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Transición energética en la 4ta revolución industrial

Universidad Tecnológica de Pereira

UNIVERSIDAD NACIONAL DE COLOMBIA

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Transición energética en la 4ta revolución industrial

Adaptive coordination of overcurrent relays with multiple setting groups in active distribution networks

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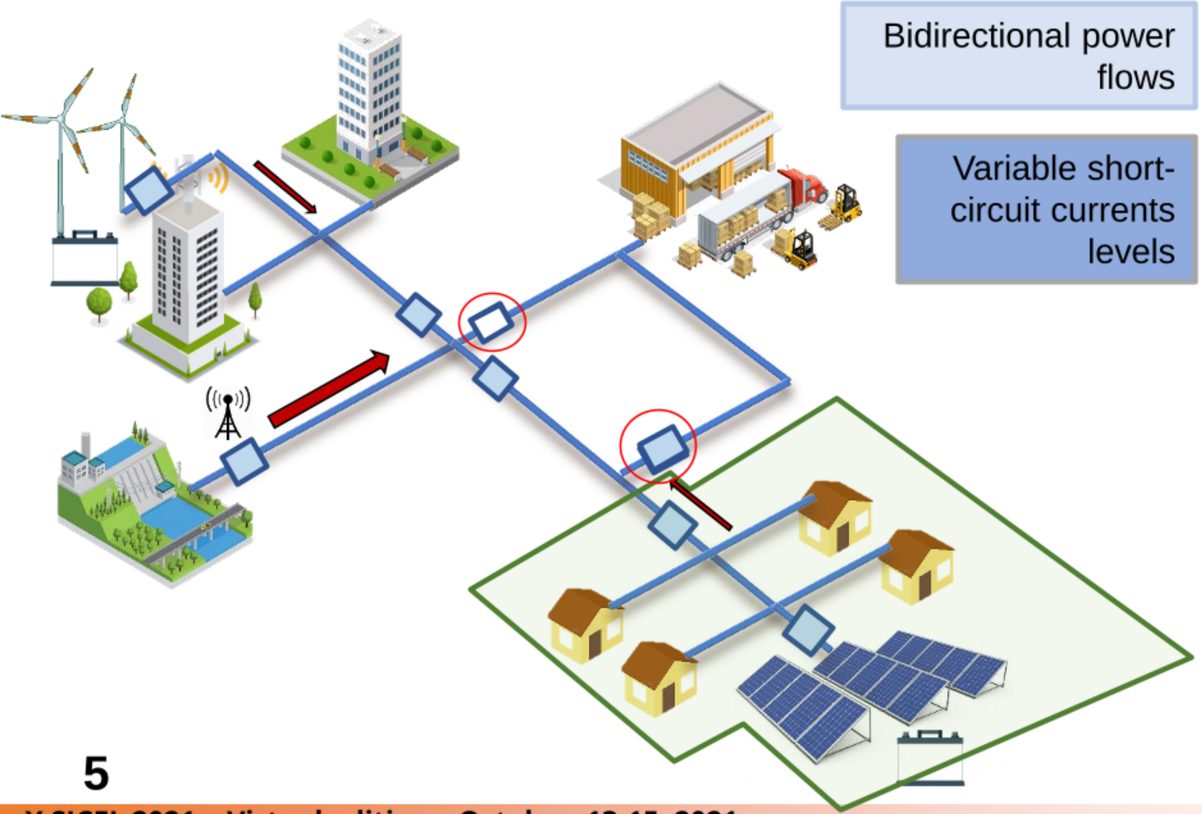

Protection System

Bidirectional power flows

Variable short-circuit currents levels

Active Distribution Networks

Power Distribution Networks

DER

DG

ESS

Operation challenges

Control functionalities

Reliability, flexibility and efficiency

I. Introduction

Protection system

$$t_{ii} = \frac{\beta \cdot TDS}{\left(\frac{I_f}{I_{Pu} \cdot CTR}\right)^{\alpha} - 1} + L$$

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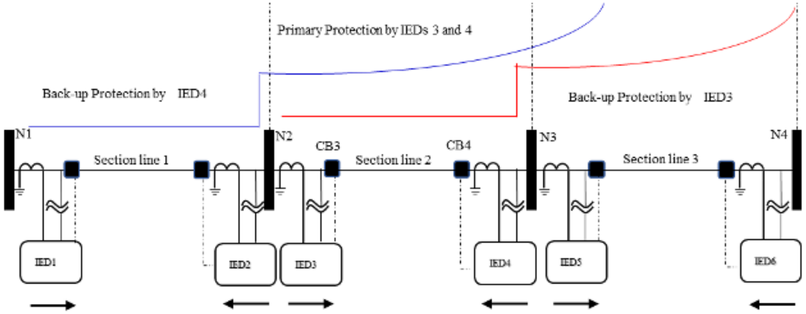
How to protect an ADN considering its topological changes?



