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Compensation of Reactive Power in Distributed Wind Generations Using Dstatcom

RAGHURAMAN.V, M.Tech (Power System Engineering), PRIST University, Thanjavur,

ABSTRACT

In this paper, wind farm is connected to the grid and it is required to provide for the load. Wind farm are confronted with increasing demands for power quality fail safe operation at grid fault. In wind turbine technology, most of the currently installed wind turbines utilize induction generators to produce electricity. Since the induction generators do not perform voltage regulation and absorb reactive power from the utility grid. Whenever the disturbance occurs due to the fault, load variations causes the wind farm goes to outage conditions. This paper deal with operation and control of a DSTATCOM for reactive power compensation in asynchronous machine based distributed generation. The power quality issues like voltage regulation, load balancing and power flow are being analyzed and simulated. The DSTATCOM is realized using a 3 leg IGBT based pulse width modulation Voltage source converter having a DC bus capacitor. The instantaneous p-q theory used to derive the gate pulse for the IGBT switches. The proposed model is developed in MATLAB/SIMULINK environment and it's observed that the DSTATCOM is effective for compensating Reactive power.

Key words : wind turbine, DSTATCOM, MATLAB/SIMULINK

INTRODUCTION

Compensation of reactive power and unbalance in load current has been a great challenge for power engineers. In this model, wind farm is connected to the grid and it's required to feed the load. An induction generator utilized in the wind turbine to generate electricity is the sink of reactive power the reactive power compensation

is needed to provide necessary voltage support at the terminals where the wind farm is connected.

Most interconnection agreements require wind farm to maintain the power factor. The output of wind farm can vary significantly from minute to minute due to the variation of wind speed.

Theoretically the reactive sources have to be adjusted to maintain the power factor within the desired range and to control the terminal voltage while wind fluctuates. In practice most wind farms install fixed capacitor banks to full fill reactive power compensation requirement at required output level.

Whenever a severe disturbance occurs due to fault, load variations causes power swing, frequency variations and instability. The capacitance reactive power can not sufficient to maintain the load level. So the DSTATCOM used to compensate the reactive power. The DSTATCOM consist of 3 leg IGBT based current controlled voltage source inverter, DC bus capacitor and AC inductors. The DC bus capacitor is used as an energy storage device and providing self supporting DC bus of STATCOM. DSTATCOM has the three phase voltage source inverter shunt connected to the distribution network through the coupling transformer. This configuration allows the device to absorb or generate controllable reactive power. The demand of reactive power is met through the

DSTATCOM under varying load conditions. The DSTATCOM has been utilized for voltage regulation, correction of power factor and elimination of current harmonics.

Low voltage ride through (LVRT) is now required for connection of large wind farms in most power systems. Although variable speed winds turbines (VSWTS) is the dominant technology nowadays, fixed speed wind turbines (FSWTS) still retains a sizeable market share as the simplest wind turbine. As wind parks have a lifetime over 20 years, it is still a matter of interest to investigate the interaction of FSWT generation system with power system

PERSPECTIVES ON DG BENEFITS

1**.** END USER PERSPECTIVE

End users who place a high value on electric power can generally benefit greatly by having backup generation to provide improved reliability. Other will find substantial benefit in high efficiency applications such as combined heat and power where the total energy bill is reduced. End users may also be able to receive compensation for making their generation capacity available to the power system in areas where there are potential power shortages.

2. DISTRIBUTION UTILITY PERSPECTIVE

The distribution utility is interested in selling power to end users through its existing network of lines and substations. DG can be used for transmission and distribution (T & D) capacity relief. DG serves as a hedge against uncertain load growth. It also can serve as a hedge against high price spikes on the power market.

3. COMMERCIAL POWER PRODUCER PERSPECTIVE

Those looking at DG from this perspective are mainly interested in selling power or ancillary services into the area power market. In the sense the DG is discussed here, most units are too small to bid individually in the power markets. Commercial aggregators will bid the capacities of several units. The DG may be directly interconnected into the grid or simply serve the load off-grid.

