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Discrete-Time Controller Design For Complete System

```
% Complete Plant
```

```
zeta=0.7;
```

```
wn=1;
```

```
Ts=0.3; % Because t_r = 3 sec therefore Ts < t_r/6
```

```
A= [0 1 0 0; -2.7451 -.2829 0 0; 0 0 0 1; 0 0 0 -.2701];
```

```
B= [0 0; 37.2021 3.5306; 0 0; 2.3892 7.461];
```

```
C= [1 0 0 0; 0 0 1 0];
```

```
D= [0];
```

```
G= ss(A,B,C,D)
```

```
G0=c2d(G,Ts)
```

```
G =
```

```
a =
```

	x1	x2	x3	x4
x1	0	1	0	0
x2	-2.745	-0.2829	0	0
x3	0	0	0	1
x4	0	0	0	-0.2701

```
b =
```

	u1	u2
x1	0	0
x2	37.2	3.531
x3	0	0
x4	2.389	7.461

```
c =
```

	x1	x2	x3	x4
y1	1	0	0	0
y2	0	0	1	0

```
d =
```

	u1	u2
y1	0	0
y2	0	0

Continuous-time state-space model.

G0 =

a =

	<i>x1</i>	<i>x2</i>	<i>x3</i>	<i>x4</i>
<i>x1</i>	0.8823	0.2759	0	0
<i>x2</i>	-0.7574	0.8043	0	0
<i>x3</i>	0	0	1	0.2882
<i>x4</i>	0	0	0	0.9222

b =

	<i>u1</i>	<i>u2</i>
<i>x1</i>	1.595	0.1513
<i>x2</i>	10.27	0.9742
<i>x3</i>	0.1047	0.3269
<i>x4</i>	0.6885	2.15

c =

	<i>x1</i>	<i>x2</i>	<i>x3</i>	<i>x4</i>
<i>y1</i>	1	0	0	0
<i>y2</i>	0	0	1	0

d =

	<i>u1</i>	<i>u2</i>
<i>y1</i>	0	0
<i>y2</i>	0	0

Sample time: 0.3 seconds

Discrete-time state-space model.

Contollers

Ts=0.3

K_1=tf([1 -1.687 .9186],[1 -1.6208 .6208],Ts);

*K_p=0.0227*K_1;*

Kp_s= ss(K_p)

K2=tf([1 -0.89] ,[1 -0.6],Ts);

K3=tf([1 -0.991],[1 -0.999],Ts);

*K_y=0.113*K3*K2;*

Ky_s= ss(K_y)

TS =

0.3000

Kp_s =

```
a =
      x1      x2
x1    1.621  -0.6208
x2      1      0
```

```
b =
      u1
x1    0.125
x2      0
```

```
c =
      x1      x2
y1  -0.01202  0.05408
```

```
d =
      u1
y1    0.0227
```

Sample time: 0.3 seconds
Discrete-time state-space model.

Ky_s =

```
a =
      x1      x2
x1    1.599  -0.5994
x2      1      0
```

```
b =
      u1
x1    0.25
x2      0
```

```
c =
      x1      x2
y1  -0.1275  0.1277
```

```
d =
      u1
y1    0.113
```

Sample time: 0.3 seconds
Discrete-time state-space model.

Combining

```
clc
Kp_s
Ky_s
K= append(Kp_s,Ky_s)
```

```

G0
Gol = series(K,G0)

Gcl= feedback(Gol,eye(2))
step(Gcl)
s=stepinfo(Gcl)
s(1,1)
s(1,2)
s(2,1)
s(2,2)

[y,t,x]=step(Gcl);
plot(t,y(:, :, 1), '*')
grid
xlabel('time (s)')
title('Step Response of pitch reference to theta and psi')
hold on
plot(t,y(:, :, 2), '*')
grid
xlabel('time (s)')
title('Step Response of pitch and yaw reference to theta and psi')

```

Kp_s =

```

a =
      x1      x2
x1    1.621  -0.6208
x2      1      0

```

```

b =
      u1
x1    0.125
x2      0

```

```

c =
      x1      x2
y1  -0.01202  0.05408

```

```

d =
      u1
y1    0.0227

```

Sample time: 0.3 seconds
Discrete-time state-space model.

