School of Engineering Science
Simon Fraser University
ENSC327 Communication Systems
Assignment #5

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1)

The message signal $m(t) = 10\,\text{sinc}(400t)$ frequency modulates the carrier $c(t) = 100\cos(2\pi f_c t)$.

The Deviation Ratio is, D=6.

a. Write an expression for the FM modulated signal $s(t)$?

b. What is the maximum frequency deviation of the modulated signal?

c. Find the bandwidth of the modulated signal using Carson's rule.

2)

The carrier $c(t) = A\cos(2\pi\, 10^6 t)$ is FM modulated by the sinusoidal signal $m(t) = 2\cos(2000\pi t)$.

The frequency sensitivity factor is $k_f = 3000$ Hz/V. First, determine the bandwidth of the signal (include frequency components up to where the Bessel function is above 0.01). Then, plot (hand written is ok) the spectrum of the modulated signal.

3)

Find the smallest value of the modulation index in a single tone FM system that guarantees that all the modulated signal power is contained in the sidebands and no power is transmitted at the carrier frequency.

4. Frequency Division Multiplexing
In an FDM communication system, the transmitted baseband signal is

$$x(t) = m_1(t)\cos\omega_1 t + m_2(t)\cos\omega_2 t$$

This system has a second-order nonlinearity between the transmitter input and receiver output. Thus the received baseband signal $y(t)$ can be expressed as

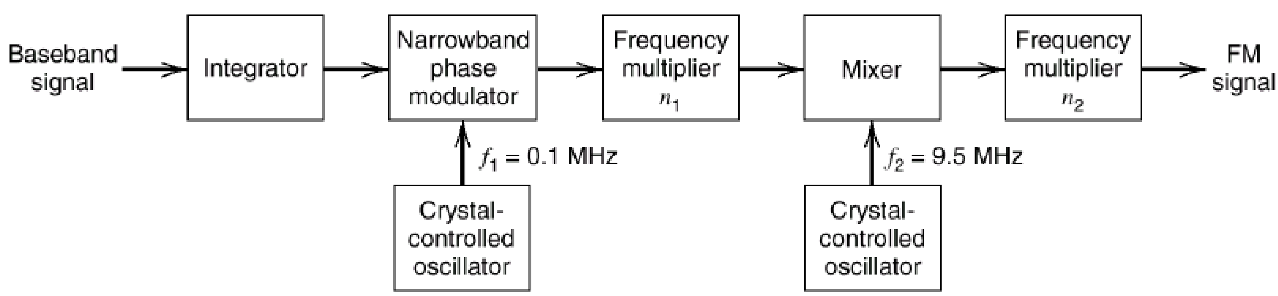
$$y(t) = a_1 x(t) + a_2 x^2(t)$$

Assuming that the two message signals, $m_1(t)$ and $m_2(t)$, have the Fourier transforms

$$M_1(f) = M_2(f) = rect\left(\frac{2f}{W}\right)$$

sketch the Fourier transform of $y(t)$. Discuss the difficulties encountered in demodulating the received baseband signal. In many FDM systems, the subcarrier frequencies ω_1 and ω_2 are harmonically related. Describe any additional problems this presents.

5. FM Generation
The block diagram of the indirect FM generation is shown below:



The system specifications are as follows:
The oscillator frequency of the narrowband phase modulation is 0.1 MHz.
The frequency deviation of the NBFM signal is $\Delta f_1 = 20Hz$,
The mixer uses **high-side tuning**. The oscillator frequency of the mixer is 9.5 MHz. A lowpass filter is used to get the mixer output.
The final carrier frequency at the output is 100 MHz.
The output frequency deviation is $\Delta f_2 = 75KHz$.

What are the value of n_1 and n_2? (Hint: Find two equations for n_1 and n_2)

6. Energy Spectral Density
Consider a half-cosine function defined as:

$$g(t) = A\text{rect}\left(\frac{t}{T}\right)\cos\left(\frac{\pi t}{T}\right)$$

Find the energy spectral density function of $g(t)$.

7. Simulink: FM Modulator

(CEAB indicators: 1.4: Discipline - specific Knowledge, 2.3: Problem Solution, 2.4: Solution Verification and Evaluation, 4.1: Requirement and Constraint Identification, 4.3: Design Candidate Generation, 4.5: Detailed Design)

Use Matlab Simulink to generate the following FM signal directly (no need to use the NBFM approximation or Armstrong's indirect method):

$$s(t) = \cos\left(2\pi f_c t + 2\pi k_f \int_0^t A_m \cos(2\pi f_m \tau) d\tau \right)$$

with fc=10,000 Hz and fm = 500 Hz.

1. Fix $A_m = 1$, what is the value of k_f such that β = 0.3, 1, 2.4, and 5? Print out the spectrum of the output in each case. Calculate the bandwidth in each case using Carson's rule, and comment on your observations (no need to measure the bandwidth from the spectrum output). Also print the scope output for β=5 only (you need to scale the X and Y display properly in order to get a clear view of the FM waveform).
2. Fix k_f = 500, choose Am to be 1, 2, and 3. Calculate the bandwidth in each case using Carson's rule. Print the corresponding spectrum, and comment on your observations (no need to measure the bandwidth from the spectrum output).

You need the following blocks:

- From the Simulink/Sources sublibrary: Sine Wave, Digital Clock (to get the time t in $2\pi f_c t$).
- From the Simulink/Discrete: Discrete-time integrator.
- From the Simulink/Math Operations sublibrary: Trigonometric function (choose cos function from its parameter setting window), Add, Gain.
- From the Simulink/Sinks sublibrary: Scope.
- From the Signal Processing Blockset/Signal Processing Sinks sublibrary: Spectrum Scope.

You can check the Simulink help for each block's usage, or simply google it. For example, type "simulink digital clock" or "simulink trigonometric" in google.

Please pay attention to the following points:

• Choose a sampling time of **1e-5** sec in all blocks that require a sample time. Although choosing the option of "-1 for inherited" is ok for simple blocks such as the Gain, the sampling time must be specified for other blocks such as the sources and integrators. Otherwise you will not be able to get the desired result and it will be difficult to debug the model. So it is better to set the sampling time of all blocks to be the same value.

• The input to an FFT-based scope should be buffered. A buffer size of 1024 and overlap of 512 are sufficient for this assignment.