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A Comparative Study of Power System Stabilizers

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Abstract: *The performance of fuzzy-logic power system stabilizer (FPSS) is investigated by applying it to a single-machine power system connected to infinite bus. FPSS is developed using speed deviation and the derivative of speed deviation as the controller input variables. The execution of the system with fuzzy logic based power system stabilizer is contrasted and the system having routine power system stabilizer and system without power system stabilizer. The recreation comes about demonstrate that the proposed FPSS shows great execution in damping power system low recurrence motions and enormously enhances control system stability.*

Keywords: *Power system stabilizer, single-machine power system, fuzzy logic control, low frequency oscillations, system stability.*

I. Introduction

The power system is a dynamic system. It is continually being subjected to unsettling influences, which cause the generator voltage point to change. At the point when these unsettling influences vanish, another worthy consistent state working condition is come to. It is vital that these unsettling influences don't drive the system to unsteady condition

In the previous five decades the PSS have been utilized to give the craved system execution under condition that requires stabilization. Stability of synchronous generator relies on upon various variables, for example, the setting of automatic voltage regulator (AVR). Numerous generators are composed with high gain, quick acting AVRs to improve extensive scale stability to hold the generator in synchronism with the power system amid vast transient blame conditions. However, with the high gain of excitation systems, it can diminish the damping torque of generator. A supplementary excitation controller alluded to as PSS have been added to synchronous generators to balance the impact of high gain AVRs and different wellsprings of negative damping [7].

To give damping, the stabilizers must create a part of electrical torque on the rotor which is in stage with speed varieties. The utilization of a PSS is to create a supplementary settling signal, which is connected to the excitation system or control circle of the producing unit to deliver a positive damping. The most generally utilized routine PSS is the lead-slack PSS, where the gain settings are settled at specific qualities which are resolved under specific working conditions to bring about ideal execution for that particular condition. In any case, they give poor execution under various synchronous generator stacking conditions. Customary PSS (CPSS) is generally utilized as a part of existing force systems and has made a commitment in improving force system dynamic stability. The parameters of CPSS are resolved in view of a linearized display [2] of the power system around an ostensible working point where they can give great execution. Since power systems are highly non-direct systems, with setups and parameters that change with time, the CPSS plan in light of the linearized model of the power system can't ensure its execution in a commonsense working environment [3].

II. Overview of Power System and Modeling

An improved schematic graph [3] of a single-machine infinite-bus system is appeared in Fig.1. The system comprises of a creating unit associated with a steady voltage transport through two parallel transmission lines. An excitation system and automatic voltage regulator (AVR) are utilized to control the terminal voltage, and a related representative screens the pole recurrence and controls mechanical power. Ignoring the homeless people in the stator circuit and the impact of rotor amortisseur, the synchronous generator can be spoken to as Park's two-hub machine display by an arrangement of streamlined direct conditions [2]. The transmission coordinate with an impedance of re + j x , is associated with a boundless transport of voltage Vb and the AVR and excitation system are spoken to by a first request differential condition. Under ordinary working conditions, a direct, time-invariant system can be inferred by applying little bother relations around a specific balance point. A linearized model [6] is shown in Block diagram form at Fig.2

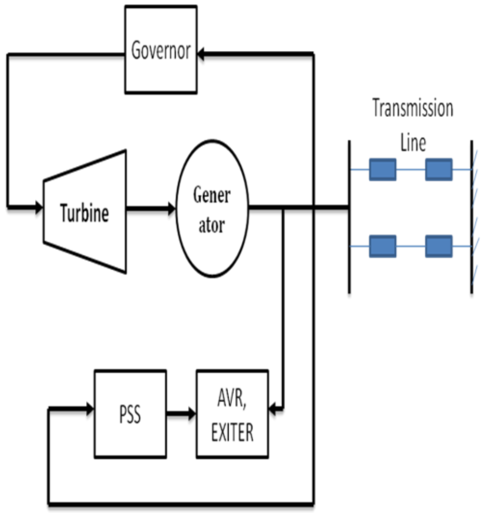

Figure 1 A Schematic Diagram of The Power System.

