Lab 1 - Prelab

Due Online by Thursday Oct. 1, 2015 by 6 PM.
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Reading Assignment

1. Through Section 3.2.1 of the first set of notes under the Downloads/Notes tab on the class web site. This link is here.
2. Sections 5.1-5.1.2 and Sections 5.3-5.4 of Goldsmith.
3. Read pages 10-19 of Agilent's basic Spectrum Analyzer tutorial.

Theory Problems

Spectrum of AM modulated signals
Let $s(t)$ be a bandlimited baseband signal with a frequency content $S(f)$ given by $1 - |f|/f_{\max}$, where f is the frequency and $f_{\max}$ is the maximum frequency of the baseband signal. This baseband signal is multiplied by $\cos(2\pi f_c t)$ to produce an amplitude-modulated passband signal $\widetilde{s}(t) = s(t)\cos(2\pi f_c t)$, where f_c is the carrier frequency and $f_c \gg f_{\max}$.

1. Sketch the amplitude of the frequency spectrum of the baseband signal $S(f)$.
   a) Sketch the amplitude of the frequency spectrum of the amplitude-modulated passband signal $\widetilde{S}(f)$.
   b) The AM signal is demodulated by multiplying $\widetilde{s}(t)$ by a coherent signal of the form $\cos(2\pi f_c t)$. The signal is filtered by an ideal lowpass filter with a cutoff frequency $f_{\max}$. Sketch the amplitude of the frequency spectrum of the demodulated signal.
2. *Frequency demodulation errors*
   Here we consider the effect of a frequency error in the demodulation. An AM signal $\widetilde{s}(t) = s(t)\cos(2\pi f_c t)$ is demodulated using $\cos(2\pi f_c[1 + x]t)$ where x is a relative frequency error, and $s(t)$ is given in Problem 1. Sketch the amplitude of the frequency spectrum of the demodulated signal for: (a) $x = 0$, (b) $x = f_{\max}/(10 f_c)$, and (c) $x = f_{\max}/f_c$. Comment on the results. Does a frequency demodulation error affect the Nyquist rate of the baseband signal? Explain.
3. *Phase demodulation errors*
   An AM signal $\widetilde{s}(t) = A\cos(2\pi f_c t)$ where A is a constant is demodulated by $\cos(2\pi f_c t + \phi)$ where ϕ represents a phase error.
   a) Determine an expression for the demodulated signal as a function of the phase error ϕ.
   b) The demodulated signal is now integrated over a time period T that is many times the period of the carrier. What is the maximum phase error ϕ that can be tolerated for the demodulated signal to ensure that the amplitude is within ten percent of the amplitude without a phase error?

4. Following the example on Page 18 of the Agilent tutorial on Spectrum Analyzers, what resolution bandwidth is required to resolve signals separated by 50 kHz that differ by 40 dB in power?
   a) Will changing the video bandwidth (filter) or averaging of the spectrum analyzer affect this result?
   b) Will averaging affect the result if the signals are in the presence of additive noise? Explain.

Matlab/Simulink Simulations

We will be using a combination of Matlab and Simulink for this class and will be transitioning to Simulink for the Capstone design project. To understand the differences between these two ways to simulate a communication system, we will work through an example of implementing a raised cosine pulse using Simulink instead of Matlab. A tutorial of constructing a Simulink block is here .

1. Construct a Simulink module that implements a raised cosine pulse with 2 samples/symbol, $\beta = 0.5$, and a delay of five. For this implementation you should only use basic functions such as delays, adds, and multiplies. This filter should be an FIR filter and not a polyphase filter.

2. Plot the impulse response and the magnitude spectrum for this filter and confirm that it agrees with the impulse response and the frequency response of the filter you generated using Matlab in WES 265. Both of the impulse response and the spectrum should be implemented within Simulink—not Matlab.

3. Using this pulse shaping filter, construct a Simulink module for a Binary-Phase-Shift Keyed (BPSK) transmitter that:
   a) Generates random binary data with values ± 1. For this part, use any built-in feature of Simulink to generate the data.
   b) Use these values from part (a) as the input to the pulse shaping filter designed in Part 1.
   c) Plot the output of the pulse shaping filter in time for a sequence of 20 symbols.
   d) Plot the magnitude of the spectrum output. What kind of function does the spectrum look like?