2)

```
>> s=tf('s');
>> Kp=1.65*10^6;
>> Kr=3.71*10^5;
>> K=1;
>> Jv=41822;
>> Actf=(Kp*K)/(Jv*s^2+Kr*s)

Actf =

        1.65e06
  --------------------
  41822 s^2 + 371000 s

Continuous-time transfer function.

>> Kctf=(Kp*K)/(Jv*s^2+Kr*s+Kp*K)

Kctf =

              1.65e06
  -------------------------------
  41822 s^2 + 371000 s + 1.65e06

Continuous-time transfer function.

>> figure(1);
>> bode(Actf)
>> figure(2);
>> step(Actf)
>> figure(3);
>> bode(Kctf)
>> figure(4);
>> step(Kctf)
>>
```

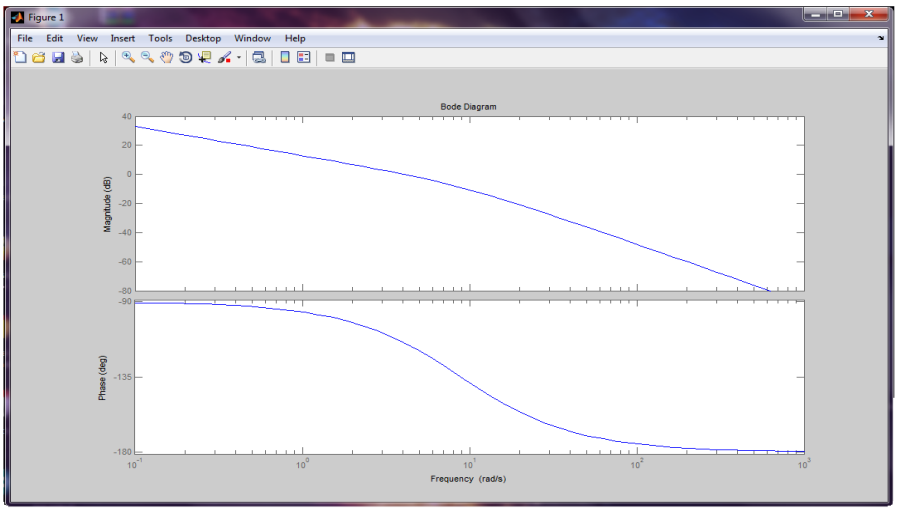
A)

Open loop transfer function: Actf(s)

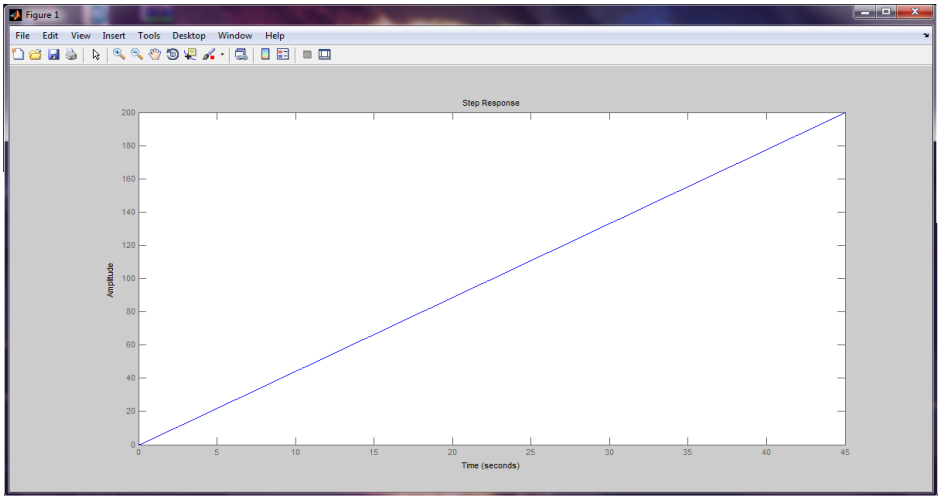
Closed loop transfer function: Kctf(s)

