ECE580 HW5 Jian Kang

Question:

1. An elliptic filter has the following specifications:

Passband ripple α_p = 0.1 dB

Minimum stopband loss α_s = 60 dB

Passband limit f_p = 1 MHz

Stopband limit f_s = 2.1 MHz

The dc gain should be 0 dB.

a. Find the zeros and poles of the transfer function $H(s) = V_{out}/V_{in}$.

b. Plot the gain and phase responses of the filter.

c. Plot the step response of the filter.

Solution:

The solution is obtained via matlab filter design tools. The code is attached in appendix.

a. Transfer Function is shown as

$$\frac{6.005e04\ s^4 + 3.711e19\ s^2 + 4.737e33}{s^5 + 1.086e07\ s^4 + 1.1e14\ s^3 + 6.073e20\ s^2 + 2.386e27\ s + 4.737e33}$$

where zeros and poles are

zero =

1.0e+07 *

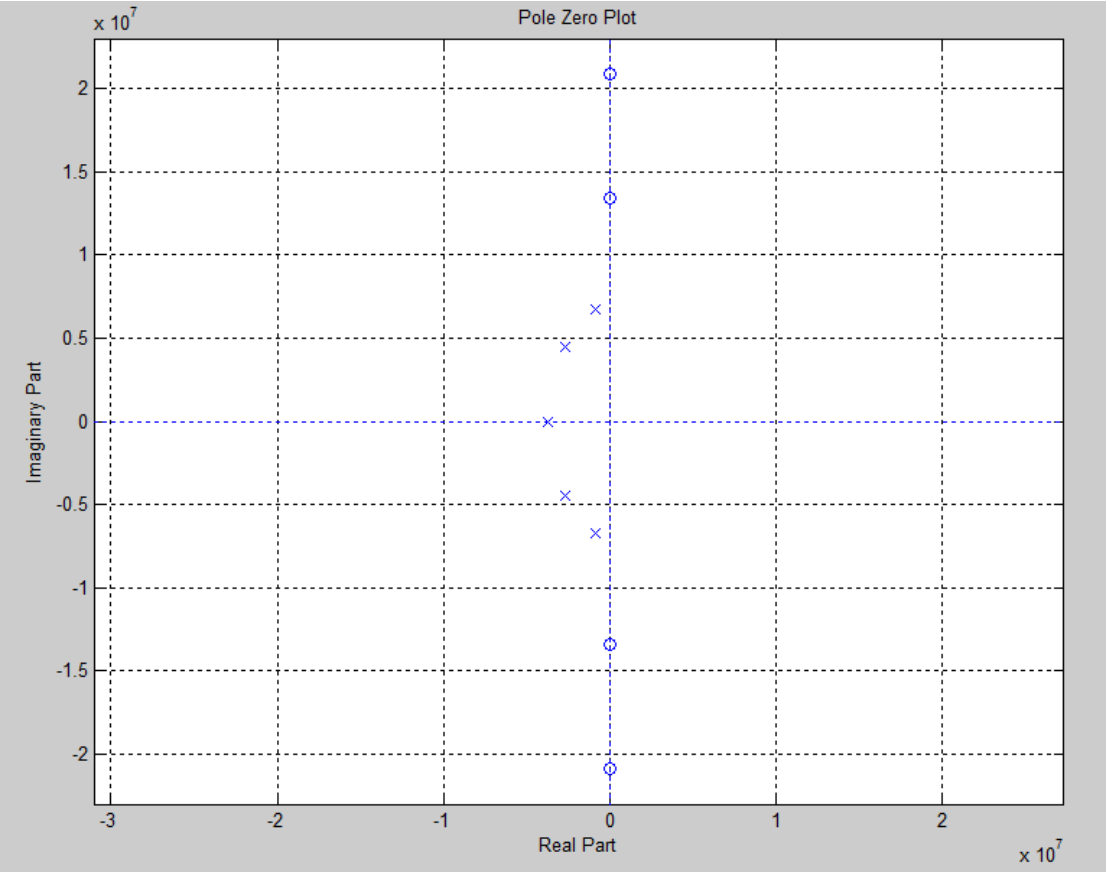
0.0000 + 2.0924i
0.0000 - 2.0924i
0.0000 + 1.3422i
0.0000 - 1.3422i

