Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 12, No.3, December : 2024

POWER QUALITY IMPROVEMENT USING THYRISTOR CONTROLLED SERIES CAPACITOR (TCSC), FACTS DEVICES

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ABSTRACT
Series compensation of transmission lines is an effective and cheap method of improving the power transmission system performance. Series capacitor virtually reduces the length of the line making it easier to keep all parts of the power system running in synchronism and to maintain a constant voltage level throughout the system. The Thyristor Controlled Series Capacitor (TCSC) is one such concept. By varying the inserted reactance an immediate and well-defined impact on the active power flow in the transmission line is obtained. Several potential applications, specifically power oscillation damping, benefit from this capability. The concept implied the requirement to design a semiconductor valve, which can be inserted directly in the high-voltage power circuit. It was also realized that the TCSC exhibits quite different behavior with respect to subsynchronous frequency components in the line current as compared to the fixed series capacitor bank. This was a very interesting aspect as the risk of subsynchronous resonance (SSR), which just involves such line current components, has hampered the use of series compensation in power systems using thermal generating plants.
Keywords: TCSC, power oscillation damping, subsynchronous resonance (SSR).

I. Introduction
The basic Thyristor-Controlled Series Capacitor with as a method of "rapid adjustment of network impedance," It consists of the series compensating capacitor shunted by a Thyristor-Controlled Reactor. Thyristor Controlled Series Capacitors (TCSC), in particular, have been widely studied and reported in the technical literature, and have been shown and used in practice to significantly enhance system stability. In dynamic applications of TCSCs, various control techniques and designs have been proposed for damping power oscillations to improve system dynamic response, whereas for steady state control, the main interest of users and researchers has been the use of the this controller for power flow control in transmission lines, usually considering optimal scheduling strategies[1-3].
Most of the available technical literature in TCSC usually deals with steady state and dynamic control and applications independently. However, to fully understand and properly utilize these types of controllers, a number of control tasks for both dynamic and steady state system improvement must be jointly considered. Since the time frames of the different control actions comprise a wide range of system responses, a hierarchical control scheme should be preferably considered for the controller. In the case of a TCSC, such a scheme should consider the different control levels acting on the same control variable, which in this paper is assumed to be the fundamental frequency equivalent impedance, as this is the control variable most commonly studied in the literature. In this kind of hierarchical control design, adverse interactions between the different control levels may be expected when not properly coordinated .The main aim is to analyze the design of a hierarchical TCSC controller for stability enhancement, taking into account interactions among the different control levels. [4-5]

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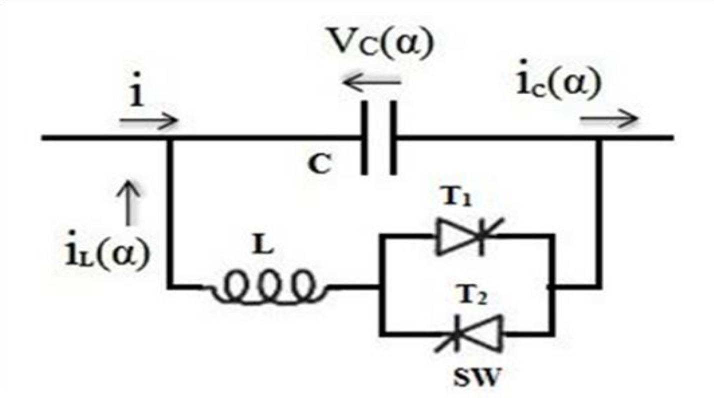

Figure 1.0: Basic Thyristor Controlled Series Capacitor

The TCSC thus presents a tunable parallel LC circuit to the line current that is substantially a constant alternating current source shown in Fig.1.0. As the impedance of the controlled reactor, $X_L(\alpha)$, is varied from its maximum (infinity) toward its minimum (ωL), the TCSC increases its minimum capacitive impedance, $X_{TCSC}.min = X_C = 1/\omega C$, (and thereby the degree of series capacitive compensation) until parallel resonance at $X_C = X_L(\alpha)$ is established and $X_{TCSC}.max$ theoretically becomes infinite. Decreasing $X_L(\alpha)$ further, the impedance of the TCSC, $X_{TCSC}(\alpha)$ becomes inductive, reaching its minimum value of $X_L X_C / (X_L - X_C)$ at $\alpha = 0$, where the capacitor is in effect bypassed by the TCR. Therefore, with the usual TCSC arrangement in which the impedance of the TCR reactor, X_L, is smaller than that of the capacitor, X_C, the TCSC has two operating ranges around its internal circuit resonance: one is the $\alpha_{Clim} \leq \alpha \leq \pi/2$ range, where $X_{TCSC}(\alpha)$ is capacitive, and the other is the $0 \leq \alpha \leq \alpha_{Clim} \leq \pi/2$ range, where $X_{TCSC}(\alpha)$ is inductive, as illustrated in Figure 1.1. [5-7]

