IJCTA, 9(39), 2016, pp. 37-44

On Tuning of Damping Factor Technique for the Power System Controller Design

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Abstract : The design of damping controller for power system using Tuning of damping factor technique has been proposed and illustrated with a typical numerical example.

Keywords : Closed loop systems, power systems, controller design.

1. INTRODUCTION

Most of the available Power system stabilizer design methods which are either classical deign or robust design [1-5] are based on considering the plant (open – loop control system) with different nominal operating conditions. Usually, the Power system stabilizer will be designed such that response of the overall compensated system will have improved damping.. The steady state stability around a system operating point is one of the stability problems. The PSS are usually used to enhance the damping of oscillations of power systems. This proposed study is based on linearized models with conventional power system stabilizer. This is considered as a SISO feedback controller incorporated on a generation set .The conventional PSS inputs are Machine shaft speed and Ac bus frequency. The controller design based on H_∞ design method leads to fixed structure and fixed parameter giving robust controllers [1]. It is established that approximating H_∞ design method to PSS design results in difficulties in the selection of weighting functions. Therefore this paper presents a study on improving the controller design method for power system which is based on tuning the damping factor of the controller.

2. PROPOSED CONTROLLER DESIGN PROCEDURE

Consider the system as shown in fig 1.Given G_f(s) and $H_f(s)$, the problem is to derive the transfer function of the controller $G_c(s)$ to yield the desired response of the compensated system. An approach is proposed for the design of the controller $C_f(s)$ is to specify the desired (also called reference) damping factor and solve for transfer function of the controller $G_c(s)$.

A standard second-order transfer function of the controller designed by any available method is chosen and modified by tuning the original damping ratio ξ to ξ' and corresponding modified controller is used to compensate the system.

The modified controller is defined as

$$G_r(s) = \frac{\omega_n^2}{s^2 + 2\,\xi\,1\omega_n s + \omega_n^2} \tag{1}$$

The closed loop transfer function from Fig.1

$$G_o(s) = \frac{G_C(s)\,G_n(s)}{1 + G_C(s)G_n(s)\,H(s)} \tag{2}$$

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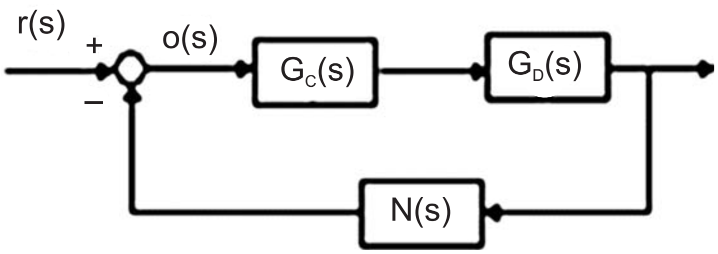


Figure 1: Control configuration

3. APPLICATION OF THE METHOD AND RESULTS

Consider the system given in [1] and the design is based on a nominal operating condition *i.e.* real power output P = 1.0 pu; reactive power output Q = 0.2 pu, transmission line reactance Xe = 0.5pu .The critical pole positions and their damping ratios under different operating conditions without PSS, PSS designed by classical method, by H_∞ method and by the proposed method given in this paper are compared in the following table 1..

Table 1

S.No.		*Open-loop system*		*Classical design*		*H ∞ design*		*Classical proposed*		*H ∞ design*	
	P q Xe	*Pole*	*Damping*	*Pole*	*Damping*	*Pole*	*Damping*	*Pole*	*Damping*	*Pole*	*Damping*
1.	1 0.2 0.2	-0·137±7.590j	0.018	-3.263±10.915j	0.286	-2.987±9.821j	0.291	-7.91±8.198j	0.7	-7.185±7.331j	0.7
2.	1 0.2 0.3	-0.036±6.958j	0.005	-3.773±9.651j	0.364	-3.142±8.564j	0.344	-7.25±7.4032j	0.7	-6.35±6.548j	0.7
3.	1 0.2 0.4	0.079±6.412j	-0.012	-4.176±8.326j	0.448	-3.205±7.298j	0.402	-6.52±6.652j	0.7	-5.575±5.696j	0.7
4.	1 0.2 0.5	0.203±5.936j	-0.034	-2.885±5.612j	0.457	-3.016±5.894j	0.456	-4.415±4.507j	0.7	-4.63±4.731j	0.7
5.	1 0.2 0.6	0.330±5.516j	-0.060	-2.065±5.125j	0.374	-2.161±4.747j	0.414	-3.865±3.947j	0.7	-3.65±3.723j	0.7
6.	1 0.2 0.7	0.457±5.145j	-0.088	-1.486±4.758j	0.298	-1.379±4.303j	0.305	-3.485±3.562j	0.7	-3.16±3.228j	0.7
7.	1 0.2 0.8	0.353±5.144j	-0.068	-1.570±4.783j	0.312	-1.514±4.334j	0.330	-3.52±3.59j	0.7	-3.21±3.281j	0.7
8.	0.8 0.4 0.5	0.047±5.679j	-0.008	-2.188±5.504j	0.370	-2.244±5.361j	0.386	-4.145±4.229j	0.7	-4.065±4.152j	0.7
9.	0.9 0.3 0.5	0.106±5.829j	-0.018	-2.586±5.596j	0.420	-2.686±5.632j	0.430	-4.31±4.3958j	0.7	-4.3675±4.45j	0.7
10.	1.1 0.1 0.5	0.341±5.976j	-0.057	-2.970±5.548j	0.472	-3.196±5.978j	0.472	-4.405±4.493j	0.7	-4.74±4.84j	0.7
11.	0.8 0.4 0.6	0.123±5.274j	-0.023	-1.713±4.972j	0.326	-1.729±4.623j	0.350	-3.677±3.752j	0.7	-3.4505±3.52j	0.7
12.	0.9 0.3 0.6	0.206±5.419j	-0.038	-1.946±5.067j	0.359	-2.015±4.705j	0.394	-3.795±3.879j	0.7	-3.58±3.658j	0.7
13.	1.1 0.1 0.6	0.427±5.642j	-0.075	-2.242±5.256j	0.392	-2.406±4.941j	0.438	-3.995±4.079j	0.7	-3.84±3.918j	0.7
14.	0.8 0.4 0.7	0.201±4.902j	-0.041	-1.332±4.557j	0.281	-1.252±4.156j	0.289	-3.32±3.387j	0.7	-3.035±3.101j	0.7
15.	0.9 0.3 0.7	0.306±5.050j	-0.061	-1.465±4.670j	0.299	-1.383±4.232j	0.311	-3.42±3.493j	0.7	-3.11±3.182j	0.7
16.	1.1 0.1 0.7	0.319±5.484j	-0.058	-2.564±5.528j	0.421	-2.711±5.546j	0.439	-4.26±4.353j	0.7	-4.32±4.408j	0.7

