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Fault Location in a Distribution Management System (DMS).

Research and Demonstrations with openXDA

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Overview

- Research and demonstrate open modular components for fault location in a Distribution Management System (DMS).
  - We want to demonstrate openXDA as an example module that has the capability and flexibility to implement different forms of fault location.
  - Some utilities use waveform acquisition approach to estimate distance to fault, others use a simple fault magnitude from a relay
- Other open modular components
  - Use system modeling software for verification for assurance and adjustments (openDSS)
  - Validating other approaches (Voltage Drop Method) with openDSS as well.
  - Integration with GIS framework (openDSS/Google-Earth type)

Why have a DMS?

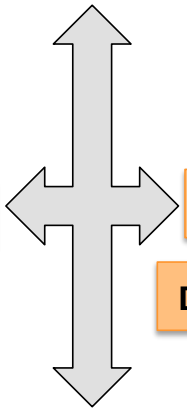
System Analysis

- Unabalanced Power Flow
- Asset Utilization
- Fault Detection & Location
- Grid Efficiency
- Demand Management

GIS

OMS

SCADA



Meter Data

Relay Data

Data & Communication Interface

Device Data

Accurate Distrubution System Models

System Outage

- Distribution Relaibility
- Unplanned/Planned
- Trouble Calls
- Customer Updates
- Crew Monitor/Assignment

Network Optimizer

- FLISR
- Feeder Reconfiguration
- Volt/Var Management

Switching Operations

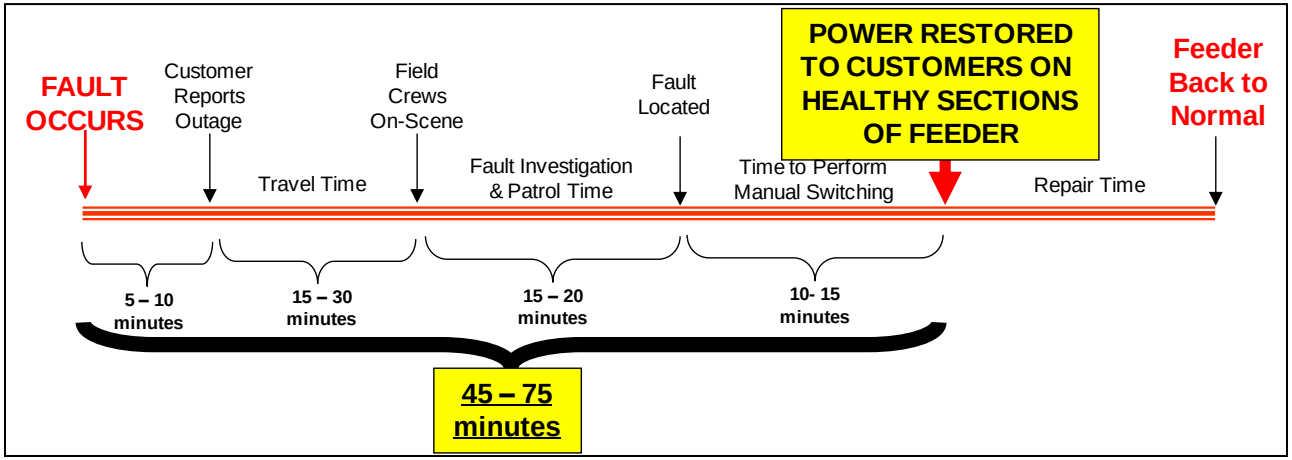
- Contingency Analysis
- System Protection & Coordination
- Support of Distributed Generation

