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SIMULATION AND ANALYSIS OF TECHNIQUE FOR FAST DETECTION OF SHORT CIRCUIT CURRENT IN SOLAR PV SYSTEM

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***Abstract*—This paper focus on the grid connected solar photovoltaic energy conversion system modeling and control in MATLAB Software. In the modeling part photovoltaic systems have SPV array, boost converter, MPPT technique, inverter, filter and transformer. It also shows the detailed representation of the main components of the SPV system. This paper proposes a new fast technique in which the slope of a PV inverter current is utilized to predict if the current is expected to exceed its rated value due to any grid faults. Two applications of this technique are demonstrated. This paper will help the researchers to understand the method available for grid integration of solar photovoltaic system as well as to model and control such system for better results.**

Keywords—Solar Photovoltaic system, Incremental Conductance MPPT, DC-DC converter,Solar Photovoltaic (SPV), Photovoltaic(PV) cell, Inverter.

I. INTRODUCTION

The main design objective of photovoltaic (PV) systems has been, for a long time, to extract the maximum power from the PV array and inject it into the ac grid. Therefore, the maximum power point tracking (MPPT) of a uniformly irradiated PV array and the maximization of the conversion efficiency have been the main design issues. However, when the PV plant is connected to the grid, special attention must be paid to the reliability of the system, the power quality, and the implementation of protection and grid synchronization functions. Modern power plants are required to maximize their energy production, requiring suitable control strategies to solve the problems related to the partial shading phenomena and different orientation of the PV modules toward the sun. Moreover, the new policy concerning the injection of reactive power into the grid makes the development of suitable topologies and control algorithms mandatory.

The conversion of light into electrical energy using photovoltaic effect can be achieved by conversion of naturally available solar energy into electrical energy. Solar cells are the energy conversion devices which convert the solar energy to electrical energy based on photovoltaic effect. Similarly, we use more number of solar cell or photovoltaic cell and combination of such cells for increasing the power output are said to be a solar module or solar array.

A PV system consists of many interconnected solar cells and other auxiliary components designed to accomplish a desired task, which may be to feed electricity into the main distribution grid or one of many more possible uses of solar-generated electricity. The design of the system depends on the task it must perform and the location and other site conditions under which it must operate. So, for the efficient conversion of solar energy we need understand major loss created by partial shading resulting non-uniform insolation. Performance of PV system is affected by the environmental condition such as change in solar insolation and temperature.

Solar energy is nature dependent and so photovoltaic working requires MPPT as an essential component. Under normal day condition it is easy to extract the power from the solar energy, but it is difficult to track power during shading or partial shading condition. The photovoltaic system is more favorable due to its advantages like direct energy conversion without any intermediate thermal process and solar energy is a versatile source of energy and it is available worldwide, non-polluting and it can easily be converted into other forms as per our requirements.

But in PV system solar cell are made of silicon, they are connected in series and parallel to obtain the desired voltage and power. Therefore, small change in irradiance due to shading of solar cell or panel affects the overall network performance. And if the affected panel is in series with other panels then the output will be affected of all the series connected panels.

The main advantage of such solar power plants includes that we can generate electricity where it is needed as a distributed generation. No pollution is created at the time of generation. We save more fossil fuels for our future. Such plants have lifespan of more than 20 years and reliability if more as no moving parts are used in the plant. Operating and maintenance cost is very less.

II. COMPONENTS MODELING

A. SOLAR PHOTOVOLTAIC ARRAY

The Solar Photovoltaic Array is formed by connecting several solar panels in series and parallel combination to generate the required power. The smallest component of the solar photovoltaic array is called photovoltaic (PV) cell. The ideal solar photovoltaic cell is represented by the equivalent circuit shown in Fig 1. These cells are connected in series of 36 or 72 cells to form one module. Similarly, several modules are assembled into a single structure to form array. Finally, assembly of these photovoltaic arrays is connected in parallel to obtain the required power. In PV module, series resistance $(R_s)$is comparatively more predominant and R_{sh} is considered equal to infinity (ideally). The open circuit voltage(V_{oc}) of the PV cell is directly proportional to solar irradiation and V_{oc} is inversely proportional to the temperature.

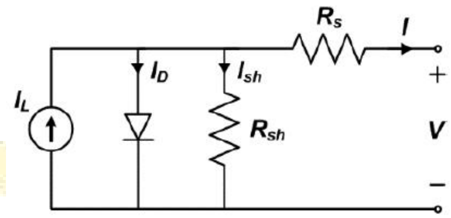


Figure 1Equivalent circuit of PV cell

The equations dominating the function of the circuit are presented below:

The characteristics of the PV cell can be represented by eq. (1), eq. (3) represents the saturation current of the diode. The value of $I_{ph}$is in proportional to the light intensity.

$$I = I_{ph} - I_s\left[e^{\left(q\frac{V+IR_s}{kT_c}\right)} - 1\right] - \frac{V+IR_s}{R_{sh}} \quad (1)$$

$$I_{ph}(\text{Photocurrent}) = \left[I_{sc} + k_i\left(T_c - T_{ref}\right)\right]\lambda \quad (2)$$

$$I_s = I_{rs}\left(\frac{Tc}{Tref}\right)^3 e^{\left[q\frac{Eg\left(\frac{1}{Tref}-\frac{1}{Tc}\right)}{ka}\right]} \quad (3)$$

Quantity	Value
P_{mp}	20160 W
V_{mp}	280 V
I_{mp}	72 A
V_{oc}	344 V
I_{sc}	78.16 A
N_s	72

Table 1. PV array Specification

Where,

I_{ph} = photo current

I_s= reverse saturation current.

V = voltage across solar panel terminal.

I = current across solar panel terminal.

ka = Boltzman constant.

a = ideality factor

Tc = cell working temperature

k_i= short circuit current temperature coefficient

Generally, in practical applications of the solar module, the inputs i.e. irradiation level and operating temperature range aren't ideal. They always vary depending on the weather conditions. Fig. 2, 3, 4 & 5 shows the various effects of change in irradiation and temperature on I-V and P-V curves.

