Learning Objective 5.1: I can create a GNU Radio out-of-tree (OOT) module and add a custom Python block to it.

Learning Objective 5.2: I can implement a custom signal-processing block from scratch and integrate it into a GNU Radio flowgraph.

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

1. **The files of a module.** A cadet runs `gr_modtool newmod beacon` and then `gr_modtool add -t sync -l python tone_finder` in the new directory.

   (a) Name the file the cadet edits for each job: (i) the signal processing, (ii) the label and parameters GRC shows, and (iii) the unit test that `ctest` runs.

   (b) The cadet builds and installs the module with GNU Radio 3.10.9. `ctest` passes, but a flowgraph that uses the block stops with

   ```
   ModuleNotFoundError: No module named 'gnuradio.beacon.tone_finder'
   ```

   Explain the cause and the fix.

   (c) After a correct install, GRC's block library still has no `tone_finder`. Give two possible causes.

2. **Choosing a block type.** For each block below, choose sync, decimator, interpolator, or general, and give the ratio of outputs to inputs.

   (a) A block that converts each float sample to dB.

   (b) A block that outputs the peak magnitude of each run of 100 complex samples.

   (c) A block that holds each bit for 8 samples.

   (d) A squelch that passes only the samples whose power is above a threshold and drops the rest.

   (e) The Energy Detector could have been a general block. Explain in words what code a decimator lets the programmer leave out.

3. **Levels.** A cadet runs the Energy Detector on a keyed tone at 48 kHz, averaging 64 samples. On the Power plot, the floor between marks sits near -12 dB and wanders about half a dB up and down, and the carrier sits just above 0 dB.

   (a) Choose a threshold halfway between the two levels on the plot.

   (b) How long does each output cover, and how many outputs does the block make per second?

   (c) Suggest a hysteresis and explain the choice in words.

   (d) The cadet changes Samples Averaged from 64 to 16. Describe what changes on the Power plot and in the key's timing, and whether the levels from (a) and (c) still work.

4. **Hysteresis by hand.** The Energy Detector, with its key starting at 0, receives these ten power values in dB:

$$-25,\ -14,\ -16,\ -14,\ -16,\ -14,\ -21,\ -16,\ -14,\ -22$$

(a) Write the ten key outputs for a threshold of -15 dB and a hysteresis of 4 dB, and count the times the key changes.

(b) Repeat for a hysteresis of 0 dB.

(c) The values -14 and -16 dB are noise on a carrier that stays on. Explain in words which key is correct, and what a Morse decoder would make of the other.

5. **A unit test.** A test feeds the Energy Detector, with 4 samples averaged, a threshold of -10 dB, and a hysteresis of 3 dB, these twelve complex samples:

$$1,\ 1,\ 1,\ 1,\ \ 0.1,\ 0.1,\ 0.1,\ 0.1,\ \ 1,\ 1,\ 0,\ 0$$

Averaged four at a time, these samples read 0, -20, and -3 dB on the power output.

(a) How many outputs does each port make, and which input samples does each output average?

(b) Give the three key outputs.

(c) The last output averages a run where the carrier switched off halfway through. Explain in words what that does to the timing of a key edge, and how the number of samples averaged sets the size of the effect.

Documentation: _____