International Journal of Research
Available at https://pen2print.org/index.php/ijr/
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 06 Issue 2
February 2019

Literature Review on Power System using TCSC with Fuzzy PID Controller

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Abstract:

The basic control objectives of a power system are system voltage control, system frequency control, protection and economic operation. Reactive power control is a subset of overall system control and stability. A power system is said to be well designed if it gives a good quality of reliable supply. By good quality is said meant the voltage levels are maintained within the reasonable limits. If the voltage variation is more than a pre specified value, the performance of the equipment suffers and the life of most of the equipment is sacrificed. When power is supplied to a load through transmission line keeping sending end voltage constant, the load voltage undergoes variations depending upon the magnitude of the load. The higher the load greater is the voltage variation. The transmission line distributed parameters through out the line, on light loads or at no loads become predominant and consequently the line supplies charging VAR (generates reactive power). In order to maintain the terminal voltage at the load bus adequate, reactive reserves are needed. FACTS devices like SVC can supply or absorb the reactive power at receiving end bus or at load end bus in transmission system, which helps in achieving better economy in power transfer. The fuzzy control has emerged as one of the most active and fruitful areas for research in the applications of fuzzy set theory. Fuzzy control is based on fuzzy logic a logical system which is much closer in sprit to human thinking and nature language than traditional logical system. The fuzzy logic controller (FLC) provides a means of converting a linguistic control strategy based on an expert knowledge into an automatic control strategy. Knowledge acquisition in FLC application plays an important role in determining the level of performance of a fuzzy control system. FLC based on the fuzzy model of a process is needed when higher accuracy and reliability are required. Only small efforts have been expended in applying fuzzy logic as a controller to damp out the small signal oscillations for the FACTS based stabilizers as closed-loop. Index Terms: fuzzy logic controller (FLC), fuzzy logic, FACTS, Reactive power control, SVC , power system stability

1.Introduction

The power system is an interconnection of generating units to load centers through high voltage electric transmission lines and in general is mechanically controlled. It can be divided into three subsystems: generation, transmission and distribution subsystems. Until recently all three subsystems were under supervision of one body within a certain geographical area providing power at regulated rates. In order to provide cheaper electricity the deregulation of power system, which includes separate generation, Transmission and distribution companies, is already being implemented. At the same time electric power demand continues to grow and also building of the new generating units and transmission circuits is becoming more difficult because of economic and environmental reasons. Therefore, power utilities are forced to rely on utilization of existing generating units and to load existing transmission lines close to their thermal limits. However, stability has to be maintained at all times. Hence, it is necessary to operate power system effectively, without reduction in the systems security and quality of supply, even in the case of contingency conditions. The contingency may be such as loss of transmission lines and/or generating units, which occur frequently, and will most probably occur at higher frequencies. So a new control strategies need to be implemented, to take care of such expected situations. Flexible AC Transmission Systems (FACTS) technology is based on the use of power electronic controlled devices for allowing transmission circuits to be used to their maximum thermal capability. In particular the FACTS devices aim principally to control the three main parameters directly effecting AC power transmission namely voltage, phase angle, and impedance. High Voltage Direct Current (HVDC) .

Fuzzy control is based on fuzzy logic – a logical system which is much closer in sprit to human thinking and nature language than traditional logical system. The fuzzy logic controller (FLC) provides a means of converting a linguistic control strategy based on an expert knowledge into an automatic control strategy. Knowledge acquisition in FLC application plays an important role in determining the level of performance of a fuzzy control system. FLC based on the fuzzy model of a process is needed when higher accuracy and reliability are required. Only small efforts have been expended in applying fuzzy logic as a controller to damp out the small signal oscillations for the FACTS based stabilizers as closed-loop.

