EE 460 L COMMUNICATIONS

LABORATORY 3: ANALOG LINEAR MODULATION AND DEMODULATION

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
UNIVERSITY OF NEVADA, LAS VEGAS

1. OBJECTIVE & BACKGROUND

Study and analyze the analog linear modulation and demodulation techniques in communication systems.

2. COMPONENTS & EQUIPMENT

- TIMS set and configurable modules
- Multimeter, Function Generator, Oscilloscope and Power Supply

3. LAB DELIVERIES

PRELAB:

1. **Go over the linear modulation in the following link, and understand how signal can be modulated or demodulated.**
    - http://eelabs.faculty.unlv.edu/docs/labs/ee460L/AnalogLinearModulation.pdf

2. **Simulating DSBSC.**

    Submit a LTSPICE simulation of the block diagram shown in Figure 9 in Prelab pdf. Use sinusoidal voltage sources for both the message and the carrier signal with amplitude of 5V and frequency of 1 kHz and 100 kHz respectively. Use transient analysis for the simulation. Submit your schematics and waveforms. The “behavioral voltage source” in LTspice can be used as an ideal multiplier.

3. Extracting the envelope from DSBSC.

Submit a LTSPICE simulation of the block diagram shown in Figure 6 in Prelab pdf. Design an envelope detector circuit using a rectifier and a capacitive low-pass filter. You may use your DSBSC signal from the previous experiment. Use transient analysis for the simulation. Submit your schematics and wave analysis.

LAB EXPERIMENTS:

1. AM

T1 plug in the TUNEABLE LPF module. Set it to its widest bandwidth, which is about 12 kHz (front panel toggle switch to WIDE, and TUNE control fully clockwise). Adjust its passband gain to about unity. To do this you can use a test signal from the AUDIO OSCILLATOR, or perhaps the 2 kHz message from the MASTER SIGNALS module.

T2 model the generator of Figure 15, and connect its output to an ideal envelope detector, modeled as Figure16. For the low pass filter use the TUNEABLE LPF module. Your whole system might look like that shown modeled in Figure 17.

T3 set the frequency of the AUDIO OSCILLATOR to about 1 kHz. This is your message.

T4 adjust the triggering and sweep speed of the oscilloscope to display two periods of the message (CH2-A).

