August 14, 2003
Northeast Power Outage

PQ data from a 345kV/115kV Station in North East

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Background

- These data were recorded by a PQ Monitor on the 115kV side of a 345kV/115kV auto transformer in the Northeast.
- This data provides some good insight on the response characteristics of a system that recovered from the events on Aug 14th.
- Note that this portion of the Eastern grid did not see any significant disturbances during the period preceding 4:10 PM. The analysis focuses only on the event which started the breakup of the system in the Northeast.
- Downstream distribution substation monitoring data will be analyzed later to see how the distribution system responded to the events.
- As more data from other monitors in the power system becomes available it will allow researchers to piece together the system response at different portions of the Northeast system.

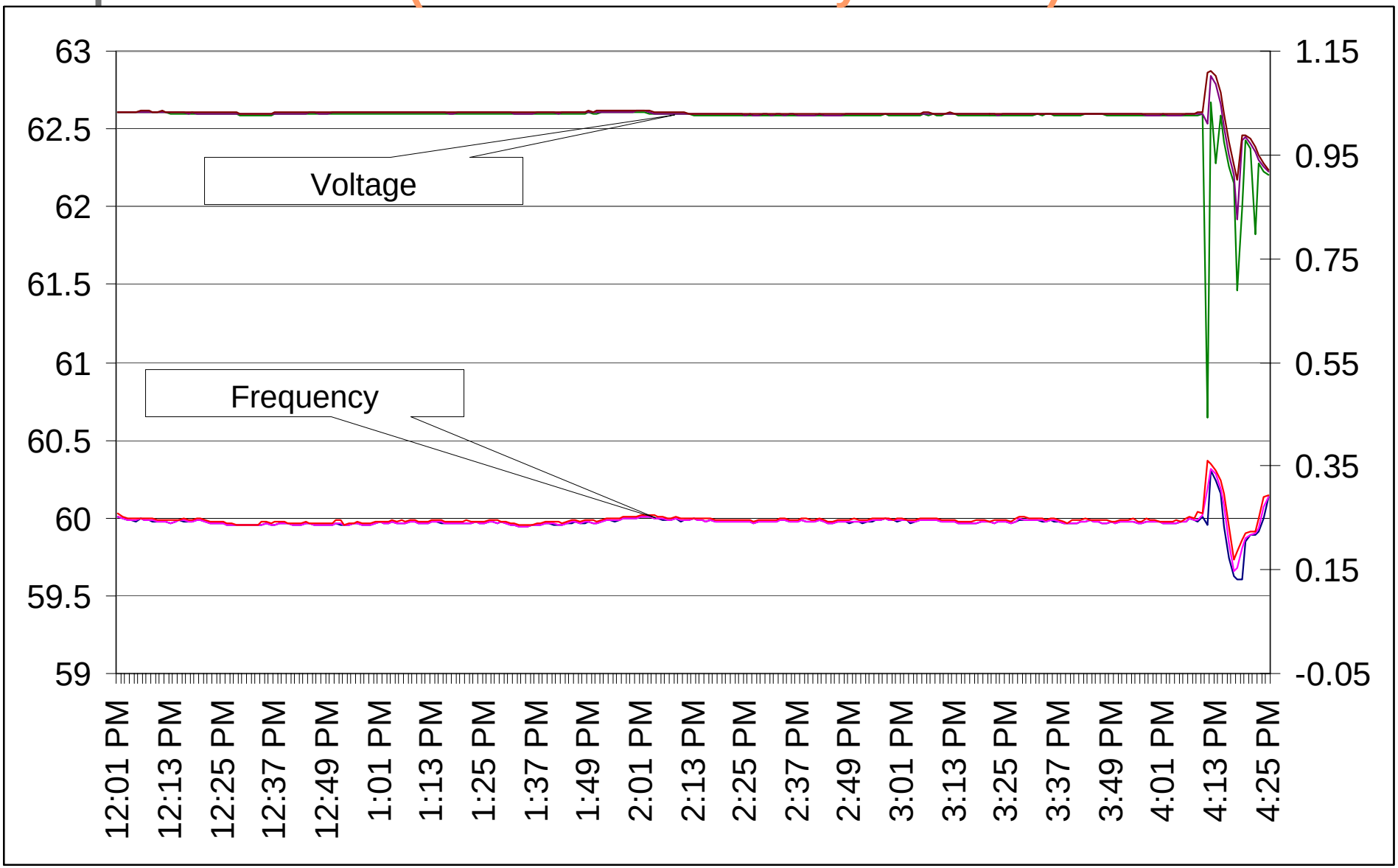
