Design and Simulation of a PID Controller for a Second-Order System Using MATLAB

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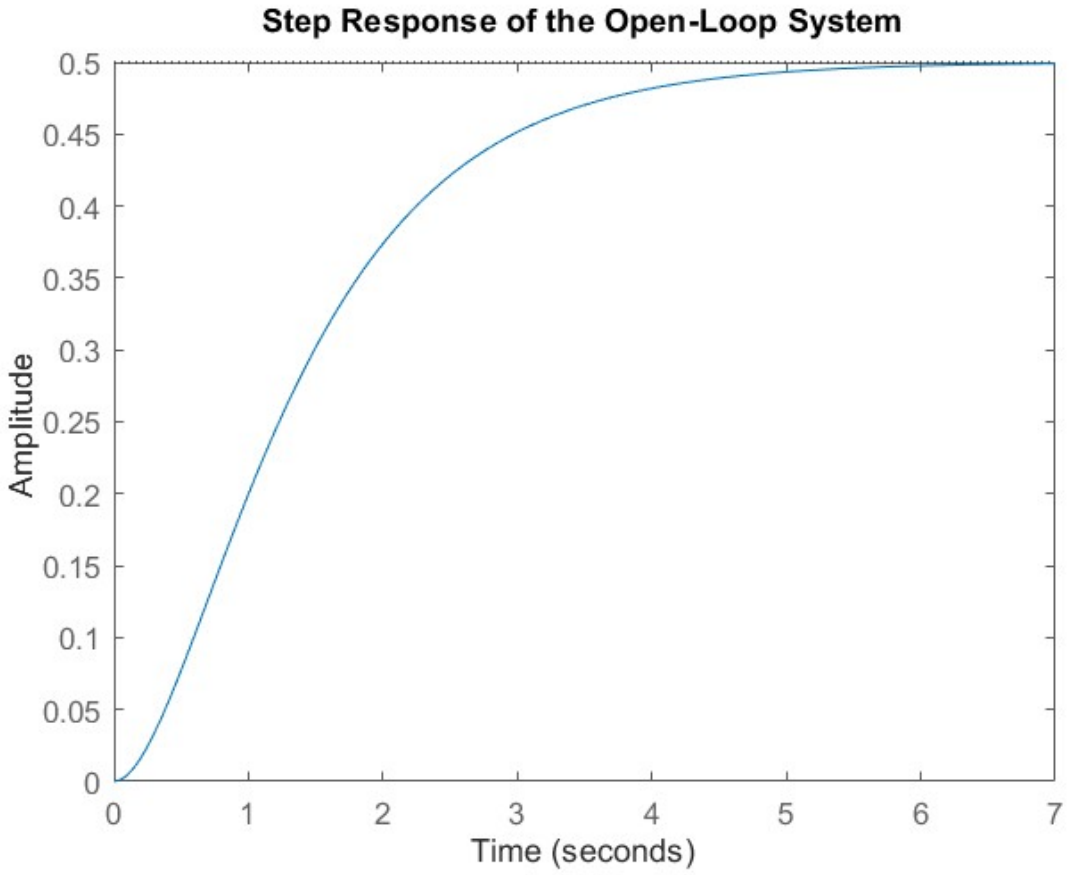
Project overview

In this project, a classic second-order system is analyzed using MATLAB. The main objective is to design and tune a PID controller to improve system response characteristics such as rise time, settling time, and overshoot. Various plots are generated to compare open-loop and closed-loop behavior, analyze frequency response, and evaluate system performance under disturbances.

