<u>LAB REPORT</u>

CONTROL ENGINEERING LABORATORY : EE208

EXPERIMENT-4

Controller design on MATLAB platform using discrete root loci.

Group No. 25

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1.OBJECTIVE:

This project therefore requires the design of a cascade feedback controller for a given digital transfer function, according to desired specifications.

2.BLOCK DIAGRAM:

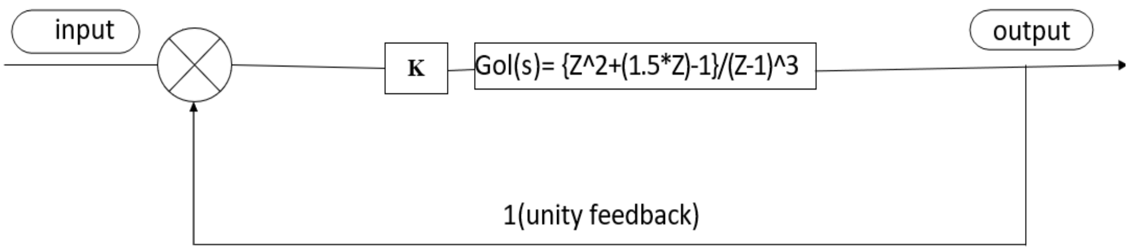


Fig: Block diagram of close loop system

$$T.F = \frac{k*(z^2+1.5z-1)}{z^3+(k-3)z^2+(1.5k+3)z-(k+1)}$$

3.THEORY:

Open loop transfer function =Gol = $\frac{Z^2+1.5Z-1}{(Z-1)^3}$

Closed loop transfer function =Gcl = $\frac{K*(Z^2+1.5*Z-1)}{\{Z^3+Z^2(K-3)+Z(1.5*K+3)-(K+1)\}}$

- First we discuss some basic stuff about stability of a system in the z domain.Strictly speaking, the stability in z domain is decided by the location of poles in the root locus plot of CLTF w.r.t. the unity circle i.e |z|= 1.

- If all poles lie inside the unity circle then the system is stable while marginally stable if pole lies on the unity circle and it is unstable if any pole lies outside the unity circle.

- Damping is an influence within or upon an oscillatory that has the effect of reducing or preventing its oscillation. In physical systems, damping is produced by processes that dissipate the energy stored in the oscillation. The damping ratio is a parameter, usually denoted by ζ (zeta), that characterizes the frequency response of a second-order ordinary differential equation.

- It can vary from undamped (ζ = 0),underdamped (ζ < 1) through critically damped (ζ = 1) to overdamped (ζ > 1).

- If the ratio is zero, that indicates there is no damping present and it will oscillate forever. If the ratio is between 0 & 1 that means it has some amount of damping and accordingly the oscillations will dissipate slowly or quickly as the damping ratio changes from 0 to 1. A system with damping ratio 1 has no overshoots and the quickest rise time and the CLTF dynamics to be damped oscillatory.

4.<u>OBSERVATION AND MATLAB SCRIPTS:</u>

The given OLTF is **Gol=**$\frac{Z^2+1.5Z-1}{(Z-1)^3}$

According the block diagram we connect in proportional gain constant K in series so cascade system total **Gol=**$k * \frac{Z^2+1.5Z-1}{(Z-1)^3}$