$$Actf(s) = \frac{K * Kp}{Jv * s^2 + Kr * s}$$

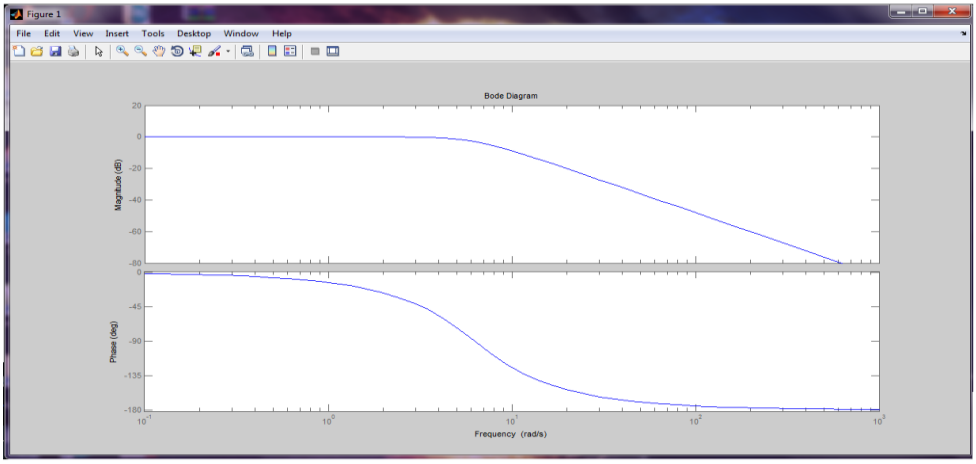
$$Kctf(s) = \frac{K * Kp}{Jv * s^2 + Kr * s + K * Kp}$$



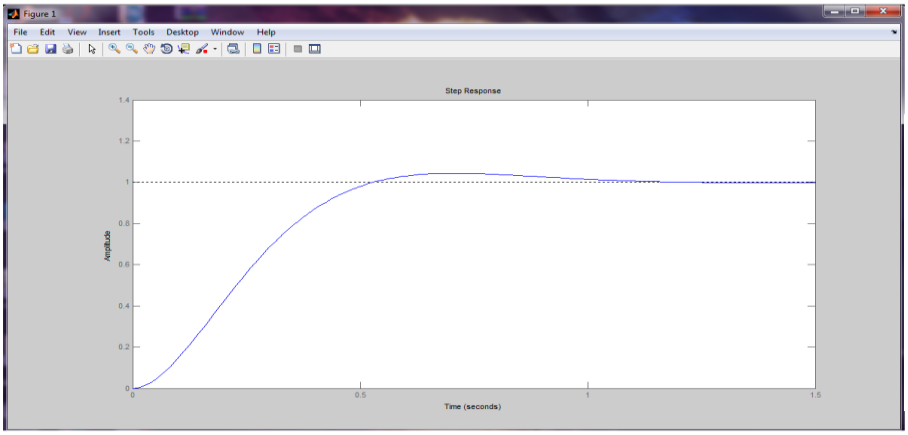
Bode of Open loop system



Unit step response of open loop system



Bode of closed loop system



Unit step response of closed loop system

B)

