# Noble-TLBO MPPT Technique and its Comparative Analysis with Conventional methods implemented on Solar Photo Voltaic System

**Ajay Patsariya[1,3], Shiwani Rai[2,4], Dr. Yogendra Kumar[5], Dr. Mukesh Kirar[5]**
Electrical AND Electronics engineering dept.
Nri Institute of Science and Technology ,Bhopal Madhya Pradesh, India
1ajay.patsariya@hotmail.com
2Shivi.avie28@gmail.com
5 Maulana Azad National Institute Of technology , Bhopal

**Abstract.** The energy crisis particularly with developing GDPs, has bring up to a new panorama of sustainable power source like solar energy, which has encountered huge development. Progressively high infiltration level of photovoltaic (PV) era emerges in keen matrix. Sunlight based power is irregular and variable, as the sun based source at the ground level is exceedingly subject to overcast cover inconstancy, environmental vaporized levels, and other climate parameters. The inalienable inconstancy of substantial scale sun based era acquaints huge difficulties with keen lattice vitality administration. Exact determining of sun powered power/irradiance is basic to secure financial operation of the shrewd framework. In this paper a noble TLBO-MPPT technique has been proposed to address the vitality of solar energy. A comparative analysis has been presented between conventional PO, IC and the proposed MPPT technique. The research  has been done on Matlab Simulink software version 2013.

## 1.Introduction

Sustainable power source is the best answer for the worldwide developing issue of energy shortage. Sun oriented vitality is a for all intents and purposes, an unlimited asset; got all around the globe. As of date, with its favourable circumstances of contamination free, productive, financially savvy and long haul utilizing, sun based vitality have been extraordinarily created [1]. The PV control era depends on the standard of the photovoltaic impact [2], and watched that, there is an exceptional time when the PV cell produces most extreme power. Now, the rate of progress of energy concerning the voltage is equivalent to zero [3]. PV cluster must be worked at MPP with a specific end goal to concentrate greatest power yield. There are Different power administration issues which concern change in the transformation productivity of a PV cluster [4], therefore amplifying PV control yield is the solution to the variable solar power. A lot MPPT technique are proposed in literature [2]-[6] to achieve the aforementioned objective; but all have their own limitation like convergence speed, effectiveness, proficiency, complexity, etc.

 A teaching–learning-based optimization (TLBO) procedure is one of the as of late proposed meta-heuristic techniques that are generally used to take care of combinatorial improvement issues [22]. The
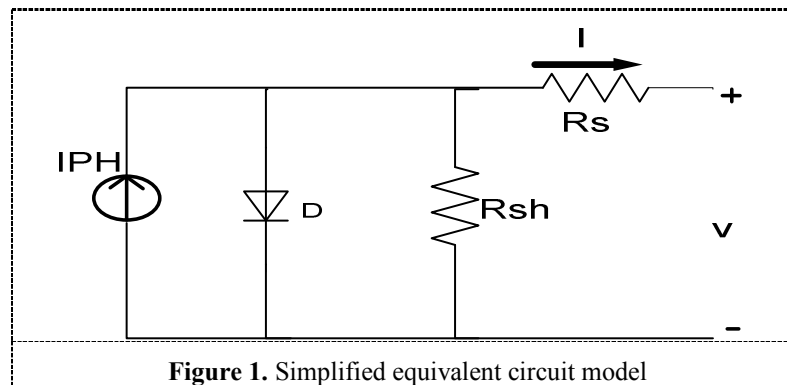
greatest energy of the PV exhibit changes with shading or potentially climatic conditions can be optimally maximized by selecting suitable parameters like irradiation, temperature and optimizing it for tracking maximum values of voltage and current. Consequently, an imperative test in a PV framework is to guarantee that greatest vitality is created from the PV cluster with a dynamic variety of its yield trademark when associated with a variable load. An answer for this issue is the addition of a power converter between the PV exhibit and load, which could progressively change the impedance of the circuit by utilizing a control calculation [5]. DC Converters are required to manage the yield voltage [6] at a required level. In this paper, a step-up converter is utilized, that has a capacity of giving a yield voltage which is higher than the input voltage [4].

