TSR-Based SVC for A Three-Phase System With Static Loads

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ABSTRACT: The Flexible Alternating Current Transmission System (FACTS) is a modern technology focused on power electronics, offers an opportunity to improve the controllability, reliability, and power transfer capability of the ac transmission systems. FACTS are alternating current transmission systems that integrate electronic and other static controllers to improve controllability and enhance power transfer capability. In this paper, the effect of the thyristor switched reactor-based Static VAR Compensator (SVC), which is one of the Flexible AC Transmission Systems (FACTS) controllers, on load voltages was proposed for static load conditions in the three-phase network. Use MATLAB / Simulink 7.04 per cent and Power Systems Toolbox, the design and testing of TSR-based SVC is checked. The results show that major improvements could be made with the use of the TSR-based SVC on reactive power compensation and bus voltage control. Furthermore, harmonic rates produced by TSR-based SVC do not lead to instability in the test device.

KEYWORDS: Flexible AC Transmission Systems, Thyristor Switched Reactors, SVC, Compensation, Voltage Regulation, MATLAB.

INTRODUCTION

The electricity supply industry is undergoing a profound global transformation. Some of the factors responsible for this drastic shift are global forces, scarcer natural resources, and ever-increasing demand for electricity. Against this backdrop of rapid development, many utilities' expansion programs are being thwarted by a variety of well-founded, environmentally sustainable, land-use and regulatory constraints that prohibit the licensing and construction of new transmission lines and power plants [1].

The transmission system's ability to transmit power is hampered by one or more of the following steady state constraints: (a) angular stability, (b) voltage magnitude, (c) thermal limits, (d) transient stability, and (e) dynamic stability. These limits describe the permissible transmittable electrical power without causing harm to transmission lines and electrical equipment. In theory, constraints on power distribution can also be eased by installing additional transmission lines and facilities for generating electricity. Alternatively, Flexible alternating current transmission system (FACTS) [2] controllers may allow the same goals to be achieved without significant power system configuration alterations. FACTS are alternating current transmission systems that integrate electronic and other static controllers to increase controllability and enhance power transfer capability. The FACTS definition is based on the extensive integration of electronic power tools and methods into the high-voltage side of the network, to make it controllable electronically. The aim of the FACTS controllers is to increase the control of power flows on the high voltage side of the network under both stable and transient conditions [3].

FACTS gained the sponsorship of electrical equipment manufacturers, utilities, and research organizations around the world due to the many economic and technological advantages it offered. That curiosity has led to significant FACTS controller technical advances. There are many types of FACTS controllers installed in various parts of the world. The most famous are: load tap changers, phase-angle regulators, static VAR compensators, thyristor-controlled series compensators, interphase power controllers, static compensators and unified power flow controls.

Static VAR Compensator has been commonly used in power systems. Set shunt condenser IFC and Thyristor Operated Reactor (TCR) are the basic structures of a Static VAR Compensator (SVC). In addition, the SVC is tested in the configurations TSC (Thyristor Switched Capacitor) [4]- TCR, MSC (Mechanically Switched Capacitor)-TCR and TSC- TSR [5].

In this paper, at static load conditions, the effect of the thyristor-converted reactor-based SVC to load voltage was investigated in the three-phase method. Using the MATLAB / Simulink 7.04 RO and Power Systems Toolbox the design and testing of TSR-based SVC is checked. Results of the simulation show that TSR-based SVC located at Load Bus provides the reactive power of static load around its base value to maintain the load voltage at the appropriate level. This device does not insert harmonic voltage components and harmonic elements of currents into the grid. Therefore, a harmonic filter is not required for the test system with TSR-based SVC and that is a great advantage of the unit.

PRINCIPLES OF THYRISTOR SWITCHED REACTOR

Thyristor Switched Reactors are shunt compensator capable of absorbing reactive energy. The TSRs have the following characteristics: its basic operating theory, delay of half a cycle and no harmonic generation. The Line. 1 Shows an analogous TSR circuit. Following on from Pg. 1, The TSR is composed of two anti-parallel thyristors and a rotating reactor.

