



CREATING A RELIABLE CAMPUS POWER DISTRIBUTION NETWORK, WITH FOCUS ON POWER QUALITY

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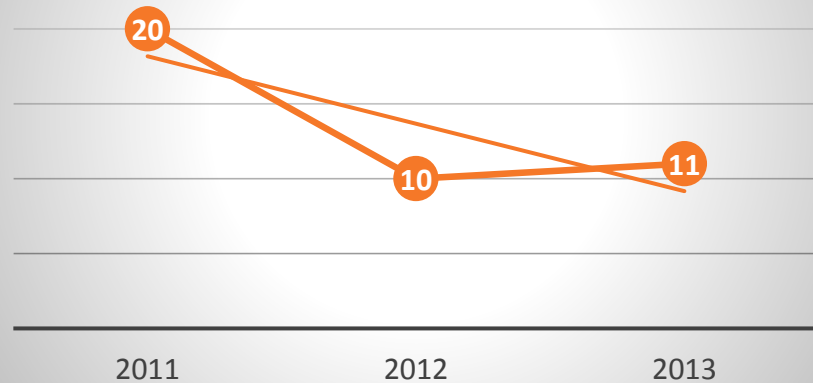
University of Virginia Overview

- Four buildings serve as State Emergency Shelters
- Dominion Energy – local provider
- Three 34.5kV to 13.2kV electric substations serve the University with redundant service
- 62 MW peak demand across three substations
- ~\$17 million annual electricity bill

