Performance Analysis of a grid Connected SOLAR PV AND WIND HYBRIDPOWER SYSTEM USING MATLAB/SIMULINK

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Abstract - *Renewable energy sources have become a prominent alternative electrical energy source where traditional power generation is impractical. Photovoltaic and wind power generation have expanded dramatically in recent years. In this study, we presented a hybrid energy system that combines solar panels and wind turbine generators as an alternative to traditional electrical energy sources such as thermal and hydro power generation. To track the operational point at which maximum power may be extracted from the PV system and wind turbine generator system under continuously changing environmental conditions, a simple and cost-effective control technique has been presented. The complete hybrid system is detailed in detail, along with comprehensive simulation results that demonstrate the system's practicality. A software simulation model is developed in MATLAB/Simulink.*

Key Words**:** PV System, Boost Converter, Wind Turbine, PMSG, Battery Charging

1. INTRODUCTION

Because of the critical state of industrial fuels such as oil, gas, and others, the development of renewable energy sources is constantly improving. This is why renewable energy sources are becoming increasingly significant. Other benefits include abundant availability in nature, being eco-friendly and recyclable. There are numerous renewable energy sources available, including solar, wind, hydro, and tidal. Solar and wind energy are the world's fastest growing renewable energy sources.

1.1 Solar PV System

In 1839, a French physicist named Edmund Becquerel claimed that few materials may generate electricity when exposed to sunlight. [2] However, in 1905, Albert Einstein elucidated the photoelectric effect and the nature of light. Later, the photoelectric effect became the fundamental basis for photovoltaic power generation technology. Bell laboratories produced the first PV module in 1954.

1.2 Wind Energy System

A wind turbine turns the kinetic energy of air, or wind power, into mechanical power, or the rotational motion of the turbine, which can then be utilised to power a machine or generator. The power captured by a wind turbine blade is a function of the blade form, pitch angle, rotational speed, and rotor radius.

2. SYSTEM CONFIGURATION

Hybrid generating systems that use more than one power source can considerably improve the consistency of load needs. A hybrid system can achieve even higher generating capacities. We can offer fluctuation-free output to the load in a stand-alone system regardless of weather conditions. To convert the PV system's energy output to storage energy and deliver consistent power from the wind turbine, an efficient energy storage method is necessary, which the battery bank can provide.

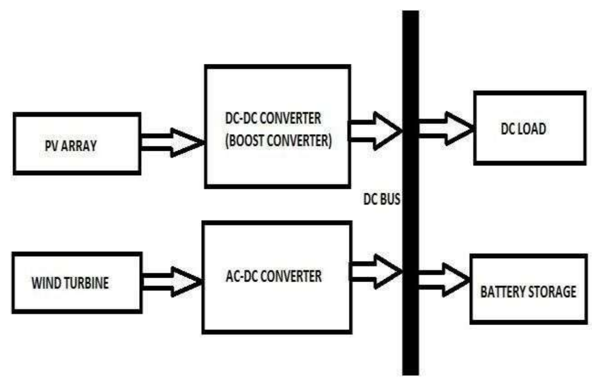

Fig.1 : Block Diagram of Hybrid System

3. DETAILED DESCRIPTION

Solar panels and wind turbines are combined in hybrid systems. This combination's output is utilised to charge batteries, and the stored energy can be sent to nearby power stations.

3.1 Solar PV System

PV modules or arrays convert solar energy in the form of solar irradiation into electric energy. The dc-dc converter modifies the voltage level to meet the electrical appliances supplied by this system. Depending on the required and available voltage levels, this DC-DC converter can be buck, boost, or buck-boost.

