

Reactive Power Control by Using Thyristor Switched Capacitor (TSC) and Thyristor Controlled Reactor (TCR) in FACTS

Krushna C. Taktode¹, Ganesh S. Rojatkar², Bhagwan T. Raut³, Madhavi H. Nerkar⁴

^{1, 2, 3}Electrical Engineering Department, SavitribaiPhule Pune University, India

⁴Assistant Professor, PDVVP COE, Ahmednagar, Electrical Engineering Department, SavitribaiPhule Pune University, India

Abstract: Nowadays, reactive power control has been playing a vital role in a systematic study of maintaining a secure voltage limit in the transmission system. When large inductive loads are connected in the transmission line then the matter of poor power factor is faced because of lagging load current. Sometimes, due to a small load, very low current flows through transmission line causing in a leading shunt capacitance in transmission line result increase in voltage to the receiving end voltage may become twice of the sending end voltage (Ferranti effect), in a long transmission line. To minimize these issues we are using a parallel combination of thyristor switched capacitor (TSC) and thyristor controlled reactor (TCR). The microcontroller/Arduino is used to vary the firing angle of thyristor then we get smooth current control range from capacitive to inductive value. This paper shows the study of FACTS devices (TSC-TCR) which are used to control reactive power in electrical power system to improve the power quality as well as enhance the power transfer capability.

Keywords: TSC-Thyristor Switched Capacitor, TCR- Thyristor Controlled Reactor, FACTS- Flexible AC Transmission System

1. Introduction

FACTS: Flexible Alternating Current Transmission system is an integrated or collective system used for the purpose of better control, enhance power transfer, better reliability and faster operation of the power system network. It is a collective name given to the application of power electronics for power flow and other quantities control for enhanced operating condition hence it does not one but many controlling schemes will come which are trying to control one or more ac transmission parameter.

IEEE has given the definition of FACTS as “A power electronics based system and other static equipment that provide control of one or more ac transmission system parameters to enhance controllability and increase power transfer capability”. For reactive power control, damping system oscillation, controlling the phase angle, controlling the power flow, voltage control, voltage regulation and voltage stability in the transmission line, various type of FACTS devices are used. In day to day life increases population and growth in small and large scale industries they have used lots of inductive loads and reactive power flow in the system and voltage profile and power quality decompose so reactive power play a very important role in electrical power systems and it must be recompense for systematic and economical working of all our equipment. To increase the power the transmission capacity of the transmission line, we modify the electrical characteristics of the transmission line is called compensation.

For compensation, many FACTS devices are developed i.e. series and shunt. Thyristor controlled reactor (TCR) and which are reactive power either absorbed and generate respectively.

1.1 Thyristor Switched Capacitor (TSC)

Fig. 01 shows Thyristor Switched Capacitor. A fixed capacitor whose switching is controlled by a thyristor. Generally, during abnormal condition a small reactor acting as surge current limiter. With the system impedance, these reactors can also help in avoiding resonance.

When the voltage across thyristor is zero (minimum) switching of the capacitor takes place and hence these condition is like a capacitor either connected or disconnected from the line. Hence to take care of current variation multiple parallel branches (banks) of TSC are employed. TSC also produce harmonics and may need a tuned filter.

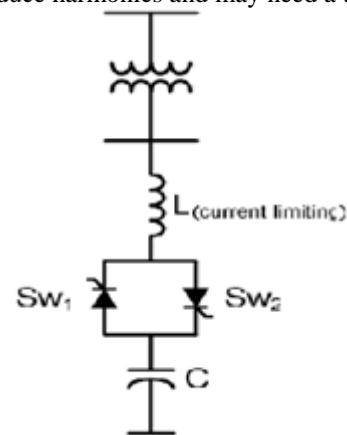


Figure 1: Thyristor Switched Capacitor (TSC)

1.2 Thyristor Controlled Reactor

Fig. 02 shows TCR type of static compensation it has fixed reactor and the conduction of current through the reactor is controlled by the delay angle of an antiparallel thyristor.

