Interim Design Report

Micromouse Power Subsystem

Prepared by:
Nicholas McFarland
MCFNIC002

Prepared for:
EEE3088F
Department of Electrical Engineering
University of Cape Town

May 17, 2024

Declaration

1. I know that plagiarism is wrong. Plagiarism is to use another's work and pretend that it is one's own.
2. I have used the IEEE convention for citation and referencing. Each contribution to, and quotation in, this report from the work(s) of other people has been attributed, and has been cited and referenced.
3. This report is my own work.
4. I have not allowed, and will not allow, anyone to copy my work with the intention of passing it off as their own work or part thereof.

May 17, 2024

Nicholas McFarland

Date

Contents

Chapter 1

Introduction

1.1 Problem Description

This year's design project aims to have a pair of students design and build a micromouse capable of solving a maze. The mouse begins at a starting position outside of the maze and is considered to have 'solved' the maze if it reaches the square opening in the middle of the maze.

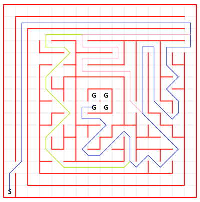


Figure 1.1: Typical maze that a micromouse should be able to solve

The mouse's final design consists of a motherboard, processor board, motors, wheels, power, and sensing subsystem. Both the motherboard and processor board will be responsible for most of the mouse's information processing. The power and sensing subsystems are not provided, and so still need to be designed. The motherboard, processor board, wheels, and motors are provided by the course.

This report provides an in-depth analysis of the designed power subsystem, which is responsible for providing power to all the aforementioned systems and subsystems, as well as driving the motors of the mouse.

1.2 Scope and Limitations

The designed circuit board uses a single 1S1P battery to power all parts of the system of the micromouse. It must be able to operate 2 motors at rated current and voltage and provide an analog connection that provides information to the processor regarding the battery's current voltage and charge state. It must be able to charge the battery from an external 5V input voltage and house an ON/OFF switch that can control the power supply to the system.

Besides the connections between the power subsystem's pin headers and motherboard, this project provides no detail into the other subsystems of the overall micromouse. It does not provide any coding required to operate the other subsystem/s.

The shape of the PCB design must feature a tab with dimensions that prevent it from obstructing the motor connections or colliding with any of the motherboard connections. The design consists of a battery with a maximum voltage of 4.2V, so any selected component cannot have an operating voltage that exceeds this. The cost of producing 2 boards may not exceed \$30 when ordered, so the cost per board may not exceed \$15. All components selected for designing the system must be readily available on JLCPCB [1]. Finally, the design must be suitable for testing any potential problem points on the board and feature alternative options to prevent these problems.

1.3 GitHub Link

https://github.com/NichTucker/Micromouse

Chapter 2

Requirements Analysis

2.1 Requirements

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

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

Req. ID	Description
R01SWT	Design must be able to switch the micromouse ON and OFF
R02SWT	When the mouse is OFF, current drawn by battery < 500uA
R01PWR	Design powers the entire micromouse and drive the 2 motors used to drive the wheels
R01CHG	Charge the battery from an input pin
R02CHG	Recommended charge at 0.5C (Capacity) for battery
R01ADC	Provides information on the battery's voltage and sense of state of charge (SoC)
R01PCB	Design must be able to fit on the motherboard without colliding with any of the other systems or the motors

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.

Spec. ID	Description
S01SWT	Design utilizes a physical switch to provide the mouse with the ability to connect and disconnect the battery from the rest of the mouse
S02SWT	When the switch is in its OFF state and the battery is disconnected from the circuit, the current drawn by the battery must be < 500uA
S01PWR	Design uses the Battery LiPo 800mAh 3.7V to power all the systems of the micromouse and uses a dual bridge motor to operate the motors, each rated at 200mA and 3.7V
S01CHG	Circuit uses a Li-Po battery charger with a 5V operating input voltage
S02CHG	Drawn current < 400mA when charging
S01ADC	Voltage divider circuit to provide batter's state of charge (SoC), as well as ensure the maximum input voltage < 3.3V
S01PCB	2x8 pin header with 2.54mm pin pitch. The height of the tab > 18mm and the width of the tab < 35mm to prevent collision with the motors

2.3 Testing Procedures

A summary of the testing procedures [2] detailed in chapter 4 is given in Table 2.3.

Table 2.3: Testing Procedures

Testing ID	Description
AT01SWT	Switch provides discreet ON/OFF states
AT02SWT	Quiescent current less than maximum rated
AT01PWR	Each motor reaches its operating current of 200mA
AT02PWR	Each motor reaches its operating voltage of 3.7V
AT01CHG	Charging circuit charges battery
AT02CHG	Battery draws < 400mA when charging and the rest of the circuit is connected
AT01ADC	Pin M210 (BATT_ADC) provided with scaling analog voltage
AT01PCB	Height and width of PCB tab smaller than area limited by motor.

