GTEN 2021
Virtual Symposium
October 18th & 19th, 2021

Training – Gas Turbine Vibration Protection System Basics

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Session Outline

- Vibration protection system overview
  - Why we need them and basic layout of the VMS design
- Instrumentation types and locations
  - Accelerometers, proximity sensors and probes, thrust probes, key phasors and speed probes (MPUs) and their locations.
  - Signal conditioning and filtering
- Rotating equipment diagnostics and some typical vibration issues
- TCE vibration system upgrades and latest technology
  - Protective functions and operational diagnostics for long-term trending, together with remote diagnostic capabilities of hi-res trending

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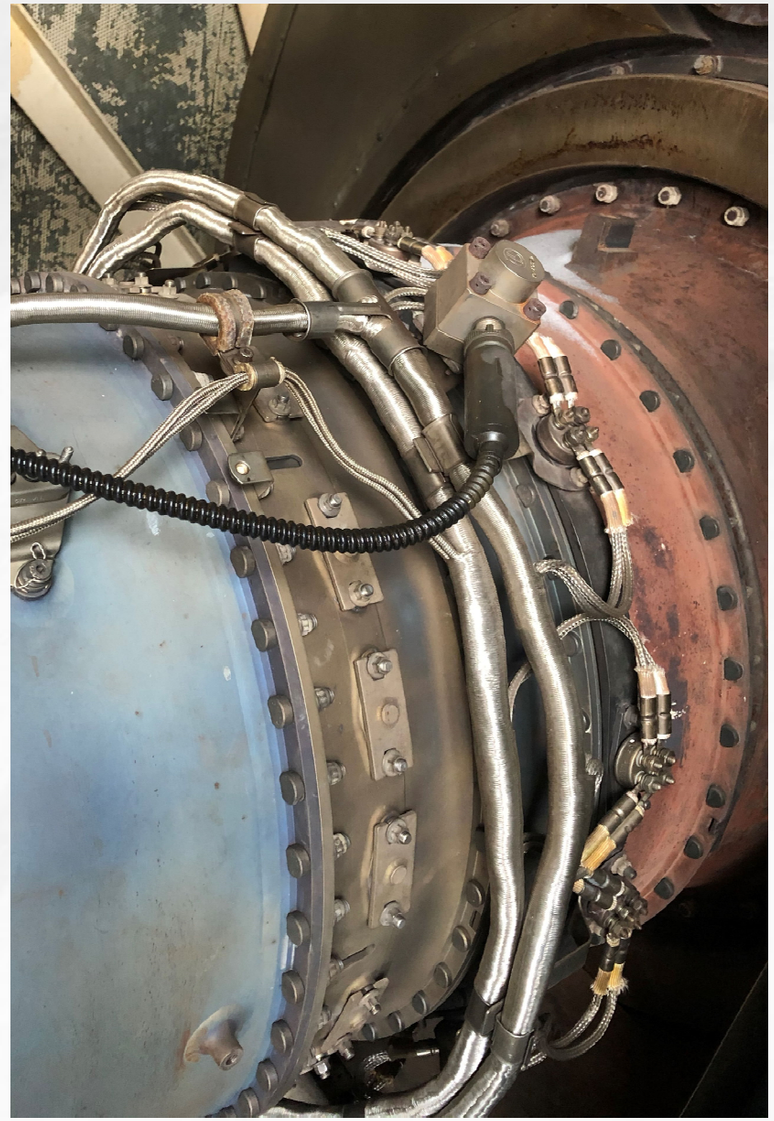
Why Monitor GT Vibration?

1. Excessive vibration levels will eventually cause equipment damage
    - Protect by safely shutting down before lost production / accidents occur

2. Monitoring and analysis provides additional troubleshooting information
    - Every rotating machine exhibits own vibration characteristics
    - Vibration changes can be caught early, and any actions/maintenance planned prior to any failure
    - Reduction of unscheduled down time, turnaround time, any major equipment damage



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Vibration Protection System Basics

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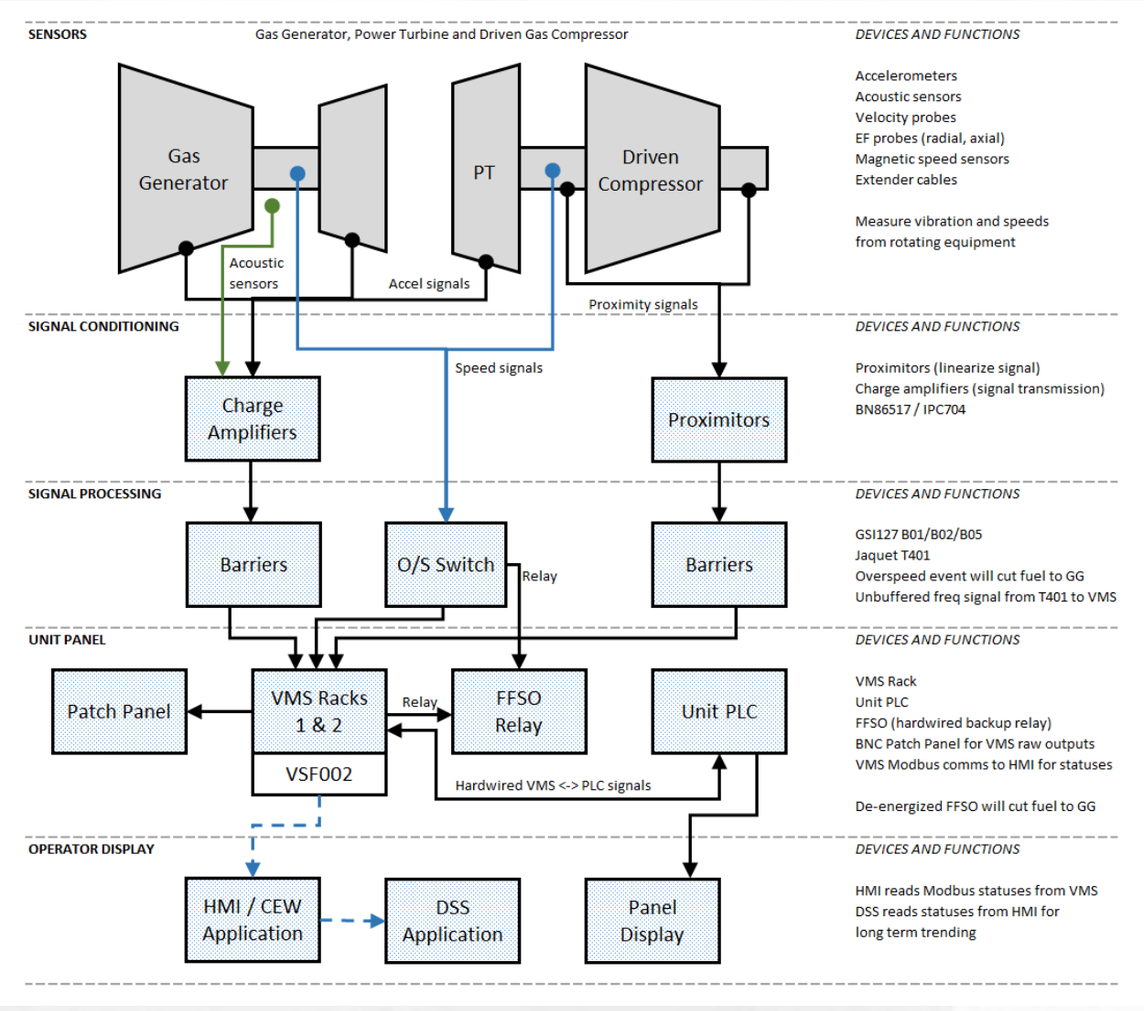
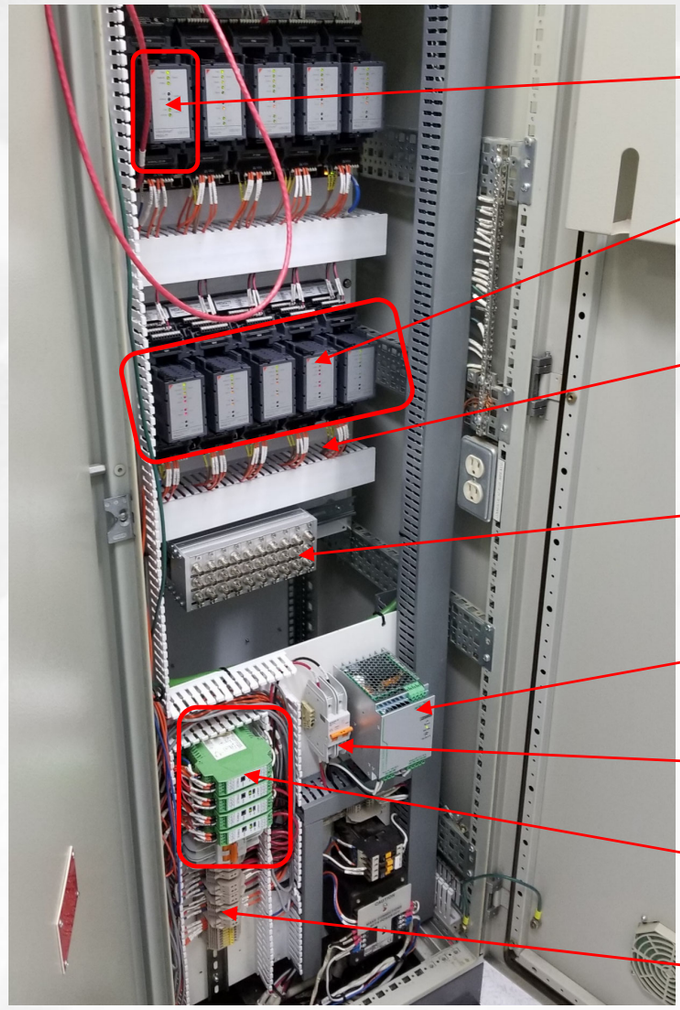
Vibration System Overview



