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Power System Stability Enhancement Using UPFC

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Abstract: **FACTS devices have different applications in power system** related to operation **and control of power system, such as scheduling power flow; damping the power oscillations and enhancing transient stability. It is proved that the FACTS devices are very much effective in power flow control and damping out the swing of the system during fault. Among all FACTS devices the UPFC most popular controller due to its wide area control over power both active and reactive, it also gives the system to be used for its maximum thermal limit. Oscillations in power system are major problem related to power system. This oscillations make the system unstable and system may collapse. To avoid this problem development of FACTS device is very much popular form last few years. Unified Power Flow Controller is one of the facts device use to damp the oscillations and system stability enhancement. The UPFC is the most flexible FACTS equipments. UPFC perform the functions of the static synchronous compensator (STATCOM), thyristor switched capacitor (TSC) , thyristor controlled reactor (TCR), and the phase angle regulator offering the flexibility for the static and dynamic operation of the power network. It controls all the electrical variables of the transmission network.**

***Index Terms*— Oscillations, stability, three phase fault , UPFC model.**

I. INTRODUCTION

Recent years, the power system with high efficiency operation and reliability has been considered more than before. Due to the growth in utilization of electrical energy, the maximum capacity of the transmission lines should be increased. Therefore in a normal condition also the stability and the security is the major part of discussion. Power system is more compound now days due to satisfy the emergent the request and superiority of power. Problem is raised when to fulfill this demand and quality restructuring of existing line required. Rearrangement of the line and increasing demand on the consumers end there is a huge burden on the connected system which is then leads to be stability as well as security problem for the whole existing system. It has been found that a quantity of black out have been caused by the lack of appropriate reactive power management which has to be mitigate also one important thing to be improve is the quality of power supplied to the distribution side. The major problem now days are to mitigate the fault as soon as possible or the fault clearing time should be minute. One other thing is also creating the stability problem is the frequent change in load demand and the excitation system.

II. CONTROL CONCEPT OF UPFC

The classical connection of upfc with transmission line shown on the figure..1. The upfc uses a two back-to back vscs, operated from a common dc link. The converter 2 injects the controllable voltage both magnitude and phase angle to the connected line via series transformer. The converter 1 called statcom supplies or absorbed the real power demand by the converter 2 via dc link which then support the real power exchange between them. Conceptually the upfc can automatically control all the system parameter that affect the power flow in a line, namely, voltage, impedance, and phase angle, hence, the name suggested “unified”. The upfc provides complete control over power flow in the line.

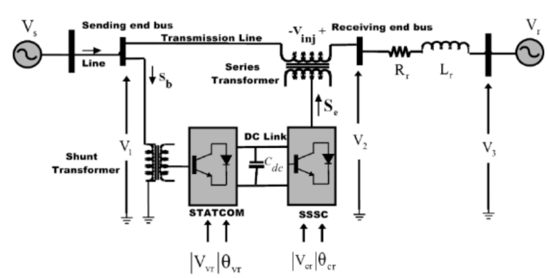


Fig.1 connection diagram of upfc with transmission line

III. UPFC BASED CONTROL SYSTEM

There is two modes of operation
1. PFC mode or automatic mode and
2. Manual voltage injection made

In the power control mode the comparison between the actual and reference values of the active and reactive power is made to produce an error p and q. This error p and q again synthesize by two voltage regulator and the VSC to compute the VD and VQ. Component (VD and VQ are the direct and quadrature axis component with the voltage v1 to control the power flow in the line). In manual voltage injection mode the use of voltage regulator is absent. The voltage of the converter is synthesized by the injected voltage VDREF and VQREF.
Fig 2 shows the block diagram of series converter

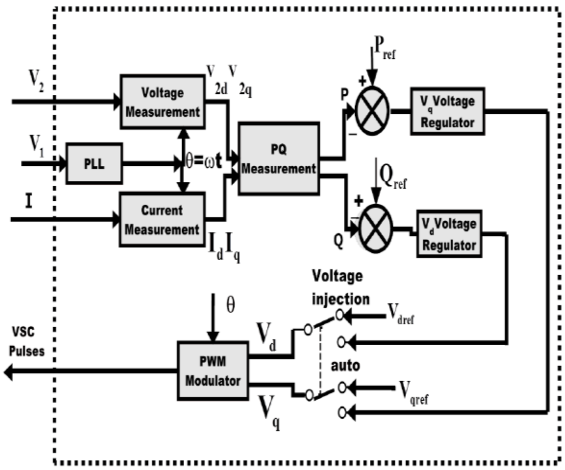


Fig 2. UPFC based control system

IV. POWER SYSTEM STABILIZER

An economic and satisfactory solution to the unstable oscillations a power system produces is to provide additional damping (to rotor windings) for the generator rotor.