The core principle underlying the operation of a single PV cell is the Photoelectric effect, which states that when a photon particle strikes a PV cell, the electrons of the semiconductor become stimulated and jump to the conduction band from the valence band, allowing them to move freely. Electron movement generates positive and negative terminals, as well as potential difference across these two terminals.[2]

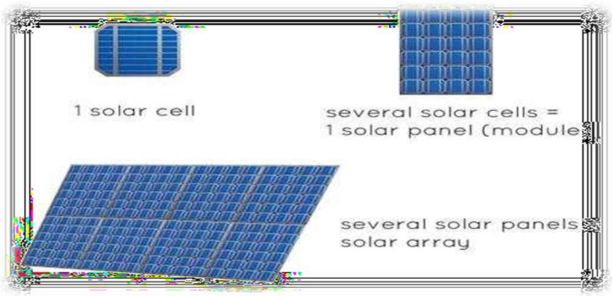

Fig: 2 PV cell, PV module and PV array [2]

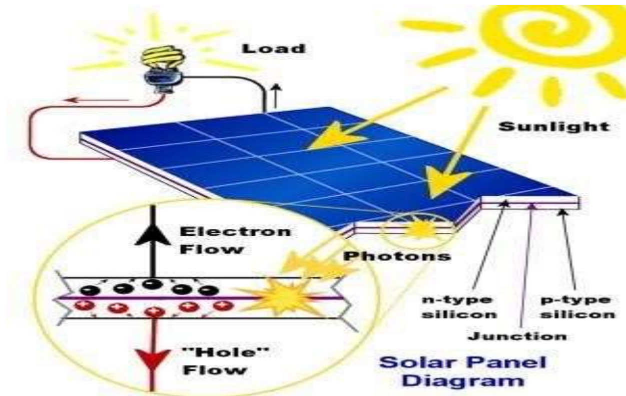

Fig.3 : Photovoltaic effect [2]

3.2 Wind Energy System

Wind is a renewable energy source. A wind turbine converts the kinetic energy of the wind into electrical energy. The generator, which is attached to the shaft of the blades, turns mechanical energy into electrical energy. The vertical axis wind turbine and the horizontal axis wind turbine are the two types of wind turbines based on the rotational axis of the blade..

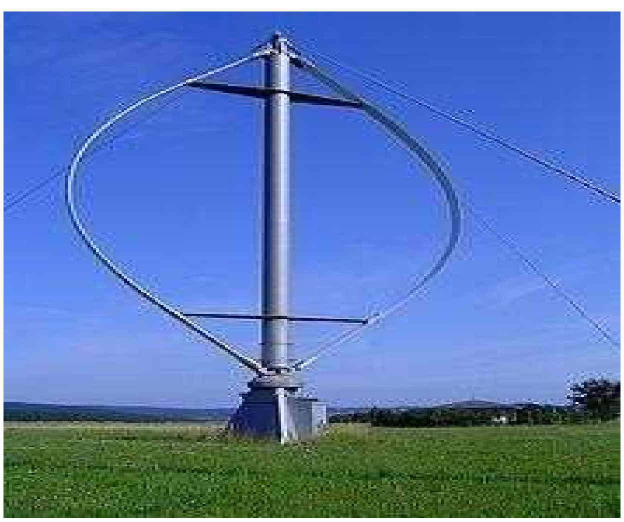

Fig.4 Vertical Axial wind turbine

Fig.5 : Horizontal Axial Wind Turbine [3]

The turbine's output is determined by the wind speed. In nature, the power generated by the turbine fluctuates. To ensure a continuous supply of power, electricity is first stored in a battery unit and then delivered to the load. Wind energy systems are more efficient than solar PV systems.

3.2.1 Components of Wind Turbine

The list of components which are used in wind energy system are given below :

1) Rotor and Rotor Blade
2) Hub
3) Main Shaft
4) Gearbox
5) Generator
6) Anemometer
7) Controller
8) Nacelle
9) Yo Motor Mechanism
10) Tower

