Project Manual

Simulation Steering Wheel

ESCE 2010 - Fall 2025

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October 14, 2025

Project Resources

LTSpice Simulation File:
Github Link to .asc File

Contents

1 Description

1.1 Complete Schematic and Block Diagram

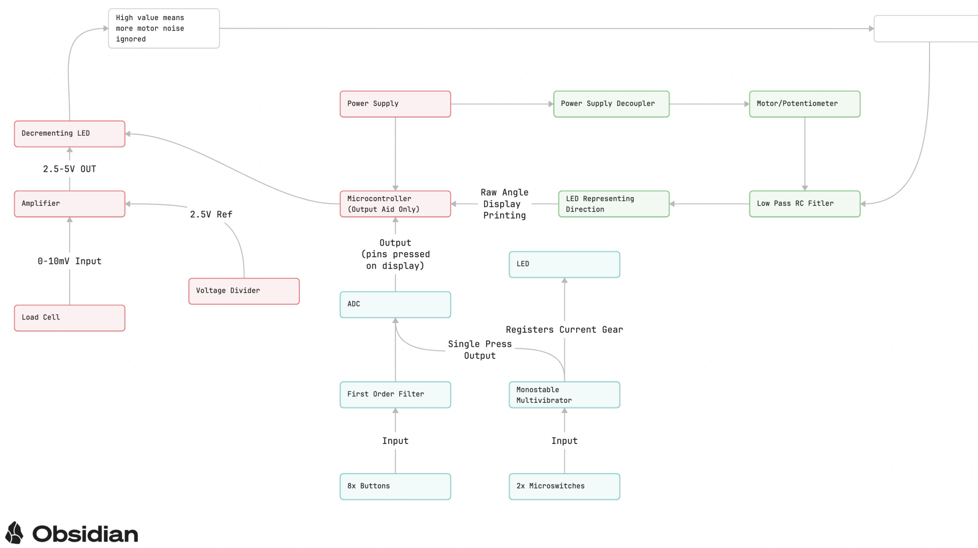


Figure 1: Circuit Schematic

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 - which 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

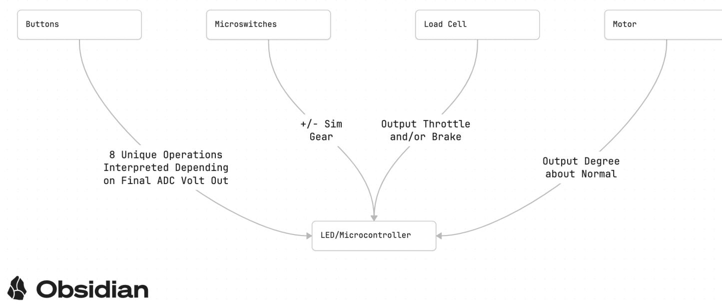


Figure 2: Input Block Schematic

2.1.2 Design Equation

Load Cell: voltage divider and load cell

$$V_{div} = V_{battery} \times (\frac{R_1}{R_1 + R_2})$$

- V_{div} : volt divider with 2 1kΩ resistors outputs 2.5V from 5V input
- $V_{1..2}$: 1kΩ resistor
- V_{load} : load cell takes grip pressure and outputs 0-10mV

