Learning Objective 4.4: I can implement a PAM link that transmits and receives ASCII text end-to-end.

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

1. **Text to bits and back.** The L10 transmitter sends each byte most significant bit first. In ASCII, 'H' is 0x48 and 'i' is 0x69.

   (a) Write the 16 bits the transmitter sends for "Hi", in order.

   (b) A receiver's Repack Bits block is set to LSB first by mistake. What byte does it produce from the first 8 bits, and does it print as a letter?

   (c) A correctly set receiver outputs `01000111 01001111`. What two characters arrived? ('A' is 0x41, and the capital letters follow in order.)

2. **One packet.** A cadet changes the L10 message to `MAYDAY 41.ON 104.8W`, 19 characters. The Vector Source adds a newline, and the packet format is the L10 one: a 64-bit access code, a 32-bit header, then the payload. The link runs at 4 kbaud with one bit per symbol.

   (a) How many bits are in one packet, and how long does it take to send?

   bits: ____

   time: ____

   (b) Write the 16-bit length field, which the header sends twice.

   ____

   (c) What fraction of the bits on the air are text? If the same packets ran at 9.6 kbaud, the rate of L9's channel example, how long would one take?

   text: ____

   time: ____

3. **The access-code search.** Correlate Access Code - Tag Stream compares the last 64 bits with the access code after every new bit and declares a packet when at most 2 bits differ.

   (a) While no packet is arriving, the bits are random. About how many of the 64 match the access code at a typical position, and why?

   (b) A teammate sets the threshold to 0, so the block declares a packet only when all 64 bits match. In words, what happens to the link as the noise rises, compared with a threshold of 2? Why not set the threshold to 20 instead?

   (c) On the PlutoSDR version of the link, no packets arrive, yet the constellation after the Costas Loop shows two tight clusters on the real axis. Explain in words what the correlator sees and why, and what the receiver should change.

4. **Watching noise break the text.** The L10 link runs at a noise amplitude of 0.3 with every line intact. A cadet raises the noise slider a step at a time while watching the receive-filter eye, the Symbol Sync output, and the Received and Lines labels.

   (a) Describe, in order, what changes on each display as the noise rises from 0.3 until no line arrives.

   (b) With the noise raised, the line reads `USAFA ECE 448: ASCII over PCM.` instead of `…PAM.` 'A' is 0x41 and 'C' is 0x43. How many bits went wrong in that character, and which one?

   (c) A teammate proposes 200-byte packets to raise the share of text on the air from 72% to 94%. In words, would the longer line start to break at a lower or a higher noise setting than the 31-byte line, and why?

   (d) The cadet sets the noise back to 0.3, the default, where every line arrives, and switches the matched filter off. Describe what the eye and the Symbol Sync output look like with the filter off, and explain why they change.

5. **Clock error.** Two radios each derive their clocks from a crystal accurate to 20 ppm, so the receiver's sample clock can differ from the transmitter's symbol clock by up to 40 ppm. The link runs at 4 kbaud.

   (a) A receiver without timing recovery samples at fixed intervals. How many symbols, and how many seconds, until its sampling point slips one whole symbol? How many 344-bit packets is that?

   time: _____

   packets: _____

   (b) The L10 link loses almost no lines up to 10,000 ppm with Symbol Sync in the receiver. Explain why the slip in part (a) does not appear in that link, and why a 40 ppm error is not a concern for it.

   (c) In the clock-error screenshot, the eye sink looks smeared while every line arrives. Explain why the eye sink and Symbol Sync disagree.

Documentation: _____