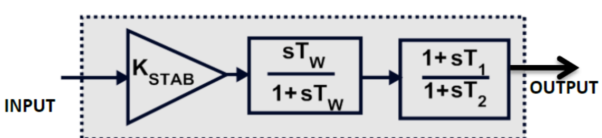


Fig 3 PSS power system stabilizer.

Three main functional blocks:

a. ***The washout gain****:* the gain is simply the proportional gain of the pss.

b. ***The washout circuit****:* at the output of the pss there is a steady state bias which modifies the generator terminal voltage; this is eliminated through the use of a washout circuit. In the input signal the power system stabilizer acts upon only the transient variations. It doesn't however take any action when dc offsets in the signal are present. By subtracting the low frequency components from the input signal (through the use of a low-pass filter essentially) the dc offset present in the signal can be removed

c. ***The dynamic compensator, lead – lag compensation****:* the final process contained within the power system stabilizer is the dynamic compensator. This stage comprises of lead-lag stages and has the transfer function as shown in figure 3 the lead-lag stage utilizes the rotor shaft angular velocity and uses it as the inputs signal.

V. POWER SYSTEM MODEL WITH UPFC

The model of a modest power system comprising of two-hydraulic power plants connected to a power grid the whole simulink model shown in figure.3. A upfc is connected to regulate the power flow in a 500/230 kv transmission line. The power system used under the study is assembled in a loop arrangement, and it combination of five buses (b1, b2, b3, b4, b5).three lines l1 to l3 are connected to make a ring system. Each plant having their own pss, excitation system, speed regulators.

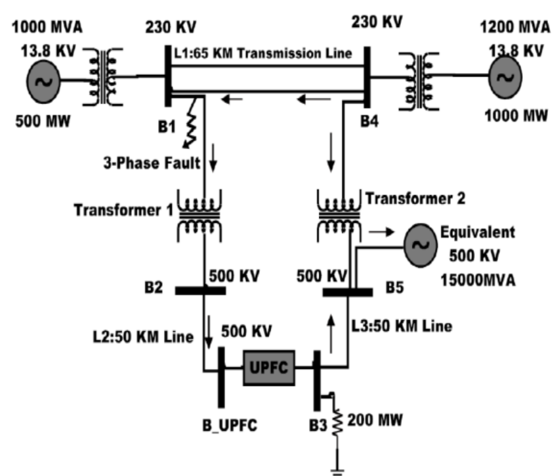


Fig4. Single line diagram of two-machine power system with UPFC controller

The total generating capacity of 1500 mw and load connected are 1500 mva, 500 kv, and 200 mw

VI. SIMULATION MODEL WITH UPFC WITH FAULT

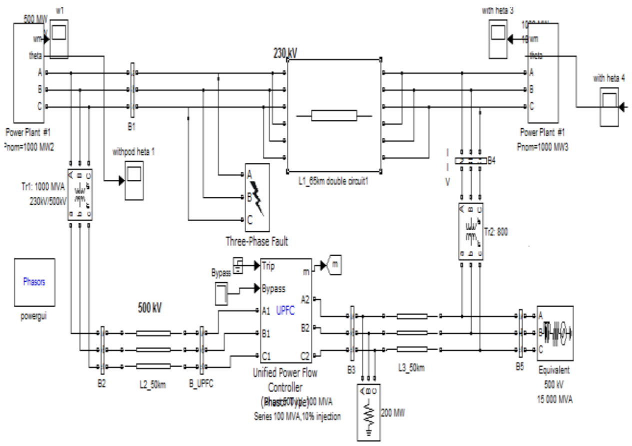


Fig 5. Two machine five bus system models with UPFC.

