Jake Garrison 3/4/16 EE 442 HW 7

CODE AND PLOTS

```
%% Question 1
%Impulse Invariance
% Initialize
T = [1 1/8000]; % part 1 and part 2
fs  = 8000;
wp = 3200*2*pi/fs;
ws = 3800*2*pi/fs;
Rp = 0.5;
As = 45;
% loop through different T values
for i = 1:length(T)
    Op = wp/T(i);
    Os = ws/T(i);
    % Build cheb filter and bilinear transformation
    [cs, ds] = afd_chb1(Op, Os, Rp, As);
    [b, a] = imp_invr(cs, ds, T(i));
    [db, mag, pha, grd, w] = freqz_m(b, a);
    % Plot
    figure;
    subplot(3,1,1); plot(mag);
    title('Magnitude Response'); grid;
    xlabel('frequency (pi)'); ylabel('Magnitude');
    subplot(3,1,2); plot(pha);
    title('Phase Response'); grid
    xlabel('w'); ylabel('Rad')
    subplot(3,1,3);plot(db); axis([0 500 -50 5]); grid;
    title('Log Magnitude Response'); xlabel('frequency (pi)');
    ylabel('Decibels');
end
```

Q1 Part 3:

Using a T value smaller than one increased the magnitude of the filter significantly. This is not surprising as T is the numerical integration step size for trapezoidal integration, and a smaller T results in more partitioning of the data

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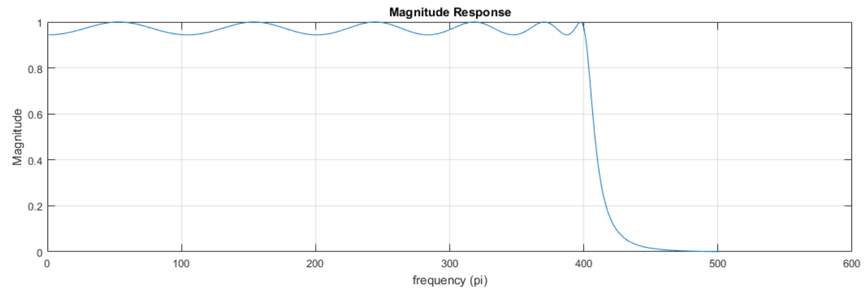

