The Diabetic Breathalyzer

Group 13

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Project Motivation

- 29.1 million Americans have diabetes
- Proper management of this disease requires picking the finger many times per day
- The Diabetic Breathalyzer will be a noninvasive option

Project Goals

- The typical breathalyzer we are familiar with takes measurements of ones *blood alcohol concentration*

- Our goal is to create a breathalyzer that can measure ones *blood glucose concentration*

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 ppm (parts per million)
- These VOC’s provide the link between breath analysis and clinical diagnosis

Objectives

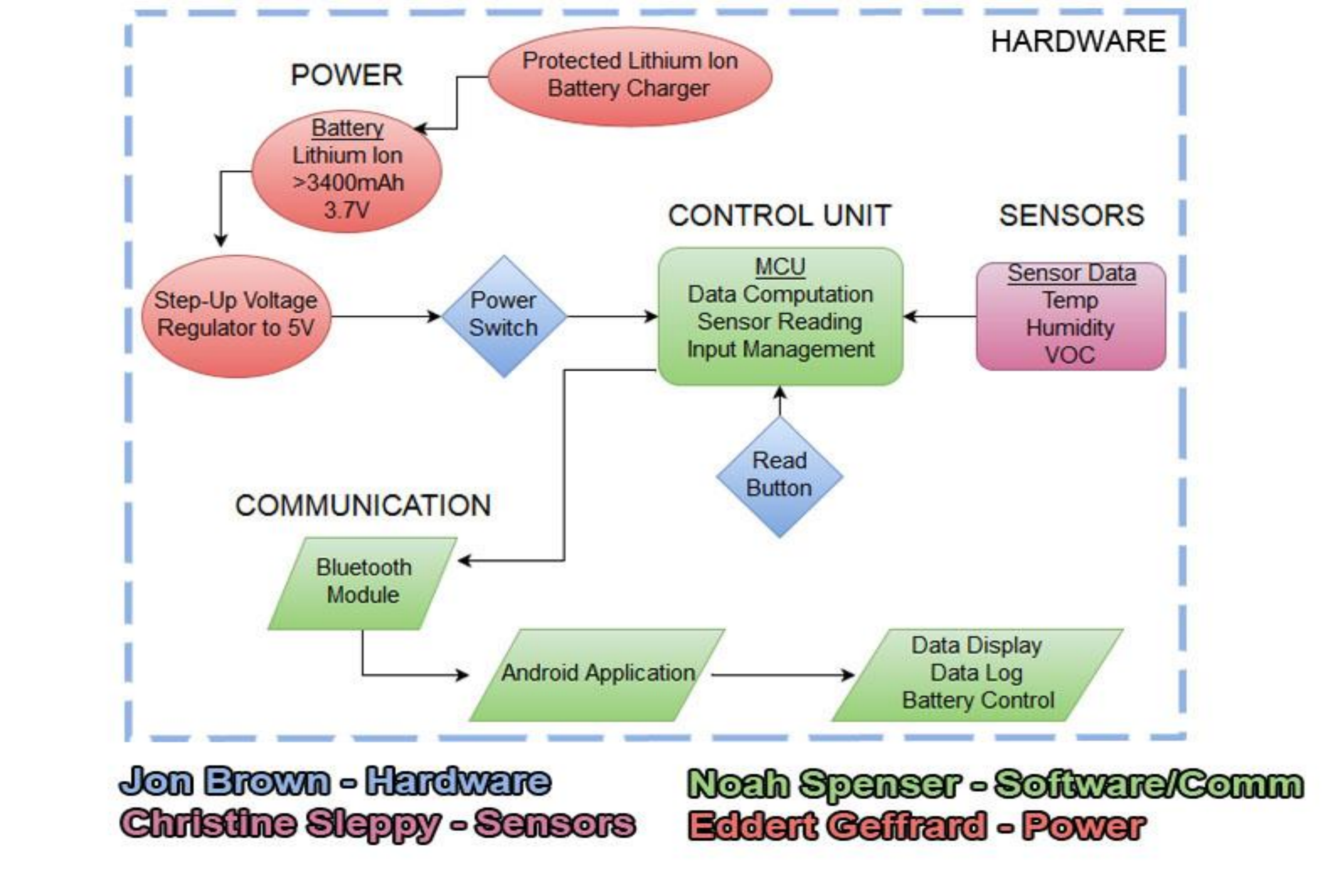
1. Hand-held design
2. Accurate VOC Sensor
3. Status LED
4. Wireless Communication
5. Rechargeable Battery

Specifications

Component	Parameter	Specification
Enclosure	Unit Dimensions	140x80x30 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	>3400 mAh

PROJECT HARDWARE DESIGN

Overall Block Diagram



Power

- Our device must be relatively lightweight
- It must be portable
- The battery must be rechargeable with the ability to last an entire day
- These requirements create a specific need for the type of power system our device has
- Goes along the lines of standard use for a cell phone type device

Power

- Lithium ion batteries come in increments of 3.7 V for each cell
- The sensor heaters run on 5V
- DC to DC step up Vpack
- These can be built by hand on the PCB with various components

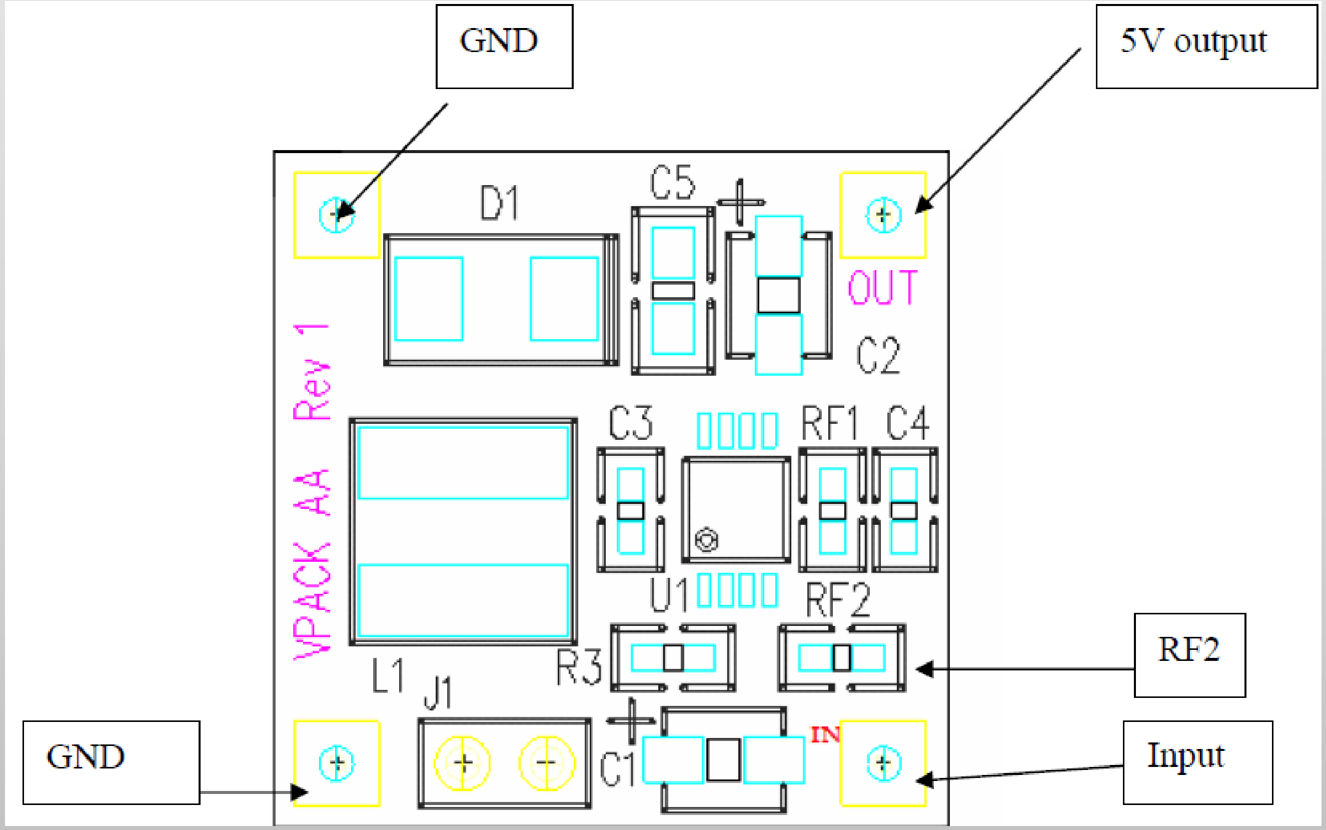
Step-up vs. Step-down

Step-up	Step-down
Lower efficiency with respect to the step-down regulator, but still >90%	Higher efficiency for the step down regulator over the step up.
More space efficient for the component and with being able to use a single cell battery instead of two.	Component itself is larger and would require 2 cells to power.
Overall costs will be lower since we only have to use a single cell.	Overall costs would be higher having to use multiple cells to reach the needed voltage.

