Gearless Variable Speed Wind Turbine In Ac/Dc Hybrid Microgrid By Using Fuzzy Logic Controller

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Abstract- The wind energy plays a vital role to meet the energy demand by making pollution free environment. It is a major challenge for wind turbine generator for generation of maximum power from the fluctuating wind. Presently, a fixed speed generation wind meet the desire energy demand of the customer which improve the efficiency and its power quality. Most of the turbines are designed for its the variable speed, having a gear box coupled with it. However, the application of gearbox causes major problems to the system when it suffers from internal faults and its malfunctioning. To avoid these problems and regular maintenance, the power electronics converter arises its head by doing the replacement of gearbox. Here, a sensor less speed estimator is proposed to estimate the speed of turbine without mechanical sensor. Grid connected wind electricity generation shows the highest rate of growth of any form of electricity generation which achieves the global annual growth rate in the order of 20-25%. Grid integration issues are the major challenges for the expansion of wind power. In this paper dynamic response of squirrel cage induction generator (SCIG) and Doubly fed induction generator are analyzed by varying the wind speed and occurrence of fault

Keywords –Fuzzy Logic Controller ,Grid, MATLAB 2016b

I. INTRODUCTION

The wind energy will paly a vital role to fulfill the energy demand, to minimize the dependency on fossil fuel, and to reduce the impact of variation of environmental influence. Presently, variable speed wind turbine technology emerges out to fulfill the increased energy captured, improve efficiency and its power quality [1]. Generally variable speed wind turbines are designed by doubly fed induction generator (DFIG) coupled with gear box [2]-[3]. The evolution of power electronic converters minimizes the regular maintenance as its connected to rotor side of the generator [4]. The performance of wind energy conversion can be enhanced by the variable speed wind turbine permanent magnet synchronous generator(PMSG) . The power factor and efficiency can be high because of the permanent magnet system [5],[6]. It has been studied about the PMSG based wind turbine which is based on surface permanent magnet-type synchronous generator [7]-[9]. A. wide speed range can be operated by flux weakening, which can allow constant power -like operation at speed higher than the rated speed [10],[11]. There are various types of control strategies have been implemented to control the variable speed wind turbines such as switch-mode boost rectifier [12],[13],three-switch pulse width modulation rectifier [14], and six -switch vector-controlled PWM rectifier [15]. In the control of PMSG-based variable speed wind turbine with switch-mode rectifier shows more advantages because of its simple structure and low cost as its only one controllable switch. However, it affects the generator efficiency because of its lack of ability to control generator power factor and which introduces high harmonic distortion [8],[14]. However, this scheme introduces high voltage surge on generator winding which can diminish the life time of the generator. The current control is normally executed at the rotor reference frame, which rotates with the rotor to achieve its high performance. Hence, coordinate transformation is involved and a position sensor is, thus, required for the torque loop. All these responsibilities introduce delays in the system [17], [18]. Also, the torque retort under this type of control is regulated by the time constant of stator windings [17]. A direct control strategy is implemented here ,where coordinate transformations are not mandatory as all the estimation are done in stator reference frame. Thus, the equipment of continuous rotor position (θ r) is eradicated. This technique is intrinsically sensor less and have several benefits compared with the traditional indirect vector control scheme [19]–[22]. However, a speed sensor is needed only for speed control loop. Therefore, a sensor less speed estimator is proposed to control the speed of rotor.
II. PROPOSED ALGORITHM

2.1 Fuzzy logic controller

Fuzzy logic control (FLC) is an artificial intelligence technique which is recently showing a lot of promise in the application of microgrid. The design of a maximum power point tracing (MPPT) strategy for a variable speed wind turbine system is presented here. The FLC has an input variable to change in mechanical power ($\Delta P_m$), change of speed ($\Delta \omega$), and the sign of ratio of mechanical power and change of speed ($\Delta P_m/\Delta \omega$). The change of reference generator current ($\Delta I^*$) is the output variable. It is very important to consider transient conditions in order to develop an accurate theoretical model, which is already designed by MATLAB 2016b. The fuzzy logic controller extracts the maximum output power from wind generator system. The proposed algorithm shows the maximum power utilization with variation of speed.

It has been examined that the direct controller can operate under varying wind speeds which introduce speed ripples and dynamic vibration in the system. Fuzzy logic controller can be implemented to reduce the torque/speed ripples. The simulation and experimental results for the sensorless speed estimator are introduced, and the results show that the estimator can estimate the generator speed quite well with a very small error.

