Digital Signal Processing Ⅱ

1^{st} EXPERIMENT

Report

(1st report of DSP2 course)

Subject	Digital Signal Processing Ⅱ
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Exercises

In this part, there are several exercise questions. Each exercise consists of code and its result. All documents including Matlab code, result, and this report are uploaded in this website :

https://github.com/Gaon-Choi/ELE3077/tree/main/lab_experiment01

Exercise 1

Explain why the plot of real(zz) is a sinusoid. What it its phase and amplitude?

Make a calculation of the phase from a time-shift measured on the plot.

```
tt = -1 : 0.01 : 1;
xx = cos(5 * pi * tt);
zz = 1.4 * exp(1i * pi / 2) * exp(1i * 5 * pi * tt);
plot(tt, xx, 'b-', tt, real(zz), 'r--') %<--- plot a sinusoid
grid on
title('TEST PLOT of a SINUSOID')
xlabel('TIME (sec)')
```

Using the Euler's identity,

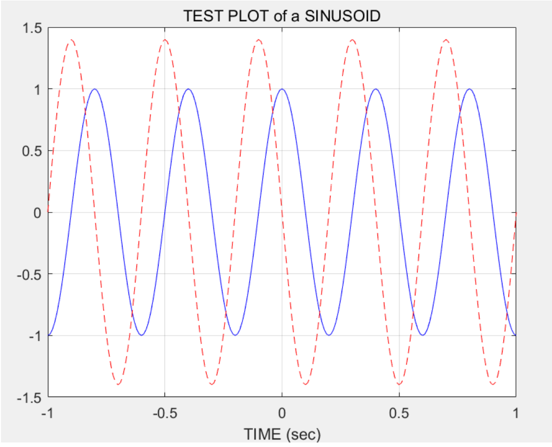
$$e^{j\theta} = \cos(\theta) + jsin(\theta)$$

$$\begin{aligned} zz = 1.4 \cdot \exp\left(j * \frac{\pi}{2}\right) \cdot \exp(\mathrm{j} * 5 * \pi * \mathrm{t}) &= 1.4 \cdot j \cdot [\cos(5\pi t) + jsin(5\pi t)] \\ &= 1.4j \cdot \cos(5\pi t) + 1.4j^2 \cdot \sin(5\pi t) \\ &= 1.4j \cdot \cos(5\pi t) - 1.4 \cdot \sin(5\pi t) \end{aligned}$$

From the equation above, we can calculate the real part of zz.

$$Re[zz] = Re[1.4j \cdot \cos(5\pi t) - 1.4 \cdot \sin(5\pi t)] = -1.4\sin(5\pi t)$$

The following plot of Re[zz] represents that the equation above is correct.

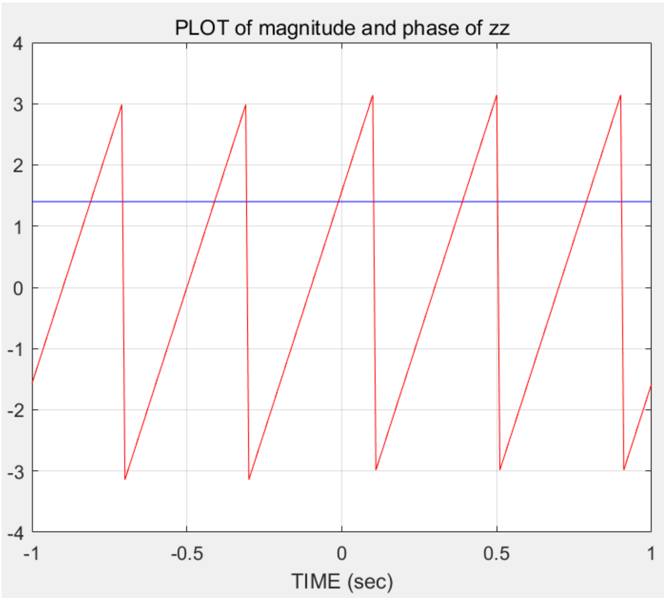


Magnitude and phase can be calculated by abs( ) function and angle( ) function each.

