ELEC3302/ELEC4402: COMMUNICATIONS SYSTEMS

Semester 1, 2013

Lab 1 (P1)

AM and FM Signal Generation and Demodulation

Environmental Systems Engineering Bldg.
Room 2.03, Project Laboratory

IMPORTANT:

1. Due date: **AC Lab1 Report: 11am, Thursday, April 11, 2013.**
Late Penalties: 10% of Lab Report marks will be deducted for each day late in the submission of the lab report and 1% for each hour overdue (to a maximum of 10% per day). Ensure all late submissions are time-stamped by the EECE General Office staff and the lab demonstrator is made aware of your late lab report submission and arrangements made for its collection.

2. All assignments /lab reports shall be submitted with a properly completed and signed assignment cover sheet

3. Total marks for Lab1: 10% of unit assessment:

   a) Lab attendance and completion of all experiments will constitute 3% of the unit assessment. Ensure the lab demonstrator checks your notes for the lab at the end of the lab.

   b) The lab report will constitute 7% of the unit assessment.

Pri_Lab Reading

- Please read the lab manual (including the materials regarding the modulation kit).

- In the labs, we will use a digital oscilloscope (Agilent Technologies Model: InfiniiVision DSO-X 2002A). You can download the manual of the oscilloscope from the following webpage:
  http://cp.literature.agilent.com/litweb/pdf/75015-97023.pdf

  From the manual please

  - Find the channel impedance of the FFT function of the oscilloscope
  - Learn how to save reference waveform files to a USB storage device

LAB ATTENDANCE AND COMPLETION (3%)

- For each lab experiment answer as many of the questions posed as possible as notes for the lab. The notes don't need to be neat but they should be legible.
- For the observed waveform and spectrum on the oscilloscope, obtain relevant screenshots and include them in your lab report, ask the lab demonstrator for assistance if necessary. Ensure lab demonstrator checks your notes for the lab at the end of the lab.

LAB REPORT (7%)

The lab report should consist of the following sections:

- **Aims**: State the aims of the this lab in one or two sentences
- **Methodology:** For each experiment briefly describe the experimental setup. Sketch a block diagram of the setup you are using.
- **Results**: For each experiment answer the questions posed. You do not need to show any derivation as in some cases these will be beyond the scope of the unit. BUT do include all final equations and a reference to the literature where their derivation is discussed.
- **Conclusions**: What you have learned from the lab, including issues that you weren't aware of (or was not evident) from the theory and any suggestions for improvements.

Equipment Required:

- Modulation Kit
- Oscilloscope

Spectrum of AM

a) Generate an AM waveform with 50% modulation factor (μ =0.5) on a 2 Vp-p 100 kHz carrier. Use a 10 kHz sinusoidal modulating signal that is

   (i.) synchronized with the carrier;
   (ii.) unsynchronized with the carrier;

   What signal should be used to trigger the oscilloscope? Observe and sketch the modulating and modulated signals.

b) For the signal generated above, **estimate** the carrier power, the power in each sideband, and the % of the power in the carrier for the signal that appears across the $1M\Omega$ input impedance of the FFT function of oscilloscope. Note please make sure that for the oscilloscope, the FFT units are displayed in dBV.

c) Observe and sketch the spectrum of the signal generated above, and **measure** the power in the carrier and in each sideband. Using the 10 kHz synchronised signal, calculate the % of power in the carrier.

d) How do the above measurements compare with the estimates? Comment your comparison.

e) To observe the phase reversal of the AM waveform

   (i.) Display both the modulating signal and the AM signal of the oscilloscope;
   (ii.) Trigger off the modulating waveform;
   (iii.) Increase the % of modulation factor by increasing the amplitude of the modulating signal to its maximum value.

   Observe and sketch the modulating and modulated signals. Note and explain why the linear relationship between the modulating signal and envelop is destroyed when the % modulation becomes greater than 100% and the phase reversal that occurs when the % modulation is greater than 100%.

Demodulation of AM

Demodulation of AM is via synchronous detection where the local oscillator is generated from a PLL.

a) Generate an AM waveform with 50% modulation factor where the carrier is a 2 Vp-p 100 KHz signal and the modulating signal is a 1 kHz sinusoid. Feed this AM waveform through the PLL demodulator. Observe and sketch the modulated signal. Note that in the PLL, the gain amplifier is contained in the loop filter block. Select 10, 25 or 100 Hz loop filter. Check that the PLL has not locked to one of the sidebands.

b) Observe and sketch the modulating and demodulated signals. Note and explain why, that demodulation is successful even when the % modulation is greater than 100 %.

c) Change the modulating signal to a 10 kHz signal (50% modulation factor). Observe and sketch the modulating and demodulated signals, and explain the form of the demodulated signal.

Frequency Modulation

a) Measure the frequency sensitivity of the VCO, k_f, by using a 2 Vp-p 1/16 Hz polar signal and the oscilloscope. Should the frequency feedback be connected or disconnected for this measurement?

b) Modulate the VCO with a 10 kHz sinusoidal signal to generate a 2 Vp-p FM signal with a modulation index, β, of 2 ($\beta = k_f A_m / f_m$). Disconnect or connect the frequency feedback as appropriate and trigger the oscilloscope so that the FM modulation can be clearly seen. Observe and sketch the modulating and modulated signals. Change the modulating signal to a 4 Vp-p polar (square wave) 10 kHz signal and observe the resulting FM waveform. Observe and sketch the modulating and modulated signals.

c) If the frequency deviation constant of the VCO is 10 kHz/volt ($k_f = 10 kHz / volt$) with 10 kHz sinusoidal modulating signal, what should be the peak to peak amplitude of the modulating signal to generate a 2 Vp-p FM signal with a modulation index β of 2? Calculate the power of its significant spectral components.

d) Observe and sketch the spectrum of a 2 Vp-p FM signal with a modulation index of 2 and a 10 kHz sinusoidal modulating signal. Measure the powers of its spectral components. How many of spectral components are significant? Compare your answer with the Carson's formula.

e) Modulate the VCO with a 1 kHz 4 Vp-p sinusoidal signal to generate a FM signal on a 2 Vp-p carrier. Observe and sketch the resulting FM spectrum. Specify the modulation index, β, of this signal and reconcile its bandwidth with that predicted by the Carson's formula.

f) Are the bandwidths of two FM signals with respective modulating signals $A_m\cos(\omega_1 t)$, and $A_m\cos(\omega_2 t)$ likely to be identical or different? Explain.

Demodulation of FM Signals

Note that the lock indicator in the demodulator does not work with an FM signal. Use the oscilloscope to ensure the PLL is tracking the carrier.

a) Set the amplitude of the FM signal to 2 Vp-p. Modulate the VCO with a 0.2 Vp-p polar 1 kHz signal to generate an FM signal. Specify the signalling frequencies of the FM signal.

b) Select the appropriate loop filter for the PLL. Observe and sketch the demodulated signal.