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Operation of Thyristor Controlled Reactor and Thyristor Switched Capacitor of Static var Compensator for Voltage Variations

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Abstract
The deviations that occur in electrical power supplied by utilities to consumers are termed as power quality disturbances. Due to power quality disturbances, a change is evident for a short duration in voltage, current or frequency. In order to maintain constant voltage to the connected load, compensation devices are used based on flexible AC transmission systems (FACTS) technology. Based on an increase or decrease in voltage, suitable correction action can be taken by power electronic based devices. The voltage and current variations of static VAR compensator, shunt connected flexible AC transmission system device, is analyzed. The variations in system voltage are due to sag and swell. The operation of thyristor-controlled reactor (TCR) and thyristor switched capacitor (TSC) are analyzed which together comprise static VAR compensator.

1 Introduction

Electric power supplied by utilities must be free of disturbances and supply voltage must be within the range specified. Any violation of these conditions results in erroneous operation of power consuming equipment. In order to minimize the impact of changes in supply voltage, the quality of power supplied must be monitored. In flexible AC transmission systems (FACTS), control is increased and power transfer capability are increased [1,11]. shunt and series connected devices, based on FACTS technology. The main objective of an electrical power system is to meet variations of load requirement with power supplied from generating stations. The capacitive and inductive nature of loads connected results in variations of reactive power. The ratio of active power to the reactive power is termed as power facto. The value of power factor will be affected due to changes in reactive power. Poor power factor results in burden on the power system with increased transmission losses and utilities can levy penalty charges on consumers whose load results in low power factor. So it is necessary to use flexible AC transmission system (FACTS) devices in transmission systems and custom power devices in distribution system for reactive power compensation and voltage control for an increase in transmission and distribution efficiency. Based on requirement, compensation devices have to either absorb or generate reactive power. IEEE has defined FACTS as alternating current transmission systems using power-electronics based and other static controllers to enhance controllability and power transfer capability. The aim of this paper is to study the dynamic response of FACTS based static var compensator for voltage sag and swell. Static var compensator and its operation are explained in section 2, and different relevant waveforms obtained are explained in section 3 and section 4 ends with conclusion.

1. Voltage variations

Sag is a decrease in voltage to between 0.1 per unit (pu) and 0.9 pu for durations from 0.5 cycles to 1 minute [2,10]. Swell is an increase in voltage above 1.1 pu for durations from 0.5 cycle to 1 minute [2,9]. Due to momentary or persistent disturbances in supply voltage, the connected loads in the system can be severely affected. Some of the reasons for the disturbances to occur are load changes, faults, lightning, and switching of loads with reactive components [3,8]. With respect to reference voltage of sag is defined with a decrease in voltage and swell with an increase in voltage as shown in fig.1, In fig.1 sag is initiated from 0.1 to 0.2 seconds and swell is initiated from 0.4 to 0.5 seconds.

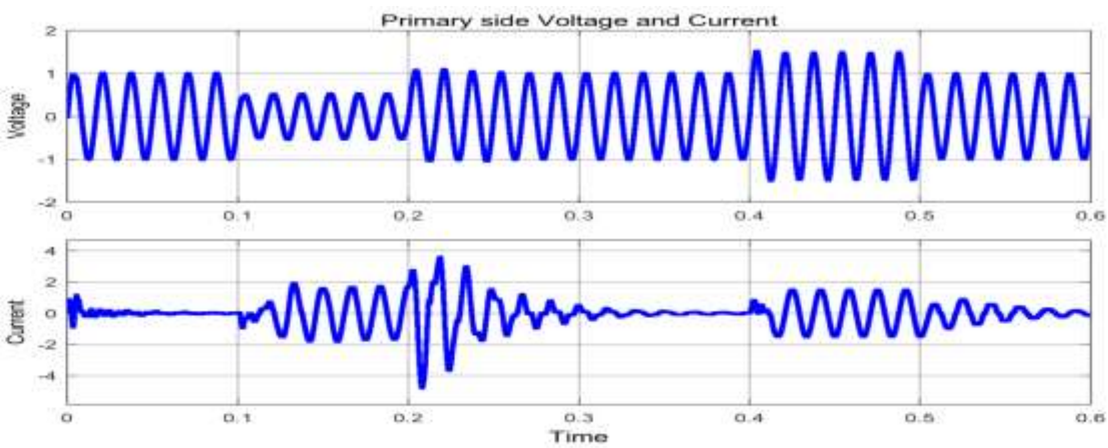

Fig.1 Supply voltage and current with sag and swell.

