6. SS Lab 6

The sixth lab of Signals and Systems covers topics such as generating, adding and plotting sinusoids in the MATLAB environment.

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

6.1 Lab Objectives

In this lab, the following areas would be covered:

- Generating sinusoids
- Addition of sinusoids with variation in parameters and their plots
- Linear phase shift concept when dealing with sum of sinusoids signals

6.2 Generating Sinusoids

Sinusoidal sequences are implemented using `sin()` and `cos()` functions.

Example: A continuous-time sinusoid can be generated quite conveniently.

```
clc;
clear all;
close all;
f0 = 3;
A = 5;
t = -1:0.005:1;
y = A*cos(2*pi*f0*t);
figure, plot(t, y,'*:');
xlabel('Time, sec'), ylabel('Amplitude');
title('Graph of sinusoid');
```

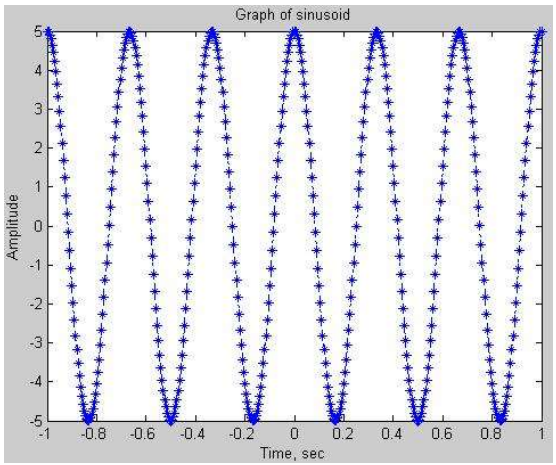

Figure 6.1: Continuous-time sinusoid

Example: A discrete-time sinusoid can also be generated using a code similar to the following:

```
clc;
clear all;
close all;
M=10; %samples/sec n=-3:1/M:3;
A=2;
phase=0;
f=1;
x=A * sin(2*pi*f*n + phase);
stem(n,x,'linewidth', 2)
title('Discrete-Time Sine Wave: A sin(2*\pi*f*n + \phi)')
xlabel('Time Index')
ylabel('Signal Amplitude')
axis([n(1) n(end) -A A])
grid
```

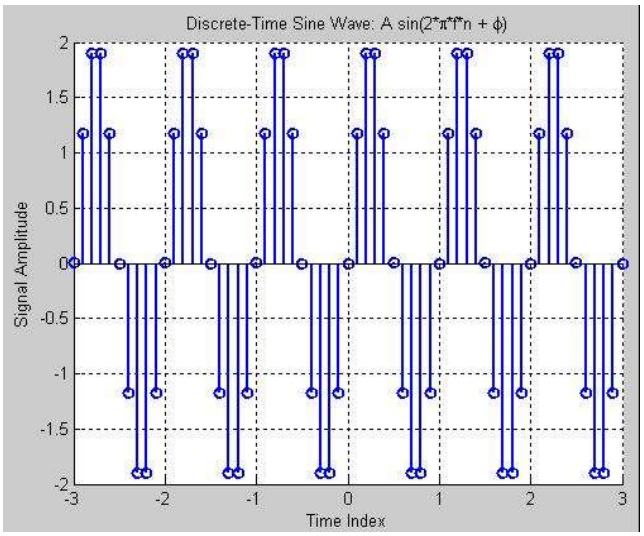

Figure 6.2: Discrete-time sinusoid

6.3 Creating Phase Shift

Phase shift can be created by adding an angle to 2πft for a sinusoid.

Example:

```
clc;
clear all;
close all;
fs=1000;
t=-3:1/fs:3;
```

```
A=2;
phase=0;
f=1;
x=A * sin(2*pi*f*t + phase);
plot(t,x, 'linewidth', 2)
title('Continuous-Time Sine Wave: A sin(2*\pi*f*t + \phi)')
xlabel('Time Index')
ylabel('Signal Amplitude')
axis([t(1) t(end) -A A])
grid
```

