STATUS REPORT

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Introduction

A maze is ‘a network of paths and hedges designed as a puzzle through which one has to find a way’. The overall goal of the project was to build a micro-mouse. A micro-mouse is a small autonomous robot that is designed to solve an unknown maze and therefore find the centre in the quickest time possible. The micro-mouse has several subsystems that have different functionalities. The micromouse needs a core, “the motherboard and processor board”, which will store and process the necessary information as the micro-mouse navigates through the maze. The micro-mouse consists of four subsystems namely the motherboard, processor, power and sensor subsystems

Achieved:

In the first semester, we began with the initial design of the micro-mouse. The sensor and power subsystem were the main designs as the motherboard and processor board were provided. The subsystem that was designed for this project was a sensing subsystem. The sensor was able to detect in 3 directions and therefore meeting its initial goal. But the achievement of this was reliant on the following being met:

- Selecting the correct components - photodiodes, IR LED and resistors from JLCPCB
- The final design being manufactured under the $30 budget.
- Debugging/Testing of the PCB after it had arrived and finding faults therefore being able to solder and desolder components on the PCB.
- Integrating the sensor subsystem with the microcontroller.

Design

The sensing subsystem purpose is to be the eyes of the micro-mouse as it navigates through the maze. This means that the sensing subsystem will be used to detect whether a particular obstacle is in the path of micro-mouse and thus notify itself that it cannot turn nor continue in that direction.

It follows the idea of a proximity sensor which detects physical objects at a particular distance. IR proximity sensor typically has two main components, which is the Photodiode and IR LED. The IR proximity sensor works on the principle in which the IR LED emits infrared light and the Photodiode senses that infrared light. The IR LED and Photodiode were placed in an indirect incidence, meaning the components are placed in parallel with each other and facing the same direction. Therefore, when an object is detected, the infrared light gets reflected and sensed by the photodiode. Negative feedback was added to the subsystem and therefore connected from the output of the photodiode to the pins of the processor board which lead to the pins of the microcontroller. This would look into the principle when voltage at non-inverting input is higher than the voltage at inverting input, then the output of comparator is high. And if the voltage of inverting input is higher than non-inverting and, then output is low.

