VIBRATION FOR NON VIBRATION ENGINEERS

Types of Maintenance Strategies

- Run to failure
- Preventive maintenance
- Predictive maintenance
- Proactive Maintenance

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Run to Failure

- Results in:
  - Catastrophic machine damage
  - Unscheduled maintenance
  - Lost production revenue

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Preventive Maintenance

- Better than “Run to failure”
- Results in:
  - Excessive scheduled downtime
  - Unnecessary maintenance
  - Failures due to improper maintenance

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Predictive Maintenance

- Maximizes motor life through abnormal operation and fault detection.
- Reduces unscheduled downtime by alerting users of degrading mechanical/electrical conditions.
- Optimizes motor utilization.

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Predictive Maintenance Methods

- Route based methods
  - Vibration
  - Tribology
  - Shaft Current/Voltage
  - Electric Current Analysis
  - Temperature
  - Flux
  - Ultrasonics
  - Infrared Thermography
  - Wireless

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Predictive Maintenance Methods

- Continuous (on-line) monitoring
- Off-line testing
  - Motor circuit parameter testing
  - Surge testing

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Proactive Maintenance

- Identify repeat failures
- Determine root causes for these failures
- Correct root cause to eliminate future failures for the same reason

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Introduction to Vibration Objectives

- Define Vibration
  - What is it, where does it come from?
- Describe measurement methods
- Discuss time and frequency
  - Relationships between the two
- Examine amplitude measurements
  - Differences between the three
- Choose proper transducer
  - Right probe for the application

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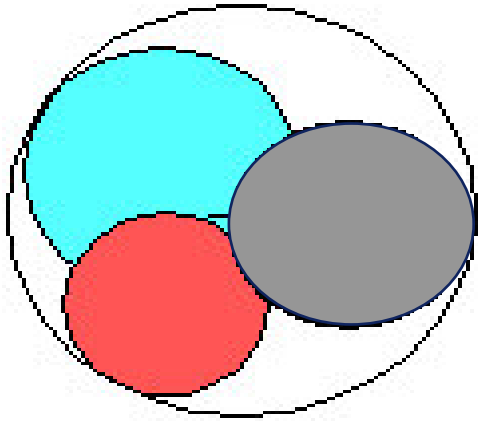
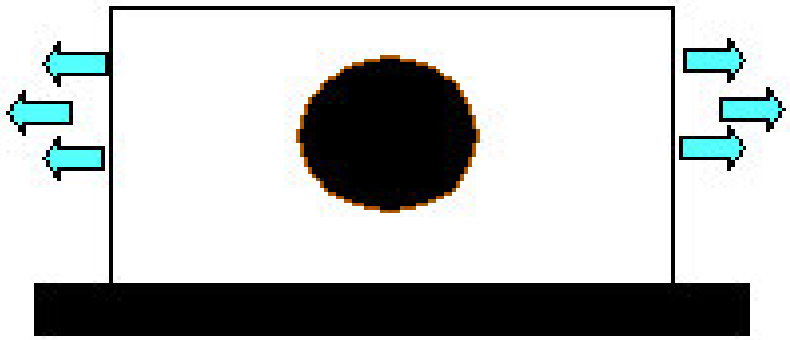
Introduction to Vibration

- Vibration :
  - Movement of a body about a reference.
    - Response to some form of excitation
    - Forcing function





Amplitude

- 3 ways to display
  - All three show severity
  - Some better than others
- Displacement
  - Distance a body moves
  - Point “A” to point “B”
- Velocity
  - Measures the speed
  - Time from point “A” to point “B”
  - rate of displacement
- Acceleration
  - Total force acting
  - Change of direction

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Sources of Vibration

- Imbalance
- Misalignment
- Belts
- Gears
- Bearings
  - Rolling Element
  - Sleeve
- Looseness
- Electrical Anomalies
- Oil Instability
- Resonance

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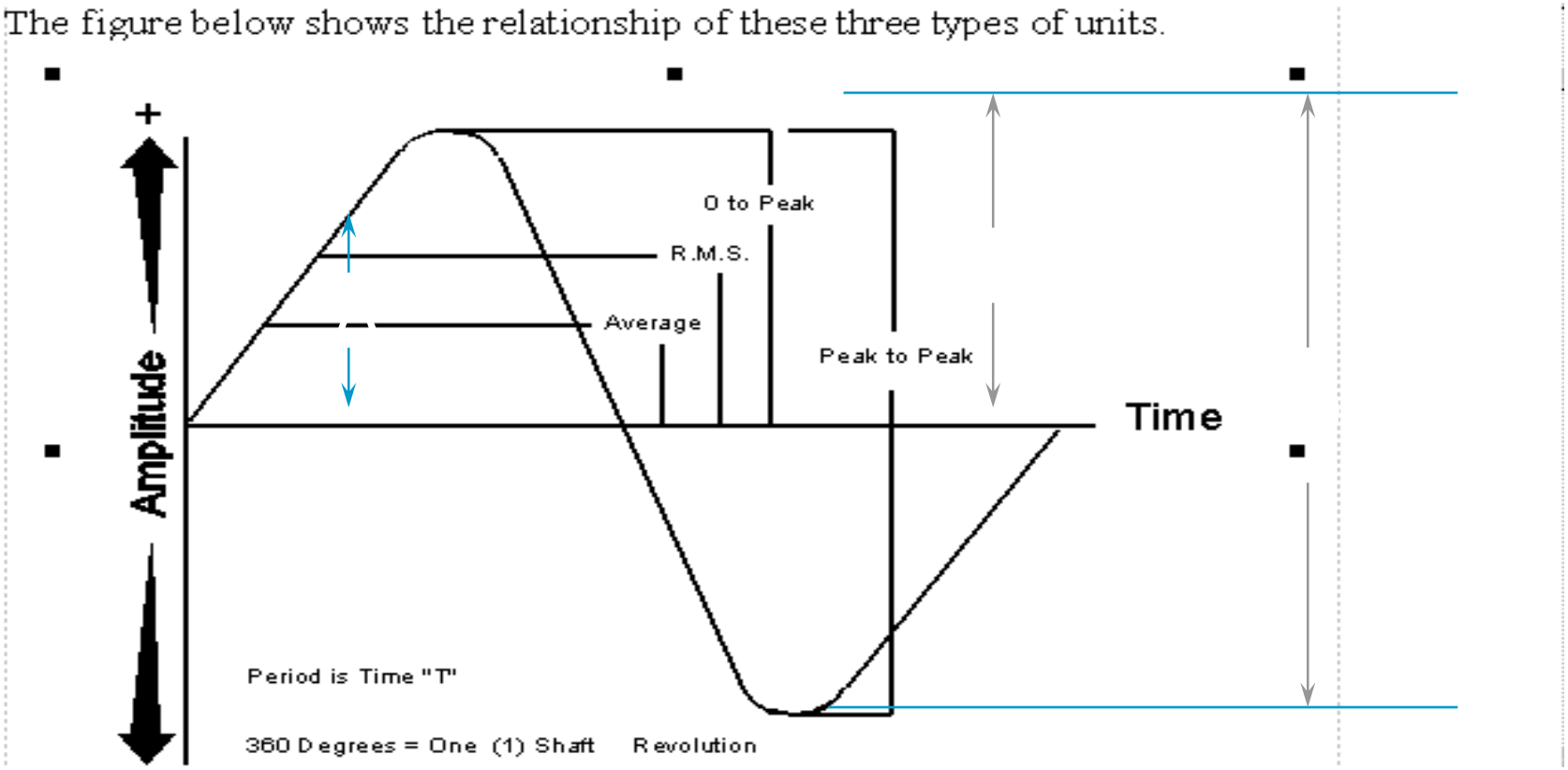
Choose units for optimum data display