TC Energy Typical VMS Panel



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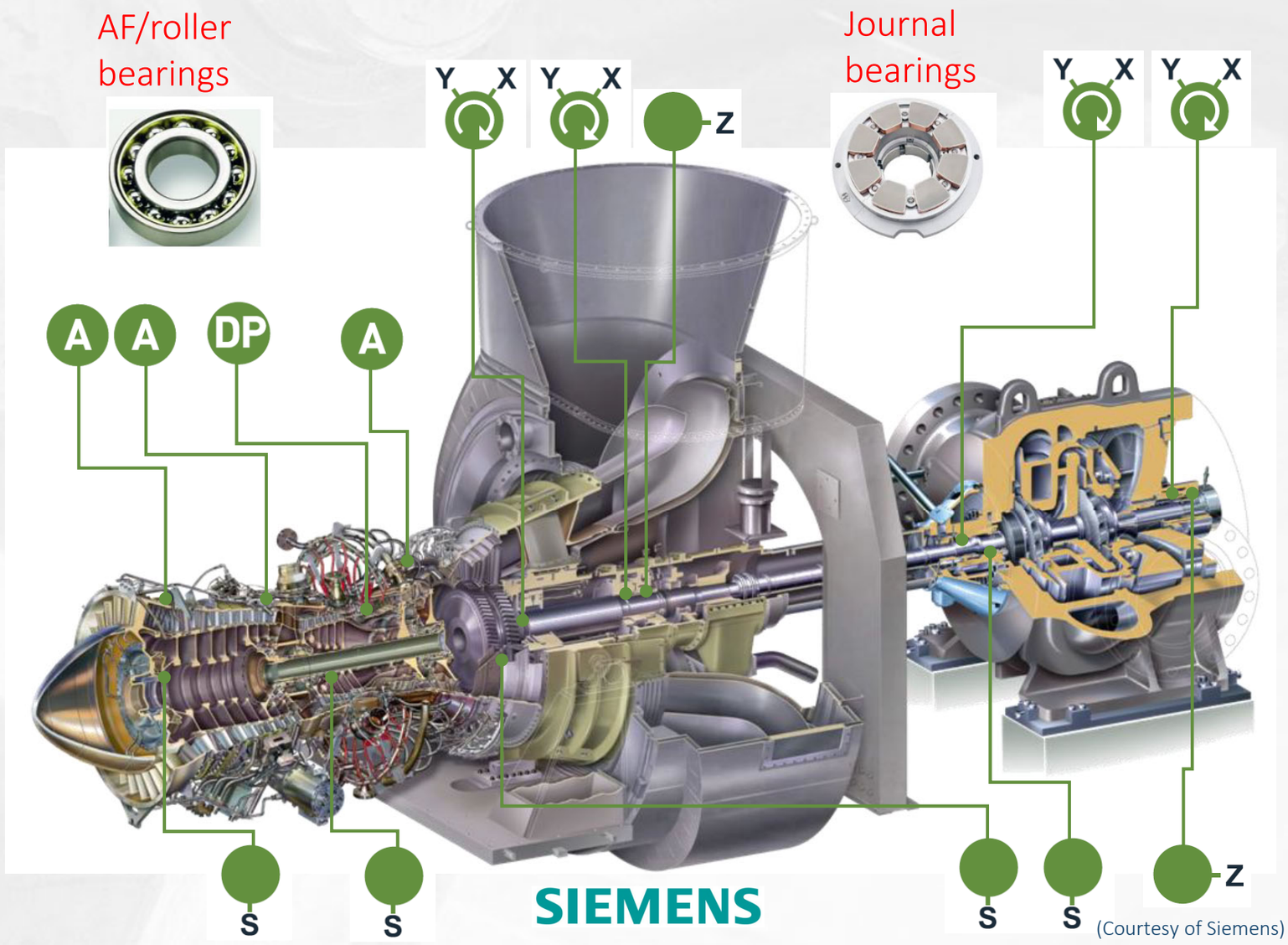
Typical VMS Monitored GT Components

- Aero-derivative GG's fitted with anti-friction/roller bearings
- PTs supported by hydrodynamic journal and thrust bearings
- Driven compressors supported by journal and thrust bearings
- Some applications monitor combustion chambers and/or gearboxes



