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STABILITY ANALYSIS USING UPFC

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ABSTRACT
Flexible AC Transmission Systems (FACTS) is an Alternating current transmission systems incorporating power electronic based and other static controllers with an aim to build flexibility in the system in order to enhance controllability and increase power transfer capability.FACTS Controller is a power electronic based system and other static equipment that provide control of one or more AC transmission system parameters. The term FACTS controllers describes power electronic based circuit configuration applied in ac transmission systems. FACTS represent flexible ac transmission system, with the term 'flexible' implying the controllability of voltage and/or current.

KEYWORDS: FACTS, Capability, ac transmission,Flexible

INTRODUCTION
The FACTS is a concept based on power electronic controllers, which enhance the value of transmission networks by increasing the use of their capacity. As these controllers operate very fast, they enlarge the safe operating limits of a transmission system without risking stability.FACTS technology also opens up new opportunities for controlling and enhancing the usable capacity of present, as well as new upgraded lines [1,16,19].Flexibility of Electric Power Transmission is the ability to accommodate the changes in the electric transmission system or operating conditions while maintaining sufficient steady state and transient margins.

A large number of literatures are available on FACTS devices. The author has done a thorough literature survey on FACTS devices. Outcome of some of the literature are dealt with briefly in the following paragraphs:

Baker, M. H.etal in [1], suggested the advantages of FACTS controllers for power system stability. Different series, shunt ,combined series- shunt devices are also discussed.

Cavaliere, C.A.C. Watanabe, E.H.etal in [2] suggested about static synchronous compensators (STATCOM) operating in electrical systems where the voltages are unbalanced and contain negative sequence components.

In balanced systems the STATCOM has a very good performance, allowing compensation of capacitive or inductive reactive power with a fast transient response. However, when there are negative sequence components, the STATCOM has its performance diminished. An analytical analysis, using the instantaneous power theory and the switching functions technique, and simulations of a STATCOM quasi 48-pulses using the electromagnetics transients program (ATP-EMTP) show how STATCOM is affected by negative sequence components and how its performance is degraded. A proposal to improve the STATCOM performance under negative sequence unbalance is shown.

De Assis, T.M.L.,Watanabe, E.H.,Pilotto, L.A.S etal in [3] suggested a new technique to control reactive power oscillations using a multipulse STATCOM. It is shown that the voltage oscillations can be controlled in a simple way maintaining the STATCOM DC voltage constant. As the reactive power flow in a specific circuit is directly related to the magnitude difference of the terminal voltages, the desired reactive power generation to control the voltage is obtained automatically when the converter voltage is maintained constant. A simplified analytical analysis is performed in a power system with an arc furnace and a 12-pulse STATCOM. The study has shown that the STATCOM can compensate the furnace reactive current, even when fast oscillations occur. The system studied was implemented in a detailed EMTP simulation program. The results show that the flicker level can be reduced at the cost of a larger size STATCOM DC side capacitor.

El Moursi, M.S., Sharaf, A.M. [4] suggested the dynamic operation of novel control scheme for both Static Synchronous Compensator (STATCOM) and Static Synchronous Series Compensator (SSSC) based on a new full model comprising a 48-pulse Gate Turn-Off thyristor voltage source converter for combined reactive power compensation and voltage stabilization of the electric grid network. The complete digital simulation of the STATCOM and SSSC within the power system is performed in the MATLAB/Simulink environment using the Power System Blockset (PSB). The STATCOM scheme and the electric grid network are modeled by specific electric blocks from the power system blockset, while the control system is modeled using Simulink. Two novel controllers for the STATCOM and SSSC are presented in this paper based on a decoupled current control strategy.

