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

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- 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

- 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:
- $\frac{dV}{dt}$
- Frequency (57Hz-63Hz)
- THD
Widespread UPS issues in Hospital

Pre-outage THD level, ~7.5%

UPSs out of tolerance, 8%
Pre-outage THD level, ~7.5%

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4:15PM – 8:48PM
UPSs “settle down”
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UPSs out of tolerance, 8%

UPS issues return
UVa opens Tie T1

Pre-outage THD level, ~7.5%

UPSs out of tolerance, 8%
4:15PM
35kV Cap Bank Closes at Utility Substation

4:15PM – 8:48PM
UPSs “settle down”

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

Dec. 19th, 2017 Underground Circuits energized

8%

5%

IEEE 519

~2% due to resonance
Confirming Hypothesis

Utility opens cap bank at UVa Substation

~2.5% due to resonance

5%
Confirming Hypothesis

UVa closes Tie T1, Returns system to auto

5% ~1.5% due to combined loads
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

<table>
<thead>
<tr>
<th>Feeder</th>
<th>Amps</th>
<th>I5(%)</th>
<th>I5 (Amps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospital MCCs</td>
<td>76A</td>
<td>18.6%</td>
<td>14.1A</td>
</tr>
<tr>
<td>Heat Plant Equipment</td>
<td>42A</td>
<td>12.6%</td>
<td>5.3A</td>
</tr>
</tbody>
</table>

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?