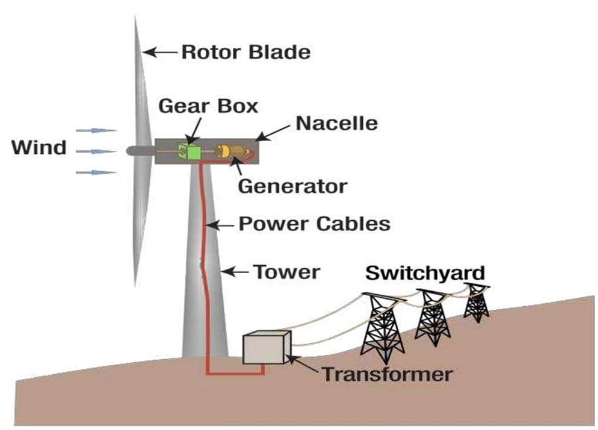

Fig 6 Wind Power Diagram

3.2.2 Types of Generator

Generators are classed based on the type of current they produce. There are two types of generators: alternating current generators and direct current generators. However, in either scenario, the voltage produced is alternating. We convert it to direct current by using a commutator. So for convenience, we go for alternating current generator.

In the AC generators, we can further classify them based on the rotor speed. There are synchronous generators (constant speed machine) and asynchronous generators (variable speed machine or the induction machine). Basically, a wind turbine can be equipped with any type of three-phase generator. Today, the demand for grid- compatible electric current can be met by connecting frequency converters, even if the generator supplies alternating current (AC) of variable frequency or direct current (DC)

- .Asynchronous (induction) generator :

1) squirrel cage induction generator (SCIG)
2) wound rotor induction generator (WRIG)

   - OptiSlip induction generator (OSIG)
   - Doubly-fed induction generator (DFIG)

- Synchronous generator :

1) wound rotor generator (WRSG)
2) permanent magnet generator (PMSG)

In this project work, permanent magnet generator (PMSG)is use for wind power generation.

Permanent Magnet Generator (PMSG)

Because excitation is delivered without any energy supply, the efficiency of the permanent magnet machine is higher than that of the induction machine. However, the materials utilised to make permanent magnets are expensive and difficult to work with during the production process. Furthermore, using PM excitation necessitates the employment of a full scale power converter to match the voltage and frequency of generation to the voltage and frequency of transmission, respectively. [7] This is an additional cost. The advantage is that electricity can be created at any pace to suit the existing conditions.

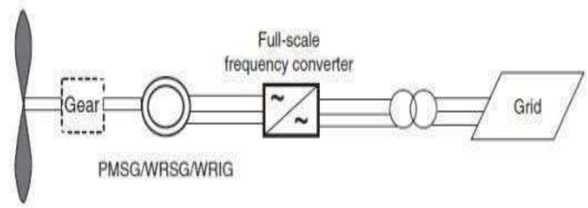

Fig.7 : Wind turbine with PMSG

PMSGs have a winding stator and a permanent magnet pole system on the rotor. The PMSG's synchronous nature may pose issues during starting, synchronization, and voltage regulation. It is difficult to provide a consistent voltage. Another problem of PMSGs is that the magnetic materials are temperature sensitive. Therefore, the rotor temperature of a PMSG must be supervised and a cooling system is required.

3.3 Batteries

The batteries are used to store the electricity generated by wind and solar energy. The capacity of the battery varies according to the size of the wind turbine or solar power plant. Battery maintenance should be minimal, and charge leaking should be minimal as well. Considering all of these factors, the free discharge type is the best option.

4. Proposed Simulink model

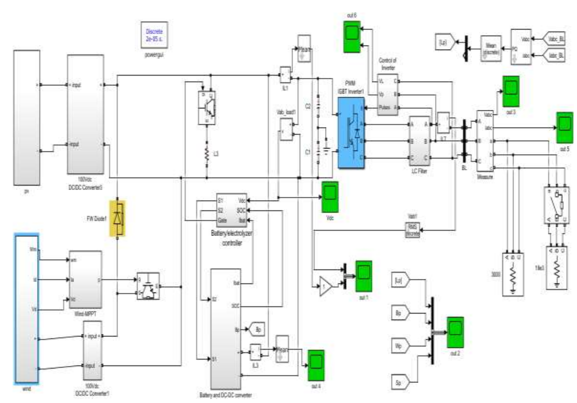

Fig 8: Simulink Model of Hybrid PV-Wind Energy System

Figure 8 depicts a grid-connected Hybrid PV-Wind energy device. The grid is a supply that acts as a backup device for renewable energy in the event of a power outage. When renewable energy systems generate surplus strength, the grid operates as a parking system. If there is a shortage of electricity from solar or wind, or if these sources are unable to meet the burden needs, the grid will automatically cover the entire demand.

