SIMULATION AND MODELLING OF WIND AND PV HYBRID STANDALONE SYSTEM

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***Abstract*: In the present paper, the analytical model of the wind and PV hybrid system is simulated. The hybrid system is more advantageous because of its reliability. The intelligent management system of fuzzy is used for optimal management and operation of wind and pv hybrid system. The power from hybrid system is stored in the battery which is managed by fuzzy control the state of charge (SOC) parameters of the battery. This hybrid stand alone system can provide uninterrupted electrical power supply to the areas where lying of transmission lines is challenging. The main aim of the paper is to reduce the dependence on fossil fuels and maintain a uninterrupted power supply to the remote and elevated areas.**

***Keywords*: fuzzy control, standalone, intelligent management system**

1. INTRODUCTION

Due to advancement in technology, demand for electricity is increasing day by day but the available plants are not able to meet the demand. Due to depletion of fossil fuels, it is necessary to consider alternative renewable energy generating techniques. Among existing renewable energy sources wind and solar sources are most freely available and environmental friendly. The hybrid system mainly consists of the solar PV array, wind energy conversion system, storage battery, chopper, inverter etc as shown in fig.1

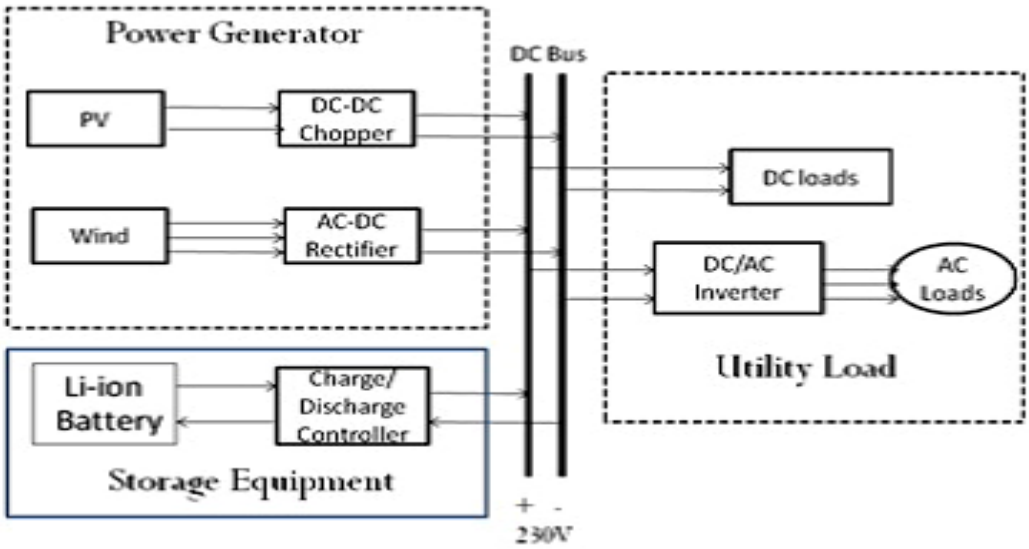

Fig 1: Configuration of hybrid system

The PV and wind system delivers power to the load via storage unit during normal conditions. The solar panel converts the light incident on it to the electrical energy. The solar gives DC as output voltage and chopper is used to convert variable DC to constant DC. The efficiency of wind and PV mainly depends on characteristic weather conditions. During night and dreary weather condition the efficiency of the PV system is less. This problem is overcome by integrating PV with wind.

The rotational energy of wind is converted to mechanical energy by wind turbine, which is again converted to electrical energy using generator. As wind produces AC output voltage rectifier is used to convert it into DC voltage. The power from both the sources is stored in a battery, where battery management is done by fuzzy. As per the load requirement, the battery will assure the reliability of the power system for all climatic conditions. The battery starts charging when the wind and PV system can produce excess of power and tends to discharge when the load demand doesn't meet the power generation. The MPPT (maximum power point tracking) are incorporated with both the subsystems to draw maximum power. MPPT is a electronic control system that can be able to coerce the maximum power from the system. Since India is a huge country with number of small villages located in remote and elevated areas, Laying transmission line to those population living in such areas is costly and impractical. In such condition standalone hybrid power generating system can provide viable option.

