SARDAR VALLABHBHAI PATEL INSTITUTE OF TECHNOLOGY, VASAD

Advance Control Theory

SUBJECT CODE :2181705

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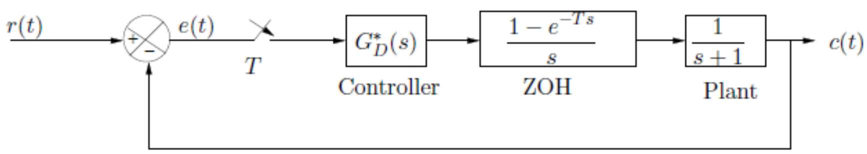
Instrumentation & Control Engineering Department

Semester VIII

PRACTICAL NO- 3

Investigate the effect of controller gain K and sampling time T on the relative stability of the closed loop system using Root Locus as shown in Figure. Assume that the controller is an integral controller, i.e., $G_D(z) = \frac{Kz}{z-1}$

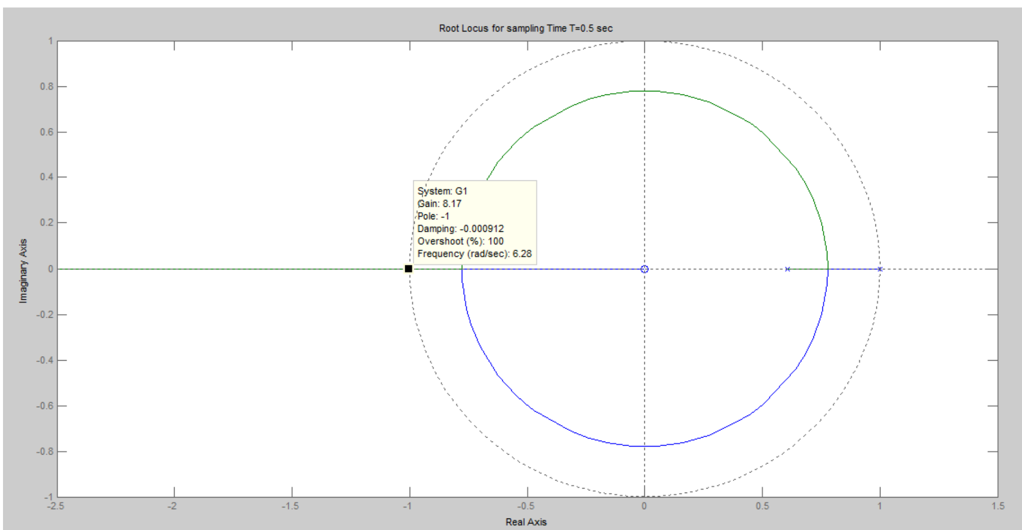


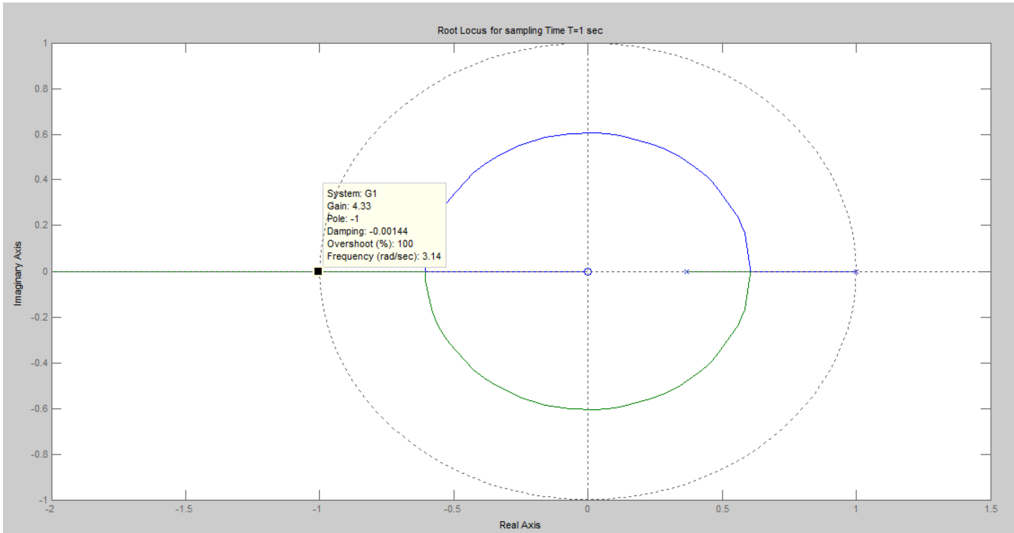
Program:

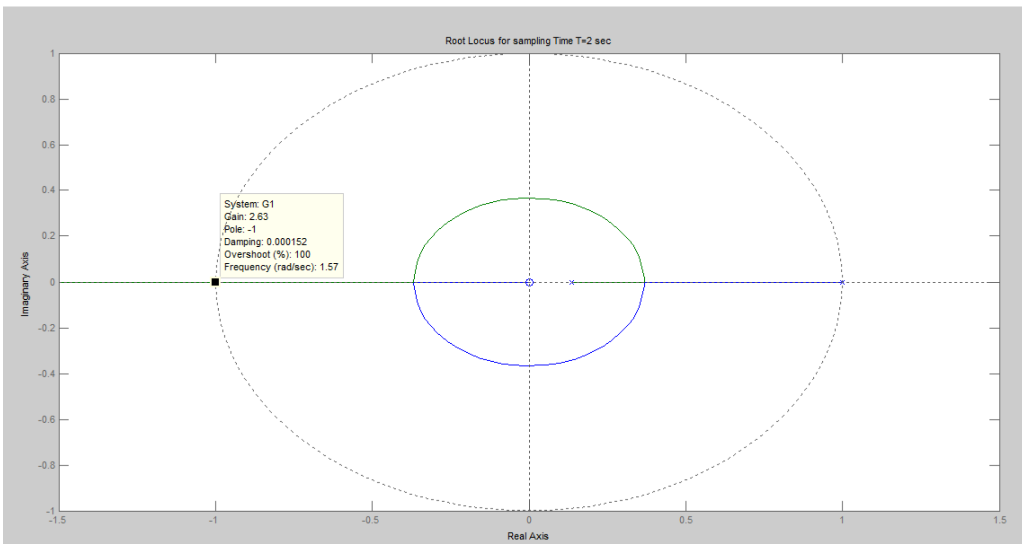
```
clc; clear all;
% T=0.5 secS
G=tf([1],[1 1]);
Gd=c2d(G,0.5); %T=0.5 sec
Gc=tf([1 0],[1 -1],0.5);
G1=series(Gd,Gc);
zpk(G1)
rlocus(G1)
title('Root Locus for sampling Time T=0.5 sec')

clc; clear all;
% T= 1 sec
G=tf([1],[1 1])
Gd=c2d(G,1) %T=1 sec
Gc=tf([1 0],[1 -1],1)
G1=series(Gd,Gc)
zpk(G1)
rlocus(G1)
title('Root Locus for sampling Time T=1 sec')

clc; clear all;
% T= 2 sec
G=tf([1],[1 1])
Gd=c2d(G,2) %T=2 sec
Gc=tf([1 0],[1 -1],2)
G1=series(Gd,Gc)
zpk(G1)
rlocus(G1)
title('Root Locus for sampling Time T=2 sec')
```

```
OUTPUT:

%T=0.5 sec
Zero/pole/gain:
   0.39347 z
----------------
(z-1) (z-0.6065)
```