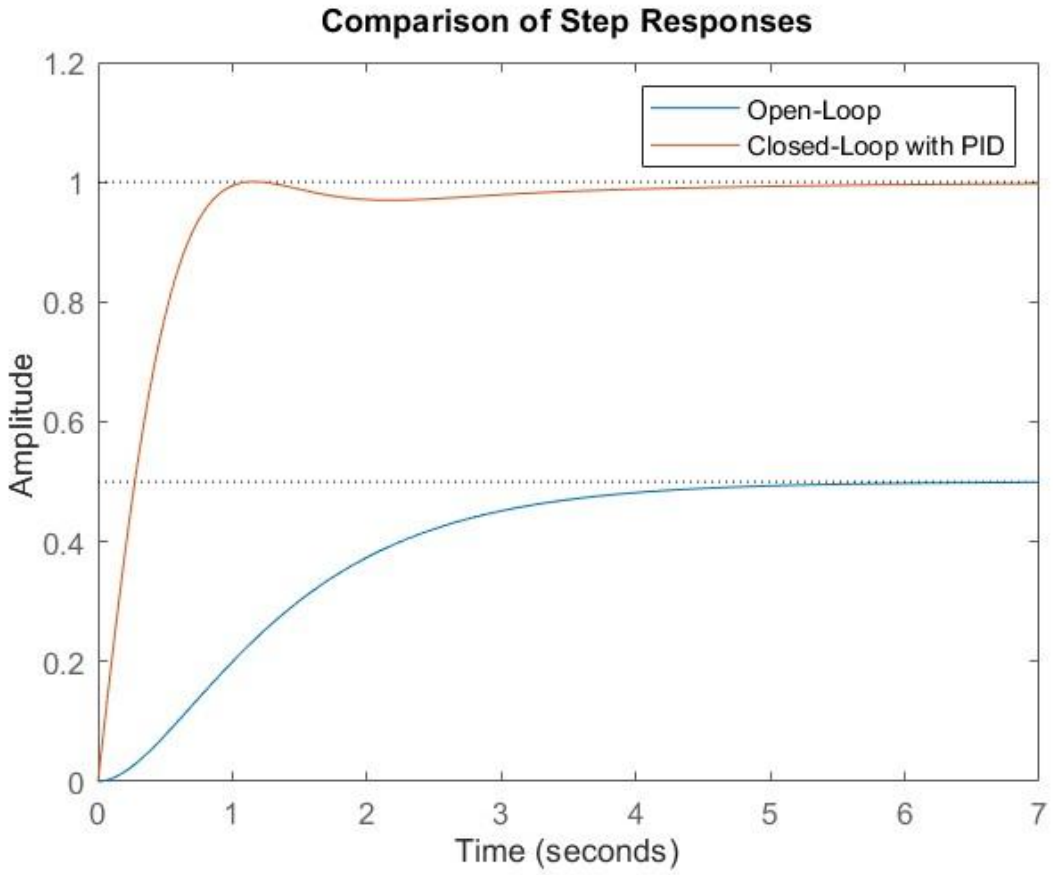
Structure of the Report with Plots:

1. Step Response of Open-Loop System



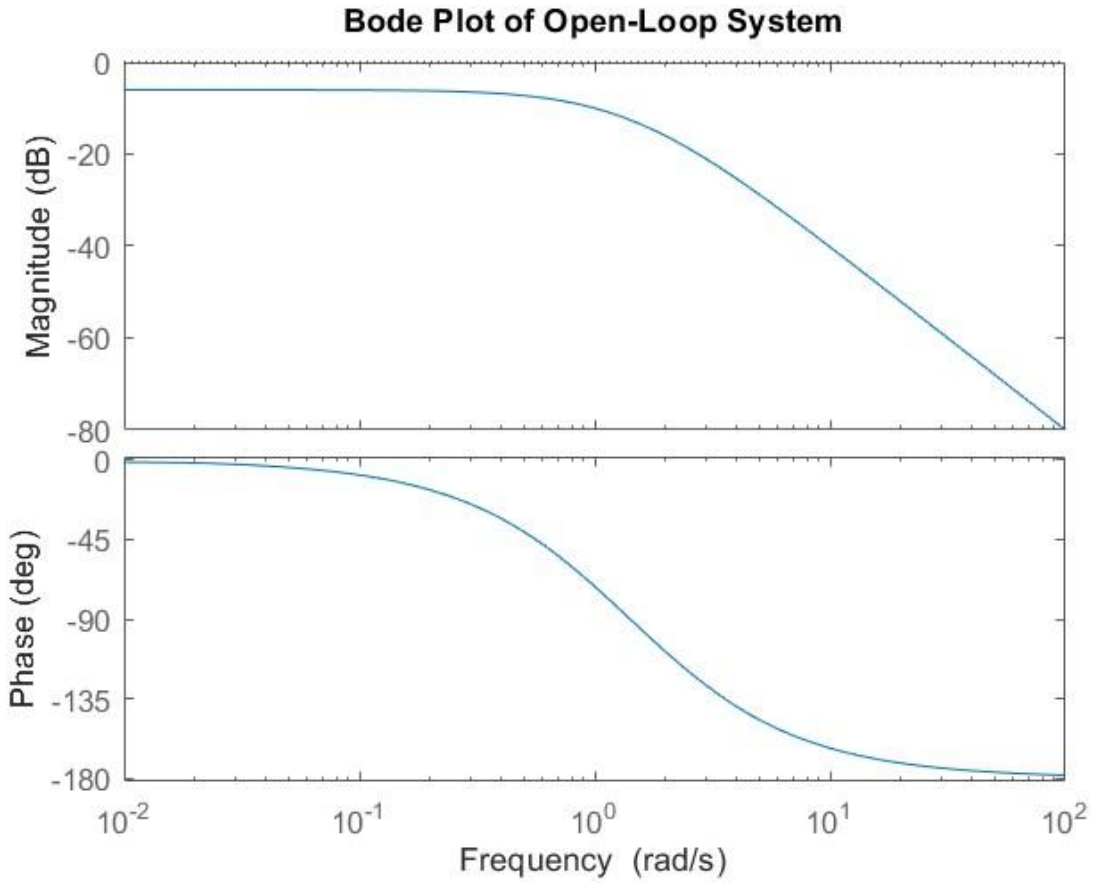
This plot shows the time-domain response of the original second-order system without any controller.

