Research Article

Reason - A Technical Magazine
ISSN 2277-1654
Volume - XI ● 2012

DESIGN OF CPSS FOR MULTIMACHINE POWER SYSTEM USING SIMULATED ANNEALING ALGORITHM CONSIDERING G-T DYNAMICS

P. Bera

Assistant Professor, Department of Electrical Engineering,
Kalyani Govt. Engineering College, West Bengal-741235, India. Email: partha_bera@rediffmail.com

Abstract : In the present work, dynamic stability analysis of power system is investigated using conventional phase lead-lag power system stabilizer (CPSS) for multimachine power system with and without considering governor-turbine (G-T) dynamics. Parameters of CPSS are optimized by minimizing an objective function using simulated annealing algorithm (SA). Analysis reveals that there is a need to consider the G-T dynamics for dynamic stability analysis and CPSS gives better dynamic performances as compared to that of without PSS. Attempt is also made to examine whether gain and parameter settings of CPSS obtained at a particular operating condition works well or not to all other operating conditions. Analysis also reveals that the proposed CPSS works satisfactorily following a transitory three-phase fault.

Keywords : Multimachine system, G-T dynamics, CPSS, Simulated Annealing (SA) algorithm.

1. Introduction

The phenomenon of stability of synchronous machine has received a great deal of attention in the past. Among several aspects of stability of a synchronous machine an important one is the mode of small perturbation stability referred to as dynamic stability and efforts have been made on the enhancement of dynamic stability of power systems. Increasing attention has been focused on the effect of excitation control on damping of oscillations which characterized the phenomena of stability. In particular, it has been found useful and practical to incorporate transient stabilizing signals derived from speed, terminal frequency or accelerating power superimposed on normal voltage error signal to provide for additional damping to these oscillations. Such devices are popularly known as power system stabilizers. Several approaches have been reported in the literature to provide the damping torque required for improving the dynamic stability. DeMello and Concordia [1] proposed the concepts of synchronous machine stability as affected by excitation control. They established an understanding of the stabilizing requirements for static excitation systems. Kundur et. al. [2] carried out a detailed analytical work to determine the parameters of conventional phase lead-lag power system stabilizer. Fleming et. al. [3] have used a pole assignment technique for parameters optimization of conventional phase lead-lag PSS. This is basically a sequential tuning method and computationally simple but incurs eigenvalue drift within the sequence. Lefebre [4] presented a technique for the simultaneous selection of stabilizer's settings in multimachine systems. This technique avoids drifting in eigenvalues encountered in the sequential type algorithms. Lim and Elangovan [5] also proposed an algorithm to determine the parameters of all the stabilizers in the system such that exact assignment of its mechanical mode eigenvalues to desired locations in the complex plane is achieved. Zhang and Connik [6] proposed a new technique based on the method of inequalities for the parameter optimization of conventional PSS. Abdel-Magid et. al. [7] proposed a technique for robust tuning of conventional phase lead-lag PSS, operating at different loading conditions. They have used eigenvalue based objective function which is minimized by tabu search algorithm. Lei et. al. [8] also proposed a global tuning procedure for conventional PSS.

Nevertheless, there have been arguments that the conventional PSS, being tuned for one operating condition, yields sub-optimal performances when there are variations in system operating load or configuration.

To solve this problem, several modern control strategies have been tested and proposed that seek to track the system conditions close to real time, such as variable structure, self tuning, artificial neural network and fuzzy logic based stabilizers [9-20]. However, practical realization of such power system stabilizers based on modern control theory is very difficult because they need real-time monitoring, measurement or estimation of system variables.

Further, a review of literature shows that, while designing PSS for enhancing the stability of an interconnected power system, the governor-turbine (G-T) dynamics has not been considered by most of the researchers, i.e., the mechanical input is assumed to remain constant. Abdalla et al. [21] and Hiyama [22] have considered G-T dynamics for the analysis of dynamic stability. However, they have not optimized the parameters of CPSS. Results presented in [21,22] suggest that one should consider G-T dynamics for PSS design. Modern large capacity turbines are equipped with fast acting governors. It is thus important to investigate the effect of G-T dynamics on the optimal parameter settings of CPSS and on the system dynamic performances. In the light of the above, the main objectives of the present work are :

(1) To optimize the parameters of the CPSS using SA with and without considering G-T dynamics.

(2) To compare the system dynamic performances obtained with and without CPSS.

2. System Investigated

In the present work, a multimachine system as given in Fig.1 [23] is considered. Machine-1 is a hydro unit and machines-2 and 3 are thermal units. Governor-turbine dynamics of hydro and thermal units are considered. Governor-turbine dynamics for hydro system [24] is shown in Fig.2a. For thermal system, it is shown in Fig.2b. This system (Fig.1) is studied for three different loading conditions, i.e., lower loading, nominal loading and higher loading. A step increase in reference setting for the mechanical power in machine-2 (ΔT_{ref2}) is considered. Data for this system are given in Appendix.

