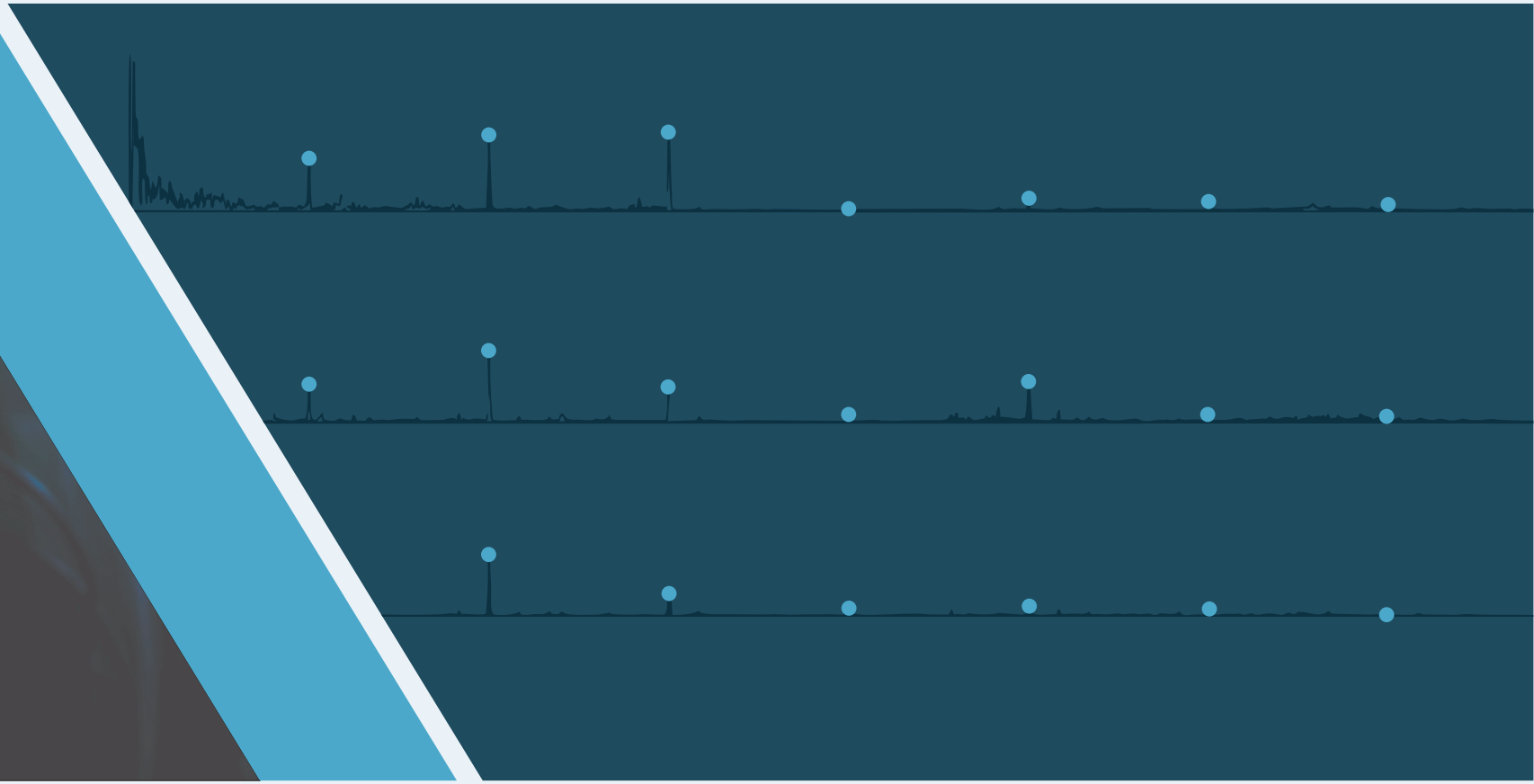
VIBRATION ANALYSIS 101

A simple guide to understanding vibration



Part 1

What is vibration, waveform and spectrum?

Why we talk about vibration analysis?

What is vibration?

What is vibration amplitude?

What is vibration frequency?

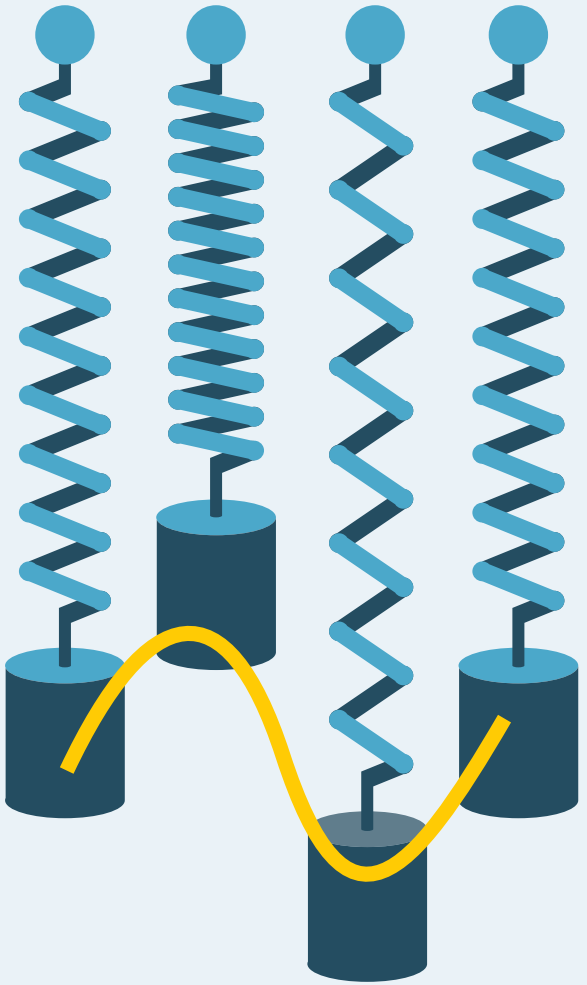
What is vibration spectrum?

How the vibration of real machine may look like?

How to understand more complex vibration patterns?

How is complex vibration transformed in a simple spectrum?

