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ANALYSIS OF LOW-DAMPED ELECTROMECHANICAL OSCILLATIONS IN LARGE POWER SYSTEMS

by

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Résumé

Frequency response and eigenvalue techniques are described for the analysis of small signal stability of multimachine power systems. A highly efficient algorithm is presented for the exact calculation of eigenvalues and eigenvectors for very large power systems. Stabilizer gain margins, as affected by the addition of power system stabilizers to other generators in the system, are evaluated.

Keywords

Damping - Electromechanical Oscillations - Excitation Control - Stability - Eigenvalues - Frequency Response

1. Introduction

The predominant hydrogeneration and the associated long transmission lines of the Brazilian power systems constitute a source of potential problems for low damped electromechanical oscillations. A great deal of attention has been given to the study of this problem in this country and a good number of generating plants already incorporate power system stabilizers or will have them installed in the near future. This paper describes the preliminary results obtained from a research work being carried out in this field.

A large amount of work has been done throughout the world in the area of small signal dynamics of power systems. The accumulated knowledge on the mechanisms leading to the build-up of undamped oscillations and also on the ways to prevent these problems via control methods is well developed [1,2,3,4].

The computation of the eigenvalues of the multimachine system state matrix through the QR transformation method is an effective analysis tool but can not handle efficiently systems with more than 200 state variables [5]. This limiting factor generates continuous research efforts on ways to obtain eigenvalues of power systems of much larger order. In this paper a highly efficient technique is presented for the exact calculation of eigenvalues and eigenvectors for very large power systems, which has low computer memory requirements. This method requires the formation of a very large and sparse system Jacobian, and the preliminary results obtained indicate that this technique will prove valuable for the analysis of low damped electromechanical oscillations of interconnected systems.

Frequency response analysis can readily be performed using a variation of the eigenvalue algorithm and were used in this work for stabilizer tuning in the multimachine environment. This technique was also used in identifying the best locations in the system for placing the damping effort and in evaluating power system stabilizer gain margins as affected by the presence of other stabilizers in the system.

2. State Space System Models

Two efficient multimachine state matrix formulations were developed. The first caters for different synchronous generators models and their controllers, while the other also incorporates models for induction motors, non-linear loads, static VAR compensators and generator incremental saturation. Sparsity techniques are fully used to ensure efficient computation of the state matrix while keeping the computer core requirements to the minimum. The more elaborate formulation is here described as it is needed in the implementation of the proposed eigenvalue algorithm.

The eigenvalue and the transient stability programs have a common input data format,which is a very desirable feature as the system eigensolution may be easily obtained before transient stability runs are made [1].

The power system stability problem can be represented by an algebraic-differential set of equations. The linearized system state matrix is derived from the Jacobian of the entire set of equations evaluated at an operating point [6]:

$$\begin{bmatrix} \Delta\dot{\underline{X}} \\ \underline{0} \end{bmatrix} = \begin{bmatrix} J_a & J_b \\ J_c & J_d \end{bmatrix} \begin{bmatrix} \Delta\underline{X} \\ \Delta\underline{Y} \end{bmatrix} \qquad (1)$$