

MISO - EPG DATA QUALITY INVESTIGATION

Ken Martin

Electric Power Group

Kevin Frankeny, David Kapostasy, Anna Zwergel

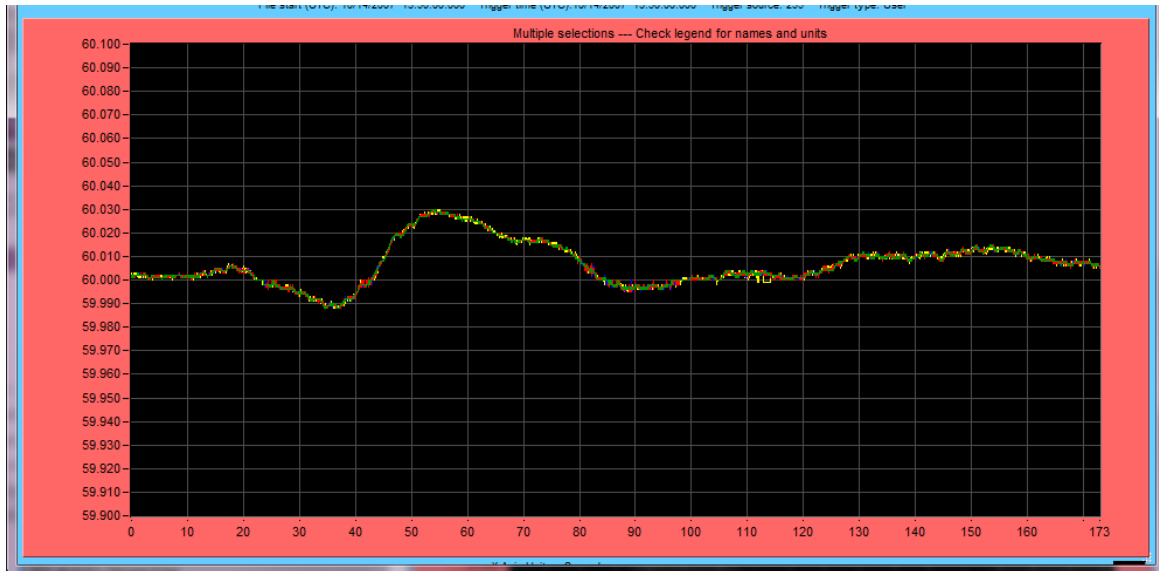
MISO

Outline

- **Case 1 – noisy frequency signal**
 - *Resolution limitations*
- **Case 2 – noisy frequency signal**
 - *Introduced oscillation*
- **Case 3 – data dropout with pattern**
 - *Communication bandwidth limitation*
- **Case 4 – scaling error**
 - *Comparison with other measurements*
- **Case 5 – timing error**
 - *Signal has undetected loss of sync*

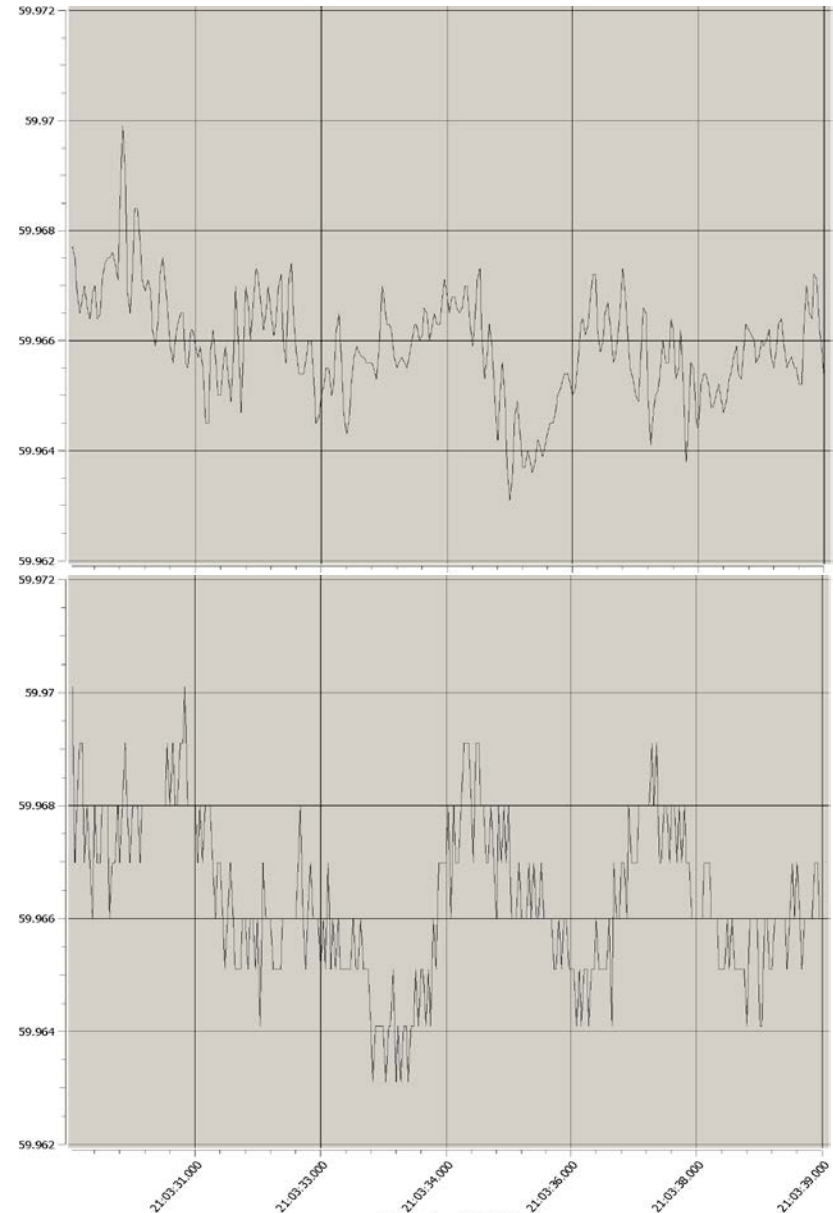
Case 1: Apparent noise in frequency signal

