

System Design for Mechatronics Engineering

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1 Revision History

Date	Version	Notes
18 January 2023	1.0	Revision 0 for System Design

2 Reference Material

This section records information for easy reference.

2.1 Abbreviations and Acronyms

symbol	description
Lipo battery	Lithium polymer battery
PCB	Printed circuit board
TFT LCD Display	Thin film transistor liquid crystal display
FSM	Finite state machine
UI	User interface
CAD	Computer aided design for 3D models

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3 Introduction

[Include references to your other documentation —SS]

4 Purpose

[Purpose of your design documentation —SS]

[Point to your other design documents —SS]

5 Scope

[Include a figure that show the System Context (showing the boundary between your system and the environment around it.) —SS]

6 Project Overview

6.1 Normal Behaviour

6.2 Undesired Event Handling

[How you will approach undesired events —SS]

6.3 Component Diagram

6.4 Connection Between Requirements and Design

[The intention of this section is to document decisions that are made “between” the requirements and the design. To satisfy some requirements, design decisions need to be made. Rather than make these decisions implicit, they are explicitly recorded here. For instance, if a program has security requirements, a specific design decision may be made to satisfy those requirements with a password. —SS]

7 System Variables

[Include this section for Mechatronics projects —SS]

7.1 Monitored Variables

7.2 Controlled Variables

7.3 Constants Variables

8 User Interfaces

8.1 Hardware User Interface

The device is worn by a participant on the wrist for measuring activity and generating prompts. The following items will be shown on the display of the activity tracker:

Description	Behaviour of TFT Display
Power up of activity tracker.	Displays Back End Developers on startup.
Default behaviour, no activity tracked.	Displays date and time.
Activity tracked.	Prompt generated on screen, for example: Are you in pain?
Answering prompts using touch sensor (bezel).	Toggle between different options on screen. For example: (Yes/No).

Table 1: Components of Hardware UI

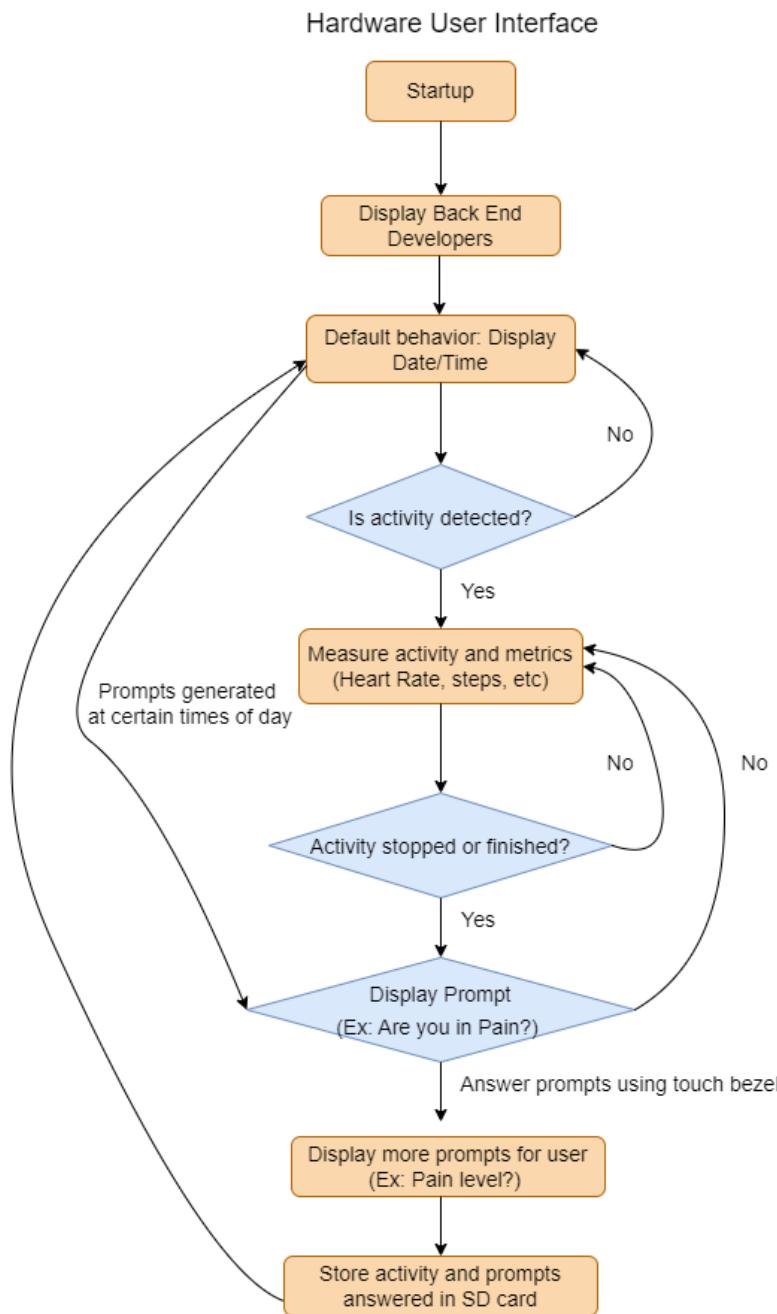


Figure 1: FSM for Hardware UI



Figure 2: Display on activity tracker at startup



Figure 3: Display of Date/time on activity tracker.