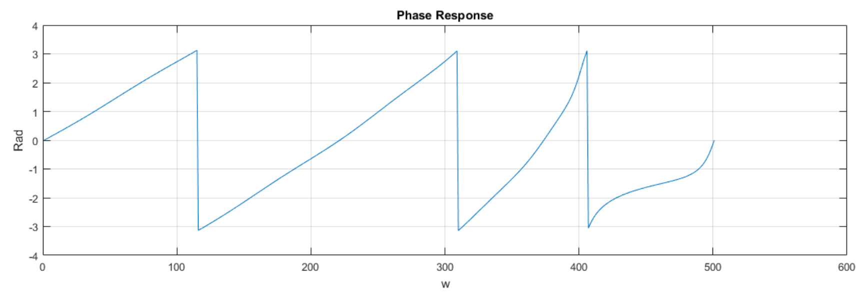

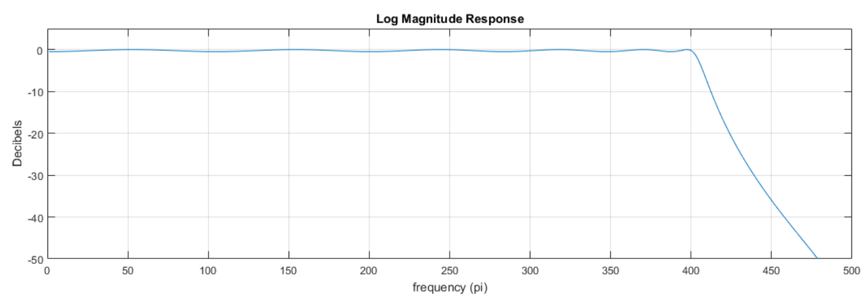

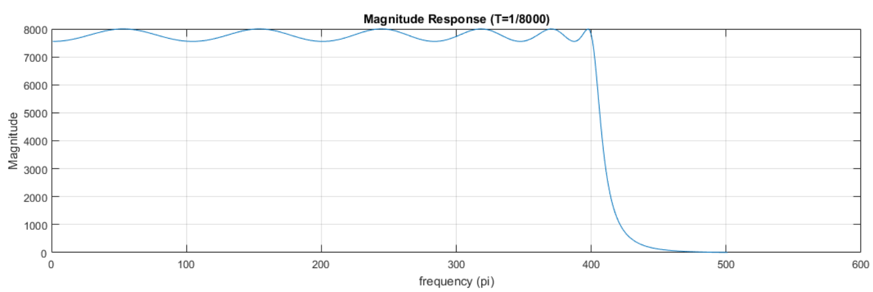

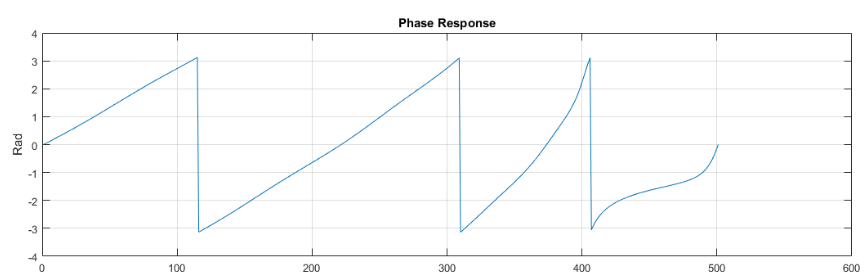

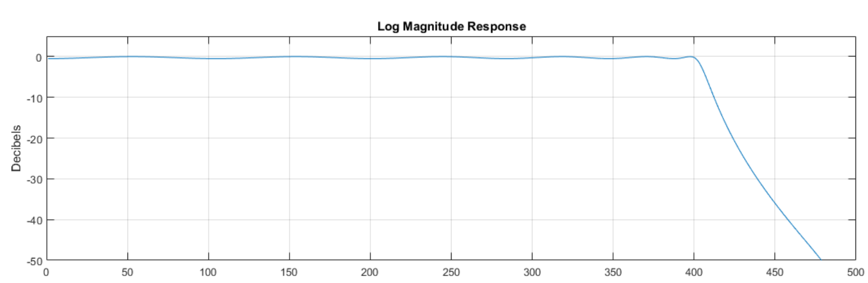

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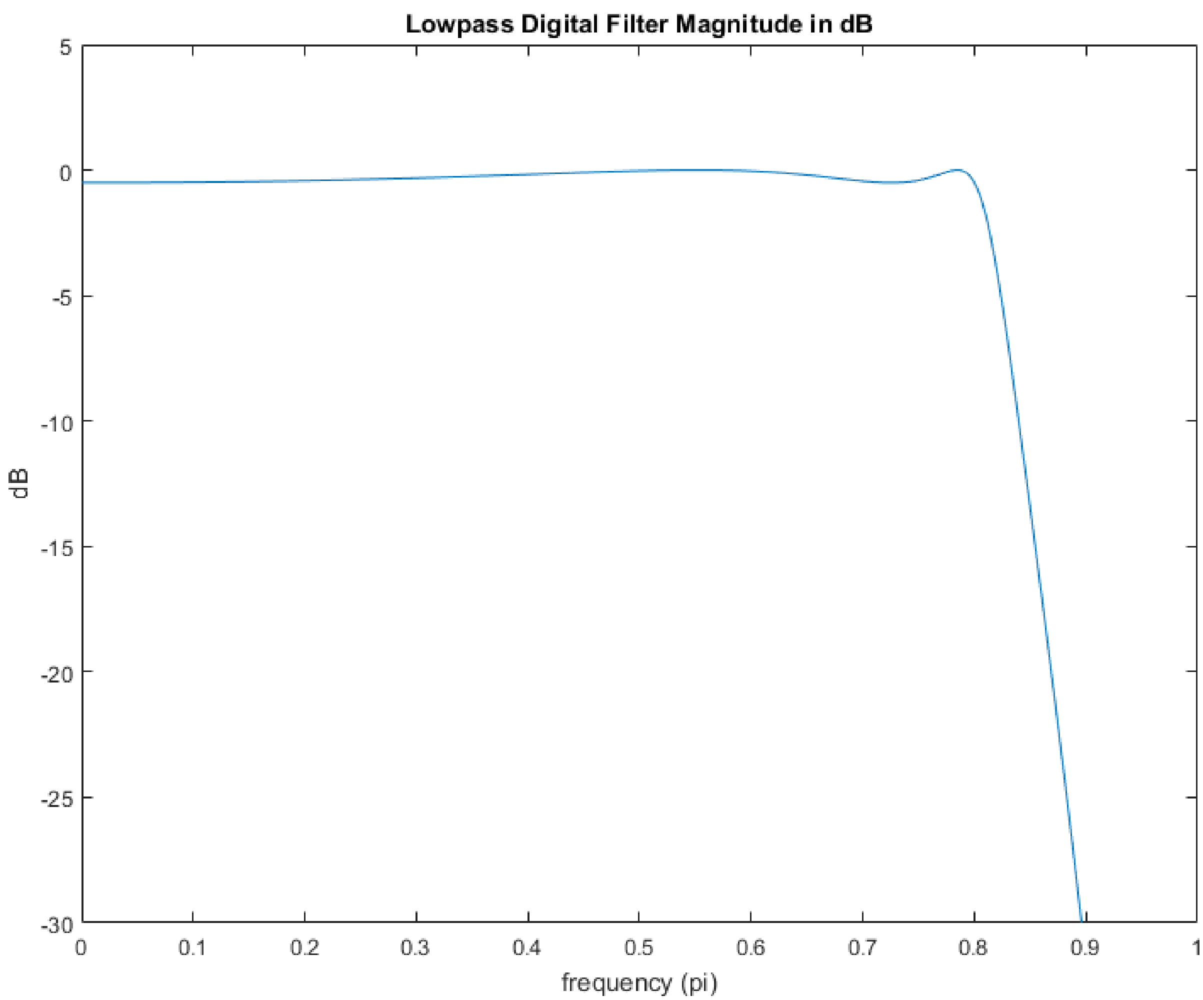
```
%% Question 2
% Bilinear Transform
% Initialize
Op = (2/T(1))*tan(wp/2);
Os = (2/T(1))*tan(ws/2);

% Build cheb filter and bilinear transformation
[cs, ds] = afd_chb1(Op, Os, Rp, As);
[b, a] = bilinear(cs, ds, T(1));
[dbl,magl,phal,grdl,w] = freqz_m(b,a);

% Plots
figure;
plot(w/pi,dbl); title('Lowpass Digital Filter Magnitude in dB');
xlabel('frequency (pi)'); ylabel('dB'); axis([0 1 -30 5]);
figure; subplot(2, 1, 1); plot(impulse(tf(b, a))); title('Digital Impulse')
xlabel('time (n)'); ylabel('Amplitude');
subplot(2, 1, 2); plot(impulse(tf(cs, ds))); title('Analog Impulse')
xlabel('time (t)'); ylabel('Amplitude');
```