Power

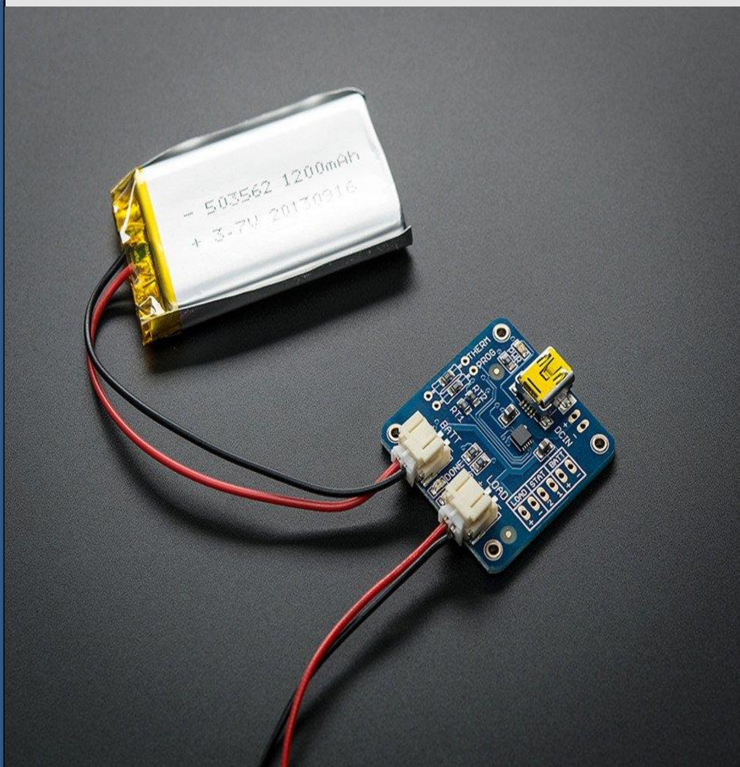
- Simple 5V power source from Bodhilabs
- This PCB uses a source of 1.1V to 4.5V and generates 5V using a DC to DC step up circuit
- Perfect for all those 5V applications that need to be small
- Run on less than 300mA from a variety of power cells

Power



GND
5V output
D1
C5
OUT
C2
Rev 1
VPACK AA
C3
RF1
C4
U1
RF2
R3
L1
J1
C1
IN
RF2
GND
Input

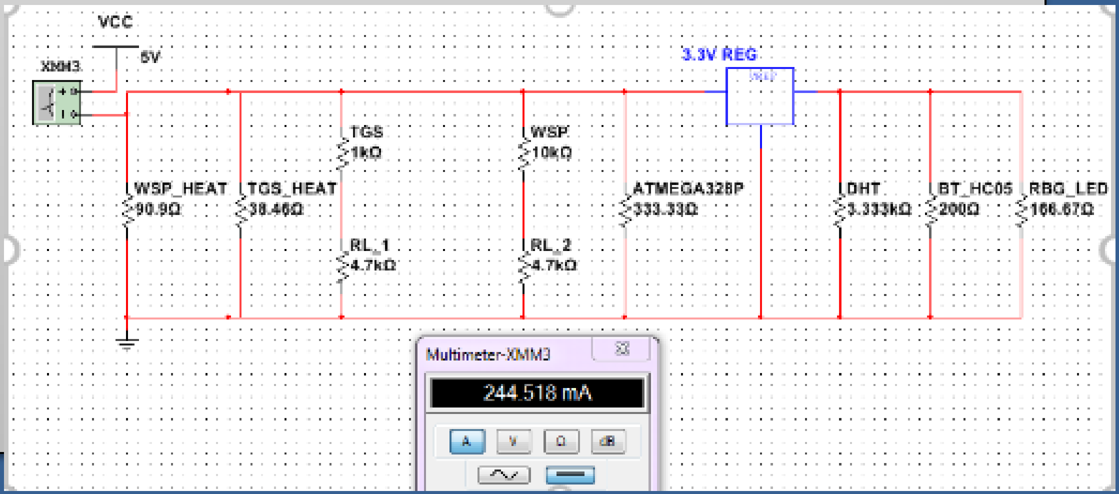
Power Recharge



- This is a Lithium Ion and Lithium Polymer battery charger based on the MCP73833.
- Uses a USB mini-B for connection to any computer or 'USB wall adapter'.
- Three stages of charging: first a preconditioning charge, then a constant-current fast charge and finally, constant-voltage trickle charge.
- Automatic End-of-Charge Control

Current Draw

- Once we have the regulated 5V, the use of basic linear regulators can be used when 3.3V is required. With lower current demand, it is sufficient.
- Overall estimated current draw is about 250mA.



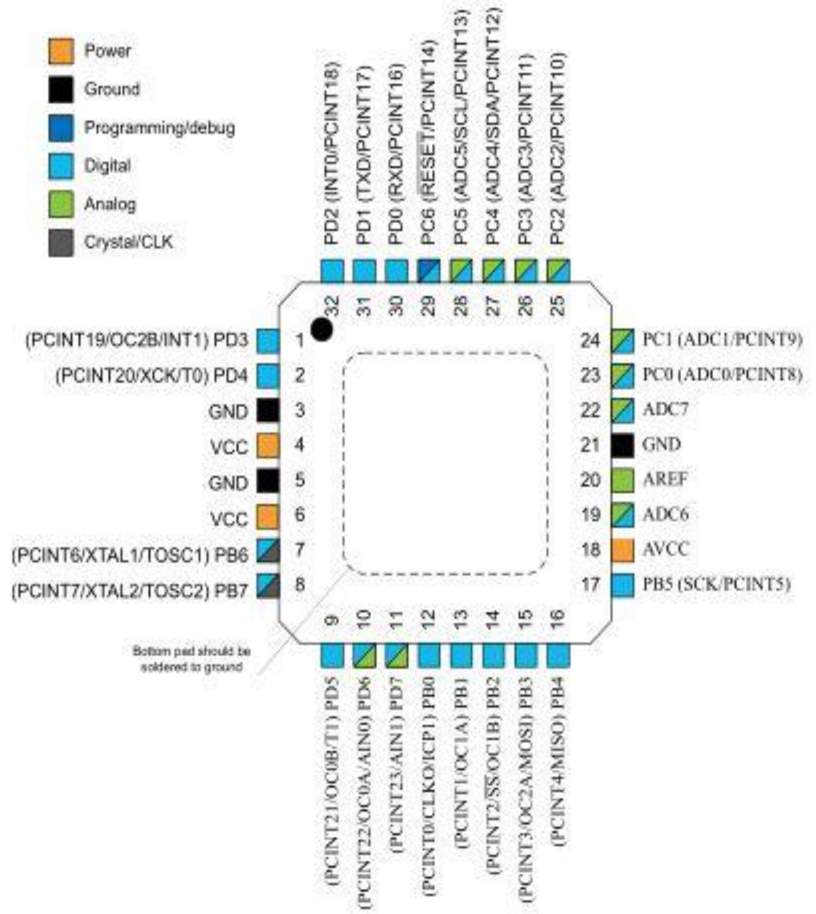
Control Unit

	ATtiny85	ATMega328p	ATSAMB11
Cost ($)	0.77	1.80	9.81
Flash (kB)	8	32	256
Pin Count	8	32	58
Max I/O Pins	6	23	30
Built-in Bluetooth Support	No	No	Yes

ATMega328p

- Has digital and analog pins, both of which 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



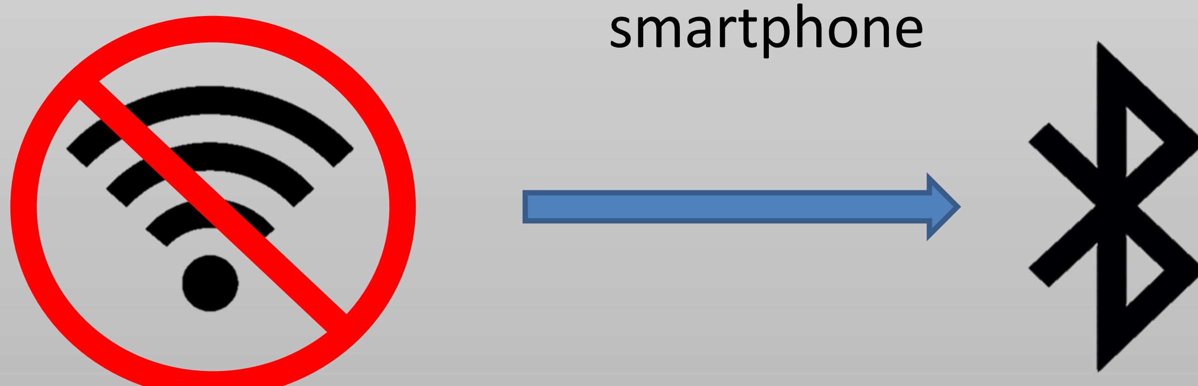
WiFi vs. Bluetooth

WiFi

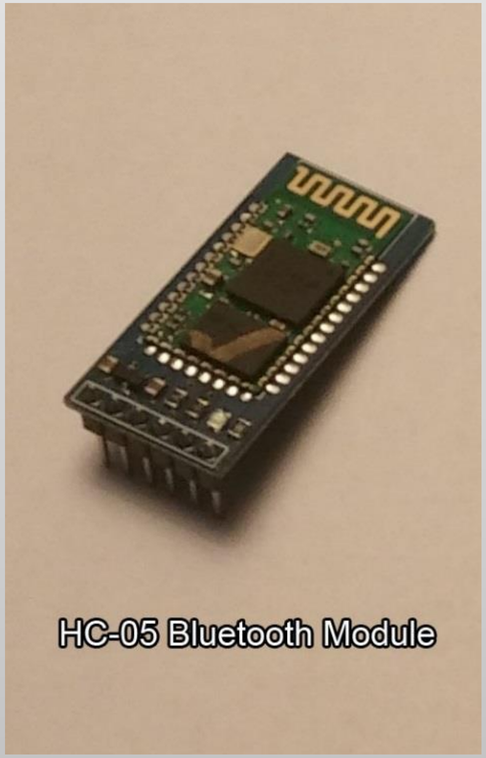
- High power consumption
- Distance between devices ranges up to 100 meters
- Designed to connect devices to a network
- Readily available in many areas

