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.

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Getting Down to Basics

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

(Interpret information relative to PF curve)

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Predictive Maintenance (PdM)

(an evolution from <u>Breakdown</u> to <u>Preventive</u>)

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

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DETECTION

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

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ANALYSIS

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

(Note: 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!

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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.

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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.)*

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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.)*

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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?

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Measurement Relationships

- Highest frequency (Fmax)

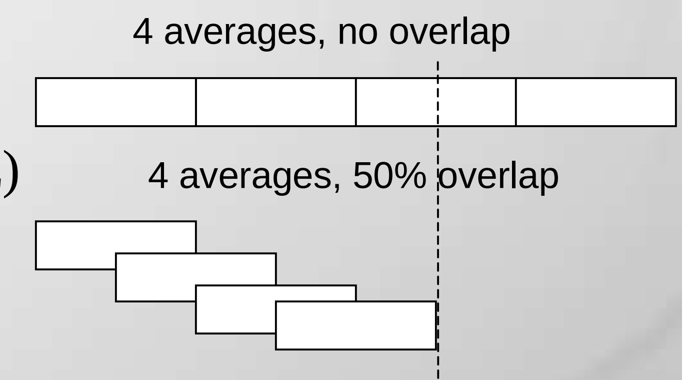
  Fmax (Hz) = # of samples / (2.56 * sample time)
  (corollary: sample time = # lines of resolution / Fmax (Hz))

- Lines of resolution

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

- Time for collection

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



- Frequency resolution

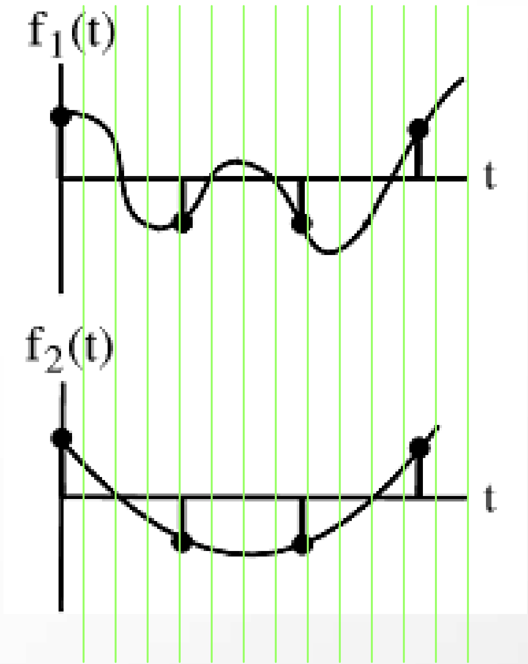
  Resolution = Fmax / # lines

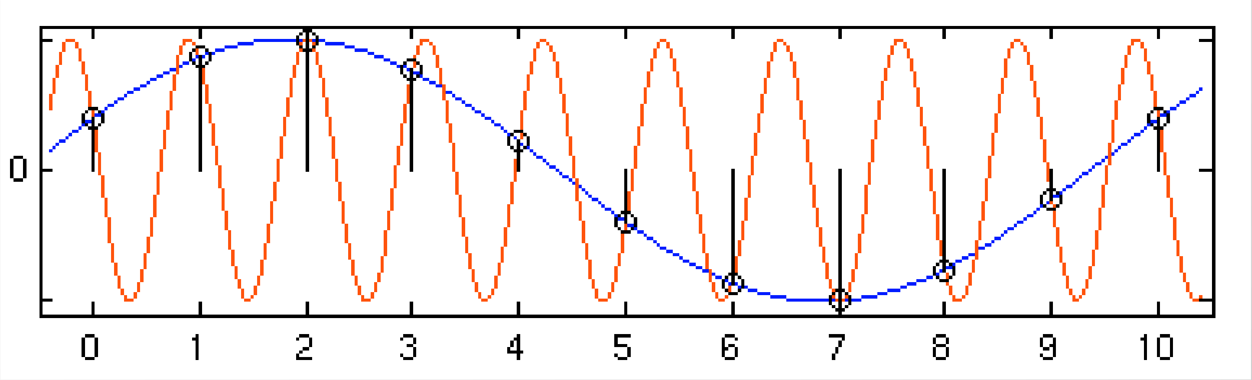
(Keep in mind the specifications for the sensor and instrumentation.)

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.

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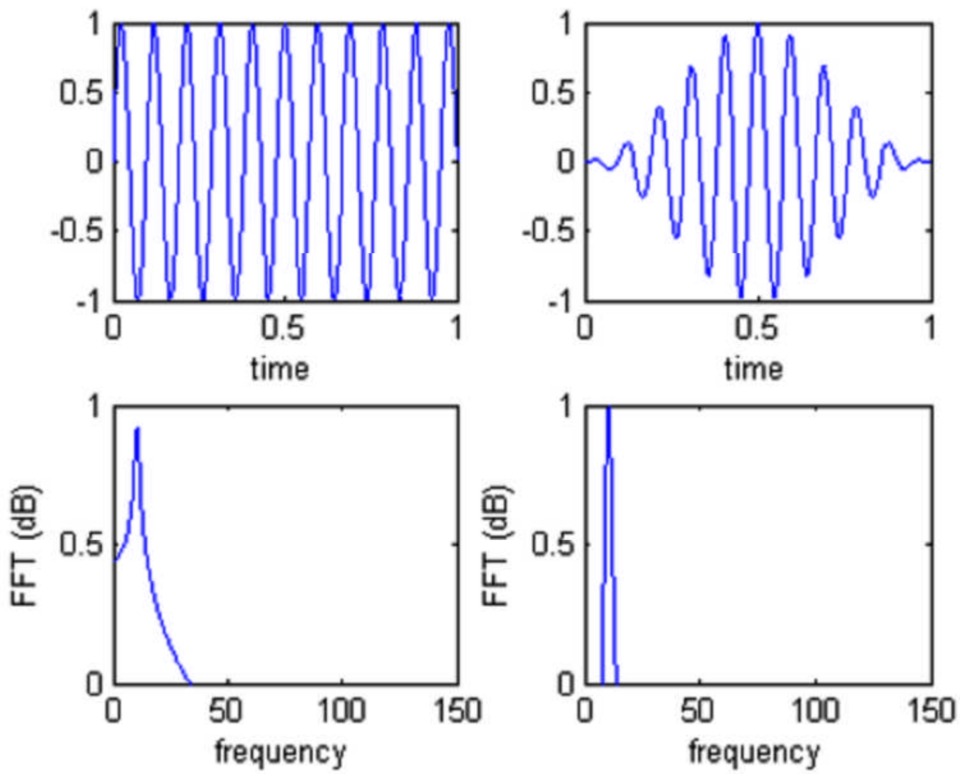
Further considerations

- 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).

