A COMPREHENSIVE STABILITY INVESTIGATION OF THE ATHABASCA-POINTS NORTH POWER SYSTEM

A Thesis

Submitted to the College of Graduate Studies and Research

in Partial Fulfillment of the Requirements

for the Degree of

Master of Science

in the

Department of Electrical Engineering

University of Saskatchewan

by

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Saskatoon, Saskatchewan

September 1993

To my eldest brother — Wufeng Ao

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ACKNOWLEDGMENTS

The author would like to thank the author's supervisors, Associate Professor T. S. Sidhu and Professor Emeritus Ronald J. Fleming and for their guidance in the work reported in this thesis.

Special gratitude is given to the following from SaskPower: Mrs. Bill Kennedy, J. A. Martin, W. G. Stangl, Lorry A. Wilson, S. S. Sachdev, Paul Baerg and J. W. Purdle for their support during the research of the project. Generous assistance is received from Mr. Len Yee and Mr. Gary Belanger of SaskPower.

The financial assistance provided by the National Science and Engineering Research Council of Canada is acknowledged.

UNIVERSITY OF SASKATCHEWAN

Electrical Engineering Abstract 93A384

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M. Sc. Thesis Presented to the

College of Graduate Studies and Research

September 1993

ABSTRACT

This thesis presents the principal results of an investigation of the Athabasca-Points North power system (APNS) that is of longitudinal structure. Its stability and stabilization by coordinated power system stabilizers (PSSs) were studied. The effects of the existing controllers on system stability are reported. If PSSs are not in service, the various modes of the system are either negatively or poorly damped and low frequency oscillations are present. Eigenvalue analysis shows that speed governors have little influence on damping while additional excitation control can considerably depress the sustained oscillations. In order to realize this

control and to enhance the overall system stability, a coordinated design procedure for power system stabilizers has been developed based on generator coherency, total coupling factor and non-linear simulation. A PSS designed using this procedure is robust to different operating conditions and is very effective for damping out oscillations following both small and large disturbances. Comprehensive simulation studies were conducted and the results obtained are presented.

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LIST OF PRINCIPAL SYMBOLS

All angles are with reference to the infinite busbar synchronous frame. All voltages, currents, power quantities and line parameters are in per unit (p.u.) based on the system base 100 MVA. Machine impedance is in per unit based on its own rated capacity. All time constants and machine inertial H, the latter is based on the machine capacity, are in second.

Abbreviations:

deg. = degree

rad = radian

s = second

APNS = Athabasca-Points North System

AVR = Automatic Voltage Regulator and Exciter

AGC = Automatic Generation Control

PSS = Power System Stabilizer

Symbols:

δ = machine rotor angle (rad or deg.)

ω = machine angular speed

ω_o = synchronous speed (rad/s)

E = voltage

E' = voltage behind transient reactance

E" = subtransient voltage

i = current

P = power

v, V = voltage

H = machine inertial constant (s)

k = saturation factor

K = gain of transfer function

D = machine damping coefficient

τ, T = time constant

ϕ = flux linkage

X = reactance

R = resistance

T = transformatiom of coordinate systems

T = torgue

Subscripts:

a = armature

e = electrical

m = mechanical

D,Q or

d, q = direct and quadrature axes

ℓ = leakage

l = loss

T, t = terminal

s = extra signal

f,fd = field

i, j = index

ref = reference

err = error

min = minimum

max = maximum

o = open circuit

ad,aq = mutual

ff = self

x,y = x and y coordinates

E = excitaion

G = generator

w = washout

Superscripts:

' = transient

" = subtransient

(0) = unsaturated value

Mathematical operators:

Δ = small change

$\sum$ = summation

$\times$ = multiply

|| = paralel

s = Laplace operator