Scenarios B Team report

MAZE SOLVING ROBOT

Circuit building n demo: 8 out of 8

Score for Scenario B: 19.5 out of 20

Scenarios Team: Group 7

Contents

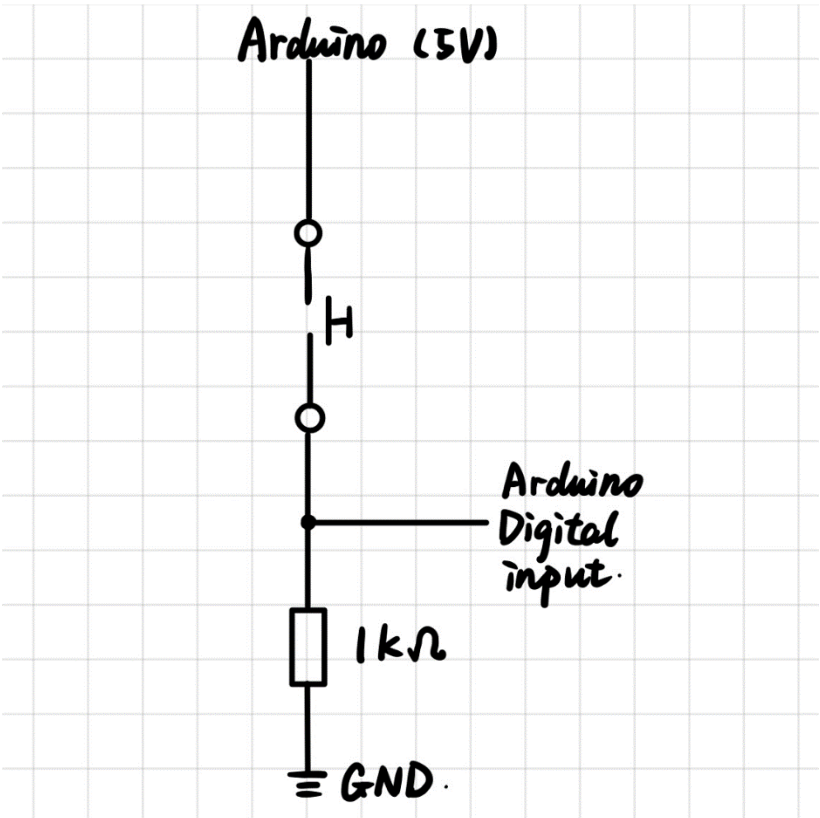
Question 1 – Sensing: Circuit to sense rigid side walls

We chose 1kΩ resistors, 5V power supply pin of Arduino and the GND terminal. ✓

The resistor in the circuit is used to limit the current value.

In our designed circuit, the 5V power supply pin of Arduino is the power supply of the whole circuit, and the final signal "HIGH" level or "LOW" level is the output back to the microcontroller.

✓



✓

✓

Figure 1: Schematic of the circuit

When the robot is not in contact with the wall, no current flows across the circuit as the pushbutton acts as an open circuit. Hence, the Arduino input would read a "LOW" voltage. ✓

When the robot hits the side of the wall, the pushbutton is pressed down, completing the circuit. Hence, current will flow across the circuit, which the Arduino's input would read a "LOW" voltage. ✓

Good.
Score for question 1: 1 out of 1

Question 2 - Sensing: Circuit to Sense Front Unstable Walls

From this issue, we know that we need to construct a circuit not only for reverse bias of photodiode with constant voltage, but also for generating voltage linearly related to photocurrent, thereby generating voltage related to incident light power. Considering the use of a BJT in the circuit, there exists a relationship between the base current and the collector current: $I_C = \beta \times I_B$. Therefore, by connecting the base of the BJT to the reverse-biased photodiode, we can use this as an input, resulting in the collector current serving as the output. In this case, the photodiode functions as a switch since current can only flow when light strikes the photodiode.

In the case of a gap in front, the light emitted from the LED is not reflected, so we can perceive it as no light striking the photodiode. In this case, since the reverse-biased photodiode is connected and there is no light, there is no base current, and the BJT is cut off.

Since the collector is connected to a power supply of 9V, and there is no voltage drop in this case, the input to the Arduino is 9V, which is greater than its maximum operating voltage (5V). So, we connect the collector to the output from Arduino 5V so that even if there is no light on the photodiode (there's a gap in front), the input voltage into the Arduino will have a maximum of 5V.