Maximum Power Point Tracking (MPPT) is winding up noticeably more imperative as the measure of vitality created by PV frameworks is expanding [7]. It ensures the Tracking of Maximum output power taking into account all environmental constraints like solar radiations and operating temperature. The proposed work has been carried out in four parts; firstly a SVP model has been simulated to produce the output power which can be boost to such a level so as to integrate with the utility grid. In section 2 review on various MPPT technique is presented. In three numerous methods proposed in literature has been tested with the model and a new Teaching Learning based MPPT technique has been developed which give better result as compare to the traditional methods. The work has been winded up by implementing the proposed MPPT technique to the Hybrid converter topology, which has been designed using heuristic approach.

**2.SVP MODELING**
PV arrays are built up with combined series/parallel combinations of PV solar cells, which are usually represented by a simplified equivalent circuit model such as the one given in Fig. 1 and/or by an equation as in (1).



**Figure 1.** Simplified equivalent circuit model

$$I = I_{PH} - I_S[\exp(q(V+IR_S)/(KT_C A)-1] - (V-IR_S)/R_{SH}$$                     1

The PV cell output voltage is a function of the photocurrent that mainly determined by load current depending on the solar irradiation level during the operation.

Where the symbols are defined as follows:
$I_{PH}$ is Photo current
$I_S$ is Saturation current
q is electron charge ($1.6*10^{-19}$C)
K is boltzman's constant ($1.388 \times 10^{-23}$J/k)
$T_C$ working temperature of cell
A is factor of ideality
Rs series resistance

Rsh shunt resistance

Photo current mainly is the function of solar radiation γ and working temperature which can be given as

$I_{PH} = I_{SC} + K_I (T_C - T_{Ref}) \gamma$                                                                   2

Where

Isc is the short circuit current of cell

$K_I$ is coefficient of temperature

$T_{ref}$ is ref temperature

The Is varies with temperature as given below.

$$I_S = I_{RS}\left(\frac{T_C}{T_{Ref}}\right)^3 \exp\left[qE_G\left(1/T_{Ref} - 1/T_C\right)KA\right]$$                    3

Where

$I_{RS}$ is the reverse saturation current

$E_G$ is band gap energy

Simulation model is developed incorporating these equations using solar cell module of matlab 2013 version using sim-electronic library block as shown in Figure-2.
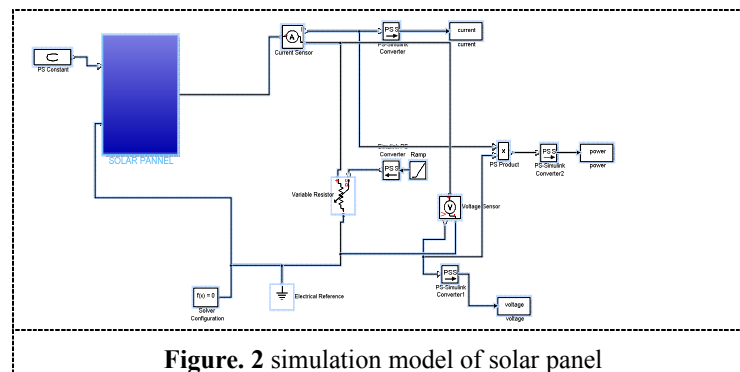


**Figure. 2** simulation model of solar panel

The model was developed for standard test conditions of cells temperature at 25°C, and spectral distribution (Air Mass) AM is equal to 1.5. The standard irradiation values of 1500, 1200, 1000, 800, 600 w/m2 were taken as input parameter for the model. For the value of open circuit voltage Voc = 21.1 v and shot circuit current ISC = 3.11 the parameters selection is as per the Table-1. For the above model PV and VI characteristics were drawn taking T constant at 25° and for the above mentioned values of irradiations (Fig-3, 4).

**Table 1**. Solar Model Parameters

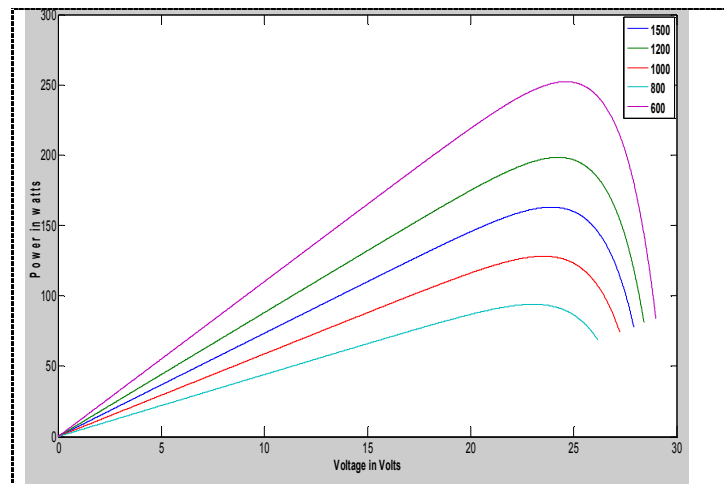| Parameter | Values |
| --- | --- |
| Series String | 36 |
| Parallel String | 45 |
| Open Circuit Voltage | 21.1 |
| Short Circuit Current | 3.11 |
| Series Resistance | 0.1049 |
| Shunt Resistance | 142.8 |

