7. SS Lab 7

This Signals and Systems lab addressed covers topics such as generating unit impulse and step sequences along with basic signal operations in the MATLAB environment.

Suggestions for improvement or correction of the manuscript would be appreciated.

7.1 Lab Objectives

In this lab, the following areas would be covered:

- Generating unit impulse and unit step sequences
- Basic signal operations

7.2 Generating Unit Impulse and Unit Step Sequences

Use MATLAB commands zeros and ones to generate unit impulse and unit step sequences.

Example: Unit impulse sequence:

```
n=-10:10;
% unit impulse x1=[zeros(1,10) 1 zeros(1,10)];
stem(n,x1,'filled');
xlabel('sample #');
ylabel('signal amplitude');
title('Unit impulse');
axis([-10 10 -1 2]);
```

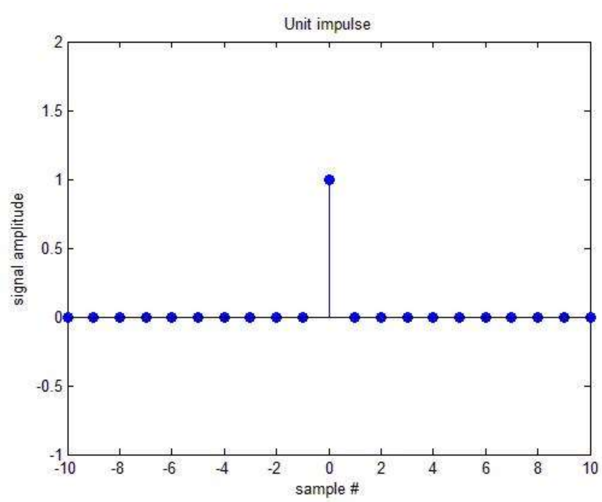

Figure 7.1: Unit impulse

Example: Unit step sequence:

```
n= -10:10;
%unit step
```

```
x1=[zeros(1,10) ones(1,11)];
stem(n,x1,'filled');
xlabel('sample #');
ylabel('signal amplitude');
title('Unit step');
axis([-10 10 -1 2]);
```

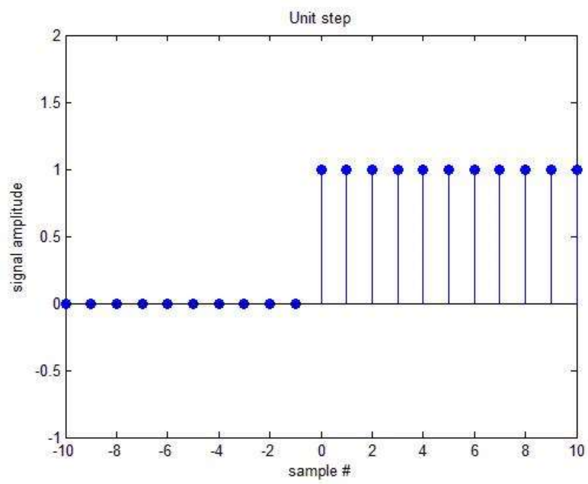

Figure 7.2: Unit step

7.3 Basic Signal Operations

7.3.1 Signal Shifting

```
clc
clear all
close all
n=0:0.002:4;
x=sin(2*pi*1*n);
subplot(2,1,1);
plot(n,x,'linewidth',2);
title('Original Signal');
xlabel('Time');
ylabel('Signal Amplitude');
axis([-3 4 -1 1]);
grid;
subplot(2,1,2);
plot(n-1,x,'linewidth',2);
```

```
title('Advanced signal');
xlabel('Time');
ylabel('Signal Amplitude');
axis([-3 4 -1 1]);
grid;
```

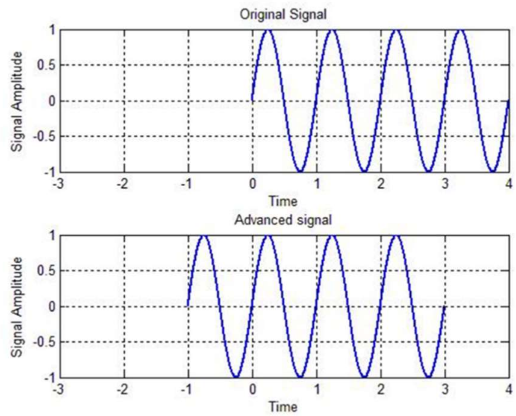

Figure 7.3: Signal shifting

7.3.2 Signal Flipping

```
clear n=-1:1/1000:1;
x1=5*sin(2*pi*1*n);
subplot(2,1,1);
plot(n,x1, 'g', 'linewidth',2);
axis([-1 1 -5 5]);
xlabel('time');
ylabel('signal amplitude');
title('Original sine wave');
grid;
subplot(2,1,2);
plot(-n,x1, 'r', 'linewidth',2);
axis([-1 1 -5 5]);
xlabel('time');
ylabel('signal amplitude');
title('Flipped sine wave');
grid;
```

