The Diabetic Breathalyzer

Group 13

Jon Brown	EE
Christine Sleppy	EE
Noah Spenser	EE
Edert Geffrard	EE

Project Motivation

- 29.1 million Americans have diabetes.
- Proper management of this disease requires pricking the finger many times per day.
- The Diabetic Breathalyzer will be a non-invasive ***option*** for daily monitoring.

Project Goals

- The typical breathalyzer we are familiar with takes measurements of ones *blood alcohol concentration.*
- Our long-term goal is to create a breathalyzer that can measure ones *blood glucose concentration.*
- Our short-term goal is to provide an easy and noninvasive way to determine whether ones diabetes is under control.

Breath Analysis

- The majority of breath is made up of nitrogen, oxygen, carbon dioxide, water, and inert gases.
- The rest of the content found in one's breath is a small fraction consisting of thousands of volatile organic compounds (VOC) with concentrations in unit of parts per million (ppm).
- These VOC's provide the link between breath analysis and clinical diagnosis.

Clinical Diagnosis for Diabetes

- Acetone is the VOC that is present in the breath for diabetics.
- If there is an immense amount of acetone found in the breath, the user is in a very unhealthy state.

Acetone/Ketone Relationship

- Ketones are present in diabetics when their body goes into a state where it starts to burn fat for energy instead of glucose.
  - Normally from high blood glucose level
  - Also present in extremely low-carb dieters
- When the user has high blood sugar levels, their ketone levels are also high, and so is the concentration of acetone levels in the breath.

Objectives

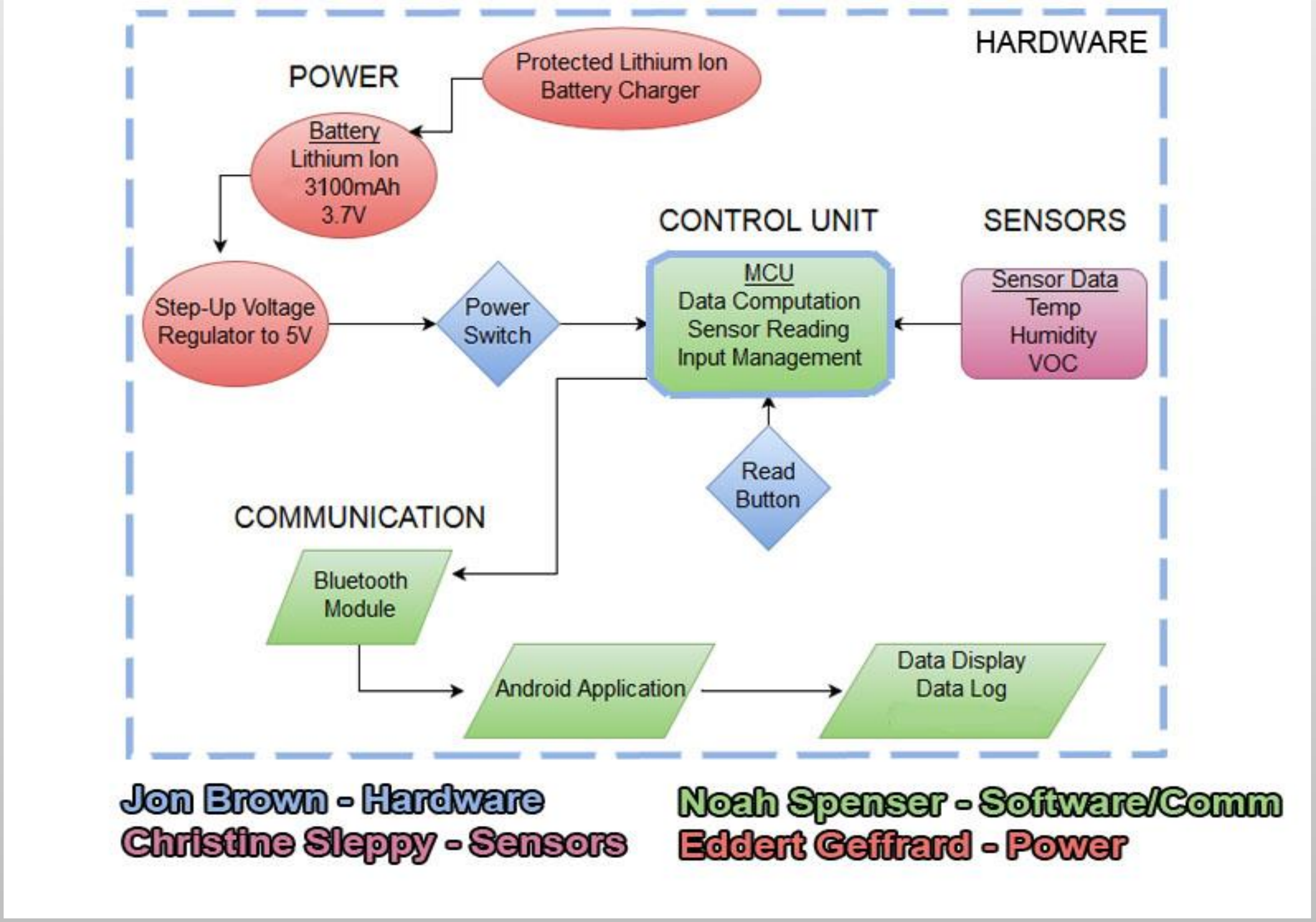
- ✓ **Hand-held design**
  - – Small enough to carry around for daily use
- ✓ **VOC Sensors**
  - – Must be able to detect acetone levels in breath
- ✓ **Status LED**
  - – Displays stability of the sensors
- ✓ **Wireless Communication**
  - – Bluetooth connection to smartphone where the final value will be displayed
- ✓ **Rechargeable Battery**
  - – Must last an entire day before needing a recharge

Specifications

Component	Parameter	Specification
Enclosure	Unit Dimensions	119.4x66x40.6 mm
TGS822 Sensor	High Concentration	50-1000 ppm
	Volts	5 V
WSP2110 Sensor	Low Concentration	1-50 ppm
	Volts	5 V
DHT22 Sensor	Temperature	-40-80° Celsius (+/-0.5°)
	Humidity	0-100% RH (+/- 5%)
	Volts	3.3 V
Bluetooth	Volts	3.3/5 V
	Frequency	2.4GHz
	Range	0-30 meters
Battery	Rechargeable lithium ion polymer	>3100 mAh

PROJECT HARDWARE DESIGN

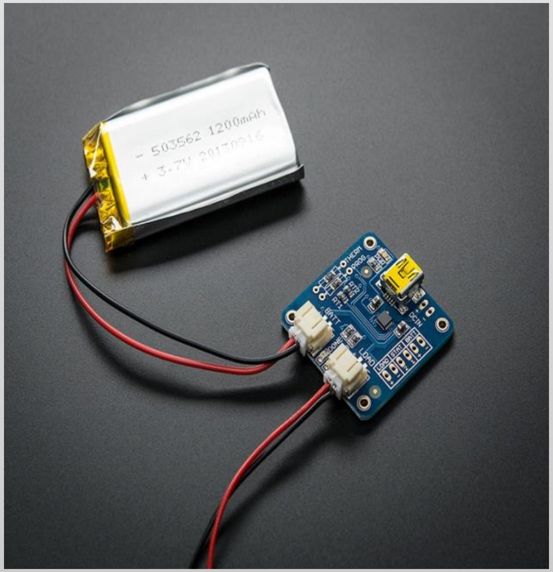
Overall Block Diagram



Power

- Relatively lightweight and portable.
- Rechargeable with the ability to last an entire day (12-14 hours).
- 3100 mAh **lithium ion polymer battery**