- Plot resolution
- With overall scale of 200 mHz, plot appears smooth
- Change resolution to 16 mHz and plot appears rough & “steppy”
- .001 Hz steps due to resolution of data
- Added “half-steps” due to plotting algorithm



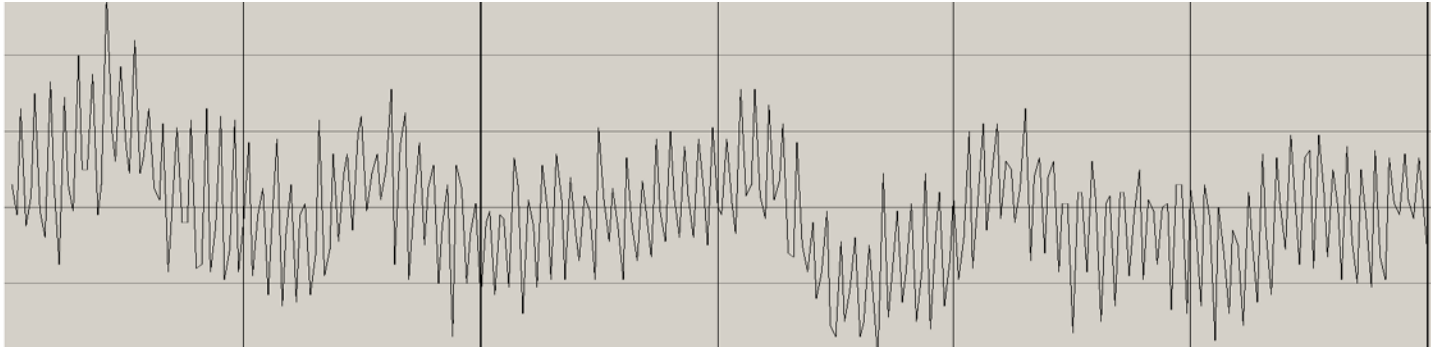
Case 1: Reporting resolution

- Require floating point reporting
 - Maximum resolution
 - Avoid “steppiness”
- Report looked “steppy”
- Resolution:
 - Report from PMU is integer
 - TO PDC converts to FP
 - Final report is FP, but still has integer resolution

