# Distributed Coordination Simulations Results: Distribution System Growth

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## I. Study Case and Results

The defined study case is modified connecting a new DER as shown in Fig. 1. Defining the same four balanced three phase fault scenarios, the performance of the proposed protection algorithm is assessed.

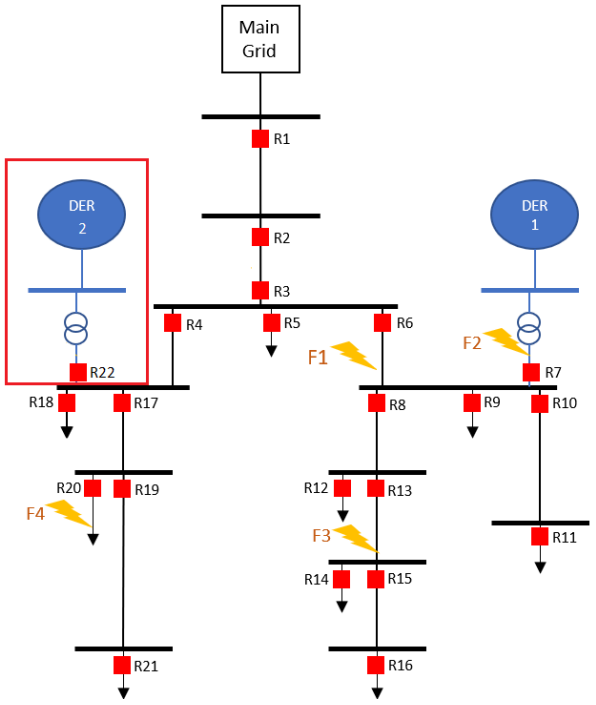


Fig. 1. Modified European MV CIGRE network with the defined fault locations under study.

With the newly connected protection equipment, the constants related to the voltage-restricted overcurrent curves of the existing equipment remain equal. For the new protection equipment, *R22*, the constants defined for *R7*, are used. In Table I all the parameters related to the operating time curves are summarized.

The calculated operating times are presented in Table II.

With the connection of a new fault source in a distribution system, due to the appearance of a new protection path in all the fault scenarios, the complexity of the coordination problem statement increase. However, as shown in Table II, the proposed protection algorithm, without impacting the global selectivity of the protection system, can afford the system growth with changes only in the distributed optimization problem of the local new protection equipment neighborhood.

TABLE I
Voltage-restricted overcurrent shape constants.

| Protection Equipment | R1, R2, R3 R4, R17 | R6, R7, R22 | R8, R13, R20 |
|---|---|---|---|
| k1 | 2 | 2 | 2 |
| k2 | 1 | 1 | 1 |
| k3 | 5 | 1 | 10 |
| k4 | 0.01 | 0.05 | 0.05 |

TABLE II
Calculated operating times for the defined study case.

| Fault Scenario | Primary operating time (ms) | Backup operating time (ms) | | | | |
|---|---|---|---|---|---|---|
| F1 | $t_{R7}$ 40 | | | | | |
| | $t_{R6}$ 40 | $t_{R3}$ 104 | $t_{R2}$ 204 | $t_{R1}$ 307 | | |
| | | $t_{R4}$ 104 | $t_{R22}$ 263 | | | |
| F2 | $t_{R7}$ 40 | $t_{R6}$ 112 | $t_{R3}$ 215 | $t_{R2}$ 316 | $t_{R1}$ 415 | |
| | | | $t_{R4}$ 204 | $t_{R22}$ 362 | | |
| F3 | $t_{R13}$ 40 | $t_{R8}$ 105 | $t_{R7}$ 306 | | | |
| | | | $t_{R6}$ 207 | $t_{R3}$ 311 | $t_{R2}$ 414 | $t_{R1}$ 510 |
| | | | | $t_{R4}$ 302 | $t_{R22}$ 400 | |
| F4 | $t_{R20}$ 40 | $t_{R17}$ 108 | $t_{R4}$ 210 | $t_{R6}$ 309 | $t_{R7}$ 409 | |
| | | | | $t_{R3}$ 310 | $t_{R2}$ 413 | $t_{R1}$ 508 |
| | | | $t_{R22}$ 210 | | | |