The figure below shows the relationship of these three types of units.



(D) isplacement	Mils	Peak-to-Peak
(V) elocity	In/Sec	Peak
(A) cceleration	G's	RMS

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Vibration Terms

- Phase
  - relationship between two events relative to a reference
- Amplitude
  - measurement of energy of a vibrating object
- Displacement
  - distance a body travels
  - units of mils (pk. to pk.)
- Velocity
  - rate at which displacement occurs
  - units of inches per second in/sec (pk.) or mm/sec RMS
- Acceleration
  - rate of change of velocity
  - units of G's (RMS)

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Vibration Terms, cont'd

- Frequency
  - how often an event occurs per unit time
- Units
  - CPS
    - cycles per second (Hz)
  - CPM
    - cycles per minute
  - RPM
    - revolutions per minute
  - Orders
    - multiples of Turning Speed

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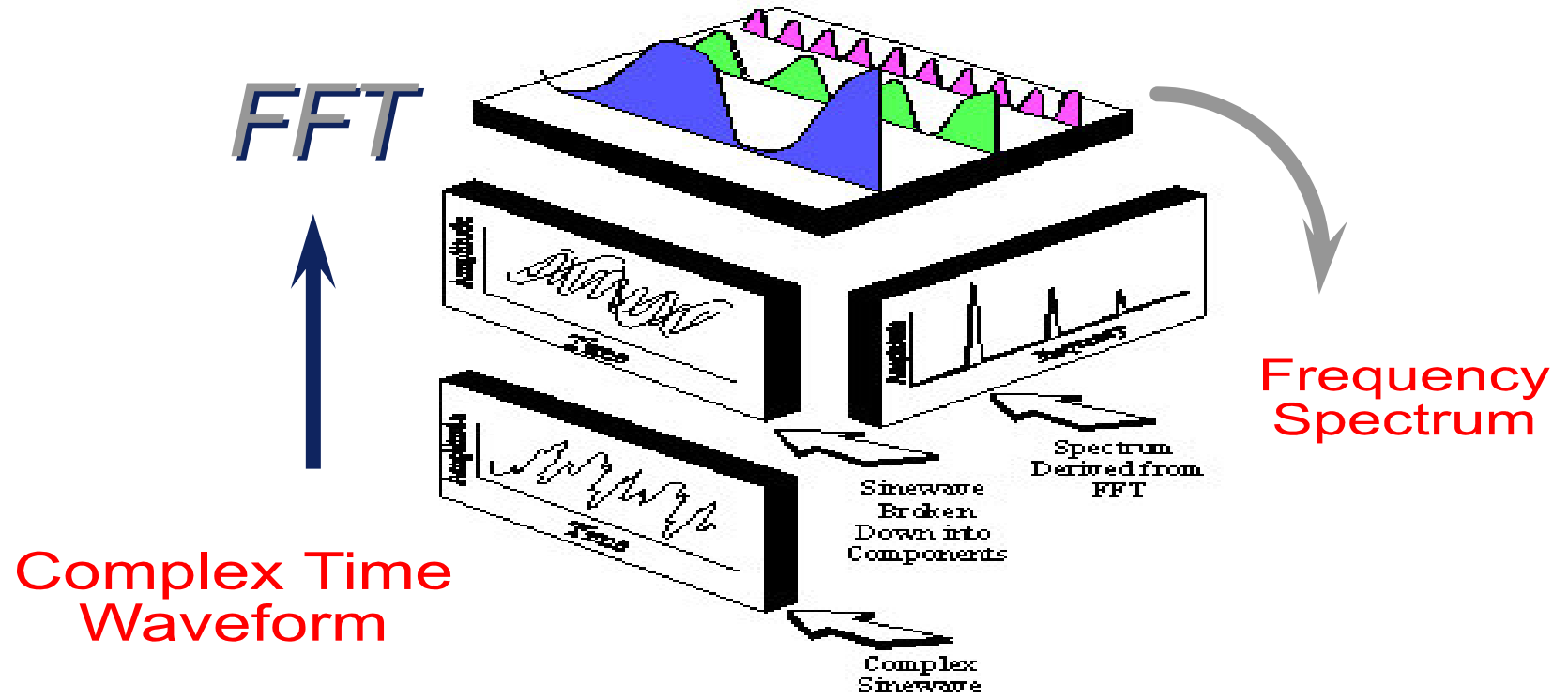
Measurement Parameters

