International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 1 Issue 5, July - 2012

Analysis of Power System Stabilizer Using Fuzzy Logic Controller

Mr. Polamuri Pradeep[1], Mr.N.Vamsi Krishna[2]
[1]M. Tech Student, [2]Assistant professor,
[1, 2] Electrical and Electronics Department,
[1, 2] V R Siddhartha Engineering College, Kanuru
[1,2]Vijayawada, India

***Abstract*—The performance of fuzzy-logic power systemstabilizer (FPSS), is investigatedby applying it to a single- machine power system connected to infinite bus. FPSS isdevelopedusingspeeddeviation andthederivativeofspeed deviationasthecontrollerinputvariables.Theperformanceofthesystemwith fuzzylogicbasedpowersystemstabilizeris compared withthesystemhavingconventionalpowersystem stabilizer andsystemwithoutpowersystemstabilizer.The simulationresultsshowthatthe proposedFPSSexhibitsverygood performanceindampingpowersystemlow frequencyoscillationsandgreatlyimprovespowersystemstability.**

***Keywords*: Power systemstabilizer, single-machine powersystem, fuzzylogiccontrol,lowfrequencyoscillations,system stability.**

I.INTRODUCTION

Thepowersystem isadynamic system.Itis constantlybeingsubjectedto disturbances,which causethe generatorvoltageangletochange.When thesedisturbances dieout,anew acceptable steadystateoperatingconditionis reached.Itis importantthatthesedisturbances donot drive thesystemto unstable condition

In the pastfive decades thePSShave beenusedto providethedesired system performanceundercondition that requiresstabilization.Stability ofsynchronousgenerator dependson anumberoffactorssuch asthesetting of automaticvoltage regulator(AVR).Manygenerators are designedwithhighgain,fastactingAVRs toenhancelarge scalestabilitytoholdthegeneratorin synchronismwith the powersystemduringlargetransient faultconditions.But withthehighgainofexcitation systems,itcan decreasethe damping torque of generator.Asupplementaryexcitation controller referred to as PSS have been added to synchronousgeneratorstocounteracttheeffect ofhigh gain AVRs and other sourcesofnegative damping[7].

To provide damping,the stabilizersmust producea componentof electricaltorqueontherotorwhichisinphase with speedvariations. The application of a PSSistogenerateasupplementarystabilizingsignal,which isapplied totheexcitationsystemorcontrolloopofthegenerating unittoproduceapositivedamping.Themostwidely used conventional PSS is the lead-lag PSS, where the gain settingsare fixed atcertain values whichare determined underparticularoperatingconditionsto resultinoptimal performanceforthatspecificcondition.However,theygivePoorperformanceunderdifferentsynchronousgenerator loadingconditions. ConventionalPSS(CPSS) iswidelyused in existing powersystemsandhasmadea contributionin enhancingpowersystemdynamicstability.Theparameters ofCPSSaredeterminedbasedon alinearizedmodel [2]of thepowersystem aroundanominaloperatingpointwhere theycanprovidegoodperformance.Sincepowersystems arehighlynon-linearsystems,with configurations and parameters thatchangewith time,theCPSS design basedon thelinearizedmodelofthepowersystemcannotguarantee its performance ina practicaloperatingenvironment[3].

II. OVERVIEWOFPOWERSYSTEMAND MODELLING

Asimplifiedschematicdiagram [3]ofasingle-machineinfinite-bussystem isshowninFig.1.The system consistsof agenerating unit connectedtoaconstantvoltage bus throughttwoparalleltransmissionlines.An excitation systemandautomaticvoltageregulator (AVR)areemployed tocontroltheterminalvoltage,andan associatedgovernor monitors theshaftfrequencyandcontrolsmechanical power. Neglectingthetransientsinthestatorcircuitandtheeffect ofrotoramortisseur,thesynchronousgeneratorcan be representedin theform of Park'stwo-axismachinemodel by aset of simplifiedlinearequations [2]**.** Thetransmission networkwithanimpedance of re+*jx***,**is connectedtoan infinite bus of voltage V_b and the AVR and excitation systemarerepresentedby afirstorderdifferentialequation. Undernormal operating conditions,alinear,time-invariant systemcan be derivedby applying smallperturbation relationsaroundacertainequilibriumpoint.A linearized model [6] isshowninBlockdiagramformatFig.2

