Stepper Machine Power Generation

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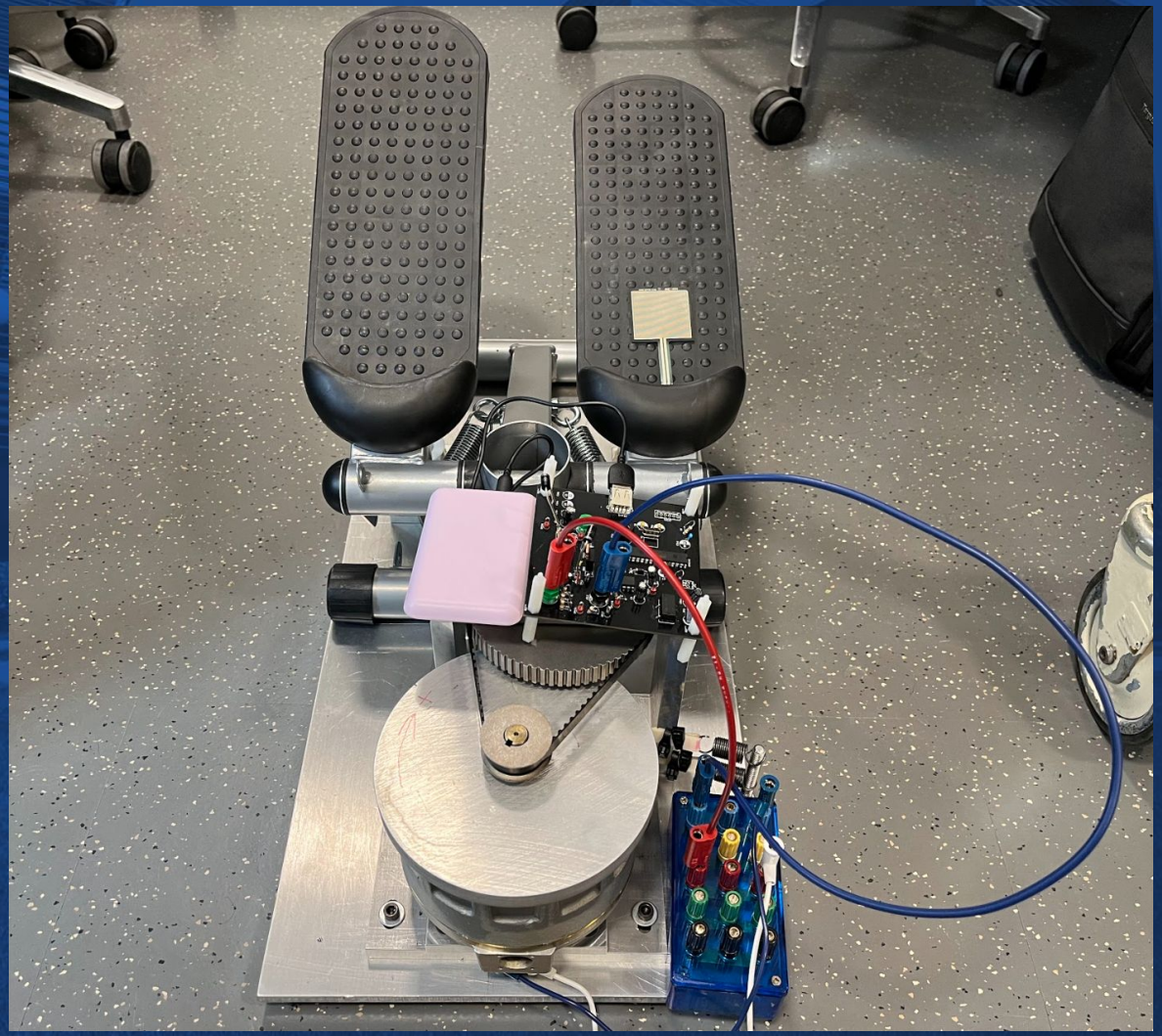
Our Problem

We found that during the pandemic and normal work days people sit in their chairs way too much. It has been found that people who sit for more than 13 hours a day are actually at a 200% higher risk of death when compared to people who sit for only 11 hours or less per day.

Our Solution



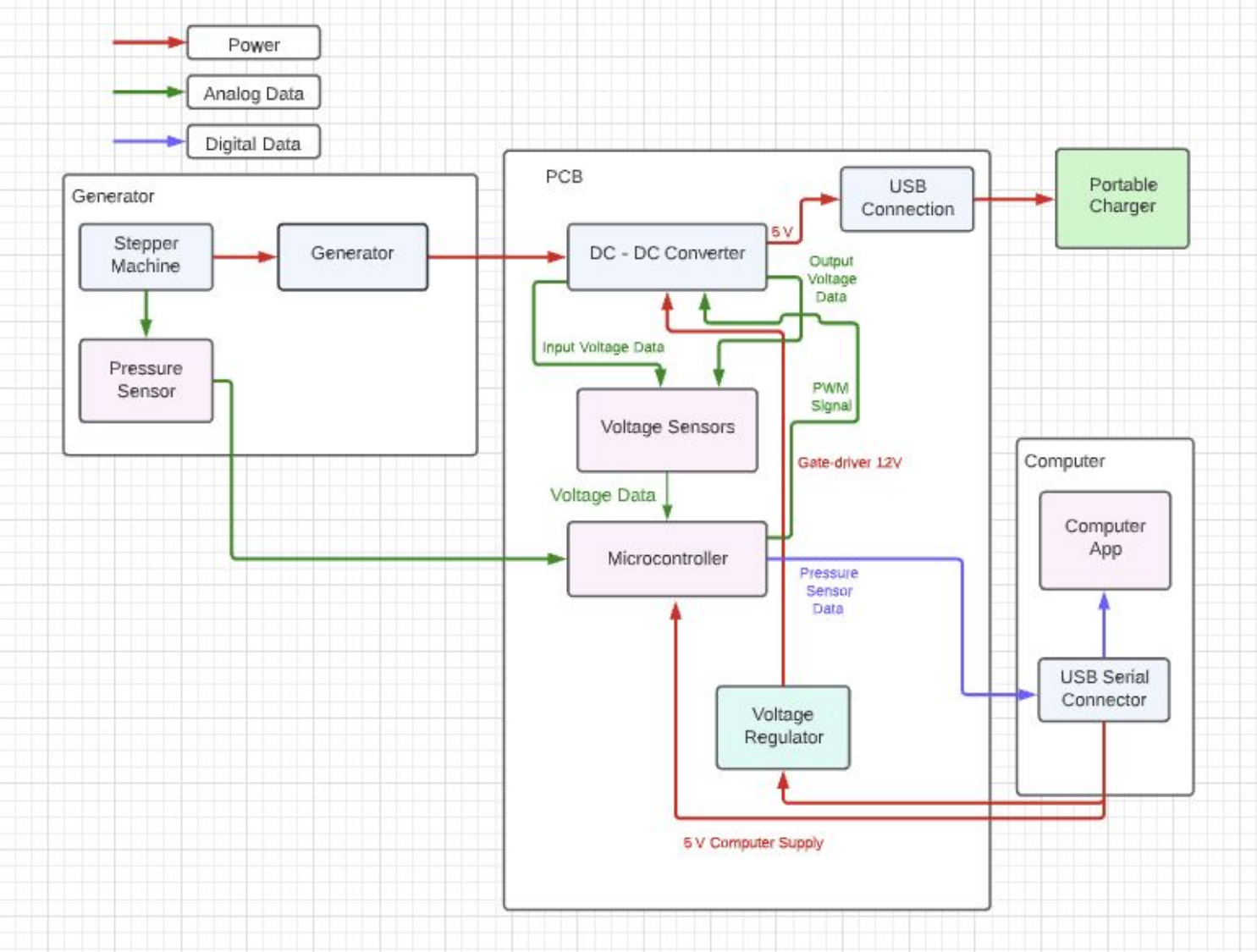
High-Level Requirements

1) **The power electronics, our DC-DC converter, needs to be able to convert the electrical energy generated from the motor and stepper into a constant 5V to supply the output to the portable charger within 5%.**

