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Secondary Circuit Model Generation Using Limited PV Measurements and Parameter Estimation

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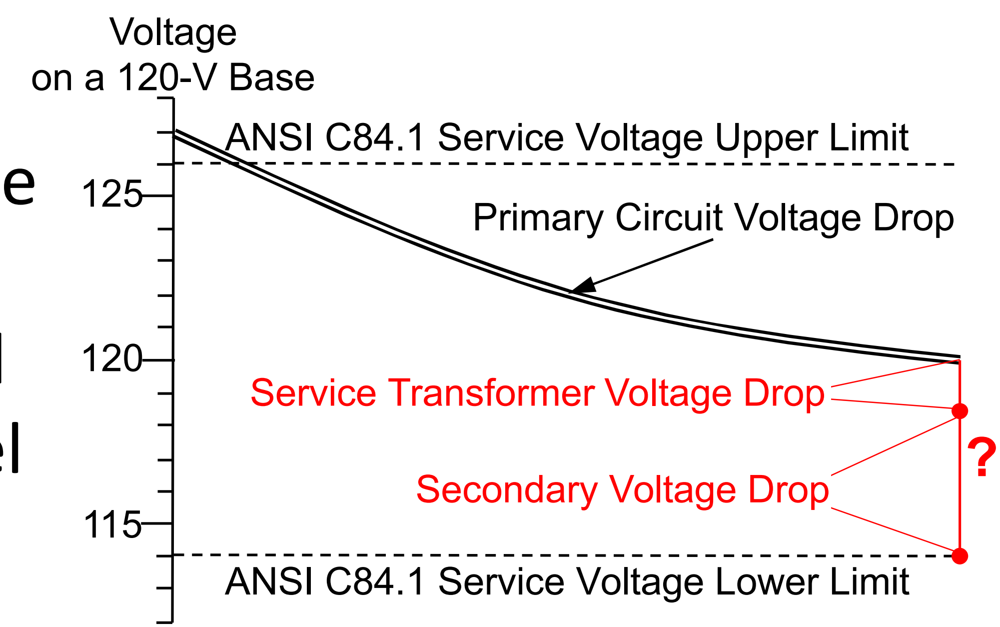
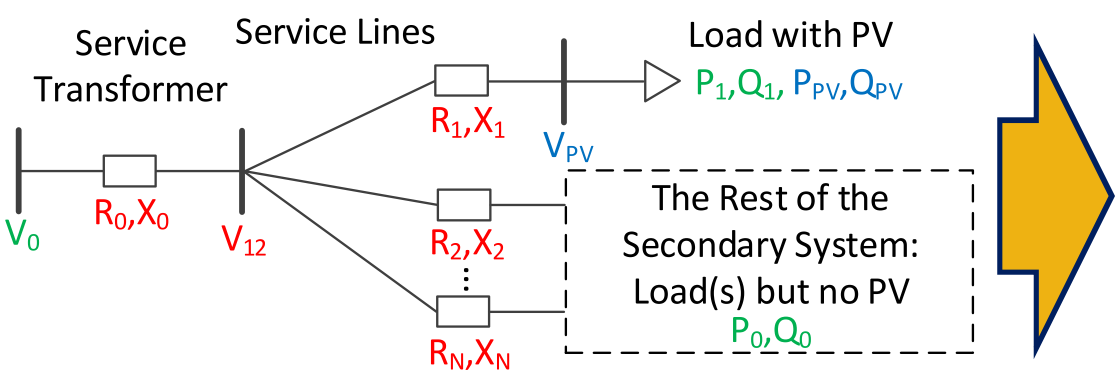
Need for Secondary Modeling

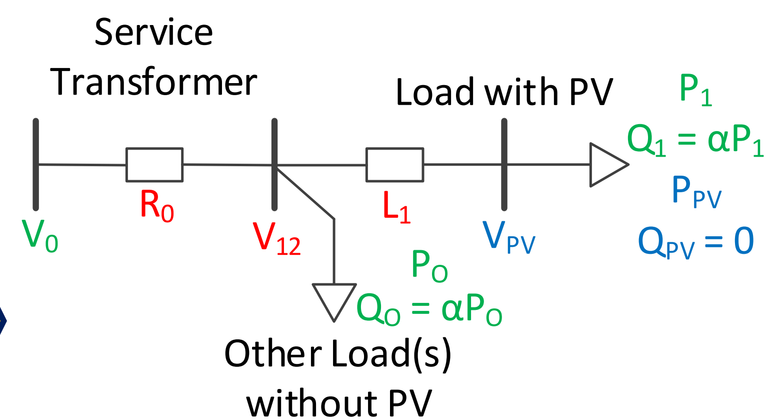
- Operating distribution systems with a growing number of distributed energy resources (DERs) requires accurate feeder models down to the point of interconnection
- Many DERs are located in the secondary low-voltage distribution circuits that typically are not modeled or modeled with low level of detail



