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Design of MPPT based Solar Photo Voltaic System for Household Applications

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Abstract: Photovoltaic system is used to capture the solar energy. By adapting power electronics converters, maximum power point tracking (MPPT) system can be achieved to trail the maximum power produced. The model consists of two DC-DC converters. For maintaining uninterrupted supply we need to detect solar panels which need proper maintenance. In this regard there is a requirement for low cost monitoring system. This paper discusses the design, development of the monitoring system which employs wireless sensor networks. The proposed system can be extended for broad spectrum of solar panels.

Key Words: Photovoltaic, PV module, MPPT controller; dc-dc converters, buck, boost.

I. INTRODUCTION

Nowadays the point of concern is rapidly increasing demand for power though usual energy sources are not enough to meet nowadays demand. At the same time presuming about forthcoming availability of usual power generation sources, it becomes essential to shift from the usual sources and explore for the renewable sources. These sources must be employed along with conventional sources to appease the demand. To meet the energy crisis renewable methods are proposed one of them being solar energy where power is extracted from approaching radiation known as Solar Energy. Solar energy is abundantly available to us on the earth surface thereby its energy can be trapped and converted to required form and use it effectively with use of maximum power point techniques (MPPT). Power generation depends on several factors such as the utility, location, availability of power grid and the generated power can be grid connected or can be isolated or can be standalone system depending upon the application. The important benefits of solar power are (1) Fuel cost is negligible and (2) During the operation no green house gases are emitted. Another advantage is its portability in small power generation. In the preceding years the power conversion for solar energy has been significantly improved. The research in the field of power electronics and material science have helped the engineers to develop a system that is compact, effective and powerful.

The efficiency of PV modules has been boosted by doing significant research in the field of semiconductors. Several techniques have been proposed to treasure the point where maximum power can be generated by a PV module. This paper analyzed how a distinct converter alters power at the output terminals of a PV module and inspects whether the particular technique is remarkably efficient and trails the true MPP under different situations. Fig. 1 represents the schematic diagram of the suggested system.

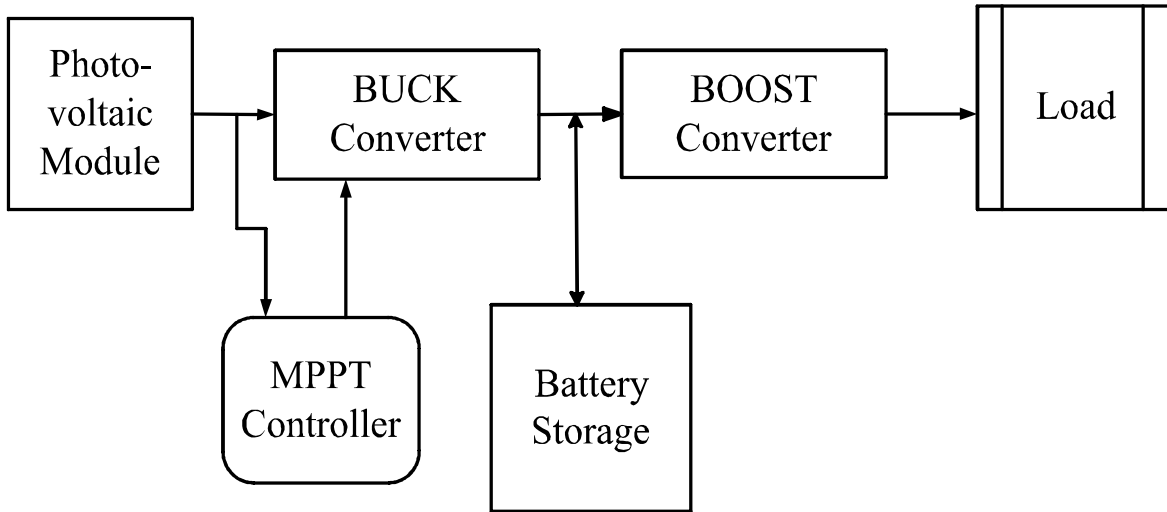


Figure 1: Schematic Diagram of the suggested system

II. DC-DC CONVERTER

The two different types of DC-DC converters are a) Buck converter b) Boost converter

(A) Buck Converter

The buck converter is among the types of DC-DC converter as shown in Fig. 2. In buck converter the output voltage is less than the input voltage so the conversion ratio $M = V_o/V_i$ is less than 1 and it alters according to switch duty ratio D . Buck converter is termed as step down converter.

