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Hybrid Photovoltaic and Wind Power System with Battery Management System Using Fuzzy Logic Controller

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ABSTRACT

In recent year, the development of hybrid renewable energy sources has the important role of power generation. This paper focused on design of hybrid PV/Wind power system and its battery management system. The fuzzy logic control based battery management system has been designed for effective power utilization. The proposed control to operate the battery charging and discharging mode during non-linear power generation. The battery will charge whenever the renewable energy power is greater than to consumer load power as well as the battery will discharge whenever the renewable energy power is lesser than to consumer load power. The proposed model will be simulated using Matlab environment and analysis the proposed system results. Finally, simulation results are evaluated and validating the effectiveness of the proposed controller.

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1. INTRODUCTION

In recent years the renewable power generations have an importance role to meet the consumer demand. The hybrid renewable energy sources are very effective to generate the power even though the absence of any one source [1]. In this paper, we have to select two different renewable energy sources such as PV and Wind power system. The PV sources, it's generating the maximum power at during day time. The wind energy system has generated the maximum power at during night time. This paper has analyzed the operation of individual and hybrid PV/ Wind system. The section II presents the operation and model of PV system. The section III presents the operation and model of the wind system. The section IV presents the proposed system simulation model and results. The section V presents the results discussion. The section VI presents the conclusion of the proposed system.

2. PHOTOVOLTAIC SYSTEM

Photovoltaic cells are made up of semiconductor materials which are capable of converting light energy into electrical energy by the principle of the photovoltaic effect [2]-[3]. The photons from sunlight provide the necessary energy for electrons in the semiconductor materials to cross the band gap to travel from one band to another. The movement of electrons from one band to another cause electron flows, thus producing the current [4]. The output voltage of a photovoltaic cell is directly dependent on the irradiance and temperature of sunlight. Open circuit output voltage can be calculated using the formula.

$$V_{OC\ ambient} = Temperature\ Coefficient\ (T_{STC}\ T_{ambient} + V_{oc\ rated}) \quad (1)$$

Where
$V_{OC\ ambient}$ = Open circuit voltage at module temperature
Temperature Coefficient = 0.12 V/C
(When the temperature decreases by one degree Celsius the voltage increases by 0.12)

T_{STC} [°C] =Temperature at Standard test conditions (25°C and 1000 W/m^2)

$T_{ambient}$ [°C] =Module Temperature

$V_{OC\ rated}$ = Open Circuit voltage at standard test conditions

The voltage waveform of the single PV array MATLAB model (Figure) At the temperature of 25°C and irradiance of 1000 W/m^2 is shown in the Figure. From the output waveform it is clearly seen that the $V_{OC\ ambient}$ is 135 volts and the saturation time for the PV array to reach $V_{OC\ ambient}$ is 0.03secs.

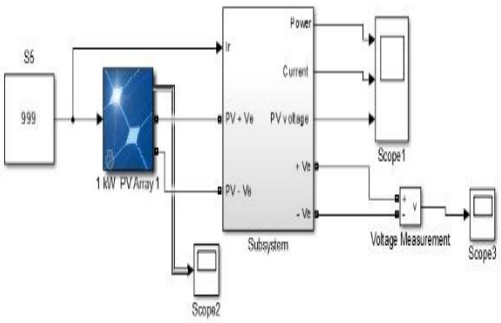

Figure 1. Simulation Model of Single PV Cell

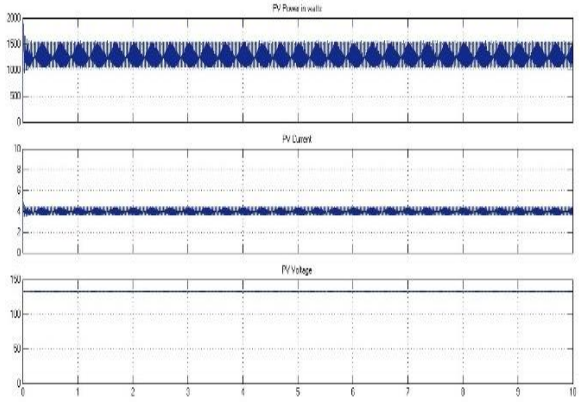

Figure 2. Output Voltage of PV Power System

3. WIND POWER SYSTEM

To utilize the non-conventional source of energy for generating power to meet our daily demand [5]. The source as a wind and converting its kinetic energy into electric energy. The system which has built is eco-friendly and does not cause any harm to the environment or to human beings. It is long term power implementation scheme and power can be generated continuously at any season condition [7]-[8].