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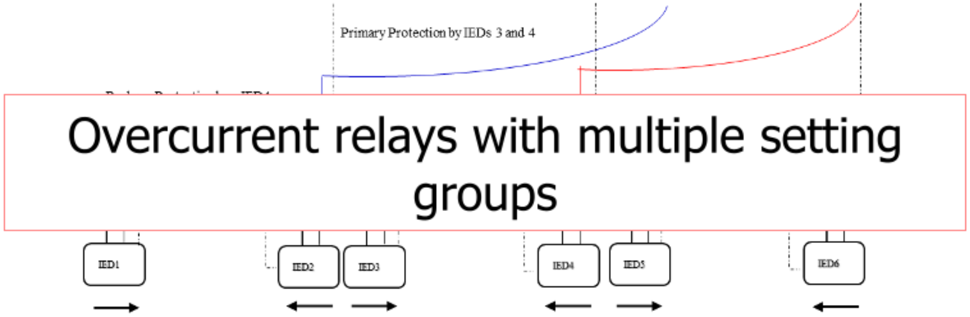

Overcurrent relays with multiple setting groups

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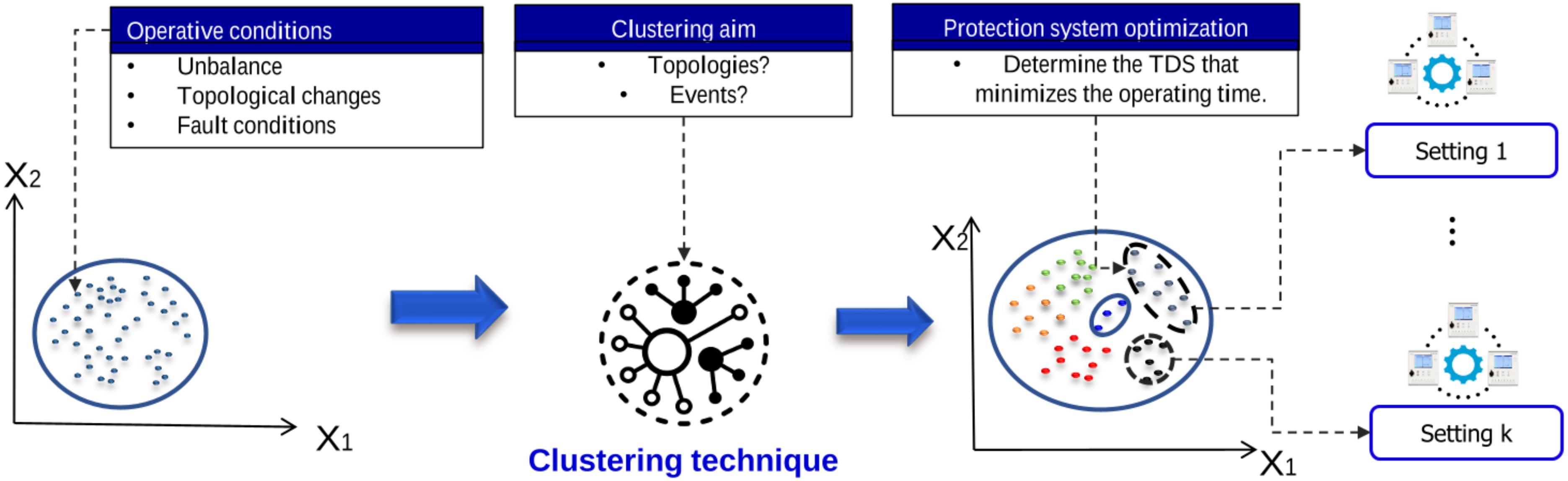
II. Mathematical formulation



