Project Manual

Simulation Steering Wheel

ESCE 2010 - Fall 2025

August Bernberg

October 8, 2025

Project Resources

LTSpice Simulation File:
Github Link to .asc File

Contents

1 Description

1.1 Complete Schematic and Block Diagram

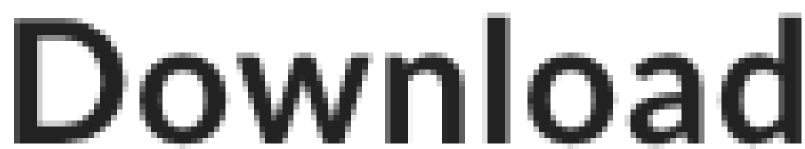


Figure 1: Complete circuit schematic - ALL major components must be clearly labeled

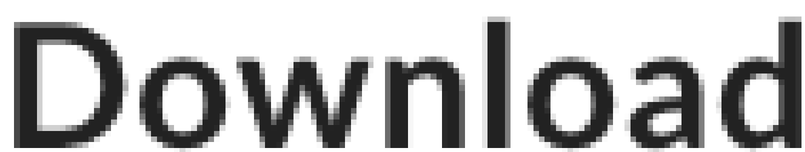


Figure 2: Block diagram showing functional relationships between stages

1.2 High-Level Description of Operation and Intended Application

This project focuses on the design and fabrication of a custom simulation steering wheel, integrating load cells, buttons, and a servo to create a realistic driving experience for the user. The load cells measure precise grip force which is translated into throttle or braking; the buttons are timely triggered for insim actions; and the servo motor's rotational data is measured for steering functionality. All sensor data is then read and translated be the HID(Human Interface Device) format and relayed to a computer via a microcontroller - the microcontroller's only purpose is to read, not manipulate external data - whihc allows for seamless communication with a simulation software/application.

1.3 Description of Related Pre-Existing Applications

There are numerous existing sim wheel options from manufacturers such as LogitechG, Thrustmaster, and others. Entry-level models typically start around $100, with midrange units costing up to $300, and high-end versions—featuring force feedback, F1-style layouts, and other advanced features—reaching significantly higher prices. In contrast, this project aims to deliver similar functionality at a fraction of the cost, while maintaining high precision, simplicity, and ease of construction. However, unlike other commercial simulation wheels that rely heavily on microcontrollers to handle sensor inputs, this design focuses on hardware solutions while using as little power from a microcontroller, besides HID formatting, which has a combination of pros and cons.

2 Operation and Design

2.1 Input Block

2.1.1 Schematic

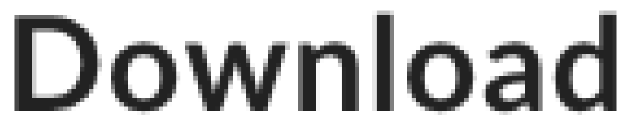


Figure 3: Input block schematic with ALL components labeled

2.1.2 Design Equation

$$V_{out} = f(V_{in}) \tag{1}$$

where all variables are defined here or in the schematic.

2.1.3 Input/Output Plot

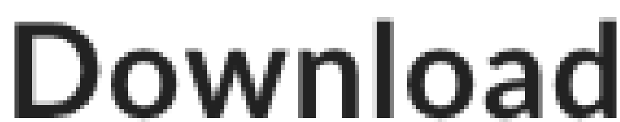


Figure 4: I/O characteristic - from measurement, simulation, or datasheet (cite source!)

3 MS1 Building Block 1

3.1 Schematic

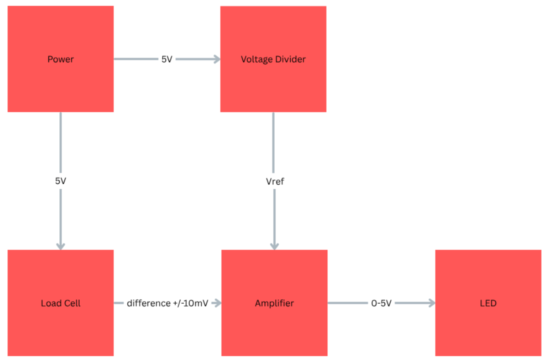


Figure 5: Building Block 1.1

3.2 Design Equation

Load Cell Output: *manufactures provide no internal resistances of wheatstone bridge besides output voltage*

$$V_{out} = \pm 10mV$$

Amplifier Gain:

$$G_m = 1 + \frac{49.4k\Omega}{R_G}$$

Voltage Divider:

$$V_{out} = V_{in} \times \frac{R_1}{R_1 + R_2}$$

Defined variables:

- G_m = gain multiplier
- R_G = resistor gain
- V_{out} = output to amplifier reference pin(6 recieving 2)
- R_1 & R_2 = resistors for voltage divider to get 2.5V output

3.3 Discussion of Component Choices

The loadcell has a 10mV output according to the manufacture(there is no information regarding the internal wheatstone bridge so cant provide a schematic for that). This means to get an LED lighting output, there needs to be a gain to 5V, which is approximately 500x multiplier. However, an input via a voltage divider supplies a baseline 2.5 volts, meaning there is only a required 50% gain, or 250x. Given the manufacture's gain of their AD8226 amp, it only requires a $\tilde{2}00$ ohm resistor to reach my threshold.

3.4 Input/Output Plot

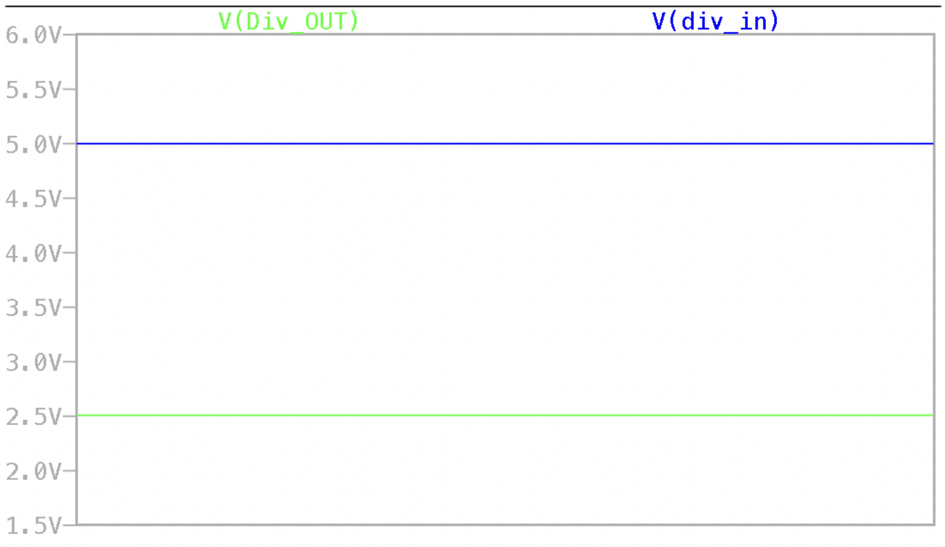
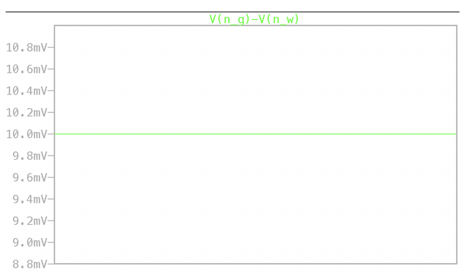


Figure 6: Voltage Divider



(a) Input

(b) Output

Figure 7: Amplifier

3.5 Output Block

3.5.1 Schematic

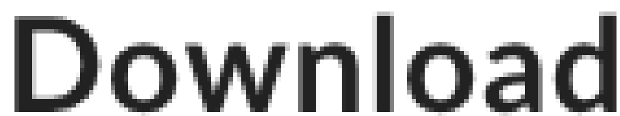


Figure 8: Input block schematic with ALL components labeled

3.5.2 Design Equation

$$V_{out} = f(V_{in}) \tag{2}$$

where all variables are defined here or in the schematic.

3.5.3 Input/Output Plot

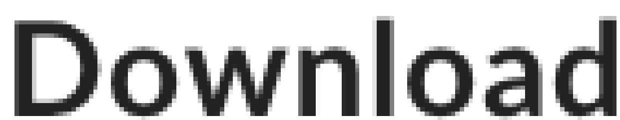


Figure 9: I/O characteristic - from measurement, simulation, or datasheet (cite source!)

4 Integration and Optimization

4.1 MS1

5 Operating Conditions

5.1 MS1

5.1.1 Limitations and Faults

A major limitation for this milestone is lack of complete data. The adafruit manufacturing team has provided poor documentation and schematics relating to their loadcell - only providing a Mandarin transcribed diagram with limited and inaccurate information(i.e. states range is 1-10kg but the one it is referencing is supposively caps at 20kg load). Besides that

5.1.2 Tradeoffs Present in the Design

5.1.3 Circuit Improvements

6 ABET 3.2 Engineering Design Considerations

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7 References

References

Appendix