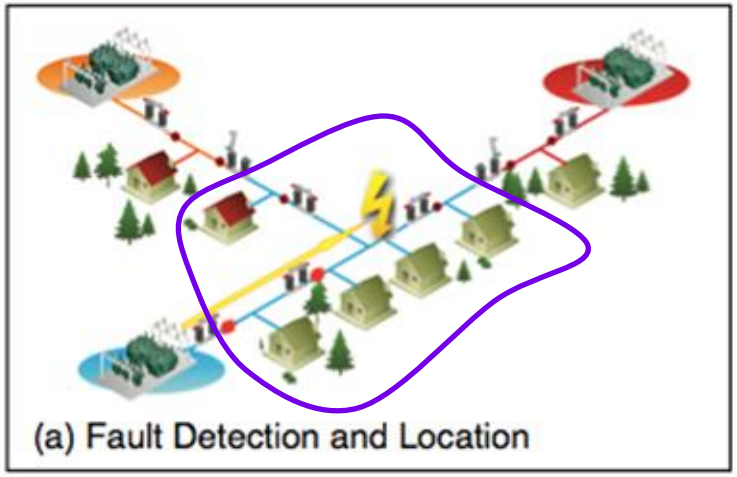
Network View

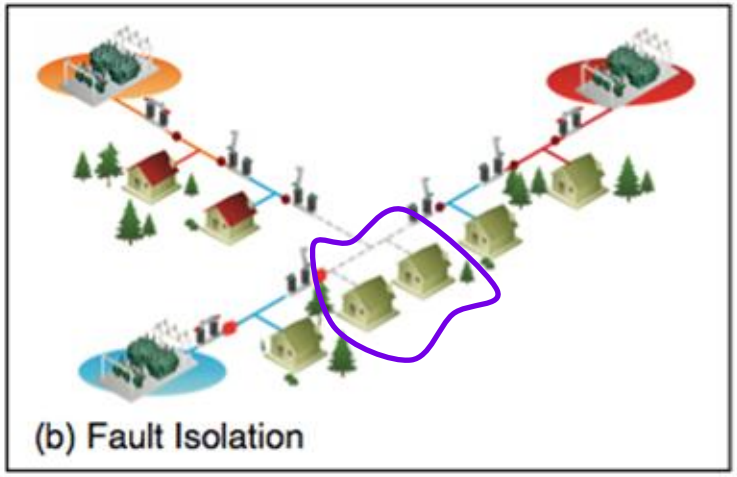
Model and Interface

FLISR Operation with DMS
(Improve Restoration to Healthy Sections)