2 Static var Compensator (SVC)

Static var compensator (SVC) comes under the category of variable impedance type FACTS devices. SVC injects or absorbs reactive power to regulate voltage at a given bus. Fig.2 shows simulation model to obtain different waveforms necessary to analyze operation of SVC. Without and with compensation provided by SVC is explained in [4,12]. In [5,13], optimization techniques are used for SVC operation. The effects of total harmonic distortion (THD) on load profile is considered in [6]. Modeling and simulation of IEEE 14 bus system were carried out in [7]

SVC consists of parallel connection of:

(i) One number of thyristor controlled reactor (TCR).

(ii) Three numbers of thyristor switched capacitors (TSC).

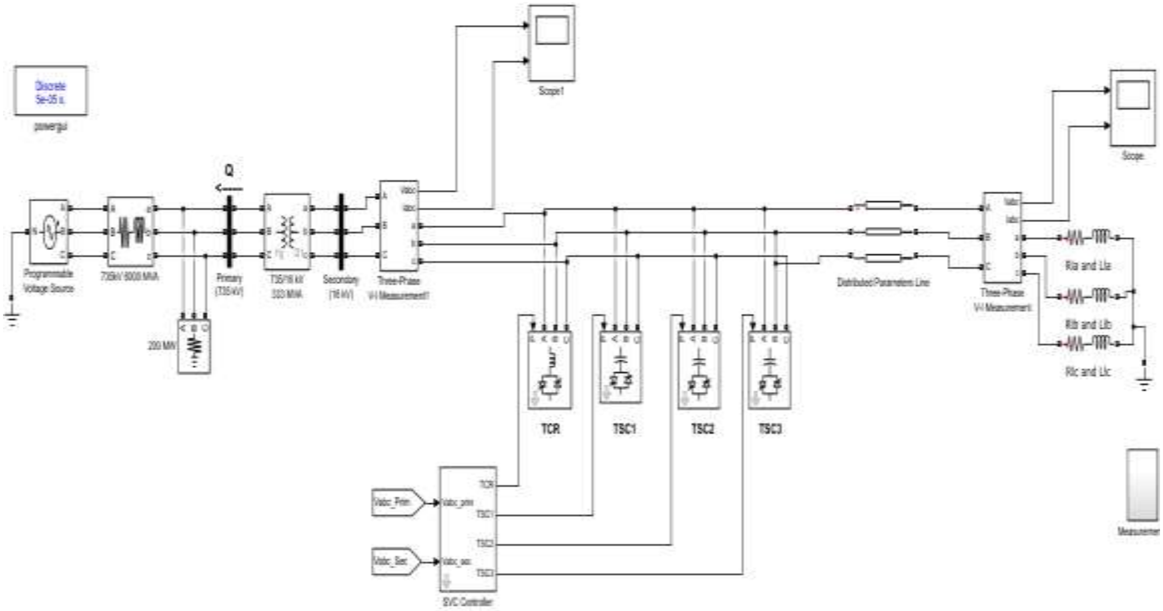

Fig.2 Simulink model to depict the operation of SVC

A transmission line forming a part of power system is considered for analysis with SVC connected across the line. In case of TSC, switch has only ON and OFF possibilities and no control is possible.

3. Different waveforms obtained during SVC operation in MATLAB Simulink environment

Input signals are measured voltage and current for SVC controller. Firing angle-controlled pulses for TCR and on/off pulses for TSCs are obtained as output. Fig.3 shows SVC connection of one TCR and one TSC out of the three TSCs.

