Power Spectral Density of Line Codes

Introduction

In this lab you will measure the Power Spectral Density (PSD) of three common line codes: NRZ, Manchester and 4B5B combined with MLT-3 (the line code used by 100 Mb/s Ethernet).

Generating the Test Signals

Matlab is a convenient language for generating test signals. We will use Matlab to generate the signals in `.RAF` format suitable for loading into the AWG. The file `linecodes.zip`, available on the course web site, contains the files `linecodes.m` and `rafwrite.m`. The `linecodes.m` script generates 10,000 random bits and encodes them using the three line codes.

Pre-Lab Report

Read through the Matlab code to see how it works and answer the following questions. You can evaluate expressions in Matlab and use the `help` command to answer the questions. You should be able to use the free FreeMat or octave software as well.

- What does the `rand(1,n)` function return? Is it a row or column vector?

- What values result from applying the `>` operator?

- How many rows and columns does a matrix defined as `[ 1 0 1 ; 0 1 0 ]` have?

- What is the effect of subscripting the above matrix with `(:)`?

- What does the `.'` operator do? What is the effect of applying it to the above vector?

- What do the `cumsum()` and `mod()` functions return?

- How does the expression `mod(cumsum([1 0 1 1 0 0 1]),4)` perform MLT-3 encoding?

Procedure

Run the Matlab script to generate the three `.RAF` files. You may want to put the script in your working directory and `cd` to this directory before running the script so that all the files end up in the same folder.

Load the `nrz.raf` file into the AWG using the instructions in previous labs. Set the sample rate to 1 MHz, HiLevel to 1 V and LoLevel to -1 V.

Connect the signal generator to the 'scope and look at the waveform. Measure the amplitude and bit period and confirm it's what you expect. Capture a screen shot for your report.

It should look something like this:
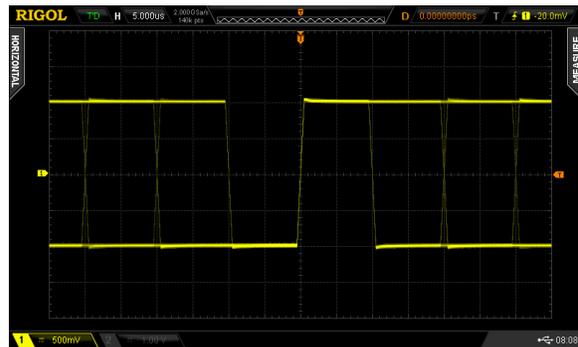
Now reduce the sweep rate to 100 μs/division. This will display 140 bits per sweep.

Press [Math] to enable the Math trace and select FFT mode and Channel 1 as the source. Select a linear scale (Vrms instead of dBV) and position the trace vertically so it is above the FFT parameter display line. Select a vertical scale of 50 mV/division. Select a Blackman window.

With the math mode still selected, adjust the horizontal scale control for a frequency resolution of 25 kHz/division and set the cursors to identify the positions of the first two spectrum nulls. Capture screen shot for your report. It will look something like this:

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Repeat the steps above for the Manchester and 4B5B+MLT-3 line codes. For example, the waveform for the 4B5B code+MLT-3 line code should look like:
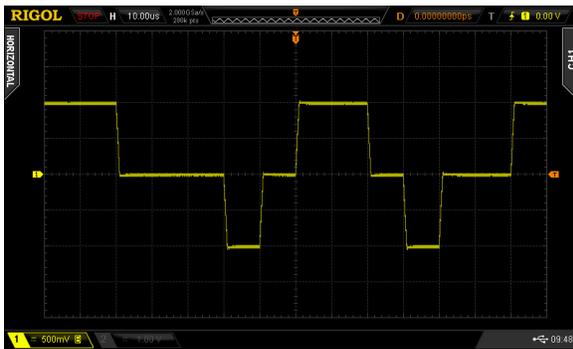
and the spectrum for Manchester should look something like:

The spectra will vary from sweep to sweep. Unfortunately, the 'scope we are using cannot average the measured spectra over multiple sweeps. However, you should still be able to draw some general conclusions.

Lab Report

Include the usual identification information, the six screen captures showing the waveforms and the spectra of the three line codes and answer the following questions for each line code:

- What is the data rate?

- What is the baud rate?

- At what frequencies does the signal have no power (a null)?

Rank (order) the three line codes in terms of (a) their bandwidths (frequency of first null above DC) and (b) power at frequencies near DC.