ECE228A
Homework #4

Agrawal (Third Edition):

Problem 3.1
Problem 3.3
Problem 3.7
Problem 3.9
Problem 3.10

Term Project:

At this point you have developed a rudimentary model for a direct modulation laser transmitter. The linewidth of the source is programmable and defines the phase noise (random average switching time of the optical phase). The linewidth of the signal that is launched into the fiber at this point is defined by the chirp parameter C only and we have ignored the modulation bandwidth. The effect of chirp is to make the frequency variable a function of time, e.g. Cos (ω_i(t)t +θ(t)). where This keeps the problem simpler although not realistic. You also have control over the bit extinction ratio by varying the power in the zero bit relative to the one bit.

In this part of the project you will take the output of your laser and launch it into an optical fiber and study the evolution of your transmitted bits and how they will look at the fiber end point assuming a perfect receiver. Next we will model a more realistic receiver to understand the impact of the whole system, but for now we just want to understand how the fiber impacts our optical data.

1. The output of your laser transmitter can be represent in either the time domain or in the frequency domain via the Fourier Transform. There are advantages to both representations and in the end you might want to do both. Take the randomly generated amplitude, phase and frequency data points you have generated and try taking a fast Fourier Transform (FFT) to see what the average optical power spectrum looks like. Plot the normalized energy as a function of optical frequency.
2. Now you need to develop a model for your fiber. You will initially consider the following physical parameters for the fiber, the loss (α), the first order dispersion (D or β_2), the second order dispersion (S or β_3) and the fiber length (L).
3. First do some back of the envelope calculations to use to verify how your simulation is doing. Use the full result of broadending factor from lecture notes and Agrawal to insert parameters. You can choose to represent actual bit rates and lengths or try to normalize everything.
    a. Plot the output bit width for one of your bits as a function of the parameters in 2 above. Vary your parameter, for example L over 1000 to 50,000 Km, β_2 in the range of -10 to +10 in increments of 2. For β_3 use a value from the lecture or grab a chart from one of the reference books. For now use an extinction ratio of 20dB out of the transmitter.
4. Next you need to decide how you are going to propagate the bits through the fiber. The first approach we will try is a time domain simulation. In our class lecture is the field

equation with respect to distance z. Ignore the nonlinear portion, and propagate your sampled laser output using all the laser parameters. You will need to figure out how to include the instantaneous phase and frequency by finding equations that related these parameters to the field evolution.

5. Now plot your bit stream for various chirp parameters for a 10km and 50km link. Plot the amplitude, phase and frequency at 2km increments for the 10km link and 5km increments for the 50km link.
6. Comment on the output that you observe for the various conditions. For each plot, at the fiber output state the pulse broadening, the extinction ratio and the chirp. What does this mean in terms of what the receiver will see?