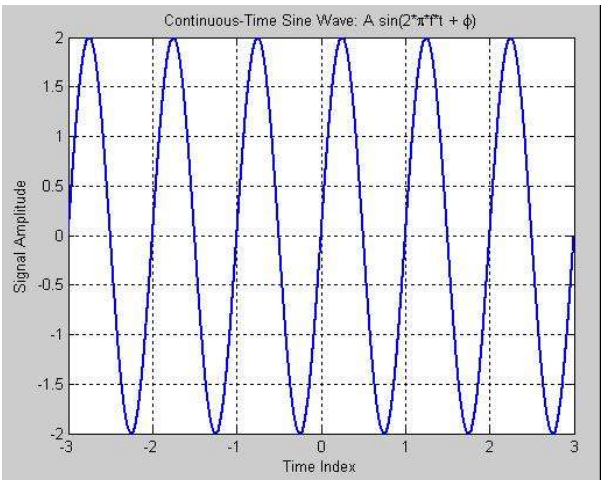

Figure 6.3: Creating phase-shift in sinusoid

6.4 Addition of Sinusoids

For the addition of sinusoids, 4 cases are considered.

Case 1: When frequencies, phases, and amplitudes of the sinusoids are the same:

```
clc;
clear all;
close all;
t=-2:0.01:2;
x1=cos(2*pi*0.5*t);
x2=cos(2*pi*0.5*t);
x3=x1+x2;
subplot(3,1,1);
plot(t,x1,'linewidth',3);
grid;
```

```
ylabel('Amplitude');
xlabel('Time');
title('COS WAVE , AMPLITUDE = 1, FREQ = 0.5 HZ, Phase = 0
RADIAN');
subplot(3,1,2);
plot(t,x2,'linewidth',3);
grid;
ylabel('Amplitude');
xlabel('Time');
title('COS WAVE , AMPLITUDE = 1, FREQ = 0.5 HZ, Phase= 0
RADIAN');
subplot(3,1,3);
plot(t,x3,'linewidth',3);
grid;
ylabel('Amplitude');
xlabel('Time');
title('SUM OF THE ABOVE TWO COSINE SIGNALS');
```

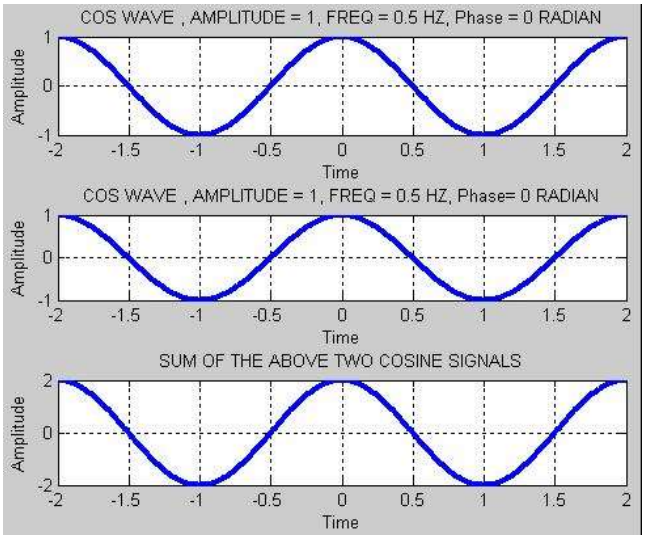

Figure 6.4: Addition of sinusoids, case 1

Case 2: When frequencies and phases of the sinusoids are the same but amplitudes are different:

```
t=-2:0.01:2;
x1=2*cos(2*pi*0.5*t);
x2=cos(2*pi*0.5*t);
x3=x1+x2;
subplot(3,1,1);
plot(t,x1,'linewidth',3);
```

```
grid;
ylabel('Amplitude');
xlabel('Time');
title('COS WAVE , AMPLITUDE = 2, FREQ = 0.5 HZ, Phase = 0
RADIAN');
subplot(3,1,2);
plot(t,x2,'linewidth',3);
grid;
ylabel('Amplitude');
xlabel('Time');
title('COS WAVE , AMPLITUDE = 1, FREQ = 0.5 HZ, Phase= 0
RADIAN');
subplot(3,1,3);
plot(t,x3,'linewidth',3);
grid;
ylabel('Amplitude');
xlabel('Time');
title('SUM OF THE ABOVE TWO COSINE SIGNALS');
```

