I J C T A, 9(2) 2016, pp. 987-995

Power Flow Management and Control of Hybrid Wind / PV/ Fuel Cell and Battery Power System using Intelligent Control

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ABSTRACT

This paper deals with the power flow modulation and control using the various power system. In this paper the efficient usage of power produced is defined. The battery management system is introduced in order to store the excess power produced and use that power in case of power deficiency. The battery management is controlled using the fuzzy logic controller which is one of the intelligent controllers. The fuzzy logic controller is responsible for the battery charging and discharging according to the dc load requirement.

There are three power systems wind, PV and fuel cell connected to the bus bar. The total power system supplies to the load of approximately 10KW. The dc load connected to the power system is variable so the power which supplied to the load is not constant. If the power produced is greater than that of load the fuzzy logic controller closes the breaker 1 contacts and opens the breaker 2 contacts so the battery gets charged. If the power produced is not up to the load requirement then the breaker 2 contacts closes and breaker 1 opens the battery gets discharged. By this method the power supply is constantly given and the wastage of power is reduced and the constant working of load is achieved. The whole setup is done using the MATlab/ SIMULINK software.

Keywords: wind, PV, fuel cell, fuzzy logic controller, battery management.

I. INTRODUCTION

The world which exists is relied on the renewable energy sources. The wind and PV are most prominently used power system because of the abundant availability in nature. This advantage is increased the hybrid usage of the wind and PV in various purpose. In additional to these two fuel cell is added to it. The fuel cell which used here is hydrogen fuel cell which produces the power of 60W it is boosted to 6.5KW. The wind power system produces the power output of 3.5KW and the PV system produces the power output of 1KW. The whole setup supplies to the load of 10KW approximately. The wind power system produces the AC output so the converter is used to convert the AC to DC output.

The wind power system which is used in this proposed model is made using the permanent magnet type. The output from the wind power system is connected to the converter and the given to the bus bar. Each system has its own bus bar and the total system bus bar is connected common bar. The battery management system is connected to the common bus bar with fuzzy logic controller with it. [1-5]

The photovoltaic system is made of polycrystalline type. The photovoltaic system generates the output of 1kw. The entire setup supplies to the peak load in any case. The circuit breakers are connected between the bus bar and the battery. The battery management has an array of 30 batteries which stores the current of 110Ah and has the voltage of 48V. These batteries are arranged in parallel connection.

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The battery management system is connected to dc-dc boost converter which converts the dc power according to the requirement of the load. The power flow management for the proposed system assures the continuous supply to the load with full demand is done. The main aim of power flow management system is to supply the load with its full demand. [5]

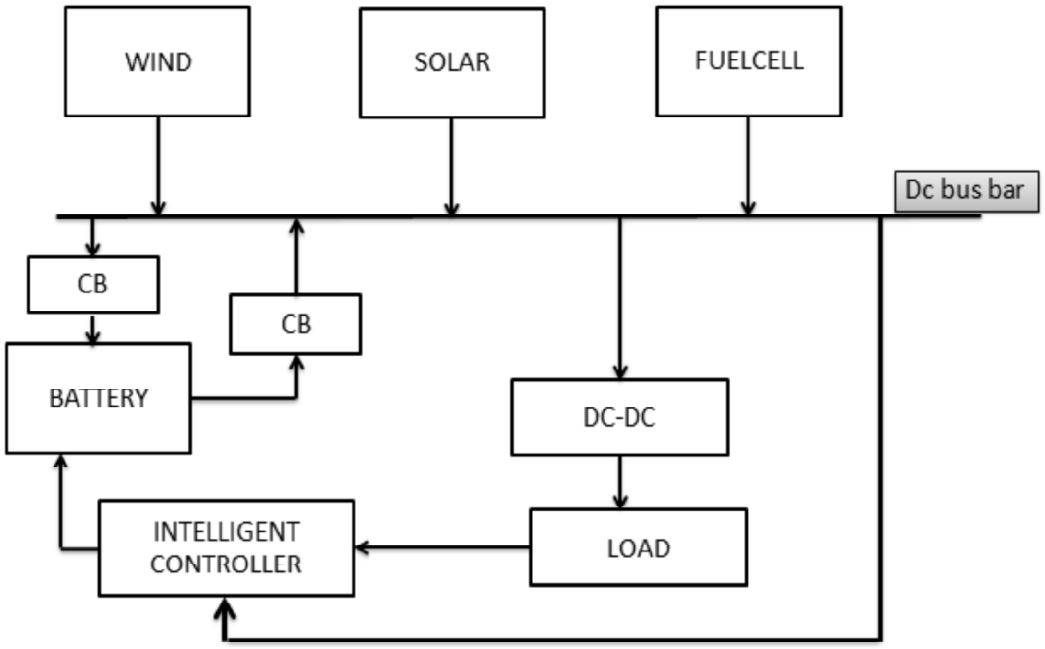

Figure 1.1: Power flow modulation block diagram

This is achieved by monitoring the wind, solar and fuel cell and comparing the output with the load demand. Issue command to the circuit breakers in order to charge and discharge the battery.