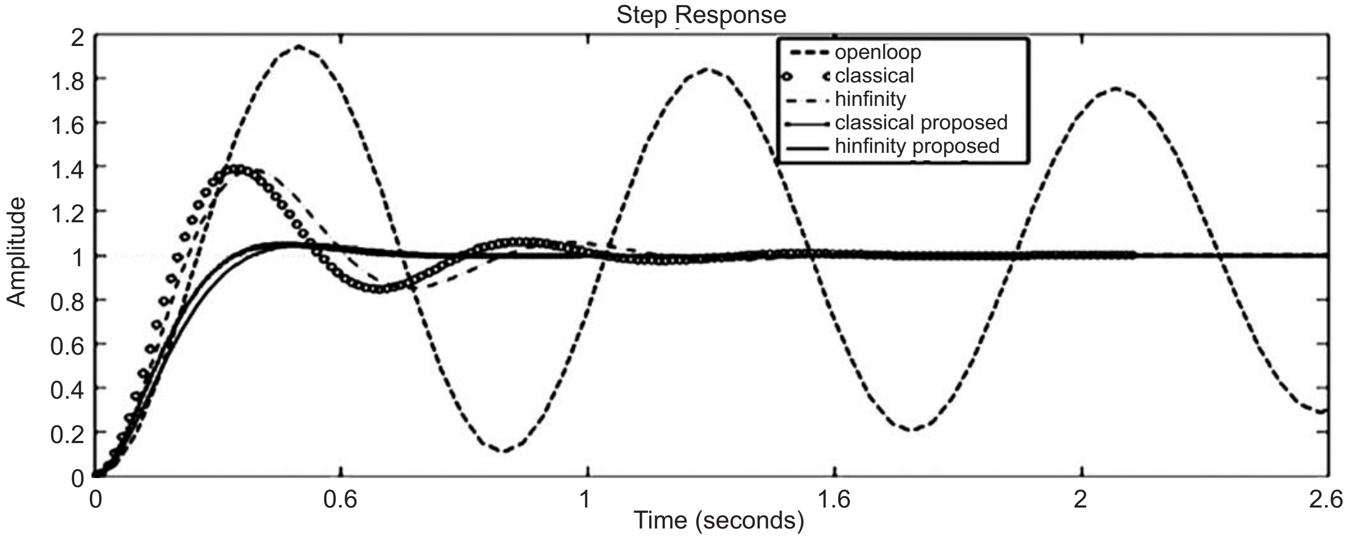
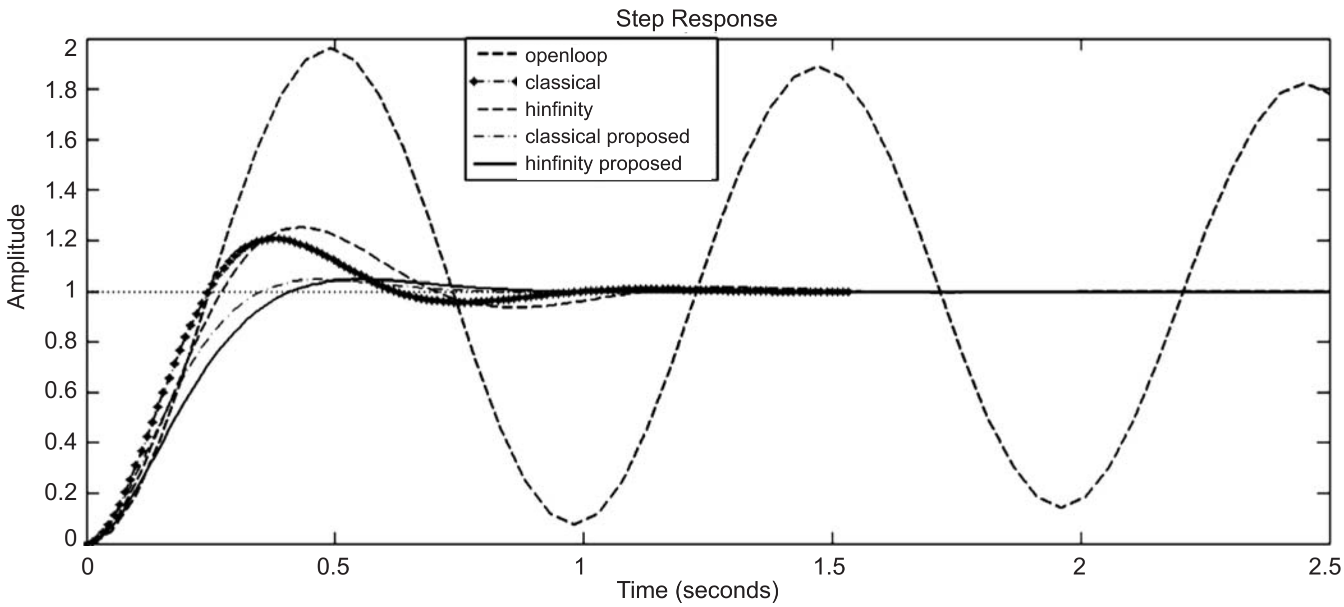