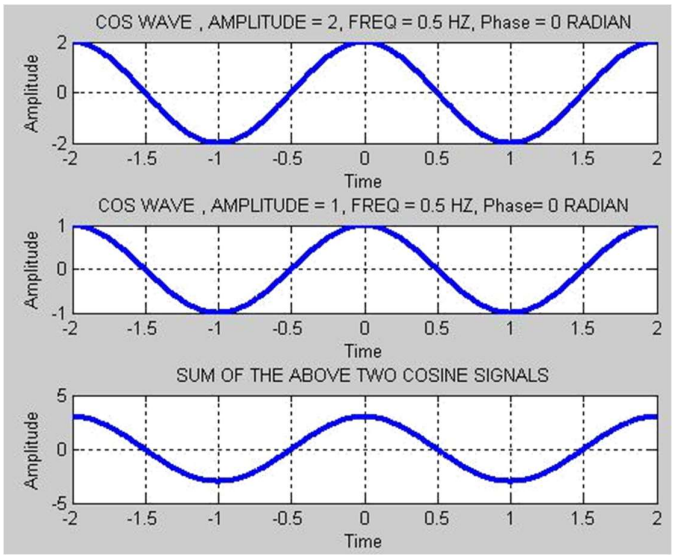

Figure 6.5: Addition of sinusoids, case 2

Case 3: When amplitudes and phases of the sinusoids are the same but frequencies are different:

```
t=-2:0.01:2;
x1=cos(2*pi*0.5*t);
x2=cos(2*pi*1*t);
```

```
x3=x1+x2;
subplot(3,1,1);
plot(t,x1,'linewidth',3);
grid;
ylabel('Amplitude');
xlabel('Time');
title('COS WAVE , AMPLITUDE = 1, FREQ = 0.5 HZ, Phase = 0
RADIAN');
subplot(3,1,2);
plot(t,x2,'linewidth',3);
grid;
ylabel('Amplitude');
xlabel('Time');
title('COS WAVE , AMPLITUDE = 1, FREQ = 1 HZ, Phase =
0
RADIAN');
subplot(3,1,3);
plot(t,x3,'linewidth',3);
grid;
ylabel('Amplitude');
xlabel('Time');
title('SUM OF THE ABOVE TWO COSINE SIGNALS');
```

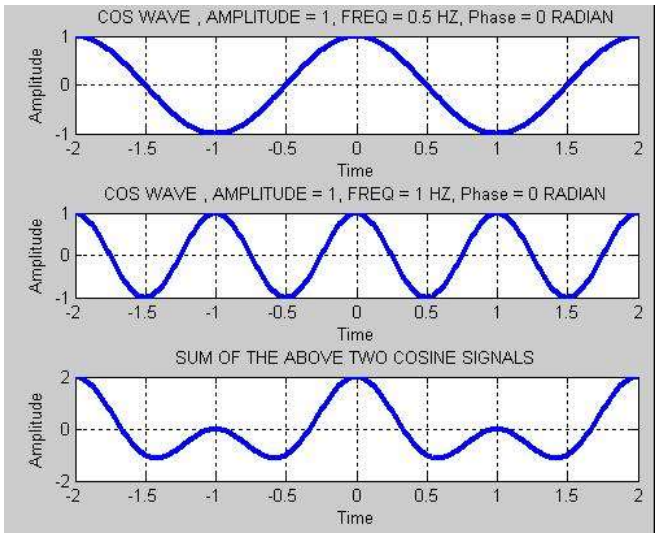

Figure 6.6: Addition of sinusoids, case 3

Case 4: When amplitudes and frequencies of the sinusoids are the same but phases are different:

```
t=-2:0.01:2;
```

```
x1=cos(2*pi*0.5*t);
x2=cos((2*pi*0.5*t)+1);
x3=x1+x2;
subplot(3,1,1);
plot(t,x1,'linewidth',3);
grid;
ylabel('Amplitude');
xlabel('Time');
title('COS WAVE , AMPLITUDE = 1, FREQ = 0.5 HZ, Phase = 0
RADIAN');
subplot(3,1,2);
plot(t,x2,'linewidth',3);
grid;
ylabel('Amplitude');
xlabel('Time');
title('COS WAVE , AMPLITUDE = 1, FREQ = 0.5 HZ, Phase = 1
RADIAN');
subplot(3,1,3);
plot(t,x3,'linewidth',3);
grid;
ylabel('Amplitude');
xlabel('Time');
title('SUM OF THE ABOVE TWO COSINE SIGNALS');
```

