The University of Queensland
School of Information Technology & Electrical Engineering

COMS3100/7100 Introduction to Communications
Semester 1, 2010

Tutorial 5

These exercises relate to material in Lectures 13, 14 and 15

Question 1: Consider the chopper-sampled waveform given by

$$x_s(t) = c_0 x(t) + 2c_1 x(t)\cos \omega_s t + 2c_2 x(t)\cos 2\omega_c t + \cdots$$

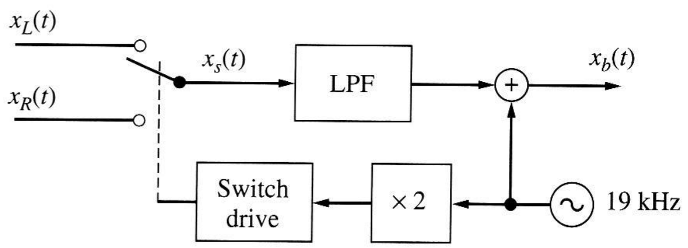
with $\tau = T_s/2$, $f_s = 100$Hz, and $x(t) = 2 + 2\cos 2\pi 30t + \cos 2\pi 80t$. Draw and label the one-sided line spectrum of $x_s(t)$ for $0 < f < 300$ Hz. then find the output waveform when $x_s(t)$ is applied to an ideal LPF with $B = 75$ Hz.

Question 2: The usable frequency range of a certain amplifier is f_l to $f_\ell + B$, with $B >> f_\ell$. Devise a system that employs bipolar choppers and allows the amplifier to handle signals having significant dc content and bandwidth $W << B$.

Question 3: The baseband signal for FM stereo is

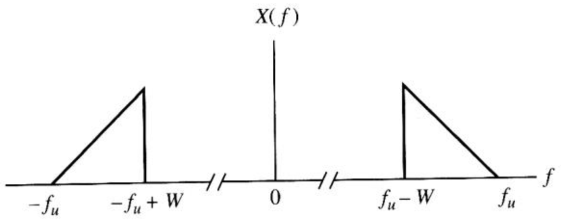
$$x_b(t) = [x_L(t) + x_R(t)] + [x_L(t) - x_R(t)]\cos \omega_s t + A\cos \omega_s t/2$$

with f_s=38kHz. The chopper system in figure below is intended to generate this signal. The LPF has gain K_1 for $|f| < 15$kHz, gain K_2 for $23 < |f| < 53$kHz, and rejects $|f| > 99$kHz. Use a sketch to show that $x_s(t) = x_L(t)s(t) + x_R(t)[1 - s(t)]$, where $s(t)$ is a unipolar switching function with $\tau = T_s/2$. then find the necessary value of K_1 and K_2.



Question 4: A popular stereo decoder circuit employs transistor switches to generate $v_L(t)=x_1(t)-Kx_2(t)$ and $v_R(t)=x_2(t)-Kx_1(t)$ where K is a constant, $x_1(t)=x_b(t)s(t)$, $x_2(t)=x_b(t)[1-s(t)]$, $x_b(t)$ is the FM stereo baseband signal in **Question 3**, and s(t) is a unipolar switching function with $\tau=T_s/2$. (a)Determine K such that lowpass filtering of $v_L(t)$ and $v_R(t)$ yields the desired left- and right-channel signals.(b) what is the advantage of a simpler switching circuit that has K=0?

Question 5: Suppose $x(t)$ has the spectrum shown in figure below with f_u=25KHz and W=10kHz. Sketch $x_\delta(f)$ for f_s=60, 45 and 25kHz. Comment in each case on the possible reconstruction of x(t) from $x_\delta(t)$.



Question 6: The signal $x(t)=\text{sinc}^2\, 5t$ is ideally sampled at t=0,±0.1, ±0.2, …, and reconstructed by an ideal LPF with B=5, unit gain, and zero time delay. Carry out the reconstruction process graphically for $t \le 0.2$.

Question 7: A rectangular pulse with $\tau=2$ is ideally sampled and reconstructed using an ideal LPF with $B=f_s/2$. Sketch the resulting output waveform when T_s=0.8 and 0.4, assume one sample time is at the centre of the pulse.

Question 8: A W=15kHz signal has been sampled at 150kHz. What will be the maximum percent aperture error if the signal is reconstructed using a (a) ZOH, (b) FOH?

Question 9: A *W*=15kHz signal is sampled at 150kHz with a first-order Butterworth antialiasing filter. What will be the maximum percent aliasing error in the passband?

Question 10: What is the Nyquist rate to adequately sample the following signals (a)sinc(100t), (b)sinc^2 (100t), (c)$10\cos^3(2\pi t 10^5)$?

Question 11: Show how a PAM signal can be demodulated using a product detector. Be sure to describe frequency parameters for the LO and the LPF.