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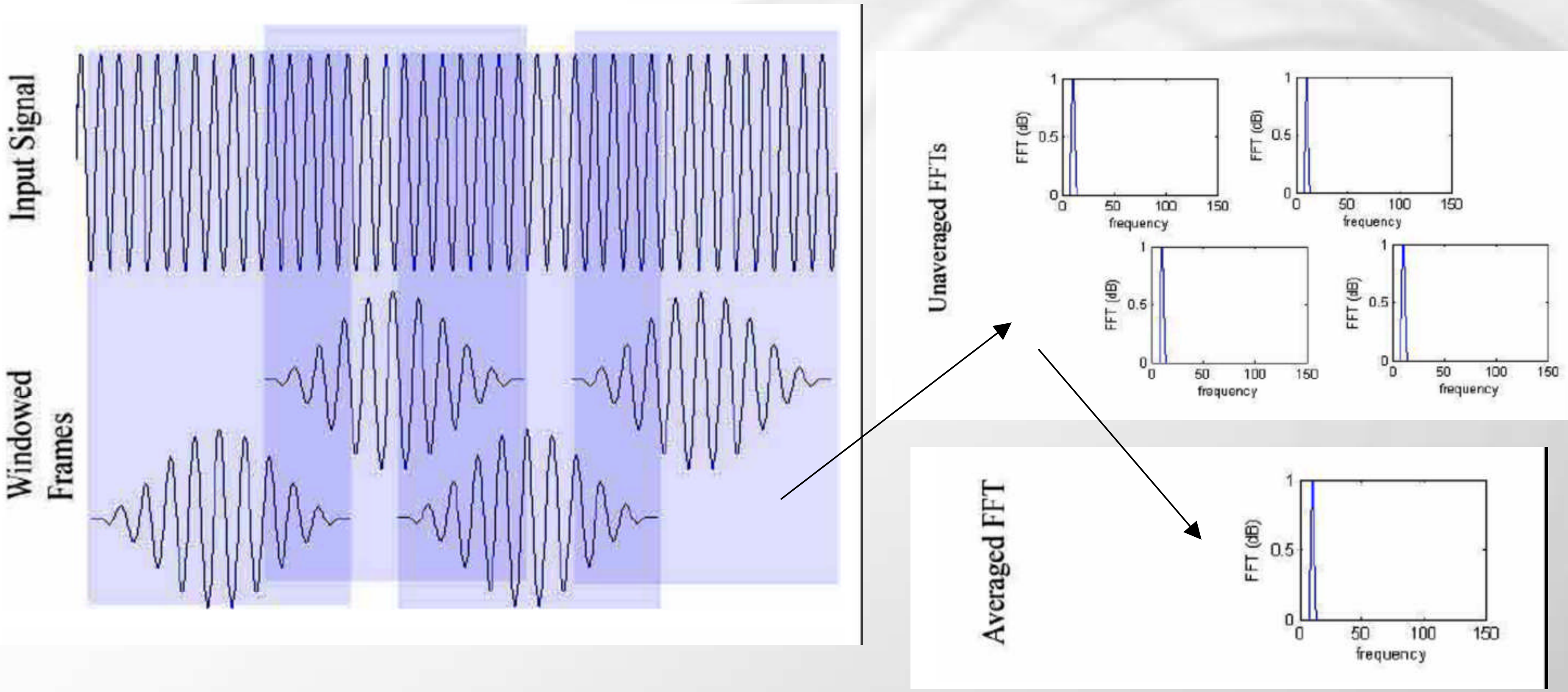
Overlapping Averages



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,

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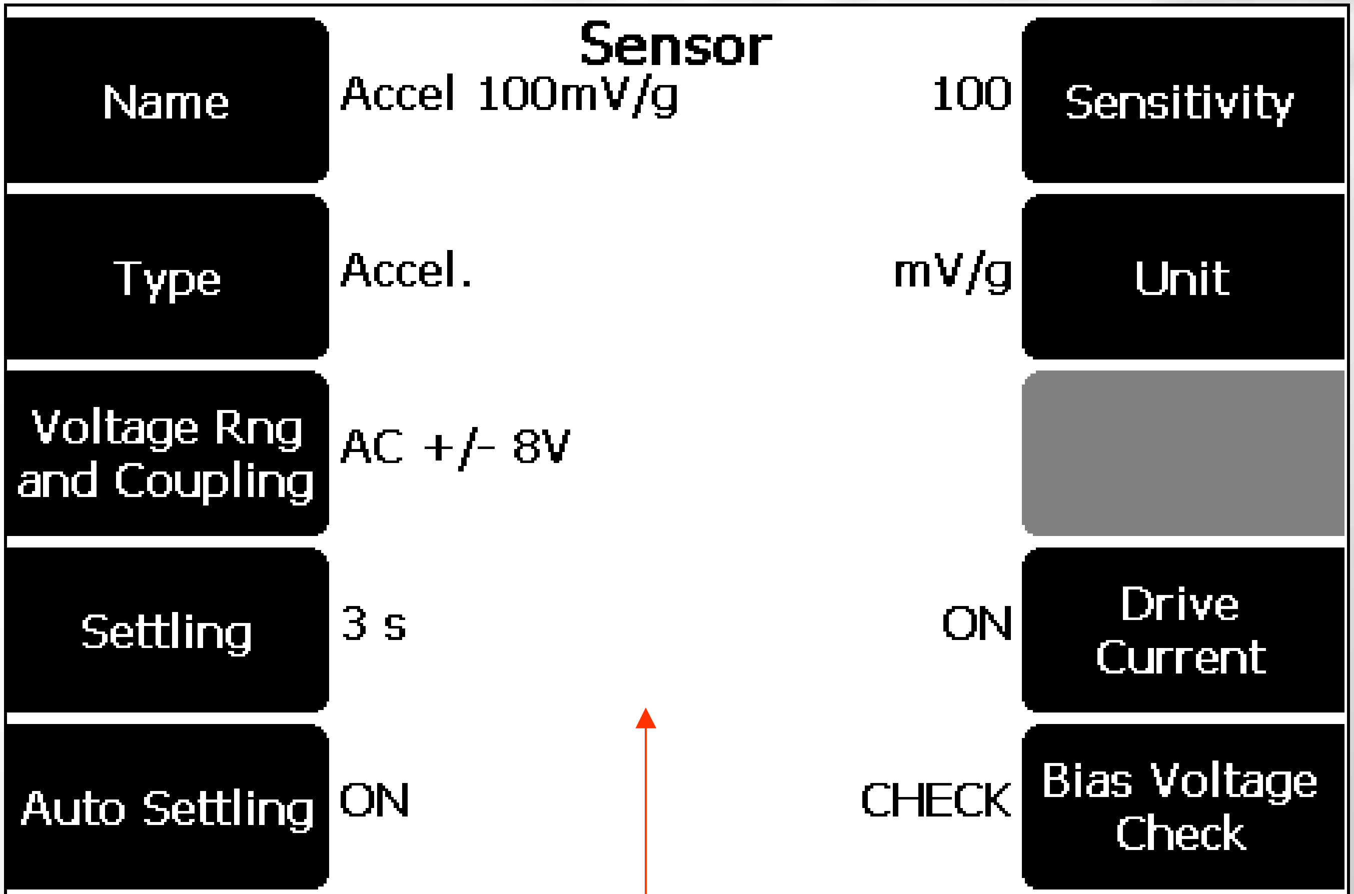
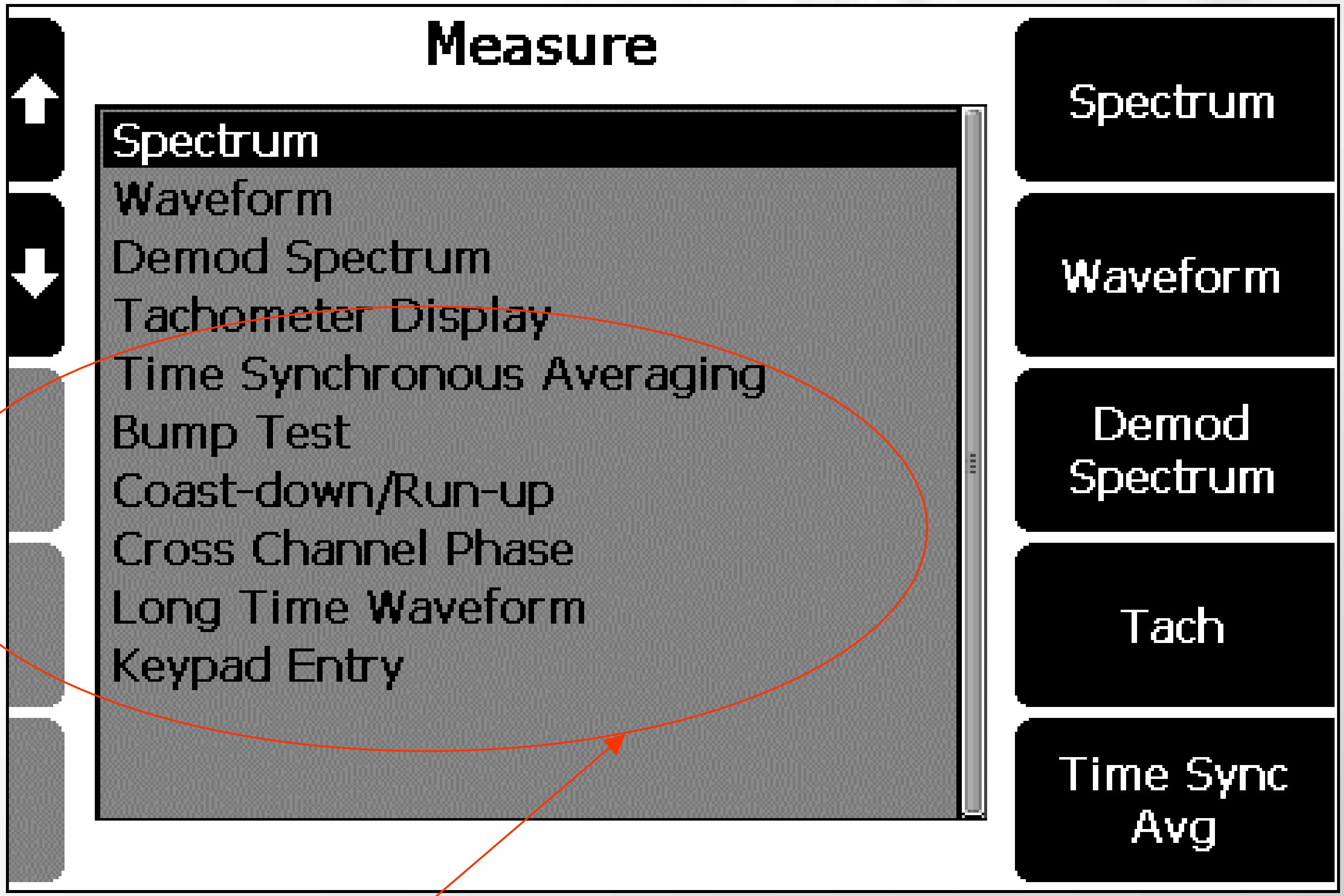
Example – at instrument side



