IOWA STATE UNIVERSITY

Senior Design Final Presentation

DAQ for Dogs

sddec15-18

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Client: Dr. Laflamme
Advisor: Dr. Neihart

Problem Statement

What:

Our client needs a Data Acquisition device (DAQ) that is capable of collecting and storing resistance data from a sensor (provided by client) which is to be attached to a dog collar.

Why:

This device is needed because it will significantly increase how veterinary surgeons can measure the efficiency of a stitch placed on a dog. This will in turn help veterinary researchers to be able to effectively collect and make changes based on the data received from this device. Conclusively, the results of all this will create a more resourceful and quick method for measuring and collecting data in the veterinary science field.

Market Survey

Our project is important because it will affect how efficiently a veterinary surgeon can measure the effectiveness of the stitches put on an animal, specifically a small dog. It is unique in the way that most people have not or are not designing a device can specifically gauge the change in resistance caused by movement affecting a medicinary stitch.

Solution

- Small, lightweight and portable DAQ attached to a dog-collar
  - Battery powered
  - SD card for storage

- DAQ for Dogs Website for storage and visualization
  - User Profiles
  - Data storage and Visualization

Functional Requirements

- Battery powered DAQ
- Data has to be stored in SD Card
- Signal Conditioning for Data Sampling
- Sensor data collected at client specified frequency
- Temperature sensor to determine skew in data and future calibration
- Online platform to safely store and visualize collected data

Non-Functional Requirements

- Battery life to sustain a full day of data collection
- Minimally sized to not hinder movement
- Protective Case for Device
- Battery life visual indicator

Engineering Constraints

- Budget of $200 for prototyping
- Operating Environment with variable temperature
- Trade off between size, battery life, accuracy, efficiency and weight

Potential Risks and Mitigation

- Battery
- Damage to DAQ
- Inaccurate Data
- Data Security (Website)

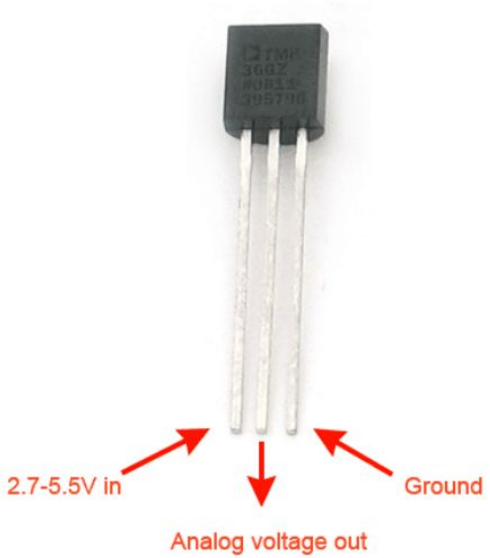
Design

- Sensor
- Temperature
- Amplifier and Filter
- Battery and Charger
- Boost Converter
- PCB
- Code
- Case
- Website

Strain Sensor and Temperature Sensor

TiO_2 strain sensor

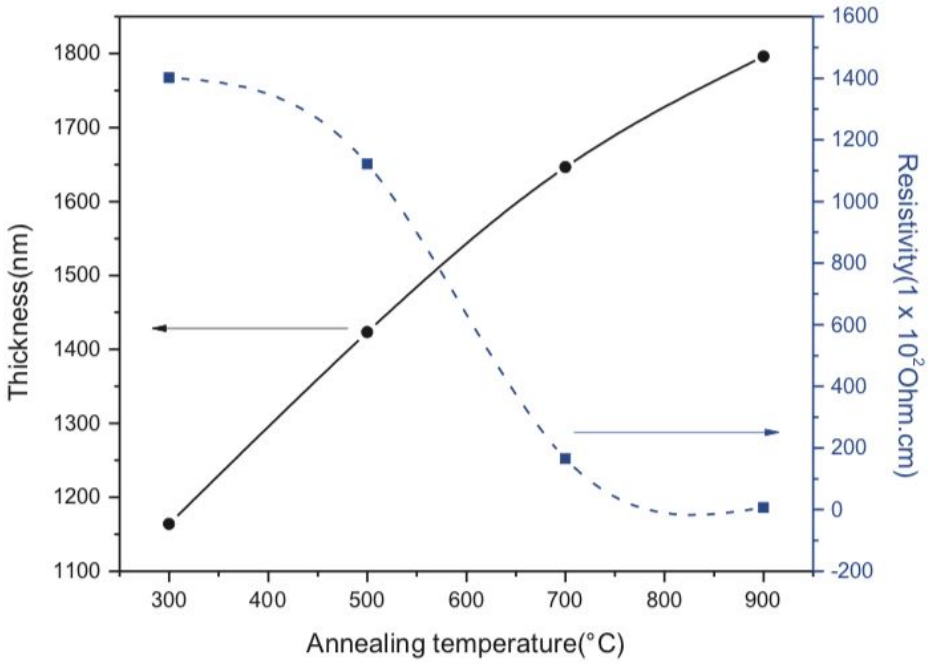
Temperature Sensor LM 61



Temperature Effects on Resistivity

Increasing the temperature results in a lower resistivity in TiO_2 due to the crystal quality and surface roughness found at the higher temperatures.

Resistivity is not significantly affected unless at extreme temperatures



Temperature Effects on Resistivity

Conductivity is the reciprocal of resistivity

$$\sigma = \frac{1}{\rho}$$

The next equation below relates the conductivity of a semiconductor to the temperature

$$\sigma = q\left[\mu_n(T)n(T) + \mu_p(T)p(T)\right]$$

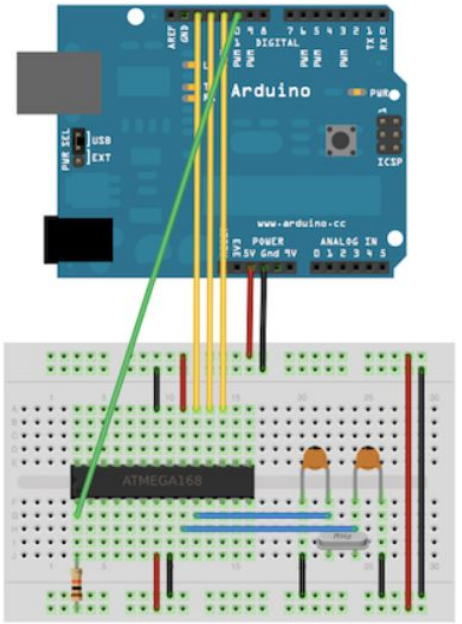
(μ_n and μ_p refer to the mobilities of the electrons and holes, and n and p refer to the density of electrons and holes)

