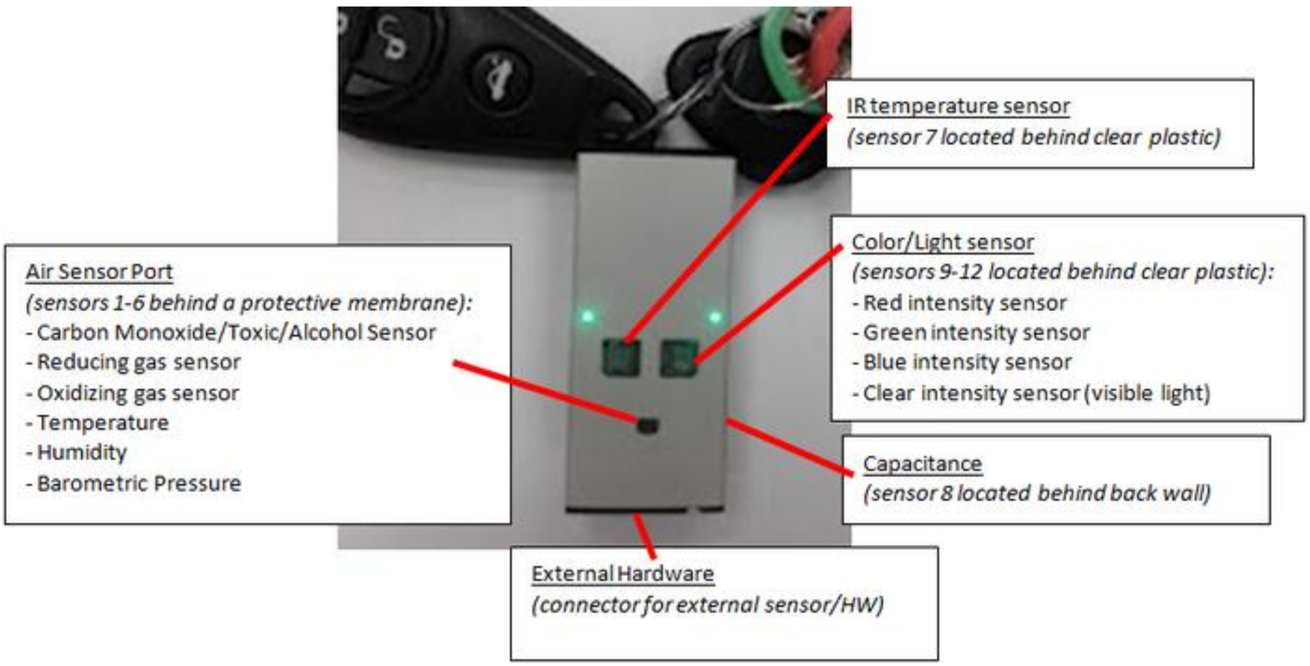
Sensordrone: Specifications & User Guide

Summary:
This document summarizes known and planned specifications for Sensordrone. It is intended to give developers and users insight into the capabilities of the various sensors included with the Sensordrone. General technical specifications and practical tips are presented.



1. Precision Gas Sensor

Description:

The precision gas sensor is a professional grade electrochemical sensor (fuel cell sensor) that is very sensitive to a variety of toxic gases, alcohol, and hydrogen. It comes pre-calibrated for Carbon Monoxide (CO). The output from the precision gas sensor is given in ppm of CO with the following specifications.

Resolution: 1ppm
Range: 0-2,000ppm
Accuracy: +/- 10% of reading
Response Time: 10-20 seconds to reach 90% of final signal

Sensitivity to Hydrogen & Other Gases:

Although the precision gas sensor comes pre-calibrated for CO, it will respond to a variety of gases. For example, the sensitivity to Hydrogen is about 10-20% of CO. What this means in practice is that if the sensor is exposed to 1,000ppm of Hydrogen, the CO output would give a reading of 100 to 200ppm. Apps can be made for various gases such as hydrogen, breath alcohol (ethanol) and various others by simply multiplying the CO output by a suitable sensitivity factor. A selection of sensitivity factors will be provided in follow on data-sheets.

Power:

The precision gas sensor is a very low power sensor that is always on. Enabling the CO data stream will have minimal influence on power consumption.

