

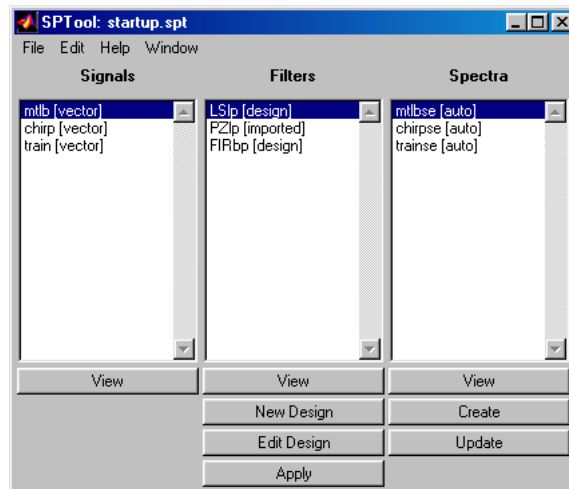
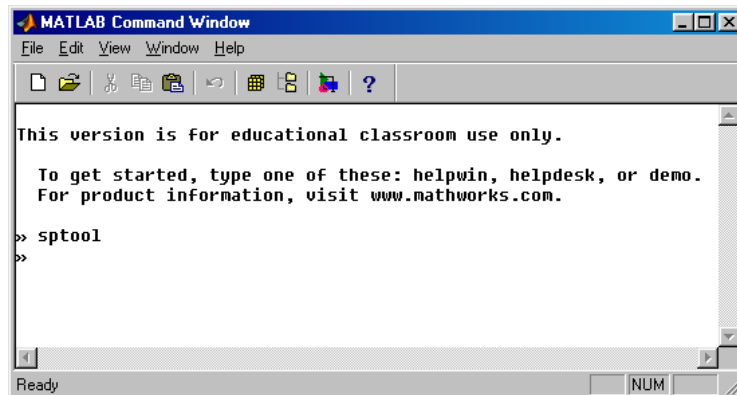
## Matlab/Simulink Exercise: Digital Filter Design

A) Design a digital FIR lowpass filter with the following specifications:

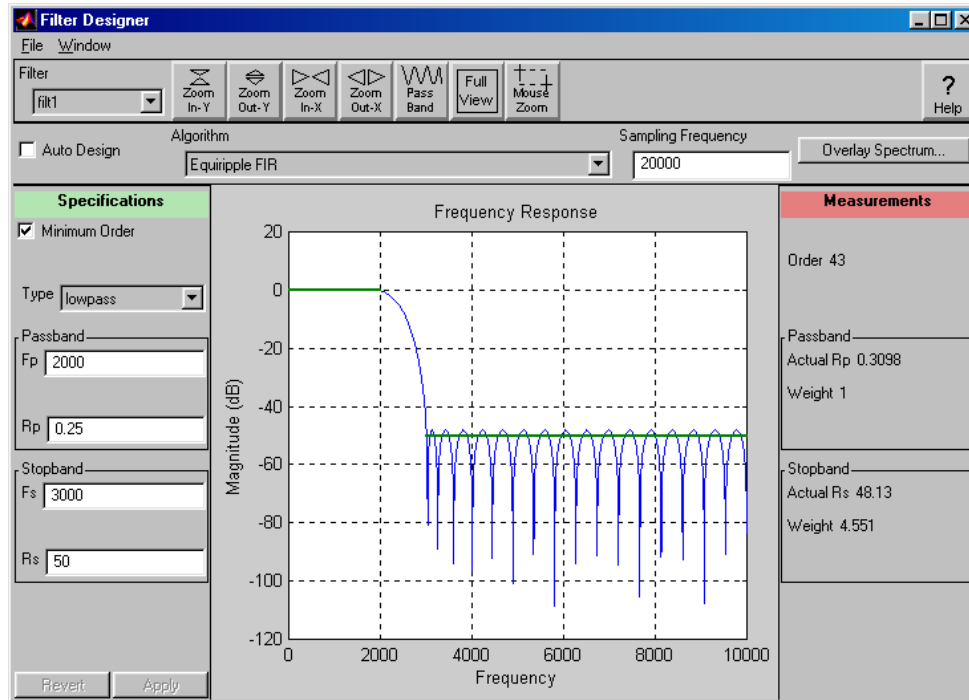
Passband cutoff frequency:  $f_p = 2$  kHz  
Stopband cutoff frequency:  $f_s = 3$  kHz  
Passband Ripple:  $R_p = 0.25$  dB  
Stopband attenuation:  $R_s = 0.25$  dB  
Sampling frequency:  $f_s = 20$  kHz