2.4 Traceability Analysis

To 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	R01SWT	S01SWT	AT01SWT
2	R02SWT	S02SWT	AT02SWT
3	R01PWR	S01PWR	AT01PWR, AT02PWR
4	R01BAT	S01BAT	AT01BAT
5	R01CHG	S01CHG	AT01CHG
6	R02CHG	S02CHG	AT02CHG
7	R01ADC	S01ADC	AT01ADC
8	R01PCB	S01PCB	AT01PCB

2.4.1 Traceability Analysis 1

From R01SWT, the design must be able to switch the micromouse on and off. This is where S01SWT is derived, as it refines R01SWT to incorporate a physical switch to turn the micromouse on and off. This can be tested through AT01SWT, which tests that the design can disconnect the battery from the rest of the circuit, providing discreet ON/OFF states.

2.4.2 Traceability Analysis 2

R02SWT states that the current drawn by the battery when the mouse is off must be < 500uA. From this S02SWT specifies that this is the current in the case when the switch is off and the battery is disconnected from the circuit. This current is tested through AT02SWT, which is implemented to measure the quiescent current of the subsystem.

2.4.3 Traceability Analysis 3

From R01PWR the design must be able to power the entire micromouse and drive the motors. S01PWR builds on this, specifying that the design must use the Battery LiPo 800mAh 3.7V to provide power to the different systems and should use a dual H-bridge motor driver to operate the motors. These are tested through AT01PWR and AT02PWR, which test that the motors reach their correct operating currents and voltages.

2.4.4 Traceability Analysis 4

R01CHG states that the design must be able to charge the battery from an input pin. From this S01CHG can be derived as it provides more insight into the charging. It must use a Li-Po battery charger with a 5V operating input voltage, as this will be the provided charging voltage by the STM. This is tested by AT01CHG which tests that the circuit can charge the battery.

2.4.5 Traceability Analysis 5

From R02CHG, since the battery must charge at 0.5C, S02CHG is derived as it specifies that to meet this requirement the battery must draw < 400mA when charging and still be connected to the rest of the circuit. This is tested through AT02CHG, where the charging current is measured.

2.4.6 Traceability Analysis 6

R01ADC requires the design to provide information on the battery's current voltage and state of charge. S01ADC provides more insight into this, describing the means to which this is met and that the maximum analog voltage < 3.3V. This is tested through AT01ADC, where this voltage is measured to ensure that it scales correctly.

2.4.7 Traceability Analysis 7

From R01PCB the design must be able to fit on the motherboard without any collisions. S01PCB is derived from this and provides more detail as to the specified dimensions that the PCB must be to prevent any collisions. This is tested through AT01PCB, which tests that the dimensions of the PCB are smaller than the area limited by the motors.

Chapter 3

Subsystem Design

3.1 Design Decisions

3.1.1 Final Design

From component browsing on JLCPCB it was found that the 0603 package resistors and capacitors were abundantly stocked, so unless explicitly stated otherwise all resistors and capacitors were selected from these packages.

Motor Driver

To turn the wheels the power subsystem requires a circuit design to drive the motors. Normally it would be easiest to drive the motor with a solo H-bridge, but with 2 motors needing to be driven simultaneously, this would not suffice. If the motors are to be driven at the same speed, each H-bridge would need identical voltages. This is practically impossible to achieve with 2 H-bridges, but this problem is solved if a dual H-bridge is used instead.

When checking JLCPCB, the options for dual H-bridge motor drivers were extremely limited, as most of the components had low stock. The only ones that had enough stock to even consider using were the DRV8833 drivers. This, in conjunction with their datasheets made the DRV8833s the best option for driving the micromouse. The selection process below consists of tabulated potential choices from JLCPCB and selecting the most viable option:

Table 3.1: Dual bridge motor driver ICs

Possible solution	**Rated Supply Voltage (V)**	**Rated Supply Current (A)**	**Price per IC($)**	**Availability**	**Dimensions (mm x mm)**
DRV8833PWP	2.7 - 10.8	1.5	1.1790	27	5 x 6
DRV8833PWPR	2.7 - 10.8	1.5	0.6660	9631	5 x 6
DRV8833RTYR	2.7 - 10.8	1.5	1.185	1315	4 x 4

from Table 3.1, the DRV8833PWPR was chosen, because of the following:

- Meets the required rated voltage and current
- Much cheaper option than option 1 and option 3
- Readily available (higher stock than 1 and 3)
- The datasheet provides a typical circuit diagram of how to implement the device

Note that the DRV8833PWPR IC's datasheet provides a suitable circuit schematic for setting up the driver's connections.

All capacitors were chosen at E24 values and added to prevent any AC noise from interfering with the motor driver circuit.

Battery Management

The power subsystem requires battery-charging capabilities to charge the battery powering the rest of the mouse. Due to the requirements of the design the charger can only be powered by a 5V supply. This was taken into account when selecting potential solutions.

