

```
%
%PLANT
%
A=[0 1 0 0; 0 0 1 0; 0 0 0 1; 1 2 3 4]
eig(A)
B=[0;0;0;1]
C=[1 0 1 0];
%
%STATE FEEDBACK - places poles at -1;delta(s)=(s+1)^4=s^4+4*s^3+6*s^2+4*s+1
%
F=[-2 -6 -9 -8]
Acl=A+B*F
eig(Acl)
```

```
%
%FULL-ORDER OBSERVER - places observer poles at s+6)^4=s^4+24*s^3+216*s^2+864*s+1296
%
```

```
Lt=acker(A',C',[6;6;6;6])
L=Lt'
Ao=A-L*C
Bo=[B L]
Co=eye(4)
%
% CHECK CLOSED-LOOP
%
```

```
Aclo=[A B*F;L*C Ao+B*F]
eig(Aclo)
```

A =

| | | | |
|---|---|---|---|
| 0 | 1 | 0 | 0 |
| 0 | 0 | 1 | 0 |
| 0 | 0 | 0 | 1 |
| 1 | 2 | 3 | 4 |

ans =

```
4.7326
-0.5664
-0.0831 + 0.6051i
-0.0831 - 0.6051i
```

B =

| |
|---|
| 0 |
| 0 |
| 0 |
| 1 |

F =

$$\begin{aligned} \dot{x} &= Ax + Bu \\ y &= Cx \\ \hat{x} &= (A - LC)\hat{x} + Bu + Ly \\ u &= F\hat{x} \end{aligned} \quad A_0 = A - LC$$

$$\Rightarrow \dot{x} = Ax + BF\hat{x}$$

$$\dot{\hat{x}} = A_0\hat{x} + BF\hat{x} + LCx$$

$$\Rightarrow \begin{pmatrix} \dot{x} \\ \dot{\hat{x}} \end{pmatrix} = \begin{bmatrix} A & BF \\ LC & A_0 + BF \end{bmatrix} \begin{pmatrix} x \\ \hat{x} \end{pmatrix}$$

-2 -6 -9 -8

Acl =

| | | | |
|----|----|----|----|
| 0 | 1 | 0 | 0 |
| 0 | 0 | 1 | 0 |
| 0 | 0 | 0 | 1 |
| -1 | -4 | -6 | -4 |

ans =

-1.0001 + 0.0001i
 -1.0001 - 0.0001i
 -0.9999 + 0.0001i
 -0.9999 - 0.0001i

It =

360.1538 -119.2308 -380.1538 258.2308

L =

360.1538
 -119.2308
 -380.1538
 258.2308

Ao =

| | | | |
|-----------|--------|-----------|--------|
| -360.1538 | 1.0000 | -360.1538 | 0 |
| 119.2308 | 0 | 120.2308 | 0 |
| 380.1538 | 0 | 380.1538 | 1.0000 |
| -257.2308 | 2.0000 | -255.2308 | 4.0000 |

Bo =

| | |
|--------|-----------|
| 0 | 360.1538 |
| 0 | -119.2308 |
| 0 | -380.1538 |
| 1.0000 | 258.2308 |

Co =

1 0 0 0

| | | | |
|---|---|---|---|
| 0 | 1 | 0 | 0 |
| 0 | 0 | 1 | 0 |
| 0 | 0 | 0 | 1 |

Aclo =

| | | | | | | | | |
|-----------|--------|-----------|--------|-----------|---------|-----------|---------|---|
| 0 | 1.0000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 1.0000 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 1.0000 | 0 | 0 | 0 | 0 | 0 |
| 1.0000 | 2.0000 | 3.0000 | 4.0000 | -2.0000 | -6.0000 | -9.0000 | -8.0000 | |
| 360.1538 | 0 | 360.1538 | 0 | -360.1538 | 1.0000 | -360.1538 | 0 | |
| -119.2308 | 0 | -119.2308 | 0 | 119.2308 | 0 | 120.2308 | 0 | |
| -380.1538 | 0 | -380.1538 | 0 | 380.1538 | 0 | 380.1538 | 1.0000 | |
| 258.2308 | 0 | 258.2308 | 0 | -259.2308 | -4.0000 | -264.2308 | -4.0000 | |

ans =

6.0007 + 0.0007i
 6.0007 - 0.0007i
 5.9993 + 0.0007i
 5.9993 - 0.0007i
 -1.0006 + 0.0006i
 -1.0006 - 0.0006i
 -0.9994 + 0.0006i
 -0.9994 - 0.0006i