Learning Report – Control Systems

LTTS GLOBAL ENGINEERING ACADEMY

L&T Technology Services

Version Number:3.0
Team Members :
Team No:
Module: Control System

Document History

Ver. Rel. No.	Release Date	Prepared. By	Reviewed By	Approved By	Remarks/Revision Details
1	15-04-2021	ShivaKumar Naga Vankadhara		DR. Pagala Prithvi Sekhar	Added the scripts
2	15-04-2021	ShivaKumar Naga Vankadhara		DR. Pagala Prithvi Sekhar	Added the Comparision for Modellica and Simulink
3	15-04-2021	ShivaKumar Naga Vankadhara		DR. Pagala Prithvi Sekhar	Added the Comaprision for Octave Script and Simulink script

Content

Title:Control System-First Order System: Analysis by poles and parameters

```
%Author:ShivaKumar Naga Vankadhara
%PS No:99003727
%Date:10/04/2021
%Version:1.7
```

This Document has equation for motion differential system

```
%Equation:mdv/dt+bv=u
```

Math analysis

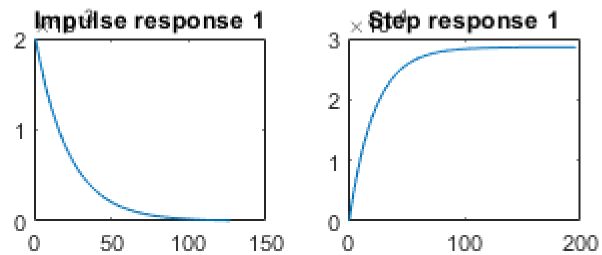
```
%dependent variables:v
%independent variables:t,u
%constant:m,b
%Root:-b/m
```

IVT

```
%for impulse is 1/m=0.002
%for step is 0
%%FVT
%for impulse is 0;
%for step is 1/b=0.00028

m1=500;
b1=3500;
Tau=m1/b1;
TF=tf([0,1/b1],[Tau,1])
T_R=4*Tau
subplot(3,3,1),plot(impulse(TF))
title("Impulse response 1")
subplot(3,3,2),plot(step(TF))
title("Step response 1")
S = stepinfo(TF)
```

```
TF =

   0.0002857
  ------------
  0.1429 s + 1

Continuous-time transfer function.


T_R =
```

```
    0.5714

S =

  struct with fields:

        RiseTime: 0.3139
    SettlingTime: 0.5589
     SettlingMin: 2.5843e-04
     SettlingMax: 2.8571e-04
       Overshoot: 0
      Undershoot: 0
            Peak: 2.8571e-04
        PeakTime: 1.5065
```

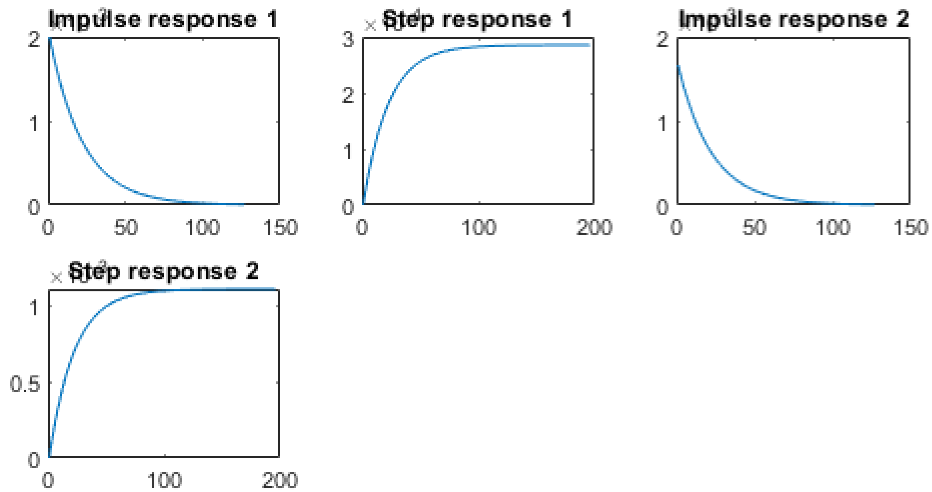


IVT

```
%for impulse is 1/m=0.00166
%for step is 0
%%FVT
%for impulse is 0;
%for step is 1/b=0.001111
```

```
m2=600;
b2=900;
Tau=m2/b2;
T_R=4*Tau
TF=tf([0,1/b2],[Tau,1])
subplot(3,3,3),plot(impulse(TF))
title("Impulse response 2")
subplot(3,3,4),plot(step(TF))
title("Step response 2")
S = stepinfo(TF)
```

```
T_R =

    2.6667


TF =

    0.001111
  ------------
  0.6667 s + 1

Continuous-time transfer function.


S =

  struct with fields:

        RiseTime: 1.4647
    SettlingTime: 2.6080
     SettlingMin: 0.0010
     SettlingMax: 0.0011
       Overshoot: 0
      Undershoot: 0
            Peak: 0.0011
        PeakTime: 7.0306
```

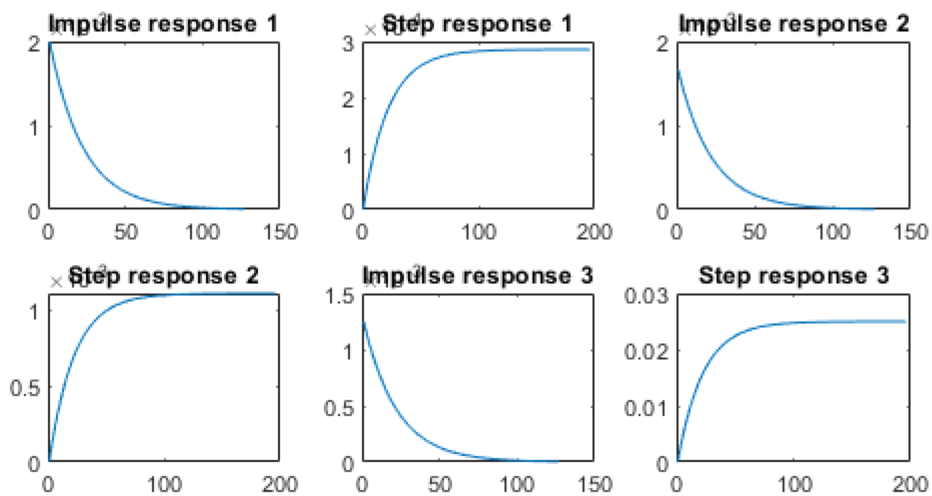


IVT

```
%for impulse is 1/m=0.00125
%for step is 0
%%FVT
%for impulse is 0;
%for step is 1/b=0.025

m3=800;
b3=40;
Tau=m3/b3;
T_R=4*Tau
TF=tf([0,1/b3],[Tau,1])
subplot(3,3,5),plot(impulse(TF))
title("Impulse response 3")
subplot(3,3,6),plot(step(TF))
title("Step response 3")
S = stepinfo(TF)
```

```
T_R =

    80
```

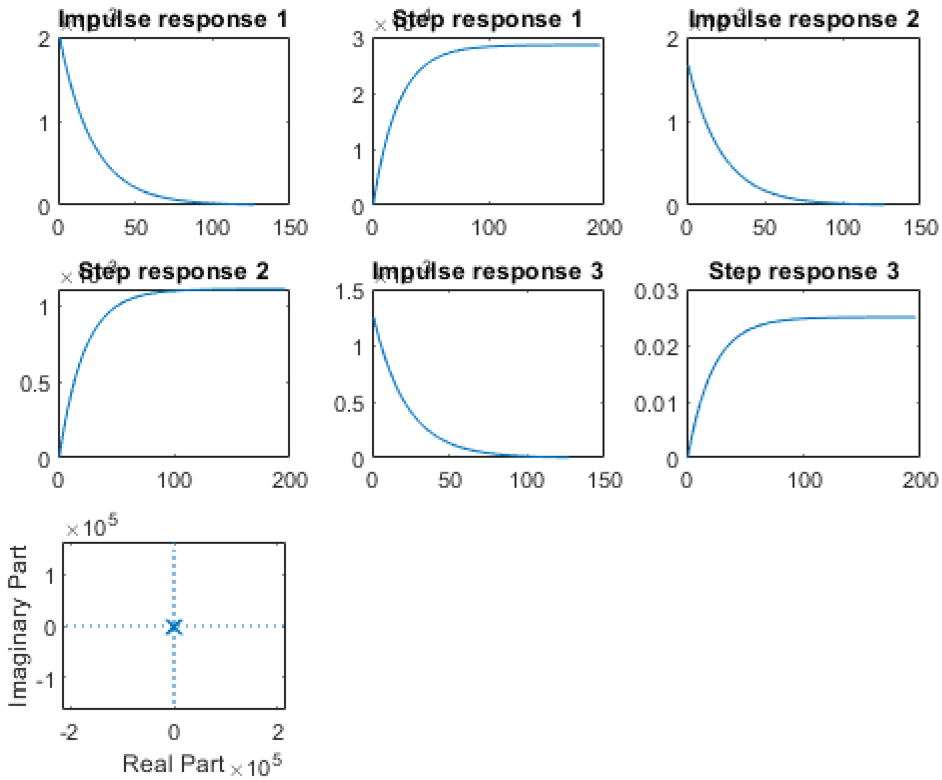
```
TF =

    0.025
  --------
  20 s + 1

Continuous-time transfer function.


S =

  struct with fields:

        RiseTime: 43.9401
    SettlingTime: 78.2415
     SettlingMin: 0.0226
     SettlingMax: 0.0250
       Overshoot: 0
      Undershoot: 0
            Peak: 0.0250
        PeakTime: 210.9168
```



Poles plotting

```
hold on

subplot(3,3,7)
[z1,p1,k1]= tf2zp([0,1/b1],[m1/b1,1])
zplane(z1,p1)

hold on

subplot(3,3,7)
[z2,p2,k2]= tf2zp([0,1/b2],[m2/b2,1])
zplane(z2,p2)

hold on
subplot(3,3,7)
[z3,p3,k3]= tf2zp([0,1/b3],[m3/b3,1])
zplane(z3,p3)
```

```
z1 =

  0×1 empty double column vector


p1 =
    -7
k1 =
    0.0020
z2 =
  0×1 empty double column vector
p2 =
   -1.5000
k2 =
    0.0017
z3 =
  0×1 empty double column vector
p3 =
   -0.0500
k3 =
    0.0013
```



Response analysis (SAS)

Rise time

```
%T1=0.3139
%T2=1.4647
%T3=43.9401
%System 1 has the least rise time so the speed of system is greatest
%System 3 has the greatest rise time so the speed of system is least

% Settling time
%S1=0.5589
%S2=2.6080
%S3=78.2415
%System 1 is taking least time to get settled so the system is accurate
%System 3 is taking most time to get settled so the system is least accurate

% Pole position
%P1=-7.0
%P2=-1.5000
%P3=-0.0500
% system 1 pole is farthest away from pole:best stablity among 3
% system 1 pole is farthest away from pole:worst stablity among 3
```

Published with MATLAB® R2021a

Title:Control System-First Order System: System analysis by changing gain

```
%Author:Shivakumar Naga Vankadhara
%PS No:99003727
%Date:10/04/2021
%Version:1.4
```

This Document has equation for motion differential system

```
%Equation:mdv/dt+bv=u
```

Math analysis

```
%dependent variables:v
%independent variables:t,u
%constant:m,b
%Root:-b/m
```

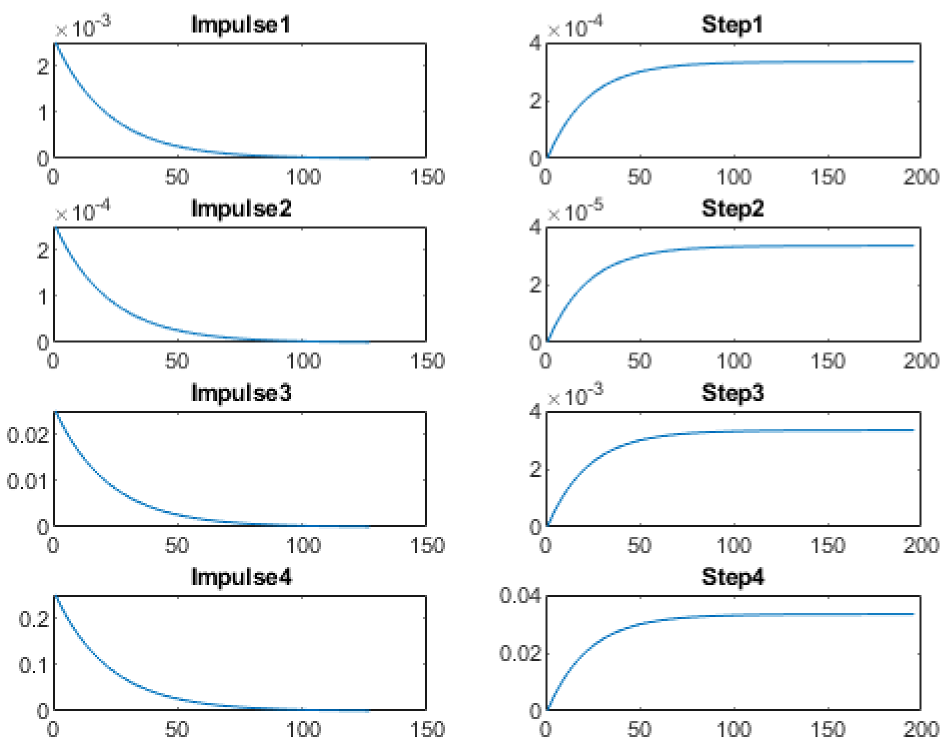
Changing the gain of system

```
%gain is 1
m1=400;
b1=3000;
Tau=m1/b1;
TF1=tf([0,1/b1],[Tau,1]);
T_R=4*Tau;
subplot(4,2,1),plot(impulse(TF1))
title("Impulse1")
subplot(4,2,2),plot(step(TF1))
title("Step1")
S = stepinfo(TF1)

%gain is 0.1
m1=400;
b1=3000;
Tau=m1/b1;
CF=0.1;
TF2=CF*tf([0,1/b1],[Tau,1]);
T_R=4*Tau;
subplot(4,2,3),plot(impulse(TF2))
title("Impulse2")
subplot(4,2,4),plot(step(TF2))
title("Step2")
S = stepinfo(TF2)

%gain is 10
m1=400;
b1=3000;
Tau=m1/b1;
CF=10;
TF3=CF*tf([0,1/b1],[Tau,1]);
T_R=4*Tau;
subplot(4,2,5),plot(impulse(TF3))
title("Impulse3")
subplot(4,2,6),plot(step(TF3))
```

```
title("Step3")
S = stepinfo(TF3)

%gain is 100
m1=400;
b1=3000;
Tau=m1/b1;
CF=100;
TF4=CF*tf([0,1/b1],[Tau,1]);
T_R=4*Tau;
subplot(4,2,7),plot(impulse(TF4))
title("Impulse4")
subplot(4,2,8),plot(step(TF4))
title("Step4")
S = stepinfo(TF4)
```

```
S =

  struct with fields:

        RiseTime: 0.2929
    SettlingTime: 0.5216
     SettlingMin: 3.0150e-04
     SettlingMax: 3.3332e-04
       Overshoot: 0
      Undershoot: 0
            Peak: 3.3332e-04
        PeakTime: 1.4061


S =

  struct with fields:

        RiseTime: 0.2929
    SettlingTime: 0.5216
     SettlingMin: 3.0150e-05
     SettlingMax: 3.3332e-05
       Overshoot: 0
      Undershoot: 0
            Peak: 3.3332e-05
        PeakTime: 1.4061


S =

  struct with fields:

        RiseTime: 0.2929
```

```
    SettlingTime: 0.5216
     SettlingMin: 0.0030
     SettlingMax: 0.0033
       Overshoot: 0
      Undershoot: 0
            Peak: 0.0033
        PeakTime: 1.4061


S =

  struct with fields:

        RiseTime: 0.2929
    SettlingTime: 0.5216
     SettlingMin: 0.0302
     SettlingMax: 0.0333
       Overshoot: 0
      Undershoot: 0
            Peak: 0.0333
        PeakTime: 1.4061
```



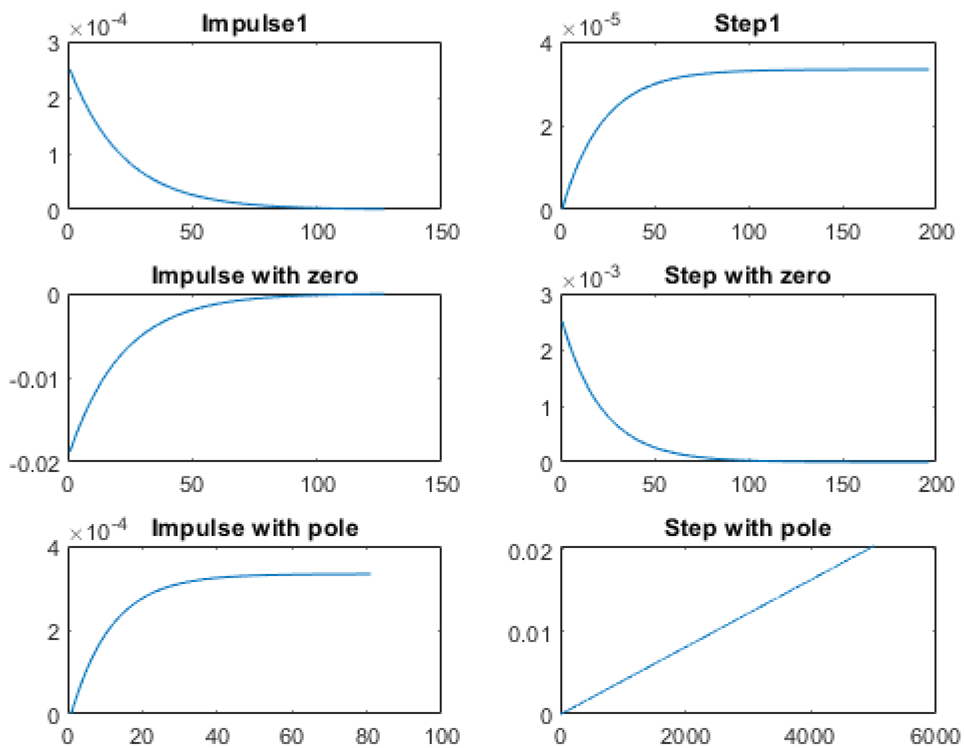
Analysis:

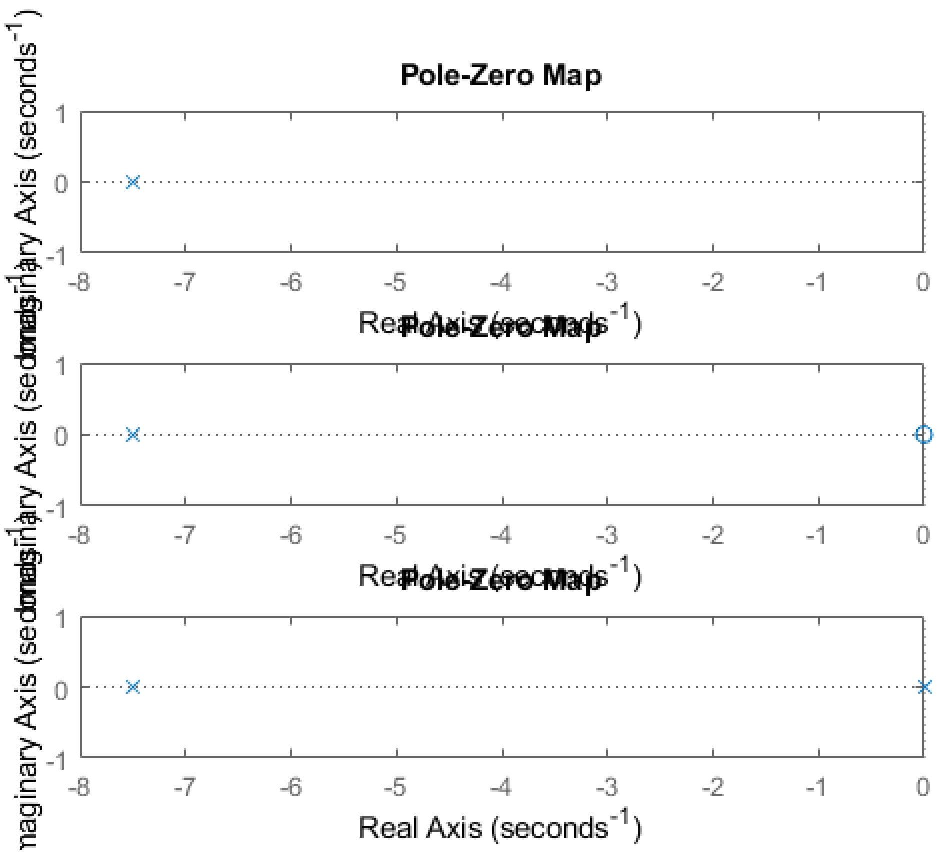
```
%On changing the gain of the transfer function:
%1. By changing gain we can see that only amplitude is getting changed.
%2. Even after changing the gain settling time,rise time and peak time is
%not getting changed
%3. peak, settling min and settling max is varying by factor of gain
%4.
```

Change the control function

```
figure
% system with proportion
m1=400;
b1=3000;
Tau=m1/b1;
CF=0.1;
TF5=CF*tf([0,1/b1],[Tau,1]);
T_R=4*Tau;
subplot(3,2,1),plot(impulse(TF5))
title("Impulse1")
subplot(3,2,2),plot(step(TF5))
title("Step1")
S = stepinfo(TF5);

% system with differentiator
m1=400;
b1=3000;
Tau=m1/b1;
CF=tf([1,0],[1]);
TF6=CF*tf([0,1/b1],[Tau,1]);
T_R=4*Tau;
subplot(3,2,3),plot(impulse(TF6))
title("Impulse with zero")
subplot(3,2,4),plot(step(TF6))
title("Step with zero")
S = stepinfo(TF6);

% system with integrator
m1=400;
b1=3000;
Tau=m1/b1;
CF=tf([0,1],[1,0]);
TF7=CF*tf([0,1/b1],[Tau,1]);
T_R=4*Tau;
subplot(3,2,5),plot(impulse(TF7))
title("Impulse with pole")
subplot(3,2,6),plot(step(TF7))
title("Step with pole")
```

```
S = stepinfo(TF7);

%poles printing
figure
subplot(3,1,1)
pzmap(TF5)
subplot(3,1,2)
pzmap(TF6)
subplot(3,1,3)
pzmap(TF7)
```





Analysis:

```
%1. Proportional: 1 pole
%2. By adding a Differentiator we are getting a zero added.
%3. By adding an integrator a pole is getting added.
%4. There is no affect on the poles in the first order only poles and
%zeroes are geeting added.
```

Published with MATLAB® R2021a

Title:Control System-First Order System: adding P,I,D controllers

```
%Author:ShivaKumar Naga Vankadhara
%PS No:99003727
%Date:10/04/2021
%Version:1.7
```

This Document has equation for motion differential system

```
%Equation:mdv/dt+bv=u
```

Math analysis

```
%dependent variables:v
%independent variables:t,u
%constant:m,b
%Root:-b/m
```

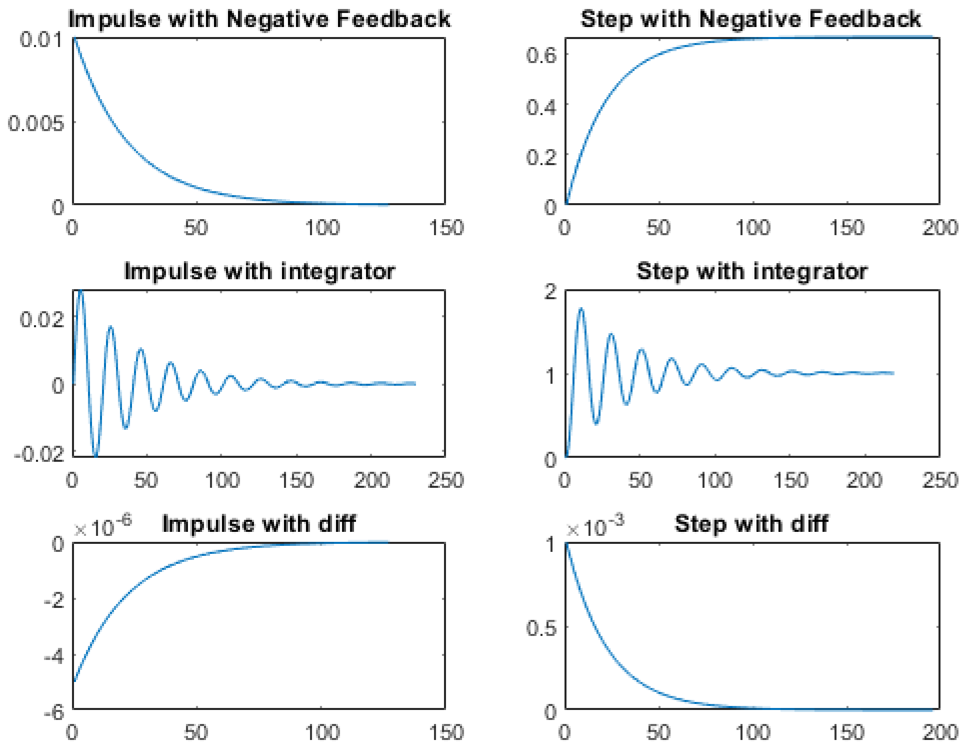
Negative feedback

```
m1=1000;
b1=5;
Tau=m1/b1;
CF=10;
TF=CF*tf([0,1/b1],[Tau,1]);
%S = stepinfo(TF)
NCTF1=feedback(TF,1);
subplot(3,2,1),plot(impulse(NCTF1))
title("Impulse with Negative Feedback")
subplot(3,2,2),plot(step(NCTF1))
title("Step with Negative Feedback")
S1 = stepinfo(NCTF1)
p1=pole(NCTF1)

m1=1000;
b1=5;
Tau=m1/b1;
CF=tf([0,1],[1,0]);
TF=CF*tf([0,1/b1],[Tau,1]);
NCTF2=feedback(TF,1);
subplot(3,2,3),plot(impulse(NCTF2))
title("Impulse with integrator")
```

```
subplot(3,2,4),plot(step(NCTF2))
title("Step with integrator")
S2 = stepinfo(NCTF2)
p2=pole(NCTF2)
z2=zero(NCTF2)

m1=1000;
b1=5;
Tau=m1/b1;
CF=tf([1,0],[1]);
TF=CF*tf([0,1/b1],[Tau,1]);
T_R=4*Tau;
NCTF3=feedback(TF,1);
T_R=4*Tau;
subplot(3,2,5),plot(impulse(NCTF3))
title("Impulse with diff")
subplot(3,2,6),plot(step(NCTF3))
title("Step with diff")
p3=pole(NCTF3)
S3 = stepinfo(NCTF3)

%%Analysis:
%1. Rise time of the system increases on adding the integartor.
%2. Rise time of the system decreases on adding the diffrentiator.
%3. settling time of the system increases on adding integrator system is
%taking some time to settle and operate.
%4. accuracy of system decreases on adding differentiator
%5. overshoot increase is greater on adding differentiator than integrator
%6. Peak increase is greater on adding integrator than differentiator
%7. all the poles of negative feedback present in left side of plane
```

```
S1 =

  struct with fields:

        RiseTime: 146.4671
    SettlingTime: 260.8050
     SettlingMin: 0.6030
     SettlingMax: 0.6666
       Overshoot: 0
      Undershoot: 0
            Peak: 0.6666
        PeakTime: 703.0560


p1 =

   -0.0150
```

```
S2 =

  struct with fields:

        RiseTime: 35.0513
    SettlingTime: 1.5129e+03
     SettlingMin: 0.3925
     SettlingMax: 1.7794
       Overshoot: 77.9429
      Undershoot: 0
            Peak: 1.7794
        PeakTime: 99.3459


p2 =

  -0.0025 + 0.0315i
  -0.0025 - 0.0315i


z2 =

  0×1 empty double column vector


p3 =

   -0.0050


S3 =

  struct with fields:

        RiseTime: 439.8407
    SettlingTime: 783.1973
     SettlingMin: 2.6276e-08
     SettlingMax: 9.5404e-05
       Overshoot: 4.6071e+17
      Undershoot: 0
            Peak: 9.9900e-04
        PeakTime: 0
```



