Modeling and Performance Analysis of Solar PV System and DC-DC Converters

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Abstract

This paper explains the modeling of solar Photo Voltaic (PV) panel model and the simulation of the circuit has been carried out using MATLAB/Simulink. The working performance of solar PV module is completely depends solar irradiation (G) and cell temperature (Tc). To develop the equivalent circuit model of the photovoltaic cell, the single diode equivalent circuit cell model is developed using embedded MATLAB function for deciding the equivalent circuit parameters and study the characteristics curves of the PV cell module and also evaluate the impact of parameters of solar cell on the I-V and P-V characteristics curve. The attained results are compared with the data in the manufactures data. And the 250W solar panel is connected with the Interleaved Boost Converter (IBC) and conventional Boost Converter (BC) and the performance of converters are also evaluated.

Keywords: conventional boost converter, equivalent circuit model, ideality factor, interleaved boost converter, MATLAB/Simulink, series resistance, solar cell

I. INTRODUCTION

In these days, electrical energy plays vital role in the developing countries to enhance the social activities and economic growth. Supremacy of energy generation from fossil fuel like coal leads to produce CO2 emission and environment pollution in the world in the last two decades. The main issue of CO2 emissions can be highly reduced through the usage of renewable energy technologies. The rapid development of renewable energy sources has revealed solar PV to attract vastly in the area of Distributed Generation (DG). For this beginning, researchers are more concentrating on the precise modeling of solar cell to generate electrical power from various sizes [1]. The electric power generation from the PV cell module is completely depends on the environmental factors and weather factor such as cell temperature and solar irradiance, the specification are given by the manufactures in manufacture data sheet does not match with the real atmospheric conditions. The parameter values are pointed out at standard test conditions as G= 1000 W/m² and cell temperature of T= 20°C [2].

The solar cell is made up of crystalline silicon, it’s characteristic is described by I-V and P-V characteristics curves. The numerous numbers of literatures shows the wide-ranging researches on solar cell equivalent circuit to extract the cell parameters. The basic equivalent circuits such as ideal diode model, single diode model with series resistance Rs [3-5] and single model with series and parallel resistance Rs and Rp [6-8] and two diode model of solar cell [9-11]. Among all of them two diode model of solar cell is more precise to demonstrate the characteristics curve and extract the parameters. But it needs to solve the equation of seven unknown parameters which is more complicate and take computational time. Some analytical methods are used solve these seven unknown parameter equations by considering some initial assumptions [12]. These analytical methods are very sensitive. Always the initial conditions on the seven parameters are not properly assumed and it may lead to inconsistent results in these methods. For the proper initialization of these parameters, the author may go for the optimization techniques or evolutionary algorithms [13].

The solar PV cell has a non-linear characteristic because the output of the cell is completely depends on dynamic nature of the environmental conditions. For the generalization the researchers and scholars chosen simplified model of solar cell as single diode model. In order to examine with a precision and reliability of the various fundamental solar PV cell parameters and extract the I-V and P-V characteristics curve. In these, there are thirty four methods have been originated by the researchers and examined in the past thirty five years of their research works [14]. The calculation of the solar cell parameters becomes more flexible and easier. That is enough to calculate the characteristics of the solar cell. The computation characteristics of I-V equations are more complex to solve because the module current recursive nature by the inclusion of series and parallel resistance Rs and Rp. Now a day’s various numerical methods are used to find the module current in solar.

In most applications in the renewable energy resources that requires the conversion of set voltage DC source to a variable voltage DC output. A DC-DC converter converts voltage directly from DC to DC and is simply known as a DC Converter. The
most popular using converter for the renewable energy sources is boost converter. It is similar to the AC transformer. The conventional boost converter is mainly used to step up the input voltage of any of the renewable energy sources to certain high level that required by the load. The exclusive capability of the conventional boost converter is got by storing energy in an inductor and that releasing its voltage to the required high level voltage of the load. These DC converters are commonly used in electric automobile traction motor control, trucks, trolley cars and marine haulers. They give high efficiency, good acceleration control and fast dynamic response. There is some drawbacks in the conventional boost converter that include maximum achievable output current and voltage, short circuit behavior and basic layout issues. DC/DC converters are exchanging system that control the normal estimation of the voltage (or current) at the output (load) fluctuating the changing times between the input (DC source) and the output, permitting adjust the uncontrolled voltage provided by the photovoltaic modules to a directed DC voltage at its output [21].