II. Mathematical formulation

1204 IEEE TRANSACTIONS ON POWER DELIVERY, VOL. 33, NO. 3, JUNE 2018

Use of Clustering to Reduce the Number of Different Setting Groups for Adaptive Coordination of Overcurrent Relays

Mansour Ojaghi, Member, IEEE and Vahid Mohammadi

$$t_{ii} = \frac{\beta \cdot TDS}{\left(\frac{I_f}{I_{Pu} \cdot CTR}\right)^{\alpha} - 1} + L$$

$$d_{ij} = \left[\sum_{m=1}^{Tp} \left(x_{im} - c_{jm}\right)^2\right]^{\frac{1}{2}}$$

$$a_{jm} = \left(\frac{1}{n_j}\right) \sum_{i=1}^{n_j} x_{im}\,, \qquad m = 1, 2, \ldots, Tp$$

$$Minimize: \quad OF = \sum_{i=1}^{N} t_{ii}$$

$Subject\ to:$

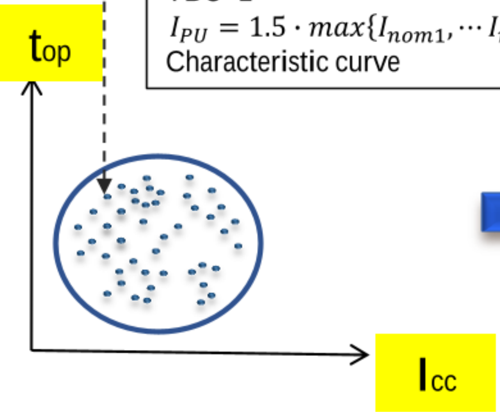
$C1: t_{ij} - t_{ii} \geq CTI;\ \forall (i,j) \in \Omega$

$C2: TDS_{i,min} \leq TDS_i \leq TDS_{i,max};\ i = 1,2,3,4, \cdots N$

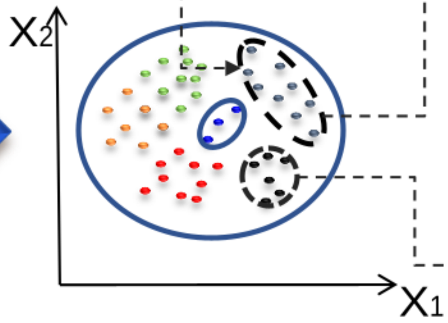
Operative conditions
Short-circuit conditions
TDS=1
$I_{PU} = 1.5 \cdot max\{I_{nom1}, \cdots I_{nom1}\}$
Characteristic curve

Clustering aim
$R_i \rightarrow \{T_k, T_j, T_m\}, \ldots, \{T_p, T_q\}$
t_{op}
$I_{cc,max}$

Protection system optimization
$R_i \rightarrow TDS\{T_k, T_j, T_m\}$
⋮
$R_i \rightarrow TDS\{T_p, T_q\}$



Clustering technique



Setting 1

⋮

Setting k

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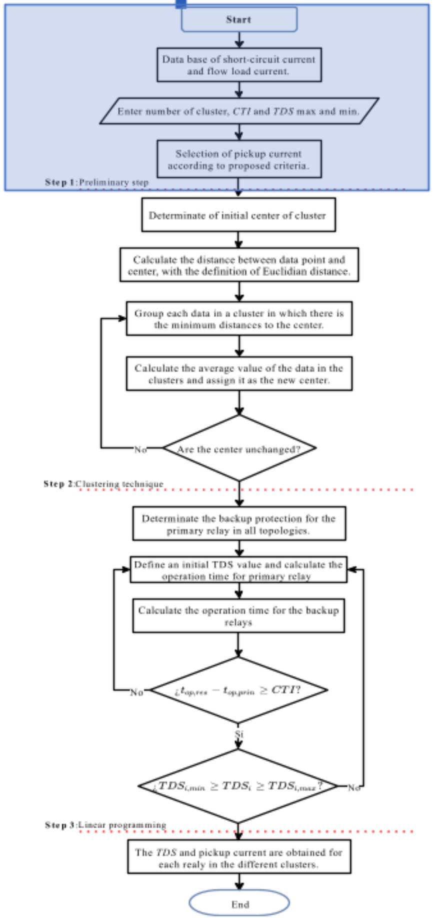
III. Adaptive coordination algorithm

