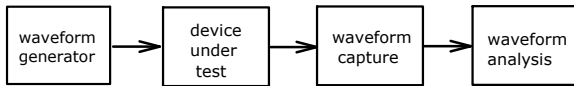# Generating Test Signals

Introduction

One way to test a communication system is to apply a test waveform as the input and analyze the output:


This approach is useful when you need to test a device or system for which there is no specialized test equipment. In this lab you will use an Arbitrary Waveform Generator (AWG) to generate a test waveform.

As the name implies, an AWG is able to generate an arbitrary waveform because it allows you to specify the output waveform as a sequence of sample values. These sample values are numbers whose value is proportional to the voltage of the waveform at equally-spaced intervals of time:
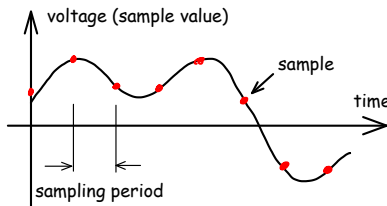

In this lab you will compute the sample values using Octave (Matlab) and write them to a file. Then you will transfer the sample values to the AWG. You will then view the waveform on the oscilloscope and check it using the 'scope's RS-232 decoding feature.
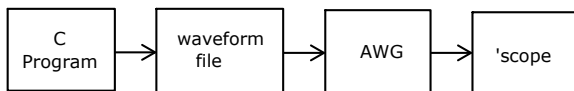
Analog Waveform Specification

The analog waveform output by the AWG should consist of a voltage that can be either +5 V or -5 V and is held steady for intervals of 208 μs. Each interval corresponds to one bit of data. For a '1' bit the voltage should have should have a voltage of -5 V and for a '0' it should have a voltage of +5 V.

Here's an example of the waveform corresponding to the sequence of bits 1, 0, 1, 1, 0:
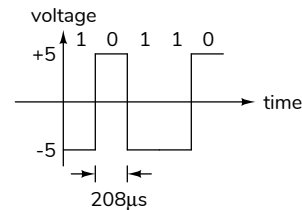
Your waveform must encode a 7-bit binary number that is the sum of all the digits of your student ID. For example, if your ID number is A00123456 the number you would output is $1+2+3+4+5+6 = 21$ (hex 0x15, binary 0010101). This number may not match that of others doing the lab.

The bits of the number should be output in *least significant bit first* (lsb-first) bit order. For the binary value 0010101, the output will begin with 101···, *not* 001···.

Note that both the bit order and the signal polarity are probably the opposite of what you were expecting.

In addition, one positive voltage interval (equivalent to a '0' bit) should be added before the data bits and ten negative voltage intervals (equivalent to ten '1' bits) should be added after the data bits:
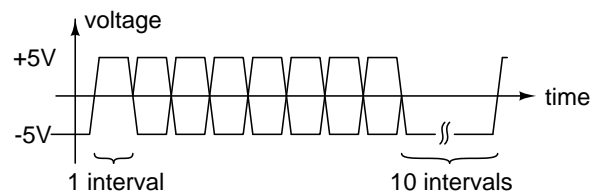
The AWG will continuously repeat your waveform and these additional "start" and "stop" bits will make it possible to identify the start and end of your waveform.

Generating the Waveform File

We will use Octave to create a CSV file with the required sample values. The commands required are listed below. By studying the comments you should

be able to change the values to produce the required waveform. Lines starting with % are comments. Variables in Matlab are two-dimensional matrices of complex numbers. This includes column vectors (an $n \times 1$ matrix), row vectors (a $1 \times n$ matrix), and scalars (1×1). Most lines below are function calls that assign values to variables.

Note that the waveform used in the examples below are *not* the required waveform. You will need to change various parameters and your output will look different.

