Pacific Northwest
NATIONAL LABORATORY

DPVProt and CIM-for-EMT Projects

SETO Webinar: "Let's work together on fast time-scale modeling of power systems with high distributed solar generation"

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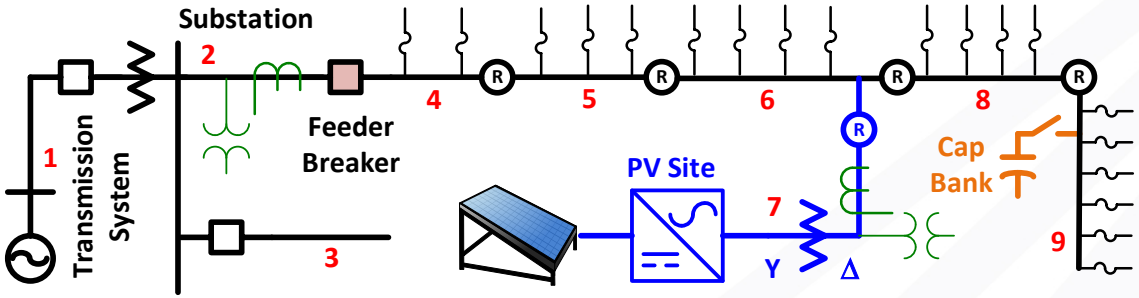
14:20-14:40 Eastern Time November 16, 2021

U.S. DEPARTMENT OF ENERGY BATTELLE

PNNL is operated by Battelle for the U.S. Department of Energy

DPVProt goal was to solve IEEE 1547-2018 protection issues in the near term, with new methods and applications on 2 utility feeders.



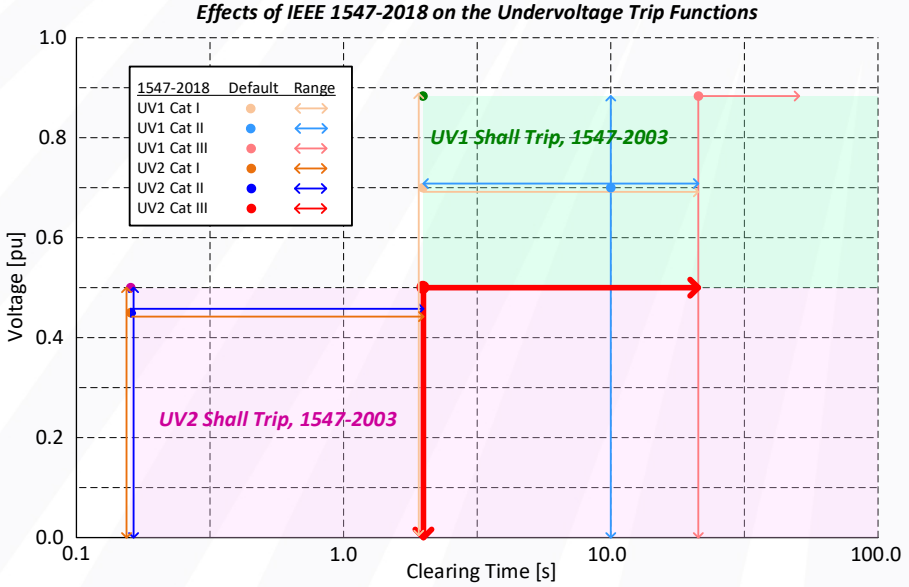
Issue: ride-through can make undervoltage trip ineffective for de facto fault detection.

Team: PNNL, ORNL, GA Tech, Dominion Energy Virginia, Chattanooga Electric Power Board