The easiest way to implement this charging is with a battery-charger IC. Using one of these, instead of designing one from scratch provides a much more reliable, stable and safe charge to the battery.

Once again, when looking at the options on JLCPCB, most of the charger ICs were too low stocked to even be considered, but the TP4056 family provided ICs that operated at the required voltages (4.2V maximum battery charge voltage charged with a 5V input) and were readily stocked at the time of ordering. The following ICs were considered for the design:

Table 3.2: battery management ICs

Possible solution	JLCPCB part #	Rated Input Voltage (V)	Quietient current/Iq (uA)	Price per IC($)	Availability	Dimensions (mm x mm)
TP4056	C725790	4.0 - 6.5	35	0.0620	29409	4 x 5
TP4056	C17702041	4.5 - 8.0	55	0.0587	10658	5 x 5
TP5000X-4.2-ESOP8	C5447152	4.0 - 9.0	180	0.2465	5022	5 x 6

From Table 3.2, the first solution (C725790) was chosen. The reasons are as follows:

- Cheaper than option 2.
- Largest available supply.
- Smallest component (reduces PCB size).
- Lowest I_q ensures lowest possible current when mouse is active.

The charging current is controlled by the R_{prog} resistor. From the given equation in the datasheet:

$$I_{bat} = \frac{V_{prog}}{R_{prog}} 1200$$

Setting R_{prog} at 1600 Ω ensures I_{bat} is (750mA) which is less than the maximum rated current (1A) and that the resistor is of E24 value. The rest of the circuit was designed with the aid of a typical charging circuit on the datasheet of a similar IC [TP4056].

*The selected IC has built-in voltage regulation and protection, so this was not needed in the design

Analog Sensing

This consists of a voltage divider circuit that reduces the battery's read voltage to a maximum of 3V3 (ADC pin's required voltage).
Since the battery has a maximum of 4.2V, simply feeding this into the ADC pin could break it, so the divider circuit must ensure $V_{out} \leq 3.3$V. from the equation of a voltage divider:

$$V_{out} = V_{in} \frac{R_7}{R_5 + R_7}$$

Setting $R_5 = 10$KΩ and $R_7 = 33$KΩ, V_{out} is set at 3.22V which is safely below its rated voltage. By setting these resistors to a magnitude of more than 10^3, it ensures that the current in this circuit is minuscule.

Circuit Switching

To ensure that the battery is fully disconnected from the circuit, the switch is connected directly after the battery (Battery -> switch -> circuit). Some of the viable JLCPCB switches that match these requirements are tabulated below:

Table 3.3: Possible switches available on JLCPCB

Possible solution	Type	Rated Voltage (V)	Rated Current (mA)	Price per Switch($)	Availability	Dimensions (mm x mm)
EG1224	Slide	15	500	0.7695	70	7 x 12
PS-5850A-6PL	Push (Latching)	30	500	0.1185	1514	5 x 5
SS12D07VG4 087	Slide	50	500	0.0278	28097	8 x 9
YTSPS-22E58LM	Push (Latching)	50	500	0.1588	1705	5 x 8

From Table 3.3 the PS-5850A-6PL was chosen. The reasons are as follows:

- Meets regulated voltage (> 4.2V) and regulated current (> 400mA).
- Push switches take up less horizontal space (reduce PCB space).
- Cheapest push switch.

Final design

The final design incorporates all the different design decisions to meet the requirements. It houses the battery that powers the micromouse, provides a physical latching switch to control the battery supply, a motor driver to drive the motors, a battery charger to charge the battery supply, and an ADC circuit to provide analog sensing.

The design choices were made to increase the efficiency of the power subsystem [3]. This includes selecting parts that; are relatively cheaper when compared to similar components, consume less current than other components/consume as close to the required current as possible, and have smaller dimensions which helps to reduce the size of the final PCB (and in doing so helps keep the micromouse's center of rotation as close to the front as possible).

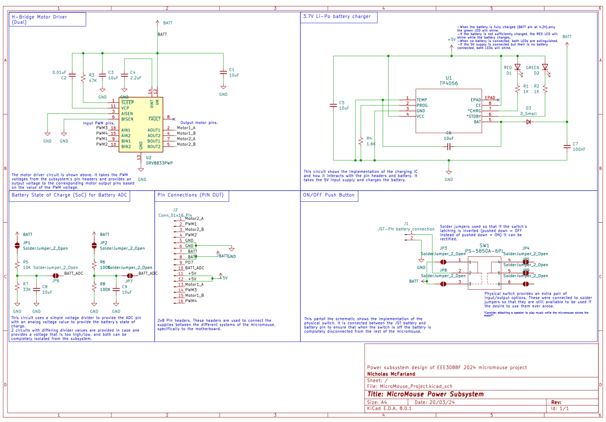
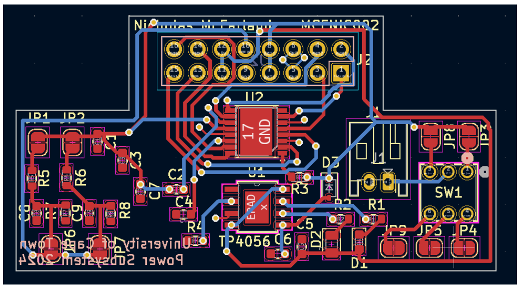
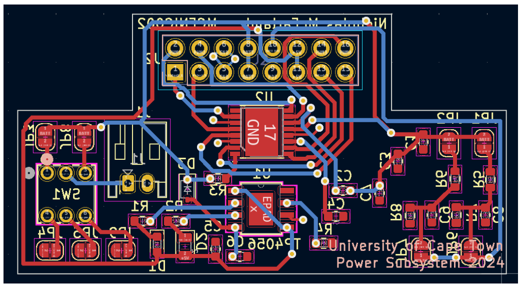