Bluetooth

- Consumes less power
- Distance between devices ranges up to 30 meters
- Designed for devices to interact with each other
- Bluetooth is on every smartphone



Communication



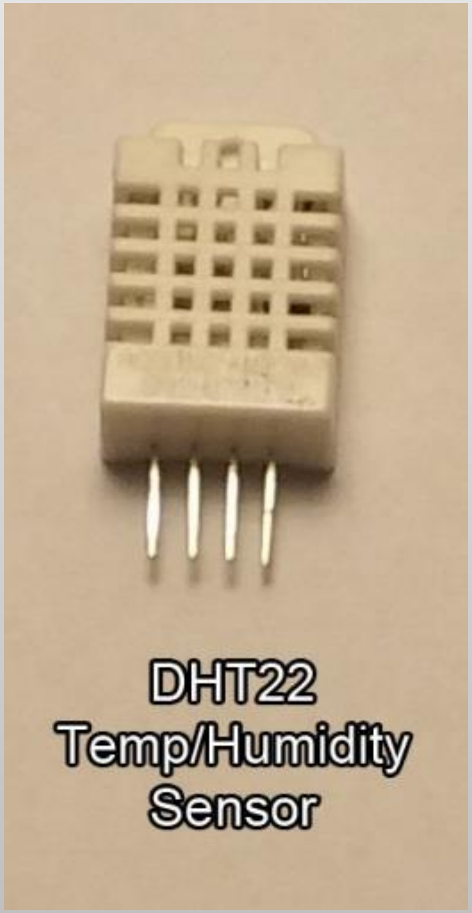
HC-05 BT Module:

- 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

<u>DHT22:</u>

- 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>

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

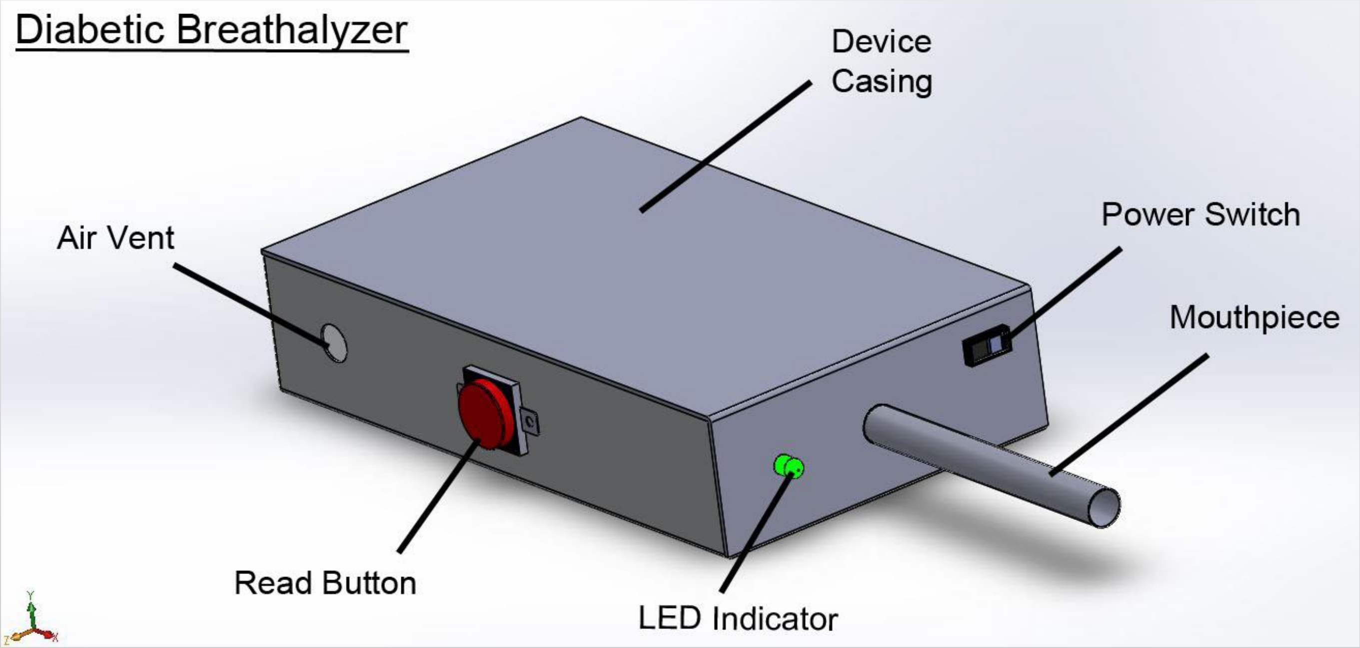
TGS822 VOC Sensor

<u>WSP2110:</u>

- 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: 140mm x 80mm x 40mm

Material: Heavy Duty Plastic Box (air tight)

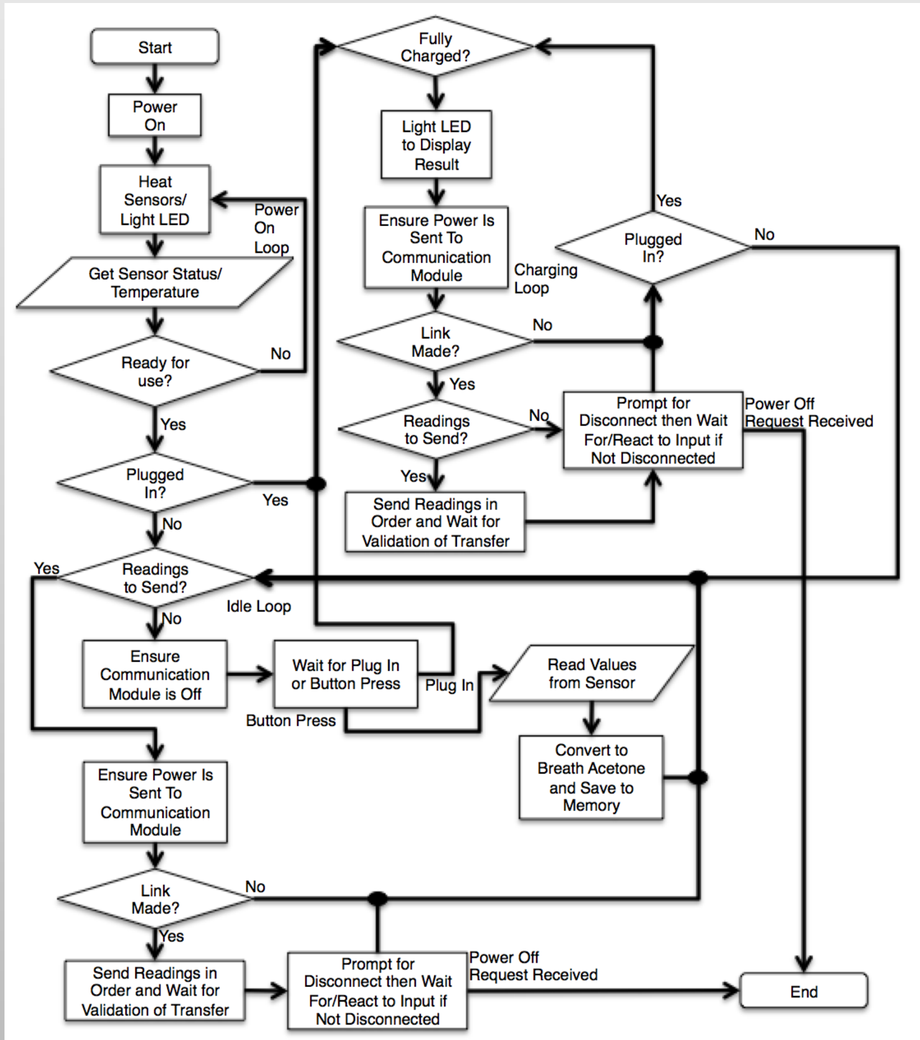
Components: Push button, slide switch, tri-color LED, and mouth piece

