Team 506: Wear Gas Detector

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1. Project Overview

1.1 Project Description

The objective of this project is to design, develop, and deploy a wearable gas sensor system tailored for CIA search and rescue operations. The specific scenario the box will be tailored to is a building collapse search and rescue mission. This system will equip CIA teams with a reliable and portable tool for detecting and monitoring hazardous gases in disaster-stricken areas, ultimately enhancing the safety and effectiveness of missions. Our project offers seamless integration into Team 505's wearable safety system, providing the flexibility to either detach from the main system or function independently as a standalone unit.

1.2 Key Goals

The objective of this project is to create a wearable gas sensor for search and rescue operations, with a focus on the CIA principles: Confidentiality, Integrity, Integration Ind Availability, to ensure the highest level of data security and reliability. Confidentiality goals include encrypting sensitive gas concentration data and controlling access to authorized personnel. For integrity, the sensor must validate data accuracy and maintain tamper-proof data logs. For our integration goals we want to be able to have the sensor ready to display information on Team 505’s search and rescue device. Availability goals require redundancy and remote monitoring to ensure uninterrupted functionality during critical missions. Comprehensive cybersecurity and physical security measures are essential to safeguard against threats. Usability goals encompass user training and an intuitive interface, while compliance ensures adherence to relevant regulations and ethical considerations, thus ensuring the effectiveness of the gas sensor in search and rescue efforts while upholding data integrity and privacy. The wearable will be modular to allow for first responders to adjust where on the body they wear the box/sensors.

1.3 Assumptions

Our assumptions have been derived from the conversations we have had with our sponsor about their goals and expectations for this project.

Our first assumption for this project is that the scenario(s) being designed for this project will be completely representative of the use case for this project. Team 506 (with team 505) is working to design appropriate scenarios for which a wearable gas sensor could be used by the CIA. While the designed product may be helpful in other situations, our design will be tailored to the selected scenario(s).

We also assume we will only try to detect known gases. We will not be responsible for quantifying novel gases' characteristics. If characteristics of unknown gases can be determined, this will be desirable, but it will not be a main goal of the project. Lastly, we assume that the individual is not in a rush to put the equipment on.

2. Component Description

Note that the bill of materials that includes all purchased items for this project is in Appendix A.

2.1 Modular Box

The modular box is made of AL2024 and consists of the microcontroller, battery, and voltage regulator which can be seen in Figure 1 below. Not pictured are the wires that are used to connect the battery, teensy, voltage regulator to the 19-pole MIL-Spec connector. The box is sealed to the environment and secured by M3 screw holes.

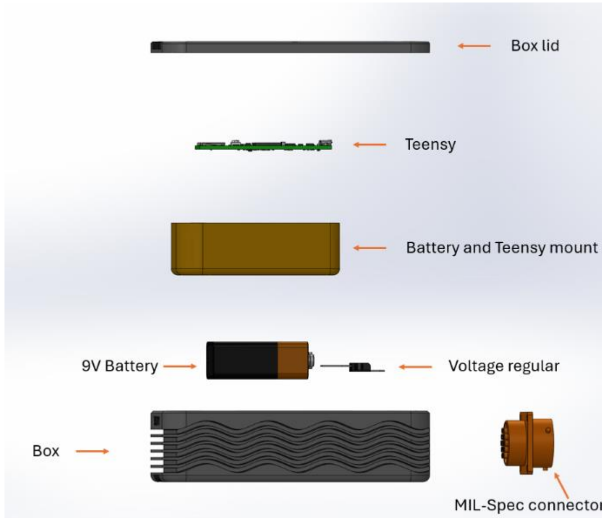

Figure 1: Box Assembly

2.2 Mounting System and Hardware

The mounting system and setup consist of a back harness to secure the box, a power switch, and 2 gas sensors: a gravity oxygen gas sensor and a combustible gas sensor.

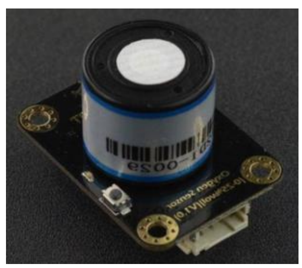

Figure 2: Gravity Oxygen Gas Sensor

The oxygen gas sensor is used to compensate for the error in the combustible gas sensor. Combustible gas sensors can underestimate the gas concentration in the air since there’s more oxygen than expected for optimal combustion. On the other hand, if the oxygen level is lower, the combustible gas sensor might overestimate the gas concentration due to lack of sufficient oxygen for combustion.