Buttons: MS2
Microswitch: MS2
Motor: MS3

2.1.3 Input/Output Plot

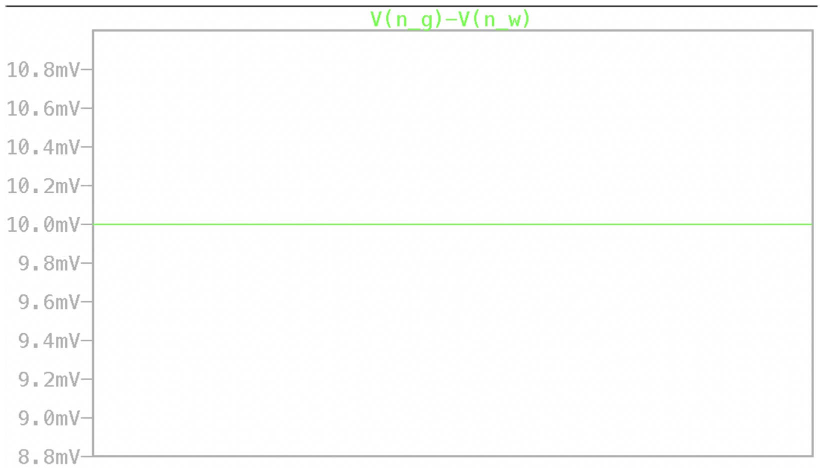


Figure 3: Input Load Cell

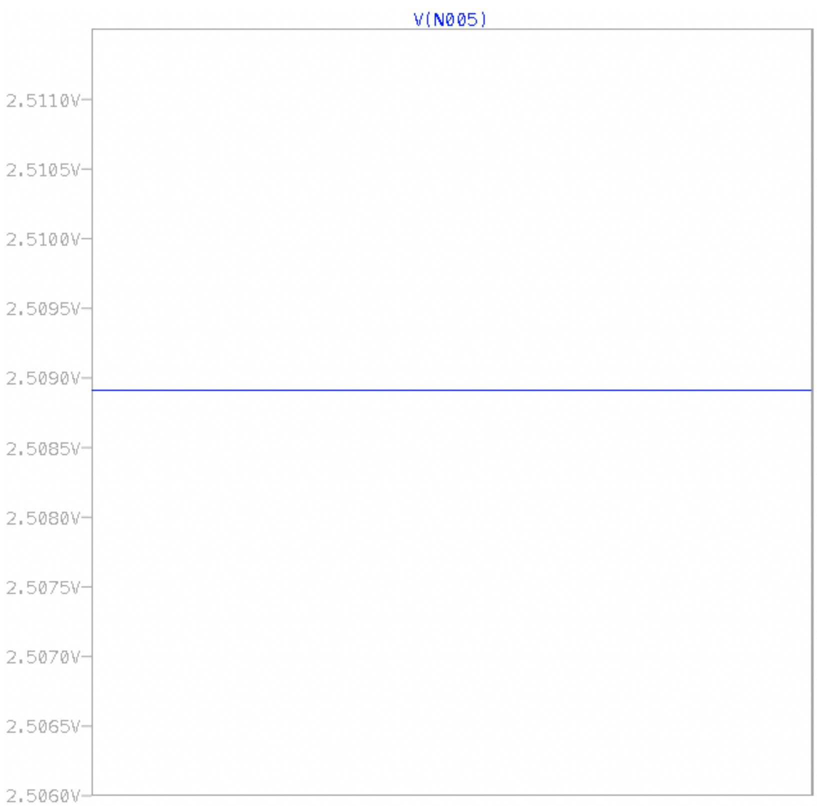


Figure 4: Input Voltage Divider

3 MS1 Building Block 1

3.1 Schematic

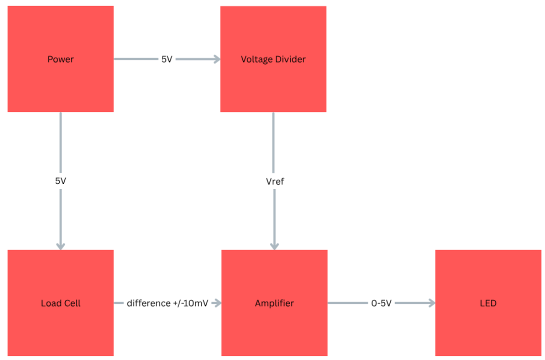


Figure 5: Building Block 1.1

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

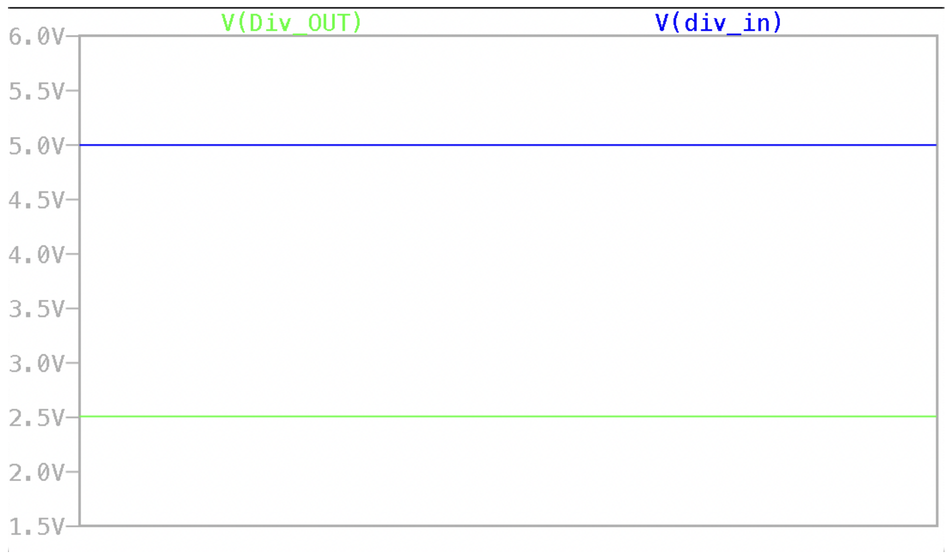
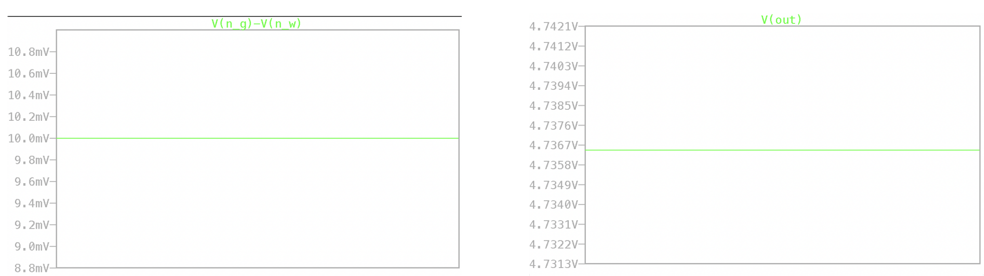


Figure 6: Voltage Divider



(a) Input (b) Output

Figure 7: Amplifier

3.5 Output Block

3.5.1 Schematic

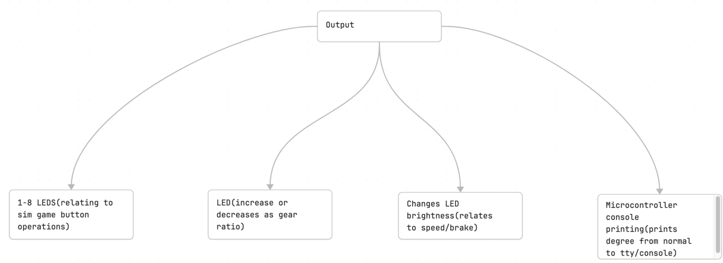


Figure 8: All Output

3.5.2 Design Equation

Speed/Brake LED: output depends on voltage divider reference and load cell output

$$V_{out} = V_{load} \times (1 + \frac{49.4k\Omega}{R_G}) + V_{ref}$$

- V_{out} : total output from buttons to an LED
- V_{load} : voltages output from load cell(0-10mV)
- R_G : gain resistor(220Ω) for optimal gain
- V_{ref} : reference from voltage divider(2.5V to get a 2.5-5V output from amp)

