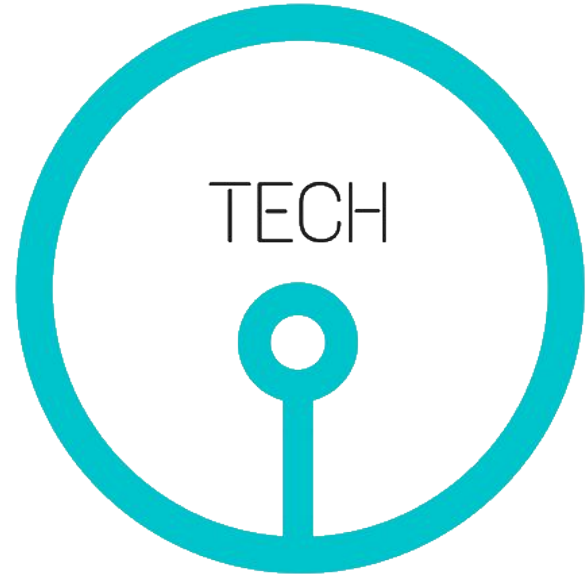


# IoTECH\*

\*Internet of Things Extensible Car Hub

## MDR Presentation





# The IoTECH Team



Chris Ingerson  
CSE



Nick Korniyenko  
EE



Nigel Paine  
CSE



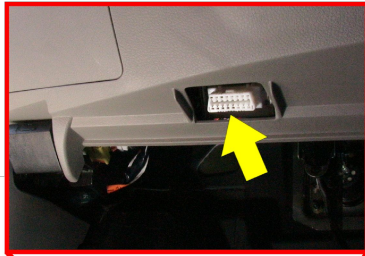
Raghid Bahnam  
EE



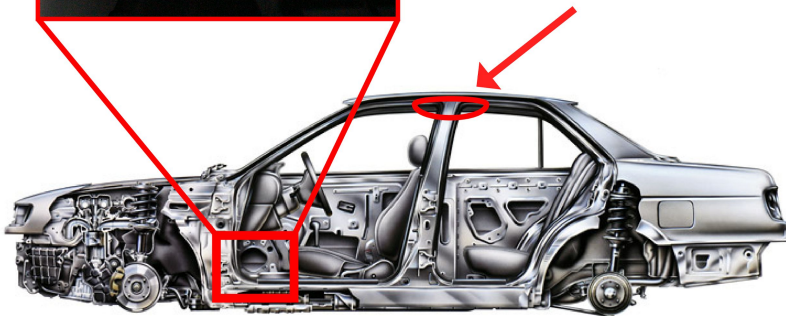
Prof. Jay Taneja  
Advisor

# IoTECH - Problem Statement & Recap

OBD-II Port  
connection spot for hub



WiFi Extension



## Problem:

Most current IoT devices don't extend beyond the home with WiFi applications. Very few automotive IoT devices on the market!

- “Smart Hub” - IoT Device
- Interface with OBD-II Port & External Sensors
- 3G/WiFi/Bluetooth data transfer
- Many potential applications

# IoT Application: TempAlert

## What does it do?

- Sense temperature and motion
- If threshold reached and motion detected, send alert via 3G to server (IFTTT) to user

## What's "In-the-box"?

- PIR Motion Sensor
- Infrared Camera
- Temperature Sensor (OBD & Dedicated)
- Particle Electron (3G)
- Redbear Duo (BLE/WiFi)





# Requirements: Specifications

- **Small and lightweight**
  - Hub: (~100g) (2.5 x 2.5 x 2 in)
  - Extension: (~200 g) (5 x 2.5 x 3 in)
- **Extensible**
  - Ability to expand IoTECH smart hub through hard-wired or wireless connections
- **Modular**
  - Able to interface with multiple sensors



# Requirements: Specifications (cont'd)

- **Fast & Reliable**
  - Relay information immediately (i.e. alerts)
  - Make sure alerts are seen by the user
- **Efficient**
  - Car battery life 160-200hrs (~1 week)
  - Extension battery life 12+ hrs (average)
- **Secure**
  - Ensure that communication between devices are encrypted
  - No vulnerabilities to 3rd parties

## Requirements: Input/Output

### Inputs:

- Power - OBD II (car battery)
- Car Data - OBD II
- Network of external sensors

### Output:

- SMS messages & notifications via IFTTT server





# MDR Deliverables

- ✓ Power electronics circuit built
- ✓ Ability to read OBD-II data from car
- ✓ Ability to read other sensor data
- ✓ Breadboard prototype circuits
- ✓ Display data from sensors on computer





## MDR Extras & Goodies

- ✓ Wireless communication between Hub and Server
- ✓ Implemented IFTTT triggers
- ✓ Able to capture images using serial IR camera



# Team Member Contributions

- **Chris**
  - Read sensor data on the Hub
  - Communication between Hub and Server
  - IFTTT triggers
- **Nick**
  - Breadboarded Hub and Extension
  - Power Circuitry and Consumption
  - Drew Schematics

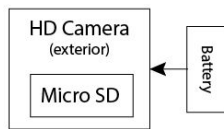
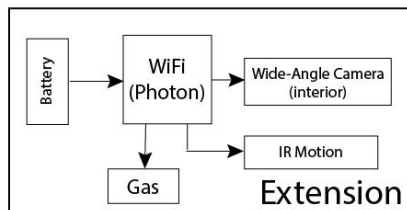
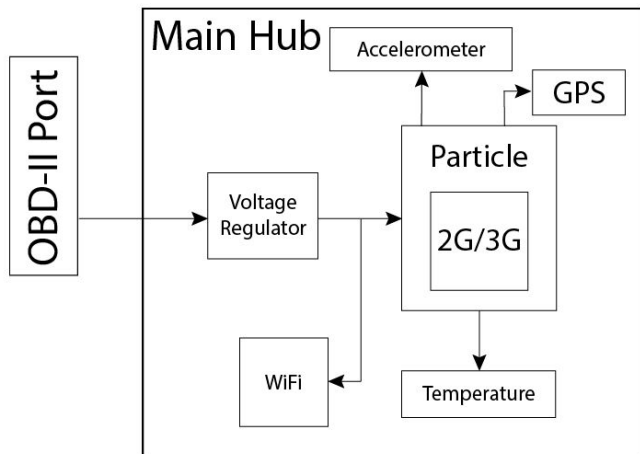


