[ARTEM DUDKO] - [Class 23 Problems] - [11/24/21]

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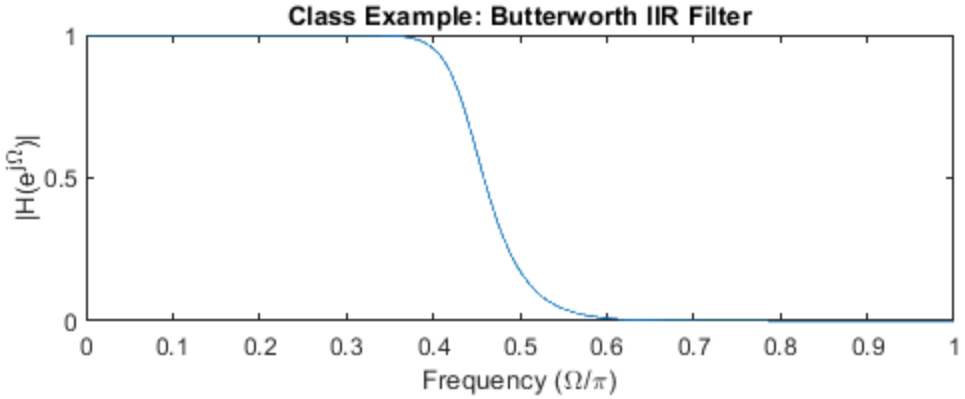
[PROBLEM #1]

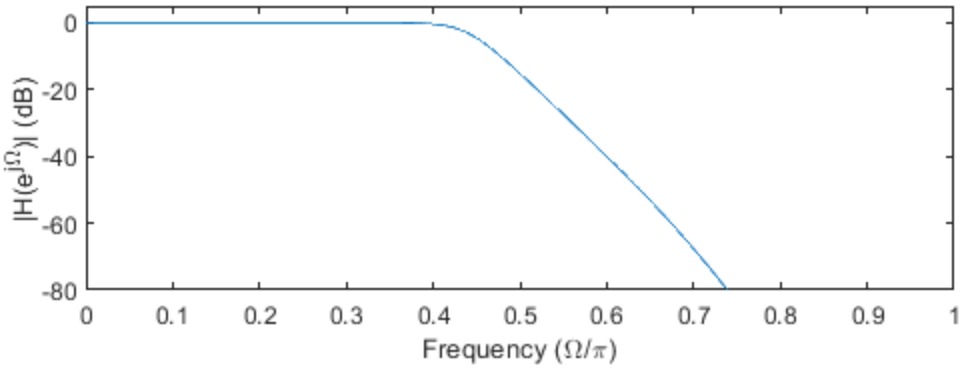
```
%butterworth
delta1 = 0.05;
delta2 = 0.01;
Rp = -20*log10(1-delta1);
Rs = -20*log10(delta2);
Omegap = 0.4*pi;
Omegas = 0.6*pi;

% find the order and natural frequency
[N,Omegan] = buttord(Omegap/pi,Omegas/pi,Rp,Rs);
% find coefficients
[b,a] = butter(N,Omegan)

[H,Omega] = freqz(b,a,2048);
figure(1)
subplot(2,1,1)
plot(Omega/pi,abs(H));
xlabel('Frequency (\Omega/\pi)'), ylabel('|H(e^{j\Omega})|')
ylim([0 1])
xlim([0 1])
title('Class Example: Butterworth IIR Filter')

subplot(2,1,2)
plot(Omega/pi,20*log10(abs(H)));
xlabel('Frequency (\Omega/\pi)'), ylabel('|H(e^{j\Omega})| (dB)')
ylim([-80 5])
xlim([0 1])

% zoom in to confirm specification met
figure(2)
subplot(2,1,1)
plot(Omega/pi,abs(H));
xlabel('Frequency (\Omega/\pi)'), ylabel('|H(e^{j\Omega})|')
title('Class Example: Butterworth IIR Filter Passband')
% Limit plot to cover passband region
xlim([0 Omegap/pi])
```

