Interim Design Report

Micromouse Sensor Subsystem

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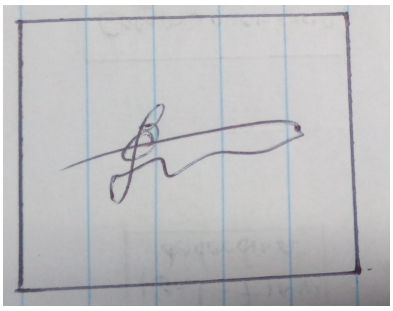

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Chapter 1

Introduction

1.1 Problem Description

The main objective of this project is to design and build a micro-mouse that will navigate and solve a maze autonomously. The greater project at large is the design of the micro-mouse's hardware. The specific problem at hand in the context of the whole micro-mouse project is to design a sensor sub-module that can detect whether a wall is present in the sense direction which might be either front, left, or right depending on the orientation of the micro-mouse. The sensor subsystem must have switching abilities to save power when not in use mode. As the micro-mouse will need to navigate through the maze, the power and current utilized by the sensor subsystem must be within the battery specifications as the micro-mouse needs to finish the maze before the battery is drained.

1.2 Scope and Limitations

1.2.1 Scope

The sensor subsystem in the micro-mouse project aims to provide correct environmental data to enable efficient navigation of the micro-mouse with its environment. The Micro-mouse sensor subsystem will make use of various infrared sensors to detect obstacles and to gather distance data from the front, left, and right sides of the maze walls.

System's Communication

As the system is controlled by the microcontroller therefore data received by the sensor subsystem is transferred to the microcontroller

1.2.2 Limitations

There have been some limitations in the design of this sensor subsystem which are as follows:

Environment

The performance of the sensors used may be affected by the lighting condition of the micro-mouse's environment

Cost

The design's bill of materials must be less than 30 dollars

Accuracy and precision

Despite calculation efforts, sensors have built-in inaccuracies measurements resulting in slight differences in navigation precision. The subsystem's ability to detect small obstacles may be affected by limitations in sensor resolution

1.3 GitHub Link

https://github.com/Bizela/README.git

Chapter 2

Requirements Analysis

2.1 Requirements

The requirements for a micromouse sensor module are described in Table 2.1.

Table 2.1: User and functional requirements of the sensor subsystem.

Requirement ID	Description
UR01(Accuracy)	The sensor subsystem is expected to deliver precise information about the micro mouse's surroundings, giving accurate obstacle detection and navigation.
UR02(Low Power Consumption)	The sensor subsystem should consume minimal power to extend the battery life and allow for longer operation time before the battery discharges to zero before reaching the maze goal.
UR03(Cost-effectiveness)	The subsystem must be designed using the given budget of 30 dollars whilst making sure of bringing the best outcome.
UR04(Real-time feedback)	Users expect real-time feedback which will be in the form of signals from the sensor subsystem to enable navigation and make corrections to the micromouse's path.
FR01(Obstacle detection)	The sensor subsystem must detect obstacles in the micromouse's route and provide the received distance data to the microcontroller using IR emitter and receiver.
FR02(Orientation and movement tracking)	The subsystem needs to monitor the micromouse's orientation and speed to enable accurate navigation and mapping
FR03(Environmental sensing)	Combine sensors to track environmental conditions like natural light intensity to retrieve information for flexible navigation means.
FR04(Communication interface)	Create a communication interface that supports data exchange and integration between the sensor subsystem and the micromouse's microcontroller

2.2 Specifications

The specifications, refined from the requirements in Table 2.1, for the micromouse sensor module are described in Table 2.2.

2.3 Testing Procedures

A summary of the testing procedures detailed in chapter 4(Acceptance testing) is given in Table 2.3.

Table 2.2: Specifications of the sensing subsystem derived from the requirements in Table 2.1.

