Interim Design Report

Micromouse Power Subsystem

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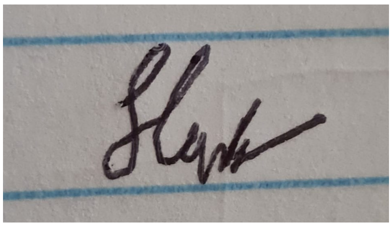


April 21, 2024

Name Surname

Date

Contents

Chapter 1

Introduction

1.1 Problem Description

This project aims at investigating and implementing a viable power subsection to a micro-mouse system, capable of powering all necessary components of the system through the use of a battery. The power subsection is part of a greater system under which two people are working towards a final product where the micro-mouse, which is a miniature robot tasked with being able to move through a maze through the programming utilizing the systems we will be creating [1]. The other subsection is the sensing system, which will be used to detect walls to allow for coordinated movement of the micro-mouse. Alongside these two subsystems, a processor and motherboard have been provided for integration purposes between the two systems and will allow for the control of the micro-mouse's movement at a later stage of development.

This report focuses on the development of the power subsystem to ensure power is given to the other subsystems and to the motors, which are needed for the movement of the micro-mouse, and to be able to communicate important information to and from the processor to allow for co-originated movement and battery charge control.

1.2 Scope and Limitations

This project has a specific focus on the power section, and although considerations can be made towards the sensing subsection, the majority of the focus will be establishing a working power system capable of charging batteries needed to power the system once it is unplugged and then use the charged batteries to power the micro-controller and the motors. Although the sensing subsection will utilize power from the power system, it is not within our scope to provide them with a specific power as they will be receiving the power from the micro-controller itself.

There are limitations with the actual project, although we are given full freedom on what components are utilized in the design project, we are bounded by the budget of the project, dimensions of the micro-mouse, and set specifications based on parts already chosen before use given this project such as the micro-processor and motors, all of which need to be considered during the initial design process.

1.3 GitHub Link

https://github.com/khnmuhaimin/EEE3088F-Group-64.git

Chapter 2

Requirements Analysis

2.1 Requirements

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

Table 2.1: Requirements of the power subsystem for the micro-mouse system.

Requirement ID	Description
R01	Use a battery as the method to power the subsystem
R02	Operate two motors with available pins
R03	Provide analogue connection for battery state of charge
R04	Battery charged from 5V pin
R05	The system needs an on/off switch
R06	The connector for the PCB needs to be in a tab off the board for proper connection
R07	Make PCB as small as possible to minimize the distance from the centre of rotation

2.2 Specifications

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

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

Specification ID	Description
SP01	Battery must be able to sustain a draw of 400mA at the highest voltage
SP02	Two Motors each drawing 200mA capable of rotating clockwise and anit-clockwise
SPO3	Battery must be charged at 5V
SPO4	Switch must operate when the battery is drawing less than 500uA and when the robot is operating at peak current
SPO5	Tab height must be 18mm or greater and width height no more than 35mm
SPO6	$3.3 \pm 0.5 V outputvoltageforBATT\_ADCline$

2.3 Testing Procedures

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

Table 2.3: CAPTION

Acceptance Test ID	Description
AT01	Verify the battery is connected correctly
AT02	Verify the battery charge is getting 5V input
AT03	Verify the battery is charging off 5V input
AT04	Verify the switch is operating correctly when in on state
AT05	Verify the switch is operating correctly when in off-state
AT06	Verify battery charger is outputting voltage
AT07	Verify the motor 1 will spin clockwise
AT08	Verify the motor 1 will spin anti-clockwise
AT09	Verify the motor 2 will spin clockwise
AT10	Verify the motor 2 will spin anti-clockwise
AT11	Verify BATT_ADC is outputting voltage
AT12	Verify BATT pin towards the microprocessor is outputting voltage
AT13	Check components are working

2.4 Traceability Analysis

The 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	R01	SP01	AT01
2	R04	SP03	AT02,AT03
3	R02	SP02	AT07, AT08, AT09, AT10
4	R05	SP04	AT11
5	R03	SP06	AT04, AT05

2.4.1 Traceability Analysis 1

R01 can be derived to get SP01 as the battery is required to perform at set specifications, which we can verify using the AT01 which will test the battery is connected correctly indicating the above factors.

2.4.2 Traceability Analysis 2

From R04, where we charge the battery from a pin, we derive SP03 where we verify the battery is being charged at 5V, from which AT02 and AT03 tests are performed to verify that the battery is not only receiving 5V, but also charging from it.