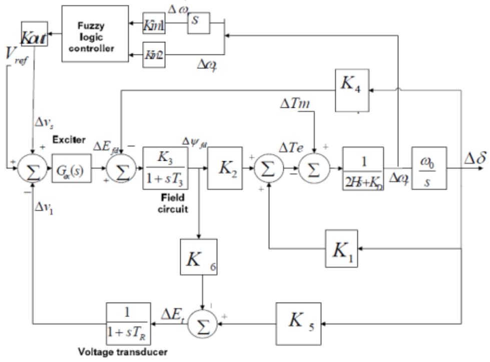

Figure 2 Linearized power system model with FPSS

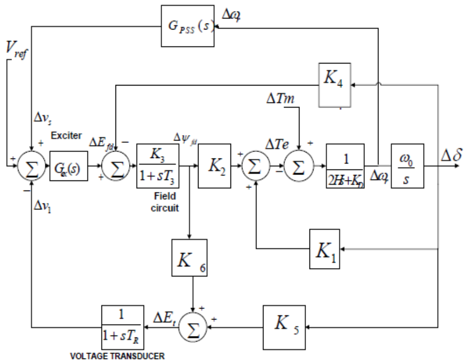

Figure 3 Linearized power system model with PSS

Table.1parameters for the Linearized Power System Model

Parameter	Value
K_1	1.5495
K_2	1.2255
K_3	0.3231
K_4	0.8910
K_5	-0.0138
K_6	0.4942
H	3.5
D	0
T_3	2.3567
$G_a(s)$	190
T_R	0.02
ω_0	314

The block diagram for power system stabilizer [6] is shown below.

Table.2: Parameters for the Analog Pss

Parameter	Value
T_1	0.154
T_2	0.033
T_w	1.4
T_R	0.02
K_{stab}	9.4

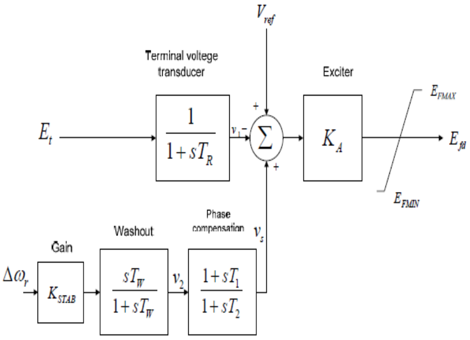

Figure 4 Thyristor excitation system with AVR and PSS

III. Fuzzy Logic Based PSS

The fuzzy controlled system are rule based system in which an arrangement of fuzzy tenets express to a control decision mechanism to modify the impacts of certain framework jolts. With a successful administer base, the fuzzy control system can supplant a gifted human administrator. The fuzzy logic controller gives a calculation which can change over the phonetic control technique in light of master information into an automatic control procedure. The Fig.5 represents the schematic outline of a fuzzy logic controller which comprises of a fuzzification interface, an information base, basic leadership logic, and a defuzzification interface.

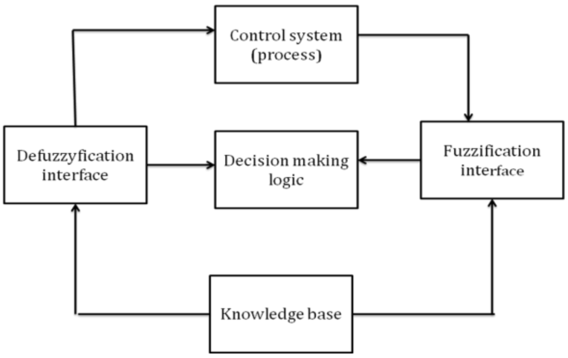

Figure 5 the principle design of fuzzy logic controller

IV. Controller Design Procedure

The fuzzy logic controller (FLC) design consists of the following steps.

1) Identification of input and output variables.
2) Construction of control rules.
3) Establishing the approach for describing system state in terms of fuzzy sets, i.e. establishing fuzzification method and fuzzy membership functions.
4) Selection of the compositional rule of inference.
5) Defuzzification method, i.e., transformation of the fuzzy control statement into specific control actions.

Membership Function: The variables chosen for this controller are speed deviation, acceleration and voltage. In this, the speed deviation and acceleration are the input variables and voltage is the output variable.

NB	Negative Big
NM	Negative Medium
NS	Negative Small
ZE	Zero
PS	Positive Small
PM	Positive Medium
PB	Positive Big

Table.3 Membership functions for fuzzy variables.

