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# INVESTIGATION OF POWER PERFORMANCE OF A PV MODULE WITH BOOST CONVERTER USING MATLAB SIMULATION

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## ABSTRACT

*Sustainable energy is the unconventional way that helps us to produce unlimited energy for ourselves so that we can use it without harming the environment. Of all renewable sources, Solar energy source is only one unlimited source that is environment friendly and has zero greenhouse effect. The solar cell is one way to collect solar photon energy and convert this energy into electrical energy that has already been invented. In this paper, we are trying to boost the solar output voltage by using the boost converter circuit. This paper proposes to boost the low voltage of the photovoltaic array by using the boost converter circuit and gain a higher output voltage. This paper investigates the modeling and simulating the photovoltaic module using MATLAB simulation along with the boost converter that will give the 95 % efficiency from the previous model. When investigating the maximum Power Point Tracking (MPPT) algorithms have improved for better efficiency.*

**Keywords:** V, Module, MPPT**,** Voltage, Power.

## INTRODUCTION

In this period of time with the extended population, economic and industrial enhancement the uninterrupted assets of organic combustible assets of usual gas and carbonize it, Mines, hydro plants in the river are very much influencing nature with worldwide warming and natural catastrophe (Ali et al., 2014). Electricity is one of the boundless discoveries for humans. We infiltrated to modernize civilization. Electricity is the most essential and required need for ours.

Modification of Solar energy converts into electricity is not only the period of electricity but also deforms the contamination for the carbonizing of fossil fuels. Solar Photovoltaic network is an extendable source with zero fuel quotation, insignificant maintenance, low uproar & environment-friendly but highly instatement cost and low energy transmutation efficiency (Marrekchi et. al., 2015). Solar energy is radiation-free with continuous supply across the day by the sun radiation. The solar panel output power banks on solar irradiance, temperature, and the solar photovoltaic module system which we are utilizing. The solar photon energy adjusted system made of solar photovoltaic converter control unit to modulate the power take out from solar photovoltaic energy. Solar Photovoltaic cells have inconsistency discriminating. Its capacity is very small & the DC power output differs with solar radiation and global temperature. The current voltage (I-V) and power voltage (P-V) countenance of a photovoltaic crossing point are non-linear. It points out that there is only one point where the module departs power. This point also modulates with the switch in sunstroke and heat (Aguillon-Garcia & Bañuelos-Sanchez, 2015).

The extraordinary load, also the source of electrical resistance comparable is completed with the support of a DC to DC converter. The duty cycle of the boost converter is finishing with the logic algorithm (Saravanan & Babu, 2017).

## MODELING OF SOLAR CELL AND ITS CHARACTERISTICS

The modeling of a solar cell is used in both current sources and also in the voltage sources. The series connection and parallel connection combining are feasible in solar cells, but the solar cell characteristic is replaceable to the current source. The diode modeling is given below (Prabaharan & Palanisamy, 2016). The modeling of the solar cell based on the current as given in the below equation 1 with figure 1

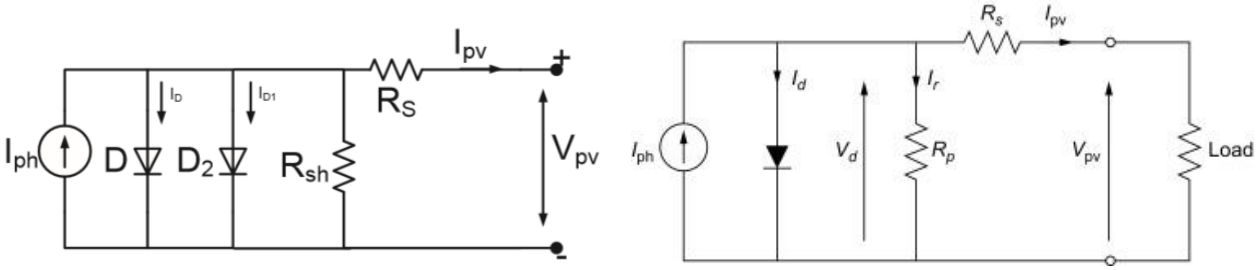


Figure 1. Equivalent Circuit of Photovoltaic Cell

The equation is

$$I_{PV} = I_{Ph} - I_S\left[exp\left\{\frac{V_{PV}+I_{PV}R_S}{N\times V_T}\right\}\right] - I_{s2}\left[exp\left\{\frac{V_{PV}+I_{PV}R_S}{N_2\times V_T}\right\}\right] - \frac{V_{PV}+I_{Ph}R_S}{R_{Sh}} \quad \ldots\ldots 1$$