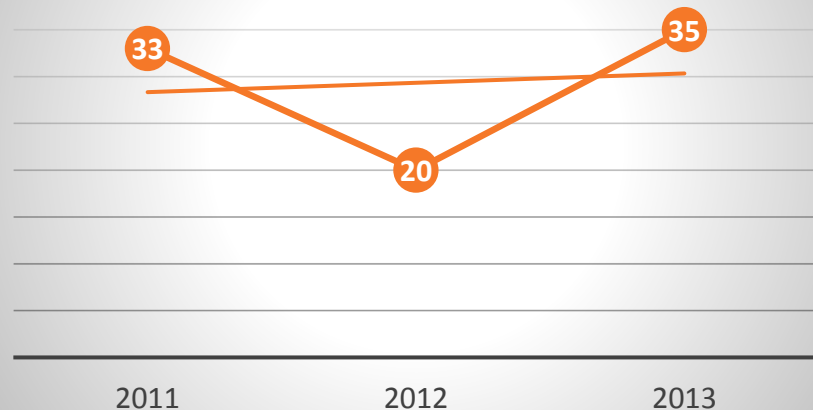


Identifying The Problem

Sustained Outages



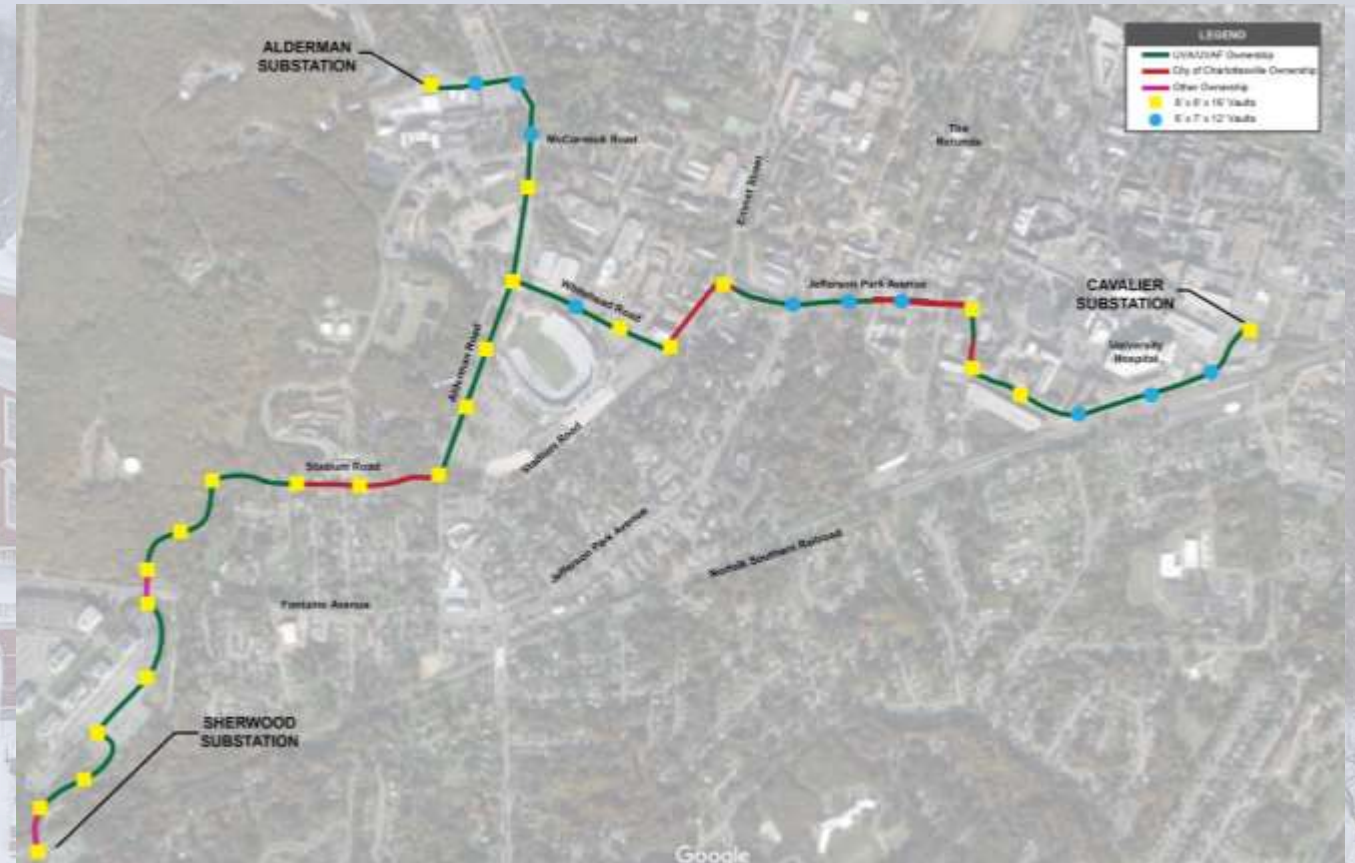
Momentary Outages



- Outages due to overhead exposure/ weather–trees (limited ROW), vehicle accidents, animals, fog, etc.
- What does an outage mean to Utility?
- Negative impact on research/healthcare operations
- Not conducive to world class research/healthcare
- In 2014, formed high level group from both UVa and Dominion Energy

Identifying The Solution and Design

- Dedicated underground feeders
- Dedicated bus
- 90% improvement; near transmission grade
- 2.96 miles of concrete ductbank, 12.85 miles of 8" conduit
- Vaults every 500-600 LF



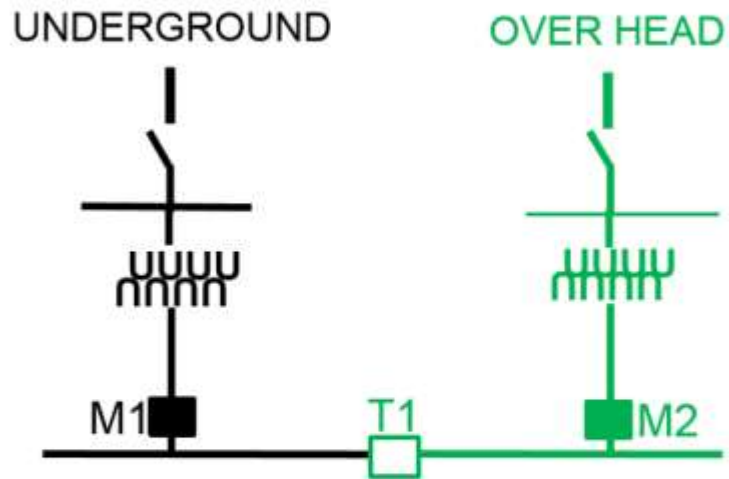
Construction

- 12 months of Construction
- Completed December 2017
- Reclosing in underground distribution system for automatic restoral
- Main(NC)-Tie(NO)-Main(NC) arrangement to Main(NC)-Tie(NC)-Main(NO) to maximize benefits of underground circuit

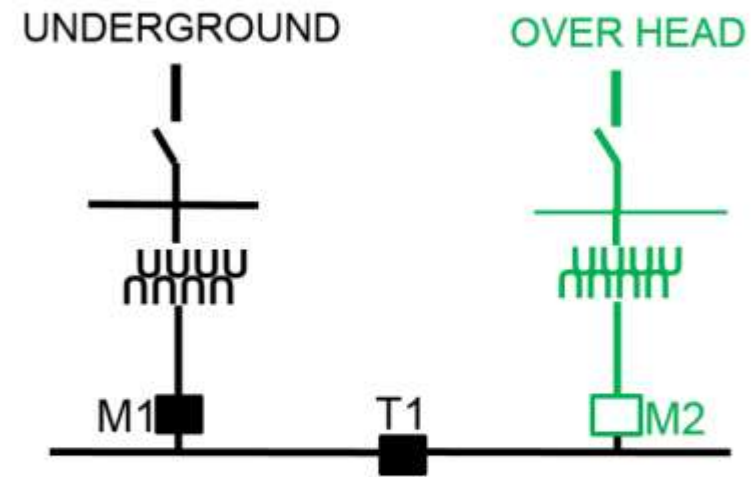


Energization

May 12th, 2018 UVa Substation Tie T1 closed



Old Configuration
(T1 N.O., M2 N.C.)



New Configuration
(T1 N.C., M2 N.O.)

Uninterruptible Power Supply (UPS)



