

## Class Project – Part I: LC-AM and DSBSC

Final Report due November 29, 2007

*Project Description:* This project will investigate the temporal, spectral and SNR properties (i.e., power efficiency) of AM and FM modulation techniques using various message signals. The project will be comprised of three parts: Part I – LC-AM and DSBSC; Part II – SSB AM, and Part III – FM. The project will result in a final report. The report should detail all findings in an orderly fashion, but *should not be a simple listing of steps taken and results obtained*. A sample report format is posted on the project web page. The final grade will be based on (a) correctness of your work, (b) completeness of your work, and (c) quality of the final report (e.g., clarity of the writing, usefulness of figures, readability of the figures, use of captions, etc.). Specific steps to be taken and questions to be answered are given in the project description below. Again, the answers to those questions are expected in the project report as part of the narrative, not as a set of questions and answers. Students should work in teams of 2-4. All team members will be given the same grade, except where it is apparent that there is considerable disparity of effort.

*Preliminaries:* The students should download the following files from the class website (<http://www.mprg.org/people/buehrer/3614/3614Projects.htm>):

- DSBAM.zip
- LabVIEW821RuntimeEngine.exe
- Design Project Report - Format.doc

Create a directory on your PC which will be dedicated to the project. Unzip DSBAM.zip and place all files in the current directory. Next, run the executable file LabVIEW821RuntimeEngine.exe. This can be done either from a DOS command prompt or by double-clicking on the file within Windows Explorer. Follow the steps given by the installer. Finally, to begin the project, double-click the file DSBAM.exe. You should see an GUI termed a virtual instrument which shows you time and frequency domain versions of the message, modulated, and demodulated signals. The signals are virtual outputs of a digital sampling oscilloscope and spectrum analyzer. The GUI allows you to examine different message signals and both the baseband and bandpass signals.

*Project Steps:*

1. Stage 1 – Examine the time domain and frequency domain versions of the message signal. Prior to any work, change the “Sound File” location to the working directory which is where the sound file and project executable files should be (Be sure to include the full path). Now, we wish to examine the following message signals: (a) sine wave; (b) square wave; (c) triangle wave; (d) sawtooth waveform; (e) Sound file. Set the message frequency equal to 1kHz for each case (except the sound file). Create a mathematical expression for each of

- the first four message signals. Determine the Fourier Transform for each. Using the GUI, capture the information for the time-domain and frequency domain measurements of each of the five message signals. Import the information into Matlab and plot. (See instructions on importing to Matlab at the end of this project description.) The plots should be included in your report. What is the measured bandwidth? (Use absolute or 30dB bandwidth as appropriate.) Compare all captured measurements to theory. Do your plots match your theoretical expressions?
2. Stage 2 – Examine the performance and characteristics of Large Carrier AM. Make sure that the “Suppress Carrier” button is not lit up. Set the modulation index  $k_a = 1$ . Set the carrier frequency of  $f_c = 10\text{kHz}$  and the message frequency (use a sinusoidal message for now) to  $1\text{kHz}$ . Set the reference SNR to  $20\text{dB}$ <sup>1</sup>. Capture the data and plot the resulting bandpass signals in both the time domain and frequency domain. Create a mathematical expression for the bandpass signal. Does your measured plots match theory? What is the bandwidth (again use the 30dB bandwidth or absolute bandwidth as appropriate)? How does the bandwidth compare with theory? Plot the demodulated signal along with the original message signal. How do they compare? What is the output SNR? What is the theoretical value of output SNR given the baseband reference SNR? How does the measured value compare with theory?
  3. Stage 3 - Change  $k_a = 0.25$  and repeat 2. What is the impact of  $k_a$  on bandwidth? What is the impact of  $k_a$  on the output SNR? What should the impact be (i.e., what does theory say it should be?)
  4. Stage 4 – Repeat Stage 2 for each message signal. For the sound file also repeat Stage 3 and listen to the demodulated message for the different values of  $k_a$ . How does the sound quality compare to the original signal? For the two output signals does a change in output SNR correspond to a change in sound quality?
  5. Stage 5 - Repeat Stages 2 and 4 for a DSBSC signal. (Ignore the questions on  $k_a$ ) Is the output SNR for the DSBSC better or worse than Large Carrier AM? Should it be better or worse? Why?

*Project Report:* You must write a report using the given format which summarizes your results. You should answer all the questions above in the report narrative (do not list the questions separately). Please see report format for additional insight into the results to be included and how to present them. **IMPORTANT:** Please also include a final section termed “Conclusions” which states what you learned in doing this project. Do the results from this project agree with what we have learned in class?

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<sup>1</sup> Note: The specified SNR is the baseband reference SNR. As discussed in class, this is the signal-to-noise ratio of an equivalent baseband system. The ratio of the output SNR to the baseband reference SNR can be viewed as a figure of merit for the modulation scheme and allows us to compare different modulation schemes.

**Appendix:** Recording and importing data into Matlab.

To record data and read it into Matlab the following steps must be taken:

1. Provide the full path to the sound file, which should be the current directory (e.g., `C:\MyDocuments\3614\Project\DesignProject.wav`) specification under “Sound File”.
2. Start Matlab and change the directory to the current working directory. (Same directory specified above)
3. Run the Matlab script `ReadData.m`. The data for all signals should now be in memory.
4. Type “`whos`” to view all the data.
5. Plot signals and scale the axes appropriately using the commands `plot`, `axis`, `xlabel`, and `ylabel`. (Be sure to make the plots readable!!)