# Team Member Contributions

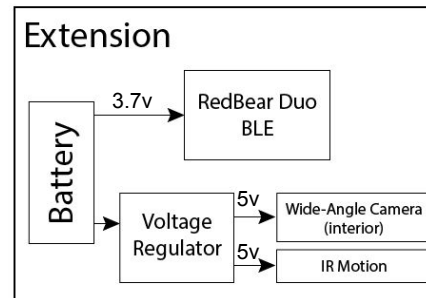
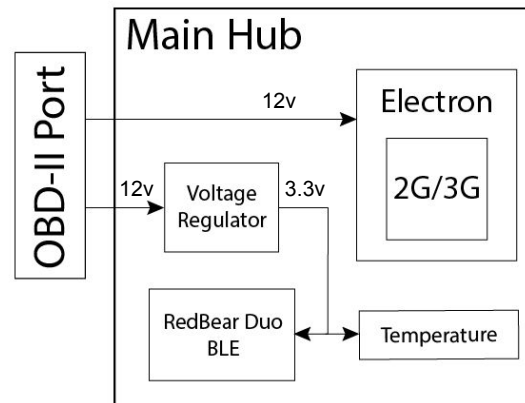
- **Nigel**
  - RedBear Duo Extension Setup
  - Infrared Camera
  - PIR Motion Sensor
- **Raghid**
  - OBD II Power Circuitry
  - OBD II CAN-to-UART Circuit
  - Debug & Read OBD II Data

# Block Diagrams - Power

PDR

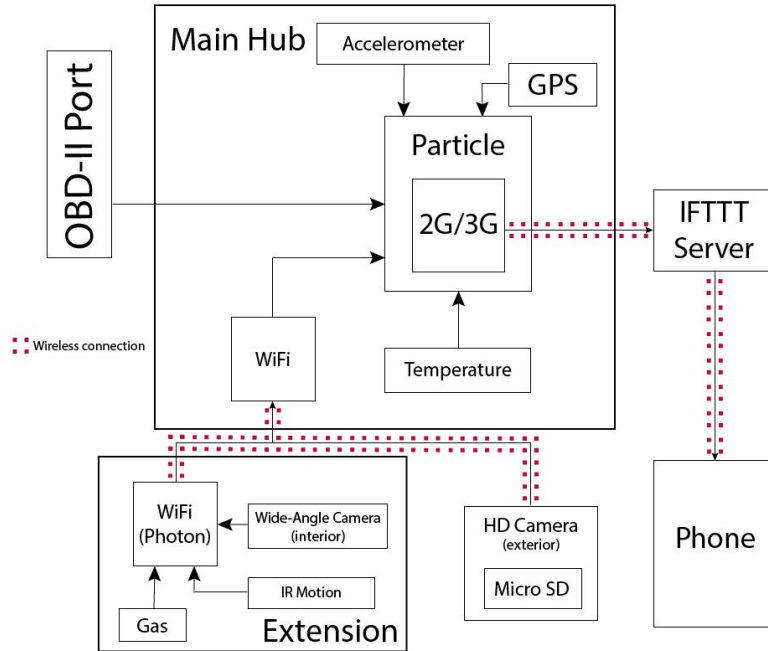


MDR

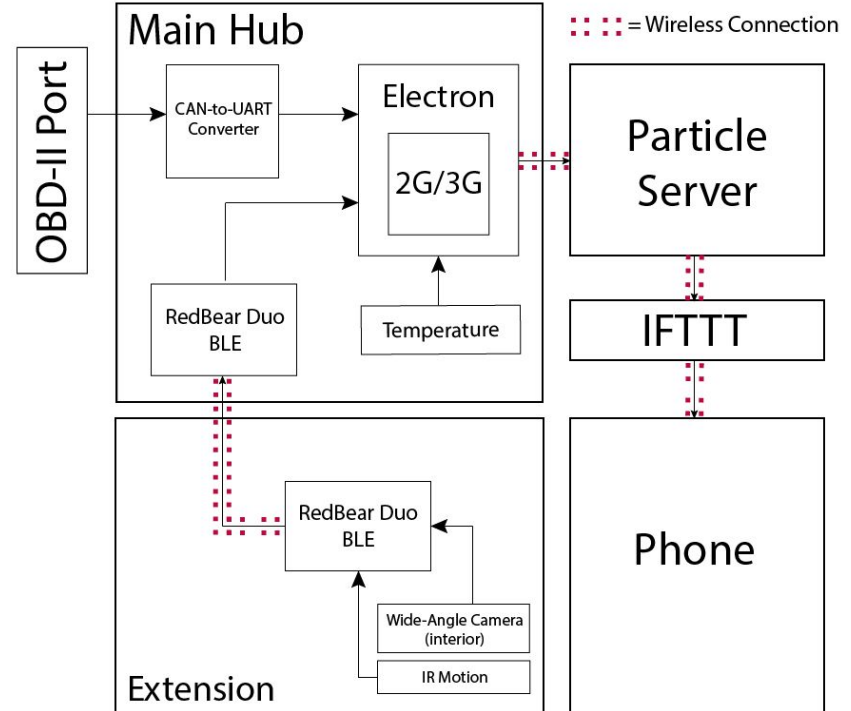


# Block Diagrams - Signals

PDR



MDR

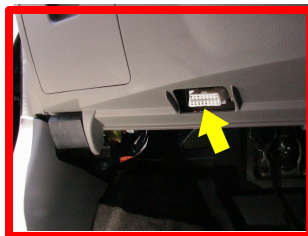


# IoTECH Sensors

## HUB



Temperature



OBD-II Port

## Extension



Wide-Angle  
Camera



IR Motion  
Detector

Demo time!



# Electron Data Consumption

- UDP
  - Less overhead
  - No handshakes needed to keep connection alive
- Each published event is 67 bytes
- One ping every 23 minutes during idle
  - 318 bytes/hour
- Able to run continuously for minimal cost





# Security

## Electron-Particle Server (3G)

- AES CCM encryption
  - Provides Authentication and Confidentiality
- Devices must be registered on Particle website
  - Unique Product ID

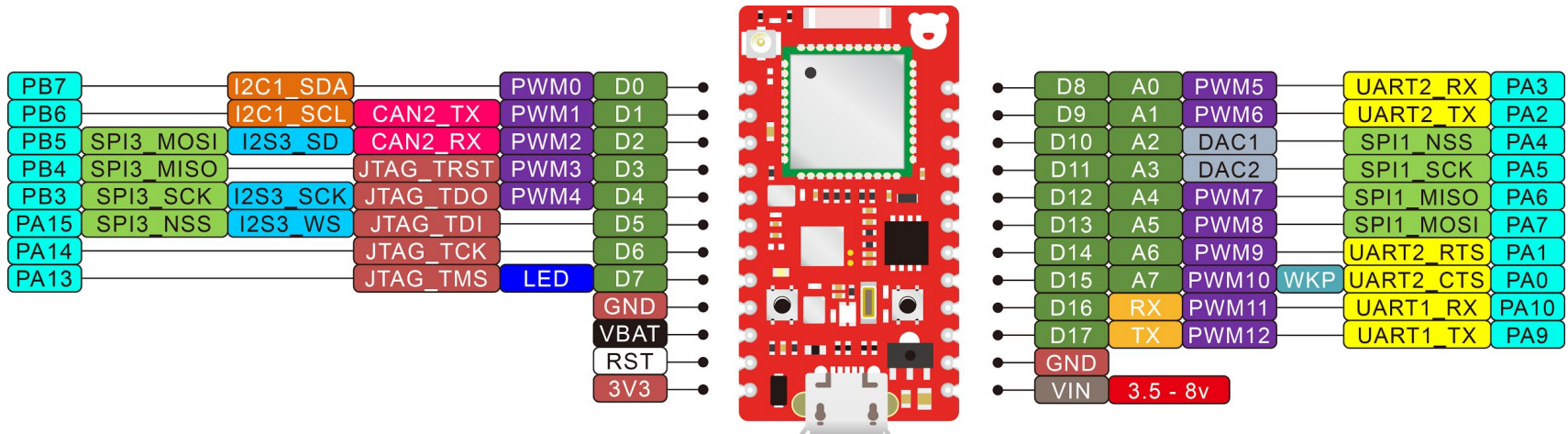
## RedBear Duo (Bluetooth)

