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Simulation of Hybrid Solar-Wind Power Plant Using MATLAB

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Abstract: ***In today's world Renewable energy sources have become a popular alternative electrical energy source. Generations through wind power and photovoltaic systems have increased in last few years. In this study we proposed a hybrid energy model which consists both solar power plant and wind turbine power plant as an alternative source of electrical energy. A simple control technique is proposed to track a point at which maximum power will be delivered by both solar power plant and wind turbine power plant under changing environmental conditions. For this purpose software named Matlab/Simulink is used for the simulation and feasibility of wind-solar hybrid power plant.***

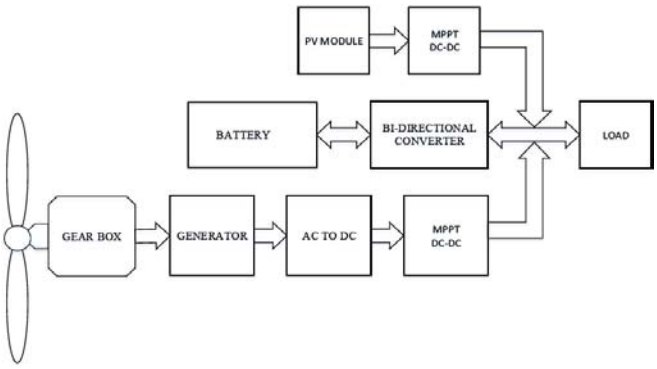
Keywords: photovoltaic system, wind system, hybrid sytem, simulation

1. Introduction

Development of renewable energy sources is continuously improving because of critical condition of fuels like coal, gas, oil and others. Due to this situation renewable energy sources becomes important in today's world. Few other reasons behind using renewable sources are abundant availability in nature, recyclable and eco friendly. There are many types of renewable energy sources are present like solar, hydro, wind, tidal and others but among these sources solar energy and wind energy are fast growing energy sources. There is no emission of any pollutants; energy will be extracted by wind turbine generator set and photovoltaic cells.

Demand of electricity is increasing day by day but available electrical energy power plants are not able to supply electricity as demand needs. So these hybrid power plants can supply the electrical power during peak loads. This type of hybrid power plant can be used as standalone power generating plants in remote areas where conventional power generation is not an easy task.

In this thesis a wind-solar hybrid power generation plant model is simulated and studied. A wind –solar hybrid power plant is more advantageous than an individual wind or solar power plant because when one system is faulted other can supply the power. A block diagram of wind-solar hybrid power system is shown below.



This wind-solar hybrid system comprises of photovoltaic systems and wind turbine systems. The PV system is used to convert solar energy into electrical energy which is abundantly present in nature. When the light falls on the PV system its converted into electrical energy. Maximum power point tracking system with perturb and absorb algorithm is used which extracts the maximum power from the PV system.

In wind turbine system wind turbine, generator, gear box and AC-DC converter is used. When wind turbines rotates with striking wind on blades there is a rotational mechanical energy is produced on shaft of turbine which is further mechanically connected with generator shaft trough gear box. When turbine rotates generator shaft also rotates with it and electricity is produced by the generator. Generally AC generator is used therefore AC-DC converter is used to convert AC power into DC power.

Wind and solar both systems are used to charge the battery through bi-directional converter. Bi directional converter is used to store the dc power in battery bank and supply the load by converting the DC power into AC power.

Hybrid generation systems are more conventional than single source power generation to fulfill the load demands all the time. By using hybrid power plants higher generating capacities can be achieved to some extent. We can provide a fluctuation free power to load irrespective to weather conditions in standalone hybrid power system. An efficient mechanism is required to store and to deliver constant power to load from both wind plant and solar plant therefore for reliability battery bank is used.