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

pkg load communications

% the value to be converted to a waveform

n=21

% convert each character to a row vector of 7 bits
% (lsb-first by default)

b=de2bi(n,7)

% add one start before and ten stop bits after

b=[0,b,ones(1,10)]

% replicate each row 10 times:

s=repmat(b,10,1)

% convert 0 to +1 and 1 to -1

v=1-2*s

% convert to a 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])
```

You can enter these commands in the Octave GUI. The file browser lets you navigate to the folder where you will store your CSV file, the Workspace window shows your variables and the command window allows you to type in commands, such as the ones above, and view the results.

Procedure

Use Octave (or Matlab if you prefer) to create a CSV file with the required sample values. The sample levels should be ± 1 (not ± 5, see below). You should replicate each sample value 10 times to get an approximation to pulses.

Use the `plot(v(:),'x-')` command to generate a plot of your waveform. An example is:
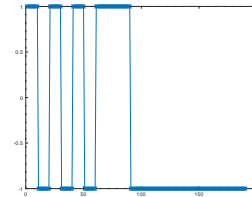
Check the waveform at this point to make sure it's correct. Use File > Save to save it to a format that you can include in your report (e.g. `.png`).

Copy your `.csv` file to your USB flash drive and load it into the AWG using the instructions in the Appendix below.

Connect the 'scope's Channel 1 probe to the AWG Channel 1 output as in the previous lab and view the AWG output on the 'scope.

Values in the CSV file between -1 and +1 will be linearly scaled to the range of voltages between the low and high voltage levels respectively. The sample rate should be set so that each bit (not each sample) has a duration of 208 μs.

Use the oscilloscope to check for a ± 5 V waveform on the AWG output. Capture a sufficiently-long portion of the waveform and adjust the horizontal scale and position to show your complete waveform.

Note: Each time the 'scope is turned on you must select CH1 -> Probe Ratio -> 10X to get correct voltage scaling. Unfortunately, there is no way to make this the default.

Set up the 'scope's decoding feature as follows to check your waveform. Use the "Decode" button to bring up the decode menu. Select "RS-232" decoding with TX as Channel 1. Set the baud rate appropriately, a threshold voltage of 0V, LSB order, 7 data bits, no check (parity) bit and decimal display format. If you've done everything correctly you should see "your" number displayed.

Once the 'scope shows the correct value, capture the 'scope screen to your flash drive by pressing the orange button with the printer icon so you can include the screen capture in your report.

2

Pre-Lab Assignment

Submit the following to the appropriate drop box before the start of the lab:

- The cover page information as described in the course information handout.

- The calculation of the sum of the digits in your student number.

- A table showing the conversion of this number to bits and voltage levels. Show the bit number (0, 1, 2, ...), the bit value (0 or 1) and the signal voltage (+5 or -5).

- A drawing of the waveform you expect to see on the 'scope. Show each bit, not necessarily each sample. Label the voltage and time axes.

- Compute the sample period (time between samples) based on the bit period and the number of samples per bit specified above. Compute the corresponding sample rate that you will need to configure into the AWG.

Lab Report

Submit a report that includes:

- The cover page information as described in the course information handout.

- The calculation of the sum of the digits in your student number.

- A table showing the conversion of this number to bits and voltage levels. Show the bit number (0, 1, 2, ...), the bit value (0 or 1) and the signal voltage (+5 or -5).

- The computation of the sample period (time between samples) based on the bit period and the number of samples per bit specified above. Compute the corresponding sample rate that you will need to configure into the AWG.

- Screen captures showing the Octave waveform, and the 'scope's display with the decoded RS-232 value.

Convert your report to a PDF format file and submit it via the appropriate course web site Assignment folder.

Appendix - Configuring The AWG

- Press [Utility] [Set To Default] [OK] to reset the AWG to it's default settings.

- Press [Arb] to select Arbitrary waveform output.

- Press [Arb Mode] until SRate (sample rate mode) is selected. Note: to access this and some of the following buttons you may need to press [▽] (gray key on the bottom) to toggle between two sets of menus.

- Plug your USB drive into the USB socket on the front of the AWG. You should see the message USB device detected and the USB icon (⬦⬌) will appear on the display.

- Press [Select Wform] [Stored Wforms].

- Press [Browser] until Dir is selected.

- Use the knob to highlight drive D: (the USB drive).

- Press [Browser] until File is selected.

- Press [File Type] [Txt File]

- Use the knob to highlight your .txt file.

- Press [Read] and you should see the message Completed! Arb Wave data have been read.

- Press [Arb] to return to the Arb menu.

- Press [Srate] and enter the sample rate on the keyboard. Terminate the entry by selecting the appropriate units.

- Press [Ampl] until HiLevel is highlighted.

- Enter the voltage that should be output for the maximum sample value (1).

- Press [Offset] until LoLevel is highlighted.

- Enter the voltage that should be output for the minimum sample value (-1).

- Press [Output1] to turn on the Channel 1 output.

Note: Keep this appendix; you will need it for future labs.