

A Review of Power Management of Wind –Diesel Hybrid System

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Abstract— this paper deals with dynamic performance of wind diesel system with variable wind speed turbine. The quality of power supplied to the autonomous system is improved by controlling the frequency to the rated value. The control system operates the wind turbine to achieve maximum power extraction using maximum power point tracking (MPPT) scheme, and simultaneously controls the dump load to absorb excessive power generation, in turn regulates the frequency of power supply. Different Power control classification are described in which Maximum power point tracking and Power control classification Generator -side converter, DC link bus, Grid side converter control, Four –quadrant control PEC in variable speed WPP. The diesel generator consists of a diesel engine with the governor system and a synchronous machine driven by the diesel engine. An alternator is coupled with the diesel engine and the kinetic energy of engine is transmitted to alternator and converted into electrical energy. Alternator works on the Faraday's law of electromagnetic induction. This electrical energy is then fed to the load. Diesel Generator set consists mainly parts are alternator, fuel tank, auxiliary alternator, starter motor, battery, control panel etc.

Index Terms— Wind-diesel system, maximum power point tracking, speed control, frequency control, Diesel generator

I. INTRODUCTION

The crude oil crisis situation which began in 1973 and continuously increasing prices for fossil fuels, has adversely affected the economic growth of developing countries. This has woken up the world to look for the alternative and sustainable energy solutions. Therefore it has become need of the hour to increasing use renewable resources with rapid economic growth, the demand for energy is increasing. Renewable energy can be defined as the energy sources that are natural and continually replenished either at the same rate or faster than the rate at which they are being used up by humans more or less indefinitely such as the sun, rain, biomass, and wind, tidal and geothermal energy. Among those, wind energy being clean and commercially competitive, one of the best choice. A very large number of wind energy conversion system (WECS) are already in use and many new systems are being planned. According to the Global wind Energy council (GWEC), the total capacity of wind power operating in the world reached 194.4GW in 2010. wind power generation is estimated to produce 12% of world's electricity requirement by 2020.[1]

Wind power conversion system differ from other conventional sources of energy due to (1) The construction of WECS, which commonly use power electronics based converters, resulting in the application of different topologies, (2) the unpredictable nature of wind power, which is uncertain and intermittent, and (3) the change from a passive distribution network into active with multiple energy sources and bidirectional flow. Due to such these factors associated with wind power, it behaves differently with power system network. The variation in wind velocity can affect the bus voltage, branch power flow, system balancing, reactive power injections, power system dynamics and stability, frequency control. It also create harmonics and flicker due to the switching action of the power electronics converter and can also affect the protection system due to the increase in fault levels. [2]

In order to maintain the power supplies quality with constant frequency and regulated voltage, variable speed wind turbine generations(VSWTG) systems using power electronic converter are considered as best option. Fully- rated VSWTG are also employed to power output fluctuations [3] and reduced the overall cost. Wind Diesel Hybrid Systems (WDHS) are isolated power systems combining wind turbine generators with diesel generator to obtain the maximum contribution by the intermittent wind resource to the total power produced, while providing continuous high quality electric power. The aim of WDHS is to reduce the fuel consumption and so lowering the running costs and environmental impact.

A hybrid wind diesel power system is one of the alternative solutions to resolve this problem. Since the wind power generation is estimated to produce 12% of world's electricity requirement by 2020 [4], HWDS are economic reality to reduce the diesel fuel consumption A HWDS is hybrid combination of a WTG system and DG unit to supply the maximum portion of the load requirements from the intermittent source of wind, while supplying quality electrical power [5]. However, highly complex controls involved in ensuring the proper sharing of intermittent wind energy and controllable DG unit forms the basis for successful integration of WTG systems with DG units to meet the power demand. Since wind is highly varying in nature, HWDS requires control system to improve power generation performance and provide economical solution. Also there is a need to utilize the intermittent wind resource effectively. For any given wind speed above the cut-in speed, the wind turbine should extract the maximum power from available wind speed. For which a maximum power extraction control system needs to be employed. Also

an isolated load, not connected to the regular electric grid, tends to have fluctuations in voltage and frequency of power supply and needs to be regulated for ensuring good quality in power supply.

The AC/DC/AC converter is divided into two components: RSC and the SSC. RSC and SSC are Voltage

