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Study and Modeling of Thyristor Controlled Series Capacitor for the Power Improvement in the Transmission Line

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Abstract

Thyristor controlled series compensator (TCSC) controller, are the type of flexible AC transmission system commonly known as FACTs. These are used to control the transmission line impedance by the thyristor-controlled capacitor in series introduced into the transmission line. Thyristor Controlled Series Compensator is used as compensator in transmission system. TCSC can control the power flow, to improve the transient stability and increase the transfer limits. These controllers provide a very response to increase the power by the mechanism of subsequent oscillations are damping. In this process quick changing of the equivalent capacitive reactance to the full compensation is achieved in the first few cycles after a fault. TCSC controllers are used for the compensation in transmission by variable impedance. The role of the compensator is mainly to mitigate the effects of voltage sag. In this paper the Simulation results represents a comparative study of output voltage and power stability across a three phase parallel load without and with Thyristor Controlled Series Compensator. The simulation was studied with help of model prepared by the Simulink in Matlab. The results showed that the proposed method of introduction of TCSC was efficient in mitigating voltage sags and improving the power quality of isolated power system.

Keywords*: TCSC, Voltage Swells, Power Improvement, Simulink, Transmission Line, Power Quality*

Introduction

In the Modern era due to increasing load demands by industrialization various economic and environmental constraints are arising to maintain the power generation systems and the power quality. The overloading of power system and transmission lines may sometimes leads to voltage collapse. Thus maintaining a stable power supply and secure operation of a power system is a challenging issue. Voltage stability may be defined as the ability of a power system is to maintain acceptable voltages and a undisturbed follow during the transmission of power to various types of consumers under all the load conditions. Flexible AC Transmission Systems controllers (FACTS) are the solution to various power problems. The main challenge is to maintain combination of voltage quality and current quality. Power quality is to maintain some electrical properties without significant loss of performance. The various problems related to power harmonics disruptions, voltage asymmetric flicker, voltage sags and voltage swells. Occurrence of above problems in the power system effect can leads to the failure of Power system or the equipment. To overcome the undesirable affects the proposed method mitigates the problems related to power transmission. The system is studied is studied using a Simulink designed model in matlab with and without the use of TCSC device. The results show that the introduction of TCSC in the power system improves the system reliability.

Literature Review

Mazilah Binti A Rahman Advisor Goro Fujita *et al* (2014) has considered the application of TCSC for closed-loop control of power flow in both constant power and constant angle modes of operation. The results shows that the power flow controller (TCSC) operation has an important influence on both the small signal and transient stability characteristic of the system.

Manisha Chadar *et al* (2013) used a method to reduce voltage sag & increase voltage quality using series compensation is considered, PWM generator six pulses based TCSC series compensator is used to reduce the voltage sag produced by non linear loads.

S.O Farid and R.Billinton *et al* (2010) has studied the impact on the reliability of employing a TCSC in power system. The results presented by them indicate that the system reliability is improved by inclusion of the TCSC. The impact on the power system such as transmission line availability, number of modules in a TCSC module and the module availability were examined. The results presented indicate that the reliability impact of transmission line availability is much higher than that of module availability.

Garima Naidu and Ganga Agnihotri *et al* (2014) presents a new power flow tracing based usage and loss allocation methodology with incorporation of TCSC. Voltage source modeling structure of TCSC for compensating the reactive power and improving the voltage profile is considered. With TCSC power flow of transmission is found to improve, hence transmission usage allocation also improved. Voltage source modeling is used for TCSC incorporation as it takes into account, effect of TCSC at each iteration.

Methodology

Voltage sags, faults and power fluctuation are the most severe disturbances among the various power quality problems. To overcome these problems TCSC is introduced into the system recently. The TCSC is connected in series with the power system. It controls the voltage in the power system. In long transmission lines large current flows which causes a large voltage drop. To compensate for this, series capacitors are connected in the system to decrease the effect of the inductance. The simple power system model having TCSC is shown in Figure 1.

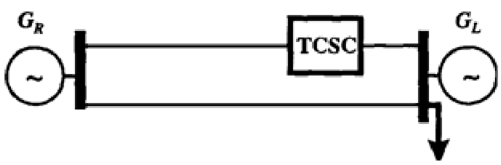


Fig: 1 Basic Circuit of TCSC in transmission line

Criteria For Optimal Placement For TCSC The optimal location of TCSC device is one of the important factors. The main goal of proposed work is to perform a most utilization of the existing transmission lines. The TCSC device should introduce in most sensitivity bus or line. For the TCSC the location is the line with most positive sensitivity index.