2 Domains : TIME and FREQUENCY



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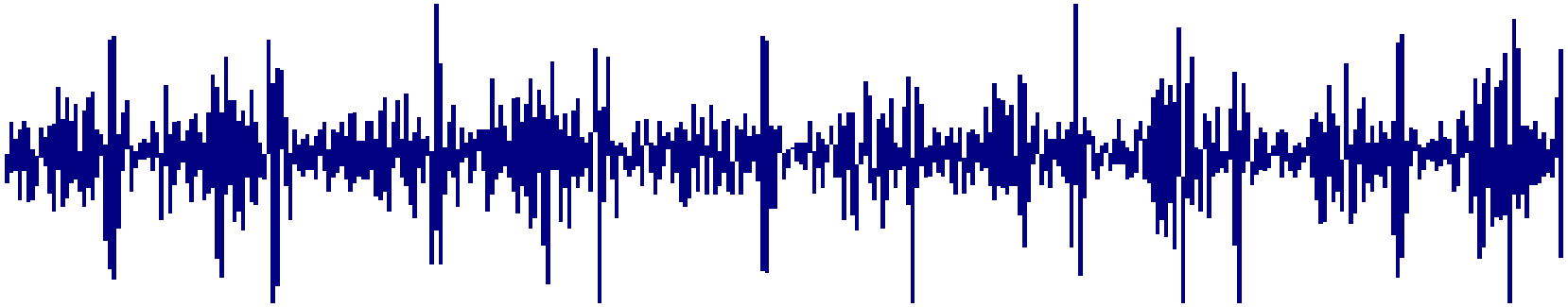
Time domain data

- Helpful :
  - Calculating frequencies
  - Detect faults not frequency domain