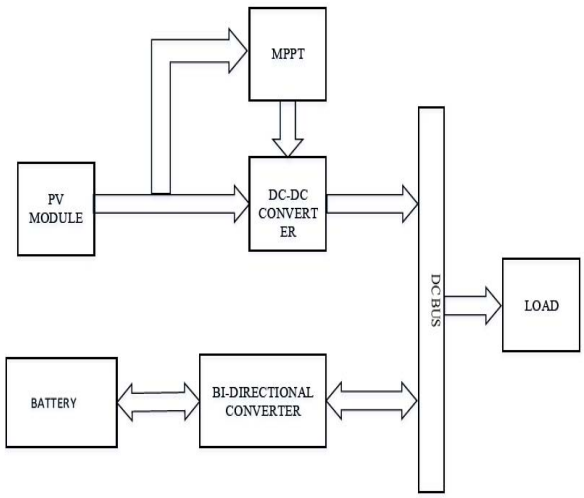
2. Problem Formulation

The main objective of this thesis is to simulate the power system having both solar photovoltaic and wind power systems. Other objectives are;

- To study characteristic curves and effect of variation of environmental conditions like radiations and temperature.
- To trace maximum power point of photo voltaic system irrespective of environmental condition changes.
- To trace the effect of wind speed on hybrid model.
- Implement hybrid solar-wind power system.

3. Photovoltaic Arrangement

A photovoltaic power system mainly powered by solar energy. The configuration of photovoltaic system shown in figure.



Photovoltaic power system contains photovoltaic module or arrays which converts radiations of solar energy into electric energy. Maximum power point tracking system is used to get maximum possible power from photovoltaic system. Bi-directional converter is used to supply the power both directions. It is used to charge the batteries when the power is surplus and discharge the batteries into load when power is in deficit.

PV Module

A Single PV cell generates very low voltage around 0.4 V, so more than one PV cells are connected either in parallel or series or in both parallel and series to form a PV module as shown in fig below. When we connect PV cells in series we get high voltage and when we connect PV cells in parallel then we get high current value. Usually there are 36 or 76 cells are present in single PV module. Front sides of PV module are transparent and build up of transparent glass and low iron material. Efficiency of module decreases as compared to PV cell because frame and glass cover reflects some amount of radiations coming from sun.

PV Array

A PV array is made up of several PV modules connected in series or parallel. This is because an individual module may not be sufficient to meet the requirement of trading applications. In a PV array modules are connected like as that of cells connected in a PV module. While making a PV array generally the modules are initially connected in serial manner to obtain the desired voltage and then stings are obtained are connected in parallel in order to produce more current based on requirement.

Wind Power System

The wind energy system consists of a wind turbine which converts wind's kinetic energy into rotating motion, gear box is attached to turbine shaft and generator. Gear box is used to increase the speed of shaft. Generator converts mechanical energy of shaft into electrical energy. A rectifier converts ac power to dc power. Battery is charged and discharge through bi-directional converter.

Operation of a Wind Turbine

In the previous paragraph, reference was made to the extensive use of horizontal axis wind turbines around the planet for electricity production instead of vertical axis turbines. Therefore it is considered appropriate to comment on the main parts of a horizontal axis wind turbine. A wind turbine consists of the following four main parts: the base, tower, nacelle, and blades, as shown in the picture below. The blades capture the wind's energy and spin a generator in the nacelle. The tower contains the electrical circuits, supports the nacelle, and provides access to the nacelle for maintenance while the base is made of concrete and steel and supports the whole structure. Moreover modern wind turbine rotor blades capture wind's energy and convert it to rotational energy of shaft. The shaft, which is connected to the generator and transfers the rotational energy to it, is distinguished in two types: high-speed shaft which drives the generator and low-speed shaft which operates about 30 to 60 rotations per minute. Inside the nacelle there is the generator and the gear box. The gearbox connects the low-speed shaft to the high-speed and increases the rotational speed from about 30 to 60 rpm to about 1200 to 1500 rpm. Generator uses rotational energy of shaft to generate electricity using electromagnetism while induction generators that produce 60-cycle AC electricity are widely used. In addition electronic control is used to shut down the turbine in case of malfunction and yaw controller is used to keep the rotor facing into the wind as the wind direction changes. Towers are usually designed in a white steel cylinder of about 50 to 70 meters tall and 3 meters in diameter. They have a ladder running up the inside and a hoist for tools and equipment. Tower supports rotor and nacelle and lifts the entire system to higher elevation where blades can be safely put in operation. Finally the base is made of concrete reinforced with steel bars and supports the whole structure.