Here,

$I_{pv}$= cell output current
$I_{ph}$= photon generated current
$V_{pv}$ = cell's output voltage
$R_s$= Series resistance of cell

$R_{sh}$ = shunt resistance of cell
$V_T$ = thermal voltage
N = diode emission coefficient or quality factor of first diode
$N_2$= diode emission coefficient or quality factor of second diode

This is the block parameter equation of solar cell in MATLAB

Where both current $I_s$ and$I_{s_2}$ are the diode saturation currents, again $V_t$ is the thermal voltage, N and $N_2$ are the quality factors known as diode emission coefficients and $I_{ph}$ is expressing photo generated current (Kabalo, 2012).

The mask gives the scope to decrease the complexity of the models. The amorphous cells are designed for variation of quality factor from 1 to 2 (Verma, 2015a). $I_r$ is the solar irradiance (photo intensity) expressed in $wm^{-2}$. The light generated current $I_{ph}$ is provided by $I_r \times \frac{I_{ph_0}}{I_{r_0}}$ where $I_{ph_0}$ is the light produced current for irradiance$I_{r_0}$

A multiple diode design is a betterment of the single diode model. This model is stripped to the combined effect inside solar PV cells by acquainting one more diode design parallel to the current (Verma et al., 2015b).

In the editor by programming we find the V-I Characteristics curve and PV Characteristics curve which is given below in the figure 2 and 3

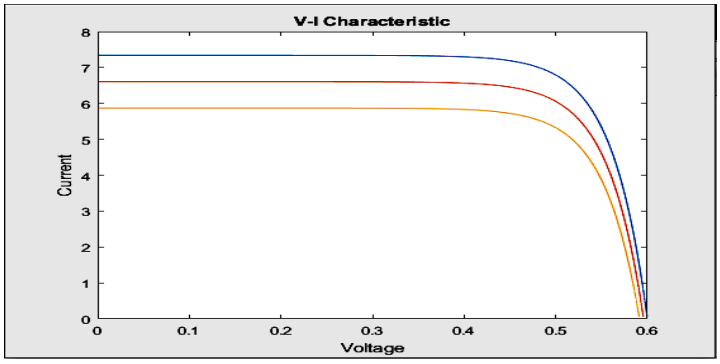


Figure 2. V-I Characteristics curve of Solarcell

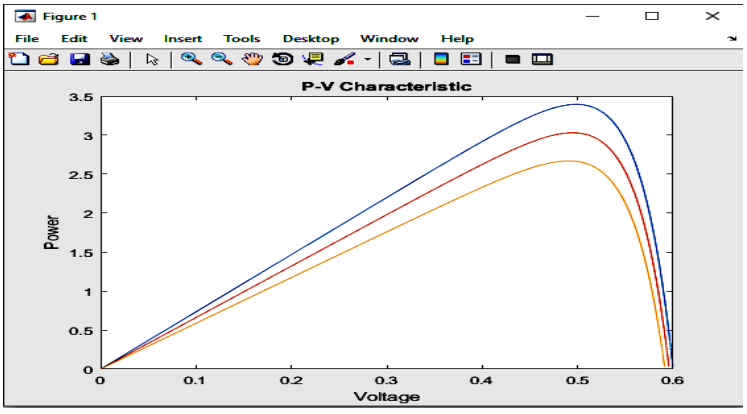


Figure 3. P-V Characteristics curve of Solar cell

From the figure, we can see that there is a common point curve in the P-V curve and V -I curve, where we are getting utmost power, also finding extreme power from the cell, the function voltage and current should be equal to the maximum Power (Kumar et al., 2014).