Standalone Atmega328

Use arduino to burn bootloader on Atmega328

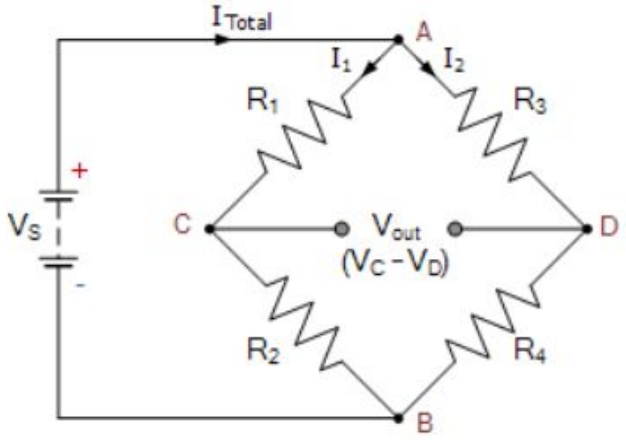
Components needed:

- 16 MHz crystal oscillator
- 10k resistor
- Two 22pF capacitors



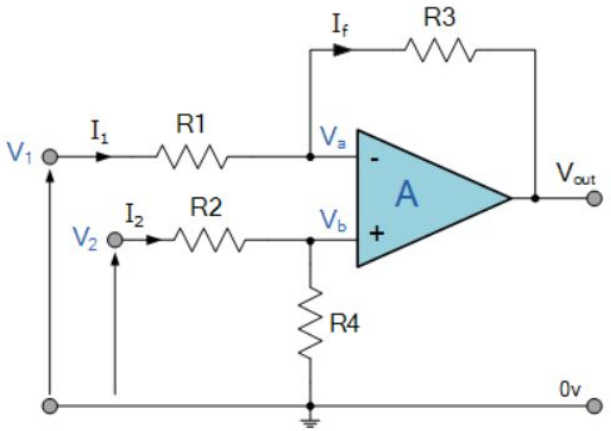
Amplifier and Filter Circuit

Wheatstone Bridge



$$V_{out} = V_{cc} * [(R_2/R_1 + R_2) - (R_4/R_3 + R_4)]$$

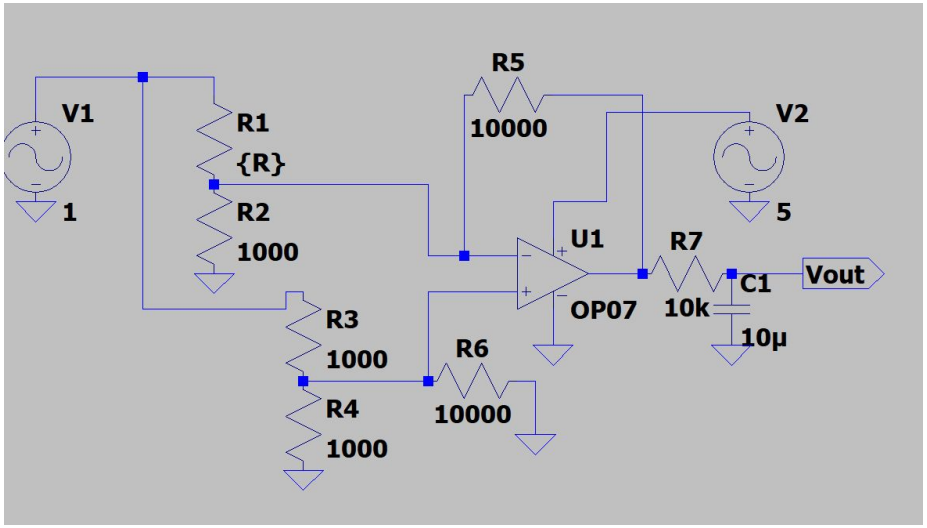
Differential Op-amp



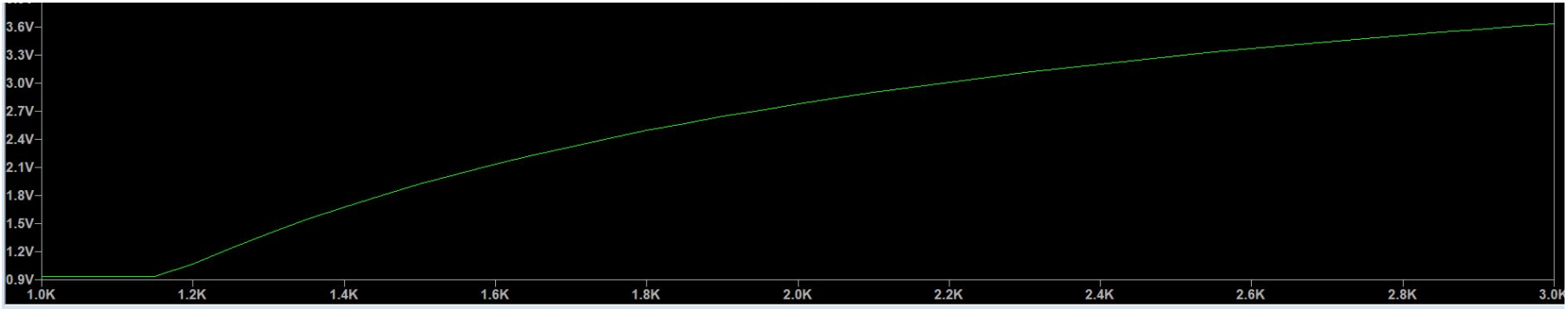
$$V_{out} = (R_3/R_1)(V_1 - V_2)$$

Amplifier and Filter Circuit

- Differential Op-amp Bridge Circuit
- Low Pass Filter
- {R} = Resistance of Strain Sensor



