48541 Signal Theory — Assignment 1

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There are two parts to this assignment: an individual part and a team part. These must be submitted as separate files by the due date and time. There will be **no extensions** granted, for any reason. *See UTSOnline for turnitin codes.*

Due date and time: Noon, Tuesday 6th September 2005
Where to submit: http://www.turnitin.com/

1 Individual part

In this part of the assignment, you will submit work that demonstrates and extends the laboratory work that you have done. There are three parts, each of which is worth four marks, for a total of twelve marks for the individual part.

1. (4 marks, 2 pages max)

   Reproduce your results for parts 2 and 3 of section L.1.2 of the Lee and Varaiya lab manual. That is:

   (a) Generate, using a sample rate of 8000 Hz, the sound described by the equation:

   $$\forall t \in [0,1], \quad f(t) = e^{-5t} sin(2\pi \times 440t)$$

   (b) Construct a sound that consist of half-second sequences of exponentially-decaying envelopes, as in the above. This time, however, the frequencies of the half-second sequences are as follows: 494, 440, 392, 440, 494, 494, 494.

   For each of the above, provide your working of the mathematics, your Matlab code (note: provide Matlab code in the body of the Word file, not as separate files), and relevant plots.

2. (4 marks, 3 pages max.)

   In section L.5.2 of the Lee and Varaiya lab manual, you created a state-space representation of a system with the impulse response give by:

   $$\forall n \in \text{Naturals}_0, \quad h(n) = e^{-5n/8000} sin(2\pi \times 440n/8000)$$

   (a) Give the state-space matrices $[A, B, C, D]$ of the system in terms of f, the desired frequency of oscillation. (In the above equation, f is equal to 440 Hz.)

   (b) Write a Matlab function that computes the state-space matrices given f.

   (c) Use this function to generate the signal consisting of half-second tones of frequencies 494, 440, 392, 440, 494, 494, 494. Compare this signal with the signal you obtained in Part 1b above.

   As before, show all relevant working, Matlab code, and plots. (Note that your own *working* is required—the Matlab code alone is not enough!)

3. (4 marks, 3 pages max)

   In this part, you will quantize and play back the signal that you generated above, to a specified number of bits.

   (a) Determine the number of bits that you will use. If the last digit of your student number is 3 or greater, that is the number of bits. If the last digit of your student number is 2 or less, then add 10 to it. You will end up with a number between 3 and 12 (inclusive). Call this n.

   (b) Draw a block diagram showing an input signal, a quantizer, and an output signal. Label the diagram using the domain $\rightarrow$ range notation.

   (c) Implement the quantizer, where the quantizer has an n-bit output. With n bits, the range of your signal contains 2^n different values. For our purposes, assume that the lowest value is $-2^{n-1}+1$ and the highest value is $2^{n-1}-1$. Thus, if $n = 4$, the output signal is in the range -7 to 7 (inclusive).

   (d) Play the output signal using the Matlab function *soundsc*. Comment on the sound quality, compared to the original.

   (e) Calculate the quantization noise present in your signal.

      i. Calculate and plot the noise signal.

      ii. Calculate the RMS noise value.

      iii. Comment on your results.

   For all of the above, show mathematical working as well as Matlab code.

2 Personal reflection

Write a personal reflection describing your learning in the course of this assignment. Your reflection should describe particular problems or issues that you have encountered, and how you overcame them.

Note: the personal reflection is not worth marks by itself, but a reasonable reflection is required to receive any marks for this assignment. Your marks may be scaled downwards if your reflection is inadequate.

The reflection is to be submitted together with the *individual part* of the assignment. It should be no longer than one page.

3 Teamwork part

In this part of the assignment, you will submit work together with a team partner. This work is the initial research and analysis into a Matlab program that you will construct together in this and the following assignments.

The instructor will provide a small number of projects from which you can choose. You must provide the instructor with a completed *team registration card* in the first two weeks after this assignment statement has been handed out. There are a limited number of cards for each project, so if you would like to have a choice about which project you undertake, get yourself organized into a team and submit a card sooner rather than later.

The projects represent realistic applications of signal theory (although somewhat simplified for the purposes of an introductory course). Each is described in terms of an initial vision or concept of a signal processing system, which will be implemented in Matlab. In this first assignment, you will analyze and expand on this initial vision.

There are two parts to the teamwork assignment, worth four marks each, for a total for the teamwork part of eight marks.

1. Research the application area (4 marks, 4 pages max)

   Based on the system concept that you have chosen, use the UTS library and the Internet to do some research into existing systems of this nature and the purposes to which they are put. Write a summary of your research. (All resources must be properly referenced.)

2. Write a system specification (4 marks, 4 pages max)

   Based on your research, write a short initial specification of your system. Your specification must include a block diagram. For each block, write a short description of its purpose, limitations, and so on. For each signal, provide the signal's name, domain, and range using the standard notation for this subject.

   In your specification, note where limitations (time, use of Matlab, unavailability of certain hardware etc) require that your project be scaled down from what you would do if you were implementing a real product. Also note any unclear areas or issues that you will address as you proceed further with development of your system.