Note on CO vs. CO_2: Many consumers get these confused. CO is a toxic gas normally present in the air at <1ppm, it typically comes from combustion processes. CO_2 is a non-toxic gas commonly present in the air at 100-1,000ppm; it comes from various sources including exhaled breath.

Common Applications:

Indoor CO monitoring, parking garages, exhaust, breath monitoring, Air Quality

2 – 3: Oxidizing & Reducing Gas Sensors

Description:

The Oxidizing and Reducing gas sensors are general purpose semiconductor sensors that respond to a broad range of gases. They are not as sensitive or accurate as the precision gas sensor, but respond to more gases, so are particularly suitable for finding gas leaks or gas emitting sources. One sensor is tuned to respond to oxidizing gases, a second sensor is tuned to respond to reducing gases.

What are Oxidizing & Reducing Gases?

Reducing gases give up an electron during a chemical reaction, Oxidizing gases accept an electron during a chemical reaction. Common examples are the following:

Common Reducing Gases:	**Common Oxidizing Gases:**
Alcohols	Ozone (O_3)
Natural Gas	Nitrogen Dioxide (NO_2)
Hydrocarbons	Chlorine (Cl_2)
Hydrogen (H_2)	
Carbon Monoxide (CO)	
Volatile Organic Compounds (VOCs)	

General Gas Sensing Implications:

The Good News!

For most consumer applications, general gas sensing is good enough. For example, you can use the reducing gas sensor to check for a gas leak (e.g. natural gas for heating in the winter or propane for grilling in the summer). In these applications the user knows what they're looking for; therefore they have a pretty good idea of what gas should be there when they get a reading from the sensor.

The Bad News… (Otherwise known as technical limitations)

General gas sensing (non-selective) means that if there are 2 gases present (e.g. methane and CO), there will be a combined response giving an artificially high reading for the reducing gas the user believes they are measuring. If both a reducing and oxidizing gas is present, they may cancel each other out, leading to low or no signal. In most consumer applications, this is not usually the case. Since the general sensors respond to many gases, you will need to characterize them for your specific application if you require high accuracy. General specifications for CO & NO2 are:

	Reducing Gas Sensor: when sensing CO	**Oxidizing Gas Sensor: when sensing NO_2**
Min. Detectable concentration:	5ppm	50ppb (0.050ppm)
Range:	1,000ppm	0-5ppm
Response Time: T_{90}/ time to reach 90% of final signal	30-60 seconds	30-90 seconds

*Note: different performance specifications will exist for other detectable gases

Power:

WARNING! Semiconductor gas sensors use a lot of power. In operation, the Reducing Gas sensor will use ~75mW of power, and the Oxidizing gas sensor will use ~45mW of power. If left on, these can drain the battery in a few hours. Applications that use these sensors should most likely be limited to short durations. Therefore, developers are advised to pay careful attention to the amount of time the Reducing or Oxidizing gas sensor data stream is enabled. A typical application would turn on the sensors, let them warm up for 2 to 3 minutes, and then begin providing the user with data for a limited duration. If a long term data-logging application is run, it is best to use a low duty cycle (e.g. on for 1 minute every 10+ minutes) or operate the Sensordrone while plugged into an external power source. For better accuracy, it is recommended that the application first request the user establish an accurate baseline in a clean environment for about 2-3 minutes, and then begin taking readings for leaks or other applications. The Oxidizing/Reducing sensors are most suited for making measurements against a recently established baseline, because the baseline can drift somewhat over time.

Common Applications:

Gas leak detection, general air quality, VOC detection, Chlorine or Ozone indicator (Air quality)

Support:

Sensorcon engineers will be available to give extra support for developers for any of the sensors, and we anticipate most of the questions/requests for help will be related to the gas sensors. Over time, we will be adding more gas sensor related software to the open software libraries & firmware to enable better gas selectivity and identification, as well as improving automatic power management features. We are open for suggestions for improvements/desired features going forward. For any additional support, please email: developer@sensorcon.com

4: Temperature Sensor

Description:

The temperature sensor is a silicon bandgap type.

Accuracy: +/- 0.5°C (+/- 1°C near lower/upper ends of range)
Range: -20°C to + 60°C (limit of overall system)
Response Time*: 20-60 seconds to reach 90% of final signal/change in signal

*Response time tip 1: It may take several minutes when transitioning from hot to cold environments. The worst case will happen when Sensordrone is heated during the initial phases of charging, and then quickly moved to a cold environment. If fast temperature measurements are required, the infrared temperature sensor may be a better choice.