Data characteristics of the PQ Monitor

- Steady State RMS
  - One minute sample data;
  - Based on 1 second min/max/average envelop during the one minute
- RMS Variation
  - Data captured based on event trigger (set at 90% and 110% RMS voltage with 1% Hysteresis)
  - Records instantaneous rms cycle by cycle for 10 pre trigger cycle and 120 post trigger cycle
  - After 120 cycle it records max/min/average envelop over 6 cycles for 8 seconds, over 20 cycles for the next 20 seconds and over 120 cycles for the next 90 seconds
  - Monitor also set to capture 1 cycle pre trigger and 9 cycle post trigger waveform at high resolution (voltage: 256 samples/cycle and current 128 samples per cycle)
- Wave fault and Impulse Trigger
  - Also captures 1 cycle of pre trigger and 4 cycle of post trigger waveform at high sampling rate based on waveform and trigger threshold.
- RMS/Wave fault/Impulse trigger provides a reference cycle to track on a cycle by cycle basis the relative position of each waveform captured by the instrument

Description of the Data/Graph that Follows

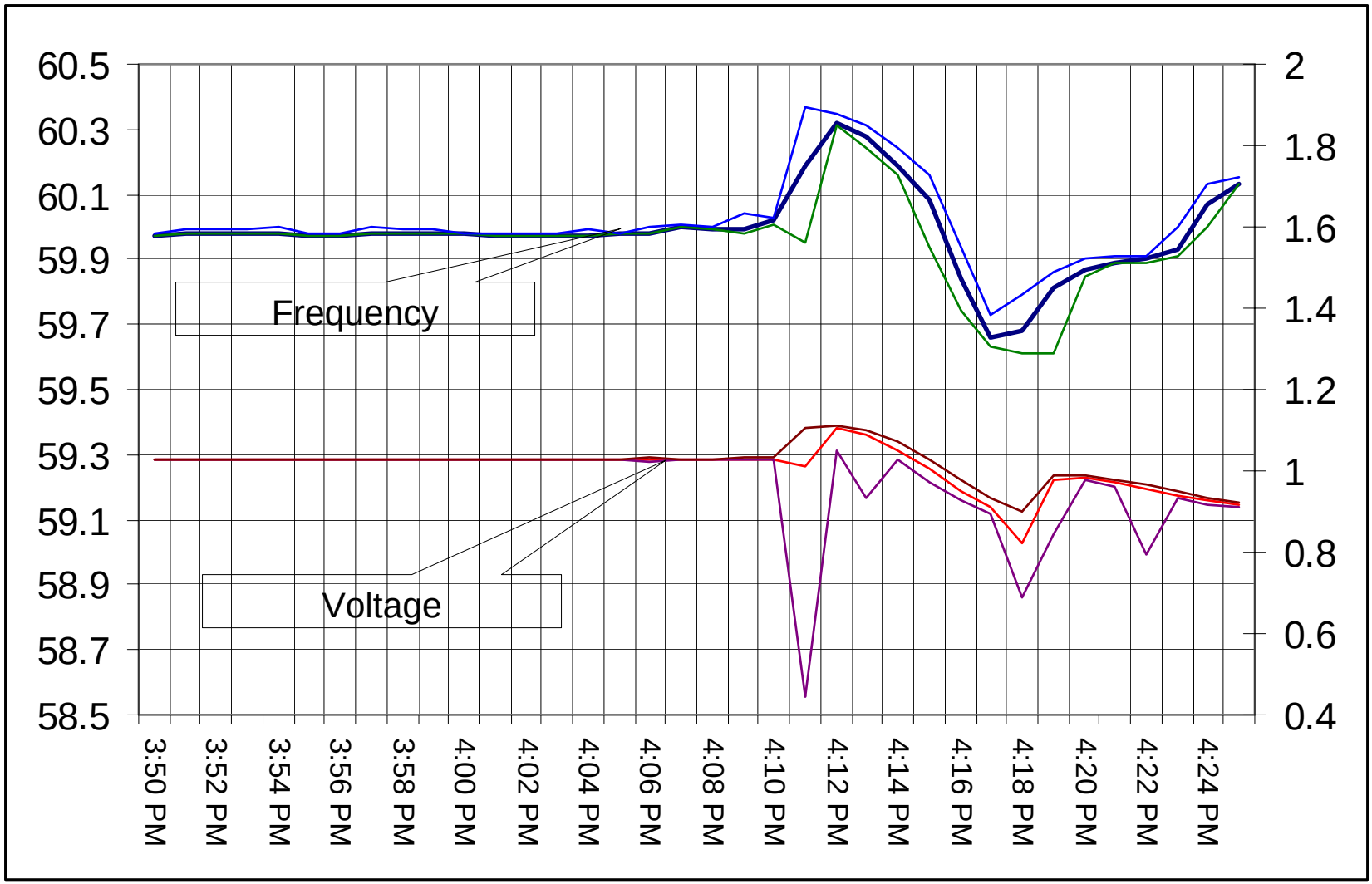
- Steady State RMS trend of Voltage/Current/Frequency from 12:01 PM to 4:26 PM (the data after 4:26 PM is currently being processed)
- Event 1 – starting at 4:10:50 (ref 0 cycle) voltage goes down to approx 42% and recovers to 90% - total duration 13.35 second.
- Event 2 – starts at ref (1177 cycle) – which is 19.16 second after the first event starts – this event was triggered when the voltage recovered and exceeded 110%. This event duration is approx 94 seconds.
- These two events were similar in characteristics to other events captured in locations in New Jersey and New York state (see www.enernex.com).
- For both these events cycle by cycle rms voltage and current is plotted. Corresponding frequency variations are also shown with one minute resolution and max/min/avg values that have 1 second resolution.

