Nonlinear dynamics: Applications in power systems

Foreword

This special issue of *Sādhanā* is devoted to discussing different aspects of nonlinear dynamics in power systems. Historically power systems have evolved over the years from a single power station supplying an isolated load to a highly interconnected complex nonlinear dynamic system. Consequently new phenomena arise and they need to be studied by power system analysts. In this issue we seek to provide some insights into a few of these areas of interest. Broadly the issue is divided into three parts – analysis, computation and control of nonlinear dynamics associated with large scale power systems.

In the first article, Hill, Hiskens and Mareels discuss the stability properties of the differential-algebraic equation (DAE) model of the power system. The DAE model is the result of neglecting the fast 60 Hz transients which occur in transmission lines and stator windings of synchronous machines. This type of model is at the heart of most simulation studies in power systems, namely stability, computation and control. In the next paper, Cheung and Chow discuss simulation of only the slow dynamics in the DAE model using singular perturbations and integral manifolds. Slow dynamics characterize the angle stability phenomena in power systems. In the third paper, Tan, Varghese, Varaiya and Wu discuss a phenomena physically present in power systems but rarely analysed in a mathematical framework, namely bifurcation and chaos. The mathematical tools of bifurcation and chaos are becoming increasingly important in the stability analysis of stressed power systems. The fourth paper by Padiyar and Sastry discusses a Lyapunov-based energy function method for DAE systems inclusive of HVDC lines. The energy-function method is going to play an important role in a quick filtering of contingencies for on-line dynamic security assessment. The fifth paper by Vittal, Khammash and Pawloski applies some of the recent results in robust control theory to the stability problem in power systems. Specifically the stability question is examined with respect to uncertainties in modelling of different subsystems in a large-scale power system. The sixth paper by Bose presents a review of parallel processing techniques in dynamic simulation of power systems. Different parallel algorithms and their implementation on large-scale power systems are discussed. The next paper by Ajjarapu discusses the application of bifurcation and continuation analysis techniques for the voltage collapse problem. The emphasis is on static bifurcation and algorithms to find the saddle node bifurcation point. The remaining three papers address issues arising out of low frequency oscillations in power systems. The paper by Sen Gupta and Sen presents a physically based explanation of the low frequency phenomenon occurring in power systems and reviews some of the adaptive power system stabilizer (PSS) schemes. A particular adaptive PSS scheme based on a frequency identification technique and gain scheduling is discussed. The next paper by Sharma and Prabhu discusses the coordination of PSS and static var compensators (SVC) for reliable operation when the PSS is inoperative. A sector criterion is used to define robust regions in the P-Q plane. Finally the paper by Ranjan, Pai and Sauer presents an analytical formulation of the small signal model for multi-machine power systems with static nonlinear loads. Using this model, voltage stability is discussed under varying loads and the phenomena of Hopf bifurcation is illustrated.

The set of papers in this issue covers the emerging interest in nonlinear dynamics as applied to power systems. Hopefully this will contribute towards greater interest in this area on the part of academia and industry. Power system analysis is rapidly becoming a scientific field of study in its own right.

I would like to thank the Editor, Prof N Viswanadham, for giving me the opportunity to organise this issue. Prof R Narasimha requested that I organise such an issue many years ago, but it is only in the 80's that the science of nonlinear dynamics has had a big impact on power systems.

September 1993

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Guest Editor