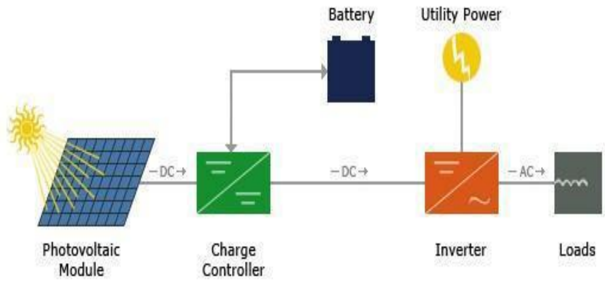

Fig. 5Grid connected PV System

III. HYBRID PV SYSTEM

The Hybrid PV system is shown in figure. In this system, more than one source of power generation are connected hence it is known as Hybrid system. The Hybrid PV system can be classified depending on the type of source it uses, e.g. PV-Wind hybrid system, PV-Diesel hybrid system, PV-Fuel cell hybrid system etc. The most common type of the Hybrid system contains a gas or diesel powered engine generator [19].

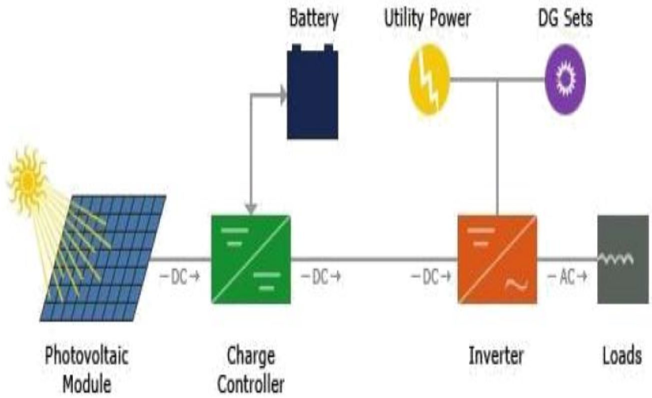

Fig 6 Hybrid PV System

Simulink Model of Solar PV System

Now, we want to obtain graphs of power, voltage and current of the designed PV array. IV characteristic and PV characteristic are also required. All these results can be obtained by the Simulink model shown in to fig.