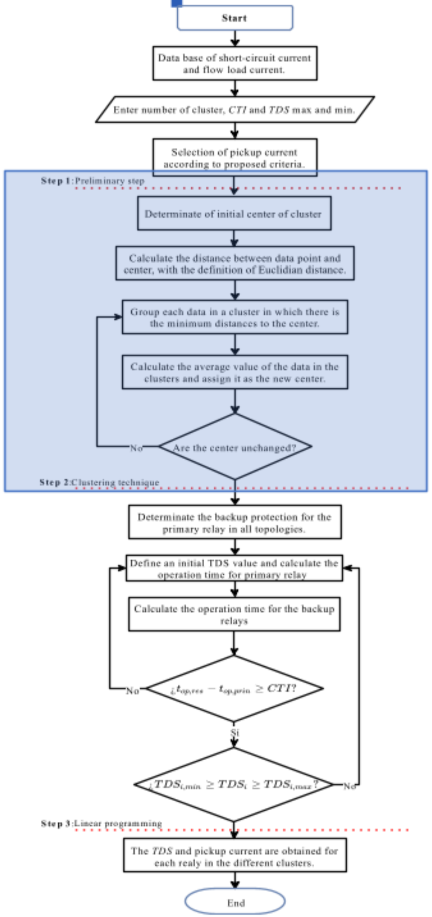


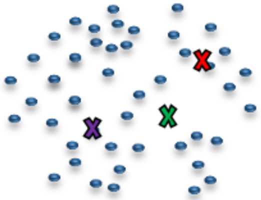
Step 1: Preliminary step

System information: Short-circuit currents, currents under normal operation, topologies.

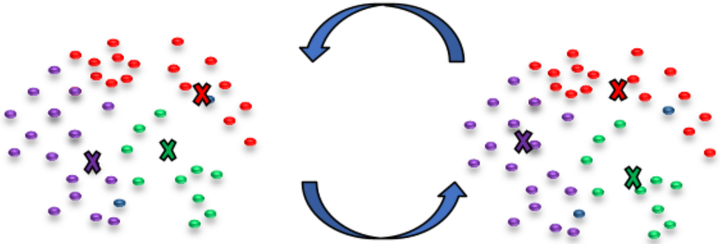
Relay information: Number of multi-setting group, CTI, and maximum and minimum value of TDS.

III. Adaptive coordination algorithm





Select the initial center for each cluster.



$$d_{ij} = \left[\sum_{m=1}^{Tp} \left(x_{im} - c_{jm}\right)^2\right]^{\frac{1}{2}}$$

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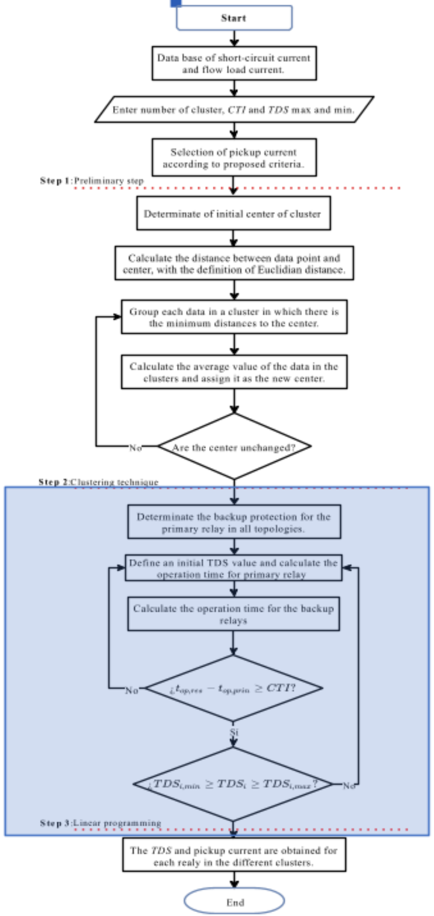
III. Adaptive coordination algorithm



$$Minimize: \quad OF = \sum_{i=1}^{N} t_{ii}$$

Subject to:

$$C1: \ t_{ij} - t_{ii} \geq CTI; \ \forall (i,j) \in \Omega$$

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*linprog

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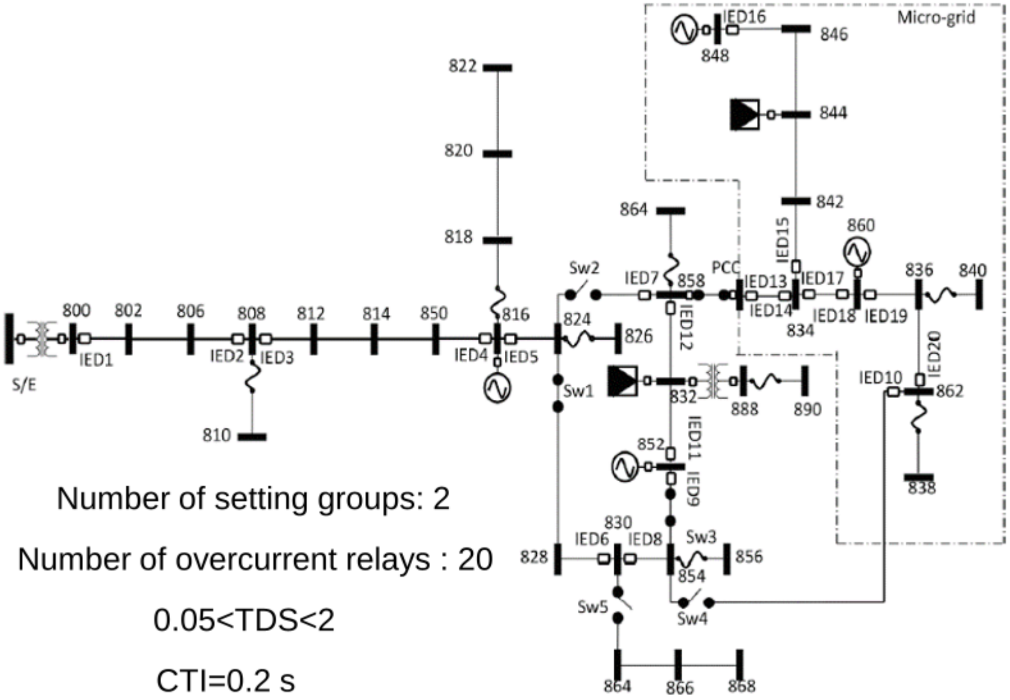
IV. Results and discussion



Number of setting groups: 2

Number of overcurrent relays : 20

0.05<TDS<2

CTI=0.2 s

Curve standard inverse IEC

- ❑ A modified IEEE 34-node test feeder. This feeder is in the state of Arizona (USA) and operates at a voltage of 24.9 kV.

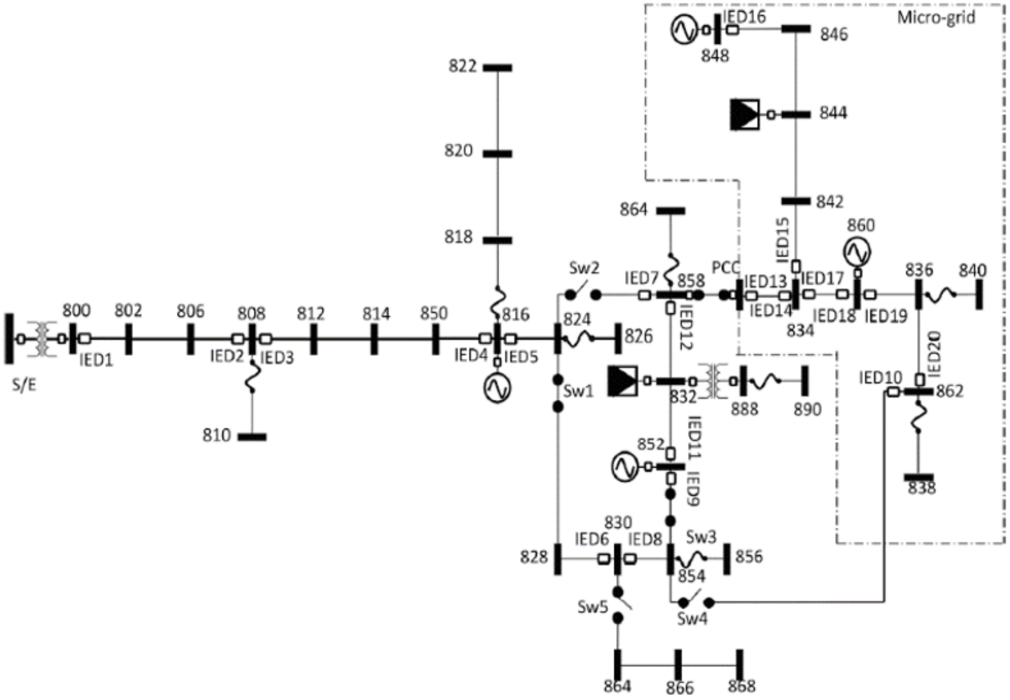
- ❑ Number of DER
  - Inverters non-interfaced DER : 3 (800 kW)
  - Inverter-interfaced DER: 2 (200 kVA)