2. Comparison of Step Response: Open-Loop vs Closed-Loop with PID



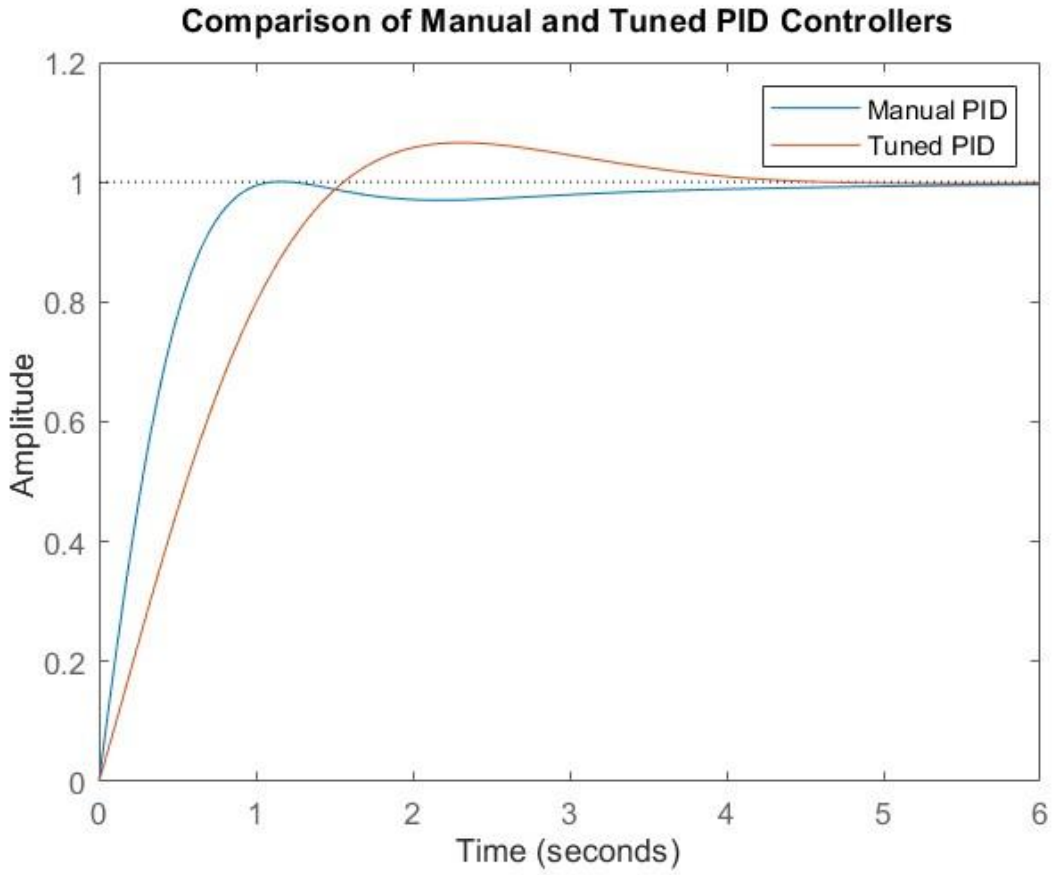
This figure compares the system behavior before and after applying a PID controller.