II. DESCRIPTION OF SYSTEM

The model which is proposed here has the following

- A 3.5kw wind power system which is attached to the converter which converts the ac output of the system to the dc output.
- A1kw photo voltaic array system which produces the dc output.
- A 6.5kw fuel cell system
- A battery which acts as auxiliary power source in case of the generated power is insufficient to supply the load.
- Managing the system operation and operating the circuit breaker with the help of controller.

III. WIND POWER SYSTEM

The wind turbine generally used in this proposed system is of the horizontal axial wind turbine which is coupled with the permanent magnet synchronous machine. The speed of the wind and the direction of the wind are governed. Normally the pitch angle is given as 0(deg) it may increase or decrease according to the wind direction. The velocity of the wind is maintained constant with the help of speed increaser and constant. [6] [7] Both of these are connected to the shaft with the help of the switch which is controlled manually. Normally the constant is used for the system to generate in case of insufficiency the speed increaser is connected. The wind speed and the pitch angle are constantly verified. The generator output power is

connected to the universal bridge which converts the ac power to the dc power. The figure 3.1 shows the simulation model of the wind power system.

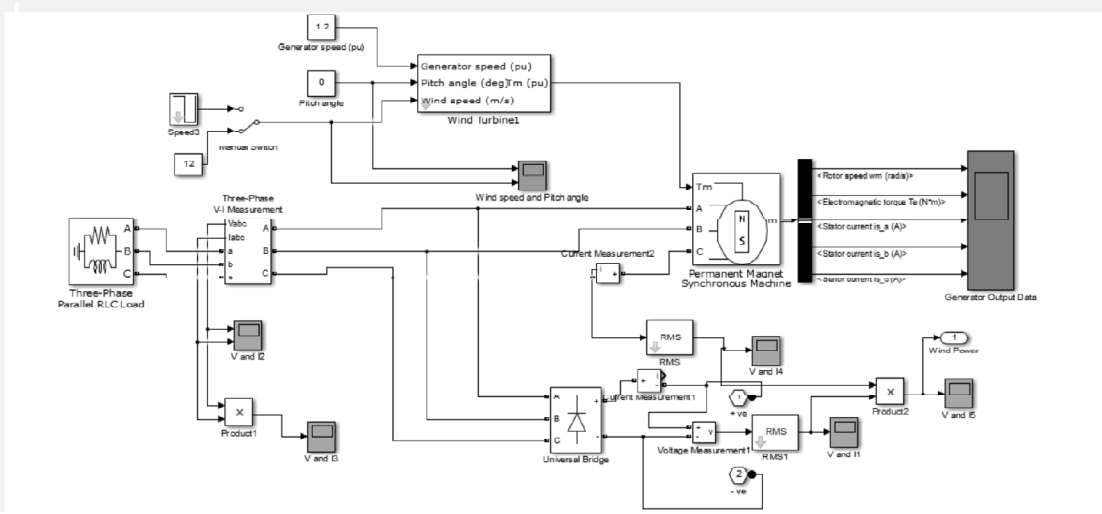

Figure 3.1: Simulation of wind power system

The power which is generated by the wind turbine is generally given as:

$$P_w = 0.5 * C_p * \rho * \pi R^2 * V_v^3$$

Where,

C_p is the coefficient of power.

ρ is the density of air (kg./m^3) .

R is the radius of the blades of the turbine (m).

V_w is the velocity of the wind (m\sec).

To make the efficient usage of power generated from the wind power system it is important to change the rotor speed with respect to the wind velocity. The rotor speed is now adjusted to the wind speed so that the maximum output is achieved from the synchronous generator.

$$P_{max}=0.0007*V_m^{\ 3}$$

The permanent magnet synchronous generator generates about 3.5 kW is employed here. The generator output voltage varies according to the wind speed. Hence the speed changer and the manual switch is employed here to rectify this effect the out is sent to the universal bridge. The universal bridge converts the input ac power to the output dc power. The universal bridge is connected to the dc bus bar which is connected to the other power systems.[8]