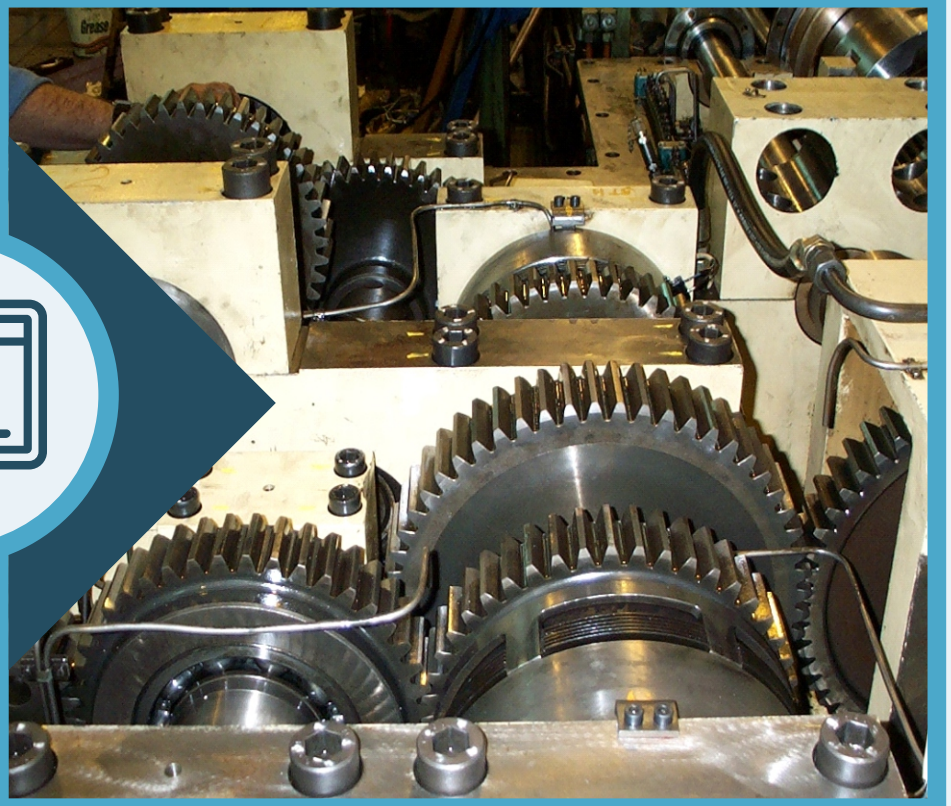
Undertesting Vibration spectrum



Part 1

Why we talk about vibration analysis?

- **VIBRATION**
- Visual Inspection
- Contamination
- Ultrasound
- Oil analysis
- Motor Current Analysis
- Non Destructive Testing
- Thermography



Vibration provides information about the health of the equipment so an action can be taken to prevent unscheduled breakdown and costly repairs.

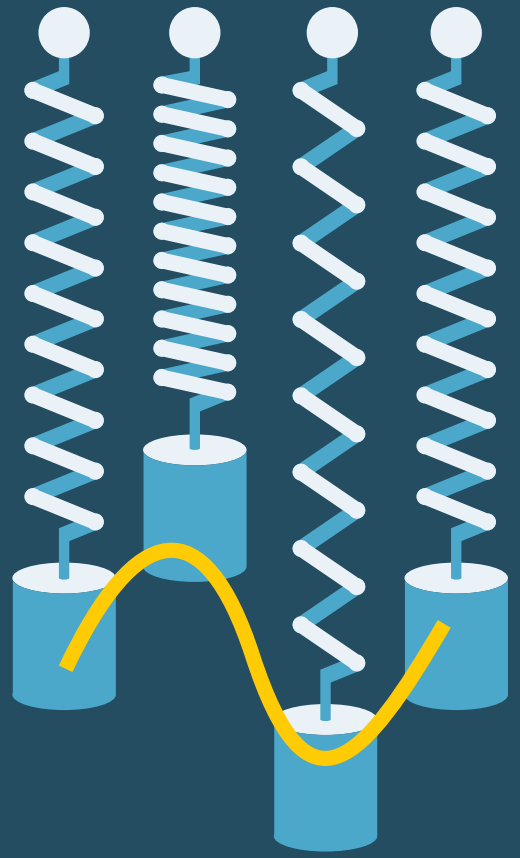
It is the most common condition monitoring and diagnostic method.

It is a technique capable of early detecting symptoms of many different equipment problems and failures.

The most common problems detected by vibration are unbalance, misalignment, looseness, bearing and gear problems, electrically induced vibrations, pipe vibration, pressure pulsation etc.

Vibration can detect bearing related problem months before we see detect the problem by our human senses.

Part 1

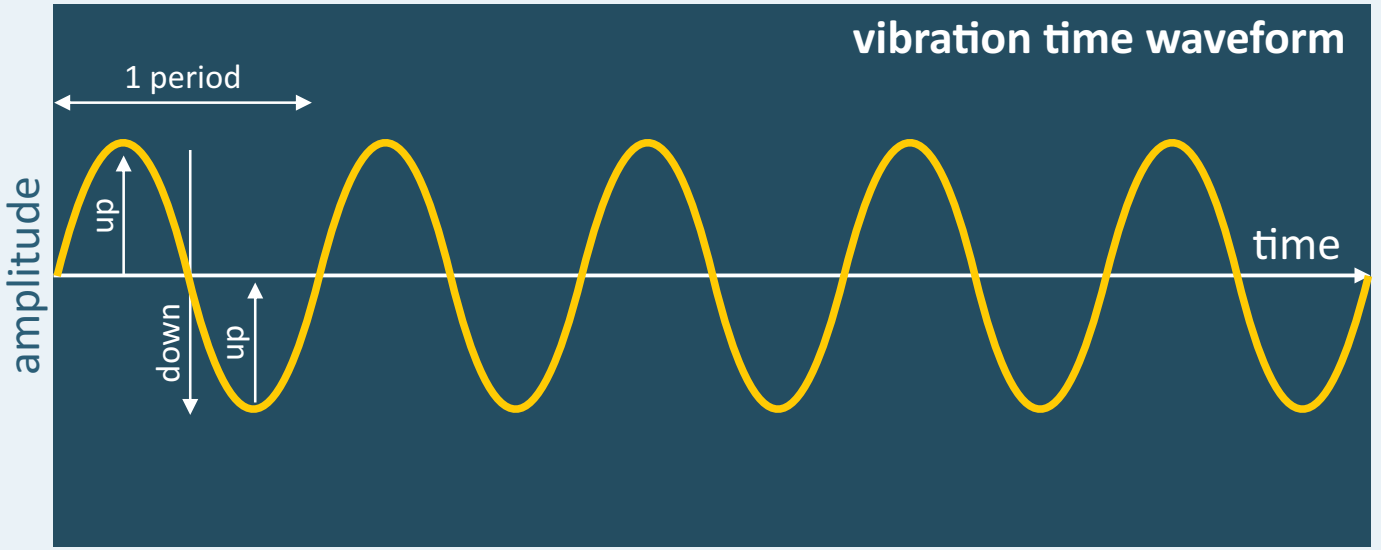


What is vibration?

