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Design & Analysis of Hybrid System using Fuzzy Controller

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Abstract-This paper presents a novel adaptive scheme for energy management in hybrid power systems. The proposed management system is designed to manage the power flow between the hybrid power system and energy storage elements in order to satisfy the load requirements based on fuzzy logic controllers. The advance fuzzy logic controller is developed to distribute the power among the hybrid system and to manage the charge and discharge current flow for performance optimization. The developed management system performance was assessed using a hybrid system comprised PV panels, wind turbine (WT), battery storage. The dynamic behavior of the proposed model is examined under different operating conditions. Real-time measured parameters are used as inputs for the developed system. The proposed model and its control strategy offer a proper tool for optimizing hybrid power system performance, such as that used in smart-house applications.

Keywords- Fuzzy, Solar PV, Wind, Battery Hybrid System.

I. INTRODUCTION

From last decade the industrial fuels like coal, gas, oil and others are in very critical condition and thus due to this there is rapid growth in the development of renewable energy resources. Due to the limited availability of these non-renewable fuels, the renewable energy resources are becoming more popular now days. There are also some other reasons for their popularity like their availability in huge amount, they are recyclable and they are eco-friendly and did not emit any harmful gases thus also provide a solution for global warming issue. There are several renewable energy resources that are present like wind, solar, tidal and hydro etc. among all these renewable resources the wind and solar energy are the techniques which are fastest growing techniques around the world. In these technologies, we use the PV cells and wind for the energy generation with no harmful gases emission [2].

As due to continuous industrialization and urbanization the demand of electrical energy around the world is continuously increasing. And the present available base load plants which are working on conventional fuels are not able to meet this increased demand of energy. So we can use these renewable energy resources to meet the demands of electrical energy and supply the power required to fulfill the energy demand.

There are some remote areas where the continuous supply of energy by conventional means is not possible thus in these areas we can set up some small energy generation plant by using renewable energy resources, which will meet the daily energy demands. In this dissertation report, we are presenting a wind-photovoltaic hybrid power system model and simulate that model. As this has been found that in individual power generation system is not much reliable so get the much advantage, we use the hybrid power generation system which provides the more advantage over individual system. Another advantage for this system is that if by any reason one energy generation plant stop working then in this condition another will work and provide the energy. In the diagram given below we have shown a block diagram for the hybrid system [5].

In this hybrid system there are mainly two components: one is PV and other is wind system. The photo-voltaic system is powered by using solar energy which is available In large amount in nature. The PV energy system is made up of PV modules and the maximum power point tracking system. In this system, we convert the solar energy incident on the PV cells by using solar harvesting means [6].

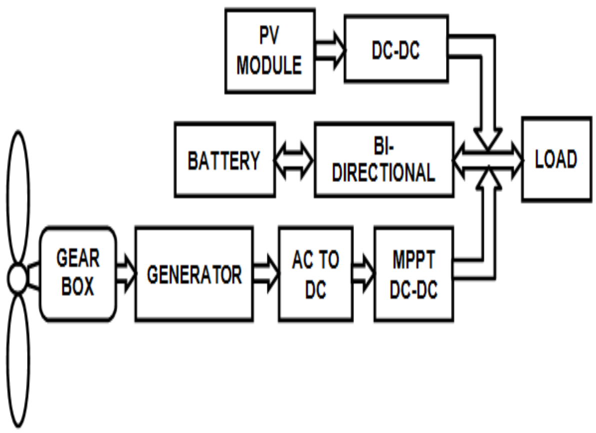

Fig 1. Architecture of hybrid system.

In this study we present the hybrid system which consists of solar system along with wind power generation system. The main component of a wind power generation system is turbine, gearbox, rotor, generator, converter etc. The main function of wind energy system is to convert the wind energy into mechanical energy through the rotation shaft and thus this shaft is connected to the generator shaft which will generate the electrical energy. As both the system which we sue in hybrid system are used to charge the battery by using bi-directional converter. Thus this bi directional converter and the battery we use will make the extra load over the wind and solar power generation system [7].

By using these hybrid systems this has been found that they can more efficiently fulfill the energy demands as compare to the single power source system. We can get the higher generation abilities by using hybrid system. As in a standalone system we can generate the output which did not have any fluctuation and did not depend over the weather conditions. Thus to store the power generated by the solar system by converting solar energy to electrical energy and the constant power deliver by the wind turbine we needs an efficient power storage device, which is realize by batter bank.

II. PHOTOVOLTAIC CELL

Generally, the structure of photovoltaic cell is simple. It contains total six different layers of material as given in Figure 1.2. In this system first layer is black cover galls which will increase the photon absorption efficiency; the function of this glass is to protect the cell from the atmospheric conditions. We can minimize the reflection losses up to 5% by using the anti-reflective coating. Then we have a contact grid which will minimize the travelling distance of photons, so that they can reach to semiconductor easily.