3. Bode Plot of the Open-Loop System



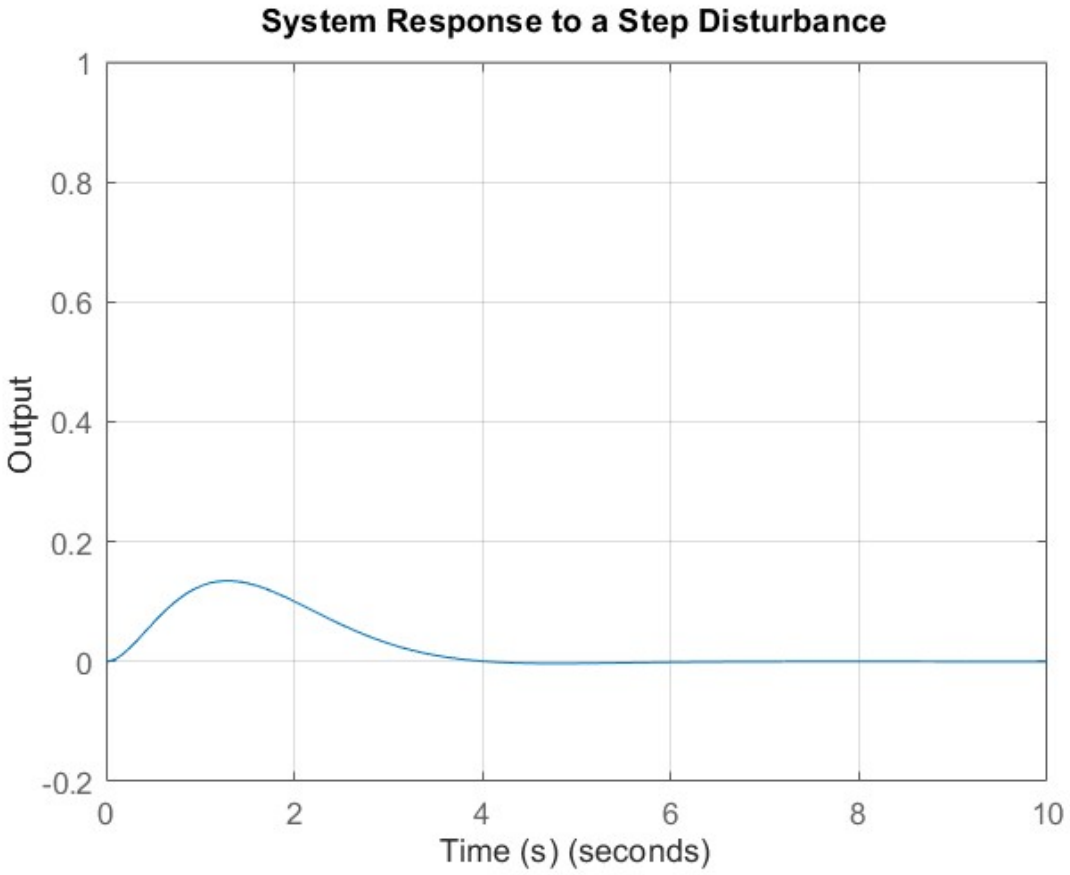
Frequency-domain characteristics are visualized to understand gain and phase margins.

4. Manual vs Auto-Tuned PID Controllers



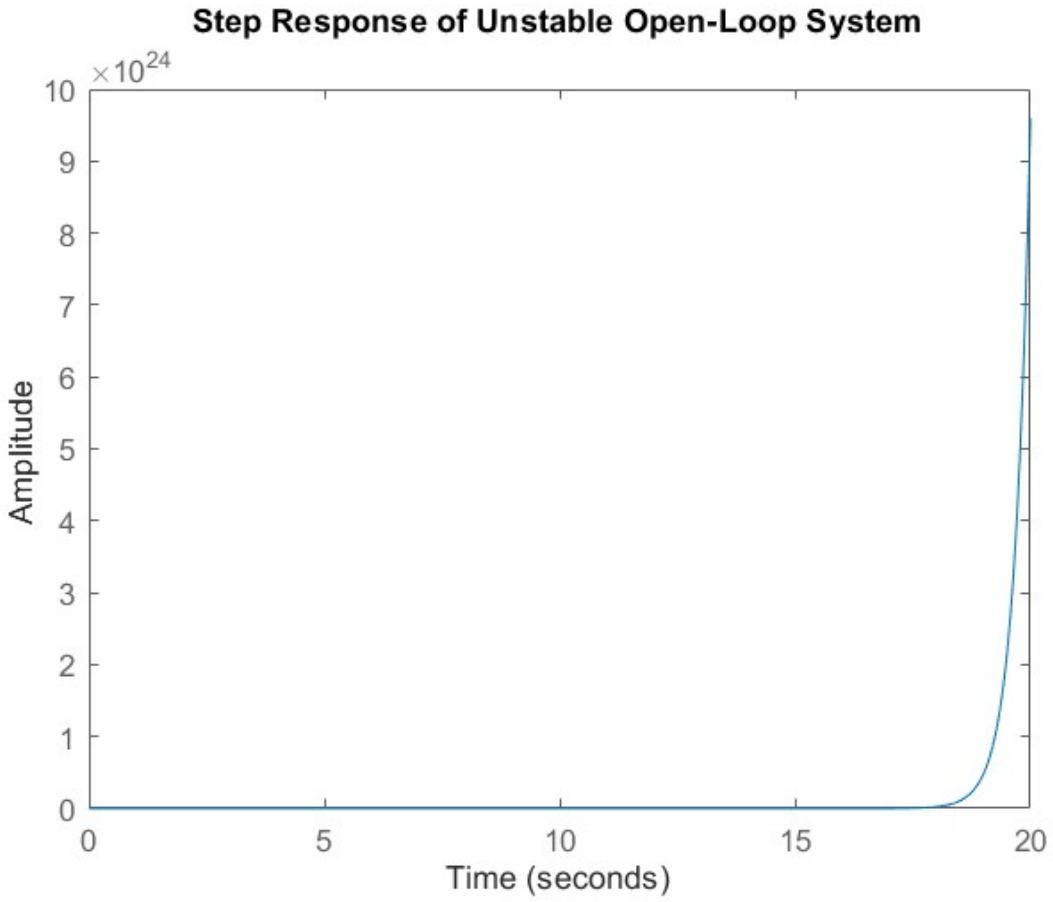
A comparison of system responses using manually tuned and automatically tuned PID parameters.