➢ i

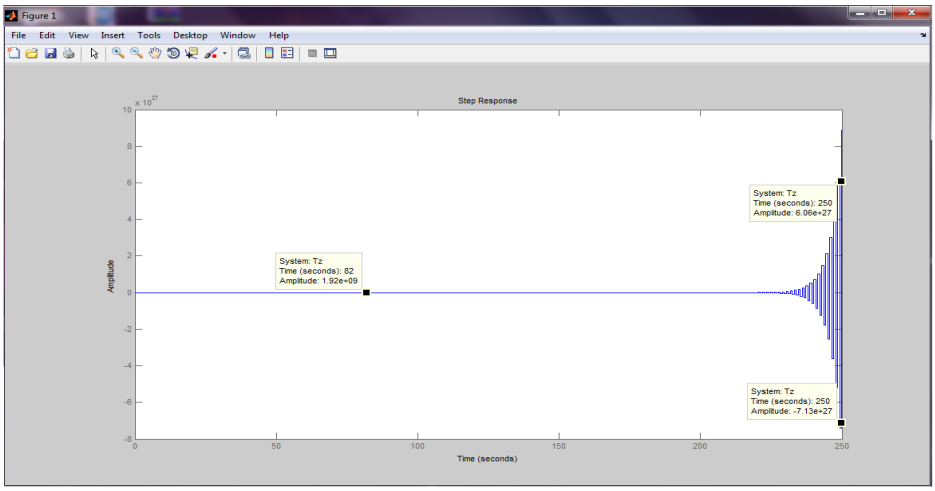
```
>> s=tf('s');
>> Kp=1.65*10^6;
>> Kr=3.71*10^5;
>> K=1;
>> Jv=41822;
>> Ts=[0.005,0.05,0.1,0.2,0.5,0.6,0.6741,0.7];
>> Actf=(Kp*K)/(Jv*s^2+Kr*s);
>> Kctf=(Kp*K)/(Jv*s^2+Kr*s+Kp*K);
>> hold on
>> step(Kctf)
>> for i=1:1:8
Gz=c2d(Actf,Ts(i),'zoh')
Tz=Gz/(1+Gz)
step(Tz)
end

Gz =

  0.000486 z + 0.0004788
  ----------------------
  z^2 - 1.957 z + 0.9566

Sample time: 0.005 seconds
Discrete-time transfer function.

Tz =

  0.000486 z^3 - 0.000472 z^2
                 - 0.000472 z + 0.000458
  ---------------------------------------
  z^4 - 3.913 z^3 + 5.741 z^2
                    - 3.744 z + 0.9156

Sample time: 0.005 seconds
Discrete-time transfer function.

Gz =

    0.04277 z + 0.0369
  ---------------------
  z^2 - 1.642 z + 0.6418

Sample time: 0.05 seconds
Discrete-time transfer function.
```

-

```
Tz =

  0.04277 z^3 - 0.03332 z^2 - 0.03313 z
                                + 0.02368
  ---------------------------------------
  z^4 - 3.241 z^3 + 3.946 z^2
                     - 2.14 z + 0.4355

Sample time: 0.05 seconds
Discrete-time transfer function.

Gz =

    0.1499 z + 0.1117
  --------------------
  z^2 - 1.412 z + 0.4119

Sample time: 0.1 seconds
Discrete-time transfer function.

Tz =

  0.1499 z^3 - 0.0999 z^2 - 0.09598 z
                                + 0.046
  ---------------------------------------
  z^4 - 2.674 z^3 + 2.717 z^2
                    - 1.259 z + 0.2156

Sample time: 0.1 seconds
Discrete-time transfer function.

Gz =

    0.4732 z + 0.2654
  --------------------
  z^2 - 1.17 z + 0.1696

Sample time: 0.2 seconds
Discrete-time transfer function.
```

```
Tz =

  0.4732 z^3 - 0.288 z^2 - 0.2302 z
                                + 0.04502
  ---------------------------------------
  z^4 - 1.866 z^3 + 1.419 z^2
                    - 0.627 z + 0.07379

Sample time: 0.2 seconds
Discrete-time transfer function.
Gz =

    1.728 z + 0.4691
  --------------------
  z^2 - 1.012 z + 0.01185

Sample time: 0.5 seconds
Discrete-time transfer function.


Tz =

  1.728 z^3 - 1.28 z^2 - 0.4541 z
                                + 0.005558
  ---------------------------------------
  z^4 - 0.2954 z^3 - 0.2322 z^2
                    - 0.4781 z + 0.005699

Sample time: 0.5 seconds
Discrete-time transfer function.
Gz =

      2.17 z + 0.4859
  ----------------------
  z^2 - 1.005 z + 0.00488

Sample time: 0.6 seconds
Discrete-time transfer function.
```

