Design of MPPT Algorithm for Solar Charge Controller to Efficiency Improvement for PSC Condition

Jaykishan Sharma[1]* Hardik Raval[2]

[1] PG Student, Electrical Department, MEC, BASNA, Visnagar, Gujarat, India

[2] HOD, Electrical Department, MEC, BASNA, Visnagar, Gujarat, India

Abstract – Maximum power point trackers (MPPTs) play an important role in photovoltaic (PV) power systems because it maximize the power output from a PV system for a given set of conditions, and therefore maximize the array efficiency. Thus, an MPPT can minimize the overall system cost. MPPTs find and maintain operation at the maximum power point, using an MPPT algorithm. Many such algorithms have been proposed. A maximum power point tracking (MPPT) is used for extracting the maximum power from the solar PV module as described in the present work. In practical application solar cells are usually influenced by partially shaded conditions (PSC). There is a bypass diode that prevents damage to the solar cell, which causes the P-V characteristic curve to have multiple peak values. As the traditional MPPT technology only tracks local maximum value, techniques which can find the global maximum value should be developed to maintain MPPT.

Keywords- Photovoltaic (PV), Maximum Power Point Tracking (MPPT), DC-DC Converter, P&O (Perturb and Observe), I&C (Incremental conductance)(INC)

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INTRODUCTION

Among all different sources of renewable energy i.e. solar, wind, geothermal, tidal etc. Solar tends as an important source of electricity generation. In this context, *photovoltaic* (PV) power generation has an important role to play due to the fact that it is a green source.

Lifetime of solar after implementation is around 25 years, so it can produce more energy than their manufacturing. It can be installed in roofs, deserts, and at place which has no use at residence, and also produce energy from their remote locations also. Now a day's trends is to improve efficiency with the solar system and to track maximum power which of generated, so MPPT techniques serves purpose of it. This will directly improves efficiency at low cost. In the past years numerous MPPT algorithms have been published [1][2][10]. They differ in many aspects such as complexity, sensors required, cost or efficiency

The objective of this paper is firstly to review best MPPT algorithms. Then the most popular, *perturb and observe* (P&O)[7], *incremental conductance* (InCond)[3][6][7][9], are analyzed in depth. After that, improvements to the P&O and the InCond algorithms are suggested to succeed in the MPP tracking under conditions of changing irradiance[7][10] by simulating it in PSIM and efficiency is compared. Finally it is concluded that Incremental Conductance is more efficient then Perturb and Observe.

1. PROPOSED MAXIMUM POWER POINT TRACKING (MPPT) TECHNIQUES

MPPT algorithms are necessary in PV applications because the MPP of a solar panel varies with the irradiation and temperature, so the use of MPPT algorithms is required in order to obtain the maximum power from a solar array[2][4][6].

There are many different MPPT techniques, Among these techniques, the P&O and the InCond algorithms are the most popular and common to easy implementation[7][9].

Below shown is block diagram of MPPT system. Here now we see basic two MPPT-P&O and MPPT-IncCond algorithm

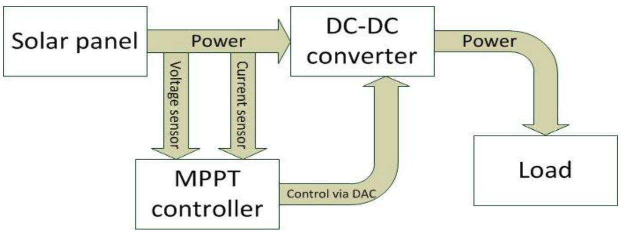

Figure 1.MPPT block diagram.

1.1 Perturb and Observe (P&O)

The first one is P&O algorithm, which used to track maximum power point. It can calculate the power at PV array by determining value of voltage and current. P&O link to determine variation in PV array voltage and current by linking present and past value of voltage and current periodically[7].

In this method, the sign of the last perturbation and the sign of the last increment in the power are used to decide what the next perturbation should be. As it can be seen in Figure 2, So on the left of the MPP incrementing the voltage to get to the Maximum power point whereas on the right of MPP decrementing the voltage to get to the Maximum power point which finally will increases the output power.

