Pre-Lab Activities:
Complete the pre-lab work sheet before you come to class.

Purpose of the experiment:
Examine the electrical signal generated by a T1 transmitter; observe the AMI bit encoding, the B8ZS method for encoding long strings of zeros, and the framing bit structure of the D4 Superframe.

Smoking and any food or drinks are not permitted in the Applications Lab!

Equipment:
- Oscilloscope
- Two T1 Test Sets
- Substantial array of connectors and probes

Steps to be Performed:
The AMI Signal
The T1 test set has been connected to the oscilloscope for you. The test set is simply sending 1 bits at the T1 rate, no framing bits or channels.

Adjust the Time/Div knob until you can see a few pulses on the screen. Push the "Cursor" button and select cursor t1. Use this cursor to point to the start of a pulse. Select cursor t2 to point to the end of this pulse. Record the difference between the cursors (Δt on the display).

Use cursors V1 and V2 to measure the difference (in volts) between the top of a positive pulse and the bottom of a negative pulse (this is called peak to peak voltage).

Adjust the Time/Div knob so you can see at least 10 pulses (remember that a pulse can be positive or negative).

On the T1 test set, push Pattern, then push the key below the "All Zeros" selection. Record what you see.

All zeros is, as we know, an invalid T1 signal as soon as we send more than 8 zeros. To work around this, you know from your readings that we can use the B8ZS method to encode strings of 8 zeros while still sending signal pulses. On the T1 test set, push Code, then push the key under the B8ZS selection. Adjust the Time/Div knob as needed to see the repeating pulse pattern. Sketch the pattern you see. In your sketch, include the bit boundaries. You can do that by "locking" the two cursors together (they are still spaced one bit time apart, right?). When you move the cursors together, you can estimate the start and end of each bit time.

On the T1 test set, push Pattern, then select "More", and select "1 in 2". Adjust the Time/Div knob so you can see about 3 positive pulses. Decode the bit pattern being sent here (hint: use the cursors locked together at a bit time apart). Record the bit pattern that is being repeated.

On the T1 test set, select "USER PROGRAM". Again, decode the bit pattern.
The T1 framing

On the T1 test set, push Frame, then select D4 (that is the Superframe structure we discussed in class). Push Code, and select AMI (we will not "repair" long strings of zeros to make the display easier to see). Push Pattern and select All Zeros. Now the test set is only sending the framing bits, all the channels are filled with zeros. The framing bits are supposed to follow the sequence 1 0 0 0 1 1 0 1 1 1 0 0. Let's see if we can find them.

Adjust the Time/Div on the oscilloscope until your time/division readout is 200µs. Push Display, and select None under the Grid button. Adjust the Volts/Div knob until the oscilloscope displays 500mV per division. Push Cursors and select Clear Cursors. Gently adjust the Level knob until you can see 7 pulses on the screen. Note their approximate position. Press Stop on the oscilloscope. Some of the pulses may have "disappeared". In that case push Run and try again, until the stopped display contains 7 pulses (they can be different heights, as long as you can find them).

Select the t1 cursor and move it close to the left side of the screen. Select t2, and adjust it so the cursors are separated by the time you computed for one Superframe. Lock the cursors together and move them so that either t1 or t2 point to a pulse. Record t1 and t2. Select t2 and adjust it so the two cursors are one frame time apart. (The scope may not let you set the exact number, just pick the closest).

Lock the cursors together and determine the value of the 12 framing bits. Compare these to the bit sequence we expect for the superframe. (Hint: there is no reason -- except for coincidence -- that the leftmost bit on your screen is frame #1 of a superframe.)

Remote T1 Testing

Disconnect the oscilloscope. Replace the ‘pigtail’ connector with the ‘loopback’ connector. At this time, the tester is talking to itself, i.e. its transmission wires are connected to its receive wires. Change the transmission pattern to QRSS: quasi random signal source. Press Results, Restart, and Clear History. There should be no red lights. The tester is sending what we’ve told it to (D4 framing, QRSS, AMI) and comparing the received signal to the same configuration (D4 framing, QRSS, AMI) and finding no errors. This tells us the short blue cable and the loopback connector are okay. Wow.

