MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Electrical Engineering and Computer Science

6.003: Signals and Systems—Fall 2003

COMPUTER LAB 2

Issued: October 7, 2003 Due: November 6, 2003

Background: To prepare yourself for these exercises, you may find it useful to look over the discussion of the functions `fft` and `fftshift`, at the start of Section 5.1 on page 90.

Problems to be handed in: In this lab, you will complete the Basic and Advanced Exercises for the Telephone Touch–Tone problem considered in Section 5.2 on pages 93–96 of Buck, Daniel, and Singer (BDS). For all of the exercises, please include your MATLAB code with your name typed in the code. As stated in the General Information Sheet, we do not expect a formal lab report, but it is still important that you present your results clearly and in an organized manner. Included below are items to be turned in, along with more specific instructions:

Corrections to the Lab: In the first paragraph on page 93 of BDS, it says that the "continuous-time waveform is sampled at 8192 **kHz**". This is incorrect, and should be 8192 **Hz** as stated in the caption to Figure 5.1.

To load the appropriate data file into `Matlab`, type:

```
>> cd /mit/6.003/data
>> load touch
```

Alternatively you can obtain the data file from the course web page.

Basic Problems

(a) Create the ten different tones as indicated, but do not turn anything in for this part. On some Linux machines, you may want to use `sound2` instead of `sound`. You can get the M file at course web site or you may want to add a path on MIT server by typing

```
>> path(path,'/mit/6.003/data;')
```

(b) Turn in plots of $|D_2(e^{j\omega})|$ and $|D_9(e^{j\omega})|$.

(c) Generate your phone number as indicated, but do not turn anything in for this part.

*****Intermediate Problems*****

(d–e) Read through these exercises so that you will understand the later exercises. However, do **not** implement anything for these parts. In addition, get the data file as specified above. **Do not** get `touch.mat` file from MathWorks ftp site. In the advanced exercises, you will write functions which segment a signal into the various tones and automatically determine the digits.

Advanced Problems

(f) Turn in a list of indices k and the corresponding ω_k which you found to be the closest to each of the touch–tone frequencies.

(g) Turn in a list of the values of $|D_8(e^{j\omega_k})|^2$ for each value of ω_k that you determined in part (f).

(h–i) Consider these two parts to be one exercise. Write the function `ttdecode` as described in part (h), but do not assume that the signal consists of 1000 samples for each digit separated by 100 samples of silence. Instead, write your function to handle the more general case as described in part (i) (*i.e.* the touch–tone signals and silences may have varying lengths). Turn in the phone numbers that you get for the signals `x1`, `x2`, `hardx1`, and `hardx2`. Make sure to turn in your MATLAB code for your function `ttdecode`, along with the code for any supporting functions.

Special Instructions: Since you are required to listen to several signals in this lab, we request that you use headphones while in the public MIT server clusters. If you decide to work in the lab, headphones are not required but may be advisable due to the noisy environment. For information about using headphones with the workstations, read the instructions given out with Computer Lab #1.

Useful MATLAB Functions:

`help`: All of the functions listed below have help pages within MATLAB that can be viewed by typing `help <function>` from the MATLAB command prompt.

`abs`: Finds the magnitude of a vector. Thus if you have a complex signal called `X`, then you could get the magnitude using `abs(X)`.

`find`: On parts (h-i) you have to split a signal into the separate tones. One MATLAB function that maybe useful to do this `find`. It will return the indices of a vector which satisfy a given conditional statement. For example:

```
>> index = find(abs(x1)>0);
```

This will find the indices of the vector `x1` which have magnitude greater than zero. You can then imagine looking for large gaps in the values of this index vector because gaps will indicate the end of one tone and the start of another. This is one possible solution which is acceptable for this lab. In practice, this approach would not be very robust.