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INTELLIGENT ENERGY MANAGEMENT SYSTEM FOR MICRO GRID APPLICATION

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Abstract— **This system deals with the Energy Management System (EMS) for the smart-micro grid applications. This system obtains power from the PV panels, wind turbine, and diesel generation systems. The EMS relies on fuzzy control for the purpose of the optimization. The RS 485 zigbee network, a communication protocol employed for the purpose of communication to know about the generation status of the power generating systems. The EMS commands this system when to operate, as per the power availability, and load demand.**

Keywords—Energy Management System, Smart micro grid, fuzzy logic control.

I. INTRODUCTION

The development of the renewable energy system has overcome all the disadvantages of the conventional or non renewable energy sources. The current green energy systems employed in the power generation are: Solar, wind, biomass, tidal [1]. These renewable energy resources are developed in many countries. In United States electrical grids consists of around 5,000 power plants, 2, 00,000 miles of high voltage transmission, and 5.5 million miles of distribution lines [2]. The EPRI (Electrical Power Research Institute) estimates the annual cost of US business power outages was discussed[2]. A smart grid is an electricity network that uses digital and other advanced technology to monitor and manage the transport of electricity from all generating sources to meet the varying electricity demands of the end users. The smart grid consists of the parallel connection of generation systems. The smart grid can able to overcome the various disadvantages of the tie line power flow system. Comparing with the tie line power flow, the smart grid enables the two way communications and power transmissions. It gives the best solution to the increase in the load demand and increase in the renewable energy sources and electrical vehicles. The monitoring systems and the wide area network systems are can be used for the purpose of communication about the generating stations. These informations are useful for the decision making such as the scheduling of the generating units, unit commitment depending on the load demand. The automation system employs PLC and SCADA. The recent development in such automation system leads to the development of the fuzzy logic control systems and neural network systems. These automations system provides a practical way for the optimization and distributed energy generations. This optimization is essential for the non linear system. The smart grid technological areas consist of the generating system, load, and storage system. The load system composed of the industrial loads, residential loads, and service stations. The electrical vehicle charging can also be utilized in this smart micro grid system.

The development of the smart grid leads to the development of the micro grid, national grid, and regional interconnections. The development of the smart grids in 2050 was discussed [3].

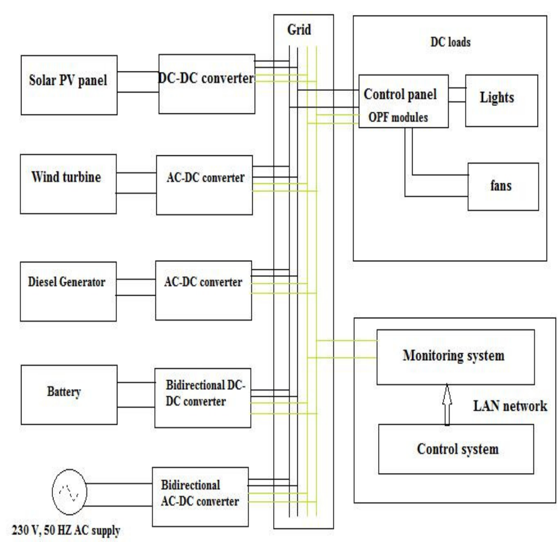

Fig. 1 Block diagram of the smart micro grid systems

The proposed system consists of the power sources which obtains its power from the PV panels, wind turbine, and diesel power generation system. The power sources are connected to the grid through the respective converters. This system employs the diesel battery and EB system acts as a stand-by system, which delivers power only during the power failure conditions or emergency load demand. The batteries and EB system are connected to the grid through the bidirectional DC-DC converter and bidirectional AC-DC converters respectively.

During normal condition, the solar and wind provides power to the grid. The maximum power trackers are associated with the solar and wind system. The diesel power generation system provides the base power during the power failure conditions.

The RS 485 ZigBee network, a communication protocol is employed in the source and load system. This communication system collects the informations about the status of the generating system, and the load demand.

The EMS relies on the fuzzy controller for the purpose of optimization and distributed energy generation. In EMS the fuzzy plays the two vital roles: regulated the constant energy flow in the grid, and battery management. The grid voltage in the system is maintained at volts.

II.EXISTING.. MODELLING OF GENERATING SYSTEMS

The generating system includes PV, wind turbine, and fuel cells, and storage system. The simulation of these systems was simulated by using the MATLAB/Simulink.

