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Energy Management between Solar Panel and Battery

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Abstract**:** ***This project ensures a reduced energy loss of the renewable source and efficiency of solar and battery network. Because of the erratic irradiations and temperature, the solar source is called an uncontrollable source. In a microgrid, an energy storage device is attached to the photovoltaic system and uses a bidirectional DC-DC converter to monitor the charging, retention and discharge of batteries based on the load requirement. They are simulated to work under five conditions which has different relationships between each other. When synchronized with the battery bank this device acts controllable. Battery helps in reduction of loss of renewable source of energy. The type of operation is determined by the situation or algorithm. An integrated strategy for handling the energy is given to increase the performance of Photovoltaic systems. The expected system efficiency is measured using MATLAB / simulink for varying loads.***

Keywords **:** ***Battery, Energy management, Photovoltaic system, boost converter.***

I. INTRODUCTION

Renewable energies become more reliable because of the precarious condition of fossil fuel declines and the effects of global warming. There are several renewable energy sources available in nature, such as solar, wind, tidal, and hydel. Nevertheless, solar power makes the renewable energy option the most common source without transforming polluting carbon emissions. Solar energy demand has grown over the past 15 years from 20% to 25%. Abundant availability and being environmentally friendly are its key benefits. Hence, in the form of distribution generation (DG), more renewable sources are integrated into the power grid. The efficiency of energy conversion of a Photovoltaic cell is generally poor. Its voltage is about 0.6V, and it is important to monitor the maximum power point of the photovoltaic panel with the help of electronic panel tracing. Because the supply of PV energy in nature is discontinuous, the battery is continuously supplied with chargeable power.

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The generated energy from the photovoltaic panel can be stored in the battery to work as a independent micro grid, or the energy can be transported to the main supply grid[6-7]. Depending on the particular mode of operation this can be changed. The difference between power supply and charging defines the operating mode[8]. The energy management framework for the management of a Micro grid is set out in[9]. This paper addresses the control of power flows to reduce electricity costs and reduce energy losses from renewable resources.

C. Marisarla[10] suggested a Framework for Energy Management to regulate the flow of energy in the off grid composed of PV, cell, super capacitor and load.

Lu and Francois[11] present a Micro Grid Energy Management Framework based on the daily power schedule, taking into consideration the demand forecast and the load forecast.

Program based energy management system for an off grid is introduced in [12]. This paper describes the ideal equilibrium between generation units and the integration of beneficial energy targets into the decision process of the EMS. The Solar Cell Modeling Equations are shown in [13].

The proposed method is applied with isolated, transformer based bidirectional converters[14]. In the given system the Lead-Acid galvanic cell is used because of its low cost and long service life[15-19]. This paper describes the foremost approach to energy storage for a standalone PV / Battery system.

The system 's efficiency is assessed under different operating conditions, and the tests acquired have strong energy management attributes. The rest of the paper is organized as follows: Segment 2 deals with the definition of the standalone device as a whole for PV / Battery. Segment 3 & 4 outlines the design of energy efficient management systems and the different operating modes. Segment 5 validates the given energy efficient management regulation with the help of the results of simulations and Segment 6 outlines the inferences strained from the finding

II. SYSTEM DESCRIPTION

This includes a PV platform with transformer boost and bidirectional converters, batteries, and load. Bidirectional Converter interconnects the battery with direct current charging, and activates three relays.

The designed model's main purpose is to regulate energy between solar panels, batteries and load. This energy transfer is carried out using the five operating modes that running their algorithm to achieve a balance between the load and the battery.

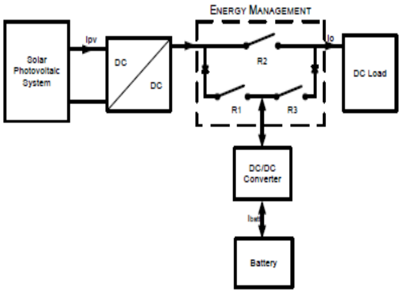

Figure 1. Suggested version of stand-alone PV / Battery network

MODELLING OF GIVEN SYSTEM

A. Dynamic PV Array Model

Normally, grouped cells known as "modules" are covered with different substances for cell protection from the surroundings. Makers supply solar cells in parallel Npm branches composed modules, each with Nsm solar cells in series. Figure 2 shows the complex Photovoltaic Cell module.

