**EE 218 LINEAR SYSTEMS II LABORATORY**
Missouri University of Science & Technology

LAB 5: SPECTRUM OF RANDOM DATA SIGNALS

**Aim:** In this lab you will learn to make a pseudo-noise (PN) generator and investigate time-domain signal and spectrums for pseudo-random data sequences generated by the PN generator.

**Required Background:**

- Sampling theorem.
- Spectrum of periodic and a-periodic power signals.
- Digital logic, binary operations.
- Filtering of continuous and discrete-time signals.

**Introduction:** In Lab 4 you generated some periodic digital signals using a 16 bit pattern generator. Many times we would like a simple way to generate a seemingly random patter of digital information. This random pattern is useful for modelling digital message sources, and also in secure communication systems and navigation systems. It is reasonably easy to modify your 16 bit pattern generator to make a pseudo-noise (PN) generator. In the pattern generator from Lab 4, you fed the output of the 16th flip-flop back to the input. Remove this connection and replace it with an XOR gate. The output of the XOR gate will go to the input of flip-flop #1. The two inputs to the XOR gate should be connected to the output of the 14th and 15th flip-flops. You will need to initialize your PN generator, just as you did the 16 bit pattern generator.

**Procedure:**

1. Load the PN generator with an arbitrary starting sequence (just not all zeros or all ones). Measure the power spectrum of the PN generator output.

2. Does the initial state, or the clock frequency, effect the power spectrum? If so, what effect does it have?

3. Pass the output of your PN generator through a low-pass filter (LPF). If you run the cutoff frequency of the LPF up to a high value, you should notice that the output looks very much like the input. The only distortion you should see is that the edges of the waveform are a little more rounded off now. You may also see a little ringing after each

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step.

4. In digital electronics and digital communications, we don't care about the exact shape of a waveform, as long as we can still reliably determine where the 1's and 0's are located. Start lowering the cutoff frequency of the LPF you set up in the last problem. Watch the waveform on the oscilloscope. How low can you set the cutoff frequency, and still be able to reliably determine where the 1's and 0's are located? Could you easily identify this frequency on the spectrum analyzer?

**For Your Report:**

- Part 1: Make sure to sketch/and or record data from the spectrum analyzer so you can plot the power spectrum of the PN generator in your report.

- Part 2: Make sure you have data to support your answers.

- Part 4: When answering the question of "how low can you set the cutoff frequency?", Express your answer as a function of the clock frequency $f_{\text{CLOCK}}$.

- From your experience in Part II of Lab 4 and the measurements you took in this lab, determine the period of the PN sequence, i.e. how many bits before it starts repeating?

- Confirm the period of the PN sequence by simulation in Matlab. This isn't that hard, just a single FOR loop and a few lines of code. Include a time domain plot of the Matlab PN generator output that shows the period as stated above. Also include the amplitude spectrum of the PN generator output.

- How does the simulated PN amplitude spectrum compare to the measurements you took in lab?

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