Vibration in a simple terms is an oscillatory motion. Every machine or component subjected to rotational forces or impacts will vibrate.

The simplest vibration pattern will be an oscillation “up and down”. If we observe this motion over time it will it will look like a wave.

The wave has amplitude (now much the object is moving from its rest position) and period (how long takes to complete one cycle).



Graph above (amplitude vs time) is called “time waveform”

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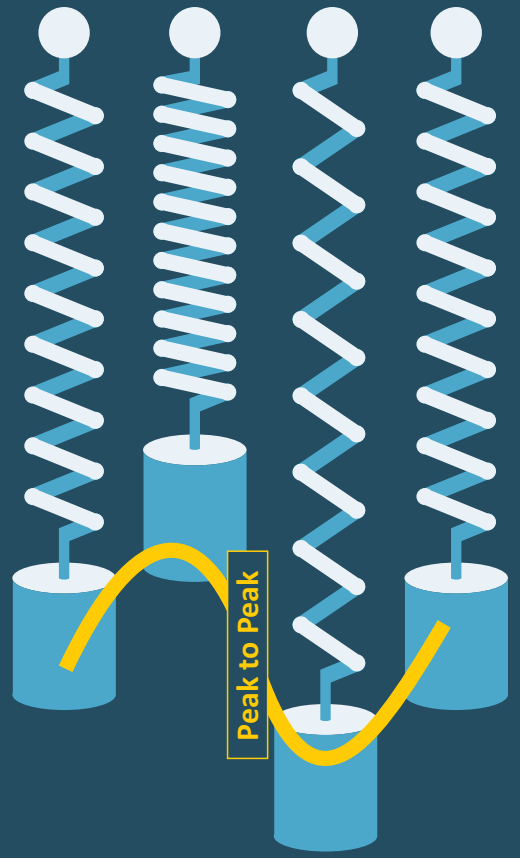
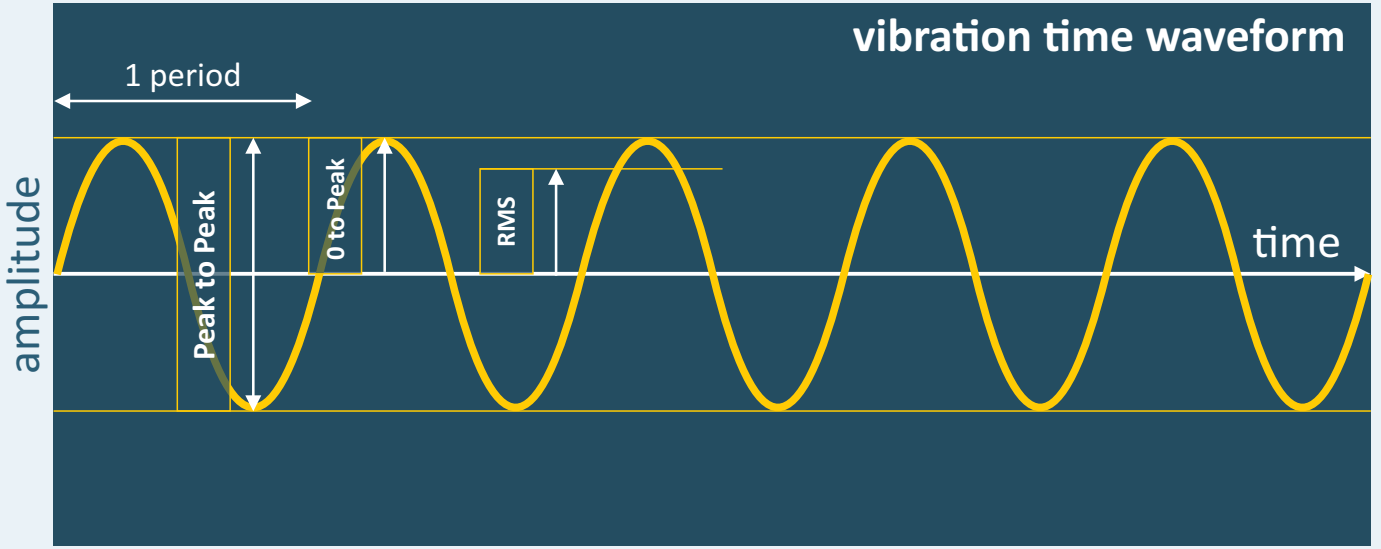


What is vibration amplitude?

If we measure from the bottom to the top of the oscillatory motion, we call that **Peak to Peak** amplitude.

If we measure from the equilibrium position, then we call that **0-Peak** amplitude.

It is a common practice to express the amplitude in **RMS** (root mean square). This is because it better relates to the vibration energy. In a simple oscillatory motion this amplitude is 0.707 of the 0-Peak amplitude.



It is very important to know what is the vibration amplitude expressed in (Peak to Peak, 0-Peak or RMS).

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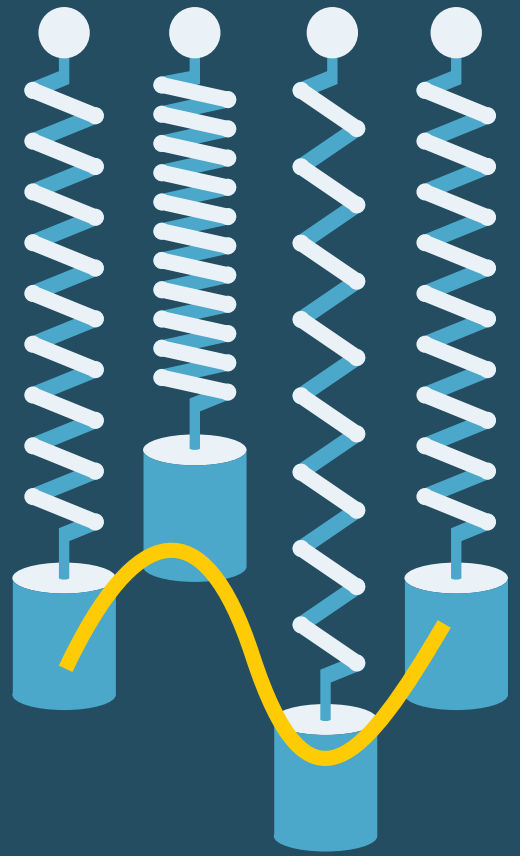


How often is the object oscillating per unit time?