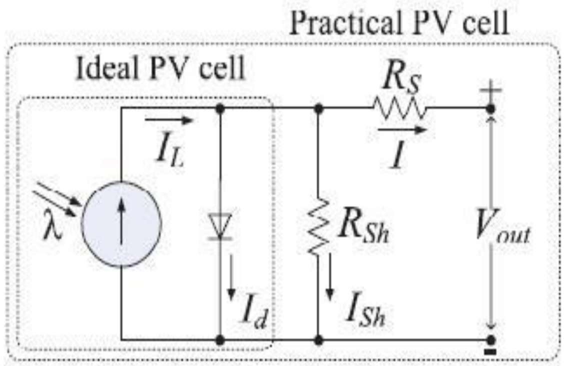

Figure 2. Equivalent photovoltaic circuit

The solar cell does not work during darkness; so it works as a diode, i.e. a P-N junction. It generates a current I_{diode} (diode current), because it is connected to an external supply.

The process of modelling solar cells is established and centered on the equations below [13].

The terminal current I is equal to

$$I = I_{light} - I_{diode} - I_{shunt} \qquad (1)$$

where,

I_{light}, : Current generated by light

I_{diode}, : Current through diode

I_{shunt}, : Leakage current through diode

$$I = I_{light} - I_{reverse} * e^{\frac{q*v}{\alpha kT}} - 1 \qquad (2)$$

where,

$I_{reverse}$: Reverse saturated current [A].

q: Charge = 1.60×10^{-19} Coulombs

k : Boltzmann constant = 1.38×10^{-23} J/k

T : Temperature across pn junction

α : Diode identity factor

B. Boost Converter

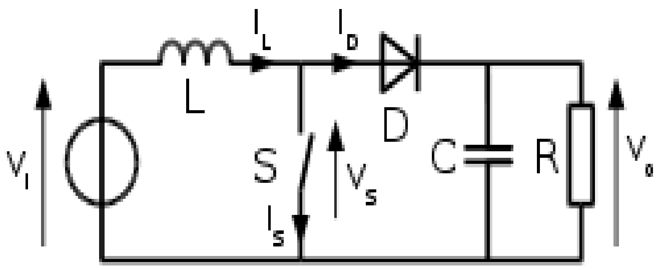

Figure 3. Boost Converter

A Boost converter basically works in two states which are clearly represented in Figure 4 and Figure 5.

- Due to distortion in magnetic field of inductor, inductor current rises. (figure 4).
- Energy transfer occurs as a result of accumulation in the capacitor during ON state. Thus the inductor current can only flow through the diode, capacitor and the load in the OFF state when the switch is open.
- Figure 5 shows that the input current is exactly the same as the current of the inductor. The requirements are relaxed over the input filter, and the input current is also continuous unlike the buck converter.

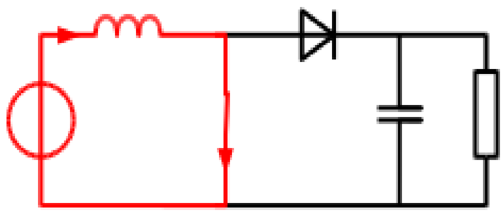

Figure 4. On-State

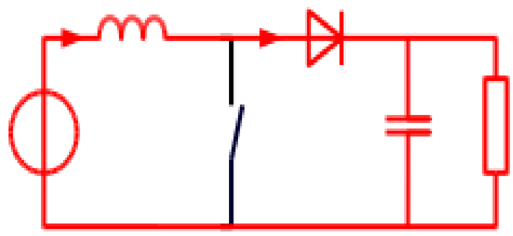

Figure 5. Off-State

C. Electrical Model of Battery

The fluctuating aspect of a PV array makes the Battery an essential element of a photovoltaic system . Figure 6 illustrates the performance feature of a lead acid battery[19] which is the main reason for its use.

