ELEX 3525 : Data Communications
2016 Fall Term

Assignment 1

Due Tuesday, October 11. Show your work. Submit your assignment using the appropriate dropbox on the course web site. Assignments submitted after the solutions are made available will be given a mark of zero.

Question 1

A sinusoidal signal is defined as:

$$s(t) = (1 + d_2)\sin(2\pi(1000 + 100d_1)t)$$

where d_1 is the least-significant (LS) digit of your student ID and d_2 is the second LS digit of your student ID.

For example if you student ID is A00123456 the LS digit is 6 and the second LS digit is 5 and the waveform would have a frequency of $1000 + 6 \times 100 = 1600$ Hz and an amplitude of $1 + 5 = 6$ V:

$$s(t) = 6\sin(2\pi 1600t)$$

This waveform is then sampled at a rate of 3 kHz. The first sample is taken at $t = 0$.

Each sample value is quantized to a 6-bit number. The quantization range is -10 to +10 V and this range is divided into $2^6 = 64$ equal voltage ranges, each corresponding to a step of $\Delta V = 20/64 = 312.5$ mV.

The sample value should correspond to the voltage range that the voltage falls into. For example if the voltage is between -10 and -10+0.3125 the sample value would be 0.

(a) What are the frequency and amplitude of the signal corresponding to your student ID?

(b) Derive an expression for the time (t) of each sample.

(c) Derive an expression for the quantized sample value, integer, corresponding to a voltage level v.

(d) What are the first 10 sample values?

You can compute the values by hand (slow and error-prone), using a spreadsheet or by writing a program. In all cases show how you obtained your answer. *Hint: convert real numbers to integers using an operation such as floor, round or truncate.*

Question 2

Find a food whose first letter is the same as that of one of your names (first, last or nickname). Use a reasonably recent web browser and operating system to visit a translation web site such as translate.google.com or www.bing.com/Translator and translate the name of the food to Chinese (Simplified).

Copy and paste the characters of the translated text into a file. Examine the text file with hexedit or other software that can display the values of the bytes in the file.

(a) What is the food (in both languages)?

(b) Give the values of the bytes in the file in hexadecimal notation?

(c) How many characters are encoded (omitting any control characters such as line feed or carriage return)?

(d) What are the Unicode code points for each of the characters?

Question 3

Consider the text of this question, not including the Hint below. Find the number of unique letters and their frequencies (number of times they occur). Consider upper- and lower-case to be the same and ignore punctuation and spaces. How often does each letter occur? Using the relative frequencies of the letters as their probabilities, what is the entropy in bits/letter? Show how you obtained your result.

Hint: There are many ways to approach this problem. You could write a program to do the calculation. Another way would be to use a text editor such as Notepadd++ to split up the text so there is one letter per line (easy with the Macro... feature), then convert to lower case (Edit -> Convert Case...) and sort lines (Edit -> Line Operations -> Sort ...). Once you have one character per line you can compute the frequencies

by hand or import the lines into a spreadsheet where the lower(), code(), char() and possibly the frequency() functions can be used to compute the letter frequencies and the entropy.

Question 4

An internet link uses an asynchronous serial interface with 8 bits (1 byte) per character. The interface is configured for 9600 b/s using 1 start bit, 1 stop bit and 1 parity bit. The data is transmitted using a protocol (PPP) that requires a 4 byte header before, and a 4 byte trailer after each 1023-byte frame. In addition, some byte values need to be "escaped." This adds, on average, an additional 2 bytes for every 256 bytes.

(a) Assuming no errors or retransmissions and that frames are transmitted one after the other, how many seconds will it take to transfer a 10 MByte file?

(b) What is the throughput in bits/second?

Question 5

The first letter of your surname, in upper case, is transmitted over a serial interface at a rate of 9600 bps. The receiving serial interface is configured to operate at 19200 bps.

(a) What character(s) will be received?

(b) Will a framing error be detected?

Show your work (e.g. the transmitted waveform and receiver sampling points). Assume that after detecting a framing error the receiver takes the next low-to-high transition as the start bit of the next character.

Question 6

Modern computers seldom have asynchronous serial ("RS-232") interfaces. A common solution that allows communicating with "legacy" devices is to use an USB-to-serial interface. There are ICs that implement almost all of the required functions.

Some products, such as the DMM in the lab, use microcontrollers that are don't have USB interfaces but do include serial ports. These products can implement a USB interface by embedding one of these USB-to-serial ICs in the device. By changing the IC's vendor and device ID, it's possible for a USB host to identify the product and load appropriate device drivers.

(a) Find such an IC (just the IC, not a packaged converter). Give the manufacturer and part number and a link to the data sheet.

(b) Can the USB vendor and product ID of the IC in part (a) be changed?

Question 7

You want to make a 10 pF capacitor using some transmission line that has a characteristic impedance of 90 Ω and uses air as the dielectric. How could you do this? How much of this transmission line do you need?

Question 8

A retailer is advertising an antenna for over-the-air (OTA) TV reception that has a gain of 16 dB[1] compared to an isotropic antenna at a frequency of 500 MHz. What is the effective aperture in square meters?

[1] This gain sometime stated in units of dBi.