8.2 Software User Interface

The Software User Interface will be used by the Researcher for configuring the activity tracker according to the participant. The interface will be on the Host Computer and will be able to store participant data, create new data and view records using encryption. The interface will also have authentication, and only the Researcher will be able to log in. The following features are available on the Software User Interface:

Options on UI	Description
Main window	Main menu that leads to different windows when clicked.
Connect to tracker	Connects to SD card for device and shows status of connection.
Create Records Window	Creates new record for participant and stores it in a database. A record can only be created if the correct username and password is provided.
Records Window	Participant records can be viewed in a tabular format and can be searched/filtered.
Data View Window	Data stored on SD card can be viewed and filtered. Data can also be plotted using Graph button. For example: Heart Rate vs Time.

Table 2: Components of Software UI

Below is an example of the Software User Interface for the Main window.

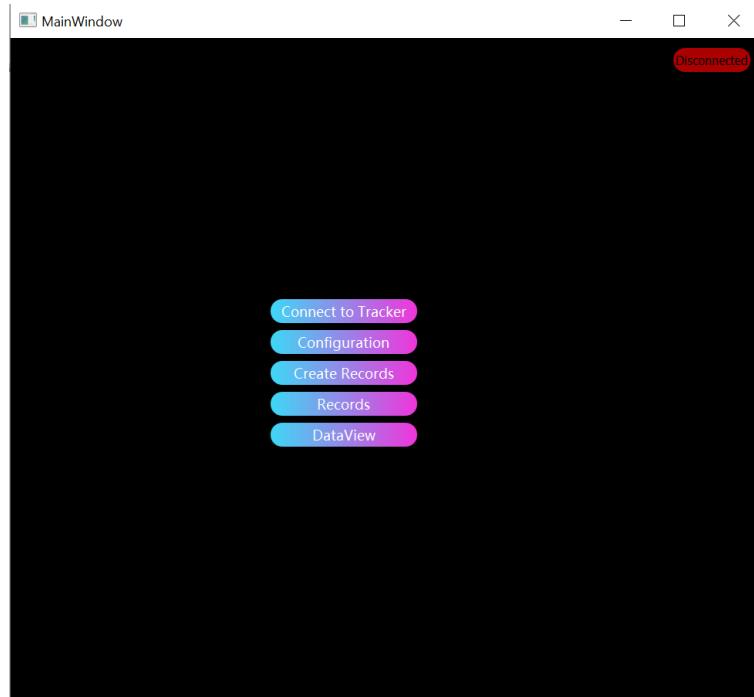


Figure 4: Main Window for Software UI

For more examples of the Software User Interface, refer to Appendix A.

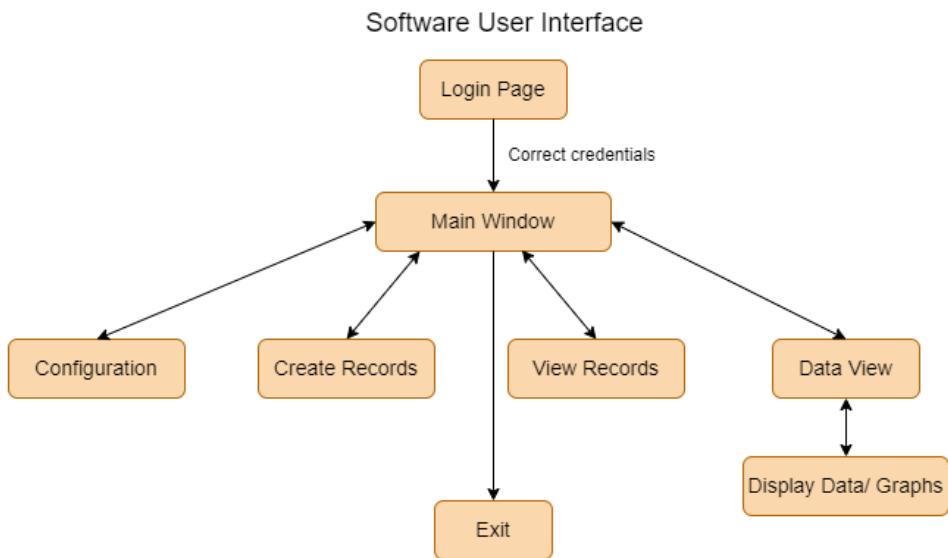


Figure 5: FSM for Software UI

9 Design of Hardware



Figure 6: TFT Display with custom 3D printed case

The touch sensor shown below will be used as a bezel to navigate options on the activity tracker. The wires connected to each segment send a corresponding signal which can be used to navigate options and select a response.

