Operation Manual

C.I.A. Team 505: Wearable Fashion Technology

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I. Project Overview

In recent years, there have been more natural disasters causing a lot of damage. Sometimes buildings collapse, trapping people underneath. The CIA asked us to make a wearable device to help rescue teams stay safe. This device can detect dangerous gases and metals quickly and let the users know, so they can stay out of harm's way when they're trying to save others.

The objective of this project is to develop an innovative wearable for the CIA, featuring an integrated gas detector, as well as additional technology to aid in building collapse search and rescue missions. To satisfy this objective the team created a helmet with an integrated Head-Up Display (HUD) that will intake from team 506's connected gas detector and pulse-Ox sensor to then display the user's status onto the HUD using an OLED screen and reflective film placed onto a polarized visor.

We split the project into three parts: helmet, technology & coding and integration. This division helped break the project down into more manageable sections and allowed for a parallel work structure. The helmet team was over the overall helmet design and ensuring the components fit securely and comfortably on the user. They were also over the ergonomics of the project and had to conduct crowd research to get multiple opinions on the overall feel and fit of the helmet, making sure it was about to accommodate to the 99th percentile of the population comfortably. The technology team was over all code and integration of technological components into the helmet, especially the connection of the HUD.

II. Component Description

Hardware Overview:

Figure 1: Teensy 4.1

Teensy 4.1 is the latest Teensy microcontroller development board from PJRC. It features an ARM Cortex-M7 IMXRT1062 processor at 600 MHz. The actual size is 2.4 by 0.7 inch, the same form-factor as Teensy 3.6. Teensy 4.1 uses the same processor as Teensy 4.0, but provides greater I/O capability, including an ethernet PHY, SD card socket, and USB host port. Teensy 4.1 also comes with 4X larger flash memory and has 2 locations to optionally add more memory. Teensy 4.1 & 4.0 use the same IMXRT1062, so most technical specifications are the same.

Figure 2: 1.3" 128X64 IIC I2C SPI Serial OLED Display Module

1.3-inch OLED display module with 128x64 resolution. The emissive electroluminescent layer is a film of organic compound that emits light in response to an electric current. Working without a backlight, the OLED display module could give out light by itself. The OLED screen can achieve a higher contrast ratio in low ambient light condition. Small dimension, suitable for MP3, function cellphone, smart watch, and smart health device.

Figure 3: RGB LED

Forward Voltage (R/G/B): 2.0 / 3.2 / 3.1V, Forward Current: 20mA, Intensity (R/G/B): 550 / 250 / 700 mcd, Common Cathode.

Figure 4: MAXREFDES117 Pulse Oxygen Sensor

MAXREFDES117 is a low-power, optical heart-rate module complete with integrated red and IR LEDs. This tiny board, perfect for wearable projects, may be placed on a finger or earlobe to detect heart rate accurately. This versatile module can work with Arduino® and Mbed™ platforms for quick testing, development, and system integration. A basic, open-source heart rate and SpO_2 algorithm are included in the example firmware. The Analog Devices MAXREFDES117 features 8 sewing tap pads for attachment and a quick electrical connection to a development platform.

Figure 5: SFM-27 Buzzer

SFM-27, 3-24V, Continuous beep active buzzer, High-decibel, 12V Electronic, 95DB Alarm buzzer alert for Arduino.

