Controller Design for Vehicle Lateral Dynamics Stability
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Abstract

This experiment uses a phase-lead controller to optimize the step response of a closed-loop control system. The response before and after the insertion of the controller is tested using Simulink, and a physical circuit is modeled using Multisim. Ideally, the controller reduces the overshoot from 40% to 17% and increases the settling time from 0.82s to 1.15s, however the experimental results in the overshoot changing from 54% to 22% and the settling time from .79s to .94s. Deviation from the ideal values occurs due to error from the circuit components, however the general trends are still observed.

Introduction

Improving the stability of a vehicle’s steering is necessary in the engineering of a safe vehicle. When the vehicle receives an input to turn, it has error before adjusting to the correct turning angle. A phase-lead controller is designed to improve the vehicle’s stability. The phase lead controller was chosen over a PID because it is a cheaper alternative; although, its applications are much more limited than a PID controller’s.

Objectives

- Design the transfer function of a phase-lead controller to increase the stability of a highway vehicle’s turning.
- Simulate the step response of the system and analyze how the controller improves the stability.
- Build a physical circuit to model the transfer function of the system before and after the controller is added.

Research and Design Challenges

- Reducing the number of circuit components used in order to simplify design and reduce cost.
- Taking into account the error of the circuit due to the non-ideal values of the resistors and capacitors used.
- Preventing the op amps from saturating by choosing the correct resistors and capacitors to keep the voltage levels at a minimum.

Methodology

- Solve for the system and controller’s transfer functions:
  - \( G(s) = \frac{114.2552s^2 + 1535.4871s + 3591.795}{s^2(s^2 + 24.3156s + 151.9179)} \)
  - \( G_c(s) = \frac{2.46s + 18}{s + 18} \)
- Develop block diagram for closed-loop system:

Results

Simulation results:

- Original system has overshoot of 40% and settling time of 0.82s
- Controlled system has overshoot of 17% and settling time of 1.15s
- The controlled system has much smaller overshoot and a slightly larger settling time.

Experimental results:

- Original system has 54% overshoot and 0.79s settling time.
- Controlled system has 22% overshoot and 0.94s settling time.

References