Power Flow Control In Power System using UPFC

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***Abstract*— To control the power flow for increasing the transmission capacity and optimizing the stability of the power system, FACTS devices are used. One of the most widely used FACTS devices is Unified Power Flow Controller (UPFC). In this paper the transient stability of nine bus systems is studied under severe disturbance in MATLAB-Simulink. Active/reactive Power, Power angle, angular speed during the various fault conditions i.e. LLL fault is studied. By load flow analysis the Transient behavior of the multi machine system is analyzed. By using a UPFC the oscillation introduced by the faults, the rotor angle and speed deviations can be damped out quickly than a system without a UPFC**.

Keywords— Transient stability, MATLAB-Simulink, UPFC

I. INTRODUCTION

The classical model of a multi machine may be used to study the stability of a power system for a period of time during which the system dynamic response is dependent largely on the kinetic energy in the rotating masses. The classical three-machine nine-bus system is the simplest model used in studies of power system dynamics and requires of minimum amounts of data.

The UPFC is the most versatile of the FACTS devices. It can not only perform the functions of the static synchronous compensator (STATCOM), thyristor switched capacitor (TSC), thyristor controlled reactor (TCR), and the phase angle regulator but also provides additional flexibility by combining some of the functions of the above controllers. The main function of the UPFC is to control the flow of real and reactive power by injection of a voltage in series with the transmission line. Both the magnitude and the phase angle of the voltage can be varied independently.

The UPFC consists of two branches. The series branch consists of a voltage source converter, which injects a voltage in series through a transformer. The inverter at the input end of the UPFC is connected in shunt to the AC power system and the inverter at the input end of the UPFC is connected in series with the AC transmission circuit. Since the series branch of the UPFC can inject a voltage with variable magnitude and phase angle it can exchange real power with the transmission line. However the UPFC as a whole cannot supply or absorb real power in steady state (except for the power drawn to compensate for the losses) unless it has a power source at its DC terminals.

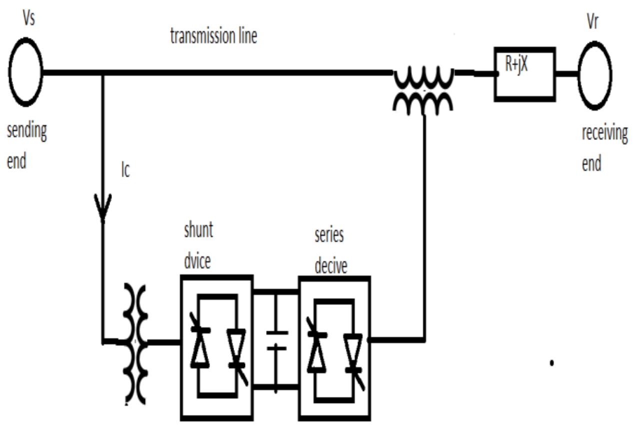

Fig.1 Schematic diagram of UPFC

The UPFC can control the transmission real power, at its series-connected output end, while independently providing reactive power support to the transmission line at its shunt connected input end. Furthermore, the UPFC can independently control real and reactive power flow along the transmission line at its output end, while providing reactive power support to the transmission line at its input end. It has been shown that it is possible to independently control real and reactive power flow at the UPFC input circuit by regulating the DC-link capacitor voltage and varying both the phase angle and the modulation index of the input inverter.

To optimize the cost and optimum use of transmission line compensation is needed, which can either, compensate the voltage, phase shift, or both the increase of voltage and phase shift, and real and reactive power enhancement. Before the introduction of static power electronics device, fixed capacitor, inductor etc. are used for compensation over which control could not be done. So after introduction of FACT devices give a control on the compensation. FACT devices like STATCOM, SVC etc. are only give the shunt compensation .So some controller should need to be used which can give both series and shunt compensation, and 5 increase its transient stability by which the transmission line loading can be closer to their thermal limits.

II. CONTROL OF THE SERIES CONVERTER

I) **Direct voltage injection mode** :-where the converter simply generates a voltage phasor in response to the reference input.