Fig 1 Windfarm connected to grid system

The proposed microgrid is simulation designed is done by considering the windfarm whose capacity of generation is 9MW which is presented in fig 1. There are six wind turbines connected to a 25KV distribution system which exports power to a 120KV through a 30km, 25KV feeder. A motor load of 1.68MW at 0.98PF and 200KW resistive load are connected in the same feeder. Both the wind turbine and the motor load have a protection system monitoring voltage, current and machine speed. The DC link voltage of the Doubly fed induction generator (DFIG) is also monitored. The Simulink model has been done by taking MATLAB 2016 Simulink model. Here, the wind turbine coupled with a doubly fed induction generator which consists of a wound rotor induction generator and an AC/DC/AC IGBT-based PWM converter. The grid is connected to the Stator winding of the generator having a fixed 50Hz frequency while rotor is fed with a variable frequency through AC/DC/AC converter. The proposed technology allows maximum energy from the wind from low wind speed by optimizing the turbine speed and minimizing the Mechanical stresses during gusts of wind. In this simulation studies, the reference speed is chosen as 10m/sec. The rotor attains the sub synchronous speed when the wind speed lower than the reference speed and it shows the hyper synchronous speed when wind speed more than its reference.
III. RESULT AND DISCUSSION
In the MATLAB Simulink we have considered the two-case study to implement the fuzzy logic controller. First one taken the turbine response with the variation of wind speed and other one is voltage sag on 120kv system.

3.1. Turbine response to a change in wind speed Fuzzy logic controller
Simulation studies can be done by increasing the speed of wind from 8m/s to 14m/s. The voltage, current, generated active and reactive powers, DC bus voltage and turbine speed can be observed with that period of time. With a period of 10sec, the generated active power starts increasing smoothly to achieve its rated value of 9MW. Within that period of time the turbine speed has increased from 0.8 pu to 1.21 pu. The pitch angle is increased from 0 deg to 0.76 deg in order to limit the mechanical power. The reactive power and the voltage have been observed. The reactive power is controlled to maintain a 1pu voltage. The wind turbine absorbs 0.68Mvar to control voltage at 1pu at nominal power. If the mode of operation changes, then it has been observed that voltage is increased to 1.021 pu when the wind turbine generates its nominal power at unity power factor.

3.2. Simulation of a voltage sag on the 120-kV system
A fault which occurs in a remote place can cause the voltage sag on the 120-kV system. It decelerate the wind speed from 14 to 8 m/s. Now, the voltage source disconnected from the system and the time period of voltage drop is increased from 0.5 sec to 5 sec without disturbing the Var regulation. Simulation has been done in a isolated mode of operation. The plant voltage and current as well as the motor speed was observed. It has been noted that wind farm is generating 1.87MW. Within a period of 5 sec, the voltage falls below 0.9 pu and when the time will exceed 5 sec i.e.5.22 sec, the protection system trips the plant because the under voltage lasting more than 0.2 sec has been detected. It has been observed that the plant current falls to zero and the motor speed decreases gradually, while the wind farm is generating 1.87MW. After the plant has tripped, 1.25MW of power is exported to the grid.

Fig 2: Performance of the traditional indirect vector control scheme: (a) wind speed, (b) q-axis current and its reference, (c) q-axis current and its reference, and (d) speed reference and measured speed.
The performance of direct control scheme is presented in fig 4 to 6. The variation of speed and its torque has been measured by taking indirect control and then compare with direct control by applying fuzzy logic controller.

![Simulation Diagram](image)

**Fig 3.** Simulation Diagram Using Fuzzy Controller for a Wind Generator-Base Gear Less Variable Speed Wind Turbine

**Fig 4.** Performance of the direct control scheme: (a) wind speed, (b) torque and its reference, (c) flux linkage and its reference, and (d) speed reference and measured.
Fig 5: Performance of the traditional indirect vector control scheme: (a) wind speed, (b) $i_q$-axis current and its reference, (c) $q$-axis current and its reference, and (d) speed reference and measured speed.

Fig 6: Performance of the direct control scheme: (a) wind speed, (b) torque and its reference, (c) flux linkage and its reference, and (d) speed reference and measured.
IV. CONCLUSION

This paper proposed a sensor less direct control strategy for an induction generator-based variable speed wind turbine. The proposed direct control scheme possesses several advantages compared with indirect vector control scheme because of the lesser parameter dependence, torque and flux control without rotor position and PI controller which reduce the associated delay in the controllers and sensor less operation is done smoothly without the application of mechanical sensor.

The results show that the direct controller can operate under varying wind speeds. The torque/speed ripple can be minimized by using fuzzy logic controller. The simulation and experimental results for the sensor less speed estimator show that the estimator can estimate the generator speed quite well with a very small error.

V. REFERENCES


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