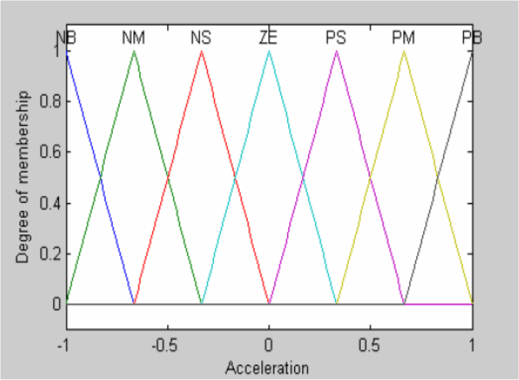

Figure 6 Membership functions for Acceleration

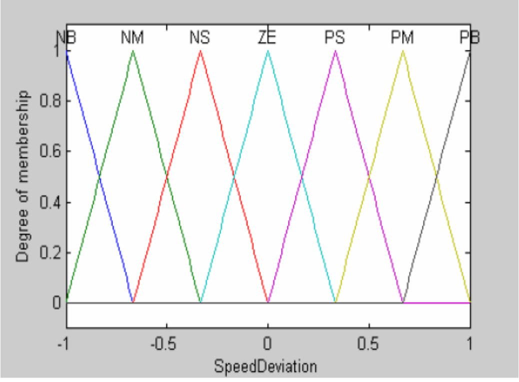

Figure 7 Membership functions for speed deviation

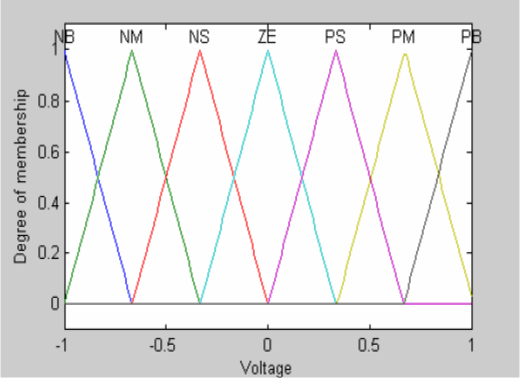

Figure 8 Membership functions for voltage

Each of the input and output fuzzy variables is assigned seven linguistic fuzzy subsets varying from negative big (NB) to positive big (PB). Each subset is associated with a triangular membership function to form a set of seven membership functions for each fuzzy variable.

The variables are normalized by multiplying with respective gains K_{in1}, K_{in2}, K_{out} so that their value lies between -1 and 1. The membership functions of the input output variables have 50% overlap between adjacent fuzzy subsets. The membership function for acceleration, speed and voltage are shown below.

Fuzzy Rule Base: A set of rules which define the relation between the input and output of fuzzy controller can be found using the available knowledge in the area of designing PSS. These rules are defined using the linguistic variables. The two inputs, speed and acceleration, result in 49 rules for each machine. The typical rules are having the following structure:

Rule 1: If speed deviation is NM (negative medium) AND acceleration is PS (positive small) then voltage (output of fuzzy PSS) is NS (negative small).

Rule 2: If speed deviation is NB (negative big) AND acceleration is NB (negative big) then voltage (output of fuzzy PSS) is NB (negative big).

Rule 3: If speed deviation is PS (positive small) AND acceleration is PS (positive small) then voltage (output of fuzzy PSS) is PS (positive small). And so on….

All the 49 rules governing the mechanism are explained in Table 3.2 where all the symbols are defined in the basic fuzzy logic terminology:

Table.4: Rule Base Of Fuzzy Logic Controller

Speed Deviation	Acceleration						
	NB	NM	NS	ZE	PS	PM	PB
NB	NB	NB	NB	NB	NM	NM	NS
NM	NB	NM	NM	NM	NS	NS	ZE
NS	NM	NM	NS	NS	ZE	ZE	PS
ZE	NM	NS	NS	ZE	PS	PS	PM
PS	NS	ZE	ZE	PS	PS	PM	PM
PM	ZE	PS	PS	PM	PM	PM	PB
PB	PS	PM	PM	PB	PB	PB	PB

V. Results and Discussion

Simulink Model:

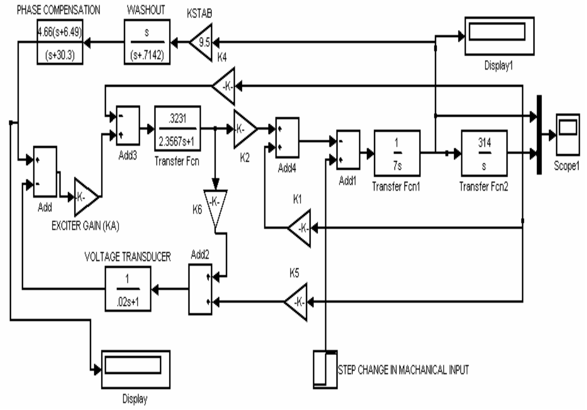

Figure 9 Simulink model for single machine connected to infinite bus with PSS

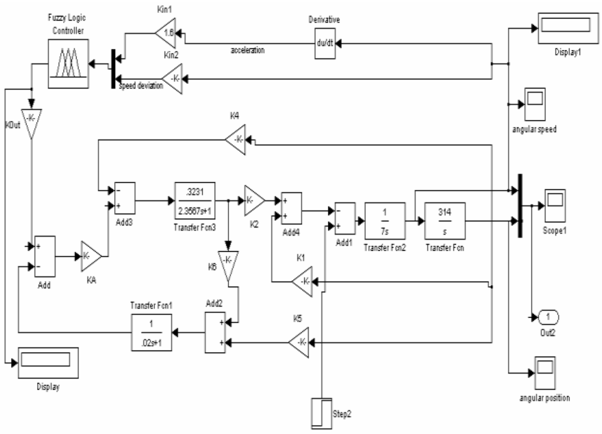

Figure 10 Simulink model for single machine connected to infinite bus with Fuzzy logic based PSS

Case I: Simulation results without PSS when voltage (0.1p.u) disturbance is applied

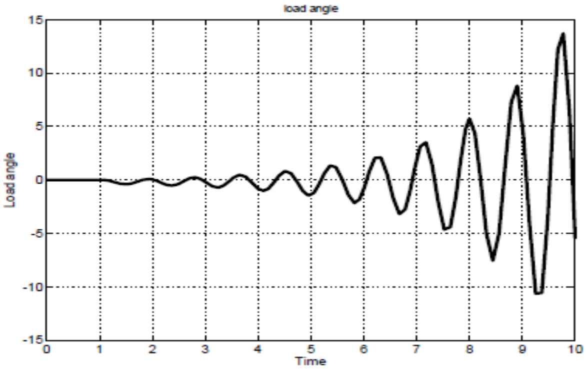

Figure 11 Load angle when 0.1 p.u voltage disturbance applied

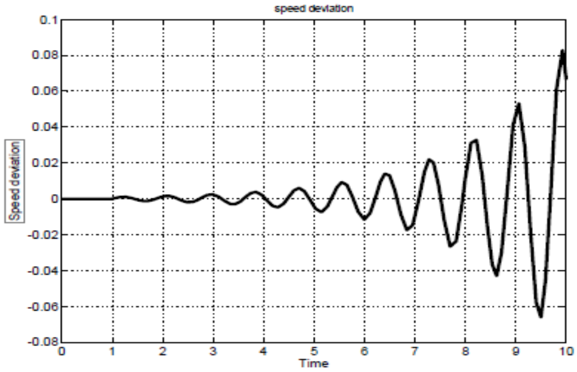

Figure 12 speed deviation when 5% torque disturbance applied

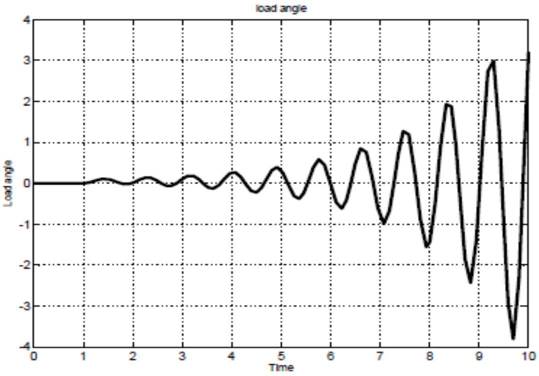

Figure 13 Load angle when 5% torque disturbance applied

Case II: Simulation results with PSS when voltage disturbance (0.1p.u) and torque disturbance of 5% is applied.

