Experiment No 10

BECS 32461

Digital Signal Processing Exercise

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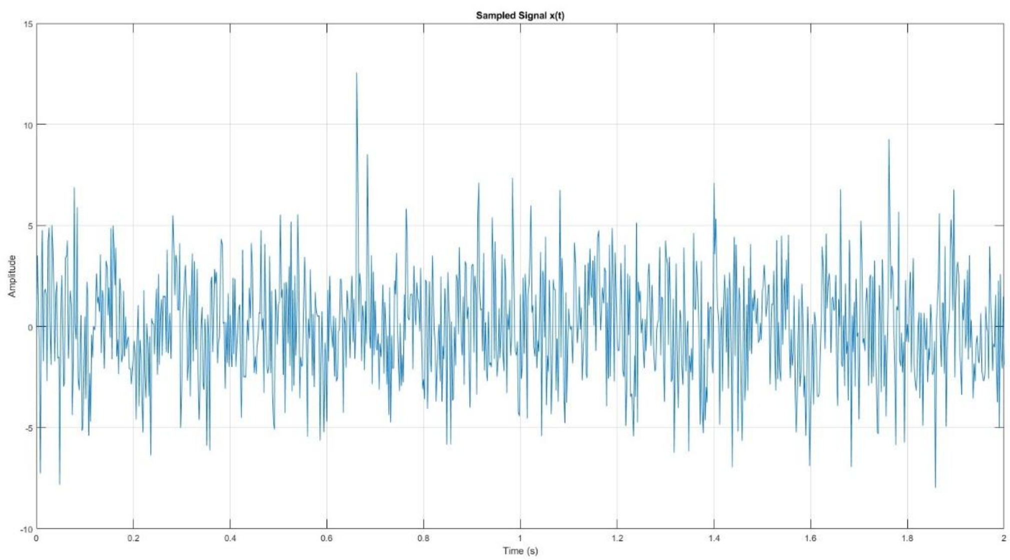
Q01.a

```
fs = 500;
t = 0:1/fs:2;
noise = 2.5*randn(size(t));
x = sin(16*pi*t) + 0.7*sin(100*pi*t) + 0.5*sin(200*pi*t) + noise;

plot(t, x);
title('Sampled Signal x(t)');
xlabel('Time (s)');
ylabel('Amplitude');
grid on;
```

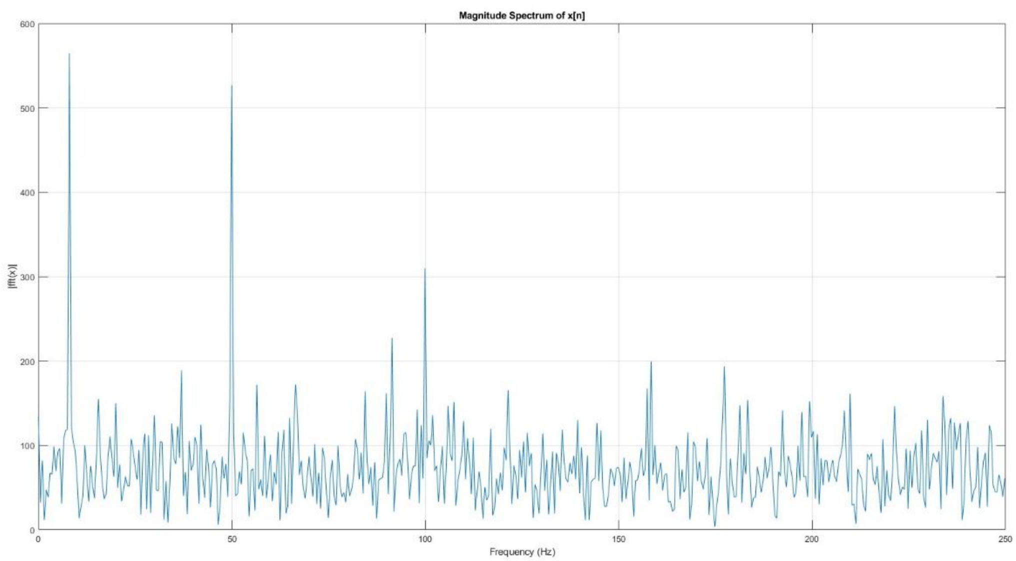


Q01.b

Yes. Choosen sampling frequency is satisfying Nyquist criteria for $x(t) = \sin(16\pi t) + 0.7\sin(100\pi t) + 0.5\sin(200\pi t) + n(t)$ because Nyquist rate of this signal is 200Hz and 500Hz(fs) is greater than that.