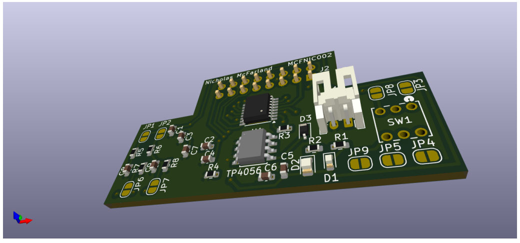
Figure 3.1: Schematic



(a) Front PCB (with ground pours omitted for clearer view of tracks)



(b) Back PCB (with ground pours omitted for clearer view of tracks)



(c) 3D PCB (with all components populated to depict the final PCB layout)

Figure 3.2: Final PCB design layouts

3.2 Failure Management

Tthe following measures were taken to reduce the possible failures that the PCB could face after production or to bypass any design decisions that were made with some uncertainty:

Table 3.4: Failure Management Table

Name	Description
Track current handling [4]	Since the motors carry currents too large for standard track width, track width was increased. All tracks' widths were increased, due to uncertainty as to which tracks would carry the highest currents.
Battery/5V Tracks	Tracks leading directly from the switch and 5V charging input were put as close to the edge of the PCB as possible to minimize any interference with other tracks. This is because they are likely to draw high currents.
Switch placement	Switch placed directly after the battery to ensure the entire circuit is cut off from power when the switch is on.
Switch solder bridges	Due to the vague diagram on the datasheet, uncertainty arose concerning pin connections. Each connection is joined with a solder bridge to ensure the right connections are made in the future.
Additional analog voltage-divider	In case the voltage-divider output voltage is too close to the rated ADC pin, a second one was designed with a much lower output voltage (half of the maximum battery voltage)
Analog solder bridges	Both circuits are separated from battery input and pin output by solder bridges. This ensures that the correct one can be connected, whilst the unused one does not draw any current from the battery (remains completely idle).
E24 component calculation rounding	All calculated E24 component values rounded to ensure the relative currents/voltages are well below rated maximums and well above rated minimums.

3.3 System Integration and Interfacing

To aid in describing the integration of the subsystem with the rest of the system, the following system integration table is provided:

Table 3.5: Interfacing specifications

Interface	Description	Pins / Output
BAT_IN	Battery supply input to power subsystem	• Li-Po battery terminals to JSTPOS, JSTNEG
BAT_OUT	Battery supply output to micromouse system	• M207, M208 to the processor through F207, F208
BAT_ADC	Battery analog state of charge output to micromouse system	• M210 to STM Pin 48 through F210
5V	External 5V supply input for charger	• M211, M212 to processor through F211, F212
GND	ground connection between subsystem and processor	• M205, M206 to ground through F205, F206
MTR01	DRV8833PWPR interfacing with motor1 output and PWM input	• Motor1_A (M213) to the physical side A of motor 1 through F213 • Motor1_B (M215) to the physical side B of motor 1 through F215 • PWM3 (M214) to STM PC6-9 (unknown at this point) through F214 • PWM4 (M216) to STMPC-9 (unknown at this point) through F216
MTR02	DRV8833PWPR interfacing with motor2 output and STM logic input	• Motor2_A (M201) to the physical side A of motor 2 through F201 • Motor2_B (M203) to the physical side B of motor 2 through F203 • PWM1 (M202) to STM PC6-9 (unknown at this point) through F202 • PWM2 (M204) to STMPC-9 (unknown at this point) through F204

