NAME: ______________________________

Some Old Exam Problems, EE 3350 Communication Systems
2/28/2011 Professor D. L. MacFarlane

This document contains some exam problems that I have used in past semesters. I recommend that your pre-test studying includes working through these alone and in conditions reasonably typical of the test. Then get together with classmates to discuss and learn from each other. I will try to do some of these in class if I have time for a review session, but please don't count on that.

Here are instructions that come with the test:

Instructions: Work through the following problems neatly and professionally, and without collaboration of any kind. Please put your name on every page of your work. A perfect score on this exam is 30 points. You may not consult any notes or text. You may not use a calculator. Please be very clear in the presentation of your work.

Note that one of the 3-4 problems on each test would be one of the assigned homework problems.

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Problems from Exam #1 (usually given 1-2 weeks after we finish chapter 3, so that it covers signals and systems and maybe a little bit of AM)

1. Find a Fourier Series of the Following:

   a) $\cos^3(\omega_c t)$
   b) $\delta(t)$
   c) sgn(t)
   d) Show that for the trigonometric Fourier Series

$$f(x) = C_0 + \sum_{n=1}^{\infty} (C_n \cos n\omega_0 t + \theta_n)$$

   The power of f(t) is given by:

$$P = (C_0)^2 + \sum_{n=1}^{\infty} (C_n)^2$$

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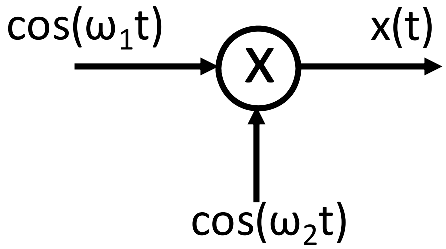
2. Consider the module:



a) Find x(t) and X(ω). Sketch the functions in both time and frequency domains.
b) Repeat the problem by changing the $\cos(\omega_1 t)$ to $\cos(\omega_1 t)+\sin(\omega_1 t)$. Sketch the functions in both time and frequency domains.
c) In words, pictures and equations, discuss the module, its application and your results of parts (a) and (b).

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Problem 3: Filtering Noise (10 points)

a) Derive the transfer function in any way you want for a bandpass filter comprising an LRC (inductor, resistor and a capacitor).

b) In words, pictures and equations describe what this filter does for an input of “flat-top” or “white” noise. This kind of noise has a frequency spectrum with an equal amount of power at all frequencies.

c) Discuss the relevance of this problem to communication systems.

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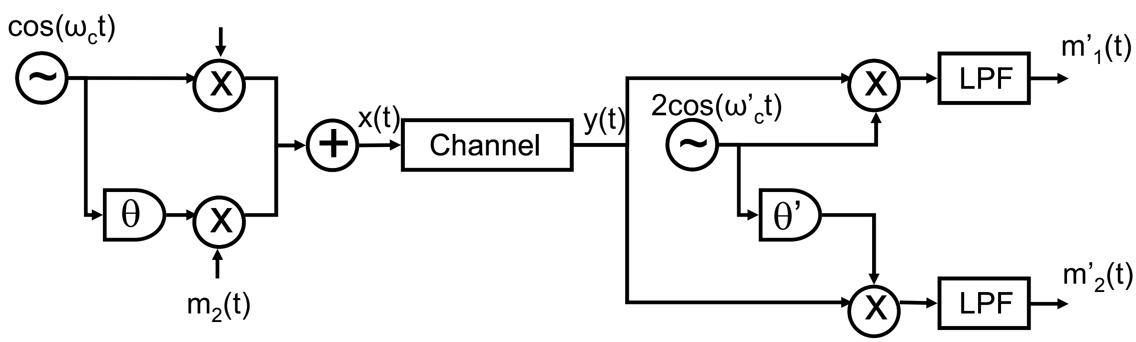
Problems from Exam #2 (usually given 1-2 weeks after we finish chapter 5, so that it covers Amplitude Modulation and Angle Modulation)

1. Consider the following Quadrature Amplitude Modulation Link.



a) If the system is ideal, confirm that m'1(t) and m'2(t) are faithful representations of $m_1(t)$ and $m_2(t)$. In this ideal case $\theta = -\pi/2$ and $\theta' = \pi/2$, $\omega_C' = \omega_C$ and there is a unity transformation in the channel so that $x(t) = y(t)$.

b) Analyze the system if there is a slight mismatch between the transmitter local oscillator frequency and the receiver local oscillator frequency $\omega_C' = \omega_C + \delta\omega$.

c) Analyze the system if there is a slight phase error, $\theta' = \pi/2 + \delta\theta$ in the receiver.

d) Comment in words pictures and equations on the effects of the impairments in parts b and c. Consider whether one error is worse than the other, or if there is a point where the effect is the same.

