

Non-Contact Thermal Scanner



Team 6

Agenda

1. Customer Requirements
2. Project Timeline
3. Product Description
4. Product Demo Video
5. Electrical Specification
6. System Overview
7. Hardware Block Diagram
8. Parts/Module Details
 - ❖ Arduino Mega 2560 microcontroller
 - ❖ Audio System
 - ❖ SD Storage
 - ❖ Motion PIR Sensor
 - ❖ Thermal IR sensor
 - ❖ Base Board
 - ❖ TFT Touch display
9. Firmware flow chart
10. System Validation and Verification
 - ❖ Black Box Testing
 - ❖ Each Module Testing
 - ❖ System Verification
11. Module Testing Demo Video
12. Mechanical Enclosure
13. BoM
14. Schematics
15. PCB Layout
16. Challenges and Future Improvement
17. Summary

Customer Requirements

1. Customer Requirement: The system should be accurate.

Engineering Requirement: The temperature readings should be within +/- 1 degrees Fahrenheit of a standard thermometer.

2. Customer Requirement: The system should alert the user when they have a fever.

Engineering Requirement: The system should indicate via sound and a display when the recorded user temperature is greater than or equal to 100.4 degrees Fahrenheit.

3. Customer Requirement: The system should require no contact to function.

Engineering Requirement: The system should be controllable by the user from 1 cm or greater with no contact.

4. Customer Requirement: The system should log user information.

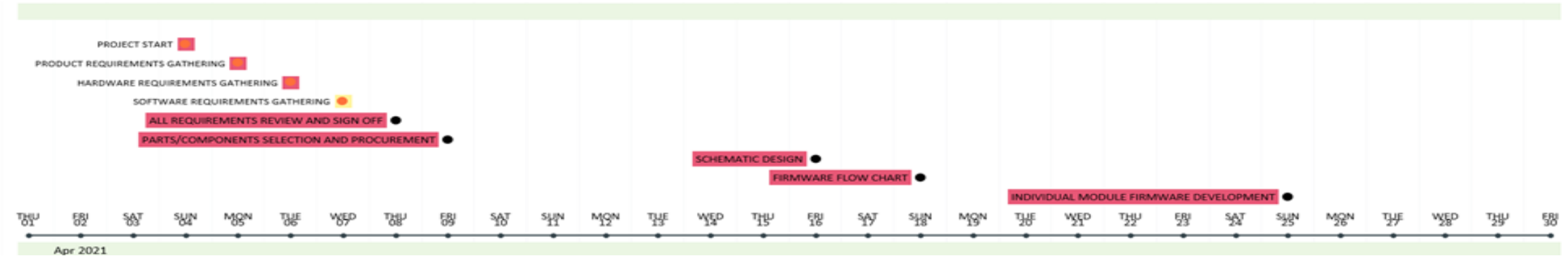
Engineering Requirement: The system should automatically record all users and their temperature for the last 24 hours.

5. Customer Requirement: The system should be intuitive.

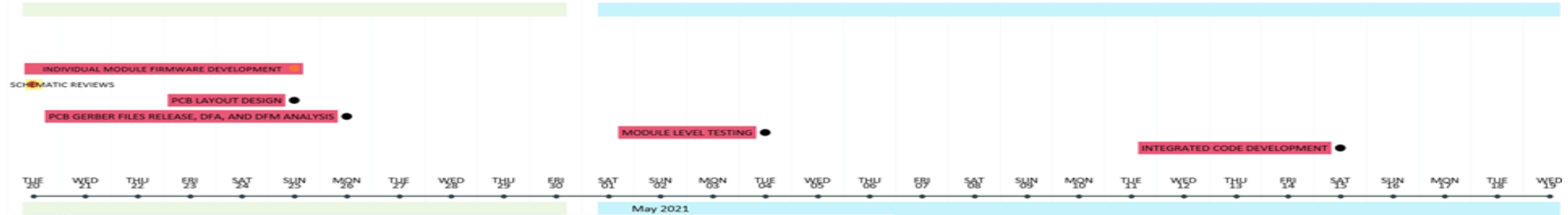
Engineering Requirement: The system should be usable with no outside instruction for at least 2 people other than the project designers.

Project Timeline

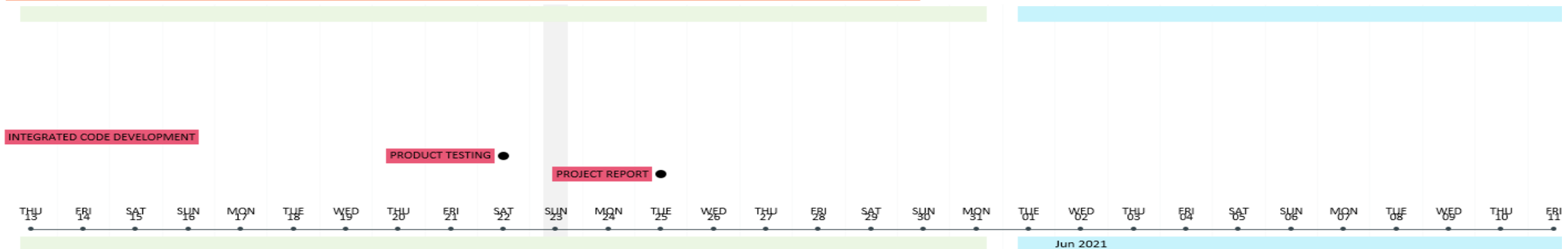
NON-CONTACT TEMPERATURE SCANNER PROJECT TIMELINE



NON-CONTACT TEMPERATURE SCANNER PROJECT TIMELINE



NON-CONTACT TEMPERATURE SCANNER PROJECT TIMELINE

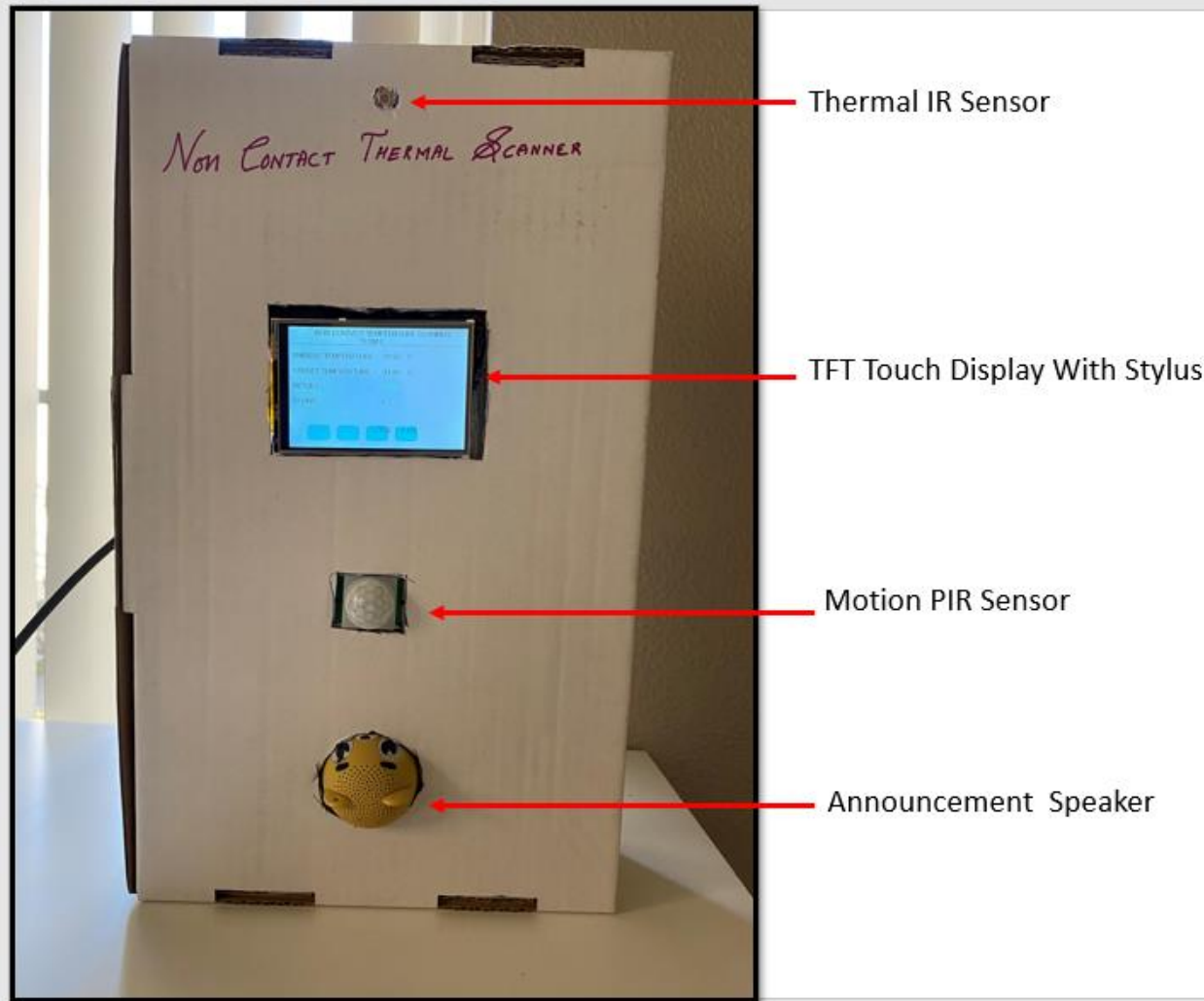


Product Description

- The non-contact temperature sensor is an accurate system which is intended to perform the following tasks:
 - ❖ Detect human presence and movement.
 - ❖ Audible voice announcement alerting the user providing the instructions, and temperature measurement results.
 - ❖ Capture user body temperature, and verify it exceeds 100.4°F with $\pm 1^\circ\text{F}$ accuracy.
 - ❖ Display the ambient temperature, user count, user body temperature with pass/fail result criteria.
 - ❖ Record the user data with timestamp in a SD storage in csv/txt format.
- Key technologies used in this project are motion detection sensor unit based on thermal imaging, accurate IR temperature sensor, speaker system with audio driver, touch color graphics tft display integrated all integrated with ATmega2560 - 8-bit AVR

