"POWER SYSTEM STABILITY ENHANCMENT USING UPFC DAMPING CONTROLLER"

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Abstract - The rising of demand of power and difficulties of constructing a newly transmission network causes the power system to be complex and stressed. Due to the stress in the power system there is a chance of losing the stability following to the fault. When the fault occurs in the power system the whole system goes to severe transients. By using PSS and AVR we can easily stabilize the system. FACTS devices (i.e. TCSC, SVC, STATCOM, and UPFC) are extremely important to suppressing the power system oscillations which efficiently control the active and reactive power. This thesis reflects a novel control technique which for faults and it also increasing the damping of the system. The power electronic device named as UPFC is based on Fuzzy Logic technique to provide external controlling signal to UPFC which is mounted in single-machine infinite bus system to suppress low frequency oscillations and also it describes the model of a UPFC with multi-machine system which is externally controlled by the signal which is generated by the newly proposed power flow controller to increase the stability of the system with occurrence of fault in which it connected. The proposed controller consists of Power oscillation damping controller and Proportional Integral Differential controller (POD&PID). The effectiveness of controller for suppressing oscillation due to change in mechanical input and excitation is examined by investigating the change in rotor angle and speed occurred in the SMIB system. FACTS devices are used the existing transmission system very efficiently with the specified stability margin.

Keywords - Renewable Energy, Wind, Solar hybrid Energy, Optimization, Modeling and Simulation, Techno-Economic, Wave Energy

I. INTRODUCTION

Now recent years, the power system design, high efficiency operation and reliability of the power systems have been considered more than before. Due to the growth in consuming electrical energy, the maximum capacity of the transmission lines should be increased. Therefore in a normal condition also the stability as well as the security is the major part of discussion. Several years the power system stabilizer act as a common control approach to damp the system oscillations [1-2].However ,in some operating conditions, the PSS may fail to stabilize the power system, especially in low frequency oscillations[3].As a result, other alternatives have been suggested to stabilize the system accurately. It is proved that the FACTS devices are very much effective in power flow control as well as damping out the swing of the system during fault. Recent years lots of control devices are implemented under the FACTS technology. By implementing the FACTS devices gives the flexibility for voltage stability and regulation also the stability of the system by getting proper control signal [4].The FACTS devices are not a single but also collection of controllers which are efficiently not only work under the rated power, voltage, impedance, phase angle frequency but also under below the rated frequency. Among all FACTS devices the UPFC most popular controller due to its wide area control over power both active and reactive, it also gives the system to be used for its maximum thermal limit It's primarily duty to control both the powers independently. It has been shown that all three parameters that can affect the real power and reactive power in the power system can be simultaneously and independently controlled just by changing the control schemes from one type to other in UPFC. Moreover, the UPFC is executed for voltage provision and transient stability improvement by suppressing the sub-synchronous resonance (SSR) or LFO [5]. For example, in it has been shown that the UPFC is capable of inter-area oscillation damping by means of straight controlling the UPFC's sending and receiving bus voltages. Therefore, the main aim of the UPFC is to control the active and reactive power flow through the transmission line with emulated reactance. It is widely accepted that the UPFC is not capable of damping the oscillations with its normal controller. As a result, the auxiliary damping controller should be supplemented to the normal control of UPFC in order to retrieve the oscillations and improve the system stability.

II. Steady-State Model of the UPFC-

In the fig1.1 it shown that the bus "i" and bus "j" act as as ending end and receiving end bus and the UPFC is installed between then, with Its steady state representation we assumed that the impedance s of both series and shunt branches of UPFC are pure reactance. If we are considering the steady state operation of the system then the real power injected by the voltage source is zero and the between two voltage source the real power exchange will take place. Fig.2.6 shown the three powers injection model converted from two voltage source. We can remove the shunt reactance from the system admittance