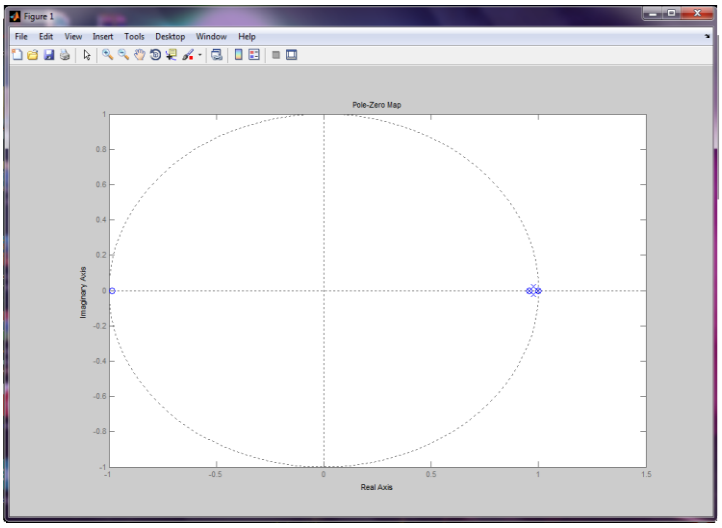
```
Tz =

  2.17 z^3 - 1.694 z^2 - 0.4777 z
                              + 0.002371
  ------------------------------------------
  z^4 + 0.1598 z^3 - 0.6747 z^2
                      - 0.4875 z + 0.002395

Sample time: 0.6 seconds
Discrete-time transfer function.
Gz =

     2.498 z + 0.4925
  ----------------------
  z^2 - 1.003 z + 0.002529

Sample time: 0.6741 seconds
Discrete-time transfer function.
Tz =

  2.498 z^3 - 2.012 z^2 - 0.4874 z
                              + 0.001246
  ------------------------------------------
  z^4 + 0.4929 z^3 - 1.002 z^2
                      - 0.4925 z + 0.001252

Sample time: 0.6741 seconds
Discrete-time transfer function.
Gz =

     2.613 z + 0.4941
  ----------------------
  z^2 - 1.002 z + 0.00201

Sample time: 0.7 seconds
Discrete-time transfer function.
Tz =
```