Power:

The temperature sensor is a low power device that is on most of the time. Enabling the temperature sensor data stream will have minimal influence on power consumption.

Applications:

Indoor/outdoor temperature, greenhouses, any ambient temperature application

5: Humidity Sensor

Description:

The humidity sensor is a capacitive type sensor.

Accuracy: +/- 2%RH from 20-80%RH (+/- 4% outside this range)
Range: 0 to 100%RH
Response Time*: 10-180 seconds depending on temperature change

*Response time tip 2: %RH is calculated based on air moisture content and temperature. If the temperature remains constant and the moisture content changes, %RH response will be fast. If both T & moisture change dramatically (e.g. moving from indoors to outdoors during winter months in a cold climate), it may take a several minutes for both the temperature sensor and humidity to stabilize. This is mainly due to the short time it takes for the local moisture content to change vs. the longer time it takes for the device temperature to stabilize per response time tip 1.

Power:

The humidity sensor is a low power device that is on most of the time. Enabling the humidity sensor data stream will have minimal influence on power consumption.

Common Applications:

Weather monitoring, indoor air quality, greenhouse, electronics manufacturing

6: Pressure

Description:

The pressure sensor is a MEMS type pressure sensor that is used for absolute (as opposed to differential) pressure measurements. It is most suited for measuring changes in ambient pressure.

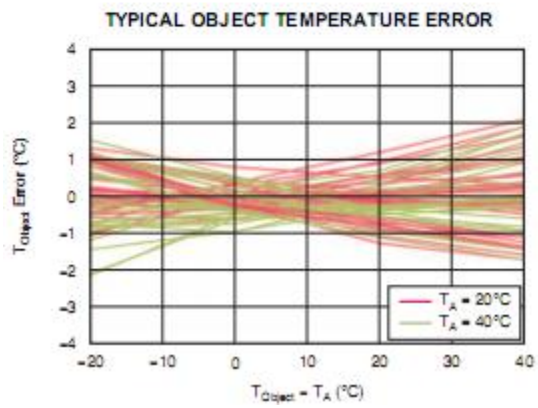
Accuracy: +/-0.1kPa
Resolution: 1.5Pa (pressure) / 0.3m (altitude)
Range: 30 to 110 kPa
Response Time: ~1 second

Power:
The pressure sensor is a low power device that is on most of the time. Enabling the pressure sensor data stream will have minimal influence on power consumption

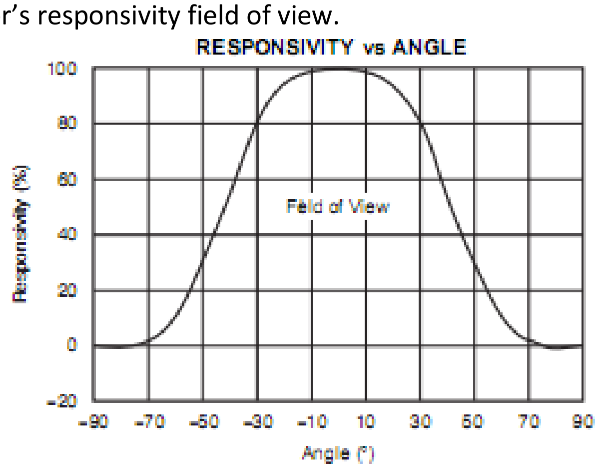
Common Applications:
Barometry, Altitude, Air Control System, Weather Monitoring, Medical

7: Infrared Temperature (non-contact/line of sight temperature sensor)
Description
The infrared temperature sensor uses a thermopile to absorb infrared energy being emitted from an object, and uses the corresponding voltage change to determine the temperature of the object. The infrared temperature sensor can be used to make non-contact temperature measurements.