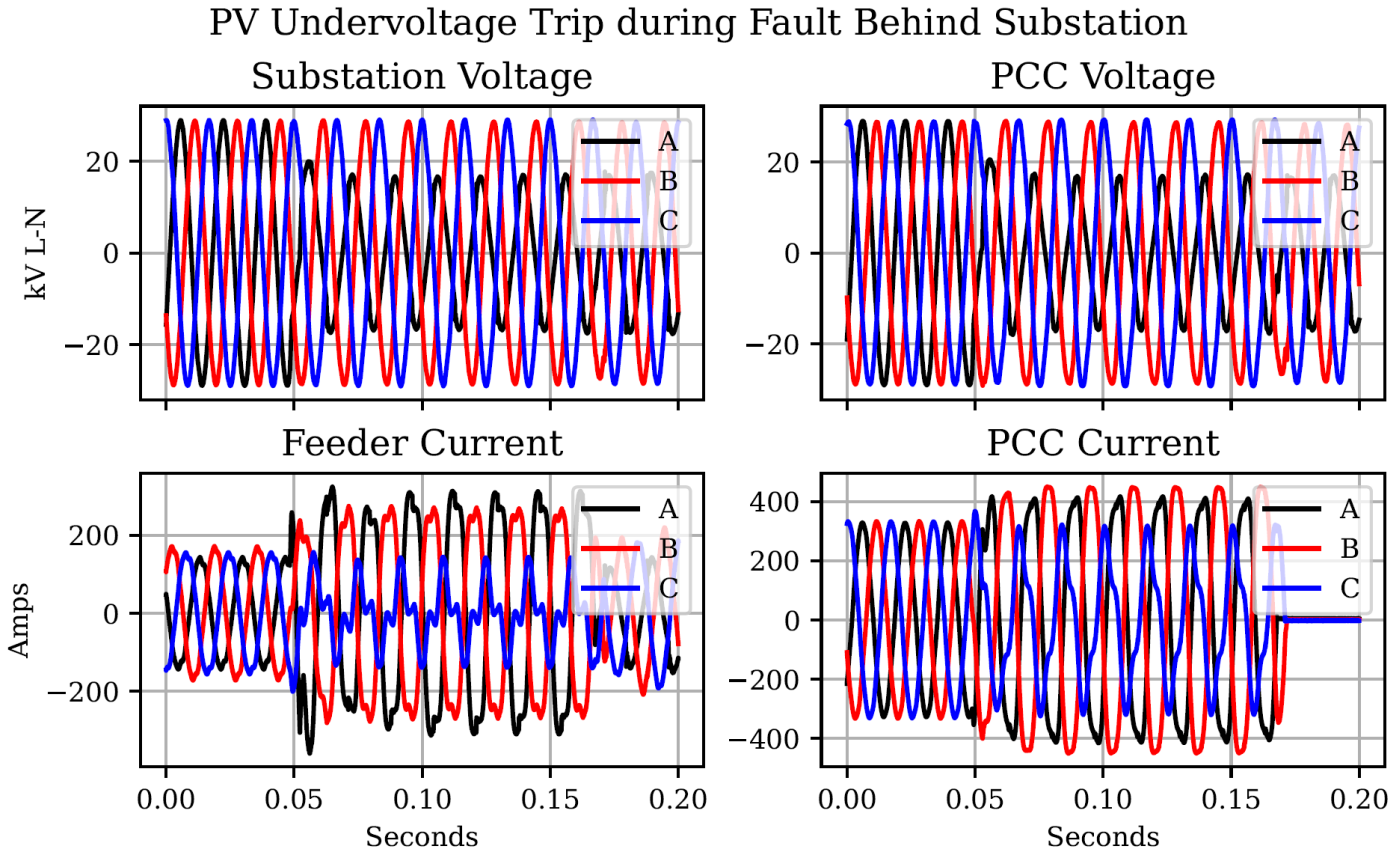
SETO Technology Manager: David Walter

References:

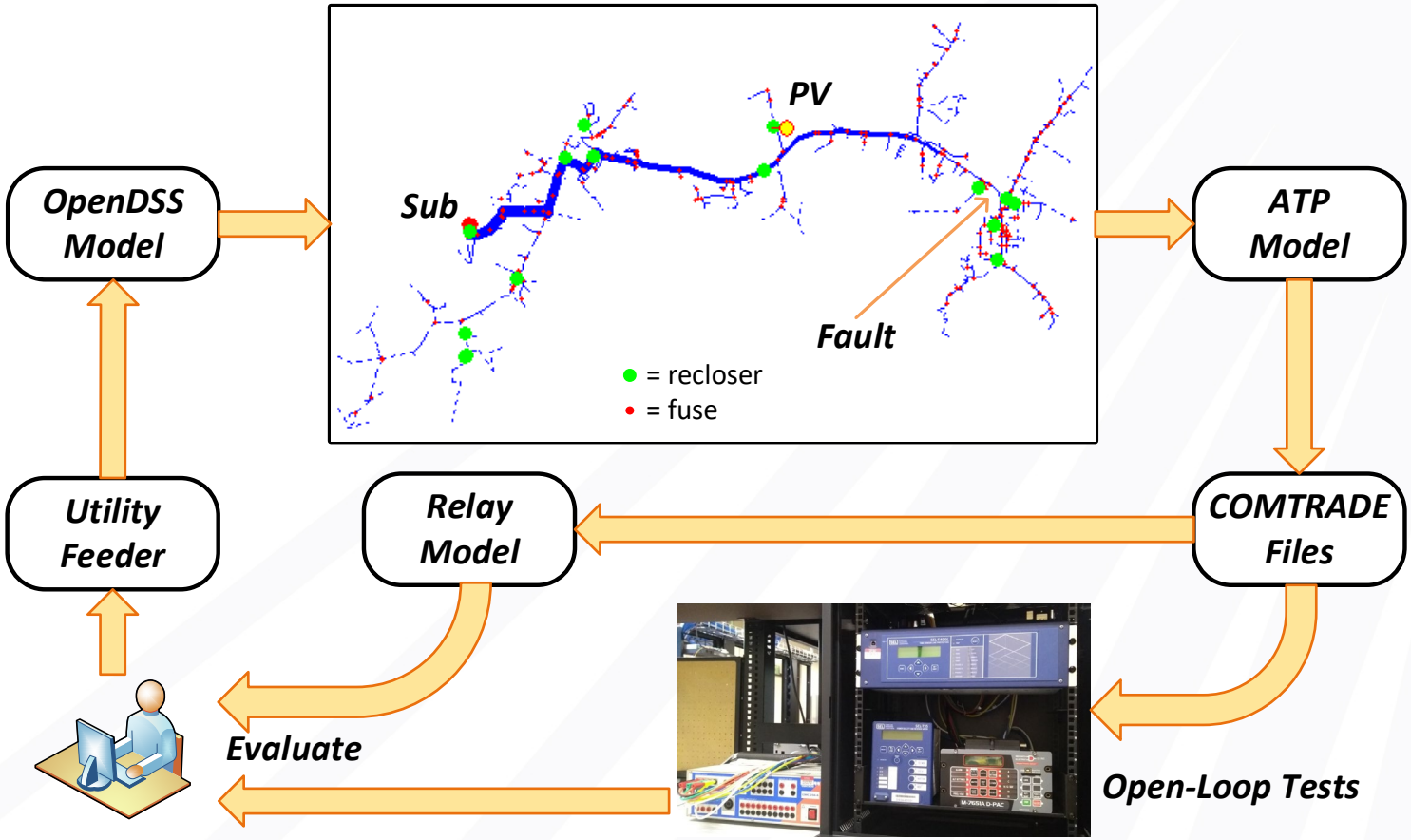
- Papers:
  - https://www.osti.gov/biblio/1821480-protection-radial-circuits-high-penetration-distributed-photovoltaics
  - https://ieeexplore.ieee.org/document/8980968
- Article: https://www.pacw.org/protection-of-distribution-circuits-with-high-penetration-of-photovoltaics
- Reports to appear on osti.gov:
  - "Protection of Distribution Circuits with High Penetration of Solar PV: Distance, Learning, and Estimation-Based Methods", October 7, 2021.
  - "Estimation Based Protection Relay--Application to Distribution System With High DER Penetration", May 2021.
- Code: https://github.com/pnnl/dpvprot