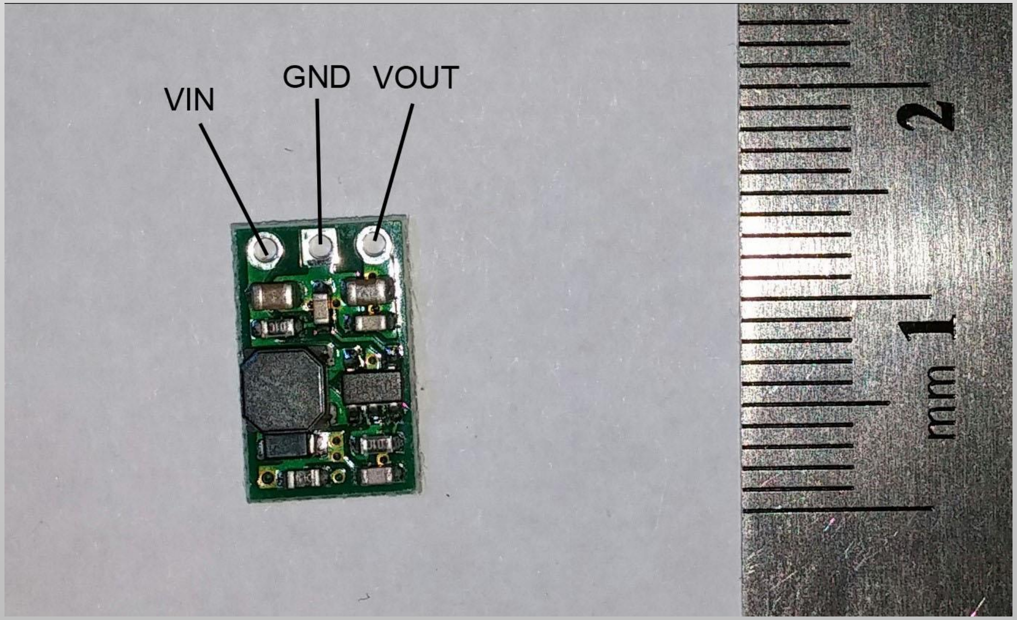
Power Recharge



- Lithium Ion and Lithium Polymer battery charger based on the MCP73833 (shown left).
- USB mini-B for connection to any computer or USB wall adapter.
- Three stages of charging:
  1. Preconditioning charge
  2. Constant-current fast charge
  3. Constant-voltage trickle charge
- Automatic End-of-Charge Control

Step-up Regulator

- Lower efficiency but still >90%
- Space efficient
- Overall costs will decrease

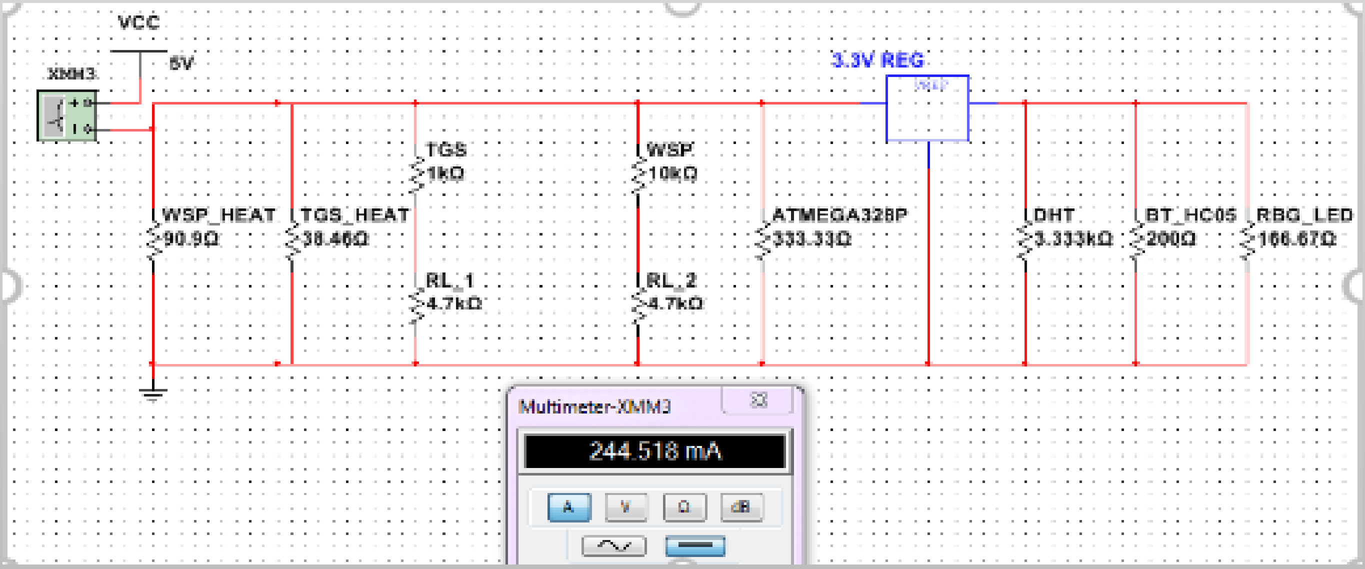


Power

- Once we have the regulated 5V, the use of basic linear regulators is used when 3.3V is required.
- Since the current draw on those 3.3V applications is small, the concern for energy loss is mitigated.
- Device utilizes simple rocker switch to provide power to entire device.

Power

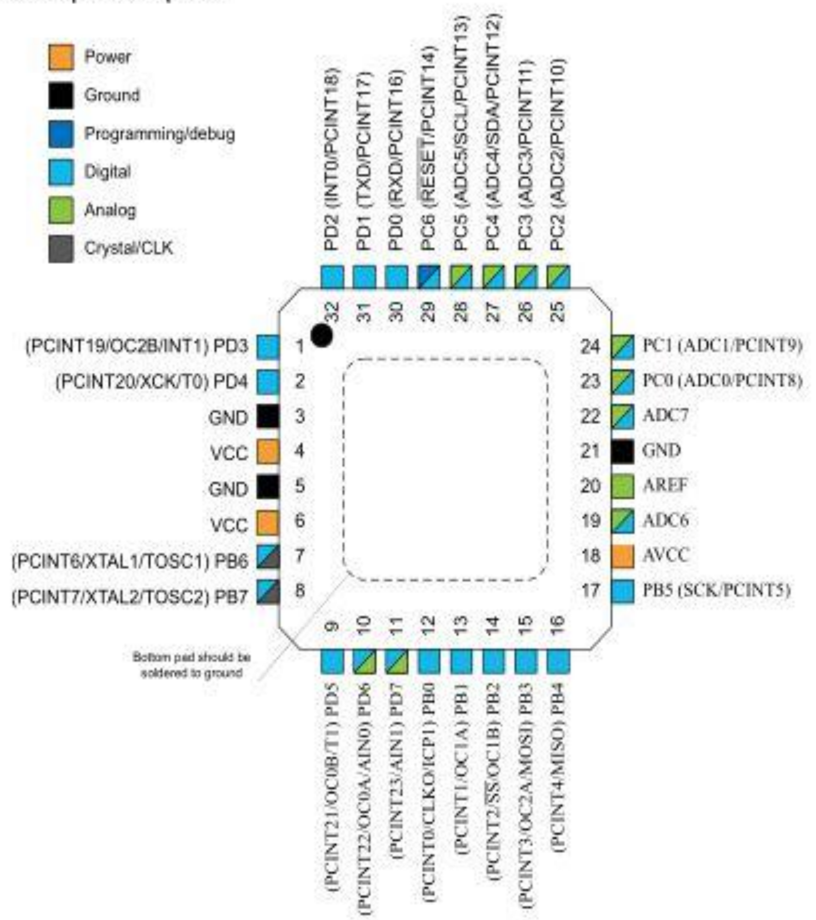
- Overall max current draw is under 250 mA, during peak usage.
- Majority of time, current draw is about 180 mA to just power sensors.



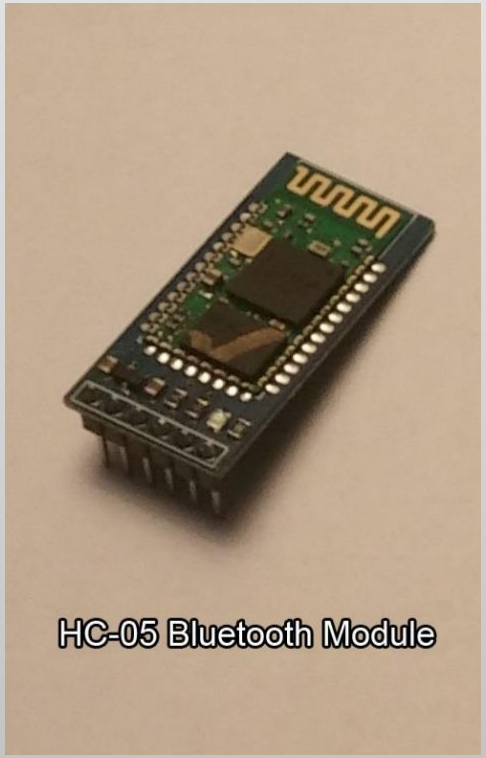
ATMega328p

- Has digital and analog pins, both of which are needed.
- Large enough (32kB) flash memory to store code and any data logged.
- 32-pin MLF package takes up minimal room (~5mmx5mm).
- Easily programmable with Arduino IDE and ISP configuration.

