DESIGN AND MODELING OF VERTICAL AXIS WIND ENERGY CONVERSION SYSTEM

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Abstract
Present energy need heavily relies on the conventional sources. But the limited availability and steady increase in the price of conventional sources has shifted the focus toward renewable sources of energy. Of the available alternative sources of energy, wind energy is considered to be one of the proven technologies. With a competitive cost for electricity generation, wind energy conversion system (WECS) is nowadays deployed for meeting both grid-connected and stand-alone load demands.
However, wind flow by nature is intermittent. In order to ensure continuous supply of power, suitable storage technology is used as backup. In this project, the sustainability of a hybrid wind and battery system is investigated for meeting the requirements of a stand-alone DC load. A charge controller for battery bank based on turbine maximum power point tracking and battery state of charge is developed to ensure controlled charging and discharging of battery. The control scheme is integrated and the efficiency is validated by testing it with various load and wind profiles in MATLAB/SIMULINK.

Keywords—Wind mills, MATLAB, SIMULINK,DC Load, AC Load.

1. INTRODUCTION

Energy is essential to everyone's life no matter when and where they are. This is especially true in this new century, where people keep pursuing higher quality of life. Among different types of energy, electric energy is one of the most important that people need every day. It is now a globally accepted reality that electrical energy is fundamental for social and economic development. Unfortunately still one third of the world's population lives in developing and threshold countries and have no access to electricity. It has been estimated that the world population will reach 8 billion by 2020. The statistic shows that the population growth is mostly in developing countries where most of the people live in remote and rural areas. So, to supply the electricity requirements for them, the extension of utility grid is complicated and expensive due to geographical, economical and social barriers. Up to now, mostly diesel generator sets are used for rural electrification. This is not a good solution since, the fuel, maintenance cost is expensive, and it is also not environment friendly. Multi-source alternative energy systems with proper control have great potential to provide higher quality and more reliable power to customers than a system based on a single resource. However, the issues on optimal system configuration, proper power electronic interfaces and power management among different energy sources are not resolved yet. Therefore, more research work is needed on new alternative energy systems and their corresponding control strategies. Furthermore, the scope of DEPARTMENT OF EEE, RCE Page 2
the technical, commercial issues coverage and typical applications is addressed. In this project is to simulate a model of wind energy conversion system for supplying electrical energy to AC and DC

loads. The power available from a WECS is very unreliable in nature and hence it cannot ensure uninterrupted power flow to the loads. In order to meet the load requirement at all instants, Suitable storage device is needed. Therefore, hybrid wind battery system is chosen to supply desired power to DC loads. In this project simulation study is done on Wind energy conversion system fed islanded DC load, wind energy conversion system fed stand alone AC load, wind turbine generation fed AC load. A wind energy conversion system (WECS) transforms wind kinetic energy to mechanical energy by using rotor blades. This energy is then transformed into electric energy by a generator. The system is made up of several components, participating directly in the energy conversion process. There are also other components that assist the system to achieve this task in a controlled, reliable, and efficient way. In order to better understand the process of wind energy conversion, descriptions of the major parts of a wind turbine Since the energy source for a WECS is wind kinetic energy, wind speed plays a key role in several aspects of the conversion process, especially in relation to the maximum power output. Therefore, this chapter introduces basic concepts of and relations between wind speed and power captured by the blades. This provides the necessary insight to explain how the power output of a wind turbine can be regulated by adjusting the blade pitch angle or by controlling the generator's torque or speed. These power control methods are essential to ensure a maximum power output over a wide range of wind speeds. They also enable reliable and safe operation, protecting the mechanical and structural parts of the wind turbine from damage during strong wind gusts.

