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Research Article

A Characteristics & Behavioral Study of TCSC Device using MATLAB/Simulink

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Abstract

In the present time of industrial and modern technologies, the demand of power is increasing day by day. In the recent past, the major problem power system instabilities with and transmission facilities with increase in the load demand of electrical power is due to rapid industrial development. So there is an immediate requirement to increase the quantity, quality and reliability of highly complex power systems. Power instability is the major problem that the industrial and domestic sector is facing nowadays. Construction of new power grids and transmission lines is not the best option due to some constraints i.e. permits granting, land acquirement and cost considerations. Here we need some improvements such as of reactive power compensation and improved the voltage control. In these aspects a TCSC is very useful in improvement of quality of supply and to reduce the power loss. The paper discusses the conceptual study of a TCSC device in the transmission line and the various characteristics and impedance curve characteristics of TCSC device using a Simulink model of TCSC in the matlab.

Keywords: *TCSC, Power Quality, Voltage sag, Voltage swell, Simulink, impedance curve characteristics.*

Introduction

To satisfy and meet the increasing demand of load and to satisfy the voltage stability and power system reliability in the existing transmission or generation, new facilities should be added to the power system due to the constraints, such as lack of new investment and the difficulties in arranging new transmission setup, the solution of the above problems can be achieved by using FACTS controllers. FACTS controllers are the inventions of FACTS technology; and a group of power electronics controllers which are expected to upgrade the power transmission and generation system in many different ways. These technologies by increasing the flexibility of the systems can enhance the power transfer capability by 20-30%. Load ability or distance to voltage collapse of power system can be increased using various devices in the transmission line such as Thyristor Controlled Series Capacitor. Large number of FACTS devices that have been modified depending upon the desired goals and needs to be achieved. Thyristor-Controlled Series Capacitor (TCSC), Static Synchronous Compensator (STATCOM), Static Synchronous Series Compensator (SSSC) are few FACTS Controllers. These devices can be connected to the power system at any location either in series or in shunt or with combination of these.

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Literature Review

The concept of basic Thyristor-Controlled Series Capacitor device was proposed by Vithayathil with others as a method of rapid adjustment of network impedance, in 1986. It consists of the series compensating capacitor shunted by a Thyristor-Controlled Reactor. The Testing of the TCSC (first single phase) began in 1991 by the American Electric Power Co., based in Columbus, Ohio. First three phases testing of TCSC was performed in 1992 by the Western Area Power Administrator, based in Golden, Colorado that results raise in the capacity of a transmission line by almost 30%. In 1999, ABB commissions the full scale TCSC for damping of power oscillations in a 500 kV power system interconnection in Brazil.

Thyristor Controlled Series Capacitor (TCSC)

For improving power transmission capability of the transmission lines series compensation is an economic method. TCSC device is introduced in the transmission line to enhance its power transfer capability; either in series or in shunt. Thyrister -controlled series capacitors (TCSC) is a series compensator that gives many benefits in a power system. It involves controlling power flow in transmission line, mitigating sub synchronous resonance and damping power oscillations. A basic TCSC has a simple main circuit. It has capacitor i.e. inserted directly in the series with the transmission line and a thyrister-controlled inductor i.e. inserted directly in parallel with the capacitor and hence no another interfacing equipment is required for example high voltage transformers. This all makes TCSC much more economic than other competing FACTS technologies. TCSC helps in following ways

- Improve system stability.
- Reduce system power losses.
- Increase power transmission capability.
- Improve voltage profile of the lines.
- Power loss has reduce due to low frequency switching.
- Overcomes the problem of Sub- Synchronous Resonance

Operation of Thyristor Switched Capacitor

TCSC is device which makes it possible to change the impedance of a transmission line. It has three components bypass inductor L, capacitor bank C and a bidirectional thyristors SCR1 and SCR2. In the basic diagramI_c and I_L shows the values of the capacitor and inductor respectively at any instant. I_S represents the current of the controlled transmission line, V represents the voltage across the TCSC. To adjust the TCSC reactance the firing angle (α) of the thyristor is controlled. A TCSC can be controlled to work in capacitive zone and Inductive zone. The equation of reactance which is function of (α) is given below

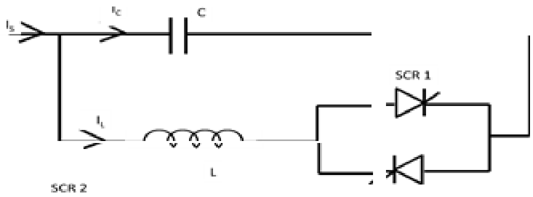


Fig.1 TCSC Circuit Diagram

$$TCSC(\alpha) = X_c - \frac{X_c^2}{X_c - X_L}\frac{\sigma + sin(\sigma)}{\pi}$$

$$* \frac{4X_c^2}{X_c - X_L}\frac{cos^2\left(\sigma/_2\right)}{K^2 - 1}$$

$$* \frac{(Ktan(K\ \sigma/_2) - tan(\sigma/_2))}{K}$$

Where X_c =Nominal reactance of the fixed capacitor C. X_L = Inductive reactance of inductor L connected in parallel with C.