Conversion of kinetic energy of the wind into mechanical energy that can be utilized to perform useful work, or to generate electricity. The axis may be horizontal, or vertical. Types of windmill:

a. Horizontal axis and
b. Vertical axis.

As the speed or the turbine increase the synchronous generator rotates above the synchronous speed and act as an induction generator which converts the mechanical energy of turbine rotation into electrical energy which is to be supplied to the off-grid [7]-[8].

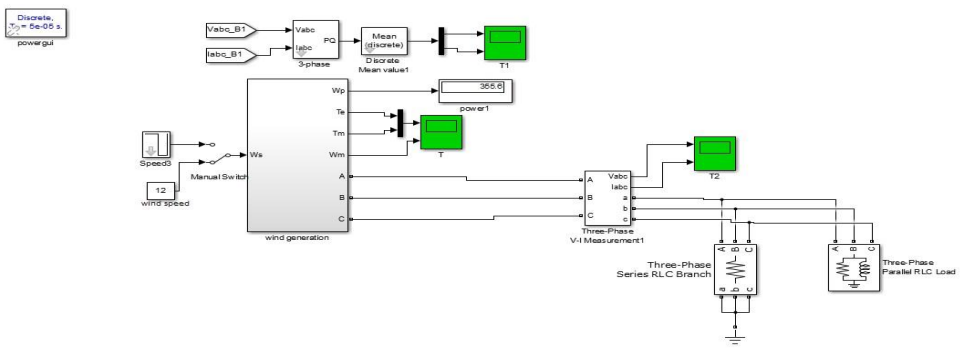

Figure 3. Wind Power System

With the advent of high powered Thyristor and high voltage DC systems, AC output of the 3-phase alternator is rectified by 3 phase rectifier circuit and then converted DC to AC using voltage source inverters. They utilize an AC source (power lines) which periodically reverses polarity and causes the commutation to occur naturally. Since frequency is robotically stable by the power line, they are also recognized as synchronous inverters. And the output from the windmill will be 3-phase AC supply, so it will be converted to DC by using the universal bridge. And it is stored directly to the battery as DC. It is shown in Figure 4.