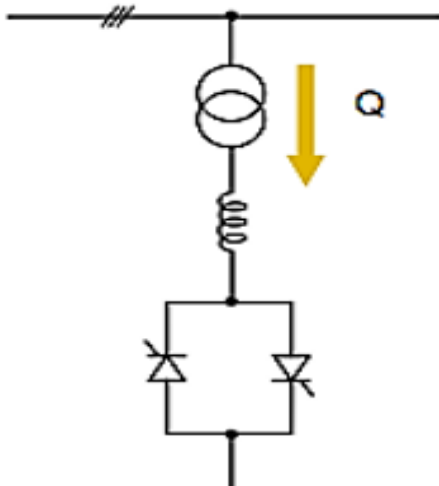


Figure 2: Thyristor Controlled Reactor (TCR)

It is possible to control the current from the maximum value to zero value. The TCR bank can be used through sequential control for higher power application. Such type of SVC's harmonic frequencies and hence tuned filter required.

1.3 TSC-TCR

As shown in Fig. 03 instead of using one single device here we are using a combination of TSC-TCR for better reactive power compensation. Bank of TSC and single TCR are connected in parallel. The size of TCR is small, therefore a reduction in harmonic generation. A condition in which all TCSs and the respective filters are switched off, an additional no switchable capacitive-filter branch is provided.

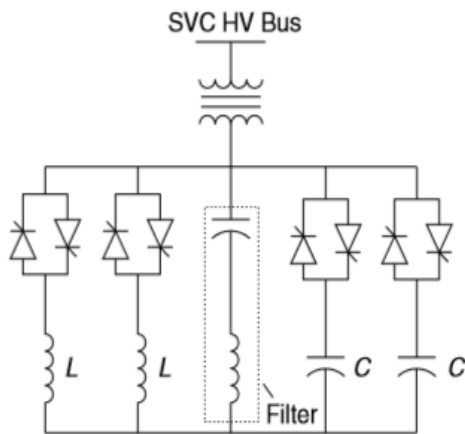


Figure 03: TSC-TCR

2. Literature Review

Nowadays the power system has become very complex consisting of several power plants, transmission system distribution system and loads of different types. We can achieve operational and economic efficiency of such a system by using flexible ac transmission.

A Flexible AC Transmission System (FACTS) is a system composed of static equipment used for the ac transmission of electrical energy. It is meant to change controllability and increase power transfer capability of the network. It is normally a system which is based on power electronics. Increase in power production and it's transmission and

distribution as reflected itself in a higher level of complexity.

3. Problem Faced and Solution

Electrical distribution system suffers from different problems like reactive power burden, unbalance loading, voltage regulation, and harmonic distortion.

This project purpose at achieving FACTS by using TSC. The FACT device has many advantages over the mechanical switch operated capacitor in the aspect of faster control, improve system performance and system voltage stability.

4. Block Diagram

Below Fig. 04 represent the basic layout of components to be used in our project for compensation of reactive power. An Arduino controller, 8051 and PIC controller are used to control the operation of TSC-TCR type SVC. In our project model, we are using Arduino UNO as the main controller for the whole system. To minimize the reactive power flow from source is the main purpose of our project and with the help of proper triggering of thyristor values in TCR and by switching of TSC, we can minimize the reactive power flow. The 230 volt supply is step down by using a transformer to 5 volt DC because Arduino UNO is the main controller and it required the supply of 5 volts.

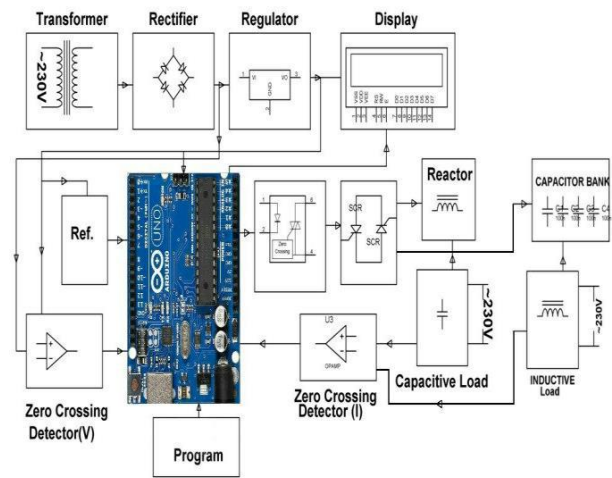


Figure 4: BlockDiagram

By using bridge circuit a step-down transformer voltage can be converted 5 volt DC The block of Zero Crossing Detector (ZCD) circuit uses an optocoupler it is used to measure lead or lag time difference between voltage and current. In this system zero voltage pulse and zero current pulse generated by ZCD is given to two analog pins of Arduino to which calculate the respective power factor. Then for the balance transmission system TSC-TCR observe or generate the reactive power as per requirement.

