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

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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.

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CONTENTS

CONTENTS (CONTD.)

CONTENTS (CONTD.)

CONTENTS (CONTD.)