Study of SVC component in transmission line for compensation

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Abstract: This paper will discuss and demonstrate how Static Var Compensator (SVC) component and how will be these components successfully applied to control reactive power in the transmission line for system disturbance and effectively regulate system voltage. SVC is basically a shunt connected static var generator whose output is adjusted to exchange capacitive or inductive current so as to maintain or control specific power variable. One of the major reasons for installing a SVC is to improve voltage control and thus increase system load ability. There are the mainly accomplishes work to construct an effective for SVC.

Keywords: FACTS, SVC and Voltage control.

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1. INTRODUCTION

A static VAR compensator (SVC) is an electrical device for providing fast-acting reactive power compensation on high voltage transmission networks and it can contribute to improve the voltage profiles in the transient state and therefore, it can improve the qualities and performances of the electric services.

SVC is a shunt connected FACTS device whose output can be adjusted to exchange either capacitive or inductive currents to the connected system. This current is controlled to regulate specific parameters of the electrical power system (typically bus voltage). The thyristor has been an integral part in realizing the SVC and to enable control of its reactive power flow. It is used either as a switch or as a continuously controlled valve by controlling the firing angle. It should be noted that the SVC current will contain some harmonic content, something that needs attention in the design process. The SVC can be used to control the voltage level at a specific bus with the possibility of adding additional damping control.

Static VAR compensator (SVC), using the latest technology of power electronic switching devices in the fields of electric power transmission systems with controlling the voltage and power flow, and improving the voltage regulation. Again, the static VAR compensators are being increasingly applied in electric transmission systems economically to improve the post-disturbance recovery voltages that can lead to system instability. A SVC performs such system improvements and benefits by controlling shunt reactive power sources, both capacitive and inductive, with high-tech power electronic switching devices. This work is presented to solve the problems of poor dynamic performance and voltage regulation in an 115KV and 230KV transmission system using SVC.

The Static VAR Compensator (SVC) composed of fixed capacitors (FC) and thyristor controlled reactor (TCR) has been employed in power system to regulate the system voltage and to improve power system stability, where the capacitive reactive power provide by FC, also can balance three-phase asymmetric load by regulating each phase TCR to eliminate the negative sequence component. However, the TCR of SVC in the distribution itself introduces harmonic currents when in operation especially in unbalanced load compensation. If each harmonic current is installed a filter branch, the FC are often tuned with small reactors to act as passive filters (PF), the size of the PF will very great, which also could introduce possible series and parallel resonances with source impedances.

Series VAR compensators are proving to be a viable alternative to shunt compensators for enhancing power transmission and distribution capability. Series capacitive VAR compensation has been used for many years to enhance transmission capacity and dynamic security of transmission systems, mainly in the form of fixed or switched capacitors. Series VAR compensators are proving to be a viable alternative to shunt compensators for enhancing power transmission and distribution capability. This paper proposes a compensator structure based on a multilevel cascade of single phase inverter bridges that can be coupled to the transmission system without transformers.

2. COMPONENT OF SVC

The shunt-connected Static VAR compensator (SVC) using solid-state switches and the series-connected controllers were proposed in transmission system application. Static Var Compensator is "a shunt-connected static Var generator or absorber whose output is adjusted to exchange capacitive or inductive current so as to maintain or control specific parameters of the electrical power system (typically bus voltage)" .SVC is based on thyristors without gate turn-off capability. The operating principal and characteristics of thyristors realize SVC variable reactive impedance. SVC includes two main components and their combination: (1) Thyristor-controlled and Thyristor-switched Reactor (TCR and TSR); and (2) Thyristor-switched capacitor (TSC). In Figure 1 shows the diagram of SVC.
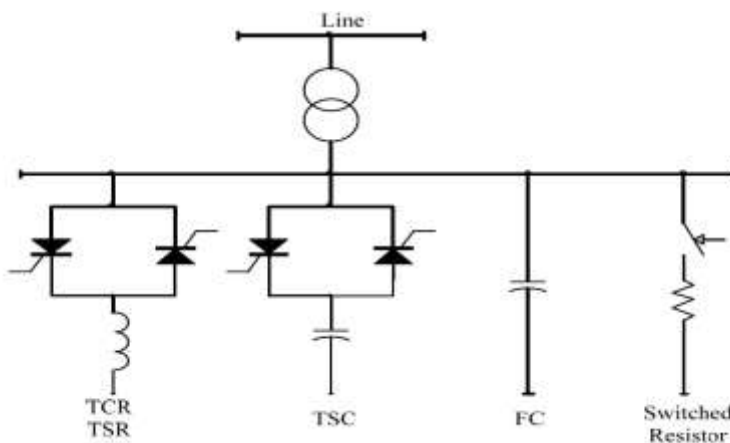