PROJECT SOFTWARE DESIGN

Code Block Layout

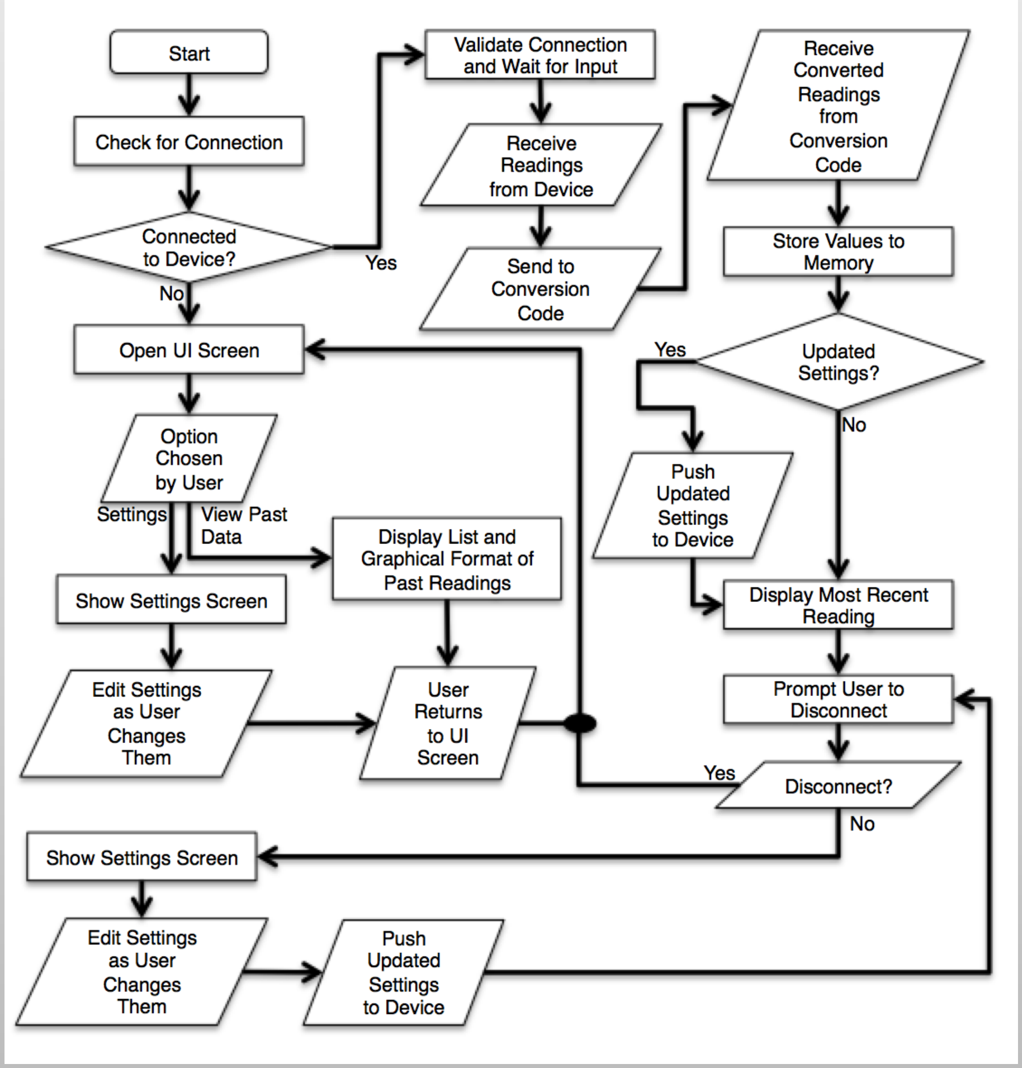
- The code was organized into three major blocks
  - Arduino Device Code
  - Android Application Framework
  - Sensor Calibration Code
- The Application Framework and Device Code are the basics required for the device to function passably
- The Sensor Calibration is the result of testing and experimentation on the functionality of the device’s concept

Device/Input Code



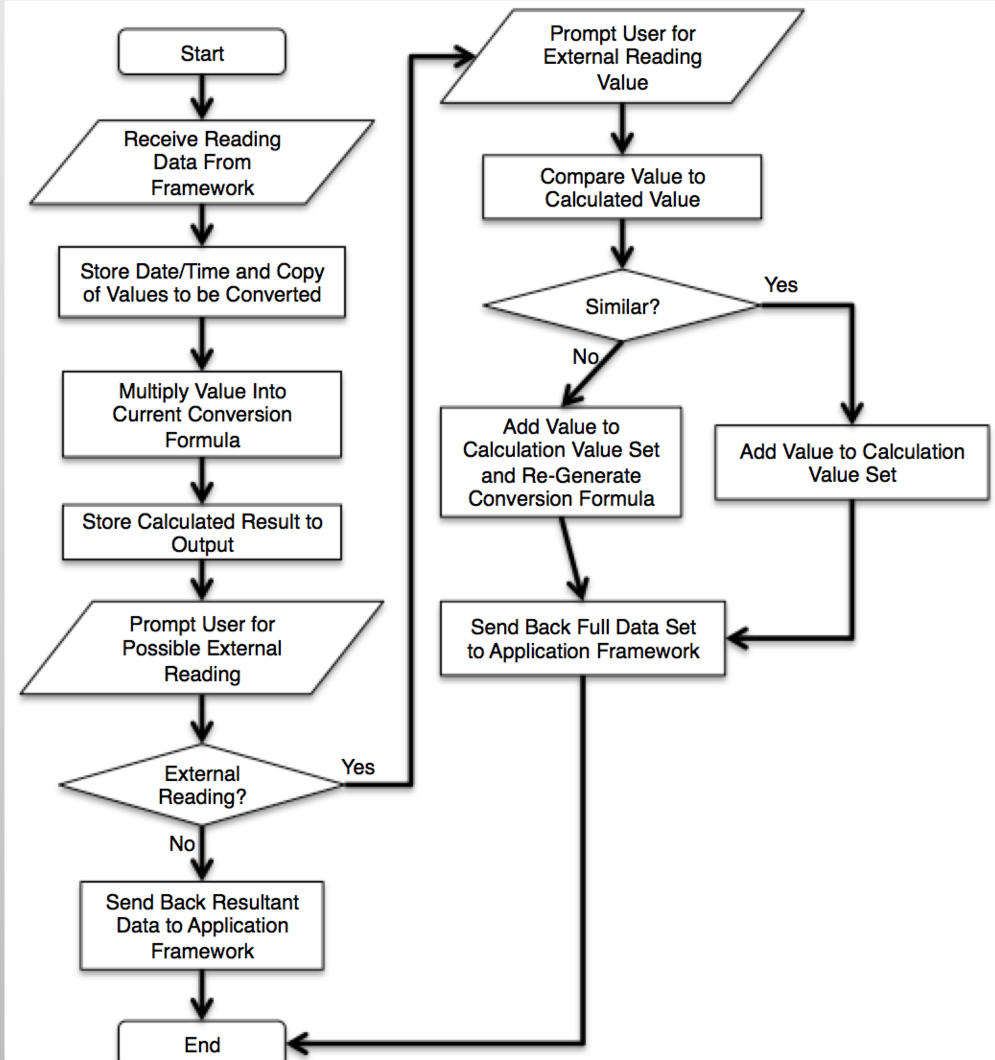
- Using Arduino IDE and writing in C
- Initial code framework has to be adjusted a bit to correct for small changes in device design and coding requirements
- Ensures functionality and power management of device as well as communication of values to user

Phone Application Code



- Initial design ideas changed a bit for the functionality and organization of the application
- Instead of initially trying to connect, has a button to engage connection
- A lot of open-ended expansion potential for phone application functionality given time

