LIST OF ABBREVIATION

Abbreviation	Description about Abbreviation
ABC	Artificial Bee Colony
AFPSS	Adaptive Fuzzy Power System Stabilizer
ANC	Adaptive Neuro Controller
ANI	Adaptive Neuro Identifier
ANN	Artificial Neural Network
ATC	Available Transfer Capacity
CPSS	Conventional Power System Stabilizer
DE	Differential Evolution
DG	Distributed Generation
EMTDC	Electromagnetic Transients including Direct Current
FA	Firefly Algorithm
FACTS	Flexible Alternating Current Transmission System
FOPTC	Flexible Operating Point Tracking Concept
FPOS	First Peak Overshoot
FPSS	Fuzzy Power System Stabilizer
GA	Genetic Algorithm
GSA	Gravitational Search Algorithm
GTO	Gate Turn-Off
HHO	Hybrid Heuristic Optimization
HVDC	High Voltage Direct Current
IGBT	Insulated Gate Bipolar Transistor
ITAE	Integral Time Multiplied by Absolute Error
KD	Knowledge Domain
KDIM	Knowledge Domain Inference Mechanism
KDSM	Knowledge Domain States Mapping
LMI	Linear Matrix Inequality
LQR	Linear Quadratic Regulator
MMPS	Multi-Machine Power System
MSLQR	Multi-Stage Linear Quadratic Regulator
OLS	Orthogonal Least Square

OT	Optimization Techniques
POD	Power Oscillation Damping
PID	Proportional Integrated Derivative
PMU	Phasor Measurement Unit
PSCAD	Power System Computer Aided Design
PSO	Particle Swarm Optimization
PSS	Power System Stabilizer
PWM	Pulse Width Modulation
RBNF	Radial Basis Network Function
RCGA	Real Coded Genetic Algorithm
RES	Renewable Energy Sources
RNN	Recurrent Neural Network
ROCOF	Rate of Change of Frequency
RTDS	Real Time Digital Simulator
SA	Simulated Annealing
SMC	Sliding Mode Control
SMIB	Single Machine Infinite Bus
SPS	Special Protection Systems
SSR	Sub-Synchronous Resonance
SSSC	Static Synchronous Series Compensator
ST	Settling Time
STATCOM	Static Synchronous Compensator
SVC	Static Var Compensator
TCSC	Thyristor Controller Series Capacitor
TS	Tabu Search
UPFC	Unified Power Flow Controller
US	Unstable System
VSC	Voltage Source Converter
VSI	Voltage Source Inverter
WADC	Wide Area Damping Controller

LIST OF SYMBOLS

Symbols used in modeling of Multi-Machine System:

v_{tij}	Terminal voltage of i^{th} generator in j^{th} area
v_{di1}	Direct axis component of terminal voltage of i^{th} generator in area 1
v_{qi1}	Quadrature axis component of terminal voltage of i^{th} generator in area 1
v_{tj}	Terminal voltage of j^{th} area
v_{dj}	Direct axis component of terminal voltage of j^{th} area
v_{qj}	Quadrature axis component of terminal voltage of j^{th} area
i_1	Armature current in generator 1
i_{d1}	Direct axis component of armature current in generator 1
i_{q1}	Quadrature axis component of armature current in generator 1
E'_{qij}	Internal voltage of i^{th} generator in j^{th} area
E_{fdij}	Voltage across field winding of i^{th} generator in j^{th} area
$\Delta\omega_{ij}$	Deviation in angular speed of i^{th} generator in j^{th} area
δ_{ij}	Rotor angle of i^{th} generator in j^{th} area
$\Delta\delta_{ij}$	Deviation in rotor angle of i^{th} generator in j^{th} area
δ_0	Initial rotor angle
x_{tij}	Terminal reactance of i^{th} generator in j^{th} area
x_{dij}	Direct axis synchronous reactance of i^{th} generator in j^{th} area
x'_{dij}	Direct axis transient reactance of i^{th} generator in j^{th} area
x''_{dij}	Direct axis sub-transient reactance of i^{th} generator in j^{th} area
x_{qij}	Quadrature axis steady state reactance of i^{th} generator in j^{th} area
T'_{doi}	Time constant of field winding circuit of i^{th} generator
n	Total number of generators connected in one area
M, N	Area number in which generators are connected
Y1	Load (Admittance) in Area 1
Y2	Load (Admittance) in Area 2
Gi	Conductance of load in i^{th} area
Bi	Susceptance of load in i^{th} area
Z	Impedance of transmission line
R	Resistance of transmission line
X	Reactance of transmission line