Figure 5-4. 32-pin MLF Top View



Bluetooth Communication



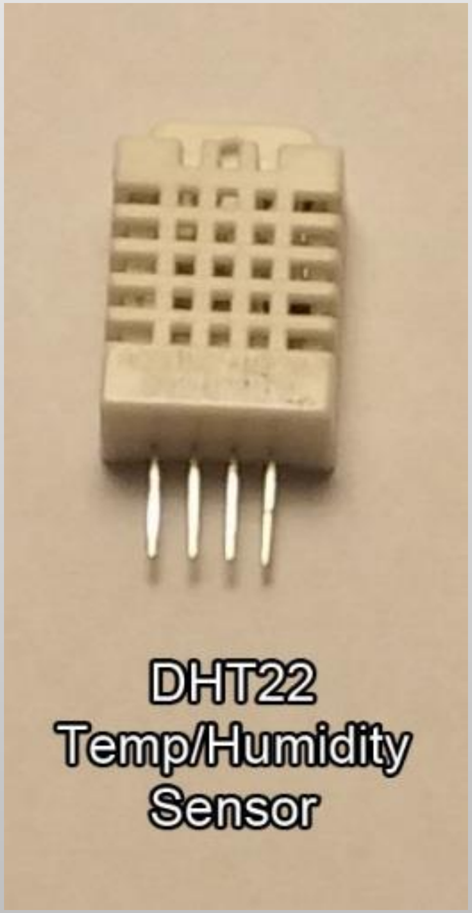
HC-05 BT Module:

- Can run on 3.3V or 5V od DC power.
- Communication over RX and TX serial pins.
- During communication draws up to 40mA of current.
- Can make easy connection to any Bluetooth enabled device.

Temperature/Humidity Sensor

DHT22:

- VOC sensors dependent on current temperature and humidity values.
- Uses digital pin to transmit data.
- Range of -40-80 degrees Celsius.
- Runs on 3.3V and draws minimal current. (<1mA)
- Functions properly in high humidity.



VOC Sensors

<u>TGS822:</u>

- High concentration sensor.
- 50-1000 ppm detection range.
- ~600mA current draw at 5V.
- Uses voltage divider circuit on PCB to monitor resistance change.

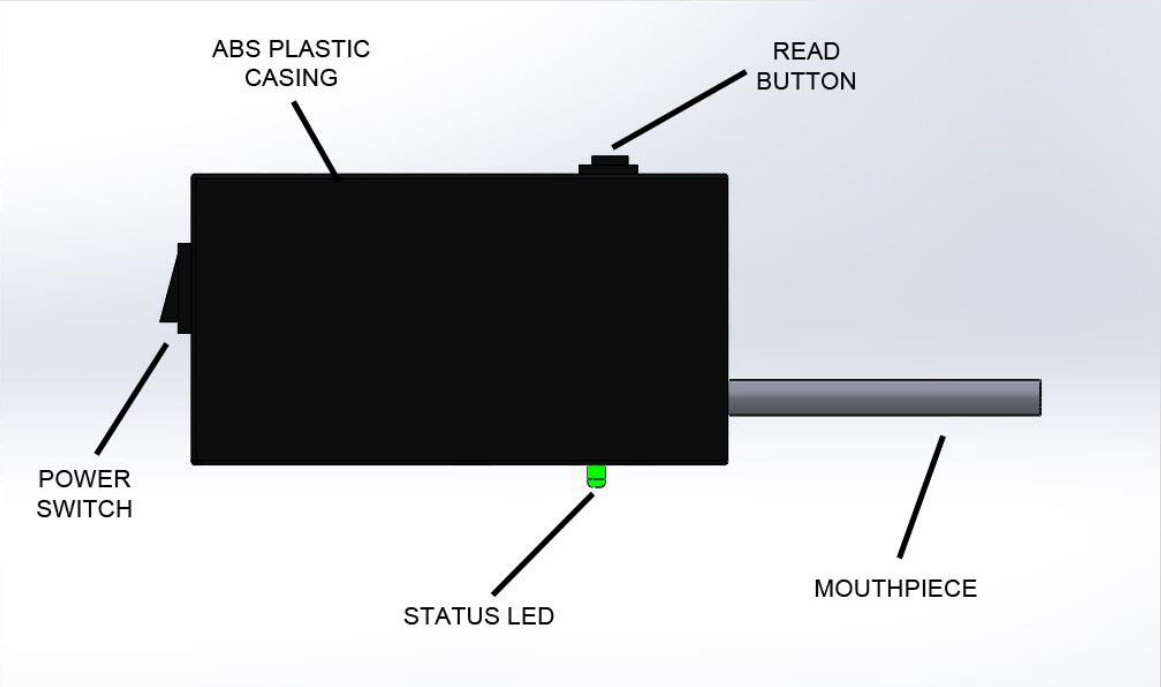
VOC Sensors

WSP2110:

- Low concentration sensor.
- 1-50 ppm detection range.
- ~300mA current draw at 5V.
- Uses built in voltage divider on module with adjustable potentiometer.

WSP2110 VOC Sensor w/ Potentiometer

Physical Design



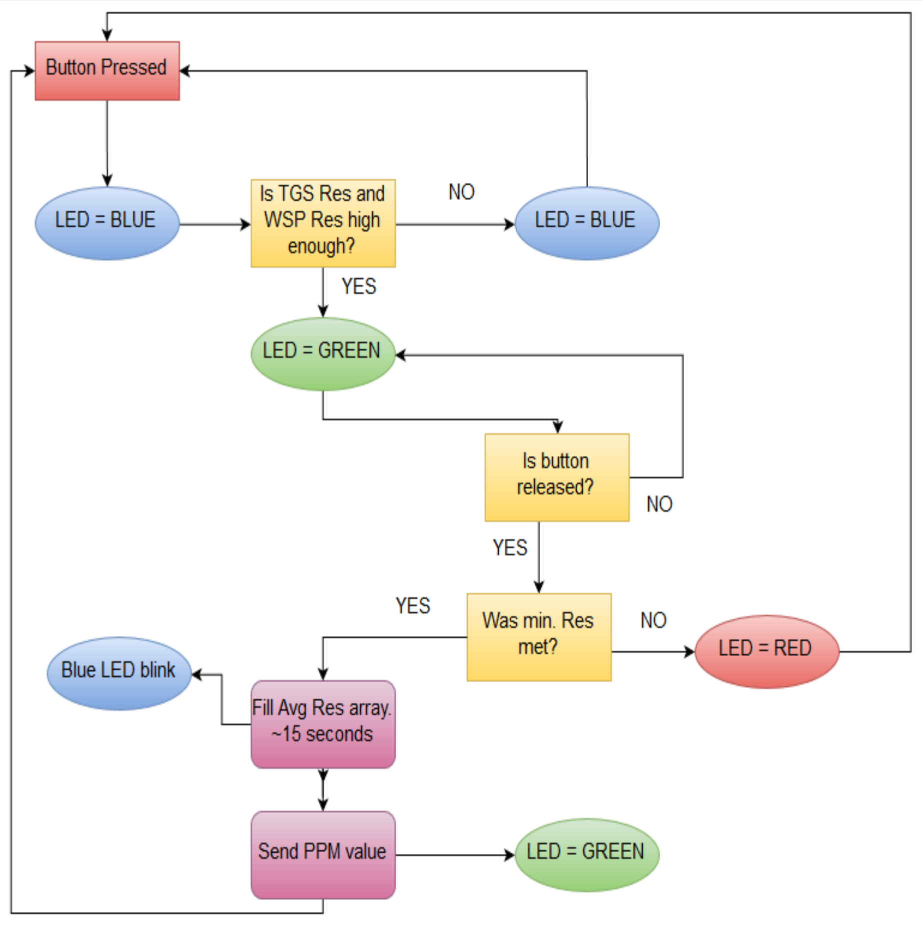
Dimensions: 119.4mm x 66.0mm x 40.6mm

Material: Heavy Duty Plastic Box (air tight)

Components: Push button, rocker switch, tri-color LED, and mouth piece

PROJECT SOFTWARE DESIGN

Device/Input Code



- Using Arduino IDE and writing in C
- Utilizes push button to check stability and read sensor values.
- Tri-color LED shows device status.