CONTROLLABLE PARAMETERS FOR FACTS CONTROLLERS

There are few basic points that are to be considered regarding the possibilities of power flow control. These are:

- Control of the line impedance X can provide a powerful means of current control.
- When the angle is not large, which is often the case, control of X or the angle substantially provides the control of active power.
- Control of angle which in turns control the driving voltage, provides powerful means of controlling the current voltage and hence active power flow when the angle is not large.
- Injecting a voltage in series with line, and perpendicular to the current flow, can increase or decrease the magnitude of the current flow. Since the current flow lags the driving voltage by 90 degree, this means injection of reactive power in series, can provide a powerful means of controlling the line current, and hence the active power when the angle is not large.
- Injecting a voltage in series with line and with any phase angle with respect to the driving voltage can control the magnitude and the phase of the current. This means that injecting the voltage phasor with variable phase angle can provide powerful means of precisely controlling the active and reactive power flow; this requires the injection of both active and reactive power in series.
- When the angle is not large, controlling magnitude of one or the other line voltages can be a very cost effective means for the control of reactive power flow through the interconnection.
- Combination of the line impedance control with a series controller and voltage regulation with a shunt controller can also provide a cost effective means to control both the active power flow and reactive power flow between the two systems.

UNIFIED POWER FLOW CONTROLLER (UPFC)

The Unified Power Flow Controller (UPFC) is the most versatile member of the Flexible AC Transmission Systems (FACTS) family using power electronics to control power flow on power grids.

The UPFC uses a combination of a shunt controller (STATCOM) and a series controller (SSSC) interconnected through a common DC bus as shown on the figure below. This FACTS topology provides much more flexibility than the SSSC for controlling the line active and reactive power because active power can now be transferred from the shunt converter to the series converter, through the DC bus. Contrary to the SSSC where the injected voltage Vs is constrained to stay in quadrature with line current I, the injected voltage Vs can now have any angle with respect to line current.The popular Western System Coordinated Council (WSCC) 3-machines 9-bus practical power system with loads assumed to be represented by constant impedance model. UPFC consists of two switching converters, which in the implementations considered are Voltage Sourced Converters (VSC) using Gate Turn-Off (GTO) thyristor valves.These converters are operated from a common D.C. link provided by a D.C. storage capacitor. his arrangement functions as an ideal A.C. to A.C. power converter in which the real power can freely flow in either direction between the A.C terminals of the two converters and each converter can independently generate (or absorb) reactive power at its own A.C. output terminal. In principle a UPFC can perform voltage support, power flow and dynamic stability improvement in one and the same device.

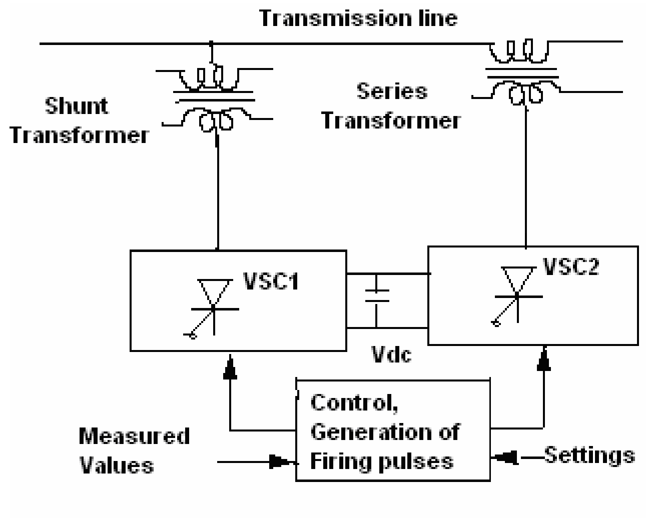


Figure 1: Block Diagram of UPFC

OPERATING PRINCIPLE OF UPFC

T The basic components of the UPFC are two voltage source inverters (VSIs) sharing a common dc storage capacitor, and connected to the power system through coupling transformers. One VSI is connected to in shunt to the transmission system via a shunt transformer, while the other one is connected in series through a series transformer.

