Novelty Journals

ISSN 2394-9678

International Journal of Novel Research in Electrical and Mechanical Engineering
Vol. 2, Issue 2, pp: (91-100), Month: May - August 2015, Available at: www.noveltyjournals.com

Implementation of Energy Management System to PV-Fuel cell Hybrid Power Generation System for DC Microgrid Applications

[1]Mr. A. Albert Martin Ruban, [2]G. Mathew Rajasekaran, [3]Mrs. N. Rajeswari

[1]Associate Professor, Kings College of Engineering, Pudukkottai
[2]PG student, Kings College of Engineering, Pudukkottai
[3]Assistant Professor, Kings College of Engineering, Pudukkottai

Abstract: **The main objective of the proposed system is to provide uninterruptible power supply to the load systems. The proposed system mainly deals with the implementation of the Energy Management System (EMS) to the DC microgrid Applications, which consists of the hybrid power sources and storage system. The power sources employed in the system, which obtains its power from the PV panels, and fuel stacks. The storage system employs battery, and the EB system acts as a standby source, which is committed during the power failure condition. The EMS consists of the RS 485 and ZigBee communication protocol for the purpose of communication. The EMS incorporates the fuzzy control, has two roles Energy Management, and battery management.**

Keywords: **Uninterruptible power supply, DC mircogrid system, Energy Management, battery management.**

I. INTRODUCTION

The microgrid system is an electrical network which consists of the interconnected loads and distributed energy generation systems. The development of the hybrid renewable generation system has overcome all the disadvantages of the conventional generation systems. The architecture of the microgrid system consists of the interconnected loads and distributed energy generation systems, that consists of the standalone and grid connected loads applications. The microgrid system enhances the load reliability, reduce emissions and improve the power quality [1]. The implementation of the microgrid components composed of the modeling and integrating the energy sources parallel to the grid. The smart microgrid consists of some challenges are commonly called as the IT challenges for the energy distribution operators. The efficiency and viability of the energy management was improved by using the automated systems that depends on capturing the fine grained data composed of voltage and current consumed by the systems, accepted load demand commands. The process of microgrid system briefly discussed in [2]. The characteristics of the microgrid system are grouping of interconnected loads and distributed energy sources, can operate in islanded mode and grid connected mode if desired, acts as a single controllable entity as load systems. The brief classification of the microgrids are discussed in [3]. The microgrids are exists in USA, Chicago, and in Maldives.

Novelty Journals

ISSN 2394-9678

International Journal of Novel Research in Electrical and Mechanical Engineering
Vol. 2, Issue 2, pp: (91-100), Month: May - August 2015, Available at: www.noveltyjournals.com

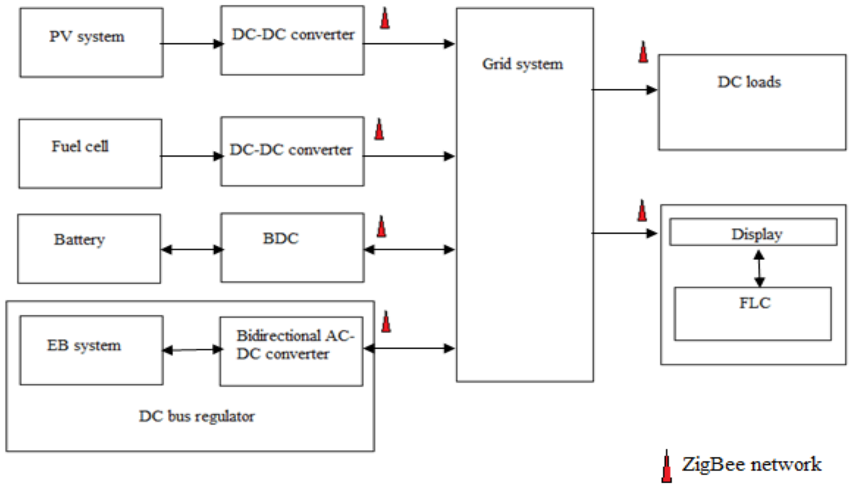

Fig.1. Block diagram of the proposed system

The block diagram of the proposed system is shown in the fig.1. The block diagram of this proposed system consists of five major blocks: generation blocks, storage block, and DC bus regulator blocks. The generation blocks consists of the hybrid power sources, which obtains its power from PV, and fuel cell stacks. The storage system consists of batteries that are the lead acid batteries. The DC bus regulator consist of the EB system, that delivers its power to the DC microgrid systems during the power failure condition. During the normal condition, the maximum power point trackers are associated with the PV system, the delivers power. This power was equally distributed to the loads, storage systems and to the DC bus regulator systems. The generation system and the storage system are connected to the DC grids through the DC-DC converters, and Bidirectional DC-DC converters (BDC) respectively. The EMS consists of the communication systems such as RS 485 and ZigBee communication network protocol. The generation systems, storage system, and DC bus regulator system are provided with the above mentioned communication system, that communicates to the EMS system. This EMS commands the generation system when to operate as per the load demand and State of Charge (SoC) of the battery. This EMS incorporates the fuzzy control algorithm, that gives first priority to the load satisfaction, battery management and selling the power to the EB system through the bidirectional AC-DC converter using the AC grid. The EMS incorporates the fuzzy control are so called as the intelligent control. Such control management system essential for the nonlinear DC microgrid system for the purpose of optimization and distributed energy generation.

