Nature of Wind Turbine Generator for Wind Power Plant

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Abstract – This paper presents a over-all review of the most needed nature of wind turbine generator activated on current wind power plant. Many types of wind turbine generators construction depend upon analysis beyond machine groups and speed limitation potentiality, stay consult on along its functional nature, voltages, reactive power or power factor limitation potentiality, voltage drive-over nature action at the time short circuit and reactive power potentiality.

Index Terms – Voltage Drive-Over, Wind Power Plant, Wind Turbine Generator.

1. INTRODUCTION

This In latest Wind Power Plants (WPPs), constitute of many numbers of Wind Turbine Generators (WTGs), a constitute scheme, constitute & attached substation employed machines that is construct to close path for the generation of power using energy in the wind. WTGs has advanced from mini machines with output power rating in an order of kilowatts to some megawatts, from limited speed controlled machines and different potentiality with variable or fluctuating speed control over wide speed range & mature control potentiality using modern power electronics.

The function of WTGs in latest WPPs depends upon a sensitive of a number of different conditions alike to the scheme and potentiality of the machines complex. Wind Turbine Generator scheme, established on analysis by machine type and speed limitation potentiality, onward with their operational nature, voltage, reactive power, or power factor limitation potentiality, voltage drive-over nature, conduct during short circuits, and reactive power potentiality.

2. RELATED WORK

The nature of the wind turbine is to conversion of kinetic energy into mechanical energy. This is cultivated by using aerodynamic rotor blades and a variety of operation for mechanical power control. The process is the electro-mechanical energy conversion by a generator that is transmitted to the electrical grid continuously. Wind turbines system can be divided by their mechanical power control, and by their speed control. All blades of turbine converting the motion of air across the air- foils to torque, and then arrange that torque in an attempt to catch as much energy as fast, yet prevent damage. At the top level turbines would be divided in stall regulated or pitch regulated. Firstly, Stall regulation is made by build the turbine blades in such way that the airfoil generates less aerodynamic force at high wind speed, eventually stalling, thus breaking the turbine's torque, cheap and robust mechanical system. Secondly, Pitch regulation, is deliver through the use of pitching devices in the turbine hub, which bend the blades all over their its axes. If the changes of wind speed, then the blade quickly pitches to the flawless angle to limit torque in order to fall the maximum energy or self-protect, as required. Now a day's some turbines are able to pitch each blade independently to acquire more balanced torques on the rotor shaft given wind speed differences at the top and bottom of the blade arcs. After mechanical power regulation, turbines are more divided into following types:

1. Fixed speed (Type 1),
2. Limited variable speed (Type 2),
3. Variable speed with either partial (Type 3)
4. Full (Type 4) power electronic conversion.

2.1: Fixed speed type 1

In type 1 system generator is used i.e., squirrel cage induction generator and this generator is smoothly connected to transformer (step up) as shown in fig.1. The turbine speed is maintain (near fixed speed) to the power grid frequency. If the generator rotates faster than power grid frequency after that t will create negative slip.

In type 1 system it will operate at much closed to synchronous speed. And the drawback of the system is that generator will consume reactive power for its excitation field and other drawback is generator will draw heavy current at a time of starting to overcome this drawback we use soft starter. For maintaining synchronization of grid, we used capacitor bank to consume reactive power.

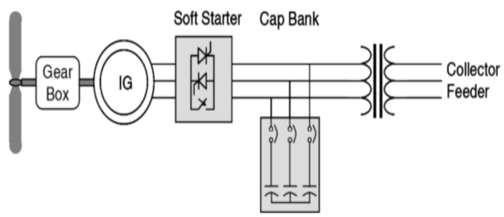

Fig. 1: Fixed Speed Type 1 WTG

Fig. 2 shows the power drawn at the SCIG terminals. While there is a little of differentially in output with slip of machine, Type 1 turbines typically work at or very near to a applied speed. A big drawback of the induction machine is reactive power i.e. consumes for its excitation field and the large amount of currents the machine can draw when started. To minimize these effects the turbine employs a soft starter and continuous steps of capacitor banks within the turbine.