II) **Phase Angle Shifter Emulation mode:-** where the injected voltage is phase shifted relative to the voltage V by an angle specified by the reference input.
III) **Line impedance emulation mode:-** where the series injected voltage is controlled in proportion to the line current.
IV**) Automatic power flow control mode:-** where the reference inputs determine the required real power (P) and the reactive power (Q) at a specified location in the line.

III. CONTROL OF THE SHUNT CONVERTER

I) **VAR control mode :-**where the reactive current reference is determined by the inductive or capacitive VAR command.

II) **Automatic voltage control mode:-** where the reactive current reference is determined by the output of the feedback voltage controller.

IV. ASSUMPTION IN TRANSIENT STABILITY

I) Mechanical input given to the synchronous generator will be constant.
II) Effect of damper winding can be neglected.
III) The voltage at generator and at the bus are assumed to be constant.
IV) Angular velocity of synchronous machine will be assumed as constant.

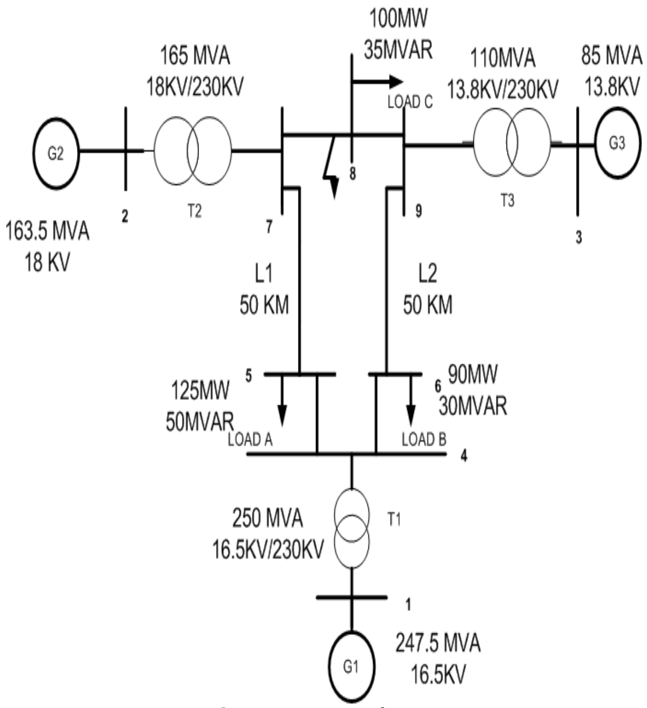

Fig.2 Single Line Diagram of 9 Bus System

The classical model of a synchronous machine may be used to study the stability of a power system for a period of time during which the system dynamic response is dependent largely on the stored kinetic energy in the rotating masses. For many power systems this time is on the order of one second or less. The classical model is the simplest model used in studies of power system dynamics and requires a minimum amount of data hence, such studies can be conducted in a relatively short time and at minimum cost. Furthermore, these studies can provide useful information. For example, they may be used as preliminary studies to identify problem areas that require further study with more detailed modeling. Thus a larger number of cases for which the system exhibits a definitely stable dynamic response to the disturbances under study are eliminated from further consideration.

V. SIMULINK MODEL

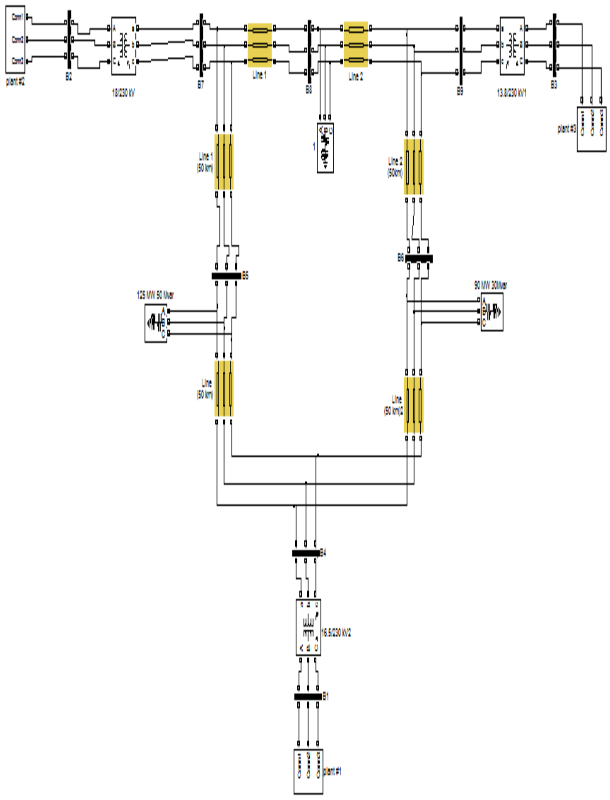
Fig.3 Simulation Diagram of 9 Bus System