- ❑ Topologies considered into ADN

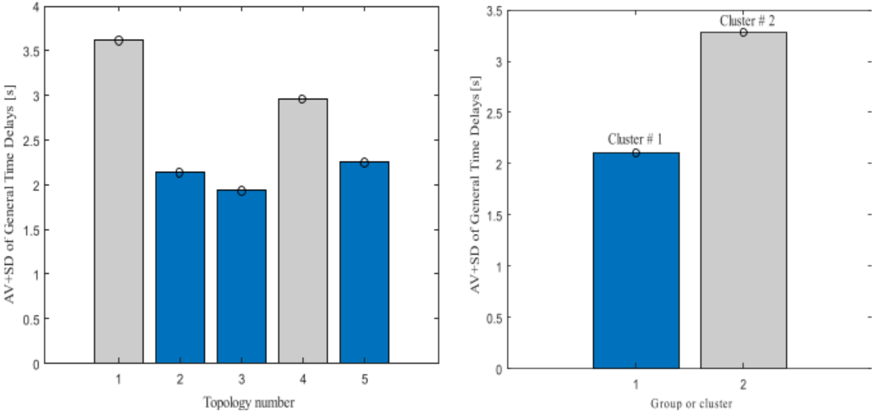
Topology	Switch	
	Close	Open
1	Sw1, Sw3	Sw2, Sw4, Sw5
2	Sw2, Sw3	Sw1, Sw4, Sw5
3	Sw1, Sw4	Sw2, Sw3, Sw5
4	Sw1, Sw3, Sw5	Sw2, Sw4
5	Sw2, Sw4	Sw1, Sw3, Sw5