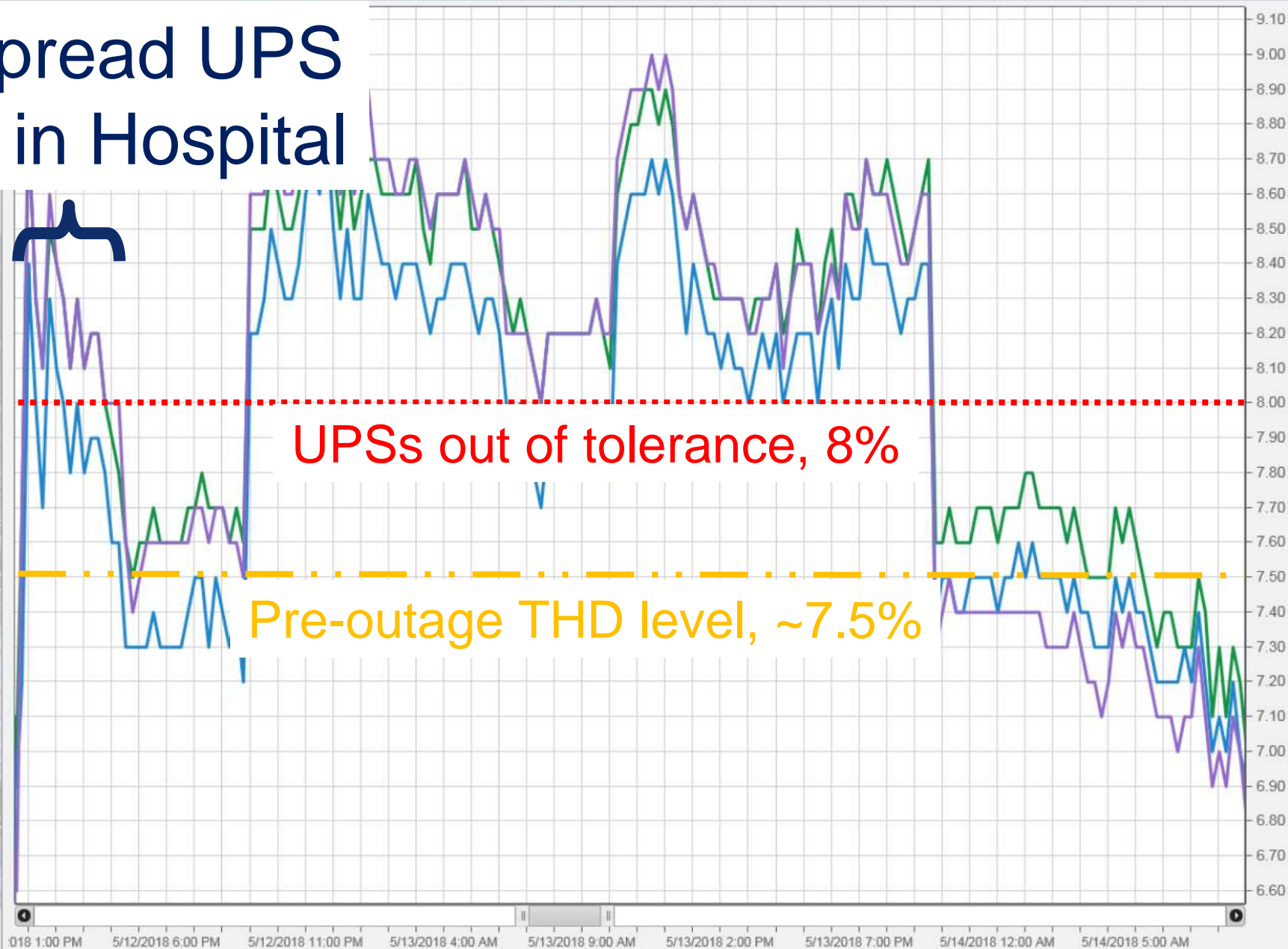
- Powers patient data monitors
- 750VA – 1000VA

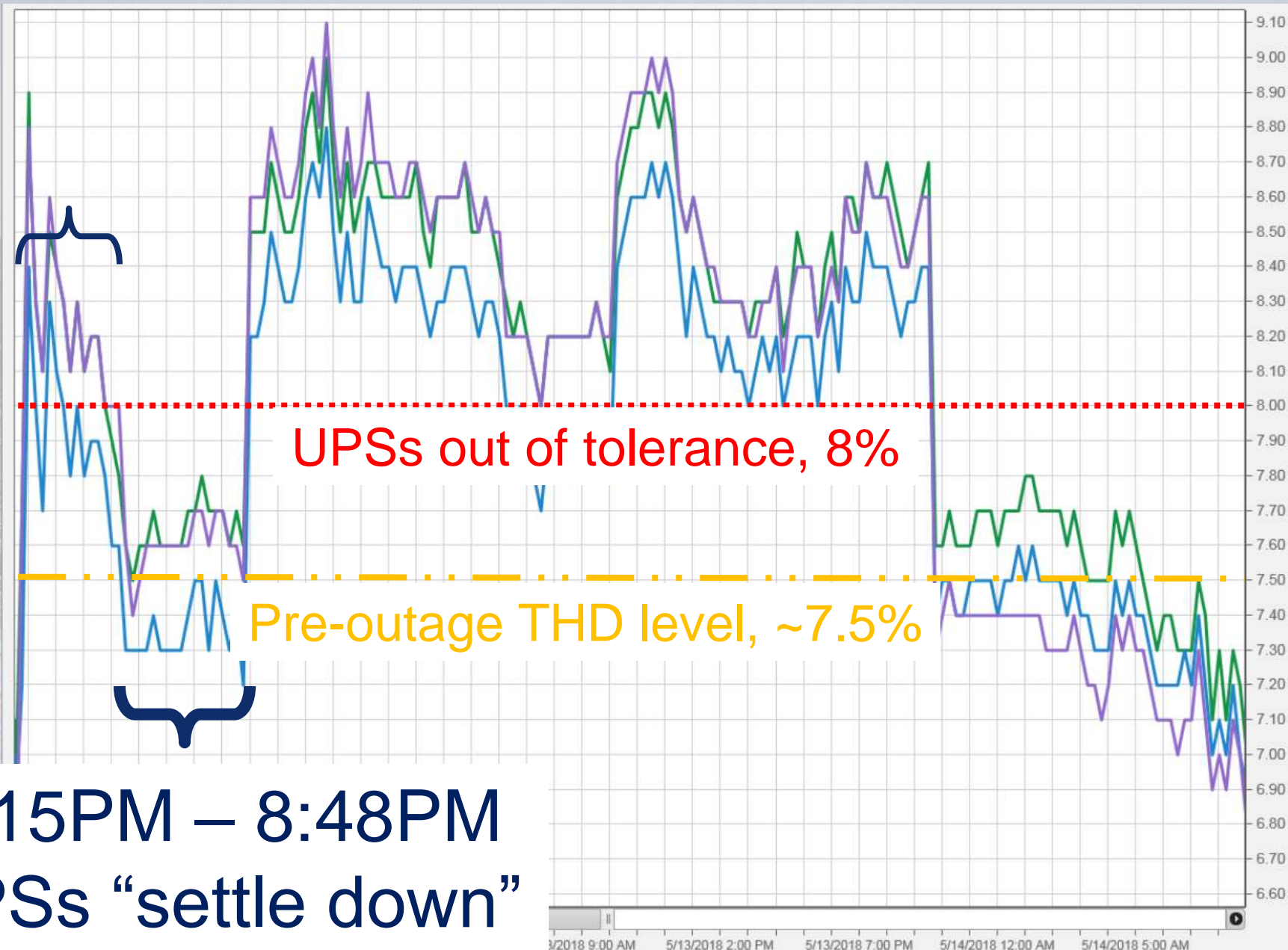
Proprietary Algorithm looking at:

- dV/dt
- Frequency (57Hz-63Hz)
- THD



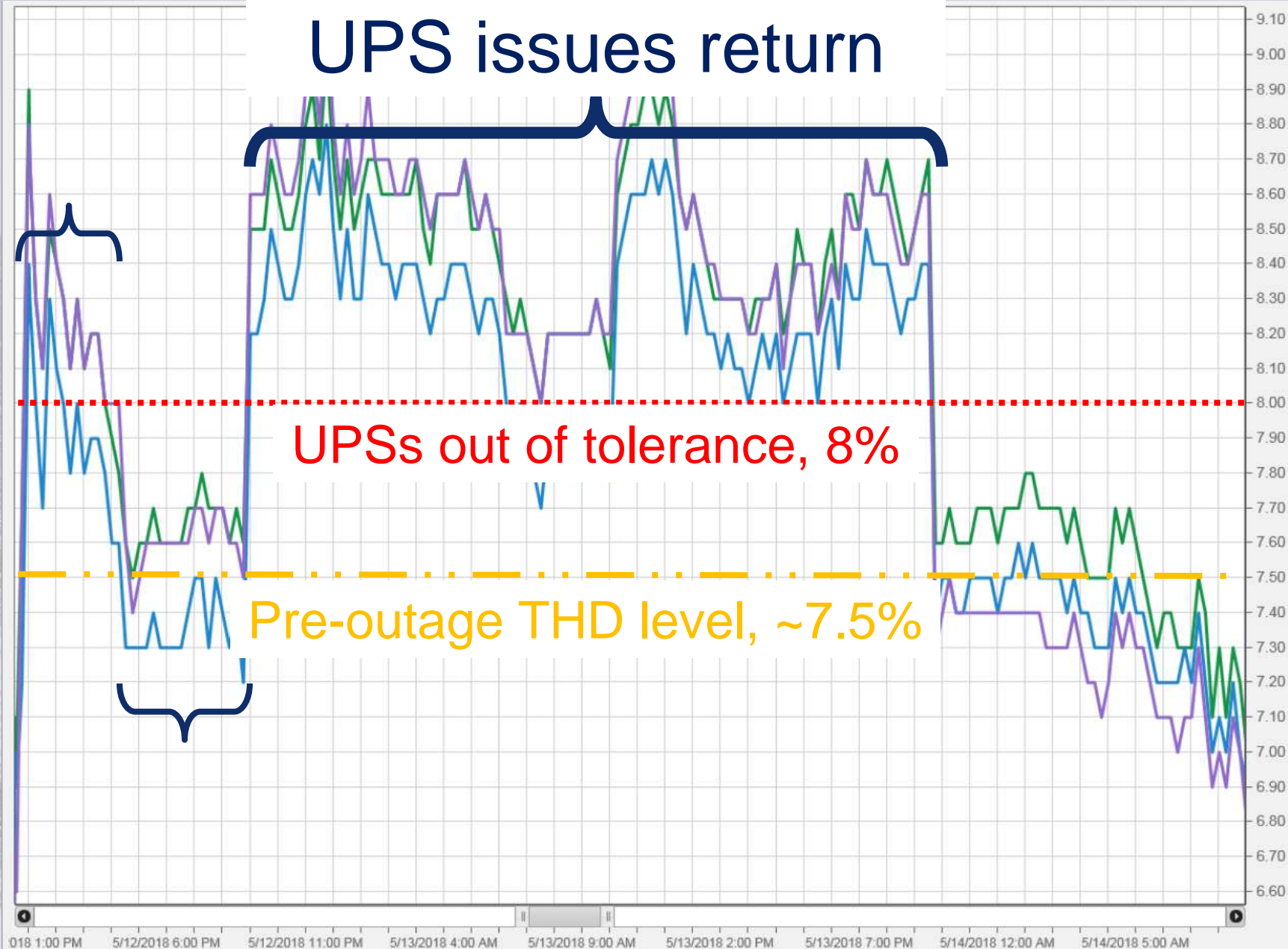
Widespread UPS issues in Hospital

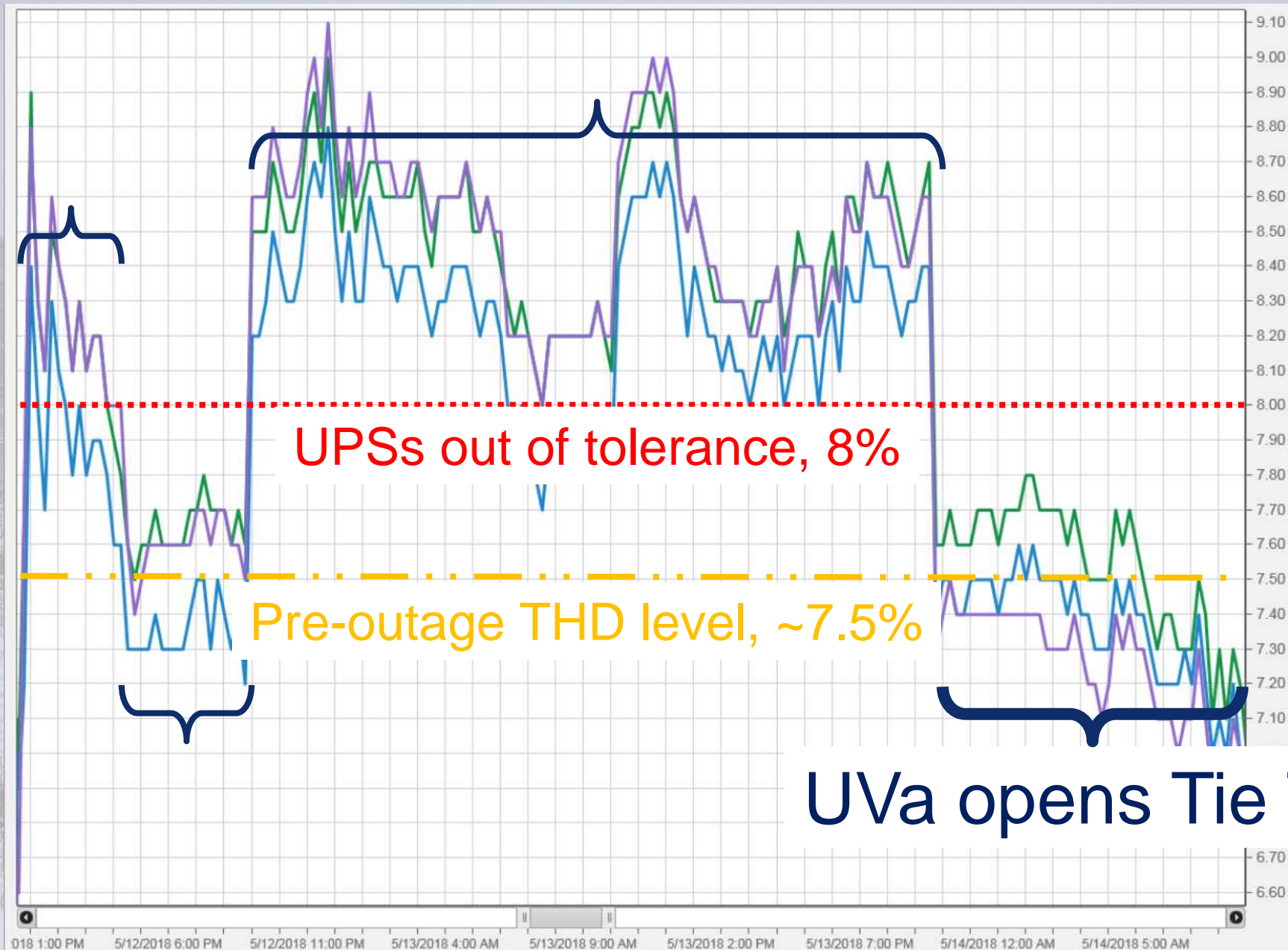




4:15PM – 8:48PM
UPSs “settle down”