Simplified Secondary Circuit Model Generation

- **Objective:** Improve the voltage simulation accuracy at metered points in the secondary circuits
- **Limitation:** All loads are not metered and some older meters may not transmit voltage measurements
- **Remedy:** Create simplified secondary circuit models and estimate their parameters





Linear Regression Model:

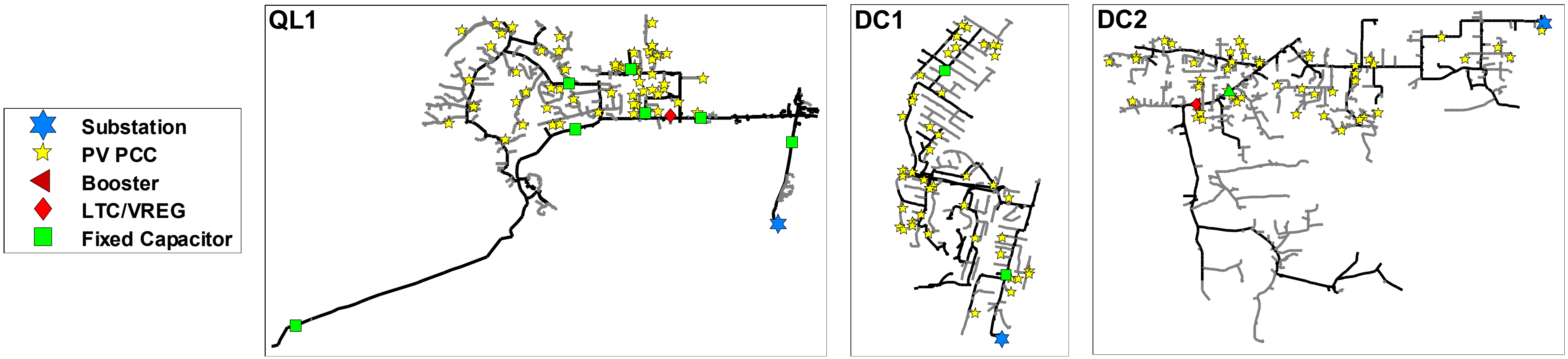
$$\boldsymbol{V}_0 - \boldsymbol{V}_{PV} = R_0 \boldsymbol{I}_0 + L_1 \boldsymbol{I}_1 + \boldsymbol{\epsilon}$$

Analyzed Utility Feeder Models

Suburban Feeder
~3500 customers
44 PV Systems*

Urban Feeder
~3700 customers
36 PV Systems *

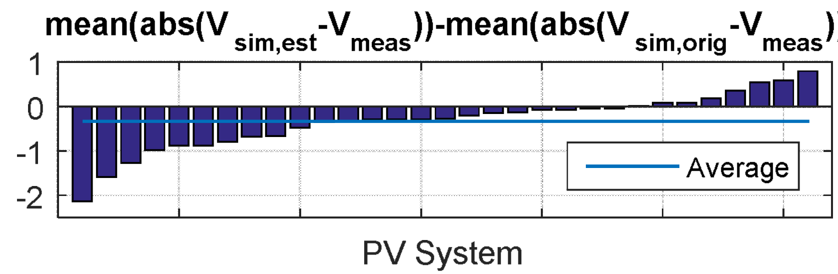
Rural Feeder
~1200 customers
31 PV Systems *



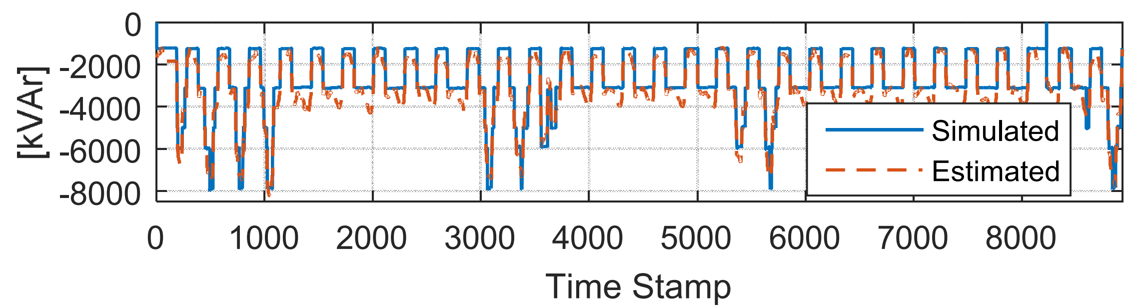
Feeder	QL1	DC1	DC2
# Capacitors – Control Mode	1-fixed, 6-temperature	2-fixed	1-voltage
# Voltage Regulators	1	0	1
Available Reliable SCADA measurements	MW, MVAr, phase currents	MW	MW