- ❑ DER and microgrids connected

IV. Results and discussion

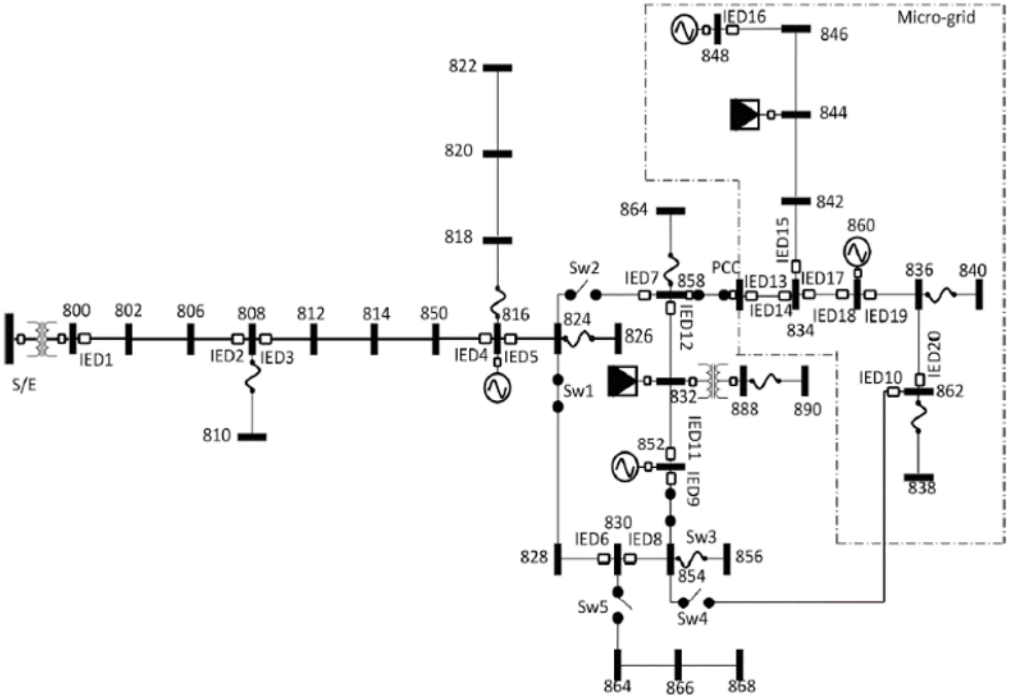


A. Clustering technique for relays operation times



Cluster 1 (center = 2.243 s)	Cluster 2 (center = 3.421 s)
Topology # 2	Topology # 1
Topology # 3	Topology # 4
Topology # 5	