2. MODELLING OF PV SYSTEM

The main source for the photovoltaic energy system is solar energy. The PV system consists of PV modules or the arrays which converts the solar energy into electrical energy. The model of PV system includes PV module/ array which harness the solar energy, dc-dc converter to convert the variable dc to constant dc, rectifier to convert dc to ac when the load is AC and MPPT to track the maximum power as shown in the Figure 2.

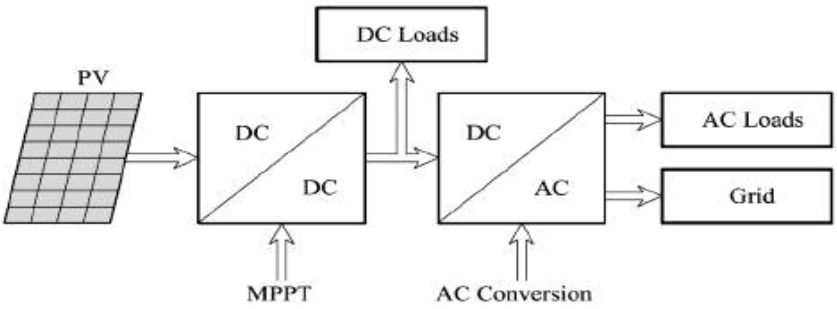

Fig 2: Block diagram of PV sytem

The PV modules are made up of several PV cells which are of a semiconductor material. When a photon of light strikes these semiconductor materials, the covalent bond inside the semiconductor material breaks to generate electrons and holes. This in result generates electric field by creating positive and negative terminals. When a conductor is connected to these terminals current starts flowing. PV array is simply a interconnection of several PV modules in series or in parallel.

3. MODELLING OF WIND ENERGY CONVERSION SYSTEM

Wind energy is one of the fastest growing renewable energies in the world. The generation of wind power does not cause any harmful effects to the environment, as it is clean and non-polluting.

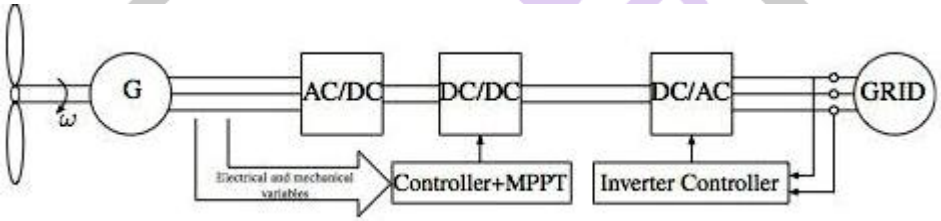

Fig 3: Block diagram of wind energy conversion system

The block diagram of the wind energy conversion system is shown in Figure 4, which comprises of wind turbine which converts wind's kinetic energy to the rotating motion, a generator which converts mechanical energy to electrical energy, rectifier for converting AC output voltage to DC voltage, MPPT with DC-DC converter to trace the maximum power point, the DC voltage to AC voltage converter is used to supply AC loads. The output power or torque of a wind turbine is associated with several parameters like (1) turbine speed (2) rotor blade tilt (3) rotor blade pitch angle (4) size and shape of the turbine (5) area of turbine (6) wind speed

The power extracted by wind turbine is given by,

$$P_W = \frac{1}{2} Cp.\rho.A.Vw^3 \quad \text{----------} \quad (3)$$

ρ is the air density, which is equal to 1.225 Kg/m^3
Cp is the power coefficient
V_W is the wind speed in m/sec
A is the area swept by rotor in m^2
The aerodynamic torque T_W in N-m is given by ratio between the extracted power from the wind P_W and speed of rotor turbine W_W in (rad/sec) is given by,

$$T_W = P_W W_W. \quad \text{----------} \quad (4)$$

4. BATTERY

The converted DC output from both the systems is stored in a battery which is called the storage system. When output from both the sub systems can satisfy the load demand then battery tends to charging and starts discharging, when generation cannot able to meet the demand depending on the state of charge(SOC). The SOC of the battery can be estimated as follows,

$$SoC = \frac{Ic}{Q} \qquad \text{----------} \qquad (5)$$

Where,
SOC is the state of charge
Q is the battery capacity
Ic is the battery current

5. BATTERY MANAGEMENT

The battery losses its durability due to frequent charging and discharging. Overcharging or insufficient charge of the battery also need to be avoid. Due to be charged weather conditions the wind speed and solar temperature are unstable naturally. With such generation system the problem is how and when the battery should be charged to best efficiency and durability. It is extremely difficult to determine whether the battery should be charged or to prevent it from being over charge or insufficiently charged based on mathematical model. So more effective way is using a system based on empirical rules. In the present paper we employ fuzzy control strategy as a solution for above problem.
The battery management with the fuzzy control also called as the intelligent management system, which is essential for the optimized load flow. The main objective of the intelligent management system is to avoid the variable operating time and for safeguard of the storage system. This intelligent management system is designed for the hybrid system to achieve the optimization of the system.