Advantages of the TCSC

- Improved stability
- improved voltage regulation and reactive power balance,
- improved load sharing between parallel lines,
- damping of active power oscillations,
- dynamic power flow control,
- minimizing system losses,
- elimination of line overloads,
- optimizing load sharing between parallel circuits,
- Increased load ability
- Low system loss
- Elimination of the need for new transmission lines
- Added flexibility in finding new generation
- Upgrade of transmission lines
- Reduce reactive power flows
- thermal capabilities
- Improve transient stability
- Reduced cost of production

Modeling of Thyristor Controlled Series Capacitor by using Matlab Simpower system

The model of electrical network required with and without TCSC device was prepared using Matlab Simulink. For identify the action of TCSC device, for power stability control has been created a simple model of electrical network in which TCSC device was subsequently implemented. The model of a consists of a voltage source, load, two parallel lines, 3 phase RLC Load, A TCSC device and few units and scopes for measuring and displaying measured electric variables.

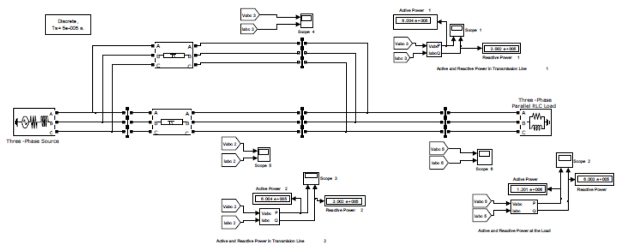


Fig:2 Simulink diagram of power system without Thyristor controlled series capacitor

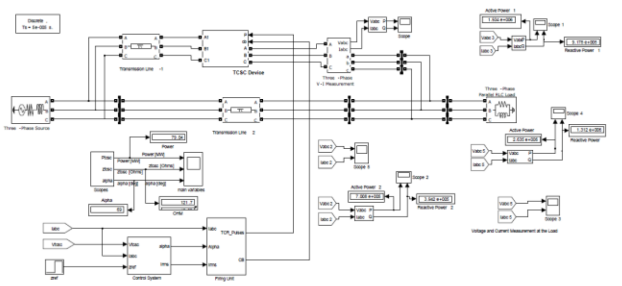


Fig: 3 Simulink diagram of power system with Thyristor controlled series capacitor in Capacitive Mode

The various parameters of the model are as follows:

• Ideal Three-Phase Voltage Source
Line to-line voltage UN = 11 kV,
Phase angle L1 α= 0°,
Frequency f = 50 Hz,
• Three-Phase Parallel RL Load
Active power P = 50 MW,
Reactive power Q = 10 MVAr,
Configuration Y (grounded),
• Three-Phase PI Section Line n.1 and n.2
Line resistance R = 0.028 Ω/km,
Line inductance L = 0.904 mH/km,
Line capacity C = 0.012707 _F/km,
Line lenght l = 100 km,

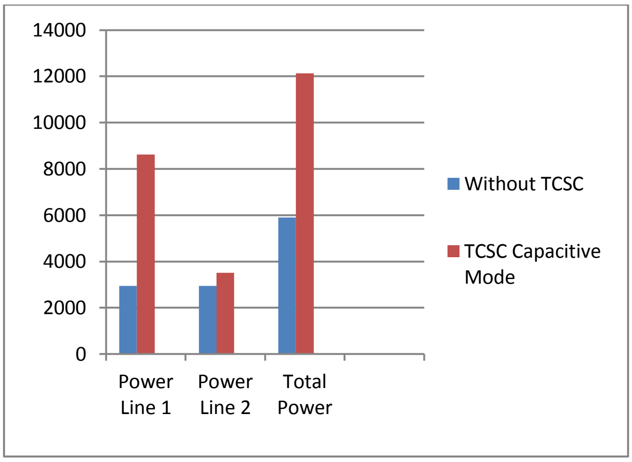
Maximum current of line Imax = 1200 A.
The parameters of TCSC device are follows:
Inductance of TCR /TCR = 6.71 mH,
Capacity of TCSC *c* = 203 _F,

Results and Discussion

In Figure 2 is electrical network model having a transmission line showed situation in the without the use of TCSC. Since the various parameters of both the transmission lines are the same therefore the flow of active and reactive power is distributed evenly on both the transmission lines as shows the displays of Fig: 5.2, i.e. the power flows of the given lines are equal. The voltage at the load drops due to loss of voltage on lines.
With addition of TCSC device into one of the line results change in the power flow in the particular line according to level desired. The desired change is basically achieved by regulating the impedance of line using installed TCSC device. With the different values firing angle α of a switching thyristors the behavior of the TCSC can be changed. Thus with different values of the firing angle TCSC can change the impedance of the line and thereby regulates the power flow as required. When such a change of power flow occurs, the power flow on lines is redistributed to another ratio, but the resulting flow performance remains unchanged.

