

SIMULATION & HARDWARE TESTING OF BOOST CONVERTER WITH MPPT CONTROL FOR SOLAR PV SYSTEM

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Abstract: Maximum power point trackers (MPPTs) play an important role in photovoltaic (PV) power systems because it maximizes the power output from a PV system for a given set of conditions, and therefore maximizes 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. However, one particular algorithm, the perturb-and-observe (P&O) method Incremental Conductance (IncCond), claimed by many in the literature to be inferior to others, continues to be by far the most widely used method in commercial PV MPPTs. Here the Simulation and Hardware testing is carried out of DC to DC boost converter for Solar PV System.

Keywords: PV, MPPT, Boost Converter, P&O, Inc.

I. 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 is generated, so MPPT techniques serve purpose of it. This will directly improve 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 (IncCond) [3-7], are analyzed in depth. After that, improvements to the P&O and the IncCond 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 than Perturb and Observe.

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 IncCond 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.

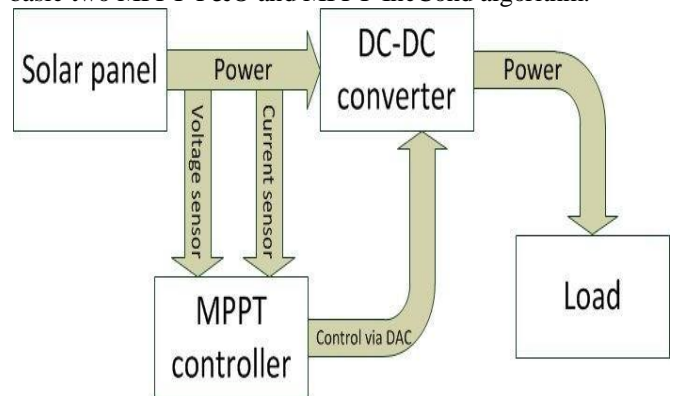


Figure 1. MPPT block diagram.

Perturb and Observe (P&O)

The first one is P&O algorithm, which is used to track the maximum power point. It can calculate the power at the PV array by determining the value of voltage and current. P&O links to determine the variation in PV array voltage and current by linking the present and past values 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, on the left of the MPP, increasing the voltage to get to the Maximum power point, whereas on the right of the MPP, decreasing the voltage to get to the Maximum power point, which finally will increase the output power.