  - Confirm / deny suspected anomalies



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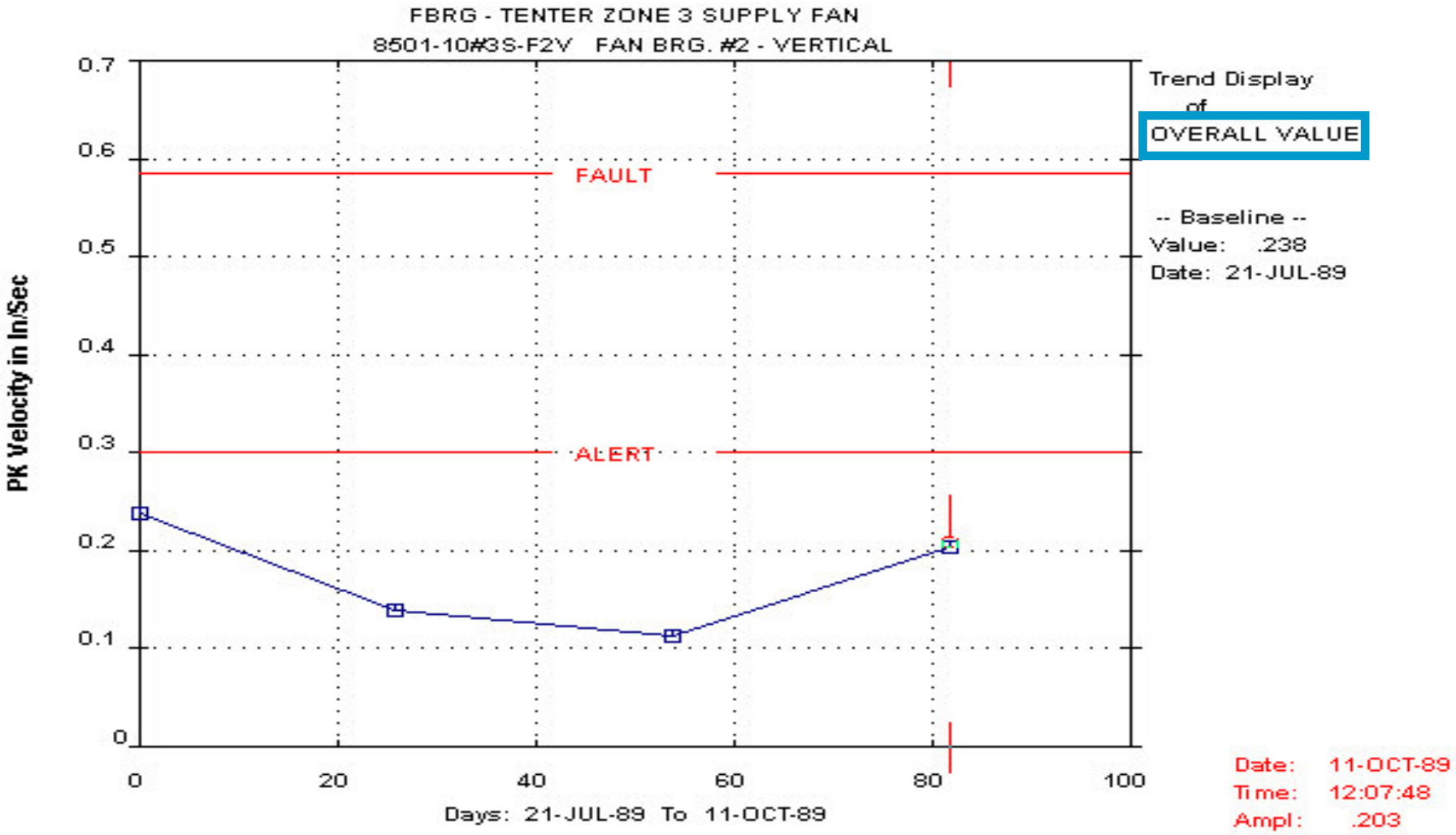
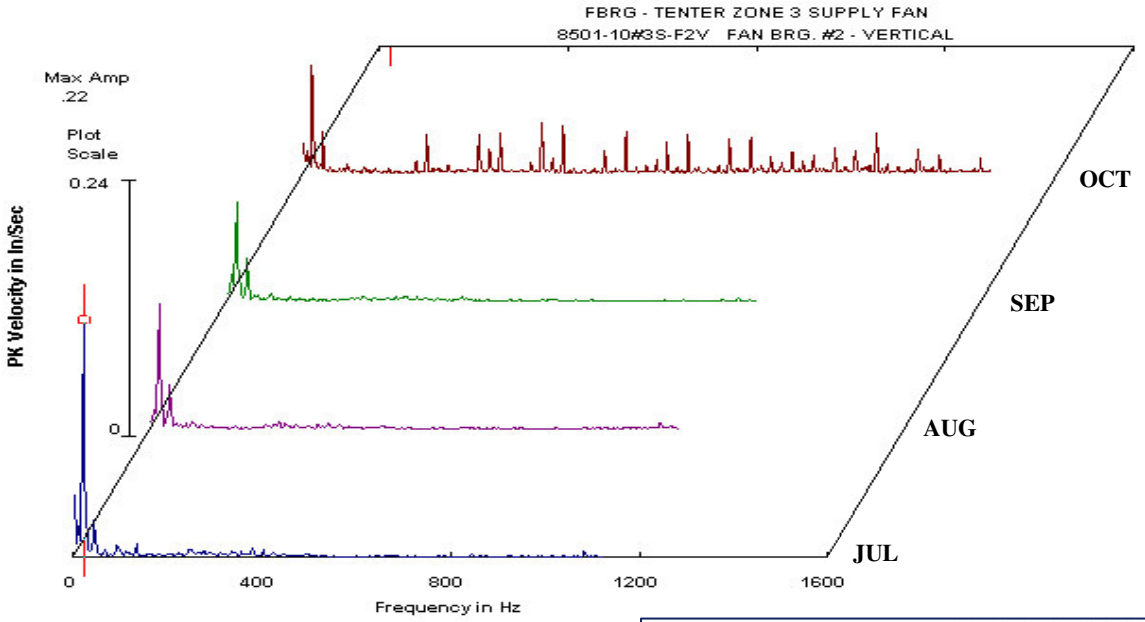
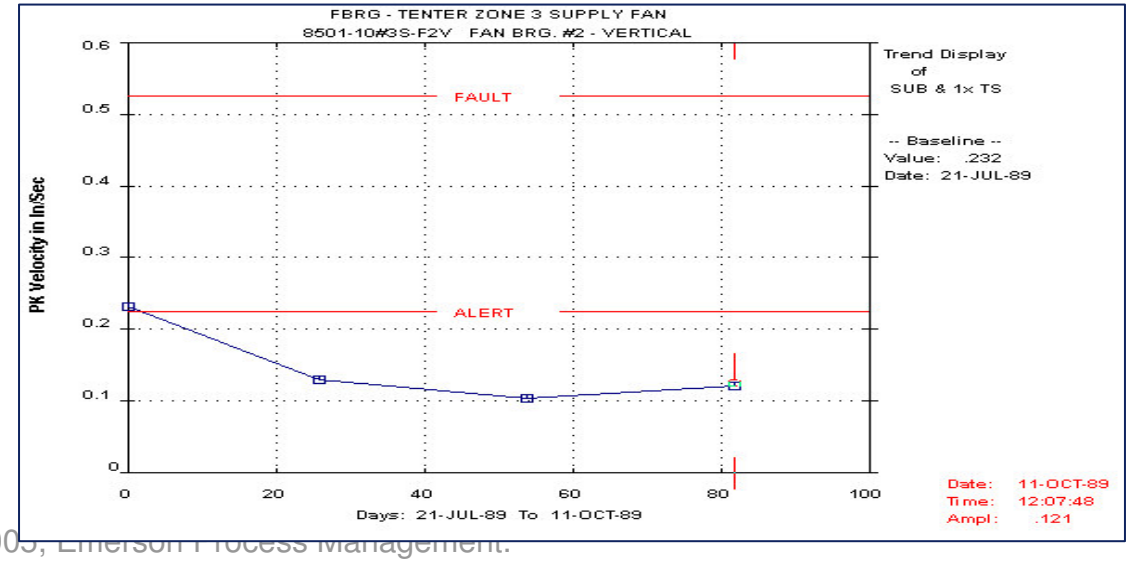
Vibration – Overall Trend