VII. SIMULATION RESULTS

The simulation is carried out for two different types of fault condition.
Case a. S-l-g fault
Case b. 3-ø fault

A. 1.s-l-g fault without UPFC
S-l-g fault created for duration of .2 sec without UPFC then system oscillations as shown in fig 6

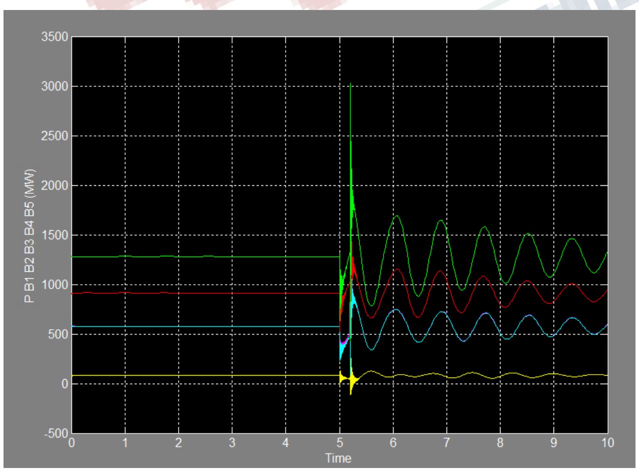


Fig 6. Active power (mw) at different buses without UPFC without PSS

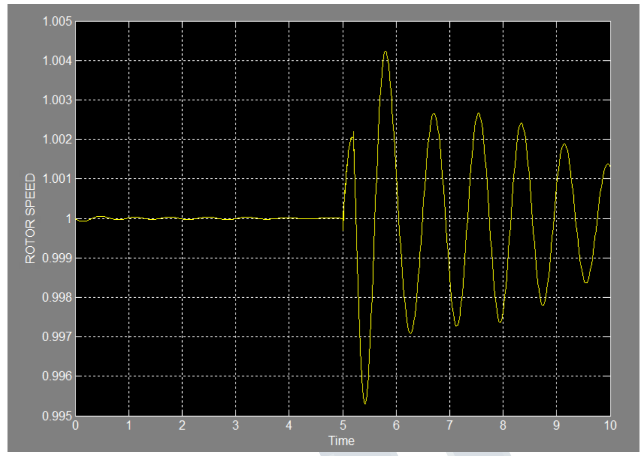


Fig 7 totor speed wm VS time

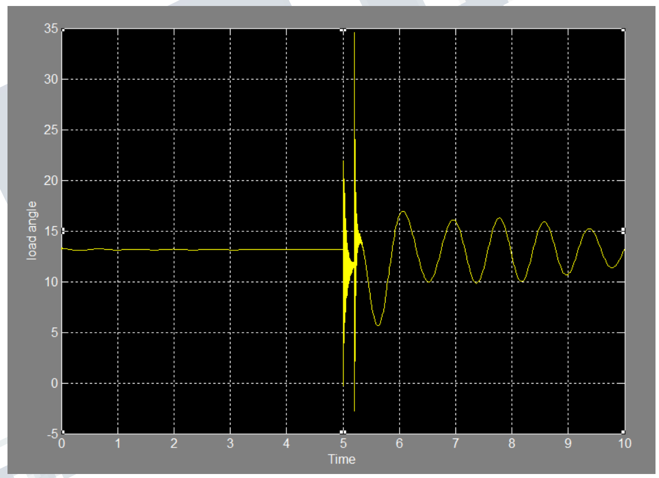


Fig 8 load angle theta VS time without PSS without UPFC

A.2. S-l-g fault with upfc
S-l-g fault created for duration of .2 sec that is from 5to 5.2and upfc is connected then system wil get stable within small duration as shown in fig 9

