Filters

Definition

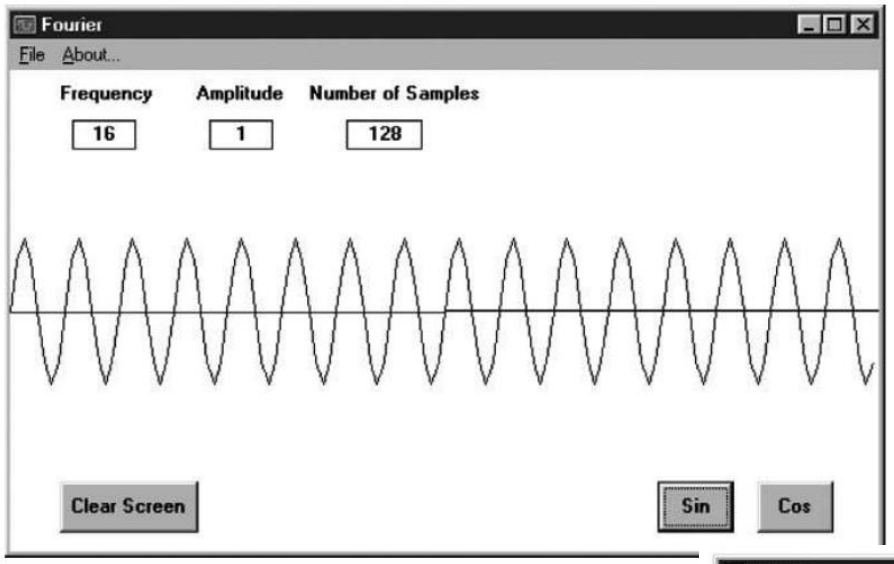
- A filter can be a device, or even a material, that is used either to suppress or minimize signals of certain frequencies.

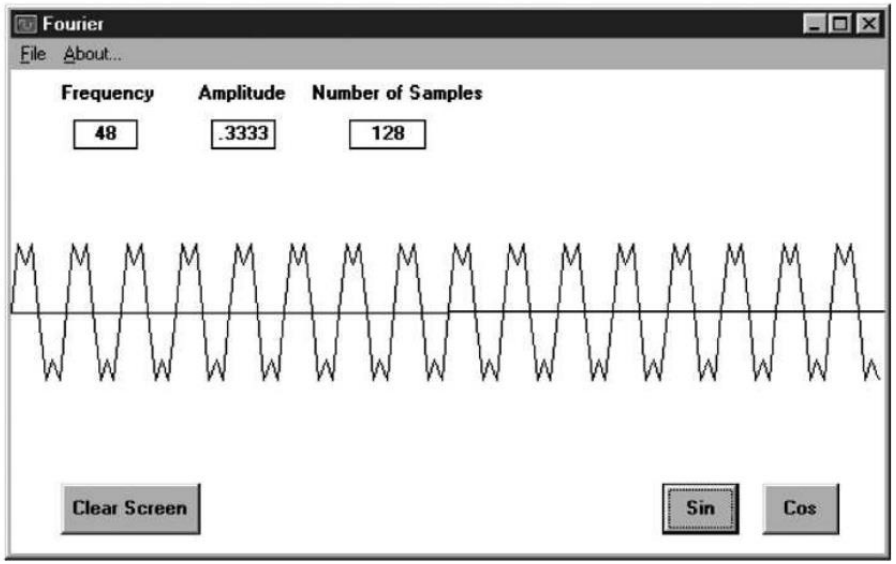
Main function of filters

- Signal separation, is used when a signal has been corrupted with noise or some other type of unwanted interference

