E9-251: Signal Processing for Data Recording Channels

Home Work #2 (Due 27th September 2012 in class)

Late Submission Policy: Points scored =Correct points scored * e$^{-\#\text{days late}}$

Part: A (Communication and Signal Processing Basics)

1) Solve problems1.10 and 1.18 from Bergmans book (10+20 pts)
2) The magnitude spectrum of a certain cascaded digital filter is given by

$$|H(e^{jw})|^2 = \frac{\frac{5}{4} - \cos(w)}{\left(1 - \frac{2}{3}\cos(w) + K_1\right)\left(1 - \frac{1}{3}\cos(w) + K_2\right)}$$

It is known that the gain at dc and at w=π/2 are 81/100 and 81/74 respectively.

(a) Using spectral factorization, obtain the minimum phase filter H(z) and the corresponding impulse response.

(b) Using Matlab or otherwise, sketch the magnitude and phase response of the derived minimum phase filter.

(c) What fraction of the minimum-phase filter bandwidth corresponds to 95% of the total energy from the impulse response? (20 pts)

Part: B (SNR Modeling)

In this exercise you will build an elementary simulation model for the longitudinal recording system assuming a first order jitter effect in both the position and width variations of the transition pulse with a first order inter-symbol-interference (ISI) (k=1). Assume that the isolated transition response is given by

$$h(t) = \sqrt{\frac{4E_t}{\pi PW_{50}}}\left(\frac{1}{1 + \left(\frac{2t}{PW_{50}}\right)^2}\right) \qquad -\infty \le t \le \infty$$

Define the SNR as the ratio of the energy in the transition response to the total noise power.

Your model should take the following inputs

- SNR in dB
- User bit density
- Code rate
- Jitter percentage

Using the above inputs and the assumptions for the model stated in this exercise, systematically show the steps through a Matlab code to generate the read back signal. (Hint: Generate equally likely sequence of NRZ bits ± 1 of length 1000 and the noise samples appropriately. Use an appropriate sampling rate using your discretion and obtain the digital signal.)

You will need to clearly write up the steps you will take to develop the model/your Matlab code. Make sure that the seeds for the noise sources and the input signal are set appropriately, such that, when you re-run your program after exiting the simulator, the random noise and NRZ bits must be exactly the same.

(a) Along with the Matlab code, provide a plot showing the read back signal at 5 dB SNR and 20 dB SNR with 0% and 50% jitter, user bit density of 1.0 and code rate = 0.75 for a 1T pattern.

(b) Plot the power spectral density of the read back signal via simulations averaging over several simulation runs for SNR = 5 dB, jitter = 50%, user bit density = 1.0 and code rate = 0.75.

(50 pts)

Extra credit: Analytically compute the power spectral density of the digital read back signal with k=0 (i.e., no ISI) and code rate = 1. Compare your theoretical calculations against what you arrive via the simulation model you have developed. (20 pts)