2nd Generation Low Power Environmental Sensor Suite

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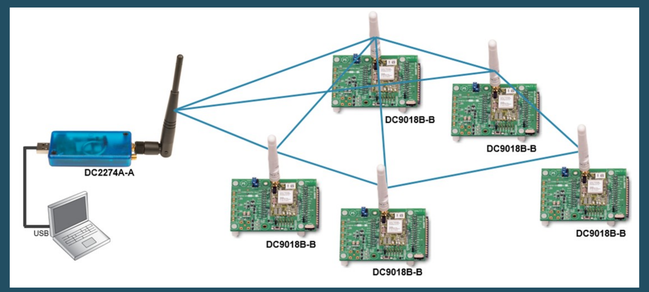
Summary

The Low Power Sensor Suite is a network of low power wireless motes that measure the environmental data within the network, and displays this data to the user in a meaningful way. The environmental data will be collected are temperature, relative humidity, and Nitrous Oxide (N2O). The main purpose of this device is to measure the N2O emissions caused by the out-gassing of radioactive decay at Oakridge Laboratories. The user will manage the Sensor Suite through setup, maintenance, and data interpretation. Management entails the deployment of new motes and a base station, recharging of old motes, and responding to environmental changes based on data presented to the user via a visual dashboard.

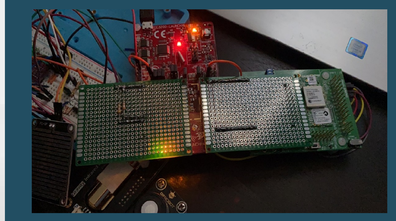
There is a need for low power systems that are able to support these high power gas sensors. N2O sensors are not power friendly sensors and therefore not easily deployable out in an agricultural field or nuclear waste storage facility, where an external source power is not available. In order for this system to be deployable in the field it needs to have a wireless communication system and the ability to enter low power modes of operation.



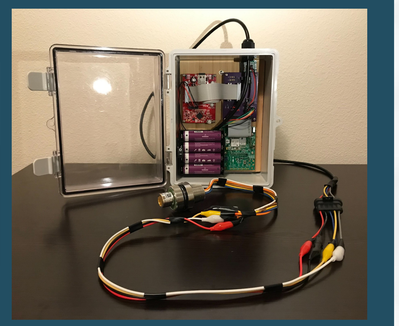
Background

The previous Capstone was able to build a breadboard prototype that was able to detect temperature, humidity, CO2 and O2, and transmit this data wireless where it was displayed on the GUI. This system, however, was not deployable in the field, and their GUI was unstable and buggy. They also had difficulty using certain sensors, since their microprocessor, the CC3200 did not output the correct voltage to operate those sensors.

Our team swapped the microcontroller to the MSP430, and rewrote new code to interface with the SmartMesh IP. We implemented an on-board SD Card storage card for data logging. We added the functionality of the N2O with the temperature and humidity sensors, Designed and built a Printed Circuit Board connecting every component and sensor together, in a sturdy, functional and stable prototype. We found the GUI code unstable and with many bugs, and so converted the GUI codebase to the newest version of Python, fixed the bugs and the corner cases to produce a bug-free stable front-end software. Our prototype is mounted inside a weatherproof IP67 enclosure, fully battery powered, and fully deployable in the field. The battery life is estimated to be 2.5 months.