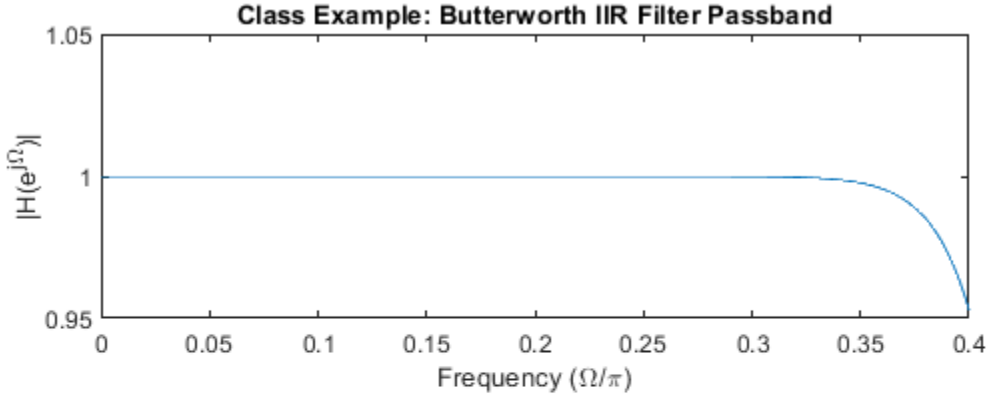
```
ylim([1-delta1 1+delta1]);

subplot(2,1,2)
plot(Omega/pi,abs(H));
xlabel('Frequency (\Omega/\pi)'), ylabel('|H(e^{j\Omega})|')
title('Class Example: Butterworth IIR Filter Stopband')
% Limit plot to cover stopband region
xlim([Omegas/pi 1])
ylim([0 delta2]);

figure(3)
pzplot(b,a)
axis square
xlabel('Real'); ylabel('Imag');
title('Poles and Zeros of Butterworth Filter')




%cheby
delta1 = 0.05;
delta2 = 0.01;
Rp = -20*log10(1-delta1);
Rs = -20*log10(delta2);
Omegap = 0.4*pi;
Omegas = 0.6*pi;

% find the order and natural frequency
[Ncheby,Omegan] = cheb2ord(Omegap/pi,Omegas/pi,Rp,Rs);
% find coefficients
% Remember tricky thing that cheby2 needs the stopband ripple Rs as an
% argument
[bcheby,acheby] = cheby2(Ncheby,Rs,Omegan);

[Hcheby,Omega] = freqz(bcheby,acheby,2048);
figure(4)
subplot(2,1,1)
plot(Omega/pi,abs(Hcheby));
xlabel('Frequency (\Omega/\pi)'), ylabel('|H(e^{j\Omega})|')
ylim([0 1])
xlim([0 1])
title('Class Example: Chebyshev Type 2 IIR Filter')

subplot(2,1,2)
plot(Omega/pi,20*log10(abs(Hcheby)));
xlabel('Frequency (\Omega/\pi)'), ylabel('|H(e^{j\Omega})| (dB)')
ylim([-80 5])
xlim([0 1])

% zoom in to confirm specification met
figure(5)
subplot(2,1,1)
plot(Omega/pi,abs(Hcheby));
```

