School of Electrical and Information Engineering
University of the Witwatersrand, Johannesburg
ELEN3024 – Communication Fundamentals

Laboratory: AM Modulation using the USRP

1 Objective

Objectives of the lab:

- To get familiar with the GNURadio software and the concepts of software defined radios.
- To observe the output-versus-input voltage characteristics of Amplitude Modulation Double Sideband Full Carrier (AM DSB FC) modulation.
- To gain some practical exposure to the AM concepts and algorithm presented in class.

2 Requirements

Note: This lab requires some preparation, in terms of theoretical background as well as the use of the tools (use of the B-Lab, GNURadio Companion, Matlab/Octave, the m-files, etc.). Students who are unable to do the lab because they have not prepared will be asked to leave.

Instructions, source material and preparation required:

- You are required to do all the preparation needed to implement the algorithms beforehand.
- You are required to have gone through the basic tutorials on the USRP, and should be able to implement an AM modulator.
- Lab partners must operate in groups of three (and no larger) and may help each other during the lab but each should use his/her own sample text in all the exercises and write his/her own lab report.

Report: The report will take the form of the following group of files which should all be attached to a single email:

- An answer sheet (in PDF format) with your name and your lab partners' names and student numbers, the date and experiment name, and your results.
- All the GRC-files used in the lab.
- All additional files (such as m files) used for the report.
- Your report should include an introduction, as well as a conclusion section, briefly explaining all important results.

3 Outcomes

1. Single-tone injection (data type: short)

1.a. Work out by hand the expected frequency spectrum and output waveform when a sinusoidal signal of amplitude A_m and frequency of 10 kHz is input straight to the USRP modulator (no other blocks should be added). Assume that the carrier frequency of the USRP is set to 2 MHz, and that all data types are of type "short". (This should be included in your report.)

1.b. Generate a single tone of 1 kHz, input this to the USRP and observe the output. Call the demonstrator to verify the results (The demonstrator has to sign your name off on a list). Calculate the period and frequency of the carrier wave, as well as the period and frequency of the envelope (if present). (The calculations should be included in your report.)

1.c. Simulate this system in Matlab and plot the output waveform and output spectrum. Include the program listing as well as the the appropriate plots in your report.

2. Single-tone injection (data type: complex)

2.a. Work out by hand the expected frequency spectrum and output waveform when a sinusoidal signal of amplitude A_m and frequency of 10 kHz is input straight to the USRP modulator (no other blocks should be added). Assume that the carrier frequency of the USRP is set to 2 MHz, and that all data types are of type "complex". (This should be included in your report.)

2.b. Generate a single tone of 1 kHz, input this to the USRP and observe the output. Call the demonstrator to verify the results (The demonstrator has to sign your name off on a list). Calculate the period and frequency of the carrier wave, as well as the period and frequency of the envelope (if present). (The calculations should be included in your report.)

2.c. Simulate this system in Matlab and plot the output waveform and output spectrum. Include the program listing as well as the the appropriate plots in your report.

3. AM Double sideband full-carrier modulation

3.a. Sketch a block diagram of how AM DSB FC can be generated with the USRP (which uses complex baseband). Show the necessary equations.

3.b. Work out by hand the expected frequency spectrum and output waveform when a sinusoidal signal of 1 kHz is input to the AM DSB FC modulator, and 100 % modulation is achieved. Assume that the carrier frequency of the USRP is set to 2 MHz, and that all data types are of type "short". (This should be included in your report.)

3.c. Generate a single tone of 1 kHz, input this to the AM DSB FC modulator and observe the output. Change the output such that 100 % modulation is achieved. Call the demonstrator to verify the results (The demonstrator has to sign your name off on a list). Calculate the period and frequency of the carrier wave, as well as the period frequency of the envelope (if present). Also determine all important amplitude levels. (The calculations should be included in your report.)

3.d. Simulate an AM DSB FC system in Matlab with the same parameters as the system above, and plot the output waveform and output spectrum. Include the program listing as well as the the appropriate plots in your report. (The simulation must not make use of complex baseband.)

4. Do the exact same steps as for Step 3, but now assume a modulation index of 50 %.

5. Do the exact same steps as for Step 3, but now assume a modulation index of 25 %.