Microcontrollers

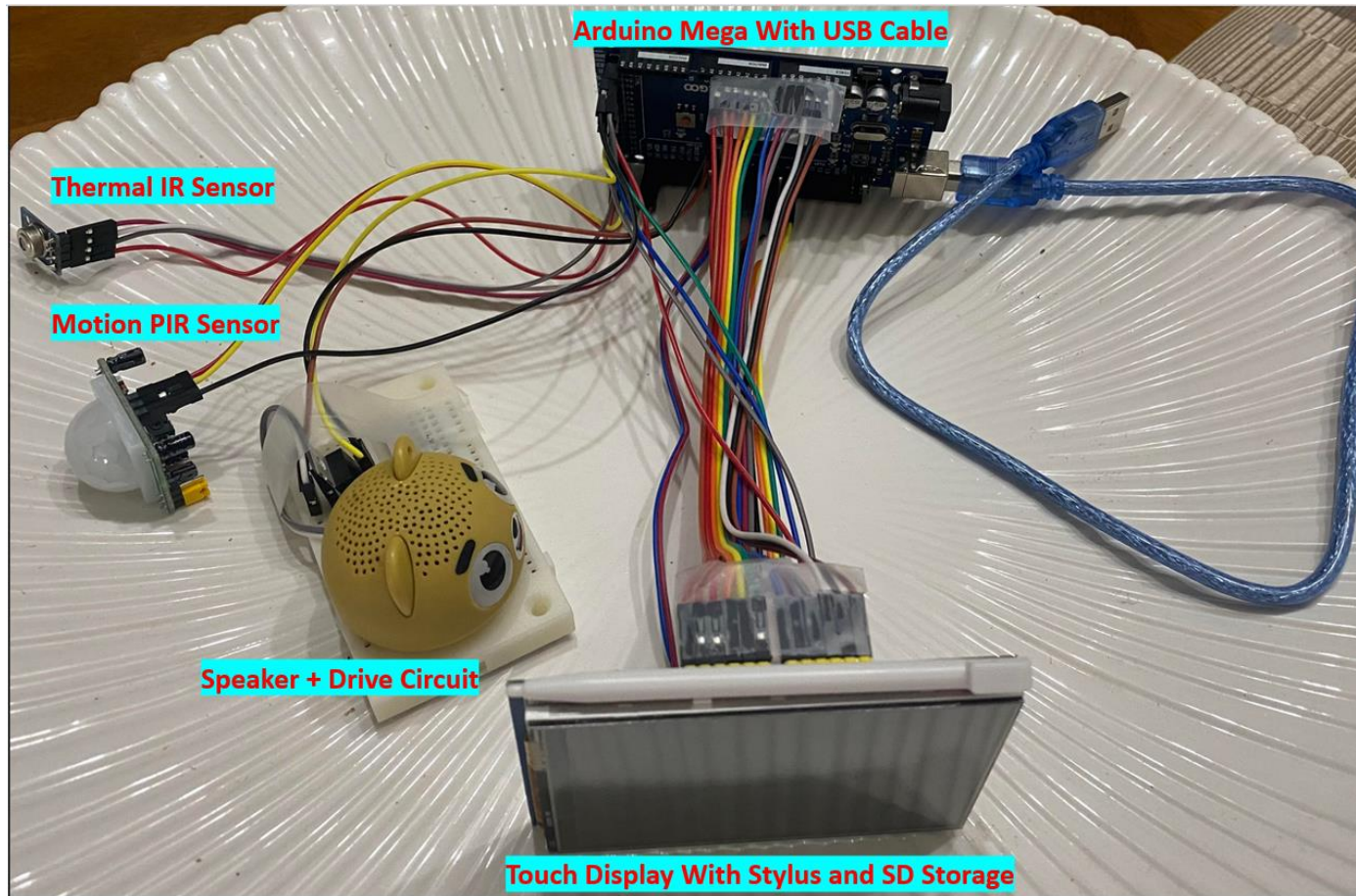
Product Demo Video



Electrical Specification

- Power Adapter input 100~240V AC 50/60Hz and output 5V, 1A DC
- Motion sensing range less than 120 degree, within 7 meters.
- Non-contact temperature sensing with +/- 1deg F accuracy and operating between
 - 89.6 deg F to 111.1 deg F range
- 3.5inch TFT LCD Screen Module 480x320 Resolution HD with touch
- Upto 4 GB external storage for data logging

System Overview



The system comprises of the following parts:

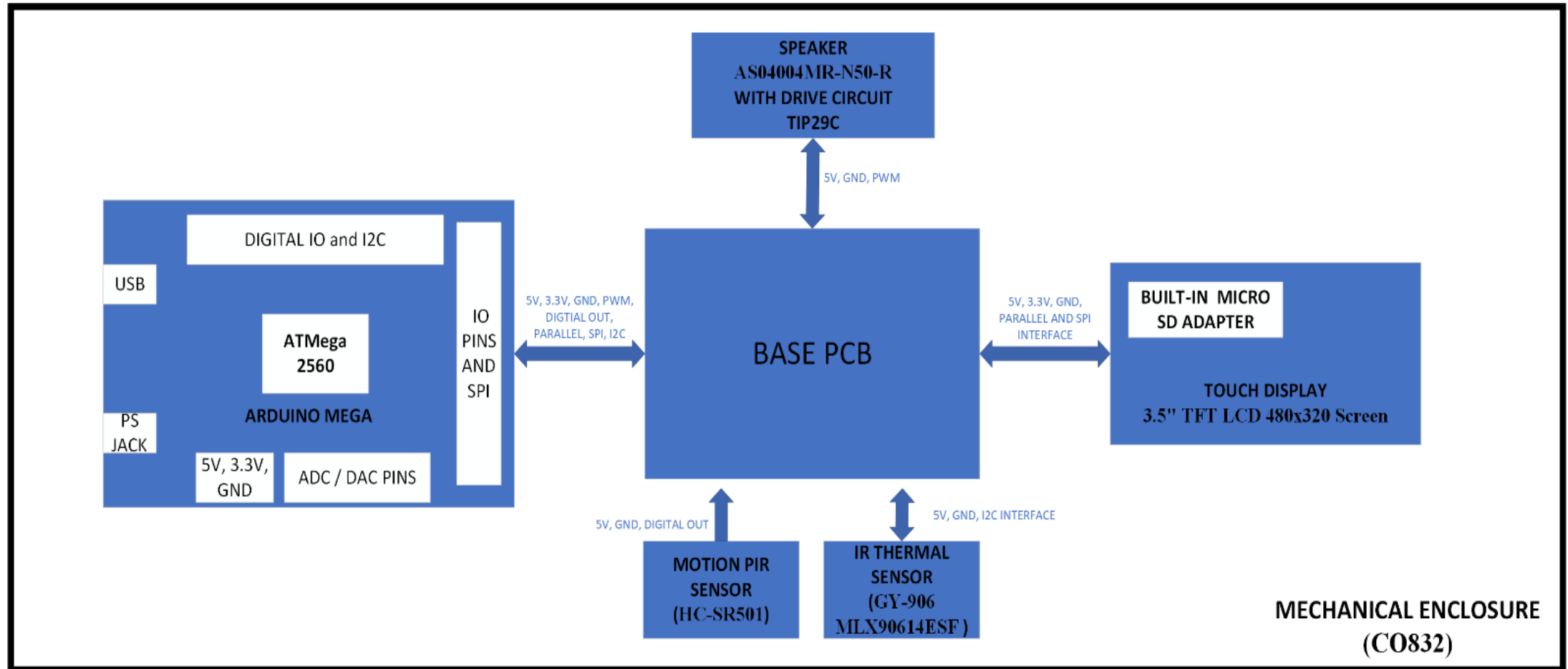
- ❖ Arduino mega 2560 with USB cable / power adapter
- ❖ Audio driver with speaker
- ❖ TFT touch display with micro-SD card slot
- ❖ IR thermal sensor
- ❖ Motion PIR sensor

Connect all the modules referring the pin connections like shown in the attached photo.

Module Connections

- Display + Micro SD Card: 24 pin connection to Arduino -> 20 signals + 2 power rails (3.3V and 5V) + 2 GND
- PIR Motion Sensor: 3 pin connection to Arduino -> 1 power rail (5V) + 1 Signal + 1 GND
- IR Thermal Sensor: 4 pin connection to Arduino -> 2 signals (SDA & SCL) + 1 power rail (5V) + 1 GND
- Speaker: 3 pin connections to Arduino -> 1 signal (PWM) + 1 power rail (5V) + 1 GND. A BJT may be required to add with speaker for high current gain.

Hardware Block Diagram

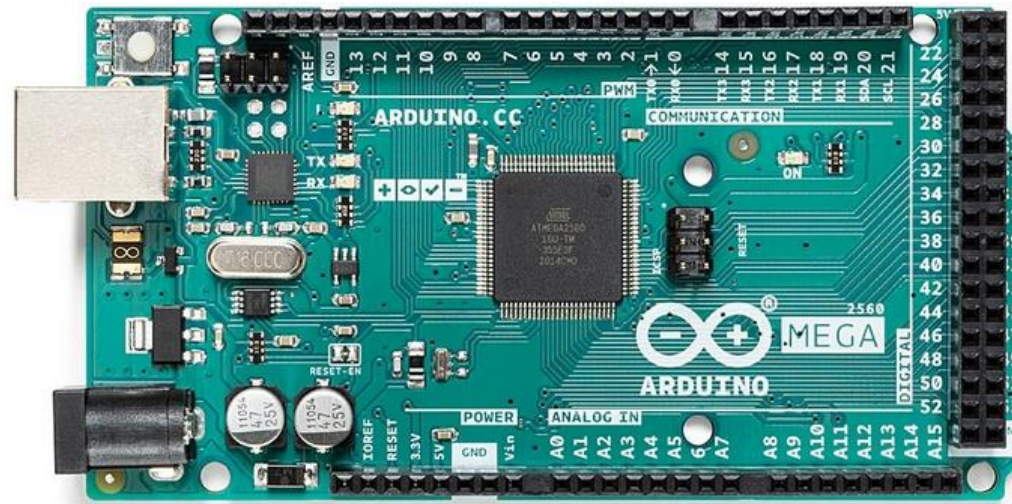


Parts/Modules Details

- ❖ Arduino Mega 2560 microcontroller
- ❖ Audio System
- ❖ SD Storage
- ❖ Motion PIR Sensor
- ❖ Thermal IR sensor
- ❖ Base Board
- ❖ TFT Touch display

Arduino Mega 2560 Microcontroller

The Arduino Mega 2560 is a microcontroller board based on the [ATmega2560](#). It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.



Audio System

- ❖ The simplest way to generate an audio signal to play on the speaker is to use a hardware PWM output. Set the PWM period to $1/\text{frequency}$ of the desired sound.
- ❖ The PWM duty cycle is set to 0.5. A lower duty cycle setting produces lower volume.
- ❖ The advantage of using the PWM hardware is that it takes minimal memory and no processor time to output an audio tone.
- ❖ A TIP29C NPN BJT was used for high current gain.



