Vehicle Fever Detection System

ECE 445 Design Document

Team 67 - Rahul Rajkumar, Vinayak Dhanawade, Vishnu Rathnam

ECE 445 Project Proposal - Spring 2021

TA: Dean Biskup

1. Introduction:

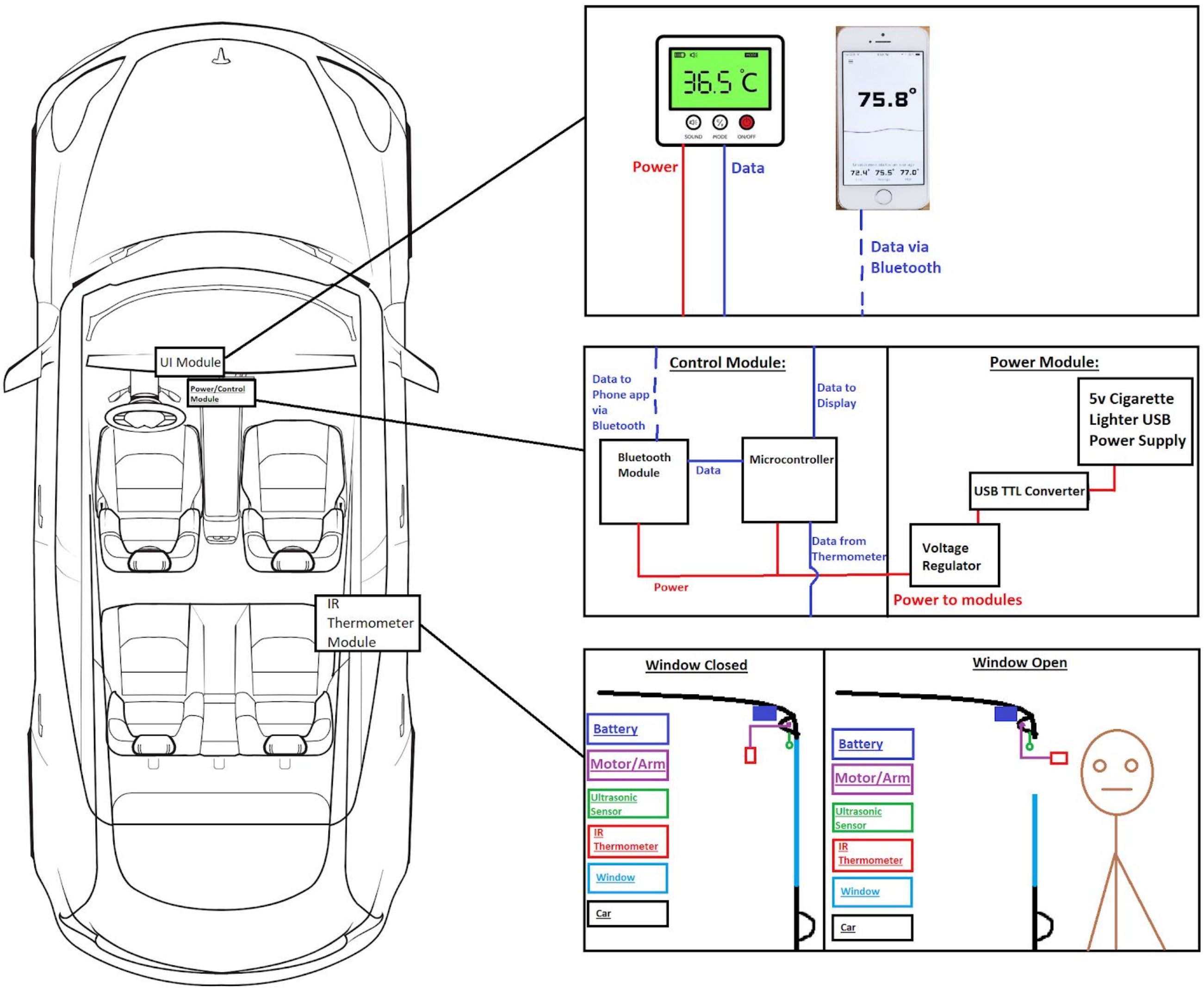
1.11 Objective:

A problem that is frequently encountered due to the COVID 19 pandemic is that of spread through rideshare services such as Uber and Taxis. This is primarily due to the fact that vehicles are a closed environment with relatively low ventilation and air circulation. This is even more true in taxis and rideshare vehicles because they are used by a large amount of different people every day. Our solution to this problem is to implement a system that can be mounted on the interior door of vehicles that extends an MLX90614 IR thermometer [1] out the window to check riders temperatures before they enter the vehicle. The arm to extend the thermometer will be activated by an ultrasonic sensor which will detect when the window has rolled down enough to safely extend the thermometer. The system will then alert the driver via a digital display as to whether the current passenger has a fever and give the specific temperature. The driver can then decide on a plan of action with this information in order to effectively limit the spread of COVID 19 and ensure both their safety and that of future passengers. This system also has applications in the future after the pandemic in that drivers can choose whether to accept riders that are sick in general based on if they have a fever, a common flu symptom.

1.12 Background:

The issue of COVID 19 being transmitted through rideshare and taxi services is pressing due to the fact that the drivers and patrons are put at a high risk of transmitting COVID 19 by being in close proximity to others in an enclosed space. This is exacerbated by the users having to touch surfaces that are frequently used and touched by many others. While masks suffice to prevent spread in open spaces, their effectiveness is severely limited in an enclosed space with limited ventilation like a car. According to a study by the Norweigan Institute of Public Health [2], Taxi and Rideshare drivers are among the highest risk groups for getting COVID 19 due to their constant proximity to many different people every day. Since this risk is so high we hope our solution will provide both those drivers and the passengers that interact with them a higher level of safety than that of simply wearing a mask.

1.2 Visual Aid:



1.3 High Level Requirements:

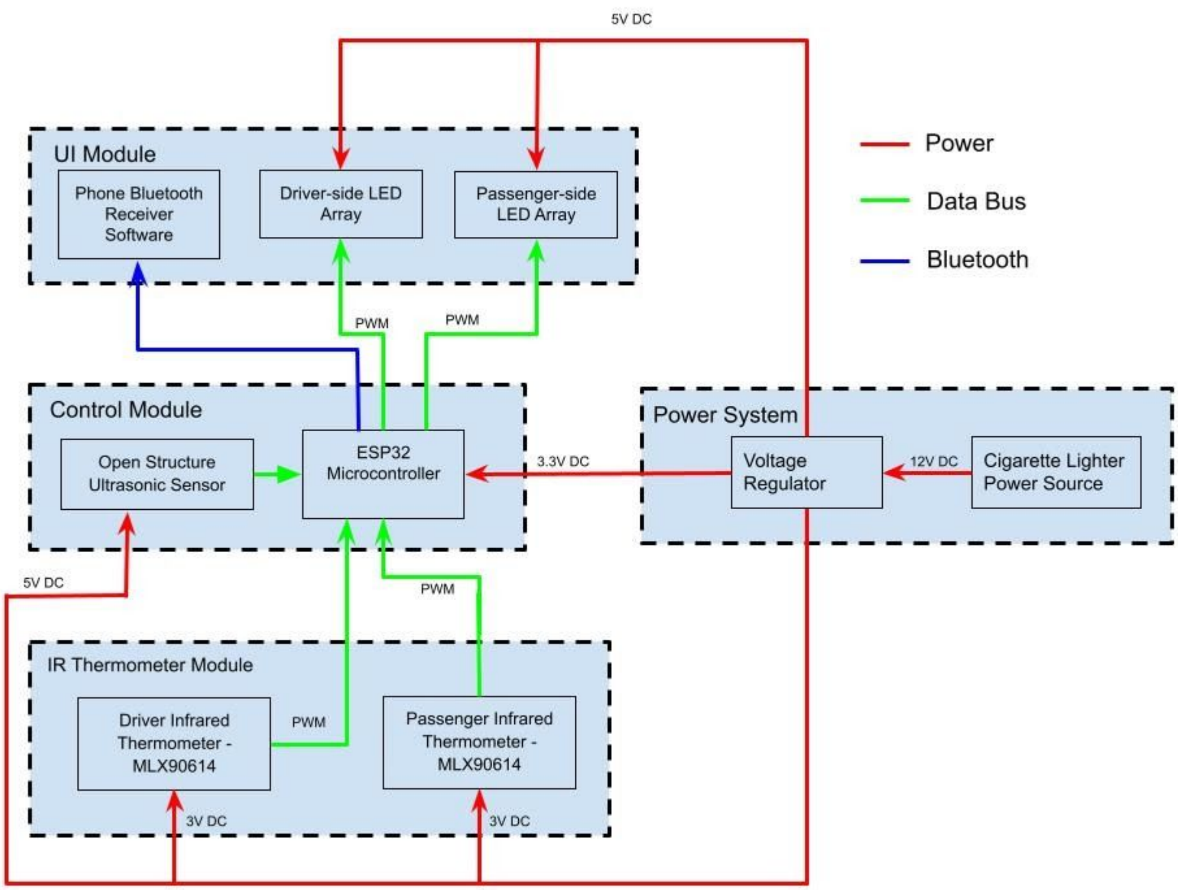
- The ultrasonic sensor operating the arm that will reach out will detect when the window has fully rolled down in order to trigger the activation of the arm to reach out the thermometer and place it in a position in which it is accessible by the patron from a standing position.
- The readings must be at least 90% accurate with a +/- .5 degree celsius variance and provide info to the driver on the display on whether the passenger is at a

