Review on Stability Mid-point of Transmission Line using STATCOM

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ABSTRACT: Regarding the power system large wind farms are greatly affected stability and control issues. So it requires a deep study to overcome this potential problems and it requires advanced control and compensating devices to avoid & recover large disturbances this paper involve the use of Static Synchronous Compensator (STATCOM) for stabilizing the grid voltage after grid-side disturbances such as a three phase short circuit fault, temporary trip of a wind turbine and sudden load changes. These will help to maintain and regulate the proper voltage. The DC voltage at individual wind turbine (WT) inverters is also stabilized to facilitate continuous operation of wind turbines during disturbances.

KEYWORDS: STATCOM, Dynamic Compensator, SVC, Transient Stability, V-Q Response.

I. INTRODUCTION

STATCOM is basically a voltage source converter, VSC that converts a dc voltage at its input terminals into three-phase ac voltages at fundamental frequency of controlled magnitude and phase angle. VSCs use pulse width modulation, PWM, technology, which makes it capable of providing high quality ac output voltage to the grid or even to a passive load (Uzunovic, 2001). STATCOM provides shunt compensation in a similar way as SVC but utilizes a voltage source converter rather shunt capacitors and reactors (Machowski, 1997). The basic principle of operation of a STATCOM is the generation of a controllable AC voltage source behind a transformer leakage reactance by a voltage source converter connected to a DC capacitor. The voltage difference across the reactance produces active and reactive power exchanges between the STATCOM and the power system (Wang and Li, 2000). The effect of stabilizing controls on STATCOM controllers have been investigated also in several recent reporting (Wang and Li, 2000), (Wang, 1999).

Recent development of power electronics introduces the use of FACTS devices in power systems. FACTS devices are capable of controlling the network condition in a very fast manner and this unique feature of FACTS devices can be exploited to improve the transient stability of a system. Reactive power compensation is an important issue in electrical power systems and shunt FACTS devices play an important role in controlling the reactive power flow to the power network and hence the system voltage fluctuations and transient stability. The flexible AC transmission system (FACTS) are now recognized as a viable solution for controlling transmission voltage, power flow, dynamic response ,etc. and represent a new era for transmission systems. It uses high-current power electronic devices to control the voltage, power flow, etc. of a transmission system.

FACTS devices are very effective and capable of increasing the power transfer capability of a line, if the thermal limit permits, while maintaining the same degree of stability. SVC and STATCOM are members of FACTS family that are connected in shunt with the system. Even though the primary purpose of shunt FACTS devices is to support bus voltage by injecting (or absorbing) reactive power, they are also capable of improving the transient stability by increasing (decreasing) the power transfer capability when the machine angle increases (decreases), which is achieved by operating the shunt FACTS devices in capacitive (inductive) mode. Previous works on the topic prove that shunt FACTS devices give maximum benefit from their stabilized voltage support when sited at the mid-point of the transmission line. The proof of maximum increase in power transfer capability is based on the simplified model of the line neglecting line resistance and capacitance. However, for long transmission lines, when the actual model of the line

is considered, the results may deviate significantly from those found for the simplified model. The primary objective of our project is to find the maximum power and the corresponding location of the shunt FACTS devices when the actual line model is considered. Based on the simplified line model it has been proved that the centre or midpoint of a transmission line is the optimal location for shunt FACTS devices. When the actual model of the line is considered, it is found that the FACTS device needs to be placed slightly off-centre to get the highest possible benefit.
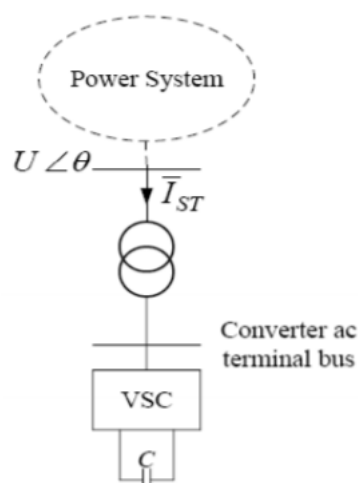

Figure 1: Line diagram of STATCOM

II. FEATURE OF STATCOM

- A STATCOM has both turn-on and turn-off control capability (IGBTs).
- It generates an output ac voltage from a dc voltage.
- The ac voltage is controllable both in magnitude and phase angle.

Flexible Alternating Current Transmission Systems (FACTS) devices, namely STATIC synchronous Compensator (STATCOM), Static Synchronous Series Compensator (SSSC) and Unified Power Flow Controller (UPFC), are used to control the power flow through an electrical transmission line connecting various generators and loads at its sending and receiving ends. FACTS devices consist of a solid-state voltage source inverter with several Gate Turn off (GTO) thyristor switch-based valves and a DC link capacitor, a magnetic circuit, and a controller. The quality of AC waveforms generated by the FACTS devices depends on the valves and the various configuration magnetic circuits. The inverter configuration used in this paper can be utilized to build a voltage source inverter.