The transfer function of CLTF $T.F = \frac{G(s)}{1+G(s).H(s)}$

$$= \frac{k*\frac{Z^2+1.5Z-1}{(Z-1)^3}}{1+k*\frac{Z^2+1.5Z-1}{(Z-1)^3}}$$

$$T.F = \frac{k*(z^2+1.5z-1)}{z^3+(k-3)z^2+(1.5k+3)z-(k+1)}$$

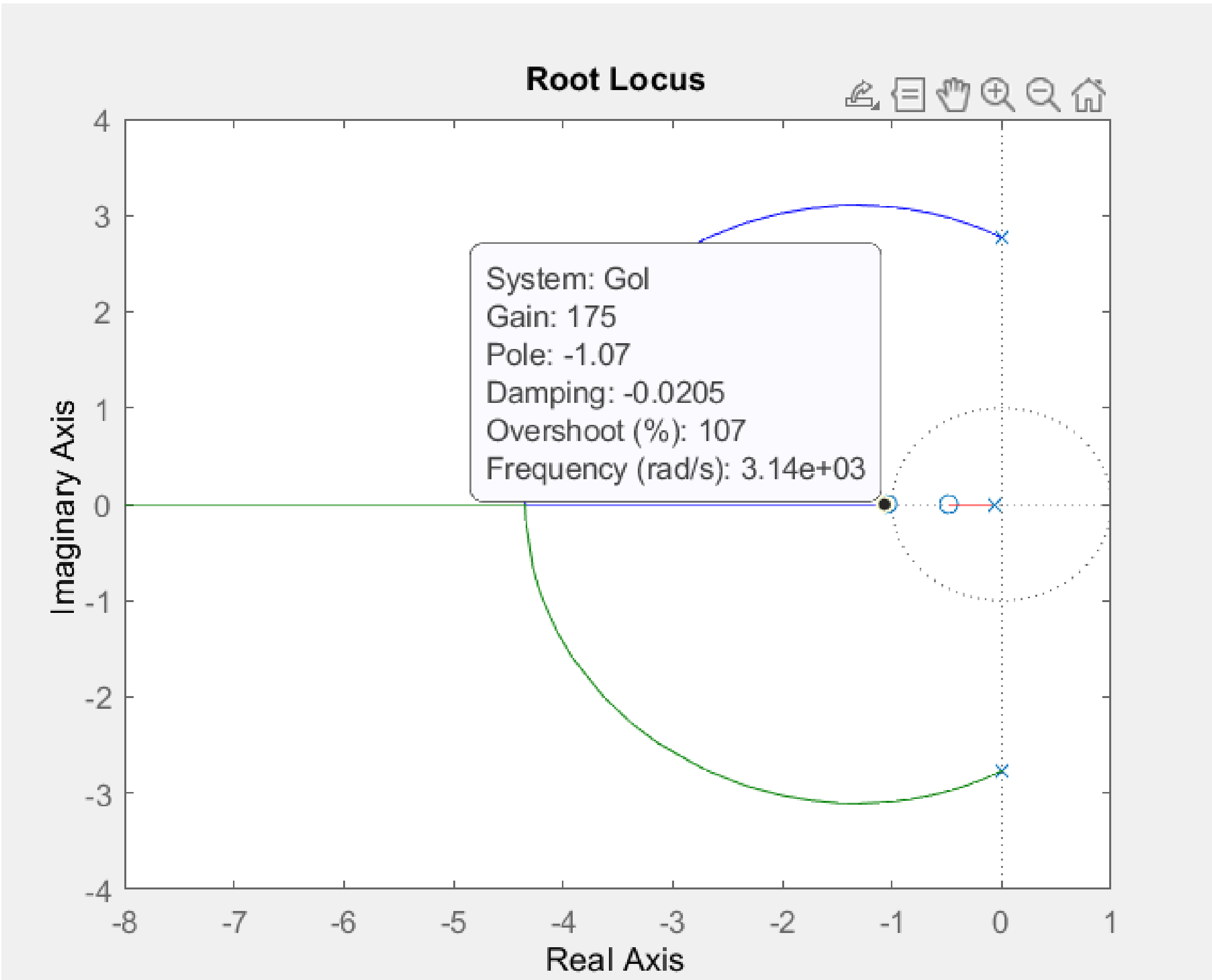
While changing the zeros and the value of proportional gain from - infinity to + infinity :

1) **By taking the value of k=3.05 and zeros were changed to -0.48 and -1.03**

$$T.F = \frac{3.05*(z^2+1.52z+0.5)}{z^3+(k-3)z^2+(1.52k+3)z+0.5k-1}$$

A.Matlab script

```
>> k=3.05;% proporinal gain factor
num=[k 1.520*k 0.5*k];
den=[1 k-3 1.52*k+3 0.5*k-1];
t=0.001; % sample time
Gol=tf(num,den,t)

Gol =

     3.05 z^2 + 4.636 z + 1.525
  --------------------------------
  z^3 + 0.05 z^2 + 7.636 z + 0.525

Sample time: 0.001 seconds
Discrete-time transfer function.

>> rclous(Gol)
Unrecognized function or variable 'rclous'.

Did you mean:
>> rlocus(Gol)
>>
```



