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Simulation of grid connected photovoltaic system

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ABSTRACT

Nowadays, we can see that the demand for energy increasing rapidly. To fulfil this demand we need to produce more and more energy. As compared to conventional energy sources we can use non-conventional energy sources which are a noiseless operation, easily available and pollution free for our environment. We can see the solar energy has a great potential to meet the energy demand acting as a standalone system or grid-connected mode, but the main problems with the solar system are irradiation level and temperature condition fluctuation and synchronization of AC power with the grid. In this project we can try to solve this problem by using MPPT for improving the efficiency, we should get maximum output under varying conditions which can be tracked continuously by a special technique called maximum power point tracking. In this project, we can make a MATLAB simulation of the solar PV system, along with i-v and p-v curves. Simulation of P&O algorithm with converters which is carried out with a grid-connected solar PV system and get maximum output under varying conditions.

Keywords— *PV system, MPPT, Boost converter, Inverter*

1. INTRODUCTION

This project proposes an up to date design and simulation of a grid-connected Photovoltaic system using MATLAB. This system cosiest Photovoltaic (PV) array, MPPT (Maximum power point tracking), a Boost converter (DC to DC Converter), Inverter (DC to AC Converter) etc. This system converts solar energy into Electricity. We can simulate this system by using MATLAB Software and study all the results.

1.1. Photovoltaic conversion system

Whenever the sun shines, the solar cells generate electricity. It is in the form of DC power. That DC power increase by using the Boost converter. The grid connects inverter converts the DC electricity produced by the solar panels into AC electricity. This can then be used to drive AC equipment.

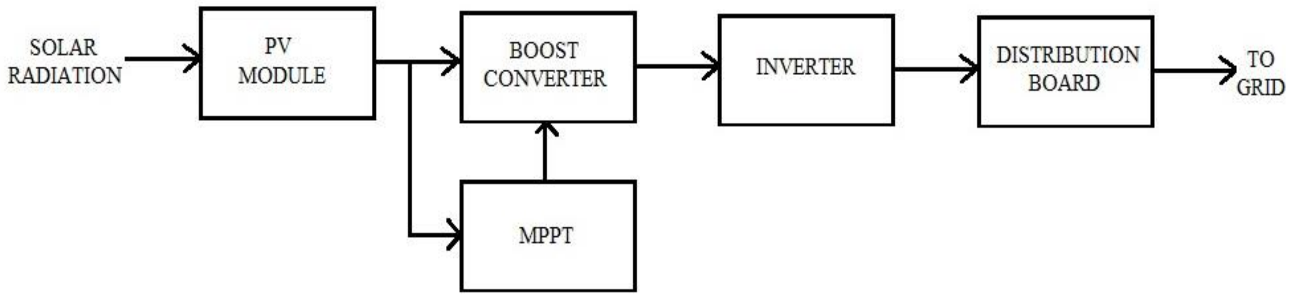

Fig. 1: Block diagram of the PV system

1.2. Modelling of Solar cell

The solar cell is the basic element of the PV system. It is made of semiconducting material. Basically silicon semiconducting materials are very popular in the system.

Standard test conditions for PV system are as follows:
Temperature (Tn) = $\mathbf{25^0}$C
Irradiance (Gn) = 1000 W/m^2

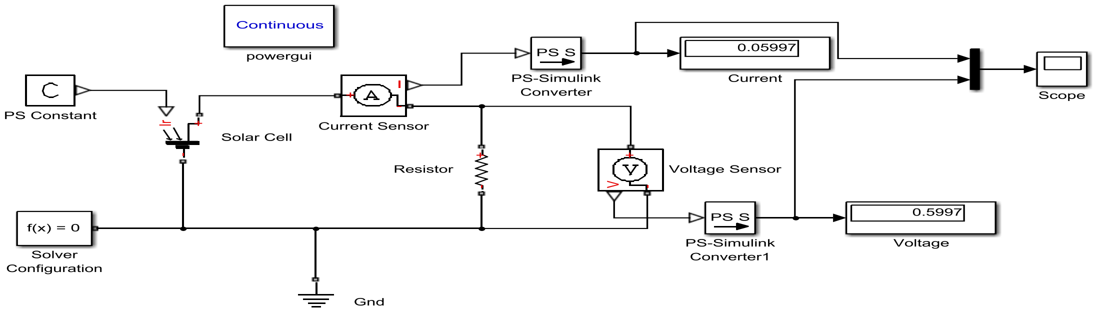

Fig. 2: Simulation of Solar cell

Table 1: Solar cell parameter

Parameters	Value
Short circuit current ($\mathbf{I}_{sc}$)	7.34 A
Open circuit voltage ($\mathbf{V}_{oc}$)	0.6 V
Irradiance (G)	1000 W/$\mathbf{m}^2$
The quality factor (N)	1.5
Series resistance ($\mathbf{R}_s$)	0 Ω
No of cell	1
Temperature	25℃