1-8 LEDs: MS2
Gear LED: MS2
Console Printing: MS3

3.5.3 Input/Output Plot

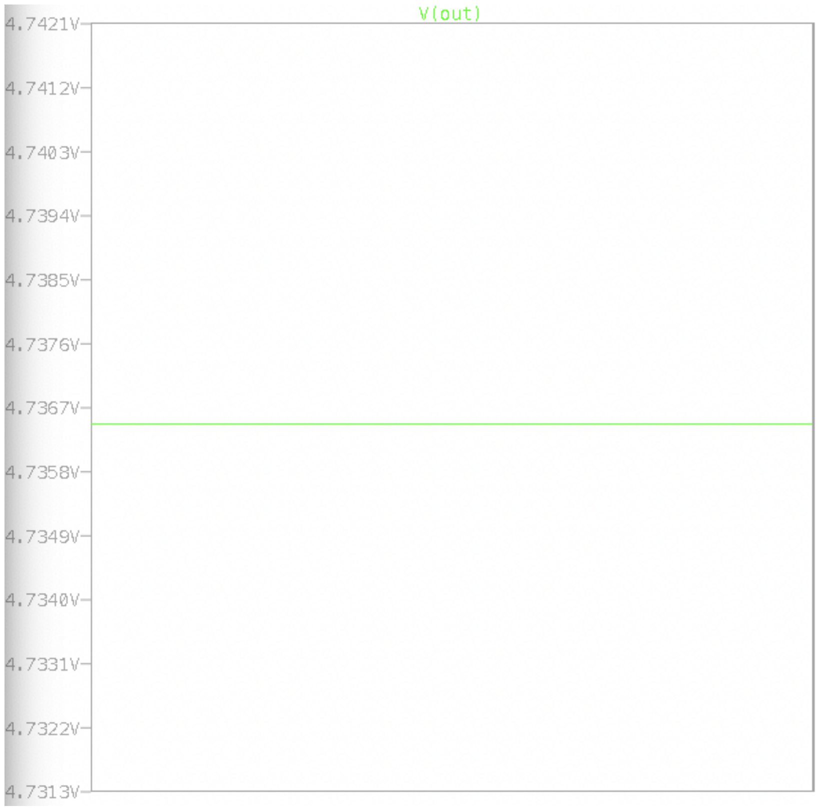


Figure 9: Amp output

4 Integration and Optimization

4.1 MS1

For this block, the V_{out} from the amplifier is the only consideration for the entire circuit. It provides a range of 2.5V to 5V which is shown in an LED, over time this will be integrated into the whole circuit as a raw digital input for the microcontroller (just interprets data, doesn't manipulate it).

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, there is an accuracy limitation. The precision of the load cell is only soo high but a more precise one is preferable with digital output for most accurate readings(not an LED).

5.1.2 Tradeoffs Present in the Design

The V_{ref} isn't a necessary component. The range is from 2.5-5V due to a reference voltage of 2.5V from the voltage divider. This isn't needed because a gain resistor of 100Ω obtains the same values; however, due to measuring limitation and proof of skills requirements, this is needed as another measurable node.

5.1.3 Circuit Improvements

The circuit could be improved with a higher quality load cell which provides better precision. Another component would be a digital display for reading the output, having an LED increase/decrease isn't an optimal testing component.

6 ABET 3.2 Engineering Design Considerations

When approaching this load cell component, I learned about the requirement of using an amplifier because although it outputs a 2.5V output, the resistive change is the only measured element which is +/- 10mV, which for most applications is unrecognizable. So to increase it, I looked for an amplifier that could take these inputs and find the difference between them. While looking into my educational hardware box, I found the AD8226 chip which took two differential outputs and measured then amplified their output, which was perfect. Once I found a useful chip, I went directly to the documentation provided by Analog.com for their documentation and used their provided gain equation which provided me with the information of requiring a 220ohm resistor to get the gain I needed. I could have looked for alternative choices; however, being that this was sufficient and powerful enough to support my requirements, it was a perfect fit.

7 References

References

Appendix