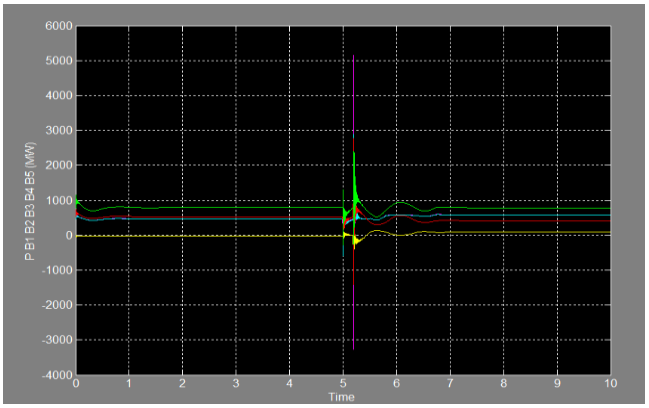


Fig 9 active power (mw) at different buses with UPFC

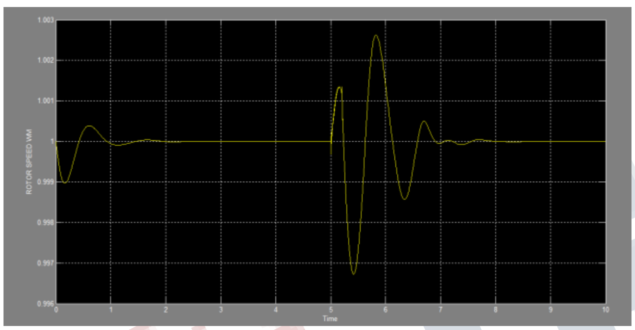


Fig 10 totor speed VS time with UPFC

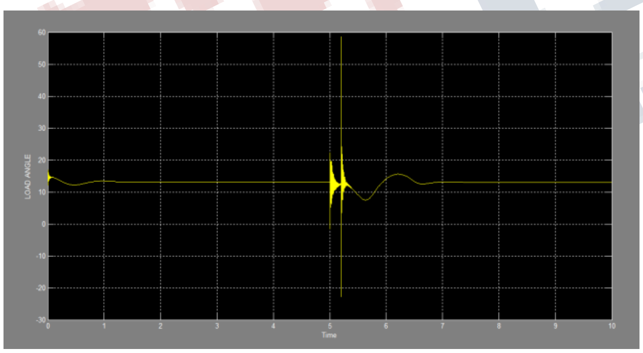


Fig 11 load angle VS time

B.1.3 phase fault without UPFC

3 phase fault created for duration of .2 sec without UPFC then system will be unstable as shown in fig 12

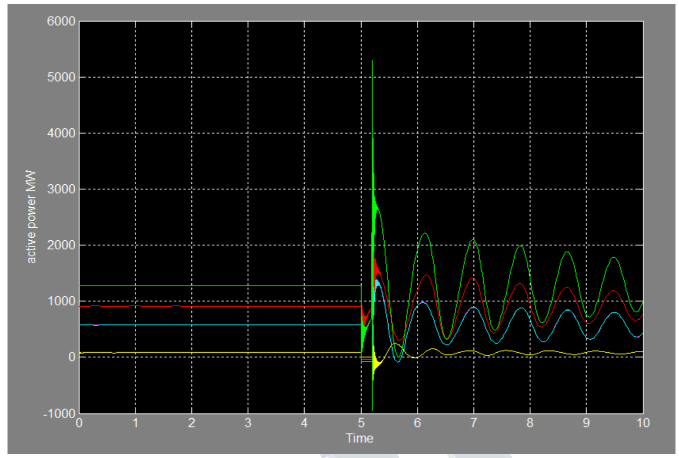


Fig 12 active power (mw) at different buses VS time in sec without UPFC without PSS.

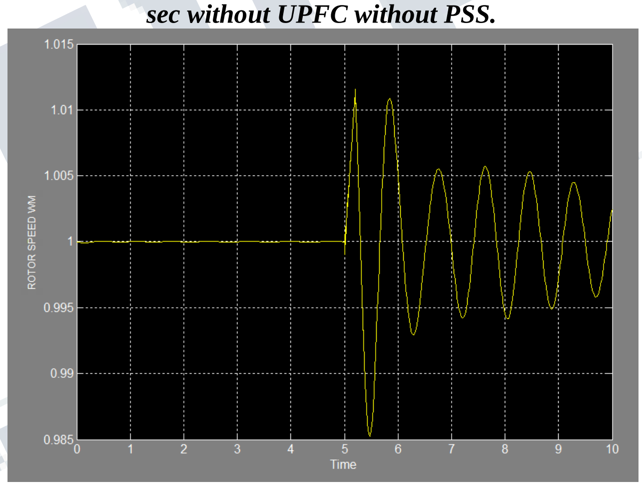
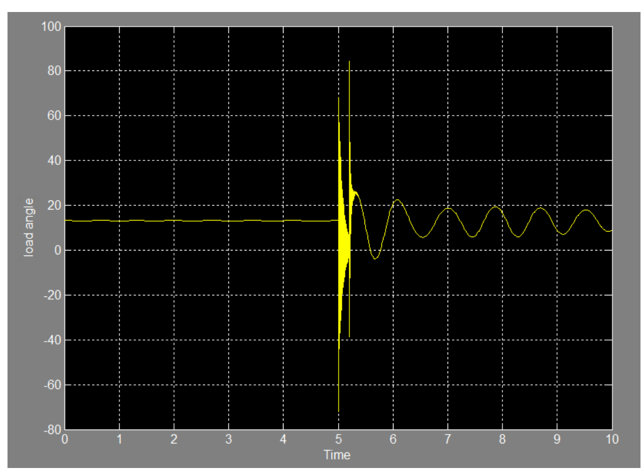