1.1 MotivationAnd Objective

In this thesis transmission line is simulated using line segments by keeping the sending end voltage constant. The receiving end voltage fluctuations were observed for different loads. In order to maintain the receiving voltage constant, shunt inductor and capacitor are added for different loading conditions. SVC is simulated by means of Fixed Capacitor and

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Thyristor Controlled Reactor (FC-TCR) which is placed at the receiving end. The firing angle control circuit is designed and the firing angles are varied for various loading conditions to make the receiving end voltage equal to sending end voltage. Fuzzy logic controller is designed to achieve the firing angles for SVC such that it maintains a flat voltage profile. All the results thus obtained, were verified and were utilized in framing of fuzzy rule base in order to achieve better reactive power compensation for the Transmission line. Based on observed results for load voltage variations for different values of load resistance, inductance and capacitance a fuzzy controller is designed which controls the firing angle of SVC in order to automatically maintain the receiving end voltage constant

2.THE SELF-TUNING CONTROL PRINCIPLE OF FUZZY PID PARAMETER FOR TCSC AND SIMULATION AND RESULTS

2.1 INTRODUCTION

PID control prerequisites display structure extremely exact, and in reasonable applications, to various degree, the greater part of modern procedures exist to the nonlinear, the fluctuation of parameters and the vulnerability of model, subsequently utilizing regular PID control can not accomplish the exact control of the plant. Be that as it may, the reliance on the scientific model of the fluffy control is powerless, so it isn't important to set up the exact numerical model of the procedure, and the fluffy control has a decent vigor and flexibility. As indicated by their own qualities, we combinate fluffy control with PID control.

Fluffy PID parameters Self-tuning Control takes mistake "e" as the contribution of Fuzzy PID controller, meets the demand of the distinctive snapshots of "e" to PID parameters self-tuning. Utilizing fluffy control governs on-line, PID parameters "kp", "ki", "kd" are revised, which establish a self-tuning fluffy PID controller, the rule of which control program as appeared in Fig2.1.

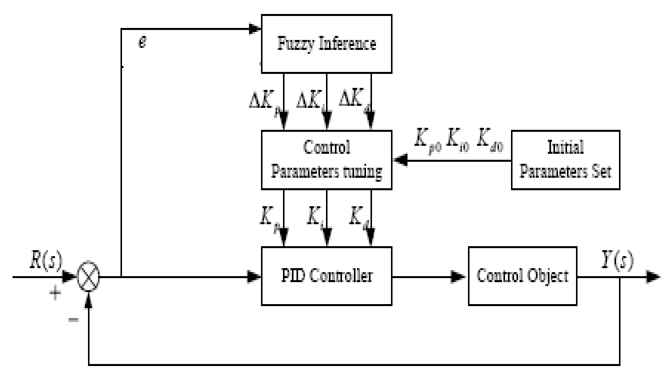

Fig2.1 Self-tuning fuzzy PID controller

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$$K_{PO}+\Delta K_P=K_P$$

$$K_{IO}+\Delta K_I=K_I$$

$$K_{DO}+\Delta K_D=K_D \ldots\ldots\ldots\ldots(2.1)$$

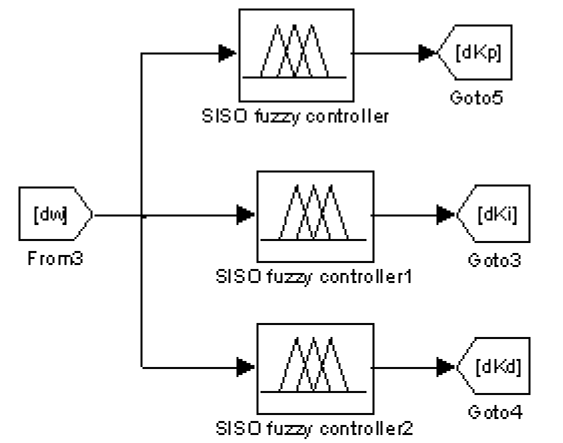
Designed a parameter self-tuning PID-controller based on fuzzy control, which can adjust PID-parameters according to error.