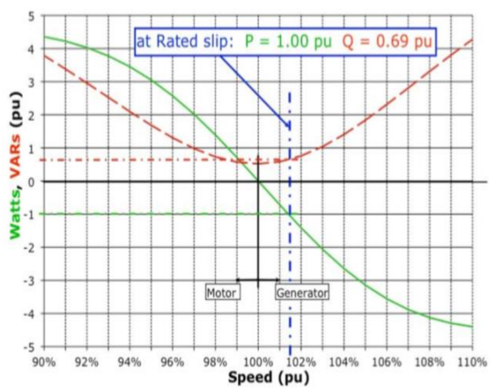

Fig. 2: Variation of Real and Reactive Power for SCIG

2.2: Limited Variable Type 2

In Type 2 turbines, wound rotor induction generators are connected directly to the WTG with the help of step-up transformer in similar to Type 1 with regards to machines stator circuit, but in that just include a variable resistor in rotor circuit. See Fig. 3. It can be accomplished with a resistors and power electronics external to the rotor with currents flowing in the resistors and rotor via slip rings. Consequently, the resistors and electronics can be mounted on the rotor to eliminating the slip ring. The variable resistors are connected with rotor circuit and can limit the rotor currents quite quickly so as to keep constant power even during critical condition, and can influence the machine's dynamic response during the grid disturbances.

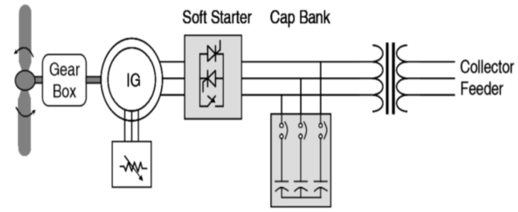

Fig. 3: Limited Variable Type 2 WTG

By inserting resistance in the rotor circuit, the real power curve in Fig. 2, can be "prolonged" to the maximum slip and maximum speed limits. In Fig. 4 i.e. said to be turbine would've to rotate faster to generate the same output power, for inserting rotor resistance. This permit some potentiality to limit the speed, with the blades' pitching mechanisms and move the turbines working to a tip speed ratio to get the best energy snap. It is speed variations of put 10% are possible, permitting for some degree of free in energy snap and itself protective torque limit.

2.3: Variable Speed with Either Partial Type 3

In that type 3, it takes the Type 2 design to the next level, by inserting variable frequency ac excitation to the rotor circuit. The extra rotor excitation is supplied through slip rings by a current regulated, voltage-source converter, which can adjust the rotor current, magnitude and phase, rotor-side converter is connected with a grid side converter which exchanges power directly to grid.

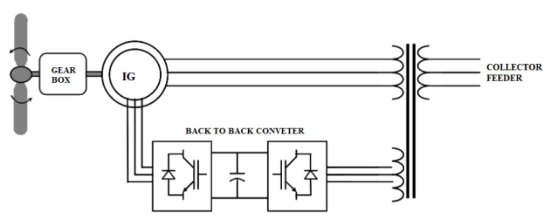

Fig. 4: Variable Speed with Either Partial Type 3 WTG

A small amount power inserted into the rotor circuit, so it can affect a large limit of power in the stator circuit. This is main advantage of the DFIG; a best deal of control output is available with the presence a set of converters. In addition to the real power delivered to grid from the generator's stator circuit, power is delivered to the grid through the grid-connected inverter when the generator is moving faster than synchronous speed real power flows from the grid, from rotor to stator. These two modes, made possible by the four-quadrant nature of the two converters, permits a much higher speed range, both above and below synchronous speed upon 50%. The greatest advantage of the DFIG, it offers the benefit of distinct real and reactive power control. Using these control idea, the torque producing components of rotor flux can made to respond fast enough that machine remains under relative control, even during significant grid disturbances.

2.4: Full (Type 4) Power Electronic Conversion

The Type 4 turbine (Fig. 5) a great deal of flexibility in design and working of output to rotating machine is feed to the grid with a full-scale back-to-back frequency converter. The gear-box may be eliminated, such that the machine rotates at the slow turbine speed and generates an electrical frequency below the grid. This is no problem for a Type 4 turbine, as the inverters convert the power, and offer the possibility of reactive power supply to the grid, much like a STATCOM.

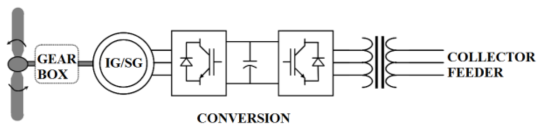

Fig. 5: Full (Type 4) power electronic conversion WTG

The ability of machine side inverter to control real and reactive power flow, any type of machine can be used. Modern in power electronic devices and limits in the last 10 years have made the converters both responsive and efficient. To compensate this reactive power we used STATCOM in power electronics basis. Reactive power will be damaged or harmful for the transmission system as well as power system.