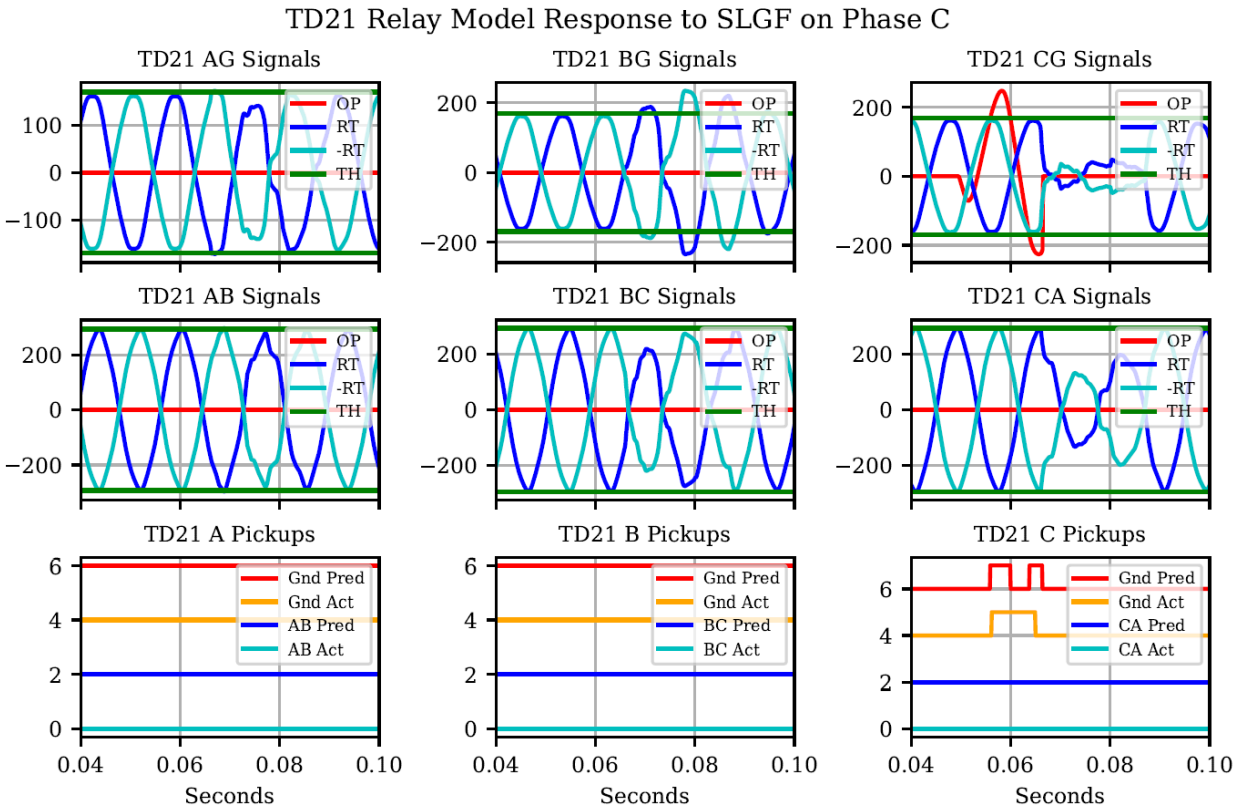
In this event, a “large” distributed PV site tripped on undervoltage, even though it was not necessary to clear a fault or island.

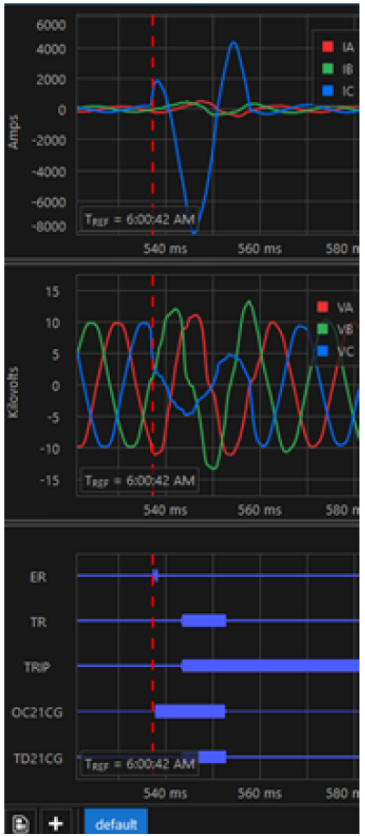


Utility feeder models were converted to OpenDSS (phasor dynamics) and Alternative Transients Program (ATP) formats.