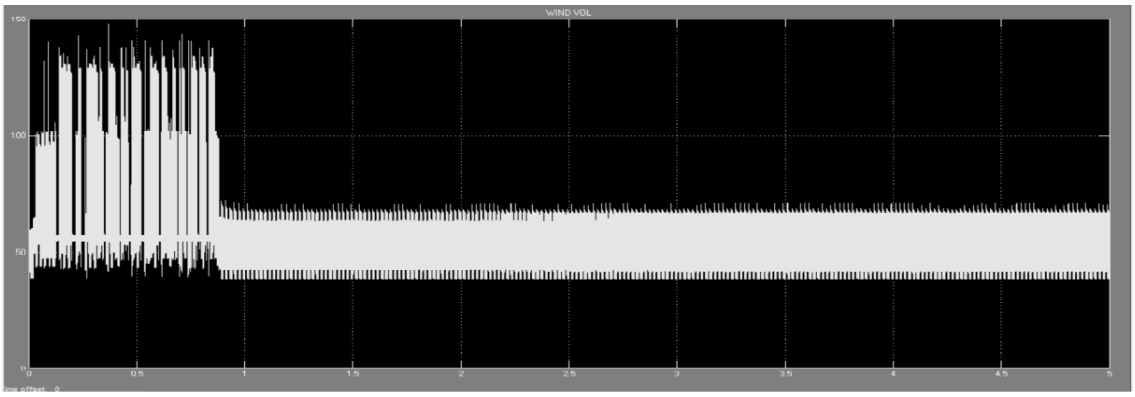

Figure 3.2: Shows the output of the wind power system

IV. FUEL CELL

The fuel cell used here is a hydrogen fuel cell. The fuel cell is a device which converts the chemical energy into electrical energy by exchanging the protons in it. A fuel cell combines hydrogen and oxygen to produce electricity, heat, and water. Fuel cells are often compared to batteries. Both convert the energy produced by a chemical reaction into usable electric power. However, the fuel cell will produce electricity as long as fuel (hydrogen) is supplied, never losing its charge.

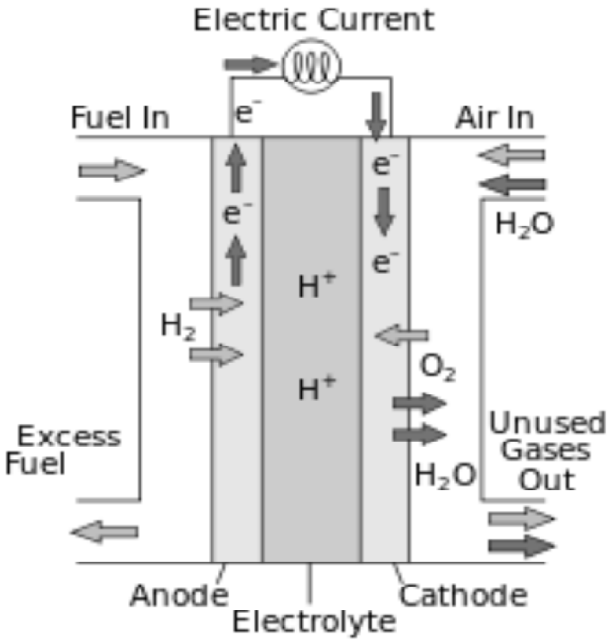

Figure 4.1: The hydrogen fuel cell

In this the fuel cell is attached to the flow rate selector and the flow rate regulator. These two governs the rate of flow of air molecules in the fuel cell in order to produce the energy. The flow rate selector is connected to the switch which selects the rate of flow. Generally the fuel cell doesn't produce much power comparatively it produces the voltage of about 45v. In order to increase the voltage produced the boost converter is used. The boost converter increases the 45v to 100v. The output from the boost converter is sent to the dc bus bar. The fuel cell produces the output power of about 6.5KW.[9][10]

