P5

Q] Describe how vibration signals are acquired in a mechanical system.

→

Vibration signal in a mechanical system are acquired using sensors like accelerometer, velocity, displacement placed at critical points to capture motion.
These sensors converts mechanical vibrations into electrical signal which are then conditioned using amplification & filtering to reduce noise.
The signals are transmitted to a Data Acquisition System (DAQ) for analog-to-digital conversion, ensuring a sufficient sampling rate to meet the Nyquist criterion.
The acquired digital signal are processed and analyzed using software like MATLAB, etc.

• Result & Conclusion

The MATLAB analysis revealed dominant vibration frequencies at some Hertz, indicating potential resonance near the system's operational range. The exp. demonstrated MATLAB effectiveness in processing & analyzing vibration signals. Vibration analysis is crucial for early fault detection

P6

(1) E

(A) H

(B)

(C)

and enhancing system performance & reliability.

P6

(1) Eqn

(A) Hamming Window:

$$\omega(n) = 0.54 - 0.46 \cos\left(\frac{2\pi n}{N-1}\right), \quad 0 \leq n \leq N-1$$

where,

$\omega(n)$: Weight of the window at sample n

N : Total number of samples in the window.

(B) Hanning (Hann) Window:

$$\omega(n) = 0.5\left(1 - \cos\left(\frac{2\pi n}{N-1}\right)\right), \quad 0 \leq n \leq N-1$$

$\omega(n)$ tapers more smoothly to zero at the ends compared to hamming window.

(C) Rectangular Window

$$\omega(n) = 1, \quad 0 \leq n \leq N-1$$

The simplest window where all weights are equal to 1. This corresponds to no tapering, and the signal is cut off abruptly.

- Observation

(1) Hamming Window

(a) Smooth Tapering with non zero end points
(b) Reduces spectral leakage better then Hanning for certain applications.

(2) Hanning Window

(a) Symmetrical & tapers to zero at both ends
(b) Better suited for signal that need smooth transitions at boundaries.

(3) Rectangular Window

(a) Abrupt cut-off at boundaries
(b) Results in more spectral deakage to Hamming & Hanning.

- Results:

(A) Windows Shape:
(a) Hamming has a bell-like shape with smoother transitions than rectangular
(b) Hann fully tapers to zero, making it smoother at the edges

(c) Rectangular is flat across the entire duration.

Conclusions:

MATLAB provides built-in functions for generating these windows, simplifying analysis.

Hanning ideal for app. requires smooth ~~po~~ tapering & minimal spectral leakage.

Hamming useful for general purpose windowing, especially when non-zero end points are acceptable.

Rectangular provides the simplest form but with higher spectral leakage, suitable for signals with no tapering requirements

P-7 →

1 Eqⁿ :

(A) General eqⁿ

$$H(s) = \frac{1}{\sqrt{1 + \left(\frac{\omega}{\omega_c}\right)^{2n}}}$$

ω : freq
ω_c : cutoff freq
n : Filter order

(B) Transfer function.

$$H(s) = \frac{B(s)}{A(s)}$$

$B(s)$: Numerator Polynomial
$A(s)$: Denominator Polynomial designed to ensure Butterworth characteristics.

For an n-order filter

$$A(s) = \sum_{K=1}^{n} \left(s + \omega_c e^{j(2K-1)\pi/2n}\right)$$

P-8 →

Same as P-7

S2 →

Q1] The sampling theorem states that a continuous-time signal can be completely reconstructed from its samples if the sampling freq is at least twice the highest freq component in the signal.

Q2] The Nyquist Criterion that the accurately sample a signal without aliasing, the sampling rate must be at least twice the signal frequency. $f_s \geq 2f_m$. This ensure that the sampled signal retains all the freq. info. of the original signal & allows for precise reconstruction.

Q3] Aliasing can lead to incorrect feedback causing instability, vibrations, oscillations. For ex.: A robotic arm may move erratically if its controller misinterprets aliased position or velocity signals. Proper sampling rate ensures accurate signal reconstruction & precise feedback, enabling smooth & reliable operation of such system.

Q5] Result:

(a) $f_s > 2f_m$: The signal is accurately sampled & reconstructed.

(b) $f_s - 2f_m$: The signal is sampled with minimal distortion but is at the limit of accurate reconstruction.

(c) $f_s < 2f_m$: Aliasing occurs, leading to significant distortion but is at the limits of accurate reconstruction.

P2 →

$f_0 = 500$

$f_s = 8\,KHz = 8000\,Hz$

$$K = 2\cos\left[2\pi \frac{f_0}{f_s}\right]$$

$$= 2\cos\left[2\pi \frac{500}{8000}\right]$$

$$= 2\cos\left[2\pi \frac{5}{80}\right]$$

$$k = 1.999953024$$

Procedure

Code will be there

Write observation & connections (draw)

P3
P4 } Same

There's nothing to be calculated theoretical it will be done through practical exp.

DSP

Practicals as per slip

P1 ⟶

Q1] What's sampling rate?

⟶

The sampling rate also known as sampling frequency, refers to the number of samples taken per second when converting a continuous analog signal into discrete digital signal.
It's measured in Hertz (Hz)

Q2] Draw waveform for I/p & O/p by changing the sampling rate

Q3] ~~(A)~~ Result & Conclusion:

To accurately reconstruct the original ~~rate~~ signal without aliasing, the sampling rate must be at least twice the highest freq in the signal.

P2 —

P3
P4