(Matlab code) lab1_experiment1.m

```
tt = -1 : 0.01 : 1;
xx = cos(5 * pi * tt);
zz = 1.4 * exp(1i * pi / 2) * exp(1i * 5 * pi * tt);
% plot(tt, xx, 'b-', tt, real(zz), 'r--') %<--- plot a
sinusoid
magZ = abs(zz);
phaZ = angle(zz);
plot(tt, magZ, 'b-', tt, phaZ, 'r-');
grid on
title('PLOT of magnitude and phase of zz')
xlabel('TIME (sec)')
```

(Result)



: Phase

: Amplitude

Exercise 2

Write a function that will generate a single sinusoid,

$$x(t) = Acos(\omega t + \phi)$$

by using four input arguments

: amplitude(A), frequency(ω), phase(ϕ) and duration(dur).

The function should return two outputs: the values of the sinusoidal signal (x) and corresponding times (t) at which the sinusoid values are known. Make sure that the function generates 20 values of the sinusoid per period. Call this function 'one_cos( )'.

(Source code) one_cos.m

```
function [time,value] = one_cos(amp, freq, pha, dur)
%ONE_COS plotting function of plotting function
%   time : corresponding time
%   value : corresponding value
time = 0:(2 * pi/freq) / 20:dur;
value = amp * cos((freq * time) + pha);
end
```

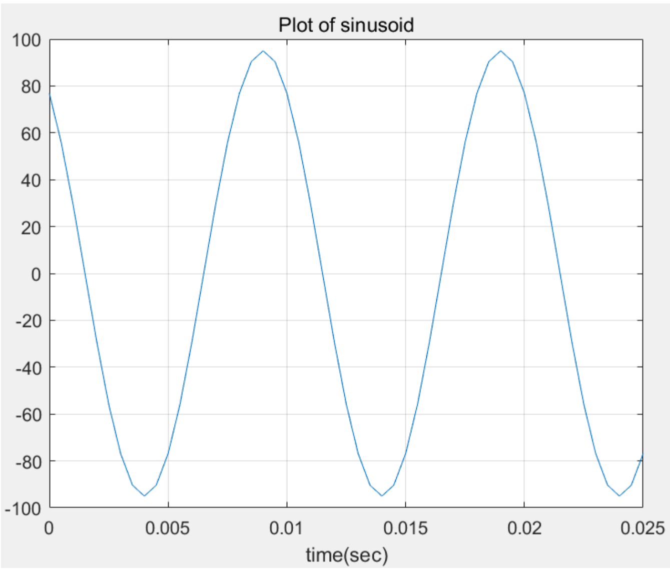
Exercise 3

Demonstrate that your 'one_cos( )' function works by plotting the output for the following parameters: $A = 95$, $\omega = 200\pi$ rad/sec, $\phi = \frac{\pi}{5}$ radians, and $dur = 0.025$ seconds.

(Source code) lab1_experiment3.m

```
% Parameters
amp = 95; freq = 200 * pi;
pha = pi / 5; dur = 0.025;

% Function Call
[t, x] = one_cos(amp, freq, pha, dur);
plot(t, x);

grid on
title('Plot of sinusoid')
xlabel('time(sec)')
```

(Result)



Exercise 4

Look at the chapter 4 of material (Experiment 01) and Solve (a)~(d).

exercise4-a

Generate a time vector (tt) to cover a range of t that will exhibit approximately two cycles of the 4000 Hz sinusoids defined in the next part, part (b). Use a definition for tt similar to part 3.2(d). If we use T to denote the period of the sinusoids, define the starting time of the vector tt to be equal to -T, and the ending time as +T. Then the two cycles will include t = 0.

Finally, make sure that you have at least 25 samples per period of the sinusoidal wave. In other words, when you use the colon operator to define the time vector, make the increment small enough to generate 25 samples per period.

(Source code) lab1_exercise4_a.m

```
freq = 4000;        % frequency: 4000Hz
T = 1/freq;     % time period

% generate time vector
ts = T / 25;    % time sampling
% starting time: -T
% ending   time: +T
tt = -T:ts:+T;
```

(Result)

tt =

1.0e-03 *

1 ~ 11 번 열

-0.2500 -0.2400 -0.2300 -0.2200 -0.2100 -0.2000 -0.1900 -0.1800 -0.1700 -0.1600 -0.1500

12 ~ 22 번 열

-0.1400 -0.1300 -0.1200 -0.1100 -0.1000 -0.0900 -0.0800 -0.0700 -0.0600 -0.0500 -0.0400

23 ~ 33 번 열

-0.0300 -0.0200 -0.0100 0 0.0100 0.0200 0.0300 0.0400 0.0500 0.0600 0.0700

34 ~ 44 번 열

0.0800 0.0900 0.1000 0.1100 0.1200 0.1300 0.1400 0.1500 0.1600 0.1700 0.1800

45 ~ 51 번 열

0.1900 0.2000 0.2100 0.2200 0.2300 0.2400 0.2500

exercise4-b

Generate two 4000 Hz sinusoids with arbitrary amplitude and time-shift.

