PID Controller for Direction Control of Autonomous Car

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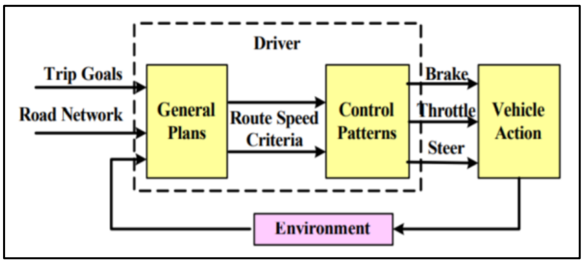
Abstract: There are two categories of vehicle control. The first category is the longitudinal control which deals with the movement of the vehicle in the forward and backward directions (responsible for regulating the vehicle cruise velocity). The second one is the lateral control which deals with sideways movements perpendicular on the vehicle's heading, in other words, the steering of the vehicle to follow a given trajectory. The focus of this paper is on the second category with the objective of minimizing the tracking error.

I. Introduction

As a significant platform to show the level of artificial intelligence technology and the future of the vehicle industry, research into autonomous vehicles has become a focus of the field of robotics worldwide. An autonomous vehicle is an intelligent mobile robot which covers a set of frontier research fields including environment perception, pattern recognition, navigation and positioning, intelligent decision and control and computer science. The purpose of the research is to realize autonomous driving by the vehicle instead of human drivers and to improve traffic safety and transport efficiency.

II. Mathematical Modelling:

A. Block Diagram:



B. Mathematical Model:

$Output_{PID} = K_p.e(t) + K_i \int e(t).dt + K_d \left(\frac{d(e(t))}{dt}\right)$

$G_{PID}(s) = K_p + \frac{k_i}{s} + K_d.s$

C. Transfer Function of car motor:

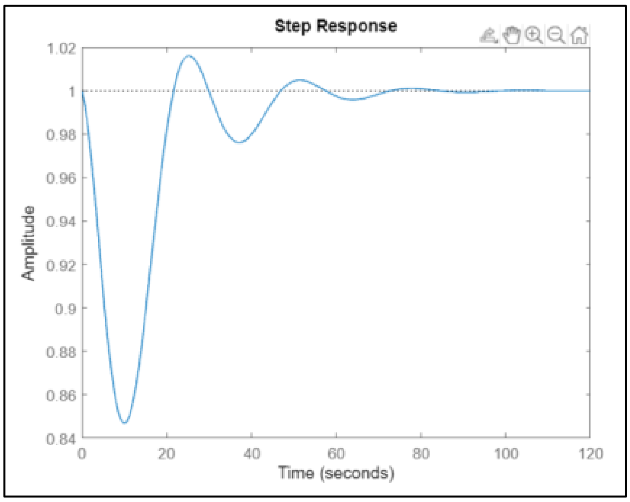
$G_s(s) = \frac{30}{s^2+20s+30}$

D. Closed loop transfer function with PID controller:

$G_s(s) = \frac{3000s^3+6005^2+180s+15}{3001s^3+6205^2+210s+15}$

III. Time Domain Analysis:

A. Step response:



Rise Time: 0.0271

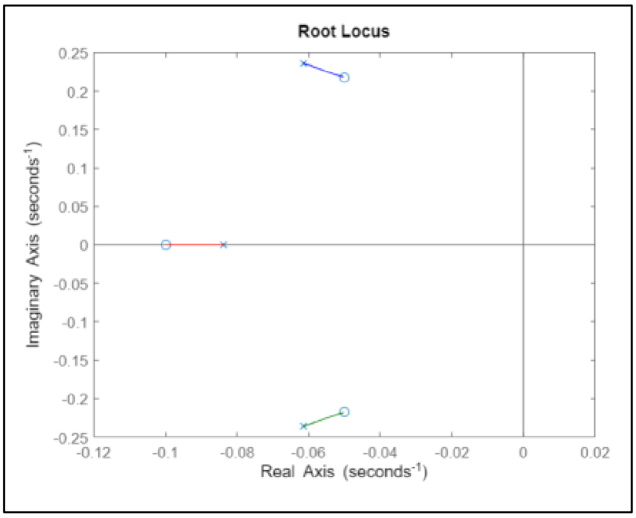
Settling Time: 67.3023

Overshoot: 1.6274

Peak: 1.0163

Peak Time: 25.4890

B. Root-Locus of representation of the system using Matlab:



C. Routh-Hurwitz:

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 Routh-Hurwitz Table:
~~~~~> it is a stable system! <~~~~~

 Number of right hand side poles = 0
Do you want roots of system be shown? Y/N
N
>> rhTable

rhTable =

    1.0000   30.0000
   20.0000         0
   30.0000         0
    0.0100         0

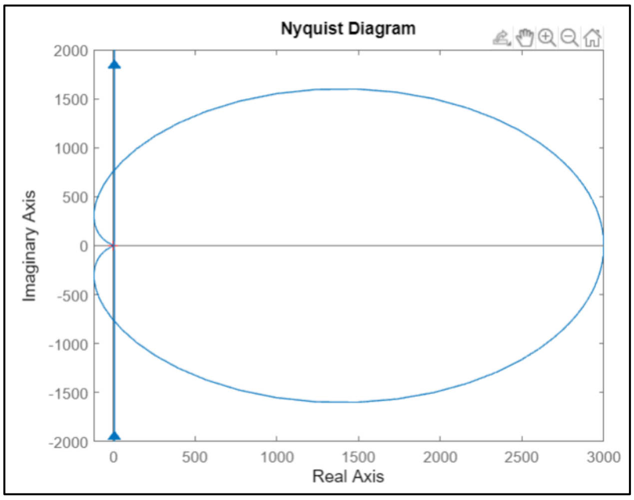
>> sysRoots

sysRoots =

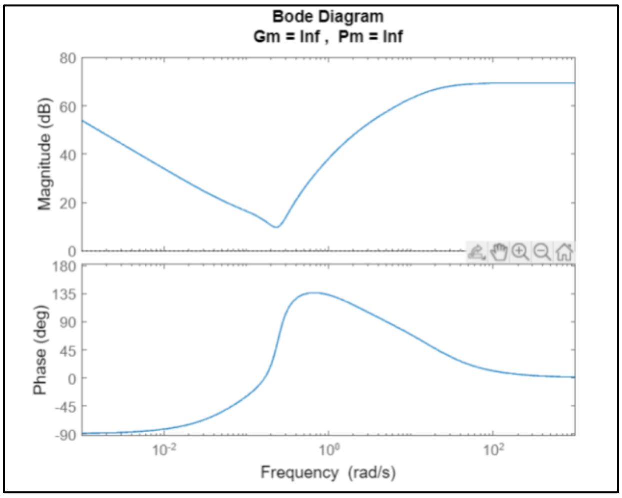
         0
  -18.3666
   -1.6334
```

