Learning Objective 2.1: I can describe what a Software Defined Radio is, contrast it with a traditional hardware radio, and identify the SDR used in this course, the PlutoSDR.

Learning Objective 2.2: I can identify the roles of the RF frontend, ADC/DAC, and host in an SDR signal chain and describe sample-rate, bandwidth, and dynamic-range trade-offs.

Use the PlutoSDR table from the lesson page. Show your work. Write a **Documentation** line at the end (**None** if you did not collaborate).

1. **Planning a capture.** The course radio is the PlutoSDR: 70 to 6000 MHz in the extended-frequency mode the course Plutos use, about 4 MS/s sustained over USB and up to 61.44 MS/s in short bursts, 12 bits, full duplex.

   (a) For each task, say whether the PlutoSDR can do it and how, or name the specification that rules it out.

   (i) Receive ship AIS at 162 MHz.

   (ii) Display the whole FM broadcast band, 88 to 108 MHz, at once.

   (iii) Transmit a 915 MHz test signal into a cable, through a 30 dB attenuator, and receive it at the same time.

   (iv) Find the direction of a 10.3 GHz beacon.

   (b) Explain how an SDR differs from a hardware FM radio, and why the same PlutoSDR can decode both broadcast FM and aircraft ADS-B.

2. **The mixer and I and Q.** We set a PlutoSDR's center frequency, its LO, to 433.0 MHz, and a key fob transmits at 433.92 MHz.

   (a) Find the two frequencies at the mixer output, and say which one the low-pass filter keeps.

   kept:

   removed:

   (b) With a single real mixer, a second transmitter would also come out at 0.92 MHz. Find its frequency, and explain how the PlutoSDR's I and Q outputs tell the two apart.

   (c) A classic FM superheterodyne mixes every station to an IF of 10.7 MHz, with its first LO 10.7 MHz above the station. Tuned to 94.5 MHz, find the LO frequency and the image, the other station that also lands on 10.7 MHz. Then explain why the preselector must remove the image before the first mixer.

   LO:

   image:

3. **Sample rate and data rate.** A team captures a 10 MHz-wide test signal centered on 2437 MHz with a PlutoSDR, in a short burst. The usable window is somewhat narrower than f_s, because the radio's filters roll off near its edges.

   (a) Find the lowest sample rate whose window just holds the signal. Then choose a rate 25% higher, to leave margin at the edges, and find the band that window covers.

   lowest: _____

   chosen: _____

   band: _____

   (b) GNU Radio stores each complex sample in 8 bytes. At 12.5 MS/s, find the data rate through the flowgraph and the size of a 10 s File Sink capture.

   rate: _____

   file: _____

   (c) The PlutoSDR sends each 12-bit I and Q over USB as a 16-bit word. Find the USB data rate at 12.5 MS/s, and compare it with the rate at the 4 MS/s the Pluto streams without dropped samples.

   USB: _____

   at 4 MS/s: _____

   (d) A teammate suggests streaming the capture live at 12.5 MS/s instead of taking a burst. Explain what goes wrong.

4. **Bits and clipping.** Use the L4 flowgraph, `L04-adc-bits.grc`, and its plots on the lesson page.

   (a) How many levels does the ADC block round to with 8 bits, the resolution of an 8-bit radio, and with 12 bits, the PlutoSDR's?

   8 bits: ____

   12 bits: ____

   (b) At 8 bits the weak tone at -0.49 MHz is not visible. Switching the menu to 12 bits makes it appear, about 40 dB above the floor. Did the weak signal change? Describe what changed on the spectrum, and why.

   (c) Set the flowgraph back to 8 bits. Raise the gain slider in steps until the time sink's I and Q just begin to flatten at full scale. Did the weak tone appear on the spectrum? Explain what you saw, and name one thing that would let an 8-bit radio show the weak signal.

   (d) In the L4 flowgraph, name two things on the plots that show the ADC is clipping.

Documentation: _____