Homework #2

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1. **Starting from the definition of the Chebyshev function**

**Show that obeys the following recursion: . Consider the cases and separately.**

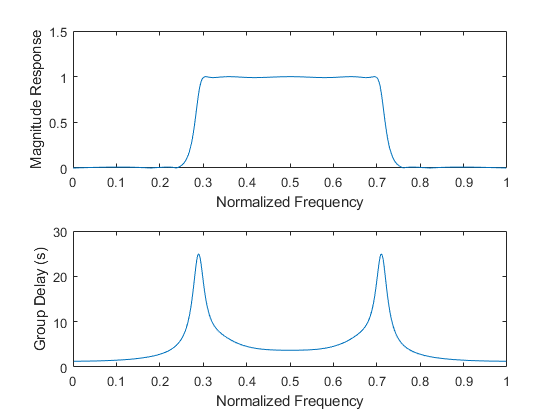
For |x| ≤ 1:

For |x| > 1:

:

1. **Design a bandpass discrete-time Elliptic filter with the following specifications: . Plot the Magnitude response and group delay for the resulting filter design. Realize the transfer function as a cascade of first-order and second-order sections with real-valued coefficients. List the coefficients for each section.**

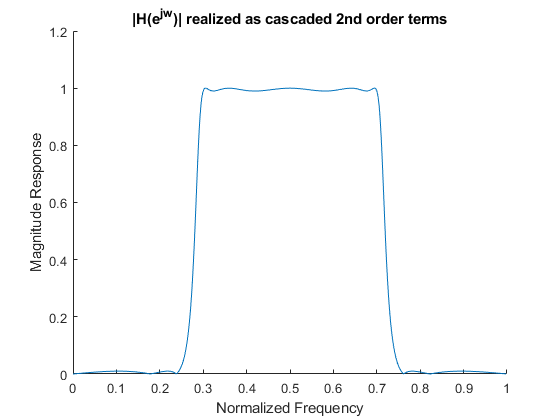
ws1 = 0.2\*pi;  
wp1 = 0.3\*pi;  
wp2 = 0.7\*pi;  
ws2 = 0.8\*pi;  
Gp = 0.99;  
Gs = 0.01;  
  
Rp = -20\*log10(Gp);  
Rs = -20\*log10(Gs);  
  
% Calculating digital Elliptic filter order and new w using normalized pass  
% band and stop band frequencies.  
[N,wpnew] = ellipord([wp1/pi wp2/pi],[ws1/pi ws2/pi],Rp,Rs);  
  
% Calculate Zeros, Poles, and Gain for digital Elliptic filter  
[z,p,k] = ellip(N,Rp,Rs,wpnew);  
  
% Calculate Z domain numerator polynomial  
Bz = poly(z);  
  
% Calculate Z domain denominator polynomial  
Az = poly(p);  
  
% Adjust for gain using k computed in line 24  
Bz = k\*Bz;  
  
% Calculating Magnitude Response  
[H,wh] = freqz(Bz,Az);  
  
% Calculating Group Delay  
[Gpd,wg] = grpdelay(Bz,Az);  
  
% Plotting Magnitude Response and Group Delay  
figure(1)  
subplot(211)  
plot(wh/pi,abs(H),'-')  
xlabel('Normalized Frequency'); ylabel('Magnitude Response');  
subplot(212)  
plot(wg/pi,Gpd,'-')  
xlabel('Normalized Frequency'); ylabel('Group Delay (s)');



## Realize transfer function as cascaded 2nd order terms

The 2nd Order terms were acquired by using MATLAB poly function on complex-conjugate pairs for variables z (zeros) and p (poles).

% 2nd Order Numerator coefficients indexed as follows:  
% Z^2\*p(1) + Z\*p(2) + p(3)  
z0 = [1 0 -1];  
z1 = [1 -1.6954 1];  
z2 = [1 1.6954 1];  
z3 = [1 1.4663 1];  
z4 = [1 -1.4663 1];  
  
% 2nd Order Denominator coefficients indexed as follows:  
% Z^2\*p(1) + Z\*p(2) + p(3)  
p0 = [1 0 0.3335];  
p1 = [1 -0.8406 0.6311];  
p2 = [1 0.8406 0.6311];  
p3 = [1 1.1701 0.9050];  
p4 = [1 -1.1701 0.9050];  
  
% Frequency response of each term  
h0 = freqz(z0,p0);  
h1 = freqz(z1,p1);  
h2 = freqz(z2,p2);  
h3 = freqz(z3,p3);  
[h4,ww] = freqz(z4,p4);  
  
% Cascading 2nd order Transfer functions  
% Compensating for Gain  
H\_cascaded = k\*(h0.\*h1.\*h2.\*h3.\*h4);  
  
figure(2)  
hold on  
title('|H(e^{jw})| realized as cascaded 2nd order terms');  
xlabel('Normalized Frequency'); ylabel('Magnitude Response');  
plot(ww/pi, abs(H\_cascaded),'-');



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