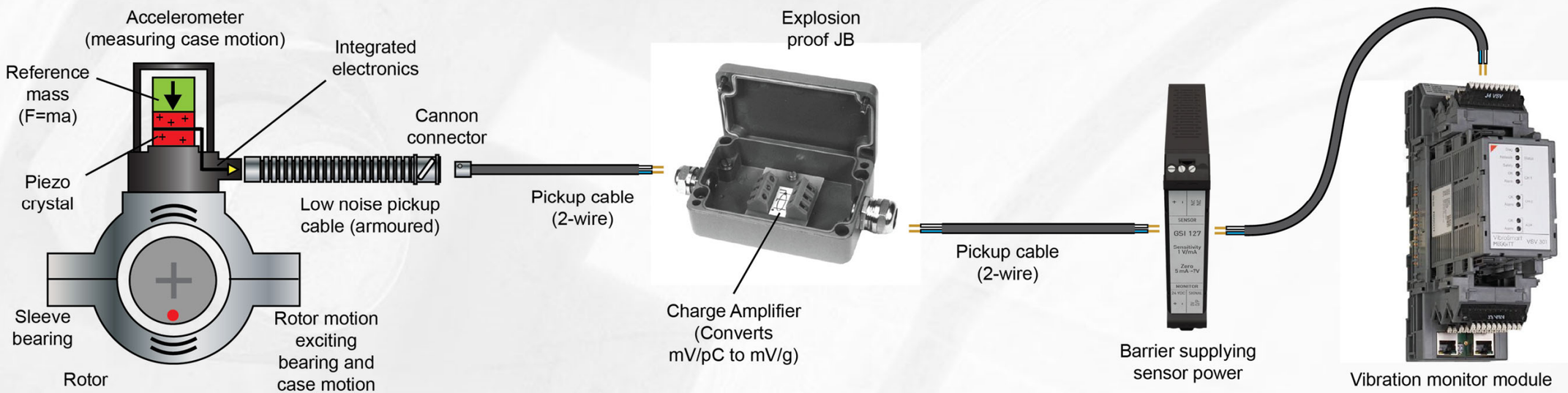
(Courtesy of Siemens)

A Case (absolute) vibration
DP Dynamic pressure [combustor chamber]
Y X Shaft relative vibration [x,y]
S Speed/phase reference
Z Thrust/axial position

Sensors – Accelerometers

- Seismic sensor measures absolute acceleration or velocity
- Mounted externally on GG/PT cases
- Signal can be integrated to velocity, velocity to displacement
- Consists of case probe, pickup cable, charge amplifier
- Charge amp generates mVAC signal (no DC offset)
- High dynamic measurement range, can withstand high temps
- Sensitive to mounting method, cable movement, EM signal noise

Typical Accelerometer



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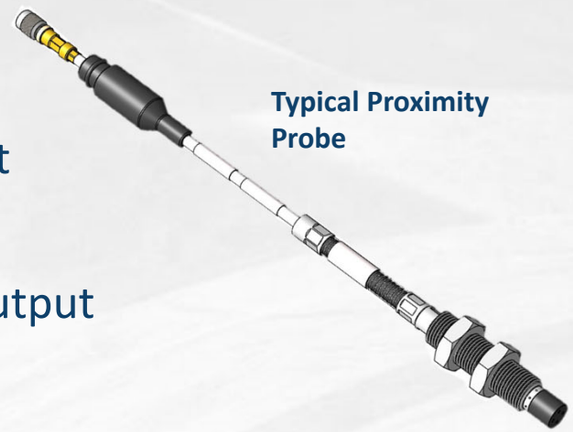
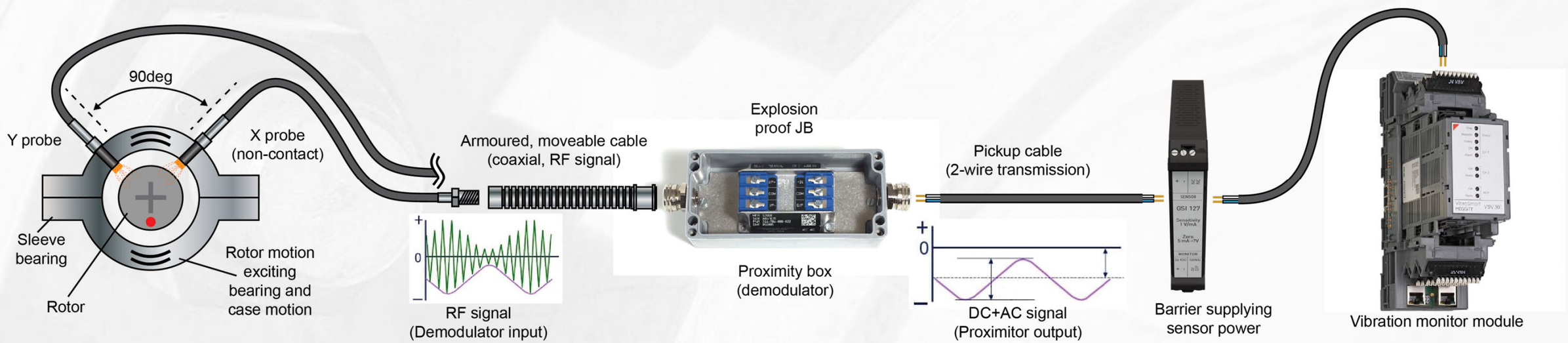
Sensors – Proximity Probes (Radial, Axial)

- Measures the distance between tip of probe and target (shaft)
- Non-contact eddy current sensors, outputs relative displacement measurement
- For axial monitoring, probe provides static displacement output
- For radial monitoring, X-Y probe (90deg) pair, provide dynamic displacement output
- Consists of probe (inserted on machine), extension cable and proximitor (in JB)
- Measure both AC (dynamic) and DC (static)
- With a key phasor, the phase (degrees) for the X-Y signals can be calculated

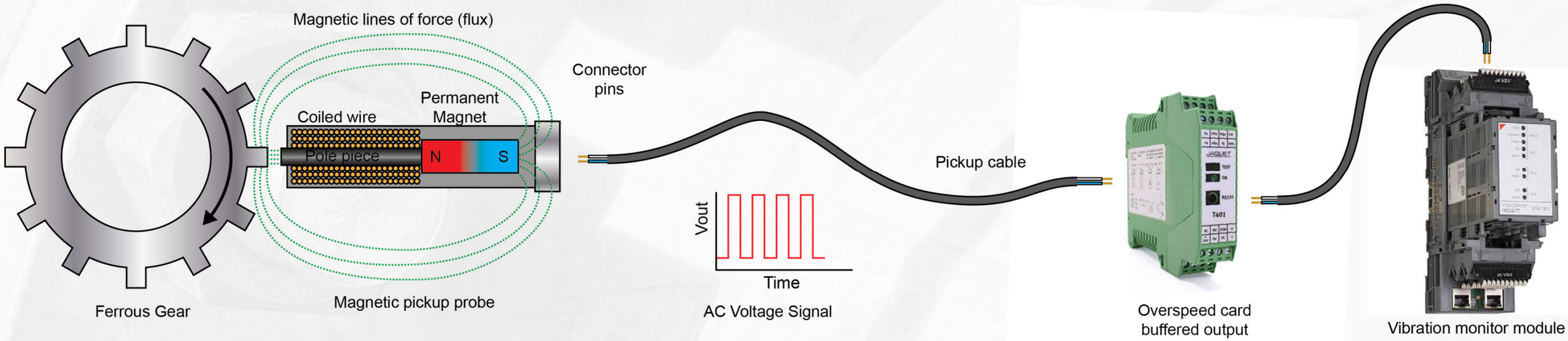


Typical Proximity Probe



Speed and Key Phasor Probes

- Magnetic pickup used to sense the speed of the rotating shaft
- Main control parameter for GT fuel control system
- Basically, MPU is a single pole, AC electric generator
- Used in VMS for tracking filters (1X, 2X etc)
- Also used in protective backup O/S system
- Keyphasor is a proximity probe, sensing a single notch