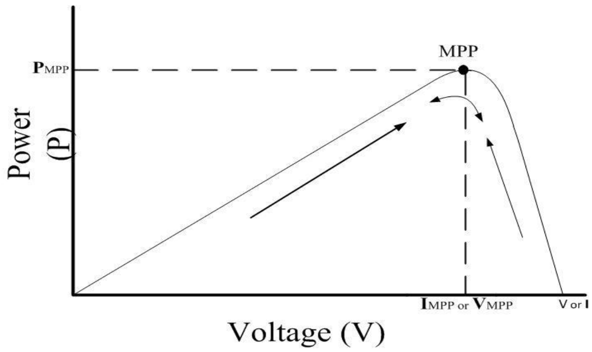

Figure 2.P-V characteristics

If there is an increment in the power, the perturbation should be kept in the same direction and if the power decreases, then the next perturbation should be in the opposite direction[7]. Based on these facts, the algorithm is implemented. The process is repeated until the MPP is reached. Then the operating point oscillates around the MPP. This problem is common also to the In Cond method, as was mention earlier. A scheme of the algorithm is shown in the figure 2.

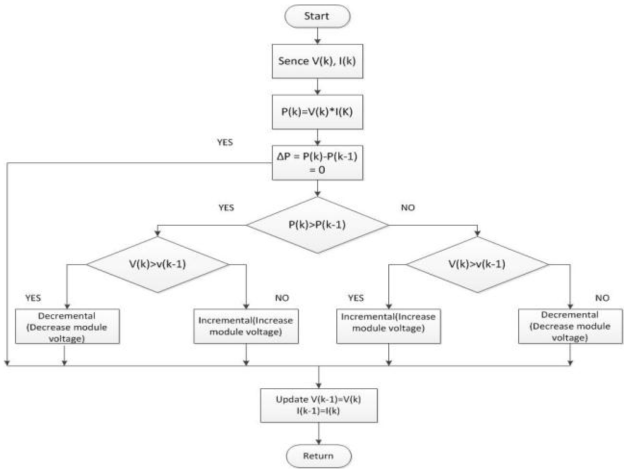

Figure 3.Perturb and Observe (P&O) flowchart

1.2 Incremental Conductance (IncCond)

The disadvantage of the perturb and observe method to track the peak power under fast varying atmospheric condition is overcome by IncCond method. The incremental conductance algorithm is based on the fact that the slope of the curve power vs. voltage (current) of the PV module is zero at the MPP, positive (negative) on the left of it and negative (positive) on the right[3][6][10], it can be written as.

$$\frac{dI}{dV} = -\frac{I}{V} \text{ or } \frac{dP}{dV} = 0 \text{ At MPP}$$

$$\frac{dI}{dV} > -\frac{I}{V} \text{ or } \frac{dP}{dV} > 0 \text{ Left of MPP}$$

$$\frac{dI}{dV} < -\frac{I}{V} \text{ or } \frac{dP}{dV} < 0 \text{ Right of MPP}$$

A scheme of the algorithm is shown in figure below.

