

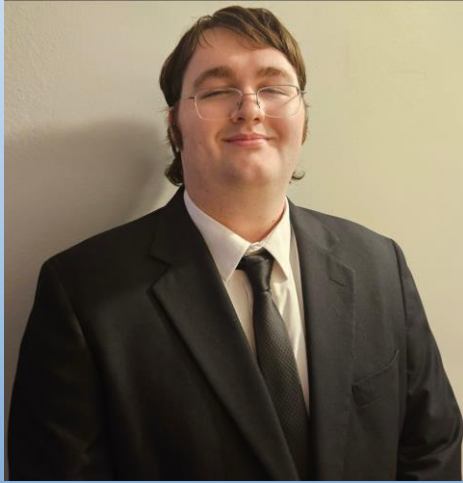
Rain Energy Harvester Presentation

Senior Design Project: Group 18





Meet the Team



Evan Mayne

Electrical Engineering



Carlos Molina

Electrical Engineering



Alexander Weatherford

Electrical Engineering



Rayan Baig

Electrical Engineering



Concept

Our project will simulate the rainwater that would flow through a gutter and use a hydroelectric turbine to generate power from it.

Motivations

- Develop an innovative and sustainable solution for energy generation.
- Use a natural source of energy that is currently not explored or utilized.
- Provide a clean energy source that contributes to the preservation of the environment.



Goals

- ❑ The device will be capable of generating energy through rainfall.
- ❑ The energy generated will then be used to power an external device.
- ❑ Information about energy generated will be shown to the user.

Objectives

- ❑ Convert mechanical energy to electrical energy using a Pelton turbine and a Stepper motor.
- ❑ Use the energy generated to provide power to low-energy consuming devices, such as LEDs.
- ❑ Use oak wood material with a water-resistant sealant and plexiglass material for the turbine and electrical casings to prevent water damage and provide visibility.
- ❑ Sensors will be used to measure the signal generated and pass this data to the MCU, which will be displayed on the LCD screen.

Engineering Specifications



Engineering Requirement	Specifications
Input to output power generation ratio of the turbine will be within a reasonable range.	30% - 70%
The speed of the turbine under active operating conditions should be a certain value for better performance.	≥ 150 RPM
Energy generated that will be used to power the output device will be within an appropriate range.	0.2 Wh – 3 Wh
The temperature range where the device can operate without the water becoming frozen or electrical components damaged.	5 °C - 35 °C
The minimum power that will be generated by the motor over time will be higher than certain value.	≥ 3 Wh
Rate at which water can flow through the entire system will be within an appropriate range to guarantee turbine speed.	2 GPM – 6 GBM
The dimensions should not exceed an appropriate size for a device that will be installed in the gutter structure of a home	Length x Width x Height $\leq (1.5 \text{ m} \times 1.5 \text{ m} \times 2.75 \text{ m})$

Major Hardware Components



- Turbine
- Microcontroller
- Motor
- Voltage Regulators
- Battery
- LCD Screen
- Voltage and Current Sensors
- Power Switches and Buttons

Hydro Turbine Selection



Pelton Turbines meet the water head level and flow rate for the scale of this project. Turgo Turbines are less efficient without higher flow rates.

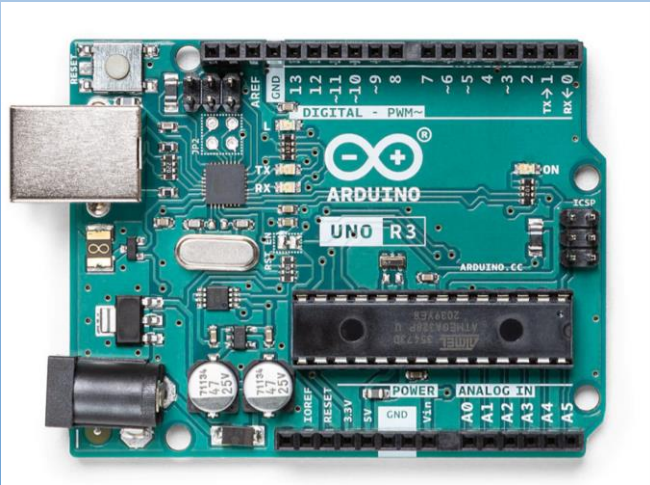
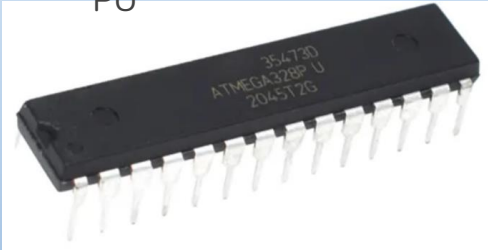


Criteria	Model 1 B0C4G29ZY9	Model 2 392349988306	Model 3 202303198415	Model 4 266448765936	Model 5 175953369509
Cost	\$53.96	\$63.48	\$39.99	\$80.04	\$41.68
Runner Diameter	9.00 inches	6.05 inches	8.03 inches	7.8 inches	3.8 inches
Shaft Diameter	1.00 inch	1.02 inches	0.79 inches	0.30 inches	0.30 inches
Bucket / Paddle Diameter	37 mm	38 mm	46 mm	55 mm,	29 mm
Bucket / Paddle Depth	16 mm	17 mm	10 mm	23 mm	14 mm
Materials	Aluminum Runner, HDPE Paddles	Sheet Metal Runner, Plastic Paddles	Die Cast Aluminum Runner and Paddles	Plastic Runner and Paddles	Plastic Runner and Paddles
Maximum Number of Paddles	32 Paddles	20 Paddles	12 Paddles	15 Paddles	14 Paddles
Weight	1.56 lb	1.0 lb	1.32 lb	1.4 lb	0.2 lb

MCU Selection

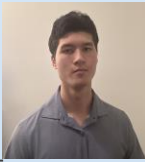


MCU: ATMEGA328P-PU



Criteria	Arduino Uno R3	Arduino Mega 2560 R3	Raspberry Pi Pico RP2040	MSP430FR6989
Cost	\$26.33	\$48.40	\$4.00	\$10.77
Bit Count	8-bit	8-bit	32-bit	16-bit
Operating Voltage	5 (V)	5 (V)	1.1 (V)	Min: 1.8 (V), Max: 3.6 (V)
Input Voltage Range	Min: 6.0 (V) Max: 20.0 (V) Recommended: 7.0-12.0 (V)	Min: 6.0 (V) Max: 20.0 (V) Recommended: 7.0-12.0 (V)	Min: 1.8 (V), Max: 5.5 (V), Recommended: 2.5-3.5 (V)	Min: 3.3 (V) Max: 5.0 (V)
Power Consumption Range	Min: at 6 (V), 20 (mA) Max: at 20 (V), 50 (mA)	Min: at 6 (V), 20 (mA) Max: at 20 (V), 50 (mA)	Min: 5 (mA), Avg: 24 (mA) Max: 90 (mA)	Active mode: (100µA/MHz) LPM3 with VLO: 0.4µA LPM3.5: 0.35µA LPM4.5: 0.02µA
RAM	32 KB Flash, 2 KB SRAM, 1 KB EEPROM	256 KB Flash, 8 KB SRAM, 4 KB EEPROM	16 MB Flash, 264 KB SRAM	128 KB FRAM 2 KB SRAM
Pin Counts	14 Digital I/O Pins, 6 PWM Pins	54 Digital I/O Pins, 15 PWM Pins	40 pins total, 26 digital only pins	83 GPIO pins,
Clock Frequency	16 (MHz)	16 (MHz)	133 (MHz)	16 (MHz)
Operating Temperature Range	-40°C to 85°C	-40°C to 85°C	-20°C to 85°C	-40°C to 85°C

Motor Type Selection



The motor will be used as a generator to convert mechanical energy to electrical energy when the turbine spins. The generated electrical energy will be used to power on small scale devices.