2) **Machine can be used while sitting, and small enough so that it can fit under a desk (About 36 inches deep, around 30 inches tall, and minimum width for a person of around 24 inches[2]).**

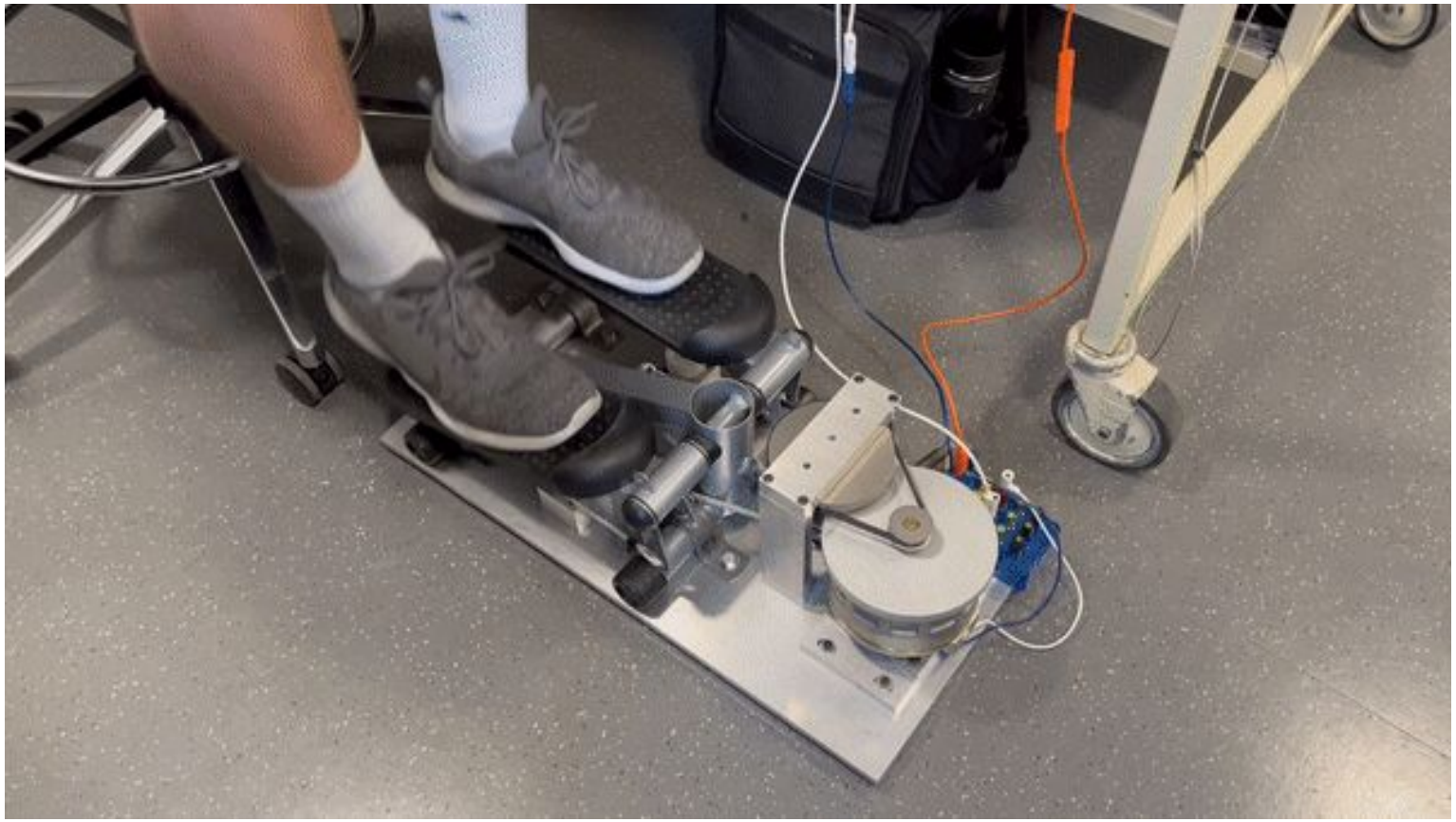
3) **The pressure sensor and computer program system is able to reinforce working out at least 8 times a day (Once every hour of an 8 hour workday).**

Block Diagram



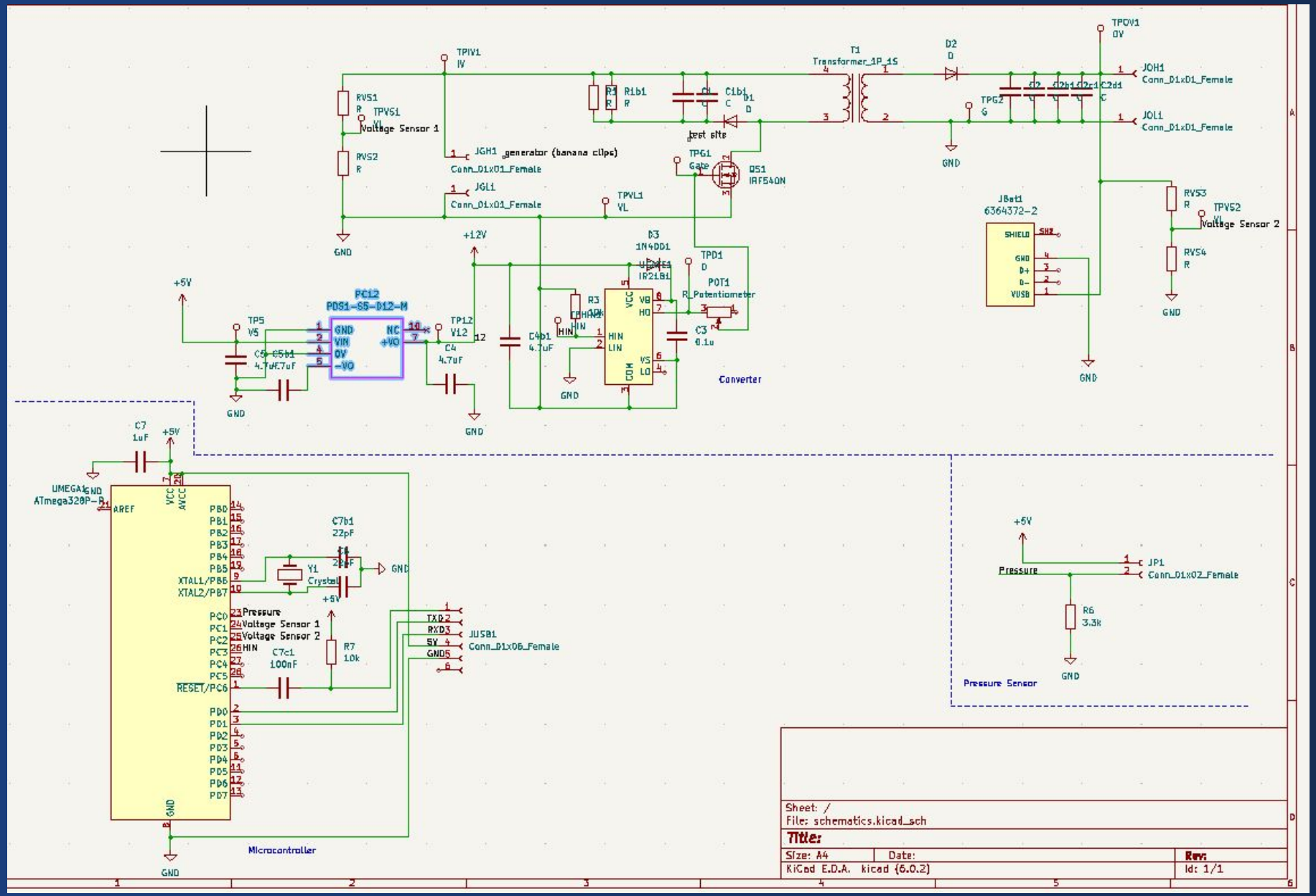
(Our Block Diagram showing major subsystems)