In the power electronics field, application of interleaving technique can be marked out back to very early days, particularly in applications of high power. In high power applications, the voltage and current stress can simply go away from the range that one power device can handle. Numerous power devices connected in parallel and/or series could be one result. However, voltage distribution and/or current distribution are still the concerns. As an alternative of paralleling power devices, paralleling power converters is another result which could be more advantageous. In addition, with the power converter paralleling structural design, interleaving technique comes in nature. Advantages like harmonic cancellation, better efficiency, better thermal performance, and high power density can be gained. In previous days, for high power applications, in order to meet some system constraint, interleaving multi-channel converter could be a advanced solution particularly considering the existing power devices with restricted performance at that time. Interleaving technique was also examined in the beginning days for the satellite or fuel cell applications and was initiated as unconventional SMPS power stage structural design. Interleaving technique can effectively reduce the filter capacitor size and weight. Boost power supplies are more familiar for producing higher dc voltages outputs from low-voltage inputs. As the power requirements from these supplies increase, however, a single power stage may be not enough. Interleaving boost converter is also called multiphasing boost converter and is useful for reducing the filter mechanisms. Interleaved boost converter is equal to a parallel connection of two sets of switches, two sets of diodes and two sets of inductors connected to a common filter capacitor and load [20].

In this research work analytical method such as Newton–Raphson (NR) method is used to produce the solar panel current because of its easy implementation and quick convergence. In this research work section II explains the basic equivalent circuit of single diode solar cell, section III describes the various parameters in the computation of solar module current, section IV exhibits the solar module simulation, section V explains the result and discussion of solar panel, conventional boost converter and interleaved boost converter. And conclusion in the section IV

II. EQUIVALENT CIRCUITS OF SOLAR CELL

The output power from the solar PV cell is the important stage in the analysis of the solar PV panel performance. Normally, solar cell contains current source with one or two anti-parallel to the diode with or without connection of series ($R_s$) or parallel resistance ($R_p$). The output of the solar cell is the current and voltage points. These two points are connected together to get I-V characteristics curve.

A. Ideal Solar Cell Equivalent Circuit Model

In solar cell equivalent circuit, without including internal resistance, the sunlight generated photo current source connected to the single diode is ideal diode model as shown in Fig.1

![Fig.1. Ideal Equivalent circuit of solar cell](image)

The current output of the solar cell single diode model is

\[ I = I_{ph} - I_D \]  \hspace{1cm} (1)

\[ I_D = I_A \left( \frac{v}{V_T} - 1 \right) \] \hspace{1cm} (2)
Where,

\[ V_T = \frac{A K T}{q} \]  

is the diode thermal voltage where \( I_{ph} \) is the incident radiation generated photo current, \( I_D \) is the diode current, \( I_o \) is the reverse saturation current, \( q \) is the electron charges, \( V \) is the voltage of the solar panel, \( K \) is the Boltzmann constant, \( T \) is the temperature of the cell, \( A \) is the ideality factor of the diode.

### B. Single diode Model

![Four parameter single diode model](image)

The initial assumption made for the progress of single diode model is absent of recombination of loss in the depletion layer. This solar cell single diode model can also be divided into two models such as four parameter model and seven parameter model. In four unknown parameter model \( R_p \) is considered as infinity. This model is easy to calculate the parameters and obtain the \( I-V \) characteristics curves. The cell current of four unknown parameter model is given by

\[
I = I_{ph} - I_D = I_{ph} - I_0 \left( \frac{V + IR_p}{V_T} \right) - \frac{V + IR_p}{R_p}
\]  

The equivalent circuit of four unknown parameter single diode model is shown in Fig.2.

While considering parallel resistance \( R_p \) makes the model has five unknown parameters is called five parameter model of solar cell shown in Fig.3.. The mathematical representation of five parameter model of solar cell is given by

\[
I = I_{ph} - I_D - I_p = I_{ph} - I_0 \left( \frac{V + IR_p}{V_T} \right) - \frac{V + IR_p}{R_p}
\]  

where \( R_p \) is the parallel or shunt resistance, \( R_s \) is the series resistance and \( I_p \) is the current flows through the parallel resistance \( R_p \) and \( I_d \) is the current through the diode.

