UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN

Rep Counter and Time-Under-Tension Tracker

Electrical & Computer Engineering

ECE 445: Senior Design Laboratory

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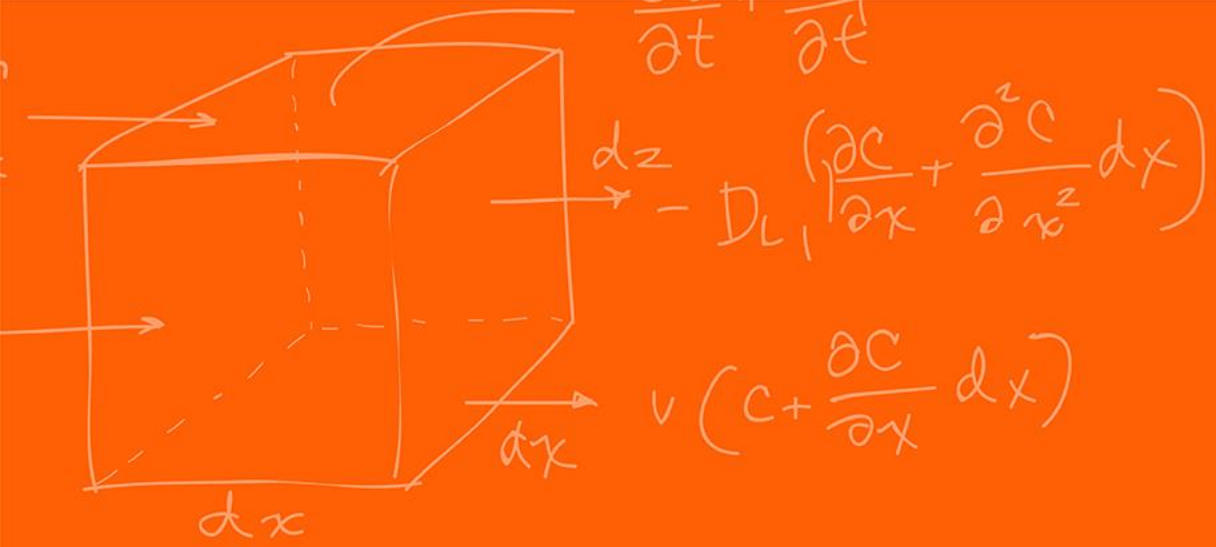
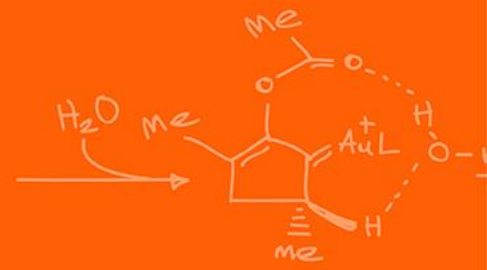
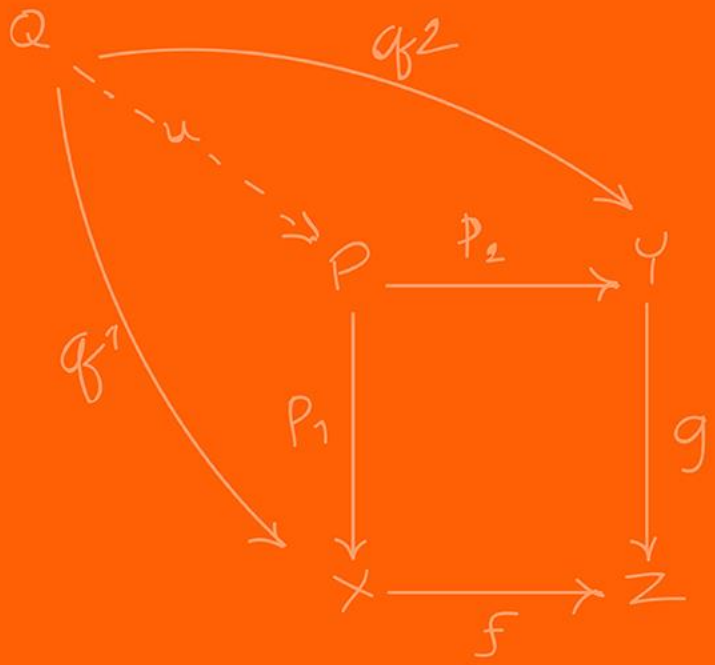
MAY 1, 2025





Introduction



Team

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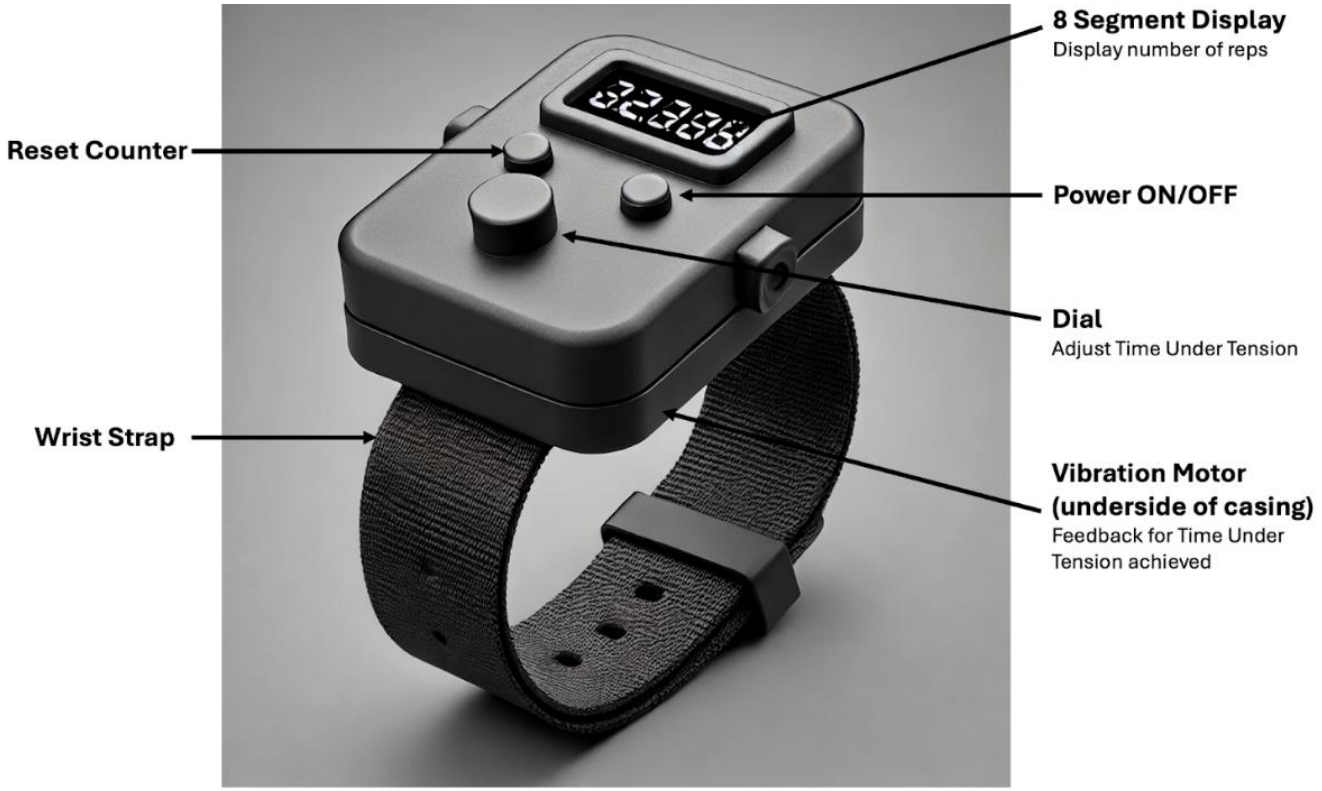
Objective