Fuzzy PID parameters Self-tuning Control takes Speed deviation Δω as the input of Fuzzy PID controller, meets the request of the different moments of " Speed deviation " to PID parameters self-tuning. Using fuzzy control rules on-line, PID parameters "k_p", "k_i", "k_d" are amended,which constitute a self-tuning fuzzy PID controller, the principle of which controlprogramme as shown in Fig.5.1.TCSC based on the self-tuning fuzzy PID CONTROL law

$$\Delta X_c=\Delta \acute{\omega}((K_{P0}+\Delta K_P)+(K_{I0}+\Delta K_I)/S+(K_{D0}+\Delta K_D)S) \quad \ldots\ldots\ldots(2.2)$$

The initial parameters of the controller are given:

$$K_{P0}=25;\ K_{I0}=15;\ K_{D0}=1\ldots\ldots\ldots(2.3)$$



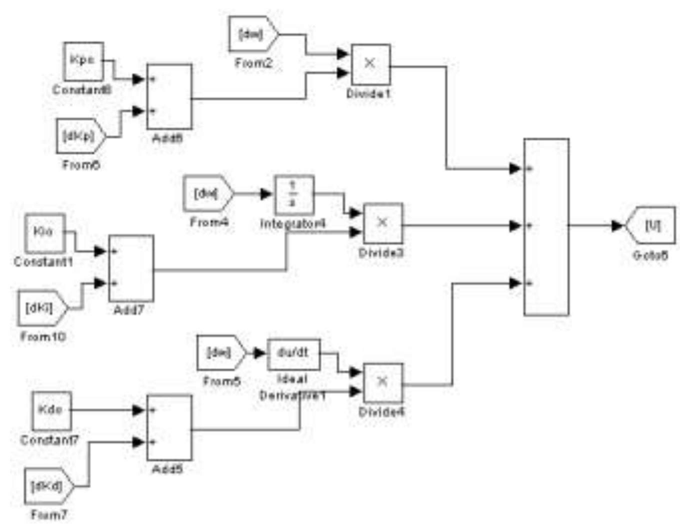


Fig 2.2: Block Diagram of TCSC based on the self-tuning fuzzy PID Control Law

3.BLOCK DIAGRAMS OF SIMULINK CIRCUITS OF FUZZY LOGIC CONTROLLER

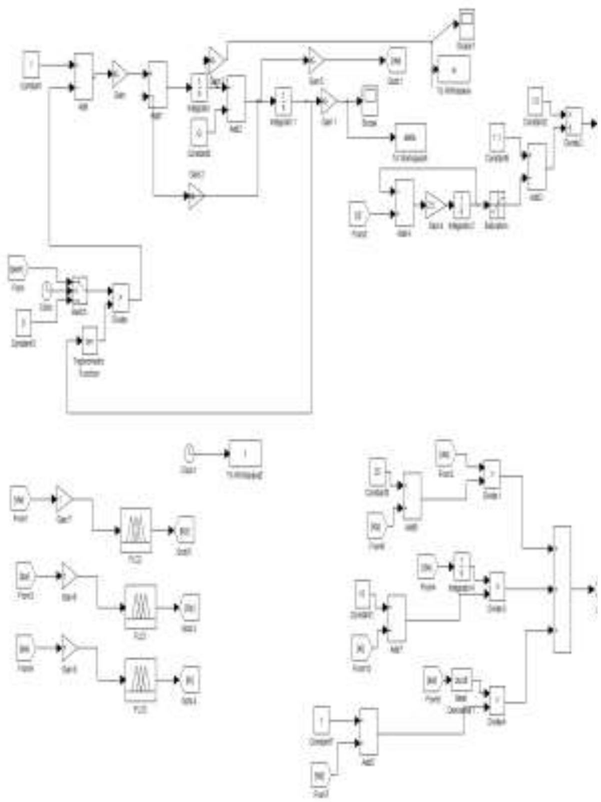


Fig 3.1Block diagrams of simulation circuit while short time 0.1 sec ,0.137 sec- fuzzy logic control

