Reactive Power Management System for Wind Power Plant

Praveen Pachauri, Chandan Kumar, Sanjay Kumar, Ajay Kumar

Abstract*— *This paper deals with the study of reactive power management system for wind power plant. In the wind power plant, there is a need of reactive power for the process of developing rotating magnetic field in the induction generator. If the value of reactive power provided to the wind power plant is not sufficient than there occurs a voltage collapse in the electric power system and the occurrence of voltage collapse results in blackout. Therefore, this paper focus on the management of reactive power needs by the wind power plant in such a way that it could fulfil the requirement of power plant in a most efficient way without undergoing into voltage collapse.

Keywords- Reactive power, active power, voltage collapse, induction generator, Reactive power management.

I. INTRODUCTION

Within the vast power system, there exist a large number of electrical components associated with the transmission and distribution system [1]. Thus, it is required to provide a complete protection from several types of faults such as lightning, over voltage, low voltage, single line to ground fault, line to line fault, etc.[2], if further action is not taken to eliminate these faults there exist a voltage collapse. The voltage collapse cannot be neglected as it may leads to the voltage imbalance thereby resulting in blackout [3],[4]. There may be a large disturbance due to the voltage collapse and voltage collapse leads to system instability. The main causes of voltage collapse are insufficient of reactive power flow at the transmission line, low voltage profile, overload system and heavy flow of reactive power [5]. Therefore, the voltage dip requires a long-term system restoration and reactive power management system from time to time so that our extended power system is protected from all types of fault and have a continuous supply of electric power from generating station to loads [6].

From the last few years, there is an increment of renewable energy resources in the existing power system [7]. Nowadays renewable energy resources like solar energy, wind energy, hydro energy etc, are coupled with electrical power system for the purpose of generating electricity. These non-conventional energy resources not only help in generating electricity but also promotes to green energy. During the peak times of electrical loads, the grid fails to fulfil the energy demand of the customers, therefore in these conditions the wind power plant can be coupled with the electrical power system to fulfil the requirement of electrical power during peak times. But the use of wind turbine always requires the reactive power to generate electricity. The value of reactive power must be at the desired level that is it does not be very high or very low. Therefore, this paper focus on the reactive power management system for providing the limited value of reactive power which is necessary for generating electric power.

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II. LITERATURE REVIEW

Conventionally, there are various devices that are developed and employed in the power system for providing and controlling the reactive power in the electric power system such as manually operated reactors, switch capacitors, switched reactor and static var compensator [8],[9],[10]. These devices are employed to provide and consume reactive power whenever needed in the power system. The main drawback of such devices is that these are very costly and require frequent maintenance and control the reactive power in steps.

In past, these devices are coupled with doubly fed induction generator (DFIG) or asynchronous generator for determining the dynamic behaviour of the wind turbine but it is limited due to the reasons mention above. Therefore, there is a need to develop a model or a system that provide a real power, reactive power and frequency control of wind power plant simultaneously.

III. PROPOSED DYNAMIC CONTROLLER MODEL

The present paper discloses about a single dynamic converter that maintains the active power, reactive power and frequency at a desired level simultaneously. As we know that the voltage is dependent on reactive power and frequency is dependent on the active power, thus to control the reactive power it is required to control the load side voltage. Fig.1 shows the relation between the reactive power and active power variation in wind turbine of the proposed model.

