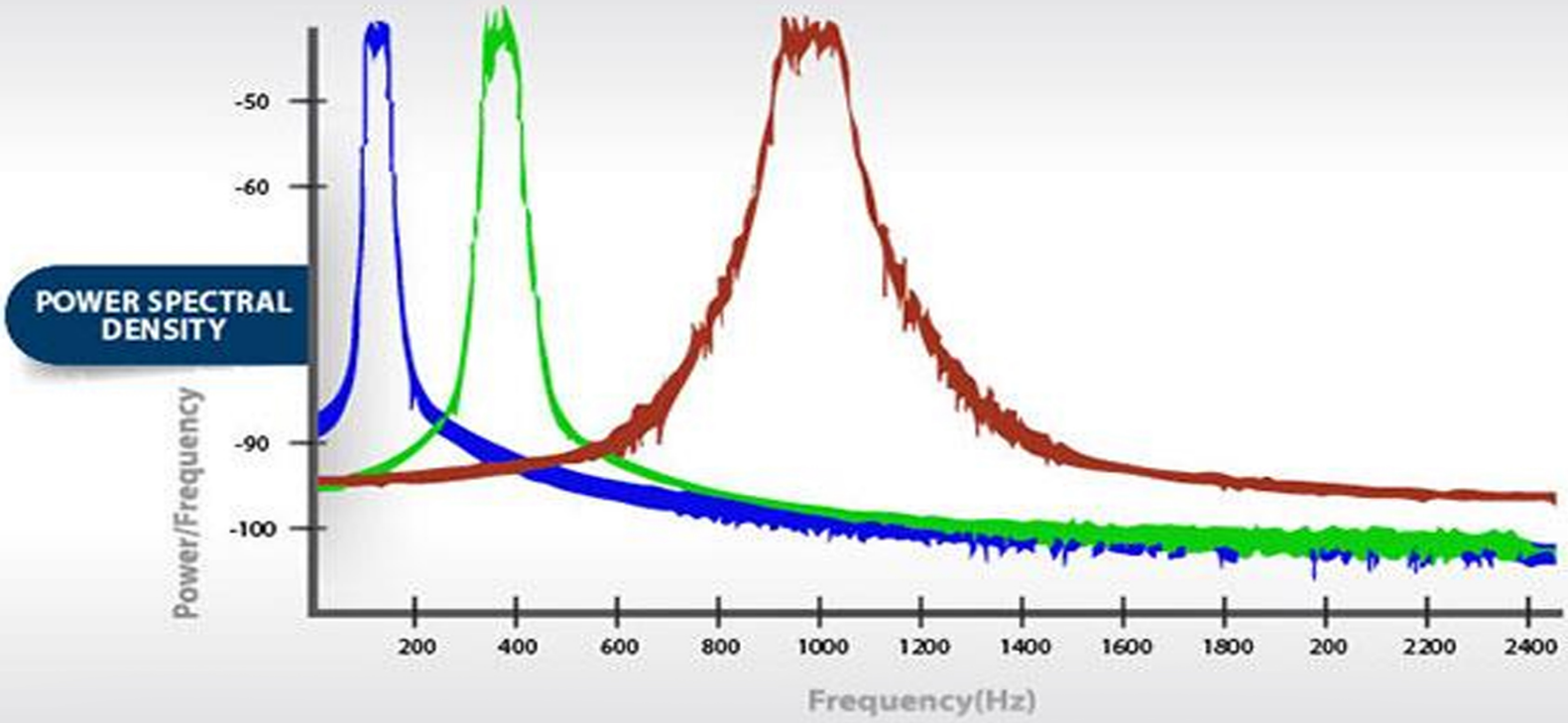
VIBRATION SPECTRAL ANALYSIS

Application of Automated Features Extraction



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Vibration Spectral Analysis:
Application of Automated Features Extraction

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Introduction

Raw vibration time waveforms become easier to analyze when viewed in the frequency domain after an FFT (Fast Fourier Transform) operation has been carried out. However, the content of the derived spectra can contain numerous peaks which is somewhat challenging for even the vibration data experts to decipher.

In this article, a new tool that can map out the content of vibration spectra by automatically extracting the primary features will be introduced. This is particularly useful in online vibration monitoring systems where it is pertinent to use massive amounts of data for making critical machinery decisions. There is no time to use traditional techniques for reams and reams of data.

Traditional Way of Looking at Vibration Spectra

When looking at spectral plots with the primary aim of identifying machinery issues, it is often easier to do the following:

- First, locate the frequency peak that signifies the running speed of the machine. This is referred to as 1x.
- Then, check if other peaks in the spectral plot are related to the 1x. This means checking for harmonics (i.e., 2x, 3x, 4x etc.).
- If there are other peaks with significant amplitude levels, best practice is to check if they are related to running speed frequency peak (synchronous) or not related (non-synchronous).

- Next, check for side bands and the amplitude levels of side bands. This sometimes involves manually calculating the difference in frequencies between the primary peak and the sidebands to make sure that they are equally spaced from the primary peak.
- Finally, check for the presence of noise or carpet levels.

Once all the frequency peaks have been identified, a look at the previous amplitude levels of these peaks to check if there has been an increase or a decrease should be conducted. Depending on the software, you may have to scroll back a couple spectral plots into the history of the unit. Alternatively, you could pull up the waterfall plots of selected historical data and look at everything at the same time. This can be cumbersome and time consuming.