Q02.a

```
fs = 500;
t = 0:1/fs:2;
noise = 2.5*randn(size(t));
x = sin(16*pi*t) + 0.7*sin(100*pi*t) + 0.5*sin(200*pi*t) + noise;

N = length(x);
Y = fft(x);

f = (0:N-1)*(fs/N);

plot(f,abs(Y));
title('Magnitude Spectrum of x[n]');
xlabel('Frequency (Hz)');
ylabel('|fft(x)|');
xlim([0 250]);
grid on;
```

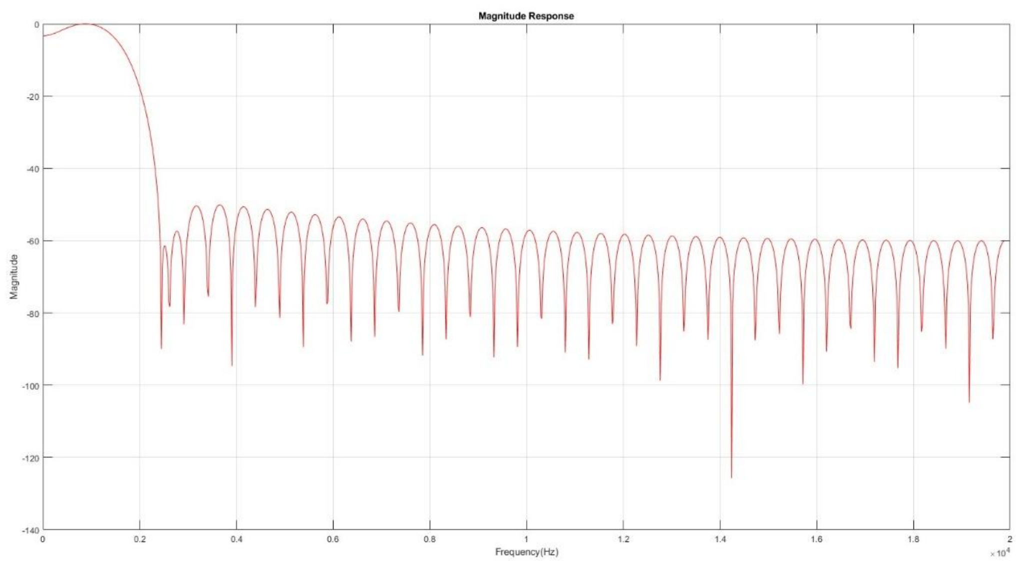


Q02.b

8Hz, 50Hz, 100Hz likely belongs to the true cosmic wave.

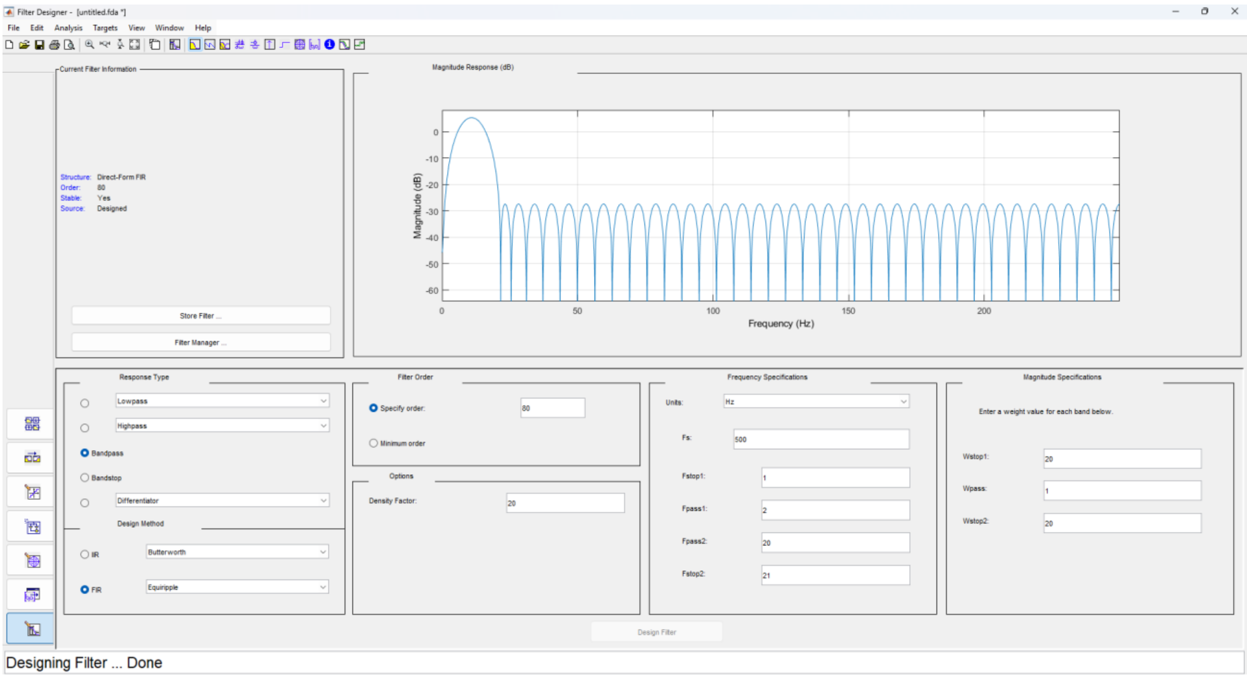
Q03.

```
N = 80;
fp = [0.008 0.08];
fs = 500;

x_fir = fir1(N, fp, 'bandpass', hamming(N+1));

figure;
[h_ham, w_ham] = freqz(x_fir, 1, 1024, fs);
plot(w_ham*fs/(2*pi), 20*log10(abs(h_ham)), 'r-'); hold on;
xlabel('Frequency(Hz)');
ylabel('Magnitude');
title('Magnitude Response');
grid on;
```

