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Simulation and modeling of STATCOM and WINDFARM in transmission line using MATLAB and analysis of bus voltage

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ABSTRACT: The concept of Var compensation embraces a wide and diverse field of both system and customer problems, especially related with power quality issues, since most power quality problems can be attenuated or solved with an adequate control of reactive power. In general, the problem of reactive power compensation is viewed from two aspects: load compensation and voltage support. Static voltage instability is mainly associated with reactive power imbalance. Thus, the load ability of a bus in a system depends on the reactive power support that the bus can receive from the system. As the system approaches the maximum loading point or voltage collapse point, both real and reactive power losses increase rapidly, therefore the reactive power supports have to be locally adequate. With static voltage stability, slowly developing changes in the power system occur that eventually lead to a shortage of reactive power and declining voltage. The Flexible AC Transmission System (FACTS) technology is a promising technology to achieve complete deregulation of power system based on power electronic devices, used to enhance the existing transmission capabilities in order to make the system flexible and independent in operation then the system will be kept within limits without affecting the stability. Increased transmission demand is met where possible by increasing the existing transmission capacity. When trying to improve the transmission capacity, a key assumption is made that if the overall system reliability is not improved, at least the existing system reliability is maintained. The research work in this work is focused on FACT'S Controllers.

Keywords: **Flexible AC Transmission System, variable-speed wind turbine, rotor-side converter, grid-side converter, doubly fed induction generator, Static Synchronous Compensator, phase-locked loop.**

INTRODUCTION

The worldwide concern about environmental pollution and a possible energy shortage has led to increasing interest in technologies for the generation of renewable electrical energy. Among various renewable energy sources, wind power is the most rapidly growing one in Europe and the United States. With the recent progress in modern power electronics, the concept of a variable-speed wind turbine (VSWT) equipped with a doubly fed induction generator (DFIG) is receiving increasing attention because of its advantages over other wind turbine generator concepts. In the DFIG concept, the induction generator is grid-connected at the stator terminals; the rotor is connected to the utility grid via a partially rated variable frequency ac/dc/ac converter (VFC), which only needs to handle a fraction (25%–30%) of the total DFIG power to achieve full control of the generator. The VFC consists of a rotor-side converter (RSC) and a grid- side converter (GSC) connected back-to-back by a dc-link capacitor. When connected to the grid and during a grid fault, the RSC of the DFIG may be blocked to protect it from over current in the rotor circuit. The wind-turbine typically trips shortly after the converter has blocked and automatically reconnects to the power network after the fault has cleared and the normal operation has been restored.

STATIC SYNCHRONOUS COMPENSATOR (STATCOM)

According to definition of IEEE PES Task Force of FACTS Working Group:

Static Synchronous Compensator (STATCOM): A Static synchronous generator operates as a shunt-connected static Var compensator whose capacitive or inductive output current can be controlled independent of the ac system voltage.

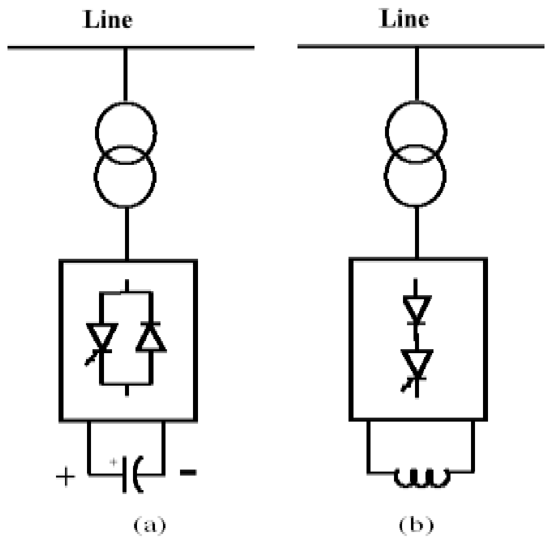

Fig 1: Static Synchronous Compensator (STATCOM) based on

(a) voltage- sourced and (b) current-sourced converter.

The STATCOM is the static counterpart of the rotating synchronous condenser but it generates/absorbs reactive power at a faster rate because no moving parts are involved. In principle, it performs the same voltage regulation functions as the SVC but in robust manner because unlike the SVC, its operation is not impaired by the presence of low voltage. The STATCOM has superior performance during low voltage condition as the reactive current can be maintained constant. (In a SVC, the capacitive reactive current drops linearly with the voltage at the limit of capacitive susceptance). It is even possible to increase the reactive current in a STATCOM under transient conditions if the devices are rated for the transient overload.

OBJECTIVES

The wind turbine that using squirrel cage induction generator needs more studies about its performances when it is connected to the grid to discuss the issues that accompany its normal operation to get better performance of it, therefore the objectives of this work are studies.