Key settings to address

Example – at instrument side

Most commonly used
On routine data collection



Advanced analysis

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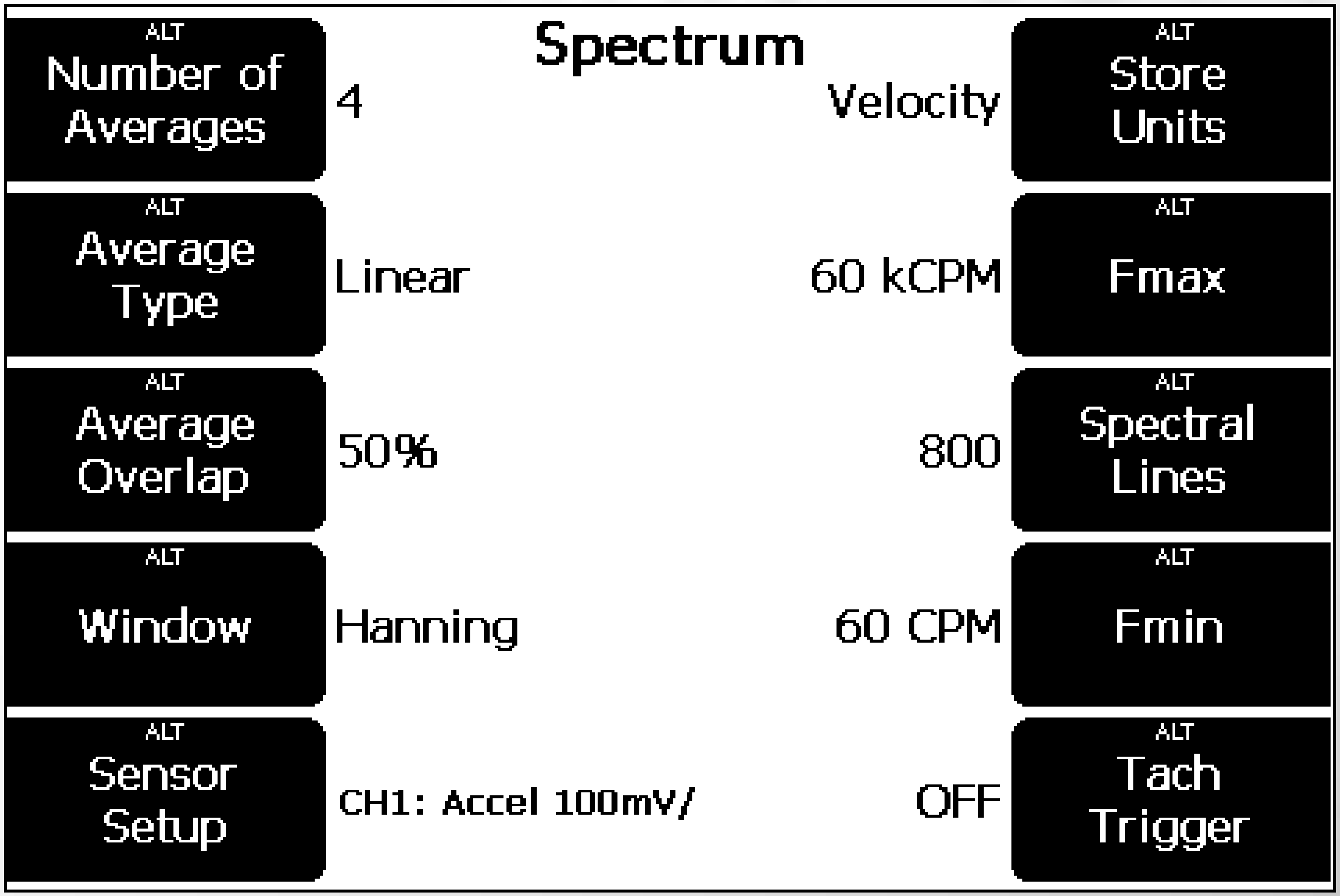
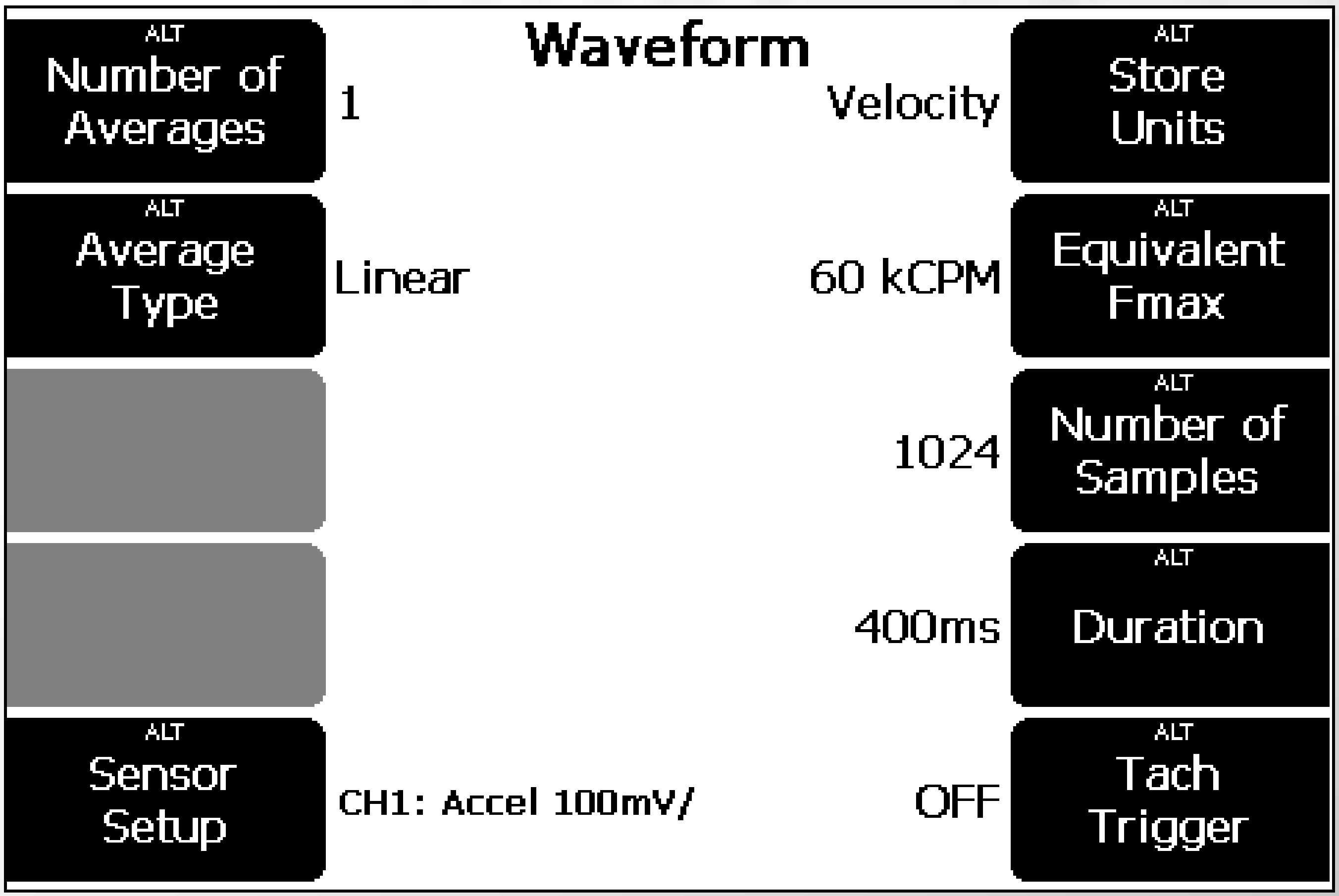
FFT (Spectrum) Measurement

