Key Setup Parameters for Meaningful Vibration Data Analysis

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Meaningful Vibration Data Analysis

- Lots of tools and techniques available.
- Sometimes can be a bit intimidating and burdensome.
- Need to take away some of the mystery.
- Make the best of the situation.
- Examine scientific terminology and industry jargon.

Getting Down to Basics

- Vibration is a leading indicator of machinery health.
- Accelerometer is like a doctor's stethoscope.
- Capture the raw data.
- Convert to a "signature" for comparison.
- Know the equipment make-up.
- Watch for patterns, amplitudes, and changes over time.

  (Interpret information relative to PF curve)

Predictive Maintenance (PdM)
(an evolution from Breakdown to Preventive)

- 4 Key Elements to the process:
  - Detection
  - Analysis
  - Correction
  - Verification
- *Pinpoint a problem, get to the root cause, take action, and verify effectiveness.*

DETECTION

- Capture details on equipment and application.
- Choose the right sensor.
- *Set up the right measurement parameters.*
- Obtain good, solid data – also, repeatable.

ANALYSIS

- Examine trends, changes, patterns, and amplitudes. *(The "Signature".)*
- Compare to known acceptable standards or baselines.

(<u>Note</u>: Signature, Spectrum, and FFT (Fast Fourier Transform) are used synonymously.)

CORRECTION

- Take actions against offending vibration levels:
  - ✓Balancing.
  - ✓Alignment.
  - ✓Replacing defective bearings.
  - ✓Tying down loose components.
  - ✓Avoiding resonance.

  The BIG 5!

VERIFICATION

- Perform a “Before and After” assessment.
- *Did the follow-up action make the situation better?*
- If the problem has been addressed, set a new measurement baseline for the future.

Primary Goals of the PdM Program

- Ensure convenient rework.
- Avoid panic.
- Avoid secondary damage.
- Promote safety.
- Reduce repair time.
- *Avoid any unnecessary downtime.*

12 Steps for Success

- **Survey the plant** in terms of critical, essential, balance of plant categories.
- **Choose the machines** to put into the program.
- **Optimize measurements** in terms of parameters and timing.
- **Choose the method** and **educate participants**.
- **Set criteria** (alarms) for assessment.
- **Baseline** the machine under consideration.
- thru 10, Setup, Measure, Store, Present **(detection)**.
- Problem assessment **(analysis)**.
- Correct the fault **(correction)**.

(After step 12, the process can be re-entered at step 6.)

Establishing the Program

- Put equipment into categories of “critical”, “essential”, and “balance of plant”.
- Start with the critical machinery.
- Get into the physical make-up of the equipment and the application.
- Decide the kinds of measurements and sensors to be used.
- Look for vibration presence, patterns, and severity.

Vibration measurement

- Choose the best location.
- Choose the proper sensor.
- Make the proper placement – firm mounting and direction. (similar to sensitive directional microphone).
- Measure in several axes.
- *Set measurement parameters to get "tell-tale" data.*
- Set alarm limits for proper assessment. (typically "warning", "alert", and "danger").

Other Key Considerations …

- Know the make-up of the machine in terms of bearings, gearbox, pulleys, couplings, cooling fans (# of blades) and pumps (# of impellor blades).
- Know the 1X (i.e., running speed) of the machine being measured.
- Know the relative phase readings on key positions of the machine. *(This will show relative motion.)*

Key Measurement Parameters

- Time or frequency data to be captured.
- Sample time.
- Number of samples.
- Number of averages.
- Frequency range.
- Frequency resolution.

Data Interpretation

- Examining presence, patterns, and severity will lead to correction.
- There are typically 5 main causes for the vibration:
  - Unbalance.
  - Misalignment.
  - Bearing defects.
  - Looseness.
  - Resonance.

Getting Good Data

- Avoid the GIGO (garbage in, garbage out) principle.
- Make certain to have a good sensor, cabling, and connections.
- Ensure proper (solid) mounting (no rocking).
- Set up instrument parameters to get the right measurements.
- Make sure that the equipment is running.
- Be sure that it is the right location.
- Recognize “bad” data before moving on.
- Utilize auxiliary tools available to build confidence in the assessment. *(Examples here include bump tests, coastdown, cross-channel phase, and demodulation.)*

Measurement Considerations

- Right place, right time.
- Minimize outside influences.
- Time or frequency?
- Frequency band, Fmin and Fmax.
- Resolution.
- Windowing.
- Sampling time.
- Number of samples.
- Number of averages
- Accompanying speed and phase information?
- Additional simultaneous channel?

Measurement Relationships

- Highest frequency (Fmax)

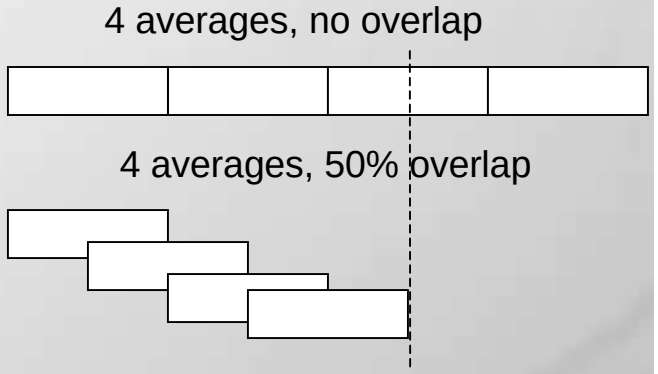
  Fmax (Hz) = # of samples / (2.56 * sample time)
  (corollary: sample time = # lines of resolution / Fmax (Hz))

- Lines of resolution

  # Lines = samples / 2.56
  (corollary: samples = 2.56 * # lines)

- Time for collection

  Time = (# averages * # lines) / Fmax (in Hz)



- Frequency resolution

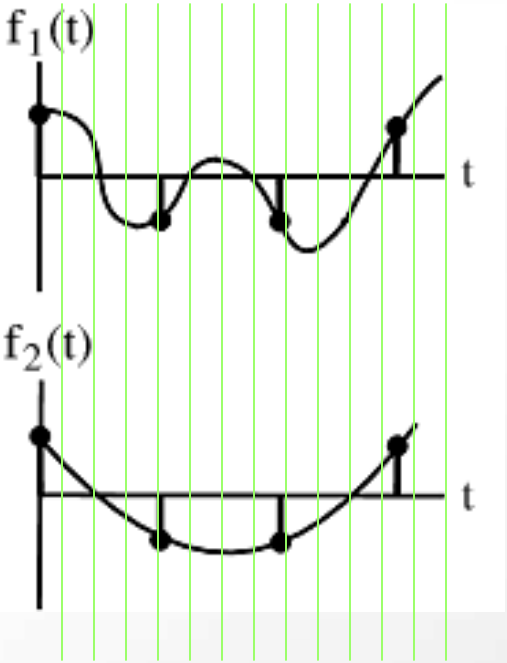
  Resolution = Fmax / # lines

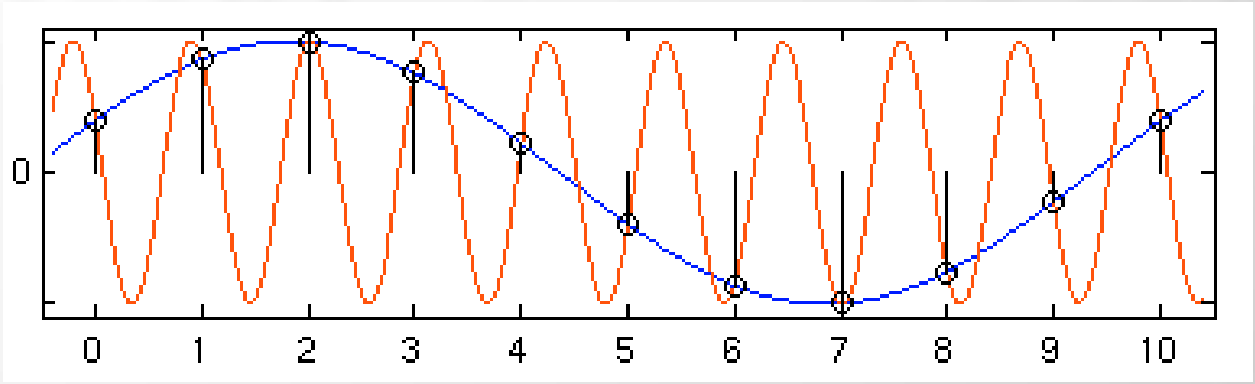
(Keep in mind the specifications for the sensor and instrumentation.)

Measurement Considerations

- Shannon (Nyquist) Sampling Theorem: Sampled signal can be completely reproduced if sampling frequency is at least twice the highest frequency content. (We use the factor 2.56 in digitizing.)
- Any attempt to do less results in “aliasing”.
- There is an inverse relationship between time sample and highest frequency content.
- More samples, less time results in higher frequency.

Digital Sampling… Example





Two very different signals with same sampling.