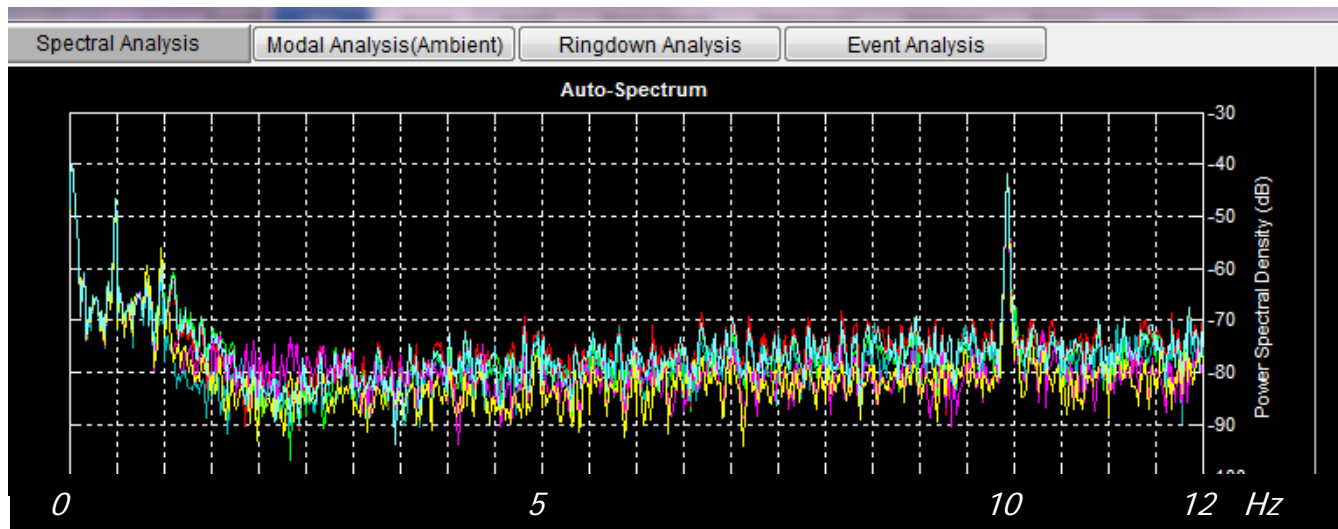


Case 2: Different aspect of measurement 'noise'