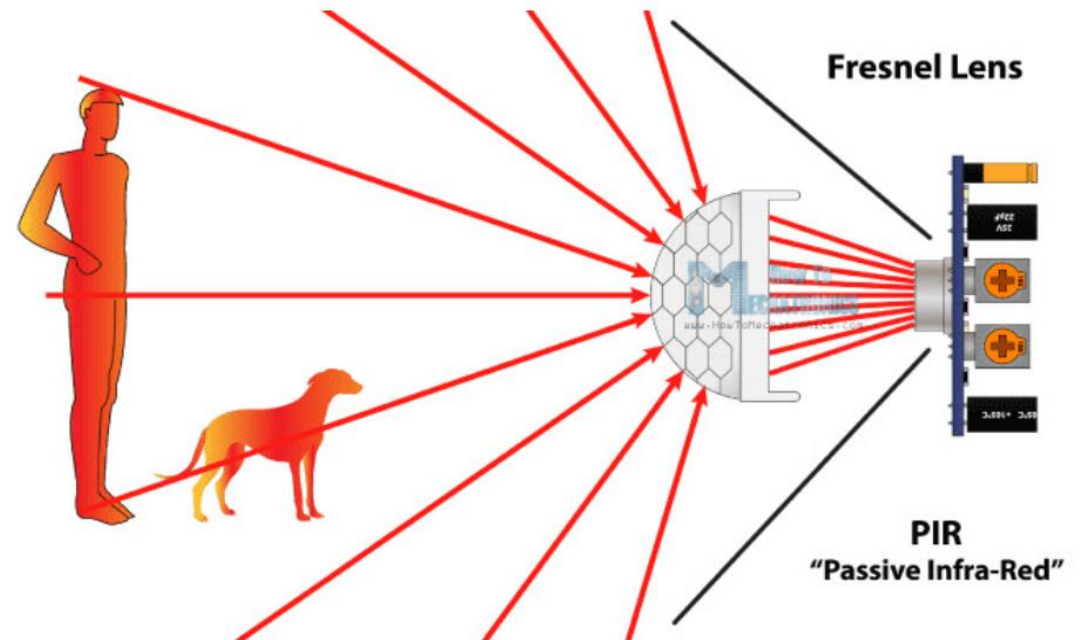
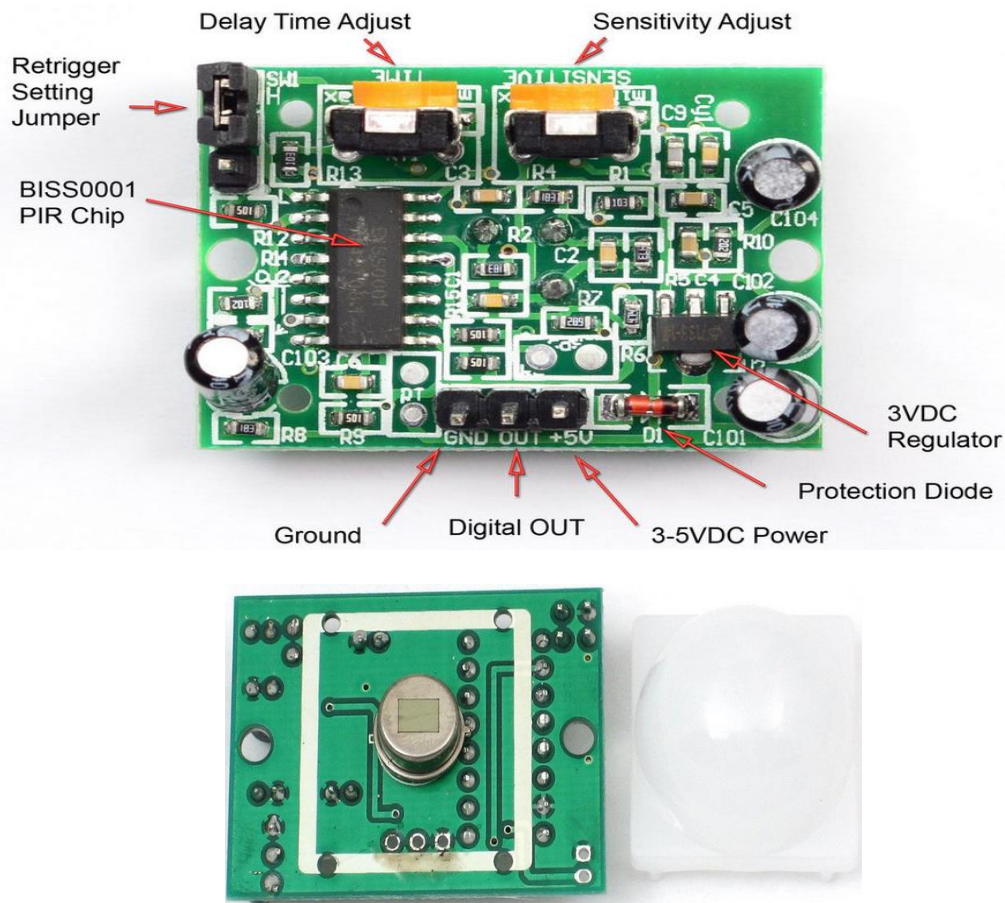
SD Card Storage

- ❖ A micro-SD card up to (4GB) can be externally plugged into the card adapter inside the system for data.
- ❖ The micro-SD is interfaced via SPI protocol to the microcontroller.



Motion PIR Sensor

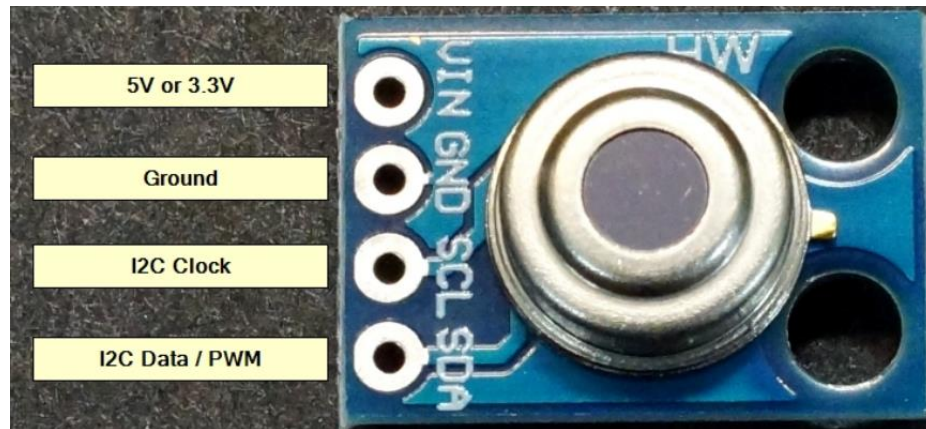
PIR sensors allow you to sense motion, almost always used to detect whether a human has moved in or out of the sensors range. They are small, inexpensive, low-power, easy to use and don't wear out.



Thermal IR Sensor

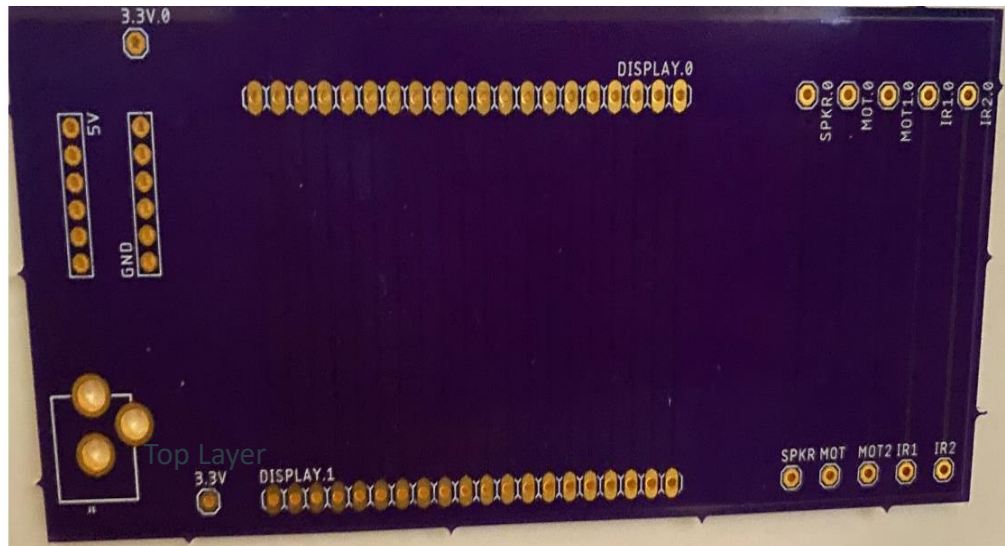
The GY-906 MLX90614 is a high precision infrared non-contact thermometer module with I2C interface and 5V or 3.3V operation.

- ❖ Non-contact measurement perfect for measuring temperature of moving objects.
- ❖ Temperature measurement range: -70°C to $+380^{\circ}\text{C}$
- ❖ I2C/SMBus interface
- ❖ Optional PWM and interrupt output
- ❖ 3.3V or 5V operation

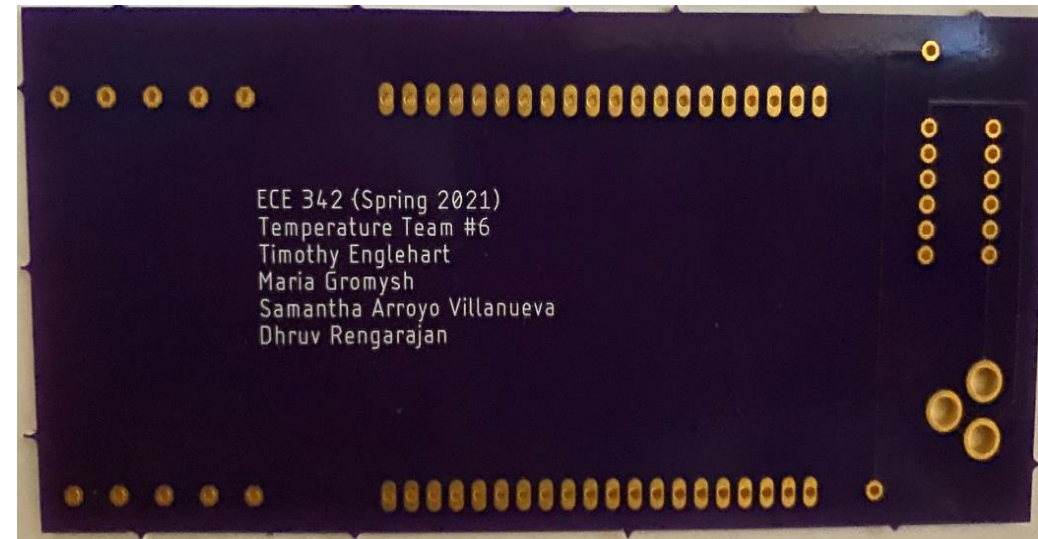


Base Board

A base board is designed to integrate all the modules such as IR sensor, motion sensor, Speaker, TFT touch display with the Arduino Mega board.



Top Layer

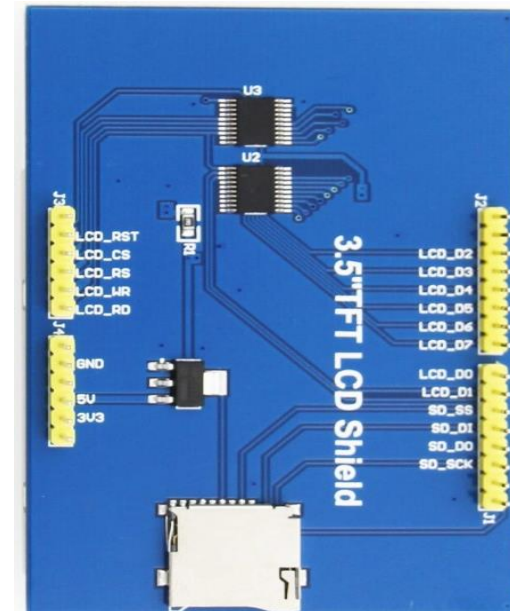
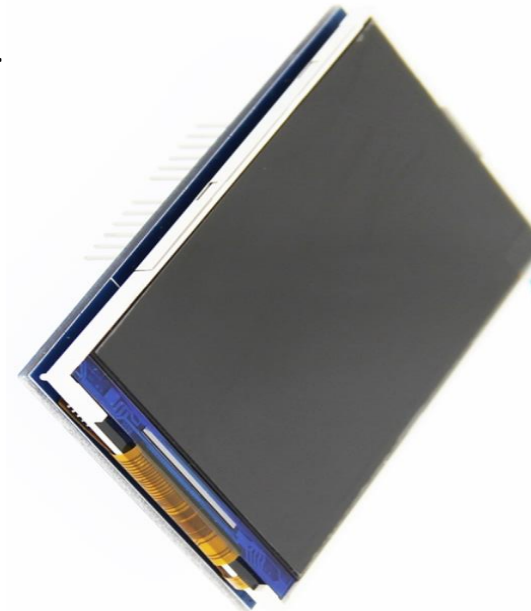