## BOOST CONVERTER WITH PID CONTROLLER

A DC- DC boost converter is an electronic circuit that works as a converter from direct current (DC) to low input voltage level or to high output voltage. It's also known as step up converter which is used in regulated switching mode of dc power sources and dc motor applications. Basically, switch-mode DC to DC boost converters are used to convert the unregulated dc input into a controlled dc output at the desired voltage level (Dash et al., 2014).

The main part of MPPT hardware is a DC to DC boost converter as a switching mode. MPPT can be used with the converter for different purposes like controlling the input voltage at the PV MPPT and facilitate load matching for transfer of maximum power to the load (Dash et al., 2014).

Boost converter circuit diagram are given below in figure 4.

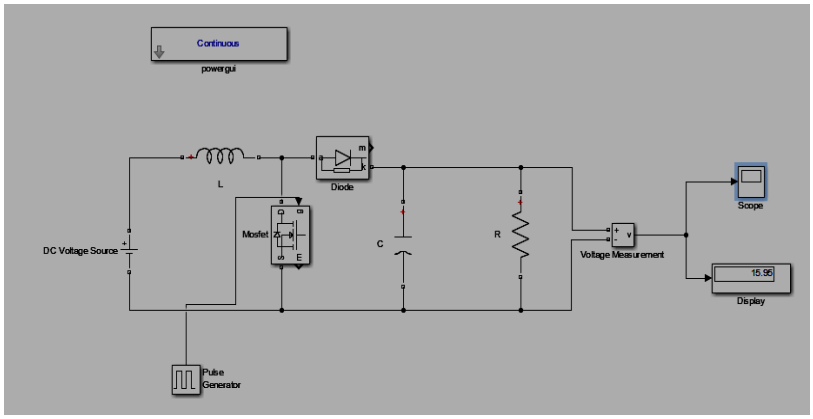


Figure 4. Boost converter Circuit diagram in MATLAB

Where DC input is 60V and Pulse generation is 70 percent output is around 198.8V which is shown in the figure 5.

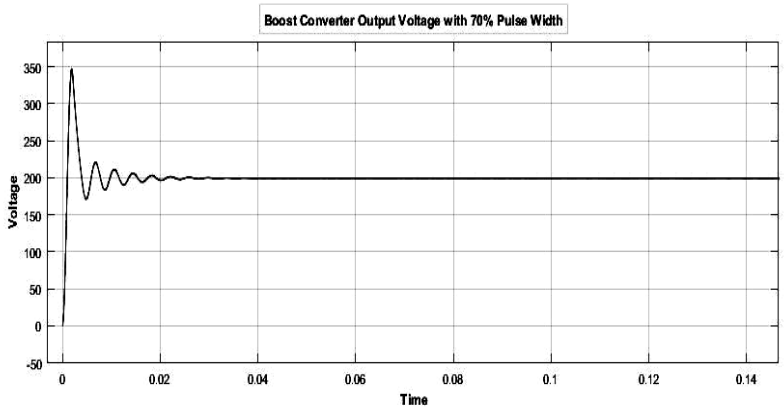


Figure 5. Boost converter output voltage in 70% Pulse width

When DC input is 5V and Pulse generation is 80 percent output is around 298.8 V which is shown in the figure 6.

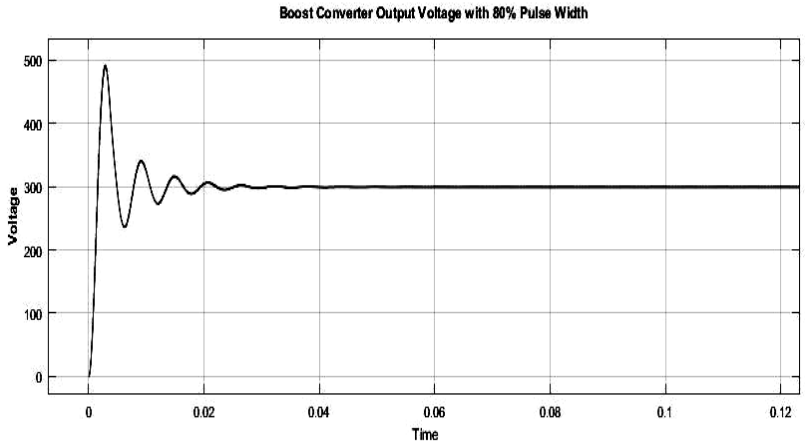


Figure 6. Boost converter output voltage in 80% Pulse width

This is a step-up DC-DC shift converter. By the help of boost converter, the lower input-voltage level can be raised up to a usable high output voltage, substantively exponential like with a boost converter