Fault Location, Isolation and Service Restoration

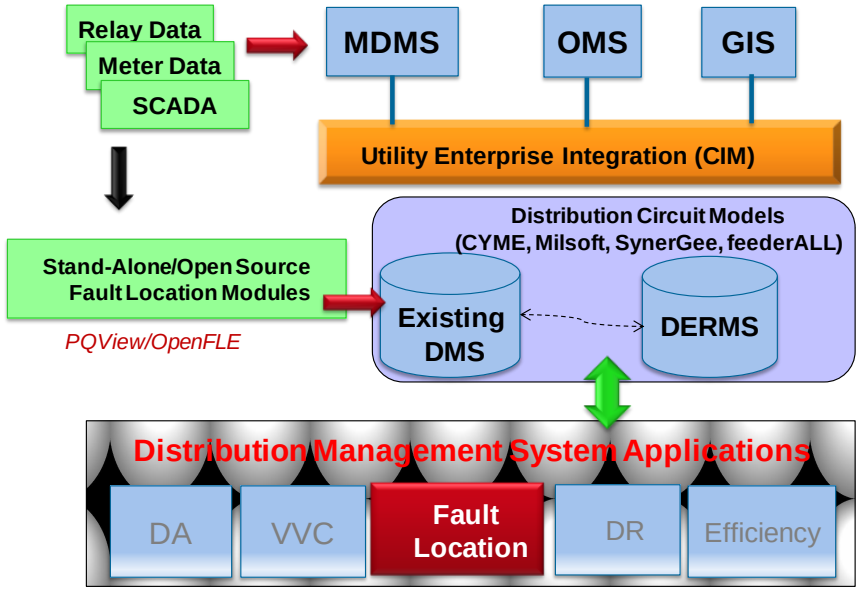






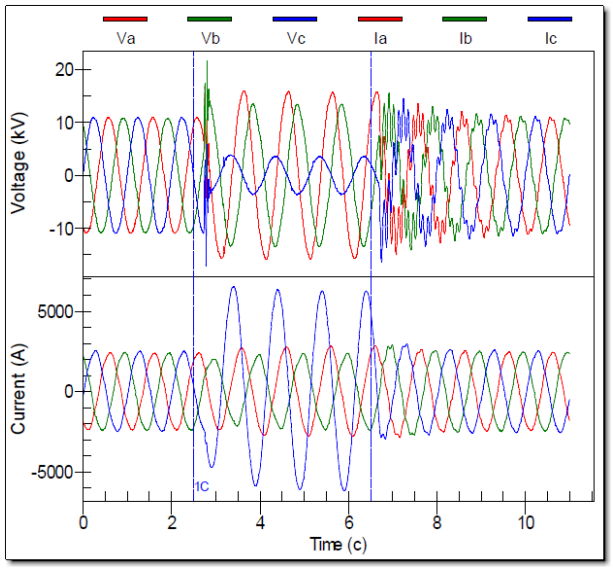
Straw-man Integrated DMS Concept for Fault Location Detection and Isolation

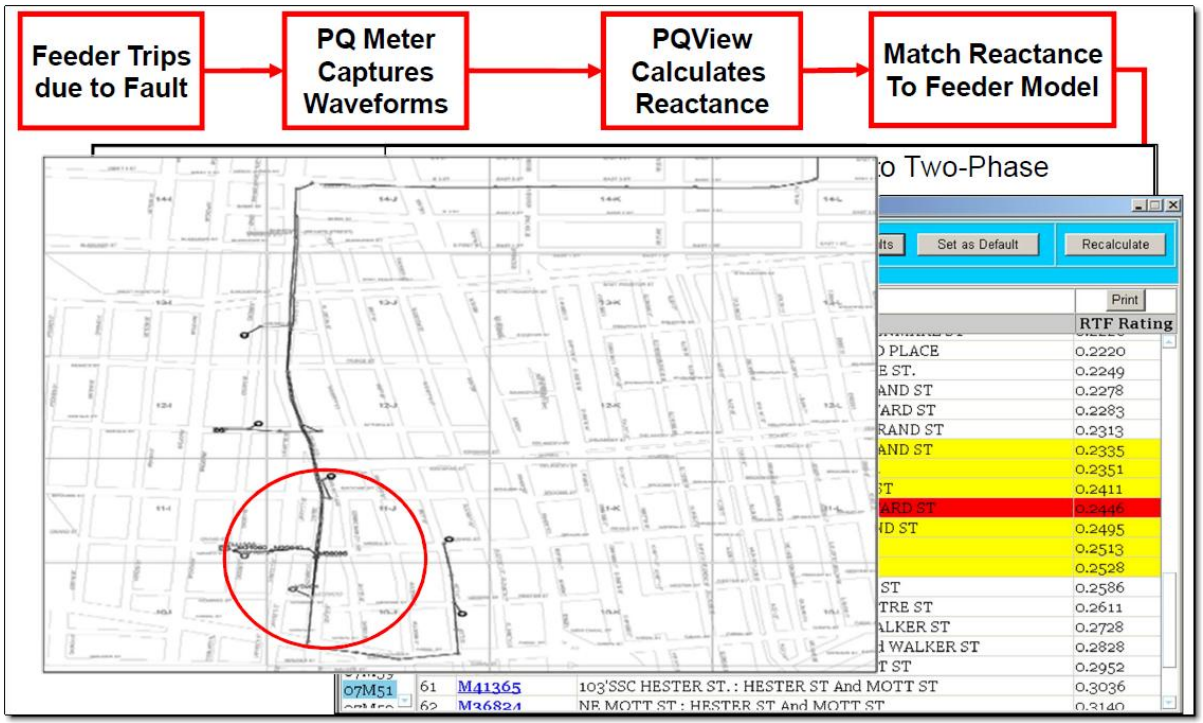
- Coordinate and integrate the utility-owned monitoring data
  - DFR/IED, typical 16-64 PPC
  - PQ Monitoring, typical 128-1024 PPC
  - Relay, Fault Magnitude/Type, Simple distance to fault
- Geographic Information System (GIS) for building the static network connectivity model, displays, and electrical model used by the distribution application functions
- The interface to Outage Management System (OMS) could be used for real time data capture of partial restorations, device status changes, and temporary device additions and deletions (jumpers and line cuts). Additionally Meter Data Management Systems (MDMS) could do the same.