2. PROPOSED METHODOLOGY

In this project is to simulate a model of wind energy conversion system for supplying electrical energy to AC and DC loads. The power available from a WECS is very unreliable in nature and hence it cannot ensure uninterrupted power flow to the loads. In order to meet the load requirement at all instants, Suitable storage device is needed. Therefore, hybrid wind battery system is chosen to supply desired power to DC loads. In this project simulation study is done on Wind energy conversion system fed islanded DC load, wind energy conversion system fed stand alone AC load, wind turbine generation fed AC load.

2.1 IMPLEMENTATION

A wind energy conversion system (WECS) transforms wind kinetic energy to mechanical energy by using rotor blades. This energy is then transformed into electric energy by a generator. The system is made up of several components, participating directly in the energy conversion process. There are also other components that assist the system to achieve this task in a controlled, reliable, and efficient way. In order to better understand the process of wind energy conversion, descriptions of the major parts of a wind turbine

A. Wind Turbine: The kinetic energy (Kinetic energy is the movement or motion of substances and objects) contained in the wind can be converted into both mechanical and electrical energy by a windmill. modern type of windmill that uses the kinetic energy of the wind to produce an electrical energy output is called a Wind Turbine. Wind turbines that are in use today are far more likely to be a type of wind generator which operates differently and more efficiently from a conventional sail windmill. Multiple wind turbines that are arranged together in clusters to capture large amounts of wind energy at the same time and convert it into electrical power feeding this power into the electrical grid are known as Wind Farms. Although wind turbines and especially wind farms take up a lot of land space, the land on a wind farm can be used simultaneously for wind generation, crops growing, animal grazing or anything else below the vanes of the turbines.

B. Turbine Blade The blade is the most distinctive and visible component of a wind turbine. It is also responsible for carrying out one of the most essential tasks of the energy conversion process: transforming the wind kinetic energy into rotational mechanical energy. Blades have greatly evolved in aerodynamic design and materials from the early windmill blades made of wood and cloth.

C. Gear Box : The rotor of a large three-blade wind turbine usually operates in a speed range from 6-20 rpm. This is much slower than a standard 4- or 6-pole wind generator with a rated speed of 1500 or 1000 rpm for a 50 Hz stator frequency and 1800 or 1200 rpm for a 60 Hz stator frequency. Therefore, a gearbox is necessary to adapt the low speed of the turbine rotor to the high speed of the generator.

The gearbox conversion ratio also known as the gear ratio, is designed to match the high-speed generator with the low-speed turbine blades. For a given rated speed of the generator and turbine, the gearbox ratio can be determined by

$$r_{gb} = \frac{n_m}{n_M} . \frac{(1-S)60fs}{P.n_M}$$

Where nm and nw are the generator and turbine rated speeds in rpm, s is the rated slip, fs is the rated stator frequency in Hz, and P is the number of pole pairs of the generator. The rated slip is usually less than 1% for large induction generators, and zero for synchronous generators.

D. Rotor Mechanical Brake: A mechanical brake is normally placed on the high-speed shaft between the gearbox and the generator, as shown in Figure 2.8, but there are some turbines in which the brake is mounted on the low-speed shaft between the turbine and gearbox. The main advantage of placing the brake on the high-speed shaft is that it handles much lower braking torque. The brake is normally used to aid the aerodynamic power control (stall or pitch) to stop the turbine during high speed winds or to lock the turbine into a parking mode during maintenance To minimize the wear and tear on the brake and reduce the stress on drive train during the braking process, most large wind turbines use the aerodynamic power control to reduce the turbine speed to a certain level or zero, and then the mechanical brake to stop or lock the wind turbine. However, the mechanical brake.

