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Research using SVC to Improve the Operation of Wind Power Generators in Vietnam

Do Nhu Y [a]

[a] HaNoi University of Mining and Geology, Vietnam
PhD
E-mail: Donhuy.humg@gmail.com

Abstract

In Vietnam, the number of wind power generators has been increased yearly. Because of geophysical characters, the generation of these generators has different properties. It depends much on wind's characteristics as well as the generation technology. Base on simulation implemented on Matlab, the paper analyzes the stability of national networks at PCC nods containing the connection of wind power station when there is a change of wind's velocity or when there is an earth fault in grid. The analyzing results are used to suggest solutions to improve the stability and effectiveness of the whole system.

Keywords: wind power, stability, SVC.

1. Introduction

Renewable energy in general and wind energy in specific has rich future not only in Vietnam but also in develop countries. Base on the research of World Bank, the capacity of wind power in Vietnam is about 513.360MW. The areas containing rich wind energy resources are CuuLong Delta and island ones [1].

In Vietnam wind's characters and wind's modes depend much on areas and seasonal properties. Wind is rich on high land areas; its velocity is also big. These characteristics affect strongly on operation modes of wind power stations.

In wind power station, the generators are usually double feed induction ones. They are mainly consumed a huge amount of power system's reactive power to maintain rotating field in themselves stator and rotor. Therefore, in some special cases called disturbances such as: wind changing, earth fault, short circuit, the applied voltage of generator is reduced dramatically. If the time of disturbances is over long, the generation system will be unstable, the generator's speed cannot come up to the previous one [6]. Consequently, the generators are disconnected from national system; the reliability of electric supply will be reduced. Therefore, this phenomenon must be limited and using Static Var Compensator (SVC) to improve the effectiveness of wind power station's operation.

2. Research Models

The connection of wind power stations and grid could be implemented at different voltage level depend on power supplying by stations or on the distance from the station to the connection points. The general connection diagram of a typical wind power station and a grid is shown in figure [1-3].

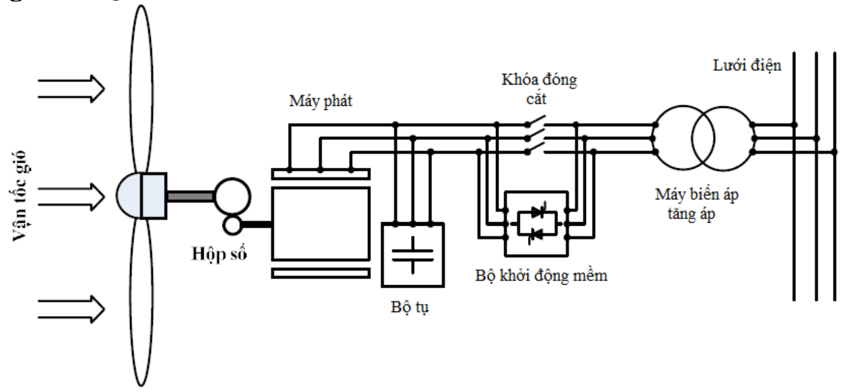


Fig. 1. The connection diagram of wind power station and national grid

Static Var Compensator (SVC) installed in power systems is used for improving the system performance in several ways [7, 8]. The SVC's are suitable to regulate system voltages, improve transient stability, increase transmission capacity, reduce temporary overvoltages, increase damping of power oscillations, and damp subynchronous resonances and torsional oscillations.

The SVC as a tool to improve power quality is a consequence of the economic pressure on electrical energy systems throughout the world. Therefore a substantial understanding of control structure and dynamic behavior of SVC's is become essential so

as to define the appropriate utilization of the compensator. This objective could be achieved by computer simulation which also plays an important role in the design and analysis of SVC's and other devices.

The Static Var Compensator device is characterized by rapid response [7], wide operational range and high reliability. From the several possible approaches to generate and control reactive power, presently thyristor valves are used almost exclusively in conjunction with capacitor and reactor banks.