Impedance Characteristics of TCSC

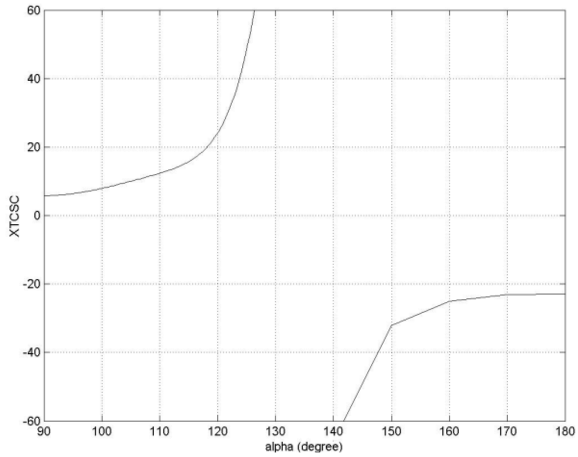
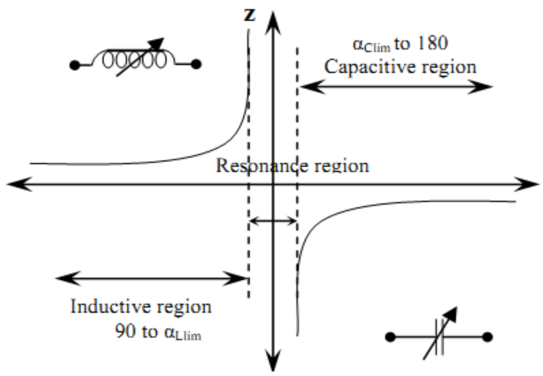


Fig: 2 The variation of TCSC reactance,(XTCSC) against of firing angle α



Modelling of TCSC

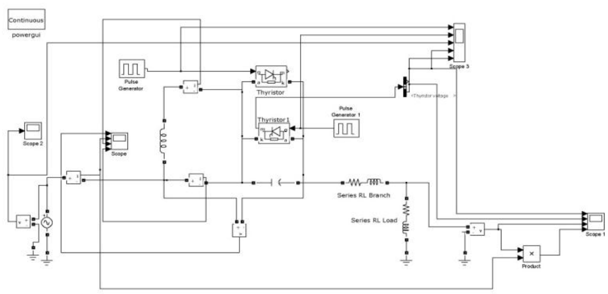


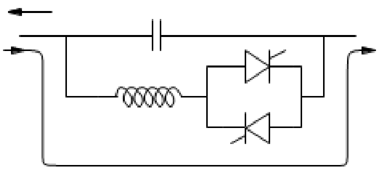
Fig: 2 Simulink Modelling of TCSC

Behavior of TCSC

TCSC basically operates in three operating modes.

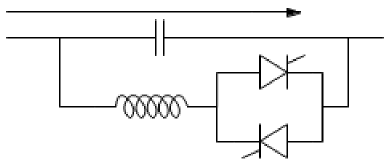
Bypass Mode

When the MOV operation is not enough to decrease the capacitor voltage; the TCR branch enters its bypass mode to protect the TCSC. In this mode, the TCR conducts in the whole cycle, and the TCSC device serves as inductance. In this mode thyristor is operated for 180° and the susceptance of the reactor is more than capacitor. And thus most of line current passes through reactor and thyristor valves. The mode is mostly used for protection of capacitor against overvoltage.



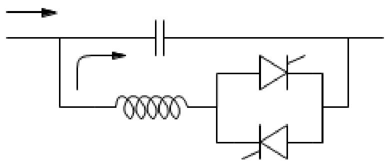
Blocked Mode

When the TCSC detects the over–voltage, the TCR branch stops its firing sequence by a protection function. The TCSC works as a series capacitor in parallel with a MOV. In this mode gate pulses remains blocked and no current pass through valves and. In this mode the reactance of TCSC and fixed capacitor is similar.



Vernier Mode

In this mode the two gate pulses in the two region to operate the thyristor valves i.e. capacitive vernier region (α_{min} < α < 90°) and inductive vernier region α is reduce to 180°.



Resultant Waveform

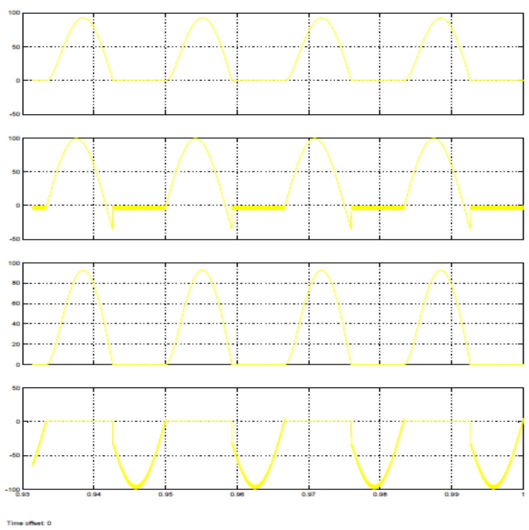


Fig: 2 Resultant Waveform of TCSC Current and Voltage

Conclusion

This paper is a study of behavior of TCSC in transmission line. The Simulink model with transmission line is represented and associated waveforms are analyzed on a scope. An open loop simulation model of TCSC device on transmission line is analyzed with waveform. The paper has a simple and basic overview of thyristor controlled series capacitor as a best devices in FACTS family and its applications in power transmission system. The two major characteristic of TCSC i.e sub-synchronous resonance in generator oscillation controller and TCSC as transient voltage stabilizing controller are studied. The results conclude that the (TCSC) operation has an important influence on both the small signal and transient stability characteristic of the system.

Future Work

The various characteristics of TCSC and behavior of TCSC is studied in this paper using Matlab Simulink Modeling. TSCS can be used along with SSSC (static synchronous series compensator) or some another fact device in transmission line for power stability and improvement.

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