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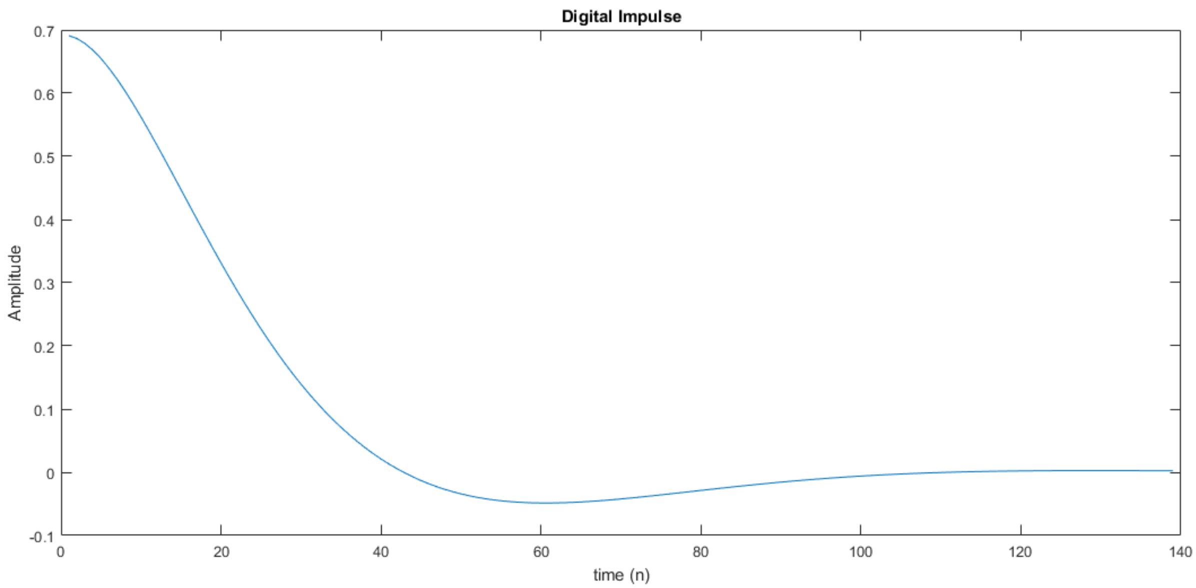