Bottom Layer

TFT Touch Display

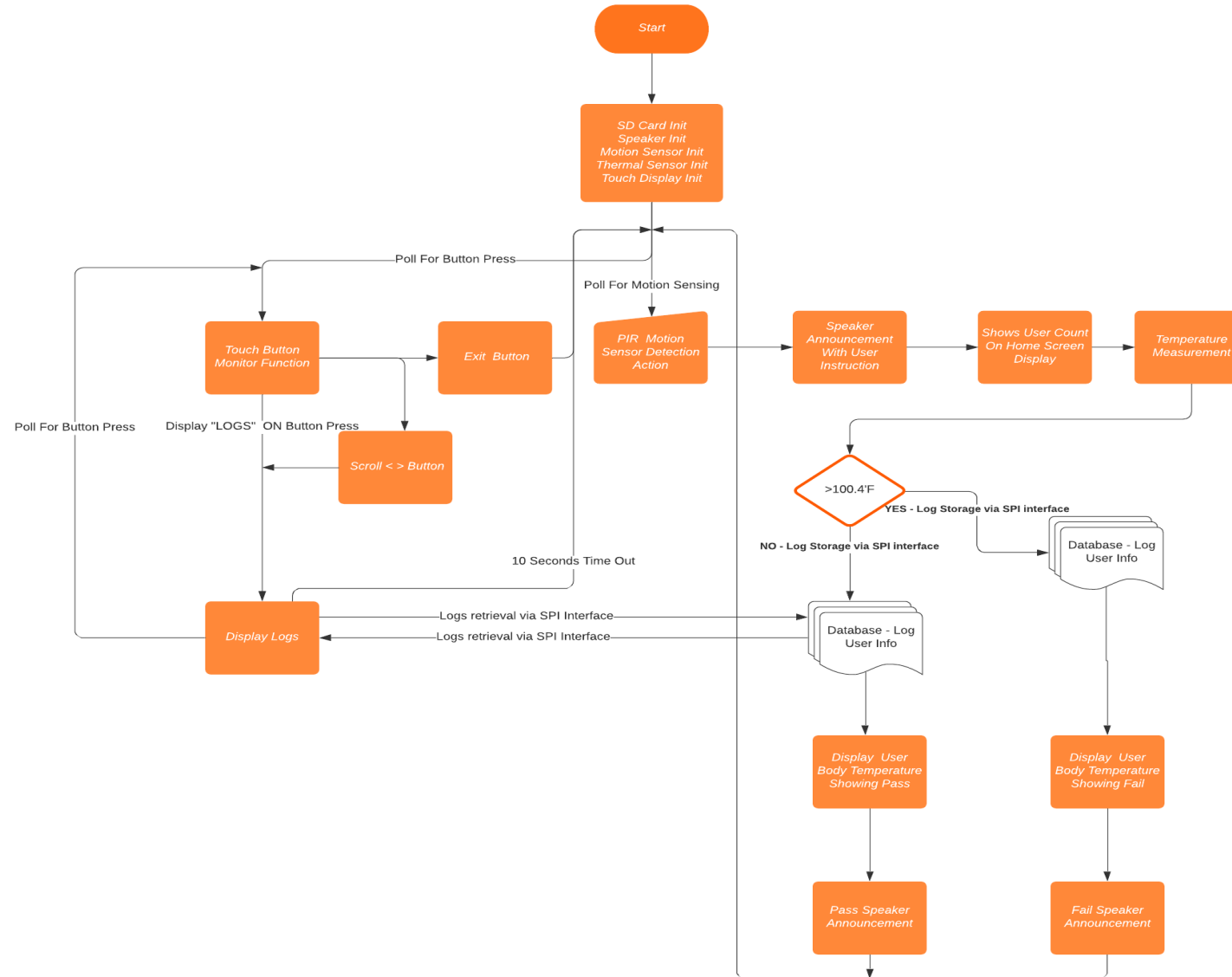
The 3.5-inch TFT LCD module with 320x480 resolution and 65K color display. It uses 8-bit line parallel port communication, and the driver IC is ILI9486. The module includes an LCD display, 5V~3.3V level conversion circuit, which can be directly plugged into the Arduino UNO and MEGA2560 development boards, and also supports SD card expansion function.

- Supports development boards such as Arduino UNO and Mega2560 for plug-in use without wiring.
- 480X320 resolution, clear display, support for touch function.
- Support 16-bit RGB 65K color display, display rich colors.
- 8-bit parallel bus, faster than serial SPI refresh.
- On-board 5V/3.3V level shifting IC, compatible with 5V/3.3V operating voltage.
- Easy to expand the experiment with SD card slot.
- Provides an Arduino library with a rich sample program.



Firmware Flow Chart

Firmware Flow Chart Of Thermal Scanner



Final Integrated Code



Integrated_Main_Code_Rev02.txt



Speaker_Init.txt



display_init.txt



Temp_IR_Init.txt



PIR_Sensor_Init.txt

Total code comes around **343** lines included header files.

System Verification and Validation

The following testing were performed as part of product/system validation.:

1. Black box testing

- ❖ Home Screen
- ❖ Pass Screen
- ❖ Fail Screen
- ❖ Log History Screen
- ❖ Log History SD Card storage verification
- ❖ Audio Announcement Verification

2. System verification – Analysis of logs printed on the serial terminal

Home Screen Verification

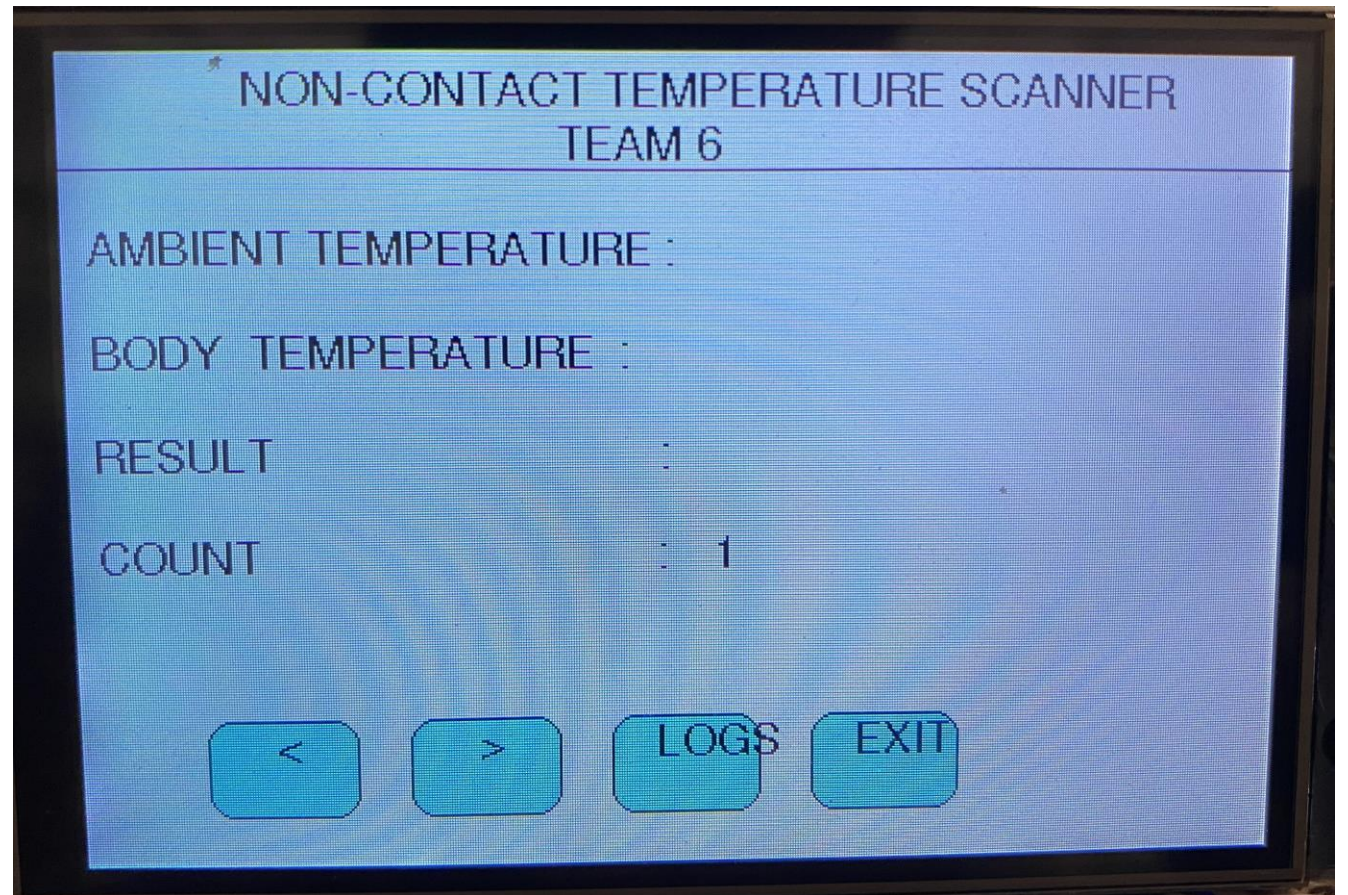
The home screen shows the banner, ambient, target, count, and result. This also includes 4 buttons as follows:

“<” Scroll Left During Logs Screen.

“>” Scroll Right During Logs Screen.

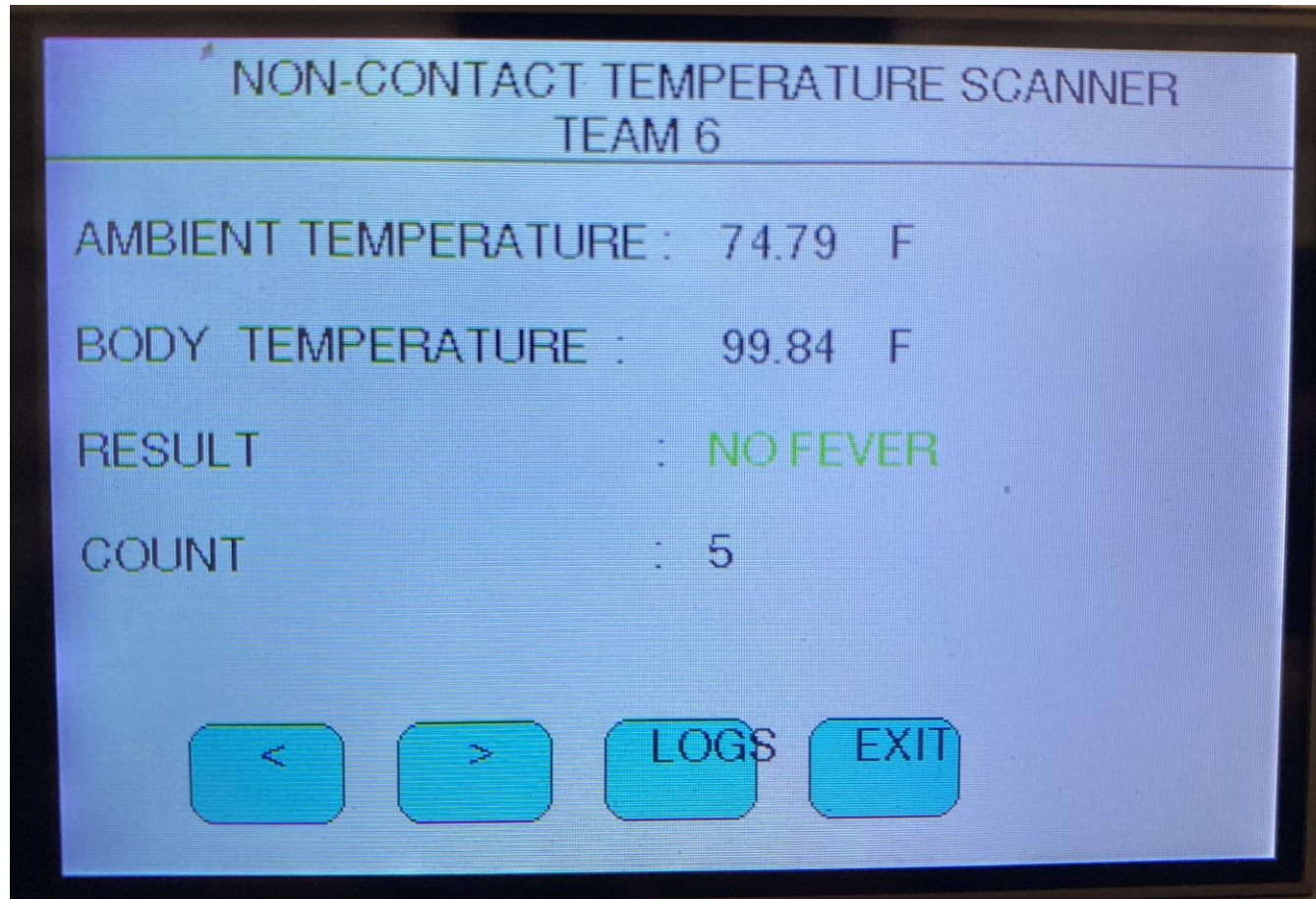
“**LOGS**” Display the past logs.