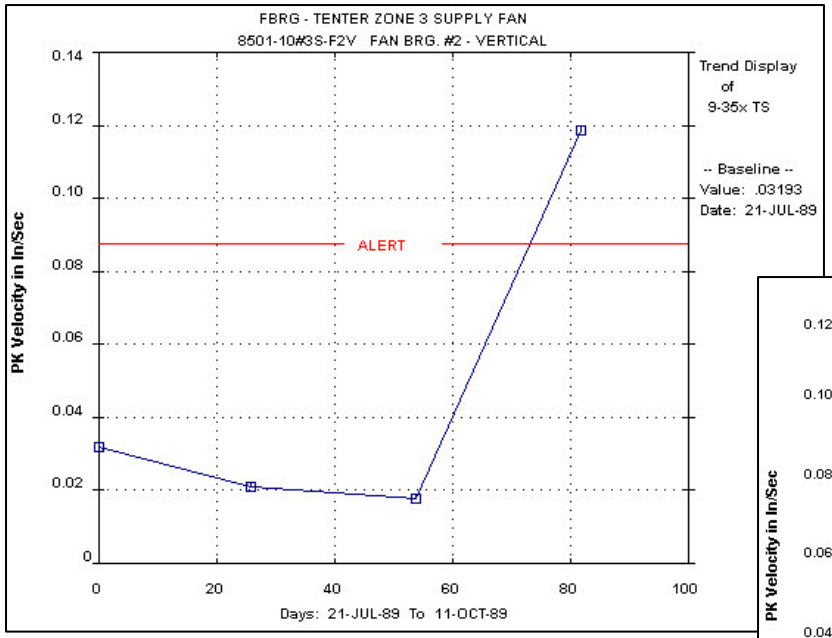


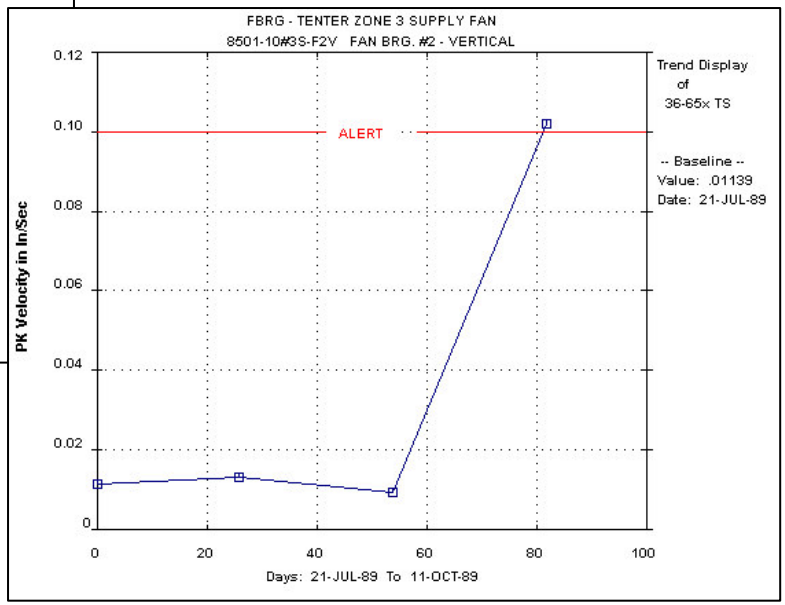
Vibration – 1 x RPM





Vibration – High Frequency





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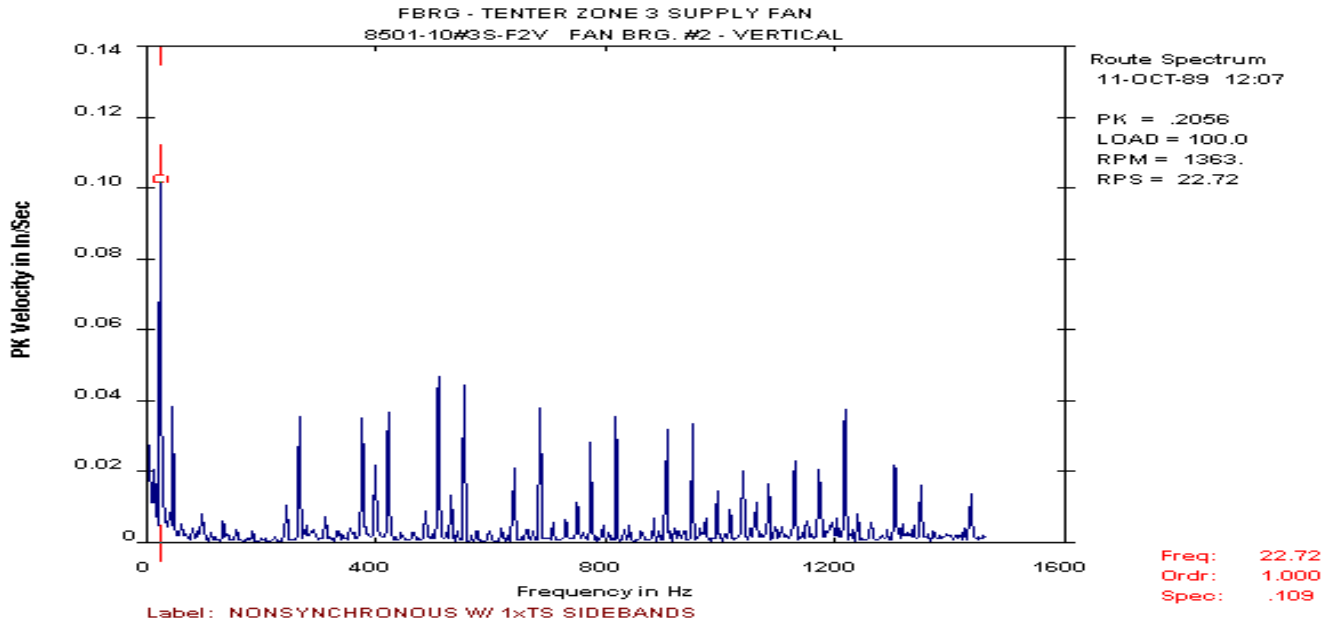
Vibration – Bearing Frequencies

- High frequency peaks
  - Usually non-synchronous peaks (with sidebands)



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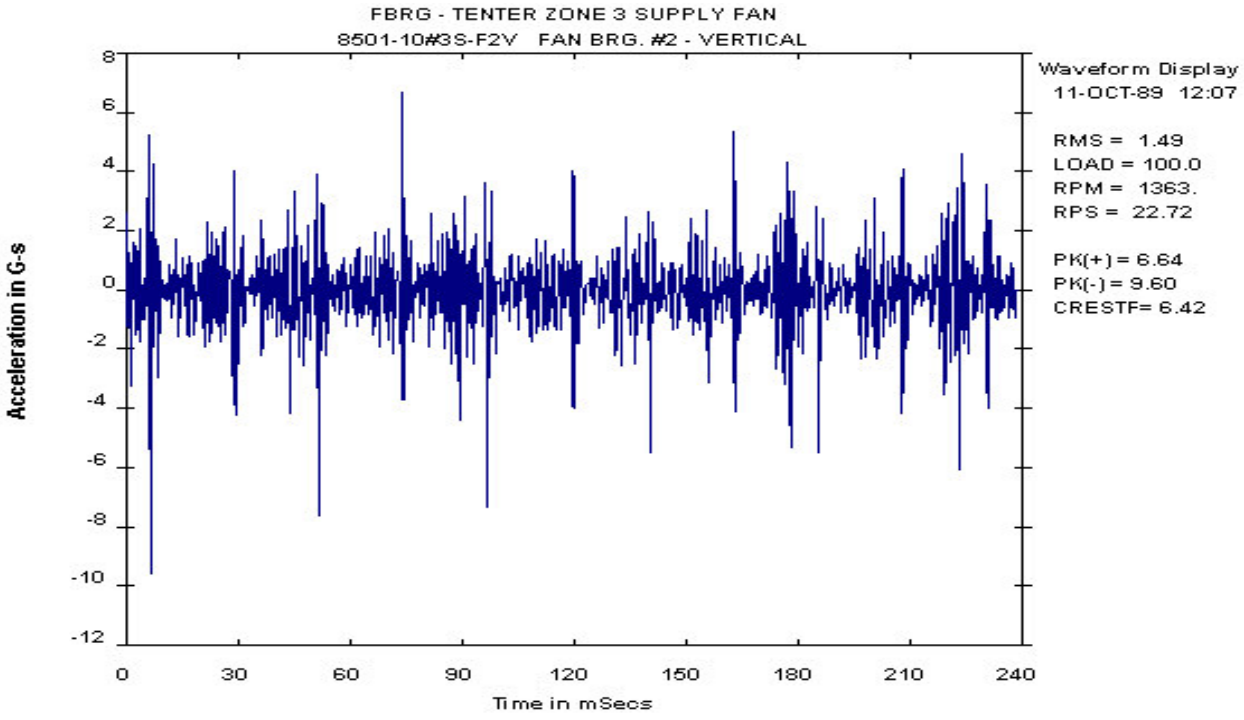
Vibration – Time Waveform