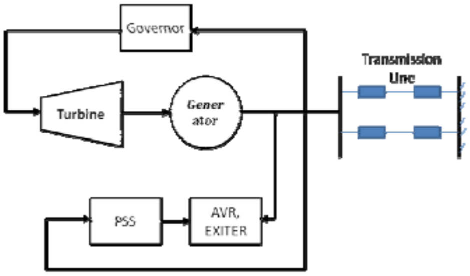


Fig.1Aschematic diagram of the powerstem.

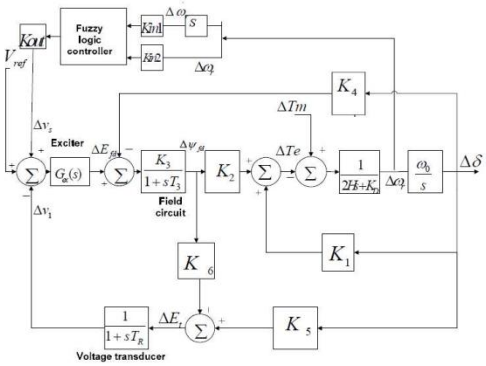


Fig.2Linearzedpower systemmodelwithFPSS

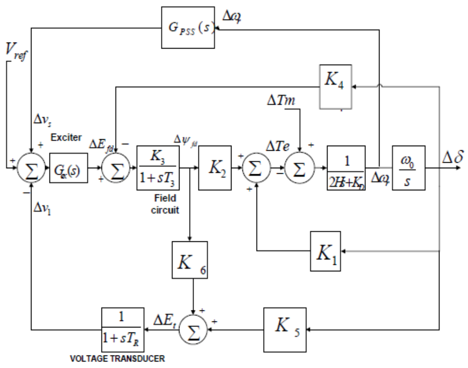


Fig.3Linearizedpower systemmodelwithPSS

TABLE.1

PARAMETERS FORTHELINEARIZED POWERSYSTEMMODEL

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
$G_a(s)$	210
T_R	0.02
ω_0	314

The blockdiagramfor power systemstabilizer [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

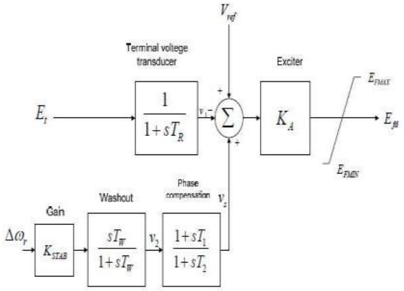


Fig.4Thermistor excitationsystemswithAVRandPSS

III.FUZZYLOGICBASEDPSS

The fuzzycontrolsystemsarerule-basedsystemsin whichasetoffuzzy rulesrepresentacontrol decision mechanismtoadjusttheeffectsofcertain system stimuli. Withaneffectiverulebase,thefuzzy controlsystemscan replaceaskilledhuman operator.Thefuzzy logiccontroller providesanalgorithmwhichcan convertthelinguistic control strategy based on expert knowledge into an automatic control strategy. The Fig.5 illustrates the schematicdesignofafuzzylogiccontrollerwhichconsists ofafuzzification interface,a knowledge base,decision makinglogic, anda DefuzzificationInterface.

