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Damping of Frequency Analysis using FACTS Devices

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Abstract: FACTS devices help to better stabilise the power systems. They are power electronic devices installed to increase stability of system post any disturbance. Control laws are applied to these existing FACTS devices to improve the damping of frequency oscillations. UPFC is used to damp the frequency oscillation. It can control the parameters of voltages, voltage angles and line impedance and subsequently damp the electromechanical oscillations to improve transient stability. It is capable of analysing and controlling all the factors that effect power flow in a transmission line like voltage and line impedance either simultaneously or selectively.

In this paper, impact of facts devices on power system such as control of power flow, transient stability enhancement, improvement in small disturbance and oscillation damping is studied.

Keywords: UPFC, Power Oscillations, MATLAB, Simulink, Three phase fault

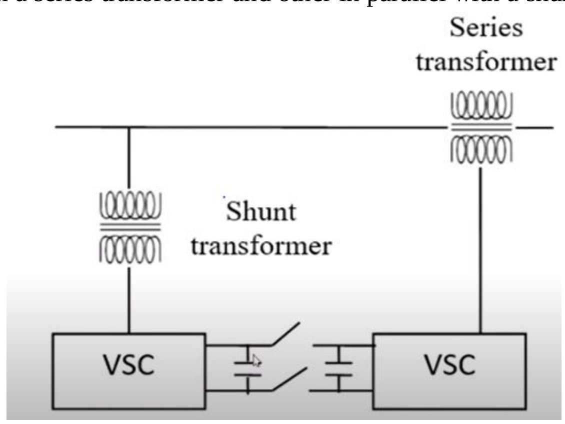
I. INTRODUCTION

In the present decade, transmission systems are becoming increasingly stressed, more difficult to operate due to increase in demand. The ability of power system to maintain or return to its stable condition following a disturbance is known as transient stability. Operating state of system before fault and scale of disturbance defines the transient stability of a power system. As a result , transient stability analysis gained a lot of importance, in terms of maintaining stability through application of FACTS devices.

Electromechanical oscillations in any electrical power system is a typical characteristic of this kind of systems. The occurrence of electromechanical oscillation is not considered as threat to the system operation, provided the damping associated with them lies above the specified limit. But if damping associated is less, it can cause major threat to the system. Hence, appropriate FACTS devices like UPFC and IPFC were used to damp these oscillations and improve stability of the power system.

II. WORKING AND CONFIGURATION OF UPFC

UPFC can control all the parameters of transmission line which influence the power flow. Power flow is influenced by voltage of sending end or with receiving end voltage and the impedance. It contains two VSC i.e voltage source converters . Right one is connected in series with the line through a series transformer and other in parallel with a shunt transformer in between.



The dc link of both the VSC are connected through a switch. When the dc link switch is open it can work independently as STATCOM or SSSC.In this AC-AC power converter, real power can flow in both direction of two converters. Each VSC can independently generate and absorb reactive power .VSC connected to shunt transformer can generate controllable reactive power, thus providing shunt reactive compensation independently.

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III.ADVANTAGES OF UPFC

There are various advantages of UPFC:

- *A.* It is capable of controlling all the parameters that effect power flow like voltage and line impedence of a transmission line either simultaneously or selectively.
- *B.* Has unique feature of injecting voltage at any phase angle.
- *C.* It can control real power (without altering reactive power).
- *D.* With DC common link open, it can be operated as SSSC, or STATCOM independently.
- *E.* Voltage regulation can be achieved continuously with variable in-phase and anti-phase voltage injection.
- *F.* Reactive control can be achieved by injecting series voltage in quadrature with line current, equivalent to capacitive or inductive impedance compensation.
- *G.* Phase angle regulation can be achieved by injecting series voltage with the desired phase angle, without changing the magnitude of line voltage
- *H.* Separate source/sink is not required for real power exchange, as one of the end buses provides/absorbs the real power as per transmission line parameters.