- Another “noisy” frequency signal has an obvious oscillation aspect

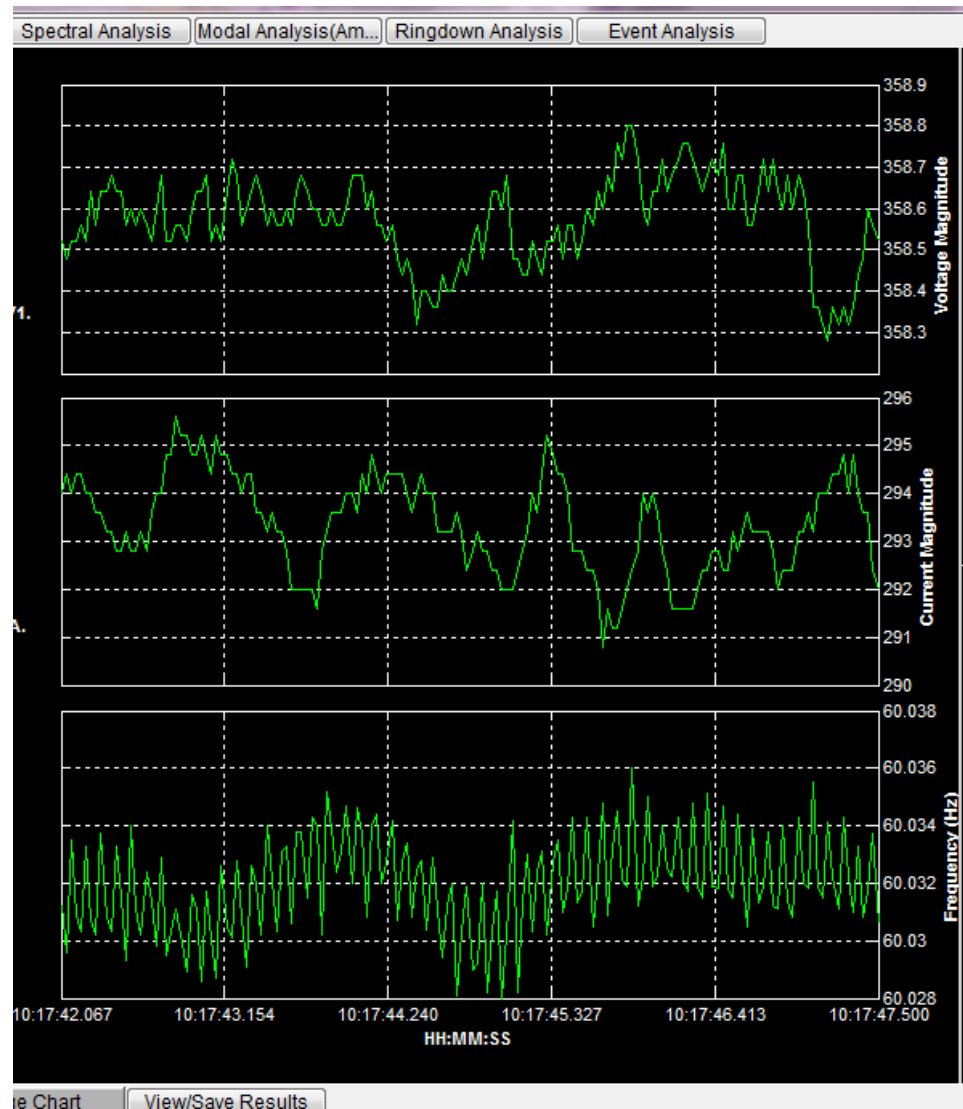


- Modal analysis showed this to be a 10 Hz mode



Case 2: Noise investigation

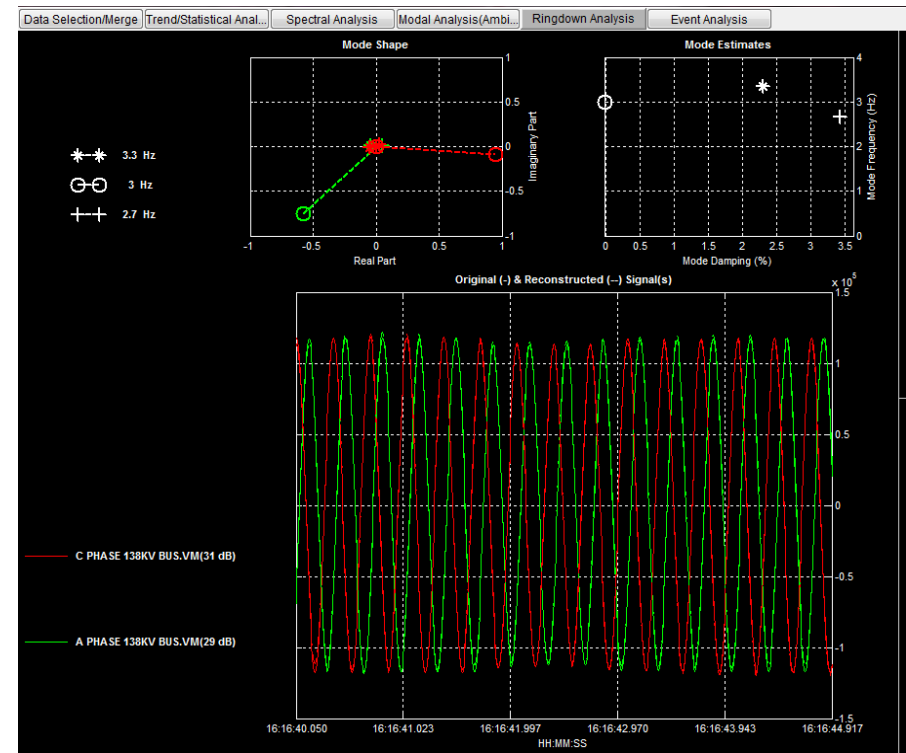
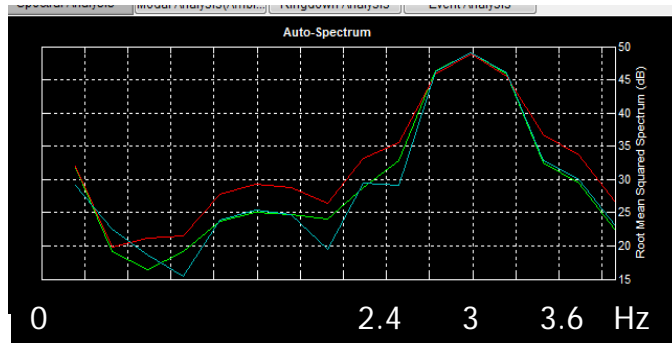
- Oscillation was in voltage & current as well as frequency
 - Only visible in frequency
- Found in several stations in the somewhat isolated transmission section
- 10 Hz is a rather high modal frequency
 - Cause would have to be a controller or resonance
 - Would typically not “travel” well, so we should be able to locate source and path
- Was not always the same amplitude in different stations, but did not show pattern as emanating at one station
- Phase angles did not correlate showing areas in-phase and areas anti-phase