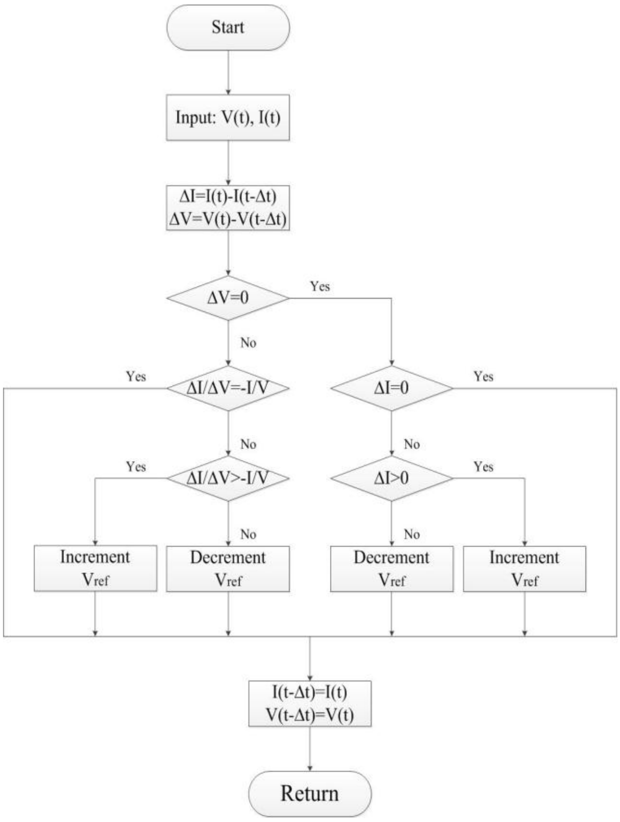

Figure 4.IncCond Flowchart

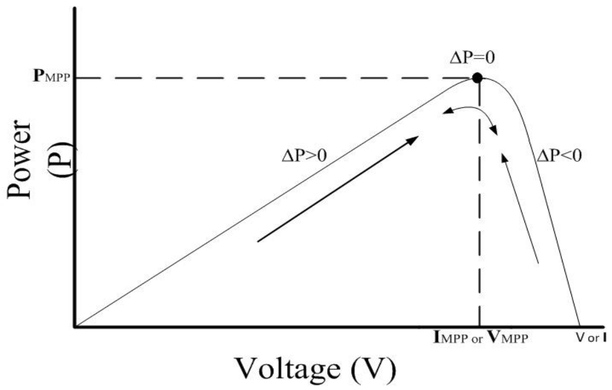

Figure 5.P-V characteristics of IncCond.

The INC can determine that the MPPT has reached the MPP and stop perturbing the operating point. If this condition is not met, the direction in which the MPPT operating point must be perturbed can be calculated using the relationship between dl/dV and –I/V This relationship is derived from the fact that dP/dV is negative when the MPPT is to the right of the MPP and positive when it is to the left of the MPP[3][7], shown in Figure 5. This algorithm has advantages over P&O in that it can determine when the MPPT has reached the MPP, where P&O oscillates around the MPP. Also, incremental conductance can track rapidly increasing and decreasing irradiance conditions with higher accuracy than perturb and observe.

DC-DC boost converter without MPPT

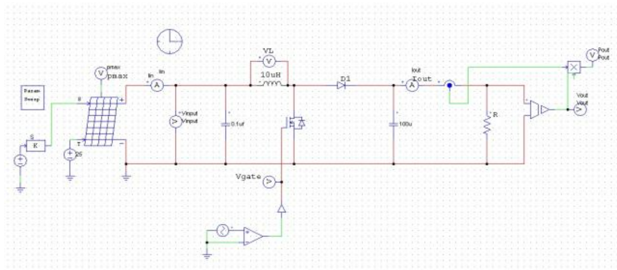

Figure 6.DC-DC boost converter without MPPT

DC-DC Boost converter without MPPT for 25 W solar panel has been used in this simulation and all the output result was taken as per different radiation and temperature data for May 27, 2007 for Lucknow city. Shown fig 6 is circuit diagram of boost converter without MPPT system. Below table shows the efficiency of the system without MPPT.

Modelling and Results of Solar-PV System: -

A 30 KW panel is considered as consisting of 24,080 solar cells arranged in 344X70 combinations. The solar array consists of number of panels connected in series-parallel configuration and a panel consists of number of cells. The power characteristics of the solar cell are formulated using its equivalent circuit. The equivalent circuit of the cell is presented as a current source in parallel with diode and a parallel resistance with a series resistance.

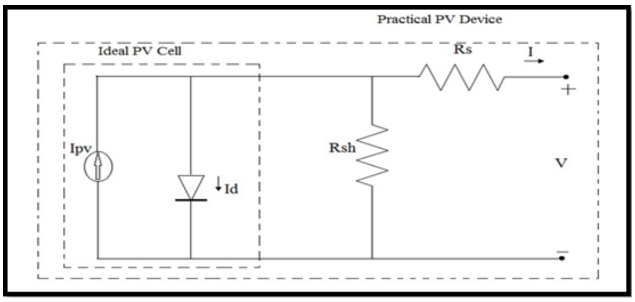

Figure 6.5 Equivalent circuit of a practical PV device

The output current can be measured by subtracting the diode currents and current through resistance from the light generated current. From this circuit, the output current of the cell is expressed as,

$$I = Ipv - Id - I_{Rsh} \qquad (6.1)$$

$$I = Ipv - I_0\left[\exp\left(\frac{V+IRs}{a}\right) - 1\right] - \left(\frac{V+IRs}{Rp}\right) \qquad (6.2)$$

Where

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$$a = \frac{NS.A.K.Tc}{q} = Ns.A.V_T$$

