Assignment 3

Due Tuesday, November 22. 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

Show the output from running the program you wrote for Question 5 of Assignment 2.

Question 2

The same amusement park as in Question 6 of Assignment 2 has a ball room which only admits children between 34 and 59 inches high. What fraction of children visiting the park can play in this room? *Hint: 1 inch is 2.54cm.*

Question 3

A communication system transmits symbols without ISI. The system encodes data using 64 different levels. The bit rate is 1.544 Mb/s. At what frequency must the gain of the channel be 1 (0 dB)? At what frequency must it be -6 dB?

Question 4

Use a spreadsheet to compute and plot channel gain versus frequency for a raised-cosine low-pass channel with an excess bandwidth parameter α equal to the fifth digit of your BCIT ID divided by 10. For example if you ID is A00123456 you would use $\alpha = 0.3$.

Plot the channel gain in linear units with a maximum gain of 1 and the frequency normalized to the symbol rate ($f_{\text{symbol}} = 1$) over a range of 0 to 2. Use enough points to obtain a reasonably smooth graph (e.g. 30 or more).

Your answer should include the plot and the first few lines of your spreadsheet showing the formulas you used[1].

[1] The control-` (control-backquote) keyboard shortcut typically switches between displaying formulas and values.

Question 5

An OFDM system operates with a sample rate of 2 MHz over a channel whose impulse response extends over a maximum of 20 μs.

What minimum guard time will allow the ISI to die down in-between OFDM symbols?

If the guard time must be less than 10% of the OFDM symbol duration, what is the minimum symbol length if the number of samples in a symbol must be a power of 2?

Give the guard time and the symbol length in both microseconds and number of samples.

Question 6

A BSC operates at a rate of 70 kb/s. What range of BER values allow communication at an information rate of 56 kb/s with an arbitrarily low error rate? *Hint: there are two ranges.*

Question 7

A channel has a "brick-wall" frequency response with a bandwidth of 1 MHz. A 10 dBmV signal is received. Noise with a standard deviation of -3 dBmV is received along with (i.e. added to) the signal.

(a) What is the maximum information rate that can be transmitted over this channel with an arbitrarily low error rate?

(b) What is the maximum symbol rate that can be transmitted over this channel without ISI?

(c) What is the bit rate if bipolar NRZ transmission is used without FEC coding? What is the bit error rate in this case?

Question 8

Compute and plot the power spectrum of random data transmitted using bipolar Delay Modulation line coding (sometimes called Miller code). Assume a bit rate of 100 kb/s. Plot the power spectral density in dB versus frequency in Hz.

You can either look up the equation for the power spectrum and compute the value at various frequencies or estimate it by computing the power spectrum of delay-coded random data as was done in Lab 6 (but without using hardware). Give references and show your work.

Do not copy an existing figure. You must calculate the spectrum yourself.

Hints: If using the approach from Lab 6, modify the encoding section of `linecodes.m` *and add* `pwelch()` *and* `plot()` *function calls to plot the power spectrum.*

The following code implements delay modulation line coding on the second through last bits in `x`*:*

```
% '0' bits preceded by a 0 bit should have a
% transition at the start of a bit period:

x0=and(x(2:end)==0,x(1:end-1)==0);

% '1' bits should have a transition in the
% middle of the bit period.

x1=x(2:end);

% insert '1's where the transitions should
% happen into an array with ns samples/bit

z=zeros(ns,length(x0));
z(1,:)=x0;
z(ns/2,:)=x1;

% perform differential encoding (each '1'
% causes a transition)

x=mod(cumsum(z(:)),2) ;

% offset 0 and 1 to +/-1 to get zero mean

x=2*x-1 ;
```

Question 9

Convert the three least-significant digits of your BCIT ID (0 to 999) to a 10-bit binary number. Show the sequence of bits that would be transmitted if HDLC framing were added. Include start and end flags and bit stuffing but ignore other aspects of HDLC (e.g. headers).

Question 10

A differential line driver outputs +5 V on TD+ and 0 V on TD- when the input is H. It outputs 0 V on TD+ and +5 V on TD- when the input is L. What are the differential and common-mode voltages?