Cybersecurity Assessment in DER-rich Distribution Operations: Criticality Levels and Impact Analysis

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Introduction

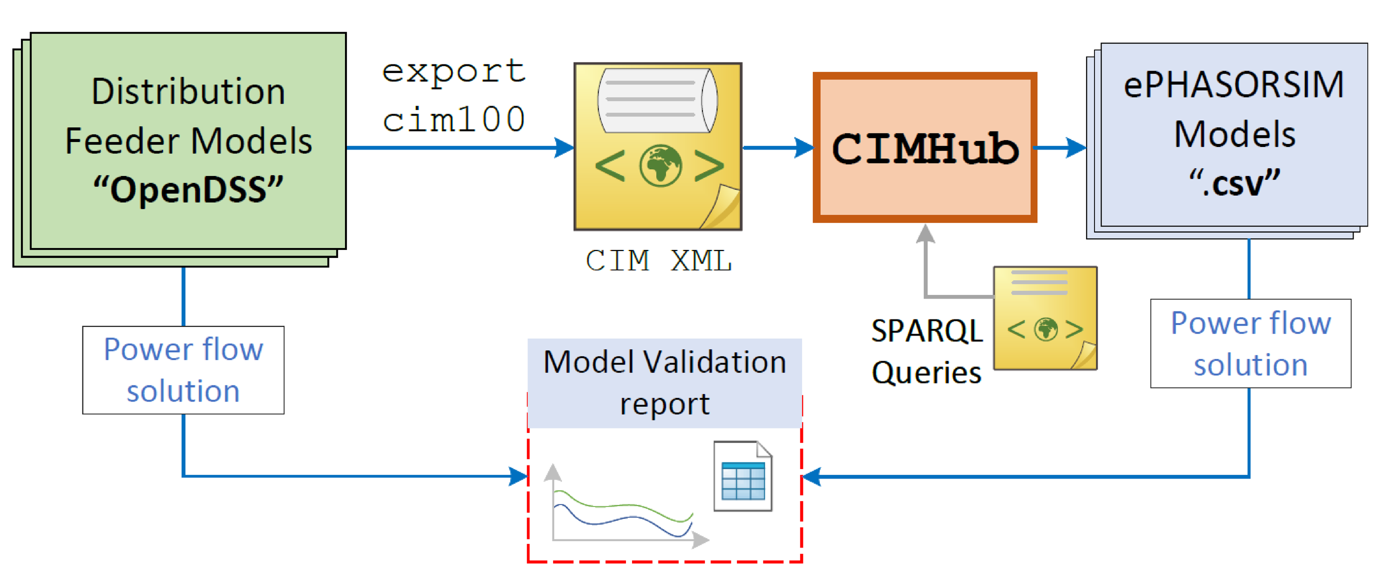
- Background
  - High penetration of distributed energy resources (DERs), increasingly to be in remote locations
    - ✓ Concerns safety and security of the electric grid
    - ✓ Security for next generation DERs connected to the distribution interconnection is crucial
  - Identification of vulnerabilities and evaluation of potential risks and impacts of cyber-attacks guide regulatory standards and guidelines for cybersecurity practices
  - Cyber-security-based model frameworks and scenarios necessary for risk and impact assessment [1]
  - **Standard, publicly available cyber-physical test systems (CPYDAR) in variety of sizes and configurations help researchers develop new algorithms or test procedures to benchmark their results**
- Objective
  - Translate publicly available distribution system models, covering a range of sizes from 13 to 9500 nodes, to enable the development, replication and benchmarking of cybersecurity test procedures and results
  - Construct DER attack scenarios to test one of the converted models, IEEE 123 bus feeder with integrated DERs
- Resource Criticality Levels for DERs
  - Determined R1 Resource Criticality Level for DER, from EPRI Security Architecture [2]
  - **Higher criticality DER units may require more robust cybersecurity measures and closer monitoring to mitigate potential risks effectively**

1. N. Duan, N. Yee, B. Salazar, J.-Y. Joo, E. Stewart, and E. Cortez, "Cybersecurity analysis of distribution grid operation with distributed energy resources via co-simulation," in 2020 IEEE Power & Energy Society General Meeting (PESGM). IEEE, 2020, pp. 1–5.
2. EPRI Security Architecture for the Distributed Energy Resources Integration Network: Risk-Based Approach for Network Design, [Online]. Available: https://www.epri.com/research/products/000000003002016781