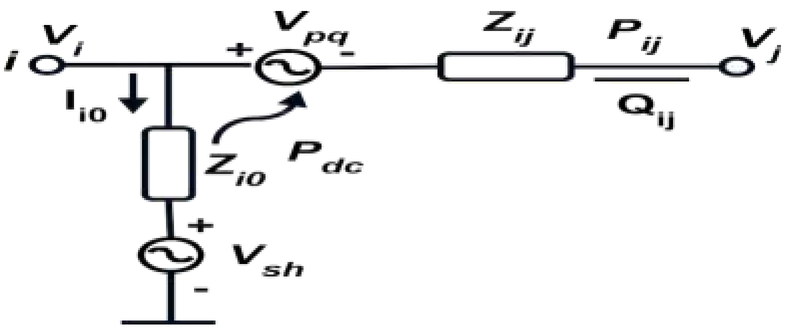


Fig.1.1. AUPFC with two-voltage source

III. Dynamic Model of the UPFC

Figure.1.1 shows a SMIB power system connected to UPFC, where the control signals mE ,mB and E,B are the amplitude modulation ratio and phase angle of the both VSC. This control signals treated as a input to the UPFC. Here we have considered two models for our study one linearized power system model for small signal stability and one dynamic model of UPFC to investigate effect over the system oscillation. Here we have to assume the transient effect and the resistance of the transformers of UPFC are zero for stability study. The dynamic equations of UPFC written as follows

$$\begin{bmatrix} v_{Ed} \\ v_{Eq} \end{bmatrix} = \begin{pmatrix} 0 & -X_E \\ X_E & 0 \end{pmatrix} \begin{bmatrix} i_{Ed} \\ i_{Eq} \end{bmatrix} + \begin{bmatrix} \frac{m_E v_{dc} \cos(\delta_E)}{2} \\ \frac{m_E v_{dc} \sin(\delta_E)}{2} \end{bmatrix}$$

$$\begin{bmatrix} v_{Bd} \\ v_{Bq} \end{bmatrix} = \begin{pmatrix} 0 & -X_B \\ X_B & 0 \end{pmatrix} \begin{bmatrix} i_{Bd} \\ i_{Bq} \end{bmatrix} + \begin{bmatrix} \frac{m_B v_{dc} \cos(\delta_B)}{2} \\ \frac{m_B v_{dc} \sin(\delta_B)}{2} \end{bmatrix} \qquad (37)$$

$$\frac{dv_{dc}}{dt} = \frac{3m_E}{4C_{dc}} [\cos(\delta_E) \ \sin(\delta_E)] \begin{bmatrix} i_{Ed} \\ i_{Eq} \end{bmatrix} + \frac{3m_B}{4C_{dc}} [\cos(\delta_B) \ \sin(\delta_B)] \begin{bmatrix} i_{Bd} \\ i_{Bq} \end{bmatrix}$$

By combining equation (37) and machine dynamic equation of the UPFC, we can envelop complete dynamic model of the SMIB system connected with UPFC as follows:

By merging and line arising Equations (37) and (38), the power system with UPFC state equations Where the deviance of control input signals of the UPFC

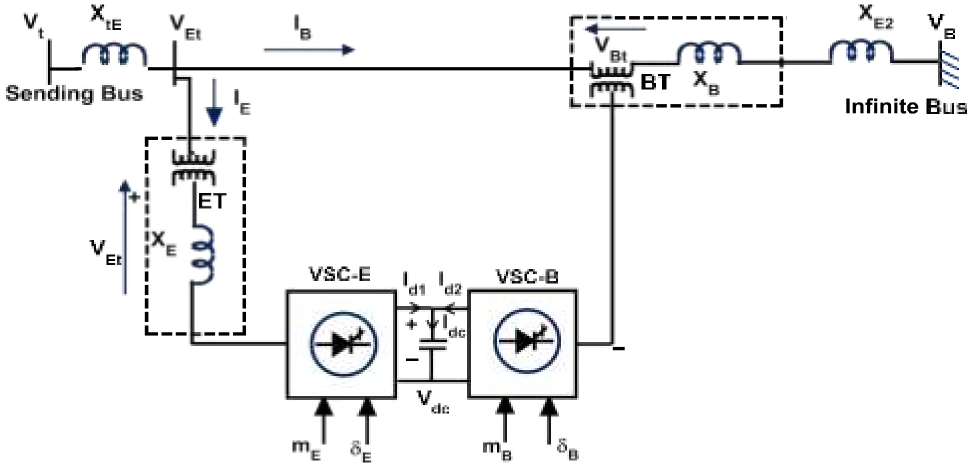
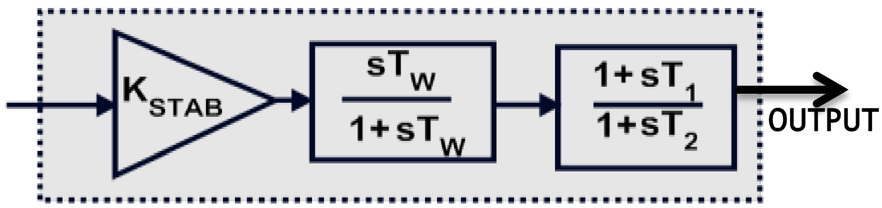


