The University of Queensland
School of Information Technology & Electrical Engineering

COMS3100/7100 Introduction to Communications
Semester 1, 2011

Assignment 2

Due date: 5pm, Thursday, 14th April.
Where to submit: through the Faculty of EAIT (Hawken Building 50) assignment chute.
Note: All assignments require a cover sheet (available from http://www.eng.uq.edu.au/courses.asp)

This assignment counts 5% towards your final mark for COMS3100/7100.

Question 1: Frequency Multiplexing and Mixers (4 Marks)

By using multiplexing in the frequency domain, that is - send two signals by separating them in frequency, a single channel can be reused for multiple purposes.

(a) Design the multiplexing circuit to send two signals, $x_1(t)$ and $x_2(t)$. Assume that in both the useful information is in the first W Hz (i.e. filtering would be required). Assume a modulation of your choice (ie AM, FM, DSB-SC). Place the carrier frequencies as close as possible.

(b) Show how it would be possible to separate these signals on the receiver. Design the filter(s) (both time and frequency domain response), for each of these.

(c) If instead of your selected modulation choice, you used the remaining methods (FM, AM, and DSB-SC), how would your choice of carrier frequencies differ? (Do not design the circuit, just calculate the required frequency separation)

(d) Show that a mixer device can be implemented by using a non linear device such as a diode. That is if the output has harmonics such as $(.)^2$ and $(.)^3$, we can get $f_c + f_m$ and $f_c - f_m$ components (amongst others). Hint: Use Euler's form, and assume a unit amplitude cosine for both message and carrier signals. (repeat for both $(.)^2$ and $(.)^3$ and note that the input signal is $x_1(t) + x_2(t)$)

Question 2: AM Modulation and FM Modulation (7 Marks)

In this question we will study the two major modulation types, amplitude and angle modulation using a sinusoidal message signal. i.e. $x_m(t) = \cos 2\pi f_m t$

(a) For an AM signal - Plot the time and frequency (magnitude response) domain bandpass signal for two different values of the modulation index. Explain the effect of the choice of μ on both the time/frequency plots, as well as the total power

transmitted. (Select appropriate values for message frequency and carrier frequency - explaining your choice).

(b) For an FM signal - Plot the time and frequency (magnitude + phase) domain bandpass signal for several values of the modulation index ($\beta = (0.2, 1, 5, 10)$). Explain the effect of the choice of β, and comment on the total bandwidth and power.

For Q2, try to combine graphs for FM an AM respectively (using subplot in MATLAB/Octave or equivalent).

Question 3: Spectral Efficiency and Immunity to Noise (4 Marks)

Spectral Efficiency is a measure of how much capacity is available in a given bandwidth. It is measured in bits/s/Hz. Depending on the choice of modulation a given bandwidth may be more or less efficiently used. In this question, the same two signals considered in Q2 will be evaluated in terms of PSD.

(a) Calculate the PSD and hence the total transmitted power for both AM and FM modulated tones (From Q2). Which of these signals uses the spectrum more efficiently?

(b) Explain why FM signals are considered more immune to noise and multipath effects. [Research] (Hints: noise is spread uniformly across frequency, but at each frequency is a Gaussian process, destructive interference requires two signals to arrive out of phase to each other.)