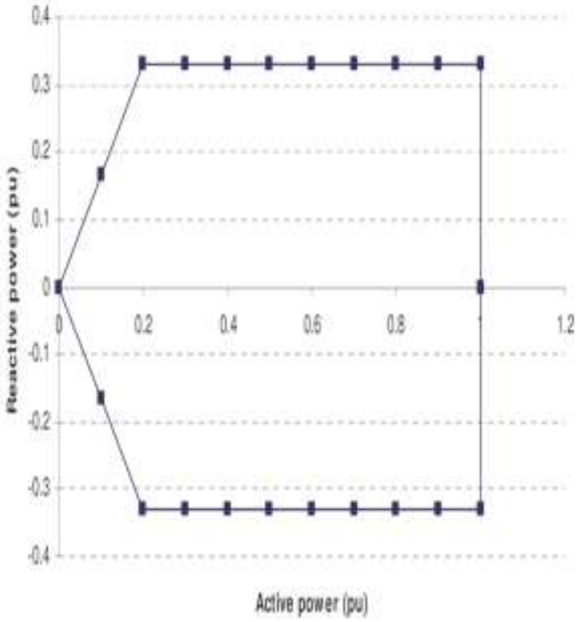


Fig1. PQ curve of wind power plant

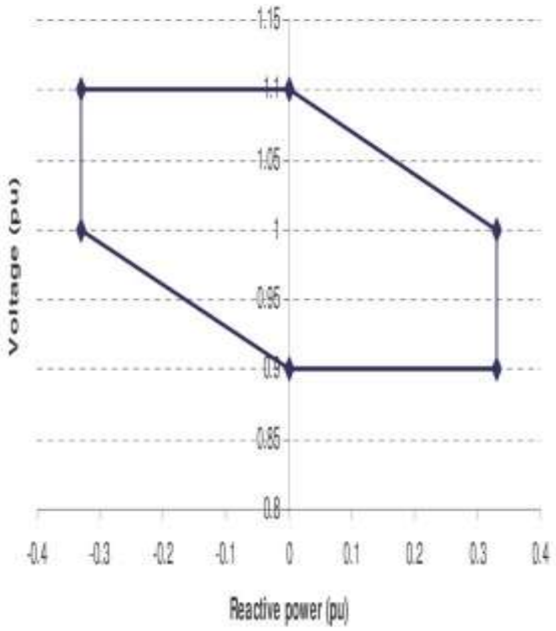


Fig.2 VQ curve of wind power plant

The reactive power is dependent on the load voltage therefore, it is required to control the load to manage the reactive power. Secondly as shown by the capability curve the VQ curve is developed in a MATLAB through a dynamic controller. The above curve shows the variation of load voltage (pu) with the reactive power (pu). The main advantage of using the proposed converter is that it provides high value of reactive power when the system gets overloaded and prevent the electrical system from overloading. The active power depends on the frequency and the frequency depends on the speed of rotation of wind turbine thus in general to control the active power the speed of wind turbine is controlled. In this proposed controller model, the fig.1 shows the variation of active power and reactive power.

IV. RESULTS AND DISCUSSION

In the experiment the simulation is done by taking 5 bus system as N1, N2, N3, N4 and N5. In this experiment the wind turbine is connected at the load side for providing the electrical power at the peak times like office time, school time or during some special event. It is assumed that during the peak hours of load the power grid fails to fulfil the energy demand and the system gets overloaded. In this case the wind turbine operating as emergency power generating source needs more reactive power to generate electricity otherwise the voltage of the system gets collapse and leads to blackout.

The below figure shows the variation of different parameters during the case of normal operation and overloading. Fig.4 (a) shows the voltage variation at bus no. 6 due to the variation of load and insufficient supply of reactive power. Fig.4 (b) represent the active power produced by induction generator of wind turbine, fig.4 (c) represent the reactive power consumed by induction generator and fig.4 (c) represent the reactive power injection at bus no. 6 with the help of shunt capacitor. Thus, from simulation the dynamic controller is used for fulling the needs of reactive power during the peak load condition or overloading.