Case 2: Further investigation

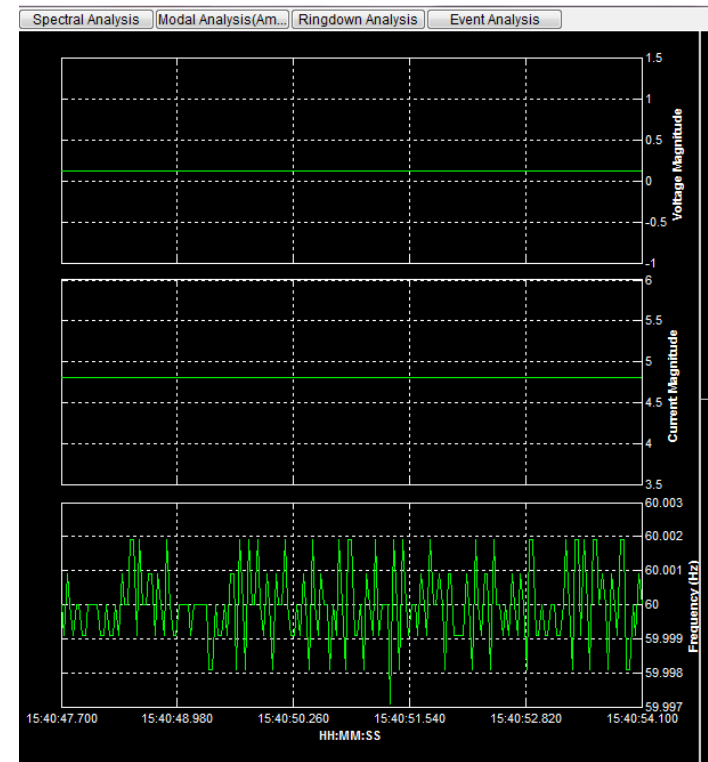
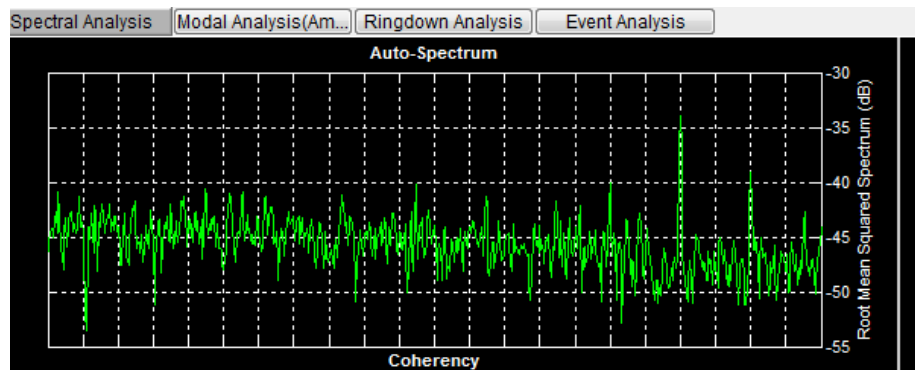
- Modal data came from same kind of PMU with same settings
- Other PMUs nearby showed no mode (but were not directly connected)
- Mode was almost exactly 10 Hz with slight frequency movement correlating with change in the nominal system frequency
- DFR data from some of the same substations did not show the 10 Hz mode, but the analysis was not conclusive (record too short)

DFR – point on wave, 2400 s/s. For analysis rescaled by 1/20 so 60 Hz appears as 3 Hz and 10 Hz mode at $3 \pm .5 = 2.5$ and 3.5 Hz.