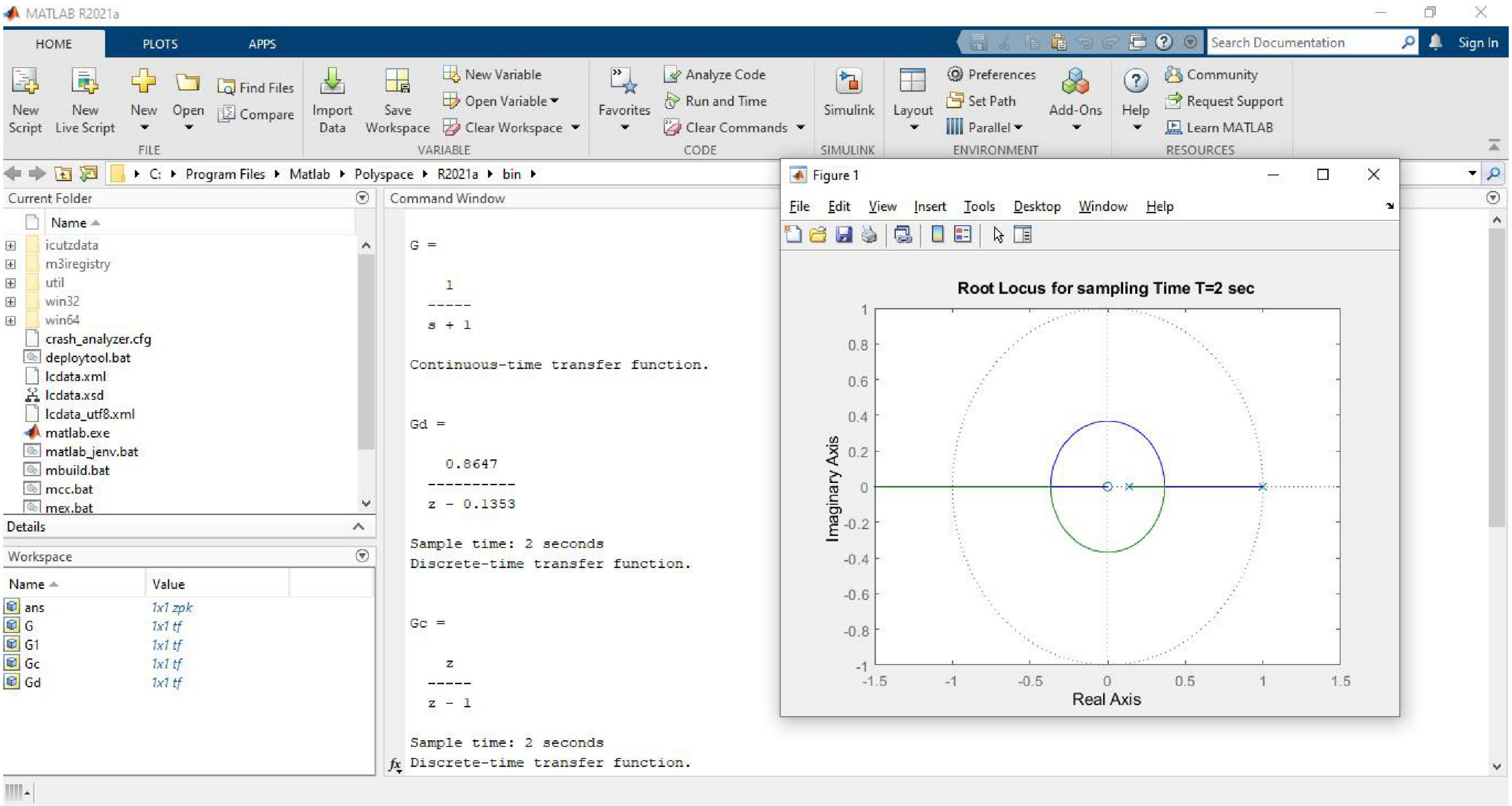
```
Sampling time: 0.5

%T=1 sec
Zero/pole/gain:
   0.63212 z
----------------
(z-1) (z-0.3679)

Sampling time: 1

%T=2 sec
Zero/pole/gain:
   0.86466 z
----------------
(z-1) (z-0.1353)

Sampling time: 2
```