![Five parameter single diode model](image)

### C. Two diode Model

Addition of one diode extra with the five parameter model is called two diode model of solar cell and this is proposed by many authors in their research work. The addition of extra diode denotes the recombination effects of the charge carriers of the diode and another one diode denotes the diffusion current in the P-N junction of the diode. This model is more precise and at the same time it makes more complicate the model of single diode.

The output cell current of two diode model is given by
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\[ I = I_{ph} - I_{D1} - I_{D2} - I_p = I_{ph} - I_{01} \left( \frac{V + IR_s}{V_i} - 1 \right) - I_{02} \left( \frac{V + IR_s}{V_i} - 1 \right) - \frac{V + IR_s}{R_p} \]  

(5)

where \( I_{D1} \) is the saturation current of the diode \( D_1 \), \( I_{D2} \) is the saturation current of the diode \( D_2 \), \( I_{01} \) is the saturation current due to diode \( D_1 \), \( I_{02} \) is the saturation current due to diode \( D_2 \), \( V_i \) is the diode thermal voltage of diode \( D_1 \) and \( V_i \) is the diode thermal voltage of diode \( D_2 \).

The equivalent circuit of two diode model is shown in Fig.4.

![Two diode model](image)

The solar modules are dispersed with data sheet values given by the manufacturer. The data sheet given by the manufacturer contains the following details: short circuit current \( (I_{sc}) \), open circuit voltage \( (V_{oc}) \), voltage at the Maximum Power Point (MPP) \( (V_m) \), Current at the Maximum Power Point (MPP) \( (I_{sc}) \), open circuit voltage temperature coefficient \( K_v \), temperature coefficient of current \( K_I \) and Maximum power \( (P_m) \). The information provided in the manufacturer data sheet are under standard test conditions (STC). [15] It explains also the equivalent circuit of three diode model of solar cell.

### III. IMPORTANT PARAMETERS OF A MODEL

The importance parameters of these models utter the behavior of solar PV module and how they respond with changing parameters and operating conditions of the solar cell.

#### A. Diode Ideality factor (A)

<table>
<thead>
<tr>
<th>Semiconducting Material</th>
<th>A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Si mono</td>
<td>1.2</td>
</tr>
<tr>
<td>Si-poly</td>
<td>1.3</td>
</tr>
<tr>
<td>a-Si:H</td>
<td>1.8</td>
</tr>
<tr>
<td>a-Si:H tandem</td>
<td>3.3</td>
</tr>
<tr>
<td>a-Si:H triple</td>
<td>5</td>
</tr>
<tr>
<td>CdTe</td>
<td>1.5</td>
</tr>
<tr>
<td>CTS</td>
<td>1.5</td>
</tr>
<tr>
<td>AsGa</td>
<td>1.3</td>
</tr>
</tbody>
</table>

Ideality factor \( A \) listed in Table.1, depends on PV cell technology [16]. This ideality factor of the diode can vary depending upon the cell technology.

The ideality factor of the diode depends on the semiconductor materials used in the PV cell technology. Depending upon the cell material, the P-N junction diodes, the semiconductor materials InGaN/GaN [17] and AlGaN/GaN [18] are used. The ideality factor of these semiconducting materials is greater than 2 is used by the researchers. The solar PV cell equations of equivalent circuit based on the model of Shockley diode using silicon (Si) which does not have ideality factors greater than 2, always less than 2.

The ideality factor of the diode is accountable for moving charge carriers across the P-N junction. The ideality factor of the diode \( A=1 \), indicates the moving carriers is purely diffusion process. \( A=2 \), indicates the recombination in the depletion region [19]. This ideality factor is one of the unknown parameter of the solar PV cell. Some researcher in their papers assumes some values to the ideality factor that always depend upon the semiconductor materials used in the solar PV module. In this work,
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The semiconductor material used in this solar panel is silicon mono-crystalline. For silicon mono-crystalline material of the solar panel A is 1.2

**B. Photo current ($I_{ph}$)**

The photo current of the solar cell is completely depends upon the solar irradiation $G$ and cell temperature $T$ and is given by

$$I_{ph} = G \times I_{sc}$$  \hspace{1cm} (6)$$

$$I_{sc} = I_{sc_r} \left[ 1 + a \times (T - T_r) \right]$$  \hspace{1cm} (7)$$

Where $I_{sc_r}$ is the short circuit current at reference temperature $T_r$. $a$ is the temperature coefficient of the short circuit current. $I_{sc_r}$ is the second unknown parameter in the solar cell model.