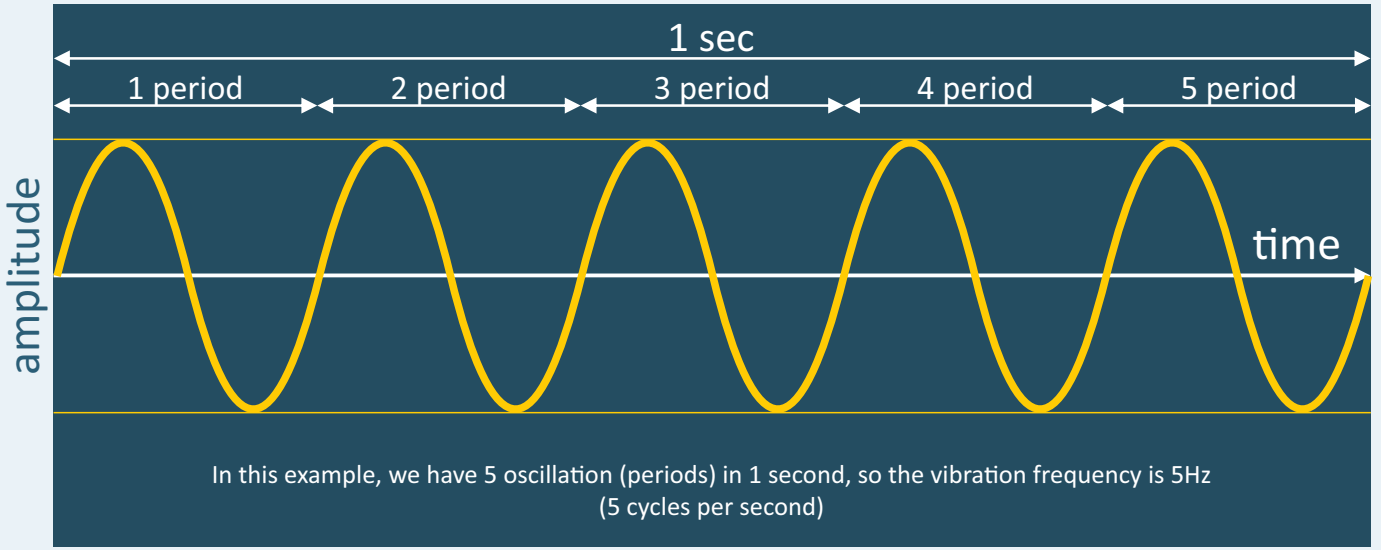
What is vibration frequency?

While vibration amplitude is a measure of the vibration intensity, the frequency is the measure of how often the object is oscillating per unit time.

Most common ways to express frequency are:

CPM – Cycles (number of oscillations) per minute

Hz – Hertz which is cycles (number of oscillations) per second.

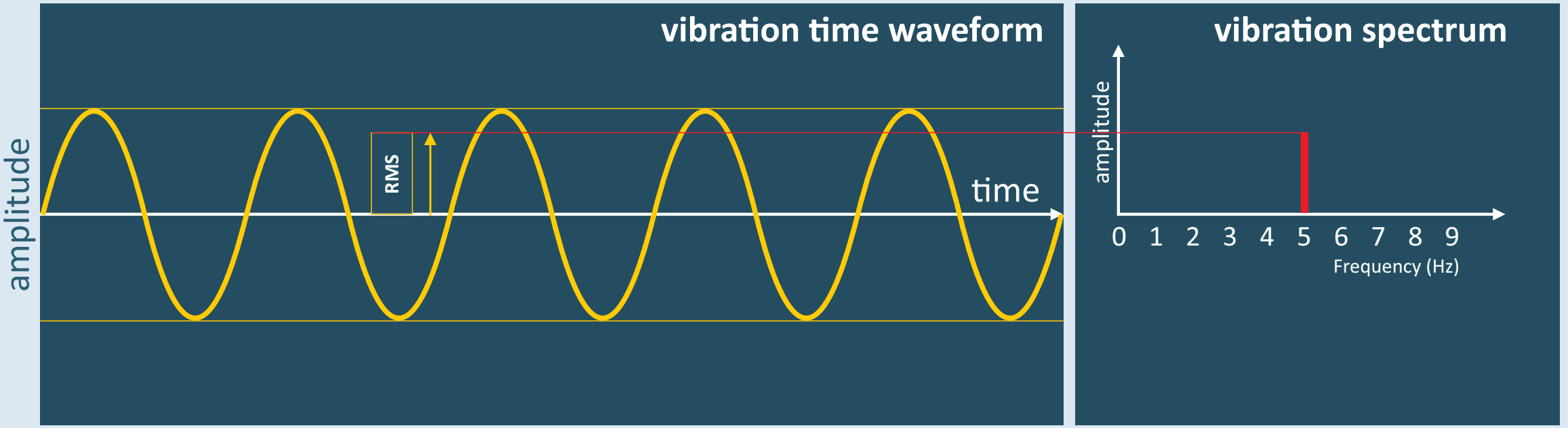


Frequency in CPM can be converted in Hz by dividing with 60.

Part 1

What is vibration spectrum?

