STABLE AND FAST ALGORITHMS FOR POWER SYSTEM TRANSIENT STABILITY

by

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C E R T I F I C A T E

Certified that the thesis entitled, "Stable and Fast Algorithms for Power System Transient Stability", which is being submitted by Mr Shivanna, in partial fulfilment for the award of the degree of Doctor of Philosophy in Centre of Energy Studies of the Indian Institute of Technology, Delhi is a record of the student's own work carried out by him under our supervision and guidance. The matter embodied in this thesis has not been submitted for the award of any other degree or Diploma.

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ABSTRACT

Transient stability studies of large power systems require considerable amount of computer time. The time required for these studies can be reduced by

(i) improving the numerical techniques employed for the solution of the differential algebraic equations, and

(ii) reducing the size of the system.

In this thesis, methods incorporating both of these aspects have been proposed to reduce the computation time.

For a large power system, stability of the system cannot be decided from the first swing considerations alone. In many cases, it is necessary to study the transient for a period larger than one second. In such cases, to get an accurate swing curve, Synchronous machines and its associated control equipments have to be represented in detail. Then, the resulting system of differential equations may be stiff due to the presence of small time constants, especially when the new fast acting static excitation systems are employed. To solve such stiff differential equations, if a method with a finite absolute stability is used, small value of time constants in the system will force the chosen step length to be excessively small.

To solve stiff differential equations, numerical methods which are A-stable have been recommended. With A-stable methods, the stepsize is decided only by the accuracy required.

In this thesis, A-stable algorithms have been proposed to solve stiff system of differential equations. These methods, which are classified as 'Semi-implicit Runge-kutta methods', possess the desirable properties of the explicit as well as the implicit methods. The performance of these algorithms to solve the transient stability problem with classical synchronous machine model is first examined. The study reveals that these algorithms, for comparable accuracy, take only 30-40 per cent of the computer time taken by the explicit R-K methods. The analysis is further extended to study the performance of these methods in case of transient stability studies with excitation system. In this case also, the algorithms gave accurate results for large step-size.

Transient stability studies of large power system are normally obtained by employing dynamic equivalents. The major approaches of dynamic equivalencing are modal analysis and coherency based concepts. Coherency based equivalents are more suitable for large power systems and have been used to much advantage in the transient stability simulation, as they can be implemented in the existing transient stability programs.

In this thesis, an analytical method has been proposed to decompose the power system into number of areas and, further, to identify the coherent groups in each area. The algorithm takes into account the strength of interconnection among the machines. The proposed method is based on the Love's methodology of grouping of related nodes of an electric network and is independent of fault location. First, the algorithm decomposes the system into number of areas using only the transfer admittance between the generator internal nodes. Further, for determining of coherent groups in each area, transfer admittance and moments of inertia of the generators are used.

The proposed algorithm has been validated by simulation tests on three large power systems. The results indicate that a large power system is composed of weakly connected areas, with each area containing groups of strongly coupled machines. The computational requirements of the proposed algorithm is found to be much less than the existing methods.

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