Typical Settings Menu



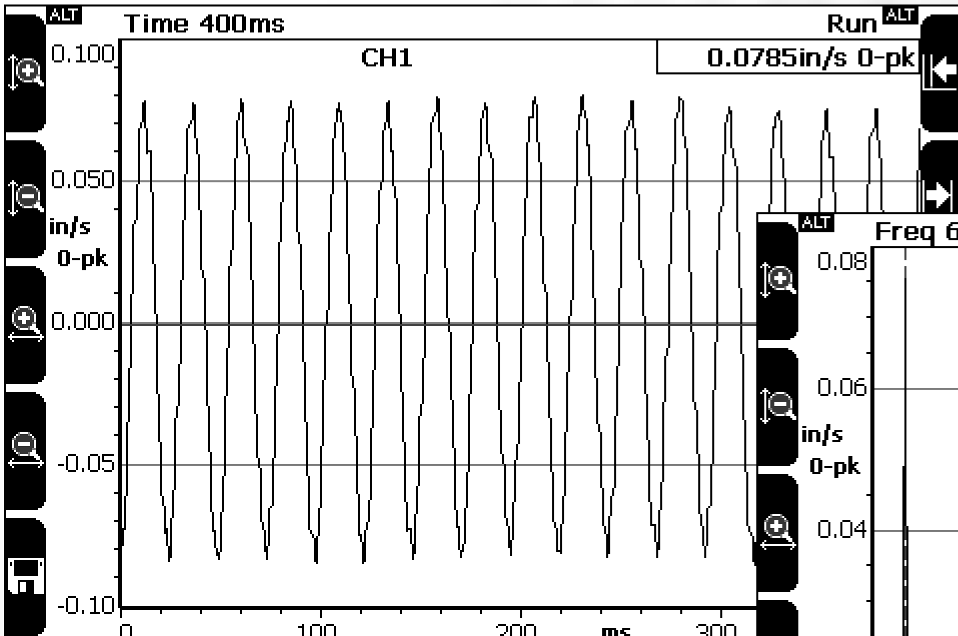
TWF (Time Waveform) Measurement

Typical Settings Menu

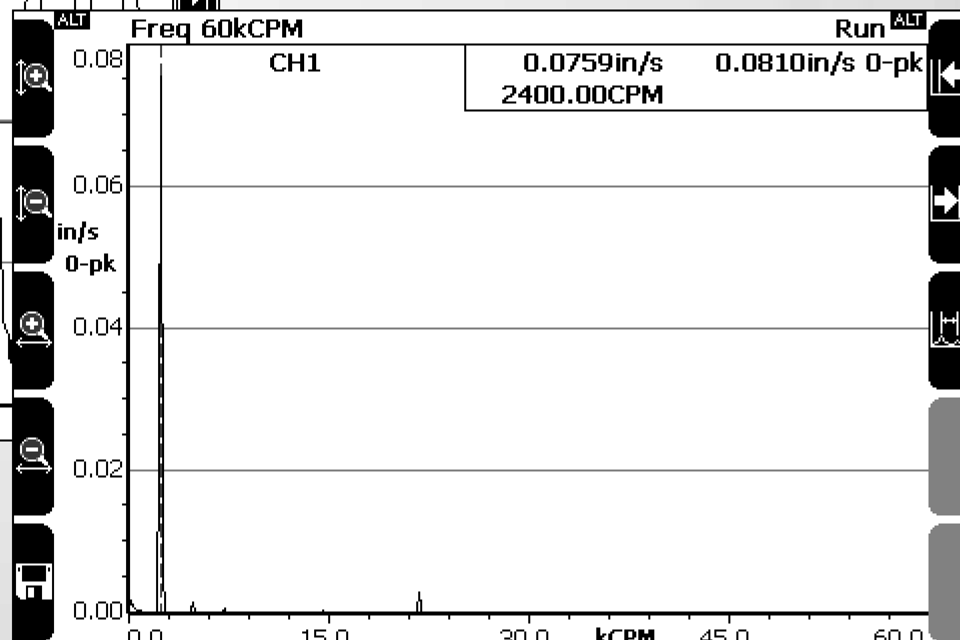


Measurements at Instrument

Time Waveform



FFT



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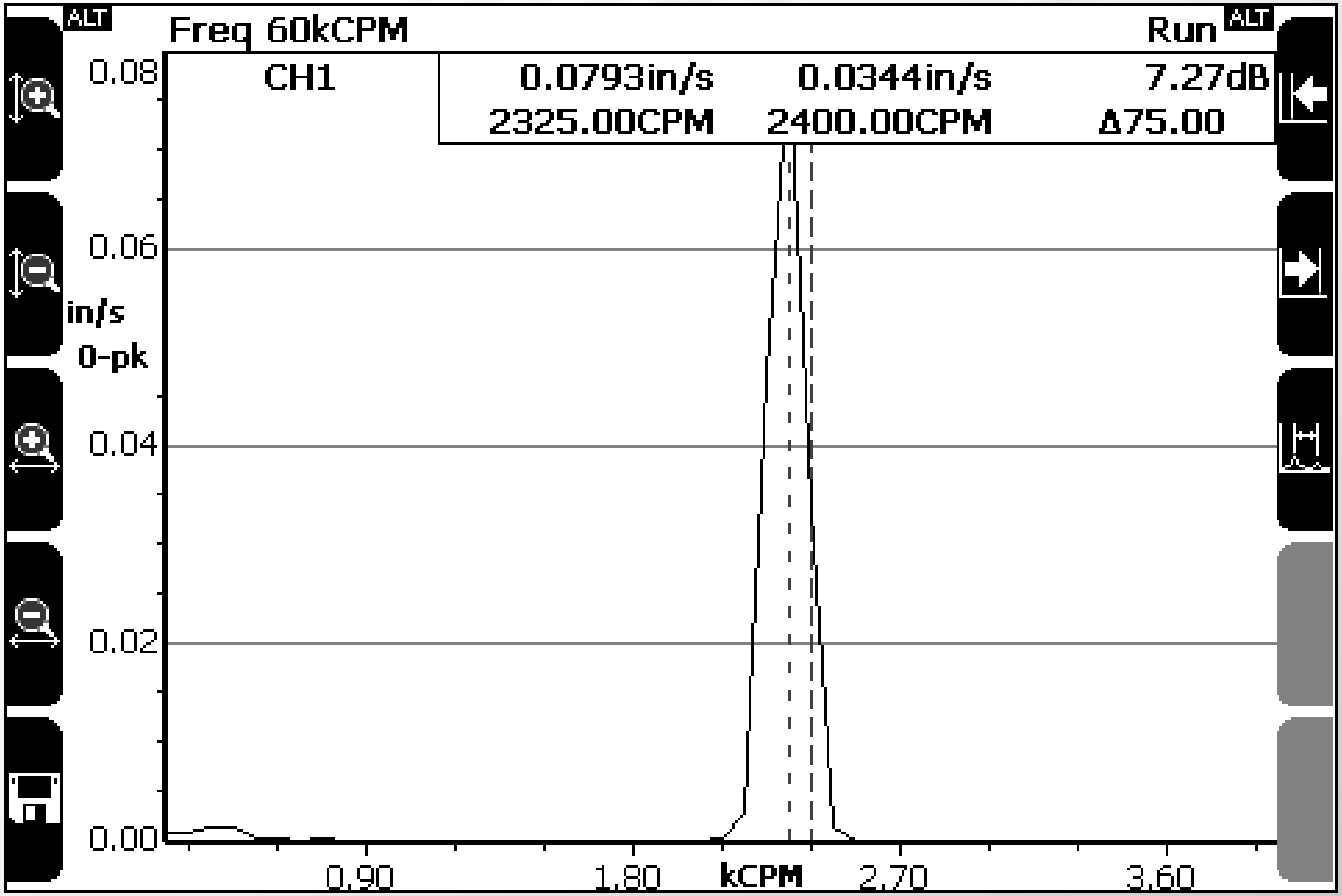
Zoomed FFT on Instrument

