AN APPROACH WITH INCREMENTAL CONDUCTANCE MPPT AND FLC BASED CHARGING CONTROLLER FOR EFFECTIVE BATTERY MANAGEMENT IN SOLAR-DIESEL HPS

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ABSTRACT

Demand for electricity today makes us to move towards the renewable energy. The effective utilization of power from renewable energy is more crucial than power generation. This paper proposes standalone solar power system for a rural area with uninterrupted power. The uninterrupted power is indispensable for many applications. In this proposed system Solar power systems with Battery Energy Storage System and Diesel Generator have contributed to the power system for continuous power. Effective utilization of solar power decides the efficiency of the power system. Effective Battery Management controller monitors and controls loading and discharging of BESS without any wastage of solar power so that the prospect of using DG gets reduced. The conventional PI controller can hold in the turning on. This paper proposes Fuzzy logic controller for a mandatory percentage of charging, which is more efficient than PI controller. Comparison of charging controller based on PI and fuzzy logic controller is analyzed in this paper. The added main feature in the proposed system is the supplement Battery Energy Storage System which may replace BESS when there is any failure in BESS, it is monitored and controlled by EBMC. The solar power source is effectively utilized and life of the battery is increased by EBMC. Dependability of the power system is increased by the battery fault management system. The integral scheme is simulated using MATLAB/Simulink.

Keywords - Battery fault management, Diesel Generator, Fuzzy Logic Controller, HPS, PI controller, PV

I INTRODUCTION

In the past decades, enormous amount of natural resources has been unlimitedly dissipated and our living environment has been severely polluted (BurriAnkaiah and Jalakanuru Nageswararao, 2013). With increasing concern about global warming and the depletion of fossil fuel reserves, many are looking at sustainable energy solutions to bear on the land for the future generations. Other than hydro power, wind and photovoltaic energy

holds the most potential to gather our energy needs. Wind energy alone is capable of supplying large quantities of power, but its availability in standard velocity is extremely unpredictable (Joanne Huiet al., 2010). The technical and functional characteristics of wind-diesel hybrid systems are found various disadvantages like power generation only in remote areas, the high price for its complicated and heavy mechanism of gears. Another vital renewable energy of solar energy is present throughout the daytime. It has emerged in the last decades since it has the aforesaid advantages and less maintenance, no wear and tear. The primary applications of PV systems are stand-alone systems such as water pumping, domestic and street lighting, electric vehicles, military and space applications (Sam C. M. Huiand Miss S. C. Chan,2011- Chandrashekhar Lavania*et al*., 2013) or grid-connected configurations like hybrid systems and power plants (AchimWoyte*et al*,. 2006). The solar irradiation levels vary due to sun intensity and unpredictable shadows cast by clouds, birds, trees, etc. It necessitates the integration of diesel generator with the solar power system for uninterrupted power supply. The energy storage systems play an important role in a hybrid system to perform both functions of storing and releasing energy at an adequate time. The battery stores the electric energy in DC form and it requires rectifier circuits (AC-to-DC converters), charging circuits, and DC-to-AC inverters to exchange energy with the AC system. The effective charging control increases the utility of the battery. This paper proposes Fuzzy logic controller for effective charging. The reliability of the system is uninterrupted supply of electricity. This paper proposes an embedded based automatic battery replacement in case of any failure in the main battery bank. This paper proposes uninterrupted power with very less pollution.

II SOLAR-DIESEL HYBRID POWER SYSTEM

The basic block diagram of solar-diesel hybrid power system is shown in Fig.1. The power generated by the PV panel is DC power and variable voltage because of the varying radiance of the sun. The Buck boost converter in the sequence of the source changes it as a constant voltage supply suitable for different applications. The MPPT, maximum power point tracking controller senses continuously the voltage and power produced by panel and controls the DC- DC converter with proper positioning of PV panel. The DC powers from Solar panels and battery are converted into AC with the help of inverter. The transformer placed after inverter helps in levelling the voltage as well as for a sine wave. The battery energy storage system is monitored and controlled by EBMC. The source selector is embedded based controller and it selects sources to grid based on availability of power and load demand. The Diesel generator is activated only when both solar and battery are incapable of supplying the load. Meantime, it charges the battery and it is deactivated while battery reaches 95 % of SOC (Raju.P and Vijayan.S, 2013). It minimizes the usage of diesel generator.