CONCLUSION: In this practical we Investigated the effect of controller gain K and sampling time T on the stability of the closed loop system using root-locus.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mbuild.bat
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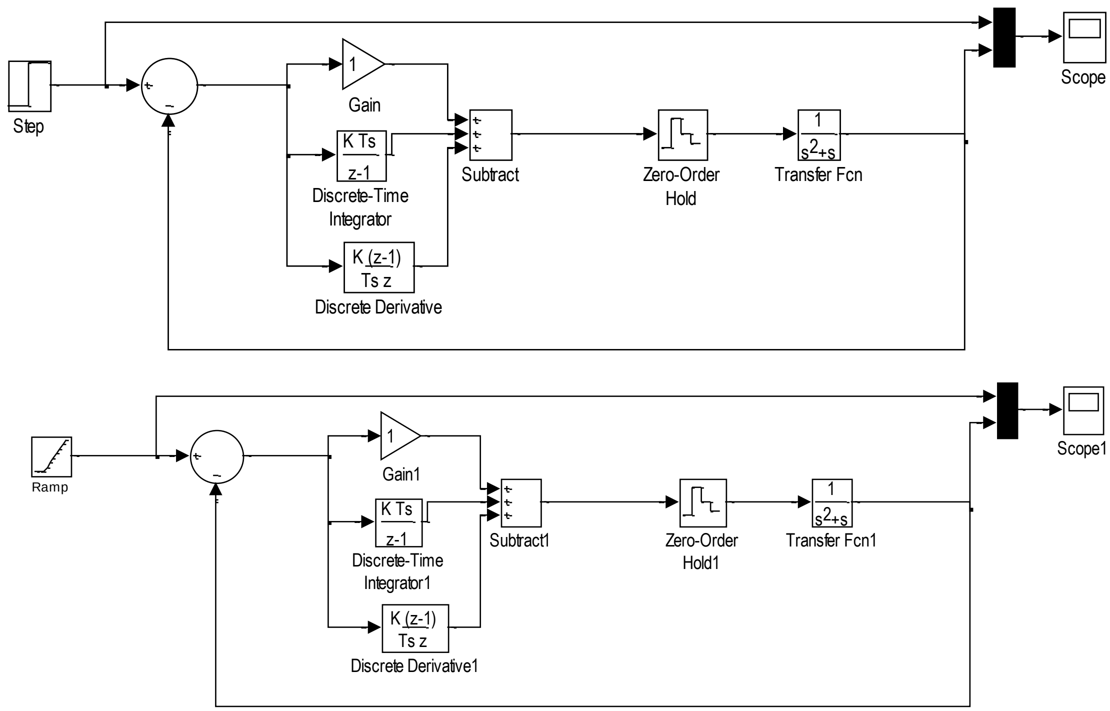
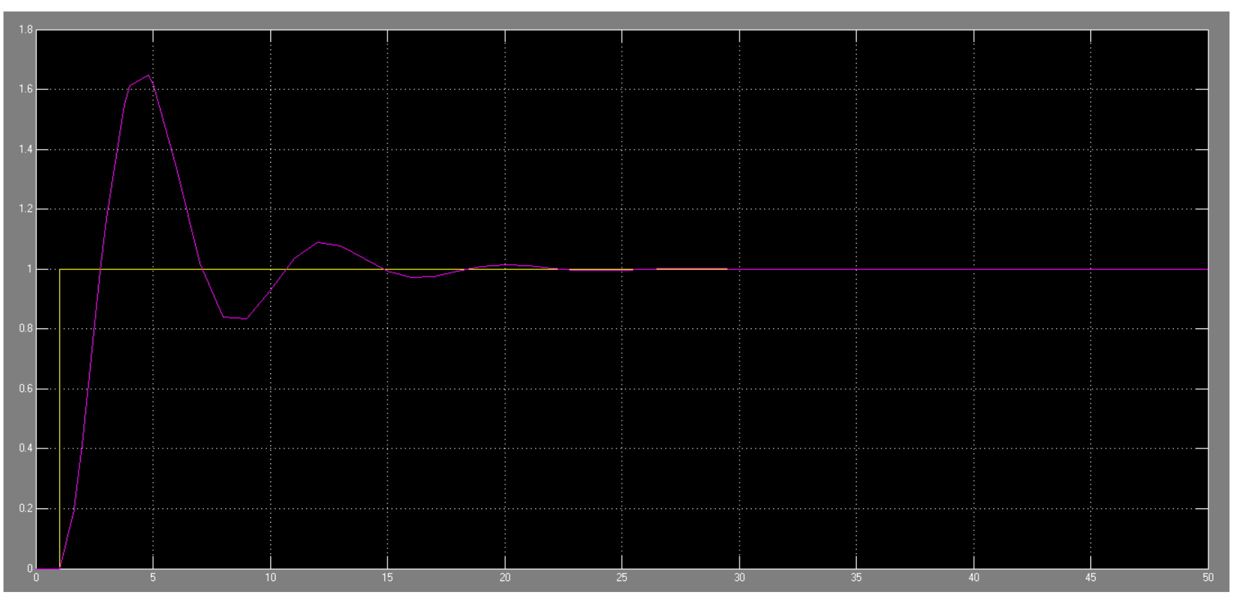
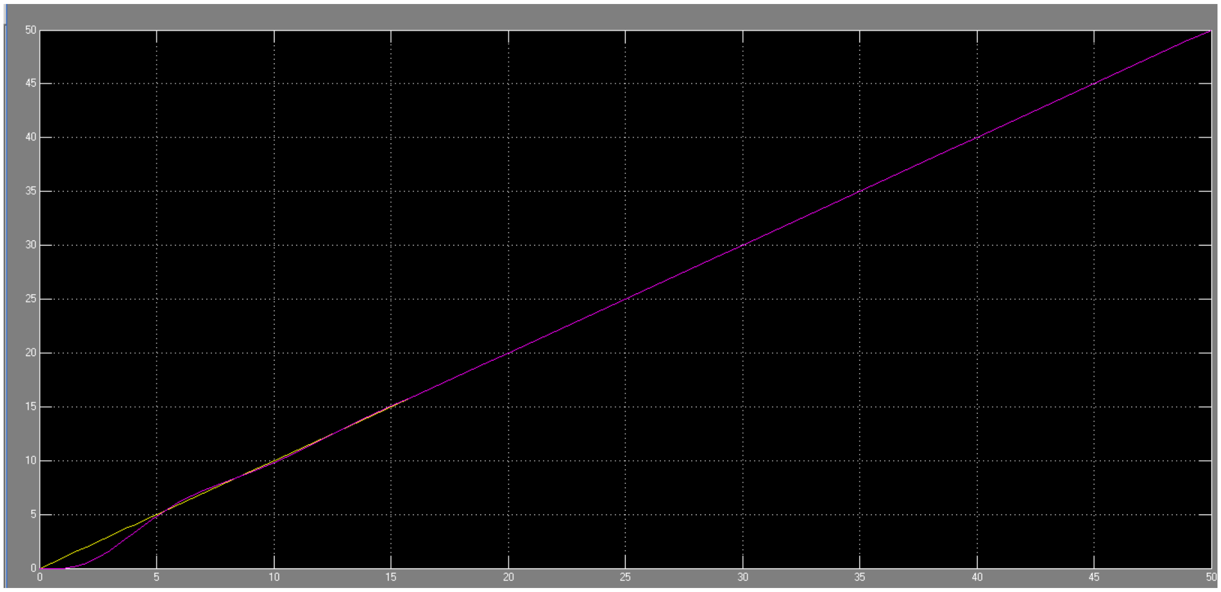
Details
Workspace
Name
Value
ans 1x1 zpk
G 1x1 tf
G1 1x1 tf
Gc 1x1 tf
Gd 1x1 tf
Command Window
G =
1
-----
s + 1
Continuous-time transfer function.
Gd =
0.8647
----
z - 0.1353
Sample time: 2 seconds
Discrete-time transfer function.
Gc =
z
-----
z - 1
Sample time: 2 seconds
Discrete-time transfer function.
Figure 1
File Edit View Insert Tools Desktop Window Help
Root Locus for sampling Time T=2 sec
Imaginary Axis
Real Axis
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1.5
-1
-0.5
0
0.5
1
1.5