“**EXIT**” Takes back to home screen always.



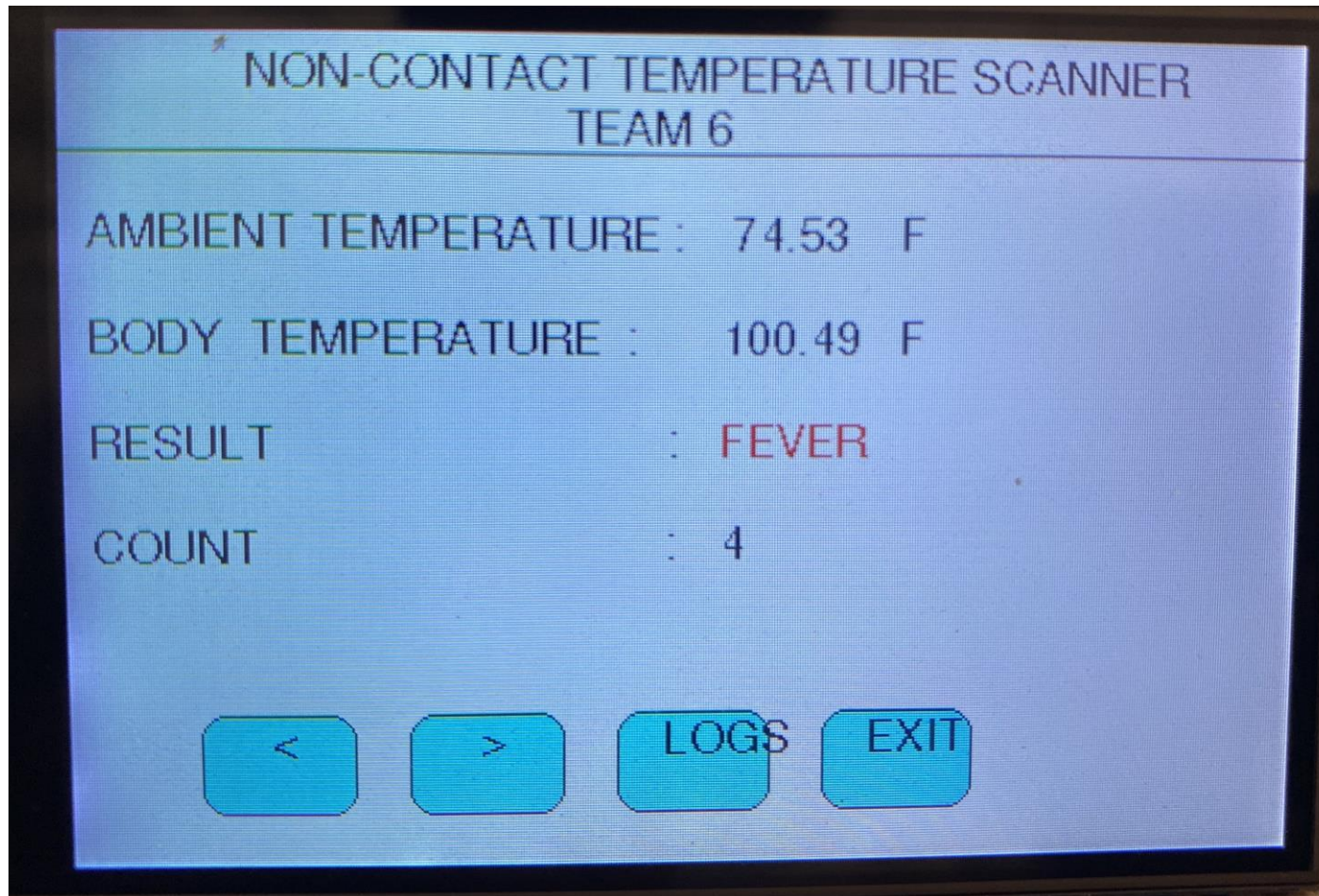
Pass Screen Verification

The pass screen shows the banner, ambient, target, count, and result as “Pass” in green color if target temperature is <100.4 F.



Fail Screen Verification

The failure screen shows the banner, ambient, target, count, and result as "Fail" in red color if target temperature is >100.4 F.

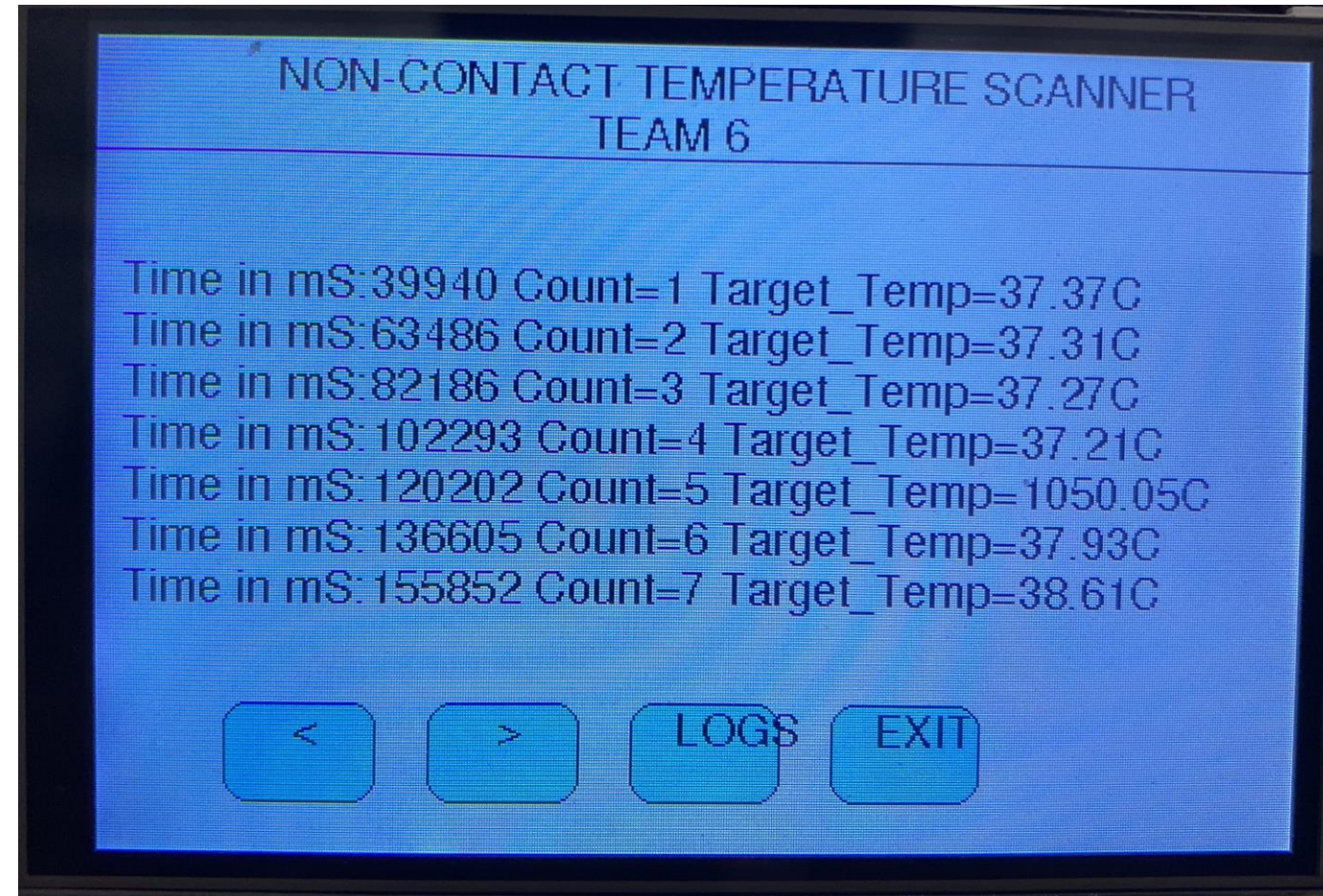


Log History Screen Verification

- ❖ When “LOGS” button is pressed, it shows the banner and past logs in the format as:

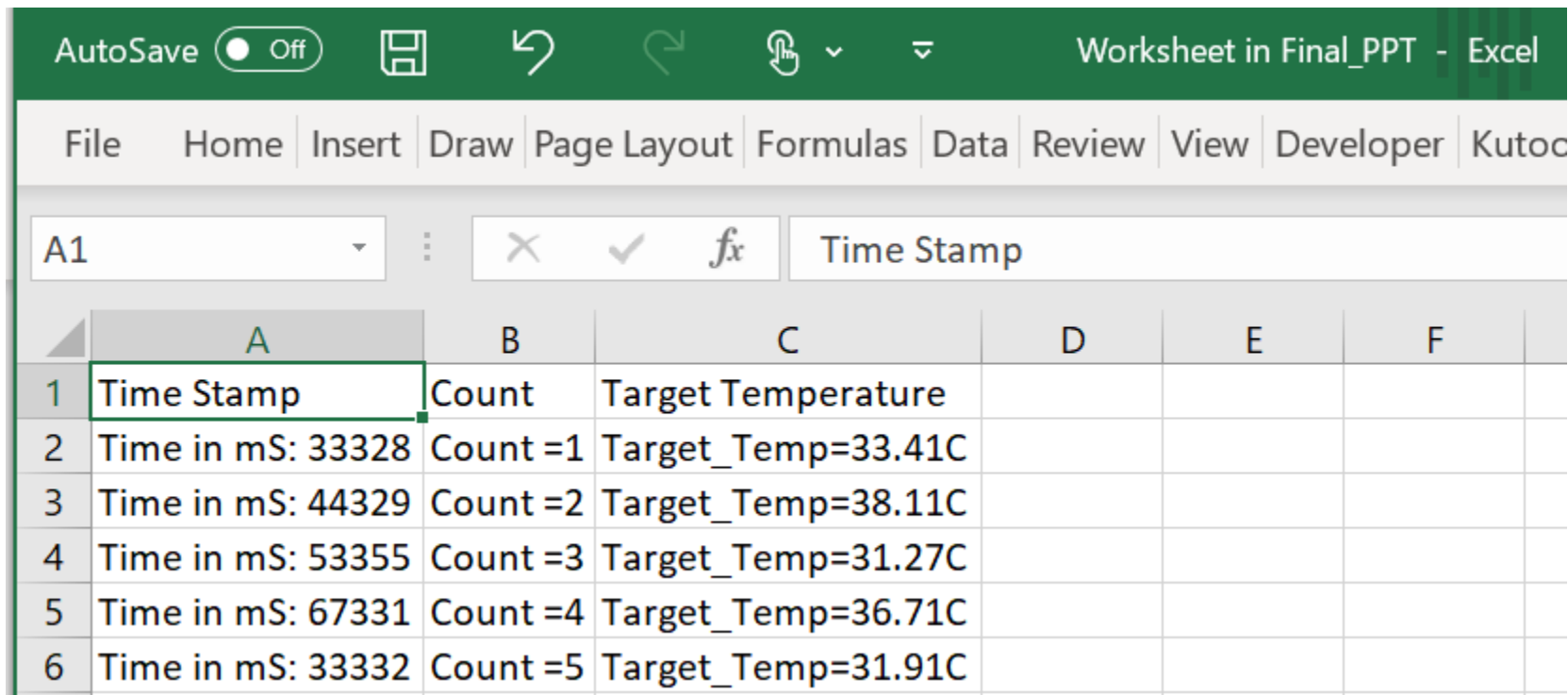
Time Stamp in mS: XXXXX Count=XX Target
Temp: XX C

- ❖ If user did not exit, it automatically goes back to home screen. During this screen, motion sensing loop will not work.



