EE110B Lab 6

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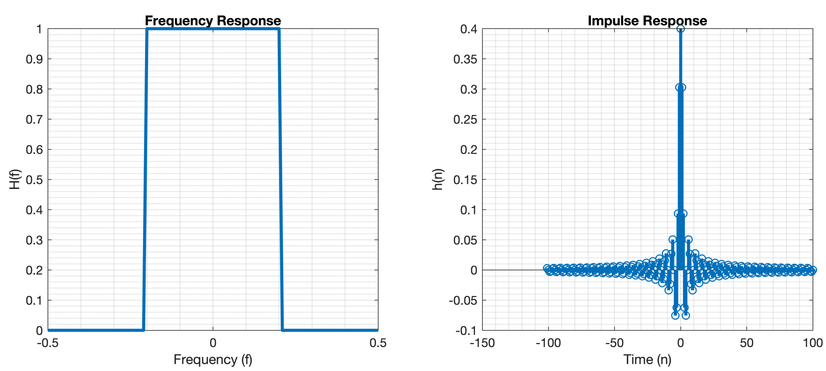
1) First, determine the analytical form of $h[n]$ by performing the inverse DTFT of $H(f)$.

```
n = -101:1:100;
f_c = 0.2;
f = -0.5:0.01:0.5;
H_f = zeros(1, length(f));
H_f(-0.2 <= f) = 1;
H_f(f> 0.2) = 0;

h_n = sin(0.4*pi*n)./(n*pi);
h_n (n==0) = 0.4;

fig1 = figure(1); fig1.Position = [100 100 800 300];
subplot(1,2,1)
plot(f,abs(H_f), 'LineWidth',2.5);
xlabel('Frequency (f)');
ylabel('H(f)');
title('Frequency Response');
grid on
grid minor
subplot(1,2,2)
stem(n,h_n,'LineWidth',2.5);
xlabel('Time (n)');
ylabel('h(n)');
title("Impulse Response")
grid on
grid minor
```



2) Second, compute $g[n] = h[n - n_o]w[n]$ where

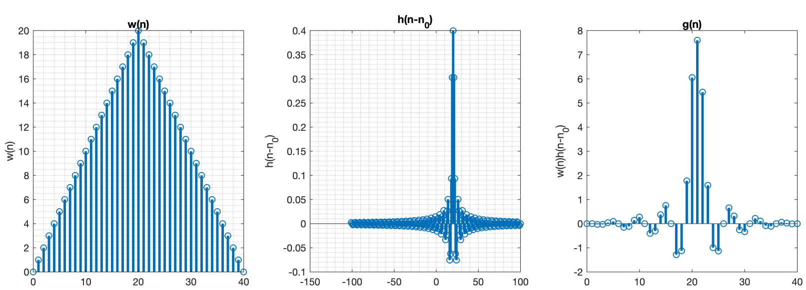
$$w[n] = \begin{bmatrix} n & 0 \le n \le n_o \\ 2n_o - n & n_o \le n \le 2n_0 \end{bmatrix}$$

```
n_0 = 20;
w_n = [0:1:n_0 n_0-1:-1:0];
h_n_n_0 = [sin(0.4*pi*(n-n_0))./((n-n_0)*pi)];
h_n_n_0(n == n_0) = 0.4;
g_n = w_n.*h_n_n_0(101:101+2*n_0);

fig2 = figure(2);
fig2.Position = [100 100 1000 300];
subplot(1,3,1)
stem([0:1:2*n_0],w_n,'LineWidth',2.5);
xlabel('Time (n)');
ylabel('w(n)');
title('w(n)');
grid on
grid minor

subplot(1,3,2)
stem(n,h_n_n_0, 'LineWidth',2.5);
xlabel('Time (n)');
ylabel('h(n-n_0)');
title('h(n-n_0)');
grid on
grid minor

subplot(1,3,3)
stem(0:2*n_0,g_n,'LineWidth',2.5);
xlabel('Time (n)');
ylabel('w(n)h(n-n_0)');
title('g(n)')
```

