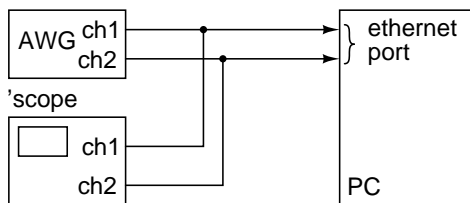


## 10 Mb/s Ethernet Transmitter

### Introduction

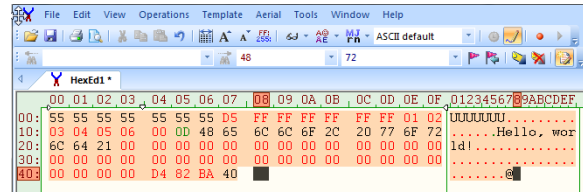
In this lab you will use a hex editor to create a file containing an Ethernet frame. Then you will use a supplied program to convert this file to a 10 Mb/s Ethernet waveform in the .raf format used by the Rigol AWG. You will read this file into the AWG and generate an Ethernet waveform that will be received 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.



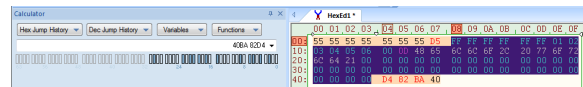
### Create an Ethernet Frame

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 as the data. Include the preamble and SFD. The destination address should be the broadcast address (all 0xff). The source address should be 1:2:3:4:5:6. Set the length/type field to the length of the packet (although the value will be ignored by the hardware). The data field should contain your name padded with zeros if necessary 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 (i.e. you will have to reverse the byte 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 length 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 a differential output and to configure burst mode so that one frame is transmitted every 16ms. This is the time interval between the normal link pulses that are included in the waveform created by the software.

To configure the AWG start by using the menu item:

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

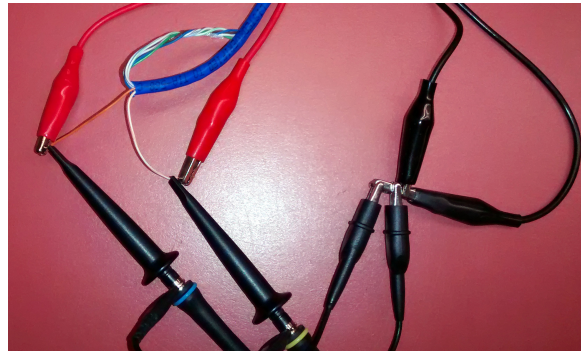
Then configure the AWG to output the generated waveforms on Channels 1 and 2 with a 16ms gap between waveforms:

- press Arb
- set Arb Mode to Freq (you may need to press the down arrow key to reach this menu item)
- set Freq/Period to Period (you may need to press the up arrow key to reach this menu item)
- set the Period to the waveform period printed by the software ( $68.266 \mu\text{s}$  for the test waveforms)
- press Amplitude 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
- press Browser until Dir is selected
- select the D: drive (USB)
- press Browser until File is selected
- select channel1 .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
- repeat the above steps for Channel 2 but use the file channel2 .raf instead. You can switch between configuring channels 1 and 2 with the CH1/CH2 button.

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 each of the outputs

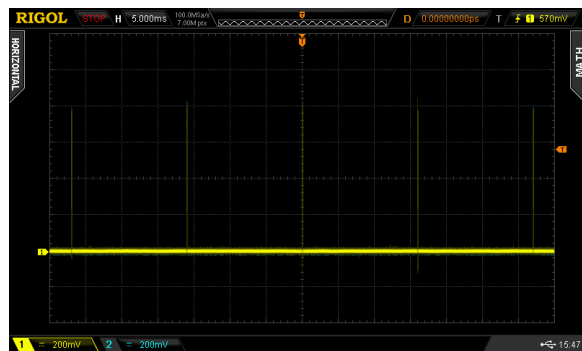
Use two BNC-to-alligator clip cables to connect the AWG channel 1 and 2 outputs to the probes for the two 'scope channels. Connect all of the ground leads together. Do not hook up the Ethernet cable yet (although it's shown in the photo below). Do not connect either waveform generator output to ground!



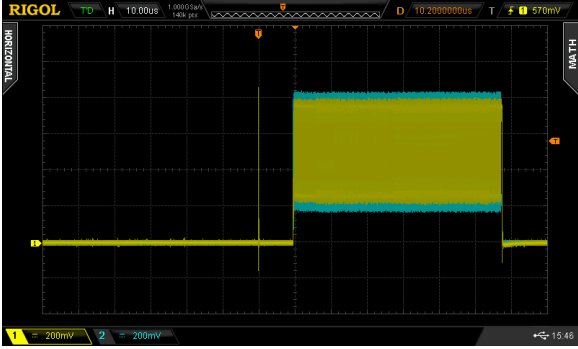
Use the oscilloscope to check that the voltage levels, signal period and the preamble waveform are as expected.

For a stable display of the waveform you will need to use the holdoff trigger feature to ensure the 'scope triggers only once per frame. To do this, on 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). Set the trigger level to about 300 mV.

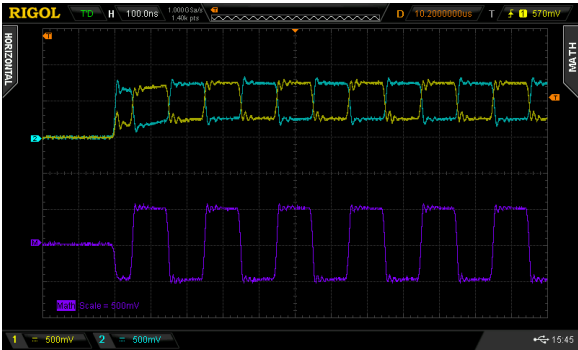
If you superimpose the two traces you should see a 10BaseT Ethernet frame being transmitted every 16ms:



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. 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  $\approx$  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. 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.

```

Frame 1: 60 bytes on wire (480 bits), 60 bytes captured (480 bits) on interface 0
IEEE 802.3 Ethernet
  Destination: Broadcast (ff:ff:ff:ff:ff:ff)
  Source: Woonsang_04:05:06 (01:02:03:04:05:06)
  Length: 13
  Padding: 00000000000000000000000000000000000000000000...
  Logical-Link control
  Data (9 bytes)
0000 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 ....llo, wor ld!....
0020 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
  
```

### 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. 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.

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## Check your Frame

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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.

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## Report

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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 waveform<sup>1</sup>? 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?

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<sup>1</sup>Read the square wave's period from the 'scope screen capture and compute the frequency. The answer may not be what you expect.