Log History SD Card storage verification

Verified all the data logs stored in a csv format in the SD card. Attached the sample data logs collected in the SD storage.







The screenshot shows the Microsoft Excel interface. The title bar indicates the file is 'Worksheet in Final_PPT - Excel'. The ribbon is set to 'Formulas'. The active cell is A1, and the formula bar shows 'Time Stamp'. The table below contains log data with columns for Time Stamp, Count, and Target Temperature.

	A	B	C	D	E	F
1	Time Stamp	Count	Target Temperature			
2	Time in mS: 33328	Count =1	Target_Temp=33.41C			
3	Time in mS: 44329	Count =2	Target_Temp=38.11C			
4	Time in mS: 53355	Count =3	Target_Temp=31.27C			
5	Time in mS: 67331	Count =4	Target_Temp=36.71C			
6	Time in mS: 33332	Count =5	Target_Temp=31.91C			



Audio Announcement Verification

Following voice phrases recorded in wav format and stored in SD card. These announcements are retrieved at the specified conditions and verified against the test cases.

- ❖ Speaker Announcement 1: "Person detected." 
- ❖ Speaker Announcement 2: "Please stand at the target location for body temperature scan." 
- ❖ Speaker Announcement 3: "Scan complete. You have no fever, access granted." 
- ❖ Speaker Announcement 4: "Scan complete. You have fever, access denied." 

System verification

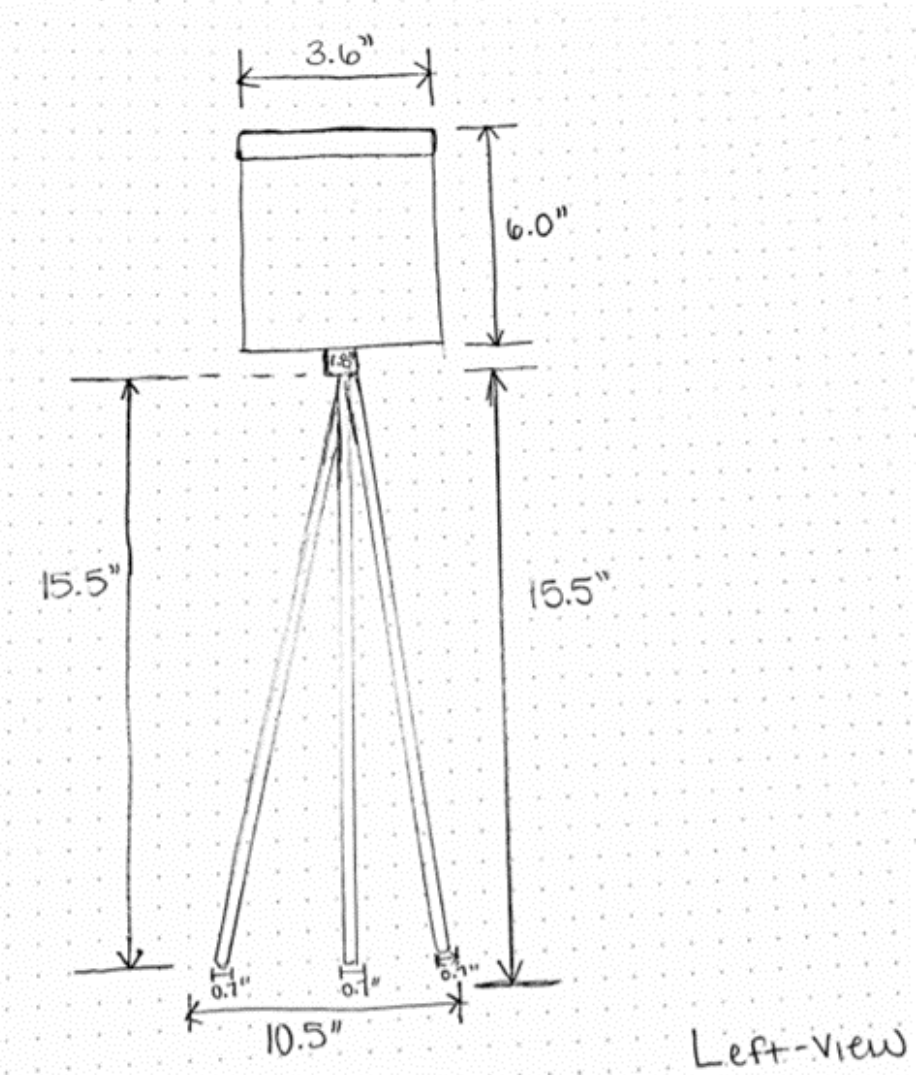
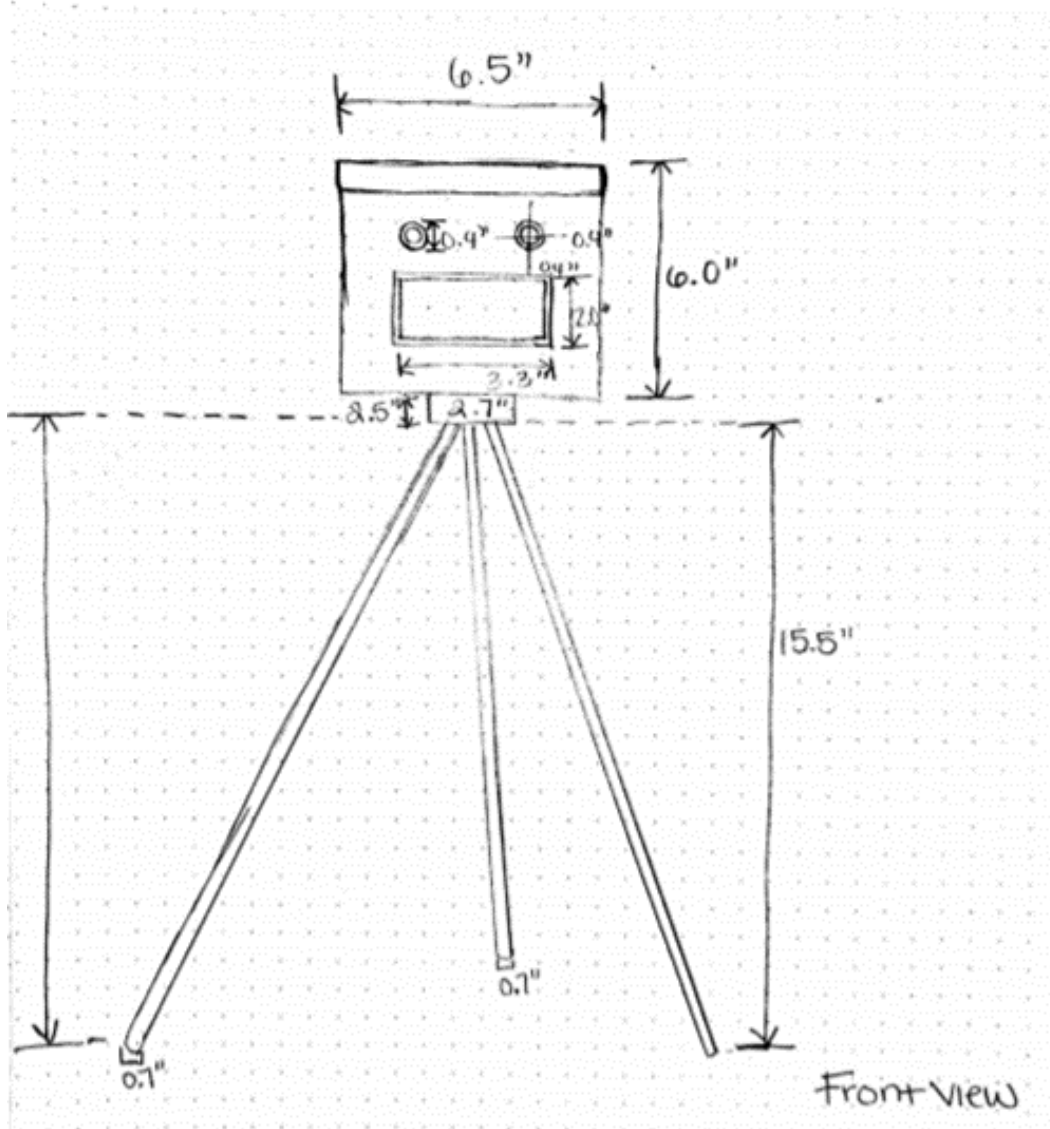
The system was verified by analyzing the logs printed on the serial terminal.