Criteria	Brushed DC	BLDC	AC	Alternator	Stepper	Servo DC/AC
Cost	\$5 - \$30	\$20 - \$150	\$5 - \$15	+\$80	\$10 - \$15	\$5 - \$15
Shaft Smoothness	Good	Fair	Poor	Good	Good	Fair/Good
Complication	none	Some	Some	Many	Few	Some
Efficiency	Fair	Good	Good	Great	Good	Good

Motor Selection and Comparisons



Criteria	Nema 17 - 17HS19-2004S1	Nema23 - 23HS30-2804	Nema 23 - 57HS56	Nema 17 - 17ME15-1504S
Cost	\$13.99	\$28.00	\$22.00	\$16.99
Steps	200	200	200	400
Rated Current	2 Amps	2.8 Amps	3 Amps	1.5 Amps
Max Voltage	55 Volts	74 Volts	54 Volts	73 Volts
Dimensions	1.65 x 1.65 x 1.80 in	5.25 x 3.25 x 3.25	2.2 x 2.24 x 2.24	1.65 x 1.65 x 1.49

Voltage Regulator Type



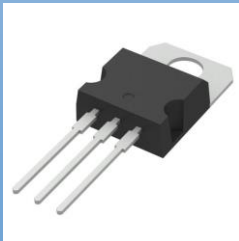
Two voltage regulators will be used for the project. One for stepping down the voltage of the battery to the microcontroller, and the other to step down the voltage from the motor output.

	Switching Regulator	Linear Regulator
Advantages	<ul style="list-style-type: none">• Step Up, Step Down, or combination of the two.• Efficient• More resilient to heat.	<ul style="list-style-type: none">• Simple Configuration• Less Expensive
Disadvantages	<ul style="list-style-type: none">• Higher Cost• Complex Design	<ul style="list-style-type: none">• Only able to Step Down.• Lower Efficiency• Less Heat Resistant

Voltage Regulator comparison



Criteria	MC7807CTG	LM317	LT3033
Cost	\$0.52	\$0.77	\$3.60
Vin	10.6V - 35V	3V - 40V	0.95V - 10V
Vout	8v	Adj (1.25V - 37V)	Adj (0.2V - 9.6V)
Iout	1A	1.5A	3A
Dropout	2V	2V	95mV



The LM317 was chosen because it was inexpensive and the range of voltage output and inputs allowed for both stepping down the voltage of the battery and the output of the motor.

Battery Type Selection

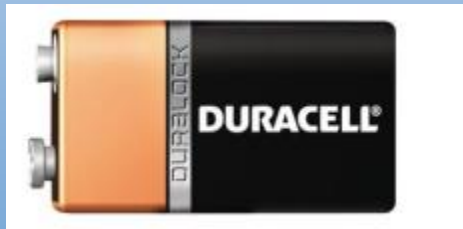


9V Batteries		AA Batteries		Lithium Coin Batteries	
<ul style="list-style-type: none">• 9 Volts• Capacity 1200 mAH		<ul style="list-style-type: none">• 1.5 Volts• Capacity 1700 mAH - 2500 mAH		<ul style="list-style-type: none">• 3 Volts• Capacity 30 mAH - 620 mAH	
Alkaline	Lithium	Carbon Zinc		NiCd	
<ul style="list-style-type: none">• High Capacity• Long Shelf Life• Commonly Sold	<ul style="list-style-type: none">• Highest Capacity• Long Shelf Life• Commonly Sold• Higher Cost	<ul style="list-style-type: none">• Low Capacity• Low Cost		<ul style="list-style-type: none">• Rechargeable• Higher Cost• Requires Independent Charger	

Battery Comparison



Criteria	MN1604	6LF22XWA	6LR61
Cost	\$3.75	\$2.34	\$1.62
Capacity	~600mAH	~600mAH	~600mAH
Duration	~10-60 hrs	~24 hrs	~ 25 hrs



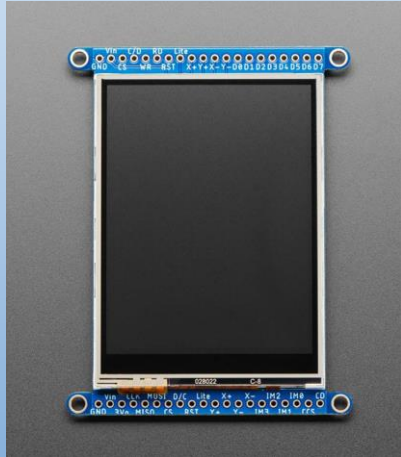
The alkaline 9 volt batteries that were compared had similar specifications. The MN1604 was chosen because they were available in store, avoiding shipping fees.

LCD Type Selection



	TN Displays	IPS Displays	VA Panels	TFT Displays	OLED Displays	PMOLED Displays	AMOLED Displays
Image Quality	Poor	Great	Best	Great	Great	Great	Great
Viewing Angles	Poor	Best	Great	Good	Great	Good	Good
Response Times	Best	Fair	Poor	Good	Good	Great	Good
Power Consumption Range	Low	High	Medium	Medium	High	High	Medium
Cost Range	Low	High	Low to Medium	Low to Medium	Medium to High	Medium to High	Medium to High

LCD Selection and Comparisons



Criteria	Teyleten OLED Display	Walfront OLED Display	Hitletgo TFT Display - Touch Panel	Adafruit TFT Display ILI9341	Adafruit TFT Display HXD8357D
Dimensions	L:2.244 in W: 1.161 in 2.42 in of Diagonal Display	L: 1.158in W: 0.579 in 1.3 in of Diagonal Display	L: 2.248 in W: 1.710 in 2.8 in of Diagonal Display	L: 2.268 in W: 1.701 in 2.8 in of Diagonal Display	L:2.891 in W: 1.928 in 3.5 in of Diagonal Display
Resolution	128 x 64 Pixels	128 x 64 Pixels	320 x 240 Pixels	320 x 240 Pixels	480 x 320 Pixels
Required Pins	4 or 5 Pins	4 Pins	8 Pins	5 or 12 Pins	5 or 12 Pins
Interface Compatibility	SPI or I2C	SPI or I2C	8-bit SPI	SPI or 8-bit Parallel	SPI or 8-bit Parallel
Input Voltage	3.3V or 5V	3.3V or 5V	3.3V or 5V	3.3V or 5V	3.3V or 5V
Cost	\$14.99	\$8.42	\$15.99	\$29.95	\$39.99