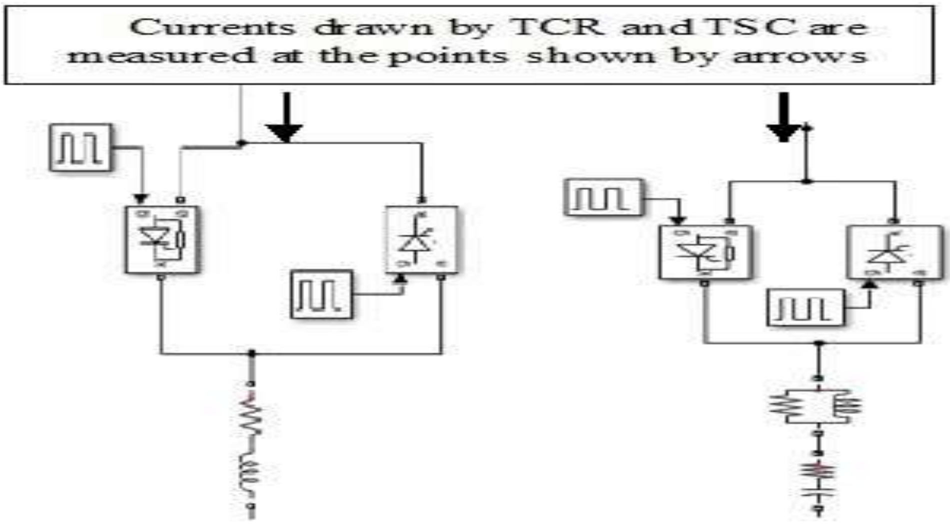

Fig. 3. (a) A portion of TCR bank (b) A portion of one of the three TSC bank

The TSC components or banks which are made on/ off are decided and the delay angle provided by reactor is calculated. TSCs must be switched to boost up voltage during sag and reactive power generation takes place. TCR must be fired into the power system during swell for reactive power absorption. In case of TSC, switch has only ON and OFF possibilities and no control is possible. In case of TCR, impedance can be controlled by varying firing angle of the pulse generators Figures 4, 5 and 6 respectively represent voltage and current of TSC 1, TSC 2, TSC 3, voltage, current of Thyristor 1 and 2 of TSC.