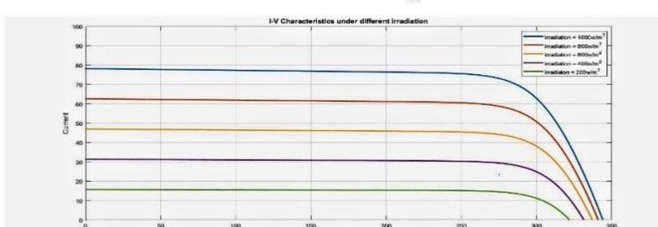


Fig.2. I-V characteristics of 20kW PV Array at different irradiation levels

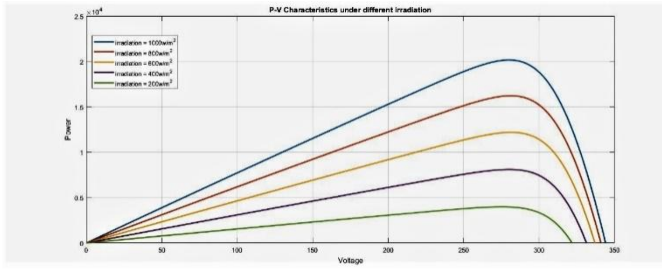


Fig. 3. P-V Characteristics of 20kW PV Array at different irradiation levels

The PV Array is characterized based on the I-V and P-V characteristic. As we can see the irradiation result direct vary the current and the curves of I-V characteristic vary largely for different level of irradiation.

The irradiation directly affects the PV Array current while the change of temperature directly affects the voltage generated by the PV Array. So same observation we can made from the above graph of I-V characteristics at different irradiation level.

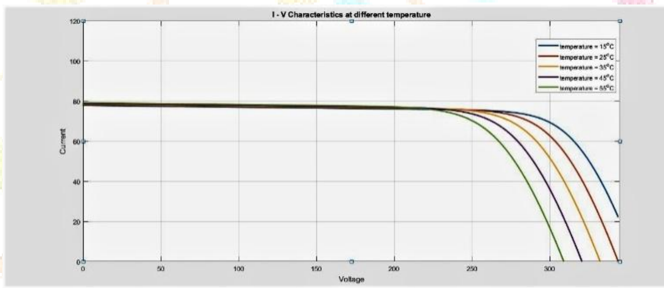


Fig. 4. I-V Characteristics of 20kW PV Array at different temperature levels

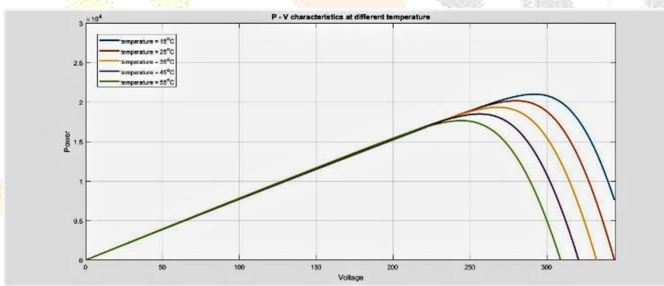


Fig. 5. P-V Characteristics of 20kW PV Array at different temperature levels

B. MAXIMUM POWER POINT TRACKING

Practically the solar efficiency is 30% to 40% with respect to incidence of solar insolation. To extract maximum power from solar photovoltaic system we use MPPT (maximum power point tracking). As per rule of maximum power transfer whenever load impedance matches source impedance. MPPT helps to improve the efficiency of PV Panel. So MPPT charge controller is used along with boost converter to control the duty cycle and get the voltage correspond to maximum power. So, we can get maximum power transfer from PV to LOAD just by varying the duty cycle of the boost converter. The Incremental Conductance method is used to reach the maximum power in P-V characteristic slope of PV Array. It works on the principle that MPP is achieved when the derivative of Photovoltaic array power with respect to its Voltage is equal to zero. The Incremental Conductance algorithm works on the following condition:

$\frac{dP}{dV} = 0$, at MPP

$\frac{dP}{dV} > 0$, left of MPP

$\frac{dP}{dV} < 0$, right of MPP

The algorithm starts by sampling the panel voltage and the current. It then calculates the incremental changes of the panel voltage and current by subtracting the values sampled at the previous MPPT cycle from the new ones. Here D indicate duty cycle and ΔD is the step change.

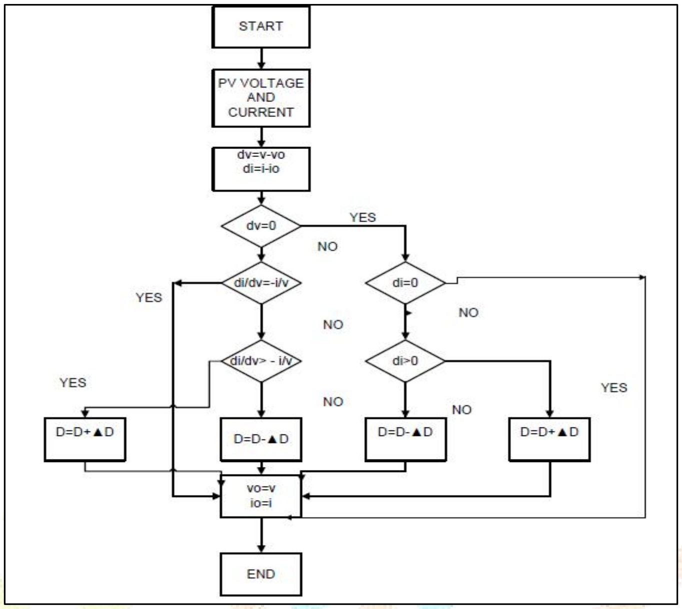


Fig. 6. Algorithm for Incremental Conductance

The main idea of incremental conductance is to be equated the incremental conductance and instantaneous conductance, so accordingly the duty cycle can be varied to get the operating voltage corresponding to maximum power.