II. MODELING OF ENERGY SOURCES

A. Modeling of PV cells:

The equivalent circuit diagram of the solar cell is shown in the fig. 3. The solar cell converts the light energy to electricity [4]

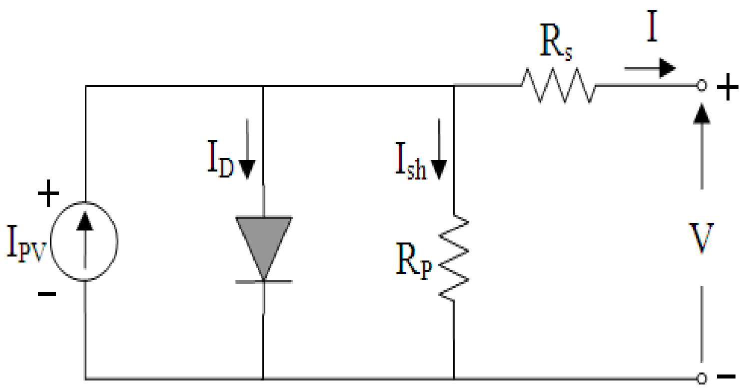

Fig.2. Equivalent circuit of PV cell

The expressions of the PV cells comprised of the PV output current I, diode saturation current I_0 expressed [4] by eqn. (1) to (3)

$$I = I_{Pv,cell} - I_0 \left[\exp\left(\frac{V + R_s I}{V_t a}\right) - I\right] \quad (1)$$

The saturating diode current of the batter is expressed by the following equations (2)

$$I_0 = \frac{I_{sc,in} + K_i \Delta T}{\exp\left(\frac{V_{oc.n} + K_V \Delta T}{a V_t}\right)} \quad (2)$$

The power in the PV panel is expressed by (3) [5].

$$\boldsymbol{P = V\left\{I_{sc} - I_0\left[exp\left(\frac{V}{A * V_t}\right) - 1\right]\right\}} \quad \mathbf{(3)}$$

Parameters of single solar cell are tabulated as follows. The fig. 4, fig. 5, shows the I-V and P-V characteristics of the solar cell.

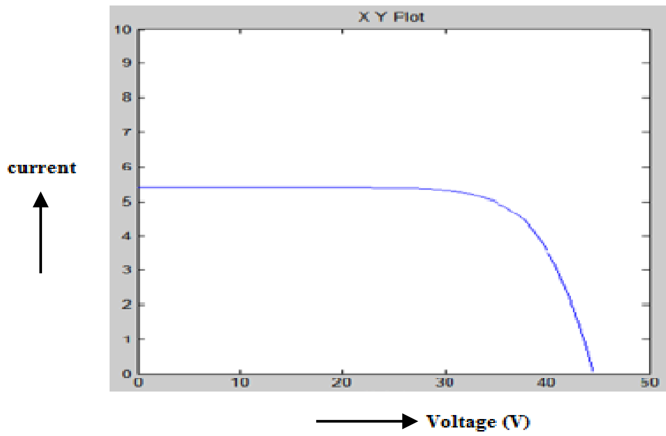

Fig.3. I-V characteristics of solar cell

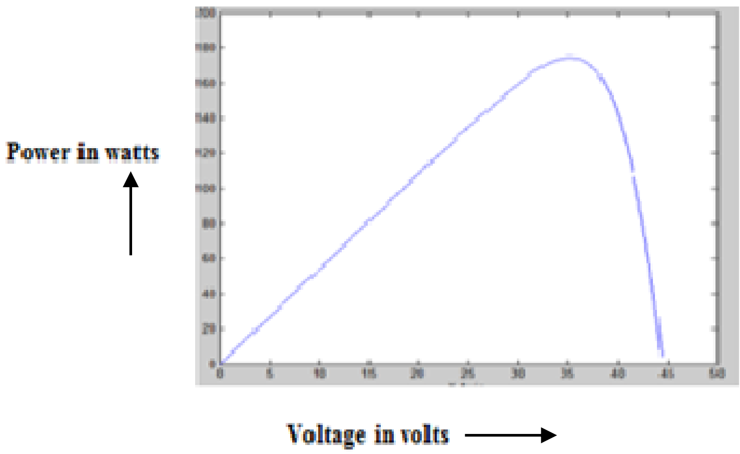

Fig.4. P-V characteristics of solar cell

B. Modeling of fuel cell:

The fuel cell has different types was discussed [6]. The modeling, analysis, simulation of fuel cell, and fuel cell flow control of the fuel cell involves Humindifier and Hydrogen flow control. The simulation of fuel cell involves the steady state simulation and dynamic simulation was discussed [7]. The fig.5. shows the characteristics of the fuel cell.