Specification ID	Description
SP01(Obstacle detection sensors)	The system uses Infared Sensors which have 2 modules, IR emitter and an IR receiver.These sensors can detect from a range of 0-2 meters and the deduction angle which is quite adjustable is 30 degrees. They're more accurate at distances of approximately 2 centimeters.
SP02(Power Management)	The subsystem will be operating at voltages between 3.3-4.2 volts. It will use a 1S1P 18650 battery as an input power source.It has to draw a maximum current of 400mA and the battery will fully discharge after 2hrs.
SP03(Feedback)	The feedback retrieved from the output of the sensor subsystem must be a signal between voltage and distance.
SP04(Environmental sensing)	The sensor subsystem should continue to function reliably without failure under these challenging conditions.

Table 2.3: Acceptance tests

Acceptance Test ID	Description
AT01	The sensor subsystem should accurately detect the presence of an obstacle at estimated distances.The detected distances should match the actual distances with the tolerance of approximately 5cm.
AT02	The sensor subsystem should function within the defined consumption limits, with the actual power usage not exceeding the maximum specified value under any operating condition.
AT03	The processed sensor data should closely match the simulated input data, demonstrating accurate data processing.
AT04	The IR light sensor should provide readings consistent with the actual light levels.

2.4 Traceability Analysis

The table below show how the requirements, specifications and testing procedures all link, Table 2.4 is provided.

Table 2.4: Requirements Traceability Matrix

#	Requirements	Specifications	Acceptance Test
1	UR01,FR01,FR02,FR03	SP01,SP04	AT01,AT04
2	UR02	SP02	AT02
3	UR04	SP03	AT03

2.4.1 Traceability Analysis 1

The requirements with IDs UR01, FR01, FR02, and FR03 revolve around the concept of light detection and navigation. Since they're about navigation and detection, they have been linked with specifications with IDs SP01 and SP04 as these also have descriptions that revolve around accurate detection of light at different distances, and despite different lighting conditions, the overall sensing subsystem should continue to function reliably without failure. These can be tested through AT01 and AT04 which tests the presence of an obstacle at different distances and the sensors should give consistent readings with the actual light levels.

2.4.2 Traceability Analysis 2

From UR02 which is linked with the specification SP02, these are about power management of the system as the system needs to finish the maze before the prescribed battery fully discharges. These can be tested through AT02 which assures that the sensor subsystem should function within the defined consumption limits and the actual power usage doesn't exceed the maximum specified value under operating conditions.

2.4.3 Traceability Analysis 3

As the feedback from the sensor subsystem needs to be a signal, UR04 is linked with the specification with ID SP03. These can be tested using AT03 as the processed signals must closely match under different conditions such as sensing at various distances.