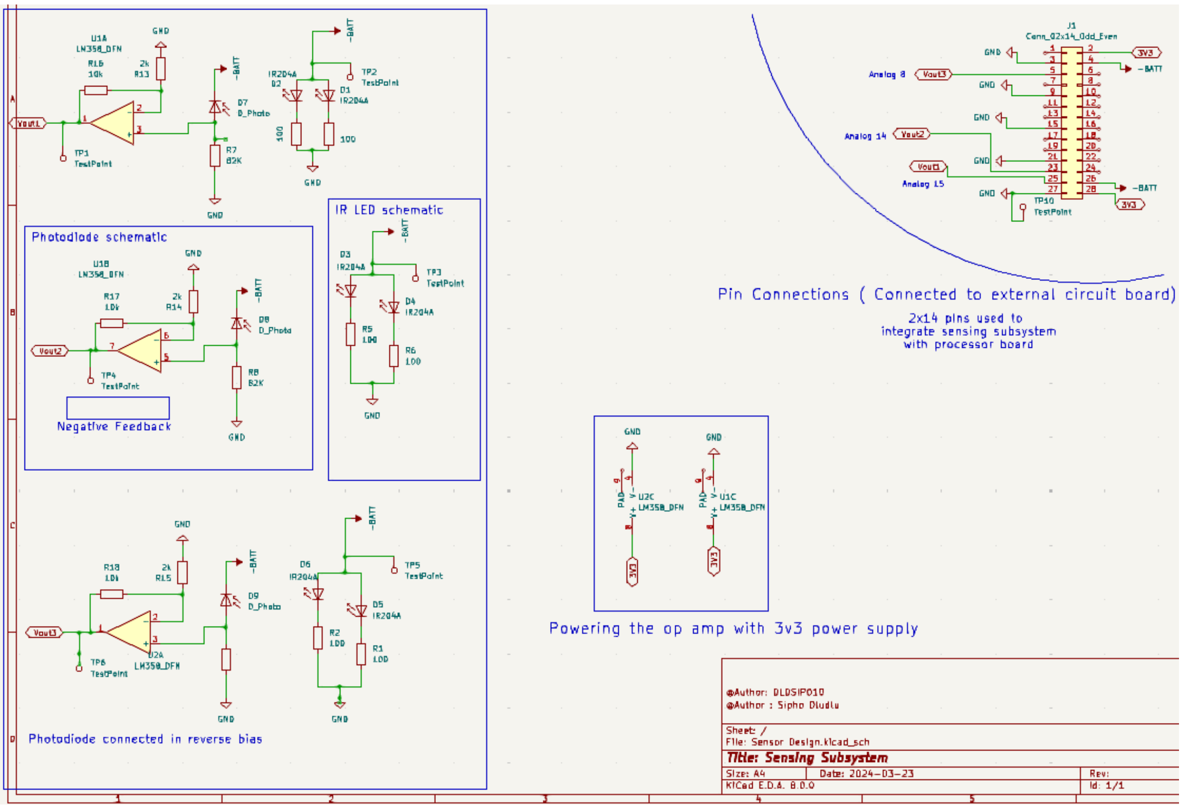

Figure 1 KICAD SCHEMATIC

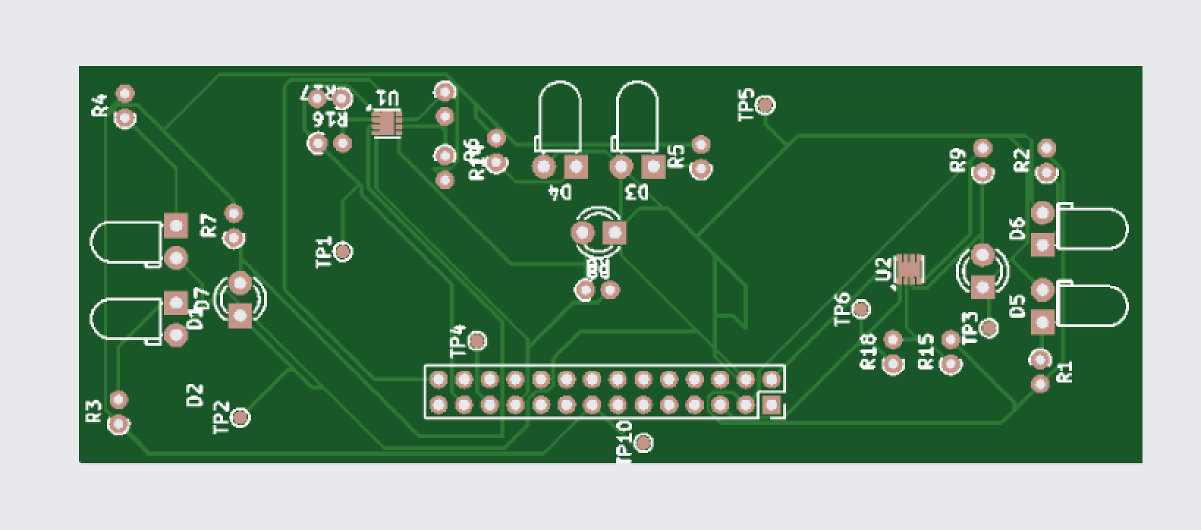

Figure 2 PCB SCHEMATIC

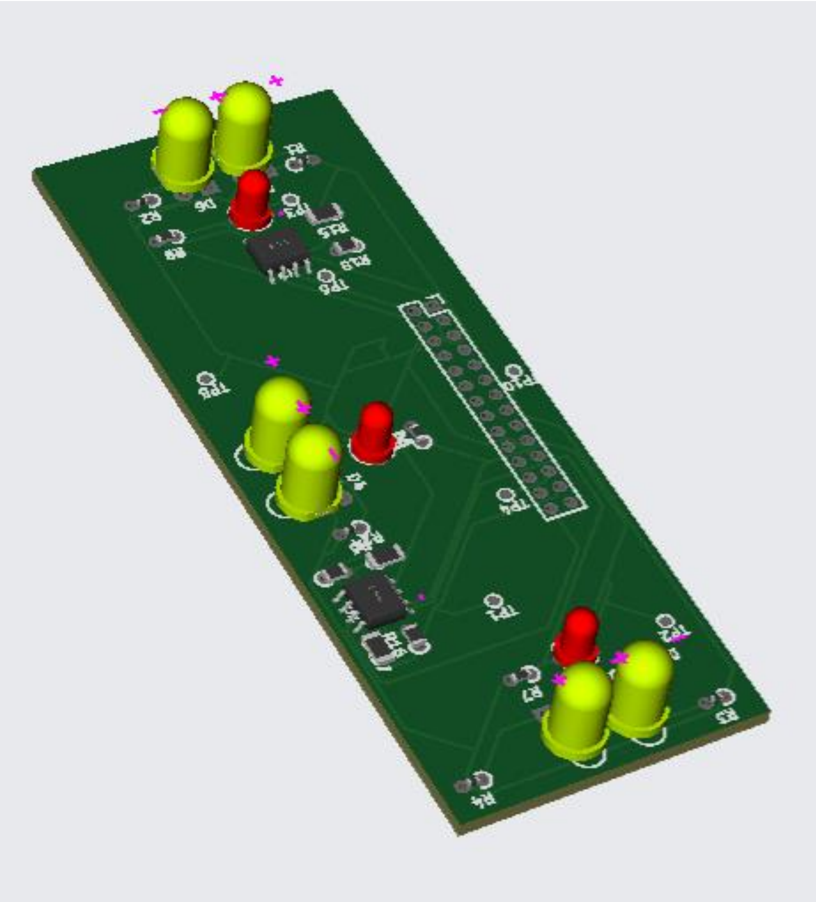

Figure 3 3D SCHEMATIC

The debugging of the design was conducted as follows:

Test nr.	Description
1	Using the multimeter to test for continuity across the components.
2	Using the supply voltage to power on the IR LED. This test will indicate whether or not the supply voltage is adequate to power the infrared LED inside the circuit, allowing it to emit light.
3	Testing to see if the IR LED emits light when it is powered on. This test will determine whether the LED is an infrared light source or a regular visible light source.
4	To check if the photodiodes were connected correctly as they needed to be reverse biased and to also check the maximum voltage range the sensor detects.
5	Measuring the output voltage at 3 different places away from the board.
6	LEDs on the micro-controller turn on when a board is placed in front of it. This test will tell one if the output from the op amps are placed at the correct analogue pins and the correct code is implemented that will toggle the necessary LEDs switch on when placed in front of it.

After these tests were conducted, the following was found to have worked or not worked:

Test nr.	Description
1	The connections between components had no short circuits. This means every trace created when designing the board has been connected successfully.
2	The measured current was a constant current of 98mA which is relatively close to the expected current of 100mA.
3	Upon seeing that there is current flowing in the circuit, from the results in test 2, a camera was used to reveal that the IR LEDs are emitting infrared light.
4	Photodiodes were placed incorrectly therefore had to be desoldered. Eventually had to be replaced by with another photodiode as they had bad sensing range.
5	The voltages varied as they were placed at the 3 different positions. When the wall was placed 5cm away from the circuit, there was a very low voltage being read, but when the board was placed 2cm away from the circuit, there was voltage increase but it was not that high. This meant that one's sensitivity was not that high and therefore did not yield the expected results.
6	When the code was generated and flashed into the microcontroller to output the necessary LEDs when a certain part of the sensor circuit is facing a board, the necessary LEDs turned on.

Flaws:

1. Based on these results, it was evident that there was effectively no need for the negative feedback. There was no need to amplify the voltage from the output of the photodiode as it did not aid in the sensing of the micro-mouse nor in determining the range of sensors.