International Journal of Novel Research in Electrical and Mechanical Engineering
Vol. 2, Issue 2, pp: (91-100), Month: May - August 2015, Available at: www.noveltyjournals.com

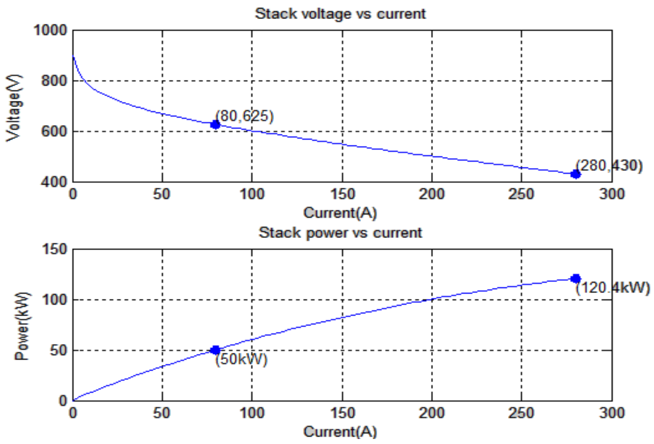

Fig.5. Characteristics of fuel cell

C. Battery:

The battery employed in this system is the lithium ion battery. The battery is meant for the storage application, it acts only during the emergency load conditions, when the SOC value reaches above 90%. The estimation of the SOC of the battery can be determined by the given equation.

$$V_{SOC}(t) = V_{SOC}(0) - \frac{1}{C_{CAP}} \int_0^T i(t)dt \qquad (4)$$

III. INTELLIGENT MANAGEMENT SYSTEM

Conventionally, the decentralized power supply systems are employed for the power generation. This decentralized system optimizes the use of components employed in the power system [8]. The intelligent management system is essential for this decentralized system for the purpose of optimization, and battery management. The intelligent management system also essential for the optimized load flow too The intelligent management system also employs cost prizing of the power, which is consumed by the load.

The switching operation of the power system, especially in the converter employed for the particular converting operation, will also be regulated by this intelligent control system.

The main objective of the installation of the intelligent management system is to avoid the inadequate operating time, protect the storage system. The intelligent management system provides better solution to the load, which supplies from the fluctuating power supply resources. The algorithm implemented in this intelligent management system has been proven, that it provides the better solution for the battery management and optimization. The intelligent management system also responsible for balanced power generation

The intelligent management system employed fuzzy control, for the purpose of optimization and distributed energy generation. The DC smart grid system is the non linear system requires this centralized control system, which offers the practical way for designing the intelligent management system. This management system requires the difference between the actual load and the total generating power of the system (PV, fuel cell) for the battery management. The SoC of the battery is directly proportional to the life time of the battery. The fuzzy employed in this maintains the SoC of the battery.

Fuzzy control:

Fig. 1 shows the block diagram of the proposed energy management system with management control. The fuzzy logic system has two inputs and one output. The fuzzy logic controller decides the charging and discharging operation of the battery, which depends on the SoC. The inputs and outputs of the fuzzy was expressed as follows.

P_e =Total power Generation-Load requirement (8)

SoC_e $=SoC_{command}-SoC_{now}$ (9)

Novelty Journals

ISSN 2394-9678

International Journal of Novel Research in Electrical and Mechanical Engineering
Vol. 2, Issue 2, pp: (91-100), Month: May - August 2015, Available at: www.noveltyjournals.com

The input membership functions P_e and SoC_e are shown in the fig. 6 and 7 respectively. The output membership function of I_C, the charging current of the battery is shown in the fig.8. The fuzzy employs the mamdani type of simulation. The fig.9. Shows the surface diagram of the fuzzy rules

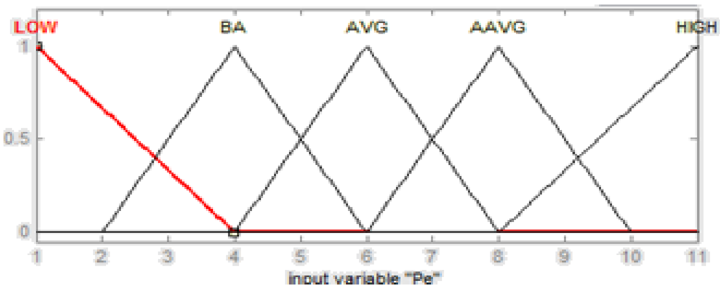

Fig.6. Input membership functions of P_e.

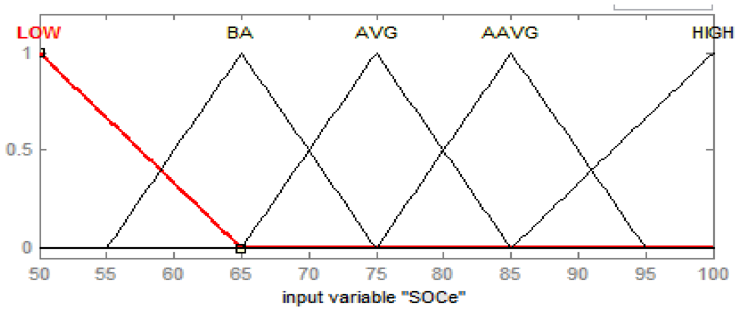

Fig.7. Input membership functions of SOC_e.