The Problem

Low-quality workouts without gym trainer: trouble counting reps and maintaining time-under-tension.

The Solution

Wristwatch to count reps and measure time-under-tension.



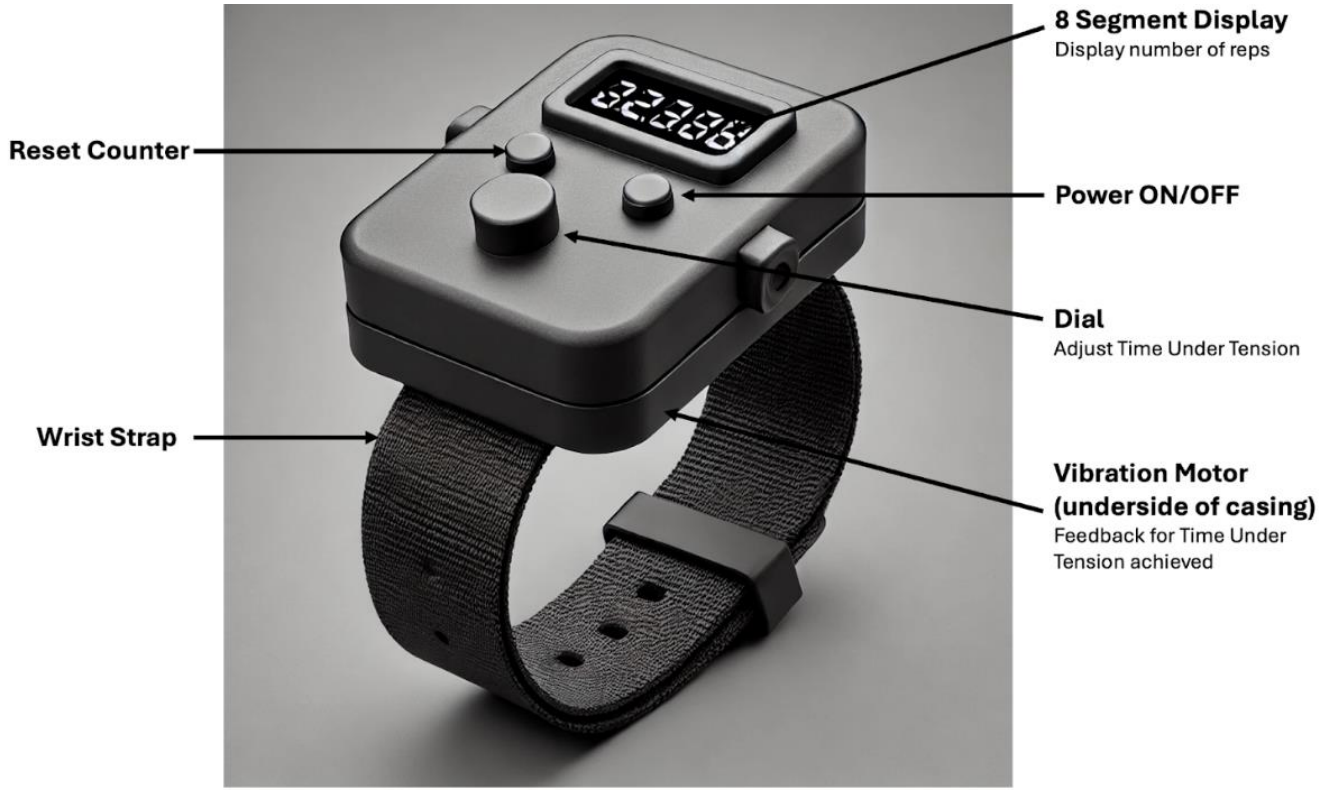
Proposed Solution

High Level Requirements

1. The user must be able to adjust the Time Under Tension duration between 1 to 10 seconds with 1 second increments using a dial.

2. The system accurately detects and counts exercise repetitions with a minimum accuracy of 90%.

3. The timer feature shall measure Time Under Tension with an error margin less than ±1 second per repetition to ensure precise workout tracking..



Proposed Solution

Alternatives

Garmin Forerunner 255 - Slate Gray,...

$249.95

Walmart

★★★★½ (4k+)

Garmin Watches

- Spotty Rep Tracking

Apple Watch Ultra 2 GPS + Cellular...