At the same time, to prevent the base current from being too high when light strikes on the photodiode, a resistor R1 can be connected to the base to control it. Since the voltage output needs to be connected to an Arduino for data collection, it is necessary to incorporate a resistor R2 in the collector circuit to induce a voltage drop. At the same time, connect an LED in parallel at another end of the battery to keep the LED glowing all the time. The circuit diagram for this light sensor (Figure 2) is presented below:

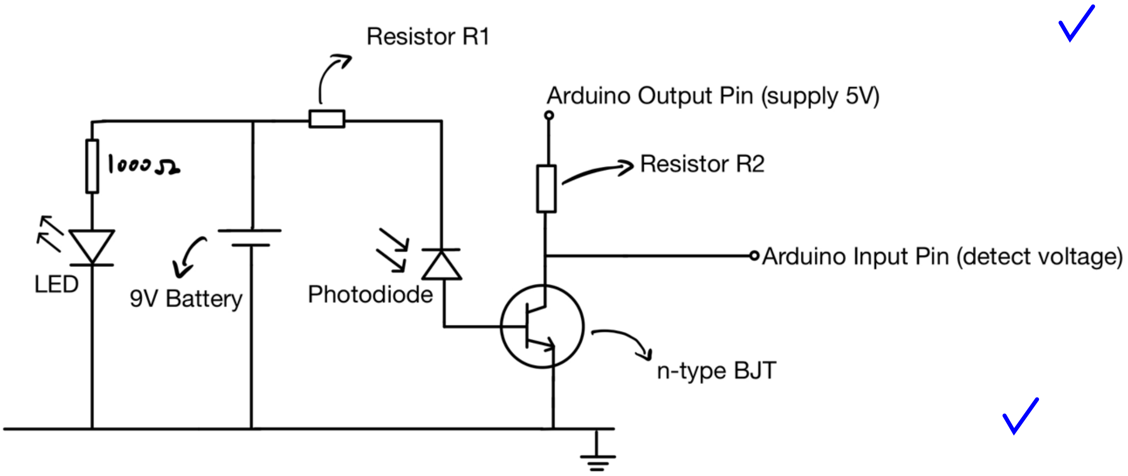


Figure 2: Schematic of the circuit

Then we focus on the value of resistors as Arduino needs to detect voltage meanwhile the maximum working voltage is 5V and needs to ensure that $V_{CE} > 0.5V$,$V_C > V_B$ keeping the

BJT in the forward-active region. So, assume the Arduino Input voltage is 1V when light strikes the photodiode, $I_{C(max)} = \frac{5V-1V}{R_2} = \frac{4}{R_2}$ and $I_C = \beta I_B$, rewrite the equations we can get that $\frac{4}{R_2} = \beta I_B$, $R_2 = \frac{4}{\beta I_B}$ for maximum R2. To prevent I_B from being too high and cause I_C to be high, assume that $I_B \leq 1mA$, and we know that $V_{BE} = 0.7V$,so $I_B = \frac{9V-0.7V}{R_1} \leq 1mA$ and we can get $R_1 \geq 8.3k\Omega$.

Regarding the Arduino input, if a significant amount of light strikes the photodiode (indicating no maze in front of the robot, resulting in greater light reflection), the photocurrent increases. This, in turn, leads to a higher base current and a consequent increase in the collector current. As a result, a larger voltage drop occurs across the resistor, leading to a lower voltage being input into the Arduino. Conversely, if a minimal amount of light strikes the photodiode (indicating the presence of a maze in front of the robot, resulting in less light reflection), the photocurrent decreases. This leads to a lower base current and a consequent decrease in the collector current. Consequently, a smaller voltage drop occurs across the resistor, leading to a higher voltage input into the Arduino.

Good.
Score for question 2: 3 out of 3.