Table 1. Boost converter configuration

| **Input Voltage** | **Inductor** | **Pulse Generator** | **Pulse Width** | **Capacitor** | **Resistor** |
|---|---|---|---|---|---|
| 60 V | $1 \times 10^{-3}$ H | $^{1}/_{25000}$ | 70 % - 80 % | $33 \times 10^{-6}$ F | 100 Ω |

Table 2. Pulse Wide variation

| Input | Pulse Width | Output |
|---|---|---|
| 61.30 V | 70 % | 198.8 V |
| 61.30 V | 80 % | 298.8 V |

In this diagram we clearly see that the output voltage is not actually fixed, to solve this problem we are trying to update this boost converter with PID controller those are shown in figure 9 and attached with the boost converter circuit in figure 10.

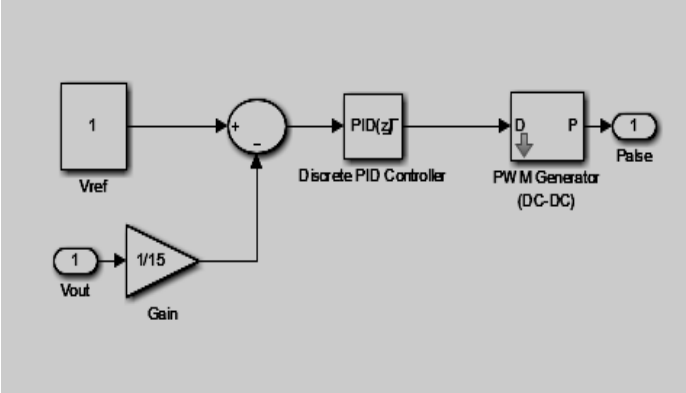


Figure 7. PID Controller

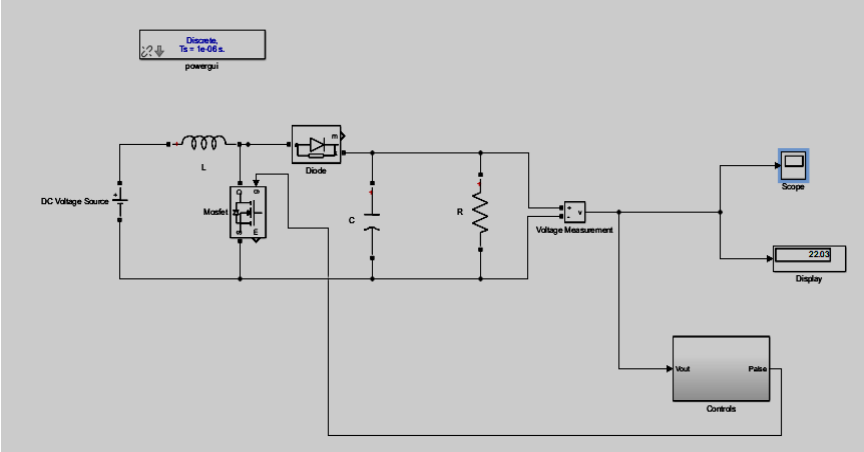


Figure 8. Boost converter with PID Controller

Table 3. Boost converter with PID configuration

| Input | PID Gain | Switching Frequency | Sample Time(Sec) | Output |
|---|---|---|---|---|
| 61.30 V | $^{1}/_{15}$ | 25000 Hz | $1 \times 10^{-6}$ | 69.29 V |
| 61.30 V | $^{1}/_{20}$ | 25000 Hz | $1 \times 10^{-6}$ | 69.29 V |
| 61.30 V | $^{1}/_{25}$ | 25000 Hz | $1 \times 10^{-6}$ | 69.29 V |

Then the output gain is shown in figure 11, 12, 13.

