

Smart Transformer Optimization and Envelopes of Self-repairability

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SUPPLEMENTARY INFORMATION

Figure 1 illustrates the random search of the optimization space to select values for the penalty parameter λ . Penalty parameters are tested in the range $[0, 20]$ in increments of 0.1.

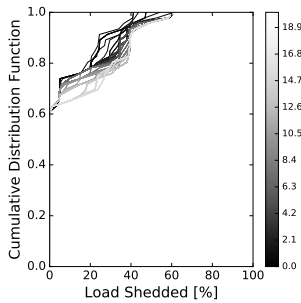


Fig. 1. Load shedding for HEALER 2 and STRATEGY 2 in case-39. A random search of the optimization space is performed in the range $[0, 20]$ in increments of 0.1 to select penalty parameters that result in low load-shedding.

Table I, II and III illustrates how the envelopes of self-repairability are computed for load shedded, lines trimmed and lines utilization. For each smart transformer placement, the values of the load shedded and lines trimmed are computed for each line removal of the N-1 attack model that form one cumulative distribution function. The aggregate result of these cumulative distribution functions for all smart transformer positioning form the envelope of self-repairability (dark grey area).

TABLE I

CALCULATION OF SELF-REPAIRABILITY ENVELOPES FOR LOAD SHEDDED (%).

Line Removal	1	2	...	46	
BASE CASE	0	0	...	41.2	CDF BASE CASE
Placement 1	0	0	...	40.1	CDF Placement 1
...
Placement 10	0	0	...	41.2	CDF Placement 10
Placement Average	0	0	...	32.5	CDF STRATEGY 1

The BASE CASE and the average performance of each strategy require the calculation of a single cumulative distribution function.

In the case of lines utilization, the lines trimmed in each iteration of the cascading failure are additionally counted. For simplicity, a single cumulative distribution function is shown in this table.

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TABLE II

CALCULATION OF SELF-REPAIRABILITY ENVELOPES FOR LINES TRIMMED (%).

Line	1	2	...	46	
BASE CASE	30.4	21.7	...	0	CDF BASE CASE
Placement 1	30.4	21.7	...	0	CDF Placement 1
...
Placement 10	30.4	21.7	...	0	CDF Placement 10
Placement Average	30	18.7	...	0	CDF STRATEGY 1

TABLE III

CALCULATION OF SELF-REPAIRABILITY ENVELOPES FOR LINES UTILIZATION (%).

Line Removal	1	...	46			
Line	Iteration 1	...	Iteration 1	...	Iteration 4	
1	26.6	...	67.4	
2	9.7	...	6.2	...	34.6	
...	
46	68.7	
Average	40	...	42.9	...	39.4	CDF BASE CASE