Adaptive Parameter Estimation of Power System Dynamic Model Using Modal Information

Song Guo, *Member, IEEE*, Sean Norris, *Student Member, IEEE*, and Janusz Bialek, *Fellow, IEEE*

***Abstract*—A novel method for estimating parameters of a dynamic system model is presented using estimates of dynamic system modes (frequency and damping) obtained from wide area measurement systems (WAMS). The parameter estimation scheme is based on weighted least squares (WLS) method that utilizes sensitivities of the measured modal frequencies and damping to the parameters. The paper concentrates on estimating the values of generator inertias but the proposed methodology is general and can be used to identify other generator parameters such as damping coefficients. The methodology has been tested using a wide range of accuracy in the measured modes of oscillations. The results suggest that the methodology is capable of estimating accurately inertias and replicating the dynamic behavior of the power system. It has been shown that the damping measurements do not influence estimation of generator inertia. The method has overcome the problem of observability, when there were fewer measurements than the parameters to be estimated, by including the assumed values of parameters as pseudo-measurements.**

***Index Terms*—Dynamic power system modeling, parameter estimation, small signal analysis, synchronous generators, wide area measurements.**

NOMENCLATURE

δ	Rotor angle.
ω	Rotor angular velocity.
$M = 2H$	Rotor inertia constant.
D	Damping coefficient.
K_s	Synchronizing torque coefficient.
E'_q	q-axis voltage behind transient reactance.
E'_d	d-axis voltage behind transient reactance.
E''_q	q-axis voltage behind subtransient reactance.
E''_d	d-axis voltage behind subtransient reactance.
T'_{d0}	d-axis open circuit transient time constant.
T'_{q0}	q-axis open circuit transient time constant.
T''_{d0}	d-axis open circuit subtransient time constant.
T''_{q0}	q-axis open circuit subtransient time constant.
X'_d	d-axis transient reactance.
X'_q	q-axis transient reactance.
X''_d	d-axis subtransient reactance.
X''_q	q-axis subtransient reactance.
I_q	q-axis armature current.
I_d	d-axis armature current.

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S. Guo is with London Power Associates Ltd., Manchester U.K. (e-mail: song.guo@lpaworld.com).

S. Norris and J. Bialek are with the School of Engineering and Computing Sciences, Durham University, Durham, U.K. (e-mail: s.w.norris@dur.ac.uk; janusz.bialek@dur.ac.uk).

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I. INTRODUCTION

KNOWLEDGE of parameter values for dynamic generator models is of paramount importance for creating accurate models for power system dynamics studies. Traditionally, power systems consisted of a relatively limited number of large power stations and the values of generator parameters were provided by manufacturers and validated by utilities. Recently however, with the increasing penetration of distributed generation, the accuracy of the models and parameters of many small generators connected to the system cannot be guaranteed. This has motivated the effort reported in this paper to develop a methodology to estimate the parameter values from online measurements. One application of such a methodology could be estimation of parameters of dynamic equivalents.

Traditionally dynamic equivalents have been used to represent an external power system [1]. Recently, dynamic equivalents are also used to represent the combined effect of a large number of small (usually renewable) power stations embedded in the distribution network [2]. [3] proposed an artificial neural network (ANN)-based boundary matching technique to derive dynamic equivalents. [4] developed a grey-box approach for validating dynamic equivalents of active distribution network cell. Quite often however, the actual observed oscillations may not match the model that combines a detailed internal network model and an external network equivalent. There could be two possible reasons for the discrepancy. Firstly the external equivalent model could have been derived using inaccurate information. Secondly the external equivalent could have been derived for certain operating conditions that were different from the actual conditions studied or, in other words, the model was not adaptive and therefore could not reflect the actual dynamic system conditions at hand. For example, if some generators in the external system are disconnected, the values of parameters of the equivalent would be changed. An adaptive model is therefore desirable for online system studies, whereby the parameters of the equivalent would change with operating conditions and reveal the physical system characteristics. This paper addresses