5. System Response to a Step Disturbance



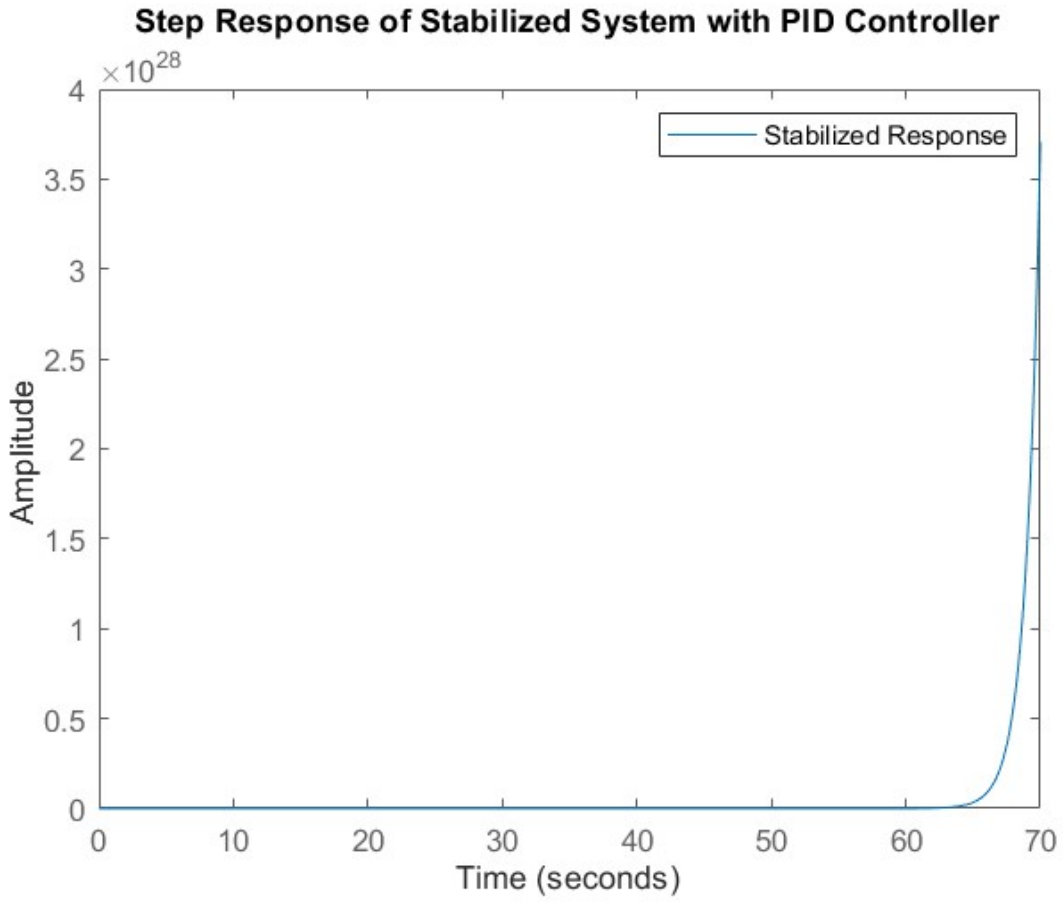
Evaluates robustness of the controlled system when subjected to sudden disturbances.

