

Harmonic Analysis of Electric Vehicle Charging on the Distribution System Network with Distributed Solar Generation

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Analysis of the impact of multiple connections of PV inverters and EV chargers on voltage harmonic distortion

Methodology

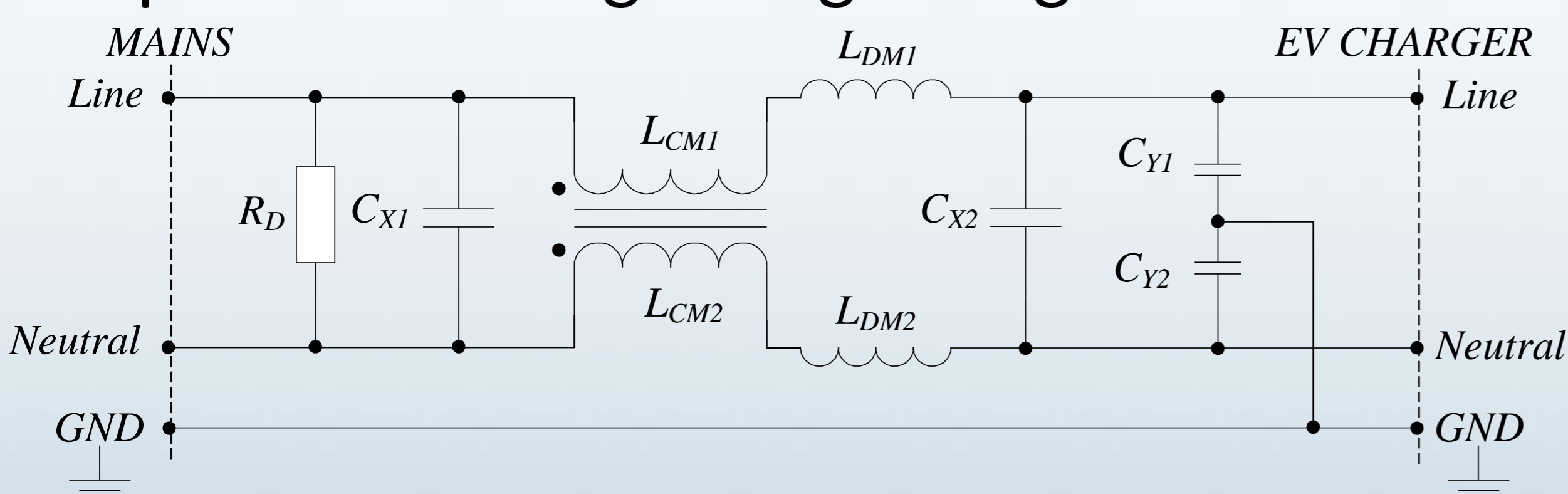
Monte Carlo simulation considering the impact of the current harmonic emissions (i.e., real measurements) and changes in the network impedance from customers with PV and EV to estimate the resulting voltage distortion at different locations of an LV-network.