pole =

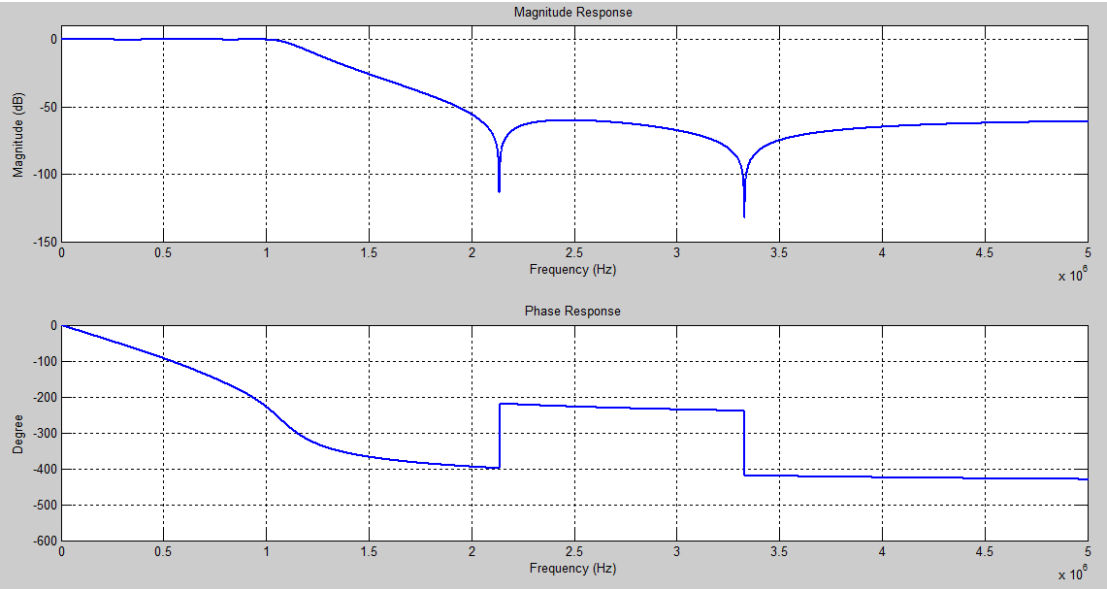
1.0e+06 *

-0.8808 + 6.7476i
-0.8808 - 6.7476i
-2.6989 + 4.5158i
-2.6989 - 4.5158i
-3.6962 + 0.0000i

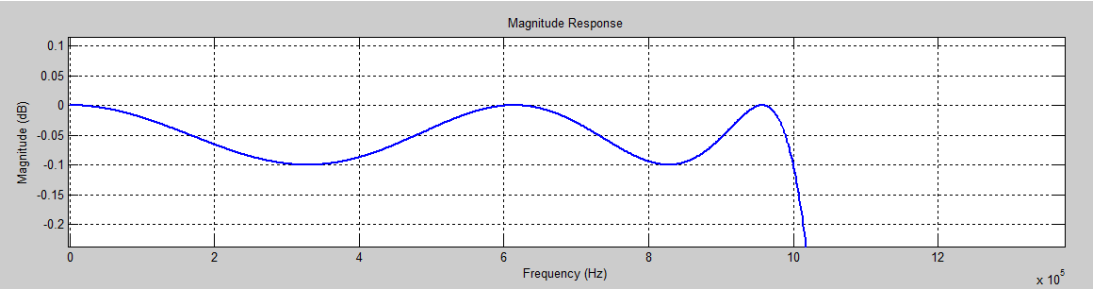
Zeros and poles are also shown in S-plane as



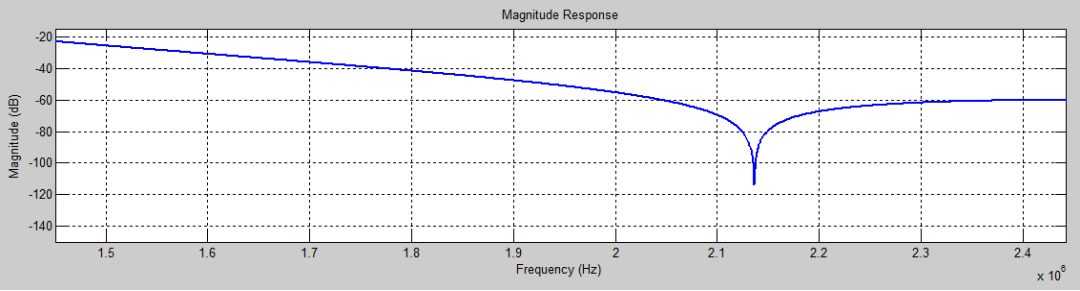
b. The gain and phase responses from DC to 5MHz are shown as