### Solution

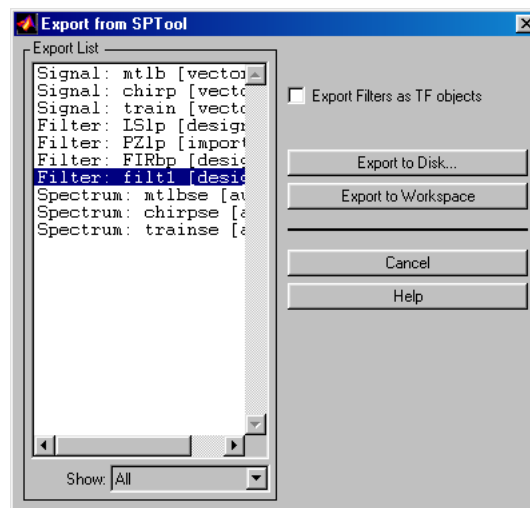
1) Start `sptool` and select New Design.



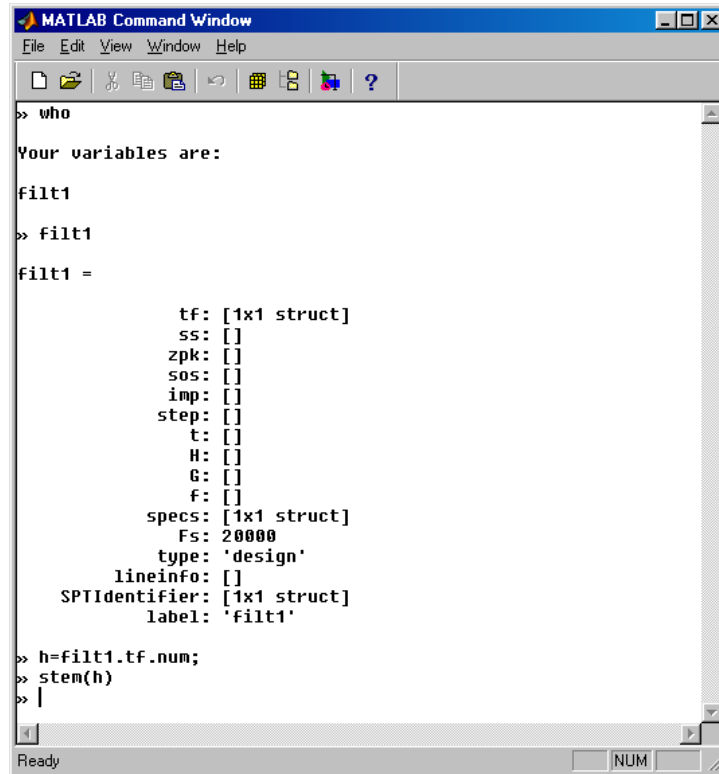
3) Insert the filter specifications and complete the filter design by pressing Apply.



4) To access the filter coefficients of the designed filter go to the SPTool window and select Export from the File Menu. Next highlight the designed filter and use the Export to Workspace button to make the filter parameters accessible on the workspace.



The filter parameters are stored under the variable name `filt1` in an object-oriented manner. You can access the filter coefficients as illustrated below.