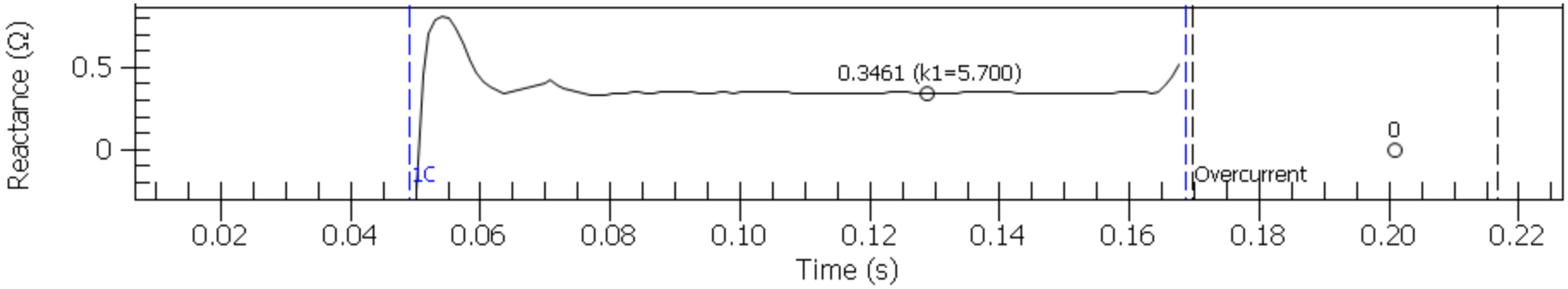


- Distribution Feeder Models
  - Complete Feeder from the HV sub xfmr, down to LV xfmr.
  - All components such as line capacitor banks, regulators, reclosures/breakers, and service transformers.
  - Three-phase model. Includes feeder laterals, and underground loops; three, two, and single-phase line segments and laterals.

Example Waveform Method via PQView







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Example SEL Fault Magnitude Report

SEL 2032 Communication Processor

- Links multiple IEDs
- Collects event reports from relays.
- Execute logic searching for fault criteria.

Since the relay is capable of sending multiple summary event reports, the SEL-2032 will **not** attempt to retrieve the new summary event reports from the relay immediately. The SEL-2032 will delay for 90 seconds from the time it received the first summary event report. This time delay needs to be long enough in order to accommodate reclosing during certain fault conditions. From relaying expertise, it was determined that a fault could theoretically last anywhere from 20 – 70 sec, so 90 seconds was chosen to make sure the fault has settled out before retrieving the magnitude.

After the 90 second delay, the SEL-2032 will issue the 20HISTORY message to retrieve the last 30 event histories. The 20HISTORY message is a compact binary message that is more efficient than the ASCII HIS message. Also, the 20HISTORY message is recognized by the SEL-2032 and the data is parsed automatically. Once the history is retrieved from the relay, it is stored into the SEL-2032 database. Figure 3 below shows an example of this history message that is returned.