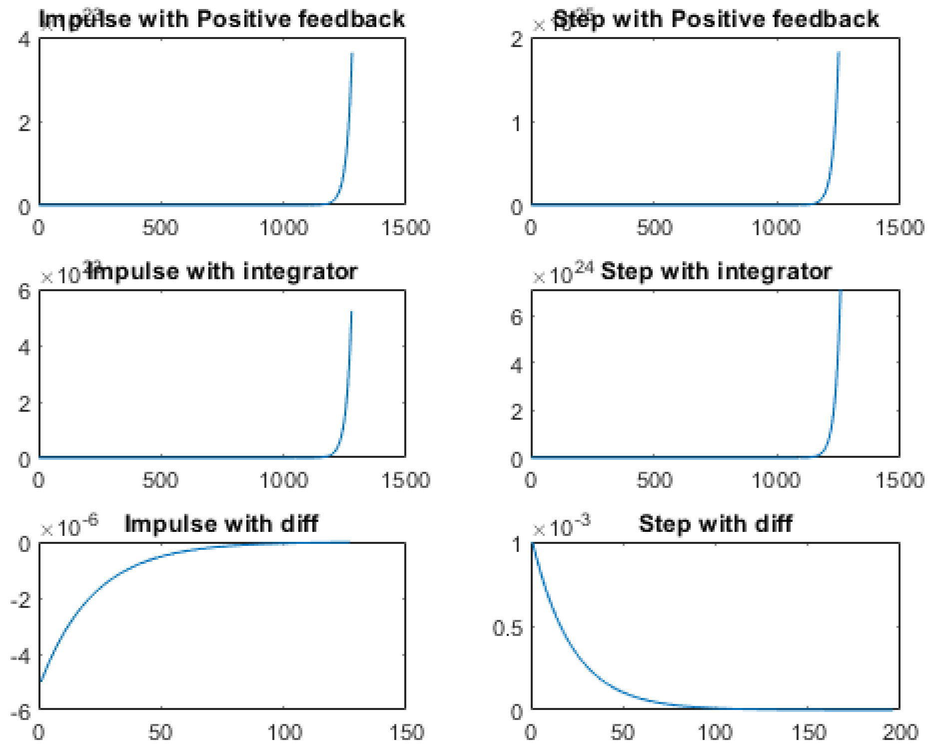
Positive feedback

```
figure
m1=1000;
b1=5;
Tau=m1/b1;
CF=10;
TF=CF*tf([0,1/b1],[Tau,1]);
%S = stepinfo(TF)
PCTF1=feedback(TF,-1);
subplot(3,2,1),plot(impulse(PCTF1))
title("Impulse with Positive feedback")
subplot(3,2,2),plot(step(PCTF1))
title("Step with Positive feedback")
S = stepinfo(PCTF1)
p4=pole(PCTF1)

m1=1000;
b1=5;
Tau=m1/b1;
CF=tf([0,1],[1,0]);
TF=CF*tf([0,1/b1],[Tau,1]);
PCTF2=feedback(TF,-1);
```

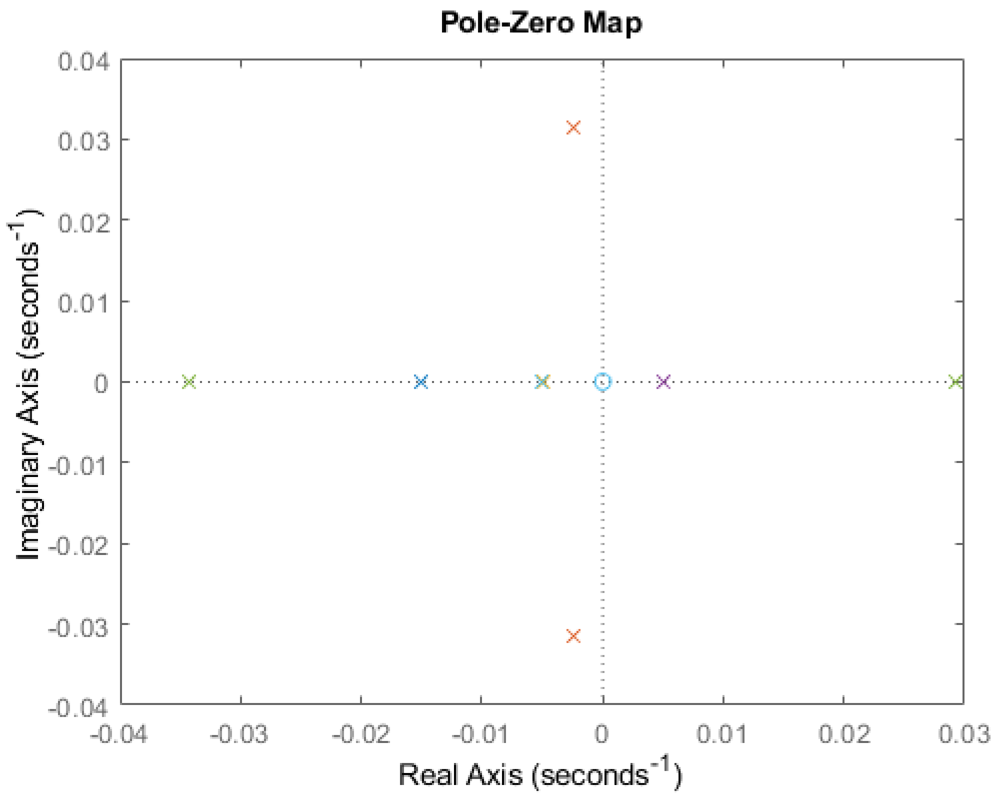
```
subplot(3,2,3),plot(impulse(PCTF2))
title("Impulse with integrator")
subplot(3,2,4),plot(step(PCTF2))
title("Step with integrator")
p5=pole(PCTF2)
S = stepinfo(PCTF2)

m1=1000;
b1=5;
Tau=m1/b1;
CF=tf([1,0],[1]);
TF=CF*tf([0,1/b1],[Tau,1]);
T_R=4*Tau;
PCTF3=feedback(TF,-1);
T_R=4*Tau;
subplot(3,2,5),plot(impulse(PCTF3))
title("Impulse with diff")
subplot(3,2,6),plot(step(PCTF3))
title("Step with diff")
p6=pole(PCTF3)
z2=zero(PCTF3)
S = stepinfo(PCTF3)

%%Analysis:
%1. on adding differentiator to positive feedback system, system is
%   becoming stable and poles got shifted to left side
%2. The system is unstable in case of positive feedback with gain
%   and integrator
%3. As the system is unstable in case of gain and integrator we are not
%   getting parameters, also the peak is infinite
%4. Parameters can be obtained in differentiator as differentiator making
%   the system stable
%5. positive feedback unstable system poles lies in right side of plane
```

```
S =

  struct with fields:

        RiseTime: NaN
    SettlingTime: NaN
     SettlingMin: NaN
     SettlingMax: NaN
       Overshoot: NaN
      Undershoot: NaN
            Peak: Inf
        PeakTime: Inf


p4 =
```

```
    0.0050


p5 =

   -0.0342
    0.0292


S = 

  struct with fields:

        RiseTime: NaN
    SettlingTime: NaN
     SettlingMin: NaN
     SettlingMax: NaN
       Overshoot: NaN
      Undershoot: NaN
            Peak: Inf
        PeakTime: Inf


p6 =

   -0.0050


z2 =

     0


S = 

  struct with fields:

        RiseTime: 438.9619
    SettlingTime: 781.6325
     SettlingMin: 2.6329e-08
     SettlingMax: 9.5595e-05
       Overshoot: Inf
      Undershoot: 0
            Peak: 0.0010
        PeakTime: 0
```




```
figure
hold on
pzmap(NCTF1)
pzmap(NCTF2)
pzmap(NCTF3)
pzmap(PCTF1)
pzmap(PCTF2)
pzmap(PCTF3)
```



Published with MATLAB® R2021a

Title:Control System-Second Order System:open loop with different values

```
%Author:ShivaKumar Naga VAnkadhara
%PS No:99003727
%Date:11/04/2021
%Version:1.7
```

This Document has equation for DC Motor

```
%Equation:Ldi/dt+Ri+Kw=V
%         Jdw/dt+bw=Ki
%T(s)=(K/LJ)/(s^2+((b/J)+(R/L)s+(R*b)/(L*J)+(K*K)/(L*J)
```

Math analysis

```
%dependent variables:w
%independent variables:t
%constant:K,R,L,J,b
%Roots:0.5*(-(b/J)-(R/L))+sqrt((((b*b)/(J*J))+((R*R)/(L*L))-((2*R*b)/(L*J))-((4*K*K)/(L*J)))
%      0.5*(-(b/J)-(R/L))-sqrt((((b*b)/(J*J))+((R*R)/(L*L))-((2*R*b)/(L*J))-((4*K*K)/(L*J)))
```

IVT

```
%for impulse is 0
%for step is 0
%%FVT
%for impulse is K/((b*L)+(R*J))=0.1667
%for step is K/((R*b)+(K*K))=0.0999001

J = 0.01;
b = 0.1;
K = 1;
R = 1;
L = 0.5;
%TF=tf([K/(J*L)],[1,((b/J)+(R/L)),(((K*K)+(R*b))/(L*J))]);
sys = tf([K/(J*L)],[1,((b/J)+(R/L)),(((K*K)+(R*b))/(L*J))])
subplot(3,3,1)
step(sys)
subplot(3,3,2)
```

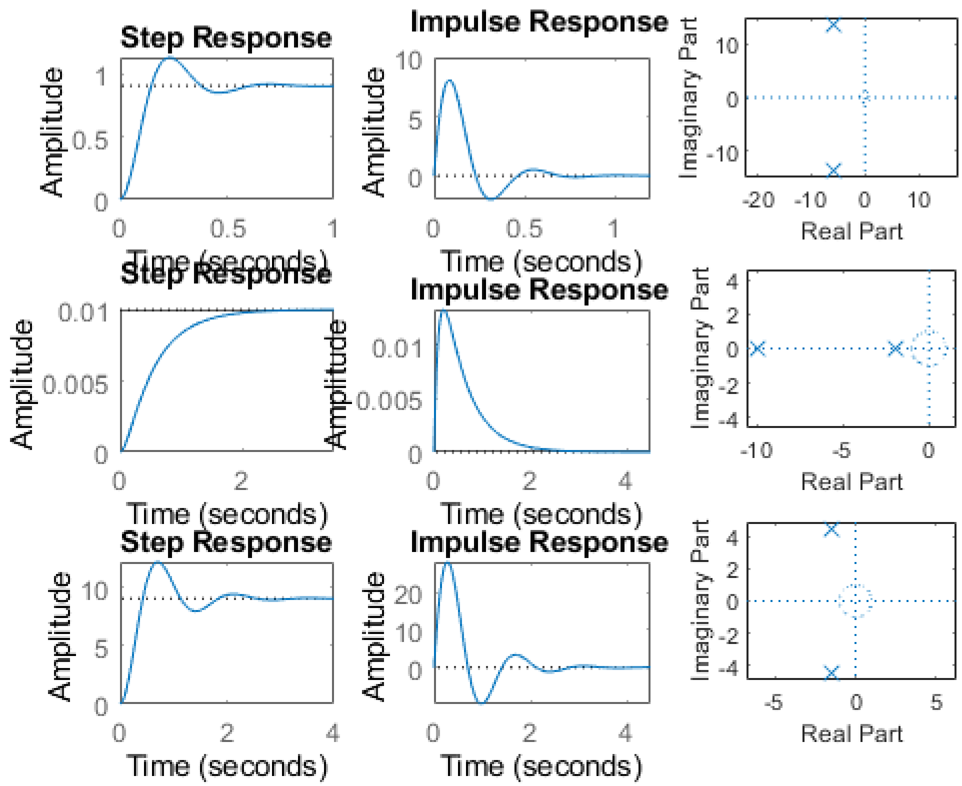
```
impulse(sys)
subplot(3,3,3)
%S = stepinfo(sys)
[z,p,k]= tf2zp([K/(J*L)],[1,((b/J)+(R/L)),(((K*K)+(R*b))/(L*J))])
zplane(z,p)
S = stepinfo(sys)

J = 0.1;
b = 1;
K = 0.1;
R = 10;
L = 5;
%TF=tf([K/(J*L)],[1,((b/J)+(R/L)),(((K*K)+(R*b))/(L*J))]);
sys = tf([K/(J*L)],[1,((b/J)+(R/L)),(((K*K)+(R*b))/(L*J))])
subplot(3,3,4)
step(sys)
subplot(3,3,5)
impulse(sys)
subplot(3,3,6)
%S = stepinfo(sys)
[z2,p2,k2]= tf2zp([K/(J*L)],[1,((b/J)+(R/L)),(((K*K)+(R*b))/(L*J))])
zplane(z2,p2)
S = stepinfo(sys)

J = 0.01;
b = 0.01;
K = 0.1;
R = 0.1;
L = 0.05;
%TF=tf([K/(J*L)],[1,((b/J)+(R/L)),(((K*K)+(R*b))/(L*J))]);
sys = tf([K/(J*L)],[1,((b/J)+(R/L)),(((K*K)+(R*b))/(L*J))])
subplot(3,3,7)
step(sys)
subplot(3,3,8)
impulse(sys)
subplot(3,3,9)
%S = stepinfo(sys)
[z1,p1,k1]= tf2zp([K/(J*L)],[1,((b/J)+(R/L)),(((K*K)+(R*b))/(L*J))])
zplane(z1,p1)
S = stepinfo(sys)
```

```
sys =

        200
  ----------------
  s^2 + 12 s + 220

Continuous-time transfer function.
```

```
z =

  0×1 empty double column vector


p =

  -6.0000 +13.5647i
  -6.0000 -13.5647i


k =

   200


S =

  struct with fields:

        RiseTime: 0.0993
    SettlingTime: 0.5669
     SettlingMin: 0.8527
     SettlingMax: 1.1356
       Overshoot: 24.9123
      Undershoot: 0
            Peak: 1.1356
        PeakTime: 0.2303


sys =

         0.2
  ------------------
  s^2 + 12 s + 20.02

Continuous-time transfer function.


z2 =

  0×1 empty double column vector


p2 =

   -9.9975
   -2.0025
```

```
k2 =

    0.2000


S =

  struct with fields:

        RiseTime: 1.1351
    SettlingTime: 2.0652
     SettlingMin: 0.0090
     SettlingMax: 0.0100
       Overshoot: 0
      Undershoot: 0
            Peak: 0.0100
        PeakTime: 3.6758


sys =

       200
  --------------
  s^2 + 3 s + 22

Continuous-time transfer function.


z1 =

  0×1 empty double column vector


p1 =

  -1.5000 + 4.4441i
  -1.5000 - 4.4441i


k1 =

   200


S =

  struct with fields:

        RiseTime: 0.2882
```

```
 SettlingTime: 2.3810
  SettlingMin: 8.0006
  SettlingMax: 12.2393
    Overshoot: 34.6325
   Undershoot: 0
         Peak: 12.2393
     PeakTime: 0.7061
```



Analysis

1.If rise time is less the system is not much stable and its speed 2.If the rise time is high the system may behave more stable its not speed in nature. 3.If the Over shoot is less the system is kind of stable. 4.If the Over shoot is more the system may behave less stable. 5.If settling time is less accuracy is high. 6.If the settling time is high accuracy is less. 7.In the above systems system 2 is more stable because overshoot is 0. 8.Peak time is inversly proportional to overshoot. so if peak time is more system is stable. 9.when we add proportional to the open loop no parameters get changed only peak time and overshoot changes.

Published with MATLAB® R2021a

Title:Control System-Second Order System:varying zeta value open system

```
%Author:ShivaKumar Naga Vankadhara
%PS No:99003727
%Date:10/04/2021
%Version:1.0
```

This Document has equation for Second Order System

```
%w=1

jeta=1;
TF=tf([1],[1,(2*jeta),1])
sys = tf([1],[1,(2*jeta),1])
figure
subplot(2,3,1)
S = stepinfo(sys)
[z,p,k]= tf2zp([1],[1,(2*jeta),1])
zplane(z,p)

jeta=0.7;
TF=tf([1],[1,(2*jeta),1])
sys = tf([1],[1,(2*jeta),1])
%hold on
subplot(2,3,2)
S = stepinfo(sys)
[z,p,k]= tf2zp([1],[1,(2*jeta),1])
zplane(z,p)

jeta=1.5;
TF=tf([1],[1,(2*jeta),1])
sys = tf([1],[1,(2*jeta),1])
subplot(2,3,3)
S = stepinfo(sys)
[z,p,k]= tf2zp([1],[1,(2*jeta),1])
zplane(z,p)

jeta=-1;
TF=tf([1],[1,(2*jeta),1])
sys = tf([1],[1,(2*jeta),1])
```

```
subplot(2,3,4)
S = stepinfo(sys)
[z,p,k]= tf2zp([1],[1,(2*jeta),1])
zplane(z,p)


jeta=-0.5;
TF=tf([1],[1,(2*jeta),1])
sys = tf([1],[1,(2*jeta),1])
subplot(2,3,5)
S = stepinfo(sys)
[z,p,k]= tf2zp([1],[1,(2*jeta),1])
zplane(z,p)

jeta=-1.5;
TF=tf([1],[1,(2*jeta),1])
sys = tf([1],[1,(2*jeta),1])
subplot(2,3,6)
S = stepinfo(sys)
[z,p,k]= tf2zp([1],[1,(2*jeta),1])
zplane(z,p)

figure
jeta=0;
TF=tf([1],[1,(2*jeta),1])
sys = tf([1],[1,(2*jeta),1])
S = stepinfo(sys)
[z,p,k]= tf2zp([1],[1,(2*jeta),1])
zplane(z,p)
```

```
TF =

        1
  -------------
  s^2 + 2 s + 1

Continuous-time transfer function.


sys =

        1
  -------------
  s^2 + 2 s + 1

Continuous-time transfer function.


S =
```

```
  struct with fields:

        RiseTime: 3.3579
    SettlingTime: 5.8339
     SettlingMin: 0.9000
     SettlingMax: 0.9994
       Overshoot: 0
      Undershoot: 0
            Peak: 0.9994
        PeakTime: 9.7900


z =

  0×1 empty double column vector


p =

    -1
    -1


k =

     1


TF =

         1
  ---------------
  s^2 + 1.4 s + 1

Continuous-time transfer function.


sys =

         1
  ---------------
  s^2 + 1.4 s + 1

Continuous-time transfer function.


S =

  struct with fields:
```

```
        RiseTime: 2.1268
    SettlingTime: 5.9789
     SettlingMin: 0.9001
     SettlingMax: 1.0460
       Overshoot: 4.5986
      Undershoot: 0
            Peak: 1.0460
        PeakTime: 4.4078


z =

  0×1 empty double column vector


p =

  -0.7000 + 0.7141i
  -0.7000 - 0.7141i


k =

     1


TF =

        1
  -------------
  s^2 + 3 s + 1

Continuous-time transfer function.


sys =

        1
  -------------
  s^2 + 3 s + 1

Continuous-time transfer function.


S =

  struct with fields:

        RiseTime: 5.8584
```

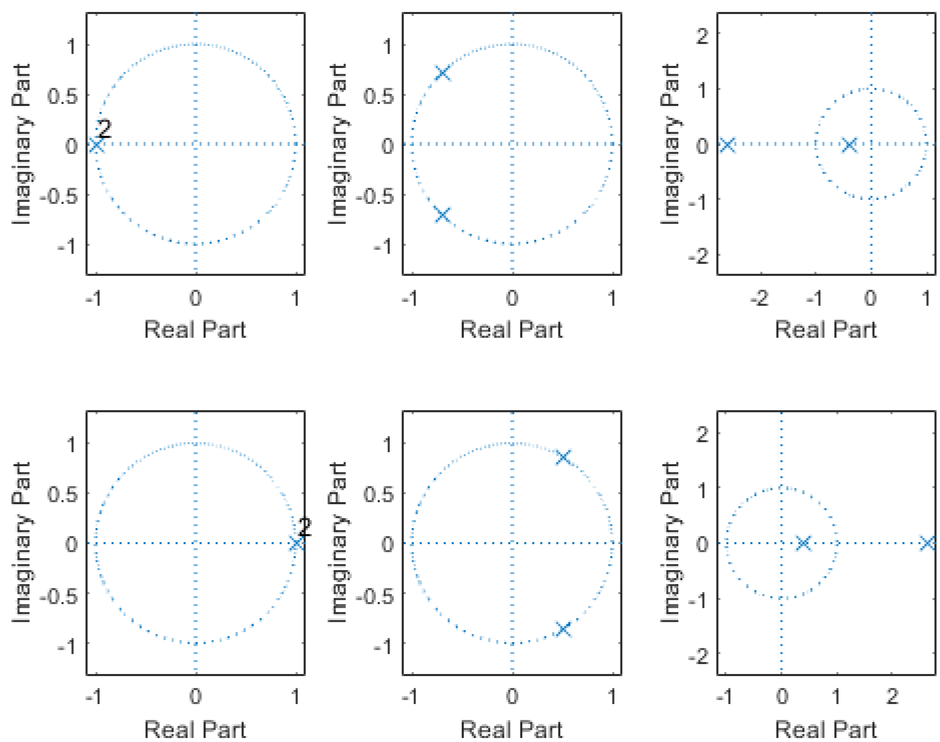
```
    SettlingTime: 10.6547
     SettlingMin: 0.9012
     SettlingMax: 0.9999
       Overshoot: 0
      Undershoot: 0
            Peak: 0.9999
        PeakTime: 25.9983


z =

  0×1 empty double column vector


p =

   -2.6180
   -0.3820


k =

     1


TF =

        1
  -------------
  s^2 - 2 s + 1

Continuous-time transfer function.


sys =

        1
  -------------
  s^2 - 2 s + 1

Continuous-time transfer function.


S =

  struct with fields:

        RiseTime: NaN
    SettlingTime: NaN
     SettlingMin: NaN
```

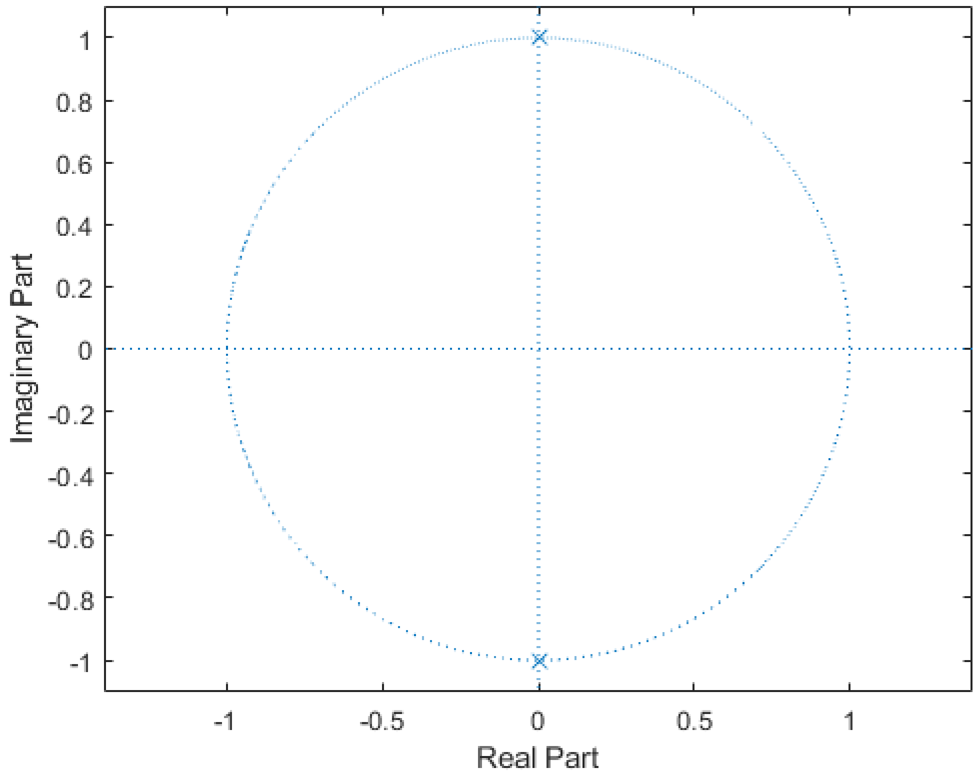
```
     SettlingMax: NaN
       Overshoot: NaN
      Undershoot: NaN
            Peak: Inf
        PeakTime: Inf


z =

  0×1 empty double column vector


p =

     1
     1


k =

     1


TF =

      1
  -----------
  s^2 - s + 1

Continuous-time transfer function.


sys =

      1
  -----------
  s^2 - s + 1

Continuous-time transfer function.


S =

  struct with fields:

        RiseTime: NaN
    SettlingTime: NaN
     SettlingMin: NaN
     SettlingMax: NaN
       Overshoot: NaN
```

```
      Undershoot: NaN
            Peak: Inf
        PeakTime: Inf


z =

  0×1 empty double column vector


p =

   0.5000 + 0.8660i
   0.5000 - 0.8660i


k =

     1


TF =

        1
  -------------
  s^2 - 3 s + 1

Continuous-time transfer function.


sys =

        1
  -------------
  s^2 - 3 s + 1

Continuous-time transfer function.


S =

  struct with fields:

        RiseTime: NaN
    SettlingTime: NaN
     SettlingMin: NaN
     SettlingMax: NaN
       Overshoot: NaN
      Undershoot: NaN
            Peak: Inf
```

```
       PeakTime: Inf


z =

  0×1 empty double column vector


p =

    2.6180
    0.3820


k =

     1


TF =

     1
  -------
  s^2 + 1

Continuous-time transfer function.


sys =

     1
  -------
  s^2 + 1

Continuous-time transfer function.


S =

  struct with fields:

        RiseTime: NaN
    SettlingTime: NaN
     SettlingMin: NaN
     SettlingMax: NaN
       Overshoot: NaN
      Undershoot: NaN
            Peak: Inf
        PeakTime: Inf
```

```
z =

  0×1 empty double column vector


p =

   0.0000 + 1.0000i
   0.0000 - 1.0000i


k =

     1
```





Analysis based on zeta

1. If zeta>0 we may get the roots on the left side of the imaginary axis. 2. If zeta<0 we may get the roots on the right side of the imaginary axis. 3. If zeta lies in the range of [0-1] we get complex conjugate roots. 4. If zeta ranges greater than 1 we get real roots and distinct. 5. If zeta is equal to 1 we get real roots. 6. If zeta is zero poles lies on the imaginary axis like complex conjugate roots system is undamped.