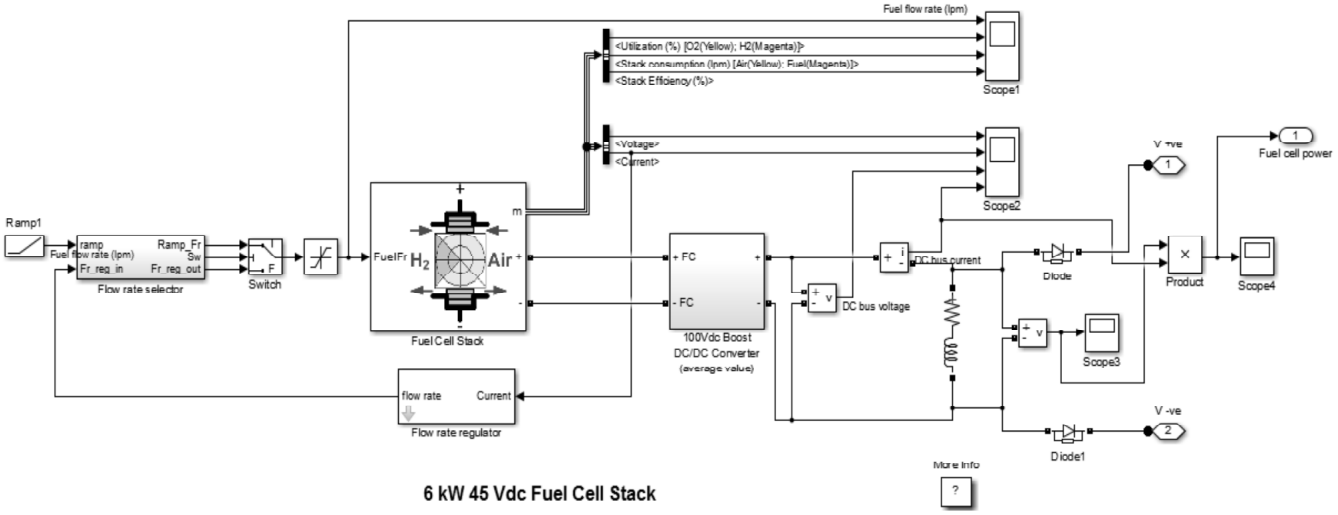

Figure 4.2: Simulation of fuel cell

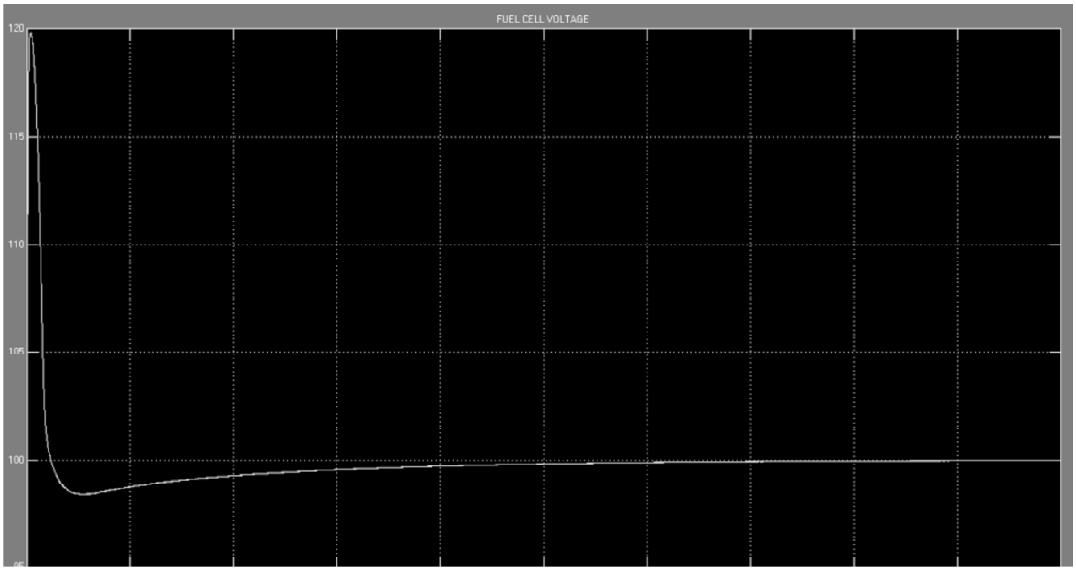

Figure 4.3: Simulation result of fuel cell

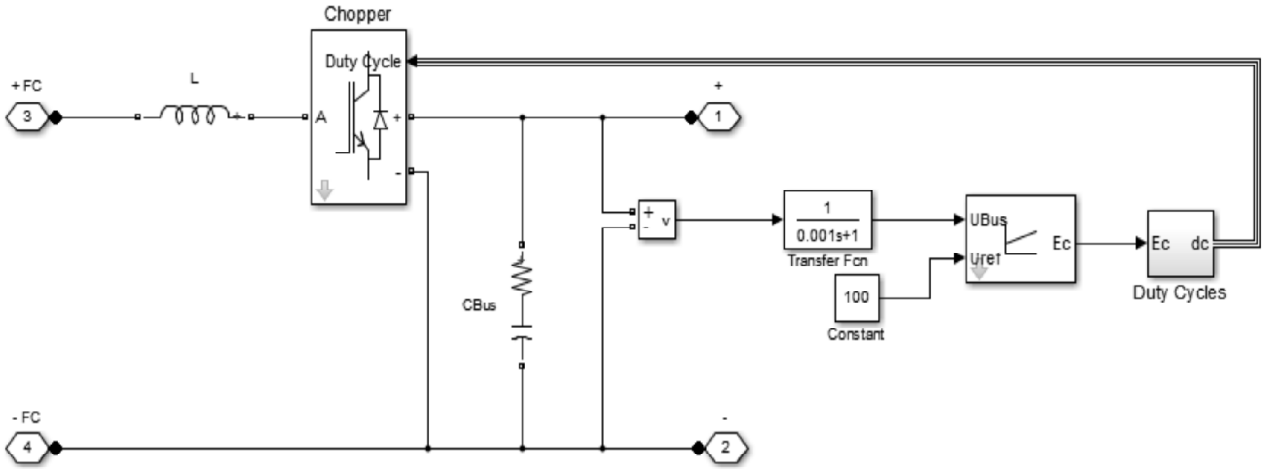

Figure 4.4: Simulation of buck converter

V. FUZZY LOGIC CONTROLLER BASED BATTERY MANAGEMENT SYSTEM

The fuzzy controller is one of the prominent controllers which are used now a day. The fuzzy logic system has the three steps involved in the fuzzy design they are

Fuzzy fication: This first step of fuzzy logic controller. It converts the crisp sets into fuzzy sets i.e. 0 and 1. The crisp values are the definite values which are obtained from the load power.