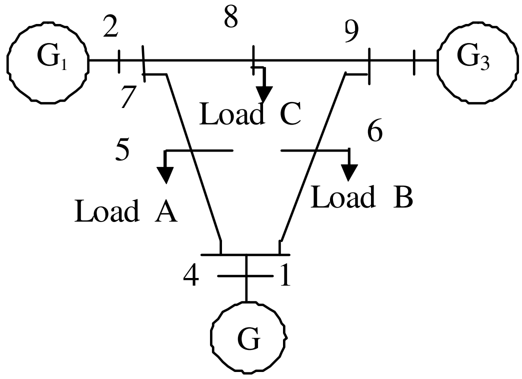

Fig.1 Three machine nine bus system

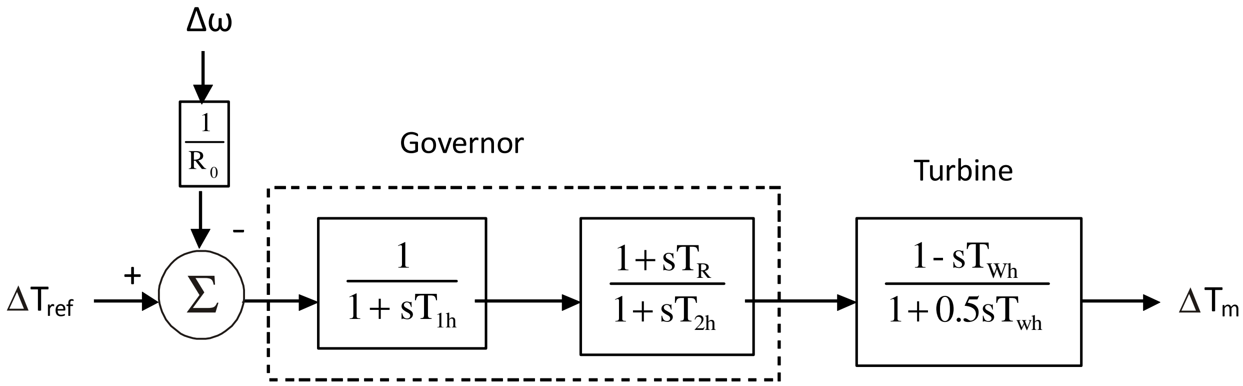

Fig.2a Governor-turbine dynamics for hydro-turbine

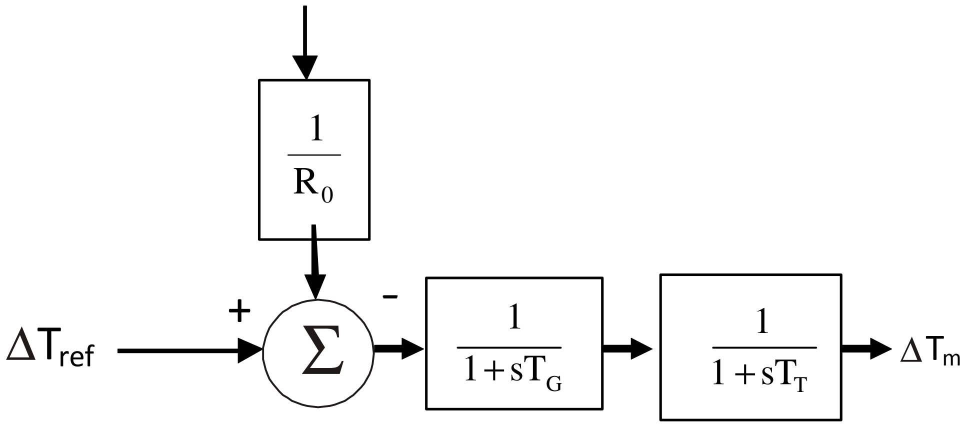

Fig.2b Governor-turbine dynamics for non-reheat turbine

3. Conventional Power System Stabilizer (CPSS)

The typical structure of a conventional PSS connected with the ith machine consists of a gain, a washout unit, phase compensation units and an output limiter which is shown in Fig.3 [2]. To provide pure damping, the CPSS should have appropriate phase-lead characteristics to compensate the phase-lag between the generator exciter input and electrical output torque. Two lead-lag blocks are used in this paper although the number and characteristics of phase compensation units could be modified according to the design requirements.

The gain and time constants of the phase compensation units therefore need to be determined such that the system should give good dynamic performances. In this case also, limits are imposed on the output of CPSS and as mentioned in Section-3, maximum positive and negative limits are considered as 0.2 pu and -0.1 pu respectively.

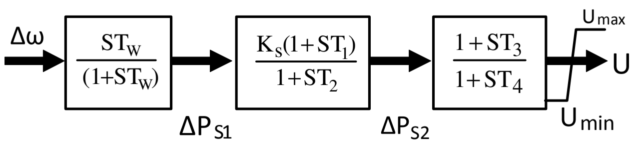

Fig.3 The structure of a conventional power system stabilizer (CPSS)