Figure 3: Combustible Gas Sensor

The combustible gas sensor is used to detect for all combustible gases; however, as stated above we will only be detecting for known gases. These known gases are methane, butane, or propane. This gas sensor is military grade and uses advanced technology to verify the gas composition and concentration in the air.

2.3 Wiring Diagram

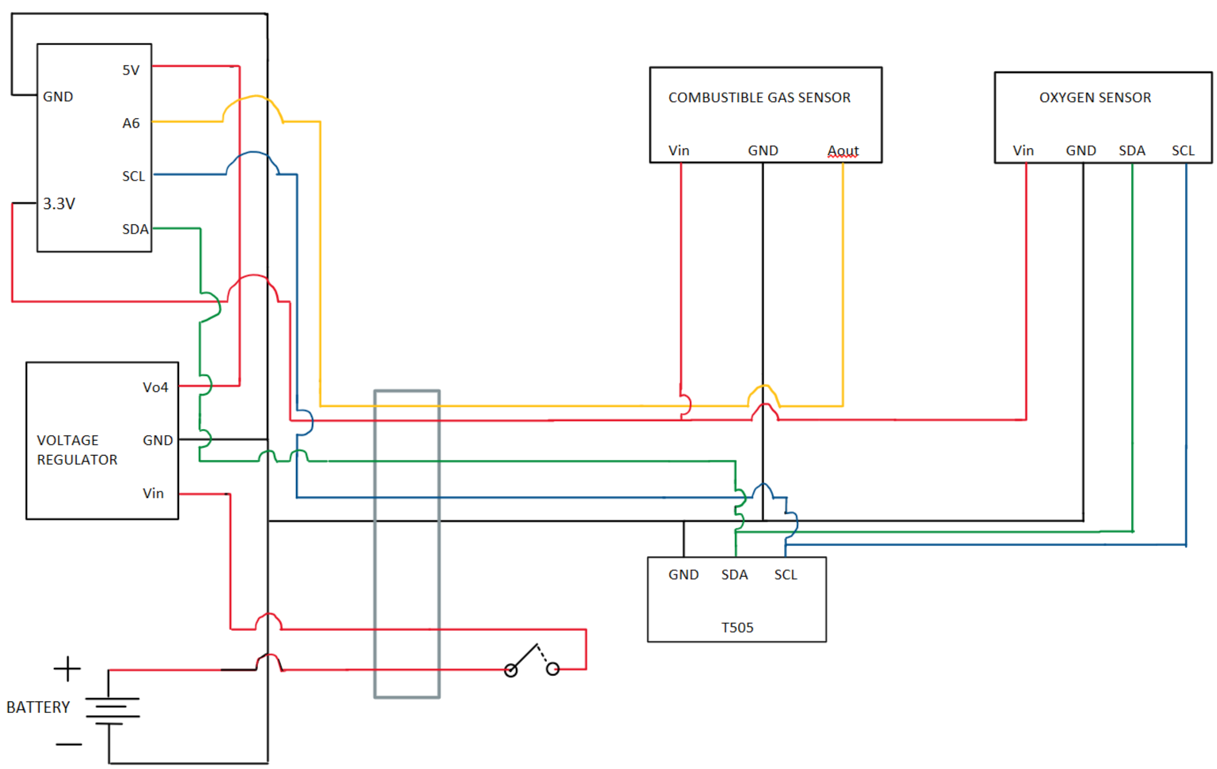

Figure 4: Wiring Diagram

2.4 Thermal Analysis

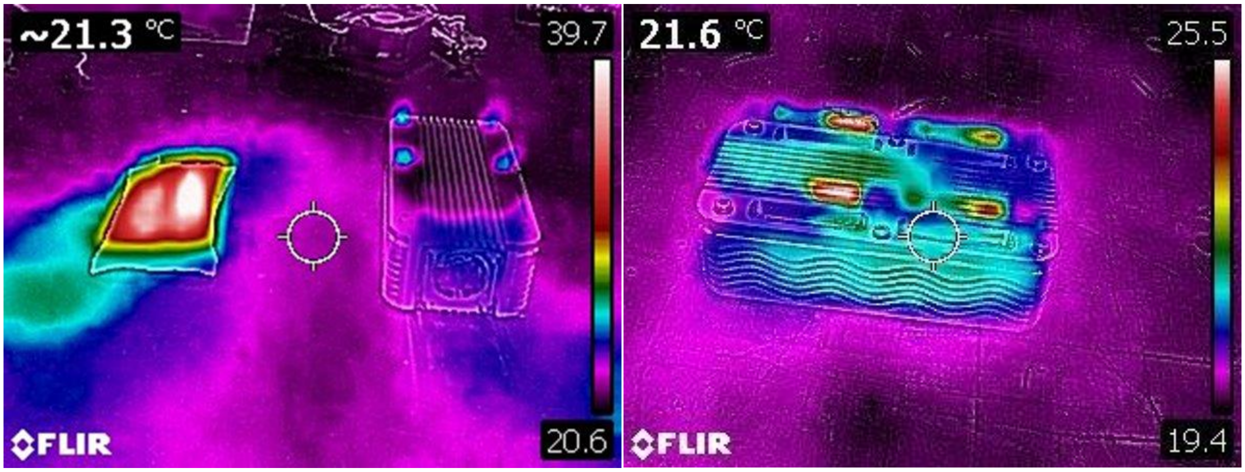

Figure 5: Thermal Analysis

Conducted in the images below was our testing of the thermal analysis. In our key goals, the modular box needs to function within the temperatures of 20°F (-6.66 C) to 100°F (37.7 C). In our thermal analysis test, we placed a heat source (heated bag) was placed next to our modular box until the box reached a steady state. The temperature of the heat source was at most 103.5°F (39.7 C). The box remained at a temperature of about 70.8°F (21.6 C), which was also around room temperature.

2.5 Software Overview

The following code is the analog read from the Nevada nano combustible gas sensor.

