Design of TCSC for reactive power control and transmission line loss minimization

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Abstract—

In this paper we compare two facts devices such as TCSC and UPFC devices for the transient stability in a two-area power system. Here the facts devices are used to for analysis and control of a power system. One series device and another is the combination of series and shunt device (UPFC) in providing solutions for transmission line congestion problems. We use the facts devices for stable operation of a power system in the case of large faults. We considered the transient stability because it gives better control which helps in stable operation of a system which can be found out suing the MATLAB Simulink. The results indicate certain findings which give certain idea which are definitely useful both academic point of it as well as the research scope of it.

Key words: TCSC, UPFC, MATLAB, Simulink.

I. INTRODUCTION

In the upcoming days the complexity of a linear power system is increasing due to various generators and transmission loads and transformers. Due to which the transmission lines will be now more loaded than the stable operation The one of the major factor for fault that may occur is the transmission limiting factor that may cause the transient stability which might give rise to the blackout. To prevent these type of problems we use the FACTS (Flexible Alternating Current Transmission System) which is new in the field of power electronics which helps to improve the stability of any power system in many ways. But our project leads to transient stability we consider the UPFC and TCSC FACTS Devices among which one gives the maximum transient stability by improving the system operation in a power system. The facts device has capacity to carry the power closer to the thermal rattings. By using so we can increase the system transmission ability and power flow ability of a power system using the FACTS Device. The transient stability of a power system deals with the synchronous machine operating in parallel. It can also be defined as the ability of a power system to remain in the synchronous state when subjected to large disturbance.

Most of the power transmission lines are ac lines operating at voltage of (10kv to 800kv). The distributed networks operated between 100kv. Modern power system are designed to operate efficiency to supply power on demand to various load centres with high reliability. Modern power system are highly interconnected for economic reasons. Fast dynamic control over reactive and active power by target power electronic controllers. Used to increase controllability and increase power transfer capability. It is defined as a power electronic base system and other state equipment that provide control of one or more ac transmission system parameters. Depending on the power electronic devices used in the control the facts controllers.

Power system stability can be defined as the property of a power system that enables it to remain in a state of operation under normal operating equilibrium under normal operating conditions and to regain an acceptable state of equilibrium after being subjected to disturbance. Instability in a power system may be manifested in many different ways depending on the system configuration and operating mode. The stability problem has been one of mainly synchronous operation. Fig: 1 shows the classification of the power system stability

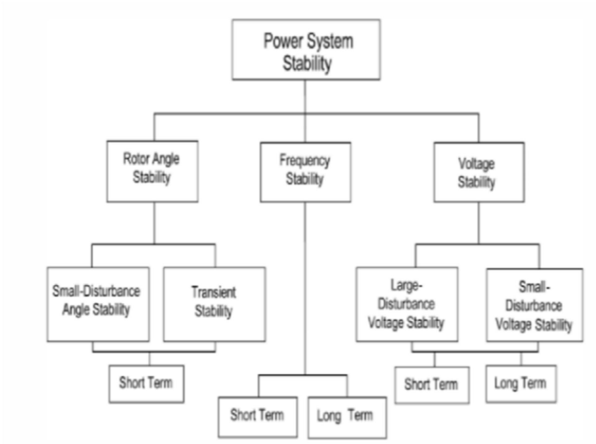

Figure 1: Power system stability classification

It is also defined as the (Flexible AC transmission system) is a new technology in power electronic devices which is mostly used in these days it is used as the switching converters used for system utilization and enhance transfer capacity in the stability analysis and it is also used in maintain the security and also most reliable in operation and also used for a good power quality of a AC system. Some of the different types of facts devices which are being used are tcsc, upfc, sssc, statcom, svc etc can be seen in fig 2.

It is a capacitive controller which consist of a capacitor bank which is connected in series along with a thyristor switching reactor in the form of a shunt which helps to provide control of series capacitive reactance. UPFC is consists of two facts devices which is synchronous series compensator and a static synchronous compensators with a DC common link coupling to allow the real power flow which flows in bidirectional between the series O/P terminals of the SSSC and the shunt O/P terminals of STATCOM. It can also independently control the shunt reactive compensation.

