Lab # 7

Domain Operations on Signals (Time Reversal, Sampling)

Objective:

____
____
____

Introduction:

A signal is classified with respect to its domain and range. Similarly operations on signals are classified into two categories.

1. Operations on domain
2. Operations on Range

Operations on Domain

Domain operations are those which involve time axis or integer axis as main focus of operations. Domain operations are classified into following categories.

1. Time Reversal
2. Sampling

1. Time Reversal

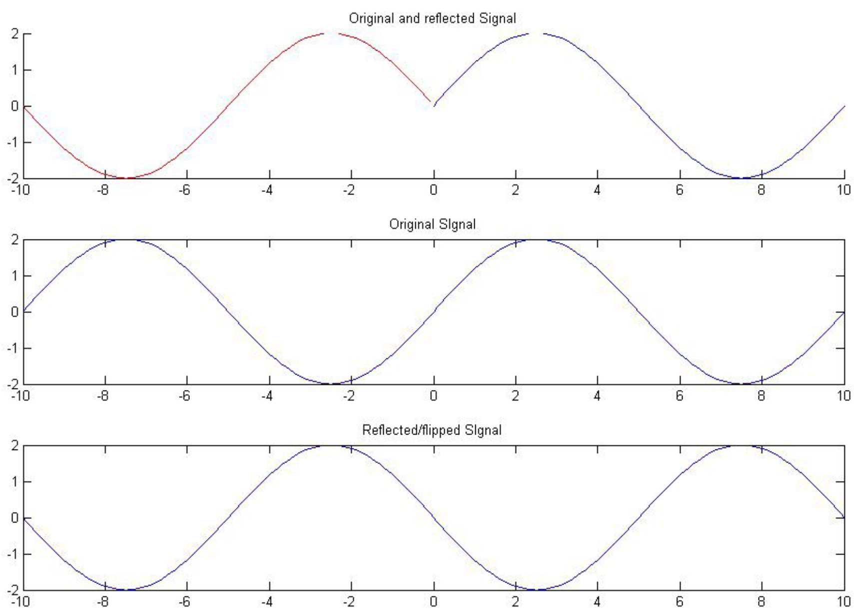
Time Reversal operation flips each sample of the signal about t=0 or n=0 to obtain a folded sequence.

$$y(n) = \{x(-n)\}$$

In Matlab fliplr(x) function is used to flip the sample values and –fliplr(x) is used to flip the indices.

```
inc=0.1;
t=-10:inc:10;
f=0.1;
a=2; % Amplitude
x=a*sin(2*pi*f*t);
rx=fliplr(x);
rt=-1*fliplr(t);
l=length(x);
subplot(3,1,1);
hold on;
plot(t(l/2:l),x(l/2:l));
```

```
plot(rt(1:l/2),rx(1:l/2),'r');
title('Original and reflected Signal');
subplot(312);
plot(t,x);
title('Original SIgnal');
subplot(313);
plot(rt,rx);
title('Reflected/flipped SIgnal');
```



A Matlab function to implement the signal flipping is given below.

```
function [y,n]=sigfold(x,m)
y=fliplr(x) %flips the amplitude levels
n=-1*fliplr(n) %flips the indices on negative sides
```

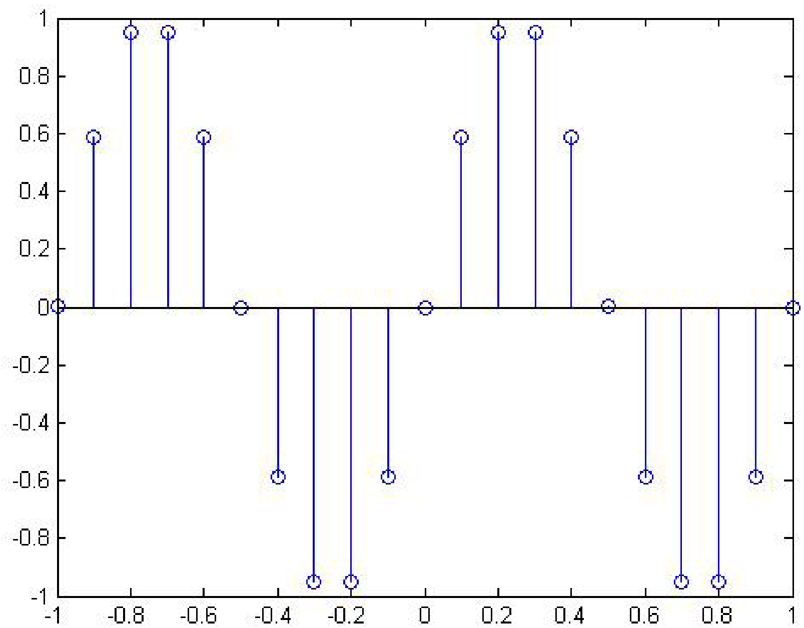
2. Sampling

Sampling is the reduction of a continuous signal to a discrete signal. A common example is the conversion of a sound wave (a continuous signal) to a sequence of samples (a discrete-time signal).