- AES coupled with Secure Pairing
  - Communication is encrypted

# Temperature/IFTTT Demo

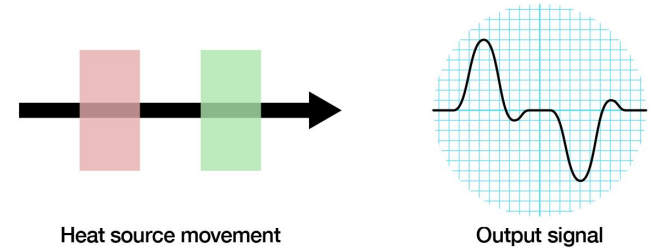
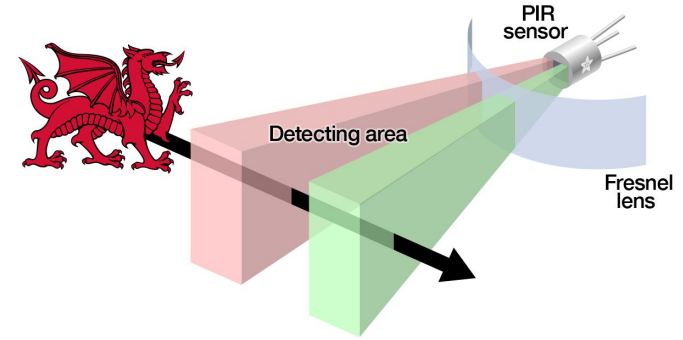
# RedBear Duo

- Uses similar code library to Particle IDE and Arduino
- Bluetooth 4.1 & WiFi 802.11b/g/n
- 1MB internal flash
- 2MB external SPI flash
- 128KB SRAM



# PIR Motion Sensor

- Detects changes in radiation (heat)
- Communicates via analog or digital (high/low)
- Variable sensitivity/delay
- Sense up to 7m away
- 3-4 second delay between firing
- 120 degree sensing range
- Communicate via RedBear Duo
- 3 Pins - Power, Ground, and Signal



# Motion Sensor Demo

# Infrared Camera

- Serial communication via UART (TX/RX)
- Baud rate, resolution, and low power settings available
- Can take images in low light settings
- Baudrate: 38400
- Resolution: 320x240
- Returns JPEG (hex data)
- Communicate via RedBear Duo
- Convert hex data to JPEG image using Python



# Camera Demo

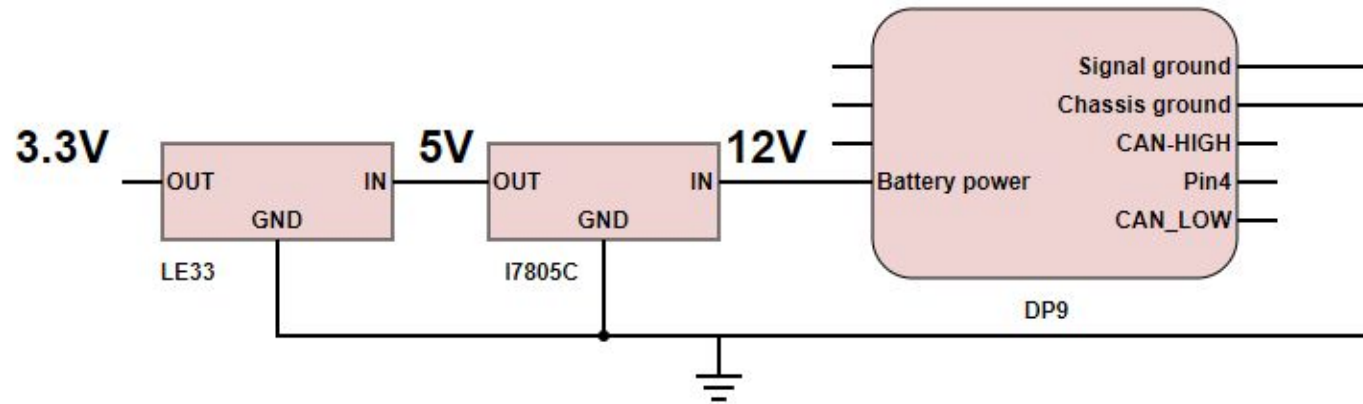


## OBD-II

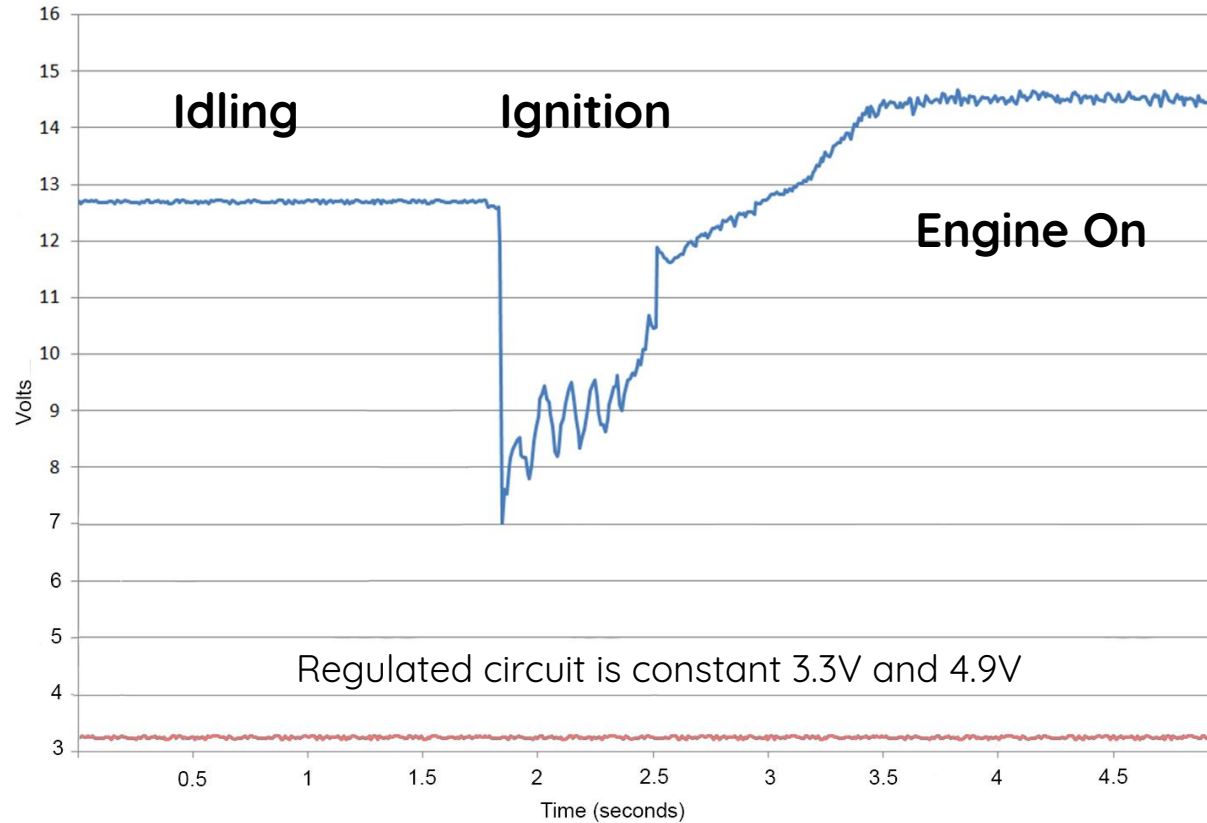
- OBD II Power Circuitry
- OBD II CAN-to-UART Circuit
- Debug & Read OBD II Data