Voltage and Current Sensor Type Selection

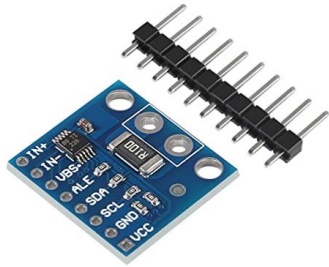
Method	Hall Effect (Non-invasive)	Shunt Based Method (Invasive)	Induction Method (Non-invasive)
Advantages	<ul style="list-style-type: none">- No direct impact on circuit voltage.- Measures voltage perpendicular to the current path.- Suitable for both DC and AC current measurement.	<ul style="list-style-type: none">- Precise measurements for both DC and AC current.- Can be used with Arduino's internal ADC.	<ul style="list-style-type: none">- Does not affect circuit voltage.- Suitable for both DC and AC current measurement.
Disadvantages	<ul style="list-style-type: none">- May have limitations in accuracy.- Performance influenced by external factors.	<ul style="list-style-type: none">- Arduino's 10-Bit resolution may reduce accuracy.- Requires low-resistance shunts for accurate readings.- Measurement may not be accurate without additional components.	<ul style="list-style-type: none">- Complexity introduced with current clamp and probe.- Accuracy influenced by various factors in specific scenarios.



Voltage and Current Sensor Selection and Comparisons

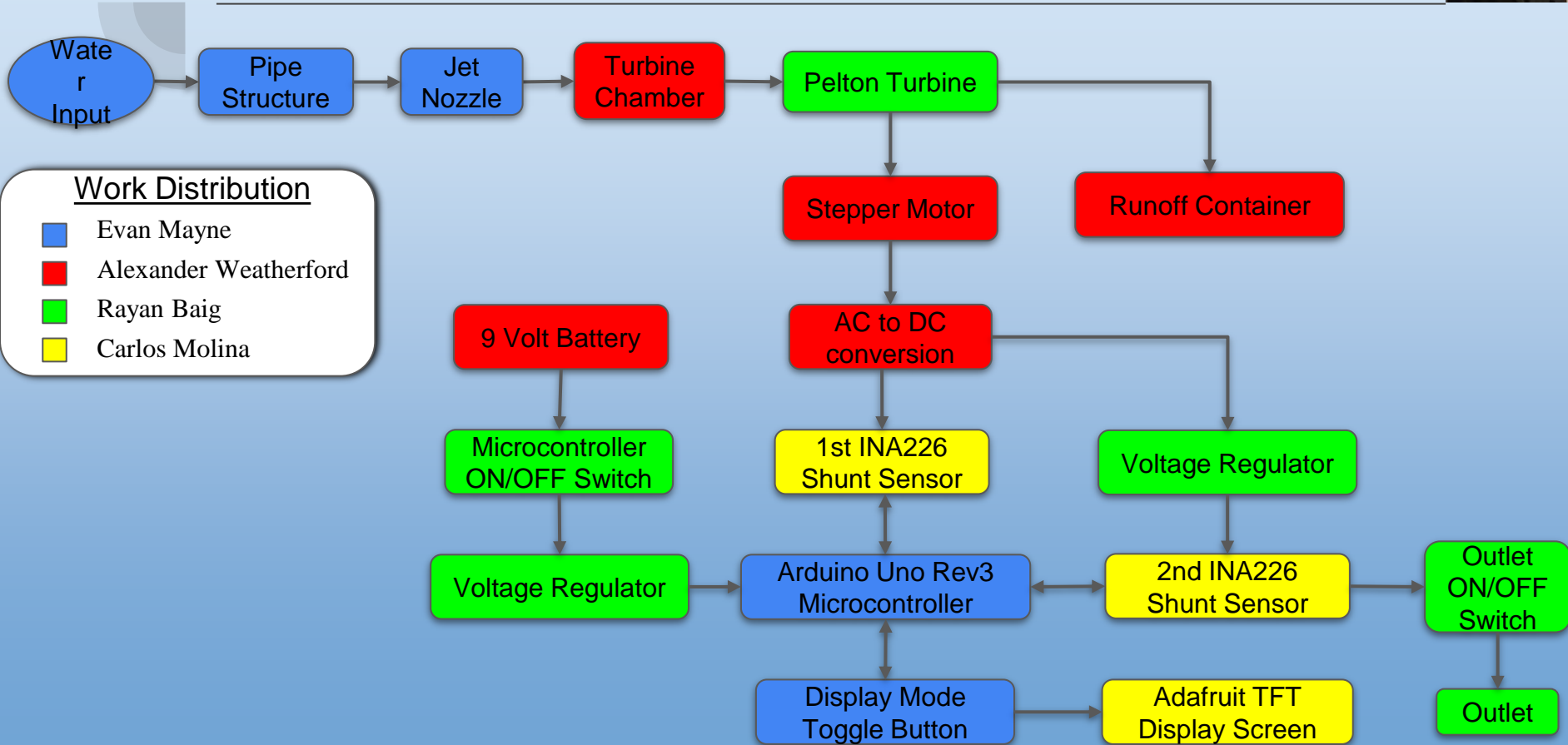
- The INA226 Sensor can measure voltage from 0 to 36V and current from 0.5 mA to 50 A

Criteria	Voltage Measuring Component	Current Measuring Components			Voltage & Current Measuring Components	
	25V DC Voltage Sensor + LM4040 Module	ACS712 Module - 5A	ADS 1115 Module	SCT0113 Current Sensor	Adafruit INA219 Sensor	DWELL INA226 Sensor
Accuracy Difference compared to Multimeter Reading	Less than 30 mV 10-bit Resolution	Less than 30 mA 10-bit Resolution	Less than 20 mA 16-bit Resolution	Less than 40 mA 10-bit Resolution	Less than 60 mA and less than 50 mV 12-bit Resolution	Less than 20 mA and less than 20 mV 16-bit Resolution
Input Signal	5V or 3.3V	5V	5V	5V	5V	5V
Required Pins	5 pins	3 pins	4 pins	2 pins	4 pins	4 pins
Interface Compatibility	5 Pin Interface	3 Pin Interface	I2C	2 Pin Interface	I2C	I2C
Cost	\$19.94	\$9.99	\$14.99	\$13	\$9.95	\$6.66





Hardware Diagram





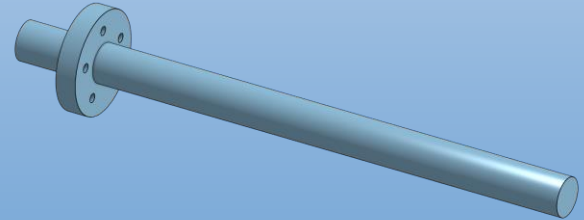
Hardware Design

- ❑ Addresses on the INA226 sensors was handled by soldering the address pins (A0, A1, A2) on each sensor to reflect the desired address.
- ❑ The 4-wire SPI option was chosen over the 8-bit parallel option for the Adafruit TFT Display.
- ❑ The the Atmega328P-PU model has dual in-line packaging, so a socket will be used.