Fig.1.2. AUPFC installed in SMIB system.

IV. Power System Stabilizer-

An economic and satisfactory solution the unstable oscillation a power system produces is to provide additional damping (to rotor windings) for the generator rotor. This is done via Conventional PSS which gives additional controllers to the excitation system [7]. The input Vs to the exciter (Figure 1.2) is, as seen in Figure 1.2 the output from the Power System Stabilizer whose input signal originates from rotor velocity (or frequency). Conventional Power System Stabilizers are model e d in the following manner: The Power System Stabilizer implemented consists, as shown in Figure 1.2, of three main functional blocks:

The Washout gain
The Washout Circuit\
The Leasd –Lag Compensation



The Gain of PSS:

The Gain is simply the proportional gain of the PSS.

1.The Wash out Circuit:

At the output of the PSS there is a steady state bias which modifies the generator terminal voltage; this is eliminated through the use of a Washout Circuit [5]. In the input signal the Power System Stabilizer acts upon only the transient variations. It doesn't however take any action when DC off set sin the signal a represent. By subtracting the low frequency components from the input signal (through the use of a low-pass filter essentially) the DC offset present in the signal can be removed. Hence it can be said that Washout Circuits are essentially High-Pass filters which pass all frequencies that are of interest. It is understood that the system under investigation is of local mode nature and so the Twv alue be placed in the range of 1 and 2.

1.2The Dynamic Compensator, Lead–Lag Compensation:

The final process contained within the Power System Stabilizer is the Dynamic Compensator. This stage comprises of lead-lag stages and has the transfer function as shown in Figure 6. The Lead-Lag stage utilizes the rotor shaft angular velocity and uses it as the inputs signal (as mentioned previously about the Washout Circuit)[7].The Lead- Lag time constants: T1 and T2 were all coated values such that when the PSS is in clouded in the feedback loop the overall closed loop of the H-P model and UPFC is stable at a set operating point.

1.3Tuning:

Given the above knowledge of PSS, the following values for the various parameters in relation to it were allocated

