UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN

# Isolated Current Sensor

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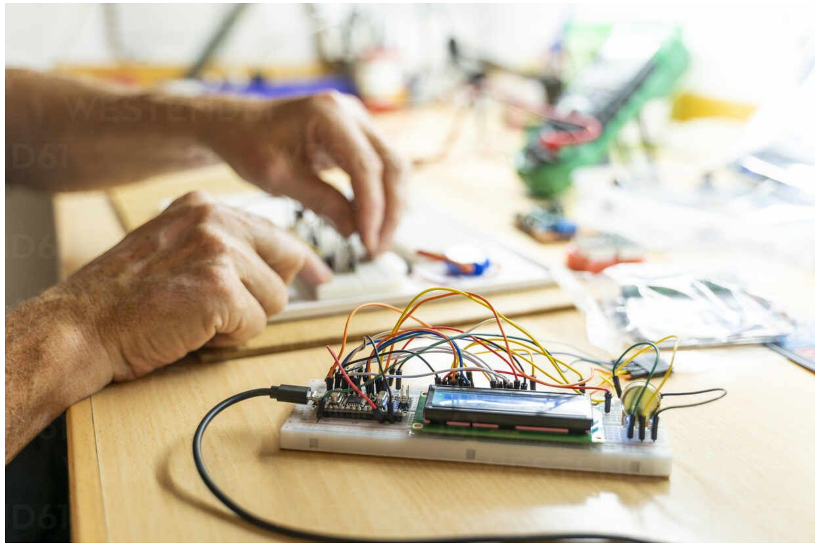
# Introduction

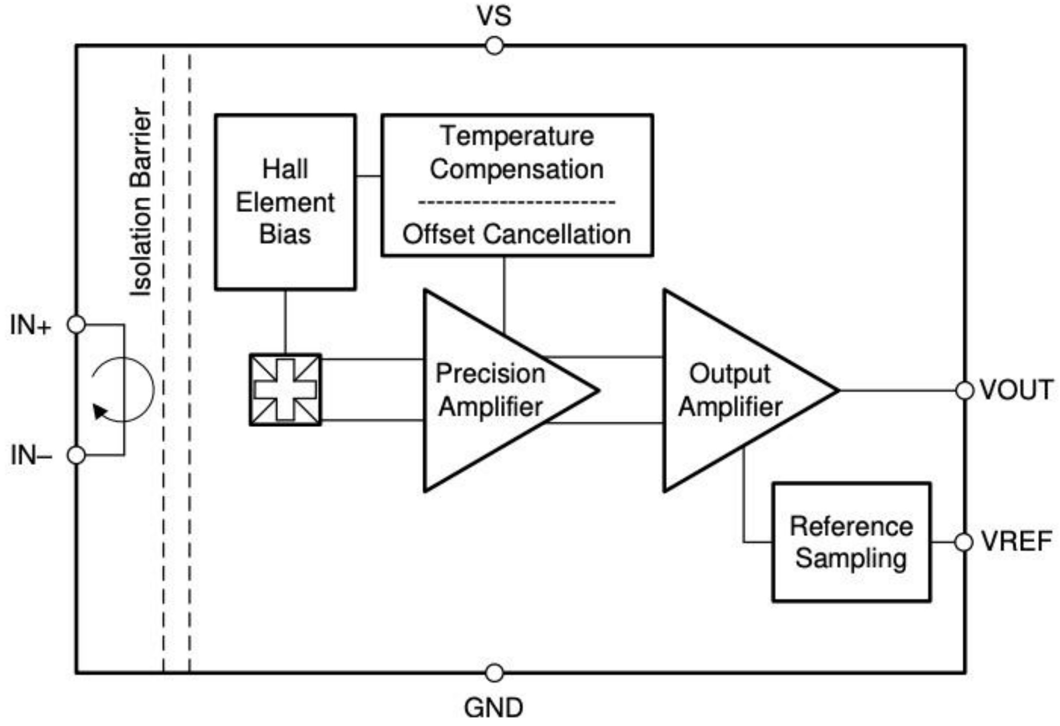
# Problem

- Power electronics researchers need to accurately know what current they are handling
- Lets user know about any safety precautions that should be taken
- This requires creating a custom test circuit for every circuit being tested
- Also do not want the test circuit to interfere with the device



