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# Enhancement of Transient Stability Performance of an Inter-area Power System using UPFC on MATLAB Simulink Platform

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***Abstract-*** The improve Transient Stability of a two area power system , UPFC based on conventional P-I control can be connected to verify that the constant power flow from one area to other area, even if severe fault occurs on the line is achieved. For this a Multimachine power system is developed (Kundur test system) and UPFC is connected on line, modeled & designed its series controls. A MATLAB Simulink model for the enhancement of transient stability technique with both without UPFC and with UPFC is developed .By the use and tuning of UPFC controllers (PI regulators) the constant power flow from one area to other area, even if severe fault appears on the line is achieved in transient state. Simulation is carried out in the MATLAB/Simulink platform. Simulations run for duration of 50 sec. with the application of three phase fault, (applied only for the 0.1 seconds and after that it is removed by the auto recloser circuit breakers) to prove that UPFC helps in enhancing transient stability of a Multi-machine power system in the event of severe fault. Detailed simulation studies are carried out with MATLAB/SIMULINK environment for three cases :(a) Without UPFC, without fault (b) without UPFC, with fault(c) with UPFC, with fault.

***Key words-*** FACTS, MATLAB, Simulink, Transient stability, Two-area power system, UPFC

**I. Introduction**

Present-day multi-machine power system or interconnected power systems (consists of many SG's having the different inertia constants, connected with heavily loaded and weakly connected large transmission network) are vast and highly complex systems to control. Power System, in general is interconnected and there is a great need of improvement in electric power utilization by maintaining reliability and security. With the increased loading of long transmission lines, the problem of transient stability after a major fault can become a transmission-limiting factor. Recent development of power electronics introduces the use of FACTS controllers to enhance controllability and increase of power transfer capability in a very fast manner.

UPFC is the most versatile one that can be used to improve steady state stability, dynamic stability and transient stability. The UPFC can independently control many parameters since it is the combination STATCOM and SSSC. These devices also offer an alternative mean to mitigate power system oscillations.

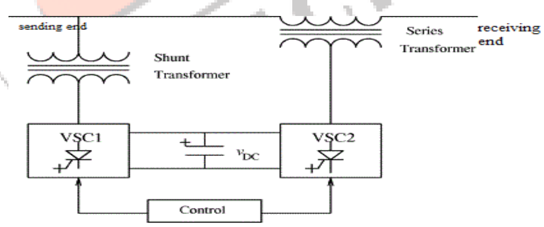


Fig. 1. UPFC

The UPFC as shown in figure 1 consist of two fully controlled inverters, series inverter is connected in series with the transmission line by series transformer, whereas parallel inverter is connected in parallel with the transmission line by parallel transformer, connected to each other by a common dc link including a storage capacitor. The real and reactive power flow in the transmission line can be controlled by changing the magnitude and phase angle of the injected voltage ($V_{SR}$) produced by the series inverter.

## 2. System investigated

For studying transient stability performance of multi-machine power system the model shown in Figure 2 is considered [34, 35, and 36]. In this study, a two-area four-machine power system is considered. Here we are using UPFC for the real power flow control by using series control of the UPFC. By the use and tuning of UPFC controllers, the constant power flow is achieved in transient state. In this study, a two area (interconnected by transmission lines) four machine 11 bus power system is considered The system consists of two fully symmetrical areas linked together by two 230 kV lines of 220 km length. It is specifically designed in two areas to study low frequency electromechanical oscillations in large interconnected power systems. Each area is equipped with two identical round rotor generators rated 20 kV/900 MVA. The load is represented as constant impedances and split between the areas in such a way that area 1 is exporting 413MW to area 2 during normal operating conditions.

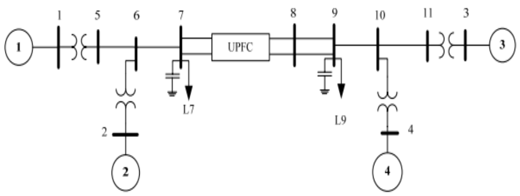


Fig.2– Kundur's inter-area power system with a UPFC

## 3. Simulation results

Simulation Results are carried out using MATLAB/Simulink for the following cases to prove that UPFC helps in enhancing transient stability of a Multimachine power system in the event of fault:

-Without fault and without UPFC

-In presence of fault and without UPFC

-In presence of UPFC based on the PI controller with fault condition

### CASE I (Without UPFC, without fault)

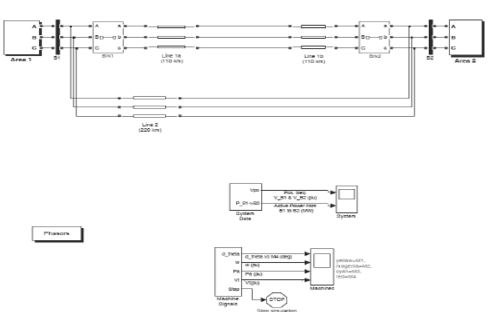

Fig. 3 Simulink model of the system without UPFC and without fault

Fig. 3 is the Simulink model of the system without UPFC and without fault. From Fig 4 to 5 gives results for real power transfer from area A1 to area A2, voltage at B1 & B2. It is found that power exported from area 1 to area 2 is 413 MW.