V. Fuzzy Logic Controller-

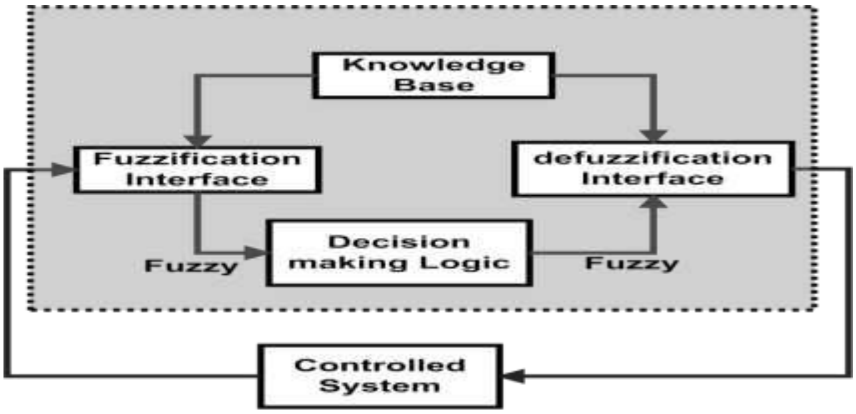
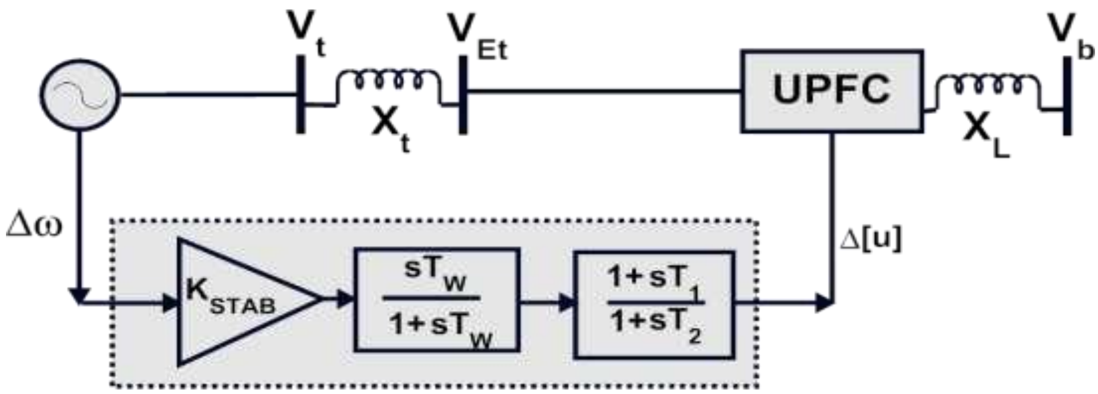
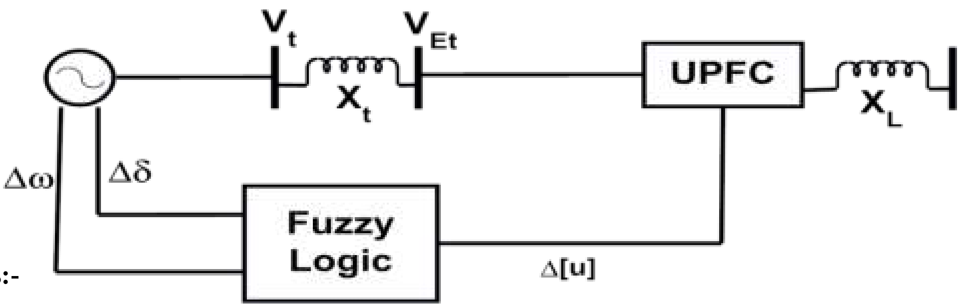


Fig.1.3 UPFC with Power System Stabilizer



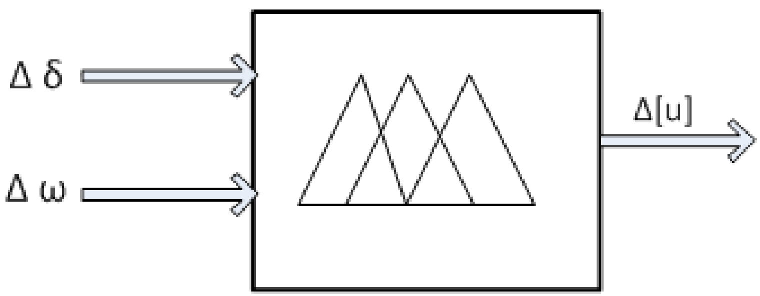
In order to providing stabilizer signal, the output of obtained model reference of power system is compared with output of real power system and the error signal is fed to a fuzzy controller. The Fuzzy controller provides stabilizer signal in order to damping system oscillations. Fig.1.3. Present the block diagram of proposed Fuzzy logic controller. In fact Fuzzy logic controller is one of the most effective operations of fuzzy set theory; its key features are the use of linguistic variables relatively than numerical variables. This control technique depends on human competency to understand the system performance and is based on quality control rules. Fuzzy logic provides a simple technique to reach at a definite conclusion created up on ambiguous, uncertain, inaccurate, noisy, or lost input in formation. FLC work on the principle of simple understanding of the system behavior of a person and simple rule based *"If x and y then z",* this rule base again defined by some membership function of FLC with proper argument to enhance the system performance .The UPFC with Fuzzy controller is shown in the figure 2.12. In accurate, noisy, or lost input information. FLC work on the principle of simple understanding of the system behavior of a person and simple rule based *"If x and y then z",* this rule base again defined by some membership function of FLC with proper argument to enhance the system performance. The UPFC with Fuzzy controller is shown in the figure 1.3.