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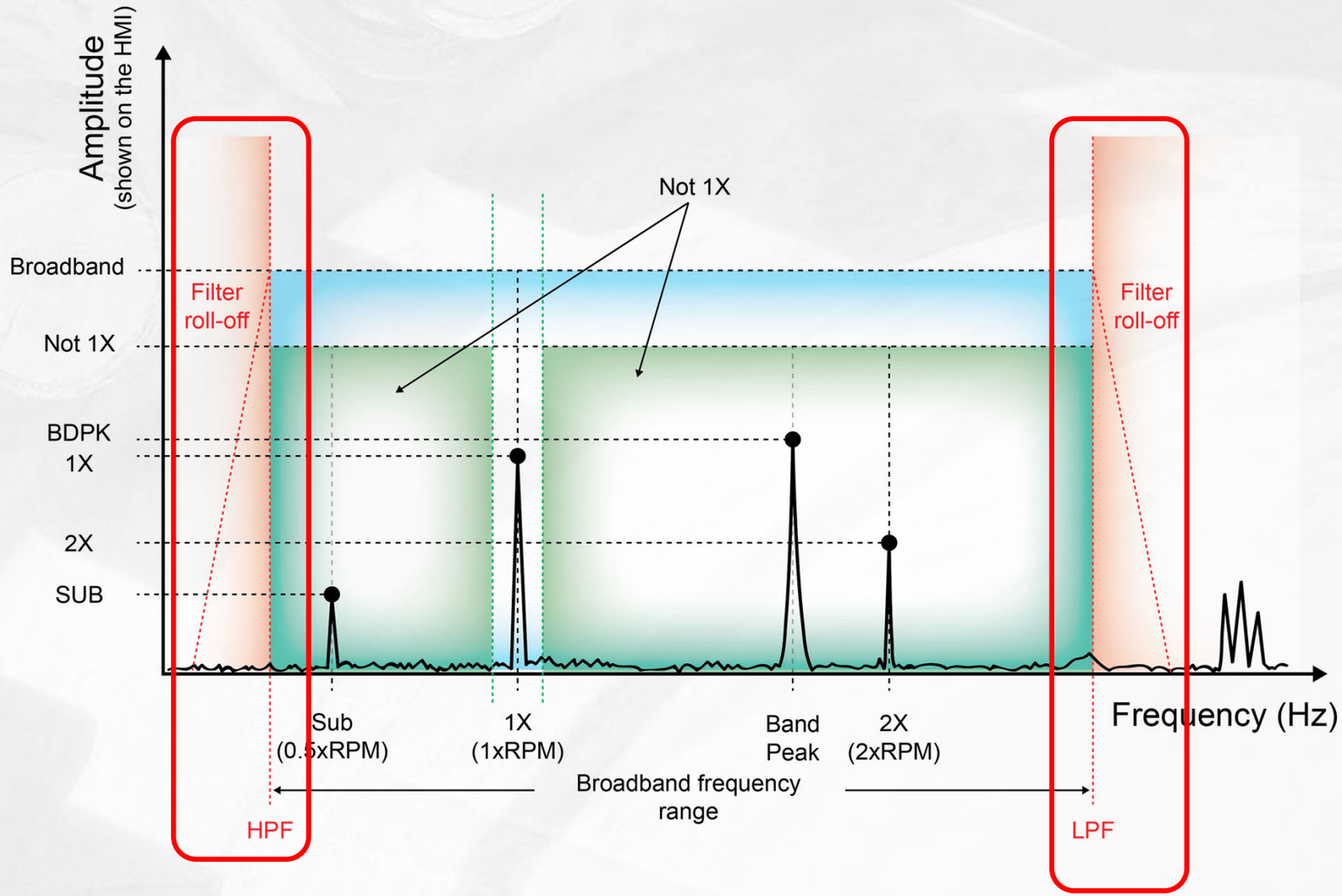
Vibration Signal Filtering

- The vibration probe will add up all energy peaks within the sensitivity range and present as one amplitude
- With no filters, this makes it difficult to diagnose issues
- 2 filters applied to remove frequencies that are of no interest
  - Low pass (LPF) removes high frequencies
  - High pass filter (HPF) removes low frequencies



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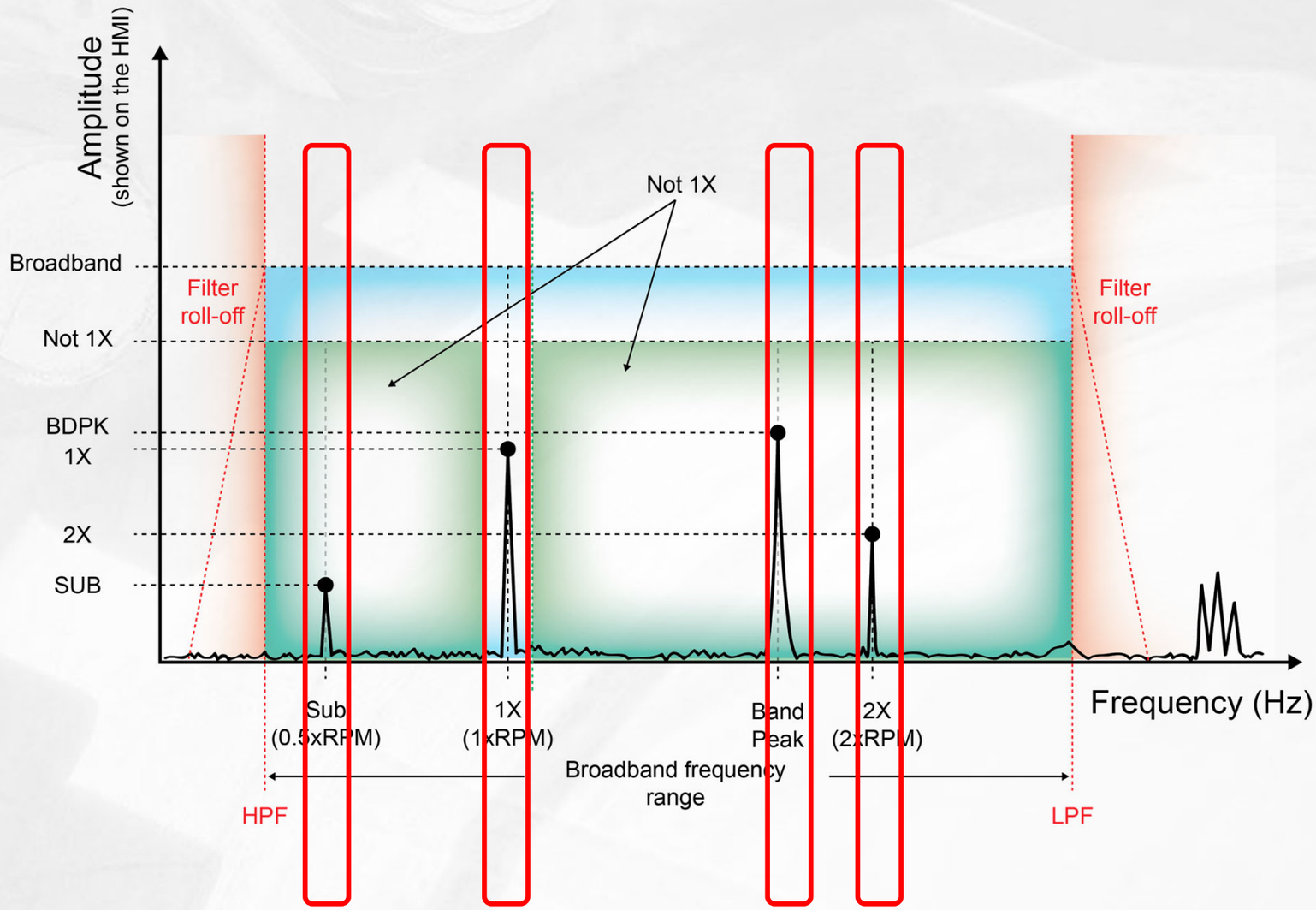
Vibration Diagnostic Filtering

