University of California, Santa Barbara
Department of ECE

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ECE228B
Fiber Optic Components and Systems
Term Project

Part 1

This quarter you are going to simulate a complete link including the receiver. Before starting on the receiver, in Part 1, you will go back and re-design your transmitter with a new level of sophistication.

1) As with last quarter, write code to generate a Pseudo Random sequence of binary bits, this time 25 bits long.
2) Using the master rate equations for N and S, write a time domain simulation for the evolution of N and S given that your random 25 bits drive the current term in the N equation. Set your drive current so that the bias point is 1.5x the threshold of the laser and the digital modulation yields 20dB optical extinction ratio around that point.
3) Plot the time evolution of N and S over the 25 bits. Assume 100 time samples per bit. Include in your simulation the nonlinear gain compression parameter using values given in class. Also include the spontaneous emission factor term. For the recombination lifetime, use the N dependent equation with the A, B and C parameters. For all values, use those listed in the lecture notes or write your assumption.
4) From N and S, derive the equations you need to plot the amplitude, phase and frequency and then plot the time domain versions of amplitude, phase and frequency for the 25 bits.
4) Using this technique you should automatically get the attributes of bit evolution including the relaxation oscillation, damping, off level, on level.

Part 2

In part 2 you are going to write a receiver simulator. In addition to the receiver you will need to control the optical signal coming in using the output of your transmitter from Part 1. Hooking up the receiver to your transmitter will give you a back-to-back baseline for the performance as you add each noise component and before we add the fiber transmission and optical amplifier to our link.

1. Build a noise generator for your signal coming out of the transmitter. Let the noise be rms variance as we have defined in class, so you have to figure out if it gets added to the field or the amplitude. This noise coming out of the transmitter is going to be shot noise from the transmitter. We want to make sure that it corresponds to the level of the output signal, and it is ok to choose an rms variance for the zero level and a different rms variance for the one level. Add this noise after you have computed the final output bits. For a Poisson statistical distribution, the variance is equal to the mean! So the fluctuation in optical field will be proportional to the optical mean for the zero or the one. That is way shot

noise is signal level dependent for a laser that outputs Poisson photon statistics. Once you figure this out, add the noise and plot out your transmitted bit stream

2. Next take your noise signal and input it into a receiver that has a responsivity of 0.95 and the photodetector connected to an amplifier that appears as a 50 ohm load. Also, assume the amplifier has a dark current of 1nA. Calculate the shot noise power (variance) with no input signal and calculate the thermal noise variance. Now make a random number generator that can take the signal input to the receiver (in this case directly from the transmitter) and builds a total shot noise term and a thermal noise term and adds these to the output current from this section of the receiver. Plot your received bit stream. Now, vary the mean input power level including the extinction ratio and the one level so that your current output from the receiver is (a) shot noise dominant and (b) Thermal noise dominant. Show two examples of each for the output bit streams and note the actual value of the rms noise power for each. Can you find an input power where the two noise terms are equal? What happens when you take away the noise from the receiver and assume it is all embedded in the receiver?
3. Now add an amplifier with noise figure 5dB and re-do part 2.

Part 3

OK, time to put your transmitter and receiver together with an optical amplifier at the receiver to see how an optically pre-amplified receiver impacts transmission.

1. Introduce enough fiber to make the system loss limited. In other words we are going to assume dispersion does not dominate so you can ignore dispersion. Assume the fiber loss is 0.2dB/km. You probably want somewhere around 18-20dB fiber loss. A typical fiber span that requires an optical amplifier is 80km.
2. Now build your optical amplifier model at the end of the fiber just before your receiver. As you did in the previous parts, identify all of the noise sources we discussed in class from the optical amplifier and define variables and equations for each of the noise variance terms. Remember these can be a function of the input power to the amplifier. Assume a 5dB noise figure and that you are running a 10Gbps system so there is an optical filter at the amplifier output matched to this bit rate. Also assume the amplifier has an output saturation power of 20dBm.
3. Now you are going to look at the received bit streams as you adjust the amplifier gain from very low to as high as it can get (saturation). The idea is to vary the received optical signal from thermal noise limited to shot noise limited.
4. As you adjust the optical amplifier gain and recover your bits, what do you observer. Clearly state your results and observations.
5. At this point your writeup should be that of a final report. Good Luck!!!