**Figure-3 PV** characteristics of SPV at different Irradiation
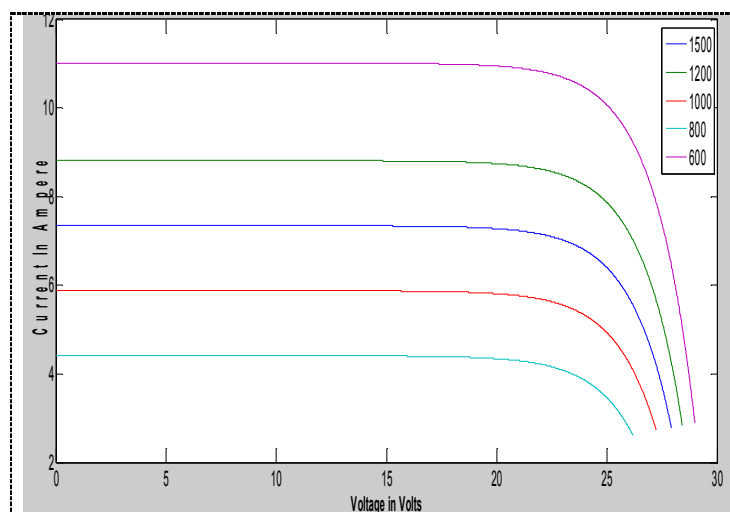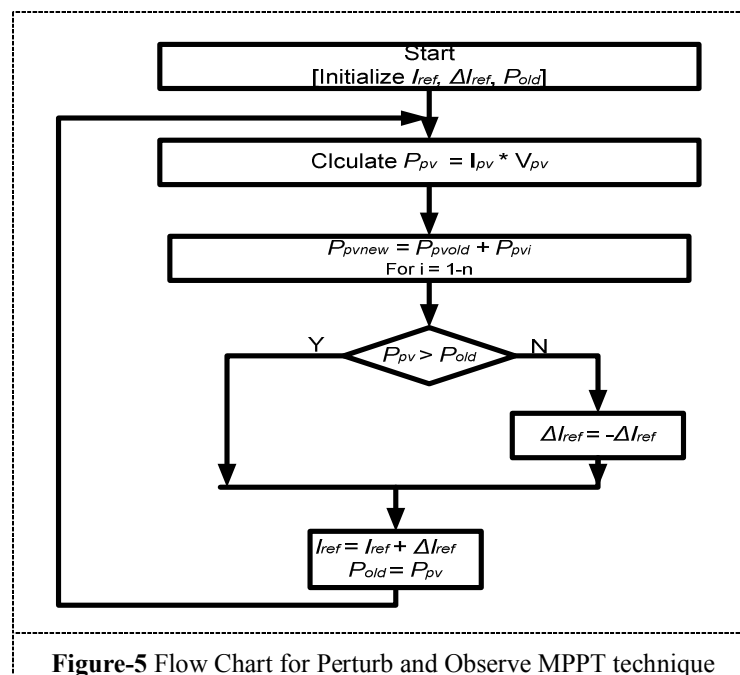