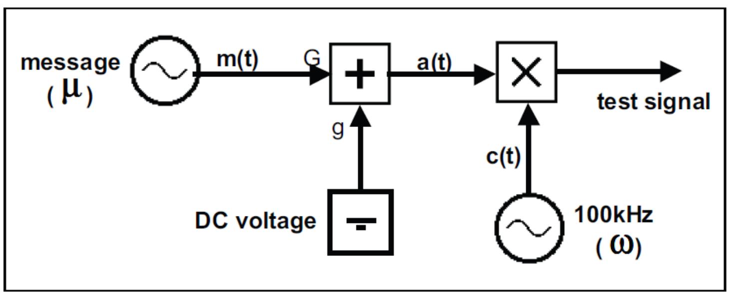

Figure 15: Generator for AM and DSBSC

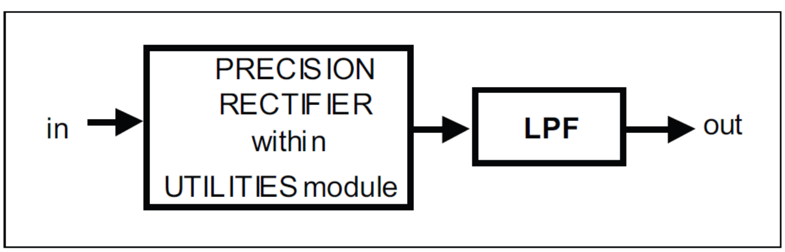

Figure 16: Modeling the ideal envelope detector with TIMS

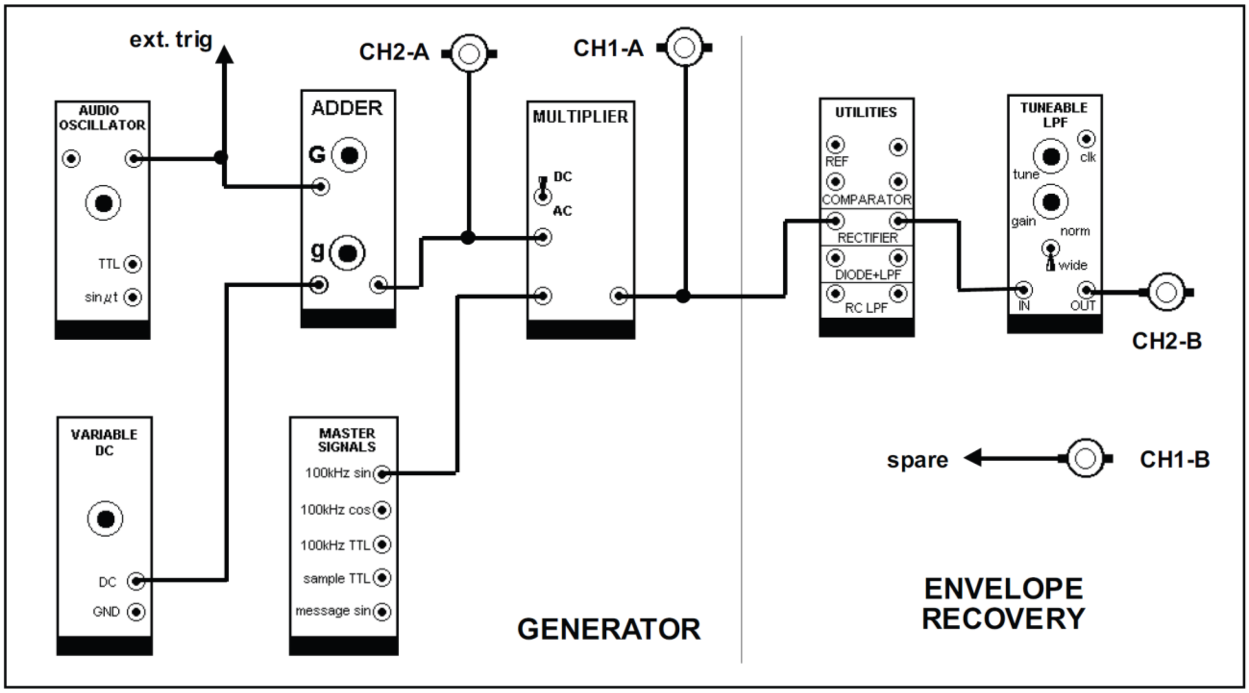

Figure 17: Modulated signal generator and envelope recovery

T5 adjust the generator to produce an AM signal, with a depth of modulation less than 100%. Don`t forget to so adjust the ADDER gains that its output (DC + AC) will not overload the MULTIPLIER; that is, keep the MULTIPLIER input within the bounds of the TIMS ANALOG REFERENCE LEVEL (4 volt peak-to-peak). This signal is not symmetrical about zero volts; neither excursion should exceed the 2 volts peak level.

T6 for the case m < 1 observe that the output from the filter (the ideal envelope detector output) is the same shape as the envelope of the AM signal, a sine wave.

2. DSBSC

Ideal envelope detector

Now let us test the ideal envelope detector on a more complex envelope - that of a DSBSC signal.

T7 remove the carrier from the AM signal, by turning ‘g’ fully anti-clockwise, thus generating DSBSC. Alternatively, and to save the DC level just used, pull out the patch cord from the ‘g’ input of the ADDER (or switch the MULTIPLIER to AC).

Were you expecting to see the waveforms of Figure 18? What did you see? You may not have seen the expected waveform. Why not?

T8 (a) lower the frequency of the AUDIO OSCILLATOR, and watch the shape of the recovered envelope. When you think it is a better approximation to expectations, note the message frequency, and the filter bandwidth, and compare with predictions of the bandwidth of a full wave rectified sine wave.