PRACTICAL NO- 4

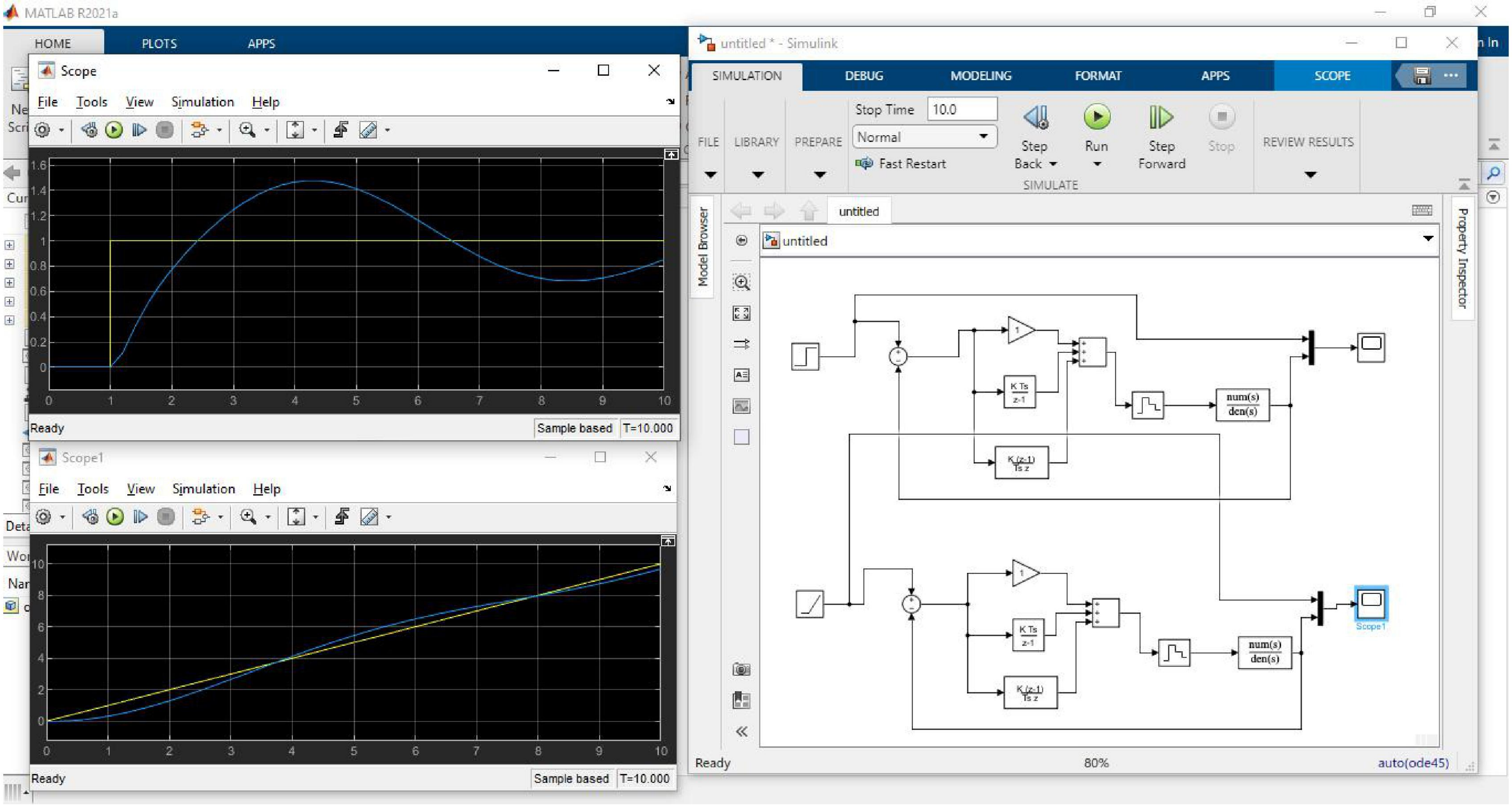
Aim: Design of Discrete PID Controller for $G_p(s) = \frac{1}{s(s+1)}$ for sampling period T=1 sec (Hint: Kp=1, Ki=0.2, Kd=0.2).







CONCLUSION: Designed discrete PID controller for sampling period of 1sec and having proportional gain, integral gain and derivative gain as 1, 0.2 and 0.2 respectively.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Step Forward
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Model Browser
Property Inspector
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den(s)
Scope1
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PRACTICAL NO- 5

Aim: Modeling of continuous and discrete time system using Matlab.

Theory: We will obtain the continuous and discrete model of DC Motor.

Derivation:
A common actuator in control systems is the DC motor. It directly provides rotary motion and, coupled with wheels or drums and cables, can provide translational motion. The electric equivalent circuit of the armature and the free-body diagram of the rotor are shown in the following figure.

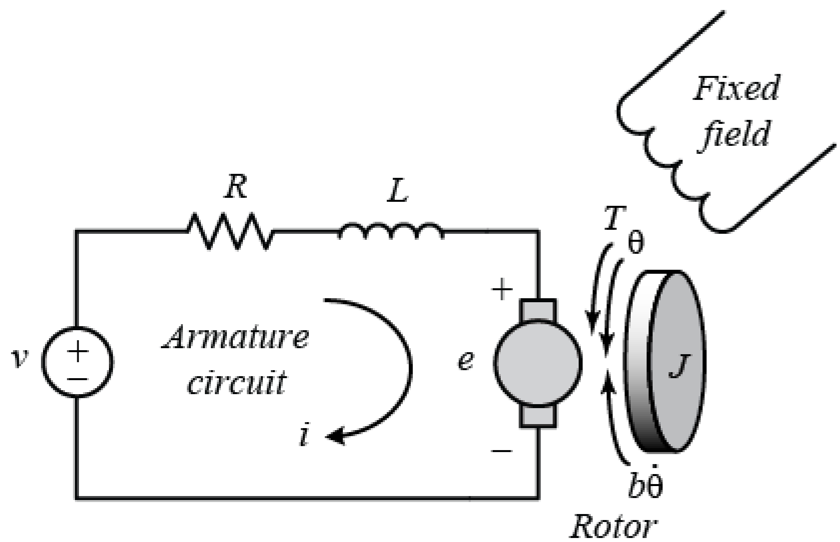


Figure 1

For this practical, we will assume the following values for the physical parameters. These values were derived by experiment from an actual motor in Carnegie Mellon's undergraduate controls lab.

