

**A MEASUREMENT-BASED PROCEDURE FOR  
DYNAMIC DATA IDENTIFICATION OF  
SYNCHRONOUS GENERATORS**

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Degree of Master of Science

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## DECLARATION

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K.W.K Priyadarshana

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## ABSTRACT

Identification of synchronous generator parameters is a vast area in research topics. In order to model an existing power system network, these parameters are very crucial in identifying the behavior of the system during steady state or dynamic state conditions. When considering the Sri Lankan grid network there exists number of power plant which does not have some design parameters of the synchronous generators and for the older machines the existing value of the parameters might be differ from the design value due to several reasons.

This thesis report is based on the identification of synchronous generator parameters using on line measurement data while giving small step response of around 2%-5% to AVR voltage reference set point. The proposed testing procedure does not create any stress to the machine and can be conducted several times without any special preparation or machine outage.

The proposed methodology to identify the synchronous generator dynamic parameters is developed using the 3<sup>rd</sup> order SG model defined in the IEEE Standards. Two new system functions have derived to estimate the generator parameter which shows the relationship between the steady state and dynamic state parameters in d-q-0 domain and time domain. The Levenberg Marquart method is used as the Nonlinear least square algorithm to extract the parameters from the measured data. Proposed methodology has applied in MATLAB SIMULINK Simulation environment and in the real environment which test conducted at Kelanitissa Combined Cycle Power Plant, Sri Lanka. The Proposed method results have validated over the results with conventional test results conducted based IEEE Standards on two power plants in Sri Lanka and from the literature of similar tests.

The results of the proposed method have showed good accuracy over the design values and the standard method results. It has showed that the output of the synchronous generator, using the estimated parameters is having a very closer behavior to same with the actual generator parameters. Therefore, this method can use to estimate synchronous generator parameters where the parameters are completely unknown or the machine is too old which may need to identify the existing parameter values.

This study further discusses the reasons for any difference between the design parameter value and the estimated parameter value comparing with the standard IEEE based test results.

This research concludes that the results of the estimated dynamic parameters obtained by the proposed method can be recommended in applying for modelling of the synchronous generators and power systems networks which will give a very close response to the actual response.

Keyword: Parameter estimation, synchronous generators, Levenberg Marquart Method, Online Measurements, Small Disturbance.

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## List of Abbreviation

$\delta$	Angle of rotor with respect to terminal voltage /load angle
$T_m$	Mechanical input torque
$T_e$	Electrical torque
$K_D$	Damping factor
$\omega, \omega_0$	Rotor speed and nominal speed
$e'_q$	Internal of stator at transient
$E_{FD}$	Internal voltage of stator
$X_d, X_q$	d and q axis reactance
$L_d, L_q$	d and q axis inductances
$L'_d, L'_q$	d and q axis transient inductances
$L_{ad}, L_{aq}$	Mutual inductance in d and q axis windings
$L_l$	Leakage inductance
$X_{ad},$	Mutual reactance between the d-axis windings
$X'_d, X'_q$	d and q axis transient reactance
$X''_d, X''_q$	d and q axis sub transient reactance
$i_d, i_q$	d and q axis currents
$i_{fd}$	Field Current
$T'_{d0}, T''_{d0}$	Direct-axis transient and sub open-circuit time constant at transient
$\Phi_f$	Field flux linkage
$R_f$	Field Resistance
$L_{ffd}$	Self-inductance of field winding
$L_{fd}$	Field winding inductance
$L_{afd}$	Mutual inductance between stator and rotor windings
$L_{f1d}$	Mutual inductance between field winding and 1 <sup>st</sup> damper winding
$R_f$	Field Reactance
$X_e, R_E$	Line reactance and resistance
$v_d, v_q$	d and q axis generator terminal voltage
$v_{bd}, v_{bq}$	d and q axis bus voltage
P	Active power
Q	Reactive Power
I	Generator Current
J	Jacobian matrix
$\Theta_k$	Set of updated parameters at kth iteration
$\eta$	Step size
$H_{k-1}^{-1}$	Inverse of the Hessian matrix.
n	Number of iterations
e	Error vector
N	Number of data points
I	Cost function in NLS algorithm
SG	Synchronous Generator
KCCP	Kelanitissa Combined Cycle Power Plant
AVR	Automatic Voltage Regulator