Raised Cosine Pulse Design and Digital Modulation with QPSK

The raised cosine pulse is a commonly used pulse shaping filter satisfying the Nyquist criterion. It is one of the most widely used pulse signals in digital PAM. In this homework, we will learn how to design such a pulse. We will observe how changing the design parameter affects the signal decay and bandwidth.

Phase-shift Keying (PSK) is a method for transmission of digital data by modulating the phase of a carrier signal. Quadrature Phase-shift Keying (QPSK) is one of the most broadly used methods of PSK. In QPSK, two bits are modulated at once, making it possible to carry twice as much information as binary PSK by using the same bandwidth. In this homework, we will learn how to simulate QPSK modulation/demodulation of a digital signal.

(1) Raised Cosine Pulse: It is described by the following equation:

$$g(t) = \frac{\sin\frac{\pi t}{T}}{\frac{\pi t}{T}} \frac{\cos\beta\frac{\pi t}{T}}{1-\left({}^{2\beta t}/_{T}\right)^2}$$

(a) Plot this filter g(t) for $\beta = 0$, $\beta = 0.5$ and $\beta = 1$. What can you say about the filter in time domain as β changes? Which β value provides the fastest decay?

(b) Now plot the frequency domain representation of the raised cosine pulse above for $\beta = 0$, $\beta = 0.5$ and $\beta = 1$. What can you say about the bandwidths of these signals? How does bandwidth vary with β? What value of β value provides the narrowest bandwidth? (You can use fftshift command to better visualize the Fourier representation of the signal.)

(c) Discuss the advantages and disadvantages of using a raised cosine pulse by using the results you got in parts (a) and (b). Why do you think this pulse shaping filter is so widely used?

(2) QPSK Modulation:

(a) Create a pseudo random bipolar binary data stream of 10 samples using the command
$[seq, cinit] = ltePRBS(cinit, n, 'signed')$.

(b) Modulate this signal using QPSK with a bitrate of 10,000 bits/sec. Plot the QPSK modulated signal. Compute and plot the In-Phase and Quadrature components of the QPSK signal. Explain how you performed the modulation process in the report. What is the bandwidth required to transmit this signal using a raised cosine pulse with $\beta = 0.25$? (Remember that for QPSK modulation you need a bipolar signal.) You are not allowed to use modulation functions of Matlab.

(c) Now demodulate this signal. Plot the output signal. Did you manage to get the signal back? Explain how you demodulated the signal. Provide your observations and plots in the report. Perform modulation and demodulation for 100, 1000 and 10,000 samples to check if it works for large amounts of samples.

Guidelines for submission

Submit your .zip file to Blackboard before 23:59 on Thursday, November 8, 2018.

Source codes and report:

(1) You should provide meaningful variable names for all your variables in your code so that we can easily understand what you are doing step by step.
(2) Please provide comments in your source codes.
(3) Reports are important. Your homeworks will be graded mostly based on your reports.
(4) Reports must integrate your results and your discussions on these. It must include your output plots with appropriate titles and your discussions (which is very important for us to decide if you understand the concepts) should refer to these plots. We do not want to read your text only report and run your code and see your output plots and relate your discussions to these external images.

File formats, naming conventions, submissions:

(1) Each question has its own .m source file.
(2) Naming for each source file must be in the form of q$questionNo$_$yourKusisUsername$.m. For example: q1_okirmemis16.m, q2_okirmemis16.m
(3) Each sub-question within a .m source file must be separated with proper lines. For example: %————- a ————-%
(4) Your reports must be in .pdf format (No .doc or .docx files).
(5) Naming for your report must be in the form of report$homeworkNo$_$yourKusisUsername$.pdf. For example: report5_okirmemis16.pdf
(6) You must put your source files and the report inside a folder named in form of hw$homeworkNo$_$your For example: hw1_okirmemis16 The folder must contain only source files and the report. It should not include the output plots, etc., as your source codes are producing those outputs and your reports are already containing those outputs.
(7) You must compress the folder in .zip format. (No .rar)
(8) Naming convention of your .zip file must be in the form of hw$homeworkNo$_$yourKusisUsername$.zip For example: hw2_kbagci.zip

Rules:
Each student must prepare MATLAB homeworks alone. Working together, sharing complete or incomplete solutions with your friends, is strictly prohibited. Students who are suspected of any such activity will be sent to the University Disciplinary Committee immediately, without any previous warning.
Remember, all Matlab homeworks MUST be submitted in order to receive a letter grade from this course. Late homeworks will be accepted to satisfy this requirement, but no credit will be given to late homeworks.
For late submissions, there will be 15 points penalty per day.