4. Result and Discussion

Simulation result of PV-wind hybrid power plant

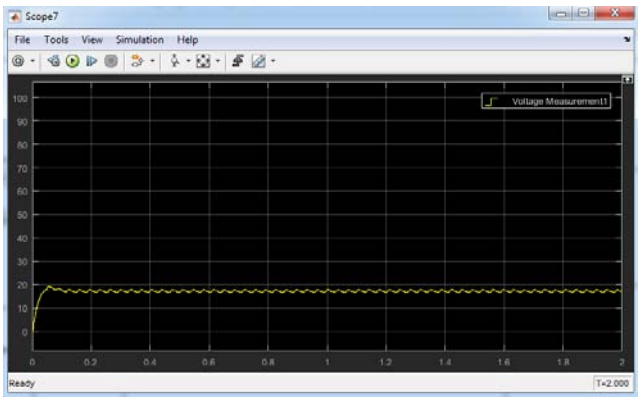


Fig shows the when the voltage produced by PV-Wind Hybrid power plant when the temperature is 20c, irradiation is 200lumens/m2 and wind turbine is rotating at 20% of full speed. Voltage produced by the hybrid power plant is approximately 18v.

Effect of MPPT of PV Plant on Hybrid Power Plant

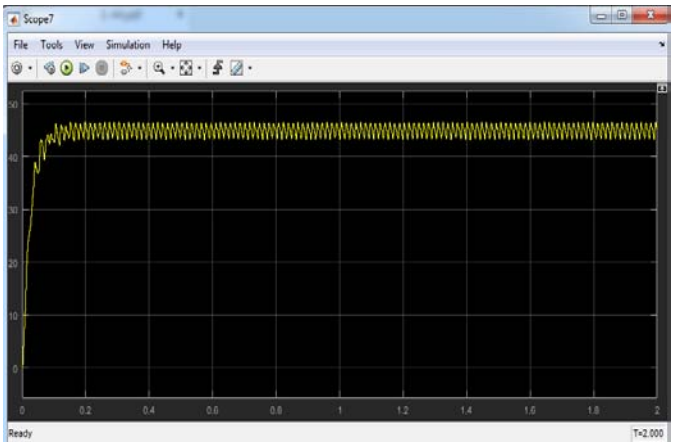


Fig shows the when the voltage produced by PV-Wind Hybrid power plant with MPPT used when the temperature is 20c, irradiation is 200lumens/m2 and wind turbine is rotating at 20% of full speed. Voltage produced by the hybrid power plant is approximately 45v.

Current Produced by PV-Hybrid Power Plant

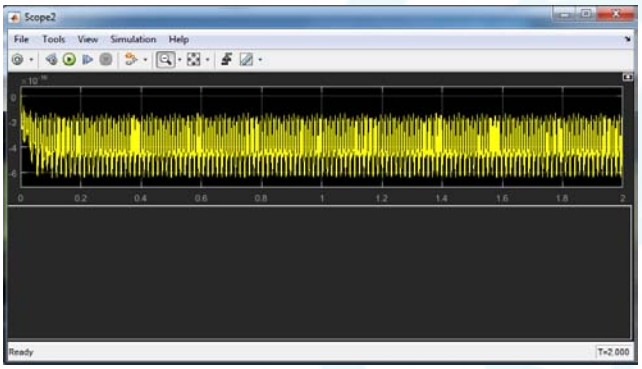


Fig shows the when the current produced by PV-Wind Hybrid power plant when the temperature is 20c, irradiation is 200lumens/m2 and wind turbine is rotating at 20% of full speed. Current produced by the hybrid power plant is approximately 4A.