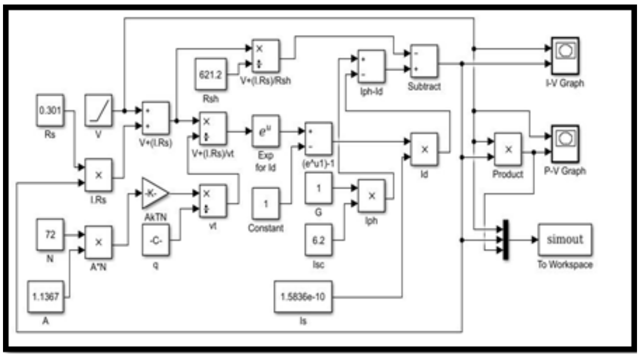

Fig- Solar PV Matlab Modelling

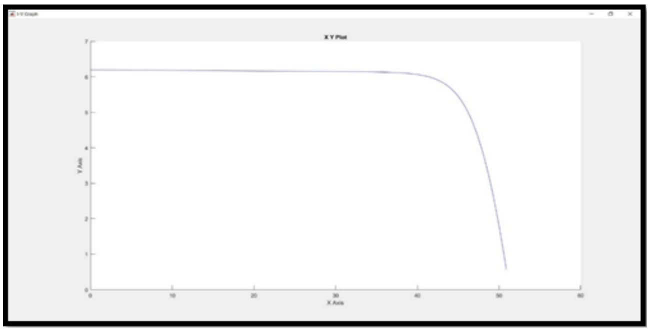

Fig- Solar Cell I-V Characteristics

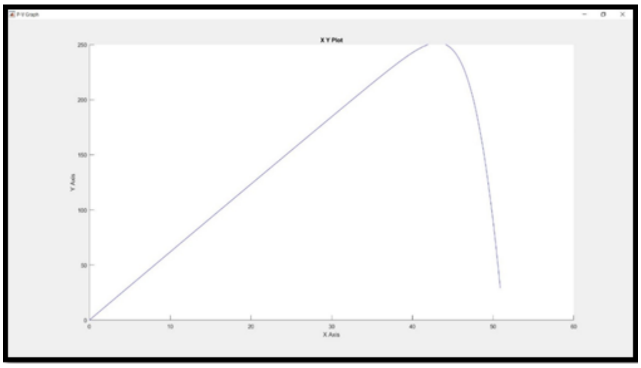

Fig 6.8- Solar Cell P-V Characteristics

Solar PV System under Partially Shaded Condition

For simplicity, it is initially supposed that the array under PSC is subjected to two different irradiance levels. Modules that receive high irradiance level (Hs) are called insolated modules and those which receive lower irradiance level (Ls) are named shaded modules. The insolated modules of a string drive the string current. Therefore, portion of the string current that is greater than the generated current of shaded modules passes through parallel resistance of the shaded modules and generates negative voltage across them. Thus, the shaded modules consume power instead of generating it. In this condition, not only the overall efficiency drops, but also the shaded modules may be damaged due to hot spots. To prevent this condition, a bypass diode is connected in parallel to each module, to let the extra current of the string pass through it. Consequently, the voltage across that module will be about and efficiency of the string will improve.

