Research Paper Engineering

Optimum Location of Static Var Compensator (Svc) in over Head Transmission Lines

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ABSTRACT

– This paper illustrates of the load has a significant effect in the electrical power systems. The effect of different static load models on the optimal location of Static VAR Compensator (SVC). The static load types, in which active and reactive powers vary with voltage as an exponential form, are used. The effect of appropriate location of the SVC on voltage control for variable load conditions is designed. For this purpose each load is varied as a stair-case and voltages are controlled at the desired levels by using minimum number of Static VAR Compensators (SVC). Modeling and simulation of the system are performed using MATLAB SIM Power Systems Block sets. PI controllers are used to control SVC firing angles. The studied power system is a simple five-bus system.

SVC is modeled as a fixed shunt capacitor and connected to different load buses in a five bus system to show the effect of different location of this device on system voltage profile for different static load types. Six static load types in which active and reactive powers vary with the voltage as an exponential form are used to show the effect of voltage dependent load models on voltage profile and location of the SVC in power systems. In case our study, each load is modeled as a stair-case dynamic load (SCDLM), in which active and reactive powers are varied at a chosen time around the base value with desired step size and realized by simultaneous switching of static loads. To keep the bus voltages at the desired level and to show the capability of the SVC on voltage control, the load voltages are controlled by using SVC controller. From the simulation results, it is obtained that bus voltages for different load models have approximately the same variation with the different location of the SVC for different static load models and the optimal location of the SVC doesn't depend on the load models.

Keywords : SVC, Load models, location of SVCs, voltage control

I. INTRODUCTION

Most of the world electric power systems are widely interconnected to reduce cost of the electricity and to improve the reliability of power supply. It is ideal to locate the generators at load centers. Because of economical and environmental reasons, the generating stations are usually located at remote locations. The interconnection of generating stations and utilities improve the reliability with minimum generation resources. If the transmission capability is less, then more generation would be required to serve the same load with same reliability. Hence the cost of electricity would be higher.

The power system is a complex network consisting of synchronous generations, transmission lines, loads, etc. As the power system grows it becomes more complex to operate the system and can become less secure for riding through the major outages. The power that can be transmitted over a line depends on series reactance of the line, bus voltages and transmission angled. The voltage profile along the line can be controlled by reactive shunt compensation. The series line inductive reactance can be controlled by series capacitive compensation. The transmission angle can be varied by phase shifting transformer. Generally the reactive power compensation and phase angle control are applied by fixed or mechanically switched capacitor, reactors and tap changing transformers to improve the power transmission. The recovery from dynamic disturbances was accomplished by generous stability margins at the price of relatively poor system compensation. Speeds of operation of mechanically controlled systems are lower compared to systems using static devices. The mechanical devices wear out quickly hence cannot be operated frequently.

FACTS technology opens up new opportunities for controlling power and enhances the usable capacity of the present transmission system for transmission planners. The opportunities arise through the ability of FACTS controllers to control the inter – related parameters that govern the operation of transmission systems including series impedance, shunt, impedance, current, phase angle and damping of oscillations at various frequencies below the rated frequency. These constraints cannot be overcome otherwise, while maintaining the required system stability, by mechanical means without lowering the useable transmission capacity. By providing added flexibility, FACTS controllers can enable a line to carry power close to its thermal rating. Mechanical switching needs to be supplemented by rapid power electronic devices.

The FACTS controllers by its function and types are shown in table

Name	Type	Main Function	Controller Used	Comment
SVC (static var compensator)	Shunt	Voltage control	Thyristor	Variable impedance device
STATCON (static condenser)	Shunt	Voltage control	GTO,IGBT or MCT	Variable voltage source
TCSC (Thyristor controlled series compensator)	Series	Power flow control	Thyristor	Variable impedance device

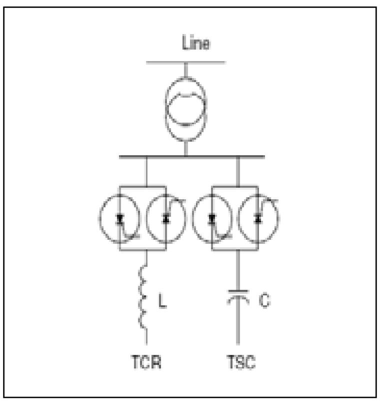
TCPAR (Thyristor controlled phase angle regulator)	Series and shunt	Power flow control	Thyristor	Phase control using series (quadrature) voltage injection
SSSC (static synchronous series compensator)	Series	Power flow control	GTO,IGBT or MCT	Variable voltage source
UPFC (Unified power flow controller)	Shunt and series	Voltage and power flow control	GTO,IGBT or MCT	Variable voltage source
IPFC (Interline power flow controller)	Series and series	Power flow controller	GTO,IGBT or MCT	Variable voltage source