UPS issues return





FM Data Plot for May 2018



8:48PM
35kV Cap Bank
Opens at Utility
Substation

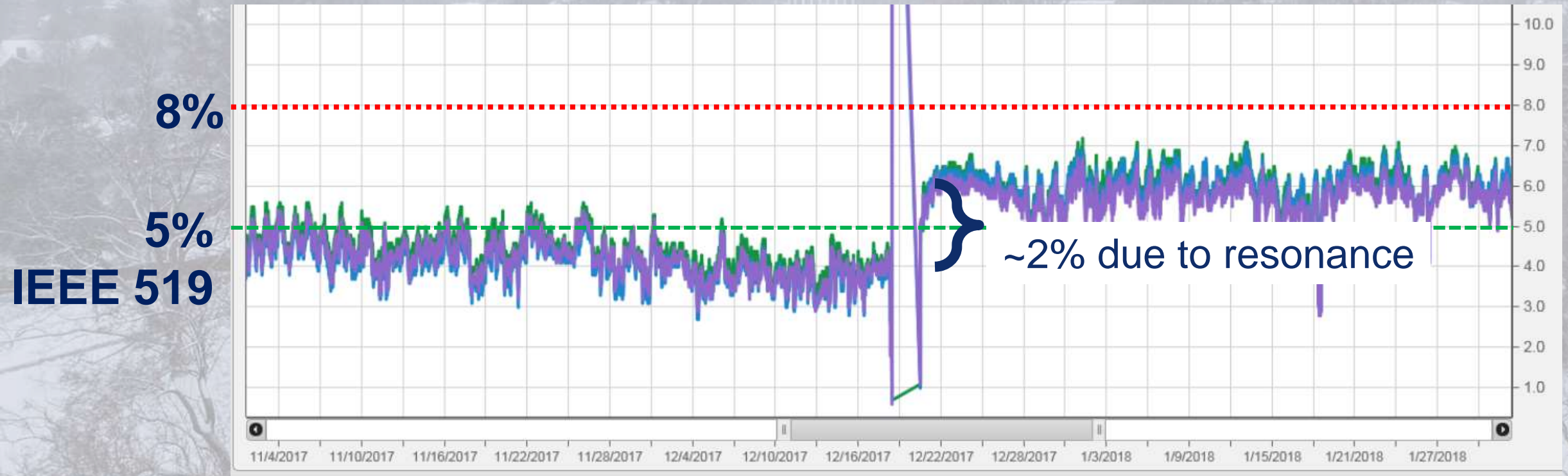
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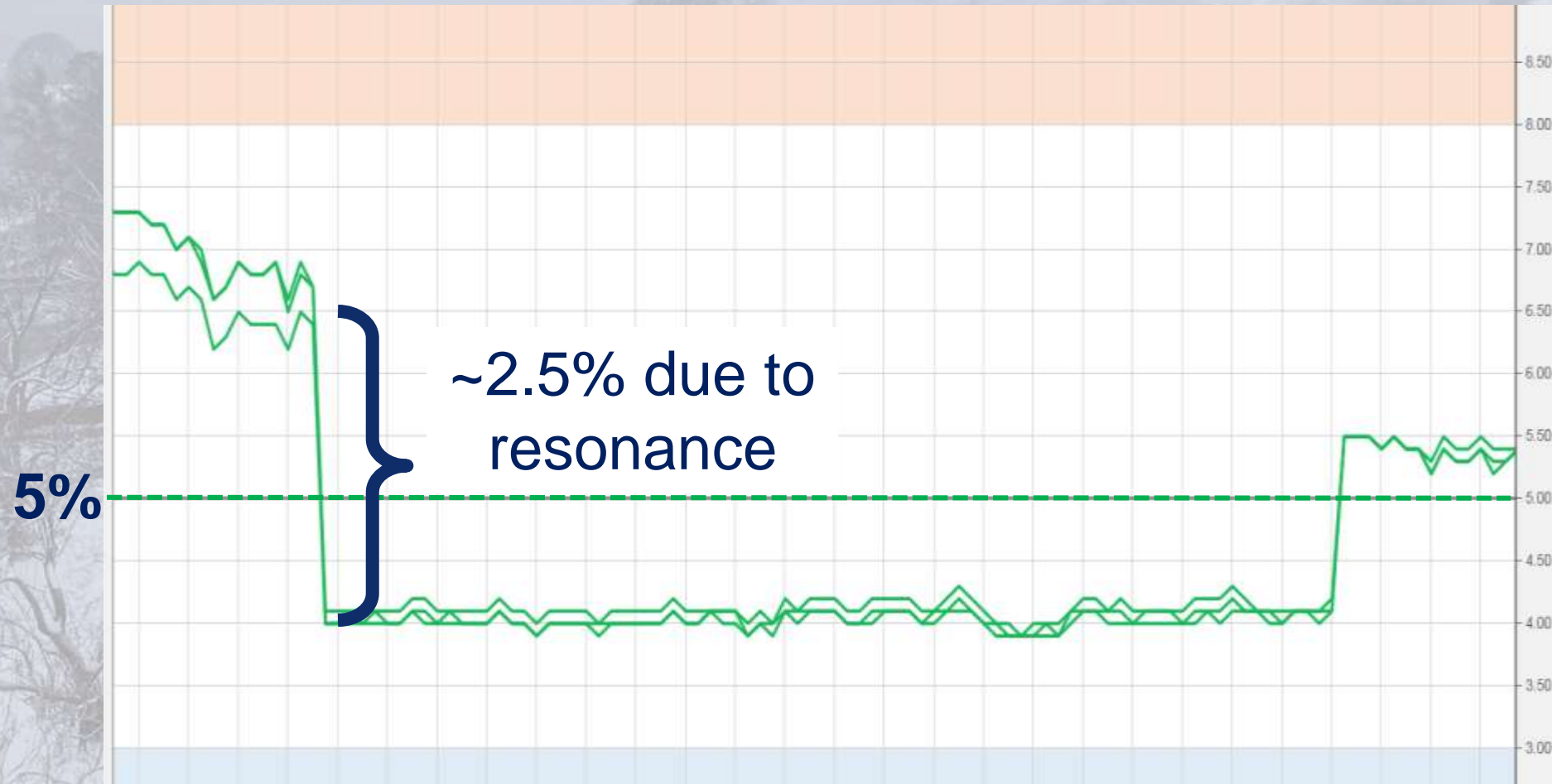
Energization