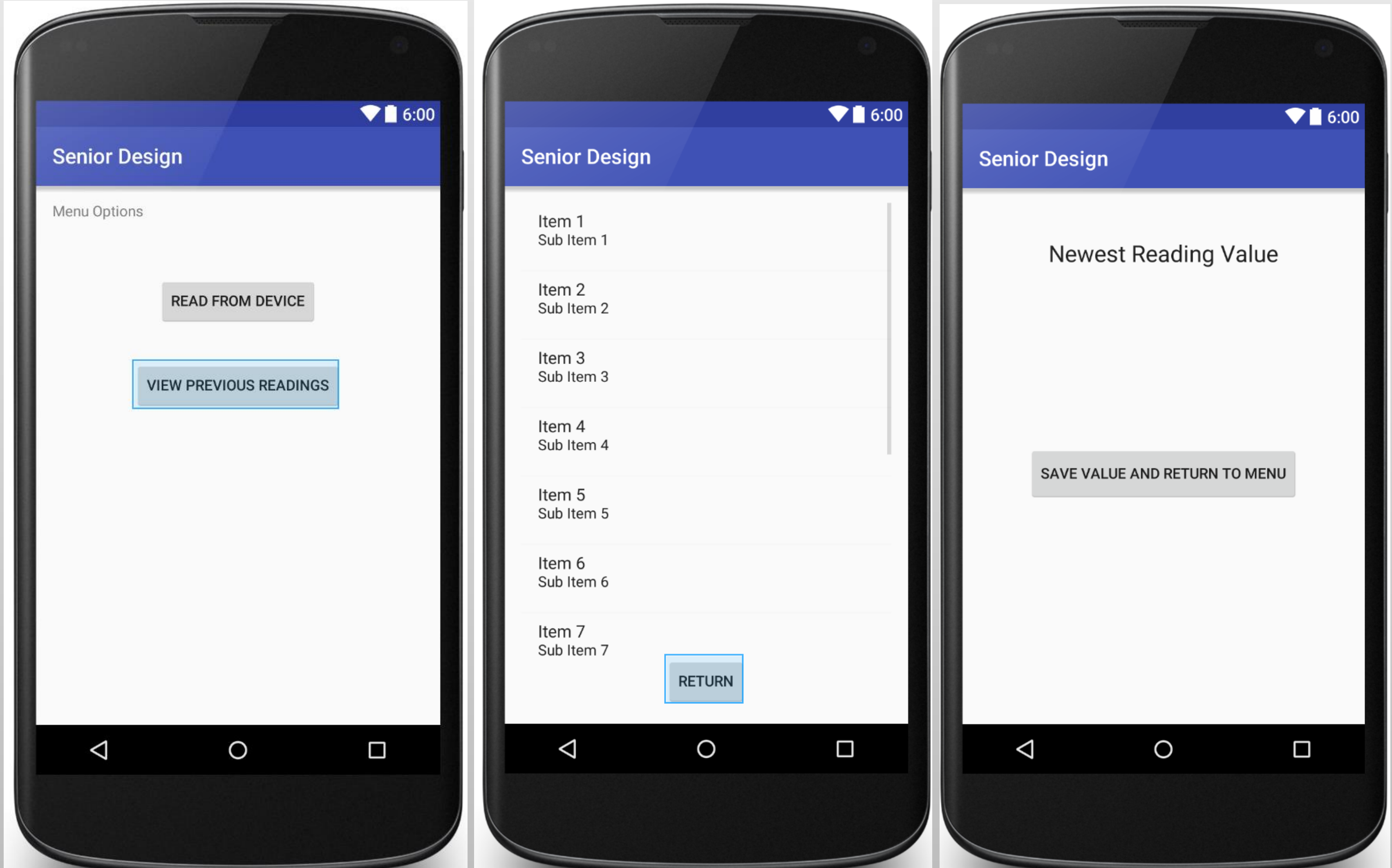
Phone Application Code Plan
Basic Requirements

- Receive values and display them to the user
- Store readings and display previous readings to user on demand
- Handle errors and bad communication
- Handle any necessary data management
- Remain open-ended and rapidly testable as project moves forward
- Have potential for easily transferrable and usable data based on changing device parameters

Phone Application Code Plan Expansion/Refinement

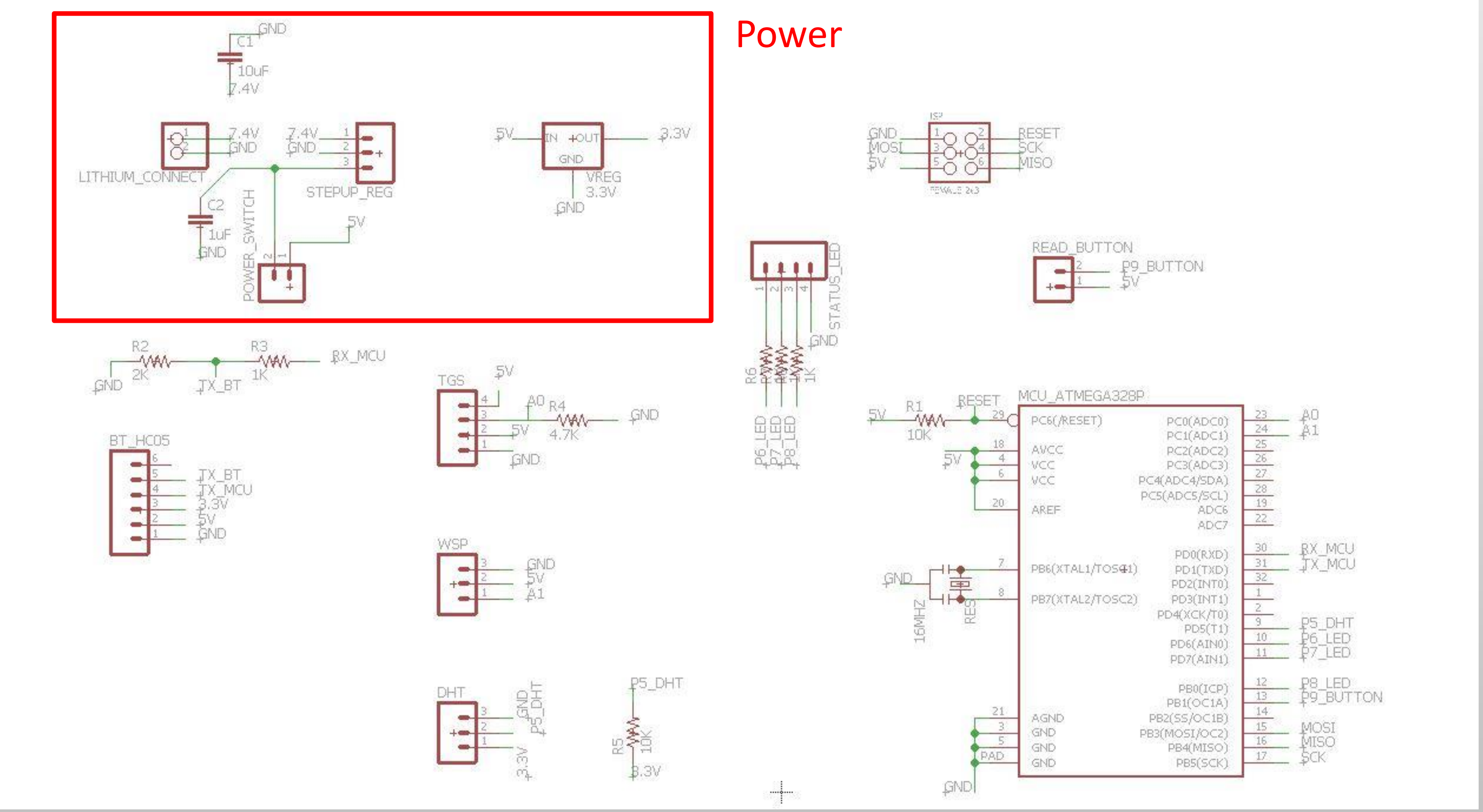
- Potential to convert readings into glucose values
- Save values in easily transferrable/manageable fashion; potential online expansion/merging with physician status
- Multiple device support and security features as well as setting and user profile management