The steady-state model of the TCSC described above is based on the characteristics of the TCR established in an SVC environment, where the TCR is supplied from a constant voltage source. This model is useful to attain a basic understanding of the functional behavior of the TCSC. However, in the TCSC scheme the TCR is connected in shunt with a capacitor, instead of a fixed voltage source. The dynamic interaction between the capacitor and reactor changes the operating voltage from that of the basic sine wave established by the constant line current. A deeper insight into this interaction is essential to the understanding of the actual physical operation and dynamic behavior of the TCSC, particularly regarding its impedance characteristic at sub-synchronous frequencies. Refer to the basic TCSC circuit shown in Figure 1.1.

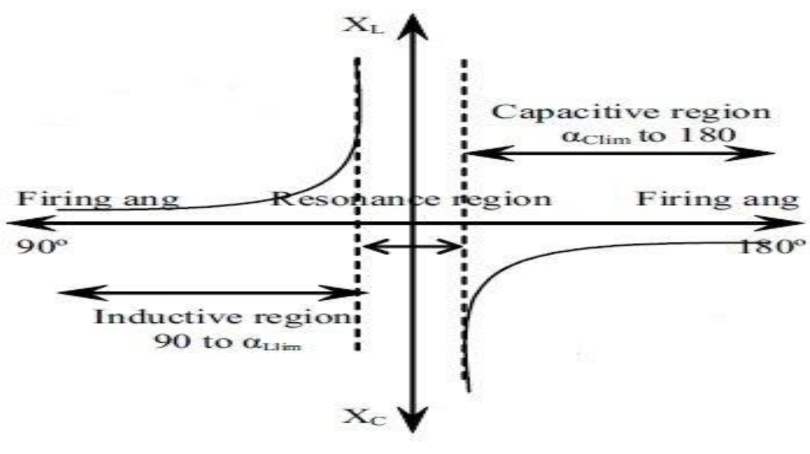

Figure 1.1 the Impedance vs. delay angle α characteristic of the TCSC

II. Methodology:

Power quality is one of the most important problems in power system. Due to large inductive load

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voltage sag may occur that cause the damage of electrical equipments, these also cause reduction in power factor .To transmit or distribute fixed amount of power at fixed voltage, the conductor have to carry more current at low power factor.[4] This requires a large conductor size. The large current at low power factor cause more copper loss in power system as well as increase kVA rating of equipments. This low power factor also cause poor voltage regulation and reduce power handling capacity of power system. All these problems can be removed by TCSC.