Shows more precise frequency and resolution



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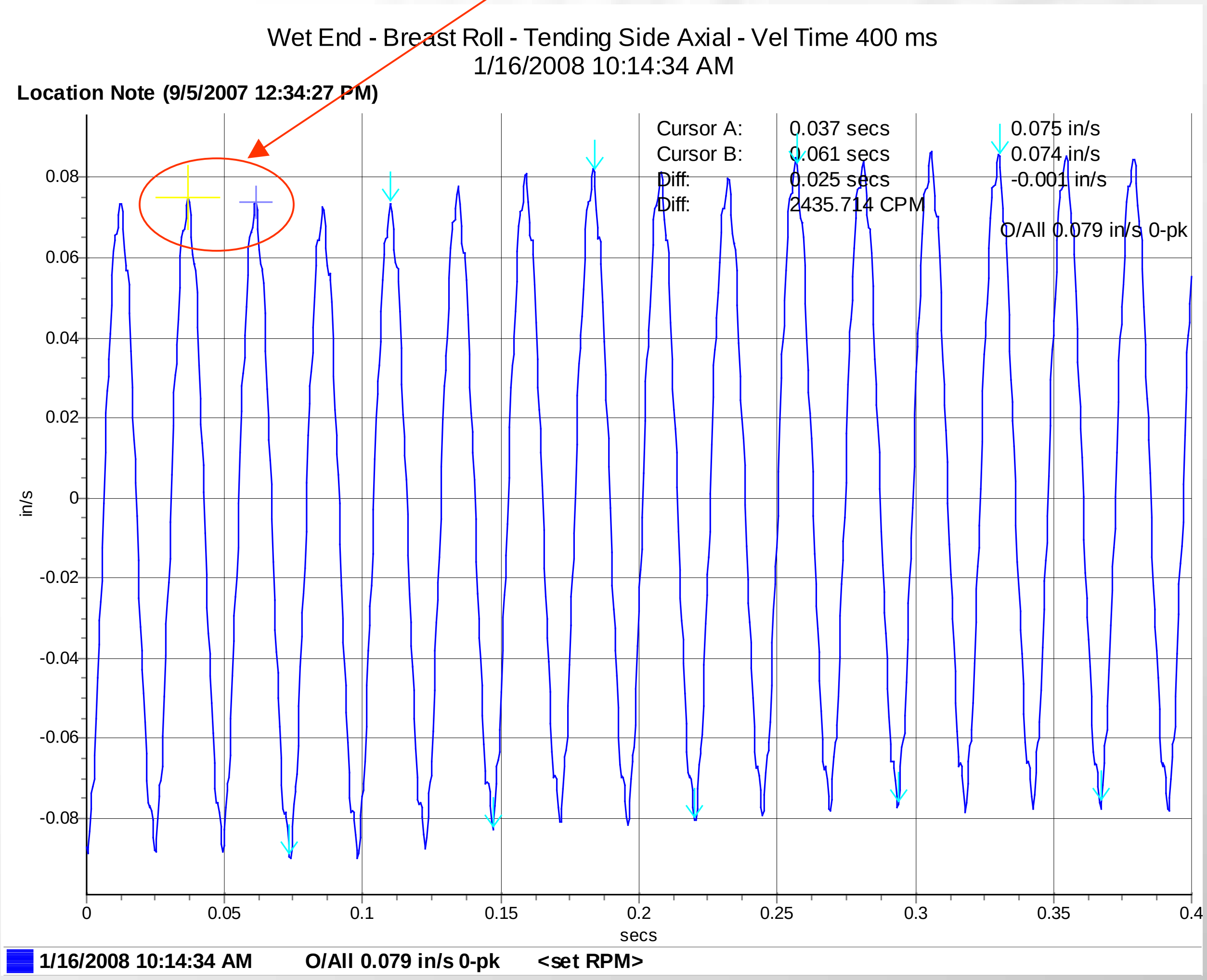
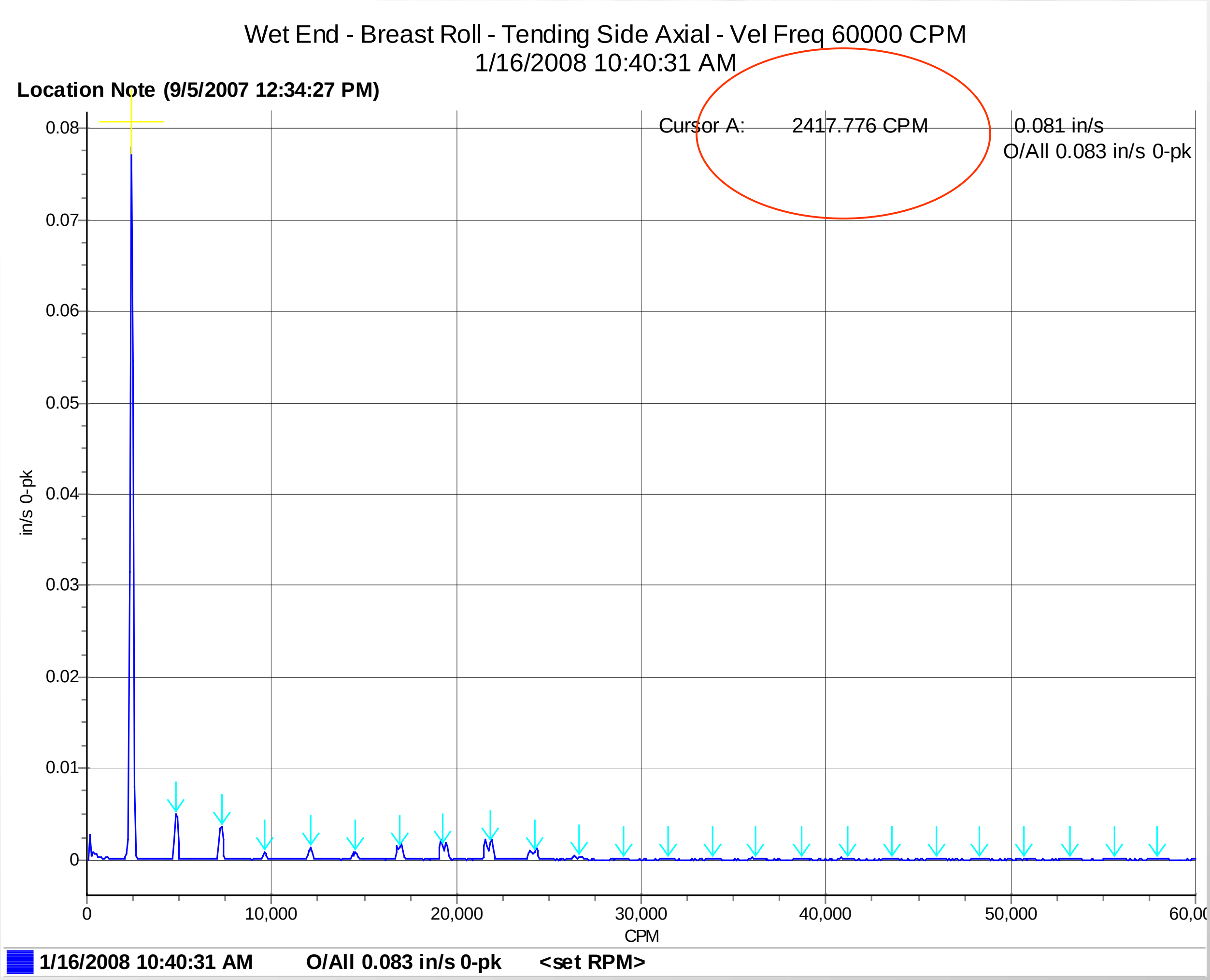
Viewed at PC

