

48541 Signal Theory — Assignment 2

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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 11th October 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 two parts worth four and six marks respectively, for a total of ten marks for the individual part.

1. (4 marks, 4 pages max)

Consider the following discrete-time signal:

$$\forall n \in \text{Integers}, x(n) = \cos(2\pi n/40) + \sqrt{2}\sin(2\pi n/20) - 0.3\cos(2\pi n/16 + \pi/4)$$

- (a) Assuming that this signal was sampled from a continuous-time signal at 8 kHz, write the equation of the continuous-time version of this signal.
- (b) Plot the amplitude and phase spectra of this waveform for the following periods (in samples): 80, 81, 800, 810.
- (c) Multiply the input to the Fourier Transform in each of the above cases by a windowing function. Matlab has built-in functions for windowing—see the *hamming* and *blackman* functions.
- (d) Analyse and explain your results.

Be sure to include *all* of your Matlab code in your submission.

2. (6 marks, 4 pages max)

Download the *modemDialing* signal from UTSONline. Then

- (a) Display the time-varying spectrum of this waveform using the spectrogram technique (see pages 48 and 49 of the Lee and Varaiya Lab Manual, as well as the Matlab online help, for explanation). Compare the spectrogram to a time-domain plot of the same waveform.
- (b) Using the spectrogram as a guide, select several different segments of the waveform, plot their spectra, and analyze your results.
 - i. Try some different segment lengths in order to determine a good choice for that part of the waveform.
 - ii. Compare the spectra with and without windowing (use the Matlab functions *hamming* or *blackman*).

Include not just your results, but also *all* of your Matlab code, and your reasoning and explanation of those results.

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

You have chosen a system to work on this semester. You will analyze a system that is provided to you, which represents a simulation of the “real world” that your project is connected to. In this part of the assignment, you will:

- Apply the concepts of linearity, time-invariance, frequency response and impulse response to analyse a system.
- Write Matlab code to implement and test system performance and characteristics.
- Apply and clearly and logically document problem solving strategies for analysis tasks in signal theory.

3.1 The simulation program

You will be provided with a system simulation, contained in a hidden Matlab function. Depending on your project, you will use one of:

- *room* — simulate a listening room
- *channel* — simulate a multi-path channel

Each of these functions takes two arguments:

1. Your student number, which the function uses to produce a customised system just for you.
2. An input signal, in a *column* vector.

The output from the function is a vector containing the output signal.

Note: since you are working in teams, you will be working with two different systems. You are expected to characterise both systems, and compare them. This will of course be easier if you write Matlab code to perform all of your tests and generate test results.

3.2 What you have to do

You have already prepared a preliminary report describing your research into the application area and your proposed system specification. (Assignment 1.) Your company’s management is happy with your report and wants you to refine the proposal, but this time with more in-depth analysis using real data and Signal Theory. They ask for another report, and promise that if this report is accepted, you will be able to play a significant role in the development of the new product.

In the report, you are to succinctly describe the analysis that you performed on a typical example of the “real world,” and analyze how it impacts on your proposed system design. In particular, your tests must determine:

1. The frequency response of the system

2. Whether or not the system is linear, and to what degree and under what conditions
3. Whether or not the system is time-invariant, and under what conditions
4. Whether or not the system has any other properties that are not captured in the idealized linear time-invariant system model.

Note: because you are not very senior in the company, it is important that you document not just your results, but also the method that you used to arrive at them. You must therefore explain why you have performed each test, include your Matlab code, carefully document all of your mathematical and logical reasoning, and explain the significance of each test result.

3.3 Assessment

The assessment criteria for this part of the assignment are as follows:

- Format and presentation (2 marks)

The report is written in plain English and is appropriate for the audience (technical management). The summary of tests and results is complete. The conclusions are logical and clearly expressed. The report includes an English language description of the system.
- Determination of system characteristics (6 marks)

(You are to determine the system frequency response, linearity, time-invariance, and any variations from the LTI model.)

A complete set of tests is described and justified, with clear and unambiguous aims. For each test, you should include:

 1. A description of the test and explanation of why it is needed.
 2. Matlab code and resulting plots, with labelled and scaled axes.
 3. Analysis of the results, and your conclusions.

See also “extra note” below.
- Revision of system specification (2 marks)

A revised system specification.

The **page limit** for this part of the assignment, including all plots, figures, and Matlab code, (but not including cover sheet, table of contents, or appendixes) is 10 pages.

Extra note: After performing the basic analysis of your system, consider the overall “real world” system. The interface to the “real world” is not ideal, and will involve loudspeakers or transmitters that have physical and electronic limitations. Consider the validity of your tests in this “real world” context, and devise additional or modified tests accordingly. (Consult with the appropriate instructor during LDC times after completing the basic tests, if you are having trouble finding direction.)