IV. CASE INTRODUCTION

System under consideration consists of transmission network in loop configuration. System consists of five buses interconnected through three transmission lines and two transformers. Total load is met by two power plants located on 230 KV system. Bus 1 is taken as a slack bus. The two synchronous generators are used to meet the demand of real power by loads. Loads are considered as constant PQ loads. Circuit diagram for system under consideration is shown below for reference.

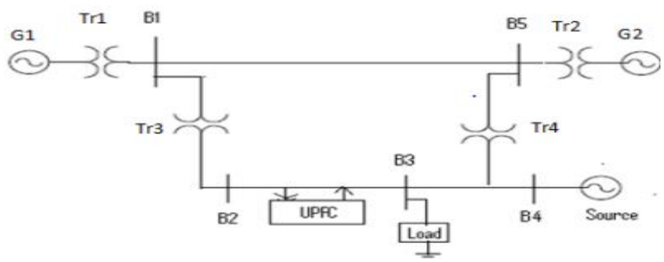

Fig 1: System under consideration

1500 MW is generated from two power plants. Load of 200MW is connected to bus 3. To study the effect of FACTS devices in damping electromechanical oscillation and power system stabilizer without fault and with fault in a multimachine system, three case have been taken into consideration:

1) Simulation model without UPFC and without any fault.
2) Model with three phase fault.
3) Simulation model with UPFC and three phase fault.

A. Case 1: Simulation Model Without Any Disturbance(Healthy System)

In this system, since no fault is there so this is a healthly system without any oscillations. Ideally there is no fault created between B1 and B5 and UPFC is absent on the line connecting buses B2 and B3.

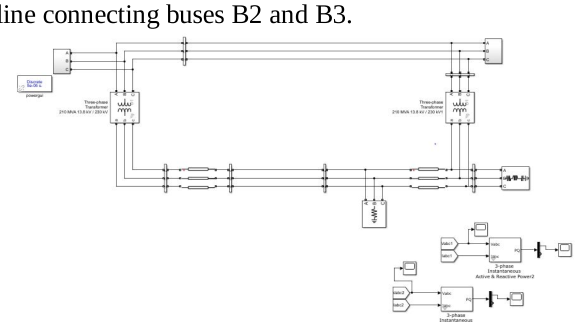

Fig 2: Model of system without fault and UPFC

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B. CASE 2: Network Without UPFC with Fault

In this model UPFC is not connected but a disturbance is created in system by adding a three phase fault at the top transmission line.

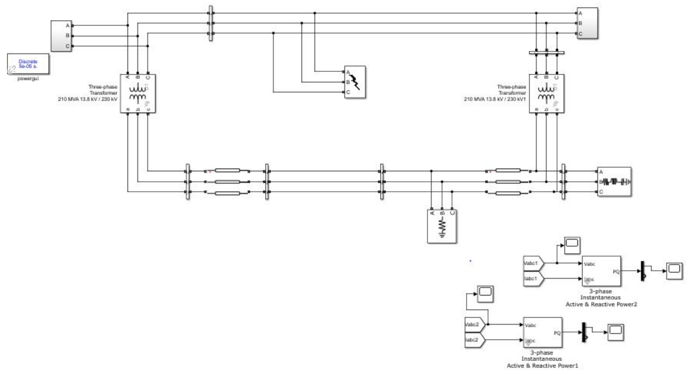

Fig 3: Model of system with fault

C. CASE 3: Network with UPFC and Disturbance

In this model, along with generation of three phase fault at line connecting bus 1 and bus 2, UPFC is also connected near bus B2 and B3 to account for damping of electromechanical oscillations.