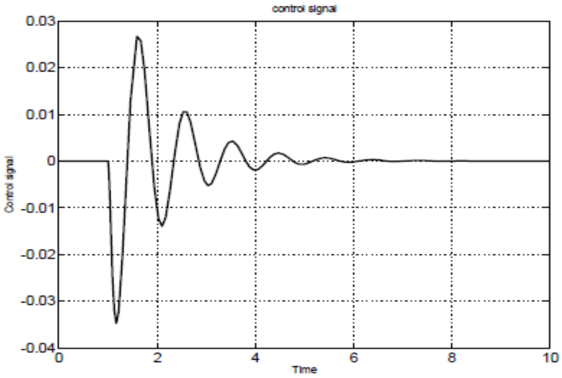

Figure 14 Control signal when 0.1 p.u voltage disturbance applied

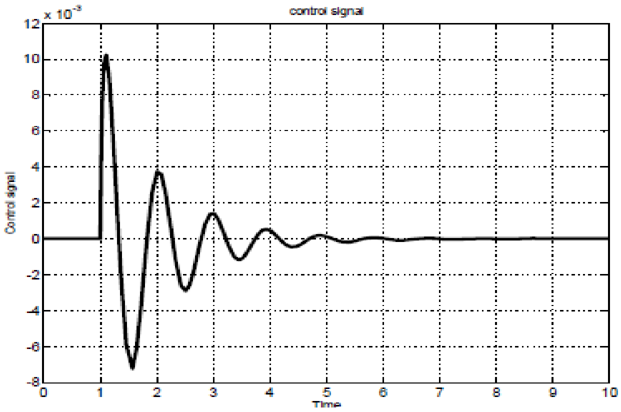

Figure 15 Control signal when 5% torque disturbance applied

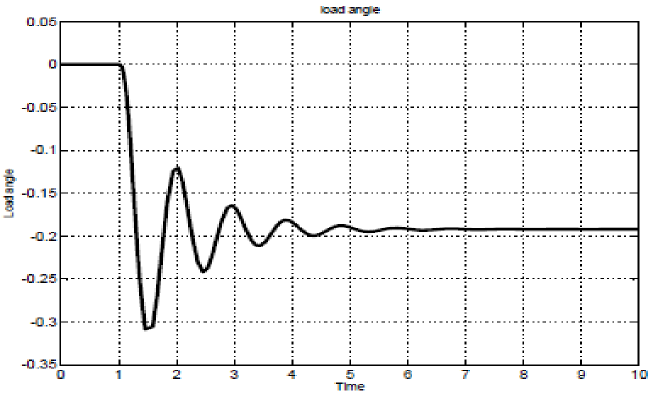

Figure 16 Load angle when 0.1 p.u voltage disturbance applied

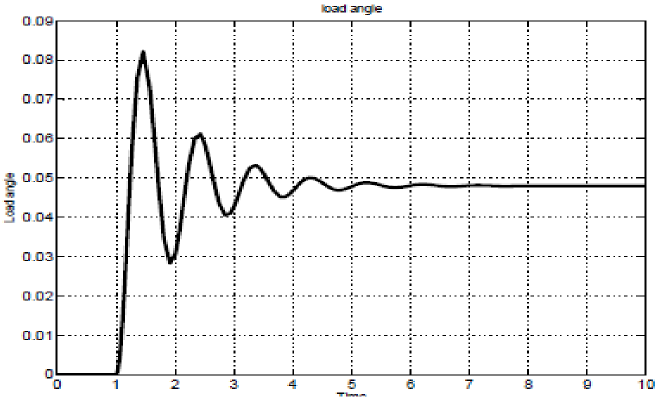

Figure 17 Load angle when 5% torque disturbance applied

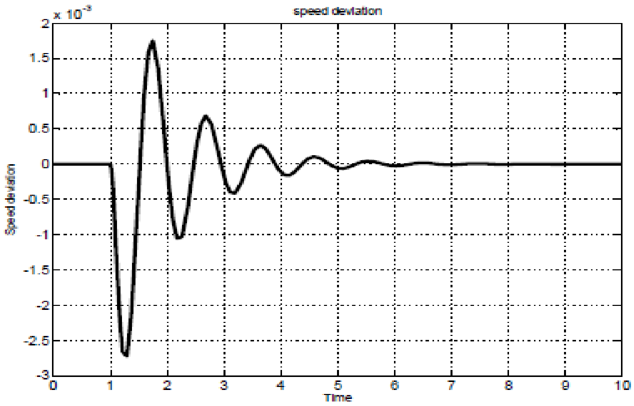

Figure 18 speed deviation when 0.1 p.u voltage disturbance applied.