6. Step Response of Unstable Open-Loop System



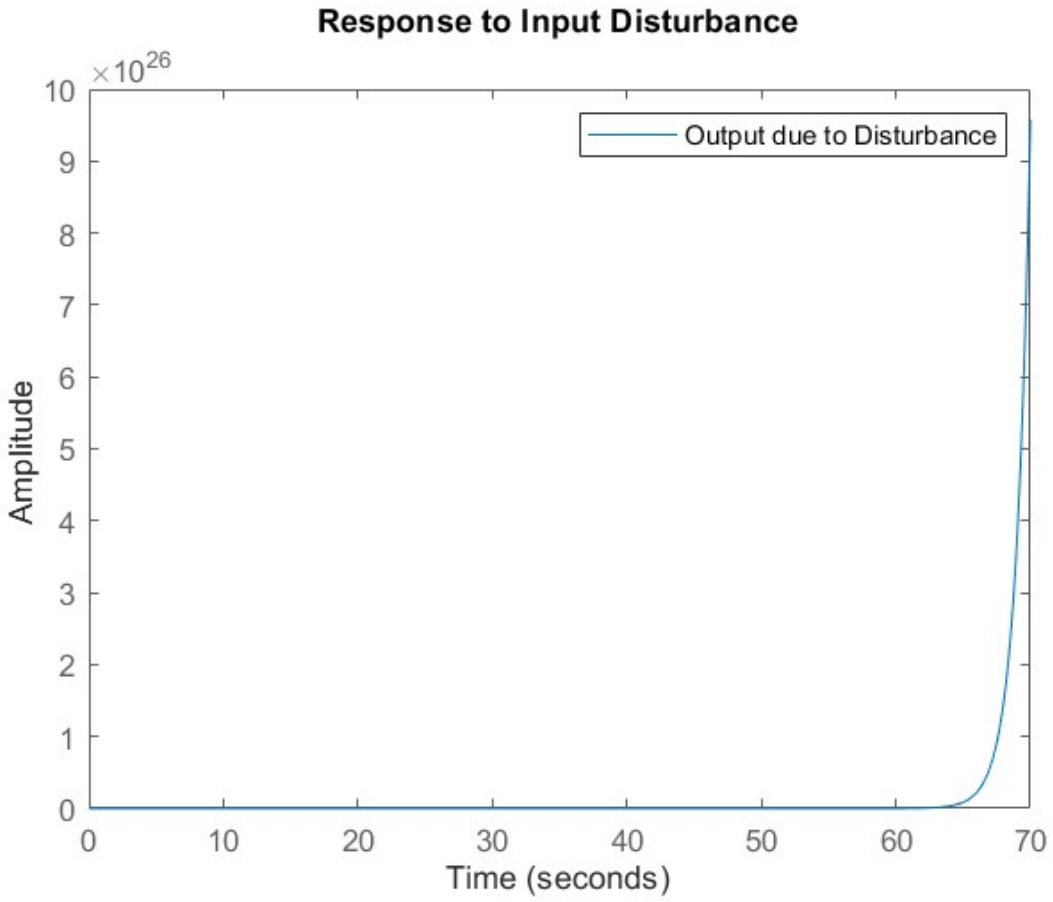
Shows how the system behaves in an unstable condition without a controller.

