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Modelling and Simulation of TSR for Compensation of Reactive Power in Transmission Line

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***Abstract*: -- For the development and improvement of dynamic performance of the modern power system, Flexible AC Transmission Systems (FACTS) devices have been used since the 1970s. FACTS devices use power electronic components to improve system performance. It is also necessary to operate power system with minimum loss in the transmission line. Flexible AC Transmission System (FACTS) devices play an important role in controlling power and enhancing the usable capacity of existing lines. FACTS devices use power electronic component to enhance controllability and increase power transfer capability. This paper present, modelling and simulation of Thyristor Switched Reactor (TSR)-Based Static VAR Compensator (SVC), which is one of Flexible AC Transmission Systems (FACTS) controllers. The effects of TSR-Based SVC on load bus voltage are simulated in MATLAB environment. The results show that significant improvement in reactive power compensation and bus voltage regulation could be achieved by using the TSR-based SVC. TSR Simulink model consist of three units single phase units which are connected in delta connection.**

***Keywords*—Static VAR Compensator (SVC); Modelling of TSR**

I. INTRODUCTION

Static VAR systems are applied by utilities in transmission applications for several purposes. The primary purpose is usually rapid control of voltage at weak points in a network. Installations may be the midpoint of transmission interconnections or in load areas. Worldwide, there is a steady increase in the number of installations. CIGRE defines a static VAR system (SVS) as a combination of a static var compensator (SVC) and mechanically switched capacitors and reactors, all under coordinated control. Most of this paper pertains to the modelling of static VAR compensators.[1] At the present, with the increasing demand for the electrical energy and rapidly growing number of new production technologies, the voltage quality requirements are becoming stricter. In order to evaluate the level of the power quality, which stipulates the limits for voltage quality [2].The concept of VAR compensation embraces an extensive and diversified field of both system and customer problems, especially related with power quality issues, since most of power quality problems can be minimized or solved with a sufficient control of reactive power. Generally, the problem of reactive power compensation is observed from two aspects, load compensation and voltage support. In the loading point of view, compensation the objectives are to increase the value of the system power factor, to balance the real power drawn from the AC supply, compensate voltage regulation and to eliminate harmonics produced by fluctuating non-linear industrial loads. The voltage support is generally required to reduce voltage fluctuation at a given terminal of a transmission line.[4] Many papers can be found on FACTS devices. FACTS devices can be found in texts with topics such as simulation and modelling, optimal placement, controller design, comparative characteristics, power system performance improving. Fig.1 provides a general classification of FACTS device. The FACTS controller is classified as mechanical switches, voltage source converter and hybrid devices. There are three main types of thyristor based FACTS controller: SVC, TCSC and TCPS. These devices control the transmission impedance, the line voltage and transmission angle respectively in order to regulate power transmission. [3].

II. STATIC VAR COMPENSATOR (SVC)

In Extra High Voltage (EHV) and Ultra High Voltage (UHV) transmission practice, when the voltage at a bus falls below the reference value, capacitive VARs are to be injective. When the bus voltage becomes higher than the reference value, inductive VARs are supplied to lower the bus voltage. In conventional methods of shunt compensation, shunt inductors are connected during low loads and shunt capacitors are connected during heavy loads and such switching operations are very slow because of the greater time required for the operation of the circuit breakers.

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Moreover, circuit breakers are not suitable for frequent switching during voltage variations. These limitations have emit gated by Static VAR Systems (SVS). In a static VAR system, thyristor are used as switching devices instead of circuit breakers. The thyristor switching is faster than mechanical switching and also it is possible to have transient free operation by controlling the instant switching. The advantage of high-speed, high-current switching has made possible by thyristors which has introduced a new concept in providing reactive compensation for optimum EHV/UHV system performance. The static VAR compensators' (SVC) use combinations of shunt reactor and shunt capacitor with thyristors of high voltage and current rating for obtaining fast and accurate control of reactive power flow. The static VAR compensation (SVC) is also known as static VAR System (SVS). [4]

The main advantage of SVCs over simple mechanically switched compensation schemes is their near instantaneous response to change in the system voltage. For this reason they are often operated at close to their zero-point in order to maximize the reactive power correction. They are in general cheaper, higher capacity, faster, and more reliable than dynamic compensation schemes[5].

III. MODELLING OF TSR

Before we can focus on the simulation study we need to address how to properly represent the SVC in computer simulations. Models must be determined for both static and dynamic power system simulations. In this section we will present both general models and how the SVC can be represented in MATLAB. A few assumptions have been made that should be kept in mind when considering the models presented in the succeeding sections. These assumptions are stated as follows:

i. The devices are considered lossless.
ii. Harmonics are being neglected, only the fundamental component is considered.
iii. Balanced operation is assumed, i.e. only the positive sequence component is considered.[5]

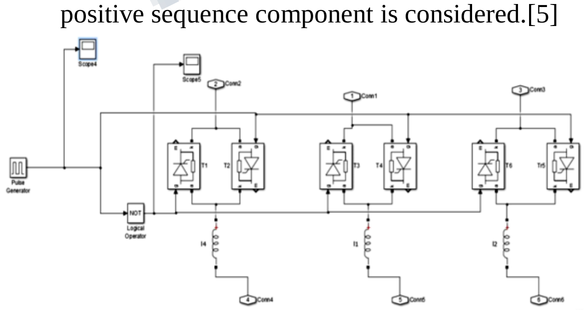

Fig.1 Thyristor Switched Reactor.