REC_NUM	DATE	TIME	EVENT	LOCATION	CURR	FREQ	GROUP	SHOT	TARGETS	
1	03/19/13	08:46:20.394	TRIG	$$$$$$$$$	259	60.01	1	0	10000000	10000000
2	03/19/13	08:45:39.017	PULSE	$$$$$$$$$	1	60.01	1	0	10000000	10000000
3	03/19/13	08:45:29.020	PULSE	$$$$$$$$$	1	60.02	1	0	10000000	10000000
4	02/16/13	23:35:25.174	CA	$$$$$$$$$	915	60.00	1	0	10000000	10000000
5	02/16/13	20:51:27.714	ABC	$$$$$$$$$	845	60.01	1	1	10000000	10000000
6	02/16/13	20:51:26.914	AB	$$$$$$$$$	941	60.01	1	0	10000000	10000000
7	01/17/13	23:44:44.630	ABCG T	$$$$$$$$$	3110	60.03	1	0	11100100	01000110
8	01/17/13	21:35:37.802	CG T	$$$$$$$$$	2805	60.02	1	2	11000010	00100110
9	01/17/13	21:35:37.057	CG	$$$$$$$$$	2729	60.03	1	2	11000010	01000110
10	01/17/13	21:35:16.618	CG T	$$$$$$$$$	2819	60.02	1	1	11000010	01000110
11	01/17/13	21:35:15.897	CG	$$$$$$$$$	2875	60.02	1	1	11100100	01000110
12	01/17/13	21:35:13.433	ABCG T	$$$$$$$$$	2817	60.02	1	0	11100100	01000110
13	08/22/12	11:59:58.046	ABC	$$$$$$$$$	858	60.00	1	1	11100100	01001110
14	08/22/12	11:59:55.574	ABCG T	$$$$$$$$$	2975	60.00	1	0	11100100	01001110
15	07/27/12	21:51:29.533	ABC T	$$$$$$$$$	238	60.01	1	2	11000000	00100000
16	07/27/12	19:20:30.347	ABC T	$$$$$$$$$	241	60.00	1	2	11000000	00100000
17	07/27/12	17:44:33.117	AB	$$$$$$$$$	1939	60.01	1	0	10000000	10000000
18	07/11/12	01:12:15.872	CA	$$$$$$$$$	1378	60.00	1	1	10000000	10000000
19	07/11/12	01:12:13.447	ABC	$$$$$$$$$	923	59.99	1	1	10000000	10000000
20	07/11/12	01:12:10.640	ABC	$$$$$$$$$	940	59.99	1	0	10000000	10000000
21	07/01/12	13:47:09.534	BC	$$$$$$$$$	1304	59.98	1	0	10000000	10000000
22	06/30/12	23:06:39.877	BC	$$$$$$$$$	1294	59.99	1	0	10000000	10000000
23	06/29/12	22:54:42.717	CA	$$$$$$$$$	1242	59.99	1	0	10000000	10000000

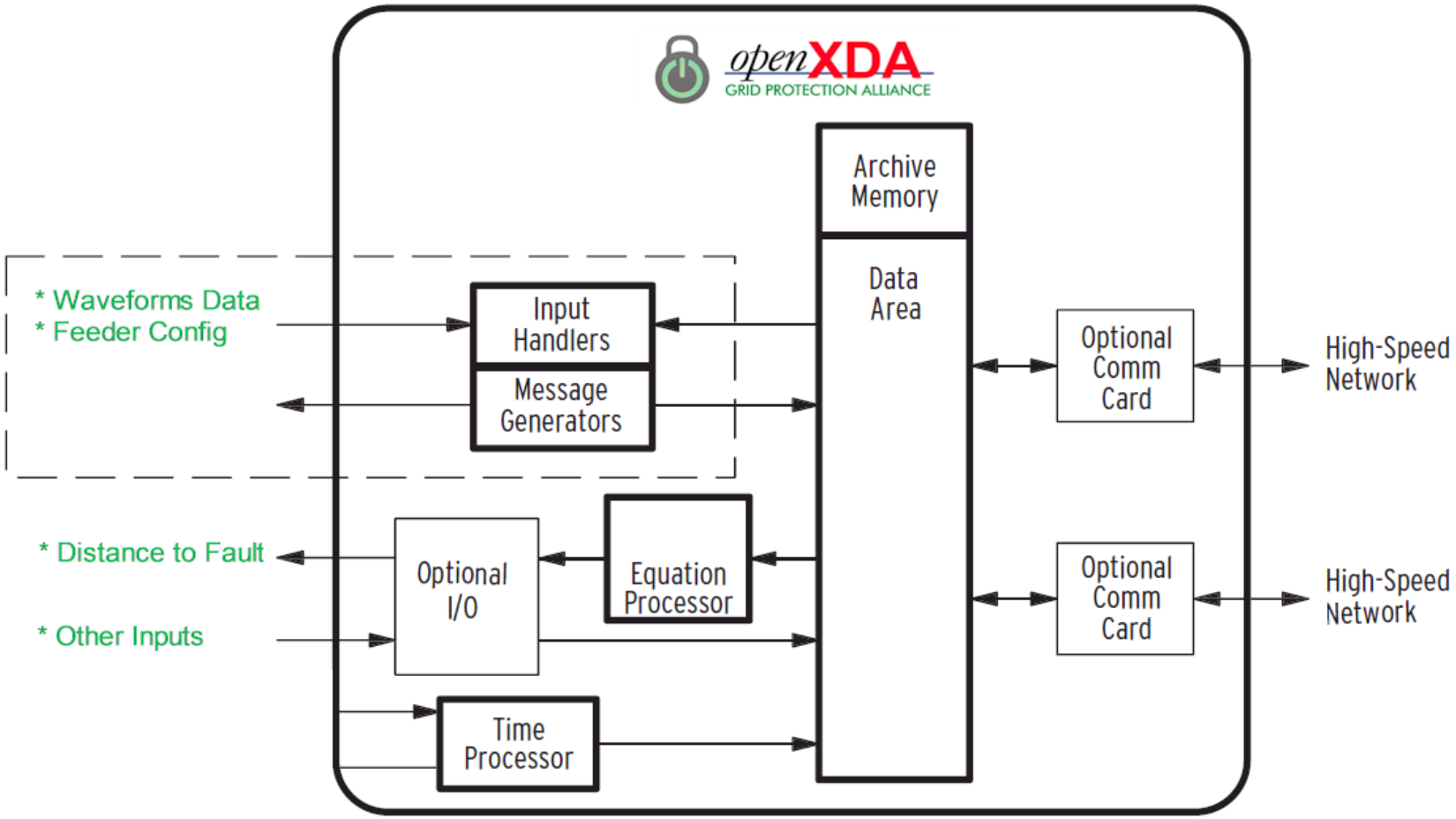
Figure 3: Sample history message from relay