WIND TURBINE

Wind turbine is a device that converts kinetic energy from the wind into mechanical energy. If the mechanical energy is used to produce electricity, the device may be called a wind generator or wind charger. If the mechanical energy is used to drive machinery, such as for grinding grain or pumping water, the device is called a wind mill or wind pump. The smallest turbines are used for applications such as battery charging or auxiliary power on sailing boats; while large grid connected arrays of turbines are becoming an increasingly large source of commercial electric power. Wind turbine work between 4 to 25 m/sec.

Three blades HAWT are more efficient, two blade turbines don’t require hub. As the number increases; noise, wear and cost increase and efficiency decreases. Multiple blade turbines are generally used for water pumping purposes.

POWER CURVE OF WIND TURBINE

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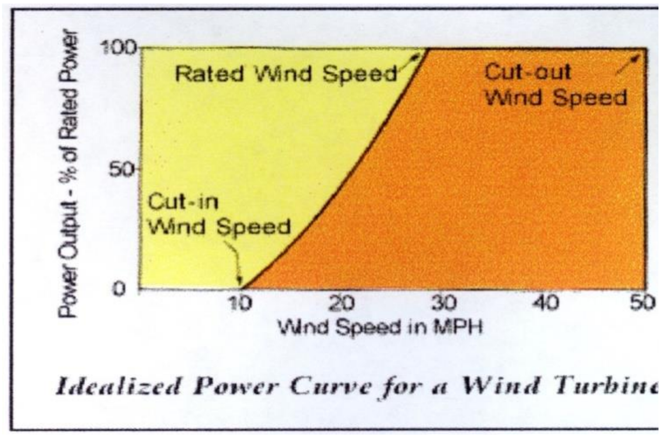


Fig.1.2 power curve of a wind turbine.

The power curve of a wind turbine is shown in fig.1.2.

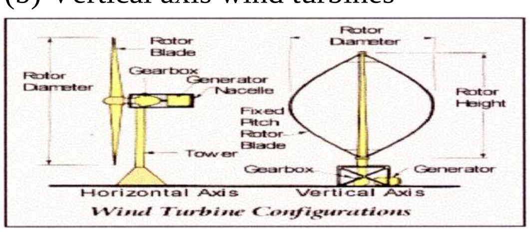
• Cut in speed: A turbine does not spin below these wind speeds.

• Cut out speed: turbine does not spin above these wind speeds.

TYPES OF WIND TURBINES

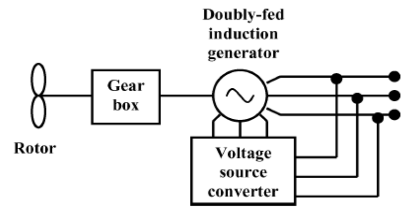
(a) Horizontal axis wind turbines

(b) Vertical axis wind turbines



DOUBLY FED INDUCTION GENERATOR

A doubly-fed induction generator is also connected to the rotor through a gearbox, and a back-to-back voltage-source converter as illustrated in Fig.1.5. The converter controls the voltage and current, as well as enabling variable-speed operation of the wind turbine. With the back-to-back voltage-source converter and pitch angle control, the doubly-fed induction generator is free from being overloaded during the high wind speed.



GRID CONNECTED WIND TURBINE MODEL

A Variable Speed Turbine is not directly connected to the Grid. The variable voltage and variable frequency generated is converted To DC power by Rectifiers, this DC power is stepped up by chopper and then through inverter (which consist of IGBT's) is converted to AC power. AC power matches the Grid voltage and frequency through Electronic systems before the Power is pumped to the Grid.

The increasing capacity of wind penetration is one of today's most challenging aspects in power-system control. Computer models of power systems are widely used by power-system utilities to study load flow, steady state voltage stability, dynamic and transient behaviour of power systems.

This paper emphasises the initialisation aspects of the models of the non-electrical wind turbine components. It is therefore beyond the scope of this paper to present a detailed description of the model of the grid-connected wind turbine and of the wind speed, as more details can be found. A typical blade angle controlled wind turbine with a squirrel-cage induction generator, connected directly to the grid, is considered. The wind turbine rotor is coupled to the generator through a gearbox, the power extracted from the wind is limited using blade angle control and the compensation for the consumed reactive power

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in the magnetisation of the induction generator is done with the help of a capacitor bank.