Question 3 – Actuation: Motor Driver Circuits (Forward)

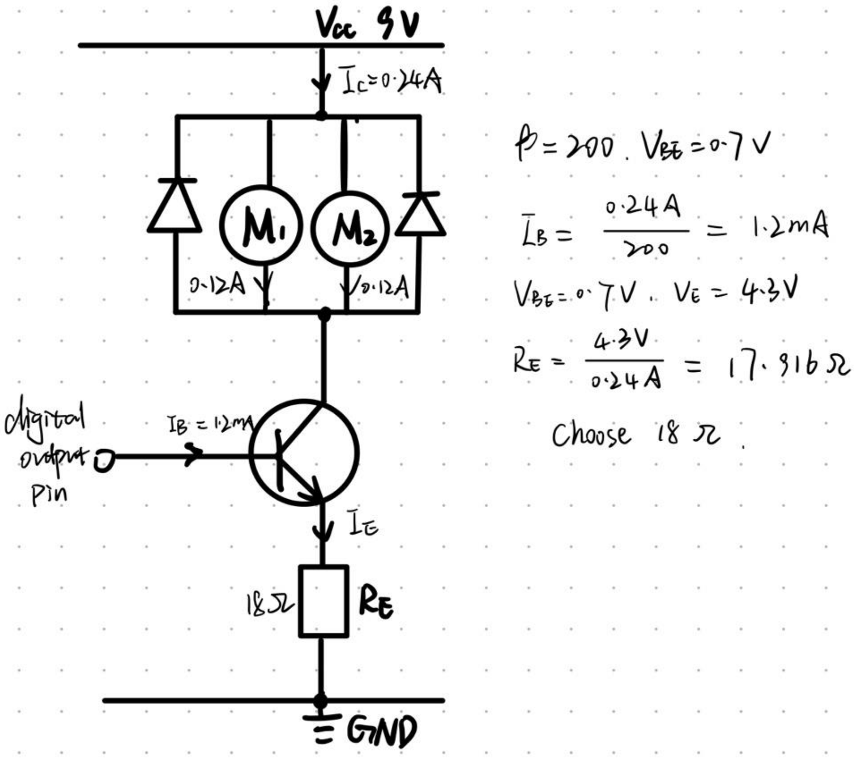


Figure 3: Schematic of the circuit and calculation results

To obtain sufficient current to drive two motors simultaneously, we used NPN-type BJT to amplify the current. The two motors are connected in parallel to the collector terminal, as shown in Figure 3. Please note that this circuit represents an ideal scenario designed under certain ideal conditions. We assume a potential difference of 0.7V (V_{BE}) between the base and emitter and a current gain of β=200 for the common emitter configuration. Based on these assumptions, we calculated the required components and appropriate resistor values.

(The calculation process is shown in the figure we provided)

As you can see in our design, we've included two diodes in parallel with the motors, but these diodes are reverse-biased. This is a safeguarding measure to protect the circuit from the "voltage spikes" that can occur when the motors are turned off. These reverse-biased diodes provide a safe path for the induced current to circulate back into the motor, allowing the energy to dissipate without damaging other components in the circuit.

Explanation for "Voltage spikes": Motors have a property where they resist changes in current. So, when the current through the motor is suddenly interrupted, as happens when we switch off the digital output pin, the energy stored in the motor's magnetic field converted quickly into a voltage spike, the reverse potential often cause a risk to potentially damage other components in the circuit, like our NPN BJT or the Arduino board (may not enough high to break them, but in case).

Good.
Score for question 3: 1 out of 1.

Question 4 – Actuation: Motor Driver Circuits (Left & Right)

In this design, we need to drive two motors to rotate, which need to be able to rotate both clockwise and anticlockwise simultaneously. So, we should turn on both the top-left PNP and bottom-right NPN transistors, as well as the top-right PNP and bottom-left NPN transistors at the same time. We encountered some problems in our design, the PNP BJT can not work in cut-off region when the digital output is high level, and I believe that using a cascade approach to solve these problems is appropriate. I have detailed the process below.