2.4.3 Traceability Analysis 3

R02 requiring functioning motors is derived to SP02 where motors draw a certain current with differing rotations, AT07-AT10 are utilized to check each of the two motors will be functioning correctly by checking there is a voltage and a rotation for the motor

2.4.4 Traceability Analysis 5

R05 requires an analogue signal which is derived to get SP04 which the expected voltage on that line which is checked using AT11

2.4.5 Traceability Analysis 4

SP06 is derived from R03 whereby the system needs a functioning on/off switch, which can be checked utilizing AT04 and AT05 tests for the different states

Chapter 3

Subsystem Design

3.1 Design Decisions

3.1.1 Design Process

Within our system, different areas needed to be focused upon, each with its own challenges that needed to be solved. The three main areas of this design process were the battery charger, battery and switch system, and the motors. Within each area of the design process, several challenges need to be factored into how the final PCB was to be designed: the budget for this project was incredibly tight and certain components would therefore be out of our price range so that had to be accounted for:

- Budget - The budget for this project was incredibly tight, which made it harder when select parts as too many of certain parts would exceed the budget given, therefor considerations had to be made for each area to ensure that this project stayed below that range. The budget can be seen in the figure below:

- Space - The PCB board had its own constraints, whereby a tab needed to be included in the design, and the dimensions of the board needed to take into consideration the turning circle of the micro-mouse such that the width and length of the PCB did not exceed the lengths. Measurements and calculations can be seen in the figure below:

- Battery - Although the system has a good sized battery, considerations do need to be made to ensure that the components we use do not over-deplete the battery as this project needs to be able to last for over 20 minutes while navigating a maze, and using too much current will deplete the battery faster.

With the above factors in mind, each section of the sub-system can be designed accordingly to ensure that the issues mentioned above are less likely to arise.

Battery Charger

The battery charger is an integral part of the design as it will be used to charge the battery for the whole system utilizing a 5V input from the microprocessor to charge itself for later use. A primary

Item	**Student 1 (Sensing)**	**Student 2 (Power)**
Starting Allowance	$30	$30
PCB Manufacture (5 units)	$4	$4
PCB Assembly (2 units)	$9.50	$9.50
Remaining Budget for components	30 – 13.5 = **$16.5 for 2 boards**	30 – 13.5 = **$16.5 for 2 boards**
OR alternatively	$8.25 per board	$8.25 per board

Figure 3.1: Budget

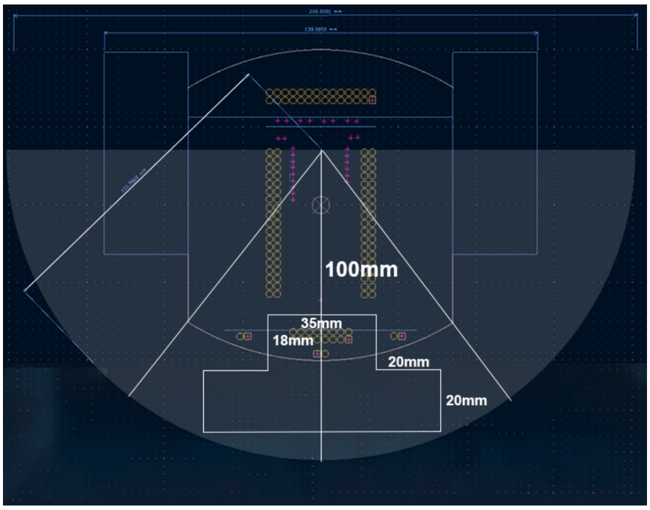


Figure 3.2: PCB Board Dimensions

concern with the battery charger that needed to be accounted for was the budget aspect, as through the website the PCBs would be ordered through, JLCPCB, certain parts would have extended costs based on whether the part was in regular production or not, and such parts would have an extra cost of 3 dollars each. This at the time did not seem a major issue as long as multiple parts were basic instead of extended, however, it quickly became apparent that the parts needed for the other sections would also need to be extended. This was the first major design decision, whereby choosing a battery charger that had no extended cost would greatly decrease the cost of the overall budget, and the battery charger TP4056-42-ESOP8 became the best choice over the other options as although it was considered an extended part since it was previously a basic part, JLC would not add the extended part cost as with the other options.

Switch and Battery system

Switches were a problematic area of the design as there was only one switch that was a basic part, and unfortunately, it was a push button, meaning that it would be harder to implement a switch configuration from it. This was the second major design decision that was made, utilizing an extended part for the switch to allow for a better selection of switches, as in most cases it was hard to verify how the switches worked with foreign data sheets with very minimal instructional use or footprints for the PCB design. It was decided to therefore use a switch called MS-22D28-G020 which verifiable data sheets and footprints were found for easy integration into the system.