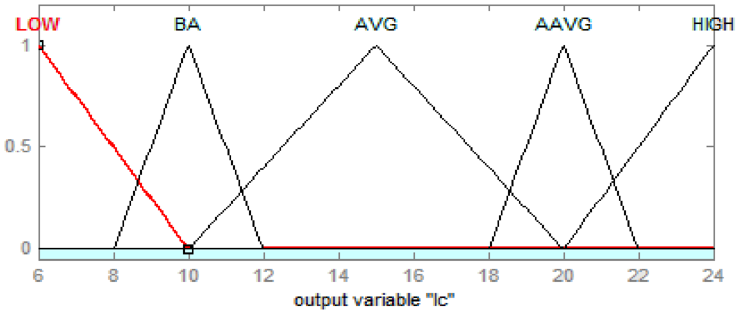

Fig.8. Output membership functions of I_c

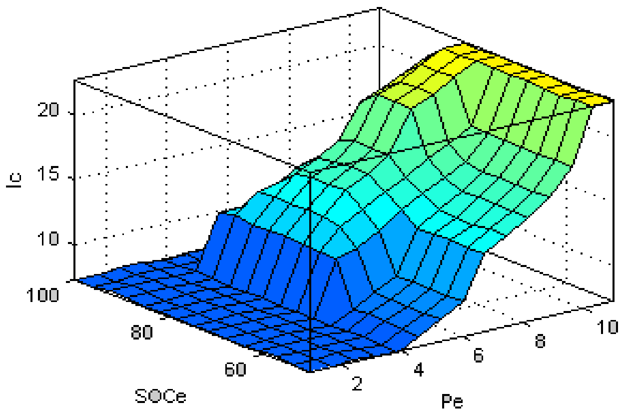

Fig.9. Surface diagram of fuzzy rules.

The control rules of the fuzzy composed of five major grades of membership functions: Low (L), Below Average (BA), Average (AVG), Above Average (AA), and High (H). When P_e is said to be low, which implies the rate generation from the generating sources are low. It (P_e) has a specified low values in the fuzzy as shown in the membership functions. When the P_e is high, which implies the generating power produced by the power resources are high. When the SOC_e is low, which implies the charging state of the battery is low, and it also says that the battery requires the charging current Ic. When the SoC_e is high, it denotes that the charging state of the battery reaches its limit, then the battery is ready to discharge its charges. The values of the SoC_e for the respective grades of the membership functions are shown in the fig. 10. The Ic, is the charging current of the battery, when the Ic is low then it implies that the charging current is low than the required current for the purpose of charging. The Ic is high which indicates the battery charging at the rated current. The fuzzy logic comprises of the number of rules, the lowest value of the SoC of the battery is the 50%. The fuzzy maintains the constant SoC parameters of the battery. The entire operation of the system is controlled by the centralized controller referred as fuzzy. The SoC of the battery is maintained at 50% as its lowest value, the battery has to discharge its charges, when the value of the SoC reaches more than 90%. The fuzzy rules are tabulated as follows:

TABLE: 1 FUZZY CONCEPT RULES

	Pe					
	Ic	**Low**	**BA**	**A**	**AA**	**H**
SoCe	**Low**	Low	Low	BA	A	H
	BA	Low	Low	BA	A	H
	A	Low	Low	A	AA	H
	AA	Low	Low	A	AA	H
	H	Low	Low	Low	Low	Low

This system consists of the PV solar module of 5.6 kW, and the fuel cell of 4.6 kW. The battery employed in this system is the lead acid battery. The initial value of the SoC of the battery is 50% and the final highest value is 100%. The value of the load employed in this system is 5 kW. The control based fuzzy algorithm gives first priority to the selling and to maintain the SoC of the battery.

IV. SIMULATION AND RESULTS

A. Simulation of PV system:

The PV system consists of the PV panel, DC-DC boost converter and the load system. The load employed in the simulation is the resistive load, which represents the DC bus system. The MPPT of the PV system was achieved by using the switched mode converter called as DC-DC boost converters.

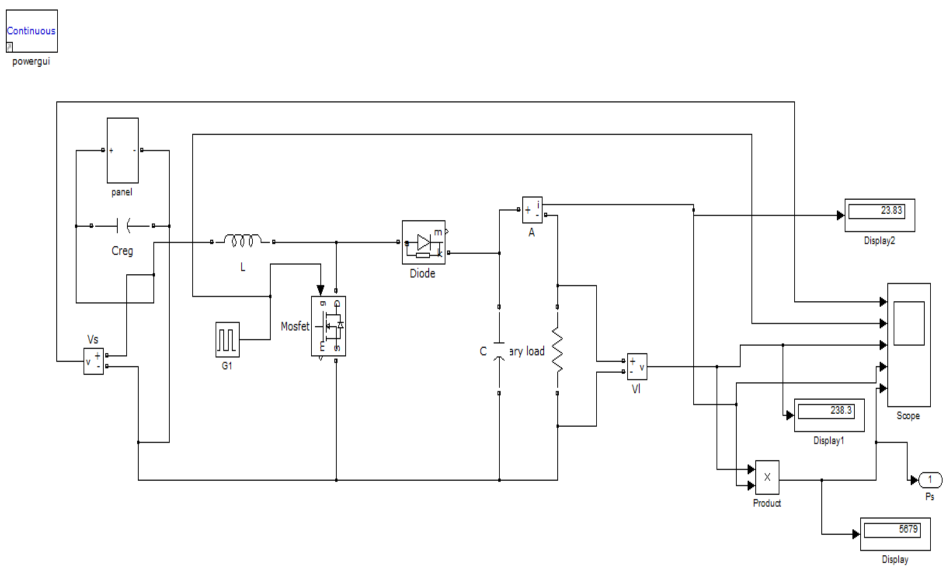

Fig.10. Simulation diagram of PV system

International Journal of Novel Research in Electrical and Mechanical Engineering
Vol. 2, Issue 2, pp: (91-100), Month: May - August 2015, Available at: www.noveltyjournals.com

