

Modeling and Simulation of Grid Connected PV System

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ABSTRACT

The paper describes the Grid connected solar photovoltaic system using DC-DC boost converter and the DC/AC inverter (VSC) to supplies electric power to the utility grid. The PV cell model is easy, accurate, and takes external temperature and solar radiation into consideration. The paper presents detailed transient models of the grid-connected PV/Battery hybrid generation system, and all these models are simulated by using MATLAB/Simulink. PV array is firstly connected to the common dc bus by a boost converter, where the battery is also connected by a bi-directional DC/DC converter, and then integrated into the ac utility grid by a common DC/AC inverter. Maximum power point tracking helps PV array to generate the maximum power to the grid, and the battery energy storage can be charged and discharge to balance the power between PV generation and utility grid.

KEYWORDS: Photovoltaic Generation, Hybrid Simulation, Maximum Power Point Tracking, Modeling

INTRODUCTION

Electric energy has been proved to be the most versatile form of energy which can be converted and utilized in any form and way, in the same way any form of energy could be converted and conserved as electric energy. Fossil fuels are main source of electric but due to their irreversible nature, they are being extinguished at an alarming speed. In this age, every country wholly agrees that electric energy is an essential factor in the economic development of the country. The advancement of technical progress, rapid industrialization and the necessities regarding the modern world has transformed electric energy into an important asset. Increase in its production runs parallel to the better and comfortable lifestyle and accumulation of wealth, In this century, resources of energy and its proper use will be a leading issue and they have been discussed many times in recent years along with natural resource depletion, the increasing demand for latest energy resources and its environmental effects [1]. To fulfill power demand in the world, renewable energy proves out as the best alternative [2]. To meet this demand, the reliable and sustainable sources of renewable energies are needed to supply power to the power

How to cite this paper: Ather Javed | Ameen Uddin Ahmad "Modeling and Simulation of Grid Connected PV System" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-5 | Issue-5, August 2021, pp.475-480, URL: www.ijtsrd.com/papers/ijtsrd43845.pdf



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grids. But this injection of renewable power creates some power quality issues and parameters of the electrical power grid fall down the standard values [3]. As it is clear from the latest review of literature now all agree that the greenhouse gas producer's causes severe destruction to environment. International surveys conclude that all the countries tremendously support the utilization of renewable energies like tidal energy, wind energy, solar power[4]. At international level, in around 30 countries, renewable energy sources are fulfilling their energy supply up to more than 20 %. It is also noticed that the national renewable energy market is increasing rapidly and expected to rise tremendously in coming years. Some places and countries like Norway and Iceland produce 100 % energy from renewable energy resources and similarly many other nations are trying to meet the benchmark of 100% renewable energy production like government of Denmark is going for 100 % switching from current energy sources to renewable energy to meet their energy supply (heating /cooling, mobility and electricity) by the end of year 2050[5].

Modeling of Solar Cell

A Basic grid-connected Photo Voltaic system includes a PV array together with inverter unit, near the point of use for generating energy for residential purpose [6]. The major technical roadblock that can put the limit to widespread Photo Voltaic use is the quick changes in the output power of Photo Voltaic systems induced by cloud transients. These events can cause fluctuations in Voltage which give rise to too much use of voltage regulation instruments and light flickering [7].

Solar irradiance variability is recorded by the help of pyranometer with a data logger. In many studies, where we want to calculate the AC power feeded into the grid by Photo Voltaic systems, we use solar irradiance variability. But these two variables, in reality, are not ideally proportional to each other and also not synchronized in time due to delays found within the controls and circuit elements of inverter. It is observed that the difference between output power variability and solar radiation that may be produced by the buffer capacitor and MPPT is negligible. Therefore, the differences in solar irradiance are reliable indication of power fluctuations.

Solar PV system captures the sunlight and directly converts it into electricity. The solar cell output is mainly depends on two factors which are variable in nature that is, ambient temperature and irradiation. Change in these two factors affect the output of the solar cell either increase or decrease. The modeling requires the mathematical equations explaining and defining the physical characteristics of the PV cell [8]. Fig. 1 represents PV cell's equivalent circuit.