The nine bus system consists of three generator buses and three load buses. The generating voltages of three generators are at different voltage levels but they are stepped up into 230 kV for transmission purpose. The nine bus system is shown in the Fig.3.

VI. SIMULATION RESULT

The MATLAB simulation result of the power system is shown in the figure given below. The fault occurred during the period between 4 to 4.1 sec. After 4.1 sec the fault is removed. The relative variation in rotor angle and the change in angular speed of the rotor is examined. Also Active Power, Reactive Power and Bus Voltage is analyzed.

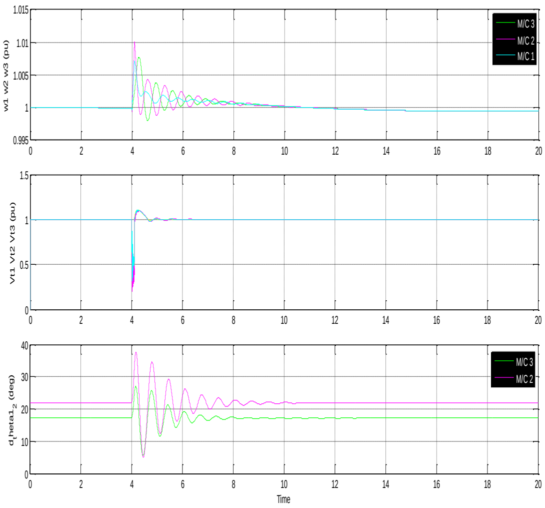

Fig.4 Angular Speed, Generator voltage and Rotor Angle without UPFC.