$799.99

Target

★★★★½ (3k+)

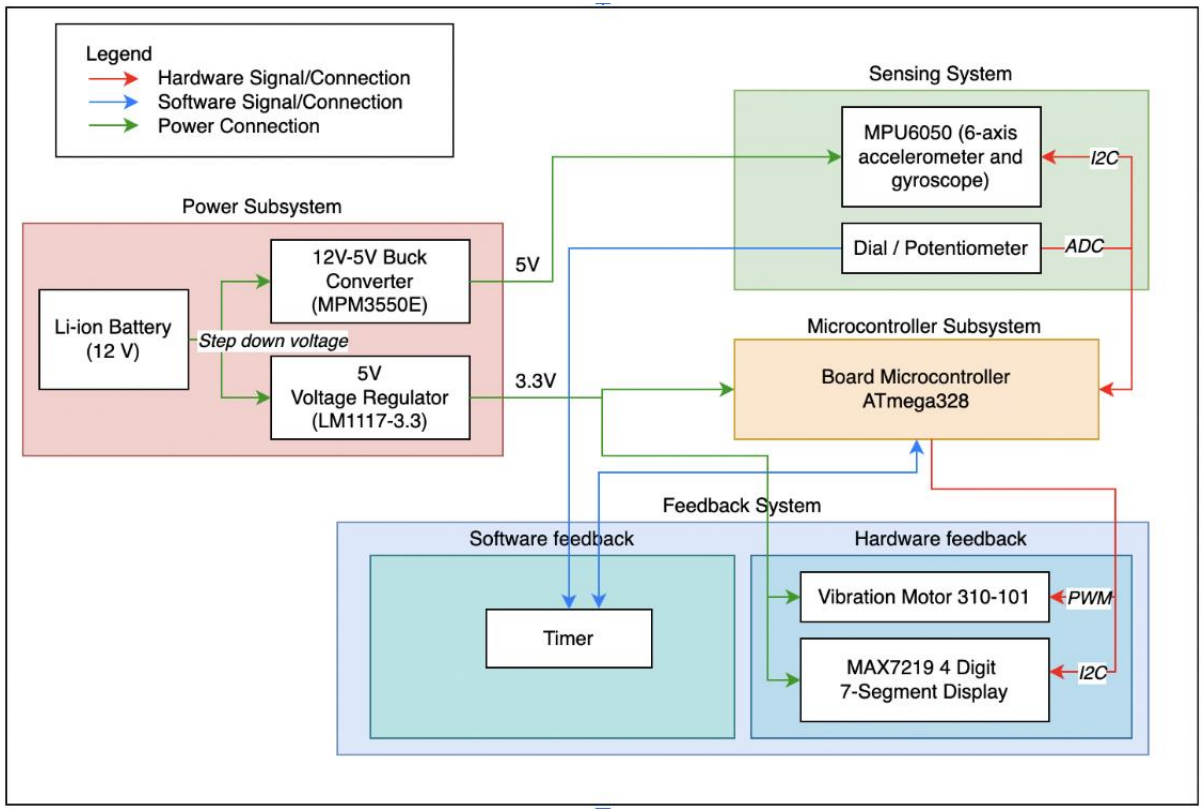
Apple Watch

- No Rep Tracking

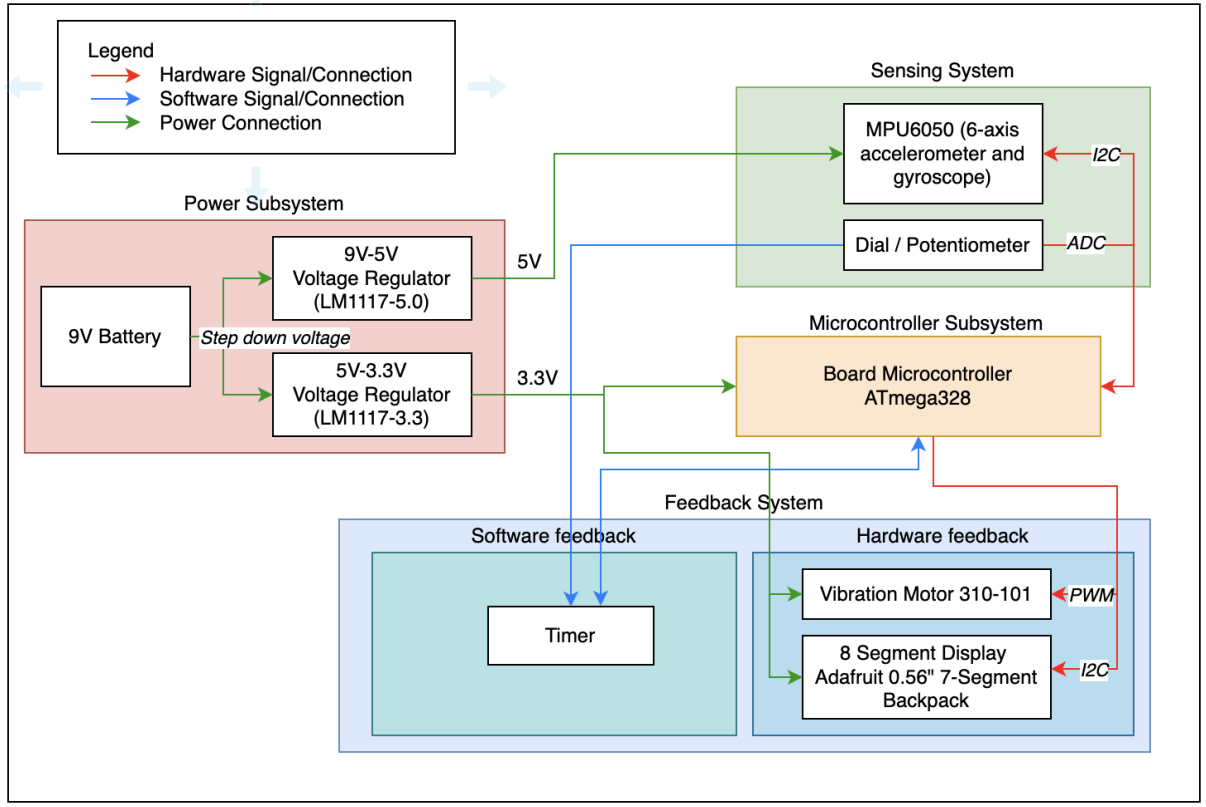
Rep Counting Apps

- Most use cameras (invasive in gym setting)
- Spotty rep tracking

Block Diagram



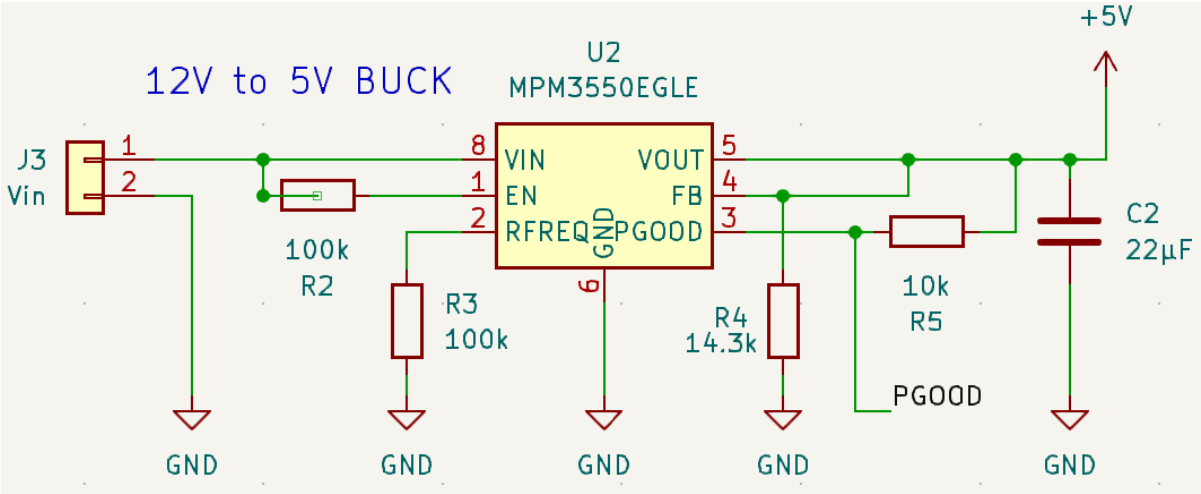