System Block Diagram

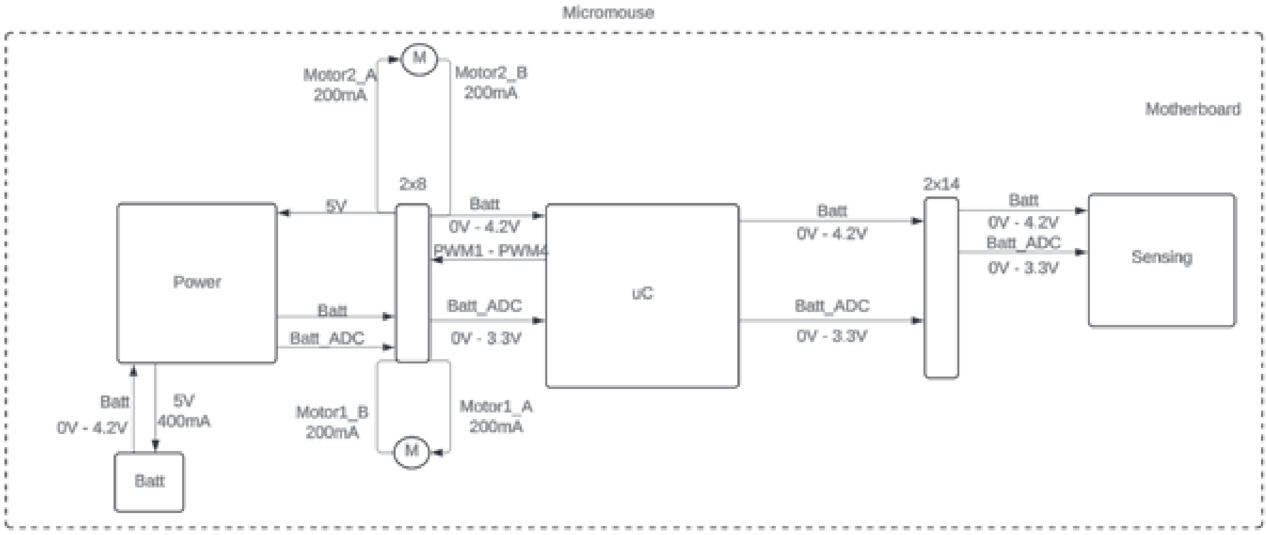


Figure 3.3: High-level block diagram showing subsystem's link into the larger system. (Information on sensing inputs/outputs limited)

Chapter 4

Acceptance Testing

4.1 Tests

Table 4.1: Subsystem acceptance tests

Test ID	Description	Testing Procedure	Pass/Fail Criteria
AT01SWT	Test that the switch connects the battery to the system when LATCHED and disconnects it when RELEASED	• Solder JP3 and connect 4.2V DC voltage supply at 4.2V to JSTPOS • use a multimeter to measure the voltage at M207 / M208 • If inverted switching, desolder JP3 and solder JP8. Provide the same voltage to JSTPOS and measure the voltage at M207 M208	Pass if the voltage at pin M207/M208 = 4.2V when LATCHED and 0V when RELEASED
AT02SWT	The current drawn by the battery when the switch is RELEASED is less than its maximum rated to ensure minimal leakage	• Disconnect the motors • Connect ammeter between LiPo positive terminal and JSTPOS • LATCH switch.	Pass if current measured is $<$ 500uA
AT01PWR	Test that the motors reach their operating current to ensure they have enough potential torque.	• Connect Motor1 side B to M215 and side A to the positive terminal of the ammeter Connect the negative terminal to M213. • Connect 4.2V DC power supply to M207 / M208 • Set switch to LATCH • Repeat for Motor2, but changing connections to motor2 equivalents (M203, M201)	Pass if currents measured for BOTH motors is at least 200mA - 5%
AT02PWR	Test that the motors reach their operating current to ensure they have enough potential speed.	• Connect Motor1 side B to M215 and side A to M213. Connect multimeter across M215 and M213 • Connect 4.2V DC power supply to M207 / M208 • Set switch to LATCH • Repeat for Motor2, but changing connections to motor2 equivalents (M203, M201)	Pass if voltage measured for BOTH motors $>$ 95% of input voltage (V $>$ 4V)
AT01CHG	The battery's voltage increases to its maximum capacity when the 5V pin is powered and the battery is connected	• Connect battery to JSTPOS / JSNEG and press switch down to ON state. • Use DC power supply to provide 5V to M211 / M212. Check that the green LED is ON. • Use a multimeter to measure the voltage at M207/ M208.	Pass if voltage = 4.2V +-5%
AT02CHG	Battery draws $<$ 400mA when charging and the rest of the circuit is connected, to charge the battery at the design's rate of charge	• Connect the positive battery terminal to the positive ammeter lead and the negative lead to JSTPOS. Connect the negative terminal to JSTNEG • Connect 5V DC supply to M211 / M212 and LATCH switch.	Pass if the current measured $<$ 400mA
AT01ADC	Analog sub-circuit produces a scaling analog voltage at a maximum of 3.3V when 4.2V is provided to the BATT pin	• Solder JP1 and JP6 • Connect multimeter to M210 and DC supply voltage to M207 / M208 • Starting at 0V, increase voltage to 4.2V • If multimeter reading $>$ 3.3V, desolder JP1, JP6 and solder JP2, JP7 and repeat steps	Pass if measured voltage scales with DC supply voltage AND measured voltage $<$ 3.3V when DC supply voltage = 4.2V
AT01PCB	Testing the height and width of the PCB tab to ensure that it does not collide with the motors	• Use a ruler to measure the height and width of the tab • Place over demo mouse's power subsystem outline	Pass if height $>$ 18mm and width $<$ 35mm OR PCB fits into demo outline

