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# PERFORMANCE EVALUATION OF A WIND ENERGY CONVERSION SYSTEM BASED ON PMSG

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**ABSTRACT**

In the twenty-first century, wind energy applications are developing far more quickly than those of other renewable resources like solar, geothermal, etc. After unconventional fuels like oil and chemicals, it becomes the third essential energy source. The renewable energy source that is developing the fastest and showing the most promise is electrical energy produced by wind power facilities. A pure, cost-free, and limitless energy source is the wind. Simple processes give rise to wind. Fixed speed and variable speed wind turbines are the two categories into which wind turbines fall. A wind turbine with variable speed produces more energy than one with constant speed, lowers power fluctuations, and enhances reactive power supply. In essence, Double Fed Induction Generator and PMSG Permanent Magnet Synchronous Generator are employed.

***Keywords: Wind Energy Conversion System (WECS), Permanent Magnet Synchronous Generator (PMSG).***

## I. INTRODUCTION

Energy that derives from resources that are constantly renewed, such as the sun, wind, rain, tides, waves, etc., is known as renewable energy. The direct driven PMSG based wind turbines are the preferable option out of all the options. In a permanent magnet synchronous generator, a permanent magnet is used to create the excitation field rather than a coil. Most of the electricity used in commerce is produced by synchronous generators. The mechanical power produced by steam turbines, gas turbines, reciprocating engines, hydro turbines, and wind turbines is frequently converted into electrical power for the grid using these devices. The reason they are referred to as synchronous generators is that the rotor's speed must constantly coincide with the supply frequency. The magnetic field of the rotor in a permanent magnet generator is created by permanent magnets. Other generator designs create a magnetic field in a rotor winding using electromagnets. Direct current is delivered into the rotor field winding via a slip ring assembly or a brushless exciter. Permanent magnet generators have been viewed as a possible candidate for new designs in high power applications since they don't need a DC supply for the excitation circuit and have great efficiency and low maintenance costs. Considering their way of operation, variable speed wind turbines. The ability to maximize power output from fluctuating wind speed, improved efficiency, and reduced mechanical stress are just few advantages versus fixed speed systems.

## II. WIND ENERGY CONVERSION

Renewable energy sources, notably wind energy, are increasing popularity as fossil fuel stocks deplete and concerns about CO2 emissions rise. Wind energy conversion systems (WECS) with variable speed constant frequency (VSCF) have been widely employed to maximize the utilization of wind energy. The two most often used methods for converting wind energy are the doubly fed induction generator (DFIG) and direct-drive permanent magnet synchronous generator (PMSG). The advantages of direct-drive PMSGs' high efficiency and durability have grown in prominence.

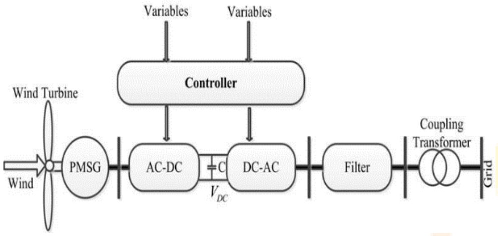



**Fig1**: System for converting wind energy

Wind turbine mechanical power is transformed by the PMSG into AC electrical power, which is subsequently supplied to the grid via a power electronic converter. A WECS based on a PMSG is generally configured in Figure 1. The wind turbine, generator, rectifier, inverter, and grid are the major elements of a wind energy conversion system.

## II. Converters Used in WECS

For direct-drive PMSG based wind turbines, there are a variety of power-converter topologies [3]. A voltage source converter (VSC) or a current source converter (CSC) will typically have an inductor as their dc-link element, while a generator-side rectifier and a grid-side inverter will typically have a capacitor (CSC). The rectifier one each setup. A controlled or uncontrolled rectifier may be used on the generator side. Grid side inverters are either VSIs or CSIs. The topologies are compared as follows.

| Topologies | Advantages | Disadvantages |
|---|---|---|
| Thyristor supply side inverter | Continuous control of firing angle. | Harmonic distortion created |
| PMSG with diode rectifier converter | Robust in construction | Lost control flexibility |
| Back-to- Back two level VSC | Good Performance characteristics | Voltage sharing issue |
| PMSG WECS using CSC | No switching harmonics | Poor stability of the system. |
| Back-to-back PWM converter | Separate control can be provided | Short lifetime |
| Multiple level VSC | Less Switching losses and Higher voltage and power capability | Voltage imbalance |

