

SEB4233

Biomedical Signal Processing

Digital Filter Design

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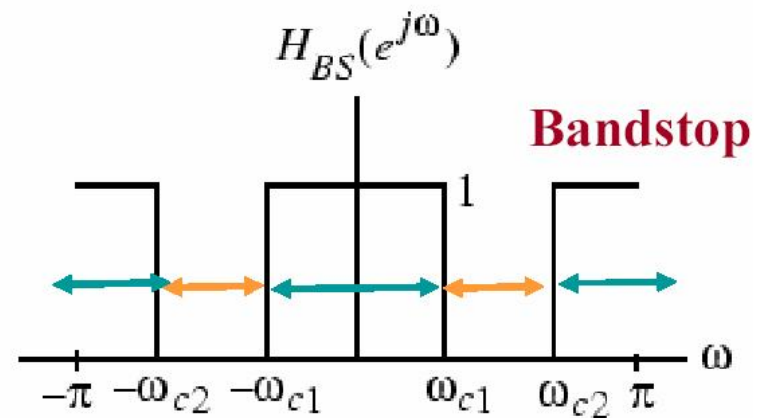
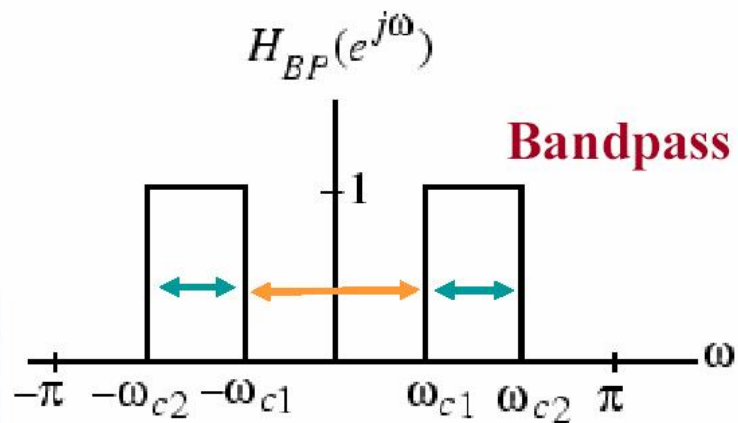
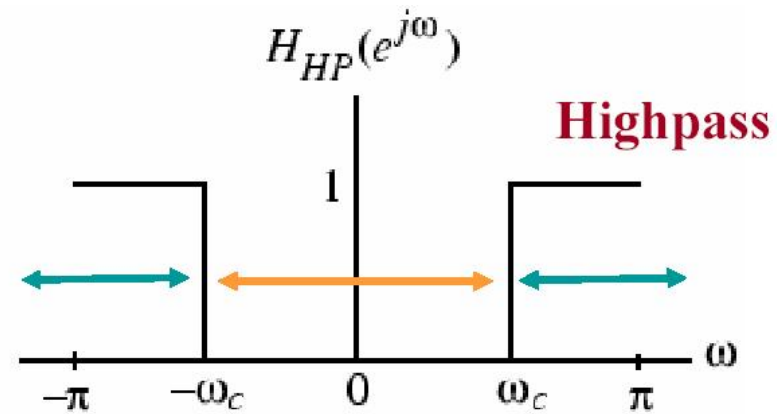
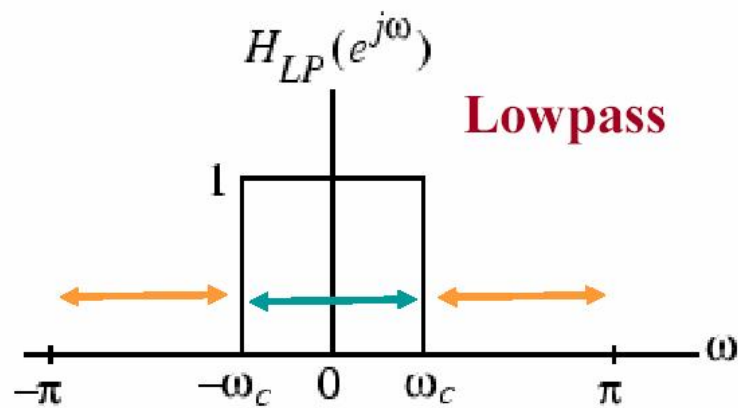
Introduction