Published with MATLAB® R2021a

Title:Control System-Second Order System: p,i,d OPEN

```
%Author:ShivaKumar Naga Vankadhara
%PS No:99003727
%Date:10/04/2021
%Version:1.7
```

This Document has equation for DC Motor

```
%Equation:Ldi/dt+Ri+Kw=V
%         Jdw/dt+bw=Ki
%T(s)=(K/LJ)/(s^2+((b/J)+(R/L)s+(R*b)/(L*J)+(K*K)/(L*J)
```

Math analysis

```
%dependent variables:w
%independent variables:t
%constant:K,R,L,J,b
%Roots:0.5*(-(b/J)-(R/L))+sqrt((((b*b)/(J*J))+((R*R)/(L*L))-((2*R*b)/(L*J))-((4*K*K)/(L*J)))
%      0.5*(-(b/J)-(R/L))-sqrt((((b*b)/(J*J))+((R*R)/(L*L))-((2*R*b)/(L*J))-((4*K*K)/(L*J)))

J = 0.01;
b = 0.1;
K = 1;
R = 1;
L = 0.5;
TF=tf([K/(J*L)],[1,((b/J)+(R/L)),(((K*K)+(R*b))/(L*J))]);
CF=1;
sys1 = CF*TF;
subplot(4,2,1)
step(sys1)
title("Step ")
subplot(4,2,2)
impulse(sys1)
title("Impulse")
S = stepinfo(sys1);
[wn,zeta]=damp(sys1)
p1=pole(sys1)
z1=zero(sys1)


J = 0.01;
b = 0.1;
K = 1;
R = 1;
L = 0.5;
TF=tf([K/(J*L)],[1,((b/J)+(R/L)),(((K*K)+(R*b))/(L*J))]);
CF=10;
```

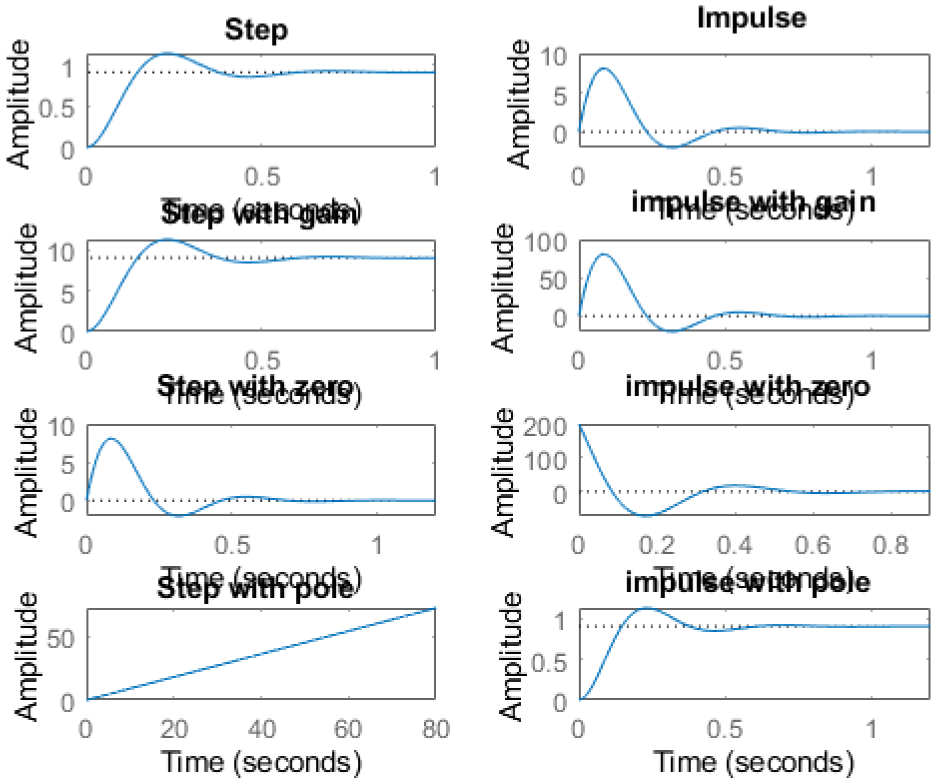
```
sys2 = CF*TF;
subplot(4,2,3)
step(sys2)
title("Step with gain")
subplot(4,2,4)
impulse(sys2)
title("impulse with gain")
S = stepinfo(sys2)
[wn,zeta]=damp(sys2)
p2=pole(sys2)
z2=zero(sys2)



J = 0.01;
b = 0.1;
K = 1;
R = 1;
L = 0.5;
TF=tf([K/(J*L)],[1,((b/J)+(R/L)),(((K*K)+(R*b))/(L*J))]);
CF=tf([1,0],[1]);
sys3 = CF*TF;
subplot(4,2,5)
step(sys3)
title("Step with zero ")
subplot(4,2,6)
impulse(sys3)
title("impulse with zero ")
S = stepinfo(sys3)
[wn,zeta]=damp(sys3)
p3=pole(sys3)
z3=zero(sys3)




J = 0.01;
b = 0.1;
K = 1;
R = 1;
L = 0.5;
TF=tf([K/(J*L)],[1,((b/J)+(R/L)),(((K*K)+(R*b))/(L*J))]);
CF=tf([1],[1,0]);
sys4 = CF*TF;
subplot(4,2,7)
step(sys4)
title("Step with pole ")
subplot(4,2,8)
impulse(sys4)
title("impulse with pole ")
```

```
S = stepinfo(sys4)
[wn,zeta]=damp(sys4)
p4=pole(sys4)
z4=zero(sys4)
```

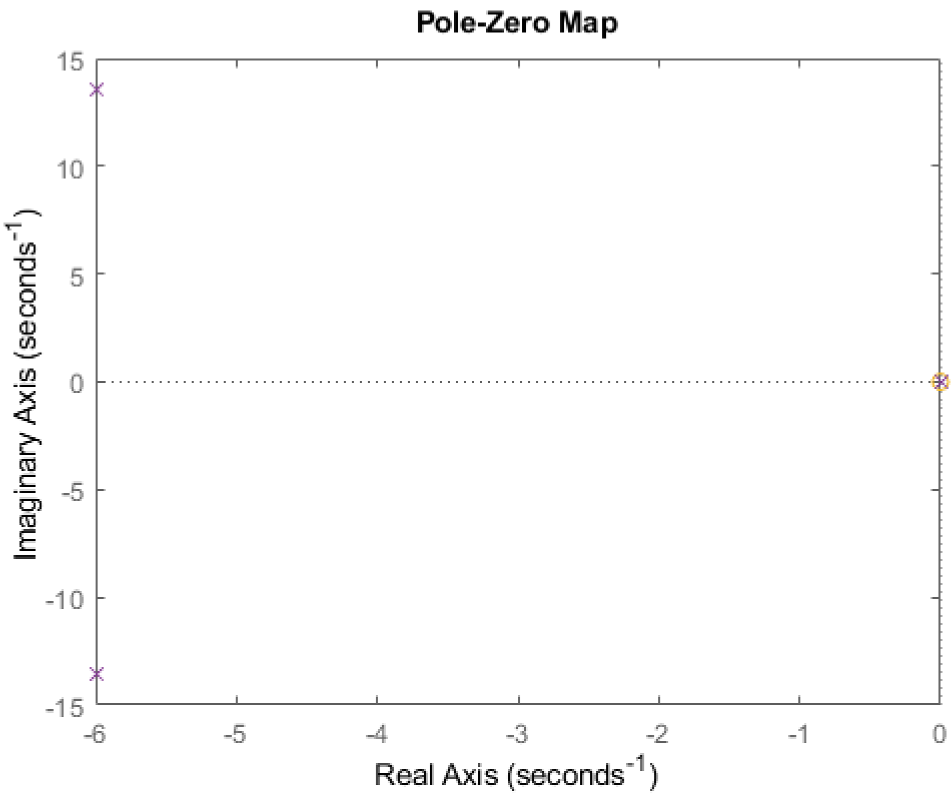
```
wn =

   14.8324
   14.8324


zeta =

    0.4045
    0.4045


p1 =

  -6.0000 +13.5647i
  -6.0000 -13.5647i


z1 =

  0×1 empty double column vector


S =

  struct with fields:

        RiseTime: 0.0993
    SettlingTime: 0.5669
     SettlingMin: 8.5269
     SettlingMax: 11.3557
       Overshoot: 24.9123
      Undershoot: 0
            Peak: 11.3557
        PeakTime: 0.2303


wn =

   14.8324
   14.8324


zeta =
```

```
    0.4045
    0.4045


p2 =

  -6.0000 +13.5647i
  -6.0000 -13.5647i


z2 =

  0×1 empty double column vector


S =

  struct with fields:

        RiseTime: 0
    SettlingTime: 0.6520
     SettlingMin: -2.0155
     SettlingMax: 8.0919
       Overshoot: Inf
      Undershoot: Inf
            Peak: 8.0919
        PeakTime: 0.0844


wn =

   14.8324
   14.8324


zeta =

    0.4045
    0.4045


p3 =

  -6.0000 +13.5647i
  -6.0000 -13.5647i


z3 =
```

```
     0


S =

  struct with fields:

        RiseTime: NaN
    SettlingTime: NaN
     SettlingMin: NaN
     SettlingMax: NaN
       Overshoot: NaN
      Undershoot: NaN
            Peak: Inf
        PeakTime: Inf


wn =

         0
   14.8324
   14.8324


zeta =

   -1.0000
    0.4045
    0.4045


p4 =

   0.0000 + 0.0000i
  -6.0000 +13.5647i
  -6.0000 -13.5647i


z4 =

  0×1 empty double column vector
```




```
figure
hold on
pzmap(sys1)
pzmap(sys2)
pzmap(sys3)
pzmap(sys4)
```



Analysis

```
%1.There is no change in the poles when we add differentiator, integrator
% and differentiator.
%2. when we add a differentiator the system becomes more stable because a
%zero is getting added to it.
%3. Adding a differentiator IVT got shifted from zero, Fvt will remain same
% for impulse response.
%4. FVT of integrator of impulse got shifted to zero.
%5. By adding integrator step response doesn't settle.
```

Published with MATLAB® R2021a

Title:Control System-Second Order System

```
%Author:ShivaKumar Naga Vankadhara
%PS No:99003727
%Date:10/04/2021
%Version:1.4
```

This Document has equation for DC Motor

```
%Equation:Ldi/dt+Ri+Kw=V
%         Jdw/dt+bw=Ki
%T(s)=(K/LJ)/(s^2+((b/J)+(R/L)s+(R*b)/(L*J)+(K*K)/(L*J)
```

Math analysis

```
%dependent variables:w
%independent variables:t
%constant:K,R,L,J,b
%Roots:0.5*(-(b/J)-(R/L))+sqrt((((b*b)/(J*J))+((R*R)/(L*L))-((2*R*b)/(L*J))-((4*K*K)/(L*J)))
%      0.5*(-(b/J)-(R/L))-sqrt((((b*b)/(J*J))+((R*R)/(L*L))-((2*R*b)/(L*J))-((4*K*K)/(L*J)))
```

Negtaive Feedback

```
J = 0.01;
b = 0.1;
K = 1;
R = 1;
L = 0.5;
TF=tf([K/(J*L)],[1,((b/J)+(R/L)),(((K*K)+(R*b))/(L*J))]);
CF=10
sys = CF*TF
NCTF1=feedback(sys,1)
subplot(3,2,1)
step(NCTF1)
title("Step with negative")
subplot(3,2,2)
impulse(NCTF1)
title("impulse with negative")
S = stepinfo(NCTF1)
[wn,zeta]=damp(NCTF1)
```

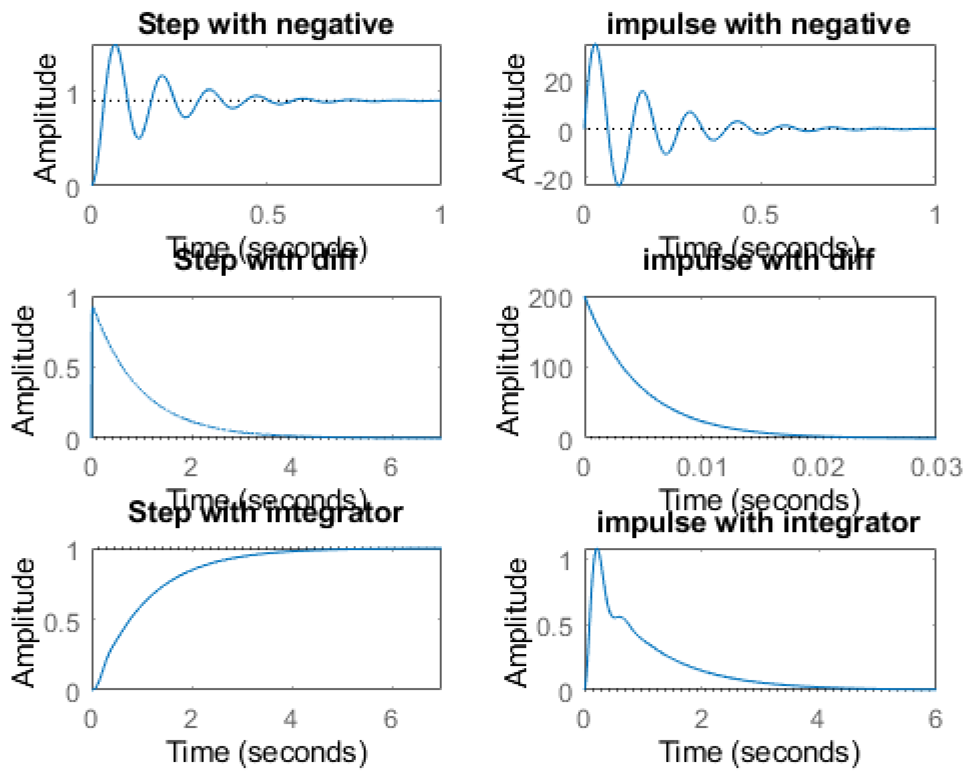
```
J = 0.01;
b = 0.1;
K = 1;
R = 1;
L = 0.5;
TF=tf([K/(J*L)],[1,((b/J)+(R/L)),(((K*K)+(R*b))/(L*J))]);
CF=tf([1,0],[1])
sys = CF*TF
NCTF2=feedback(sys,1)
subplot(3,2,3)
step(NCTF2)
title("Step with diff")
subplot(3,2,4)
impulse(NCTF2)
title("impulse with diff")
S = stepinfo(NCTF2)
[wn,zeta]=damp(NCTF2)




J = 0.01;
b = 0.1;
K = 1;
R = 1;
L = 0.5;
TF=tf([K/(J*L)],[1,((b/J)+(R/L)),(((K*K)+(R*b))/(L*J))]);
CF=tf([1],[1,0])
sys = CF*TF
NCTF3=feedback(sys,1)
subplot(3,2,5)
step(NCTF3)
title("Step with integrator")
subplot(3,2,6)
impulse(NCTF3)
title("impulse with integrator")
S = stepinfo(NCTF3)
[wn,zeta]=damp(NCTF3)
```

```
CF =

    10


sys =

        2000
  ----------------
  s^2 + 12 s + 220
```

```
Continuous-time transfer function.


NCTF1 =

        2000
  -----------------
  s^2 + 12 s + 2220

Continuous-time transfer function.


S =

  struct with fields:

        RiseTime: 0.0245
    SettlingTime: 0.6206
     SettlingMin: 0.4993
     SettlingMax: 1.5026
       Overshoot: 66.7860
      Undershoot: 0
            Peak: 1.5026
        PeakTime: 0.0667


wn =

   47.1169
   47.1169


zeta =

    0.1273
    0.1273


CF =

  s

Continuous-time transfer function.


sys =

       200 s
  ----------------
```

```
  s^2 + 12 s + 220

Continuous-time transfer function.


NCTF2 =

        200 s
  -----------------
  s^2 + 212 s + 220

Continuous-time transfer function.


S =

  struct with fields:

        RiseTime: 0
    SettlingTime: 3.7813
     SettlingMin: 6.5963e-04
     SettlingMax: 0.9234
       Overshoot: Inf
      Undershoot: 0
            Peak: 0.9234
        PeakTime: 0.0253


wn =

    1.0429
  210.9571


zeta =

     1
     1


CF =

  1
  -
  s

Continuous-time transfer function.


sys =
```

```
        200
  --------------------
  s^3 + 12 s^2 + 220 s

Continuous-time transfer function.


NCTF3 =

           200
  --------------------------
  s^3 + 12 s^2 + 220 s + 200

Continuous-time transfer function.


S =

  struct with fields:

        RiseTime: 2.2719
    SettlingTime: 4.1463
     SettlingMin: 0.9044
     SettlingMax: 0.9993
       Overshoot: 0
      Undershoot: 0
            Peak: 0.9993
        PeakTime: 7.6683


wn =

    0.9549
   14.4725
   14.4725


zeta =

    1.0000
    0.3816
    0.3816
```



Positive Feedback

```
figure
J = 0.01;
b = 0.1;
K = 1;
R = 1;
L = 0.5;
TF=tf([K/(J*L)],[1,((b/J)+(R/L)),(((K*K)+(R*b))/(L*J))]);
CF=10
sys = CF*TF
PCTF1=feedback(sys,-1)
subplot(3,2,1)
step(PCTF1)
title("Step with positive")
subplot(3,2,2)
impulse(PCTF1)
title("impulse with positive")
S = stepinfo(PCTF1)
[wn,zeta]=damp(PCTF1)
```

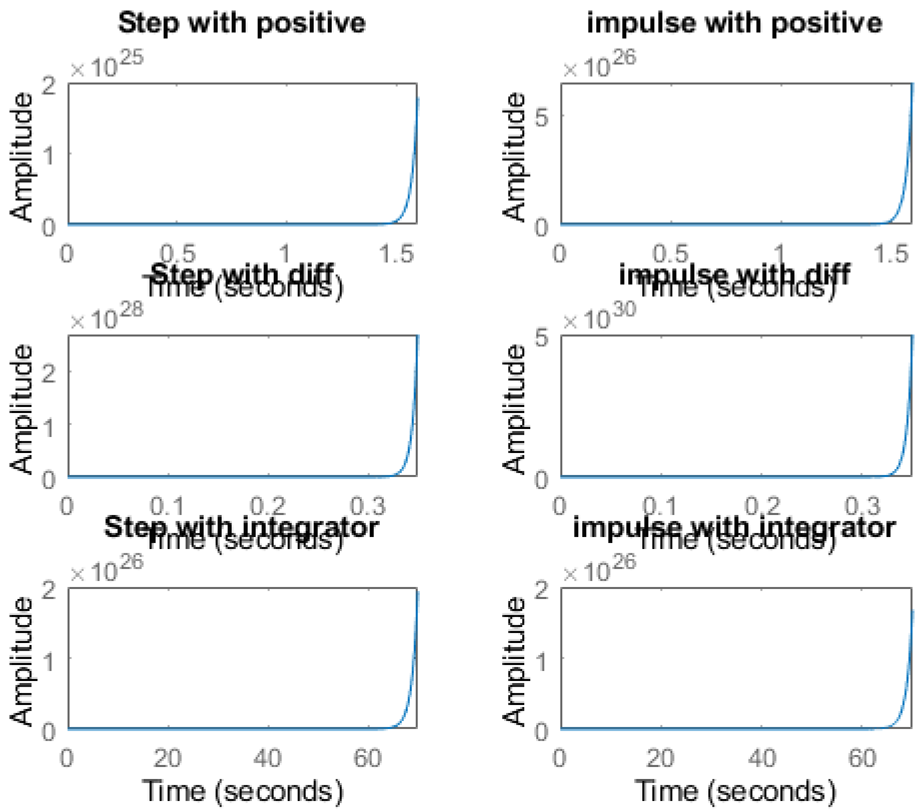
```
J = 0.01;
b = 0.1;
K = 1;
R = 1;
L = 0.5;
TF=tf([K/(J*L)],[1,((b/J)+(R/L)),(((K*K)+(R*b))/(L*J))]);
CF=tf([1,0],[1])
sys = CF*TF
PCTF2=feedback(sys,-1)
subplot(3,2,3)
step(PCTF2)
title("Step with diff")
subplot(3,2,4)
impulse(PCTF2)
title("impulse with diff")
S = stepinfo(PCTF2)
[wn,zeta]=damp(PCTF2)




J = 0.01;
b = 0.1;
K = 1;
R = 1;
L = 0.5;
TF=tf([K/(J*L)],[1,((b/J)+(R/L)),(((K*K)+(R*b))/(L*J))]);
CF=tf([1],[1,0])
sys = CF*TF
PCTF3=feedback(sys,-1)
subplot(3,2,5)
step(PCTF3)
title("Step with integrator")
subplot(3,2,6)
impulse(PCTF3)
title("impulse with integrator")
S = stepinfo(PCTF3)
[wn,zeta]=damp(PCTF3)
```

```
CF =

    10


sys =

        2000
  ----------------
  s^2 + 12 s + 220
```

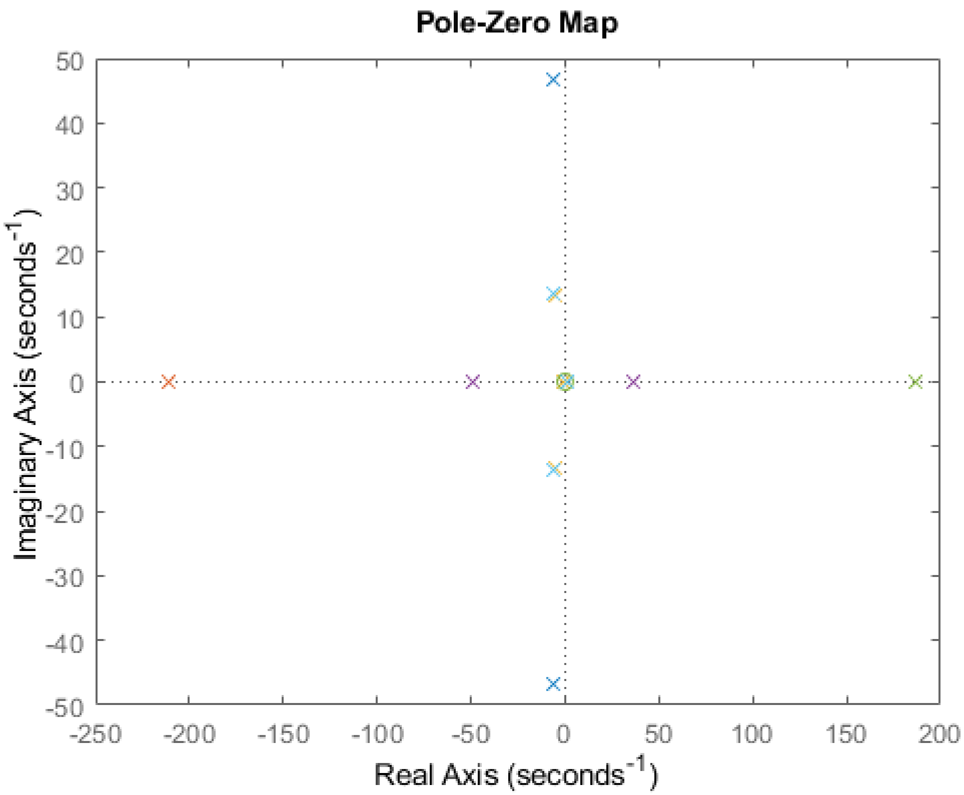
```
Continuous-time transfer function.


PCTF1 =

        2000
  -----------------
  s^2 + 12 s - 1780

Continuous-time transfer function.


S =

  struct with fields:

        RiseTime: NaN
    SettlingTime: NaN
     SettlingMin: NaN
     SettlingMax: NaN
       Overshoot: NaN
      Undershoot: NaN
            Peak: Inf
        PeakTime: Inf


wn =

   36.6146
   48.6146


zeta =

    -1
     1


CF =

  s

Continuous-time transfer function.


sys =

       200 s
  ----------------
```

```
  s^2 + 12 s + 220

Continuous-time transfer function.


PCTF2 =

        200 s
  -----------------
  s^2 - 188 s + 220

Continuous-time transfer function.


S =

  struct with fields:

        RiseTime: NaN
    SettlingTime: NaN
     SettlingMin: NaN
     SettlingMax: NaN
       Overshoot: NaN
      Undershoot: NaN
            Peak: Inf
        PeakTime: Inf


wn =

    1.1776
  186.8224


zeta =

    -1
    -1


CF =

  1
  -
  s

Continuous-time transfer function.


sys =
```

```
         200
  --------------------
  s^3 + 12 s^2 + 220 s

Continuous-time transfer function.


PCTF3 =

             200
  --------------------------
  s^3 + 12 s^2 + 220 s - 200

Continuous-time transfer function.


S =

  struct with fields:

        RiseTime: NaN
    SettlingTime: NaN
     SettlingMin: NaN
     SettlingMax: NaN
       Overshoot: NaN
      Undershoot: NaN
            Peak: Inf
        PeakTime: Inf


wn =

    0.8653
   15.2030
   15.2030


zeta =

   -1.0000
    0.4231
    0.4231
```




```
figure
hold on
pzmap(NCTF1)
pzmap(NCTF2)
pzmap(NCTF3)
pzmap(PCTF1)
pzmap(PCTF2)
pzmap(PCTF3)
```



Analysis

```
%1. Positive feedback system when P,I,D are added system becomes unstable.
%2. Rise time will decrease when you add a differentiator because over
%shoot increases, Ts also increases.
%3. when we add an integrator to this system rise time bacame higher and
%overshoot became zero this says that system is getting towards stable.
%4. Adding the positive feed back makes the zeta value change.
```

Published with MATLAB® R2021a

Title:ControlSystemsecondorder:negative fb with different parameter values

```
%Author:Shivakumar Naga Vankadhara
%PS No:99003727
%Date:10/04/2021
%Version:1.4
```

This Document has equation for DC motor system

```
%Equation1:vi=IR+L(di/dt)+kw
%Equation2:J(dw/dt)+bw=kI
```

Math Analysis

Independent variables: T Dependent Variables:w,I Constants:L,K,R

```
%Roots:-(((RJ+bL)/JL)+-(2((R^2*J^2+b^2*L^2+2JbL)/J^2*L^2)-4((bR+k^2)/JL))^1/2)/2
```

```
J = 0.01;
b = 0.1;
K = 1;
R = 1;
L = 0.5;
TF=tf([K/(J*L)],[1,((b/J)+(R/L)),(((K*K)+(R*b))/(L*J))]);
CF=10
sys = CF*TF
NCTF=feedback(sys,1)
subplot(4,2,1)
step(NCTF)
title("Step 1")
subplot(4,2,2)
impulse(NCTF)
title("impulse1")
S = stepinfo(NCTF)
[wn,zeta]=damp(NCTF)

J = 0.1;
b = 1;
K = 0.1;
R = 10;
L = 5;
TF=tf([K/(J*L)],[1,((b/J)+(R/L)),(((K*K)+(R*b))/(L*J))]);
CF=10
sys = CF*TF
NCTF1=feedback(sys,1)
subplot(4,2,3)
```

```
step(NCTF1)
title("Step 2")
subplot(4,2,4)
impulse(NCTF1)
title("impulse 2")
S = stepinfo(NCTF1)
[wn,zeta]=damp(NCTF1)

J = 0.01;
b = 0.01;
K = 0.1;
R = 0.1;
L = 0.05;
TF=tf([K/(J*L)],[1,((b/J)+(R/L)),(((K*K)+(R*b))/(L*J))]);
CF=10
sys = CF*TF
NCTF2=feedback(sys,1)
subplot(4,2,5)
step(NCTF2)
title("Step 3")
subplot(4,2,6)
impulse(NCTF2)
title("impulse 3")
S = stepinfo(NCTF2)
[wn,zeta]=damp(NCTF2)



J = -0.01;
b = -0.01;
K = -0.1;
R = -0.1;
L = -0.05;
TF=tf([K/(J*L)],[1,((b/J)+(R/L)),(((K*K)+(R*b))/(L*J))]);
CF=10
sys = CF*TF
NCTF3=feedback(sys,1)
subplot(4,2,7)
step(NCTF3)
title("Step 3")
subplot(4,2,8)
impulse(NCTF3)
title("impulse 3")
S = stepinfo(NCTF3)
[wn,zeta]=damp(NCTF3)
```

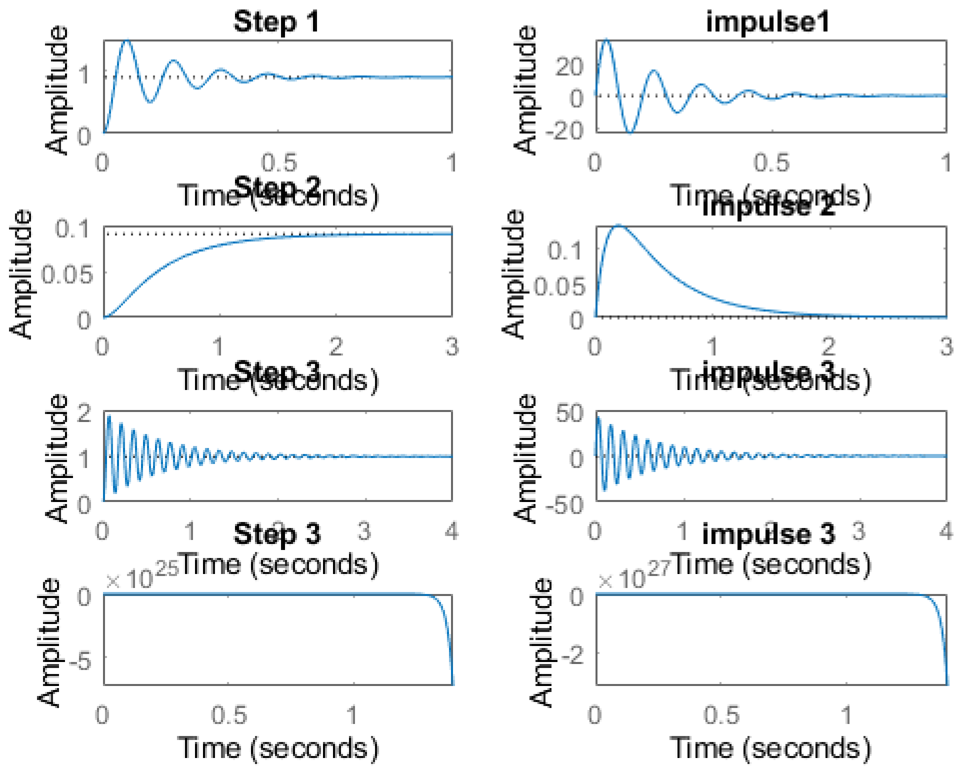
```
CF =

    10
```

```
sys =

        2000
  ----------------
  s^2 + 12 s + 220

Continuous-time transfer function.


NCTF =

        2000
  -----------------
  s^2 + 12 s + 2220

Continuous-time transfer function.


S =

  struct with fields:

        RiseTime: 0.0245
    SettlingTime: 0.6206
     SettlingMin: 0.4993
     SettlingMax: 1.5026
       Overshoot: 66.7860
      Undershoot: 0
            Peak: 1.5026
        PeakTime: 0.0667


wn =

   47.1169
   47.1169


zeta =

    0.1273
    0.1273


CF =

    10
```