What does an error look like? The section of the tester called “Transmit Error Insert” allows us to intentionally insert errors for diagnostic purposes. Make sure the Logic and Err Free lights are lit. Press Single. What happens? Press it a few times. What do the abbreviations ES, EFS, and % EFS mean?

Disconnect the short blue cable from the tester (hereafter to be called the local tester) and connect the cable labeled T1 220. Across the room, there’s another test set (we’ll call it the remote tester) and another cable labeled T1 220. Connect a loopback connector to that cable. Press Restart on the local tester. We don’t know what’s between the two; what can we say about it?

At the remote site, connect the T1 220 cable to the remote tester, removing the loopback. Change both testers to ESF/B8ZS/QRSS. Press both Restart and Clear History buttons. Both testers should be red-free, displaying error free transmission. Introduce an error at the remote site. Which tester shows an incremented error count? Clear the error results by pressing Restart.

On each tester, press Aux and look for Loopcodes type to be “Out-band”. If it’s not change it, using the down arrow and softkey. Press Results.

Note the section of the tester panel called “Send Loopcodes.” These buttons allow the user to send commands to the remote machine using the FDL. “Loop Up” means to order the remote tester to simply loop back whatever data it receives. “Loop Down” disables this.

Press Loop Up on the local tester, noticing the transient messages on the display. Press Restart.
Send an error from the local tester. What happens on the local display? On the remote display? Note the status of the Tester Loop lamp on the remote tester.

Go to the remote machine and change the pattern setting from QRSS to something else. What happens to the error data at each of the two testers? Be sure to note the Receive Status lights. Press “Loop Down”, then Restart on both testers; what do you see now?

Set the testers so that both use QRSS and get to a point where both are red-free, displaying error free transmission. Change both testers so they display “Signal Results”. Look for the Volts Pk-Pk (that stands for volts peak to peak). This is the same measurement as the one you took with the oscilloscope at the start of the lab. How do these measurements compare?

On the Local tester, change the LBO setting from 7.5 to 0, then go to the Remote tester and record the new signal level. On the Local tester, change to the LBO 15 setting and record the result on the Remote tester. Why do T1 devices make this setting adjustable?
Requirements for your lab report

General Rules

Your report must be typed, except that drawings may be made by hand. While your raw data sheet must be attached, all relevant data must be copied into your typed report. **Do not** put things like “see data sheet” into your typed report.

Things to put into your lab report

A header section with your name, your teammates’ names, group number, and date/time of the lab.

The initialed raw data sheet (always attach this **at the end** of the report)

The signed pre-lab.

Each of the subsections below requires a brief description of what you measured, your results, and – when requested – a reference to and a quote from a reference source that you can compare your measurement to (for example, one of our readings or an internet source).

- Comparison of measured and computed bit duration
- Measured peak-to-peak voltage
- Measured B8ZS pattern and comparison to the expected pattern
- Decoded bit patterns (2) and sketches of the pulse pattern they came from
- The observed framing bit sequence and a comparison to what is expected.
- Test results:
  - Explanation of the various tester results.
  - Loop-back results
  - Error insertion results
  - Signal results (volts pk-pk), compare to oscilloscope measurement
  - Signal level (volts pk-pk) and changes based other LBO setting
- Definitions for ES, EFS, %EFS
- Definition for LBO
Measurement of a bit time

Measurement of the B8ZS pattern.

Decode bit patterns

Locate and decode the superframe framing bits.

Tester read-outs after error insertion (with the loop-back plug)
Tester read-outs after error insertion with two testers

Tester read-outs after error insertion after sending “Loop Up”

Results when the remote tester is set to a test pattern other than QRSS (with and without a loop-back set)

Signal results (with LBO at 7.5, 0, and 15)