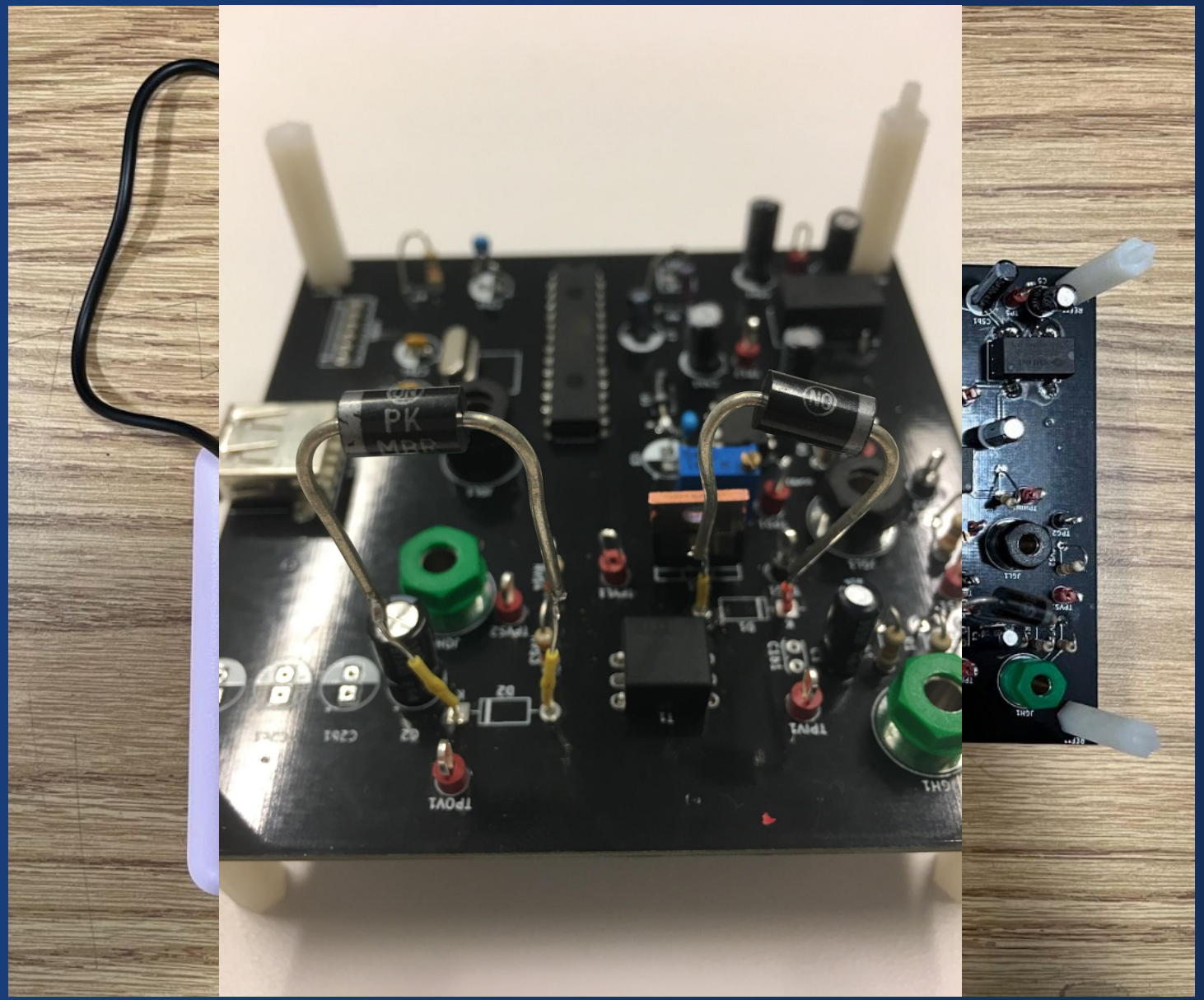
Stepper Machine Power Generation



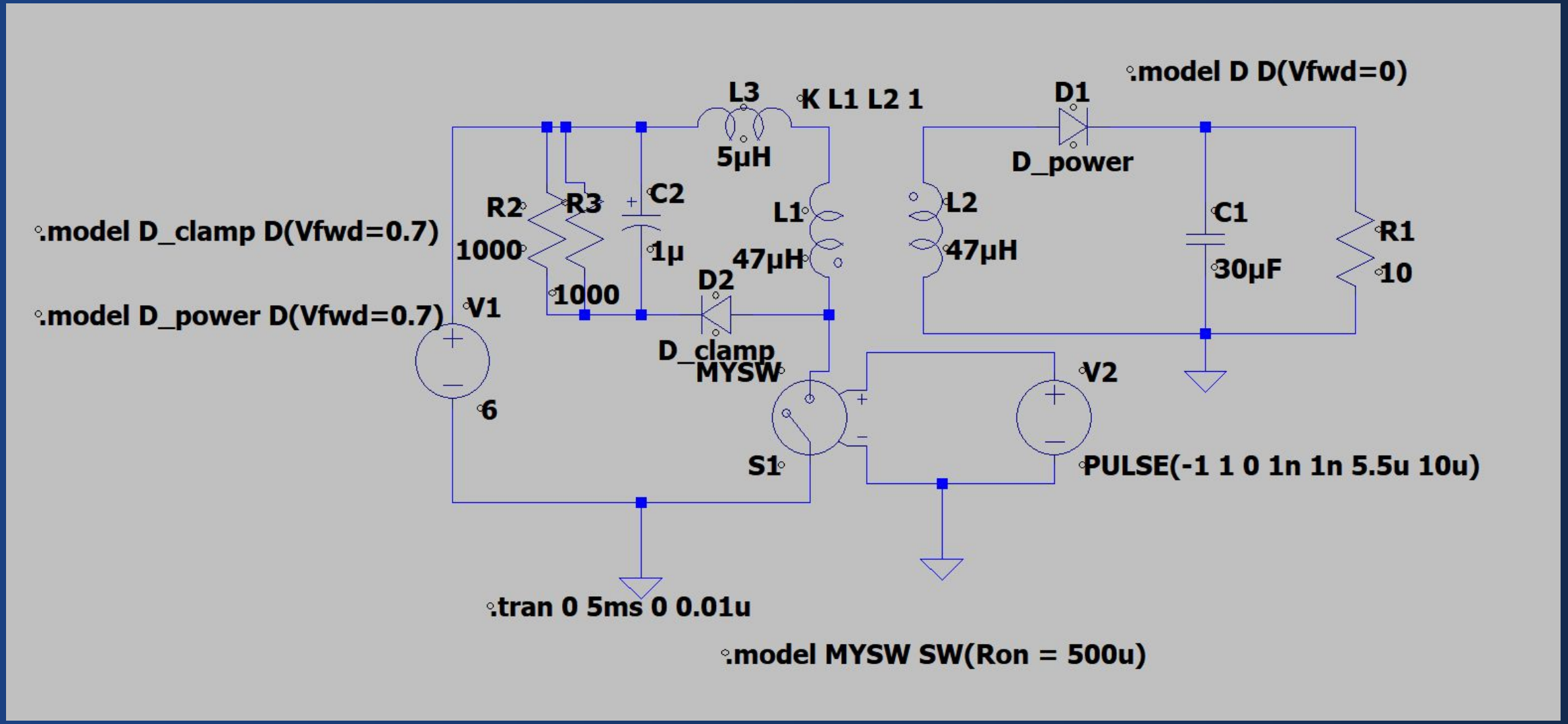
Stepper Machine Creating Electricity!