Membership function: A membership function (MF) is a curve that defines how each point in the input space is mapped to a membership value (or degree of membership) between 0 and 1.

Defuzzy fication: The process of producing a quantifiable result in fuzzy logic, given fuzzy sets and corresponding membership degrees. It is typically needed in fuzzy control systems.

The battery management system consists of the series arrangement of the batteries which supports as the secondary power in case of power deficiency. The batteries which are used here is a Nickle-Metal-Hydride type which has the nominal voltage of 43V and rated capacity of 100 Ah and initial state of charge is of 100%.

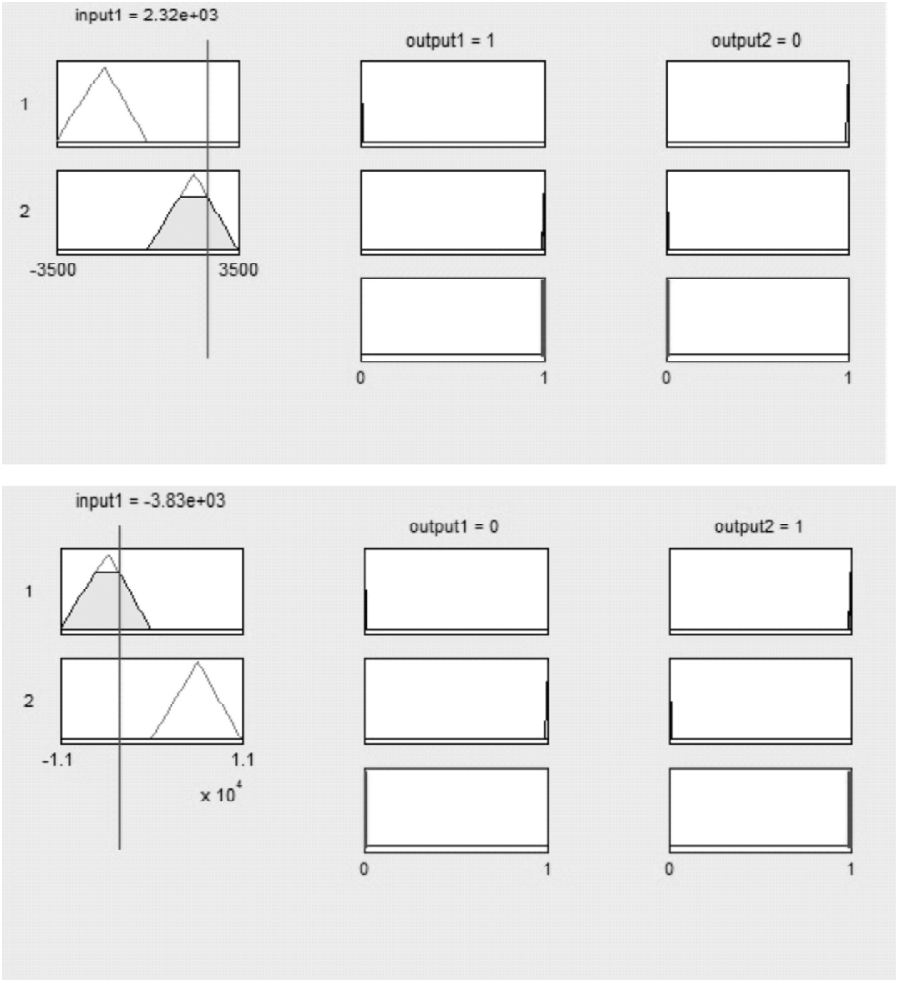

