USAF ACADEMY
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
LESSON 7 LAB - AM and FM Receivers
Lab Packet
Spring 2027

Name: _____ **Section:** _____ **Date:** _____

Learning Objective 3.3: I can implement an FM receiver in GNU Radio, demodulate a live broadcast FM signal, and decode its RDS data.

Learning Objective 3.4: I can explain and demonstrate the trade-off between bandwidth and noise performance for AM vs. FM.

This packet is the L7 Lab, in three parts, and you turn it in once, complete, before Lesson 8. Do **Part 1** on your own before the lab period: work out the receiver settings you will need. **Part 2** is your own measurements and observations, on your own laptop and PlutoSDR, recorded in class. Do **Part 3** on your own after the lab: explain what you saw.

Grading. We grade one submission against Objectives 3.3 and 3.4 on the course's 1 / 0 scale, and you may revise it under course policy. Paste screenshots where a question asks for one.

Receive only. Every flowgraph in this lab receives or simulates. The receivers use only the PlutoSDR's receive port, and nothing in this lab needs a license. Start every receiver with the volume low.

Files. Download the six L7 flowgraphs from the L7 lesson page into one folder, with your `fm_capture.cfile` from the L5 Lab. Open `L07-rds-rx.grc` first and confirm that GRC shows no missing blocks: gr-rds comes with radioconda; if GRC reports the RDS blocks missing, run `mamba install gnuradio-rds` from the radioconda prompt. Then, before the period, run `L07-fm-test-tx.grc`, which also uses an RDS block, and `L07-am-test-tx.grc` once each; they write `L07-fm-test.sigmf-data` and `L07-am-test.sigmf-data` into that folder and stop on their own.

Part 1: Pre-Lab (individual, before the lab period)

1. **Receiver settings.** You will use each of these at the bench.

   (a) Fill in the receiver settings for a capture centered on 101.5 MHz, and for your own L5 capture. The shift is the Frequency Xlating FIR Filter's center frequency.

Recording	SDR center (MHz)	Station (MHz)	Shift (kHz)
Example capture	101.5	101.1	
`fm_capture.cfile`			

   (b) The receiver you build at the bench decimates 2.4 MS/s by 5 at the channel filter and then by 10 at the audio filter. Find the two rates, and the Quadrature Demod gain that makes 75 kHz of deviation an output of 1.

gain = _____

(c) Find the ATIS frequency of an airport near you in the FAA Chart Supplement or on a sectional chart. Choose an SDR center 200 kHz above it, and fill in the AM receiver's settings.

Airport	ATIS (MHz)	SDR center (MHz)	Shift (kHz)

Part 2: Measurements (your own laptop and PlutoSDR, in class)

2. **Build the WBFM receiver.** Start GRC with an empty canvas. Do not open `L07-wbfm-rx.grc`: build the receiver yourself.

   - `samp_rate` 2.4e6, a QT GUI Entry `fc_mhz` (100.0), a QT GUI Entry `station_mhz` (100.3), and a QT GUI Range `vol` from 0 to 1.
   - A File Source on `L07-fm-test.sigmf-data`, repeat on.
   - A Frequency Xlating FIR Filter, decimation 5, center frequency `(station_mhz - fc_mhz) * 1e6`, with a Low-pass Filter Taps variable `chan_taps`: cutoff 105 kHz, transition 30 kHz, at `samp_rate`.
   - A Quadrature Demod with the gain of Question 1(b).
   - A Decimating FIR Filter, decimation 10, with taps `firdes.low_pass(1, samp_rate/5, 15e3, 3e3)`.
   - FM Deemphasis at 48 kHz with $\tau = 75$ μs, a Multiply Const `vol`, an Audio Sink at 48 kHz, and a float QT GUI Frequency Sink on the de-emphasis output. Do not add a Throttle.

   (a) Paste a screenshot of your flowgraph on the GRC canvas. Every connection must be black, not red.

   (b) Run it. Read the audio frequency sink. Check that its lines match the L6 two-tone message the test station sends, and record how far the higher-frequency line sits below the lower one.

   (c) Type 99.5 into Station. Describe what you hear, and explain why the station at 100.3 MHz disappears.

3. **Your L5 capture.** In your receiver from Question 2, set the File Source to `fm_capture.cfile`, SDR center to the frequency you recorded it at, and Station to the station you centered. Add a float QT GUI Frequency Sink on the Quadrature Demod output, with bandwidth `samp_rate/5`.

   (a) Paste a screenshot of the demodulated multiplex. Mark each part of the broadcast multiplex you can see: mono audio, the 19 kHz pilot, the stereo band from 23 to 53 kHz, and RDS at 57 kHz.

(b) Describe the audio. Your capture is about 3 s long, and the File Source repeats it.

4. Live FM and RDS. Find and hear a station on the PlutoSDR first, then decode its RDS data.

(a) Run `L05-fm-spectrum.grc`, find a strong station between 88 and 108 MHz, and stop it. Then run `L07-wbfm-rx.grc` with the File Source disabled and the PlutoSDR Source enabled, SDR center about 300 kHz below the station, and Station set to it. Record the frequency, the call sign the station announces (or the FCC lists for it), and whether the 19 kHz stereo pilot shows on the demodulated multiplex.

	Frequency (MHz)	Call sign	Pilot?
Station			

Now stop it and open `L07-rds-rx.grc`. Disable the File Source, enable the PlutoSDR Source, set SDR center about 300 kHz below the station from part (a), and set Station to its frequency. Set RF gain from your L5 Lab gain table.

(b) Record what the RDS panel shows, and compare the station name with the call sign from part (a). The panel prints the PI code under "Program Type" and the program type under "PI"; record each under its correct name.

Station (MHz)	
Station name (PS)	
PI code (hex)	
Program type	
Radiotext	

(c) Paste a screenshot of the RDS constellation and the panel. Explain what the two clusters show about the receiver.

(d) Restart the flowgraph three times and time how long the station name takes to appear. Record the longest time, and describe how the name fills in.

5. ATIS. Open `L07-am-rx.grc`. Check it first on `L07-am-test.sigmf-data`, then disable the File Source, enable the PlutoSDR Source, and enter the settings of Question 1(c).

(a) Paste a screenshot of the receiver on the live ATIS, and record the information letter and the altimeter setting it broadcasts.

(b) Lower RF gain until the voice is hard to understand, and describe how the AM audio degrades. You will compare it with FM in Question 6(b).

6. AM and FM in the same noise. Open and run `L07-am-vs-fm.grc`. It needs no hardware.

(a) Set the deviation to 25 kHz and Input SNR to 30 dB. Record the two output SNR meters, and say which output looks cleaner on the frequency sink.

(b) Choose FM under Listen To. Turn the noise up: lower Input SNR slowly until you first hear clicks, and record that slider value in the table. Keep going to 10 dB, and describe what you hear and what the FM meter does. Then repeat the click search at 5 kHz and at 50 kHz deviation (at 5 kHz, go below 10 dB if you hear no clicks yet), and record each FM meter reading at 30 dB too.

FM deviation	Clicks begin at (dB)	FM meter at 30 dB
5 kHz		
25 kHz		
50 kHz		

Part 3: Writeup (individual, after the lab)

7. Analysis.

(a) Your mono receiver plays a stereo station correctly. Using your multiplex screenshot from Question 3(a), explain why.

(b) Use your table from Question 6(b) to describe, in words, what a wider FM deviation buys and what it costs.

(c) Aircraft use AM, and broadcasters use wideband FM. Using your measurements from Questions 5 and 6, explain one reason for each choice.