Fig 13 rotor speed WM VS time



B.2. 3 phase fault with UPFC

3 phase fault created for duration of .2 sec that is from 5to 5.2and upfc is connected then system will get stable within a small duration of time as shown in fig 14

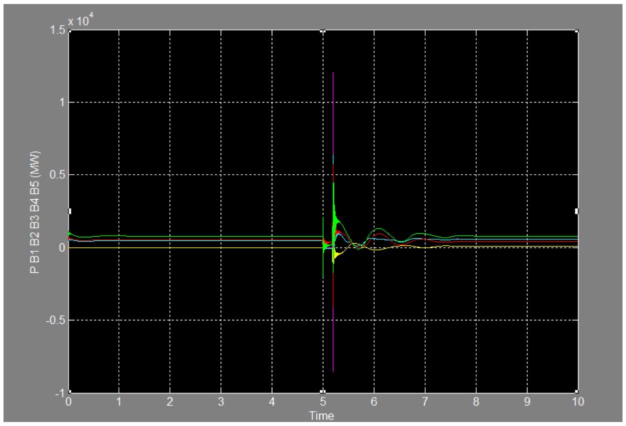


Fig 14 active power (mw) at different buses VS time in sec

		Settling time					
		1 phase fault			3 phase faut		
Status	Upfc	Power	Wm	Theta	Power	Wm	Theta
No upfc	No	∞	∞	∞	∞	∞	∞
Upfc	100 mva	6.5 sec	7.5 sec	6.4 sec	7.5 sec	7.8 Sec	7.5 sec

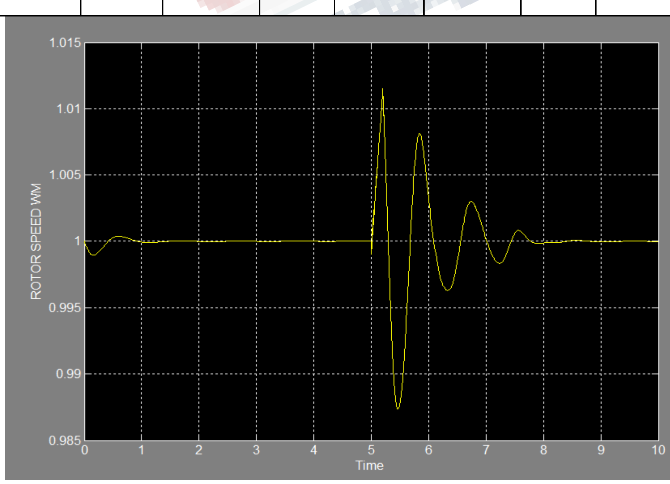


Fig 15 rotor speed WM VS time

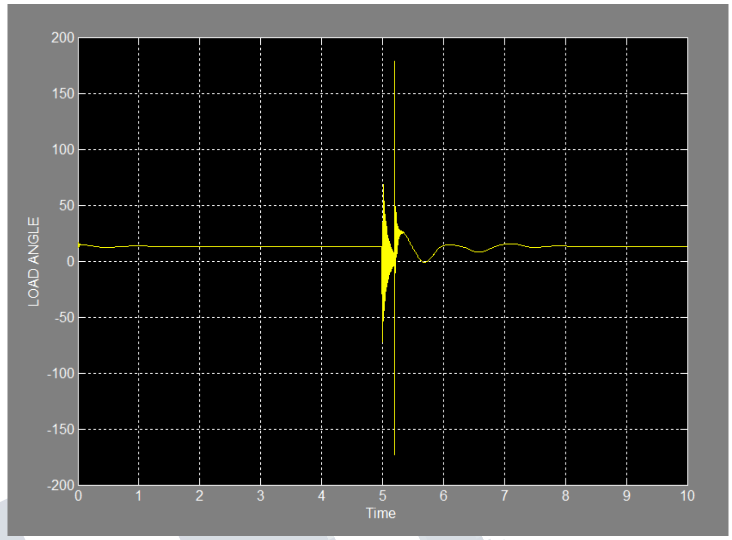


Fig 16 load angle VS time

Table 1
The performance of without UPFC and with UPFC

VIII. CONCLUSION

This paper presents the effectiveness of the upfc on power system stability improvement. Time required for damping power system oscillations is much reduce when use upfc and we get stabilize system in small duration of time. Also upfc is able to damp oscillations in rotor speed and load angle. Pss is used with upfc for effectively damping.we are considered two types of fault that is 1 phase and 3 phase and found that upfc is effectively damp oscillations in active power , rotoe speed and load angle in both the cases.

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