- The VMS has diagnostic filters to output the various amplitudes
- 1X amplitude related to the frequency of the rotating shaft (1 x rpm)
- If key-phasor present, then can output 1X-phase value
- 2X amplitude related to twice the frequency of the rotating shaft (2 x rpm)
- Sub-harmonic amplitude related to half the frequency of the rotating shaft (0.5 x rpm)
- Not 1X amplitude is all 1X related frequencies removed
- Band Peak/ /Freq provides the dominant amplitude and its associated frequency



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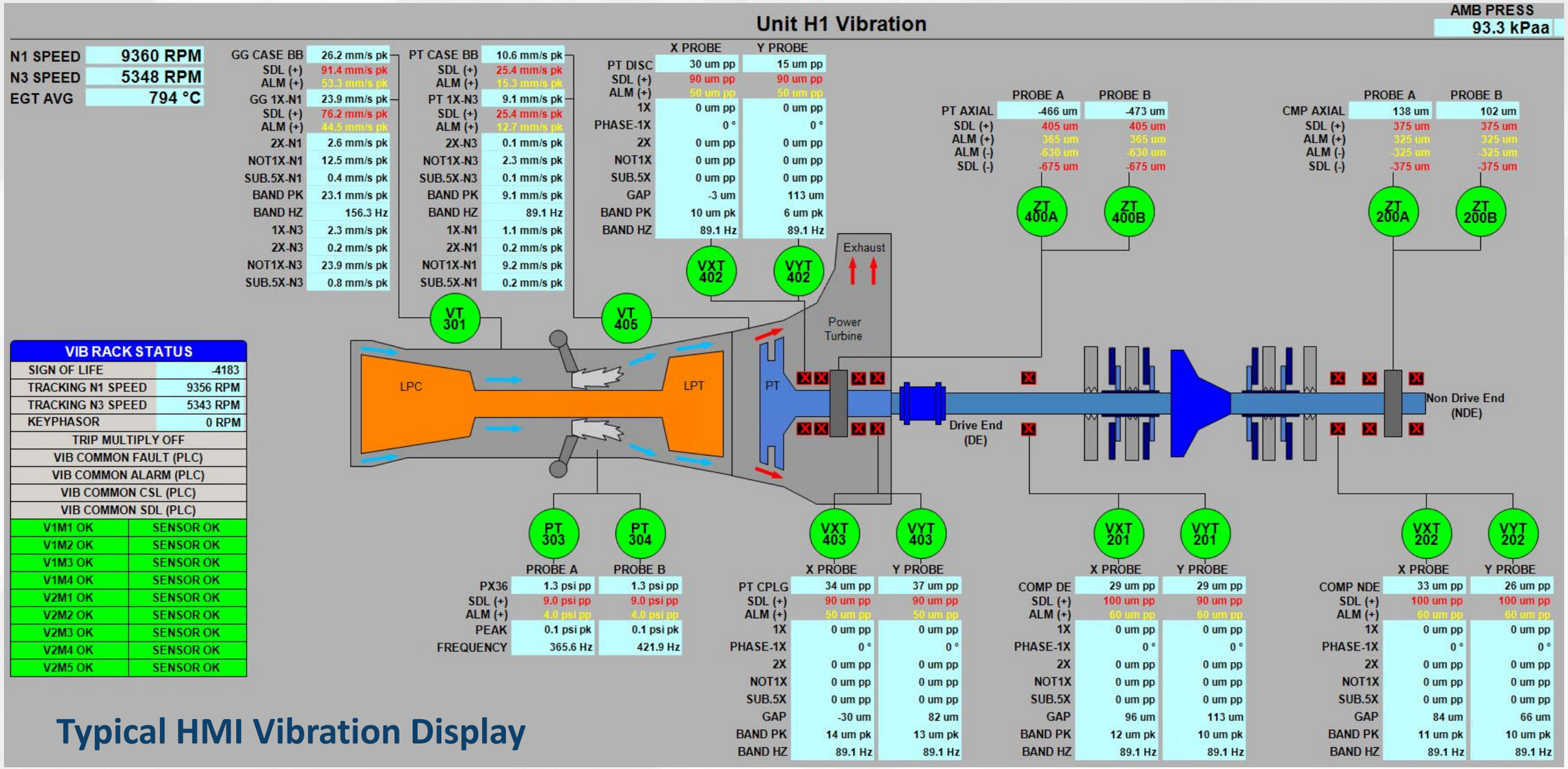
Vibration Protection System Basics