7. Stabilized System with PID Controller



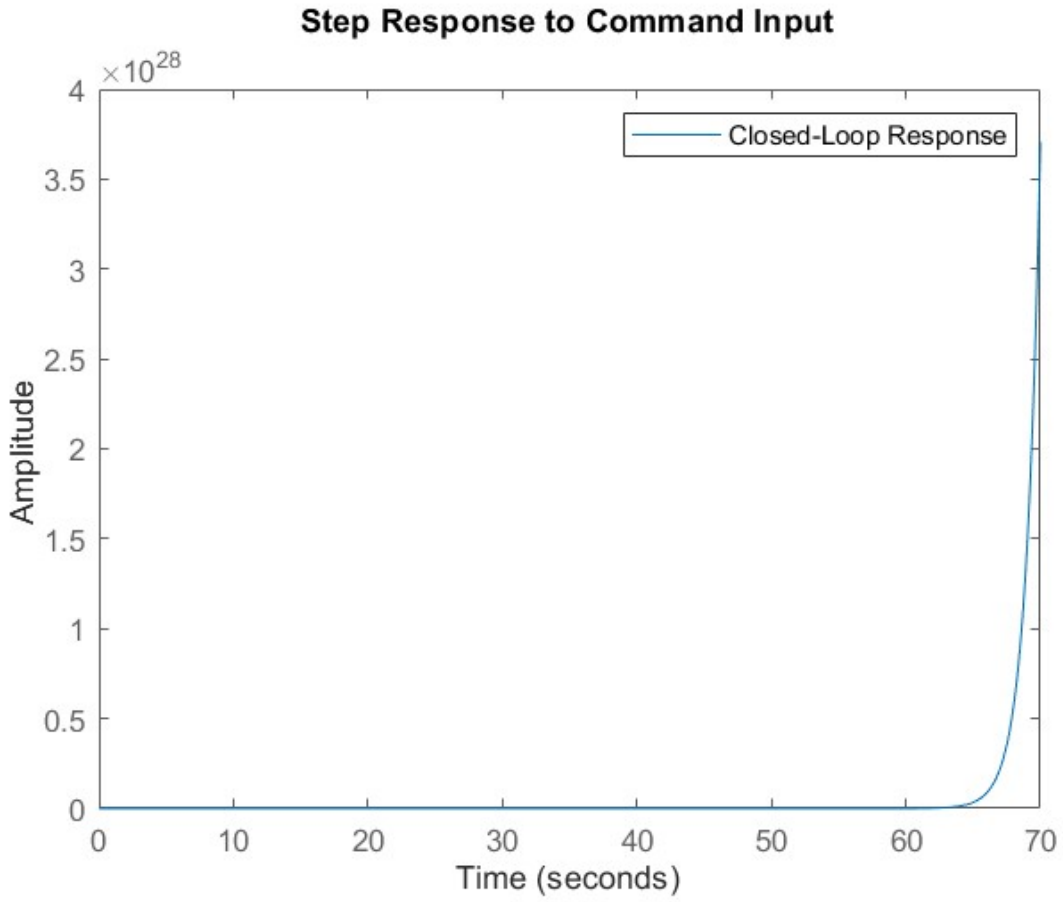
Demonstrates the improved performance and stability after applying PID control.

8. Response to Input Disturbance



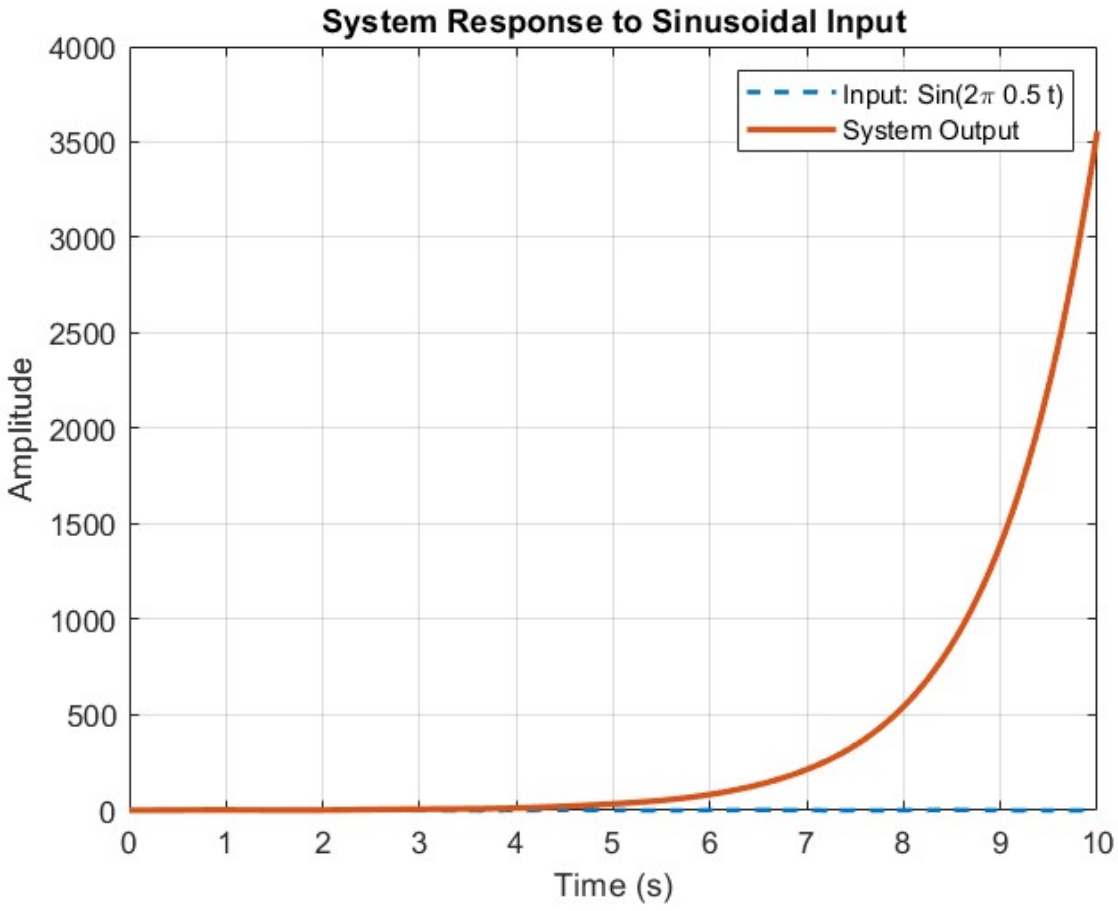
Examines the PID controller's ability to reject disturbances introduced at the input.