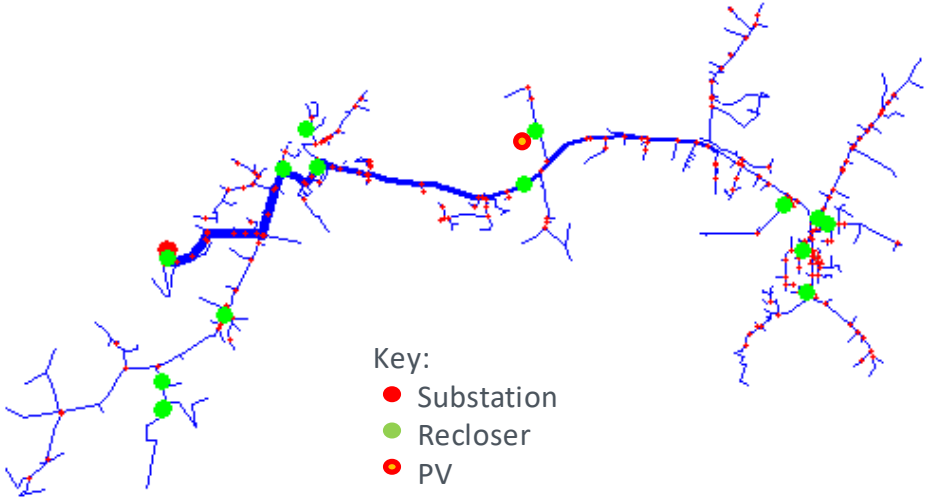


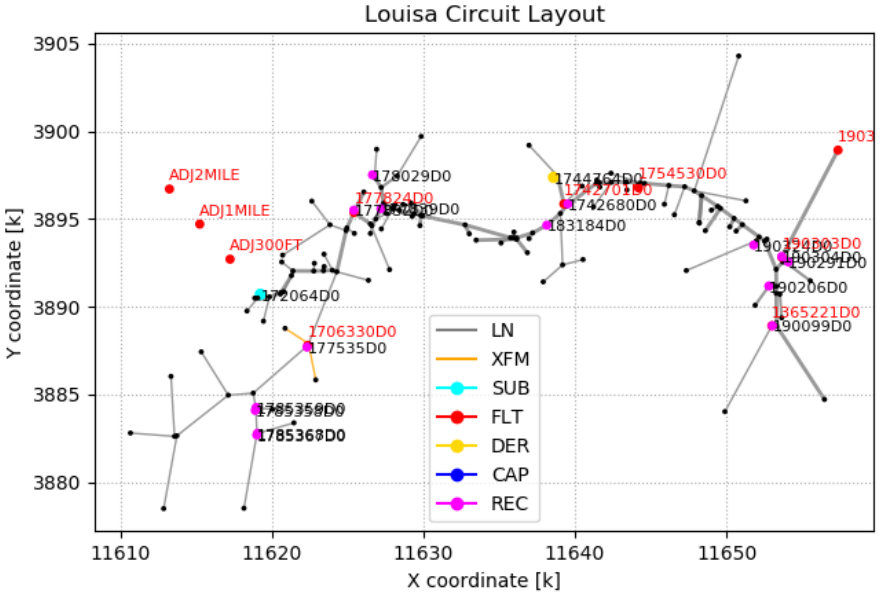
ATP simulations and field event records provided COMTRADE files to check relays and algorithms.





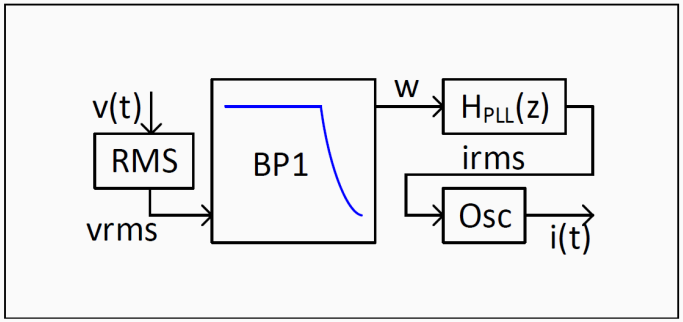
For efficiency, feeder models from CYMDIST and Synergi Electric were reduced in order using OpenDSS, then exported for EMT.