Case III: Simulation results with FPSS when voltage disturbance (0.1p.u) and torque disturbance of 5% is applied

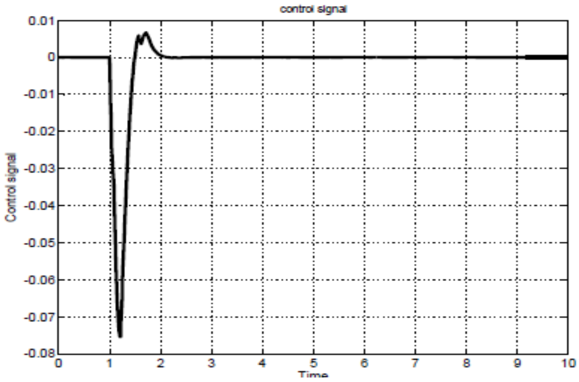

Figure 19 Control signal when 0.1 p.u voltage disturbance applied

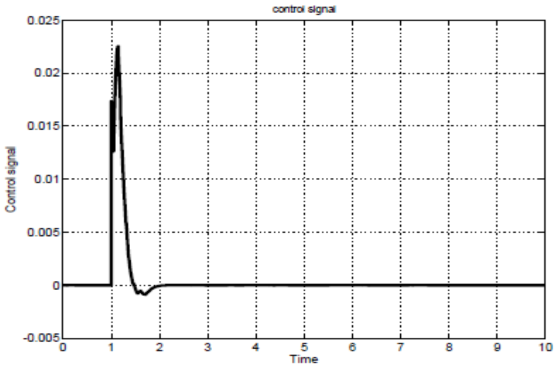

Figure 20 Control signal when 5% torque disturbance applied

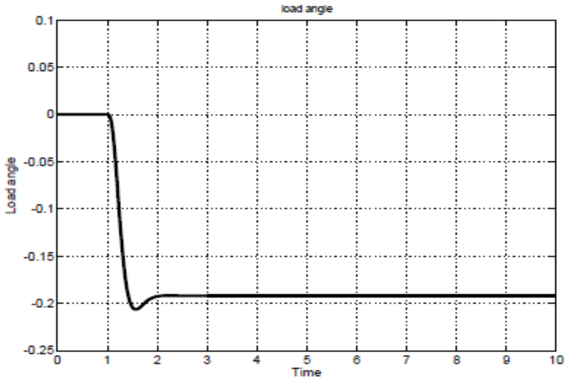

Figure 21 Load angle when 0.1 p.u voltage disturbance applied

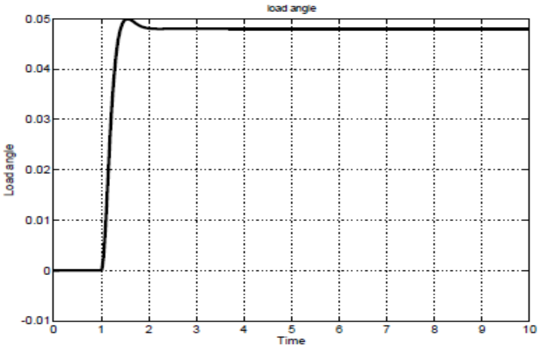

Figure 22 Load angle when 5% torque disturbance applied

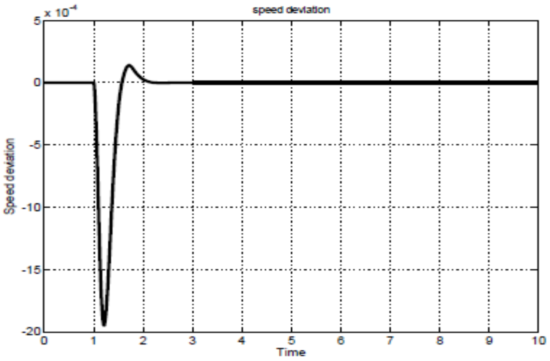

Figure 23 Speed deviation when 0.1 p.u voltage disturbance applied

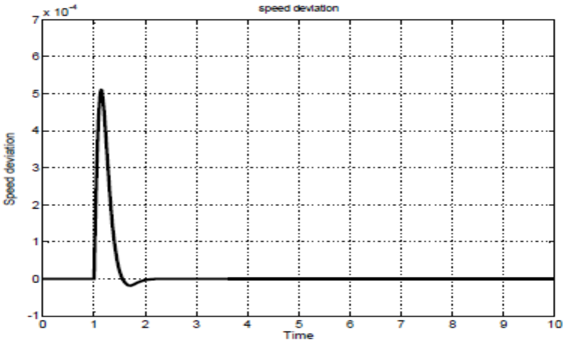

Figure 24 Speed deviation when 5% torque disturbance applied

VI. Conclusions

From the above results we can say that FPSS shows the better control performance than power system stabilizer in terms of settling time and damping effect. It is thus possible to realize the controller efficiently. Therefore, it can be concluded that the performance of the proposed FPSS is much better and the oscillations are damped out much quicker.

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