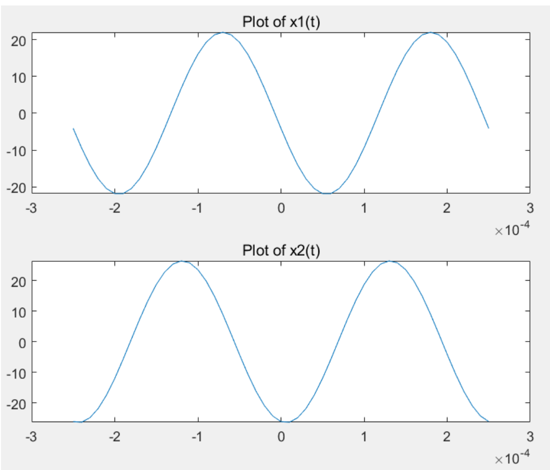
$$x_1(t) = A_1 \cos\big(2\pi(4000)(t - t_{m1})\big)$$

$$x_2(t) = A_2 \cos\big(2\pi(4000)(t - t_{m2})\big)$$

(Source code) lab1_exercise4_b.m

```
freq = 4000;        % frequency: 4000Hz
T = 1/freq;    % time period

% generate time vector
ts = T / 25;   % time sampling
% starting time: -T
% ending   time: +T
tt = -T:ts:+T;

A1 = 22;    A2 = 1.2 * A1;  % 22 years old
M = 10; D = 28  % birthday: 2000.10.28.
T_m1 = (37.2 / M) * T;
T_m2 = -(41.3 / D) * T;

x1 = A1 * cos(2*pi*freq*(tt - T_m1));
x2 = A2 * cos(2*pi*freq*(tt - T_m2));

subplot(2,1,1)
plot(tt, x1)
title("Plot of x1(t)")
subplot(2,1,2)
plot(tt, x2)
title("Plot of x2(t)")
```

(Result)



exercise4-c

Create a third sinusoid as the sum:

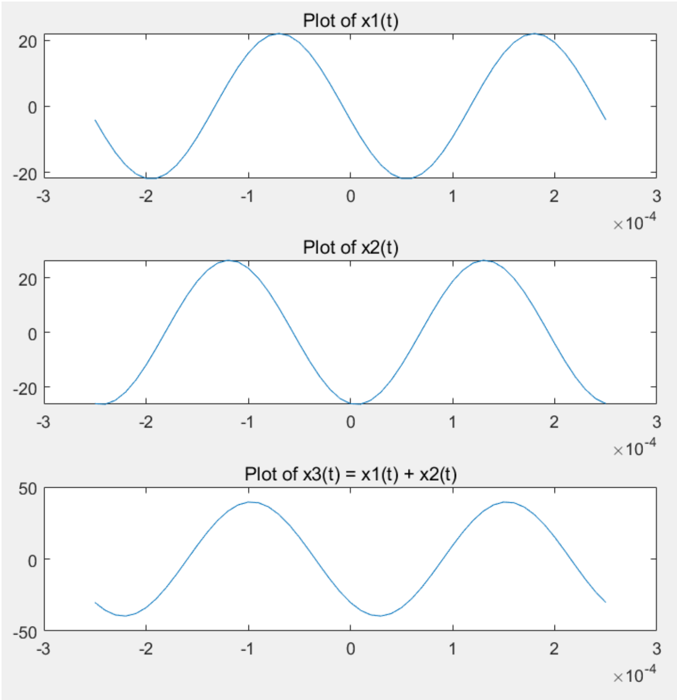
$$x_3(t) = x_1(t) + x_2(t)$$

In MATLAB this amounts to summing the vectors that hold the values of each sinusoid. Make a plot of $x_3(t)$ over the same range of time as used in the plots of part (b). Include this as the third panel in the plot by using subplot(3, 1, 3).