After the data has been successfully stored in the SEL-2032 database, logic will be executed in the USER (MATH) region to search the EVENT column for the character "T" along with phasing (A, B, C, or G). It will not bring back the words TRIP or TRIG. The history records are organized in chronological order where the first record is the most recent event.

If the search locates an EVENT record that matches this criteria, it then checks to see if the SHOT = 0. If SHOT = 0, the fault magnitude is then recorded.

Theoretical Substitute for SEL 2032 with openXDA

The SEL-2032 collects, stores, processes and transmits time-stamped sequential event records from Relays and other IEDs.



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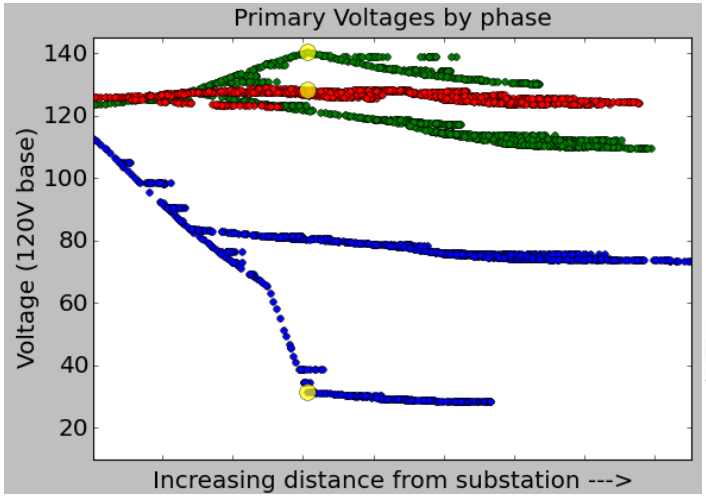
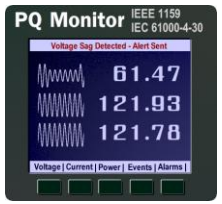
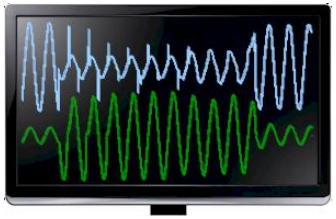
Example Supplement with Voltage Drop Method