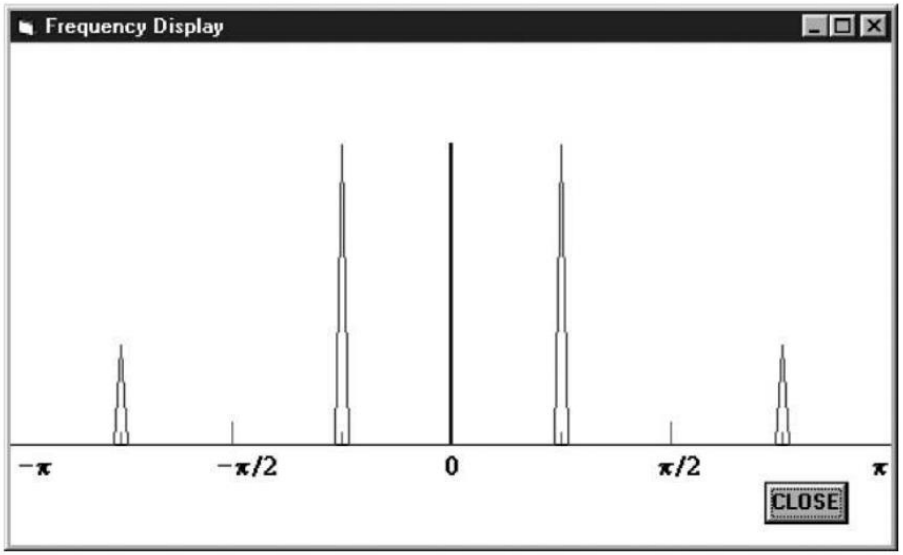
- Signal restoration, is used when a signal has been distorted in some way and needs to be processed to better represent the signal as it actually occurred.

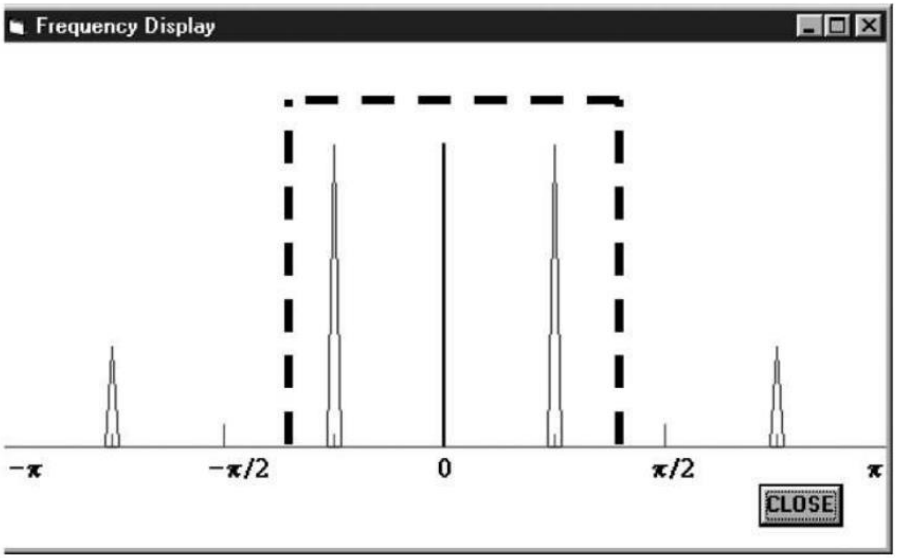
How to remove noise?



