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# Various types of Wind Generator Systems and Their Comparisons

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***Abstract : Considering the increasing share of wind generation interfaced to grid it is necessary to study the power quality and reactive power issues considering voltage quality and stability issues. In case of Induction type wind energy converter reactive power management in cost effective way is essential. In many wind farm wind energy converter using Synchronous generator and Induction generator are used. Use of Synchronous generator leads to distortion of wave shape and are sensitive to grid disturbances. Considering the challenges to be faced related to interfacing of large wind farms using Induction and Synchronous generators, it is necessary to study the different wind generator systems and their comparisons. The wind energy conversion system is demanded to be more cost competitive, so that comparisons of different wind generator systems are necessary. An overview of different wind generator systems and their comparisons are presented. Also Critical Power Quality issues & Problems related with Grid connections are also discussed.***
***Keywords: Wind generator, Speed, Power Quality issues, Grid connection.***

## I. INTRODUCTION

Wind electricity installed capacity in India is around 8757.2 MW till March 31st 2008 and gross potential is 45,000 MW. Wind generation installed capacity in Maharashtra state is 1,755.9 MW and a gross potential is 3,650 MW. It ranks 2nd after Tamilnadu having capacity 3,873.4 MW in India. Today India is a major player in the global wind energy.
Considering the increasing share of wind generation interfaced to grid it is necessary to study an overall perspective on various types of existing wind generator systems and possible generator configurations, critical power quality issues, problems related with grid connections and some comparisons of different wind generator systems.

### *A. Classification On The Basis Of Prime Movers Used, And Their Locations*

#### *1) Fixed Speed Concept Using A Multistage Gearbox*

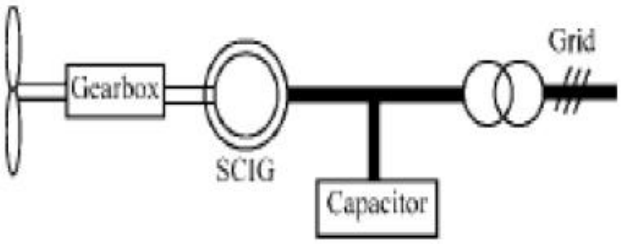



Figure: 1. Fixed speed concept using a multistage gearbox

Rotor of Squirrel Cage Induction Generator (SCIG) is directly connected to the hub of turbine through multistage gearbox. Stator is connected to the grid through coupling transformer. The wind turbine equipped with this type of generator is often called the fixed-speed wind generator system.

#### *2) Advantages*

*a)* Smoother grid connection is possible by using soft starter
*b)* Pole changeable SCIG used, which gives two rotation speeds.
*c)* It is robust, cheap, and easy.
*d)* It is used to operate at a constant speed which provides stable control frequency.

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*3) Disadvantages*

*a)* The speed is not controllable & variable only over a very narrow range, in which only speeds higher than synchronous speed are possible

*b)* Fixed speed concept means that wind speed fluctuations are directly translated into electromechanical torque variations this causes high mechanical & fatigue stresses on the system & result in swing oscillations between turbine & generator shaft

*c)* Periodical torque dips arises & results in higher flicker

*d)* Due to gearbox, cost increases

*B. Limited Variable Speed Concept Using A Multistage Gearbox*

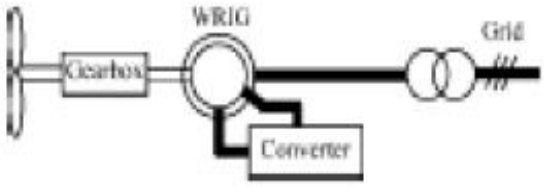



Figure: 2. Limited Variable speed concept using a multistage gearbox

This wind turbine concept uses a wound rotor induction generator (WRIG) with variable rotor resistance by means of a power electronic converter. The stator of WRIG is directly connected to the grid, whereas the rotor winding is connected in series with a controlled resistor.

*1) Advantages:* Variable speed operation can be achieved by controlling the energy extracted from the WRIG rotor. The power is dissipated in the external resistor.

*2) Disadvantages*

*a)* Reactive power compensation & soft starter required

*b)* Due to gearbox & converter system, cost increases.

*C. Variable Speed Concept With A Partial Scale Power Converter*

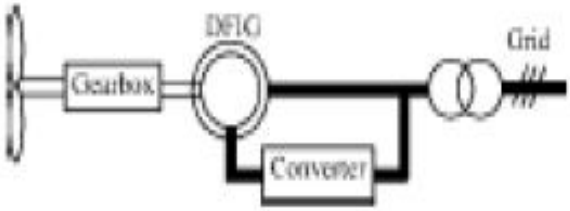



Figure: 3. Variable speed concept with a partial scale power converter

This configuration is known as the DFIG concept, which corresponds to a variable speed wind turbine with a WRIG and a partial-scale power converter on the rotor circuit. The stator is directly connected to the grid, whereas the rotor is connected through a power electronic converter. The power converter controls the rotor frequency and thus the rotor speed.