Phone Application Code Pictures

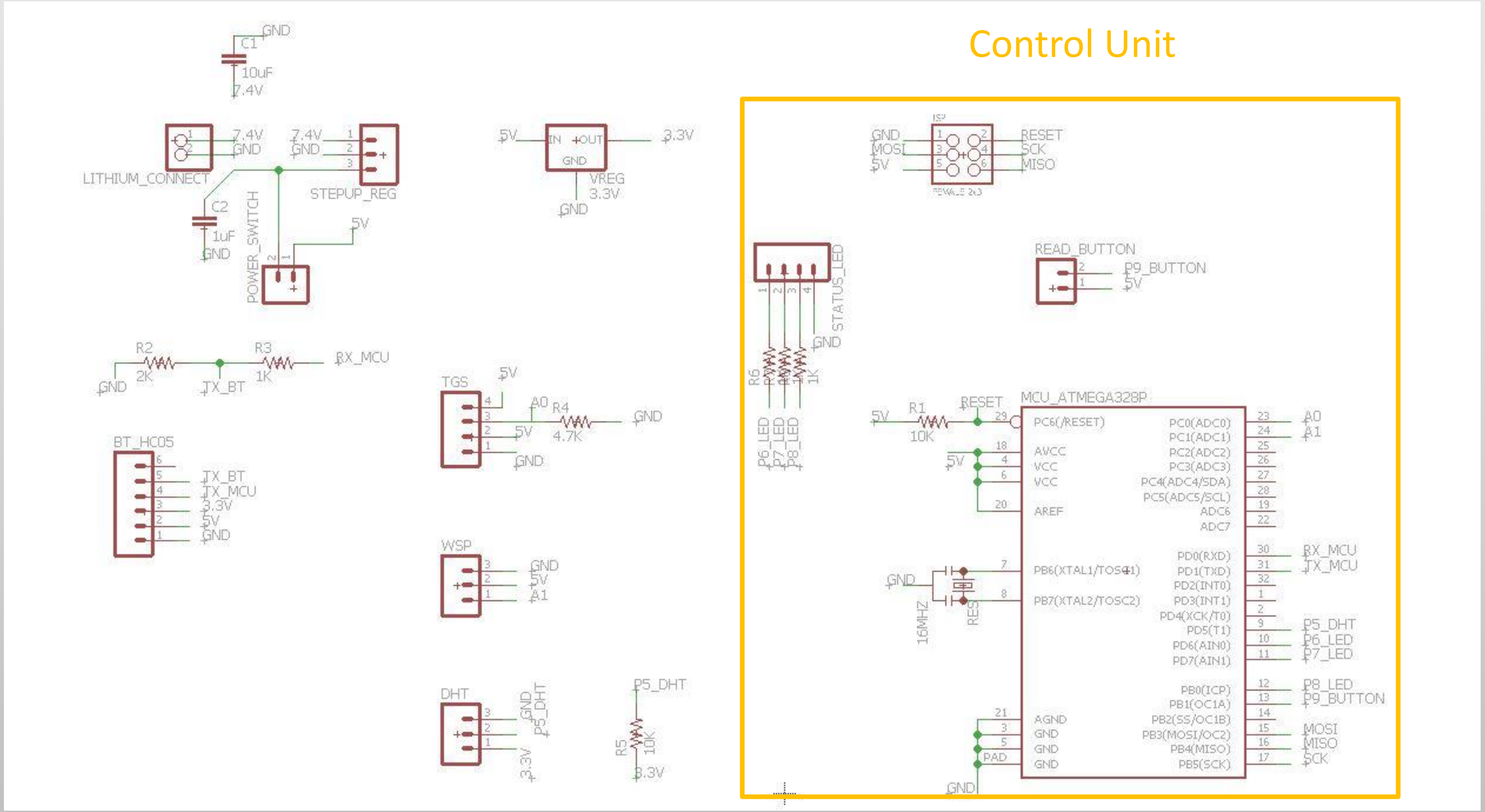


PCB CONSTRUCTION

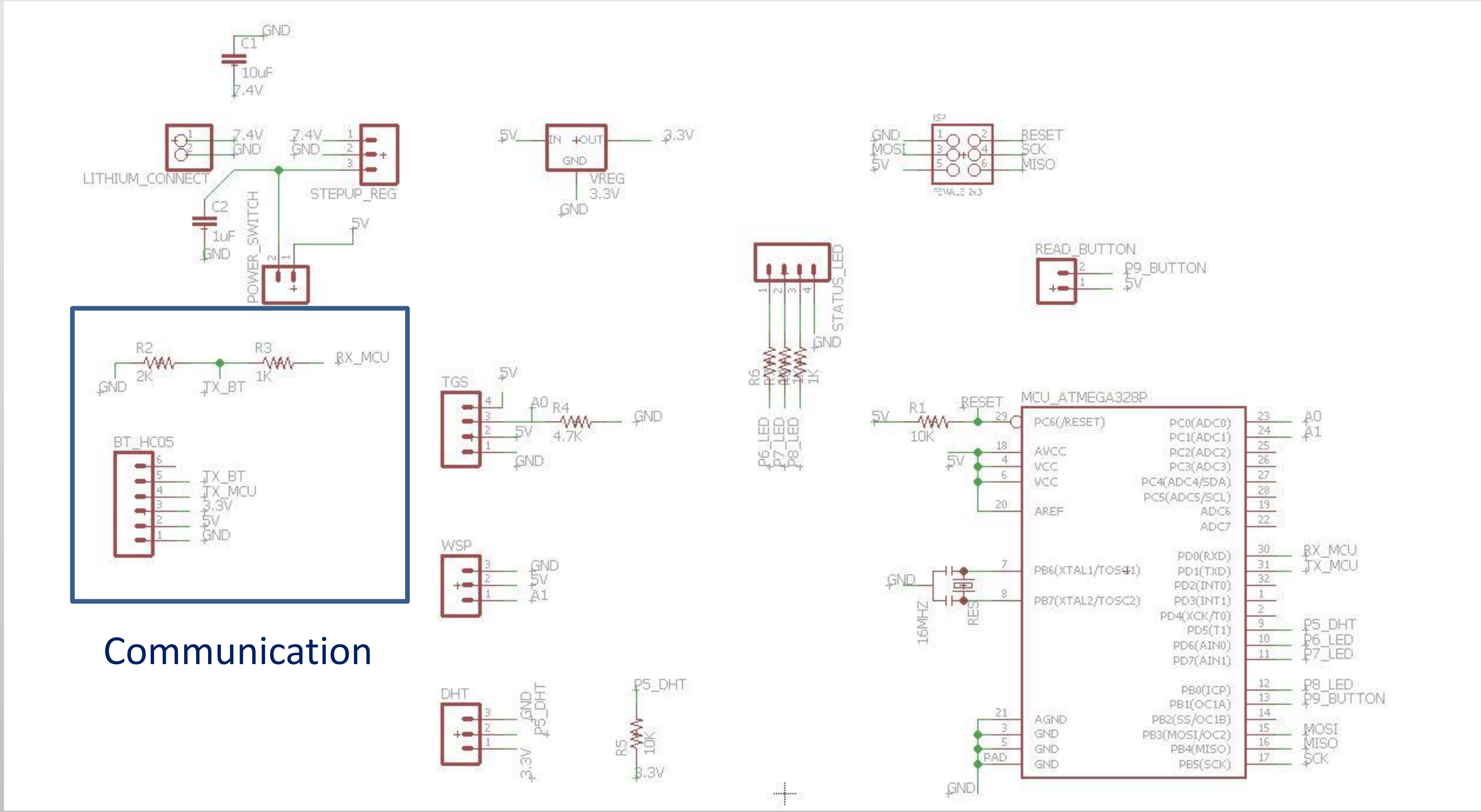
PCB Design-Schematic



PCB Design-Schematic

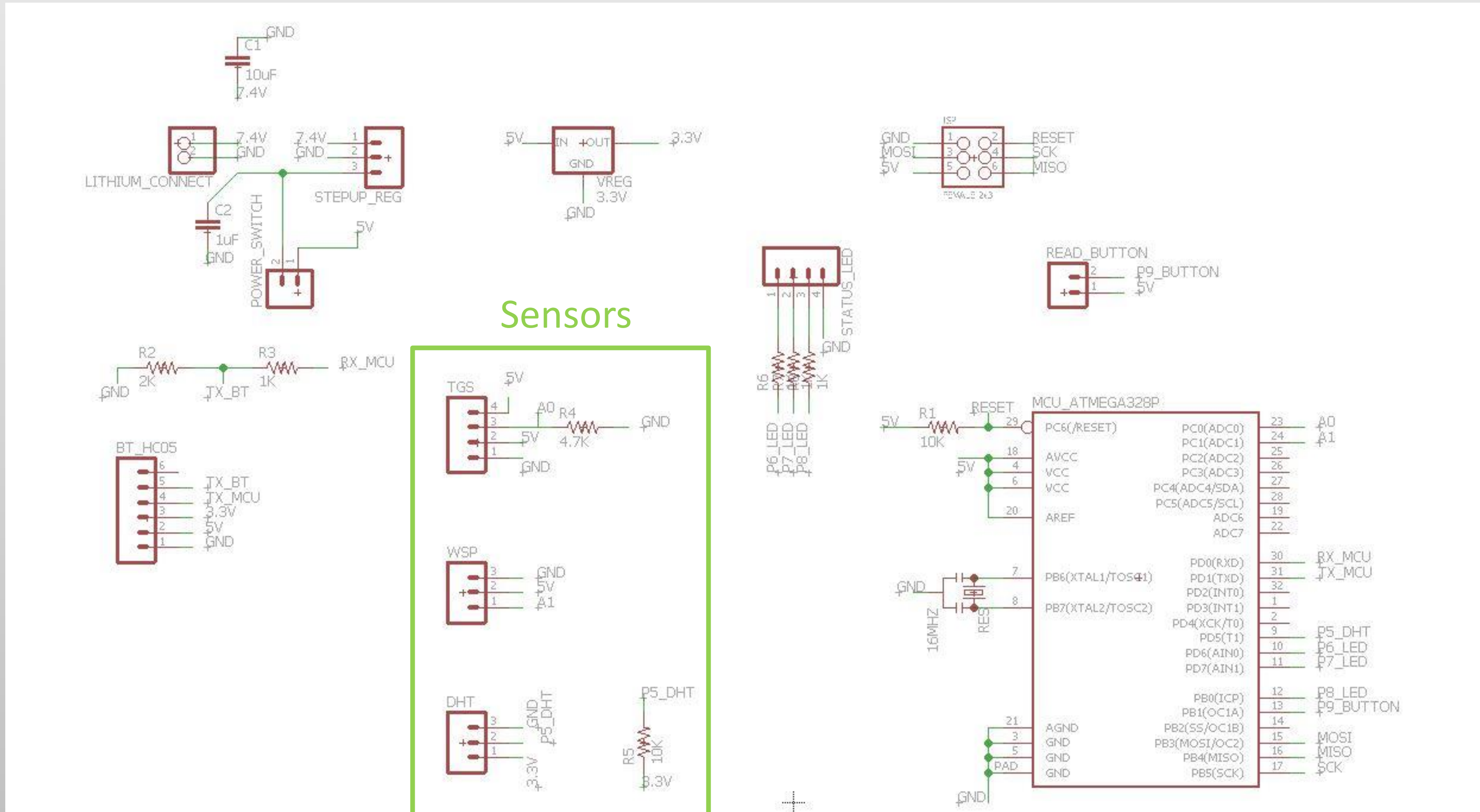