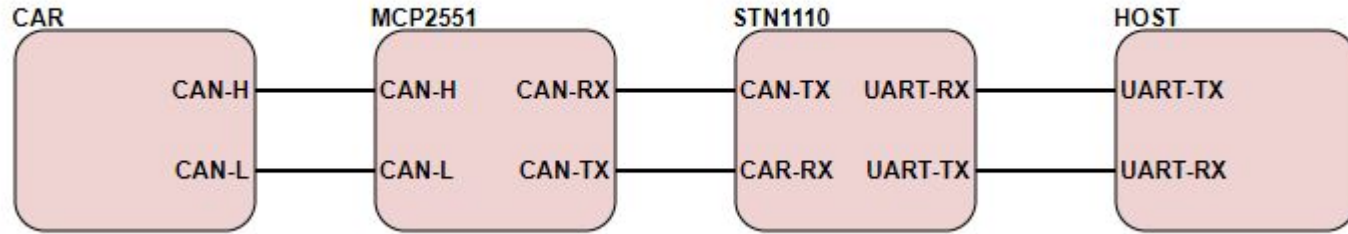
# Power circuitry



# Car Battery Voltage

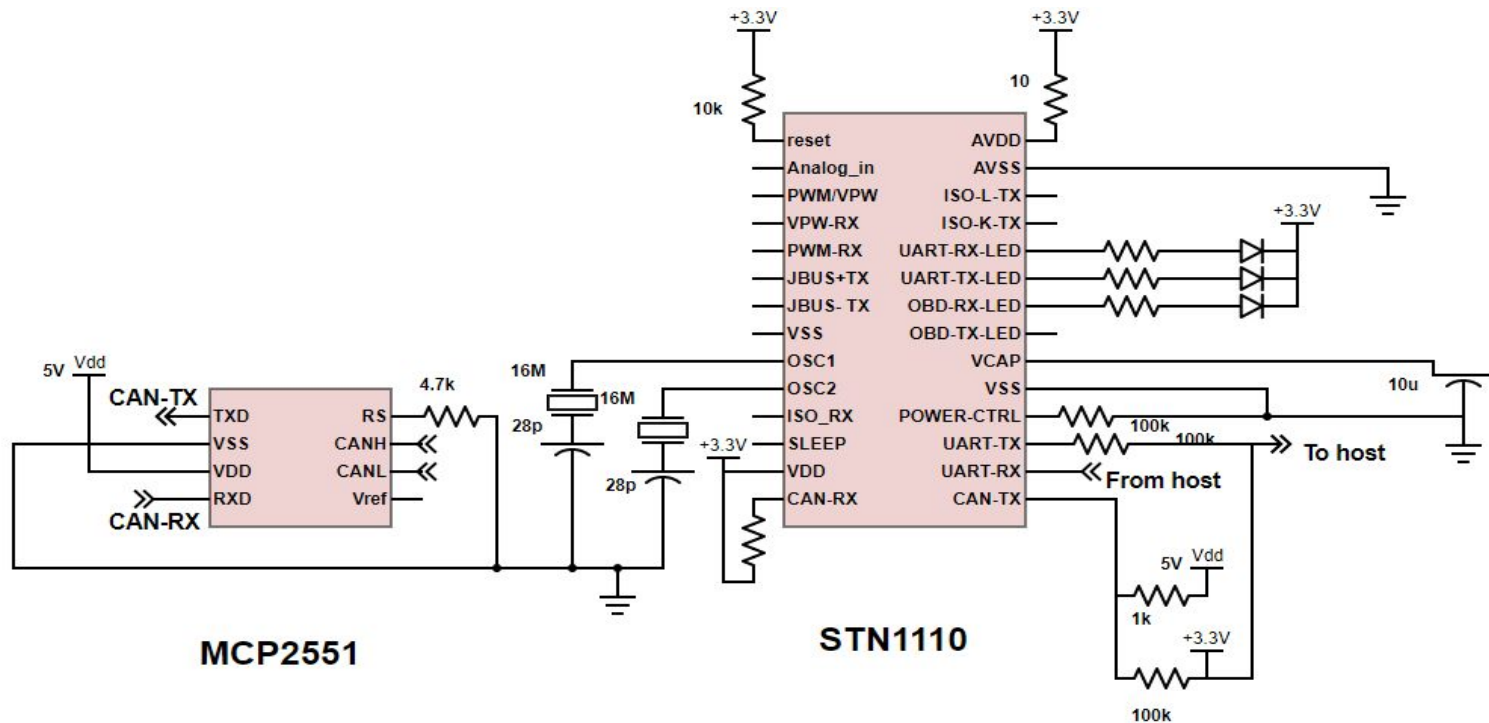


# OBD-II to UART



UART : 9600 bps, 8 data bits, 1 stop bit and no parity.