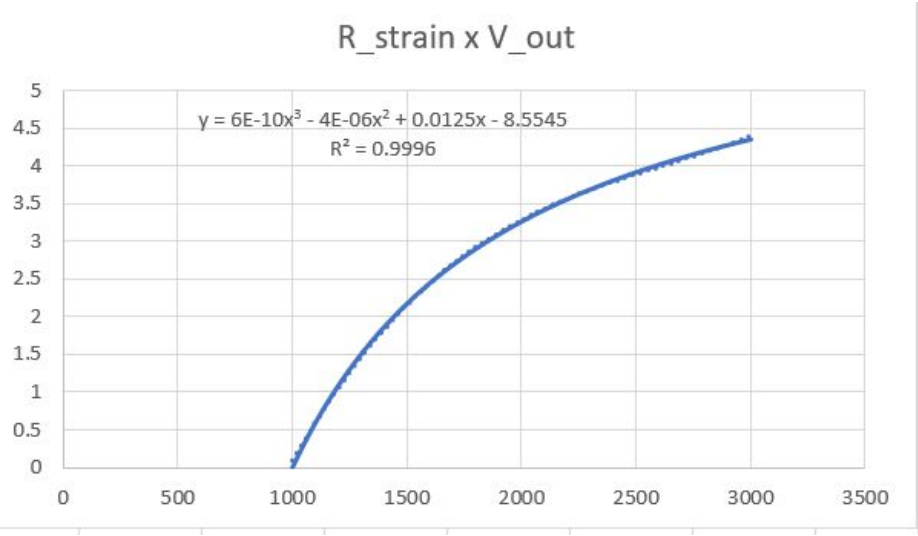
$$V_{out}/V_{cc} = R5[(R_2^{-1} + R_5^{-1} + R_{strain}^{-1})/R_3(R_4^{-1} + R_6^{-1} + R_3^{-1}) - R_1^{-1}]$$

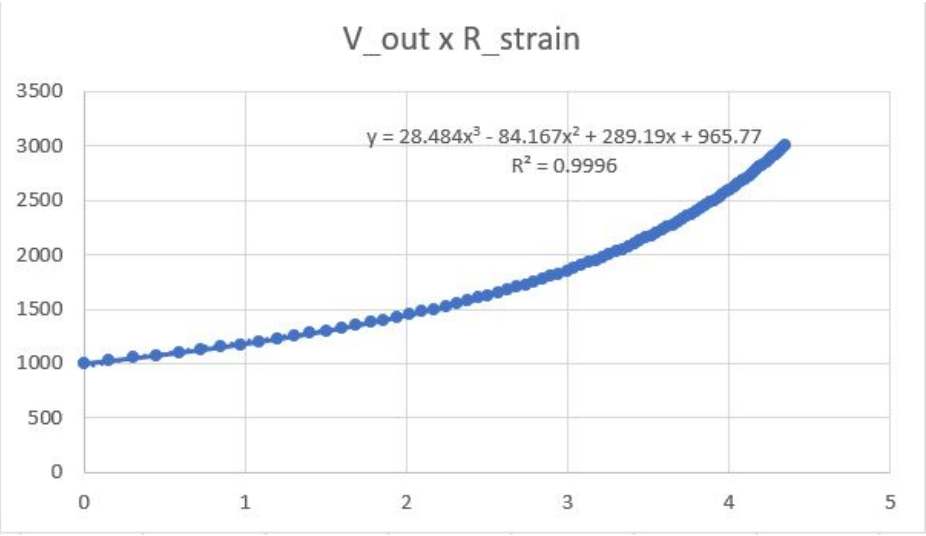


Amplifier and Filter Circuit

Error propagation:

- Resistor conversion, R^2=0.9996
- 10 bit Adc conversion, (1/1024) = 0.004
- Resistor tolerance, 0.1%

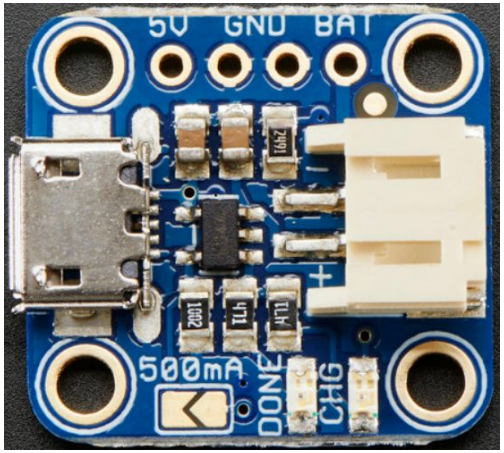




Battery and Charger

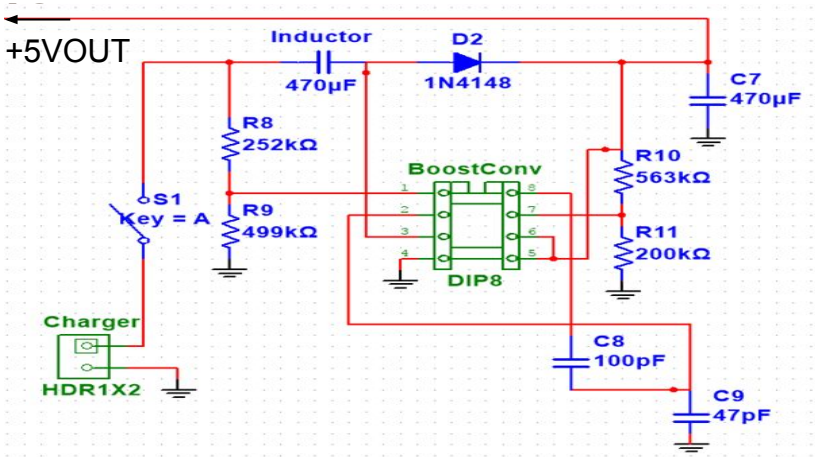
Lithium Ion Battery
Working Current: 60mA
Sleeping Current: 10mA

Battery charger:
Constant current and constant voltage charging



Boost Converter

Boost Converter with MAX 4193



Output Voltage Calculation

$$10\Omega \leq R2 \leq 1M\Omega \rightarrow R1 = R2 \times (Vout - 1.31V)/1.31$$

$$When\ R1 = 563k\Omega\ and\ R2 = 200k\Omega$$

$$\Rightarrow Vout = 1.31 \times (R1 + R2)/R2$$

$$\Rightarrow Vout = 1.31 \times (563k\Omega + 200k\Omega)/200k\Omega$$

$$Therefore,\ \ Vout = 5V$$

Testing Result

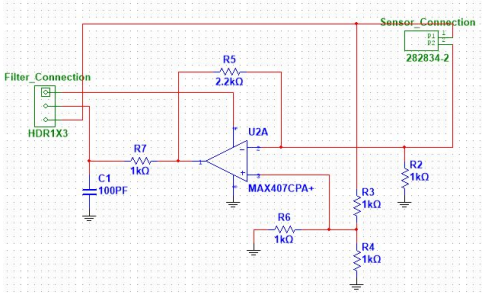
→ When input voltage with the voltage drop range, the output voltage maintains 5V.

