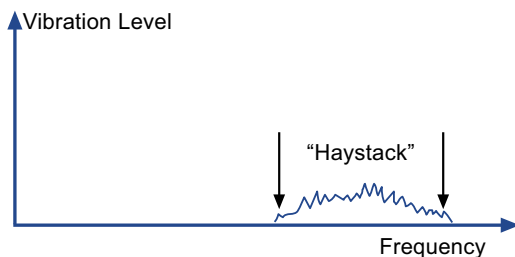
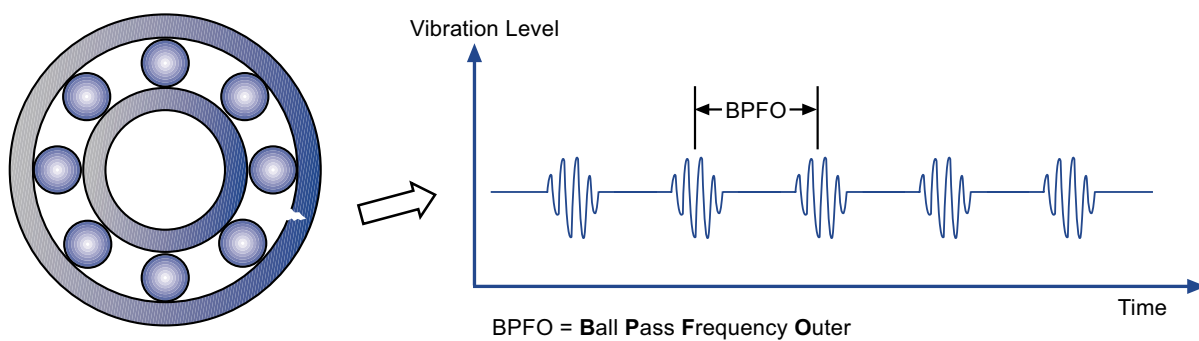


# Introduction to Demodulation

## The Problem

Many serious machine problems can be diagnosed in early failure stages with normal FFT-based vibration analysis techniques. However, there are certain kinds of problems that can remain dangerously hidden in a normal vibration reading until a catastrophic stage is reached, thus not allowing corrective action early on. These critical problems that can hide in normal vibration data are those associated with impulse or impact events. These "impact events" are high-energy, high-frequency events of very short duration. Impact events typically occur in the early stages of rolling-element bearing wear, and during gear meshing.

Take for example the bearing below, which is developing a crack in its outer race. Each time a ball passes over the crack it creates a high-energy burst of vibration, with each burst lasting for a very short time.



When the vibration signal is passed through the FFT analyzer to create a frequency-based spectrum, we would normally expect to see a big spike or peak occurring at the same frequency (or rate of occurrence) that each ball passes over that crack. Unfortunately we do not. Instead we will commonly see what is referred to as a high frequency "haystack" as displayed at left.

Why does the FFT analyzer display a haystack instead of distinct peaks? The reason is that the FFT process looks for repeating **sinusoidal** (wave-shaped) components at individual frequencies, and due to the short duration and low amplitude nature of these impact events, the FFT correctly tells us that there is not enough occurring at the BPFO frequency to stand out on its own.

This can be further illustrated by picturing yourself trying to listen to someone tapping on a drinking glass filled with water while at the same time you are standing next to a loud and low toned gong or church bell. What happens is the longer and louder vibration event of the gong drowns out or masks our ability to hear the softer and shorter sound coming from the tapping event; this is true even though both events are occurring at the same time. Our ears hear the combination of both events, but we are unable to separate and distinguish the two.

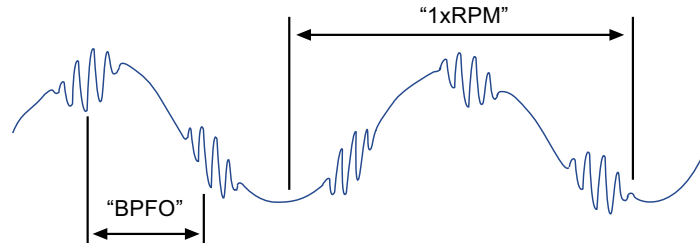
## The Solution - Demodulation!

Reviewing the time waveform at the top of the page, we note that repetitive noise bursts are occurring. So, how can we use the **vb** to "hear" them?

Enter "Envelope Demodulation" also known as "High Frequency Enveloping". The Demodulation process looks for the repetitive patterns created by impact events that lie embedded within the time waveform. The **vb** will then display a demodulated frequency spectrum that will greatly emphasise these fault frequencies. But how does it work? \_\_\_\_\_

## The Process

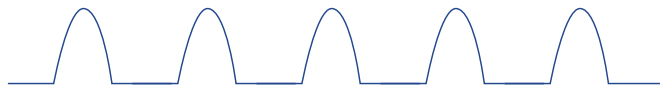
On the “typical” time waveform below, the large wave indicates a large low-frequency component (perhaps due to misalignment, or unbalance). This would be like the loud gong sound. On top of the low-frequency component are superimposed the bursts of high frequency noise from the impact events, like the tapping on the glass.



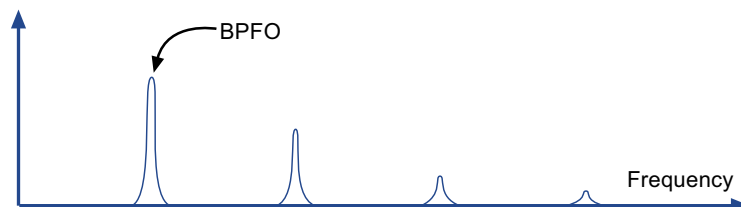
Our first step is to apply a high-pass filter that removes the large low-frequency component(s). The illustration below gives an idea of what the FFT analyzer then “hears” – only the tapping on the water-filled glass:



Next we trace an “envelope” around the bursts in the waveform to identify the impact events as repetitions of the same fault.



And now this **enveloped** signal is passed through the FFT process, to obtain a frequency spectrum. It now clearly presents the BPFO peaks (and harmonics), as we first hoped for:



## How do I interpret the results?

Think of Demodulation as an “early warning” indicator.

Look for peaks at known bearing fault frequencies in both the normal vibration and the demodulated spectra:

1. No peaks in either spectrum: Condition is good, use as a baseline for future comparisons.
2. Peaks appear in Demod only: Early warning indication that defects exist (or bearing needs lubrication).
3. Peaks appear in Normal and Demod spectra: Plan replacement at next maintenance period.
4. Peaks appear in Normal only, combined with rise in Demod noise floor: Replace now!

## How do I use demodulation on my **vb**?

From the main menu, choose option 1 and set the Mode/Domain to “Demod”.

Choose the Demod Frequency Bandwidth to include the haystacks, but exclude low frequencies.

(We suggest 2 - 10 kHz as a starting point, refer to the **vb** Owner’s Manual for more details).

Set the display Fmax as usual (e.g. at about 20x running speed).

Record away!

This document is solely an introduction to “demodulation” techniques. The information contained herein is for illustrative purposes only and should not be used to diagnose genuine machine faults. Morgan Diagnostics can assist you in acquiring advanced Vibration Analysis consultation services and educational texts.