Original Block Diagram



Final Block Diagram

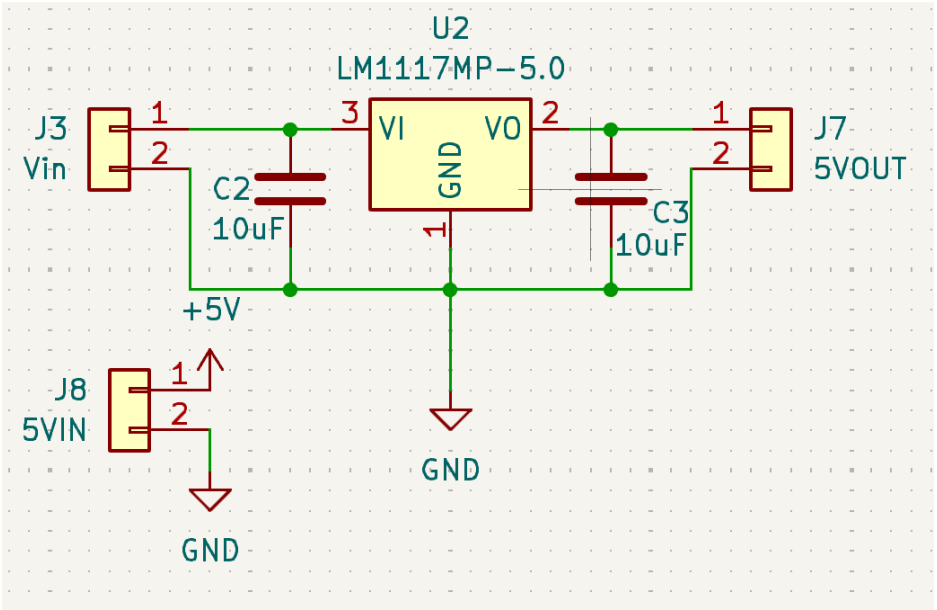
Subsystem Design

Power Subsystem Design Changes



Why Buck Converter?

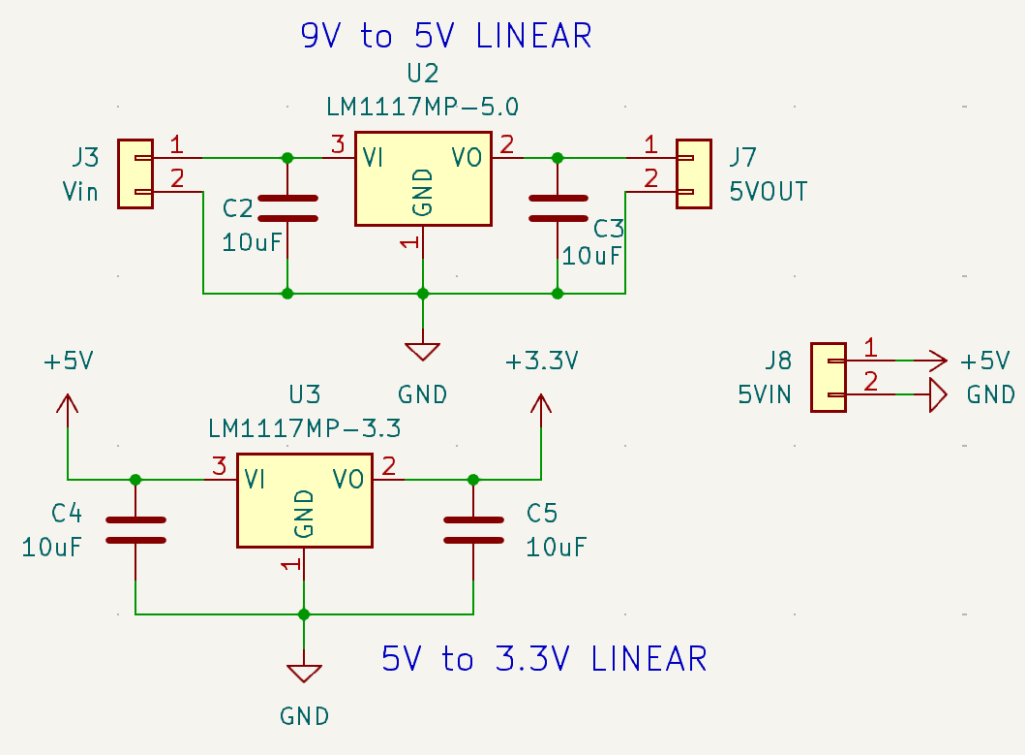
- Lower Heat Dissipation -> Necessary for 12V-5V conversion