Table 1 Power Flow on the Transmission Line during the Conductive and Inductive Mode of TCSC

	Without TCSC	With TCSC	
		Capacitive Mode α= 69 °.	Inductive Mode α= 47 °.
PV1 (W)	2948	8614	2058
PV2 (W)	2948	3517	2760
PV SUM (W)	5895	12131	4819
QV1 (Var)	589.5	1574	420.7
QV2 (Var)	589.5	858.3	542
QV SUM (Var)	1179	2432	962.7



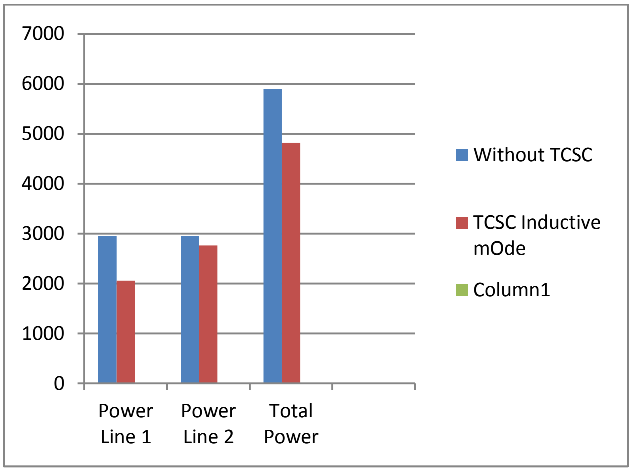


Fig: 4 Power Variation Analysis using TCSC in the Capacitive and Inductive Mode

In Figure 3 has a model of electrical network in which TCSC is adjusted at angle α= 69°. In this mode the impedance of TCSC remains capacitive and due to this the change occurs in power flow on the transmission lines No.1 and No.2. This change of value of firing angle will results the increase in the value of power flow on the transmission line 1 from PV1= 2948 W to PVT= 8614 W.
Similarly in the a model of electrical network in which TCSC is adjusted at angle α = 47 In this mode the impedance of TCSC remains inductive and due to this the change occurs in power flow on the transmission lines No.1 and No.2. This change of value of firing angle will results the decrease in the value of power flow on the transmission line 1 from PV1= 2948 W to PVT= 2058 W.
In this mode of operation the resulting inductive action of the TCSC increase the impedance of line No.1due to that there is decrease in the flow of power on line No.1 and a increase the flow on line No.2.

Similarly in the capacitive mode of operation impedance of line No.1, will decline impedance of line No.1 and due to this there will increase the power flow through the line No.1 and power flow through the line No.2. get reduced.

Conclusion

The projected work deals with the implementation of TCSC in the power system. Basically in the long transmission lines the control of power quality and loss of voltage are the major issues to be considered because the consumer at long distant needs a power of good quality for the performance of his equipments. The TCSC device has the ability to change impedance transmission lines as desired and thus increase the transmission capacity and power flow control. TCSC with the different composition can be used in lots of application of the power system. It can be used also for following application

1. Damping of active power oscillations
2. Improve dynamic and voltage stability

3. Eliminating SSR
4. Raising the Transmission Capacity and other.
5. Reduction of Voltage sags

It is important to determine the various parameters of TCSC device before the installation, to analyse the power system and to study the behavior of TCSC in various applications. Here the subject of analysis is a transmission line model of electrical network having two parallel lines which simulates the behavior of TCSC in the transmission line. Based on simulations and the results obtained we can conclude that the TCSC has the ability to change the impedance of the line in which it is installed of a power system. With such a great advantage power flows on lines can be controlled. Since Having such advantages and characteristics of a TCSC device the power flow control and power quality can be ensured for the better and safe operation in power transmission. The Advantages of TCSC results various implementations of TCSC in many major projects across the world.

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