



AL- MUSTAQBAL UNIVERSITY COLLEGE
DEPARTMENT OF BIOMEDICAL ENGINEERING

Signals and Systems for BME

BME 322

Lecture 4

- Impulse Response -

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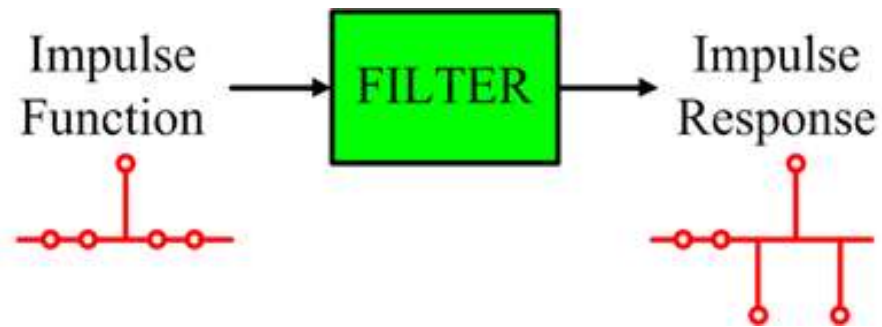
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- An impulse response for a filter is a the response of the filter to an impulse.



- The impulse response for a filter is designated as $h[n]$.
- The impulse response can be calculated from the difference equation by replacing the input $x[n]$ and output of the filter by $\delta[n]$ and $h[n]$ respectively.



- Transfer function, $H(z)$ of digital filters is the ratio of output to input in the z domain.

$$H [z] = \frac{Y [Z]}{X [Z]}$$

Term-by-term transformation of a general difference equation.

$$\sum_{K=0}^N a_k y[n - k] + \sum_{K=0}^M b_k x[n - k]$$

$$H [Z] = \frac{\sum_{K=0}^M b_k Z^{-1}}{\sum_{L=0}^M a_k Z^{-1}}$$

Example



Determine the transfer function of a digital filter described by the difference equation.

$$2y[n] + y[n - 1] + 0.9y[n - 2] = x[n - 1] + x[n - 4]$$

Taking z transforms term by term

$$2Y[z] + z^{-1}Y[z] + 0.9z^{-2}Y[z] = z^{-1}X [z] + z^{-4}X [z]$$

$$H [z] = \frac{z^{-1} + z^{-4}}{2 + z^{-1} + 0.9z^{-2}}$$



- Recursive digital filters are filters which rely on both inputs and past outputs.
- Difference equation for recursive digital filters:

$$y[n] = - \sum_{K=1}^N a_k y[n - k] + \sum_{K=0}^M b_k x[n - k]$$

a_k and b_k are the filter coefficients

Example



A digital filter has the difference equation:

$$y[n] = 0.5 y[n - 1] + x[n]$$

- (a) Determine the type of filter (recursive or Nonrecursive).
- (b) Determine the filter coefficients.

Example (Sol)



- a) Since the output, $y[n]$ depends on both the inputs, $x[n]$ and past output $y[n - 1]$, the digital filter is recursive.
- b) Rewrite the difference equation:

$$y[n] - 0.5 y[n - 1] = x[n]$$

$$a_0 = 1, a_1 = -0.5, \text{ and } b_0 = 1$$



- Nonrecursive digital filters are filters which rely only on inputs and not on past outputs
- Difference equation for nonrecursive digital filters:

$$y[n] = \sum_{K=0}^M b_k x[n - k]$$

b_k are the filter coefficients



A digital filter has the difference equation:

$$y[n] = 0.5x[n] - 0.3x[n-1]$$

- (a) Determine type of filter (recursive or Nonrecursive).
- (b) Determine the filter coefficients.

(a) Since the output, $y[n]$ does not depend on the past output, $y[n-k]$, the digital filter is nonrecursive.

(b) The filter coefficients:

$$a_0 = 1, b_0 = 0.5, \text{ and } b_1 = -0.3$$