Diode saturation current ($I_0$)

$$I_0 = I_{sc_r} \left( \frac{T}{T_r} \right)^{\frac{1}{2}} \exp \left[ -b \left( \frac{1}{T_r} - \frac{1}{T} \right) \right]$$  \hspace{1cm} (8)$$

Where $b = \frac{E_g \times q}{A \times K}$ $I_{sc_r}$ is the reverse saturation current at the reference cell temperature at $T_r$. The diode saturation current is completely relays upon the cell temperature. $E_g$ is the energy band gap (eV) of the semiconductor.

**C. Series and Parallel resistance ($R_s$ and $R_p$)**

The value of series resistance $R_s$ and parallel resistance $R_p$ are other unknown parameters in the solar cell model. In research work, some researchers find the values by initial assumptions. The inaccurate initial assumption tends the mathematical model is imprecise. The values of series resistance $R_s$ and parallel resistance $R_p$ can be computed from the slope at $V_{oc}$ and $I_{sc}$ respectively from the $I$-$V$ solar cell characteristics curve. The equations for series resistance $R_s$ and parallel resistance $R_p$ are:

$$R_s = -\frac{dV}{dI_{V_{oc}}} - \frac{1}{X_V}$$  \hspace{1cm} (9)$$

$$R_p = -\frac{dV}{dI_{I_{sc}}} - \frac{1}{X_V}$$  \hspace{1cm} (10)$$

where,

$$X_V = \frac{V_t}{I_{sc}} \frac{1}{e^{\frac{V_t}{V_i}}}$$  \hspace{1cm} (11)$$

$$I_0 = \frac{I_{sc}}{e^{\frac{V_t}{V_i}} - 1}$$  \hspace{1cm} (12)$$

**IV. MODEL OF BOOST CONVERTER**

The vital rule that drives the boost converter is the inclination of an inductor to oppose changes in current by making and destroying a magnetic field. In a boost converter, the output voltage is constantly higher than the input voltage. A schematic of a boost control stage is appeared in Fig. 5

![Fig. 5: Block diagram of Boost Converter](image-url)
a) At the point when the switch is shut, current moves through the inductor in clockwise bearing and the inductor stores some vitality by creating an magnetic field. Extremity of the left half of the inductor is certain.

b) At the point when the switch is opened, current will be diminished as the impedance is higher. The magnetic field already made will be crushed to keep up the current towards the load. In this manner the extremity will be turned around (means left half of inductor will be negative at this point). Subsequently, two sources will be in arrangement bringing about a higher voltage to charge the capacitor through the diode D.

A. Designing Parameter of conventional Boost Converter

The conventional boost converter designing includes the duty cycle \( D \), Inductor \( L \) and Capacitor \( C \). These are explained as follows

1) Duty Cycle

The designing formula for duty cycle of the conventional boost converter requires output voltage \( V_{out} \) and input voltage \( V_{in(min)} \).

\[
D = 1 - \frac{V_{in(min)}}{V_{out}}
\]  

(13)

2) Inductor

The designing formula for inductors of the conventional boost converter requires input voltage \( V_{in} \), output voltage \( V_{out} \), switching frequency \( f_s \) and change in inductor ripple current \( \Delta I_L \).

\[
L = \frac{V_{in} \cdot (V_{out} - V_{in})}{\Delta I_L \cdot f_s \cdot V_{out}}
\]  

(14)

Where, the ripple current is given by,

\[
\Delta I_L = (20\text{to}40)\times I_{out} \cdot \frac{V_{out}}{V_{in}}
\]  

(15)

3) Capacitor

The designing formula for capacitors of the conventional boost converter requires output current \( I_{out} \), Duty cycle \( D \), switching frequency \( f_s \) and change in inductor ripple voltage \( \Delta V_{out} \).

\[
C_{out} = \frac{D \cdot I_{out}}{f_s \cdot \Delta V_{out}}
\]  

(16)

V. MODEL OF INTERLEAVED BOOST CONVERTER

Interleaved converters can decrease output current swell with no change on the PWM method (need phase shift only) and circuit theory of boost converter. Despite the fact that the quantity of switches and inductors of interleaved converter are more than the conventional boost converters and it appears to raise the materials cost, the interleaved converters are efficient strategies to diminish the EMI.

