Brüel & Kjær Vibro

Application Note

Technique description – CPB measurements give early fault detection with minimal risk of false alarms

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ABSTRACT

An effective vibration measurement is available for automatic fault detection that is simple to set up and use, has good reproducibility, optimal resolution, and gives early, reliable warning for most machine faults. It is called the ***Constant Percentage Bandwidth*** *measurement, or* ***CPB****, and has proven itself through the years to play an important role in condition monitoring for a wide range of machinery.*

Early fault detection

Condition-based maintenance is the optimal solution for reducing the life-cycle costs of many industrial machines. One of the fundamental requirements for this strategy to be successful, however, is the ability to be able to detect faults reliably enough to minimize the costly risk of false alarms, and early enough so maintenance can be cost-effectively planned ahead of time with minimal interruption of production.

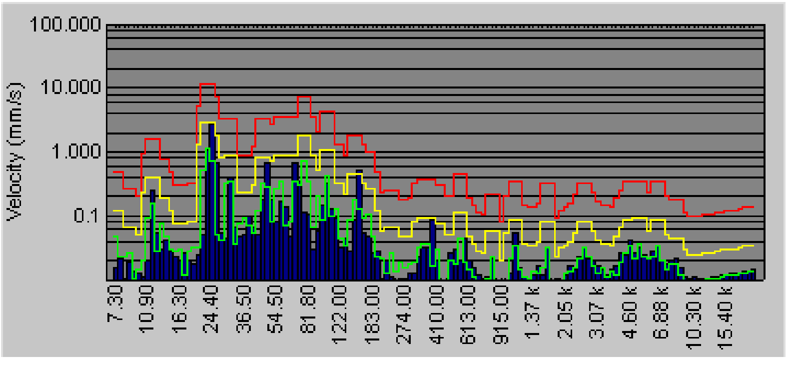


Figure 1. CPB23% spectrum measurement with alarm limits..

Vibration measurements remain one of the most effective techniques for fault detection and diagnosis of the most common machine faults. Different machine faults or potential failure modes are characterized by specific frequencies or frequency ranges, and these are detected (and trended) by monitoring minute changes in the vibration amplitude at those frequencies. There are many types of vibration measurements for different types of applications, but for automatic condition monitoring purposes, there is a big difference in how early or effectively you can detect changes.

CPB for automatic fault detection

The Constant Percentage Bandwidth or CPB measurement has been developed specifically to provide early fault detection for the most common machine faults with minimal risk of false alarms. This is made possible by an ingenious filtering algorithm that provides sufficient resolution for reliably detecting the most common types of faults.

The CPB is based on a constant relative bandwidth on a logarithmic scale - i.e. the bandwidth of each spectrum bar is a fixed percentage of the center frequency, as shown in Figure 2. This means the frequency resolution is relatively high at the lower frequencies and coarser at the higher frequencies, which is ideal for reliable, early fault detection.

At the lower frequencies much resolution is needed for detecting isolated, narrow harmonic signals such as that found in unbalance, rotor instability, misalignment and coupling problems.

In the high frequency end of the spectrum, less resolution is needed since this is where periodic impulse signals and distributed random noise are produced, for example, by rolling-element bearing faults, lubrication problems, local gear tooth problems, blade noise and gas-seal leaks.

The CPB has a frequency resolution that allows it to automatically detect all these faults, both in the low and high frequency ranges. The simplicity of the CPB spectrum plot display makes it also ideal for quick, at-a-glance diagnosis.

CPB offers minimal risk of false alarms

The CPB is built up on a number of relatively wide frequency lines or bars that allow small changes in frequency and speed to be "absorbed" without significantly changing the vibration signal. The number of frequency bars (and their consequential width) is user configurable, as shown in Figures 2 and 3. A greater number of bars provide earlier fault detection capability, whereas fewer bars provide faster access and analysis time and require less disk space. This makes the CPB flexible for many different types of applications.

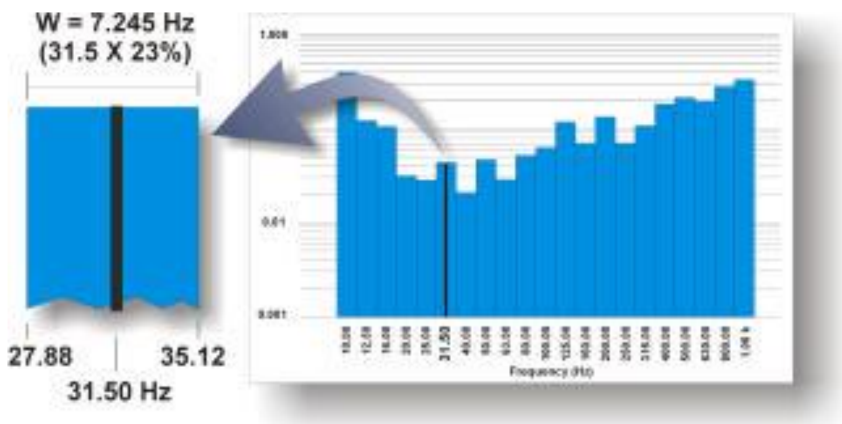
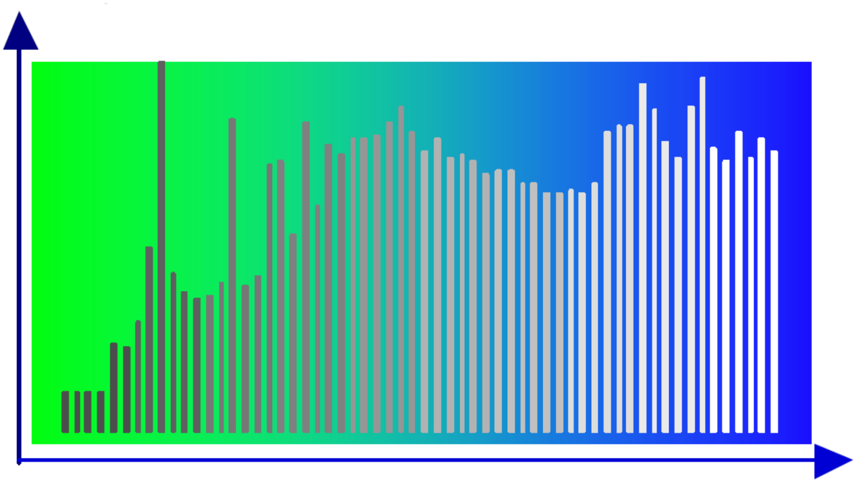