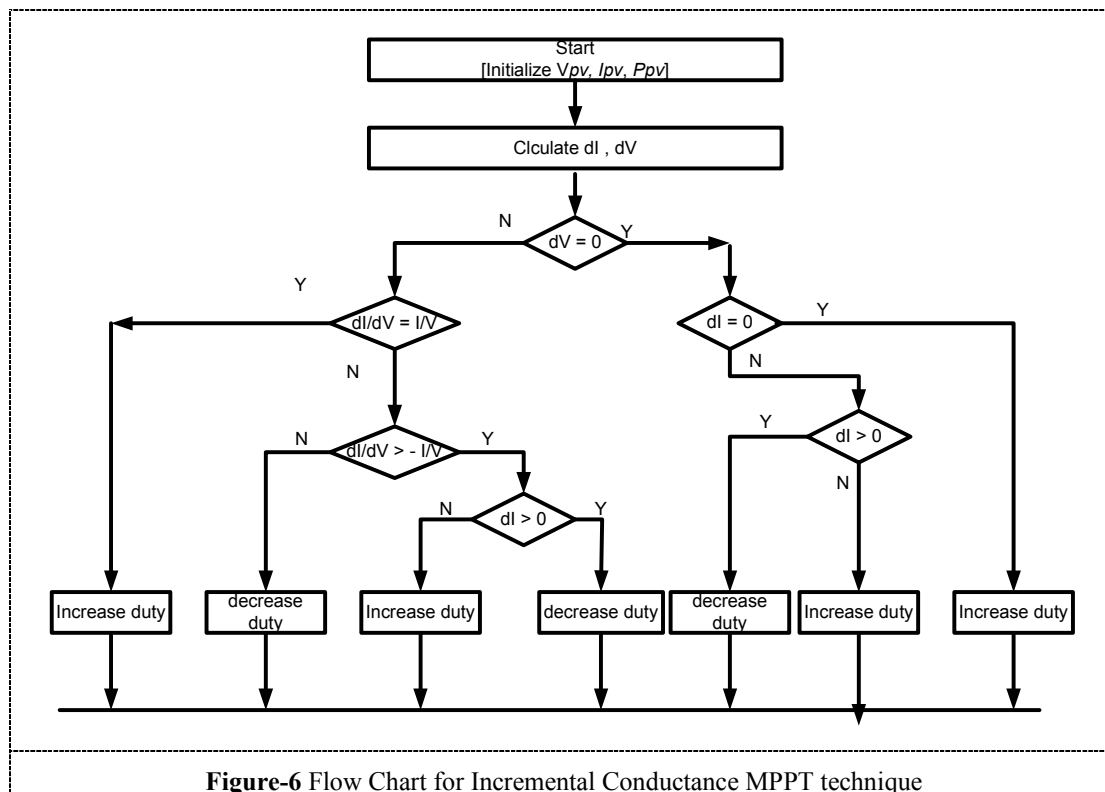**Figure-4** VI characteristics of SPV at different Irradiation

From the above graph it is clear that output power of the solar photovoltaic changes with change in solar radiations. That is the output power of solar cell is not constant at any time of day. This makes the solar energy very vulnerable hence the stability and reliability of solar cell is questionable. For extracting maximum output voltage and power at any instant of time in literature various MPPT techniques is suggested for solar panel which has been discussed in next section.

**3. MPPT Techniques**
The paper covers the Fixed Duty Cycle, Constant Voltage (Vcte), Perturb and Observe (P&O), Modified P&O, Incremental Conductance (IC), Modified IC, IC in light of PI, Swell Correlation, System Oscillation and Temperature strategies, which are quickly portrayed in this segment. The Fixed Duty Cycle speaks to the most straightforward of the strategies and it doesn't require any input, where the heap impedance is balanced once for the greatest power point and it is not balanced once more. The Constant Voltage technique utilizes observational outcomes, showing that the voltage at MPP (VMPP) is around 70% to 80% of the PV open circuit voltage (VOC), for the standard climatic condition. Among the purposes of MPP (fluctuating climatic conditions), the voltage at the terminals of the module shifts almost no notwithstanding when the power of sunlight based radiation changes, yet it differs when the temperature changes. So this technique must be utilized as a part of areas where the temperature differs practically nothing. A positive point is that lone the PV voltage is important to be measured, and a basic control circle can come to the MPP [6, 8, 15, 16]. The P&O technique (Figure-5) works occasionally augmenting or decrementing the yield terminal voltage of the PV and looking at the power acquired in the present cycle with the energy of the past one. In the event that the voltage differs and the power expands, the control framework changes the working point toward that path generally change the working point the other way. Once the course for the change of voltage is known, the voltage is fluctuated at a steady rate. This rate is a parameter that ought to be changed in accordance with permit the balance between quicker reaction with less variance in consistent state [5, 6, 12, 16-18]. An altered adaptation is gotten when the means are changed by the separation of the MPP, bringing about higher productivity. This is a brilliant strategy to come to the MPP and it is freely from the PV board/maker, in spite of the fact that this technique may endure from quick changes in ecological conditions.