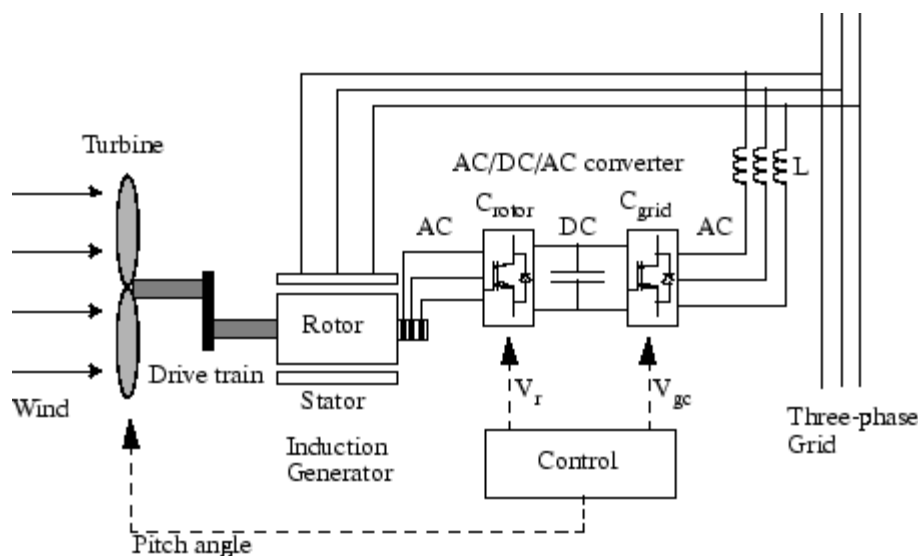


Fig-1 connection block diagram of wind turbine system.

Sourced Converters that use forced commutated power electronic devices (IGBTs) to synthesize an AC voltage from a DC voltage source. A capacitor connected on the DC side acts as the DC voltage source the three-phase rotor winding is connected to RSC by slip rings and brushes. As in figure-1 The power captured by the wind turbine is converted into electrical power by the induction generator and transmitted to the load by stator and the rotor windings. The control system generates the pitch angle command and the voltage command signals V_r and V_s for RSC and SSC respectively in order to control the power of the wind turbine, the DC bus voltage and the reactive power. The model is based on using the SSC for the wind turbine terminal voltage regulation. This is carried out in parallel with its main function and that is to regulate the DC bus voltage of the back-to back converter. Moreover, the maximum power tracking job is carried out by the RSC [6]

II. Power control classification

there are two major strategies for the power control of WPPs. in this two control strategies are independent, they can be closely interrelated (1) Aerodynamics control (2) Power electronics control Aerodynamic control method of limiting the power from the wind is generally adapted when the power available in the wind is higher than the power for which the WPP has been designed. This method of control is also called the principle of positive feed forward control the acceleration and deceleration of the rotor blades have to be controlled to limit the electrical load on the generator and mechanical stresses on the rotor blades, the hub and rest of drive as well. However continues control of the rotor speed by pitching of blades leads to continuous fluctuation of the power output to the grid which is not desirable. If a quick variation of speed is possible by this control when there is a large difference between the input power and output power, then the stress on the blades is increased on the account of the large torque needed.

Power electronics control is the ability of the WPPs to adapt its electrical generator rotor speed during normal energy production operation. This control depends on the type of electric generator used in the WPP and is called the principle of negative feedback control. This method of speed control technique offers a smooth operation, as it does not involve any mechanical action. Power electronic control is applicable when there is a power electronic converter (PEC) interface between the electric generator and local grid.

A. Maximum Power Point Tracking

The characteristics of the optimal power produced by a WPP is strangely non linear and is the shape of bell curve. For every change in speed of the wind, the WPP has to find the optimal RPM for the maximum power to be produced. In figure dotted line indicates the locus of the points of maximum power for every speed changes; the WPP will only function continuously when the operating point is the right of the line of maximum power. For maximum ideal wind power extraction, the control system of the WPP requires a perfect follow-up of the dotted curve and this control is called the maximum power point tracking (MPPT) curve as shown in Figure-2.

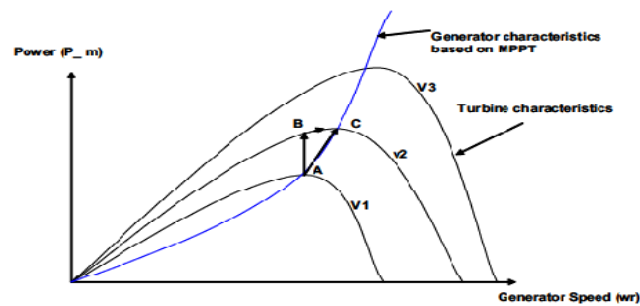


Figure- 2 Wind turbine power characteristics and maximum power extraction curve

By the variable speed operation, the wind speed is constantly tracked by the WPP mitigation the torque ripples caused due the varying wind speed. The strategy consist of the electromagnetic torture to adjust the mechanical speed in order to maximize the generator electric power. Through MPPT implementation, the annual energy yield can even go up to 10% to 15% more energy. this is quite significant revenue increase over 20 to 25 year of life of operation of a WPP By For every new wind speed, there is a different rotor speed for maximum power production .the control system of these variable speed WPPs maintains the mechanical power of the wind turbine rotor at its rated value to develop their peak aerodynamics efficiency C_p for the optimum TSR through MPPT. The MPPT curve maximizes the efficiency C_p for the optimum TSR through MPPT. The MPPT curve maximizes the efficiency of the WPP. Adapting MPPT, when the wind speed changes, the wind turbine rotor speed also changes. Concurrently, the electric generator speed changes should be able to adjust simultaneously for the maximum energy extraction ,butit should be noted that both constant and variable speed WPPs reach their maximum speed WPPs are becoming more popular. As the variable WPP is allowed to be driven in the with the varying wind speed resulting in electric power production which has variable voltage and current and its has to be fed inevitably through a PEC to render it grid compatible at constant voltage and frequency [7]