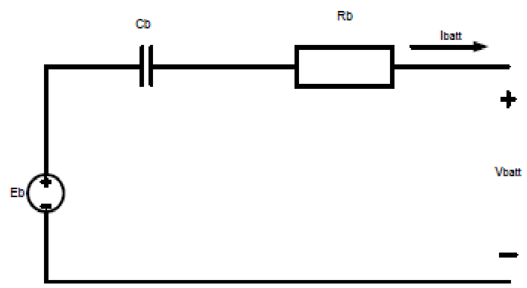

Fig. 6. Equivalent Battery Circuit

For the source voltage E the electromagnetic force is holding in order(series). $R_{internal}$ is the internal resistance.

The battery's terminal voltage is given by:

$$V_{battery} = E - R_{internal} * I_{battery} - V$$

In the equation below, the battery charging status is given as follows:

State Of Charge is the volume of power accumulated while charging.

$$State\ Of\ Charge = 1 - \frac{Q}{C_{battery}} = 1 - \frac{I_{battery} * t}{C_{battery}}$$

where,

Q : amount of energy stored in the battery in ampere hours with current $I_{battery}$ during time t.

$C_{battery}$:nominal battery capacity.

D. Bidirectional DC-DC Converter

Figure 7 represents isolated bidirectional converter which is transformer based.

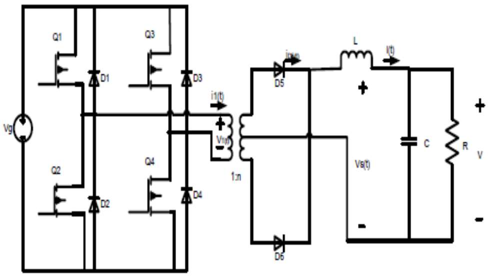

Figure 7. Isolated bidirectional DC-DC Converter (Transformer based)

Compared to other converters the advantages of this particular converter are high since isolated buck is used. The following characteristics are essential to this converter. The bus is connected to the energy storage system. It can be operated through a wide array of power outputs. The additional benefits are its long-lasting bi-directional power flow, operation with high voltage, galvanic insulation, battery life. The battery life is extended by a small ripple DC current draining out of the battery.

III. MODES OF OPERATION OF PROPOSED SYSTEM

A. Modes Of Operation

The proposed stand-alone PV/Battery system works in each of the 5 modes.

Mode- 1: If the power over the photovoltaic array is greater than the power over the load i.e. the photovoltaic array generates excess power than the actual demand, then the excess power is used to charge the battery (Battery Charging).

Mode- 2: If the power over the photovoltaic array is less than the power over the load, i.e. the photovoltaic array generates insufficient power than the actual demand, then the power required is taken from the battery (Battery Discharging).

Mode- 3: When the photovoltaic array produces no energy, the battery supplies full power to the load

Mode- 4: If the power generated by the photovoltaic array is the same as the power over the load then the photovoltaic array provides the load completely without the interference of the battery.

Mode- 5: When the photovoltaic array produces no power, and the battery is drained completely, the load will be disconnected.

B. Simulation Circuit Diagram

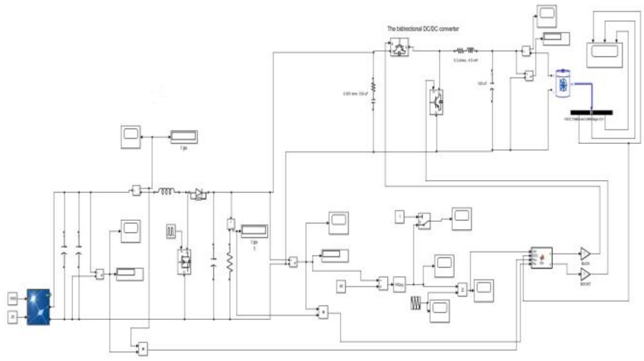

Figure 8. Diagram for simulation of the proposed device

C. Proposed Energy Management Algorithm

```
function [x,y] = fcn(SOC,Ppv,Plo)
x=0; y=0;
Pav=0;
smin=10;
smax=97;
Pav=Ppv-Plo;
If  Pav>0 && SOC<smax
          x=1;
          y=0;
elseif  Pav<0 && SOC>smin
          x=0;
          y=1;
else
     x=0;
     y=0;
end
```