## SCHEMATIC



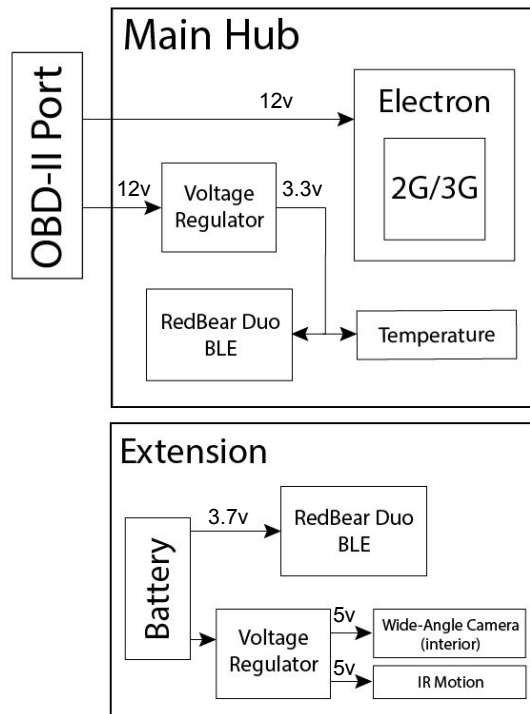
# Reading OBD-II data

ELM327 Command with extended ST commands

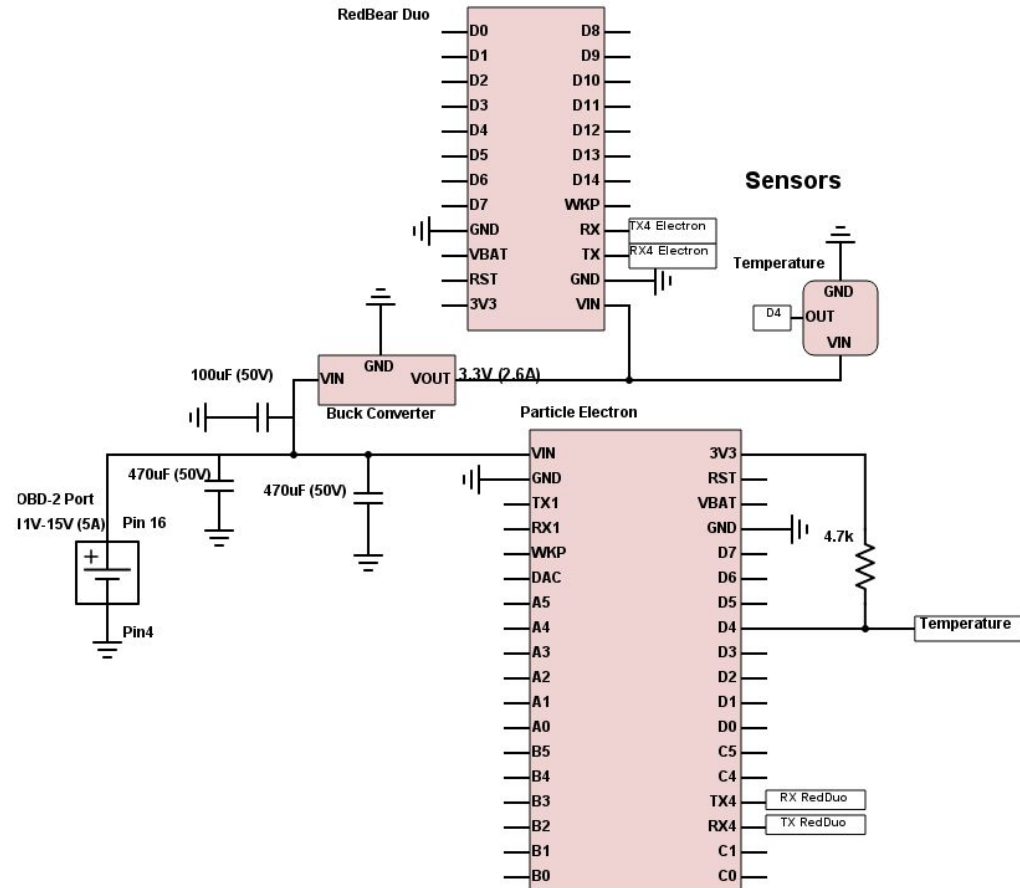
PID	Tx	Rx	equation	result
Ambient Temperature	0146	41 46 3C	A - 40 °C	68 °F
Coolant Temperature	0105	41 05 7E	Value - 40	186.8 °F
RPM	010C	41 0C D1 CC	Value / 4	13427 RPM
Speed	010D	41 0D DE	-	66 km/h

# OBD-II Demo

# Power Block Diagram

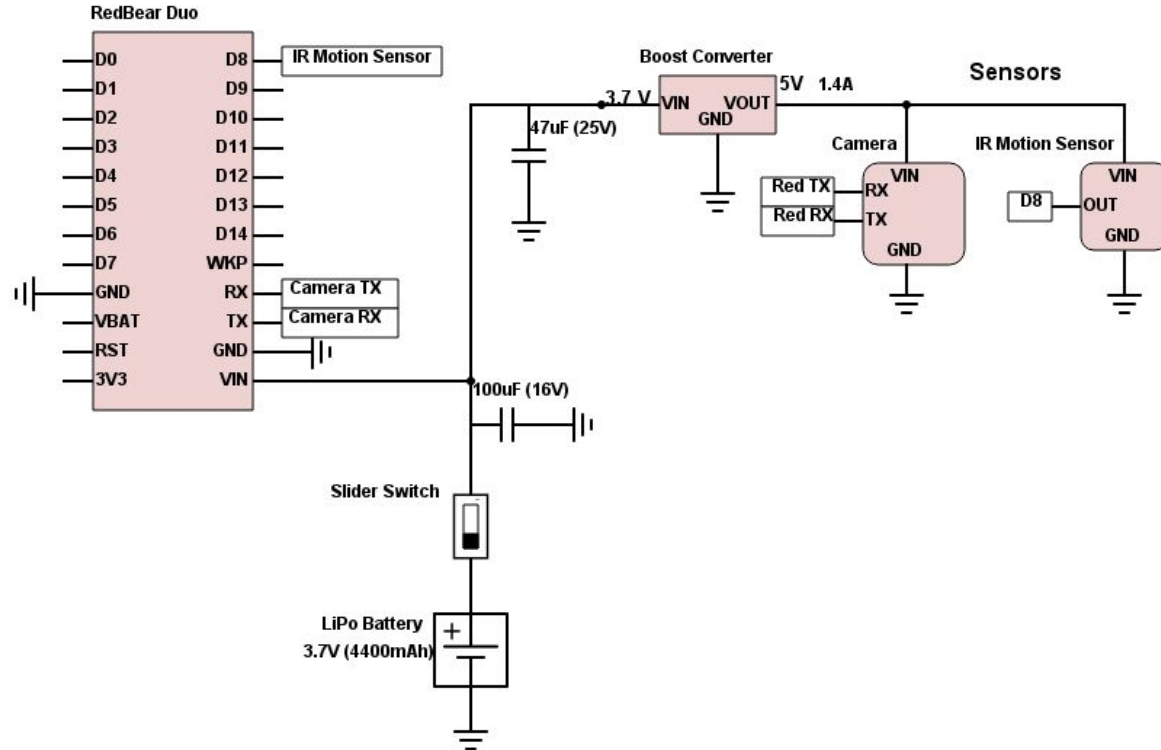


# Hub Schematic





# Extension Schematic





# Hub Power Consumption

<i>Hub Temperature Alert System</i>			
<b>Max</b>	<b>Max Power Consumption</b>	<b>Typical Power Consumption</b>	<b>Sleep Power Consumption</b>
<b><i>Electron</i></b>	27000 mW	2750 mW	30mW
<b><i>Sensors</i></b>	3040.95mW	500mW	4.7mW
<b><i>Voltage Reg.</i></b>	264 mW	55.5 mW	2.31mW
<b><i>Total</i></b>	30.3W	3.3 W	37.01 mW
<b><i>Current at 12-15 volts</i></b>	2.02Amps-2.525 Amps	227mA- 275mA	2.5 mA-3.1mA
<b><i>Hours Battery would Last</i></b>	18 Hours - 22 Hours	163 Hours-200 Hours	14516 Hours-18000 Hours

