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PV-INDUCED LOW VOLTAGE AND MITIGATION OPTIONS

Jimmy E. Quiroz, Matthew J. Reno, and Robert J. Broderick
Sandia National Laboratories, Albuquerque, NM, USA

Abstract - With increasingly high penetrations of PV on distribution systems, there can be many benefits and impacts to the standard operation of the grid. This poster focuses on simulation of voltages below the allowable range caused by the installation of PV on distribution systems with line-drop compensation enabled in the voltage regulation controls. The examples demonstrate how this type of under-voltage issue has the potential to limit the hosting capacity of PV on a feeder and impact other feeders served off a common regulated bus. Examples of mitigation strategies are shown, including the use of advanced inverter functionality to mitigate over-voltages, while also illustrating the ineffectiveness of inverter voltage control as a mitigation of under-voltages.

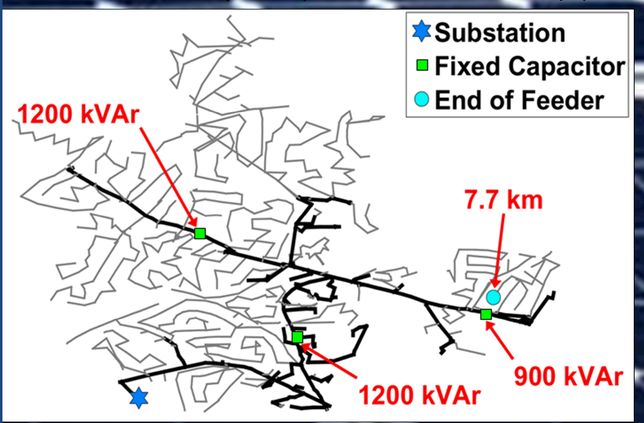
Ckt24 Example – Volt/VAr Snap-Shot Hosting Capacity Analysis

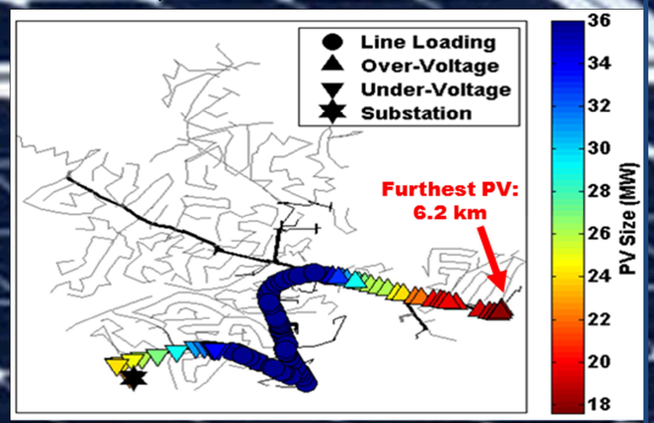
CIRCUIT

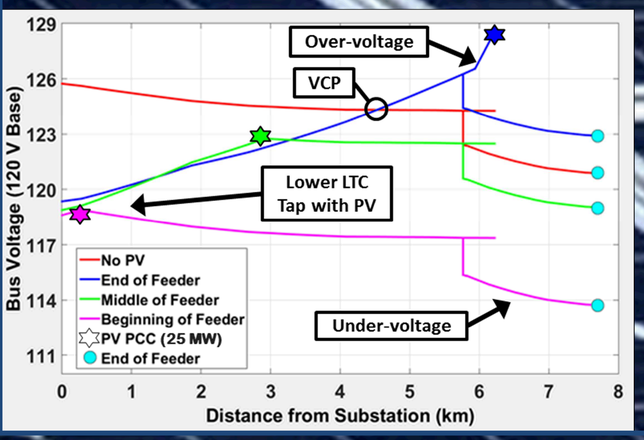
- EPRI model included in download of OpenDSS
- 34.5 kV feeder with a 28 MW peak load
- Several 13.2 kV step-down transformers
- Longest primary path – 7.7 km
- No VREGs, 3 fixed capacitors total 3.3 MVAr
- LTC settings:
  - Voltage setpoint: 123 V
  - 3 V bandwidth, 45 second delay
  - Line-drop compensation: R=7, X=0 (V)