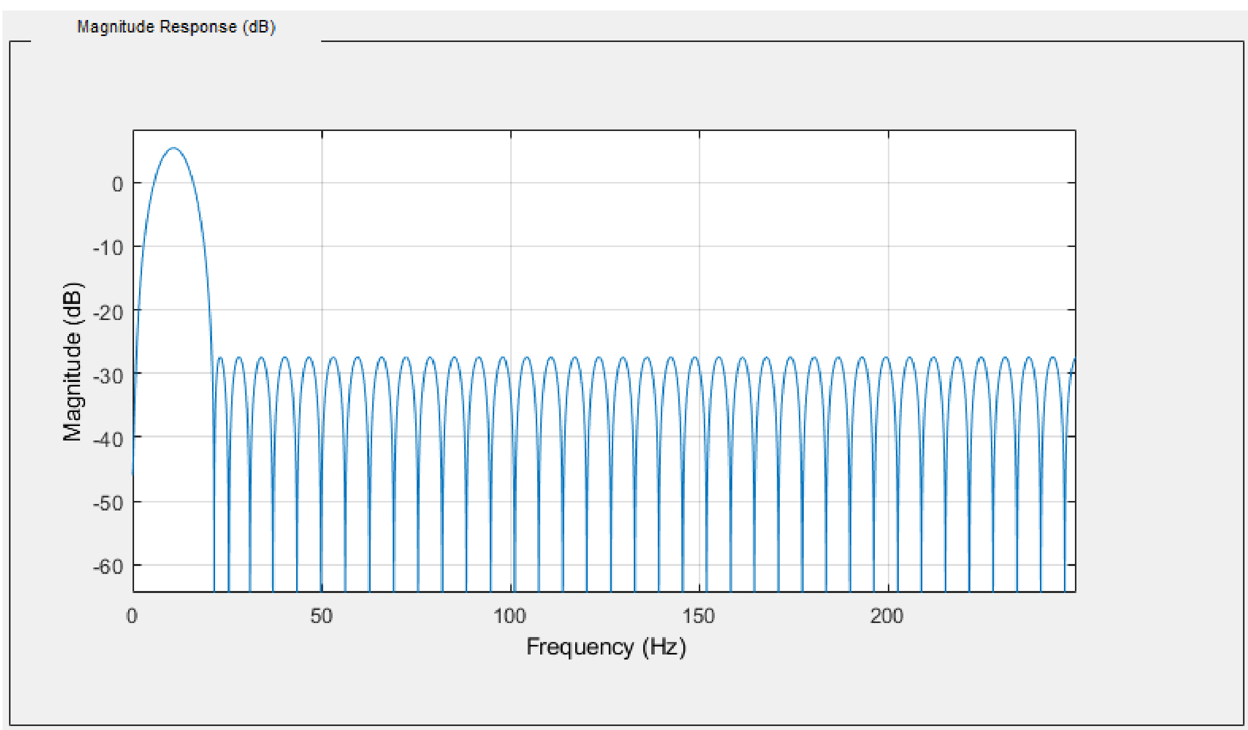


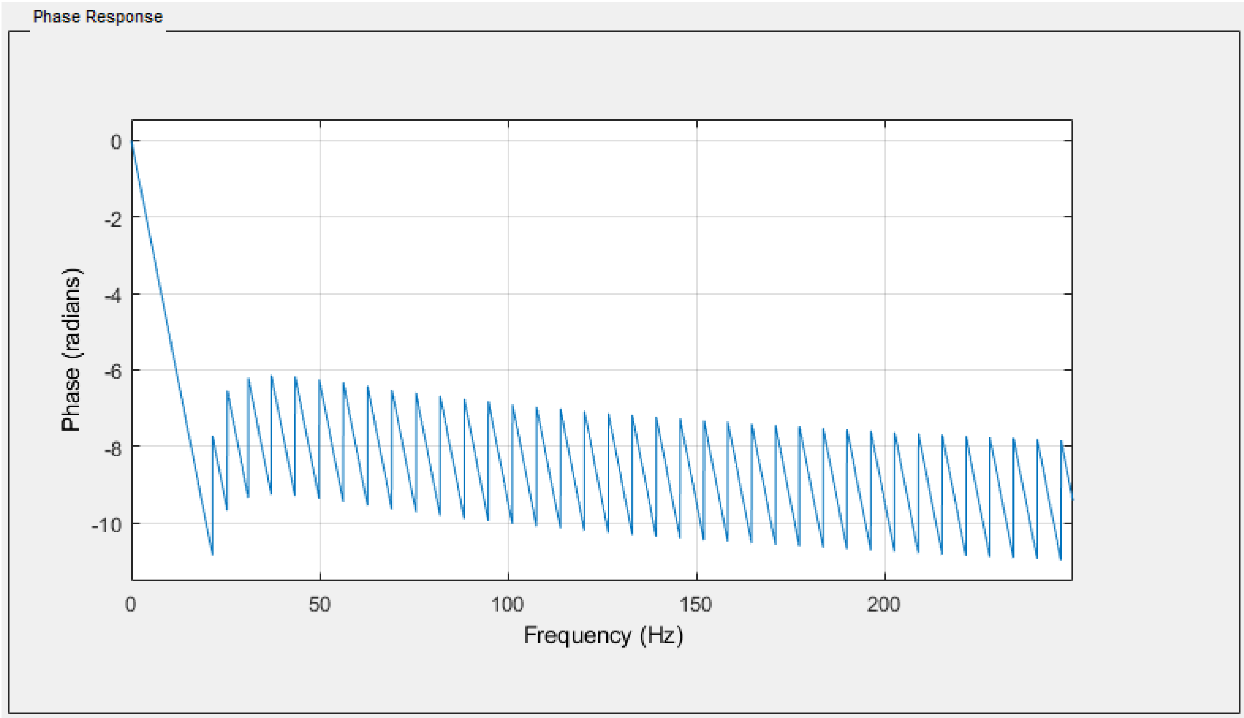