Requirement	Verification
The stepper system needs to be able to fit under a desk.	1. Measure the width and height of the machine. 2. Verify that depth < 36 inches, height < 30 inches, width < 24 inches

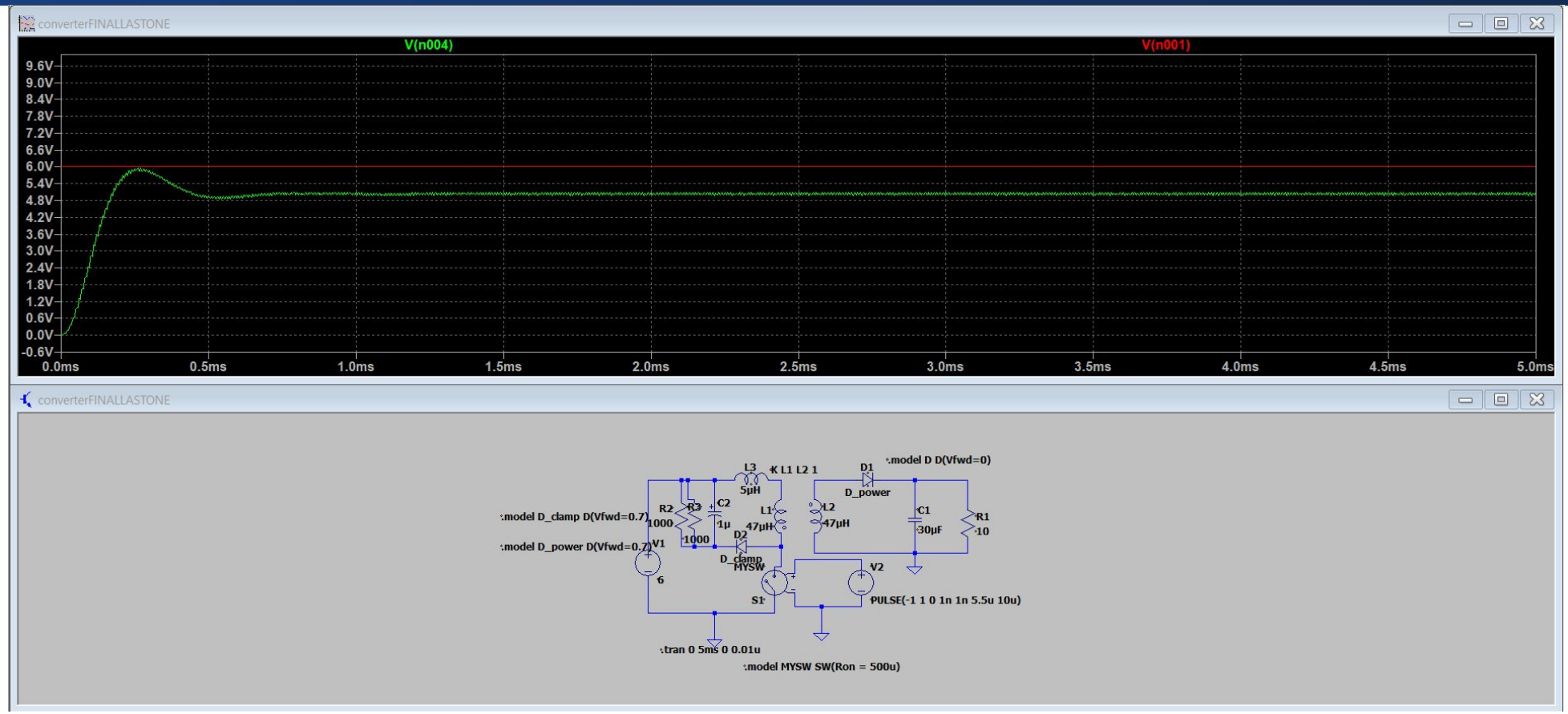

Converter
Microcontroller
Pressure Sensor
Sheet: /
File: schematics.kicad_sch
Title:
Size: A4
Date:
Rev:
KiCad E.D.A. kicad (6.0.2)
Id: 1/1


