International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 03 Issue: 09 | Sep-2016 www.irjet.net p-ISSN: 2395-0072

Power System Stability Using Unified Power Flow Controller

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Abstract - *UPFC is one of the most widely used FACTS devices. To control (Kw) and (Kvar) in power system FACTS devices are usually used. In this paper case study of 9 bus system is considered under the three phase to ground fault in MATLAB Simulink. Active power, reactive power and rotor angle, angular speed during the fault is analyzed.*

Key Words: *MATLAB-Simulink, UPFC*

1.INTRODUCTION

In recent year the technology is advances so that transmission network reliable and easy to design. There are many technologies in interconnected power system such as, HVDC and EHVAC. On other side as power system network grow, the interconnected network become increasingly more composite to operate and system can be less protected for riding through the major outages. The power system interconnected network of today is large and complex. There is widely use of microelectronic, computers and high speed communication for control and protection of present interconnected system. The main purpose of FACTS is to improve system controllability and to increase power system bound by using power automated devices. Generally, FACTS devices are more expensive than HVDC devices. In case study consists of 3 generators nine bus system having three load and three transformer. The single line diagram of nine bus system as shown in fig. 1.It is simple diagram of power system to analyzed dynamic behavior and also power oscillation damping. In this system three phase fault is occurs at bus 8.Duration of fault time is 4 to 4.1 sec. After 4.1 sec. the fault is remove system try to maintained stability, also active power, reactive power and bus voltage of different buses is calculated.

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.

2. 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.

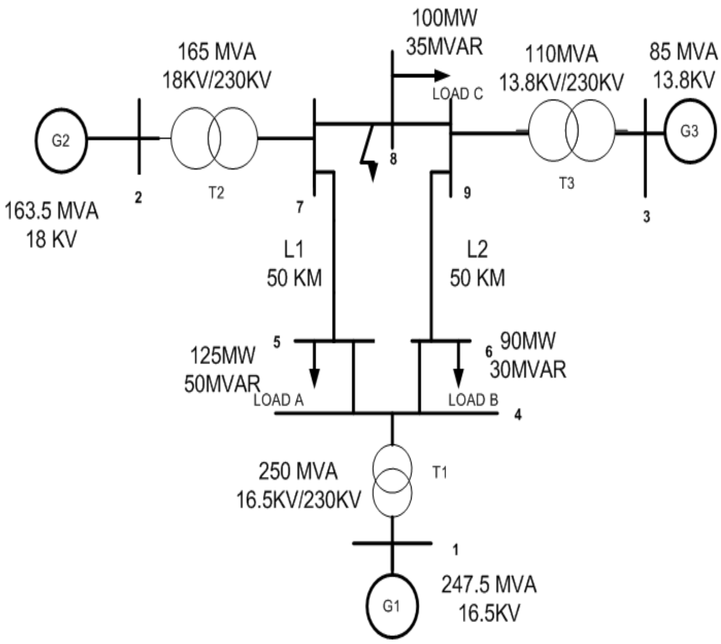

Fig.*1* Single Line Diagram of 9 Bus System

Single line diagram consist of 9 bus power system having generator, load, transformer and transmission line having length 50km. UPFC is connected between buses 7 and 5. Three phase to ground fault takes place at near to the bus no.4. Duration of fault is 0.1 sec. After 4.1 sec. the fault is removed.

The main constraint in a power system i.e. line impedance (XL), terminal voltage (Vt) and rotor angle (δ). The performance of system is studied and damping of the oscillation in rotor angle (δ) and angular speed (dw) is investigated in the three machine of nine bus system.

3. UPFC

Static power electronics device consist of capacitor and inductor etc. are used for compensation. So after introduction of FACT devices give a control on the compensation. FACT devices like STATCOM, SVC, and SSSC.

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. It is to control the flow of KW and KVAR by inoculation of a voltage in series with the transmission line. Magnitude of voltage and the phase angle of the voltage can be diverse independently.

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 some controller should need to be used which can give both series and shunt compensation.