TABLE 1: FACTS controllers by its function and type

II. STATIC VAR COMPENSATOR (SVC)

It is a shunt connected static VAR generator or absorber as shown whose output is adjusted to exchange capacitive or inductive current so as to maintain or control specific parameters of the electrical system (typically bus voltage). SVC is based on thyristors without gate turn off capability. They are also employed for transient and dynamic stability improvement. The controllable parameter of the SVC is Impedance.

Fig.1. Block diagram of static VAR compensators



It has a single port with a parallel connection to the power system. The thyristors are naturally commutated. They switch at the main (low) frequency; it contains insignificant energy storage elements; the SVC has no DC port as shown in Fig.1.

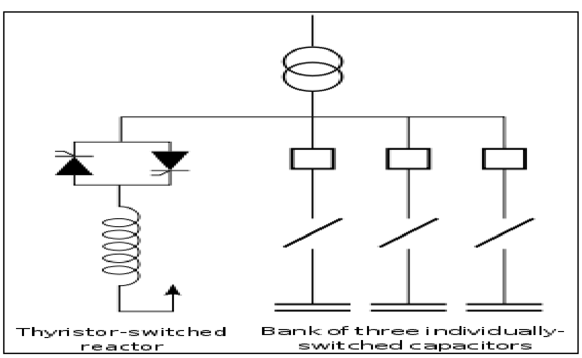


Fig.2. Description of SVC

Typically, a SVC comprises a bank of individually switched capacitors in conjunction with a Thyristor-controlled air- or iron-core reactor. By means of phase angle modulation switched by the thyristors, the reactor may be variably switched into the circuit, and so provide a continuously variable MVAR injection (or absorption) to the electrical network. In this configuration, coarse voltage control is provided by the capacitors; the Thyristor-controlled reactor is to provide smooth control. Smoother control and more flexibility can be provided with Thyristor-controlled capacitor switching.

III. SVC USING A TCR AND TSC

This compensator overcomes two major shortcomings of the earlier compensators by reducing losses under operating conditions and better performance under large system disturbances.

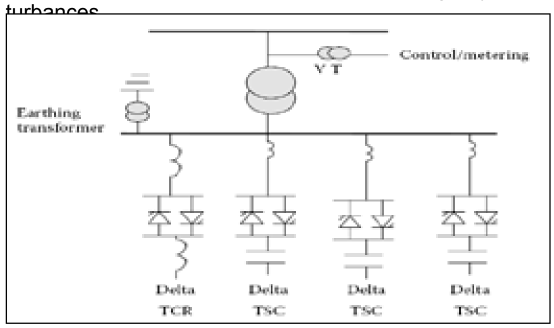


Fig.3. SVC using a TCR and TSC

In view of the smaller rating of each capacitor bank, the rating of the reactor bank will be 1/n times the maximum output of the SVC, thus reducing the harmonics generated by the reactor. In those situations where harmonics have to be reduced further, a small amount of FCs tuned as filters may be connected in parallel with the TCR.

IV. SVC OF COMBINED TSC AND TCR TYPE

In the TSC–TCR scheme, due to the flexibility of rapid switching of capacitor banks without appreciable disturbance to the power system, oscillations can be avoided, and hence the transients in the system can also be avoided. The capital cost of this SVC is higher than that of the earlier one due to the increased number of capacitor switches and increased control complexity.

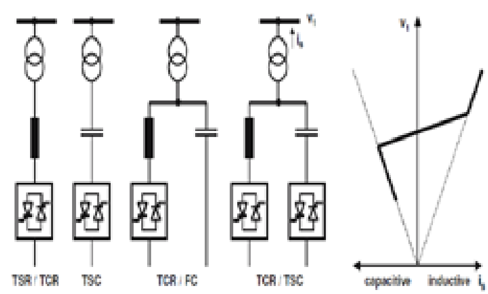


Fig.4. SVC of combined TSC and TCR type and voltage/ current characteristics

V. SVC USING A TCR AND AN FC

In this arrangement, two or more FC (fixed capacitor) banks are connected to a TCR (Thyristor controlled reactor) through a step-down transformer. The rating of the reactor is chosen larger than the rating of the capacitor by an amount to provide the maximum lagging VARS that have to be absorbed from the system.