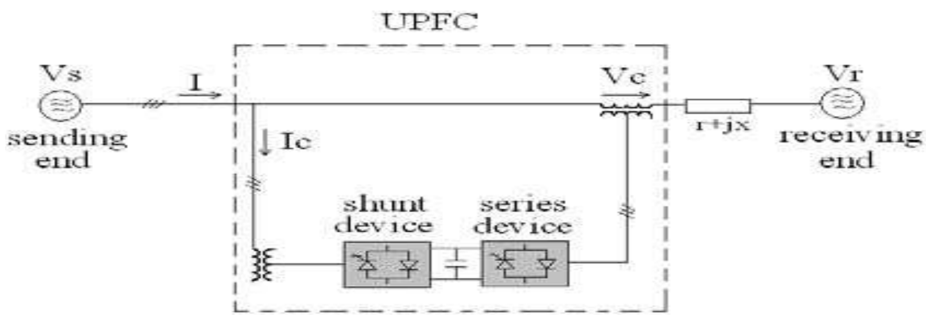
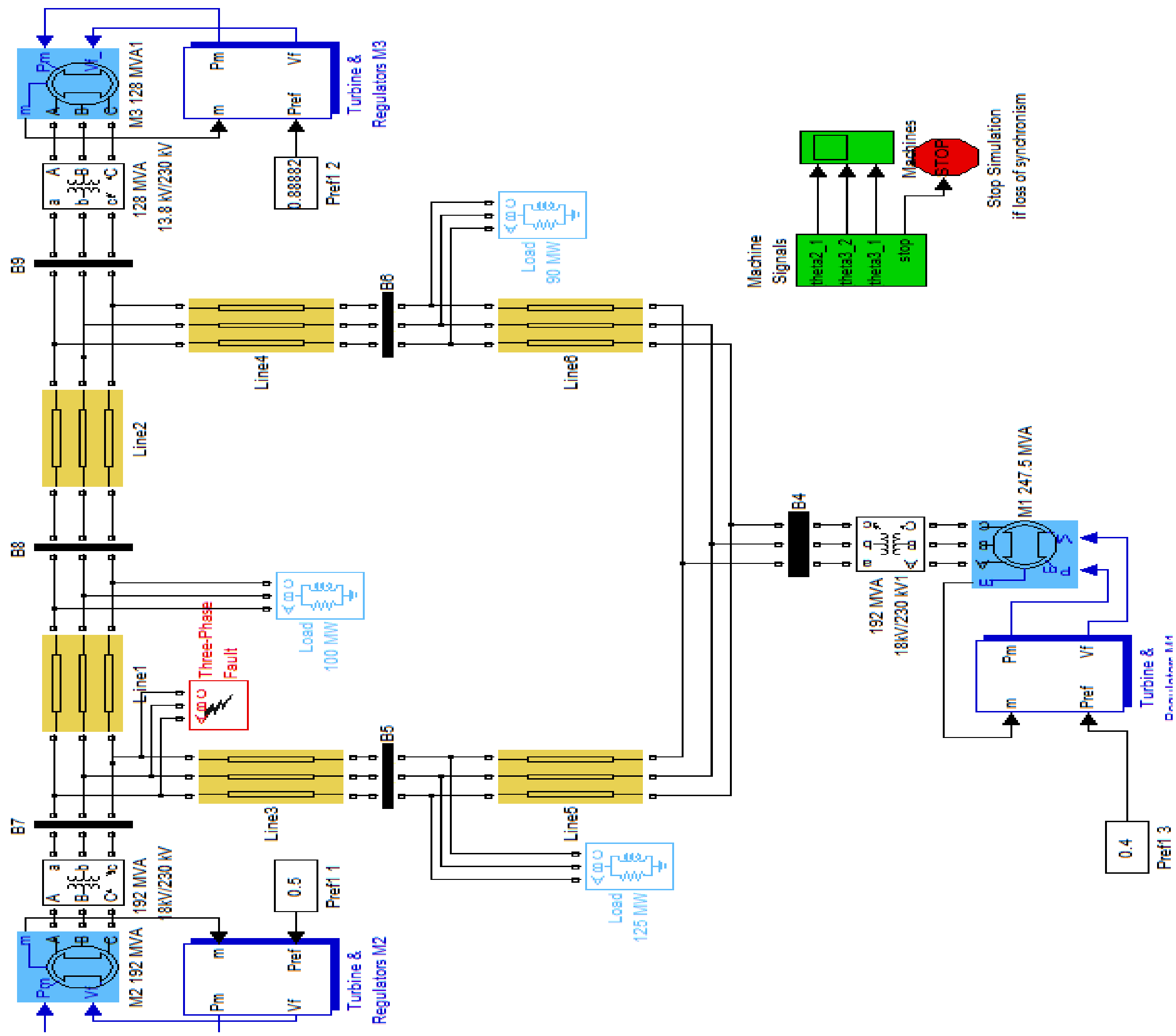


