



# Frequency Response Analysis Tool (FRAT)

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North American SynchroPhasor Initiative Working Group Meeting  
March 23-24, 2015



# Frequency Response

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

Frequency Response Tool
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Events DataBase

Event Name	Date	Time	Disturbance	FRM NERC	FRM BA
Event 1	01/10/14	5:00:00	2000	1562.5	78.125
Event 2	04/22/14	13:10:00	2000	2857.143	265.497
Event 3	11/20/13	0:00:00	2300	3285.714	1979.783
Event 4	07/06/14	00:00:00	1300	1911.765	2186.526

Event Characteristics

Event Description

Name: Event 4

Date: 7/6/2014 Time: 00:00:00

Day: Sunday

Qualifying Ev: Comments: trip of Gen A

Load/Generation

Time/Frequency

Initial Time: 52.396	Initial Frequnc: 59.99
Minimum Time: 9.654	Minimum Freq: 59.889
Settling Time: 22.854	Settling Freque: 59.925
Frequency 20: 59.917	Frequency 30: 59.927
Frequency 60: 59.934	Frequency 90: 59.935

NERC Performance

Interconnection		Balancing Authority	
FA NERC	59.994	PA Interchange	10172.954
FB NERC	59.926	PB Interchange	10359.792
FRM NERC	1911.765	FRM BA	2186.526
		PA Generation	16171.825
		PB Generation	16303.395
		FR Gen BA	2105.25