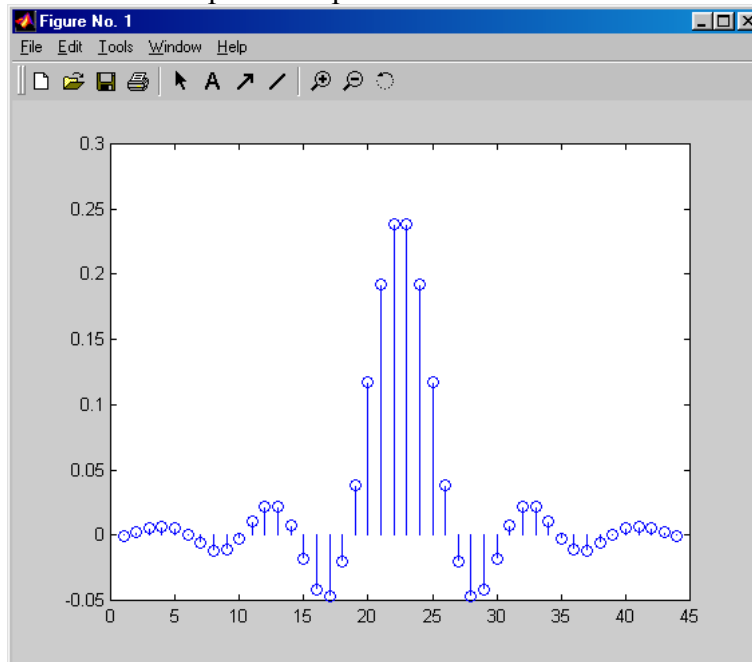


```

MATLAB Command Window
File Edit View Window Help
>> who
Your variables are:
filt1
>> filt1
filt1 =
    tf: [1x1 struct]
    ss: []
    zpk: []
    sos: []
    imp: []
    step: []
    t: []
    H: []
    G: []
    f: []
    specs: [1x1 struct]
    Fs: 20000
    type: 'design'
    lineinfo: []
    SPTIdentifier: [1x1 struct]
    label: 'filt1'
>> h=filt1.tf.num;
>> stem(h)
>> |
Ready

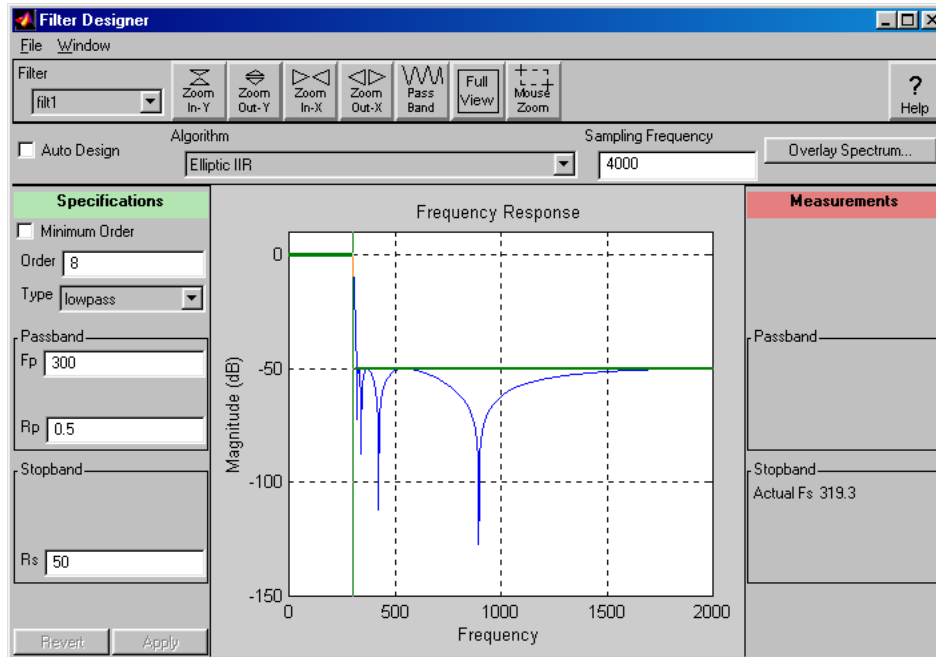
```

FIR Impulse Response / Filter coefficients



B) Design a digital IIR lowpass filter with the following specifications:

Filter Order:  $8^{\text{th}}$   
 Filter type: elliptic IIR  
 Passband cutoff frequency:  $f_p = 300$  Hz  
 Passband Ripple:  $R_p = 0.5$  dB  
 Stopband attenuation:  $R_s = 50$  dB  
 Sampling frequency:  $f_s = 4$  kHz