Interleaved Boost converter is more competent for photovoltaic model that there is ripple cancellation both in the input and output waveforms, the equivalent circuit diagram is shown in Fig.6. The productivity of the parallel associated converter system can be enhanced if an appropriate number of converters in the system are actuated and it is accomplished by soft start controller and it has been connected in existing products. By and by, less active components might be sufficient for power exchange when the light on photovoltaic is reductions to low level because of changes in physical conditions. In opposite, more segments might be active when the power exchanges expanding past the most extreme point of confinement of the initiated converters. In this manner, interleaved boost converter can be worked at a discretionary power level to enhance the change productivity.

Fig. 6: Equivalent circuit diagram of the Interleaved Boost Converter
**A. Designing Parameter of Interleaved Boost Converter**

The interleaved boost converter designing includes the duty cycle ($D$), Load Resistor ($R_o$), Inductor ($L$) and Capacitor ($C$). These are explained as follows.

1) **Duty Cycle**

The designing formula for duty cycle of the interleaved boost converter requires output voltage ($V_o$) and input voltage ($V_{in}$).

$$D = \frac{(V_o - V_{in})}{V_o} \quad (17)$$

2) **Load Resistor**

The designing formula for load resistor of the interleaved boost converter requires output voltage ($V_o$) and output current ($I_o$).

$$R = \frac{V_o}{I_o} \quad (18)$$

3) **Time**

The designing formula for time in seconds of the interleaved boost converter requires MOSFET switching frequency ($f_s$).

$$T_z = \frac{1}{f_s} \quad (19)$$

4) **Inductor**

The designing formula for inductors of the interleaved boost converter requires input voltage ($V_{in}$), Duty cycle ($D$), Time in seconds ($T_{sec}$) and change in inductor ripple current ($\Delta I_L$).

$$L = \frac{V_{in}DT_z}{\Delta I_L} \quad (20)$$

5) **Capacitor**

The designing formula for capacitors of the interleaved boost converter requires output current ($I_o$), Duty cycle ($D$), Time in seconds ($T_{sec}$) and change in inductor ripple voltage ($\Delta V$).

$$C = \frac{I_o D T_z}{2 \Delta V} \quad (21)$$

**VI. SIMULATION OF SOLAR PANEL MODEL**

Find the equations using the parameters, so it is simple to create a mode using Embedded Matlab function in MATLAB simulation as shown in Fig. 7. The output current of the solar cell $I$ can be acquired as function of Voltage $V_a$, Irradiation $G$ and cell temperature $T$.

![Fig. 7: Simulink model of PNX 250W solar panel using Embedded matlab](image_url)
There are various types of solar modules are obtainable in the market. In this work, the manufacturer date sheet PNX-250W is taken to estimate the solar cell model parameters.

The table.2 list the specified parameter of the solar module given by the PNX-250W manufacture at standard test conditions $G = 1000 \text{ W/m}^2$ (1 Suns) and $T = 25 ^\circ \text{C}$.

<table>
<thead>
<tr>
<th>Technical Specifications of PNX-250W</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter</td>
</tr>
<tr>
<td>Power $(P_{m})$ in Watts (nominal)</td>
</tr>
<tr>
<td>Open Circuit Voltage $(V_{oc})$ in Volts</td>
</tr>
<tr>
<td>Short Circuit Current $(I_{sc})$ in Amps</td>
</tr>
<tr>
<td>Voltage at Maximum Power $(V_{mp})$ in Volts</td>
</tr>
<tr>
<td>Current at Maximum Power $(I_{mp})$ in Amps</td>
</tr>
<tr>
<td>Maximum System Voltage</td>
</tr>
<tr>
<td>Solar Cells per Module (Units)</td>
</tr>
</tbody>
</table>

The table.3 shows the temperature coefficients on current, voltage and power for the solar panel PNX-250W.