**Table 1:** Converter topologies

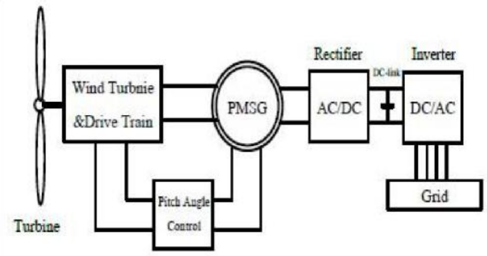



**Fig 2:** Grid-connected PMSG for direct-drive wind turbine

## III. SYSTEM MODEL

The mechanical output of the wind turbine is supplied directly into the generator's rotor in a WECS with a PMSG foundation. A gear box is not necessary because the wind turbine system is direct driven. A power electronic converter transmits the generator's ac output to the grid. The wind turbine, driving train, and PMSG are the system's key parts. Wind Turbine: The fundamental idea of a wind turbine is to transform the wind's linear motion into rotational energy, which is then used to power an electrical generator, converting the wind's kinetic energy into electrical power [8]. With a wind turbine, the wind's energy is converted into:

P = 0.5 CPρAV3 -----(1)

Were, = Kg of air density M2 A= Turbine blade area in m2 V= Wind speed in m/s

Power coefficient = CP The percentage of kinetic energy that the wind turbine converts into mechanical energy is known as the power coefficient (CP). The coefficient is defined as ratio of actual power to the theoretical power.

**Cp=P actual/P theoretical -------(2)**

**Pitch Management:** To maximize the power extracted from the WT and prevent overrated power generation in strong winds, the pitch angle of the blade is adjusted [10]. The pitch control is activated, and the pitch angle is set so that the turbine power can be limited to its rated value when the generator speed exceeds the rated rotor speed. In this case, pitch control is offered in the wind turbine system.

## IV. SIMULATIONS

MATLAB/SIMULINK has been used to run simulations. The grid is interconnected with the wind energy conversion technology, as seen in the fig (4). Analysis of system performance is done while it is running normally. A fault is applied to the primary system as depicted in figure 3 to analyze the performance of the system in a faulty condition. When a failure occurs, the load, wind power plant, and grid side are unable to provide the necessary voltage and electricity.

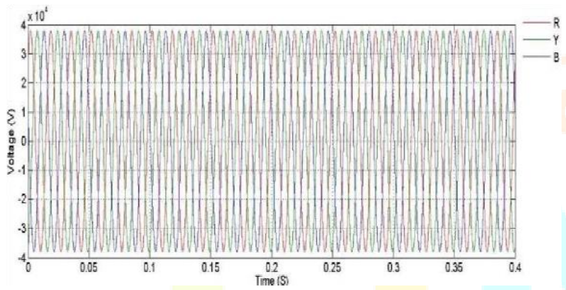



**Fig 3:** Active power wind under normal operation

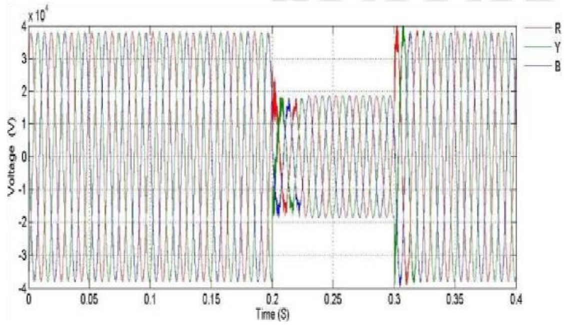
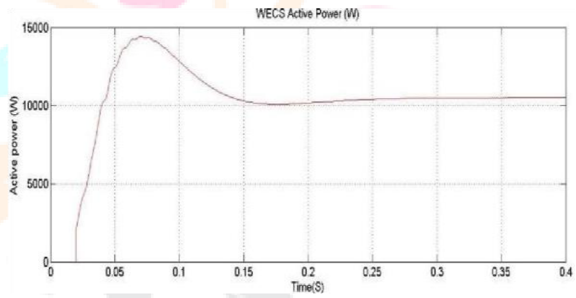



**Fig.4**: Grid voltage profile under normal condition

## VII. CONCLUSION

Due to its self-excitation and low speed characteristics, the permanent magnet synchronous generator (PMSG) is suggested as a wind turbine generator and results in a direct-drive wind energy conversion system (WECS). The load is linked to and shielded from the stator winding. Permanent magnet poles are attached to the rotor. Due to the removal of the rotor's external excitation and conductor losses, PMSG also offers the advantages of high efficiency and dependability. The disconnecting of the generators in the event of a network voltage drop below a specific value, or voltage dip, is one of the most significant issues with the integration of wind generators into the grid. A voltage dip is a brief (10 ms to 1 min) occurrence that results in a decrease in the rms voltage magnitude. Usually,




just two variables—depth/magnitude and duration—are specified.

**Fig.5**: Grid voltage profile under faulted condition

The voltage dip has a duration of up to one minute and an intensity that ranges from 10% to 90% of the usual voltage. The voltages from phase to phase and from phase to ground are affected by a voltage drop in a three-phase system. As a result, swift voltage dip elimination is crucial for avoiding voltage instability, and several control mechanisms should be included inside the system to accomplish this.

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