A sample refers to a value or set of values at a point in time and/or space.

Let $x = \sin(2\pi ft)$ be the signal with highest frequency component f. We sample the signal at different rates as follows.

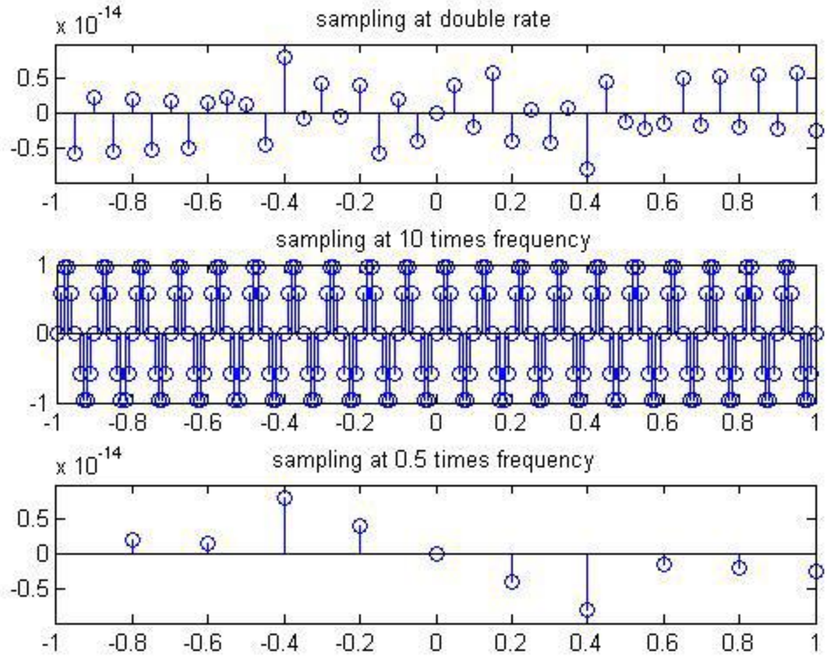
```
% Sampling of single frequency component
f=1;
fs=10*f; %Sampling frequency
ts=1/fs; % Sampling Interval
t=-1:ts:1;
x=sin(2*pi*f*t);
stem(t,x);
```



Following example shows the sampling of the given signal at different rates. The output graph shows how sampling rate predicts the signal behavior and loss of information.

```
% Sampling of single frequency component at different rates
f=10;
fs1=2*f; %Sampling frequency
fs2=10*f;
fs3=0.5*f;
ts1=1/fs1; % Sampling Interval
ts2=1/fs2;
```

```
ts3=1/fs3;
t1=-1:ts1:1;
t2=-1:ts2:1;
t3=-1:ts3:1;
x1=sin(2*pi*f*t1);
x2=sin(2*pi*f*t2);
x3=sin(2*pi*f*t3);
subplot(311); stem(t1,x1);
title('sampling at double rate');
subplot(312);stem(t2,x2);
title('sampling at 10 times frequency');
subplot(313);stem(t3,x3);
title('sampling at 0.5 times frequency');
```



Post Lab Questions

a) **What is Sampling?**

b) **What is command fliplr used for?**

c) **Differentiate between time shifting and time reversal.**

Lab Tasks

Task 1

a) Let x(n)={1, 2,3, 4,5,6,7,-7,-6,-5,- 4,-3,- 2,-1}. Determine and plot the following sequences.

a) $x1(n) = 2sin(n - 5) + 53sin(n + 4)$

b) $x2(n) = sin(3+n) + 2sin(n - 2)$

Task 2

a) Generate and plot a 2Hz square wave. Use the command square to generate the signal and plot a time reversed signal aswell.

b) Using the same example as done in Lab , Sample a signal by changing its frequency and sampling rate.