Adaptive Steering Solutions

Four Wheel Steering

Adaptive Steering Solution

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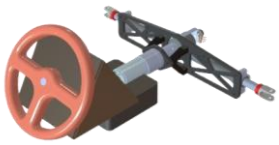
Introduction

- Objective
  - Implement the four-wheel steering system on FSAE race car
- Continuation of previous project group, Quad Steering Solutions
  - Electrically driven servo system for rear steer
- Constraints/rules
  - 6 degrees of turning
  - Integration with existing car, F16



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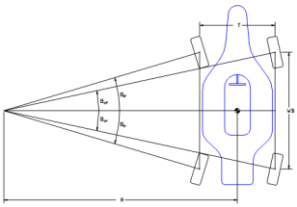
Theory

- Parallel-steering
  - All four wheels turn in the same direction
  - High speeds
- Counter-steering
  - Turn the rear wheels opposite of the front wheels
  - Low speed
- This project will only focus on counter-steering
  - Small vs large steering inputs



Woods, Bob, "Four-Wheel Variable Counter Steering."

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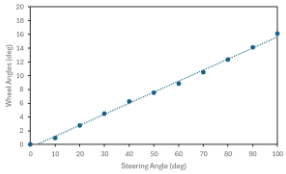
Approach



Steering Wheel Angle vs Front Wheel Angle on Car

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Equations

Control System Equations

Theoretical

$$Turn\ Radius = \frac{\frac{WB}{\tan(\delta_o)} - \frac{TF}{2}}{12}$$

Measured

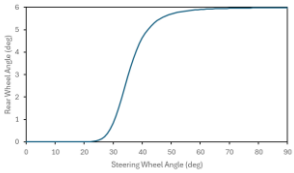
$$Turn\ Radius = 2231.6\,(\emptyset_{SW})^{-1.155}$$

Percentage Rear Steer

$$PRS = -50\tanh(0.1(Turn\ Radius) - 4.5) + 50$$

Desired Rear Angle Degrees

$$\emptyset_{Desired} = PRS \times 6.0$$



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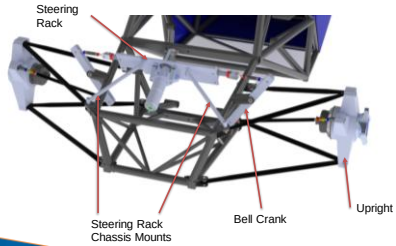
Suspension Modifications



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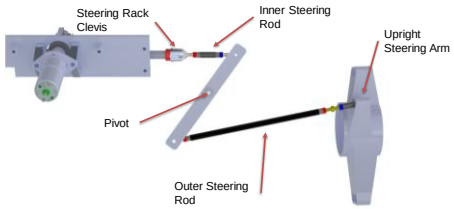
Suspension Modifications



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Suspension Modifications

Old Upright Design

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System Testbed

Includes:

- Steering Rack
- Servo Motor
- Control Components
- Electronics Board
- Steering wheel mounted to potentiometer for user input

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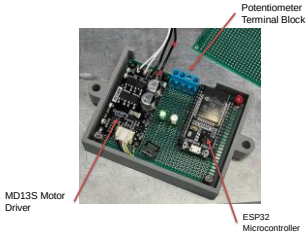
Control Component - Electronics

- ESP32 Microcontroller for its processing speed.
- Sealed connectors and housing for automotive use
- Ready to install on F16



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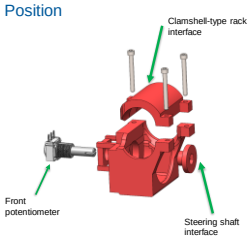
Control Components

Desired Rear Steer Position

- Front steering position sensor
  - Input to Control System
  - Mounts to existing F16 front steering rack input shaft
- Determines desired rear steering position



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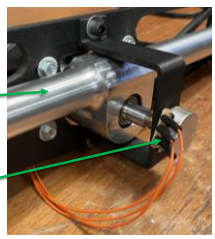
Control Components

Actual Rear Steer Position

- Actual rear steering position determined using second potentiometer



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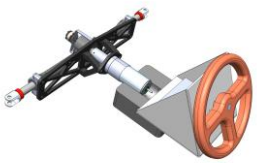
Testbed Demonstration



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Questions?

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Supplemental Information

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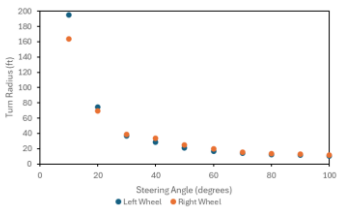
Supplemental Information – Turn Radius



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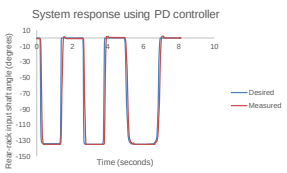
Supplemental Information – PD Strategy

Control Component – Closed Loop Feedback



- PD type feedback loop used to align desired rear steering position and actual rear steering position
- Desirable characteristics:
  - Minimize overshoot of desired position
  - Minimize oscillation
  - Maximize response to change in desired position
  - Maintain steering angle with varying wheel load

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Supplemental Information - Code

- The code was designed to be easily adjusted and adaptable for future implementation.
- Wrote in C as it is a pre-compiled language meaning faster computing speed and more control over the memory and hardware
- The measured values for the car are stored as variables therefore when changes are made the code is quick to adjust

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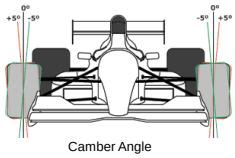
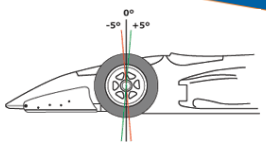
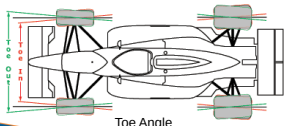


Camber Angle



Caster Angle



Toe Angle

Source:TireRack

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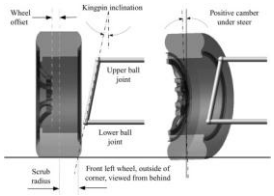
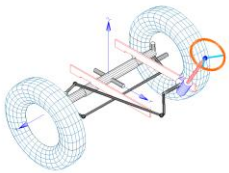


King Pin Inclination



Bump Steer

Source: wikimedia commons

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Reference

- [1]. Woods, Bob, "Four-Wheel Variable Counter Steering," February 20, 2022, UTA Internal Documentation, file: "Four-Wheel Variable Counter Steering.docx"

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