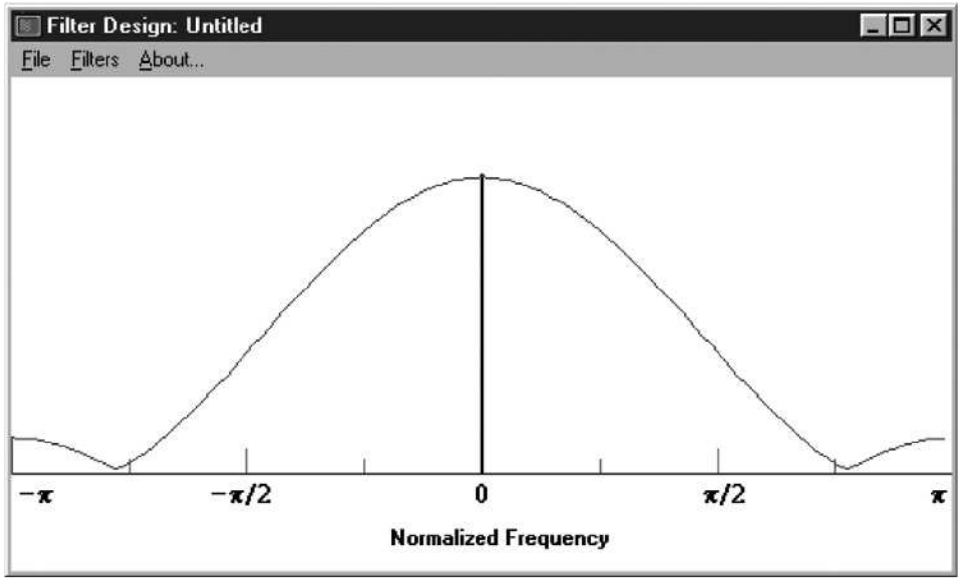


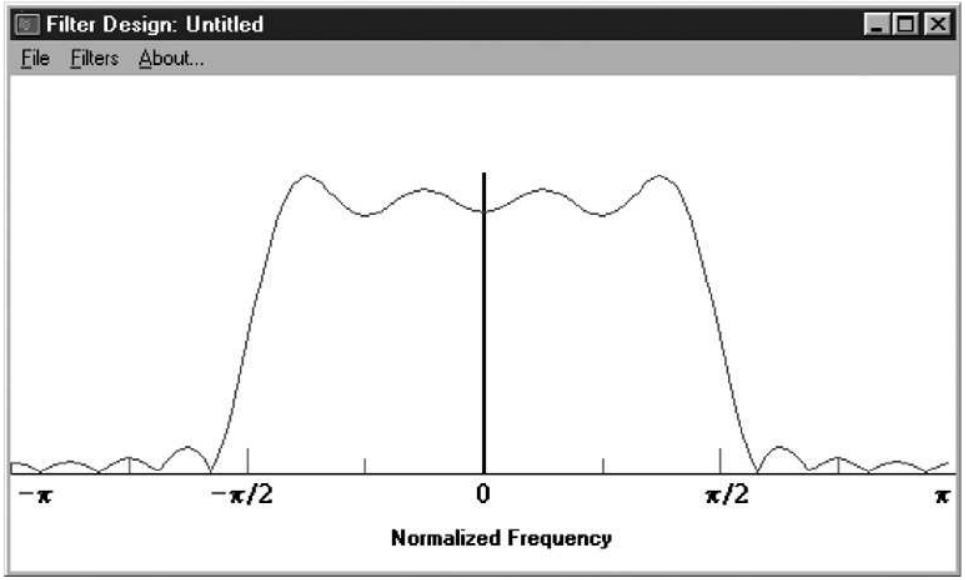
… this way


Frequency Display
−π
−π/2
0
π/2
π
CLOSE


Frequency Display
−π
−π/2
0
π/2
π
CLOSE

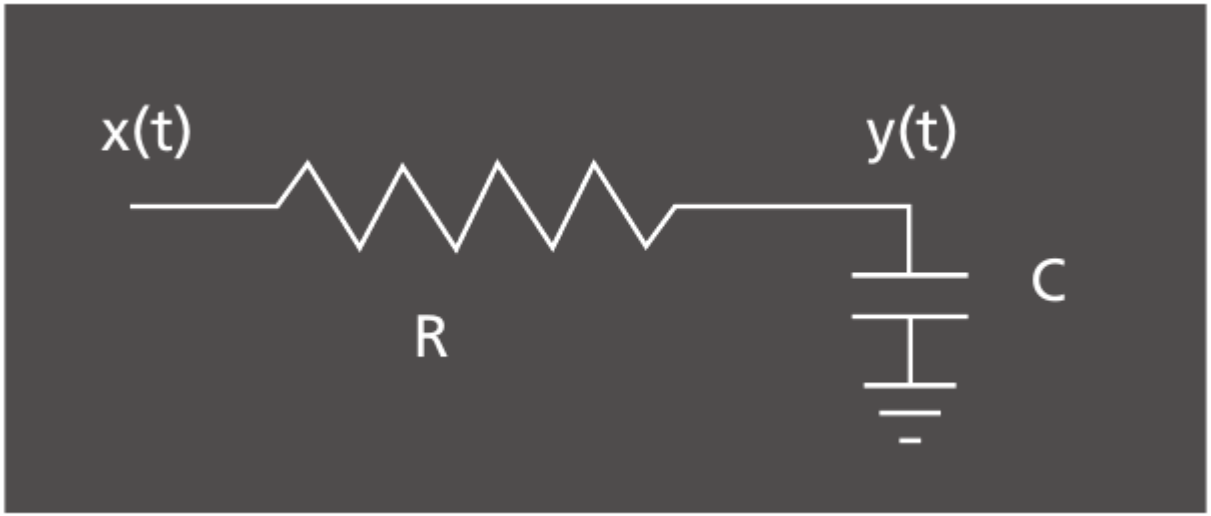
How should be the filter?