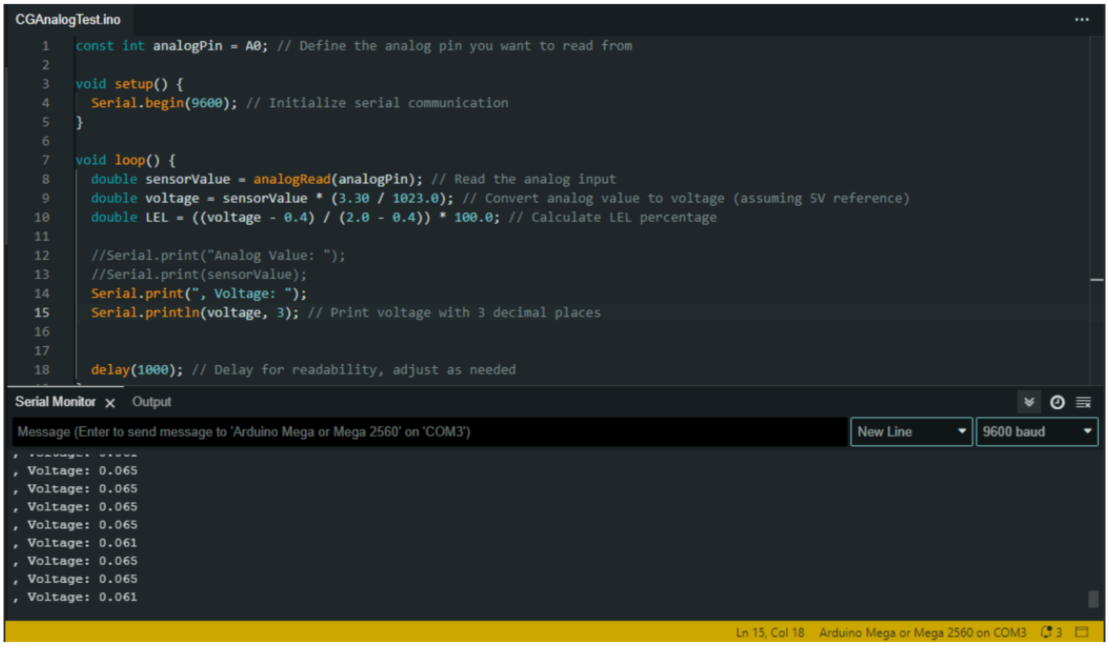

Figure 6: Code Sample

3. Integration

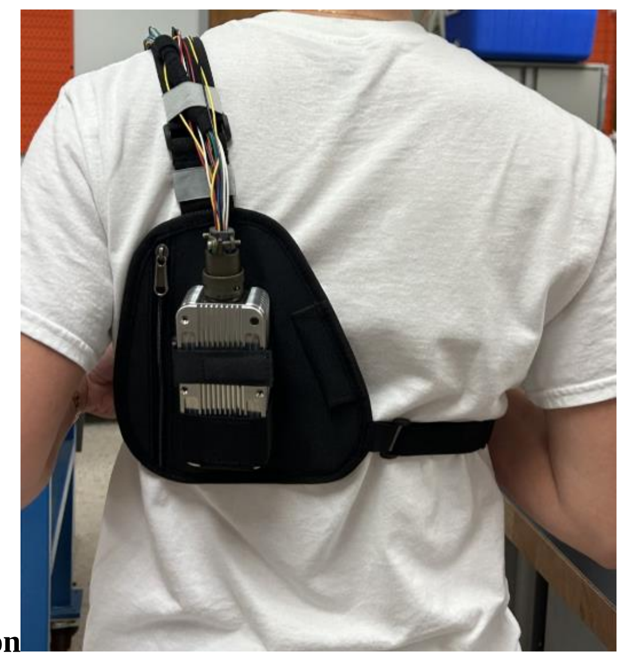

Figure 7: Integration

Our project has been broken down into 2 main systems: the wearable technology and the gas detector. These systems must integrate to be successful in this project. The gas detector is the box and the back harness that has been discussed for much of this paper and the main focus for our team. The box, sensors, switch and helmet are connected individually to the microcontroller via the MIL-Spec connector. The sensors and power switch on the back harness are directly connected to the microcontroller inside the box. The 3 wires that get connected to the helmet are connected from Team 506's microcontroller to Team 505's microcontroller. These 3 wires ensure that there is communication between both teams. For any reason, the device is disconnected, and the user will be notified immediately through the LED on the back harness.

4. Operation

The user should first check that the lid is fastened into the box containing the microcontroller, voltage regulator, and battery. Then, place the box inside the straps that are on the back harness. Adjust the straps to ensure the device will not fall out. When the user has done so, connect the male and female MIL-Spec connector. This connection will help establish communication between Team 505 and Team 506. Check that the wires running up the strap are attached to the 2 gas sensors and the switch. The user can now strap the back harness on using the clips. Connect the 3 remaining wires, that are not fixed to the strap, to the back of the helmet. Lastly, power on the device through the switch attached to the strap. A light should turn on to notify the user, but if not, troubleshooting details can be found in the following section. The light will be green if no toxic gases are detected and will turn red where there are. If the light turns red, the user should leave the area and return to safety. The following image shows the step-by-step process.