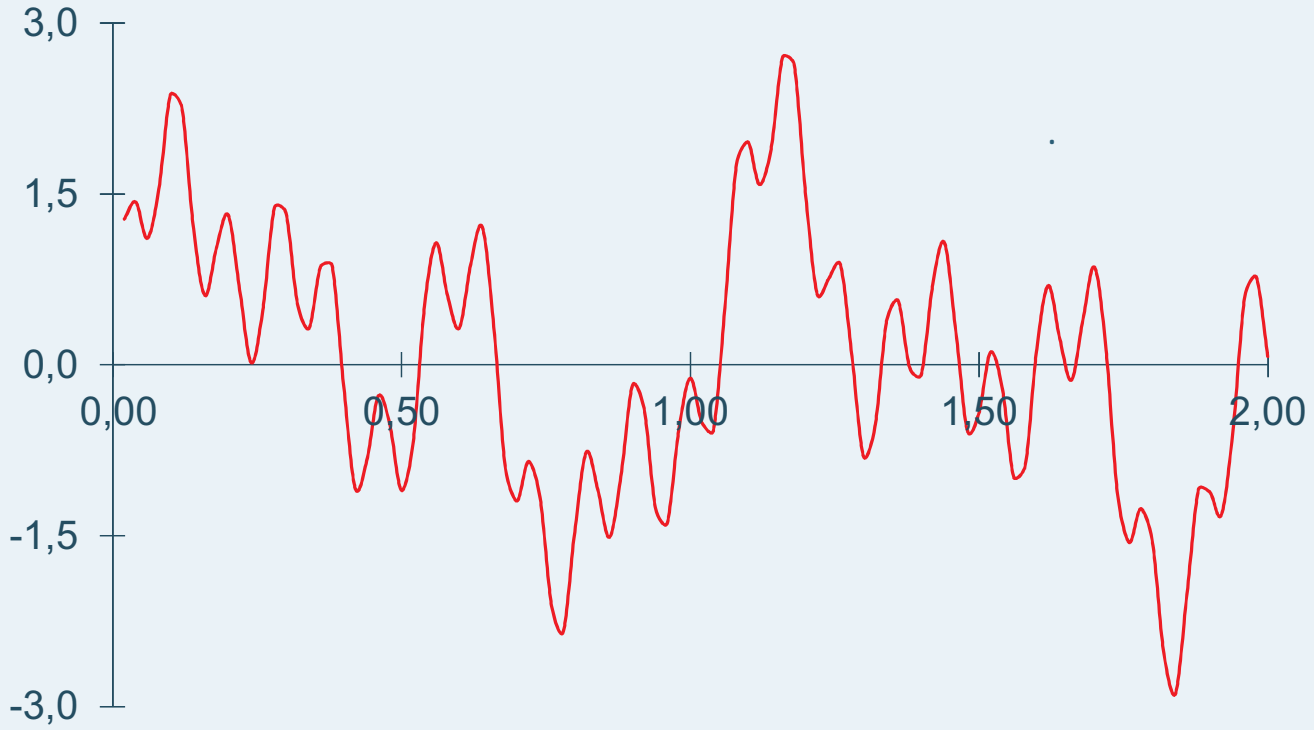
We understood that vibration as a wave can be described with its amplitude and frequency. So, rather then looking the oscillatory motion in amplitude versus time plot, we can express the same information in amplitude versus frequency plot. This amplitude vs frequency plot is called **vibration spectrum**.
Scale, we can simply.



In the spectrum, a simple time waveform can be represented just with 2 numbers - amplitude and frequency

Part 1

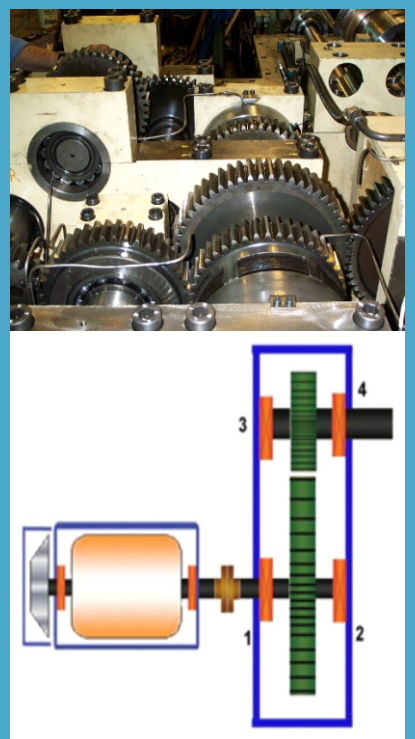
How can a complex vibration pattern be presented by a simple spectrum?

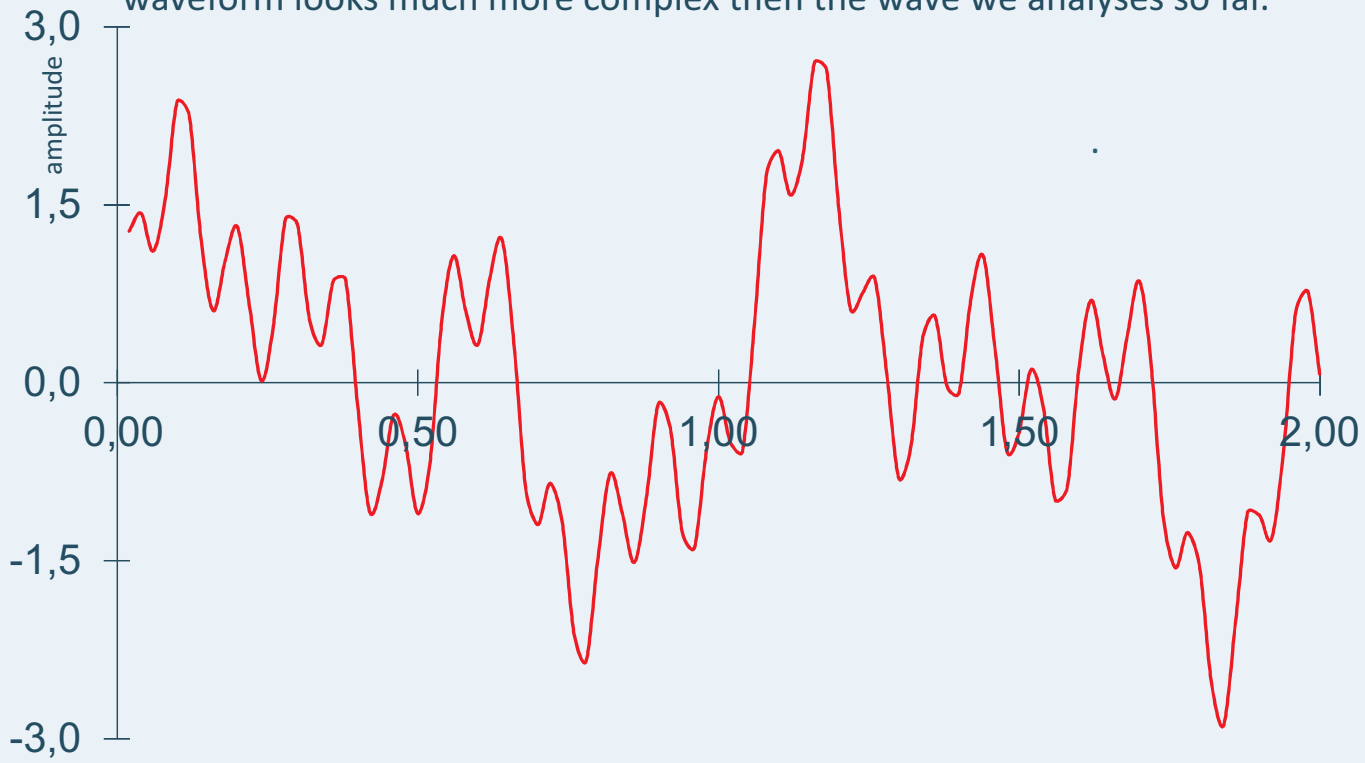


Part 1

How the vibration of real machine may look like?