IV. Frequency Domain Analysis

A. Nyquist Plot:



B. Bode Plot:



C. Stability using GM & PM

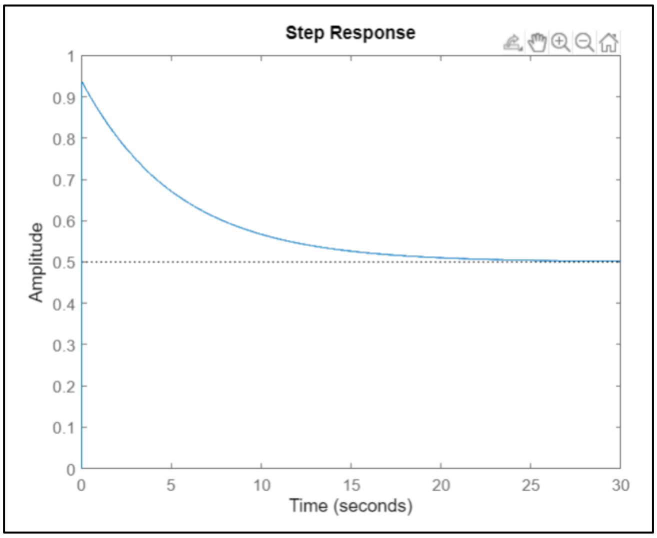
The gain margin(GM) of the system is infinity, this means that the system is stable if we increase or decrease the gain by any value.

The phase margin(PM) refers to the amount of phase, which can be increased or decreased without making the system unstable. Here the phase margin is infinity, which means the maximum phase which can be varied in infinity, for the system to remain stable.

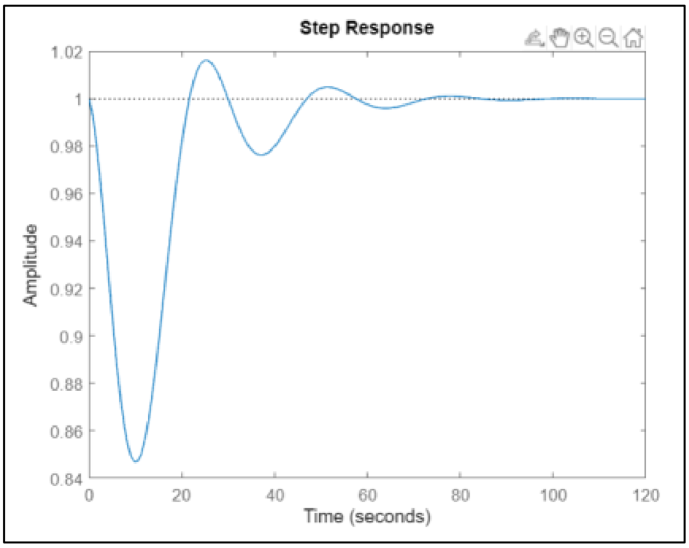
V. PID Controller Design and testing

A. System Response

a. Without controller:



b. With PID Controller:



VI. Results & Discussions

We were targeting 10% overshoot and the achieved outcome is 1.6274. Our model also satisfies Routh-Hurwitz and Nyquist stability criteria. Hence, we have achieved desired control objectives in this project.

VII. Conclusion & Future Scope

In this paper, a control system for direction control of autonomous vehicles is investigated. Research into autonomous vehicles has become a focus of the field of robotics worldwide as it can be a significant platform to show the level of artificial intelligence technology and the future of the vehicle industry. Autonomous vehicles don't drink alcohol nor take drugs, they are never tired or sick, they never take medicines, they never lose their concentration or talk by phone, they know how to drive since the first moment and don't need to learn, they never act recklessly when driving.

VIII. Reference

[1] Track Manoeuvring using PID Control for Self-Driving Cars, Wael Farag, Electrical Engineering Dept., American University of the Middle East, Kuwait (2020).

[2] Marcel Bergerman, OmeadAmidi, James Ryan Miller, Nicholas Vallidis, Todd Dudek, "Cascaded Position and Heading Control of a Robotic Helicopter", Proceedings of the 2007 IEEE/RSJ International Conference on Intelligent Robots and Systems San Diego, CA, USA, Oct 29 - Nov 2, (2007).

[3] S.Chaiyaporn. "System Identification of an Electrical Car for Steering and Speed Control." Asian Institute of Technology Master Thesis, Dec 2007.

[4] Ian Schworer, "Navigation and Control of an Autonomous Vehicle", Virginia Polytechnic Institute and State University Master thesis.