- A Fuzzy fiction is a presses or platform in which we can convert the input data in to linguistic variable.
- A Knowledge Base which contains the data base with the required linguistic definitions and control rule set.
- A De fuzzy fiction interface which yields a non-fuzzy control action after an incidental fuzzy control action.
- A Decision Making Logic creates a platform where fuzzy logic action from the knowledge base with the linguistic variable and human decision process get to gather to give the appropriate decision.



FLC parameters:-

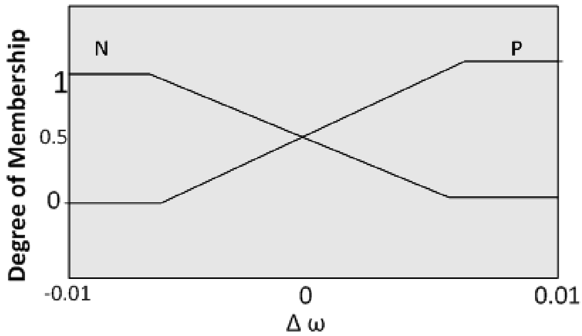
FLC structure:



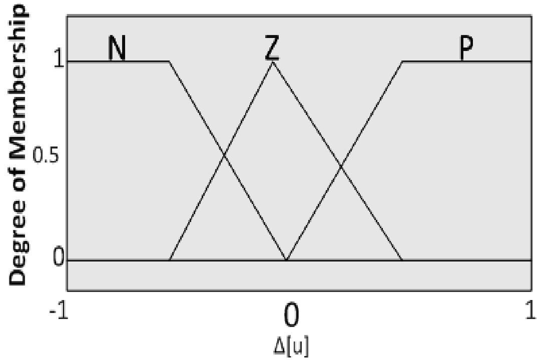
VI. The Rules used in this controller are chosen as follows:

If Δω is P and Δδ is P then Δ[u] is P. If Δω is P and Δδ is N then Δ[u] is Z. If Δω is N and Δδ is P then Δ[u] is Z. If Δω is N and Δδ is N then Δ[u] is N.

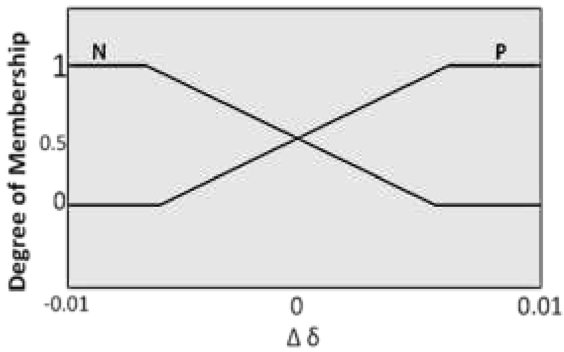
Input and output membership functions:



Input Membership Function



Output Membership Function



VII. Hybrid Fuzzy Logic Controller-

It is a combination of conventional FLC and conventional PI controller. The internal arrangement of the hybrid fuzzy damping controller displayed in the Fig.1.4.The membership functions, the rule base used here is same as of conventional FLC.

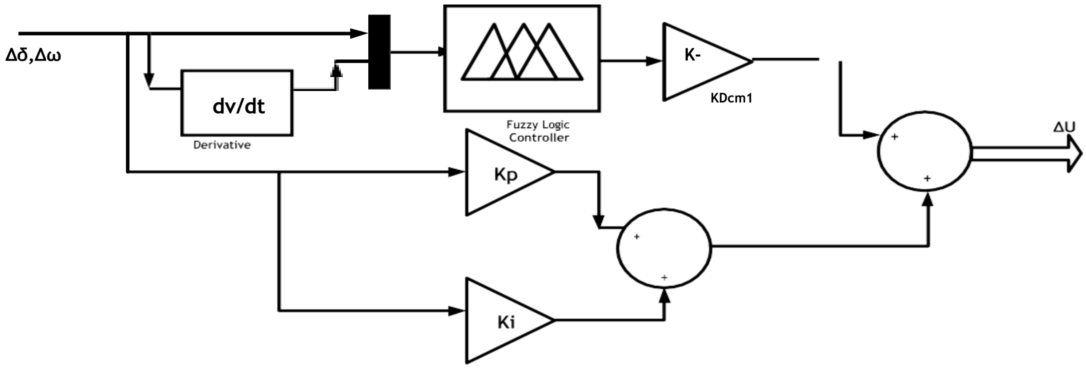


Fig.1.4 Hybrid fuzzy damping controller structure

The output of the simulation model is taken as speed deviation (Δω) angle deviation (Δδ). So, the following response is performed for speed deviation (Δω) and angle deviation (Δδ) against time from simulation model using SMIB system. The simulation processes carries for duration of 10seconds [11].