Figure 2



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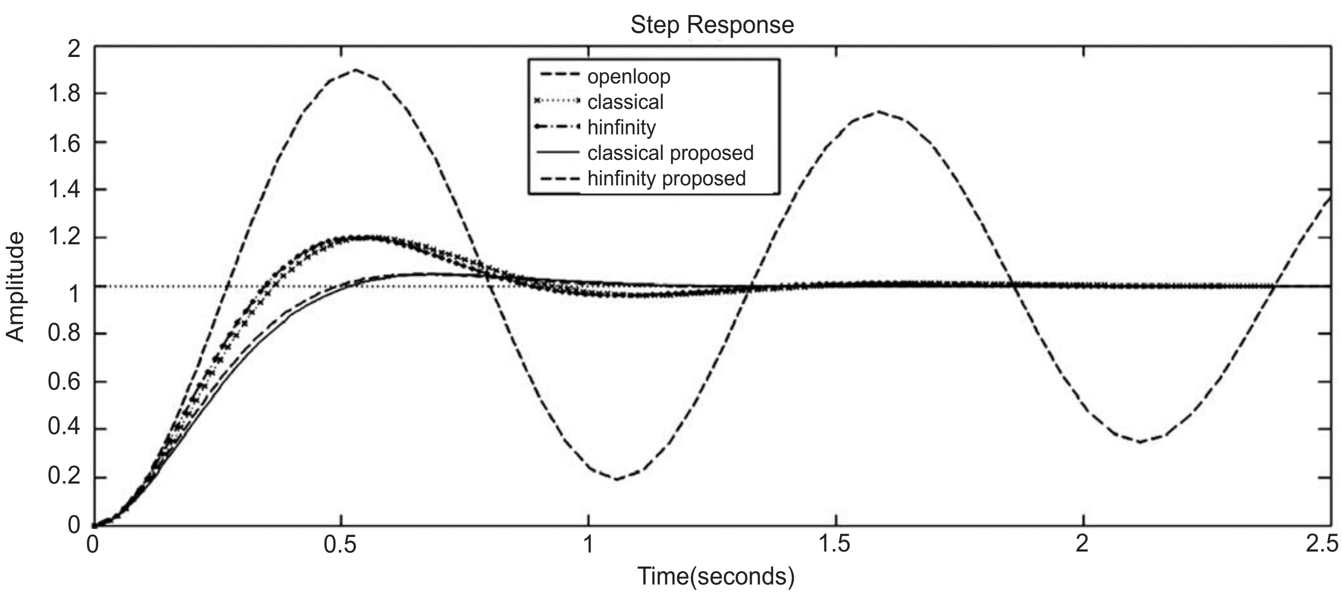

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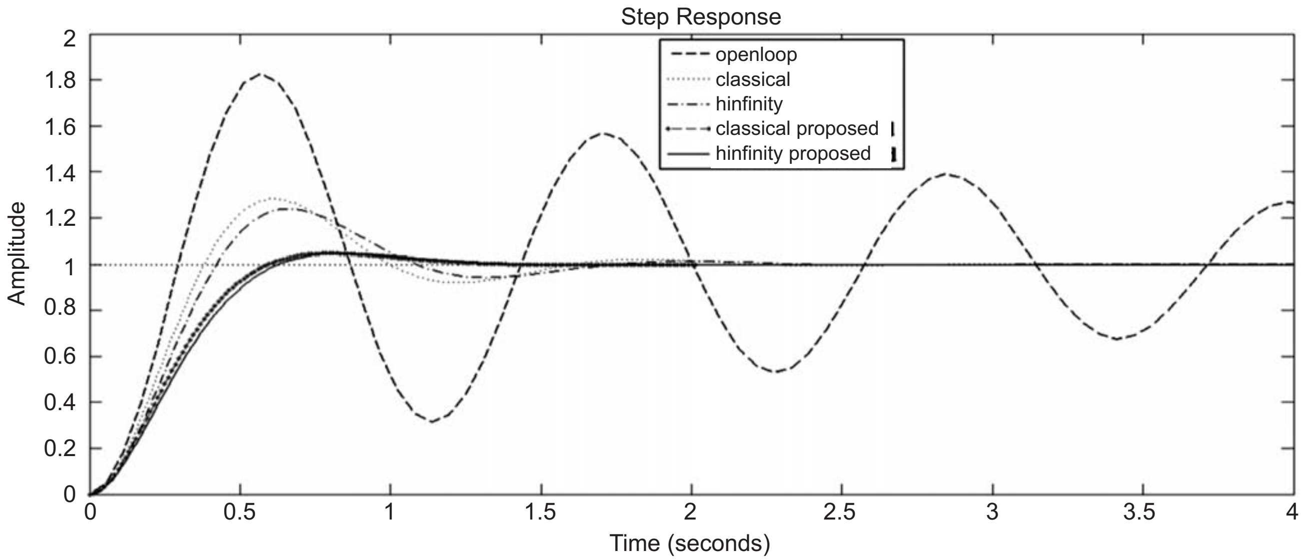