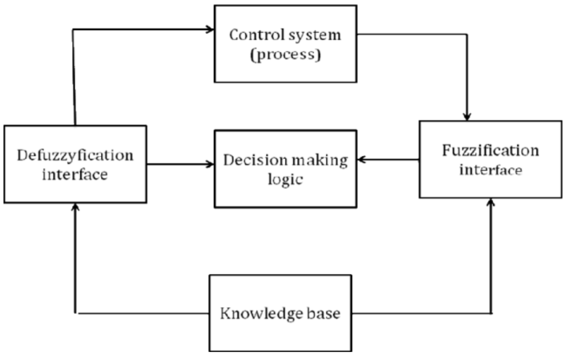


Fig.5Theprincipledesign of fuzzy logic controller

IV.CONTROLLERDESIGNPROCEDURE

Thefuzzylogiccontroller(FLC)designconsistsofthe followingsteps.

1) Identificationofinputandoutputvariables.
2) Constructionofcontrolrules.
3) Establishingthe approachfor describingsystemstate in termsoffuzzy sets,i.e.establishingfuzzificationmethod andfuzzymembershipfunctions.
4) Selectionofthe compositionalrule ofinference.
5) Defuzzification method, i.e., transformation of thefuzzycontrol statementintospecific controlactions.

MEMBERSHIPFUNCTION:

Thevariableschosenforthiscontrollerarespeed deviation, accelerationandvoltage. In this, the speedDeviationandaccelerationaretheinputvariablesandvoltageisthe outputvariable.

NB	NegativeBig
NM	NegativeMedium
NS	NegativeSmall
ZE	Zero
PS	Positive Small
PM	Positive Medium
PB	Positive Big

Table3. Membership functions for fuzzyvariables.

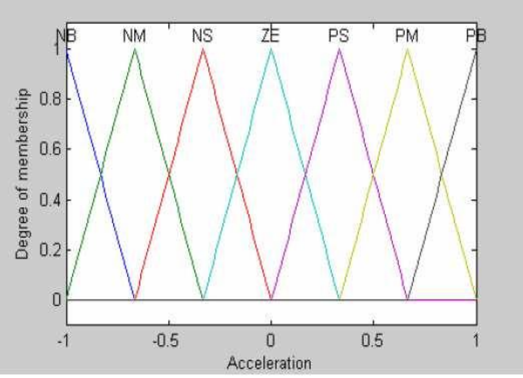


Fig.6Membership functionsfor Acceleration

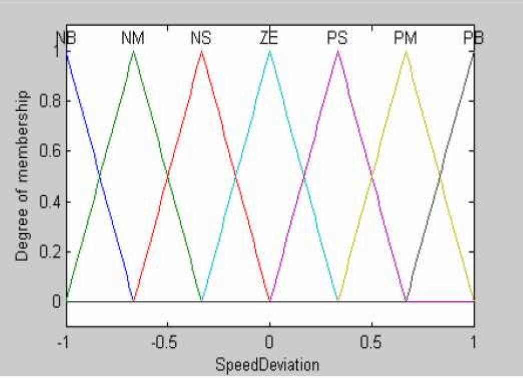


Fig.7Membership functionsfor speeddeviation

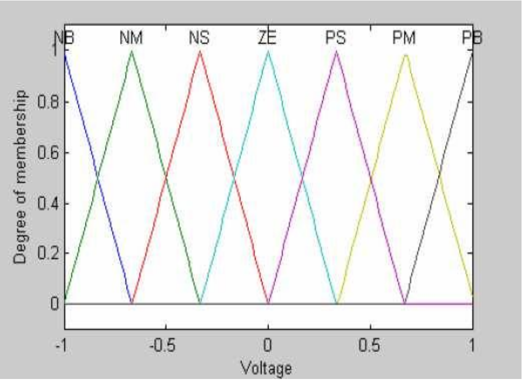


Fig.8Membership functionsfor voltage

Eachoftheinput andoutputfuzzyvariablesisassigned seven linguisticfuzzy subsets varyingfromnegativebig(NB)topositivebig(PB).EachsubsetisassociatedwithaTriangularmembershipfunction toform asetofseven membershipfunctionsfor eachfuzzyvariable.Thevariables arenormalizedby multiplyingwith respective gainsK_{in1},K_{in2},K_{out}sothat theirvalueliesbetween-1and1. Themembershipfunctions ofthe inputoutputvariableshave 50% overlap between adjacent fuzzy subsets.Themembershipfunctionfor acceleration,speedandvoltageare Shown below.