 The IC technique (Figure-6) depends on the way that the power slant of the PV is invalid at MPP ($dP/dV = 0$), positive in the left and negative in the privilege, as appeared in Fig. 4 [3, 5, 16-18]. In this manner, because of this condition, the MPP can be found as far as the augmentation in the cluster conductance.



**Figure-5** Flow Chart for Perturb and Observe MPPT technique

**Figure-6** Flow Chart for Incremental Conductance MPPT technique

## 4. TLBO-MPPT

Regardless of the considerable number of focal points exhibited by the era of vitality through PVs, the productivity of vitality transformation is right now low and the beginning expense for its usage is as yet viewed as high, and subsequently it is important to utilize procedures to track the most extreme power from these panels, with a specific end goal to accomplish most extreme productivity in operation. It ought to be noticed that there is just a single purpose of maximum power (MPP - maximum Power Point), and this changes as per climatic conditions. The photovoltaic power attributes is nonlinear, as appeared in Fig. 3, 4, which fluctuate with the level of sun powered illumination and temperature, which make the extraction of most extreme power an unpredictable undertaking, considering load variations. The choice of any MPPT technique depends upon the conversions characteristics, ripple factor, tracking factor, ease of implementation, robustness, etc. The TLBO-MPPT technique proposed in the paper has high speed of conversion and high efficiency.

Teaching–learning based optimization (TLBO) is proposed by Rao et al. [23, 24], enlivened from reasoning of teaching and the learning procedure. This procedure is executed on the premise of impact of an instructor on the result of the learners in a gathering which is taken in term of results or evaluations [32, 34].It likewise has a populace based calculation where a gathering of learners make the populace. The calculation basically emulates the ability of teaching–learning of educator and learners speaking to in a classroom or in a gathering. The different plan factors are like variant subjects offered to learners and the learners result is equivalent to objective. The best arrangement is considered as instructor in TLBO because the educator is taken as most learnt individual in a gathering. TLBO consists of two phases: first stage is of instructor stage (i.e. learning from educator),

while second stage is of learner stage Detailed information and exhaustive audit about the TLBO algorithm its usage and its code have been displayed by Rao et al.

To design a TLBO-MPPT the output of the solar panel is considered as the initialization function with respect to solar radiation and temperature;

Let, Vmi, Imi be the initial values of position and Gi is the initial velocity vector, then

$$Vmp = Vmi + ri(Gi – Gi+1) \qquad for\ Gi \quad > Gi+1 \qquad\qquad 4$$

$$Imp = Imi + ri(Gi – Gi+1) \qquad for\ Gi \quad > Gi+1 \qquad\qquad 5$$
$$Vmpnew = Vmi + \ Vmpi+1 \qquad\qquad\qquad\qquad\qquad\qquad\qquad 6$$
$$Impnew = Imi + \ Impi+1 \qquad\qquad\qquad\qquad\qquad\qquad\qquad 7$$
$$mean\_Vmpi = n[Vmpnew – Tf\ Vmi] \qquad\qquad\qquad\qquad\qquad 8$$
$$mean\_Impi = n[Impnew – Tf\ Imi]$$

Where; ri is random value at ith iteration and Gi and Gi+1 is the irradiation at consecutive iteration. Tf is tracking factor

## 5. ALGORITHM

Different steps involved in the proposed TLBO-MPPT technique are;

Step-1 Extract the output of solar panel, which will be the initialization function for TLBO.

Step-2 Generate ri.

Step-3 Calculate Vmp and Imp using 4and 5.

Step-4 Optimize maximum voltage and maximum current output from

$$Vmpnew = Vmpold + \ Vmpi$$
$$Impnew = Impold + \ Impi$$

Step-5 Calculate mean_ Impi and mean_ Vmpi i.e. the difference between the mean results.

Step-6 Update 'Vmpnew and Imp new'.

Let the updated values of voltage and current be Vmpnew1 and Impnew1.

Step-7 If Vmpnew1 and Impnew1 performs better select it. Otherwise accept Vmpnew and Impnew.

Step-8 Let the learners of existing position are interacting with other learners at global position to generate a new solution.

Step-9 Select the solution which is performing better as the final output of voltage and current.