1.3. Modelling of PV Module

A solar cell generates a very low voltage (around 0.5V to 0.6 V) so that, Number of solar cells are connected in series (for high voltage) and in parallel (for high current) to form a PV module for desired output. Separate diodes may be needed to avoid reverse currents, in case of partial or total shading, and at night. The p-n junction's silicon cells may have adequate reverse current characteristics and these are not necessary. Solar cells become less efficient at higher temperatures and installers try to provide good ventilation behind solar panels. Some important equation which used in this modelling of PV module are given below:

Photocurrent: Iph=(Isc+(Ki*(T-298)))*G/1000,
Saturation current: Io=Irs*(T/Tn)^3*exp((q*Ego*(1/Tn-1/T))/(n*k))
Reverse saturation current: Irs=Isc/(exp(q*Voc)/(n*Ns*k*t))-1)
Shunt resistor current: Ish=(V+I*Rs)/Rsh
Output current: I=Iph-Io*(exp((V+I*Rs)*q/(n*K*T*Ns))-1)-Ish

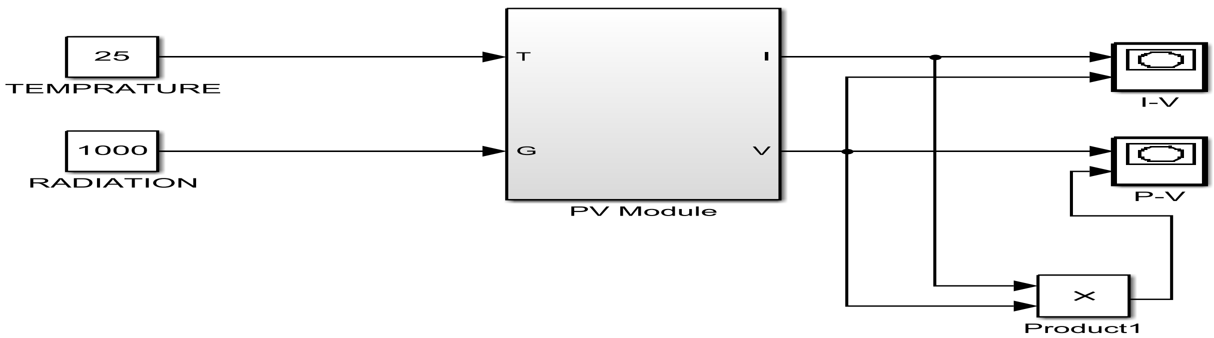

Fig. 3: Simulation of PV module

Table 2: PV module parameter

Parameters	Value
Short circuit current of the cell at 25°C and 1000 W/$\mathbf{m}^2$ radiation ($\mathbf{K}_i$)	0.0032
Electron charge (q)	1.6×$\mathbf{10}^{-19}$C
Boltzman constant (K)	1.38×$\mathbf{10}^{-23}$ $\frac{J}{K}$
Ideality factor of Diode (n)	1.3
The band gap of the semiconductor ($\mathbf{E}_{go}$)	1.1 eV
Series resistance (Rs)	0.22 Ω
Rated power	250 W
Shunt resistance (Rsh)	415 Ω
Normal temperature (Tn)	298.15 K
Open circuit Voltage (Voc)	37.41 V
Short circuit current (Isc)	8.61 A
Number of the series cell (Ns)	60