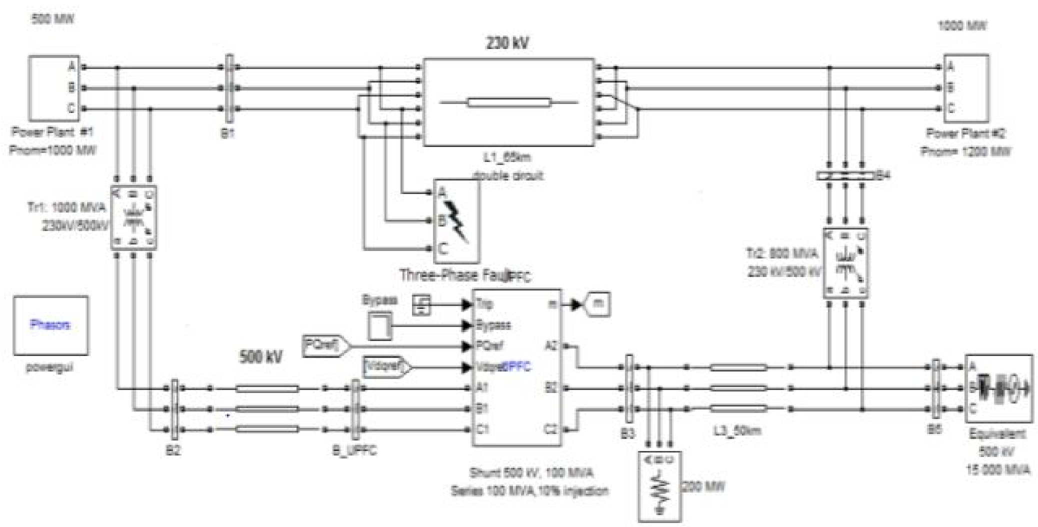

Fig 4: Model of system with fault and UPFC

V. MATLAB SIMULATION RESULTS

Digital Simulation studies are carried out using MATLAB. The above diagram is considered to study the effectiveness of UPFC in damping of oscillations for disturbances created using three phase fault.

A. Considering Two Machine Five Bus Healthy System I.E Without Creating Any Disturbance In It, The Scope Will Show The Results Without Any Oscillation

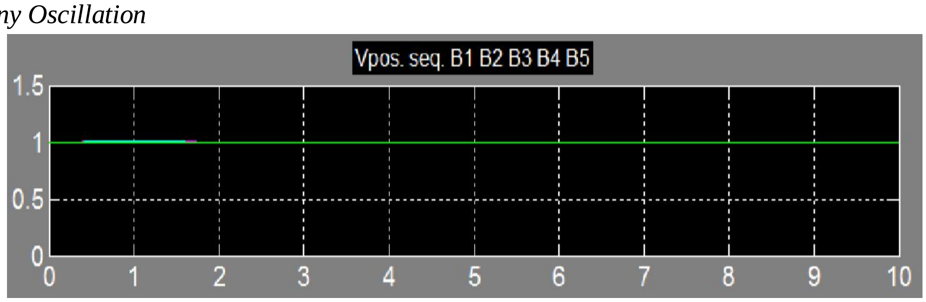

Fig 5: Bus voltages at all the buses without fault expressed in pu

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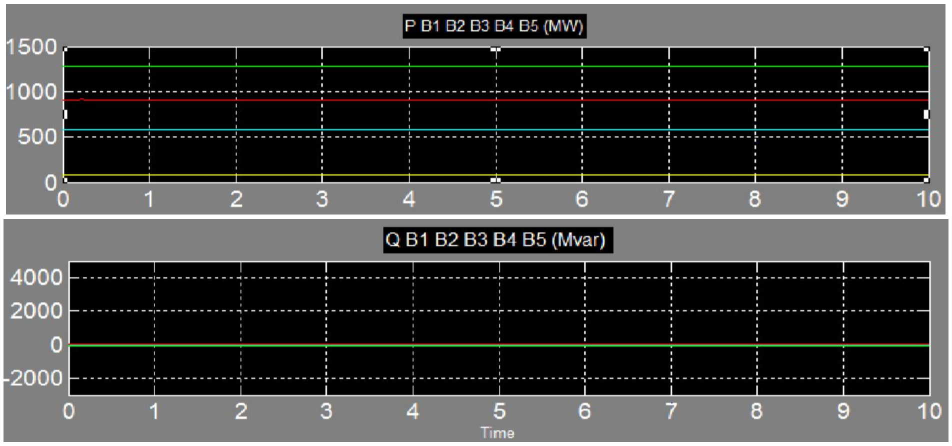

Fig 6: Active power at buses without fault

B. Simulation Results For System With Three Phase Fault

When three phase faults is created in a system, it becomes unstable. Hence oscillations can be seen in voltage and power waveforms. These oscillations damp out after certain amount of time. But since no facts device is connected in this system, so it takes significantly takes large amount of time.