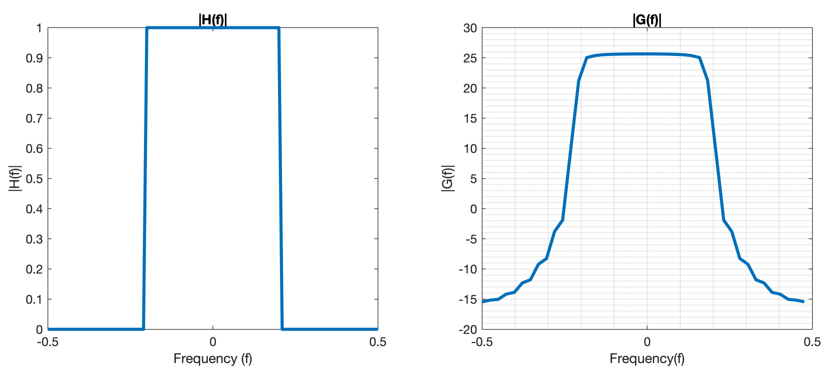


3) Choose different values for n_0 (such as 20 and 30) and compute and plot the amplitude specturm $|G(f)|$ of g_n for $-0.5 < f < 0.5$

4) Compare $|G(f)|$ with $|H(f)|$ and discuss the effect of n_o

```
G_f = fftshift(fft(g_n));
f_g = -0.5:1/length(G_f):0.5-(1/length(G_f));
fig3 = figure(3);
fig3.Position = [100 100 800 300];
subplot(1,2,1)
plot(f,abs(H_f), 'LineWidth',2.5);
xlabel('Frequency (f)');
ylabel('|H(f)|');
title('|H(f)|')

subplot(1,2,2)
plot(f_g,20*log10(abs(G_f)),'LineWidth',2.5);
xlabel('Frequency(f)');
ylabel('|G(f)|');
title('|G(f)|');
grid on
grid minor
```

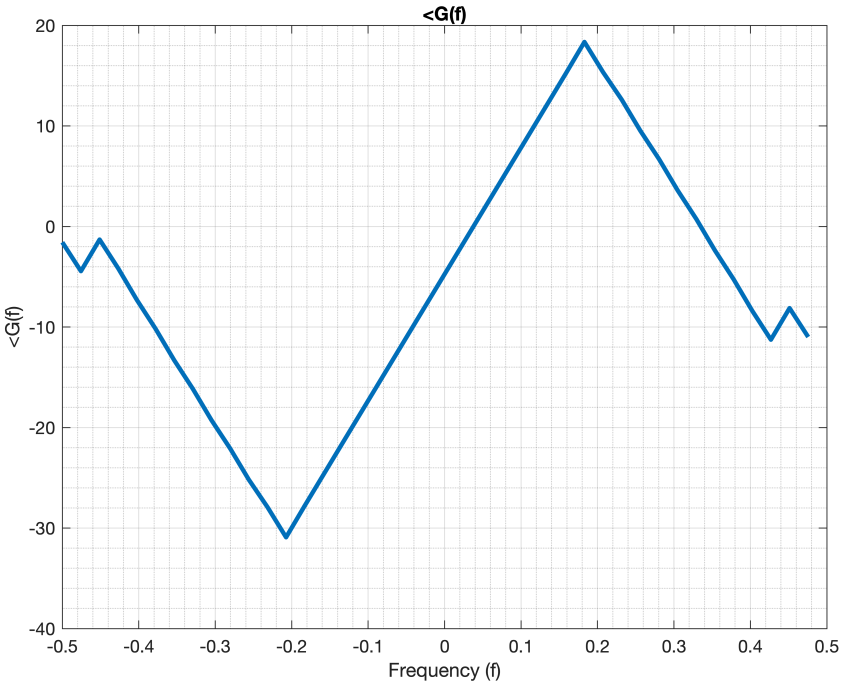


The effect of n_0 is as follows the bigger the value the more coefficents. Therefore, the filter becomes less ideal. A small value of n_0 produces a better filter

5) Compute and plot the phase spectrum $\angle G(f)$ of g_n

```
figure
plot(f_g,unwrap(angle(G_f)),'LineWidth',2.5);
grid on
grid minor
xlabel('Frequency (f)');
```

```
ylabel('<G(f)');
title('<G(f)');
```

