

Signals & Systems Laboratory

CSE- 301L

Lab # 05

OBJECTIVES OF THE LAB

In this lab, we will cover the following topics:

- *Gain familiarity with Complex Numbers and plot them*
 - *Complex exponential signals*
 - *Real exponential signals*
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5.1 COMPLEX NUMBERS

A complex number z is an ordered pair (x, y) of real numbers. Complex numbers can be represented in rectangular form as $z = x + iy$, which is the vector in two-dimensional plane. The horizontal coordinate x is called the *real part* of z and can be represented as $x = \text{Re}\{z\}$, while the vertical coordinate y is called the *imaginary part* of z and represented as $y = \text{Imag}\{z\}$. That is:

$$\begin{aligned} z &= (x, y) \\ &= x + iy \\ &= \text{Re}\{z\} + i \text{Imag}\{z\} \end{aligned}$$

Another way to represent a complex number is in polar form. In polar form, the vector is defined by its length (r) or magnitude ($|z|$) and its direction (θ). A rectangular form can be converted into polar form using formulas:

$$\begin{aligned} |z| &= r = (x^2 + y^2)^{1/2} \\ \theta &= \arctan(y/x) \\ z &= r e^{j\theta} \end{aligned}$$

where $e^{j\theta} = \cos \theta + i \sin \theta$, and known as the Euler's formula.

5.2 BUILT-IN MATRIX FUNCTIONS

Function Description

real	returns the real part x of z
imag	returns the imaginary part y of z
abs	returns the length r of z
angle	returns the direction θ of z
conj	returns the complex conjugate \bar{z} of z

Here are some examples:

Example

To define the complex number, for instance, $z = (3, 4)$ in matlab write in matlab

```
editor >> z = 3 + 4i
```

z =

```
3.0000 + 4.0000i
```

Example

To find the real and imaginary parts of the complex number,

```
write >> x = real(z)

x =

    3

>> y = imag(z)

y =

    4
```

Example

To find the length and direction of z,

```
write >> r = abs(z)

r =

    5

>> θ = angle(z)

θ =

    0.9273
```

Example

To find the conjugate of z, write

```
>> zx = conj(z)

zx =

    3.0000 - 4.0000i
```

-----TASK 01-----

Write matlab function **zprint**, which takes a complex number and returns it real part, imaginary part, magnitude, phase in radians, and phase in degrees.

A sample run of program is:

```
>> zprint(z)

Z= X + jY Magnitude Phase Ph(deg)
    3    4    5    0.927 53.13
```

-----TASK 02-----

Compute the conjugate \bar{z} (i.e. `z_conj` [give variable name]) and the inverse $1/z$ (i.e. `z_inv` [give variable name]) for any complex number z . Display the results numerically with `zprint`.

-----TASK 03-----

Take two complex number and compute $z_1 + z_2$ and display the results numerically using `zprint`.

-----TASK 04-----

Take two complex numbers and compute $z_1 z_2$ and z_1/z_2 . Use `zprint` to display the results numerically.

5.3 COMPLEX EXPONENTIAL SIGNALS

The complex exponential signal is defined as

$$x'(t) = A e^{j(w_0 t + \phi)}$$

which is a complex-valued function of t , where the magnitude of $x'(t)$ is

$$|x'(t)| = A \quad \Rightarrow \quad \text{magnitude or length of } x'(t)$$

$$\arg x'(t) = (w_0 t + \phi) \quad \Rightarrow \quad \text{angle or direction of } x'(t)$$

Using Euler's formula, it can be expressed in rectangular or Cartesian form,

$$\text{i.e. } x'(t) = A e^{j(w_0 t + \phi)} = A \cos(w_0 t + \phi) + j A \sin(w_0 t + \phi)$$