(J) Moment of inertia of the rotor: 3.2284E-6 kg.m^2

(b) Motor viscous friction constant: 3.5077E-6 N.m.s

(K_b) Electromotive force constant: 0.0274 V/rad/sec

(K_t) Motor torque constant: 0.0274 N.m/Amp

(R) Electric resistance: 4 Ohm

(L) Electric inductance: 2.75E-6H

In this example, we assume that the input of the system is the voltage source (*V*) applied to the motor's armature, while the output is the position of the shaft (*theta*). The rotor and shaft are assumed to be rigid. We further assume a viscous friction model, that is, the friction torque is proportional to shaft angular velocity.

System equations

In general, the torque generated by a DC motor is proportional to the armature current and the strength of the magnetic field. In this example we will assume that the magnetic field is constant and, therefore, that the motor torque is proportional to only the armature current *i* by a constant factor *Kt* as shown in the equation below. This is referred to as an armature-controlled motor.

$$T = K_t i \text{.........(1)}$$

The back emf, *e*, is proportional to the angular velocity of the shaft by a constant factor *Kb*.

$$e = K_b \dot{\theta} \text{..........(2)}$$

In SI units, the motor torque and back emf constants are equal, that is, *Kt = Ke*; therefore, we will use *K* to represent both the motor torque constant and the back emf constant.
From the figure above, we can derive the following governing equations based on Newton's 2nd law and Kirchhoff's voltage law.

$$J\ddot{\theta} + b\dot{\theta} = Ki \text{..........(3)}$$

$$L\frac{di}{dt} + Ri = V - K\dot{\theta} \text{........(4)}$$

State Space Model (continuous)

The differential equations from above can also be expressed in state-space form by choosing the motor position, motor speed and armature current as the state variables. Again the armature voltage is treated as the input and the rotational position is chosen as the output.

$$\frac{d}{dt}\begin{bmatrix} \theta \\ \dot{\theta} \\ i \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & -\frac{b}{J} & \frac{K}{J} \\ 0 & -\frac{K}{L} & -\frac{R}{L} \end{bmatrix} \begin{bmatrix} \theta \\ \dot{\theta} \\ i \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ \frac{1}{L} \end{bmatrix} V$$

$$y = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} \theta \\ \dot{\theta} \\ i \end{bmatrix}$$

MATLAB code:

```
clc;
clear all;
J=3.2284E-6;
b=3.5077E-6;
K=0.0274;
R=4;
L=2.75E-6;
T=1;
A=[0 1 0;0 -b/J K/J;0 -K/L -R/L];
B=[0 0 1/L]';
C=[1 0 0];
D=[0];
dc_motor_ss=ss(A,B,C,D) %State Space Model(continuous)
dc_motor_discrete=c2d(dc_motor_ss, T, 'ZOH')
```

