CPE381 HW4
Christopher Bero

P1

```
% HW4 - P1
% Christopher Bero

clear all;

syms s;

% H1(s)
numerator=((s-1)*(s-(1+pi))*(s-(1-pi)));
denominator=((s+1)*(s-(-1+pi))*(s-(-1-pi)));
fig1=figure;
magnitudeResponse(numerator, denominator, fig1);

% H2(s)
numerator=((s-pi)*(s+pi));
denominator=((s+1)*(s-(-1+pi))*(s-(-1-pi)));
fig2=figure;
magnitudeResponse(numerator, denominator, fig2);

% H3(s)
numerator=(s-1);
denominator=((s+1)*(s-(-1+pi))*(s-(-1-pi)));
fig3=figure;
magnitudeResponse(numerator, denominator, fig3);
```

magnitudeResponse()

```
function [ ] = magnitudeResponse( numerator , denominator, fig )
% Helper function for CPE381 homework #4
% Expected input format: un-tiered polynomial: (s-1)*(s-(z))*(s-(-
z))

% expand() to break equation into polynomial form
% coeffs() to pull just coefficients from the equation
% double() to turn syms matrix back into numerical form
% roots() to calculate the roots of the polynomial,
%       which are plotted with splane()

% Sections adapted from ex5_18.m

syms s;

numerator_poly=fliplr(double(coeffs(expand(numerator),s)));
denominator_poly=fliplr(double(coeffs(expand(denominator),s)));

%n=roots(numerator_poly)
%d=roots(denominator_poly)

n=numerator_poly;
d=numerator_poly;
```

```
wmax=50;
[w,Hm,Ha]=freqresp_s(n,d,wmax);
figure(fig);
subplot(211)
plot(w,Hm)
axis([0 wmax 0 1.1*max(Hm)])
ylabel('|H(j \omega)|')
grid
xlabel('\omega')
title(' Magnitude response')
subplot(212)
plot(w,Ha)
axis([0 wmax 1.1*min(Ha) 1.1*max(Ha)])
ylabel('< H(j \omega)')
xlabel('\omega')
title(' Phase response')
grid
%subplot(223)
%splane(n,d)
%title('Poles/Zeros')
%grid
```

P6

```
X=[1 zeros(1,4)];
B=ones(1,5);
A=ones(1,5)/5;
y=filter(A,B,X);
x=[0:1:4];
stem(x,y);
```

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1. For a $H(s)$, given K, p_k, z_i.
Know
$$H(s) = K \cdot \left(\frac{s - z_i}{s - p_k} \right)$$
Using script "p1" in Matlab,

a $H_1(s)$: $K = 1$; $p = -1, -1+\pi, -1-\pi$; $z = 1, 1+\pi, 1-\pi$

Numerator: $(s-1)(s-(1+\pi))(s-(1-\pi))$
Denominator: $(s+1)(s-(-1+\pi))(s-(-1-\pi))$
- Is an "all-pass" filter.

a $H_2(s)$: $K = 1$; $p = -1, -1+\pi, -1-\pi$; $z = \pi, -\pi$

Numerator: $(s-\pi)(s+\pi)$
Denominator: $(s+1)(s-(-1+\pi))(s-(-1-\pi))$
- Is a notch filter.

a $H_3(s)$: $K = 1$; $p = -1, -1+\pi, -1-\pi$; $z = 1$

Numerator: $(s-1)$
Denominator: $(s+1)(s-(-1+\pi))(s-(-1-\pi))$
- Is a band pass filter.

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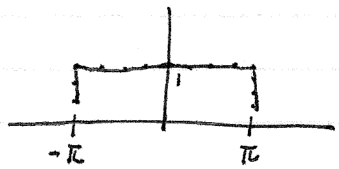
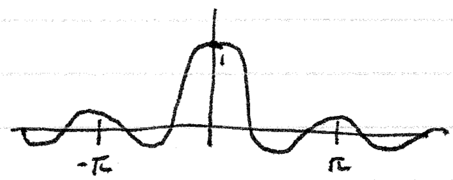
2. a) $h(t) = \sin(t)/t$.

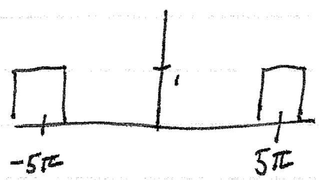
f:

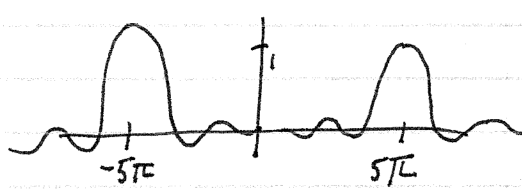


t:



b)





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3. 12-bit ADC, $V_{R-} = 0.5V$, $V_{R+} = 2.5V$

a) Quantization Step: $(V_{R+} - V_{R-})/(2^n - 1)$

$(2.5V - 0.5V)/(4095) = \boxed{0.0004884V} = \Delta$

b) $V_{R-} + (Val \cdot \Delta) = V_{in} \Rightarrow Val \cdot \Delta = V_{in} - V_{R-}$