Effect of Variation of Irradiation

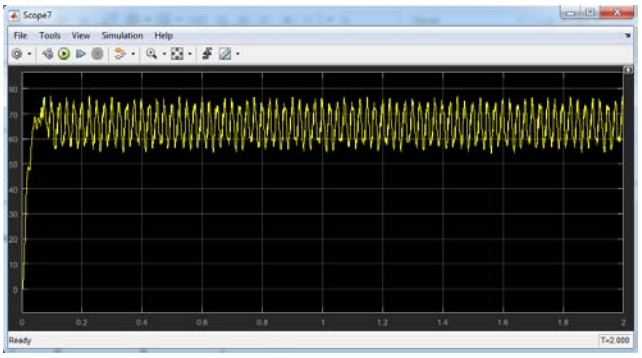


Fig shows the when the voltage produced by PV-Wind Hybrid power plant when the temperature is 20c, irradiation is 500lumens/m2 and wind turbine is rotating at 20% of full speed. Voltage produced by the hybrid power plant is approximately 65v.

Effect of Wind Speed

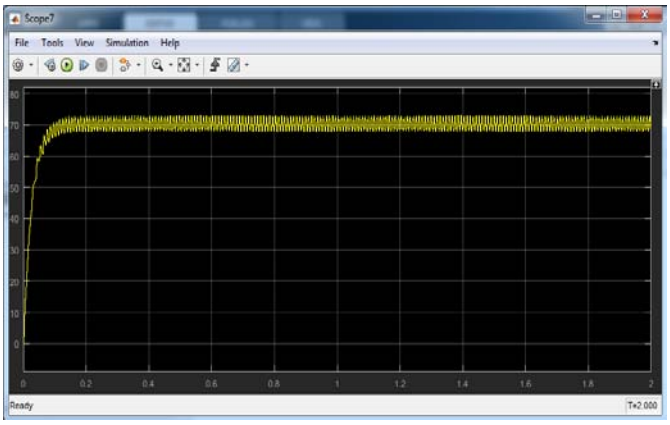


Fig shows the when the voltage produced by PV-Wind Hybrid power plant when the temperature is 20c, irradiation is 200lumens/m2 and wind turbine is rotating at 50% of full speed. Voltage produced by the hybrid power plant is approximately 70v.

Effect of Wind Speed, Irradiation, Temperature

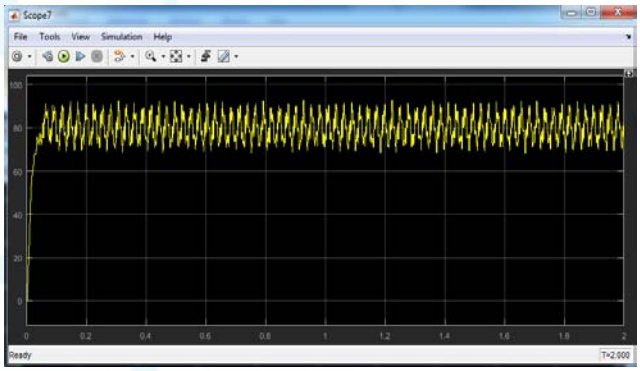


Fig shows the when the voltage produced by PV-Wind Hybrid power plant when the temperature is 40c, irradiation is 500lumens/m2 and wind turbine is rotating at 50% of full speed. Voltage produced by the hybrid power plant is approximately 80v.

5. Conclusions and Future Scope

Conclusions

- PV power Plant is simulated and effect of environment conditions on their output voltage is studied.
- Wind power plant is simulated and effect of wind on their output voltage is studied.
- Maximum power point is tracked for solar power plant using Perturb and observe.
- Both PV and Wind systems are integrated and hybrid system is used for charging the battery.

Future Scope

- There are many MPPT techniques. It can be tracked by using other techniques
- Battery charge controller can be designed for more reliable operation and better battery life

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