Regulation Signal Analysis
Single-Signal Approach

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Agenda

- Review of the PJM’s Regulation Simulation Tool
- Output Metric
- Testing Approach
- Simulation Parameters and Assumptions
- Simulation Results
- Next Steps
PJM Regulation Signal Simulation Tool

ACE Formulation

Controller Design Types (PI, AC2, Conditional Neutrality, etc.)

Historical Interchange & Frequency minus Response to Historical Signals (Uncorrected ACE)

Actual Interchange Delta

Signal Formulation (RegA, RegD)

Generation Response (MW)
What is CPS1 Metric?

- CPS1 is the 12-month rolling average control performance metric that compares the RTO ACE against measured frequency deviation over periods of time.

- It is expressed as follows:

\[ CPS1 = (2 - CF1) \times 100\% \]

\[ CF1 = \left( \frac{CF_{1_{min}}}{12\text{month}} \right) \left( \varepsilon_1 \right)^2 \]

\[ CF_{1_{min}} = \frac{ACE_{1_{min}}}{-10B} \times \Delta f_{1_{min}} \]

- B is the control area frequency bias, \( \Delta f_{1_{min}} \) is the 1 minute average of frequency deviation. \( ACE_{1_{min}} \) is the 1 minute average of ACE. \( \varepsilon_1 \) is the specified steady state frequency bound for each interconnection (for the Eastern Interconnection, it is equal to 0.018 Hz.)

- If the CPS1 is greater than 100%, the control area is helping the interconnection frequency response.
• We assume to have one generic response for all the resources.

• We used Traditional PI Controller (controller that was used prior to 2017) to send the response to RegA resources.

• The response sent to RegD signal resources has been set to 0.

• The simulation parameters were tuned based on the numbers from RTO Regulation Control.
Simulation Parameters and Assumptions

• The results are for a week in June 2022 (6/1/2022 to 6/7/2022). The summer ramping hours are from 6 to 14 and from 19 to 24.

• In this analysis, we ran multiple simulation with Traditional PI Controller and RegD signal was zeroed out to get the results for a similar condition to when we have a single regulation signal.

• The results were compared to Actual CPS1 scores (which we got from performance compliance) for the same days.

• In this analyses, RegD value was 0 and the variables were RegA MW and RegA Response Times.
Sample Results: CPS1 Comparison for Different RegA MW

- Descriptive Statistical Analysis on CPS1 Scores (for 7-day time span)

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Mean</td>
<td>134.52</td>
<td>130.34</td>
<td>130.87</td>
<td>131.13</td>
<td>131.26</td>
<td>131.34</td>
<td>131.40</td>
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<tr>
<td>Change in Overall Mean*</td>
<td>-</td>
<td>-3.11%</td>
<td>-2.71%</td>
<td>-2.52%</td>
<td>-2.42%</td>
<td>-2.36%</td>
<td>-2.32%</td>
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<tr>
<td>Standard Deviation</td>
<td>39.87</td>
<td>55.71</td>
<td>54.91</td>
<td>54.53</td>
<td>54.37</td>
<td>54.29</td>
<td>54.25</td>
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<tr>
<td>Range</td>
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<td>303.86</td>
<td>299.86</td>
<td>299.33</td>
<td>299.11</td>
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<td>298.67</td>
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<td>Confidence Level (95.0%)</td>
<td>6.07</td>
<td>8.49</td>
<td>8.36</td>
<td>8.31</td>
<td>8.28</td>
<td>8.27</td>
<td>8.26</td>
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</tbody>
</table>

* It shows the difference between each case with the actual CPS1 score over the one-week analysis time-span.
Sample Results: Daily CPS1 Score Comparison
Sample Results: Regulation Signal and the Response

- RegA requirement is 800 MW for this simulation. This graph shows the results between 10 AM to 11 AM on June 3rd of 2022.
CPS1 Score Comparison for Different RegA Response Times

- RegA requirement is 800 MW and RegD is 0 for this simulation.

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Actual Score</th>
<th>RT = 35 s</th>
<th>RT = 15 s</th>
<th>RT = 6 s</th>
<th>RT = 4 s</th>
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</thead>
<tbody>
<tr>
<td>Mean</td>
<td>134.52</td>
<td>131.13</td>
<td>132.10</td>
<td>132.76</td>
<td>132.95</td>
</tr>
<tr>
<td>Change in Overall Mean</td>
<td>-</td>
<td>-2.52%</td>
<td>-1.80%</td>
<td>-1.30%</td>
<td>-1.17%</td>
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</table>
Next Steps

• Conducting more simulations to compare the current construct to a single-signal approach.
• Researching on additional details and parameters for a single-signal design proposal.
• Researching on the other performance metrics and comparing the results with the same metrics from status quo.
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Regulation Signal Analysis

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