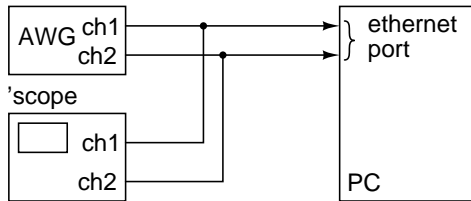


10 Mb/s Ethernet Transmitter

Introduction

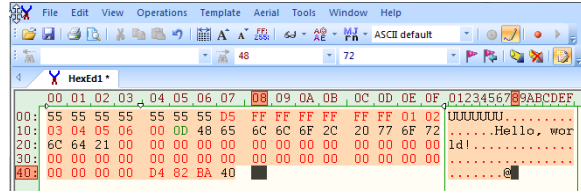
In this lab you will use a hex editor to create a file containing an Ethernet frame. Then you will use a supplied program to convert this file to a 10 Mb/s Ethernet waveform in the `.raf` format used by the Rigol AWG. You will read this file into the AWG and generate an Ethernet waveform that will be received by the Ethernet interface on the lab PC. You will use a scope to measure the interface voltages and signal timing. You will use the Wireshark protocol analyzer to display the frame contents.



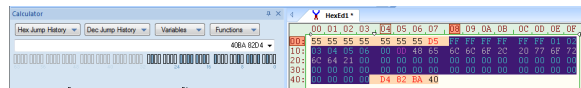
Create an Ethernet Frame

Run HexEdit (available on the course web site) and use the menu item `File⇒New` to create a new file. Select a file size of 0 bytes. Right-click in the data area and select “Allow Changes”. Use the Insert key to switch between inserting and over-writing existing values. Use the Tab key to switch between entering values as hex or ASCII characters.

Enter the bytes of an Ethernet packet that contains your full name and student ID as the payload (data). Include the preamble and SFD. The destination address should be the broadcast address (all 0xff). The source address should be the last six digits of your student ID (e.g. if you ID was A00123456 you would use a source address of `01:02:03:04:05:06`). Set the length/type field to the number of bytes in the payload (i.e. in your name). This value will prevent decoding of the payload because it will not correspond to a known Ethertype (e.g. IP). The data field should contain your name padded with zeros to reach the minimum frame length.



To compute the FCS, select the bytes *following the preamble* and compute the 32-bit CRC using the menu item `Operation⇒Checksum⇒CRC 32`. Add this 4-byte value to the end of the packet. Note that the CRC value computed by HexEdit is a 32-bit value that must be transmitted in order from LS to MS bit (you will have to reverse the byte order and the program will reverse the bit order).



Use `File⇒Save` to save the data to a file called `frame.bin`. Make sure the length of the file in bytes is the minimum Ethernet frame length¹ plus the preamble length (including the SFD).

Pre-Lab Report

Create the `frame.bin` file according to the instructions above. Submit a PDF file containing the usual identification information and a screen capture showing the contents of your packet including the CRC.

Bring the `frame.bin` file when you come to the lab.

Configure the AWG and Verify Waveform

Download the `test1.raf` and `test2.raf` from the course web site, put them on your flash drive and plug the flash drive into the AWG.

The configuration of the AWG is somewhat complicated by the need to use both channels to obtain

¹Unless your name is very long, it should fit into the shortest-allowable Ethernet frame.

a differential output. The AWG also has to be set up in burst mode so that one waveform (frame) is transmitted every 16ms. This is the time interval between the NLP (“normal link”) pulses that are included in the waveform created by the software.

To configure the AWG start by using the menu item:

- Press **Utility** / **Set to Default** / **OK** to reset most of the settings.

Then configure the AWG to output the generated waveforms on Channels 1 and 2 with a 16ms gap between waveforms:

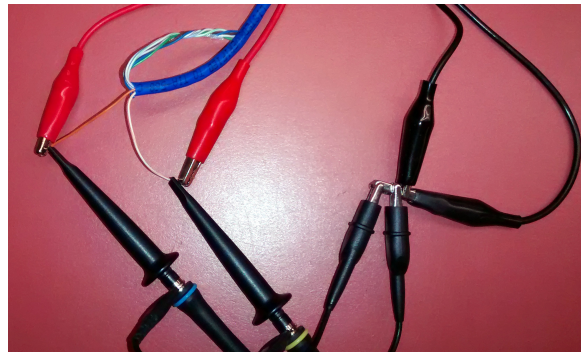
- press **Arb**
- press **Arb Mode** until Freq is selected (you may need to press **▽** to reach this menu item)
- set Freq/Period to Period (you may need to press **△** to reach this menu item)
- set the Period to the waveform period printed by the software (68.266 μ s for the test waveforms)
- press **Ampl** until it is in HiLevel/LoLevel mode
- set HiLevel to 1 V
- set LoLevel to 0 V
- press **Select Wform** to enter the waveform selection menu
- select **Stored Wforms**
- select **File Type** **Arb File**
- press **Browser** until Dir is selected
- select the D: drive (USB)
- press **Browser** until File is selected
- select **test1.raf** and press **Read**
- press **Burst**
- verify that the mode is NCycle with 1 waveform cycle per burst and internal triggering
- set the burst Period to 16 ms

- Press **CH1/CH2** to switch to configuring Channel 2. Repeat the above steps for Channel 2 but use the file **test2.raf** instead.

Now align the waveform phases and enable both outputs:

- press **Arb** **Align Phase** to ensure the start of both waveforms are time-aligned
- press **Output1** and **Output2** to turn on both outputs

Use two BNC-to-alligator clip cables to connect the AWG channel 1 and 2 outputs to the probes for the two 'scope channels. Connect all of the ground leads together. Do not hook up the Ethernet cable yet (although it's shown in the photo below). Do not connect either waveform generator output to ground!

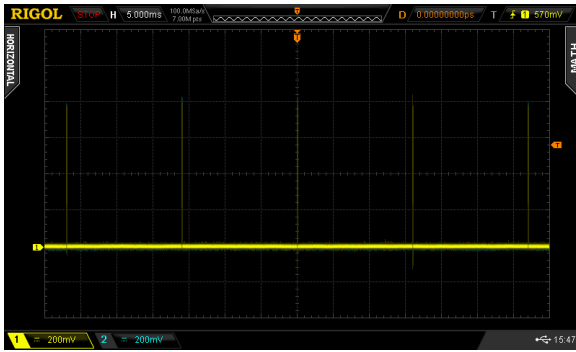


Use the oscilloscope to check that the voltage levels, signal period and the preamble waveform are as expected.

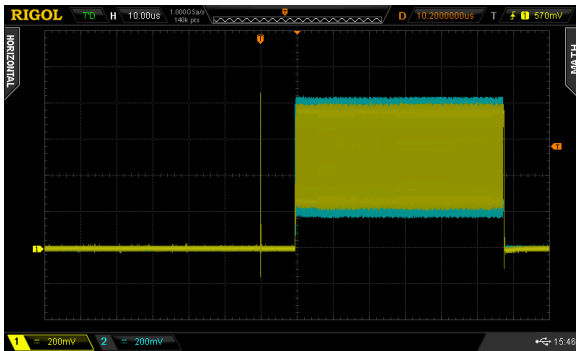
For a stable display of the waveform you will either need to capture and hold one waveform or use the holdoff trigger feature² to ensure the 'scope triggers only once per frame.

If you superimpose the traces from the two channels you should see a 10BaseT Ethernet frame being transmitted every 16ms:

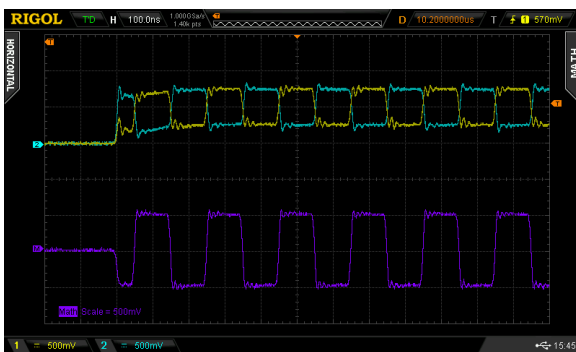
²On the 'scope's Trigger menu select Channel 1 source, rising edge, select Settings / Holdoff and set the holdoff to a value longer than the waveform duration (e.g. 80 microseconds) but shorter than the time interval between frames (about 16 ms). Set the trigger level to about 500 mV.



and each frame should be preceded by a normal link pulse:



Enable the Math channel and display the differential voltage (A-B with A as channel 1 and B as channel 2) as well as the two AWG channels superimposed. The initial portion of the frame should look something like:



Obtain a screenshot of the start of the frame and another of the end of the frame for use in your report.