2. Another flaw that was evident in the subsystem was the lack of failure managements. The design had no jumpers to connect external resistors, meaning that the sensitivity predetermined could not be altered.
3. The Photodiode that was selected from JLCPCB was found to have a weak sensing range, therefore they had to be soldered and replaced with photodiodes, SFH205, found at the white lab.
4. The sensor subsystem lacked power saving means. This was not designed for therefore not meeting one of the requirements that was specified.
5. (Based on CHVRIF001 2023 power subsystem) - Power efficiency: Chose components that used more power which led to the draining of the battery quickly.

SUBSYSTEMS

I. Motherboard

The Motherboard, which joins all the PCBs together, was provided by the department. It is the base board which all the designed modules were slotted onto. It provides physical, mechanical and electrical interfaces with all the other modules. Figure 1 Pin-view of the MM Motherboard PCB

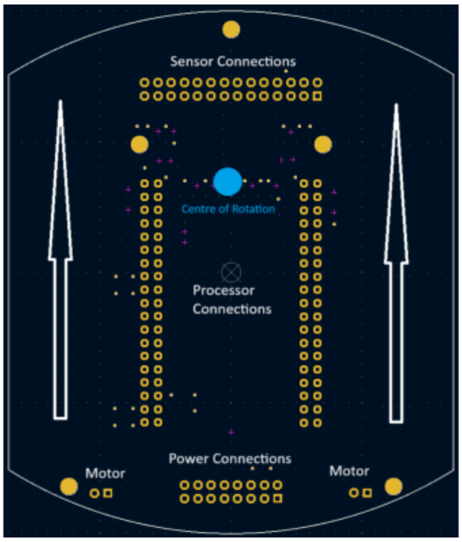

Figure 4 3D Pin-view of the MM Motherboard PCB

II. Processor

A STM32L476 processor board was provided by the department. It consists of a 100-pin package and has 78 output pins available for use.
The processor is basically the brains of the micro-mouse as it processes the sensor readings and executes decisions in real-time to get through the maze. The processor depends on the readings from the sensors to navigate through the maze and controls the movement and directions of the motor through the power module. It is also powered up by the power module. The processor relies on sensor data for navigation and directs power distribution to drive the motors effectively.

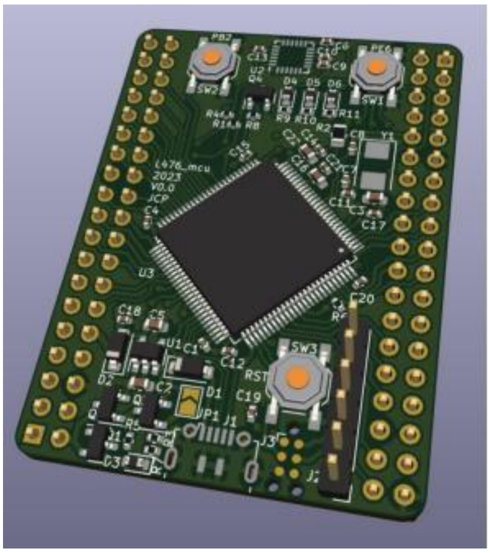

Figure 5 3D render of the MM Processor PCB

III. Power

(The information about the power module is based on the 2023 EEE3088F Designs project, which after research and familiarising myself with the 2024 EEE3088F micro-mouse project, the related content was extracted.)

This subsystem powers up the entire micro-mouse system and manages power distribution. It is responsible for supplying and regulating the power from the 5V battery to all the other components and modules, including the motors and processor. Since some of the components require a specific amount of voltage (e.g. 3.3V), the power subsystem is responsible for dropping down and regulating that voltage.

The power module is also responsible for the charging of the LiPo 800mAh 3.7V - Micro Robotics 1S1P battery that was used for this project from a 5V input USB port. It interfaces with the processor to monitor the voltage level of the battery and its charging. It supplies power to all the other component for them to function.