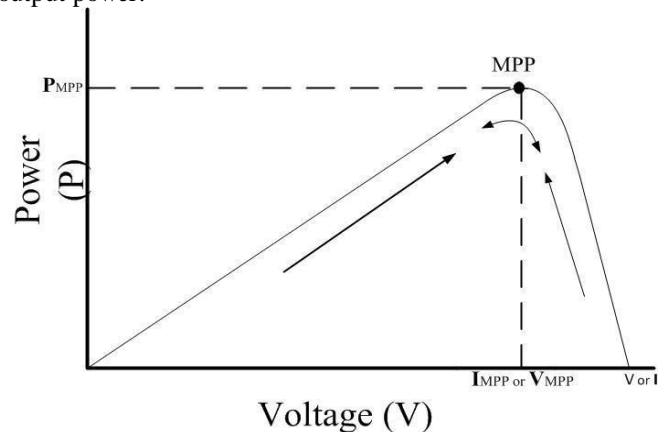


Figure 2. P-V characteristics

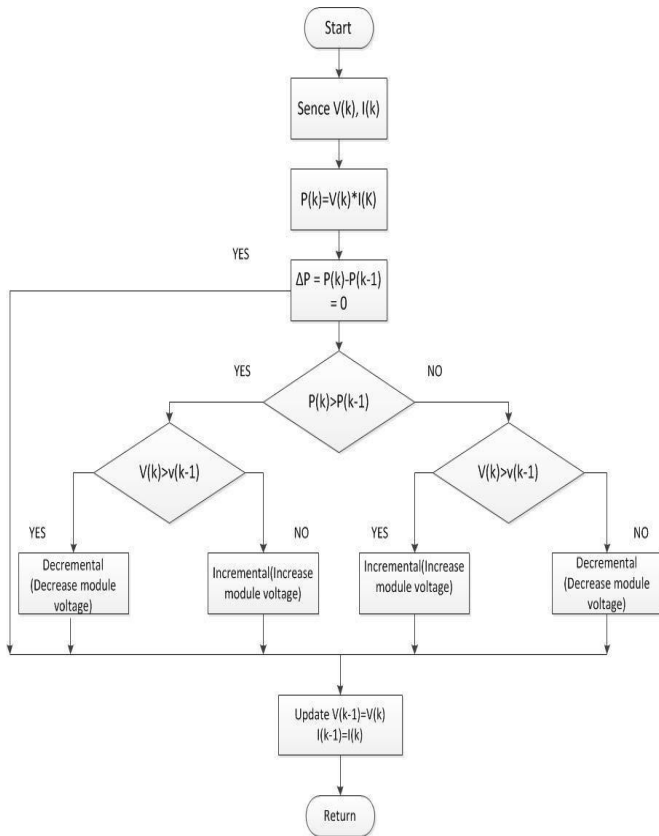


Figure 3. Perturb and Observe (P&O) flowchart

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 IncCond method, as was mentioned earlier. A scheme of the algorithm is shown in the figure 2.

Incremental Conducance (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.

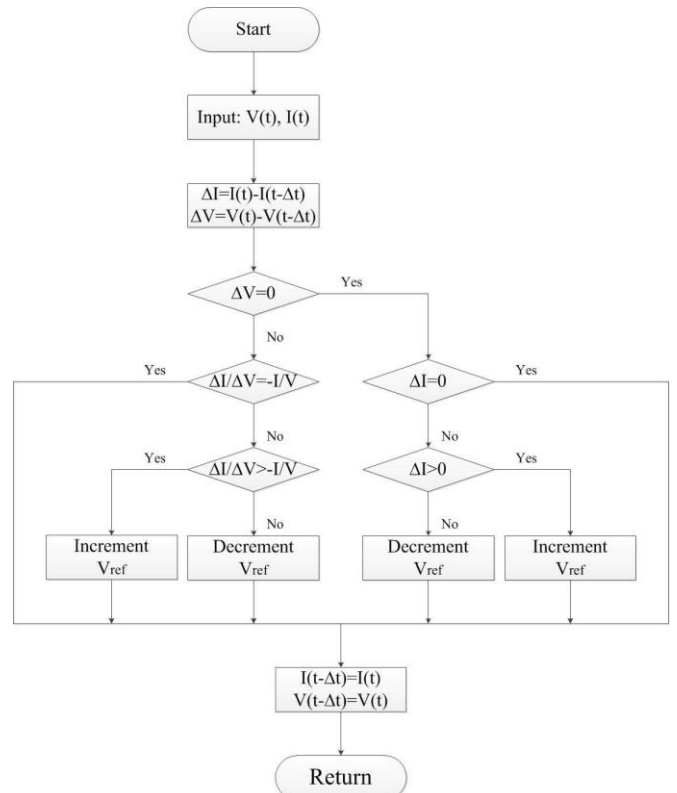


Figure 4. IncCond Flowchart

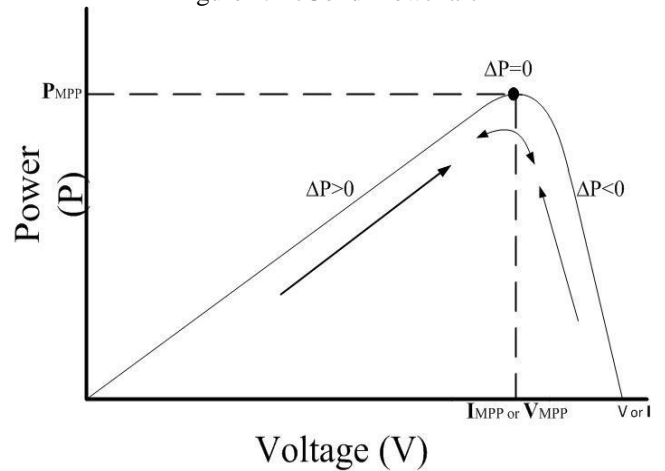


Figure 5. P-V characteristics of IncCond.