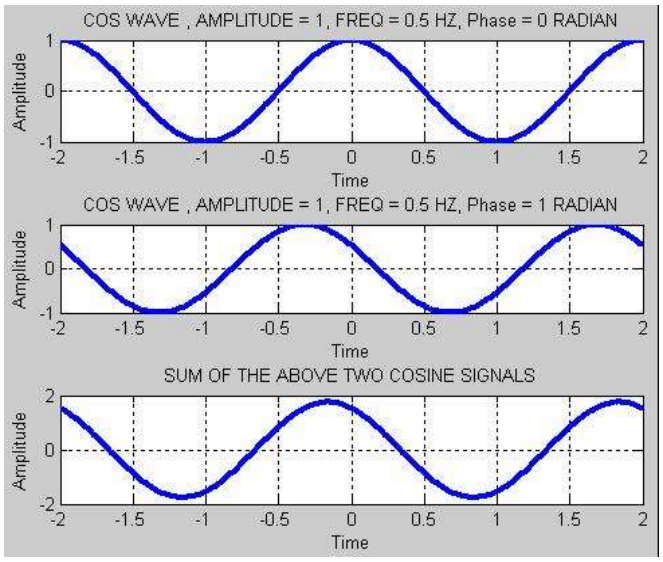

Figure 6.7: Addition of sinusoids, case 4

6.5 Tasks

Perform the following tasks:

6.5.1 Task 01

Generate a 1×10 row vector `v` whose i^{th} component is $\cos(i\pi/4)$.

6.5.2 Task 02

Write a MATLAB code that draws a graph of $\sin(n\pi x)$ on the interval $-1 \leq x \leq 1$ for $n = 1, 2, 3, \ldots, 8$. (Hint: Use `for` loop)

6.5.3 Task 03

Given the signal $\exp(-x)\sin(8x)$ for $0 \leq x \leq 2\pi$, plot its continuous-time and discrete-time representations. Use the subplot and label properly.

6.5.4 Task 04

Modify the example given in the section 6.2 to generate a sine wave with a phase shift of $+pi/2$. Then plot a cosine wave of the same frequency, amplitude, and phase shift of 0 in another subplot. Compare both the signals and determine the relationship between the two.

6.5.5 Task 05

Write a program to generate a continuous-time sine wave of frequency 3 Hz, positive phase shift of $pi/2$, and amplitude of 5. Also, generate a continuous-time cosine wave of frequency 3 Hz, amplitude of 5, and phase shift of 0. Plot the two signals on separate subplots and label them properly. Determine the relationship between the two signals.

6.5.6 Task 06

Write a general program that takes `n` sinusoids from the user having the same frequency, amplitude, and phase. Plot the individual sinusoids and the resultant using the subplot function on the same figure. Do perform proper labeling.

Note: Take the amplitude, frequency, and phase given in case 1 in section 6.4. Run the code for different values of `n` and display the results.

6.5.7 Task 07

Write a general program that takes `n` sinusoids of the same frequency from the user and phase with varying amplitudes. Take amplitude from the user in run time. Plot the individual sinusoids and the resultant using the subplot function on the same figure. Do perform proper labeling.

Note: Take the amplitude and frequency given in the example of case 2. Run the code for different values of `n` and display the results.

6.5.8 Task 08

Write a general program that takes `n` sinusoids of the same amplitude and phase with varying frequencies from the user. Take each frequency from the user in run time. Plot the individual

sinusoids and the resultant using the subplot function on the same figure. Do perform proper labeling.

Note: Take the amplitude and phase given in the example of case 3. Run the code for different values of `n` and display the results.

6.5.9 Task 09

Write a general program that takes `n` sinusoids of the same amplitude and frequency with varying phases from the user. Take each phase from the user in run time. Plot the individual sinusoids and the resultant using the subplot function on the same figure. Do perform proper labeling.

Note: Take the amplitude and frequency given in the example of case 4. Run the code for different values of `n` and display the results.