Test Feeders

- **Three publicly available cyber-physical test systems[3]**
  - IEEE 13 node, IEEE 123 node, EPRI DPV J1
  - Model files available for hardware-in-loop (HIL) simulation

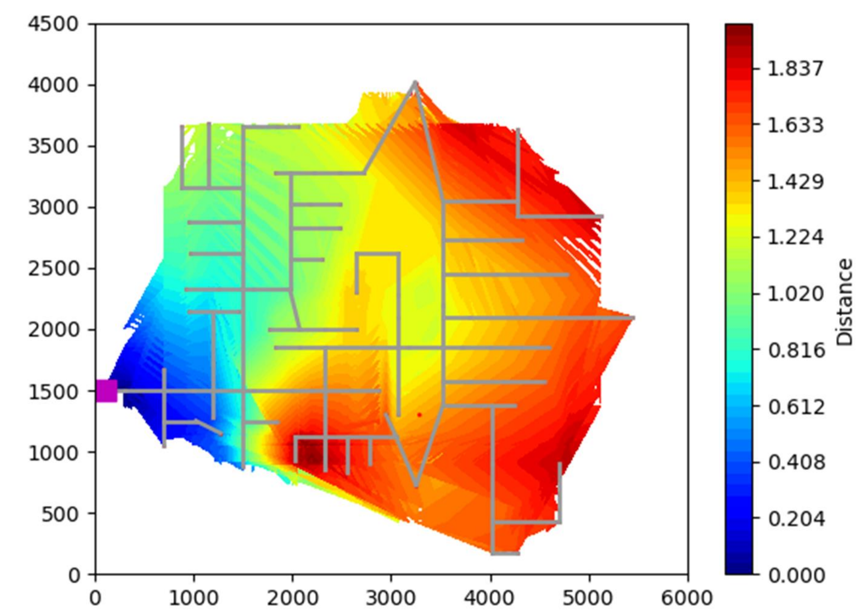
Model translation and validation[4]: OpenDSS models are converted to CIM XML, then CIMHub generates ePHASORSIM spreadsheets



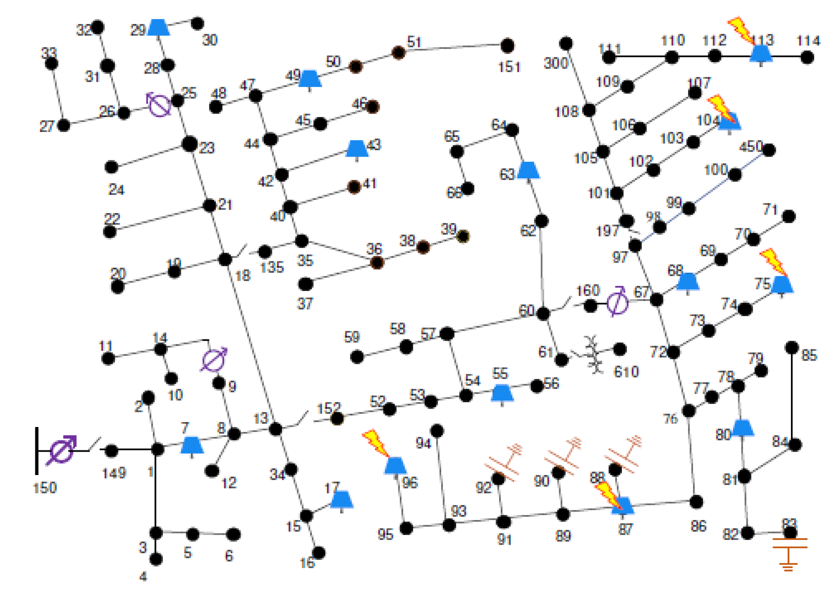
3. CIMHub Test Cases for S2G CPYDAR, Online: https://github.com/GRIDAPPSD/CIMHub/tree/feature/SETO/CPYDAR
4. CIMHub, "Tool set for translating electric power distribution system models between various formats, using the IEC Standard 61970/61968 Common Information Model (CIM) as the Hub", Online: https://cimhub.readthedocs.io/en/latest/