- The biomedical signal such as heart sounds, electrocardiogram, EEG are much likely to be interfered by various factors such as muscle and joint movement, breathing sounds, environmental noise as well as power line interference.
- An **IDEAL** digital filter is design to pass signal components of certain frequencies without any distortion.
- **IDEAL** digital filters has a frequency response of value equal to one at these frequencies and frequency response of value equal to zero at all other frequency to totally block the signal component with those frequencies

Introduction

- The range of frequencies where the frequency response takes the value one is called the *passband*
- The range of frequencies where the frequency response takes the value of zero is called the *stopband*
- The transition frequency from a passband to stopband region is called the *cutoff frequency*
- There four general types of digital filter: lowpass filter, highpass filter, bandpass filter and bandstop filter

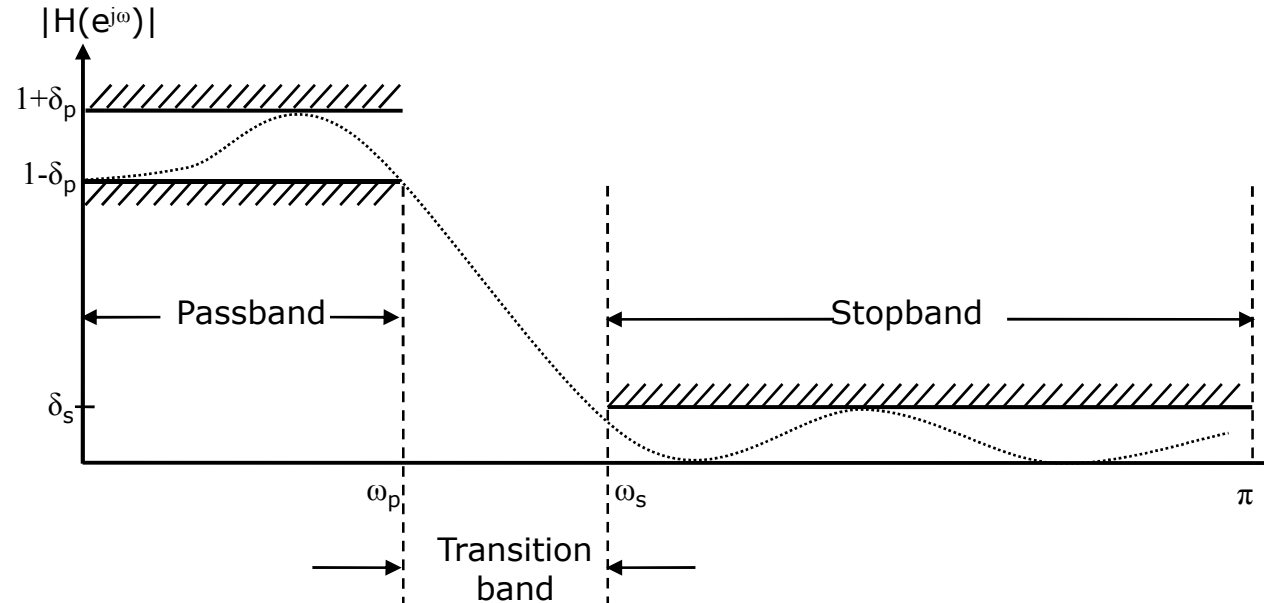
Ideal Filters



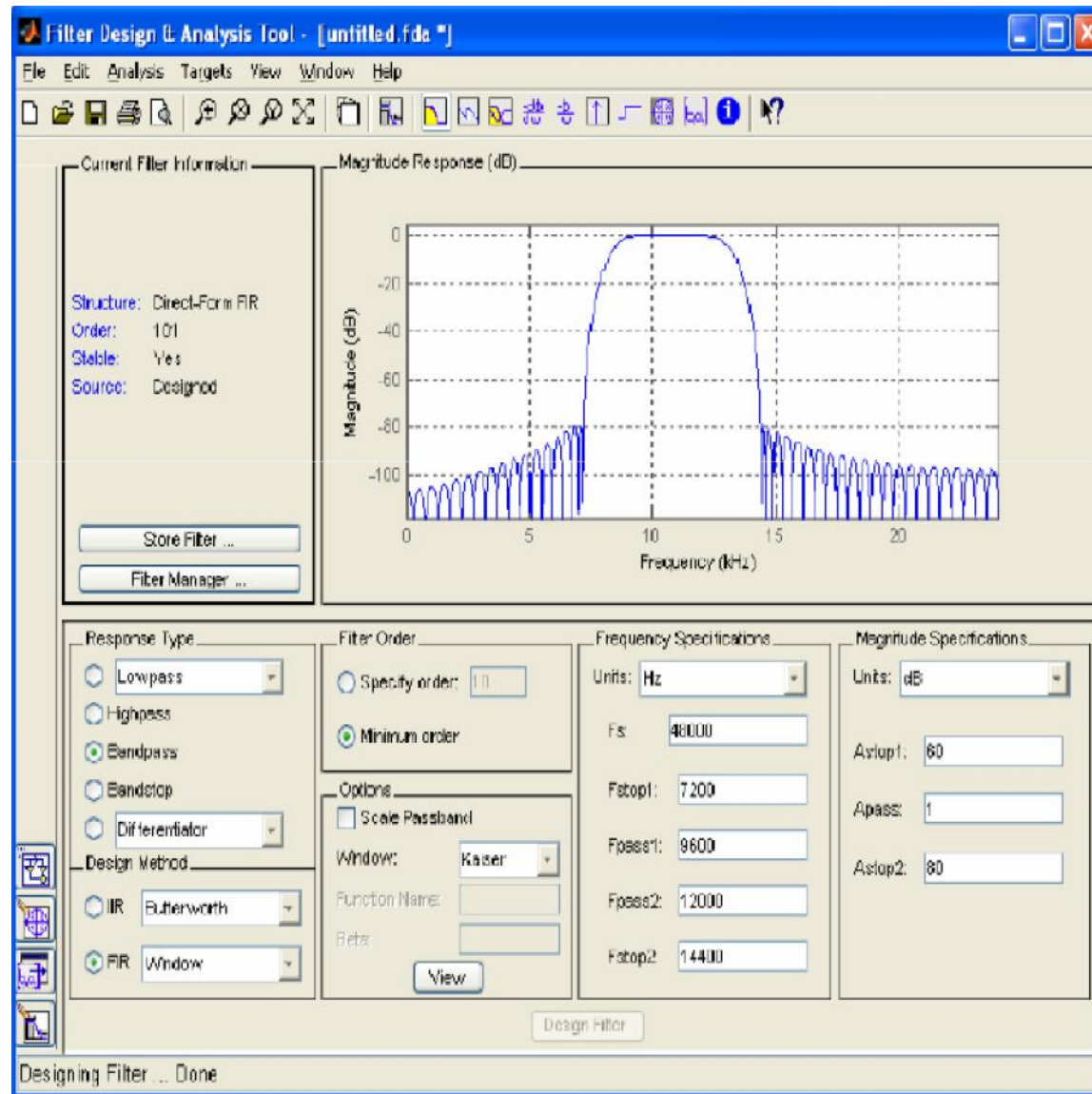
 **Passband**
 **Stopband**

Filter Specifications

- Filter specification includes passband cutoff frequency, ω_p , the stopband cutoff frequency, ω_s , the passband deviation, δ_p , and the stopband deviation, δ_s .
- Figure shows the filter specification for a low-pass filter.



