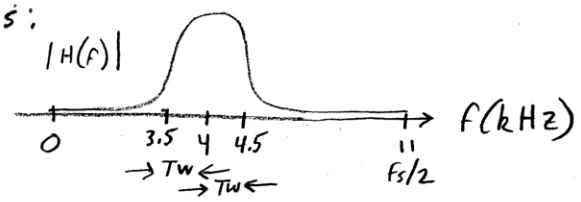
EE432 In-class exercise-11/02/11

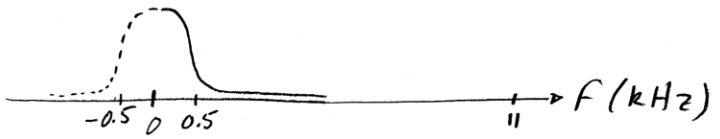
Example 9.10-modified. Design an FIR BPF for a system with the following specifications. Your final answer will be the equation for the impulse response of the filter, h[n].

Center frequency of filter: 4 kHz
Pass band edges at: 3.5 kHz and 4.5 kHz
Transition widths: 500 Hz
Stop band attenuation: 80 dB
Sample frequency: 22 kHz

Solution: The filter will have a freq response that looks like this:



- so the Associated LPF would have a freq response like this:



multiplying this LPF's impulse response by a cosine of freq 4kHz will shift the LPF's freq response to be centered at 4kHz.

- Now design the LPF:

$$f_1 = 500 + \frac{Tw}{2} = 500 + \frac{500}{2} = 750\ Hz, \text{ so } \Omega_1 = 2\pi\frac{f_1}{f_s} = 0.06818\pi$$

- the digital sinc is $h_1[n] = \frac{\sin(n\Omega_1)}{n\pi} = \frac{\sin(0.06818\pi n)}{n\pi}$

- Stop band attenuation $> 80\ dB$, use a Kaiser window w/ $\beta = 8$

$$\#\text{ terms } N = \frac{5.25\, f_s}{Tw} = 5.25\,\frac{22000}{500} = \underline{231}$$

$$w[n] = \frac{I_o\left(\beta\sqrt{1-\left(\frac{2n}{N-1}\right)^2}\right)}{I_o(\beta)} = \frac{I_o\left(8\sqrt{1-\left(\frac{2n}{231}\right)^2}\right)}{I_o(8)}, \quad -115 \le n \le 115$$

- since center freq of cosine is 4 kHz ($= f_o$), Then

$$\Omega_o = \frac{2\pi f_o}{f_s} = 0.3636\pi$$

$\therefore\ h[n] = 2h_1[n]\, w[n] \cos(\Omega_0 n)$

$$= 2\,\frac{\sin(0.06818\pi n)}{n\pi}\;\frac{I_0\left(8\sqrt{1-\left(\frac{2n}{231}\right)^2}\right)}{I_0(8)}\cos(0.3636\pi n)$$

$$-115 \le n \le 115$$

After this $h[n]$ is computed, a right shift of 115 makes it a causal filter.