SYSC 4405 In-class Quiz 3A: Nov 14, 2011

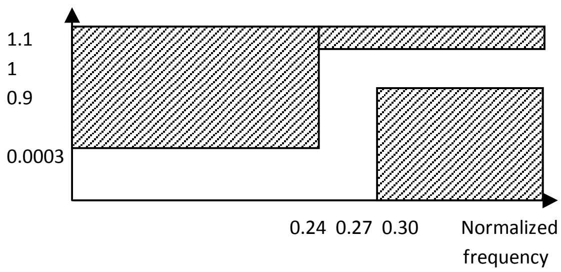
Question 1 (1 point): What is your name and student number?

Name: ___________________________________ Lab Section: ________________________

Student Number: ___________________________

Question 2 (4 points): A DSP system is sampled at T_s=100µs, you need to design a windowed high pass FIR filter, *h*[*n*], with the following attributes: Accept frequencies above 3000Hz (to within 10%) and reject frequencies below 2400Hz by at least .03%. Show the expression for a causal FIR filter h[n], including window function, ideal filter function, ω_c and length L.

T_s = 100uS → F_s = 10kHz



$\omega_a = \pi\,(.3+.24) = .54\pi$

$\omega_c = \pi - \omega_a = .46\pi$

Stop band spec = $-20\log_{10}(.0003)$

= 70.5dB → Blackman window

2.79/L = .06

L = 2.79/.06 = 46.5 → L=47

Window = .42+.5cos(π(n-47)/47)+.08cos(2π(n-47)/47)

$h_{HPIDEAL} = (-1)^{N-47}(0.46)\mathrm{sinc}(.46(n-47))$

H[n] = Window .* $h_{HPIDEAL}$

=(.42+.5cos(π(n-47)/47)+.08cos(3π(n-47)/47)) .* $(-1)^{N-47}(0.46)\mathrm{sinc}(.46(n-47))$

For n = 0:2L → n=0:94

some useful formulas

$$h_{LP}[n]=\frac{\omega_c}{\pi}sinc\left(\frac{\omega_c}{\pi}n\right),\ h_{LP}[n]=\frac{sin(\omega_c(n-L))}{\pi(n-L)},\ sinc(x)=\frac{\sin\pi x}{\pi x},$$

$$h_{HP}[n]=(-1)^n\frac{\omega_c}{\pi}sinc\left(\frac{\omega_c}{\pi}n\right)\ ,\ \omega_c=\pi-\omega_a$$

$$h_{BP}[n]=2\cos(n\omega_0)\frac{\omega_c}{\pi}sinc\left(\frac{\omega_c}{\pi}n\right)$$

Cosine based windows

$$W[n+L]=a_0+a_1\cos\left(\frac{\pi n}{L}\right)+a_2\cos\left(2\frac{\pi n}{L}\right)+a_3\cos\left(3\frac{\pi n}{L}\right)$$

Centre at *n=L* for FIR

Window name	Stop band Attenuation (dB)	Transition band width (/L)	a_0	a_1	a_2	a_3
Rectangular	20.8	0.46	1	0	0	0
Hann	43.9	1.56	0.5	0.5	0	0
Hamming	53.9	1.90	0.53836	0.46164	0	0
Blackman	75.3	2.79	0.42	0.5	0.08	0
Blackman-Nutall	112.7	4.09	0.3635819	0.4891775	0.1365995	0.0106411

SYSC 4405 In-class Quiz 3B: Nov 14, 2011

Question 1 (1 point): What is your name and student number?

Name: ___________________________________ Lab Section: ________________________

Student Number: ___________________________

Question 2 (4 points): A DSP system is sampled at T_s=200μs, you need to design a windowed low pass FIR filter, *h*[*n*], with the following attributes: Accept frequencies below 1000Hz (to within 10%) and reject frequencies above 1200Hz by at least .001%. Show the expression for a causal FIR filter h[n], including window function, ideal filter function, ω_c and length L.

T_s = 200uS → F_s = 5kHz

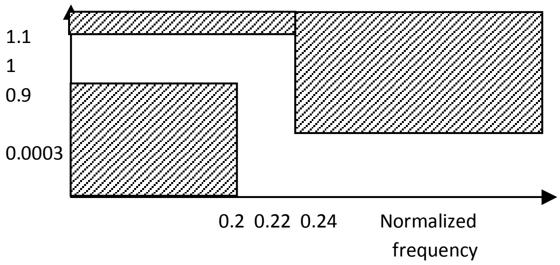
$\omega_c = \pi\,(.2+.24) = .44\pi$

Stop band spec = $-20\log_{10}(.00001)$

= 100dB → Blackman-Nutall window

4.09/L = .04

L = 4.09/.04 = 102.35 → L=103



Window = 0.3635819+0.4891775cos(π(n-103)/103)+0.1365995cos(2π(n-103)/103)+0.0106411cos(3π(n-103)/103)

$H_{LPIDEAL}$ = (0.44)sinc(.44(n-103))

H[n] = Window .* $h_{LPIDEAL}$

=(0.3635819+0.4891775cos(π(n-103)/103)+0.1365995cos(2π(n-103)/103)+0.0106411cos(3π(n-103)/103)).*(0.44)sinc(.44(n-103))

For n = 0:2L → n=0:206

some useful formulas

$$h_{LP}[n]=\frac{\omega_c}{\pi}sinc\left(\frac{\omega_c}{\pi}n\right),\ h_{LP}[n]=\frac{sin(\omega_c(n-L))}{\pi(n-L)},\ sinc(x)=\frac{\sin\pi x}{\pi x},$$

$$h_{HP}[n]=(-1)^n\frac{\omega_c}{\pi}sinc\left(\frac{\omega_c}{\pi}n\right)\ ,\ \omega_c=\pi-\omega_a$$

$$h_{BP}[n]=2\cos(n\omega_0)\frac{\omega_c}{\pi}sinc\left(\frac{\omega_c}{\pi}n\right)$$

Cosine based windows

$$W[n+L]=a_0+a_1\cos(\frac{\pi n}{L})+a_2\cos(2\frac{\pi n}{L})+a_3\cos(3\frac{\pi n}{L})$$

e at n=L for FIR

Window name	Stop band Attenuation (dB)	Transition band width (/L)	a_0	a_1	a_2	a_3
Rectangular	20.8	0.46	1	0	0	0
Hann	43.9	1.56	0.5	0.5	0	0
Hamming	53.9	1.90	0.53836	0.46164	0	0
Blackman	75.3	2.79	0.42	0.5	0.08	0
Blackman-Nutall	112.7	4.09	0.3635819	0.4891775	0.1365995	0.0106411