Hamming gives low ripple and good side-lobe suppression.

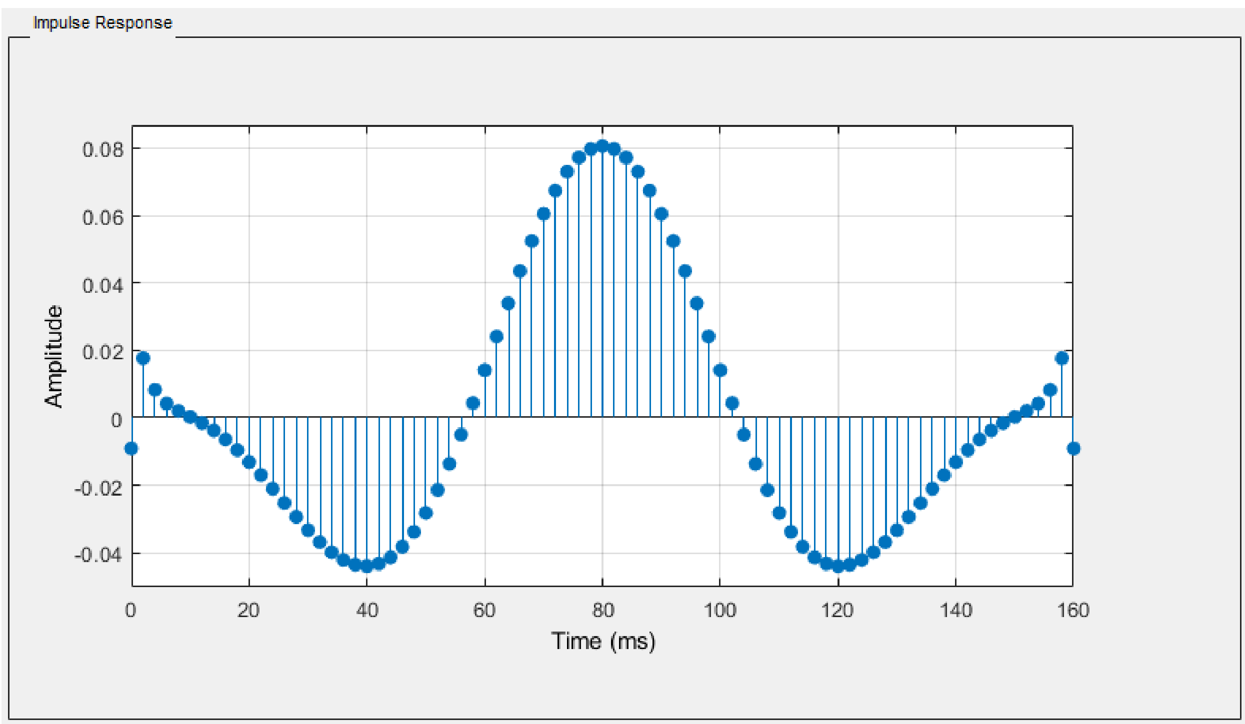
Q04.