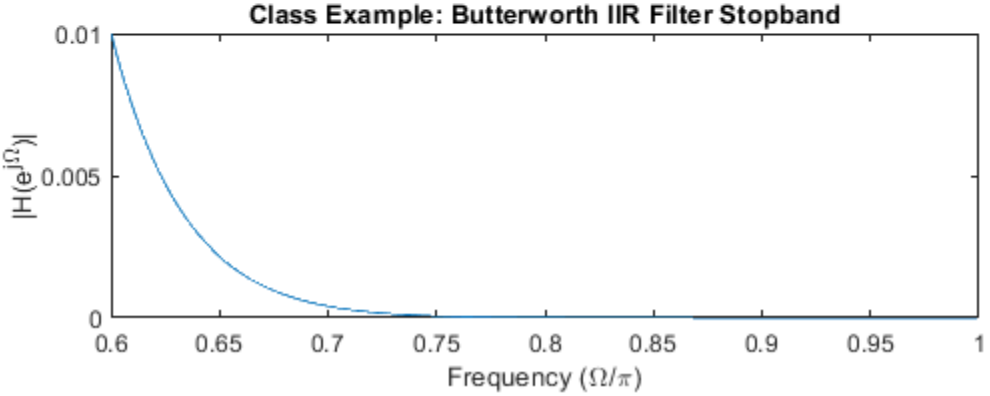
```
xlabel('Frequency (\Omega/\pi)'), ylabel('|H(e^{j\Omega})|')
title('Class Example: Chebyshev Type 2 IIR Filter Passband')
% Limit plot to cover passband region
xlim([0 Omegap/pi])
ylim([1-delta1 1+delta1]);

subplot(2,1,2)
plot(Omega/pi,abs(Hcheby));
xlabel('Frequency (\Omega/\pi)'), ylabel('|H(e^{j\Omega})|')
title('Class Example: Chebyshev Type 2 IIR Filter Stopband')
% Limit plot to cover stopband region
xlim([Omegas/pi 1])
ylim([0 delta2]);

figure(6)
pzplot(bcheby,acheby)
axis square
xlabel('Real'); ylabel('Imag');
title('Pole-zero plot of Cheby2 IIR Filter')

%For part 1 the chevyshev II has less orders to it, only order 6
 compared
%to the butterworth order 9, but the butterworth is smoother as an
 upside.
```

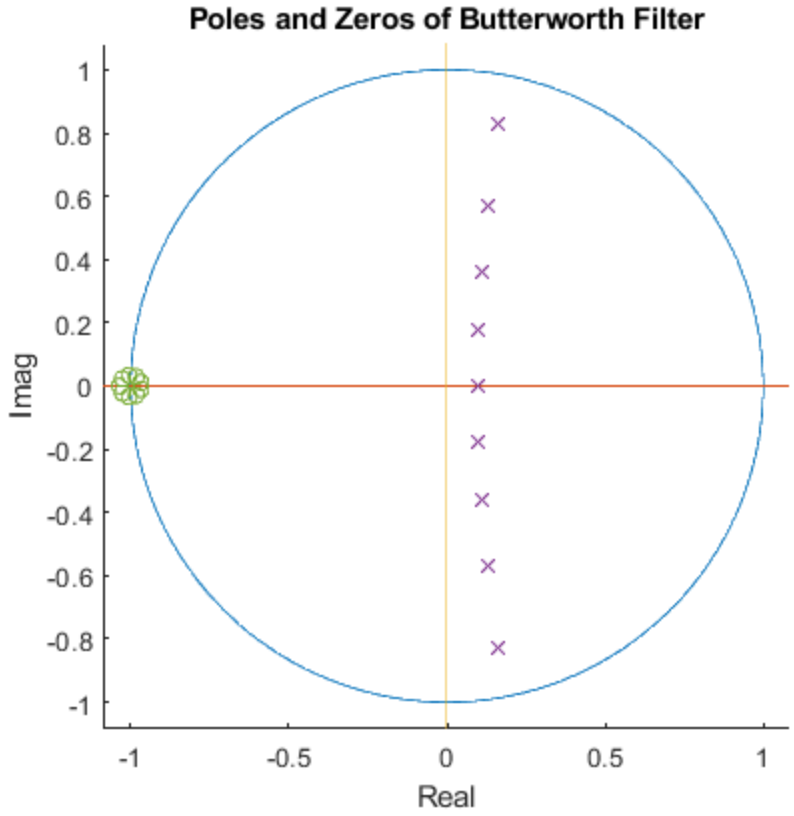
```
b =

  Columns 1 through 7

    0.0021    0.0186    0.0745    0.1739    0.2609    0.2609    0.1739

  Columns 8 through 10

    0.0745    0.0186    0.0021


a =

  Columns 1 through 7

    1.0000   -1.0893    1.6925   -1.0804    0.7329   -0.2722    0.0916

  Columns 8 through 10

   -0.0174    0.0024   -0.0001
```