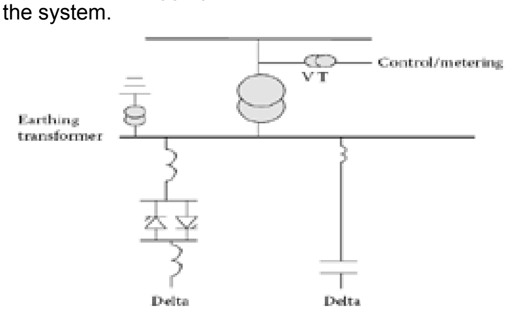


Fig.5. SVC USING A TCR AND AN FC

SVC of the FC/TCR type:
The main disadvantage of this configuration is the significant harmonics that will be generated because of the partial conduction of the large reactor under normal sinusoidal steady-state operating condition when the SVC is absorbing zero MVAR. These harmonics are filtered in the following manner. Triplex harmonics are canceled by arranging the TCR and the secondary windings of the step-down transformer in delta connection. The capacitor banks with the help of series reactors are tuned to filter fifth, seventh, and other higher-order harmonics as a high-pass filter. Further losses are high due to the circulating current between the reactor and capacitor banks.

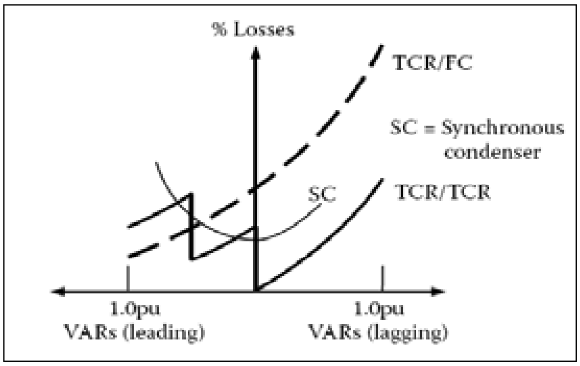


Fig.6. Comparison of the loss characteristics of TSC–TCR, TCR–FC

VI. SIMULATION RESULTS

SIMULINK CIRCUIT MODEL-I

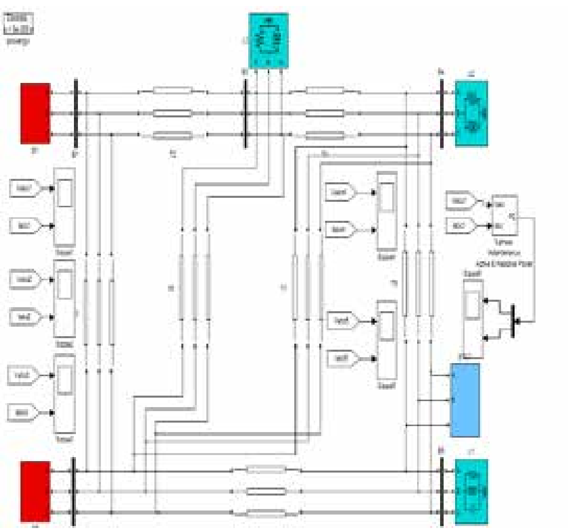
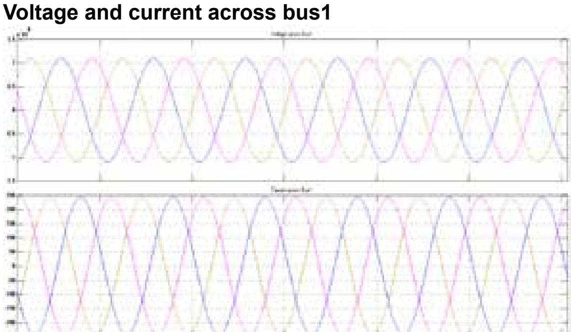
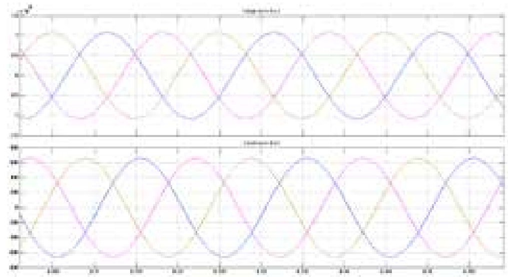


