Distribution Congestion Management by Using CVSR Devices: Optimization and Clustering

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INTRODUCTION:

- A continuously variable series reactor (CVSR) is series of line reactor for power-flow control in meshed power grids.
- High load density networks (i.e., spot networks, secondary networks) should be highly reliable to sustain the system following a contingency.
- Grid network transformers play an important role for these spot networks.
- Relief overload power on supply transformers can be accomplished via CVSRs.

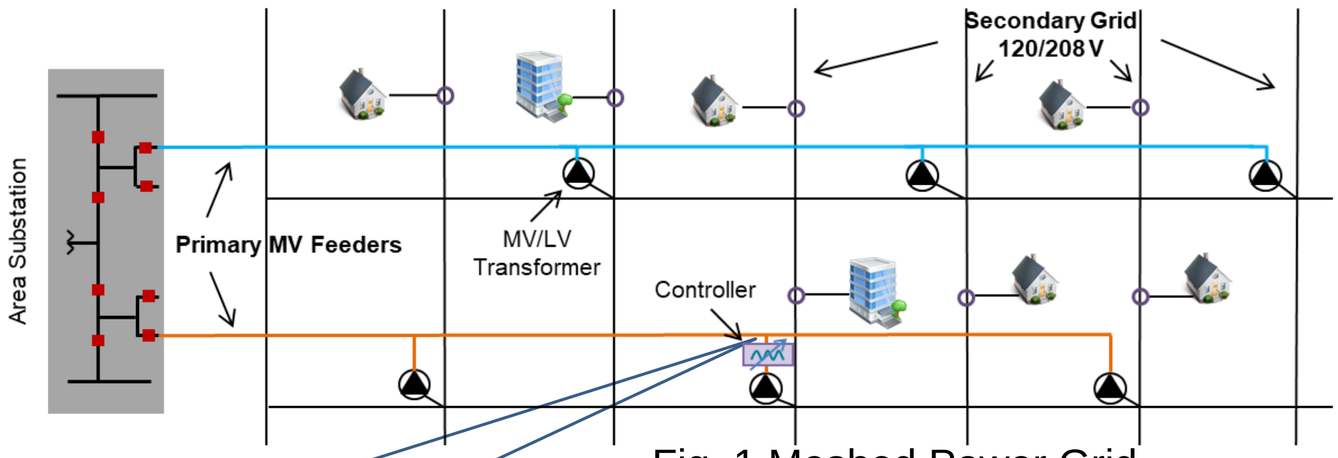
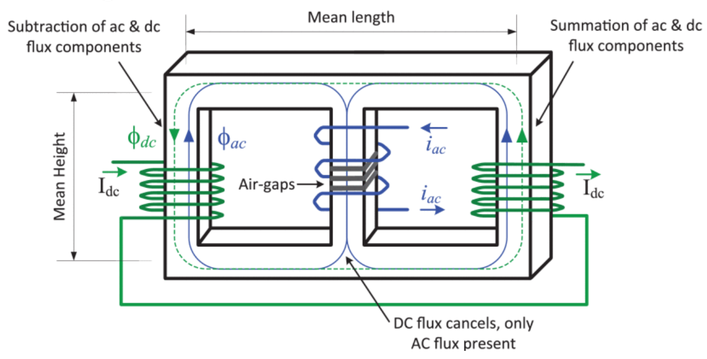


Fig. 1 Meshed Power Grid

Fig. 2 CVSR Device



PIECEWISE OPTIMIZATION AND CLUSTERING APPROACH

- Calculations by linear optimization may give large errors since assumption is made on the sensitivity curves.
- Therefore, piecewise linearization can be a solution for more accurate transformer sensitivities.
- System can be divided into clusters as seen in the figure.
- Increasing the electrtical distance, transformers with CVSR do not affect the other transformer loading significantly.
- Results from Table I are very close to the benchmark results.