# Solution

- The Isolated Current Sensor
- Utilizes a Hall-Effect sensor
- A universal current testing circuit
- Saves researchers time and effort




Hall-Effect Sensor (TMCS1100A3QDR) Functional Block Diagram

# Design

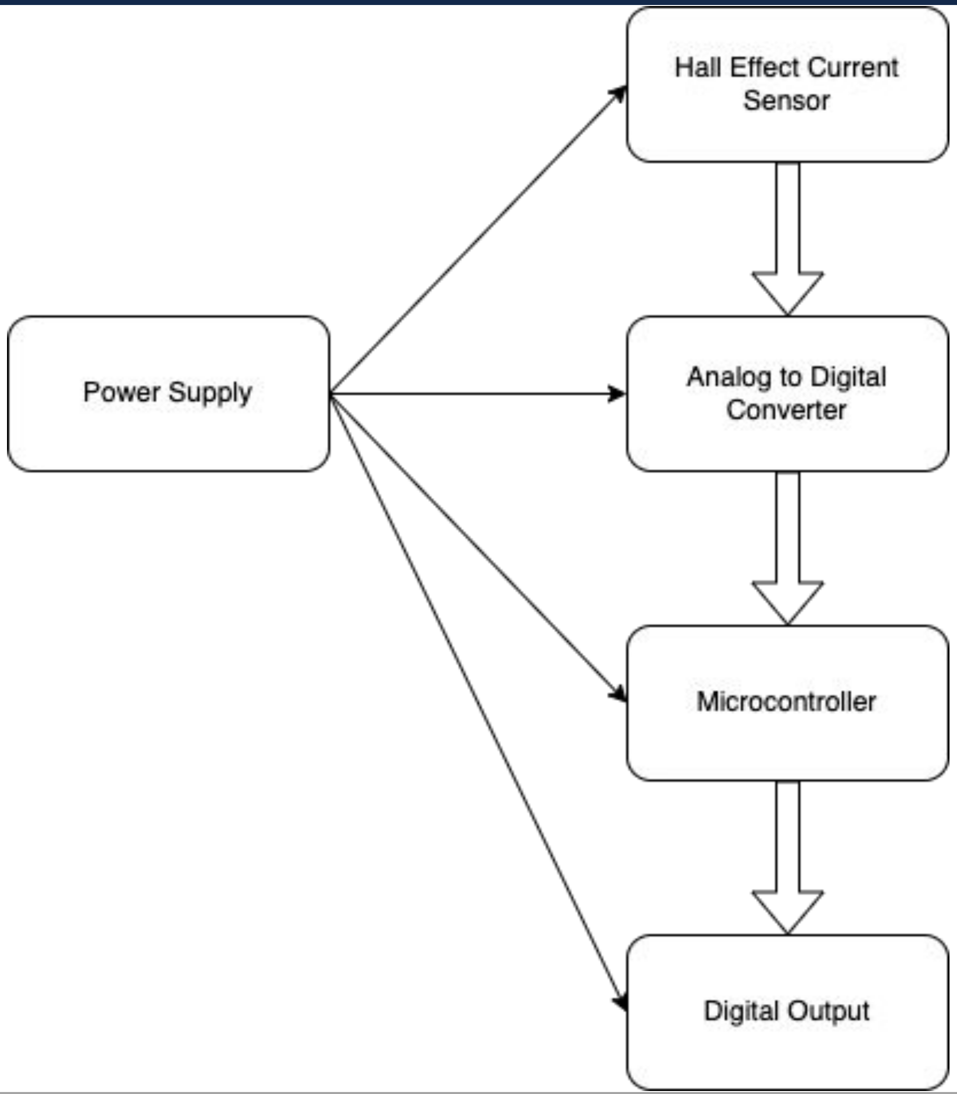
# Design

**High-Level Requirements:**

1. This product should have a reading