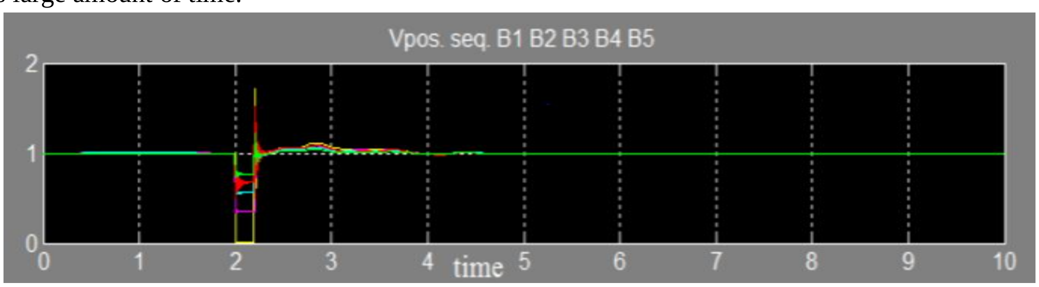

Fig 7. Bus voltage waveforms when three phase is created

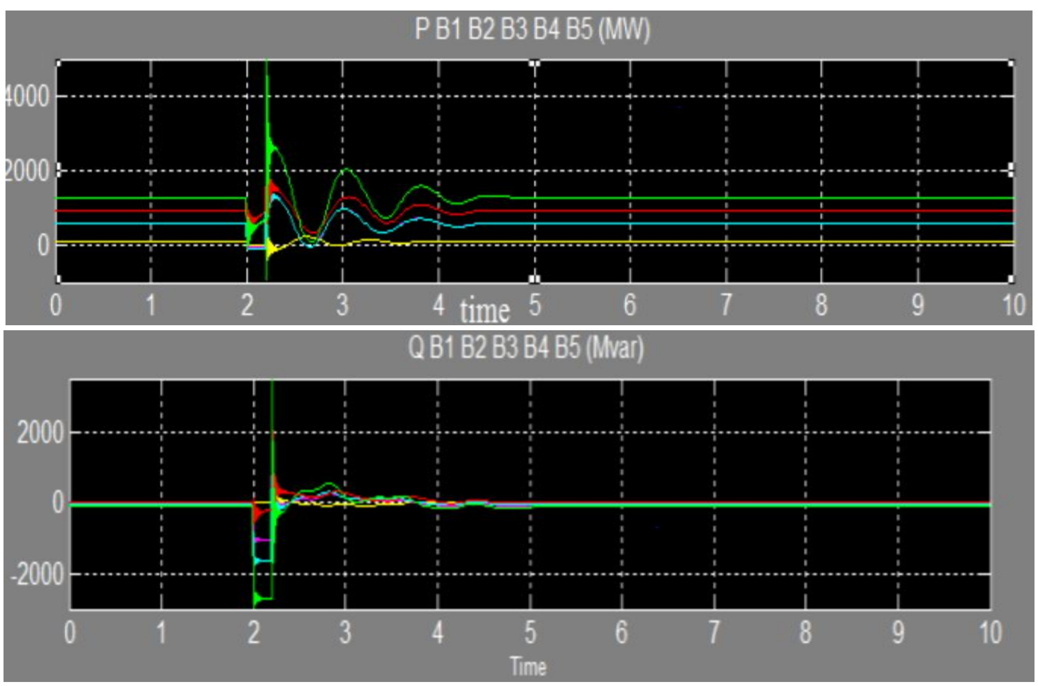

Fig 8. Variation on active and reactive power due to fault

C. Simulation Results For System with UPFC And Three Phase Fault

During the fault if UPFC is applied then voltage becomes stable much earlier as compared to one without UPFC. Hence, using UPFC oscillations damp out much faster than before, thus making system stable in quick time.

