Vibration testing

Outlines:

- Measurement Hardwares
  - Sensors
  - Actuators
  - Signal analyzer
- Signal analysis
  - Sampling method
  - Fourier transform, FFT
  - Frequency response function (FRF)
- Testing method
  - Modal testing

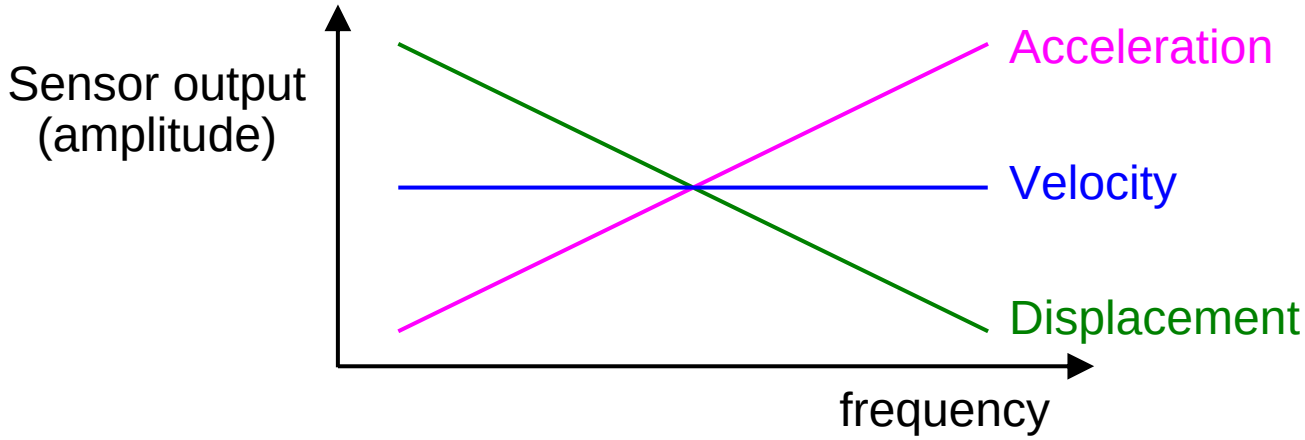
Importance of vibration testing

- To determine the modal parameters: natural frequencies, dampings, and mode shapes
- To verify an analytical model
- To determine dynamic durability: shock test, drop test, operating life test
- To continuously monitor machine condition

Measurement hardware

- Object to be tested for vibration characteristics
- Sensors: convert a mechanical force or motion into an electrical signal
- Actuators: source of excitations
- Signal amplifiers: condition or amplify the signal to match with the input range of the analysis devices
- Signal analyzers: used to determine Fourier transforms of signal and FRF of the structure

What should be measured?

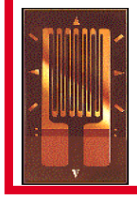


- Displacement is most sensitive at low frequency.
- Acceleration is most sensitive at high frequency.
- Vibration at low frequency should be measured by displacement sensors or velocity sensors, on the other hand acceleration sensor is suitable to use at high frequency.

Sensors (1)

Contact sensors:

- Relatively cheep
- Easy to use
- Mass effect



Strain Gauge

Accelerometers

Non-contact sensors

- No effect on vibration
- Effectively use on the moving part
- Sensor should be isolate from vibration

Displacement sensor:

Laser Doppler Vibrometer

Sensors (2)