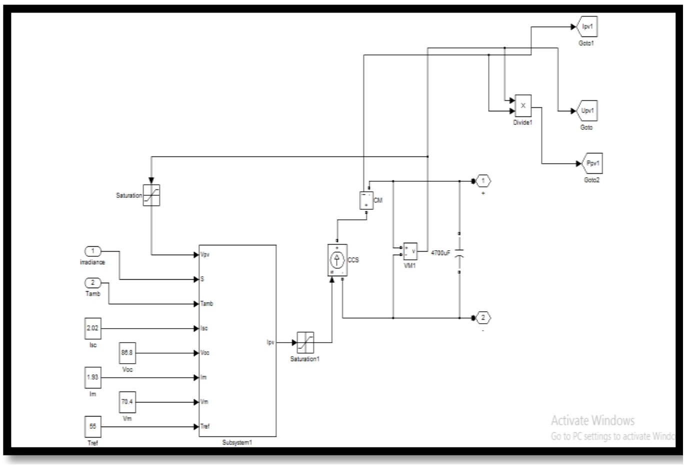

Fig - Solar PV System

Simulink Model of Solar PV Sub System

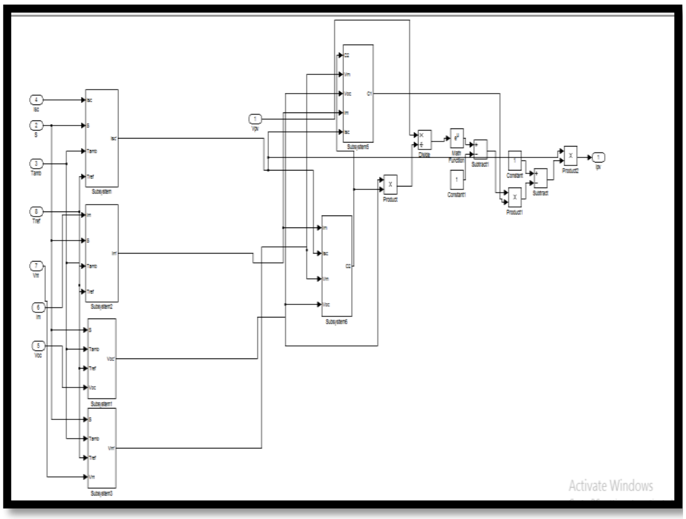

Fig- Solar PV Subsystem

Simulink Model of Solar system with MPPT, boost converter and inverter

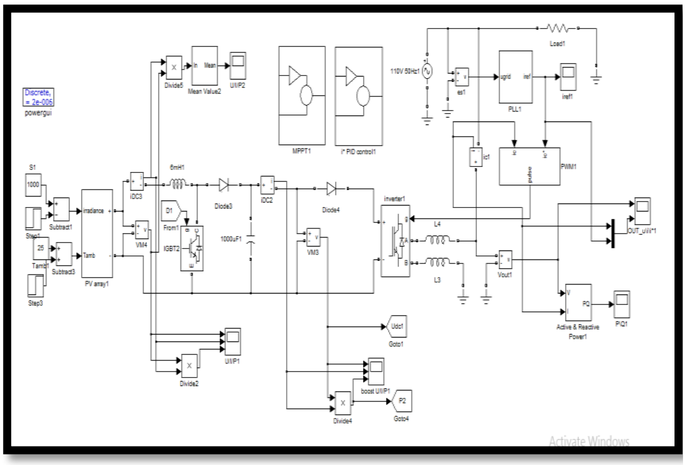

Fig - Solar PV System with MPPT, Inverter and Boost Converter

The fig shows the Solar PV System integrated with boost converter for boost up the voltage value, MPPT controller for maximum power point tracking in the system, Inverter section for D.C to A.C conversion in the system.