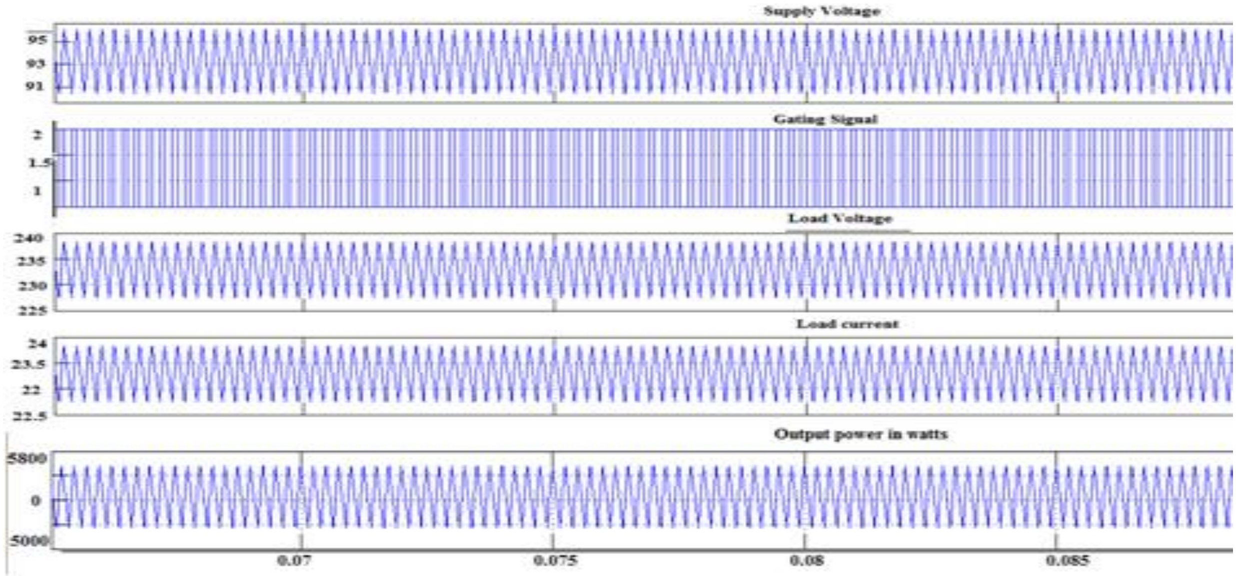

Fig.11. Output waveform of PV system

B. Simulation of fuel cell system:

The simulation of the fuel cell system consists of the hydrogen oxygen fuel cell. The fuel cell system consists of the fuel cell stack, DC-DC converter and a resistive load that represent the DC bus system.