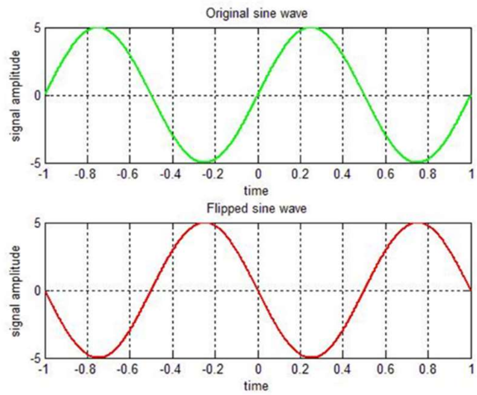

Figure 7.4: Signal flipping

7.3.3 Amplitude Scaling

```
clear n=1:7;
x=[1 2 2 3 2 2 1];
subplot(2,1,1);
stem(n,x, 'filled');
title('Original signal');
xlabel('Time index');
ylabel('Signal Amplitude');
axis([1 7 0 4]);
grid;
S=2;
subplot(2,1,2);
stem(n,S*x, 'filled');
title('Amplitude Scaled signal');
xlabel('Time index');
ylabel('Signal Amplitude');
axis([1 7 0 8]);
grid;
```

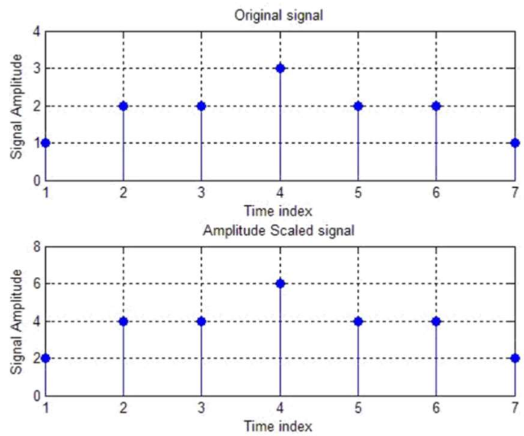

Figure 7.5: Amplitude scaling

7.3.4 Time Scaling

```
%Decimation (down-sampling) clear
n=-2:1/1000:2;
x1=sin(2*pi*2*n);
x2=decimate(x1,2);
subplot(2,1,1);
plot(x1);
title('Original signal');
xlabel('Sample Number');
ylabel('Signal Amplitude');
axis([0 4000 -1 1]);
grid;
subplot(2,1,2);
plot(x2);
title('Decimated signal');
xlabel('Sample Number');
ylabel('Signal Amplitude');
axis([0 2000 -1 1]);
grid;
```

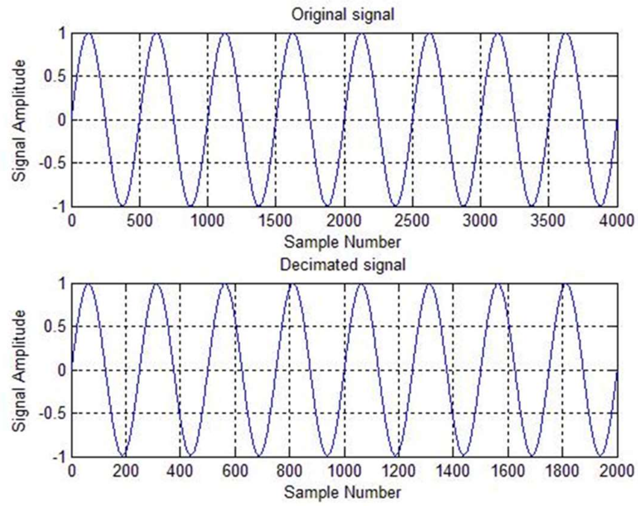

Figure 7.6: Time scaling

7.3.5 Amplitude Clipping

```
clear
x=[3 4 4 2 1 -4 4 -2];
len=length(x);
y=x;
hi=3; lo=-3;
for i=1:len
  if(y(i)>hi)
    y(i)=hi;
  elseif(y(i)<lo)
    y(i)=lo;
  end
end
subplot(2,1,1);
stem(x,'filled');
title('original signal');
xlabel('Sample number');
ylabel('Signal Amplitude');
subplot(2,1,2);
stem(y,'filled');
title('Clipped Signal');
xlabel('Sample number');
```

```
ylabel('Signal Amplitude');
```

