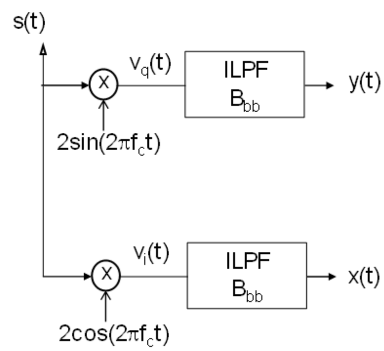
EECS 361
Homework #11

1. Section 5.12 & 5.13 & 5.14 Participation Activities
5.12.1: AM and DSB Spectra, with envelope detection.
5.12.2: DSB and AM.
5.13.1: FDM total bandwidth.
5.13.2: AM radio station bandwidth.
5.14.2: Sampling theory.

2. (Concept: Properties of double sideband suppressed carrier (DSC-SC) signals.)
Plot the time domains signal and magnitude spectrum and find the average transmitter power, in a double sideband suppressed carrier (DSC-SC) signal, $x_{\mathrm{DSB-SC}}(t)$ where $x_{\mathrm{DSB-SC}}(t)= 4\cos(2\,\pi f_m\, t)\cos(2\,\pi f_c\, t)$, here $f_m =$ 100 Hz and f_c=1 kHz. Hint: Use trigonometry identities to expand signals into a sum of cosines

3. (Concept: Properties of double sideband large carrier (DSC-LC) signals.)
Plot the time domains signal and magnitude spectrum and find the average transmitter power, in a double sideband large carrier (DSC-LC) signal, $x_{\mathrm{DSB-LC}}(t)$ where $x_{\mathrm{DSB-LC}}(t)= 4(1+0.8\cos(2\,\pi f_m\, t))\cos(2\,\pi f_c\, t)$, here $f_m =$ 100 Hz and f_c=1 kHz. Hint: Use trigonometry identities to expand signals into a sum of cosines.

4. (Concept: Quadrature modulation)
Let $s(t) = g(t)\cos(2\,\pi f_c\, t)+z(t)\sin(2\,\pi f_c\, t)$, g(t) and z(t) are lowpass signals with a bandwidth of B_{bb}. The signal s(t) is processed by the receiver shown below. The bandwidth of the ILPF is B_{bb}. Assume $f_c >> B_{\mathrm{bb}}$.



a. Find the signal $v_i(t)$ in the time and frequency domains.

Hint: Use trigonometry identities to expand signals into a sum of sines/cosines.

b. Find x(t) and y(t).

5. (Concept: The spectrum of a sampled signal is periodic)
The signal x(t) has a Fourier transform of X(f) and is band-limited to B_x Hz. The impluse sampling waveform is $\delta_{T_0}(t) = \sum_{k=-\infty}^{\infty} \delta(t - kT_s)$ where T_s = sample spacing in time and $f_s = \frac{1}{T_s}$ is the sample rate. The sampled signal in the time domain is $x_s(t) = x(t)\delta_{T_0}(t)$. Show that the spectrum $X_s(f)$ of a impulse sampled signal $x_s(t)$ is periodic.

6. (Concept: The Nyquist sampling rate is twice the signal bandwidth)
a. Let $y(t) = x(t)g(t)$ with $x(t)=\frac{30}{\pi}\mathrm{sinc}(30t)$ and $g(t)= \frac{50}{\pi}\mathrm{sinc}(50t)$, plot y(t).
b. Find the Nyquist sampling rate for y(t) Hint: see Homework 9 Problem 5
c. Make a stem plot of $y(kT_s)$ for k -5 to 5. Use the sampling interval $T_s = \frac{1}{26}$. Try to overlay the plot of y(t) with stem plot of $y_s(kT_s)$

7. (Concept: Sample rate must be greater than 2B)
Let $x(t) = 24\mathrm{sinc}(24\pi t)(1+2\cos(48\pi t))$
a. Plot x(t).
b. Plot X(f) (do the plot in f-Hz).
c. What is the highest frequency in Hz present in x(t)?
d. Sample x(t) at the Nyquist rate and plot the spectrum of the sampled signal.
e. What is the inverse Fourier Transform of the spectrum of the sampled signal?

f. The discrete time sampled signal $x(n\Delta t)$=x[n] where $\Delta t = \frac{1}{\text{Nyquist rate}}$.
The first sample is at t=0.
What are the values of the first 5 samples, i,e, x[n] for n=0...4?

8. (Concept: Aliasing)
Exercise 5.16.1

9. (Concept: Aliasing)
A signal x(t) = 500sinc$^2(\pi 500t)$ is sampled at a rate of 900 samples/sec. What portion of the spectrum can be recovered from the samples? What is the Nyquist rate for x(t)? Hint[Bsinc$^2(\pi B t) \longleftrightarrow \text{tri}\left(\frac{f}{B}\right)$]

10. (Concept: Sampling a non-band-limited signal, aliasing, and the benefit of oversampling)
A high fidelity audio signal has an spectrum of $X(f) = e^{\frac{-|f|}{14430}}$.

a. Plot $X(f)$. On your plot indicate that the 6dB bandwidth of X(f) which is about 10kHz
b. Assuming X(f) is band-limited to its 6dB bandwidth of 10k Hz, what is the Nyquist sampling rate for this signal.
c. Using the sampling rate from part b, plot the spectrum, $X_s(f)$, of the sampled signal, that is, plot $\sum_{k=-\infty}^{\infty} X(f - kf_s)$ for k= -4,-3,-2, -1, 0, 1, 2, 3, 4.

d. The reconstruction filter $H(f)$ is used to reconstruct the analog signal from the samples, $H(f)=\frac{1}{1+\left(\frac{f}{35000}\right)^2}$.
Plot $H(f)$.
e. Using the sampling rate from part b, the spectrum at the output of the reconstruction filter, is $Y(f)=X_s(f)H(f)$.
Define the reconstruction error as $|\, X(f) - Y(f) \,|$. Using the sampling rate from part b, plot the reconstruction error for k= -4,-3, -2, -1, 0, 1, 2, 3, 4

f. Using an oversampling ratio of 10, that is, use a sampling rate of ten times the sampling rate from part b, plot the reconstruction error.
g. Comment of the value of oversampling.