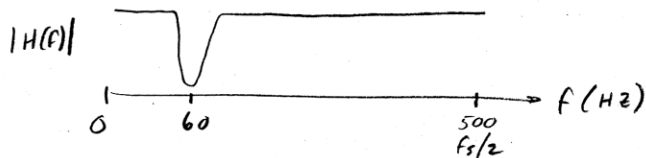


EE432 In-class exercise-11/04/11

Example 9.14. A signal that was sampled at 1 kHz has a 60 Hz disturbance. Design an FIR band stop filter to remove the disturbance. Your final answer will be the equation for the impulse response of the filter, $h[n]$.

- The band stop filter will be a combination of a LPF and a HPF, with a frequency response that looks like:



- let the stop band edges be 40 Hz for the LPF, and 80 Hz for the HPF.
- Use a Hamming window to get a stop band attenuation > 55 dB
 - use $N = 151$ coefficients to give a narrow transition width

$$N = \frac{3.44 f_s}{TW}, \text{ so } TW = \frac{3.44 f_s}{N} = \frac{3.44 \cdot 1000}{151} = 23 \text{ Hz}$$

$$\text{- The window is } w[n] = 0.54 + 0.46 \cos\left(\frac{2\pi n}{150}\right), \quad -75 \leq n \leq 75$$

- Now determine the sinc function we will use for the LPF

- Desired LPF pass band edge is 40 Hz,

$$\text{so } f_1 = 40 \text{ Hz} + \frac{TW}{2} = 40 + 11.5 = 51.5 \text{ Hz}$$

$$\Omega_1 = \frac{2\pi f_1}{f_s} = 0.103\pi$$

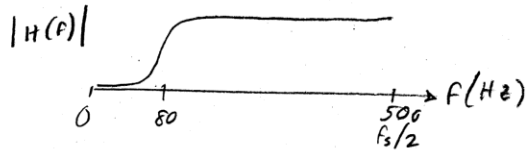
$$\text{so the digital sinc is } h_1[n] = \frac{\sin(n\Omega_1)}{n\pi} = \frac{\sin(0.103\pi n)}{n\pi}$$

- The LPF impulse response is

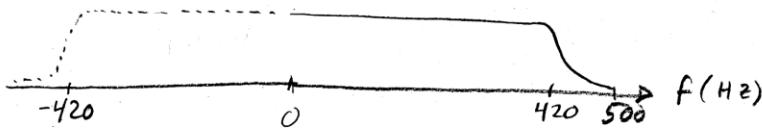
$$h_{LPF}[n] = h_1[n] w[n]$$

$$= \frac{\sin(0.103\pi n)}{n\pi} \left(0.54 + 0.46 \cos\left(\frac{2\pi n}{150}\right) \right), \quad -75 \leq n \leq 75$$

- The HPF has a pass band edge of 80 Hz, so its Freq response looks like:



- so The Associated LPF had a passband edge at $f_s/2 - 80 = 500 - 80 = 420$ Hz



Note: if you multiply this LPF's impulse response by a cosine of 500 Hz, its freq response shifts it up to be centered at 500 Hz which is what I want.

- For the Associated LPF, desired pass band edge is 420 Hz.

$$\text{so } f_1 = 420 + \frac{TW}{2} = 420 + \frac{23}{2} = 433.5 \text{ Hz}$$

$$\Omega_1 = \frac{2\pi f_1}{F_s} = \frac{2\pi \cdot 433.5}{1000} = 0.863\pi$$

- For the associated LPF, the digital sine is

$$h_1[n] = \frac{\sin(0.863\pi n)}{n\pi}$$

- The window will be the same as used before, 151-term Hamming window

$$w[n] = 0.54 + 0.46 \cos\left(\frac{2\pi n}{150}\right) \quad -75 \leq n \leq 75$$

- The impulse response for the HPF is

$$h_{\text{HPF}}[n] = h_1[n] w[n] \cos(n\pi)$$

$$= (-1)^n \frac{\sin(0.863\pi n)}{n\pi} \left(0.54 + 0.46 \cos\left(\frac{2\pi n}{150}\right)\right)$$

- FOR the BSF, $h_{\text{BSF}}[n] = h_{\text{LPF}}[n] + h_{\text{HPF}}[n]$, $-75 \leq n \leq 75$

- Shift $h_{\text{BSF}}[n]$ right by 75 to make causal.