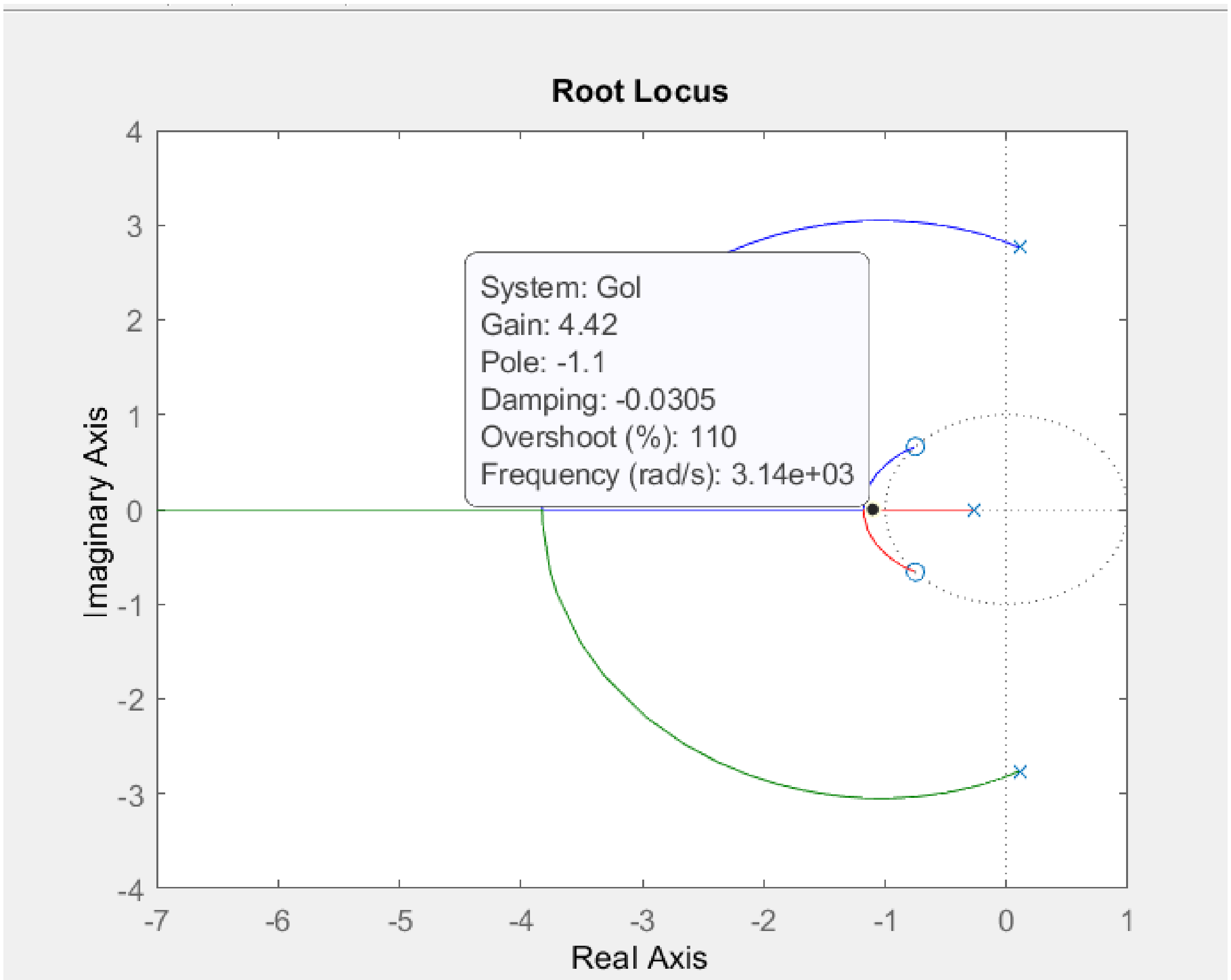
- The damping ratio for this case is -0.0205
- The value of overshoot is 107 %
- The frequency of this case is 3.14e+3
- As all the three poles lie on the imaginary axis so we can say that the system is marginally stable .

