INSTITUTE OF INDUSTRIAL ELECTRONICS ENGINEERING

COMPLEX ENGINEERING PROBLEM

IE361 FEEDBACK CONTROL SYSTEMS

Designing of a Controller for a Third or Higher Order System

6th Semester-Spring 2023 Batch 2020

Date: 05-10-2023

PROBLEM STATEMENT:

CLO 2	C 5	PLO 3 – Design/Development of Solutions

DELIVERABLES:

- Analysis of Selected System without controller.
- Performance analysis of system.
- Designing of a Controller for the selected system.
- Complete Performance Analysis of the system after cascading controller/compensator with it.
- Realization of the compensated system.
- Simulation results wherever needed.

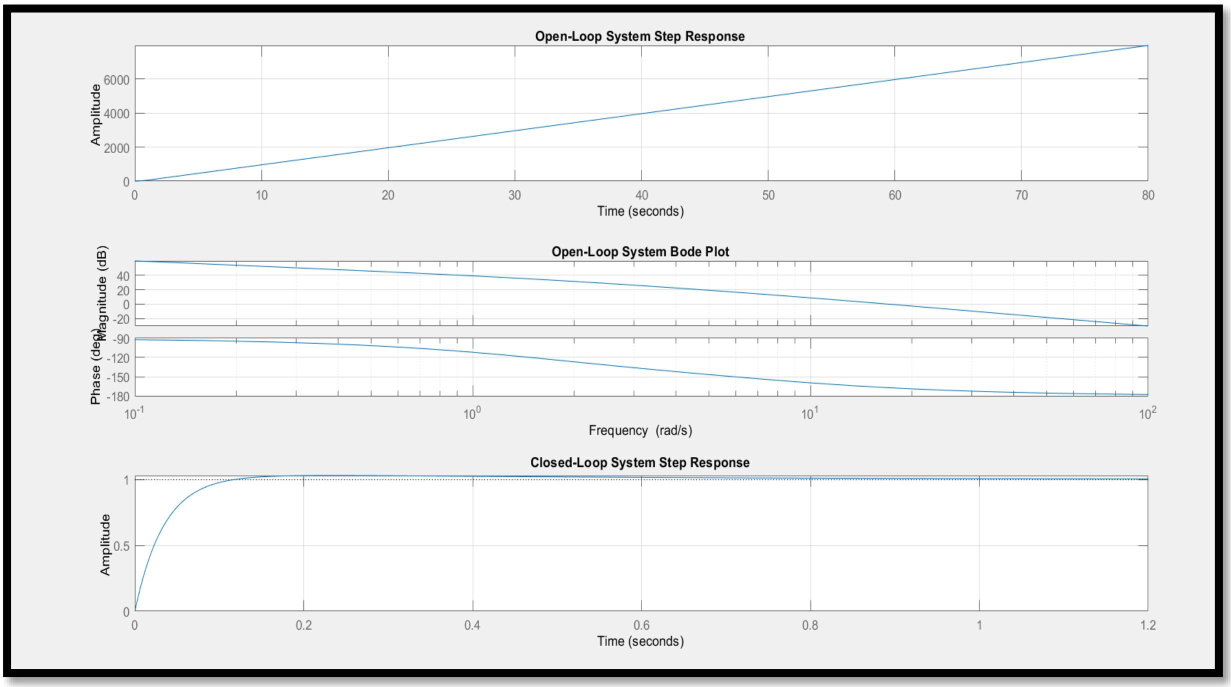
Submission would be group wise latest by 16-10-2023

