

WEAK COUPLING, COHERENCY AND TIME-DOMAIN AGGREGATION
IN POWER SYSTEM TRANSIENT STABILITY STUDIES

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Thesis submitted

to the

Indian Institute of Technology, Delhi

for the award of

DOCTOR OF PHILOSOPHY

DEPARTMENT OF MECHANICAL ENGINEERING

INDIAN INSTITUTE OF TECHNOLOGY, DELHI

MARCH 1984

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ABSTRACT

Transient stability simulation of large scale power systems are normally obtained by employing dynamic equivalents. Two principal approaches, viz. modal analysis and coherency amongst machines, have been widely tested for the construction of dynamic equivalents. This thesis reexamines these approaches to highlight the associated problems and to propose new, efficient and more general solutions. In particular the use of time-domain models and aggregation procedures has been fully explored.

The need for a systematic procedure for division of total system into study and external areas has been critically examined in this thesis and a procedure based on a joint application of weak coupling and small perturbations has been proposed. The results indicate that a study area should be composed of one or more weakly coupled subsystems of the large scale power system.

Coherency based dynamic equivalents have been used to much advantage in the transient stability simulations, as these can be employed in existing stability programs without any modifications. Identification of groups of coherent machines and development of an equivalent machine model for each group of coherent machines are two principal steps for utilising these equivalents. This thesis addresses the problem of development of efficient methodologies for these objectives.

The existing methods of coherency identification are computationally expensive as they either involve full system simulation or else an eigensystem evaluation. In this thesis an analytical method is proposed to identify the slowly (or practically) coherent areas in a given power system. The procedure is based on a determination of weakly coupled subsystems from a linearised system model. The non-singular decomposition obtained by this procedure is independent of fault location and also enables an easy identification of relatively strongly coupled machines within each slowly coherent area.

In the past, coherent machines represented with detailed models have been aggregated mostly using an iterative frequency-domain approach. It was considered desirable to develop more efficient and general algorithms for evaluation of dynamic equivalents by employing a direct time-domain approach and by a utilisation of the large body of results on model order reduction. Such an investigation led to a non-iterative structure-preserving time-domain aggregation procedure for developing dynamic equivalents. Two separate applications of the proposed time-domain aggregation are presented in this thesis; one for the case of similar models of coherent machines to be aggregated and the second for the case of dissimilar models.

The proposed coherency identification and time-domain aggregation procedures have been validated by simulation tests on two large systems from the Indian power grid. The computational requirements of the proposed algorithms for both of the above mentioned objectives have been systematically computed and found to be much less than those of the existing methods.

ACKNOWLEDGEMENTS

The author would like to express his appreciation to his supervisors Professor Surrinder S. Lamba and Professor B.C. Makra for their continued advice and guidance during the course of this work. He would specially like to express the gratitude he feels towards Professor Surrinder S. Lamba for his systematic organisation of the entire work and the numerous hours of fruitful discussions that have been helpful in the preparation of this thesis.

The author highly regards the stimulating discussions he had with Prof. K.S. Prakasa Rao of IIT Delhi and Prof. C.L. Narayana and Dr. C. Radhakrishna of Osmania University, Hyderabad.

The author wishes to thank Dr. A. Gopalakrishnan and Dr. P. Jagannathan of BHEL, Hyderabad, for providing all the facilities necessary for completing this work. Special thanks are due to Dr. P. Jagannathan for all his encouragement and keen interest in this investigation. The author acknowledges the support received from the Department of Science and Technology, Government of India, for the preparation of this thesis.

The author wishes to thank all his friends and colleagues who have helped him at various stages of this work. He thanks Shri P.M. Padmanabhan Nambiar for his excellent typing of this thesis.

Finally, the author can only partially acknowledge the understanding and patience of his wife Kunkum and the co-operation of his son Master Pranay, who helped to make all this possible.

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