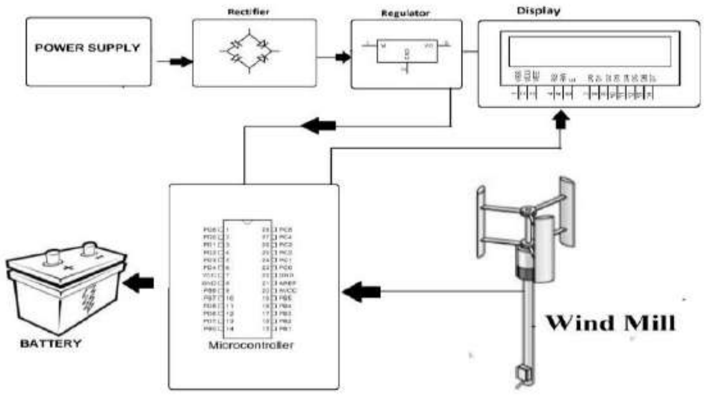
E. Yaw Drive The main function of the yaw drive is to maximize the captured wind energy by keeping the turbine facing into the wind. It usually consists of more than one electric motor drive, yaw gear, gear rim, and bearing, where a four drive yaw system is illustrated. A set of yaw brakes are disposed around the yaw rim to lock the position of the turbine when facing the wind or during maintenance. The yaw drive uses a planetary gear to lower the rotating speed of the yaw gear. All the motors are commanded by the same signals and lock after turning the wind turbine into the desired position. The yaw system typically needs to generate torque from 10,000 to 70,000 Nm to turn the nacelle.

F. Wind Sensors (Anemometers): The pitch/stall and yaw control systems require wind speed and direction measurements, respectively. The pitch/stall control needs the wind speed to determine the angle of attack of the blade for optimal operation. The yaw control requires the wind direction to face the turbine into the wind for maximum wind power capture. In addition, in variable speed turbines, the wind speed is needed to determine the generator speed for maximum power extraction.

F. Generator : The conversion of rotational mechanical energy to electric energy is performed by the generator. Different generator types have been used in wind energy systems over the years. These include the squirrel cage induction generator (SCIG), doubly fed induction generator (DFIG), and synchronous generator (SG) (wound rotor and permanent magnet) with power ratings from a few kilowatts to several megawatts,

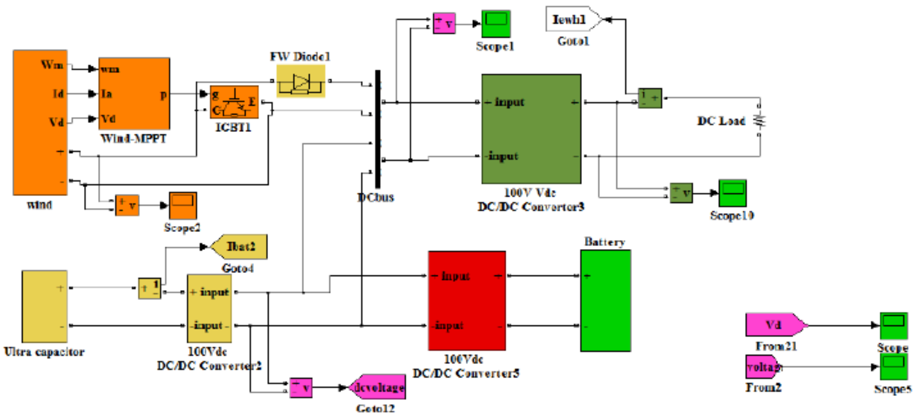
The SCIG is simple and rugged in construction. It is relatively inexpensive and requires minimum maintenance. Traditional direct grid-connected wind energy systems are still available in today's market.

Block Diagram:



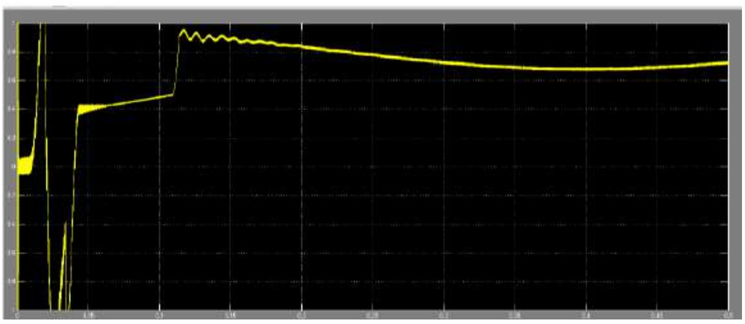
Block diagram of Hardware setup of prototype Wind mill