IX. SIMULATION RESULTS:

Effect Step change in mechanical Power input on Power System Oscillations without UPFC. From viewing response of the system in figure 2.14 we have, the variation in speed and angle is oscillatory in nature. Due to formation of these oscillations the system is unstable. To improve the system performance and getting the stable position we have to eliminate these oscillations. To eliminate these oscillations we install UPFC with this SMIB system.

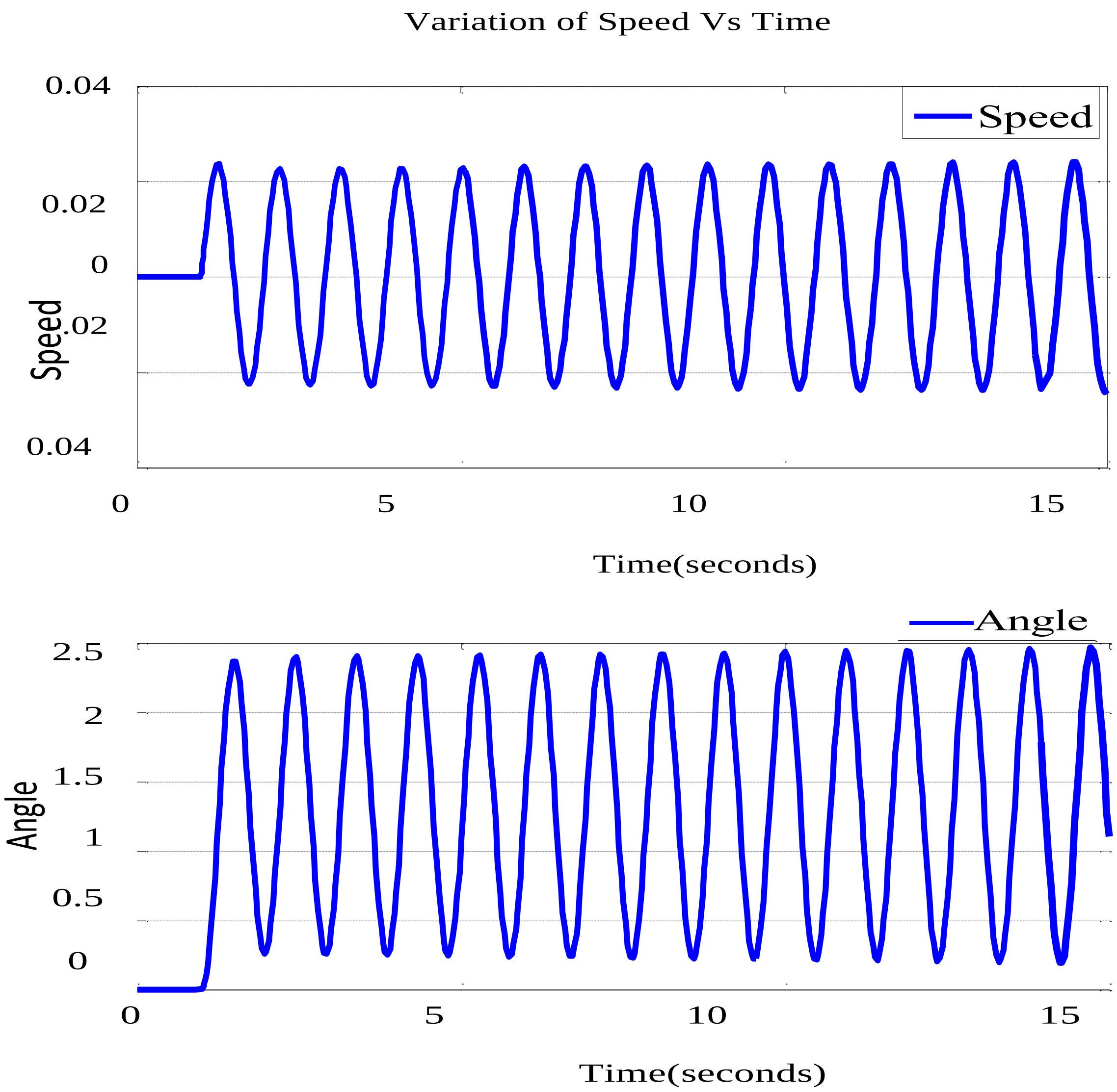


Fig.1.5 Response of SMIB system without UPFC