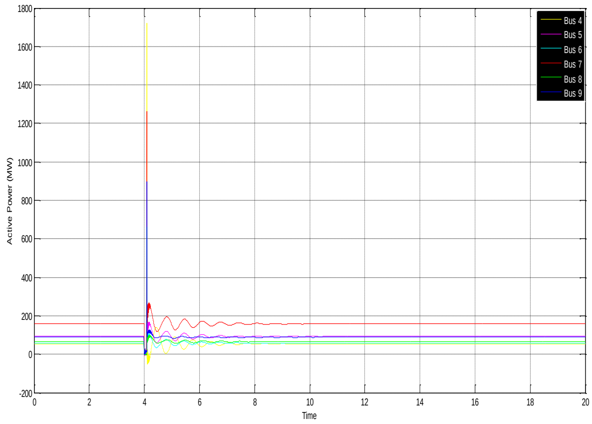

Fig.5 Active Power Without UPFC

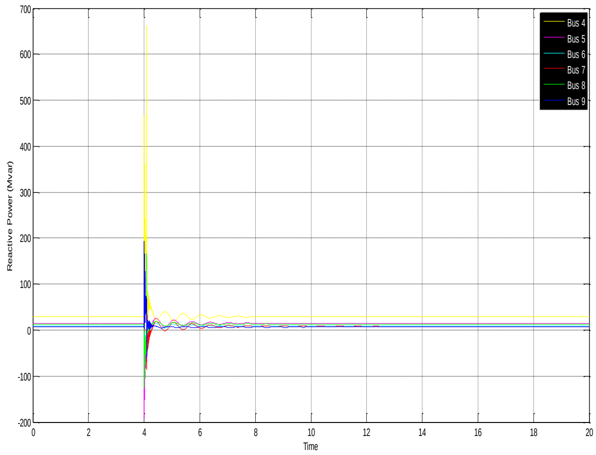

Fig.6 Reactive Power Without UPFC

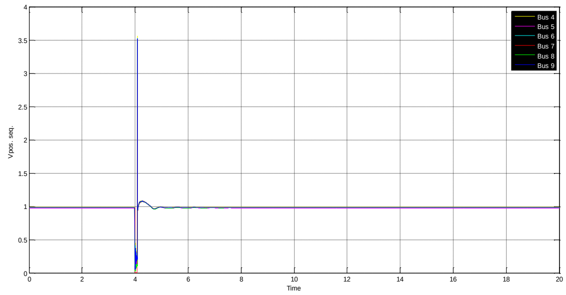

Fig.7 Bus Voltage Without UPFC

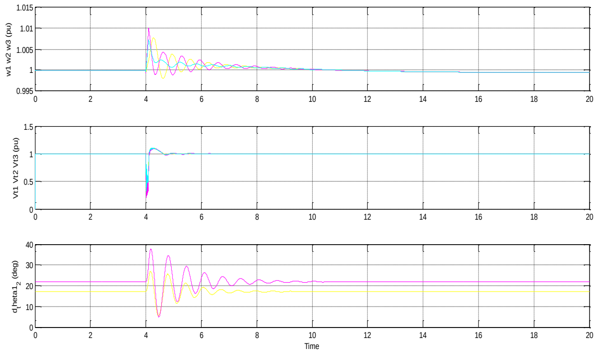

Fig.8 Angular Speed, Generator voltage and Rotor Angle With UPFC Using PI controller.

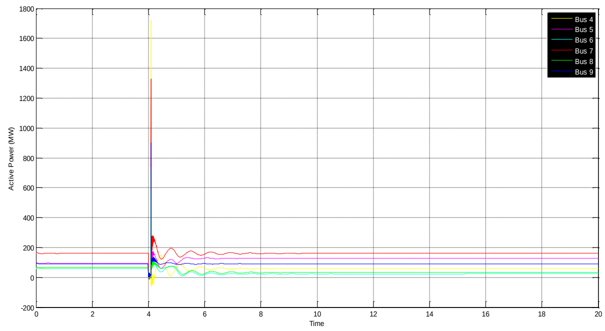

Fig.9 Active Power With UPFC Using PI controller

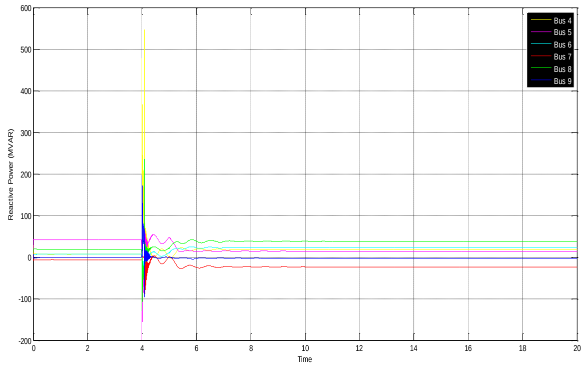

Fig.10 Reactive Power With UPFC Using PI controller

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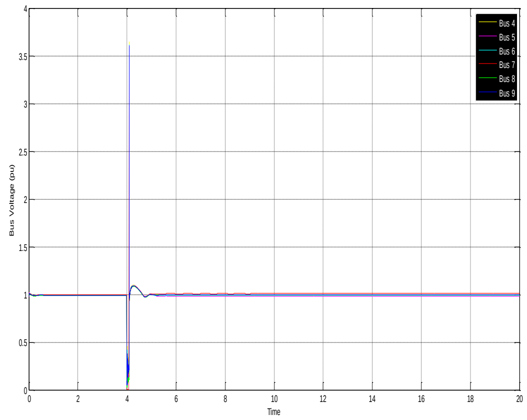

Fig.11 Bus Voltage With UPFC Using PI controller

VII. CONCLUSIONS

From comparative study of the relative variation in rotor angle and angular speed of the three machines nine-bus system is analyzed. Also active power and reactive power and bus voltage of different buses is done. By using a UPFCwe obtain better transient stability performance than the case without a UPFC.

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