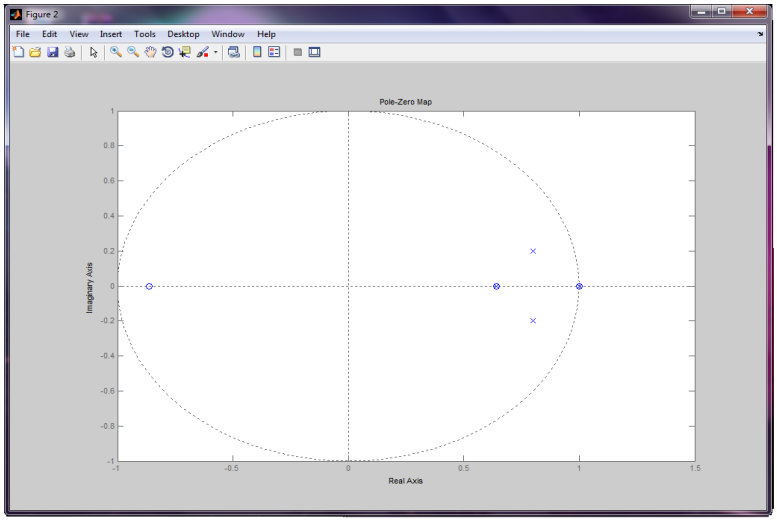
Unit step response

- **ii**

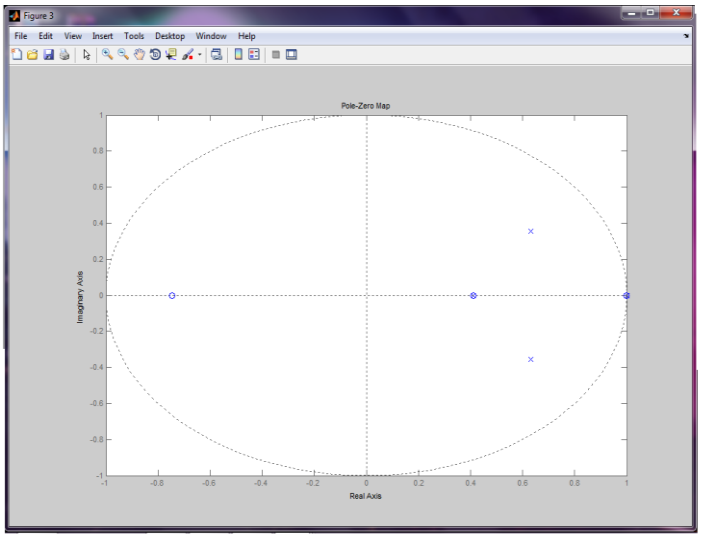
```
>>  s=tf('s');
Kp=1.65*10^6;
Kr=3.71*10^5;
K=1;
Jv=41822;
T=[0.005,0.05,0.1,0.2,0.5,0.6,0.6741,0.7]
Actf=(Kp*K)/(Jv*s^2+Kr*s);
Kctf=(Kp*K)/(Jv*s^2+Kr*s+Kp*K);
for i=1:1:8
Gz=c2d(Actf,T(i),'zoh')
TZ=Gz/(1+Gz)
figure(i)
pzmap(Tz)
end

T =

  Columns 1 through 3

    0.0050    0.0500    0.1000

  Columns 4 through 6

    0.2000    0.5000    0.6000

  Columns 7 through 8

    0.6741    0.7000


Gz =

  0.000486 z + 0.0004788
  ----------------------
  z^2 - 1.957 z + 0.9566

Sample time: 0.005 seconds
Discrete-time transfer function.


Tz =

  0.000486 z^3 - 0.000472 z^2
            - 0.000472 z + 0.000458
  ---------------------------------

  z^4 - 3.913 z^3 + 5.741 z^2
```



T=0.005



T=0.05



T=0.1

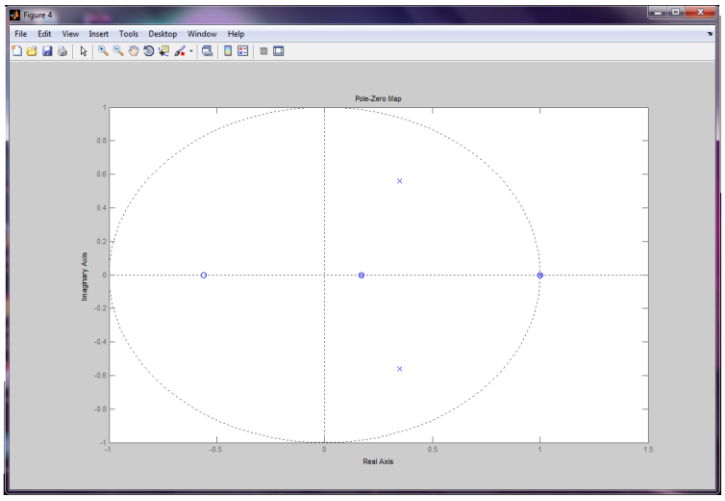


Figure 4
File Edit View Insert Tools Desktop Window Help
Pole-Zero Map
Imaginary Axis
Real Axis

T=0.2

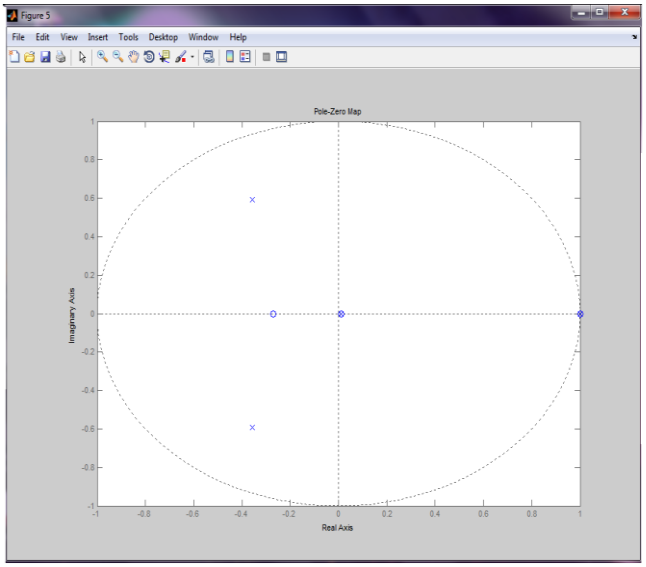


Figure 5
File Edit View Insert Tools Desktop Window Help
Pole-Zero Map
Imaginary Axis
Real Axis