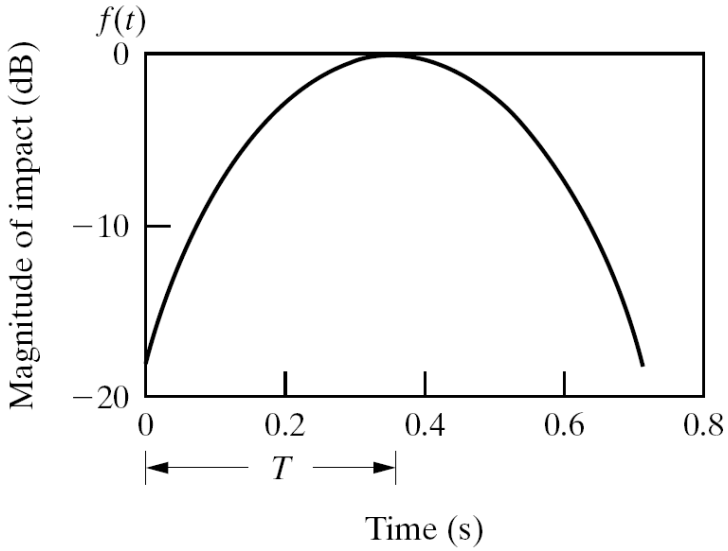
Laser Doppler Vibrometer

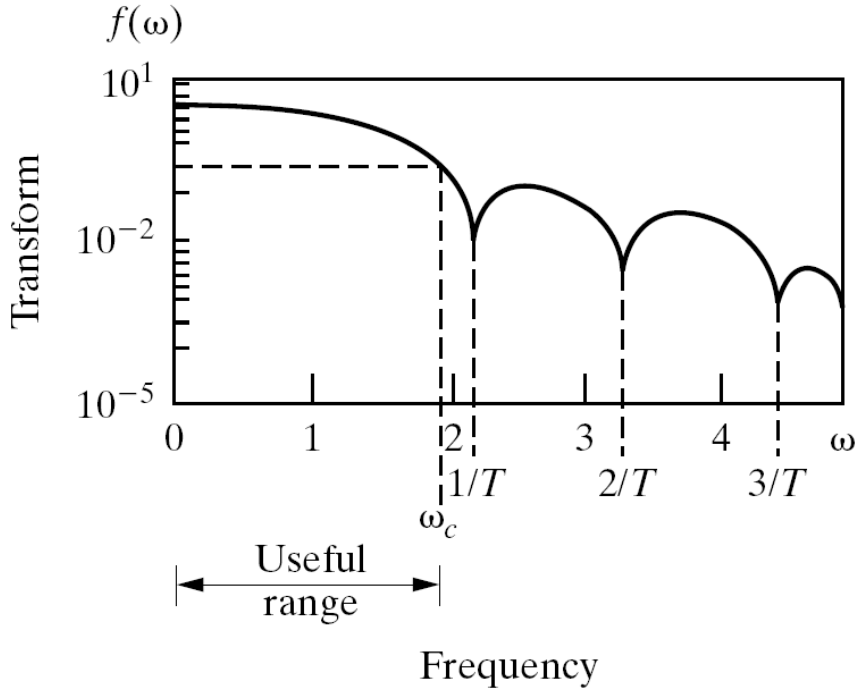
- A **LDV** consists of an optical head that emits laser light and a converter that processes the Doppler frequency of the reflected laser light.
- The voltage signal from the converter is proportional to the velocity of the object.
- Velocity can be convert to acceleration and displacement by using FFT

Actuators (1)

Impulse hammer

provides impulsive force to the tested structure.
(Excite wide frequency range)



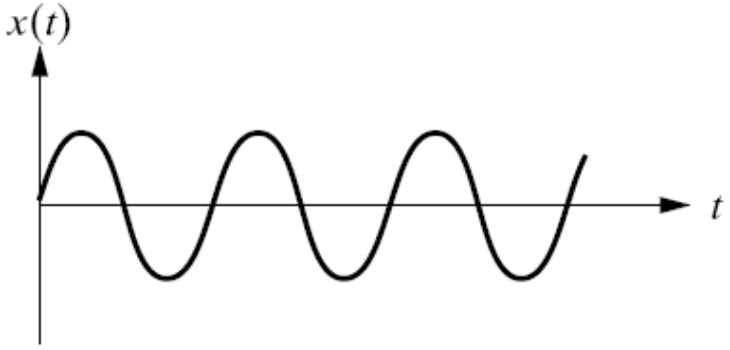


Actuators (2)

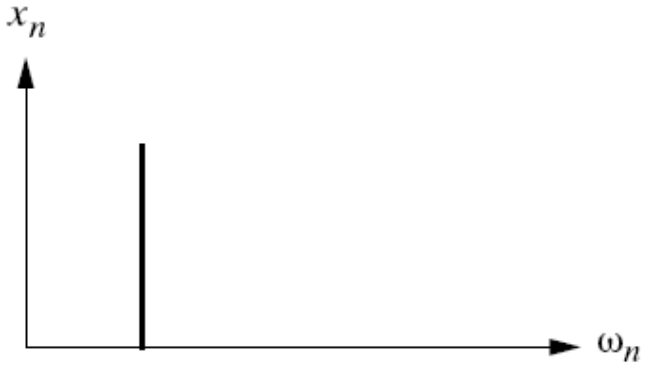
Vibration shaker
(force generator)

provides harmonic, sine-sweep, or random excitations to the structure

- Performance under vibration
- Measure structural fatigue



Time signal



Fourier spectrum

Signal Analyzer

Dynamic signal analyzers

- Waveform recording
- Digital filtering
- Fast Fourier Transform (FFT)
- Determine FRF

Vibration test set up