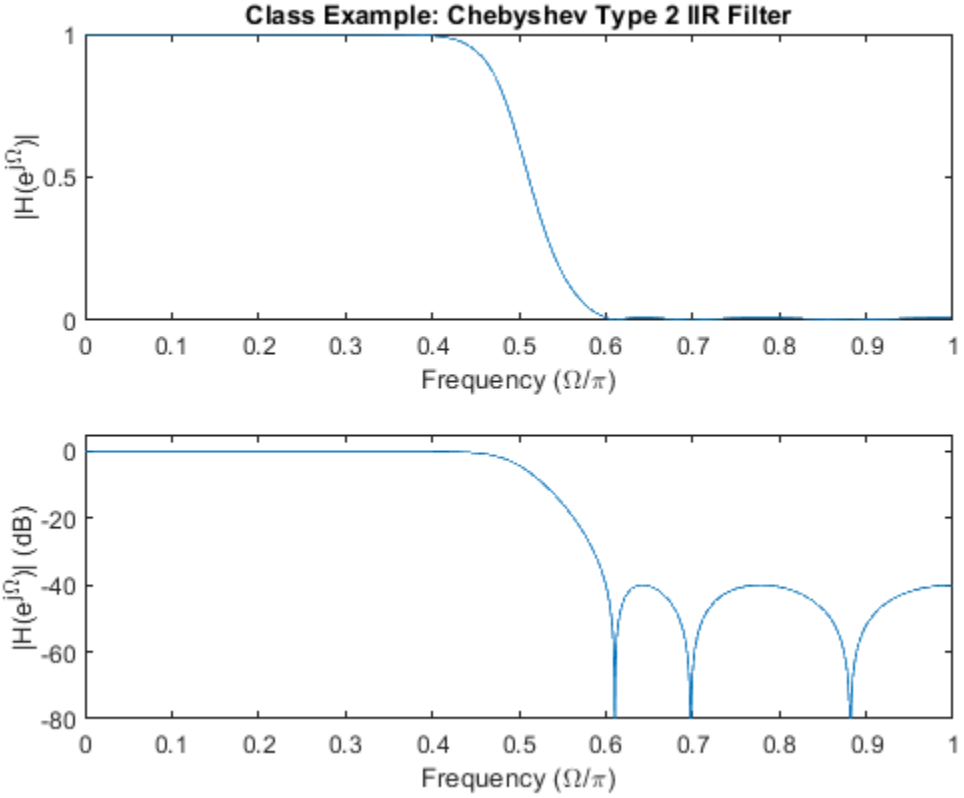

Class Example: Butterworth IIR Filter
|H(e^jΩ)|
Frequency (Ω/π)

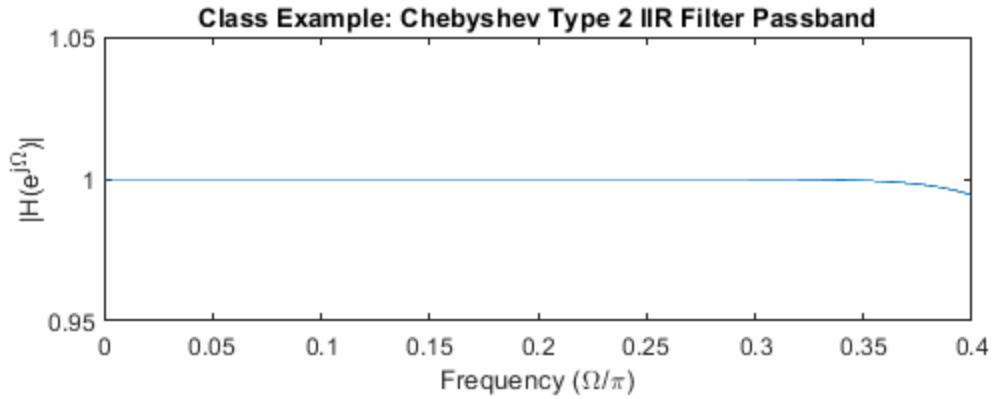

|H(e^jΩ)| (dB)
Frequency (Ω/π)