The basic TSR elements are connected in delta within the 3-phase applications. TSR's control technique is only usable in two states: either entirely on or off.

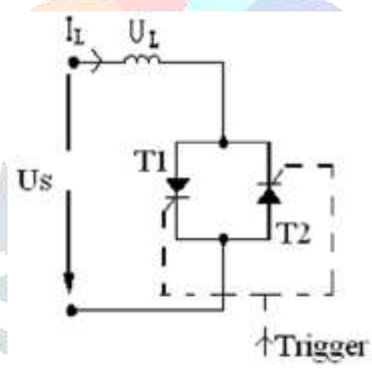

Fig. 1: Main Strucure of TSR

TSR-Based Static VAR Compensator

The most general structures of a Static VAR Compensator (SVC) are fixed shunt condenser (FC) and thyristor controlled reactor (TCR), as described above. Because of low cost, filters are typically used to absorb harmonics produced by the SVC structure and large industrial loads.

In this paper, it was agreed to use a TSR instead of a TCR, in order to abstain from harmonic generation. In addition, both voltage stability and stepwise bus voltage control were given with the option of TSR. The Line. 2 Displays an analogous TSR- Based SVC circuit. According to Fig. 2, The TSR-based SVC consists of a single TSR and a fixed condenser (FC) [6].

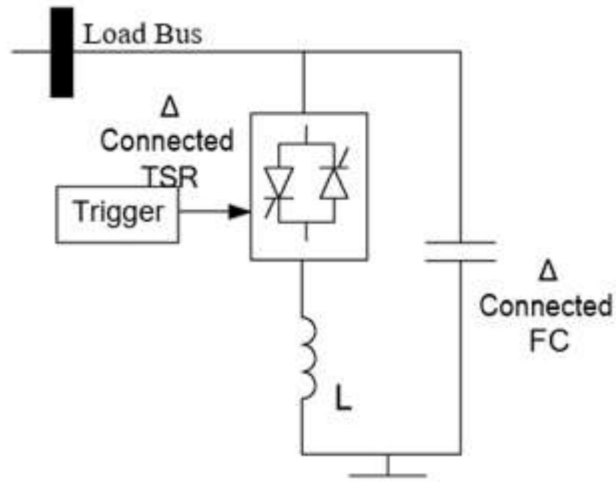

Fig. 2. TSR-Based SVC Configuration

The SVC is acquired for both reactive and capacitive period of operation. In this paper, thyristors in TSR structure are fired at the source voltage's positive / negative max, or at line current's zero crossing. Therefore harmonic generation in the energy system has been stopped.

Modeling of TSR-Based SVC and Power System in MATLAB

MATLAB / Simulink 7.04OR and Power Systems Toolbox a schematic diagram of a single phase TSR-based SVC 1S shown in Fig. was used to model the TSR-based SVC. 3. A three-phase TSR-based SVC configuration is composed of three single-phase TSRs and a fixed condenser linked to the delta. It is connected to the Load bus in parallel. Six TSR thyristors were fired via a six-pulse generator [7].

For this analysis, the effect of the TSR-based SVC on voltage control is seen using a three-phase, two-bus network with a 360 km transmission line modeled as a z-equivalent circuit. Popular device parameters in this study are 380 k+ LL network voltage, and 50 Hz network frequency. For three separate static load conditions, the Bus I AC Source 380 k Transmission Line 360 Fixed TSR Block simulations were carried out. Firstly, the parameters of static loads, transmission line and source are shown in Table 1 [8].

Static loads have been analyzed separately in this paper. The main link between the Bus 1 and Bus 2 is 380 kV. Bus 2 is chosen as charging vehicle. Resistive and inductive parts of the static charge occur as active power from 148-207-360 MW and 198-277-478 MVAr as reactive power, respectively. This analogous circuit is often used to demonstrate the effect of the dynamic load model on the TSR-based SVC, in which the static load model is replaced with the dynamic load model [9].