The main objectives of this work are:

1. Facilitate continuous operation of wind turbines during disturbances
2. Stability improvement (during grid faults)
3. Proper reactive power compensation by using STATCOM.

FACTS TECHNOLOGIES

1. Series compensation

In series compensation, the FACTS is connected in series with the power system. It works as a controllable voltage source. Series [[inductance]] exists in all AC transmission lines. On long lines, when a large current flows, this causes a large voltage drop. To compensate, series capacitors are connected, decreasing the effect of the inductance.

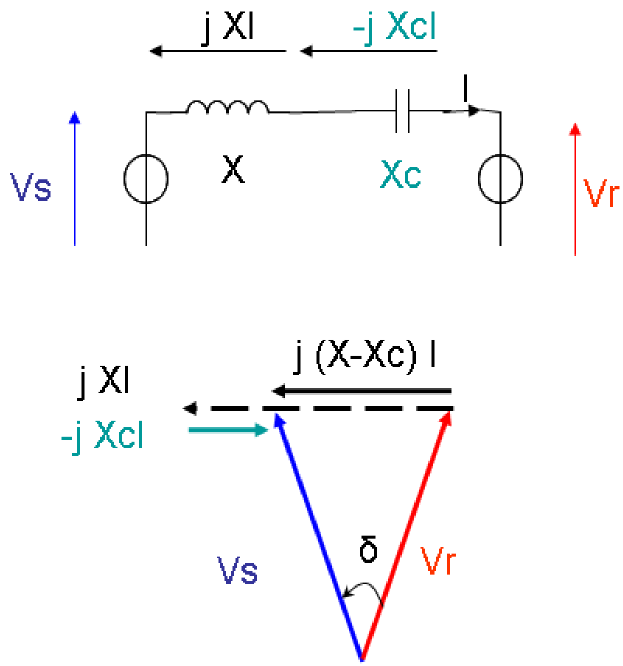

Fig. 2: series compensation

2. Shunt compensation

In shunt compensation, power system is connected in shunt (electrical) or shunt (parallel) with the FACTS. It works as a controllable current source. Shunt compensation is of two types:

a. **Shunt capacitive compensation**
b. **Shunt inductive compensation**

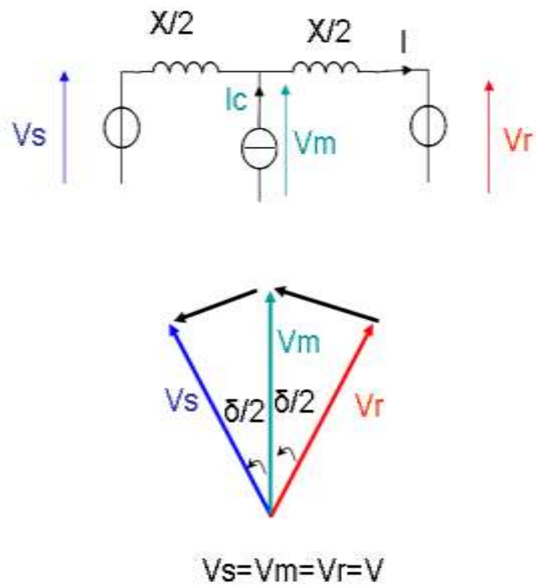

Fig. 3: Shunt compensation

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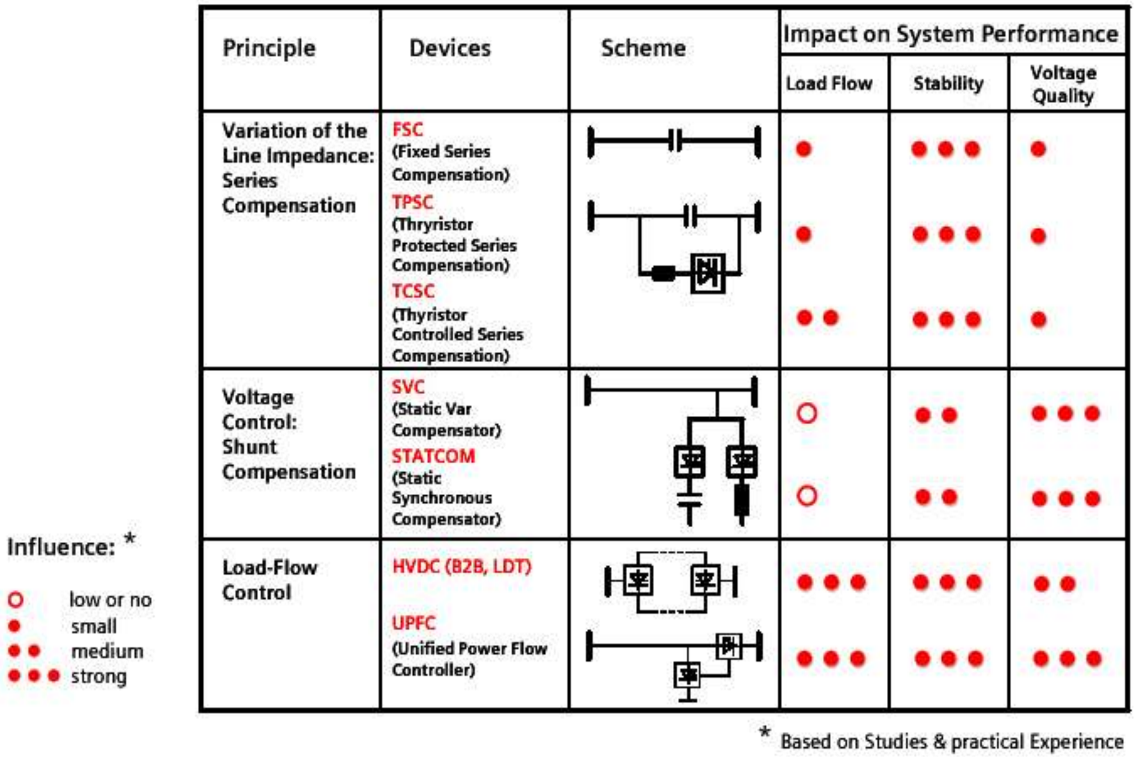

Fig. 4: Facts Overview & Description

MODELING AND SIMULATION RESULTS

The investigated power system network is modeled and simulated in MATLAB / SIMULINK as shown in Fig. 5 and Fig. 6 to study the steady state behavior with SVC and STATCOM. The fault is initiated between 10 and 10.1 sec from starting of the simulation. The purpose of running simulation in this mode is to verify the dynamic reactive power compensation capability of STATCOM during the event of fault, while integrating wind power in a distribution network. The network consists of a 132 kV, 50 Hz, grid supply point, feeding a 33 kV distribution system through 132/33 kV, 62.5 MVA step down transformer. There are two loads in the system; one load of 20 MW and another load of 4 MW at 50 Km from the transformer. The 33 kV, 50-kM long line is modeled as line. A 9 MW wind farm consisting of six 1.5 MW wind turbines is to be connected to the 33 kV distribution network at 4 MW load point. Dynamic compensation of reactive power is provided by a STATCOM located at the point of wind farm connection. The 9 MW wind farm have conventional wind turbine systems consisting of squirrel-cage induction generators and variable pitch wind turbines. Each wind turbine has a protection system monitoring voltage, current and machine speed. Test system is simulated in MATLAB/Simulink. Fig. 5 and Fig. 6 shows the Simulink model of the test system. Phase simulation is used to simulate the test system; so as to make it valid for intended purpose. Variable-step ode23tb solver is used for simulation. The simulation time is 20 sec.

The total MVA loading on the system is 50 MVA; considering the T & D losses in the system it is over loaded and representing weak distribution network. Dynamic compensation of reactive power is provided by a STATCOM located at the point of wind farm connection.

The simulation is run in three different modes, as follows :

