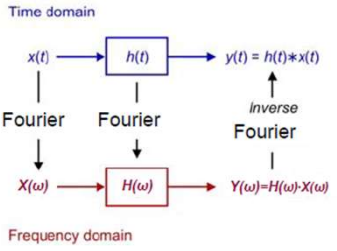
SIGNAL & DATA ANALYSIS IN NEUROSCIENCE 2017
FILTERS

Ayala Matzner

biu.sigproc@gmail.com

Reminder: Time domain vs. frequency domain

- Convolution in the time domain is equivalent to multiplication in the frequency domain.



Filters

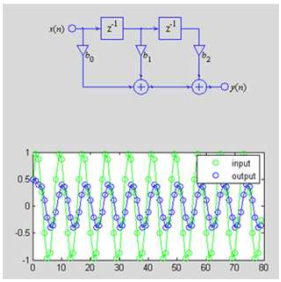
- A device or process that removes from a signal some unwanted component or feature.
- Filter classification:
  - Spectral response: LPF, HPF, BPF, BSF, notch.
  - Digital filters:
    - FIR, IIR
    - Linear phase
- Options/tools for filter construction:
  - Matlab code (firls, fir1, butter,…)
  - Matlab's filter visual tools (FDA tool, wintool)
  - Fvtool – Filter viewing tool

4

Matlab example 1

$$y(n) = b_0 x(n) + b_1 x(n-1) + b_2 x(n-2)$$

```
N = 80; k = 0:(N-1);
b0 = 1;
b1 = -1;
b2 = 1;
B = [b0 b1 b2];
f = 1/8;
x = sin(2*pi*f*k+pi/6);
y = filter(B,1,x);
```

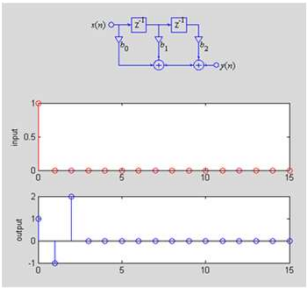


5

Matlab example 2

$$y(n) = b_0 x(n) + b_1 x(n-1) + b_2 x(n-2)$$

```
N = 16; k = 0:(N-1);
b0 = 1;
b1 = -1;
b2 = 2;
B = [b0 b1 b2];
x = (k==0);
y = filter(B,1,x);
```

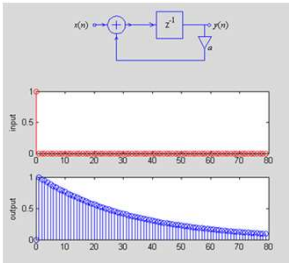


6

Matlab example 3

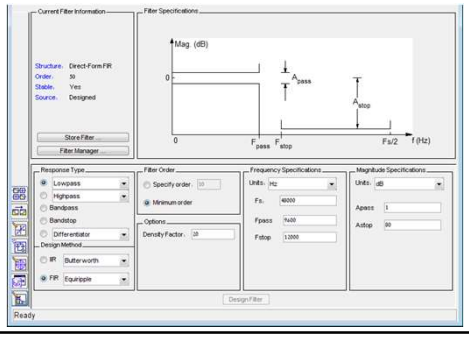
$$y(n) = x(n-1) + ay(n-1)$$

```
N = 80; k = 0:(N-1);
a = 0.97;
B = [0 1];
A = [1 -a];
x = (k==0);
y = filter(B,A,x);
```



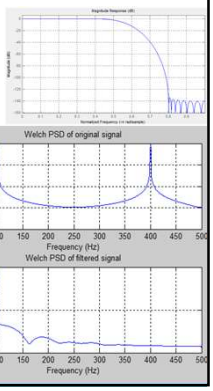
Filter design example - 1

- Matlab: fdatool



Filter design example - 2

```
fs = 1e3;  t = 0:1/fs:10;
x = sin(2*pi*100*t) +sin(2*pi*400*t);
b = firls(32,[0 0.3 0.8 1],[1 1 0 0]);
y = filter(b, 1, x );
%[b,a] = iirnotch(w0, bw, m);
%y = filter(b, a, x );
% optional, filter response
fvtool(b, 1);
%filter signal and show PSD
subplot(2,1,1);
pwelch(x, fs, 0, fs, fs);
subplot(2,1,2);
pwelch(y, fs, 0, fs, fs);
```

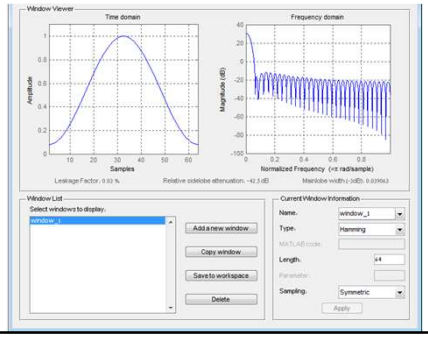


Windows

- Definition
- Types:
  - Spectral amplitude response: LPF, HPF, BPF, BSF, notch
  - Spectral phase response
  - Implementation: FIR / IIR
- Why do we need them?

Filter design using window

- Matlab: wintool



Exam 2006: spectrum+ aliasing +filter

The signal V(t) = X * sin(20*t*2π) + Y * cos(180*t*2π) is sampled at 100 samples/sec. The sampled signal is then filtered using a 40Hz perfect high pass filter. The power spectrum of the sampled signal displays the following:

a. Single peak at 20Hz.
b. Two peaks at 20Hz & 180Hz.
c. Single peak at 180Hz.
d. No peaks in the spectrum.

Exam 2007: Filters +FIR/IIR

Two filters are given by the following equations:

1. y(n) = x(n)-y(n-1)
2. y(n) =x(n)-x(n-1)

a) Draw the impulse response of the two filters.
b) For each filter: is it FIR or IIR? Explain.
c) What is the output of the filters assuming a constant non-zero input? Explain

Exam 2005A: filters

Two filters are given by the following equations:

(1) y(n)=2*y(n-1)+x(n)

(2) y(n)=8*x(n-3)+ 4*x(n-2)+ 2*x(n-1)+x(n)

a) Draw the impulse response of the two filters.

b) For each filter: is it FIR or IIR? Explain.

c) What is the output of the filters assuming a constant non-zero input? Explain.