III. BASIC CONFIGURATION OF STATCOM

By using thyristor-controlled reactors (TCR) and thyristor-switched capacitors (TSC), SVC provides voltage regulation and dynamic reactive power for VAR absorption and production respectively. A STATCOM accomplishes the same effect by using a VSC to synthesize a voltage waveform of variable magnitude with respect to the system voltage. The STATCOM branches provides both production and reactive power absorption capability and 111 incase of an SVC requires separate branches for each. The STATCOM, with the use of PWM, perform faster response and thereby improves power quality. This is very useful to flicker from disturbances caused by electric arc furnaces at steel mills. To increase the power transfer capability by installing an SVC or STATCOM in transmission networks and it is limited by post-contingency voltage criteria or under voltage loss of load probability. Determining the optimum mix of dynamic and switched compensation is a challenge. Control systems are designed to keep the normal operating point within the middle of the SVC or STATCOM dynamic range. The voltage-sourced converter (VSC) is the basic electronic part of a STATCOM, which converts the dc voltage into a frequency, and phase. There are different methods

to realize a voltage sourced converter for power utility application and it is based on harmonics and loss considerations, pulse width modulation (PWM) or multiple converters are used. Inherently, STATCOMs have a symmetrical rating with respect to inductive and capacitive reactive power. For example, the rating can be 100 MVAR inductive and 100 MVAR capacitive. For asymmetric rating, STATCOMs need a complementary reactive power source. Figure 6 shows Static Synchronous Compensator (STATCOM) used for midpoint voltage regulation on a 500-kV transmission line.
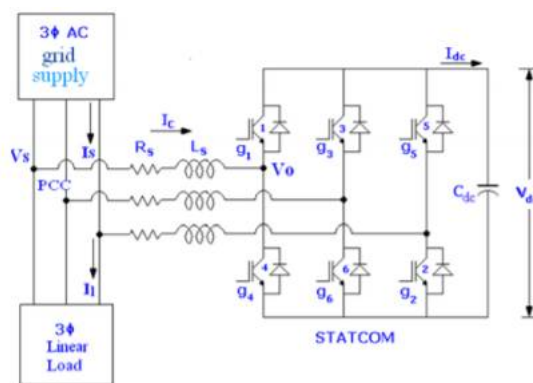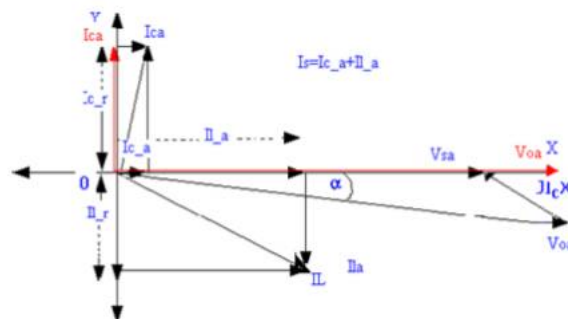

Figure 2: Schematic Diagram of STATCOM

Figure 3: Phasor diagram for inductive load operation

In the last one decade commercial using of Gate Turn-Off thyristor (GTO) devices with high power handling capability, and the advancement of other types of power-semiconductor devices such as IGBT's have to led the development of controllable reactive power sources utilizing electronic switching converter technology. These technologies additionally offer considerable advantages over the existing ones in terms of space reductions and performance. The GTO thyristor enable the design of solid-state shunt reactive compensation equipment based upon switching converter technology. This concept was used to create a flexible shunt reactive compensation device named Static Synchronous Compensator (STATCOM) due to similar operating characteristics to that of a synchronous compensator but without the mechanical inertia. By using of Flexible AC Transmission Systems (FACTS), it is gives a new family of power electronic equipment emerging for controlling and optimizing the performance of power system, e.g. STATCOM, SSSC and UPFC. The use of voltage-source inverter (VSI) has been widely accepted as the next generation of reactive power controllers of power system to replace the conventional VAR compensation, such as the thyristor-switched capacitor (TSC) and thyristor controlled reactors (TCR). A FACT is the acronym for Flexible AC Transmission Systems and refers to a group of resources used to overcome certain limitations in the static and dynamic transmission capacity of electrical networks. The IEEE defines FACTS as "alternating current transmission systems incorporating power-electronics-based and other static controllers to enhance controllability and power transfer capability."

