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STATE FEEDBACK CONTROLLER DESIGN ON MATLAB PLATFORM

OBJECTIVE

To design the state feedback gain matrix for a given analog state-space system to satisfy required performance specifications

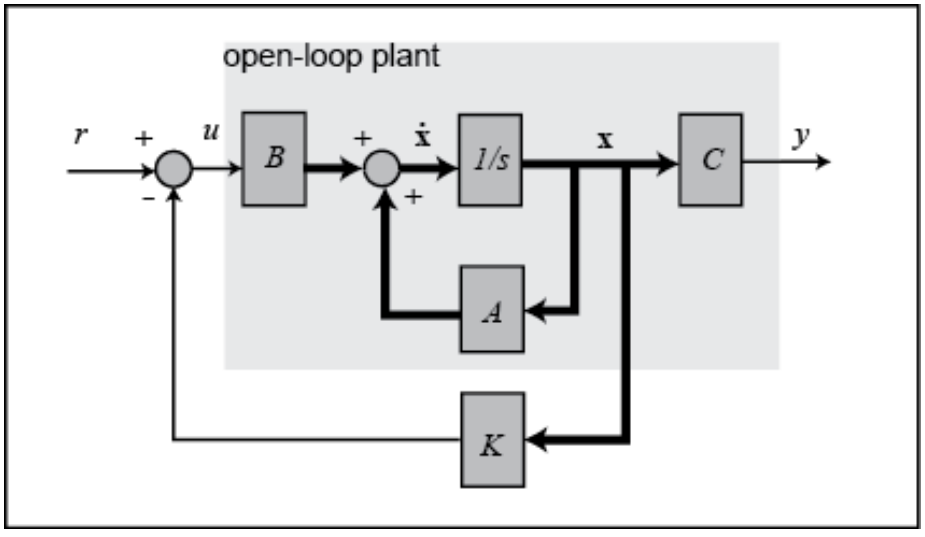
DESIGN SPECIFICATIONS

- Settling time of individual states are retained as those of nominal eigen values
- Maximum magnitude of all eigenvalues is as in the nominal set
- The CL system is always observable

ANALYSIS AND DESIGN

Nominal eigen values assigned = [-0.8, -0.3-0.3i, -0.3+0.3i]

$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -0.1 & -0.22 & -1.4 \end{bmatrix}$ $B = \begin{bmatrix} 0 \\ 0 \\ 5 \end{bmatrix}$ $C = \begin{bmatrix} 0.5 & 1 & 0 \end{bmatrix}$ D = 0



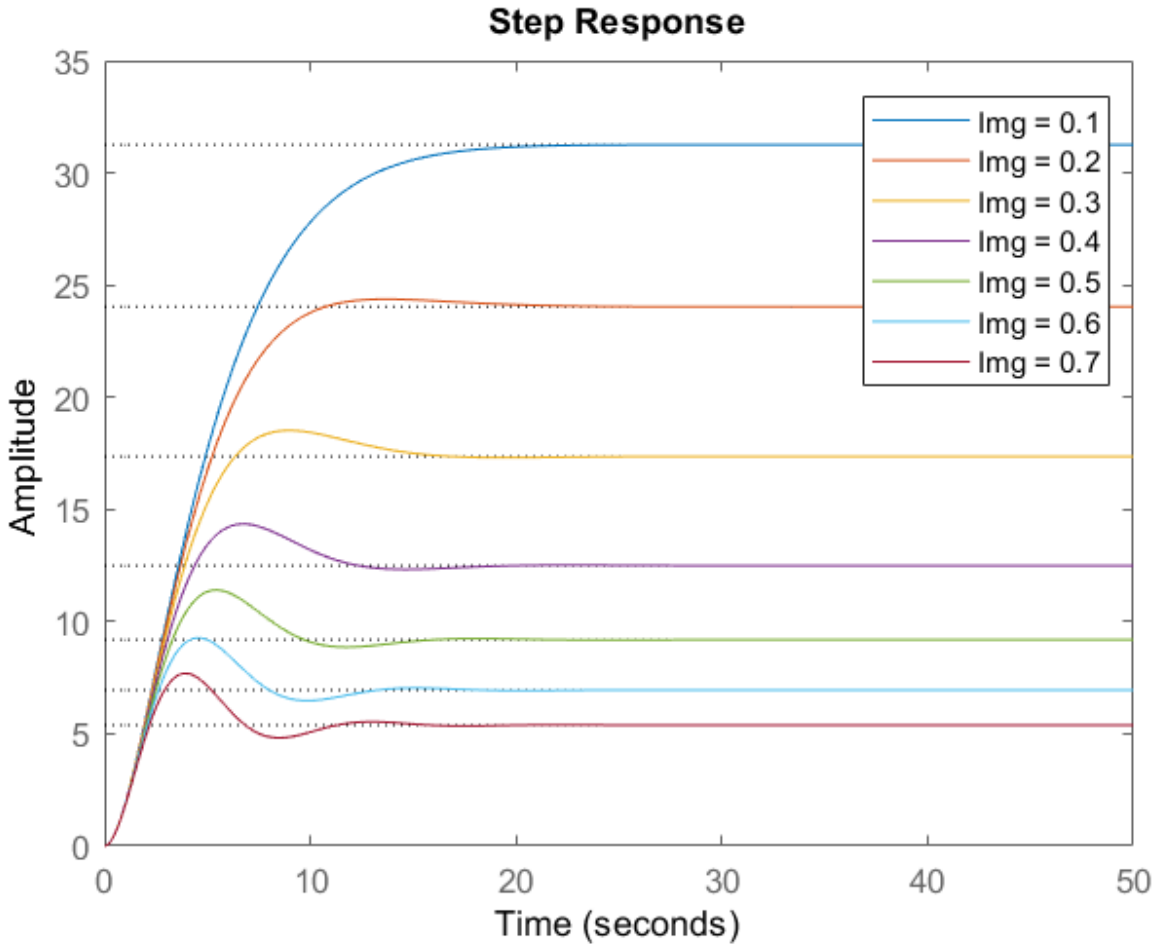
To keep the settling time of individual states same as that of nominal eigen values (qualitatively) implies that we have to keep the real part of nominal values as assigned. Since settling time is proportional or decay which is governed by the real part of the pole. The constraint on magnitude limits the Img(Pole)

However, it is important to note that since settling time is defined as time at which the error falls between 2% or 5% of the steady state is a mathematical description and its value would change depending upon the frequency of oscillation as well and how its calculated.

One should know that controllability considers input to state relationship and observability considers state to output relationship. Therefore, if we want to control the behavior of states, we need to check controllability as well. And when we want to design state feedback control then observability is important as you can't provide feedback if you can't observe the states.

The system under investigation is always controllable and observable.

Shown below is the response of system when for different feedback Gain matrices such that the design constraints are satisfied.



As we can clearly assess, with the increase in imaginary part of the pole results in overshoot. This is a result of improved responsiveness of the system. Characteristics like Steady state value decreases which would need to be compensated by an amplifier.

Tabulated below are a few performance metrics:

Img (p)	Rise Time	Settling Time	Overshoot	Peak Time
0.1	8.97	15.19	0.0125	28.80
0.2	6.26	9.56	1.3860	13.70
0.3	4.21	13.55	6.678	8.98
0.4	2.99	11.2373	14.80	6.68
0.5	2.266	13.80	24.11	5.41
0.6	1.798	12.27	33.56	4.60
0.7	1.485	4.81	42.75	3.92