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**FIGURE NO.** **TITLE** **PAGE NO.**

# LIST OF SYMBOLS AND ABBREVIATIONS

| | | |
|---|---|---|
| $P_{ij}$ and $Q_{ij}$ | - | Active and reactive power flow from bus-$i$ to $j$ respectively |
| $\Psi$ | - | Augmented objective function |
| BBO | - | Biogeography based optimization |
| $x_{ij}'$ | - | buses-$i$ and $j$ along with FACTS device |
| CP | - | Capacitor placement |
| $\Delta\alpha_{SVC}$ | - | Change in firing angle of SVC |
| $\Delta G_{ij}$ | - | Change in line conductance between bus i and j |
| $\Delta B_{ij}$ | - | Change in line susceptance between bus i and j |
| $\Delta Q_i$ | - | Change in reactive power injection at bus-$i$ by a FACTS device |
| $g_k$ | - | Conductance of the transmission line-$k$ |
| $\psi$ | - | Constant |
| $F_{ij}$ | - | Elements of hybrid –F matrix |
| $g(x,u)$ | - | Equality constraints |
| FACTS | - | Flexible AC transmission systems |
| GA | - | Genetic algorithm |
| $P^{\text{mod}}$ | - | Habitat modification probability |
| $HSI$ | - | Habitat suitability index |
| $\lambda$ and $\mu$ | - | Immigration and emigration rates respectively |
| ISO | - | Independent system operator |
| $h(x,u)$ | - | Inequality constraints |
| $S_{ic}$ | - | Injection of apparent power at i-th bus |
| $S_{jc}$ | - | Injection of apparent power at j-th bus |

| | | |
|---|---|---|
| IPFC | - | Inter line power flow controller |
| X & Y | - | Left & right eigen vector |
| V & W | - | Left & right singular vector |
| $x_C$ | - | Line Capacitance |
| $\eta_k$ | - | Line compensation factor in the range of (-0.8, 0.2) for $k^{th}$ FACTS device |
| $L_i$ | - | Line indicator |
| $x_L$ | - | Line Inductance |
| LP | - | Linear programming |
| LS | - | Load shedding |
| $Q_{Gi}^{\min}$ and $Q_{Gi}^{\max}$ | - | Lower and upper limit reactive power generation at bus-$i$ respectively |
| $V_i^{\min}$ and $V_i^{\max}$ | - | Lower and upper limits of voltage magnitude at bus-$i$ respectively |
| $E^{\max}$ | - | Maximum emigration rate |
| $I^{\max}$ | - | Maximum immigration rate |
| $m^{\max}$ | - | Maximum mutation rate |
| $Iter^{\max}$ | - | Maximum number of iterations |
| $P^{\max}$ | - | Maximum probability |
| $S^{\max}$ | - | Maximum species in the habitat |
| $Q_I$ | - | Mega var injection |
| MVAR | - | Mega volt ampere reactive |
| $m(s)$ | - | Mutation rate for habitat possessing S species |
| $L_k$ | - | Number of a line, where $k^{th}$ FACTS device is to be located |
| $neh$ | - | Number of elite habitats |
| $nf$ | - | Number of FACTS devices |