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 dI/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.

II. D.C TO D.C BOOST CONVERTER

Boost converter is used to boost the DC voltage from the PV Array to a higher value to satisfy the required output voltage. Boost converter is controlled by MPPT to extract maximum power by controlling the duty cycle of PWM generator. Boost converter can easily be designed by using formula as given below:

Here, D is the Duty Cycle which is to be calculated for V_{in} = minimum input voltage to boost converter. V_{out} = output voltage and efficiency is considered because boost need to also supply the dissipated energy:

$$D = 1 - \frac{V_{IN(min)} \times \eta}{V_{out}} \quad (1)$$

I_L = Inductor ripple current is to be calculated and considered to be 20% to 40% of the maximum output current $I_{out(max)}$:

$$\Delta I_L = (0.2 \text{ to } 0.4) \times I_{out} \times \frac{V_{out}}{V_{IN}} \quad (2)$$

Inductor value is calculated by obtaining all the values including switch frequency as per the equation where F_s is switching frequency:

$$L = \frac{V_{IN} \times (V_{out} - V_{IN})}{\Delta I_L \times f_s \times V_{out}} \quad (3)$$

The below equation is used to adjust the output capacitor values for limited output voltage ripple:

$$C_{out(min)} = \frac{I_{out(max)} \times D}{f_s \times \Delta V_{out}} \quad (4)$$

After studied all materials on D.C to D.C boost converter, I have conclude that the working of boost converter is depends on MOSFET triggering pulse control. The duty cycle is control the ON and OFF operating time of MOSFET while the inductor and capacitor design is also useful for the maximum output voltage at load side in the proposed boost converter. The boost voltage is calculated as given below:-

$$V_o = \alpha V_{dc}$$

Where,

$$\alpha = \text{Duty Cycle of Boost Converter}; \alpha = \frac{T_{on}}{T} = \frac{T_{on}}{T_{on} + T_{off}}$$

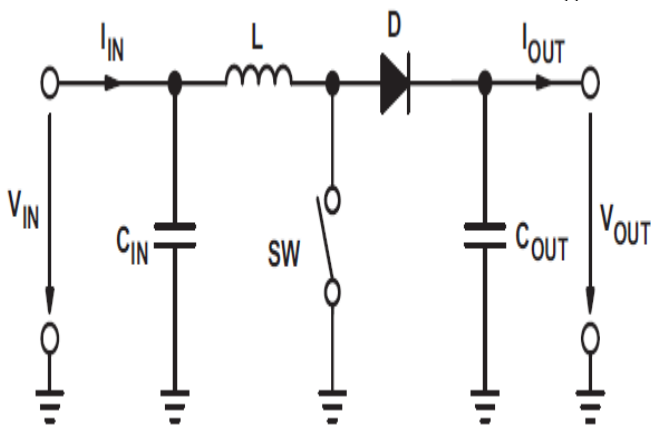


Fig.6- Boost Converter Configuration

As shown in the figure below the boost converter voltage is varied using triggering pulses given to MOSFET for conduction.