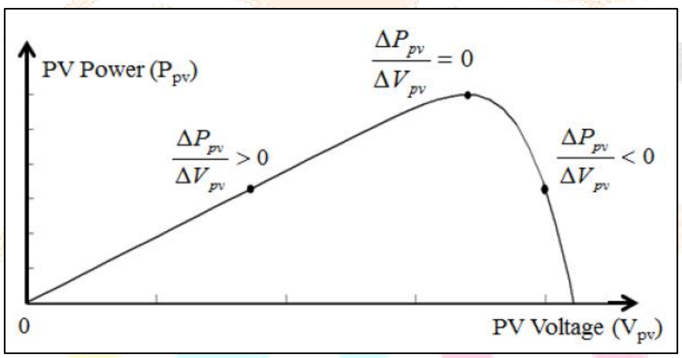


Fig. 7. Working Principle of Incremental Conductance method

Therefore,

$\frac{\Delta I}{\Delta V} = -\frac{I}{V}$, at MPP

$\frac{\Delta I}{\Delta V} \geq -\frac{I}{V}$, left of MPP

$\frac{\Delta I}{\Delta V} \leq -\frac{I}{V}$, right of MPP

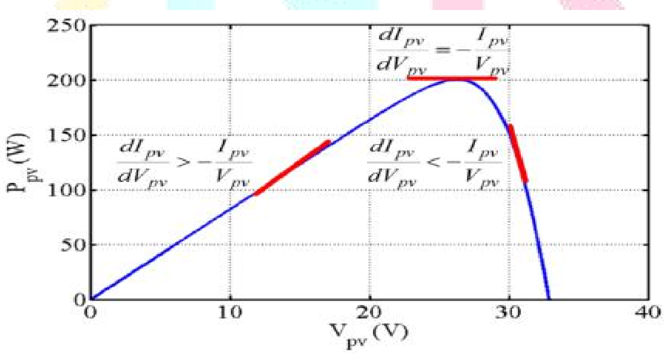


Figure 8. Incremental Conductance Algorithm graph

III. SIMULATION

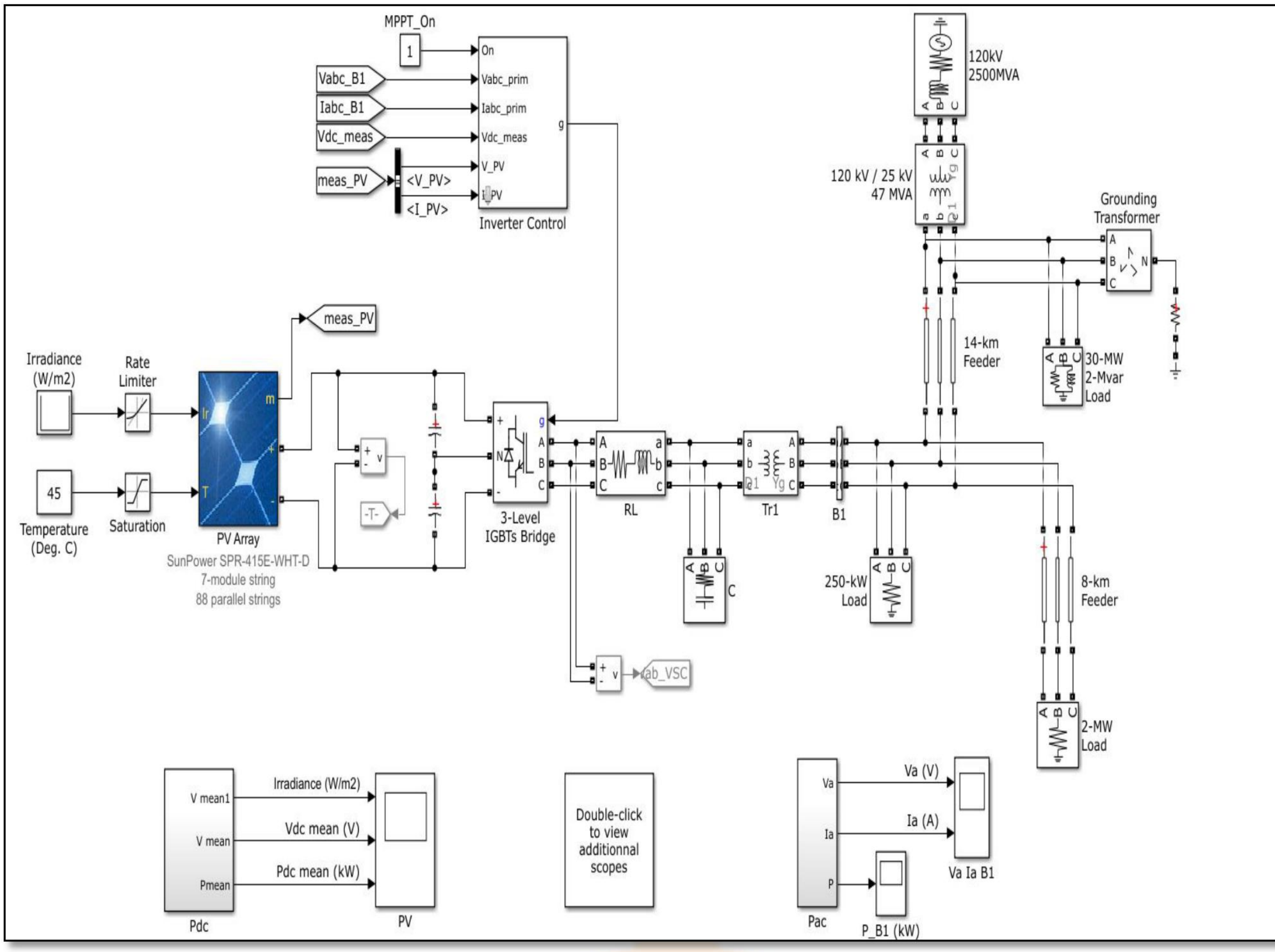


Fig 9 Solar PV array connected with Grid

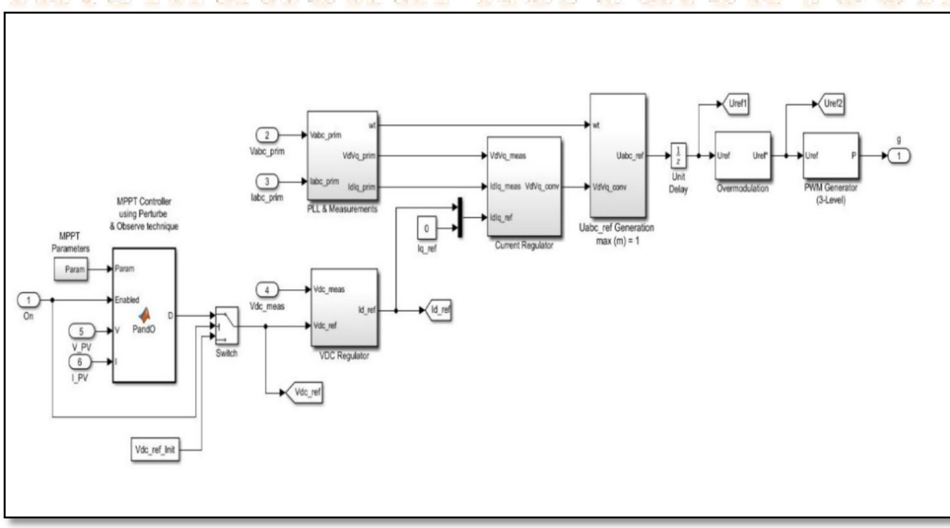


Fig 10 Matlab Simulation of Inverter control of proposed system