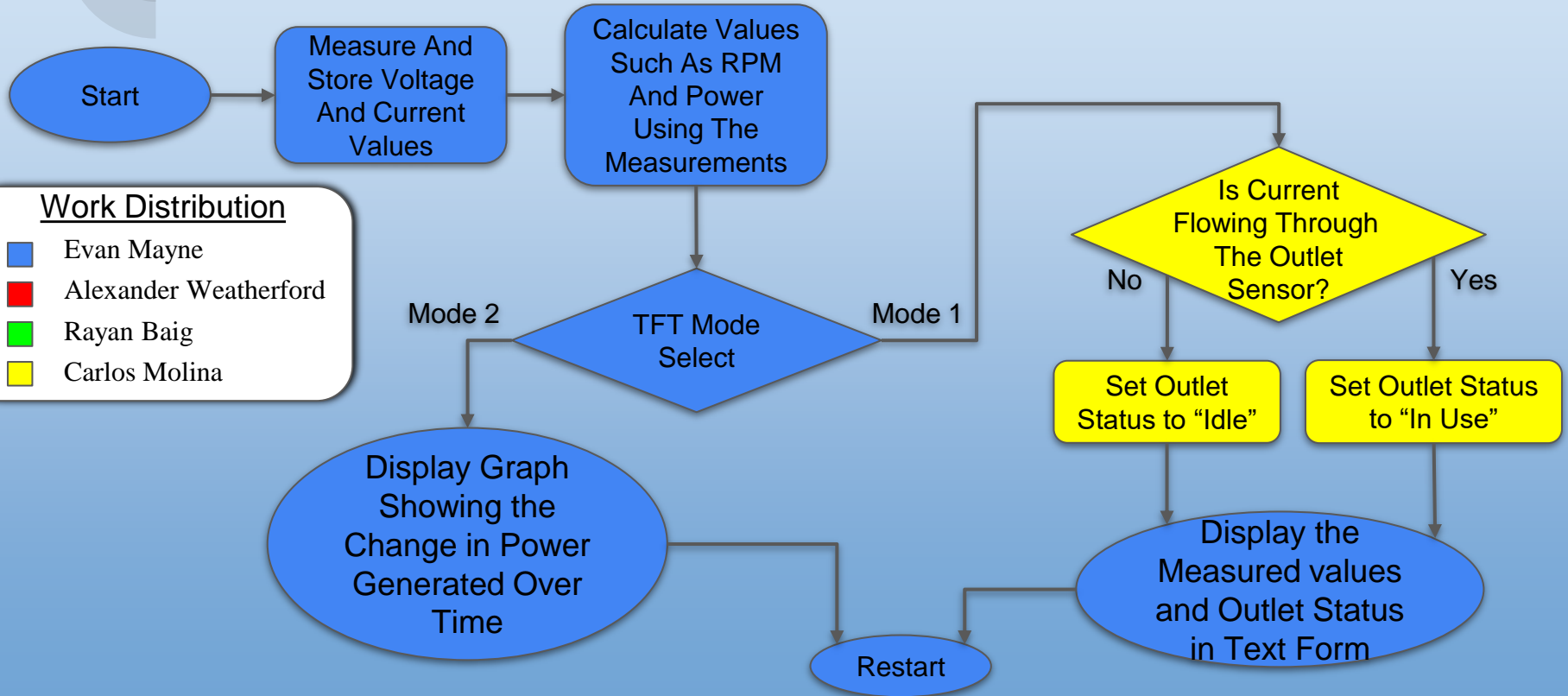
Major Mechanical Components



- ❑ Piping Structure
- ❑ Gearbox and Shaft Connections (Couplings/Flanges)
- ❑ Turbine Chamber & Electronics Casing
- ❑ Wall Mounted Bearings



Software Diagram





Software Design

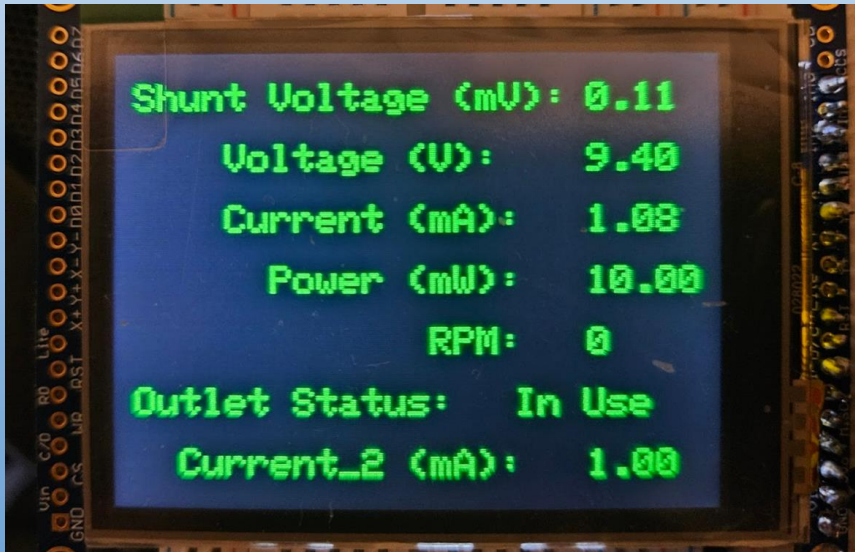
- ❑ Arduino IDE
- ❑ C++ language
- ❑ Github libraries
 - ❑ Tyeth (LCD libraries)
 - ❑ Rob Tillaart (Sensor libraries)
 - ❑ Kris Kasprzak (Graphing libraries)
- ❑ Button based interrupt



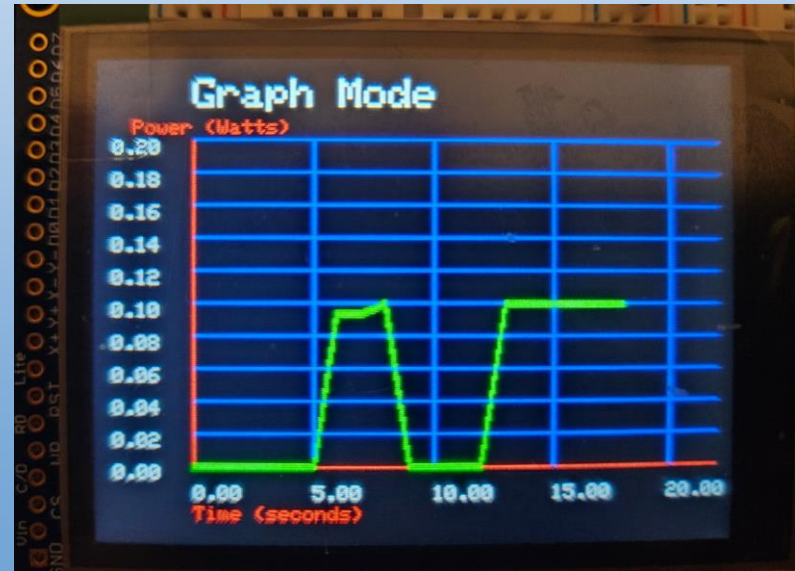
User Interface

- ❑ LCD Toggle Button will be located to the right of the LCD.
- ❑ Switches for powering the prototype and the outlet.
- ❑ Openings in the Electronics casing.