FUZZYRULE BASE:

Asetof ruleswhich definetherelation between the inputandoutputoffuzzycontrollercan befoundusingthe availableknowledgeintheareaofdesigningPSS.These rulesare definedusing thelinguisticvariables.Thetwo inputs,speedandacceleration, resultin49rulesforeach machine. The typical rules are having the following structure:

Rule1**:**Ifspeeddeviation isNM (negativemedium)AND acceleration is PS (positivesmall)thenvoltage(output of fuzzyPSS) isNS(negative small).

Rule2**:**IfspeeddeviationisNB (negative big)AND accelerationis NB(negativebig) thenvoltage (outputof fuzzyPSS) isNB(negative big).

Rule 3**:** If speeddeviationisPS(positive small) AND Acceleration isPS(positivesmall)thenvoltage(outputof fuzzyPSS) isPS(positive small). Andso on….

Allthe49rulesgoverningthemechanism areexplainedin Table3.2whereallthesymbolsaredefinedinthebasic fuzzylogic terminology:

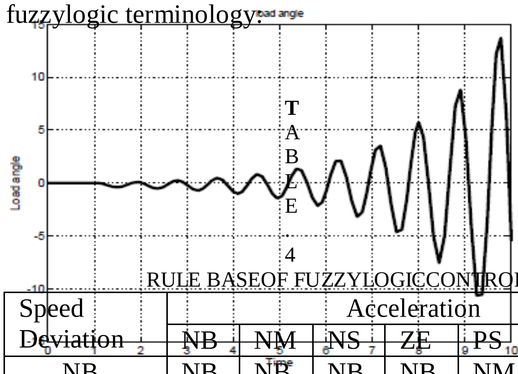


TABLE 4

RULE BASEOF FUZZYLOGICCONTROLLER

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.RESULTSANDDISCUSSION

SIMULINKMODEL:

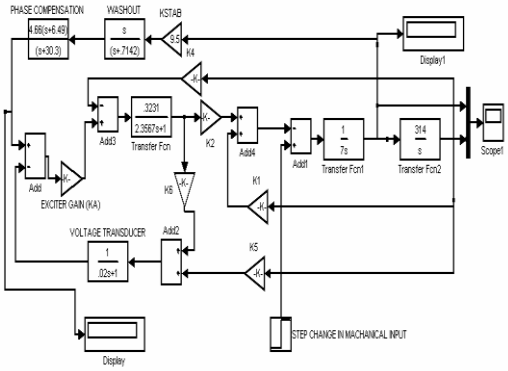


Fig.9Simulinkmodel forsinglemachine connectedtoinfinitebuswithPSS

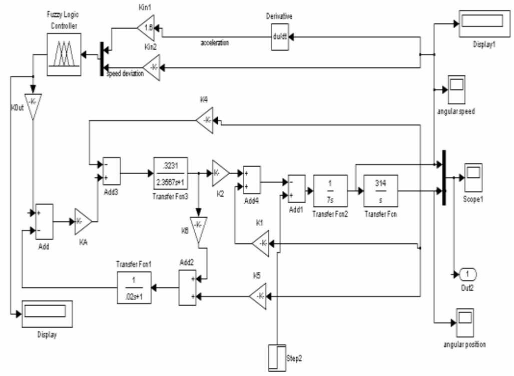


Fig.10Simulink model for singlemachineconnected toinfinitebuswith Fuzzylogic basedPSS

CaseI:

Simulation resultswithoutPSS when voltage(0.1p.u)Disturbanceisapplied

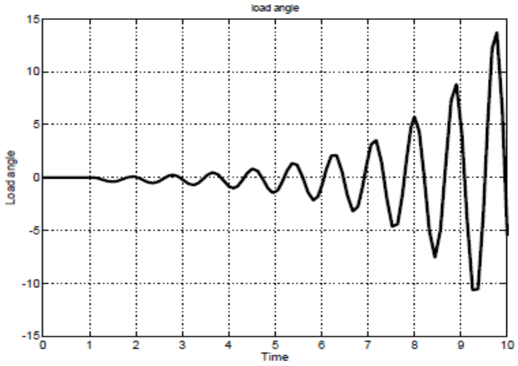


Fig.11Loadanglewhen0.1 pp.voltagedisturbanceapplied

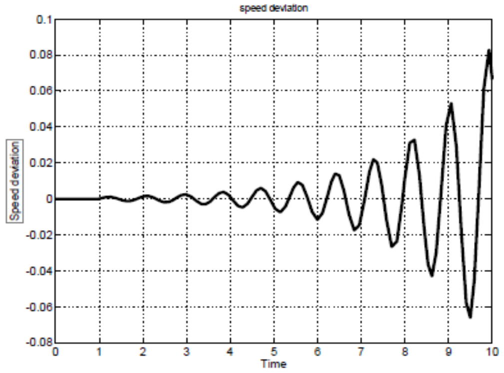


Fig.12Speeddeviation when5% torque disturbanceapplied

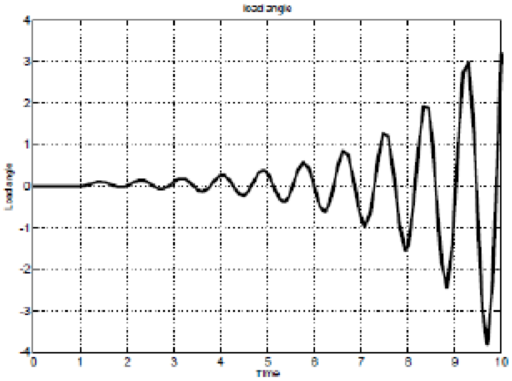


Fig.13Loadanglewhen5%torquedisturbanceapplied

CaseII:

Simulation resultswithPSS when voltagedisturbance (0.1p.u)andtorquedisturbanceof5%isapplied.