Serial_Print_Logs.txt

Module Testing Demo Video

Mechanical Enclosure

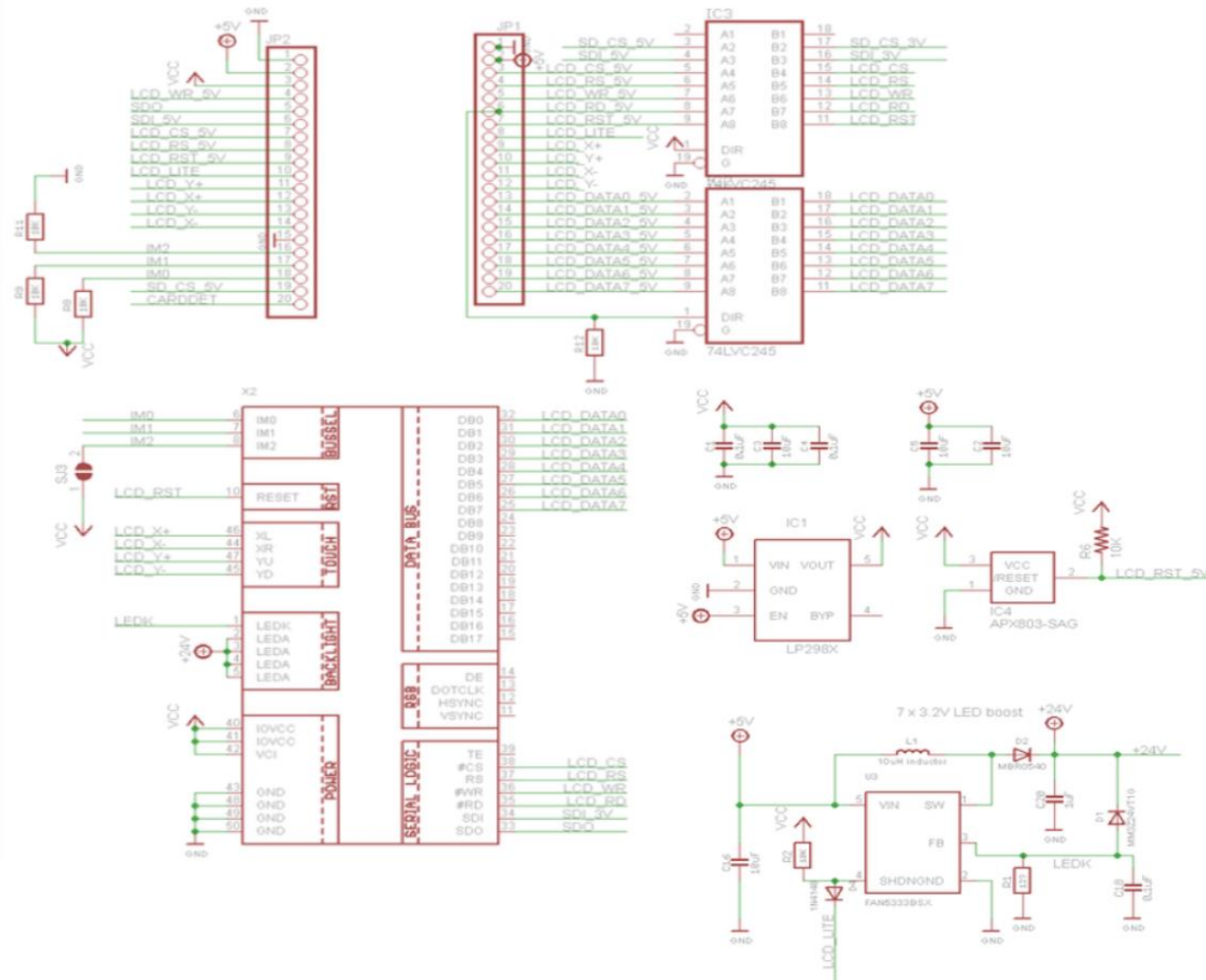


Bills of Materials

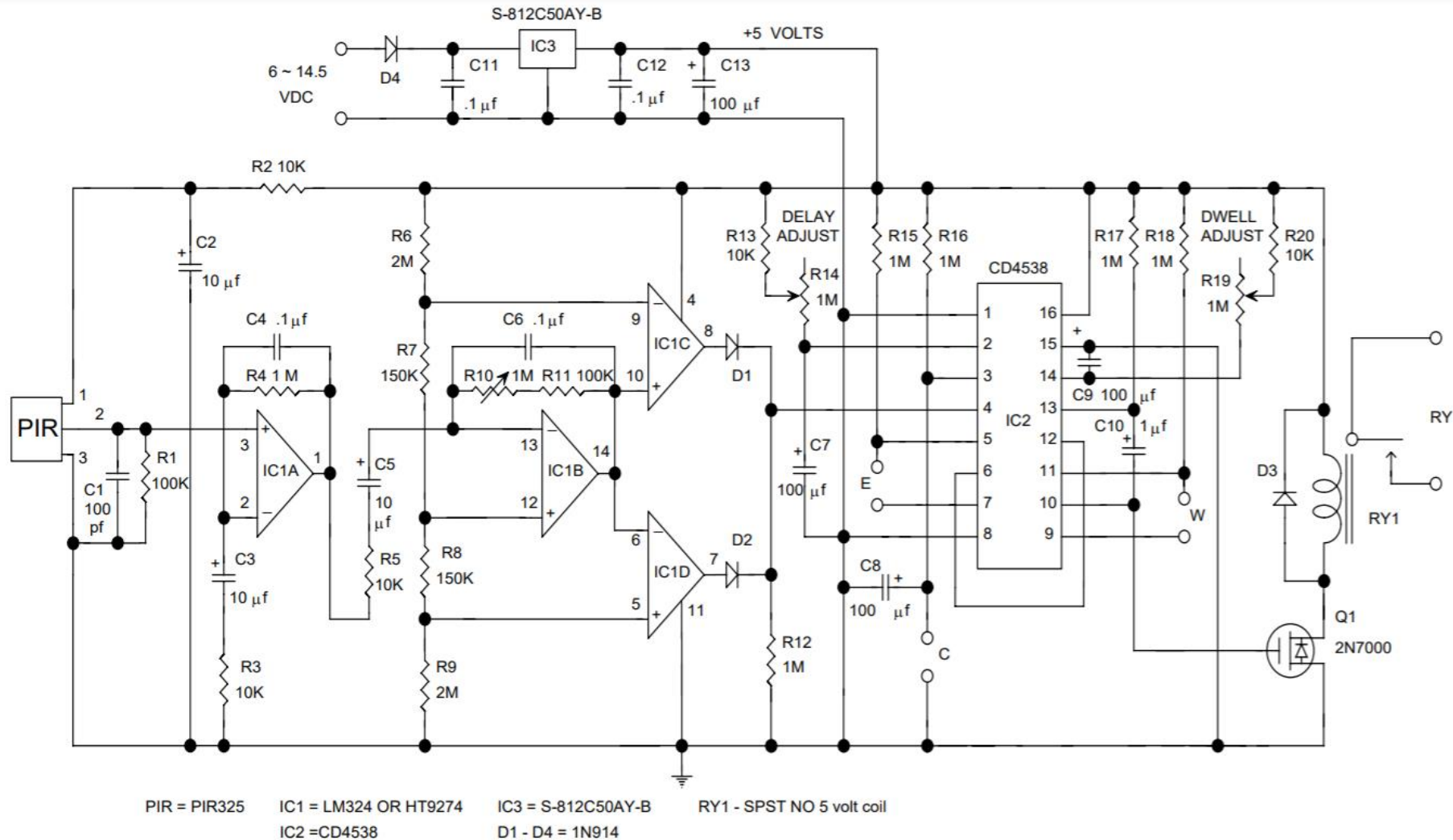
Item	Description	Quantity	Cost Per Unit (USD)	Total Cost (USD)
HC-SR501 PIR Sensor	Motion Sensor Module	1	10.99	10.99
Arduino Mega	Microcontroller Module	1	17.47	17.47
3.5" TFT LCD 480x320 Screen	Touch Display Module + Micro SD Card Adapter	1	19.49	19.49
Transcend 2 GB SD Flash	Memory Card	1	7.98	7.98
GY-906 MLX90614ESF Infrared	Temperature Sensor Module	1	15.16	15.16
CSS-66668N	8 Ohms General Purpose Speaker 3 W 160 Hz ~ 15.0 kHz Top Round, Square Frame	1	3.87	7.04
PCB	Base printed circuit board	1	20	20
TIP29C	NPN power transistors	1	0.88	0.88
Jumper wires	Male to Female connector	36	0.0582	2.094
CO832	Enclosure Fiberglass/Polyester Gray Cover	1	46.08	46.08
TOTAL COST				147.184

Note: The above BoM is based on purchase quantities used for prototype. The total cost will can be significantly reduced in high volume manufacturing.