PK
MBR

DC DC Converter



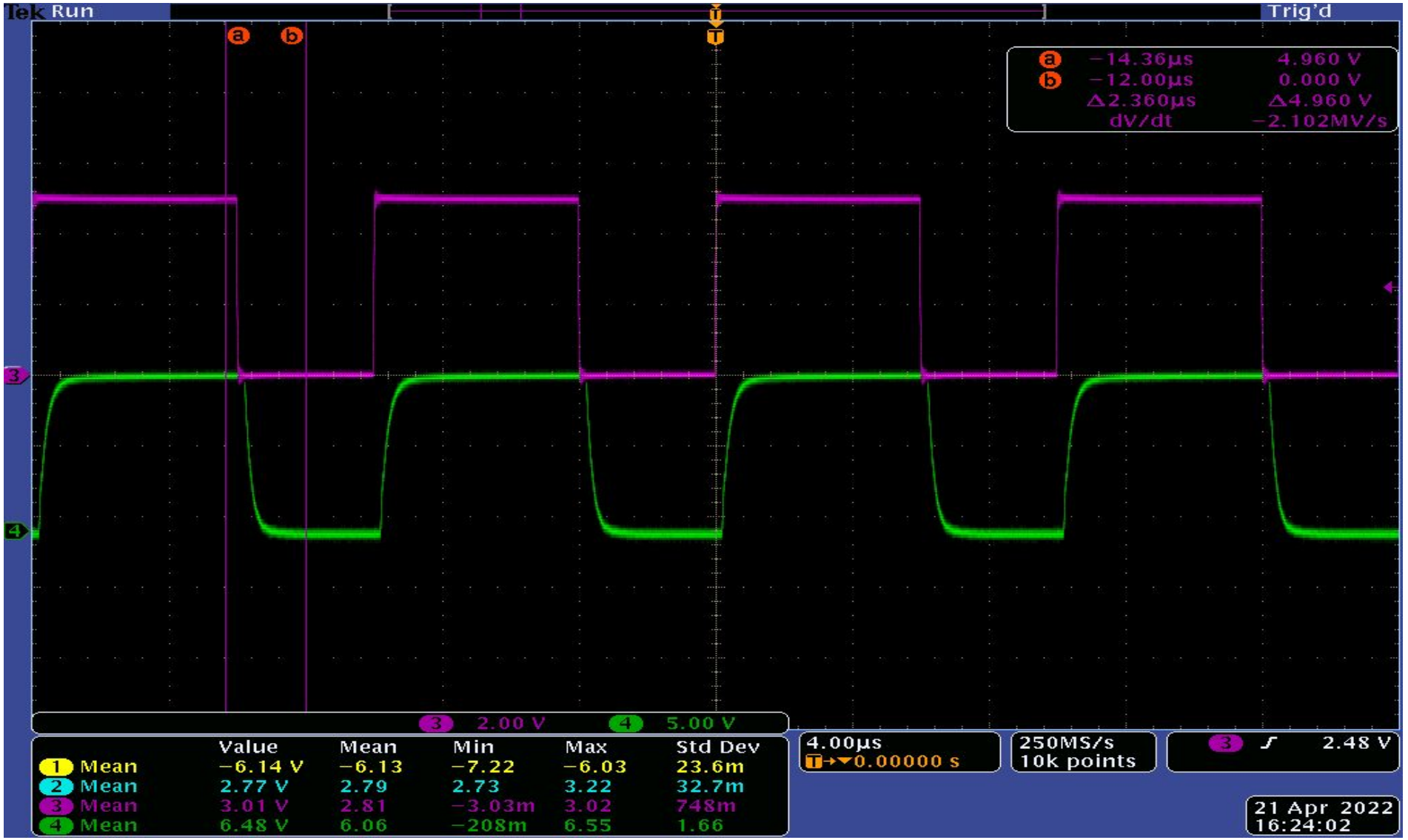
DC DC Converter



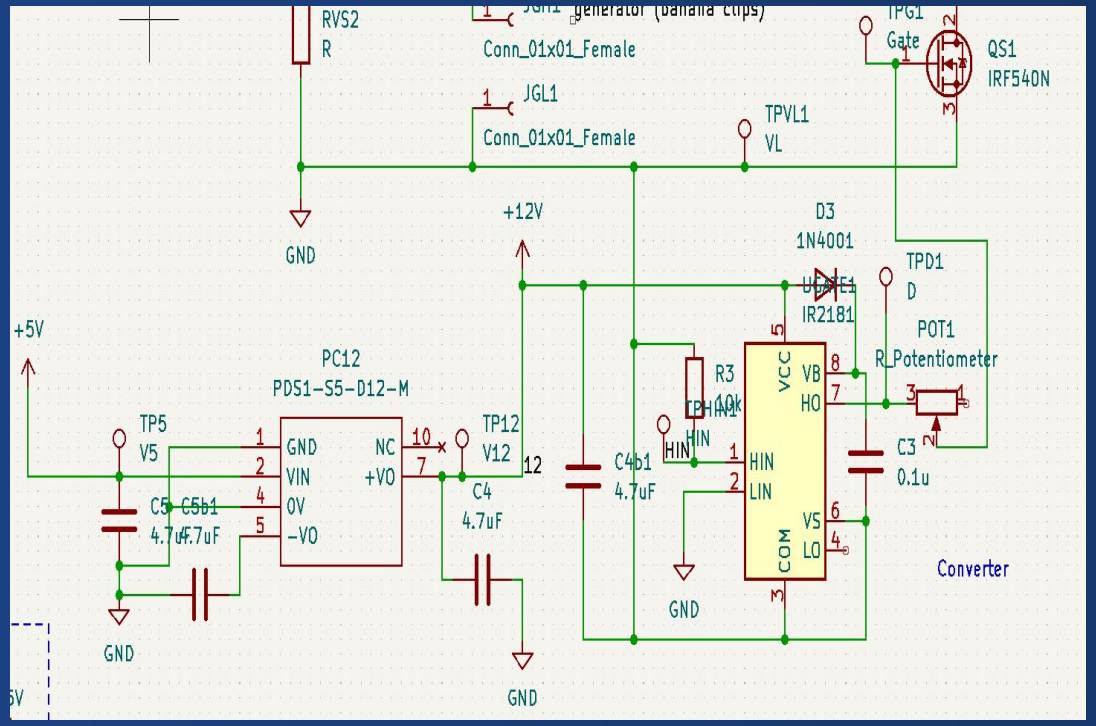
Requirement	Verification
Needs to output 5V with a tolerance of ±2.5%.	1. Use a variable DC voltage supply to the converter input. 2. Connect a 3ohm (10% tolerance), 30 ohm (10%), 100ohm (10%) to the output. 3. Measure the output with an oscilloscope 4. Change the values of the DC voltage supply from 1V to 10V. 5. Check that the output is 5V ±2.5


Tek Run
Trig'd
a −14.36µs 1.000 V
b −12.00µs 3.000 V
Δ2.360µs Δ2.000 V
dV/dt 847.5kV/s
1 THDP0200 Probe Setup
Range
150 V 1.50kV
AutoZero
Alarm Enabled
Attenuation 500 X
Measure Current
Yes No
Fine Scale
Offset
Position
Probe Setup
Deskew
More
1 25.0 V 2 10.0 V 3 10.0 A 4 1.00 A
Value Mean Min Max Std Dev
1 Mean 2.11 V 2.14 2.05 2.23 46.1m
2 Mean −162mV −147m −176m −117m 13.1m
3 Mean 6.61 V 5.92 −378m 6.66 2.08
4 Mean 782mA 694m −7.65m 815m 263m
4.00µs
T→▼0.00000 s
3 3.80 V
Coupling DC AC
Termination 1MΩ 50Ω
Invert On Off
Bandwidth Full
1 Label
21 Apr 2022
16:40:00

