DOE/OE Transmission Reliability Program

Reliability Standards Analysis and Assessment

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June 3-4, 2014
Washington, DC
Research Projects

Reliability Standards Analysis and Assessments:
- Frequency Response Event Collection and Analysis
- NERC Interconnections 2013 Annual Grid Reliability Performance Analysis and Report
Reliability Standards Analysis and Assessment

Objective:

Provide analytical support to the NERC committees/groups (Resource Subcommittee and RS-Frequency Working Group) to:

- Perform grid reliability metrics analysis using data collected in CERTS applications as requested by the RS

- Analyze collected data to assess reliability performance at different levels – Interconnection, Reliability Coordinator, Balancing Authority

- Perform analysis, testing, and monitoring of current and proposed reliability standards
Reliability Standards Analysis and Assessment

Major technical goal for this year:

— **Frequency Response Event Collection and Analysis**
  - Use the delta frequency and Point C methodologies to detect, capture, and analyze significant frequency events and related key parameters in support of NERC Frequency Response Standards development
  - Refine the current methodologies and thresholds to be monitored and refined/modified as necessary
    - New T0 detection method
    - New HQ detection threshold

— **NERC Interconnections 2013 Annual Grid Reliability Performance Analysis and Report**
  - Analyze 2013 Load-Generation control performance metrics for the Eastern, WECC, and ERCOT interconnections, and prepared report for the Resource Subcommittee
Frequency Response Event Collection
and Analysis Background

First day of each month
Request missing FNET data
Check frequency data availability for all interconnections
Detect events for all interconnections

A frequency event is detected and captured if, during a 15-second rolling time window, the change in frequency exceeds the predetermined threshold. The following criteria are applied for the Eastern and ERCOT interconnections:

- **Eastern**: Frequency at/below 59.96 Hz and delta frequency of at least 30 mHz within a 15-second time window.
- **ERCOT**: Frequency at/below 59.90 Hz and at/above 60.10 Hz.

Points:
- **T(0)** (beginning of event) - The point with the minimum frequency change of 5 mHz within a 1-second window.
- **Value A** - Average frequency values between T(-16) and T(-1).
- **Value B** - Average frequency values between T(20) and T(52).
- **Point C** - Min/Max Frequency within 12 seconds after T(0).

Collect actual MW loss reported by NERC SA/Calculate estimated MW loss:

\[ \text{MWLoss (Est.)} = \text{Max}(\text{Delta ACE(BA)}) \times 0.1 \times \text{FreqBias} \times \text{DeltaFreq} \]

The Constants are:
- EI & WECC = 0.6
- ERCOT = 0.3
- HQ = 0.1

Send monthly report to NERC RS Frequency Working Group (FWG)

The NERC RS-FWG reviews at their Quarterly meetings and jointly selects the final candidate events that BAs will use to measure their yearly Frequency Response performance.

Identify key parameters: T0, FreqA, FreqB, and FreqC

NERC SA Reported

Identify key parameters: T0, FreqA, FreqB, and FreqC
Old Method to Detect T(0)

- **T(0) Definition:** Beginning of event
- Finding the correct location for T(0) is very important since every other parameter depends on it
- **Current detection method:**
  - The point with the minimum frequency change of 5 mHz within 1-second
  - Current detection method does not always find the correct location and a manual process has to be utilized
- **Why?**
  - The fixed threshold are for all four interconnections
  - The normal fluctuation ranges from different interconnections are different
  - Even in same interconnection, the normal fluctuation ranges from difference sources are different
- **Solution:**
  - Combination of the first derivative and second derivative method is used
  - There is no fixed threshold. A statistical test, Grubbs Test, is implemented to find the T(0)
New Method to Detect $T(0)$

Outliers detected by Grubbs Test
HQ Frequency Event Detection Threshold Tuning

- The old frequency event detection threshold for HQ is 300 mHz
- The number of events detected have increased substantially. 25 events were detected in July 2013
- CERTS/EPG tested the number of events with different thresholds for last 9-months and presented the result to RS in the October 2013 meeting
- The RS decided to revise the HQ detection threshold to **350 mHz** for loss of Generation and for loss of Load events.
- Implementation of the revised threshold keeps the number of events detected manageable and still provide sufficient number (2 to 3) of candidate events per month for BAL-003
Frequency Response Event Collection and Analysis

Results and Conclusion:
– A monthly report summarizing the frequency events collected with the corresponding plots is prepared, analyzed and submitted to the NERC RS-FWG
– These monthly summary reports are posted on the NERC RS website under “Candidate Frequency Events”
– The NERC RS-FWG reviews the submitted summary reports at their Quarterly meetings and jointly select the final candidate events that BAs will use to measure their yearly Frequency Response performance
– The current process and methodologies have been accepted and approved by the NERC RS as being effective in identifying candidate events for the implementation of Reliability Standard BAL-003

