STABILITY ANALYSIS BASED ON BIFURCATION METHOD: A CASE STUDY OF LAKVIJAYA POWER STATION, SRI LANKA

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Degree of Master of Science

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Thesis/Dissertation submitted in partial fulfilment of the requirements for the degree
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Declaration

I declare that this is my own work and this thesis does not incorporate, without acknowledgement, any material previously submitted for a Degree or Diploma in any other University or institute of higher learning to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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Dr. L N W Arachchige Date:…………………….

Abstract

The power system is a dynamic system, which consists of nonlinear elements. Generally, methods based on linearization are sufficient to analyse the system under both normal operating conditions and perturbations of the variables. However, due to the stressed operating conditions, system behaviour is highly influenced by the nonlinear elements of the system. Therefore, analysis based on linearized methods is not sufficient to understand the system behaviour under such conditions. In this thesis, a nonlinear analysis is carried out based on bifurcation theories to identify the system behaviour more accurately.

The case study considers the effect of integrating the Lakvijaya power station to the Sri Lankan power system, which can be considered as a small system. Dynamic voltage stability assessment based on bifurcation analysis for both intact and contingency conditions were carried out for a system under consideration. The critical state variables for a bifurcation were identified and mitigation criterions are suggested.

Keywords: Bifurcation Analysis, Dynamic Voltage Stability, Hopf Bifurcation, Lakvijaya Power Plant, Saddle Node Bifurcation, Sri Lankan Power System,

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t	time
x, u, y	state vector, input vector, output vector
α	bifurcation parameter
V	bus voltage
λ	eigenvalue
$\sigma, i\omega$	real part and imaginary part of an eigenvalue
Δw_r	rotor speed derivation from synchronous speed
w_0	synchronous speed
δ	generator rotor angle
ψ_{fd}	field winding flux
ψ_{1d}	direct axis damper winding flux
ψ_{1q}, ψ_{2q}	quadrature axis damper winding flux
P_m	per unit mechanical power input of a synchronous generator
P_e	per unit electrical power output of a synchronous generator
P_0, Q_0	static active and reactive component
P_1, Q_1	dynamic active and reactive component
P_2, Q_2	real and reactive power supplied to the load at bus 2
P_4, Q_4	real and reactive power supplied to the load at bus 4
i_d, i_q	stator phase currents along d - q axis
e_d, e_q	stator voltage along d - q axis
R_{fd}	field winding resistance
R_{1d}	direct axis damper winding resistance
R_a	stator winding resistance
R_{1q}, R_{2q}	quadrature axis damper winding resistance
L_{fd}	field winding inductance
L_{1d}	direct axis damper winding inductance

L_{1q}, L_{2q}	quadrature axis damper winding inductance
L_{adu}	unsaturated direct axis mutual inductance
$L_{ads}^{''}, L_{aqs}^{''}$	saturated direct axis sub transient mutual inductance
T'_{d0}, T''_{d0}	direct axis transient and sub transient open circuit time constant of a synchronous generator
T'_{q0}, T''_{q0}	quadrature axis transient and sub transient open circuit time constant of a synchronous generator
E_{fd}	field voltage
E_t	terminal voltage
T_a, T_b, T_e	exciter time constants for regulator and lead lag compensator
k_1	exciter gain
Y_{ij}	i j th element of Y_{bus} matrix
V_2, δ_2	voltage magnitude and the angle at bus 2
V_4, δ_4	voltage magnitude and the angle at bus 4