*1) Advantages*

*a)* The rotor energy, instead of being dissipated, can be fed into the grid by the power electronic converter

*b)* Grid side power converter system can perform reactive power compensation & smooth grid connection.

*2) Disadvantages*

*a)* A multi-stage gearbox required. So there will be heat dissipation from friction, require regular maintenance, audible noise occurs, costs also increases

*b)* The slip ring is used to transfer the rotor power by means of a partial scale converter, which requires a regular maintenance, & may be result in machines failures & electrical losses.

*c)* Under grid fault conditions, large stator currents result in large rotor currents, so that power electronic converter needs to be protected from destroy.

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*D. variable speed direct drive concept with a full-scale power converter*

Types of Variable speed direct drive concept with a full-scale power converter

*1) Electrically excited Synchronous generator (EESG)*

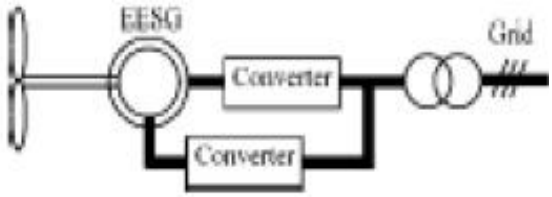



Figure: 4. Electrically excited Synchronous generator

*2) Advantages*

*a)* The direct drive generator rotates at a low speed, because the generator is directly connected on the hub of the turbine rotor. No gearbox, so costs also decrease

*b)* It does not require the use of PM, which is, might suffer from performance loss in harsh atmospheric condition. So generator costs also decreases.

*2) Disadvantages*

*a)* In order to arrange space for excitation windings & pole shoes, it requires a large diameter. So a large number of parts & windings make it a heavy weight & becomes a expensive

*b)* It is necessary to excite the rotor windings with DC using slip rings & brushes or brush less exciter, employing a rotating rectifier & the field losses are inevitable.

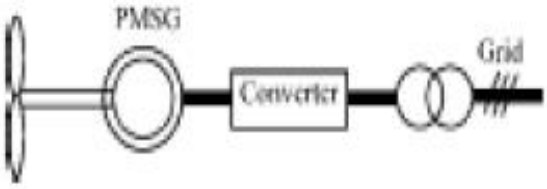



Figure: 5. PM Synchronous generator

*E. Variable Speed Single Stage Geared Concept With A Full Scale Power Converter*

*1) PM Synchronous generator (PMSG)*

*2)* Advantages

*a)* It has a higher speed than the direct drive concept & a lower mechanical component than a multiple stage gearbox concept.

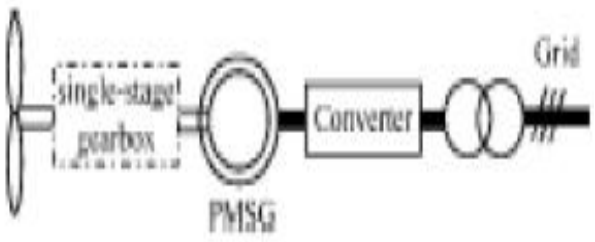



Figure: 6. PM Synchronous generator

*F. Variable speed multiple stage geared concept with a full scale power converter*

Types of Variable speed multiple stage-geared concepts with a full-scale power converter

*1) PM Synchronous generator (PMSG)*

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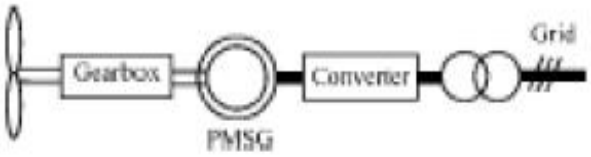



Figure: 7. PM Synchronous generator

*2) Advantages:*

Compared with DFIG system, it has the following advantages.

*a)* It has a better efficiency

*b)* The generator can be brush less.

*3) Disadvantages*

*a)* Larger, more expensive converter.

*b)* The losses in the converter are higher because the power electronic converter processes all powers.