- Waveform useful for diagnosing bearing faults
  - Impacts show as spikes



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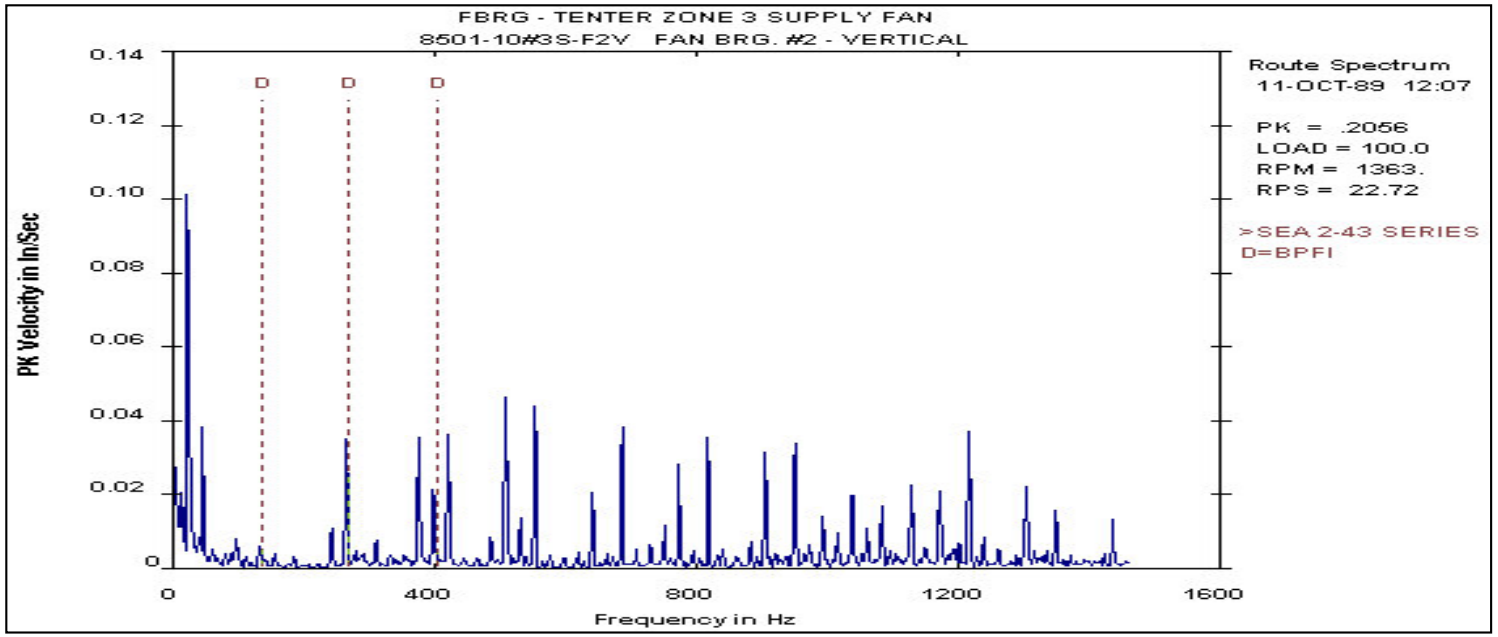
Vibration – Bearing in FFT

- Bearing faults generate peaks at specific frequencies



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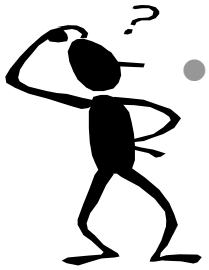
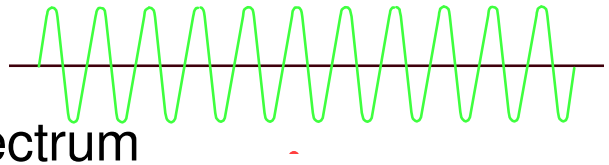
An effective program...



- Choosing the transducer
  - the right one for the best data
- Signal processing



  - time waveform or spectrum

- Problem detection
  - examine both sets of data
  - is there a problem?
- Diagnosis
  - what is the source ?
  - Root Cause

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Transducers

- Function
  - Convert mechanical signal to electrical
- Three basic types
  - Displacement transducer
  - Velocity transducer
  - Accelerometer

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Displacement Transducers

- Advantages +
  - Measures relative movement
  - good for sleeve brg. machines
  - very good for heavy machines
- Disadvantages -
  - permanently installed
  - frequency response : DC to 1KHz
  - power required