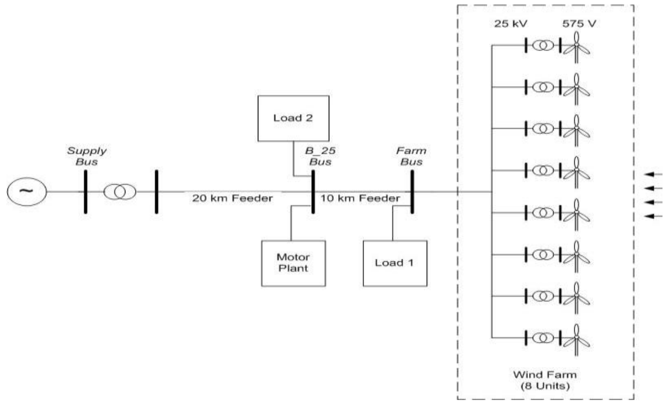

Fig.1.7 grid connected wind farm system

WHY DO WE NEED REACTIVE POWER

Reactive power (VARs) is required to maintain the voltage to deliver active power (watts) through transmission lines. Motor loads and other loads require reactive power to convert the flow of electrons into useful work. When there is not enough reactive power, the voltage sags down and it is not possible to push the power demanded by loads through the lines.

DSTATCOM

The demand of reactive power is met through the DSTATCOM under varying load conditions. The DSTATCOM act as a source of lagging or leading current to maintain the constant terminal voltage, harmonic elimination and load balancing. The DSTATCOM consist of 3 leg IGBT based current controlled voltage source converter, DC bus capacitor and AC inductors. The DC bus capacitor is used as an energy storage device and provides self supporting DC bus of STATCOM. Fig.4.1 is the basic structure of distribution system. The DSTATCOM has been utilized for voltage regulation, correction of power factor and elimination of current harmonics.

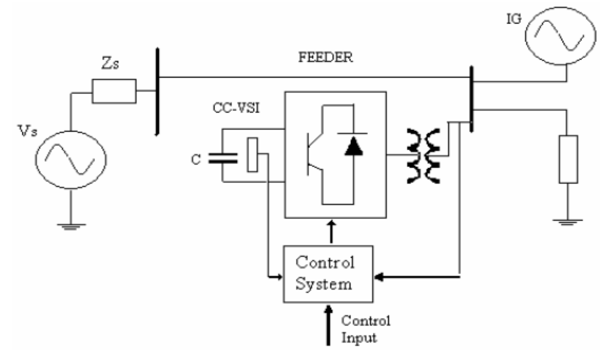

Fig.4.1. Basic structure of distributed system.

Recently, in distribution systems, major power consumption has been in reactive loads, such as industrial applications using large motors, fans, pumps, etc. These loads draw lagging power-factor currents and therefore give rise to reactive power burden in the distribution system. Also, frequent voltage sag and swell in power industry are highly undesirable and must be compensated.

PRINCIPLE OF OPERATION OF DSTATCOM

The DSTATCOM is a three phase and shunt connected power electronics based device. It is connected near the load at the distribution systems. In its most basic function, the DSTATCOM configuration consist of a voltage source converter (VSC), a dc energy storage device, a coupling transformer connected in shunt with the ac system, and associated control circuit The major components of the DSTATCOM are shown in Fig.4.3.

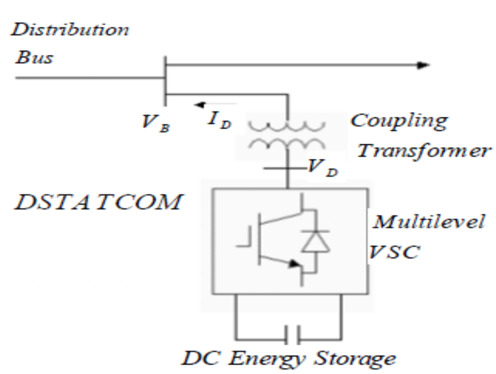

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Fig.4.3 Basic Structure of DSTATCOM.