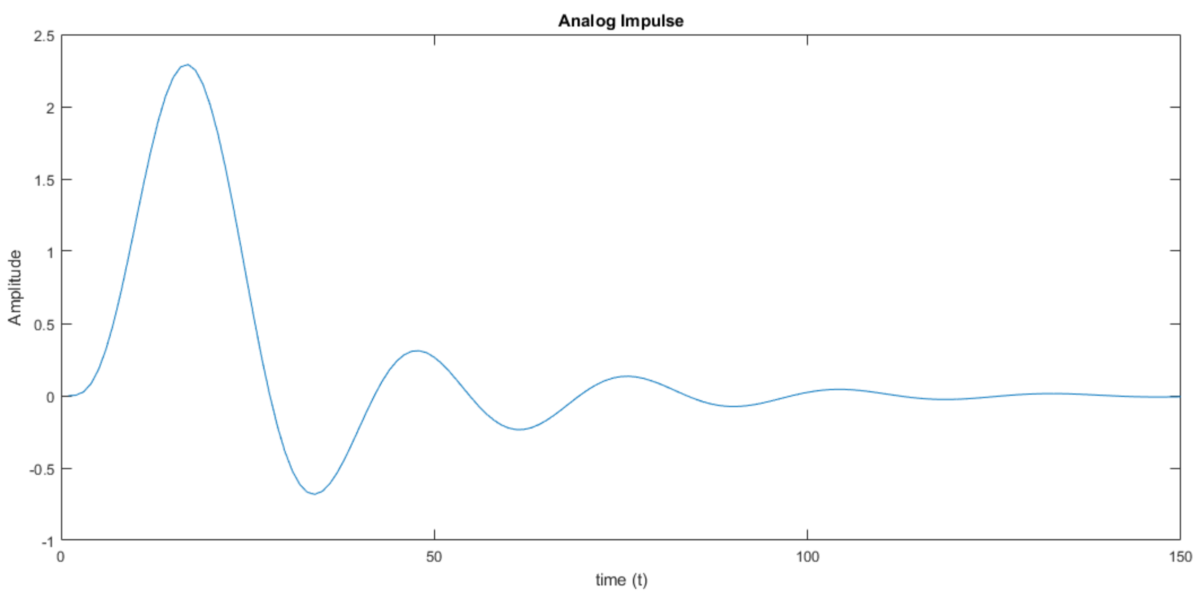

Compared to the analog impulse response, the digital one seems to be missing peaks. I suppose this may be due to the sampling time being too slow such that certain peaks are missed. It almost looks like the digital version is a smoother version of the analog equivalent.