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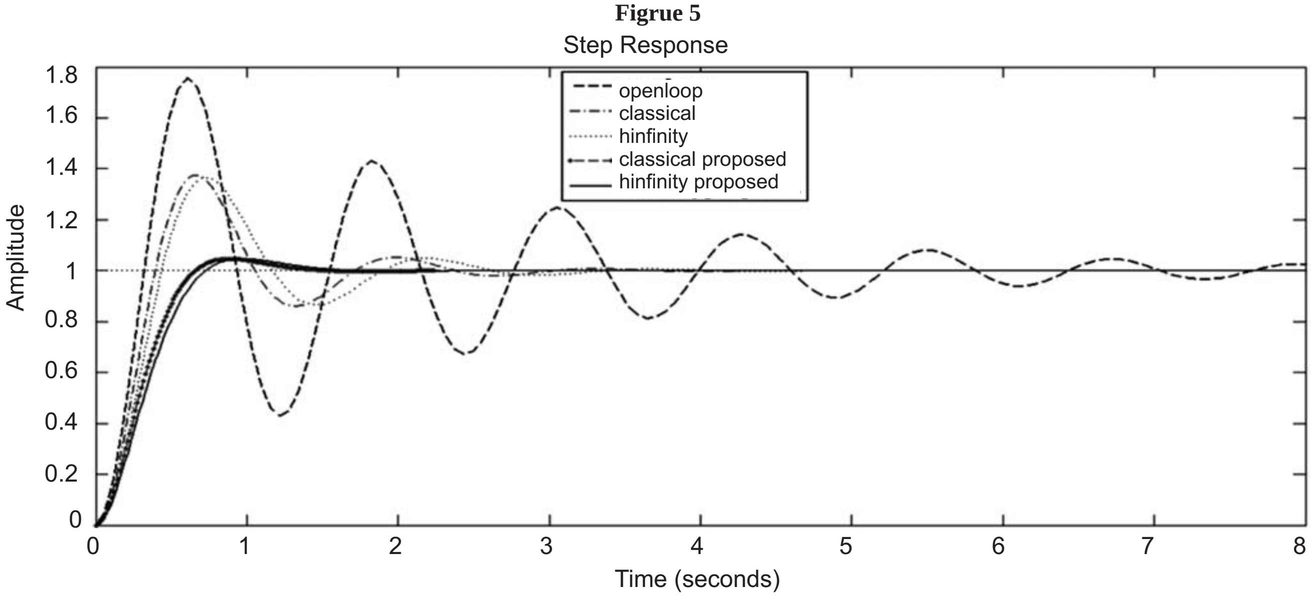

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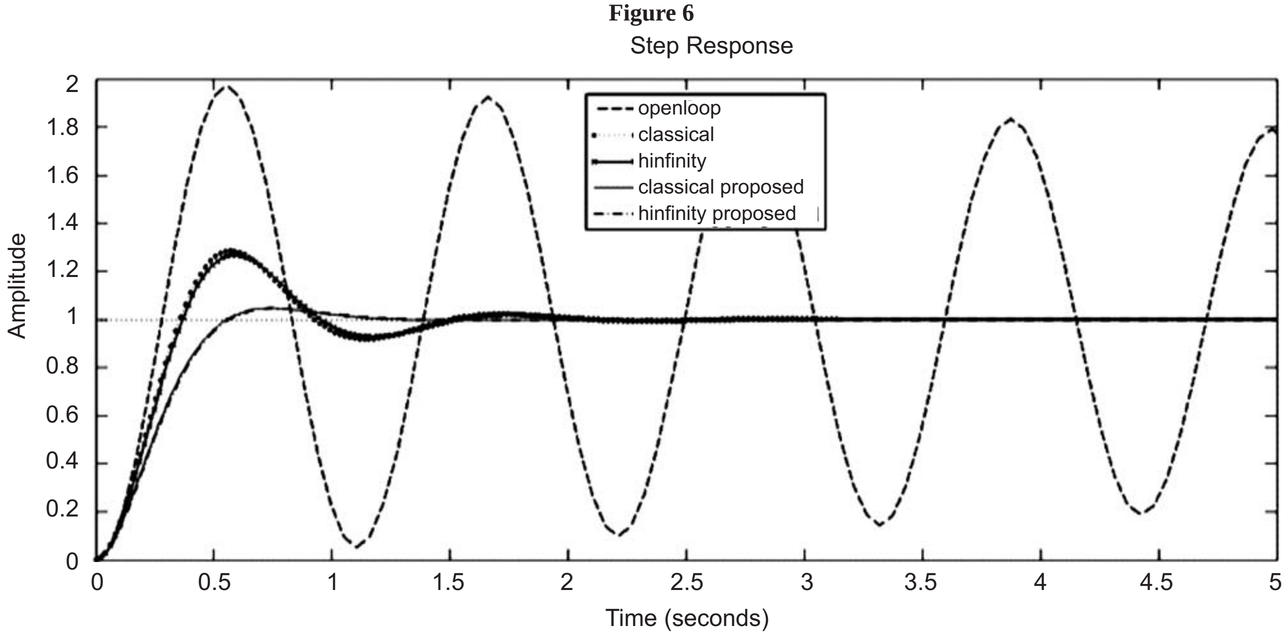

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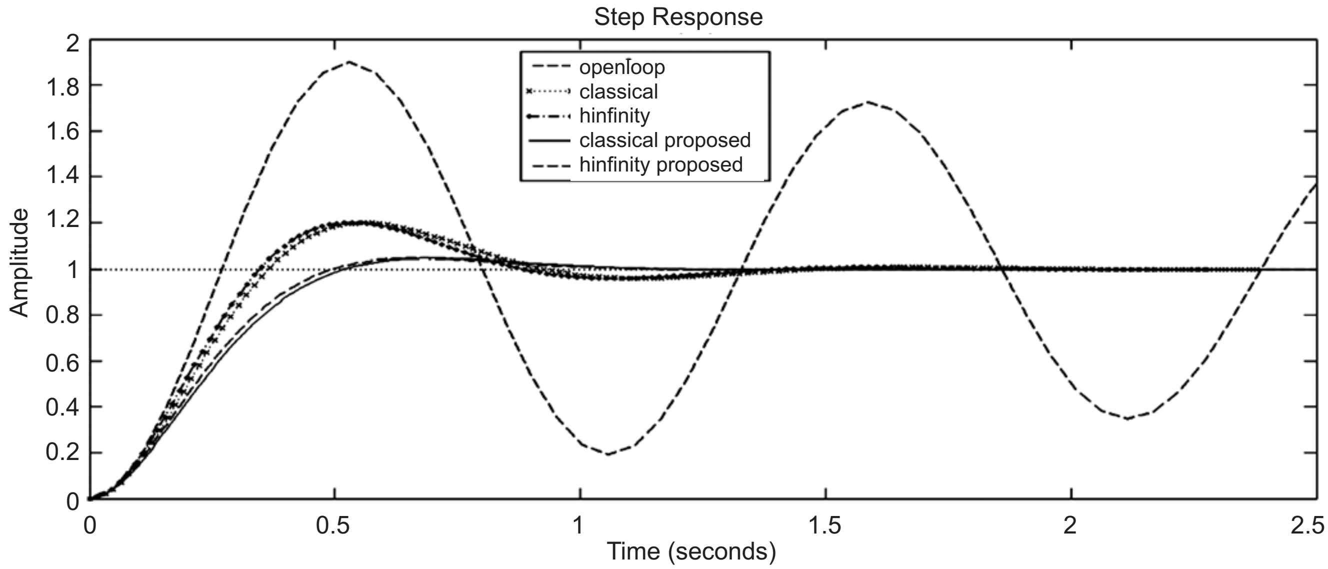