Automated Features Extraction

Vibration Spectra Features Extraction is a concept whereby the vibration spectral plot content is mapped out with the main aim of extracting the primary features and trending it continuously. Machine Running speed frequency, Forcing frequencies and other Frequency peaks which dominate the vibration spectral plot, energy content of the spectra, side bands, noise or carpet levels, etc. can be extracted and trended as linear plots for easier analysis.

Vibration Spectra Features Extraction allows for vibration spectral plot content to be mapped out with the main aim of extracting the primary features and trending those features continuously. Machine running speed frequency, forcing frequencies and other frequency peaks (which dominate the vibration spectral plot), energy content of the spectra, side bands, noise or carpet levels can be extracted and trended as linear plots for easier analysis.

The transformation process of the Raw Time waveform can be further explained if we consider a scenario of a complex waveform with 1x RPM (59Hz) and 2x RPM (118Hz) as components. First the time waveform gets transformed from the Time domain to the Frequency domain by performing an FFT (Fast Fourier Transform). Then the Vibration spectra is further processed by using Features Extraction technique where specific spectra content are automatically trended for easier analysis. See figure 1.

Using Vibration Data Analysis

The following steps can be used to create meaning out of spectral plots:

- Dozens of features are automatically extracted from the spectral plots and trended by default. The running speed frequency peak is also automatically identified by the software.
- In addition to the default features extracted, spectral bands can be added around frequency peaks that are prevalent in each component (Blade Pass Frequency for pump impeller vanes, Gear Meshing Frequency, etc.).
- If a feature (2x RPM) has increased compared to historic levels, you can dive into the spectral data and explain probable causes of increase with recommended actions to correct any issues.
- To be a step ahead, the system can be set to send automated email alerts anytime one or more of these extracted features change (increase or decrease) over time or when band limits are broken.

Benefits of Automated Features Extraction

- Easy to set up as most features are already present by default.
- Alarm and warning limits can be set on the trends of extracted features.
- Analysis time is reduced and more efficient as the focus is monitoring trends that have changed significantly.

- The behavior of the machine can be easily ascertained as the features extracted can be compared with one another.
- The system is non-expert friendly as it makes it easier for non vibration analysis experts to also make meaning of the complex vibration spectra. This is very crucial to the success of any Predictive Maintenance program using vibration data – non-experts can comprehend and contribute to the solutions much faster.

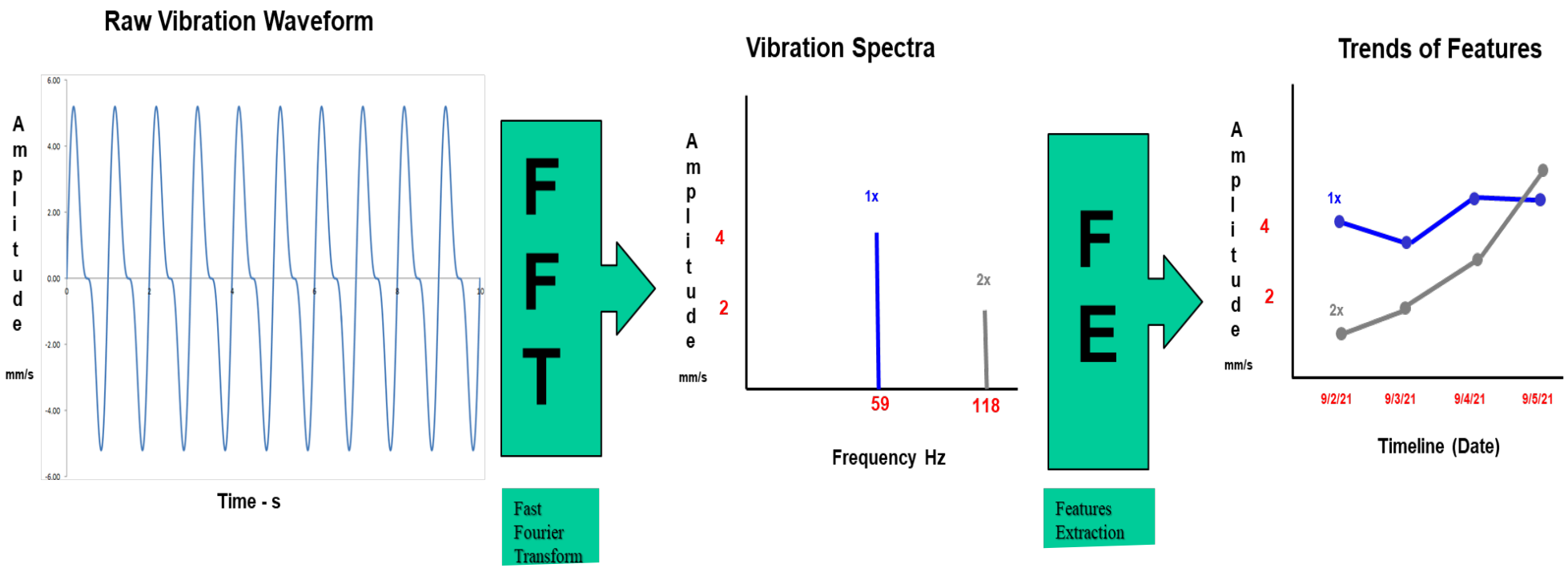

Figure 1: Transformation of Raw Vibration Time Waveform into Vibration Spectra and into trends of features extracted.

Brain Teasers: Check your Comprehension

Q1: Which one of the following aids in the conversion of raw vibration data in the time domain into spectra in the frequency domain? (A): Frobenius Theorem (B): Fast Fourier Transform (C): Laplace Transform

Q2: Automate Features Extraction allows for automated trending of frequency peaks of importance? (A): Not Sure (B): False (C): True

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