Figure 5.1: Fuzzy rules

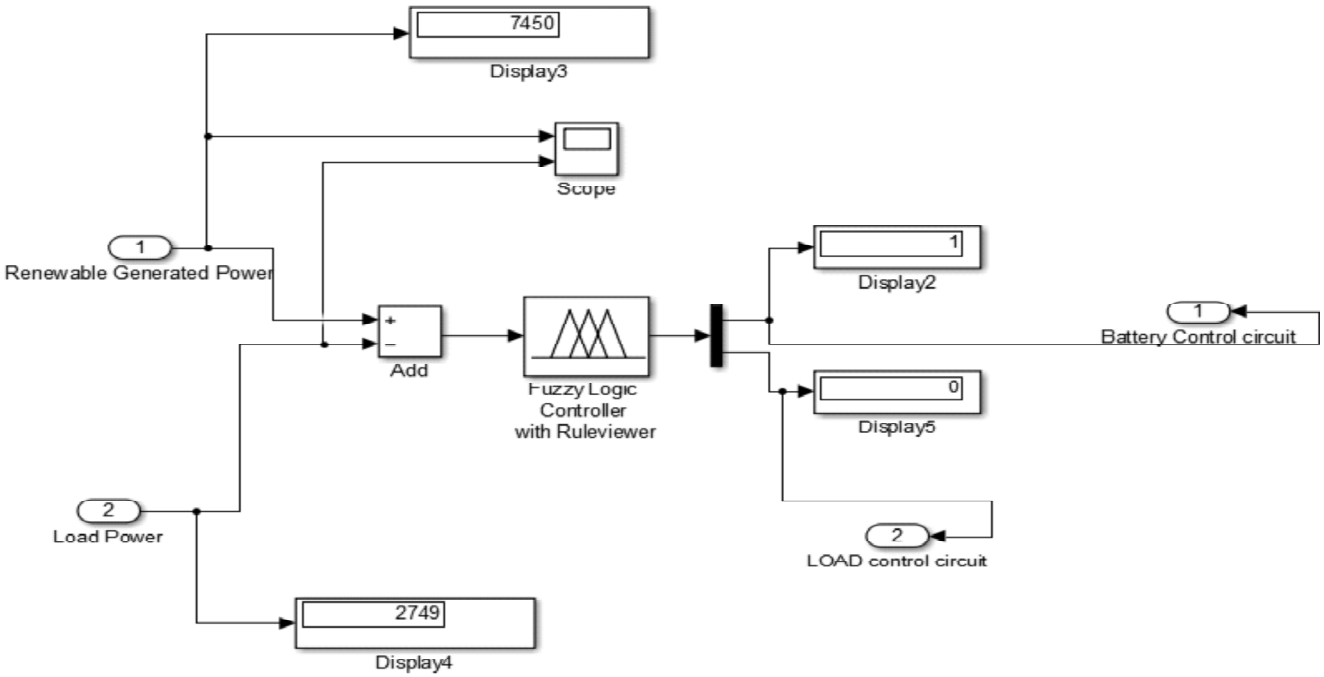

Figure 5.2: Fuzzy logic controller based battery management system

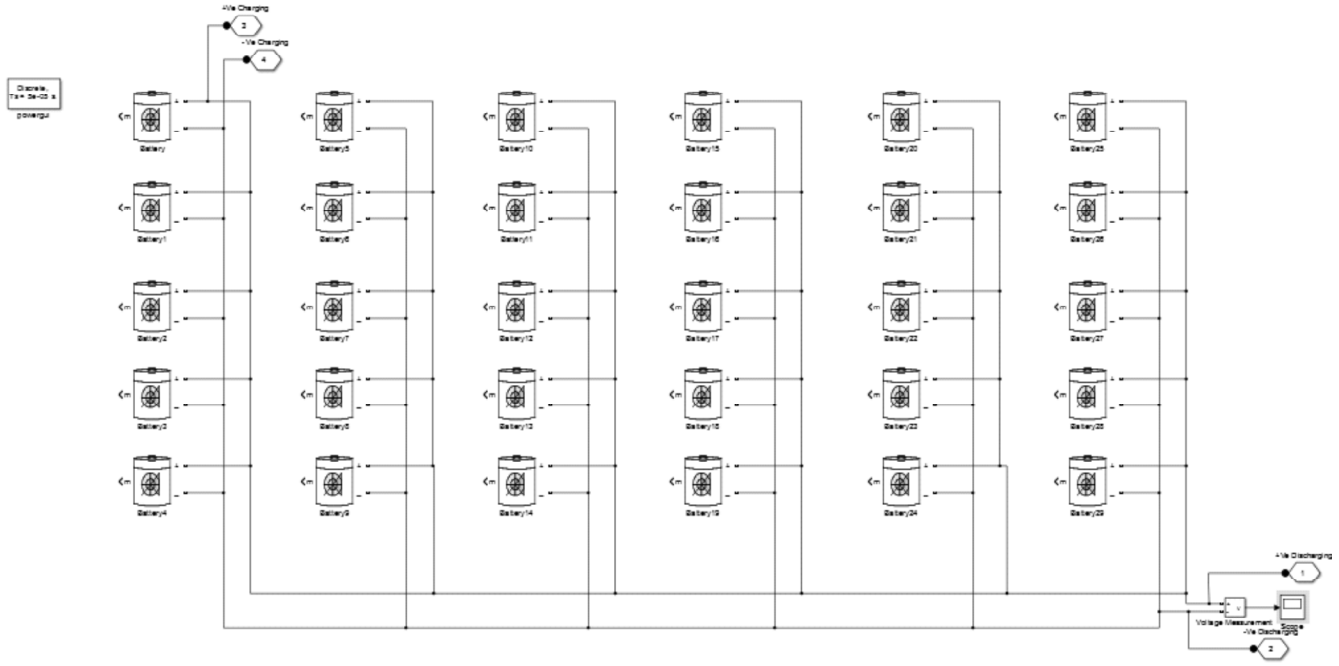

Figure 5.3: Shows the battery arrangement

VI. SIMULATION

The proposed model consists of three power systems which produce the approximate power up to 10 kW. The dc bus is connected to the dc to dc converter through the load which stabilizes the input of the dc load. In addition to it the battery management system is also introduced in order to support the dc load in case of any power shortage. The battery is connected to the dc bus bar with two circuit breakers. These breakers are controlled using the fuzzy logic controller. [10-14]