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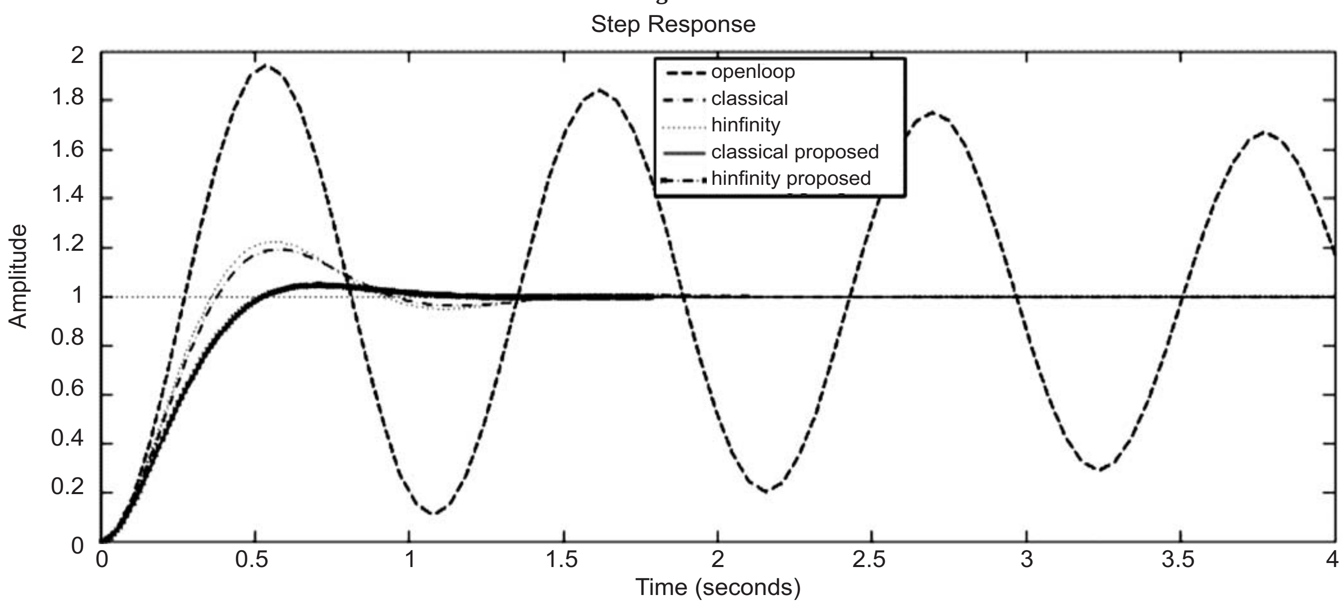

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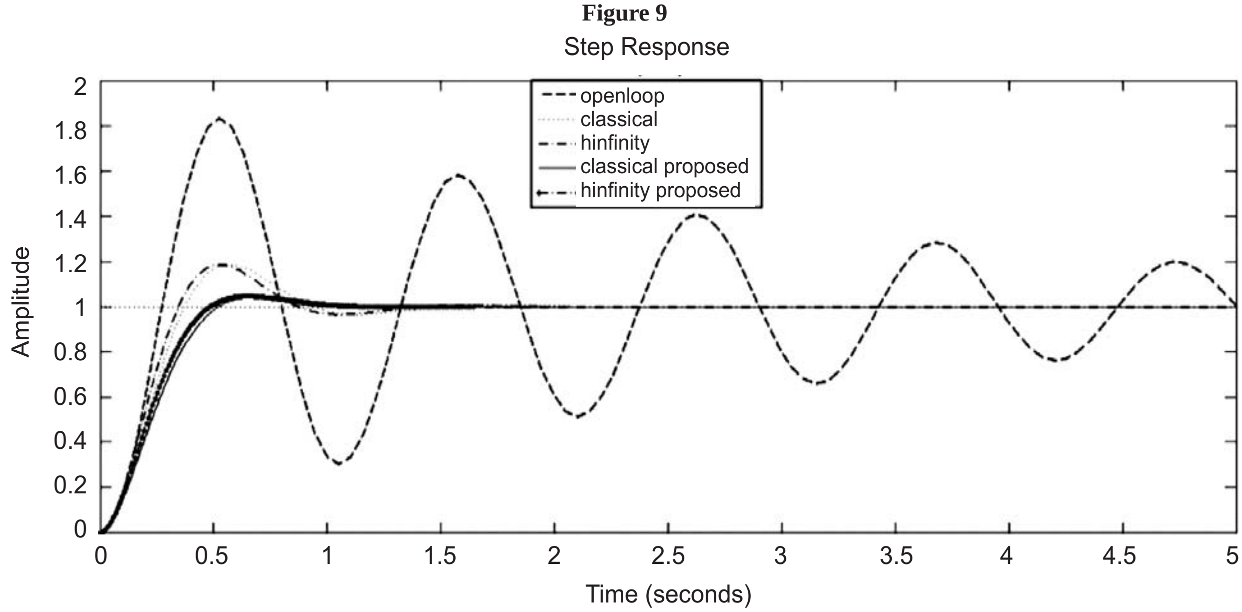