IV. RESULTS:-

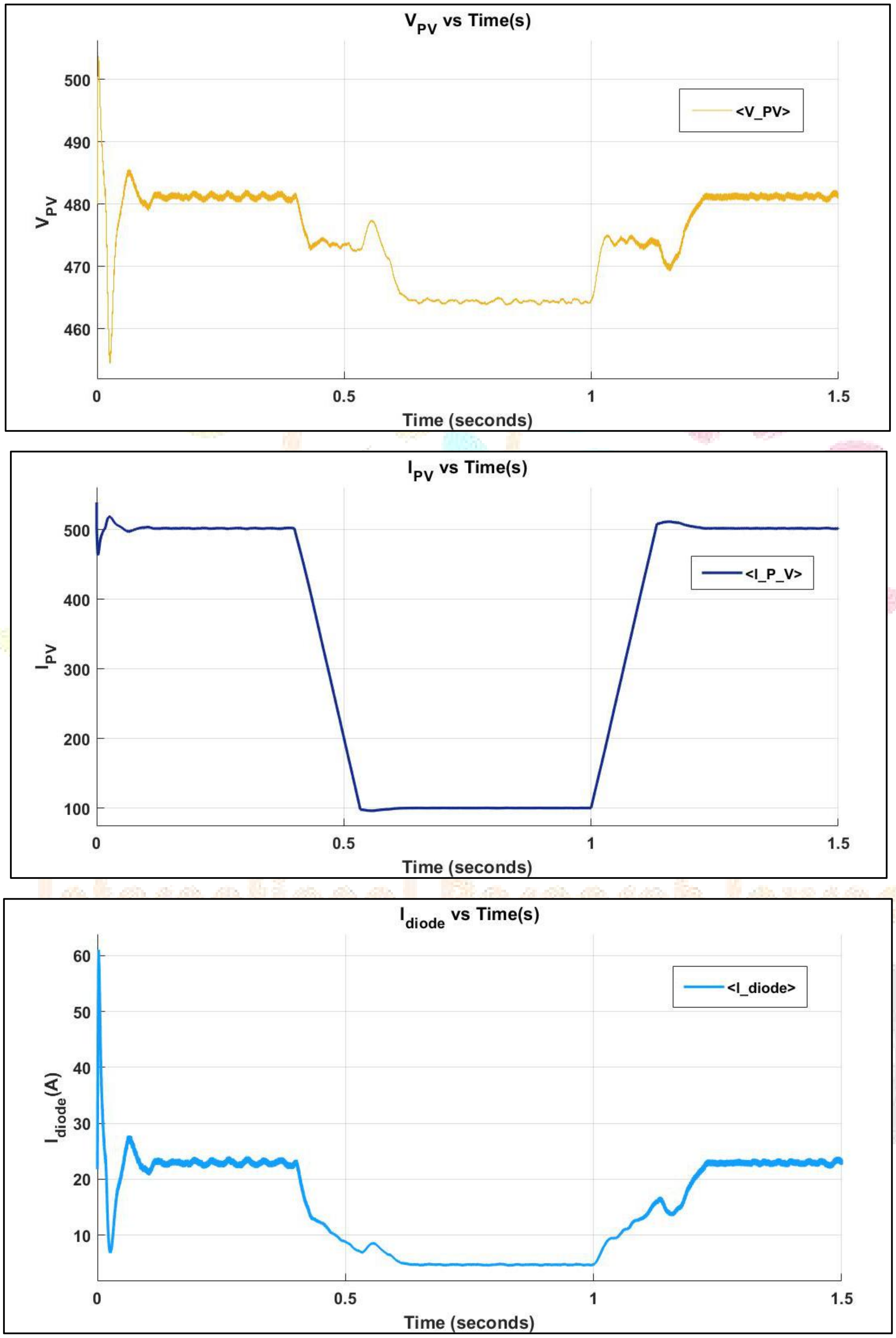


Figure 11 Solar PV array output parameters

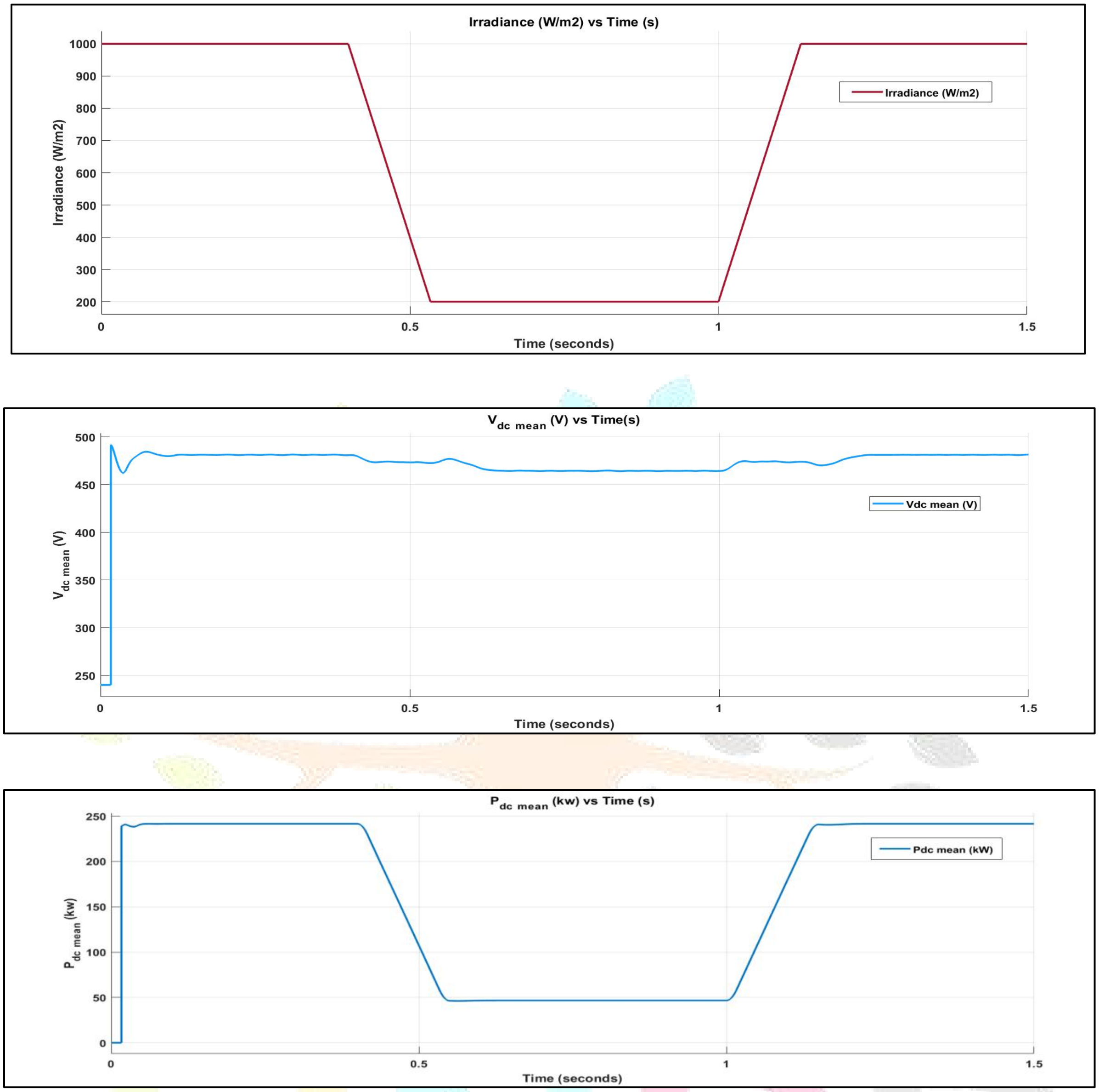


Figure 12 Solar Parameters

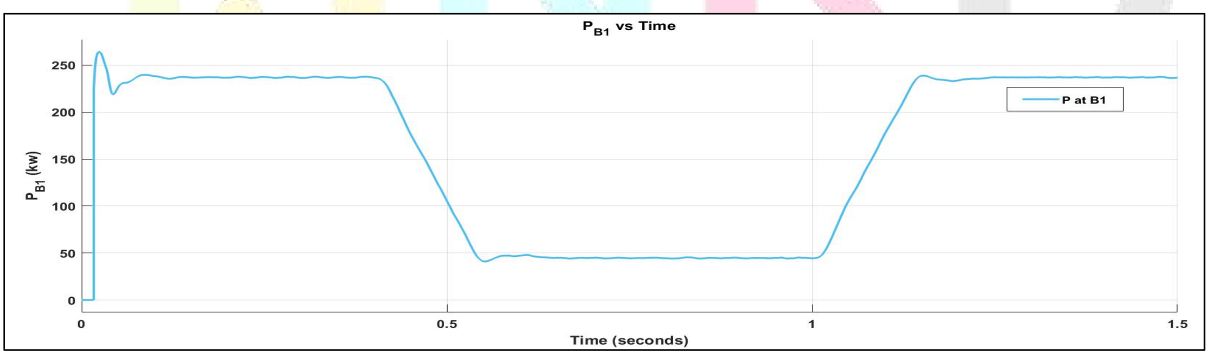
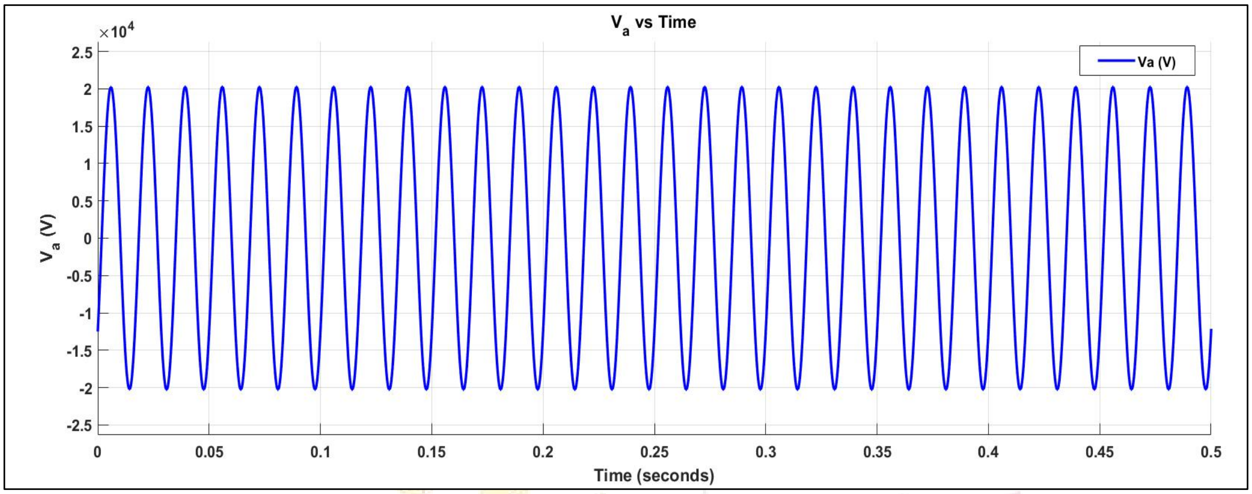