IV. SIMULATION RESULTS

A. MODE 1

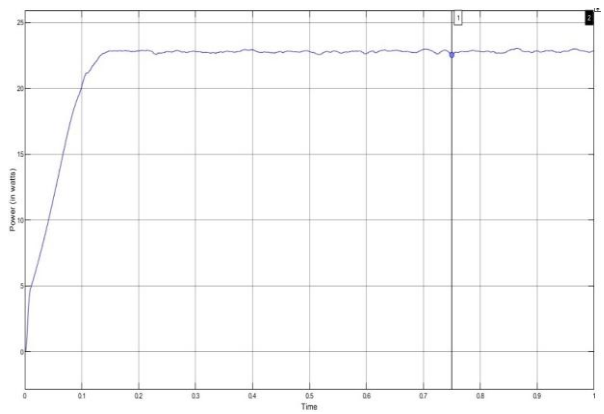

Figure 9. Power across the Load

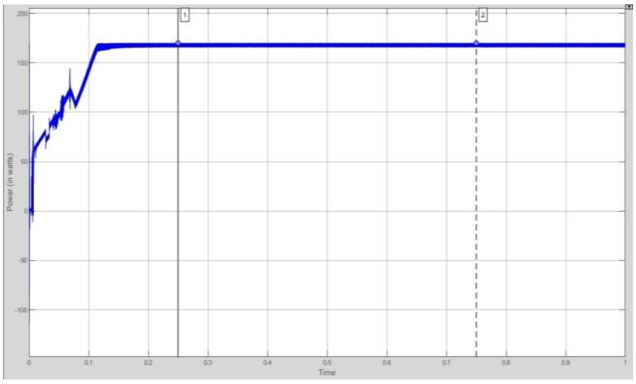

Figure 10. Power across the PV

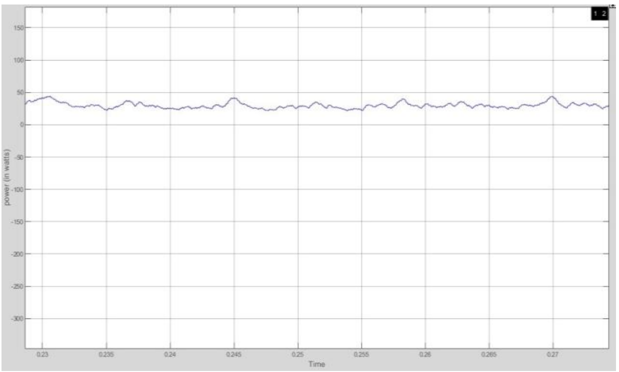

Figure 11. Power across the Battery

B. MODE 2

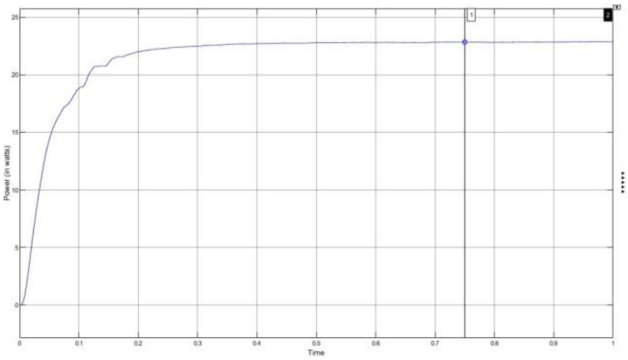

Figure 12. Power across the Load

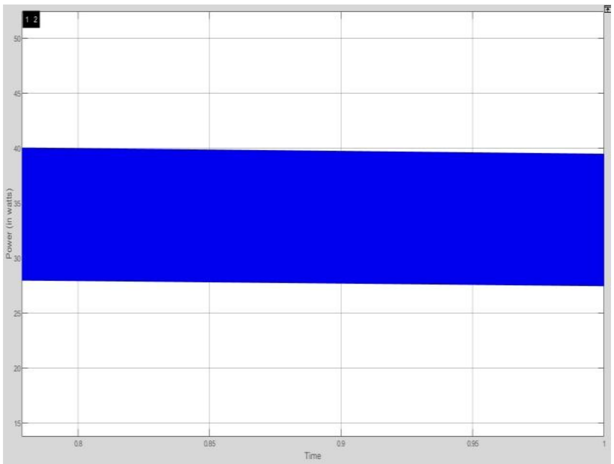

Figure 13. Power across the PV

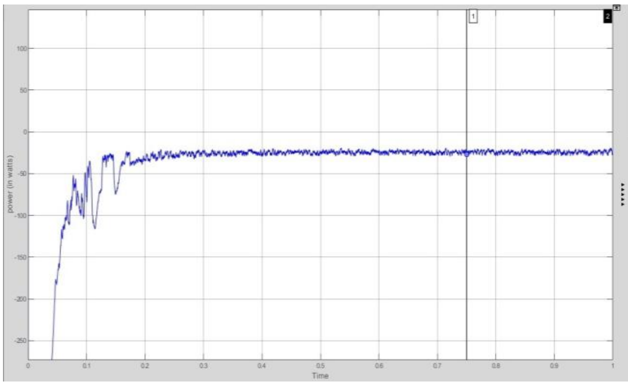

Figure 14. Power across the Battery

C. MODE 3