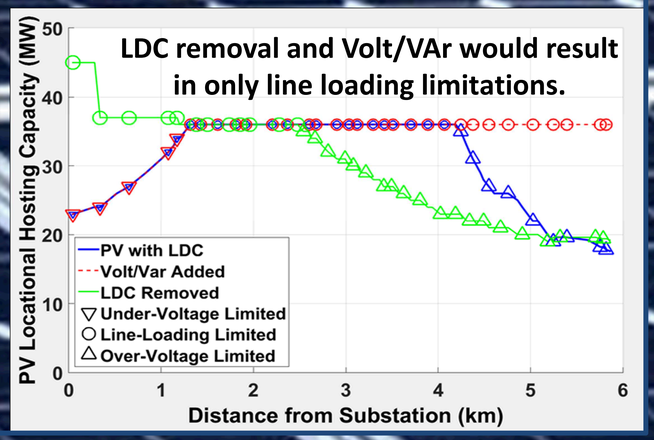
ANALYSIS

- SNL snap-shot hosting capacity analysis tool based in OpenDSS
  - Range of PV deployments varying in size and location
  - Range of load levels, capacitor states, and voltage regulation tap positions
- Only 3-phase deployments along backbone shown below (94 locations) simulated
- Several impacts monitored to determine limits









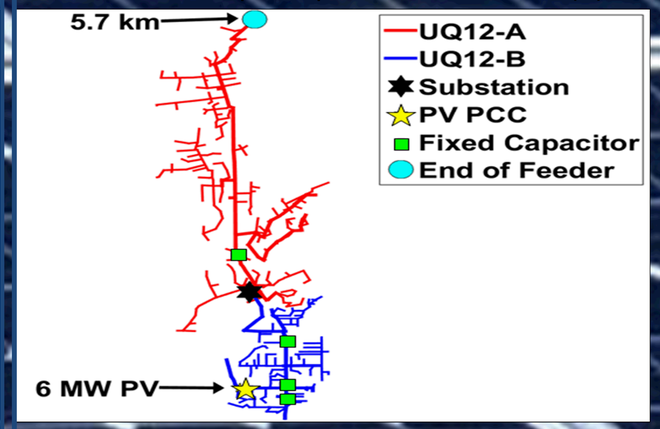
UQ12 Example – Other Feeders Served GridPV Toolbox QSTS Analysis

CIRCUIT

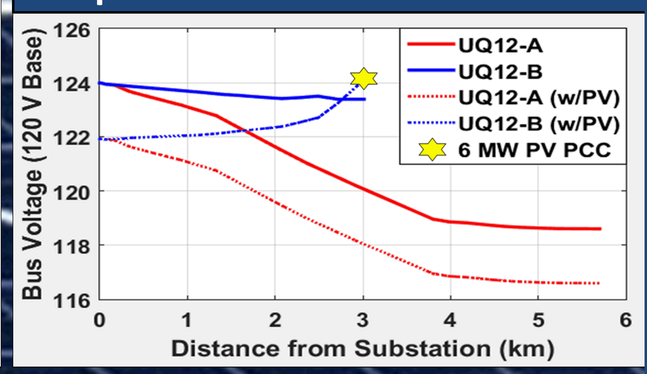
- SNL model from feeder in Utah
- 12.47 kV circuit with a 6.2 MW peak load
- Longest primary path – 5.7 km
- No VREGs, 4 fixed capacitors total 1.8 MVAr
- Equivalent to two feeders off same LTC
- LTC settings:
  - Voltage setpoint: 121 V
  - 2 V bandwidth, 60 second delay
  - Line-drop compensation: R=5, X=3 (V)