Next Steps:
– EPG will continue to work closely with CERTS and the NERC RS-FWG to detect, capture and analyze all significant frequency events for all interconnections
– The current methodologies and thresholds will continue to be monitored and refined/modified as necessary

EPG acknowledge the collaborative effort of Mr. Carlos Martinez at Advanced Systems Researchers in the preparation and production of the monthly summary reports
NERC Interconnections 2013 Annual Reliability Performance Analysis

Background:

– Currently EPG uses the NERC ACE and Frequency data to generate and distribute an automated Interconnections Daily Reliability Report to the FERC/NERC authorized users

– On an annual basis, EPG uses the same NERC ACE and Frequency data to analyze several key grid reliability metrics and prepare a grid performance summary report for submittal to the NERC Resource Subcommittee for their review and assessment of the reliability performance at the interconnection level
Interconnections Annual Reliability Report

Results and Conclusion:

- Number of hours during which Interconnections Epsilon Variability Exceeded Statistical Process Control (SPC) Criteria increased from year 2012 for the EI and ERCOT, and decreased for WI
  - Eastern, increased from 4 to 6
  - ERCOT, increased from 2 to 4
  - Western, decreased from 5 to 4
- Interconnections CPS1 and CPS2 Trend:
  - All three Interconnections operated above CPS1 threshold
  - Eastern and Western operated below CPS2 threshold; ERCOT operated above CPS2 threshold (ERCOT is exempted from CPS2)
  - Graph for 6 years attached
- Number of Events when Frequency > FTL Low/High Limits:
  - FTL Low limit – Eastern and ERCOT decreased, Western increased
  - FTL High limit – Eastern and ERCOT decreased, Western increased

Next Steps:
- Continue to monitor and performance interconnection reliability performance and present results to NERC RS
Interconnections CPS1 6-Year Trend

- Eastern
- Western
- ERCOT

CPS1 [Percent]

Interconnections CPS2 6-Year Trend

CPS2 Standard Threshold

Year

2008 2009 2010 2011 2012 2013

CPS2 [%]

65 70 75 80 85 90 95 100 105

Eastern Western ERCOT
Interconnections Frequency Response Trend

These Frequency Response values are calculated for the BAL-003-1 field trial candidate events by using 1-second frequency data and the reported actual MW loss data. (El 76 events, WI 28 events and HQ 53 events)

Frequency Response values are calculated by the equation:

\[ Fr = \frac{MW\text{Loss}}{10(FreqB - FreqA)} \]

![Graph showing the trend of interconnections frequency response for events from 2008 to 2013.](image)

<table>
<thead>
<tr>
<th>Interconnection</th>
<th>2013</th>
<th>2012</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastern</td>
<td>2254</td>
<td>2187</td>
<td>NA</td>
</tr>
<tr>
<td>Western</td>
<td>1491</td>
<td>1294</td>
<td>NA</td>
</tr>
<tr>
<td>ERCOT</td>
<td>899</td>
<td>611</td>
<td>530</td>
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</table>

<table>
<thead>
<tr>
<th>Interconnection</th>
<th>2013 %</th>
<th>2012 %</th>
<th>2011 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastern</td>
<td>36</td>
<td>34</td>
<td>NA</td>
</tr>
<tr>
<td>Western</td>
<td>76</td>
<td>65</td>
<td>NA</td>
</tr>
<tr>
<td>ERCOT</td>
<td>134</td>
<td>92</td>
<td>81</td>
</tr>
</tbody>
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Summary

Accomplishments and Next Steps:

– Frequency Response Event Collection and Analysis
  • EPG will continue to work closely with CERTS and the NERC RS-FWG to detect, capture and analyze all significant frequency events for all interconnections
  • The current methodologies and thresholds will continued to be monitored and refined/modified as necessary
  • The estimate MW loss parameters need to be re-evaluated since the frequency response as the percentage of yearly frequency bias changes

\[
\text{MWLoss (Est.) = Max(DeltaACE(BA)) - Const*10*FreqBias*DeltaFreq}
\]

The Constants are: EI & WECC = 0.6; ERCOT = 0.3; HQ = 0.1

– NERC Interconnections 2013 Annual Reliability Performance Analysis and Report
  • The 2013 Annual Grid Reliability Performance Report for the Eastern, WECC, and ERCOT interconnections has been completed and submitted to the NERC Resource Subcommittee

Risks and Challenges:

– Availability of quality data reliably and timely
– Consensus on methodology to be used and its application

Next Steps:

– Continuing support of this activity is critical to continue to research and analyze reliability performance and proposed standards in light of changing resource mix, smart grid technologies, and integration of intermittent renewable resources