PWM Signal and Voltage Control Algorithm

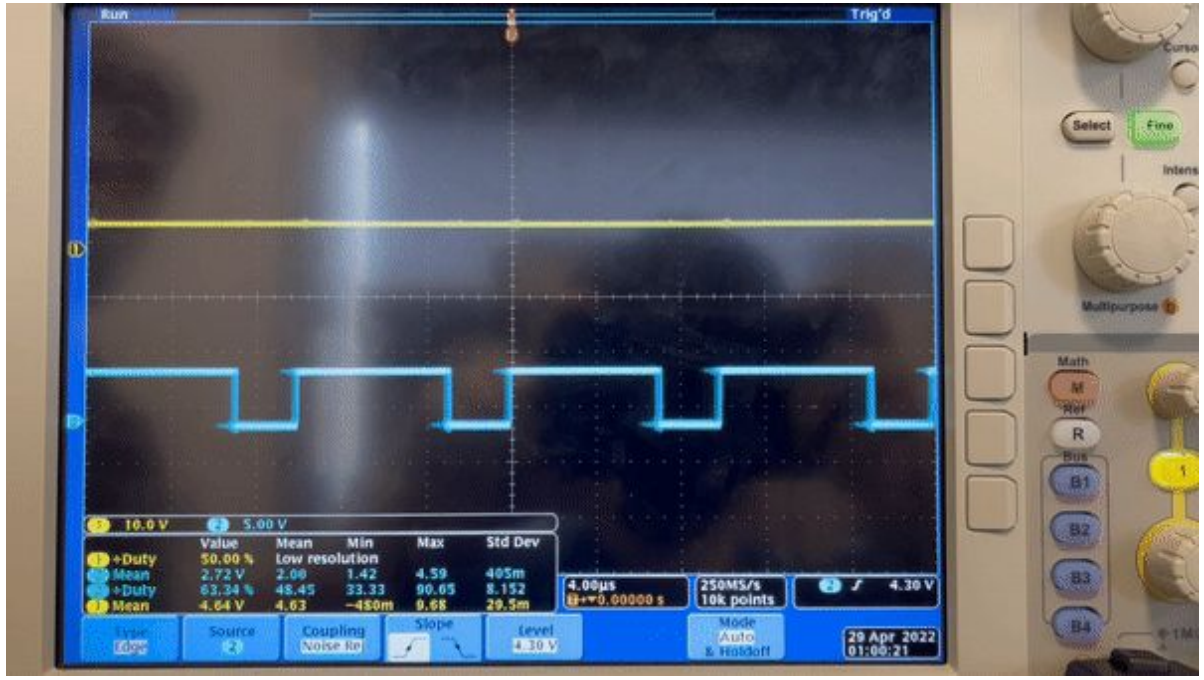


PWM Signal and Voltage Control Algorithm

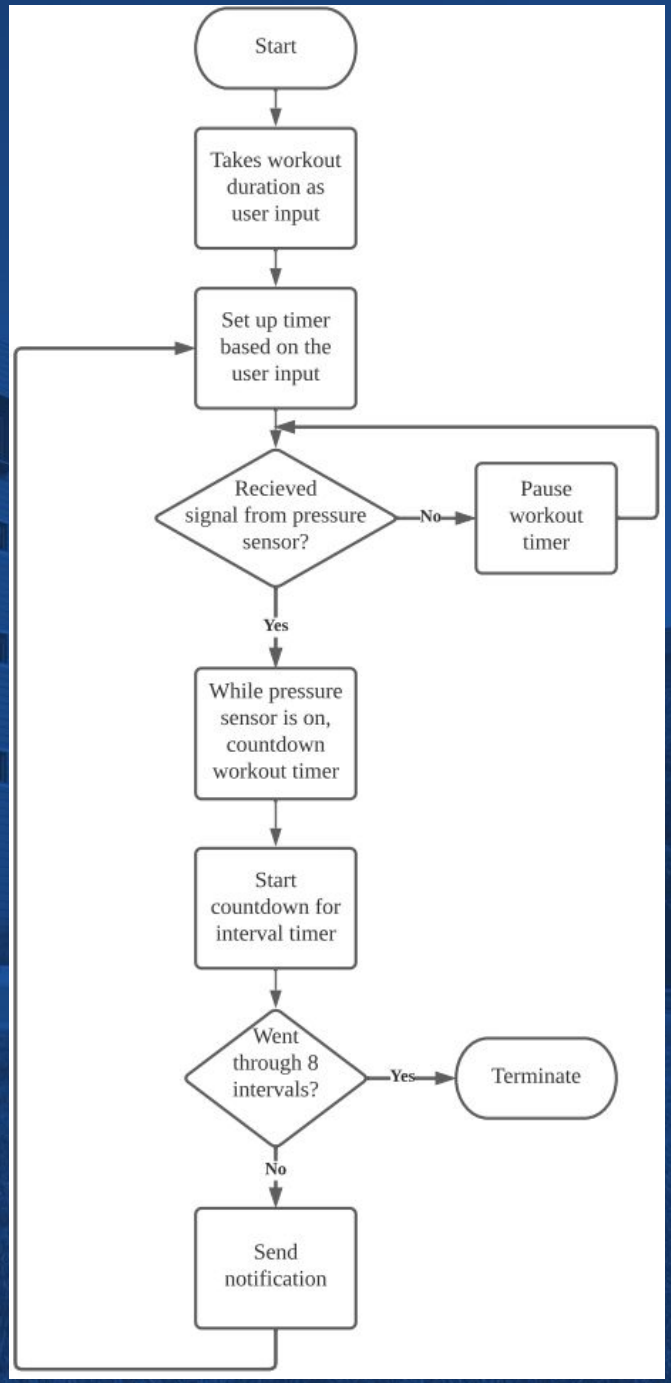


PWM Signal and Voltage Control Algorithm

Requirement	Verification
Must take in voltage at the input and output of the DC-DC converter and create the appropriate duty cycle for the converter. (PWM capability)	1. Connect an oscilloscope to the gate drivers. 2. Produce a DC voltage at the inputs for the microcontroller (1V to 10V) 3. Run control code mode for the microcontroller. 4. Ensure that the microcontroller is producing correct PWM by probing the input to the gate driver circuit. 5. Change input DC voltage and ensure that microcontroller changes PWM signal correctly.