Fig.7. Five bus MODEL-1

Voltage and current across bus1

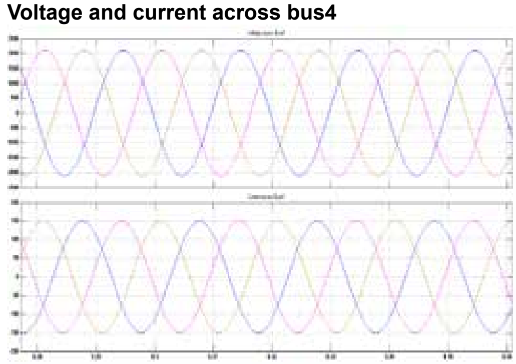


Voltage and current across bus2

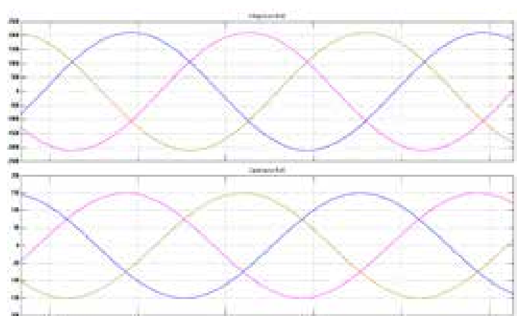


Voltage and current across bus3

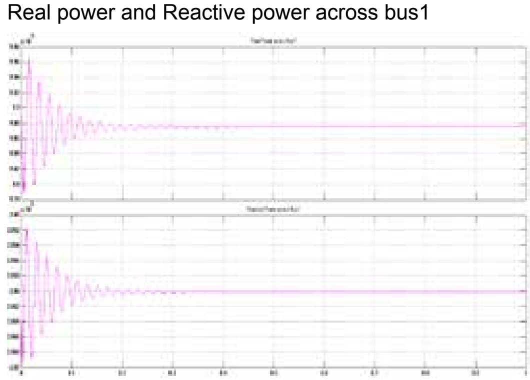
Voltage and current across bus4



Voltage and current across bus5



Real power and Reactive power across bus1



SIMULINK CIRCUIT MODEL-II

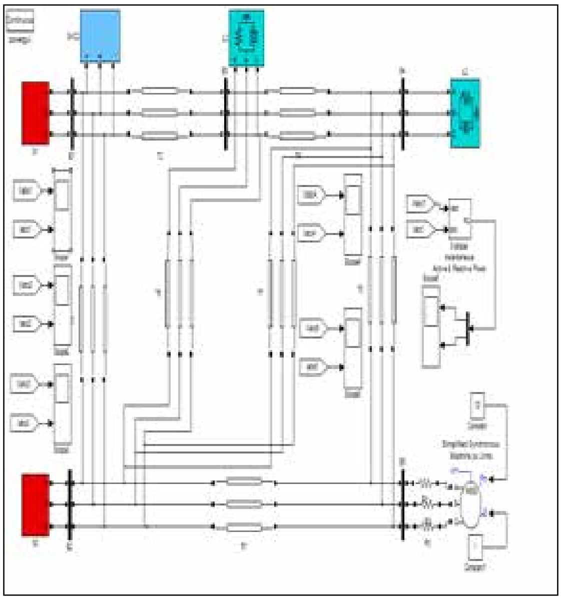
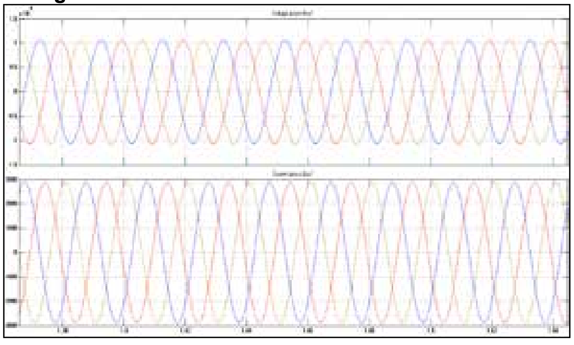
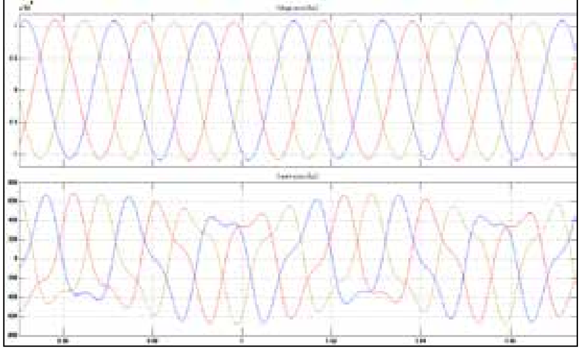