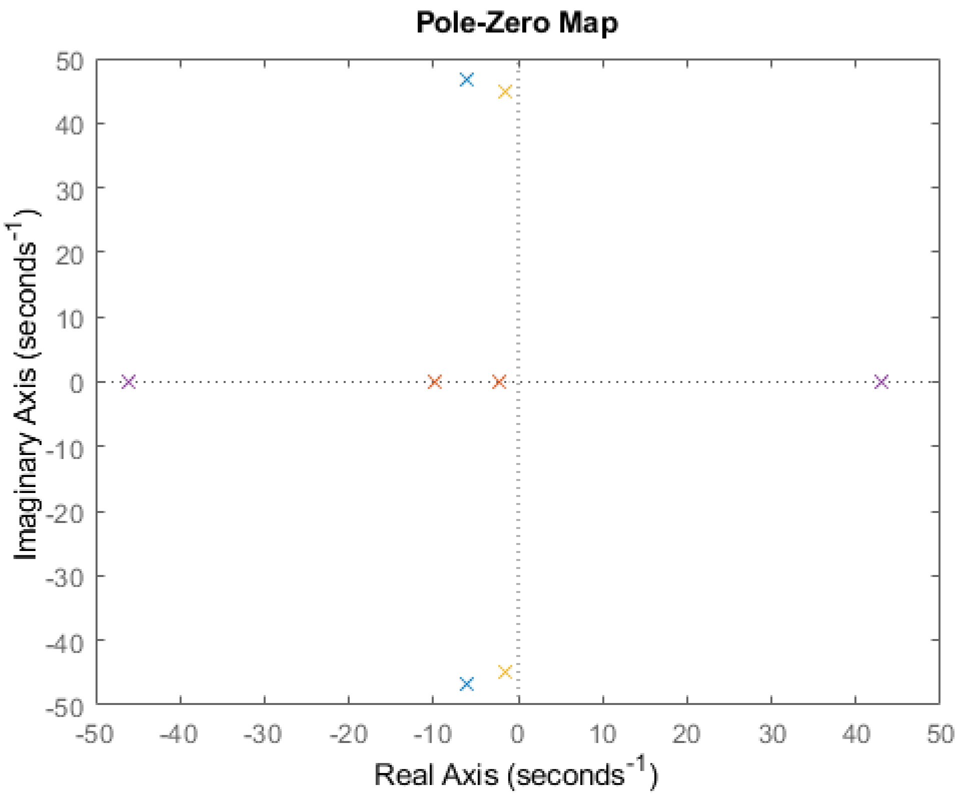
```
sys =

          2
  ------------------
  s^2 + 12 s + 20.02

Continuous-time transfer function.


NCTF1 =

          2
  ------------------
  s^2 + 12 s + 22.02

Continuous-time transfer function.


S =

  struct with fields:

        RiseTime: 1.0161
    SettlingTime: 1.8471
     SettlingMin: 0.0819
     SettlingMax: 0.0907
       Overshoot: 0
      Undershoot: 0
            Peak: 0.0907
        PeakTime: 3.0168


wn =

    2.2610
    9.7390


zeta =

     1
     1


CF =

    10
```

```
sys =

       2000
  --------------
  s^2 + 3 s + 22

Continuous-time transfer function.


NCTF2 =

        2000
  ----------------
  s^2 + 3 s + 2022

Continuous-time transfer function.


S =

  struct with fields:

        RiseTime: 0.0238
    SettlingTime: 2.5921
     SettlingMin: 0.1871
     SettlingMax: 1.8798
       Overshoot: 90.0453
      Undershoot: 0
            Peak: 1.8798
        PeakTime: 0.0699


wn =

   44.9667
   44.9667


zeta =

    0.0334
    0.0334


CF =

    10


sys =
```

```
      -2000
  --------------
  s^2 + 3 s + 22

Continuous-time transfer function.


NCTF3 =

       -2000
  ----------------
  s^2 + 3 s - 1978

Continuous-time transfer function.


S =

  struct with fields:

        RiseTime: NaN
    SettlingTime: NaN
     SettlingMin: NaN
     SettlingMax: NaN
       Overshoot: NaN
      Undershoot: NaN
            Peak: Inf
        PeakTime: Inf


wn =

    43
    46


zeta =

    -1
     1
```




```
figure
hold on
pzmap(NCTF)
pzmap(NCTF1)
pzmap(NCTF2)
pzmap(NCTF3)
```



Analysis:

```
%1. For negative variables the root of a system becomes positive so the syste
%m is unstable.
%2. Rise time of negative feedback closed loop system is less when compared
% to open loop system of the same second order.
%3. Zeros & Poles locations got changed when we added a negative feed back.
%4. System becomes under damped
%5. Overshoot is high when compared to open loop system.
%6. For the 3rd negative variables risetime, passtime every other parametrs
%becomes inf.
```

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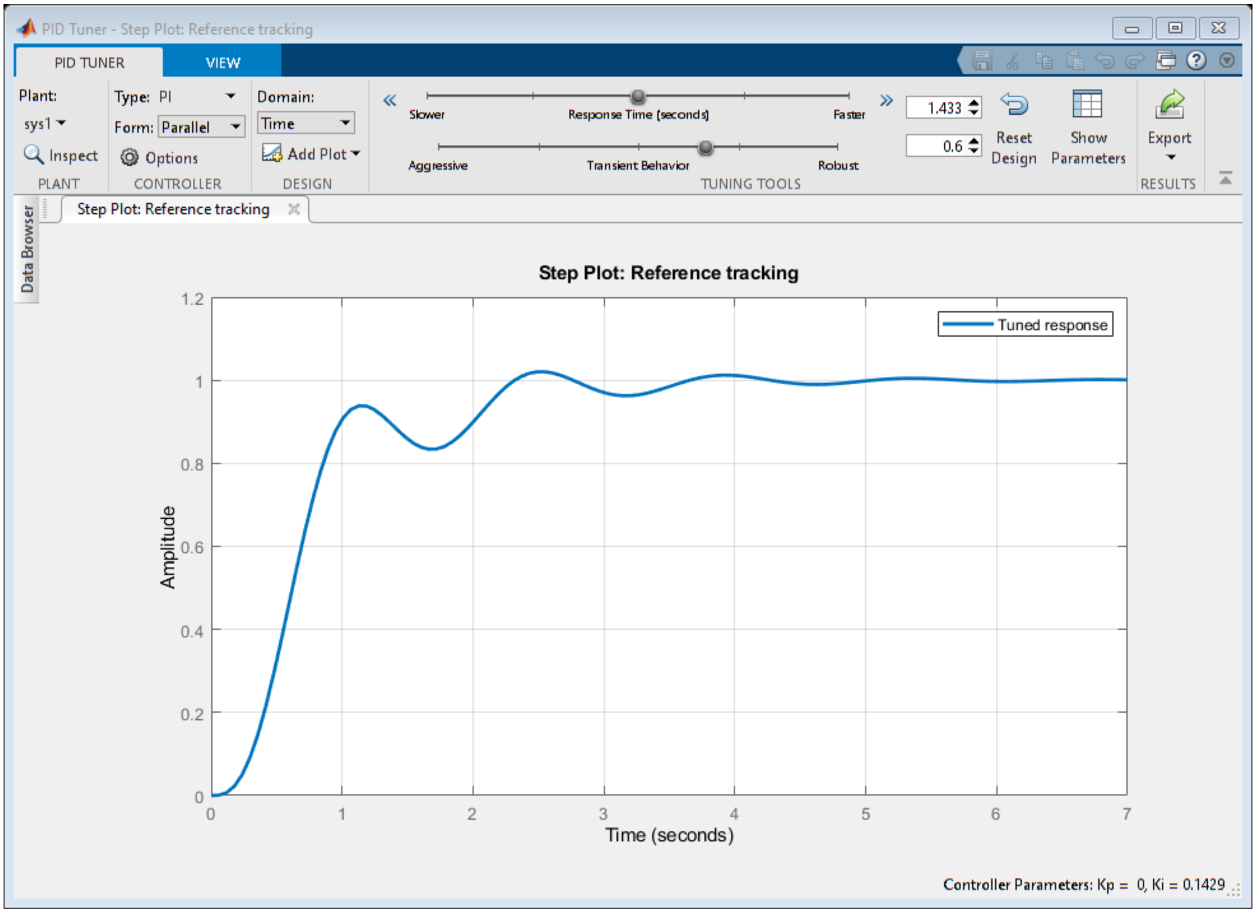
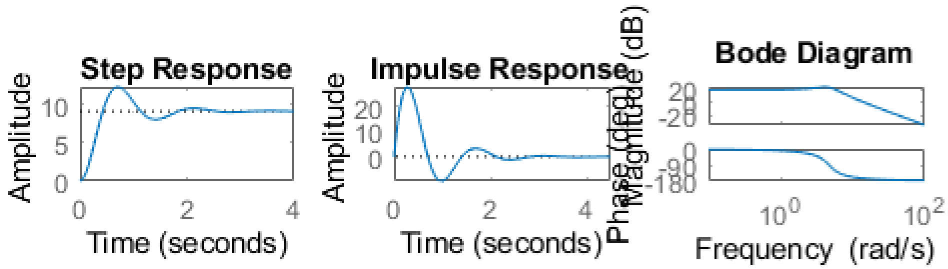
normal

```
J1 = 0.01;
b1 = 0.01;
K1 = 0.1;
R1 = 0.1;
L1 = 0.05;
sys1 = tf([K1/(J1*L1)],[1,((b1/J1)+(R1/L1)),(((K1*K1)+(R1*b1))/(L1*J1))])
subplot(4,3,1)
step(sys1)
subplot(4,3,2)
impulse(sys1)
subplot(4,3,3)
S = stepinfo(sys1)
pzmap(sys1)
 pidTuner(sys1)
 bode(sys1)
```

```
sys1 =

       200
  --------------
  s^2 + 3 s + 22

Continuous-time transfer function.


S =

  struct with fields:

        RiseTime: 0.2882
    SettlingTime: 2.3810
     SettlingMin: 8.0006
     SettlingMax: 12.2393
       Overshoot: 34.6325
      Undershoot: 0
            Peak: 12.2393
        PeakTime: 0.7061
```


PID Tuner - Step Plot: Reference tracking
PID TUNER
VIEW
Plant:
sys1
Inspect
PLANT
Type: PI
Form: Parallel
Options
CONTROLLER
Domain:
Time
Add Plot
DESIGN
Slower
Response Time (seconds)
Faster
Aggressive
Transient Behavior
Robust
TUNING TOOLS
1.433
0.6
Reset Design
Show Parameters
Export
RESULTS
Data Browser
Step Plot: Reference tracking
Step Plot: Reference tracking
Tuned response
Amplitude
Time (seconds)
Controller Parameters: Kp = 0, Ki = 0.1429

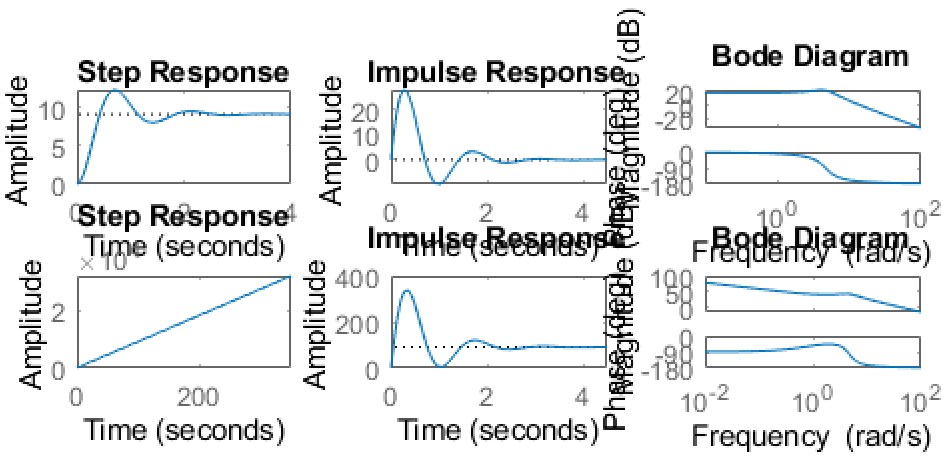


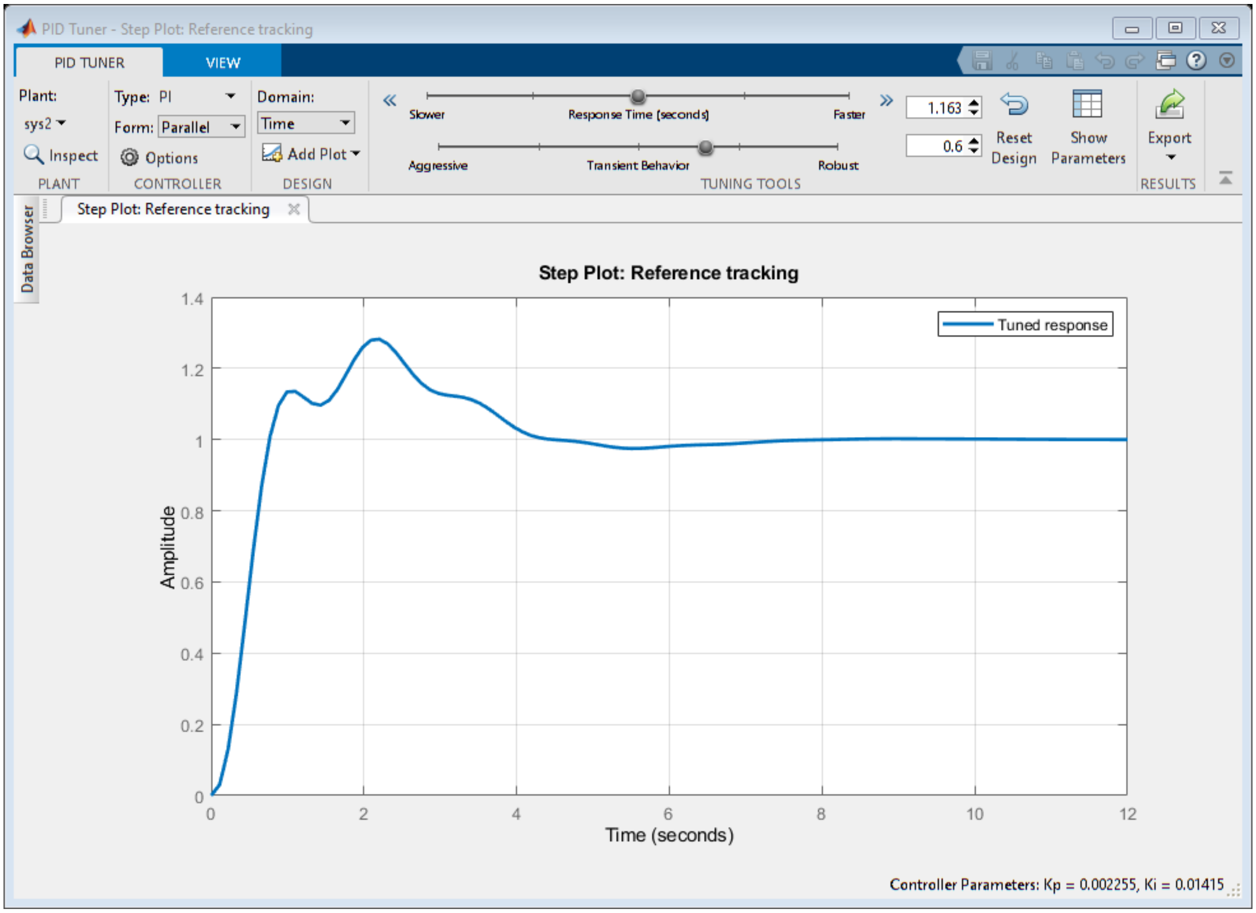
pi

```
J2 = 0.01;
b2 = 0.01;
K2 = 0.1;
R2 = 0.1;
L2 = 0.05;
Kp=10;
I=tf([10],[1,0]);  %Ki
PI=Kp+I;
sys2 = tf([K2/(J2*L2)],[1,((b2/J2)+(R2/L2)),(((K2*K2)+(R2*b2))/(L2*J2))])*(PI)
subplot(4,3,4)
step(sys2)
subplot(4,3,5)
impulse(sys2)
subplot(4,3,6)
S = stepinfo(sys2)
pzmap(sys2)
 pidTuner(sys2)
bode(sys2)
```

```
sys2 =
```

```
     2000 s + 2000
  ------------------
  s^3 + 3 s^2 + 22 s

Continuous-time transfer function.


S =

  struct with fields:

        RiseTime: NaN
    SettlingTime: NaN
     SettlingMin: NaN
     SettlingMax: NaN
       Overshoot: NaN
      Undershoot: NaN
            Peak: Inf
        PeakTime: Inf
```

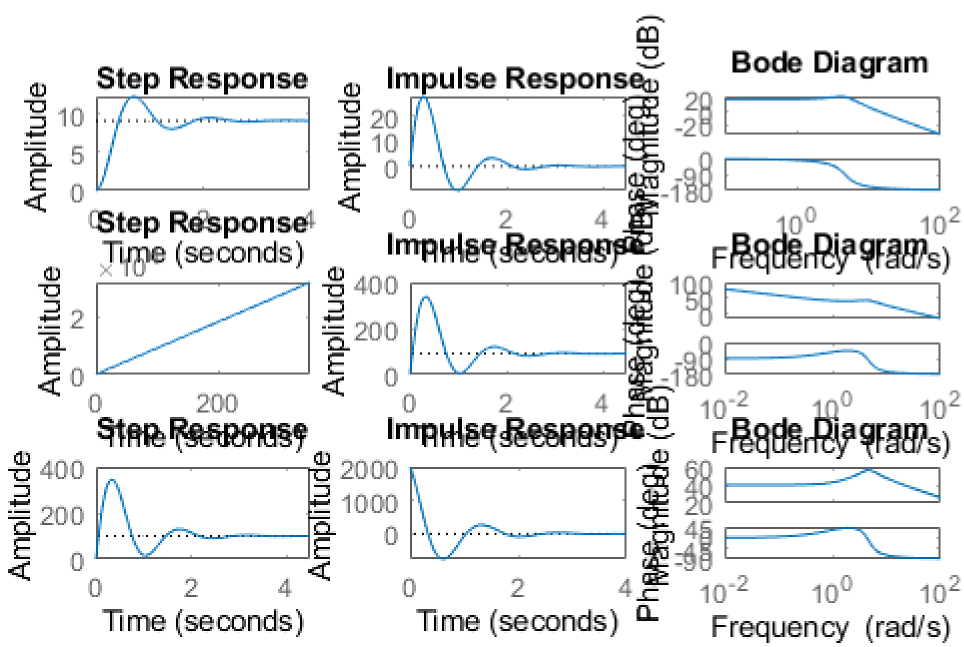


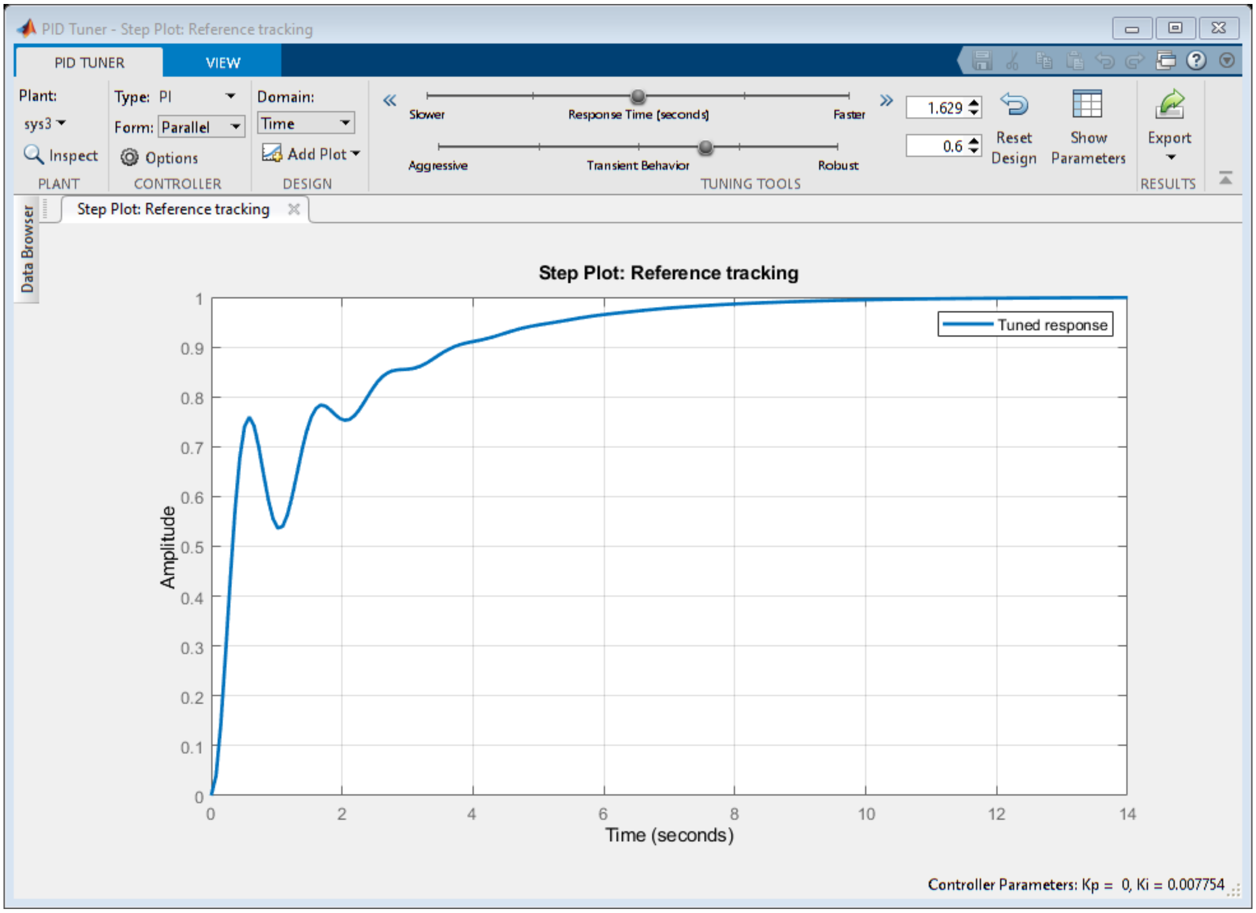


PD

```
J3 = 0.01;
b3 = 0.01;
K3 = 0.1;
R3 = 0.1;
L3 = 0.05;
Kp=10;
D=tf([10,1],[0,1]);  %Kd
PD=Kp+D;
sys3 = tf([K3/(J3*L3)],[1,((b3/J3)+(R3/L3)),(((K3*K3)+(R3*b3))/(L3*J3))])*(PD)
subplot(4,3,7)
step(sys3)
subplot(4,3,8)
impulse(sys3)
subplot(4,3,9)
S = stepinfo(sys3)
pzmap(sys3)
 pidTuner(sys3);
 bode(sys3)
```

```
sys3 =

  2000 s + 2200
  --------------
  s^2 + 3 s + 22

Continuous-time transfer function.


S =

  struct with fields:

        RiseTime: 0.0426
    SettlingTime: 2.7143
     SettlingMin: 14.7945
     SettlingMax: 346.0086
       Overshoot: 246.0086
      Undershoot: 0
            Peak: 346.0086
        PeakTime: 0.3377
```

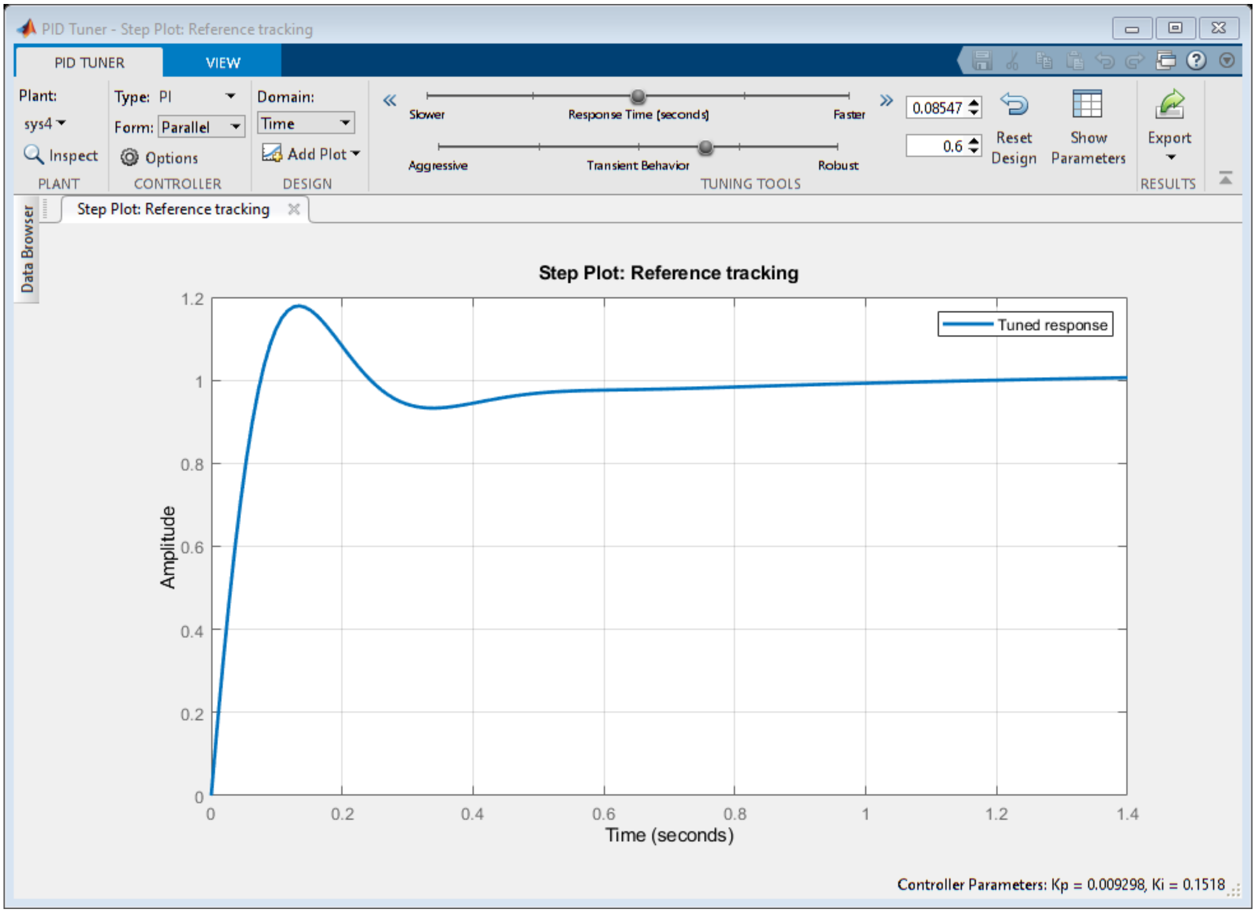


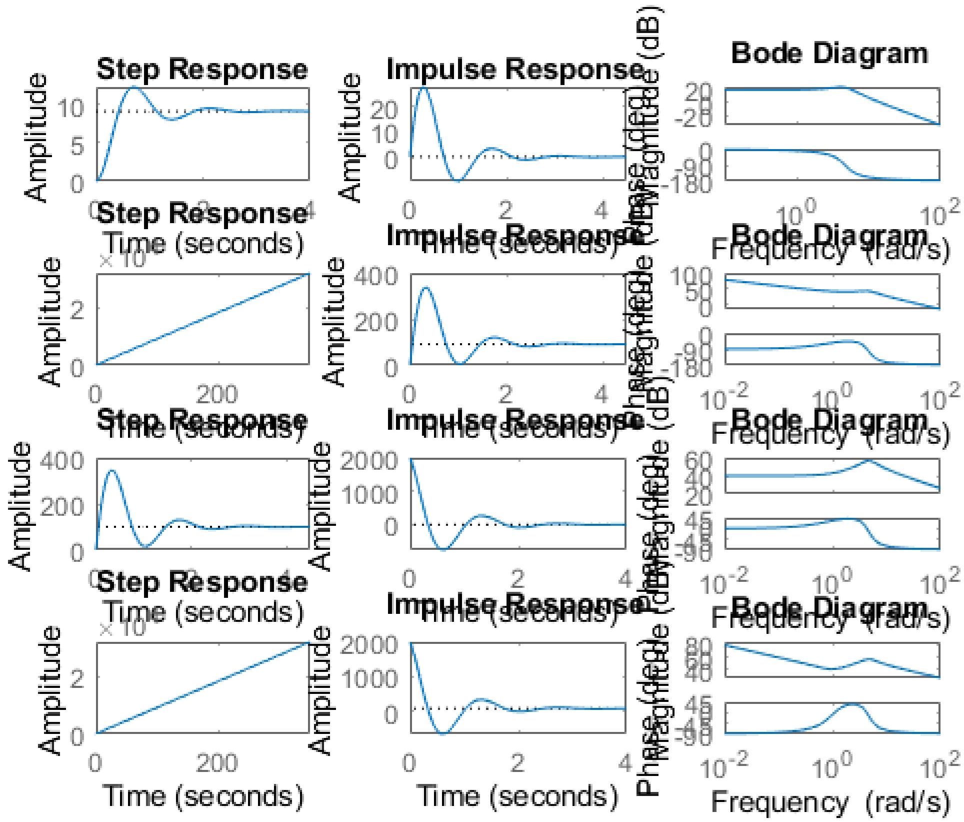


PID

```
J4 = 0.01;
b4 = 0.01;
K4 = 0.1;
R4 = 0.1;
L4 = 0.05;
Kp=10;
D=tf([10,1],[0,1]);  %Kd
I=tf([10],[1,0]);  %Ki
PID=Kp+D+I;
sys4 = tf([K4/(J4*L4)],[1,((b4/J4)+(R4/L4)),(((K4*K4)+(R4*b4))/(L4*J4))])*(PID)
subplot(4,3,10)
step(sys4)
subplot(4,3,11)
impulse(sys4)
subplot(4,3,12)
S = stepinfo(sys4)
pzmap(sys4)
 pidTuner(sys4)
 bode(sys4)
```

```
sys4 =

  2000 s^2 + 2200 s + 2000
  ------------------------
     s^3 + 3 s^2 + 22 s

Continuous-time transfer function.


S =

  struct with fields:

        RiseTime: NaN
    SettlingTime: NaN
     SettlingMin: NaN
     SettlingMax: NaN
       Overshoot: NaN
      Undershoot: NaN
            Peak: Inf
        PeakTime: Inf
```