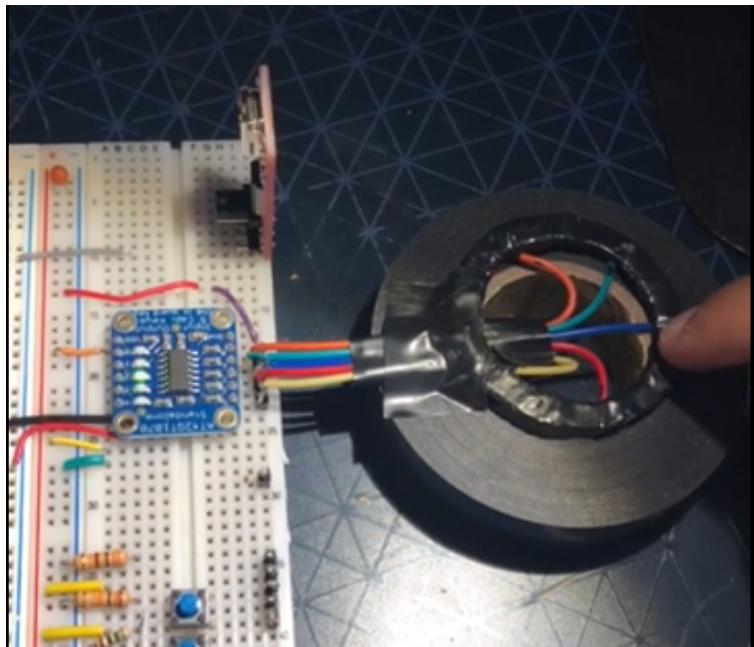


Figure 7: Circuit of custom built reactive touch sensor

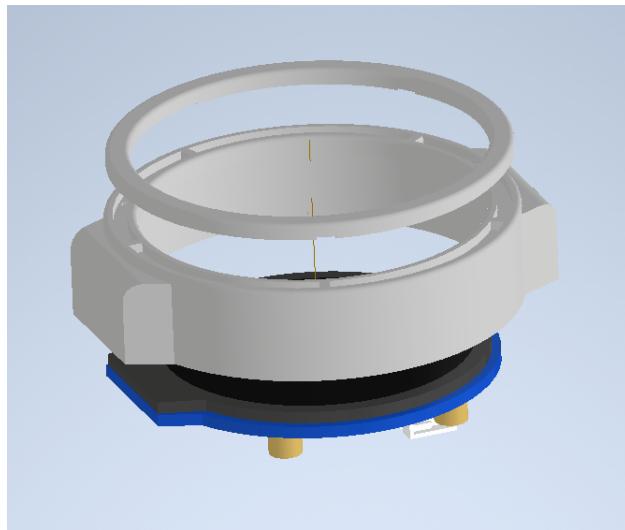


Figure 8: CAD Assembly of Touch Bezel, Display case and TFT Display

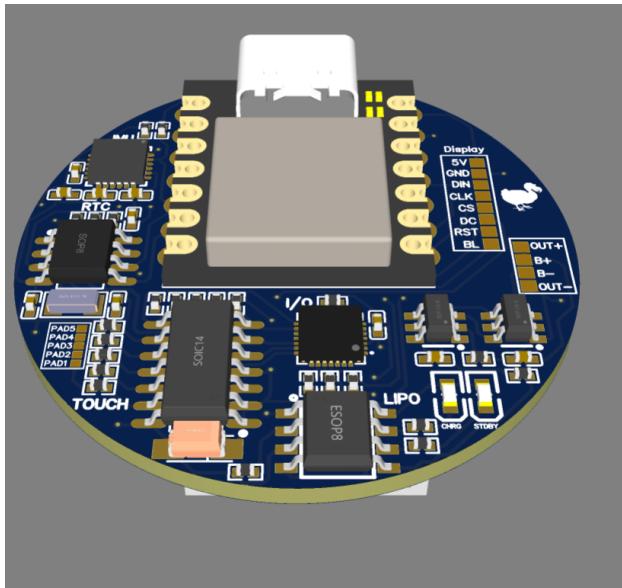


Figure 9: Top view of Custom PCB

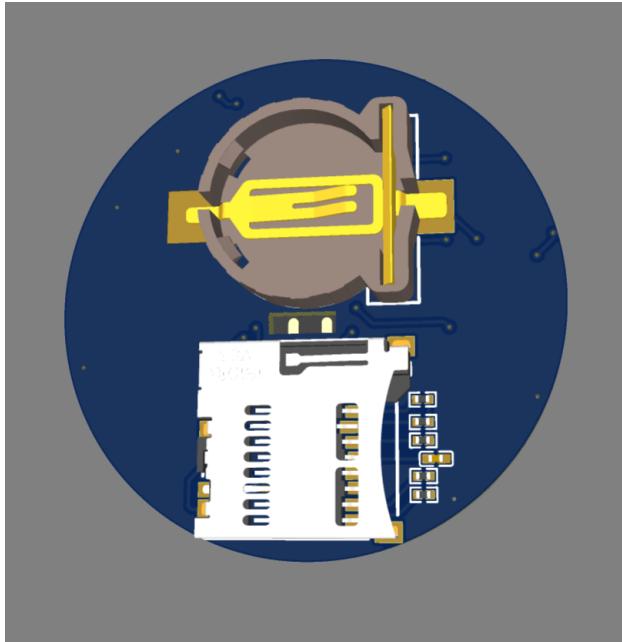


Figure 10: Bottom view of Custom PCB (Lipo battery holder and SD card slot)

Refer to Appendix [B](#) for individual CAD designs.

The following list of items will be custom designed and fabricated:

- Custom PCB designed using Easy EDA and fabricated using JLCPCB.
- 3D printed casing for TFT Display/activity tracker.
- Touch sensor (bezel) to navigate activity tracker.

Refer to table 3 in Appendix for detailed information on high-level hardware components used.

10 Design of Electrical Components

The schematic/circuit diagrams shown below are used to generate the PCB layout.