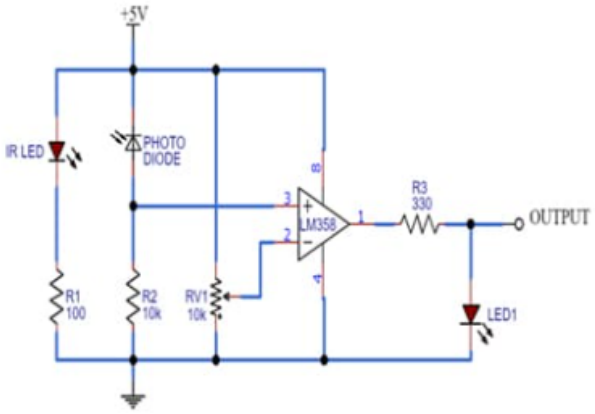
Chapter 3

Subsystem Design

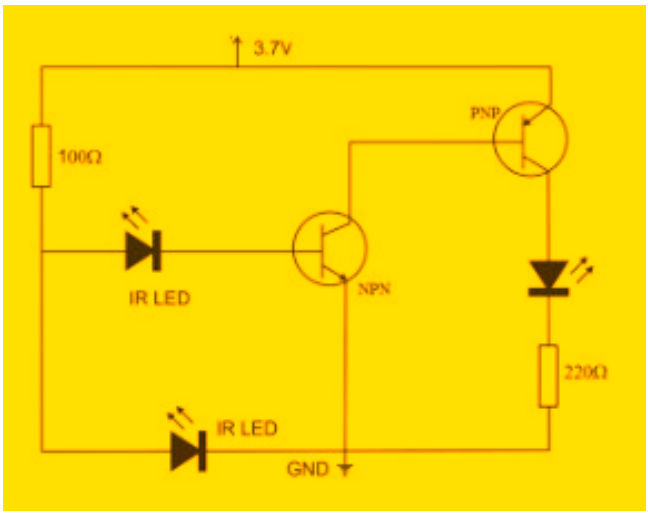
3.1 Design Decisions

3.1.1 Design decisions

Figures



[design1]



[design2]

#	Option image	Design description
1	design1	An IR sensor module consist of an IR receiver and emmiter and other components used to
2	design2	When the infrared LED is detected, the reflected light from the object will generate a smal
3	Schematic	The circuit requires 3.3V from the power supply which will power the transistor and provi

Table 3.1: Design Decisions

3.1.2 Final Design

The following design is the final design of the sensor subsystem of the micromouse project. The working principle of this circuit is mainly dependent on the IR emitter and receiver components. The circuit requires 3.3V which is within the battery limit from the power supply which will power the transistor and provide a suitable current for the IR emitter that will emit light with high intensity. This emitted light will be received by the IR receiver which will output accurate signals of voltage at different distances supplying important information to the microcontroller. The circuit also uses fewer components and is budget-friendly.

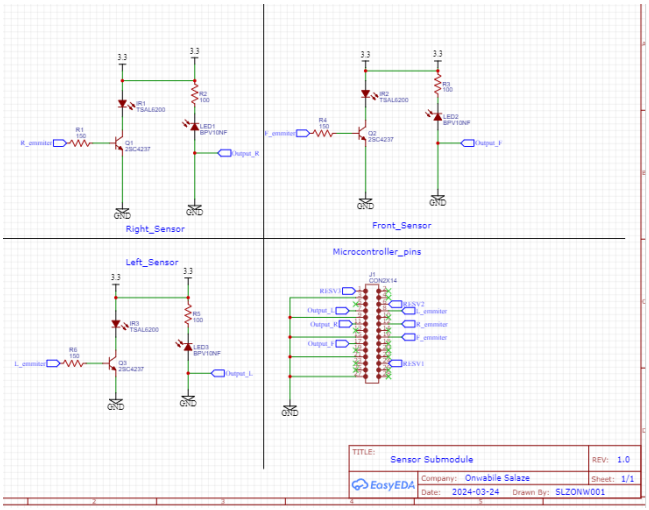
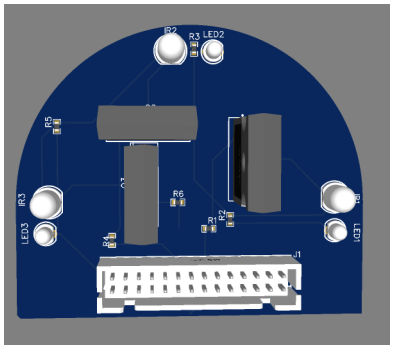
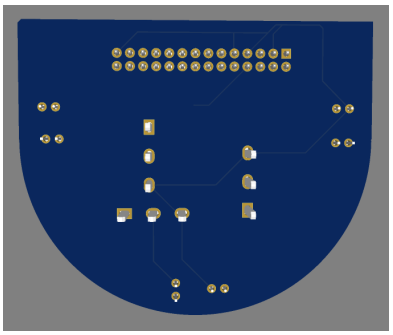