Figure 13 Power at B_1



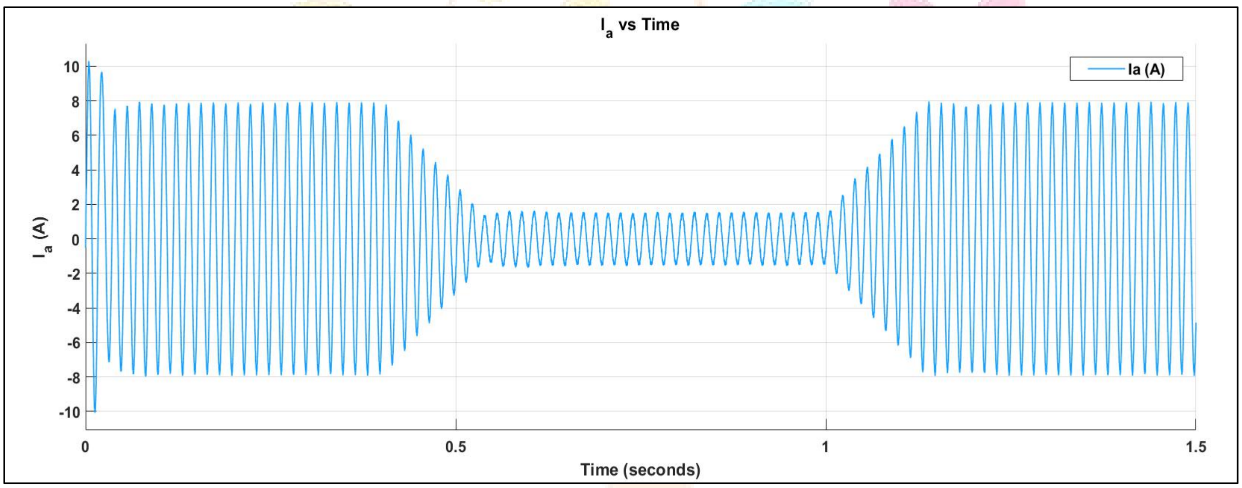


Figure 14 Voltage & Current at B_1

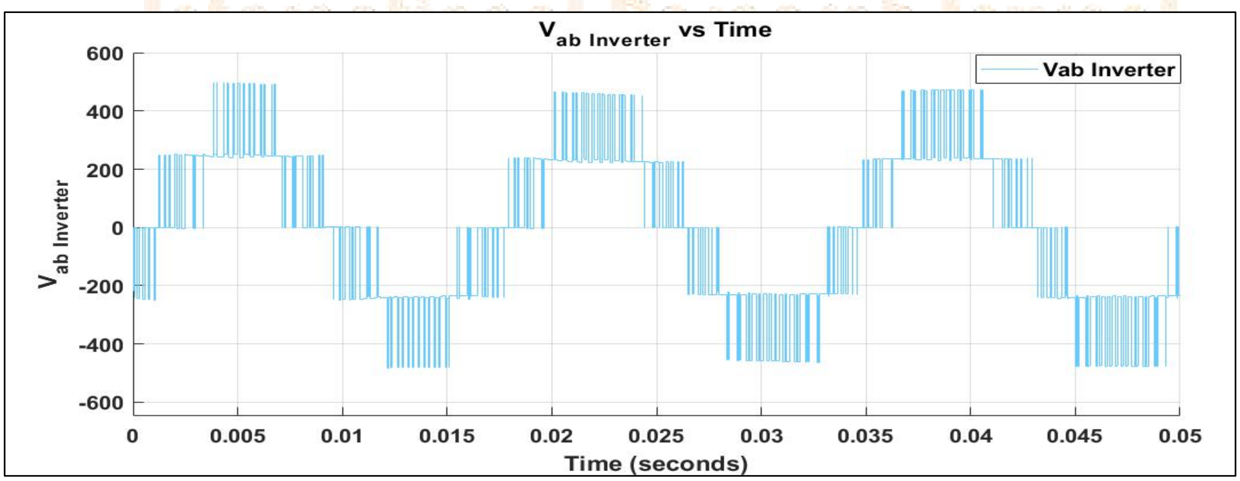


Figure 15 $V_{ab\ inverter}$ Output Voltage

V. MATLAB SIMULATION OF SOLAR PV WITH STATCOM

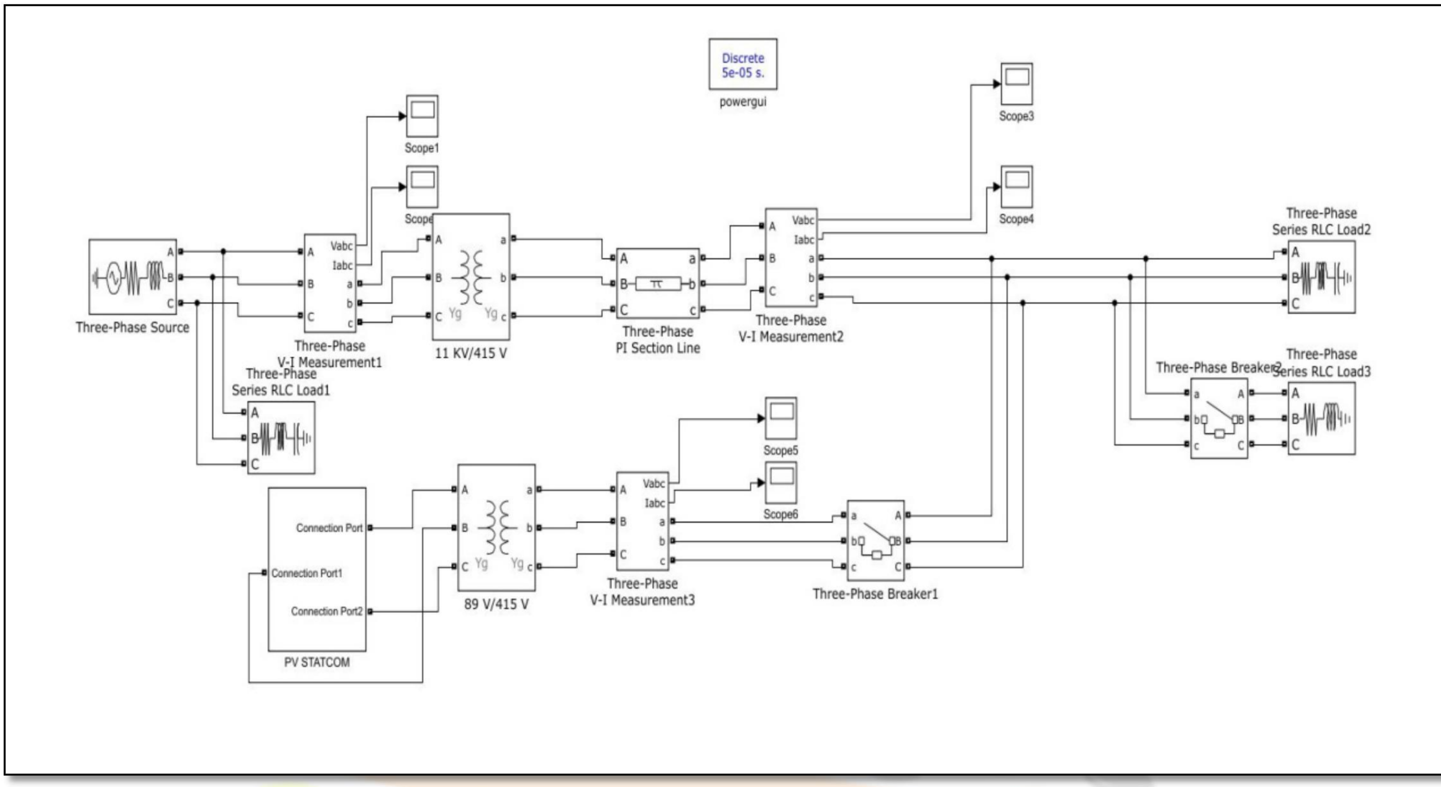