Figure 1: Static VAR Compensators (SVC) TCR/TSR, TSC, FC and Mechanically Switched.

TCR and TSR are both composed of a shunt-connected reactor controlled by two parallel, reverse-connected thyristors. TCR is controlled with proper firing angle input to operate in a continuous manner, while TSR is controlled without firing angle control which results in a step change in reactance. TSC shares similar composition and same operational mode as TSR, but the reactor is replaced by a capacitor. The reactance can only be either fully connected or fully disconnected zero due to the characteristic of capacitor. With different combinations of TCR/TSR, TSC and fixed capacitors, a SVC can meet various requirements to absorb/supply reactive power from/to the transmission line. This section presents the different \building blocks" that are commonly used when designing an SVC. The components are presented individually to describe their influence on the line. We will also briefly discuss some of the problems associated with the components and how these could be handled. This is done to give some insight into how an SVC operates.
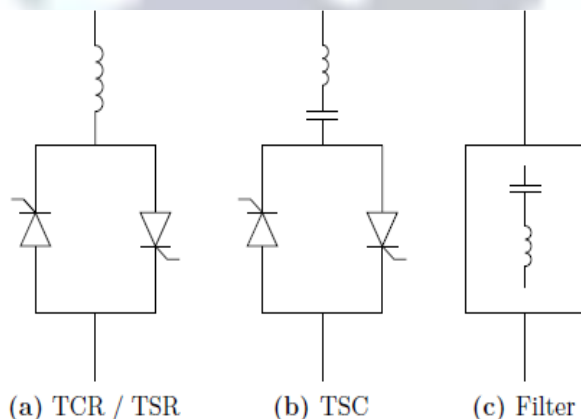The different building blocks presented in this section are illustrated in figure 2.

Figure 2: One-line diagram of the common SVC components.

2.1 Thyristor Controlled Reactor

For the TCR-FC system shown in Figure 2.1, controllable lagging to leading VARs are provided by thyristor control of reactor current only. Leading VARs are supplied by two or more fixed capacitor banks. The TCR is generally rated larger than the total of fixed capacitance to compensate (or cancel) this capacitance and provide net lagging VARs. Given the proportional relationship between harmonic magnitudes and TCR size, the large reactor required in the TCR-FC can be a source of significant odd harmonics. Arranging the TCR and coupling transformer secondary in delta serves to cancel triple harmonics, but the remaining six-pulse harmonics must be filtered. Thus small reactors are usually included in the fixed capacitor branches to tune these ranches as filters to dominant harmonics (e.g., 5th, 7th, and high pass).

When phase-angle control is used, a continuous range of reactive power consumption is obtained. It results, however, in the generation of odd harmonic current achieved with a gating angle of 90°. Partial conduction is obtained with gating angles between 90° and 180°. By increasing the thyristor gating angle, the fundamental component of the current reactor is reduced. This is equivalent to increase the inductance, reducing the reactive power absorbed by the reactor. However, it should be pointed out that the change in the reactor current may only take place at discrete points of time, which means that adjustments cannot be made more frequently than once per half-cycle. Static compensators of the TCR type are characterized by the ability to perform continuous control, maximum delay of one half cycle and practically no transients. The principal disadvantages of this configuration are the generation of low frequency harmonic current components, and higher losses when working in the inductive region.