Note delta cursors to determine approximate frequency

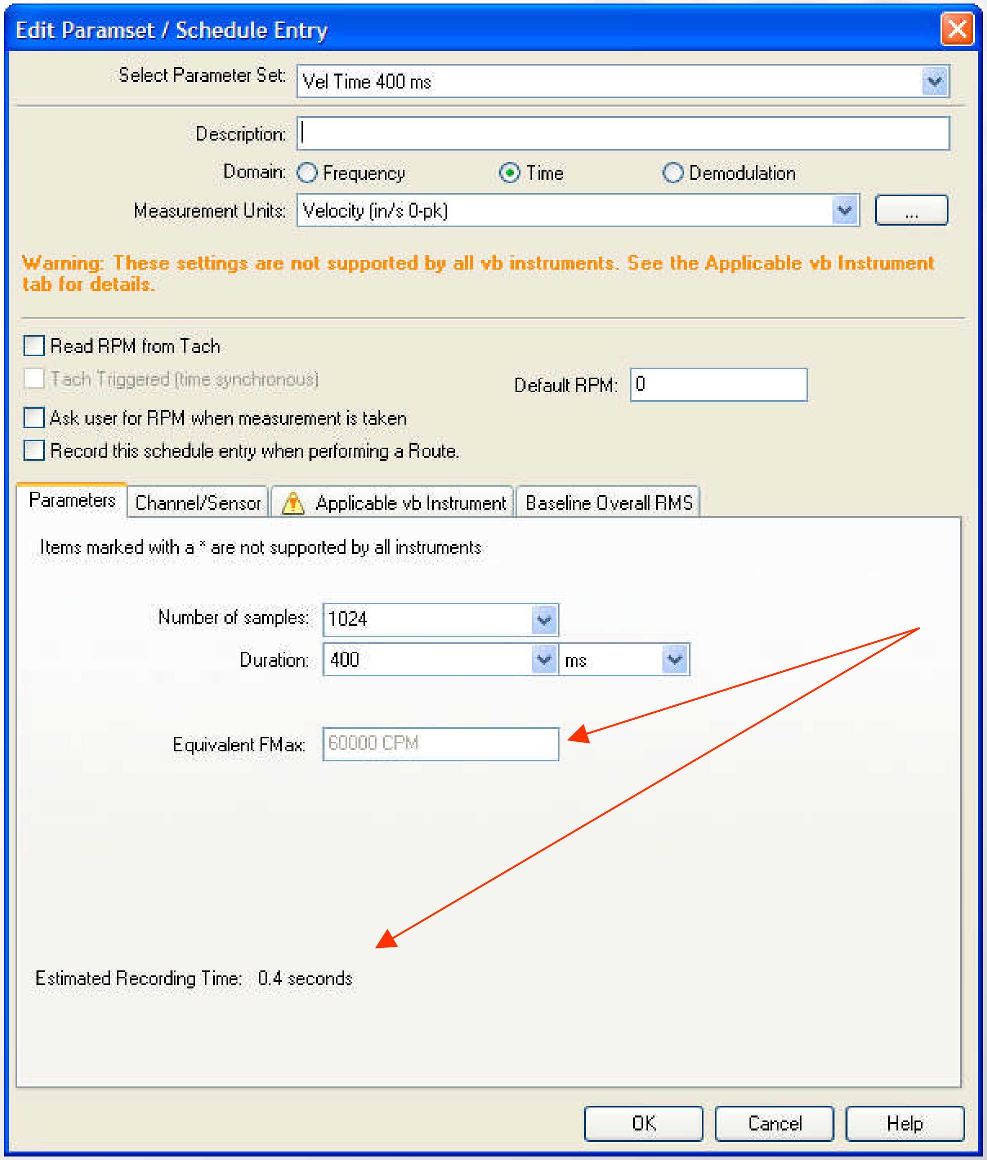


Viewed at PC

Interpolated running frequency

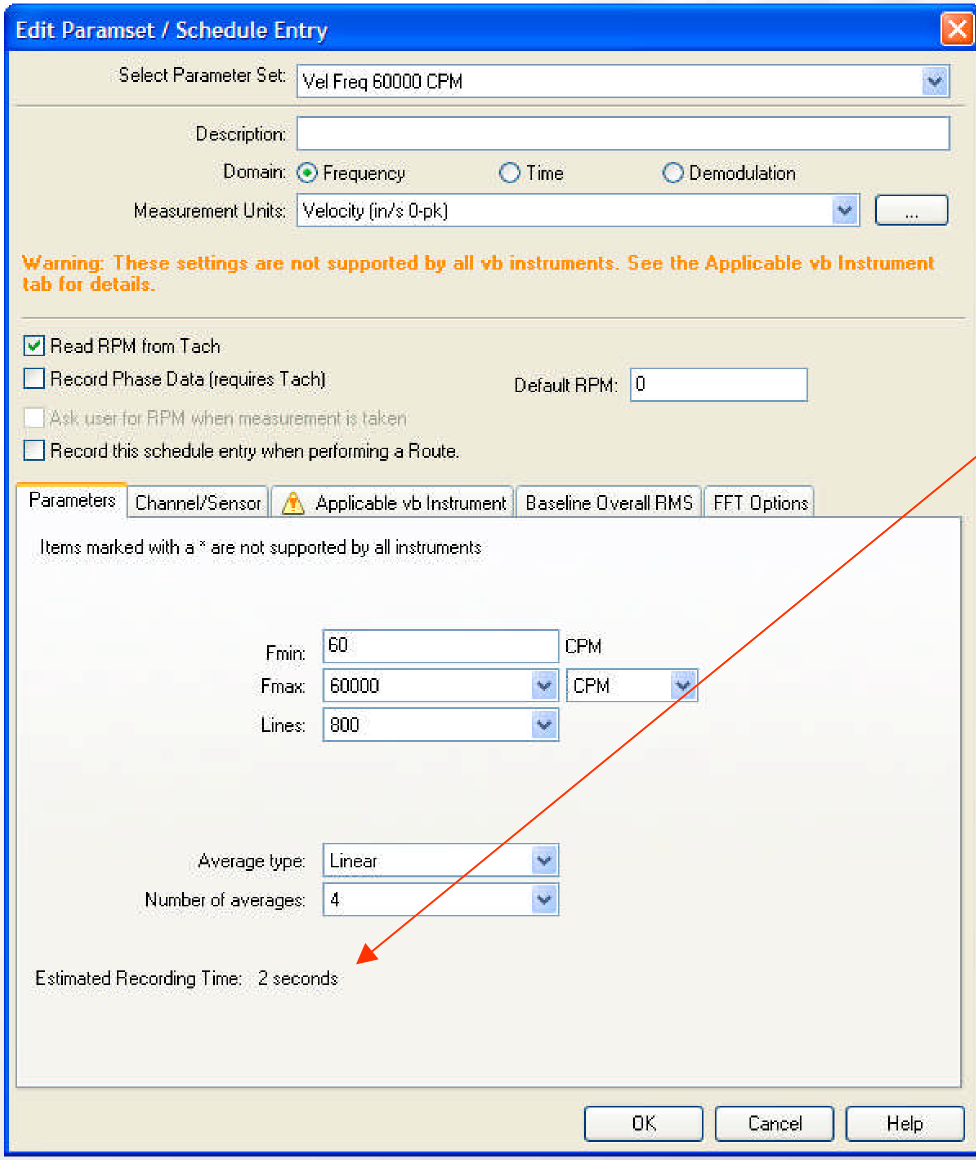


Setup Parameters - TWF