Some assumptions

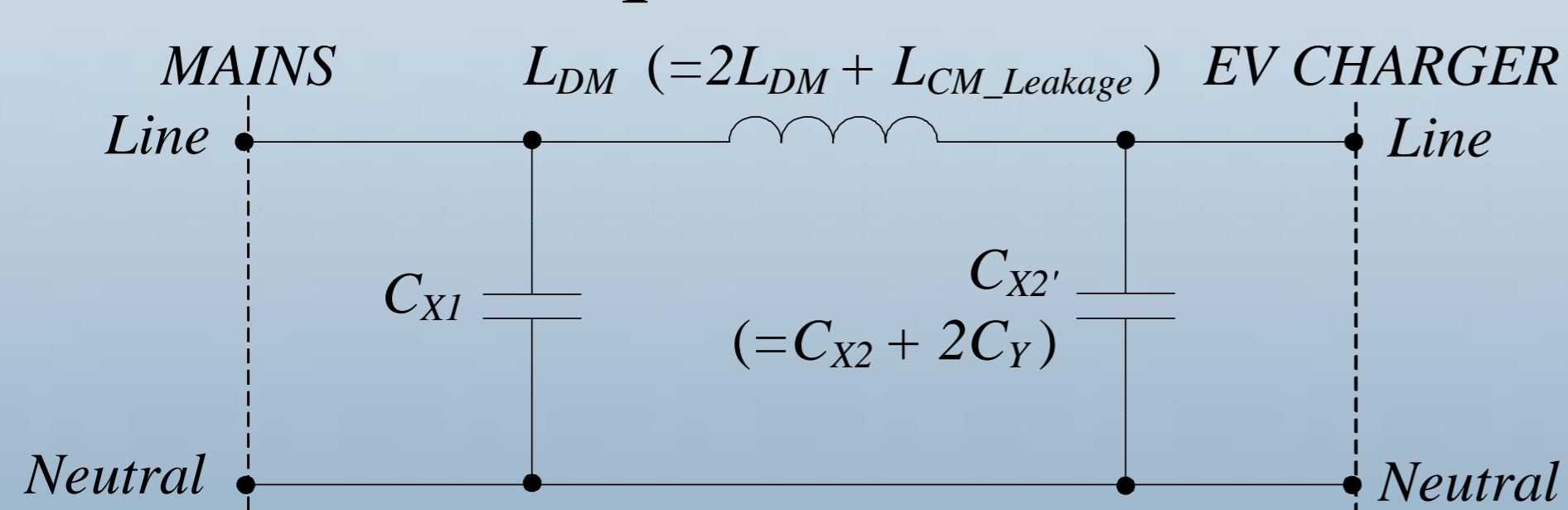
- Single-phase PV connections up to 4.6 kW
- EV-Chargers in Mode 1 and 2 (IEC 61851-1)
- Considers customer load variation (acc. [3])
- Harmonic aggregation acc. IEC 61000-3-6
- PV capacitance: [0.5 2.5 5.0 7.5 10] μF

EV Charger Input Impedance

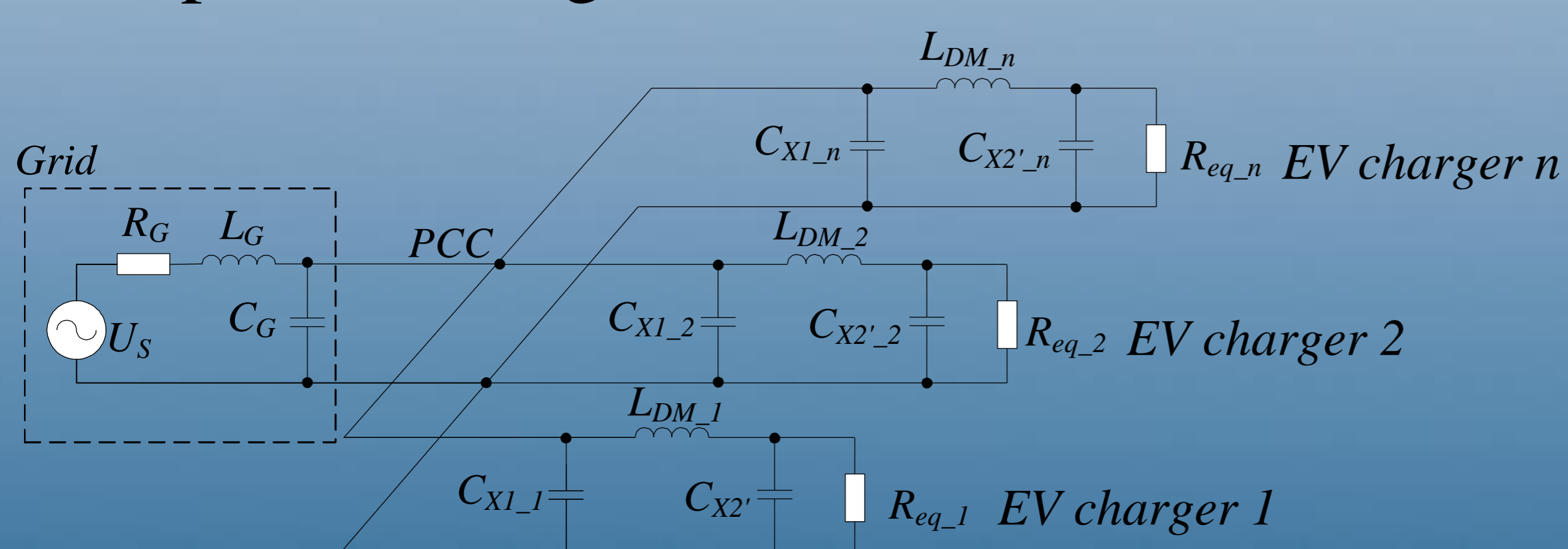
Simplified EV charger single-stage EMI filter