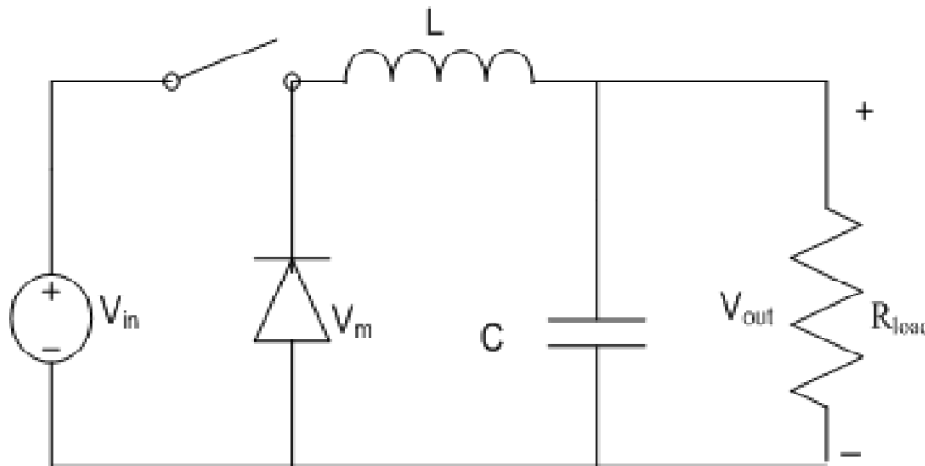


Figure 2: Buck Converter

(B) Boost Converter

The boost converter is another type of DC-DC converter as shown in Fig 3. It is termed as step-up converter. As the name entails this converter converts a low input to a high out-put hence the conversion ratio M is greater than 1.

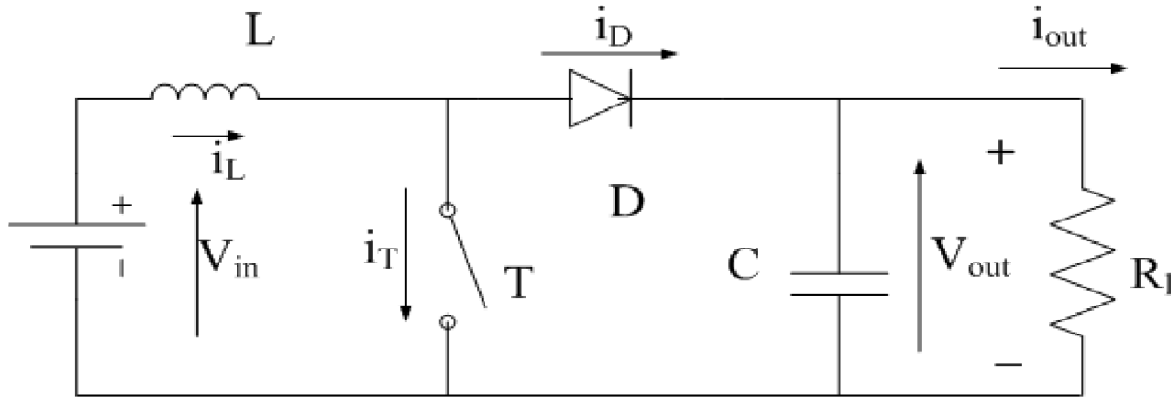


Figure 3: Boost Converter

III. PROPOSED MPPT CIRCUIT

The basic impediment with the renewable energy sources is its intermittent nature. Solar and wind energy are the two important sources of power generation. But the limitations available with both the sources are i) presence of wind energy is unpredictable and ii) irradiation levels of solar energy vary due to different climatic conditions. These limitations make these renewable systems inefficient. But these systems efficiency can be improved by assimilating MPPT techniques.