4.2 Critical Analysis of Testing

The following tests were selected due to; their importance in the overall project, and the roles that they played in the demonstration of the PCB:

Table 4.2: Subsystem acceptance test results

Test ID	Description	Result
AT01PWR	Motors reach operating currents	Pass
AT02PWR	Motors reach operating voltage	Pass
AT01CHG	Battery charges fully from charger	Fail
AT02CHG	Battery draws < 400mA when charging	Pass
AT01ADC	Circuit produces scaling ADC with a maximum < 3.3V	Pass

4.2.1 AT01PWR

Aim

The AT01PWR test is carried out to measure the current that the motors draw when the circuit is in full operation. The currents that the motors draw determines the torque that they experience, so they require their rated current to produce a torque sufficient to run the motors. This rated current is the current that AT01PWR tests for.

Testing

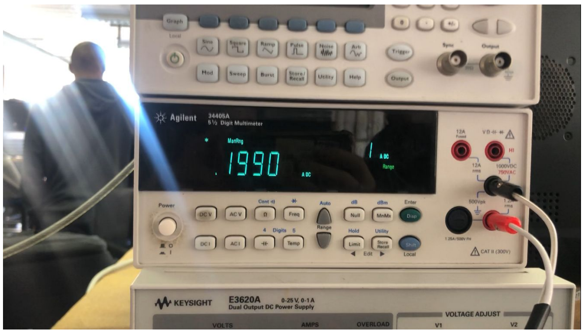
The testing procedures for AT01PWR are as follows:

1. Connect side B of Motor1 to pin M215 and side A of Motor1 to the positive terminal of the ammeter. Connect the negative terminal to pin M213. This connects the ammeter in series to the motor to measure the current.
2. Set the DC voltage supply to 4.2V (representing the battery's maximum voltage) and provide this voltage to pins M207/M208. This represents the battery at its maximum voltage.
3. Push the switch down (set to LATCH).
4. Record the measurement displayed on the ammeter.
5. repeat steps 1-4 for Motor2 to record its current.
   Note that for Motor2: M215 (Mot1) = M203 (Mot2), M213 (Mot1) = M201 (Mot2)

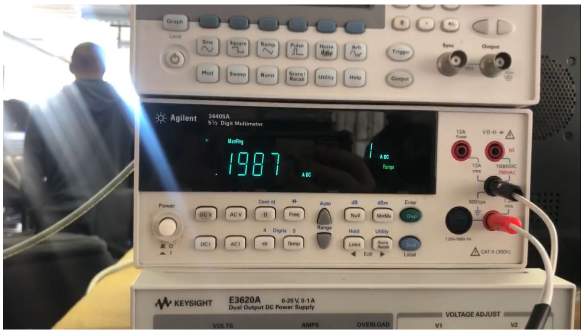
Results

During testing, the following results were recorded:

- Motor1 current - 199mA
- Motor2 current - 198mA



(a) Measured current of Motor1



(b) Measured current of Motor2

From these results, it can be concluded that AT01PWR was passed, as the PCB produces the rated motor current of 200mA per motor.

4.2.2 AT02PWR

Aim

The AT02PWR test is carried out to measure the voltage across the motors when the circuit is in full operation. The voltages that the motors operate at determine the speed at which they rotate, so they require their rated voltage to produce a speed fast enough to run the motors. This rated voltage is the voltage that AT02PWR tests for.

Testing

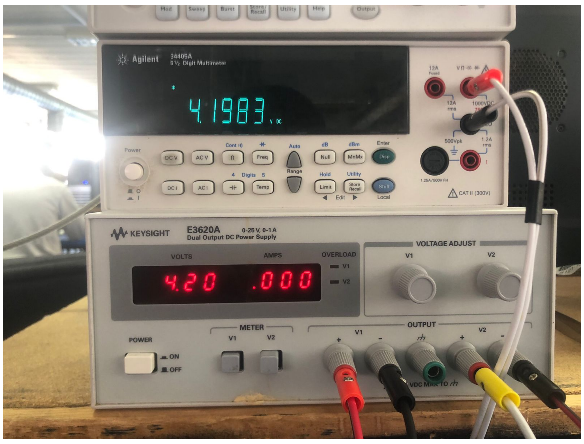
The testing procedures for AT02PWR are as follows:

1. Connect side B of Motor1 to pin M215 and side A of Motor1 to pin M213. Connect the positive terminal of the multimeter to pin M215 and the negative terminal to ground. This connects the multimeter in parallel to the motor to measure the voltage across the motor.
2. Connect the DV voltage supply to M207/M208 and set its voltage to 4.2V. Once again, this represents the battery connection at its maximum voltage.
3. Push the switch down (set to LATCH).
4. Record the measurement displayed on the multimeter.
5. repeat steps 1-4 for Motor2 to record its voltage.
   Note that for Motor2: M215 (Mot1) = M203 (Mot2), M213 (Mot1) = M201 (Mot2)