2) **<u>By taking the value of k=3.05 and zeros were changed to 0.75 + 0.66ι and 0.75-0.66ι</u>**

$$T.F = \frac{3.05*(z^2+1.50z+1)}{z^3+(k-3)z^2+(1.5k+3)z+k-1}$$

A.Matlab script

```
>> k=3.05;% proporinal gain factor
num=[k 1.5*k 1*k];
den=[1 k-3 1.5*k+3 1*k-1];
t=0.001; % sample time
Gol=tf(num,den,t)

Gol =

     3.05 z^2 + 4.575 z + 3.05
  --------------------------------
  z^3 + 0.05 z^2 + 7.575 z + 2.05

Sample time: 0.001 seconds
Discrete-time transfer function.

>> rclous(Gol);
Unrecognized function or variable 'rclous'.

Did you mean:
>> rlocus(Gol);
>> 
```



- The damping ratio for this case is -0.0305
- The value of overshoot is 110 %
- The frequency of this case is 3.14e+3

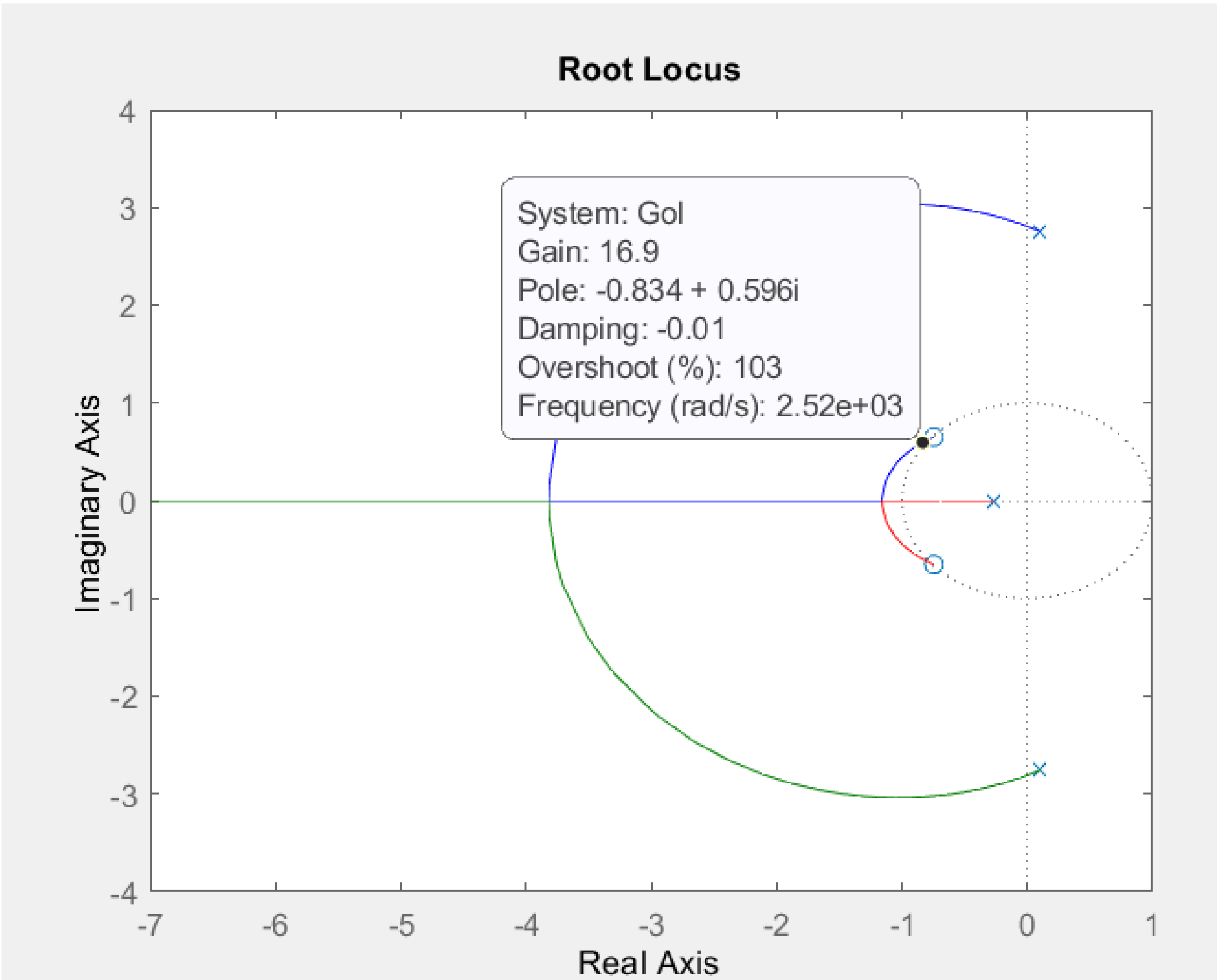
- As all the three poles lie on the imaginary axis so we can say that the system is marginally stable