Additional Performance Indexes

Event Plot

Active Power

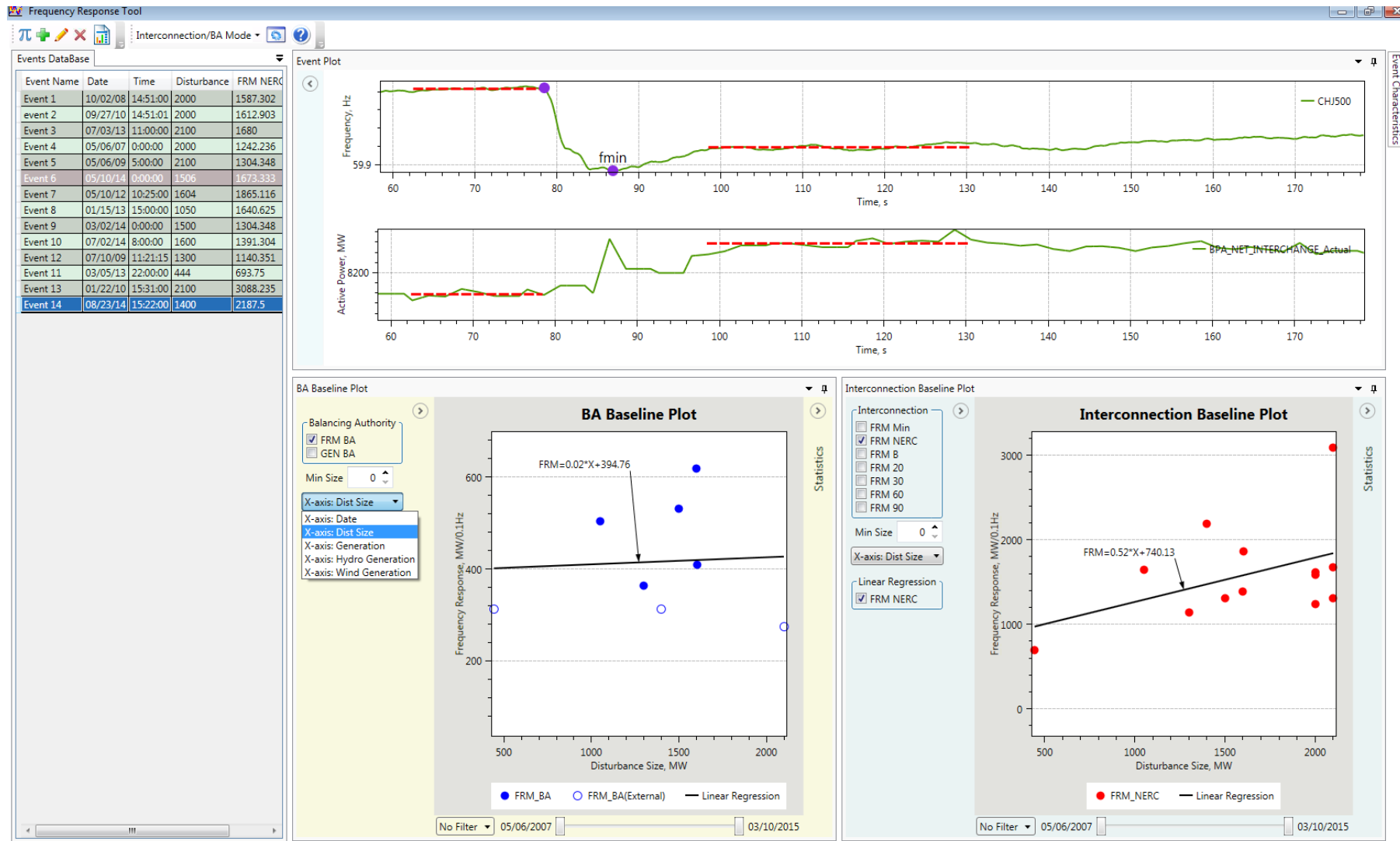
BA Baseline Plot

Statistics

Parameter	Value
Mean	1127
Median	1123
STD	1109

BA FRM PDF

4





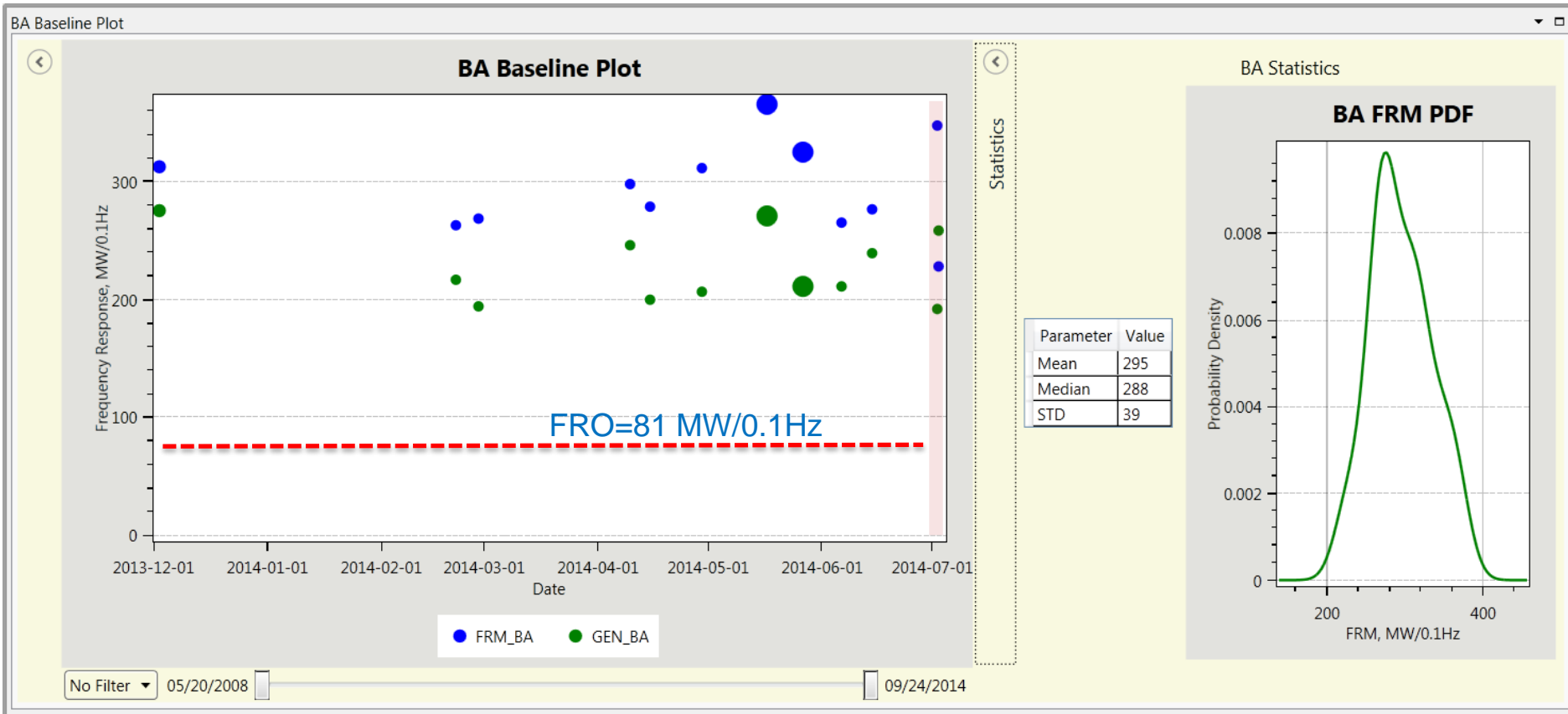
# Statistics



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- ▶ Read information from PI server
- ▶ Configurable presets
- ▶ Time-series aligning

The screenshot shows the 'PI Database Reader' application window. It features a table of data points, a control panel for reading from the PI server, and two time-series plots. A vertical red dashed line is positioned at approximately Time = 54 in both plots, indicating a time-series alignment point.

TimeStamp	Time	DemoBA:Frequency	DemoBA:NetInterchange
01/2/2015 10:00:00.000	0.000	59.985	10195.00
01/2/2015 10:00:00.100	0.100	59.985	10194.98
01/2/2015 10:00:00.200	0.200	59.985	10194.96
01/2/2015 10:00:00.300	0.300	59.985	10194.94
01/2/2015 10:00:00.400	0.400	59.985	10194.92
01/2/2015 10:00:00.500	0.500	59.985	10194.90
01/2/2015 10:00:00.600	0.600	59.985	10194.88
01/2/2015 10:00:00.700	0.700	59.985	10194.86
01/2/2015 10:00:00.800	0.800	59.985	10194.84
01/2/2015 10:00:00.900	0.900	59.985	10194.82
01/2/2015 10:00:01.000	1.000	59.985	10194.80
