

EEE 482F LABORATORY 3

Bit Error Rate

Exercise 1 – Direct-sequencing spread spectrum

- Read Section 10.5 in Stremler.
- Implement the DS-BPSK spread spectrum modulation and demodulation schemes from the block diagram on pg. 629. Use the following settings:
Amplitude = 1V, $f_b = 10$ Hz, $f_{ch} = 1000$ Hz, modulating frequency = 100 Hz;
System time = 10s, system rate = 10 000 Hz;
For the integrate-and-dump filter, select the 'hold value' output and set the integration time to T_b . View the spectrum of the signal after spreading. Correlate the output of the filter with the input code to determine the delay introduced to the system by the filter. Synchronise the system using a delay token. Confirm that the system is now synchronised by correlation.
- Find the bit error rate (BER) of the system using the following methods:
 1. XOR the delayed input signal with the output of the filter. Set the threshold to zero.
 2. Use a BER token with the same inputs as the XOR. Set the number of trials to 1, the threshold to 0, and the offset equal to the delay determined above.
- Introduce a jamming signal at 100 Hz via a gain token. Set the amplitude of the jamming signal to 1V and the gain to 1. View the spectrum of the jammed signal. View the BER.
- Loop the system, increasing the amplitude of the jamming signal with each loop. To do this, go to the tool dropdown menu and open 'Global Parameter Links'. Select the gain token. Define the algebraic relationship as $(cl - 1)*5$. This will increase the gain from zero in steps of 5. Go to the system time menu and set the number of system loops to 5 and select the 'Reset system on loop' option. The gain, and therefore the amplitude of the jamming signal, will now go from 0 to 20 in steps of 5. Set the stop time to 5. Close all viewing sinks except for those attached to the XOR and the BER tokens. Run the system to find the number of errors. Vary the processing gain, fill in the table below and comment on the results. Note that the number of errors registered by the system has to be divided by the ratio of the system sample rate to the signal rate.

Processing Gain (f_{ch}/f_b)	Amplitude of Jamming Signal	Theoretical P_e (Equation 10.42)	Expected Errors In 5 seconds	Recorded Errors In 5 seconds
100	0			
	5			
	10			
	15			
	20			
10	0			
	5			
	10			
	15			
	20			

Exercise 2 – 16-ary QAM

- Load qam.svu from the examples and run the system.
- Modify the system to calculate the BER as done in Exercise 1, by replacing the lowpass filter on each channel with an integrate-and-dump filter and comparing the input and the output, after synchronization. Refer to the schematic. Select the ‘density in 1 ohm’ option for the Gaussian noise. Loop through the system, incrementing the density of the noise from 0 W/Hz to 1 W/Hz in steps of 0.2. To do this, define the algebraic relationship as $((cl-1)*2)/10$, in the global parameter link library. In the system time menu, set the number of loops to 6, set the stop time to 50 seconds, and set the system sample rate to 200 Hz. Run the system and fill in the table below. To calculate the total number of errors, simply add the errors from each channel. As before, divide the number of errors by the ratio of the system sample rate to the signal rate.

η (W/Hz)	E_s / η	Theoretical P_e (Equation 10.52)	Expected Error In 50 seconds	Recorded Errors In 50 seconds
0	Inf.			
0.2	2.5			
0.4	1.25			
0.6	0.833			
0.8	0.625			
1.0	0.5			