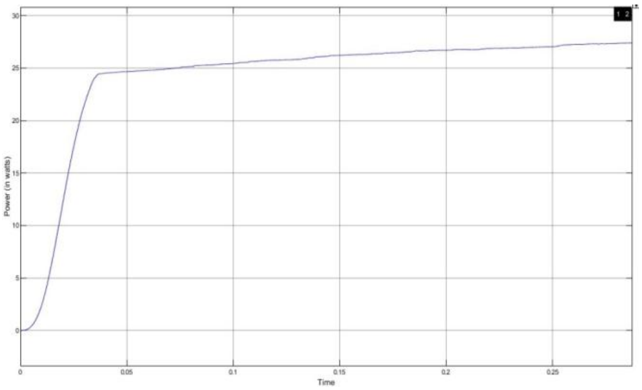

Figure 15. Power across the Load

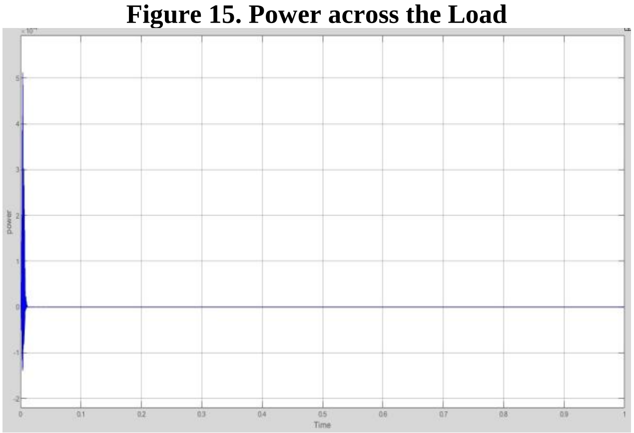

Figure 16. Power across the PV

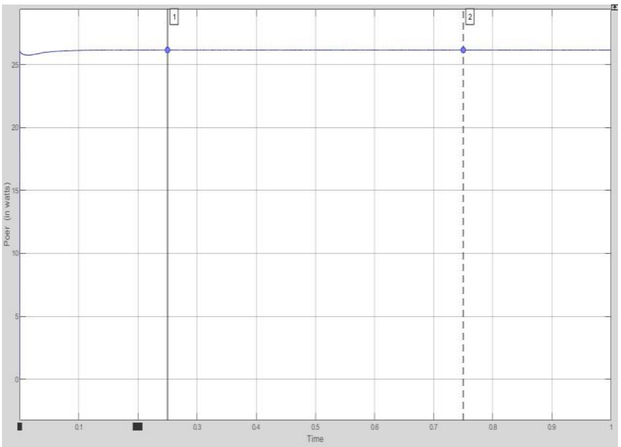

Figure 17. Power across the Battery

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D. MODE 4

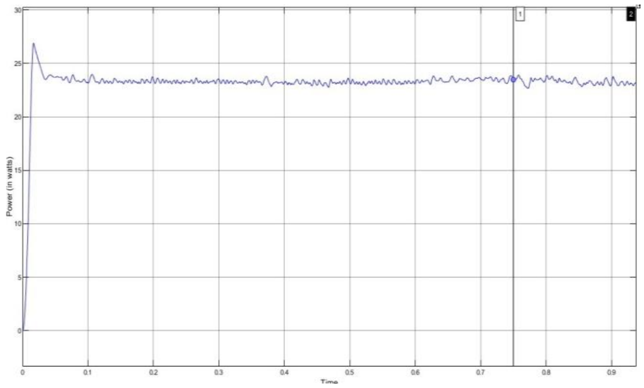

Figure 18. Power across the Load

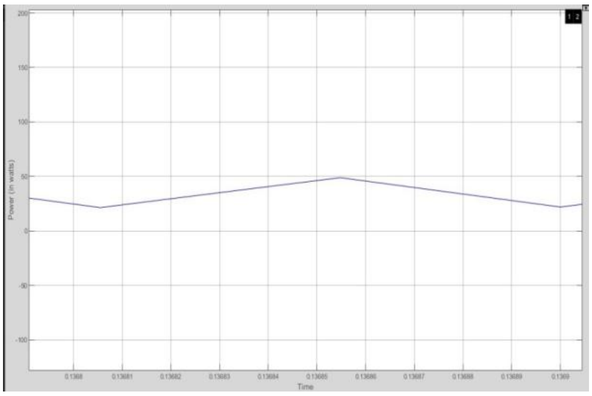

Figure 19. Power across the PV

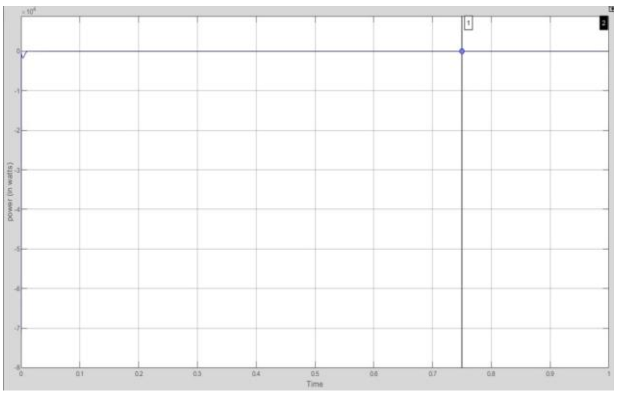

Figure 20. Power across the Battery

E. MODE 5