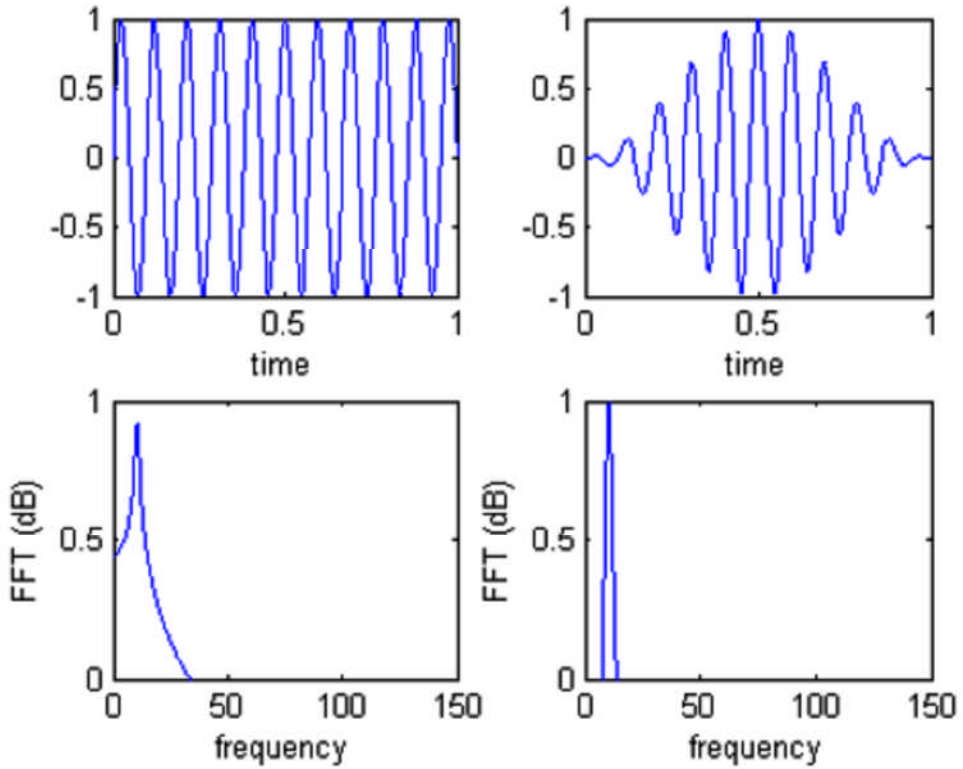
The more samples, the better reconstruction.

2.56X is a nice sampling factor in digitizing.

Further considerations

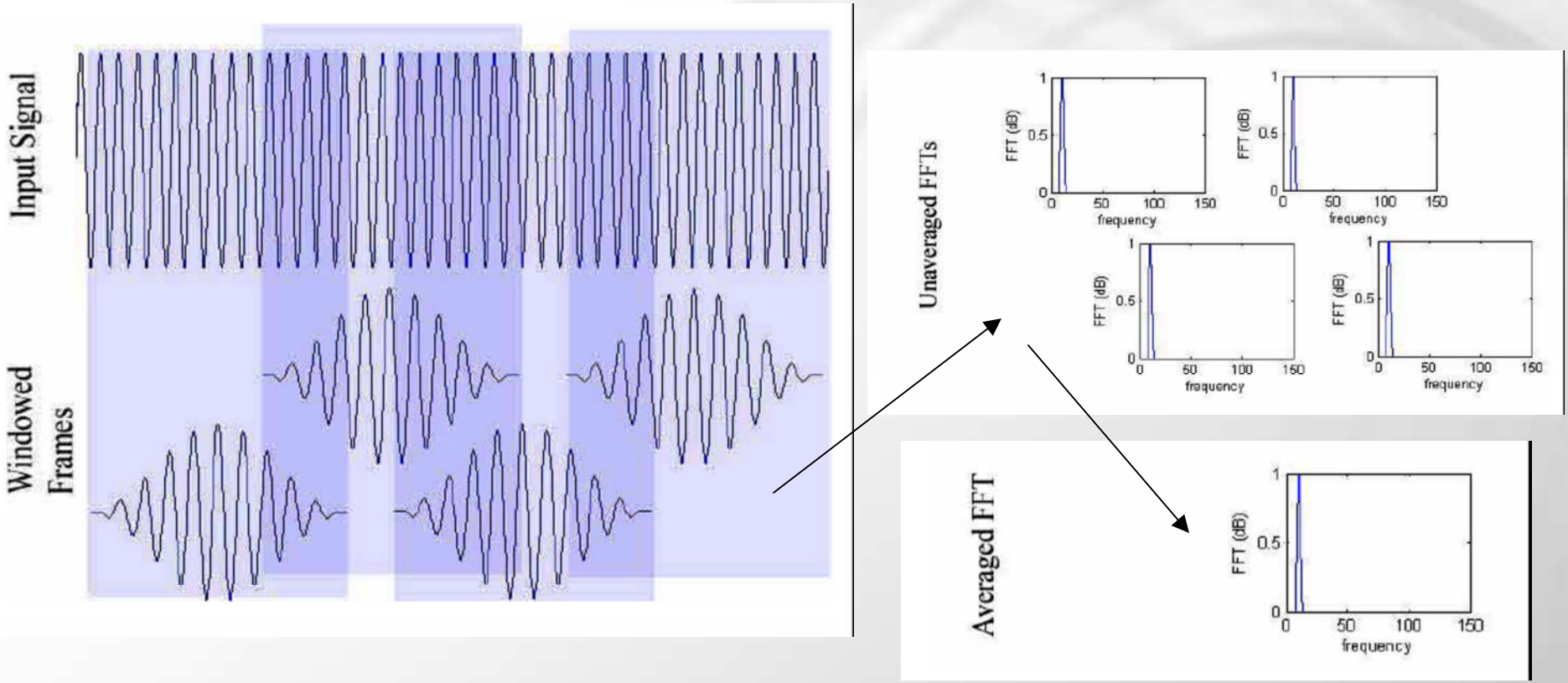
- Product(s) specifications and limitations.
- Measurement capture.
- Measurement processing.
- Measurement unit (acceleration, velocity, displacement).
- Measurement scaling (rms, average, peak, pk-pk).

Windowing for sampling



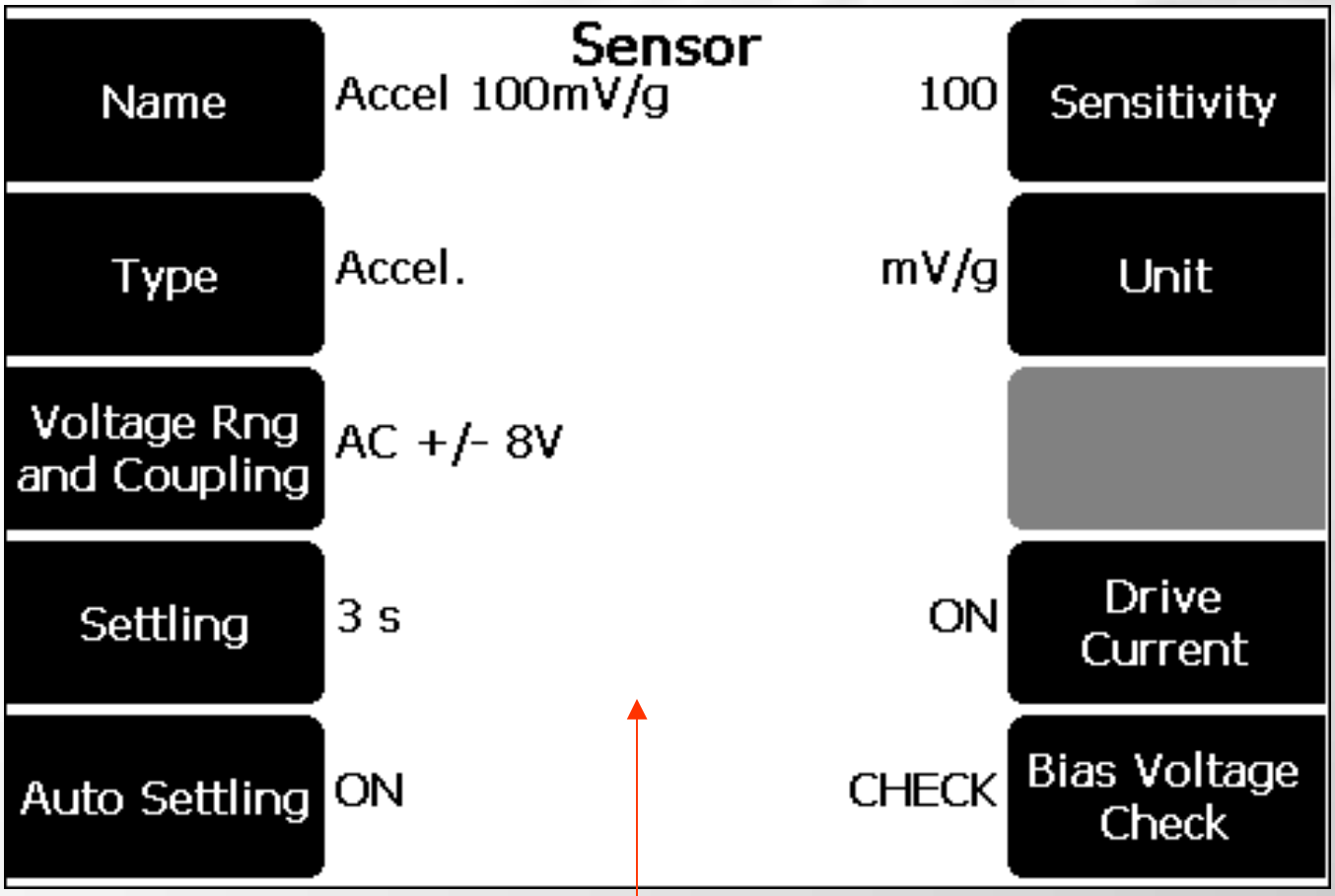
Comparison of non-periodic sine wave and FFT with leakage (left) to windowed sine wave and FFT showing no leakage (right).