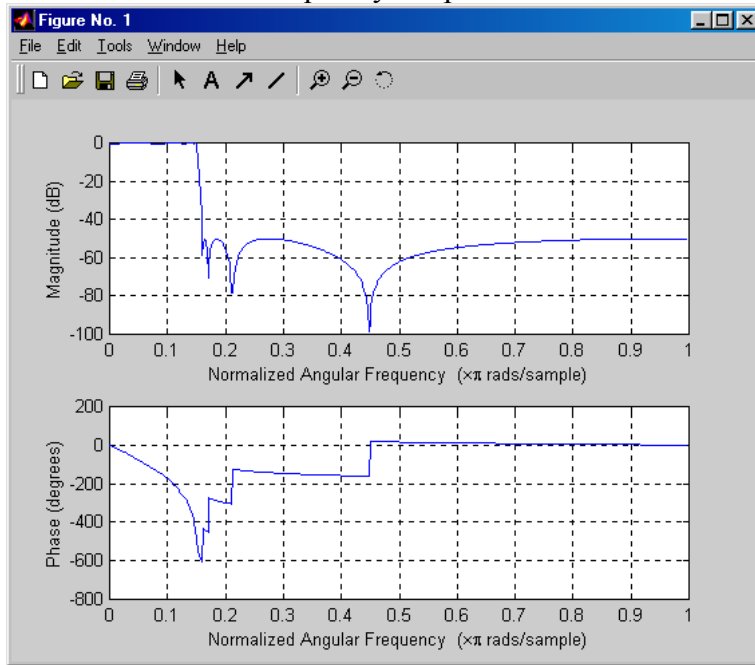


2) Export the filter parameters in the workspace as in the previous example. For IIR filters both the numerator and the denominator are required to compute the frequency and impulse response of the IIR filter.

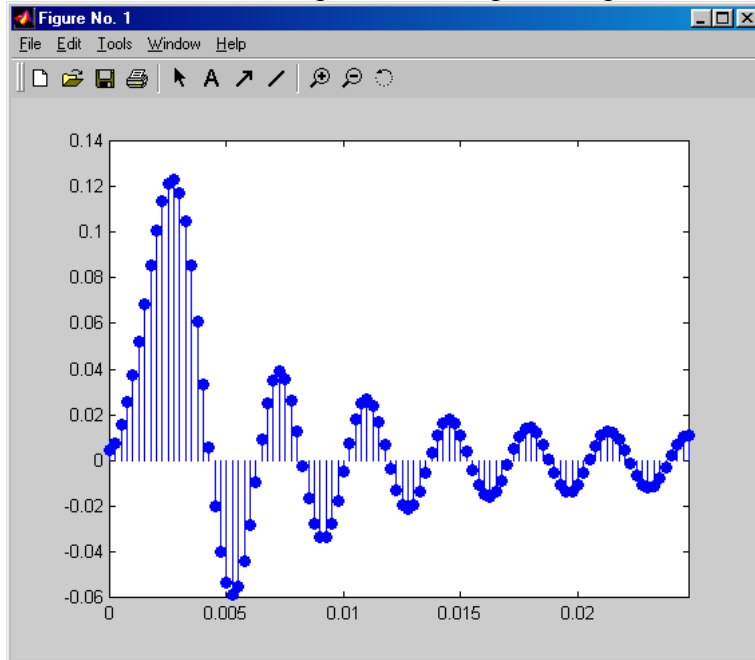
```

MATLAB Command Window
File Edit View Window Help
>> A=filt1.tf.den;
>> B=filt1.tf.num;
>> freqz(B,A)
>> impz(B,A,100,4000);
>> |
Ready NUM
  
```

### Frequency Response



### The first 100 samples of the impulse response



Repeat the Design for the following digital Filters:

C) Design a digital FIR bandpass filter with the following specifications:

Passband:	8-12 kHz
Stopband Ripple:	$R_s = 0.001$
Passband Ripple:	$R_p = 0.001$
Transition width:	3kHz
Sampling frequency:	$f_s = 44.1$ kHz

Obtain the filter coefficients and frequency response for the above FIR using the Blackman window method.

D) Design a digital IIR bandpass filter with Butterworth characteristics meeting the following specifications:

Passband:	8-10 kHz
Sampling frequency:	$f_s = 44.1$ kHz
Filter Order:	4
Filter Characteristics:	Butterworth

Obtain the filter coefficients and frequency response for the above FIR using the Blackman window method.