Imagine if we can isolate each vibration source and Vibration of real machines is more complex. Real machines have different components and shafts that may be rotating at different speeds generating vibration with different amplitudes and frequencies. When all these vibration signals are added together, the resulting waveform looks much more complex then the wave we analyses so far.



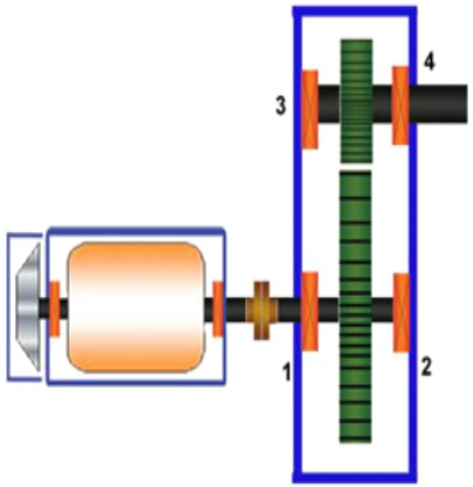


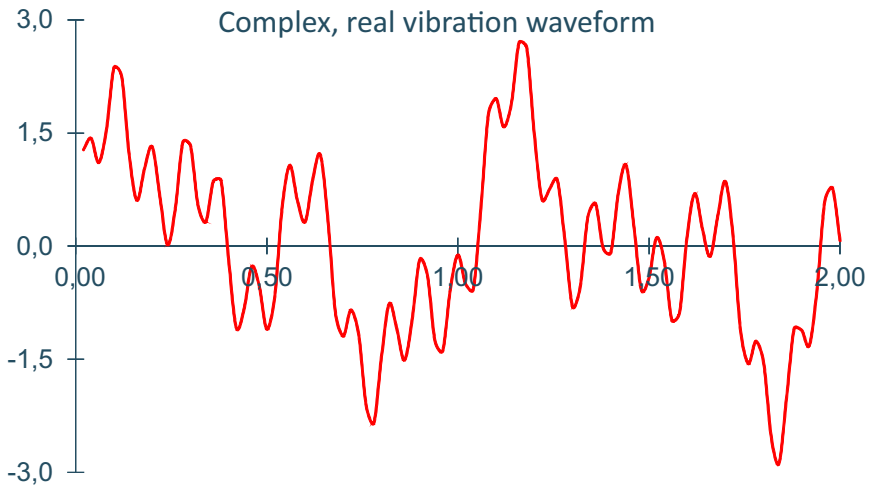
Real machines have complex vibration waveform

Part 1

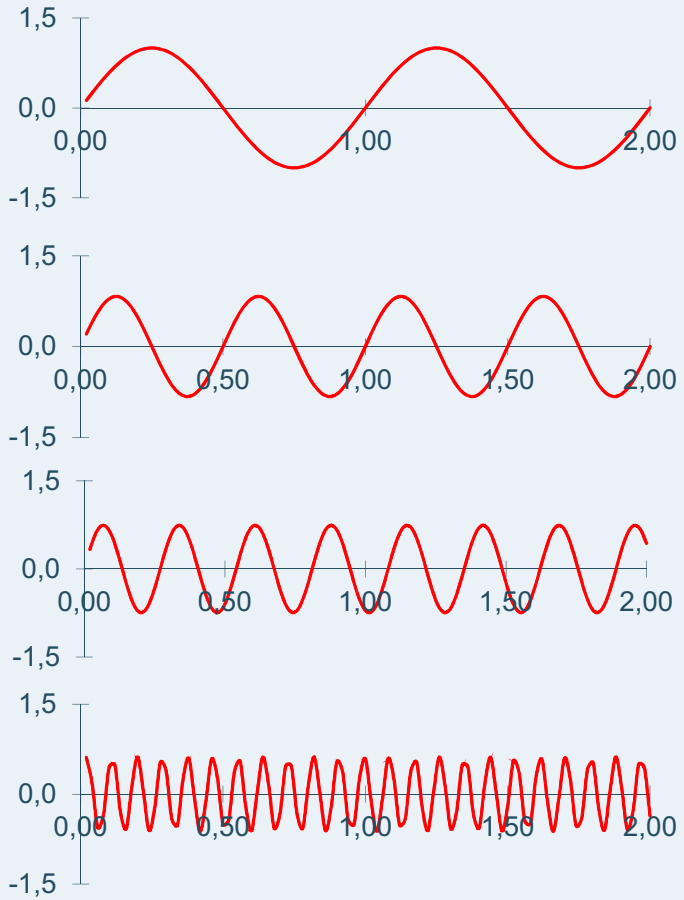
How to understand more complex vibration patterns?

To be able to identify each vibration sources in amore complex vibration pattern, we will need to find out each individual simple wave that contributed to the final vibration signal.





Complex real vibration broken down in components

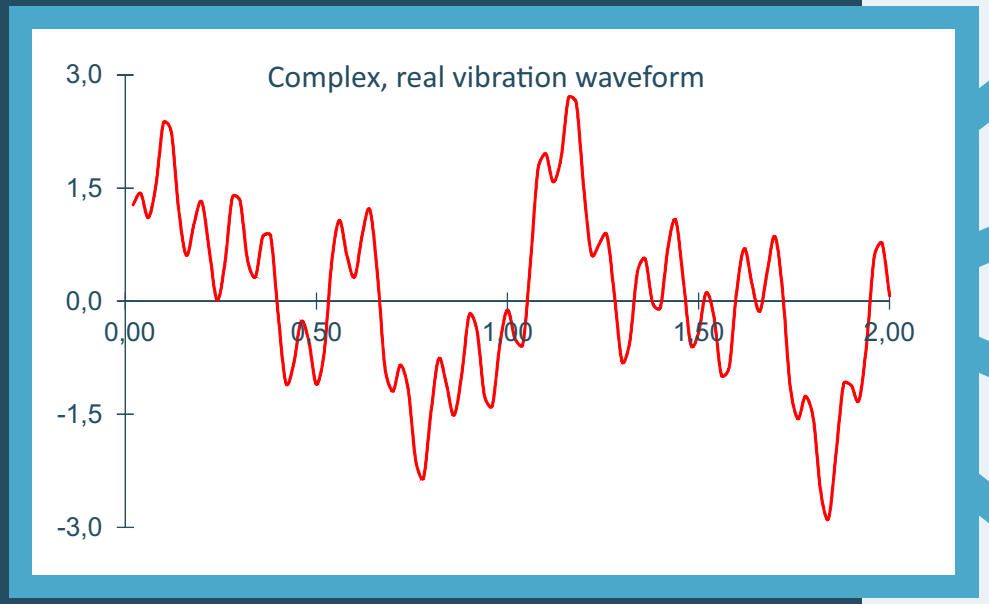


In this example, the pattern on the left is a sum of the simple patterns on the right.