For a normal steady state operating point of 0 MVAR, 60-Hz current in the TCR is controlled by the thyristor switches to a level sufficient to cancel the leading current drawn by the fixed capacitor. Generally this current is below the reactor rating, and so the thyristors are in partial conduction. Harmonics are thus continually generated and must be filtered, and the continuously circulating current between the TCR and FC gives rise to significant losses in the thyristors and controlled reactor.

2.2 Thyristor Switched Reactor

The thyristor switched reactor (TSR) is a shunt-connected reactor in series with a thyristor valve that is used to switch the reactor ON or OFF. A one line diagram of a TSR is shown in figure 2.1.

Basically, the TSR fulfills the same purpose as the shunt-connected mechanically switched reactor which has been employed in the AC transmission system since its early days. The only difference between these two components is that the former uses a thyristor to switch the reactor in and out of operation, while the latter uses a mechanical switch. Compared to the mechanical switch, the thyristor allows the switching process to be a lot faster. Another advantage is that it will not face the same limitations on wear and tear as a mechanical switch, which is only capable of a finite number of switches. The higher investment cost could possibly be earned by the reduction in service and maintenance costs of the mechanical switches. As the switched reactor is not a common component in SVC installations, only this short description is provided for the sake of completeness. The controllable reactor is a much more useful and common component and this will be described in the following section.

2.3 Thyristor Switched Capacitor

The thyristor switched capacitor (TSC), first introduced by ASEA in 1971, is a shunt connected capacitor that is switched ON or OFF using thyristor valves. Figure 1 shows the one-line diagram of this component. The reactor connected in series with the capacitor is a small inductance used to limit currents. This is done to limit the effects of switching the capacitance at a non-ideal time.

We assume that the TSC in figure 2.1 comprises the capacitance C, the inductance L and that a sinusoidal voltage applied is given by

$$V(t) = V \sin(wt)$$

Where w is the nominal angular frequency of the system. The TSC-TCR compensator shown in Figure 3 generally consists of one thyristor controlled reactor, and n capacitor banks each in series with a solid state switch. The scheme is very similar to a conventional controlled-reactor scheme (with fixed capacitor) except that the rating of the reactor bank is kept relatively small (nearly l/n times the maximum output), and the amount of capacitance is changed in discrete steps so as to keep the operation of the reactor bank within its normal control range. Continuously controllable lagging compensation from the TSC-TCR arrangement can be provided up to the rating of the controlled reactor bank.
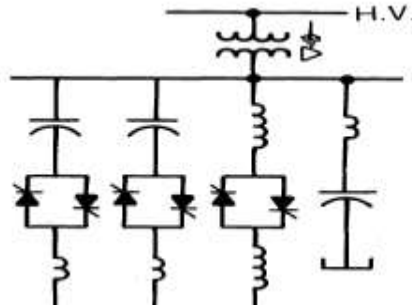
Figure 3: Thyristor switched capacitor

All capacitor banks are switched out, and the reactor bank is controlled in the usual manner. However, when operating in this mode, no harmonic filters are available for attenuating the harmonics generated by conduction angle control of the reactor. This may or may not lead to significant problems. For example, since the rating of the TCR is small (compared to TCR rating in a TCR-FC compensator), harmonics will be reduced and can possibly be neglected, depending on system characteristics and SVC control system harmonic sensitivity. On the other hand, a small amount of "fixed" capacitors, serving as tuned filters, may be required as shown in Figure 3. The TSC-TCR compensator was developed specifically for utility applications with the intention of overcoming two major shortcomings of compensators employing "fixed" capacitors; performance during large system disturbances .and operating losses. Disturbances in the power system are termed large when compensation demands exceed the linear control range of the SVC. Such disturbances are often characterized by rapid voltage change (i.e., high frequency content).

3. RESULT

By increasing and deacreasing in the value of capacitor and inductor value of reactive power also increasing and deceasing alternatively. This shows that reactive power is compensated and hence stability of power system is improved.

4. CONCLUSION

Hence it is concluded that SVC (Static VAR Compensator) will successfully control the performance of power system and will effectively do voltage regulation of the power system. The proposed controller shows better performance and also regulates the active and reactive power along with the voltage stability.

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