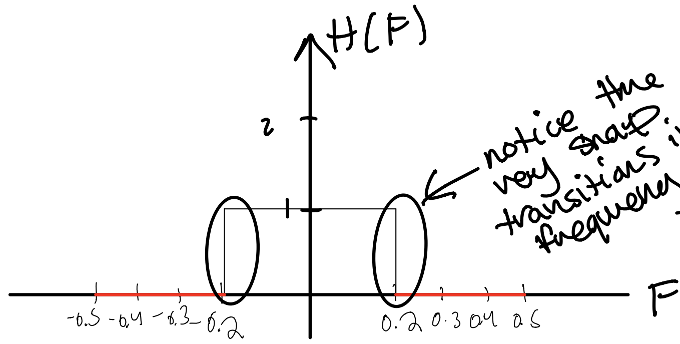


6) What do you expect at the output

I'm sorry I just did not do my best on this lab. This week has been trying I will do better next time.

①

$$H(F) = \begin{cases} 1, & |F| \le 0.2 \\ 0, & 0.2 < |F| \le 0.5 \end{cases}$$



notice the very sharp transitions in the frequency response

* the result is an unlimited amount of samples in the time domain * this is not practical cannot have a filter with infinite coefficients

① h(n)

$$h(n) = F^{-1}[H(F)]$$

$$h(n) = \int_{-0.5}^{0.5} H(F) e^{j2\pi fn} \, df$$

$$h(n) = \int_{-0.2}^{0.2} (1) e^{j2\pi fn} \, df$$

$$= \frac{1}{j2\pi n} e^{j2\pi fn} \Big|_{-0.2}^{0.2} \Rightarrow \frac{1}{j2\pi} \underbrace{\left[e^{j2\pi 0.2n} - e^{-j2\pi 0.2n} \right]}_{\Downarrow \; 2j\sin(2\pi 0.2n)}$$

$$h(n) = \frac{1}{\cancel{j2}\pi n} \cdot \cancel{2j} \sin(2\pi 0.2n)$$

$$h(n) = \frac{1}{\pi n} \sin(2\pi 0.2n)$$

Real sinc function

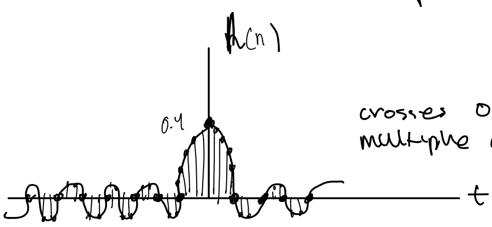
* $\text{sinc}(x) = \frac{\sin(\pi x)}{\pi x}$

* So that MATLAB code runs correctly we need to find the value of the sinc function at 0 analytically

$$\lim_{n \to 0} \frac{\sin(0.4\pi n)}{\pi n} \qquad \lim_{n \to 0} h(n) = 0.4$$

$$\lim_{n \to 0} \sin(n) = n$$

$\boxed{inc(x) = \frac{\sin(\pi x)}{\pi x}}$ ⟵ mathematical form for the ideal low pass filters impulse response



crosses 0 by integer multiple of T

• Thus one can see that as you move away from the origin the amplitude decreases

$h(n-n_0) \rightarrow$ shifted to the right by n_0

The purpose of this lab is as such:

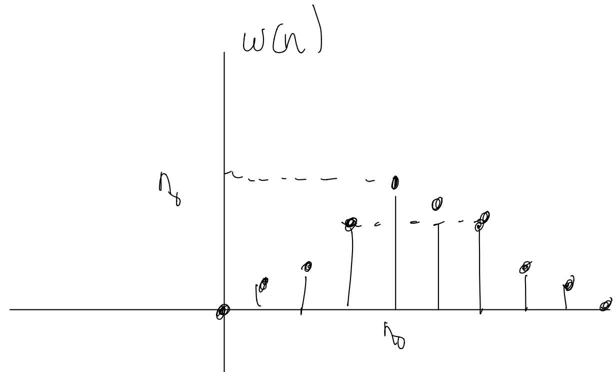
Starting from an ideal filter, how can we change it to make it more practical.

(2) $g[n] = h[n-n_0]\, w[n]$

where

$$w[n] = \begin{cases} n, & 0 \leq n \leq n_0 \\ 2n_0 - n, & n_0 \leq n \leq 2n_0 \end{cases}$$

w(n)



$0.4\pi n = K\pi$

$K = \frac{2}{5} \times n$

length of triangle $2n_0 + 1$ = # of samples