Accuracy: +/- 1 to 3 °C (depending on ambient vs. measured object temp, see graph below)
+/-0.2-0.3 °C (with suitable averaging and stable temperate)
Normal Range: -20°C to + 60°C (-40°C to +125°C with increasing error)
Response Time: 1-5 seconds



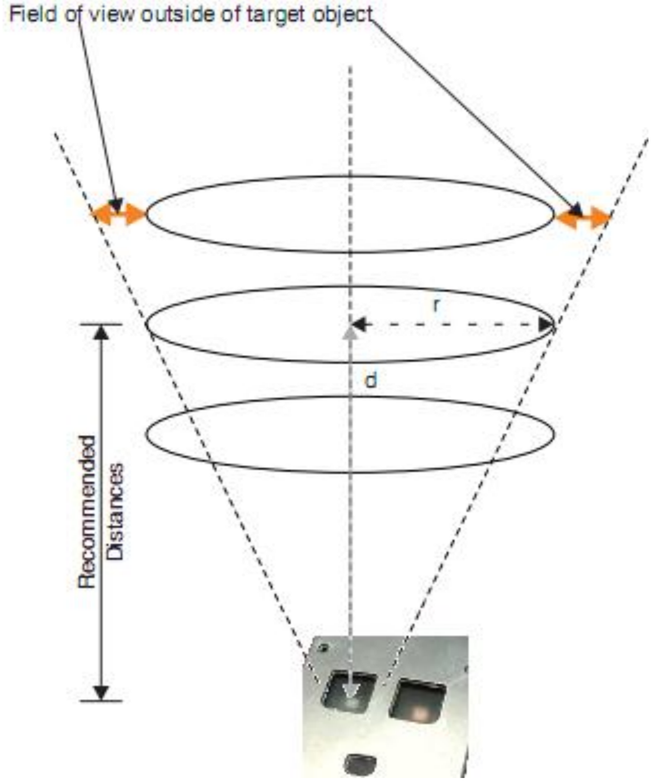
Non-contact temperature measurement considerations:
Non-contact means you essentially scan an object for its temperature. To ensure a user is measuring the object of interest and not the surrounding environment, users must ensure the object of interest is completely filling the sensor's responsivity field of view.



The easiest way to achieve this is by making sure the measurement is made close enough to the object of interest. Based on the sensors responsivity vs. angle, and the field of view diagram on the next page, best results (>90% of signal from intended object), will be achieved under the following conditions.

$$d < r/2$$

(d & r define in diagram on next page)



Measurement Error Considerations:
The easiest way to minimize error and present simple data to users is to take an average of data measurements over time. This is particularly the case with the infrared temperature sensor since it has a fast response and will be influenced by any object that is within its field of view. Additional statistical techniques can be implemented the software to improve accuracy/stability for more demanding applications. Sensorcon will be improving the lower level sensor algorithms over time to improve accuracy over a wider range of values. The Sensordrone libraries with these updated algorithms when each new firmware version is released. In the short term, developers can contact Sensorcon for additional support if their application requires more precision: developer@sensorcon.com

Power:
The infrared temperature sensor uses a medium amount of power (~1mW) while making measurements. Enabling the infrared temperature sensor data stream will have a noticeable but small influence on power consumption. This sensor should be left off if not being used in your application.

Common Applications:
Non-contact ambient temperature measurements, hot or cold surface temperature, health monitoring

8: Proximity Capacitance

Description:

The proximity capacitance sensor consists of a set of electrodes located underneath the bottom cover of the Sensordrone, and a capacitance to digital converter circuit. Any material within close proximity to the electrodes will cause a change in the capacitance between the electrodes.

Resolution: 0.5fF (in lowest range, 12bit of full scale in all other ranges)
Range: 4 selectable ranges (0 to 0.5pF, 0 to 1pF, 0 to 2pF, 0 to 4pF)
Response time: <1 second

How to develop an application with the capacitance sensor?

The key parameter you need to determine is which range you should operate in for your intended application. Electrodes are mounted inside the Sensordrone underneath the back cover (they will not be visible). The figure below gives a graphical representation of their approximate location and the resulting "capacitive flux." Note the density of the flux lines is at its maximum between the electrodes; this represents the location where maximum capacitance will be generated by the sensed object.

What's the difference between this sensor and touch pads or capacitive touch screens?

The main difference is high resolution and the ability to generate an analog signal of various magnitudes. Touch screens are generally just on/off. This means you can do things like estimate distances to an object or detect minute changes in water content, like in a stud finder application.

Power:

The proximity capacitance sensor uses a medium amount of power (~0.5mW) while making measurements. Enabling the capacitance sensor data stream will have a minor influence on power consumption.