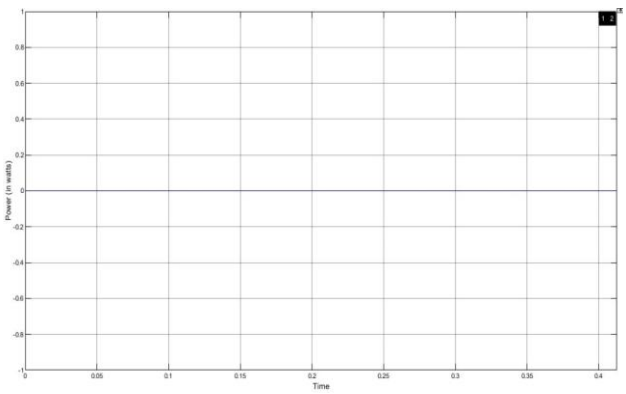

Figure 21. Power across the Load

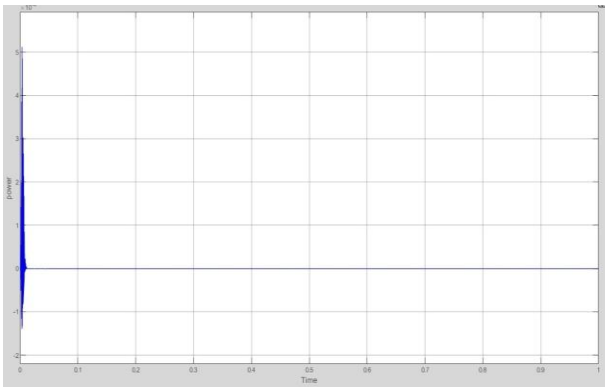

Figure 22. Power across the PV

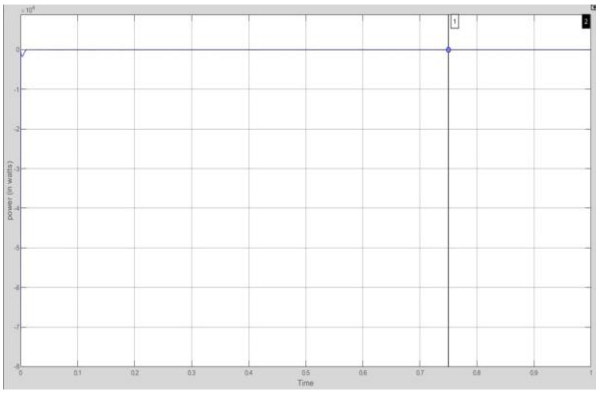

Figure 23. Power across the Battery

F. BATTERY PARAMETERS

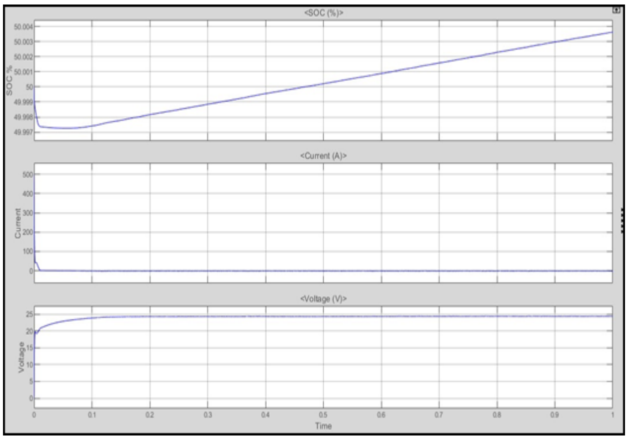

Figure 24. Battery Parameters (when charging)

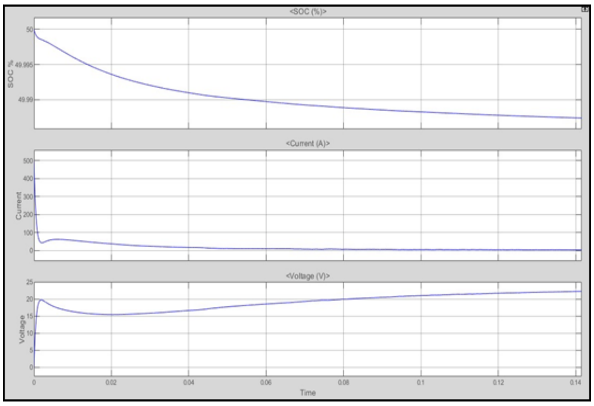

Figure 25.Battery Parameters (when discharging).

V. CONCLUSION

An energy efficient management algorithm has been designed for off grid PV / Battery system. The designed algorithm has an ability to handle and drive through various modes of operation. The study of PV cell modeling was accomplished. To stabilize theamount charge, the battery and PV system are connected to a bidirectional DC/ DC converter. The above simulation result explains that the energy efficient management algorithm will work properly for various charging and discharging values of current in a battery. The bidirectional DC/DC converter compensates for the varying demand of the load.