| | | |
|---|---|---|
| $nh$ | - | Number of habitats |
| $nload$ | - | Number of load buses |
| $\Phi(x,u)$ | - | Objective function |
| PSO | - | Particle swarm optimization |
| $V_{sh}$ | - | Positive sequence shunt voltage |
| $P^s(t)$ | - | Probability that the habitat contains exactly S species at time $t$ |
| PM | - | Proposed method |
| $X_{SVC}$ | - | Reactance of SVC |
| $x_F$ | - | Reactance of the FACTS device |
| $x_{ij}$ | - | Reactance of the transmission line between buses-$i$ and $j$ |
| $Q_k$ | - | Reactive power at k-th bus |
| $Q_{sh}$ | - | Reactive power at shunt connected source |
| $Q_{ji}$ | - | Reactive power flow from $j^{th}$ bus to $i^{th}$ bus |
| $Q_{Gi}$ | - | Reactive power generation at bus-$i$ |
| $Q_{Fi}$ | - | Reactive power supplied by the FACTS device at bus-$i$ |
| $Q_F^k$ | - | Reactive power support by $k^{th}$ FACTS device in MVAR |
| $Q_v$ | - | Reactive power voltage |
| $P_{sh}$ | - | Real power flow at shunt voltage source |
| $P_{ji}$ | - | Real power flow from $j^{th}$ bus to i bus |
| $P_v$ | - | Real power voltage |
| $V_{se}$ | - | Series connected voltage source |
| $\theta_{se}$ | - | Series converter angle in IPFC |
| $V_{se}$ | - | Series converter voltage of IPFC |

| | | |
|---|---|---|
| $Z_{se}$ | - | Series source impedance |
| $\alpha G$ | - | Set of generator buses |
| $\alpha L$ | - | Set of load buses |
| $Q(V,\delta)$ | - | Set of reactive power expressions at PQ buses |
| $P(V,\delta)$ | - | Set of real power expressions at PV and PQ buses |
| $Q^{sp}$ | - | Set of specified reactive powers at PQ buses |
| $P^{sp}$ | - | Set of specified real powers at PV and PQ buses |
| $G_{sh}$ | - | Shunt converter conductance |
| $B_{sh}$ | - | Shunt converter susceptance |
| $Q_{sh}$ | - | Shunt converter reactive power |
| $P_{sh}$ | - | Shunt converter real power |
| $Z_{sh}$ | - | Shunt source impedance |
| SA | - | Simulated annealing |
| $\dot{P}^{s}$ | - | Species count probability |
| $S$ | - | Species in the habitat |
| V0 | - | Starting voltage at a bus |
| $-jX_c$ | - | Static reactance |
| $-jX_c$ | - | Static reactance |
| STATCOM | - | Static synchronous compensator |
| SSSC | - | Static synchronous series compensator |
| SVC | - | Static VAR compensator |
| $\mathbf{Y}_{LL}\&\mathbf{G}_{LG}$ | - | Sub matrices of the Y- bus matrix |
| $SIV$ | - | Suitability index variable |
| SVSI | - | Sum of voltage stability index |
| $B_{SVC}$ | - | Susceptance of SVC |
| $\alpha^{i}{}_{SVC}$ | - | SVC firing angle at $i^{th}$ iteration |
| $Q_{svc}$ | - | SVC reactive power |

| | | |
|---|---|---|
| $B_{svc}$ | - | SVC susceptance |
| $B^{i}_{svc}$ | - | SVC susceptance at i$^{th}$ iteration |
| $P_L$ | - | System real power loss |
| Subscript $i$ and $j$ | - | Terminal buses of line-$m$ |
| TCPAR | - | Thyristor controlled phase angle regulator |
| TCSC | - | Thyristor controlled series compensator |
| $n$ | - | Total number of species in the habitat |
| $T_k$ | - | Type of $k^{th}$ FACTS device |
| UPFC | - | Unified power flow controller |
| $\alpha_{SVC}$ | - | Variable firing angle of SVC |
| $u$ | - | Vector of control or independent variables |
| $x$ | - | Vector of dependent variables |
| $\delta_{ij}$ | - | Voltage angle between buses-$i$ and $j$ |
| $V_{di}$ | - | Voltage deviation at bus-$i$ |
| $V_i$ | - | Voltage flow at i-th bus |
| $V_i$ and $V_j$ | - | Voltage magnitude at buses-$i$ and $j$ respectively |
| VP | - | Voltage profile |
| VR | - | Voltage regulators |
| VS | - | Voltage stability |
| RVI | - | voltage stability index |
| $w_1$ and $w_2$ | - | Weight constants |