Project 2 "The Q Function and Baseband Data Communication"

The objective of this project is to demonstrate a selection of construction elements and tools for analyzing and designing a baseband digital communication system.

Part 1 "The Eye Diagram for a Digital Communication Channel".
Reference: [Ziemer, 2015] Example 5.8 page 237 and computer example 5.2 page 239, with Matlab scriptfile c5ce2a.m , which is handed out.

Part 1.1 Explain how an eye diagram is generated and the function of an eye diagram.
Part 1.2 Explain the code in c5ce2a.m in greater detail than the present comments. Insert the comments directly in a renamed (new) version of the script.
Part 1.3 Explain the channel model, used for demonstrating the eye diagram. This should include an explanation of normalized bandwidth.
Part 1.4 Augment the present eye diagram demonstrations, generated by c5ce2a.m with the following channel normalized bandwidths

$$B_N = 0.15;\ 0.3;\ 0.7; 1.2; 4$$

Part 1.5 Insert the plots of the original eye diagrams and those in the augmented demonstration in the report and comment on their structure. Specificially it is commented on the case of very low inter symbol interference (ISI), very high ISI and the case where the bandwidth is ~ bitrate.
Part 1.6 Insert the modified script file, with appropriate comments, for generation of the eye diagram as an appendix in the report.

Part 2 "The Q Function"

Part 2.1 Plot the normal (Gaussian) probability density function (pdf) in an appropriate interval and include the formula for it and explain all variables.
Part 2.2 Explain the $Q(u)$ function in relation to the normal probability density function.
Reference: [Ziemer, 2015] Equation (6.200) page 295.

$$Q(u) = \int_u^\infty \frac{\exp(-0.5y^2)}{\sqrt{2\pi}}\,dy$$

Part 2.3 Prepare a script file for plotting the $Q(u)$ function for argument values of relevance to the detection problems for digital communication receivers.
Part 2.4 Insert the $Q(u)$ function script, with appropriate comments, in an appendix in the report.
Part 2.5 In the above script for plotting the Q-function, the inverse Q-function is described. Furthermore the relation between the Q function and the complementary error function is described. The inverse Q function is plotted in an interval of relevance to this course.

Part 3 "The Matched Filter Base Band Receiver".
Reference: [Ziemer, 2015] Computer example 9.1 page 412, with the Matlab scriptfile c9ce1a.m which is handed out.

Part 3.1 Explain the principles of a matched filter receiver for binary data in white Gaussian noise, thus using the so called AWGN (Additive White Gaussian Noise) model. The description should include a definition of all the necessary variables in the system and a block diagram.

Part 3.2 Explain the code in c8ce1a.m in greater detail than the present comments. Insert the comments directly in a renamed version of the script.

Part 3.3 Create the Matlab function qfn called from c9ce1a.m , according to the Matlab code shown in [Ziemer, 2015] page 412.

Part 3.4 Extend the code in c8ce1a.m such that the number of input correlations can be up to 8. Presently 4 is the maximum of input arguments.

Part 3.5 Apply the following correlation coefficients in the c8ce1a script

[-1 -0.75 -0.5 0 0.5 0.75 0. 8 .995]

and insert the resulting plot in the project report. Explain the plot and verify that it is correct.

Part 3.6 Explain how a matched-filter receiver can be implemented by a correlator. The explanation should include the most important formulas leading to the matched filter implementation using a cross correlation.

Part 3.7 Explain what the consequences are with respect to a matched-filter receiver if there is noise on the timing synchronization in the receiver.

Part 3.8 Explain why the bit error probability of a matched filter receiver only depends of the cross correlation properties of the two waveforms applied for signaling and the waveform energies and is independent of the individual signal waveforms. This explanation should include the explicit expression of the signal waveform energies.

The Project Report

The report should have a title page, with author(s), date, course title, table of contents, sections and list of references. The most important formulas for explaining the solutions to Part 1, 2 and 3 should be included in the report together with the respective results. Furthermore the Matlab code developed should be included in the appendix of the report. The report is printed and handed in to the teacher pigeon room in the secretariat. Furthermore a pdf version of the report is mailed to jaas@dtu.dk . The mailed pdf file should contain the word
Project_2 and the family name(s) of the student(s).

Reference

[Ziemer, 2015] Rodger E. Ziemer, William H. Tranter, "Principles of Communications".
John Wiley & Sons, Seventh Edition, 2015.

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