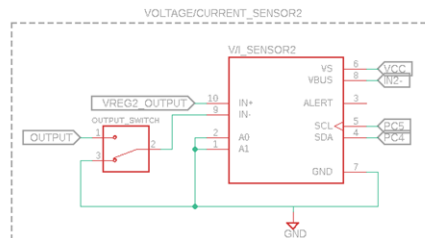
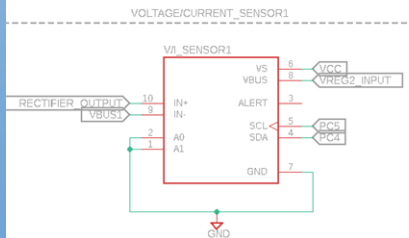
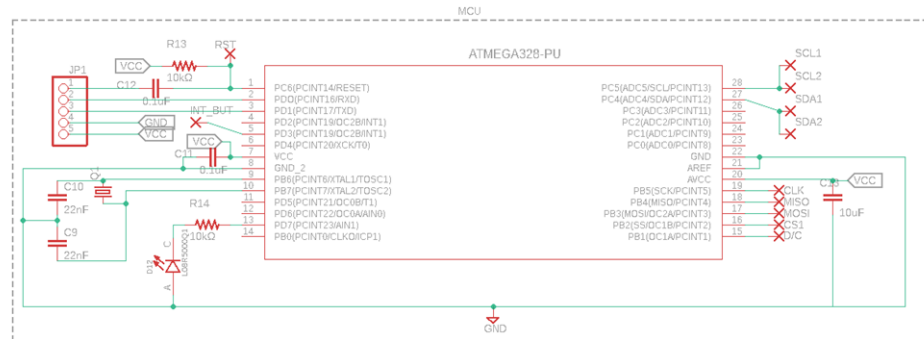
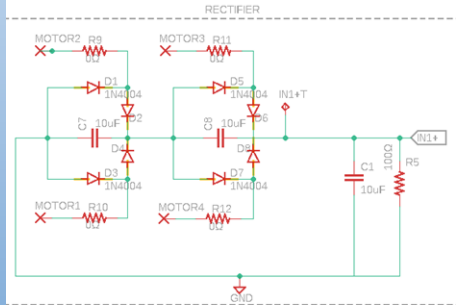
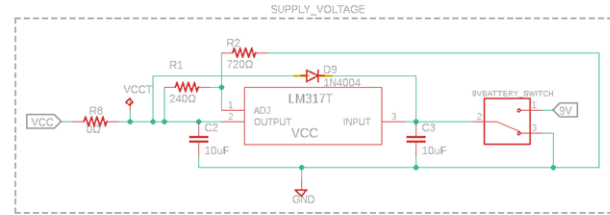
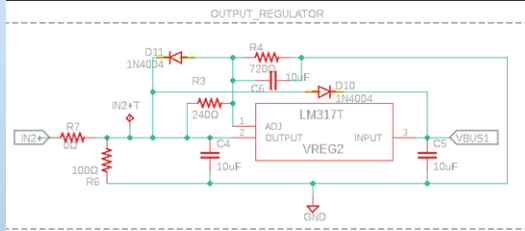
Text Display (Mode 1)



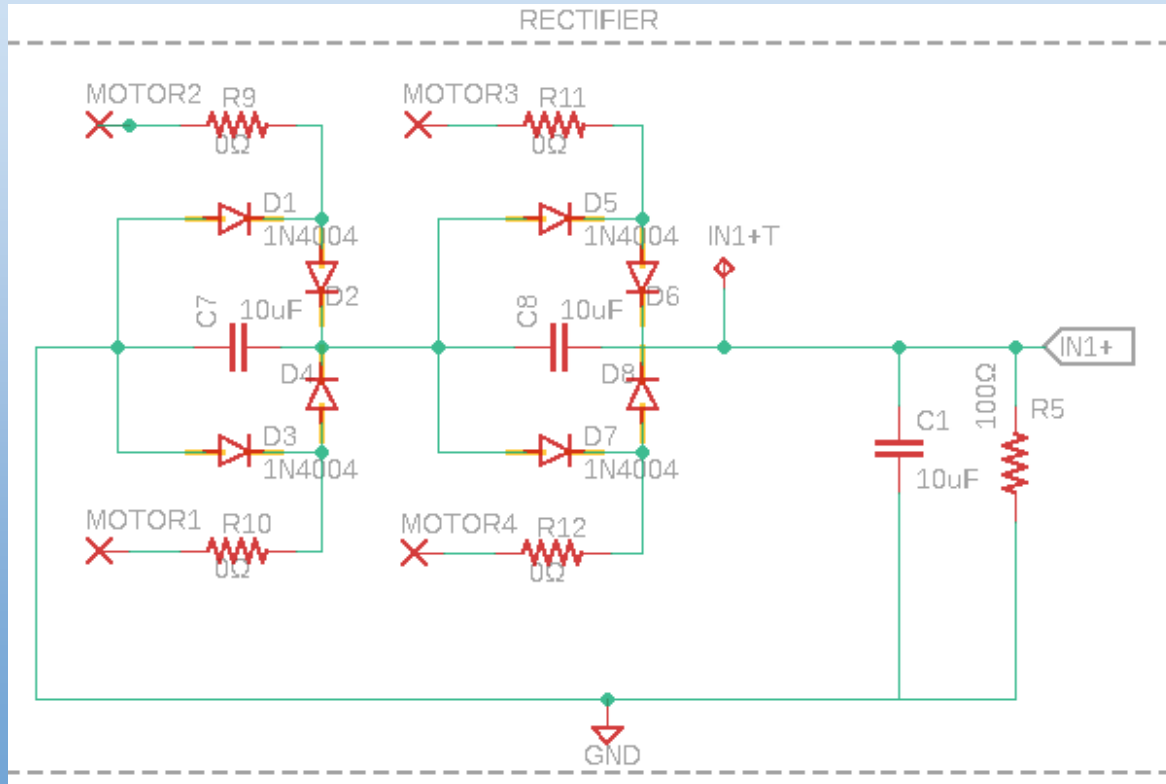
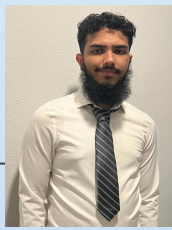
Graph Display (Mode 2)