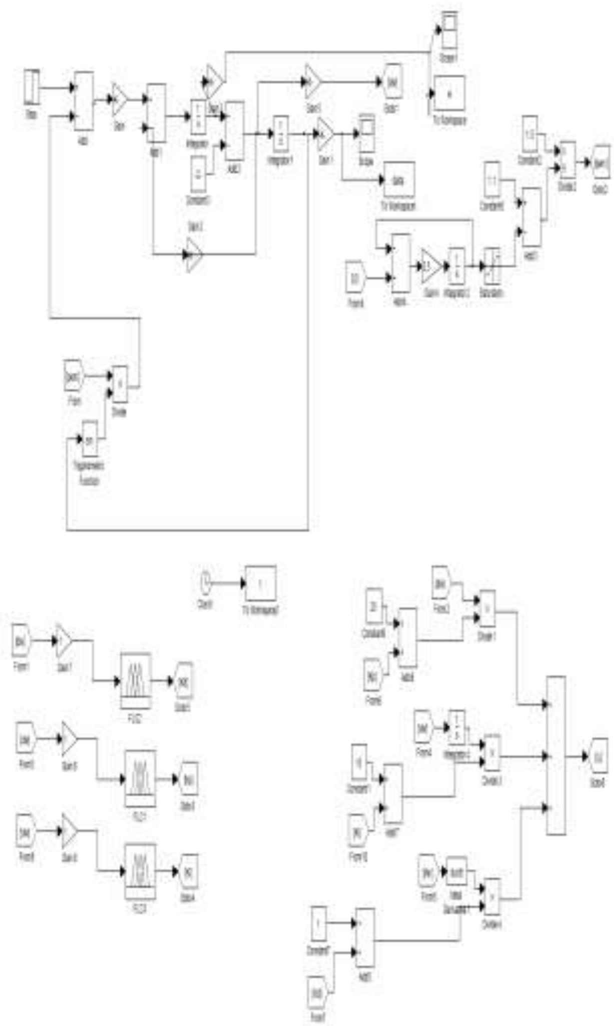


Fig.3.2Block diagrams of simulink circuit of while power disturbance -5%, 10% fuzzy logic control :

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4.SIMULATIONS AND ANALYSIS OF THE SYSTEM

The one machine-infinity bus system shown in figure 1 is studied through the computer simulation using the software MATLAB/ Simulink. The related parameters and initial state of the system are given as below:here, it chooses 3 control laws respectively to compare the simulation:

1) Capacity) fixed series capacitor (FSC)
2) TCSC based on PID control law

$$Xc=\Delta \acute{\omega}(KP)+ (KI)/S+ (KD)S \qquad (15)$$

The parameters of controller are given:

$K_P=25$; $K_I=15$; $K_D=1$

Nonlinear control TCSC based on precise linearization method, Power angel and rotor speed are studied using digital simulation under all kinds of disturbances:

1) At the initial time *t* =0 sec, three phase short circuit occurs at the infinity bus, at t= t_c =0.1 sec the failure is cut off;

2) At the initial time *t* =0 sec, three phase short circuit occurs at the infinity bus, t= t_c = 0.137 sec the failure is cut off;

3) At the initial time *t* =0 sec, it spears small power **disturbance Δp=−5%; t=t_c**=0.1 sec the disturbance is disappeared;

4) At the initial time *t*=**0 sec, it spears small power disturbance Δp=10%; t=t_c**=0.137 sec the disturbance is disappeared; it indicates that nonlinear control TCSC can also suppress small disturbance ,large power disturbances and improve the static stability of power system, compared under the same situation, its performance is much better than two others.