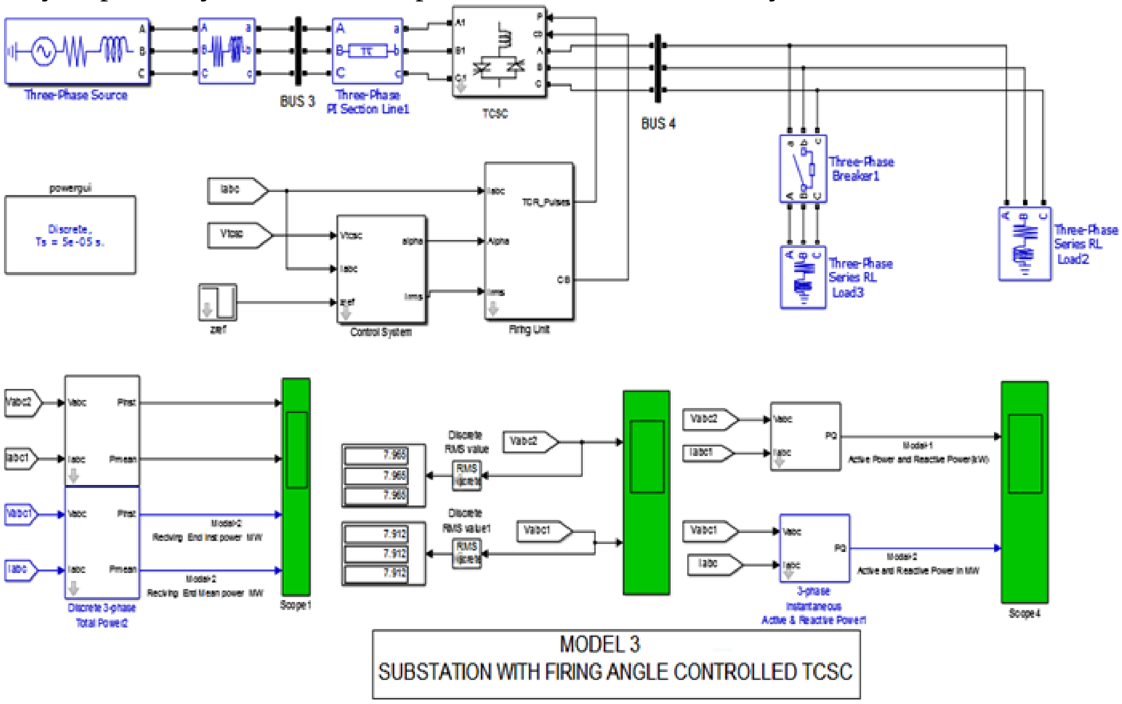


Figure 2.0: Simulation model for Power quality improvement with TCSC

Thyristor controlled switched capacitor can be used for power factor correction, flicker reduction, and steady-state voltage control, and also have the benefit of being able to filter out harmonics from the system [8-10]. The simulation model for power quality improvement is shown in fig2.0.

III. Simulation and Results:

Now summaries the overall simulation result by a Table-1 and Table -2

Table 1: Harmonics

S.No.	Sending End Voltage (KV)	Harmonics % Without TCSC	Harmonics % With TCSC	
			Model-2	Model-3
1	11	13.95	2.66	5.27
2	33	14.2	8.59	9.31
3	66	12.84	6.29	6.85

Table 2: Voltage Profile with TCSC

Variation in Real Power in Model-1 and Model-2

Power quality, like quality in other goods and services, is difficult to quantify. There is no single accepted definition of quality power. There are standards for voltage and other technical criteria that may be measured, but the ultimate measure of power quality is determined by the performance and productivity of end-user equipment. If the electric power is inadequate for those needs, then the “quality” is lacking.

The variation of real power in such above transmission line the 11 kV transmission line power oscillation in very small time that is over come show in fig.3 .and the 33 kV transmission line the power oscillation the transmission capacity is improve above 0.2MW show in fig 4 (i) similarly

66kV transmission line power oscillations and capacity is improve on open and short circuit duration show in fig 4 (ii) Power Vs Time Waveform.