A. FUZZY CONTROL

A fuzzy logic was first proposed by lotfi A. Zadeh of the university of California at Berkeley in a 1965 paper. A fuzzy control system is based on fuzzy logic-a mathematical system that analyses the analog input values in terms of logical variables. The fuzzy is a tool of quantitative expressions for concepts that could nat be clearly defined. This management system requires the difference between the actual load and the generating power of both the system wind and PV for the battery management. The SOC of the battery is directly proportional to its durability. The fuzzy logic system has two inputs and one output. The controller in the fuzzy logic decides the charging and discharging operation of the battery, which depends on the SOC. The inputs and outputs of the fuzzy can be given as,

P_e = Total generated power-load power
$SOC_e = SOC_{command} - SOC_{now}$

The control rules of the fuzzy consist of four grades of function namely, Low (L), below average (BA), Average (Avg), above average (AA) and High (H). The low value of Pe shows that the renewable energy source does not provide enough energy to the load. Similarly the high value of Pe denotes the high rate of generation from the generating sources.

6. SIMULATION AND RESULTS

6.1. SIMULATION DIAGRAM OF PV SYSTEM

The simulation diagram of the PV system consists of the PV panel, DC-DC converters as shown in figure 9. The simulation diagram of subsystems and equivalent solar cell are shown in figure 11 and 12 respectively. The output waveform of the PV simulation shows the load voltage in volts and load current in amperes and is shown in figure 12.

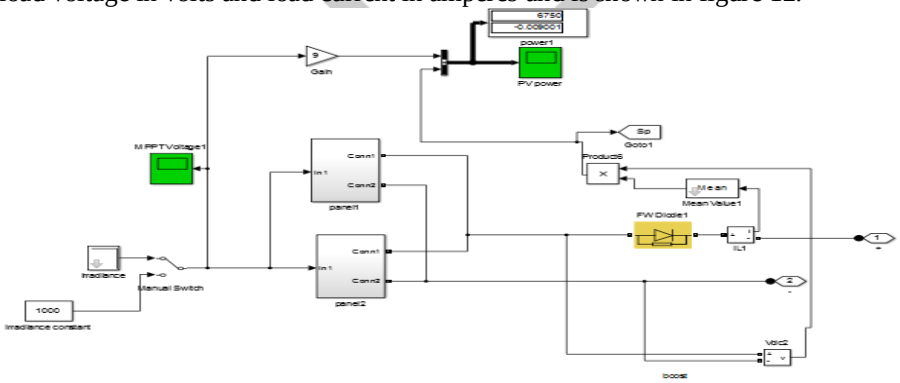

Fig 4: Simulation diagram of PV hybrid system

6.2. SIMULATION DIAGRAM OF WIND ENERGY CONVERSION SYSTEM

The simulation diagram of wind energy conversion system consists of wind turbine, pitch angle controller, PMSG (permanent magnet synchronous generator), uncontrolled rectifier unit. It also consists of filter circuit to remove the distortions present in the sinusoidal AC before supplying it to the load. The output waveform of the wind energy conversion system shows the load voltage in volts, load current in amperes and the load power in watts.