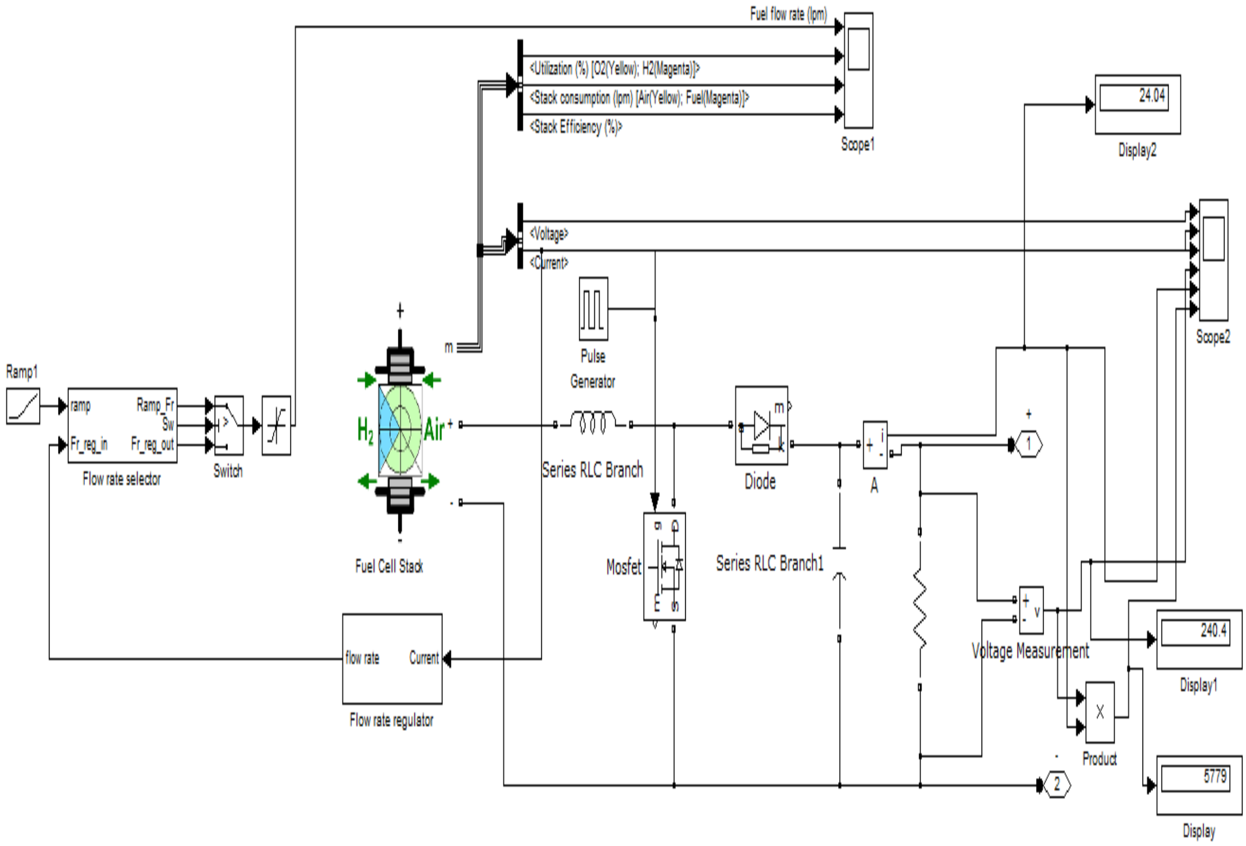

Fig.12. Simulation diagram of fuel cell system

International Journal of Novel Research in Electrical and Mechanical Engineering
Vol. 2, Issue 2, pp: (91-100), Month: May - August 2015, Available at: www.noveltyjournals.com

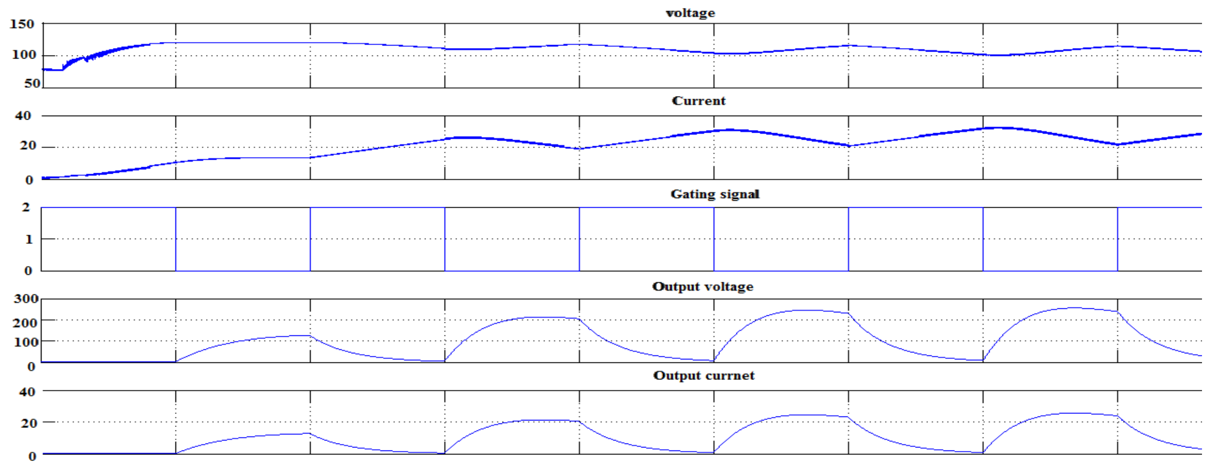

Fig.13. Output waveform of fuel cell system

C. Simulation of battery:

The simulation of the battery consists of the battery with the Bidirectional DC-DC converters, and the resistive loads, which represents the DC bus system.