3. Simulink Models



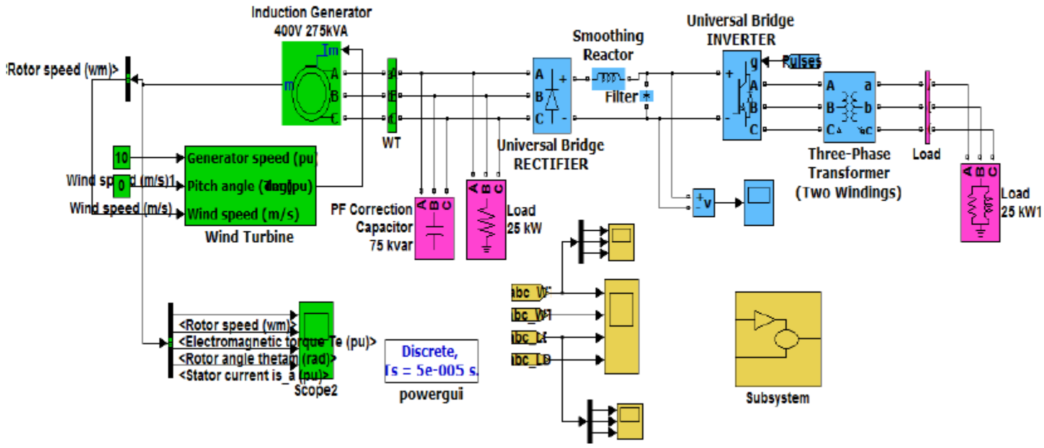
Simulink model of Wind energy conversion system fed DC load

3.1 outputs :

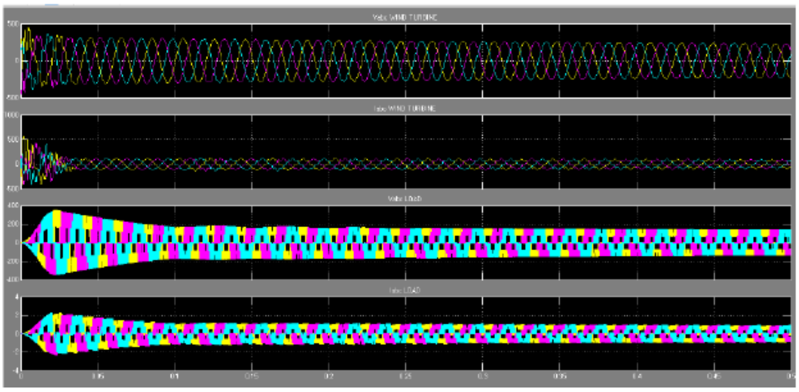


Output Voltage of Wind Turbine

4. Wind energy conversion system fed Islanded AC load :



4.1 output :



Output Voltage and Currents of Wind Turbine and Load

5. ADVANTAGES

- Good torque response.
- Accurate speed control
- Full torque at zero speed.
- Performance approaching DC drive
- Flux vector control achieves full torque at zero speed, giving it a performance very close to that of a DC drive.

6. CONCLUSION:

he model of wind energy conversion system is simulated for supplying electrical energy to AC and DC loads. The power available from a WECS is very unreliable in nature and hence it cannot ensure uninterrupted power flow to the loads. In order to meet the load requirement at all instants, Suitable storage device is needed. Therefore, hybrid wind battery system is chosen to supply desired power to DC loads. In this project simulation study is done on Wind energy conversion system fed islanded DC load, wind energy conversion system fed stand alone AC load, wind turbine generation fed AC load, Hybrid wind battery system fed AC and DC loads.

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