4.3.4 The Subsystem and controlling systems are shown in the below fig

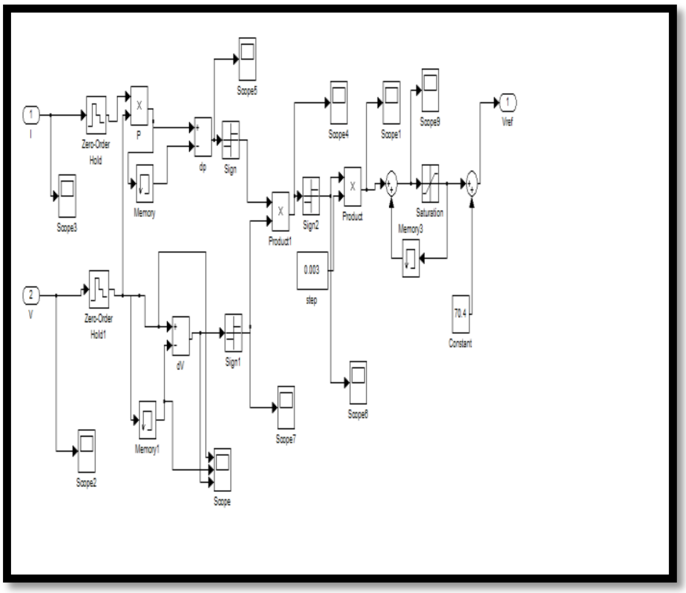

Fig -MPPT Controller Logic

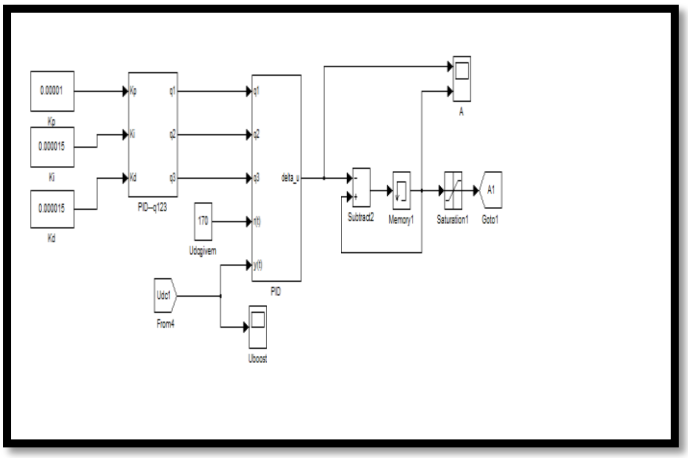

Fig- PID Controller Subsystem

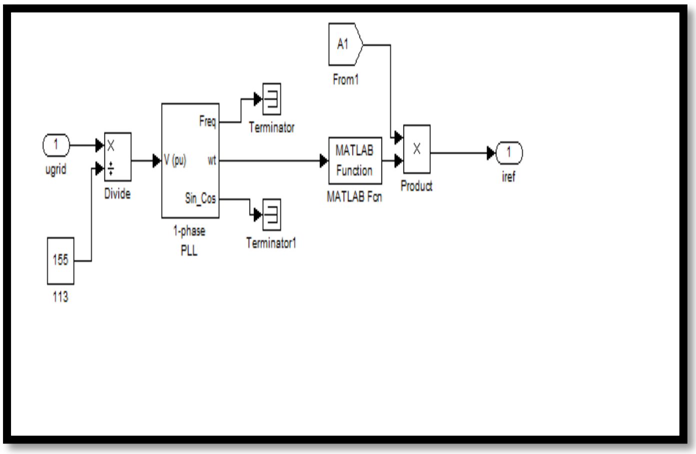

Fig -PLL Control subsystem for grid

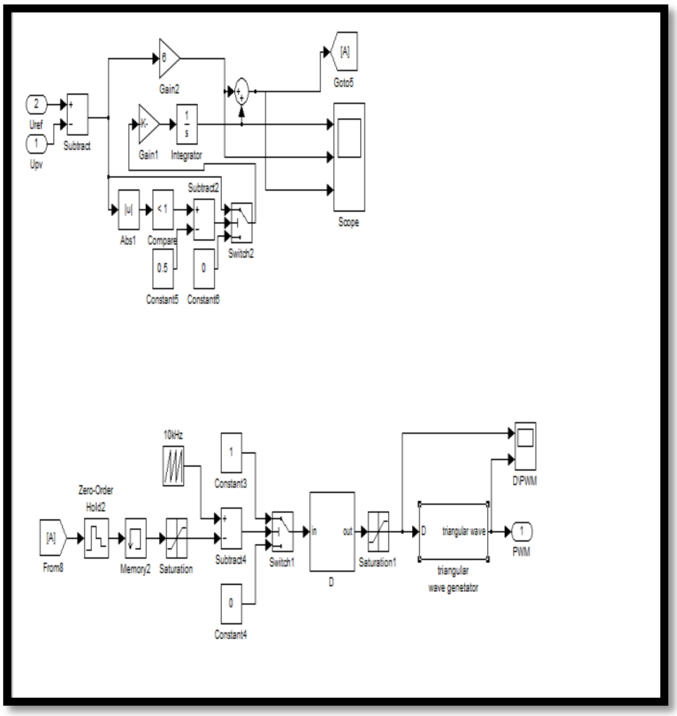

Fig- PWM Control circuit for MPPT Controller

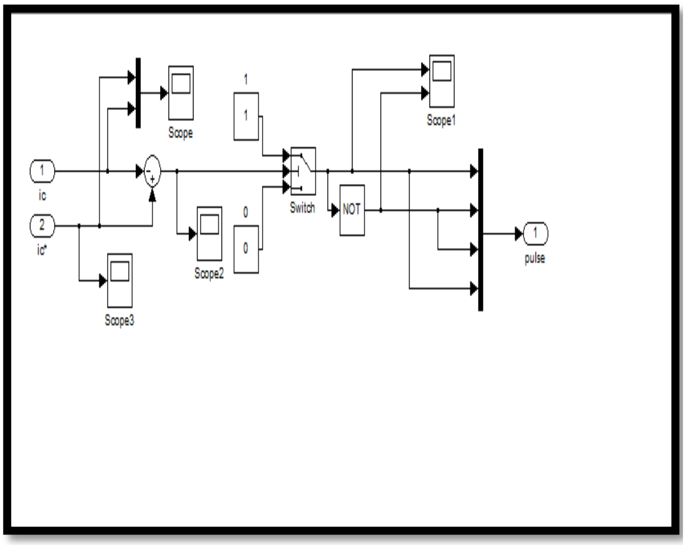

Fig - PWM logic for PLL Block

Simulation Results:

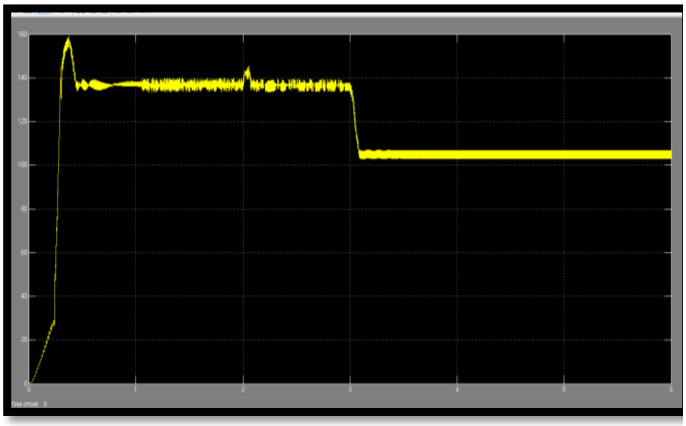

Fig -Constant D.C output after controlling

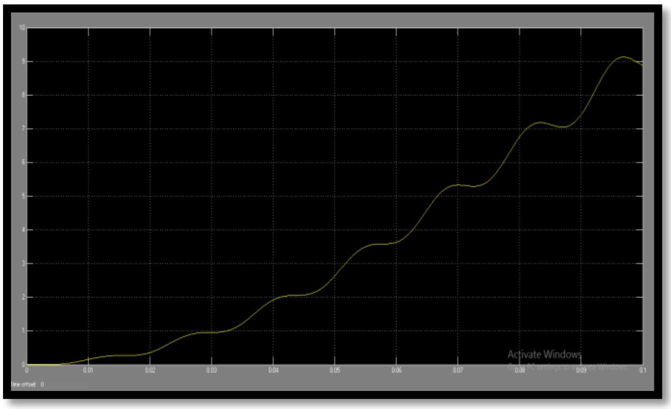

Fig - MPPT Output for power tracking to maximum

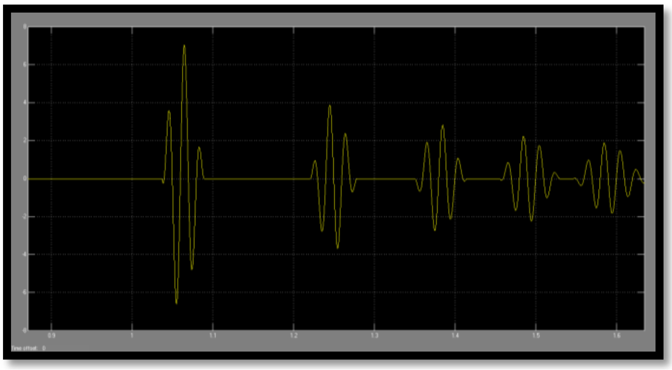

Fig -Switching operation of Inverter

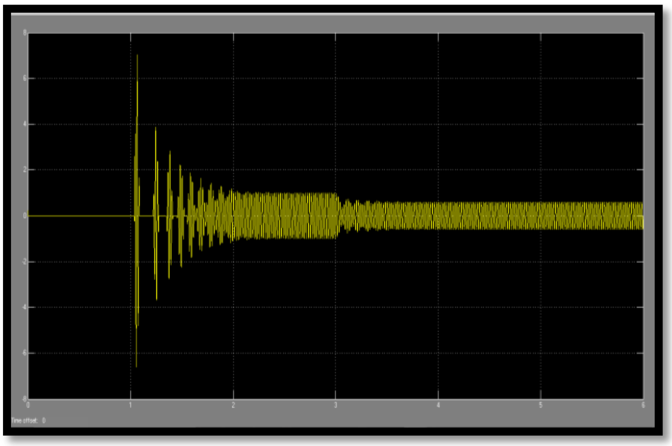

Fig -Grid side A.C output after controlling

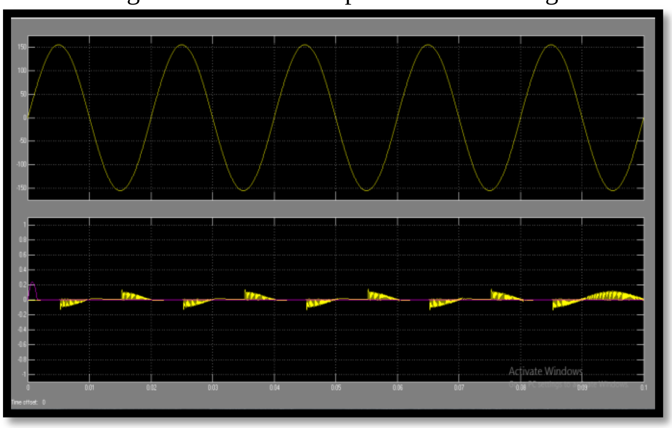

Fig -Grid Side output Voltage and Current

Simulation of Proposed System

The fig below shows the Solar PV System integrated with boost converter for boost up the voltage value, MPPT controller for maximum power point tracking in the system, Inverter section for D.C to A.C conversion in the system. The proposed system is integrated with grid system and the simulation results also shown in the below sections.