# Extension Power Consumption

<i>Extension Temperature Alert System</i>			
	<b>Max</b>	<b>Typical</b>	<b>Sleep</b>
<b>Boost Converter</b>	155 mW	61 mW	59 mW
<b>Sensors</b>	1.25 W	0.55 W	0.4 W
<b>Red Duo</b>	3.4 W	0.56 W	5.2 mW
<b>Total</b>	4.8 W	1.1 W	0.5 W
<b>Total Current (At 3.7V)</b>	1.3 A	0.3 A	0.1 A
<b>Hours Battery Would Last (2000mAH)</b>	1.5 Hours	6.3 Hours	16 Hours
<b>Hours Battery Would Last (4400mAH)</b>	3.4 Hours	14 Hours	35.2 Hours



# Power Consumption - Measured

## Hub-

### Whole circuit-

- Connecting to Cell Tower 780 mW-975 mW
- Startup: 780 mW-1800 mW
- Connecting to Particle Server: 1344 mW-1680 mW
- Completely Connected and Idle or Reading Data: 468-615 mW
- With Bluetooth it would be probably: 2280 mW-2850 mW
- Power at Idle and measuring 2280 mW - 2850 mW
- 236 Hours

# Car Battery w/ Temperature

**Battery Voltage and State of Charge: (80 Deg. F)**

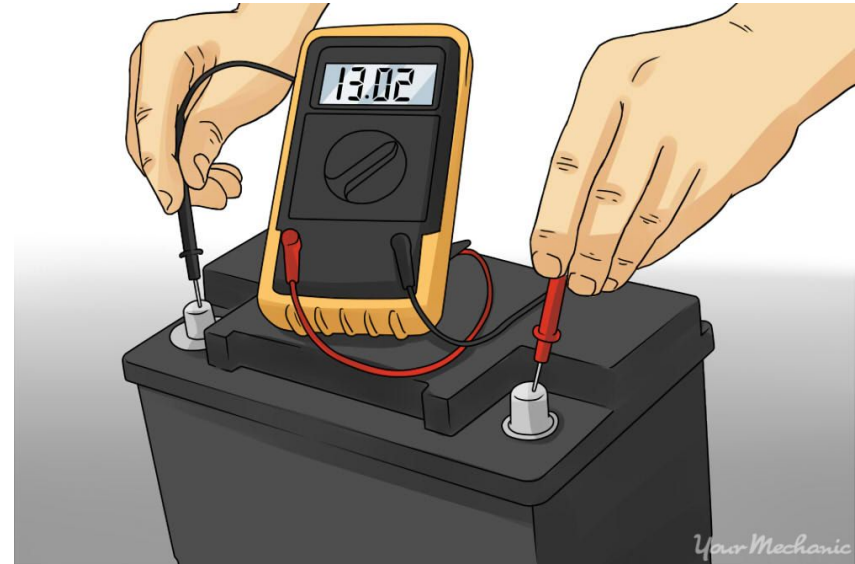
**12.66v = 100%**

**12.45v = 75%**

**12.24v = 50%**

**12.06v = 25%**

**11.89v = 0%**



**Battery Voltage Drops: 0.01 Volts for every 10 degrees Celsius**

**So a Fully Charged Car Battery would be 11.66 Volts at -20 Degrees F. and 10.89 Volts if at 0%**



# Power Consumption - Measured

Measured Extension Power Instances								
Camera	ON	ON	ON	ON	ON	ON	ON	ON
IR Light	ON	ON	ON	ON	OFF	OFF	OFF	OFF
Low Power Camera Mode	OFF	ON	OFF	ON	OFF	ON	OFF	ON
IR Sensor	ON	OFF	ON	OFF	ON	OFF	ON	OFF
Bluetooth Transm.	ON	ON	OFF	OFF	ON	ON	OFF	OFF
Power (mW)	1831-1887	1653	1460-1520	1284	910-976	773	540-606	403
Battery Life (Hours)	8.6-8.9	9.84	10.7-11.1	12.6	16.6-17.8	21	26-30	40



# CDR Deliverables

- PCB schematic designs finalized
- Bluetooth/WiFi communication between Hub & Extension
- Combined Hub & OBD circuits
- Add 1 more application beyond Temp Alert (i.e. parental control)



# CDR Timeline

## CDR Timeline

Website (Chris)	x												
Draft Report (Everyone)	x	x											
Humidity Sensor (Chris)			x	x	x	x	x						
WiFi Connectivity (Nigel & Nick)			x	x	x								
Bluetooth Connectivity (Nigel & Nick)						x	x						
MDR Report (Everyone)							x	x					
Merge OBD & Hub Breadboards (Raghid & Nick)								x					
Combine Sensor Code (Chris & Nigel)								x					
Work on Add'l Sensors (Raghid & Nick)									x	x	x		
Work on Add'l Software (Chris & Nigel)									x	x	x		
Design PCB (Nigel & Raghid)											x	x	
Schedule CDR (Nigel)													x
	12/7	12/14	12/21	12/28	1/4	1/11	1/18	1/25	2/1	2/8	2/15	2/22	3/1
			WINTER BREAK										



Thank  
you

# Extra Slides



# Potential IoT Car Applications

## Temperature Alert System

- *Detect motion inside car and report abnormally high temperatures (e.g. pets, kids, etc.)*
- Sensors: IR Motion, Wide-Angle Camera OBD Data: Ambient Temperature

## Parked Collision Detection System

- *Detects spikes in acceleration caused by a collision when parked*
- Sensors: Accelerometer, HD Camera OBD Data: Parked Mode

## Theft Detection System

- *Detects unexpected changes in vehicle location (e.g. being towed or a theft)*
- Sensors: GPS, HD Camera, Wide-Angle Camera



# IoT Car Applications - Parental Supervision

## Speed Detector

- *Detects speed, notifies if goes over threshold speed based on location speed limit (parental monitoring)*
- Sensors: GPS, OBD Data: Velocity

## Contaminant Detection

- *Detects presence of carbon monoxide, smoke, and alcohol in vehicle*
- Sensors: Gas



## Extra Specs

Photon: <https://store.particle.io/products/photon>

Electron/Sensors: <https://store.particle.io/products/sensor-kit>

ARM Processor, Programmed in C/C++ or Arduino

1MB Flash, 128KB RAM

3G Data: 1900 MHz cellular frequency, most major cell-phone carriers  
(Verizon, T-mobile, AT&T, etc.)

