ECE 4670 Lab Report Grading

Lab 4: Radio Receivers for Analog and Digital Modulation

Points	Lab Exercise Number	Laboratory Exercise Description	Check off
		Wideband FM Receiver	
5	Part a	**Spectrum Analyzer** Observe FM stations in the area on spectrum analyzer. (Note: set analyzer from 87.5 – 108 MHz) Verify spacing of stations are at least 200KHz. Verify that the center frequency of stations are at odd multiple of 200KHz (capture data). Zoom into a station and verify the BW (capture data). Include captured data in report.	
5	Part b	Develop two formulas for determining the required LO frequency to receive a station using either high-side or low-side LO tuning. Your functions should take as input the desired station frequency, e.g., 99.1 MHz and return the LO frequency. (Be sure your formula takes into account the frequency doubler in the LO signal path)	
5	Part c	Configure and setup wideband receiver (antenna, power supply, function generator, scope/speaker and spectrum analyzer) as shown in fig. 7 (note you will not be setting up the optional test generator, simply attach antenna to RF port on your receiver box). Verify it is functioning.	
5	Part c	**Tune-in** one or more of the stations you identified in part a.	
5	Part d	**Spectrum analyzer:** Setup and observe the spectrum of the Mixer output. Verify the ordering of stations dependent on high or low side tuning. Explain how they are ordered dependent on which tuning scheme you use. (Be sure to use a passive scope or similar as input to the SA)	
		Narrowband Dual Conversion FM Receiver	
5	Part a	**Spectrum analyzer:** Try to find WXM56 (162.475 MHz) on the spectrum analyzer using an antenna. (Capture spectrum data for report)	
5	Part b	Derive a useful formula for setting the function generator to receive this station. What is the LO frequency you will use?	
5	Part c	Configure and setup the **narrowband receiver** (antenna, power supply, function generator, scope/speaker and spectrum analyzer). Verify it is functioning. (That is verify noise in the speaker before you connect the LO)	

5	Part d	Configure the Keysight 33600 to produce a narrowband FM signal at 10.7 MHz and a deviation of about 2 kHz. Set the output to about 100 mv pp. Just bringing the BNC cable lead end close to the 10.7 MHz IF input should quiet the noise in the PC speakers and you should hear the modulation tone. This verifies that the backend of the receiver is working properly. Do you hear the modulated tone?	
5	Part e	Reconnect 1^{st} LO signal and 1^{st} IF output to 2^{nd} IF input, connect your LO to the LO input (at 600 mV amplitude). Verify you can hear the station. What LO frequency are you using to tune in WXM56? How is the sound audio quality?	
5	Part f	Spectrum analyzer: Observe second IF mixer output to see WMM56 is down converted to 455 KHz. Adjust the LO slightly +/- 100 KHz or so to see the station signal is translated down to 455 KHz. Again, use a high-impedance buffer, like a passive scope probe, for this measurement. Capture spectrum data for report.	
		Digital Signal Receiver	
5	Preliminary	Setup and run the PN code as shown in Figure 14 of the lab reader. Be sure to have the Sound dongle installed before running Python. *You need to have pyaudio configured if using your own machine*. Capture a screen shot of the scope for this operation.	
5	Part a (Step 1 & 2)	**Set up the generator of the 33600A as follows:** (See figure 20) 1. Use Channel 1 as the transmitted RF signal that will pass thru the RF board **doubler** to produce 163 MHz carrier and data. Set the power level to -15 dBm when directly cabling to the narrow band receiver RF Input. Press the Modulate button on the front panel of the 33600 and choose FM modulation with a frequency deviation of 2.0 kHz (this will produce 4 KHz after doubler.) For the modulation source choose External with Mod In equal to 1V. 2. Use Channel 2 as the local oscillator, note the **doubler** in the narrow band receiver, determine the LO frequency that has a 1^{st} IF of 10.7 MHz to tune-in the 163 MHz FSK signal. Set this amplitude to 600mV pp.	
5	Part a (Step 3)	**In conjunction with Python code, generate and receive FSK digital data.** 3. In the Jupyter notebook sample start the audio stream with T_record = 0 so the output waveform runs continuously and no capture is made. You will need to adjust the mic gain closer to 100% in Figure 16. Verify on the scope the FSK demodulator output, when the cable to the USB audio device input is pulled off, is similar to Figure 17 in the Lab reader.	
5	Part a (Step 4)	Place the doubler output into the spectrum analyzer to verify that you have a signal centered on 163 MHz. Save a screenshot or csv file for display in the Jupyter notebook. Is your spectrum similar in shape to figure 23 in the lab reader? (NOTE: The Jupyter notebook sample has a section on FSK modulation theory and contains a code cell for simulating the	

		expected power spectral density with a repeating M-sequence bit stream and random bits. The exact shape of the spectrum depends upon the amplitude swing of the NRZ waveform coming from the USB audio device and the frequency deviation set on Channel 2 of the 33600A generator. In the Python code I assume the rear modulation input on the 33600A is 790 mV pp. The resulting spectrum for random data bits is shown in Figure 23, but can be changed to a repeating PN pattern.)	
5	Part b	Perform a long T_record = 30 s capture. Document the capture with plots similar to Figures 14, 16, and 17. Finally verify that the bit error probability (BEP) estimate is zero (BEP = 0.00e+00). What do you get?	
5	Part c	Repeat part b except reduce the signal power before the doubler to -17 dBm (i.e decrease SNR, by lowering power input). You may have to make some fine adjustments on the LO (33600A Channel 2) to get the best demodulated NRZ bit stream waveform on the scope. Determine you BER for several settings of SNR. What did you get?	
85		Total Points	