

Permanent Magnet Synchronous Generator Based Wind Energy Conversion System

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Abstract: Wind energy is one of the world's fastest growing energy technologies. It is estimated that 16% of the world's electricity will be harnessed from wind power by 2020. There are many loads (such as remote villages, islands, ships etc) that are away from the main grid. They require stand-alone generator system (which can provide constant nominal voltage and frequency) to provide for their local electrification. This requirement has lead to widespread research on development of new technologies for stand-alone generators.

So this paper discuss about the recent research on Wind Energy Conversion System, the advancement of wind energy conversion system is permanent magnet synchronous generator based wind energy conversion system. PMSG based WECS have higher efficiency than other generator based wind energy conversion system. In this system, there are no requirements of gear box. Permanent Magnet Synchronous Generator excited by permanent magnet.

I. INTRODUCTION

The conventional energy sources are limited and have pollution to the environment. So, more attention and interest have been paid to the utilization of renewable energy sources such as wind energy, fuel cell and solar energy etc. movement of large air masses on the surface of the earth, i.e., the wind. Wind energy conversion systems convert the kinetic energy of the wind into electricity or other forms of energy. Wind power generation has experienced a tremendous growth in the past decade, and has been recognized as an environmentally friendly and economically competitive means of electric power generation.

In wind energy conversion system, the wind power is utilized by wind mills or turbines which convert the kinetic energy in wind into mechanical energy or other form of energy, mechanical energy is convert in electricity by using generator. The generator is connected to grid for supply the power to consumers.

II. WIND ENERGY

Wind energy is a form of solar energy produced by heating of the earth's surface. The wind speed is extremely important for the amount of energy a wind turbine can convert it to electricity.

The power in the wind turbine can be defined as follows,

$$P_w = \frac{1}{2} \rho A V^3$$

Where ρ : air density, kg/m³

A: Cross sectional area of wind of wind parcel, m²

V: The wind speed, m/sec.

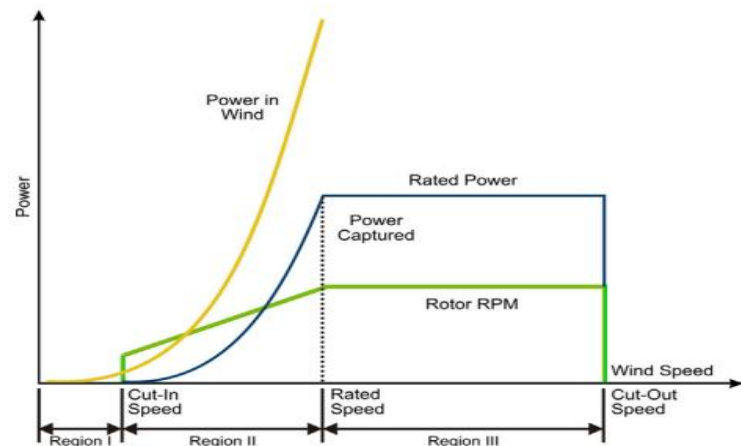


Fig.1 Wind Power, Turbine Power and Rotor speed in different operating regions

In region I the wind speed is too slow to derive the turbine and produce valuable energy. The Cut-in speed is 4-5 m/s in modern wind turbines.

When the wind speed is above the cut-out speed, 22-25m/s, the turbines must stop operation to prevent overloads and damage to the turbine's components.

In Region II the turbine has to operate at the maximum possible efficiency by adjusting the speed of the generator. Generally two basic schemes of wind turbine control system can be considered.

In region III, the wind speed is strong enough to produce the rated or maximum power. Pitch control mechanism is used to keep output turbine power constant.

III. WIND TURBINE

A wind turbine is a device that converts kinetic energy from the wind into mechanical energy also called wind energy, this

process known as wind power. If the mechanical energy is used to produce electricity, the device may be called wind turbine or wind power plant.

Types of Wind Turbine: The two main types of wind turbine are as following.

1. Horizontal Axis Wind Turbine

2. Vertical Axis Wind Turbine

1. Horizontal Axis Wind Turbine: A horizontal axis machine has its blades rotating on an axis parallel to the ground. Horizontal-axis wind turbines (HAWT) have the main rotor shaft and electrical generator at the top of a tower, and must be pointed into the wind. Most have a gearbox, which turns the slow rotation of the blades into a quicker rotation that is more suitable to drive an electrical generator.

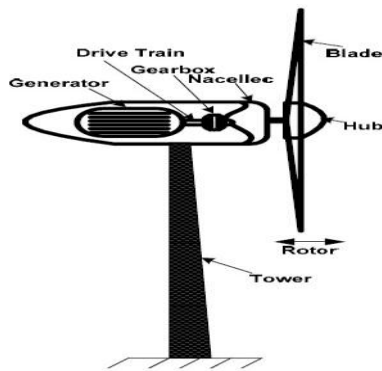


Fig.2 Horizontal Axis Wind Turbine

The most common design of modern turbines is based on the horizontal-axis structure. Horizontal axis wind turbines are mounted on towers as shown in Fig.2.

Advantages of the HAWT:

- Higher efficiency.
- Ability to turn the blades.
- Lower cost-to-power ratio.

Disadvantages of HAWT:

- Generator and gearbox should be mounted on a tower, thus restricting servicing.
- More complex design required due to the need for yaw or tail drive.

2. Vertical Axis Wind Turbine: A vertical axis machine has its blades rotating on an axis perpendicular to the ground. Vertical axis wind turbines (VAWTs) have the main rotor shaft arranged vertically. With a vertical axis, the generator

and gearbox can be placed near the ground, using a direct drive from the rotor assembly to the ground-based gearbox, hence improving accessibility for maintenance.