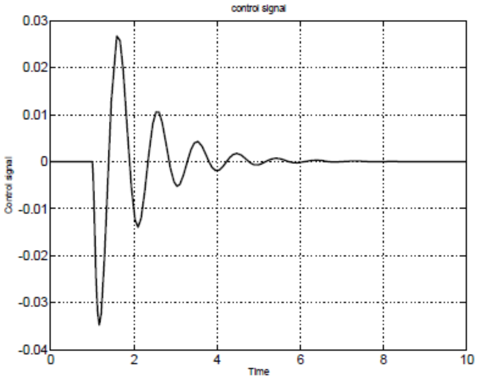


Fig.14Controlsignalwhen0.1 pp. voltagedisturbanceapplied

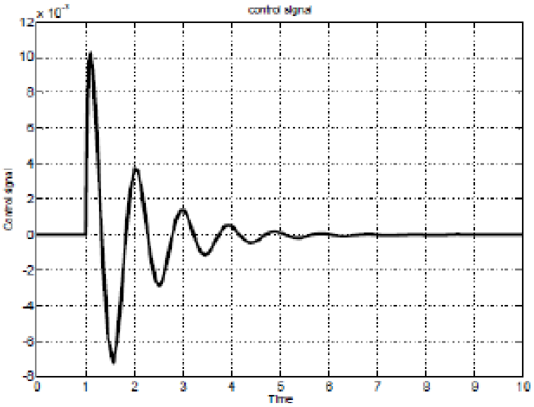


Fig.15Controlsignalwhen5% torquedisturbanceapplied

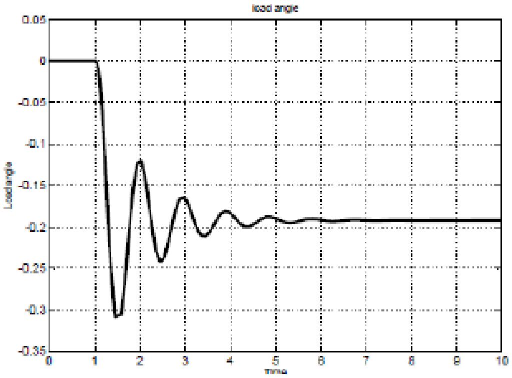


Fig.16 Load angle when 0.1 p.u voltage disturbance applied

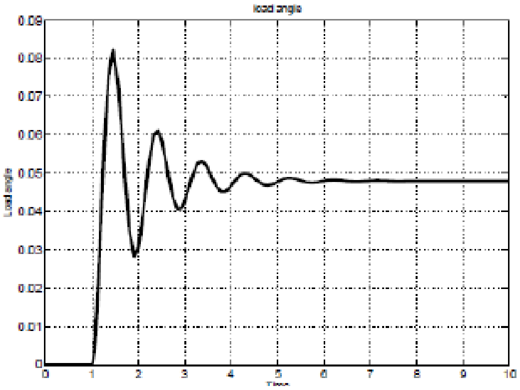


Fig.17Loadanglewhen5%torquedisturbanceapplied

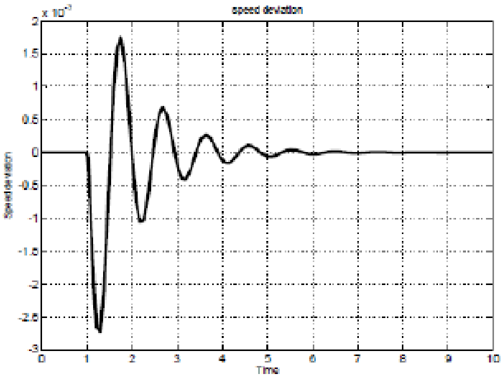


Fig.18Speeddeviation when0.1 pp.voltagedisturbanceapplied.

CaseIII:

Simulation resultswithFPSS when voltagedisturbance(0.1p.u)andtorquedisturbance of5%isapplied

