Proactive Use of PQ Data

Beyond Post-mortem Analysis

Bill Howe, PE
Program Manager, Power Quality

17th Annual PQSynergyTM International Conference and Exhibition

Chiang Rai, Thailand
24 – 26 April 2017
Approaches for PQ Data

Step 1: Identification of Goals for PQ Monitoring
(CIGRE C4.112 Guidelines for PQ Monitoring)

- **Compliance Verification**
  - Regulatory requirements
  - Conformance to standards (e.g.: IEC 61000-3-6, 7, and 13)

- **Performance analysis / benchmarking**
  - Strategic planning and asset management (IEC 61000-4-30)
  - Average PQ and overall trends

- **Site Characterization**
  - Usually customer specific, either for service quality or compliance
  - Often done with temporary monitoring

- **Troubleshooting**
  - Investigation of specific customer or grid PQ issues
  - Often conducted with temporary monitoring

- **Advanced Applications**
  - Aggressive use of PQ data in near- or real-time
  - Enabling outcomes beyond mere measurement and investigation
  - Active PQ management
Approaches for PQ Data

Step 2: Implementation of monitoring

- **PQ Monitoring Type**
  - Portable
    - Characterization
    - Troubleshooting
  - Fixed, but transitory
    - Compliance and verification
    - Benchmarking
  - Permanent
    - Advanced applications plus other outcomes

- **PQ Monitoring Locations**
  - Customer PCC
  - Substations
    - Subset / Sample
    - All buses
  - Proximity to important grid assets
Classic approaches using PQ data

- Post-mortem analysis of grid events
- Threshold-based alarming when limits are exceeded
- Benchmarking based on past performance
- Investigating customer complaints

We can -- and must -- do better!

Source: IEEE 1250
Proactive Use of PQ Data

Continuous tracking of PQ Performance

- Monitoring of PQ parameters on a continuous basis rather than only after-the-fact
- Statistical Process Control (SPC) techniques can be adapted from other industries
Statistical Process Control for PQ

Example
Statistical Process Control for PQ
Detecting problems/issues before they become problems

- In addition to continuous tracking of PQ, SPC techniques allow detection of a very wide range of issues
- Other benefits include data validation
## Proactive Use of PQ Data

### Scenario Analysis of PQ future impact of grid configurations and loads

#### 3) Edit Capacitor Bank Attributes

<table>
<thead>
<tr>
<th>Capacitor Name</th>
<th>Bus</th>
<th>Status</th>
<th>Kvar</th>
<th>Filter</th>
<th>Tuning</th>
<th>Connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacitor.mdv201_hn_2_116_ab...</td>
<td>26285</td>
<td></td>
<td>600</td>
<td></td>
<td>0</td>
<td>wye</td>
</tr>
<tr>
<td>Capacitor.mdv201_hn_2_818_ab...</td>
<td>63707</td>
<td></td>
<td>300</td>
<td></td>
<td>0</td>
<td>wye</td>
</tr>
<tr>
<td>Capacitor.mdv201_hn_2_345_ab...</td>
<td>8081</td>
<td></td>
<td>450</td>
<td></td>
<td>0</td>
<td>wye</td>
</tr>
<tr>
<td>Capacitor.mdv201_da_8_153_ab...</td>
<td>74433</td>
<td></td>
<td>600</td>
<td></td>
<td>4.7000</td>
<td>wye</td>
</tr>
<tr>
<td>Capacitor.63711</td>
<td>63711</td>
<td></td>
<td>600</td>
<td></td>
<td>4.7000</td>
<td>wye</td>
</tr>
</tbody>
</table>
Scenario Analysis of PQ *future* impact of grid configurations and loads

Comparing configurations

- Type (positive/Zero)
- Cap configuration
  - ✓ User selected
  - ✓ All possible combinations
- Screening capability to identify potential problem configurations
2030 Load Mix Harmonic Analysis

- Below is the estimate of proportion of loads belonging to category of non-linear loads based on EIA outlook
- Assumptions for the load mix

<table>
<thead>
<tr>
<th>Load category</th>
<th>2010</th>
<th>2030 Projection (Excluding electronic Lighting and Drives)</th>
<th>2030 Projection (Including electronic Lighting and Drives)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial</td>
<td>40%</td>
<td>48%</td>
<td>60%</td>
</tr>
<tr>
<td>Residential</td>
<td>44%</td>
<td>50%</td>
<td>60%</td>
</tr>
</tbody>
</table>
Combined Impact of Various Harmonic Sources

- The combined impact is not linear as individual harmonics are added vectorally.

Voltage Harmonics at Substation

<table>
<thead>
<tr>
<th>Harmonic</th>
<th>Base Case</th>
<th>Added CFL Alone</th>
<th>Added PEV Alone</th>
<th>Added Entert. Load Alone</th>
<th>Added ECM HVAC Alone</th>
<th>Added All the Loads</th>
</tr>
</thead>
<tbody>
<tr>
<td>H3 (%)</td>
<td>1.9</td>
<td>2.2</td>
<td>1.8</td>
<td>2.1</td>
<td>2.3</td>
<td>2.8</td>
</tr>
<tr>
<td>H5 (%)</td>
<td>2.7</td>
<td>2.2</td>
<td>2.4</td>
<td>2.8</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>H7 (%)</td>
<td>2.1</td>
<td>4.9</td>
<td>1.9</td>
<td>2.7</td>
<td>3.2</td>
<td>4.5</td>
</tr>
<tr>
<td>THD (%)</td>
<td>4.2</td>
<td>6.0</td>
<td>3.9</td>
<td>4.7</td>
<td>4.7</td>
<td>5.9</td>
</tr>
</tbody>
</table>

Predicted increase in THD: ~40%
Proactive Use of PQ Data

Incipient Failure Detection

- PQ Monitors are an important sensor
  - Strategically located
  - Higher resolution data

- PQ monitoring, however, is NOT just a sensor
  - A dedicated team committed to design, O&M, and application of the data

- Many grid-connected devices can be monitored using PQ data
  - Transformers
  - Capacitors
  - Load Tap Changers
  - Reclosers
  - Etc.
Incipient Failure Detection using PQ Data
Capacitor Switch Assessment

- CSA Extended Analytics Service for PQ Dashboard (Software)
  - Gap:
    - Last year's Capacitor Switching Assessment Module (CSA-DLL), does not have the appropriate interface for automated reporting through PQ Dashboard.
  - Objective:
    - Provide an automated reporting function through PQ Dashboard or other platform to report Capacitor Switching Assessment
  - Description:
    - 2015 delivered:
      - Implementation of Capacitor Switching Assessment Module (CSA-DLL), a Matlab Based DLL, Product ID: 3002005960
      - Open Source Extended Analytics Service Template (EAS-T), Product ID: 3002005961
    - The EAS-T will be used to develop an EAS to run the CSA-DLL utilizing PQ data through OpenXDA for reporting through the PQ Dashboard
  - Benefits & Value:
    - Automatic process performs near real-time analysis in time to react to CSA condition instead of post event analysis.
    - Currently being applied at TVA and other utilities
Capacitor Switching Assessment using PQ Data Sample CSA Event & Report
Together…Shaping the Future of Electricity