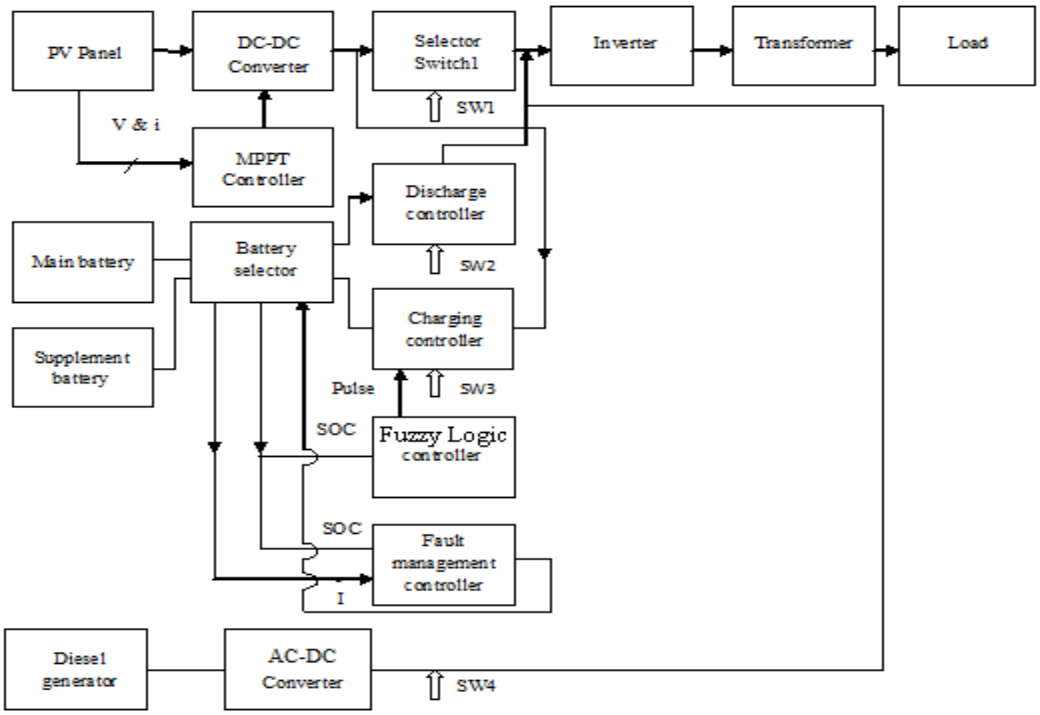


Fig.1: Block Diagram of HPS.

2.1. PV panel

The solar photovoltaic –PV cell modules generate DC electricity whenever sunlight falls on solar cells. Solar radiation sustains all forms of life on earth. According to estimates, the sun radiates 1.74 x 10^{17} W of power per hour to earth, the daily solar energy radiation varies from 4-7 KWh per m^2 and there are 270-300 sunny days in a year. The Single PV cell produces a rather small voltage that has a less practical use. The real PV panel always uses many cells to generate a large voltage.

2.1.1 Incremental Conductance Mppt

In this paper Incremental Conductance algorithm is proposed for MPPT. It decides duty ratio based on the power deviation. In incremental conductance method the array terminal voltage (Snyman D *et al*, 1993)(M.Lokanadham and K.VijayaBhaskar, 2012) is always adjusted according to the MPP voltage it is based on the incremental and the instantaneous conductance of the PV module. The Flow chart of incremental conductance MPPT is shown in Fig 2.

In this method the peak power of the module lies at above 98% of its incremental conductance. This method is easy to implement.