4. STATCOM (Static Synchronous Compensator)

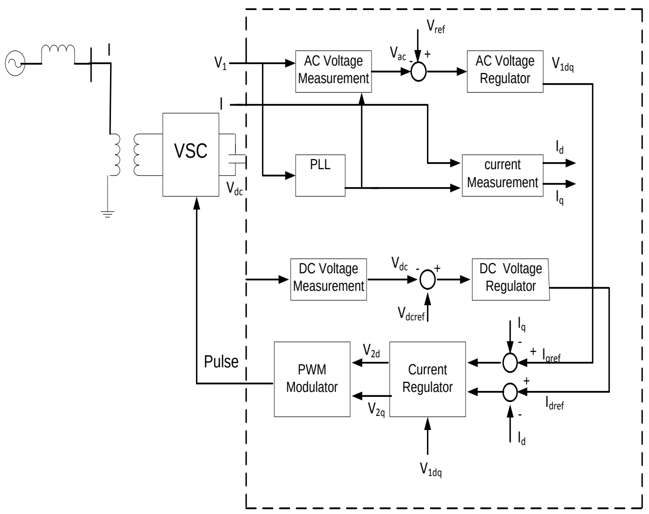

Fig.2 Schematic Diagram of STATCOM

The shunt converter worked as STATCOM. The shunt inverter controls the ac voltage and voltage of dc bus. It uses a two voltage parameter loop inner current control loop and outer loop regulating AC and DC voltages. The control system contains: A phase-locked loop which synchronizes on the positive sequence component of the three phase primary voltage V_1. The output of the PLL is used to calculate the direct axis and quadrature axis component of the three phase voltage and current. Measurement system measured the V_d and V_q component of ac positive sequence voltage and current which can be measured as well as the DC link voltage V_{dc}.

An outer parameter loop comprising of an AC voltage regulator and DC voltage regulator. The output of the ac voltage regulator is the ref. current I_{qref} for the current regulator. The o/p of the DC voltage regulator is the ref. current I_{dref} for the current regulator. The current regulatory control the magnitude phase of voltage generating by the pulse width modulation inverter.

5. SSSC (Static Synchronous Series Compensator)

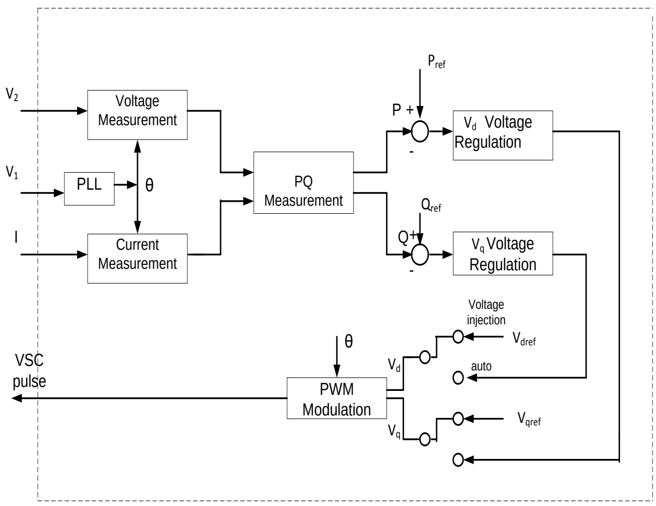

Fig.3 Schematic Diagram of series inverter

It controls the series branch which is different from the SSSC. In the SSSC the two degree of freedom of the series converter is used to control the DC link voltage and reactive power. In case of a UPFC the two degree of freedom is used to control the active power and the reactive power.

The series inverter may operate either in power flow control the measured active power kw and reactive power kvar are compared with value to produce P_{ref} and Q_{ref}. The P and Q error are used by two P.I. regulators to calculate the Vq and V_d component of voltage to be manufactured by the VSC.

