Interim Design Report

Micromouse Sensor Subsystem

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April 21, 2024

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Date

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Chapter 1

Introduction

1.1 Problem Description

Aim of this project is to create a micro-mouse robot that can solve a maze. Main aim of this project is to design an efficient Sensor subsystem for a micro-mouse that will solve the maze.

1.2 Scope and Limitations

The Sensor part of the project entails to design a sensor with the limitations of the budget and also keeping in mind the size of the robot, and also size of the maze. Even though the sensor works hand in hand with the micro-mouse. For this project that won't be the in our scope.

Limitations The project is mainly limited by the availability of parts from JLCPCB. And also the budget constrictions, since we are only given a budget of $8.5 for two separate PCB boards. Also more importantly the design is limited to the Size of the board,

1.3 GitHub Link

https://github.com/MphoCasey/Main-Project.git

Chapter 2

Requirements Analysis

2.1 Requirements

The requirements for a micro mouse Sensor module are described in Table 2.1.

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

Requirement ID	Description
R01	Output should be clear and repeatable
R02	Fits into the micro-mouse
R03	Energy-efficient
R04	It should be under budget
R05	Only use components that are available on JLCPCB
R06	Use IR emitter diodes
R07	Gets powered by the Power subsystem

2.2 Specifications

The specifications, refined from the requirements in Table 2.1, for the micro mouse sensing module are described in Table 2.2.

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

Specification ID	Description
SP01	Detect wall at different distances
SP02	Be less sensetive to angle changes relative to the wall
SP03	Output should be an analogue signal
SP04	The system must be powered by a battery of voltage (3.5-4.2)
SP05	If there's a large change in the angle it should be the same at the output
SP06	Use PWM from Micro controller to save energy.

2.3 Testing Procedures

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

2.4 Traceability Analysis

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

Table 2.3: CAPTION

Acceptance Test ID	Description
AT01	Powered by a battery
AT02	Produces a repeatable Analogue output
AT03	The sub-system is Energy-saving
AT04	Senses a wall at different distances and Angles

Table 2.4: Requirements Traceability Matrix

#	Requirements	Specifications	Acceptance Test
1	R07	SP04	AT01
2	R01	SP02	AT02
3	R03	SP06	AT03
4	R06, R01	SP01, SP02, SP05	AT02

2.4.1 Traceability Analysis 1

SP04 is linked to R07 since the system will be powered by the Power Subsytem. SP04 just shows which specific values the system is ought to use. And this specs and requirement can be tested using AT01.

2.4.2 Traceability Analysis 2

From R01, SP02 can be derived because for the sensor to be less sensitive to sudden movements and small angle changes the output has to be clear and repeatable. Clear meaning it has less noise. This is tested via AT02.

2.4.3 Traceability Analysis 3

From R03 (**Energy saving**) SP06 can be derived because it was decided that to save energy a PWM will be used. Which allows to save energy since the emiter will be on half of the time and off the other half. To test this AT03 is needed.

2.4.4 Traceability Analysis 4

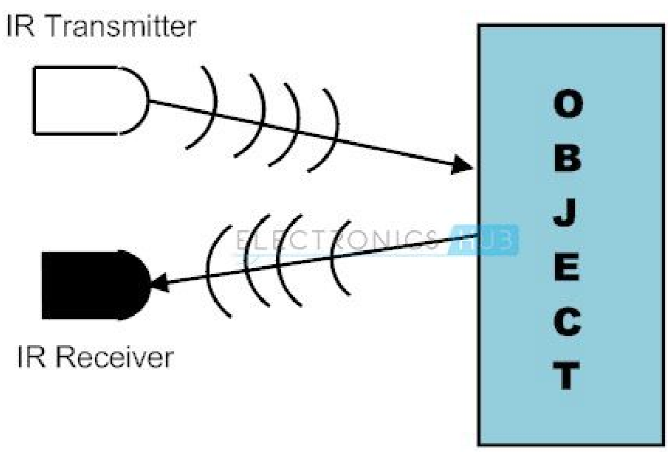


Figure 2.1: Demonstration of how the sensor works

As seen from the diagram above R06 links SP01, SP02, and SP05 in such a way that with small changes in angles relative to the wall. The receiver will still get IR from the emitter but if the angle changes a lot the receiver will receive less IR thus more change in the output. This can be done using AT04.