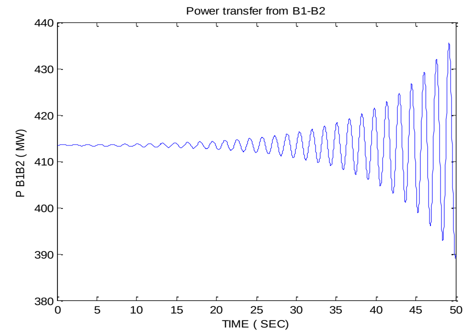


Fig **4** Power transfer from B1 to B2

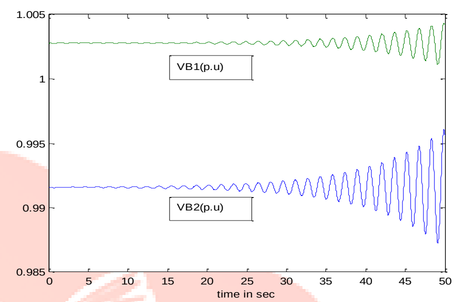


Fig **5.** Voltage at B1, B2

Fig. 6-7 represents inter area & local mode oscillations, without any damping device (PSS or FACTS device). It is observed that system is stable as oscillations are of very low value.

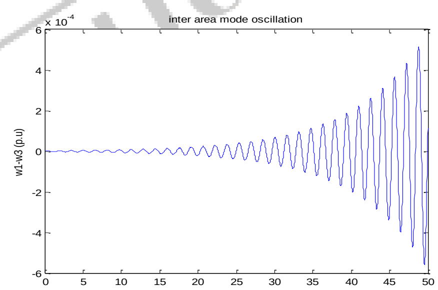


Fig.6 Inter area mode of oscillation

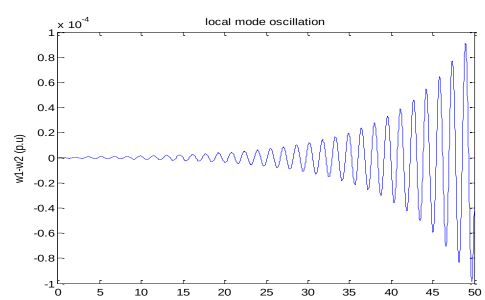


Fig.7 Local mode of oscillation

**CASE II (Without UPFC and with fault)**

Figure 8 shows model of a two-area power system, with the three-phase fault, the fault is applied only for the 0.1 seconds and after that, it is removed by the auto recloser breakers. The purpose of three-phase fault is to produce the transient condition in the system

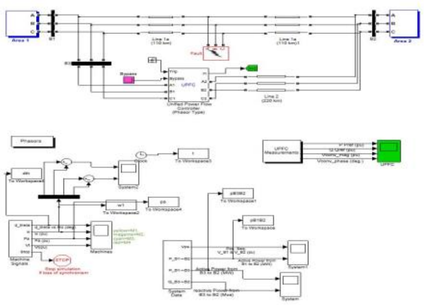

Fig. 8 Simulink model of the system without UPFC and with fault

The results are as shown in fig.9. In this case (without UPFC) due to large fault, it is observed that oscillations are very large which collapses the system i.e. makes the system unstable.

**Fig. 9.** Terminal Voltage and Real Power vs time

**CASE III (With UPFC, with fault)**

To maintain system stability after faults, the UPFC is connected on the tie line (fig.10). Now due to UPFC, the oscillations die out very fast, and we get the steady state of the system. Fig. 11-14 shows results of the system when three phase-to-ground fault is applied for 0.1 sec. (5 cycles) and it is removed by auto recloser circuit breaker (without change in network configurations).The maximum stable power flow possible is found to be 413 MW.

