Learning Objective 6.8: I can receive and decode AIS messages from marine vessels.

Show your work. Write a **Documentation** line at the end (**None** if you did not collaborate).

1. **Slots.** Each AIS channel divides every minute into 2,250 slots, and sends 9600 b/s.

   (a) Find the length of one slot in milliseconds and in bits.

   ms: [ ]

   bits: [ ]

   (b) A burst carries an 8-bit ramp, 24 training bits, two 8-bit flags, the message, and a 16-bit CRC. How many slots does a 168-bit position report need, and how many does a 424-bit name and voyage report need, before stuffed bits?

   position: [ ]

   name: [ ]

2. **Stuffing and NRZI by hand.** The data bits `011111111100` are about to be sent. The transmitter stuffs a 0 after every five 1s in a row, then applies NRZI: a 0 changes the level and a 1 keeps it. The level before the first bit is high (H).

   (a) Write the bits after stuffing.

   (b) Write the level, H or L, of each of the 13 transmitted bits.

   (c) In words, explain why the receiver does not need to know which FM frequency, up or down, stands for H.

3. **Receiver settings.** A classmate brings back a SigMF recording whose `.sigmf-meta` file says `cf32_le`, a sample rate of 250000, and a center frequency of 162000000.

   (a) Set the Frequency Xlating FIR Filter's center frequency for channel A and for channel B.

   A: ____

   B: ____

   (b) Choose `decim` so that the rate after the filter is about 48 kS/s, and find the samples per bit that Symbol Sync needs.

   decim: ____

   sps: ____

   (c) The Quadrature Demod's gain is the rate after decimation divided by $2\pi \times 2400$, so that a 2.4 kHz shift comes out as 1. Find it.

   ____

4. **An NMEA sentence.** A decoder prints

```
!AIVDM,2,1,7,B,55NQj<02D1o9L@gGG788iDF0PE8tp0000000000t:0I8840Ht>0CSPD3k2Dh,0*14
!AIVDM,2,2,7,B,00000000000,2*20
```

(a) Which channel carried it, and into how many sentences was it split?

(b) Each character carries 6 bits: subtract 48 from its ASCII code (and 8 more if the result is above 39). The first character is `5`, ASCII 53. Find the message ID and say what kind of message it is.

(c) Explain why this message needed two sentences when a position report needs one.

5. **Noise and the squelch.** You run `L19-ais-rx.grc` on the lesson's recording.

   (a) You raise the Added noise slider until channel B's trace in the time plot swings wildly between bursts and frames start failing the CRC. Explain what has happened, and which slider you move to fix it.

   (b) Explain what goes wrong if you raise the Squelch slider too far.

   (c) AIS uses a Gaussian filter with BT = 0.4. In words, say what a smaller BT would gain and what it would cost.