PID Tuner - Step Plot: Reference tracking
PID TUNER
VIEW
Plant:
sys4
Inspect
PLANT
Type: PI
Form: Parallel
Options
CONTROLLER
Domain:
Time
Add Plot
DESIGN
Slower
Response Time (seconds)
Faster
Aggressive
Transient Behavior
Robust
TUNING TOOLS
0.08547
0.6
Reset Design
Show Parameters
Export
RESULTS
Data Browser
Step Plot: Reference tracking
Step Plot: Reference tracking
Tuned response
Amplitude
Time (seconds)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
Controller Parameters: Kp = 0.009298, Ki = 0.1518



Published with MATLAB® R2021a

Title:Control System-Individual System(Thermometer)

```
%Author:ShivaKumar Naga Vankadhara
%PS No:99003727
%Date:12/04/2021
%Version:1.0
```

This Document has equation for First Order Thermometer Equation

```
%Equation:Tdm/dt+m=tem
%T_F=1/Ts+1
```

Math analysis

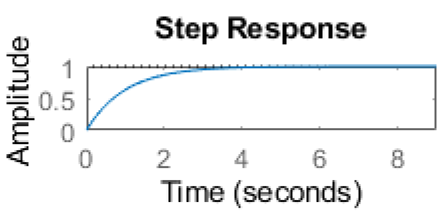
```
%dependent variables:m,temp
%independent variables:t
%constant:T
%Roots:-1/T
```

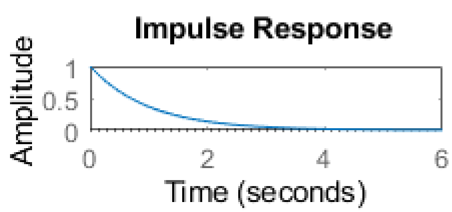
Basic

```
T=1
sys1 = tf([1],[T,1])
subplot(5,2,1)
step(sys1)
subplot(5,2,2)
impulse(sys1)
S = stepinfo(sys1)
p1=pole(sys1)
z1=zero(sys1)
```

```
T =

     1


sys1 =

    1
  -----
  s + 1

Continuous-time transfer function.


S =
```

```
  struct with fields:

        RiseTime: 2.1970
    SettlingTime: 3.9121
     SettlingMin: 0.9045
     SettlingMax: 1.0000
       Overshoot: 0
      Undershoot: 0
            Peak: 1.0000
        PeakTime: 10.5458


p1 =

    -1


z1 =

  0×1 empty double column vector
```

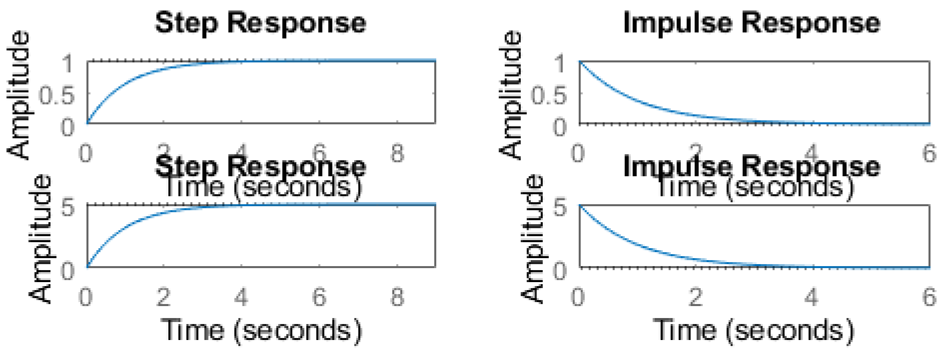




With Gain

```
T=1;
k=5;
sys_G = k*tf([1],[T,1])
subplot(5,2,3)
step(sys_G)
subplot(5,2,4)
impulse(sys_G)
S = stepinfo(sys_G)
p_g=pole(sys_G)
z_g=zero(sys_G)
```

```
sys_G =

    5
  -----
  s + 1

Continuous-time transfer function.


S =

  struct with fields:

        RiseTime: 2.1970
    SettlingTime: 3.9121
     SettlingMin: 4.5225
     SettlingMax: 4.9999
       Overshoot: 0
      Undershoot: 0
            Peak: 4.9999
        PeakTime: 10.5458


p_g =

    -1


z_g =

  0×1 empty double column vector
```

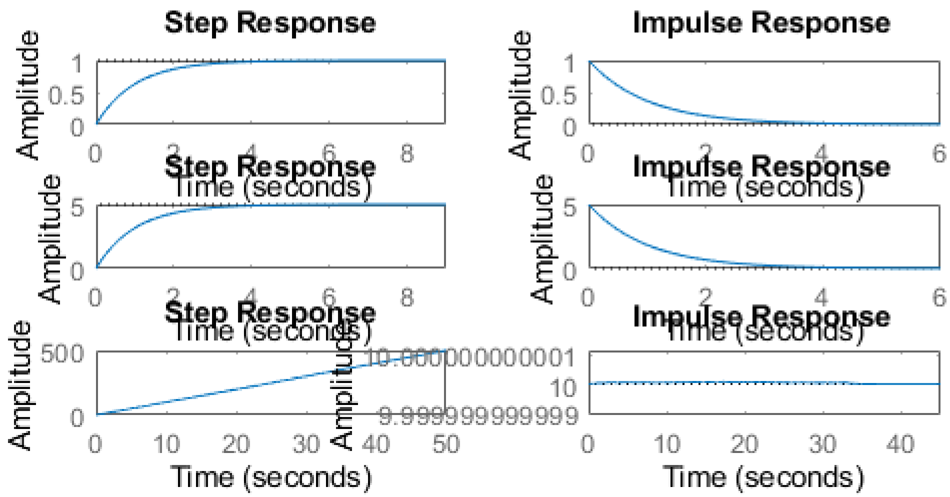


With PI

```
T=1;
k=5;
Kp=10;
I=tf([10],[1,0]);  %Ki
PI=Kp+I;
sys_PI = PI*tf([1],[T,1])
subplot(5,2,5)
step(sys_PI)
subplot(5,2,6)
impulse(sys_PI)
S = stepinfo(sys_PI)
p_pi=pole(sys_PI)
z_pi=zero(sys_PI)
```

```
sys_PI =

  10 s + 10
  ---------
   s^2 + s
```

```
Continuous-time transfer function.


S =

  struct with fields:

        RiseTime: NaN
    SettlingTime: NaN
     SettlingMin: NaN
     SettlingMax: NaN
       Overshoot: NaN
      Undershoot: NaN
            Peak: Inf
        PeakTime: Inf


p_pi =

     0
    -1


z_pi =

    -1
```

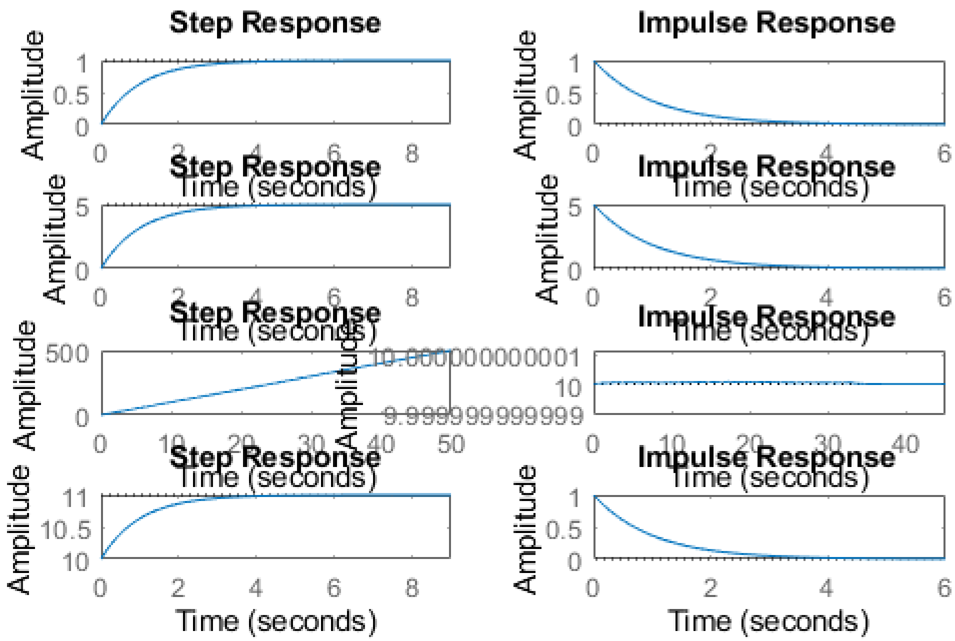


With PD

```
T=1;
k=5;
Kp=10;
D=tf([10,1],[0,1]);  %Kd
PD=Kp+D;
sys_PD = PD*tf([1],[T,1])
subplot(5,2,7)
step(sys_PD)
subplot(5,2,8)
impulse(sys_PD)
S = stepinfo(sys_PD)
p_pd=pole(sys_PD)
z_pd=zero(sys_PD)
```

```
sys_PD =

  10 s + 11
  ---------
    s + 1
```

```
Continuous-time transfer function.


S =

  struct with fields:

        RiseTime: 2.1970
    SettlingTime: 3.9121
     SettlingMin: 10.9045
     SettlingMax: 11.0000
       Overshoot: 0
      Undershoot: 0
            Peak: 11.0000
        PeakTime: 10.5458


p_pd =

    -1


z_pd =

   -1.1000
```

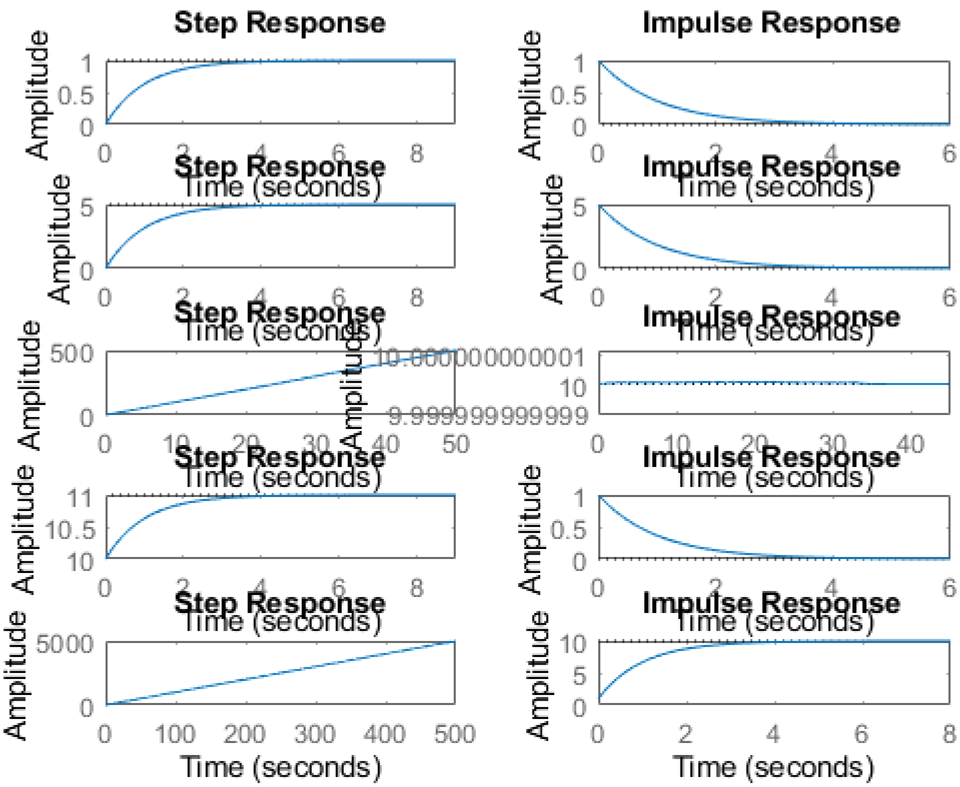


With PID

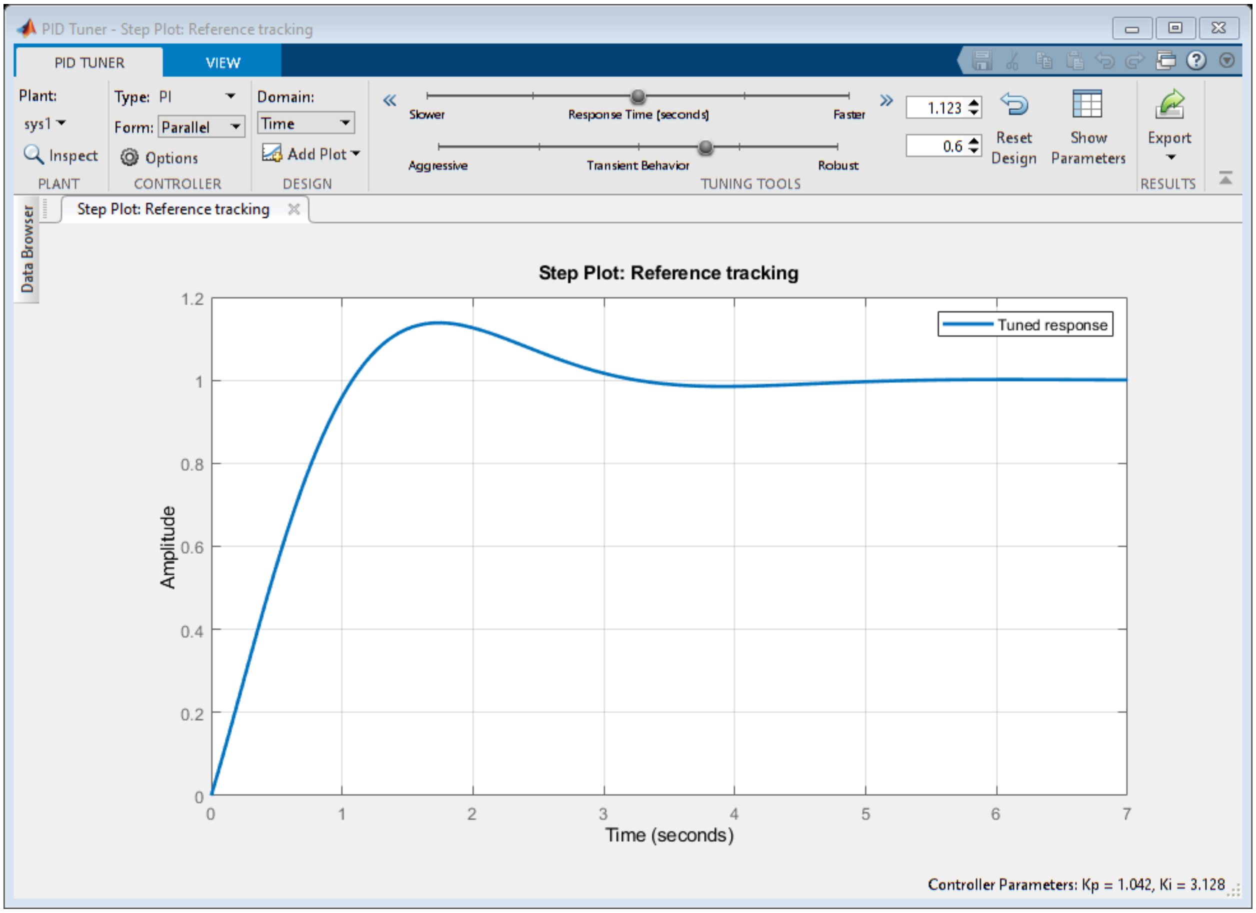
```
T=1;
k=5;
Kp=10;
D=tf([10,1],[0,1]);  %Kd
I=tf([10],[1,0]);  %Ki
PID=Kp+D+I;
sys_PID = PID*tf([1],[T,1])
subplot(5,2,9)
step(sys_PID)
subplot(5,2,10)
impulse(sys_PID)
S = stepinfo(sys_PID)
p_pid=pole(sys_PID)
z_pid=zero(sys_PID)
```

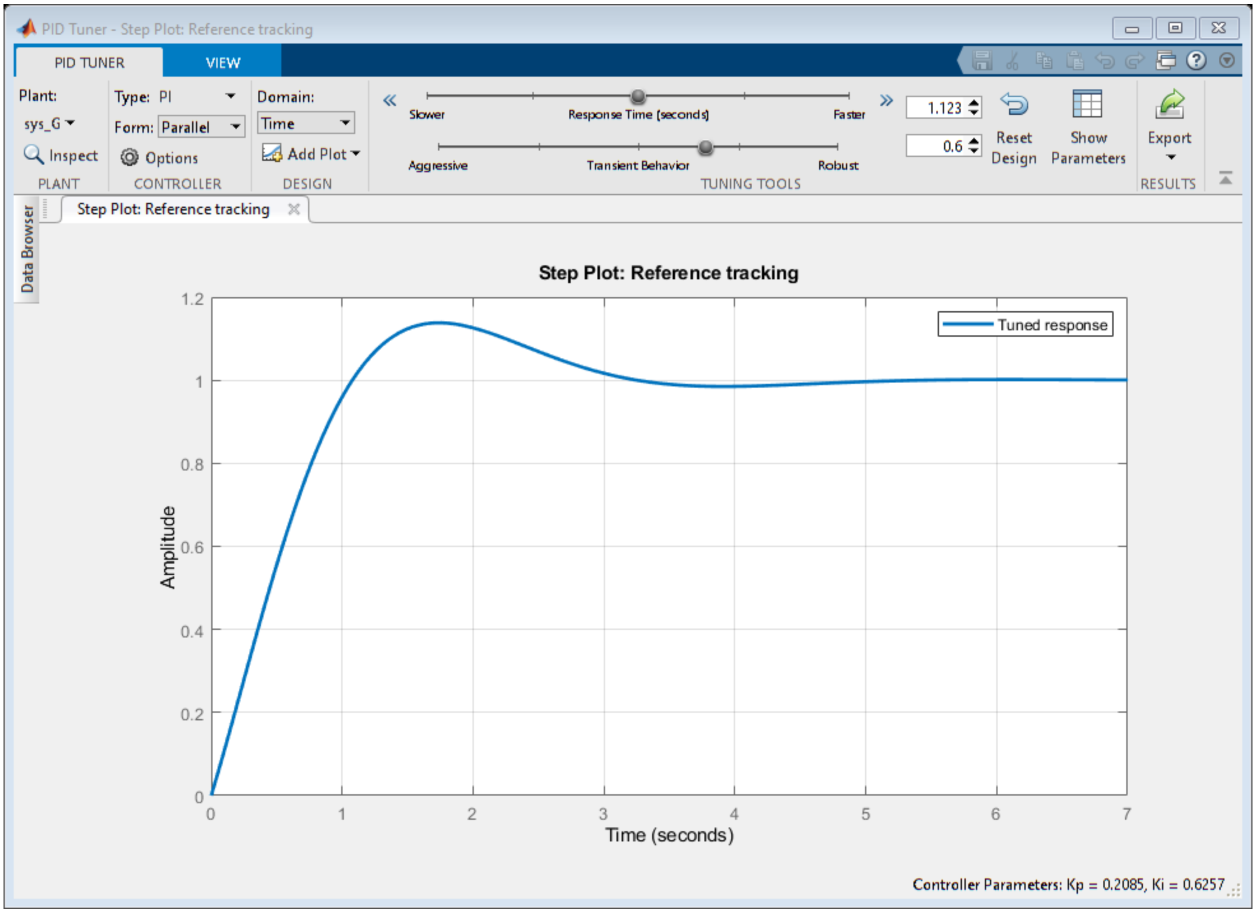
```
sys_PID =

  10 s^2 + 11 s + 10
  ------------------
       s^2 + s
```

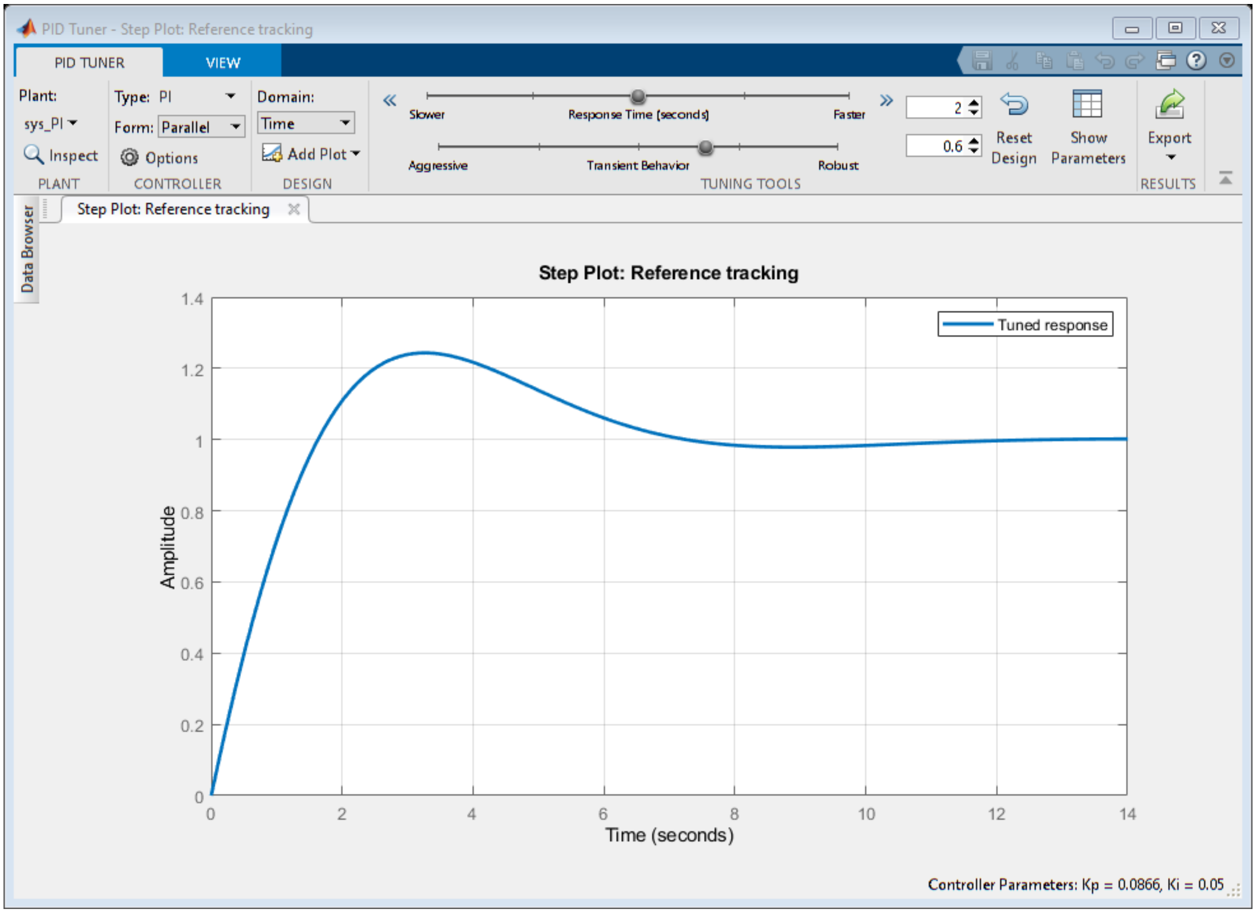
```
Continuous-time transfer function.


S =

  struct with fields:

        RiseTime: NaN
    SettlingTime: NaN
     SettlingMin: NaN
     SettlingMax: NaN
       Overshoot: NaN
      Undershoot: NaN
            Peak: Inf
        PeakTime: Inf


p_pid =

     0
    -1


z_pid =

  -0.5500 + 0.8352i
  -0.5500 - 0.8352i
```