Benefits Of Change

- Lowered Input Voltage
- Baking Issues
- Circuit Complexity

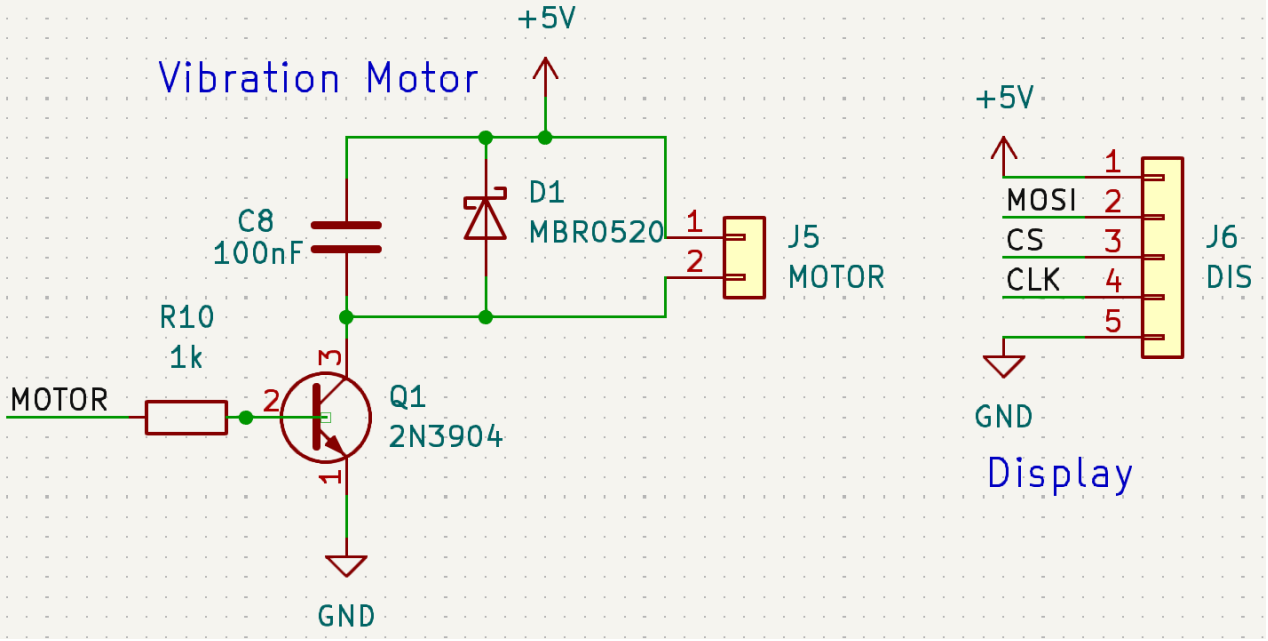
Power Subsystem and Requirements



Subsystem Requirements:

- ✓ The subsystem must output 3.3V ±0.2V (for the microcontroller and MPU6050) and 5.0V ±0.2V (for the display and motor).
- ✓ The battery must support ≥2 hours of continuous operation under peak load (300mA @ 5V, 100mA @ 3.3V).
- ✓ Includes overcurrent protection on both output rails.

Feedback Subsystem



Subsystem Requirements:

- ✓ The 8-segment display must update within 1s of a detected rep.
- ✓ The vibration motor must vibrate strong enough such that it is felt by the user
- ✓ The display must support 2-digit output for timer and 2 digit output for rep count

Feedback Subsystem Code

Feedback Code Details

- Mode On Startup (FB/UD)
- “dOnE” When TUT is met
- Displays the newly input TUT setting
- Keeps track of time taken for current rep and ensures rep is counting it time > TUT
- Turns the motor on and off when desired

```
inline void motorOn()  { analogWrite(MOTOR_PIN, MOTOR_DUTY); }
inline void motorOff() { analogWrite(MOTOR_PIN, 0);          }
void buzz(unsigned long d) { motorOn(); delay(d); motorOff(); }
```