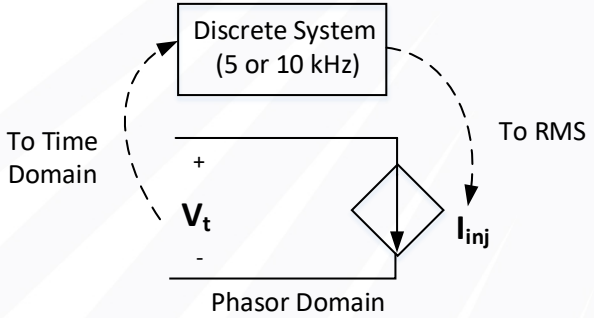


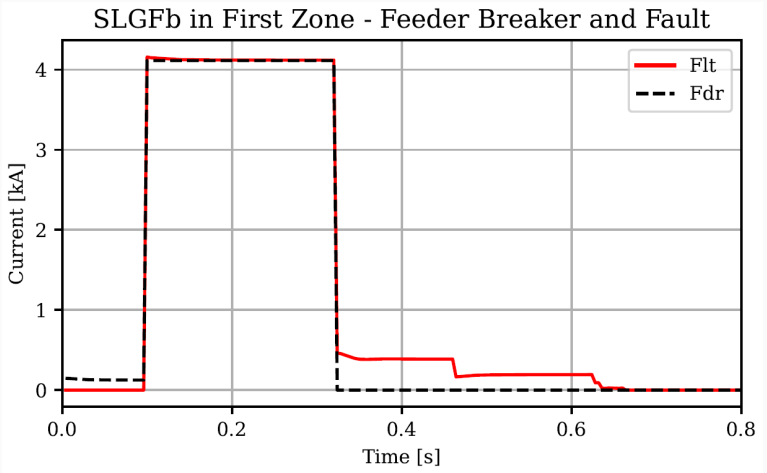


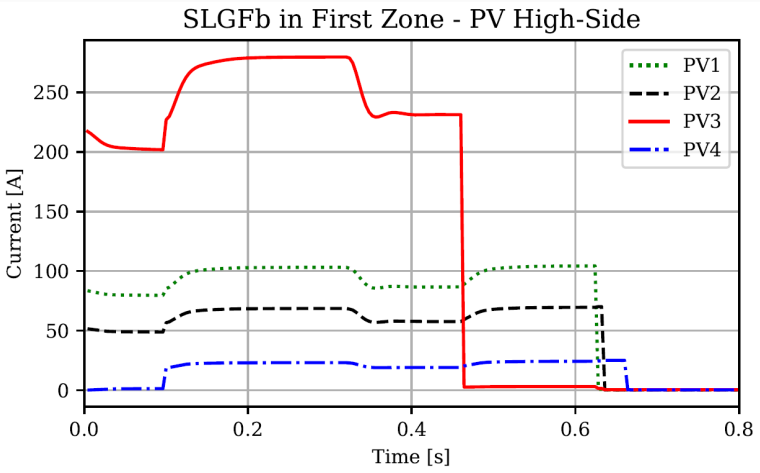
- OpenDSS: retained buses, load flow, short circuit.
- NetworkX: topology reduction, equivalent branches, heuristics for ATP load equivalents.
- Custom scripted: add the transient IBR models, run event simulations in ATP.
- Code and public models on https://github.com/pnnl/dpvprot, need ATP license to get supplemental code.

OpenDSS now includes fast-phasor inverter models that replicate first-order effects on fault current contributions.



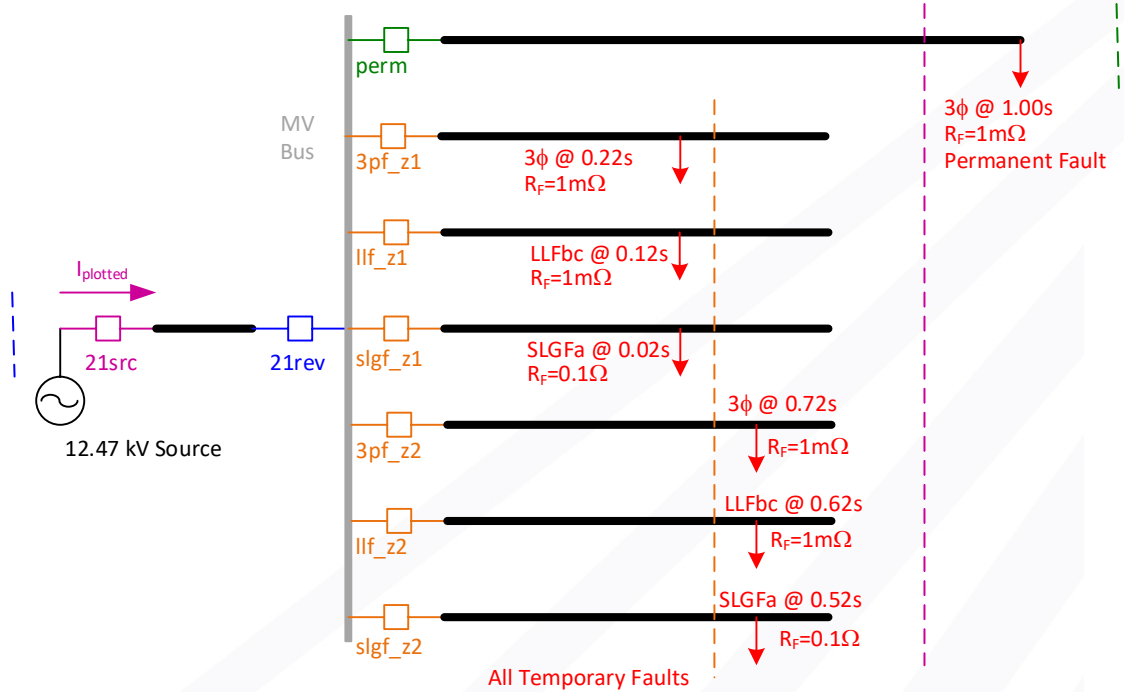


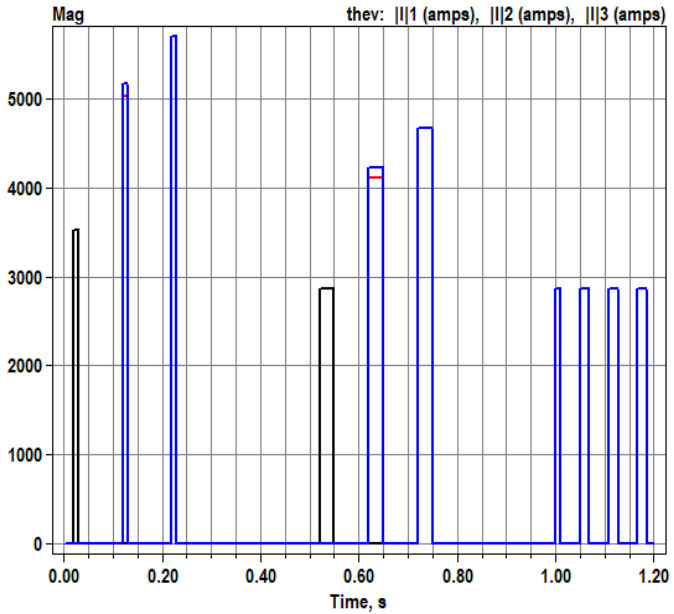




Ref: "OpenDSS Tech Note: Voltage-Controlled Current Source"

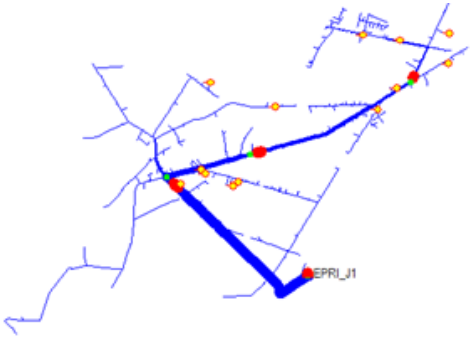
OpenDSS now includes distance and incremental distance relay models, for simulating faults at 1-ms time steps.