Ky_s =

```

a =
      x1      x2
x1    1.599  -0.5994
x2      1      0

```

```

b =
      u1
x1  0.25
x2   0

c =
      x1      x2
y1 -0.1275  0.1277

d =
      u1
y1  0.113

```

Sample time: 0.3 seconds
Discrete-time state-space model.

```

K =

a =
      x1      x2      x3      x4
x1  1.621 -0.6208      0      0
x2      1      0      0      0
x3      0      0  1.599 -0.5994
x4      0      0      1      0

b =
      u1      u2
x1  0.125      0
x2      0      0
x3      0  0.25
x4      0      0

c =
      x1      x2      x3      x4
y1 -0.01202  0.05408      0      0
y2      0      0 -0.1275  0.1277

d =
      u1      u2
y1  0.0227      0
y2      0  0.113

```

Sample time: 0.3 seconds
Discrete-time state-space model.

```

G0 =

a =
      x1      x2      x3      x4
x1  0.8823  0.2759      0      0
x2 -0.7574  0.8043      0      0
x3      0      0      1  0.2882

```

x4	0	0	0	0.9222
----	---	---	---	--------

b =

	u1	u2
x1	1.595	0.1513
x2	10.27	0.9742
x3	0.1047	0.3269
x4	0.6885	2.15

c =

	x1	x2	x3	x4
y1	1	0	0	0
y2	0	0	1	0

d =

	u1	u2
y1	0	0
y2	0	0

Sample time: 0.3 seconds
Discrete-time state-space model.

Gol =

a =

	x1	x2	x3	x4	x5
x6					
x1	0.8823	0.2759	0	0	-0.01917
0.08624					
x2	-0.7574	0.8043	0	0	-0.1234
0.5551					
x3	0	0	1	0.2882	-0.001258
0.00566					
x4	0	0	0	0.9222	-0.008277
0.03723					
x5	0	0	0	0	1.621
-0.6208					
x6	0	0	0	0	1
0					
x7	0	0	0	0	0
0					
x8	0	0	0	0	0
0					

	x7	x8
x1	-0.01929	0.01933
x2	-0.1242	0.1244
x3	-0.04166	0.04175
x4	-0.274	0.2746
x5	0	0
x6	0	0
x7	1.599	-0.5994
x8	1	0

```

b =
      u1      u2
x1  0.0362  0.0171
x2  0.233   0.1101
x3  0.002376 0.03693
x4  0.01563  0.243
x5  0.125    0
x6  0        0
x7  0        0.25
x8  0        0

```

```

c =
      x1  x2  x3  x4  x5  x6  x7  x8
y1  1    0    0    0    0    0    0    0
y2  0    0    1    0    0    0    0    0

```

```

d =
      u1  u2
y1  0    0
y2  0    0

```

Sample time: 0.3 seconds
Discrete-time state-space model.

```
Gc1 =
```

```

a =
      x1      x2      x3      x4      x5
x6
x1  0.8461  0.2759 -0.0171      0 -0.01917
0.08624
x2 -0.9905  0.8043 -0.1101      0 -0.1234
0.5551
x3 -0.002376      0  0.9631  0.2882 -0.001258
0.00566
x4 -0.01563      0 -0.243  0.9222 -0.008277
0.03723
x5 -0.125      0      0      0  1.621
-0.6208
x6      0      0      0      0      1
0
x7      0      0 -0.25      0      0
0
x8      0      0      0      0      0
0

      x7      x8
x1 -0.01929  0.01933
x2 -0.1242   0.1244
x3 -0.04166  0.04175
x4 -0.274    0.2746
x5      0      0

```

```

x6      0      0
x7      1.599  -0.5994
x8      1      0

```

```

b =
      u1      u2
x1      0.0362    0.0171
x2      0.233    0.1101
x3      0.002376  0.03693
x4      0.01563    0.243
x5      0.125      0
x6      0      0
x7      0      0.25
x8      0      0