A. Modelling of Solar cells

The photocurrent generating principle is shown in the fig. 2. The equivalent circuit diagram of the solar cell is shown in the fig. 3. The solar cell converts the light energy to electricity [9].

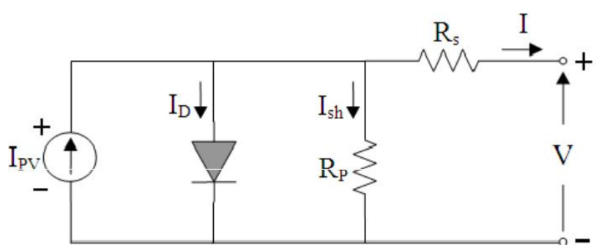

Fig. 2 Equivalent Circuit of Solar cell

The expressions of the PV cells comprised of the PV output current I, diode saturation current I_0 expressed [9] by eqn. (1) to (3)

$$I \quad I\,, \qquad I \quad \exp\frac{V \; R \quad I}{V\,a} \qquad I \qquad 1$$

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

$$I \qquad \frac{I \quad , \quad K\,\Delta T}{\exp \dfrac{V_{.} \quad K\,\Delta T}{aV}} \qquad 2$$

The power in the PV panel is expressed by (3) [10].

B. Wind Energy Conversion System

The wind energy conversion system consists of the wind turbine, uncontrolled rectifier and a boost converter. The expressions for the wind energy generating system is was expressed as

,

Where

	Air density (kg/m) Turbine
S	swept area (m) Performance
C_p	coefficient of the turbine
V_{wind}	Wind speed in m/s

The tip speed ratio is expressed by Lambda

=Mechanical speed of the turbine

— ,

The fig. 3 shows the characteristics of the wind turbine

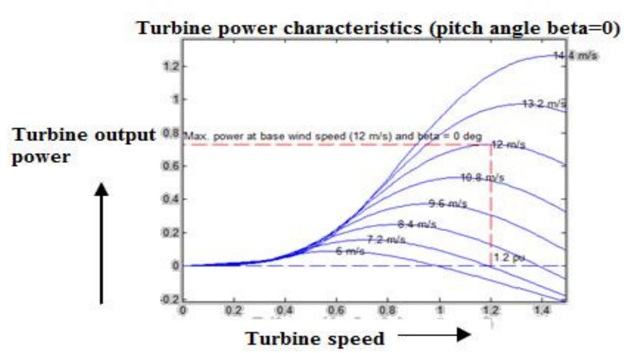

Fig. 3 Characteristics of Wind turbine

The power electronics has rapidly changed the application of the windmill in many grid connected applications; it is due to the development of the semiconductor devices and microprocessors. The gated switching devices employ MOS transistors, and the number of controlled characteristics is presented [12].

The wind turbine can be employed for the variable speed and constant speed operation, by using DFIG and PMSG respectively. [12], [13].

C. Diesel Power generating systems

The diesel generator employed in this system is the synchronous generator. The regulator and actuator transfer function are expressed as

Where

K	Regulator gain
T_{r1}, T_{r2}, T_{r3}	Regulator time constants
T_{a1}, T_{a2}, T_{a3}	Actuator time constants

D. 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.

III.PROPOSED METHODOLOGY INTELLIGENT MANAGEMENT SYSTEM

Fig. 1 shows the block diagram of the proposed system. Conventionally the decentralized power generation system was employed for the power production process. The intelligent management system is essential for such non linear system for the purpose of optimization and distributed energy generations. The intelligent management system plays two vital roles battery management and energy flow management. The intelligent management system can also be used for the cost pricing.

The cost pricing of such generating systems and the consumer system can be achieved by employing Home Area Network (HAN), and there are the other networking system can also be employed for the cost pricing functions. The switching operation of the converters can also be regulated by employing the intelligent management system.

The main objective of the intelligent management system is the battery management and the balanced energy dispatch to the load. The intelligent management system provides the better solution to the load supplies power from the fluctuating power sources. The algorithm implemented in the intelligent management system is the better solution for the purpose of optimization.

The DC smart micro grid system is the non linear system, which provides the practical way for the optimization and distributed energy generation. The Energy Management System has to meet the design specifications of the sources and converter system.

The intelligent management system is responsible for the unit commitment and generator scheduling depending upon the load requirement and SOC of the battery. The intelligent Energy Management System relies on Fuzzy logic control. The fuzzy based energy management system has two inputs and one outputs.