Zoom in detail of the passband ripple is shown as

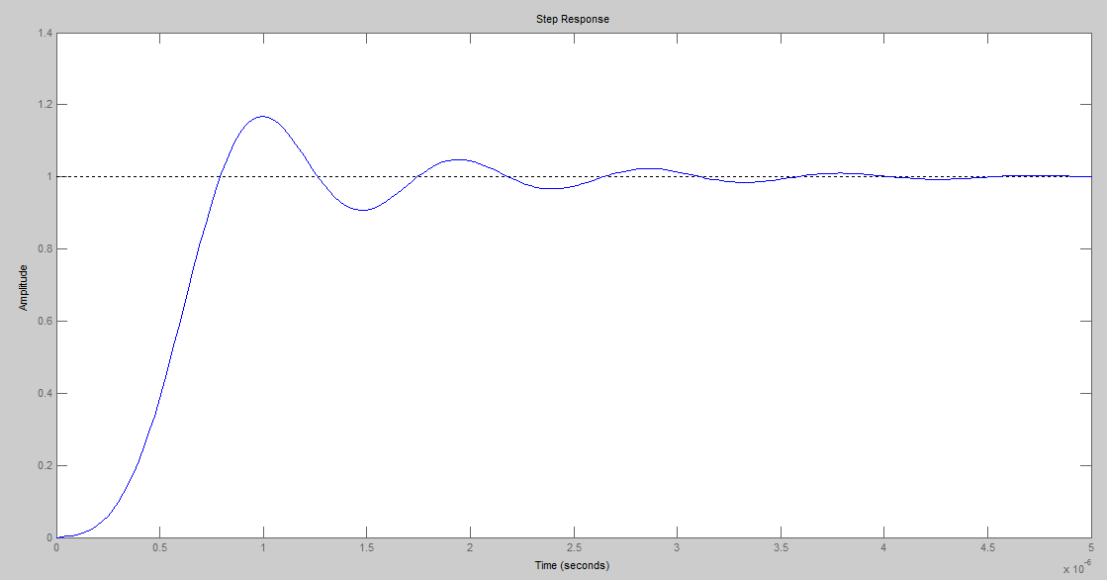


Zoom in detail of stopband loss is shown as



It can be seen that both passband and stopband meet requirements.

c. The step response is shown as



Appendix-Matlab Code

```
%% ECE580 HW5 Jian Kang

clear all;
close all;

%% Specification
fp = 1e6; % Passband Edge frequency(Hz)
fs = 2.1e6; % Stopband Edge Frequency(Hz)
Wp = 2*pi*fp; % Passband Edge frequency(rad/s)
Ws = 2*pi*fs; % Stopband Edge frequency(rad/s)
Rp = 0.1; % Passband Ripple(dB)
Rs = 60; % Stopband Ripple(dB)

%% Determine Filter Order
[N, Wn ] = ellipord(Wp, Ws, Rp, Rs, 's');

%% Design Filter
[num, den] = ellip(N, Rp, Rs, Wn, 's');

%% Display Transfer Function
tf(num,den) % Display transfer function
```

```
%% Display Zeros and Poles
[zero,pole,gain] = tf2zpk(num,den)

%% Frequency Analysis
w = 2*pi*(0:1e3:50E6);
[H] = freqs(num,den, w);

%% Plot Figures
%-------------------------------------------------------------
% Plot Magnitude Response
%-------------------------------------------------------------
subplot(2,1,1)
plot(w/(2*pi), 20*log10(abs(H)),'LineWidth',2);
grid on;
xlabel('Frequency (Hz)'); ylabel('Magnitude (dB)');
title('Magnitude Response');
axis([0 5e6 -150 10]);

%-------------------------------------------------------------
% Plot Phase Response
%-------------------------------------------------------------
subplot(2,1,2)
plot(w/(2*pi), 180/pi*phase(H),'LineWidth',2);
grid on;
xlabel('Frequency (Hz)'); ylabel('Degree'); title('Phase Response');
axis([0 5e6 -600 0]);

%-------------------------------------------------------------
% Plot Pole-Zero
%-------------------------------------------------------------
figure(2)
zplane(num,den);
grid on;
title('Pole Zero Plot');

%-------------------------------------------------------------
% Plot Step Response
%-------------------------------------------------------------
figure(3)
T = tf(num, den);
step(T);
```