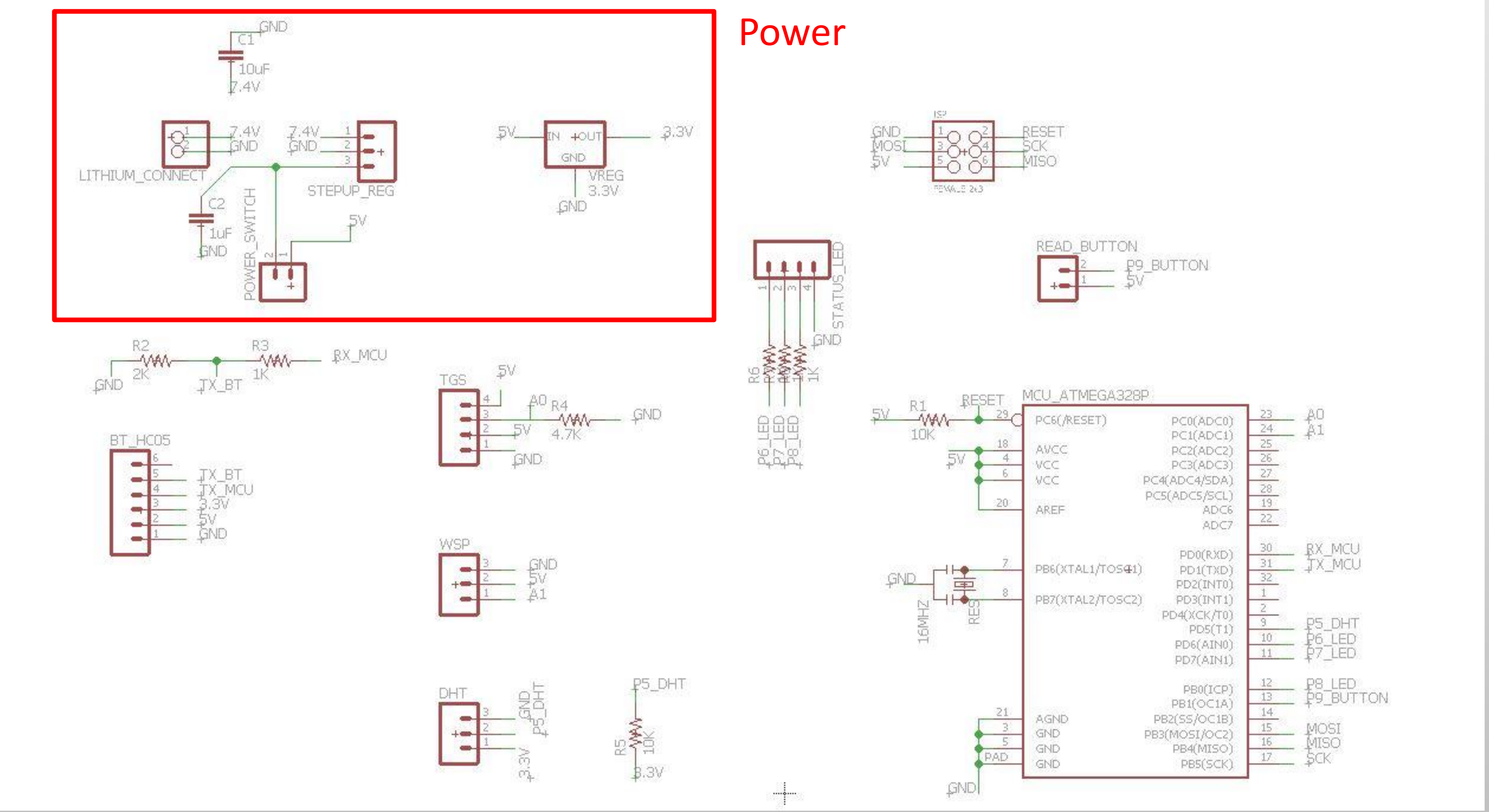
Sensor Calibration Coding



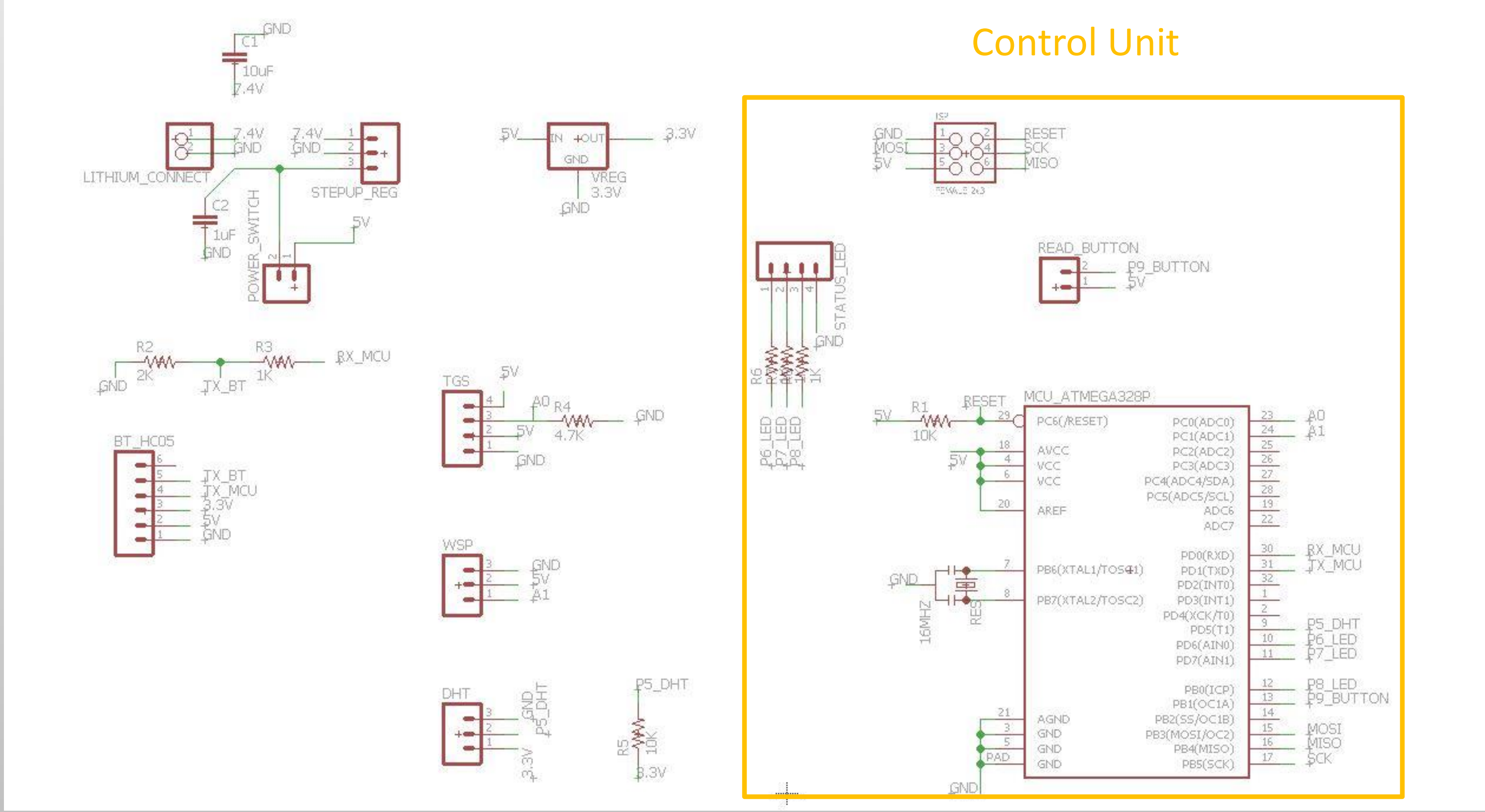
- The function relationship between blood glucose and breath acetone is still unknown
- Will develop an algorithm and the method of algorithm generation per user based on initial tests and value input