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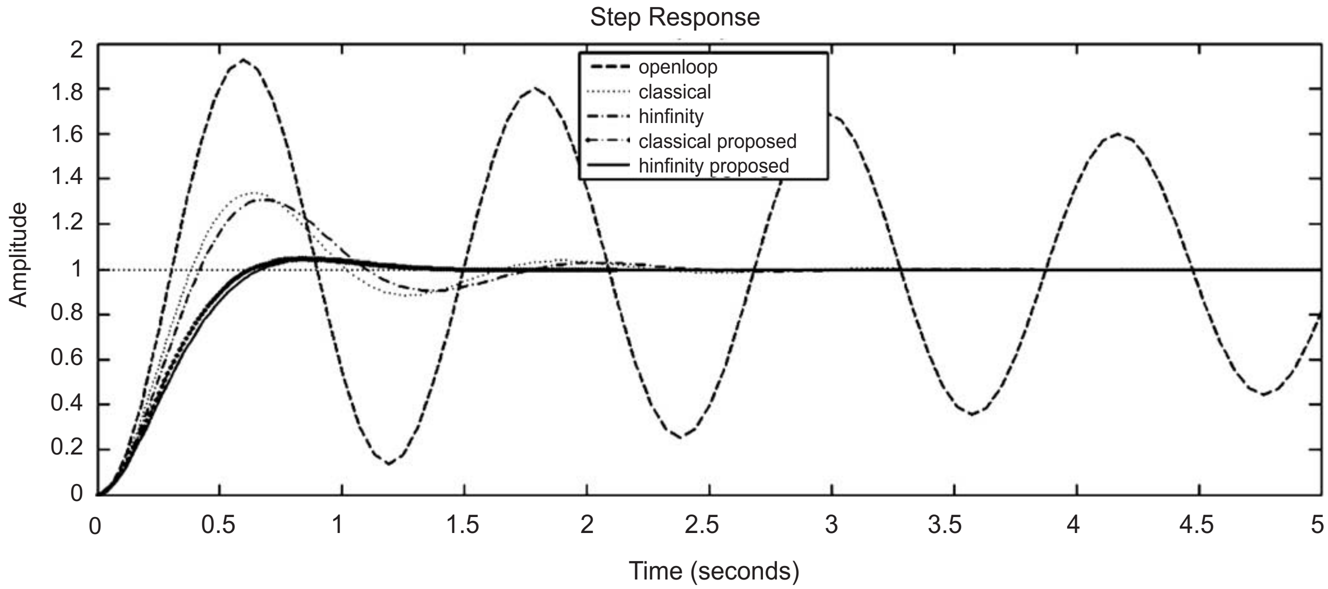

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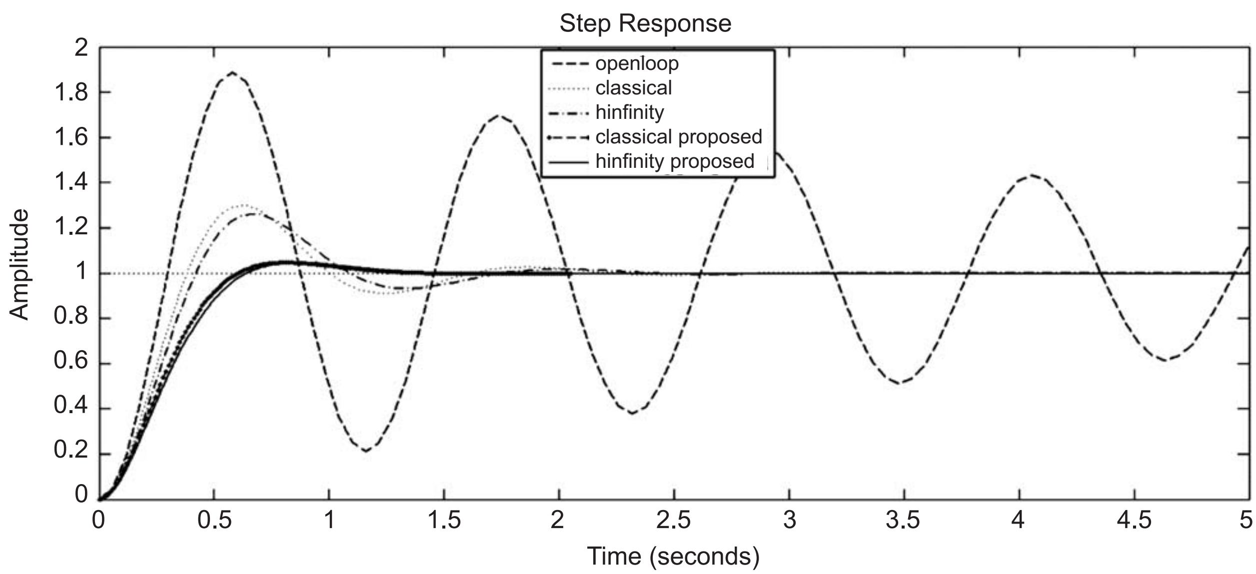

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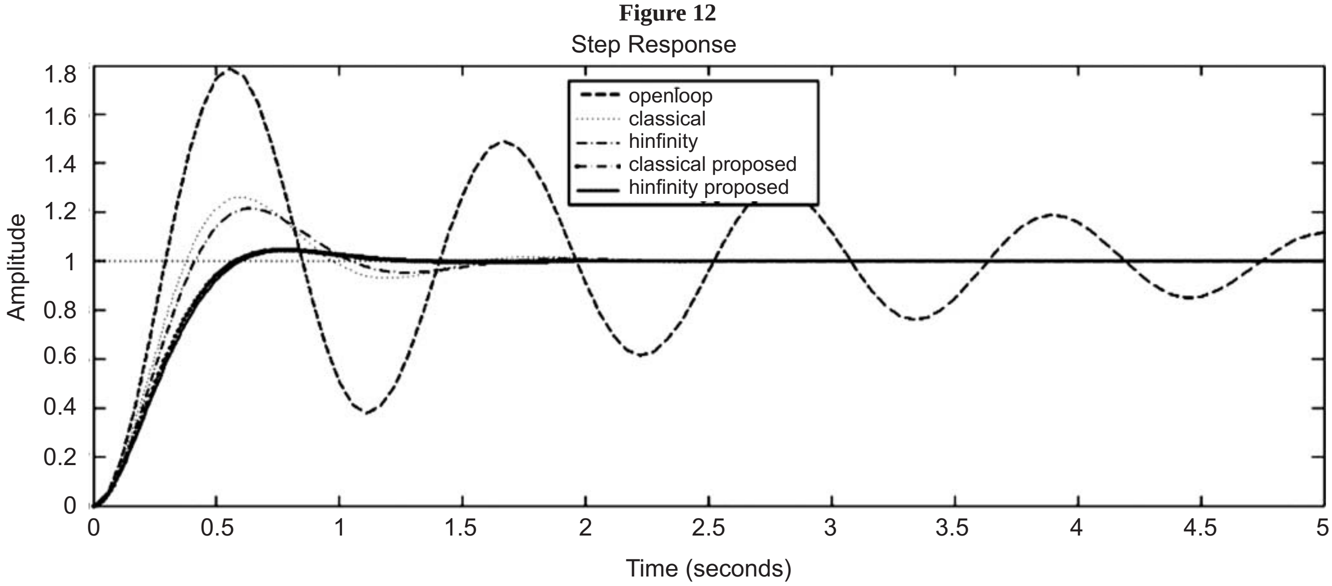