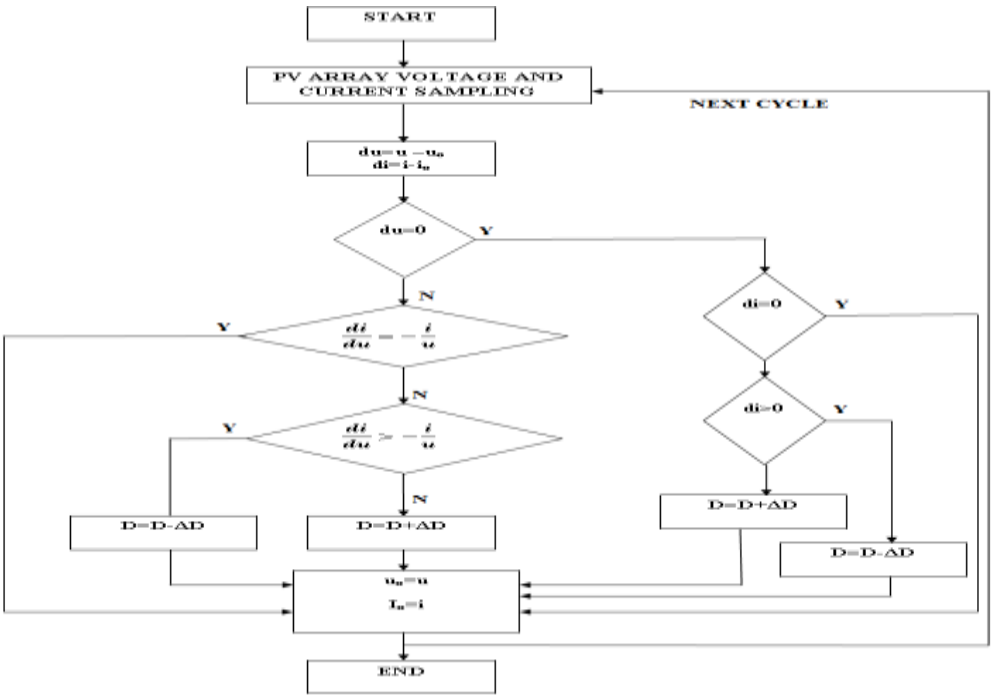


Fig. 2: Incremental conductance MPPT Flow chart.

2.1.2 DC–DC buck-boost converter

In buck–boost, step-down/up or bi-directional converters, the output voltage magnitude may be lower or higher than the input voltage magnitude (Jain S *et al,*. 2007), so this topology can be used in connecting nearly-matched battery or load and module voltages. A negative output also results from the common terminal of the input current. It is a class of switched-mode power supply (SMPS) containing at least two semiconductor switches (a diode and a transistor) and at least two energy storage element, a capacitor and an inductor. The switch is typically of a MOSFET, IGBT or BJT. Buck–boost topology can be achieved through a cascade connection of the two basic converters (buck converter and boost converter). The output–input voltage conversion ratio is the conversion ratio of the two converters in cascade when the switches in both the converters have the same duty cycle.

Battery Energy Storage System

BESS plays vital role in renewable power system to store the energy generated as well as to supply the load. The lead-acid battery is proposed in this paper for energy storage. It has two modes of operation charging and discharging modes. Based on the direction of current flow into the battery or from the battery modes are desired (Raju.P and Vijayan.S, 2013). Different parameters were used for modelling the battery (M. Kalantar and S.M. Mousavi G, 2010).

2.1.3 Effective Battery Management Controller

This paper proposes an embedded system based EBMC for fault management. EBMC continuously monitors the SOC (state of charge) of battery whenever the SOC of the battery is not raised as per defined conditions it is noted as a fault. Then EBMC replaces main battery with supplement battery to the system. Also the main advantage of EBMC is to control the charging with the help of Fuzzy logic controller for effective charging. The effectiveness of proposed charging is analysed with the conventional PI controller.

2.1.4 PI controller

Proportional plus Integral Controller is the simple control and widely used in industries. It increases the speed of response (Govind Anil) (HeberttSirra Ramirez, 1991) and produces very low steady state error. In this paper error of SOC is given as input to PI controller and output is taken to the charging controller. PI controller produces a duty ratio for MOSFET in charge controller. In this paper Ziegler Nichols' method of tuning is implemented to find the optimum value of Kp & Ki values. The Output of the PI controller is compared to the saw tooth and produces triggering pulses for charging controller and produces pulsed DC for battery charging.

2.1.5 Fuzzy Logic Controller

To determine the duty ratio of the charging controller, Fuzzy logic controller is proposed in this paper. Fuzzy logic is the mathematical technique for dealing with imprecise data and problems have multiple solutions rather than one. Linguistic, non numerical, variables are used, making it similar to the way humans think. Fuzzy control methodology is considered as an effective method to deal with disturbances and uncertainties in terms of ambiguity. In this paper Fuzzy Logic Controller (FLC) is implemented to reduce overshoot and settling time. Fig.3 shows the basic block diagram of fuzzy logic controller (Zadeh. L.A, 1965).