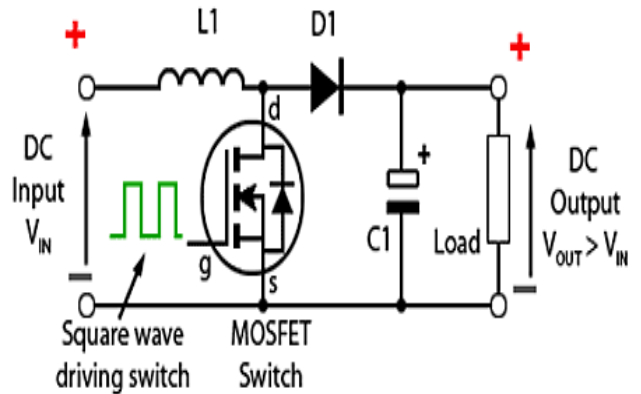


Fig.7- D.C to D.C Boost Converter Design

III. SIMULATION AND HARDWARE SETUP

Solar PV System under MPPT Control

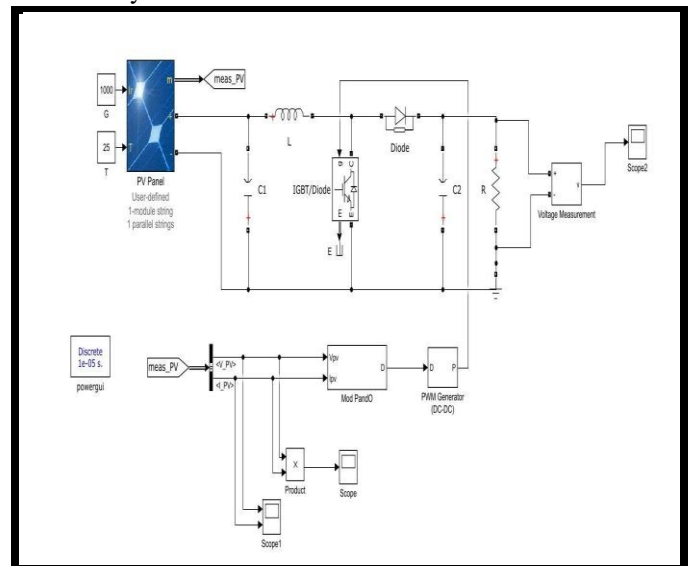


Fig.8- Matlab simulation of Solar PV system integrated with Boost converter and MPPT

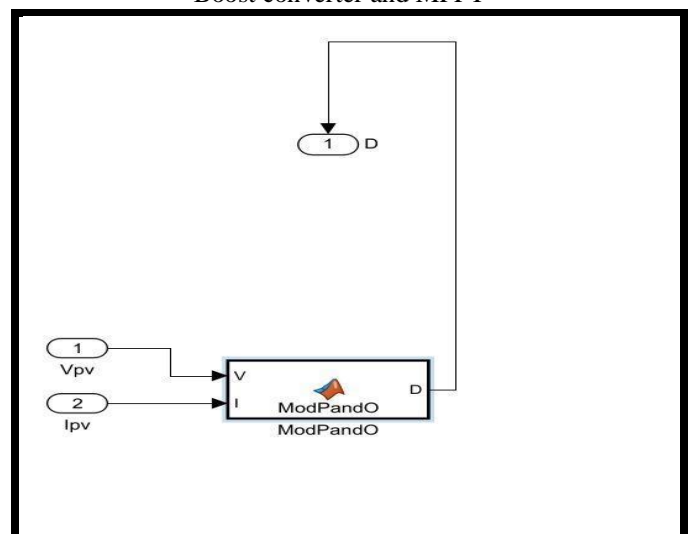


Fig.9 - MPPT Subsystem

The figure shows the Matlab simulation model Solar PV panel is integrated with Boost converter and MPPT. As shown in the fig. we have used Modified P and O algorithm for MPPT control in this paper. The physical parameters of solar PV array are taken as Solar Radiation with 1000 Watt/m² and Temperature with 25 ° C.

The algorithm calculates the parameters and define the duty cycle to achieve maximum output voltage from boost converter.