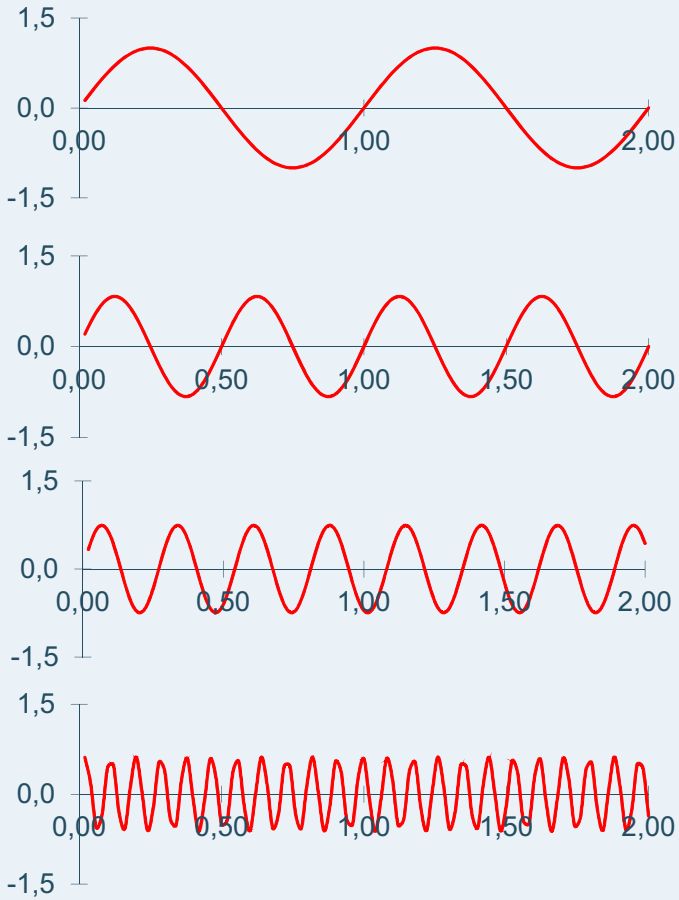
By breaking down complex vibration signal in its simple components, we can better understand what is causing the vibration

Part 1

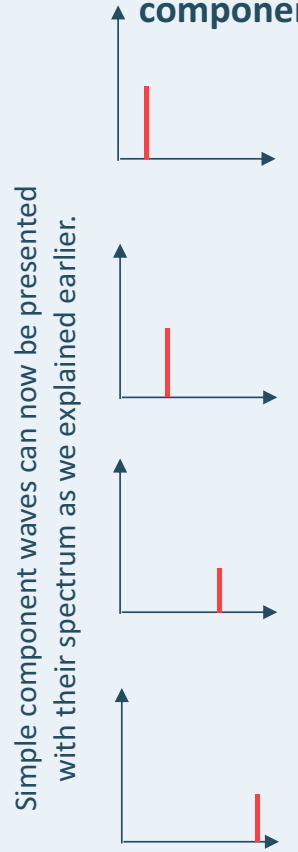
How to understand more complex vibration patterns?



Complex real vibration broken down in components



Spectrum of each component



Simple component waves can now be presented with their spectrum as we explained earlier.

Each vibration component now can be easily converted in its spectrum.
We can now see different amplitude at different frequencies.

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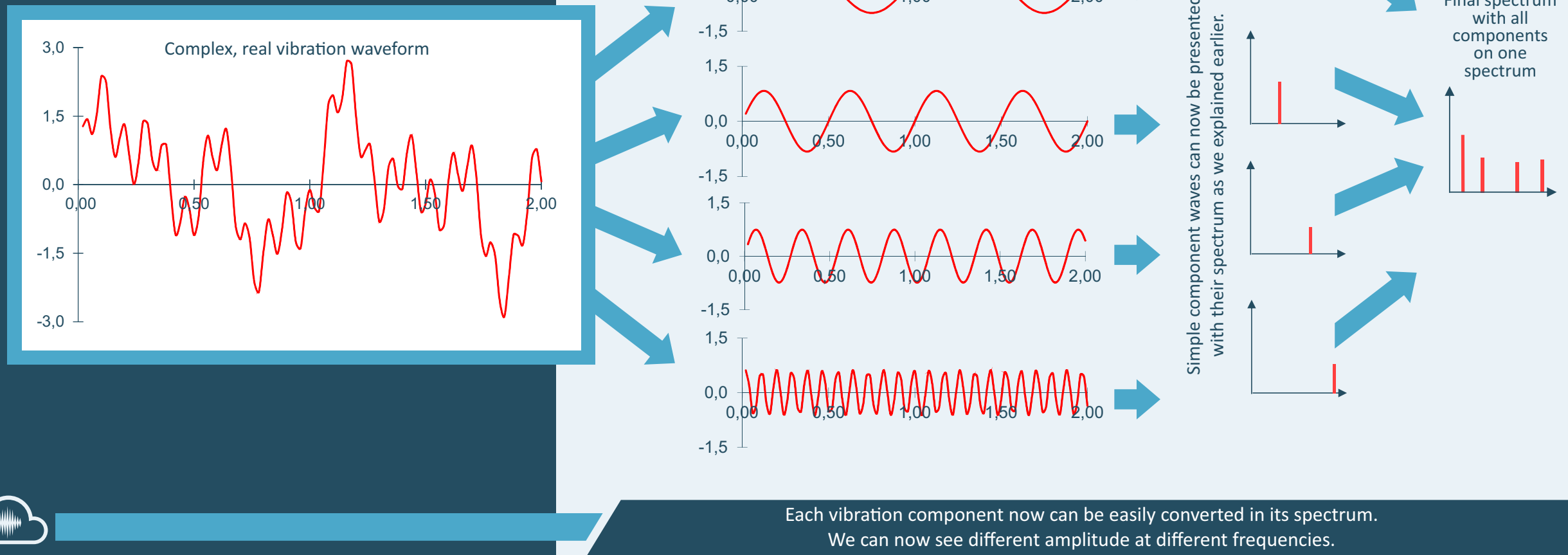
How to understand more complex vibration patterns?