According to reactive power compensation, the shunt reactor and shunt capacitance come in the system. The load is connected to observe the improvement of power factor when TSC and TCR connected in the system.

5. MATLAB Simulation

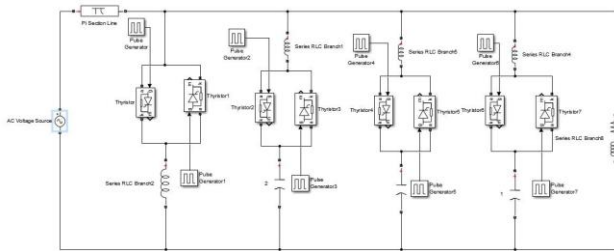


Figure 05: Simulation of Compensated system

Table 1: Compensated System

| Sr. No. | Vs | Vr | Il | P | Q | α° |
|---------|-----|-------|-------|----|--------|----------------|
| 1 | 230 | 230 | 0 | 0 | 0 | 180 |
| 2 | 230 | 223.6 | 0.35 | 20 | 95.37 | 175 |
| 3 | 230 | 236.7 | 0.68 | 36 | 172.68 | 174 |
| 4 | 230 | 238.8 | 0.884 | 52 | 224.03 | 179 |

Vs- Sending End Voltage, Vr- Receiving End Voltage, Il- Load Current, P- Active Power, Q- Reactive Power, α° - Firing Angle

6. Result

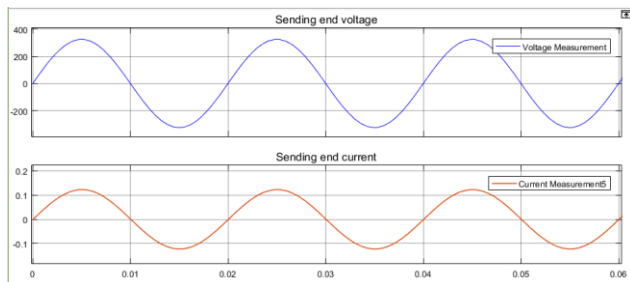


Figure 6: Sending end Voltage and Current

Above graph shows the sending end voltage of the transmission line. Both waveforms are sinusoidal and in phase

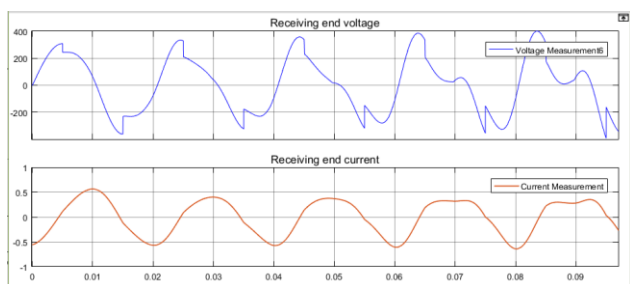


Figure 7: Receiving end Voltage and Current

Above graph shows load end voltage of the transmission line. Waveforms are distorted because of the harmonics.

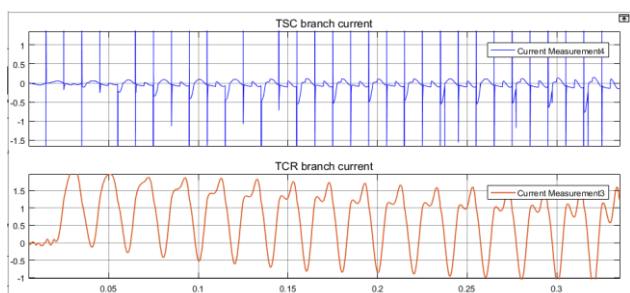


Figure 8: Waveform current in the TSC and TCR branches. Above graph shows the current in the TSC and TCR branches. As the inductor doesn't allow the sudden change in current through it so that waveform of the TCR branch current start after sometime.