6. SIMULINK MODEL

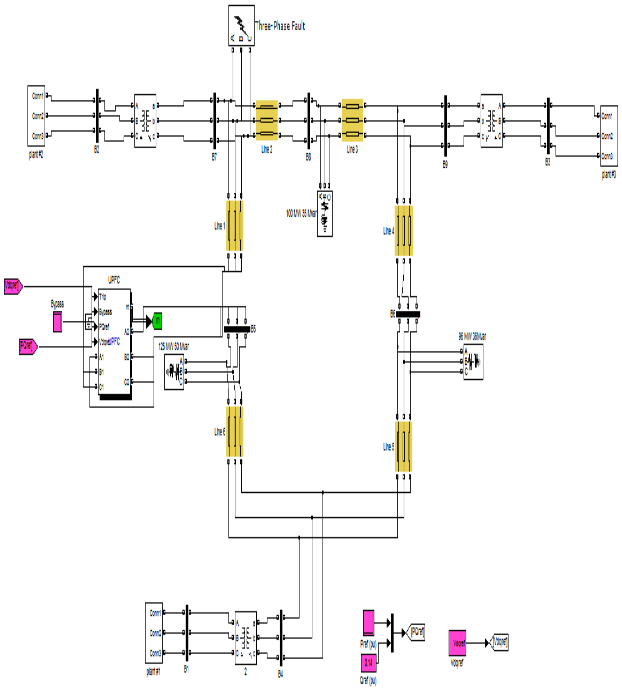

Fig.4 Simulation Diagram of 9 Bus with UPFC System

7. SIMULATION RESULT

The MATLAB simulation result of the power system is shown in the figure given below. The three phase to graund fault takes in between 4 to 4.1 sec. After 4.1 sec the fault is removed. Also Active Power, Reactive Power and Bus Voltage are analyzed.

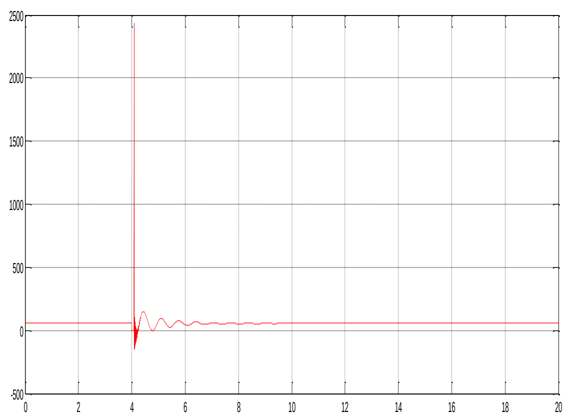

Fig.5 Active Power of Bus no.4 without UPFC

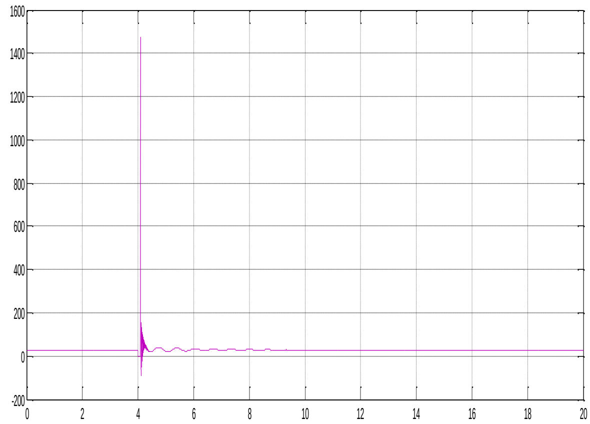

Fig.6 Reactive Power of Bus no.4 Without UPFC

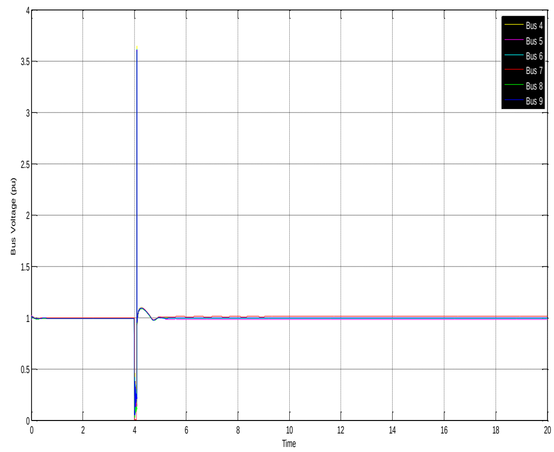

Fig.7 Bus voltage without UPFC

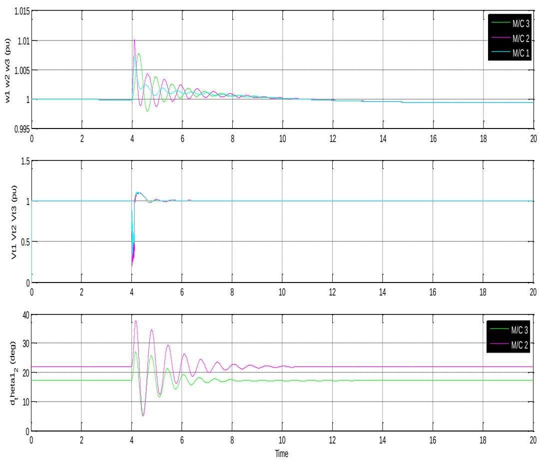

Fig.8 Angular Speed, Generator voltage and Rotor Angle without UPFC.