Repeat the above mention process till the optimal solution is reached or till the half of the total number of iterations i.e. from itotal/2 to itotal.
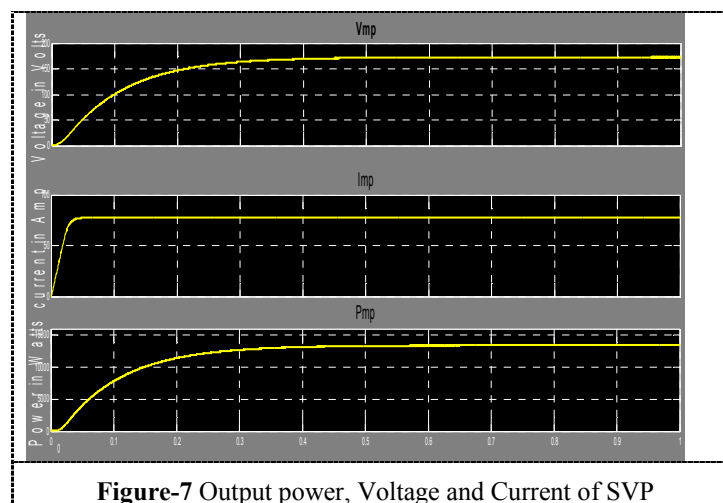