Fig 16- Solar PV system grid integration with STATCOM

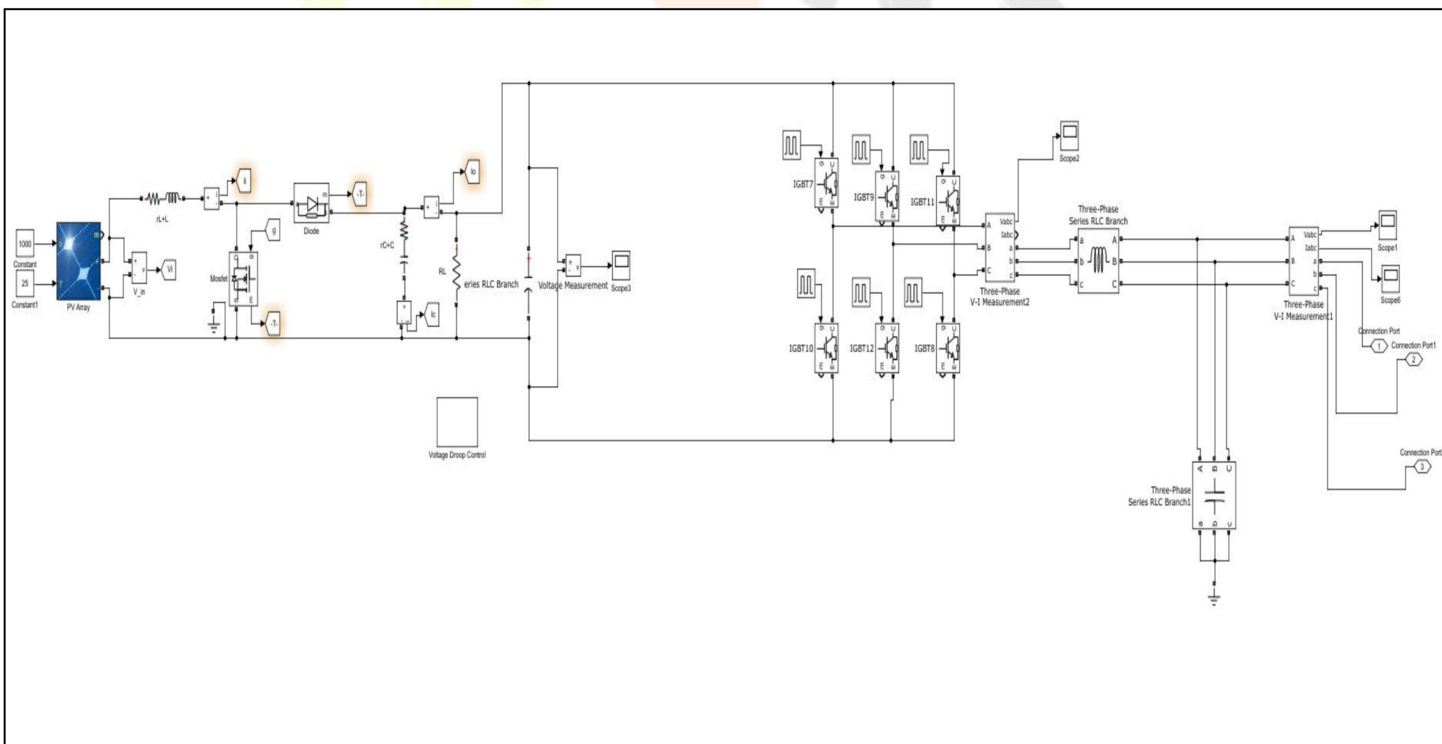


Fig 17- Solar PV with STATCOM subsystem

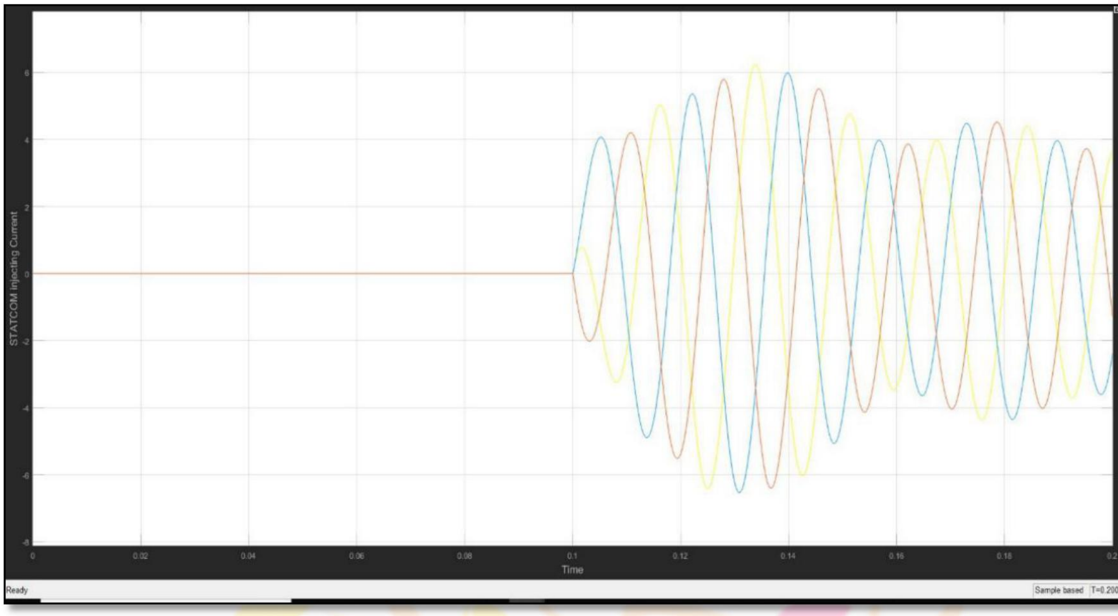


Fig 18- STATCOM injecting Current (During C.B operation of 0.1 to 0.2 sec)