Computer Application



PWM Signal and Voltage Control Algorithm

Requirement	Verification
Needs to be able to sense voltage within plus or minus 2.5%.	1) Attach a known DC supply to the voltage sensor circuit from 0 - 8 V. 2) Probe the voltage going to the microcontroller to see what the true reading should be. 3) Ensure with simple test code that the microcontroller is correctly sensing the voltage within the tolerance range.

```
Reference Voltage: 0.73  Vsense_high: 12.62  Vsense_mid: 4.98  Output Voltage: 5.01  D
Reference Voltage: 0.73  Vsense_high: 12.59  Vsense_mid: 5.05  Output Voltage: 5.00  D
Reference Voltage: 0.73  Vsense_high: 15.57  Vsense_mid: 5.04  Output Voltage: 5.04  D
Reference Voltage: 0.73  Vsense_high: 15.83  Vsense_mid: 4.97  Output Voltage: 4.97  D
Reference Voltage: 0.73  Vsense_high: 9.16  Vsense_mid: 4.97  Output Voltage: 4.97  Du
Reference Voltage: 0.73  Vsense_high: 9.09  Vsense_mid: 5.02  Output Voltage: 5.02  Du
Reference Voltage: 0.73  Vsense_high: 10.75  Vsense_mid: 5.00  Output Voltage: 4.98  D
Reference Voltage: 0.73  Vsense_high: 9.34  Vsense_mid: 4.97  Output Voltage: 5.00  Du
Reference Voltage: 0.73  Vsense_high: 9.21  Vsense_mid: 5.03  Output Voltage: 4.99  Du
Reference Voltage: 0.73  Vsense_high: 9.29  Vsense_mid: 5.03  Output Voltage: 4.97  Du
Reference Voltage: 0.73  Vsense_high: 11.26  Vsense_mid: 5.01  Output Voltage: 4.97  D
Reference Voltage: 0.73  Vsense_high: 11.44  Vsense_mid: 4.98  Output Voltage: 4.97  D
Reference Voltage: 0.73  Vsense_high: 11.35  Vsense_mid: 5.00  Output Voltage: 5.05  D
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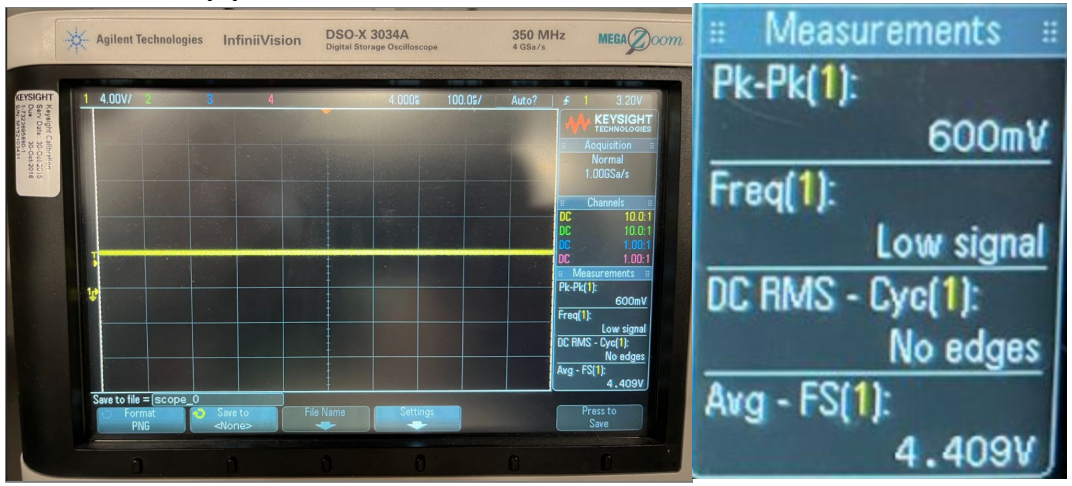
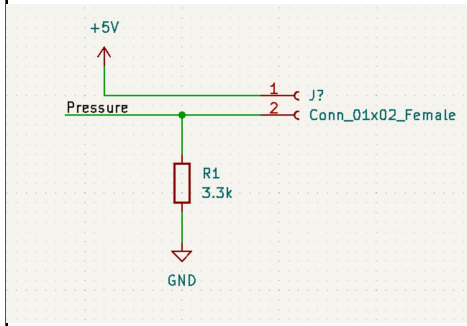
Pressure Sensor R&V

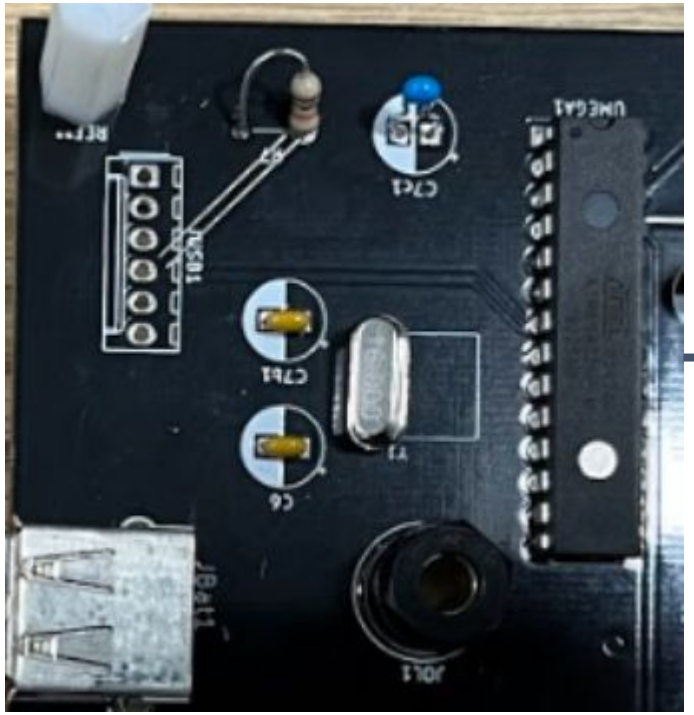
Pressure not applied:

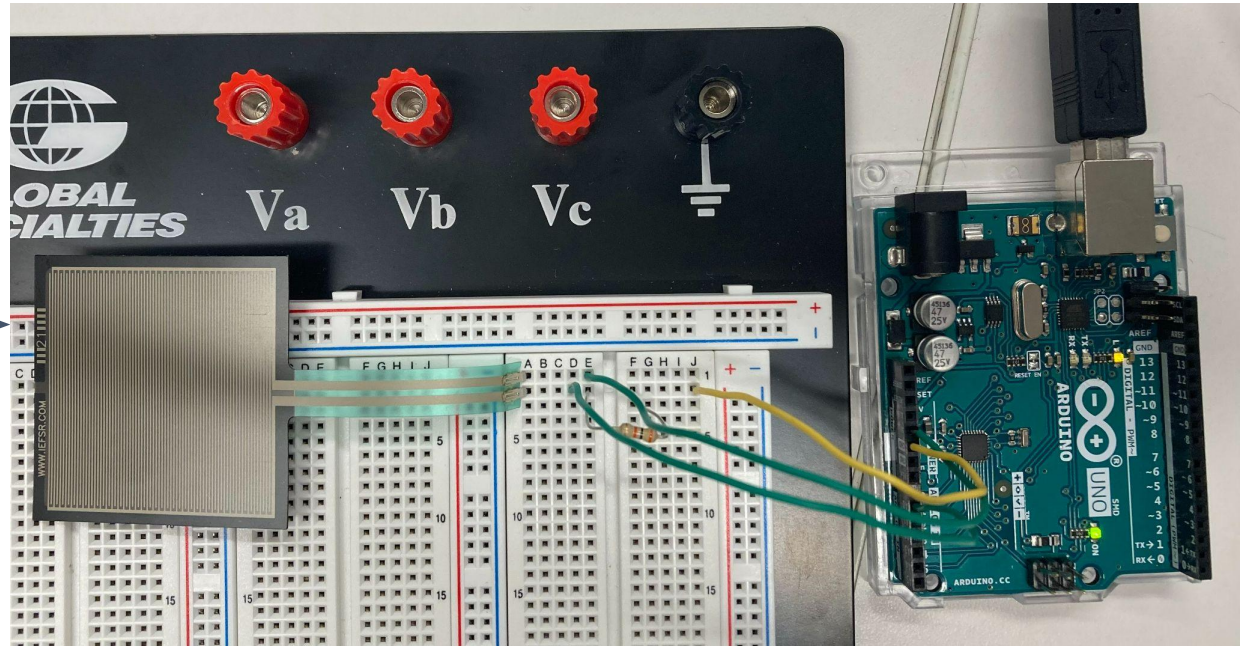
Pressure applied:



Requirement	Verification
