High-Frequency Enveloping (HFE) or Demodulation Mode

High-frequency enveloping (HFE), or demodulation, is an advanced technique used for detecting subtle, yet significant high-frequency impacts and friction embedded within a carrier waveform.

This mode is commonly available and heavily used by vibration analysts using handheld FFT data collectors. These signals, often low in amplitude but crucial for early fault detection, typically get obscured by stronger, lower frequency vibrations in traditional spectrum analysis.

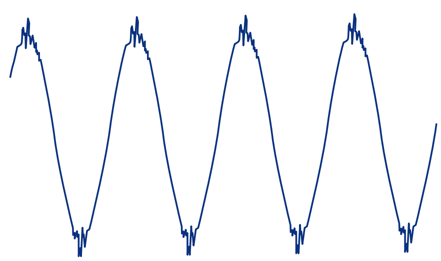
When using HFE or demodulation, data from those bearing tones become visible much earlier than a traditional spectrum for diagnosing things like bearing defects, lubrication issues, cavitation, rotor rubs, and gear faults. The benefits of HFE lie in its ability to capture these early fault indicators, which can be crucial for proactive maintenance to prevent costly downtime. By monitoring RMS and peak scalar data derived from HFE analysis, trends can be established to predict potential failures well in advance, irrespective of asset load or speed. As the faults appear, the repeating signals within the demodulation spectrum increase in amplitude driving up the peak and RMS scalars. As the faults continue to progress, the floor of the HFE spectrum increases, driving the scalar values even higher. When paired with a lower FMax setting on the QM30VT3, the sample frequency remains at maximum level but the sensor will take a much longer sample, meaning the data can be used to trend these types of defects on very slow-speed assets that would normally require a special sensor type such as an ultrasound accelerometer.

HFE works by isolating the low amplitude, high-frequency impact signals, and creating an ‘envelope’ around the signals to isolate the repetitions on the carrier signal. The spectrum with the low-frequency data removed clearly shows those high-frequency impact signals and any harmonics.

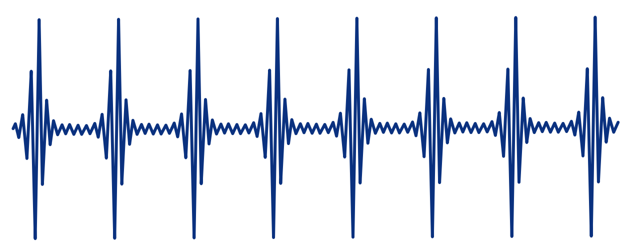
Implementation of HFE requires strategic placement of sensors, such as the QM30VT3, close to the bearings or gears of the asset. This ensures optimal coupling and maximizes sensitivity to high-frequency signals. Mounting considerations include avoiding locations that could distort signals, such as fins, guards, or footings, and opting for solid mounting surfaces like stud mounts, epoxies, or strong magnets on bare metal.

The process for HFE/demodulation involves the following steps with some simplified images.

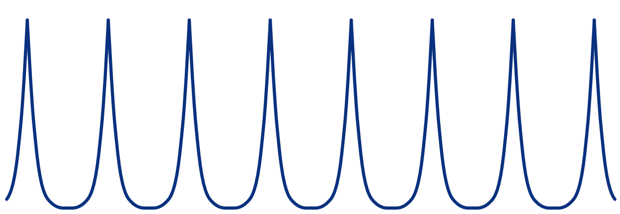
Acceleration signal collection



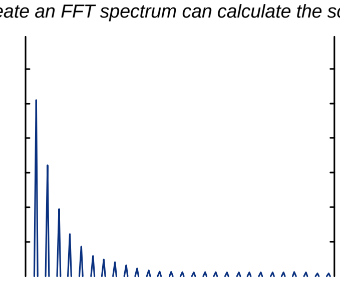
Use a high-pass filter to remove the low-frequency signal



Envelope the remaining data



Create an FFT spectrum can calculate the scalars



Within the QM30VT3, data is reported in 4 different ways providing either the Peak or RMS value from inside the HFE window of each sample from either a Peak or RMS enveloping filter. The magnitudes across the 3-axis for each filter type is available as well to give many ways to trend the data. Typically, these values should be very low and consistent on a new asset with no impact or friction issues. As those asset faults appear, all the data points begin trending upward, providing a much easier way to identify that an issue is beginning and to take action to mitigate potential early failures.

Original Instructions
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