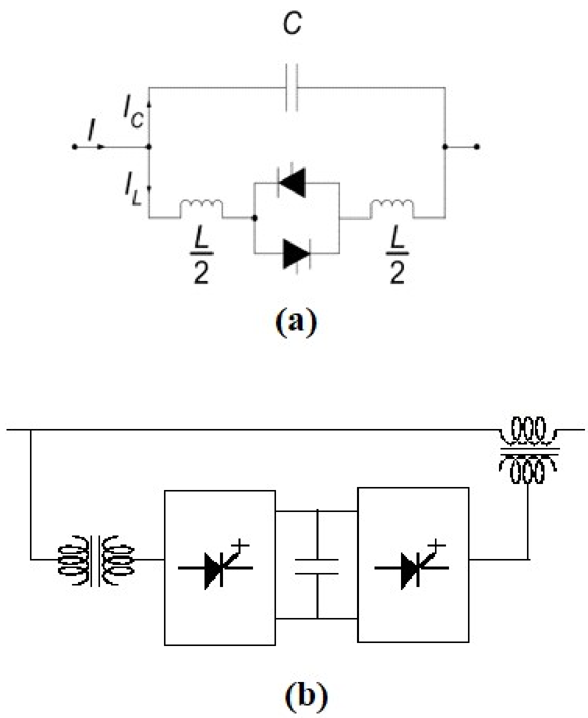

Figure 2: a) TCSC b) UPFC structures

FACTS devices can control power transmission parameters such as series impedance, voltage, and phase angle by their fast control characteristics and continuous compensating capability. They can reduce flow of heavily loaded lines, resulting in low system losses, improved both transient and small signal stability of network, reduced cost of production, and fulfillment of contractual requirement by controlling the power flow in the network. They can enable lines to flow the power near its nominal rating and maintain its voltage at desired level and thus, enhance power system security in contingencies [1-6]. For a meshed network, an optimal allocation of FACTS devices allows to control its power flows and thus, to improve the system loadability and security [1].

II. TCSC AND UPFC MODULE MODELING

In this chapter, we select three different FACTS devices to place in the suitable locations to improve security margins of power systems. They are TCSC (Thyristor Controlled Series Capacitor) and UPFC (Unified Power Flow Controller) that are shown in Fig. 3. Power flow through the transmission line i-j namely P_{ij}, depends on the line reactance X_{ij}, the bus voltage magnitudes V_i, and V_j, and phase angle between sending and receiving buses δ_i and δ_j, expressed by Eq. 1.

$$P_{ij} = \frac{V_i V_j}{X_{ij}} \sin(\delta_i - \delta_j) \tag{1}$$

TCSC can change line reactance and UPFC is the most versatile member of FACTS devices family and controls all power transmission parameters (i.e., line impedance, bus voltage, and phase angles). FACTS devices can control and optimize power flow by changing power system parameters. Therefore, optimal device and allocation of FACTS devices can result in suitable utilization of power systems. TCSC compensates the reactance of the transmission line. This changes the line flow due to change in series reactance. In this chapter, TCSC is modeled by changing transmission line reactance as follows:

$$X_{ij} = X_{line} + X_{TCSC} \tag{2}$$

$$X_{TCSC} = r_{TCSC} \cdot X_{line} \tag{3}$$

where, X_{line} is the reactance of the transmission line, and r_{TCSC} is the compensation factor of TCSC. The rating of TCSC depends on transmission line. To prevent overcompensation, we choose TCSC reactance between $-0.7X_{line}$ to $0.2X_{line}$ [26-27]. Two types of UPFC models have been studied in the literature; one is the coupled model [28],
and the other the decoupled type [29-31]. In the decoupled model, UPFC is modeled with two separated buses. The first model is more complex than the second one because the modification of the Jacobian matrix is inevitable. In conventional power flow algorithms, we can easily implement the decoupled model. In this chapter, the decoupled model has been used to model the UPFC as in Fig. 3. UPFC controls power flow of the transmission lines. To present UPFC in load flow studies, the variables P_{u1}, Q_{u1}, P_{u2}, and Q_{u2} are used. Assuming a lossless

UPFC, real power flow from bus i to bus j can be expressed as follows:

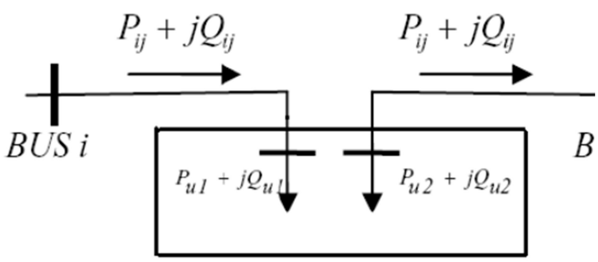

Figure 3. Decoupled model for UPFC

$$P_{ij} = P_{u1} \quad (4)$$

Although UPFC can control the power flow but, it cannot generate the real power. Therefore, we have:

$$P_{u1} + P_{u2} = 0 \quad (5)$$

Reactive power output of UPFC, Q_{u1}, and Q_{u2}, can be set to an arbitrary value depending on the rating of UPFC to maintain bus voltage.