01/2/2015 10:00:01.100	1.100	59.985	10194.78
01/2/2015 10:00:01.200	1.200	59.985	10194.76
01/2/2015 10:00:01.300	1.300	59.985	10194.70
01/2/2015 10:00:01.400	1.400	59.985	10194.60
01/2/2015 10:00:01.500	1.500	59.985	10194.50
01/2/2015 10:00:01.600	1.600	59.985	10194.40
01/2/2015 10:00:01.700	1.700	59.985	10194.30
01/2/2015 10:00:01.800	1.800	59.985	10194.20
01/2/2015 10:00:01.900	1.900	59.985	10194.10
01/2/2015 10:00:02.000	2.000	59.985	10194.00
01/2/2015 10:00:02.100	2.100	59.986	10193.45
01/2/2015 10:00:02.200	2.200	59.986	10192.91
01/2/2015 10:00:02.300	2.300	59.985	10192.37

**Frequency Plot**  
 The plot shows Frequency (Hz) on the y-axis (ranging from 00059.90 to 00060.00) versus Time on the x-axis (ranging from 50 to 80). The data series 'DemoBA:Frequency' shows a sharp drop from approximately 59.985 Hz at Time 54 to a minimum of about 59.980 Hz around Time 60, followed by a gradual recovery.

**Active Power Plot**  
 The plot shows Active Power on the y-axis (ranging from 10000.00 to 10000.00) versus Time on the x-axis (ranging from 50 to 80). The data series 'DemoBA:NetInterchange' shows a sharp increase from approximately 10000.00 at Time 54 to a peak of about 10000.00 around Time 60, followed by a gradual decrease.