Fig.8. Five bus MODEL-2

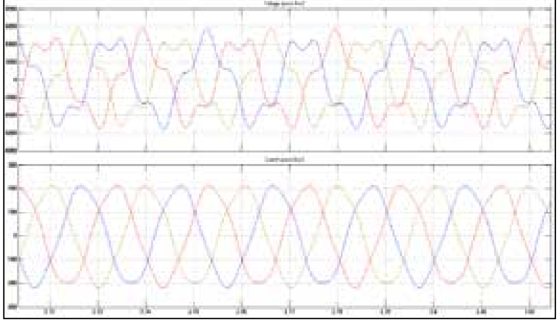
Voltage and current across bus1



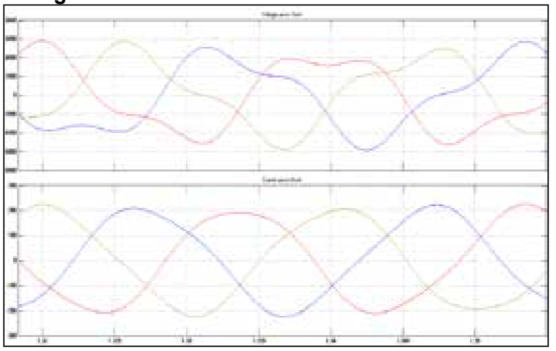
Voltage and current across bus2



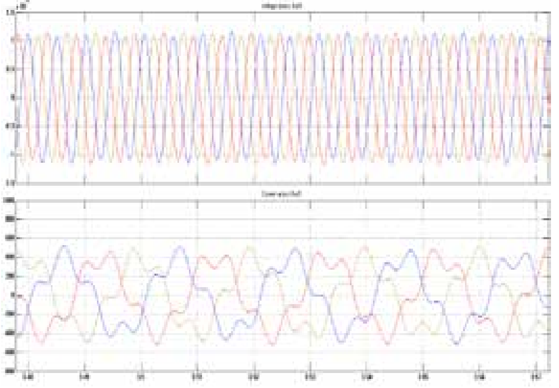
Voltage and current across bus3



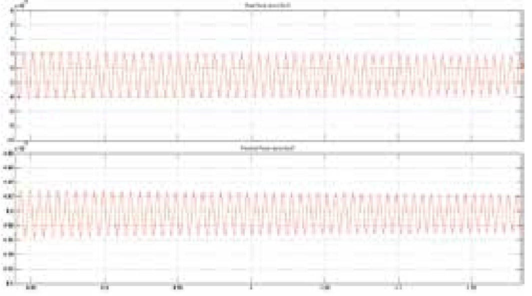
Voltage and current across bus4



Voltage and current across bus5



Real power and Reactive power across bus1



SIMULINK MODEL CIRCUIT-III

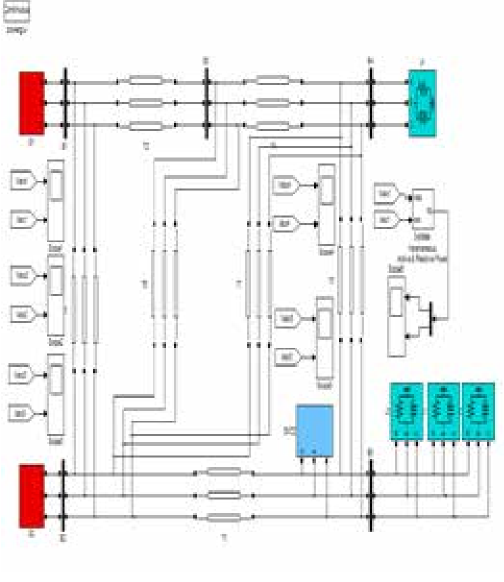
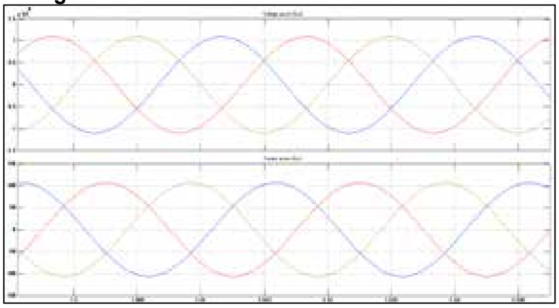
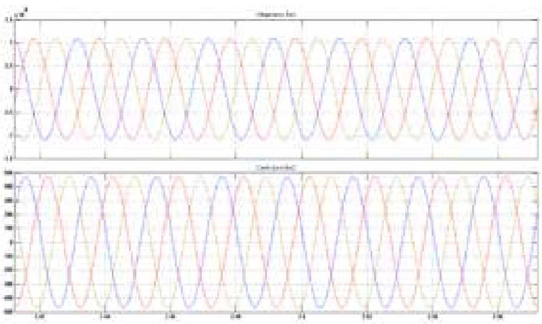