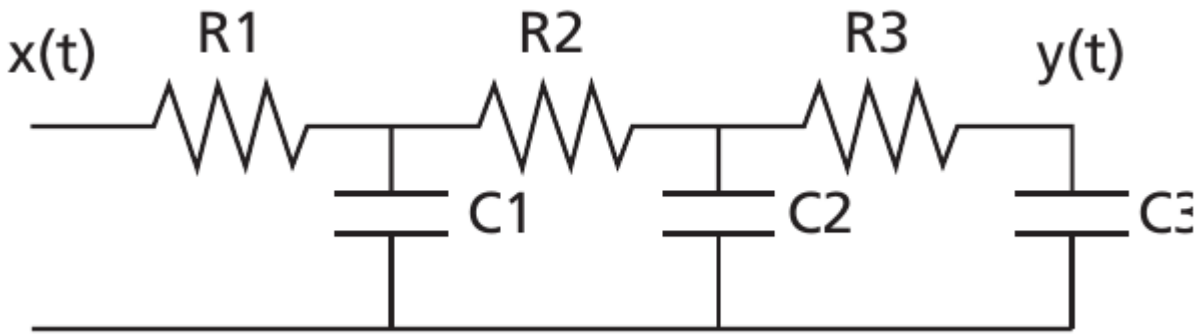


Analog filters

Simple R/C filter (analog)