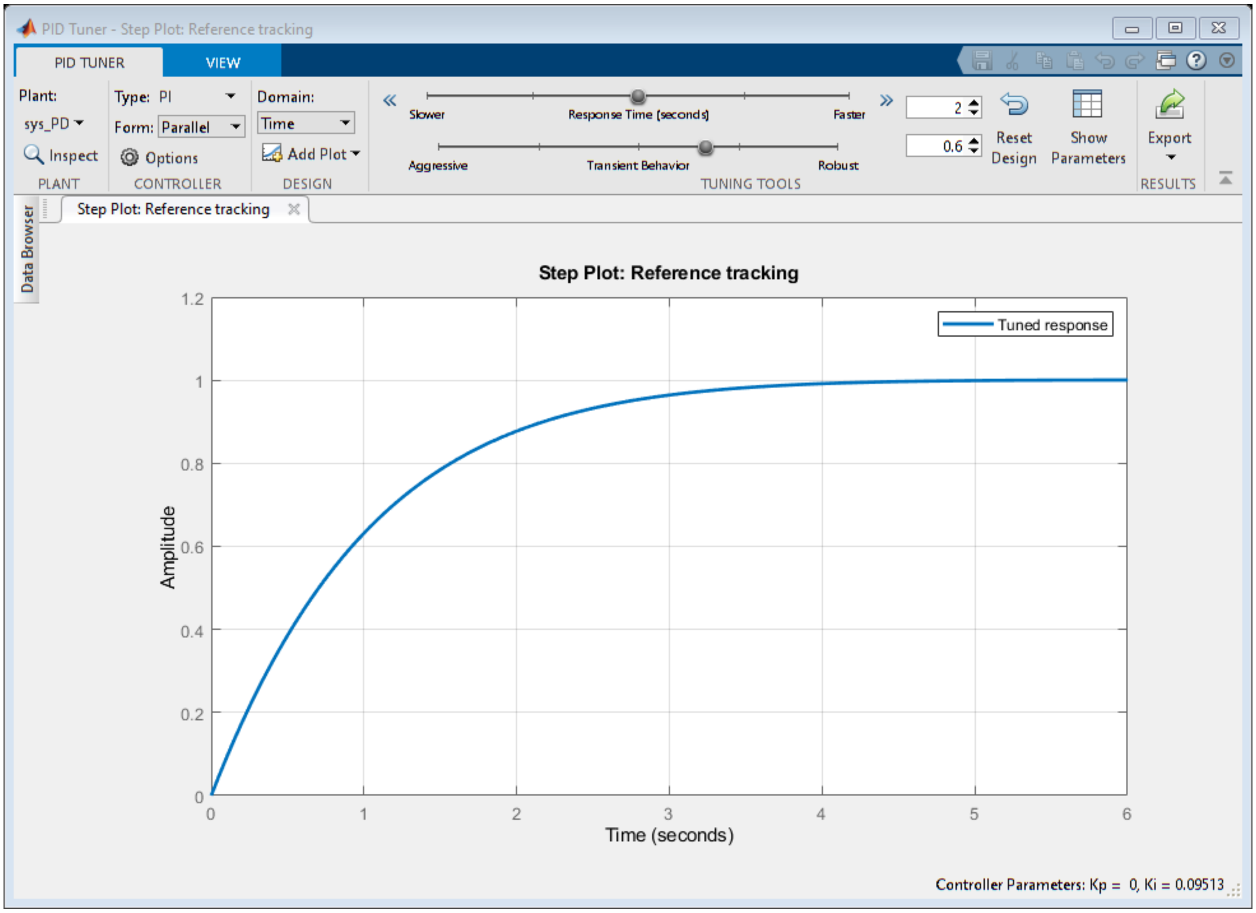


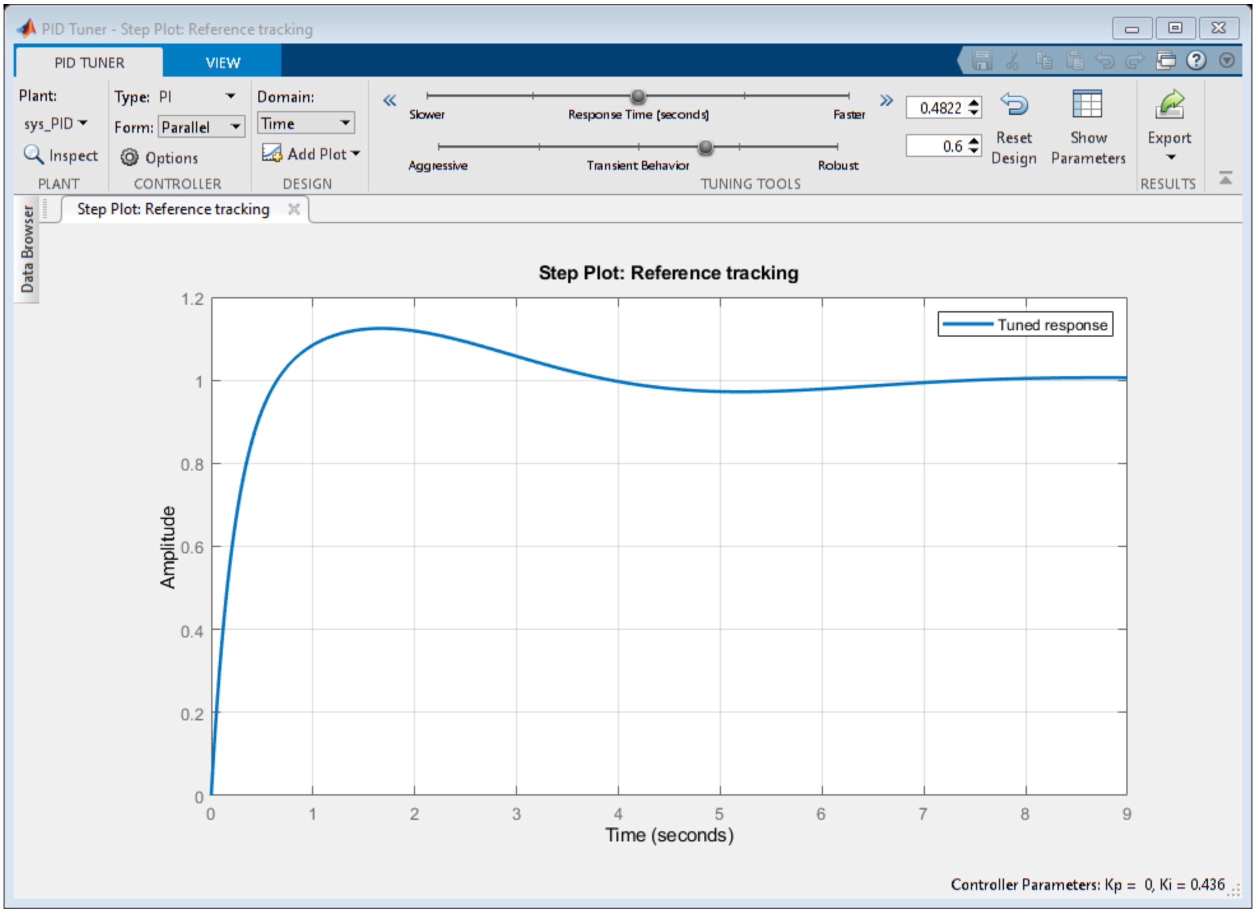

```
figure
pzmap(sys1)
pzmap(sys_G)
pzmap(sys_PI)
pzmap(sys_PD)
pzmap(sys_PID)


pidTuner(sys1)
pidTuner(sys_G)
pidTuner(sys_PI)
pidTuner(sys_PD)
pidTuner(sys_PID)
```

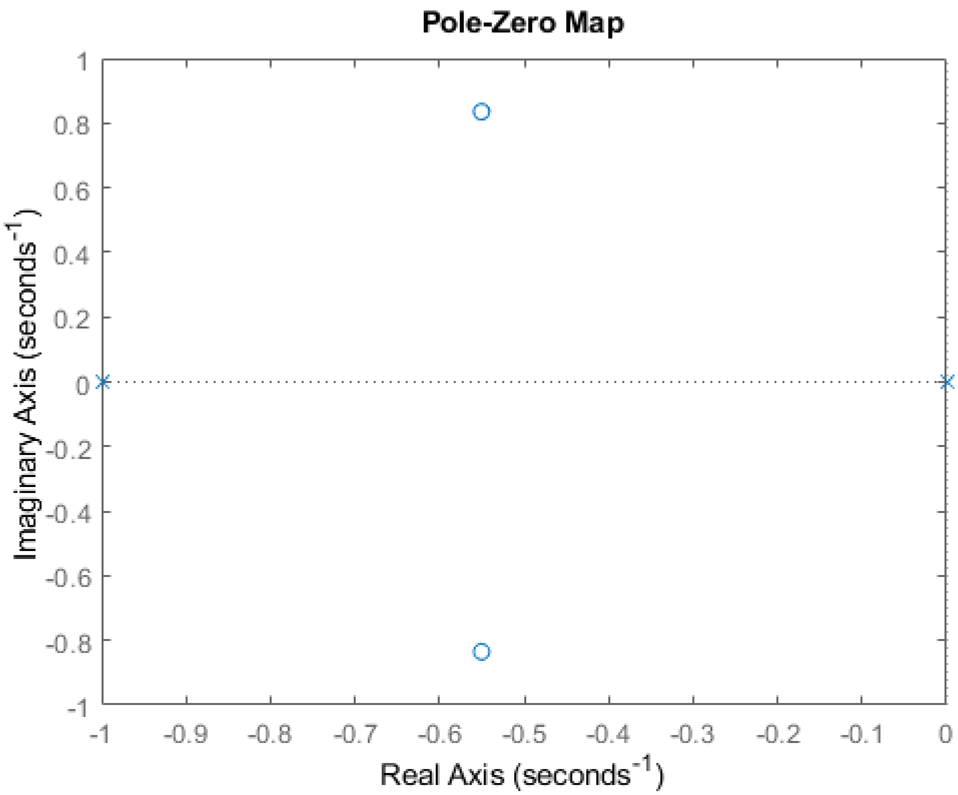

PID Tuner - Step Plot: Reference tracking
PID TUNER
VIEW
Plant:
sys1
Inspect
PLANT
Type: PI
Form: Parallel
Options
CONTROLLER
Domain:
Time
Add Plot
DESIGN
Slower
Response Time (seconds)
Faster
Aggressive
Transient Behavior
Robust
TUNING TOOLS
1.123
0.6
Reset Design
Show Parameters
Export
RESULTS
Data Browser
Step Plot: Reference tracking
Step Plot: Reference tracking
Tuned response
Amplitude
Time (seconds)
Controller Parameters: Kp = 1.042, Ki = 3.128


PID Tuner - Step Plot: Reference tracking
PID TUNER
VIEW
Plant:
sys_G
Inspect
PLANT
Type: PI
Form: Parallel
Options
CONTROLLER
Domain:
Time
Add Plot
DESIGN
Slower
Response Time (seconds)
Faster
Aggressive
Transient Behavior
Robust
TUNING TOOLS
1.123
0.6
Reset Design
Show Parameters
Export
RESULTS
Data Browser
Step Plot: Reference tracking
Step Plot: Reference tracking
Tuned response
Amplitude
Time (seconds)
Controller Parameters: Kp = 0.2085, Ki = 0.6257


PID Tuner - Step Plot: Reference tracking
PID TUNER
VIEW
Plant:
sys_PI
Inspect
PLANT
Type: PI
Form: Parallel
Options
CONTROLLER
Domain:
Time
Add Plot
DESIGN
Slower
Response Time (seconds)
Faster
Aggressive
Transient Behavior
Robust
TUNING TOOLS
2
0.6
Reset Design
Show Parameters
Export
RESULTS
Data Browser
Step Plot: Reference tracking
Step Plot: Reference tracking
Tuned response
Amplitude
Time (seconds)
Controller Parameters: Kp = 0.0866, Ki = 0.05


PID Tuner - Step Plot: Reference tracking
PID TUNER
VIEW
Plant:
sys_PD
Inspect
PLANT
Type: PI
Form: Parallel
Options
CONTROLLER
Domain:
Time
Add Plot
DESIGN
Slower
Response Time (seconds)
Faster
Aggressive
Transient Behavior
Robust
TUNING TOOLS
2
0.6
Reset Design
Show Parameters
Export
RESULTS
Data Browser
Step Plot: Reference tracking
Step Plot: Reference tracking
Tuned response
Amplitude
Time (seconds)
Controller Parameters: Kp = 0, Ki = 0.09513


PID Tuner - Step Plot: Reference tracking
PID TUNER
VIEW
Plant:
sys_PID
Inspect
PLANT
Type: PI
Form: Parallel
Options
CONTROLLER
Domain:
Time
Add Plot
DESIGN
Slower
Response Time (seconds)
Faster
Aggressive
Transient Behavior
Robust
TUNING TOOLS
0.4822
0.6
Reset Design
Show Parameters
Export
RESULTS
Data Browser
Step Plot: Reference tracking
Step Plot: Reference tracking
Tuned response
Amplitude
Time (seconds)
Controller Parameters: Kp = 0, Ki = 0.436



Analysis

```
%1.For the Basic the root lies on the left side of the imaginary axis that
% means the system is stable.
%Rise time is : 2.1970
%settling time is:3.9121 & Overshoot=0 for the basic
%2. For the system with gain also the root lies on the left side of the
%imaginary axis that means the system is stable.
%Rise time is:2.1970, settling time:3.9121, overshoot=0 for the gain. poles
%is also same only there is a change of amplitude.
%3. For the system with PI we got 2 poles one pole is at p1=0, p2=-1 and
%one zero is at z=-1 so we can say that 1 pole will nullify the effect of
%zero and we will be remained with 1 pole left on the left side so we can
%say that system is stable.
%4. For the system with PD we got 1 pole at -1 and 1 zero at -1.10000 on
%the left side of imaginary axis the settling time is 2.1970, R_t is 3.9121
%5. For the system with PID controller we got 2 poles and 2 zeroes p1=0,
%p1=-1 and z1=-0.5500+0.8352i,z2=-0.5500-0.8352i the poles and zeores le on
%the left side of the imaginary axis again the system is stable again here
%also.
```

With POsitive feedback

```
figure
T=1
sys = tf([1],[T,1])
sys_P=feedback(sys,-1)
subplot(5,2,1)
step(sys_P)
subplot(5,2,2)
impulse(sys_P)
S = stepinfo(sys_P)
p1=pole(sys_P)
z1=zero(sys_P)

T=1;
CF=10;
sys = CF*tf([1],[T,1]);
sys_G_P=feedback(sys,-1);
subplot(5,2,3)
step(sys_G_P)
subplot(5,2,4)
impulse(sys_G_P)
S = stepinfo(sys_G_P)
p_g=pole(sys_G_P)
z_g=zero(sys_G_P)

T=1;
Kp=10;
I=tf([10],[1,0]);  %Ki
PI=Kp+I;
sys = PI*tf([1],[T,1]);
sys_PI_P=feedback(sys,-1);
subplot(5,2,5)
step(sys_PI_P)
subplot(5,2,6)
impulse(sys_PI_P)
S = stepinfo(sys_PI_P)
p_pi=pole(sys_PI_P)
z_pi=zero(sys_PI_P)

T=1;
Kp=10;
D=tf([10,1],[0,1]);  %Kd
PD=Kp+D;
sys = PD*tf([1],[T,1]);
sys_PD_P=feedback(sys,-1);
subplot(5,2,7)
step(sys_PD_P)
subplot(5,2,8)
```

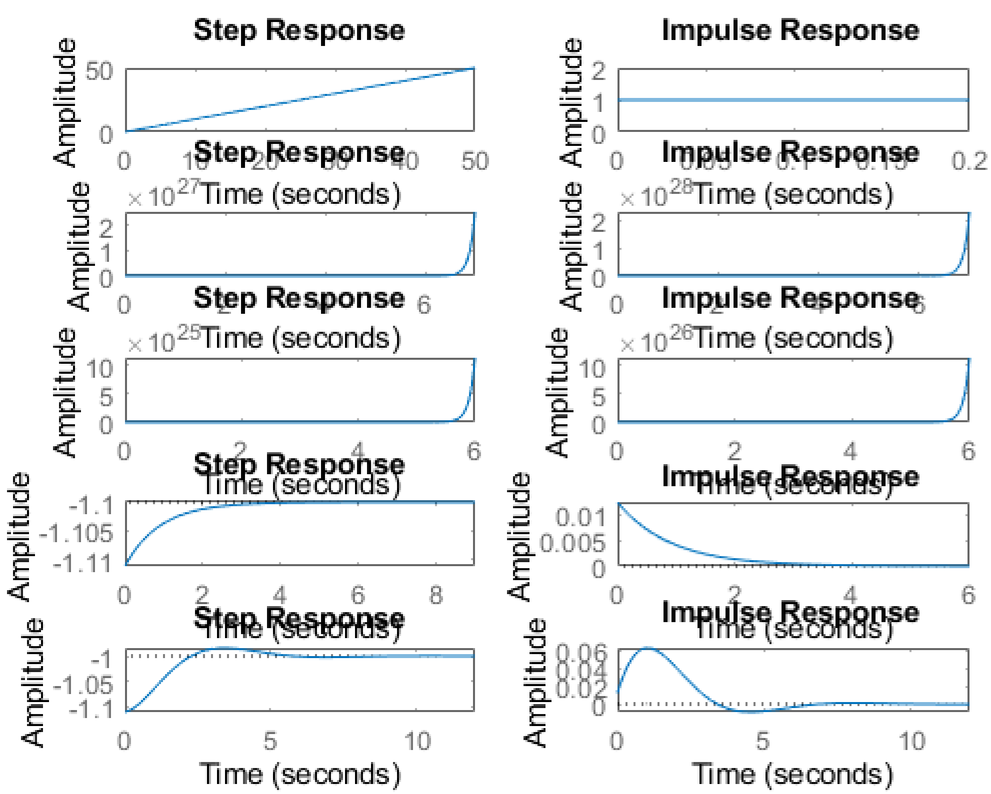
```
impulse(sys_PD_P)
S = stepinfo(sys_PD_P)
p_pd=pole(sys_PD_P)
z_pd=zero(sys_PD_P)

T=1
Kp=10;
D=tf([10,1],[0,1]);  %Kd
I=tf([10],[1,0]);  %Ki
PID=Kp+D+I;
sys = PID*tf([1],[T,1]);
sys_PID_P=feedback(sys,-1);
subplot(5,2,9)
step(sys_PID_P)
subplot(5,2,10)
impulse(sys_PID_P)
S = stepinfo(sys_PID_P)
p_pid=pole(sys_PID_P)
z_pid=zero(sys_PID_P)
```

```
T =

     1


sys =

    1
  -----
  s + 1

Continuous-time transfer function.


sys_P =

  1
  -
  s

Continuous-time transfer function.


S =

  struct with fields:

        RiseTime: NaN
    SettlingTime: NaN
```

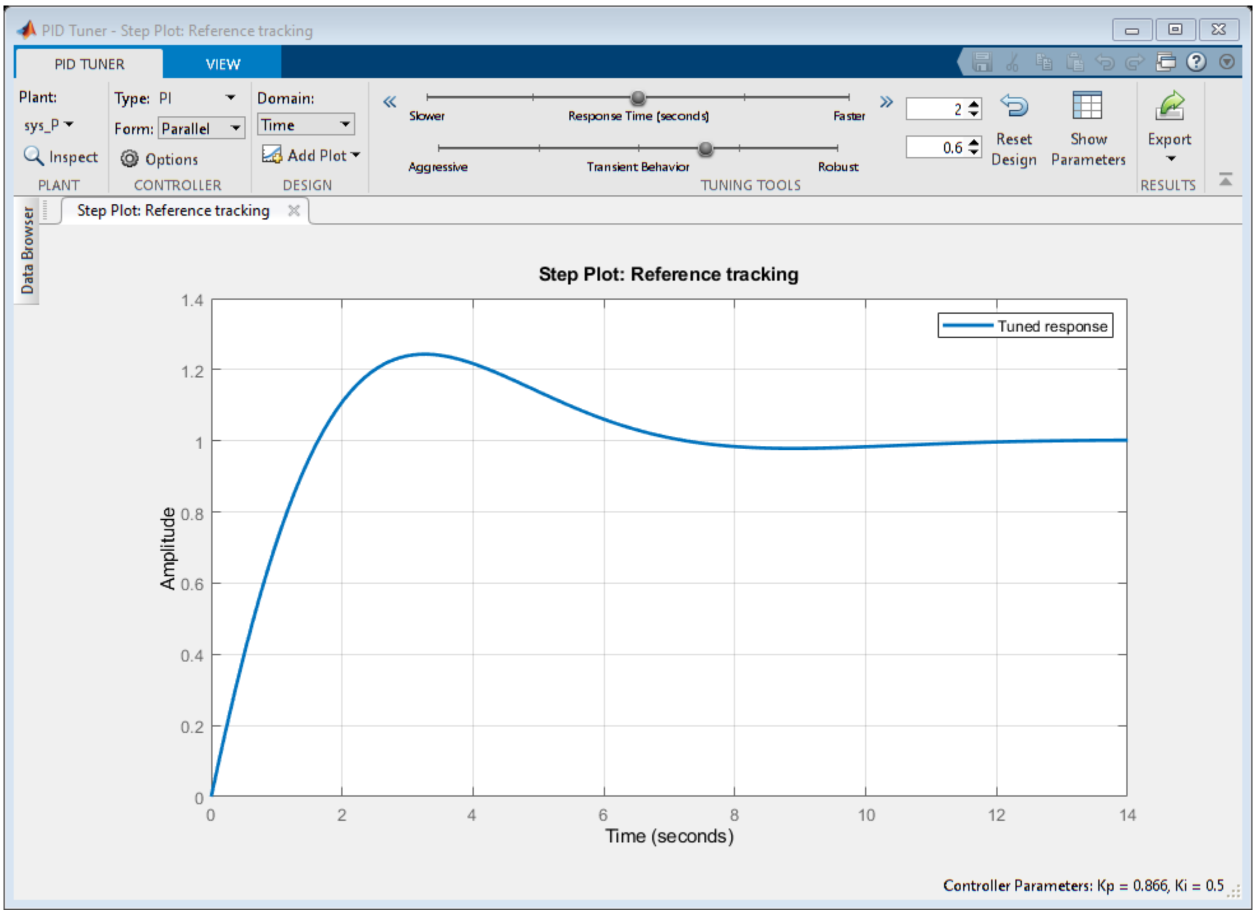
```
     SettlingMin: NaN
     SettlingMax: NaN
       Overshoot: NaN
      Undershoot: NaN
            Peak: Inf
        PeakTime: Inf


p1 =

     0


z1 =

  0×1 empty double column vector


S =

  struct with fields:

        RiseTime: NaN
    SettlingTime: NaN
     SettlingMin: NaN
     SettlingMax: NaN
       Overshoot: NaN
      Undershoot: NaN
            Peak: Inf
        PeakTime: Inf


p_g =

     9


z_g =

  0×1 empty double column vector


S =

  struct with fields:

        RiseTime: NaN
    SettlingTime: NaN
     SettlingMin: NaN
     SettlingMax: NaN
```

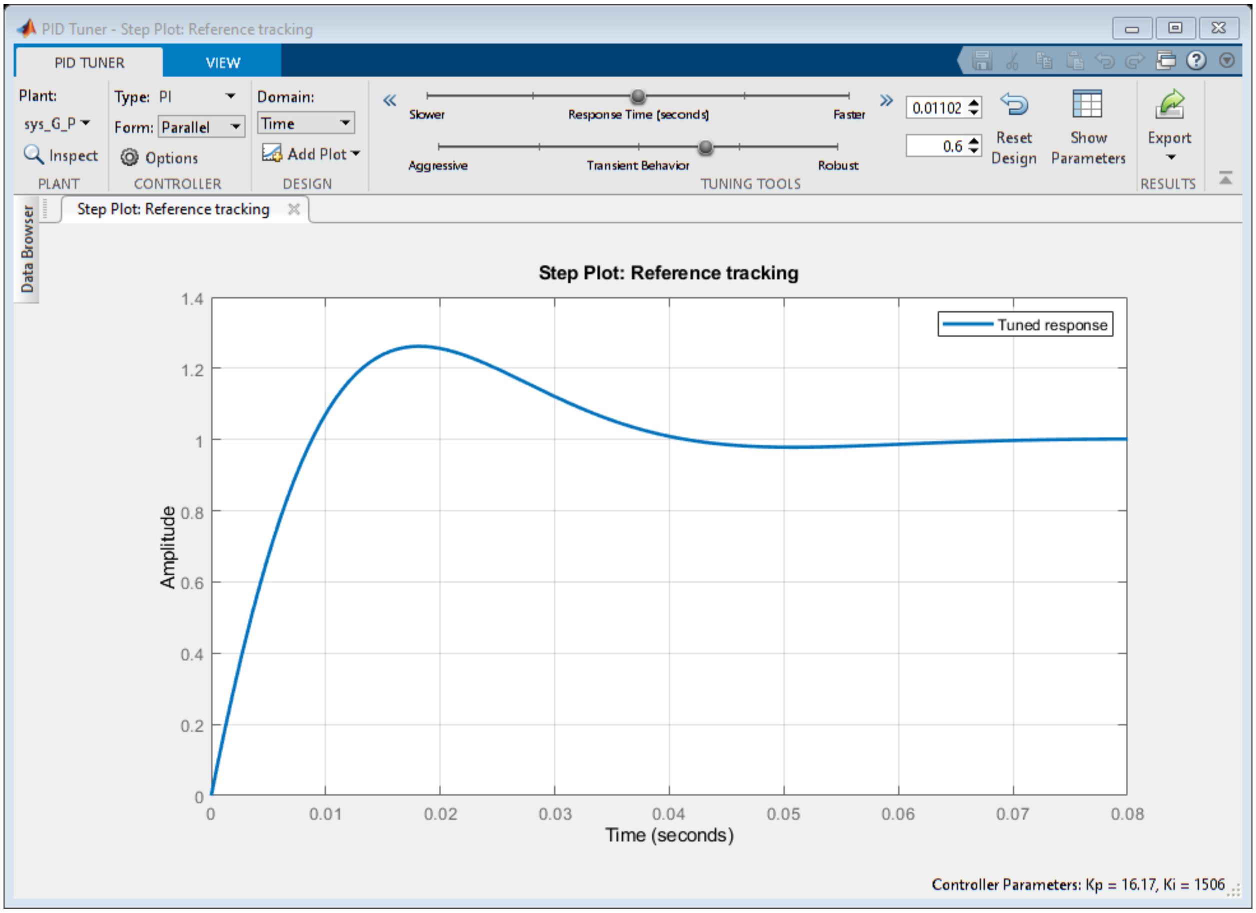
```
       Overshoot: NaN
      Undershoot: NaN
            Peak: Inf
        PeakTime: Inf


p_pi =

    10
    -1


z_pi =

    -1


S =

  struct with fields:

        RiseTime: 1.9773
    SettlingTime: 3.5209
     SettlingMin: -1.1011
     SettlingMax: -1.1000
       Overshoot: 1.0101
      Undershoot: 0
            Peak: 1.1111
        PeakTime: 0


p_pd =

   -1.1111


z_pd =

   -1.1000


T =

     1


S =

  struct with fields:
```

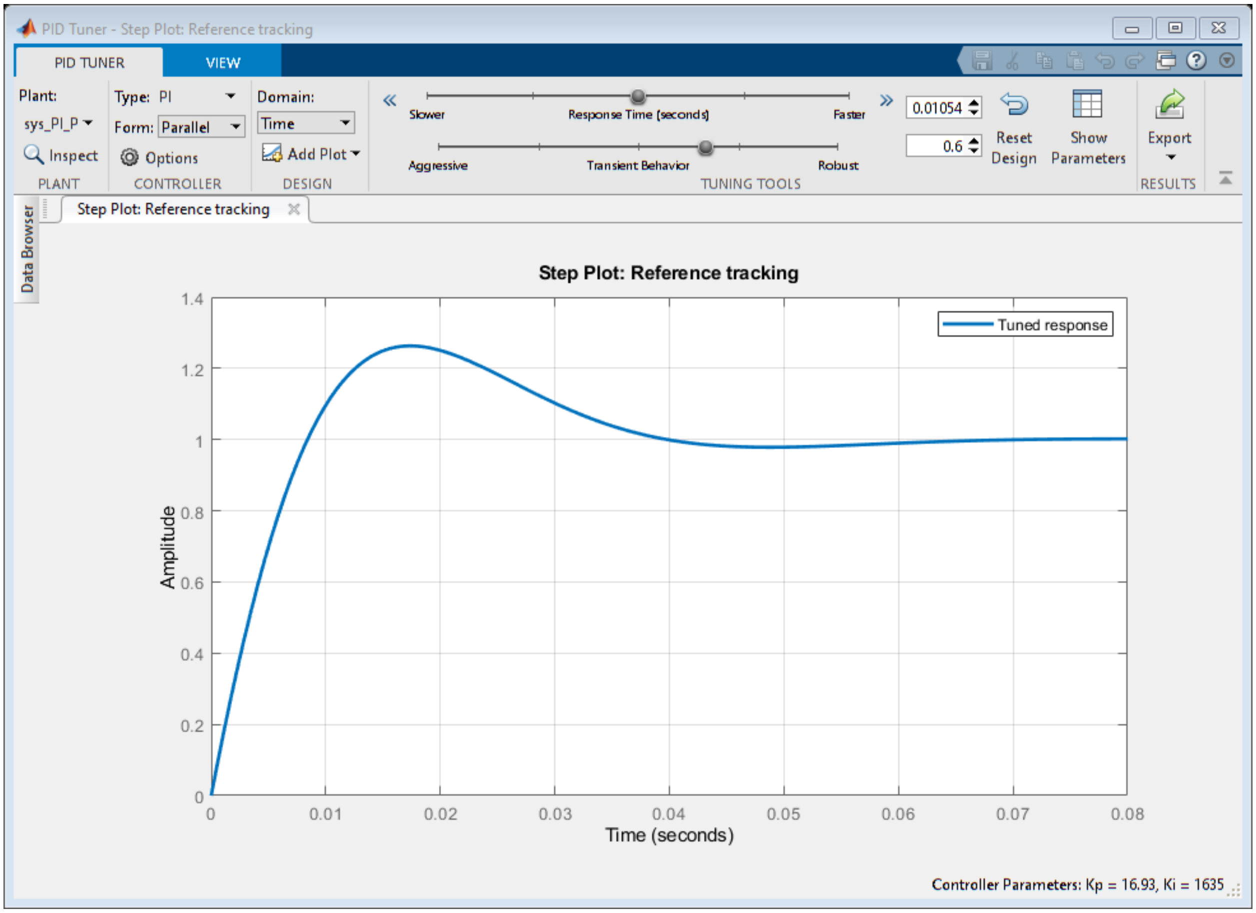
```
        RiseTime: 1.5943
    SettlingTime: 7.1081
     SettlingMin: -1.0101
     SettlingMax: -0.9841
       Overshoot: 11.1111
      Undershoot: 0
            Peak: 1.1111
        PeakTime: 0


p_pid =

  -0.5556 + 0.8958i
  -0.5556 - 0.8958i


z_pid =

  -0.5500 + 0.8352i
  -0.5500 - 0.8352i
```