Motor system

The subsection required us to have two systems each capable of running a motor at 200mA. Originally, the design decision was made to create an H-bridge configuration utilizing various parts such as MOSFETs and transistors to create a switching system to allow for the rotation of the motors in different directions, however, it became complicated to select the parts and to verify that the H-bridge design would function correctly, and it became easier to try to find a substitute. The third major design decision was deciding to use an H-bridge extended part, which although had an increased cost, had verifiable evidence the part itself would work, and because it would be using an Integrated Circuit (IC), it would reduce the space needed for it to run, which was a major issue with the original design.

3.1.2 Final Design

The following design integrates the decision decisions made above, utilizing the parts mentioned to create a system whereby a battery charger is used to charge the battery, the battery provides power to the circuit upon the switch being switched on, protected by a polarity protector. The battery will power two motors, the microprocessor and all things connected to that, and an ADC line in which the state of charge of the battery can be checked. Standard capacitors are used as a discharging method throughout, with resistors and LEDs for the TP4056 selected based on the datasheet for the component. The BATT_ADC line is protected by utilizing large resistors to protect the microprocessor.

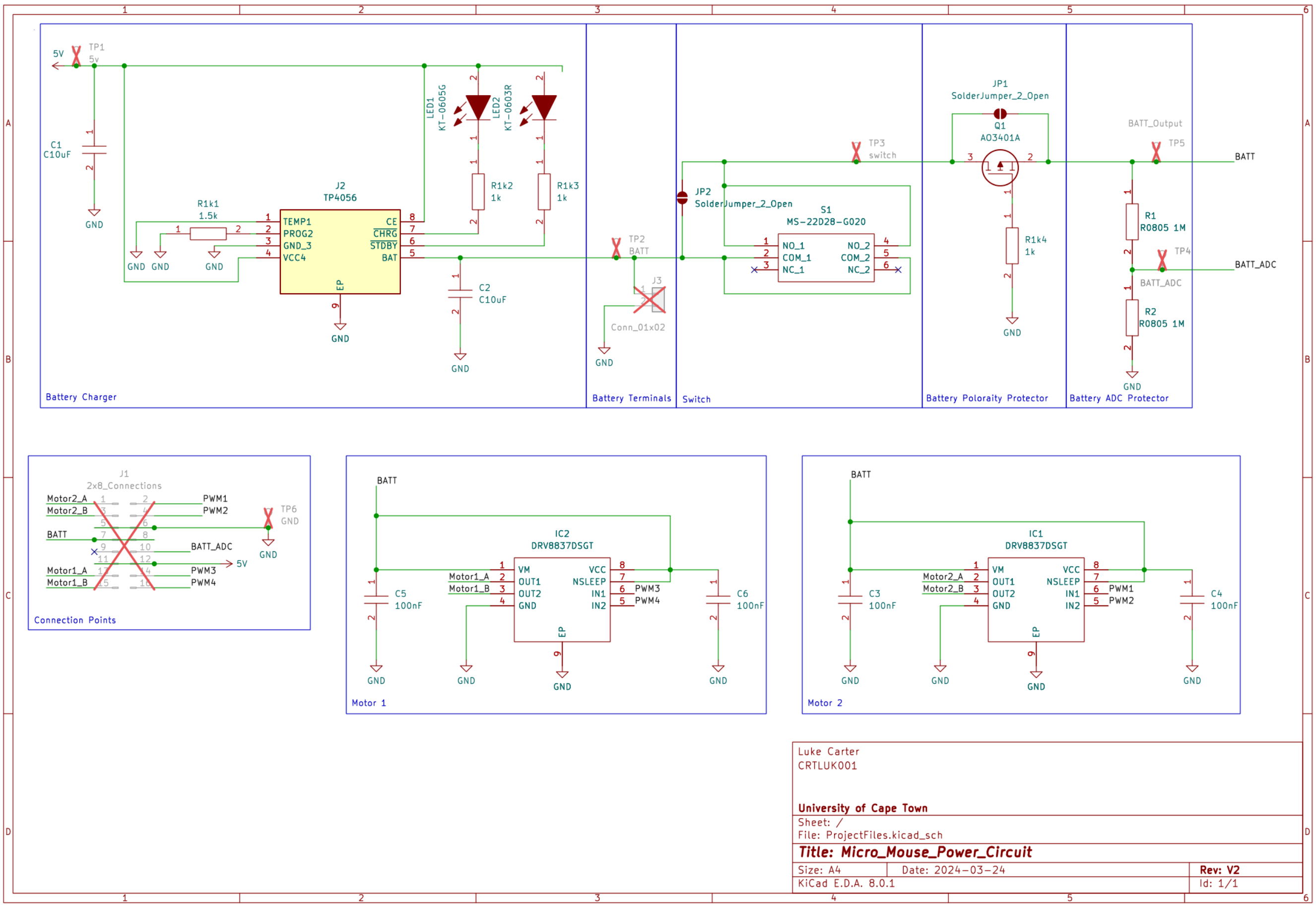
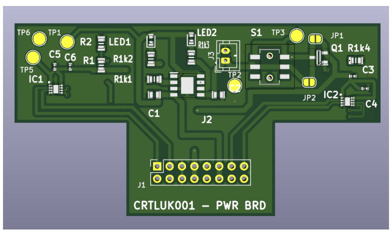
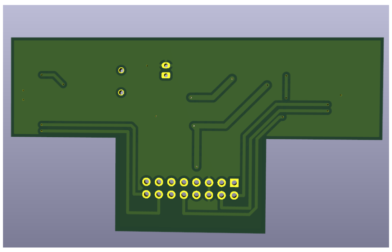