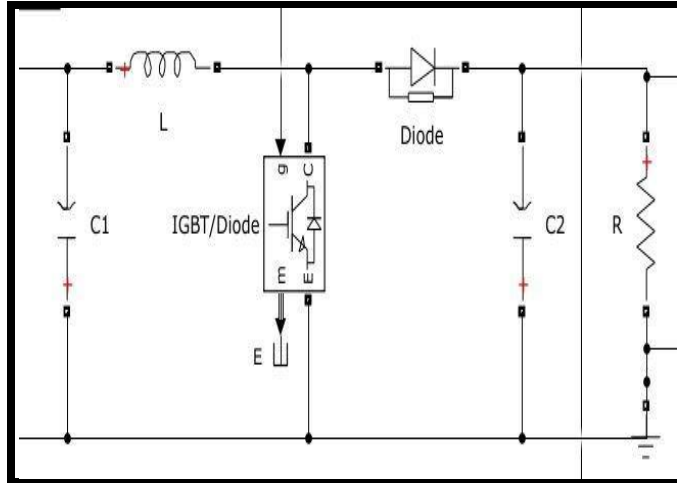


Fig.10- DC to DC boost converter configuration

Simulation Results

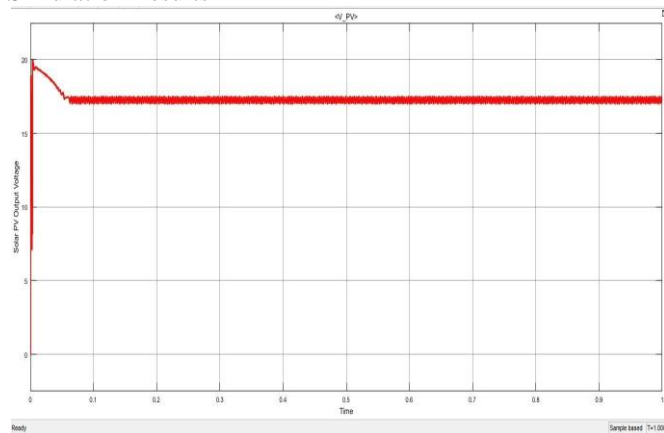


Fig.11 – Vpv

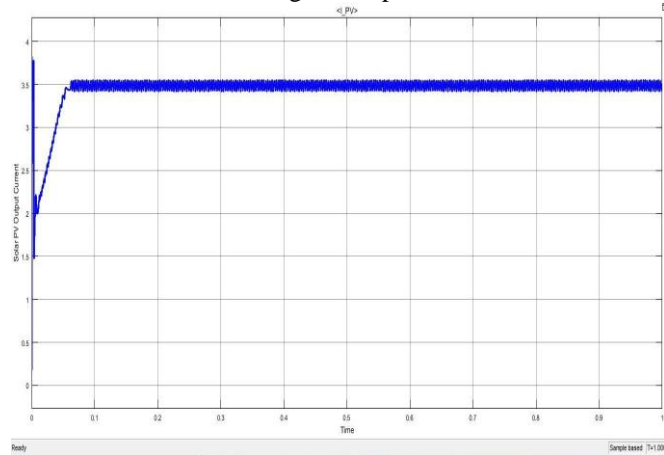


Fig.12 – Ipv

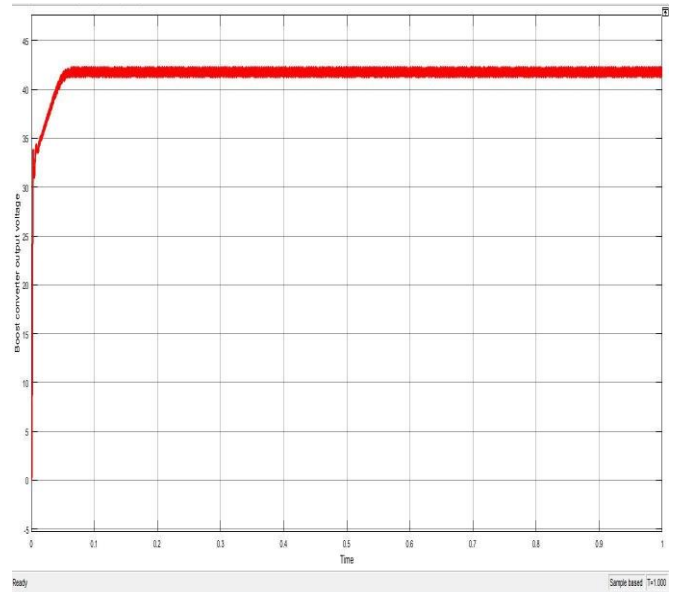