III. SIMULATION RESULTS

Installing facts devices is a great idea but there are some issues for installing facts devices such as the we need the maximum efficiency we must find a suitable place for installing the facts device and for the feedback signals for the facts based stabilizers and the other problem is that for the robustness of these stabilizers to the variations is also an important factor which needs to be considered. Even the coordination among the stabilizers needs to be taken into consideration which helps to avoid the adverse effects.

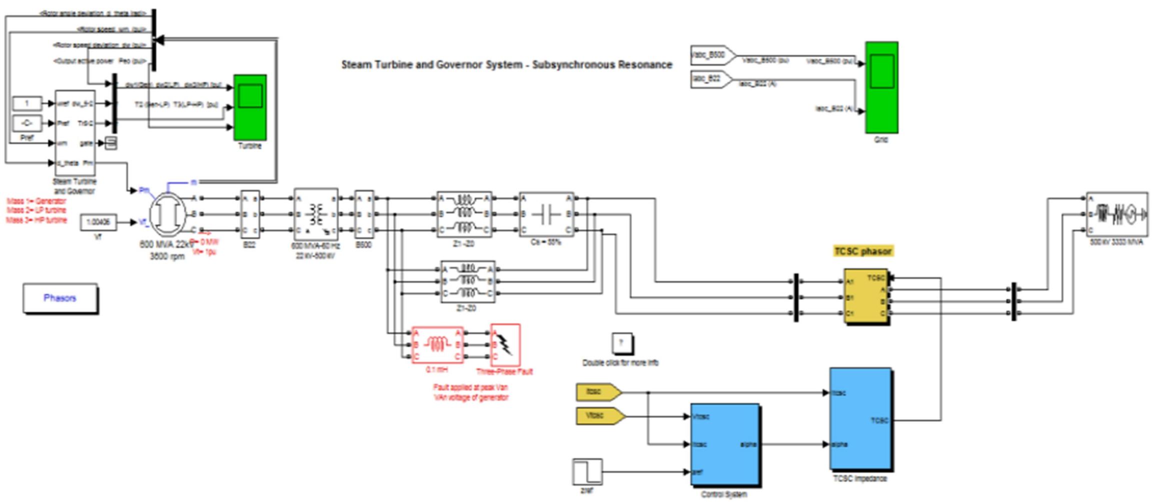

Figure 4: Simulink model with TCSC

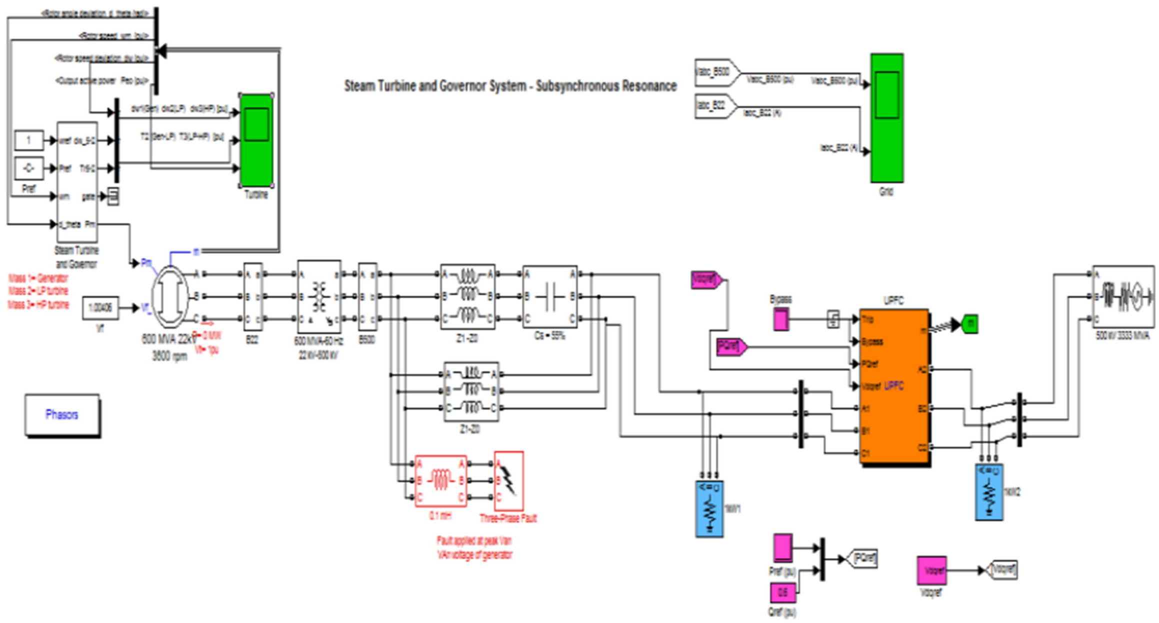

Figure 5: Simulink model with UPFC

Here in this project the tcsc is placed on a 500kv, long transmission line which helps to improve the power factor with and without the tcsc the power transfer is carried out and it's around 110MW in the first 0.5sec and then the tcsc placed then the nominal compensation is about 75% using capacitors and firing angle is about 90deg. But the natural oscillation frequency of a tcsc is 163Hzwhichg is 2.7 times of fundamental frequency can be seen in fig 6.