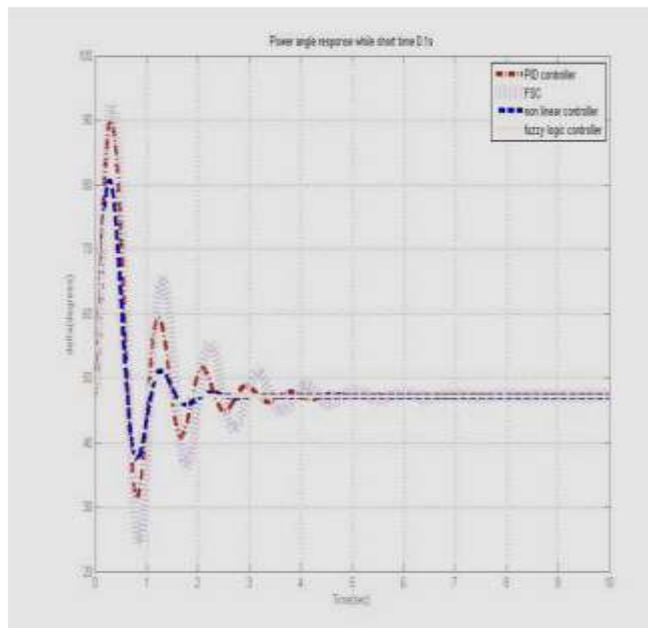

Fig (1) power angle response while short time 0.1 s

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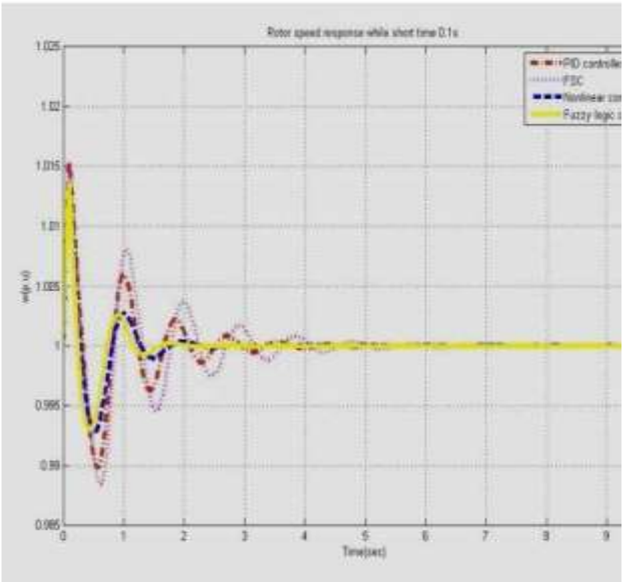