PCB Design-Schematic

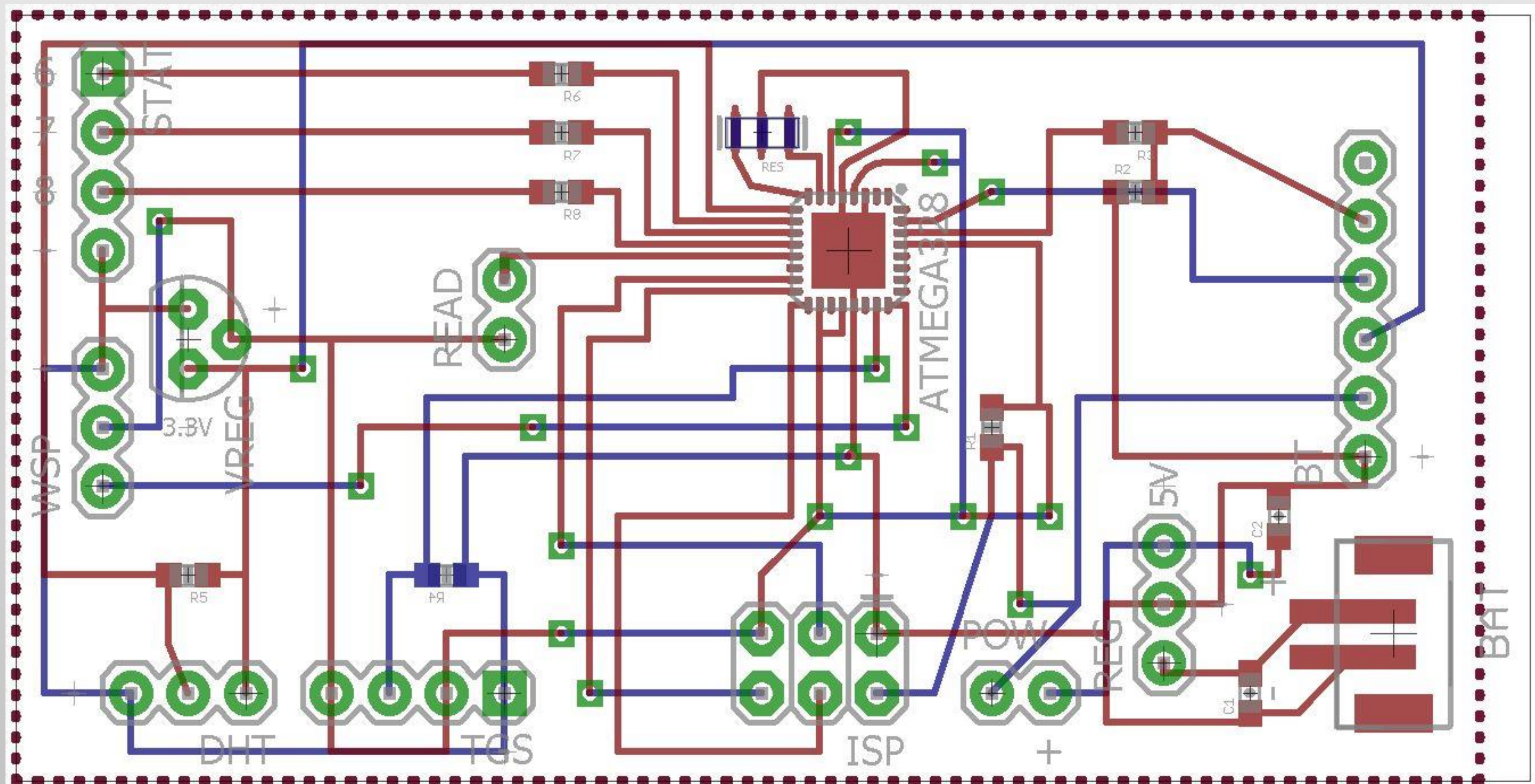


Communication

PCB Design-Schematic

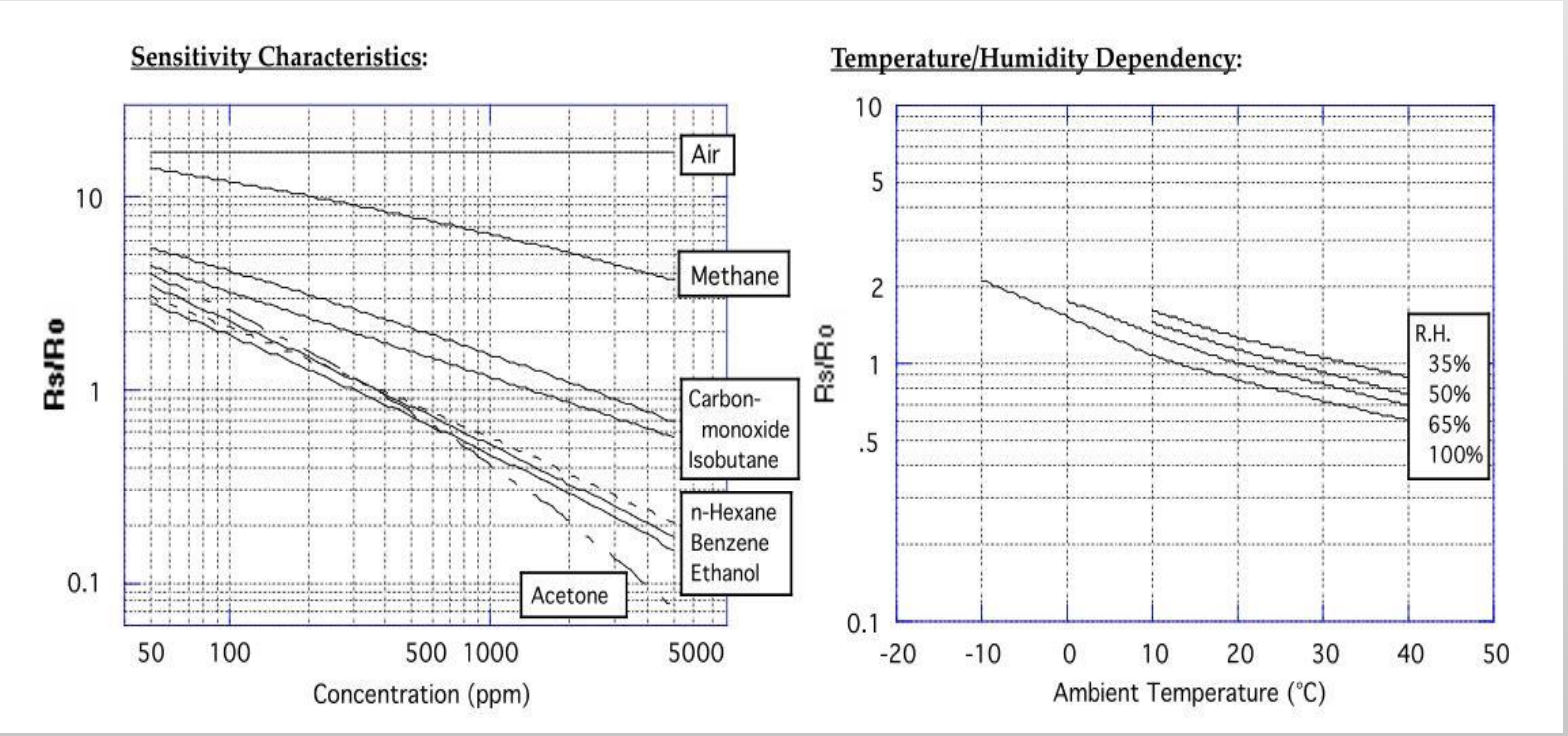


PCB Design-Board



Prototype Testing

Concentration Relationship



TGS822 VOC Sensor