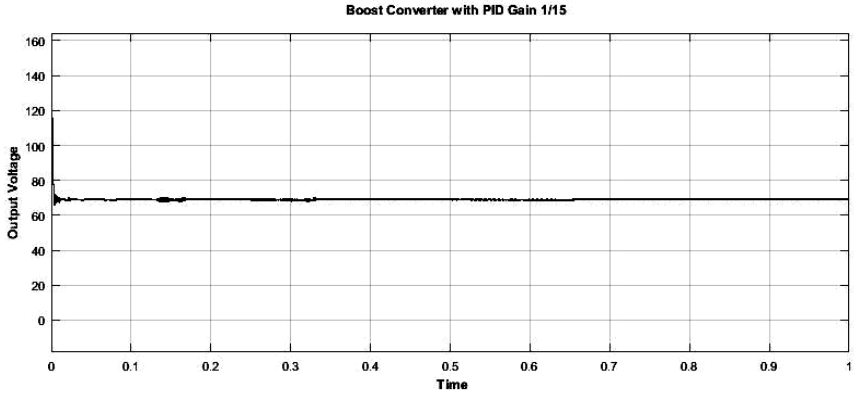


Figure 9. Output voltage in 1/15 gain

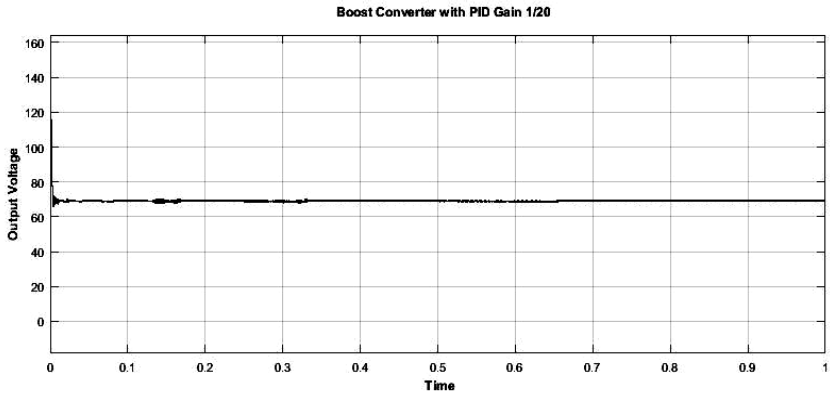


Figure 10. Output voltage in 1/20 gain

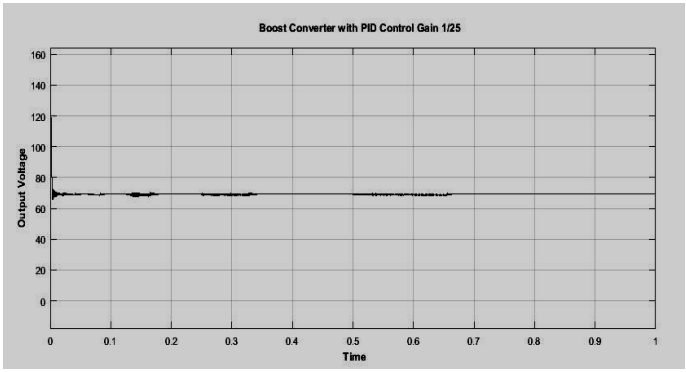


Figure 11. Output voltage in 1/20 gain

## MPPT ALGORITHM

MPPT is also known as Maximum Power Point Track which is a large-speed photovoltaic pulse charger used in battery of lead-acid controlled by an incremental-conductance maximum power point tracking process. For promoting the efficiency of solar modules' performance the researchers take great concern on the solar photovoltaic system. The non-linear property of solar cell characteristics provides a great scope to track the maximum power from the PV module using some modern techniques such as maximum power point tracking developed by the scientists. Thus,

Maximum Power Point Tracking (MPPT) techniques were largely utilized for this issue (Verma et al., 2015b). Lots of MPPT techniques have been invented recently but still most commercial systems utilize perturb & observe MPPT technique because of its simplicity. Researchers have tried to make an algorithm program in MATLAB editor to upgrade the boost converter and to find the better efficiency and output.