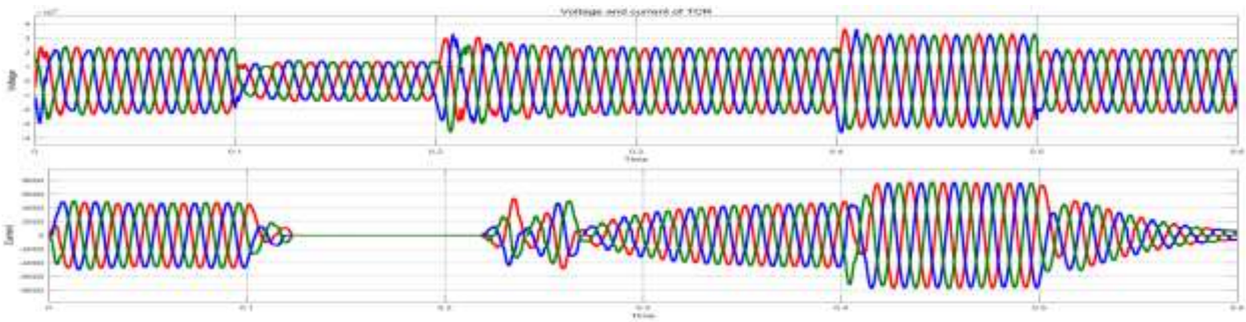

Fig.4 Voltage and current of TCR

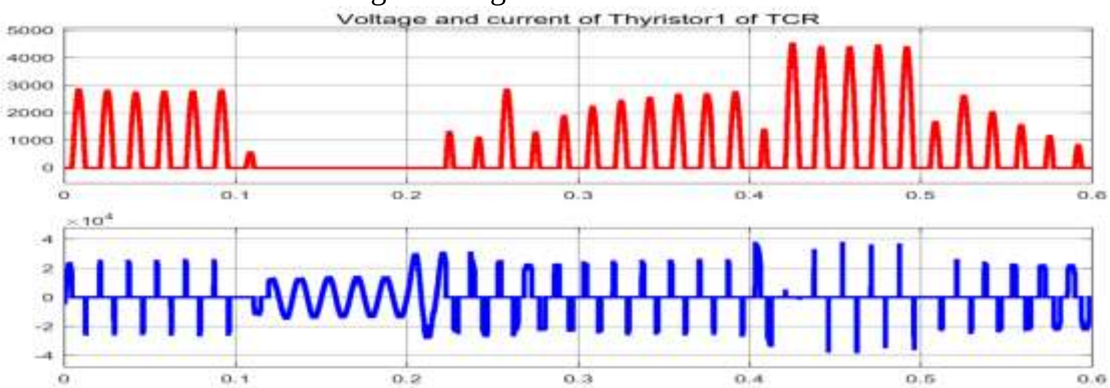

Fig.5 Voltage and current of thyristor 1 of TCR

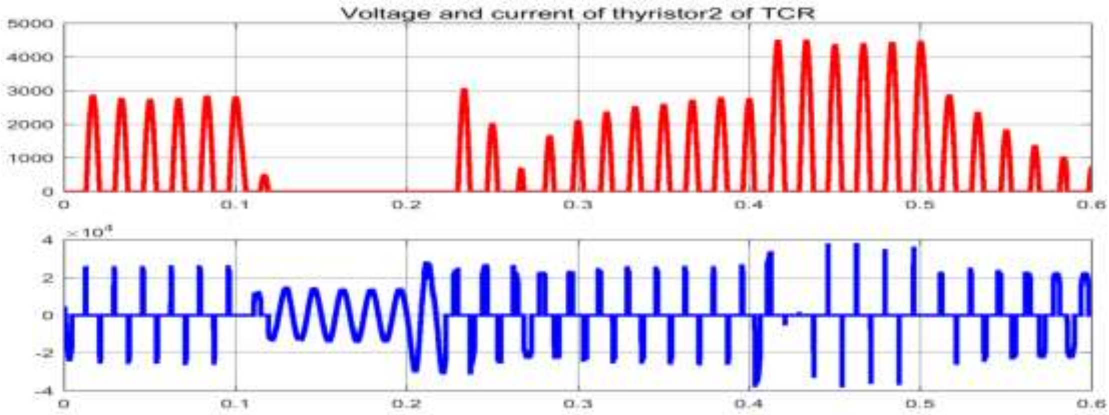

Fig.6 Voltage and current of thyristor 2 of TCR

Figures 7 to 11 respectively represent voltage and current of TCs, voltage, current of Thyristor 1 and 2 of TCR

