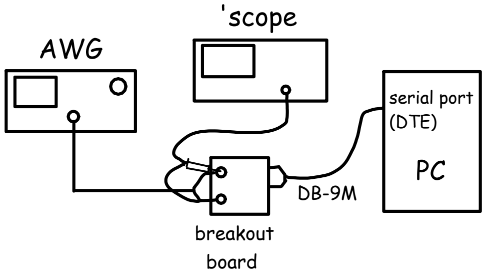
RS-232 Serial Interface Waveform

Introduction

In this lab you will generate an asynchronous serial ("RS-232") waveform that transmits your name to the serial port ("UART") on the lab PC.

A diagram of the equipment setup in the lab is shown below. The waveform is generated by the Arbitrary Waveform Generator (AWG) from samples loaded into it from a CSV file. The AWG output is connected to a PC serial port (UART) on the back of the PC through a cable. A "breakout board" allows test equipment to connect to the signals on the serial interface. A "terminal emulator" program running on the PC displays the characters received over the serial port and this confirms that you created a valid RS-232 signal.



Software

You will use the following software to complete this lab:

- Octave: the same numerical analysis software used in previous labs. Your commands will generate samples of an RS-232 waveform and save them to a CSV file that can be loaded into the AWG using the supplied Python script.
- TeraTerm: an application called a "terminal emulator". This application displays ASCII- or UTF-8 encoded characters received on the PC's serial port. You will use it to verify that you've generated the correct waveform.

This software is freely available.

Generate the Waveform

The waveform you created in the previous lab generated a 7-bit asynchronous serial interface ("RS-232") waveform. In this lab you will create a longer waveform that encodes the characters of your name.

In this lab we will again use Octave commands operating on vectors and matrices to generate the waveform.

In the Matlab language a string (a sequence of characters) is stored as a row vector containing the ASCII values of the characters in the string. The commands below convert this string to an asynchronous serial interface waveform.

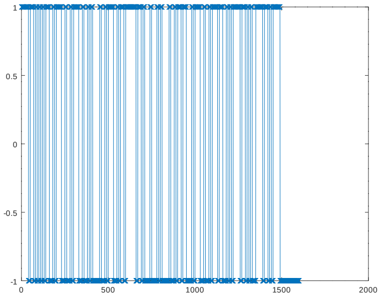
```
% load the communications package to access the
% de2bi() (decimal to binary) function

pkg load communications

% define the string, a vector of character values,
% to transmit including a carriage return and line
% feed

s="Hello, world!\r\n"

% convert to a matrix with 8 bits per character in
% each row and one row per character; the bits are
% in lsb-first order

b=de2bi(s,8)

% for convenience set 'n' to the number of rows:

n=size(b,1)

% we add start (0) and stop (1) bits before and
% after the data bits in each row (character):

c=[zeros(n,1),b,ones(n,1)]

% indexing a matrix with ':' yields a column
% vector containing all the elements in
% column-wise order.  To read the values row-wise
% we transpose the matrix with the transpose
% operator ('), read the values column-wise and
% transpose back to a row vector:

c=c'(:)'

% add a 10-bit gap in the waveform to allow the
% UART to synchronize quickly

c=[c,ones(1,10)]

% with all the bits in a row, the conversion to
% normalized voltages is as in the previous lab:
```

```
% replicate the rows to get 10 samples per bit:

s=repmat(c,10,1)

% convert 0 to +1 and 1 to -1:

v=1-2*s

% reshape v to column vector

v=v(:)

% write the samples, in one column, to a text file
% with a 3-line header (number of samples, max and
% min values)

csvwrite('samples.txt',[length(v);1;-1;v])
```

Procedure

Generate and Check the CSV File

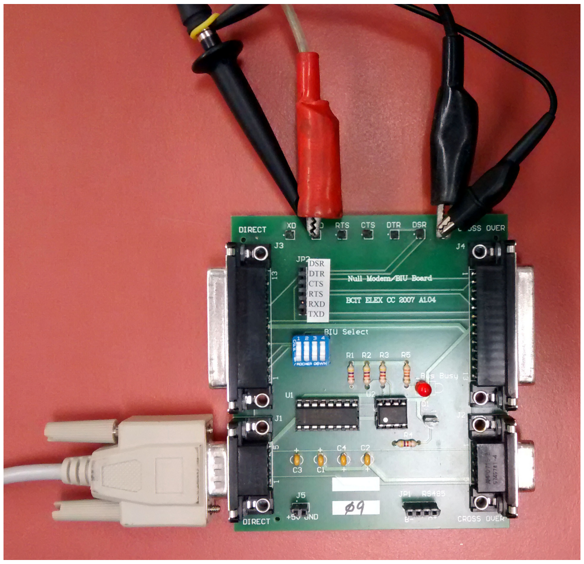
Use Octave to generate a CSV file containing the waveform required to transmit your name as an asynchronous serial signal. As in the previous lab, use the **plot(v(:),'x-')** command to generate a plot of your waveform. An example is:



Check the waveform at this point to make sure at least the start and end polarity are correct and you have approximately the right number of samples (number of characters × number of bits per character × number of samples per bit). Use File > Save to save it to a format that you can include in your report (e.g. **.png**).