PCB Design

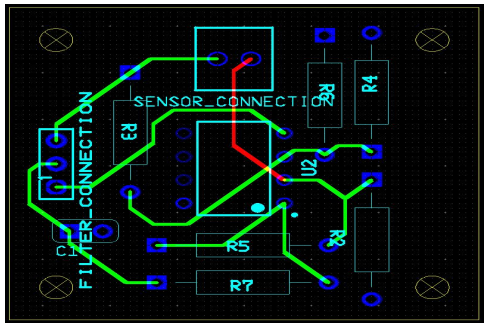
- Used Multisim/Ultiboard software.
- Two PCB layers

Filter Circuit

Multisim Schematic

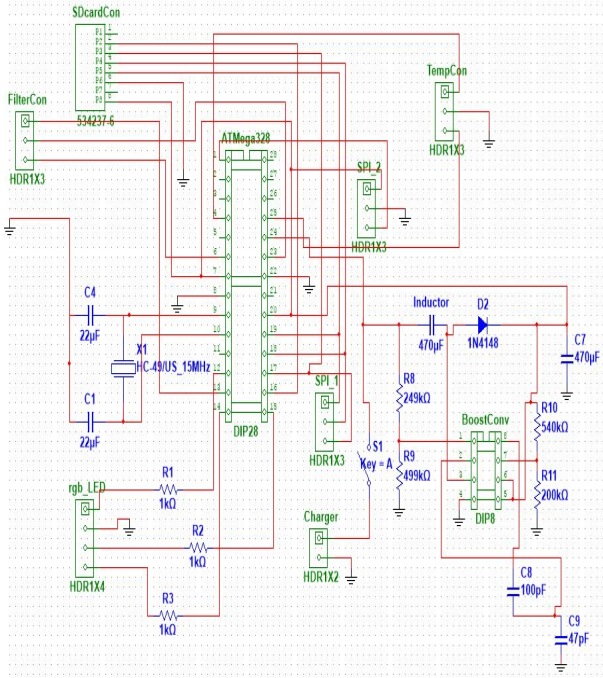


Ultiboard Design

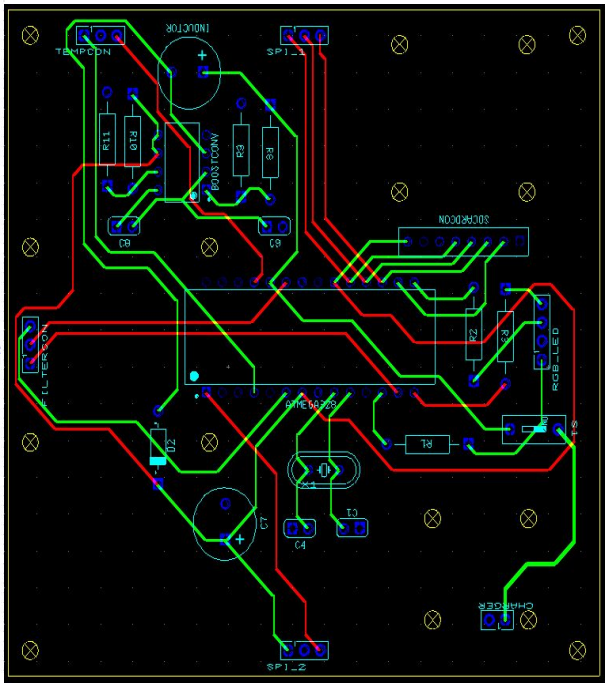


ATmega328 & Boost Converter

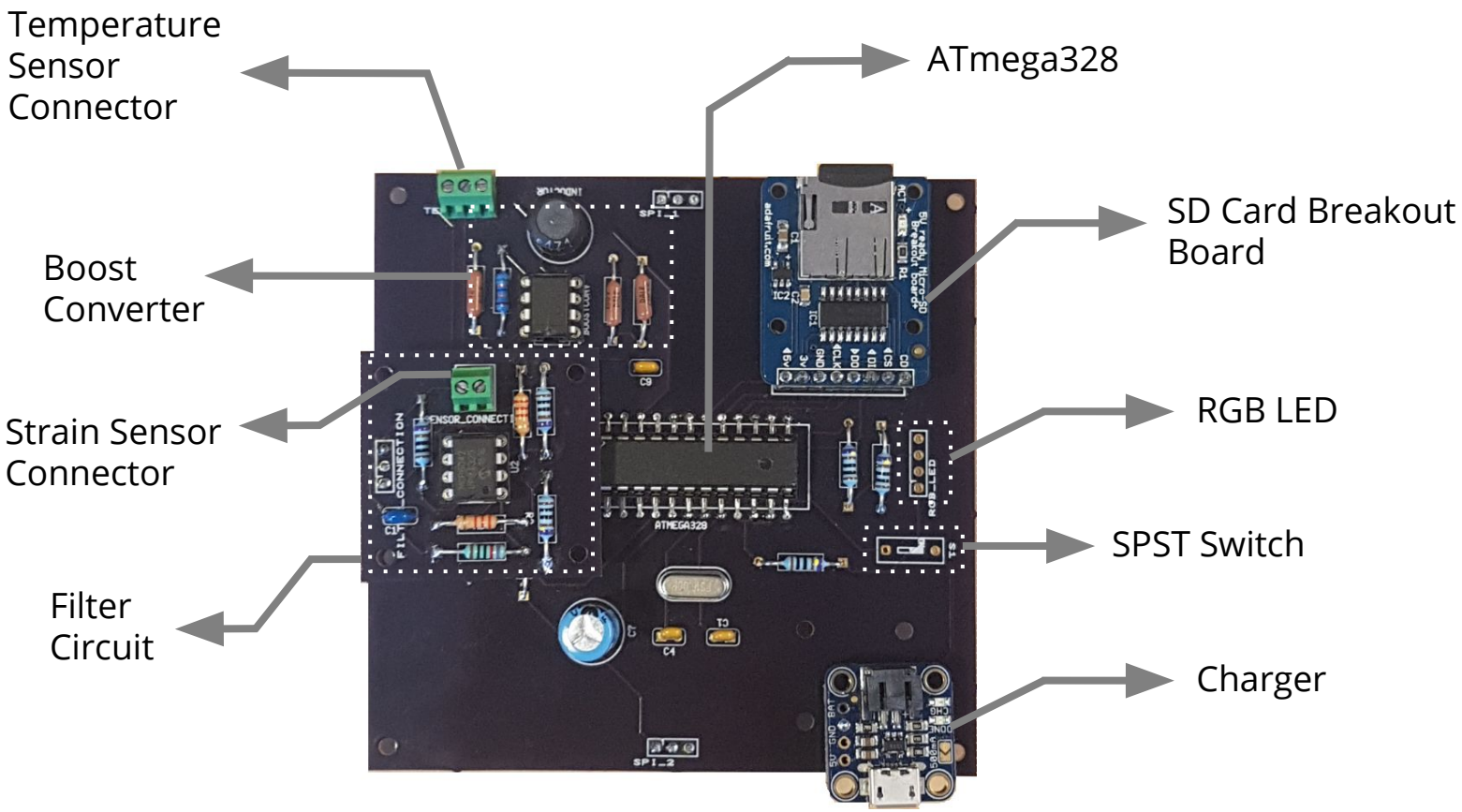
Multisim Schematic



Ultiboard Design



Final Design

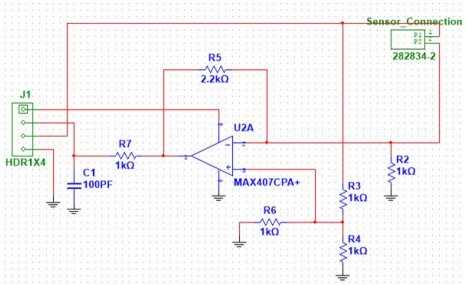


Size: 3.7 by 3.6 inches

