APPLICATION OF MODEL ORDER REDUCTION TECHNIQUES IN MODERN POWER SYSTEMS

by

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CERTIFICATE

This is to certify that the thesis entitled "**Application of Model Order Reduction Techniques in Modern Power Systems**", being submitted by **Mr. Sudipta Ghosh** for the award of the degree of **Doctor of Philosophy**, is a record of bonafide research work carried out by him in the Department of Electrical Engineering of the Indian Institute of Technology Delhi.

Mr. Sudipta Ghosh has worked under my supervision and guidance and has fulfilled the requirements for submission of this thesis, which to my knowledge has reached the requisite standard. The matter recorded in this thesis has not been submitted in part or full for the award of any other degree or diploma.

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ABSTRACT

This thesis applies model order reduction (MOR) techniques to large modern power systems that preserve particular dynamic characteristics of the original system. Depending upon the nature of the characteristic to be retained, two MOR approaches have been considered. In the engineering approach, an innovative index, L_{index}, is introduced to measure the localness of an electromechanical mode in a power system. This L_{index} captures the dynamic behavior of the system, with changing system conditions. Some of the potential applications of this index are controller placement, coherency identification, dynamic aggregation as well as model order reduction of power system. The actual MOR of the power system on the basis of L_{index}, resembles established dynamic aggregation techniques based on modal synchrony and slow coherency and consequently have similar limitations, such as heuristic based approach, local validation, high computational burden, prior knowledge of the system, repeated evaluation etc. More mathematical approaches towards MOR in power systems have been explored and compared – Balanced truncation (BT) and Krylov subspace. The ability of both approaches to detect coherency between generators has been studied. A 246-bus representation of the Northern Grid of India has been used in this thesis, and some unique results related to the coherency patterns of the constituent generators, have been obtained. The thesis also proposes a technique for tuning of PSS in large power systems, ideally suited for online implementation owing to the improved computational performance of the reduced order system models obtained using Balanced Truncation,.

The final portion of the thesis contributes to model order reduction of variable-speed wind turbines and wind farms. The wind turbines are controlled for primary frequency response and linearized models have been obtained between the wind velocity/system frequency and the power output. These linear models, validated using Dig-SILENT based nonlinear model, are then reduced and the efficiency of reduction has been related to the modeling of the drive-train.

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