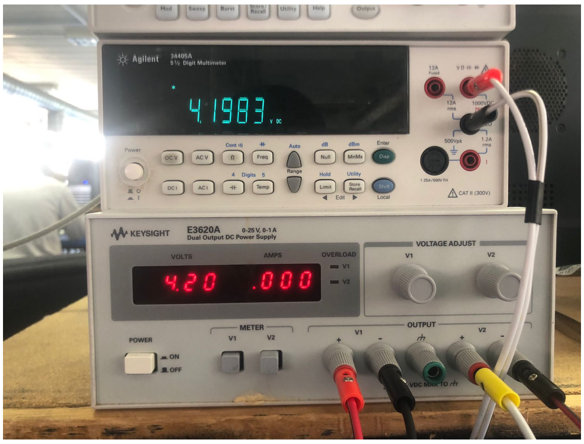
Results

During testing, the following results were recorded:

- Motor1 voltage - 4.2V
- Motor2 current - 4.2V



(a) Measured voltage of Motor1



(b) Measured voltage of Motor2

From these results, it can be concluded that AT01PWR was passed, as the PCB produces the required rated voltage of at least 95% of the input voltage ($V > 4V$) to each motor.

4.2.3 AT01CHG

Aim

The AT01CHG test is carried out to determine that the battery charging section of the PCB, when powered by a 5V input voltage supply, can charge the battery to its maximum storage voltage of 4.2V.

Testing

The testing procedures for AT01CHG are as follows:

1. Connect the battery's positive terminal to JSTPOS and the negative terminal to JSTNEG. Push the switch down to LATCH.
   Note that no battery was provided for testing, so a resistor-capacitor circuit was used instead to produce the same charging effect as the battery.
2. Connect the DC voltage supply to pin M211/M212 and set the voltage to 5V.
3. Connect the positive terminal of the multimeter to pin M207/M208.
4. Ensure that the green LED is ON. This means that the circuit is charging correctly.
5. Record the value displayed on the multimeter.

Results

During testing, the following results were recorded:

- maximum battery voltage (Lab testing) - 3.866V
- maximum battery voltage (Demo) - 4.18V

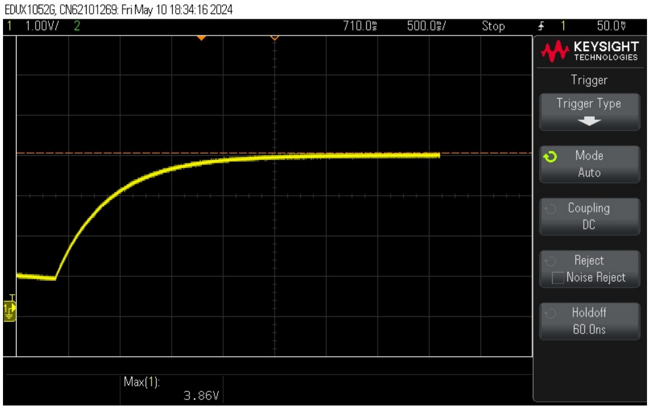


Figure 4.3: Voltage across RC circuit as a function of time.

Although this result means that the test failed in the lab, it should be noted that the circuit used to mimic a charging battery would not produce the same voltage as an actual battery. The test carried out during the demonstration, with the proper battery, produced the correct voltage and so this test case failed in the lab but passed in the demo, as the battery was able to reach its maximum voltage of 4.2V when charged.
The voltage drop recorded is due to the Schottky diode connected between the pin M207/M208 and the output of the charging IC.

4.2.4 AT02CHG

Aim

The AT02CHG test is carried out to determine the current drawn by the battery when it is charging, specifically if it is less than its rated current draw. This rated current draw ensures that the battery charger meets the IC's rate of charge.

Testing

The testing procedures for AT02CHG are as follows:

1. Connect the positive terminal of the battery to the positive terminal of the ammeter and the negative lead of the ammeter to the JSTPOS pin.
2. Connect the DC voltage supply to pin M211/M212 and set the voltage to 5V.
3. Push the switch down to LATCH.
4. Record the ammeter display.

Results

During testing, the following results were recorded:

- Drawn battery current - 383mA

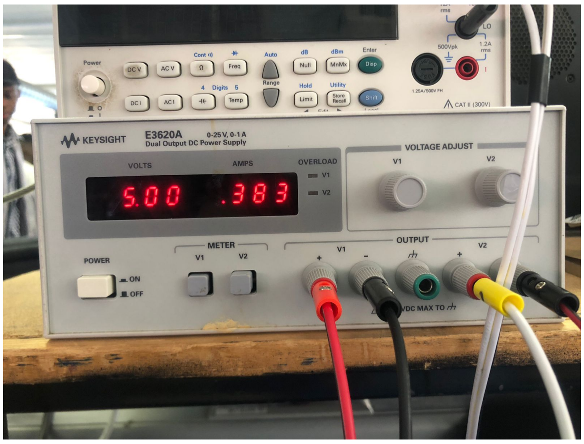


Figure 4.4: Drawn battery current.

