Improving Power Quality of a Transmission Line using Static VAR Compensator

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Abstract: In this paper improvement of power quality and efficiency of transmission line has been discussed using Static VAR Compensator (SVC). The Matlab Simulink model of SVC addressed here comprises of Thyristor Switched Capacitor (TSC) and Thyristor Controlled Reactor (TCR) which gave the enhanced results in terms of voltage, current and improved power quality in the transmission line.

1. Introduction

Over the last few years, power quality has been an important issue in the field of power system. Need of rapid dynamic response, ability to adapt the frequent variations in output and smooth adjustable output, an improvement of voltage flicker in power transmission has led to the use of FACTS devices. Among various FACTS devices the SVC plays an important role in regulation of voltage and improvement of power transfer capability in power system. There are two main applications of SVCs:

Transmission SVC: - They are connected to power system to regulate the transmission voltage

Industrial SVC: - They are connected near large industrial loads, to improve power quality.

1.1. SVC

It is series compensated power electronics device which provides fast acting reactive power on high voltage electricity transmission network. SVCs either absorb or supply reactive power based on the change of VAR requirement of the load. Thus SVC provides power factor correction to maintain the unity power factor at variable loads. In this paper SVC has been modeled using TSC and TCR.

The SVC can be operated in two different modes: In voltage regulation mode and in VAR control mode (the SVC Susceptance is kept constant).

The system characteristic is represented by the load line A which intersects the SVC characteristics at reference voltage. The load line B intersects the SVC characteristics at voltage V2. Since voltage V2 is above the reference voltage, the reactive power needs to be absorbed from the system (indicates inductive reactive power is required). The current I1 corresponds to voltage V2 in the inductive region and therefore it requires the operation of the Thyristor Controlled Reactor (TCR). The load line C intersects the SVC characteristics at a voltage V1 which is below the reference voltage and hence reactive power needs to be provided to the system (capacitive reactive power is required). Thus the current I2 corresponding to voltage V1 is in the capacitive region of operation [1].

1.2. TCR

The TCR is a Thyristor Controlled Reactor whose effective reactance can be varied continuously by partial conduction control of thyristor valve [2,3]. The basic principle of TCR is to control the reactive power by controlling the firing angle of the thyristor valve. The controlled element is the reactor and the controlling element is the thyristor controller consisting of two oppositely poled thyristors which conducts at every alternate half cycles of the supply frequency [4].

Figure 1. V–I Characteristics of the SVC
1.3. TSC

The circuit diagram of Thyristor Switched Capacitor (TSC) is shown in Figure 3. Each thyristor valve consists of two oppositely poled thyristors. The thyristor valves are delta connected in order to eliminate zero sequence harmonics (3rd, 9th,...). The harmonics remain trapped inside the delta and thus reduce harmonic injection into the power system. When thyristor is switched ON under abnormal operating condition reactor L limits the surge current. As compared to the mechanically switched capacitors, TSC provides instantaneous response to the changes occurring in the system parameters and hence more reliable [1].

2. Modeling of SVC

The Simulink Model of the test system as shown in Figure 4, comprises of the three phase source from where 11kV is being generated. The 11kV has been then stepped up to 33kV using three phase transformer under a three phase Pi (∏) section of 10 KM. Further the phase voltage has been stepped down to 11kV with an apparent power of 20 MVA. Three parallel loads are connected with respective active and reactive power at 0.8 p.f lagging.

The SVC controller has been designed in this paper to maintain the system voltage at 33 kV bus. If the bus voltage decreases, the SVC will inject reactive power (Q) into the system and if the bus voltage increases the SVC will absorb the reactive power to the system. The Simulink diagram of SVC controller is shown in Figure 6.
3. Results and Discussion

3.1. Voltage, Current and Power profile without the SVC controller

To introduce disturbance in the three-phase power system, transient time 2 s and 4 s in the three-phase breakers has been considered. One of the breaker was connected in series and the other in parallel to the transmission line. The voltage, current and power drop due to the connected load was observed as shown in Figure 7, Figure 8, Figure 9 and Figure 10 respectively.

3.2. Voltage, Current and Power profile with the SVC controller

To overcome the disturbance at 2 s and 4 s, the SVC controller has been connected to the three-phase transmission line. Once the SVC has been introduced, the effect in the voltage, current and power profile of the designed power system has been shown in Figure 11, Figure 12, Figure 13 and Figure 14 respectively.
4. Conclusion

In this paper, the basic structure of a SVC, operating under bus voltage and its model has been addressed. The model has been designed as a controller with variable impedance that changes with the firing angle of the TSC and TCR. Disturbances at 2 s and 4 s have been introduced such that the designed SVC could mitigate the problem of voltage, current and power drop at 2 s and 4 s respectively. Therefore, the designed SVC could successfully control the voltage and stabilize the power system at the point where it has been connected to the system.

5. References