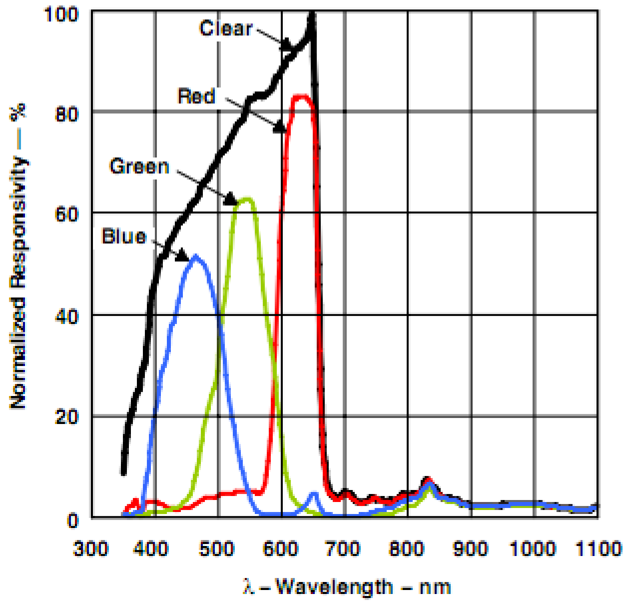
Possible Applications:

Level sensing, position sensing, proximity detection, touch sensing, stud finder, surface moisture content

9-12: Red, Green, Blue, Clear Illumination Light Sensors

Description:

A photodiode array with filters for Red, Green, Blue and Clear (visible light) are used for these sensed parameters. The response time is <1second. Line of site considerations are similar to as previously described on page 5/6. Other performance parameters are best described by the responsivity vs. wavelength spectrum.



How is the data presented for higher level application development?

Each of the 4 parameters (Red, Green, Blue, Clear) is presented as an overall magnitude. Applications such as color matching will require additional calculations to convert to a RGB scale. Additional application notes will be provided in the future for such applications, as with the other sensors, email developer@sensorcon.com for specific application support.

Lighting Considerations:

Ambient lighting dramatically influences the colors measured. Essentially, all channels will measure a lower signal in lower lighting. This can be somewhat compensated for by the clear channel, as it can be treated as a light intensity sensor, though additional calculations will need to be done to convert to more common units (e.g. Lux). Keep in mind that different lighting has different color intensities (e.g. incandescent bulbs are more red/yellow than outdoor lighting).

Power:

WARNING! The optical sensors (photodiodes) use a significant amount of power, about 30mW when in active mode. These sensors should be active only at the time of measurements. It is advised to create a start/stop button in end user applications for operating the color/illumination sensors.

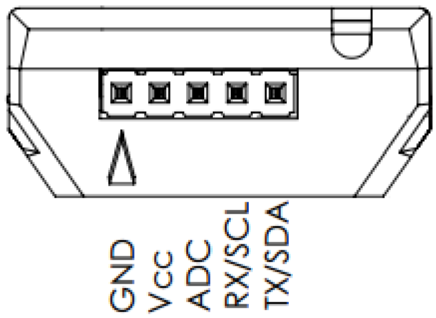
Common Applications:

Light sensing, illumination level, intrusion detection, Color sensing for lighting or other control, color estimation/matching, RGB graphics, spectrometry

13: External Hardware

Description:

The Sensordrone supports communication with external hardware (such as other sensors or any other peripheral that can communicate via the supported protocols). Connection is made via a standard 0.1" (2.54mm) pitch 5 pin receptacle. For development purposes, this should allow direct connection with a 5 pin header into a standard breadboard. The developer must set the external data stream on and select which communication protocol their external hardware is using, as well as the sampling rate and Bluetooth transmission frequency. Raw digital data is then provided from the Sensordrone to the Android interface for application level processing. The pin-out description is below:



1. GND: Pin 1 is connected to the Sensordrone's local ground (0V).

2. Vcc: Regulated 3.3V DC.

3. ADC: Pin 2 supports analog inputs from 0V (local ground) to 3.3V (local power). The analog voltage is fed into a 12 bit A/D. Digitized data is sampled at a rate determined by the application, and then transmitted to the Android application layer at a developer/user defined rate.

4. RX/SCL: The Sensordrone currently supports 2 digital communication standards: UART (3.3V TTL UART), and I2C. If UART is used, pin 3 serves as the Receive data line (RX). If I2C is used, pin 3 serves as the clock line (SCL). The Android application must identify which communication protocol is being used.