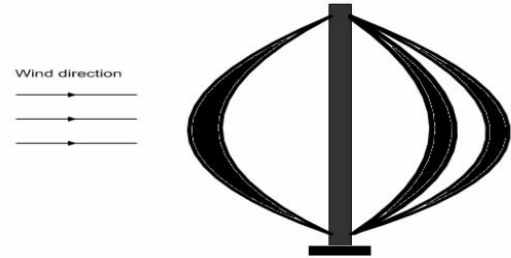


Fig.3 Vertical Axis Wind Turbine

VAWTs include the Darrius rotor, as shown in Fig.3

Advantages of the VAWT are:

- Easy maintenance for ground mounted generator and gearbox.
- Receive wind from any direction (No yaw control required).
- Simple blade design and low cost of fabrication.

Disadvantages of Vertical-Axis Wind Turbine are:

- Not self-starting, thus, require generator to run in motor mode at start.
- Lower efficiency (the blades lose energy as they turn out of the wind).
- Difficulty in controlling blade over-speed.
- Oscillatory component in the aerodynamic torque is high.

IV. PERMANENT MAGNET SYNCHRONOUS GENERATOR BASED WIND ENERGY CONVERSION SYSTEM

A permanent magnet synchronous generator is a generator where the excitation field is provided by a permanent magnet instead of a coil.

Synchronous generators are the majority source of commercial electrical energy. They are commonly used to convert the mechanical power output of steam turbines, gas turbines, reciprocating engines, hydro turbines and wind turbines into electrical power for the grid. They are known as synchronous generators because the speed of the rotor must always match the supply frequency. In a permanent magnet generator, the magnetic field of the rotor is produced by permanent magnets.

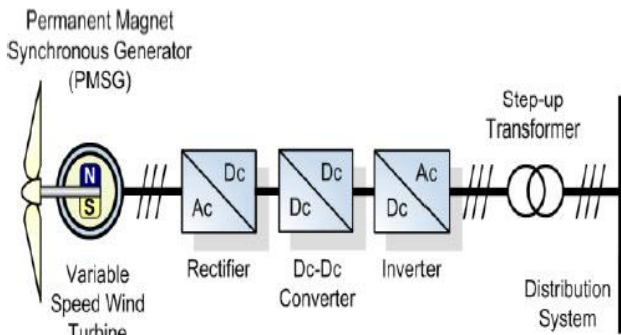


Fig.4 General Scheme of the proposed wind energy conversion system

This work presents a full detailed modeling and a novel control scheme of a three phase grid connected wind energy conversion system. The control algorithms incorporate a maximum power point tracker (MPPT) for optimal active power generation. Furthermore, reactive power compensation of the electric grid is included, operating simultaneously and independently of the active power generation. Thus Voltage Source Inverter (VSI) is used to convert the energy produced by wind turbines into useful electricity and to provide requirements for power grid interconnection. Moreover, the VSI meets all the constraints of high quality electric power, flexibility and reliability imposed for applications of modern distributed energy resources (DER).

V. POWER CONDITIONING SYSTEM

The power conditioning system (PCS) used for connecting renewable energy sources to the distribution utility grid requires generation of high quality electric power, being at the same time flexible, efficient and reliable. The PCS proposed is composed of a back to back ac-dc-ac power converter that fulfills all the requirements mentioned above, as depicted in Fig.4. Since the permanent magnet synchronous generator produces an output voltage with variable amplitude and frequency, additional conditioning is required to meet the amplitude and frequency requirements of the utility grid. A three phase uncontrolled full wave rectifier bridge is proposed here for performing the ac-dc conversion. This device has the benefit of being simple, robust, cheap, and needs no control system. On the other hand, a three phase dc-ac voltage source inverter using IGBTs is employed for connecting to the grid. As the power rating of the inverter is intermediate to small, the output voltage control of the VSI can be achieved through Fuzzy Logic techniques.

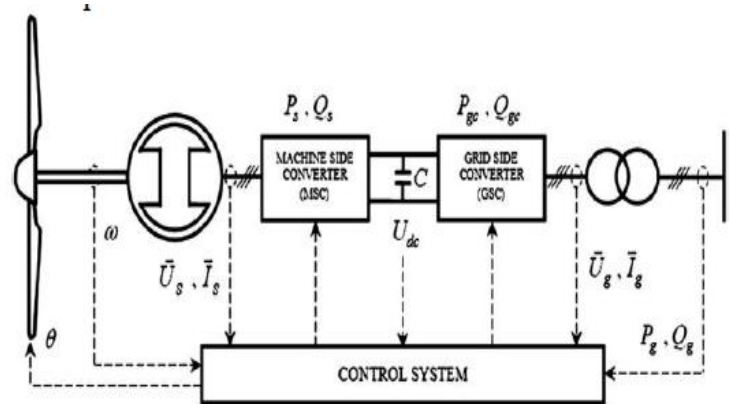


Fig.5 Detailed model of proposed WECS

Advantages of PM in synchronous Generator:

- Do not require an additional dc supply for excitation circuit.
- PMG avoid use of slip rings, so it is simpler and maintenance free.
- Condensers are not required for power factor maintenance in synchronous generator as in Induction generator.

Disadvantages of PM in Synchronous Generator:

- Large Permanent Magnets are costly.
- Permanent Magnets performance gets affected by heat.
- Uncontrolled air-gap flux density leads to over voltage and poor electronic control reliability.

VI. CONCLUSION

By comparing the Permanent Magnet Synchronous Generator and Induction Generator based Wind Energy Conversion System, this is proven that PMSG system is advantageous over geared drive segment IG system. Induction generator requires leading reactive power to build up terminal voltage.

VII. REFERENCES

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