Concentration Relationship

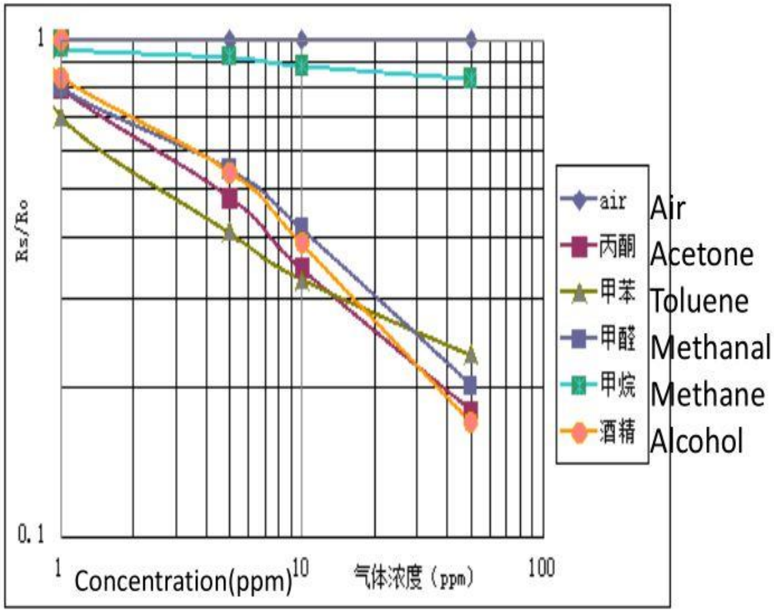


Fig3.Typical Sensitivity Curve

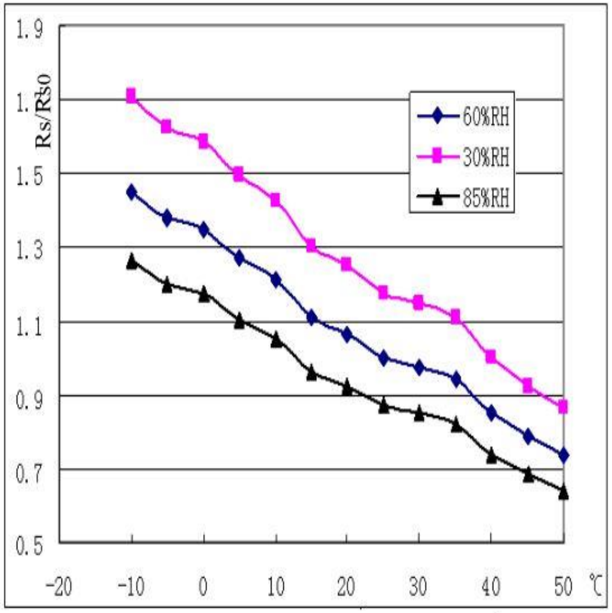
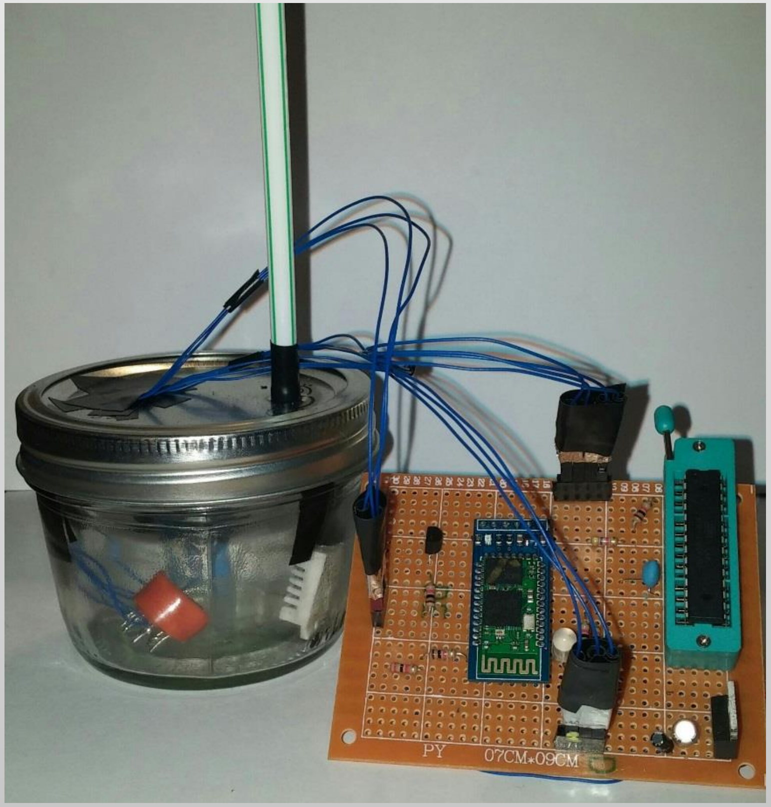
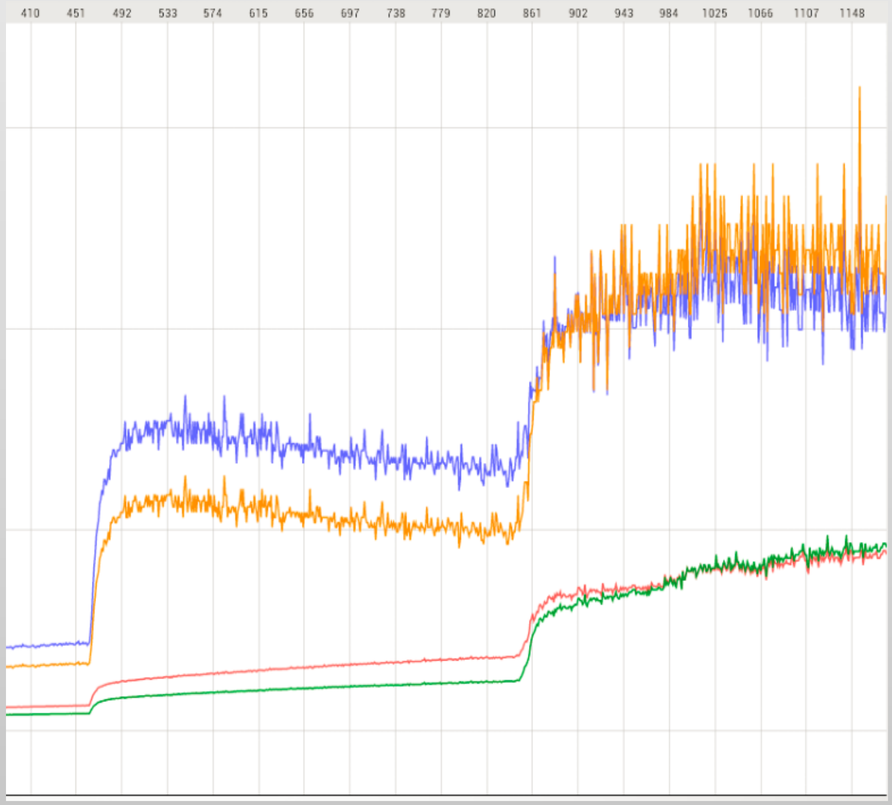


