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

$E^{\mathrm{SW,Feed}}$ / $E^{\mathrm{SW,Trans}}$ / $E^{\mathrm{SW,Sub}}$	Set of feeder/transformer/substation tie (low/medium/high level) switch branches
E/ $E^{\mathrm{SW,Sect}}$ / E^{SW}	Set of branches/ sectionalizing switch branches/ switch branches
B	Set of nodes
B^{Sub} / B^{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^{loss} / c_t^{Sub} / c^{LR}	Price for power loss/ main grid power/load reduction
$c_{ij}^{\mathrm{SW,Sect}}$ / $c_{ij}^{\mathrm{SW,Feed}}$ / $c_{ij}^{\mathrm{SW,Trans}}$ / $c_{ij}^{\mathrm{SW,Sub}}$	Switching price for sectionalizing switch/feeder tie switch/transformer tie switch/substation tie switch
$P_j^{\mathrm{Sub,max}}$	Upper bound of substation active power at node *j*.
$P_{j,f}^{\mathrm{Trans,max}}$ / $P_{j,f}^{\mathrm{Trans,min}}$ / $Q_{j,f}^{\mathrm{Trans,max}}$ / $Q_{j,f}^{\mathrm{Trans,min}}$	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^{Sub} / N^{Trans}	Number of substations/transformers
N_j^{Trans}	Number of transformers connected to substation node *j*.
$N_{j,f}^{\mathrm{Feed}}$	Number of feeders connected to transformer *f* at substation node *j*.
$N_{ij}^{\mathrm{SW,max}}$	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 “bigM”-type constant
E^{Always}	Number of unadjustable branches

Variables

B_t^{Sub} / B_t^{Trans} / B_t^{Feed}	Substation/transformer/feeder load balancing index at time period *t*.
$P_{j,t}^{\mathrm{Sub}}$ / $Q_{j,t}^{\mathrm{Sub}}$ / $R_{j,t}^{\mathrm{Sub}}$	Active power /reactive power/load rate for substation node *j* at time period *t*.
$R_t^{\mathrm{Sub,avr}}$	Average load rate of substations at time period *t*.
$P_{j,f,t}^{\mathrm{Trans}}$ / $Q_{j,f,t}^{\mathrm{Trans}}$ / $R_{j,f,t}^{\mathrm{Trans}}$	Active power/reactive power/load rate/ of transformer *f* for substation node *j* at time period *t*.
$R_{j,t}^{\mathrm{Trans,avr}}$	Average load rate of transformers for substation node *j* at time period *t*.
$B_{j,t}^{\mathrm{Trans}}$	Transformer load balancing index for substation node *j* at time period *t*.
$R_{jk,t}^{\mathrm{Feed}}$	load rate of feeder *jk* at time period *t*.
$R_{j,f,t}^{\mathrm{Feed,avr}}$	Average load rate of feeders for transformer *f* in substation node *j* at time period *t*.
$B_{j,f,t}^{\mathrm{Feed}}$	Feeder load balancing index of transformer *f* for Substation node *j* at time period *t*.
A^{PV}	PV curtailment
$P_{j,t}^{\mathrm{PV}}$ / $P_{j,t}^{\mathrm{PV,tru}}$	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*.
$P_{j,t}^{\mathrm{L}}$ / $Q_{j,t}^{\mathrm{L}}$	Active/reactive power demand for load node *j* at time period *t*.
$P_{j,t}^{\mathrm{LR}}$ / $Q_{j,t}^{\mathrm{LR}}$	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 148-node system is used to verify the proposed method in this paper. All 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 modified 148-node system comprises two substations, four transformers and eight feeders. The spatial-temporal distribution of power generation and demand in practical UDN is unbalanced in fact. For brevity, PVGs are deployed in one feeder in each transformer. Moreover, the forecast data of PV power is assumed to be the same in each node. The forecast basic data of the active power of load in eight feeders is shown in Fig. 2. The number of sectionalizing switch, low level switch, medium level switch and high level switch are 13, 7, 3 and 2 respectively, and the maximum regulation number in the whole time horizon are 4, 4, 3 and 2. As for BPSO algorithm, the inertia weight is updated adaptively and restricted to [0.4, 0.9]. The learning factors c1 and c2 are both 2, while the size of the swarm N and iterations limit are 30 and 80.