(b) if you want to work with a 2 kHz message then replace the TUNEABLE LPF with a 60 kHz LOWPASS FILTER. Now the detector output should be a good copy of the envelope. Record the highest frequency that gives good envelope with this filter.

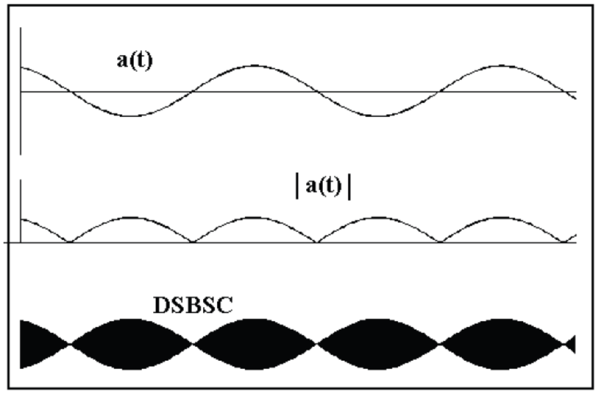

Figure 18: DSBSC signal

Diode detector

T9 connect an AM signal with m<1 directly to the ANALOG INPUT of the 'DIODE + LPF' in the UTILITIES MODULE, and the envelope (or its approximation) can be examined at the ANALOG OUTPUT. You should not add any additional low pass filtering, as the true 'diode detector' uses only a single RC network for this purpose, which is already included.

T10 repeat the previous Task, but with the RECTIFIER followed by a simple RC filter. This compromise arrangement will show up the shortcomings of the RC filter. There is an independent RC LPF in the UTILITIES MODULE.

T11 you can examine various combinations of diode, ideal rectifier, RC and other Low pass filters, and lower carrier frequencies (use the VCO). The 60 kHz LPF is a very useful filter for envelope work.

T12 check by observation: is the RECTIFIER in the UTILITIES MODULE a half wave or full wave rectifier.

Product demodulator

T13 patch up the model of Figure 19. This shows w0 = w1. Before plugging in the PHASE SHIFTER, set the on-board switch to HI.

T14 create an AM signal with m = 0.5 and connect it to input of the synchronous demodulator. Examine the output of demodulator. Record your observation. Increase depth of modulation to 100% and 150%. Did this demodulator work for these signals? Remember that Envelope detector cannot use in these cases.

T15 create a DSB and connect it to input of the synchronous demodulator. Examine the output of demodulator. Record your observation.