Fig (2) rotor speed response while short time 0.1 s

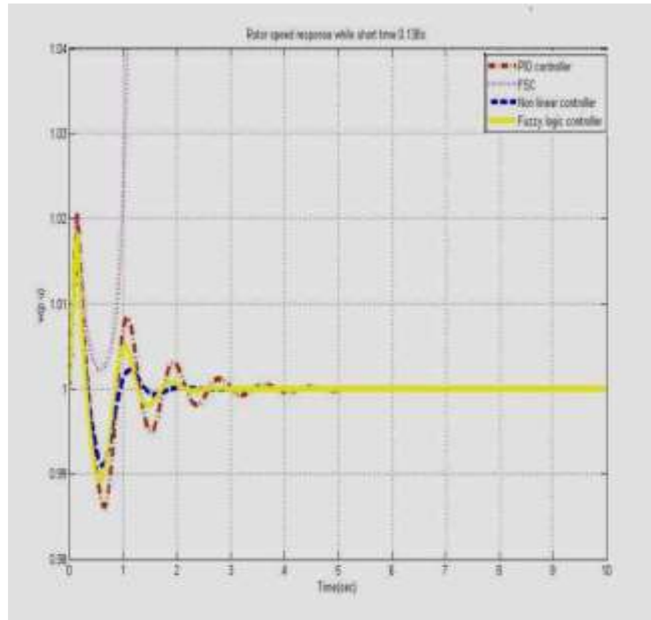

Fig (4) rotor speed response while short time 0.138s

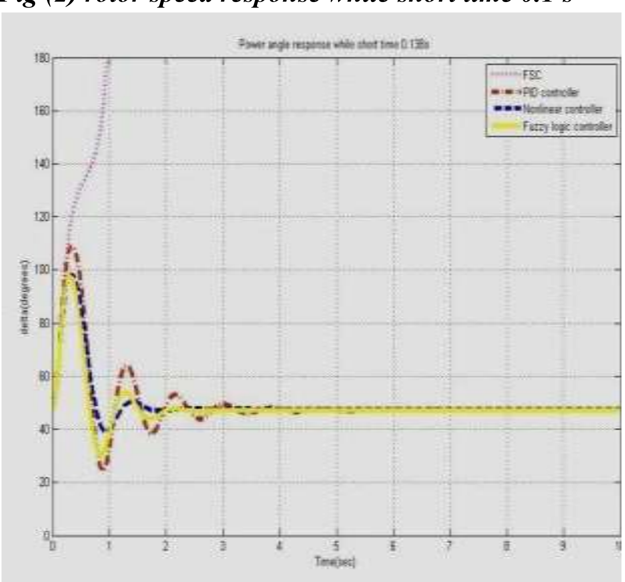

Fig (3) power angle response while short time 0.138s

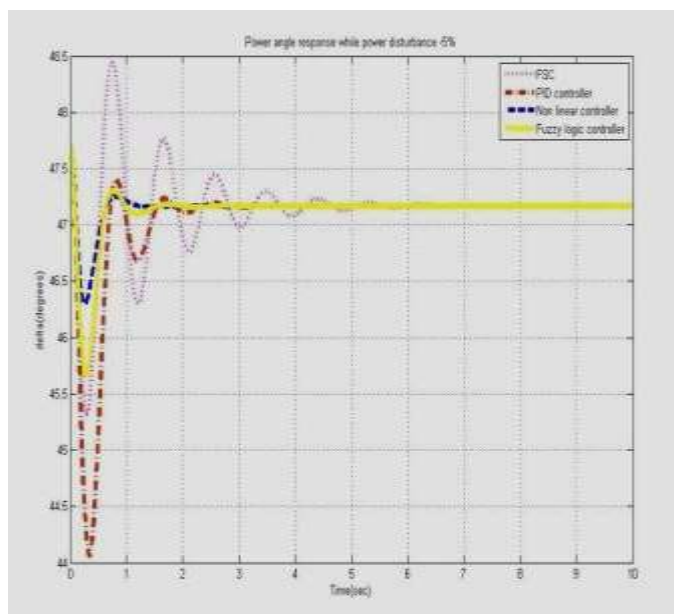

Fig (5) power angle response while power disturbance -5%

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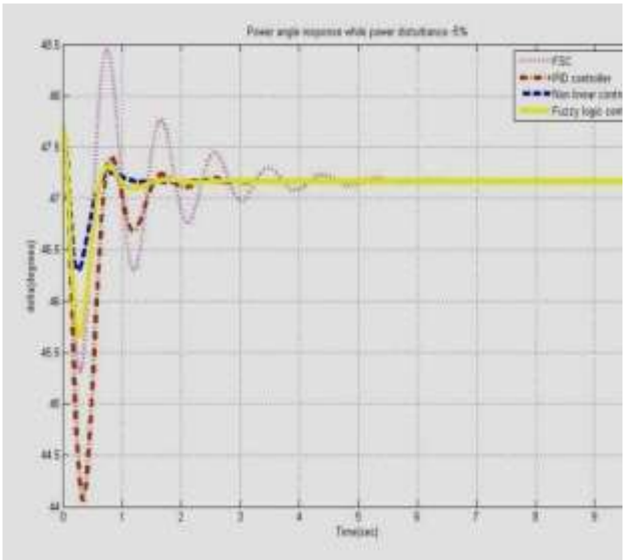
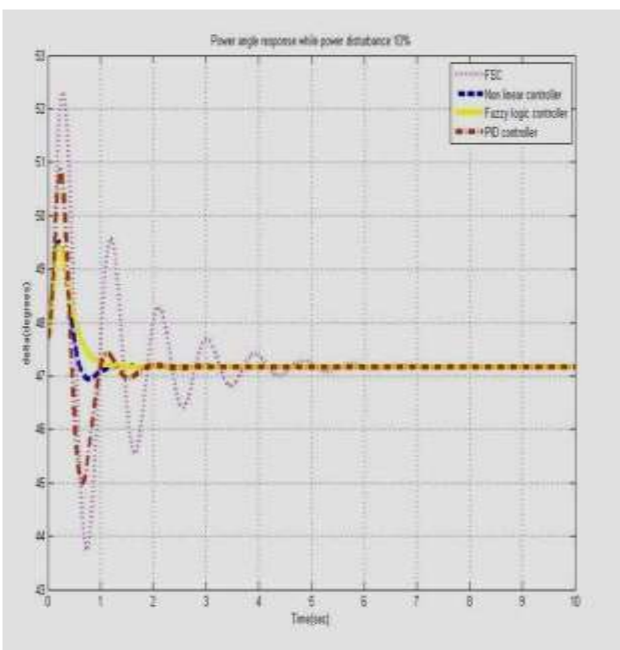
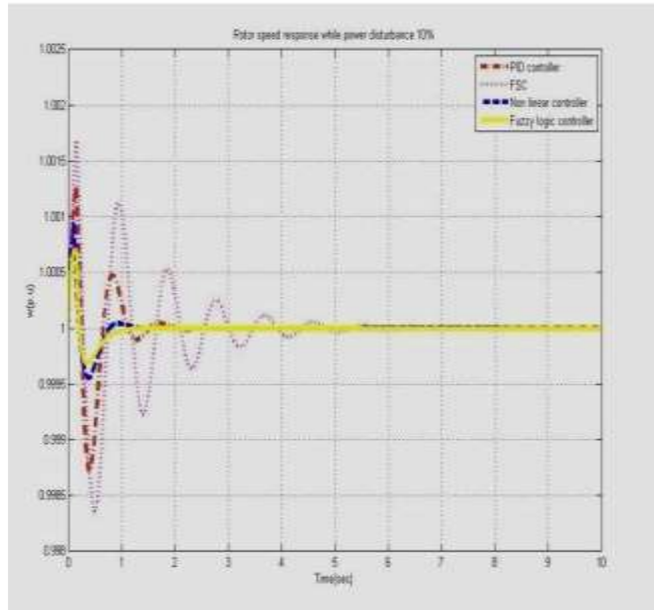


Fig (6) rotor speed response while power disturbance -5%



Fig(7) power angle response with power disturbance 10%



Fig(8) rotor speed response with power disturbance 10%

5.CONCLUSION

Considering improving power system transient stability and effectively damping power oscillation as control objective, in this project in order to obtain the varying effective fundamental equivalent reactance, three different controllers selected are a simple speed deviation based conventional PID controller, nonlinear controller and Self-tuning Fuzzy PID Controller. Self-tuning Fuzzy PID Controller can not only improve the static stability of system, but also effectively damp power oscillation and enhance the transient stability of system by the computer simulation when the power system suffers small disturbance and short circuit. Simulation results show that Self-tuning Fuzzy PID Controller provides an improved transient stability and power oscillation damping compared

e-ISSN: 2348-6848
p-ISSN: 2348-795X
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to other controllers. In addition, it also illuminates that Self-tuning Fuzzy PID Controller is more effective than other controllers, and possess certain robustness and self- adaptability.

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