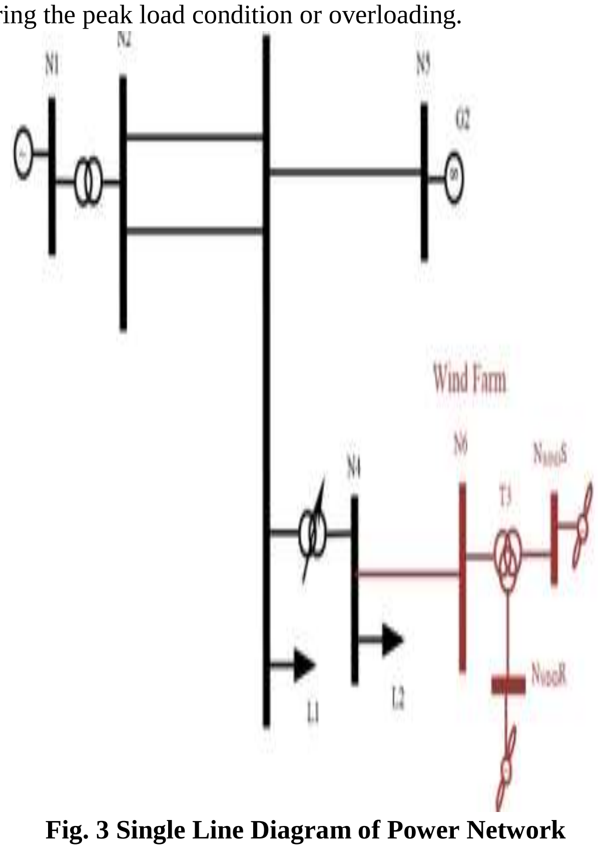
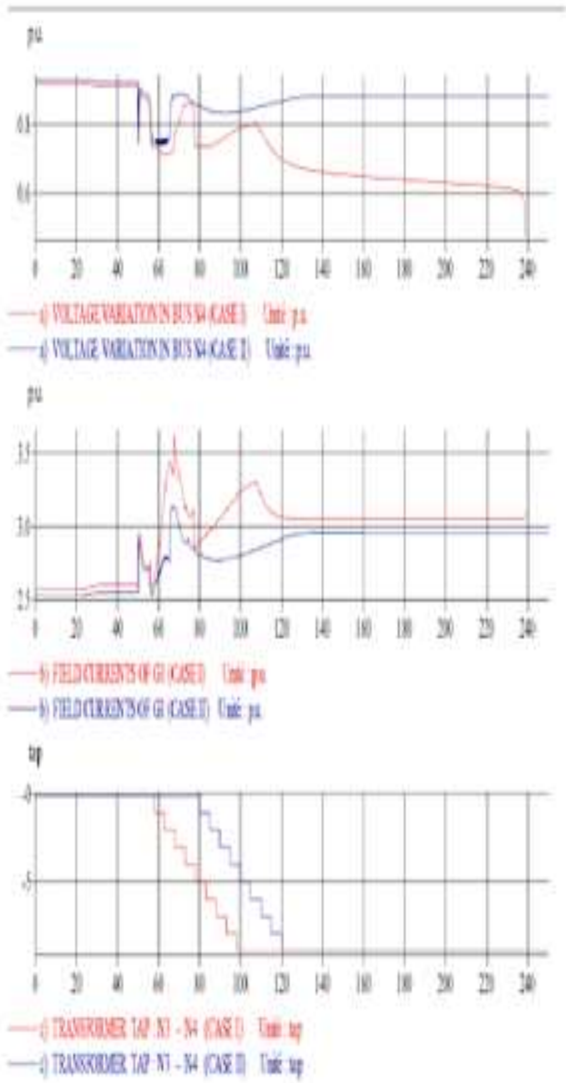


Fig. 3 Single Line Diagram of Power Network



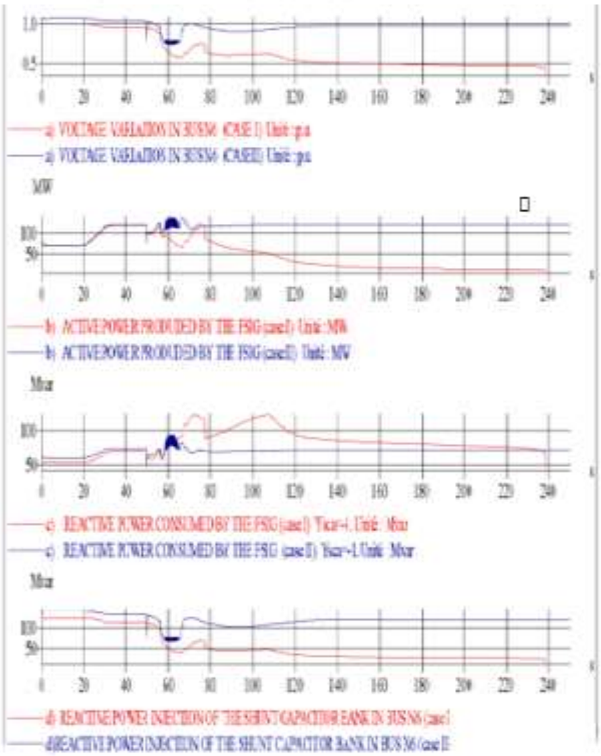


Fig. 4| a) Voltage variation in bus N6, b) Active power produced by the FSIG c) Reactive power consumed by the FSIG, d) Reactive power injection of the shunt capacitor bank in bus N6.

V. CONCLUSION

This paper presents the study of reactive power as well as active power management in the wind power plant. The complete experiment is performed in the MATLAB simulation by taking a 5-bus system. The wind power plant is connected in the electric power system at the load side for providing extra power during the peak load. It is assumed that in case of overloading condition, the electrical power system fails to provide power to the load and an external power generating source i.e. wind turbine is used to fulfil the requirement of peak load. When wind turbine is run for providing the energy to the load then it is assumed that there is a voltage collapse due to insufficient management of reactive power. Thus, this paper provides a dynamic controller that is capable of managing the reactive power and providing continuous and uninterrupted power supply to the customers.

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