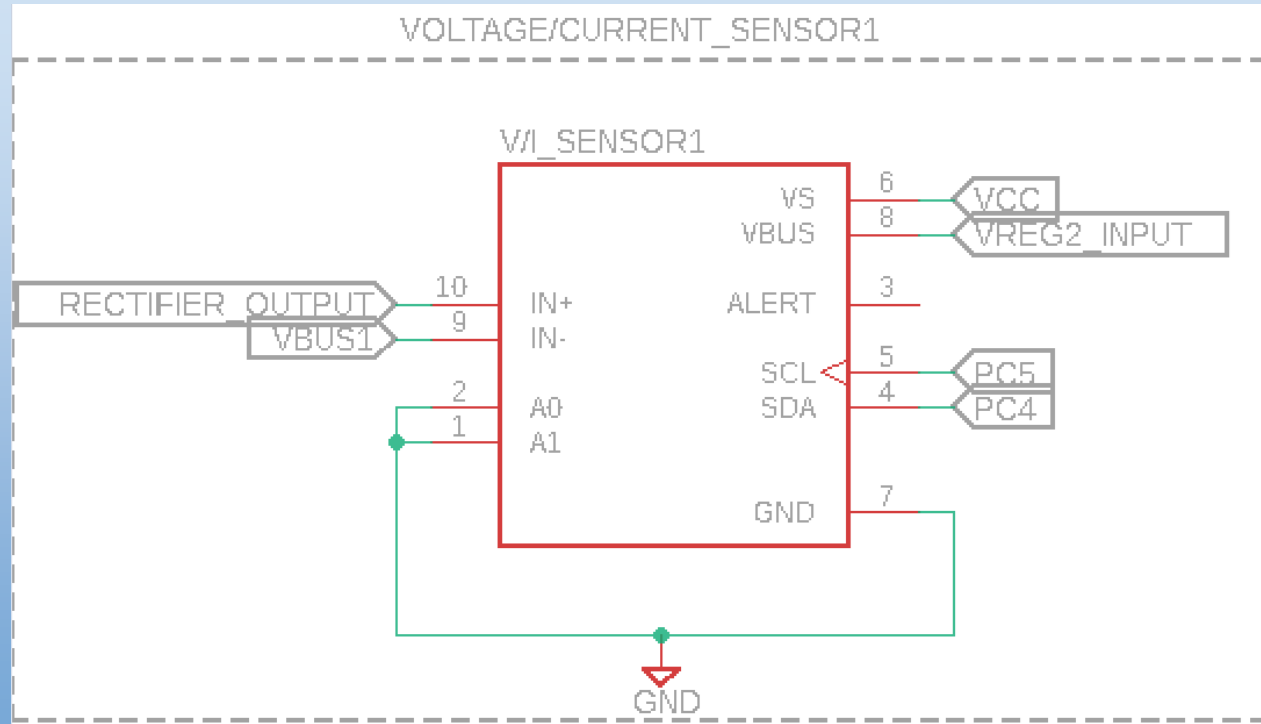
Overall PCB Schematic



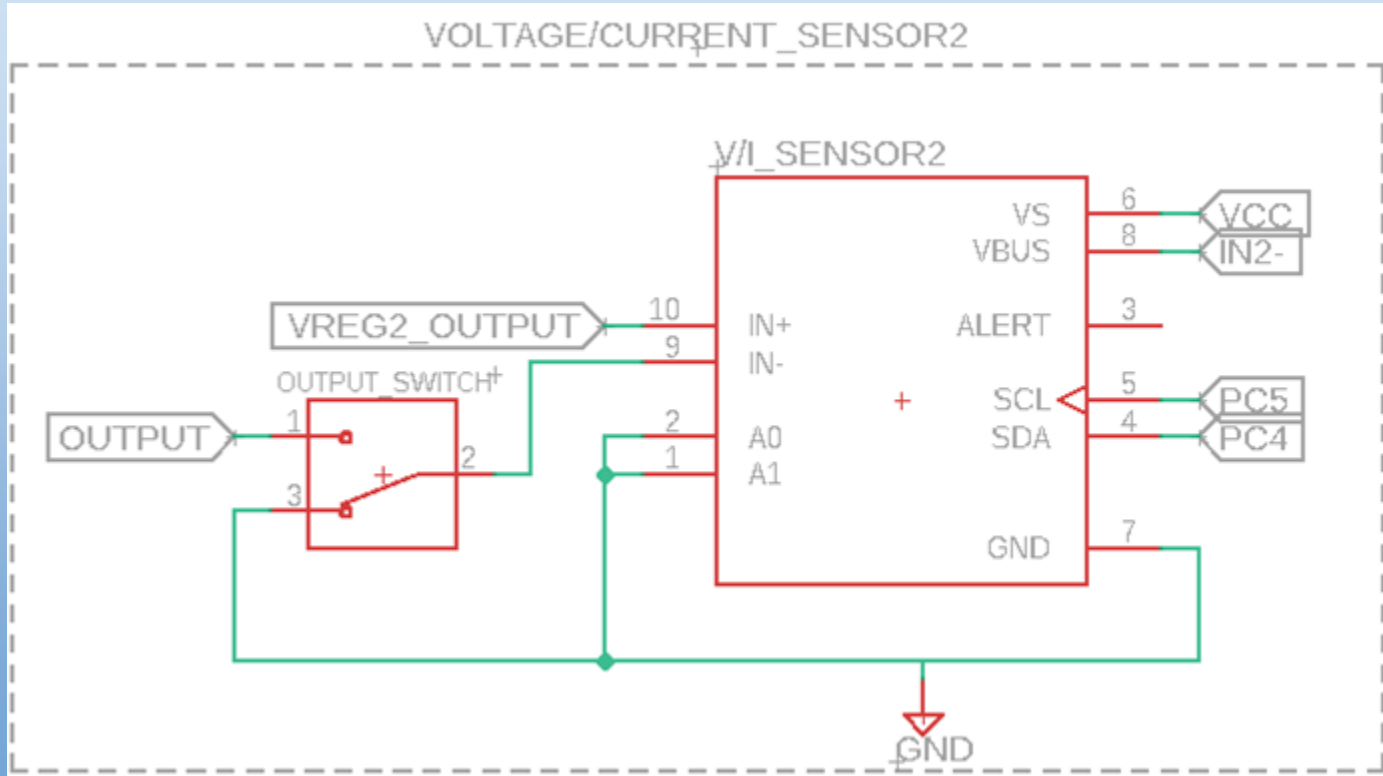
Full Bridge Rectifier PCB Schematic



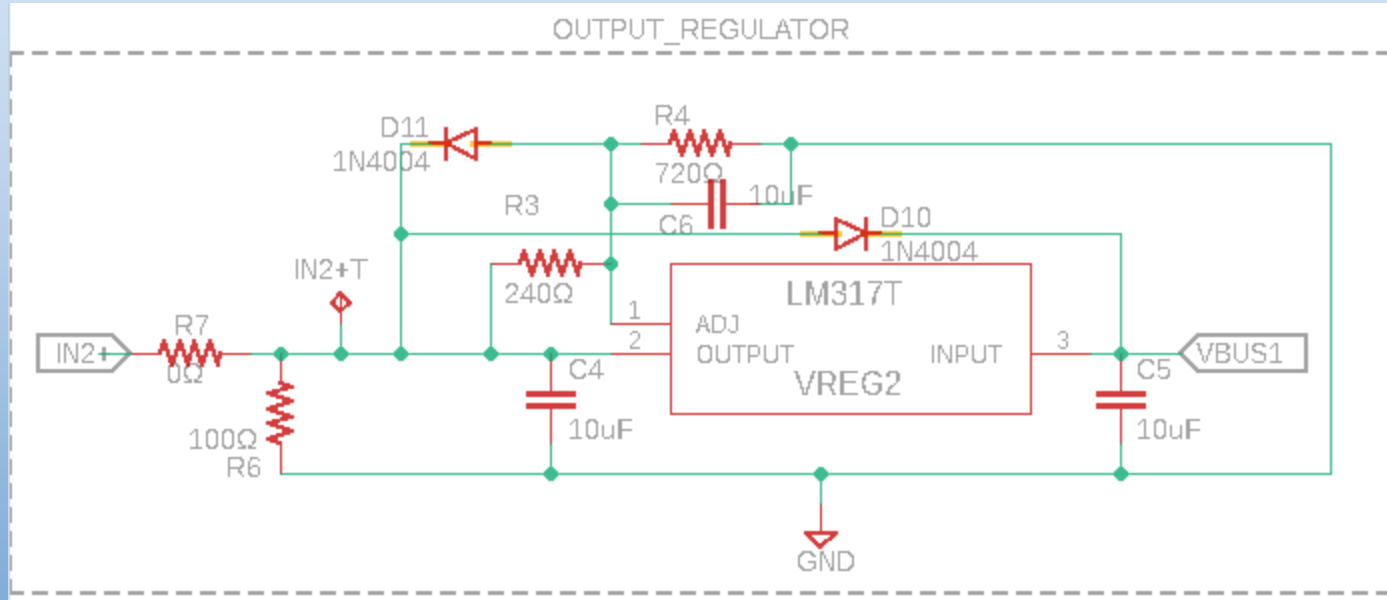
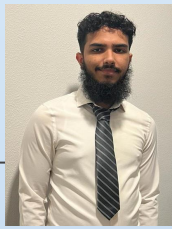
Voltage/Current Sensor 1 PCB Schematic