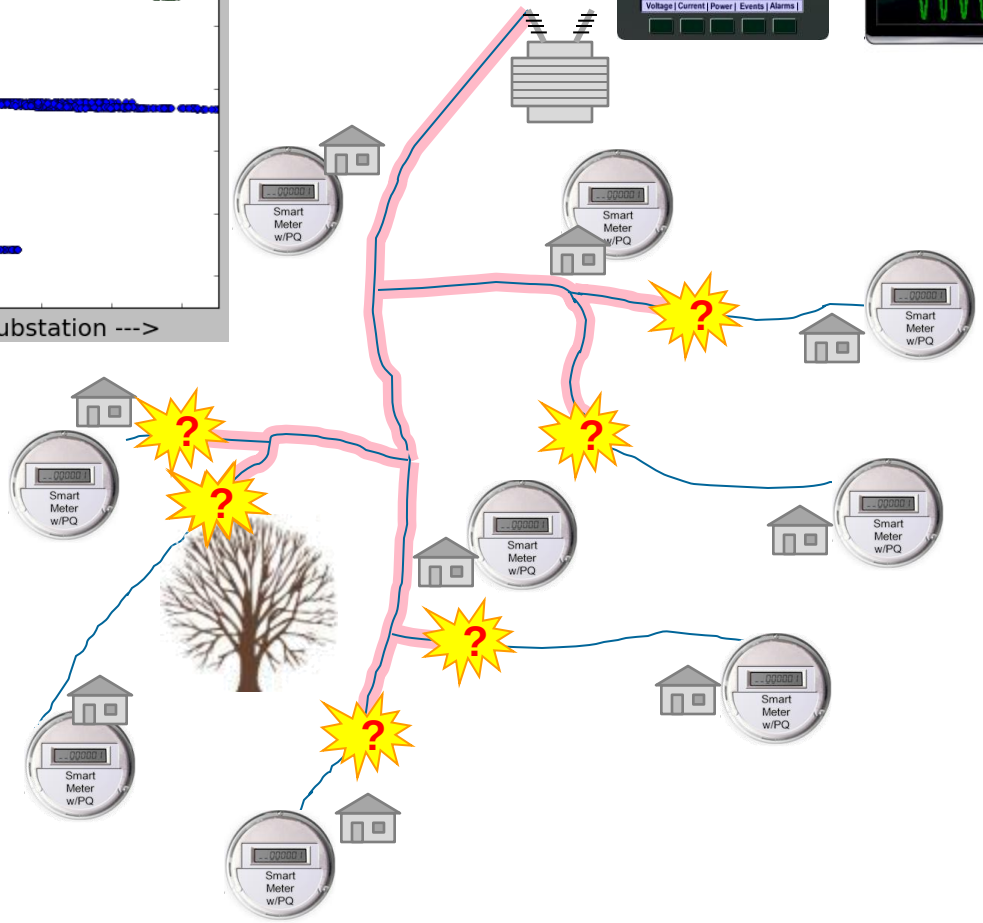


Verification with OpenDSS

Distribution **S**ystem **S**imulator







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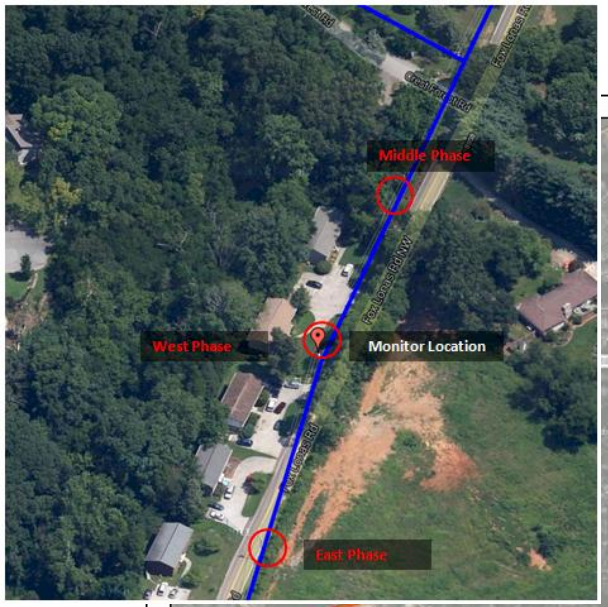