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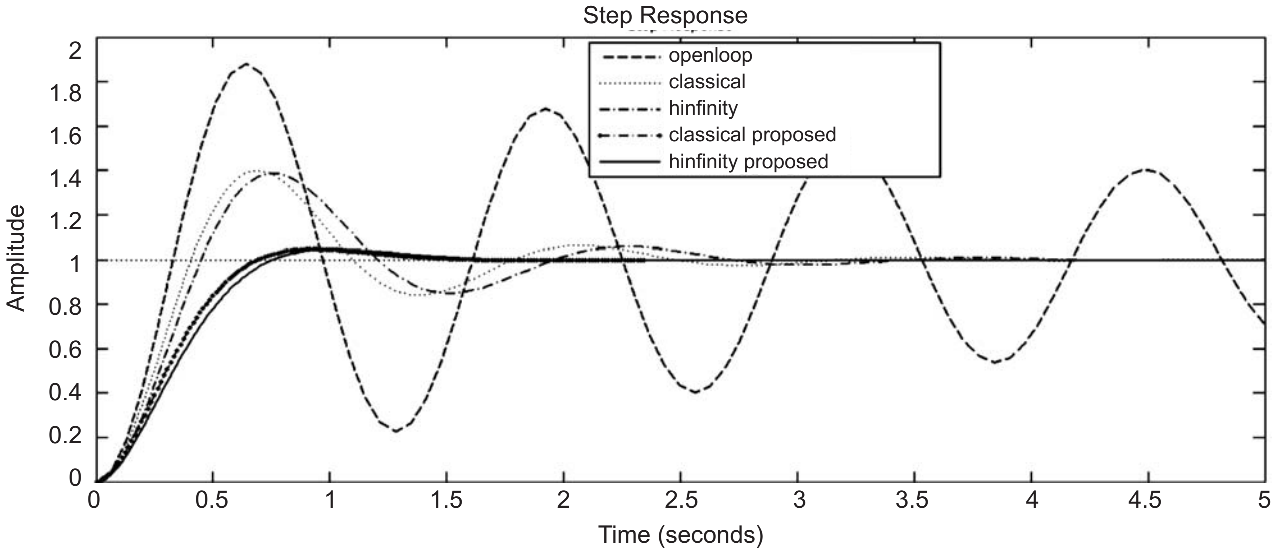

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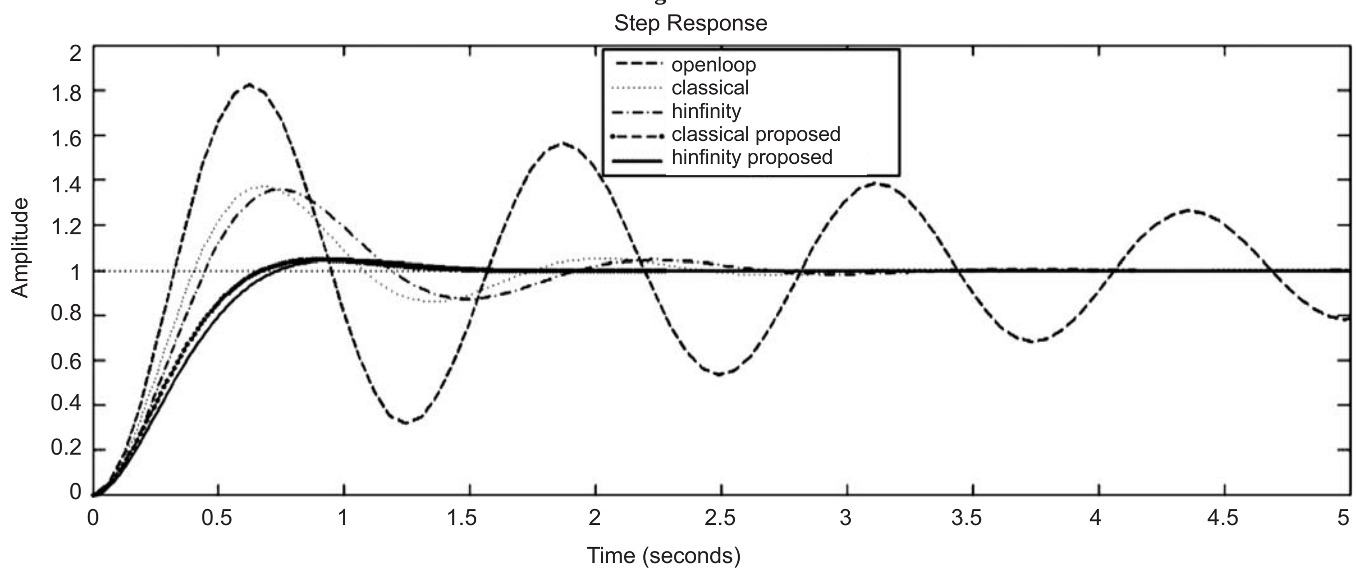