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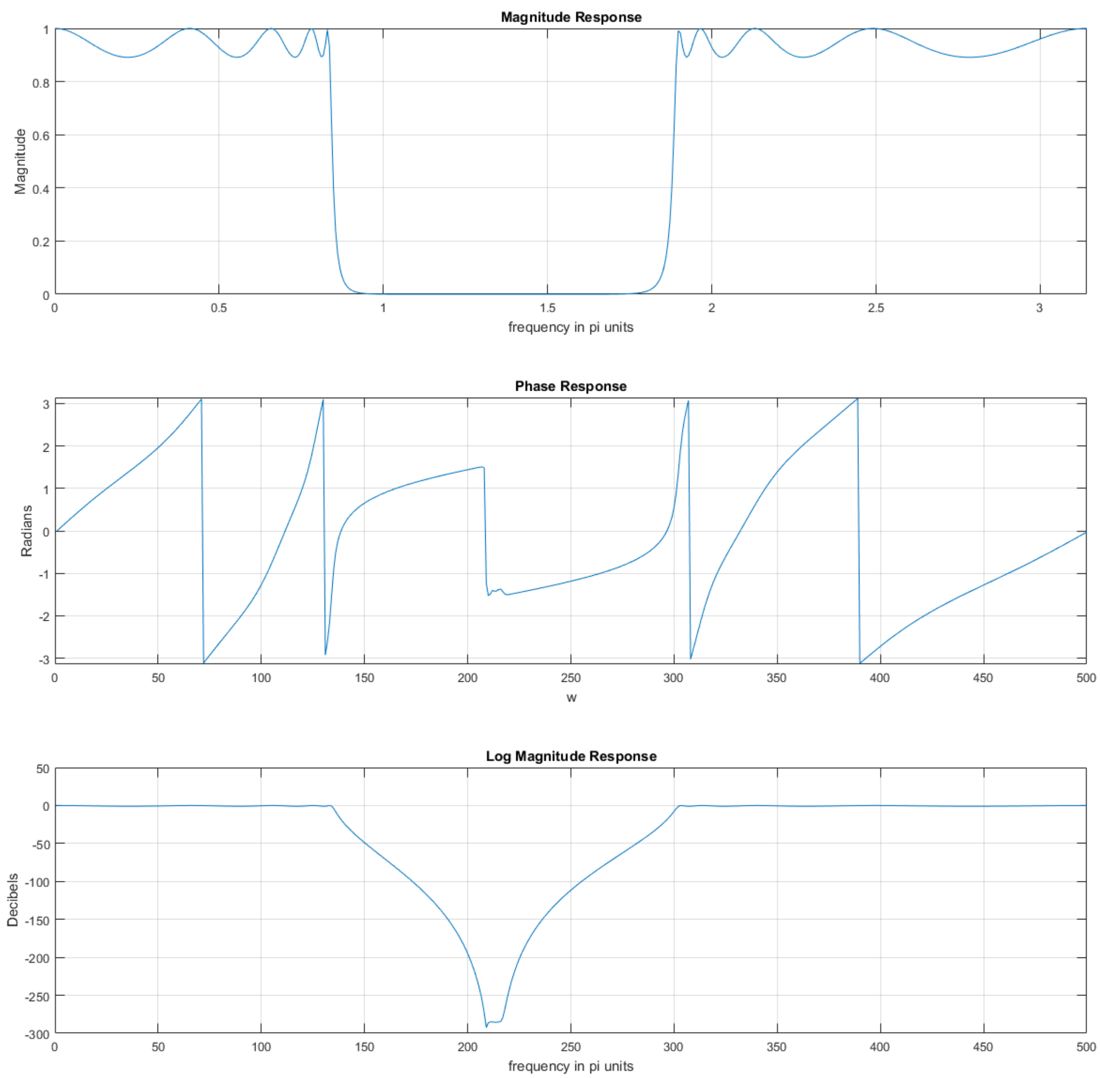
```
%% Question 3
% Initialize
w1p = 0.2*pi; w1s = 0.3*pi;
w2s = 0.7*pi; w2p = 0.8*pi;
w0 = (w1s + w2s)/2; bw = w2p - w1p; % bandwidth and center
Rp = 1; As = 50;
% Build cheb filter
[N, Wc] = cheb1ord([0.2 0.8], [0.3 0.7], Rp, As, 's');
[Z, P, K] = cheb1ap(N, Rp);
[num,den] = zp2tf(Z,P,K);
[numt, dent] = lp2bs(num, den, w0, bw);
% Bilinear transformation
[nt, dt] = bilinear(numt, dent, 1);
[db,mag,pha,grd,w] = freqz_m(nt,dt);
% Plot
figure;
subplot(3,1,1); plot(w, mag); axis([0 pi 0 1]);
title('Magnitude Response'); grid;
xlabel('frequency (pi)'); ylabel('Magnitude');
subplot(3,1,2); plot(pha); axis([0 500 -pi pi]);
title('Phase Response'); grid
xlabel('w'); ylabel('Rad')
subplot(3,1,3); plot(db); grid; axis([0 500 -300 50]);
title('Log Magnitude Response'); xlabel('frequency (pi)');
ylabel('dB');
```



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(4) $P_1 = -3 \quad P_2 = -5 \quad q = -8 \quad H(j0) = 1 \quad F_s = 10$

$T = 0.1$

a) $H(s) = \frac{s+8}{(s+3)(s+5)} = \frac{A}{s+3} + \frac{B}{s+5} = \frac{5/2}{s+3} - \frac{3/2}{s+5}$

Impulse Invariance

$A \rightarrow -3/2 \quad B \rightarrow 5/2$

$H(z) = \frac{5/2}{1-e^{-0.3}z^{-1}} - \frac{3/2}{1-e^{-0.5}z^{-1}} \rightarrow \boxed{\frac{1 - 0.4z^{-1}}{1 - 1.347z^{-1} + 0.45z^{-2}}}$

b) $H(s) = \frac{s+8}{(s+3)(s+5)} = \frac{s+8}{s^2+8s+15} \quad \left[H(z) = H\left(s = \frac{2}{T}\left(\frac{z-1}{z+1}\right)\right)\right]$

Bilinear Transform

$\frac{2}{T} = 20$

let $\lambda = 20\frac{1-z^{-1}}{1+z^{-1}} \quad H(z) = H(s=\lambda) = \frac{\lambda + 8}{\lambda^2 + 8\lambda + 15}$

Simplify the expression by multiplying $\frac{(1+z^{-1})^2}{(1+z^{-1})^2}$

$$\boxed{H(z) = \frac{28 + 16z^{-1} - 12z^{-2}}{575 - 772z^{-1} + 255z^{-2}}}$$

could maybe simplify more