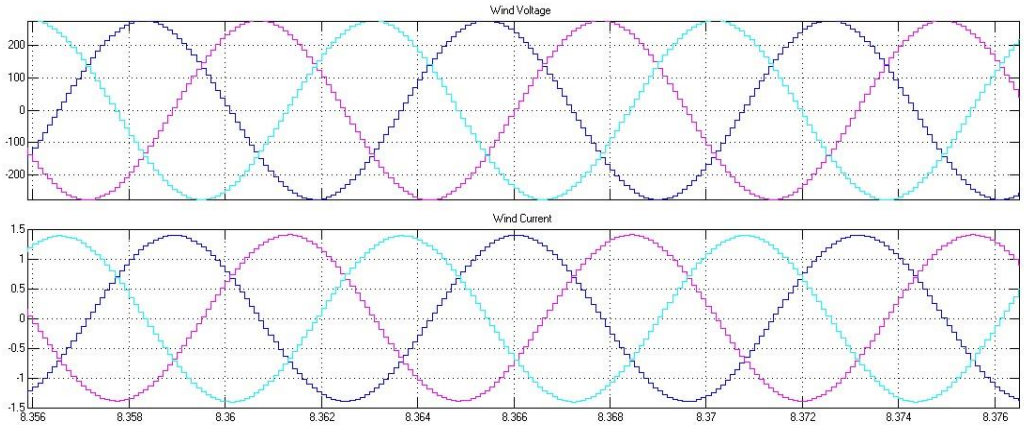

Figure 4. Wind Power System Output Voltage

Block diagram

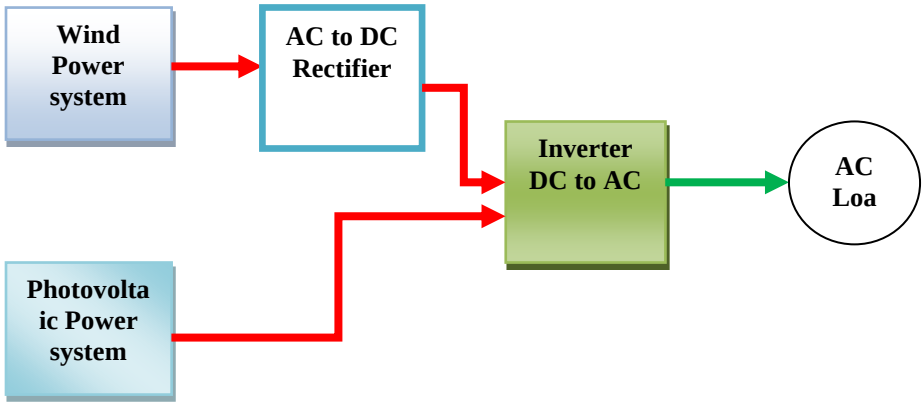

Figure 5. Proposed Hybrid PV/ Wind Power System

The proposed model has simulated used the Matlab environment as shown in Figure 6. The simulation model we have used Photovoltaic and wind power system and common inverter in a PV/wind system as shown in Figure 1 and Figure 3. The voltage controller circuit is always evaluating the Common connecting point voltage profile and compare with PV/Wind generation voltage on inverter side [9-13]. The fuzzy logic controller is developed using Matlab software. The fuzzy logic control will control the battery charging and discharging operation shown in Figure 7 and Figure 8. The proposed controller will operate the circuit breaker of battery charging mode and battery discharging mode shown in Figure 9. [14-16].