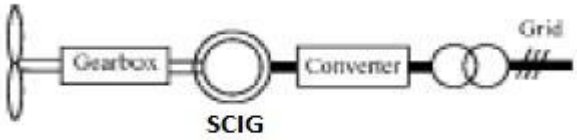



Figure: 8. Squirrel cage Induction generator

## II. CRITICAL POWER QUALITY ISSUES

Critical power quality issues related to integration of wind farms in weak grids in India is as follows to characterize the power quality:

*A.* Grid availability and capacity
*B.* Reactive powe
*C.* Voltage unbalance
*D.* Voltage ranges
*E.* Frequency range
*F.* Harmonics and inter harmonics
*G.* Voltage fluctuations

## III. PROBLEMS RELATED WITH GRID CONNECTIONS

*A.* Poor grid stability
*B.* Low frequency operatio
*C.* Impact of low power facto
*D.* Power flow
*E.* Short circuit
*F.* Power Quality

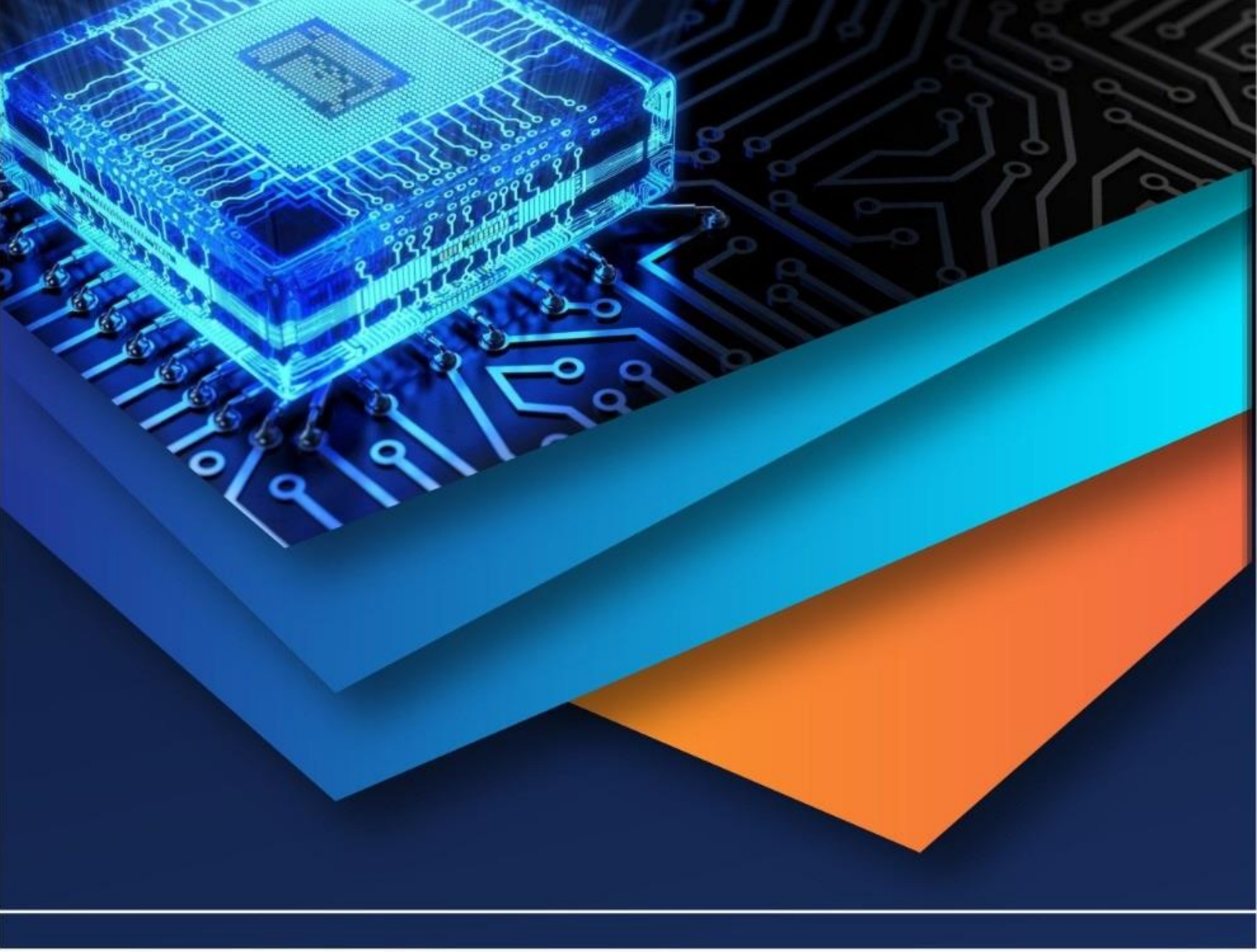
## IV. CONCLUSION

The paper provides an overview of different wind generator types. The basic configurations and characteristics of various wind generator systems based on contemporary wind turbine concepts are described with their advantages and disadvantages.

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