Resource Criticality Levels in IEEE 123-bus

Criticality level of various nodes based on location (distance from substation) and DER injections



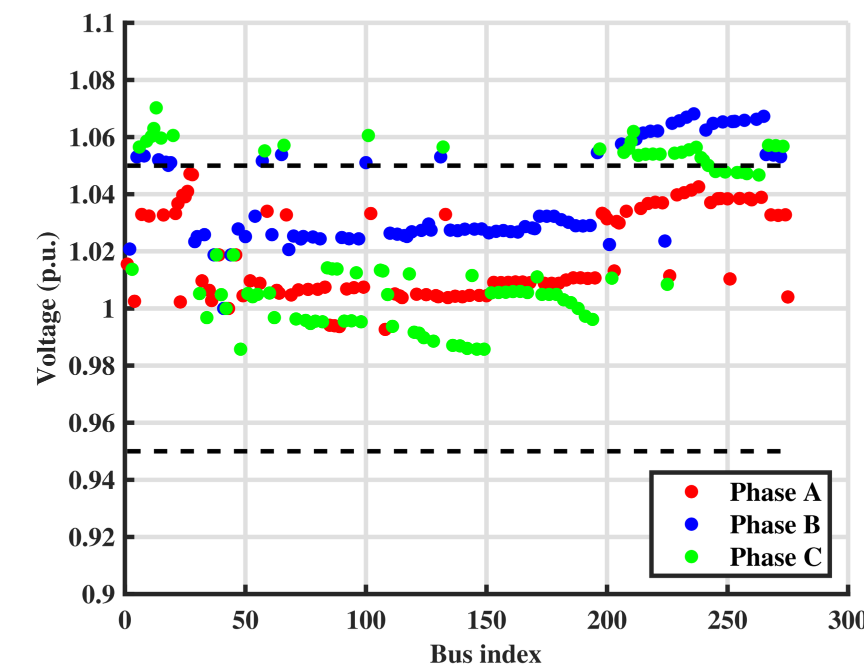
Most sensitive PVs are located farthest from the substation; i.e., buses 104, 113, 75, 96, and 87



Demonstration

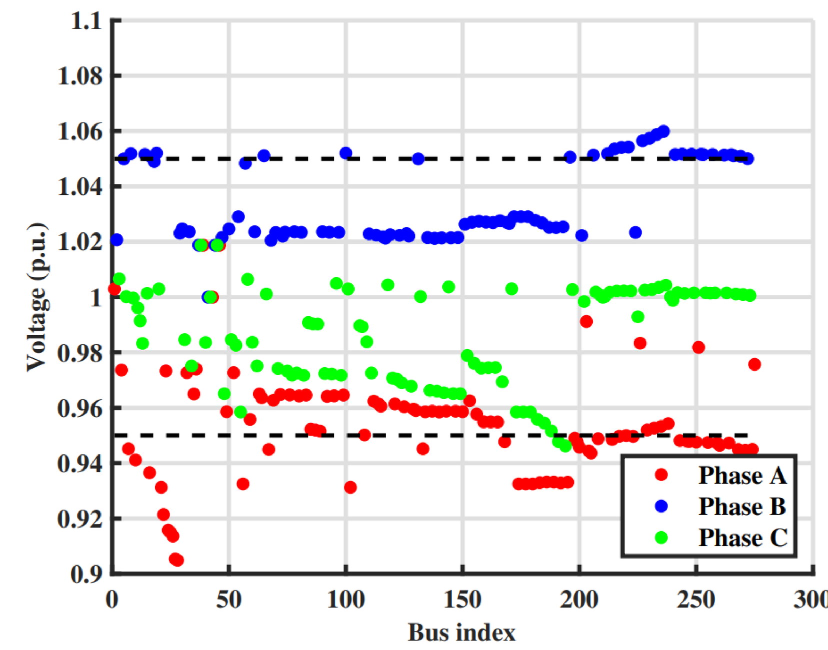
Scenario 1: Change in PV curtailment signals

- Attack on 5 PVs during low load period
  - ✓ Blocked curtailment signals
- Increase in voltage violations and reverse flow