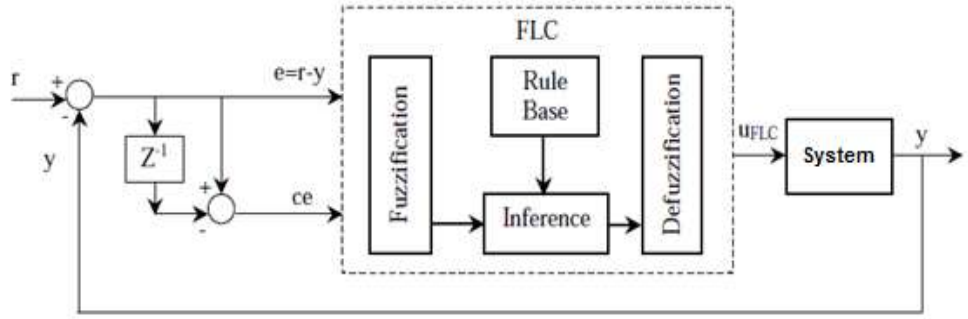


Fig. 3: Fuzzy Logic controller.

Fuzzy inference system is the overall name for a system that uses fuzzy reasoning to map an input space to an output space. There are several ways to define the result of a rule; this paper implies max-min method of inference. Here, Mamdani type of fuzzy has been implemented. It has two inputs such as Battery SOC error (e) , change in error (ce) and one output ΔD which decides the duty ratio of charging controller (Raju.P and Vijayan.S, 2013). Both input and output have five membership functions such as NB-negative big, NS-negative

small, Z –zero, PS-Positive Small and PB-Positive Big. Defuzzification is the mathematical procedure to convert fuzzy values into crisp values. Many methods of defuzzification are available. In this study we have selected centroid method of defuzzification. Table-I shows the fuzzy rules. Fig.4Shows the membership functions of inputs and output.

Table-I: Fuzzy Rules.

e \ ec	NB	NS	Z	PS	PB
NB	NB	NS	NS	Z	PS
NS	NB	NS	NS	PS	PB
Z	NB	NS	Z	PS	PB
PS	NB	NS	PS	PS	PB
PB	NS	Z	PS	PS	PB

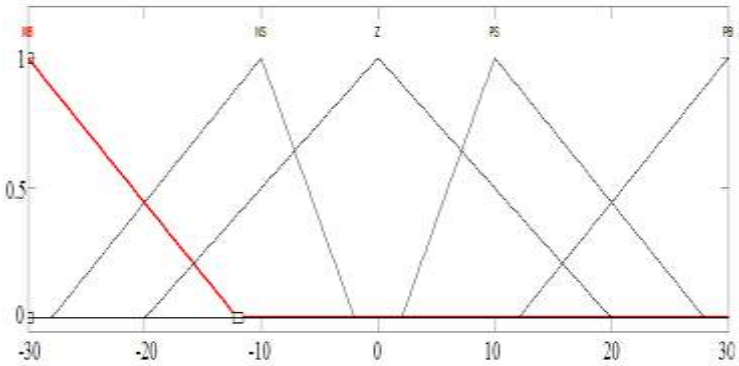
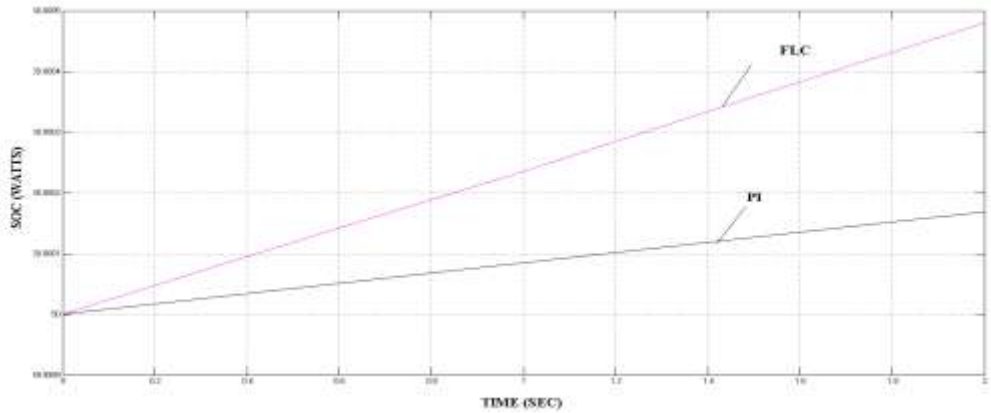


Fig.4: Membership Functions of e, ce and ΔD.