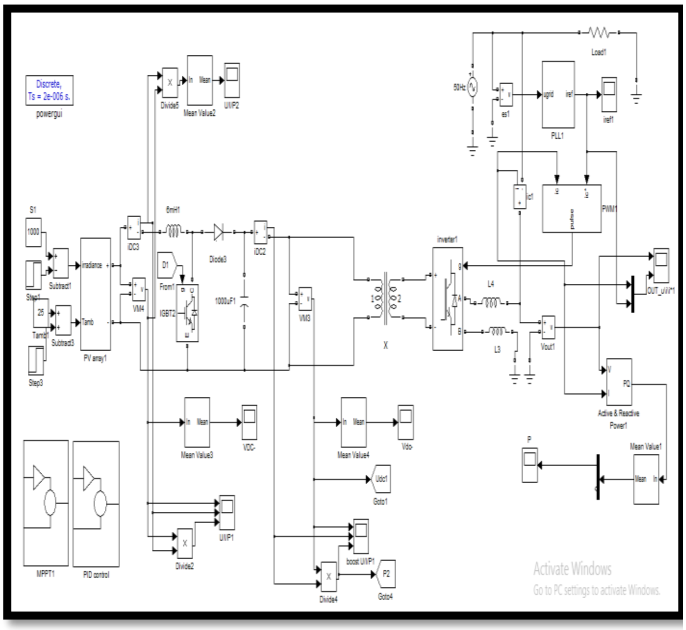

Fig- Proposed system integrated with Grid

Simulation results after grid integration:-

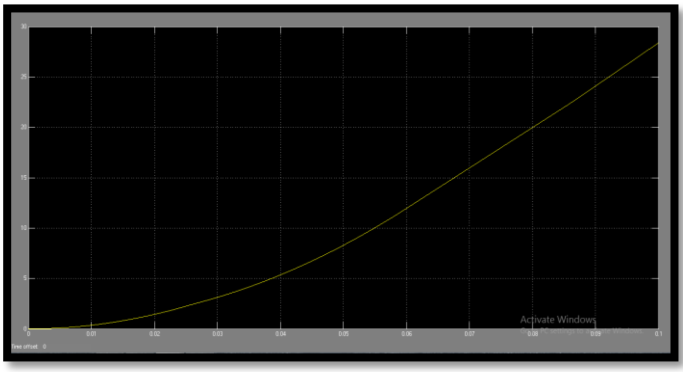

Fig- D.C voltage before boost converter

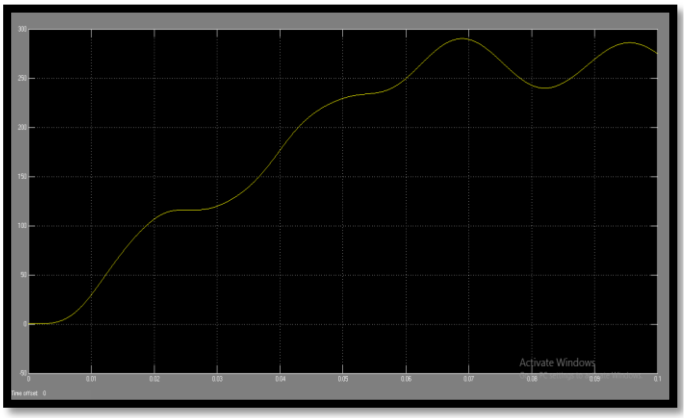

Fig- D.C voltage after boost converter

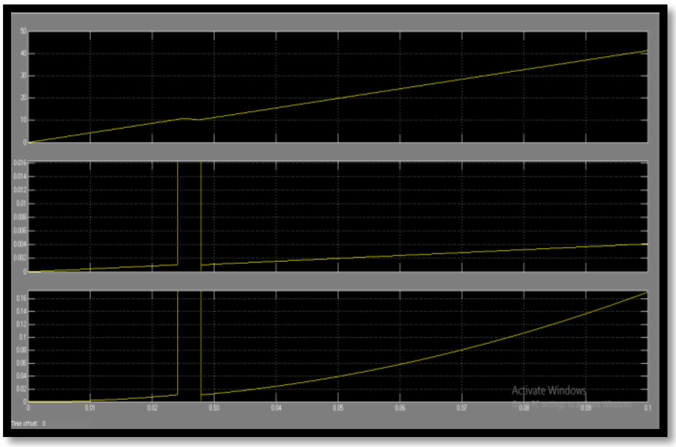

Fig- Output D.C voltage, current and power of Solar PV

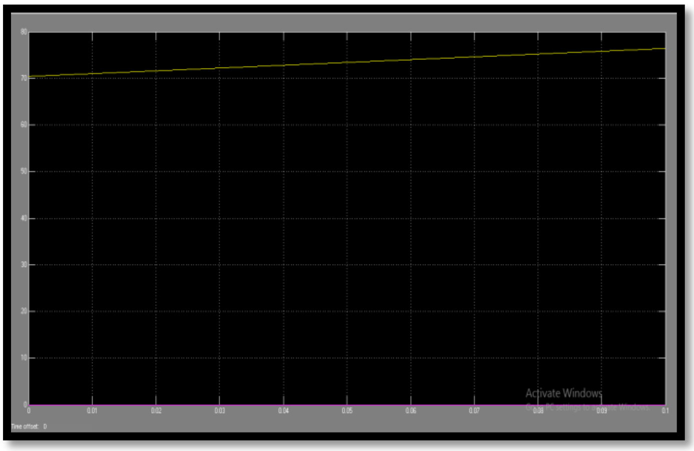

Fig- MPPT output D.C voltage

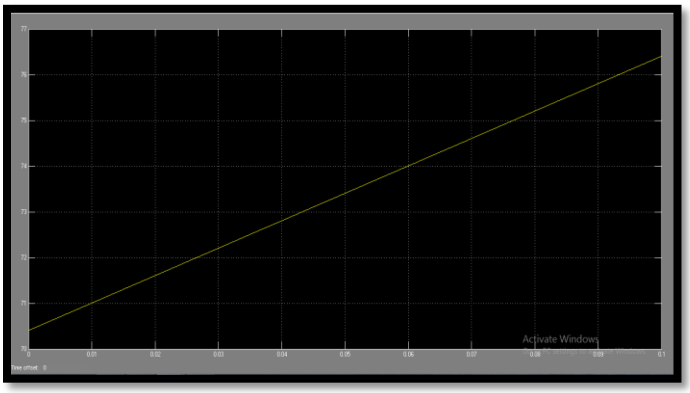

Fig-Reference of MPPT

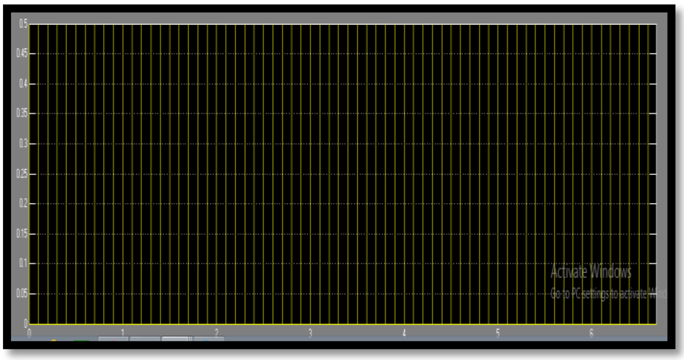

Fig- Triggering pulses of MPPT

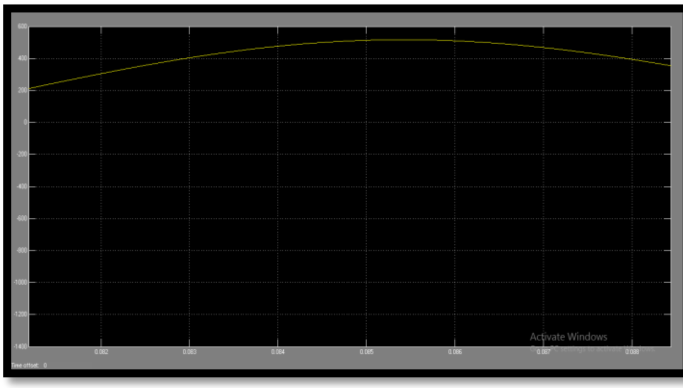

Fig- Output power of solar

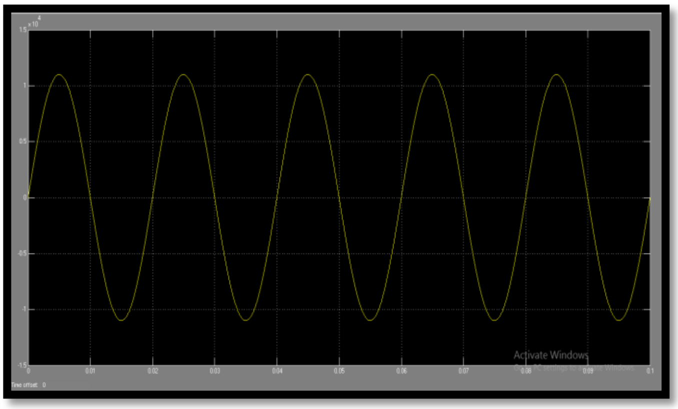