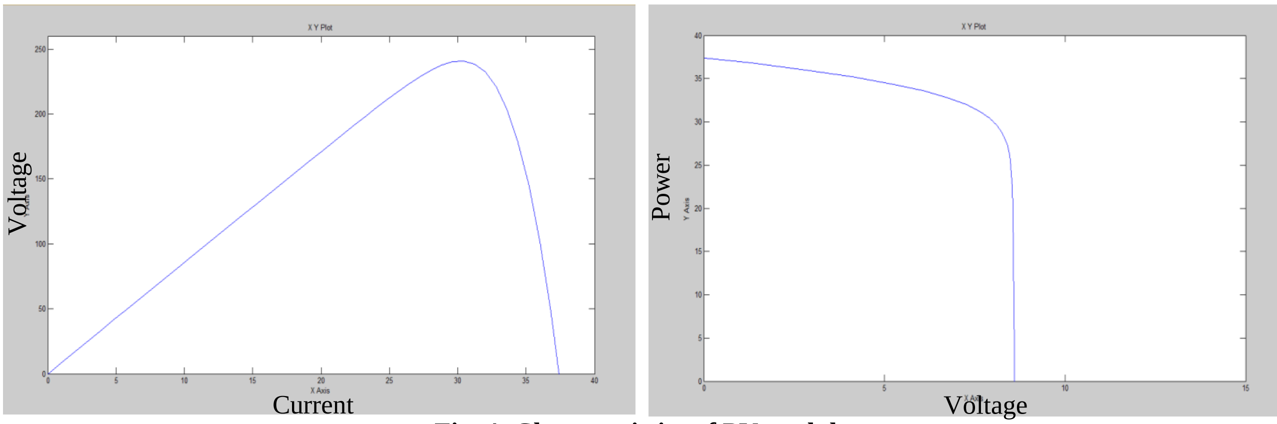

Fig. 4: Characteristics of PV module

1.4. MPPT (Maximum power point tracking)

In the case of PV modules, there is one operating point at any given point in time where maximum power can be drawn. We need to locate this point, Track this point and see that the operating point of the PV module is always at that pointed ear around this point. The process of doing this always trying to maintain the operating point of the PV panel at maximum power point is called Maximum Power Point Tracking.

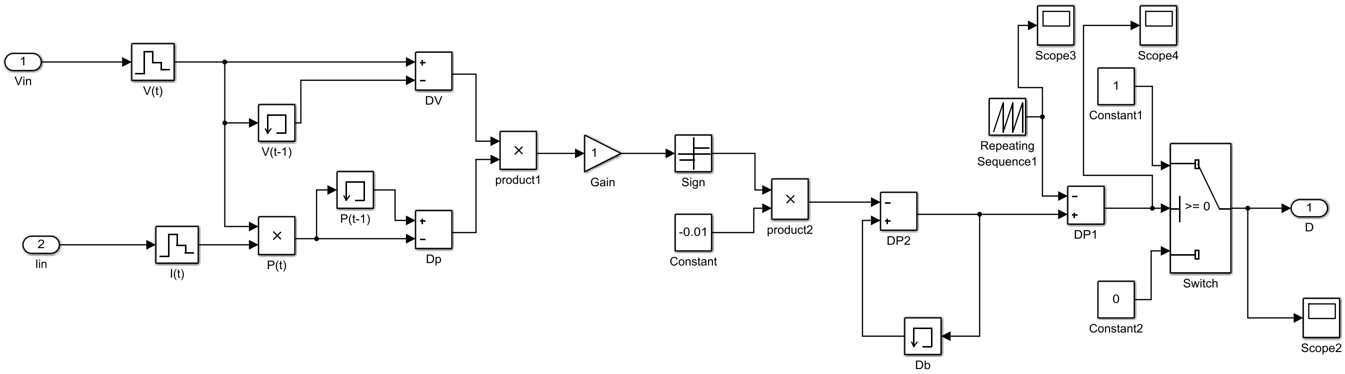

Fig. 5: Simulation of MPPT

1.5. Boost converter

The boost converter is DC to DC converter. BJT, IGBT or MOSFET used in this converter Boost converter increase the value of DC voltage so we can use this converter to increase the voltage of solar panel. In this, we use PWM technique.