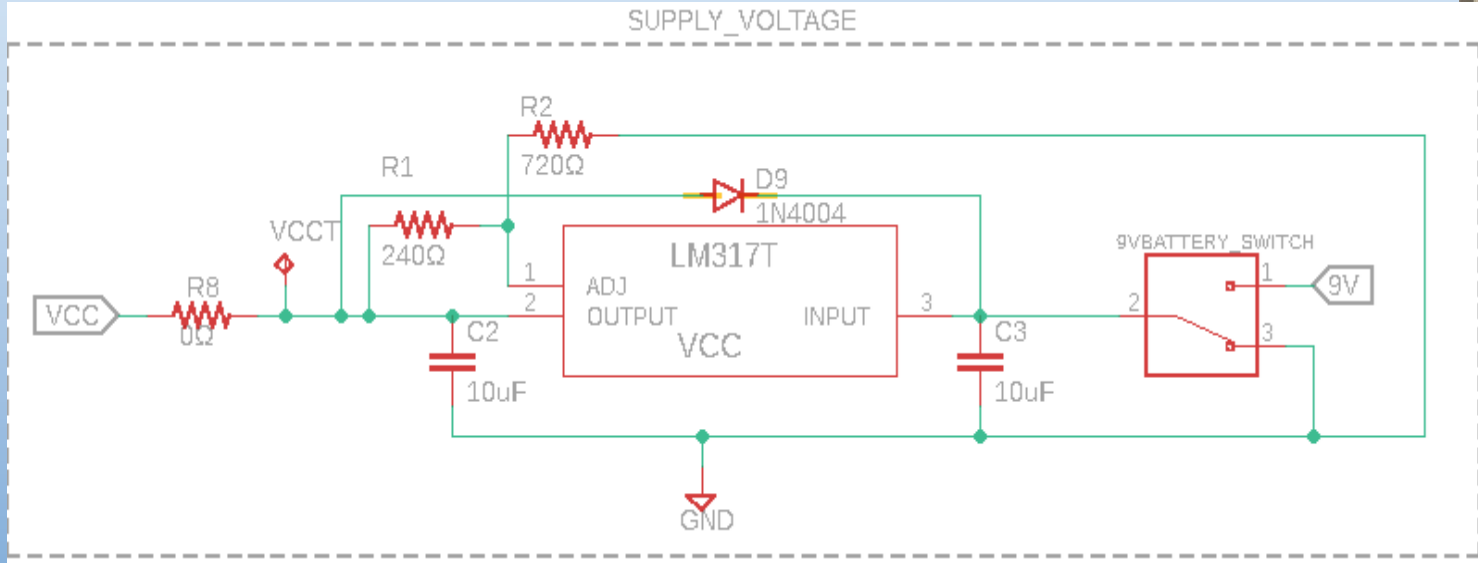
Voltage/Current Sensor 2 PCB Schematic



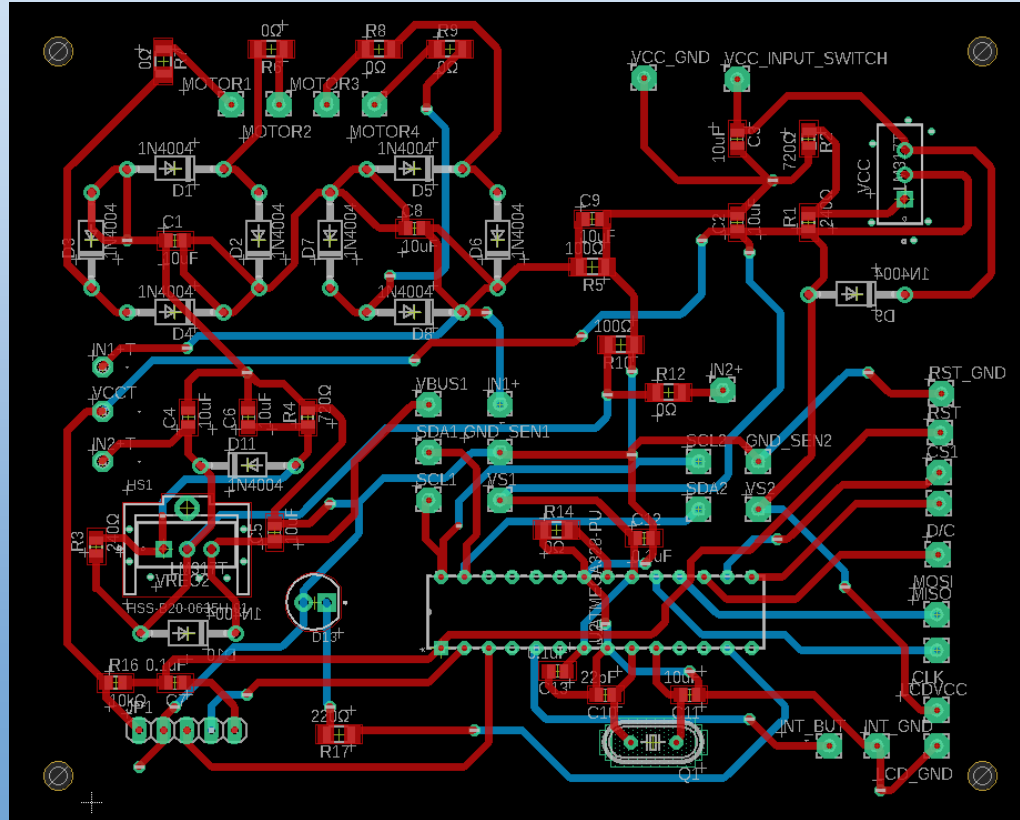
Output Voltage Regulator PCB Schematic



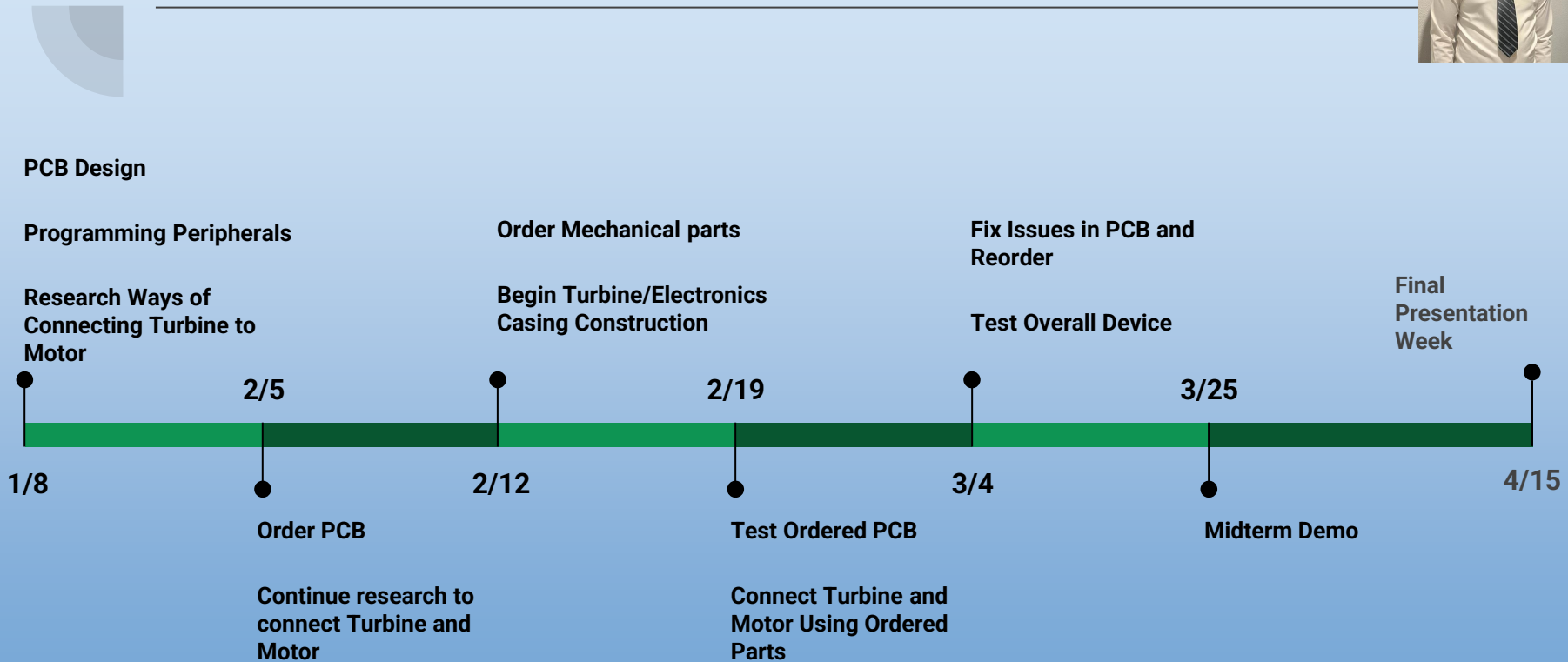
Supply Voltage PCB Schematic



PCB Board Layout



Project Progress





Work Distribution

Team Members	Roles
Rayan Baig	PCB Design Voltage Regulator Design/Testing Turbine Assembly
Alexander Weatherford	Stepper Motor Testing Full Bridge Rectifier Design/Testing Voltage Regulator Testing
Evan Mayne	PVC Piping Design Voltage/Current Sensor Programming/Testing MCU Programming/Testing SPI Programming/Testing
Carlos Molina	LCD Display Testing Voltage/Current Sensor Testing I2C Programming/Testing

Budget



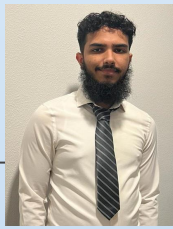
Part Description	Quantity	Total Cost
Pelton Turbine Model B0C4G29ZY9	1	\$53.96
ATMEGA328P-PU (Microchip)	1	\$2.80
Nema 17 Stepper Motor	1	\$16.99
9V Battery (MN1604)	1	\$3.75
Adafruit TFT Display (ILI9341)	1	\$29.95
Voltage/Current Sensor (DWEII INA226)	2	\$13.32 (6.66 ea.)
PVC Piping Segments and Nozzle	N/A	\$75.42
Plexiglass Casing (12-in x 36-in)	1	\$23.62
Oak Wood Casing (6-in x 1-ft x 1-in)	3	\$40.32 (13.44 ea.)

Budget Cont.



Part Description	Quantity	Total Cost
Oak Wood Casing (1-ft x 1-ft x 1-in)	1	\$26.88
Linear Voltage Regulator (LM317)	2	\$7.16 (\$3.58 ea.)
PCB	1	\$5.35
Mechanical Parts	N/A	\$70
Combined Total Cost		\$372.41

Current Challenges



- ❑ Mechanical Design
 - ❑ Gears, Shafts, Flanges, Couplings
- ❑ FTDI connection testing
- ❑ Budget



THANK YOU FOR LISTENING!

Have a nice day!

Citations can be found in our document.