EE440 HW#5

February 27, 2011

1. In class we discussed narrow band angle modulated signals (NBFM/NBPM) as the truncation of an infinite series. We justified the truncation by saying that $k_p a(t)$ was small, so the higher order terms are negligible. The bandpass signal model we discussed in class (quadrature signal model) can also be used to justify the NBFM/NBPM approximation. When we derived the in-phase and quadrature components in class we used the identity $\sin(a+b) = \sin a \cos b + \cos a \sin b$. We could have defined $I(t)$ and $Q(t)$ slightly differently and used the identity $\cos(a+b) = \cos a \cos b - \sin a \sin b$. Use this identity and the small angle approximations ($\cos(x) \approx 1, \sin(x) \approx x$ for x small) to derive form of a NBFM/NBPM signal when $k_p a(t)$ is small.

2. Use MATLAB to plot an FM signal with $w_c = 1Hz$ and message signal $m(t) = 10t$. Use a sampling frequency of 10000Hz and plot the signal over the range $t \in [0, 3]$s. Make two plots: one using the closed form expression for the message, and one using a numerically integrated approximation of the message. (Hint: use the rectangle rule and find a MATLAB command that takes the cumulative sum of a vector!). What are the minimum and maximum instantaneous frequencies for the signal you have been working with?

3. Given a message $m(t) = 5\sin(2\pi 10^3 t)$ find the output of an FM modulator using a carrier frequency of 10^7Hz.

4. Draw block diagrams which use only summing junctions, mixers/multipliers, integrators, and $\frac{\pi}{2}$ phase shifters to generate:

   (a) NBFM
   (b) NBPM

5. In April 1970 RCA introduced a new recording format for music, the Quadraphonic 8-Track. Unlike formats common today, this format allows for four channels of recorded music to be played. This format is matrix encoded, JVC also introduced a system using discrete encoding.

   (a) Investigate the difference between matrix encoding and discrete encoding.
   (b) Design a system similar to broadcast FM that would allow for the broadcast of quadraphonic recordings. Assume that the FCC has mandated that you must still allow monophonic receivers to play the sum of all four channels. Do not worry about maintaining compatibility with current stereo receivers. If you come up with a method that does, you get extra credit. Document your design with block diagrams for both the transmitter and receiver. Be sure to correctly account for gains in your signal path, that is if the original channels of sound are A, B, C, and D you must recover them with the correct power levels at the receiver. Also, draw a spectral diagram of your signal format.
   (c) Although popular music formats are two channel these days, another form of entertainment comes with six channels of sound. It is called 5.1 channel something. What is the something? Why do they call it 5.1 when it has 6 channels?

6. In class when I guessed where the RDS signal is placed in an FM signal I was totally wrong. Look up RDS and explain where it is located in the FM signal and what its bit rate is. Explain one or two of the services that RDS carries.