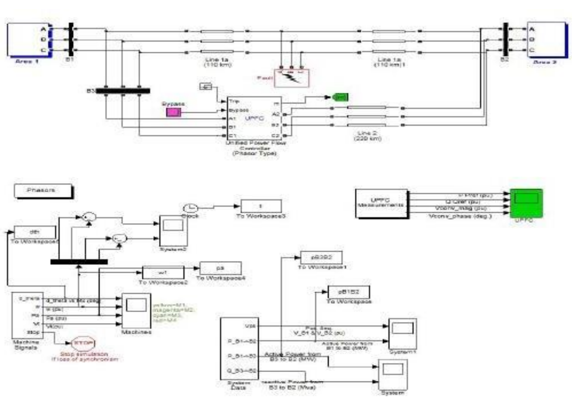

**Fig. 10.** Simulink model of the system with an UPFC and withfault

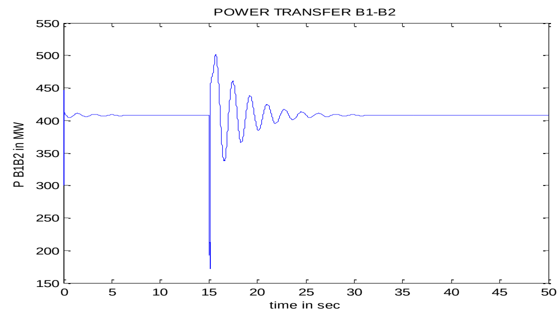


Fig 11 Power transfer from area B1 to B2 (for 3-phase fault).

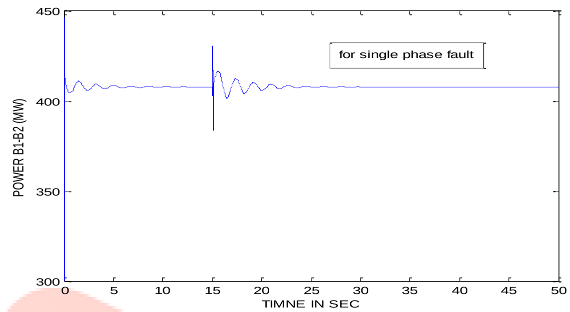


Fig 12 Power transfer from area B1 to B2 (for 1-phase fault).

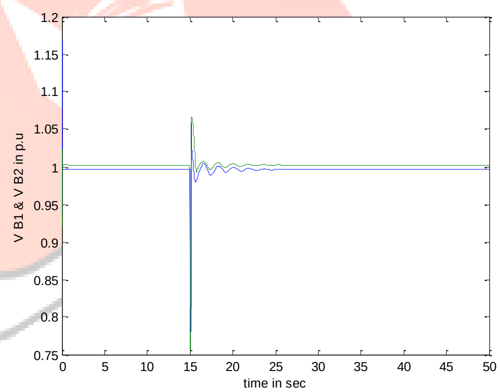


Fig 13 Voltage at B1 & B2

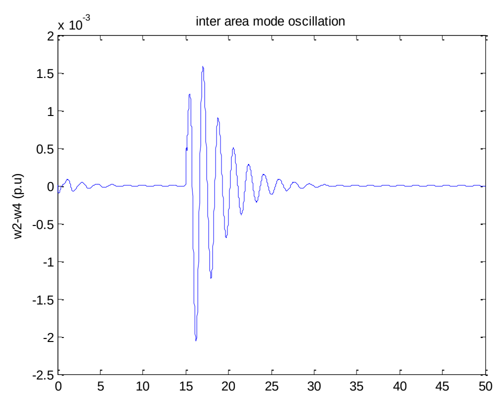


Fig.14 Inter area mode of oscillation

## 4. Conclusion

It is observed that UPFC damps oscillations quickly and makes the system stable even though large disturbances like 3-phase fault is applied suddenly to the system. Constant power flow (413 MW) is maintained from area 1 to area 2. As compared to 3-phase fault UPFC takes less time to damp oscillations when 1-phase fault is applied.

The conclusions drawn from the work are:

- The performance of the UPFC controller under fault conditions has been demonstrated using a two area 4-machine power system.
- When a large disturbance is applied, simulation results show that the UPFC can significantly enhance power system operation and performance.
- By the use and tuning of UPFC controllers the constant power flow (413 MW) from area 1 to area 2 is achieved in transient state.
- The objective of exporting the constant power flow from one area to other area, even if severe fault appears on the line is achieved in transient state by the use and tuning of UPFC controllers (PI regulators).
- Both inter-area and local mode oscillations are damped by the P-I controller based UPFC for secure system operation.

## 5. Future scope

Most of the controllers for FACTS devices are based on the PI controller. Although the PI controllers are simple and easy to design, their performance deteriorates when the system operating conditions vary widely and large disturbances occur. In this work tuning of PI controllers are done manually by hit and trial method. However, the PI type controller cannot yield a good control performance if a controlled object is highly nonlinear (real system is nonlinear) and uncertain. To take care of the nonlinearity, fuzzy logic controller or any artificial intelligence technique can be employed to replace PI Controller.

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