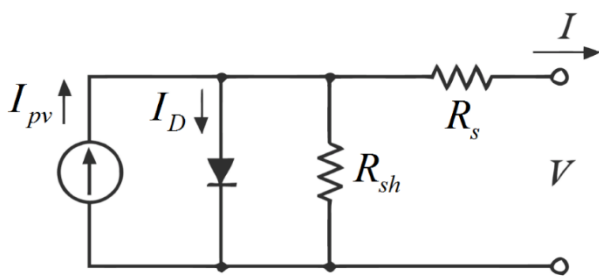


Fig. 1 PV cell - Equivalent circuit

$$I = I_{PVcell} - I_{ocell} \left[\left(\exp \left(\frac{q(V + IR_s)}{nkT} \right) - 1 \right) - \left(\frac{V + IR_s}{R_p} \right) \right] \quad (1)$$

Incident photocurrent is calculated by the temperatures T_1 and T_2 .

$$I_{PVcell} = I_{PVcell} + (T - T_1)K_0 \quad (2)$$

$$I_L(T) = I_{SC_{T_1}} \left(\frac{G}{G_{nom}} \right) \quad (3)$$

$$K_0 = (I_{SC_{T_1}} - I_{SC_{T_2}}) / (T_2 - T_1) \quad (4)$$

G_{nom} is the reference solar radiation and current solar radiation is represented by G .

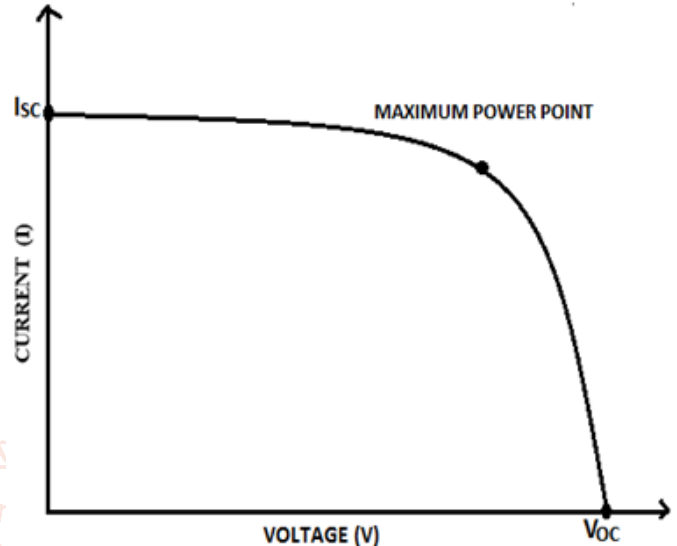


Fig. 2 V - I characteristic of a solar cell

During the dark, the cell is inactive and behaves like diode. The shunt resistance and internal resistance of the solar cell are denoted by R_p and R_s respectively. The maximum power (for a given resistive load) is given by

$$P_{Max} = I_{Max} * V_{Max} \quad (5)$$

Solar cell's efficiency can be defined by

$$\eta = \frac{P_{Max}}{P_{Min}} = \frac{(V_{Max} * I_{Max})}{A * G} \quad (6)$$

Here, A represent area of the cell whereas is the incident solar radiation on cell

To measure the quality of the solar cell, we use Fill Factor (FF). The FF should be more than 0.7. It is inversely proportional to the cell temperature.

$$FF = \frac{(I_{sc} * V_{oc})}{(V_{Max} * I_{Max})} \quad (7)$$

PV Subsystem without MPPT

The Fig. 3 below is of PV subsystem without MPPT. The maximum power point is not achieved in this technique and the power from the PV array lost in many folds. The PWM technique is used in this to provide gate pulse to the inverter switches.