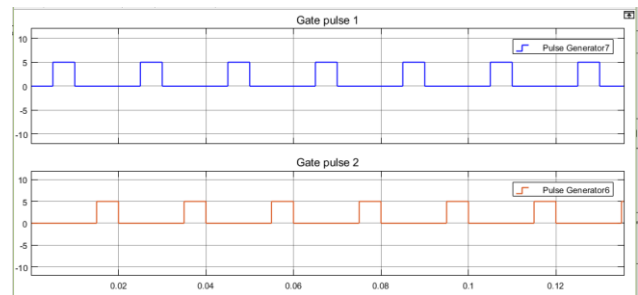


Figure 9: Gate pulse applied to the anti-parallel TRIAC's of the TSC branch

Above graph shows the gate pulses applied to the antiparallel TRIAC's of the TSC branch TRIAC-1 is trigger at 90° and TRIAC-2 is trigger at 180°

7. Future Scope

The variables and compensation using SVC can be extended to a large rating machine and large interconnected power systems. The can also be fabricated by using IGBT's and testing can also be performed using DSP. Moreover, TSC-TCR based SVC can also be implemented for SMSL test system.

However, it is well known that these FACTS controller have the additional advantage of being able to control fast system oscillation due to their quick response. Hence by properly modeling these controllers in transient stability programs, it would be interesting to determine any possible advantage of these controllers in voltage stability studies.

8. Conclusion

In the transmission system many times at short intervals load variation has occurred which result voltage variation at the load side and there is a possibility to damage the electronic equipment. In these paper significance of reactive power controlled in transmission line has been studied. Also, the reactive power can be compensated by using FACTS devices are used for a different application such as voltage control, voltage balancing and stability improvement it will be more advantageous to execute it in industries, distribution, and transmission system to maintain the flow of reactive power and the power factor of the system at unity power factor. With the increase of loads the supply voltage decreases in an uncompensated power system. As increase in reactive power demands the power factor of load decreases. Hence by using TSC and TCR, we get successful compensation with power factor near to unity.

References

[1] KumarshanuChaurasiya, Sagar Rajput, Sachin Parmar, Prof.Abhishek Patel, "Reactive Power Management Using TSC-TCR", IRJET-Volume 05 Issue 04 Apr-2018

- [2] AmarnathSanyal, Archita Ghosh, RajuBasak, SourishSanyal, Subhasree Chatterjee, Dipayan Biswas, "An Article On Flexible AC Transmission" IRJET- Volume 03 Issue 05 May 2016
- [3] B. Vamsi Krishna, "Significance of TSC On Reactive Power Compensation" IJAREEIE- Volume 03 Issue 02 Feb 2014
- [4] Mr.Bhavesh S. Patel, "Reactive Power Compensation In Transmission System with the help of FACTS device Thyristor Switched Capacitor" IJETSR- Volume 04 Issue 12 Dec 2017
- [5] C. Dinkaran, "Implementation of Series and Shunt FACTS Devices for Transmission Lines" Vol. 06 (2015) No.08 pp. 2009-2017
- [6] Dr. D. G. Bhardwaj, P. D. Bhardwaj, "Power System Operation and Control" July 2018 ISBN 978-93-88200-21-9
- [7] Malvik K. Lad, PatilKalpesh, "Design and implementation of TSC-TCR for reactive power compensation" IJIERE Volume- 03 Issue no. 05, 2016
- [8] RachanaChavan, Rakesh Singh Lodhi, "Selection of FACTs Devices for Better Reactive Power Compensation through Capacitor", International Journal of Engineering and Techniques - Volume 2 Issue 5, Sep – Oct 2016.
- [9] AyetulGelen, and TankutYalcinoz, "The BehaviourOf TSR-Based SVC and TCR-Based SVC", IEEE I 2008.
- [10] Rohan Khonde, M. V. Palandurkar, "Simulation model of Thyristor controlled reactor", IJERT.