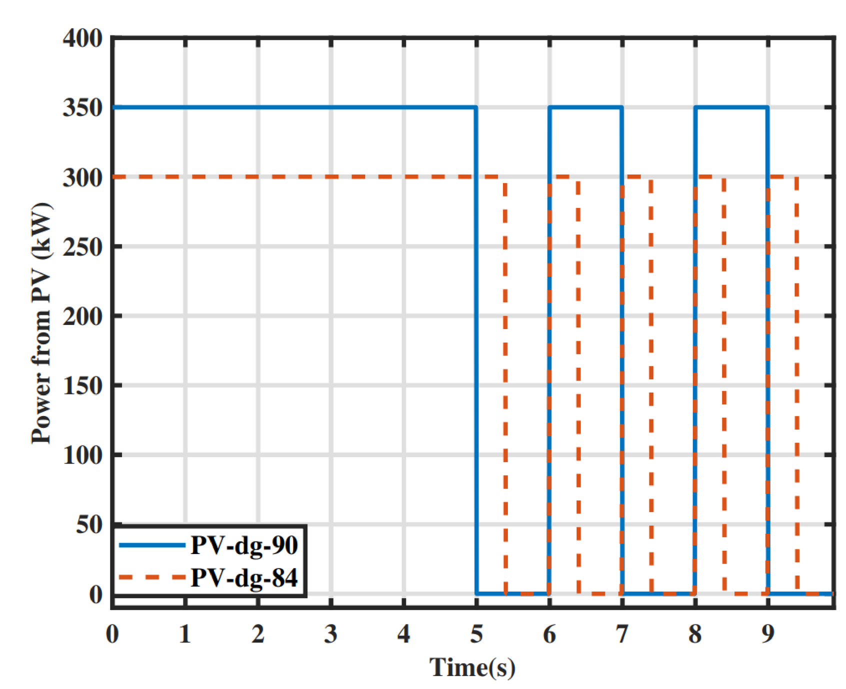
Scenario 3 : Change in Q setpoints

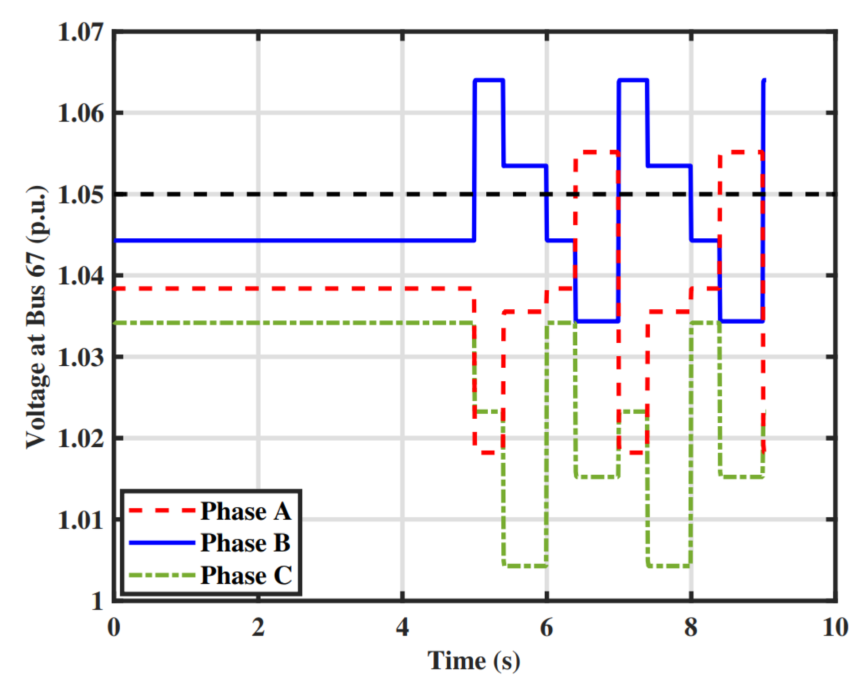
- Attack on 2 PVs with highest criticality levels
  - ✓ Q increased during low irradiance time
- Increase in voltage violations



Scenario 2 : Attacker toggles P setpoints of PVs with high criticality levels

- Voltage variations at bus 6, near the regulators, resulting frequency tap-changing actions; additional wear and thermal overloads





Summary

- Presented a framework for modeling different cyber-security scenarios in a real-time simulation platform, ePHASORSIM
- Demonstrated impacts of emulated cyber scenarios on the feeder through voltage violations in different locations of the feeder.

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