Overlapping Averages



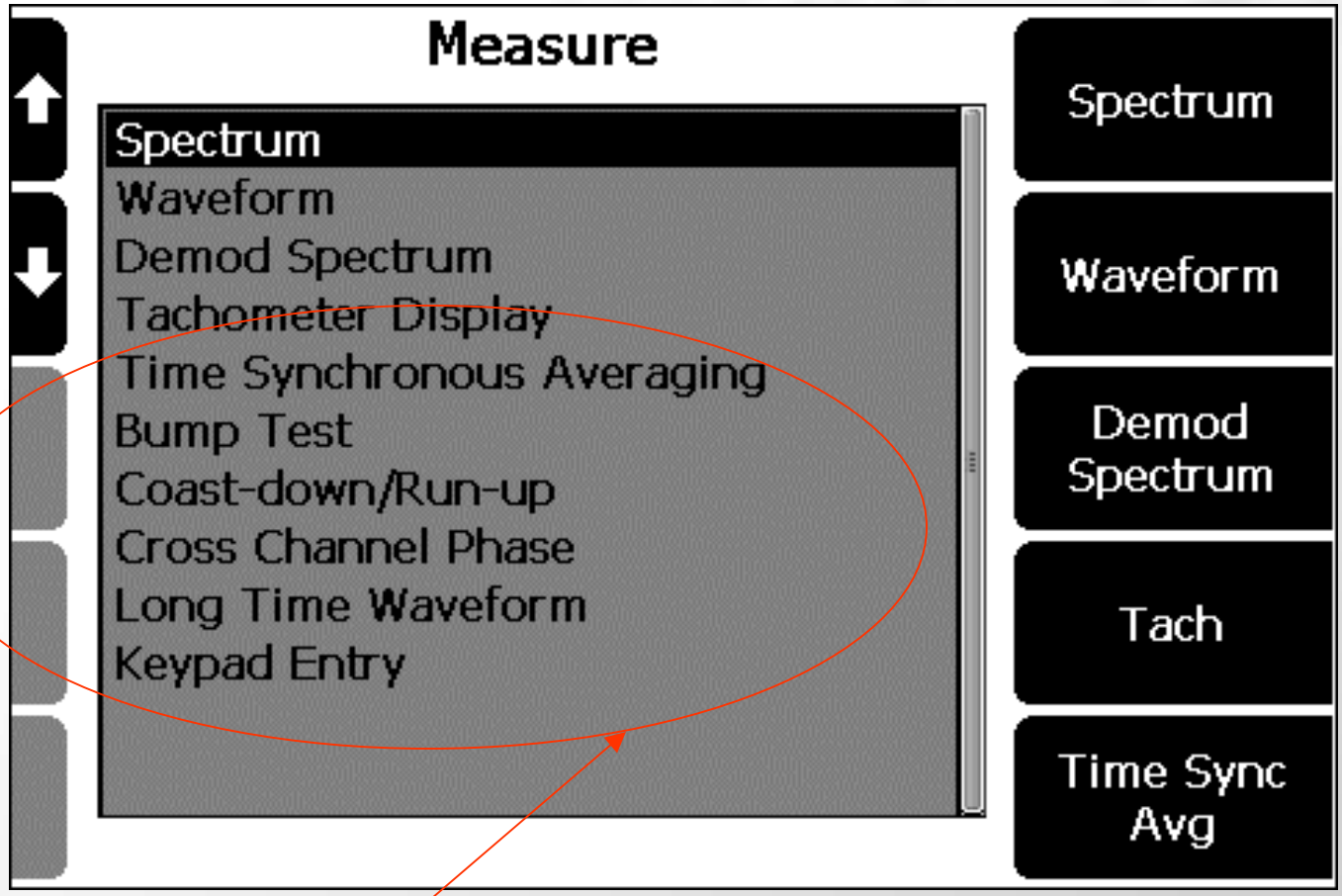
Overlap processing shortens the acquisition time by recovering a portion of each previous frame that otherwise is lost due to the effect of the FFT window,

Example – at instrument side



Example – at instrument side

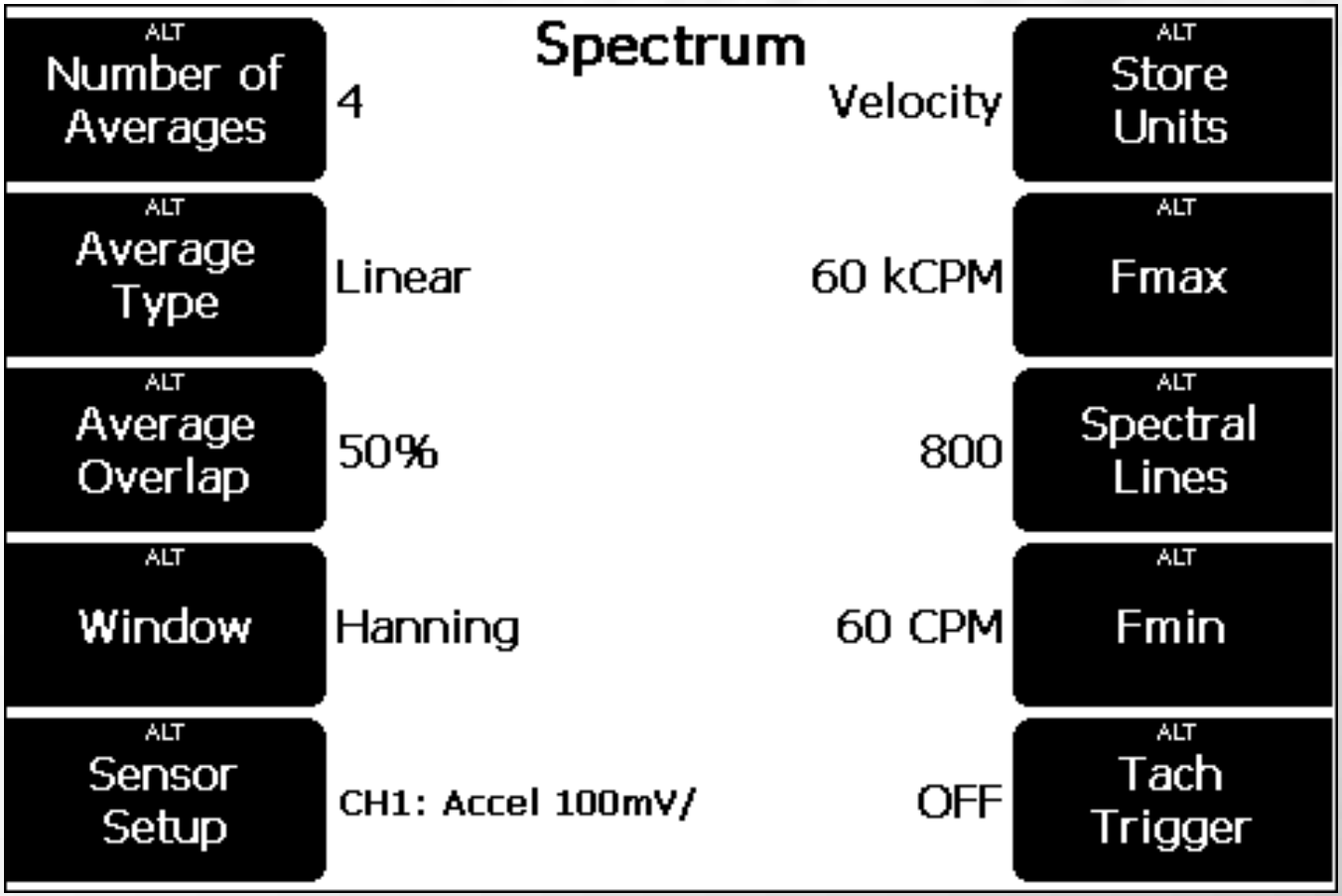
Most commonly used
On routine data collection