Fig4.Typical temperature/humiditycharacteristics

WSP2110 VOC Sensor

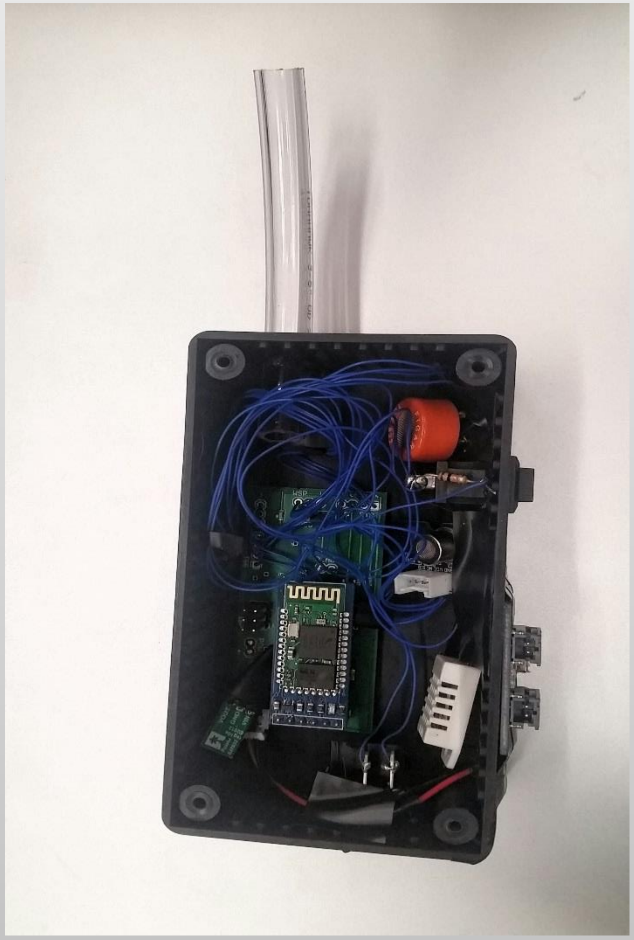
Prototype Testing Procedure

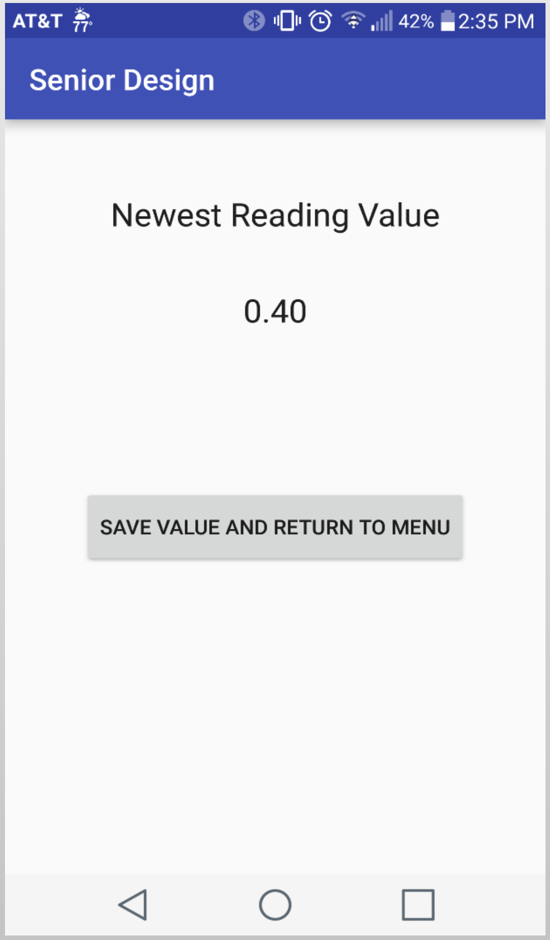




Testing set up and real-time response

Device Testing Procedure





Device Interior and App Readout

Healthy Experimental Results

- ✓ Breathalyzer readings correspond to the ketone urine test.

	Urine Ketone Level	Breathalyzer acetone PPM	Notes
User 1	5-Trace	1.75	No diet changes
User 2	5-Trace	1	
User 1	15-Small	8.7	After a week of low carb dieting
User 2	10-Trace	6.2	

(Readings vary from person to person)

Diabetic Experimental Results

- ✓ Breathalyzer readings still correspond to the ketone urine test.
- ✓ Expected the difference between healthy and diabetic results to be more drastic.

	Urine Ketone Level	**Breathalyzer Acetone PPM**	**Notes**
User 1	5-Trace	1.2	No diet change
User 2	5-Trace	0.8	Small breath
User 1	15-Small	5	After drinking a soda
User 2	15-Small	8.83	Larger breath

Project Budget

Item	Cost
Switch	$10.45
Button	
Step up regulator	$15.90
PCB Fabrication	$132
PCB Assembly	$184
Box	$12.35
Charger	$23.34
Battery	$19.58
TGS VOC Sensor	$9.20
WSP VOC Sensor	$16.80
DHT22 T/H Sensor	$3.90
HC05 BT Radio	$4.40
Total Production Cost	**$431.92**

Work Distribution

	PCB Design	Software	Sensor Management	Power Management
Jon Brown	Primary	Secondary		
Christine Sleppy	Secondary		Primary	Secondary
Noah Spenser	Secondary	Primary		
Edert Geffrard	Secondary		Secondary	Primary

Project Difficulties

- Our project is based upon ideas that are still under extensive research.
  - We do not have access to the resources that make for more accurate results.
- Relating the acetone concentration found in the breath to the exact corresponding blood glucose concentration is not attainable with the given resources.
- The VOC sensors are sensitive to open air causing varied baseline resistances, making it difficult to keep the results consistent.
- All four group members are EE.

Project Successes

- ✓ Our device works to give the user a range of healthy versus unhealthy values using the Acetone-Ketone relationship.
  - A diabetic user can infer their approximate blood glucose level and health status from this range.
  - This provides a noninvasive option for diabetic health management.
- ✓ Sensors detect acetone in the breath.
- ✓ Bluetooth is communicating between devices and sends a value to the smartphone.
- ✓ Able to show the correlation between resistance and concentration.
- ✓ Low cost, low power, battery efficient, and hand-held.

QUESTIONS?

Demo 1

- Our first demonstration will show how our device intakes breath from a normal healthy person.
  - Determines value in ppm (a healthy result)
  - Sends value to phone via Bluetooth
  - Displays value on phone app

Demo 2

- Our second demonstration will show how our device intakes acetone heavy air.
  - Mimics an unhealthy person with high acetone levels in their breath
  - Shows the difference in value from Demo 1 (an unhealthy result)
  - Sends value to phone via Bluetooth
  - Displays value on phone app