Typical HMI Vibration Display

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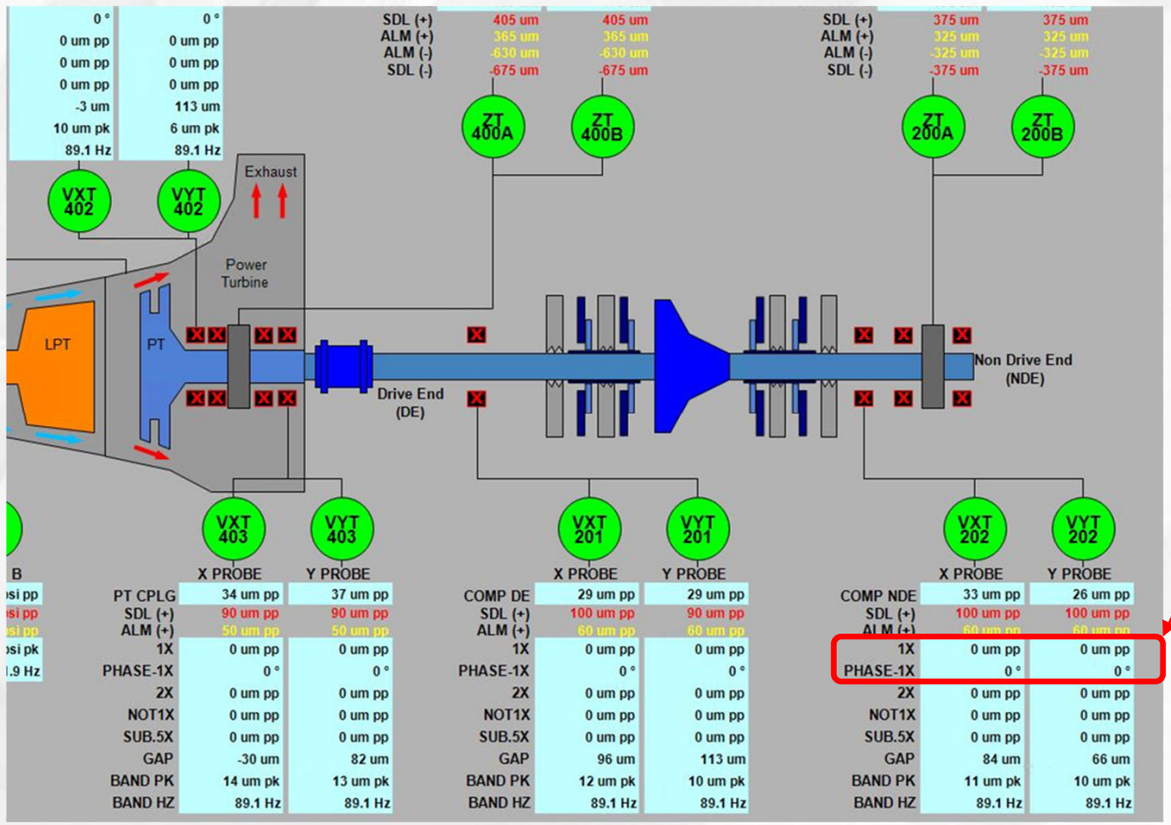
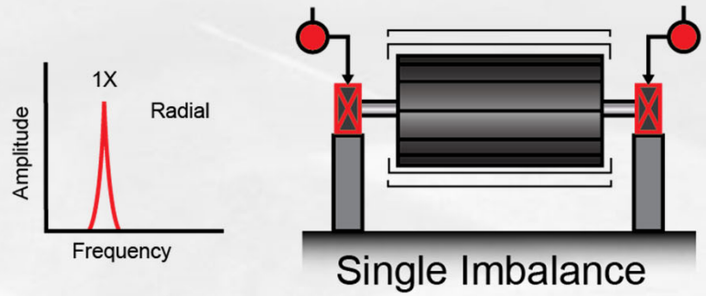
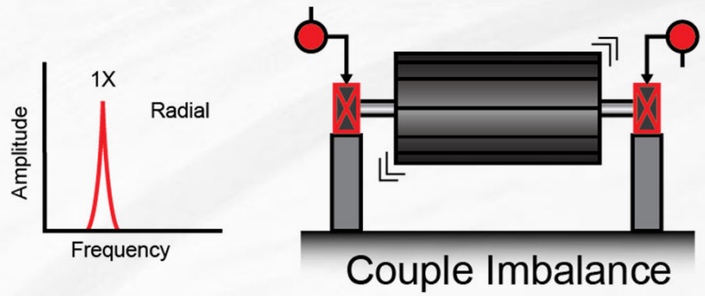
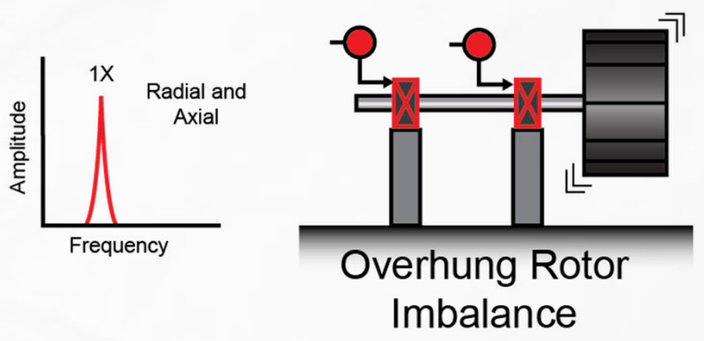
Vibration Problems – Imbalance

- Imbalance occurs when mass and rotational centers do not align
- Exhibit 1X amplitudes, phase can help with problem differentiation









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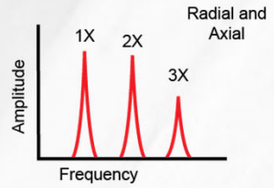
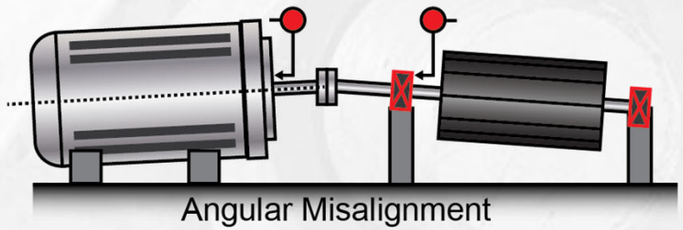
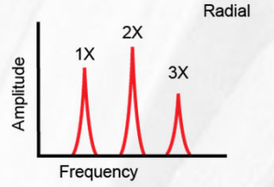
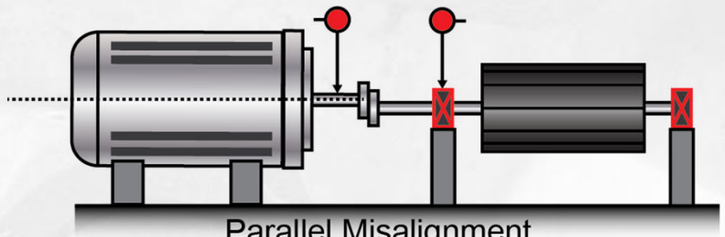
Vibration Problems – Misalignment

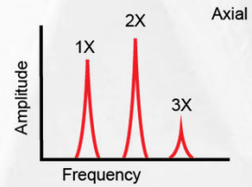
- Misalignment occurs when inaccuracy in alignment between couplings, bearings and shafts