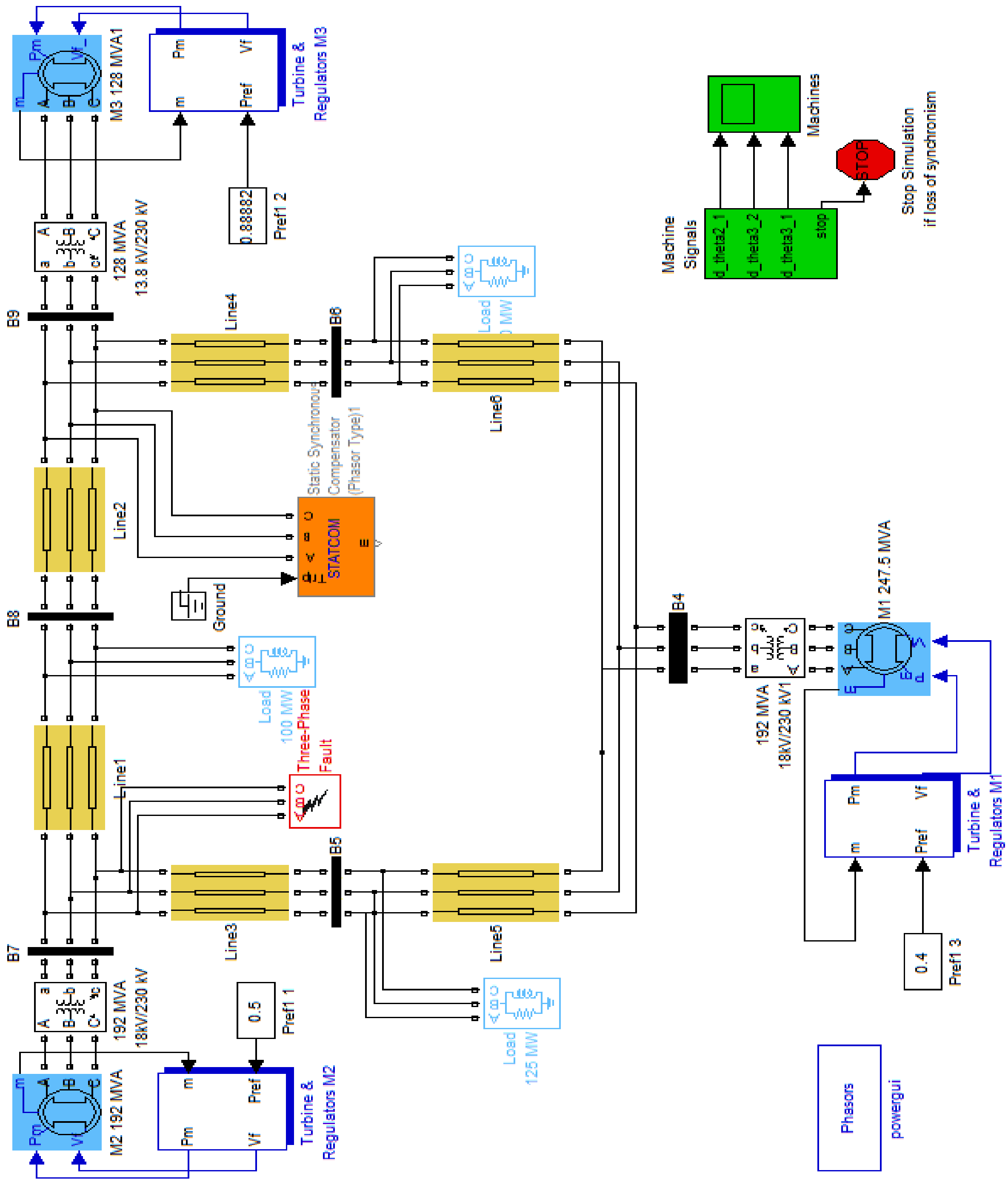
Figure 2: A Basic UPFC functional scheme