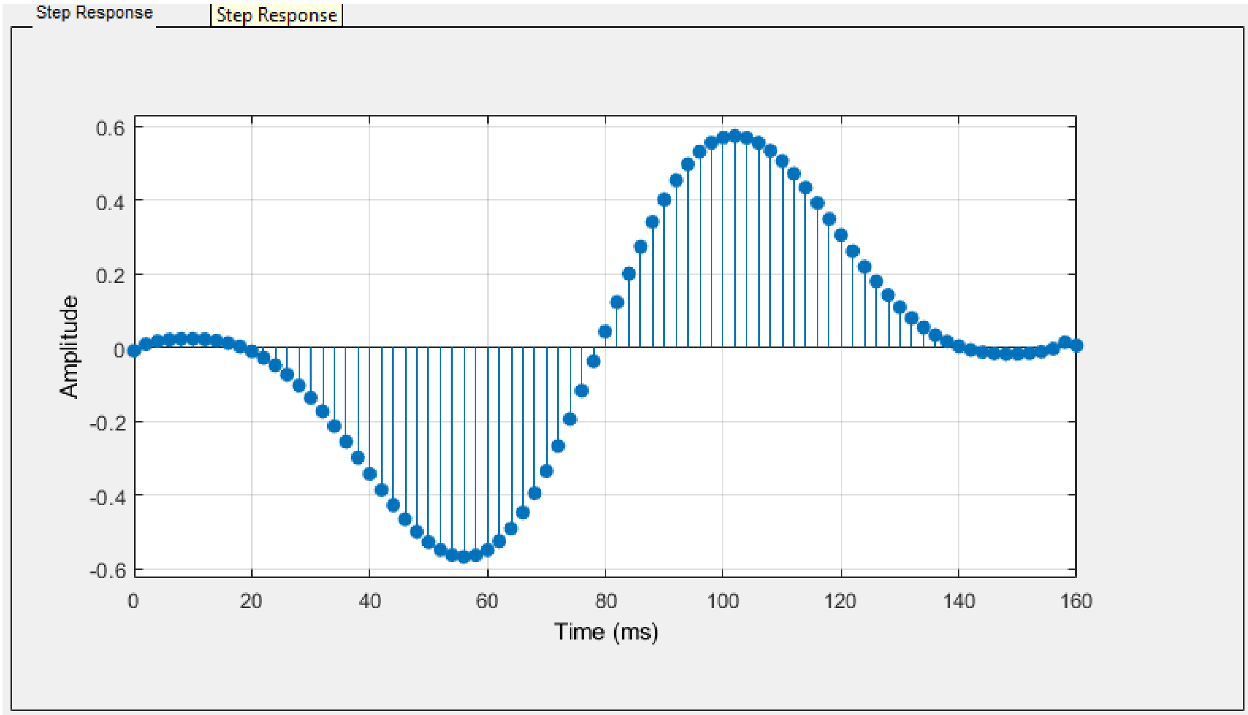

Filter Designer - [untitled.fda *]
File Edit Analysis Targets View Window Help
Current Filter Information
Structure: Direct-Form FIR
Order: 80
Stable: Yes
Source: Designed
Store Filter ...
Filter Manager ...
Magnitude Response (dB)
Magnitude (dB)
Frequency (Hz)
Response Type
Lowpass
Highpass
Bandpass
Bandstop
Differentiator
Design Method
IIR
Butterworth
FIR
Equiripple
Filter Order
Specify order:
80
Minimum order
Options
Density Factor:
20
Frequency Specifications
Units:
Hz
Fs:
500
Fstop1:
1
Fpass1:
2
Fpass2:
20
Fstop2:
21
Magnitude Specifications
Enter a weight value for each band below.
Wstop1:
20
Wpass:
1
Wstop2:
20
Design Filter
Designing Filter ... Done

Q04.a


Magnitude Response (dB)
Magnitude (dB)
0
-10
-20
-30
-40
-50
-60
0
50
100
150
200
Frequency (Hz)