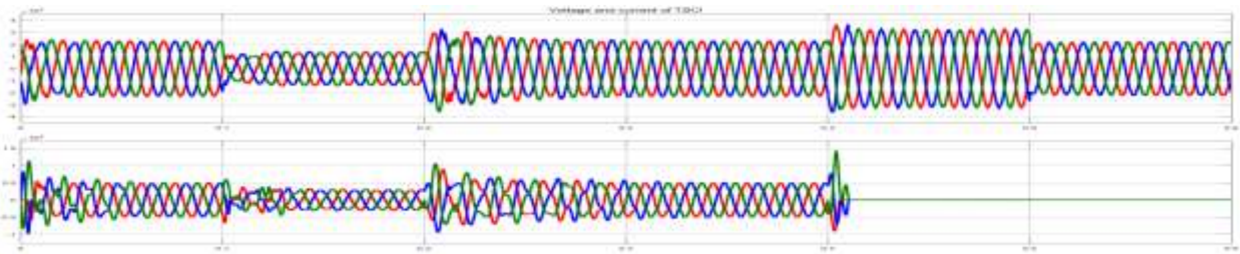

Fig.7 Voltage and current of TSC

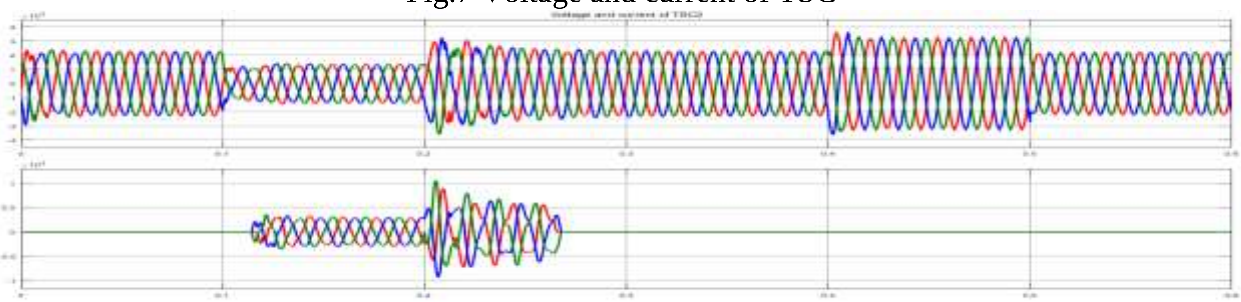

Fig.8 Voltage and current of TSC2

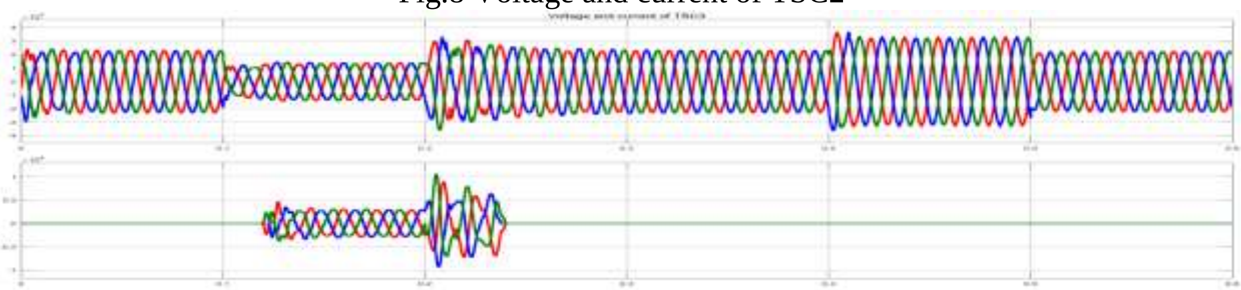

Fig.9 Voltage and current of TSC3

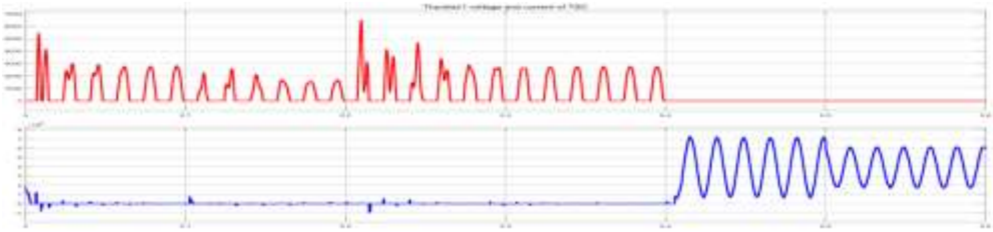

Fig.10 Voltage and current of thyristor 1 of TSC

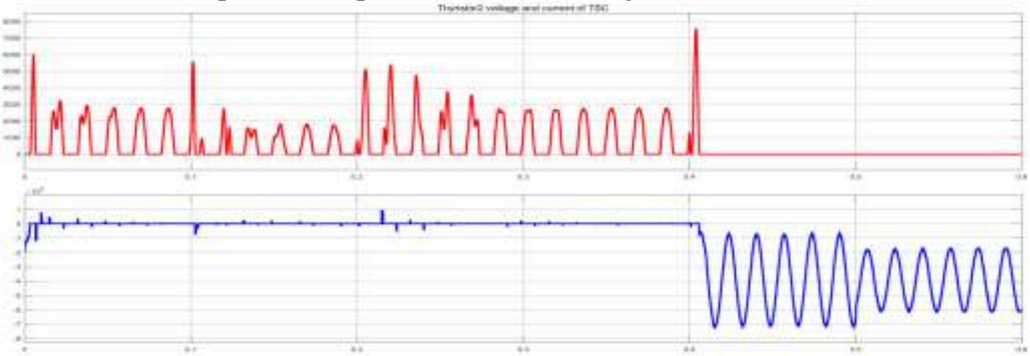

Fig.11 Voltage and current of thyristor 2 of TSC

Due to reduction in voltage due to sag, TSCs must be switched into the power system to boost up the voltage and produce leading reactive power. Due to increase in voltage due to swell, TCR must be fired into the power system to control the voltage and produce lagging reactive power. SVC controller provides suitable control action for reactive power generation and absorption based on variations in supply voltage with respect to reference voltage. All the waveforms above depict the operation of SVC depending upon the variations in voltage.

4 Conclusion

SVC injects reactive power in the line by thyristor switched capacitor. SVC absorbs reactive power from the line by thyristor-controlled reactor. The supply or absorption of reactive power is done to regulate voltage against changes in voltage. As by switching on or off capacitors, capacitive admittance can be directly connected. or disconnected based on reactive power variation. According to the changes in voltage magnitude, necessary action of reactive power absorption or generation is taken by SVC. The voltage and current generated waveforms of TCR and TSC depict the overall voltage and current injected by SVC for voltage variations.

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