# Nomenclature and Base Data for “Multi-objective Dynamic Reconfiguration for Urban Distribution Network Considering Multi-level Switching Modes”

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***Abstract*—This material presents nomenclature and some base data of 148-node system in the paper “Multi-objective Dynamic Reconfiguration for Urban Distribution Network Considering Multi-level Switching Modes”.**

## NOMENCLATURE

*Indices*

| | |
|---|---|
| $i, j$ | Index of nodes. |
| $f$ | Index of transformers at substation node $j$. |
| $k$ | Index of feeders for transformer $f$ at substation node $j$. |
| $ij, jk$ | Index of branches. |
| $t$ | Index of time periods. |

*Sets*

| | |
|---|---|
| $E^{\text{SW,Feed}}$ / $E^{\text{SW,Trans}}$ / $E^{\text{SW,Sub}}$ | Set of feeder/ transformer/ substation tie switch branches |
| $E$/ $E^{\text{SW,Sect}}$ / $E^{\text{SW}}$ | Set of branches/ sectionalizing switch branches/ switch branches |
| $B$ | Set of nodes |
| $B^{\text{Sub}}$ / $B^{\text{PV}}$ | Set of nodes connected with substation/ PVG. |
| $\gamma(j)$ | Set of transformers at substation node $j$ |
| $\alpha(j,f)$ | Set of feeders for transformer $f$ at substation node $j$. |
| $\alpha(j)$ / $\beta(j)$ | Set of nodes whose parent/child is node $j$. |

*Parameters*

| | |
|---|---|
| $c^{\text{loss}}$ / $c_t^{\text{Sub}}$ / $c^{\text{LR}}$ | Cost for power loss/main grid power/load shedding |
| $c_{ij}^{\text{SW,Sect}}$ / $c_{ij}^{\text{SW,Feed}}$ / $c_{ij}^{\text{SW,Trans}}$ / $c_{ij}^{\text{SW,Sub}}$ | Switching cost for sectionalizing switch/ feeder tie switch/ transformer tie switch/ substation tie switch |
| $P_j^{\text{Sub,max}}$ | Upper bound of substation active power at node $j$. |
| $P_{j,f}^{\text{Trans,max}}$ / $P_{j,f}^{\text{Trans,min}}$ / $Q_{j,f}^{\text{Trans,max}}$ / $Q_{j,f}^{\text{Trans,min}}$ | Upper/lower bound of active/reactive power for transformer $f$ at substation node $j$. |
| $P_{ij}^{\max}$ | Upper bound of active power for branch $ij$. |
| $N^{\text{Sub}}$ / $N^{\text{Trans}}$ | Number of substations/transformers |
| $N_j^{\text{Trans}}$ | Number of transformers connected to substation node $j$. |
| $N_{j,f}^{\text{Feed}}$ | Number of feeders connected to transformer $f$ at substation node $j$. |
| $N_{ij}^{\text{SW,max}}$ | Maximum regulation number of switch of branch $ij$. |
| $r_{ij}$ / $x_{ij}$ | Resistance/reactance of branch $ij$. |
| $g_j$ / $b_j$ | Conductance/susceptance from node $j$ to ground. |
| $M$ | A “big-M”-type constant |
| $E^{\text{Always}}$ | Number of unadjustable branches |

*Variables*

| | |
|---|---|
| $B_t^{\text{Sub}}$ / $B_t^{\text{Trans}}$ / $B_t^{\text{Feed}}$ | Substation/ transformer/ feeder load balancing index at time period $t$. |
| $P_{j,t}^{\text{Sub}}$ / $Q_{j,t}^{\text{Sub}}$ / $R_{j,t}^{\text{Sub}}$ | Active power/ reactive power/ load rate for substation node $j$ at time period $t$. |
| $R_t^{\text{Sub,avr}}$ | Average load rate of substations at time period $t$. |
| $P_{j,f,t}^{\text{Trans}}$ / $Q_{j,f,t}^{\text{Trans}}$ / $R_{j,f,t}^{\text{Trans}}$ | Active power/ reactive power/ load rate of transformer $f$ for substation node $j$ at time period $t$. |
| $R_{j,t}^{\text{Trans,avr}}$ | Average load rate of transformers for substation node $j$ at time period $t$. |
| $B_{j,t}^{\text{Trans}}$ | Transformer load balancing index for substation node $j$ at time period $t$. |
| $R_{jk,t}^{\text{Feed}}$ | Load rate of feeder $jk$ at time period $t$. |
| $R_{j,f,t}^{\text{Feed,avr}}$ | Average load rate of feeders for transformer $f$ in substation node $j$ at time period $t$. |
| $B_{j,f,t}^{\text{Feed}}$ | Feeder load balancing index of transformer $f$ for Substation node $j$ at time period $t$. |
| $A^{\text{PV}}$ | PVG curtailment |
| $P_{j,t}^{\text{PV}}$ / $P_{j,t}^{\text{PV,tru}}$ | Active power/ available active power for PV node $j$ at time period $t$. |
| $P_{j,t}$ / $Q_{j,t}$ | Active/ reactive power injection for node $j$ at time period $t$. |
| $I_{ij,t}^{\wedge}$ / $V_{ij,t}^{\wedge}$ | Square current of branch $ij$/ square voltage of node $j$ at time period $t$. |
| $P_{ij,t}$ / $Q_{ij,t}$ | Active/reactive power flow from node $i$ to node $j$ at time period $t$. |
| $P_{j,t}^{\text{L}}$ / $Q_{j,t}^{\text{L}}$ | Active/reactive power demand for load node $j$ at time period $t$. |
| $P_{j,t}^{\text{LR}}$ / $Q_{j,t}^{\text{LR}}$ | Active/reactive power reduced for load node $j$ at time period $t$. |

$w_{ij,t}$ — Operation state of switch branch $ij$ at time period $t$; binary variable.