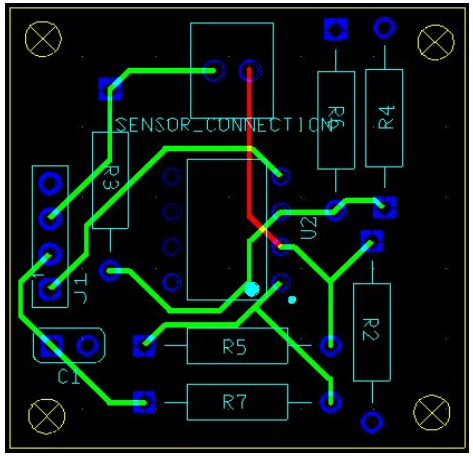
PCB Redesign

Filter Circuit

Multisim Schematic

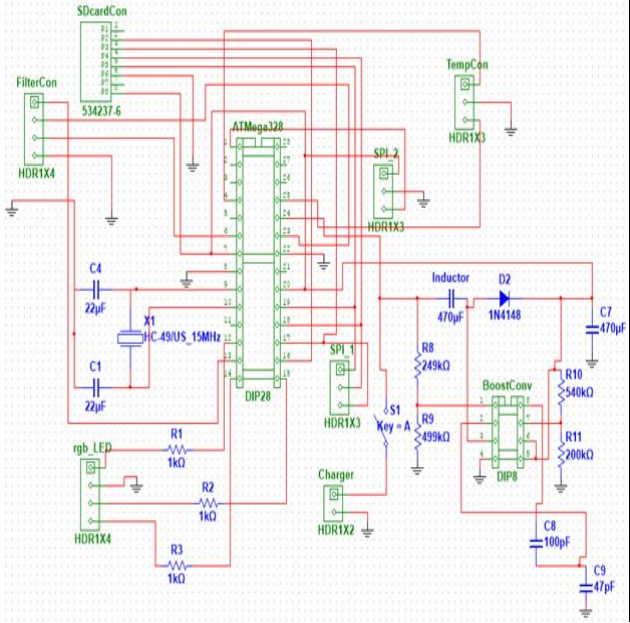


Ultiboard Design

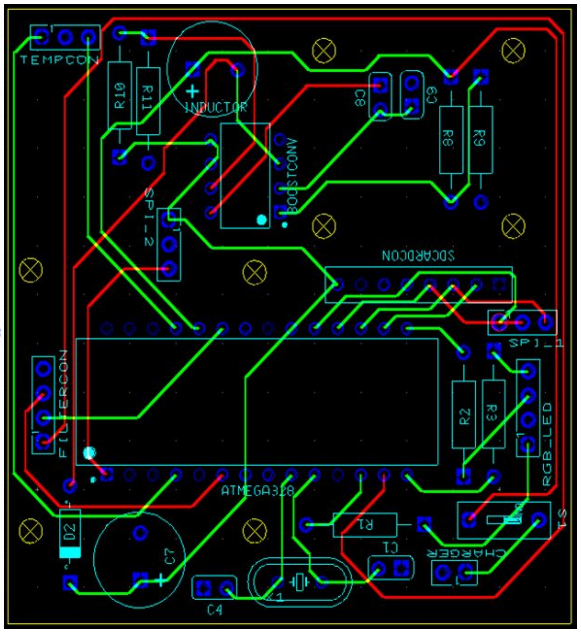


ATmega328 & Boost Converter

Multisim Schematic



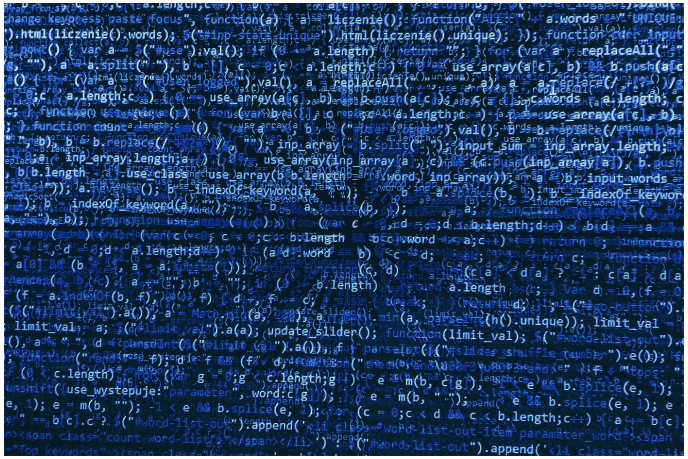
Ultiboard Design



- Size: 2.4 by 2.5 inches → 49% smaller than the original size
- Put 4 pins connectors
- Relocated the connector for the charger