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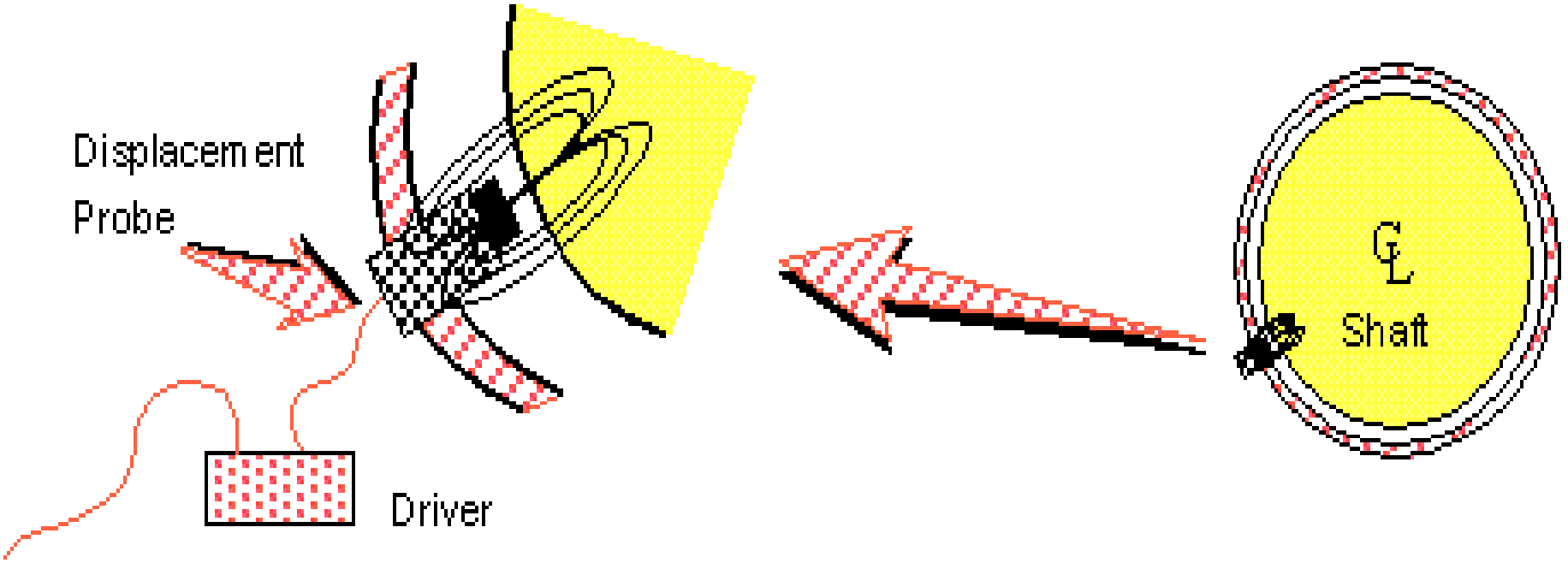
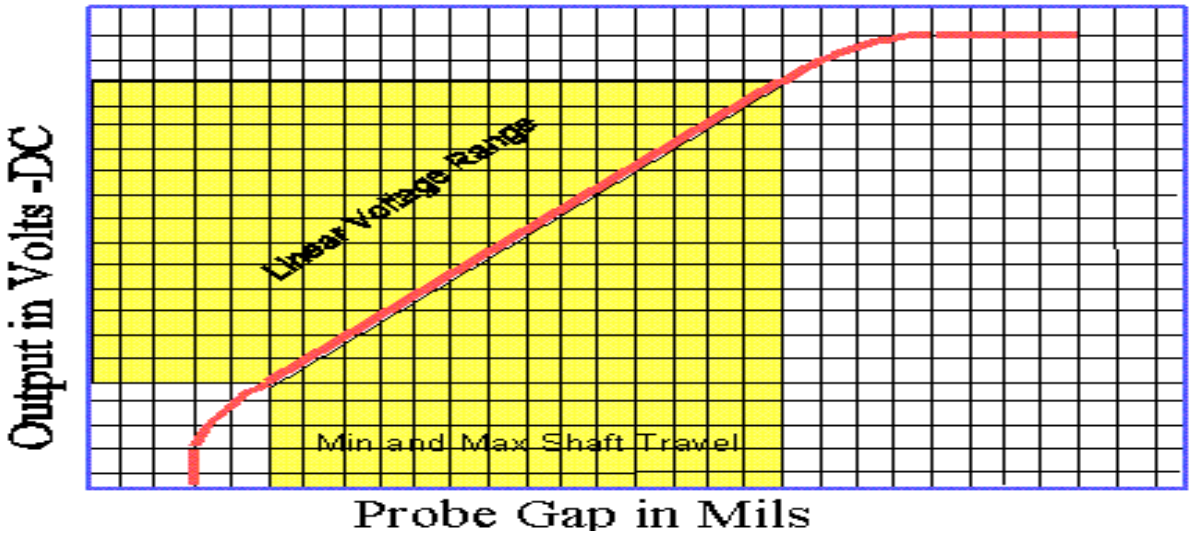
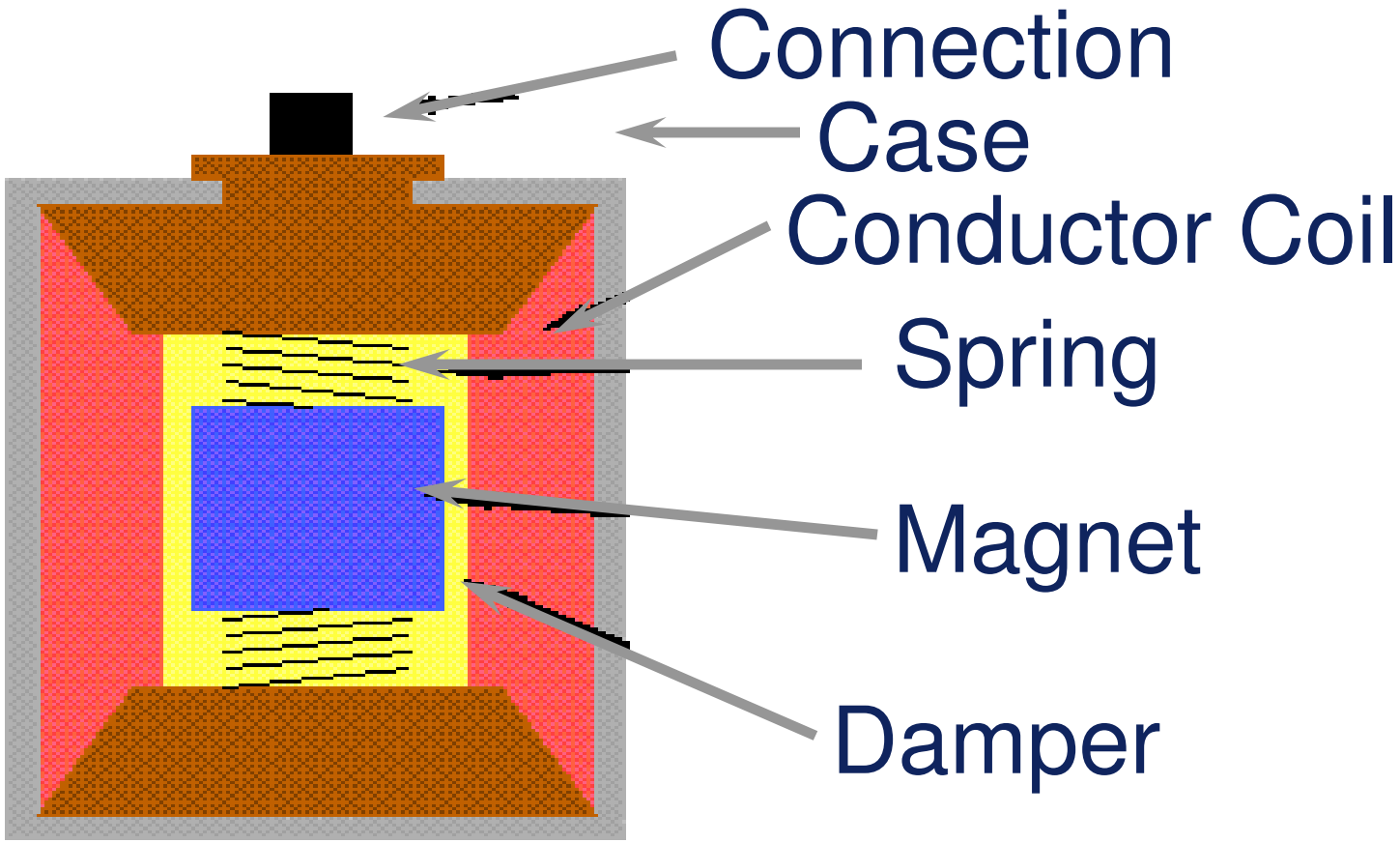


Displacement probes act much like a transformer.