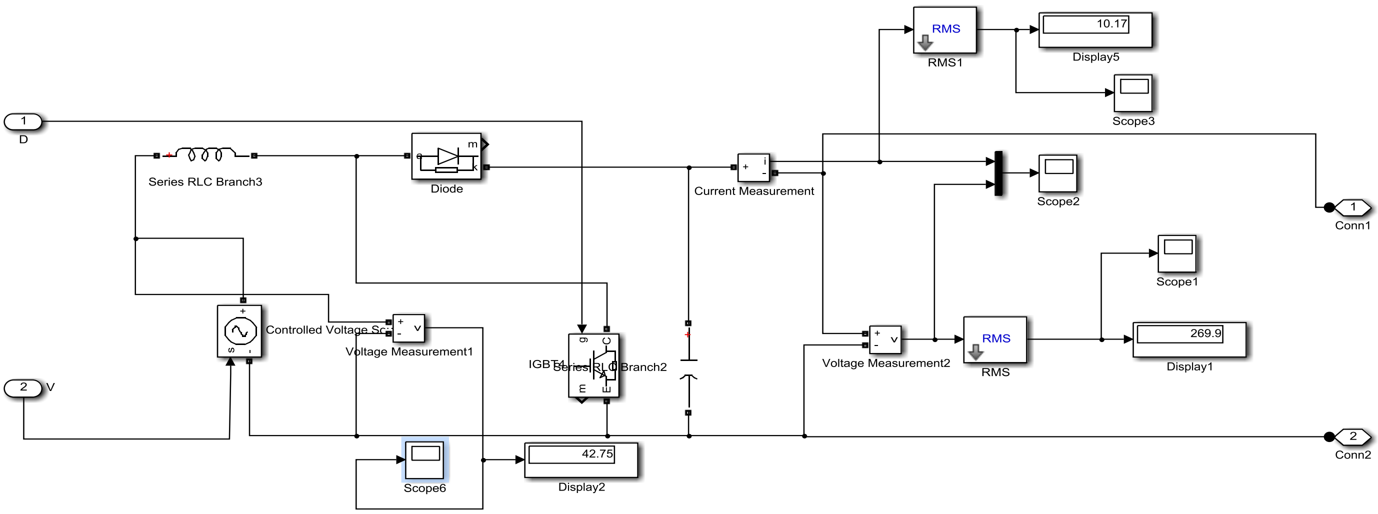

Fig. 6: Simulation of the Boost converter

1.6. Inverter with PWM technique

An inverter is basically a device that converts electrical energy of DC form into that of AC. The purpose of DC-AC inverter is to take DC power from a battery/DC source and converts it to AC. For example, the household inverter receives DC supply from 12V or 24V battery and then inverter converts it to 240V AC with a desirable frequency of 50Hz or 60Hz. The DC-AC inverters usually operate on Pulse Width Modulation (PWM) technique. The PWM is a very advanced and useful technique in which the width of the Gate pulses are controlled by various mechanisms.