Fig- Grid side a,c voltage waveform

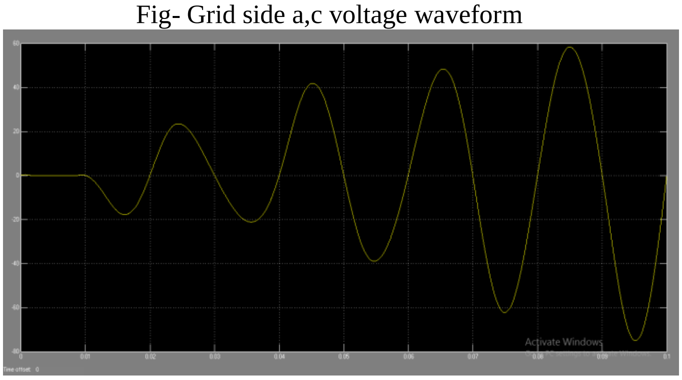

Fig- Grid side a,c current waveform

IV. CONCLUSION

The complete simulation of Literature review based on impacts of PV penetration levels on distribution system and mathematical modelling of PV system has been done. Based on the literature review and theories, PV system will be designed. Designed PV system was developed in MATLAB/Simulink software. Simulink based Model of a photovoltaic (PV) system using the single-diode model of a PV solar cell was developed with variation in solar irradiation. MPPT is also designed to utilize maximum power using perturb and observe method. In this paper I have completed the complete simulation of Literature review based on impacts of PV penetration levels on distribution system and mathematical modelling of PV system has been done. Based on the literature review and theories, PV system will be designed. Designed PV system was developed in MATLAB/Simulink software. Simulink-based Model of a photovoltaic (PV) system using the single-diode model of a PV solar cell was developed with variation in solar irradiation. MPPT is also designed to utilize maximum power using perturb and observe method. Boost converter is designed for constant output voltage which is given to inverter to convert DC quantity in to AC. This model is implemented with Simulink blocks.

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