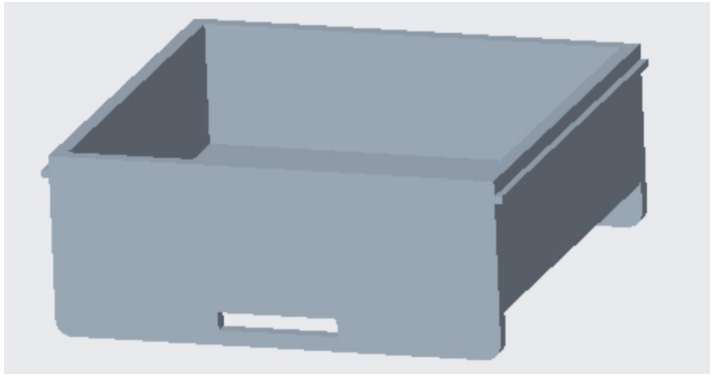
Arduino Code

- Interrupts for precise data sampling
- Time/Date Function vs RTC
- Data Averaging and conversion
- Battery Level



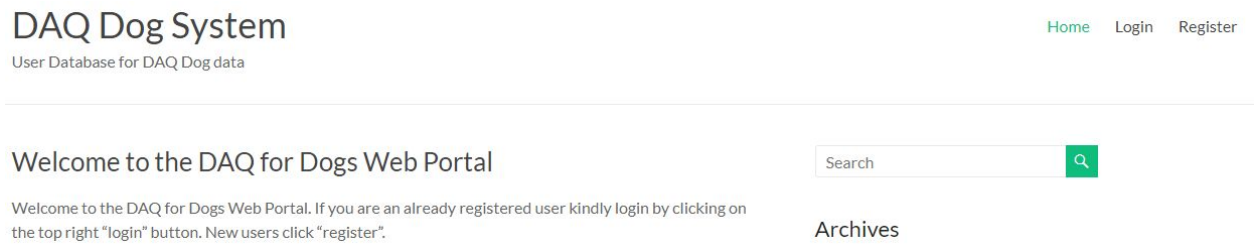
DAQ Case

- Designed in Creo
- Cost = $15
- Snap on lid to prevent water leakage
- Further modifications
  - Openings for power switch, LED, wires to sensor
  - Minimize entire design proportional to PCB



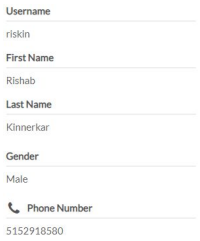
Website

The web-application would be responsible for storing the DAQ data which users collect and graphing them the corresponding user profile. When the user accesses the website they would be on the homepage which would look as follows:



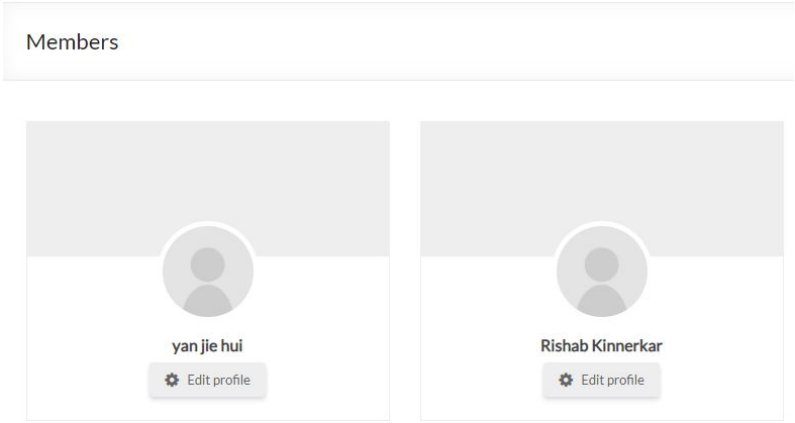
Website

After registering, users would have the option to see other user's graph on the web portal and compare their results



Website

While searching users can search other users based on name, email, phone number and organization.



Users can download DAQ data of other users or organizations in CSV format which they could use for research purposes.

Website

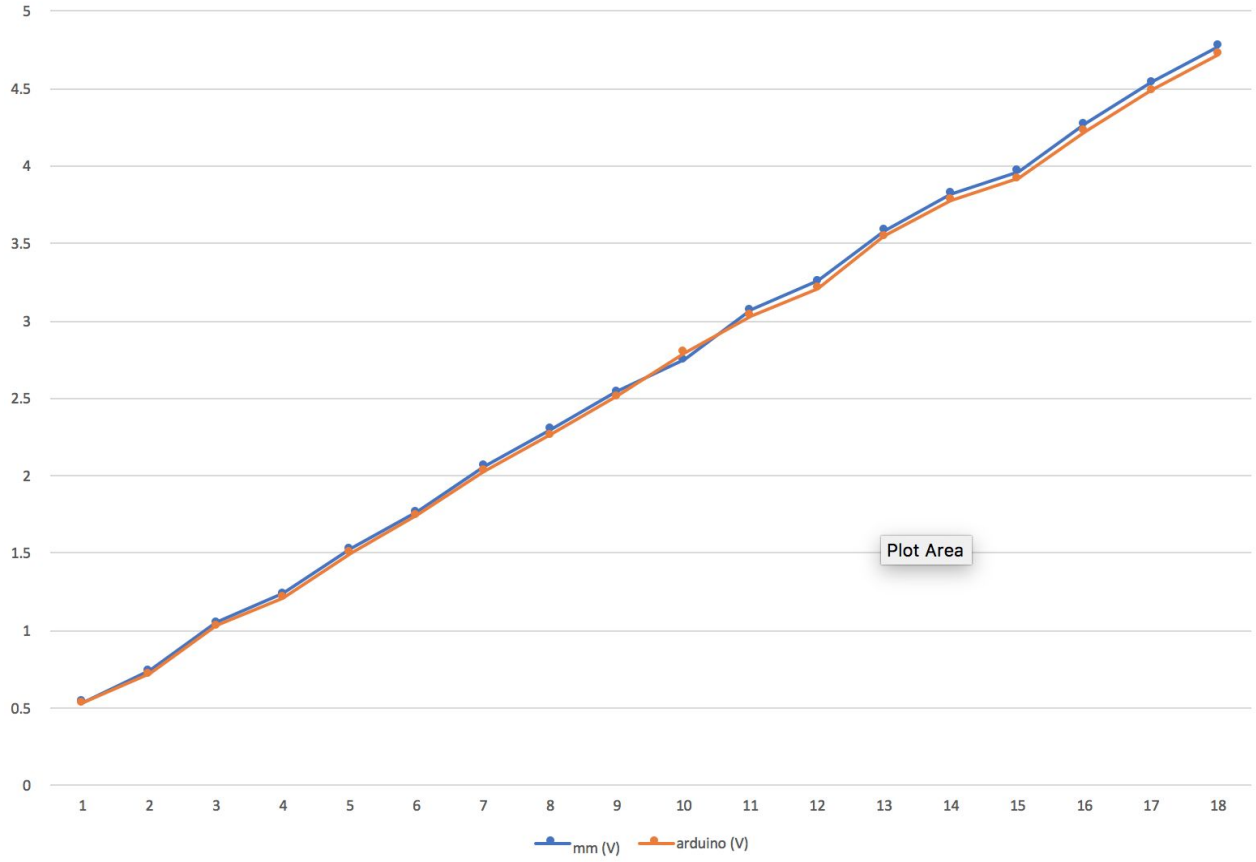
- Was tested with 500 Dummy users.
- Tested to see how the server and website handles users.
- Accessibility was tested