Chapter 3

Subsystem Design

3.1 Design Decisions

Table 3.1: Unique Design Decision

Unique Decision	**Pros**	**Cons**
Capacitors	Can be used to filter noise at the output. Noise from the switching using Mosfet and the PWM. Use the Capacitors to reduce the turn on time of IR emitter.	• Finding the good range for the value of the Capacitors to filter out noise.
Mosfet for a switch and Current Amplifier for the IR Diode.	Mosfets are good when it comes to switching and amplifying current.	If the mosfet is not configured properly it is easy for it to burn. And the whole PCB will lose functionality.
Pull-down Resistor at the Mosfet Gate	Since a PWM is being used as input. Pull down resistor will make sure that input to the Gate of Mosfet doesn't float. Keeping it grounded.	Doesn't really have a con.
Using a BJT as a switch and an Amplifier	A BJT works well, and it is easier to configure it for Amplifying collector voltage and current.	It doesn't work well for switching compared to a Mosfet.

For the receiver (IR reciever The SFH 205FA is much cheaper and it is suited for solving

Different types of Sensors (reciever)		
Phototransistor SFH 313 FA-3/4	SFH 205FA	
0.8	0.4394	Price ($)
20	120	Beam Angle(°)

Figure 3.1: Comparison of 2 different sensors

the maze since it has a bigger Beam Angle. Thus the SFH 205FA is chosen over the SFH 313 FA-3/4.

Through serious consideration of the budget and the functionality of the circuit. The following Design was chosen as the final design for the sub-system.

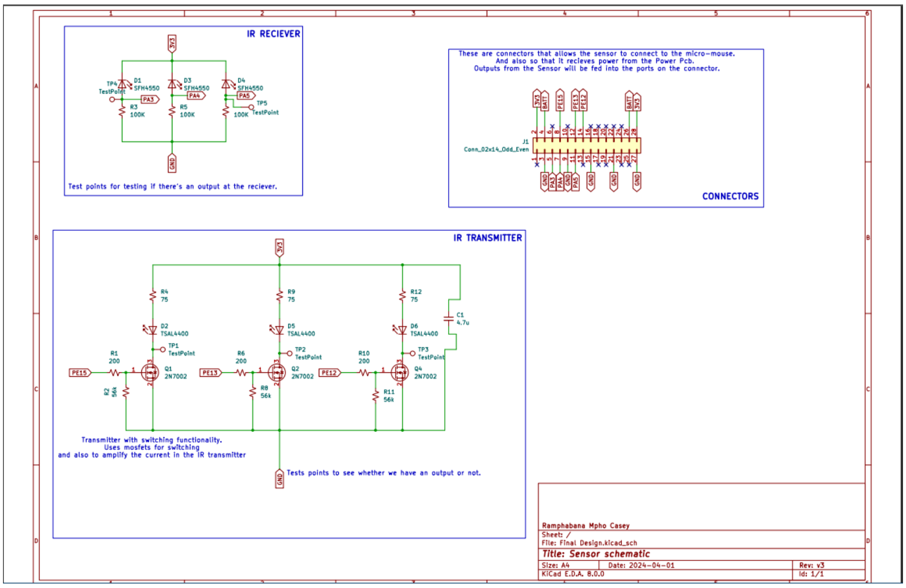


Figure 3.2: Schematic

Calculations for the Sensor Sub-system:

IR emiter:

Datasheet of TSAL4440:

Angle of intensity = $\pm 25\,\text{deg}$

Max Forward Current = 100mA

Voltage drop across the Emiter = 1.35 Volts

It is safer to operate the TSAL4440 below it's max rated conditions.

let Operating current be:

$$I = 50mA$$

$$V_{drop} = 3.3 - 1.35 = \ 1.95Volts$$

but

$$V_{drop} = I * Resistor$$
$$Resistor = \frac{V_{drop}}{I} = \frac{1.95}{50mA}$$
$$Resistor = 39\Omega$$

But that specific value of Pull-down resistor was not available at the JLCPCB website. Thus ended up choosing a higher value 75 Ω

IR Reciever:

Note the IR receiver on the Schematic is not the SFH205 which was a mistake when doing the PCB. The sensor is supposed to use the SFH205 not the SFH 4550 Which will be fixed when the board comes back, as part of 'Fixing the board.'

Datasheet values for SFH205

For this part of the circuit it is a little bit harder to find the values of the Resistor that will keep the Current through the photodiode below Max rated conditions while maintaing operation.