The main functionality of the SVC is to regulate the voltage at a chosen bus by controlling the reactive power injection at that location. Maintaining the rated voltage levels is important for proper operation and utilization of loads. Undervoltage causes degradation in the performance of loads such as induction motors, light bulbs, etc... Whereas overvoltage causes magnetic saturation and resultant harmonic generation, as well as equipment failures due to insulation breakdown.

In its simplest form [8], the SVC consists of a TCR in parallel with a bank of capacitors. From an operational point of view, the SVC behaves like a shunt-connected variable reactance, which either generates or absorbs reactive power in order to regulate the voltage magnitude at the point of connection to the AC network. It is used extensively to provide fast reactive power and voltage regulation support. The firing angle control of the thyristor enables the SVC to have almost instantaneous speed of response.

A schematic representation of the structure of an SVC is shown in figure 2, where it is a shuntconnected device composed of several modules built of a fixed capacitance in parallel with a thyristor controlled reactor [5, 6].

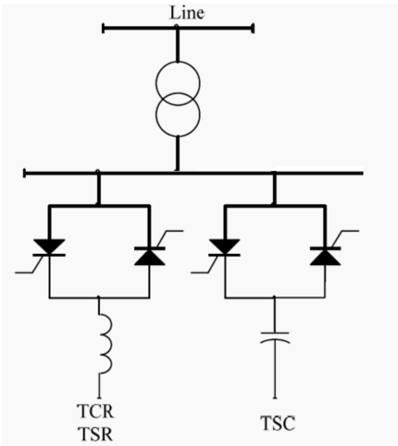


Fig. 2. Static Var Compensator (SVC)

The steady state control law for the SVC is the typical current-voltage characteristic the V-I characteristic is described by the flowing three equations:

$V = V_{ref} + X_s I$ SVC is in regulation range ($-B_{cmax}<B<B_{lmax}$)

$V = \frac{I}{B_{cmax}}$ SVC is fully capacitive ($B=B_{cmax}$)

$V = \frac{I}{B_{lmax}}$ SVC is fully inductive ($B=B_{lmax}$)

where: V - positive sequence voltage (pu); V_{ref} - reference voltage (pu); I - reactive current (pu/pbase) (I> 0 indicates an inductive current); X_s - slope or droop reactance (pu/pbase); $B_{c\,max}$ - maximum capacitive susceptance (pu/pbase) with all TCSs in service, no TSR or TCR. B_{lmax} - maximum inductive susceptance (pu/pbase) with all TSRs in service or TCRs at full conduction, no TSC.

Figure 3 presents the model of 9MW wind power station containing 3 turbines (each of 3MW). The station is connected to the 22kV distribution grid at PCC named B22. The power generated by station is transmitted to 110kV grid by 20km lines of 22kV. Generators in station are squirrel-cage induction type; the wind's velocity is 9m/s. Each generator has its own protection system to ensure their voltage, current and speed. A compensated capacitor having the value of 400kVAr is connected at the coming end of generator, the entire power needing to maintain voltage at B22 equal by 1pu (22kV) is supplied by SVC (Static Var Compensator).

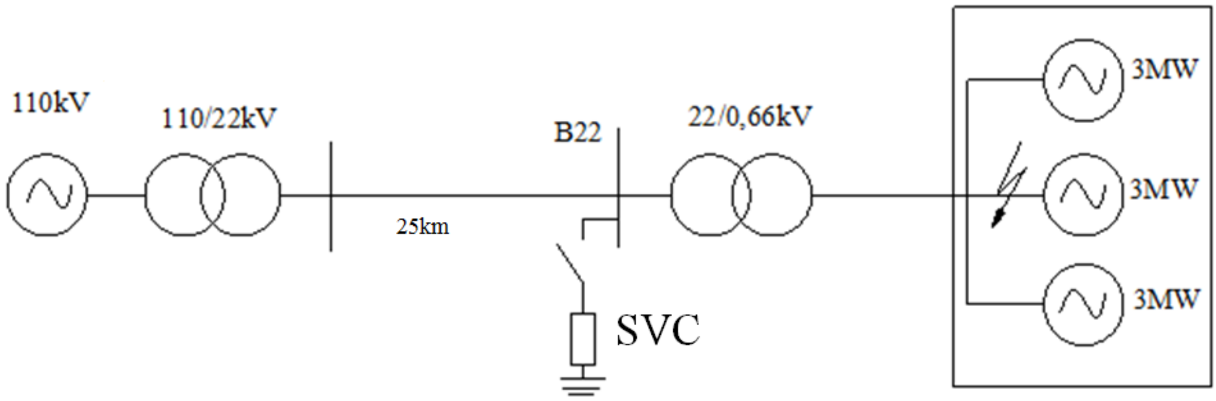


Fig. 3. Model of wind power station connected with national grid

A simulation model is formed in figure 4 that is used to analyze the effectiveness of SVC in improving the operation of wind power station.