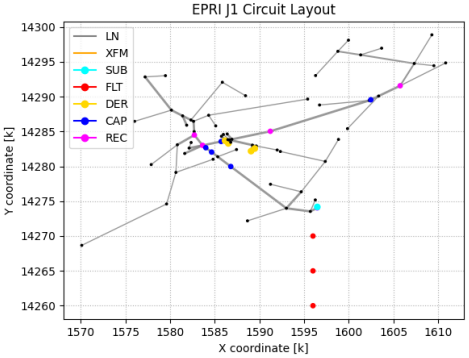


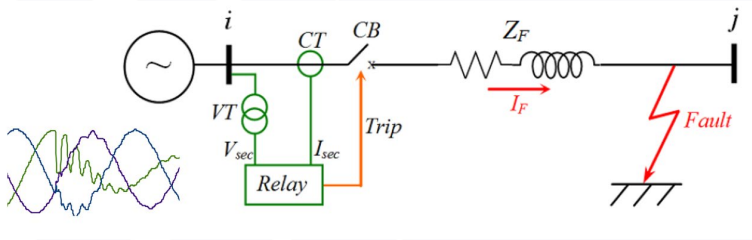


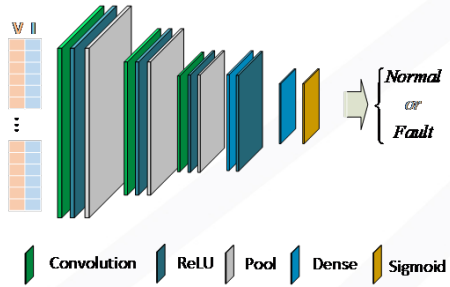
Ref: "OpenDSS Tech Note: Distance Relays"

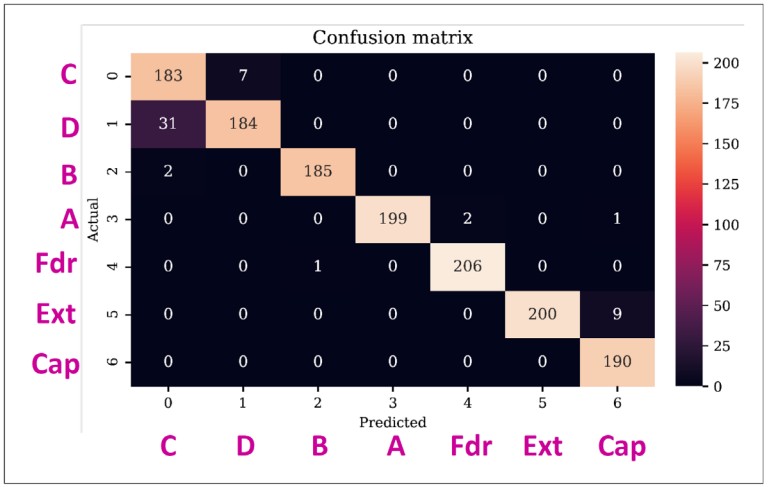
EPRI J1 feeder with Convolutional Neural Network relay based on 7000 ATP simulations; achieved greater than 95% testing accuracy.



