EE 311 Signals and Systems Hwk_10

I.- Design a notch filter that meets the following specifications:

• It eliminates 100 Hz.

• $|h(t)| \leq 0.001$ **for** $t > 0.5$ **s.**

Use the following code to plot the resulting impulse and frequency responses.

```
clear;f=[0:0.01:200];w=j*2*pi*f;a=21;
Z=[j*2*pi*100 -j*2*pi*100];P=Z-a; N=poly(Z);D=poly(P);H=polyval(N,w)./polyval(D,w);
[R1 P1 K1]=residue(N,D);t=[.5:0.0001:.5999];h=real(R1.*exp(P1*t)); subplot(211),plot(f,
```

Questions:

1) what is a?

how can it be found?

2) Determine the expression for the Transfer Function.

II. What does the filter, whose code is below do? What type of filter is it?

```
clear;f=[0:0.01:600];w=j*2*pi*f;a=25; Z=j*2*pi*[-500:100:500]';P=Z-a;
N=poly(Z);D=poly(P);H=polyval(N,w)./polyval(D,w);
[R1 P1 K1]=residue(N,D);t=[.5:0.0001:.5999];h=real(R1.*exp(P1*t));
subplot(211),plot(f,abs(H)),subplot(212),plot(t,h)
```

Determine the expression for the Transfer Function.

III. Design a Butterworth lowpass filter that meets the following two specifications:

(1) $|H(\omega)| = 0.9$ **at 10 Hz and (2)** $|H(\omega)| = 0.1$ **at 28 Hz**

Compute the following:

(a) The order N **and cutoff frequency** ω_c

(b) The locations of the poles

(c) The transfer function $H(s)$

(d) Plot the magnitude and phase responses

Hint:

The squared gain of a Butterworth filter of order N with cutoff f_c Hz is

$$|\mathbf{H}(2\pi f)|^2 = 1/[1 + (f/f_c)^{2N}].$$

IV. Problem 6.73

What does aliasing *sound* like? Load the file P6.73.mat from the S^2 website. This is a speech signal (a single sentence) sampled at 24000 samples/s.

(a) Listen to the signal using

```
load P6.73.mat; soundsc(X,24000). %Describe it
```

(b) Plot the one-sided magnitude spectrum from 0 to 8 kHz using

```
N=length(X)/3;F=linspace(0,8000,N);
FX=abs(fft(X));plot(F,FX(1:N))
```

(c) Repeat (a) and (b) after reducing the sampling rate to 6000 samples/s. Do this by keeping only every fourth sample and discarding the other three samples.

(d) Use

```
Y=X(1:4:end);soundsc(Y,6000). %Describe it. It should sound different.
```

(e) Plot the one-sided magnitude spectrum of the signal in (c) from 0 to 3 kHz using

```
N=length(Y)/2;F=linspace(0,3000,N);
FY=4*abs(fft(Y));plot(F,FY(1:N))
```

(f) Compare (note differences) answers to (a) and (c), and to (b) and (d).

V. Signal $x(t) = cos(14\pi t) - cos(18\pi t)$ is sampled at 16 sample/s. The result is passed through an ideal brick-wall lowpass filter with a cutoff frequency of 8 Hz.

Compute and sketch the spectrum of the output signal.