So through trial and error and other circuit online. It is recommended to use a large Resistor of atleast $100k\Omega$.

let:

$$R_{reciever} = 100k\Omega$$

Mosfet part of the circuit:

Pull-down resistor:

The value of this resistor need to be high enough so that when the Mosfet is in operation-mode no/less current as possible flows to ground. But when Mosfet is not in operation the resistor should pull down any current down to the Ground.

$$R_{pull-down} = 56k\ \Omega$$

Capacitor values

Range values for a Bypass-Capacitor for a supply is from nanofarads (nF) to microfarads (μF).

$$C = 4.7\mu F$$

Any changes made to the circuit due to availability and budget constraints.:

3.2 Failure Management

Table 3.2: Failure Management

Name	Description
ERC	Used to check for errors in the Schematic, such as unused connections and label nets.
Design Rule Check	Used to verify correct routing and ensure components are within PCB boundaries.
Manual checking	Verifying component connections and correct placement by visual inspection.
Component selection	Selecting components rated below maximum conditions, considering factors like ambient light, temperature variations, and current fluctuations.
3D viewer in KiCad	Verifying correct footprints and component placement, ensuring components like Photodiodes and IR diodes are properly oriented.

3.3 Final Design

The following design...

3.4 System Integration and Interfacing

To integrate the subsystem with the rest of the system ....

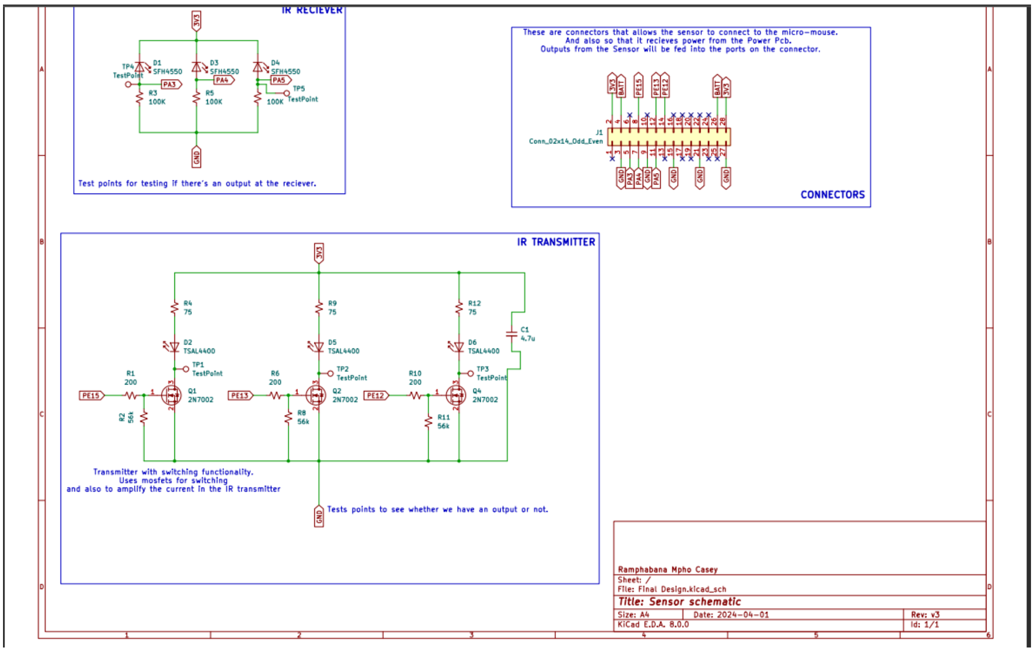
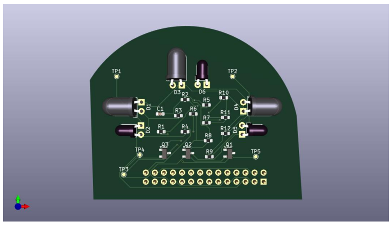
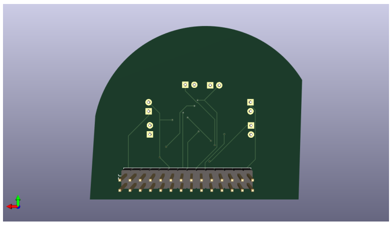