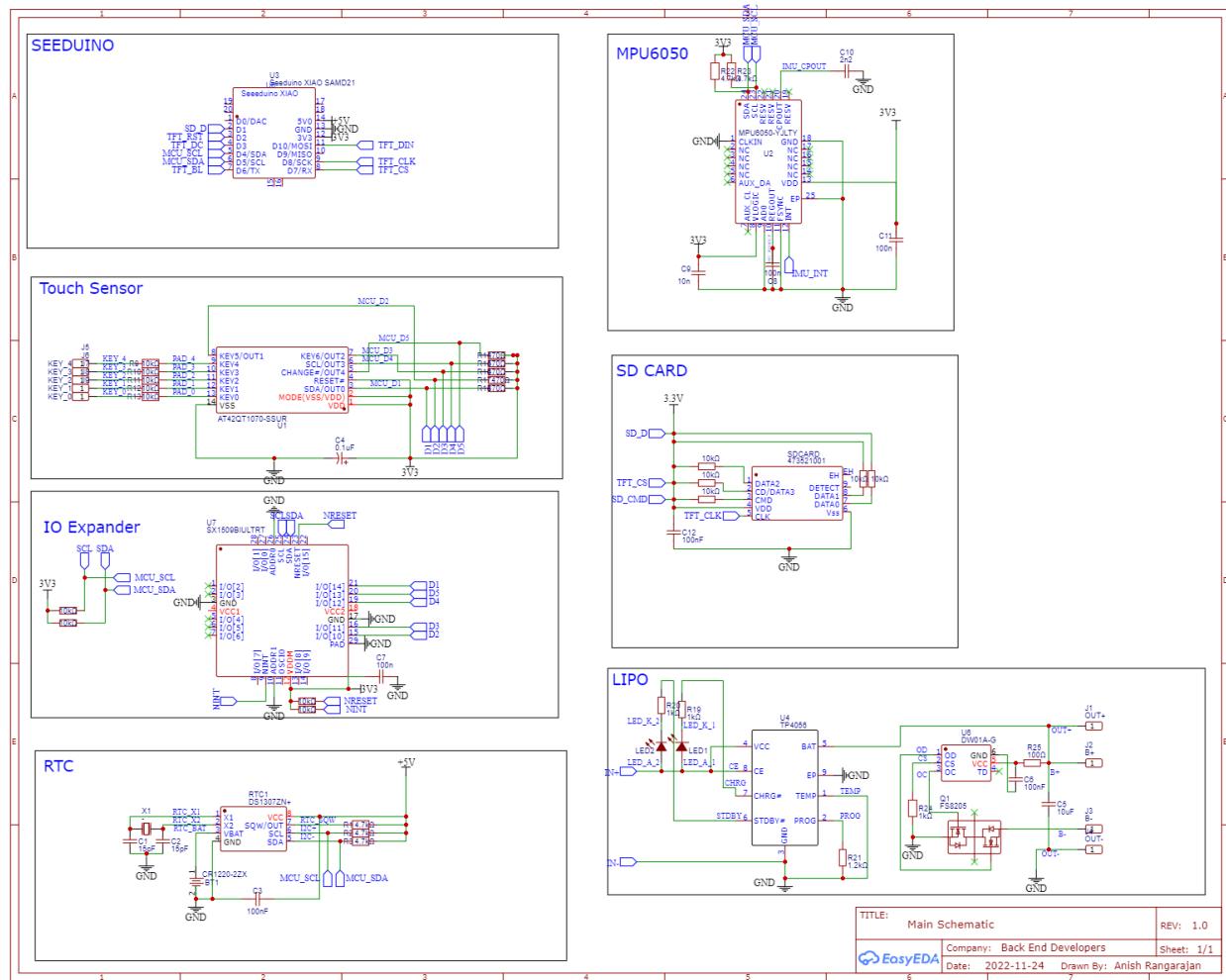


Figure 11: Schematic for PCB

The custom designed PCB is shown below.

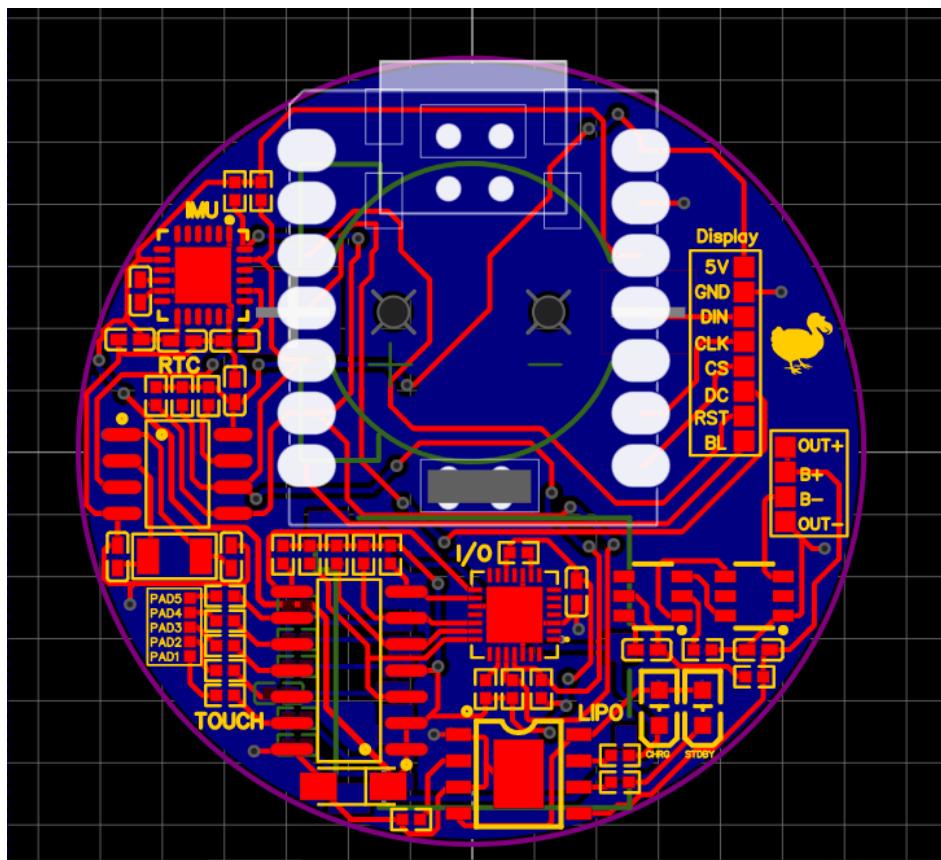


Figure 12: Layout of PCB design

Refer to table 4 in Appendix for detailed information on Electrical components used in PCB design.

11 Design of Communication Protocols

[If appropriate —SS]

12 Timeline

[Schedule of tasks and who is responsible —SS]