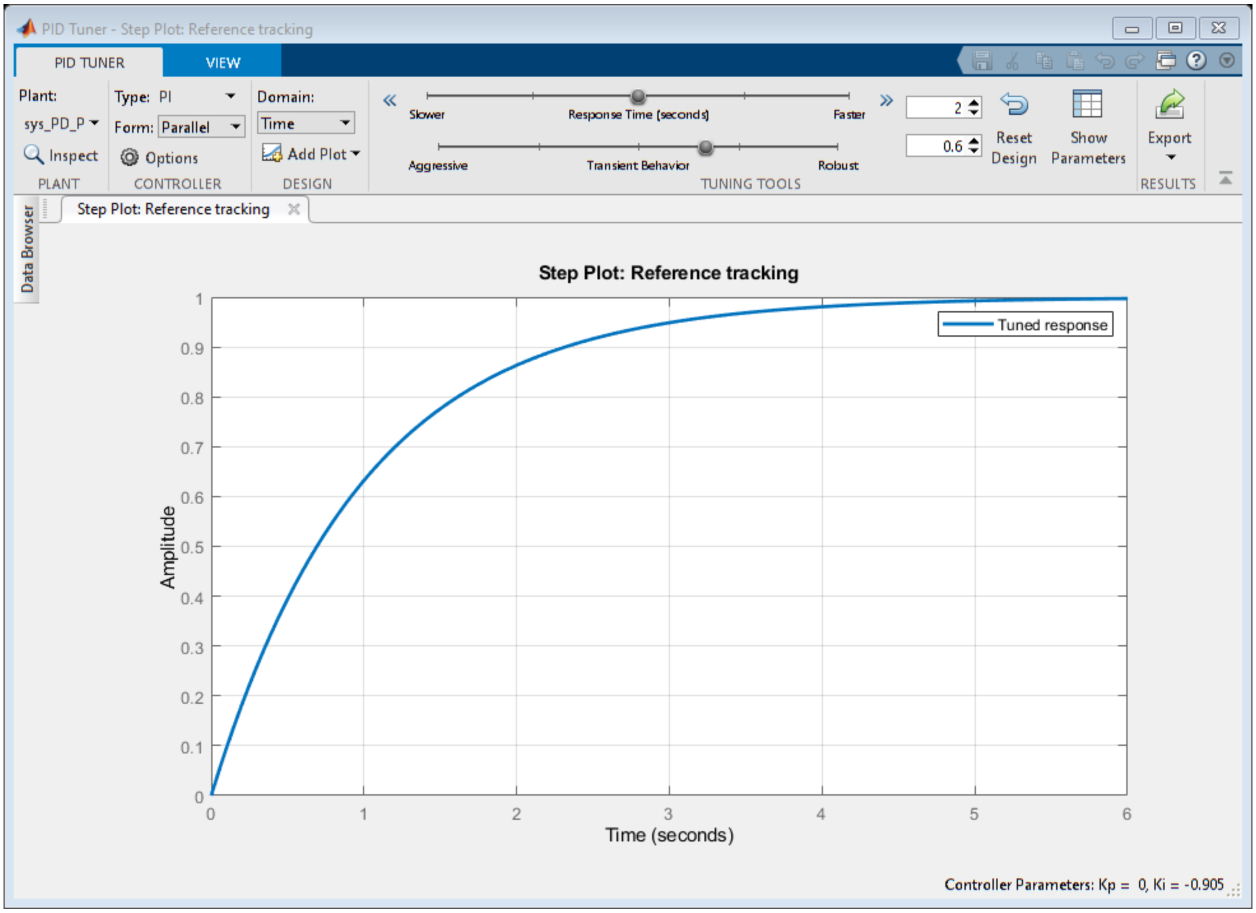


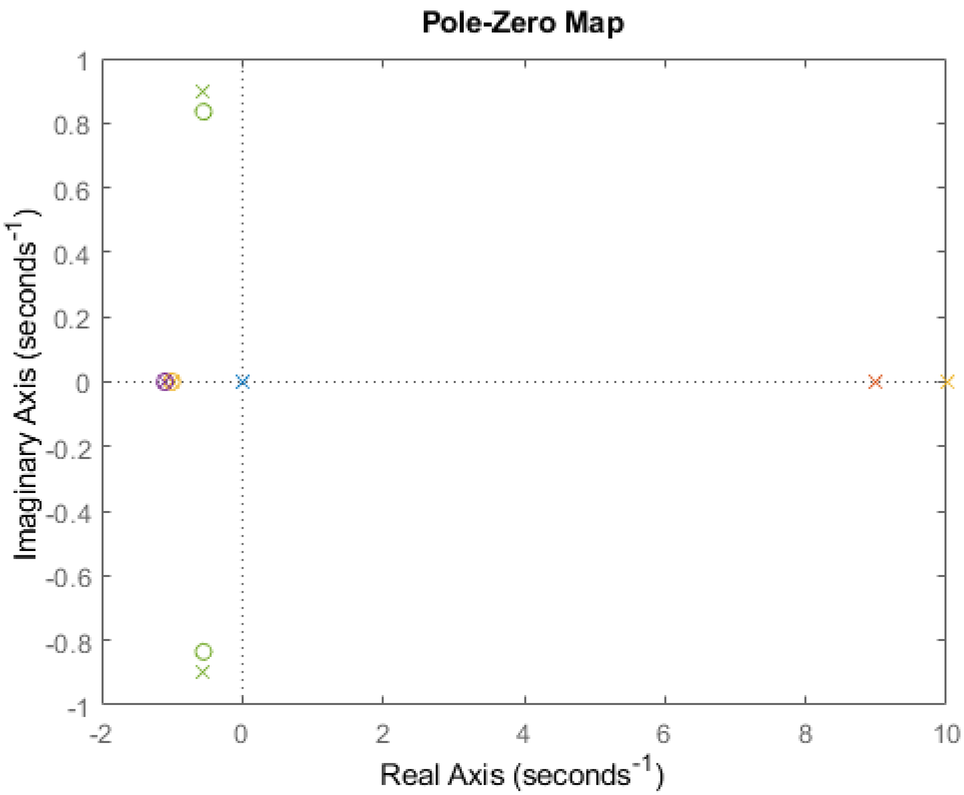
```
figure
hold on
pzmap(sys_P)
pzmap(sys_G_P)
pzmap(sys_PI_P)
pzmap(sys_PD_P)
pzmap(sys_PID_P)


pidTuner(sys_P)
pidTuner(sys_G_P)
pidTuner(sys_PI_P)
pidTuner(sys_PD_P)
pidTuner(sys_PID_P)
```

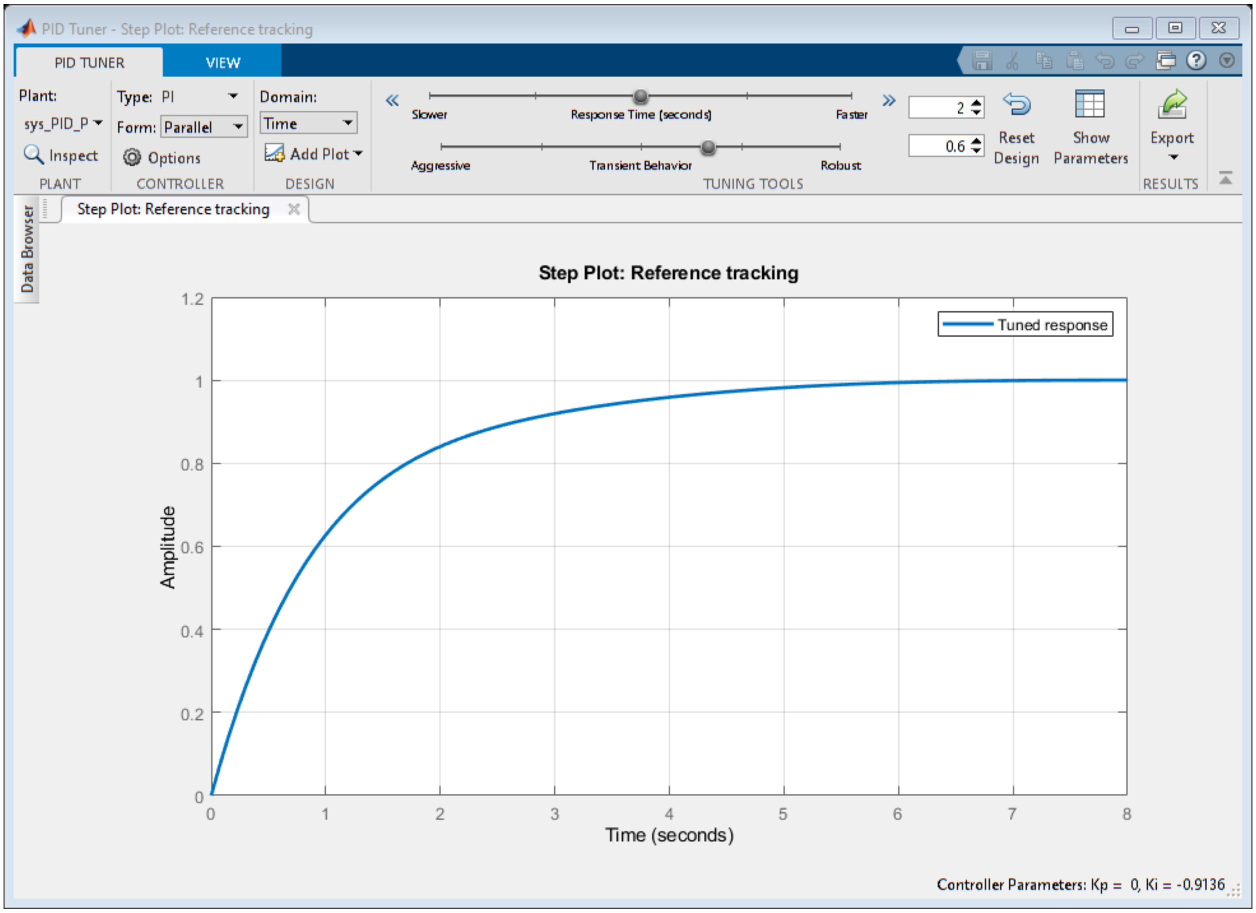



PID Tuner - Step Plot: Reference tracking
PID TUNER
VIEW
Plant:
sys_G_P
Inspect
PLANT
Type: PI
Form: Parallel
Options
CONTROLLER
Domain:
Time
Add Plot
DESIGN
Slower
Response Time (seconds)
Faster
Aggressive
Transient Behavior
Robust
TUNING TOOLS
0.01102
0.6
Reset Design
Show Parameters
Export
RESULTS
Data Browser
Step Plot: Reference tracking
Step Plot: Reference tracking
Tuned response
Amplitude
Time (seconds)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
Controller Parameters: Kp = 16.17, Ki = 1506


PID Tuner - Step Plot: Reference tracking
PID TUNER
VIEW
Plant:
sys_PI_P
Inspect
Type: PI
Form: Parallel
Options
Domain:
Time
Add Plot
PLANT
CONTROLLER
DESIGN
Slower
Response Time (seconds)
Faster
Aggressive
Transient Behavior
Robust
TUNING TOOLS
0.01054
0.6
Reset Design
Show Parameters
Export
RESULTS
Data Browser
Step Plot: Reference tracking
Step Plot: Reference tracking
Tuned response
Amplitude
Time (seconds)
Controller Parameters: Kp = 16.93, Ki = 1635


PID Tuner - Step Plot: Reference tracking
PID TUNER
VIEW
Plant:
sys_PD_P
Inspect
PLANT
Type: PI
Form: Parallel
Options
CONTROLLER
Domain:
Time
Add Plot
DESIGN
Slower
Response Time (seconds)
Faster
Aggressive
Transient Behavior
Robust
TUNING TOOLS
2
0.6
Reset Design
Show Parameters
Export
RESULTS
Data Browser
Step Plot: Reference tracking
Step Plot: Reference tracking
Tuned response
Amplitude
Time (seconds)
Controller Parameters: Kp = 0, Ki = -0.905


Pole-Zero Map
Imaginary Axis (seconds^{-1})
Real Axis (seconds^{-1})
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-2
0
2
4
6
8
10



Analysis

1.With the positive feed back system by giving the gain as 10 we got a

```
%pole at p=9 that says that system is unstable.
% 2.with the Positive feed back system by givng the PI controller we got 2
% poles 1 at p1=10,p2=-1 and 1 zero at z1=-1 so the pole and one zero
% nullify each other and left a pole on the left side of imaginary axis
% making the system stable.
% 3.With the Pd controller we can see that 1 zero is getting added, and 1
% pole is getting fixated at -1.1111 and a zero at -1.10000 as pole is
% located at the left side of the imaginary axis the system is stable with
% a rise time 1.9773, and settling time of 3.5209 with a overshoot of 1.010
% 4.With the PID controller we can see that w eare getting complex
% conjugate poles and pair. p1=-0.5556+0.8958i,p2=-0.5556-0.8958i and
% zeroes arwe z1=-0.5500+0.8352i, z2=-0.5500-0.8352i anfd the s_t=7.1081,
% R_t=1.5943
% 5.So By observing the above mentioned settling time and rise time of the
% different controllers we are getting a stable system with PID controller.
```

With Negative feedback

```
figure
T=1;
sys = tf([1],[T,1])
sys_N=feedback(sys,1)
subplot(5,2,1)
step(sys_N)
subplot(5,2,2)
impulse(sys_N)
S = stepinfo(sys_N)
p_n=pole(sys_N)
z_n=zero(sys_N)

T=1;
CF=10;
sys = CF*tf([1],[T,1])
sys_G_N=feedback(sys,1)
subplot(5,2,3)
step(sys_G_N)
subplot(5,2,4)
impulse(sys_G_N)
S = stepinfo(sys_G_N)
p_gn=pole(sys_G_N)
z_gn=zero(sys_G_N)

T=1;
Kp=10;
I=tf([10,0],[1,0]);  %Ki
PI=Kp+I;
sys = PI*tf([1],[T,1])
sys_PI_N=feedback(sys,1)
subplot(5,2,5)
step(sys_PI_N)
subplot(5,2,6)
impulse(sys_PI_N)
S = stepinfo(sys_PI_N)
p_npi=pole(sys_PI_N)
z_npi=zero(sys_PI_N)

T=1;
Kp=10;
D=tf([10,1],[0,1]);  %Kd
PD=Kp+D;
sys = PD*tf([1],[T,1])
sys_PD_N=feedback(sys,1)
subplot(5,2,7)
step(sys_PD_N)
subplot(5,2,8)
```

```
impulse(sys_PD_N)
S = stepinfo(sys_PD_N)
p_npd=pole(sys_PD_N)
z_npd=zero(sys_PD_N)

T=1;
Kp=10;
D=tf([10,1],[0,1])  %Kd
I=tf([10],[1,0])  %Ki
PID=Kp+D+I
sys = PID*tf([1],[T,1])
sys_PID_N=feedback(sys,1)
subplot(5,2,9)
step(sys_PID_N)
subplot(5,2,10)
impulse(sys_PID_N)
S = stepinfo(sys_PID_N)
p_npid=pole(sys_PID_N)
z_npid=zero(sys_PID_N)
```

```
sys =

    1
  -----
  s + 1

Continuous-time transfer function.


sys_N =

    1
  -----
  s + 2

Continuous-time transfer function.


S =

  struct with fields:

        RiseTime: 1.0985
    SettlingTime: 1.9560
     SettlingMin: 0.4523
     SettlingMax: 0.5000
       Overshoot: 0
      Undershoot: 0
            Peak: 0.5000
```

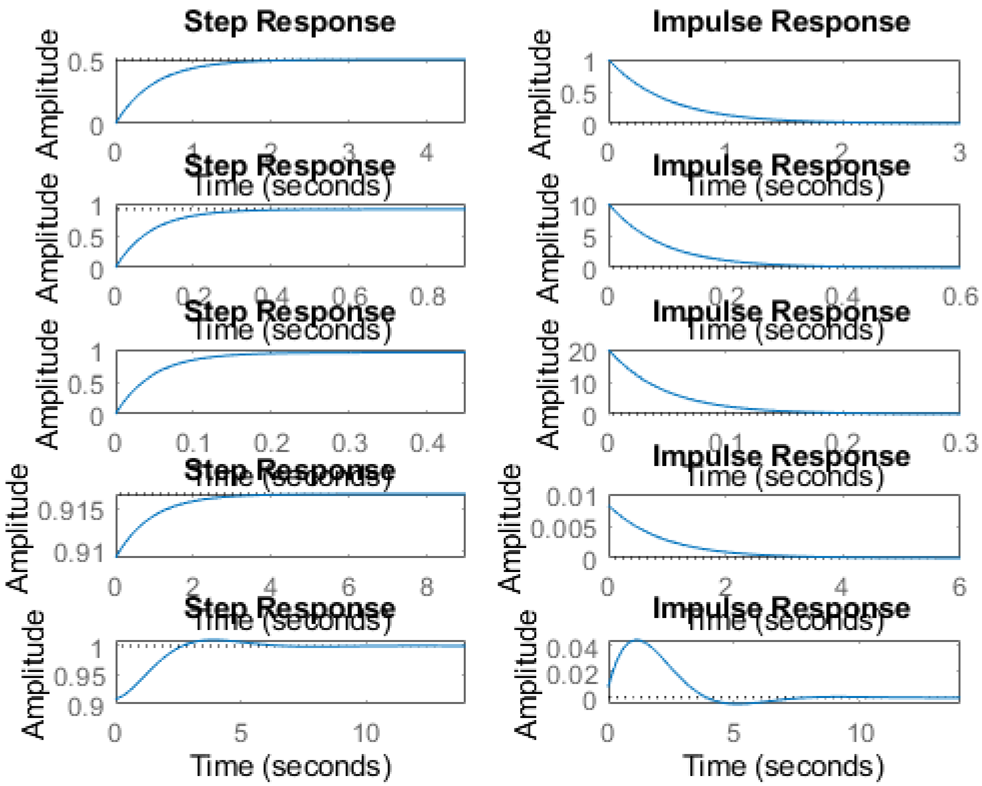
```
        PeakTime: 5.2729


p_n =

    -2


z_n =

  0×1 empty double column vector


sys =

   10
  -----
  s + 1

Continuous-time transfer function.


sys_G_N =

    10
  ------
  s + 11

Continuous-time transfer function.


S =

  struct with fields:

        RiseTime: 0.1997
    SettlingTime: 0.3556
     SettlingMin: 0.8223
     SettlingMax: 0.9091
       Overshoot: 0
      Undershoot: 0
            Peak: 0.9091
        PeakTime: 0.9587


p_gn =

   -11
```

```
z_gn =

  0x1 empty double column vector


sys =

   20 s
  -------
  s^2 + s

Continuous-time transfer function.


sys_PI_N =

     20 s
  ----------
  s^2 + 21 s

Continuous-time transfer function.


S =

  struct with fields:

        RiseTime: 0.1046
    SettlingTime: 0.1863
     SettlingMin: 0.8614
     SettlingMax: 0.9524
       Overshoot: 0
      Undershoot: 0
            Peak: 0.9524
        PeakTime: 0.5022


p_npi =

     0
   -21


z_npi =

     0


sys =
```

```
  10 s + 11
  ---------
    s + 1

Continuous-time transfer function.


sys_PD_N =

  10 s + 11
  ---------
  11 s + 12

Continuous-time transfer function.


S =

  struct with fields:

        RiseTime: 2.0139
    SettlingTime: 3.5861
     SettlingMin: 0.9159
     SettlingMax: 0.9167
       Overshoot: 0
      Undershoot: 0
            Peak: 0.9167
        PeakTime: 9.6670


p_npd =

   -1.0909


z_npd =

   -1.1000


D =

  10 s + 1

Continuous-time transfer function.


I =

  10
```

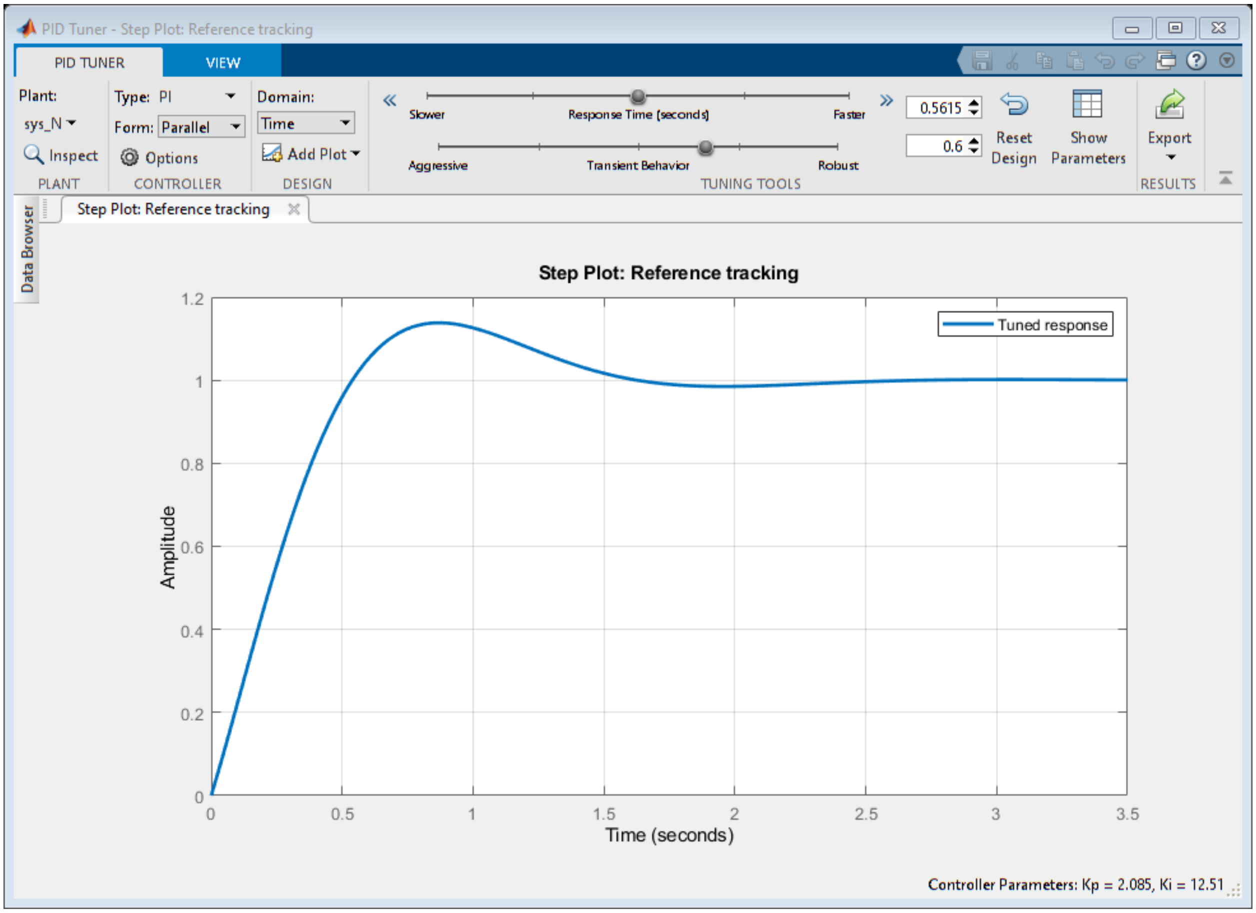
```
  --
  s

Continuous-time transfer function.


PID =

  10 s^2 + 11 s + 10
  ------------------
          s

Continuous-time transfer function.


sys =

  10 s^2 + 11 s + 10
  ------------------
       s^2 + s

Continuous-time transfer function.


sys_PID_N =

  10 s^2 + 11 s + 10
  ------------------
  11 s^2 + 12 s + 10

Continuous-time transfer function.


S =

  struct with fields:

        RiseTime: 1.8654
    SettlingTime: 6.0686
     SettlingMin: 0.9929
     SettlingMax: 1.0102
       Overshoot: 1.0208
      Undershoot: 0
            Peak: 1.0102
        PeakTime: 3.8837


p_npid =

  -0.5455 + 0.7820i
```

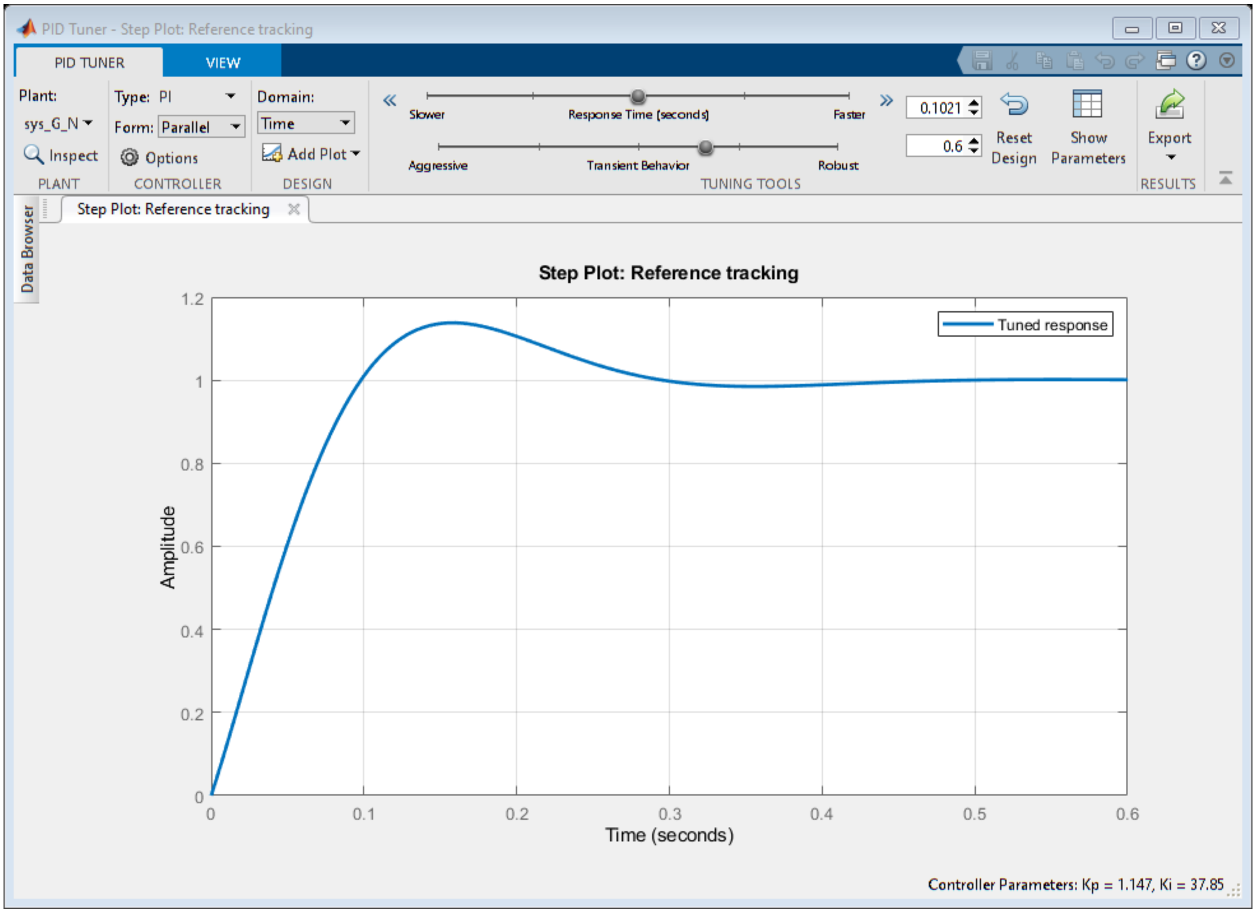
```
  -0.5455 - 0.7820i


z_npid =

  -0.5500 + 0.8352i
  -0.5500 - 0.8352i
```

