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Economical and Efficient Way of Supplying Electricity to Remote Locations

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***Abstract*— The model consists of hybrid wind and diesel energy conversion systems. The basic components of the wind energy conversion system are wind turbine, two mass drive train, permanent magnet synchronous generator, pitch angle controller, power converter, boost converter. The diesel energy conversion system consists of diesel engine, generator, power converter. In addition, a battery energy storage system can be connected, which provides the necessary power whenever there is a decrease in wind speed. The diesel engine is switched on basing on the requirement.**

Keywords— ***Wind turbine, drive train, permanent magnet synchronous generator, power converter, diesel generator.***

I. Introduction

The global warming has been increasing very rapidly in recent years by the usage of conventional energy sources for electricity generation. Moreover the area required for the installation of these plants is very large. In order to overcome these drawbacks, conventional sources must be replaced with non-conventional energy sources like wind, solar, biogas etc. Among these solar and wind energy are available in abundant form and wind energy[1] can be harvested easily when compared with solar. For a desired value of power, the number of wind turbines used is very much less than the numbers of solar panels required.

But solely dependence on the natural resources is not feasible even they exist in larger proportions because extraction of energy completely from them is not possible. A fraction of total energy is only available. So, they alone cannot supply the demand and must be coupled with the conventional sources. But the use of conventional sources must be limited so as to avoid effects to the environment. The wind energy conversion system when coupled with diesel energy conversion system provides a better way of supplying power to remote areas or even islands that are far away from main grid which in turn reduce the stress on it. Thus the complexity in building new lines from the main grid is eliminated.

II. Proposed Mathematical Models

1. Proposed Wind System Model

1.1. Wind Turbine

This is used to convert the kinetic energy in wind to mechanical torque. The torque value can be calculated from mechanical power at the turbine extracted from wind power. The power coefficient of the turbine is a function of pitch angle and tip speed which is the ratio of rotational speed and wind speed. Generally horizontal axis wind turbines[2] are preferred.

1.2. Drive Train

It acts as link between the wind turbine and the generator. It transfers the mechanical energy from turbine to the generator. The selection of the drive train should be in such a way that it has to with stand the stress. It should be maintenance free, robust and its construction should be simple. The drive train used here is two mass drive train.

1.3. Generator

The generator used here is permanent magnet synchronous generator[3]. Since it rotates with a constant speed as that of wind turbine, gearbox can be eliminated. This in turn reduces the lubrication and frictional problems. Hence the overall weight of the turbine, drive train, generator unit has been reduced.

1.4. Pitch Angle Controller

Pitch angle control is the most common means for adjusting the aerodynamic torque of the wind turbine when wind speed is above rated speed and various controlling variables may be chosen, such as wind speed, generator speed and generator power. As conventional pitch control usually use PI controller.

1.5. Power converter

The converter acts as rectifier and transforms ac to dc. As the wind turbine output is fluctuating, a converter must be employed to overcome this problem. Although the converters

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are costlier, they are useful in maintaining the desired output values and even frequency.

1.6. Mathematical model

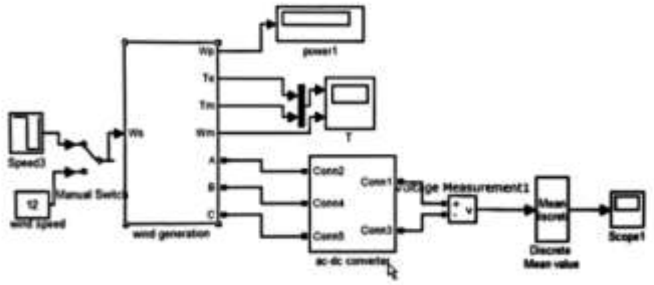

Fig 1.1.1., Wind energy system model

2. Proposed Diesel System Model

2.1. Diesel Engine

The diesel engines[4] are one of the most robust engines that are available at present. The turn on and turn off times of these engines is less. These can be used to supply the grid whenever the demand increases. Generally for these applications a 6KW diesel engine is sufficient for supplying a small village.

2.2. Generator and Power Converter

The generator and the power converter that are employed in wind energy conversion system can also be employed here for an economical operation.

2.3. Battery Energy Storage System

This is an external optional device connected to the dc link through a power converter. Its helps in supplying the load whenever there is a shortfall in wind energy.

