Simulation and modeling of grid connected TSC/TSR system using MATLAB

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Abstract: **-** This paper deals with literature collection on power quality improvement using TSC / TSR system. In the drawback of TSC is that it gives stepped variation of reactive power . A TSR is added to obtain smooth reactive power in 3 – bus system with TSR / TCR is modeled using the elements of MATLAB simulink various papers are collected and its decided to work study the power quality improvement using TSC /TCR

Key-Words: **-** Power Quality, MATLAB / Simulink /Flexcible *AC Transmission Systems (FACTS), Thyristor Switched Reactor (* ***TSC)*** ***and*** *Thyristor Controlled Reactor (TCR),etc.,*

INTRODUCTION:

The increasing Industrialization, urbanization of lifestyle has lead to increasing dependency on the electrical energy. This has resulted into rapid growth of PSs. This rapid growth has resulted into few uncertainties. Power disruptions and individual power outages are one of the major problems and affect the economy of any country. In contrast to the rapid changes in technologies and the power required by these technologies, transmission systems are being pushed to operate closer to their stability limits and at the same time reaching their thermal limits due to the fact that the delivery of power have been increasing. The major problems faced by power industries in establishing the match between supply and demand are:

- Transmission & Distribution; supply the electric demand without exceeding the thermal limit.
- In large PS, stability problems causing power disruptions and blackouts leading to huge losses.

Controlled reactive compensation in electric power system is usually achieved with the following configuration corridors: thyristor controlled reactor(TCR), fixed capacitor (FC), thyristor switched capacitor/reactor (TSC/TSR) and mechanical switched capacitor/reactor SVC.In this paper, we are discussing TCR/TSR SVC combination and its control system. The output of the compensator is controlled in steps by sequentially switching of TCRs and TSCs. By stepwise switching of reactors rather than continuous control, the need for harmonics filtering as part of the compensator scheme is eliminated.

1. MATERIALS AND METHODS

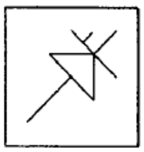
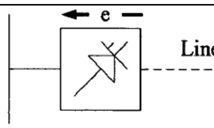
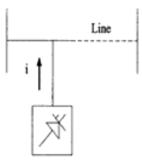
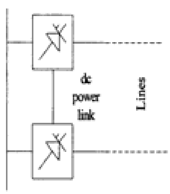
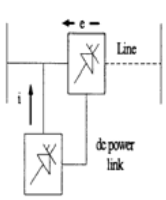
Past work deals with the simulation of TCR system using PSCAD / EMTP. The literature (Miller, 1982) to (Haung , *et al*., 2001) does not deal with the simulation of TSR-TCR system. An attempt is made in the present work to simulate TSR-TCR system using MATLAB Simulink.

2. FACTS Categories and Their Functions

FACTS Categories:

In general, FACTS devices can be divided into four categories on basis of their connection diagram in PSs mentioned in table 1:

TABLE 1: BASIC TYPE OF FACTS CONTROLLERS

SL.NO	SYMBOL	DESCRIPTION
1.		General symbol for FACTS controller.
2		Known as series FACTS controller such as TCSC. The controllers inject voltage in quadrature with the line current The controllers supply /absorb variable RP
3		Known as shunt FACTS controller such as SVC, STATCOM. The controllers inject capacitive or inductive current in quadrature with the line voltage The controllers supply/absorb variable RP
4		Known as combined series-series FACTS controller such as IPFC It is a combination of separate series controllers Provide independent series RP compensation for each line Transfer AP among the lines via the dc power link
5		Known as combined series-shunt controller such as UPFC etc. It is a combination of separate series and shunt controllers Provide series and shunt RP compensation Transfer AP between the series and shunt controllers via the dc power link

***2.1 Series Connected -FACTS Devices*:**

Series FACTS devices could be variable impedance, such as capacitor, reactor, etc., or power electronics based variable source of main frequency, sub synchronous and harmonic requencies (or a combination) to serve the desired need. In principle, all series FACTS devices inject voltage in series with the transmission line.

