Interim Design Report

Micromouse Power Subsystem

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Chapter 1

Introduction

1.1 Problem Description

It is required to design and build a power subsection for a micro mouse that will be placed in a maze and will be required to sense and react to walls around it. The power subsection will is needed to supply power to all parts of the mouse to allow it to operate.

1.2 Scope and Limitations

The subsection will entail a battery that will be the source of all power used when the mouse is operational. There will be a way to sharge the battery with a micro ucb. There will be no other sources of power. The subsection will include designs that will supply the processor and motors with the correct input power they require to operate and will include a design to drive the motors depending on a supplied output from the processor. The subsection will not do any further processing and will not do any sensing. The overall mouse should be able to sense how far away walls are in the front and on the sides and should be able to spin the motors connected to the wheels accordingly. The mouse will not yet be able to solve a maze. The project is limited by due dates which constrict time for each section of the design process. The project is also limited by cost, manufacturer JLCPCB and size as the mouse needs to fit in the maze.

1.3 GitHub Link

https://github.com/shwlau003/Design-Project-2024

Chapter 2

Requirements Analysis

2.1 Requirements

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

Table 2.1: Requirements of the power subsystem.

Requirement ID	Description
R01	Solution must be on a single breadboard
R02	The breadboard must be able to fit in the maze and allow for maneuvering when connected to the mouse body
R03	The breadboard requires a tab for the connection to the motherboard to be placed
R04	Drive two motors using 4 separate logic input signals
R05	Only use components available from JLCPCB
R06	Use the supplied battery to power the circuit and micromouse
R07	The circuit must have capabilities to charge the battery when needed
R08	Have a switch to turn the micro mouse on and off
R09	Design the subsection in the allocated budget
R10	Supply a connection for the processor to access the State of Charge of the battery
R11	Include the connections for connecting to the battery and for the pin header
R12	The subsection must be compatible with the rest of the mouse

2.2 Specifications

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

2.3 Testing Procedures

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

2.4 Traceability Analysis

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

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

Specification ID	Description
SP01	Design the circuit to handle 200mA drawn by the motors at a maximum of 4.2V
SP02	Design the circuit to operate with a 1S1P battery within its operating range
SP03	When the switch is off the draw on the battery must be less than 500uA
SP04	When the switch is on the circuit must allow for peak current draw from the battery
SP05	The board must have a slot for a JST PH 2mm pin pitch connector
SP06	The board must have a slot for a 2x8 pin header with 2.54mm pin pitch
SP07	The tab that the connector must be centered on can have a maximum width of 35mm and can have a height of 18mm or greater
SP08	The circuit must adhere to the assigned associations of the pins of the connector
SP09	The maximum budget for each subsection is $30
SP10	A 5V input pin must be used to charge the battery when needed
SP11	The subsection must connect to and work with the motherboard, processor and sensor system by supplying power to the mouse for the other subsections to use

Table 2.3: Testing procedures for the power subsection related to the requirements in Table 2.1 and the specifications in Table 2.2

Acceptance Test ID	Description
AT01	Visual inspection for completeness, damage and shorts
AT02	Check input voltage in to the processor with the different possible battery voltages
AT03	Test switching circuit
AT04	Motor test at different potential voltages
AT05	Off state test, all elements but the charging circuit off
AT06	On state test, all elements running optimally
AT07	Test the battery charging circuit
AT08	Battery and circuit compatibility test
AT09	Test adding the connection for the motherboard in the board
AT10	Test connecting the board to the main mouse body
AT11	Test the mouse fits in the maze rotated at every angle
AT12	Test adding the battery connection to the board
AT13	Test the pins for the connector and that they correlate to the assigned associations
AT14	The budget reviewed before any purchase