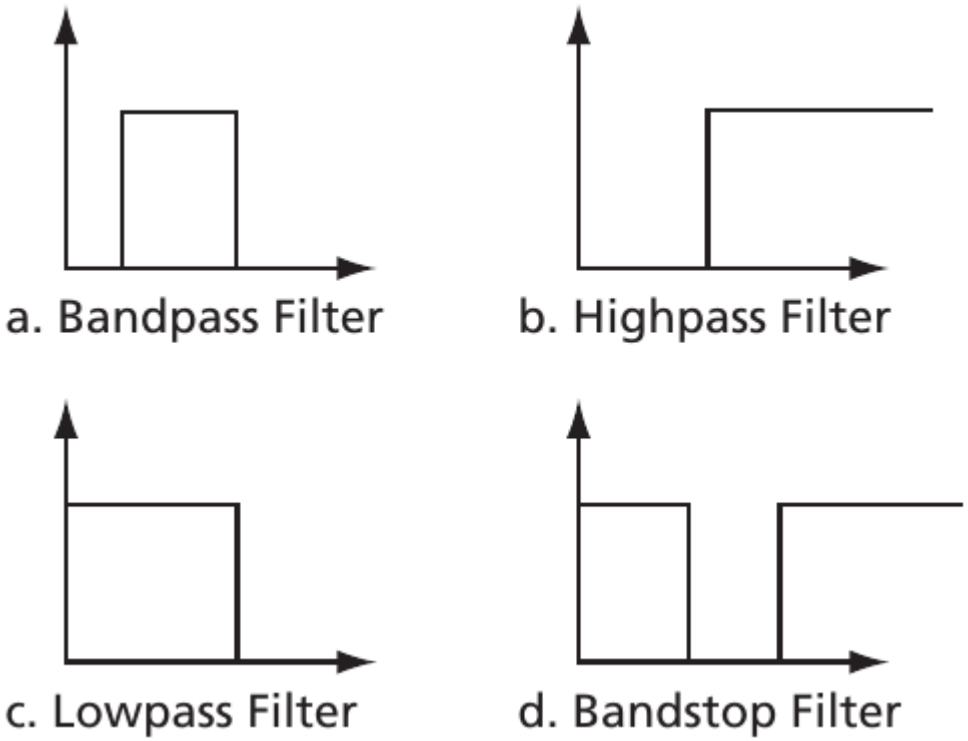


More selective filters



Other types of selective filters

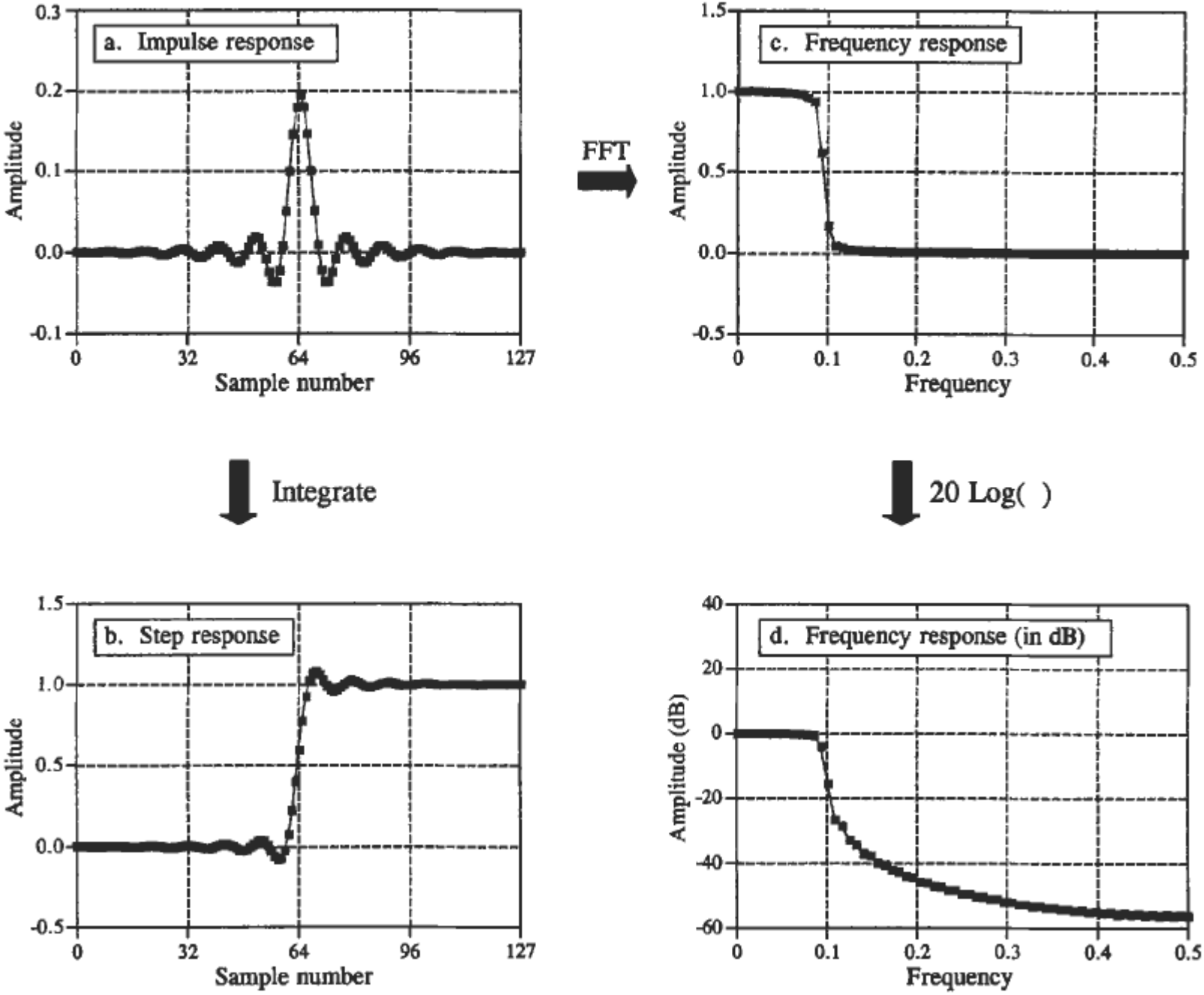
- Bandpass
- High-pass
- Low pass
- Bandstop