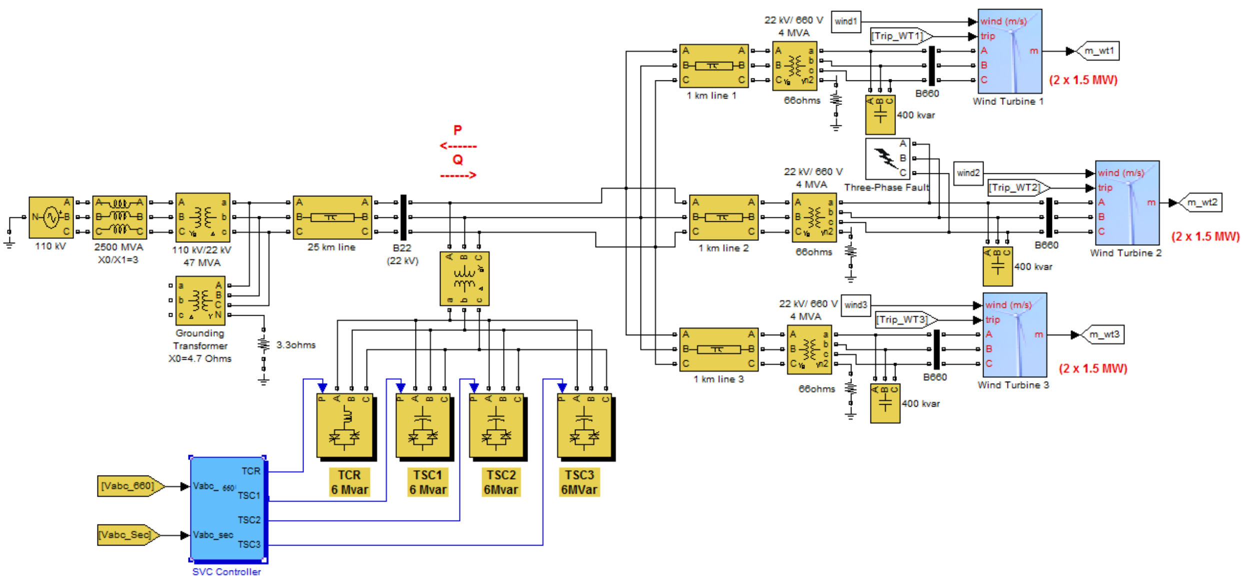
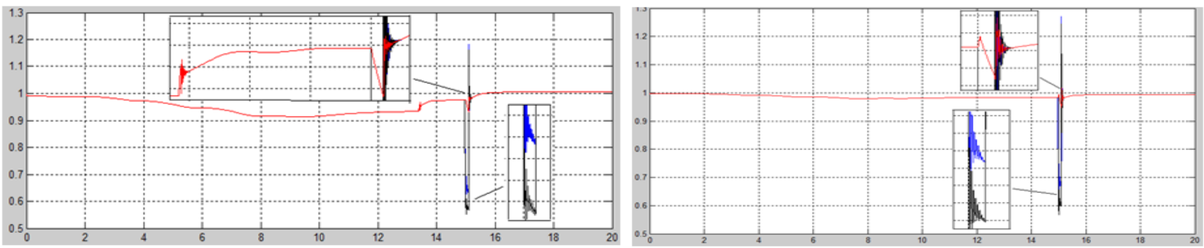