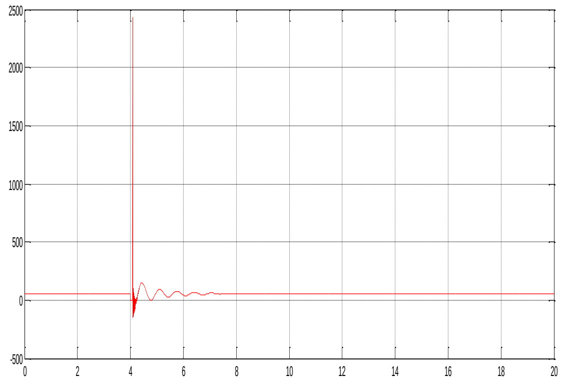

Fig.9 Active Power of Bus no.4 with UPFC Using PI controller

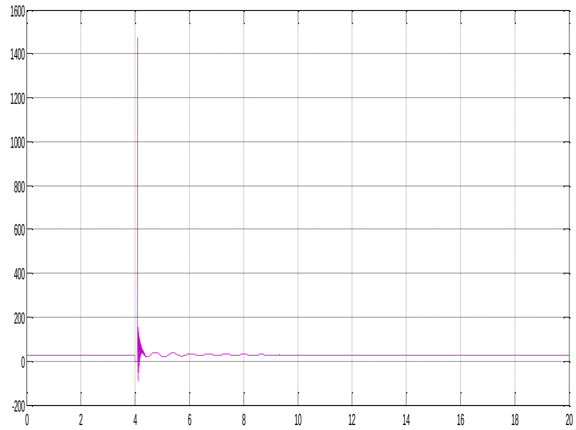

Fig.10 Reactive Power of Bus no.8 With UPFC Using PI controller

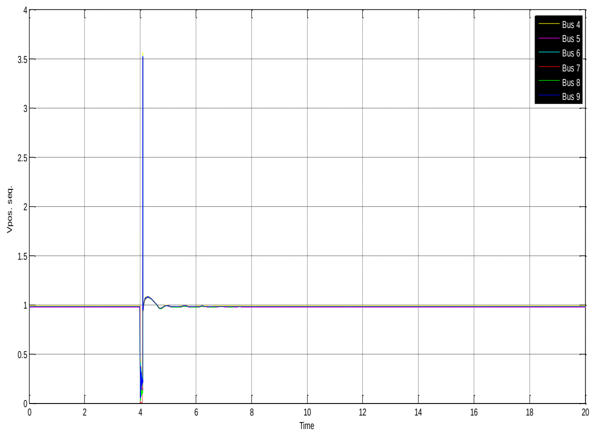

Fig. 11 Bus Voltage with UPFC

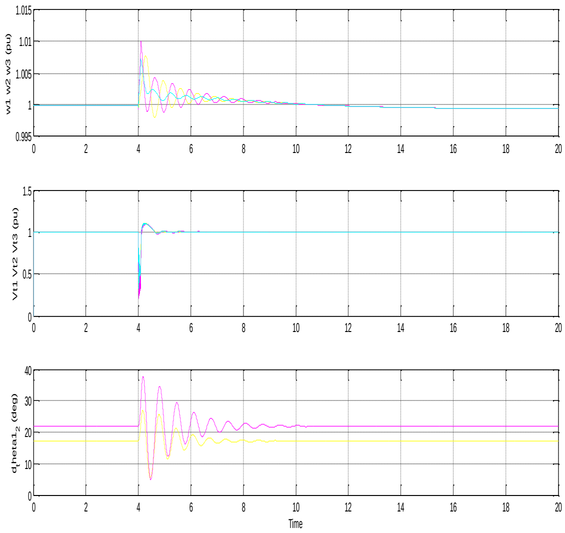

Fig.12 Angular Speed, Generator voltage and Rotor Angle With UPFC Using PI controller

8. 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 of bus is done. By using a UPFC we obtain better transient stability performance than the case without a UPFC.

9. APPENDIX

MACHINE RATINGS

Sr. no	*Generator*	*Transformer*
1	247.5MVA/16.5KV	250MVA,16.5Kv/230kV
2	163.2MVA/18 kV	165MVA,18Kv/230kV
3	85MVA/13.8 kV	110MVA,13.8Kv/230V

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