**Figure-7** Output power, Voltage and Current of SVP

## 6. DC-Dc Boost Converter

The maximum output voltage of SPV is 170 volts; maximum output current is 77.5 ampere and maximum output power is 13KW. As shown in Figure 8 this output voltage has to be increased to such a level which can be easily integrated with utility grid. DC-Dc boost converters are high speed power electronic devices which tune the input impedance of the SPV panel to match the load requirement by varying gating signals. These gating signals are tuned with the output of the MMPT. In literature four broad types of converters are available namely; boost converter, buck converter, buck boost converter, cuk converter. In this paper DC-DC boost converter are designed by heuristic approach. The outputs of the converter are matched with the load requirement by tuning it with the output of the TLBO-MPPT output i.e. Vmp and Imp. The converter topology is shown in Figure 8 For designing boost converter power mosfet as switching device is selected since it has a high switching frequency of 5000 Hz and duty cycle of 1/10000. Delay pulse is 0.85. the diode forward voltage is 0.8 volt. Other parameters are given in the table-2
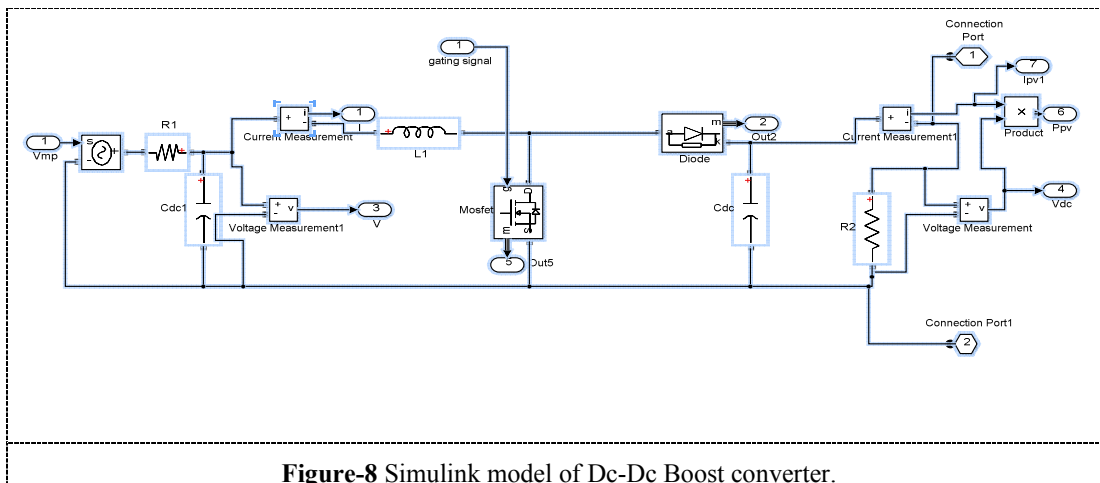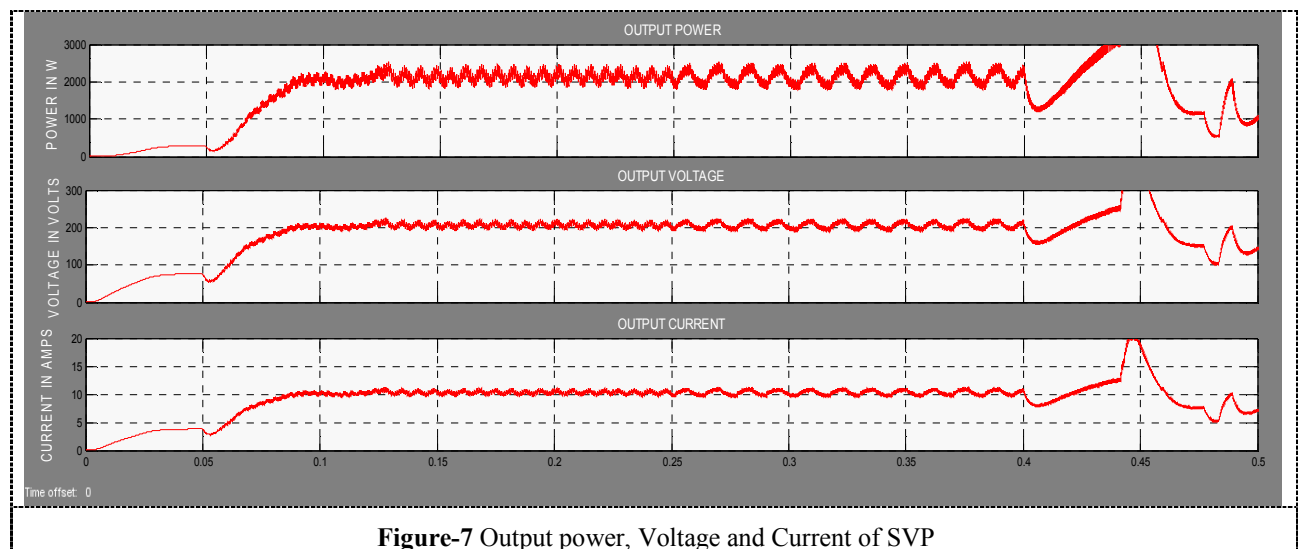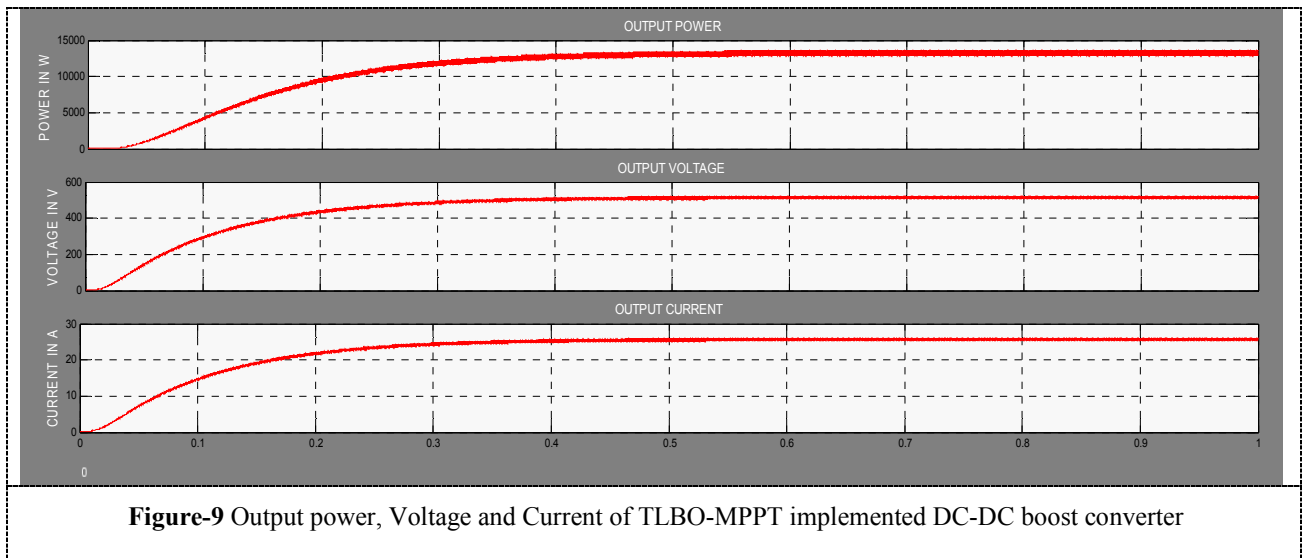


**Figure-8** Simulink model of Dc-Dc Boost converter.

**Table 2** DC-DC Boost converter values

| Parameter | Values |
| --- | --- |
| Input voltage | 77.1 volts |
| Output voltage | 520 volts |
| R1 | 0.001 ohm |
| Rload | 20 ohm |
| $C_{dc}$ | 350e-6 F |