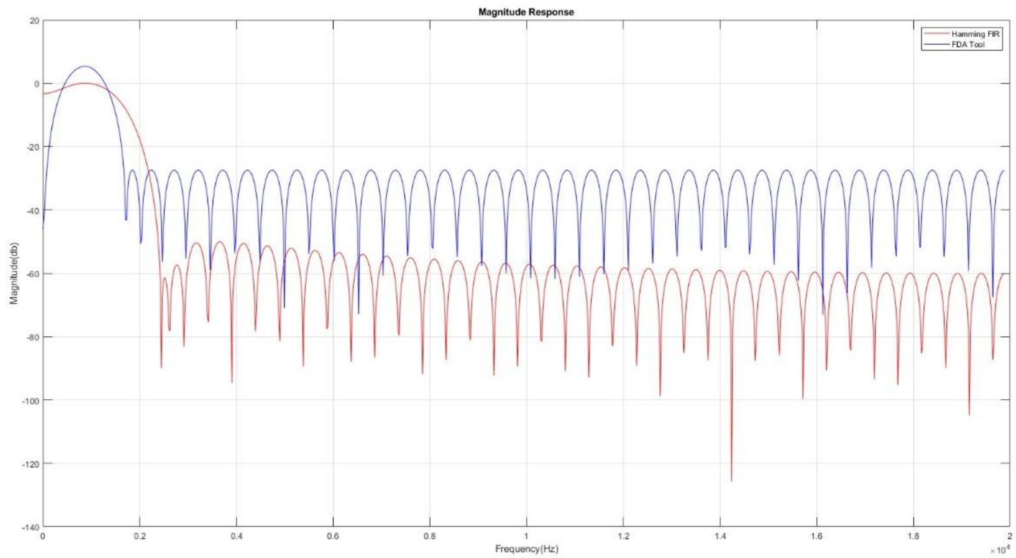

Phase Response
0
-2
-4
-6
-8
-10
Phase (radians)
0
50
100
150
200
Frequency (Hz)


Impulse Response
0.08
0.06
0.04
0.02
0
-0.02
-0.04
Amplitude
0
20
40
60
80
100
120
140
160
Time (ms)



Q04.b

```
N = 80;
fp = [0.008 0.08];
fs = 500;
a = 1;

x_fir = fir1(N, fp, 'bandpass', hamming(N+1));

figure;
[h_ham, w_ham] = freqz(x_fir, 1, 1024, fs);
[h_fda, w_fda] = freqz(b, a, 1024, fs);

plot(w_ham*fs/(2*pi), 20*log10(abs(h_ham)), 'r-'); hold on;
plot(w_fda*fs/(2*pi), 20*log10(abs(h_fda)), 'b-');
xlabel('Frequency(Hz)');
ylabel('Magnitude(db)');
title('Magnitude Response');
grid on;

legend('Hamming FIR','FDA Tool');
```

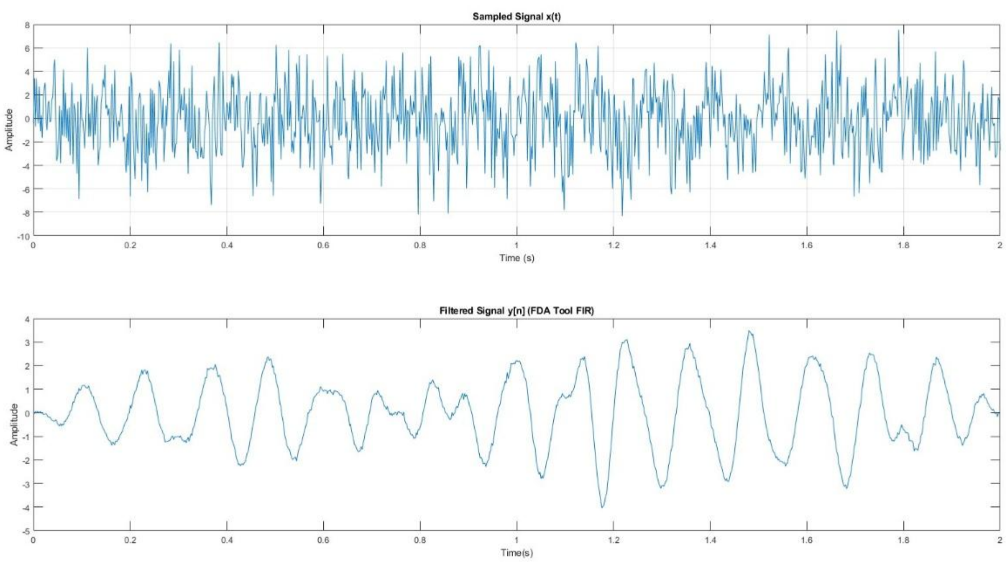


Q04.c

- FDA tool signal sharper than previously designed filter.
- So FDA tool is more suitable for preserving the cosmic message ehile removing interference.