accuracy of +/- 1% with 3 concurrent current inputs.

2. This product should have the ability to handle up to 50 KHz in bandwidth.

3. This product should have the ability to handle up to 10 Amps of current



# Design

## Hall-Effect Sensor:

- Handle up to 10 Amps

## ADC:

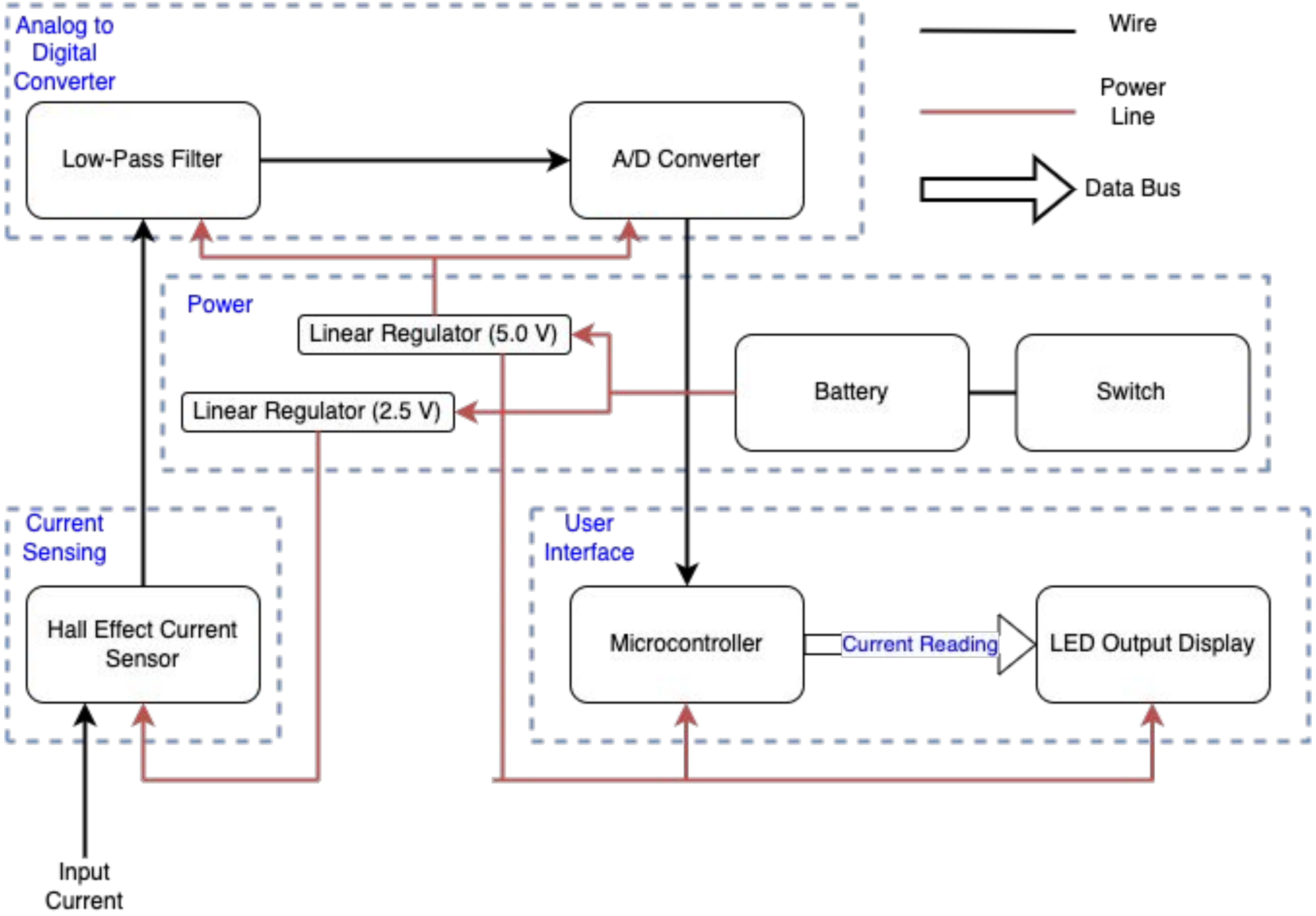
- LPF filters freq > 50 KHz