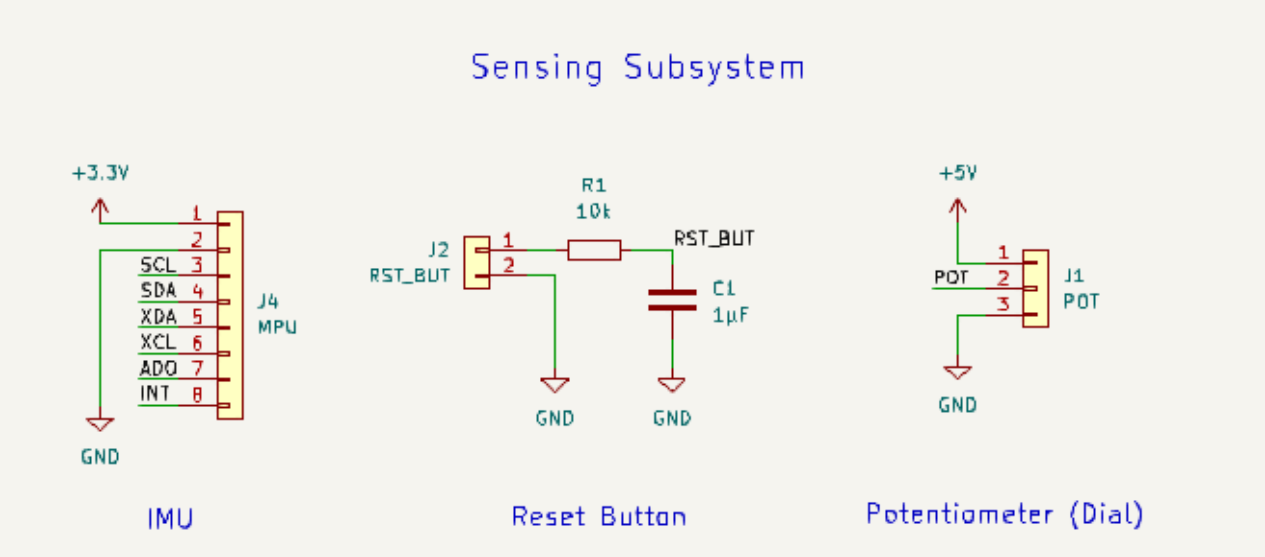
Motor Code

```
/* -------- Display -------- */
display.clear();
if (showMode && (now-modeStart<1000)) {
  display.writeDigitAscii(0, modeFB ? 'F' : 'U');
  display.writeDigitAscii(1, modeFB ? 'B' : 'P');
  display.writeDigitAscii(3, 'M');  display.writeDigitAscii(4, 'd');
}
else if (showDone && (now-doneStart<1000)) {
  display.writeDigitAscii(0,'d'); display.writeDigitAscii(1,'O');
  display.writeDigitAscii(3,'n'); display.writeDigitAscii(4,'E');
}
else if (showSec && (now-secStart<1000)) {
  display.print(secSet,DEC);
}
else {
  showDone = showSec = showMode = false;
  uint8_t tut = 0;
  uint16_t repsShown = 0;
  if (!modeFB) {
    tut = lifting ? (now-repStart)/1000 : 0;
    repsShown = repCount;
  } else {
    tut = outward ? (now-repStartFB)/1000 : 0;
    repsShown = repCountFB;
  }
  display.writeDigitNum(0,(tut/10)%10);
  display.writeDigitNum(1, tut%10);
  display.drawColon(true);
  display.writeDigitNum(3,(repsShown/10)%10);
  display.writeDigitNum(4, repsShown%10);
}
display.writeDisplay();

delay(LOOP_DELAY_MS);
```

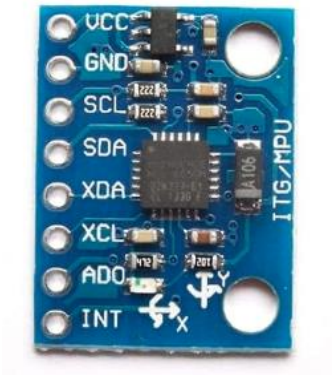
Update Display Code

Sensing Subsystem

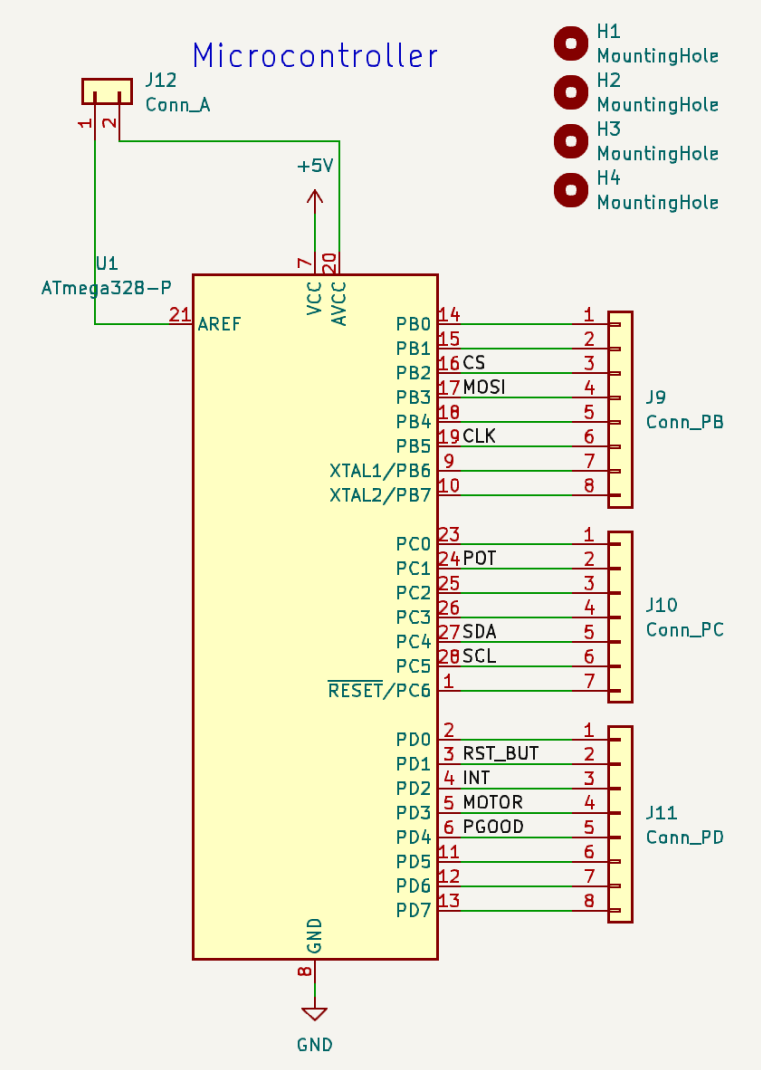


Subsystem Requirements:

- ✓ The MPU6050 must sample acceleration/gyro data at ≥ 10Hz.
- ✓ The potentiometer must adjust TUT in 1–10s increments using a dial.