The characteristic equation of turbine power has been described by Eq (1). The equation communicates the mechanical power which has been originated by the wind in terms of turbine parameters

$$P_m = 0.5 \rho A C_p (\lambda, \beta) v_w^3 \quad (1)$$

where C_p is the power coefficient which is a nonlinear function that represents the efficiency of the wind turbine. Efficiency in case of wind turbine is the ratio at which wind energy is converted into mechanical energy. The pitch angle, β , refers to the angle in which the turbine blades are aligned with respect to its longitudinal axis. The tip speed ratio TSR λ , refers to a ratio of the turbine angular speed over the wind speed. TSR can be calculated mathematically as shown in Eq (2).

$$\lambda = \frac{R\omega_b}{v_w} \quad (2)$$

A photo voltaic (PV) cell comprises of a P-N semiconductor junction which harvests current. A number of PV cells are connected in series and in parallel to build PV arrays. Basically a PV cell is a diode of a large-area forward bias with a photo voltage and the equivalent circuit of PV cell is shown in Fig.4.

$$I = I_{ph} - I_D \quad (3)$$

$$I = I_p - I_o \left[\exp\left(\frac{q(V - R_s I)}{AK_B T}\right) - 1 \right] - \frac{V + R_s I}{R_{sh}} \quad (4)$$

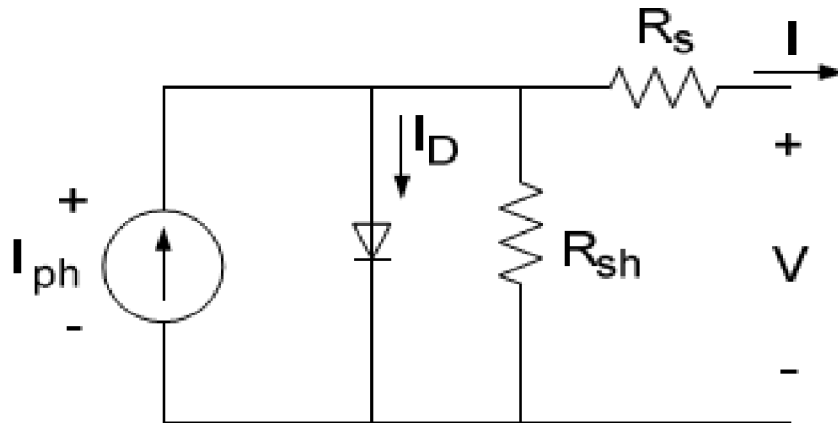


Figure 4: Equivalent circuit of PV cell

Generally, the shunt resistance (R_{sh}) in a PV cell is hefty and the series resistance (R_s) is minuscule. To facilitate the modeling of PV cell the resistances are neglected. The ideal equation of PV cell is given by Eq(5) and characteristics by Fig. 5 and Fig. 6.

$$I = I_p - I_o \left[\exp\left(\frac{qV}{KT}\right) - 1 \right] \quad (5)$$

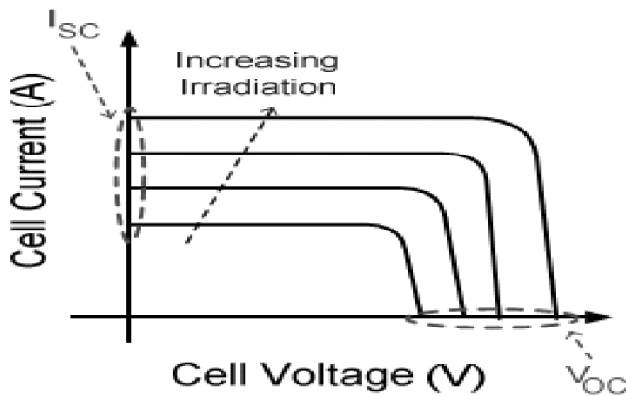


Figure 5: PV Cell voltage current characteristic

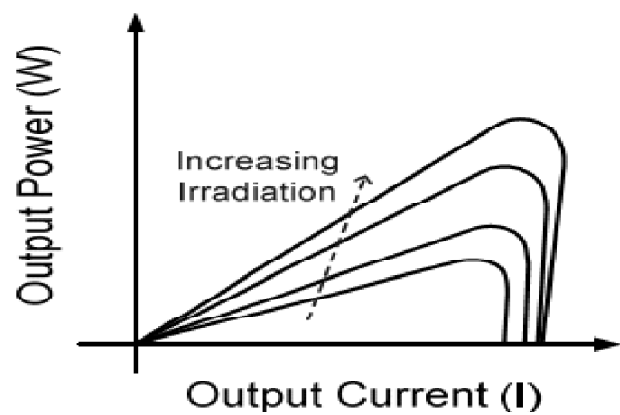


Figure 6: PV Cell power characteristic

PV cell voltage current characteristics are represented in Fig. 5. Fig. 5 clearly indicates that for obtaining maximum output power, there is a particular optimal voltage for each irradiation level. So by regulating current (or voltage) of the PV array, maximum power can be extracted from the array thereby increasing the efficiency of the system.