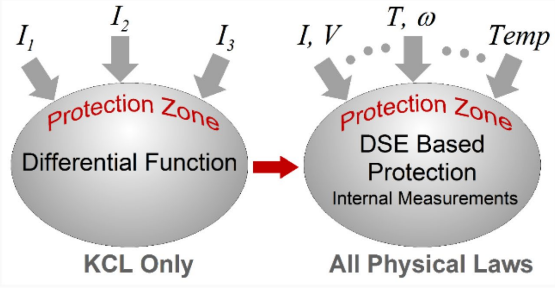


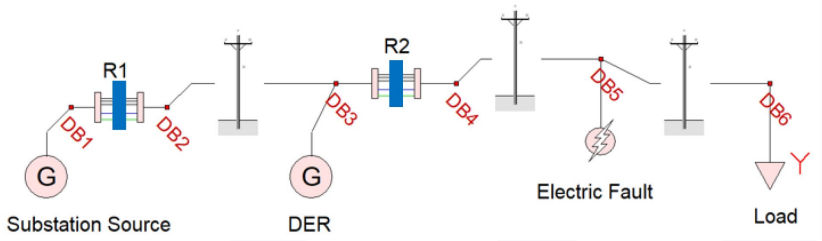


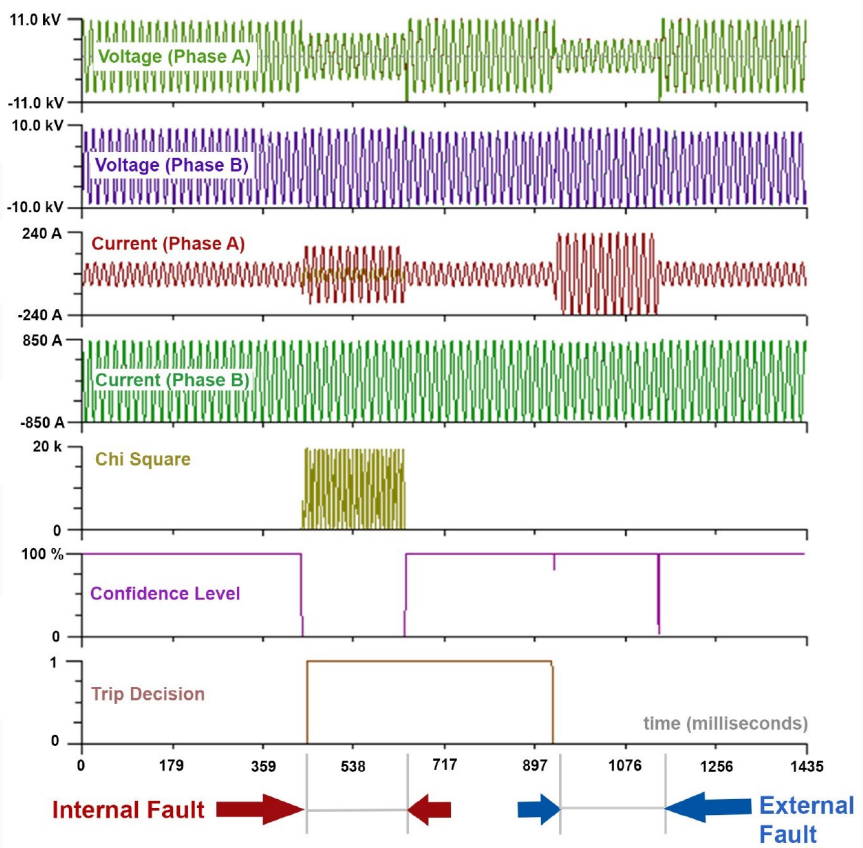




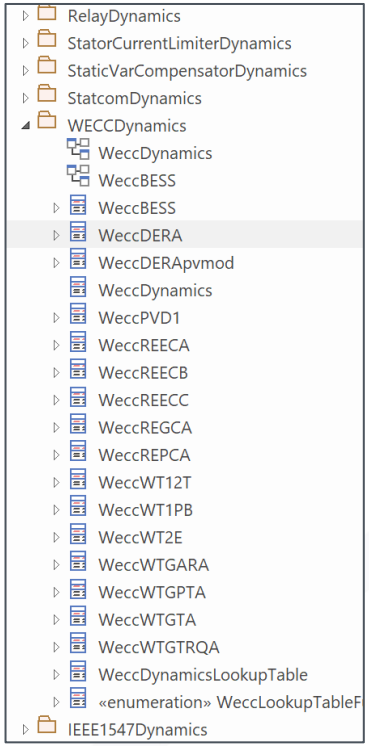
Estimation-based protection discriminated internal and external faults, even with incomplete measurements.







CIM-for-EMT builds on CIMHub, PGSTech modeling of the French 225/400-kV system, and new IEEE 1547-2018 models in CIM.



IEC 61970-302 CDV

- September 2021
- IEEE 1547
- DER_A
- WECC Active Load

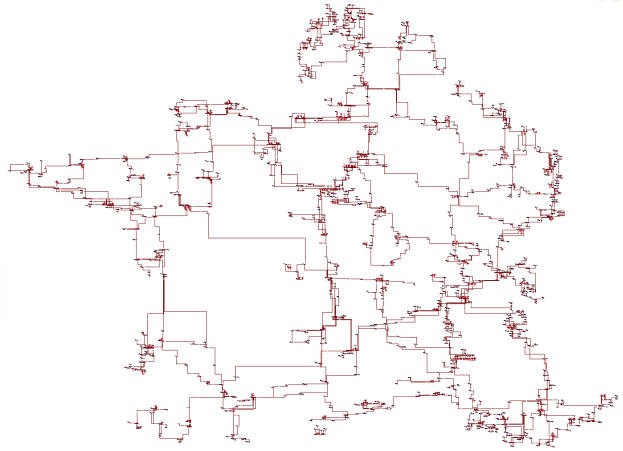
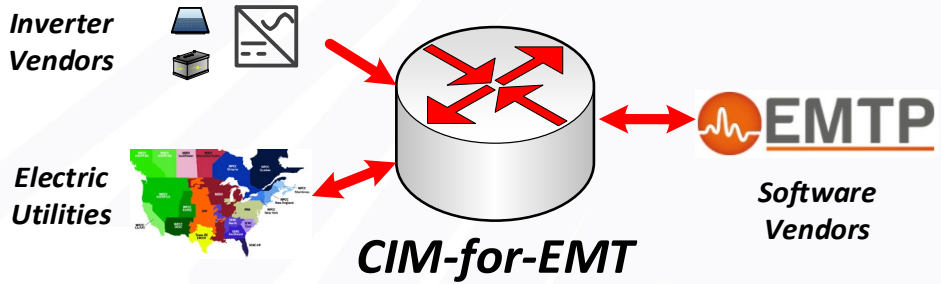