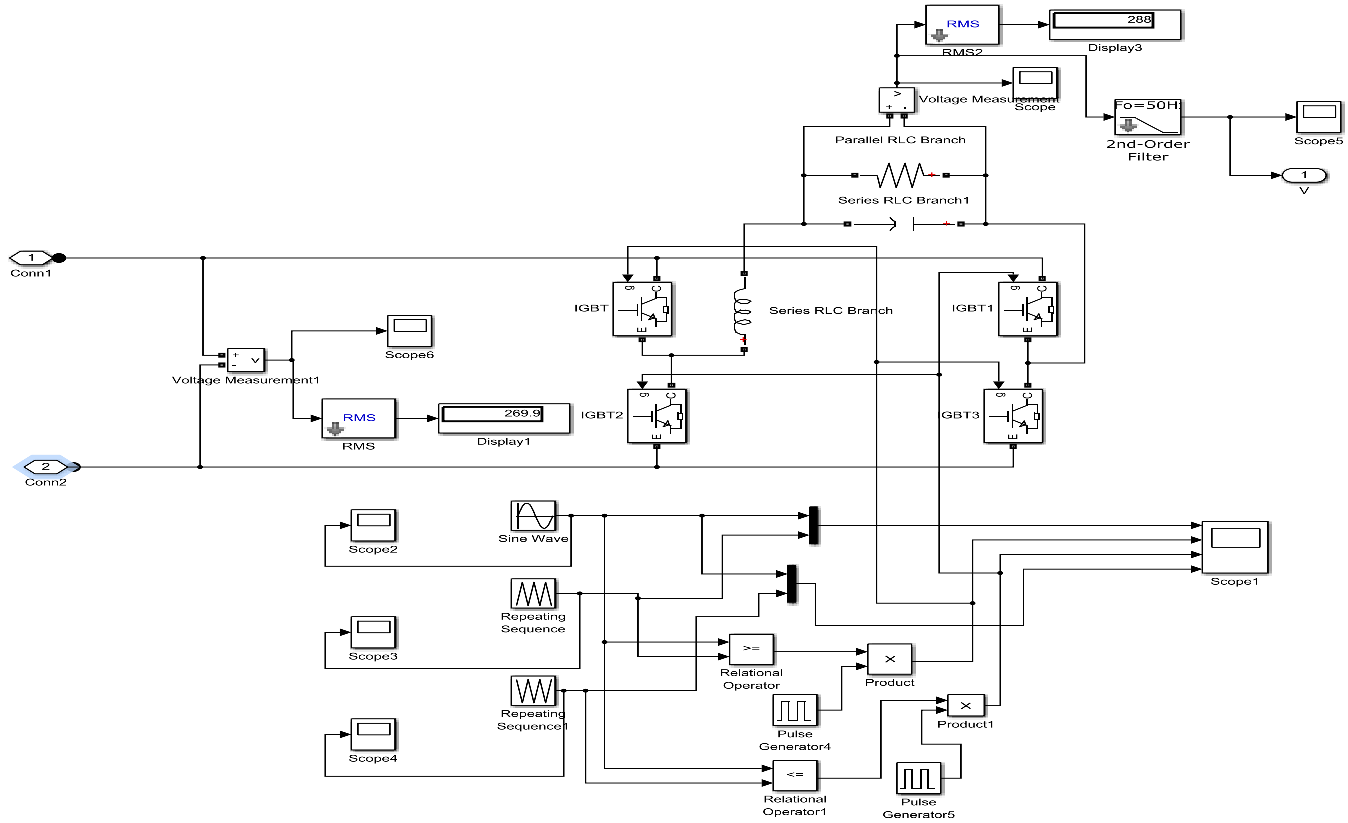

Fig. 7: Simulation of inverter

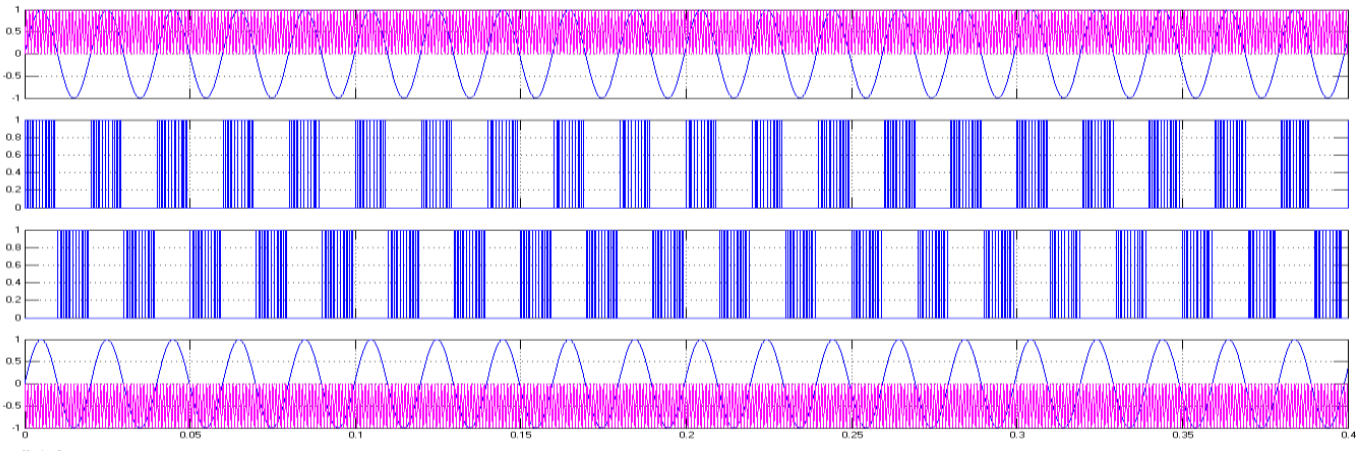

Fig. 8: Inverter PWM waveform

1.7. Simulation of a photovoltaic system (solar panel, MPPT, a boost converter, Inverter)

We connect solar panel, MPPT, Boost converter and Inverter and get the AC power as an Output. That Ac output we can inject to the grid.

