

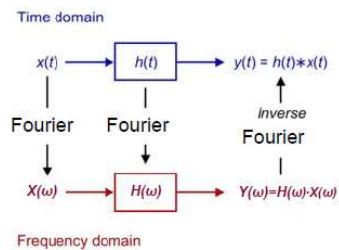
SIGNAL & DATA ANALYSIS IN NEUROSCIENCE 2018 FILTERS

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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

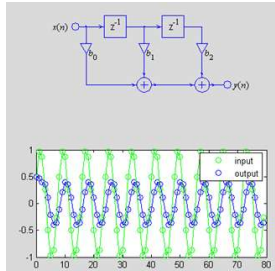
Matlab example 1

$$y(n) = b_0x(n) + b_1x(n-1) + b_2x(n-2)$$

```

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

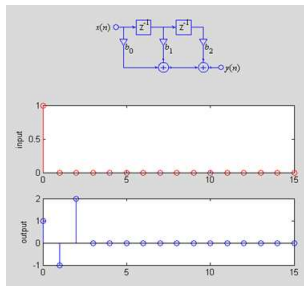
Matlab example 2

$$y(n) = b_0x(n) + b_1x(n-1) + b_2x(n-2)$$

```

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

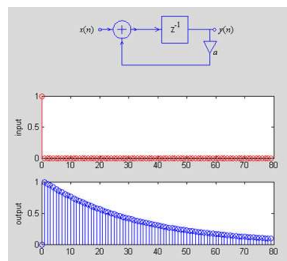
Matlab example 3

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

```

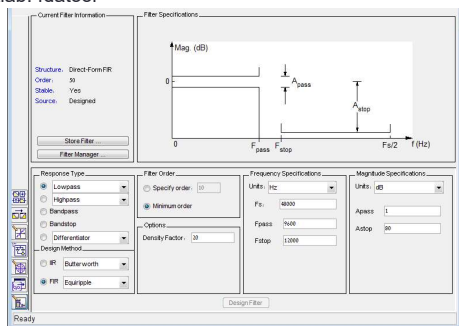
N = 80; k = 0:(N-1);
a = 0.97;
B = [0 1];
A = [1 -a];
x = (k==0);
y = filter(B,A,x);

```



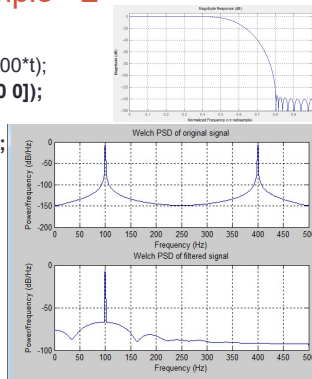
Filter design example - 1

• 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);
```

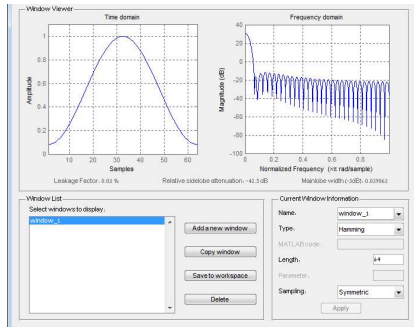


Windows

- 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 $V(t) = X \sin(20\pi t) + Y \cos(180\pi t)$ 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:

- Single peak at 20Hz.
- Two peaks at 20Hz & 180Hz.
- Single peak at 180Hz.
- No peaks in the spectrum.

Exam 2007: Filters +FIR/IIR

Two filters are given by the following equations:

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

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