Table 2.4: Requirements Traceability Matrix

#	Requirements	Specifications	Acceptance Test	Analysis
1	R01		AT01	Visual inspection is the most effective to see this requirement
2	R02		AT11	As the dimensions of the maze is not given and just advised to make the boards small so to check if this will work it must be done by using manual testing with the physical maze using potential orientations the mouse may have when navigating.
3	R03	SP07	AT09	To test that the connection fits it must be tested with the mouse
4	R04	SP01	AT04	To test functionality and operation using known and controlled input values will allow to see if the motors are working as predicted
5	R05	SP05, SP06	AT14, AT01	The check is performed if the board is fully populated once the 2 connections are added and shows JLCPCB was able to populate the board
6	R06	SP02	AT08, AT02	Using a controlled and known signal to test the expected operations of the circuit and then observing the operations with the battery will allow to see the compatibility between the circuit and battery
7	R07	SP10	AT07	The sub circuit must be tested to see its operation aligns with the specifications
8	R08	SP03, SP04	AT03	The sub circuit must be tested to see its operation aligns with the specifications
9	R09	SP09	AT14	The budget must be observed intermittently to ensure it is kept
10	R10	SP08	AT13, AT07	By testing the charging circuit it can be tested to see if the processor is receiving the State of Charge and by testing the associations the it can be ensured that the state of charge is supplied to the correct pin
11	R11	SP05, SP06	AT09, AT12, AT13	The connections must be fitted into the board to test connection and fit and the connections need to be tested to ensure full use of the connectors
12	R12	SP11	AT09, AT10, AT11	The subsection must be tested for compatibility and this can be done by connecting it to the tested other subsections to test fit and operations

Chapter 3

Subsystem Design

3.1 Design Decisions

3.1.1 Final Design

The following design was chosen with cost and efficiency prioritised.

The switching and supply circuit need to supply the motors with the full supply of the battery and to convert the supply to a usable/lower voltage for the microcontroller's input.

The design decisions went as follows for the switching and supply circuit: The use of a voltage divider allowed for a cheaper solution for dropping the voltage and was done with higher resistors to reduce power loss. E12 resistors were used as they have the highest stock and are cheaper. Originally the circuit was designed with resistors greater than 100k to maximise reduction in power loss however when researching the resistors in jlcpcb the resistors were not available as a basic part. Resistors that were greater than 1k were chosen instead as the price for extended parts was too much to make it worth having higher resistance. To choose the resistance the ratio needed was calculated from the maximum possible voltage of the battery to the maximum voltage that the processor accepts (4.2V:3.2V). That was compared with combinations of available resistors to get the closest ratio with the highest resistors. The values 1k, 2k and 10k were chosen.

A basic switch was chosen to reduce costs as all other switches were extended parts. Costs needed to be reduced to allow for the use of the 3 ICs that were used in the motor and charging circuits.

ICs were used for the motor circuits as designing an h bridge uncovered many issues related to power loss and overdesign and using ICs allowed for an affordable, more efficient solution with more functionalities.

An IC was used for the charging circuit as it fit the budget and allowed for a better design to protect the battery and charge the battery safely and efficiently to allow for a more stable and longer lasting battery lifespan.

This design prioritised the protection of the components for a higher reliability and lower replacement costs. It used ready researched and designed circuits packaged as ics to aim for the highest efficiency and functionality at an affordable price.