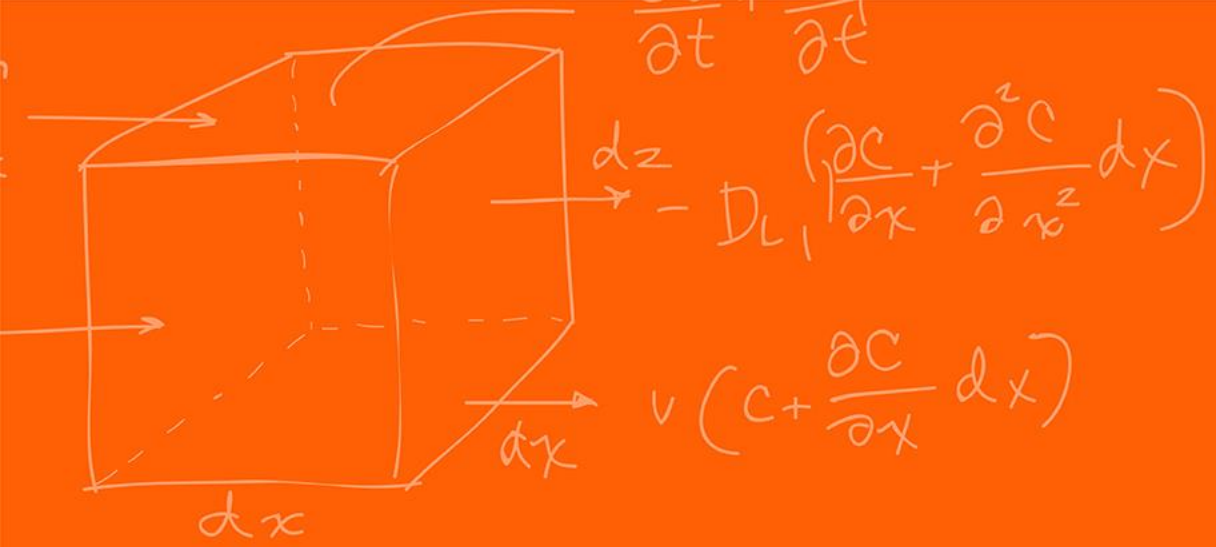
Microcontroller Subsystem

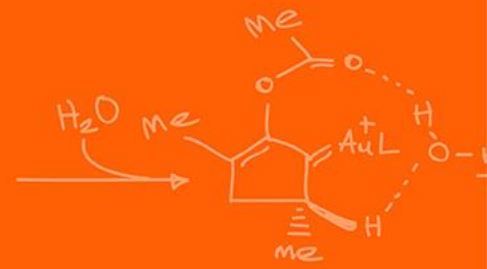


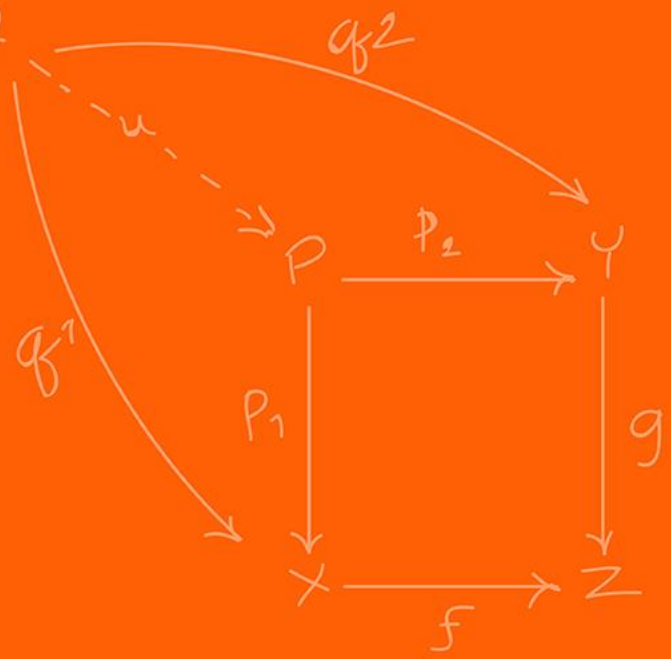
Subsystem Requirements:

- ✓ Native I2C ports must interface with MPU6050
- ✓ The PWM pin (for motor control) has adjustable frequency and duty cycle.

Project Outcome







The Product

Mid-Exercise
Display shows 5s elapsed and 1 rep so far

“Ready” State
Device calibrated for new start position/new exercise

Exercises Supported right now

- Bicep Curls
- Hammer Curls
- Bench Press (flat, incline, decline)
- Shoulder Press
- Upright Row
- Shoulder Shrugs
- Rear Delt Fly
- Lateral and Front Raises
- Bent Over Rows
- …&c.

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Successes

Up / Down Rep Count

- Used acceleration due to gravity as the baseline.
- Fine-tuned the margins to make sure its counting reps accurately.

Reset Button

- Able to recalibrate and reset rep count before new workout.

Charging port

- Be able to recharge battery.

Challenges

Buck Converter

- Expensive part ~$12/piece.
- Failed to bake it on to the board.