Must be able to sense pressure of force above 10 kg.  Resistance: 657628.00 ohms Force: 2.37 g Resistance: 3124.40 ohms Force: 497.87 g Resistance: 409806.25 ohms Force: 3.80 g Resistance: 468811.41 ohms Force: 3.32 g Resistance: 217056.02 ohms Force: 7.17 g	1. Without connecting to PCB first construct circuit below on testing breadboard. 2. Connect 5 V DC supply to the pressure sensor circuit. 3. Read voltage across the 3.3k ohm resistor 4. Apply pressure and make sure that voltage increases. 5. Apply weight of around 10 kg to ensure that the sensor can handle sitting person weight.

Microcontroller Integration Challenges

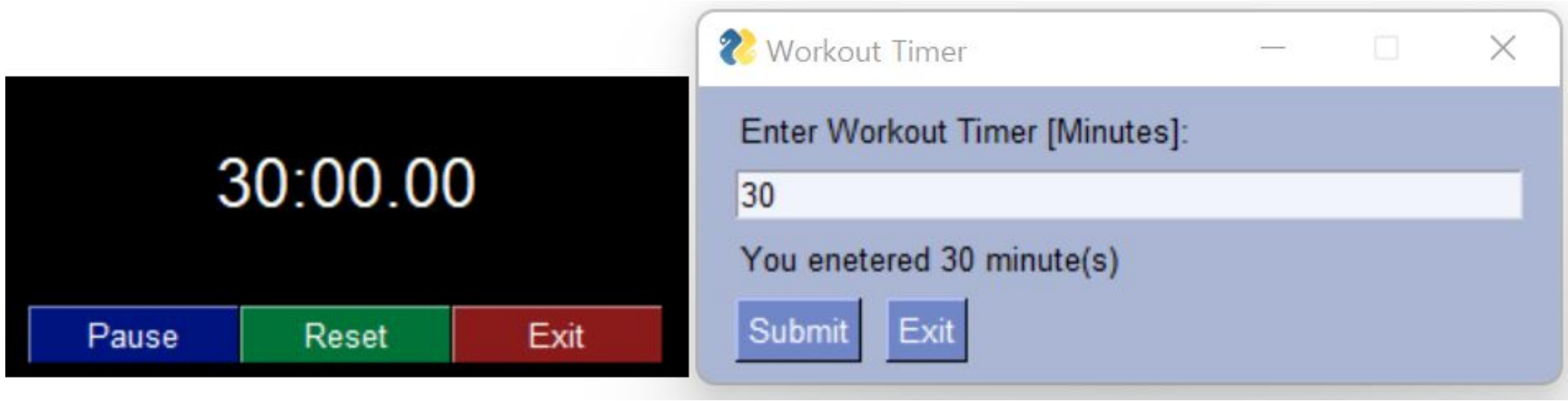




Requirement	Verification
USB must transmit information from the microcontroller to the computer.	1. Write and apply dummy code with LED circuit to the microcontroller that won't hurt the system. 2. Test the code to ensure that the microcontroller is able to send data to the computer through the USB data pins and that a simple LED can blink.

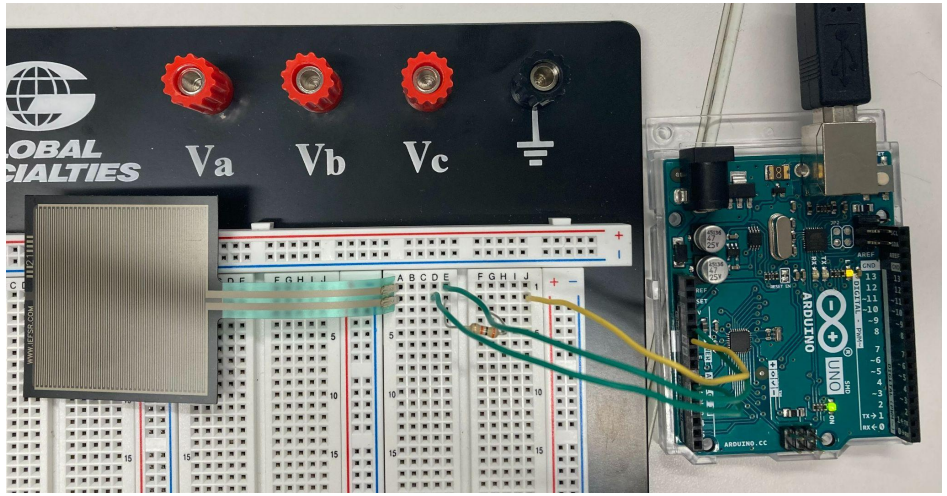
Computer Application R&V

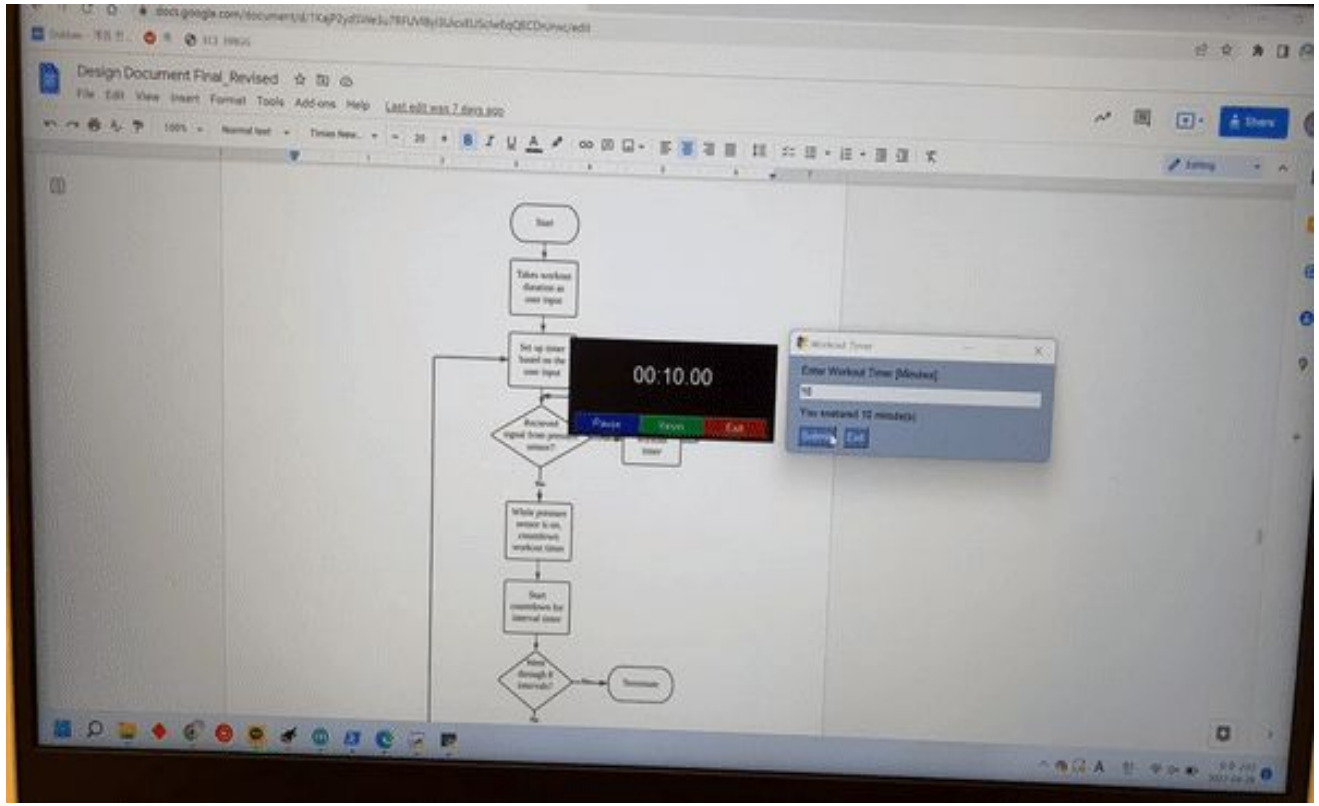
Requirement	Verification
When activated, the computer app must take in the amount of time the user wants to work out every hour	1. The user inputs a workout duration. 2. Verify that the application can display the amount of time the user imputed and have a countdown.



Computer Application R&V

Requirement	Verification
When the user touches the pressure sensor the computer app must start the timer.	1. Check that the timer counts down when the user applies force on the sensor. 2. Check if the timer stops counting down when the force is not applied





Computer Application R&V

Requirement	Verification
Must be able to send notification to remind users to work out after an hour break.	1. Verify that the interval counter appears after the duration timer is done. 2. Verify that the app sends out notification when the interval timer hits 0.

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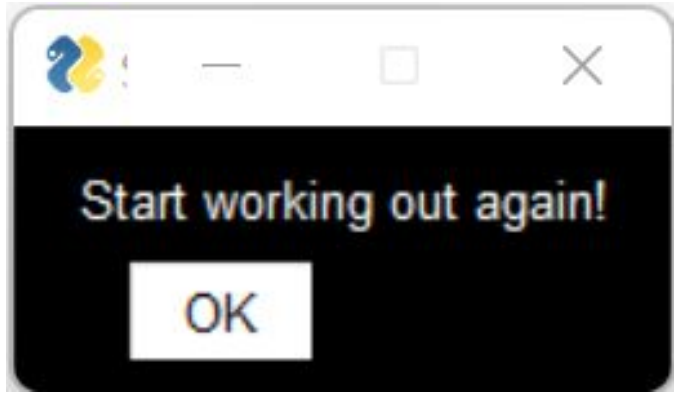

The Future

Thank you for listening!
Questions?

The Grainger College of Engineering

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