2.4. Mathematical Model

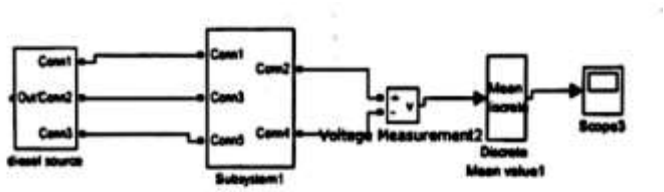

Fig 2.2.1., Diesel energy system model

III. Simulation Model

The above hybrid mathematical model[5] with the presented techniques is constructed and verified in MATLAB/ SIMULINK at a varying wind speed . The output voltage of the system in fig 3.1, pitch angle of the blade in fig 3.2 and power output of pmsg in fig 3.3 are graphically shown.

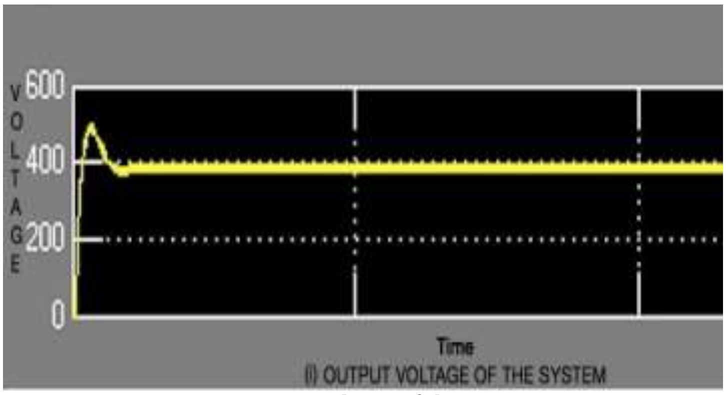

Fig 3.1., Output Voltage of the System

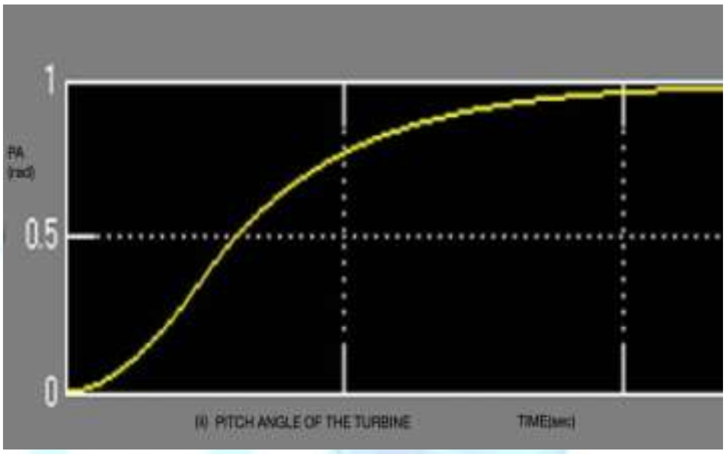

Fig 3.2., Pitch Angle of the Turbine

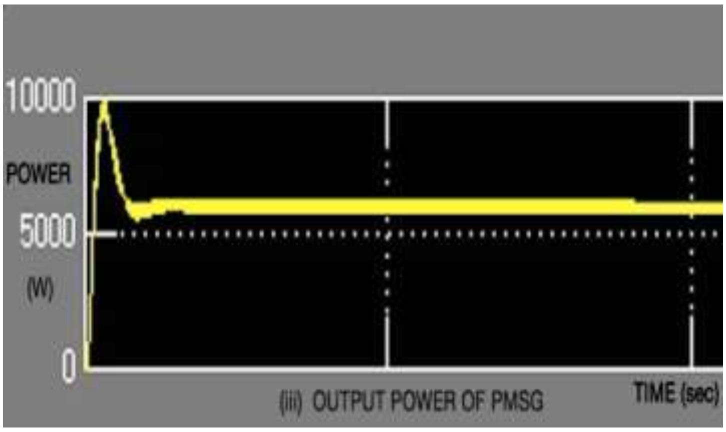

Fig 3.3., Output Power of PMSG

IV. Results and Analysis

The results are found to be satisfactory. Power output at the generator is 6000W, pitch angle is observed to be varying with changes in wind speed and voltage is 400V. The use of a transformer after the generator will increase the ac voltage level but the overall system becomes costlier.

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V. Conclusion

The effectiveness of overall operation and control techniques[6] can improved by employing a controller in the diesel energy conversion system for optimal utilization of the fuel and boost converters for increasing the dc voltage levels. If there is an increase in the demand in the future, a wind farm can be formed by increasing the number of wind turbines. Thus it may transform into a generation plant with its own grid supplying a huge number of regions.

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