Advanced analysis

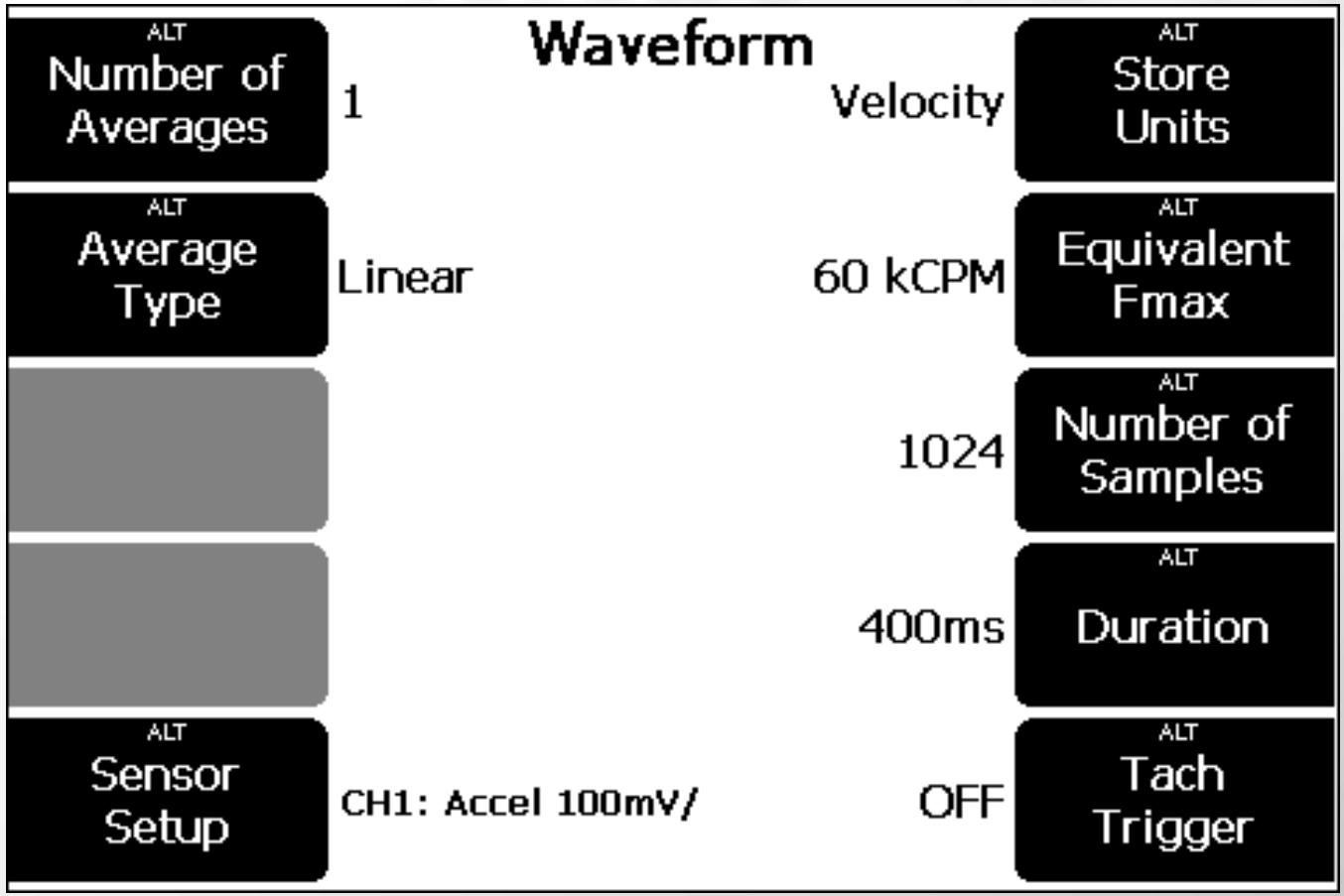
FFT (Spectrum) Measurement

Typical Settings Menu



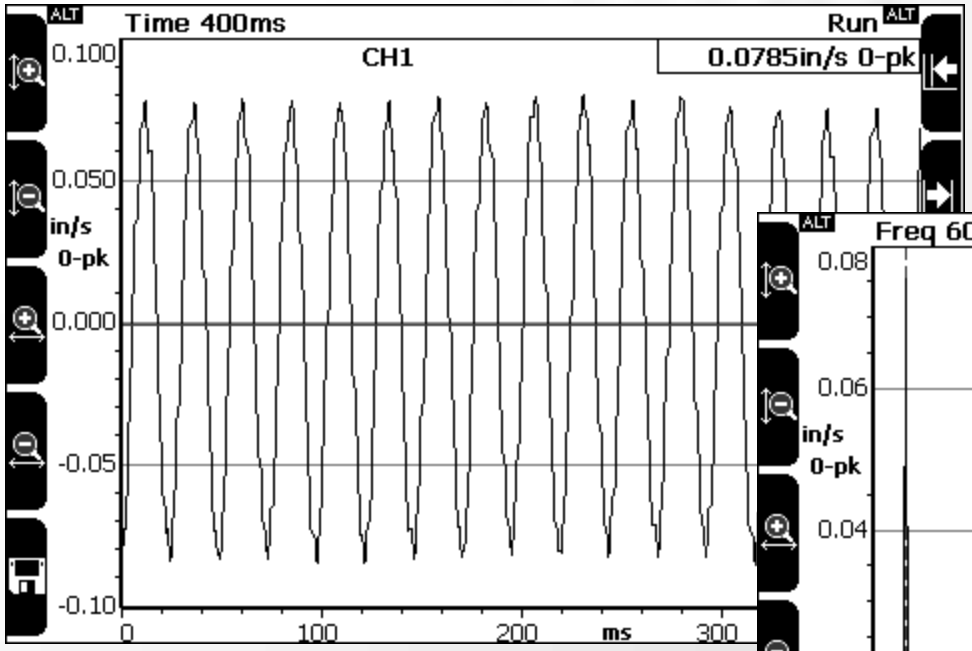
TWF (Time Waveform) Measurement

Typical Settings Menu

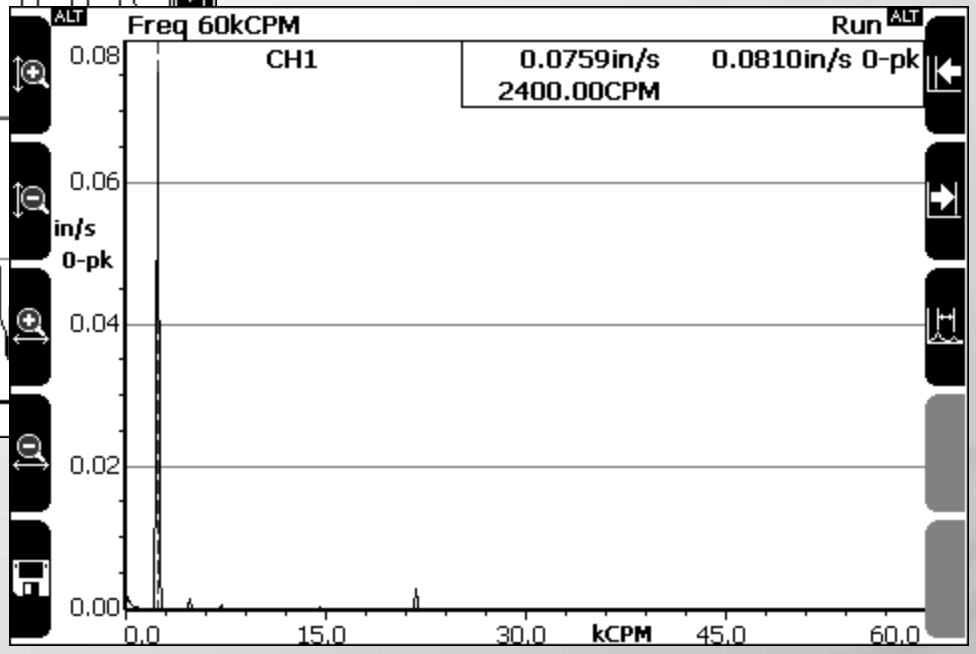


Measurements at Instrument

