

**A GENERALIZED PROCEDURE TO DEVELOP
TRANSFER FUNCTION BASED MODELS OF
ELECTRICAL POWER SYSTEMS**

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Declaration of the candidate and supervisor

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Abstract

More and more renewable electricity generating sources such as wind and solar power plants are being integrated into electrical power systems, which in turn complicates processes such as power system stability studies due to the complex nature of controls in these power plants. Since most such studies are done using simulations, it is necessary to have accurate dynamic models of those power plants which describe the behaviour of the power plant during a disturbance to the network or to an internal control of the power plant. Nevertheless, it might be difficult to obtain these detailed models from manufacturers due to proprietary concerns and even if the detailed model is available, modelling complicated power electronic components in the simulation environment might be a difficult without knowing how each component operates. Moreover, when parameters change over time, physical parameters of these models need to be updated and it cannot be done without standard practical measurements. These standard tests require the generating sources to be taken out of the system for testing purposes.

Therefore, instead of a detailed model, a dynamic equivalent model could be used for achieving the same requirement. This research presents a generalized procedure that can be used to accurately estimate black-box dynamic equivalent models of synchronous generators, wind and solar power plants by utilizing measurements and estimating parameters of the dynamic equivalent model. Simulations have been conducted to estimate and verify the accuracy of the proposed methodology by comparing the accuracy of the actual model and the estimated models.

Keywords: Dynamic equivalent, power system stability, black-box, parameter estimation

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List of Abbreviations

Abbreviation	Description
AC	Alternating Current
AIC	Akaike's Information Criterion
ANN	Artificial Neural Networks
ARMAX	Autoregressive Moving Average eXogenous
ARX	Autoregressive with Extra Input
AVR	Automatic Voltage Regulator
BIC	Bayesian Information Criterion
BJ	Box-Jenkins
CSP	Concentrated Solar Power
CVA	Canonical Value Analysis
DC	Direct Current
DE	Differential Evolution
DEM	Dynamic Equivalent Model
GA	Genetic Algorithm
HPP	Hydro Power Plant
LFO	Low Frequency Oscillations
MIMO	Multiple Input Multiple Output
MOESP	Multi-variable Output-Error State Space
N4SID	Numerical algorithm for Subspace State Space System Identification
NREL	National Renewable Energy Laboratory
OE	Output Error
PBSID	Predictor Based Subspace Identification
PCie	Peripheral Component Interface Express
PEM	Predictive Error Method
PMU	Phasor Measurement Unit
POI	Point of Interconnection

PSO	Particle Swarm Optimization
PSS	Power System Stabilizer
PV	Photovoltaic
RAM	Random Access Memory
REEC	Renewable Energy Electrical Controller
REGC	Renewable Energy Generator Controller
REPC	Renewable Energy Plant Controller
RLS	Recursive Least Squares
SIMO	Single Input Multiple Output
SISO	Single Input Single Output
SPP	Solar Power Plant
SSD	Solid State Drive
SSSA	Small Signal Stability Analysis
WECC	Western Electricity Coordinating Council
WLS	Weighted Least Squares
WPP	Wind Power Plant