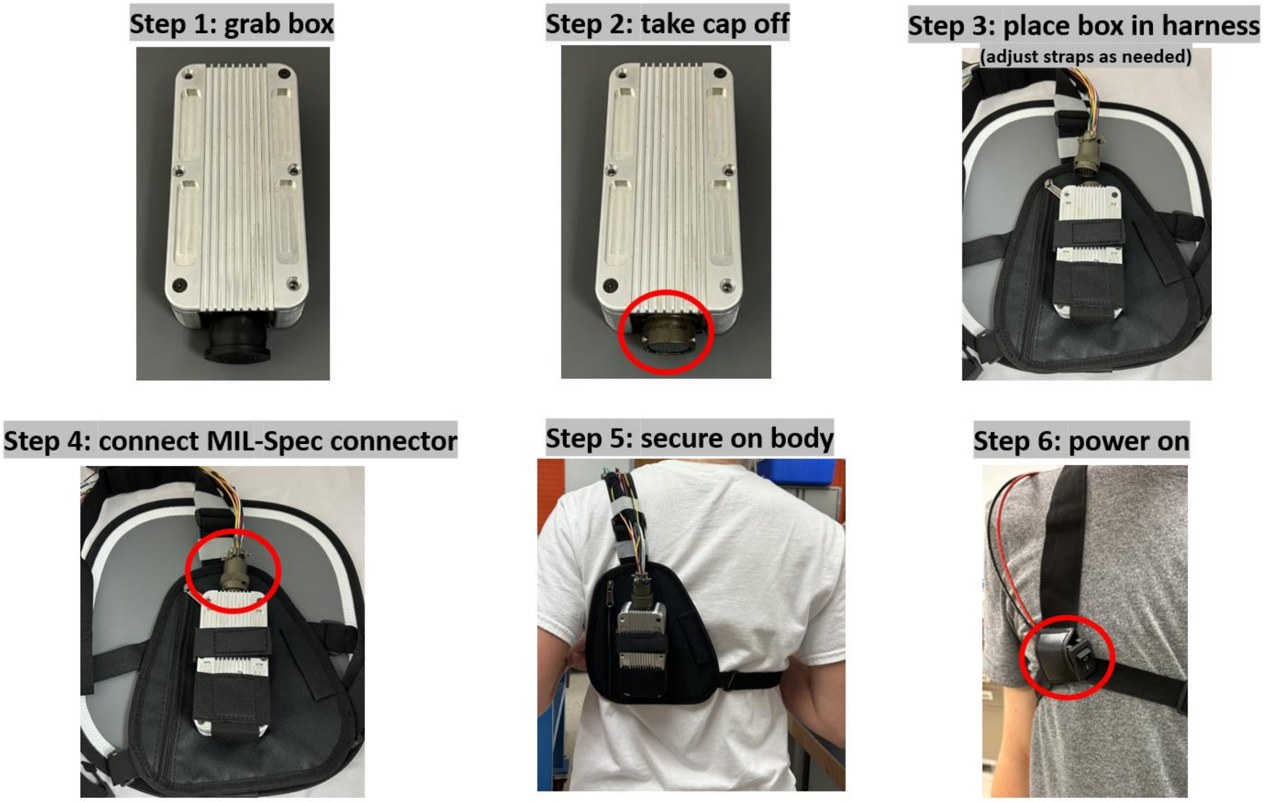

Figure 8: Steps to Operation

5. Troubleshooting

To ensure proper connection between the modular gas box and lcd device ensure the two devices are within 15 feet of each other. Ideally, close to the time of connection (less than 5 feet). Make sure the wires are fully connected and there are no lose connections between any connections. Check to make sure both the Gas sensor has a charged battery in the device and the lcd screen is powering on properly. To prevent error messages when powering up the Modular

Gas box make sure the sensors are not covered by clothing or anything that can block airflow. Also, if the screen is not displaying use another screen and connect it to the gas box to see if the screen is faulty. Retry the steps above to ensure a reading before attempting to connect again. If issues persist, check the wiring to ensure all components are clean and properly connected to their terminals.

If at any point joints or connections produce noise that indicates a loose fit. Check comer joint bolts making sure all are tightened down and in the right place. Check the wheel mounts to make sure everything is in place. Check the motor mounts and the actuator casing to make sure they are in-line with the platform and wheel gears respectively. If the noise originates from the gears, ensure a tight tolerance between both parts and lubricate if necessary.

Appendix A: Bill of Materials

Box	Mnf	Vendor	Vendor Part #
Ardunio Teensey	Spark Fun	Mouser	474-DEV-16771
Battery	Tattu	Amazon	TA-45C-1300-3S-XT60
O'Ring cs2 ID125	McMaster Carr	McMaster Carr	1302N086
Voltage Regulator	Onsemi	Mouser	863-LM337BTG
Mil-Spec Connector Male	McMaster Carr	McMaster Carr	6134T46
Mil-Spec Connector Female	McMaster Carr	McMaster Carr	6134T36

Outer Components	Mnf	Vendor	Vendor Part #
Oxygen Gas Sensor	DFRobot	Mouser	426-SEN0322
Switch	McMaster Carr	McMaster Carr	7194K45
Wire guard	McMaster Carr	McMaster Carr	55545K89
Back Harness	TWAYRDIO	Amazon	B0BY253WV3
Hook and loop ties	McMaster Carr	McMaster Carr	3955T286
Combustile Gas Sensor	Nevada Nano	Nevada Nano	5487N8