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COMPARISION OF RESULTS FOR A CONTROLLER DESIGNED USING MODEL ORDER REDUCTION TECHNIQUE IN HYBRID AND CONTINUOUS METHOD

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Abstract—*Power System under consideration consists of the single machine connected to an infinite bus (SMIB) through a tie-line. Analysis of a large interconnected power system is time consuming and may even exceed the storage capacity of modern fast computers because high order model is costly. Therefore a low order linear model will be derived for high order system to obtain optimized design. Here, a controller is designed using model order reduction technique using hybrid and continuous methods and results are compared with the controller designed using PID-PSS.*

1. INTRODUCTION

Stability of the power system is one of the important aspects in electrical engineering due to increased complexity of interconnected systems as it leads to difficulty of system-wide coordination of back up protection and also causes more disturbances. Another reason is the fast increasing power supply demand exceeds the increase in power plant construction. It causes the generators overload and become more sensitive to the disturbance, which cause the generator protection relays to more frequently trip off the generators and cause more generators overload. Then, the chain of unwanted events may occur. In order to stabilize the system many conventional as well as advanced controllers are used. In this paper, order reduction technique based controller is designed and results are compared with PID based PSS.

2. COVENTIONAL STABILIZER

A Power system stabilizer is considered as conventional stabilizer and is pertained to certain network configurations and if the operating conditions change the system comes back from the stability range of operation as conventional power system stabilizer operates for particular network configurations. To overcome this, different controlling techniques have been developed and implemented among which PID-PSS and controller designed using order reduction technique results are compared in this paper.

3. PID BASED PSS

The limiter and compensator blocks of a conventional power system stabilizer is replaced with a PID controller in order to obtain better results and the tuning of PID controller is done using zeigler Nichols method.

4. HYBRID ORDER REDUCTION TECHNIQUE

This Technique is used in order to reduce the peak overshoot due to which noise occurs and even the settling time compared to the results obtained from PID based PSS. The steps required to develop the technique is as follows.

4.1 Higher Order Transfer Function:

The dynamic parameters of Single Machine Infinite Bus interconnected system is represented in a state space form which is transformed into a transfer function of higher order.

4.1.1 Lower Order Transfer Function

The higher order transfer function is reduced using different order reduction techniques such as routh stability criterion, differentiation method, routh pade approximation method; modified routh pade method etc., In this, routh pade approximation technique is used to derive the lower order function.

4.1.2 Controller Design using Lower Order

Stability margins are obtained from the lower order transfer function using bode plot analysis and bode gain is determined which is in the form of overall gain, poles and zeros. Phase difference is calculated and maximum phase is calculated from the obtained difference which does not exceed 5^0-10^0.From that, parameter ‘a’ is calculated and based on the characteristic of frequency oscillations choice of compensator is made.

Compensator pole p_c is selected and controller is given by transfer function $G_C = \frac{as+p_c}{s+p_c}$

5. CONTINUOUS METHOD

In hybrid order reduction technique, there are many steps involved such as obtaining lower order, bode plot analysis, choice of controller and design of controller and is time taking. In order to avoid many steps of designing a controller, a continuous method is developed for large scale modeling known as dominant pole time moment matching method. The results obtained are similar to that of hybrid method.

5.1 Advantages of Proposed Method

1) The proposed method always generates stable reduced models for stable original high order systems. Hence it always retains stability of the original system in its low order models unlike majority of order reduction techniques.

2)This method avoids the necessity of formulation of two separate routh arrays for generating numerator and denominator reduced order models unlike routh approximation method.

3) This method gives a simple algebraic approach for obtaining controller transfer function using R-H criterion.

5.2 Steps for Designing Controller:

1) Let the higher order transfer function G(S) is given as

$$G(S) = \frac{B_0+B_1+B_2+\cdots+B_{n-1}s^{n-1}}{A_0+A_1S+A_2S^2+\cdots+A_ns^n}$$

2) Obtain the reduced order function

$$R(S) = \frac{n_m(s)}{d_m(s)}$$

$$\frac{b_0+b_1s+\cdots+b_ms^{m-1}}{a_0+a_1s+\cdots+a_ms^m}$$

Where m is the order of the reduced model and $n_m(s)$ is obtained by time moment matching technique and $d_m(s)$is obtained by dominant pole retention method.

3) Determine the poles of the original higher order system, they given as:

$d_n(s) =(s+p_1)(s+p_2)(s+p_3)\ldots\ldots(s+p_n)$

Where $p_1, p_2, p_3 \ldots p_n$ are poles of original higher order system.

4) For m[th] order reduced model, retain "m" dominant poles of the original system in the reduced model. They are:

$d_m(s) =(s+p_1)(s+p_2)(s+p_3)\ldots.(s+p_m)$

5) obtain $n_p(s)$,$d_p(s)$,$n_m(s)$,$d_m(s)$and $d_{n-m}(s)$ from the original system and reduced model.

6) Obtain the range of controller gain K_2 for the equation

$d_p+n_p+n_p(k_2-n_m(d_{n-m}))=0$ using routh hurwitz criterion.

7)Obtain the range of K_2 satisfying all the constraints in (5)&(6).

8) Obtain the controller transfer function using the equation

$$C(S) = \frac{(K_2+1)d_m}{d_n-n_m}$$

6. RESULTS

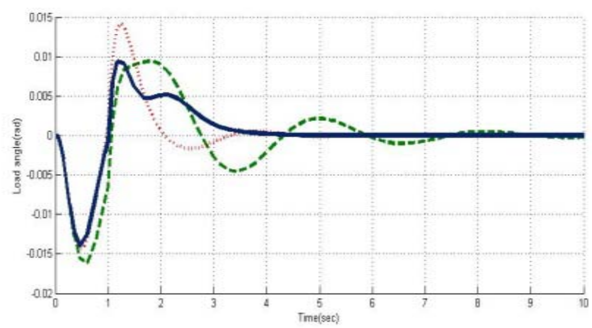

Fig. 1: Waveforms a)without controller(green) b)PID-PSS(pink) c)hybrid order reduction

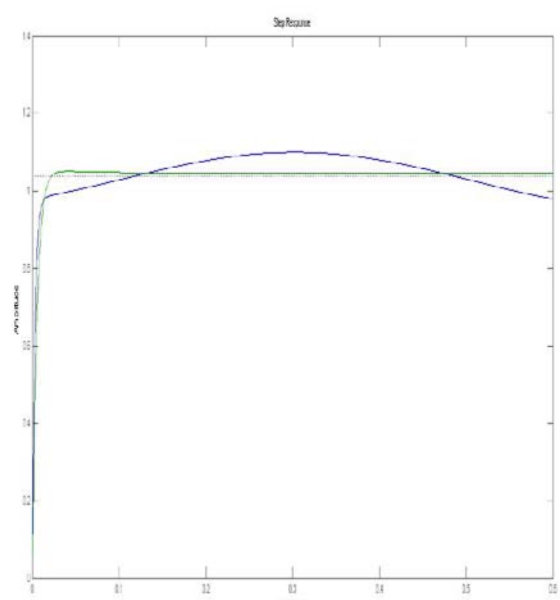

Fig. 2: Step Response of continuous controller design method a)without controller(b)with controller(green)

7. CONCLUSION

From the waveforms obtained above, it is observed that the hybrid controller yielded better result by reducing settling time and peak overshoot compared with PID controller. It is also observed that the continuous method opted for controller design yielded better response compared to the response without controller.

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