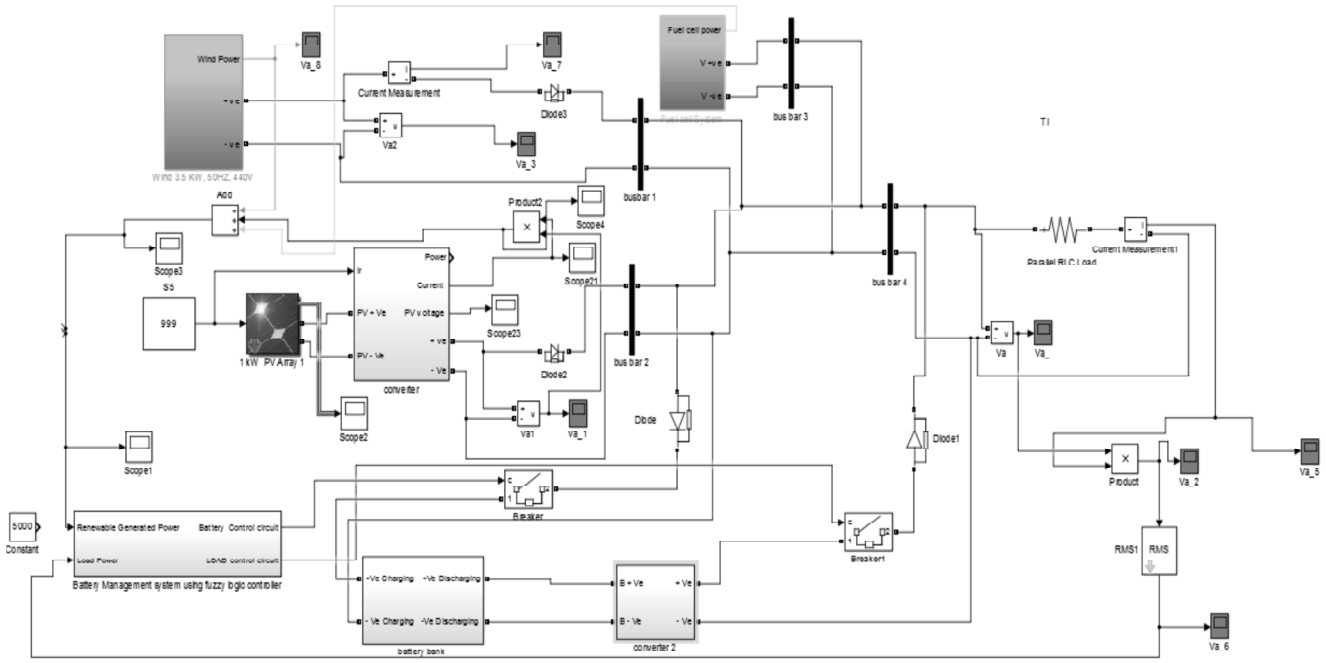

Figure 6.1: Matlab model

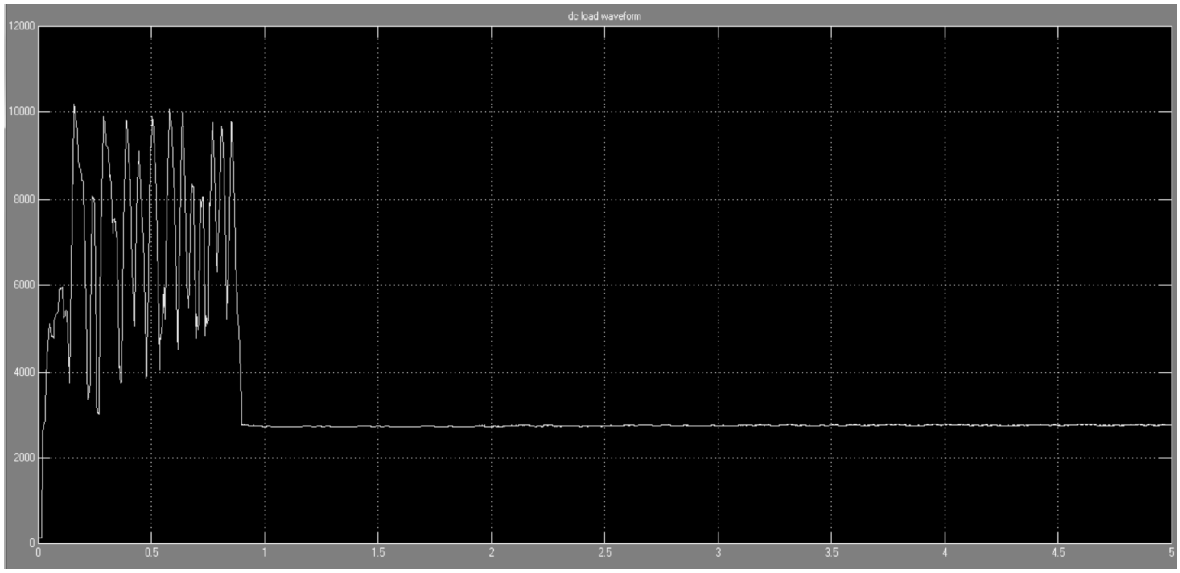

Figure 6.2: DC load waveform

VII. CONCLUSION

In this paper a power system consists of three energy sources, namely; PV, wind, and fuel cells, is proposed. Each of the three energy sources delivers the power at optimum efficiency. The battery is acted as a secondary source for the dc load. Fuzzy logic control is employed to control the battery management system charging and discharging according to the load requirement. Therefore load is supplied with its required power. The results obtained from the proposed paper are the feasibility of the fuzzy logic controllers for maintains the power flow to the load. The power wastage can be reduced by using the excess power produced to charge the battery and it can be used for later deficiency of load power.

REFERENCE

[1] A. Tofighi and M. Kalantar, "Power management of PV!battery hybrid power source via passivity-based control," *Renewable Energy*, vol. 36, pp. 2440-2450, 2011.

[2] W. Jiang and B. Fahimi, "Active current sharing and source management in fuel cell-battery hybrid power system," *IEEE Trans. Ind. Electron.*, vol. 57, no. 2, pp. 752-761, Feb. 2010.

[3] K. Jin, X. Ruan, M. Yang, and M. Xu, "A hybrid fuel cell power system," *IEEE Trans. Ind. Electron.*, vol. 56, no. 4, pp. 12 12-1222, Apr. 2009.

[4] K. Jin, X. Ruan, M. Yang, and M. Xu, "A hybrid fuel cell power system," *IEEE Trans. Ind. Electron.*, vol. 56, no. 4, pp. 12 12-1222, Apr. 2009.

[4] S. Armstrong, M. E. Glavin, and W. G. Hurley, "Comparison of battery charging algorithms for standalone photovoltaic systems," in IEEE Power Elect. Specialists Conference, 2008, pp. 1469-1475.