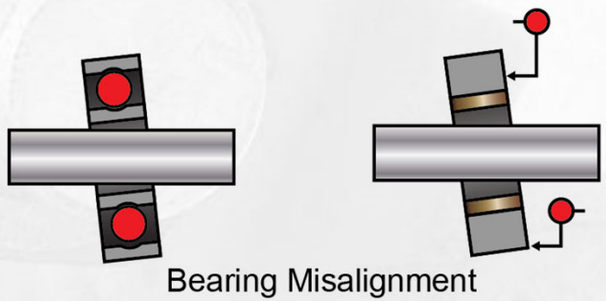


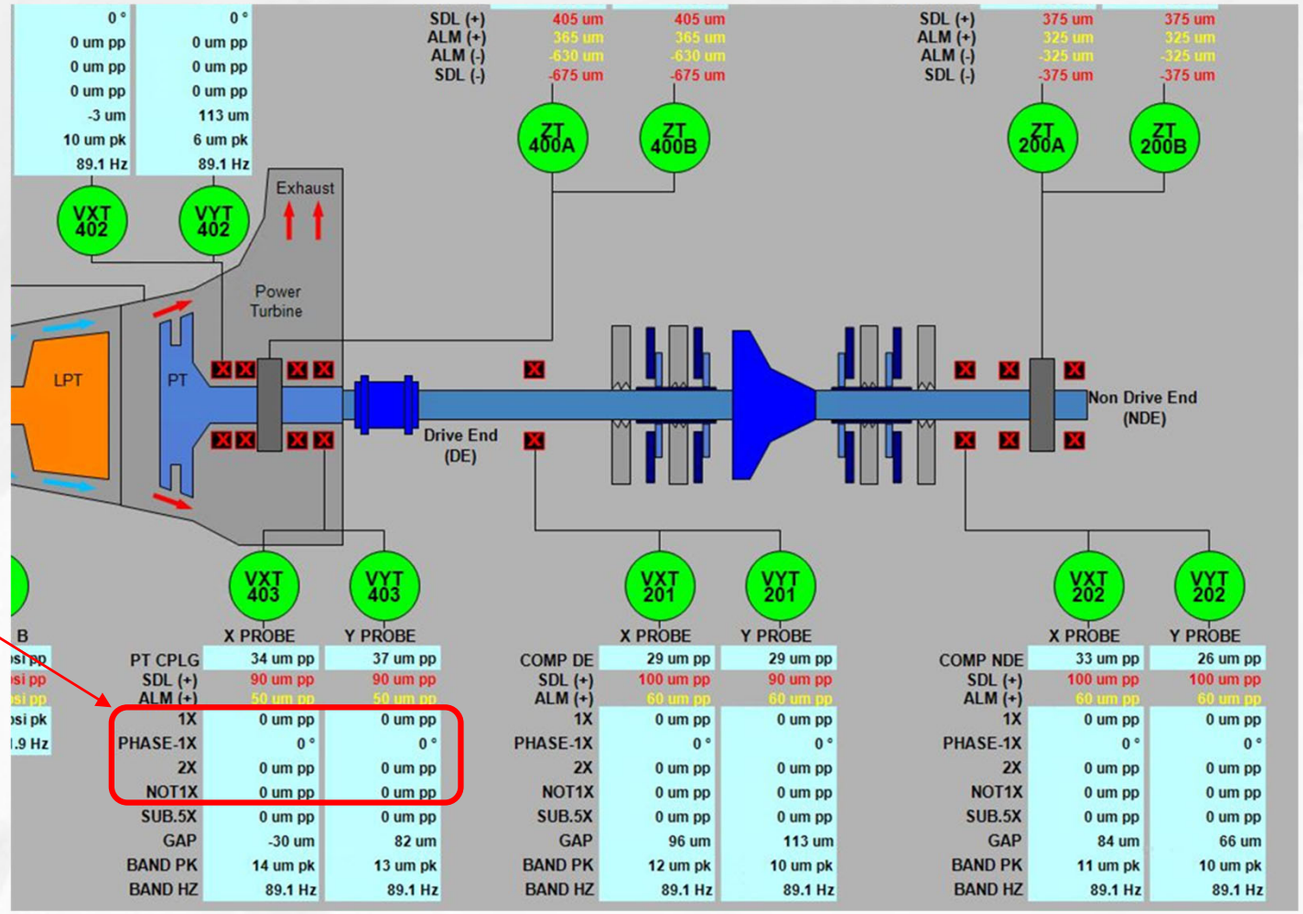












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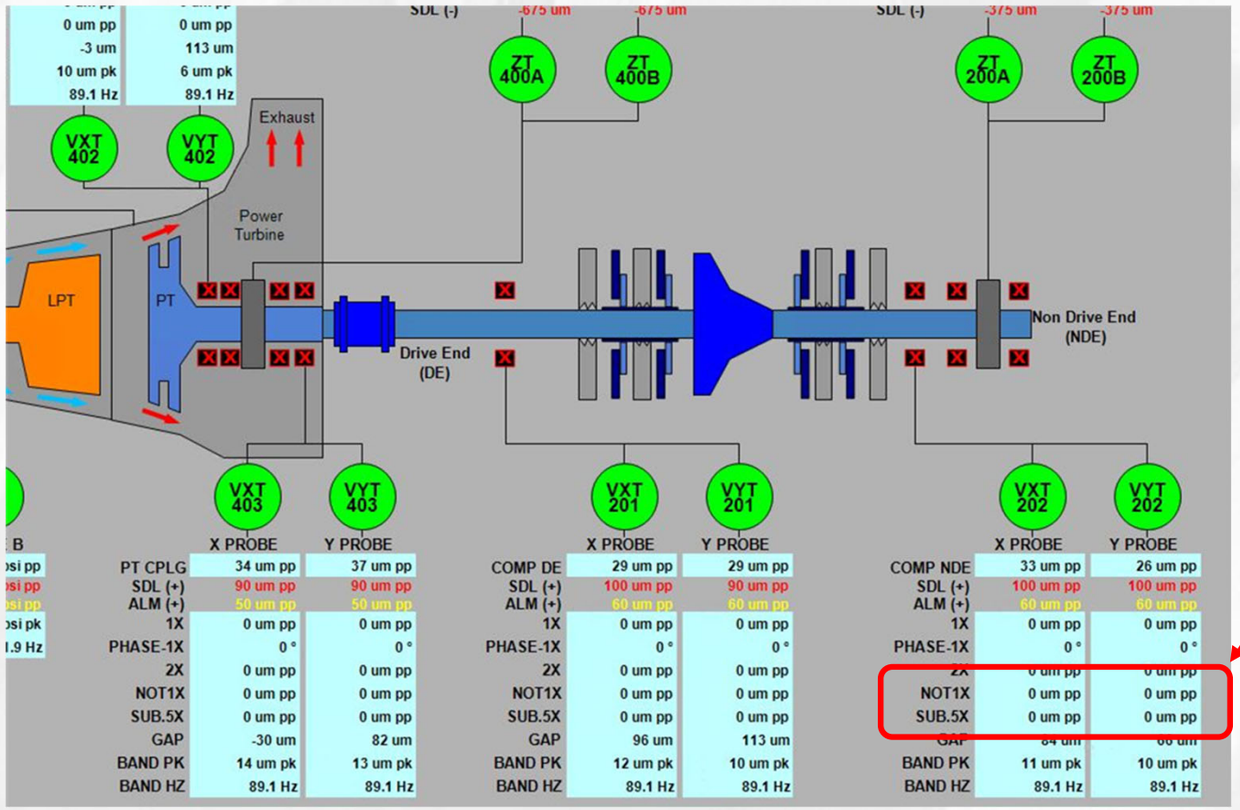
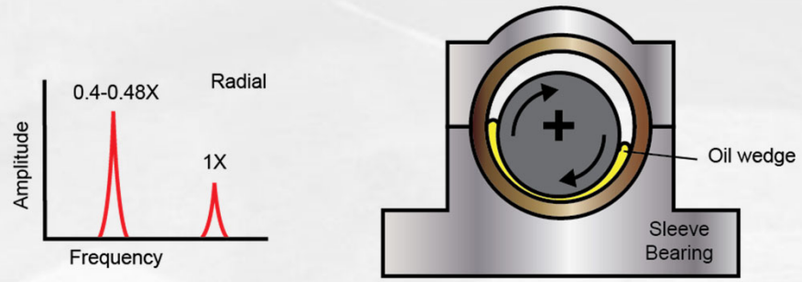
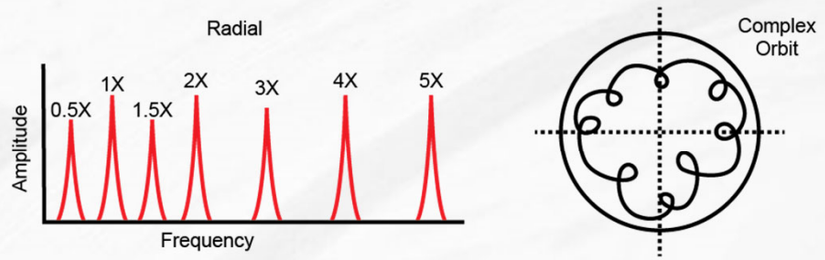
Vibration Problems – Rubs, Oil whirl, Looseness

- Sub-harmonic vibration can be caused by phenomena such as rubs and oil whirl, where oil wedge forms in journal bearings or oil trapped in rotor