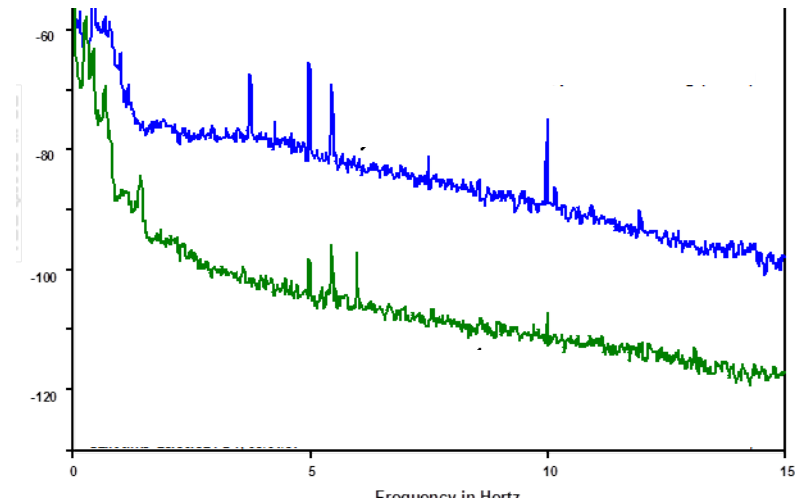
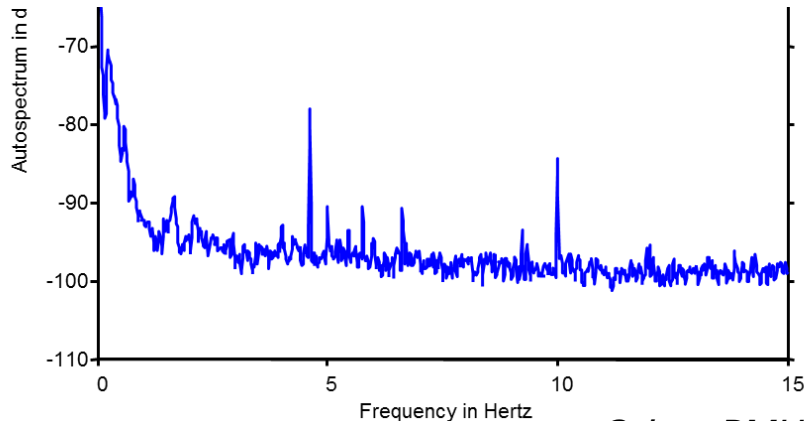
Case 2: Noise investigation conclusions

- Tested PMU with test set
 - Same settings showed 10 Hz mode
 - Other settings showed less or no 10 Hz mode
- Conclusions:
 - The oscillation is from an internal process in the PMU
 - It is small but big enough to be annoying
 - It can be resolved by using another setting in the PMU processing



Case 2: Noise investigation recommendations

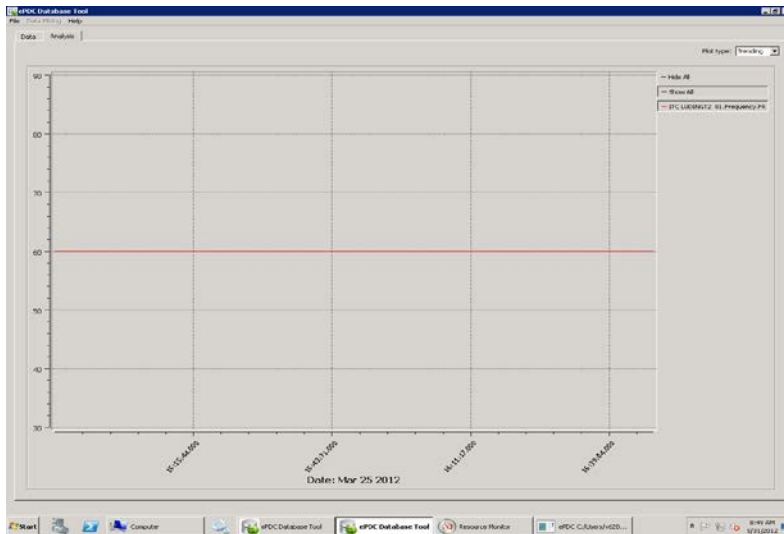
- Validate measurements that show unexpected system behavior
- If observed, carefully check for supporting evidence--
 - Data from other measurement devices
 - A source of the unusual system behavior
 - Logical interaction between other parts of the system as observed by other measurement
- Be wary of oscillations at higher frequencies, particularly even integer frequencies
- If there are no other causes located or corroborating evidence, the data is probably something from the measurement processing (PMU)