3) **By taking the value of k=3.05 and zeros were changed to -0.745+0.65 ɩand -0.745-0.65ɩ.**

$$T.F = \frac{3.05*(z^2+1.49z+0.98)}{z^3-(k-3)z^2+(1.49k+3)z+0.98k-1}$$

A.Matlab script

```
>> k=3.05;% proporinal gain factor
num=[k 1.49*k 0.98*k];
den=[1 k-3 1.49*k+3 0.98*k-1];
t=0.001; % sample time
Gol=tf(num,den,t)

Gol =

     3.05 z^2 + 4.544 z + 2.989
  --------------------------------
  z^3 + 0.05 z^2 + 7.544 z + 1.989

Sample time: 0.001 seconds
Discrete-time transfer function.

>> rclous(Gol)
Unrecognized function or variable 'rclous'.

Did you mean:
>> rlocus(Gol)
>>
```



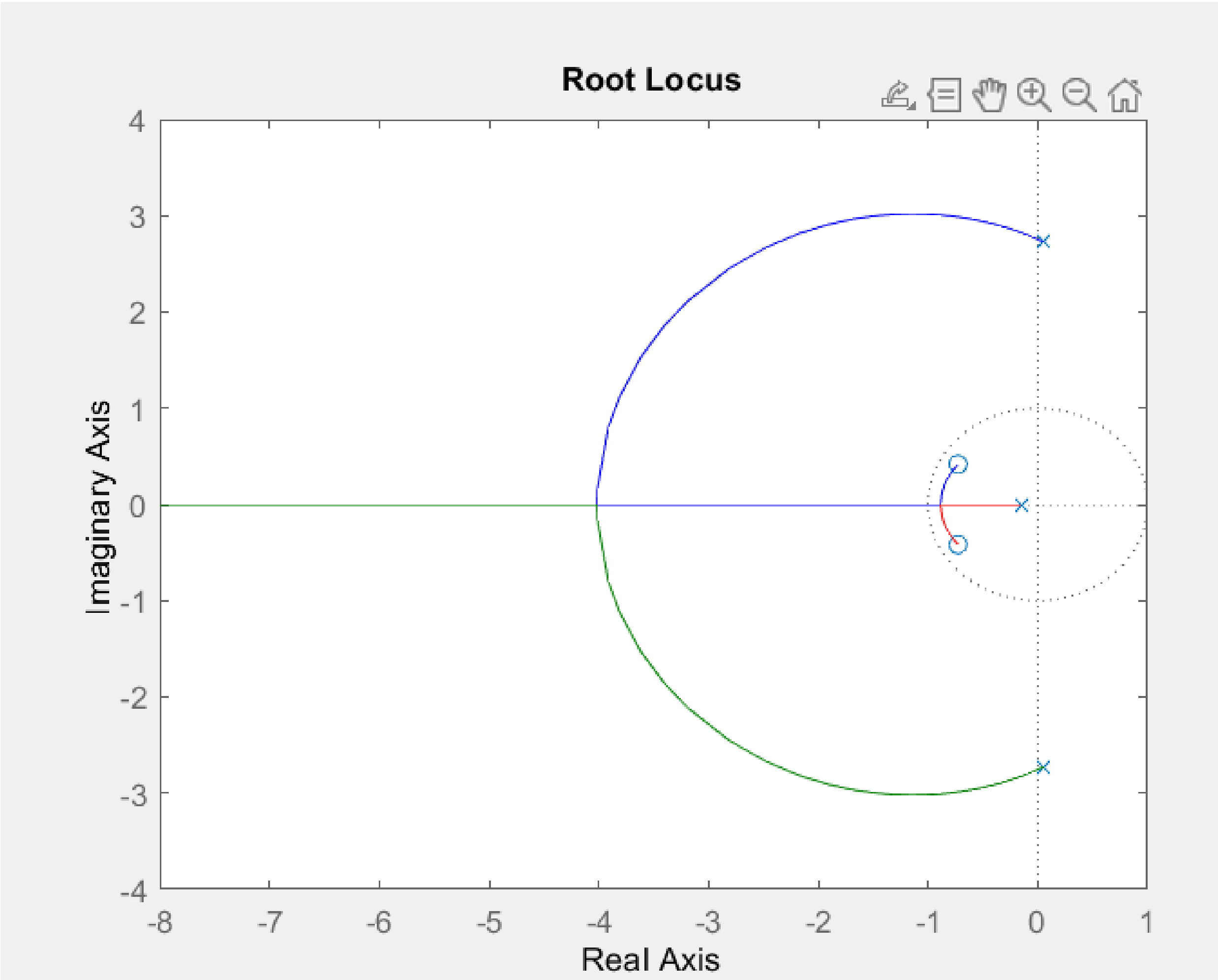
- The damping ratio for this case is -0.01
- The value of overshoot is 103 %
- The frequency of this case is 2.52e+3
- As all the three poles lie on the imaginary axis so we can say that the system is marginally stable