Effect Step change in mechanical Power input on Power System Oscillations with UPFC without external controlling signal is shown in the Figure 2.15. By calculating constants for FACTS device(UPFC) *i.e.Kp, Kq and* K_V.We can see the effect of UPFC on power system. As we know that, the significant control parameters of UPFC are m_E,m_B and $\square_B\square_E$. By controlling these parameters we can control the magnitude of voltage through reactive power compensation at a bus where the UPFC is installed, also we can control the magnitude of the series injected voltage. Also we can regulate the d.clink voltage.

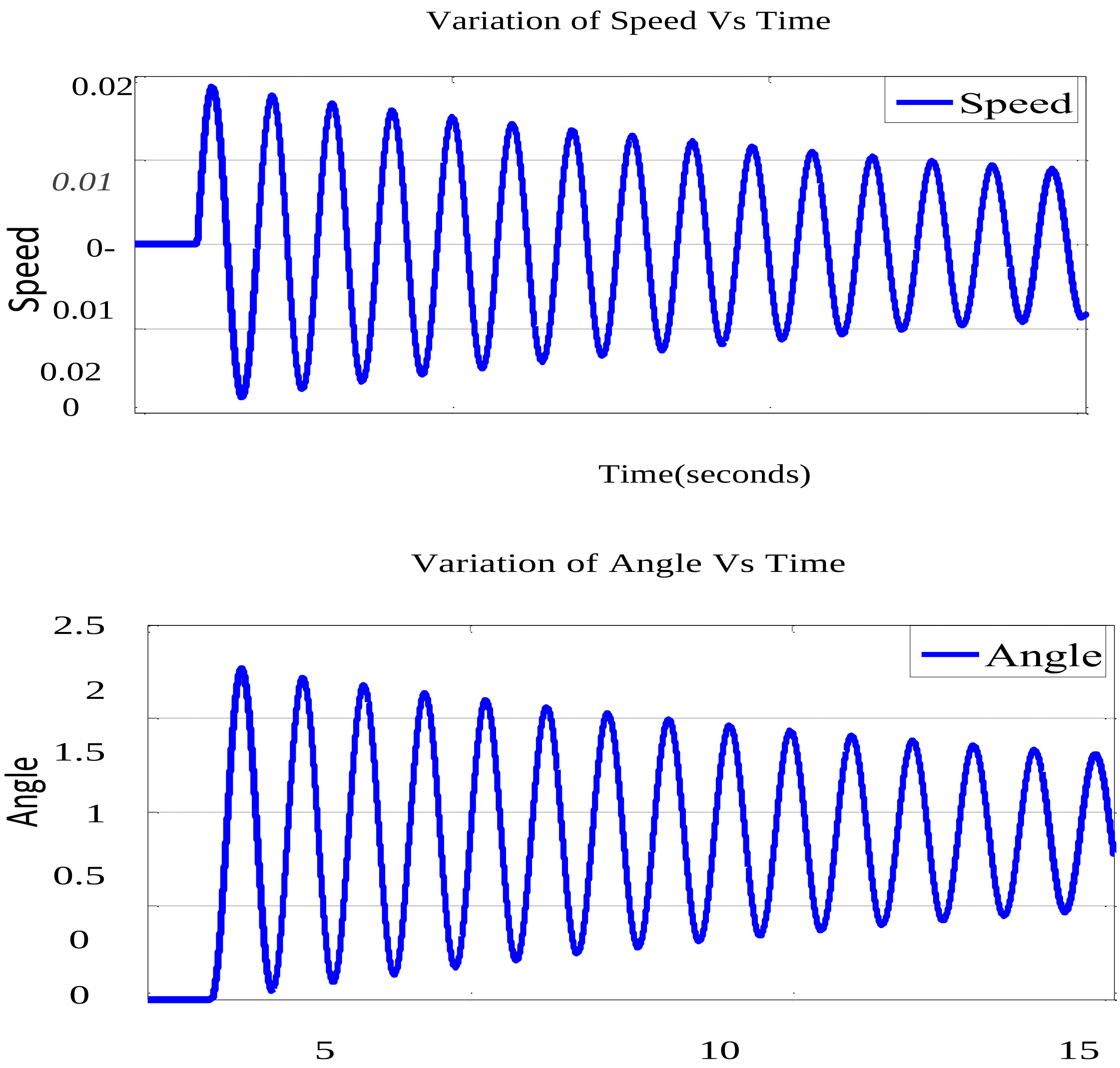
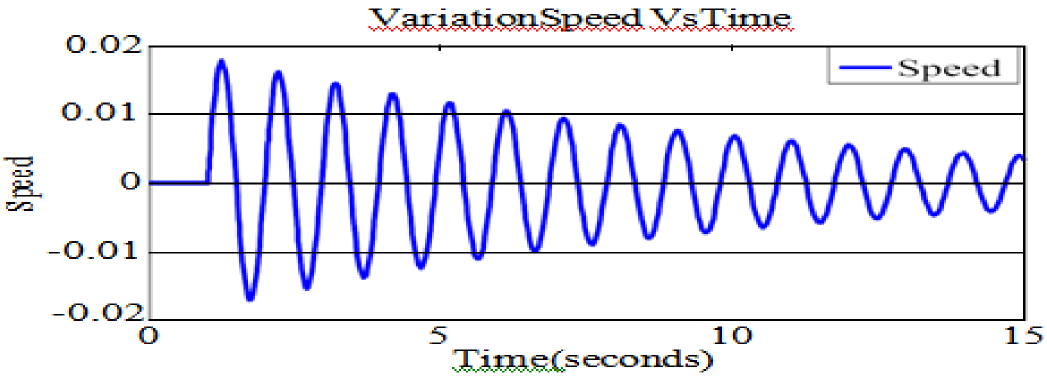


