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

Lab 7

Deliverables Due: At 11:59pm on Nov. 10, 2025.

Requirements: Please bring your SDR and headphones for use in this lab!

Goals

- Learn about demodulator of FM signals
- Build a demodulator for a FM signal using GRC and SDR

FM Demodulator Design

Given an FM signal

$$A\cos\left[\omega_c t + k_f \int_{-\infty}^{t} m(\alpha)d\alpha\right] \tag{1}$$

How can we recover the information $m(t)$.

Differentiating with respect to time yields

$$A\left[\omega_c t + k_f m(t)\right]\sin\left[\omega_c t + k_f \int_{-\infty}^{t} m(\alpha)d\alpha - \pi\right] \tag{2}$$

which has an envelope proportional to $m(t)$. Now we can recover $m(t)$ with an envelope detector.

Lab

We will implement the differentiator digitally with an FIR filter

$$h[n] = a_0 x[n] + a_1 x[n-1] + \cdots \tag{3}$$

1. Find a set of filter coefficients (taps) that will implement a simple differentiator.
2. Test your filter in GRC using the "Decimating FIR Filter" block. Provide screenshots or drawings of the input and output for the following inputs
   - Sinusoid
   - Triangle wave

Lab Experiments

GRC components:

- 1 Osmocom Signal Source block

- Low Pass Filter blocks
- 1 Decimating FIR Filter block
- 1 Complex to Magnitude block
- 1 DC Blocker block
- 1 FM Deemphasis block (optional)
- 1 Audio Sink block
- QT GUI Time Sink blocks
- Any other blocks as you see fit

Design Requirements:

1. The broadcast FM signal format will be discussed in class. Or you may look in up from the textbook and Wikipedia.
2. The frequency discriminator consists of a differentiator followed by a rectifier demodulator (envelope detector). You may use the FIR block to implement the differentiator by setting a proper impulse response for the FIR filter.
3. Set the sampling rate of the Osmocom Source block to 264.6 kHz.
4. The demodulated mono FM signal should be played through the audio sink.
5. Your design should allow users to tune to all FM stations in the U.S., namely from 88 to 108 MHz. Also you may want to allow the users to adjust the RF gain and the volume of the audio playback.
6. You need to determine where to use LPFs and set their BW judicially to properly implement your demodulator.
7. You need to demonstrate to the TAs an audible voice quality of your demodulated FM signal. In addition, you need to generate the PSDs of the received FM signal and the demodulated FM signal.