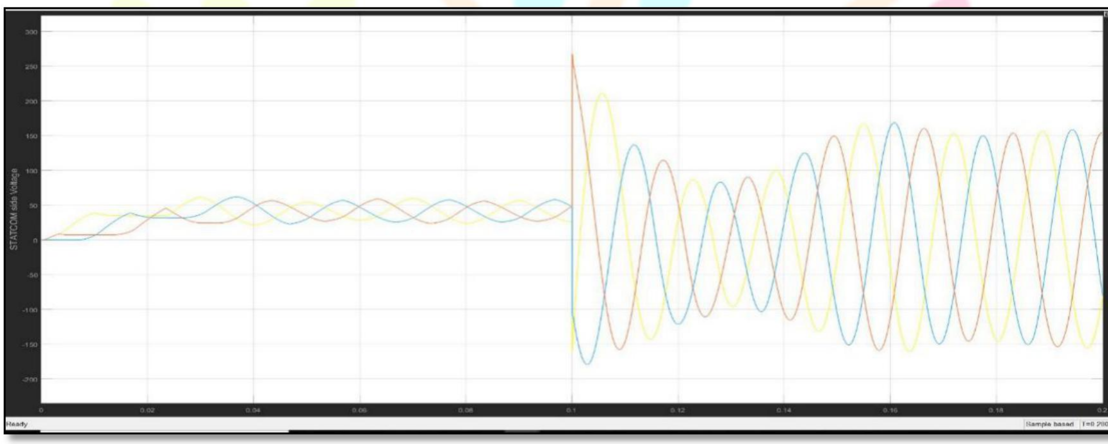


Fig 19- STATCOM voltage (During C.B operation of 0.1 to 0.2 sec)

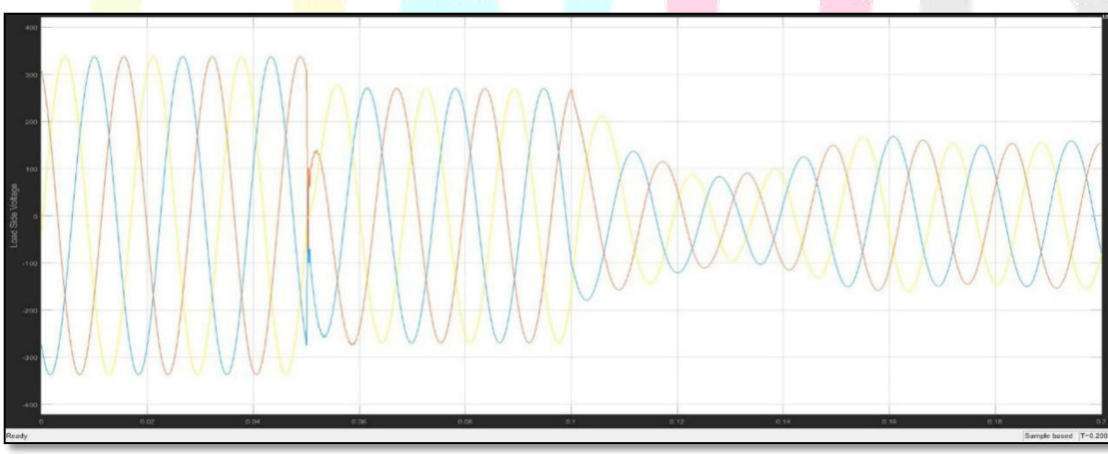


Fig 20- Load side voltage waveform

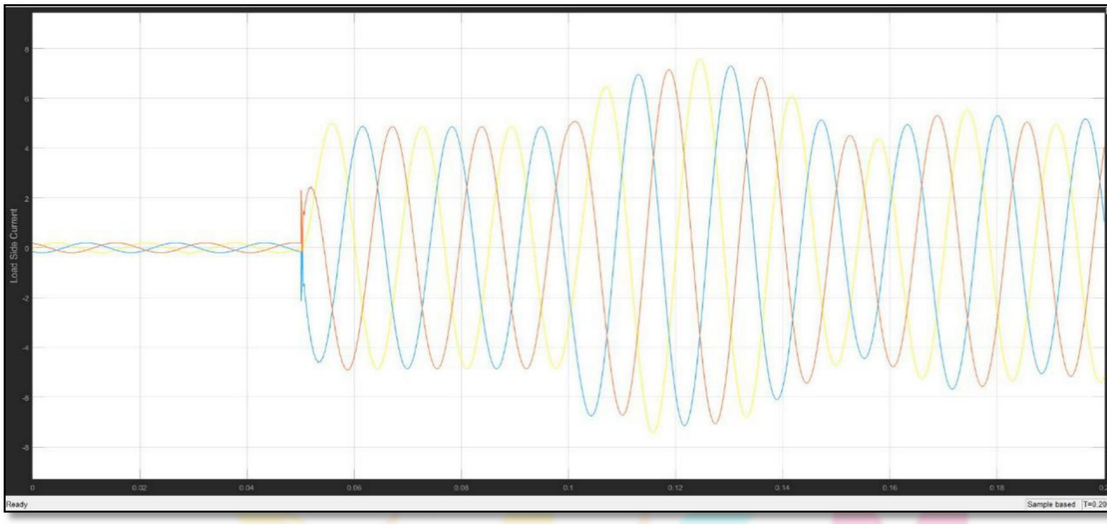


Fig 21- Load side Current waveform

VI. CONCLUSION

The PV system performance mainly varies as per the location, surrounding condition, temperature and irradiation. That's why prediction of irradiation is very important for the generation. There is lot of scope for the researchers in Maximum Power Point Tracking technique and how-to make it more efficient by increasing the tracking speed and accuracy for maximum power output from SPV system. One of biggest challenges in solar power conversion system is of storing the power generated. Also, the choice of location and size of PV system directly affect the performance and other operational problem. Partial shading of PV array is the biggest problem for all the MPPT Technique. Here the Multilevel inverter is very helpful and reduces the distortions. The Matlab Simulation of Solar PV array with STATCOM is done with different grid parameters control as well as the fault analysis is successfully done with the proposed system. The proposed system and analysis is done using Matlab-Simulink.

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