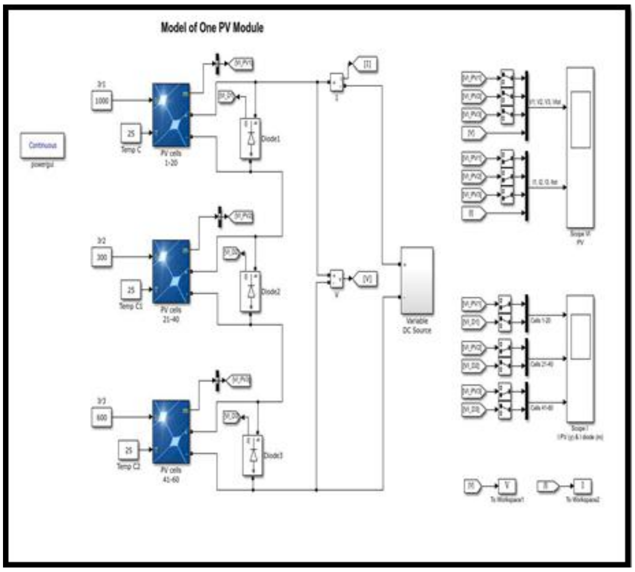

Fig- Solar PV System Matlab under Partial Shading Condition

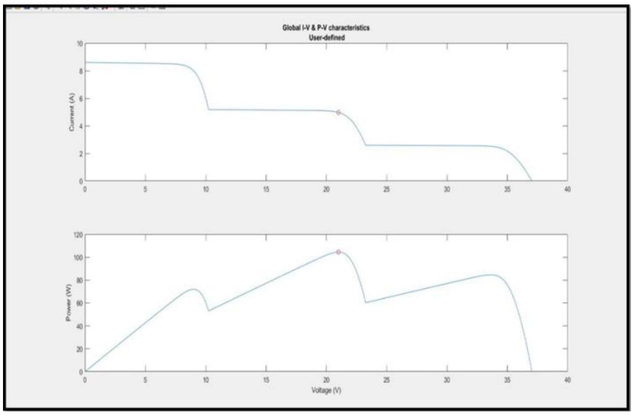

Fig- Solar PV Array I-V and P-V Characteristics under Partial shading condition

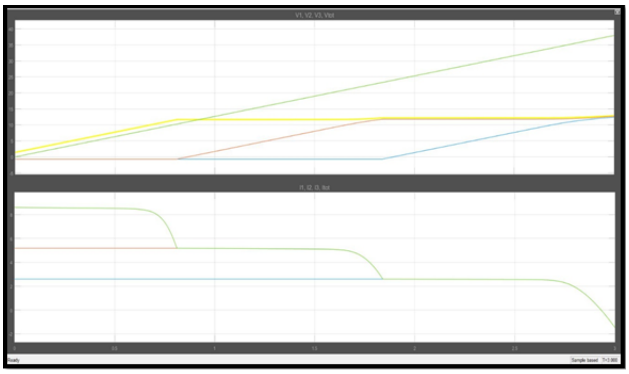

Fig- Partial shading condition Voltage and Current variation

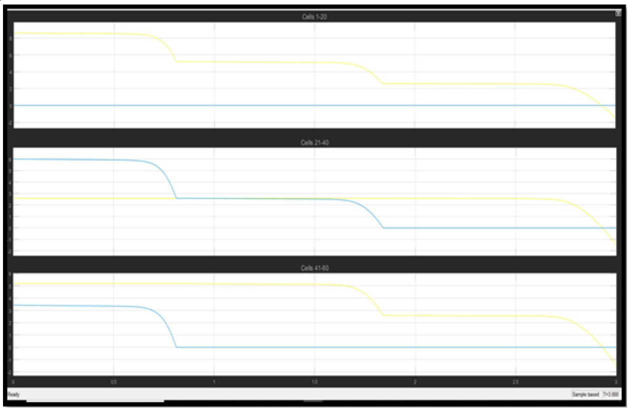

Fig- individual Solar PV Arrays Ratings

Matlab Simulation of Solar PV with MPPT in PSC

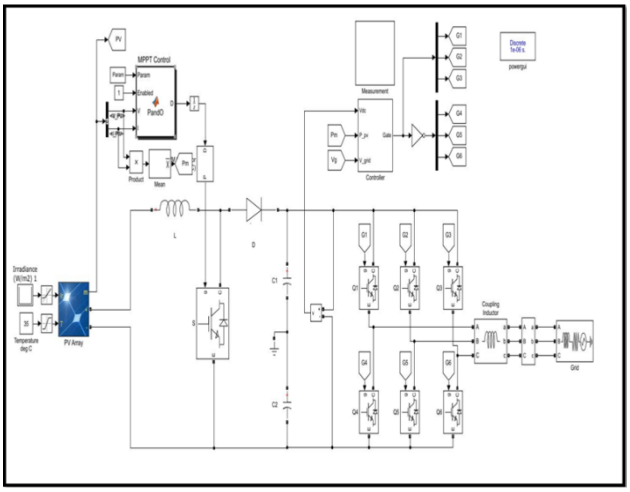