WiFi: 802.11 b/g/n (2.4 or 5GHz band)

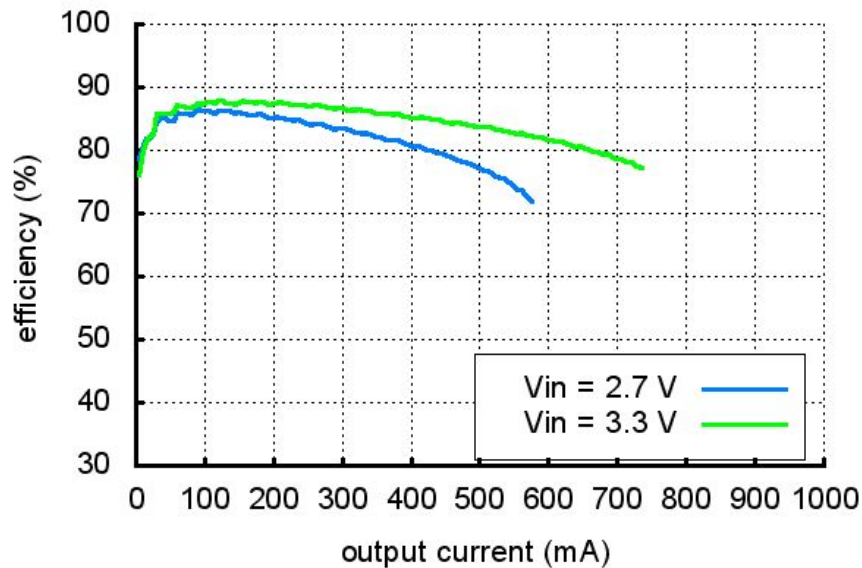
Max WiFi data rate is 600 Mbps (or 75 MBps)

Max Bluetooth data rate

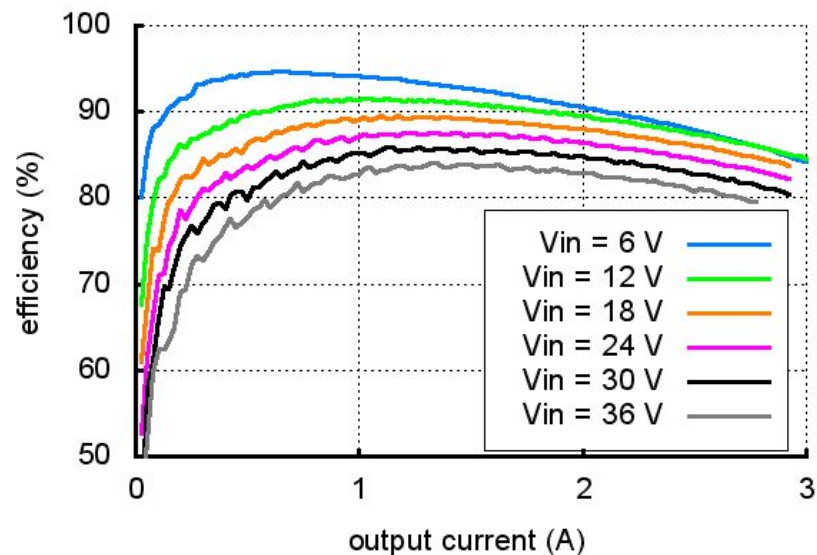


# Voltage Regulator Efficiency Charts

Pololu U3V12F5 Regulator Efficiency ( $V_{out} = 5\text{ V}$ )



Pololu D24V22F3 Regulator Efficiency ( $V_{out} = 3.3\text{ V}$ )





# Full Hub Power Consumption

<i>Hub Temperature Alert System</i>			
	<b>Max Power Consumption</b>	<b>Average Power Consumption</b>	<b>Sleep Power Consumption</b>
<b><i>Electron</i></b>	27 W	2.750 W	30 mW
<b><i>Sensors</i></b>	3.102 W	582 mW	73.92 mW
<b><i>Voltage Reg.</i></b>	306 mW	147 mW	36.4 mW
<b><i>Total</i></b>	30.4 W	3.4 W	140.3 mW
<b><i>Current at 12-15 volts</i></b>	2 A - 2.53 A	227 mA - 283 mA	9.35 mA - 11.7 mA
<b><i>Hours Battery would Last</i></b>	18 Hours - 22 Hours	160 Hours - 200 Hours	3846 Hours - 4812 Hours

# Full Extension Power Consumption

<i>All Sensor Extension Temperature Alert System</i>			
	<b>Max</b>	<b>Average</b>	<b>Min.</b>
<b>Boost Converter</b>	280 mW	105 mW	60 mW
<b>Sensors</b>	2.05 W	950 mW	400.5 mW
<b>RedBear Duo</b>	3.404 W	555 mW	5.2984 mW
<b>Total</b>	5.734 W	1610 mW	465 mW
<b>Total Current (At 3.7V)</b>	1550 mA	435 mA	126 mA
<b>Hours Battery Would Last (2000mAH)</b>	1.3 Hours	4.6 Hours	16 Hours
<b>Hours Battery Would Last (4400mAH)</b>	2.8 Hours	10.1 Hours	35 Hours





# Power Consumption- Measured Hub.

## ***Electron - 12V***

- Connecting to Cell Tower: 48 mA
- Start Up: 20 - 80mA
- Connecting to Particle Server: 60 mA
- Completely Connected and Idle: 27mA
- **Power at Idle: 324 mW**