MATLAB/SIMULINK MODEL OF MULTI-MACHINE (3-MACHINE 9-BUS) SYSTEM



SIMULATION RESULTS FOR MULTI-MACHINE SYSTEM

a) STATCOM is placed between Bus 8 and Bus 9



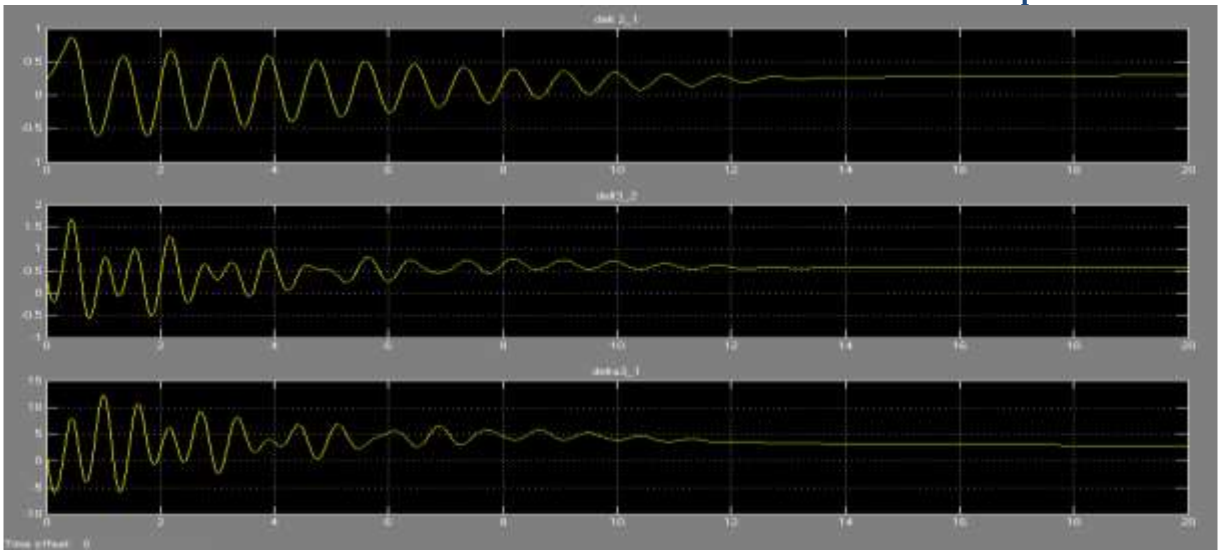


Figure shows the relative angular positions for delt2_1, delt3_2and delt3_1 for multi-machine system with STATCOM controller placed between Bus 8 and Bus 9 and fault taking place between Bus 5 and Bus 7.The total simulation time taken is 20 sec.

Stability time for STATCOM placed between Bus 9 and Bus 6

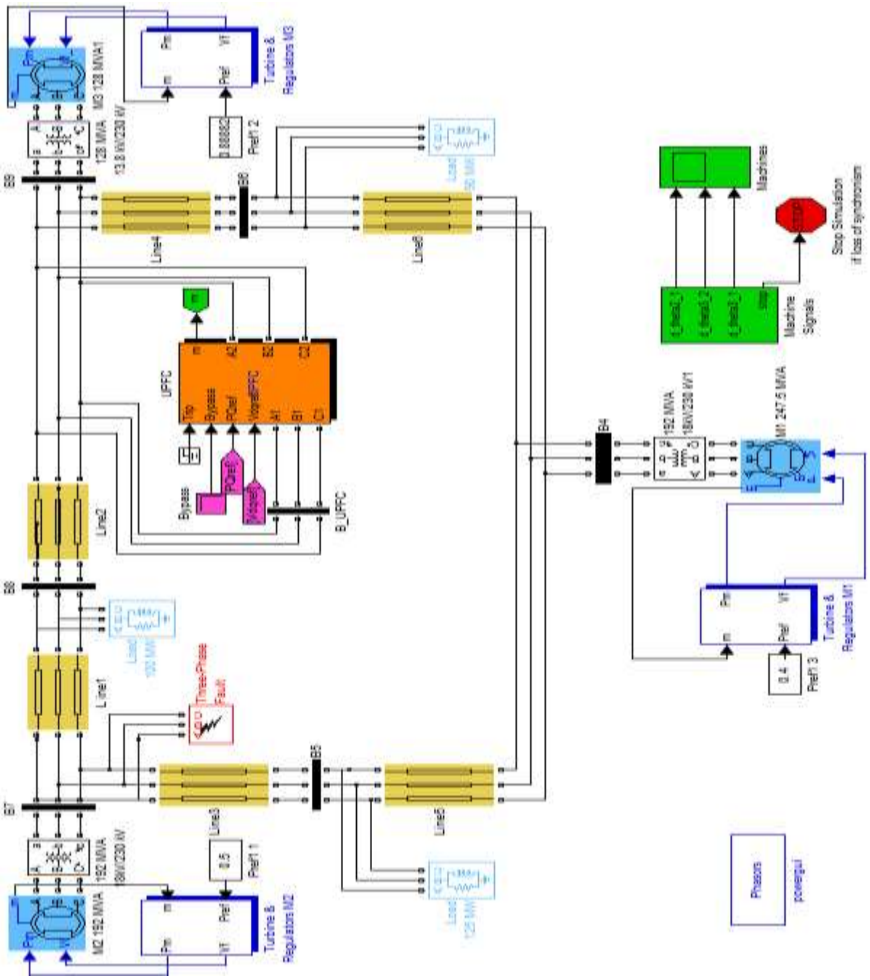
FAULT POSITION	STATCOM POSITION	Stability time for delt2_1 (in sec.)	Stability time for delt3_2 (in sec.)	Stability time for delt3_1 (in sec.)
Between Bus 5 & Bus 4	Between Bus 9 & Bus 6	13.8	13	12