Dec. 19th, 2017 Underground Circuits energized



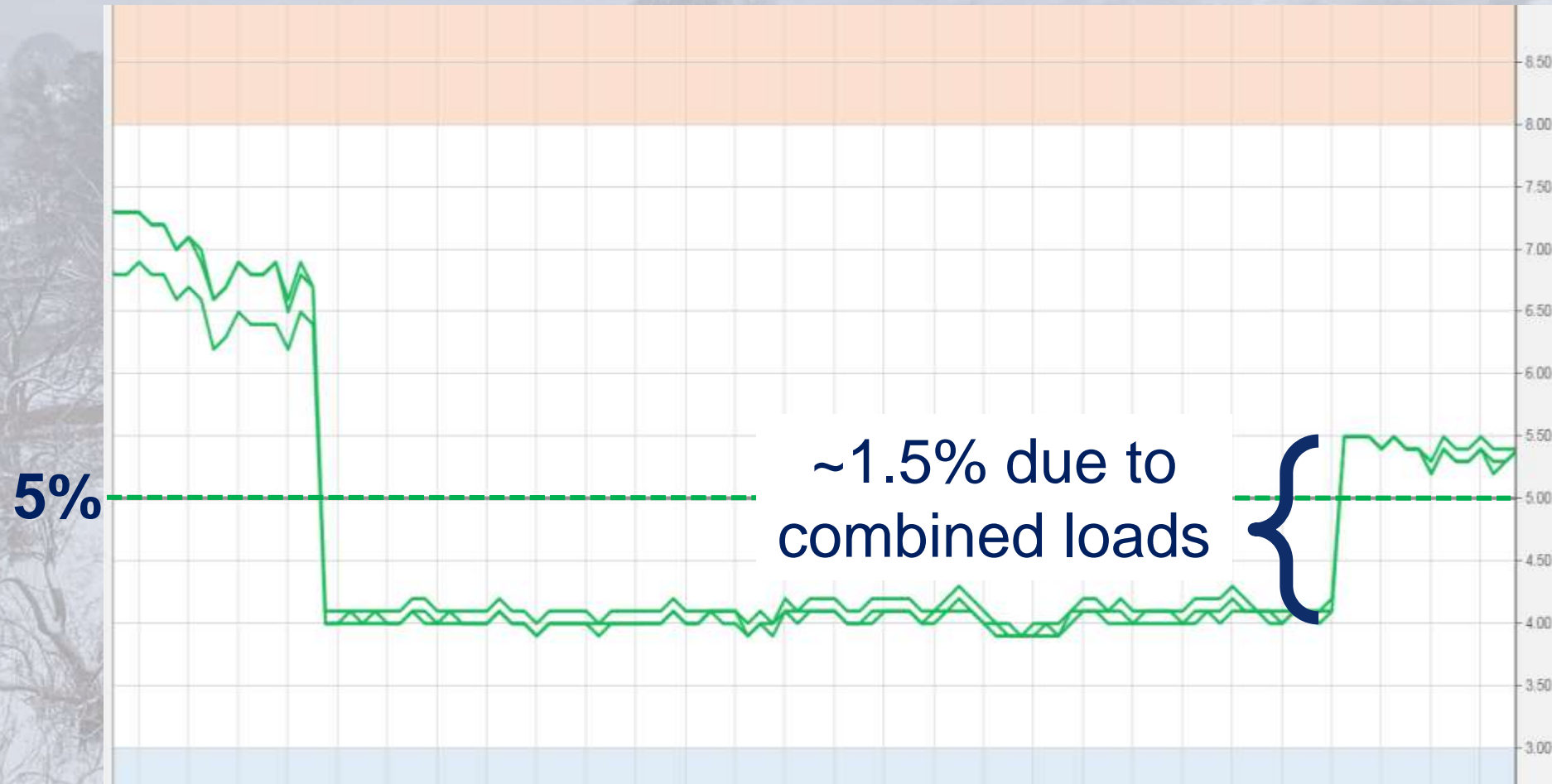
Confirming Hypothesis

Utility opens cap bank at UVa Substation



Confirming Hypothesis

UVa closes Tie T1, Returns system to auto



Contributing Factors

- System Frequency Response
 - Underground Circuit resonance
 - Short-Circuit Capacity (I_{SC}/I_L)
 - Capacitor banks (voltage support, power factor improvement)
- Non-linear loads (harmonic current sources)
 - VFDs, Inverters, Switch Mode Power Supplies
- Combining loads onto a single bus
- Temperature/Season

Dealing with Resonance