Time Waveform

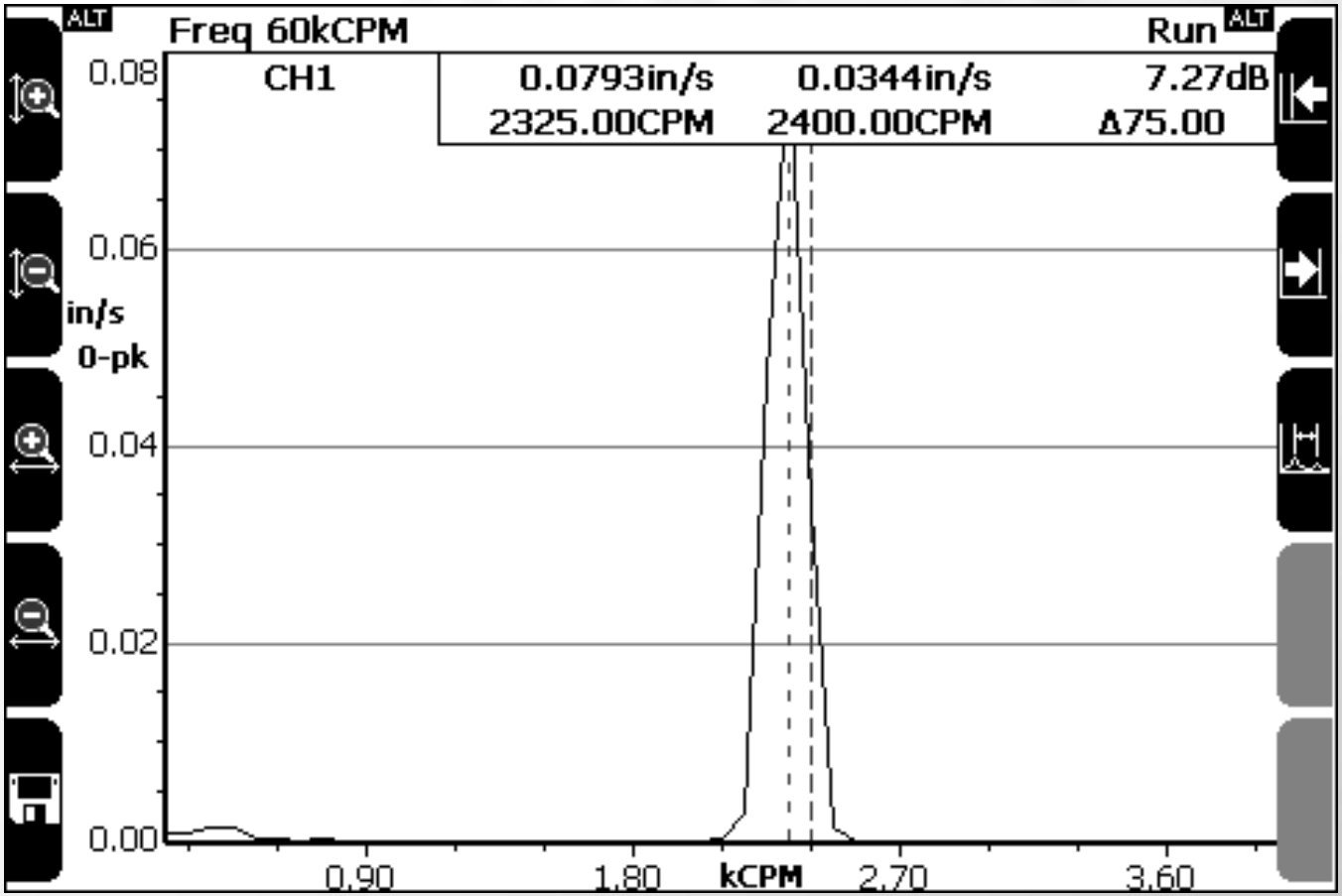


FFT



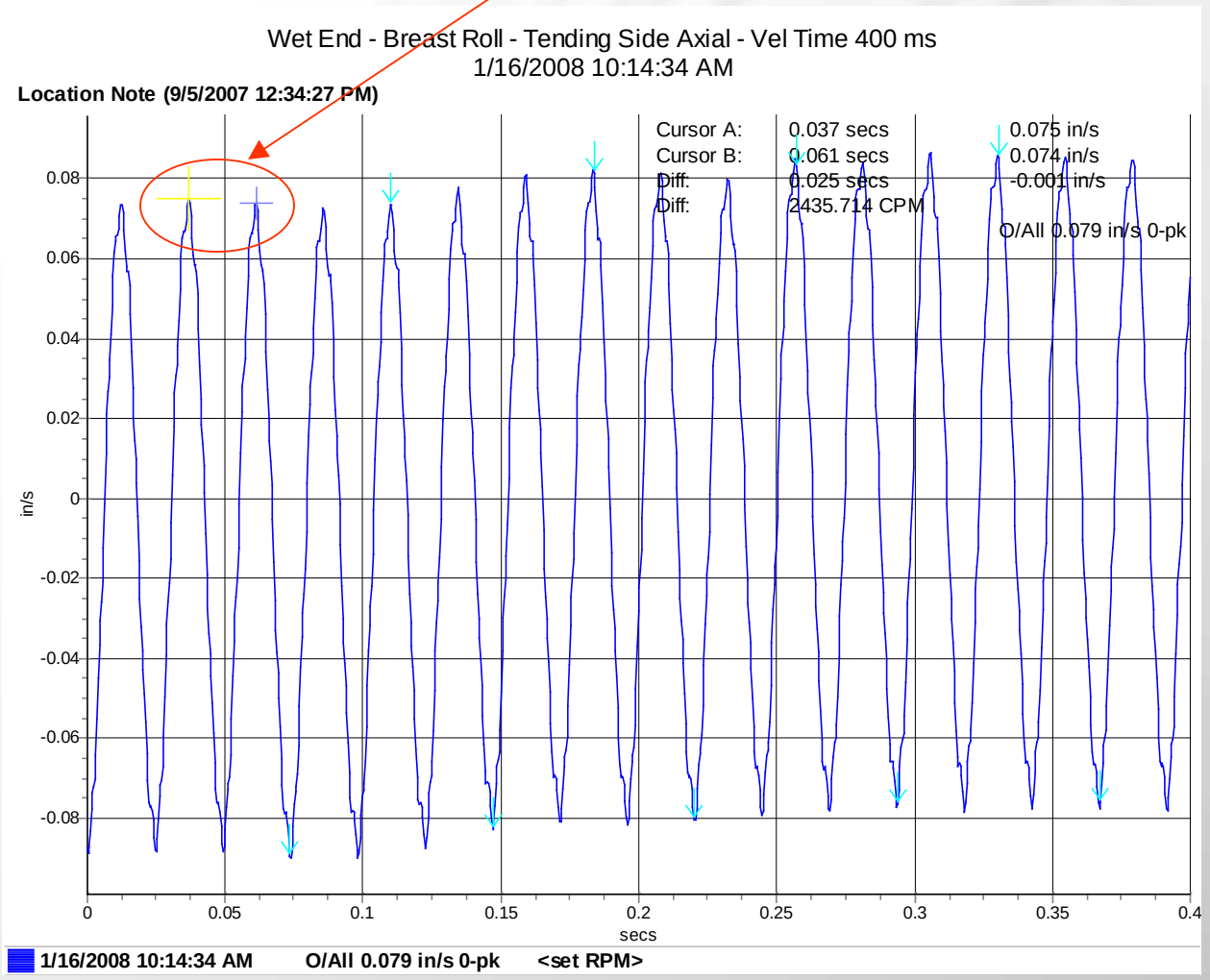
Zoomed FFT on Instrument

Shows more precise frequency and resolution



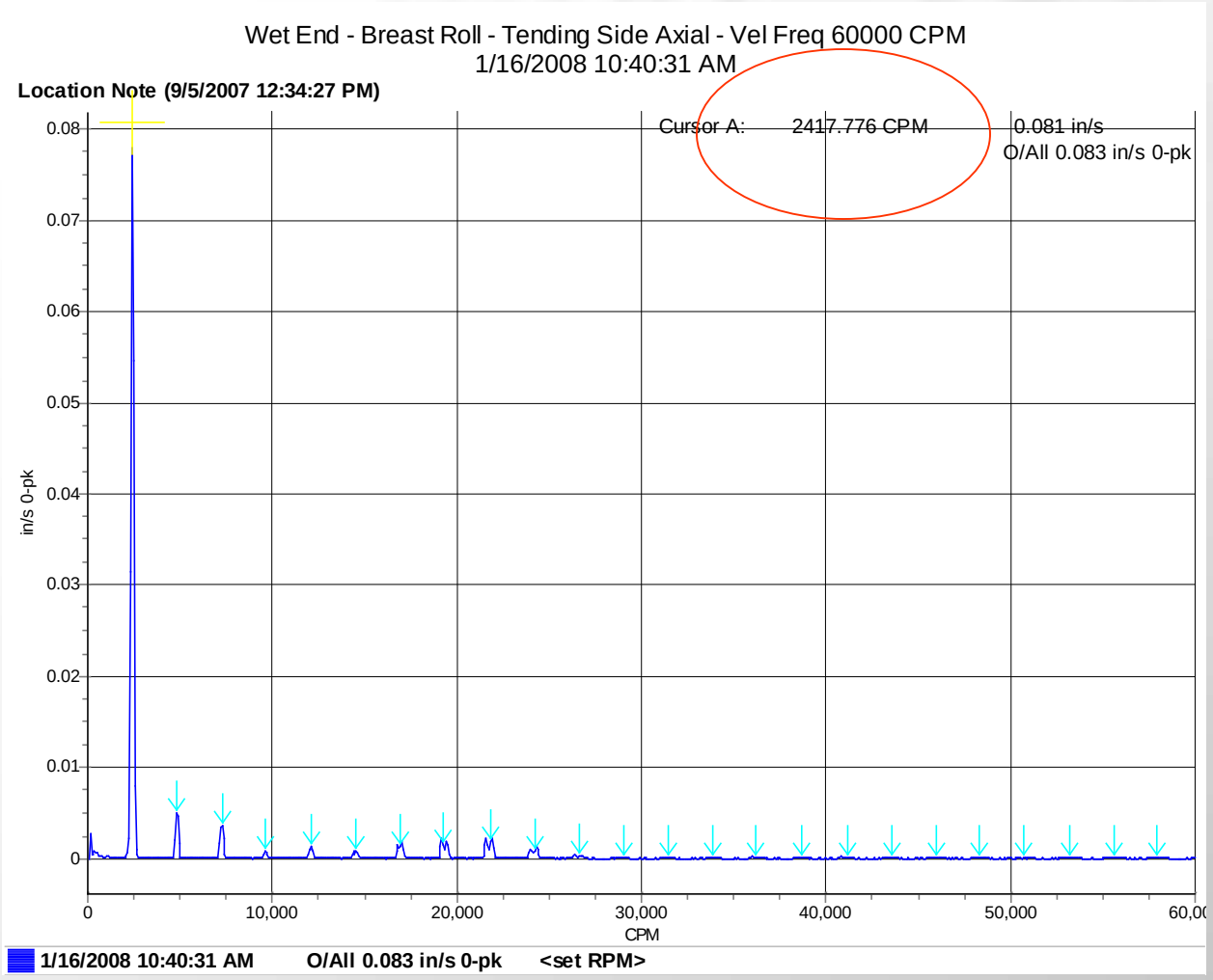
Viewed at PC

Note delta cursors to determine approximate frequency