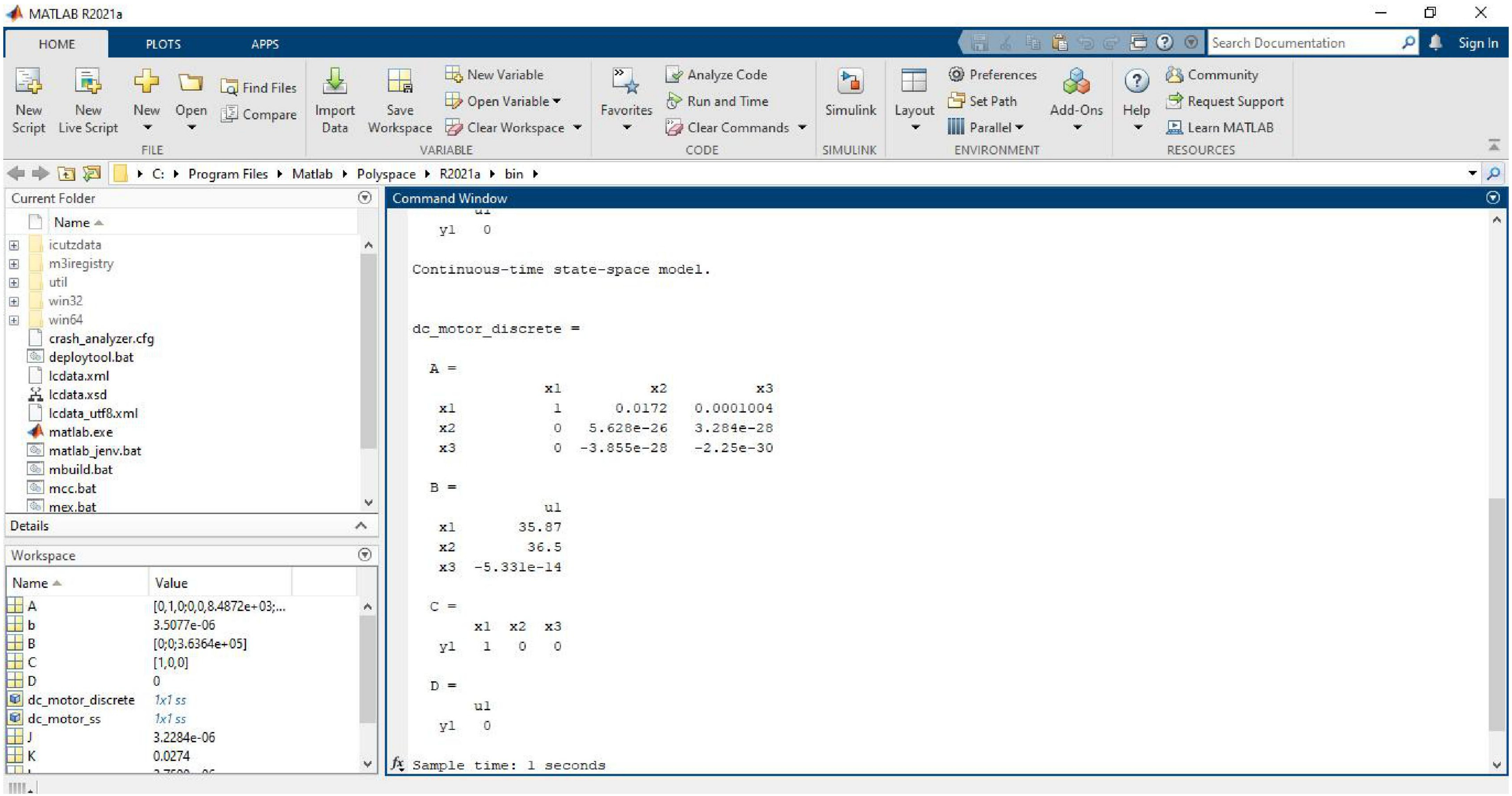
```
OUTPUT:
a =
                 x1            x2            x3
   x1             0             1             0
   x2             0        -1.087          8487
   x3             0         -9964    -1.455e+006

b =
                u1
   x1            0
   x2            0
   x3   3.636e+005

c =
        x1   x2   x3
   y1    1    0    0

d =
        u1
   y1    0

Continuous-time model.

a =
                 x1            x2            x3
   x1             1       0.01689    9.852e-005
   x2             0    1.899e-026    1.108e-028
   x3             0   -1.301e-028    -7.59e-031

b =
              u1
   x1      35.22
```

```
   x2     35.83
   x3  0.004586

c =
       x1  x2  x3
   y1   1   0   0

d =
       u1
   y1   0
```

Sampling time: 1
Discrete-time model.

Q.2 Obtain Continuous and Discrete Model of R-L-C series circuit.

Conclusion: in this practical we studied about modelling of continuous and discrete system using MATLAB and also obtained continuous and discrete model of DC motor and R L C circuit.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lcdata.xsd
lcdata_utf8.xml
matlab.exe
matlab_jenv.bat
mbuild.bat
mcc.bat
mex.bat
Details
Workspace
Name
Value
A [0,1,0;0,0,8.4872e+03;...
b 3.5077e-06
B [0;0;3.6364e+05]
C [1,0,0]
D 0
dc_motor_discrete 1x1 ss
dc_motor_ss 1x1 ss
J 3.2284e-06
K 0.0274
Command Window
y1 0
Continuous-time state-space model.
dc_motor_discrete =
A =
x1 x2 x3
x1 1 0.0172 0.0001004
x2 0 5.628e-26 3.284e-28
x3 0 -3.855e-28 -2.25e-30
B =
u1
x1 35.87
x2 36.5
x3 -5.331e-14
C =
x1 x2 x3
y1 1 0 0
D =
u1
y1 0
Sample time: 1 seconds