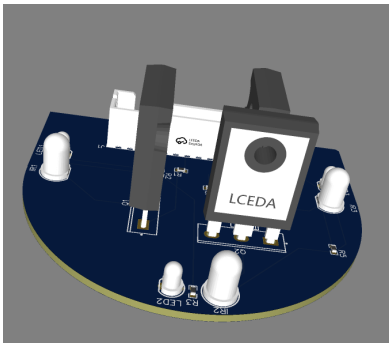
Figure 3.1: Schematic



(a) Front PCB



(b) Back PCB



(c) 3D PCB

Figure 3.2: PCB

3.2 Failure Management

3.3 System Integration and Interfacing

The MCU receives environmental data via infrared sensors. Through the communication channel, the MCU processes the sensor data and exchanges information with the micro-mouse control unit. In order to navigate the maze, the micro-mouse control unit takes judgments based on the sensor

Table 3.2: CAPTION

Name	Description
Failure detection	Implement continuous monitoring of sensor data to detect any deviations from expected behavior.
Fault localization	Upon detecting a failure, analyze sensor readings to pinpoint the source of the fault.
Documentation	Maintain comprehensive documentation detailing failure management procedures, diagnostic routines, and troubleshooting steps for the sensor subsystem.
Continuous Improvement	Gather and assess data on system failures to pinpoint common issues and opportunities for enhancing the design of the sensor subsystem.

data. The micro-mouse system's major elements and their interconnections are high-levelly outlined in this diagram, with special attention paid to the sensor submodule's function in supplying vital environmental data for autonomous navigation

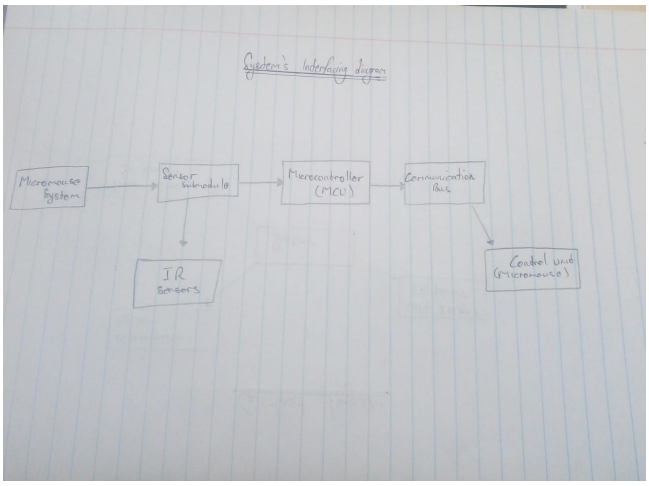
[SII] 

Table 3.3: Interfacing specifications

Interface	Description	Pins/Output
I01	Micromouse supply power subsystem to Sensor subsystem	• PC6-9 to PE15 • PC6-9 to PE13 • PC6-9 to PE11
I02	Sensor subsystem output pin to Microcontroller for output data signals	• Analog9 to STM PA4 • Analog10 to STM PA5 • Analog12 to STM PA7

Chapter 4

Acceptance Testing

4.1 Tests

Table 4.1: Subsystem acceptance tests

Test ID	Description	Testing Procedure	Pass/Fail Criteria
AT01	The sensor subsystem should accurately detect the presence of an obstacle at estimated distances. The detected distances should match the actual distances with the tolerance of approximately 5cm.	Place various obstacles at different distances within the micromouse's environment.•	Pass
AT02	The sensor subsystem should function within the defined consumption limits, with the actual power usage not exceeding the maximum specified value under any operating condition	Monitor power consumption of the subsystem under various operating conditions, including active sensing and idle states•	Fail
AT03	The processed sensor data should closely match the simulated input data, demonstrating accurate data processing.	Input or use known distances into the sensor subsystem and verify if data is as expected•	Pass
AT04	The IR light sensor should provide readings consistent with the actual light levels	Expose the micromouse to different environmental conditions, varying light levels.•	Fail

4.2 Critical Analysis of Testing

4.2.1 AT01

This worked, this did not work. I suspect that is because of x y and z.

Table 4.2: Subsystem acceptance test results

Test ID	**Description**	**Result**
AT01		
AT02		
AT03		
AT04		

Chapter 5

Conclusion

5.1 Recommendations

Bibliography

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