IV. MODELING OF THE STATCOM AND ANALYSIS

The fundamental phasor diagram of the STATCOM terminal voltage with the voltage at PCC for an inductive load in operation, neglecting the harmonic content in the STATCOM terminal voltage, is shown in figure 7. Ideally, increasing the amplitude of the STATCOM terminal voltage Voa above the amplitude of the utility voltage Vsa causes leading (capacitive) current Ic to be injected into the system at PCC. Iac, the real component of Ic, accounts for the losses in the resistance of the inductor coil and the power electronic converter. Ideally, if the system losses can be minimized to zero, Ic_a, would become zero, and Ic would be leading at perfect quadrature. Then, Voa , which is lagging and greater than Vsa , would also be in phase with Vsa. The STATCOM in such a case operates in capacitive mode (when the load is inductive).
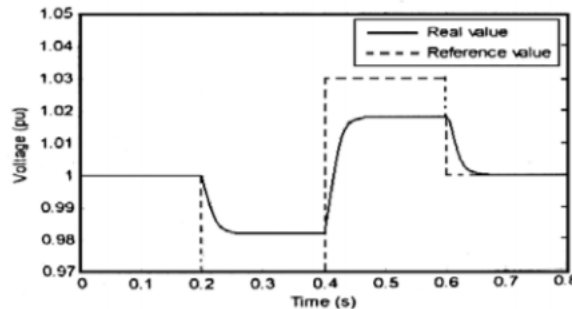

Figure 4: Vref signal (dotted lines) along with the measured positive-sequence voltage vm at the STATCOM

We will now verify the dynamic response of our model. Open the STATCOM dialog box and select "Display Control parameters". Verify that the "Mode of operation" is set to "Voltage regulation" and that "External control of reference voltage Vref" is selected. Also, the "droop" parameter should be set to 0.03 and the "Vac Regulator Gains" to 5 (proportional gain Kp) and 1000 (integral gain Ki). Close the STATCOM dialog block and open the "Step Vref" block (the red timer block connected to the "Vref" input of the STATCOM). This block should be programmed to modify the reference voltage Vref as follows: Initially Vref is set to 1 pu; at t=0.2 s, Vref is decreased to 0.97 pu; then at t=0.4 s, Vref is increased to 1.03; and finally at 0.6 s, Vref is set back to 1 pu. Also, make sure that the fault breaker at bus B1will not operate during the simulation (the parameters "Switching of phase A, B and C" should not be selected).
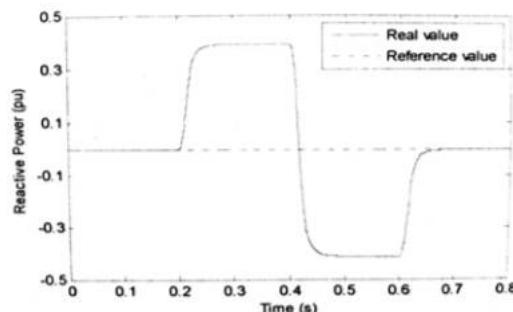

Figure 5: The reactive power generated (negative value) by the STATCOM

Run the simulation and look at the "VQ_STATCOM" scope. The first graph displays the Vref signal (magenta trace) along with the measured positivesequence voltage Vm at the STATCOM bus (yellow trace). The second graph displays the reactive power Qm (yellow trace) absorbed (positive value) or generated (negative value) by the STATCOM. The signal Qref (magenta trace) is not relevant to our simulation because the STATCOM is in "Voltage regulation" and not in "Var Control".

This time constant depends primarily on the power system strength at bus B2 and on the programmed Vac Regulator gains of the STATCOM. To see the impact of the regulator gains, multiply the two gains of the Vac Regulator Gains by two and rerun the simulation. You should observe a much faster response with a small overshoot.
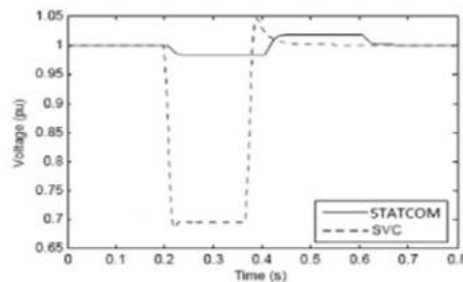

Figure 6: Measured voltage Vm on both systems

We will now compare our STATCOM model with a SVC model having the same rating (+/- 100 MVA). If you double-click on the "SVC Power System" (the magenta block), you will see a SVC connected to a power grid similar to the power grid on which our STATCOM is connected. A remote fault will be simulated on both systems using a fault breaker in series with fault impedance. The value of the fault impedance has been programmed to produce 30% voltage sag at bus B2.Before running the simulation; you will first disable the "Step Vref" block by multiplying the time vector by 100. You will then program the fault breaker by selecting the parameters "Switching of phase A, B and C" and verify that the breaker is programmed (look at the "Transition times" parameter) to operate at t=0.2 s for a duration of 10 cycles. Check also that the fault breaker inside the "SVC Power System" has the same parameters. Finally, set the STATCOM droop back to its original value (0.03 pu).

V. CONCLUSION AND FUTURE WORK

It is found that if STATCOM is installed at 250 km from sending end i.e. midpoint of the line, system becomes transiently stable as shown in the results. The study has shown that FACTS devices obtain maximum benefits from their stabilized voltage support when placed at the mid-point of the line. The mid-point siting is also most efficient in terms of control of reactive power. The transmission line must be operating under the thermal limit and the transient stability limit.

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