Block Description

Power Circuits
The OBD port on all vehicles have a 12V rail. The 12V will be stepped down using a Buck converter, controlled using a PWM signal from the microcontroller, to charge the battery (discussed later) at 3.7 V. In order to prevent overcharging, this circuit will use diodes that will cut
off current into the battery when the voltage is too great. When the car is no longer supplying 12V and the battery is discharging, another diode will prevent the flow of current back into the charging circuitry. To provide power to the microcontroller, sensors, and telemetry module an LDO regulator will convert the 3.7V to 3.3V, as needed for the devices. Our logic will primarily rely on 3.3V logic and level-shifters may be necessary to communicate with the ICs.

## Circuit Schematic

Buck converter charging circuit

## Calculation

Access to power is essential to our project’s operation. This is true both when the vehicle is operational and when it isn’t. When the vehicle is not on, a battery is required to allow for our device to function for a set period of time. The device will send out a GPS location ping to the server at regular intervals. We estimate that we will require 23.5mA current on average when using battery power. This was calculated as follows:
**Current consumption of microcontroller** = 4mA

**Current consumption of GPS module** = 45mA

**Current consumption of WiFi module per transmit** = 270mA

**Number of transmits per hour** = 2

**Current consumption of WiFi module** = 270 * 2 = 540mA

**Total Current Consumption when transmitting** = 4 + 45 + 540 = 589mA

**Total Current consumption when not transmitting** = 4mA

**Average current consumption** = \( \left( \frac{2}{60} \right) \times 589 + \left( \frac{58}{60} \right) \times 4 \) = 23.5mA

Our requirement is that the device be able to function for at least 48 hours after the vehicle has been turned off. To meet this requirement, we will need a battery capacity as follows.

\[ 23.5mA \times 48 \text{ hours} = 1128mAmh \]

This is the minimum capacity which the battery will need to satisfy, and we would ideally prefer to use a battery which has much greater capacity to allow for longer battery life and lower voltage drop after discharge. To measure the capacity of the battery, we will discharge it at a rate of 1 C, where C is the rated current draw for discharge of the course of 30 minutes. We will then recharge the battery so as to be able to ensure that it can be brought back up to full charge again. When the device is not running on battery power, the consumption will be as follows.
Since the device will be powered by the car battery which on average have a capacity of >50Ah, we don’t expect our device to experience any issues in functionality. Another aspect of operation which using a battery will affect is the functioning temperature range. Since batteries are not very resilient to extreme temperatures, we must ensure that the battery can operate at the extremes of its temperature range. To validate this, the device must provide rated voltage and current at 20°F and 100°F. A heat gun and thermometer can be used to bring the temperature of the battery up to 100°F and the battery will be loaded using a resistor bank and it will be metered to verify the rated specs are met. The same can be done in the converse by placing the battery in the freezer to bring it to 20°F. This will ensure that the battery doesn’t get damaged and will not harm the other components.

| Current consumption of microcontroller = 4mA |
| Current consumption of accelerometer and gyroscope = 2 mA |
| Current consumption of GPS module = 45mA |
| Current consumption of WiFi module per transmit = 270mA |

Number of transmits per hour = 10

Current consumption of WiFi module = 270 * 2 = 540mA

Total Current Consumption when transmitting = 4 + 2 + 45 + 540 = 591mA

Total Current consumption when not transmitting = 2 + 4 = 6mA

Average current consumption = \(\frac{10}{60} \times 591 + \frac{50}{60} \times 6\) = 103.5mA
Plot

Charging Current Simulation

Requirements and Verification

| Buck converter charging circuit | a) 3.7V output voltage ±1%  
|                                | b) Efficiency > 85%        
<table>
<thead>
<tr>
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<th>c) Battery voltage sensing to prevent overcharging and low discharge</th>
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<tbody>
<tr>
<td></td>
<td>a) Use oscilloscope to measure voltage ripple</td>
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<tr>
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<td>b) Use Yokogawa power meters to measure efficiency</td>
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<td>c) Current flow into battery should be shut off once maximum charge is reached.</td>
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Safety Statement

Since our project involves primarily embedded components, we do not believe that our project will pose any significant health and safety hazards to the general public. While it might be possible for a user to experience minor shock if they decide to touch active power leads, we plan on designing
a safe housing for all components to prevent this from happening unintentionally. Since our project does not envision itself as a safety enhancement device, any use as such will not be within our scope. Our primary function is data collection, and with this in mind we don't think there are any further safety hazards that need to be accounted for.