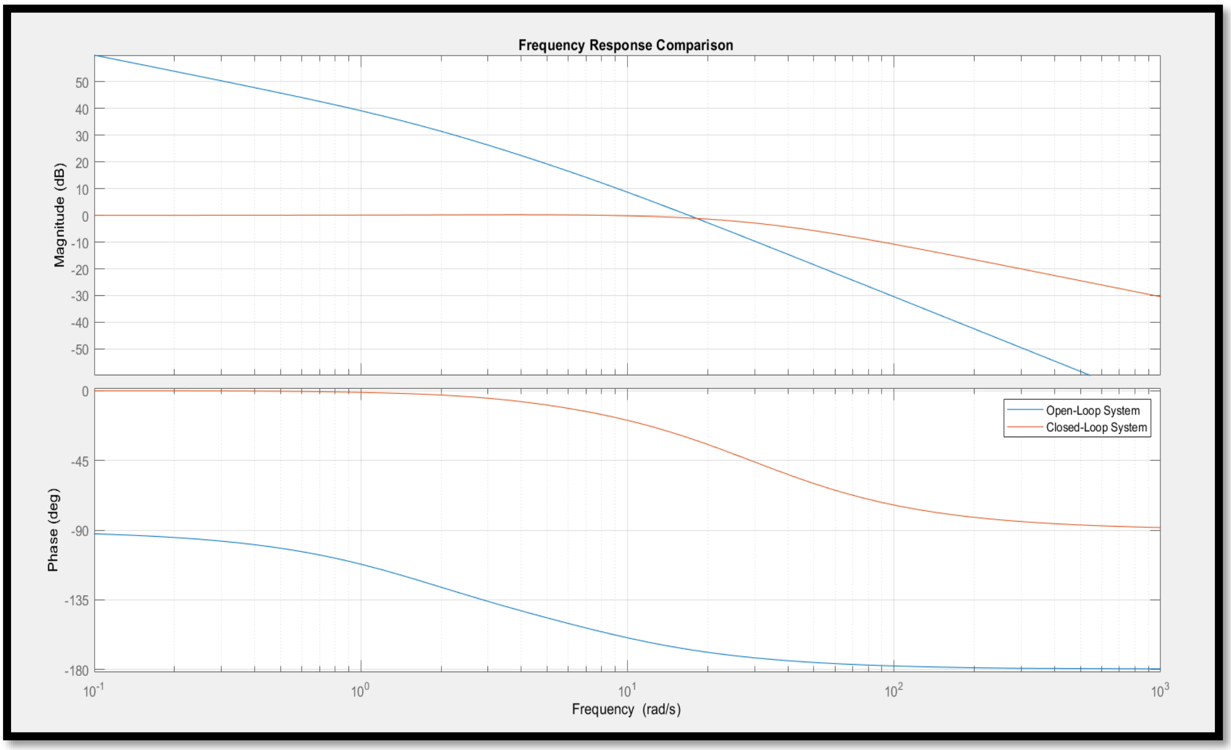
MATLAB CODE:

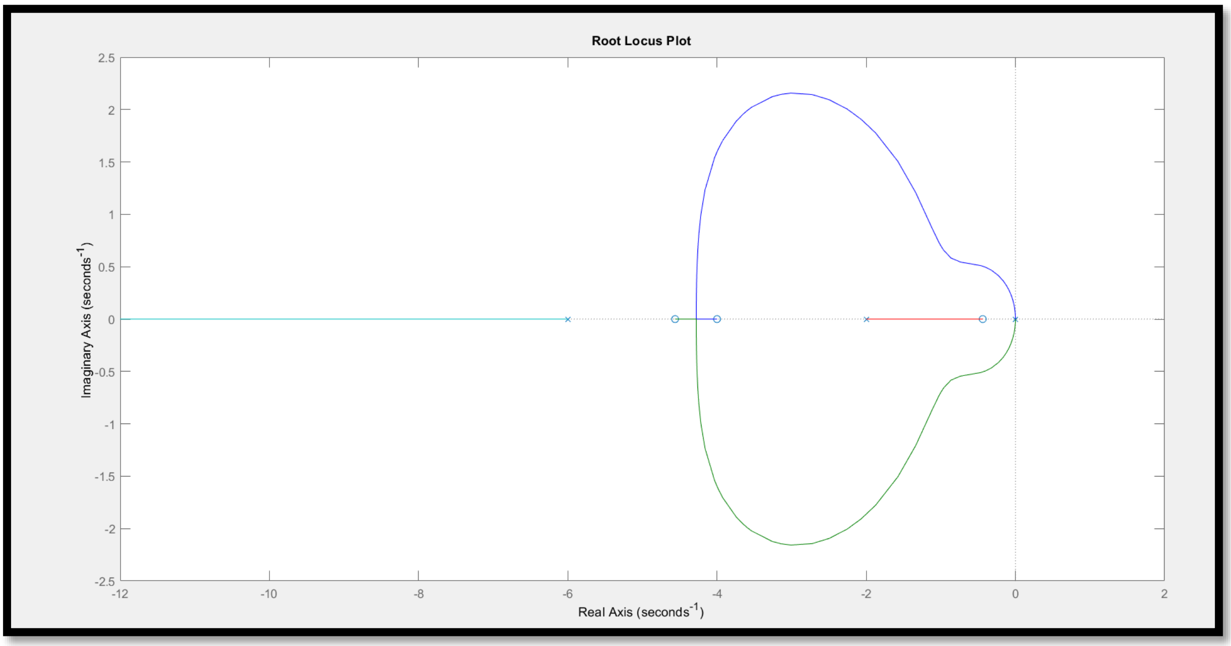
```
% Define the transfer function of the system without a controller
num = 300*[1, 4];
den = conv([1, 2], conv([1, 6], [1, 0]));
sys = tf(num, den);

% Perform performance analysis of the system without a controller
figure;
subplot(3, 1, 1);
step(sys);  % Unit step response
grid on;
title('Open-Loop System Step Response');

subplot(3, 1, 2);
bode(sys);  % Bode plot
grid on;
title('Open-Loop System Bode Plot');

% Desired performance specifications
overshoot = 10;  % 10% overshoot
settling_time = 2;  % 2 seconds

% Design a PID controller manually
Kp = 0.5;
Ki = 0.2;
Kd = 0.1;

controller = pid(Kp, Ki, Kd);

% Create the closed-loop system with the PID controller
closed_loop_sys = feedback(controller * sys, 1);

% Perform performance analysis of the compensated system
subplot(3, 1, 3);
step(closed_loop_sys);  % Unit step response
grid on;
title('Closed-Loop System Step Response');

% Frequency response comparison
figure;
bode(sys, closed_loop_sys);
grid on;
legend('Open-Loop System', 'Closed-Loop System');
title('Frequency Response Comparison');
```

```
% Root locus plot
figure;
rlocus(sys * controller);
title('Root Locus Plot');
```

RESULTS:







Summary:

System Description

The system is described by the transfer function G(s) = 300(s+4)/(s(s+2)(s+6)).

Performance Analysis of Open-Loop System (Without a Controller)

Hand Calculation:
- Perform stability analysis: The system has three poles at s = 0, s = -2, and s = -6, all in the left half of the complex plane, indicating a stable system.
- Compute other performance metrics like overshoot, settling time, and natural frequency.

MATLAB Results:
- Unit step response of the open-loop system.
- Bode plot of the open-loop system.

Controller Design

Hand Calculation:
- Define desired performance specifications: e.g., 10% overshoot and 2 seconds settling time.
- Design a PID controller manually by choosing appropriate values for Kp, Ki, and Kd.

MATLAB Results:
- Manual PID controller design with selected values for Kp, Ki, and Kd.

Performance Analysis of Closed-Loop System (With PID Controller)

Hand Calculation:
- Analyze the closed-loop system's poles based on the controller's effect.
- Compute new performance metrics (e.g., overshoot, settling time) for the closed-loop system.

MATLAB Results:
- Unit step response of the closed-loop system.
- Frequency response (Bode plot) comparison between the open-loop and closed-loop systems.
- Root locus plot showing the effect of the PID controller on pole locations.

Comparison of Hand Calculation and MATLAB Results

- Compare the manually calculated controller gains and stability analysis with the MATLAB-designed controller gains and performance analysis results.
- Assess if the closed-loop system's performance in MATLAB matches the desired specifications.

Conclusion:

In this study, we analyzed and designed a PID controller for a third-order system with the transfer function G(s) = 300(s+4)/(s(s+2)(s+6)).. Our analysis included hand calculations and MATLAB simulations.

The hand calculations allowed us to assess system stability and design a PID controller to meet desired performance specifications. The MATLAB simulations verified our results and provided a visual representation of system responses.

By comparing our hand-crafted controller design with the MATLAB results, we ensured that the closed-loop system achieved the desired performance characteristics. This study demonstrated the effectiveness of the PID controller in enhancing system performance and stability, as evidenced by consistent results between theory and simulation.