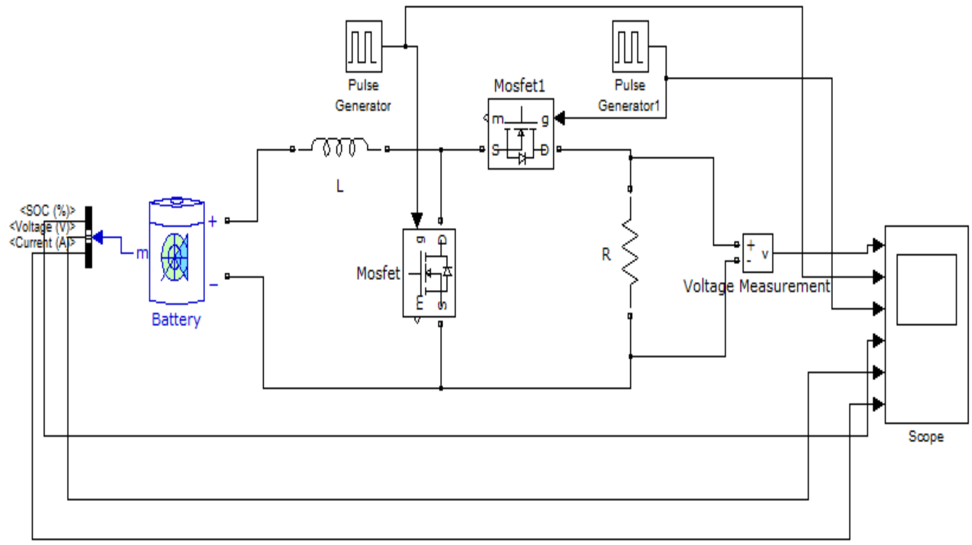

Fig.14. Simulation of battery system

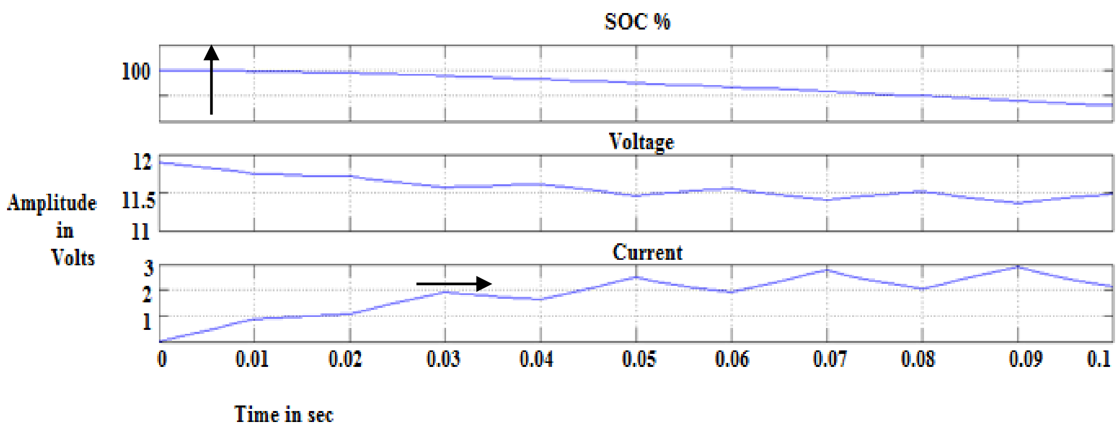

Fig.15. Output waveform of battery system

International Journal of Novel Research in Electrical and Mechanical Engineering
Vol. 2, Issue 2, pp: (91-100), Month: May - August 2015, Available at: www.noveltyjournals.com

D. Simulation of integrated hybrid system:

The hybrid power system consists of the hybrid power sources consists of the PV system, fuel cell system, and battery system.