PROTOTYPE CONSTRUCTION

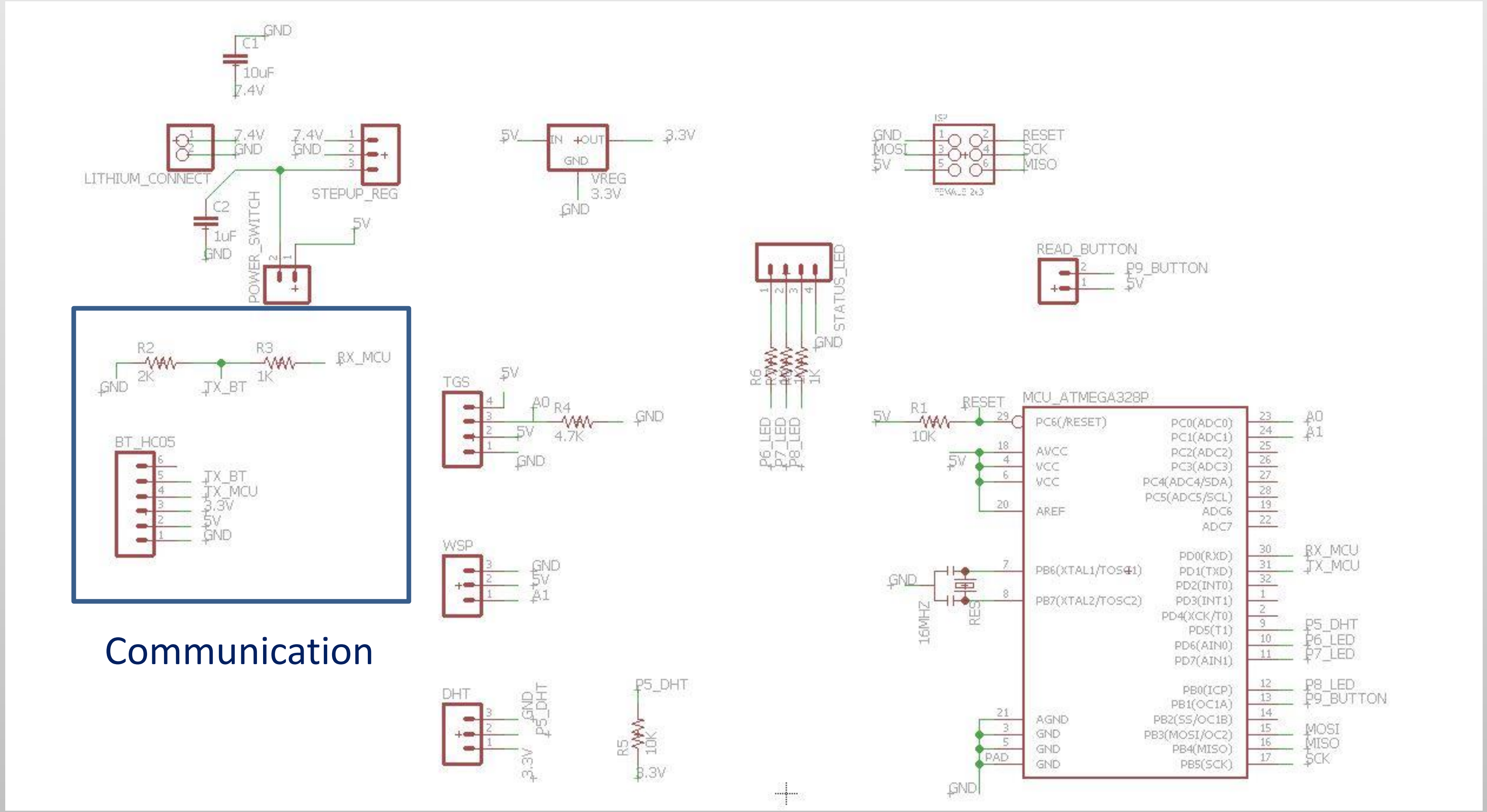
PCB Design-Schematic



PCB Design-Schematic

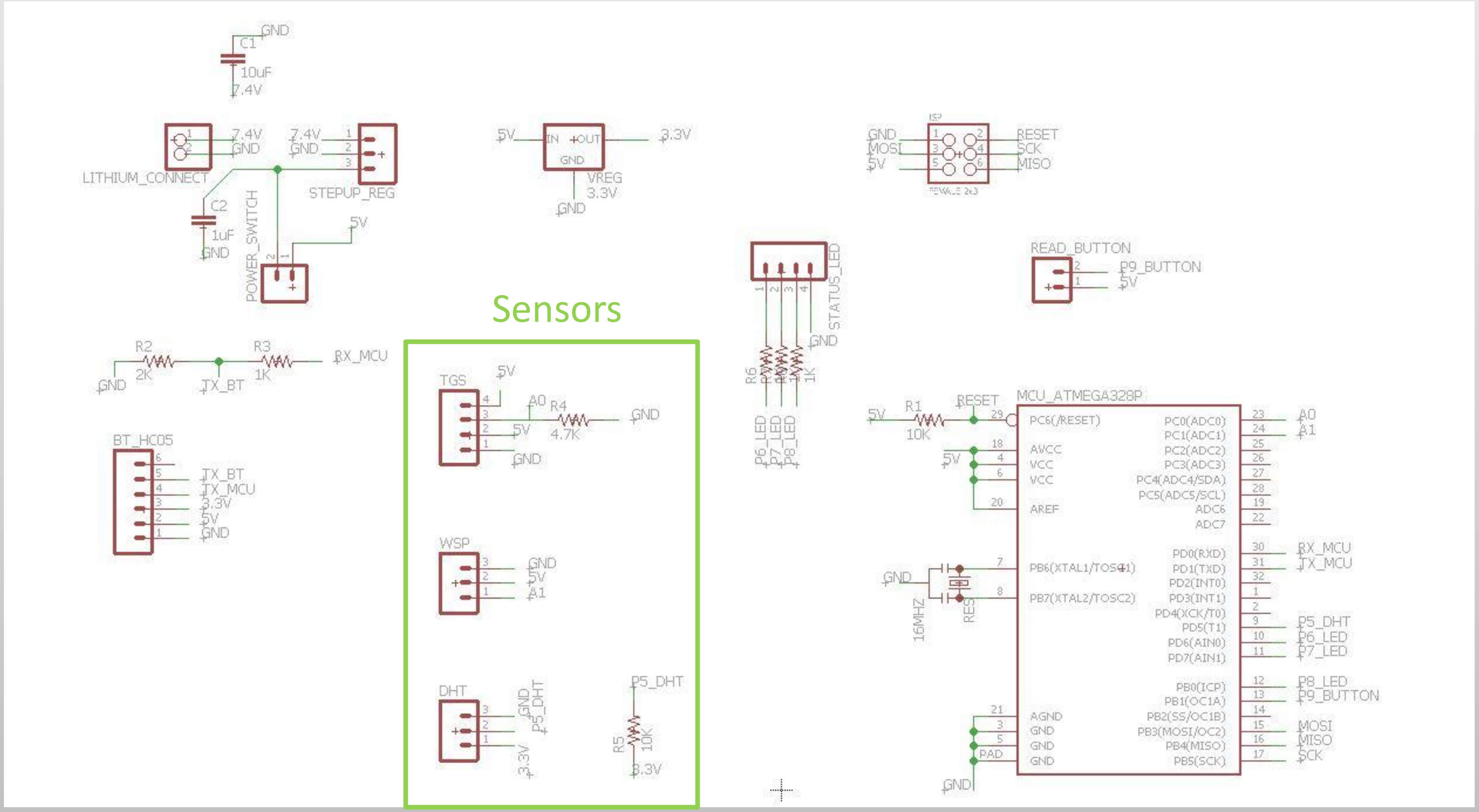


PCB Design-Schematic

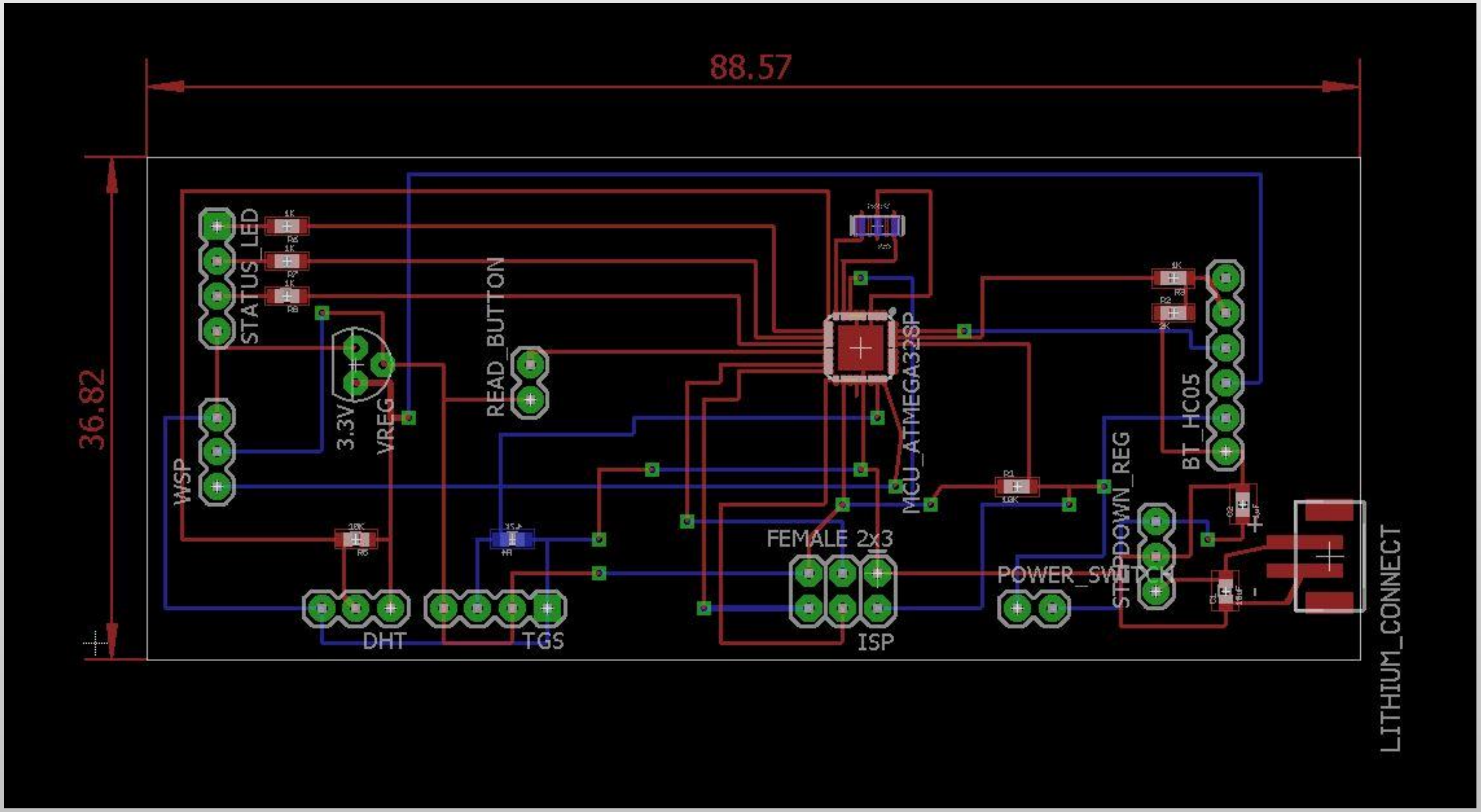


Communication

PCB Design-Schematic

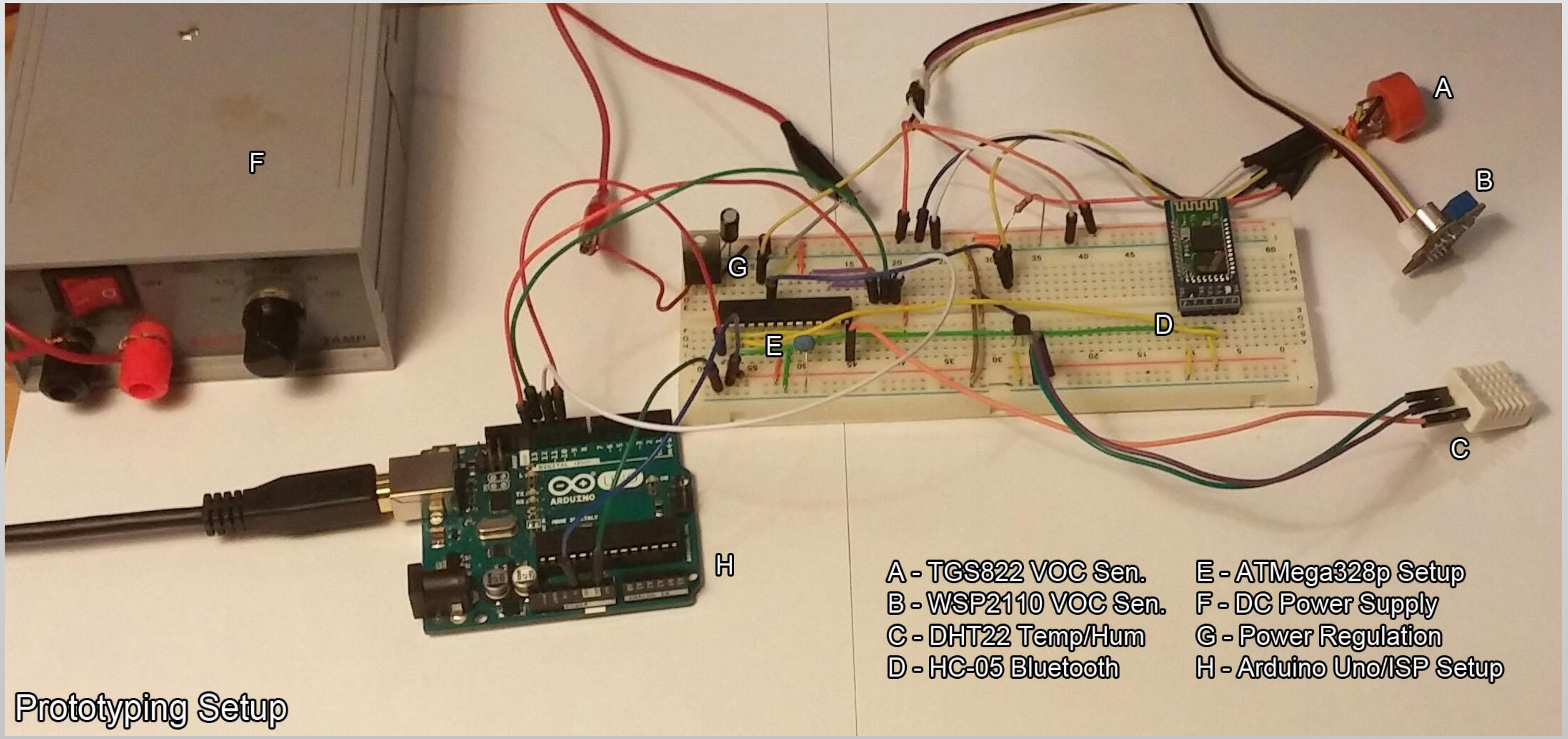


PCB Design-Board



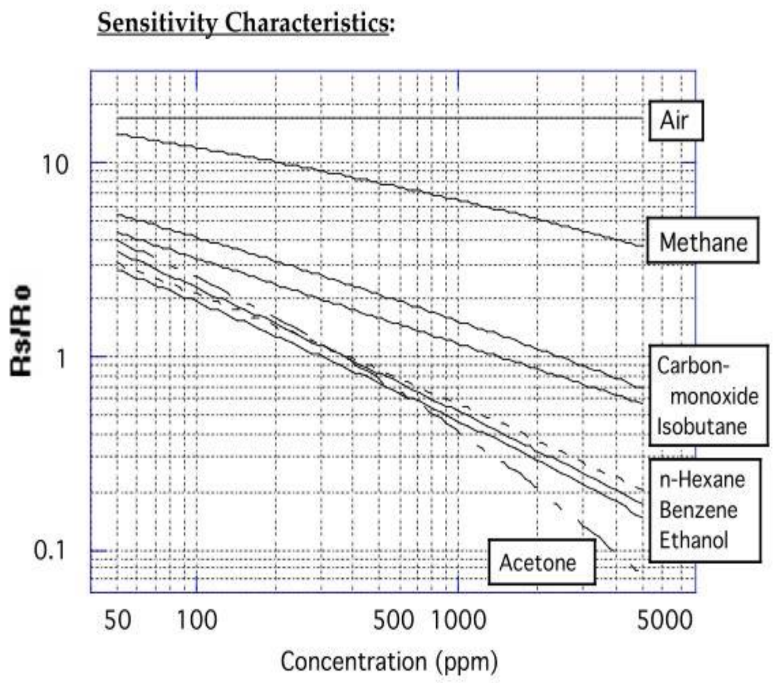
Prototype Testing

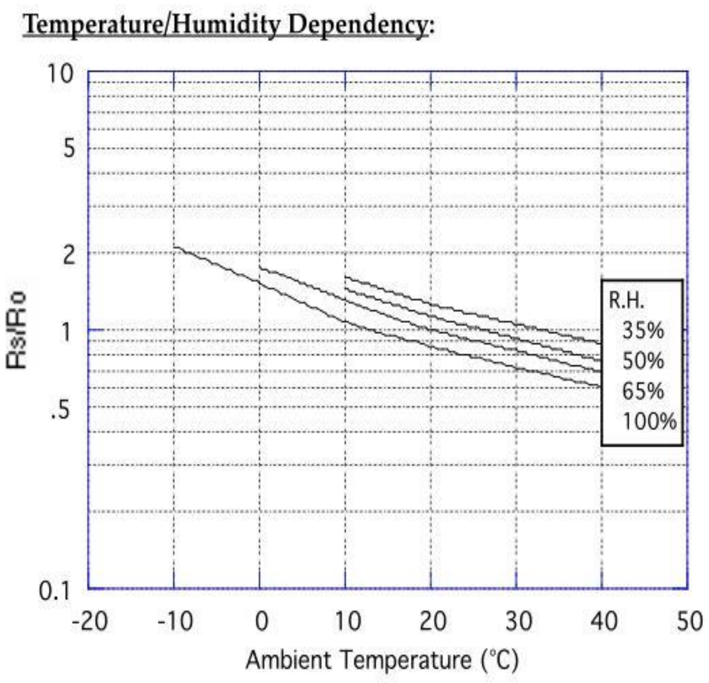
Breadboard Design



Concentration Relationship

TGS822 VOC Sensor





Concentration Relationship

WSP2110 VOC Sensor

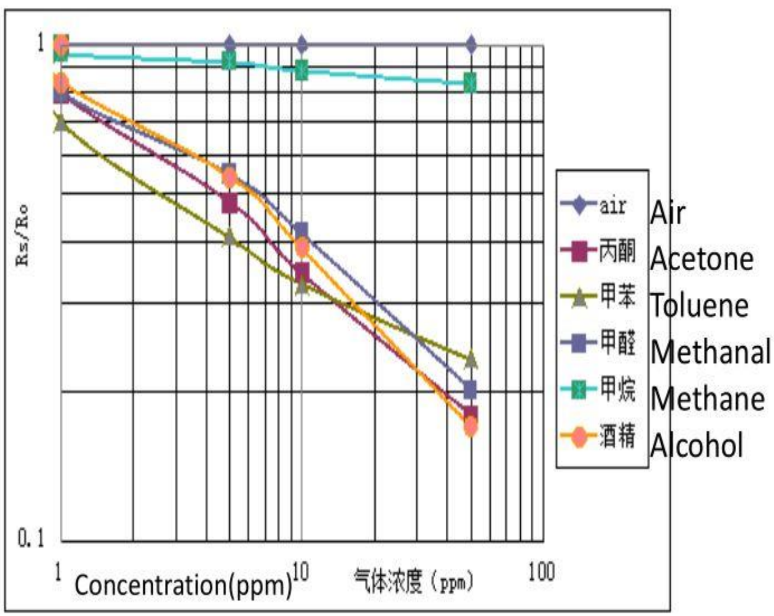


Fig3.Typical Sensitivity Curve

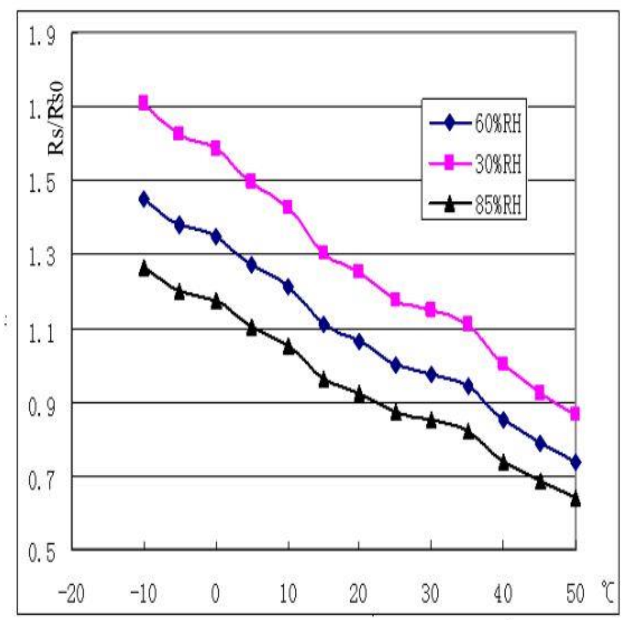