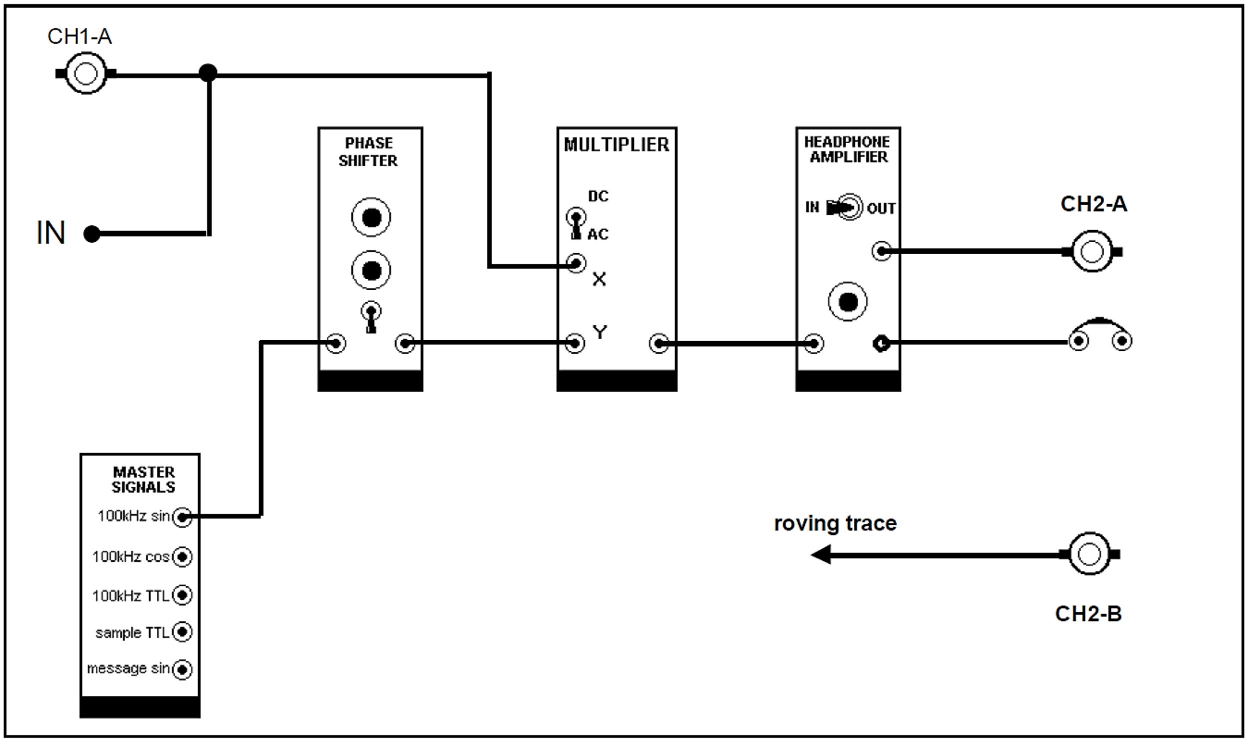

Figure 19: TIMS model of product demodulator

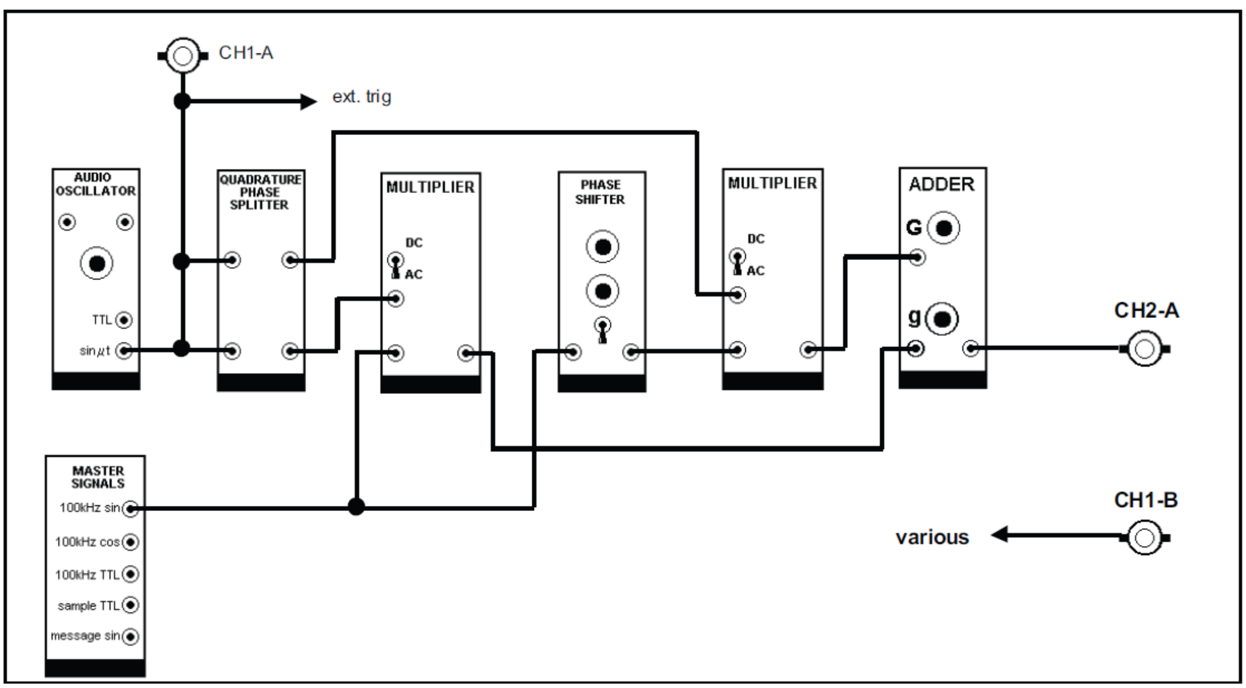

Figure 20: SSB phasing generator model

3. SSB (Bonus)

T17 patch up a model of the phasing SSB generator, following the arrangement illustrated in Figure 20. Remember to set the on-board switch of the PHASE SHIFTER to the 'HI' (100 kHz) range before plugging it in and set the AUDIO OSCILLATOR to about 1 kHz.

T18 switch the oscilloscope sweep to 'auto' mode, and connect the 'ext trig' to an output from the AUDIO OSCILLATOR. It is now synchronized to the message.

T19 connect an SSB signal to the demodulator input. Tune the VCO slowly around the 100 kHz region. Record output. Report results.

POSTLAB REPORT:

Include the following elements in the report document:

<table>
<tr><th>Section</th><th colspan="2">Element</th></tr>
<tr><td>1</td><td colspan="2">Theory of operation
Include a brief description of every element and phenomenon that appear during the experiments.</td></tr>
<tr><td>2</td><td colspan="2">Prelab report
1. None</td></tr>
<tr><td rowspan="3">3</td><td colspan="2">Results of the experiments</td></tr>
<tr><th>Experiments</th><th>Experiment Results</th></tr>
<tr><td>T1 ~ T19</td><td>Photos and screenshots of major steps in the experiment.</td></tr>
<tr><td rowspan="6">4</td><td colspan="2">Answer the questions</td></tr>
<tr><th>Questions</th><th>Questions</th></tr>
<tr><td>1</td><td>What is the frequency of the signal $y(t) = Ecos(mt)\cos(wt)$?</td></tr>
<tr><td>2</td><td>Explain the major differences in performance between envelope detectors with half and full wave rectifiers</td></tr>