## 7.Simulation Results And Discussion

In this paper three methods of MPPT has been tested on the designed DC-DC boost converter; namely TLBO-MPPT, Perturb & Observe MPPT and incremental & conductance MPPT technique, the dc voltage output of the SVP were fed to these technique to track the maximum output voltage and current. The tuned output of MPPT techniques is fed to the discrete Pulse width modulator through which high frequency switching device is triggered. The implemented results of various MPPT algorithms on matlab Simulink are shown in figure. The comparative analyses are tabulated in Table-4. It is clear from the results as shown in Figure 9, 10, 11 that the proposed TLBO-MPPT has high performance efficiency and is ripple free. The output voltage modulated by TLBO-MPPT is upto 520v which 70% of the input 77 volts. This is highest against 80 V of P & O and 200V of IC MPPT technique.

**Figure-9** Output power, Voltage and Current of TLBO-MPPT implemented DC-DC boost converter



**Figure-7** Output power, Voltage and Current of SVP

**Table 3** Comparative analysis of proposed TLBO-MPPT with conventional methods

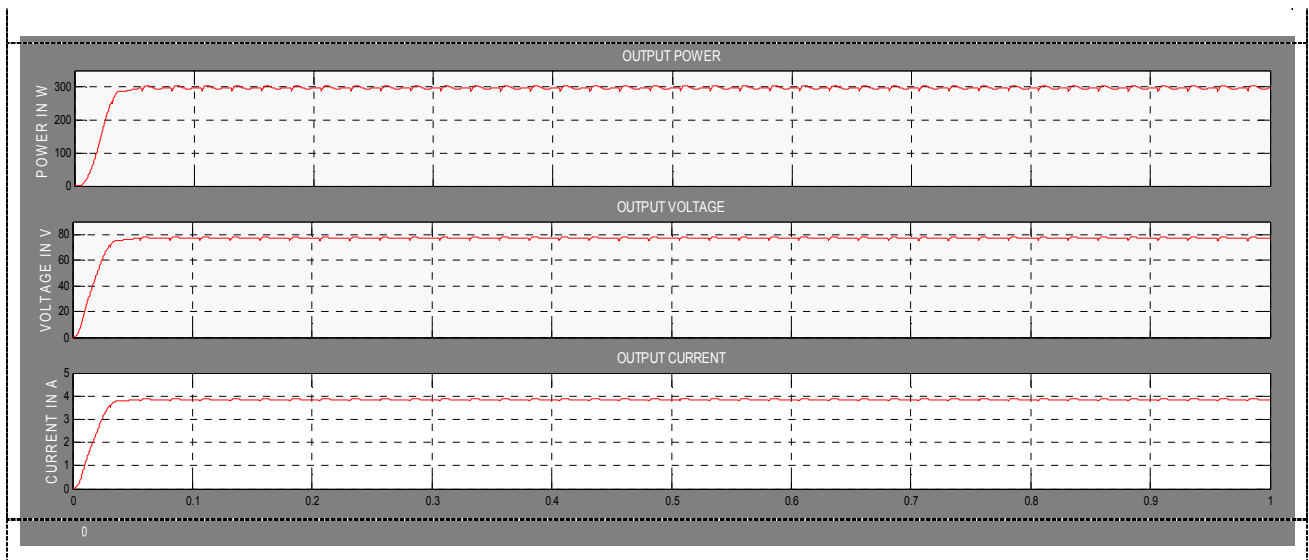| PARAMETER | VALUE | | |
|---|---|---|---|
| | *TLBO-MPPT* | *P & O MPPT* | *IC MPPT* |
| Output Power in KW | 13 | 0.3 | 2 |
| Output Voltage V | 520 | 80 | 200 |
| Output Current A | 77.5 | 4 | 10 |
| Ripple % | 10 | 25 | 45 |
| Efficiency % | 72.8 | 61.2 | 67.8 |

**Figure-7** Output power, Voltage and Current of SVP

8**. Conclusion**

In this paper SPV is modelled with 50 series connected cell to obtain Ipv, Vpv, Ppv. the characteristics waveform PV and VI of SPV is plotted at STC for different values of irradiation. The output power of SPV is tracked for maximum values of voltage and current using different MPPT techniques. The test results shows that proposed TLBO-MPPT method gives more efficient results on the designed DC-DC boost converter as compare to the conventional P&O and I&C techniques.

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