4) **By taking the value of k=3.05 and zeros were changed to -0.766+0.68ι and -0.766-0.68ι.**

$$T.F = \frac{3.05*(z^2+1.45z+0.7)}{z^3-(k-3)z^2+(1.45k+3)z+0.7k-1}$$

A.Matlab script

```
>> k=3.05;% proporinal gain factor
num=[k 1.45*k 0.7*k];
den=[1 k-3 1.45*k+3 0.7*k-1];
t=0.001; % sample time
Gol=tf(num,den,t)

Gol =

     3.05 z^2 + 4.422 z + 2.135
  --------------------------------
  z^3 + 0.05 z^2 + 7.422 z + 1.135

Sample time: 0.001 seconds
Discrete-time transfer function.

>> rlcous(Gol)
Unrecognized function or variable 'rlcous'.

Did you mean:
>> rlocus(Gol)
>>
```



- The damping ratio for this case is -0.042
- The value of overshoot is 102 %
- The frequency of this case is 3.03e+3
- As all the three poles lie on the imaginary axis so we can say that the system is marginally stable .

5.ANALYSIS:

Sensitivity analysis :

$$\frac{del(Gcl)}{del(k)} * \frac{k}{Gcl} \text{ ,Where Gcl is } \frac{Gol}{1+Gol}$$

As we know any changes in the parameter will change the system performance so any small change in the gain yields high change in the sensitivity of the system. So, very large changes in the gain(k), will yield low sensitivity to change in gain. From the above observation we analyze that as the value of setting time increases then value of the gain(k) decreases. Therefore as the setting time increases , sensitivity of the system will increase.

6.CONCLUSION:

- In this project we have understood the design of a cascade feedback controller for a given digital transfer function, according to desired specifications

- For absolute cases the value of ξ equal to 0 (undamped system) in marginally stable but we calculate the value 0.012 <ξ<0.03 in practical case.

- As the given transfer function is unstable for any value of K so we have changed the value of zeros for the transfer function and we get the transfer function $T.F = \frac{3.05*(z^2+1.52z+0.5)}{z^3-(k-3)z^2+(1.52k+3)z+0.5k-1}$. marginally stable for the value of K from 2 to 3.05 with sampling time 0.001sec.

- For marginally stable the poles should lie on the imaginary axis with non repeated poles and we got the poles -0.0006547+0.001i ,0.00774+2.7635i & 0.00774-2.7635i .