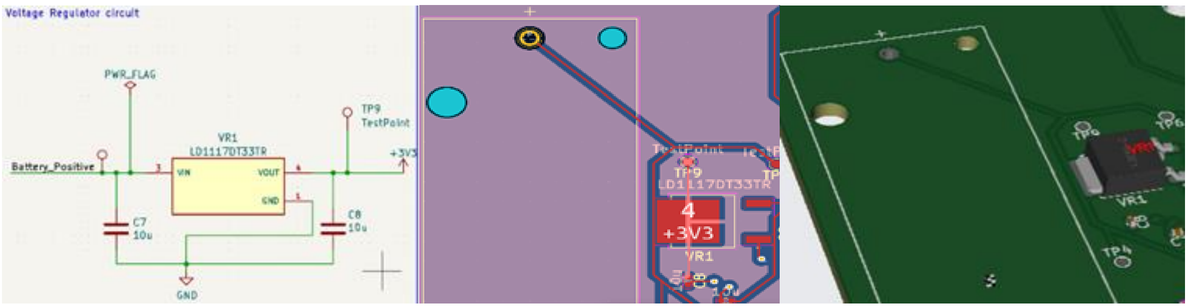

Figure 6 Voltage regulator circuit schematics. The circuit above drops down the 5V from the battery to 3.3V that is required by the processor.

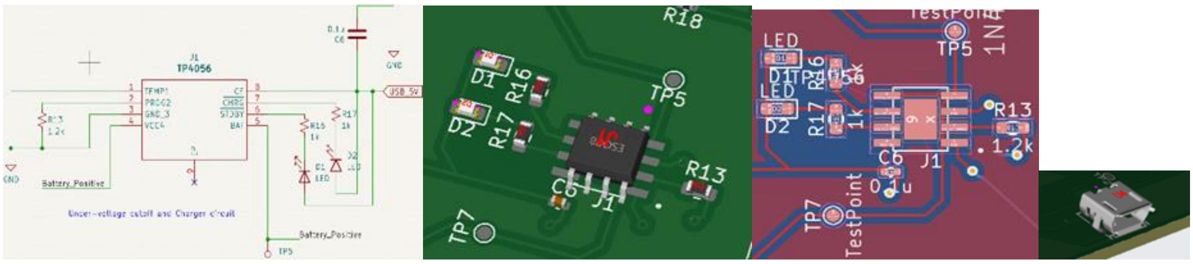

Figure 7 Battery charger circuit. The circuit above is responsible for the charging of the LiPo battery. It uses a micro-USB that is connected to a TP4056 charging chip that will charge up the battery on detection of low voltage.

IV. <u>Sensor</u>

The sensor module is essentially the eyes of the micro-mouse as it will assist it in “seeing” the walls on its left/right and in front of it, helping it navigate the maze. The sensor subsystem provides information to the processor to determine if there an obstruction in front of, or besides the micro-mouse. It detects and measures proximity to obstacles and walls. The sensor module interfaces with the processor and the rest of the subsystems. This information regarding detection should be sent to the STM32L476 which lies in the processor board processor to be analysed, which will then help the micro-mouse navigate the maze. The processor board will be responsible in showing the output to users. As all subsystems and designs are finalised, they will be connected to the motherboard.

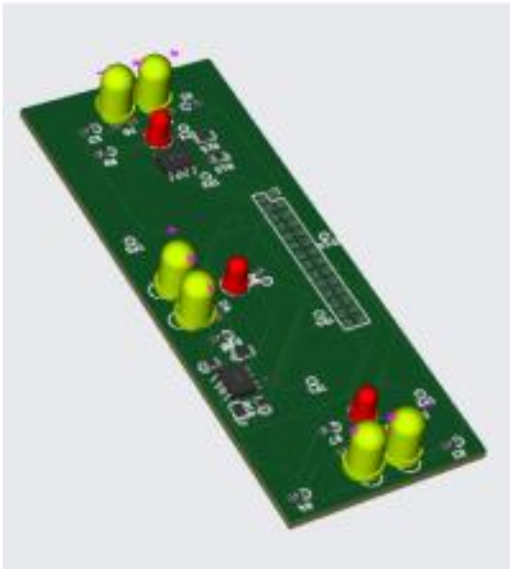

Figure 8 Sensor subsystem PCB