IV. Results and discussion

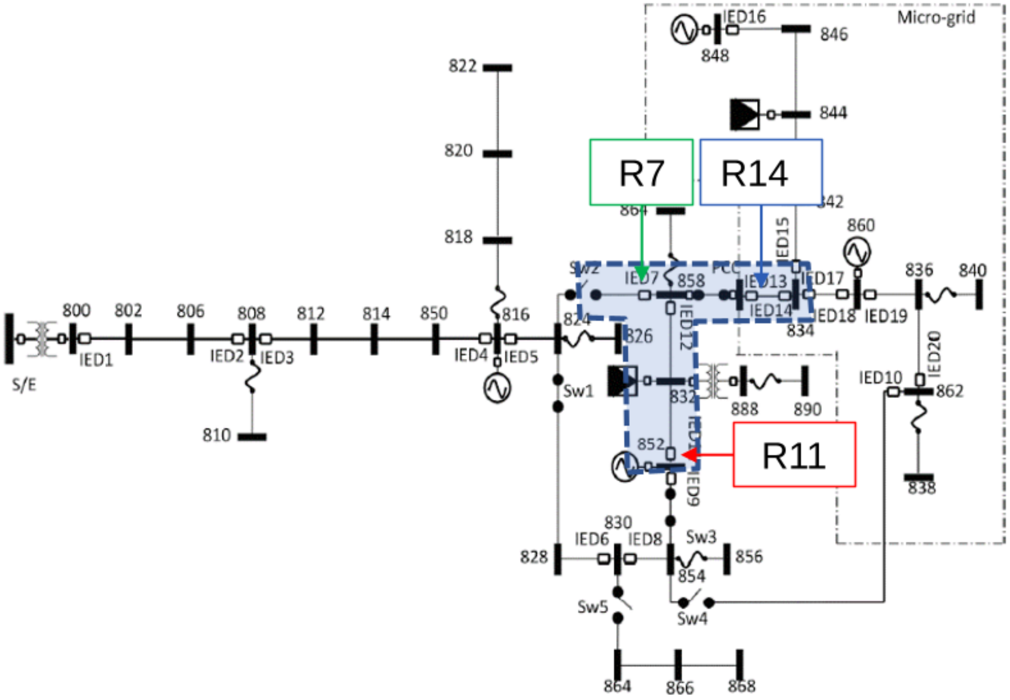


B. TDS by relay for each cluster according to the lineal programming solution.

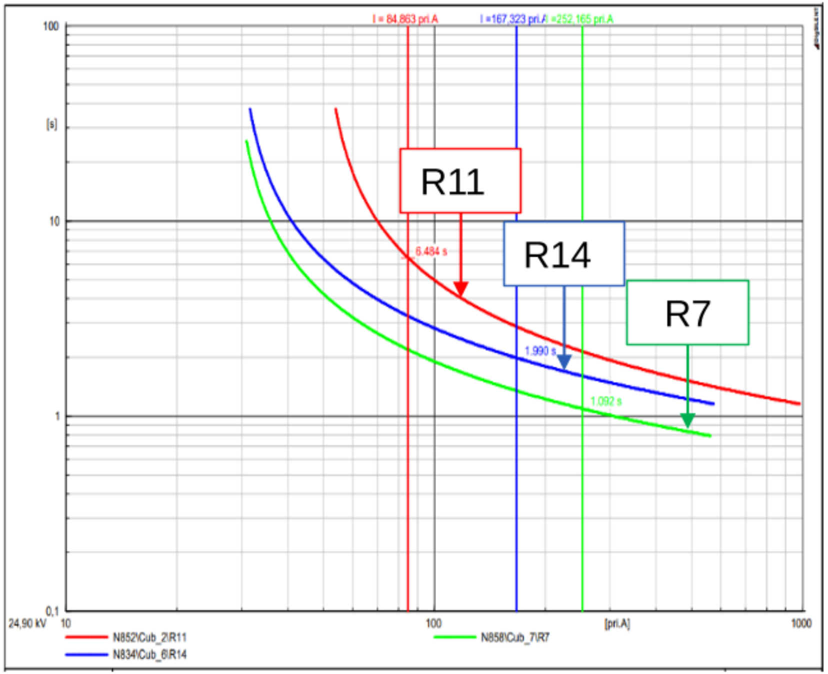
Relay number	Pickup current [A]
1	53.653
2	54.093
3	54.093
4	54.9
5	53.843
6	42.849
7	28.107
6	42.849
7	28.107
8	41.579
9	41.647
10	38.302
11	49.082
12	28.107
13	49.082
15	34.245
16	5.984
17	34.269
18	34.245
19	32.818
20	38.302

Relay number	TDS Cluster 1	TDS Cluster 2
1	0.67	0.97
2	0.05	0.05
3	0.52	0.82
4	0.20	0.20
5	0.38	0.67
6	0.05	0.35
7	0.35	0.05
6	0.05	0.51
7	0.05	0.50
8	0.05	0.05
9	0.51	0.36
10	0.21	0.66
11	0.21	0.21
12	0.51	0.83
13	0.05	0.05
15	0.68	0.99
16	0.09	0.09
17	0.68	0.99
18	0.05	0.05
19	0.05	0.05
20	0.05	0.05

IV. Results and discussion



C. Coordination validation



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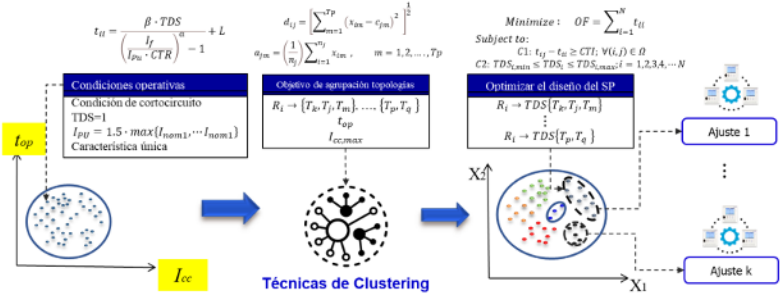
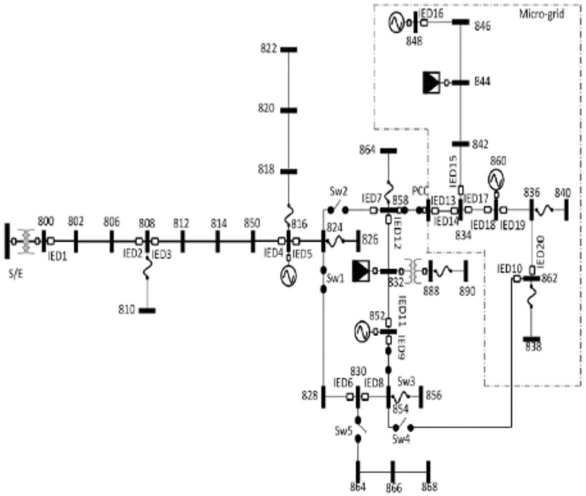
V. Conclusions

- This paper presented an adaptive coordination of overcurrent relays with multiple setting groups considering the topology changes of the ADN.





- The clustering by topologies allows that the implementation of the proposed strategy to be simple and only needs to know the current topology, which the system operates to define its setting group.

- The results obtained show that the strategy guarantees the coordination of the overcurrent devices, and the minimization of the operating time of the group of relays.

$$Minimize: \quad OF = \sum_{i=1}^{N} t_{ii}$$

Subject to:

$$C1: t_{ij} - t_{ii} \geq CTI; \ \forall (i,j) \in \Omega$$

$$C2: TDS_{i,min} \leq TDS_i \leq TDS_{i,max}; \ i = 1,2,3,4, \cdots N$$

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Thank you

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