Differential mode equivalent circuit



Multiple EV chargers connected to a PCC



Low-voltage network

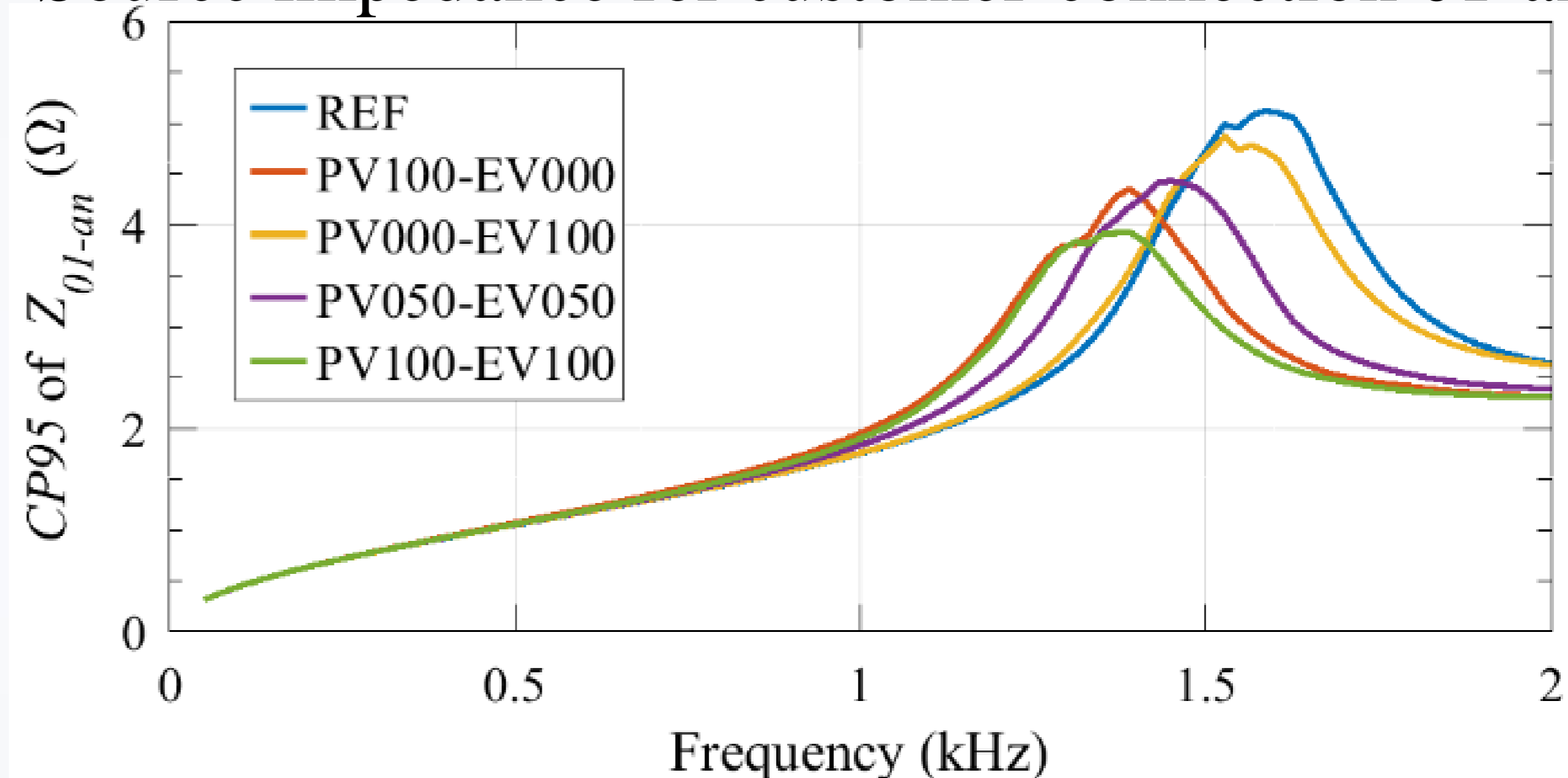
Suburban grid with 28 customers connected to a 500-kVA transformer, 10/0.4 kV, Dyn11, 4.9%.