As the power curves of wind and PV array resemble the same MPPT scheme acknowledged as hill climb search (HCS) strategy is usually practiced to these sources so as to extract maximum power. HCS strategy basically includes Perturb and Observe (P&O) method and Incremental Conductance method. In HCS strategy the output is observed by perturbing the operating point of the system. On observing the output if the change is positive then the control algorithm continues in the previous perturbation. On the other hand if a negative change

is observed then the control algorithm will reverse the direction of the previous perturbation. This process is repeated until the change in power is close to zero (within a specified range). As the change in power is close to zero then the algorithm will invoke no changes to the system operating point as it corresponds to the MPP. The proposed MPPT scheme in this paper is a version of the HCS strategy. Fig.7 is the flow chart that illustrates the implemented MPPT scheme.

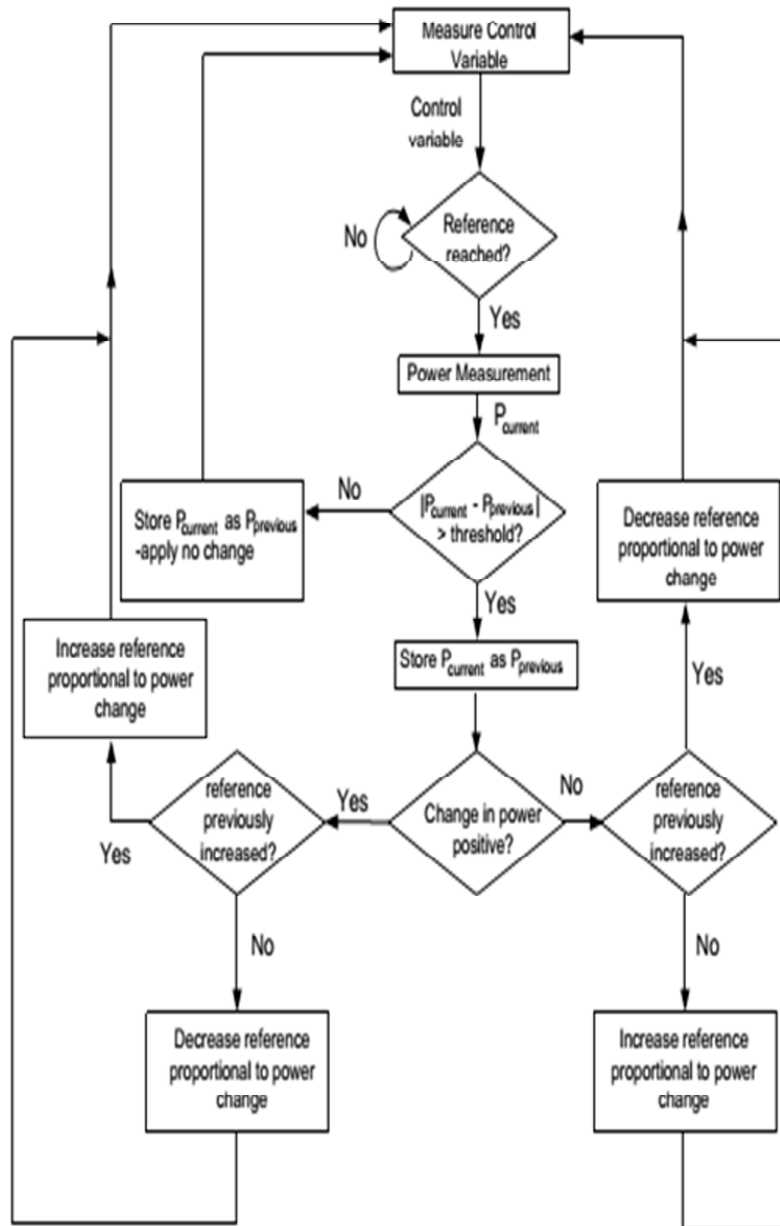


Figure 7: Flowchart of the proposed MPPT scheme

IV. MATLAB/SIMULINK RESULTS

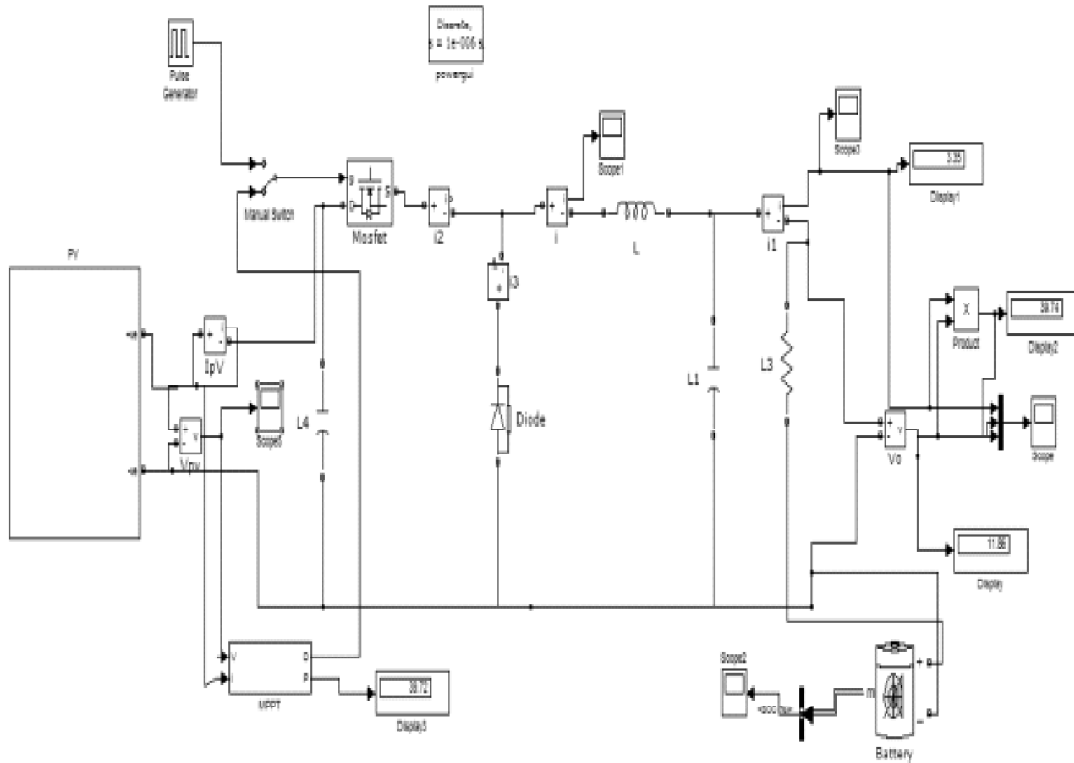