(Source code) lab1_exercise4_c.m

```
freq = 4000;        % frequency: 4000Hz
T = 1/freq;    % time period

% generate time vector
ts = T / 25;   % time sampling
% starting time: -T
% ending   time: +T
tt = -T:ts:+T;

A1 = 22;    A2 = 1.2 * A1;  % 22 years old
M = 10; D = 28  % birthday: 2000.10.28.
T_m1 = (37.2 / M) * T;
T_m2 = -(41.3 / D) * T;

x1 = A1 * cos(2*pi*freq*(tt - T_m1));
x2 = A2 * cos(2*pi*freq*(tt - T_m2));

subplot(3, 1, 1)
plot(tt, x1)
title("Plot of x1(t)")
subplot(3, 1, 2)
plot(tt, x2)
title("Plot of x2(t)")

x3 = x1 + x2;
subplot(3, 1, 3)
plot(tt, x3)
title("Plot of x3(t) = x1(t) + x2(t)")
```

(Result)



Plot of x1(t)
20
0
-20
-3
-2
-1
0
1
2
3
×10^-4
Plot of x2(t)
20
0
-20
-3
-2
-1
0
1
2
3
×10^-4
Plot of x3(t) = x1(t) + x2(t)
50
0
-50
-3
-2
-1
0
1
2
3
×10^-4

exercise4-d

Create a third sinusoid as the sum:

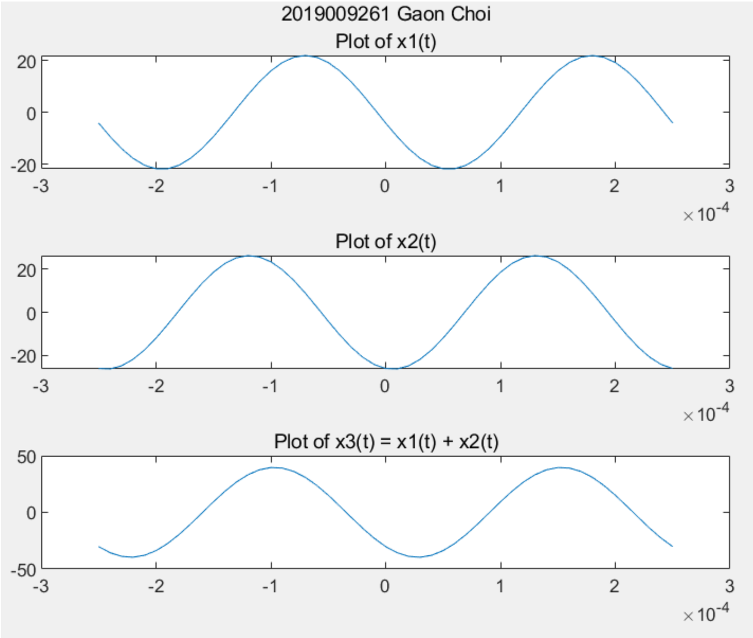
$$x_3(t) = x_1(t) + x_2(t)$$

In MATLAB this amounts to summing the vectors that hold the values of each sinusoid. Make a plot of $x_3(t)$ over the same range of time as used in the plots of part (b). Include this as the third panel in the plot by using subplot(3, 1, 3).

(Source code) lab1_exercise4_d.m

```
freq = 4000;        % frequency: 4000Hz
T = 1/freq;    % time period

% generate time vector
ts = T / 25;   % time sampling
% starting time: -T
% ending   time: +T
tt = -T:ts:+T;

A1 = 22;    A2 = 1.2 * A1;  % 22 years old
M = 10; D = 28  % birthday: 2000.10.28.
T_m1 = (37.2 / M) * T;
T_m2 = -(41.3 / D) * T;

x1 = A1 * cos(2*pi*freq*(tt - T_m1));
x2 = A2 * cos(2*pi*freq*(tt - T_m2));

subplot(3, 1, 1)
plot(tt, x1)
title({"2019009261 Gaon Choi", "Plot of x1(t)"})
subplot(3, 1, 2)
plot(tt, x2)
title("Plot of x2(t)")

x3 = x1 + x2;
subplot(3, 1, 3)
plot(tt, x3)
title("Plot of x3(t) = x1(t) + x2(t)")
```

(Result)



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Plot of x1(t)
20
0
-20
-3
-2
-1
0
1
2
3
×10^-4
Plot of x2(t)
20
0
-20
-3
-2
-1
0
1
2
3
×10^-4
Plot of x3(t) = x1(t) + x2(t)
50
0
-50
-3
-2
-1
0
1
2
3
×10^-4