A. Fuzzy Concept

The fuzzy based concept is first developed by Lofti. A. Zadeh in 1965, called as the fuzzy sets. The fuzzy calculation and the simulation have two types' mamdani type and sugeno type. The control system is similar to the fuzzy logic thinking [18]. It employs the logic function 0s and 1s.

The fuzzy control operating is similar to the fuzzy human thinking. The fuzzy control employed in the proposed system is the part II fuzzy system. The part II fuzzy system is the rule based system, which consists of the natural language represents the human knowledge. The syntax of the fuzzy logic system is expressed as follows.

IF premise (Antecedent), THEN conclusion (Consequent)

The syntax represent the fuzzy logic system resembles the human thinking. Depending on the inputs and the outputs of the fuzzy (P_e and SOC_e) and the output (Ic), the membership functions of the fuzzy was designed. The grades of the membership functions are Low (L), Below Average (BA), Average (A), Above Average (AA), and High (H). The fuzzy system, the grades of the membership functions the low, below average, average values of the inputs and outputs.

The inputs of the fuzzy system is expressed as follows.

$$P_e = \text{Total power Generation} - \text{Actual load demand} \quad (10)$$

$$SOCe = SOC_{command} - SOC_{now} \quad (11)$$

The P_e is low, which represents the total power generation capacity of the generating system is low. When the P_e is Below Average (BA), then the power delivered by this generating system is higher than the low value but not the optimum value. The Pe is Average, which represents that the power generated by the system is medium but not optimum. The Pe is Above Average (AA), which represents that the power delivered by the source to the load is higher than the average value. The Pe is high, which represents that the power generating capacity reaches the rated value. Similarly, the State of Charge (SOC) of the battery, the SOC of the battery is expressed as the command SOC and the actual SOC command. The SOCe is low, which implies that the battery has the low SOC value, it needs the charging current for the purpose of charging. The SOCe is Below Average (BA), then it implies that the SOC is greater than the lowest value, it requires the charging current. The SOCe is Average (A), which implies that the SOC value is less than the optimum, when the SOCe reaches the Above Average (AA), which implies that the SOC of the battery reaches less than the rated value. The SOCe high, which implies that the State of Charge reaches the rated value. The I_c is the charging current of the battery. If the charging current I_c is low(L), which implies that the charging current of the battery very lower than the optimal charging current. If the Charging current is Below Average (BA), the charging current is low but not optimum. If the charging current is Average (A), the current is medium, less than the rated value. If the charging current is Above Average (AA), which implies that the charging current is less than the rated value. The charging current is high (H), which implies that the charging current reaches the rated value. The membership function includes the inputs and outputs of the fuzzy. The fig. 4(a), (b), and (c)

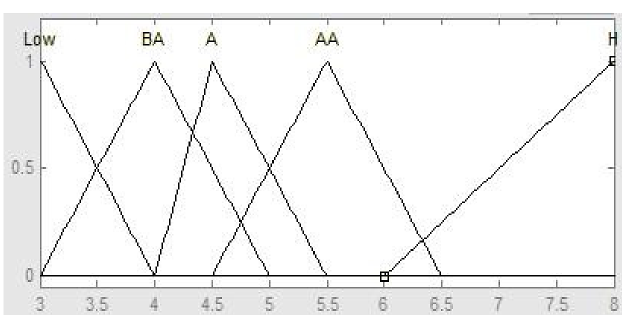

Fig. 4(a) Input membership function Pe

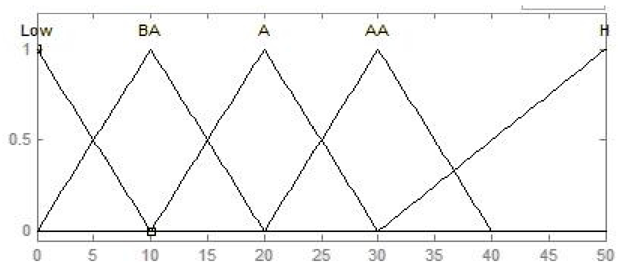

Fig. 4(b) Input membership function SOC_e.

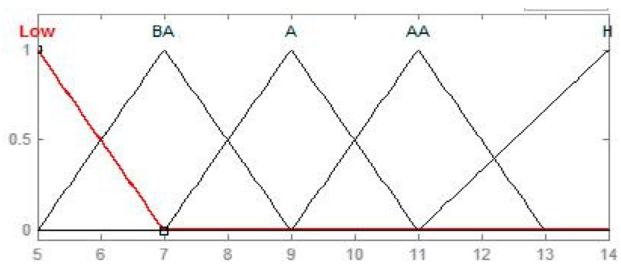

Fig. 4(c) Output membership function I_c.