Testing

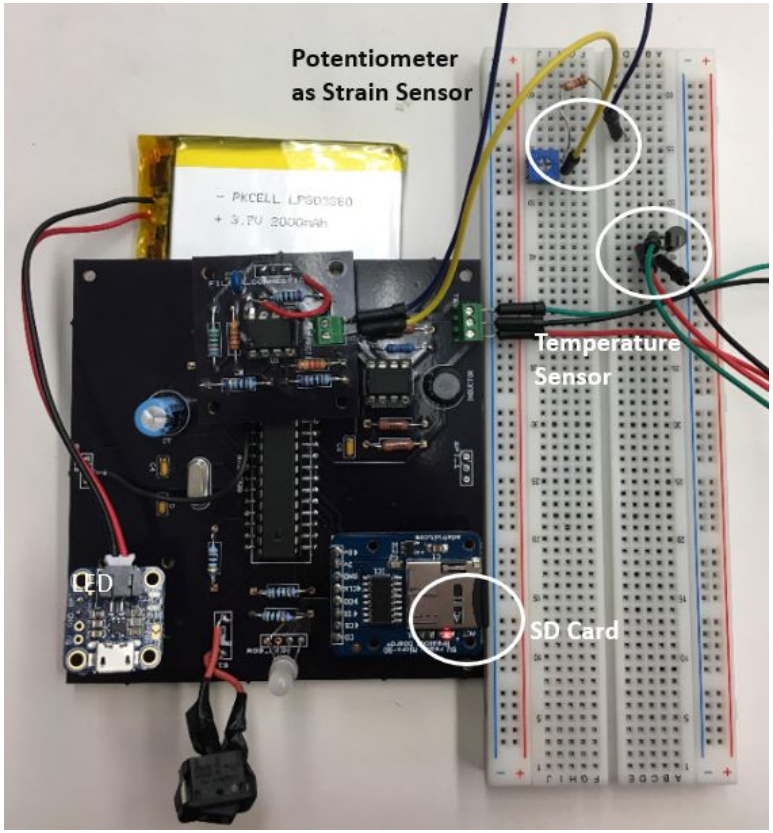
- Sensor testing
- boost converter testing
- filter testing
- website testing
- battery usage testing (full load consumption vs sleep mode consumption)

Testing

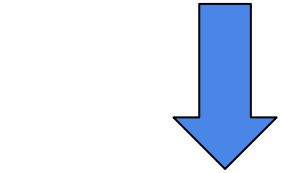
mm (V)	arduino (V)
0.54	0.5322
0.742	0.72265
1.05	1.03
1.2368	1.21
1.5281	1.503
1.7676	1.743
2.0624	2.031
2.2976	2.265
2.541	2.509
2.75	2.797
3.071	3.032
3.255	3.212
3.582	3.544
3.822	3.779
3.966	3.9205
4.27	4.223
4.539	4.487
4.774	4.721