1 minute sample data of V and F min/avg/max envelop
(1 sec for F and 1 cycle for V)



From 12:00 PM to 4:26 PM

1 minute sample data of V and F min/avg/max envelop
(1 sec for F and 1 cycle for V)

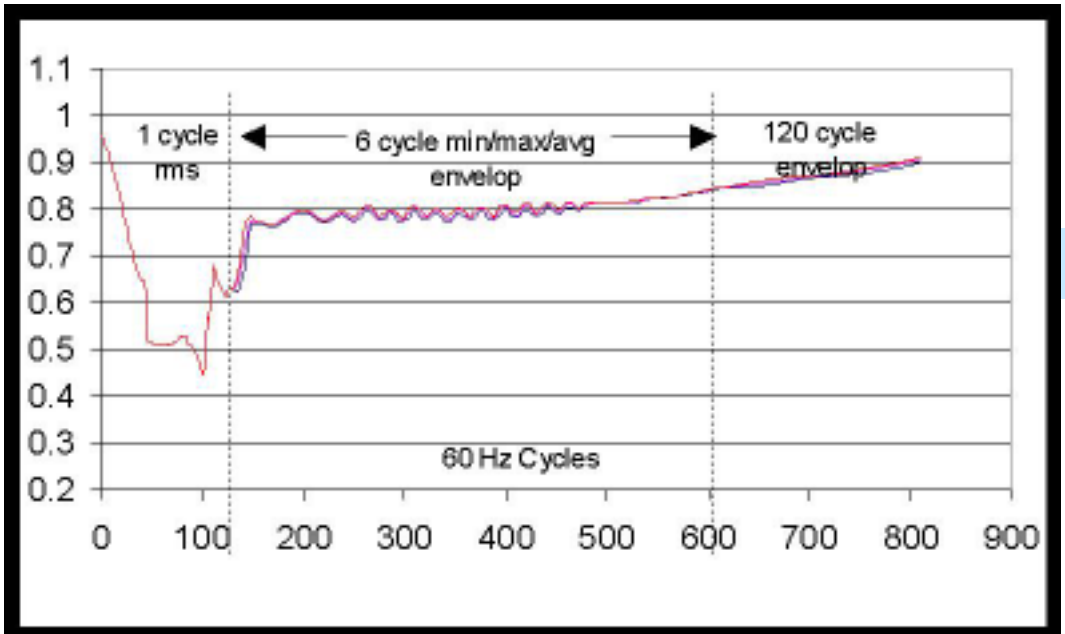


From 3:50 PM to 4:26 PM

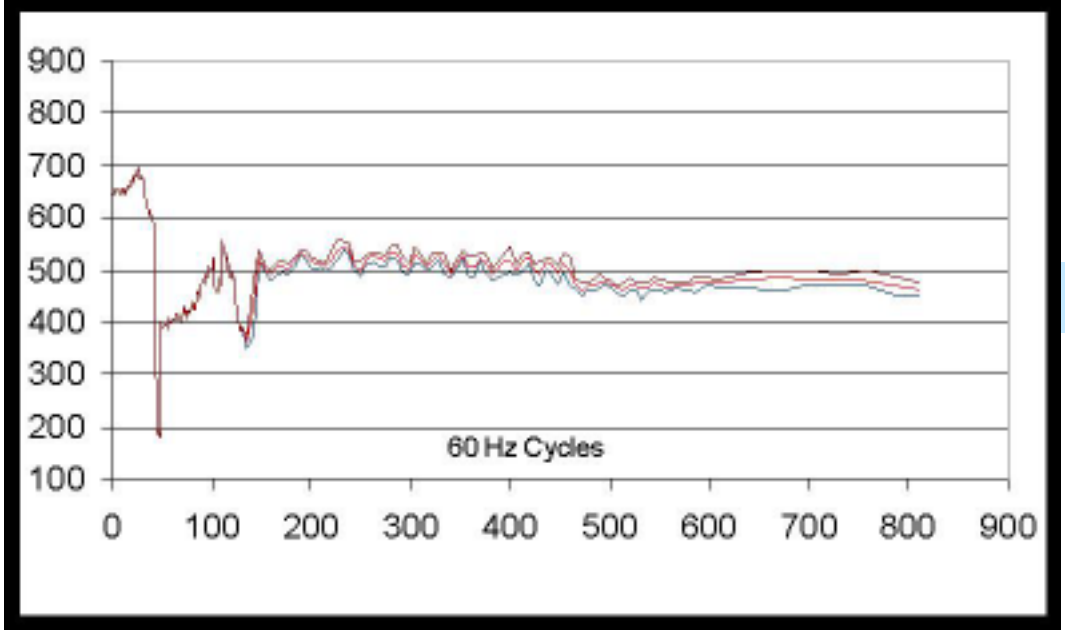
RMS Events

- Two RMS variation events were captured by the PQ monitor.
- The first event started at 4:10:50 (reference cycle 0) and was triggered by undervoltage. This event lasted for 13.5 second (ref cycle 811). During this event the voltage on a cycle by cycle basis went down to approx40% and then recovered back to the 90% value.
- The second event was triggered on cycle 1177 which is 19.6 seconds after the 1st event started. This RMS event was triggered by overvoltage and lasted for 94.5 seconds.
- There are no events from ref cycle 811 to ref cycle 1177 (from 13.5s to 19.6 s). Most likely during this 6.1s (19.6s-13.5s) the voltage increased gradually from 90% to the overvoltage trigger level and was within the threshold of 90%-110% during which the monitor does not trigger.
- During these two events initial 10 cycle of waveform was captured along with some events that were captured by the wave fault trigger (cycle by cycle variations in the waveforms).