I. Without Wind Farm and STATCOM,
II. with Wind Farm and without STATCOM,
III. with Wind Farm and STATCOM

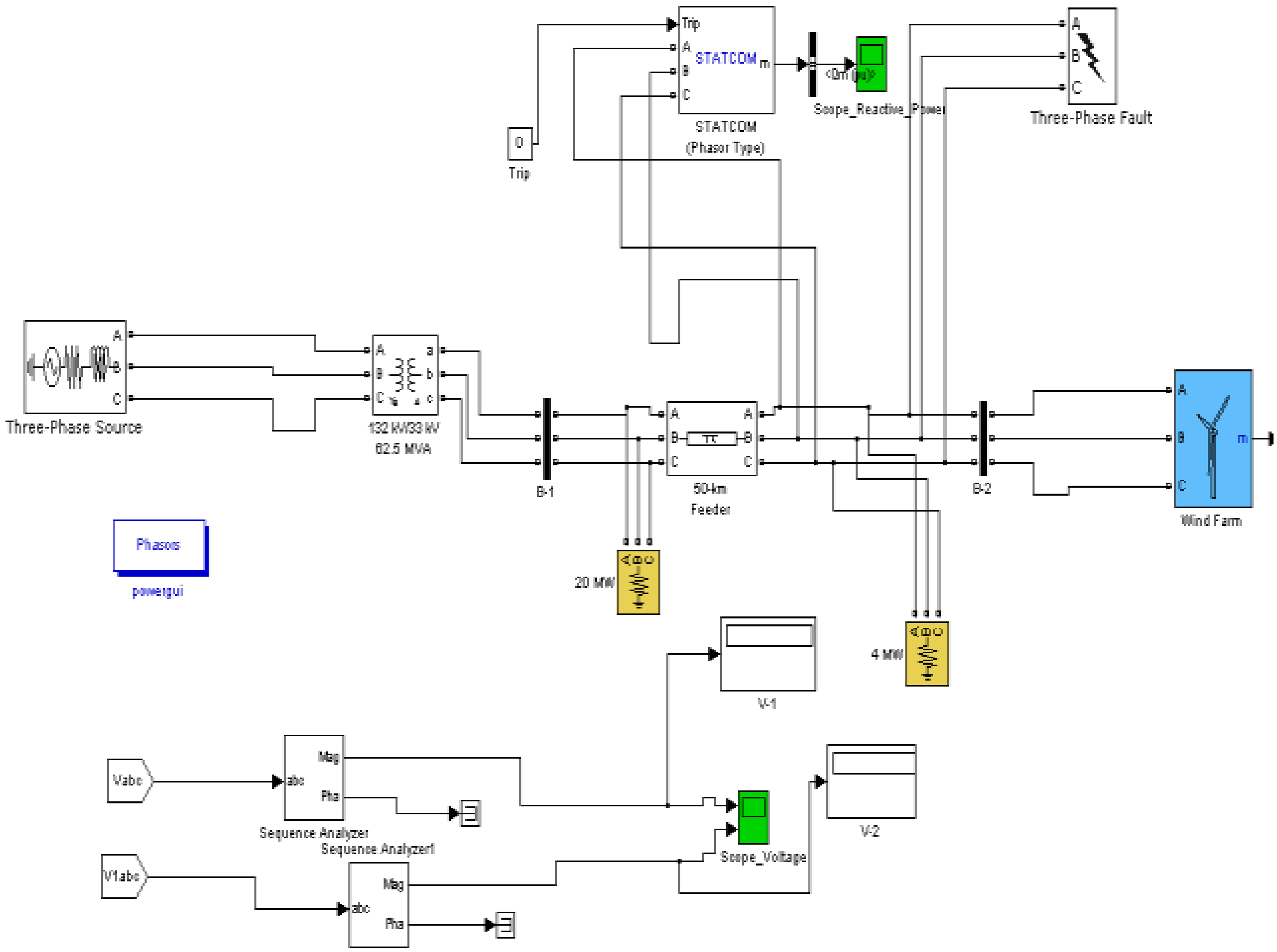

Fig. 5: Simulink Model of IG with STATCOM

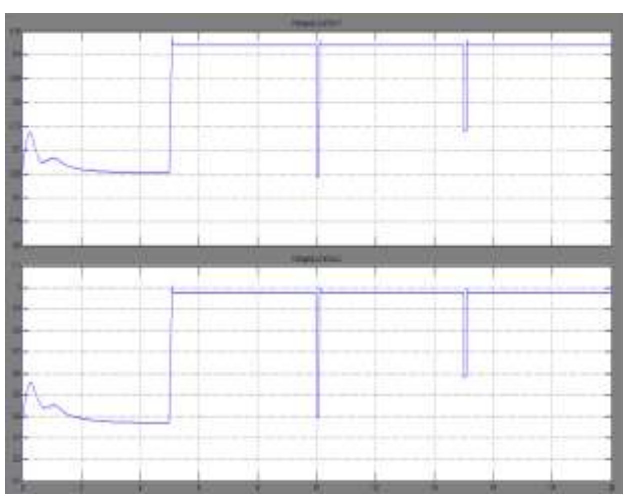

Fig.6: Voltages at 33 kV Bus – 1 and Bus – 2 during STATCOM

CONCLUSIONS

For the proposed work stability improvement of wind generation system using induction generators is investigated. The wind farms supply the active power to the grid when the wind turbines are connected to the grid, but at the same time, the reactive power is absorbed from grid. Induction machines are mostly used as generators in wind power based generations. Without reactive power compensation, the integration of wind power in a network causes voltage collapse in the system and under-voltage tripping of wind power generators. Therefore, it is necessary to compensate the reactive power for grid-connected wind farm to eliminate the effects of voltage fluctuations which is caused by reactive power loss in grid. With the rapid development of power electronics technology, traditional reactive power compensation shows some obvious drawbacks and connecting the Flexible AC Transmission System (FACTS). STATCOM is proposed in this study to compensate the reactive power & improve the stability of the system.

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