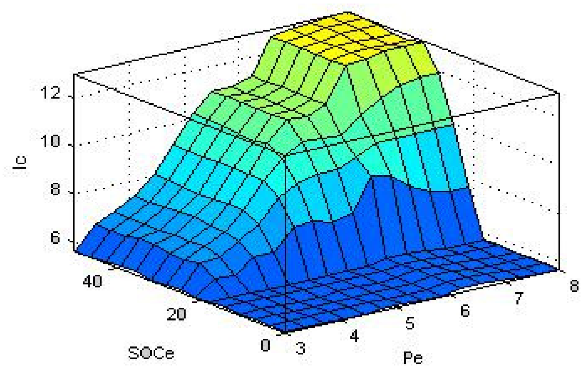

Fig. 5 Surface diagram of fuzzy rules

TABLE 1
FUZZY RULE TABLE

		Pe				
	Output=Ic	**Low**	**BA**	**A**	**AA**	**H**
SOCe	**Low**	Low	Low	Low	Low	Low
	BA	Low	Low	Low	Low	Low
	A	Low	Low	Low	Low	Low
	AA	Low	BA	A	AA	H
	H	Low	BA	A	AA	H

IV SIMULATION AND RESULTS

The simulation and results of the system includes: Solar PV power generation system, Wind energy conversion system, and Diesel power generation system. The integrated parallel connected power sources are simulated with the battery. The DC bus voltage is maintained at 240 volts.

A. PV system

The solar PV power generation system comprises of the solar panel and the DC-DC converter for the purpose of MPPT. The fig. 6 shows the matlab simulation diagram of the solar PV power generation system, and fig. 7 shows the output waveform of the solar power generation system. The PV system produces the output voltage of 240 V.

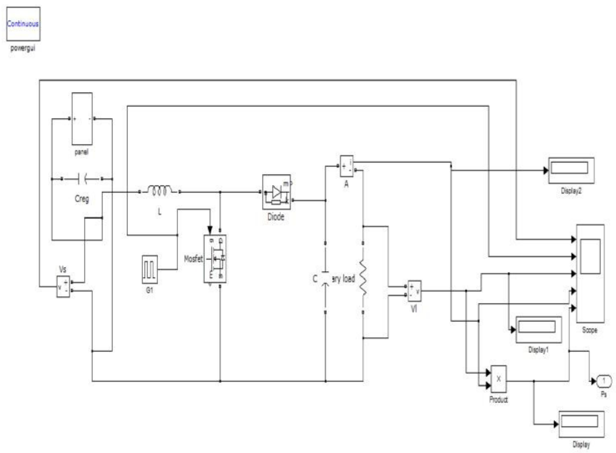

Fig. 6 Simulation Circuit diagram of PV system.

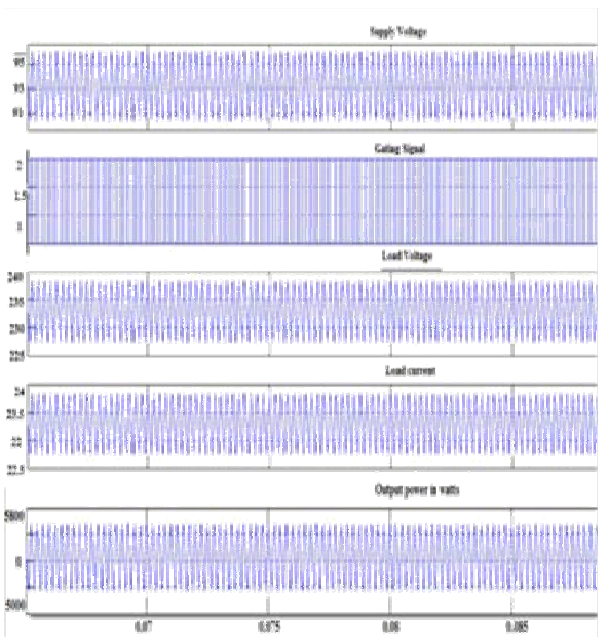

Fig. 7 Output waveform of PV system.

B. Wind Energy Conversion System

The wind energy conversion system consists of the wind turbine, asynchronous generator. The conversion system employs the uncontrolled rectifier and the DC-DC boost converters. Fig. 8 and 9 shows the matlab circuit and its output waveform respectively. The output waveform of the wind energy conversion system consists of the supply voltage, gating signal, output voltage, output current, and the output power in watts. The specification of the asynchronous generator employed in the 1500 rpm, 400 V AC supply.