- Cap Bank at Utility's 115kV/35kV substation out of automatic operation, manually closed
- Cap Bank at UVa's 35kV/13.2kV substation opened
- 35kV Line Reactors modeled and sized by Utility to be installed to allow Cap banks to go back into operation (Spring 2019)

Investigating Harmonic Current Sources

| Feeder | Amps | I5(%) | I5 (Amps) |
|----------------------|------|-------|-----------|
| Hospital MCCs | 76A | 18.6% | 14.1A |
| Heat Plant Equipment | 42A | 12.6% | 5.3A |

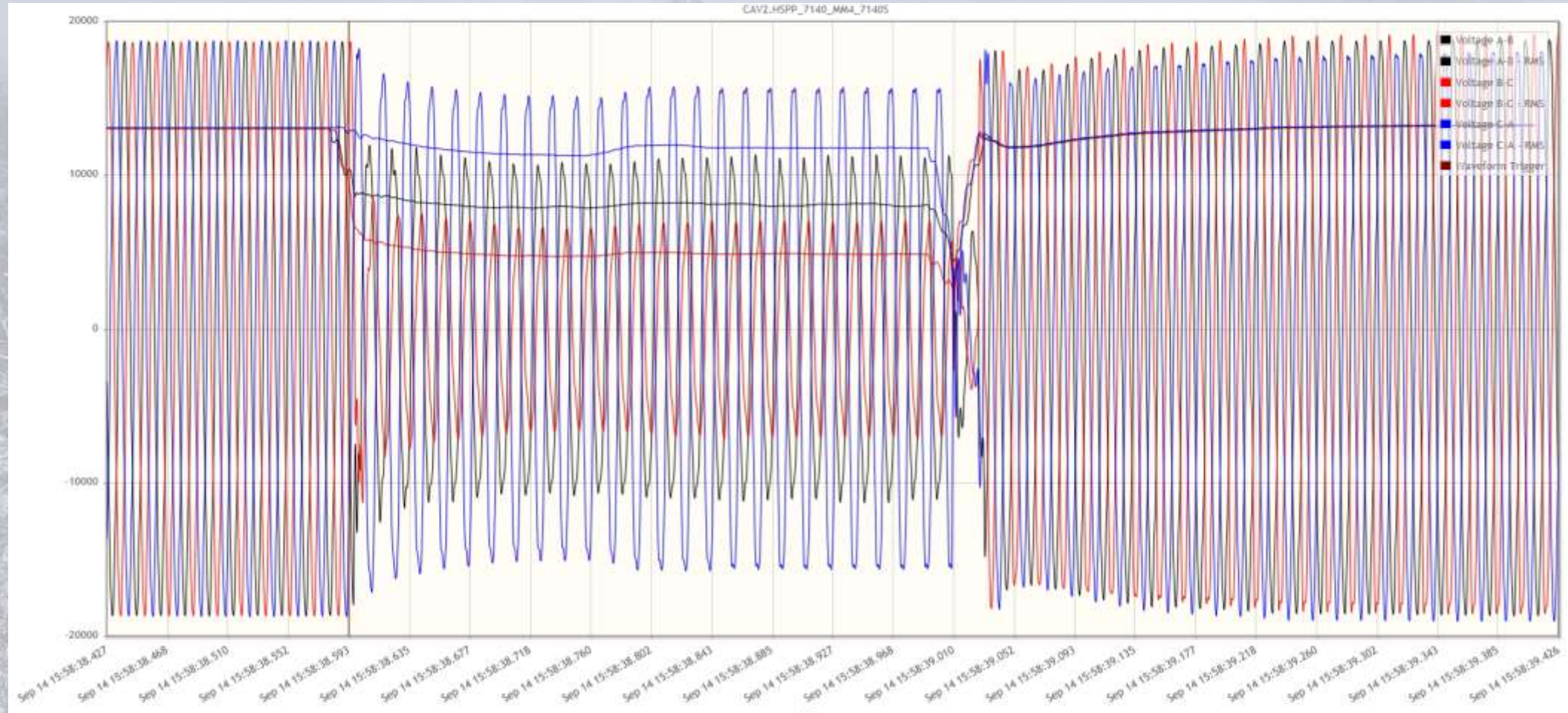
Installing 480V Harmonic Filters w/in Hospital