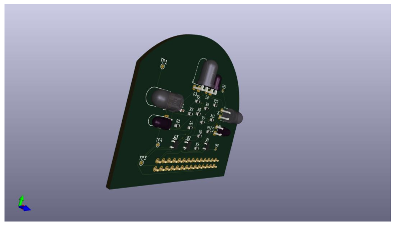
Figure 3.3: Schematic



(a) Front PCB



(b) Back PCB



(c) 3D PCB

Figure 3.4: PCB

high-level block diagram

Table 3.3: Interfacing specifications

Interface	Description	Pins/Output
I001	Allows the Subsystem to be powered by the Power subsystem Module	• Pin 2/28: Breakout 1V8-5V5* to PCB(sensor) • Pin 3/21/27: Breakout GND* to PBC (sensor) GND
I002	Connects the Analogue outputs to the Micro-controller	• Sensor (PCB) PA3 (Analogue) to Connectors Pin 5 • Sensor (PCB) PA4 (Analogue) to Connectors Pin 7 • Sensor (PCB) PA5 (Analogue) to Connectors Pin 11
I003	Supplies input to the Sensor from the Micro-controller	• PWM from micro-controller is connected to Pin 8/12/14 (Connectors) then that PWM is fed into the transmitter part of the sensor through PE15/PE13/PE12
I004	Test Points for different parts of the PCB	All the through holes on the PCB used as Test Points

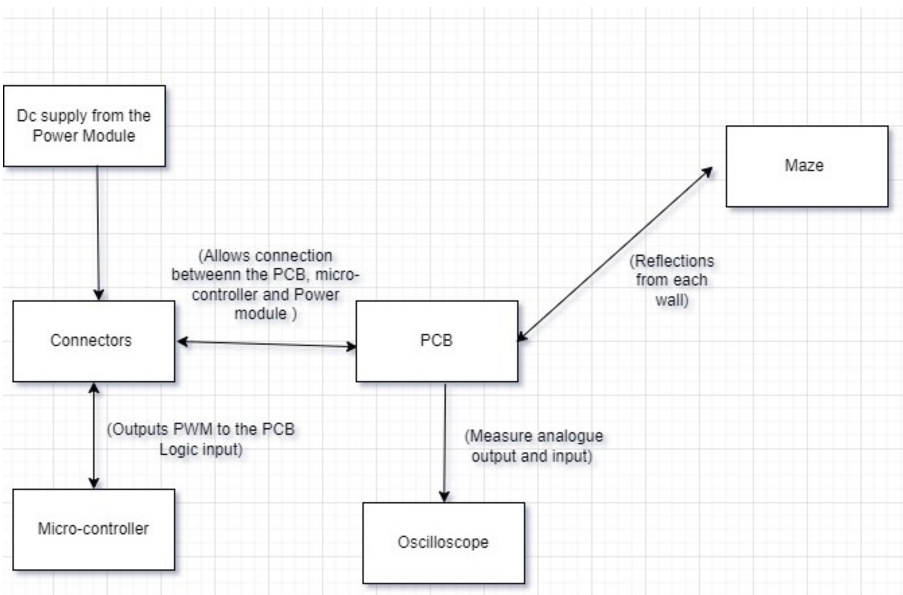


Figure 3.5: High-level block diagram

Chapter 4

Acceptance Testing

4.1 Tests

Table 4.1: Sensor Subsystem acceptance tests

Test ID	Description	Testing Procedure	Pass/Fail Criteria
AT01	Powered by a battery	• Use an Ammeter to do continuity test over the whole PCB • Using a Camera check for Infrared radiation from the IR diodes	If it passes the continuity test and Can see the IR radiation from the IR diodes then it is a PASS
AT02	Produces a repeatable Analogue output	• Check if there's an output at pins for Output using an Oscilloscope. • Also can check the values from the ADC if they're repeatable or not	If there's a readable value on the Oscilloscope (Pass). If the ADC is giving values that are repeatable it is also a Pass.
AT03	The sub-system is Energy-saving	• When micro-controller is fully functional how long does it last??	If it can last to a point where it can finish the Maze then it is a Pass
AT04	Senses a wall at different distances and Angles	• This is tested by putting the micro-controller through a Maze test.	A pass when it is able to navigate the Maze properly without running into walls.

4.2 Critical Analysis of Testing

Table 4.2: Subsystem acceptance test results

Test ID	Description	Result
AT01	Powers on	

4.2.1 AT01

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

Chapter 5

Conclusion

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5.1 Recommendations

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