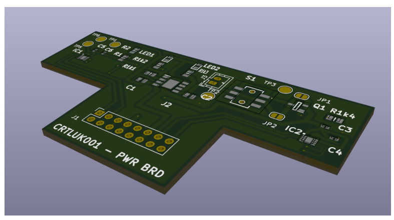
Figure 3.3: Schematic Drawing



(a) Front PCB



(b) Back PCB



(c) 3D PCB

3.2 Failure Management

Table 3.1: Failure Management

Name	Description
Switch Bypass	The switch is an area of concern because if the switch is incorrectly selected or implemented, there could be no power coming from the battery, so a solder jumper was added over the switch such that if a problem arose, the component could be bypassed completely.
Battery Polarity Bypass	Similar to the switch, a solder jumper was added to the battery polarity protector in the case the component was dysfunctional, it could be bypassed to ensure the circuit still worked.
Motor Controller IC Placement	In the design process, the IC for the motor controller was placed on the edge of the board to prevent potential overheating of the component as it was planned to have high current flowing through it and placing it in tight proximity to other components could increase the base temperature.
Trace Widths	Using online calculators, steps were taken to mitigate trace burning which occurs when the traces are too small, and in areas where there was high current, thicker traces were used to try to mitigate that potential problem.

3.3 System Integration and Interfacing

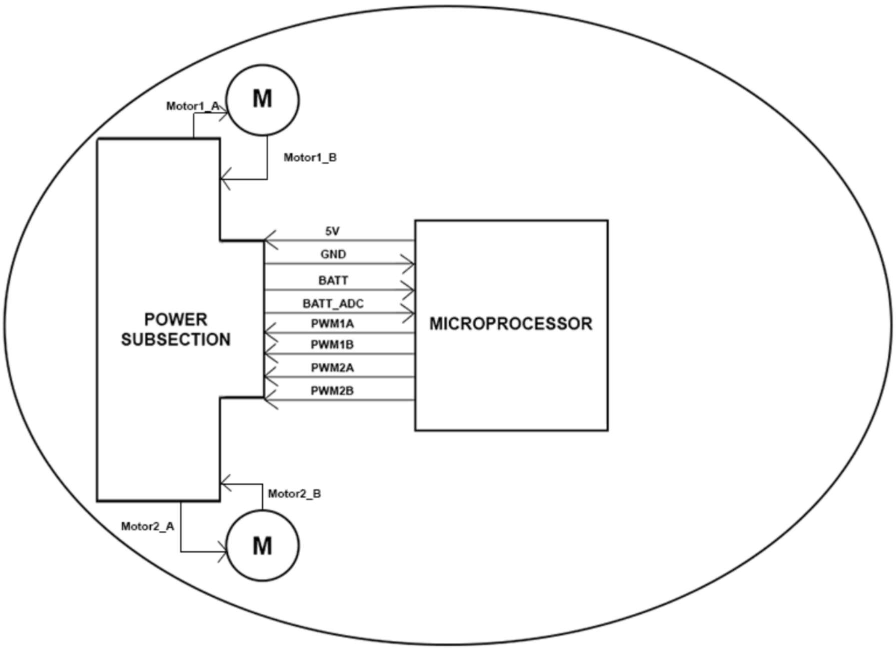


Table 3.2: Interfacing specifications

Pins	**Description**	**Pins/Output**
1: Motor2_A	Pin from the motor controller IC on the board, to the one connection of the Motor	Motor2_A -> Motor 2 Connector Positive
2: PC6-9	Pin from microprocessor to indicate rotation of motor, set clock wise or anti-clockwise	Motor2_A <- Microprocessor selected Pin
3: Motor2_B	Pin from the motor controller IC on the board, to the one connection of the Motor	Motor2_B -> Motor 2 Connector Negative
4: PC6-9	Pin from microprocessor to indicate rotation of motor, set clock wise or anti-clockwise	Motor2_B <- Microprocessor selected Pin
5: GND	Ground pin used to ground the power subsection	GND -> GND of microprocessor
6: GND	Ground pin used to ground the power subsection	GND -> GND of microprocessor
7: BATT	Pin used to provide microprocessor with power	BATT -> Microprocessor power pin
8: BATT	Pin used to provide microprocessor with power	BATT -> Microprocessor power pin
9: PD7	Spare pin, not in use	N/A
10: BATT_ADC	Used to check state of charge of Battery	BATT_ADC -> Microprocessor for conversion
11: 5V	5V pin to charge the battery	5V <- 5V supplied from the microprocessor
12: 5V	5V pin to charge the battery	5V <- 5V supplied from the microprocessor
13: Motor1_A	Pin from the motor controller IC on the board, to the one connection of the Motor	Motor1_A -> Motor 1 Connector Positive
14: PC6-9	Pin from microprocessor to indicate rotation of motor, set clock wise or anti-clockwise	Motor1_A <- Microprocessor selected Pin
15: Motor1_B	Pin from the motor controller IC on the board, to the one connection of the Motor	Motor1_B -> Motor 1 Connector Negative