Here is the program algorithm

```
function duty = MPPT_algorithm(vpv,ipv,delta)
duty_init = 0.1
duty_min=0;
duty_max=0.85;
persistent VoldPolddduty_old;
if isempty(Vold);
Vold=0;
Pold=0;
duty_old=duty_init;
end
P= vpv*ipv;
dV= vpv - Vold;
dP= P - Pold;
if dP ~= 0 &&vpv>30
if dP< 0
if dV< 0
duty = duty_old - delta;
else
duty = duty_old + delta;
end
else
if dV< 0
duty = duty_old + delta;
else
duty = duty_old - delta;
end
end
else
duty = duty_old;
end
if duty >= duty_max
duty=duty_max;
elseif duty<duty_min
duty=duty_min;
end
duty_old=duty;
Vold=vpv;
Pold=P;
```

## MODELING OF SOLAR PHOTOVOLTAIC PANELWITH BOOST CONVERTER USING OF MPPT ALGORITHM

This simulation is experimented with different irradiation because in day light all time the sun radiation is not constant that's why we take the value 0 0 300 300 500 500 1000 1000 500 500 0 0 with different time zones. We are using two parallel photovoltaic array cell which is connected with the boost converter and MPPT algorithm block in figure 14.

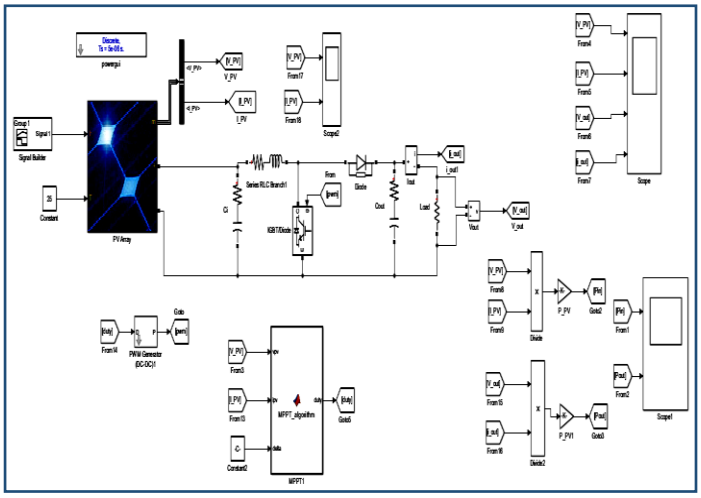

Figure 12. Simulink model of PV Panel with boost converter by using MPPT

### PV Mathematical Terms of PV Module

To observe the output power performance of the solar module under several atmospheric situations, it is needed to determine IV and PV characteristics with the control of PS constants. The solar PV characteristics curves are provided in this paper. Here NREL System Advisor Model (Jan. 2014) (Dash et al., 2014) is used in this paper.

Table 4. Power Calculation of PV Array

| PS Constant | Voltage | Current | Power |
|---|---|---|---|
| 800 | 61.30 V | 5.972 A | 366.08 W |
| 900 | 61.30 V | 11.86 A | 727.018 W |
| 1000 | 61.30 V | 15.45 A | 947.085 W |

Table 5. PV Panel Specification

**Model: 1 Sol tech 1 STH-230-P**

| Constant | Values | Constant | Values |
|---|---|---|---|
| Power at STC | 230W | Voltage at Max. Power | 29.9 V |
| Power at PTC | 203W | Current at Max. Power | 7.65 A |
| Power density at STC | 146.5 $\boldsymbol{Wm^{-2}}$ | Open Circuit Voltage | 37.1 V |
| Power density at PTC | 129.4 $\boldsymbol{Wm^{-2}}$ | Short Circuit Current | 8.18 A |