## Microcontroller:

- Output has error <1%

## LED Display:

- Outputs correct values

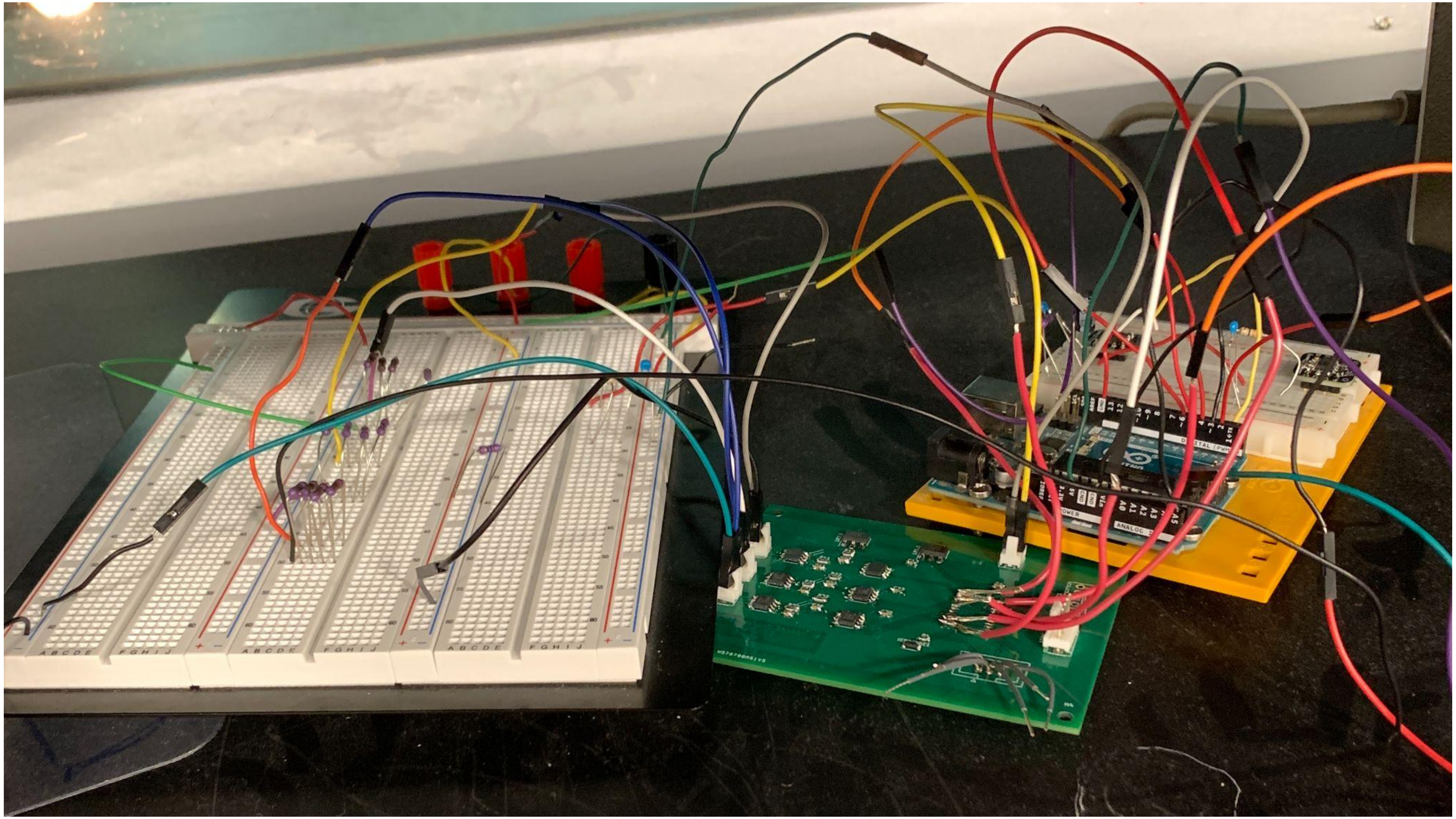


# Design

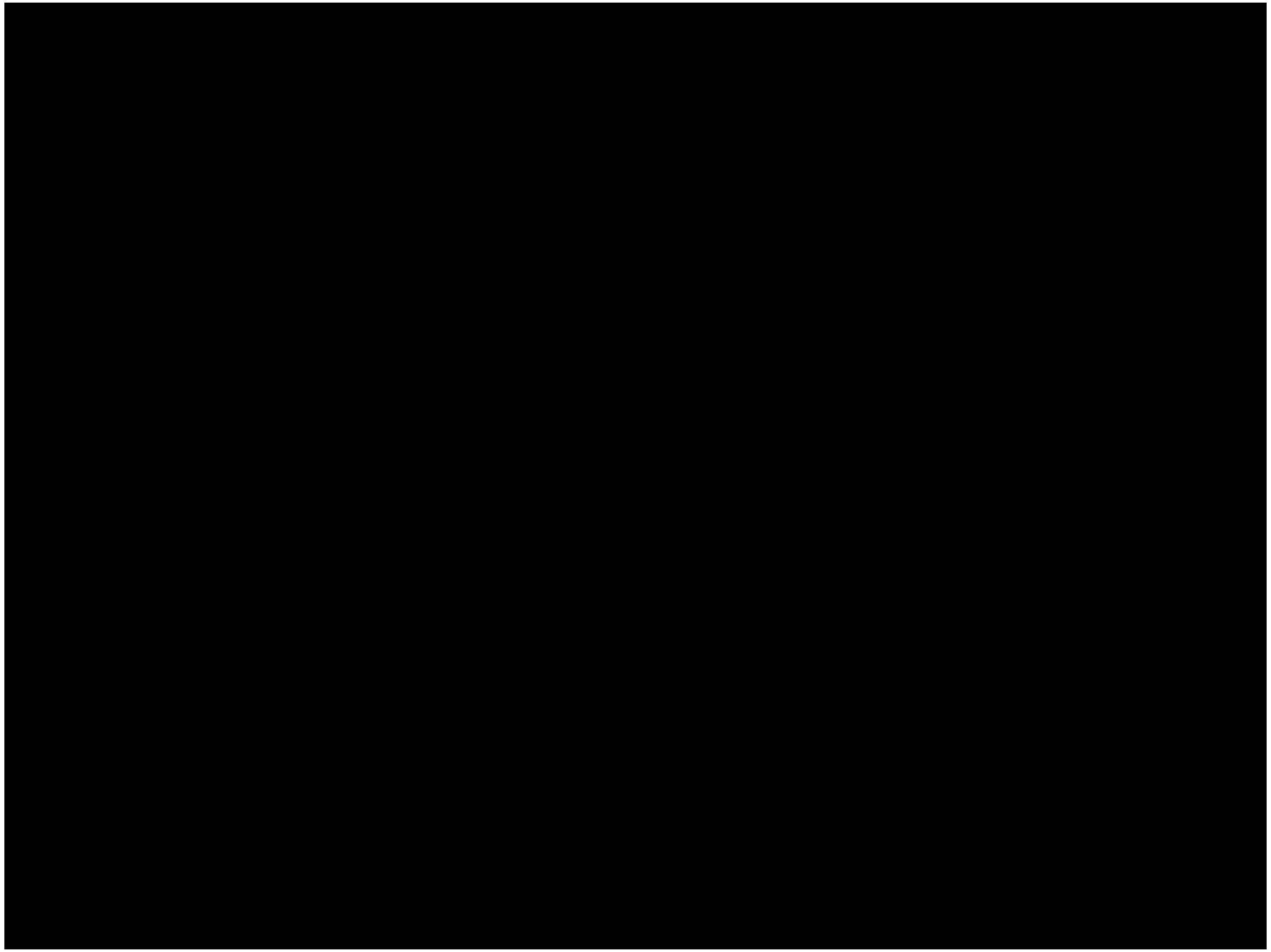
| **Mathematical Step** | **Reasoning** |
|---|---|
| 5/4096 = 1.221e-3 V | This represents the step voltage of the ADC. |
| Input Voltage  - Digital Output < 1.221e-3 /2 | This is the largest value that difference can have. |
| \|Input Voltage - Digital Output\| /0.2 = .00304 = Current Reading | Converts the voltage to Amps |
| (\|Input Current - Current Reading\| /Input Current) <0.01 | Percent Error Formula |
| Input Current = .00304/.01 = .304 Amps | Using Substitution from Above |