Fig.13 – Boost Converter Output Voltage across load

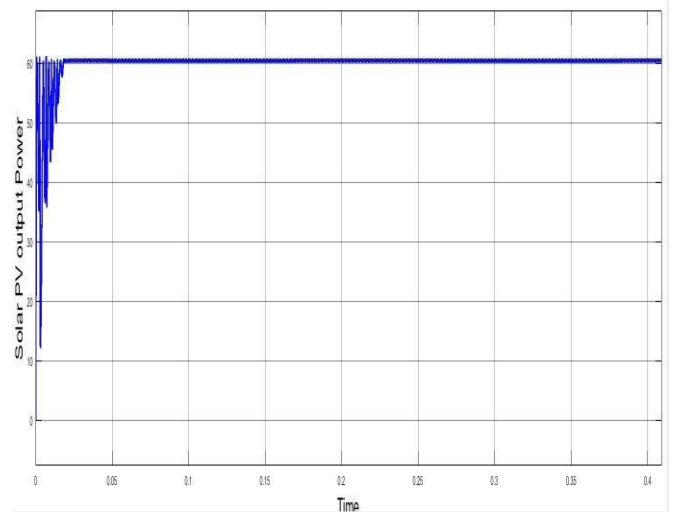


Fig.14- Ppv (O/P power of PV)

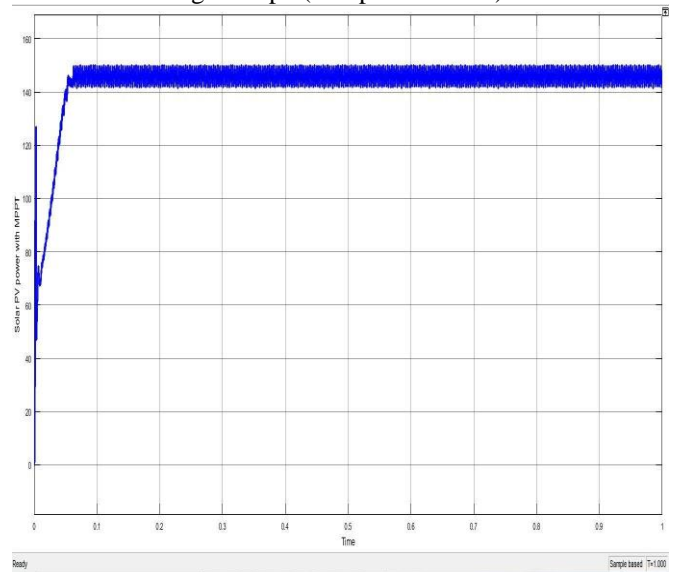


Fig.15- Ppv using Boost converter (O/P power of PV using Controlling)