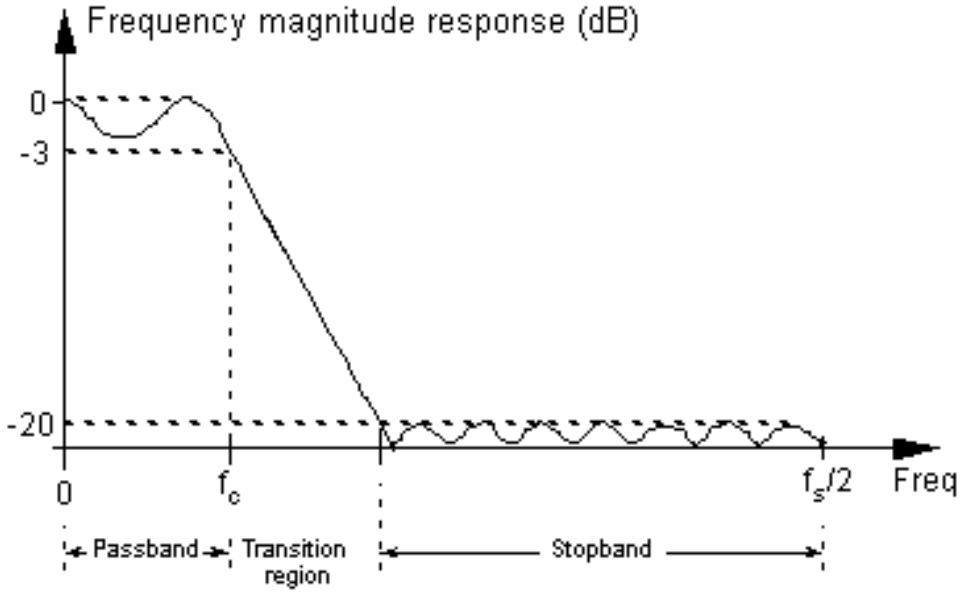


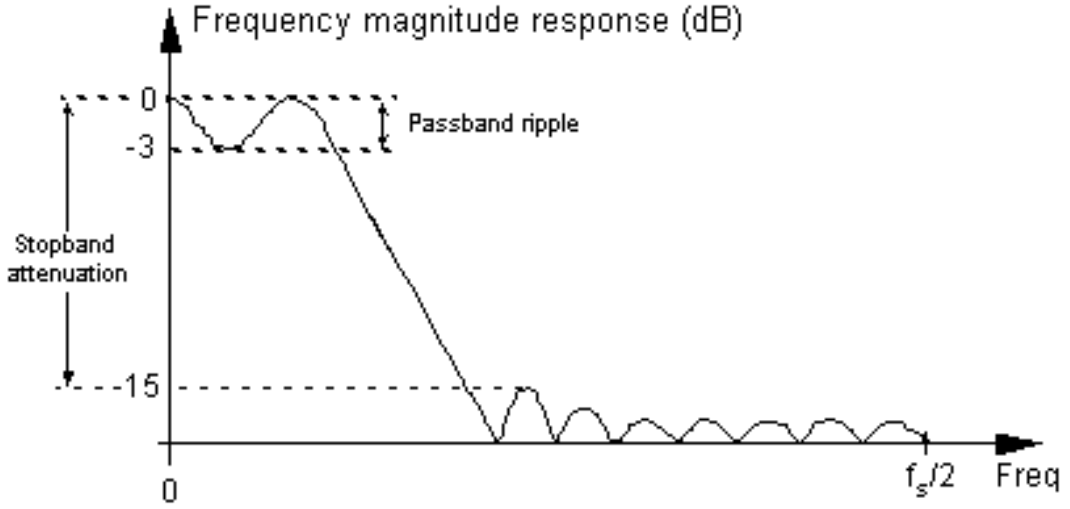
Digital filters

Filter response parameters

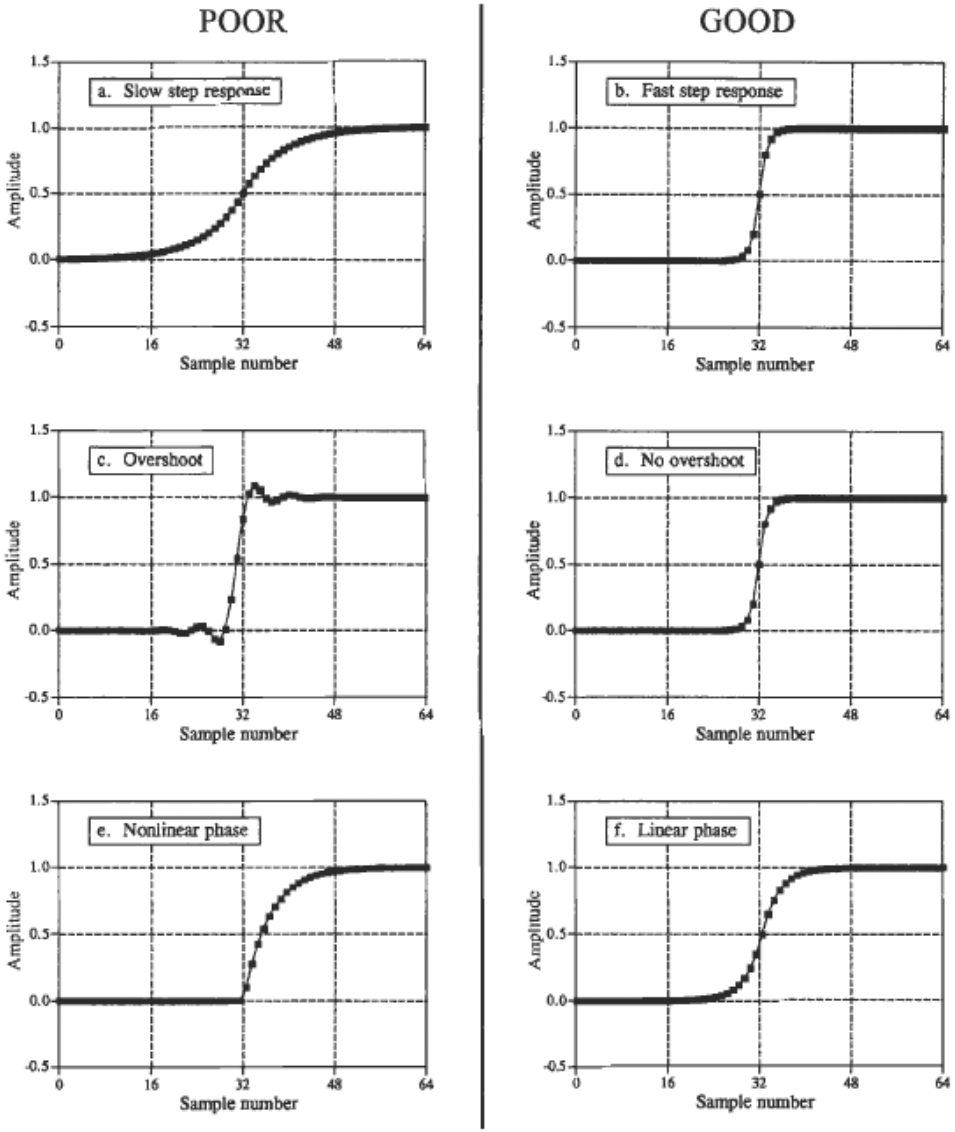
- Impulse response
- Step response
- Frequency response.


a. Impulse response
Amplitude
Sample number
FFT
c. Frequency response
Amplitude
Frequency
Integrate
20 Log( )
b. Step response
Amplitude
Sample number
d. Frequency response (in dB)
Amplitude (dB)
Frequency