Results

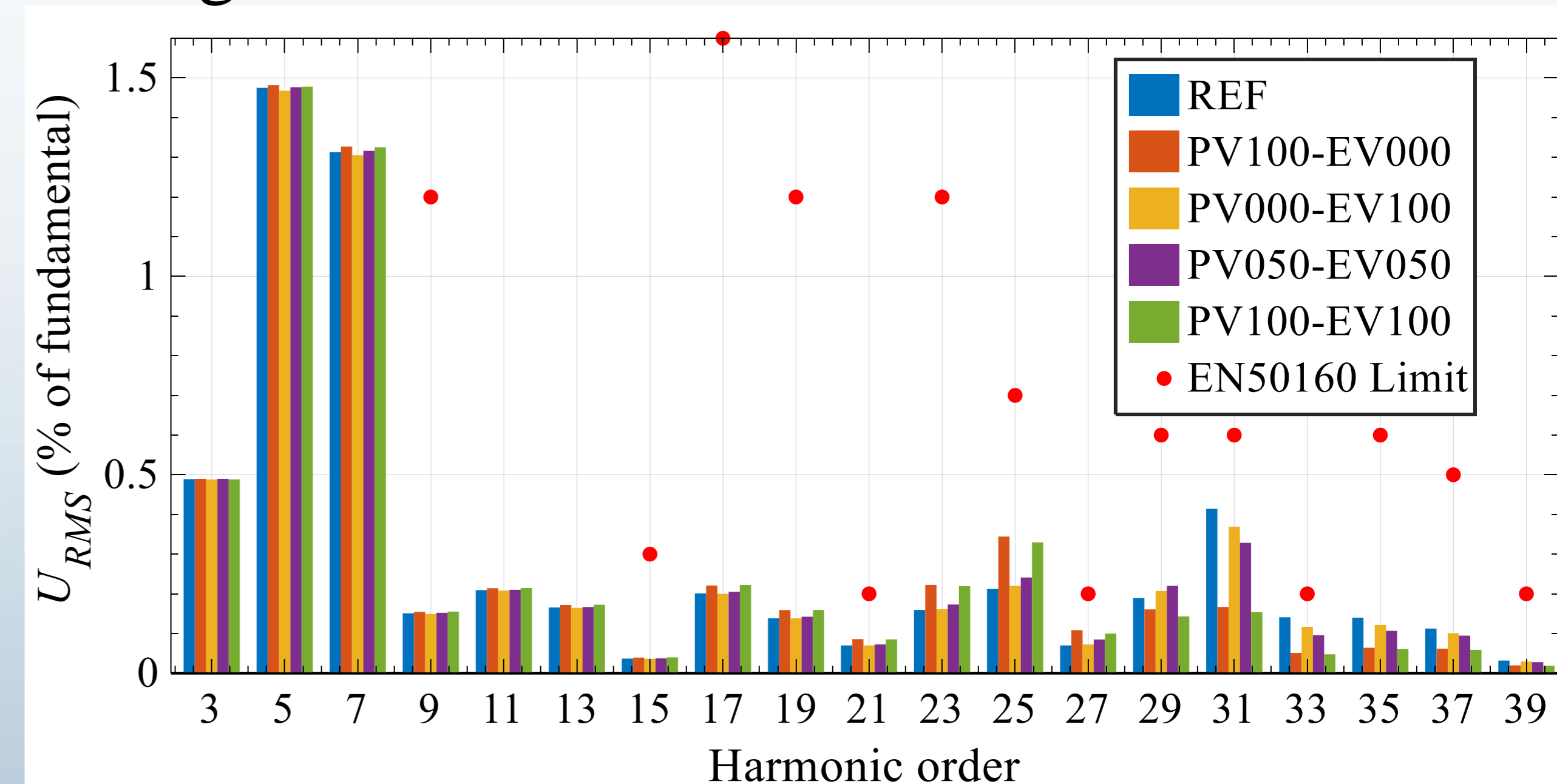
EV and PV penetration scenarios:

Scenario	PV penetration	EV penetration
REF	0.0 %	0.0 %
PV100-EV000	100.0 %	0.0 %
PV000-EV100	0.0 %	100.0 %
PV050-EV050	50.0 %	50.0 %
EV100-PV100	100.0 %	100.0 %

Source impedance for customer-connection 01-an



Voltage harmonic for customer-connection 01-an



Conclusions

- Impact of the penetration of PV's and EV's is higher on harmonic resonance
- Some harmonics may increase by about 76 % with penetration of EV's and PV's
- Resulting harmonic levels are well below the standard limits for the considered study case
- THD is not significantly impacted by the change in the harmonic resonances