EEL 4514C: Communication Systems and Components (Fall 2025)

Lab 4: AM Demodulation

Deliverables Due: At 11:59pm on October 13, 2025.

NOTE: Please bring headphones for use in this lab. You do NOT need your SDR for this lab.

You will learn how to build coherent and noncoherent demodulators for amplitude-modulated signals (DSB-SC and AM), and you will also investigate the effects of phase offsets at the receiver.

Pre-Lab

Part I: Review your notes and draw a block diagram (don't just copy and paste a drawing – make your own version) for each of the following receivers:

1. A correlation receiver for DSB-SC, which mixes the received signal with a sinusoid at the carrier frequency and then filters the result.
2. An enveloped detector for AM.
3. A squaring detector for AM.

Part II: For the following questions, use the following scenario: A sinusoidal message signal at a frequency of 1 kHz is sent using DSB-SC with a carrier frequency of 10 kHz.

4. Sketch the Fourier transform (provide separate sketches of the real and imaginary parts) of the DSB-SC signal. Give the equation for the message signal and the carrier signal, so we can understand which sinusoid (sine or cosine) and what phase you have selected for your signals.
5. Sketch the PSD of the DSB-SC.
6. At a receiver, the DSB-SC signal is mixed with a local oscillator (LO) that has carrier frequency of 10 kHz (and phase matched to the incoming signal). Sketch the Fourier transform (provide separate sketches of the real and imaginary parts) of the signal at the output of the mixer.
7. Sketch the PSD of the signal at the output of the mixer.
8. Now suppose that the phase of the LO is in quadrature to that of the incoming signal (i.e., it is 90° different). Sketch the Fourier transform (provide separate sketches of the real and imaginary parts) of the signal at the output of the mixer.
9. Sketch the PSD of the signal at the output of the mixer.
10. In a sentence or two, describe how the different PSDs at the output of the mixer affect the ability to recover the message signal.

Lab

Note that all blocks in this lab should be set to float inputs and/or outputs. You can easily switch from complex to float by selecting the blocks and pressing the down arrow key.

Lab Part I: Correlation Receiver:

GRC components:

- File Source block
- Signal Source block
- Multiply block
- Low Pass Filter block
- 2 QT GUI Frequency Sink blocks
- QT GUI Range block
- Rational Resampler block
- Audio Sink block
- Delay block
- Any other blocks, as you see fit

Design Requirements:

In this part, you will build a coherent correlation receiver for a DSB-SC modulated signal that has been received in the presence of noise. Because the SDRs we are using cannot tune down to the AM band, I have created a DSB-SC signal with noise and stored it in the file `dsbsc-source.bin`. The message signal has been filtered to have a bandwidth of 4 kHz, and the message is sent using DSB-SC with a carrier frequency of 10 kHz. The resulting signal has been sampled at 120 kSamples/s, so you will want to set the `samp_rate` parameter of your flowgraph to 120000.

1. Set the File Source block to load the data from `dsbsc-source.bin` and to repeat.
2. Build a correlator receiver using the appropriate blocks.
3. Put Frequency Sinks at the output of the mixer and the output of the filter to check that your receiver is working as expected. Be sure to set the Name parameter so you know which is which when the flowgraph is run. Take a screen capture showing these outputs.
4. Connect the output of your receiver to a Rational Resampler block and then to an Audio Sink. Set the Sampling Rate of the Audio Sink block to a rate that is compatible with your system's audio card. I suggest to try 48 kHz first. Then set the Interpolation and Decimation parameters of the Rational Resampler to the smallest possible integers such that (samp_rate)*Interpolation/Decimation is equal to the Sampling Rate you set in the Audio Sink. Demonstrate the ability to play the audio message to the TA.
5. Now add a Delay block at the output of the File Source and set up a QT GUI Range block to allow the Delay to be varied from 0 to 6 while your flowgraph is running. Set the Type

of the GUI Range to `int`. Test your flowgraph for all of these values of Delay. In your lab report, discuss the audio quality as the Delay changes. Explain the result.