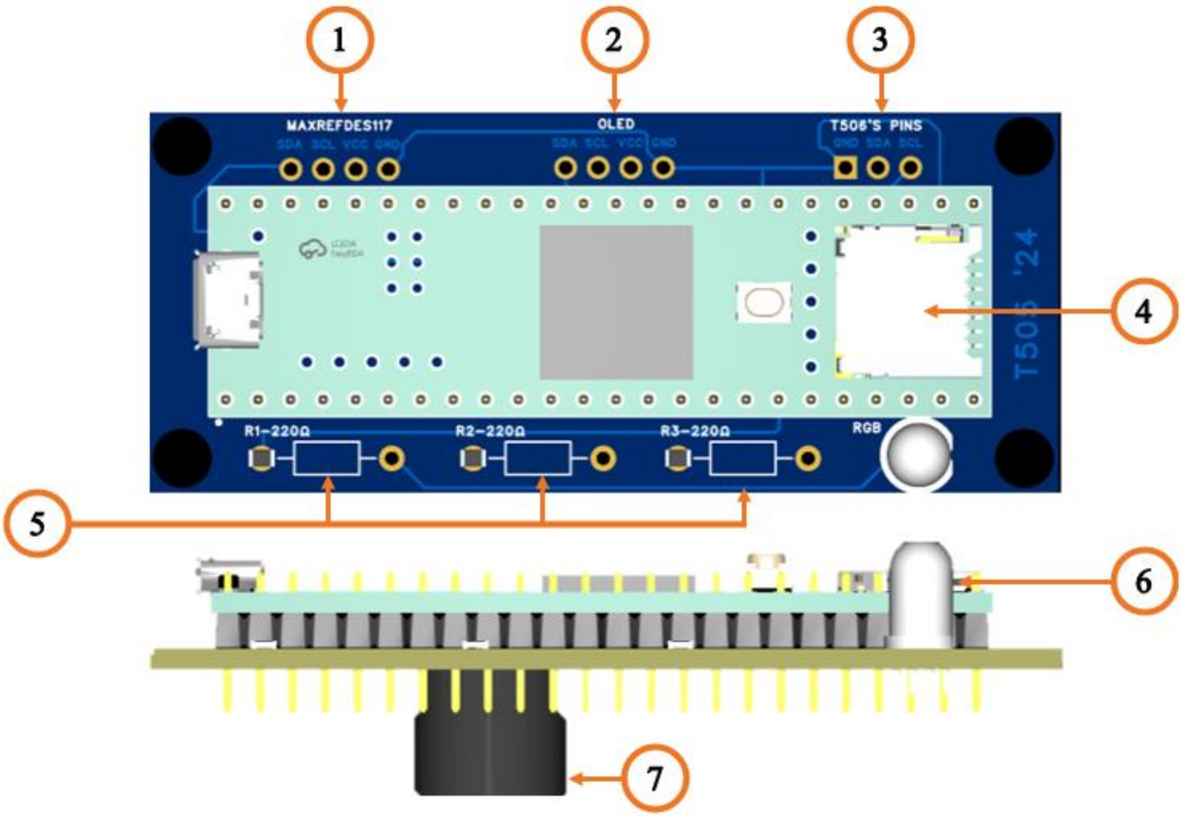


Figure 6: Printed Circuit Board Model

A specially designed printed circuit board (PCB), also called printed wiring board (PWB), is used to connect, or wire components to one another in the circuits. Utilizing a PCB in combination with the Teensy microcontroller will allow direct connections for the specific modules. The PCB decreases excess wires and solidifies the connection to the headers.

Number	Description
1	MAXREFDES117 headers
2	OLED headers
3	Team 506's headers
4	Teensy Microcontroller
5	RGB LED resistor headers
6	RGB LED headers
7	SFM-27 Buzzer header

Software Overview:

The following code is the code for the alerting system, for both the gas alert and the vitals alert. If any problems occur in the code, please refer to the troubleshooting section.

```
#include <U8g2lib.h>
#include <Wire.h>

#define SCREEN_WIDTH 128 // OLED display width, in pixels
#define SCREEN_HEIGHT 64 // OLED display height, in pixels

U8G2_SH1106_128X64_NONAME_F_SW_I2C u8g2(U8G2_R0, /* clock=*/ 16, /* data=*/ 17,
/* reset=*/ U8X8_PIN_NONE); // SH1106 OLED (128x64 pixels)

const int buzzer = 11; //Buzzer to arduino pin 11

int redPin= 7; //Red pin 7
int greenPin = 6; //Green pin 6
int bluePin = 5; //Blue pin 5

void setup() {
  Wire1.begin(); // SDA on pin 17, SCL on pin 16
  u8g2.begin();

  pinMode(buzzer, OUTPUT); // Set buzzer - pin 11 as an output

  pinMode(redPin, OUTPUT); //Set redpin to output
  pinMode(greenPin, OUTPUT); //Set greenpin to output
  pinMode(bluePin, OUTPUT); //Set bluepin to output

  pinMode(2, INPUT); //Pin 2 as input
}

void loop(){

  int heartRate = 96 ; //Declaring input for heart rate *replace with sensor
reading*
  int o2Level = 98 ; //Declaring input for o2 level *

  if(digitalRead(2) == HIGH) { //If the button is pressed

  u8g2.firstPage();
  do {
    u8g2.setFont(u8g2_font_ncenB08_tr); // Choose a font
```

```
  // Line 1: Gas alert
  u8g2.setCursor(10, 30);
  u8g2.print("GASES DETECTED");

  // Line 2: Gas alert
  u8g2.setCursor(15, 45);
  u8g2.print("SEEK SHETLER");

} while (u8g2.nextPage());
//delay(1000); // Delay to slow down the text update rate

setColor(255, 0, 0); //Red Color
tone(buzzer, 3000); //Send xHz sound signal...
delay(500);
setColor(0, 0, 0); //No color
tone(buzzer, 3200); //Send xHz sound signal...
delay(500);
}
else{ //If the button is not pressed
setColor(0, 255, 0); // Green Color
noTone(buzzer);     // Stop sound...

u8g2.firstPage();
do {
  u8g2.setFont(u8g2_font_ncenB08_tr); // Choose a font

  // Line 1: Heart Rate
  u8g2.setCursor(0, 15);
  u8g2.print("Heart Rate: ");
  u8g2.print(heartRate);
  u8g2.print(" bpm");

  // Line 2: O2 Level
  u8g2.setCursor(0, 30);
  u8g2.print("O   Level: ");
  u8g2.print(o2Level);
  u8g2.print(" %");
  u8g2.setFontMode(1); // Enable transparent mode for the subscript
  u8g2.setDrawColor(1); // Set the draw color to white
  u8g2.setCursor(8, 35); // Set cursor position for subscript
  u8g2.print("2"); // Print subscript "2"
  u8g2.setFontMode(0); // Disable transparent mode for normal text
  u8g2.setDrawColor(1); // Set the draw color back to white

  // Line 3: Status
```

```
    u8g2.setCursor(0, 45);
    u8g2.print("Status: ALL CLEAR");

  } while (u8g2.nextPage());
  delay(1000); // Delay to slow down the text update rate
  }
}

void setColor(int redValue, int greenValue, int blueValue) { //Closing setup for RGB pins
  analogWrite(redPin, redValue);
  analogWrite(greenPin, greenValue);
  analogWrite(bluePin, blueValue);
}
```

III. Integration

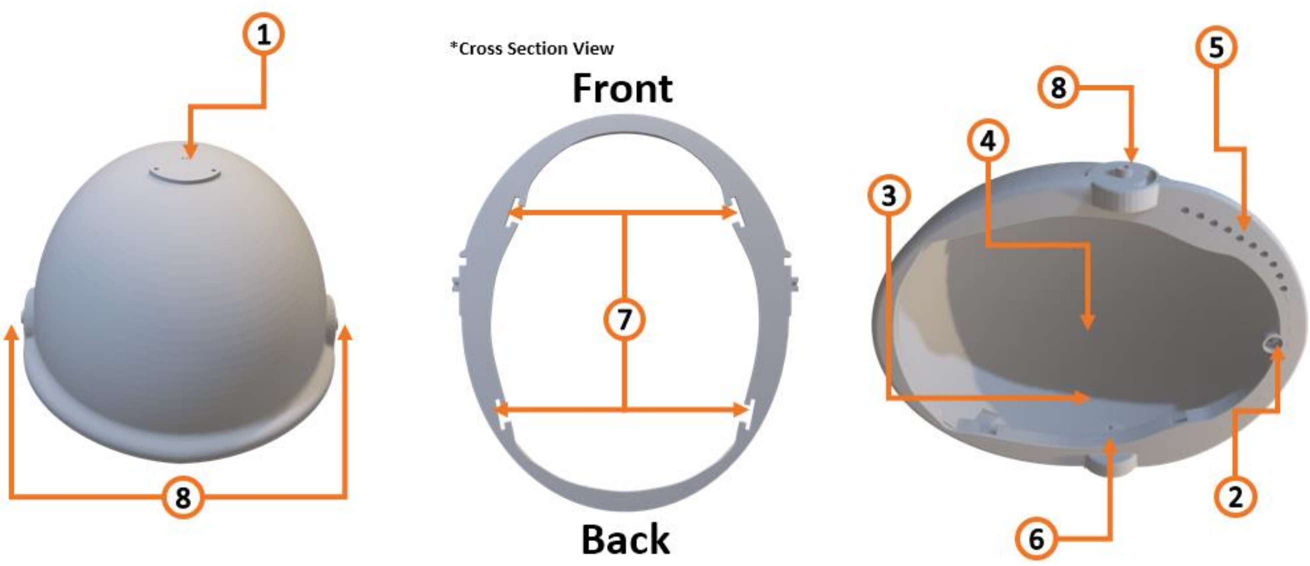


Figure 7: Schematic for Helmet Components

Number	Description
1	SFM-27-W Speaker
2	RGB LED
3	T-CORE Power Bank
4	Printed Circuit Board (PCB)
5	OLED LED
6	Chin Strap
7	Head Harness