Report
▼ □ ×

Add Event Plot
 

FR Report
NERC FRS1

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3/10/2015 3:52:38 PM

**Frequency Response Analysis Report**

Event Name	Event Date	Event Time	Disturbance Size	Load Loss	Time of Load	FRM NERC	FRM BA	Gen Response BA
Event 1	10/2/2008	14:51:00	2000	1000	5	1587.302	0	0
Event 2	9/27/2010	14:51:01	2000	444	10	1612.903	0	0
Event 3	7/3/2013	11:00:03	2100			1680	0	0
Event 4	5/6/2007	0:00:00	2000	500	11	1242.236	0	0
Event 5	5/6/2009	5:00:00	2100			1304.348	0	0
Event 6	5/10/2014	0:00:00	1506			1073.333	-216.13	246.667
Event 7	5/10/2012	10:25:00	1604	650	5	1865.116	409.52	260.349
Event 8	1/15/2013	15:00:00	1050	700	5	1640.625	504.66	398.667
Event 9	3/2/2014	0:00:00	1500	100		1304.348	531.81	441.43
Event 10	7/2/2010	8:00:00	1600			1391.304	619.88	529.079
Event 11	7/10/2009	11:21:15	1300			1140.351	363.38	273.039
Event 12	3/5/2011	22:00:03	444			693.75	312.08	213.155
Event 13	1/22/2010	15:31:21	2100			3088.235	274.37	192.643
Event 14	8/23/2014	15:22:00	1400			2187.312	312.36	208.523

**Interconnection Baseline Plot**

Event: "Event 1"

**Event Characteristics Table**

Event Name	Event Date	Event Time
Event 1	10/2/08	14:51:00

Frequency Plot

Time	Initial Time	Initial Frequency	Frequency point A NERC Minimum Time	Frequency point B NERC Minimum Time	FRM NERC Min
63.363	59.995	59.857	8.304	59.773	1612.903

**Active Power Plot**

Event2: "event 2"

**Event Characteristics Table**

Event Name	Event Date	Event Time
event 2	9/27/2010	14:51:01

Active Power Plot

◀ 1 of 10 ▶



Frequency Response Tool
Single Unit Mode

Event Name	Date	Time	Disturbance	F
Event 1	10/02/08	14:51:00	2000	15
event 2	09/27/10	14:51:01	2000	14
Event 3	07/03/13	11:00:00	2100	14
Event 4	05/06/07	0:00:00	2000	12
Event 5	05/06/09	5:00:00	2100	13
Event 6	05/10/14	0:00:00	1506	14
Event 7	05/10/12	10:25:00	1604	18
Event 8	01/15/13	15:00:00	1050	14
Event 9	03/02/14	0:00:00	1500	13
Event 10	07/02/14	8:00:00	1600	13
Event 12	07/10/09	11:21:15	1300	11
Event 11	03/05/13	22:00:00	444	66
Event 13	01/22/10	15:31:00	2100	30
Event 14	08/23/14	15:22:00	1400	23