Source voltage	380-390 kVrms (LL)
System frequency	50 Hz
Line R	6.5 D
Line L	145 mH
Transmission line length	380 km
Static load-1-2-3 P	148-207-360 MW
Static load-1-2-3 Q	198-277-478 MVAr
Dynamic load P	300 MW
Dynamic load Q	225 MVAr

Table.1: Loads And System Parameters

Depending on the power relationship to the voltage, the characteristic of the dynamic charge model can be divided into constant power, constant current and constant impedance load. Within Matlab, the active and reactive power that is consumed by the static charge is proportional to the square of the voltage applied.

RESULT

Voltage Regulation for Static Load

For this analysis, the output of the TSR-based SVC device on voltage control for the static charge is seen using a two-bus system. Table I provides the device parameters and the static load. A six-pulse generator is used to control the TSR's firing angle in compensator configuration. Second, there is consideration of the system without the thyristor switched reactor-based SVC. For this case study, Table II displays the simulation results obtained and gives the load voltage as rms, (ALL (kV)); the load current as rms value, (Iload)) (/total active load power as load); (total load reactive power as Qload (Ar) and power factor as Cos o.

From Table II it is clearly shown that rising static load consumes an active power of 136.45 MW, 180.78 MW, 272.3 MW and a reactive power of 175.80 MVAr, 240.03 MVAr, 357 MVAr at a lagging factor of approximately 0.6. Required active and reactive power of the static load is far from the nominal values provided in Table I. Therefore it would be desirable to correct the power factor to improve the quality of the power. Illustration. 6 It shows differences in the second charge level voltage and the source voltage. It is clearly seen that the 365 kV charge voltage, which is 0.921 pu for a 380 kV base, is less than the static charge model source voltage. The reactive power compensation for the voltage control should be certainly made.

Vt,,d(kVpp)	Vp,, .t	359.45
	Vppaa-z	365.25
	Vp,, .	328.44
It,, (kA)	Ipt	0.36
	Ir z	0.48
	Ip	0.79
'••" I)	P p,, .t	136.45
	roaa-z	180.78
	P p,, .	272.3
Qt,,d (MVAK)	Q.,, t	175.80
	Q maa-z	240.03
	Q q	357
COST	Cos ip1	0.598
	Cos ip2	0.598
	Cos ip3	0.600