Uncertainty of Primary Circuit Models

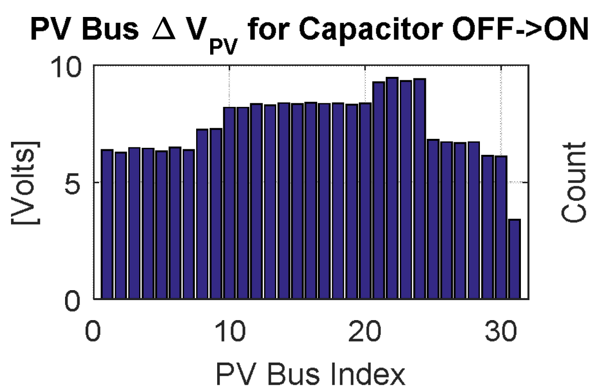
- LTC set points uncertain

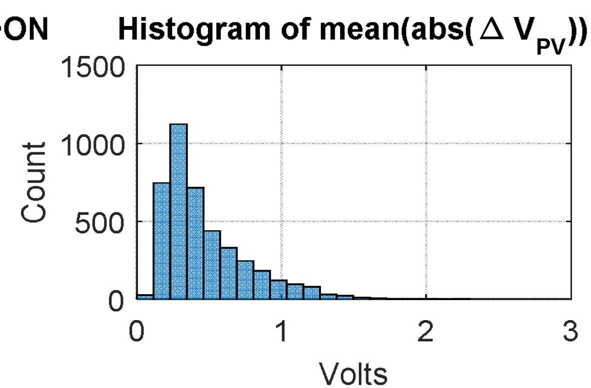


- Feeder QL1 had 6 temp.-controlled capacitors with unknown states



- Feeder DC2 had a voltage controlled capacitor with unknown states





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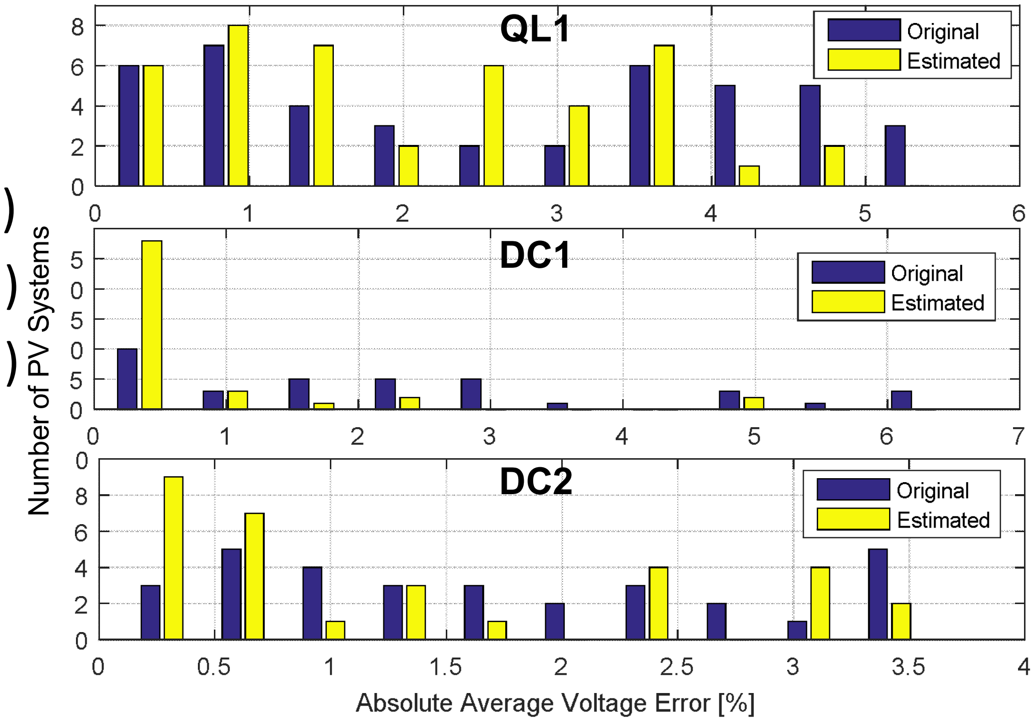
Results

- Average error reductions in simulated PV voltages:
  - QL1: 0.57 Volts (19.3% reduction)
  - DC1: 1.64 Volts (71.5% reduction)
  - DC2: 0.40 Volts (22.5% reduction)
- Two main challenges
  - Load allocation
  - Primary circuit modeling



- Using estimated parameters changes PV hosting capacity significantly (±90%)