Fig.9. Five bus MODEL-3

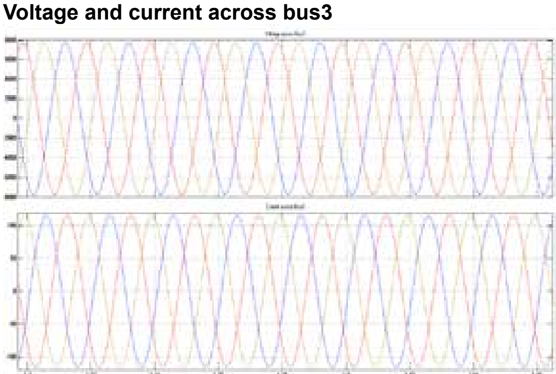
Voltage and current across bus1



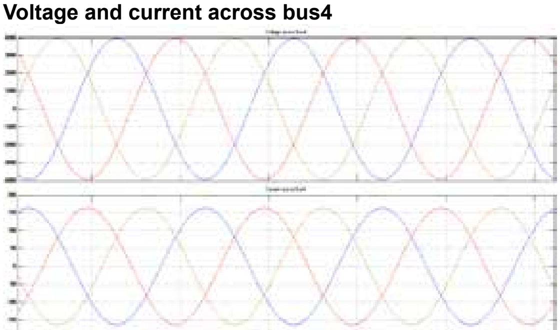
Voltage and current across bus2



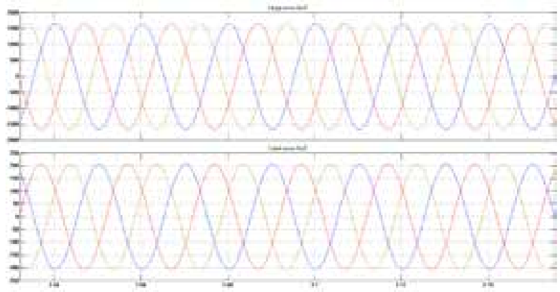
Voltage and current across bus3



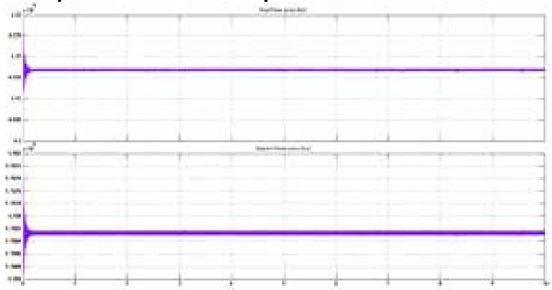
Voltage and current across bus4



Voltage and current across bus5



Real power and Reactive power across bus1



VII. CONCLUSION

This Paper concludes that the location of SVC at different places to maintain power quality and power factor as unity. Commercially the FACTS controllers are used to control the voltages in power systems and maintain the power angle as nearer to zero so that utility of power is more or less equal to sending power.

The area of voltage stability and control for power systems has yielded an extensive and diverse array of analytical contributions. It is now well-accepted that the basic problem is under influence of static and dynamic aspects of system equipments. The voltage stability and control are dynamic phenomenon. Accordingly, these lead to dynamic modeling and formulation of the system. Consequently one of the most important issue states itself as the modeling requirement, and adequacy of the various system components.

The SVCs are generally used as load balancing and power factor correcting devices by adjusting the suspectance in each phase by controlling the conducting angles of the TCR. SVC is basically a shunt connected static VAR generator/load whose output is adjusted to exchange capacitive or inductive current. So the SVC maintains or controls the specific power system variables typically, the controlled variable is the bus voltage.

The paper focuses on location of SVC at three different places which are nearer to the load, nearer to the generating station and between the transmission lines and it gives the best location of SVC with good voltage regulation by connecting the filters in the feeder. By choosing the SVC at nearer to load side is the best reduction of losses, maintain good voltage regulation and power factor without any recovery of time for compensating the voltage levels.

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