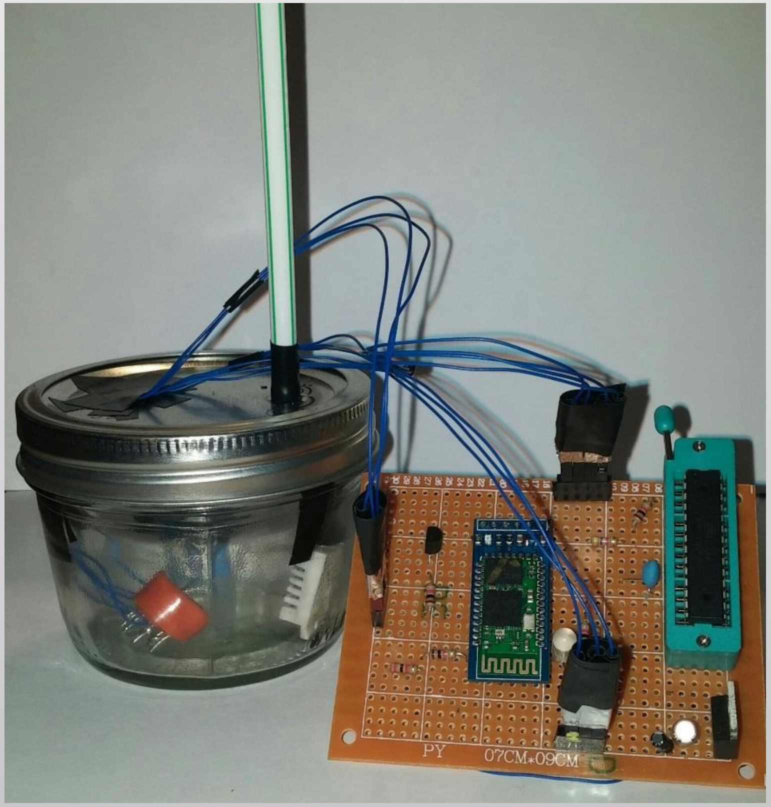
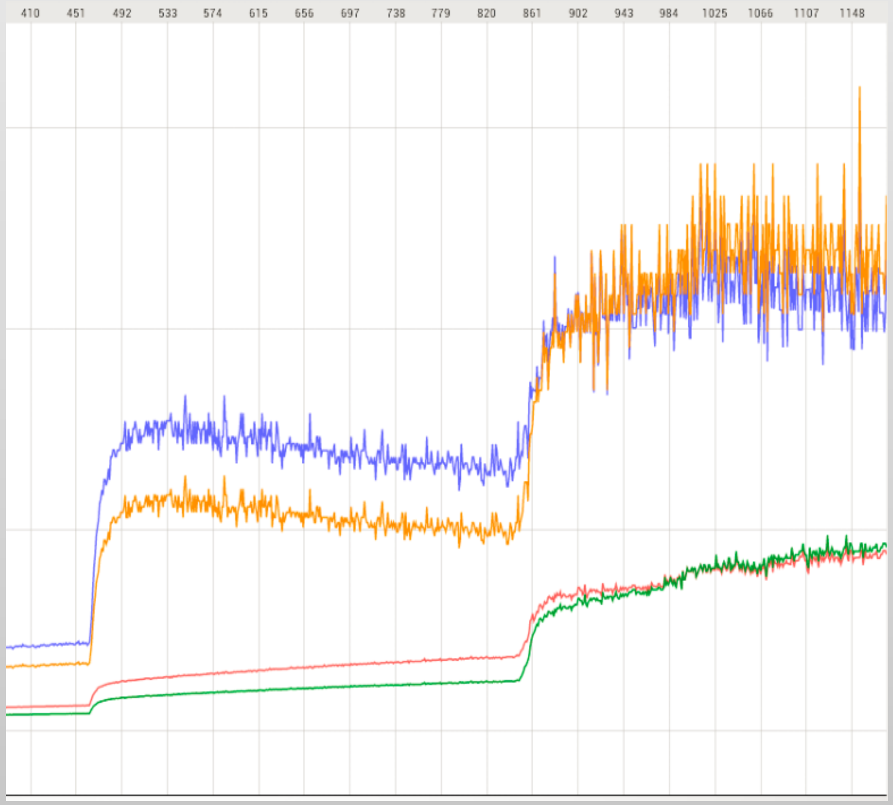


Fig4.Typical temperature/humiditycharacteristics

Testing Procedure





Current testing set up with real-time response

Successes and Difficulties

<u>Successes:</u>

- We have a working prototype that sends data via Bluetooth to another device
  - ✓ Sensors are working as planned
  - ✓ Bluetooth is communicating between devices
  - ✓ Showing correlation between resistance and concentration

<u>Difficulties:</u>

- All four group members are EE
- Our project is based upon ideas that are still under extensive research