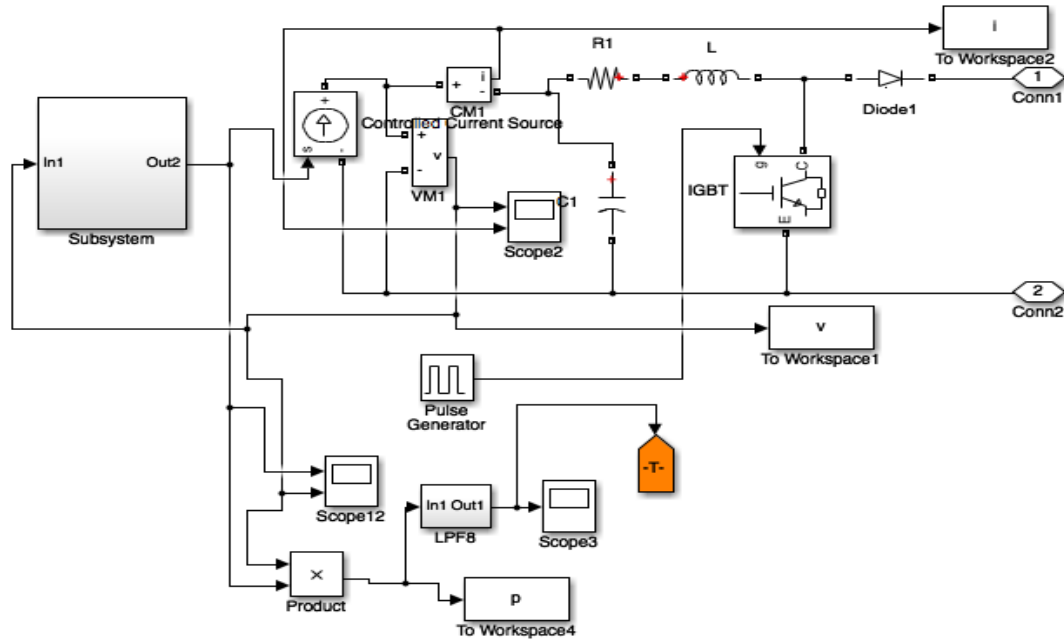


Fig. 3 PV subsystem without MPPT

Results and Discussion

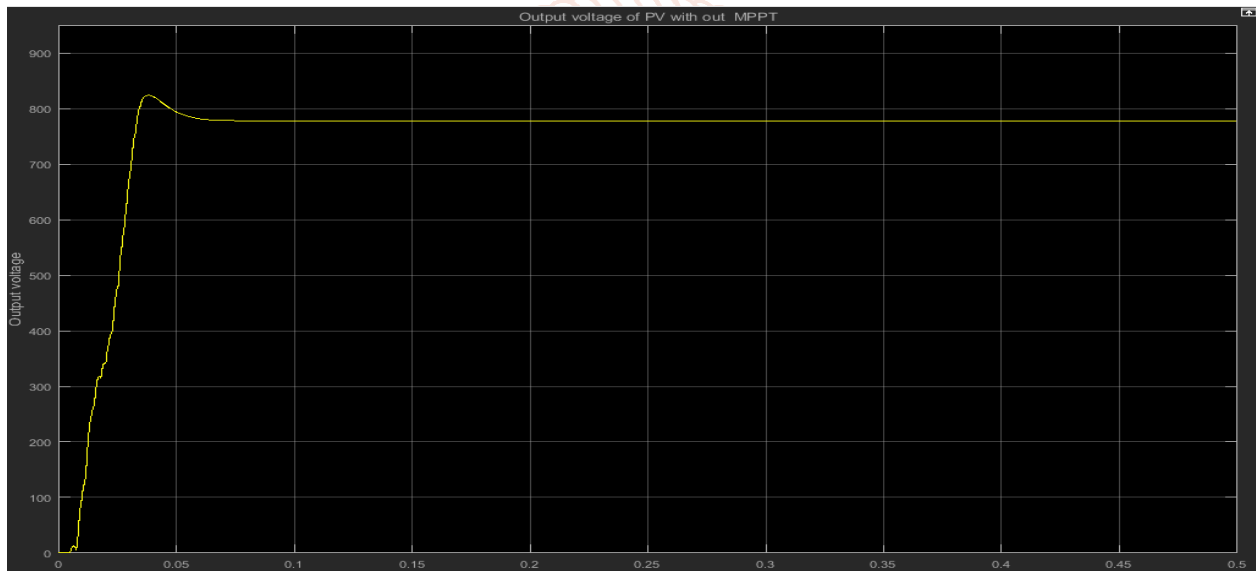


Fig. 4 Output of PV (V_{ac}) without MPPT

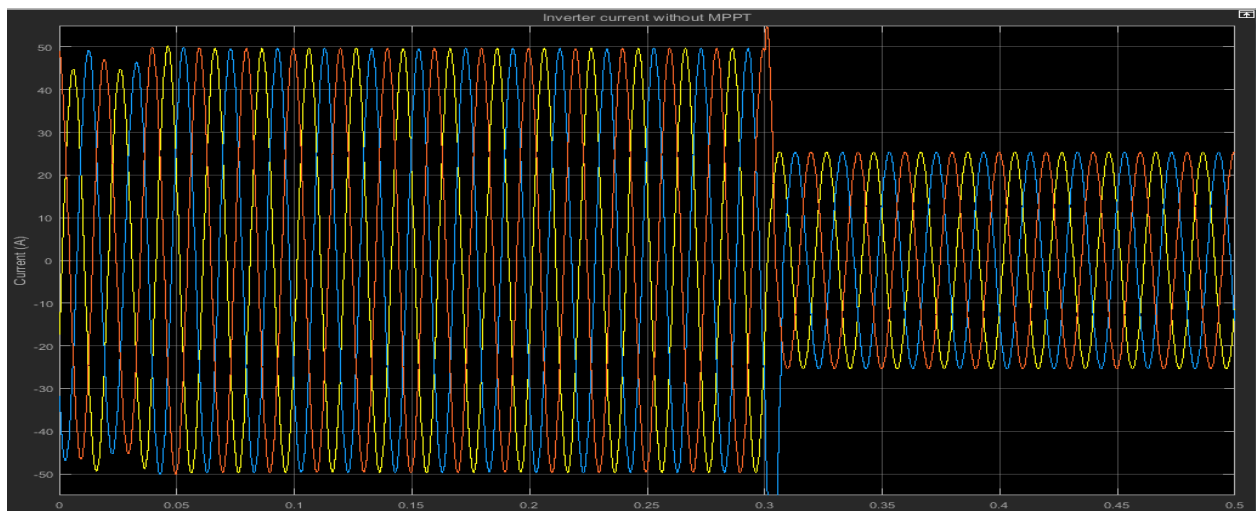


Fig. 5 Inverter current without MPPT

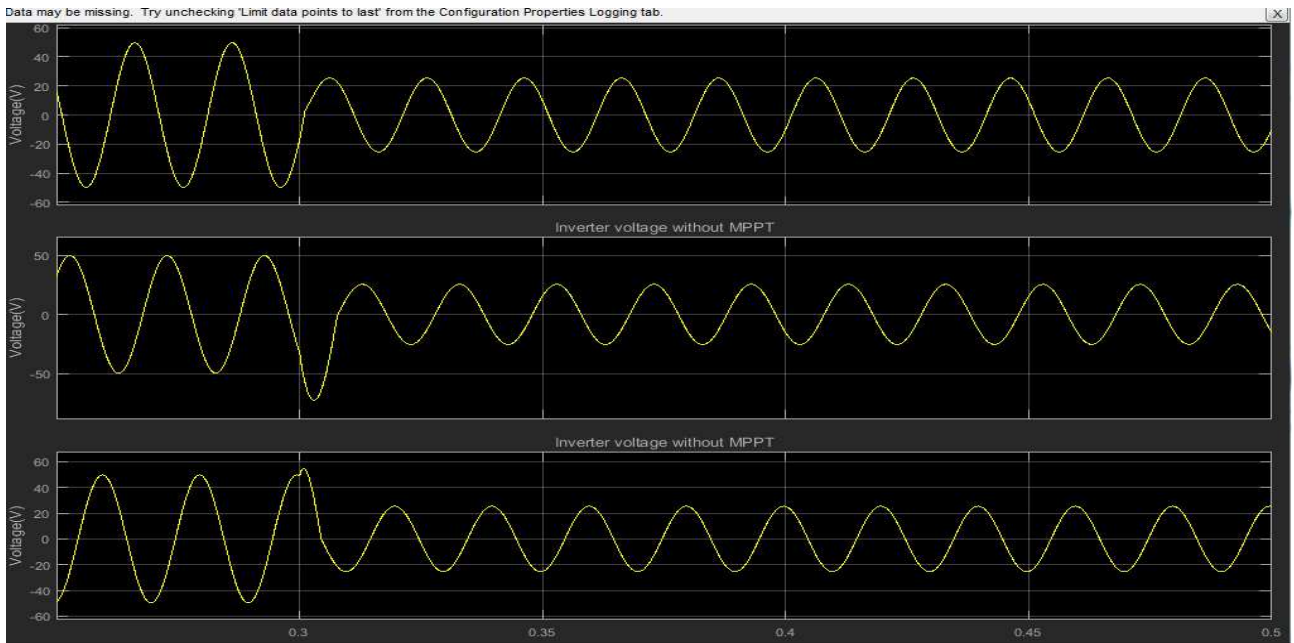


Fig. 6 Inverter voltage without MPPT