A Software Interface

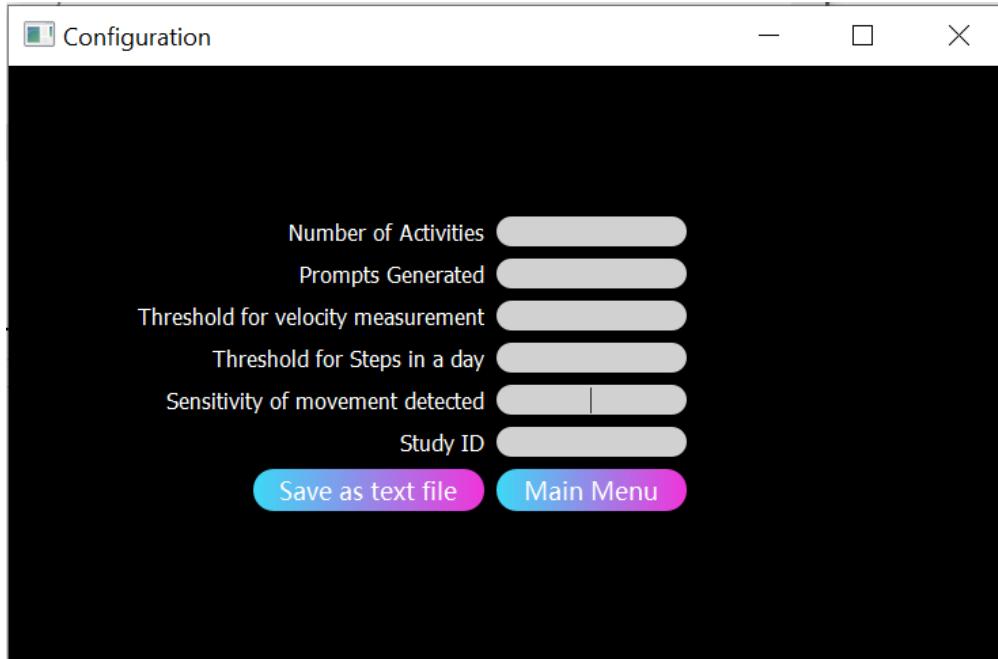


Figure 13: Configuration Window

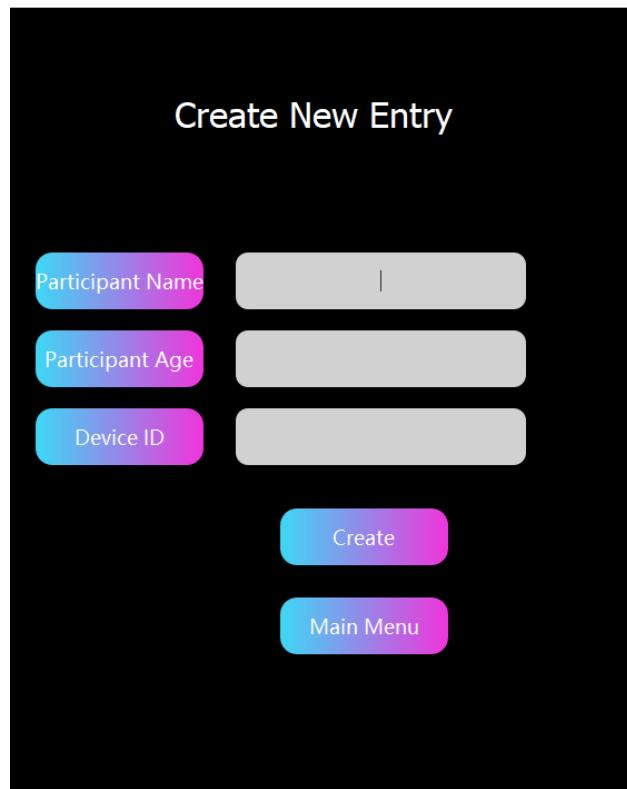


Figure 14: Create Record Window

Record

The Record window contains a top section with input fields for First Name, Last Name, Age, Participant ID, Gender, Weight, Height, Phone Number, Email, Address, Monitoring Period, and Tracker ID. It includes a "Load CSV" button, a "Search" button, and a "Filter" button. Below this is a table with 4 rows of data:

	First Name	Last Name	Age	Participant ID	StudyID	Gender	Weight (kgs)	Height (cm)	Phone number	Email ID	Address	Monitoring Period	Tracker model
1	Jack	Jones	60	1	32	Male	75	180	(338) 437-5840	jack@gmail.com	8710 Hilltop St.	13	1
2	Rose	Lindt	65	2	32	Female	63	150	(864) 315-3964	rose@gmail.com	Mundelein, IL 60060	12	2
3	Ashley	Dunder	63	3	32	Female	57	160	(238) 233-4530	ashley@gmail.com	9022 Jennings Drive	15	1
4	May	Potter	75	4	32	Prefer Not ...	80	172	(990) 200-7813	may@gmail.com	North Miami Beach, FL 33160	15	1