The output of the fuzzy controller is compared to the saw tooth and produces pulses for charging controller. The comparison of the SOC of batteries using PI and FLC based charging controller are shown in Fig.5

Fig. 5: Comparisons of SOC of batteries using PI and Fuzzy logic controller (FLC)



III SOURCE SELECTION CONTROLLER

Source selection controller continuously monitors the power of solar panel, SOC of BESS and load power. Based on the available power and load it selects sources to the grid. The sources may select individually as solar power or BESS or combination of Solar and battery or Diesel generator. It activates the power system in 5 modes of operation based on sources and load demand. The different modes are Solar alone Supplies load when solar power is greater than load power, Solar Supplies load and battery when solar power is very greater than load power, Solar and Battery Supplies load when solar power is lesser than load power, Battery alone Supplies load when solar power is very lesser than load power and DG alone Supplies load when solar power and battery power is very lesser than load power. The source selector effectively selects the sources based on load demand and available power. This controller minimizes the usage of Diesel Generator.

IV SIMULATION RESULTS AND DISCUSSION

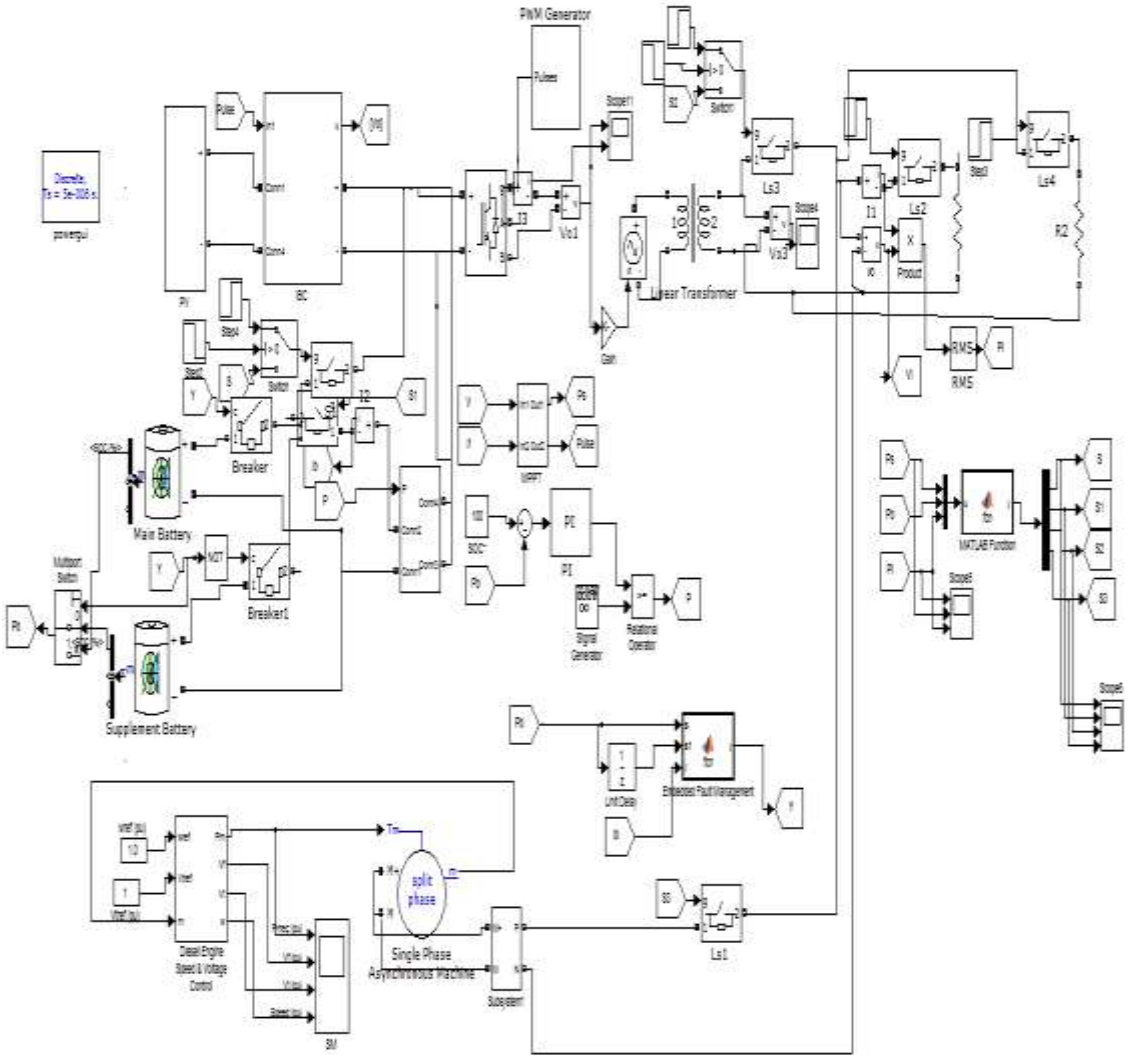


Fig. 6: Simulation model of the HPS.