**Irradiance value of PV**
**Taking The value are 400, 800, 1000**

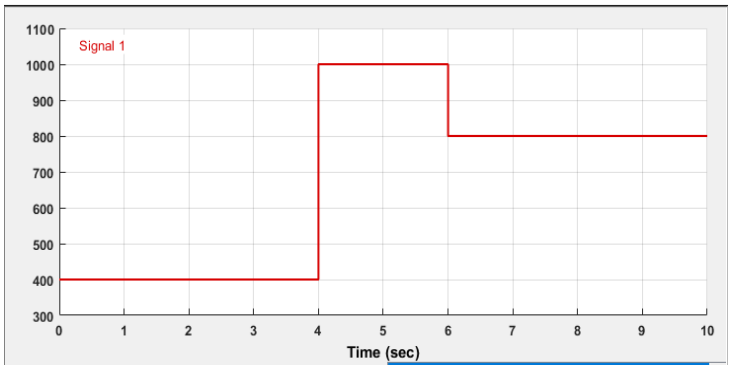


Figure 13. Irradiation Curve

Table 6. PV array Input and output calculation

| Irradiation | Boost Converter Input | | | Boost converter Output | | |
|---|---|---|---|---|---|---|
| | Voltage | Current | Power | Voltage | Current | Power |
| 400 | 61.30 V | 5.972 A | 366.08 W | 82.75 V | 4.42 A | 366.08 W |
| 800 | 61.30 V | 11.86 A | 727.018 W | 116.4 V | 6.24 A | 727.018 W |
| 1000 | 61.30 V | 15.45 A | 947.085 W | 128.4 V | 7.37 A | 947.085 W |

Boost Converter Input Voltage and current with 61.30 V and 5.972 A for 400, 800, 1000 Irradiation