Main Menu

Figure 15: Record Window

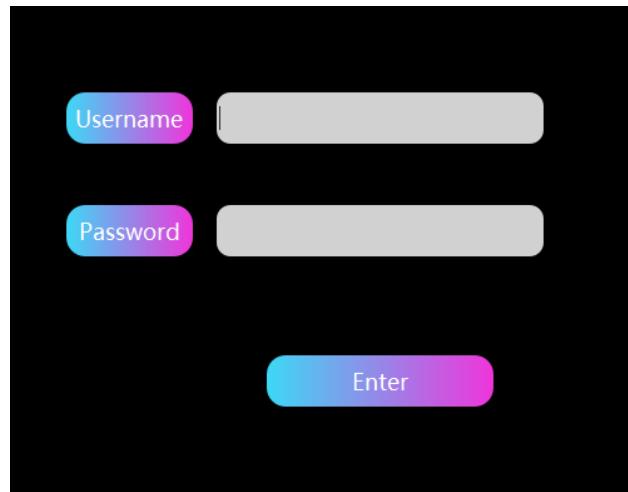


Figure 16: Login Dialogue box



Figure 17: Data View Window

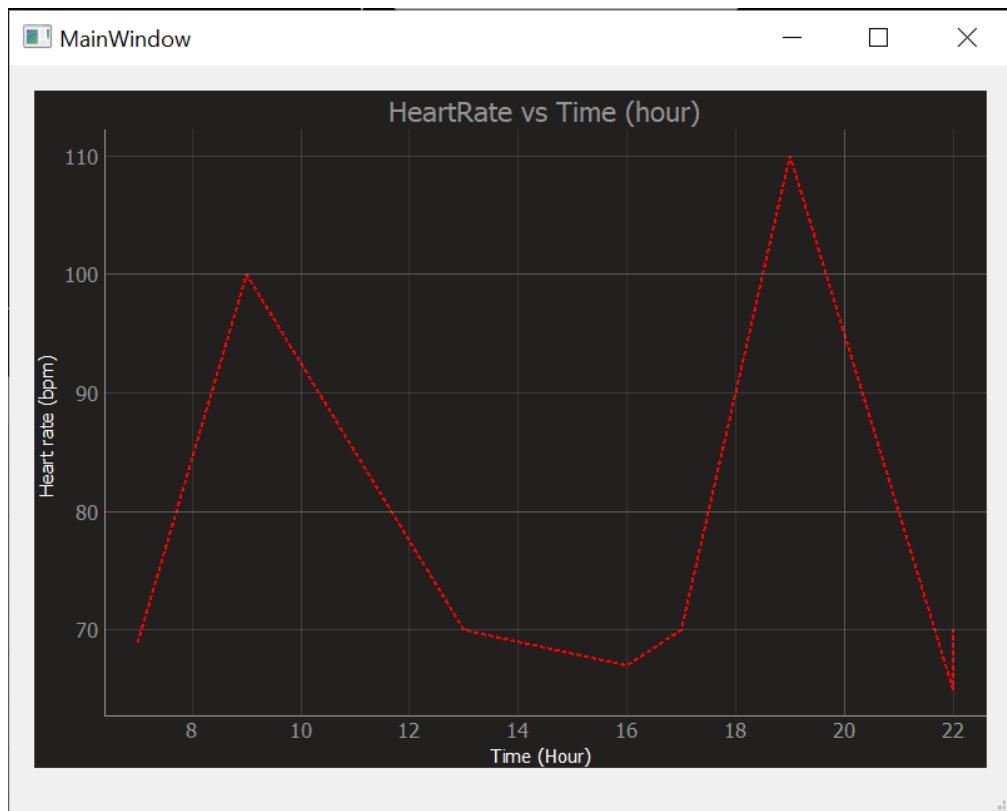


Figure 18: Generated Graph for Heart Rate vs Time

B Mechanical Hardware

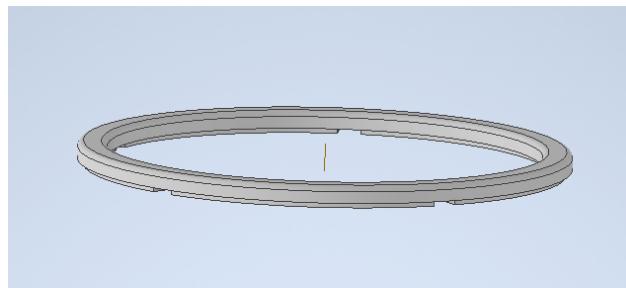


Figure 19: CAD model of touch sensor (bezel)