8	Photochromatic Visor

Our helmet consists of three main sections in terms of assembly: helmet shell, alerting/electronics, and headgear. Each component's location is specified by a number in the figure above. When assembling, it is most efficient to connect the alerting/electronics systems into the helmet shell prior to the headgear. **(1)** The SFM-27-W Speaker is first mounted onto the top of the outer shell of the helmet. M3-0.5 screws are used to secure the speaker in place using a T8 Allen wrench. **(2)** Then the RGB LED is snapped into place in the front of the brim of the helmet shell. **(3)** Next the T-CORE Power Bank is fitted into place using Velcro straps. **(4)** The Printed Circuit Board (PCB) is attached to the inside top surface of the shell using set screws. **(5)** The OLED screen can be attached to the front of the helmet using heat inserted set screws. Multiple holes are available for the user to place the screen in a personalized location best suited to the user's vision. Wires are used to connect the listed components to the PCB. All wiring from the electronics can be held in place using the wire guides built into the helmet's shell. After attaching all the electronics, the headgear can be connected to the helmet. **(6)** The chin strap can be attached to the side of the inside of the helmet using a heat inserted screw as well a washer to keep it in place. **(7)** Next the adjustable head harness can be clipped into place in the four holes shown in the figure above. The adjustable portion of the head harness should be exposed in the back of the helmet. **(8)** Finally, the photochromatic visor can be attached on both sides of the helmet using heat inserted screws and washers to reduce the amount of play in the device but still maintain its adjustability so the user can move it up or down.

IV. Operation

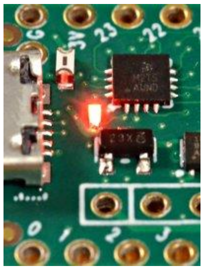
To begin operation of the device, the user must first take the battery pack out of the helmet by loosening the Velcro straps holding it in place. Once the battery pack is out, press the power button to power the battery pack on and wait for the light to flash, this is to indicate that the battery pack is on. Before replacing battery, check the current percentage of battery and either plug in battery or replace in the helmet. When the battery is placed back into the helmet, plug in the main wire from the PCB and secure the battery with the Velcro straps. Once the battery is securely fastened, the OLED screen should be powered on and begin displaying the vitals information and status onto the HUD.

This is with the assumption that the gas detector and helmet have already been assembled and were correctly connected and then powered off prior to this current use. If this assumption is incorrect, please refer to the integration section and connect the helmet and gas detector to each other. If any problems persist after connecting, please refer to the troubleshooting section below.

V. Troubleshooting

General Power Loss:

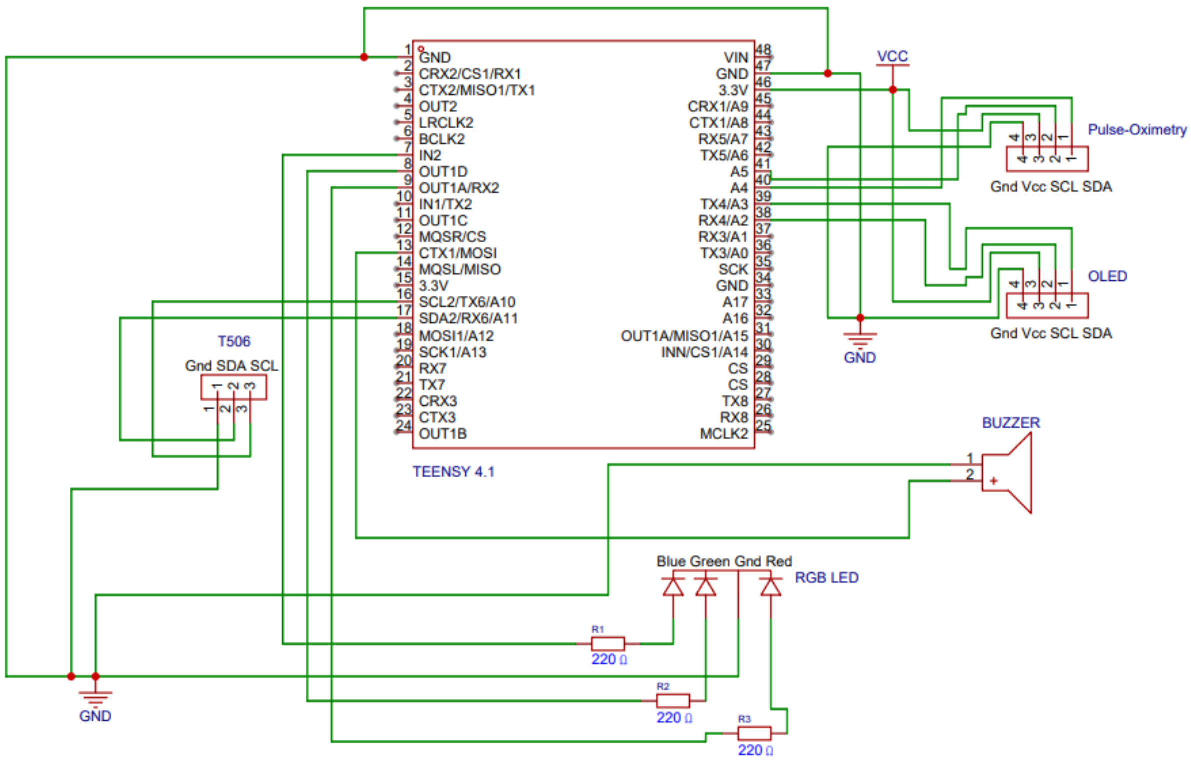
If the device loses power, first ensure the battery is fully charged. This information will be on the side of the battery. If the battery is not fully charged, obtain a USB cord and plug the battery into a wall outlet. If the battery will not charge, replace it. If the battery is fully charged, check the connection between the battery and the Teensy. The light on the Teensy indicates if it is receiving power.



If the light is not on, try a different micro-USB cord to see if the current cord is the issue. If the cord is functioning, remove the Teensy from the PCB, and plug it into a computer. If the light still does not turn on, then the Teensy will need to be replaced.

Electrical Components Not Working:

If the OLED, pulse-ox, speaker, or RGB LED is not working, obtain a multimeter to test for continuity between the Teensy and the PCB. Each of the previously mentioned components has labeled pins on the PCB. Trace each of the sensors' pins back to their respective Teensy pins (the traces can be seen on the surface of the PCB). Place one of the leads on one of the labeled pins for the faulty component on the surface of the PCB and the other lead on the correct Teensy pin that is connected to the labeled pin through the trace (shown above). Test each pin for the faulty component to ensure that the PCB is not damaged. If it is damaged, replace it and test if that fixes the problem. If there is continuity between the Teensy and the PCB pins test the continuity of the wires that connect the components to the PCB. If there is a faulty wire, replace it with a new wire, ensuring that it is placed in the correct place. If there is continuity, but the components are still not working check to see if there is any physical damage to the components. Even if there is not and everything else is checked, such as power and all wiring connections, replace the components.



Pulse-Oximetry Sensor Readings:

If the values of the pulse-oximetry sensor seem inaccurate, first check a certified medical device to ensure your suspicions are true and that there are no serious medical issues present. Seek immediate help if the certified device also gives alarming readings. If it has been deducted that it is an ensure with the sensor and not a medical emergency, check the senor placement. Ensure that it is firmly pressed on the ear lobe. Wait a few moments and check the readings. It is important to note that the readings from the sensor might fluctuate due to internal limitations.

Physical Problems:

If the visor, chin strap, or the head harness system becomes loose, check to make sure that they are all securely fastened and not damaged. If they appear to be damaged, replace them. If the threaded inserts for the chin strap and/or visor are loose, remove the inserts and replace them with new ones.

To install new inserts, place the insert on the tip of a soldering iron and gently press them back into the plastic. The plastic will soften, once the threads are flush with the surface of the plastic, stop pressing and remove the soldering iron. Let the plastic harden and then the components with their respective screws can be reattached. For the head harness, first check to ensure that the mounting points on the helmet are not damaged. If it is not damaged, place the harness back in its' desired location and secure it in place with glue.