The main component of photovoltaic system is p and n semiconductors which are available in the form of two thin layers. In the last we have back metal contact which used for the better conduction [5].

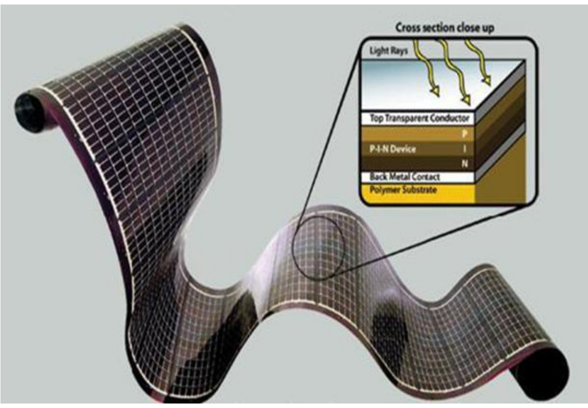

Fig 2. Basic structure of a generic silicon PV cell.

As in previous article we mention about the photovoltaic cell that this consist of two p and n thin layers of semiconductors which are made up of crystalline silicon. The n type semiconductors are generally producing by replacing the silicon atom with another element tom which have higher valence band than the silicon like 15 group elements for example phosphorus [6]. Thus due to this the n type semiconductor thus form consist of large amount of free electrons in their valence bond structure. And on the other hand p type semiconductors are produce by replacing the silicon atom with a lesser valence atom like boron. Thus due to this there is vacancy of missing electron which will propagate through the cell to conduct electricity.

III. WIND ENERGY SYSTEM

Wind energy is the kinetic energy generated by virtue of the movement of large air masses caused by differential heating of atmosphere by sun. It is one of the clean, renewable energy sources that hold out the promises of meeting of a significant portion of energy demand in the direct, grid connected modes as well as remote application like water pumping, desalination, telecommunication, etc. The wind resource is more intermittent and is strongly influenced by terrain or geographical factors.

A wind energy conversion system (WECS) is a machine which generates mechanical energy powered by wind energy that can be directly converted into electrical energy. The major components of a typical WECS include a wind turbine, generator, interconnected apparatus and control systems. The wind turns large turbine blades, which spins a generator shaft and produces electricity. This electricity then charges batteries which can be connected to a building’s mains power, or to the power grid. In particular, medium and large scale WECS are designed to operate in parallel with public or local AC grid.

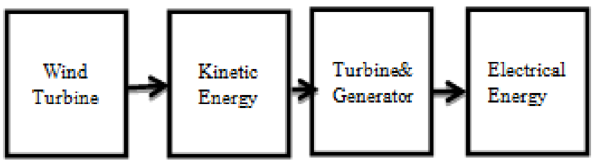

Fig 3. Basic Flow of Wind Power Generation.

The aerial view of a wind power plant shows how a group of wind turbines can make electricity for the utility grid. The electricity is sent through transmission and distribution lines to homes businesses schools, and so on.These three-bladed wind turbines are operated "upwind," with the blades facing into the wind.

The other common wind turbine type is the two-bladed, downwind turbine. Simply stated, a wind turbine works the opposite of a fan. Instead of using electricity to make wind, like a fan, wind turbines use wind to make electricity. The wind turns the blades, which spin a shaft, which connects to a generator and makes electricity. Utility scale turbines range in size from 50 to 750 kilowatts. Single small turbines, below 50 kilowatts, are used for homes, telecommunications dishes, or water pumping.

IV. BATTERY SYSTEM

Battery is the electric energy storage devices which will store the excess power generated and then use this energy to supply to the load in place of generators when power is needed. As is stated in the previous chapters here we integrate both the wind power generation system and photovoltaic system which connect with the common DC bus of the constant voltage and this battery bank is also connects with the DC bus.

In this power generation system every energy transfer whether it is from battery to load or generator to battery or from direct generator to load is performed through the constant voltage DC bus. As it mention in the previous study that there are several applications of bidirectional converter are present and in this study this converter is used to charge of discharge the battery which is based on additional and deficient power supply.

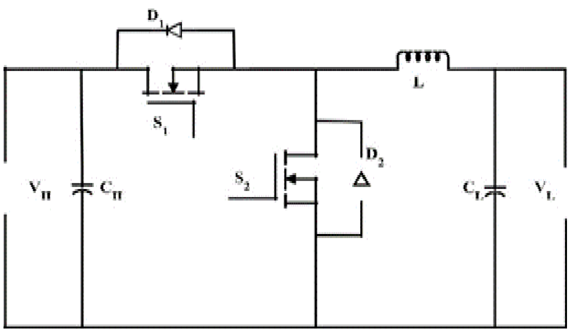

Fig 4. Circuit diagram of the buck-boost converter.