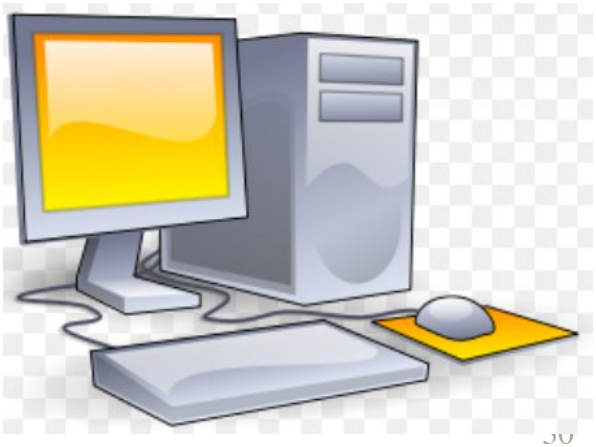


Demo


Potentiometer
as Strain Sensor
Temperature
Sensor
LED
SD Card


Apacer
256MB
Kingston
micro SD
ADAPTER
CHINA



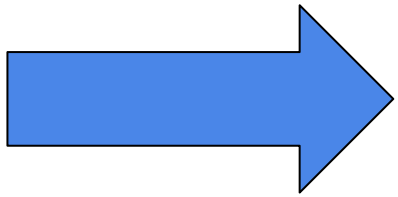


Demo

DATALOG.TXT - Notepad

File Edit Format View Help

```
1212.49 23.01    5:0:24 AM        12/31/2018
1267.06 23.01    5:0:24 AM        12/31/2018
1324.25 23.01    5:0:24 AM        12/31/2018
1382.77 23.01    5:0:24 AM        12/31/2018
1424.55 23.01    5:0:25 AM        12/31/2018
1464.04 23.01    5:0:25 AM        12/31/2018
1497.01 23.01    5:0:25 AM        12/31/2018
1525.80 23.01    5:0:25 AM        12/31/2018
1500.26 23.01    5:0:26 AM        12/31/2018
1454.99 23.01    5:0:26 AM        12/31/2018
1412.05 23.01    5:0:26 AM        12/31/2018
1377.63 23.01    5:0:26 AM        12/31/2018
1361.27 23.01    5:0:27 AM        12/31/2018
1412.05 23.01    5:0:27 AM        12/31/2018
1461.00 23.01    5:0:27 AM        12/31/2018
1503.53 23.01    5:0:27 AM        12/31/2018
1533.89 23.01    5:0:28 AM        12/31/2018
1479.48 23.01    5:0:28 AM        12/31/2018
1430.21 23.01    5:0:28 AM        12/31/2018
1389.27 23.01    5:0:28 AM        12/31/2018
1384.19 23.01    5:0:29 AM        12/31/2018
1461.00 22.52    5:0:29 AM        12/31/2018
1505.17 23.01    5:0:29 AM        12/31/2018
1408.64 23.01    5:0:29 AM        12/31/2018
1390.59 23.01    5:0:30 AM        12/31/2018
1479.48 23.01    5:0:30 AM        12/31/2018
1414.80 23.01    5:0:30 AM        12/31/2018
1378.52 23.01    5:0:30 AM        12/31/2018
1508.47 23.01    5:0:31 AM        12/31/2018
1445.08 23.01    5:0:31 AM        12/31/2018
1308.33 23.01    5:0:31 AM        12/31/2018
1420.35 23.01    5:0:31 AM        12/31/2018
1435.50 23.01    5:0:32 AM        12/31/2018
1382.77 23.01    5:0:32 AM        12/31/2018
1438.67 23.01    5:0:32 AM        12/31/2018
1449.05 23.01    5:0:32 AM        12/31/2018
1449.05 23.01    5:0:33 AM        12/31/2018
1449.05 23.01    5:0:33 AM        12/31/2018
1449.05 23.01    5:0:33 AM        12/31/2018
1449.05 23.01    5:0:33 AM        12/31/2018
1449.05 23.01    5:0:34 AM        12/31/2018
1449.05 23.01    5:0:34 AM        12/31/2018
```



AutoSave Off

File Home Insert Draw Page Layout Formulas

E20

	A	B	C	D	E	F
1						
2	974.17	22.52	5:00:00 AM	12/31/2018		
3	974.17	23.01	5:00:00 AM	12/31/2018		
4	974.17	23.01	5:00:00 AM	12/31/2018		
5	974.17	23.01	5:00:01 AM	12/31/2018		
6	974.17	23.01	5:00:01 AM	12/31/2018		
7	974.17	23.01	5:00:01 AM	12/31/2018		
8	974.17	23.01	5:00:01 AM	12/31/2018		
9	974.17	23.01	5:00:02 AM	12/31/2018		
10	974.17	23.01	5:00:02 AM	12/31/2018		
11	974.17	23.01	5:00:02 AM	12/31/2018		
12	974.17	23.01	5:00:02 AM	12/31/2018		
13	974.17	22.52	5:00:03 AM	12/31/2018		
14	974.17	23.01	5:00:03 AM	12/31/2018		
15	974.17	23.01	5:00:03 AM	12/31/2018		
16	974.17	23.01	5:00:03 AM	12/31/2018		
17	974.17	23.01	5:00:04 AM	12/31/2018		
18	974.17	23.01	5:00:04 AM	12/31/2018		
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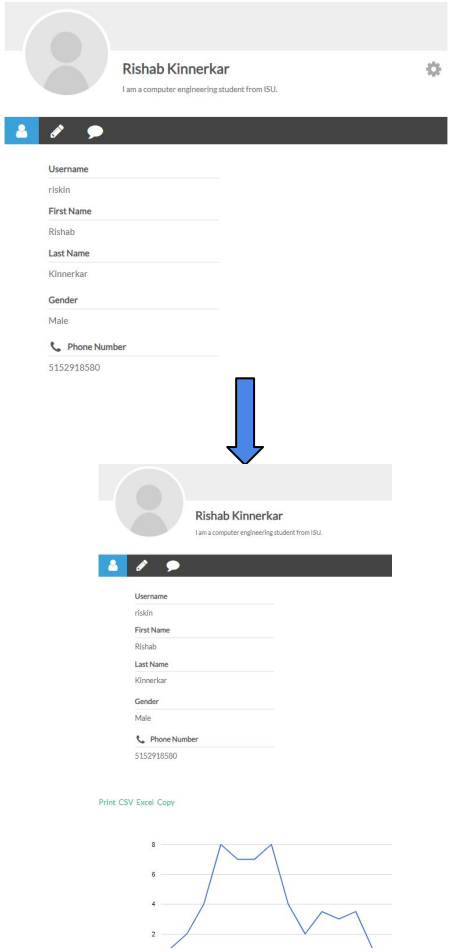
22	974.17	23.01	5:00:05 AM	12/31/2018		
23	974.17	22.52	5:00:05 AM	12/31/2018		
24	974.17	23.01	5:00:05 AM	12/31/2018		
25	974.17	23.01	5:00:06 AM	12/31/2018		
26	974.17	22.52	5:00:06 AM	12/31/2018		
27	974.17	23.01	5:00:06 AM	12/31/2018		
28	974.17	23.01	5:00:06 AM	12/31/2018		
29	974.17	23.01	5:00:07 AM	12/31/2018		
30	974.17	23.01	5:00:07 AM	12/31/2018		
31	974.17	23.01	5:00:07 AM	12/31/2018		
32	974.17	23.01	5:00:07 AM	12/31/2018		
33	974.17	23.01	5:00:08 AM	12/31/2018		
34	974.17	22.52	5:00:08 AM	12/31/2018		

Sheet1

Ready

Demo



- Click on the settings icon and
  - upload CSV
- After the CSV file has been
  - uploaded the graph would
  - be associated with that user
  - profile and would appear as
  - shown below.

Individual Contributions

Yan - Filter Circuit, PCB design, Arduino Code

Rohan - Arduino Code, DAQ Case

Daeyoo - Boost Converter, PCB Design

Rishab - Website

Matt - Temperature Data, Power Management

Conclusion

- Further Improvements for the project
- Challenges
- What we learned

Questions