ANALYSIS

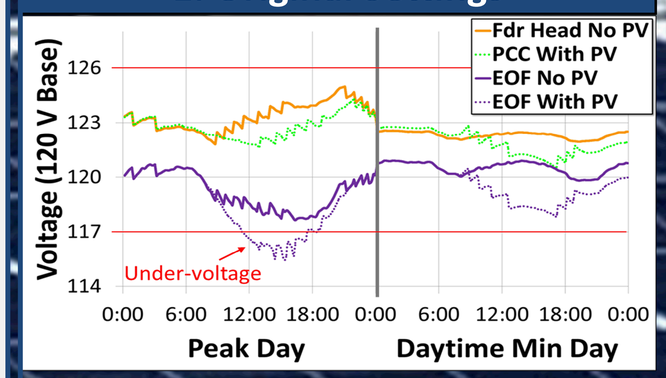
- SNL GridPV QSTS analysis tool based in OpenDSS
  - Peak and daytime minimum load days simulated at one-second resolution
  - Time-series plots consist of 10-minute rolling averages of results for ANSI C84.1
- Clear-day 6 MW PV simulated at end of UQ12-B
- Only focused on voltage impacts
- QSTS ANSI C84.1 Range A limits shown from 117 V to 126 V apply to 12.47 kV service voltage.



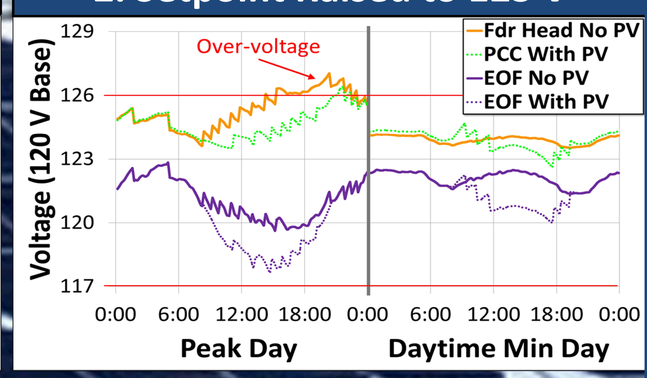
Snap-Shot Simulation – Peak Load



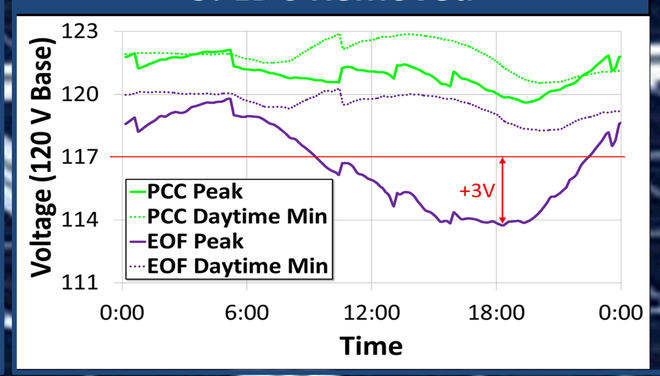
1. Original Settings



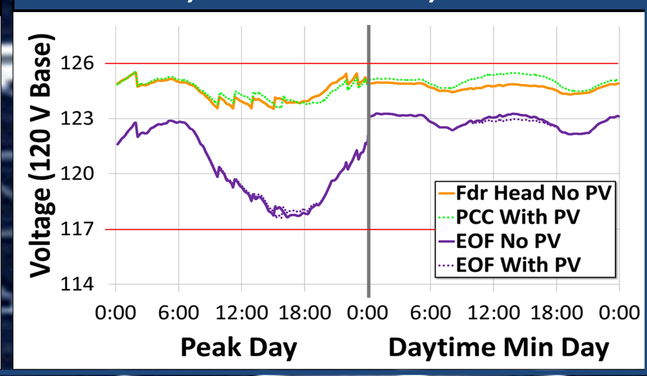
2. Setpoint Raised to 123 V



3. LDC Removed



4. No LDC, LTC at 124.5 V, PV PF -0.99



Conclusions

- PV-induced under-voltage depends on interconnection location and magnitude.
- LDC elimination can be a viable mitigation strategy for under-voltages, but may require LTC setpoint raise and PV voltage rise reduction strategy.
- Advanced inverter voltage regulation functions cannot mitigate PV-induced under-voltages, since they do not occur at the PCC.
- Mitigation strategies must be derived and verified using sufficient simulation platforms and validated at load extremes, both with and without PV, before ensuring feasibility.

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