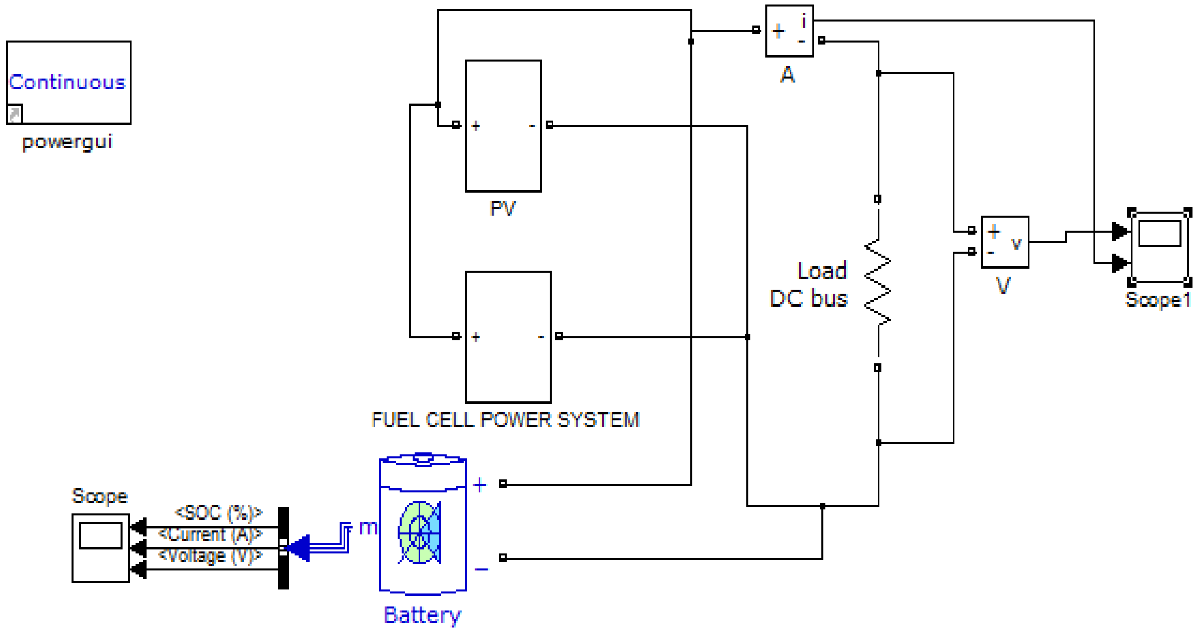

Fig.16. Simulation of integrated hybrid system

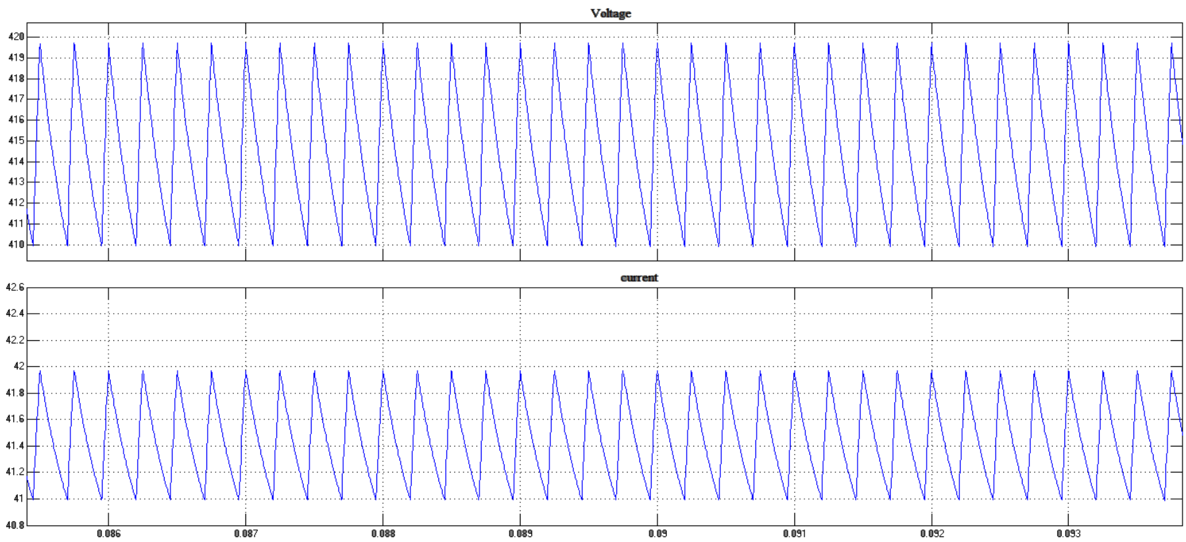

Fig.17. Output waveform of integrated hybrid systems

V. CONCLUSION

This proposed system implements the fuzzy control in the DC microgrid system composed of the DC loads, battery and the EB system. The fuzzy based Energy Management System achieves the optimization and distributed energy generation. The simulation of the integrated system shows the dynamic model of the DC microgrid systems. In future, this system can be implement by using the ultra capacitors, or supercapacitors in order to overcome the disadvantages of the battery. The main disadvantage of the battery is that it requires regular maintainance. The fuzzy based management system can be implement by using the Artificial Neural Network (ANN) concepts.

ISSN 2394-9678

International Journal of Novel Research in Electrical and Mechanical Engineering
Vol. 2, Issue 2, pp: (91-100), Month: May - August 2015, Available at: www.noveltyjournals.com

REFERENCES

[1] Chicago illinous Institite of Technology in “the Smart grid : A Perfect Power.

[2] Advanced Microgrid Solutions “Advanced Microgrid Solutions wins contract to build fleet of Hybrid Electrical Buildings^{TM} for Souther California Edison Co.

[3] Mohd Saifuzam Jamri and Tan Chee Wei “Modeling and Control of a Photovoltaic Energy System using the State Space Average Technique.

[4] Tarak Saluki, Moniur Bouzguenda, and Abel Gastli, “MATLAB/Simulink Based Modeling of Solar PV cells,” International Journals of Renewable Energy Research, vol. 2, No. 2, 2012.

[5] Dominique Boukoungou, Zacharie Koaloga, Douatien Njomo, “Modelling and Simulation of PV considering Single diode equivalent Circuit Model in MATLAB,” ISSN. 2250-2459, Vol. 3, and issue. 3, March 2013.

[6] EG & G Technical services, Inc, “Fuel cell Handbook” edition November 2004.

[7] Jay Taweer Pukur Shipan, “Modeling and Control of fuel cell system and fuel cell processors”, Department of Mechanical Engineering, University of Michigan, Ann Arbor, Michigan.

[8] G. Winkler, “Intelligent Energy Management of Electrical Power system with Distributed Feeling on the basis of forecasts of Demand and Generations.

BIOGRAPHIES

Mr. A. Albert Martin Ruban, M.E., (Ph.D).,
He is currently working as a Associate Professor of EEE department in Kings College of Engineering. He completed his B.E in REC Trichirapally during 1997, and completed his M.E in Power Electronics and Drives in Sathyabama University during 2005. His area of interest is Renewable Energy & Power Electronics and Drives.
Email Id: albertrubankings@gmail.com

G. Mathew Rajasekaran, B.E., (M.E).,
He is a PG student of Kings College of Engineering. He is doing his M.E in Power Electronics and Drives. He completed his B.E-Electrical and Electronics Engineering in Chendhuran college of Engineering during 2013, Pudukkottai. His field of interest is Electrical Machines, Digital Electronis, and Renewable Energy Sources
Email Id: matheweee2013@gmail.com.

Mrs. N. Rajeswari, M.E.,
She is currently working as a Assistant Professor of EEE department, in Kings College of Engineering. She completed her B.E-Electrical and Electronics Engineering in Sudharsan College of Engineering during 2006, and completed her M.E in Applied Electronics during 2009 in Jayaram college of Engineering. Her area of interest is Electromagnetic fields, Electrical Machines, and Renewable Energy
Email Id: rajeswarikings@gmail.com.