**Unit Characteristics**

**Unit Info**

Gen Name: Hydro 0  
 Gen Type: Hydro  
 F Signal: CHJ500.F    P Signal: JDA1.P

**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

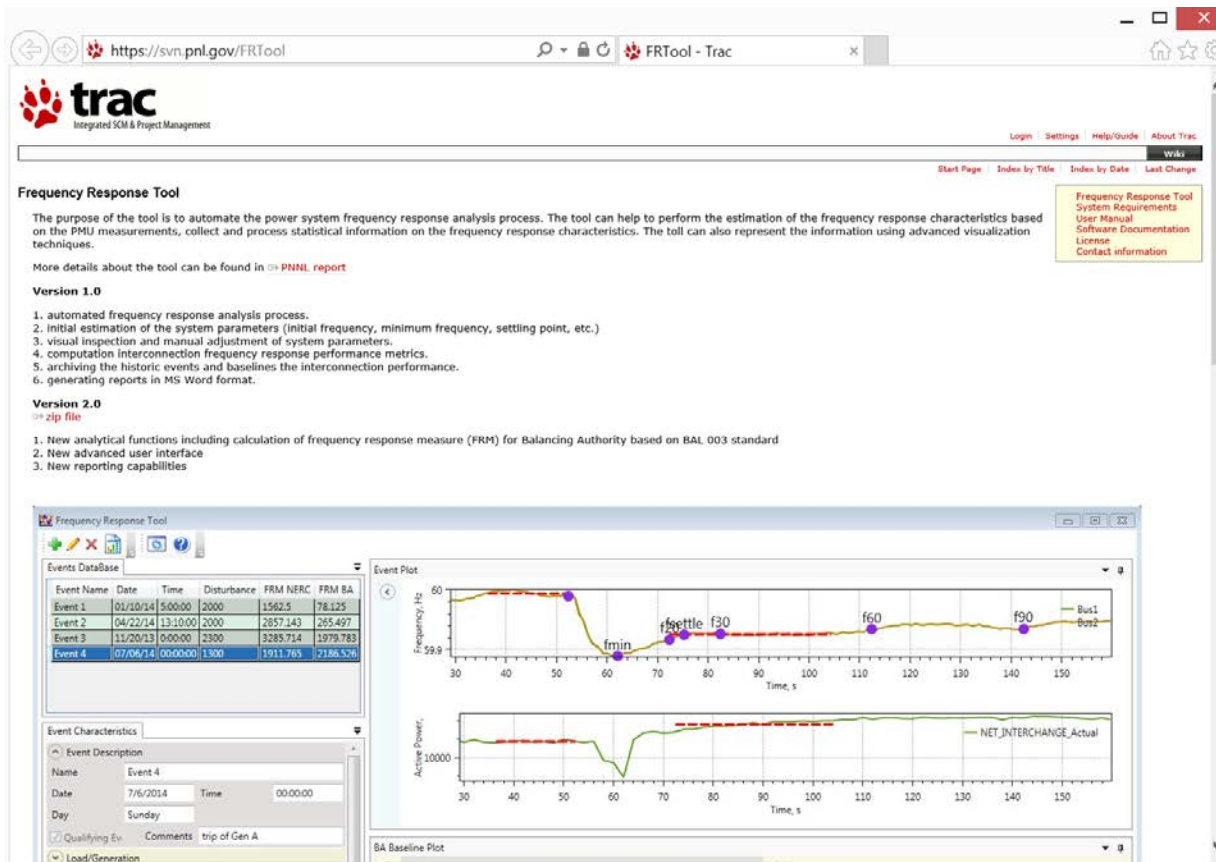
**Model Diagram**

**Frequency Response Characteristics**

Initial Time	52.293	Initial Frequency	59.99
FA	59.994	FB	59.926
PA	878.085	PB	888.881
FRM	15.684		

**Event Plot**

- <https://svn.pnl.gov/FRTool>
- [dnkosterev@bpa.gov](mailto:dnkosterev@bpa.gov)
- [pavel.etingov@pnnl.gov](mailto:pavel.etingov@pnnl.gov)



The screenshot displays the web interface for the Frequency Response Tool (FRAT) at <https://svn.pnl.gov/FRTool>. The page includes a navigation menu with 'Login', 'Settings', 'Help/Guide', and 'About Trac'. A sidebar on the right provides links to 'Wiki', 'Start Page', 'Index by Title', 'Index by Date', and 'Last Change'. The main content area is titled 'Frequency Response Tool' and contains a description of the tool's purpose, a link to a 'PNNL report', and two versions of the tool:

- Version 1.0**
  1. automated frequency response analysis process.
  2. initial estimation of the system parameters (initial frequency, minimum frequency, settling point, etc.)
  3. visual inspection and manual adjustment of system parameters.
  4. computation interconnection frequency response performance metrics.
  5. archiving the historic events and baselines the interconnection performance.
  6. generating reports in MS Word format.
- Version 2.0**
  1. New analytical functions including calculation of frequency response measure (FRM) for Balancing Authority based on BAL 003 standard
  2. New advanced user interface
  3. New reporting capabilities

Below the text, a software window titled 'Frequency Response Tool' is shown. It features an 'Events DataBase' table with the following data:

Event Name	Date	Time	Disturbance	FRM NERC	FRM BA
Event 1	01/10/14	5:00:00	2000	1562.5	78.125
Event 2	04/22/14	13:10:00	2000	2857.143	285.497
Event 3	11/20/13	0:00:00	2300	3285.714	1979.783
Event 4	07/04/14	00:00:00	1300	1911.763	2186.526

The software window also displays two plots: an 'Event Plot' showing Frequency (Hz) vs. Time (s) with markers for f<sub>min</sub>, f<sub>settle</sub>, f<sub>30</sub>, f<sub>60</sub>, and f<sub>90</sub>; and a 'BA Baseline Plot' showing Active Power vs. Time (s) with a line for NET\_INTERCHANGE\_Actual.