***2.2 Shunt Connected -FACTS Devices*:**

Shunt FACTS devices may be variable impedance, variable source, or a combination of these. They inject current into the system at the point of connection.

3. TSR-TCR System:

The TSR-TCR system is modified by introducing TCRs. The TSR system gives stepped variation of current and TCR gives smooth variation of current. Thus the range of control of reactive power can be increased by using TSR. The TSR system consists of three reactors and three IGBT's. Three different amplitudes of currents can be obtained by using three switches. The TSR-TCR system is best suitable for dynamic loads.

4. LITERATURE SURVEY :

Mahesh Singh [1], he identified the prominent concerns in the area and thereby to recommend
measures that can enhance the quality of the power, keeping in mind their economic viability and technical repercussions. In this paper electromagnetic transient studies are presented for the following two custom power controllers: the distribution static compensator (D-STATCOM), and the dynamic voltage restorer (DVR). Comprehensive results are presented to assess the performance of each device as a potential custom power solution.

Charles. S [2], he proposed a three of the three-phase shunt active filtering algorithms in time domain have been compared for a non-linear load. The non-linear load chosen here is a soft-start for a three-phase induction motor. The comparison of the simulation results show the effectiveness of both the algorithms although the time domain current detection modified algorithm is more complex in terms of its implementation aspects.

N. Karpagam[3], he proposed a fuzzy logic based supplementary controller for Static VAR
Compensator (SVC) is developed which is used for damping the rotor angle oscillations and to
improve the transient stability of the power system. Generator speed and the electrical power are chosen as input signals for the Fuzzy Logic Controller (FLC).
S. Abaz S.Abazariari[4], he presents the application of a rule- based control scheme for an Advanced Static VAR Compensator (ASVC) to improve power system transient stability. The
proposed method uses a current reference, based on the Transient Energy Function (TEF)
approach. The proposed scheme provides, also, a continuous control of the reactive power owe.

Mark Ndubuka N. [5], he investigates of the effects of Static Var Compensator (SVC) on
voltage stability of a power system. The functional structure for SVC built with a Thyristor
Controlled Reactor (TCR) and its model are described. The model is based on representing the controller as variable impedance that changes with the firing angle of the TCR. A Power System Computer Aided Design Electromagnetic Transients including DC (PSCAD/EMTDC) is used to carry out simulations of the system under study and detailed results are shown to access the performance of SVC on the voltage stability of the system.

4. MOTIVATION

Mitigation of power quality problems is synonymous with reduction of harmonic currents or voltage distortion at ac mains. These problems can also be mitigated by improving the immunity of the equipment using better quality material along with proper protection arrangements, but it may not result in an effective and economical solution.

5. OBJECTIVE

Study different method already proposed for mitigation of harmonics due to non linear load. Design, modelling and simulation of thyristor controlled reactor (TCR) and thyristor switched capacitor (TSC) for reactive power and harmonics compensation.

6. Theory of TSR-based SVC and TCR-based SVC:

The most general structure of a static var compensator consists of a fixed shunt capacitor and a thyristor controlled reactor. A SVC is basically a shunt connected static var enerator/customer whose output is adjusted to exchange capacitive or inductive current so as to maintain or control specific power system variables. In this paper, the TCR-based SVC prototype consists of one TCR, which contains two thyristors in antiparallel and a reactor to be controlled, and one fixed capacitor (FC). Filters are traditionally used to absorb the harmonics generated by the SVC structure and large industrial loads. A three-phase SVC is comprised of three single-phase SVC's connected in a delta configuration. The delta connection of the SVC's prevents harmonics from passing through the transmission lines. Furthermore, to prevent the generation of harmonics., a TSR was employed instead of a TCR . TSRs are shunt compensators that can absorb reactive power and have the properties of delaying one half cycle with no generation of harmonics . Figure 1 demonstrates an equivalent circuit of the TSR-based SVC. According to Figure 1, the TSR-based SVC consists of one TSR, which contains two thyristors in anti-parallel and a reactor to be switched, and one fixed capacitor (FC). In three-phase applications, the basic TSR-based SVC elements are connected in a delta configuration.

