Vehicular Electronics HW4

2018324133 김태우

All code is written in matlab.

**Q1.**

**Description**

To place the pole by state feedback, the system must be completely state conrollable.

Here is controllable canonical form of the system

and used place function to find the gain matrix K

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| --- |
| A = [0 1 0; 0 0 1; -6 -11 -6];  B = [0; 0; 1];  p = [-2 + 2j \* sqrt(3), -2 - 2j \* sqrt(3), -10];  K = place(A, B, p) |

|  |
| --- |
| K =  154.0000 45.0000 8.0000 |

**Q2.**

**Description**

Similar to Q1, I used place function to find gain matrices.

We can find observer gain matrix by transposing A and substituting B as transpose of C.

Unfortunately, place function does not support overlapped poles, so I put some small differences to distinguish them.

|  |
| --- |
| A = [0 1 0; 0 0 1; -6 -11 -6];  B = [0; 0; 1];  C = [1 0 0];  p = [-1 + 1j, -1 - 1j, -5];  K = place(A, B, p)    pe = [-6 + 0.001j, -6 - 0.001j, -6];  Ke = place(A', C', pe).' |

|  |
| --- |
| K =  4.0000 1.0000 1.0000  Ke =  12.0000  25.0000  -72.0000 |

Also, The transfer function of the observer-controller is

|  |
| --- |
| syms s;  TF = simplify(K \* inv(s \* eye(3) - A + Ke \* C + B \* K) \* Ke) |
| TF =    (s^2 + 119\*s + 618)/(s^3 + 19\*s^2 + 121\*s + 257) |

**Q3.**

Here is controllable canonical form of the system

Similar to Q1, I used place function to find gain matrices.

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| --- |
| A = [0 1; 0 -1];  B = [0;1];  C = [1 0];  p = [-2 + 2j, -2 - 2j];  K = place(A, B, p)    pe = [-8 + 0.0001j, -8 - 0.0001j];  Ke = place(A', C', pe).' |

|  |
| --- |
| K =  8.0000 3.0000  Ke =  15.0000  49.0000 |

And we can find The transfer function of the observer-controller.

|  |
| --- |
| syms s;  TF = simplify(K \* inv(s \* eye(2) - A + Ke \* C + B \* K) \* Ke) |

|  |
| --- |
| TF =    (267\*s + 512)/(s^2 + 19\*s + 117) |

Now transfer function of both system are

(a)

(b)

steady-state output is 117/(512\*N) , where original output is 1.

So N must be 117/512

And plot the unit step response using step function.

|  |
| --- |
| sys1 = tf([0 0 0 267 512], [1 20 136 384 512])  sys2 = tf([0 0 1 19 117] \* 512/117, [1 20 136 384 512])  hold on  step(sys1)  step(sys2) |

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**Q4.**

Firstly, find controllable canonical form of the system

And find full-order observer by same method as previous questions.

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| A = [0 1; 0 -2];  B = [0;4];  C = [1 0];  p = [-2 + 2j \* sqrt(3), -2 - 2j \* sqrt(3)];  K = place(A, B, p)    pe = [-8 + 0.0001j, -8 - 0.0001j];  Ke = place(A', C', pe).' |

|  |
| --- |
| K =  4.0000 0.5000  Ke =  14.0000  36.0000 |

And minimum order observer is

|  |
| --- |
| pe2 = [-8];  Ke2 = place(A(2, 2), A(1, 2), pe2) |

|  |
| --- |
| Ke2 =  6 |

To get the response of initial condition, I used

So we can get response from fully order observer.

used initial function to get response at certain initial condition.

|  |
| --- |
| syms s;  An = [A - B \* K, B \* K; [0,0;0,0], A - Ke1 \* C];  sys1 = ss(An, eye(4), eye(4), eye(4));  x0 = [1; 0; 1; 0];  initial(sys1, x0) |



And to get response from minimum order observer, I used modified version.

|  |
| --- |
| An2 = [A - B \* K, B \* K(1, 1); 0, A(2, :) - Ke2 \* C];  sys2 = ss(An2, eye(3), eye(3), eye(3))  x0 = [1; 0; 1];  initial(sys2, x0) |