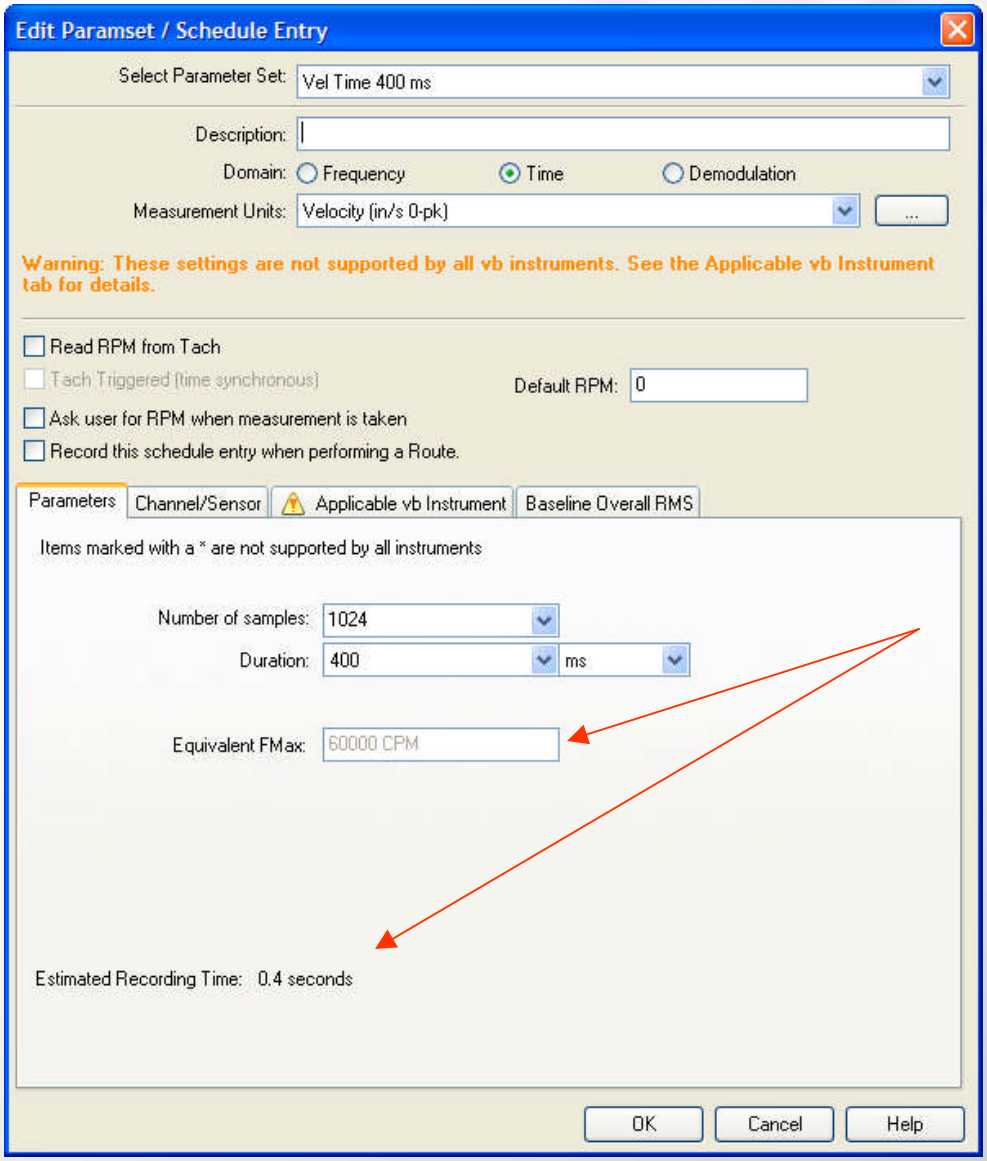


Viewed at PC

Interpolated running frequency

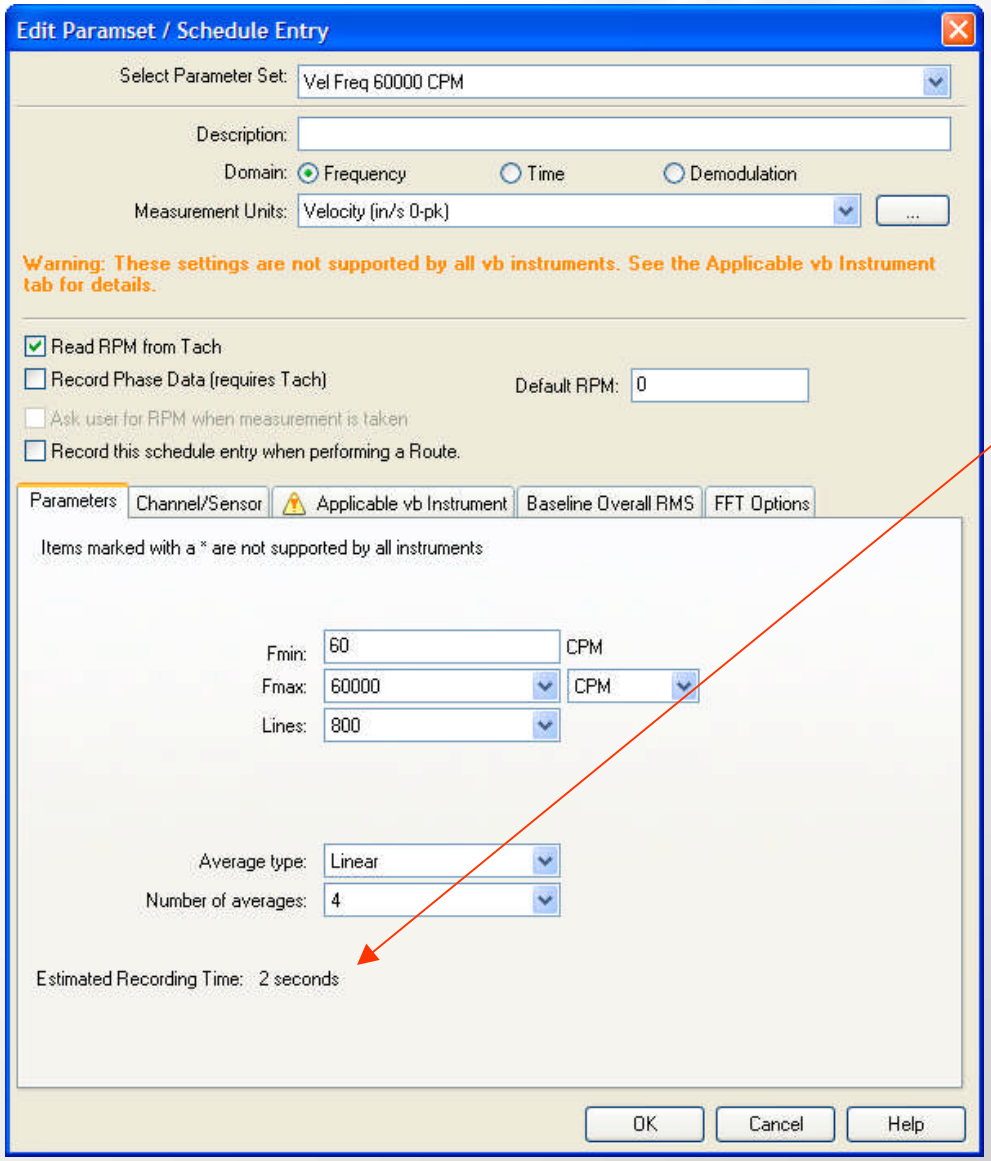


Setup Parameters - TWF



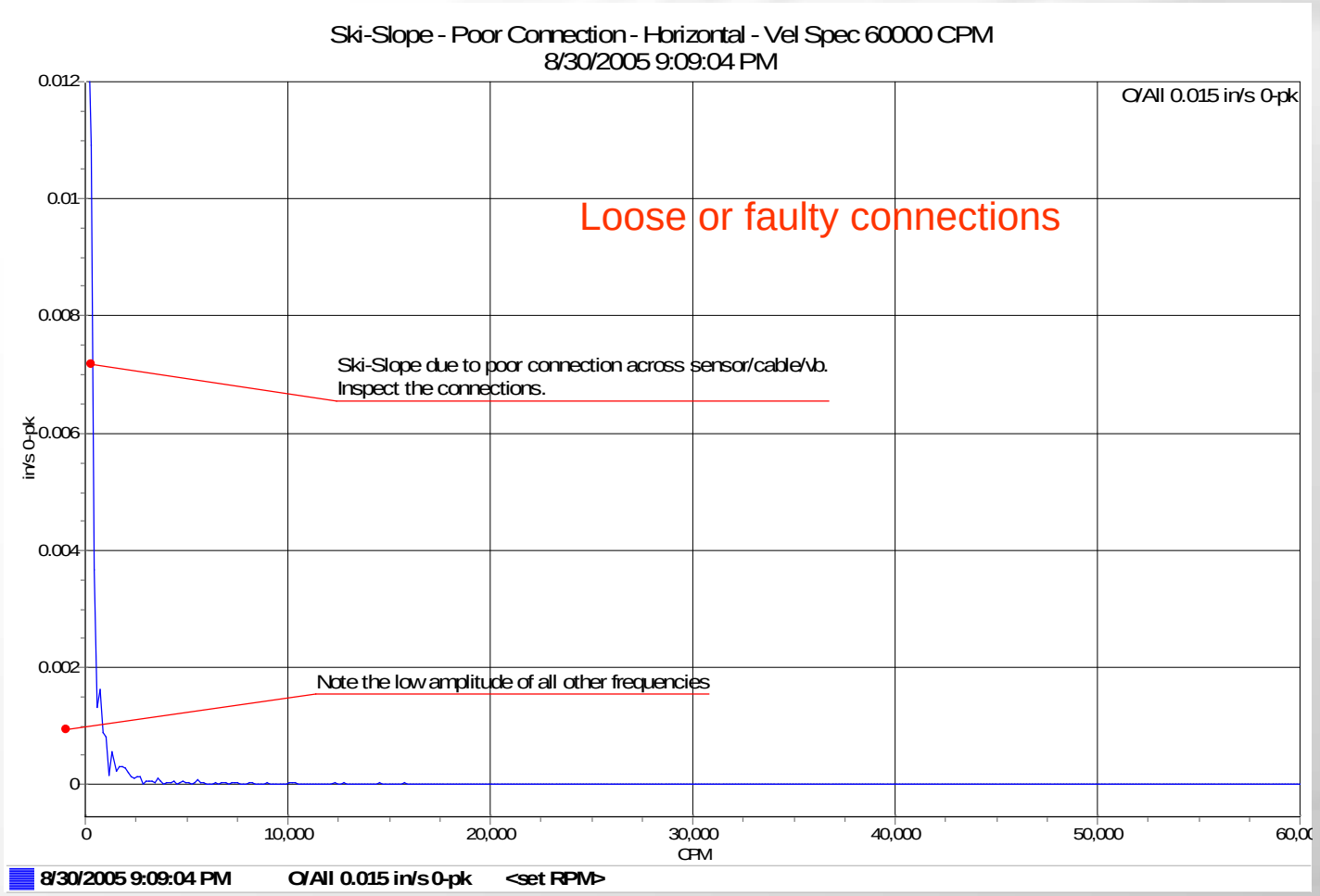
Note the settings and calculated equivalent Fmax value and estimated time.