RMS Variation Event # 1



Voltage

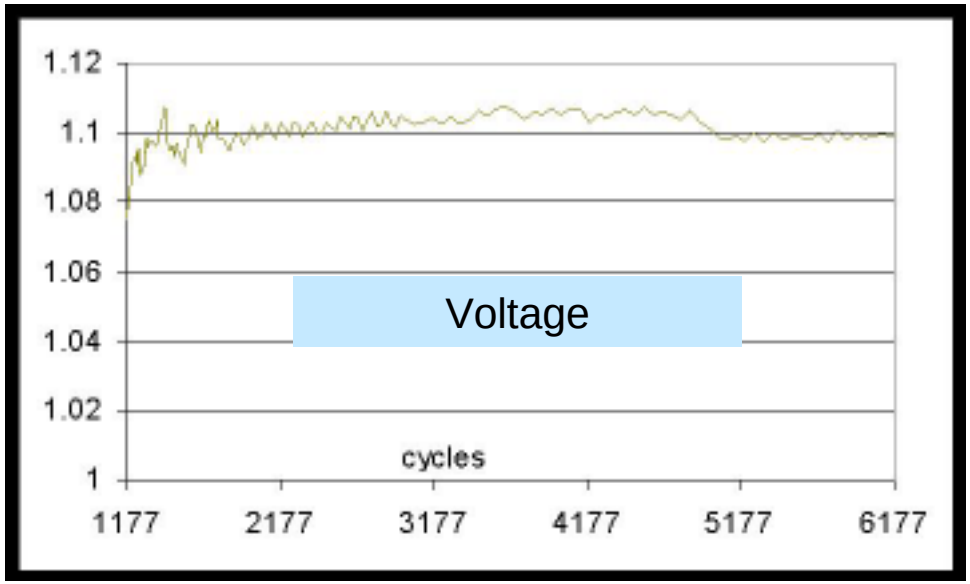


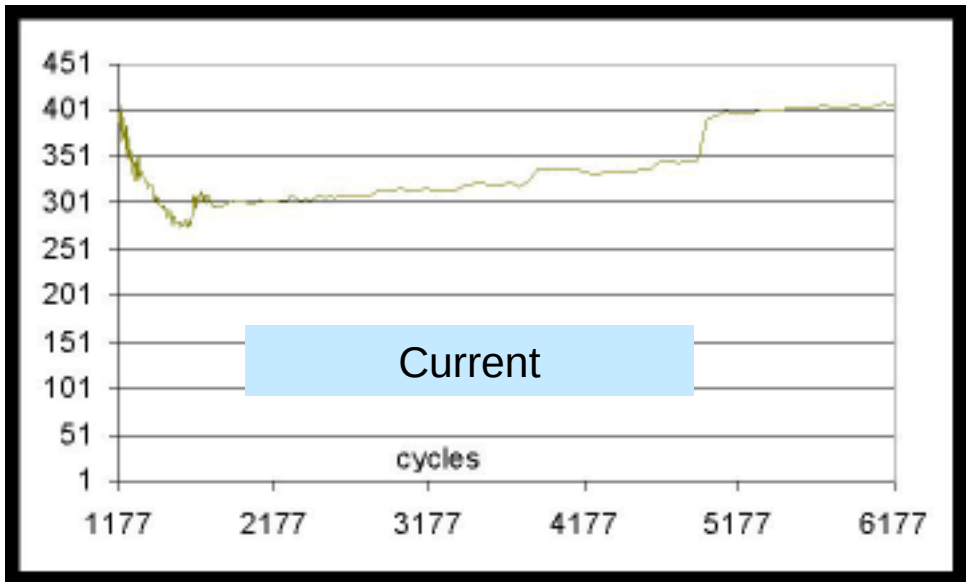
Trigger
16:10:50.690 Local
Reference Cycle
30025 is the starting cycle

Duration 13.35 sec

Current

RMS Variation Event # 2





Trigger 16:11:10.190 Local Reference Cycle 30025 is the starting cycle

Duration 94.38 sec

After the the first 13.35 second event the voltage recovers and exceeds the 110% trigger threshold when the second RMS Variation event is captured by the monitor

Summary

- This data set along with some other data that we have analyzed seems to indicate that the voltage reduction during event #1 was as a result of generation/load mismatch (real and reactive power) rather than a fault on the system.
- Lines tripped as a result of this mismatch and resulting voltage collapse and this portion of the grid was able to recover (although very slowly).
- The recovery included an overvoltage condition when generation levels likely exceeded the load on the islanded system but this voltage slowly came back within limits and the system held together.
- This event provides excellent system response information for verification of system models used in dynamic stability and system response studies.

Acknowledgement

- Carl Miller, Chris Melhorn and Bill Roettger of EPRI PEAC helped in analyzing the data from the PQ monitor