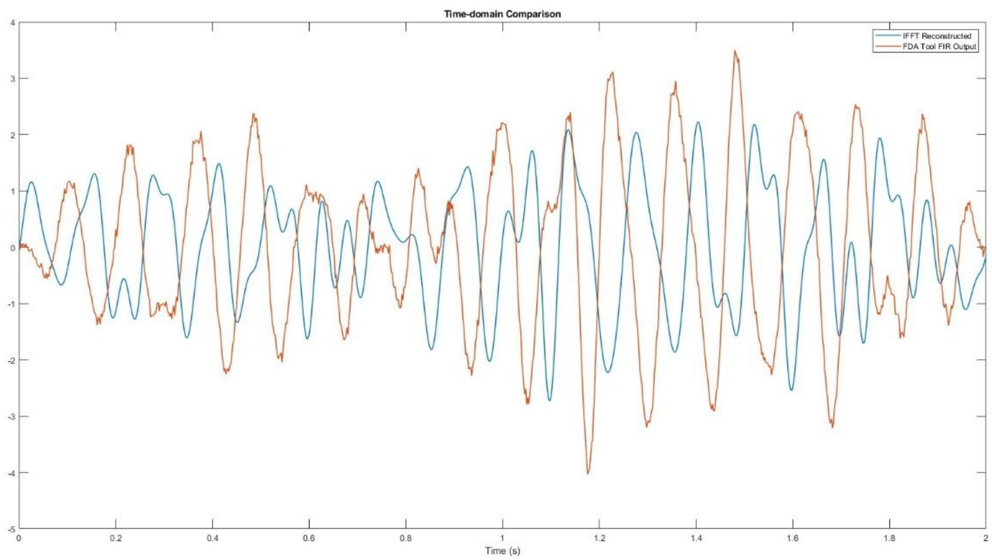
Q05.

```
fs = 500;
t = 0:1/fs:2;
a = 1;

figure;
subplot(2,1,1);
plot(t, x);
title('Sampled Signal x(t)');
xlabel('Time (s)');
ylabel('Amplitude');
grid on;

subplot(2,1,2);
y_fda = filter(b, a, x);
plot(t, y_fda);
title('Filtered Signal y[n] (FDA Tool FIR)');
xlabel('Time(s)');
ylabel('Amplitude');
```



Q06.

```
fs = 500;
t = 0:1/fs:2;

X = fft(x);
mask = zeros(size(X));

for k = 1:length(f)
    if (f(k) >= 2 && f(k) <= 20)
        mask(k) = 1;
        mask(end-k+1) = 1;
    end
end

X_masked = X .* mask;
x_rec = real(ifft(X_masked));

figure;
plot(t, x_rec, 'LineWidth', 1.2); hold on;
plot(t, y_fda, 'LineWidth', 1.2);
legend('IFFT Reconstructed','FDA Tool FIR Output');
title('Time-domain Comparison');
xlabel('Time (s)');
```