B. Back-to-back PEC IN WPP

The back-to-back PEC for rendering the power output of the variable speed electric generator compatible to the grid are quite common in variable speed WPPs. the general working of this PEC, in context of typical variable speed WPP.its main advantage are its comparatively simpler, proven technology and the possibility of the building redundancy into the string series connected switching devices, usually IGBTs [8]

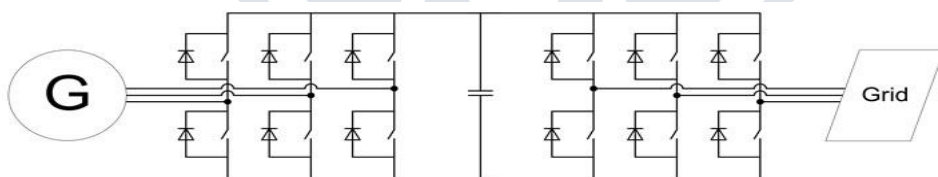


Figure-3 typical simplified back-to back VSI-based PEC commonly used in variable speed WPPs

1. Generator -side converter

The varying voltage V_s and varying frequency f_s of the generator –side converter do not match with the constant grid side converter that converts it to match the grid parameter. The PEC controls its d and q component for independent active and reactive power control on the grid. The generator side converter controls the active power output of the WPP helping it to operate over a wide variable speed range and produce power at unity power factor

2. DC link bus

DC link bus(capacitor) decouples the two converter (or inverter) whereby one does not influence the order .the DC link bus is also for energy storage in order to keep the voltage variations(or ripples) in the DC link voltage small. This voltage is kept constant by the rotor side converter control and the active power of the generation is transferred via DC link to grid side converter. As the constant stator voltage control is beneficial and to ensure that the generated active power is fed through the DC link to the

grid, the DC link voltage must be kept constant ensuring that no energy is dissipated in the DC link. The size of the DC link is very large which is not desirable

3. Grid side converter control

The grid side converter is not involved in the reactive power exchange between the WPP and the grid. The grid-side converter (or inverter) has to keep the DC link capacitor voltage at a set value, regardless of the magnitude and the direction of the rotor power and guarantee a converter operation at unity power factor. To achieve full control of the grid line to line voltage. Thus, the active power production of the WPP can be controlled by the grid –side converter. The grid side converter must be an active inverter (GTO, IGBT or IGCT as switching element, depending capacity of the WPP), since it converts DC link voltage to AC grid voltage with fixed frequency of the power system. The grid-side converter (DC-AC) maintains the DC link voltage constant and ensures unity power factor operation [9]

4. Four –quadrant control PEC in variable speed WPP

To operate a WPP over a wide range of wind speed and thereby, to increase the annual energy output, the advancements in the power electronic and the PEC came to the rescue for greater control of WPPs leading to the development of more advanced and high technology type –C and type -D WPPs in the market. Since the power flow is bidirectional through the PEC, they have to operate in a four –quadrant mode .the torque T_{gen} of the electrical generator equation can be written as

$$T_{gen} = \frac{3Es \frac{Vs}{XS}}{Wr \sin \delta} \quad (1)$$

Where

Wr = rotor angular frequency in mechanical radians per second

δ =Generator power angle (load angle).

III. Diesel generator

The diesel generator is a compact and robust machine in which mechanical energy is converted into electrical energy. It uses high speed diesel oil and work on diesel cycle .in particular system the air comes into the cylinder and compressed to a high ratio (14:1 to 25:1).during this compression, air is heated to a temp of 700 – 900C approximately. A metered quantity of diesel fuel is then injected into the cylinder, which ignites spontaneously because of the high temperature of compressed air. The diesel is injected through injector in the chamber. Hence, the diesel engine is also known as compression ignition (CI) engine.

An alternator is coupled with the diesel engine and the kinetic energy of engine is transmitted to alternator and converted into electrical energy. Alternator works on the Faraday's law of electromagnetic induction. This electrical energy is then fed to the load. Diesel Generator set consists mainly parts are alternator, fuel tank, auxiliary alternator, starter motor, battery, control panel.

IV. Conclusion

The proposed control strategy operates the HWDS in wind diesel mode of operation. The maximum power point tracking. Scheme for tracking the optimum turbine speed has been to show maximum power extraction performance for the wind turbine. The hybrid system consists of wind turbine generator, diesel generator (synchronous generator) and the consumer load was simulated. Frequency and voltage are Quality of power supplied to the autonomous system is improved by controlling the frequency to the rated value.

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