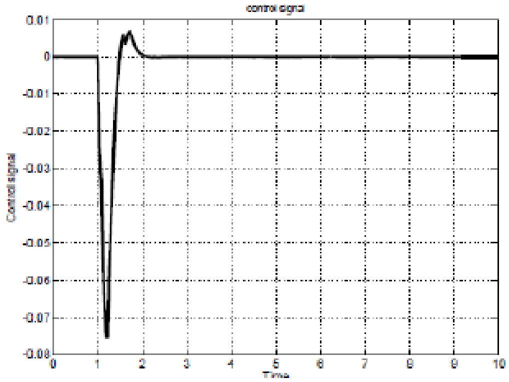


Fig.19Controlsignalwhen0.1 pp. voltagedisturbanceapplied

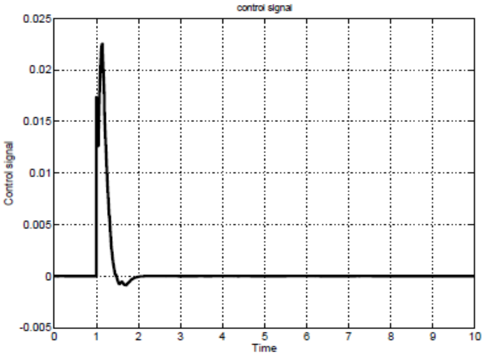


Fig.20Controlsignalwhen5% torquedisturbanceapplied

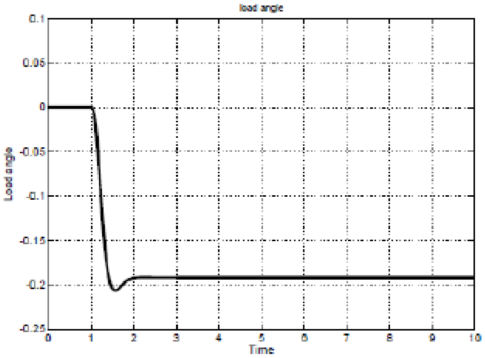
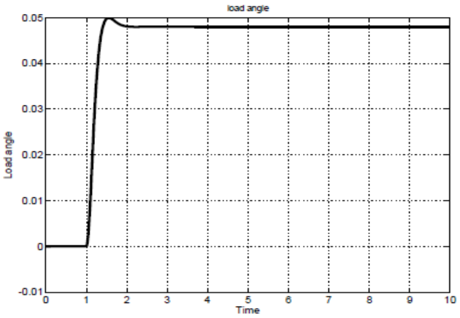


Fig .21Loadanglewhen0.1 pp.voltagedisturbanceapplied



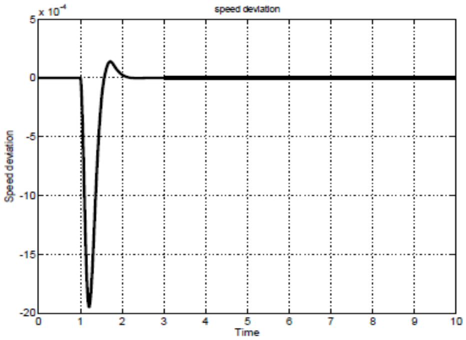


Fig.23Speeddeviations when0.1 pp.voltage disturbanceapplied

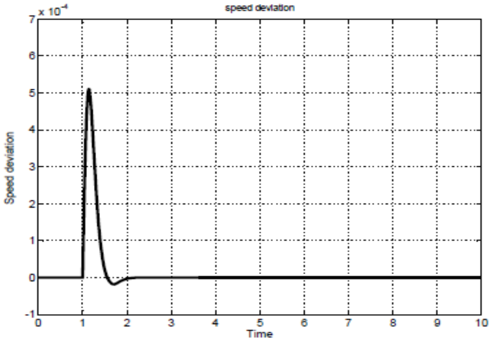


Fig.24 Speeddeviationswhen5% torque disturbanceapplied

VII.CONCLUSION

FromtheaboveresultswecansaythatFPSS shows thebettercontrolperformancethanpowersystemstabilizer interms ofsettling timeanddamping effect.Itisthus possibleto realizethecontrollerefficiently.Therefore,it can beconcludedthat the performanceofthe proposedFPSSis much better andtheoscillations are dampedoutmuchquicker

REFERENCES

[1] N.Rafee,T.Chen,andO.P.Malik,"Atechniqueforoptimal digital redesign ofanalogcontrollers", IEEE TransactionsonControl *SystemsTechnology*,vol. *5, no.1*pp. 89-99,Jan. 1997

[2] F.P.deMelloand Concordia “Conceptsof synchronousmachine Stability aseffectedbyexcitationcontrol”.IEEE Transactions*onPowerapparatusand systems*.vol.PAS-88,no.4, 316-329,1969.

[3] S.Chen, O.P.Malik, “Power system stabilizer design using mu synthesis”.IEEE *Transactions on Energy conversion*, vol.10, no.1, 175-181.1996.

[4] S.Chen and O.P.Malik, “An H-inf optimization based power system stabilizer design”.IEEE proceedings-*Genaration, Transmision and Distribution*, vol.142, no.2, pp.179-184, 1993.

[5] HanguShu, “Optimal Design of Multirate Systems”.thesis The University of Calgary, April 1997

[6] P Kundur, “Power System Stability and Control”,

McGraw-Hill 1994

[7] H.Othman and J.J.Sanchez, M.A.Kale and J.H.Chow, "On the design of robust power system stabilizers", Proceedings of the 28th Conference on Decision and Control .Tampa, Florida December 1989.