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2. Consider an angle modulated signal of the form

$$A\cos[\omega_c t + \cos(\omega_1 t) + \cos(\omega_2 t)]$$

a) Find the average power of the signal.
b) Find the instantaneous frequency of this signal.
c) Estimate the bandwidth of the signal ($\omega_2 > \omega_1$).
d) What would be the message contained in the signal (state your assumption)?

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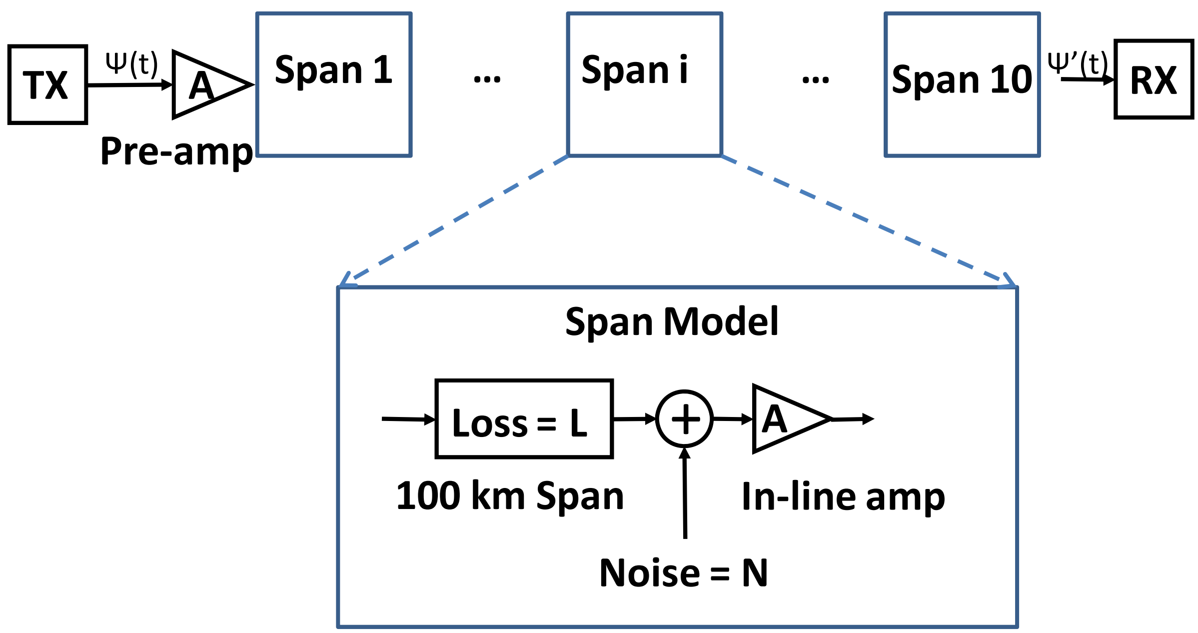
A problem from a Final Exam

1. SNR in a multi-span link

Consider the following fiber optic link that is made up of a transmitter, 10 "spans" and a receiver. Each span comprises a 100 km of fiber with a loss L and an "in-line" amplifier with gain A. The gain and loss coefficients multiply the signal that enters the component, i.e. if the input signal to an amplifier is x, the output is Ax.

The signal ψ(t) leaves the transmitter and is immediately pre-amplified by an amount A. The signal then goes into the first 100 km span, incurring a loss L. The noise that accumulates on the span is modeled as an additive source at the end of the attenuation and right before the in-line amplifier. The in-line amplifier boosts the signal (and the noise) by A. The output of the amplifier goes into the next span.

There are 10 identical spans in the link.



a) Trace the signal ψ(t) through the first few spans until you see a pattern.
b) If the product of the loss and gain coefficients, AL=1, what is the final signal power to noise power for the input into the receiver ψ'(t)? *hint: think carefully about what happens when you time average the noise power.*
c) Does AL=1 give an optimum for the SNR? *Hint: rederive the SNR with without the assumption AL=1.*