When the energy is available in surplus amount this means the energy supply is higher than the demand than in this case the battery will charge and thus this permit the converter ti operate in the forward direction. In the case when we have deficiency of power then the battery will start discharging and supply the power to load. Thus in this condition the converter will operate in the reverse direction. Thus by using bi-directional converter we can perform the charging and discharging function of battery. [20].

V. SIMULINK MODEL

The proposed system model is shown in figure. This model is designed in Matlab/ Simulink Software. In the proposed work, we are taking integration of Solar, wind and battery controlled by fuzzy logic.

Systems in the energy industry need to be controlled. Each system works with some rules, and these rules determine the system's instant situation.

For example, in a system in which the speed is controlled, the speed data of the motor shaft are compared to the reference data, and, according to the rules, the power of the motor can be increased or decreased. In this situation, a controller is required.

The model contains:

- Solar PV Array
- Wind Turbine
- Battery
- Fuzzy Logic Controller
- IGBT Inverter
- LC Filter

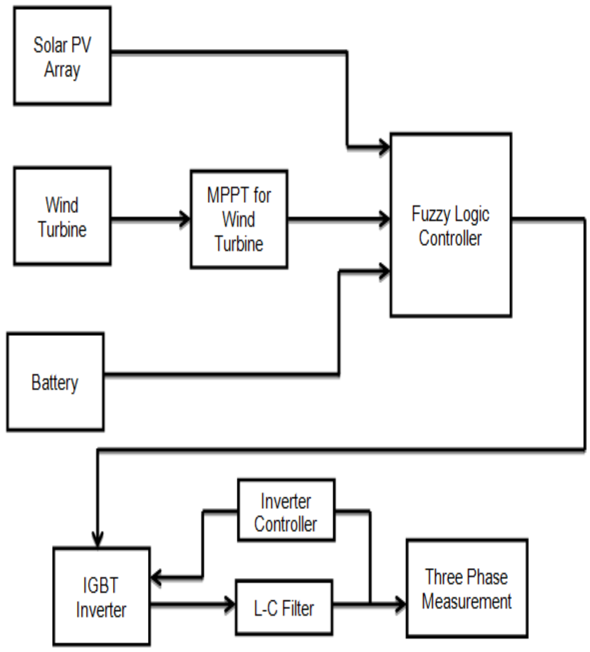

Fig5. Proposed Models.

VI. RESULT ANALYSIS & DISCUSSION

The result is anlysis for controoling of maximum renewable energy in the domestic system. In this section, we anlysedsolar, wind and batteries output in terms of current, voltage and power. The fuzzy logic controller applied to controller the power output from these sources and delivered to applied variable load.

The solar current is produced by the solar cells and the variation of current is due to irradiance alteration of PV Module Solar Current. The maximum solar current is 15.2 ampere. Three phase output current, volatge and power after Fuzzy logic controller is discussed in this section.The three phases current is shown in fig 6. Max current delivered by controller to load is 12 Ampere.

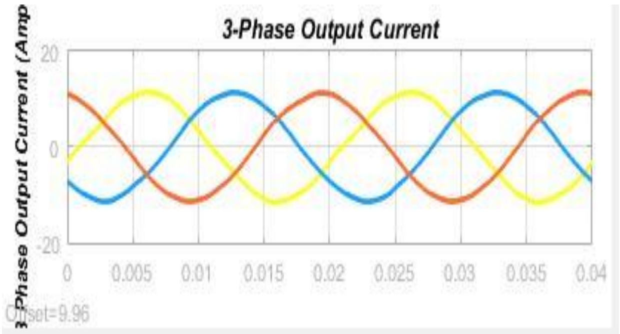

Fig 6. 3-Phase Current.

Fig 7. 3-Phase Voltage.

Fig 8. 3-Phase Power.

Three Phase output voltage is varies from -100 V to 100 V. The load voltage is varries in accordance to demand. The three phase output voltage is shown in fig 7.Three Phase power is varies as shown above with maximum 14000 watt power. The three phase power is approximate 600 watts. The three phase output power is shown in fig 8.

VII. CONCLUSION

In this study we are studied about the photovoltaic cells, module and array and also studied about the various effects of atmospheric factors over their characteristics. Consequently, we also studied about the wind power generation system. For both the PV and wind system we track the maximum power point of operation by using the P&O MPPT algorithm. Thus, in this study to get the advantages of both the system we integrate both these systems and this resulted hybrid system is sued for the charging and discharging of batteries.

Thus, after studying this model we make the following observations:

- Minimum ripple in solar PV model DC current and Voltage.
- Track maximum power in solar PV mode and wind turbine.
- Total harmonics distribution is 2% in 3 phase inverter current as compared to previous algorithm.
- Perfect DC current and voltage at solar PV panel
- 2 KHz switching frequency of SVPWM in Voltage source inverter very less power device loss.

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