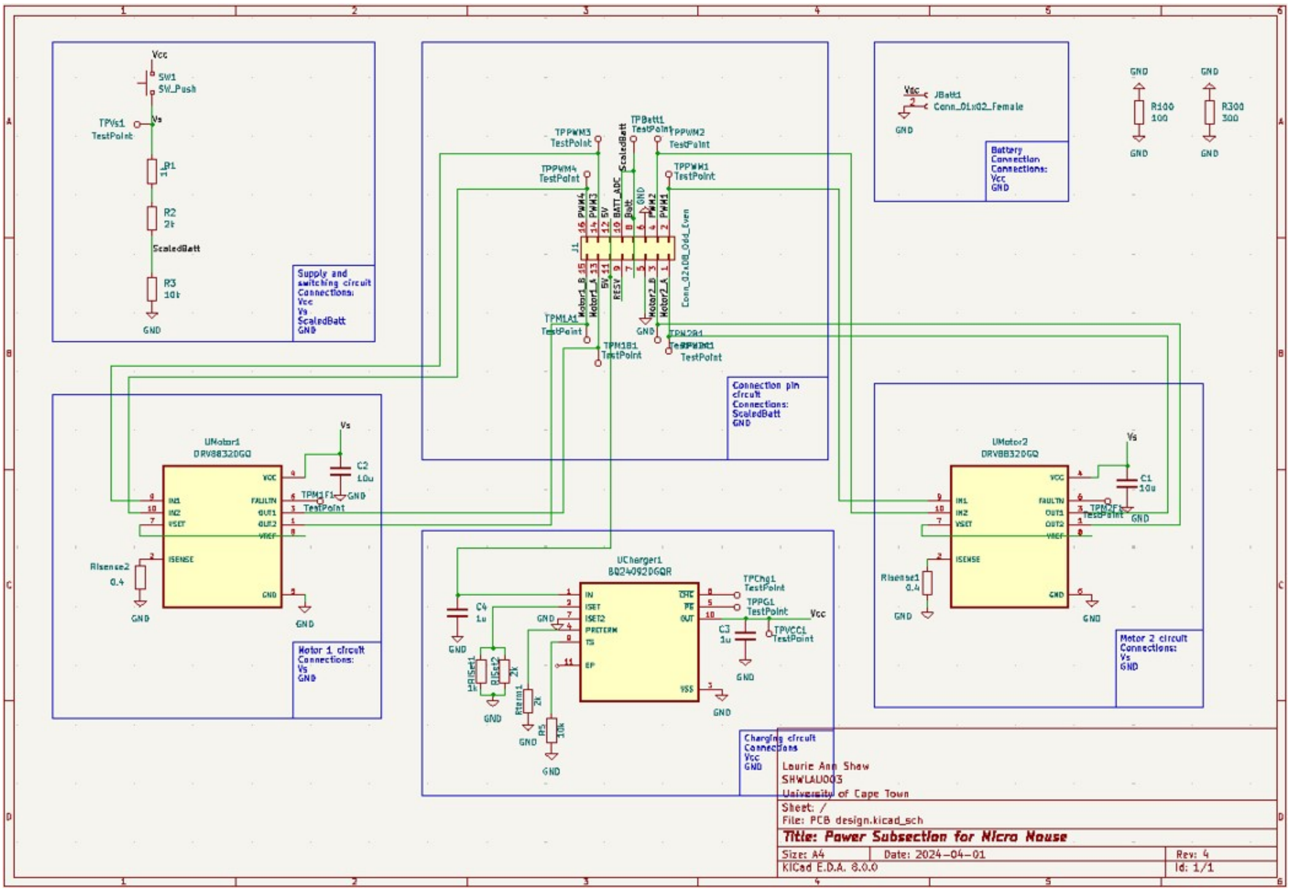
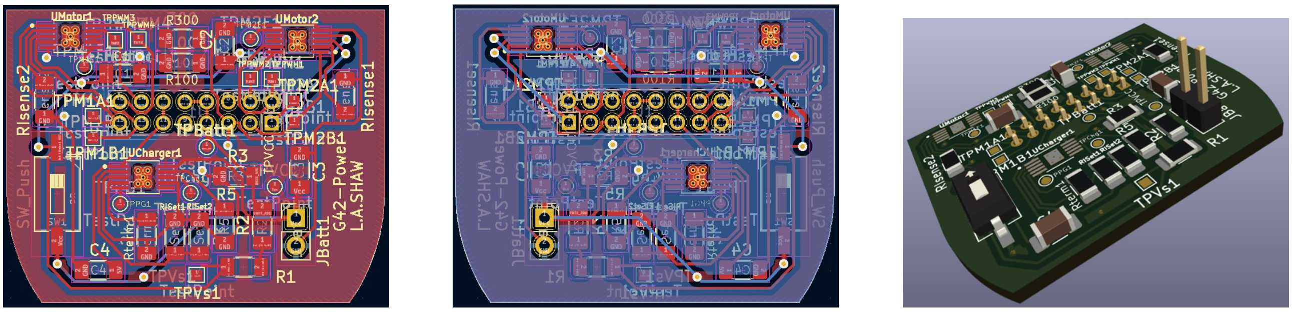