[5] Z. Jiang and R. A. Dougal, "A compact digitally controlled fuel cell!battery hybrid power source," *IEEE Trans. Ind. Electron.*, vol. 53, no. 4, pp. 1094-1 104, Aug. 2006.

[6] M.G.Simoes, B. K. Bose,R.Spiegel, Fuzzy Logic Based Intelligent Control of a Variable Speed Cage 352 Machine Wind generation System, *IEEE Trans. PE*, Vol. 1.

[7] Ph.D Thesis Fuzzy Modeling and Simulation of Photovoltaic Systems, Qiro Univ., Faculty of Eng., 1998.

[8] K.U.Leuven, Wind Energy for the Eighties Peter Peregnhus Ltd., Stevenge, UK, 1982.

[9] YimShu Lee, Computer Aided Analysis and Design of Switch Mode Power Supplies , Marcel Dekker Inc., 1993. [10] Thanaa El-Shater, Mona Eskander and Mohsen ElHagry, Hybrid PV/Fuel Cell System Design and Simulation , 36th Intersociety Energy Conversion Engineering Conference, July 29 -August2,2001, Savannah, Georgia.

[11] Z. Jiang, "Power management of hybrid photovoltaic - fuel cell powersystems," in IEEE Power Engineering Society General Meeting, 2006.

[12] S. Kim, J. Jeon, C. Cho, J. Ahn, and S. Kwon, "Dynamic modeling and control of a grid-connected hybrid generation system with versatile power transfer," *IEEE Trans. Ind. Electron.*, vol. 55, no. 4, pp. 1677-1688, Apr. 2008.

[13] Z. Jiang and R. A. Dougal, "A compact digitally controlled fuel cell!battery hybrid power source," *IEEE Trans. Ind. Electron.*, vol. 53, no. 4, pp. 1094-1 104, Aug. 2006.

[14] Z. Jiang, "Power management of hybrid photovoltaic - fuel cell power systems," in IEEE Power Engineering Society General Meeting, 2006.