System Characterization

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Lecture - Outline

- System Transfer Function
- System Frequency response
- Testing Methods
    - Frequency testing
    - Step response
    - Fourier transform methods
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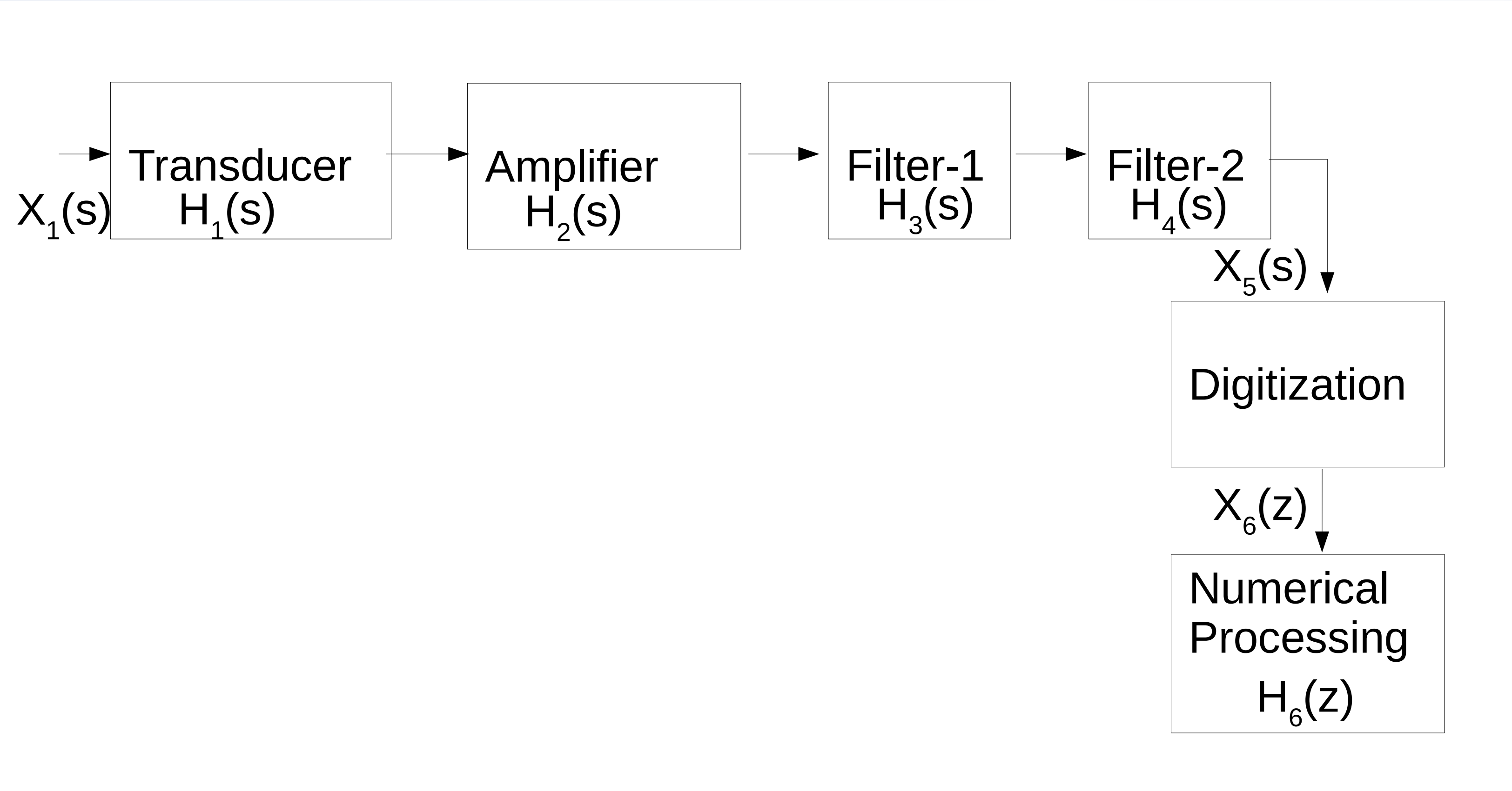
Measurement schematic



Transfer function estimation-I

$$H(j\omega)=\frac{Y(j\omega)}{X(j\omega)}$$

$$|H(j\omega)|=\frac{|Y(j\omega)|}{|X(j\omega)|}$$

$$\measuredangle H(j\omega)=\measuredangle Y(j\omega)-\measuredangle X(j\omega)$$

$$H(j\omega)\approx\Sigma H(j\omega_n)\Big|_{\omega_n=\text{various test frequencies}\ldots}$$

- Sinusoids are Eigen functions of linear systems – function does not change
- When a sinusoid is input, the output is also a sinusoid

Using Sinusoidal testing for systems

- Electronic circuit sub-systems – sinusoidal voltage
  - Amplifiers
  - Filters
- Transducers – use known or calibrated sinsoidal input
  - Force and pressure transducers
  - Audio transducers
- Important consideration
  - Requirement of a known or calibrated input signal that can be controlled to have a sinusoidal time variation

Transfer function estimation – IIa

- White noise as input signal

$$Fourier\ transform\{\text{white noise}\}=1$$

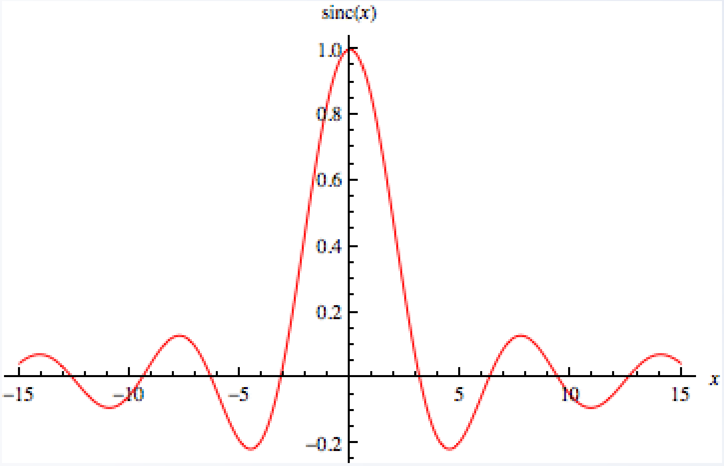
- $$H(j\omega)=\frac{Y(j\omega)}{1}$$

Transfer Function Estimation - IIb

- Simultaneous application of multiple sinusoids
  - Sinc function
  -
- Sinc test function

$$x(t) = 2\,sinc(t) = \frac{2\sin(t)}{t}$$

$$X(j\omega) = 1 \qquad for \quad -1 < \omega < +1$$



Transfer function estimation - III

- Step input signal
  - Easy to apply
- Assume or guess the order of the system
- Step response is the solution of the system differential equation
- First order system:

$$y(t) = k[1 - e^{-t/\tau}]$$

- Second order system

$$y(t) = K[1 + \frac{e^{-\zeta \omega_n t}}{\sqrt{1-\zeta^2}} \sin(\sqrt{1-\zeta^2}\,\omega_n t + \phi)]$$