where

A = amplitude,

ϕ =phase shift

w_0 = frequency in rad/sec

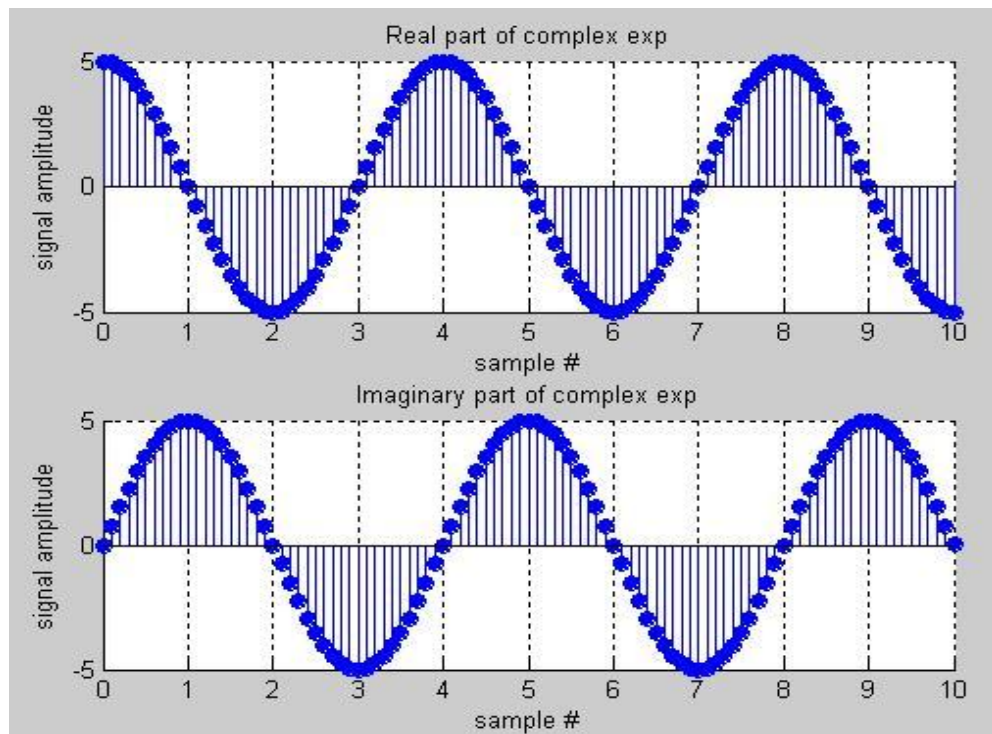
Example

```
clear, close all, clc
n=0:1/10:10;
k=5;
a=pi/2;
x=k * exp(a*n*i);
% plot the real part
subplot(2,1,1)
stem(n, real(x), 'filled')
```

```

title('Real part of complex exp')
xlabel('sample #')
ylabel('signal amplitude')
grid
% plot the imaginary
part subplot(2,1,2)
stem(n, imag(x), 'filled')
title('Imaginary part of complex exp')
xlabel('sample #')
ylabel('signal amplitude')
grid

```



-----TASK 05-----

Determine the complex conjugate of the exponential signal given in above example and plot its real and imaginary portions.

-----TASK 06-----

Generate the complex valued signal and plot its magnitude, phase, the real part, and the imaginary part in separate subplots.

$$y(n) = \exp^{(-0.2 + j0.5n)}, -10 \leq n \leq 10$$

-----TASK 07-----

- Generate a real-exponential $x = a * \exp^{(n)}$ for $a=0.7$ and n ranging from 0-10. Find the discrete time as well as the continuous time version of this signal. Plot the two signals on same graph (holding both the graphs).
- Repeat the same program with value of $a=1.3$.

-----TASK 08-----

Multiply the two discrete signals $x_1 = 5 \exp^{(i*n*\pi/4)}$ and $x_2 = a * \exp^{(n)}$ (use point-by-point multiplication of the two signals). Plot the real as well as the exponential parts for $0 < a < 1$ and $a > 1$.

-----TASK 09-----

Plot the discrete signal $x = a^{|n|}$ for n ranging from -10 to 10. Draw two subplots for $0 < a < 1$ and $a > 1$.

-----TASK 10-----

- Generate the signal $x(t) = A e^{(j\omega t + \pi)}$ for $A = 3$, $\pi = -0.4$, and $\omega = 2\pi(1250)$. Take a range for t that will cover 2 or 3 periods.
- Plot the real part versus t and the imaginary part versus t . Use subplot(2,1,i) to put both plots in the same window.
- Verify that the real and imaginary parts are sinusoids and that they have the correct frequency, phase, and amplitude.