1. **Voltage, Reactive Power and Power Factor Limitation Potentiality**

The voltage limit potentiality of a WTG depends on the wind turbine type, Type 1 and Type 2 WTGs can typically not limit voltage. Instead, these WTGs typically use Power Factor Correction Capacitors (PFCCs) to maintain the power factor or reactive power output on the low-voltage terminals of the machine to a set point. Types 3 through 5 WTGs can control voltage. These WTGs are capable of varying the reactive power at a given active power and terminal voltage, which enables voltage limit.

In a Type 3 WTG voltage is controlled by changing the direct component of the rotor current (this is the component of the current that is in-line with the stator flux). In a Type 4 WTG voltage control is achieved by varying the Quadrature (reactive) component of current at the grid-side converter. To allow voltage control capability, the grid-side converter must be rated above the rated MW of the machine and to needed Automatic Voltage Regulator for boost up or injecting the reactive power.

2. **Reactive Power Potentiality**

The reactive power potentiality of latest WTGs are significant as most grid require the WPP to have reactive power potentiality at the point of interconnect over a specified power factor limit, for example 0.95 leading (inductive) to 0.95 lagging (capacitive). Typical interconnect requirements related to total WPP reactive power potentialities. As, Type 1 and Type 2 WTGs uses PFCCs to maintain the power factor or reactive power of the machine to a specified set point. The PFCCs may be sized to maintain a slightly leading (inductive) power factor of around 0.98 at rated power output. This is often referred to as no-load compensation. With full-load compensation, the PFCCs are sized to maintain unity power factor, in some cases, a slightly lagging (capacitive) power factor at the machine's rated power output. The PFCCs typically consists of multiple stages of capacitors switched with a low-voltage AC contactor power factor of the machines over a wide range.

Type 3 (DFIG) WTGs typically have a reactive power capability corresponding to a power factor of 0.95 lagging (capacitive) to 0.90 leading (inductive) at the terminals of the machines. Options for these machines include an expanded reactive power capability of 0.90 lagging to 0.90 leading. Some Type 3 WTGs can deliver reactive power even when the turbine is not operating mechanically, while no real power is generated. As previously stated, Type 4 WTGs can vary the grid- side converter current, allowing control of the effective power factor of the machines over a wide range. Reactive power limit curves for different terminal voltage levels are typically provided. Some Type 4 WTGs can deliver reactive power even when the turbine is not operating mechanically, while no real power is generated.

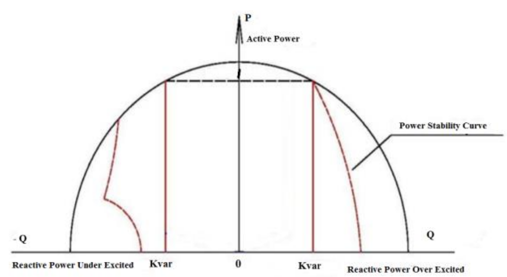

Fig. 6: Reactive Power Potentialities

3. VOLTAGE DRIVE OVER

The voltage drives over (VDO) capabilities of WTGs vary widely and have evolved based on requirements in various grid requirement. Some of the Type 1 WTGs have limited VDO potentiality and may require a central reactive power compensation system to meet wind power plant VDO potentiality. Many of the Types 2, 3, and 4 WTGs have VDO potentiality that may meet the requirements. Most WTGs are expected to ultimately meet the FERC 661-A requirements [4]. The VDO of a Type 5 WTG is very similar to that of standard grid-connected synchronous generators, which are well understood. The capabilities of the excitation system (AVR) and physical design of the generator (machine constants, time constants) will determine the basic performance of a synchronous generator during transient conditions. In order to meet utility VRT requirements, the settings and operation of the turbine control system, excitation system and protection systems must be generally coordinated and then fine-tuned for a specific site.

4. ADVANTAGES & DISADVANTAGES

4.1 Advantages

1) The generator and gear box can be placed on the ground.
2) The structure is usually simpler.
3) They used for various location at not constant speed in certain area.
4) They are easier to mount high enough to avoid much of the ground effect.
5) Grid synchronizes.
6) Wind turbines can be built on existing farms or ranches.

4.2. Disadvantages

1) Wind turbines are noisy.
2) Threat to wildlife, wind can never be predicted.
3) Required large open areas for setting up wind farms.

5. APPLICATION

1) A future companion WPP SCADA and control capabilities.

6. CONCLUSION

In this way, it discussed about the nature of wind turbine for wind power plant. At that it uses or take a 4 types of condition to well known about the nature or characteristics about it at various speed and with or without resistance. From this it shows that the speed variation has affected on the generation of the wind power plant. And also this has what affect on Voltage, Reactive Power and Power Factor Limitation Potentiality, Reactive Power Potentiality and Voltage Drive Over.

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