Setup Parameters - FFT



Note the settings and estimated time.

Examples of Field Problems



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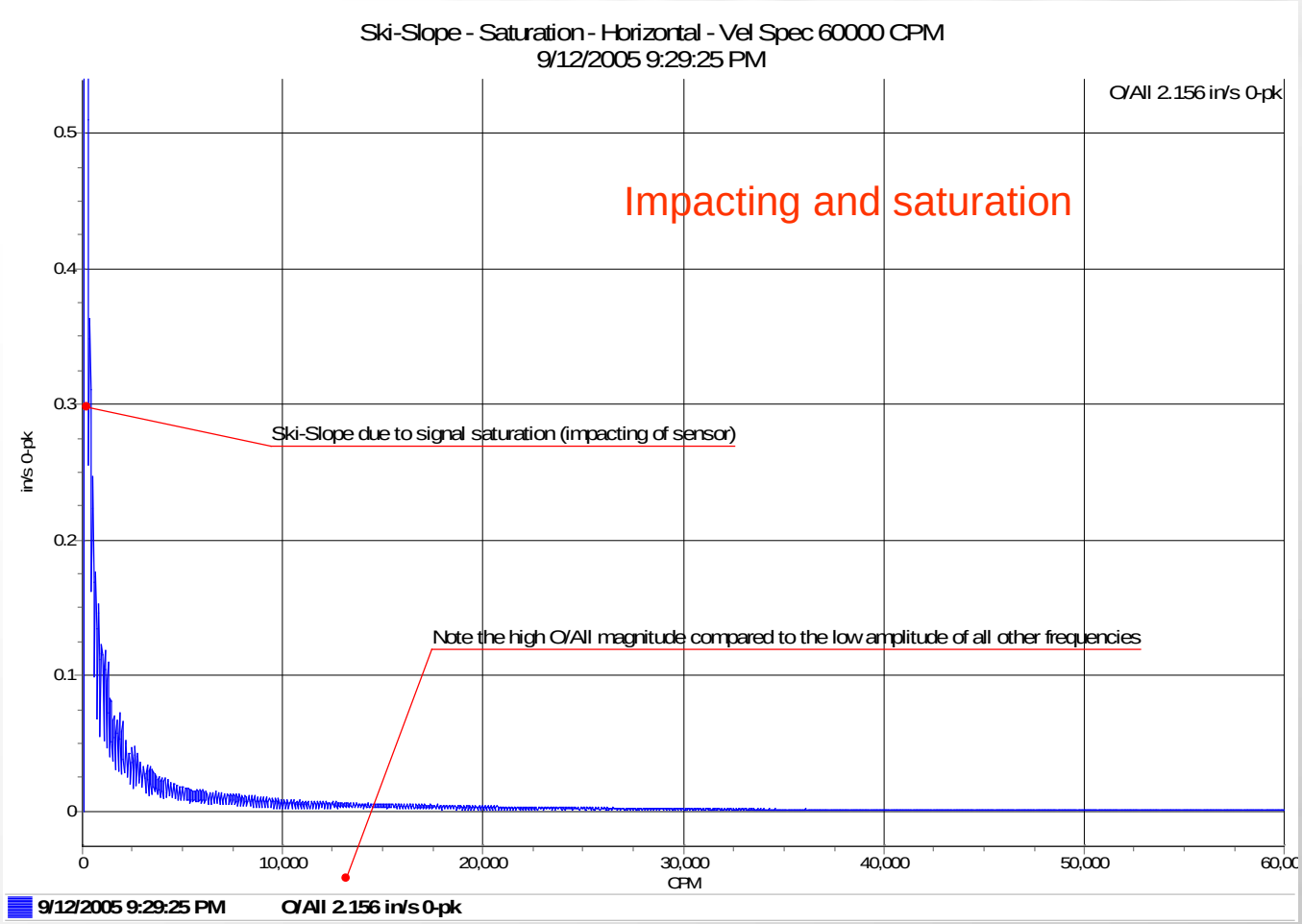
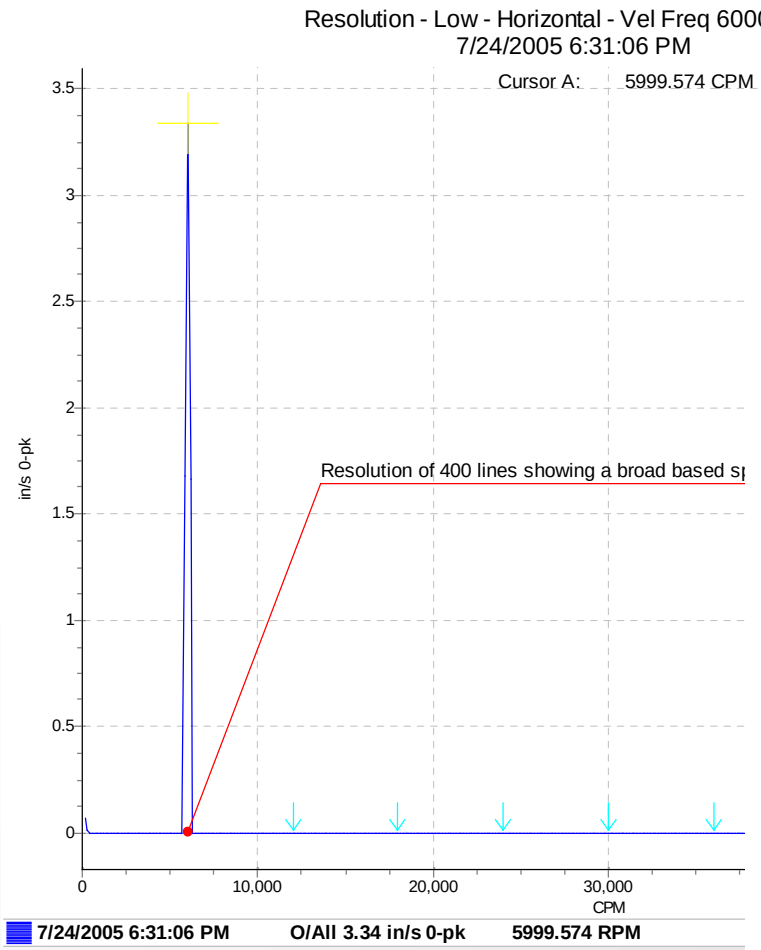
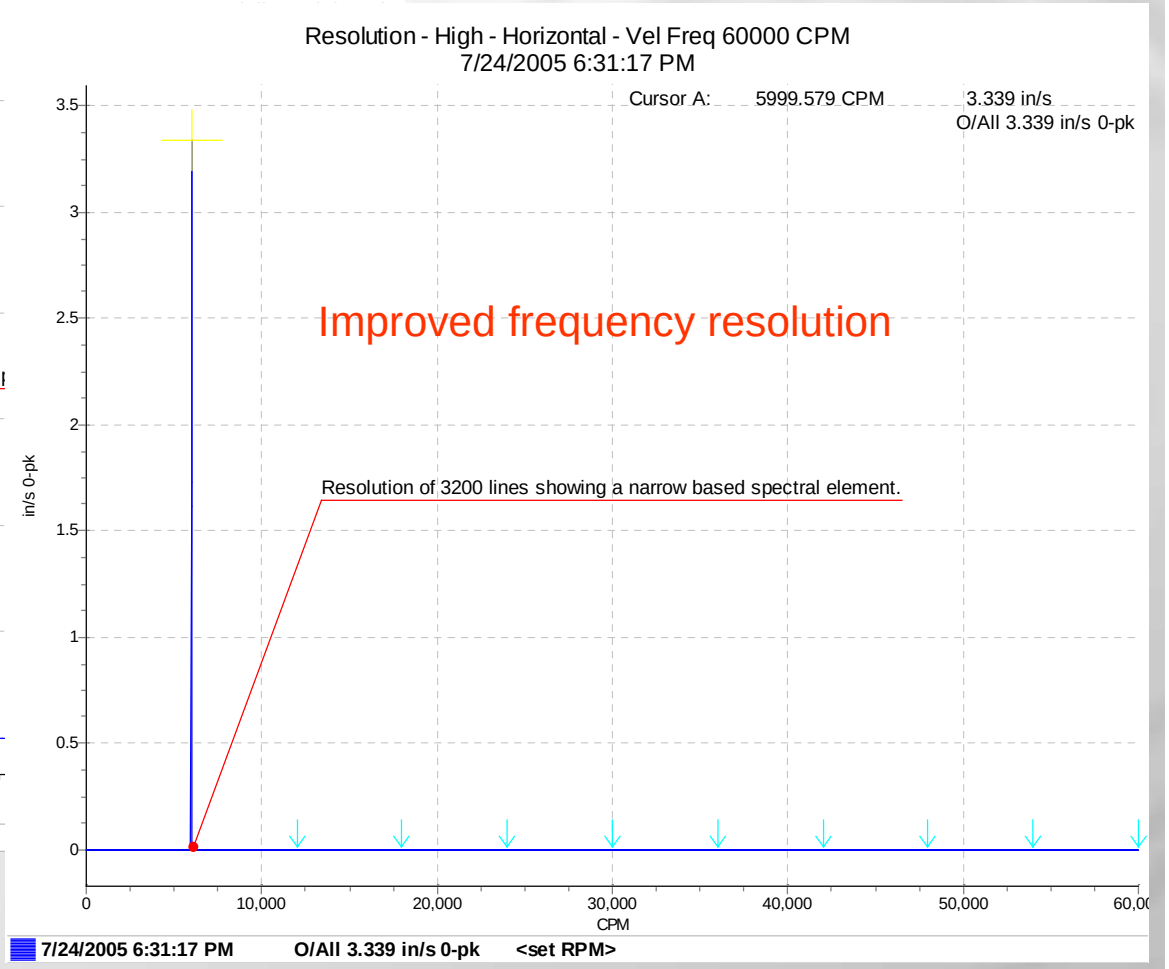