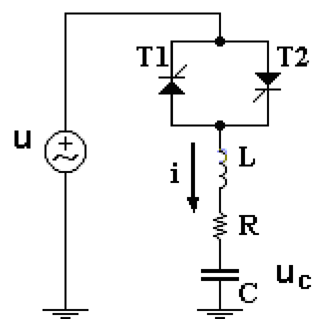


Fig. 1. Main structure of TSC

The SVC has reactive and capacitive operation intervals. In this paper, the thyristors in the structure of the TSR are fired at the positive/negative peak of the source voltage or at the zero crossing of the line current,thereby preventing harmonic generation in power systems. Table 1 shows the performance comparison of TSR and TCR.

Table 2. The performance comparison of TSR and TCR.

The compensator	Positive Characteristics	Negative Characteristics
TSC	No harmonic generation, Fast recovery time, Switched structure, Simple operating principle, In the 3-phase applications, it is connected in delta. It is used for compensation, regulation and damping of oscillations in power systems.	It is not able to prevent over voltage. It can be in interaction with system at low fequencies. Its performance is variable
TCR	Fast response time,Controlled structure, The control range is wide, In the 3-phase applications, it is connected in delta. It is used for compensation, regulation and damping of oscillations in power systems.	It generates harmonics. Its performance is variable. Operating principle is not simple.

7 . A three-bus system with TSR-based SVC

In this study, an application of a three-bus system with TSR-based SVC is presented to show the effect ofTSR-based SVC on voltage regulation. A one-line diagram of the studied system is given in Figure 2. In thisstudy, the three-bus system consists of 120 km, 360 km and 360 km length transmission lines, which are modeled as a π -equivalent circuit. The 120 km transmission line has a line resistance of 4.3 Ω and a line inductance of 100 mH. The static load absorbs active power of 540 W and reactive power of 145 Var and two sources of 440 V have been used in this system. The three-phase TSR-based SVC prototype consists of three single phase.

TSR-based SVC's connected in a delta configuration and connected in parallel to the load bus. A six-pulse generator is used to control the firing angles of the TSR for three-phase applications. Table 2 shows parameters of the transmission line and the source for this system.

Table 3. The system parameters.

Source voltage	440 V
Network frequency	50 Hz
Line 1,2 R	6.5 Ω
Line 1,2 L	145 Mh
Line 1,2 C	1 *Mf*
Line model	π equivalent circuit
Line 1 and Line 2 length	360 km
Line 3 length	120 km
Line 3 R	4.3 Ω
Line 3 L	100 Mh

First, the uncompensated system is considered. the practical system in the laboratory environment. The devices used in the experiment are an AC power supply (#1) , a PC (#2), a breaker (#3), transmission line 1 (#4), transmission line 2 (#5), transmission line 3 (#6), a six-pulsegenerator and thyristors (#7), a TSR-based SVC (#8), an ohmic-inductive load (#9), a 0-30 V DC powersupply for obtaining the firing pulse (#10), and an energy analyzer (#11).
Here, the effect of TSR-based SVC will be examined for reactive power compensation.
variations of three-phase load voltages in a test period of 2 minutes for the 3-bus system. For the first minute,the uncompensated system is considered and the measured load voltage of 373 V is less than the nominal voltage for the static load. After this period, the TSR-based SVC prototype is install 3ed in the system and the loadvoltage of 378 V is recorded for one minute. The load voltage becomes very close to the nominal value after installing the TSR-based SVC prototype. The inductive power of TSR-based SVC is 309 Var and its capacitivepower is 408 Var.

CONCLUSION

The variation of reactive power using tapped inductor TSR /TCR is analysed. The variation of reactive power with the variation in the firing angle is studied. The range of reactive power control can be increased by using the combination of thyristor controlled reactor and fixed capacitor system . The circuit model for TSR /TCR is obtained and the same is used for simulation using Matlab Simulink. From the simulation studies, it is observed that reactive power variation is smoother by using TSR / TCR system. The simulation results are almost similar to the theoretical results.

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