Taking the basic scenario as an example, the scheduled time horizon is divided into six clusters by FCM. As shown in Fig. 3, the strip represents the cluster center, while the curves on the strip are the spatial distribution of the load demand in some periods belonging to this cluster. The scheme of time division is summarized as follows: 1~6 time period, 7~9 time period, 10~17 time period, 18~20 time period, 21~22 time period, 23~24 time period.

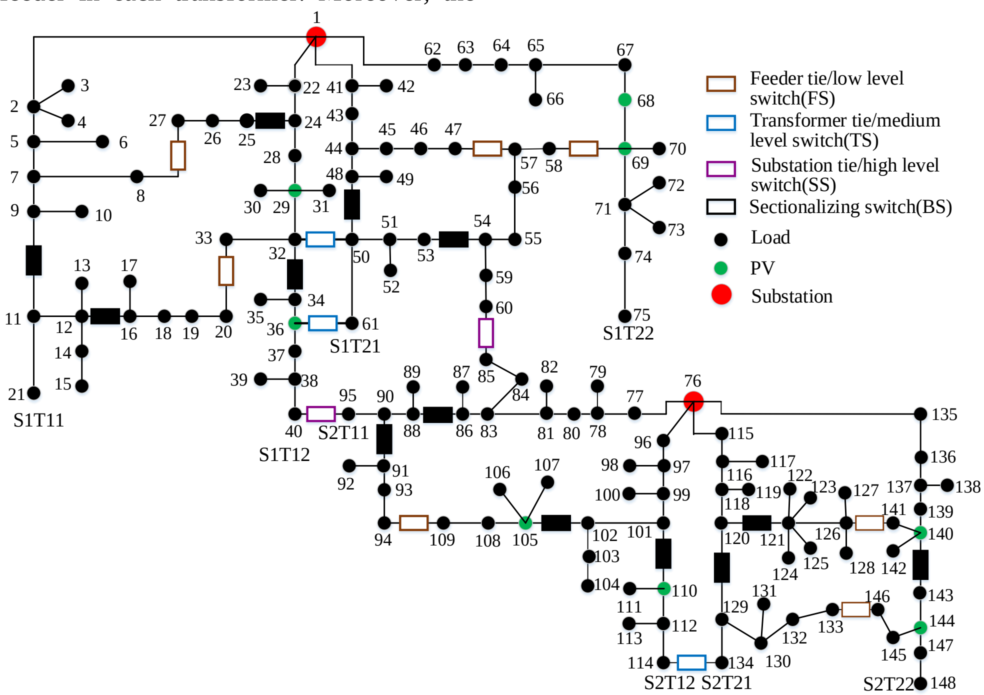

Fig. 1. The topology of 148-node system

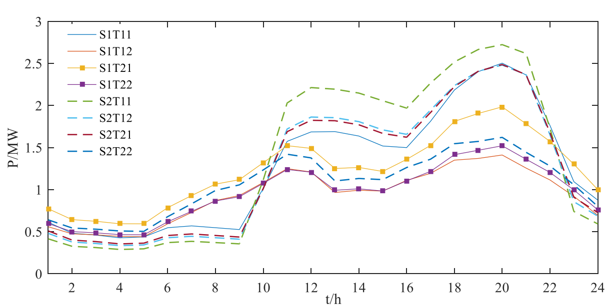

Fig. 2. Forecast basic data of load active power of eight feeders

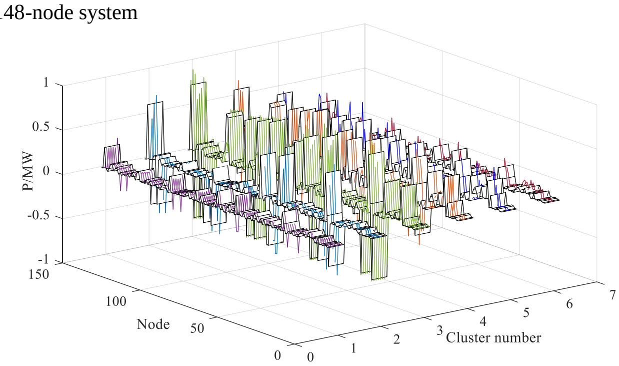

Fig. 3. Clustering results of basic scenario