<table>
<thead>
<tr>
<th>Temperature coefficients of PNX-250W solar panel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameters</td>
</tr>
<tr>
<td>Voltage</td>
</tr>
<tr>
<td>Current</td>
</tr>
<tr>
<td>Power</td>
</tr>
</tbody>
</table>

VII. SIMULATION OF BC AND IBC

Form the Fig.8, the conventional Boost Converter, changing DC voltages starting with one level then onto the next is regularly accomplished by utilizing an ordinary non-isolated DC-DC power converter. These converters work to change input DC voltages to output DC voltages at a required level, and there are two methods of operations in the conventional boost converter: continuous current mode operation and discontinuous current mode operation. In a few applications, the converter can work in both methods of operation with various characteristics related with each.

![Simulation Circuit of Conventional Boost Converter](image)

Fig. 8: shows the simulation circuit of conventional Boost Converter

Fig.9 shows, In Interleaved Boost Converter, parallel connection of at least two conventional boost converters is called an interleaved boost converter. With suitable control, it might be utilized to enhance power conversion effectiveness and to better work the solar cell array exhibit at most extreme power.
VIII. RESULT AND DISCUSSION

8.1 Effect of irradiation and temperature on characteristics of solar PV cell

The output voltage and power from the solar cell is mainly depends upon the solar irradiation. Depending upon the climate change, the irradiation is increased or decreased, the output voltage and power from the solar panel also varied accordingly. The Fig. 10 & 11 shows the $P$-$V$ and $I$-$V$ characteristics curves of the PNX-250W solar panel at $T=25\degree$ C under standard test condition. When the values of irradiation increase the open circuit voltage is also increased logarithmically and increases the short circuit current linearly.
Fig. 11: I-V characteristics curves of PNX 250W solar panel varying irradiation G.

The Fig 12 & 13 shows the P-V and I-V characteristics of PNX 250W solar panel for varying cell temperature $T$, generally the cell temperature can vary from 25 $^\circ$C to 75 $^\circ$C. When the cell temperature increases the panel voltage becomes reduce and also reduce the output power of the solar panel.

Fig. 12: P-V characteristics curves of PNX-250W solar panel varying temperature

Fig. 13: I-V characteristics curves of PNX 250W solar panel varying temperature
In a practical solar PV cell there is a resistance in the current path through the metal contact and semiconductor material. This resistance is composed together form a series resistance $R_s$. The variation in series resistance reveals the changes near the open circuit voltage. The Fig. 14 shows the variation in series resistance at standard test conditions changes the slope of $I$-$V$ characterized curve near the $V_{oc}$. By using this effect the value of $R_s$ can be computed using the slope $dV/dI$ at $V_{oc}$.

![Fig. 14: Effect of series resistance $R_s$ under standard test conditions](image)

The ideality factor of diode ($A$) is one of the unknown parameter in the equation of solar cell current calculation. The value of ideality factor ($A$) assumes between 1 and 2 for silicon materials. The Ideality factor 1 denotes the ideal diode model. The Fig. 15 shows the effect of the variation of ideality factor. When the value of ideality factor decreases that leads to smoothen the characteristics curve.

![Fig. 15: Effect of diode ideality factor under standard test conditions](image)

In the solar technology, a single solar cell will produce voltage of 0.6 V and power upto 1.5W. The change in number of solar cells produce change in voltage of the cell. The cells connected in series increase the panel voltage and cell connected in parallel increases output current in the solar panel. The Fig. 16 shows the increasing number of series cells connection leads to increase as the panel voltage.
Fig. 16: Effect of series connected cells in solar panel

The Fig. 17 shows the maximum output power under standard conditions of PNX 250W solar panel.

![Graph showing maximum power of PNX 250W solar panel under standard test conditions](image)

Fig. 17: Maximum power of PNX 250W solar panel under standard test conditions

Table – 3
Comparison of Maximum Power between manufacturer data and simulation output

<table>
<thead>
<tr>
<th>Test condition</th>
<th>Pmax (W) As per simulation</th>
<th>Pmax (W) As per Manufacture data</th>
<th>Relative Error (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>G= 1 Suns T=25 °C</td>
<td>244.1</td>
<td>250</td>
<td>2.36</td>
</tr>
</tbody>
</table>

From the Table.3, the maximum power obtained by using the manufacturer data sheet, the output is compare with the given output of the manufacturer. The error between them is analysed. The relative error between simulation result and the manufacturer result is 2.36%.