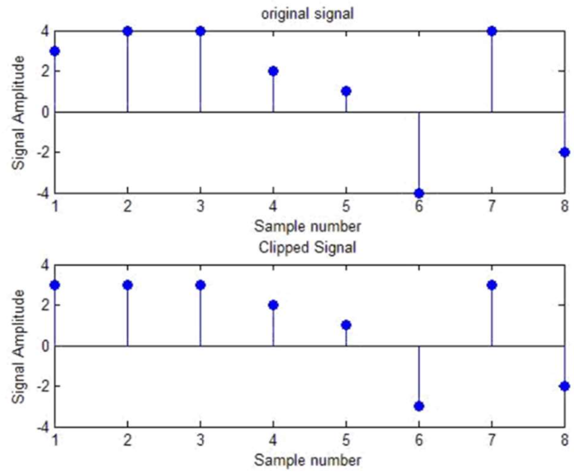

Figure 7.7: Amplitude clipping

7.3.6 Signal Replication

```
clear
x=[1 2 3 2 1];
y=[x x x x];
subplot(2,1,1);
stem(x,'filled');
title('Original Signal');
xlabel('Sample Number');
ylabel('Signal Amplitude');
axis([1 20 0 3]);
grid;
subplot(2,1,2);
stem(y,'filled');
title('Replicated Signal');
xlabel('Sample Number');
ylabel('Signal Amplitude');
axis([1 20 0 3]);
grid;
```

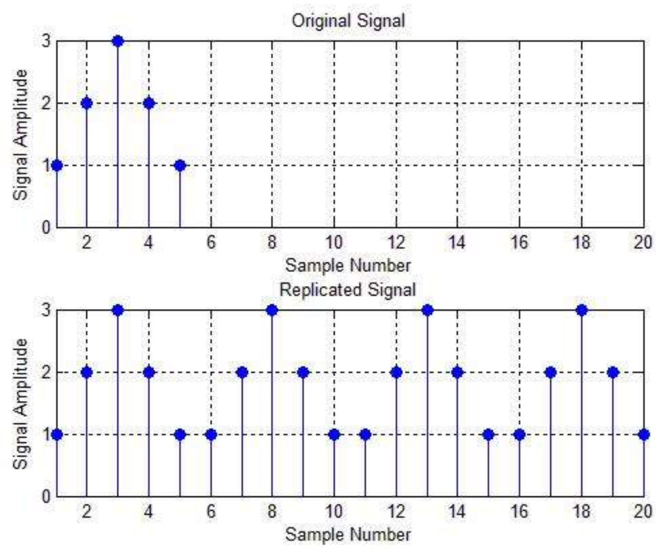

Figure 7.8: Signal replication

7.4 Tasks

Perform the following tasks:

7.4.1 Task 01

Using `ones` function, plot the `signum` sequence over interval - $10 \leq n \leq 10$. It can be defined as:

$$\begin{cases} 1 & \text{for} \quad n = 1,2,3,\dots \\ -1 & \text{for} \quad n = -1,-2,-3,\dots \\ 0 & \text{for} \quad n = 0 \end{cases}$$

7.4.2 Task 02

Prove the following:

$$\delta[n] = u[n] - u[n-1]$$

7.4.3 Task 03

Delay the original signal given in section 7.3.1 by 1 sec. Plot both the delayed and original signal in the same figure.

7.4.4 Task 04

Flip the following signal:

$$y = 5\exp\left(i * n * \frac{\pi}{4}\right)$$

Plot the original signal as well as the flipped one in the same figure.

7.4.5 Task 05

Flip the following signal:

$$x[n] = 2\delta[n] + 5\delta[n-1] + 8\delta[n-2] + 4\delta[n-3] + 3\delta[n-4]$$

Plot the original signal as well as the flipped one in the same figure.

7.4.6 Task 06

Scale the continuous-time sinusoid used in signal shifting example in section 7.3.1 by a factor of 2.

7.4.7 Task 07

Use `interp` command in the program in section 7.3.4 to interpolate (up-sample) the signal by a factor of 2.