Velocity Transducer



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Velocity Transducer

- Advantages +
  - best signal to severity ratio
  - good signal to noise ratio
  - no power required
  - single dif. / int. needed
  - usually pretty hardy
- Disadvantages -
  - usually big
  - heavy
  - freq. 10 to 2Kz
  - temperature sensitive
  - comparatively expensive
  - magnetic field sensitive
  - orientation sensitive
  - wear and temp. changes calibration

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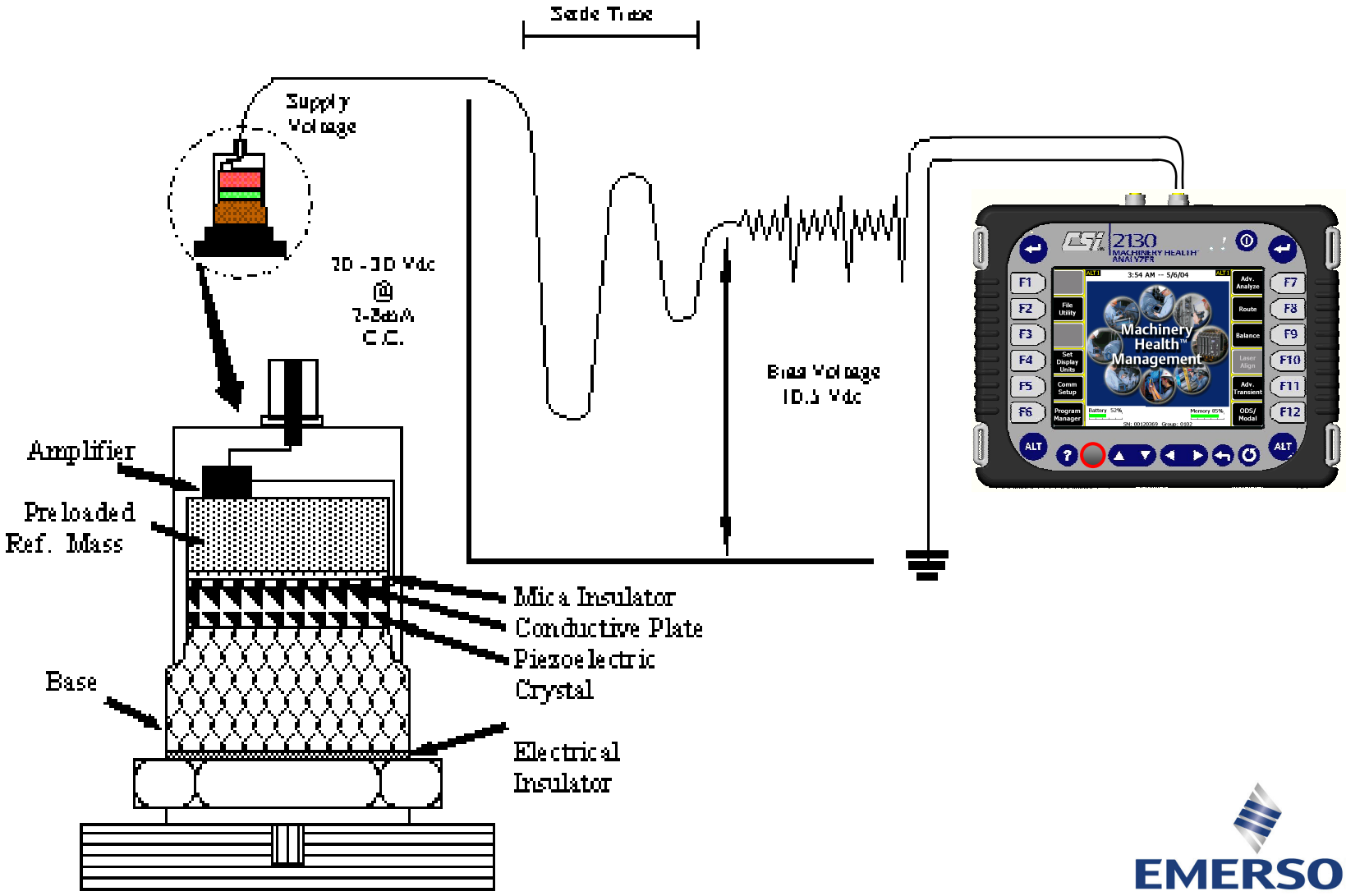
Accelerometers



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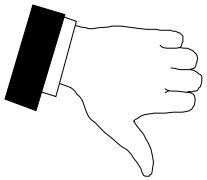
Accelerometers

- Advantages
  - broad frequency range
  - small, light, rugged
  - ICP needs no signal conditioning
  - easy to mount

- Disadvantages
  - poor as a hand held
  - limited signal to noise ratio
  - reads acceleration
  - power required
  - double integration needed



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Frequency Signature

Frequency signal is an X,Y plot. X represents the frequency, Y represents the amplitude or magnitude of the signal. The data is divided into 3 categories :

- Synchronous
  - NxRPM where N is an integer (phase locked)
- Subsynchronous
  - <1 x RPM
- Non-synchronous
  - F x RPM where F is >1x RPM but not integer

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Causes - Subsynchronous

- Another component in the machine
- Another machine
- Belt drives
- Hydraulic instability
  - Oil whirl, oil whip
- Rubs
  - rotor, shaft, wheel
- Cage
  - fundamental train - rolling element brgs.

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Causes - Synchronous

- Imbalance
- Pitch line run-out
- Misalignment
- Bent shaft
- Looseness
- Blade / vane pass
- Reciprocals
- Gears
- Slot / Rotor Bar pass

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Causes - Nonsynchronous

- Another machine
- Belt multiples
- Bearings
- Resonances
- Electrical
- Chains
- Compressor surge
- Detonation
- Sliding surfaces
- Lube pumps
- Centrifugal clutches
- U-joints

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