dangerous temperature (above 37.5° C as defined by the national institute for health research [3]) for various infrared thermometers.

- Bluetooth latency must be under 300 ms between the bluetooth module and the phone

2. Design:

2.1 Block Diagram :



2.2 Physical Design:

2.3 Subsystem Descriptions / R&V Tables:

Power Subsystem : The power system of our project consists of two components, the cigarette lighter power source from the car, and the voltage regulator. The power source will be 12V DC, and this power will be delivered to the voltage regulator. The voltage regulator will bring this output voltage down to a manageable level and will route the power to the other components of our system. That is, it will power the UI , control, and thermometer modules.

UI Subsystem : The overall system must be able to deliver accurate results from the control module to the driver. These results must be delivered in the form of LEDs which represent the suggested course of action for the driver and passenger (the results will be displayed to both the driver and the passenger). While minimal, one of the LEDs will light up to recommend the driver to reject or admit the potential passenger, based on the data passed by the microcontroller. The driver will also receive this information via bluetooth on their phone. The data will be sent via bluetooth from the ESP32 microcontroller, to the driver’s phone on receiver software. The passenger-side LEDs will notify the passenger if he/she is within the correct distance from the thermometer in order to get an accurate reading. Depending on the distance between the thermometer and the passenger, as measured by the ultrasonic sensor, the green LED will light up to represent correct positioning of the passenger, or the yellow/red LEDs will indicate if the passenger needs to move closer or farther.

IR Thermometer Module :
The thermometer module will contain two IR thermometers (MLX90614) [1] that will read the potential passenger’s temperature as well as the driver’s temperature and send that data to the microcontroller. The passenger thermometer reading will be used by the control module to determine if the passenger should be allowed into the vehicle, while the driver side thermometer will be to confirm that the reading for the passenger is accurate.

Control Module :
This module will house the ESP32 microcontroller that will process the data from the thermometer and produce results to be displayed on the UI subsystem for the driver to view. This module also contains an open structure ultrasonic sensor that will detect if the passenger is too close or too far or properly positioned from the IR Thermometer in order to get an accurate reading. The control module overall servers as a middle man, as well as the core processing unit for the overall system. It links all three main components of the system together, and will generate the recommended course of action (either to allow the passenger into the vehicle or to turn them away) for the driver. It will also generate the recommended change in positioning for the passenger to get an accurate temperature reading.

Thermometer Module : This module consists of the two IR thermometers

Requirement	Verification
1. IR Thermometer measures temperature with at least 95% accuracy within +/- 1 degree celsius variance	1 equipment : IR thermometer, 1a. Take various temperature measurements with both IR thermometer and traditional under tongue thermometer 1b. Measure temperatures and compare variance and accuracy between temperatures 1c. Repeat 10-15 times

Power Module : This module handles the power delivery to each of the other components. It derives the system's power source from a car's cigarette lighter, and regulates it to be sent to the other components.