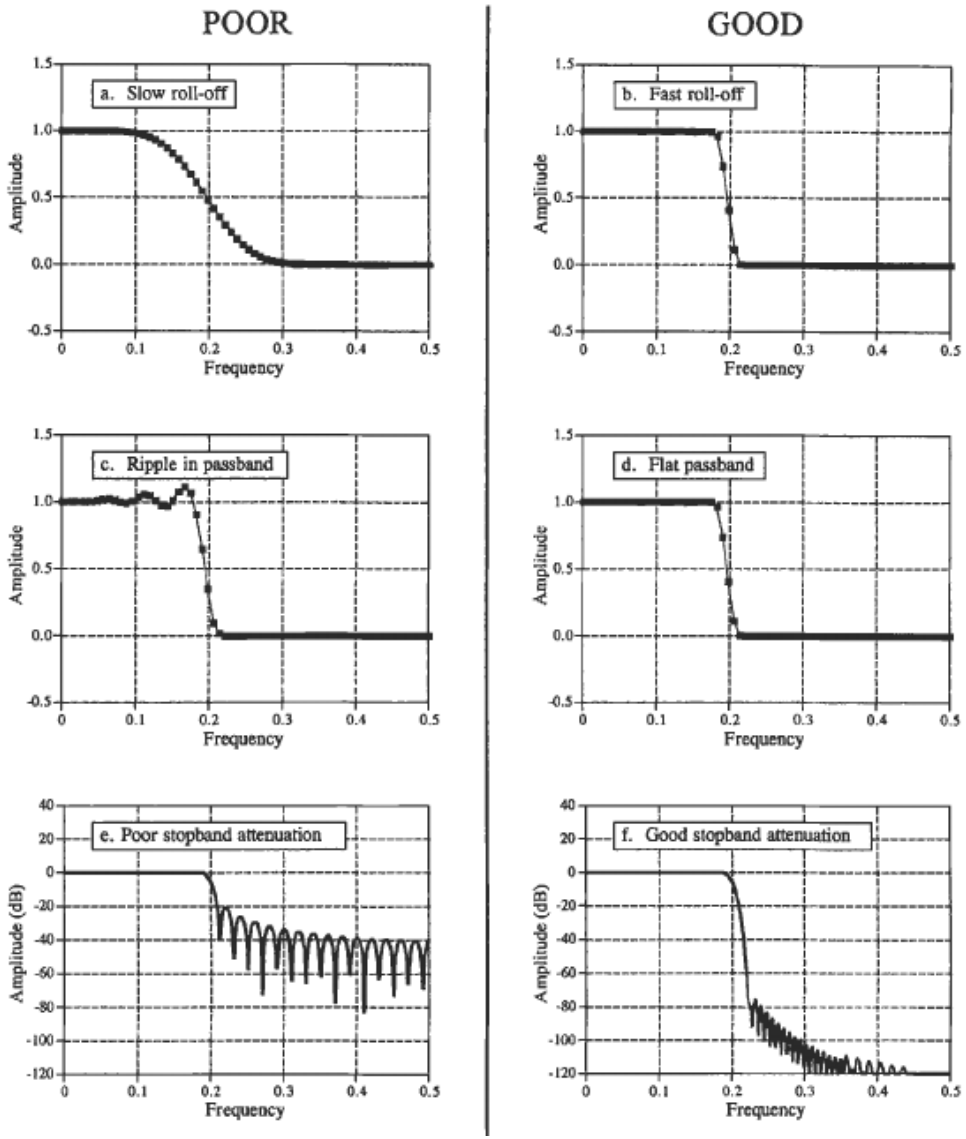

Frequency magnitude response (dB)
0
-3
-20
0
f_c
$f_s/2$
Freq
Passband
Transition region
Stopband


Frequency magnitude response (dB)
0
-3
Passband ripple
Stopband attenuation
-15
0
$f_s/2$
Freq

Time Domain Parameters



Frequency Domain Parameters



Order of a filter

- The order of a digital filter is defined as the number of input used to calculate the current output.

$$a(1)\,y(n) = b(1)x(n) + b(2)x(n-1) + \ldots + b(N_b)x(n-N_b+1) - a(2)\,y(n-1) - \ldots - a(N_a)\,y(n-N_a+1)$$

Types of digital filters

- FIR (Finite Impulse Response)
  - Moving average filter
  - Windowed-Sinc Filters
- IIR (Infinite Impulse Response)
  - Single pole
  - Chebyshev