Figure 2. A CPB23% measurement from 10 to 1000 Hz has 21 frequency bars. In this example each bar has a bandwidth that is 23% of the center frequency.



LOW FREQUENCIES (higher resolution)	**HIGH FREQUENCIES** (coarser resolution)
Typical faults: Journal bearings/shaft, coupling	**Typical faults:** Gearbox, rolling-element bearings
Characteristics: Narrow, isolated peaks, harmonics	**Characteristics:** Side-band families, periodic impulses

Figure 3. CPB has optimal resolution for detecting many kinds of faults.

For speed changes that are greater than the width of the frequency bars, it is a simple task to automatically shift the entire spectrum to its reference position so that all of the fundamental frequencies, harmonics and sidebands, etc. are realigned.

Other Vibration measurements for other applications

The CPB is the ideal measurement for early fault detection for condition monitoring applications. It actually combines the benefits of other measurements that are used for entirely different purposes.

Like the CPB the overall vibration measurement is fast, reproducible, stable and is immune to small frequency variations. This is ideal for protective monitoring - but it lacks frequency information that is needed for early fault detection for condition monitoring purposes. The vibration signature of many faults manifest themselves as narrow spikes at specific frequencies, and the proportional energy contribution of such a fault signature in an overall measurement is very small in relation to the total broad-band energy content. This means a well-developed fault may increase the overall value only slightly. The result; less lead-time in detecting a fault and more monitoring rounds needed in off-line monitoring applications.

Unlike the overall value, the FFT spectrum measurement has a tremendous amount of diagnostic information. FFTs have many

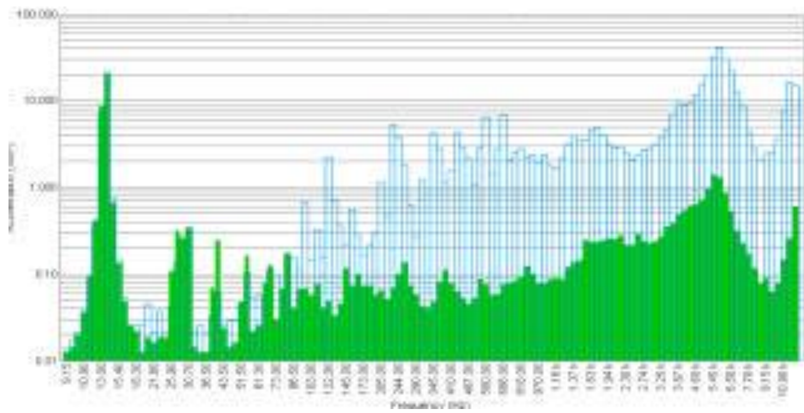


Figure 4. CPB6% plot showing increased medium and high frequency vibrations caused by excessive clearance in a rolling-element bearing (note that there is little change in the running speed frequency).

frequency components that are perfect for analysing and diagnosing a wide variety of faults. But the FFT, however, is also sensitive to process and speed changes. A slight speed change can shift a narrow peak away from its reference signature.

For this reason it can be difficult to set up “tight” alarm limits on an FFT for automatic fault detection without getting false alarms. The FFT also requires more measurement time and more averages than for a CPB, which can be inconvenient in off-line monitoring applications.

In addition to the FFT, there are other measurements that are also better suited to diagnosis and analysis than to automatic early fault detection, such as:

- **Envelope** (SED) – Analyzes modulated high-frequency random noise and Impacts in rolling-element bearings

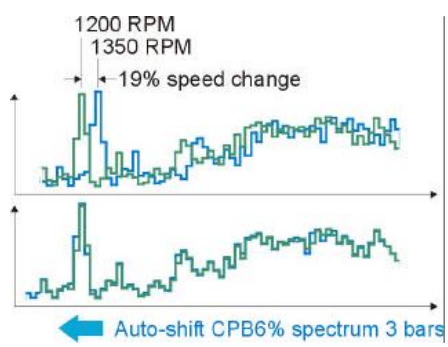


Figure 5. Example of an automatic speed compensation routine. In this example, each CPB bar is 6% wide, so a 19% speed change corresponds to moving the entire spectrum three lines.

- **Cepstrum** – Analyzes complex harmonics and side-band families generated by gearbox faults
- **Orbit** – Two perpendicular proximity probes for analyzing journal bearing and shaft behavior

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Conclusion

The CPB is one of the most reliable, stable and economical methods for detecting the widest possible range of machine faults at an early stage of development. It is has good reproducibility with optimum resolution and thus a “standard” for early fault detection for condition monitoring applications.

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