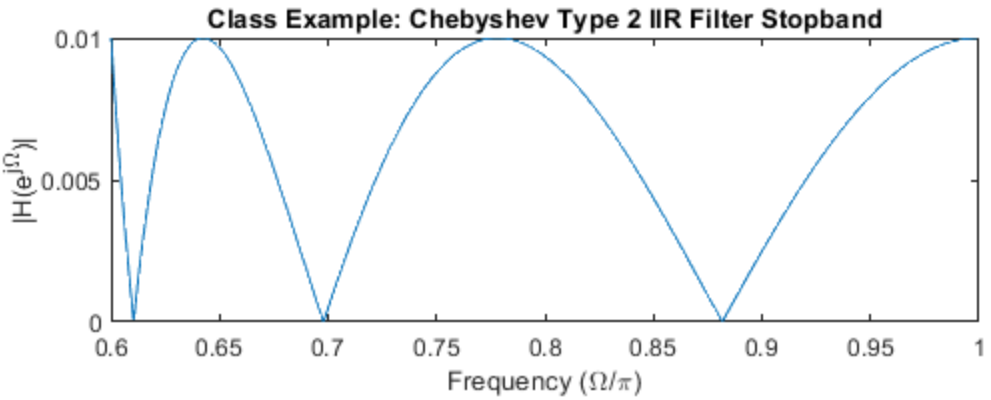

Class Example: Butterworth IIR Filter Passband
|H(e^jΩ)|
Frequency (Ω/π)

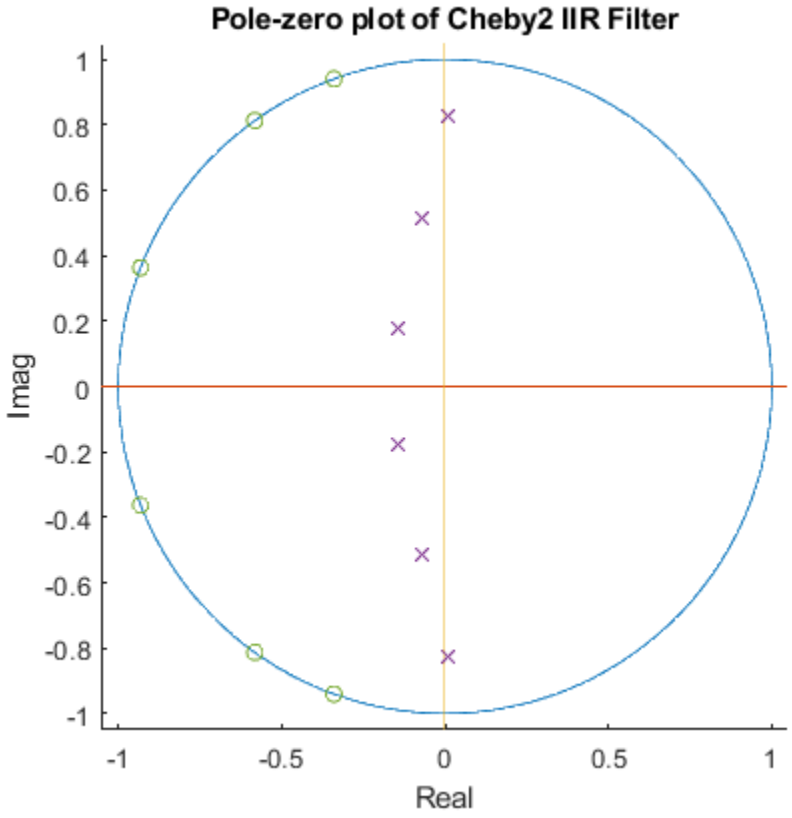

Class Example: Butterworth IIR Filter Stopband
|H(e^jΩ)|
Frequency (Ω/π)


Poles and Zeros of Butterworth Filter
Imag
Real
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1
-0.5
0
0.5
1


Class Example: Chebyshev Type 2 IIR Filter
|H(e^jΩ)|
Frequency (Ω/π)
|H(e^jΩ)| (dB)
Frequency (Ω/π)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
-20
-40
-60
-80


Class Example: Chebyshev Type 2 IIR Filter Passband
1.05
1
0.95
|H(e^jΩ)|
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
Frequency (Ω/π)


Class Example: Chebyshev Type 2 IIR Filter Stopband
0.01
0.005
0
|H(e^jΩ)|
0.6
0.65
0.7
0.75
0.8
0.85
0.9
0.95
1
Frequency (Ω/π)


Pole-zero plot of Cheby2 IIR Filter
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
Imag
-1
-0.5
0
0.5
1
Real

[PROBLEM #2]

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