REFERENCES

1. S.K. Kim, J.H. Joen, C.H. Cho, J.B. Ahn, and H Kwon, Dynamic modelling and control of a grid-connected hybrid generation system with versatile power transfer, *IEEE Trans. Ind. Electron.*, vol. 55, no. 4, p. 1677-1688, Apr. 2008.
2. F. Valenciaga and P.F. Puleston, Supervisor control for a stand-alone hybrid generation system using wind and photovoltaic energy, *IEEE Trans. Energy Conv.*, vol. 20(2), p. 398-405, June 2005.
3. Hamrouni N, Jraidi M, Chérif A. New control strategy for 2-stage grid connected photovoltaic power system. *Renewable Energy*, 2008; 33(10):p. 2212–21.
4. Barbosa PG, Rolim LGB, Watanabe EH, Hanitsch R. Control strategy for grid connected DC–AC converters with load power factor correction. *IEEE Procedings. Gener, Transm Distrib*, 1998; 145(5): p. 487– 492.
5. Koutroulis E, Kalaitzakis K, Voulgaris NC., Development of a microcontroller based, photovoltaic maximum power point tracking control system. *IEEE Transactions on Power Electronics*, 2001; 16(1): p. 46–54.
6. Boucetta Abd Allah, Labed Djamel, Control of Power and Voltage of Solar Grid Connected. *International Journal of Electrical and Computer Engineering (IJECE)*, Vol. 6, No. 1, February 2016, pp. 26~33.
7. Use of Photovoltaics in Microgrid as Energy Source and Control Method using MATLAB/Simulink, *International Journal of Electrical and Computer Engineering (IJECE)*, Vol. 6, No. 2, April 2016, pp. 851~858.
8. http://www.batteryuniversity.com/partone-24.htm
9. R.J. Wai and R.Y. Duan, High-efficiency bidirectional converter for power sources with great voltage diversity, *IEEE Trans. Power Electron*, vol. 22, no. 5, p. 1986-1996, Sep. 2007.
10. C. Marisarla and K.R. Kumar, "A Hybrid Wind and Solar Energy System with Battery Energy Storage for an Isolated System, *International Journal of Engineering and Innovative Technology (IJEIT)*, vol.3, no. 3, p. 99-104, September 2013.
11. S.W. Mohod and M.V. Aware, Micro Wind Power Generator With Battery Energy Storage for Critical Load, *IEEE Systems Journal*, vol. 6, no. 1, p. 118-125, March 2012.
12. C.A. Hill, M.C. Such, D. Chen, J. Gonzalez and W.M. Grady, Battery Energy Storage for Enabling Integration of Distributed Solar Power Generation, *IEEE Transactions on Smart Grid*, vol. 3, no. 2, p.850 - 857, June 2012.
13. Matthew Clayton Such, Cody Hill, "Battery Energy Storage and Wind Energy Integrated into the Smart Grid", *IEEE PES Innovative Smart Grid Technologies (ISGT'12)*, p. 1-4, January 2012.
14. J.F. Manwell and J.G. McGowan, Lead Acid Battery Storage Model for Hybrid Energy Systems, *Solar Energy*, vol. 50, no. 5, p. 399-405, 1993.
15. Lombardi, P., Powalko, M., Rudion, K., Optimal operation of a virtual power plant, *IEEE Power & Energy Society General Meeting*, 2009.
16. Lagorse, J., Somoes, M., A multiagent fuzzy-logic- based energy managment of hybrid systems, *IEEE Industry Applications Society Annual Meeting (IAS)*, 2009.
17. Lu, D., Francois, B., Strategic framework of an energy management of a microgrid with a photovoltaic-based active generator, *ELECTROMOTION*, 2009
18. Pourmousavi S.A., Nehrir M.H., Colson C.M., Wang, C., Real-time energy management of a stand-alone hybrid wind-microturbine energy system using particle swarm optimization, *IEEE Transactions on Sustainable Energy*, 2010
19. Lalouni S, Rekioua D, Rekioua T, Matagne E, "Fuzzy logic control of Standalone photovoltaic system with Battery Storage", *Journal of Power Sources*, vol. 193, no. 2, pp. 899–907, 2009.
20. Akassewa Tchapo SINGO, "Système d'alimentation photovoltaïque avec stockage hybride pour l'habitat
21. énergétiquement autonome", *Doctorat Theses Nancy-I*, 2010.
22. S. Sallem, M.Chaabene, M.B.A.Kamoun, "Energy management algorithm for anoptimum control of a photovoltaic water pumping system". *Applied Energy*, vol.86, pp.2671-2680, 2009.
23. Vellanki Mehar Jyothi, T. Vijay Muni, S. V. N. L. Lalitha "An Optimal Energy Management System for PV/Battery Standalone system". *International Journal of Electrical and Computer Engineering (IJECE)*, Vol. 6, No. 6, December 2016, pp. 2538~2544 ISSN: 2088-8708,

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