Figure 3.1: Schematic



(a) Front PCB (b) Back PCB (c) 3D PCB

Figure 3.2: PCB

Table 3.1: Failure management and implentation

Name	Description
Larger components	Larger resistors and capacitors were used to allow for desoldering and resoldering of components if the components need replacing or changing
Test points	Test points are used to check the operations of components and the circuit to track what is happening and where an issue may be
Built in failure management	The chosen ICs have built in failure management and output pins that can communicate issues that will be checked
Extra components	Extra resitors with different values were added to the board incase the chosen values do not work optimally
Bigger spacing	The extra spacing between components and traces allow for easier fault finding for an untrained eye and easier to work with the board with less chance of damaging the board in a way that damages the circuit
Isolatation of systems	By isolting the separate cicuits of the sub system it is a damage control technic incase a single circuit doent work as expected the rest of the circuits should not break

3.2 Failure Management

3.3 System Integration and Interfacing

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

Microcontroller pinout	**Connection name**	**Connected to**
Pin1	Motor2_A	UMotor2 pin3
Pin2	PWM1	UMotor2 pin9
Pin3	Motor2_B	UMotor2 pin1
Pin4	PWM2	UMotor2 pin10
Pin5	GND	GND
Pin6	GND	GND
Pin7	Batt	• Pin8 • Pin10 • ScaledBatt point
Pin8	Batt	• Pin7 • Pin10 • ScaledBatt point
Pin9	RESV	
Pin10	BATT_ADC	• Pin7 • Pin8 • ScaledBatt point
Pin11	5V	• Pin12 • UCharger Pin1
Pin12	5V	• Pin11 • UCharger Pin1
Pin13	Motor1_A	UMotor1 pin3
Pin14	PWM3	UMotor1 pin9
Pin15	Motor1_B	UMotor1 pin1
Pin16	PWM4	UMotor1 pin10

Table 3.2: Interfacing

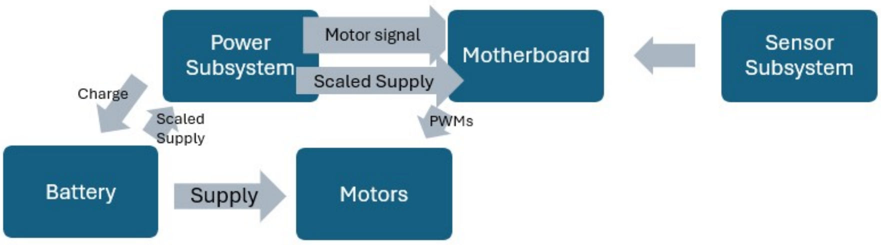


Figure 3.3: Block diagram of interaction with main system

Chapter 4

Acceptance Testing

4.1 Tests

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 4.1: Subsystem acceptance tests

Test ID	Description	Testing Procedure	Pass/Fail Criteria
AT02 AT08	Battery can supply the circuit at all accepted charge values	• voltage supply will be connected to the battery pin • the supply will be varied from 4.2V to 3.2V • test point TPBatt will be monitored	The test point must output a voltage above 1V at all input voltage
AT03 AT05 AT06	Switches on and off	• voltage supply will be connected to the battery pin • the supply will be set to 4.2V • the switch will be turned off and on • test point TPVs will be monitored	The test point must output 4.2V with a small tolerance when the switch is on and must output approximately 0V with a small tolerance if the switch is off
AT04	Motor operates	• motor loads will be attached • processor will be programmed to output the signals that will vary to the highest pwm for combinations of outputs • the test points around the circuit and motors will be monitored for signs of issues	motors spin forward
AT07	Test the battery charging	• voltage supply will be connected to the battery pin • The supply is set to to 3V • Test point TPVCC	TPVCC will output 4.2V
AT09 AT10 AT12 AT13	The subsystems go together	• Add the connection pins for the motherboard and battery to the board • connect the board to the main mouse	The mouse all connects together and stays together
AT11	The mouse fits in the maze	• place the whole mouse in the maze • rotate the mouse to face every angle and check that the mouse fits	the mouse does not get stuck
AT14	The budget is adhered to	• The budget is checked after the order for the board	The amount paid was less than $30

Table 4.2: Subsystem acceptance test results

Test ID	Description	Result
AT01	Powers on	

Chapter 5

Conclusion

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5.1 Recommendations

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