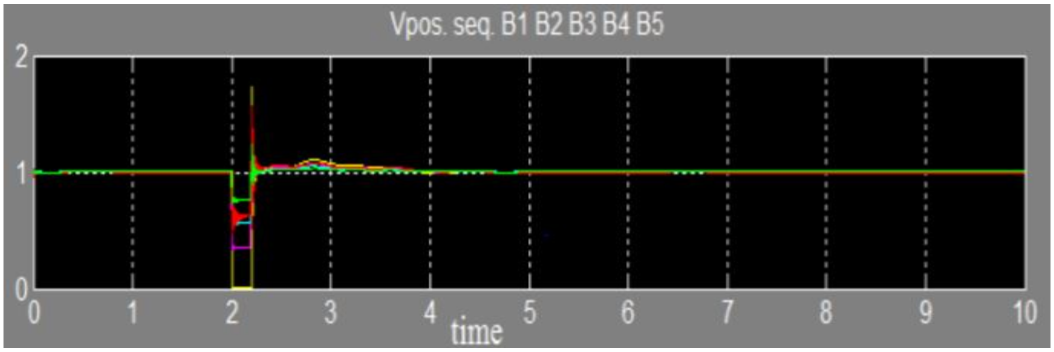

Fig 7. Bus voltage waveforms when UPFC is connected

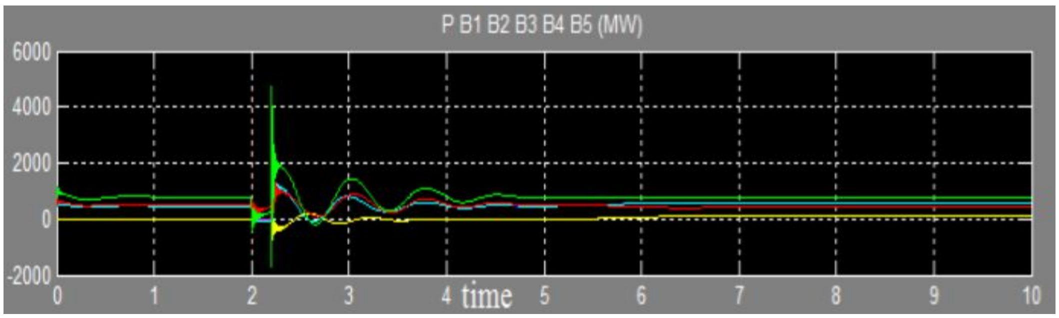

Fig 8. Active voltage waveforms

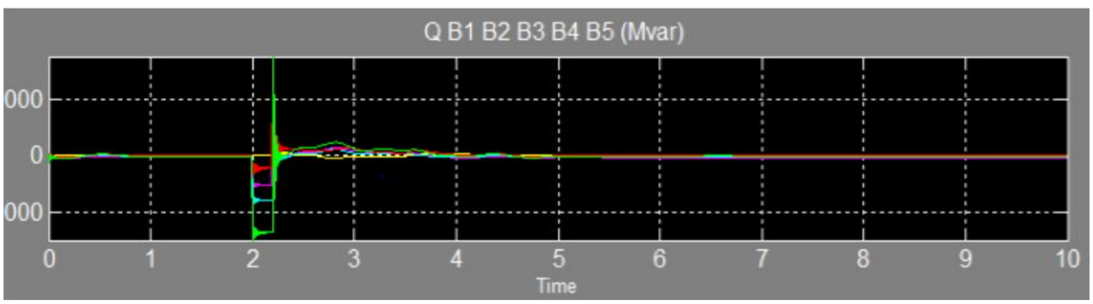

Fig 9: Reactive voltage waveforms at all buses with UPFC connected in system.

VI. CONCLUSION

The load angle of machine increases when disturbance is created and decreases during the post fault period.

From the above graphs it is clear that UPFC is efficiently able to damp out oscillations in power system when large disturbance is created. As oscillations are damping out quickly, system retains its stability quickly.

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