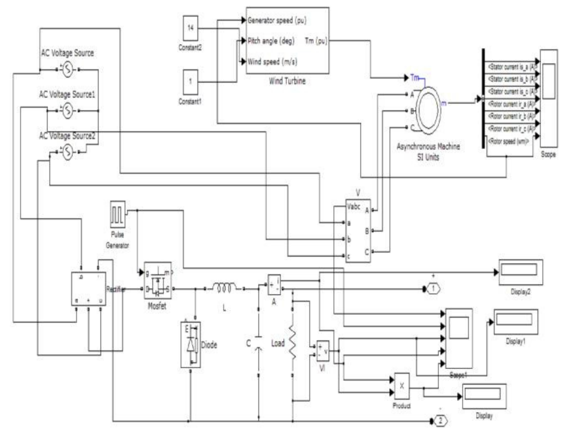

Fig. 8 Simulation diagram of wind energy Conversion system

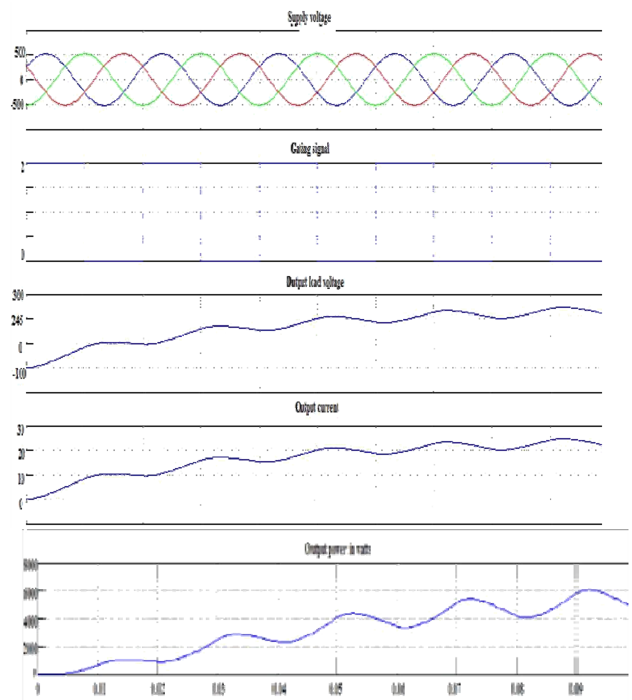

Fig. 9 Output waveform of Wind energy Conversion system.

C. Diesel Power Generation System

The diesel power generation consists of the diesel generator. The generating system includes the diesel generator governor and the generator excitation system. The diesel generator employed here is the synchronous generator, which produces the output voltage of 238 volts. Fig. 10 and 11 shows the matlab circuit diagram of the diesel generator system and the waveform of the diesel generating system.