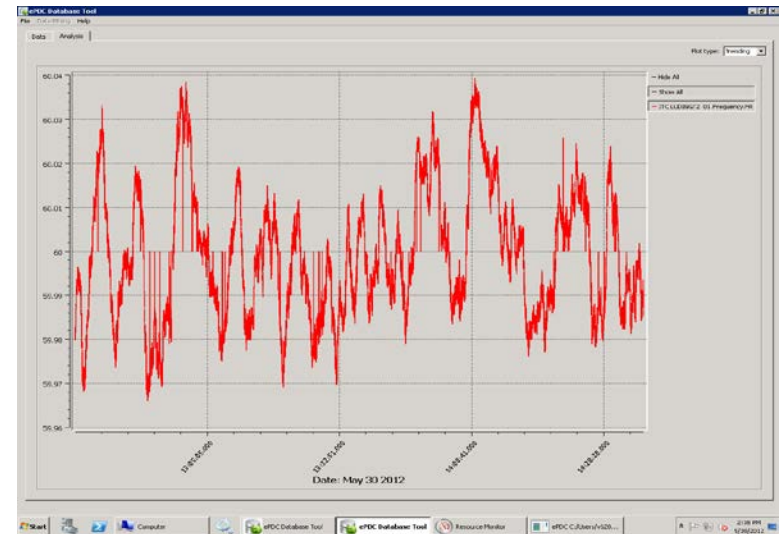
Other PMUs showing 10 Hz modes

Case 3: Security Camera Issue

- In Mid-March, a Transmission Owner installed new security cameras at a site where a PMU was installed
- The communication data link to the control center overloaded (saturated)
- Both RTU and PMU traffic was effected
- Resolution managed traffic; included an implementation of QoS



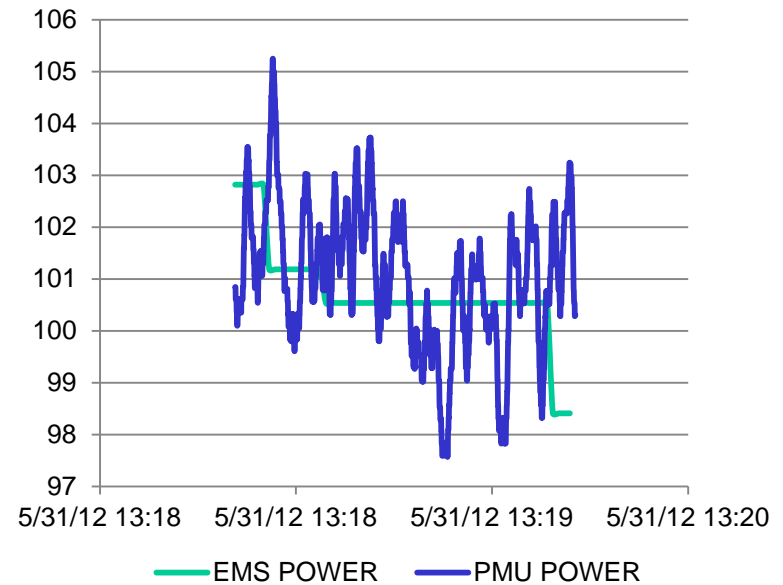
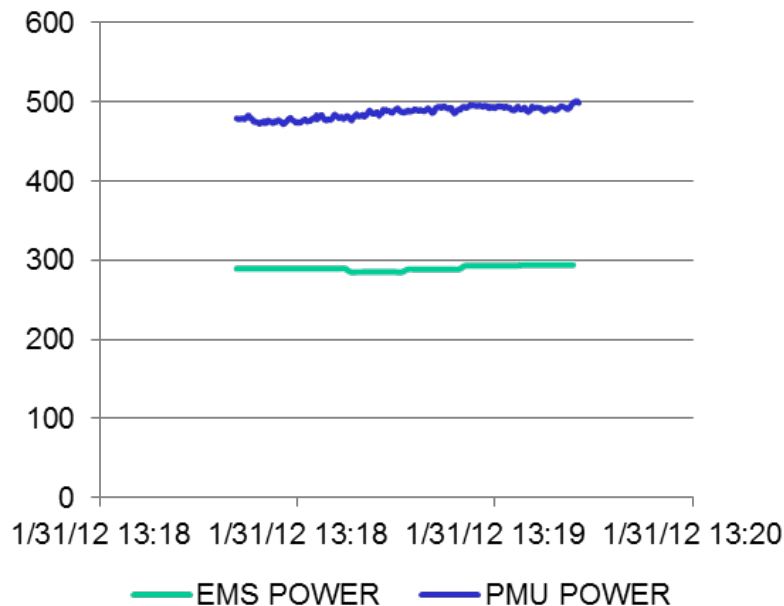
While saturated, data lost & frequency flatlined



Saturation resolved, data & frequency good

Case 4: Scaling Error

- Comparison of PMU with EMS data showed error factor ~ 1.73
- Investigation showed PMU current reading was mis-scaled by $\sqrt{3}$
- PMU – EMS data comparisons are an important part of MISO's standard verification process



Case 5: Time error problem

- PMU receives unsync time
 - No time quality provided with time signal
- PMU reports data with bad time but sync error flag not set
- PDC synchronizes data by reported PMU time
- PDC time deviates between PMUs
 - Good data is lost
 - No way to distinguish since all times marked good