Figure 8: Simulink model of DC-DC converter with PV cell, MPPT and battery

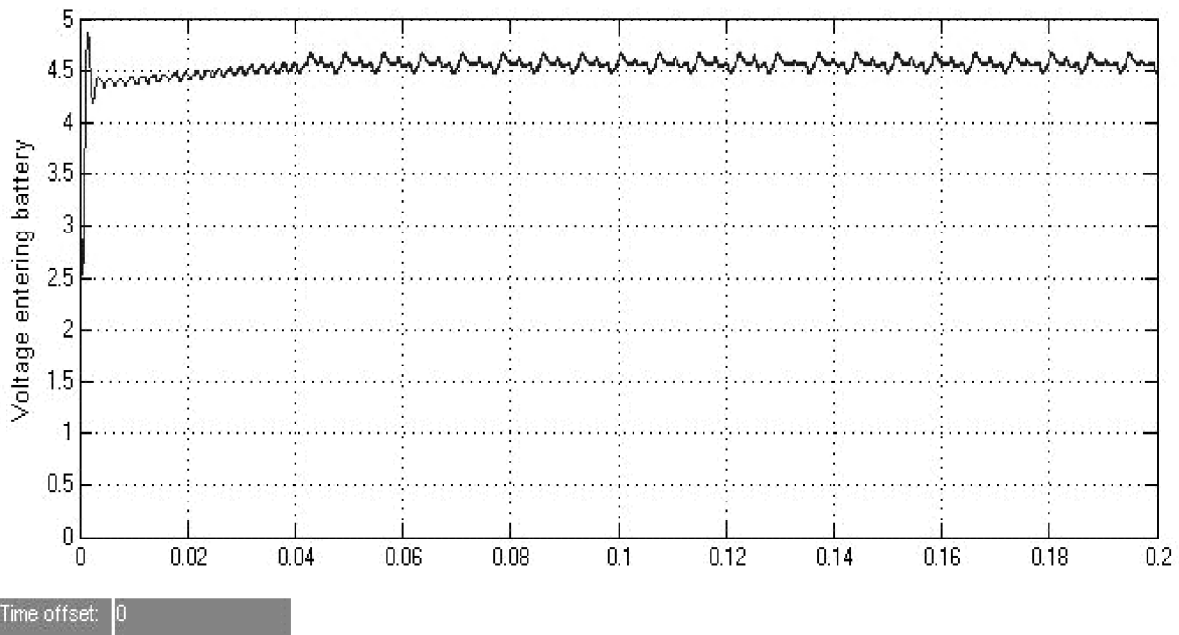


Figure 9: O/P voltage of buck converter with battery

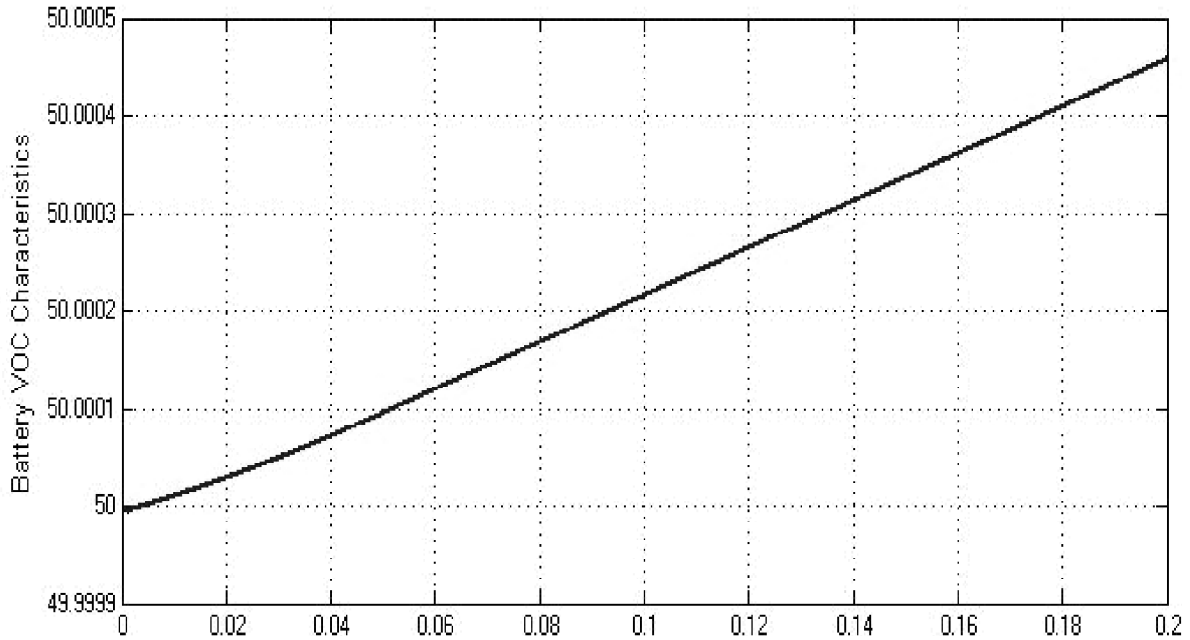


Figure 10: Battery voltage for converter

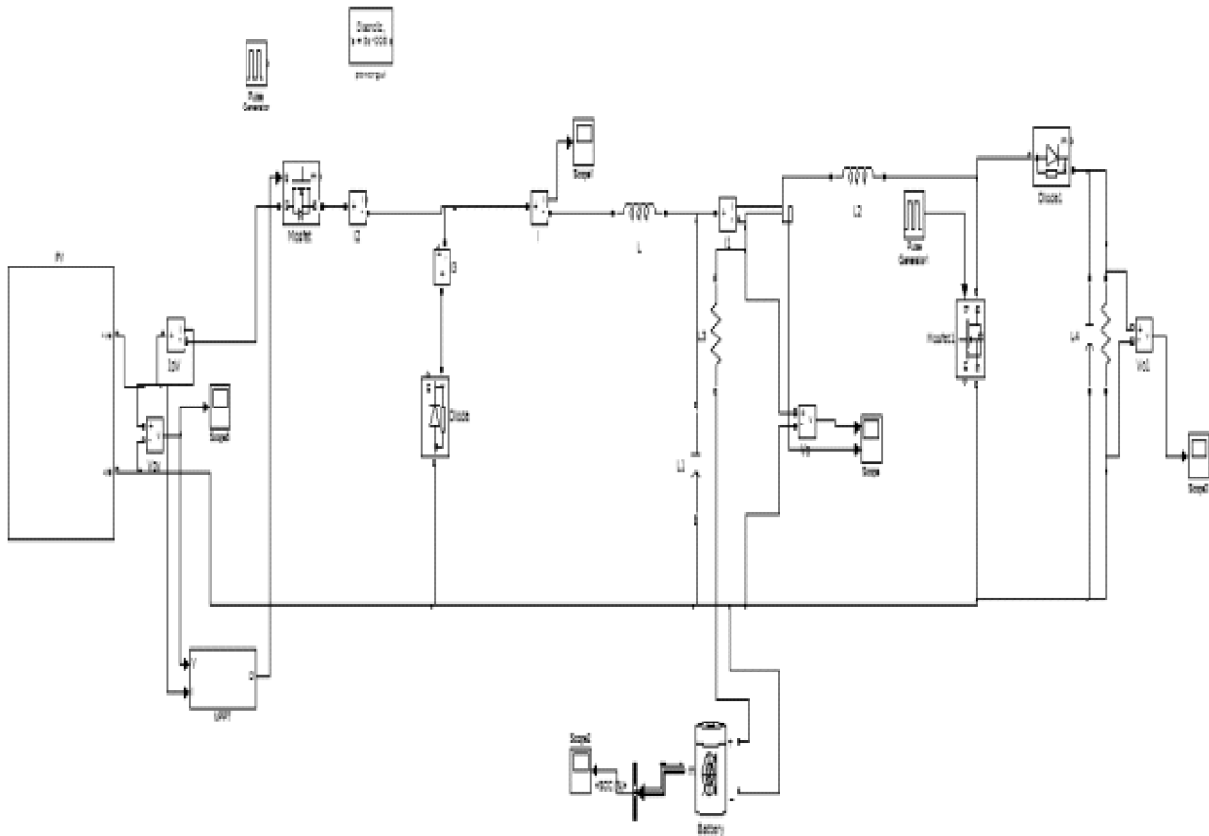


Figure 11: Simulink model of DC-DC buck and boost converter with PV cell, MPPT and battery