5. SIMULATION RESULTS

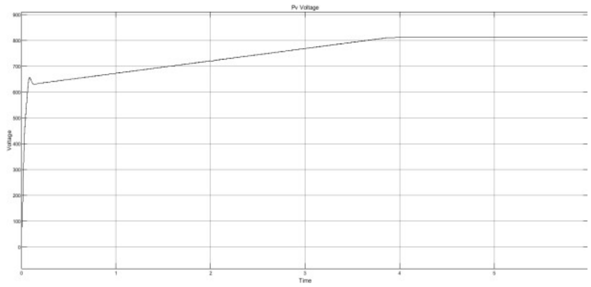

Fig 9: Voltage of the PV Module

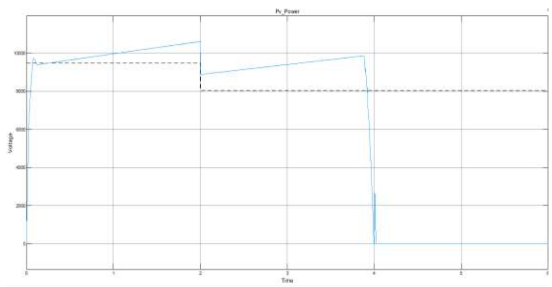

Fig 10: Power Curve of PV Module

The above figures 9 and 10 represents the P-V and I-V characteristics for a PV module at wellknown take a look at conditions of temperature 25°C and solar irradiance of 1000W/m2. In the determine 5.8 the y-axis shows the voltage values in volts and y-axis indicates the energy values in watts. While in determine 5.8 the y-axis indicates the voltage values in volts and y-axis shows the cutting-edge values in amperes. From the discern the short circuit modern Isc is 74A and open circuit voltage Voc is 360V and the most power obtained is 20KW.

Observations were achieved on various the sun irradiance values. The irradiance values are numerous from 250W/m2 to 1000W/m2 at a temperature of 25°C. On various the irradiance cost maintaining the temperature consistent it's miles observed that the modern-day will increase. The sun irradiance has influence on the cutting-edge price. The impact of solar irradiance on voltage could be very minimum. As the irradiance cost is growing the power also increases. Power is extended due to the increment in current cost.

Observations are completed on varying the temperature value. The temperature values are varied from 25°C to a hundred°C preserving the irradiance price at 1000W/m2. On varying the temperature price maintaining the irradiance identical it's miles determined that the cost of voltage decreases, and the cutting-edge cost remains fairly identical. Temperature variant has tons greater effect on voltage. As the temperature fee will increase the electricity price decreases. Power is decreased because of the decrement in the voltage value.