It is clear from the table that the time required by delt3_1 to get stable is minimum i.e 12 seconds

b) UPFC is placed between Bus 6 and Bus 9
Figure shows the relative angular positions for delt2_1, delt3_2and delt3_1 for multi-machine system with UPFC controller placed between Bus 9 and Bus 6 and fault taking place between Bus 5 and Bus 7.The total simulation time taken is 20 sec.

It is clear from the table that the time required by delt3_1 to get stable is minimum i.e 12 seconds.

b) UPFC is placed between Bus 8 and Bus 9



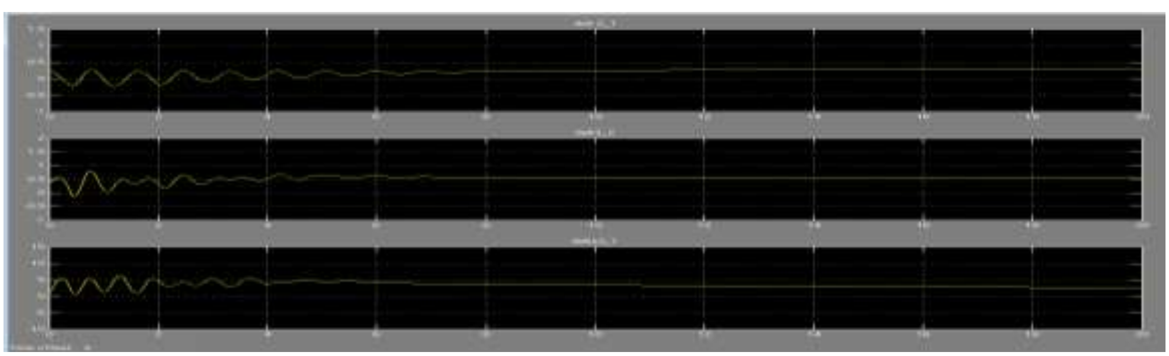


Figure shows the relative angular positions for delt2_1, delt3_2and delt3_1multi-machine system with UPFC controller placed between Bus 8 and Bus 9 and fault taking place between Bus 5 and Bus 7.The total simulation time taken is 20 sec.

Stability time for UPFC placed between Bus 8 and Bus 9

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FAULT POSITION	UPFC POSITION	Stability time for delt2_1 (in sec.)	Stability time for delt3_2 (in sec.)	Stability time for delt3_1 (in sec.)
Between Bus 5 & Bus 7	Between Bus 8 & Bus 9	8	7	6

It is clear from the table that the time required by delt3_1 to get stable is minimum i.e 6 seconds

RESULT AND ANALYSIS

FACTS CONTROLLER	STATCOM	UPFC
STATCOM & UPFC POSITION :- Between Bus 8 & Bus 9		
Stability time for delt2_1(in sec)	14	8
Stability time for delt3_2(in sec)	13	7
Stability time for delt3_1(in sec)	12	6

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