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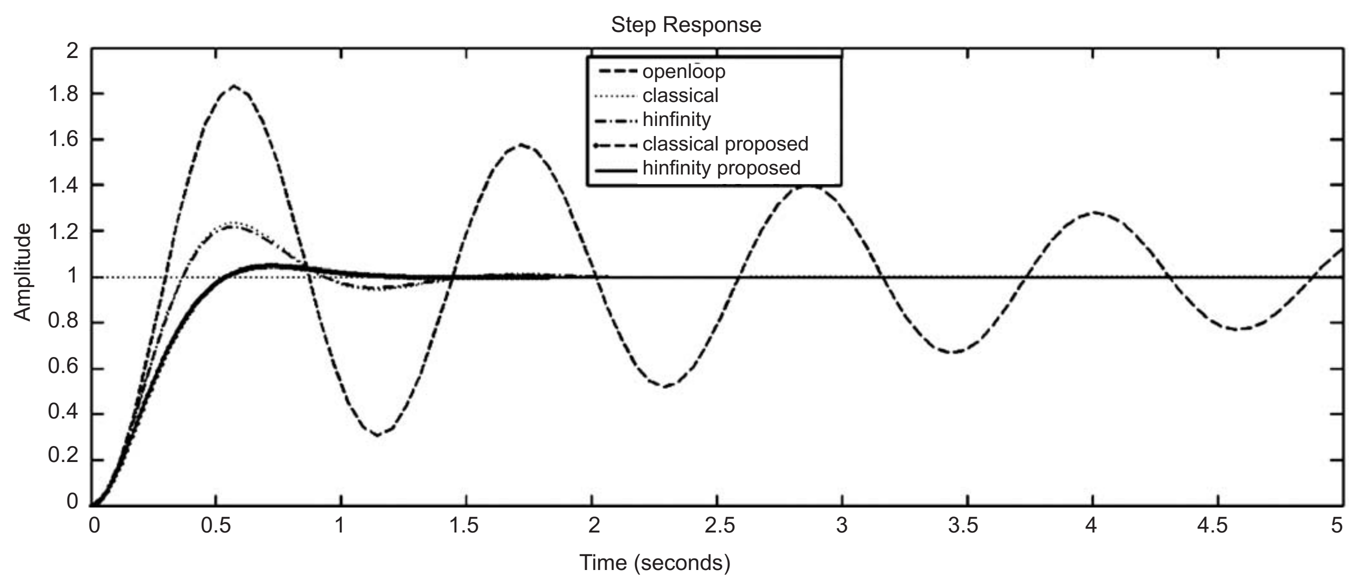

Figure 16

Table 2

S.No				*Open loop*		*Classical*		*H infinity*		*Classical proposed*		*H infinity proposed*	
	P	*q*	*Xe*	*Mp*	*ts*	*Mp*	*ts*	*Mp*	*ts*	*Mp*	*ts*	*Mp*	*ts*
1.	1	0.2	0.2	0.98	49.55	1.37	2.75	1.39	2.5	1.02	1.6	1.01	1.4
2.	1	0.2	0.3	0.97	49.9	1.25	2.2	1.3	2.3	1.02	1.7	1.03	1.9
3.	1	0.2	0.4	0.98	49.8	1.2	2	1.22	2.2	1.02	1.8	1.01	1.7
4.	1	0.2	0.5	0.92	49.9	1.2	3	1.2	2.5	1.03	2.01	1.04	2.1
5.	1	0.2	0.6	0.89	45.5	1.25	4	1.21	3	1.03	2.4	1.03	2.5
6.	1	0.2	0.7	0.89	45.8	1.39	4.9	1.36	5	1.02	2.5	1.04	2.5
7.	1	0.2	0.8	0.9	45.9	1.3	5	1.32	4.9	1.04	2.5	1.03	2.6
8.	0.8	0.4	0.5	0.94	45.6	1.25	3.4	1.23	2.7	1.04	2.2	1.02	2.3
9.	0.9	0.3	0.5	0.95	49.5	1.9	3.0	1.21	2.5	1.02	2.2	1.01	2.3
10.	1.1	0.1	0.5	0.9	49.9	1.8	3.0	1.9	2.5	1.03	2.2	1.02	2.3
11.	0.8	0.4	0.6	0.94	49.5	1.3	4	1.3	3.9	1.04	2.4	1.02	2.5
12.	0.9	0.3	0.6	0.91	49.5	1.3	4	1.24	2.8	1.02	2.5	1.01	2.4
13.	1.1	0.1	0.6	0.87	49.5	1.23	3.2	1.2	2.5	1.03	2.3	1.02	2.1
14.	0.8	0.4	0.7	0.94	49.8	1.38	5	1.4	5	1.02	2.5	1.01	2.4
15.	0.9	0.3	0.7	0.91	49.5	1.36	5	1.36	5	1.03	2.5	1.01	2.5
16.	1.1	0.1	0.7	0.91	49.5	1.22	3	1.21	2.5	1.03	2.2	1.02	2.3

The time response specifications (peak value Mp and settling time ts) of step responses under different operating conditions ie. without PSS, incorporating PSS designed by classical method, by H_∞ method and by the proposed method given in this paper are compared in the following table. By observation, it can be concluded that incorporating PSS designed by proposed method results in improved step response over other methods considered.

4. CONCLUSION

A procedure for improving the controller design method for power system is proposed based on tuning the damping factor of the controller. The method is illustrated through typical numerical example.

5. REFERENCES

1. Tai C.Yang,"Weighting function selection for H∞ based power system stabilizer design"IEEE Trans, 1995
2. F.P.deMello and C.Concordia,"Concepts of synchronous machine stability as affected by excitation control", IEEE trans.,Vol.PAS-88,pp.316-325 1969
3. R Asgharian,"A robust H_∞ power system stabilizer with no adverse effect on shaft torsional modes",IEEE trans., Vol. EC-9,No.3,pp.475-481,1994
4. J.H.Chow, L.P.Harris,M.A.Kale,H.A.Othman,J.J.Sanchez-Gasca,"Robust control design of power system stabilizers using multivariable frequency domain tecniques", Proc.29th CDC Conf.pp.2067-2073,Dec.1990.
5. Sastry. G.V.K.R.,Sravanthi,J.N.V. and Tejeswara Rao,K.., "Closed Loop Controller Design For Power System Using Time Moment Matching Technique**,** International Conference EESCO, 2015.