# Project Build and Video

# Project Build



# Video



# Successes and Challenges

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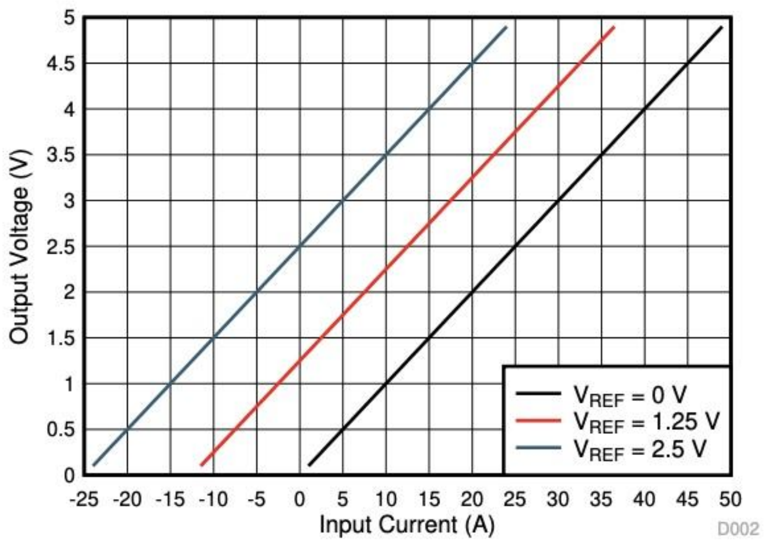
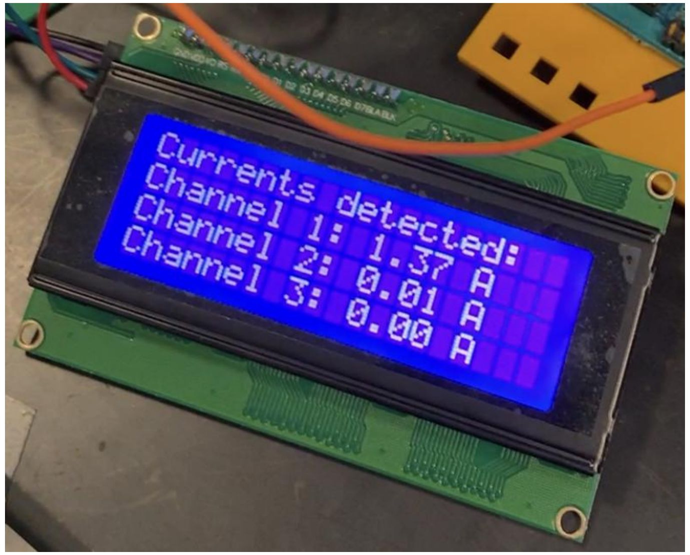
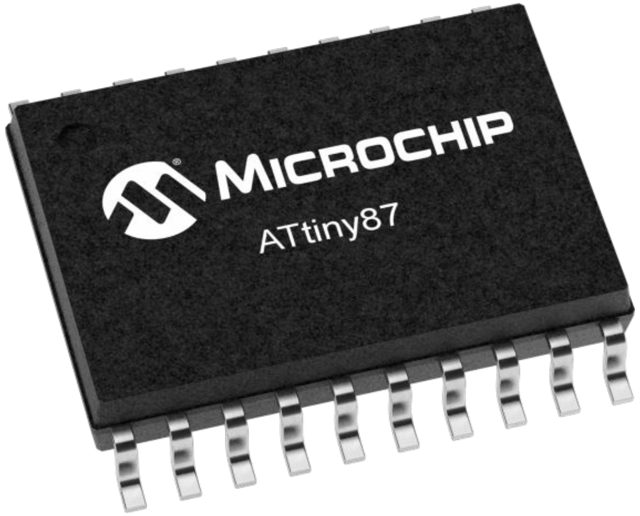