Fig.1.6 Response of SMIB system with UPFC

Effect Step change in mechanical Power input on Power System Oscillations with UPFC and external controlling signal from power system stabilizer is shown in the Figure 2.16.As we can see that using UPFC the oscillation of SMIB is reduced. But still the system is having oscillations which should be damped. So we install damping controller on UPFC.



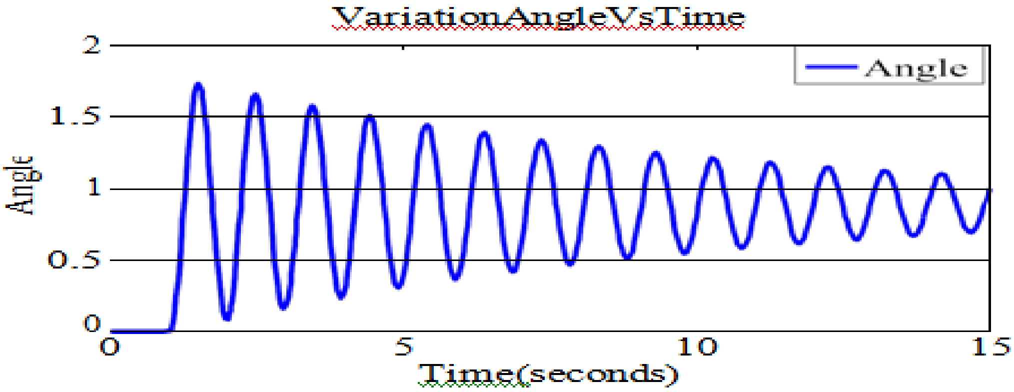


Fig.1.7 Response of SMIB system with UPFC and Power System Stabilizer

Effect in mechanical power input to the excitation on System Oscillations with UPFC and external controlling signal from Conventional -FLC is shown in the Figure 2.17. In this sub section we install a fuzzy damping controller for UPFC

CONCLUSION

From the above study with SMIB system connected to UPFC, PSS and also with FLC, simulation experiments and simulation results it is concluded that we can effectively damp out the low frequency oscillations by using Fuzzy and Hybrid Fuzzy logic controllers with only 7.2s and 3s, hence the stability of the system increases

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