IV. HARDWARE IMPLEMENTATION

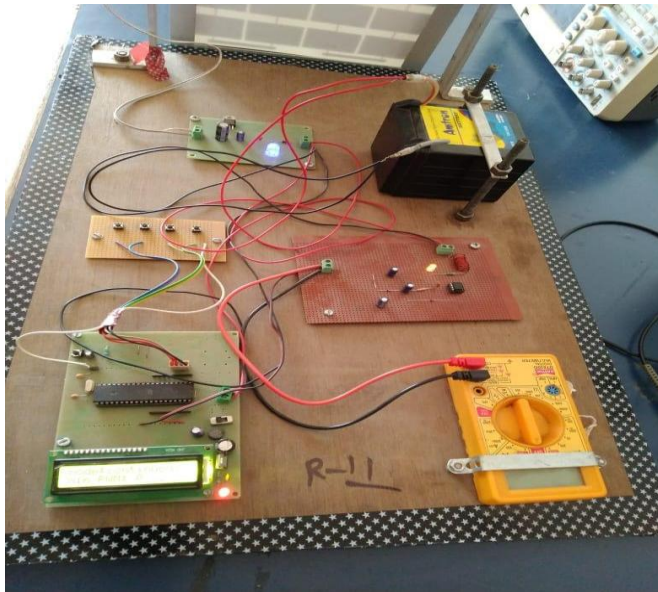


Fig.16- Solar PV System with Boost Converter

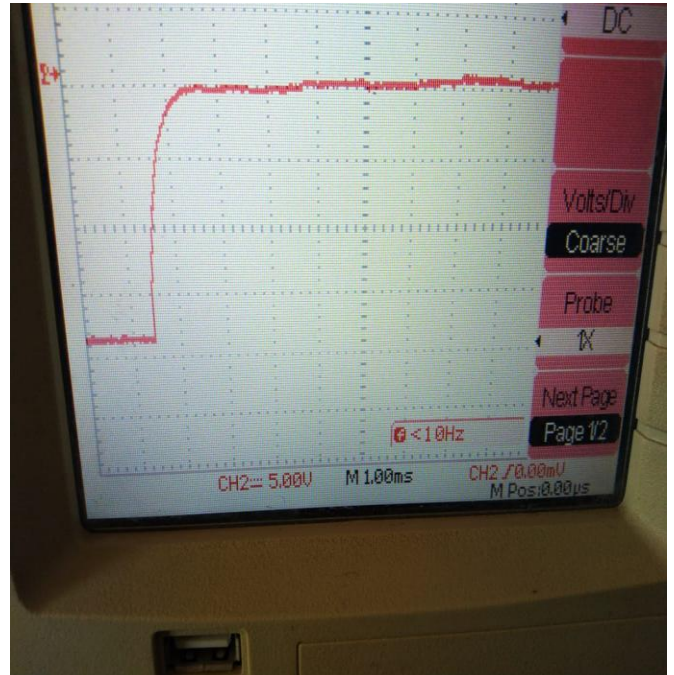


Fig.19- D.C output voltage of Boost Converter

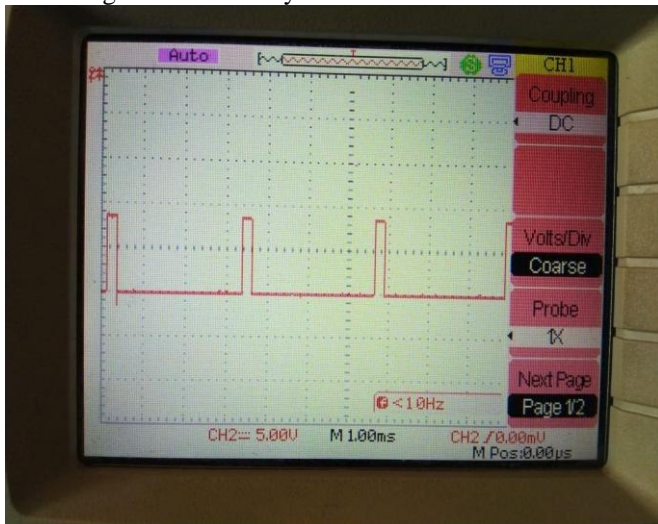


Fig.17- Triggering Pulses for Boost Converter

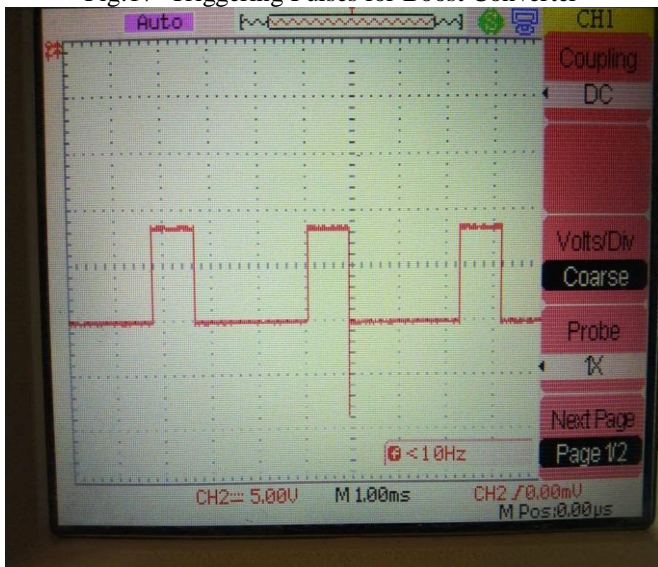


Fig.18- Triggering Pulses for Boost Converter

V. CONCLUSION

This paper presents a Solar PV energy system for standalone system. 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 and MPPT & Boost converter Simulation shows the boost up voltage level done successfully done. The Simulation and Hardware testing is successfully carried out of DC to DC boost converter for Solar PV System.

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. Kaamil 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 RA ECS UIET Panjab University Chandigarh, 06 - 08 March, IEEE-2014.