## Successes :

- The Hall Effect Sensor was able to produce the correct output voltage based on the reference voltage and input current being provided to it
- The data was successfully read in and the arduino microcontroller was able to output the result smoothly onto the LCD display. Numbers would update in real time

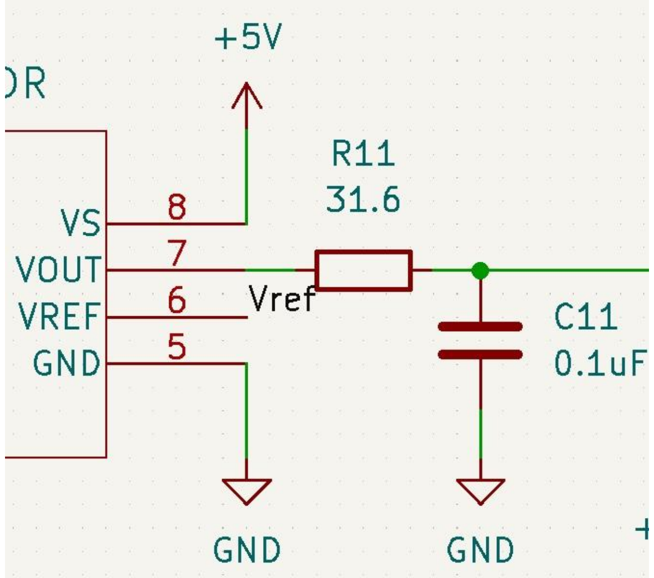




## Microcontroller :

- We were unsuccessful in our attempts to upload the program into our microcontroller, the ATTINY87
- We realized late that we had not set the programming pins layout to the default SPI layout
- The arduino microcontroller (ATmega328P) was used as a substitute and wires were soldered on the board based on the pins needed for the clock, chip select, and data