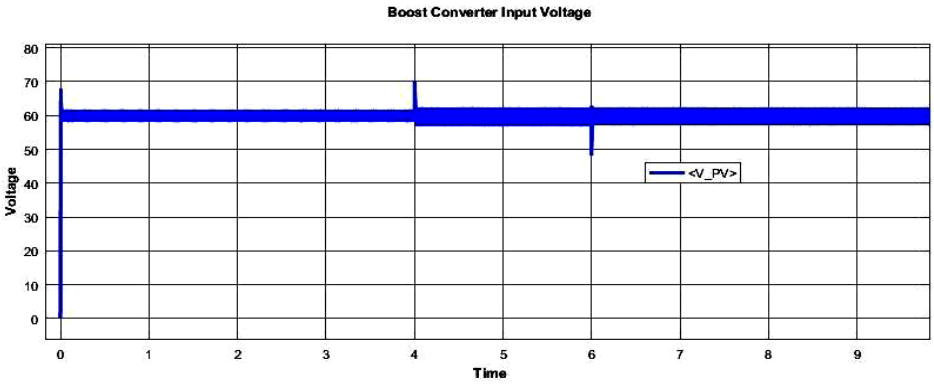


Figure 14. Boost Converter Input Voltage

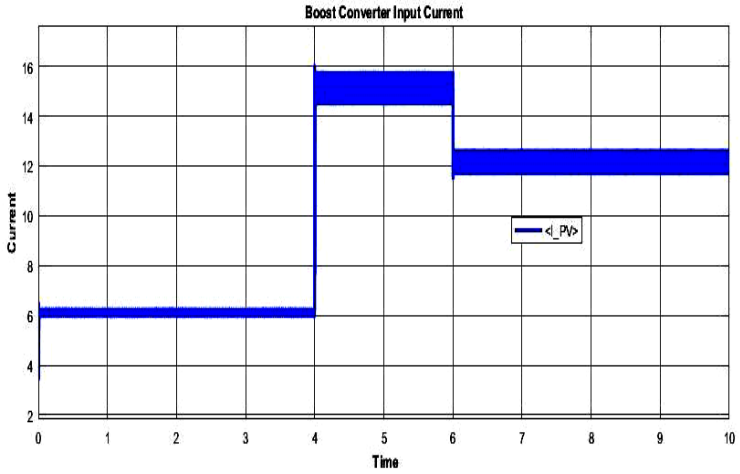


Figure 15. Boost Converter Input Current

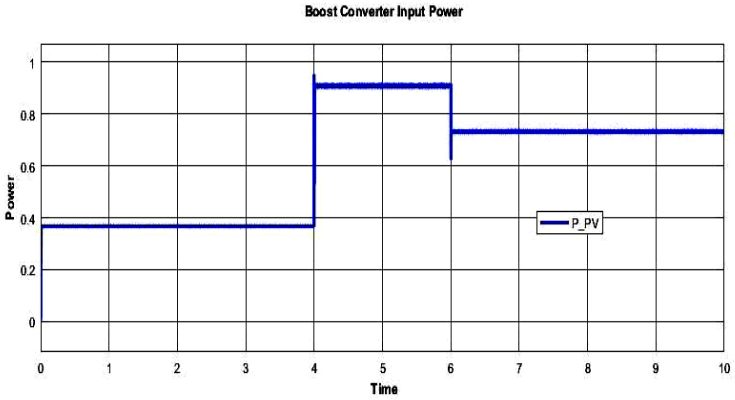


Figure 16. Boost Converter Input Power

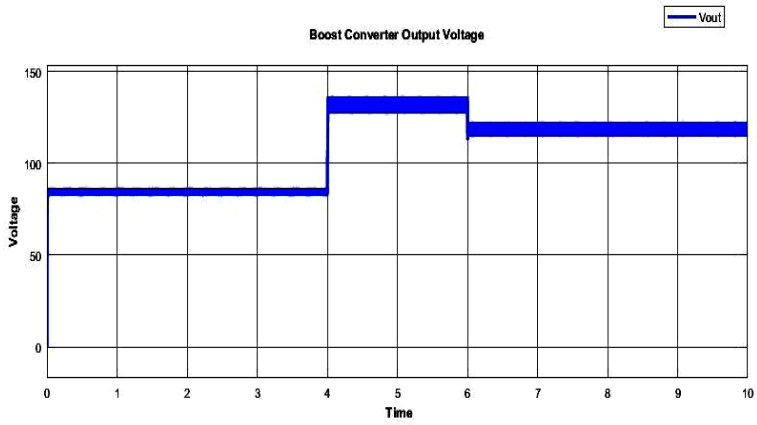


Figure 17. Boost Converter Output Voltage

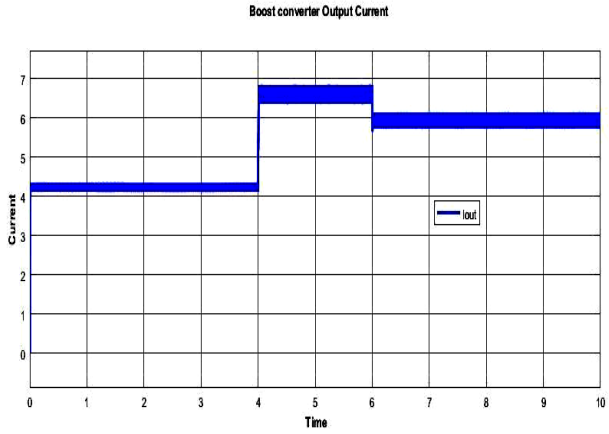


Figure 18. Boost Converter Output Current

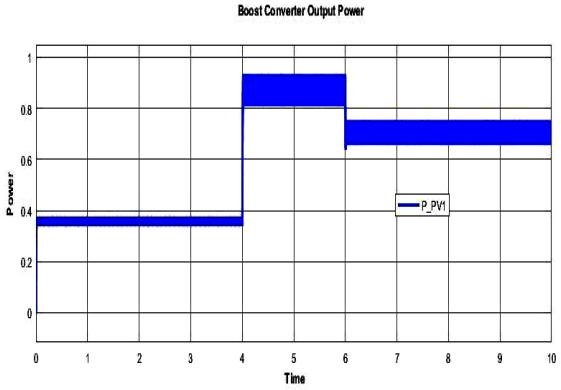


Figure 19. Boost Converter Output Power

## CONCLUSION

The DC-DC conversion section holds important criteria for the application of PV systems to track the maximum power. This paper tries to present a detailed analysis on boost converters including dynamics. The mathematical equations are investigated to search the characteristics of the PV system with the boost converter. The simulation is handled by SIMSCAPE tool of MATLSB. Simulation results express that the input current behavior of the boosts converter is continuous with a limited deviations of inductor current and the output voltage. The result shows that maximum 947.085 W of output power can extracted from the PV array with a 1000 W/m2 solar radiation in the tracking system. Still a great deal of work load can be handled for the further research in this research field with several modern techniques like Fuzzy logic implementation in the tracking system.

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