6. Take a screen capture of the Frequency Sinks outputs when the Delay is 3. Compare the shape of the Frequency Sink at the output of the filter when the Delay is 0 versus when the Delay is 3. Why is it like this? What are you seeing when the Delay is 3?

7. Take a screen capture of your GRC flowgraph for including in your lab report.

Lab Part II: Envelope Receiver:

GRC components:

- File Source block
- Abs block
- Low Pass Filter block
- DC Blocker block
- 2 QT GUI Frequency Sink blocks
- QT GUI Range block
- Rational Resampler block
- Audio Sink block
- Delay block
- Any other blocks, as you see fit

Design Requirements:

In this part, you will build a noncoherent envelope detector for an AM modulated signal that has been received in the presence of noise. As with the DSB-SC signal, we will load the AM signal from a file called `am-source.bin`. As before, The message signal has been filtered to have a bandwidth of 4 kHz, and the message is sent using AM with a carrier frequency of 10 kHz. The resulting signal has been sampled at 120 kSamples/s, so you will want to set the `samp_rate` parameter of your flowgraph to 120000.

1. Using your knowledge of the envelope detector and your experience with Part I, construct an Envelope Detector Receiver. Instead of a Rectifier, we will use GnuRadio's Abs block, which takes the absolute value of the input signal, which is equivalent to the operation of a rectifier.

2. Put Frequency Sinks at the output of the Abs block and the output of the DC blocker to check that your receiver is working as expected. Be sure to set the Name parameter so you know which is which when the flowgraph is run. Take a screen capture showing these outputs.

3. Connect the output of your receiver to a Rational Resampler block and then to an Audio Sink.

4. Now add a Delay block at the output of the File Source and set up a QT GUI Range block to allow the Delay to be varied from 0 to 6 while your flowgraph is running. Set the Type

of the GUI Range to `int`. Test your flowgraph for all of these values of Delay. In your lab report, discuss the audio quality as the Delay changes. Explain the result.

5. Take a screen capture of your GRC flowgraph for including in your lab report.

6. Now change the File Source block to load the data from `dsbsc-source.bin` and listen to the audio. In your lab report, describe what you hear.

Lab Part III: Squaring Receiver:

GRC components:

- File Source block
- Multiply block
- Low Pass Filter block
- Transcendental block
- QT GUI Time Sink block
- QT GUI Range block
- Add Const block
- 2 QT GUI Frequency Sink blocks
- Rational Resampler block
- Audio Sink block
- Delay block
- Any other blocks, as you see fit

Design Requirements:

In this part, you will build a noncoherent squaring detector for an AM modulated signal that has been received in the presence of noise. As in part II, we will load the AM signal from the file called `am-source.bin`.

1. Using your knowledge of the squaring detector and your experience with Parts I and II, construct a Squaring Detector Receiver. You can implement squaring by multiplying a signal by itself. The square-root operation can be implemented using the Transcendental block with the Function Name set to `sqrt`. (Even though square-root is **not** a transcendental function.)

2. I did not have success in using a DC Blocker after the Transcendental block – using it seemed to block the whole signal. If you have that problem, you can use a QT GUI Time Sink to determine the approximate DC Value and then use an Add Const block with the Constant value set to the negative of the DC Value at the input.

3. Put Frequency Sinks at the output of the Multiply block and the output of the Add Const block to check that your receiver is working as expected. Be sure to set the Name parameter so you know which is which when the flowgraph is run. Take a screen capture showing these outputs.

4. Connect the output of your receiver to a Rational Resampler block and then to an Audio Sink. (You do not need to demonstrate to the TA.)
5. Now add a Delay block at the output of the File Source and set up a QT GUI Range block to allow the Delay to be varied from 0 to 6 while your flowgraph is running. Set the Type of the GUI Range to `int`. Test your flowgraph for all of these values of Delay. In your lab report, discuss the audio quality as the Delay changes. Explain the result.
6. Take a screen capture of your GRC flowgraph for including in your lab report.

Lab Part IV: Quality Comparison:

1. Run each of your receivers (with Delay 0 for each) and compare the audio outputs. Adjust the volume or multiply by a constant to get equivalent loudness? In your lab report, discuss the relative audio qualities of the different demodulators.