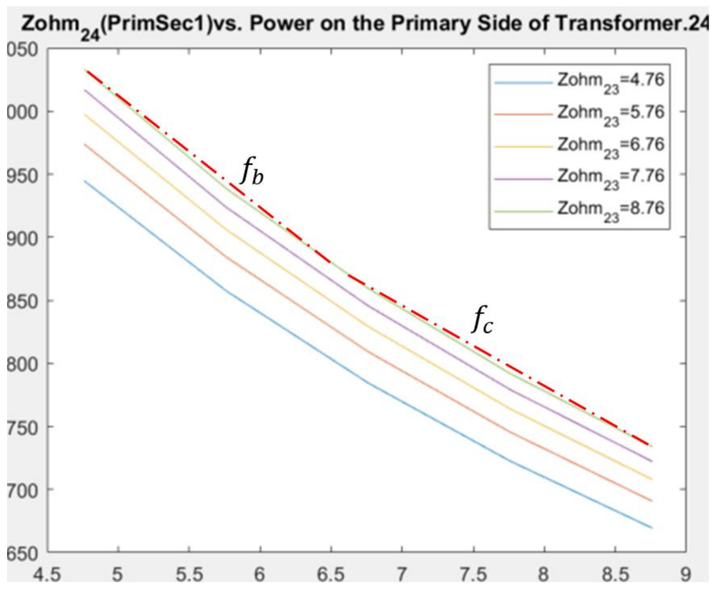


Fig. 3: Linear Optimization Converted to Piecewise Optimization

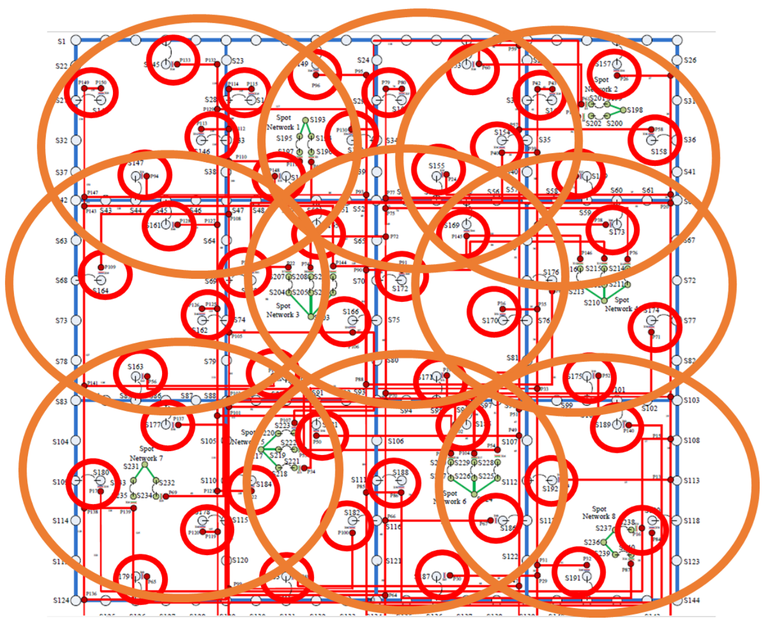


Fig. 4: Cluster method to obtain all transformer sensitivities

Xhl23 (ohm)	Xhl24 (ohm)	P23 by OpenDSS	P23 by Sensitivities	P24 by OpenDSS	P24 by Sensitivities	Transformer Limits
4.76	4.76	1133.96 kVA	1133.96 kVA	944.72 kVA	944.72 kVA	No Limit
4.76+1.283	4.76+0	999.11	1000	981.11	980.757	1000
4.76+1.997	4.76+0.529	947.48	950	947.07	950	950
4.76+2.88	4.76+1.364	892.84	900	891.88	900	900

Table I: 4-Segment Piecewise Optimization Results for IEEE 342 Test System

CONCLUSION

- Transformer sensitivity analysis helped us to determine the device specifications.
- Piecewise optimization results are close to the benchmark results.
- Optimization results shows the effect of CVSR devices.
- Clustering approach reduces the computational time.

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