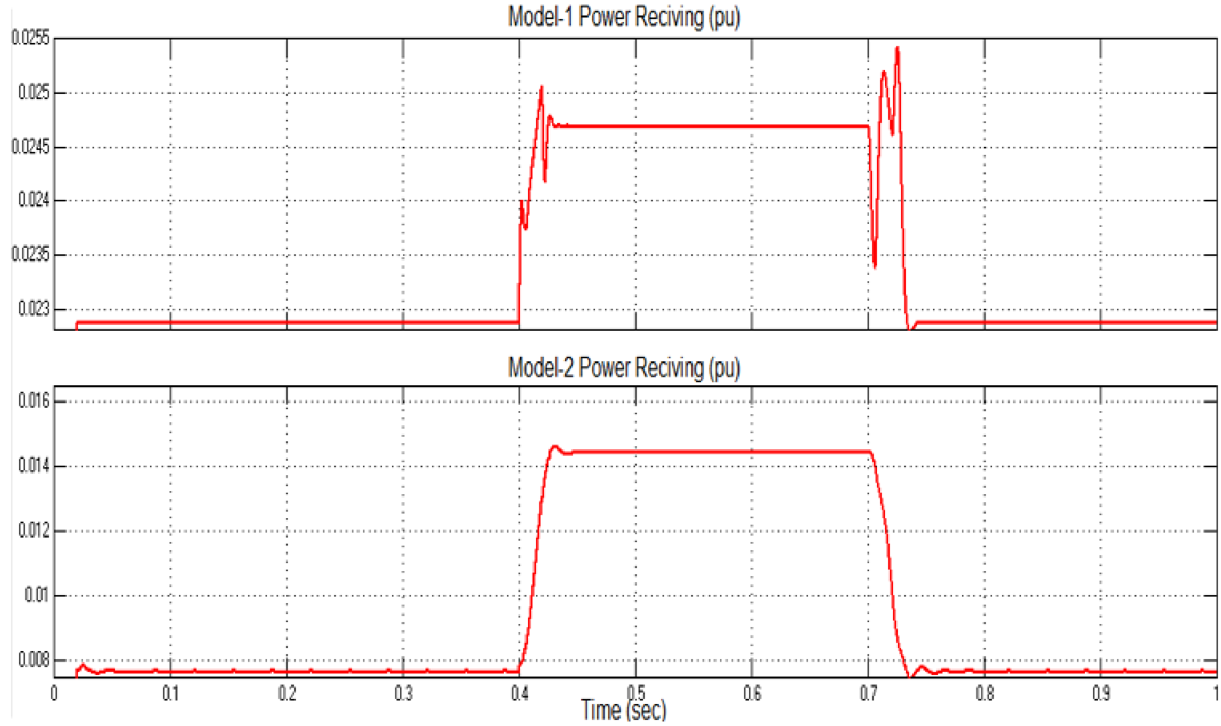
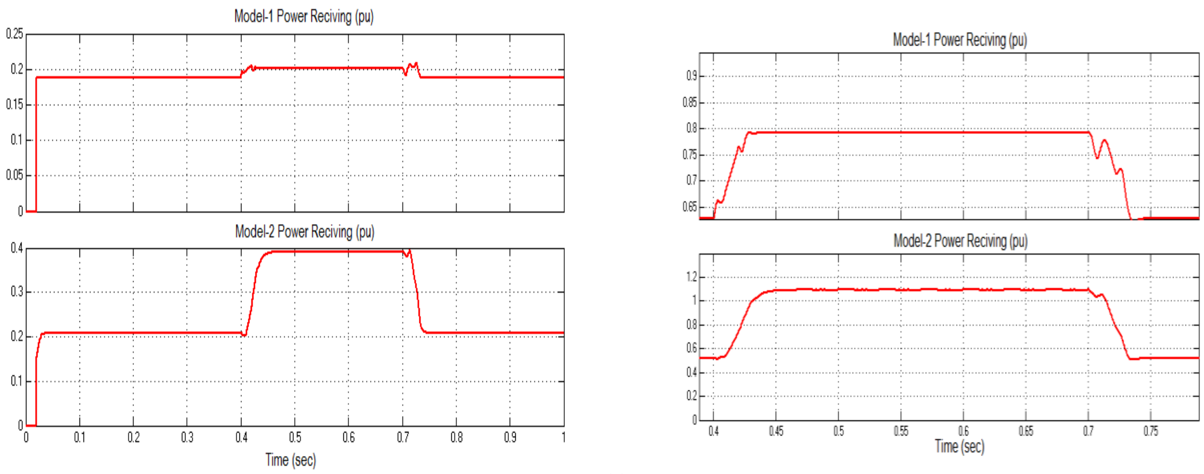


Fig3: Power Vs Time waveform in 11kV Transmission Line



(i)

(ii)

Fig 4: Power Vs Time Waveform in 33 KV & 66kV Transmission Line

IV. Conclusion:

The use of TCSC compensating device with the Pulse control is continuous, effective and it is a simplest way of controlling the reactive power of transmission line. It is observed that TCSC device was able to compensate both over and under voltages, TCSC controller is more efficient than conventional method. The use of TCSC has facilitated the closed loop control of system, which decides the Pulse controlled given to thyristor to attain the required voltage. With MATLAB simulations it is observed that thyristor switched series capacitor provides an effective reactive power control irrespective of load variation and also provide voltage stability during fault conditions. The FACTS technology is not a single high-power Controller, but rather a collection of Controllers, which can be applied individually or in coordination with others to control one or more of the interrelated system parameters mentioned above. The TCSC has useful devices in power system to improve the power quality.

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