Fig- Proposed system of Solar PV in PSC with MPPT and Grid

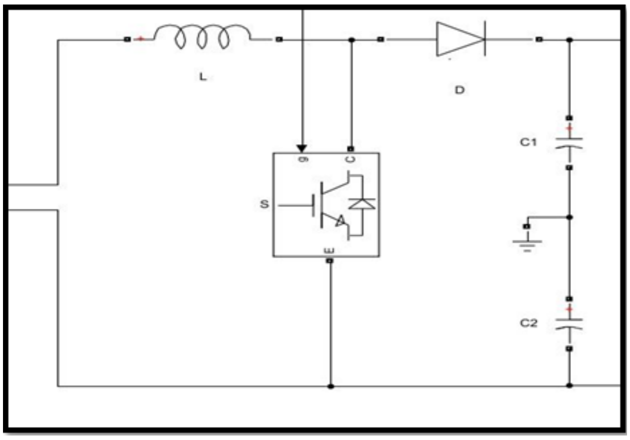

Fig- Solar PV DC-DC converter

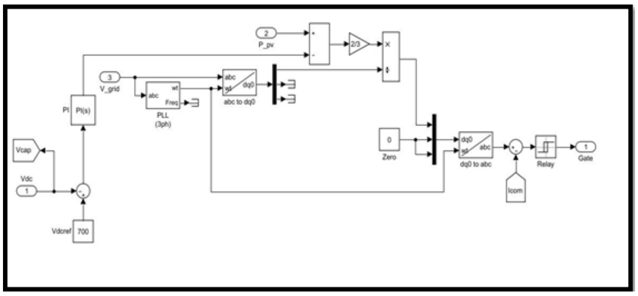

Fig- Grid Controlling subsystem

Simulation Results

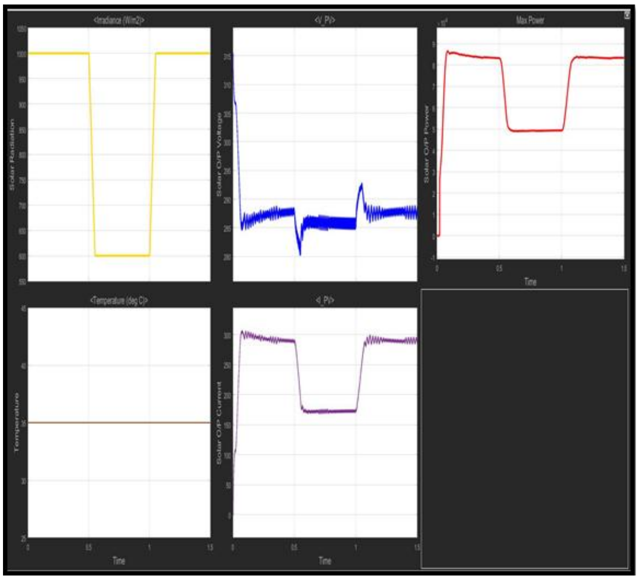

Fig- Solar PV Array Output

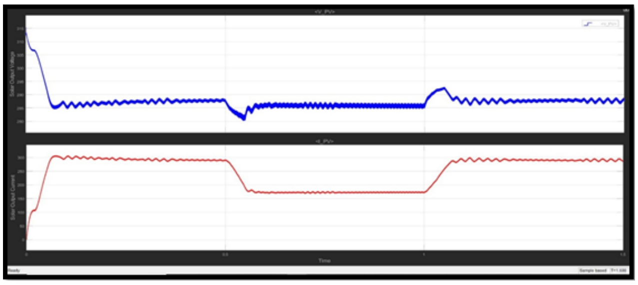

Fig- Solar PV output Voltage and Current

Fig- Grid Side Output Voltage and Current

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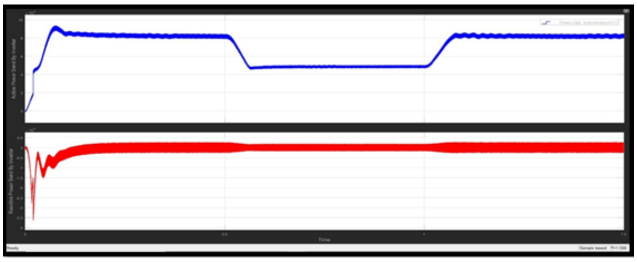