$\delta_{ij,t}^{\mathrm{SW,IN}} / \delta_{ij,t}^{\mathrm{SW,DE}}$ — Operation state change of switch branch $ij$ at time period $t$; binary variable.

$(\bullet)^{*}$ — Dummy variable for connectivity constraints

*Operators*

$(\bullet)^{\mathrm{T}}$ — Transpose of a matrix.

A modified 148-node system is used to verify the proposed method in this paper. All the computations are carried out on a 2.9GHz personal computer with 8GB RAM, and the proposed method is programmed in Matlab 2016a.

As shown in Fig. 1, the test system consists of two substations, four transformers, and eight feeders. The spatial-temporal distribution of power generations and demands in practical UDN is unbalanced. For simplicity, it is assumed that PVGs are only connected to one feeder of each transformer. Moreover, the forecasted power outputs of PVGs are assumed to be the same in each node. The forecasted loads in eight feeders are shown in Fig. 2. The numbers of sectionalizing switches, feeder tie switches, transformer tie switches and substation tie switches are 13, 7, 3 and 2, respectively, and the maximum regulation number in the whole time horizon are 4, 4, 3 and 2, respectively. The inertia weight of the BPSO algorithm is updated adaptively and is restricted within [0.4, 0.9]. The learning factors c1 and c2 are both 2. The size of the swarm is 30. The maximum number of iterations is 80.

Take the basic scenario as an example, the schedule horizon is divided into six clusters by the FCM. Specifically, the time division includes 1~6 time period, 7~9 time period, 10~17 time period, 18~20 time period, 21~22 time period and 23~24 time period. As shown in Fig. 3, the curves on the strip (the cluster center) represent the spatial distribution of the load demands at different periods belonging to this cluster.

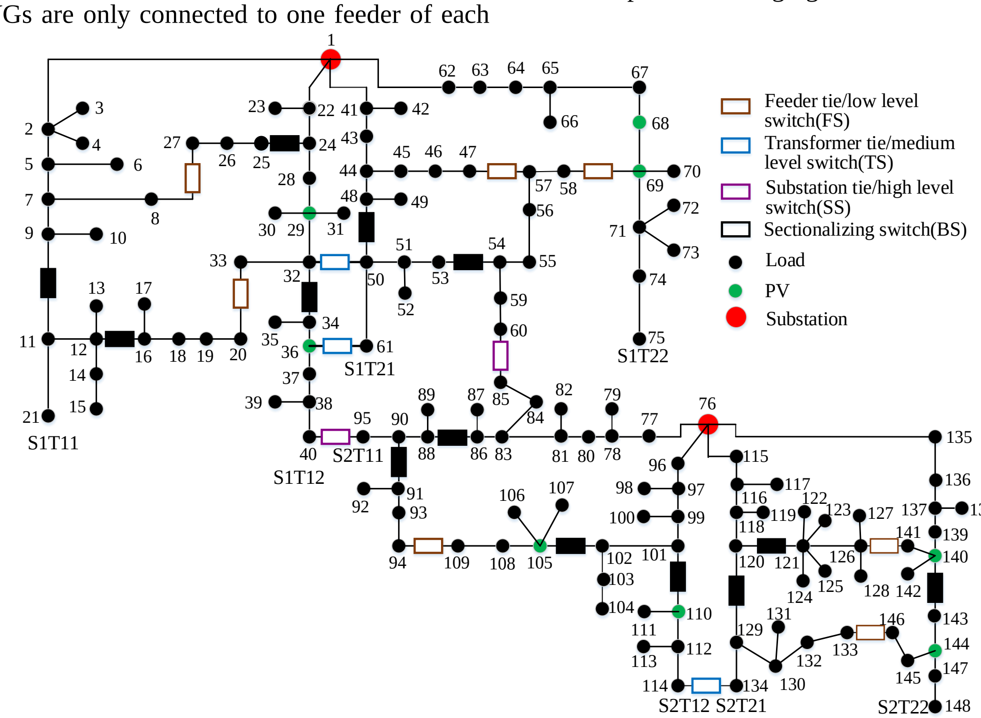


Fig. 1. The topology of the 148-node system

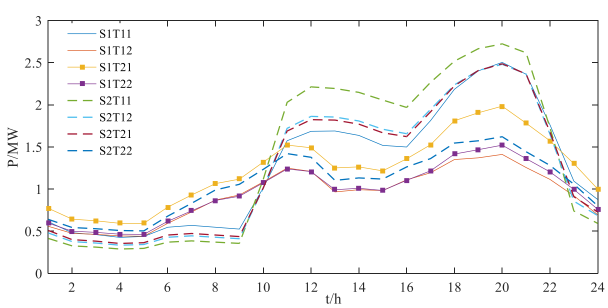


Fig. 2. Load Forecast data (active power) in the eight feeders

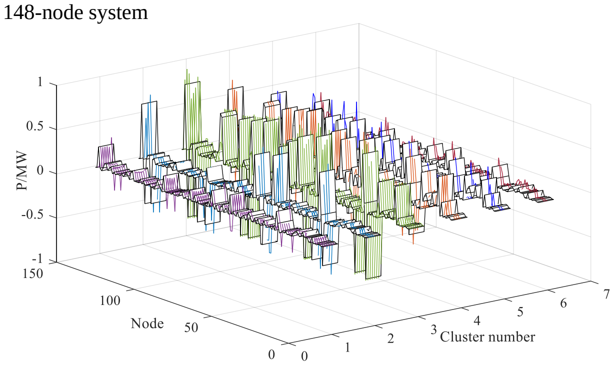


Fig. 3. Clustering results of the basic scenario