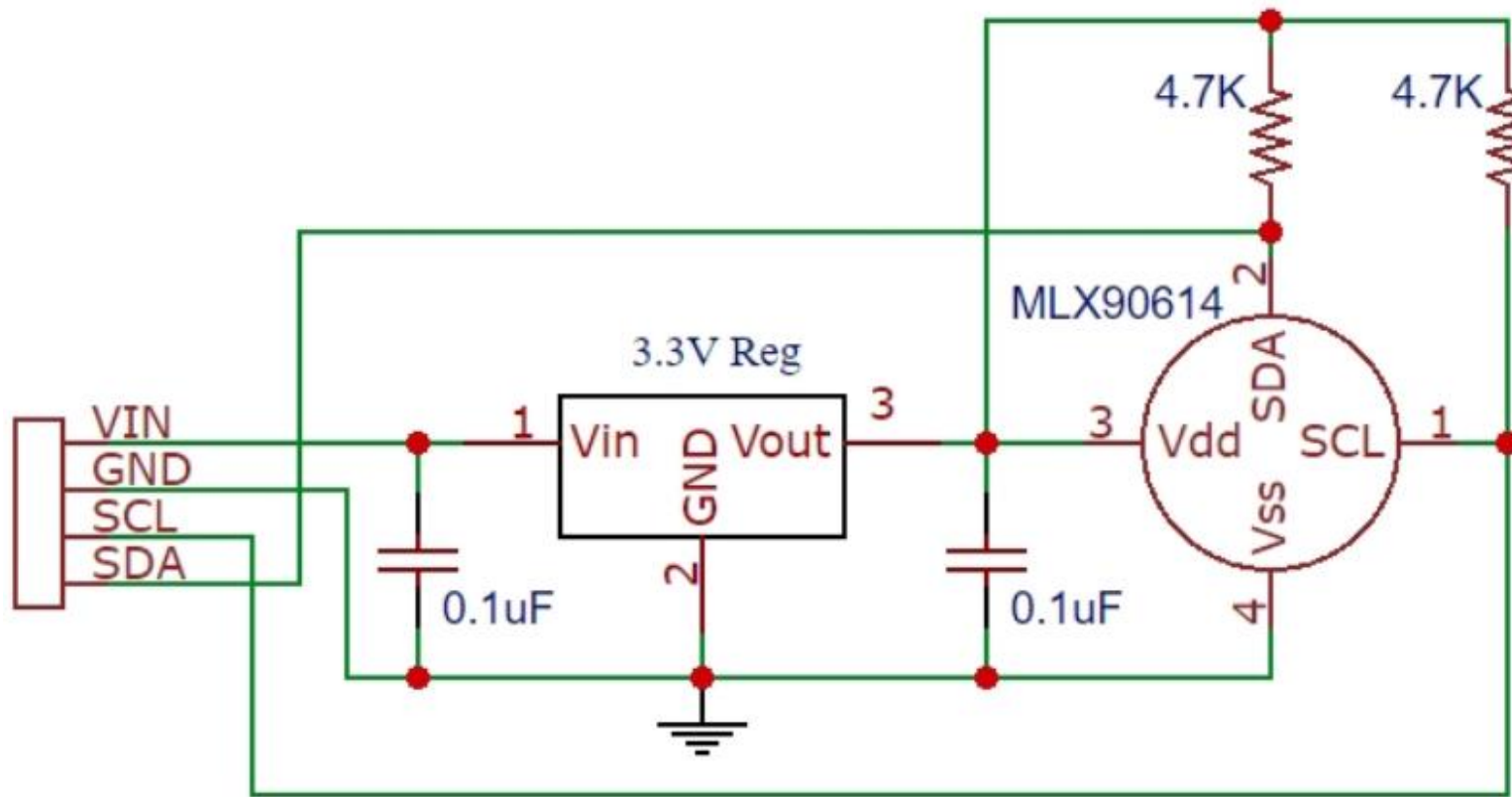
TFT Touch Display Circuit



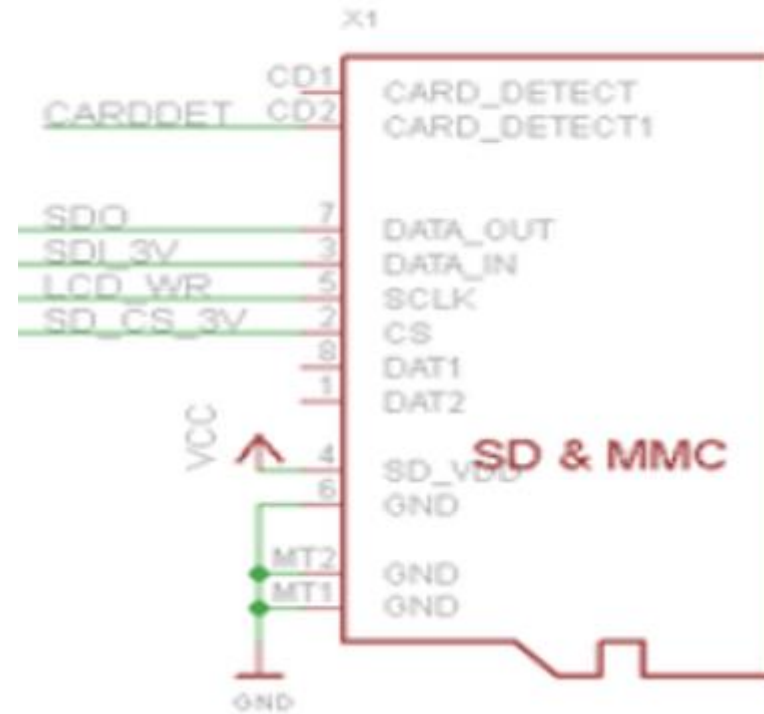
Motion Sensor Circuit



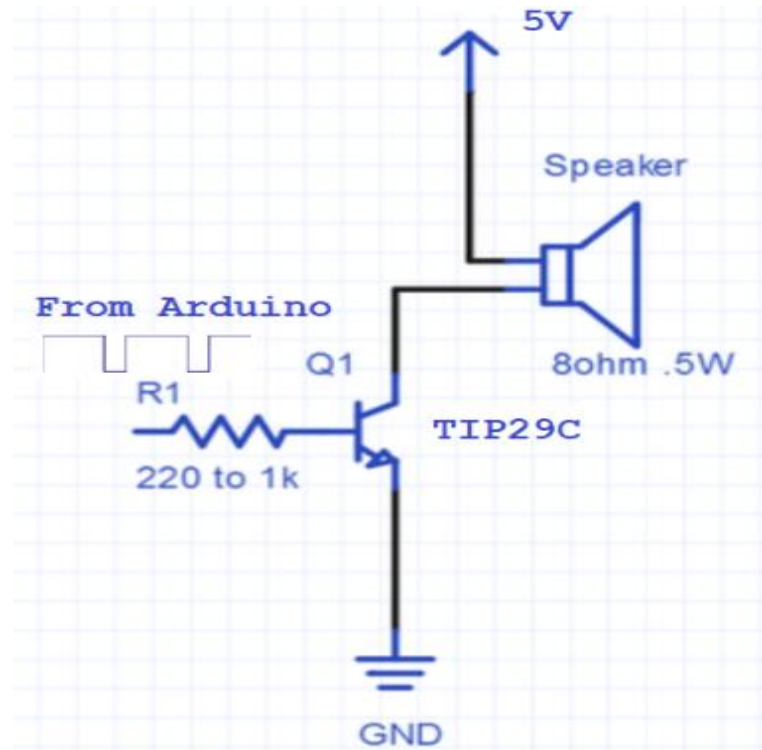
Thermal IR Sensor Circuit



Micro SD Card Adapter Circuit

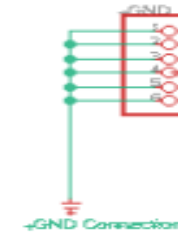
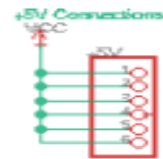
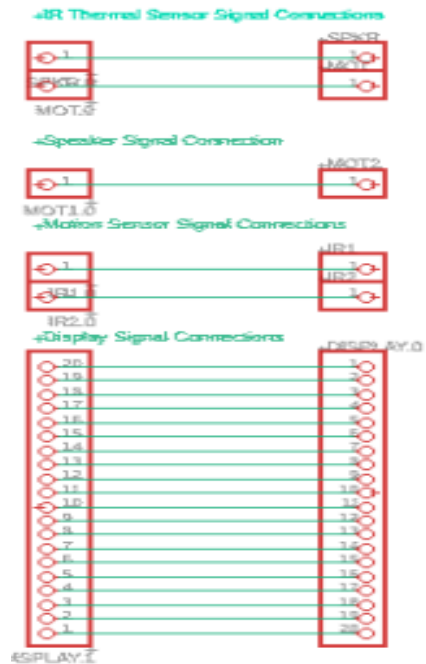
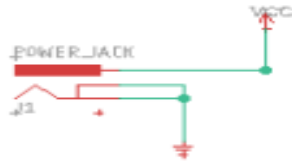


Audio Driver Circuit



Base Board Circuit

A base board is designed to integrate all the modules such as IR sensor, motion sensor, Speaker, TFT touch display with the Arduino Mega board.



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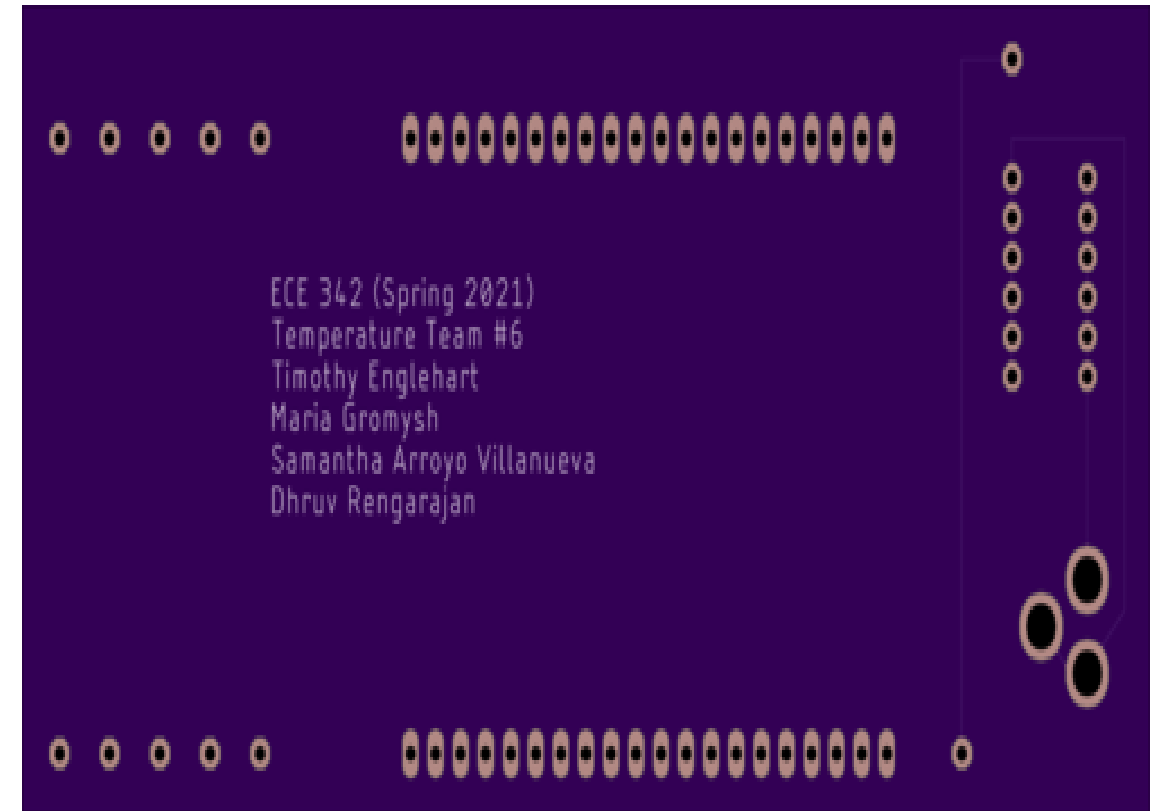
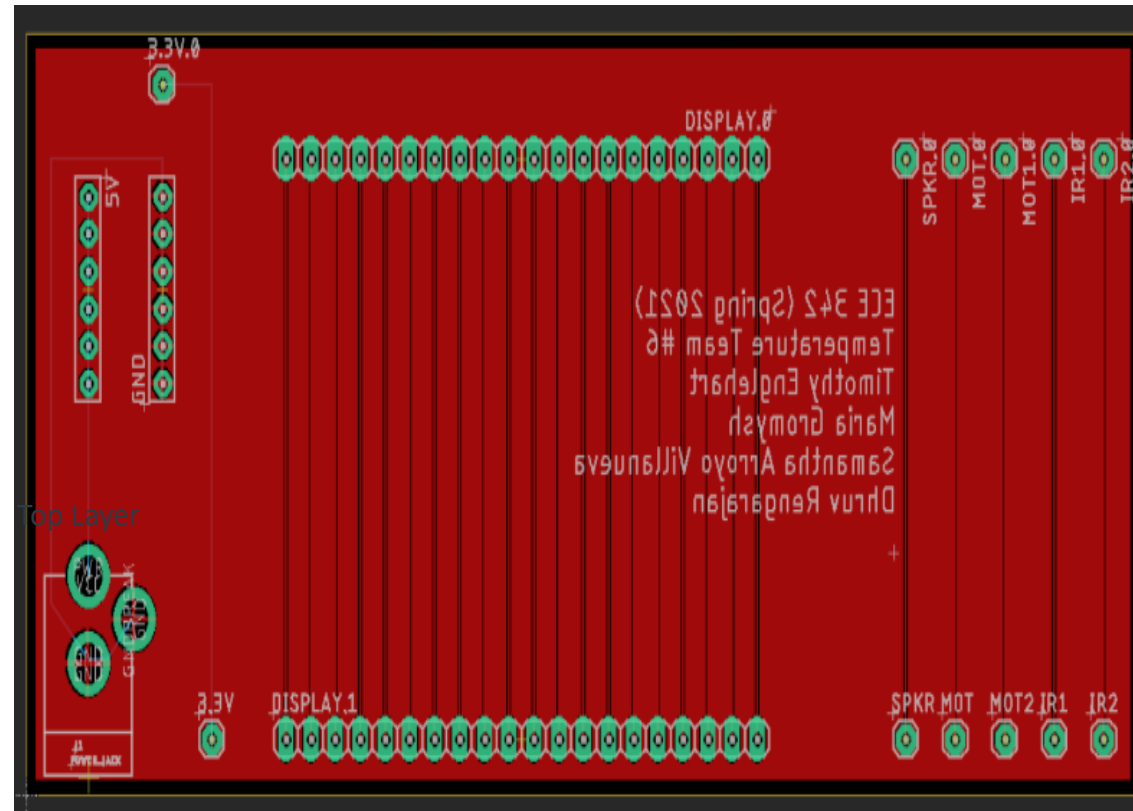
TITLE: draft(1)

Design by:

Date: 5/11/2021 10:22 AM

PCB Layout

A two layer 4.5" x 2.5" PCB designed to integrate all the modules such as IR sensor, motion sensor, Speaker, TFT touch display with the Arduino Mega board. A base board is designed to integrate all the modules such as IR sensor, motion sensor, Speaker, TFT touch display with the Arduino Mega board.



Challenges and Future Enhancement

- ❖ Writing touch display firmware driver, SD storage data logging and integrating all sensor module codes were the challenging parts of this project and considerable accomplishments.
- ❖ The area of future development will be designing the system to detect human body temperature at a larger distance (greater than 6ft) but with $\pm 1^{\circ}\text{F}$ accuracy.

Summary

Based on the customer requirements, a complete system non-contact thermal scanner was designed meeting all the 5 criteria following the product development the process described below.