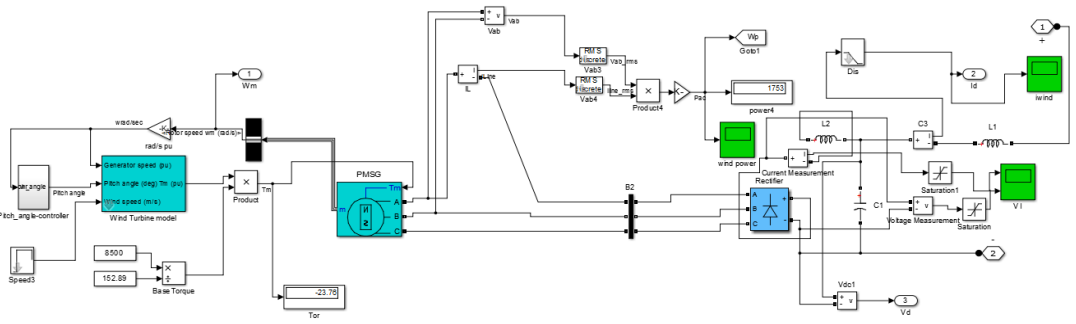

Fig 5: Simulation diagram of wind energy conversion system

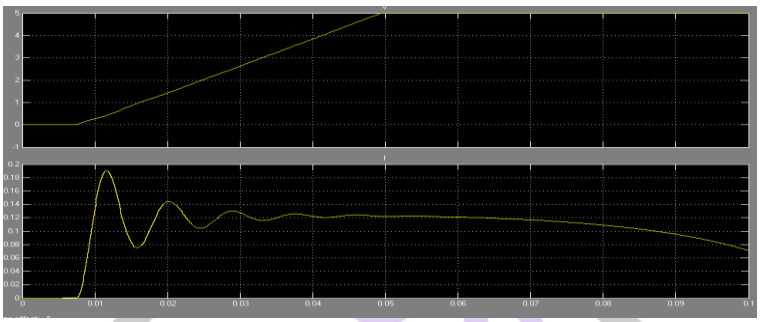

Fig 6: Output waveform of voltage and current

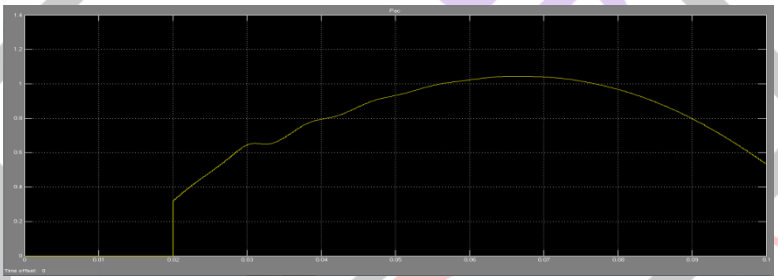

Fig 7: Output waveform of power v/s time

6.3: SIMULATION DIAGRAM OF BATTERY

The simulation diagram of battery consists of battery with the bidirectional DC-DC converter. The batter employed in the paper is lithium ion battery 200 Volts and 6.5Ah.

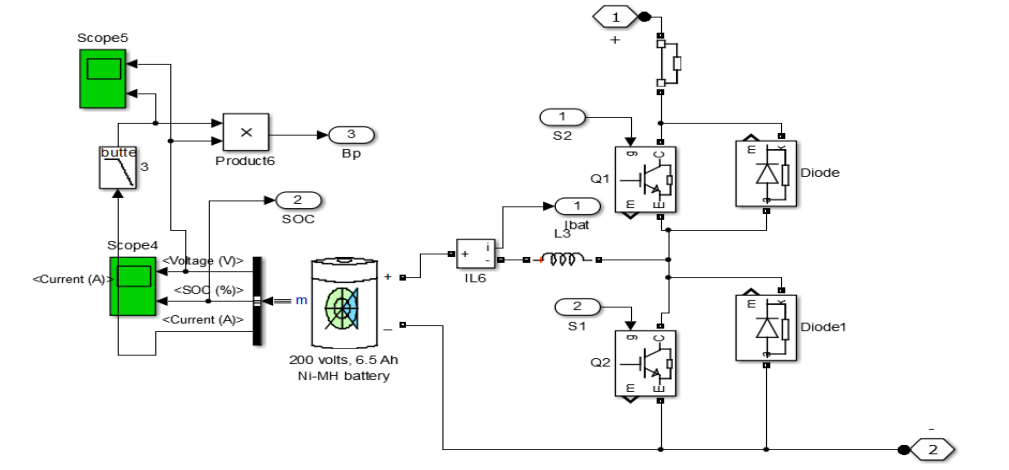

Fig 8: Simulation diagram of battery

7. CONCLUSION

This paper presents the modeling, simulation and designing of intelligent management system of a battery management for wind and PV hybrid solar system. The optimization control of the load flow was done through implementation of fuzzy, which consists of number of rules. Such type of battery management system helps to increase the accuracy of the non-linear system and it also achieves equilibrium energy distribution.

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