DESIGN AND ANALYSIS OF PID-P CONTROLLER FOR LOAD FREQUENCY CONTROL OF MULTI AREA MULTI SOURCE POWER SYSTEM

By

Ahmed Nabil Abd Alzaher Ibrahim

A thesis submitted to the

Faculty of Engineering at Cairo University

In Partial Fulfillment of the

Requirements for the Degree of

MASTER OF SCIENCE

In

Electrical Power and Machines Engineering

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Title of Thesis: Design and analysis of PID-P controller for load frequency control of multi area multi source power system

Key Words: PID-P controller, Linearized Biogeography Based Optimization (LBBO), Generation rate constraint (GRC), Governor dead band (GDB), Load frequency control (LFC).

Summary:

In this investigation, a new application of PID-P controller for developing the performance of LFC is presented. The PID-P controller is proposed to overcome the structure limitation of PID in controlling the integration process.

At first, a two-area of non-reheat thermal system is considered to investigate the performance of the proposed controller. Further, the proposed controller is extended to a more realistic power system model including thermal with reheater, hydro, wind and diesel power generation units with physical constraints such as governor dead band (GDB), generation rate constraint (GRC) time delay and boiler dynamics.

The parameters of the PID-P controller are optimized using Linearized Biogeography Based Optimization technique (LBBO), Biogeography Based Optimization (BBO) and Genetic Algorithm (GA) with Integral of Time multiplied Absolute Error (ITAE) as a fitness function.

The superiority of the proposed PID-P controller is examined by comparing its results with some recently published modern heuristic optimization approaches tuned PI, PID, 2-Degree of freedom PID (2-DOF-PID), Fuzzy-PI, fuzzy PID, IDD, PIDD controllers for the same power systems. Moreover, the ability of the proposed controller to handle large variation in operating load conditions, time delay, participation factors and system parameters has been verified comprehensively.

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1- Symbols

B	:	Frequency bias factor.
$\mathrm{C(S)}$	:	Transfer function of PID controller
D	:	Load damping constant.
$D\Delta\omega_r$	:	Frequency sensitive load change.
E_i	:	Voltage source of area i.
$E(s)$	:	Error signal.
Δf	:	Frequency deviation in Hz.
Δf_{SS}	:	Steady state frequency deviation.
H	:	Inertia constant.
K_d	:	Derivative gain.
K_i	:	Integral gain.
K_p	:	Proportional gain.
K_{psi}	:	Power system gain.
K_r	:	Reheater gain.
M_{eq}	:	Equivalent inertia constant.
P_0	:	Initial value of power.
P_e	:	Electrical power.
P_L	:	Load power.
P_m	:	Mechanical power.
ΔP_{Di}	:	Load demand change in p.u.
ΔP_{Gi}	:	Change in the governor valve position in p.u.
ΔP_L	:	Non-frequency sensitive load change.
ΔP_{Ti}	:	Change in the turbine output in p.u.
R	:	Speed regulation in Hz/p.u.
$\mathrm{R(S)}$	:	Reference signal.
T	:	Synchronization torque coefficient.
T_0	:	Initial value of torque.
T_{12}	:	Synchronizing coefficient.
T_a	:	Acceleration torque.

T_e	:	Electrical torque.
T_{e0}	:	Initial value of electrical torque.
T_f	:	Derivative term filter time constant in sec.
T_{GH}	:	Hydro turbine speed governor main servo time constant in sec.
T_{gi}	:	Speed governor time constant in sec.
T_m	:	Mechanical torque.
T_{m0}	:	Initial value of mechanical torque.
T_{psi}	:	Power system time constant in sec.
T_{RH}	:	Hydro turbine speed governor droop time constant in sec.
T_{RS}	:	Hydro turbine speed governor reset time in sec.
T_r	:	Reheater time constant in sec.
T_{ti}	:	Turbine time constant in sec.
T_{wi}	:	Water starting time in sec.
$U(s)$	:	Controller output.
U_i	:	Controller output signal.
U_{TH}	:	Control output of thermal unit.
U_{HY}	:	Control output of hydro unit.
U_W	:	Control output of wind turbine.
ω	:	Rotational speed.
ω_0	:	Speed reference.
ω_{FL}	:	Steady state speed at full load.
ω_{NL}	:	Steady state speed at no load.
$\Delta\omega_r$	:	Rotor speed deviation in rpm.
X_{tie}	:	Reactance of tie line.
X_i	:	Reactance of area *i*.
ΔY	:	Control signal.
Y(S)	:	Process output.
β_i	:	Composite frequency response characteristic for area *i*.