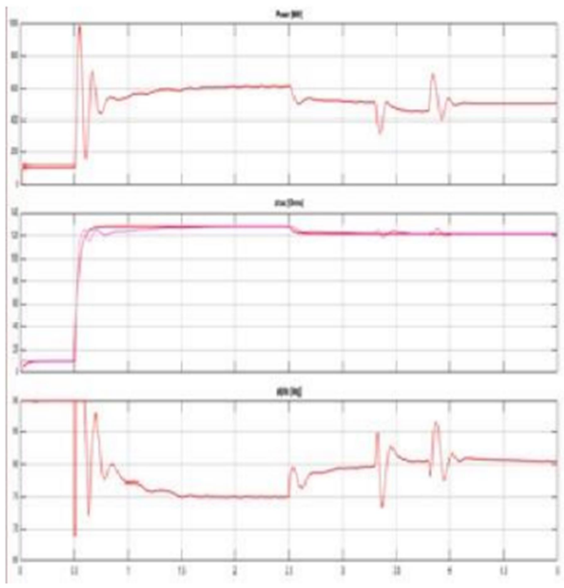

Fig. 6: TCSC device outputs

Here the UPFC is used to control the power flow in a 500KV transmission line and it is places left at 75km line between the 500KV buses which is used to control both active and reactive power flowing through the buses it also consist of two 100MVA, 48 pulse GTObased converter connected to bus the shunt and series will exchange power through the DC bus which can inject a max of 10% nominal power

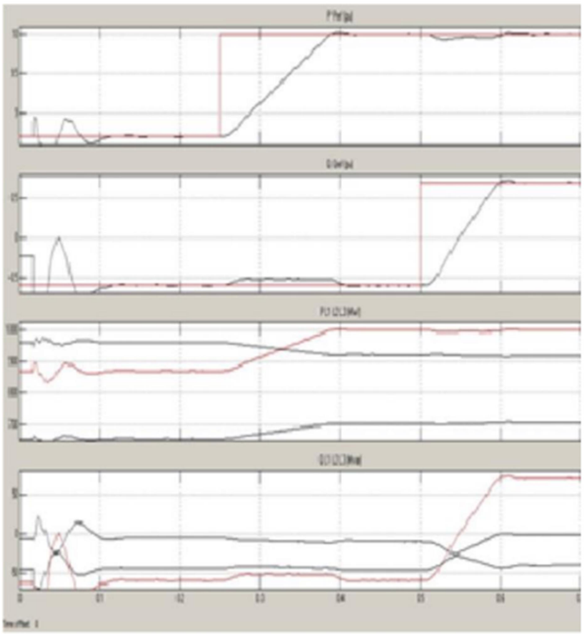

Figure: UPFC device outputs

This converter can be operated in three different modes: Unified Power Flow Controller (UPFC) mode, when both shunt and series converters are interconnected through DC bus. When the disconnect switches between the DC buses of shunt and series converter will open two additional modes will be available. Shunt converter when operating as Static Synchronous Compensator controlling voltage at bus B1 Series converter when operating as Static Synchronous Series Capacitor controlling injected voltage, while keeping injected voltage in quadrature with the current. The mode of operation the reference voltage and reference power values can be changed by UPFC GUI block.

