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

Lab 6: QAM

Deliverables Due: At 11:59pm on November 03, 2025.

Goals

- Learn about quadrature amplitude modulation (QAM)
- Build a coherent receiver for a QAM signal using GRC

Pre-Lab

1. What is the benefit(s) of using QAM? How does it compare to SSB transmission?

2. What is the drawback(s) of using QAM?

3. Consider the demodulator shown in Fig. 4.17. Draw a block diagram that shows how the demodulator would need to change if the incoming signal experienced a phase shift of θ.

4. Review the coherent demodulator for a complex signal from Part 5 of Pre-lab 5. Show a modified block diagram to receive a QAM signal instead of a DSB-SC signal. (The modifications are minimal.)

Lab Experiments

GRC components:

- 6 Signal Source blocks
- 4 Multiply blocks
- 1 Noise Source block
- 1 Adder block
- 1 Float To Complex block
- 1 Low Pass Filter block
- QT GUI Range blocks, QT GUI Time Sink blocks, QT GUI Frequency Sink blocks, Throttle blocks, Audio Sink blocks (for control and observation)
- Any other blocks as you see fit

Design Requirements:

1. Set the sampling frequency to all blocks to 44.1 KHz. You'll simulate a QAM modulator on the TX side, and a complex quadrature coherent receiver on the RX side. All blocks on the TX side operate with real-valued (float) I/Os while all blocks on the RX side operate with complex-valued (complex) I/Os, except for the Float To Complex block which converts the real-valued received signal to a complex-valued signal for further processing.
2. Use one Signal Source block to generate a tone (cosine) message of frequency 200Hz and another Signal Source block to generate a tone (cosine) message of frequency 300Hz.
3. Use two Signal Source blocks to generate a cosine carrier and a sine carrier at frequency 15kHz. Set the Initial Phase parameters of both carriers to $\frac{\pi}{4}$. Use one Multiply block to mix the 200Hz-tone message with the cosine carrier and another Multiply block to mix the 300Hz-tone message with the sine carrier. Use the Adder block to sum up the two modulated signals in order to implement QAM.
4. Use the Noise Source block to simulate thermal noise. Use the Adder block to add the noise generated to the QAM signal generated in 2. above. Set the value of the Amplitude parameter to 0.15. This completes the TX side, and the output of the Adder block represents the real-valued RX signal.
5. Connect the real-valued RX signal to the real (re) input of the Float To Complex block, leaving the imaginary (im) input open. The output of the block gives the complex-valued RX signal.
6. Show the spectrum the RX QAM signal using a QT GUI Frequency Sink block.
7. For this and the next few steps, you will implement the complex quadrature coherent receiver in **Pre-lab 5** above to demodulate the QAM signal. Use one Signal Source block to generate the complex carrier reference at the RX. Set the Initial Phase parameter to 0. Add a Multiply block and a Low Pass Filter block to implement to implement the complex quadrature receiver shown in **Pre-lab 5**. You must determine proper values for the Frequency parameter in the

Signal Source block and the Cutoff Freq parameter in the Low Pass Filter block to correctly implement the complex quadrature receiver.

8. Use the last Signal Source block and Multiply block to implement the phase correction portion of your answer in **Pre-lab 5** above to implement coherent reception. You may set the Frequency parameter in the Signal Source block to 0 in order to generate a complex constant. You should use a QT GUI Range block to select the Initial Phase parameter to enter the proper phase correction value.

9. Adjust the phase correction value until you correctly demodulate the two tone messages in the I and Q channels. Show the demodulated messages for both the I and Q channels on a QT GUI Time Sink block for different choices of the phase correction value. Explain what you observe.