Requirement	Verification
1. The voltage regulator must deliver power within a 3.3-5V +/- .5% range, from a 12V DCcigarette lighter source 2. The current delivered is between 0-150 mA	1a. Using an oscilloscope, measure the output voltage from the voltage regulator to see that the voltage stays within 5% of some voltage between 3.3 and 5 V. 2a. Connect the output from the voltage regulator to the input voltage (VDD) of a constant-voltage test circuit 2b. Alter resistance values in this circuit until a consistent nonzero current at most 150mA is reached 2c. Once this current is reached, ensure that the voltage is within 5% of the 3.3-5V range using an oscilloscope.

UI Module : This subsystem contains the deliverables for the driver. That is, it displays the temperature reading to the driver and the recommended course of action (either to allow or reject the potential passenger).

Requirement	Verification
1. The phone software receiving	1a. Run bluetooth receiver software on

measurement data from the microcontroller receives/displays this data with the recommended course of action and delivers a notification within 500ms 2. The LEDs display the results of a measurement within 30sec consistently. 3. The passenger-side LEDs display the status of the passenger's positioning immediately, within 500ms of changing position. 4. Calculated results are displayed both on phone and via LEDs accurately (at least 95% accuracy in displaying the intended results)	phone 1b. Send randomized temperature data via the microcontroller's bluetooth capabilities to a phone 1.c Track in a table how the latency of receiving data and pushing a notification to phone 2a. The LEDs will display the recommended course of action to both the passenger and the driver within 30sec 3a. Place something in front of ultrasonic sensor, change distances, measure how quickly LEDs change 4a. Keep feeding various temp values and track accuracy of the decisions made

Control Module : This subsystem contains the core processing unit of the overall system. It contains an ultrasonic sensor to control movement of the thermometer module, as well as a microcontroller that will process measurements, determine results and transmit them via bluetooth and LEDs.

Requirement	Verification
1.The thermometer should be positioned between 4-6 inches so as to maintain accuracy of the measurement taken. The ultrasonic sensor must accurately detect this distance within a .5inch accuracy. 2. The ESP32 microcontroller must accurately determine the recommended course of action to the driver such that if the passenger's body temperature is above 99 degrees F (37.2 C), the passenger should not be allowed into the car. 3. The microcontroller should send measurements and recommendations to the driver's phone via bluetooth within 500ms of taking the temperature.	2a. Take various temperature measurements with both IR thermometer and traditional under tongue thermometer 2b. Measure temperatures and compare variance and accuracy between temperatures 2c. Repeat 10-15 times

Points Summary :

Module Name	Requirement	Points
Thermometer Module		10
Power Module		10
UI Module		15
Control Module		15

2.4 Circuit Schematic

2.5 Tolerance Analysis:

One of the tolerance factors we will test is the bluetooth modules. We will test both the receiver and transmitter using over-the-air link testing. A bluetooth connection is established between the tester and DUT and the tester conducts a series of tests and measurements while maintaining connectivity. The main points we will test are latency, power output, data rate and range. For our connection to be successful, the data has to be sent to the receiver phone under 500ms. The range of the device has to be at least 3m and the power output must not exceed the maximum power draw of 5V. We are considering multiple bluetooth transmitters such as the HC-05 which has been tested thoroughly and suits our conditions [8].

Our IR sensor is another tolerance factor. A paper from an IOP conference [9] shows the error and tolerance analysis of an ultrasonic sensor (HC SR-04) and an IR sensor (SHARP GP2Y0A21YKOF). Both these errors fall within our acceptable tolerance range. These sensors are also able to calculate the full range of our temperature reading use case within a reasonable amount of tolerance [10].

3 Costs & Schedule:

3.1 Cost Analysis:

We calculated our labour costs at approximately $30/hr for 3 graduate engineers over the course of 16 weeks working 10 hrs/week.

$$3 \times 30 \times 10 \times 16 \times 2.5 = \$36,000$$

Part	**Cost**
HC05 Bluetooth controller	$8.80
7-Segment Display - 20mm (White) COM-11409 ROHS	$3.25
ATMEGA328P-AUR	$2.18
Infrared Thermometer - MLX90614	$29.95
Ultrasonic Distance Sensor - HC-SR04	$3.95
Voltage Regulator - 3.3V COM-00526 ROHS	$1.95
USB DC 5V to 3.3V DC/DC Step-Down Converter Power Supply Module	$1.37
12V Car Cigarette Lighter Socket Splitter Dual USB Charger Power Adapter	$7.95
Total	**$59.40**