Benefits of Duct Bank & Dedicated Bus

- >1 hour of voltage loss avoided
- Avoided events due to weather—trees, vehicle accidents, animals, fog, etc.
- Dedicated bus helps to isolate UVa from non-UVa circuits in heavily wooded areas
- Greatly reduced impact of sags

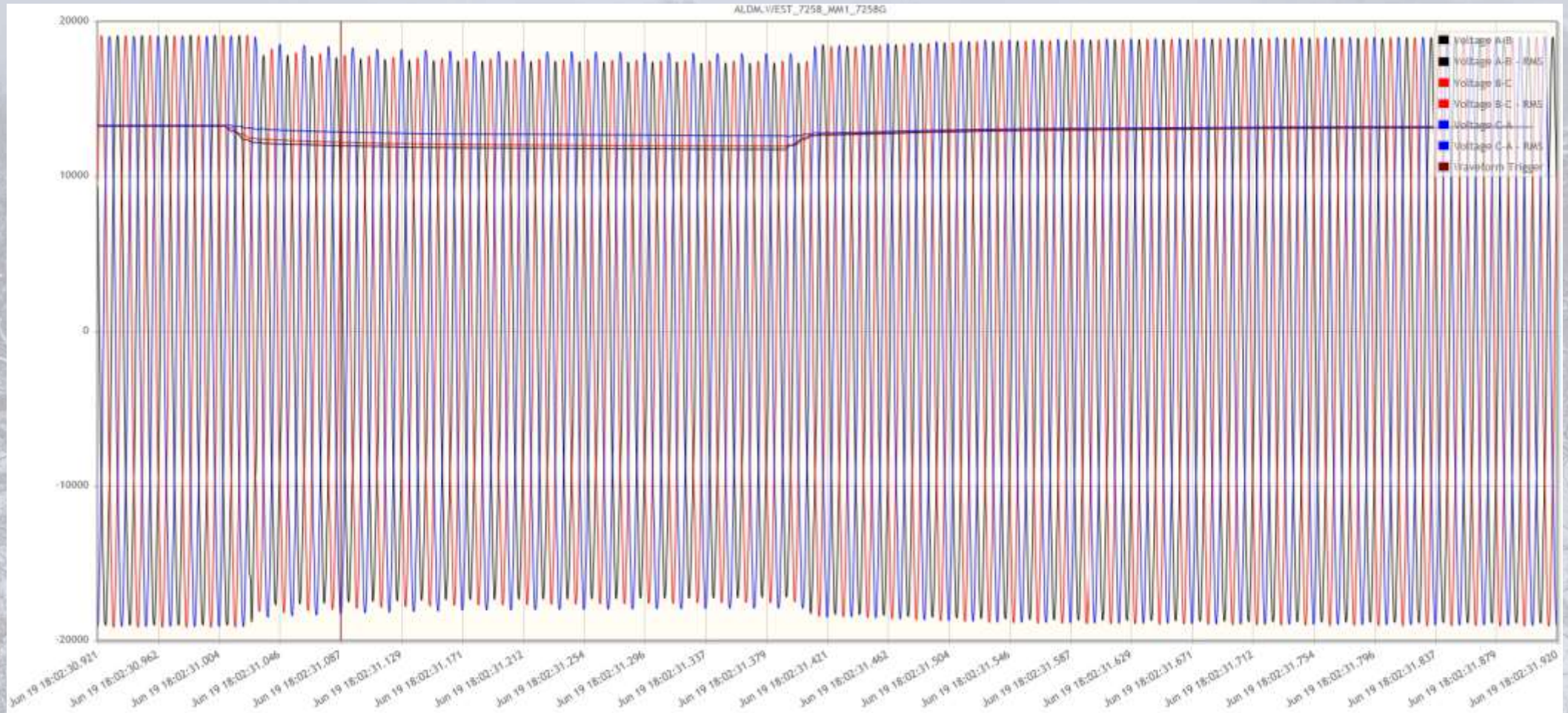
Pre 35kV Duct Bank:

An event on 9/14/2017



Post 35kV Duct Bank:

An event on 6/19/2018



Conclusions

- Keep an eye on Harmonics!
 - Strive to meet IEEE-519 recommendations
 - Archive historical trend data
- Develop partnership w/ your local Utility
- In-house engineering

Questions?

