Control Systems Project

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SECTION: A

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Project steps

1. Firstly check the stability of the system steady state modal.
    - Using all the stability method I know.
2. Compute controllability and observability tests for the system.
    - If both test passes design a suitable controller.
3. Simulate the system using design controller.
4. Design PID controller and compare the response with designed suitable controller.
5. Compute the steady state errors.
6. Design tracking controller for the signals 5u(t) and 5t(t).

State-Space modal

State-space modal:

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 4 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0.4 \\ 0.3 \end{bmatrix} u$$

$$y(t) = \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

Checking Stability: 1st method

Finding eigenvalues of the system.

- The system is unstable If all values is/are non-negative.

MATLAB code:

```
%stability check 1st method: eigenvalues, poles of the system
egen_values = eig(A);
disp('eigenvalues of matrix A are: ');egen_values
[nom den] = ss2tf(A,B,C,D);    poles_tf = roots(den);
disp('Poles of tranfer fuction are: ');poles_tf
```

Commad line result: -

eigenvalues of matrix A are: egen_values =

1

4

poles of matrix A are: Poles_p =

4

1

Checking Stability: 2nd method

Finding poles and zeros map.

- The system unstable if all poles are on the positive side.

MATLB code:

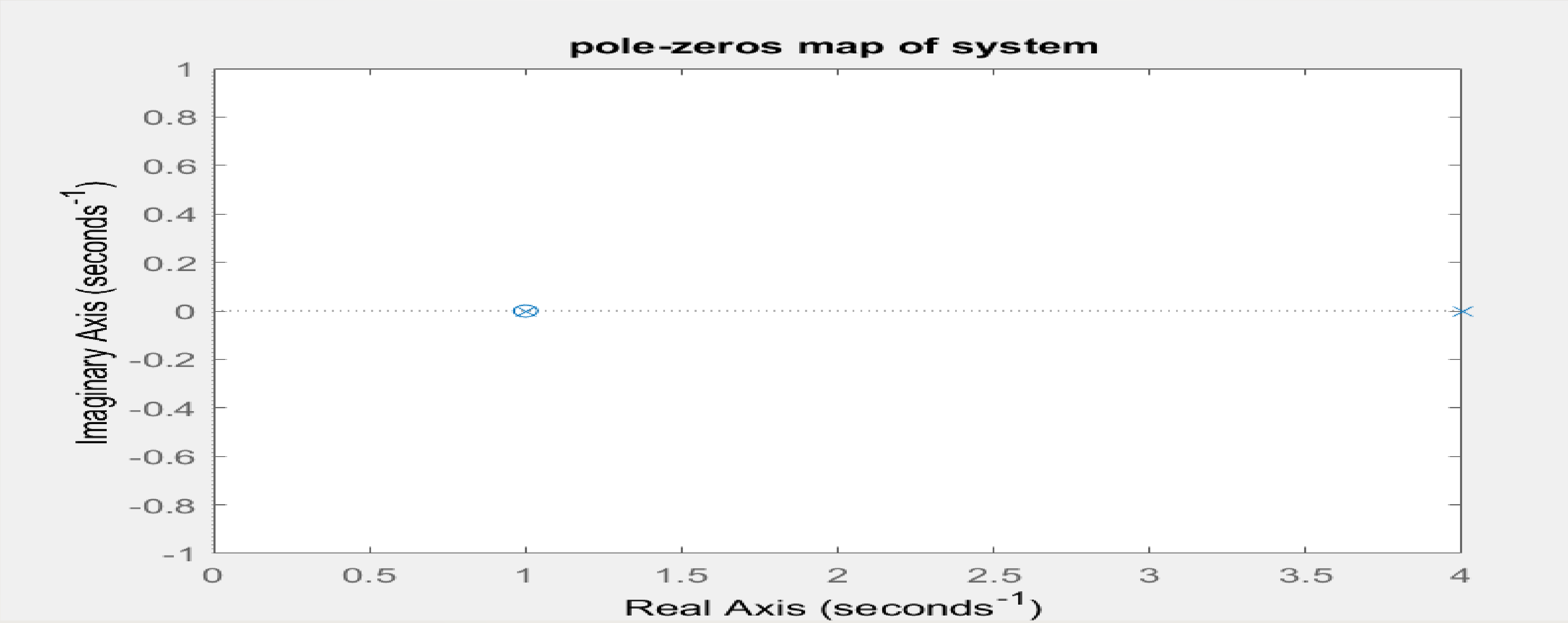
```
%poles zeros map

pzmap(A, B, C, D);

title('pole-zeros map of system')
```

Poles-zeros Map

- Cross denote poles and zero donate zeros of the system.