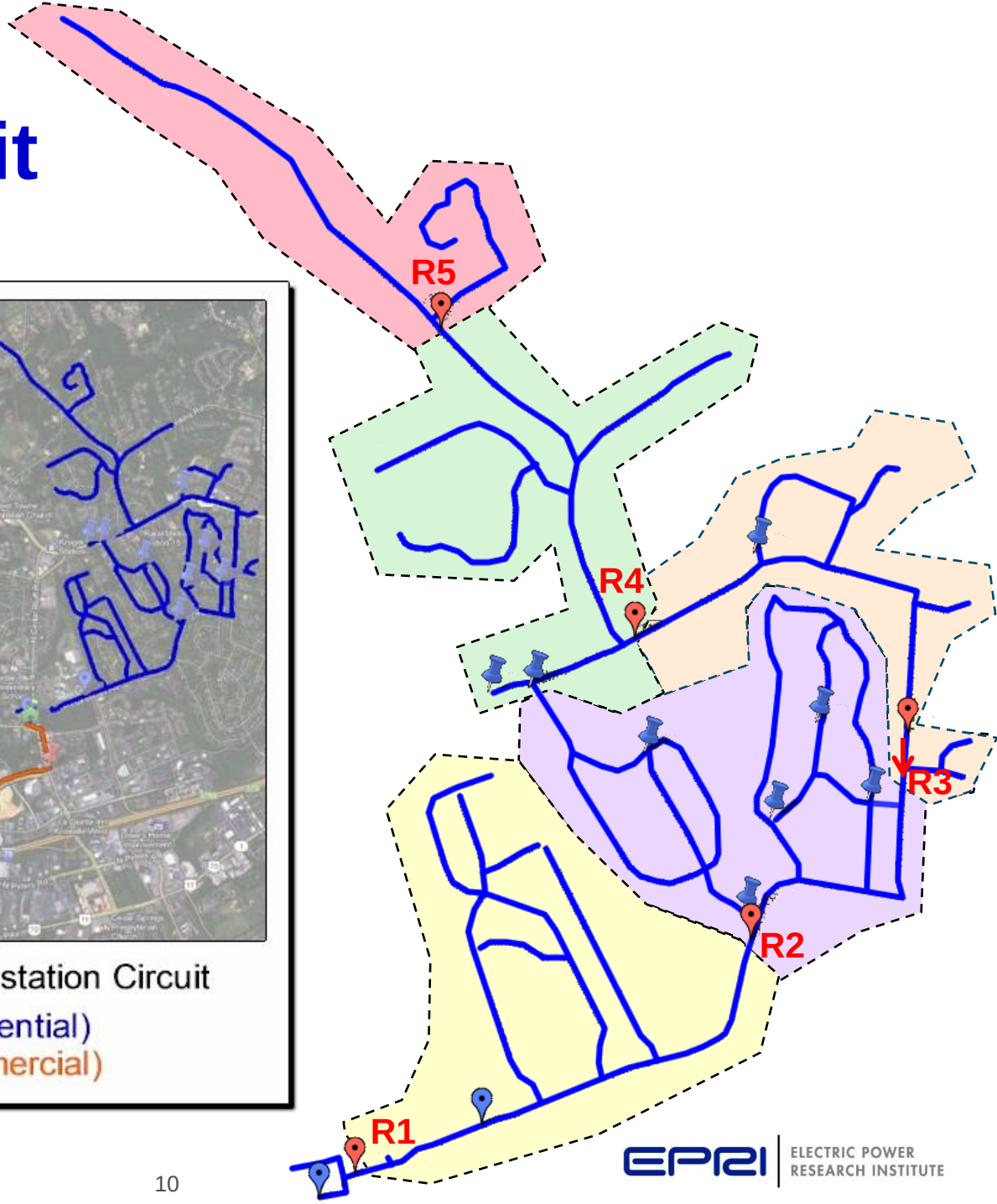

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