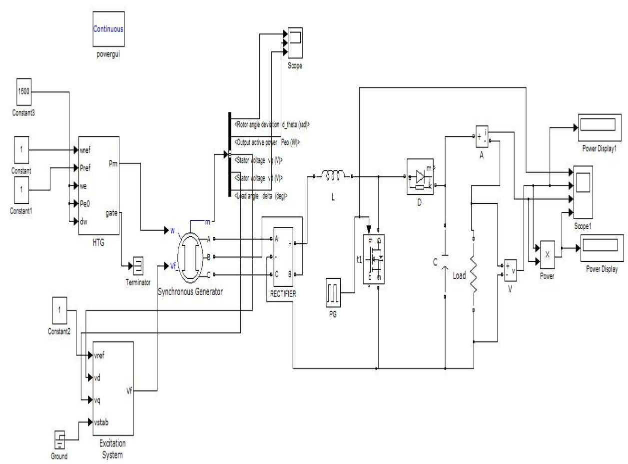

Fig. 10 Simulation diagram of Diesel power generation system

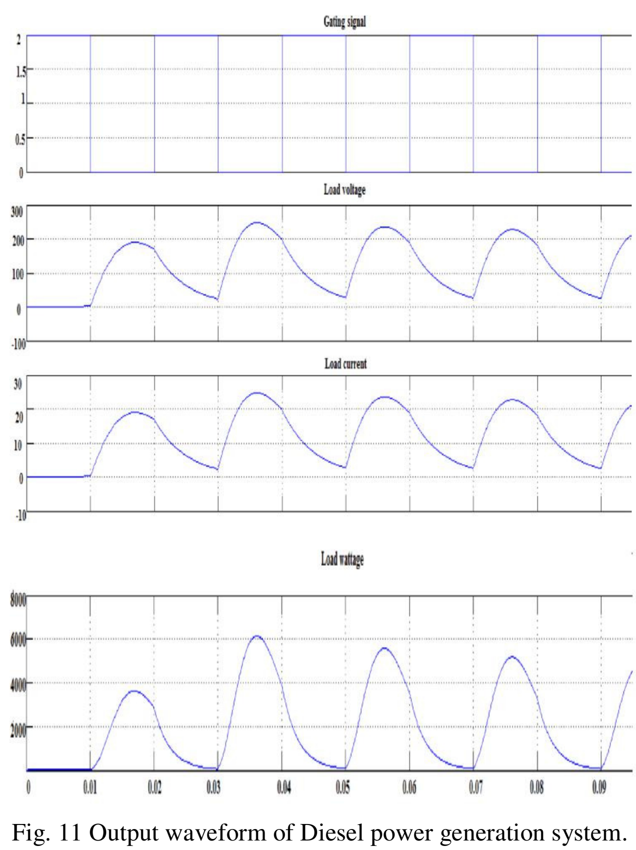

Fig. 11 Output waveform of Diesel power generation system.

D. Simulation of Integrated Hybrid system

The integrated hybrid system consists of the solar power source, wind energy conversion system, hydro power system, and diesel power generation system. Fig. 18 and 19 shows the matlab circuit diagram and waveform of the integrated hybrid system

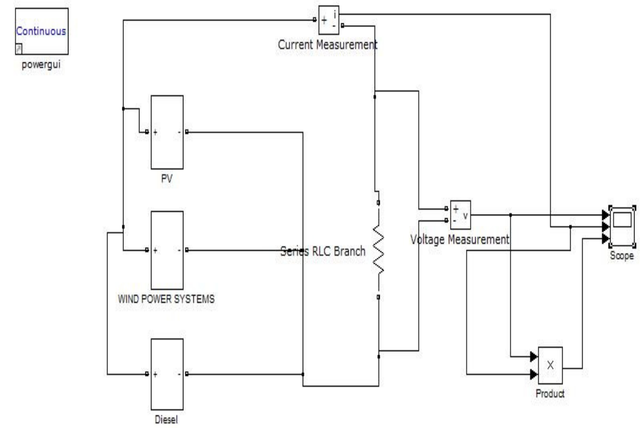

Fig. 12 Simulation diagram of integrated system

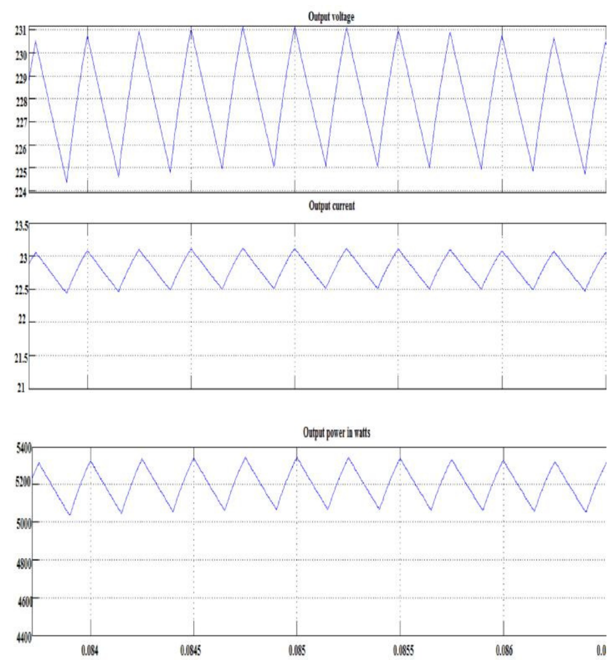

Fig. 13 Waveform of Integrated system.

VII. CONCLUSION

This proposed system implements the fuzzy control to achieve the optimization of an energy management system for the smart micro gird applications. From the simulation the dynamic model of the DC micro smart grid system was simulated, and from this simulation of this one can able to understand how the fuzzy maintains the SOC parameters of the battery. The optimization control of the DC smart micro grid was done through the employment of the fuzzy by its membership functions and the fuzzy rules. The intelligent management increases the accuracy of the non linear system and it also achieves the optimization of the energy distribution of the smart micro grid system by its control algorithm.

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