Simulation model of HPS with the energy management controller is developed using MATLAB/ Simulink R2011b. Rating of the HPS is given below

Solar power plant : 3 KW

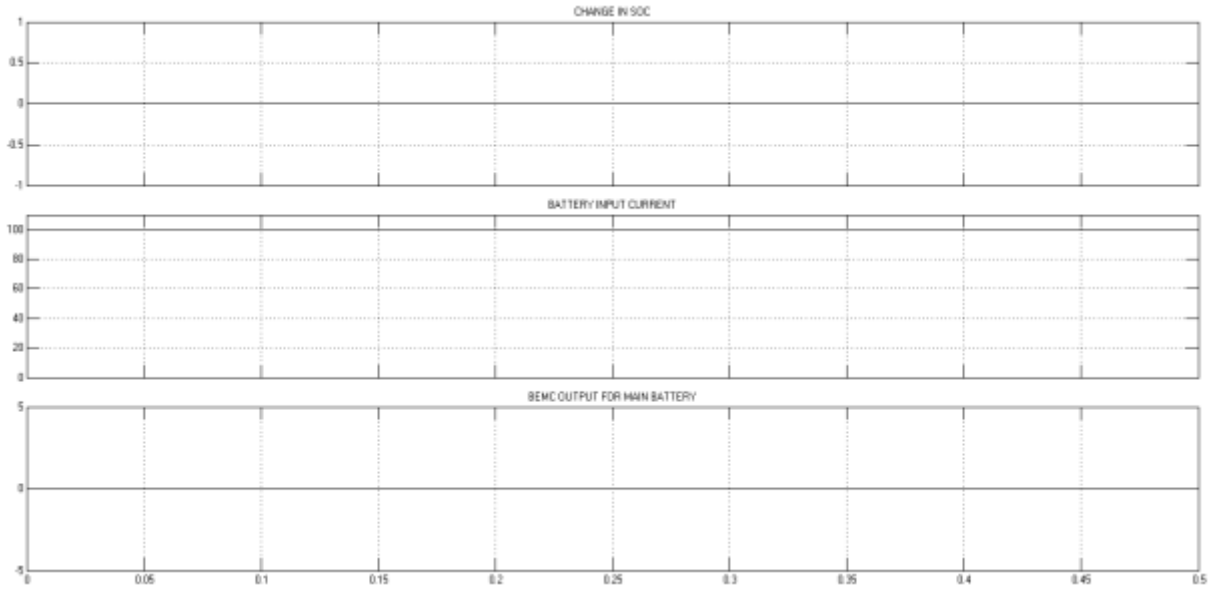
Battery : 3 KW

Diesel Generator : 6 KW

Load (AC) :3KW, 230 V, 50Hz, 1 Phase

The comparison of the SOC of batteries using PI and FLC based charging controller shows that proposed Fuzzy logic controller is more efficient than PI controller. The addition of supplement Battery Energy Storage System which may replace BESS when there is any fault in BESS is the added advantage; it is monitored and controlled by EBMC. In general the solar power source is effectively utilized and life of the battery is increased by EBMC also the usage of Diesel generator gets reduced. Simulation model of the HPS is shown in Fig. 6. Operation of EBMC in case of failure of the main battery is shown in Fig, 7.

Fig. 7: Operation of EBMC in case of failure of main battery.



IV CONCLUSION

Green energy is the essential power today for its pollution free process of power generation. Demand of electricity and fossil fuel also necessitates it. The PV power resource is advantageous than any other resources as it is suitable for any individual application or for grid. The effective utilization of energy is proposed in this paper with the help of Embedded based source selector. Reliability of the power system is increased by using automatic replacement of the battery in case of any fault by EBMC. Lifetime and efficiency of batteries are increased with the help of Fuzzy logic controller based charging controller. The FLC based charging controller reduces the charging time compared to PI controllers. Uninterrupted power is delivered by solar-diesel hybrid power system. The proposed system reduces utilization of diesel generator which results in reduction of cost for fossil fuel and reduced pollution.

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