

Vibration analysis basics: velocity, acceleration and spectrum

Data from a vibration sensor cannot be interpreted without knowing which quantity it measures, which frequency range it sees and how it was mounted.

In short

- Vibration can be expressed as displacement, velocity or acceleration, and each is most informative in a different frequency range.
- An FFT splits a time series into frequency components, where an unbalance usually shows at running speed and a misalignment at its multiples.
- Sensor mounting shapes the measurement, and the sampling rate must be at least twice the highest frequency of interest.

01 / Displacement, velocity, acceleration

Vibration is expressed as displacement, velocity or acceleration. Displacement is more informative at low frequencies, velocity at mid frequencies and acceleration at high frequencies. For overall machine condition the RMS of velocity is commonly tracked; for high-frequency events such as bearing defects, acceleration and envelope analysis are used.

02 / From time domain to frequency domain

The fast Fourier transform (FFT) splits a time series into frequency components. An unbalance usually shows at the running frequency, a misalignment at multiples of it. That is a general rule; the interpretation on a particular machine depends on its geometry and speed. If speed varies, normalize the spectrum to the running frequency.

03 / Measurement quality

Mounting position and method change the measurement; a loose mount suppresses high frequencies. The sampling rate must be at least twice the highest frequency of interest, with an anti-alias filter before it. When these conditions are not met, components visible in the spectrum may not be real.

04 / Features for a model

Overall level, RMS, peak, crest factor and energy in selected frequency bands can be model inputs. Store every feature with its load and speed context. Take acceptance limits from the relevant standards and the machine manufacturer; this guide gives no limit value for a specific machine.

Try it

Generate a synthetic sine at a known frequency, lower the sampling rate and observe the false component that appears in the spectrum.

References and online guide

[Open the online guide](#)

[SciPy: FFT tutorial](#)

Proposed pilot steps do not claim field accuracy. Synthetic examples are not measurements from a production site.