Case 5: Time synchronization of data

- Data is sorted by time (data put into table by time stamp)
 - If time is in error data is displaced
- PDC must determine there is a time error
 - Flag in data warns that there is a time error
 - Time error must be large enough to detect without flag
- PDC can take action to minimize effect of time error
 - Apply local “best guess” time stamp (sort by arrival)
 - Place data in separate data store
 - Discard data

Example:

PMU1 – good time, in sync

PMU2, PMU3 – not in sync, time does not match data

Key-

TS – time stamp provided in data

Data – actual time of measurement

Table	PMU1	PMU2	PMU3
11:34:20.1	TS 11:34:20.1 Data 11:34:20.1	TS 11:34:20.1 Data 11:34:18.8	TS 11:34:22.5 Data 11:34:20.0
11:34:20.2	TS 11:34:20.2 Data 11:34:20.2	TS 11:34:20.2 Data 11:34:18.9	TS 11:34:22.6 Data 11:34:20.1
11:34:20.3	TS 11:34:20.3 Data 11:34:20.3	TS 11:34:20.3 Data 11:34:19.0	TS 11:34:22.7 Data 11:34:20.2
11:34:20.4	TS 11:34:20.4 Data 11:34:20.4	TS 11:34:20.4 Data 11:34:19.1	TS 11:34:22.8 Data 11:34:20.3

Table row time

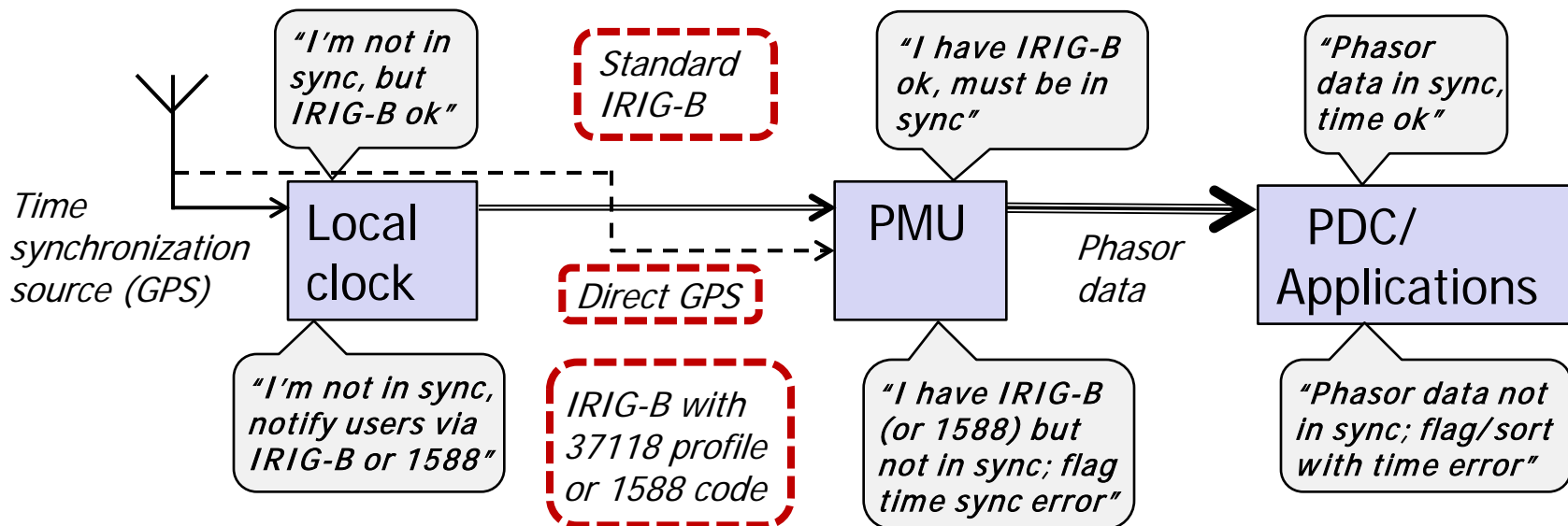
PMU1 in sync

PMU2 unsync, incorrect flag

PMU3 unsync, good flag, sort by arrival

Case 5: Time synchronization chain

- The PMU needs to detect and flag time errors
 - Time directly from GPS provides time quality
 - Time indirect must include time quality
 - Eg: IRIG-B or IEEE1588
 - PMU provides sync information to PDC & applications



Case 5: Time error problem resolution

- Assure PMUs receive time quality
 - Check they report time error correctly
- Set PDC to detect time errors
 - Must be accurately and reliably timed
 - It must make allowances for reporting delays
- Check that PDC detects PMU time outliers
 - Responds correctly

Questions??