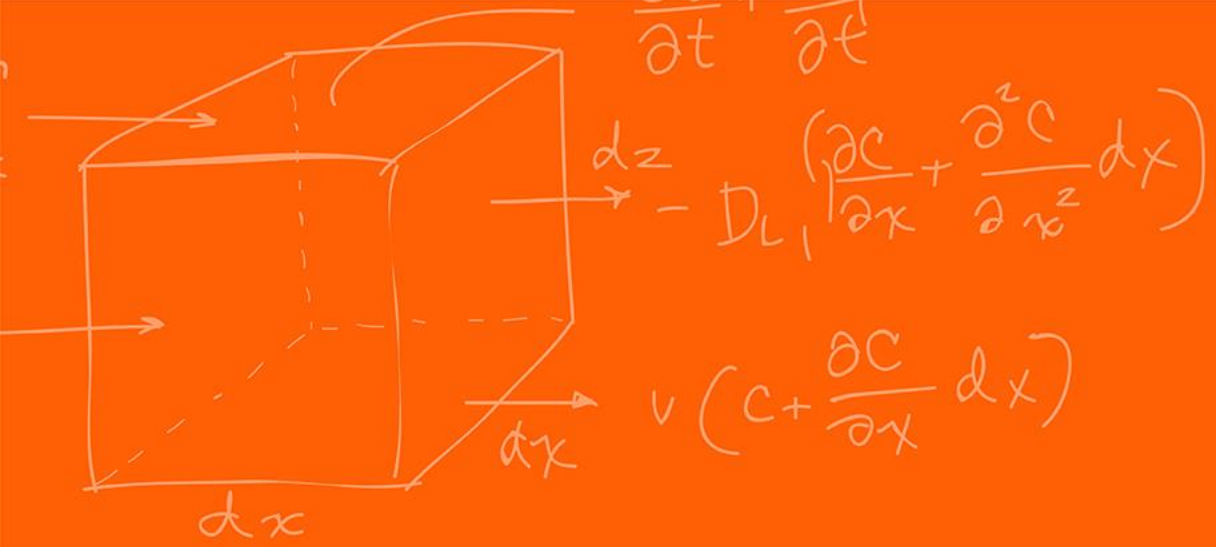
Forward / Backward Rep Count

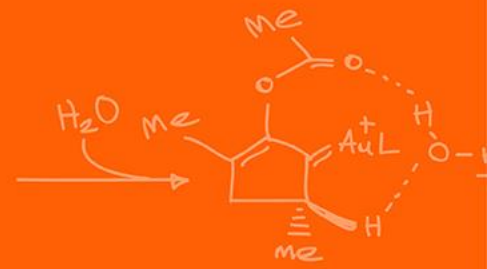
- Unable to get steady readings from the MPU.
- Had to do more research on how to get such readings accurately.

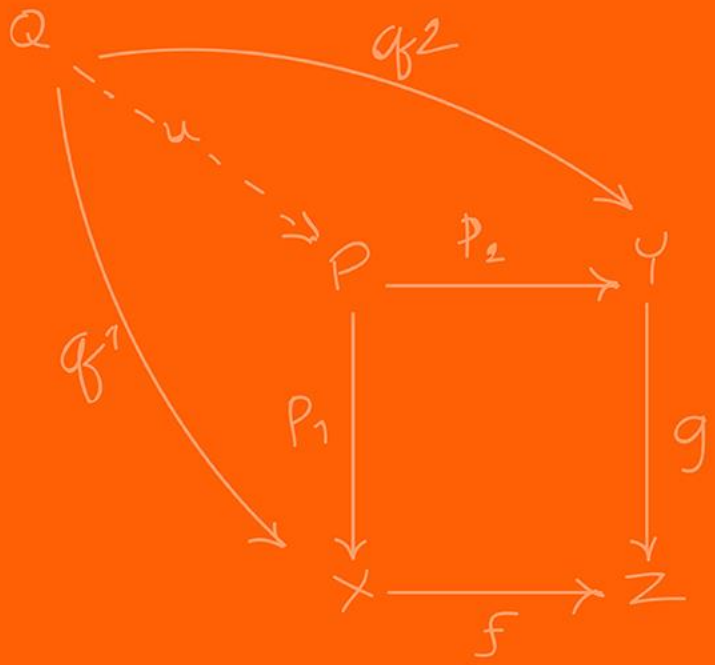
Things we would do different

- Smaller design with more compact PCB
- Spend more time in calibration

Future Work







Future Work

1 Refine forward-backward logic

- We already support upward-downward motion to 98% accuracy
- Adding forward-backward support will cover 85% of gym exercises

2 Integrate into Existing Smart Watch

- Easy integration of logic, sensor, and circuit into Apple Watch
- Can also make sensitivity tunable for different rep speeds

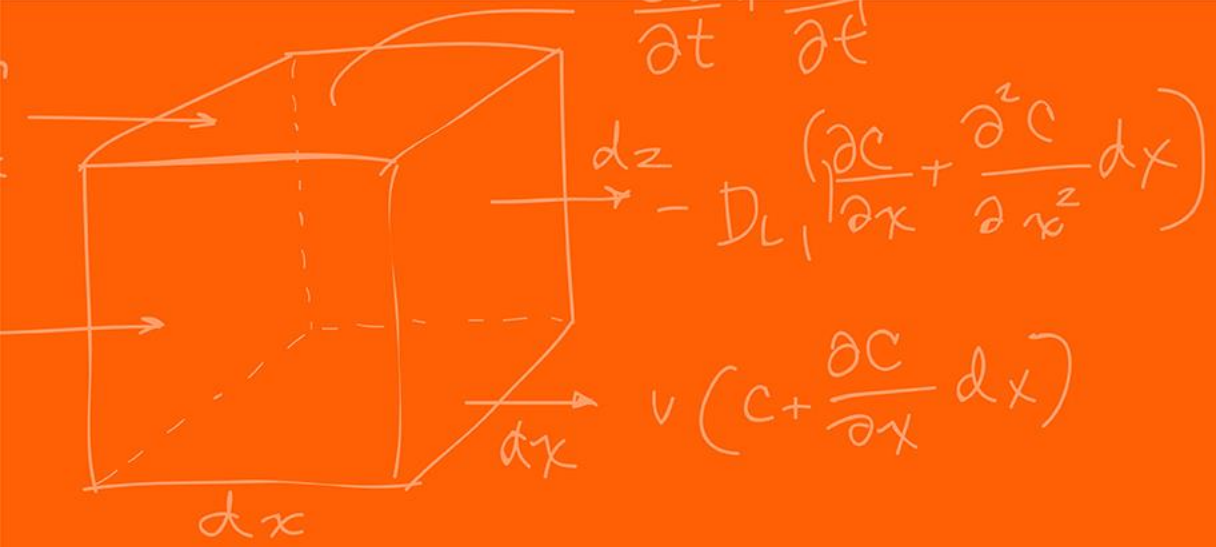
3 Idea: Minimalistic cloth band with built in sensor

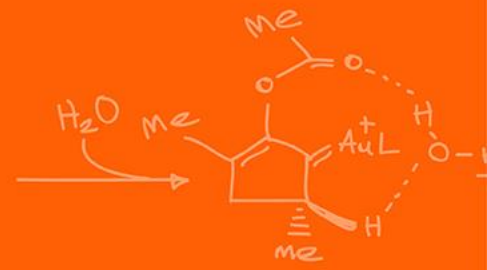
- Making an adjustable band with a motion sensor will allow users to put the device on their legs to count reps for lower body exercises

Conclusion

- Met all our high-level requirements

  - ✓ The user must be able to adjust the Time Under Tension duration between 1 to 10 seconds with 1 second increments using a dial.
  - ✓ The system accurately detects and counts exercise repetitions with a minimum accuracy of 90%.
  - ✓ The timer feature shall measure Time Under Tension with an error margin less than ±1 second per repetition to ensure precise workout tracking..





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