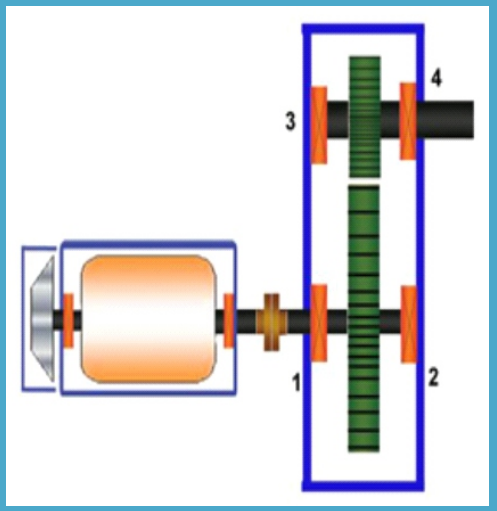


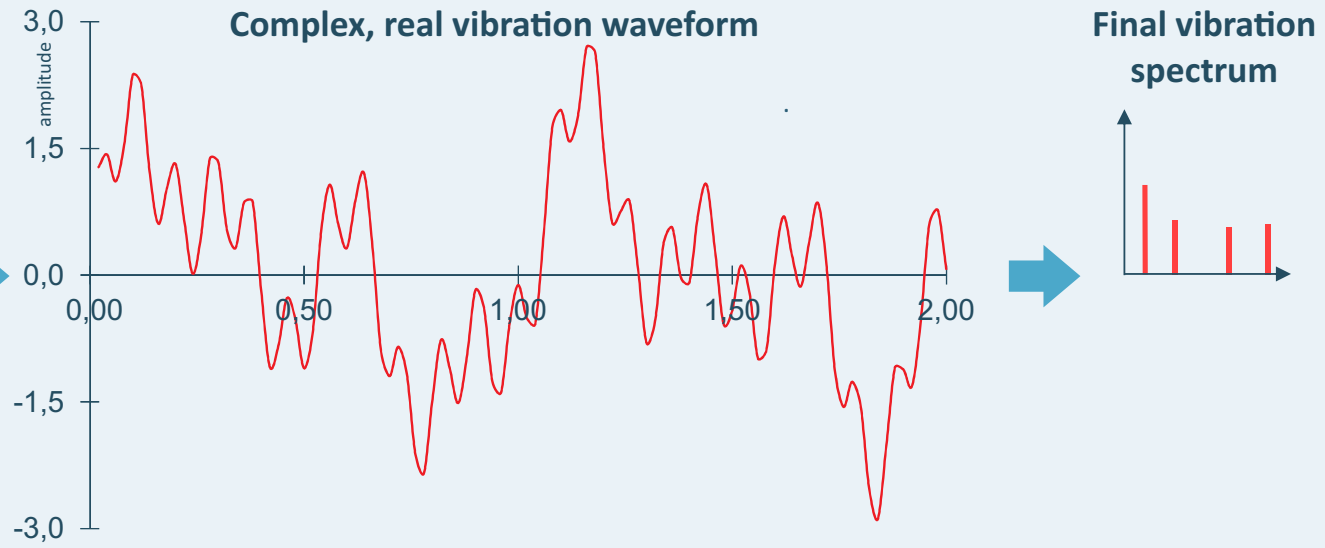
Each vibration component now can be easily converted in its spectrum.
We can now see different amplitude at different frequencies.

Part 1

How is complex vibration transformed in a simple spectrum?

A mathematical process called **Fast Fourier Transform (FFT)** is used to convert complex vibration pattern into a spectrum that shows all vibration components (amplitudes and frequencies). This process is critical part in a modern vibration analyser.



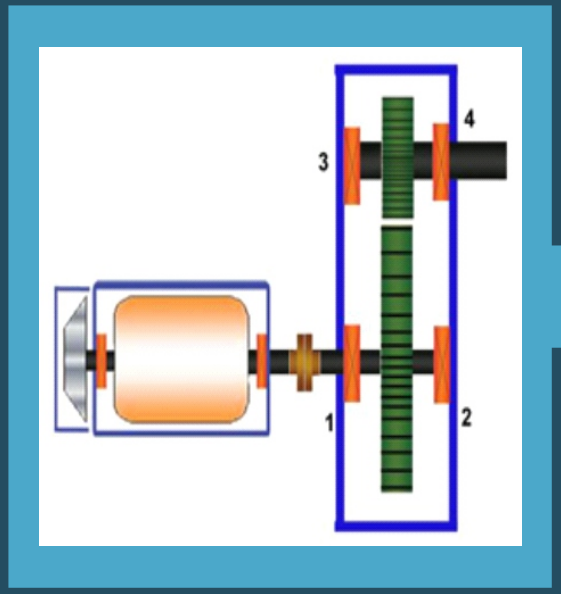


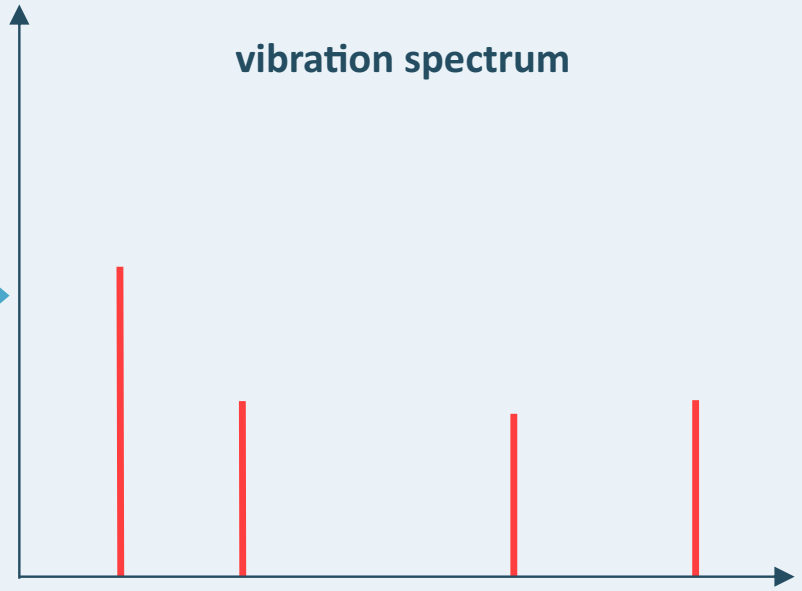
The FFT is used to convert complex vibration pattern in a simple spectrum.

Part 1

Undertesting Vibration spectrum

After the vibration of the real machine is presented in a spectrum, we can analyse the spectrum by looking each of the amplitude peaks and interpreting what may be casing them, are they high or low, are they changing over time etc. In the most cases, problems present themselves in the vibration spectrum at characteristic frequencies which makes diagnostic easier.





Before we go dipper in understanding the characteristic frequencies associated with common problems, we need understand bit more about units in which vibration is measured.

The FFT is used to convert complex vibration pattern in a simple spectrum.