The MATLAB simulation is carried using three specifications (1) System without FACTS device (2) System with TCSC (3) System with UPFC. Without FACTS device the system become more unstable for three phase fault at infinite bus. When FACTS device is connected to the series compensated line, it stabilizes the common mode oscillations. Simulation results are tabulated as shown in the table. These results clearly show that peak torques & rotor speed deviations gradually reduced with inclusion of TCSC & UPFC as compared to without FACTS controller.

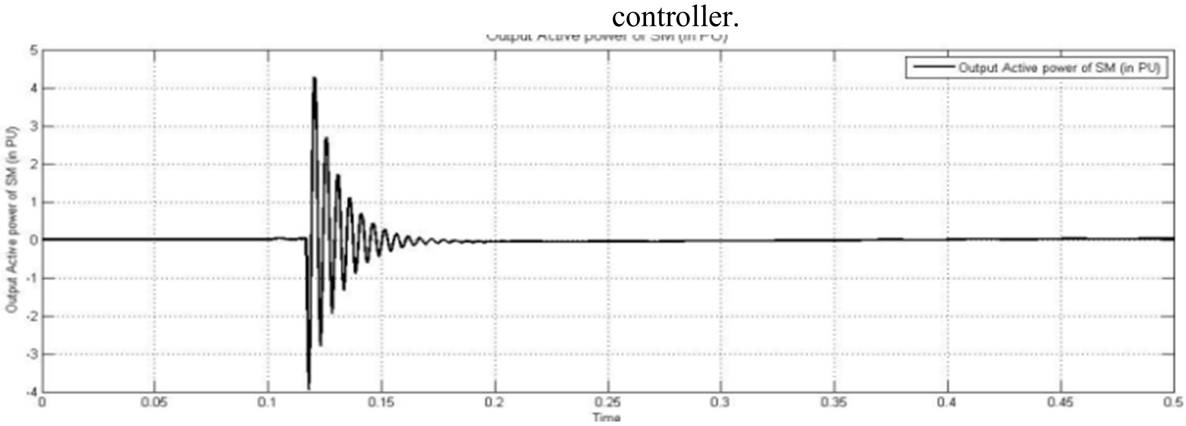

Figure 8: Variation of power with TCSC

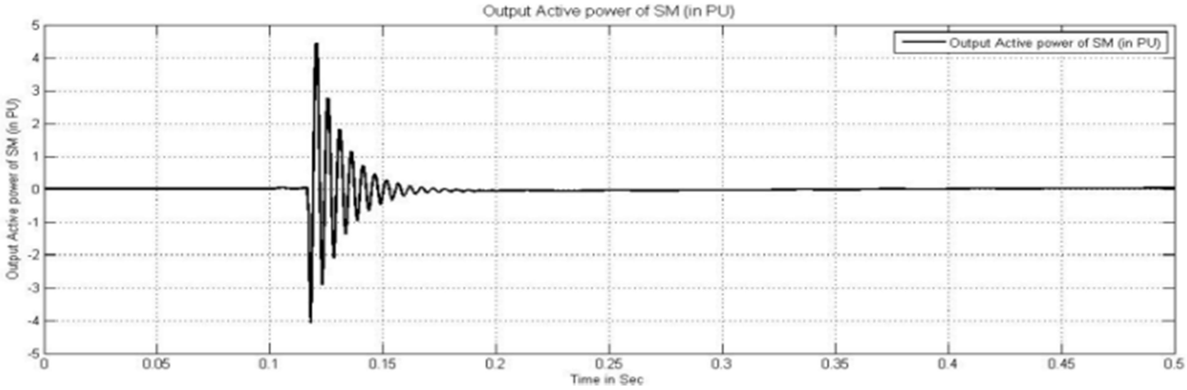

Figure 9: Variation of power with UPFC

IV. CONCLUSION

In his project we compare the transient stability of a two area power system using different types of facts devices like UPFC and TCSC. Here we can conclude that the performance of the UPFC is better for load flow control and voltage control which improves the power system voltage stability when compared to the other FACTS devices like TCSC which improves transient stability and dynamic stability is same in both the FACTS devices. Hence we consider the TCSC for better transient stability of a power system but in other cases we consider UPFC FACTS device for more stability of the power system. Here we compared the facts device with the series and shunt facts devices and hence found out that TCSC has maximum efficiency I the transient stability in a power system. By using this method we can also find the voltage stability of a power system.

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