<tr><td>3</td><td>What are the differences, and similarities, between a multiplier and a modulator?</td></tr>
<tr><td>4</td><td>Suppose, while you were successfully demodulating a DSBSC based on 100 kHz carrier, a second DSBSC based on a 90 kHz carrier was added to it. Suppose SNR, i.e. the ratio of the amplitude of 100kHz 'wanted' DSBSC over that of the 'unwanted' 90kHz DSBSC.
a) would this new signal at the demodulator INPUT have any effect upon the message from the wanted signal as observed at the demodulator output?
b) SNR = 1. Would it then have any effect?
c) SNR = 0.1. Would it then have any effect? Explain</td></tr>
<tr><td>5</td><td colspan="2">Conclusions
Write down your conclusions, things learned, problems encountered during the lab and how they were solved, etc.</td></tr>
<tr><td>6</td><td colspan="2">Images
Paste images (e.g. scratches, drafts, screenshots, photos, etc.) in Postlab report document (only .docx, .doc or .pdf format is accepted). If the sizes of images are too large, convert them to jpg/jpeg format first, and then paste them in the document.

Attachments (If needed)
Zip your projects. Send through WebCampus as attachments, or provide link to the zip file on Google Drive / Dropbox, etc.</td></tr>
</table>

4. REFERENCES & ACKNOWLEDGEMENT

1. TIMS student experiment instruction manuals
2. http://eelabs.faculty.unlv.edu/docs/guides/TIMS_User_Manual.pdf

I appreciate the help from faculty members and TAs during the composing and revision of this instruction manual. I would also thank students who provide valuable feedback so that we can offer better higher education to the students.