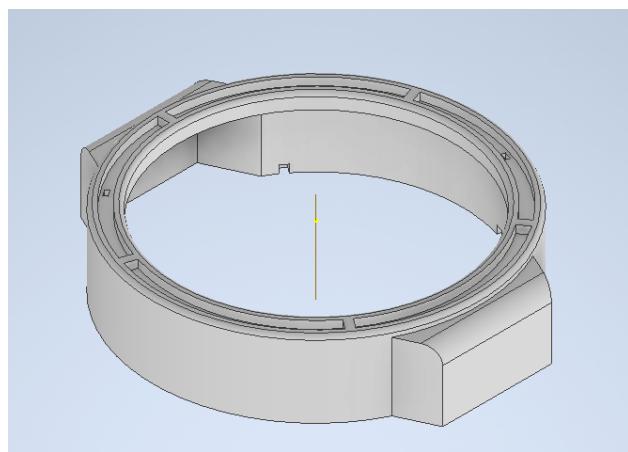


Figure 20: CAD model of case for TFT Display

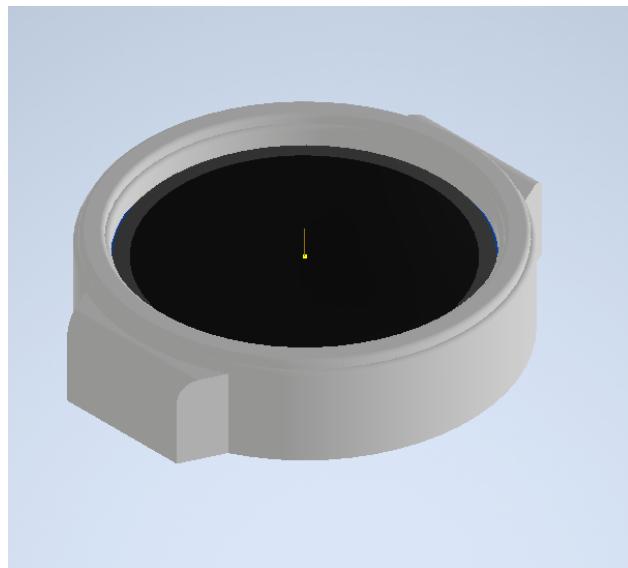


Figure 21: CAD model of watch assembled

Hardware Component	Description
Custom PCB	Custom PCB designed to fit in activity tracker.
Touch sensor module	Custom touch sensor (bezel) used to interact with activity tracker.
Outer casing for TFT Display	Designed using Autodesk Inventor and 3D printed.
AT42QT1070-SSUR	Off-shelf microchip for capacitive touch sensors, used in touch sensor schematic.
MPU 6050	Accelrometer/Gyroscope, off-shelf component.
Seeeduino xiao samd21	off-shelf microcontroller for activity tracker.
DS1307 RTC	Real time clock, off-shelf component.
Waveshare 1.28 LCD-192 Display	Off-shelf TFT display used in activity tracker.
Pulse sensor	Plug and play Heart Rate sensor for Arduino (off-shelf component)
Li-Po Battery	Generic off-shelf lipo battery used for smart watches.
TP4056 Li-Ion BMS	Off-shelf constant-current/constant-voltage linear charge for battery, used in Lipo schematic.
DW01A-G	Off-shelf battery protection IC to protect battery from overcharge, used in Lipo schematic.
USB Type-B charger	Generic off-shelf usb to Type-B charger to charge device.
MicroSD card	Standard off-shelf SD card.
SDCARD connector 473521001	MicroSD connector (off-shelf component)
IO Expander SX1509BIULTRT	off-shelf IO Expander used in PCB.
Watch straps	Generic watch-straps for strapping device onto the wrist.

Table 3: Components of Hardware Design

C Electrical Components

D Communication Protocols

E Reflection

The information in this section will be used to evaluate the team members on the graduate attribute of Problem Analysis and Design. Please answer the following questions:

1. What are the limitations of your solution? Put another way, given unlimited resources, what could you do to make the project better? (LO_ProbSolutions)
2. Give a brief overview of other design solutions you considered. What are the benefits and tradeoffs of those other designs compared with the chosen design? From all the potential options, why did you select documented design? (LO_Explores)

Module from schematic	Electrical component
MPU 6050	<ul style="list-style-type: none"> • Capacitors (2nF, 10nF, 100nF) • Resistors (4.7k ohms)
Touch sensor	<ul style="list-style-type: none"> • Capacitors (0.1uF) • Resistors (470 ohms, 10k ohms)
IO Expander	<ul style="list-style-type: none"> • Capacitors (100nF) • Resistors (10k ohms)
RTC	<ul style="list-style-type: none"> • Capacitors (15pF, 100nF) • Resistors (4.7k ohms)
SD CARD Module	<ul style="list-style-type: none"> • Capacitors (100nF) • Resistors (10k ohms)
Lipo Module	<ul style="list-style-type: none"> • Capacitors (100nF, 10uF) • Resistors (100 ohms, 1k ohms, 1.2k ohms) • FS8205 MOSFET
LEDs	Various LEDs in modules used to identify status of operation.

Table 4: Electrical Components of modules from PCB schematic