Checking Stability: 3rd method

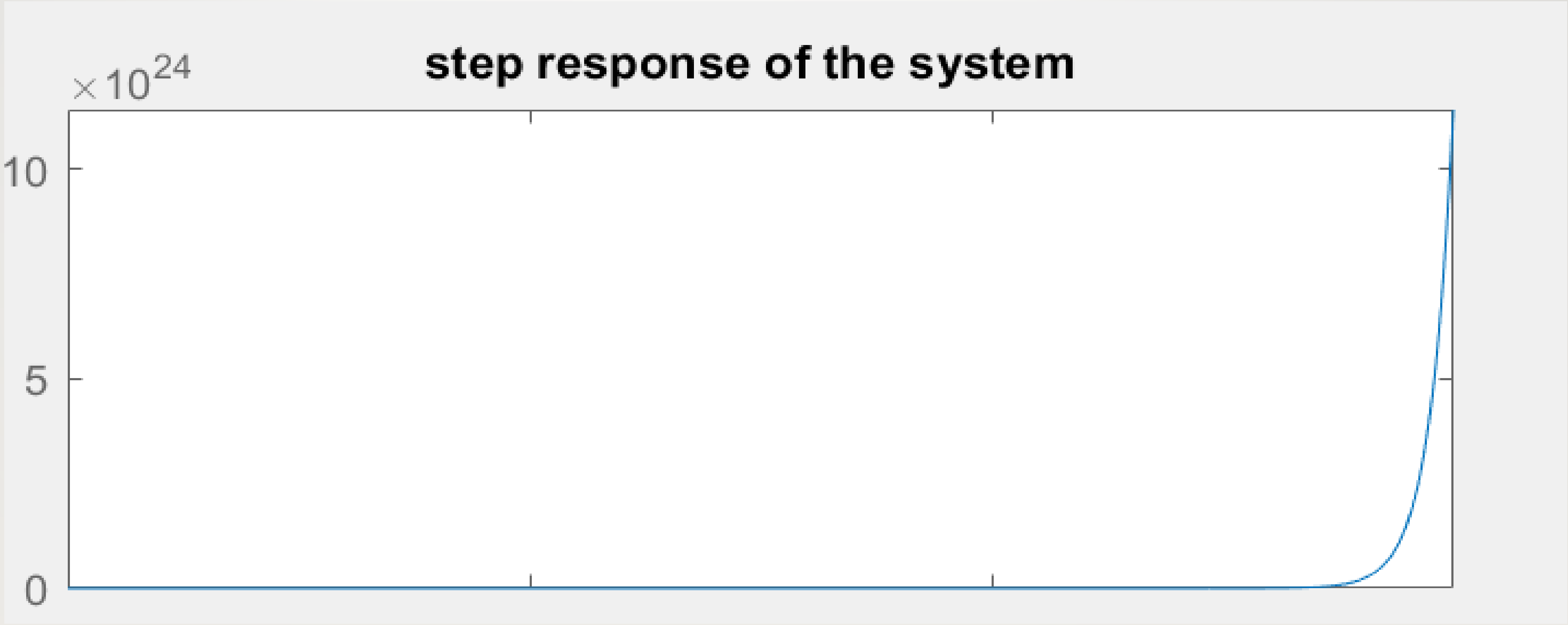
- Finding step response of the system.
  - The system unstable if the response is unbounded.

MATLAB code:

```
%stability check method 3rd: step response
figure;
step(A,B,C,D);
title('step response of the system ')
ylabel('Amplitude of step response')
```

Step response

- Unbounded response of the system.



Designing suitable controller
observer based state feedback controller

- There are some prerequisites to design a controller.
  1. Matrix C must not be equal to identity and matrix D must be zero or absent.
  2. The system must pass controllability test.
  3. The system must pass observability test.

Note: according to the given state space modal 1st prerequisite is satisfied, I will design the suitable controller(observer based state feedback) if others two prerequisites are satisfied.

Prerequisite 2:Controllability test

A system is controllable if the following criteria satisfied.

- Find determinate of the system and denote as n.
- Construct P matrix follows:
- $P = [B \;\; AB]$
- Compute rank of P and check if rank is equal to n or not.

Note: The system is controllable and can proceed to design of controller if rank(P)=n, otherwise No controller can not be design.

Prerequisite 2:Controllability test

MATLAB CODE:

```
%controllability test
%P = [B A*B] determinate = det(P)
P = ctrb(A,B);
Rank_ctrb = rank(P);
disp('Rank of controllability matrix is')
Rank_ctrb
```

Prerequisite 2:Controllability test

MATLAB result:

Rank of controllability matrix is

Rank_ctrb = 2

order of the system

Order = 2

- Rank(P) = n, So the system passes Controllability test

Prerequisite 3:Observability test

A system is observable if the following criteria satisfied.

- Find determinate of the system and denote as n.
- Construct Q matrix follows:
- $Q = [C; CA]$
- Compute rank of Q and check if rank is equal to n or not.

Note: The system is observable and can proceed to design of controller if rank(P)=n, otherwise No controller can not be design.

Prerequisite 3:Observability test

MATLAB code:

```
%observability test
Q = [C; C*A];
q = obsv(A,C);
Rank_Q = rank(q);
disp('the rank of matrix Q is')
Rank_Q
```

Prerequisite 3:Observability test

MATLAB result:

the rank of matrix Q is

Rank_Q =   1

order of the system

Order =   2

- Rank(Q) != n, So the system not observable.

Conclusion

- The system fulfill first prerequisite.
- The system is controllable or it passes controllability test.
- The system is NOT observable or didn't passes observability test.

So STOP No controller can be design.

And the system is unstable So no steady state error can be computed.