T=0.5

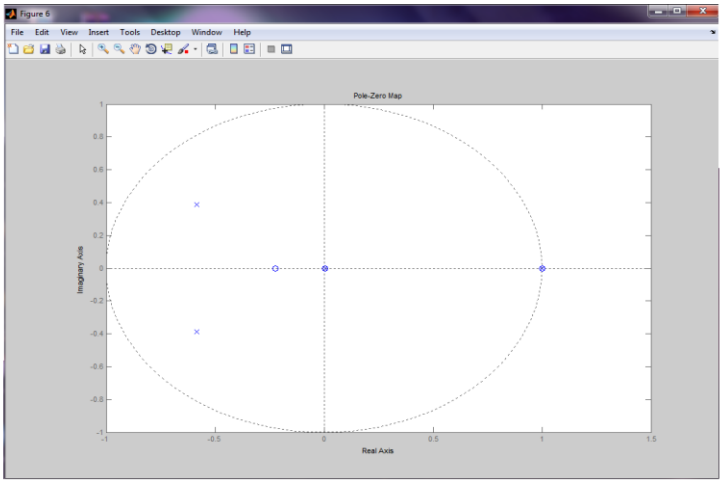
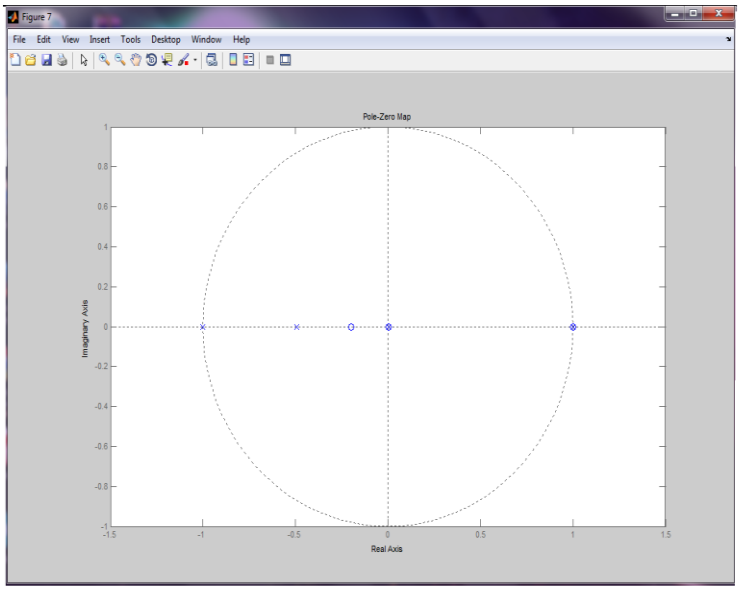
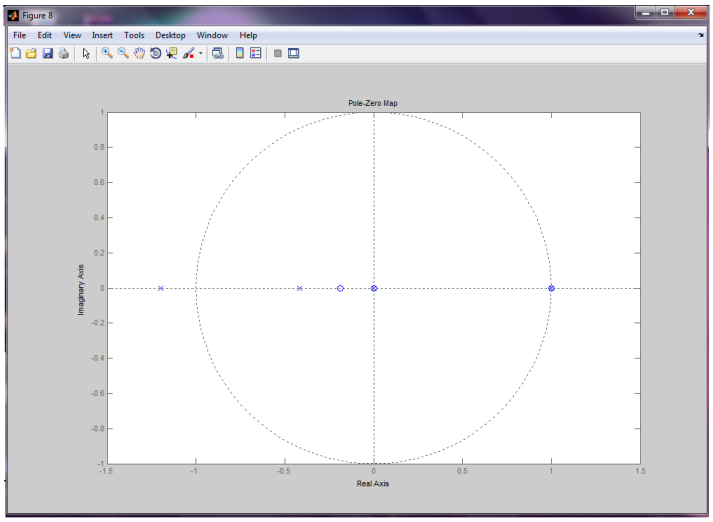


Figure 6
File Edit View Insert Tools Desktop Window Help
Pole-Zero Map
Imaginary Axis
Real Axis

T=0.6



T=0.6741



T=0.7

- **iii**

As the T value increases, the poles move outside the unit circle and the system becomes unstable. For T=0674 the system is critically stable. For the values that are larger than that the system is unstable.