Fig.1 represents three phase unit represents modelling of TSR it means three units of single phase TSR are connected in delta connection. In each unit of TSR two Thyristors are connected in anti parallel connection in series of inductor. Thyristors are fired by giving Pulse to the each gate terminal of the SCR. A six-pulse generator has been used to fire six thyristors of the TSR. The output voltage (V) and output current (I) waveforms of the TSR model are seen on the Scope. The pulse generator output is seen on the scope.

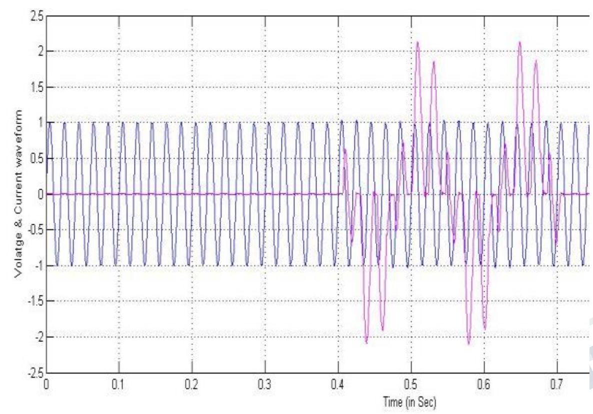

Fig.2 Output Waveform of Voltage and Current Waveform

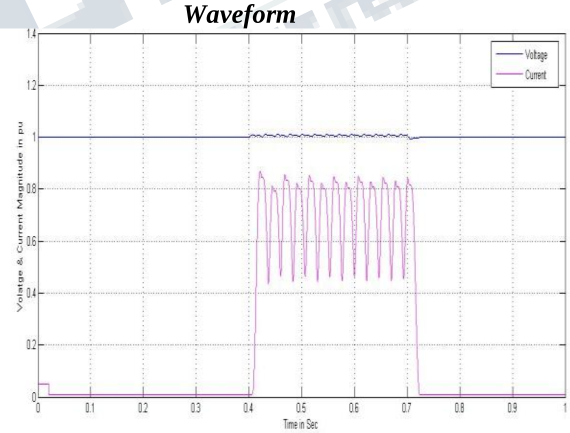

Fig.3 Output of Per unit Voltage and Current

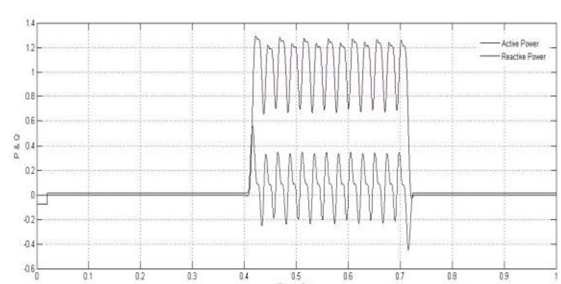

Fig. 4 Output of Active & Reactive (P&Q) Power

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Fig.2 represents output waveform of voltage and current of the system when system is compensated condition. The per unit voltage and current are seen in fig.3. Fig.4 represents the output of active and reactive power simulink model on the scope.

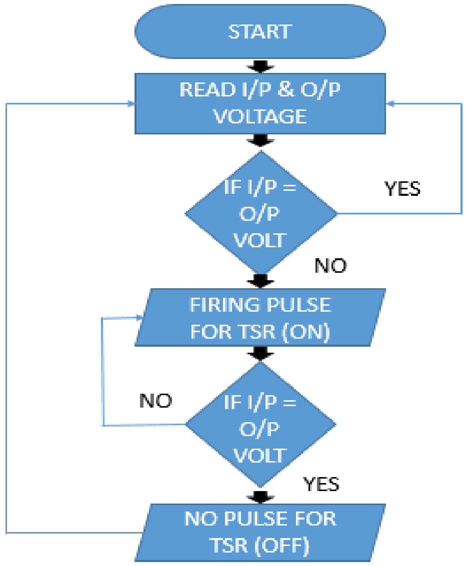

Fig.5 Flowchart of the Simulink Model

Fig.5 represents flowchart is the basic working of the simulink model. First it reads the input and output voltage magnitude of the system. Then after comparing these values if there is any error signal produced then the TSR is switched on till the output voltage becomes equal to input voltage. It continuously checks for this condition and when it happens then TSR is switched off.

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