Connect to Ethernet Interface

Connect the Ethernet cable to the unused (lower) RJ-45 connector on the back of the PC. This should be

brought out to a connector on the desktop. If necessary, ask the instructor for help in locating the right port.

Strip enough insulation from the ends of the orange/white and orange wires so you can connect them to both the 'scope probes and AWG outputs (see photo above):

- the white/orange wire is Ethernet signal **RX+** and should be connected to AWG channel 1 and 'scope channel 1.
- the orange wire is Ethernet signal **RX-** and should be connected to AWG channel 2 and 'scope channel 2.

Each AWG channel has a fixed 50 ohm output impedance which matches the approximately 100 ohm impedance of the cable and Ethernet port. Note that the AWG output voltage drops due to the load presented by the Ethernet port.

Also verify that the signal is not distorted. If the end of the cable is not connected, the unterminated cable will reflect the signal back with a delay of ≈ 10 ns per meter of cable and result in ISI that will be visible on the 'scope.

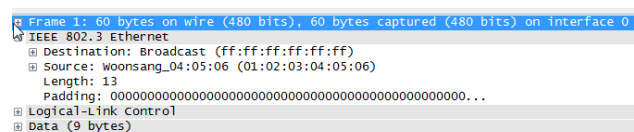
View Packet Contents Using Wireshark

From the Start menu search for “View Network Connections”. Find the network interface with the Realtek network interface card (NIC).

Run the Wireshark protocol analyzer.

If the Type/Length field is less than 0x600 Wireshark will treat the packet as IEEE 802.3 instead of Ethernet 2. The rarely-used 802.3 format uses the Type/Length field as a length field and includes a 4-byte LLC header immediately following the type length field. Disable decoding of the 802.2 LLC protocol under the menu item Analyzer / Enabled Protocols... and de-selecting the LLC checkbox.

Select the network interface found above and click on “Start.” You should now see packets being displayed that say “Hello world” in the data portion as shown in the screen capture below.



```

0000 ff ff ff ff ff ff 01 02 03 04 05 06 00 0d 48 65 .....He
0010 6c 6c 6f 2c 20 77 6f 72 6c 64 21 00 00 00 00 00 11o, wor ld!....
0020 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
0030 00 00 00 00 00 00 00 00 00 00 00 00 .....

```

Report

Submit a report including the following:

- the usual identification information
- a printout from HexEdit showing your packet's contents in hex and ASCII (including any corrections you made in the lab)
- a 'scope screen capture showing the single-ended and differential voltages at the start and end of the packet showing the preamble and start-of-idle waveforms
- screen captures from Wireshark showing the received Ethernet header and data fields.
- Answers to the following questions:
 - (1) What is the minimum length of an 802.3 frame, not including the preamble? Does this include the header and FCS?
 - (2) What is the frequency of the preamble waveform³? Why?
 - (3) Assuming the minimum frame size, how many bytes will be transmitted per frame, including preamble and FCS?
 - (4) What part(s) of the frame you created does Wireshark not show?

Convert Frame Data to Waveform

Now that you have verified that everything is configured and connected properly, you need to transmit the Ethernet frame you prepared in the Pre-Lab to see if it is correct.

The `etherlab.c` program reads a file and encodes the bits as a Manchester-encoded waveform. The bits are encoded in order from LS to MS bit. Therefore, if the bytes in your file represent a complete and correct Ethernet frame (including preamble and CRC) the output waveforms will represent a valid 10BASE-T frame.

The program reads a file called `frame.bin` and generates two files, `channel1.raf` and `channel2.raf` corresponding to the files that should be output on channels 1 and 2 of the AWG respectively.

Download the compiled copy of the program, `etherlab.exe`, to the folder in which you've put your `frame.bin` file. Run the program (Shift-right-click, select "Open Powershell Here" and enter `.\etherlab.exe`). The program should create the `channeln.raf` files. Copy these to your flash drive so you can load them into the AWG.

The program will also print the duration of the waveform. Record this – you will need the waveform duration to configure the AWG correctly.

Check your Frame

Load the `channel1.raf` and `channel2.raf` files into the AWG as described earlier and view the decoded frames using Wireshark.

Show the instructor your packets being decoded to get marks for completing the lab.

Take a screen capture (or two) showing the contents of the 802.3 header and the complete contents of the packet in both hex and ASCII (as shown above) for your report.

³Read the square wave's period from the 'scope screen capture and compute the frequency. The answer may not be what you expect.