16: PC6-9	Pin from microprocessor to indicate rotation of motor, set clock wise or anti-clockwiser	Motor1_B <- Microprocessor selected Pin

Chapter 4

Acceptance Testing

4.1 Tests

Table 4.1: Subsystem acceptance tests

Test ID	Description	Testing Procedure	Pass/Fail Criteria
AT01	Verify the battery is connected correctly	• Plug a multi-meter across the connection points, postive to positive and negative to negative	There is no voltage measured across the multi-meter meaning that there is no voltage travelling across the pings
AT02	Verify the battery charge is getting 5V input	• Using the multi-meter, put the positive probe on the TP1 and negative probe on TP6	Multi-meter shows value of 5V
AT03	Verify the battery is charging off 5V input	• Power the system with 5V • Put the multi-meter probes across the battery	Measure the battery at two separate intervals, if the voltage increases, the battery is being charged by the input
AT04	Verify the switch is operating correctly when in on state	• Put multi-meter positive probe on TP3 and negative on TP6 • Put switch on	Continuity checker does not make a noise
AT05	Verify the switch is operating correctly when in off-state	• Put multi-meter positive probe on TP3 and negative on TP6 • Put switch off	Continuity checker does make a noise
AT06	Verify battery charger is outputting voltage	• Put multi-meter positive probe on TP2 and negative on TP6	Multi-meter shows value of 4.2V$\pm 0.5V$

Table 4.2: Subsystem acceptance tests

Test ID	**Description**	**Testing Procedure**	**Pass/Fail Criteria**
AT07	Verify the motor 1 will spin clockwise	• Put Multimeter positive probe on Motor1_A and negative probe on Motor1_B	There is a positive voltage across Motor1_A and Motor1_B
AT08	Verify the motor 1 will spin anti-clockwise	• Put Multimeter positive probe on Motor1_A and negative probe on $Motor1_B$	There is a negative voltage across Motor1_A and Motor1_b
AT09	Verify the motor 2 will spin clockwise	• Put Multimeter positive probe on Motor2_A and negative probe on $Motor2_B$	There is a negative voltage across Motor2_A and Motor2_b
AT10	Verify the motor 2 will spin anti-clockwise	• Put Multimeter positive probe on Motor2_A and negative probe on Motor2_B	There is a negative voltage across Motor2_A and Motor2_b
AT11	Verify BATT_ADC is outputting voltage	• Put multi-meter positive probe on TP4 and negative on TP6	Multi-meter records a value of 3.3V$\pm 1V$
AT12	Verify BATT pin towards the microprocessor is outputting voltage	• Put multi-meter positive probe on TP5 and negative on TP6	Multi-meter value records a voltage of 3.7V$\pm 0.5V$
AT13	Check components are working	• Put multimeter probes across the postive and negative ends of the resistors and capacitors on the board to check for short circuit issues	Continuity checker does not go off

Bibliography

[1] UKMARS, "Classic micromouse)," 2020. [Online]. Available: https://ukmars.org/contests/micromouse/