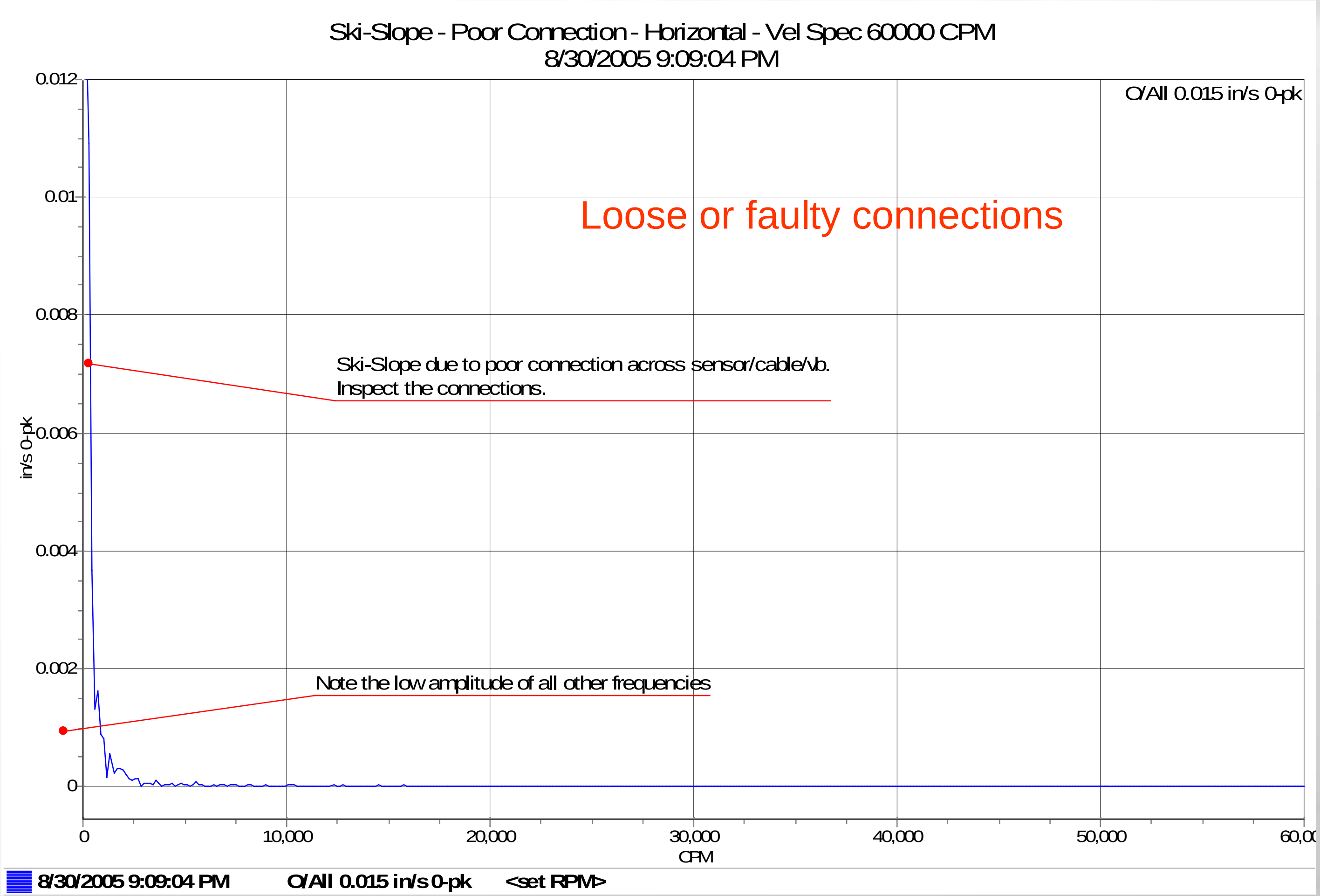
Note the settings and calculated equivalent Fmax value and estimated time.

Setup Parameters - FFT

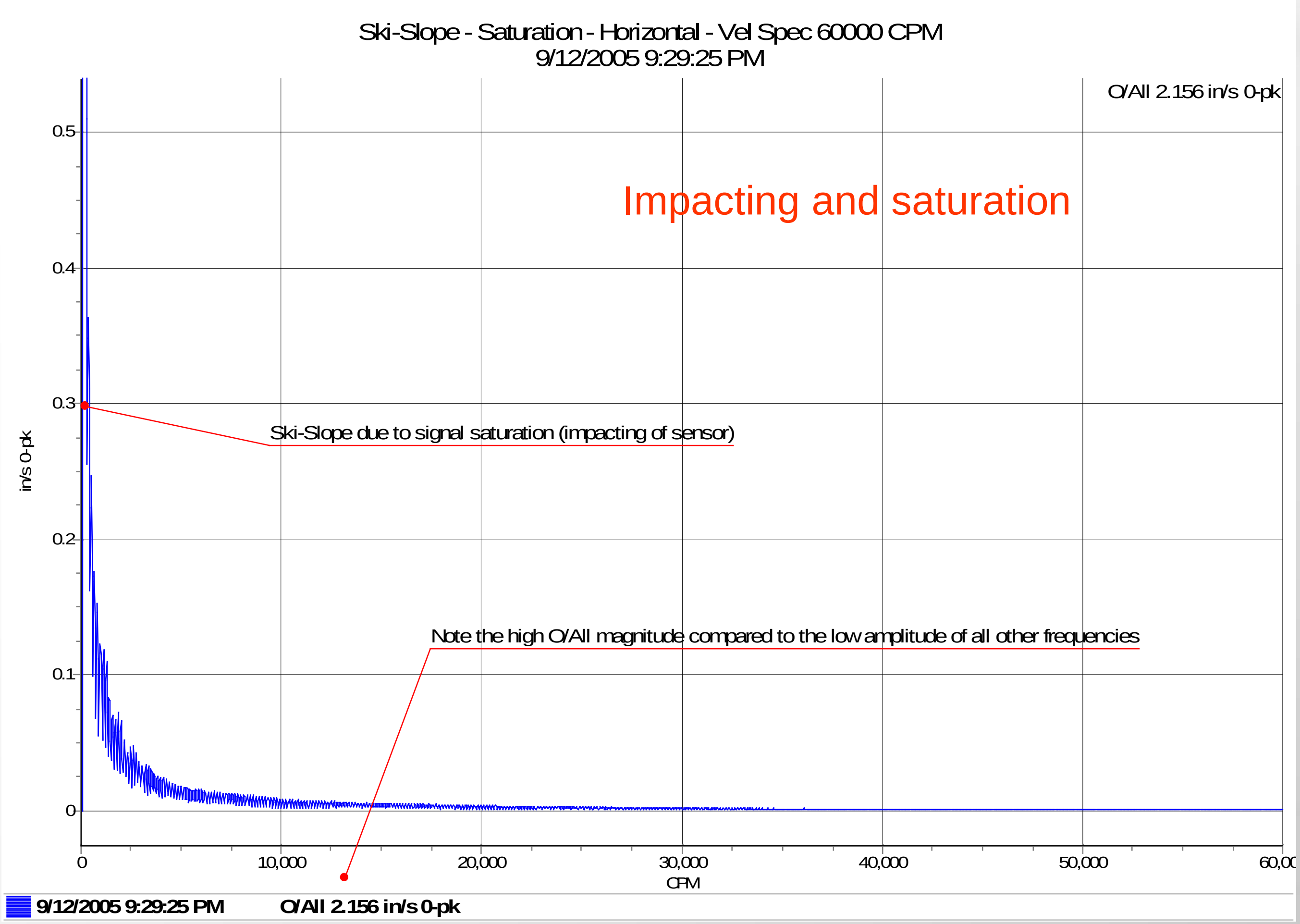


Note the settings and estimated time.