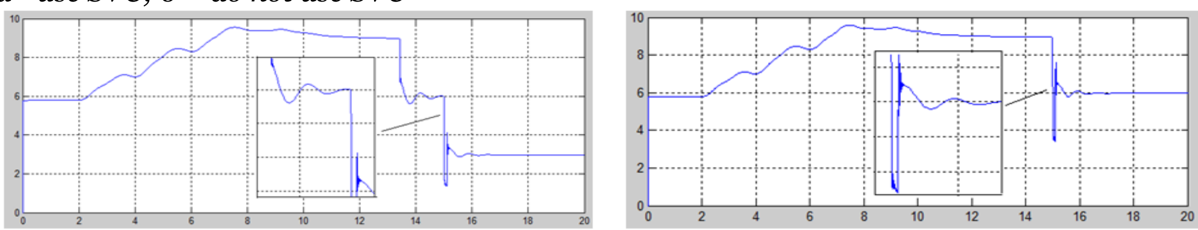
Fig. 4. Matlab-Simulink simulation of a wind power station connected to the grid

The simulation is implemented with the following data: The velocity of wind is 8m/s, at the time of 2s, it is increased to 11m/s. The wind's velocity flowing into 2nd and 3rd turbines is also increased correspondingly at 4s and 6s. At t=15s, and earth fault is occurred on the out put pole of generator 2. The results showing the responses of system corresponding to 2 cases: using SVC and do not using SVC are presented in figure 5.



a) *b)*

Fig. 5. Voltage wave form at the bus B22
a - use SVC; b – do not use SVC



a) *b)*

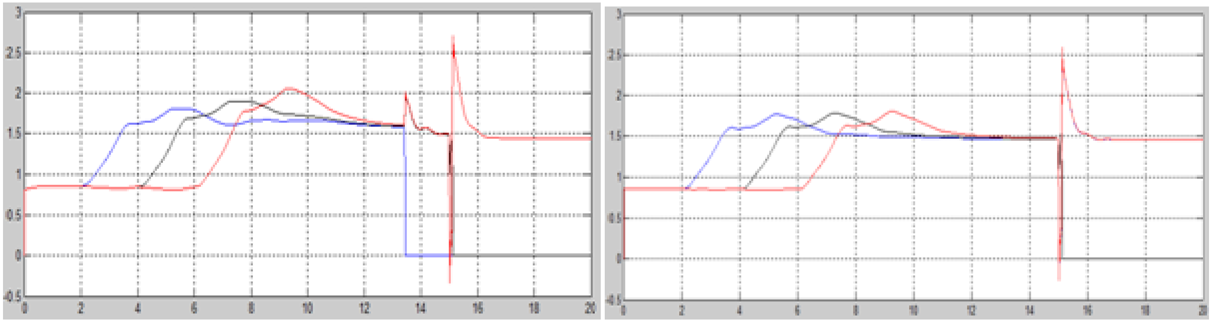
Fig. 6. Active power P at bus B22
a - use SVC; b – do not use SVC

The simulation proved that, when the wind's velocity is over rated one (9m/s) active power generated by generator is increased, but its consuming reactive power is also increased.

Without utilizing Statcom, at B22 because of lacking reactive power, the bus's voltage is only 0,92pu (at t= 8s), consequently the generator is overload. The generator stops its operation at t=13,2s. Latter on, because of generator 2 and 3 still operate well, the emitted power is 3MW, and voltage is recovered around 0,98pu.

With utilizing SVC, because at B22 the reactive power is compensated by SVC, voltage is not sag, it remain at 0,98pu (figure 5b) There is no disconnected of the system.

The similar simulation is implemented with earth fault on generator 2. At t=15s the disturbance is occurred with generator 2, voltage is down to 0,52pu the protection system isolated the generator 2 from the system. Without using SVC, the system is only stable after 2s. The reactive power of 2 cases mentioned above is shown in figure 7.



a) b)

Fig. 7. Reactive power Q consuming by turbines a – use SVC; b – do not use SVC

3. Conclusion

The results shown in above simulation proved that with SVC the interval of system's disturbance is lower significantly. The system is operated more stable even when there is the change of wind's velocity or abnormal operation such as earth faults.

Another advantage of using SVC is the output voltage of generators is in better performance; this will help to protect generators from unwanted mechanical shocks and to lengthen the age of wind turbine.

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