1.

* Elliptic Filter:



* Chebyshev 2 Filter:



* Chebyshev 1 Filter:
* Butterworth Filter:



a) Butterworth Order: 51

Chebyshev 1 Order: 16

Chebyshev 2 Order: 16

Elliptic Order: 8

b) The attenuation of the elliptic and chebyshev 2 filters are nearly identical, however the butterworth filter had the worst attenuation and the chebyshev 1 filter has the best attenuation.

2.

Chebyshev 1 Bandstop Filter Magnitude and Magnitude in dB:

Transfer Function H(Z):

0.005381 - 4.613e-18 z^-1 + 0.03767 z^-2 - 2.768e-17 z^-3 + 0.113 z^-4 - 6.92e-17 z^ -5 + 0.1883 z^-6 - 9.226e-17 z^-7 + 0.1883 z^-8 - 6.92e-17 z^-9 + 0.113 z^-10 - 2.768e-17 z^-11 + 0.03767 z^-12 - 4.613e-18 z^-13 + 0.005381 z^-14

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1 + 4.663e-15 z^-1 - 1.655 z^-2 - 8.882e-15 z^-3 + 2.793 z^-4 + 2.22e-14 z^-5 - 2.841 z^-6 - 1.932e-14 z^-7 + 2.341 z^-8 - 2.22e-15 z^-9 - 1.383 z^-10 + 2.22e-16 z^-11 + 0.5714 z^-12 + 3.747e-16 z^-13 - 0.1377 z^-14

3.

Elliptic High Pass Filter



The input signal must be pre-warped so that the filter’s characteristics affect the correct frequencies

MATLAB Code:

% Problem 1:

Wp = 0.45;

Ws = 0.5;

Rp = 0.5;

As = 60;

[N, Wn] = buttord(Wp, Ws, Rp, As);

[b, a] = butter(N, Wn);

[H, W] = freqz(b, a);

figure('Name', 'Problem 1 - Butterworth');

subplot(2, 1, 1);

plot(W/pi, mag2db(abs(H)));

grid;

subplot(2, 1, 2);

grpdelay(b, a);

[N, Wp] = cheb1ord(Wp, Ws, Rp, As);

[b, a] = cheby1(N, Rp, Wp);

[H, W] = freqz(b, a);

figure('Name', 'Problem 1 - Chebyshev 1');

subplot(2, 1, 1);

plot(W/pi, mag2db(abs(H)));

grid;

subplot(2, 1, 2);

grpdelay(b, a);

[N, Ws] = cheb2ord(Wp, Ws, Rp, As);

[b, a] = cheby2(N, As, Wp);

[H, W] = freqz(b, a);

figure('Name', 'Problem 1 - Chebyshev 2');

subplot(2, 1, 1);

plot(W/pi, mag2db(abs(H)));

grid;

subplot(2, 1, 2);

grpdelay(b, a);

[N, Wp] = ellipord(Wp, Ws, Rp, As);

[b, a] = ellip(N, Rp, As, Wp);

[H, W] = freqz(b, a);

figure('Name', 'Problem 1 - Elliptic');

subplot(2, 1, 1);

plot(W/pi, mag2db(abs(H)));

grid;

subplot(2, 1, 2);

grpdelay(b, a);

% Problem 2:

rp = 0.01;

Rp = 40\*log10((1+rp)/(1-rp));

Ws = [0.35 0.65];

Wp = [0.25 0.75];

[N, Wp] = cheb1ord(Wp, Ws, Rp, As);

[b, a] = cheby1(N, Rp, Wp,'stop');

filt(b, a)

[H, W]= freqz(b, a);

figure('Name', 'Problem 2');

subplot(2, 1, 1);

plot(W/pi, abs(H));

grid;

subplot(2, 1, 2);

plot(W/pi, mag2db(abs(H)));

grid;

% Problem 3:

fs = 10000;

Ws = 1500;

As = 40;

Wp = 2000;

Rp = 1;

[n, Wp] = ellipord(Wp, Ws, Rp, As, 's');

[b, a] = ellip(n, Rp, As, Wp, 'high', 's');

[H, W] = freqs(b, a);

figure('Name', 'Problem 3');

subplot(2, 1, 1);

plot(W, abs(H));

grid;

xlim([0 5000]);

Wp = 2\*tan(Wp\*2\*pi/fs/2);

Ws = 2\*tan(Ws\*2\*pi/fs/2);

[n, Wp] = ellipord(Wp, Ws, Rp, As, 's');

[b, a] = ellip(n, Rp, As, Wp, 'high', 's');

[b, a] = bilinear(b, a, 1);

[H, W] = freqz(b, a);

subplot(2, 1, 2);

plot(W/pi, abs(H));

grid;