D-STATCOM is to suppress voltage variation and control reactive power in phase with system voltage. It can compensate for inductive and capacitive currents linearly and continuously.
The VSC converts the dc voltage across the storage device into a set of three-phase ac output voltages. These voltages are in phase and coupled with the ac system through the reactance of the coupling transformer. Suitable adjustment of the phase and magnitude of the D-STATCOM output voltages allows effective control of active and reactive power exchanges between the D-STATCOM and the ac system. Such configuration allows the device to absorb or generate controllable active and reactive power.

COMPENSATION STRATEGY

The reactive and harmonic compensation is carried by injecting appropriate currents into the circuit through a compensator i.e., shunt active filter as shown in Fig.4.

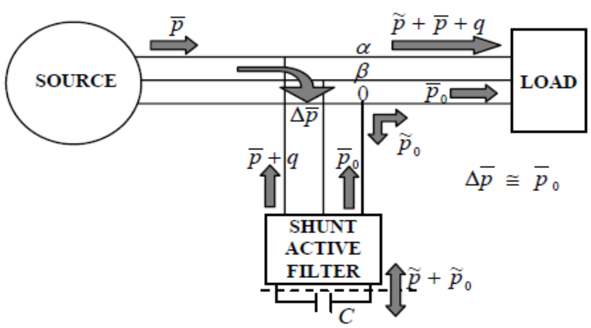
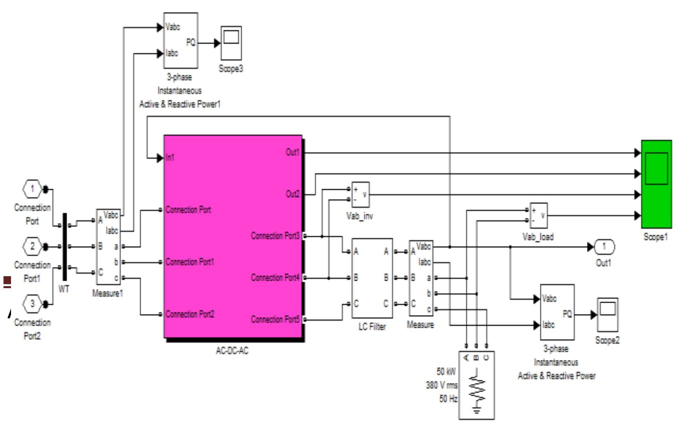
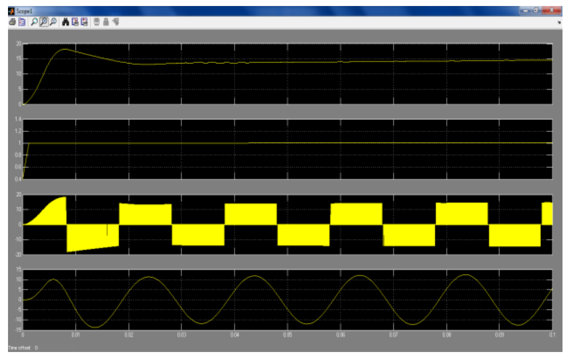


Fig.4 Strategy of instantaneous power theory.

STATCOM DESIGN



RESULT & DISCUSSION



CONCLUSION

Wind generation is one of the most mature renewable energy technologies. In the wind generation industry, most of the installed wind turbines utilize induction generators to produce the electricity. Induction generators do not perform voltage regulation and will absorb reactive power from the utility grid. According to the interconnection requirement, these reactive sources have to be adjusted regularly to maintain PF within the desirable range when wind fluctuates. In practice, however, most wind farms install fixed-capacitor banks to meet the reactive power compensation requirement at their maximum output level. The capacitor has fixed values can be compensated it cannot varied. But the DSTATCOM has compensated at required level. The Reactive power can be compensated by using distributed static compensator (DSTATCOM) with the control circuit as instantaneous p-q theory is simulated. The control circuit of DSTATCOM has been implemented in fuzzy logic controller also. Operation and control of DSTATCOM in low voltage distribution system with distributed generation has been demonstrated in this paper. MATLAB based simulated results demonstrate quite satisfactory operation of the proposed for voltage regulation, reactive power compensation and load balancing in low voltage distribution system with distributed generation.

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