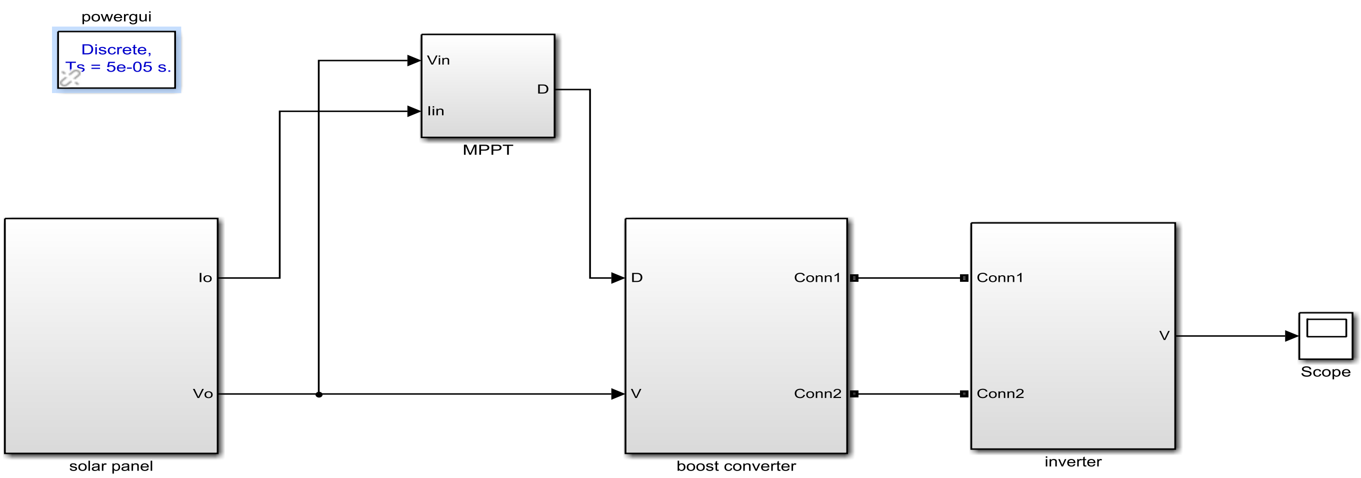

Fig. 9: Simulation photovoltaic system

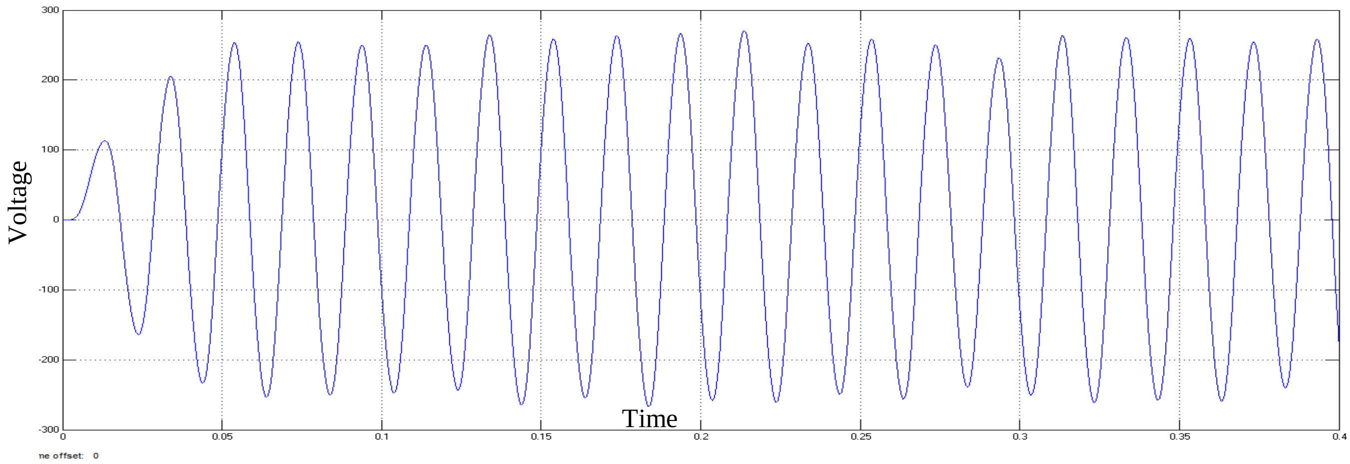

Fig. 10: Output waveform of the photovoltaic system

2. CONCLUSION

In this paper, we deeply study the whole photovoltaic system. Also, we can know and understand the components of the photovoltaic system like a solar panel, MPPT, a Boost converter, inverter etc. Simulation of each and every component of the photovoltaic system we can deeply understand by referring this paper. These simulation results prove the performance and the efficiency of the developed theoretical research.

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