1st Gen. Prototype

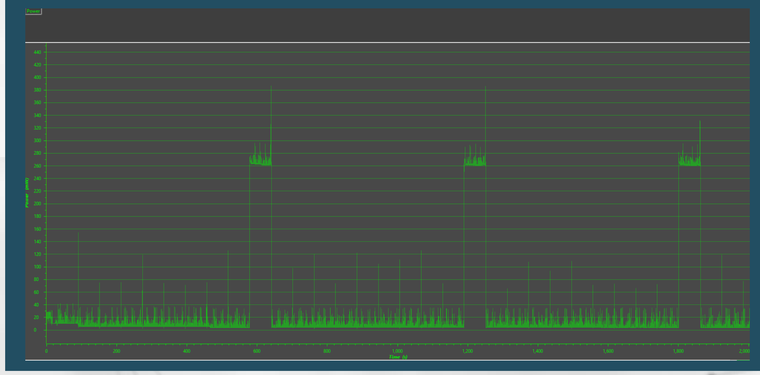


2nd Gen. Prototype

Low Power

The sensor suite runs entirely on batteries without an external source of power, therefore, running at the lowest power is a crucial feature of the system. We chose the MSP430 as it is designed to enter deep lower power states. The highest draw of energy was the N2O sensor, so a separate transistor circuit was implemented to disconnect its power during low power modes to prevent any current leakage. The sensor suite runs on 4 lithium-ion 18650 batteries, at 3.7V, each providing 3400 mAh. The system can run on these batteries for approximately 2.5 months. If desired, the N2O sensor can be disconnected, and the sensor suite would run for over a year.

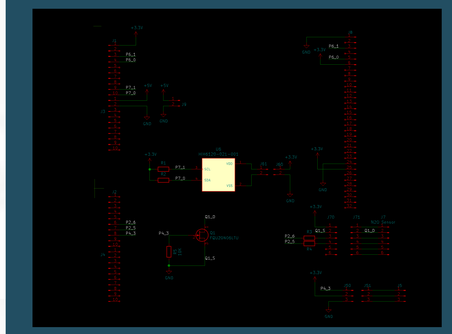
- Battery Power: Four Li-ion, 3.7V, 3400 mAh 18650 batteries
- Sleep mode power consumption: 12 mW
- Temperature/Humidity power consumption: 5 mW
- N2O (maximum) power consumption: 270 mW
- Average Power Consumption: 27 mW
- Overall battery life time with 4 batteries (days): 76 days

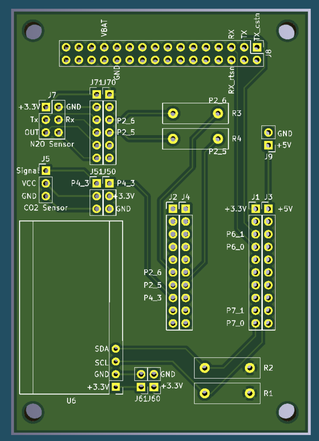


Design and Build

The mote is built with off-the-shelf components found on Digikey and Amazon websites. The components of the system are firmly mounted inside a weather proof IP67 enclosure, protecting it from rain, dust and other common environmental factors. The N2O sensor is connected via an external cable that passes through a waterproof port on the bottom of the enclosure.

The Junction Board (purple PCB) is built with flexibility in mind. It connects all pins of the MSP430 and the SmartMesh via ribbon cables, allowing future circuits to already have full access to the MSP430 GPIO and UART pins, to easily add more sensors to the system.



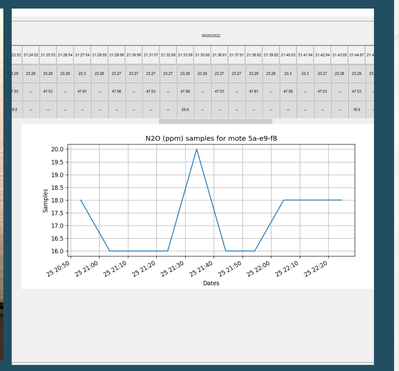


Sensor Data

The sensor suite is designed to be used with hundreds or thousands of motes in a massive network mesh that can relay sensor data throughout the mesh network to a remote base station. Utilizing the SmartMesh IP allows for easy setup and instant wireless connections between all of the nodes and the base station, where live data is stored and can be accessed by a graphical user interface.

The sensor data is also stored on-board in an SD Card as backup due to device failure. The MSP430 has a built-in SD Card reader for this purpose. Although, there was no existing SD Card library that immediately worked, our team was able to implement and modify an existing library and write the functions to format and log the data. The SD Card can store up to 32 GB of CSV (text) file data logging.

This build has temperature, humidity and N2O sensors, and will be deployed at Oakridge laboratories to measure N2O outgassing caused by radioactive decay.



GUI

The end user is able to collect and review live data updating on the Front-end software graphical user interface. The front-end software is easy to install and load with a simple double-click. The end user is easily able to switch between the different sensors taking data, where it updates in real time, and can be left updating indefinitely.

Our team converted the entire GUI code base to the newest version of Python, and resolved all bugs and corner cases, ensuring the end user as a stable and bug free user interface. The GUI updates the data live, and will display incoming data indefinitely.