## ***Temperature Sensor - 3.3V***

- 0.07 uA when Turned off
- 0.56 mA when Reading



# Power Consumption - Measured Ext.

## ***RedBear Duo- 3.7 V***

37 mA-54 mA

Assuming when Sending data 150mA

## **IR Sensor- 5V**

0.178 mA Detect

37 uA Idle

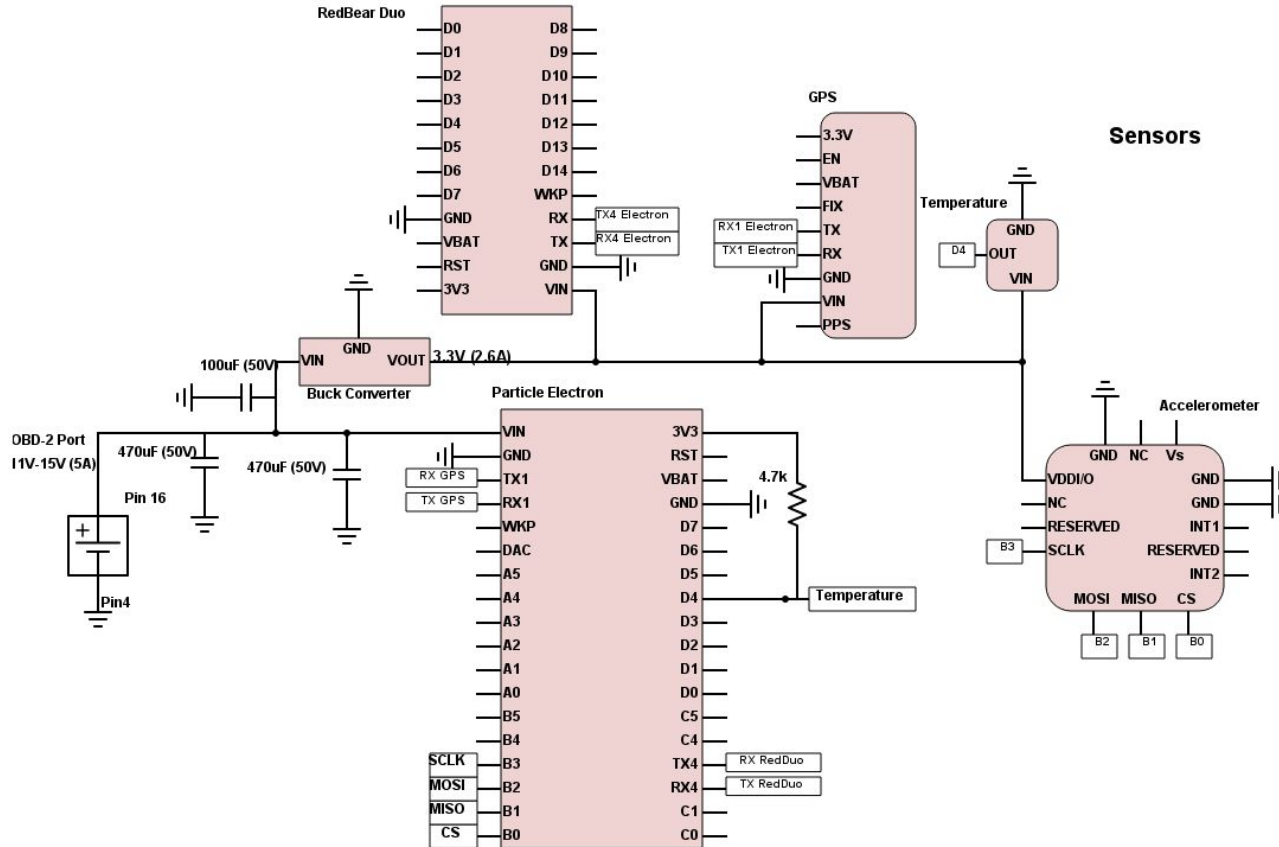
## **Camera- 5V**

On w/out IR Lights - 74 mA

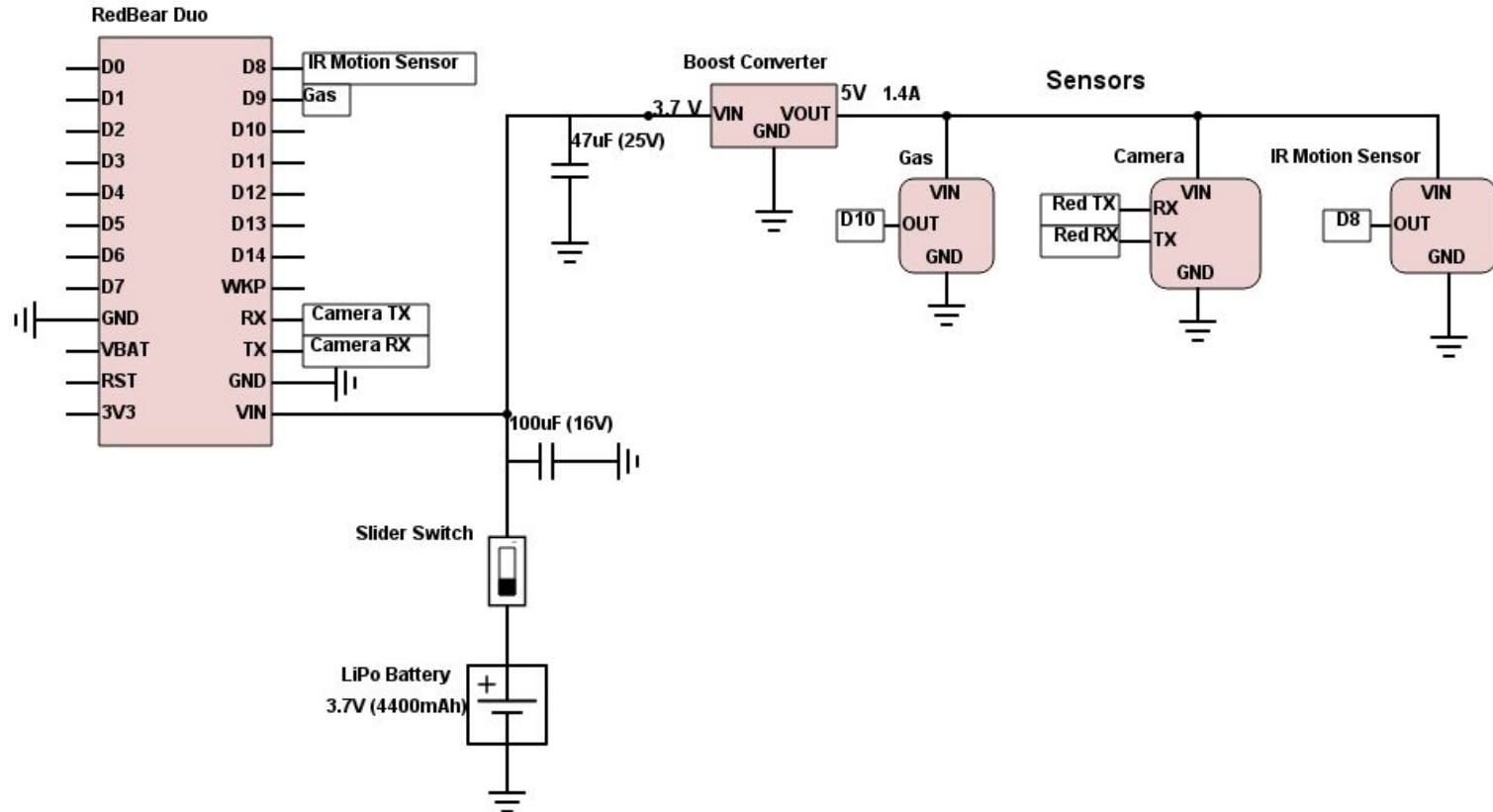
On w/IR Lights - 204 mA

Low Power Mode without IR Lights - 50 mA

Low Power Mode with IR Lights - 178 mA



# Schematic - Potential Extension





# Hardware Budget

[https://docs.google.com/spreadsheets/d/1hlk14Tolm\\_3y21gWLB1YkYPZu6LEQL-wq\\_8bVloB2G4/edit#gid=0](https://docs.google.com/spreadsheets/d/1hlk14Tolm_3y21gWLB1YkYPZu6LEQL-wq_8bVloB2G4/edit#gid=0)