- Relating the acetone concentration found in the breath to the corresponding blood glucose concentration

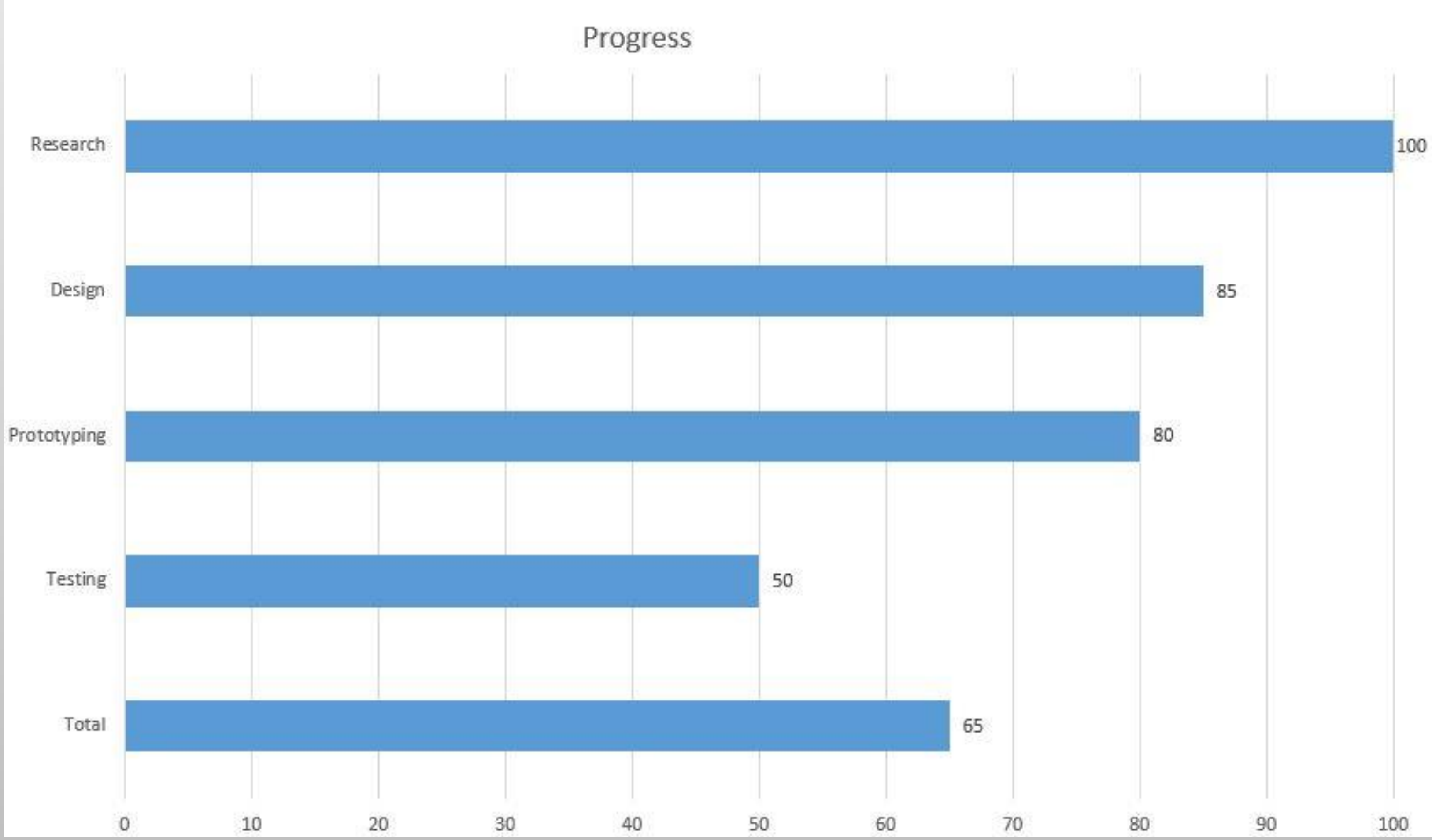
Project Budget

Description	Name	Quantity	Price
Temp/Humidity Sensor	DHT22/AM2302	1	$7.84
High Concentration VOC Sensor	TGS822	2	$11.88
Low Concentration VOC Sensor	WSP2110	1	$16.80
Bluetooth Module	HC-05	2	$17.60
Microcontroller	ATMEGA328P	4	$14.80
PCB		2	$60
Battery	Lithium Ion Polymer Battery	2	$19.90
Charger	LiPoly Charger	1	$12.50
Physical Design Components	Outside container, buttons, switches, etc.	1	~$15.00
		Total	<$180

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

Current Progress



QUESTIONS?