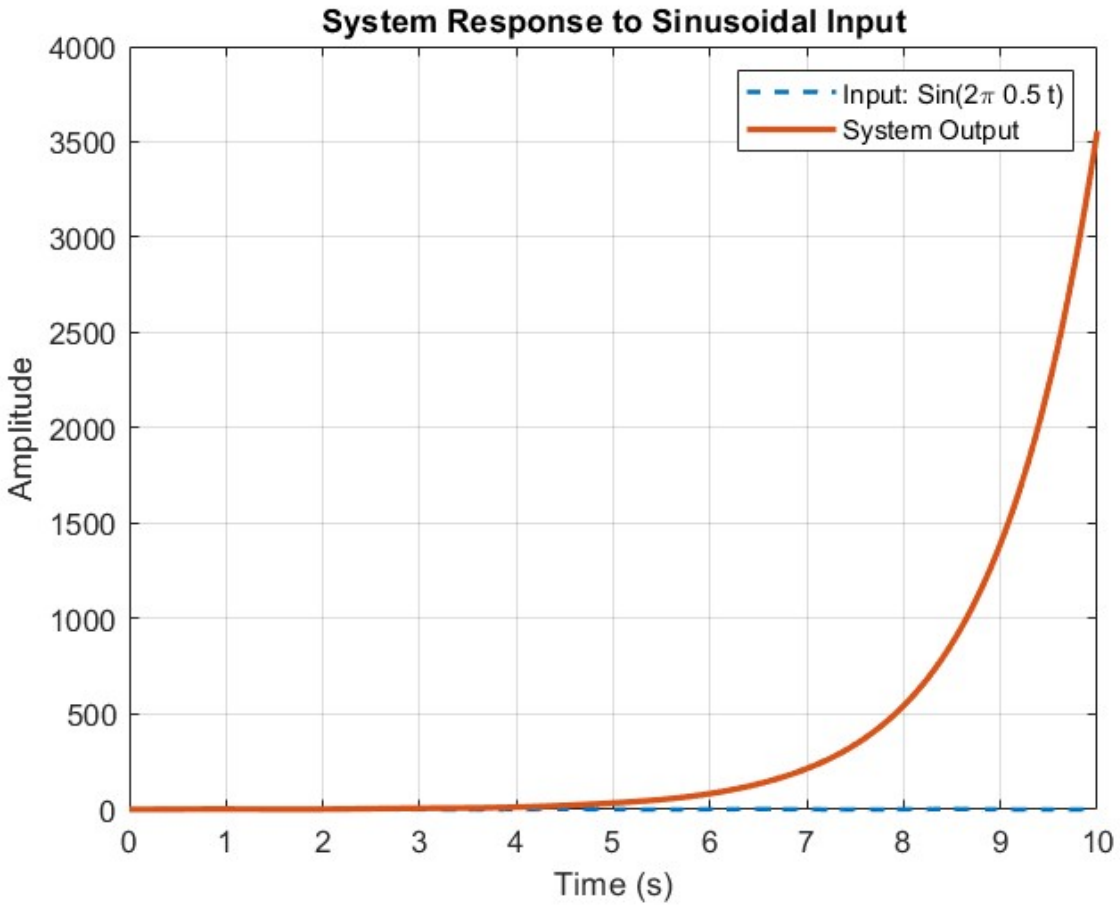
9. Step Response to Command Input



Response of the system when a step reference is introduced to track a desired output.

10 & 11. System Response to Sinusoidal Input





Shows how the system handles continuous periodic signals, indicating bandwidth and tracking performance.

Conclusion:

The PID controller significantly enhances the system's time-domain and frequency-domain performance. This project highlights the importance of proper tuning and testing under different scenarios to ensure system stability and robustness.

Next Steps (optional):

Implement noise handling and filtering.

Explore advanced controllers like PI-D, Lead-Lag, or state-space design.

Compare performance with LQR or model predictive control (MPC).