Total Parts + Labour = $36,000 + $48.13 = $36,059.40

3.2 Schedule:

Week	Rahul	Vinayak	Vishnu
3/7	Finalize design for PCB	Start developing software to connect sensors to display	Finalize parts list and place orders

3/14	Place order for PCB. Validation tests for Thermometer module	Validation tests on UI modules	Test and confirm sensor reliability
3/21	Validation tests for control module	Begin testing UI connection through bluetooth	Validation tests for power module
3/28	Assemble control module	Assemble UI module	Assemble power and thermometer modules
4/4	Unit test control module	Unit test UI module	Unit test Power and thermometer modules
4/11	Connect modules and verify basic operation	Connect modules and verify connectivity	Connect modules and verify power delivery
4/18	Bug fixing and final modifications and adjustments	Stress testing, particularly with UI module and bluetooth connection	Begin working on presentation and final paper
4/25	Fix any lingering issues and begin work on report and presentation	Fix any lingering issues and begin work on report and presentation	Fix any lingering issues and begin work on report and presentation
5/2	Finalize and wrap up presentation and paper	Finalize and wrap up presentation and paper	Finalize and wrap up presentation and paper

Ethics and Safety:

To follow the ECE 445 Safety Guidelines while working on this project, we will have at least 2 people in the lab working at all times, have completed the mandatory online safety training and have certification, have proper planning and additional safety training completed when working with high voltages, and follow safe battery usage guidelines.

We will wear safety glasses while working on the project and proper hand protection while soldering. We will also be careful of electrical circuitry by grounding ourselves and the circuit properly before turning on the power.

In order to follow all of the Code of Ethics as determined by the IEEE [4], we will not identify a specific individual with their temperature results and will not store any temperature data. Also, we will disclose to the patient that their temperature results will be shared with the driver but not stored or shared with anyone else. All our wiring will be enclosed in insulation and routed safely throughout the vehicle, preventing any entanglement, static hazards, or loose/hazardous electrical connections. Our unit will also be stress tested for durability and will be able to withstand travelling at high speeds without detaching from the car door and being a potential debris hazard. All this combined ensures that we will be following all ethical and safety guidelines set by OSHA [5].

References:

[1] Sparkfun, ‘Infrared Thermometer - MLX90614’ 2015 [Online]. Available: https://www.sparkfun.com/products/9570

[2] Norweigan Institute of Public Health, ‘More COVID-19 in some occupational groups’ 2020 [Online]. Available: https://www.fhi.no/en/news/2020/more-covid-19-in-some-occupational-groups/

[3] National Institute for Health Research, ‘Non-contact infrared thermometers’ 2013 [Online]. Available: https://www.community.healthcare.mic.nihr.ac.uk/reports-and-resources/horizon-scanning-reports/hs-report-0025#:~:text=Two%20studies%20defined%20fever%20as,%2Dglass%20thermometer%20(17).

[4] IEEE code of ethics. (n.d.). 2021 [Online] Available: https://www.ieee.org/about/corporate/governance/p7-8.html

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[6] Murata, ‘Basic knowledge about ultrasonic sensors: Features of each type of ultrasonic sensor’ 2014 [Online]. Available: https://www.murata.com/en-us/products/sensor/ultrasonic/library/basic/feature

[7] EDGEFX, ‘How Bluetooth Module Interfacing with Microcontrollers’ 2017 [Online]. Available: https://www.edgefxkits.com/blog/interfacing-hc-05-bluetooth-module-with-microcontroller/#:~:text=The%20microcontroller%20can%20communicate%20with,information%20to%20other%20Bluetooth%20devices.

[8] HC-05 Latency Test [Online] Available: https://www.youtube.com/watch?v=AnqPpt8dsbE&ab_channel=GautamM

[9] S Adarsh et al 2016 IOP Conf. Ser.: Mater. Sci. Eng. 149 012141 [Online] Available: https://iopscience.iop.org/article/10.1088/1757-899X/149/1/012141/pdf

[10] GP2Y0A21YK Data Sheet [Online] Available: https://www.sparkfun.com/datasheets/Components/GP2Y0A21YK.pdf