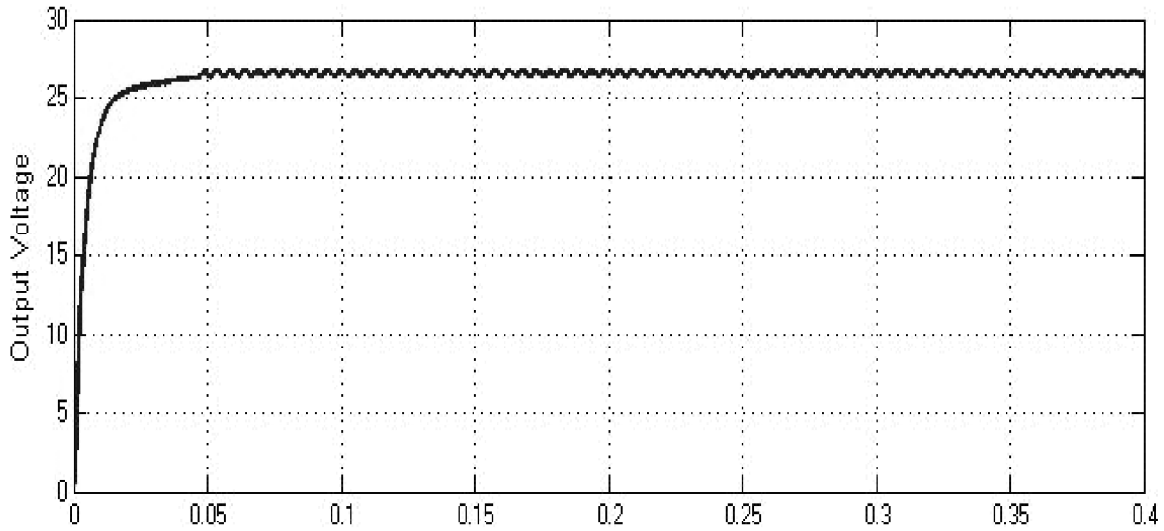


Figure 12: Converter output voltage

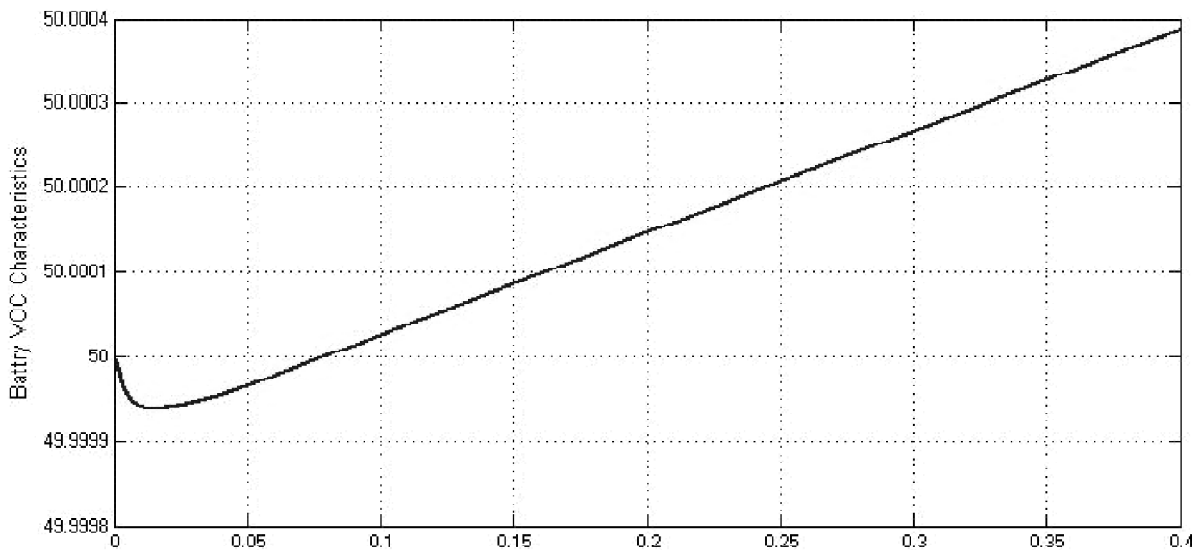


Figure 13: Battery charging voltage with 1W power

V. CONCLUSION

This paper focus on a standalone system operated by combination of two different converters one of converter is operated by MPPT. PV panel used in the simulation has been considered with standard value of irradiation and temperature. On analyzing all the MPPT techniques it has been observed that the best technique is Perturb and Observe (P&O) method. This technique provides a stable output when operated with buck converter. So it can be easily operated for load. So this paper shows that without changing the rating of storage equipment we have implemented two stages of conversion. To satisfy the increase load demand we increase the input PV-module rating thereby maintaining the storage constant. If there is any fault in the battery storage for replacement we have to disconnect entire PV-system, but in this paper, it shows that in place of higher rating storage equipment by using smaller rating storage we can easily replace them and if storage demand increase we can connect them

in parallel with the existing storage equipment. This type of model is used in areas like forest check-posts, toll gates and street lights and house in area where ac-transmission grid network is not available.

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