T_{eij}	Output torque of i^{th} generator in j^{th} area
P_{ei1}	Real power output of i^{th} generator in area 1
Q_{ei1}	Reactive power output of i^{th} generator in area 1
ΔP	Deviation in output power
Δf	Frequency deviation
f_0	Nominal frequency
ω_0	Nominal or rated rotational speed
M_i	Inertia constant of i^{th} generator
T1i, T2i	Time constant of PSS for i^{th} generator
Kci	Gain of PSS for i^{th} generator
T_{Ai}	Time constant of excitation system for i^{th} generator
T_{Aij}	Time constant of excitation system for i^{th} generator in j^{th} area
K_{Ai}	Gain of excitation system for i^{th} generator
K_{Aij}	Gain of excitation system for i^{th} generator in j^{th} area
T_m	Input mechanical torque
UE	Supplementary excitation in PSS
X5	Intermediate state variable in PSS
Ac	Controlled system matrix
A	System matrix
B	Control matrix
Δ	Deviation

Symbols used in modeling of multi-machine with FACTS controller:

m_e	Amplitude modulation ratio of shunt converter of UPFC
δ_e	Phase angle of shunt converter of UPFC
m_b	Amplitude modulation ratio of series converter of UPFC
δ_b	Phase angle of series converter of UPFC
ω_i	Angular speed of i^{th} generator
C_{dc}	Capacitance of DC link capacitor
V_{dc}	Voltage across DC link capacitor
X_{te}	Transmission line reactance to the shunt part of UPFC location
X_{bv}	Transmission line reactance to the series part of UPFC location
X_{ijd}	Direct axis synchronous reactance of i^{th} generator in j^{th} area

X'_{ijd}	Direct axis transient reactance of i^{th} generator in j^{th} area
X_{ijq}	Quadrature axis synchronous reactance of i^{th} generator in j^{th} area
V_1, V_2	Terminal voltage of generator 1 and generator 2 respectively
V_{1d}, V_{1q}	Direct and quadrature axis component of voltage V_1 respectively
V_E	Voltage generated in shunt side of UPFC
V_B	Voltage generated in series side of UPFC
V_{Ed}	Direct axis component of voltage connected in shunt side of UPFC
V_{Eq}	Quadrature axis component of voltage connected in shunt side of UPFC
V_{Bd}	Direct axis component of voltage connected in series side of UPFC
V_{Bq}	Quadrature axis component of voltage connected in series side of UPFC
V_{Et}, V_{Bt}	Terminal voltages of shunt and series side of UPFC respectively
I_i, I_o	Currents in VSC for shunt and series terminal respectively
I_1, I_2	Armature currents of generator 1 and generator 2 respectively
I_{1d}, I_{1q}	Direct and quadrature axis component of current I_1 respectively
I_E, I_B	Currents connected in shunt and series side of UPFC respectively
I_{Ed}	Direct component of current connected in shunt side of UPFC
I_{Eq}	Quadrature component of current connected in shunt side of UPFC
I_{Bd}	Direct component of current connected in series side of UPFC
I_{Bq}	Quadrature component of current connected in shunt side of UPFC
E'_{q1}, E'_{q2}	Internal voltage of generator 1 and 2 respectively
E'_{qij}	Internal voltage of i^{th} generator in j^{th} area
E_{fd1}, E_{fd2}	Voltage across filed winding of generator 1 and 2 respectively
E_{fdij}	Voltage across filed winding of i^{th} generator in j^{th} area
I_{Edi}	Direct axis current in shunt part of UPFC for i^{th} generator
I_{Eqi}	Quadrature axis current in shunt part of UPFC for i^{th} generator
I_{Bdi}	Direct axis current in series part of UPFC for i^{th} generator
I_{Bqi}	Quadrature axis current in series part of UPFC for i^{th} generator
k	Ratio between AC and DC voltage of the converter
L1, L2	Load in area 1 and area 2 respectively
X_1, X_2	Transmission line reactance
X_e, X_b	Transformer reactance of shunt and series side of UPFC respectively
T'_{ido}	Time constant of field winding circuit of i^{th} generator
T_{iA}, K_{iA}	Time constant and gain of excitation system for i^{th} generator respectively

D_i	Damping coefficient of i^{th} generator
K	Feedback gain matrix in LQR Control

Symbols used in Intelligent Optimization Techniques:

pbest	Personal best of each particle
gbest	Global best
r1, r2	Random numbers between [0,1]
c1, c2	Acceleration constants
$x_{id}^{\ t}$	Position of i^{th} particle in dimension 'd' for iteration 't'
$v_{id}^{\ t}$	Velocity of i^{th} particle in dimension 'd' for iteration 't'
$S(v_{id}^{\ t})$	Sigmoidal Function
I(r)	Light intensity of firefly at distance 'r'
r_{ij}	Distance between two fireflies 'i' and 'j'
I_0	Initial light intensity
β	Attractiveness of firefly
α	Randomization parameters
G(t)	Gravitational constant at iteration 't'
M_{aj}	Active gravitational mass of 'j^{th}' agent
M_{pi}	Passive gravitational mass of 'i^{th}' agent
$M_i(t)$	Mass of agent 'i' for iteration 't'
$F_i^d(t)$	Force on agent 'i' in dimension d for iteration 't'
$F_{ij}^{\ d}(t)$	Force on agent 'i' due to agent 'j' in dimension 'd' for iteration 't'