From this result, it can be concluded that AT02CHG was passed, as the battery draws a current that is less than the rated current of 400mA, which ensures that the battery will charge at the correct rate.

4.2.5 AT01ADC

Aim

The AT01ADC test is carried out to determine if the voltage produced by the ADC circuit meets the required scaling, and that its maximum output is less than the maximum voltage that the ADC pin (M210) should hold.

Testing

The testing procedures for AT01ADC are as follows:

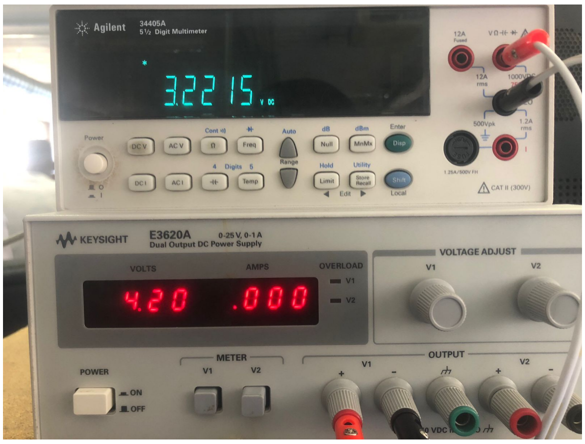
1. Solder JP1, JP6 to connect divider 1 or JP2, JP7 to connect divider 2.
2. Connect the positive terminal of the multimeter to pin M210.
3. Connect the DC supply voltage to pin M207/M208. This voltage represents the battery's changing voltage.
4. Starting at 0V, slowly increase the input DC voltage and watch the multimeter display. Once the input voltage reaches 4.2V, leave the voltage and record the multimeter display.

Results

During testing, the following results were recorded:

- pin M210 voltage when 3.7V is at pin M207/M208 - 2.83V.
- pin M210 voltage when 4.2V is at pin M207/M208 - 3.22V

(a) Voltage at pin M210 at 3.7V battery voltage.



(b) Voltage at pin M210 at maximum 4.2V battery voltage.

From these results, it can be concluded that AT01ADC was passed, as the design provides a scaling analog voltage to pin M210 as the battery voltage increases, with a maximum ADC pin voltage < 3.3V at the battery's maximum voltage.

Chapter 5

Conclusion

This report provides an in-depth analysis of the power subsystem designed to power a maze-solving micromouse and operate its motors through use of a single 1S1P battery. The system provides switchable power to all parts of the mouse's system, charges the battery through an external 5V input supply voltage, provides motor control from logic input pins, and provides the motherboard with the ADC equivalent voltage of the battery.

The power distribution is handled through a latching switch connected to a battery pin. this pin is connected to the motherboard, where its voltage is accessible by the other systems. The design incorporates a charging IC to charge the battery with an external 5V input voltage and LEDs to indicate the state of charge when charging. It handles the operation of the motor through a dual H-bridge motor driver, which is capable of providing the motors with controllable logic voltage signals. Finally, it utilizes a simple voltage divider circuit to provide the ADC pin with a 3.3V logic equivalent voltage of the battery's current state of charge.

The switch provides complete connection and disconnection between the battery and micromouse, which allows for minimal quiescent current. The dual H-bridge motor provides both motors with identical voltages and currents when powered with equivalent logic inputs, which allows the motors to operate synchronously. The ADC circuit provides a consistent scaling analog voltage to the ADC pin, with a maximum value less than the pin's maximum allowable voltage.

5.1 Recommendations

Switching

The switch used in this design has a maximum current rating of 500mA and so cannot handle large currents (< 1A). This is important when powering the micromouse, as additional torque on the motors can draw significantly more current than it was originally designed for. This can be solved by using a MOSFET in conjunction with the switch, where the MOSFET can limit the current through the switch.

Component bypassing

From the battery charging section of the design choice, it was noticed that the Schottky diode provided an unwanted voltage drop. In the future, it would be better to have the option to short any components whose function is uncertain. This can be done with solder jumpers in parallel to the component, which can then be shorted to bypass the component.

Bibliography

[1] [Online]. Available: https://jlcpcb.com/parts/all-electronic-components

[2] "Preventing pcb failure: Causes, symptoms, and maintenance tips." [Online]. Available: https://www.pcbaservices.com/preventing-pcb-failure/

[3] "Kicad design pcb: Tips and tricks for successful printed circuit." [Online]. Available: https://hillmancurtis.com/kicad-design-pcb/

[4] "Trace width calculator." [Online]. Available: https://forum.kicad.info/t/trace-width-calculation/16091