Table 2: Simulation Results For The System Without Tsr-Based Svc

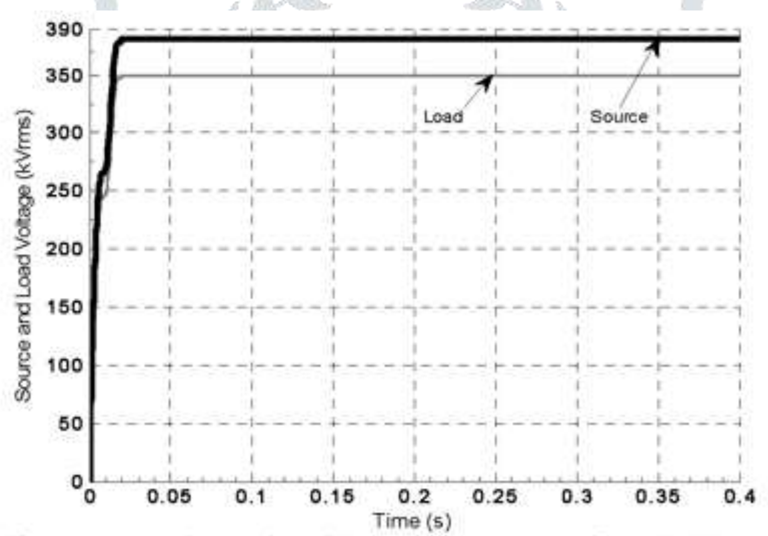

Fig. 3 Source And Second Load Voltage- System Without TSR- Based SVC

The effect of TSR-based SVC on the reactive power compensation will be discussed here. The rated TSR power is 309 MVAr, the FC provides 476 MVAr, 544 MVAr and 816 MVAr, respectively, for each static charge. The test device simulation results with TSR-based SVC are given in Table III. As indicated in Table III, the load voltage is very similar to the source nominal value. For a 380 kV base the load voltage is increased from 0.921 pu to 0.985 pu using TSR-based SVC. The calculated active power of the static charge is therefore very similar to the nominal value of the static load. Using TSR- Based SVC, the reactive power compensation is made perfectly. Based SVC. Thus power factor (Cos o) is significantly closed to 1 and installation of TSR-based SVC is caused to increase the power factor. Illustration. 4 Shows the source voltage and the TSR-based SVC load voltage, as shown in Fig. 4, The TSR-based SVC located at bus 2 provides adequate reactive power to maintain the load voltage at an appropriate level for the static load around its base value. Yet as seen in Fig from the first periods. 4, As reactors turn to circuit, a voltage overload occurred. The condition is because of the configuration of the reactor. Here this voltage overflow will increase if TCR used instead of TSR.

V_{load} (kV_{LL})	V_{Load-1}	377.34
	V_{Load-2}	374.36
	V_{Load-3}	378.66
It,, (kA)	$I_{line\ 1.1}$	0.23
	Ippe rz	0.42
	It,,	0.59
Pt,, (MW)	P p,, .t	149.64
	P ppaa-z	205.1
	P p,, .	359.83
Qt,,d (MVAK)	Q p,, t	28.99
	Q roaa-z	45.14
	Q p,,	33.54
COS tJt	Cos ip1	0.94
	Cos ip2	0.94
	Cos ip3	0.93

Table 3: Simulation Results For The System With TSR-Based SVC

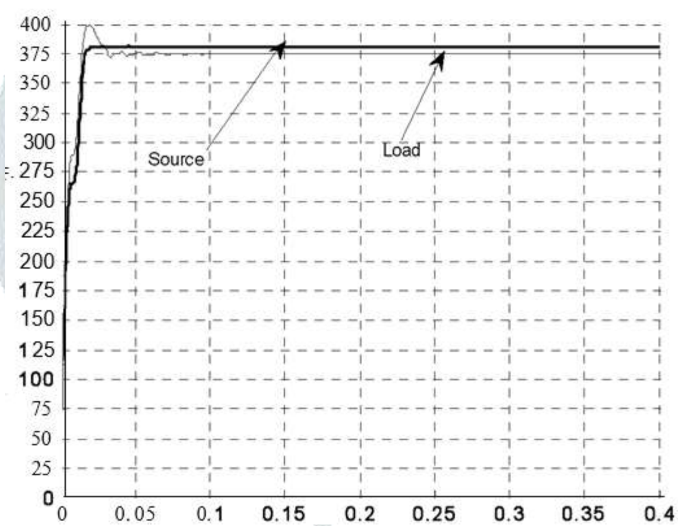

Fig. 4: Source and Load Voltage For The System With TSR-Based SVC

CONCLUSION

The voltage stability and stable state stability have been the most important subjects of power systems of recent years. One solution of these problems is the reimbursement for reactive capacity. For the reactive power compensation and voltage control, switching ON or OFF of a TSR-based SVC bank is suggested here. This FACTS device generates less harmonics and thus utilities that tend to install it in power systems. The effect of the TSR-based SVC on load voltage is discussed in this paper. TSR-based SVC modeling and simulation was verified using the Matlab7.04 RR SimPowerSystems Blockset. The power system under review was a two-bus system with static charges. Results of the simulation showed that installing TSR-based SVC in the device is caused to increase the power factor and voltage profile for both static charges. At each load level in the test device, TSR-based SVC provides rapid voltage control at week stages. A harmonic filter is not required for testing system with TSR-based SVC, and this is a great advantage of TSR-based SVC.

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