# Successes & Challenges



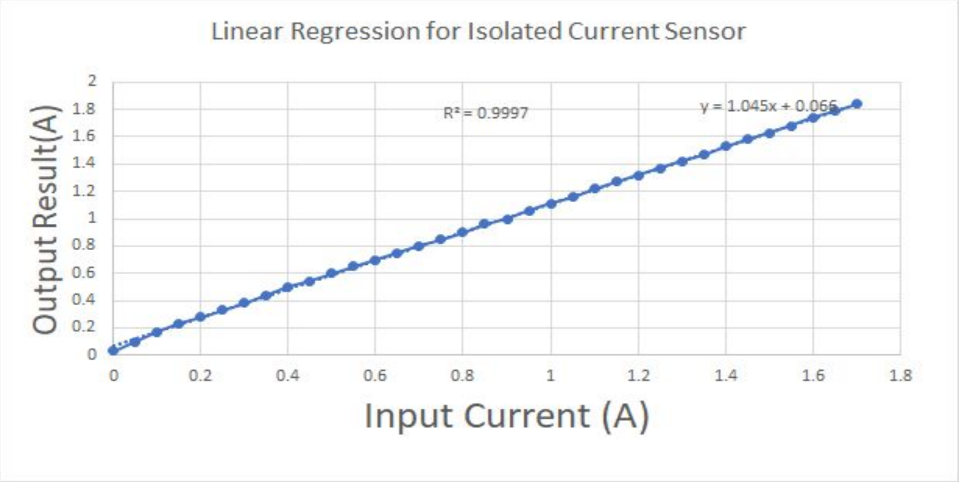

```
for (int i = 0; i < 1000; i++) {
  tmp1 = (readADS7817(D1)/4096.0)*5;
  tmp2 = (readADS7817(D2)/4096.0)*5;
  tmp3 = (readADS7817(D3)/4096.0)*5;
  if (tmp1 > 2) {
    a = a + tmp1;
    c1++;
  }
  if (tmp2 > 2) {
    b = b + tmp2;
    c2++;
  }
  if (tmp3 > 2) {
    c = c + tmp3;
    c3++;
  }
}
```

## Filter :

- Initially, results tended to be all over the place and inaccurate
- This was due to the high bandwidth (50 KHz) being used by the circuit
- The higher the bandwidth value, the more chances of noise passing through
- ‘To account for this, the microcontroller ignores those values lower than a certain threshold in the code

# Successes & Challenges

| Input Current (A) | Output Result (A) |
|---|---|
| 0 | 0.03 |
| 0.1 | 0.17 |
| 0.2 | 0.28 |
| 0.3 | 0.38 |
| 0.4 | 0.5 |
| 0.5 | 0.6 |
| 0.6 | 0.7 |
| 0.7 | 0.8 |
| 0.8 | 0.9 |
| 0.9 | 1 |
| 1 | 1.11 |
| 1.1 | 1.22 |
| 1.2 | 1.32 |
| 1.3 | 1.42 |
| 1.4 | 1.53 |
| 1.5 | 1.63 |
| 1.6 | 1.74 |
| 1.7 | 1.84 |




## Accuracy :

- Even accounting for the filtering, the offset seen between the expected value and the actual output were large
- To tackle this problem, we decided to take readings of the output between 0 A and 1.7A and plot a linear regression model
- After the model was implemented in code, results were a lot more accurate and the final result was around the ± 1% our device needed to hit as per the high level requirement

# Safety and Ethical Concerns

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- Working with high current can be dangerous
- Not only for us testing the device, but also for the end-users
- We each took an electronics safety training
- Always had at least two group members in the lab when testing
- Tested on lower values to be more safe

# Conclusion and Further Work

# Conclusion

Learned a lot about the entire engineering process

- Choosing components
- Sourcing components
- Designing schematic and layout of printed circuit board
- Assembling components onto board
- Testing components
- Debugging
- Keeping a record of the process in writing

# Conclusion

Things we would have done differently

- Use a less complex microcontroller
- Look more into the filter design
- Spend more time on functionality rather than appearance
- Started debugging earlier, especially the microcontroller

# Further Work

Ideas to continue this project:

- Add UART component to send data to a computer
- Design a better filter for cleaner data
- Create enclosure for device, incorporate battery and switch
- Put it into practice

# Thank you for listening

# Questions?

The Grainger College of Engineering

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