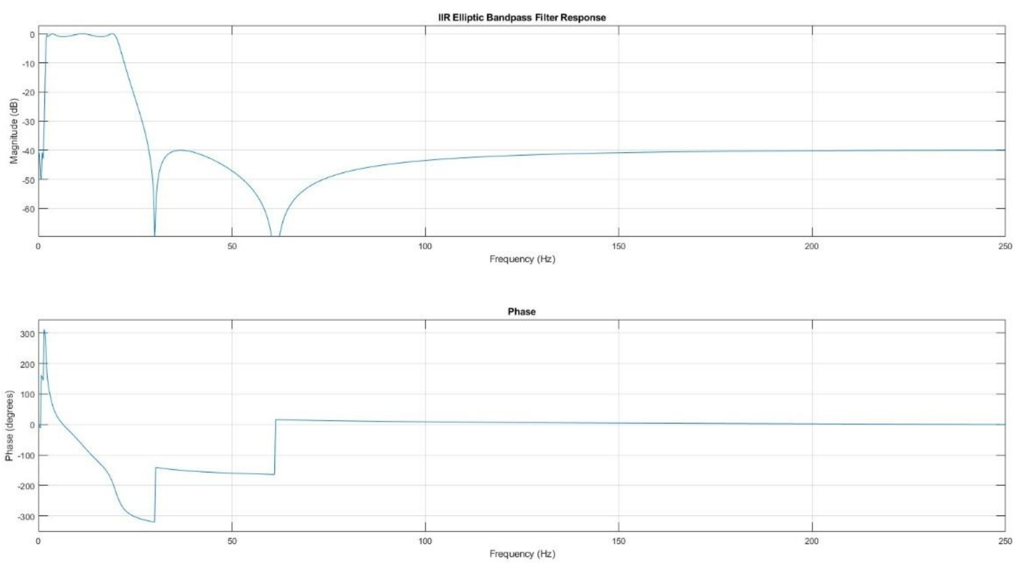


Q07.a

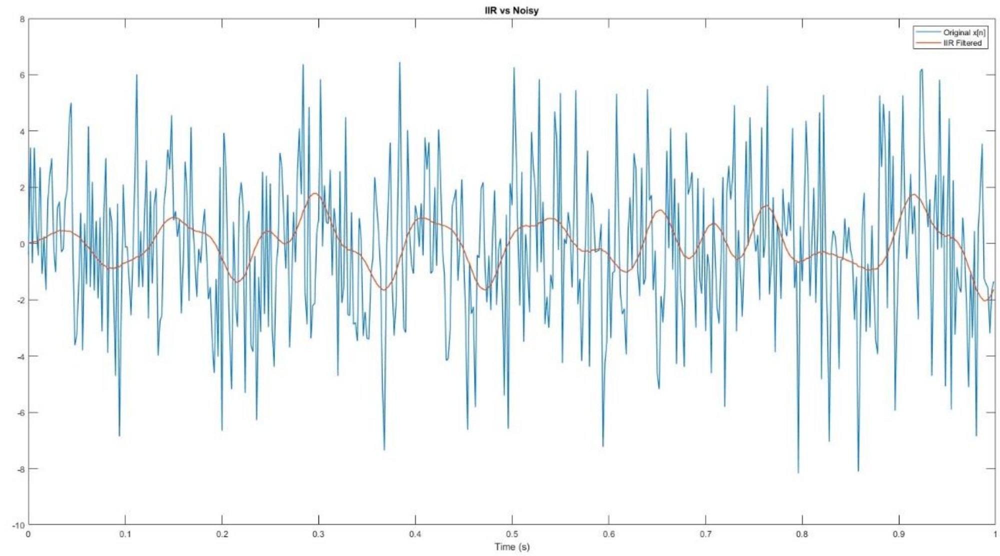
I choose Elliptic because it is more stable one.

```
Fs = 500;
Wp = [2 20] / (Fs/2);
Ws = [1 25] / (Fs/2);
Rp = 1;
Rs = 40;

[biir, aiir] = ellip(4, Rp, Rs, Wp, 'bandpass');

figure;
freqz(biir, aiir, 1024, Fs);
title('IIR Elliptic Bandpass Filter Response');

y_iir = filter(biir, aiir, x);

figure;
plot(t(1:500), x(1:500), 'LineWidth', 1); hold on;
plot(t(1:500), y_iir(1:500), 'LineWidth', 1.2);
legend('Original x[n]','IIR Filtered');
title('IIR vs Noisy');
xlabel('Time (s)');

figure;
zplane(biir, aiir);
title(' Pole-Zero Plot of Elliptic IIR Filter');
```

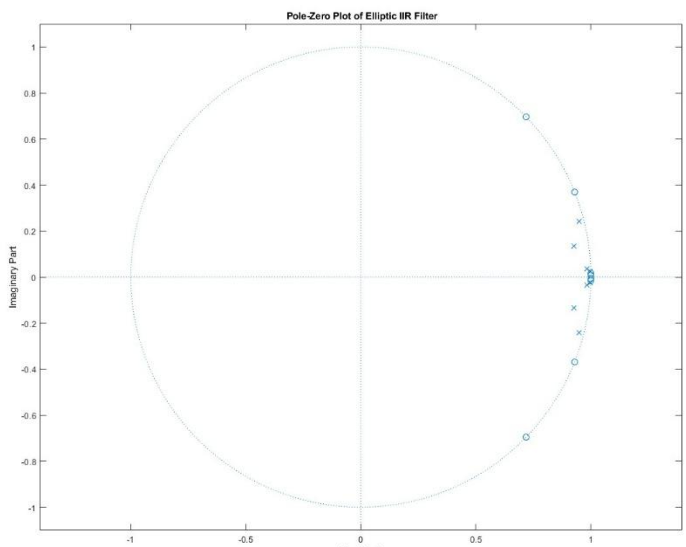
Q07.d



Q07.e



Q07.f



Q07.g

- IIR has sharper transition but FIR is more stable (all poles at 0).
- FIR FDA Tool filter better for distortion-free cosmic signal recovery.