```

```

c =
      x1  x2  x3  x4  x5  x6  x7  x8
y1      1   0   0   0   0   0   0   0
y2      0   0   1   0   0   0   0   0

```

```

d =
      u1  u2
y1      0   0
y2      0   0

```

Sample time: 0.3 seconds
Discrete-time state-space model.

```
s =
```

2x2 struct array with fields:

```

RiseTime
SettlingTime
SettlingMin
SettlingMax
Overshoot
Undershoot
Peak
PeakTime

```

```
ans =
```

```

      RiseTime: 2.4000
      SettlingTime: 5.4000
      SettlingMin: 0.9394
      SettlingMax: 1.0257
      Overshoot: 2.5731
      Undershoot: 0
      Peak: 1.0257
      PeakTime: 4.5000

```

ans =

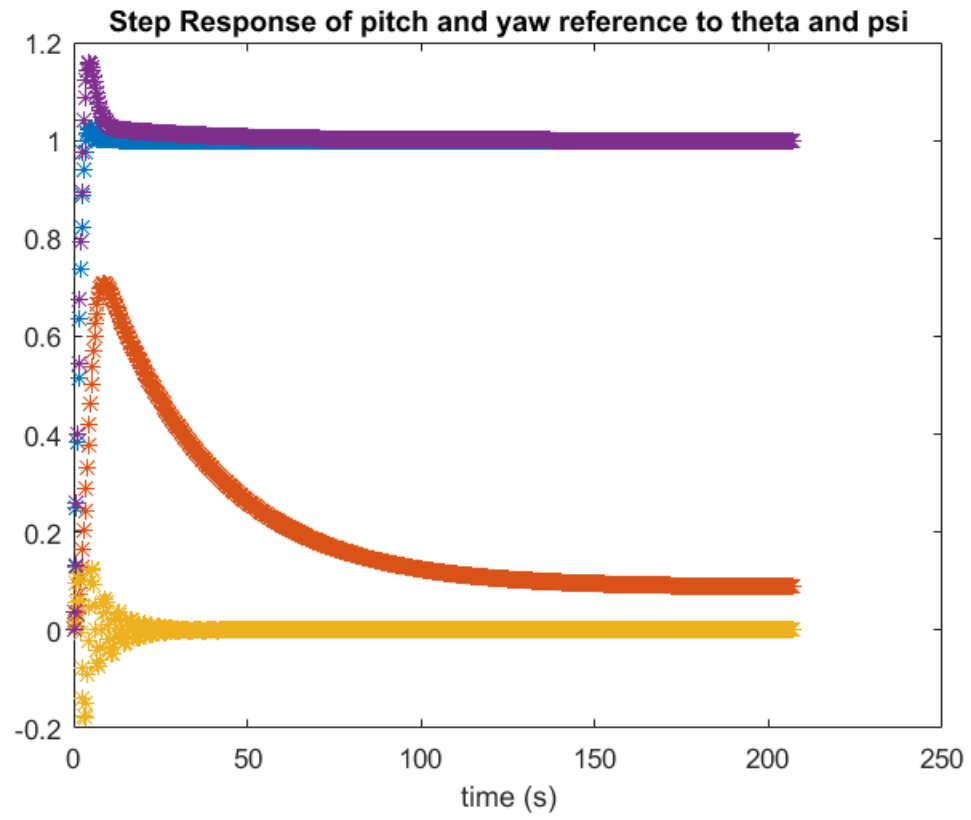
RiseTime: 0
SettlingTime: 28.5000
SettlingMin: -0.1792
SettlingMax: 0.1240
Overshoot: 1.2751e+18
Undershoot: 8.8230e+17
Peak: 0.1792
PeakTime: 3.3000

ans =

RiseTime: 1.5000
SettlingTime: 135.3000
SettlingMin: 0.0876
SettlingMax: 0.7065
Overshoot: 710.8492
Undershoot: 0
Peak: 0.7065
PeakTime: 8.7000

ans =

RiseTime: 2.1000
SettlingTime: 16.8000
SettlingMin: 0.9762
SettlingMax: 1.1585
Overshoot: 15.8453
Undershoot: 0
Peak: 1.1585
PeakTime: 4.5000



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