# INTELLIGENT TECHNIQUES FOR ENHANCEMENT OF SMALL SIGNAL ROTOR ANGLE STABILTY

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# CERTIFICATE

I, PRANSHU Roll No. 2K13/C&I/09 student of M. Tech. (Control & instrumentation), hereby declare that the dissertation titled "INTELLIGENT TECHNIQUES FOR IMPROVEMENT OF SMALL SIGNAL ROTOR ANGLE STABILTY" under the supervision of Dr. Narendra Kumar of Electrical Engineering Department, Delhi Technological University in partial fulfillment of the requirement for the award of the degree of Master of Technology has not been submitted elsewhere for the award of any Degree.

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# ABSTRACT

The utilisation of power system stabilizers (PSS) has developed gigantically customary in living up to expectations of huge electric power systems. Nonetheless, it was difficult to create a stabilizer that would exist with capability to perform in every single working purpose of electric power systems. With a soal aim to cover all the possible range of working conditions, Fuzzy logic has been prescribed the conceivable response to control this complication, by use of linguistic data and evading a complex structure mathematical model.

In this theme, a step wise resemble to fuzzy logic and PID controller object is suggested. This theme presents a comparative study of, without use of PSS and conventional PSS along with the use of Fuzzy and PID control techniques for solidness heightening of a single machine infinite bus system. With a soul objective to get the stability heightening, precise speed deviation $\Delta\omega$ and acceleration $\Delta\dot{\omega}$ of the rotor synchronous generator taken as inputs to fuzzy logic controller while only speed deviation $\Delta\omega$ has been used as input for PID control and conventional PSS. These variables have given significant outcome on damping out the mechanical oscillations created by generator shaft. Relying on these inconstants the stabilized signals were find out using the function of fuzzy membership and also by using PID controller. The values of $K_p$, $K_i$, $K_d$ are found out using trial and error method. The fuzzy controller used has been compared with different overlapping of the membership function. Simulink has been used in matlab-10 for block designing of above.

# LIST OF FIGURES

# LIST OF ABBREVIATION

SMIB: SINGLE MACHINE INFINITE BUS SYSTEM

PSS: POWER SYSTEM STABILIZER

PID: PROPORTIONAL-INTEGRAL-DERIVATIVE

FLPSS: FUZZY LOGIC POWER SYSTEM STABILIZER

AVR: AUTOMATIC VOLTAGE REGULATOR

CPSS: CONVENTIONAL POWER SYSTEM STABILIZER

FLC: FUZZY LOGIC CONTROLLER

GA: GENETIC ALGORITHM

ANN: ARTIFICIAL NEURAL NETWORK

ANFIS: ADAPTIVE NEURO FUZZY INFERENCE SYSTEM

BFO: BACTERIAL FORAGING ALGORITHM

# LIST OF TABLES

# LIST OF SYMBOLS

| SYMBOL | QAUNTITY |
|---|---|
| $\delta$ | Rotor angle |
| $\omega_r$ | Rated Speed (in electrical rad/s) $2\pi f$ |
| $\Delta\delta$ | Rotor Angle Deviation |
| $\Delta\omega_r$ | Speed Deviation (in p.u.) = $\left( (\omega_r - \omega_o) / \omega_o \right)$ |
| $\Delta\omega$ | Speed deviation (Input to fuzzy logic Controller) |
| $\Delta\dot{\omega}$ | Deviation in angular acceleration |
| $\omega_n$ | Undamped Natural Frequency (in rad/s) |
| $\Delta T_m$ | Deviation in Mechanical Torque |
| $\xi$ | Damping Ratio |
| $\psi_{fd}$ | Field Circuit Flux Linkage |
| $\psi_d, \psi_q$ | d-axis and q-axis Flux Linkage |
| $L'_{ads}, L'_{aqs}$ | Saturated values of Transient Inductances |
| $\psi_{ad}, \psi_{aq}$ | Air Gap Flux Linkage |
| $A_{SAT}, B_{SAT}$ | Constants defining Saturation Characteristics of Machine |
| $E_B$ | Infinite Bus Voltage (in p.u) |
| $E_t$ | Generator Terminal Voltage |
| $e_d, e_q$ | d-axis and q-axis component of $E_t$ |
| $E_{fd}$ | Exciter Output Voltage |
| H | Inertial Constant (in MW-s/MVA) |
| I | Line Current (in p.u.) |
| $I_d, I_q$ | d-axis and q-axis components of line current |
| $I_{fd}$ | Field Current |
| J | Combined Moment of Inertia of generator and turbine (in Kg-m$^2$) |
| $K_1, K_2, K_3, K_4, K_5, K_6$ | K-Constants of Phillips Heffron Model |
| $K_A$ | Exciter Gain |
| $K_D$ | Damping Torque Coefficient (in p.u torque/ p.u speed deviation) |
| $K_S$ | Synchronizing Torque Coefficient (in p.u. torque/rad.) |
| $K_{sd(incr)}, K_{sq(incr)}$ | Incremental Saturation Factor |

| | |
|---|---|
| $K_{stab}$ | Stabilizer Gain |
| $L_l$ | Leakage Inductance |
| $L_{fd}$ | Field Winding Inductance |
| $L_{ad}$, $L_{aq}$ | d-axis and q-axis Mutual Inductance |
| $L_{ads}$, $L_{aqs}$ | Saturated values of d-axis and q-axis Mutual Inductance |
| P | Active Power (in p.u.) |
| $P_e$ | Air Gap Power (in p.u.) |
| Q | Reactive Power (in p.u.) |
| $R_a$ | Armature Resistance per Phase (in p.u.) |
| $R_E$ | Transmission Line Resistance (in p.u.) |
| $R_{fd}$ | Field Circuit Resistance |
| $R_T$ | Total Resistance (in p.u.) |
| s | Laplace Operator |
| $T_1$, $T_2$ | Phase Compensation Time Constant |
| $T_3$ | Time Constant of Field Circuit |
| $T_a$ | Accelerating torque (in N-m) |
| $T_e$ | Electromagnetic Torque (in N-m) |
| $T_m$ | Mechanical Torque (in N-m) |
| $T_W$ | Time Constant of Wash out block |
| $X'_d$ | Transient Reactance of Generator |
| $X_E$ | Transmission Line Reactance (in p.u.) |
| $X_T$ | Total Reactance (in p.u) |

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