Fig. 5 French 225 kV grid after CIM import in EMTP



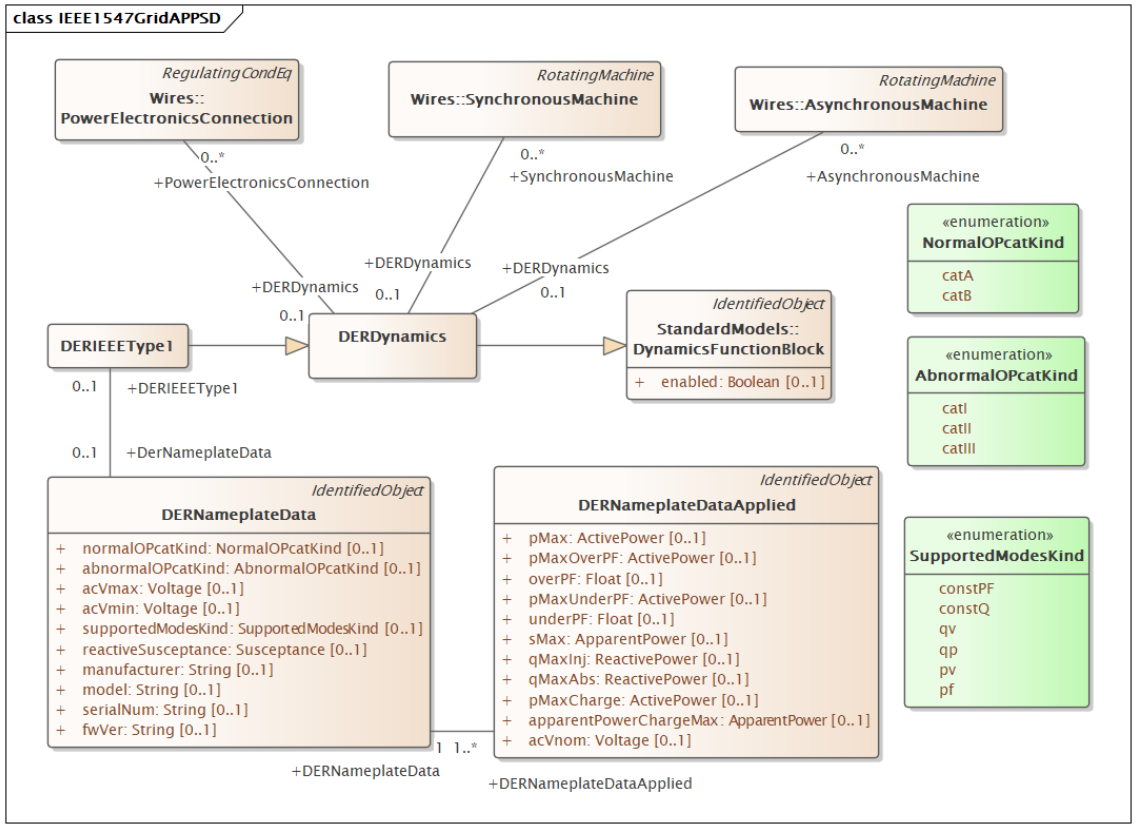
Project Outline

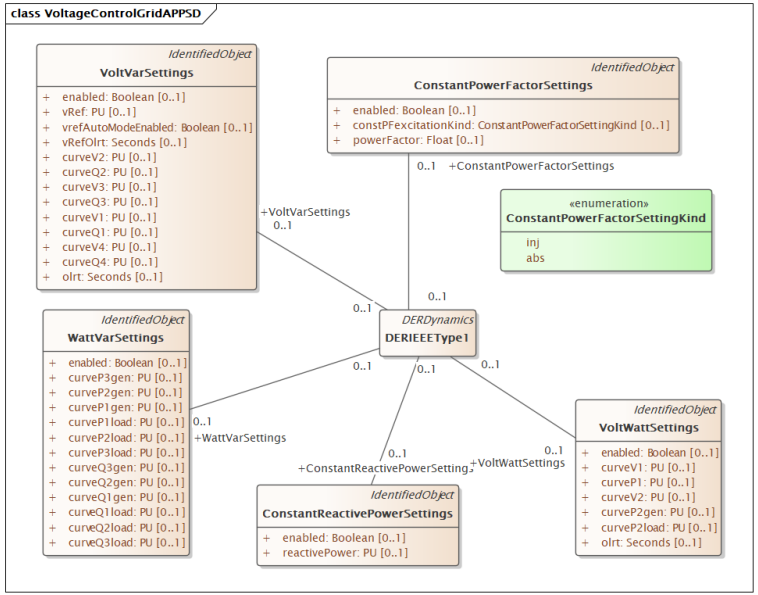
- Automate modeling of the bulk system for EMT studies
- Standard interfaces for inverter based resource (IBR) models
- PacifiCorp and MISO providing data, testing, and review
- PoP: 10/15/2021 - 10/14/2022

https://www.ipstconf.org/papers/Proc_IPST2017/17IPST099.pdf

OE/TCF Technology Manager: Alireza Ghassemian

IEEE 1547-2018 interoperability tables have been translated to Unified Modeling Language (UML) for the CIM Dynamics Profile.





P1547.2/D6.2 (Annex F.2)

- Ballot pool forming now
- UML for 1547, 1547.1 tables
- Mappings to OpenDSS and GridLAB-D

Doc: https://gridappsd.readthedocs.io/en/develop/developer_resources/index.html#der-models-from-ieee-1547-2018

Transient feeder models through the Open Energy Data Initiative (OEDI) and Securing Solar for the Grid (S2G) lab call projects.

Name	Type	V_{LL} [kV]	#Loads	#DER	Load [MW]	Notes
IEEE 13x	Radial	4.16	9	4	3.4	Common starting point; DER added for GridAPPS-D; EMT model built.
IEEE 123x	Radial	4.16	114	14	3.8	Includes 11 switches for radial reconfiguration; NREL added PV for GridAPPS-D.
EPRI DPV J1	Radial	12.47	1384	13	11.6	A real feeder monitored in the EPRI distributed photovoltaics project. EMT model built.
IEEE 9500	Configurable	12.47	1275	12	12.3	PNNL & WSU added substations, DER, switches and microgrid options to IEEE 8500. Derived from a real feeder.
IEEE LVN	LV Network	13.20	624	TBD	42.2	Typical urban core distribution with one 208-V grid network and eight 480-V spot networks; EMT model built.
RIV 209	Radial	12.47	101	1	9.6	Time domain data; 1 MW PV; Chattanooga EPB feeder; EMT model built.
SHE 215	Radial	12.47	105	2	11.8	Time domain data; 2 MW PV; Chattanooga EPB feeder; EMT model built.
Louisa	Radial	34.50	1527	1	27.0	Time domain data; 20 MW PV; Dominion Energy Virginia feeder; EMT model built.
PNNL	2 Substations	12.47	743	3	16.4	150-kW and 4-MW PV; 1-MW battery; City of Richland feeders.
Nantucket	8 Feeders	13.20	13,794	62	50.6	6-MW PV; 6-MW BESS; National Grid feeders.
UDistrict	2 Feeders	13.20	582	4	10.1	Avista feeders for WA Clean Energy Fund project.

- Utility feeder models (shaded) are available now but will need new NDAs for the OEDI project.
- Public feeder models (unshaded) have no restriction for OEDI or S2G projects.