Fig- Grid Side Output Active & Reactive Power send by Inverter

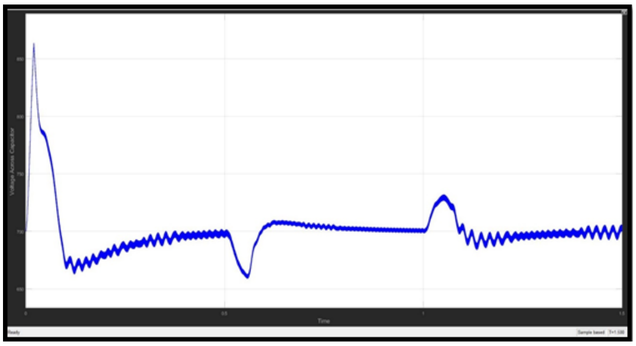

Fig- Capacitor across Voltage

CONCLUSION

This paper presents a Solar PV energy system for standalone system. The standalone Solar PV System is consider under Partial Shading Condition for Maximum Power Tracking using MPPT. This Paper also highlights the future developments, which have the potential to increase the economic attractiveness of such systems and their acceptance by the user. This Paper also represents the modelling and Simulation of Solar PV System using MATLAB-SIMULINK software. The Simulation results show the ideal I-V and P-V characteristics of the solar PV system under Partial Shading Condition for Maximum Power Tracking using MPPT. The Simulation of Grid integration of proposed solar PV system with MPPT under PSC is successfully done.

REFERENCES

1. Maximum Power Point Tracker Applied in Batteries Charging with PV Panels José António Barros Vieira, Alexandre Manuel Mota, Escola Superior de Tecnologia de Castelo Branco, IEEE 2008.

2. Design and Realization of a Photovoltaic System Equipped with a Digital MPPT Control, M.F. Yaden, Ka. Kassmi, M. El Ouariachi, B. Tidhaf, T. Mrabti, EL. Chadli and K. Kassmi, 2010 IEEE.

3. Simulation and Hardware Implementation of Incremental Conductance MPPT With Direct Control Method Using Cuk Converter Azadeh Safari and Saad Mekhilef, Member, IEEE, IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS, VOL. 58, NO. 4, APRIL 2011.

4. Solar PWM Inverter Using Artificial Neural Network, T. RajaSundra Pandiyan Leebanon and R.Ashok Department of EEE, Sri Shakthi Institute of Engg and Technology, Coimbatore, Proceedings of 7th International Conference on Intelligent Systems and Control (I SCO 2013)

5. Development of a Fuzzy Logic based, Photovoltaic Maximum Power Point Tracking Control System using Boost Converter, S. Vasantharaj, G. Vinodhkumar, M. Sasikumar, Chennai and Vivekanandha College of Technology for women, Third International Conference on Sustainable Energy and Intelligent System (seiscon 2012),VCTW, Tiruchengode, Tamilnadu, India on 27-29 December, 2012.

6. Assessment of the Incremental Conductance Maximum Power Point Tracking Algorithm Mohammed A. Elgendy, Bashar Zahawi, Senior Member, IEEE, and David J. Atkinson, IEEE TRANSACTIONS ON SUSTAINABLE ENERGY 1, 2012.

7. An Enhanced Methodology for Maximum Power Point Tracking in Solar Powered UPS Application A.Velu, N.Kalaiarasi, Subhranshu, Sekhar Dash and G.Surendra Babu. 2013 IEEE

8. Simulation. optimization and performance analysis of an analog, easy to implement, perturb and observe MPPT technique to be used in a 1.5 KWp PV system, KHELIF Messaoud, M'RAOUI Abdelhamid and MALEK Ali. 2013 IEEE.

9. Comparative Analysis of Incremental Conductance Base MPPT for Multi-String Photovoltaic System. Kaumil B. Shah ,Lokin P. Joshi, 2013 Nirma University International Conference on Engineering (NUiCONE). 2013 IEEE.

10. Design & Simulation of PV system using Incremental MPPT algorithm. Jay Patel, Vishal Seth and Gaurang Sharma. IJAREEEIE, Vol 2, Issue 5, May 2013.

11. Real Time Simulation and Analysis of Maximum Power Point Tracking (MPPT) Techniques for Solar Photo-Voltaic System, D. S. Karanjkar, S. Chatterji and Shimi S. L. And Amod Kumar, Proceedings

of 2014 RAECS UIET Panjab University Chandigarh, 06 - 08 March, IEEE-2014

Corresponding Author

Jaykishan Sharma*

PG Student, Electrical Department, MEC, BASNA, Visnagar, Gujarat, India