Examples of Field Problems



Examples of Field Problems



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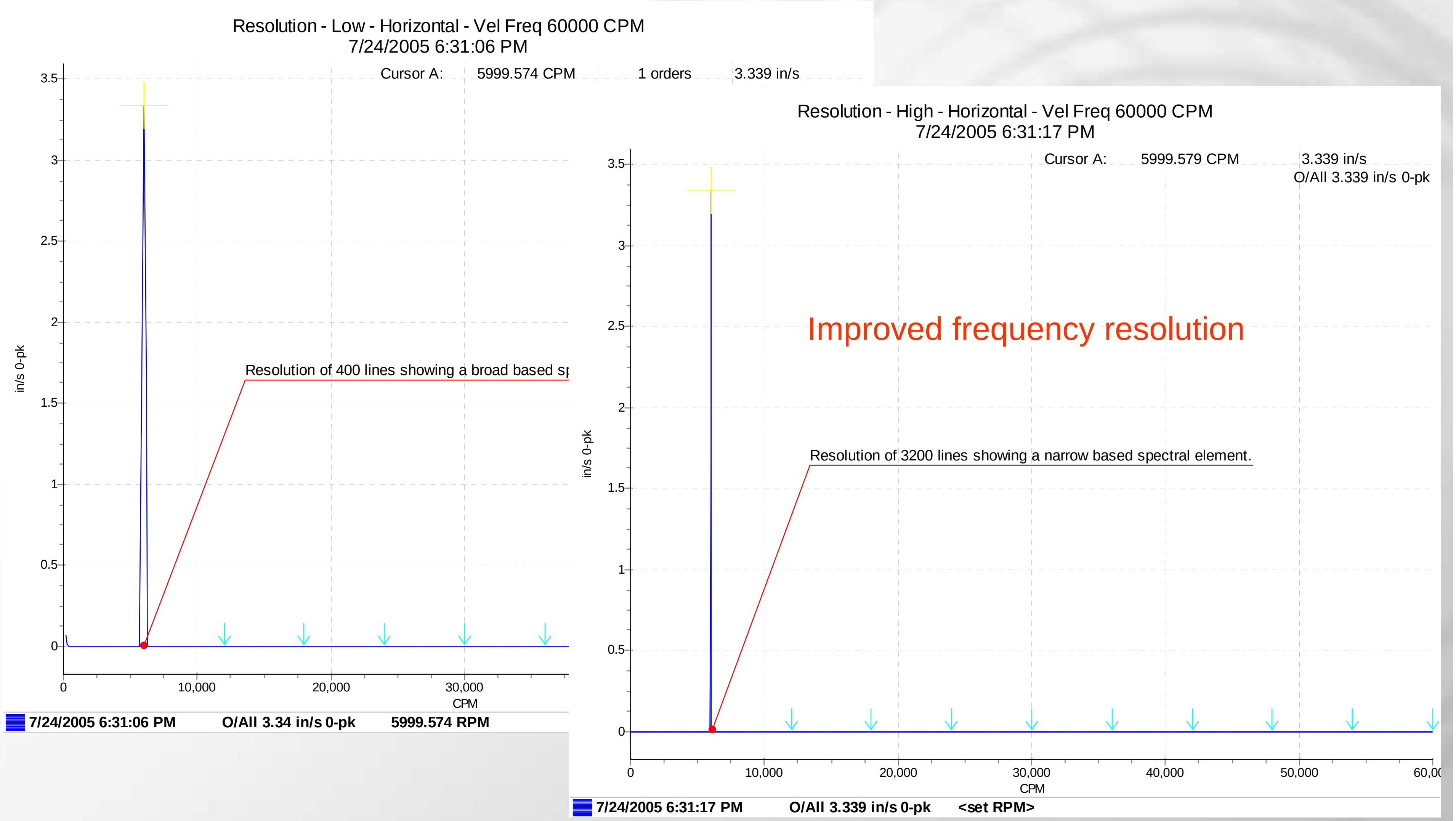
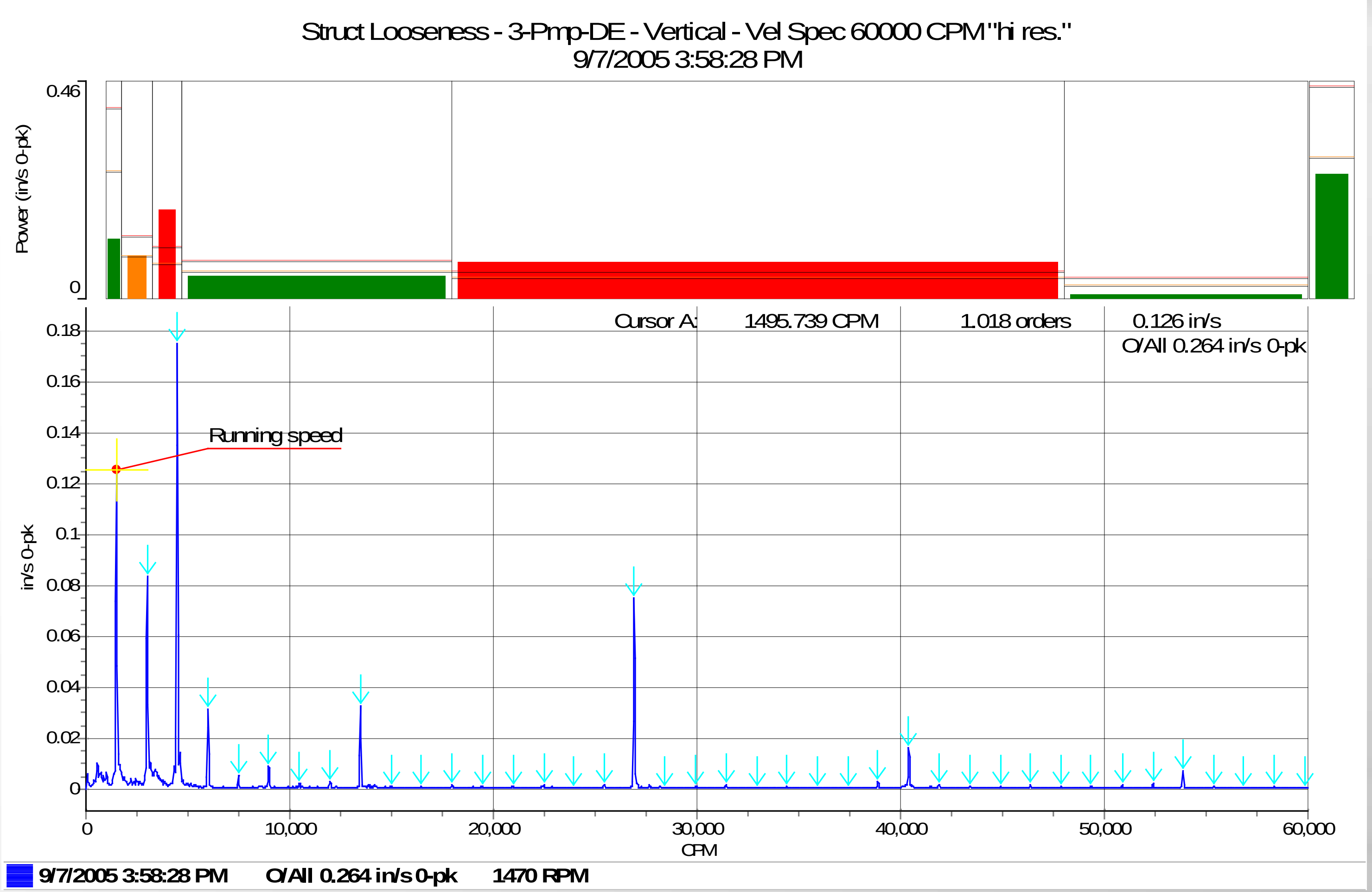
Example of Setup Issues



Example of Good Data for Analysis



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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.

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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.

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Questions and/or Comments?

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