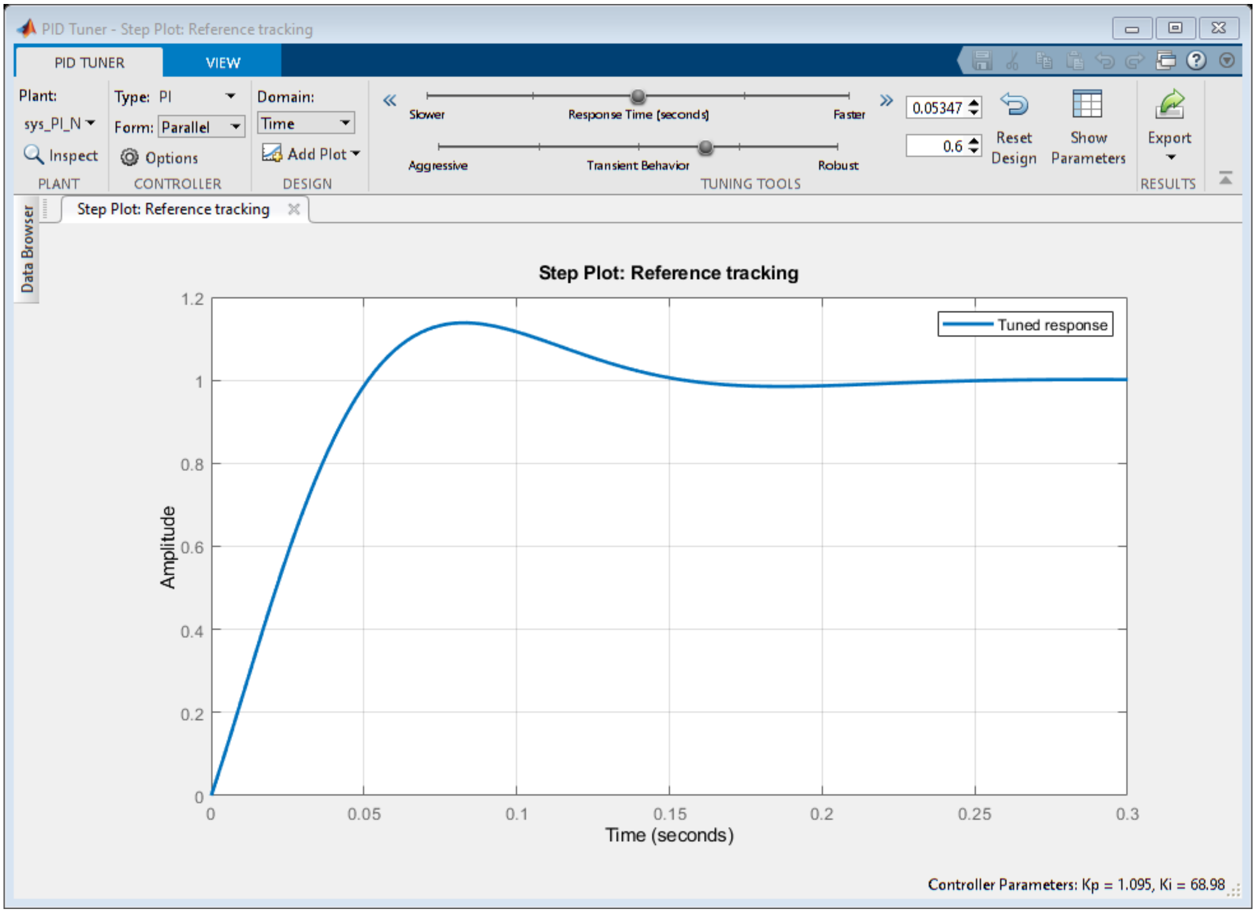


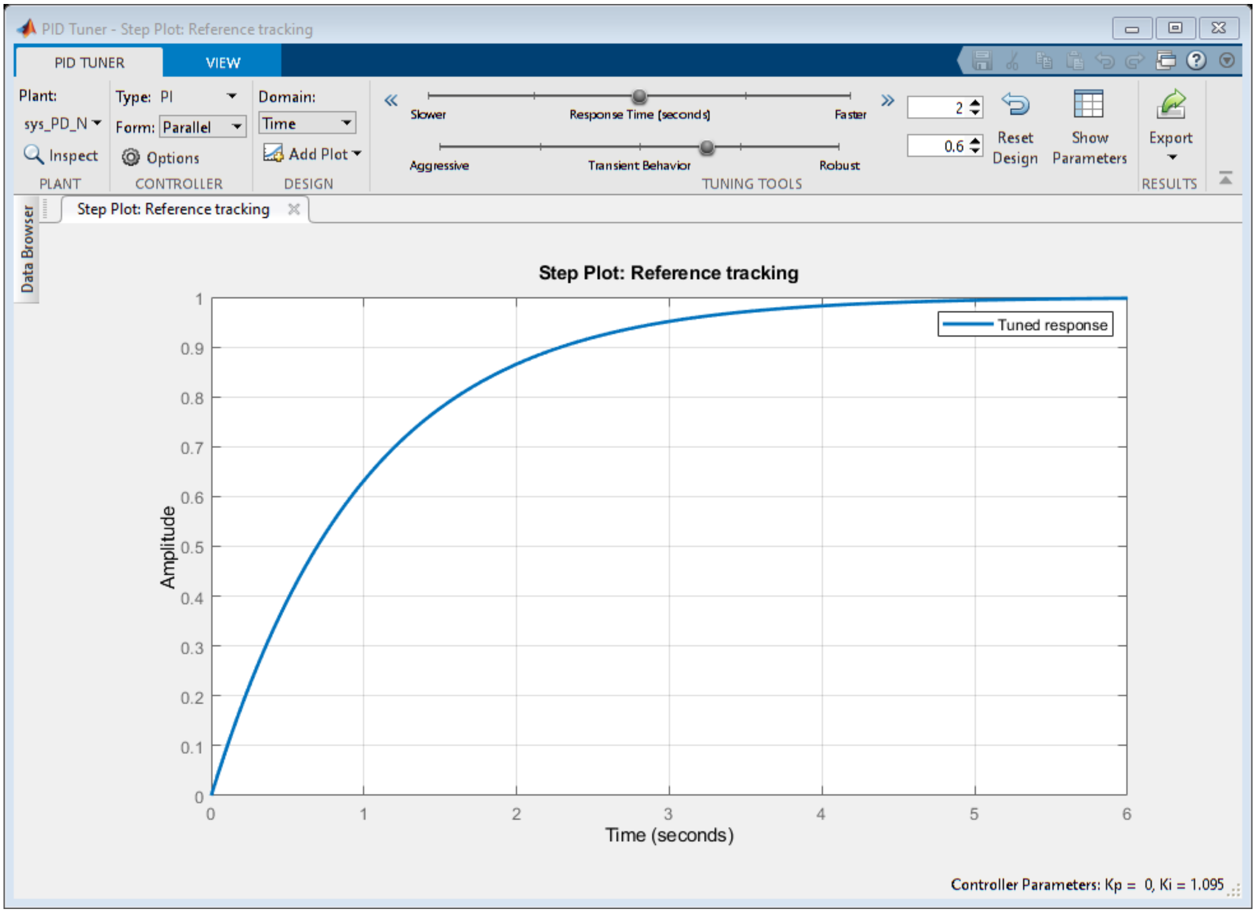

```
figure
hold on
pzmap(sys_N)
pzmap(sys_G_N)
pzmap(sys_PI_N)
pzmap(sys_PD_N)
pzmap(sys_PID_N)


pidTuner(sys_N)
pidTuner(sys_G_N)
pidTuner(sys_PI_N)
```

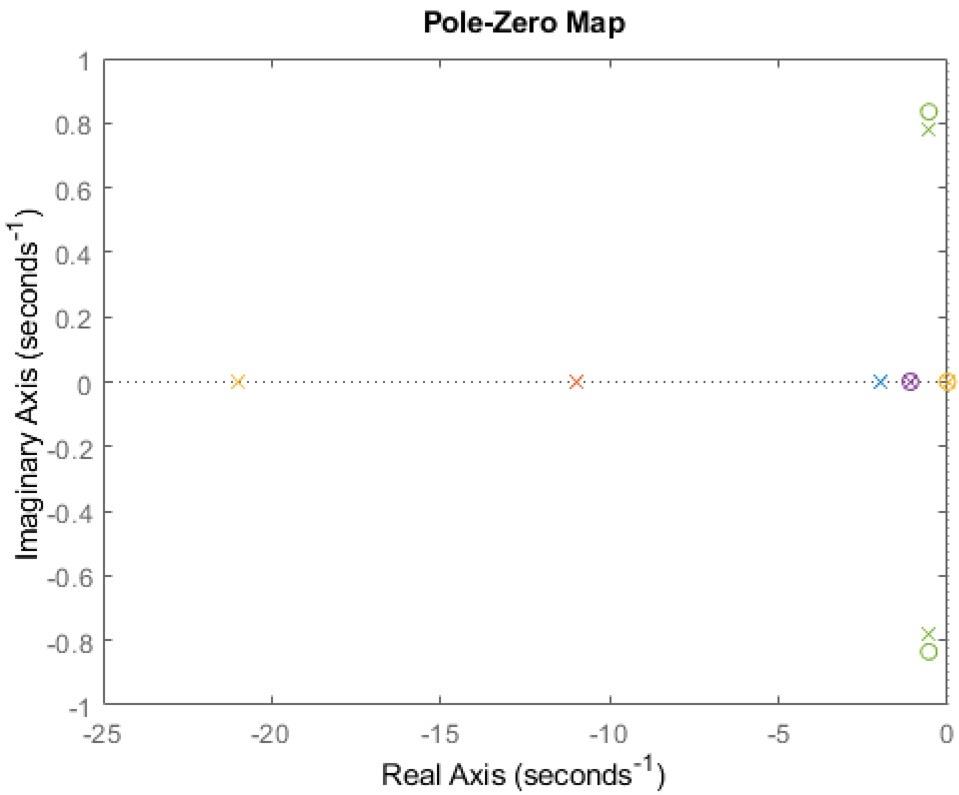
```
pidTuner(sys_PD_N)
pidTuner(sys_PID_N)
```

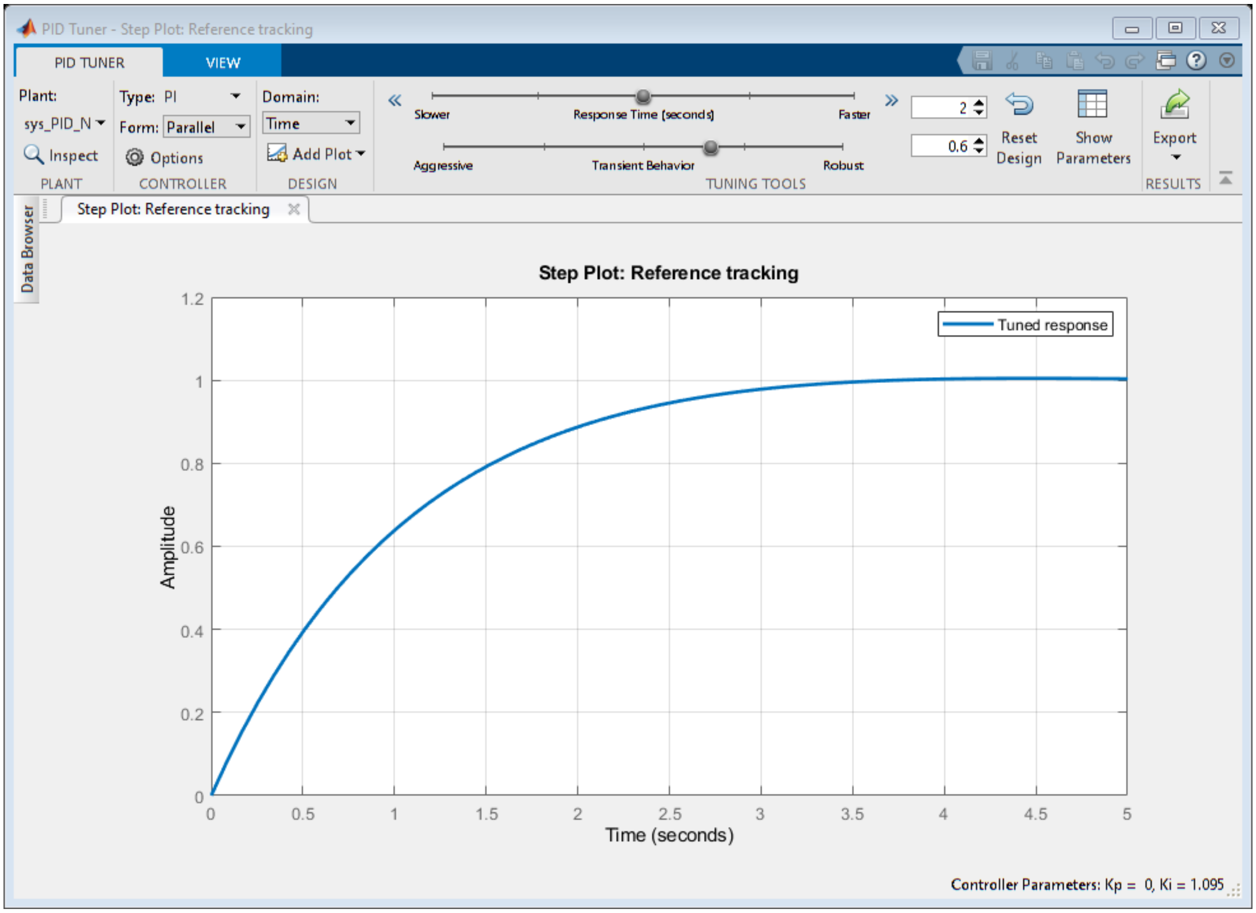



PID Tuner - Step Plot: Reference tracking
PID TUNER
VIEW
Plant:
sys_G_N
Inspect
PLANT
Type: PI
Form: Parallel
Options
CONTROLLER
Domain:
Time
Add Plot
DESIGN
Slower
Response Time (seconds)
Faster
Aggressive
Transient Behavior
Robust
TUNING TOOLS
0.1021
0.6
Reset Design
Show Parameters
Export
RESULTS
Data Browser
Step Plot: Reference tracking
Step Plot: Reference tracking
Tuned response
Amplitude
Time (seconds)
Controller Parameters: Kp = 1.147, Ki = 37.85


PID Tuner - Step Plot: Reference tracking
PID TUNER
VIEW
Plant:
sys_PI_N
Inspect
PLANT
Type: PI
Form: Parallel
Options
CONTROLLER
Domain:
Time
Add Plot
DESIGN
Slower
Response Time (seconds)
Faster
Aggressive
Transient Behavior
Robust
TUNING TOOLS
0.05347
0.6
Reset Design
Show Parameters
Export
RESULTS
Data Browser
Step Plot: Reference tracking
Step Plot: Reference tracking
Tuned response
Amplitude
Time (seconds)
Controller Parameters: Kp = 1.095, Ki = 68.98


PID Tuner - Step Plot: Reference tracking
PID TUNER
VIEW
Plant:
sys_PD_N
Inspect
PLANT
Type: PI
Form: Parallel
Options
CONTROLLER
Domain:
Time
Add Plot
DESIGN
Slower
Response Time (seconds)
Faster
Aggressive
Transient Behavior
Robust
TUNING TOOLS
2
0.6
Reset Design
Show Parameters
Export
RESULTS
Data Browser
Step Plot: Reference tracking
Step Plot: Reference tracking
Tuned response
Amplitude
Time (seconds)
Controller Parameters: Kp = 0, Ki = 1.095


Pole-Zero Map
Imaginary Axis (seconds^{-1})
Real Axis (seconds^{-1})
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-25
-20
-15
-10
-5
0



Analysis

1.with negaitve feed back gain we get 1 pole at p1=-11 which has a rise time of 0.1997, settling time of 0.3556 the system is stable. 2.with negative feed back Pi controller we get 2 poles at p1=-10,p2=-1 and a zero at z=-1, because of integrator in PI controller we are getting an extra pole in it now Risetime=0.2197,settling time=0.3912 as the poles are on the left side of imaginary axis we can say that system is stable. 3.with a negative feed back PID controller we are getting complex conjugate poles and zeroes which are z1=-0.5500+0.8352i,z2=-0.5500-0.8352i,p1=-0.5455+0.7820i, p2=-0.5455+0.7820i the settling time is 1.8654 and the rise time is6.0686 so we can say that PID controller can not make the system more stable than PI and PD controllers did.

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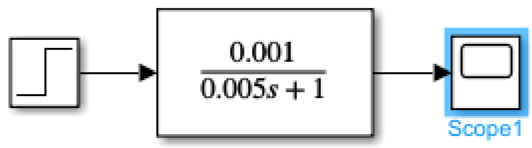
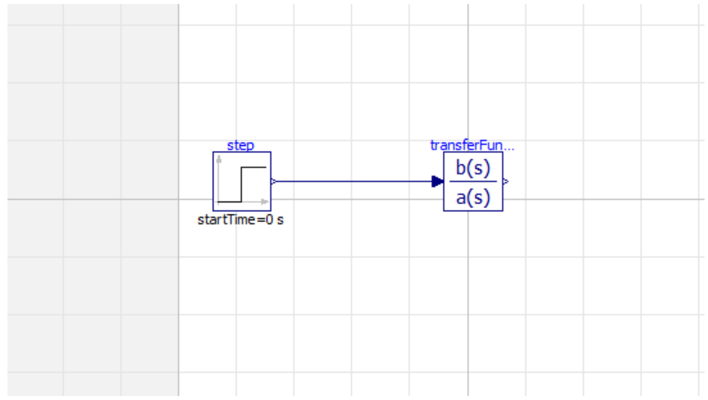
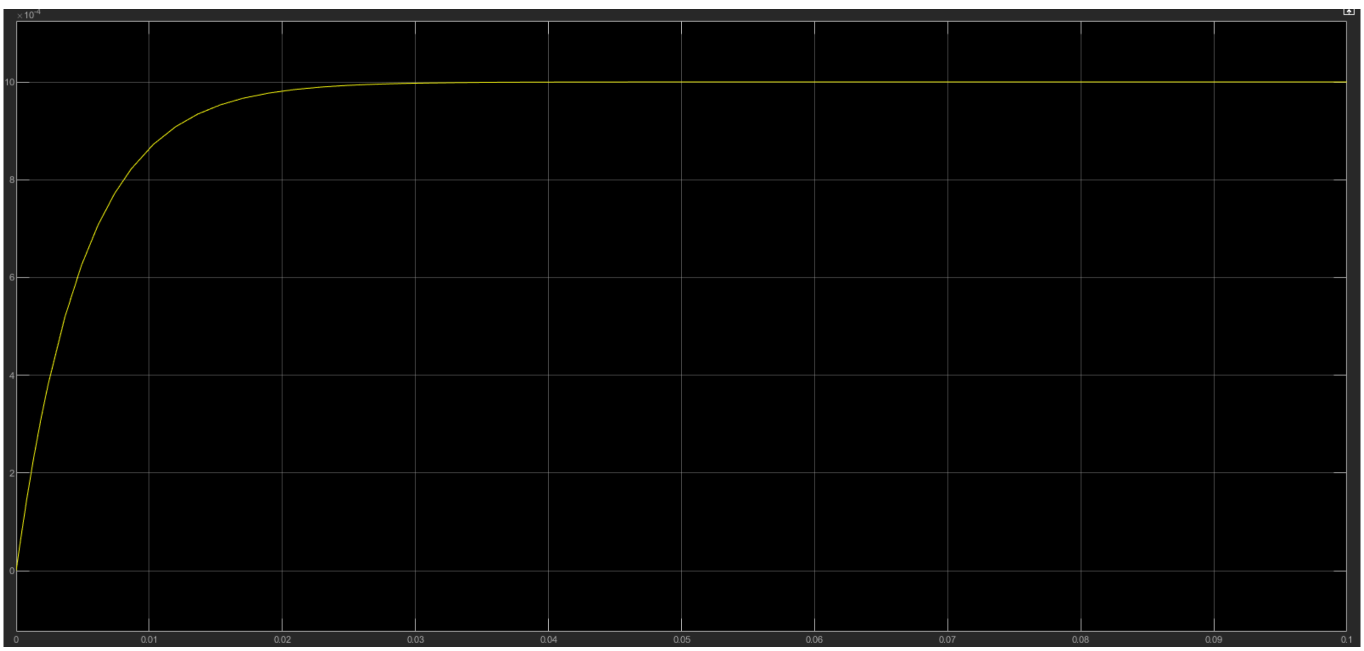
Comparison between Simulink & Modellica:

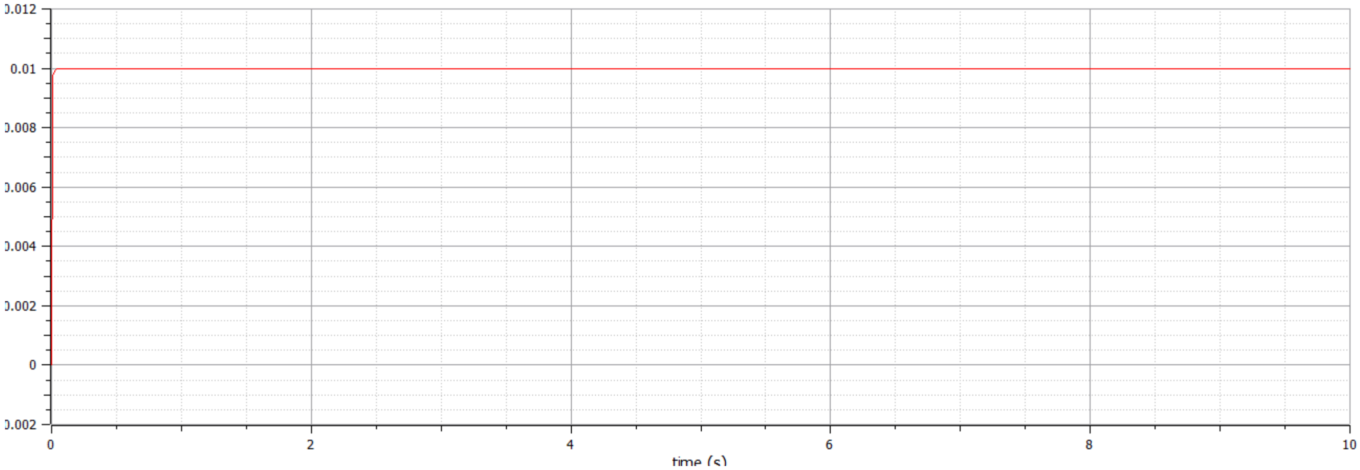




Model designing in Simulink & Modellica



Simulink First Order Graph



First Order Graph in modellica

Analysis:

We took the same values in the transfer function and when we have done the model in Simulink and modellica so when we compare the step response we got the same values for both the models.

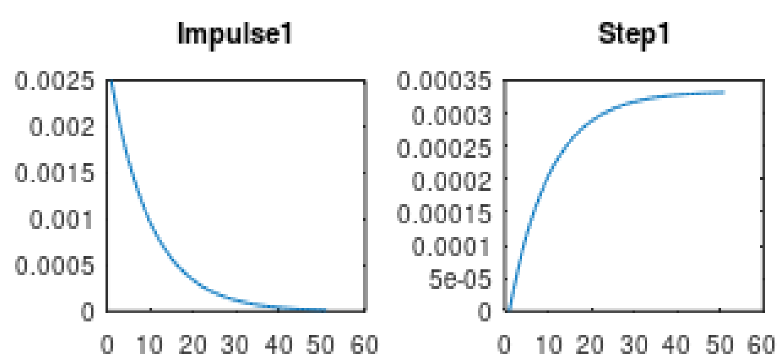
Comparison between Matlab Script and GNU Octave Script:

```
%% Title:Control System-First Order System: System analysis by changing gain
%Author:Shivakumar Naga Vankadhara
%PS No:99003727
%Date:7/04/2021
%Version:R2020b

%% This Document has equation for motion differential system
%Equation:mdv/dt+bv=u

%% Math analysis
%dependent variables:v
%independent variables:t,u
%constant:m,b
%Root:-b/m

%% Changing the gain of system
%gain is 1
m1=400;
b1=3000;
Tau=m1/b1;
TF1=tf([0,1/b1],[Tau,1])
T_R=4*Tau;
risetime=2.2/(b1/m1)
delaytime=1/(b1/m1)
settlingtime=4/(b1/m1)
steadystatevalue=1/b1
subplot(3,3,1),plot(impulse(TF1))
title("Impulse1")
subplot(3,3,2),plot(step(TF1))
title("Step1")
figure(2)



pzmap(TF1)
```

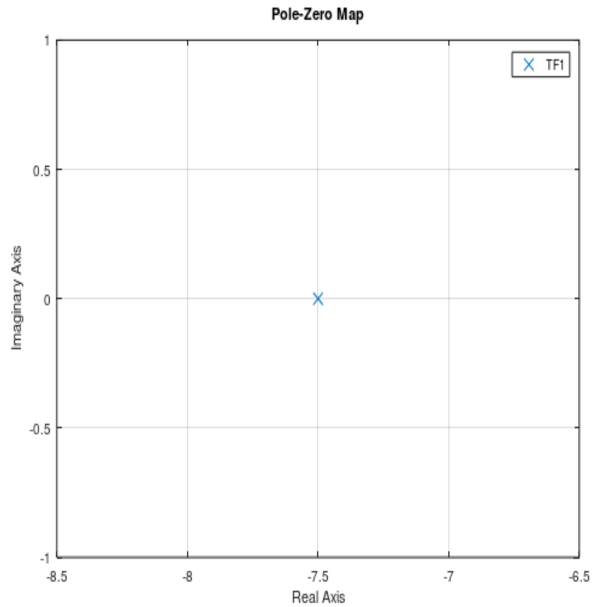
Octave First Order script

```
%% Title:Control System-First Order System: System analysis by changing gain
%Author:Shivakumar Naga Vankadhara
%PS No:99003727
%Date:10/04/2021
%Version:1.4

%% This Document has equation for motion differential system
%Equation:mdv/dt+bv=u

%% Math analysis
%dependent variables:v
%independent variables:t,u
%constant:m,b
%Root:-b/m

%% Changing the gain of system
%gain is 1
m1=400;
b1=3000;
Tau=m1/b1;
TF1=tf([0,1/b1],[Tau,1]);
T_R=4*Tau;
subplot(4,2,1),plot(impulse(TF1))
title("Impulse1")
subplot(4,2,2),plot(step(TF1))
title("Step1")
S = stepinfo(TF1)
```

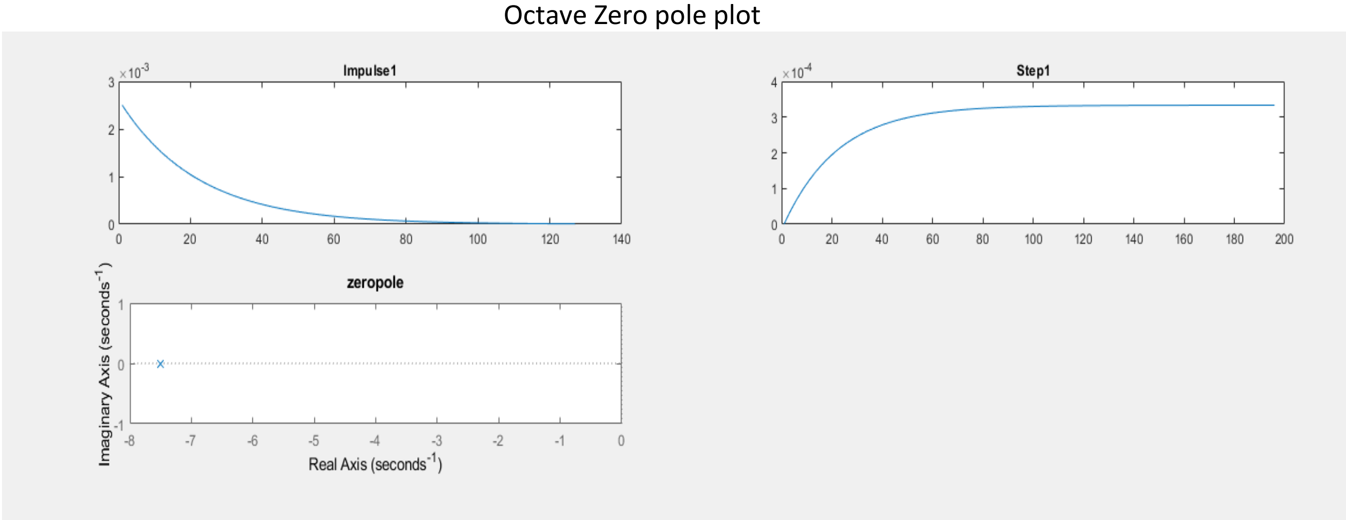
Matlab Script for First Order



Octave Script Step & Impulse Response



Octave Zero pole plot



Analysis:

For both the Octave scripting and Matlab scripting we got the same impulse response and step response and we also got the rise time, Settling time same in both the scripts.