$Val = (V_{in} - V_{R-})/\Delta$

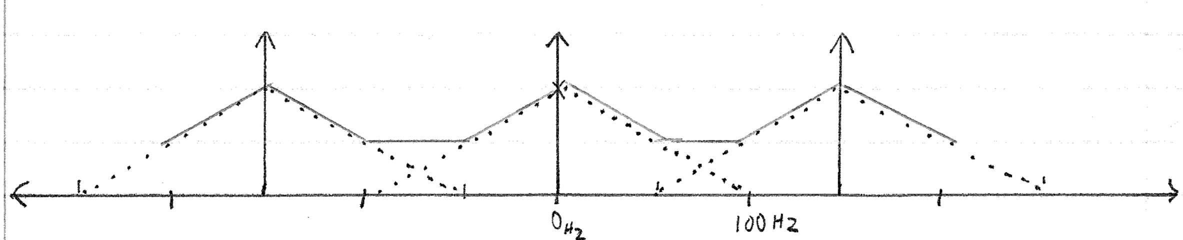
$(2.2V - 0.5V)/0.0004884V = \boxed{3480}$

c) $0.4V < 0.5V_{R-}$, $Val = \boxed{0}$

d) $3V > V_{R+}$, $Val = \boxed{4095}$.

4. $\Omega_{max}: 100 Hz$; $F_s = 150 Hz$

Sampled Signal:



Because $F_s = 150 Hz \not\geq 2 \cdot \Omega_{max}$, Nyquist Conditions are not met and the sampled signal is distorted.

5. 12 or 16 bit ADC; $f_m = 5KHz$; Range: 2.5V

☐ Determine sampling period T_s.

- $f_s = 2 \cdot f_m = 10KH_z$ minimum to satisfy Nyquist Criteria
- $T_s = 1/f_s = 0.0001s$

☐ For 12 bit ADC:

- $\Delta = 2.5V/4095 = 0.000610$
- Quantization Error: $\emptyset \leq \varepsilon(nT_s) \leq \Delta$

☐ For 16 bit ADC:

- $\Delta = 2.5V/65535 = 0.000038$
- Quantization Error = $\emptyset \leq \varepsilon(nT_s) \leq \Delta$

☐ Testing with a value from the high end of a given viable range $V_{R-} = 0V$ $V_{R+} = 2.5V$:

- 12 bit error: $((\Delta)/2.5V) \times 100\% = 0.024\%$
- 16 bit error: $((\Delta)/2.5V) \times 100\% = 0.002\%$

☐ Going from a 12 bit to a 16 bit ADC results in more than a magnitude of order reduction in error.

$$y[n] = 0.2 \cdot y[n-2] + x[n]$$

6.

a) $y[n] = h[n] = 0, \quad n < 0 \; ; \quad x[n] = \delta[n]$

$$y[n] = 0.2 \cdot y[n-2] + x[n]$$
$$y[n-2] = 0.2 \cdot y[n-4] + x[n-2]$$
$$y[n] = 0.2\,[0.2 \cdot y[n-4] + x[n-2]] + x[n]$$
$$= 0.04 \cdot y[n-4] + (x[n-2] + x[n])$$
$$y[0] = 0.04 \cdot y[-4] + (x[-2] + x[0])$$

$$y[n] = \sum_{k=0}^{n} 0.2^k \cdot x[n-k] \qquad n \geq 0$$

$$h[n] = \sum_{k=0}^{n} 0.2^k \cdot x[n-k] \qquad n \geq 0$$

b) $h[0] = 0.2 \cdot \cancel{h[-2]}^{\,0} + \cancel{\delta[0]}^{\,1} = \cancel{0.2}^{\,0} + 1$

$h[1] = 0.2 \cdot h[-1] + \delta[1] = 0 + 0$

$h[2] = 0.2 \cdot h[0] + \delta[2] = \cancel{0.2^2} + 0.2$

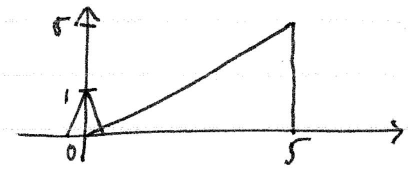
$h[3] = 0.2 \cdot h[1] + \delta[3] = 0$

$h[4] = 0.2 \cdot h[2] + \delta[4] = 0.2^2$

$$h[n] = \cancel{\sum_{k=0}^{n}} \; 0.2^n \quad \text{for } n \in [\text{Even Numbers}]$$

$$h[n] = \emptyset \quad \text{for } n \in [\text{Odd Numbers}]$$

7. a) $h[n] = 0 + \delta[n-1] + 2\delta[n-2] + 3\delta[n-3]$
$+ 4\delta[n-4] + 5\delta[n-5].$



b) for no $n<0$ is $h[n] \neq 0$, is not causal.
Does not damp, is not stable.

d) $h[5] = 5$