5.1 SIMULATION RESULT OF WIND ENERGY SYSTEMS

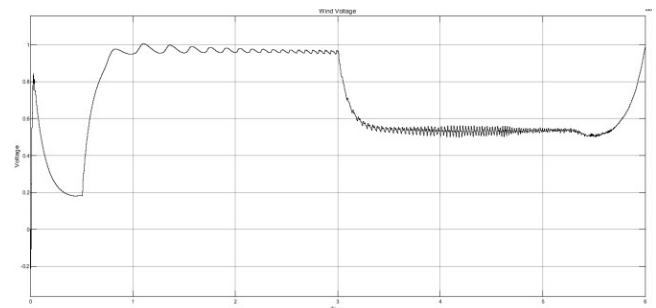

Fig 11: Output Voltage of Wind Power System

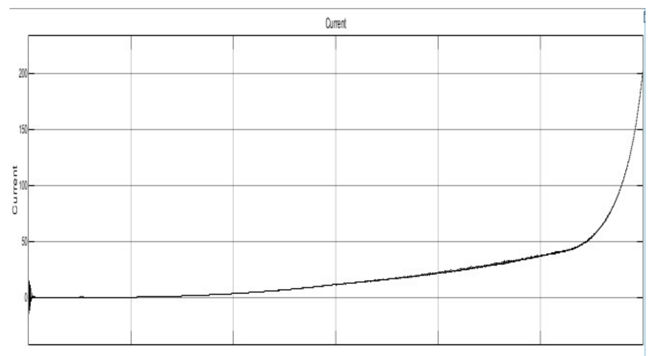

Fig 12: Output Current of Wind Power System

The figure 11 and 12 represents the output waveforms of wind power systems. The figure 5.10 is the output graph of voltage and the figure 5.10 is the output graph of current. The x-axis indicatesthe time and the y-axis is the voltage and current.

5.2 SIMULATION RESULT OF HYBRID ENERGY SYSTEM

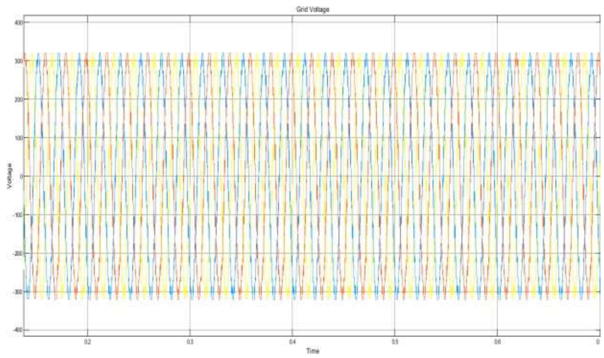

Fig 13 (a) Grid Voltage

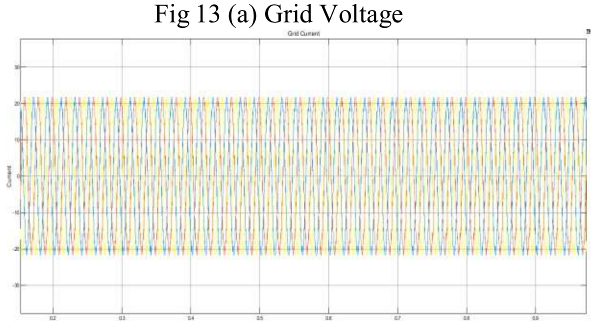

Fig 13 (b) Grid Current

The above figure 13 represents the output from the mixed sun and wind strength machine. The output for the hybrid system will be the blended solar strength plus the wind power. The output from the hybrid version first graphs is the output of Vrms and Irms that's the DC equal output waveforms. The middle graphs constitute the real electricity and reactive power of the strength distribution of the hybrid strength machine. The backside graphs represent the sinusoidal voltage and modern output from the hybrid energy device. From the hybrid system deliver is fed to the load also and electricity ultimate is furnished to the grid.

On combining the hybrid gadget the use of the solar and the wind energy to power the grid. The generated power from wind is attached parallel and shared with PV system. There is a distinction in technology from wind and sun because resources rely on various climatic conditions consequently, there may be in all likelihood to be inequality in the measurement of energy even though the 2 structures are related in parallel to the grid.

6. CONCLUSION

This dissertation is on modelling of a hybrid wind/PV alternative energy system. The main part of the dissertation focuses on the modelling of different energy systems. A hybrid wind/PV system is proposed in this dissertation. Wind and PV are the primary power sources of the system, and the battery is used as a backup and long term storage unit. Based on the dynamic component models, a simulation model for the proposed hybrid wind/PV energy system has been developed successfully using MATLAB/Simulink. The overall power management strategy for coordinating the power flows among the different energy sources is presented in the dissertation. Simulation studies have been carried out to verify the system performance under different scenarios using practical load profile and real weather data. The results show that the overall power management strategy is effective and the power flows among the different energy sources and the load demand is balanced successfully.

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