Example of Setup Issues





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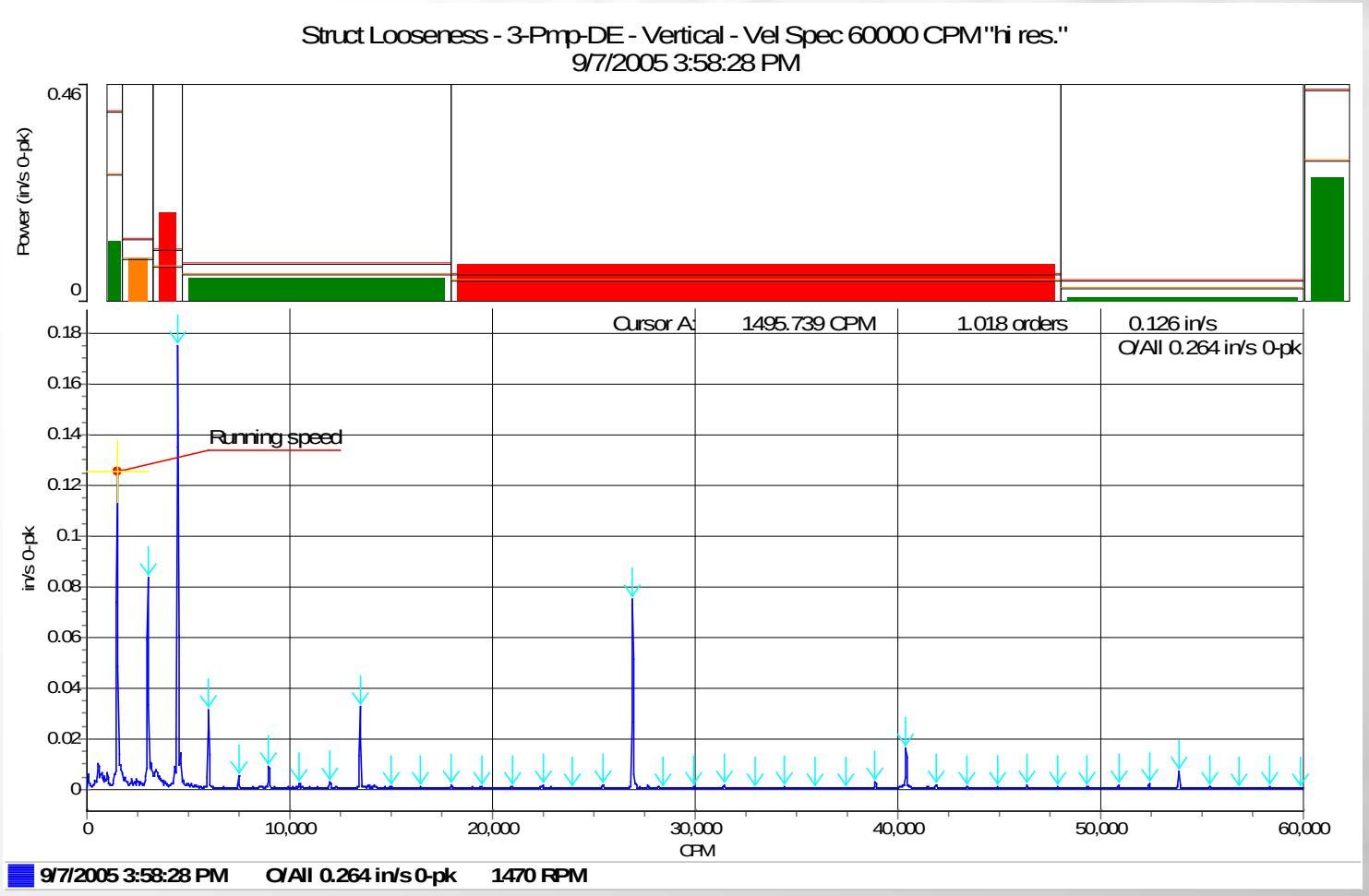
Example of Good Data for Analysis



Summary – Key Considerations

- Know the equipment and application.
- Recognize changing conditions.
- Choose the best shot at capturing the event.
- Choose the best sensor for the job.
- Choose the best location for the measurement.
- Make appropriate settings for the measurement.
- Capture good quality data.
- Transform data to information.
- Identify tell-tale signs of trouble.
- Decide a course of action.

Concluding Remarks

- Vibration is a primary measurement for an effective PdM program.
- Education and experience in the technology and techniques are essential for success.
- Get management ‘buy-in’ on the process.
- Know the equipment in terms of physical make-up and intended operation.
- Know standards for acceptable operation.
- Know the tell-tale signs for potential problems.
- Know the tools available for the program.
- Perform the proper setup for acquiring data.
- Be confident in assessing the situation.
- Have confidence in making the call for action.

Questions and/or Comments?

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