Generate and the Check Waveform

Plug the cable from the serial port on the back of the PC into the “Direct” side of the breakout board. Connect the AWG channel 1 output and the ’scope channel 1 input to the appropriate pin on the “breakout board” (PC serial ports are wired as DTEs).

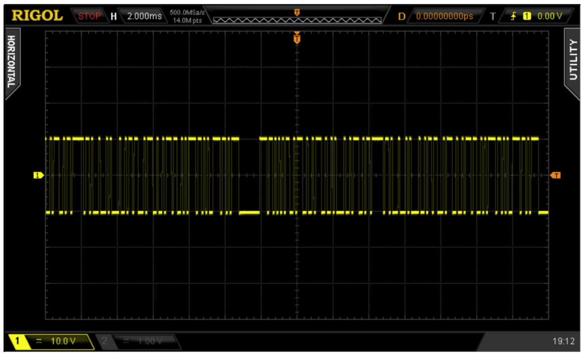


Load the **.txt** file into the AWG as described in the previous lab. The sample rate should be set so that the serial interface bit rate is set to a value determined by the last digit of your BCIT ID:

Last digit of your ID	bit rate (Hz)
0,1,4,7	4800
2,5,8	9600
3,6,9	19200

You will need to calculate the AWG sample rate based on the number of bits per sample that you used when generating the waveform.

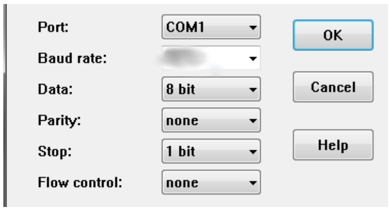
Adjust the ’scope vertical and horizontal scales so that you can see at least one period of the waveform. Remember to change the probe scaling to 10X. Stop the ’scope. The display should look similar to:



Set up serial protocol decoding as in the previous lab but use the ascii format display for this lab so you can see the characters in the string being transmitted.

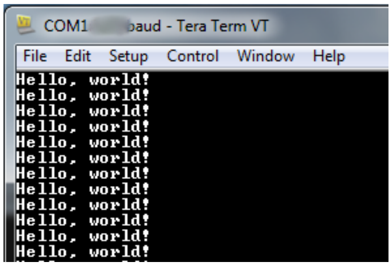
Display Characters

Run Teraterm. Select serial port input using COM1 when the program starts. Select Setup->Serial Port and *set the COM1 settings for the correct baud rate, number of data bits, parity, and stop bits*[1]. Set flow control to none.



Port: COM1
Baud rate: [redacted]
Data: 8 bit
Parity: none
Stop: 1 bit
Flow control: none

If you've done everything correctly you should now see your name displayed repeatedly on the terminal:



```
Hello, world!
Hello, world!
Hello, world!
Hello, world!
Hello, world!
Hello, world!
Hello, world!
Hello, world!
Hello, world!
Hello, world!
Hello, world!
Hello, world!
```

Save a copy of the screen capture showing the Teraterm output, and a screen capture of the 'scope display showing the initial portion of the decoded serial waveform.

Pre-Lab Assignment

Use the sample rate corresponding to your BCIT ID as shown in the table above to answer the following questions:

1. What values could you configure for the high and low AWG output levels so that the output conforms to the RS-232 specification?

2. If the PC's connector is a DTE, to which RS-232 pin name do you need to connect the AWG's output?

3. What should you configure as the PC's serial port baud rate assuming 8 samples per bit and that the AWG sample rate is set according to the table above?

4. How many characters are in your string (including CR and LF)? What is the duration of the waveform (including the 10 trailing mark bits) in units of bit periods? What is the duration in milliseconds?

Create a PDF file containing the answers to the above questions. Submit your pre-lab report *before the start of your lab* using the appropriate assignment folder on the course website.

Lab Report

Create a report in PDF format containing:

- the required identification information (your name, etc.),
- the waveform as plotted by Octave,
- a screen capture of the waveform displayed by the 'scope (without decoding),
- the 'scope display with decoding showing your decoded name (or a portion of it),
- a screen capture showing the Teraterm window with your name displayed.

Submit your lab report using the appropriate Assignment folder on the course website.

[1] Hint: Do this step carefully. A significant number of students mis-configure the software and then waste time tracking down non-existent problems elsewhere.