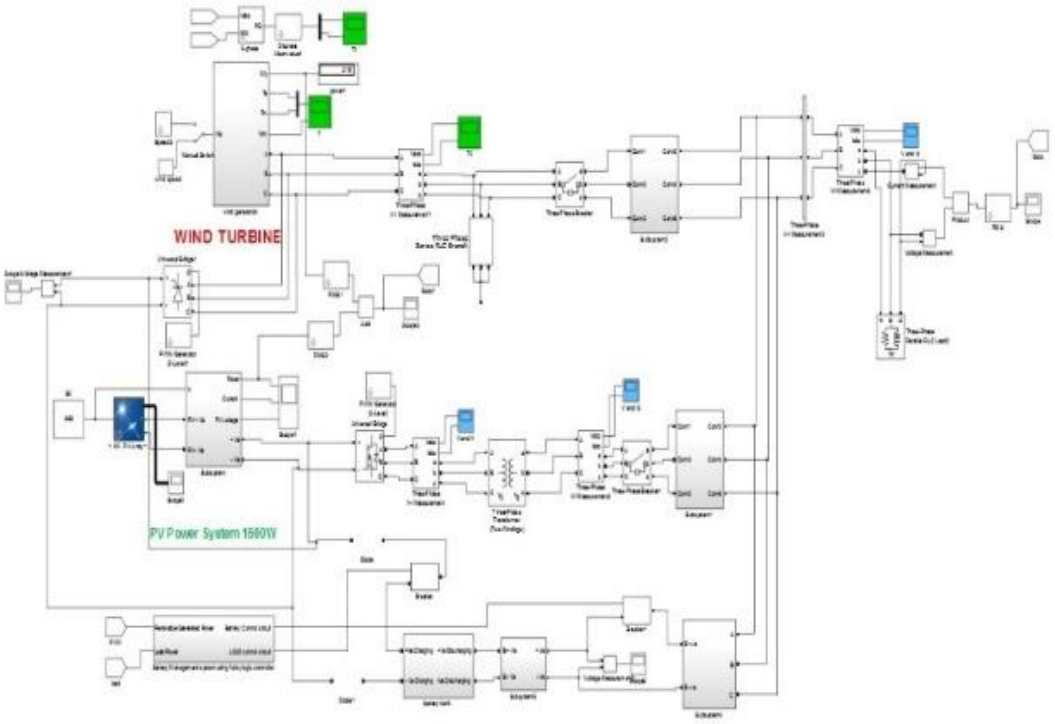

Figure 6. Hybrid PV/Wind Power System with Battery Management System

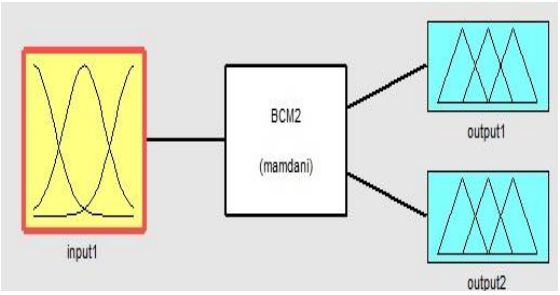

Figure 7. Fuzzy Control Design

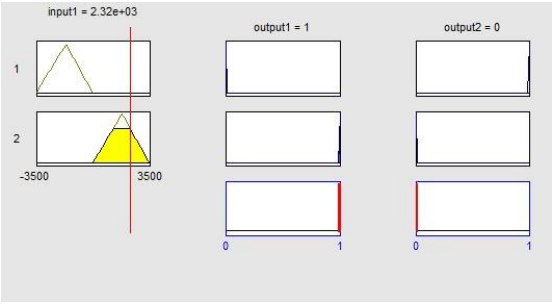

Figure 8. Fuzzy Rule

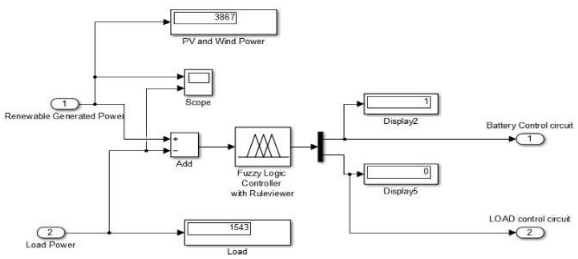

Figure 9. Fuzzy Controller Based Battery Management System

4. RESULTS AND DISCUSSION

The hybrid PV and Wind power system are connected to load and the load voltage and load power are presented in Figure 10 and 11.

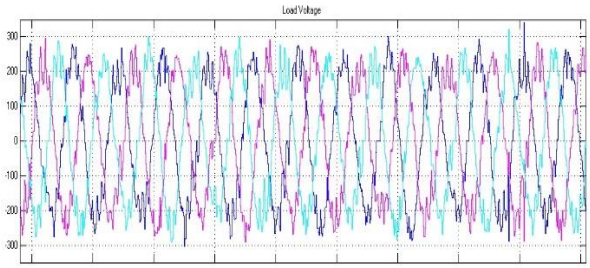

Figure 10. The Hybrid PV/Wind Voltage Profile

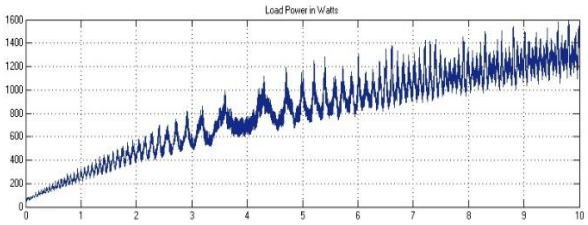

Figure 11. Full Load Power 1500Watts

5. CONCLUSION

This paper the 7.5 kW hybrid photovoltaic and wind power systems was simulated using Matlab Simulink environment. Effective power utilization of the above hybrid system battery management technology is developed by using the fuzzy logic controller and simulated in Matlab. The fuzzy logic controller to operate the two circuit breakers, such as battery charging mode and discharging mode. The battery charging mode circuit breaker is closed and discharging mode circuit breaker opened whenever the generation of renewable energy power is greater than consumer load. The battery discharging mode circuit breaker is closed and charging mode circuit breaker opened whenever the generation of renewable energy power is lesser than consumer load. The proposed model simulation results are evaluated and show the effectiveness of the controller.

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