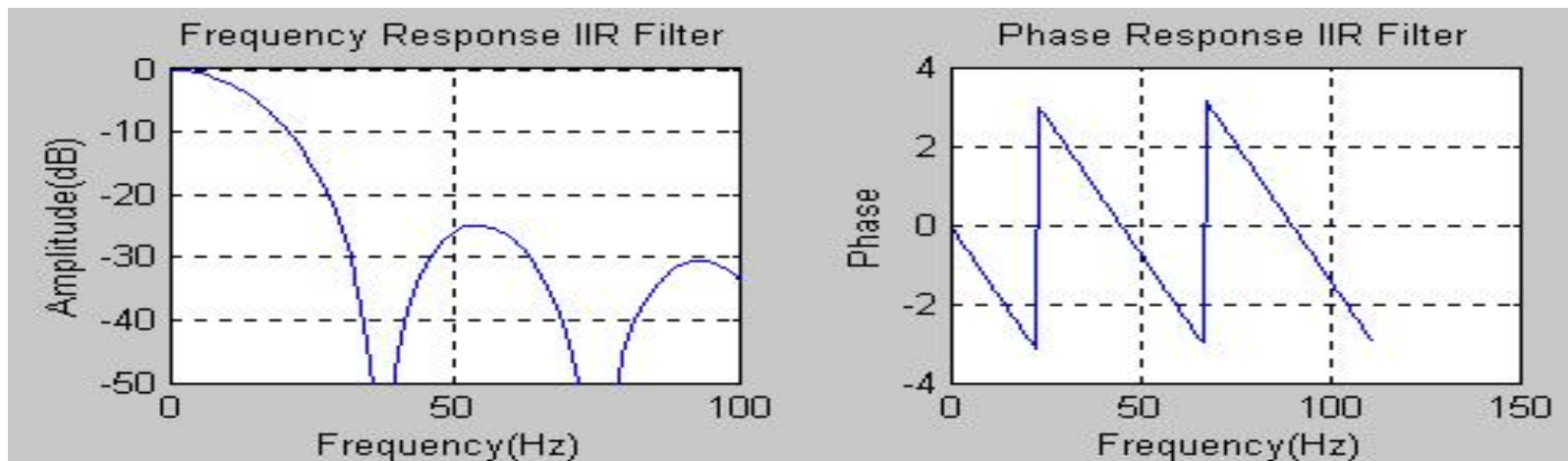
Filter Tool in Matlab



Example: Filter used in ECG

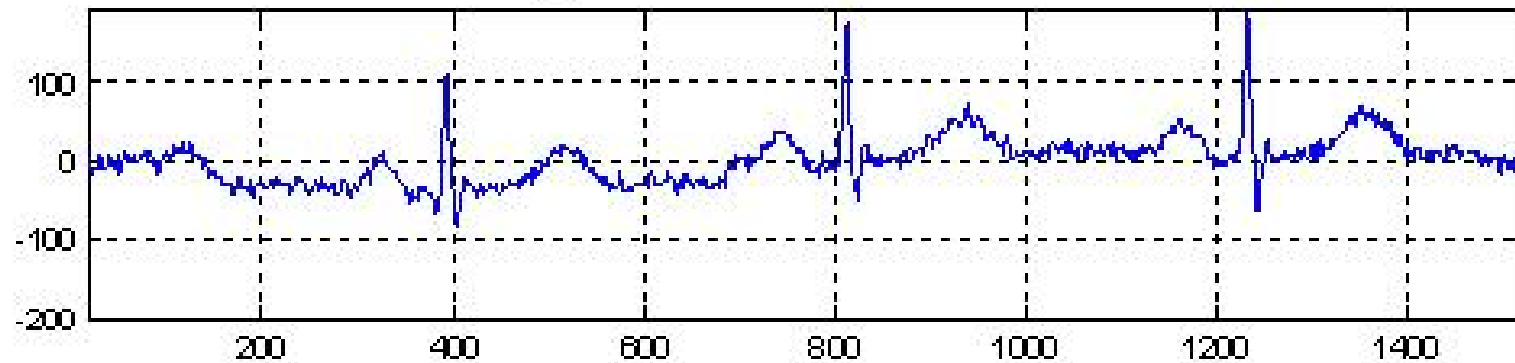
- **Lowpass filter:** Eliminate noise such as the EMG and 50Hz power line noise
- Cutoff frequency=11 Hz
- $y[n]=2y[n-1]-y[n-2]+x[n]-2x[n-6]+x[n-12]$
- Transfer function:

$$H(z) = \frac{(1 - z^{-6})^2}{(1 - z^{-1})^2}$$

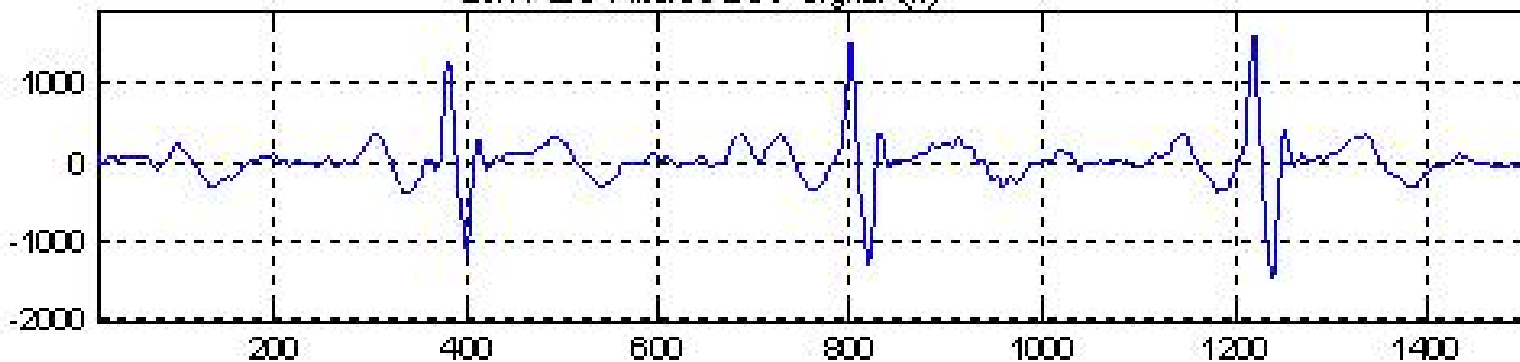


Results of ECG

ECG Signal of Lead 2 for Normal



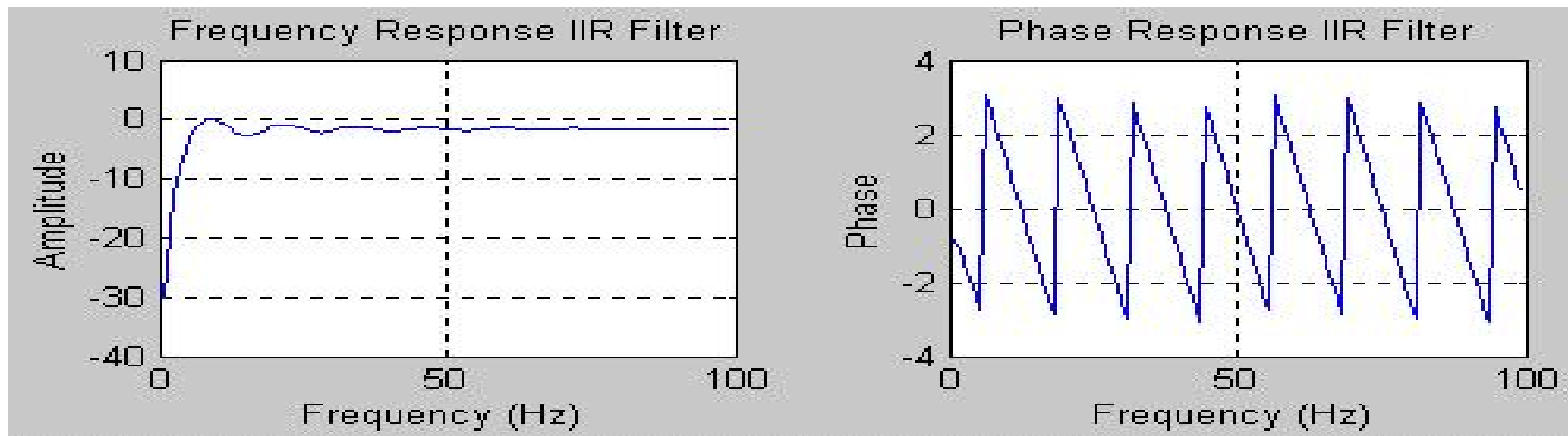
Low Pass Filtered ECG Signal $f(k)$



Example:

Filter used for QRS detection of ECG

- Highpass filter: Eliminate motion artifacts, P wave and T wave.
- Cutoff frequency=5Hz
- $y[n] = y[n-1] - x[n]/32 + x[n-16] - x[n-17] + x[n-32]/32$
- Transfer function:
$$H(z) = \frac{[-1/32 + z^{-16} - z^{-17} + z^{-32}]/32}{1 - z^{-1}}$$



Results of ECG

