Fifth Problem Assignment

EE603 - DSP and its applications

Assigned on: October 29, 2018 Due on: November 9, 2018

Notes:

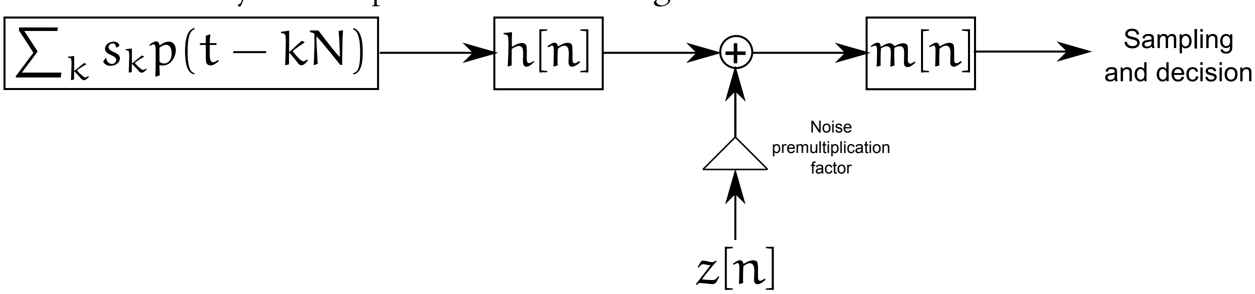
(1) Copying will be dealt with strictly. Institute disciplinary procedures will be invoked if any form of cheating is detected.

(2) The submissions must include the comments, plots AND the code in a SINGLE PDF. Without the code, the submission will not be evaluated. If you submit a zip file containing the code, plots etc., this PDF must STILL be included in the zip file.

(3) The computer assignments should be solved using GNU Octave or any other free/open source software kit approved by the instructor. Solutions that work only on Matlab will not be accepted.

PROBLEM 1

(10 points) In this problem, you will build a simulator that will find the bit error rate for a communication system. Implement the following in Octave.



(a) Consider the pulse $p(t) = e^{-\pi t^2}$. Find the width of this pulse, where the width is defined to be the difference between the positive and negative values of t where the pulse amplitude falls below 10^{-2}. We refer to the part of the pulse with the values above 10^{-2} as the truncated pulse.

(b) If you now implement a communication system where you use the truncated pulse to perform the communication, what will the data rate be?

(c) We now have to sample the pulse. Sampling will add amplitudes of the aliased spectrum. We are able to tolerate a total amount of aliasing of 10^{-2} at the zero frequency. What should the minimum sampling frequency? Repeat this for 10^{-3} and 10^{-4}
Hint: Evaluate the contribution of the aliased spectrum components at $f = 0$, i.e. evaluate

$$\sum_{k=-\infty,k\neq 0}^{k=\infty} X(f-kf_s)$$

and check for what value it is smaller than 10^{-2}.

(d) For the further simulations, we will use a sampling frequency of 10 Hz. Sample $p(t)$ at 10 Hz to obtain $p[n]$. (Decide how many samples you need to retain based on when the amplitude decays to a small value). Plot $p[n]$.

(e) Now, the data signal passes through an RC filter, whose impulse response is $h(t) = e^{-t/RC}u(t)$, with $RC = 0.5$ seconds. Find the amount of aliasing and determine whether 10 Hz is a sufficient sampling frequency. Sample this impulse response and retain enough samples at least till the amplitude remains above 10^{-3}.

(f) Now, you are going to build a 0.4 bits per second binary phase shift keying system. That is, you are going to randomly generate symbols s_k taking values 1 and -1, and send them using the pulse $p[n]$ as

$$\sum_k s_k p[n-kN]$$

Generate 100,000 random s_k values and create the above signal. What would be the value of N?

(g) Pass the above signal through the filter $h[n]$. What do you observe?

(h) Add noise with to each sample of the output of the previous stage using the `randn` function. Premultiply the noise by the factor 0.5 before adding it. Observe the resulting signal.

(i) Finally, construct the matched filter $m[n]$ by convolving $p[n]$ and $h[n]$ and reversing it. Sample the outputs at the appropriate peaks of the matched filter to obtain $\hat{s}_k$, as discussed in class. What is the BER?

(j) Repeat the above for noise premultiplication factors of 0.1, 0.2, 0.8 and 1.0. What is the observed BER for each case?