ECE 329NL

Experiment No. 5
SAMPLING AND DATA ACQUISITION

OBJECTIVES

1) To illustrate the sampling process using an approximate continuous-time signal.
2) To know how to acquire audio signals using a microphone and a soundcard.

SAMPLING

Sampling is the process of obtaining a discrete-time signal from an analog or continuous-time signal. It is done by acquiring the value of the analog signal at specified intervals of time. If the time interval between samples is constant, the process is called uniform sampling and the time interval is called the sampling period.

For example, consider a continuous-time signal $x_a(t) = \sin 2\pi Ft$. With uniform sampling, the discrete-time signal obtained is defined only at $t = nT$. The resulting discrete-time signal is $x(nT) = \sin 2\pi FnT$. The sampling period T is equal to the reciprocal of the sampling frequency F_s. When $1/F_s$ is substituted to T,

$$x(nT) = \boldsymbol{x(n)} = \sin 2\pi(F/F_s)\, n = \mathbf{\sin 2\pi\, fn}$$

which is a discrete-time sinusoid obtained by sampling a continuous-time sinusoidal function.

Sampling a Continuous-time Signal Approximation

Create a folder named **'Expt5'** in your Z:\ drive. Generate approximations of continuous-time signals by writing the following lines in a script m-file named **'group#_expt5.m'**

```
t = [0:1/1000:1]';
xt = sin(2*pi*2*t);
yt = exp(-t/0.2);
xyt = xt.*yt;

t1 = 0:1/8000:0.06;
zt1 = 2*cos(2*pi*200*t1).*exp(– t1/0.01);
```

Assume that the signal **xt** represents an analog signal *x(t)*. We want to obtain *x(n)* by taking samples of *x(t)* with a sampling period T of 1/20 seconds. A function m-file named **sampler** has been written for this purpose for use in this experiment. Type the

following on a new Editor window and save using the function name **sampler** as filename.

```
function xn = sampler(t,xt,T)
% SAMPLER Sample an approximate continuous-time signal.
%   xn = SAMPLER(t,xt,T) returns a vector of samples xn taken from
%   the signal xt, where xt is defined over an approximate continuous-time
%   vector t. Samples are taken at a sampling interval of T seconds.

% Code by: I. A. Rabuya 07-24-05
% Documentation by: your name/s here, date

if length(xt) ~= length(t)   %
  error('? ? ? The signal and time vectors must be of the same length.')   %
end

time_increment = t(2)-t(1);   %
N = floor(t(end)/T);   %

if N == 0   %
  error('? ? ? Sampling period is too long.')   %
end

n = [0:N]';   %
xn = zeros(N+1,1);   %

for i = 0:N   %
  xn(i+1) = xt(floor(i*T/time_increment+1));   %
end

figure, subplot(2,1,1), plot(t,xt,'r'), grid   %
axis([0   n(end)*T   min(xt)   max(xt)])   %
hold on, plot(n*T,xn,'bo')   %
xlabel('t'), ylabel('CT Signal and Samples')
title(['Approximate Continuous-time Signal Sampled every ',num2str(T),' seconds'])

subplot(2,1,2), stem(n,xn), grid   %
axis([0   n(end)   min(xt)   max(xt)])
xlabel('n'), ylabel('DT Signal')
```

Save the function. See what the function does by entering the following on the command window

```
>> xn = sampler(t,xt,1/20)
```

What do the plots show? Try other values of sampling interval.

Obtain samples for the signals **yt**, **xyt** and **zt1**. For **zt1**, try the following values of *T*: 1/10, 1/20, 1/100, 1/200, 1/400 and 1/2000. Make observations. How do the results of various sampling intervals differ?

Create your own analog signal approximations and convert them to discrete-time signals using the **sampler** function.

Notice that most lines of code for the function **sampler** end with the % character. Write comments for these lines describing what that particular line of code accomplishes.

DATA ACQUISITION

An audio signal can be acquired in MATLAB using the *Data Acquisition Toolbox* along with the computer's soundcard and a microphone. Connect a microphone to the correct (*color code*: pink) audio port of the CPU. Double-click on the **Volume Control** icon on the right side of the Taskbar and enable the microphone.

The MATLAB code for this section should be written on a separate script m-file. Write the following lines on a new Editor window. For information on what a specific function does, refer to the online help **help *function***.

```
out = daqhwinfo
hardware_available = out.InstalledAdaptors
```

Evaluate on the command window. What information is given?

```
out = daqhwinfo('winsound')
```

What information does the above line give? Answer this same question for every block of code given below.

```
out.ObjectConstructorName(:)

ai = analoginput('winsound')

out = daqhwinfo(ai)

addchannel(ai,1)
addchannel(ai,2)

ai.Channel.ChannelName

set(ai,'SampleRate',44100)
ActualRate = get(ai,'SampleRate')
```

set(ai,'TriggerType')

set(ai,'SamplesPerTrigger',220500)

From the above lines, what is the duration of acquired data in seconds per trigger?

Trigger MATLAB to acquire data by entering the following on the command window

>> **start(ai)**

Speak into the microphone right away after the above line is entered in the command window.

Plot and listen to the acquired signal

```
data = getdata(ai);

t = [1:220500]'/44100;

left = data(:,1);
right = data(:,2);
figure, plot(t,left)
figure, plot(t,right)

soundsc(left,44100), pause(6)
soundsc(right,44100)
```

What sound did you hear?

EXERCISES

1) Acquire a 10-second signal of yourself singing a line or two of your favorite song using the following sampling rates:
   a) 8000 Hz
   b) 44100 Hz

2) Convert the above signals to *wav*-files using the function **wavwrite**.

/iarabuya
072505