Project 4: Digital Bandpass Communication

In this project, you will build a digital communication system with bandpass transmission. See the system model below.

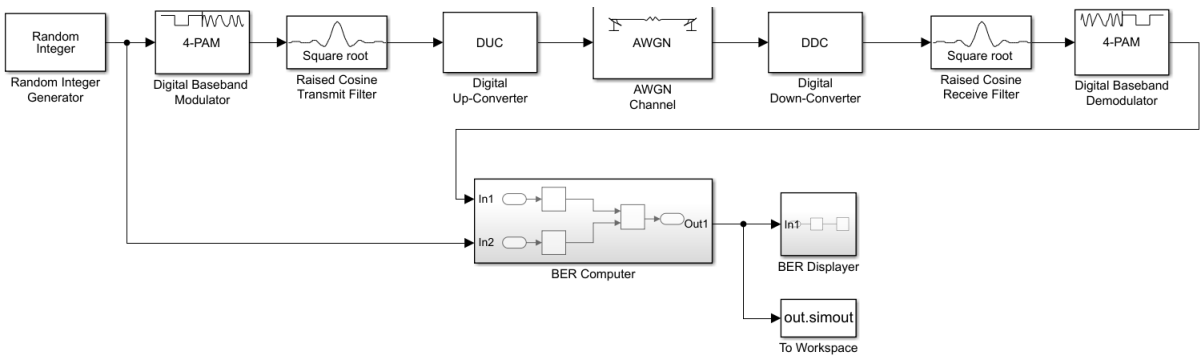

Fig. 1: Digital communication system with bandpass transmission.

Now, follow the instructions below.

1. Design a random integer generator in Simulink. Take the symbolling period as 1 μs. Test it for $N = \{2, 4, 8, 16\}$ and make sure it works properly. Then set $N = 4$ and plot a random integer sequence of length 8. Include this plot as a single graph in your report.

2. Design a subsystem which converts integers to their corresponding bits. Try it for a few integers to make sure it works properly. You will use this part at the receiver side. Plot an integer sequence of length 8 with its corresponding output and include it in your report.

3. Design a baseband BPSK modulator, which converts integers to BPSK symbols. Then design a BPSK demodulator, and connect its input to the output of the modulator. Take a sample integer sequence of length 8 and feed it to the modulator and observe the output of the demodulator. Make sure it resembles the input signal. Create seperate figures for both the modulator and demodulator, plot the corresponding input/output pairs and include these 2 figures in your report.

4. Repeat the previous step for 4-PAM.

5. Repeat the previous step for 8-PSK.

6. Repeat the previous step for 16-QAM.

7. Design a square-root raised cosine transmit/receive filtering pair. Set the roll-off factor to 0.2. Plot the impulse response and the frequency response of the transmit filter, and include both in the report. Then, cascade the transmit and receive filters, take a sample modulated sequence of length 8 and feed it to the transmit filter. Observe the output of the receive filter, and make sure it resembles the input to the transmit filter (you may observe some delay, explain why). Create seperate figures for both the transmit and receive filters, plot the corresponding input/output pairs and include these 2 figures in your report. Briefly explain your graphs.

8. Design an upconverter to bring your baseband signal up to the bandpass region. Use the carrier frequency of 2.5 MHz. Also design a downconverter to bring your bandpass signal back to the baseband. Examine your upconverter/downconverter pair for a few pulses and make sure it functions properly. For the report, take a sample input pulse sequence of length 8, and show us graphically that your upconverter works as required. Do the same for the downconverter. Briefly explain your graphs.

9. Design an AWGN channel. Your design should be able to work at different SNR (E_s/N_0 not E_b/N_0) levels. Now try it for a few inputs and make sure it works as expected. For the report, take a sample transmitted sequence of length 8 and show graphically that your AWGN channel works for an SNR level of your choice.

10. Design a BER counter and a BER display, which compares two streams of bits, and displays the number of bit errors along with the total number of bits. Try it for a few bit inputs and make sure it works properly. Insert the screenshot of your design in your report.

11. Design a bandpass BPSK digital communication system. Try it for a few SNR levels, and compare the BER outputs with the theoretical values. Make sure the obtained BER values are correct. Insert the screenshot of the complete bandpass BPSK system in your report.

12. Simulate the bandpass BPSK system for $E_s/N_0 = (0 : 2 : 10)$. Create a figure with the simulated BER vs E_s/N_0 curve along with the theory and include it in your report and comment.

13. Design a bandpass 4-PAM digital communication system. Try it for a few SNR levels, and compare the BER outputs with the theoretical values. Make sure the obtained BER values are correct. Then, simulate the bandpass 4-PAM system for $E_s/N_0 = (0 : 2 : 14)$. Create a figure with the simulated BER vs E_s/N_0 curve along with the theory and include it in your report and comment.

14. Repeat the previous step for 8-PSK.

15. Repeat the previous step for 16-QAM. This time, simulate your model for $E_s/N_0 = (0 : 2 : 20)$.

Report and Demonstration

You are required to prepare a report and perform an online demonstration separately for this project.

In your reports, simply enumerate your replies to the instructions given in the previous sections. Each of your replies should provide the relevant figures, derivations, and/or explanations, necessary to complete the instruction. Your reports should be prepared electronically (on Office, LATEX, etc.). Handwritten reports will not be accepted. Do not also forget to give reference to the sources that you have used, in your report. The procedure for demonstrations will be announced on MOODLE.

Make a .zip file consisting of your report, all Simulink and MATLAB files and upload it to MOODLE before the announced deadline.

References

[1] Proakis and M. Salehi, Communication systems engineering, 2nd ed. Upper Saddle River: Prentice Hall, 2002, pp. 474-576.