Frequency Response Analysis Tool (FRAT)

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FERC defines in RM13-11:

“Frequency response is a measure of an Interconnection’s ability to stabilize frequency immediately following the sudden loss of generation or load, and is a critical component of the reliable operation of the Bulk-Power System, particularly during disturbances and recoveries.”

► The frequency response measure (FRM) can be computed from the single event frequency response data (SEFRD).
► FRM is expressed in MW/0.1Hz
Frequency Response Analysis Tool (FRAT)

- Developed under BPA guidance by PNNL
- Development is co-funded by US DOE and BPA
- Frequency response monitoring
  - Interconnection
    - Balancing Authority
      - Power Plant (*Under development*)
      - Individual Unit (*Under development*)
- Calculation NERC FRM using PMU and SCADA measurements
- Compliance reporting
- Baselining frequency response for interconnection and BA
- Supporting different data formats (csv, xml, OSIsoft PI, COMTRADE)
- Statistical Analysis
Graphical User Interface

The image shows a graphical user interface (GUI) for monitoring and analyzing frequency response events. The interface includes:

- Event Database:
  - **Event Name**: Event 4
  - **Date**: 07/06/14
  - **Time**: 00:00:00
  - **Event Characteristics**:
    - **Qualifying Event**: Trip of Gen A
    - **Load/Generation**:
      - **Initial Time**: 52.396
      - **Initial Frequency**: 59.99
    - **Minimum Time**: 9.654
    - **Minimum Frequency**: 59.89
    - **Settling Time**: 22.854
    - **Settling Frequency**: 59.92
    - **Frequency 20**: 59.917
    - **Frequency 30**: 59.927
    - **Frequency 60**: 59.934
    - **Frequency 90**: 59.935
  - **NERC Performance**:
    - **Interconnection**:
      - **FA NERC**: 59.994
      - **FB NERC**: 59.926
      - **FRM NERC**: 1911.765
    - **Balancing Authority**:
      - **PA NERC**: 10172.954
      - **PA Interchange**: 10359.792
      - **FB Interchange**: 2186.556
      - **FRM BA**: 18171.825
      - **PA Generation**: 16303.395
      - **PB Generation**: 2105.25

- Frequency Response Analysis:
  - **Event Plot**:
    - **f_{min}**, **f_{30}**, **f_{60}**, **f_{90}**
    - **Time, s**
    - **Actual Power**: NET_INTERCHANGE_Actual
  - **BA Baseline Plot**
    - **BA FRM PDF**
    - **Statistics**:
      - **Parameter** Value
        - Mean: 1127
        - Median: 1123
        - STD: 1109

The GUI includes various tools for data analysis and visualization, enabling users to monitor and understand frequency response events.
Interconnection and BA Baselining

![Frequency Response Tool](image)

- **Event Database**
- **Event Plot**: Frequency vs. Time
- **Interconnection Baseline Plot**: FRM = 0.52^x - 740.13

**March 26, 2015**
Statistics

FRO = 81 MW/0.1 Hz
OSIsoft PI database support

- Read information from PI server
- Configurable presets
- Time-series aligning
Automated reporting

Frequency Response Analysis Report

Event 1: "Event 1"

Event Characteristics Table

Event 2: "Event 2"

Event Characteristics Table
Power Plant Performance (under development)

Event Database

<table>
<thead>
<tr>
<th>Event Name</th>
<th>Date</th>
<th>Time</th>
<th>Disturbance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Event 1</td>
<td>10/02/08</td>
<td>14:51:00</td>
<td>2000</td>
</tr>
<tr>
<td>Event 2</td>
<td>09/27/10</td>
<td>14:51:01</td>
<td>2000</td>
</tr>
<tr>
<td>Event 3</td>
<td>07/33/13</td>
<td>11:00:00</td>
<td>2100</td>
</tr>
<tr>
<td>Event 4</td>
<td>05/06/17</td>
<td>20:00:00</td>
<td>2000</td>
</tr>
<tr>
<td>Event 5</td>
<td>05/06/19</td>
<td>5:00:00</td>
<td>2100</td>
</tr>
<tr>
<td>Event 6</td>
<td>05/10/14</td>
<td>9:00:00</td>
<td>1900</td>
</tr>
<tr>
<td>Event 7</td>
<td>05/10/12</td>
<td>10:20:00</td>
<td>1604</td>
</tr>
<tr>
<td>Event 8</td>
<td>01/15/13</td>
<td>15:00:00</td>
<td>1050</td>
</tr>
<tr>
<td>Event 9</td>
<td>03/04/14</td>
<td>08:00:00</td>
<td>2000</td>
</tr>
<tr>
<td>Event 10</td>
<td>02/02/14</td>
<td>15:00:00</td>
<td>2000</td>
</tr>
<tr>
<td>Event 11</td>
<td>02/14/14</td>
<td>15:00:00</td>
<td>2000</td>
</tr>
<tr>
<td>Event 12</td>
<td>02/14/14</td>
<td>15:00:00</td>
<td>2000</td>
</tr>
<tr>
<td>Event 13</td>
<td>03/05/13</td>
<td>22:00:00</td>
<td>2100</td>
</tr>
<tr>
<td>Event 14</td>
<td>08/23/14</td>
<td>15:22:00</td>
<td>2000</td>
</tr>
</tbody>
</table>

Unit Characteristics

- Gen Name: Hydro 0
- Gen Type: Hydro
- F Signal: CH500.F
- P Signal: JDALP

Speed Governor Parameters

- Pmax: 900
- Pmin: 200
- Permanent Droop: 0.05
- Temporary Droop: 0.5
- Deadband 1: 0.01
- Deadband 2: 0
- Tg: 0.5
- Tp: 0.03
- Opening Velocity: 0.1
- Closing Velocity: -0.1
- Tr: 1
- Tw: 2
- Pref: 878.75
- Fnominal: 60

Frequency Response Characteristics

- Initial Time: 52.293
- Initial Frequency: 59.99
- FA: 59.964
- FB: 59.926
- PA: 878.085
- PB: 888.881
- FRM: 15.684

Model Diagram

- Gate or Valve: \( \frac{(1-sT_w)}{(1+0.5sT_w)} \)

Event Plot

- F0
- Fmin
- CH500

Active Power MW

- Time, s

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FRAT web page

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