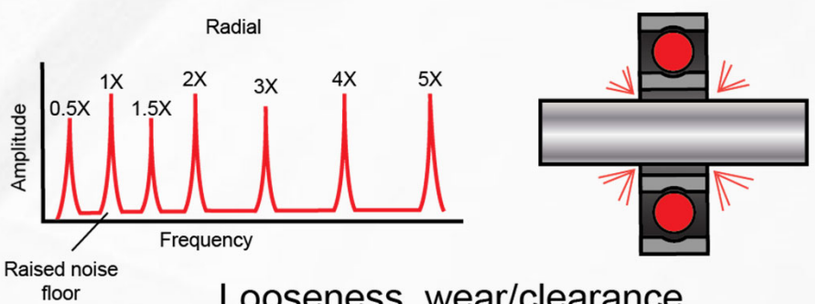




Oil Whirl



Rubs



Looseness, wear/clearance

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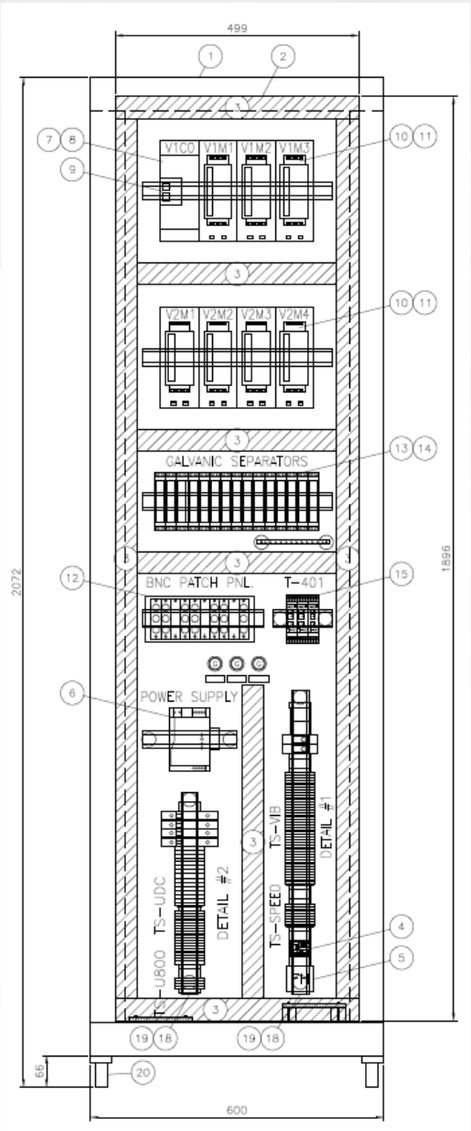
TC Energy Vibration System Upgrades

- Current TCE upgrades replacing obsolete VMS hardware with new
  - Inhouse upgrades 2016 to present
  - Typically keeping instrumentation
  - 40+ sites upgraded
- Standardized design
  - Using the Meggitt VibroSmart platform
  - Software configuration for equipment type
  - I&C drawing based on instrumentation type
  - Standardized data mapping
  - HMI object-orientated code for import
- Improved capabilities



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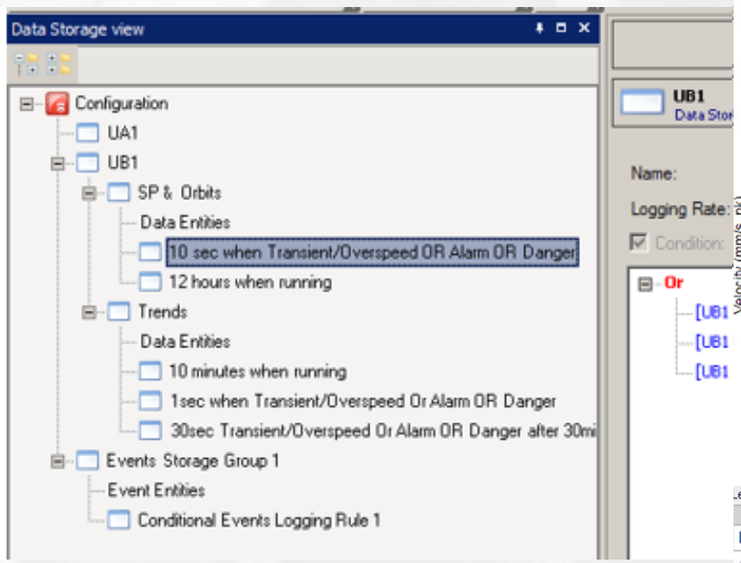
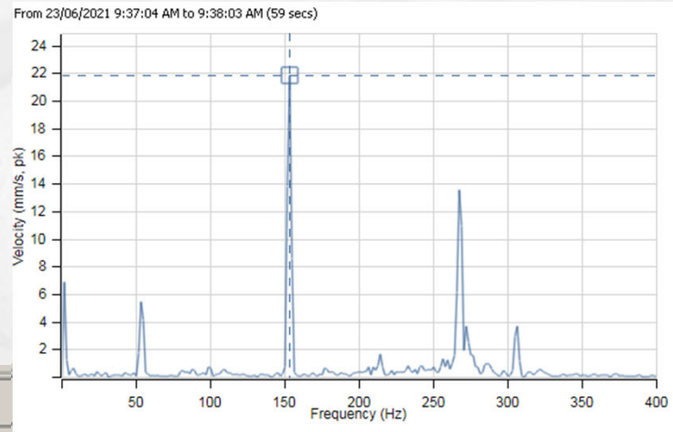
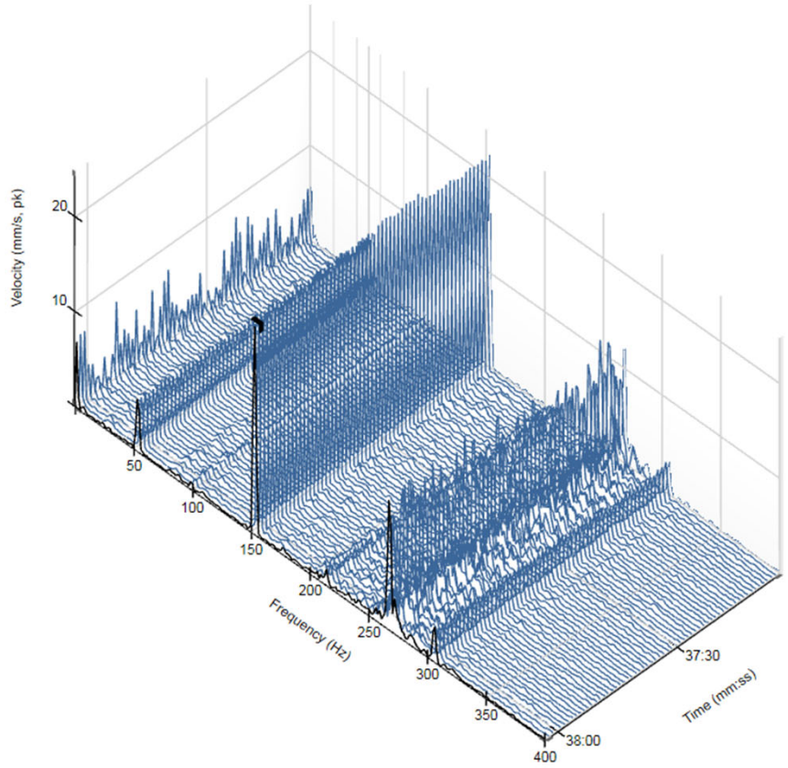
VMS Improved Capabilities







Legend | Measurement Block 1 > V1M2 PT CASE > PT Case

Curve	Visible	Timestamp	Speed	State	Main cursor	Resolution	Location
Spectrum	☑	23/06/2021 9:38:03 AM	9175 rpm		21.9 mm/s s_pk @ 153 Hz	1.56 Hz	0° EU

Frequency | Time | 1 x 1 | Projections