The performance analysis of the conventional boost converter and the interleaved boost converter are obtained by using the matlab simulation. The output voltage of the boost converter and interleaved boost converter are compared.

Table. 4 & 5, shows the parameter values involved in the designing of conventional Boost Converter and Interleaved Boost Converter (IBC). The designing are done according to the formula given. By using the formula, we can design the converter according to the rating. Here, the converter is designed for the input voltage of 100V and the output voltage of 400V. The performance are evaluvated for both the converters.

Table – 4
Ratings of conventional Boost Converter (BC)

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Input Voltage</td>
<td>100V</td>
</tr>
<tr>
<td>2.</td>
<td>Output Voltage</td>
<td>399.2V</td>
</tr>
<tr>
<td>3.</td>
<td>Duty Cycle</td>
<td>0.75</td>
</tr>
<tr>
<td>4.</td>
<td>Inductor</td>
<td>37.5µH</td>
</tr>
<tr>
<td>5.</td>
<td>Capacitor</td>
<td>125µF</td>
</tr>
<tr>
<td>6.</td>
<td>Switching frequency</td>
<td>100KHz</td>
</tr>
<tr>
<td>7.</td>
<td>Resistor</td>
<td>160Ω</td>
</tr>
</tbody>
</table>
Table – 5
shows the values used in the design of Interleaved Boost Converter (IBC)

<table>
<thead>
<tr>
<th>S.No</th>
<th>Parameters</th>
<th>Values / Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Input Voltage ($V_d$) range</td>
<td>100V</td>
</tr>
<tr>
<td>2</td>
<td>Output Voltage ($V_o$)</td>
<td>400V</td>
</tr>
<tr>
<td>3</td>
<td>Switching Frequency Of MOSFET</td>
<td>100KHz</td>
</tr>
<tr>
<td>4</td>
<td>Inductors L</td>
<td>484.5µH</td>
</tr>
<tr>
<td>5</td>
<td>Capacitor C</td>
<td>63µF</td>
</tr>
<tr>
<td>6</td>
<td>Resistor</td>
<td>123.08Ω</td>
</tr>
</tbody>
</table>

Fig 18, denotes the output voltage of the conventional Boost Converter, the input given to the conventional Boost converter is 100V. The target output of BC is 400V. After proper designing using the formulas for the parameters involved in BC. The output gained is 399.2V

![Conventional Boost Converter Output Voltage Graph](image1)

Fig. 18: shows the output voltage of the conventional Boost Converter

Fig 19, denotes the output voltage of the Interleaved Boost Converter, the input given to the Interleaved Boost converter is 100V. The target output of IBC is 400V. After proper designing using the formulas for the parameters involved in IBC. The output gained is 400V and also the output contained the less ripple content.

![Interleaved Boost Converter Output Voltage Graph](image2)

Fig.19. shows the output voltage of the Interleaved Boost Converter
From the Table 6, output of the conventional Boost Converter is compare with the Interleaved Boost Converter. The input given to the conventional boost converter and Interleaved boost converter are same, but the output of the conventional boost converter is 399.2V. We can achieve the output as 400V fully by using the Interleaved Boost Converter. There is high level of ripple reduction in the Interleaved Boost Converter when compare to the conventional Boost Converter.

<table>
<thead>
<tr>
<th>S.No</th>
<th>DC/DC Converter</th>
<th>Input Voltage (V)</th>
<th>Output Voltage (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Conventional Boost Converter (BC)</td>
<td>100</td>
<td>399.2</td>
</tr>
<tr>
<td>2</td>
<td>Interleaved Boost Converter (IBC)</td>
<td>100</td>
<td>400</td>
</tr>
</tbody>
</table>

### IX. Conclusion

In solar cell parameter analysis, there are numerous mathematical models used to determine the optimal values. In this work, there are four parameter model was employed to get the characteristics curves and to examine the effect of these parameters used in the model. The simulation model is examined using manufactures data. The output simulation result shows the good compromise between manufactures data and the results from the simulations. Due to unique advantages of Newton-Raphson method is widely preferred than other numerical methods to obtain the values of the parameters. The Interleaved Boost Converter is also have the advantage of the accurate output voltage and high ripple reduction of the conventional Boost Converter.

### REFERENCES