5. TX/SDA: If UART is used, pin 2 is the Transmit data line (TX). If I2C, pin 4 is the data line (SDA).

14: Color LEDs

2 programmable LEDs are on the Sensordrone. They can be individually adjusted for color based on Red, Green, & Blue color intensities.

A. Bluetooth Communications & Operating System Support

Bluetooth
Sensordrone will support Bluetooth 2.1 and Bluetooth 4.0 wireless communication protocols. Support for Bluetooth 2.1 will come first, and Bluetooth 4.0 will be available later via a free firmware update.

USB
Initially, Sensordrone will use USB for charging only. In the future, likely with Firmware version Lithium, USB communications will be supported.

Firmware
Sensordrone's firmware and lower level support software will be released in versions corresponding to the periodic table. Devices shipped starting in December 2012 will have Hydrogen firmware, with Helium anticipated to be available in the 1st half of 2013. Firmware upgrades will be provided free of charge and will be performed by a user via either Bluetooth or USB.

Android
Sensordrone will initially ship with support for Android 2.2 (Froyo) and later using Bluetooth 2.1. Software for Android devices using Bluetooth 4.0 will be available shortly after initial shipments begin for 2.1 (~1-2 months). The published API for developing Android Apps is available at Sensordrone.com

iOS
Sensordrone will support iOS devices using Bluetooth 4.0 only. iOS support is estimated to be available in February/March 2013. An API for iOS will be available when iOS support starts. This API will continuously be updated.

Windows, Blackberry, Linux
There are plans to support Windows, Blackberry, and Linux devices, but launch dates are currently TBD.

B. Communication Modes
Sensordrone will support 3 modes of communication, which will be easily configured in the API.

1. Call Response Mode: In this mode, data is transmitted only when the App calls it. (Available with Hydrogen and later)

2. Streaming Mode: Data is sent on continuously at a predefined sample rate (Helium & later)

3. Data Logging Mode: Sensordrone stores data in memory at a predefined sample rate, and data is later downloaded by mobile device (Helium/Lithium & later). Sensordrone has 1Mb of on-board memory available for recording sensor data.

3a: Sensordrone Logic: Programmable logic in Sensordrone's firmware will be supported with Lithium and later releases. This will enable LED indicator/intelligent sensing & logging algorithms on Sensordrone without the need for a continuous connection.

C. Application Development Suggestions

Entertainment vs. Utility Applications:
For the most part, the common applications listed are utility type applications; they use the sensors as a tool. Entertainment applications should also be possible, though not as common today because for the most part, the sensors that the Sensordrone contains are only available as single use devices today.

Since the Sensordrone is intended to be used in numerous situations by running different Android applications, entertainment applications such as games that use the included sensors are now possible. Such efforts may be a somewhat pioneering effort, though the use of accelerometer sensors for games was not widely understood just a few years ago.

Sensorcon encourages both application types, and will do our best to support both. From our perspective, utility applications may be more likely to find customers willing to pay for the apps in the short term, but entertainment applications may ultimately be much more lucrative in the long term, though the “winning formula” is unknown today.

Use of Multiple Sensors:
Developers are encouraged to make applications that utilize the data from multiple sensors. An obvious combination is all of the environmental sensors for weather monitoring. Multiple sensor combinations may make for better entertainment applications. For example, combining the color sensing with gas sensing may enable a new method for evaluating foods. The infrared temperature and capacitive sensors may be combined with other sensors for motion control or automation projects. Multiple Sensordrones (either locally or remotely via internet applications) should also be considered for even larger scale applications.

External Hardware:
The external hardware support was added to allow both the addition of additional sensors (e.g. Sensorcon will also offer additional gas sensor modules), but also to serve as an easy to use Android interface for hardware hobbyists & developers. You might use the external connector to connect force and strain sensors, or perhaps radiation sensors. You can also use the external connection to connect to any other project, such as a different type of interface (e.g. a keyboard or a remote controlled device).

For all of these applications, support will be available at developer@sensorcon.com and on the developer’s forum at www.sensorcon.com/forum

Power:
Mobile devices including the Sensordrone run off a battery, so power management is critical. The most important thing for you as a developer to do is to carefully plan out/minimize the time that the high powered sensors are enabled, and to wirelessly transmit data via Bluetooth as little as possible. A power consumption/battery life estimator will be provided to estimate the Sensordrone’s battery life (before requiring recharging) based on your application’s settings.

Mechanical Outline