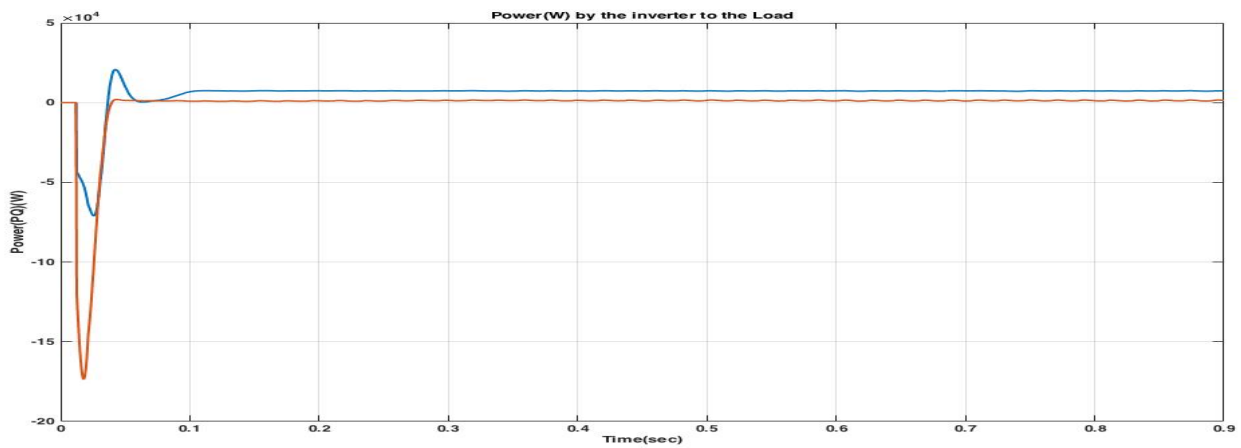


Fig. 7 Active and reactive power to load from inverter without MPPT

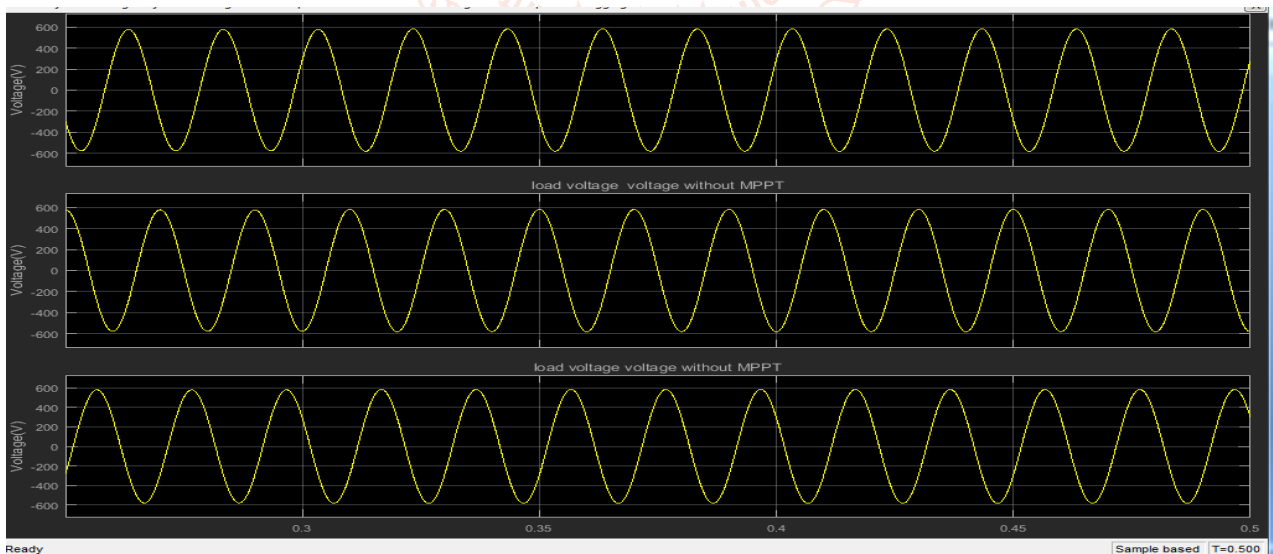


Fig. 8 Simulated waveform of three - phase load voltage without MPPT

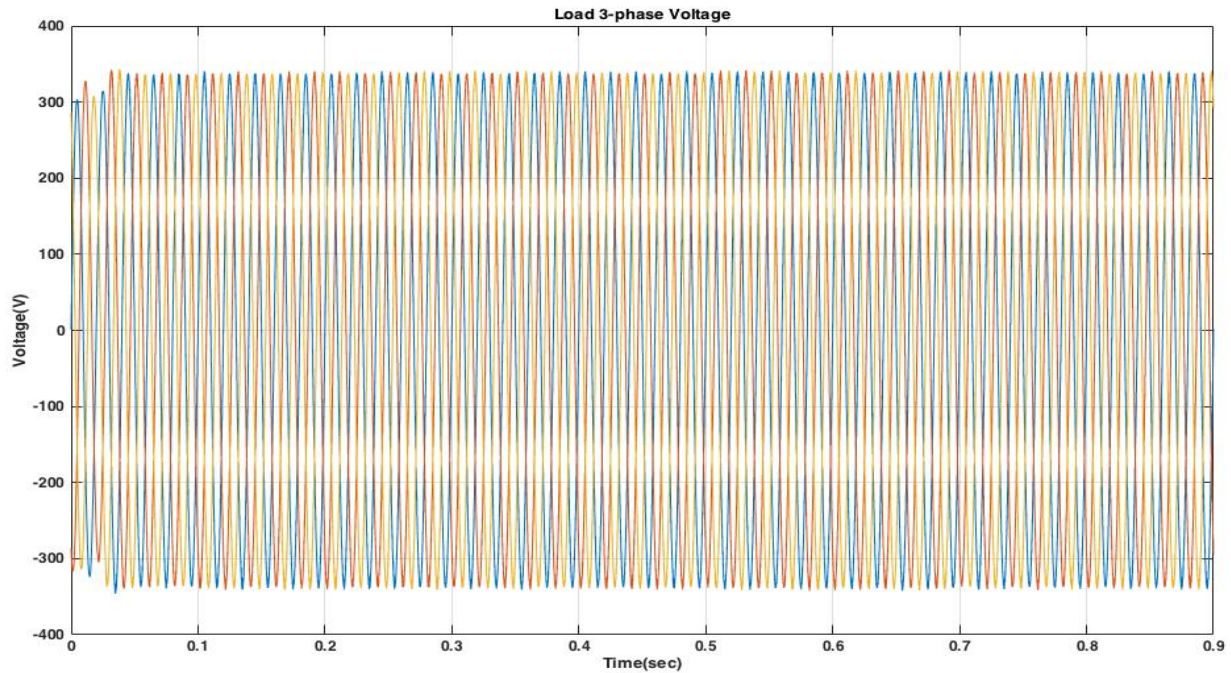


Fig. 9 Load Voltage with MPPT

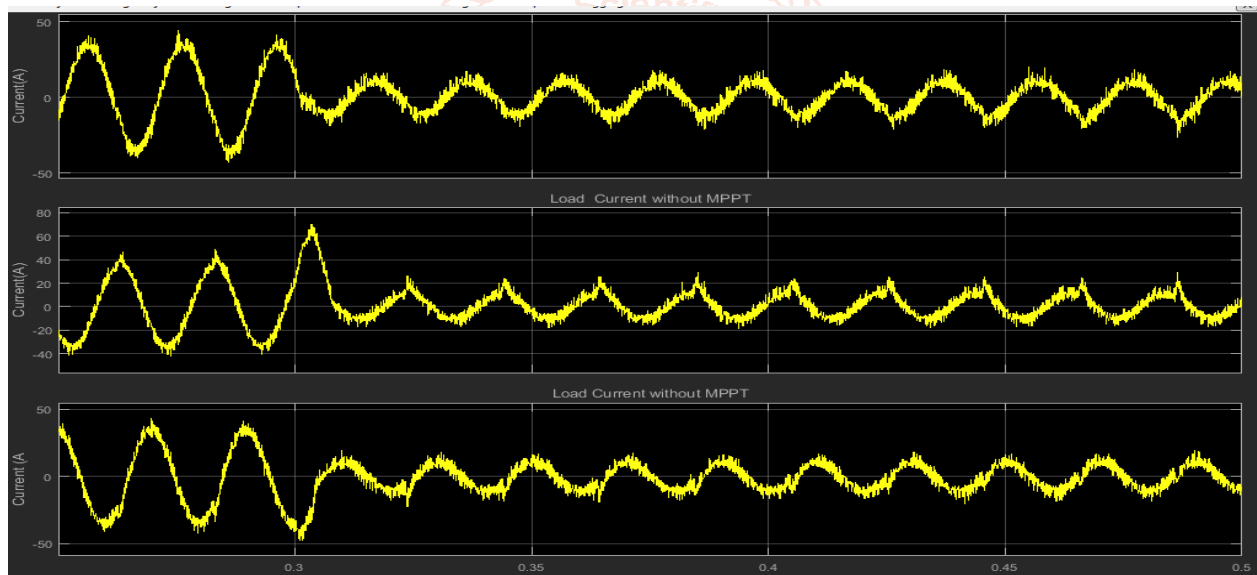


Fig. 10 Load Current with MPPT

Conclusion

In the current it is an attempt has been made to develop a simulation model for grid – tied 10 kW PV system with and without MPPT (feed local loads at remote places) in MATLAB to study the enhancement in the efficiency, reliability and sustainability of the system. We feed the generated power from a PV array and in changing weather conditions, we calculate the unitary PF. And, output waveforms for both the models (with and without MPPT) have been obtained and are verified. The models are compared and the generated output waveforms have been studied comparatively based on the simulation results, we can conclude that it is necessary to operate our system at the Maximum Power Point (MPP) of a Photo Voltaic array.

Beside inverters, Pulse width modulation (PWM) technique has also been developed. At the output of the inverter, which lead to a sinusoidal waveform and reduction in output voltage's total harmonic distortion (THD).

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