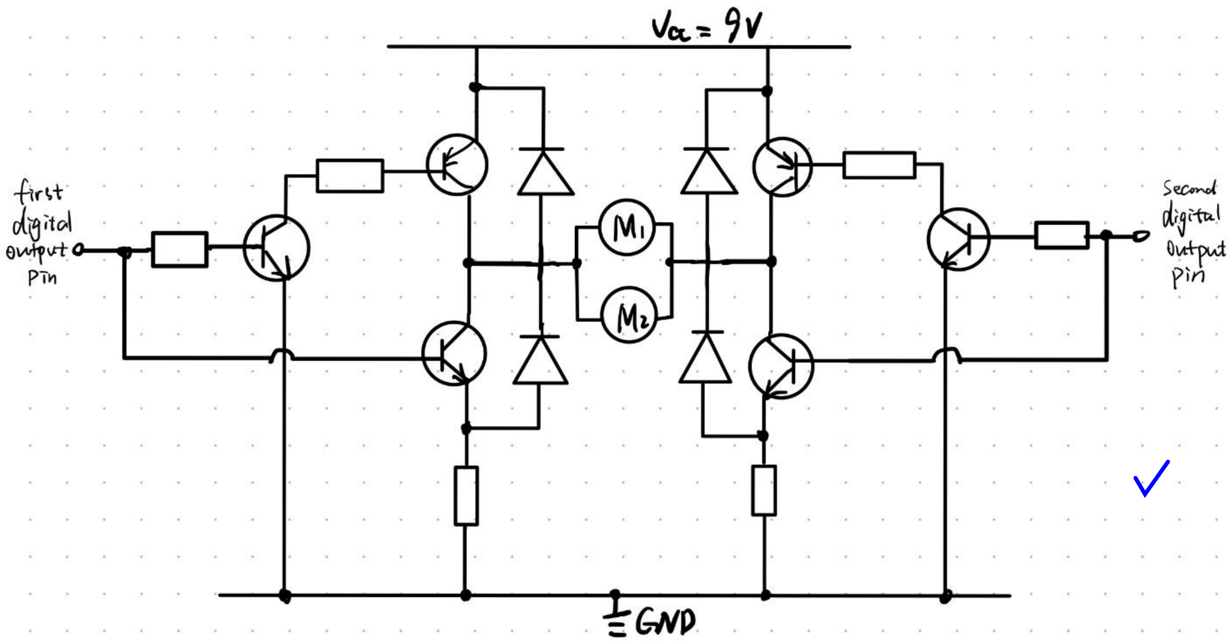


Figure 4: Schematic of the circuit

During the problem-solving process, I realized that regardless of whether we provide a low voltage of 0V or a high voltage of 5V from the Arduino's output pin, the base voltage (V_B) of the PNP BJT is always lower than its emitter voltage (V_E). This means we can't turn off the PNP BJT, as its emitter is directly connected to the 9V power source. To tackle this, we decided to cascade a NPN BJT with the PNP BJT and adjust the base voltage of the PNP BJT through a resistor. In other words, we want the PNP transistor to turn off when we provide a high level voltage by out board to the cascaded NPN BJT, then use the resistor which connected the collector terminal of the NPN BJT to raise the voltage potential at Base terminal of the PNP one. The advantage of this design compared to lowering the emitter voltage of the PNP BJT is that we can significantly reduce energy dissipation. This is because we only need a small current to enter the NPN BJT, allowing us to utilize almost all the current to flow into the motors.

The same as I explained in Q3, these diodes are to resist the "voltage spike".

Good.
Score for question 4: 3 out of 3.

Question 5 – Planning: Pseudocode

Below is the pseudo-code for the robot to navigate through the maze:

//Step 0: Setup input pins to Arduino

```
push_left = A0;        //pushbutton on left
push_right = A1;       //pushbutton on right
front_wall = A2;       //Infrared sensor
T = 2s;                //Arbitrary time
//If front_wall > threshold voltage, then there's a gap ahead of the robot
//If front_wall < threshold voltage, then there's a gap ahead of the robot
```

//Step 1: Move the robot forward until it reaches a wall

```
If front_wall > threshold voltage{
        Turn on motor 1 and motor 2, moving the robot forward;}

If front_wall < threshold voltage{
        Stop motors 1 and 2, then proceed to step 2;}
```

//Step 2: Moves the robot left

```
Turn on motors 3 and 4, moving the robot to the left;
Constantly take readings from the infrared sensor;

If front_wall > threshold voltage {
        T1 = start_time;      //Record the current time, T1 (Where first gap is detected}

If (current_time – T1) > T(2 sec) AND front_wall > threshold voltage{
        Comb-shaped irregularity detected, loop step 2;}

If (current_time – T1) > T(2 sec) AND front_wall > threshold voltage{
        gap detected, jump to step 1;}

If push_left == 1{
        Touched the left wall, jump to step 3;}
```

//Step 3: Moves the robot right

```
Turn on motors 3 and 4, moving the robot to the right;
Constantly take readings from the infrared sensor;

If front_wall > threshold voltage (detects first gap) {
        T1 = start_time          //Record the start time, T1(when first gap is detected)

If (current_time – T1) > T(2 sec) AND front_wall > threshold voltage{
        Comb-shaped irregularity detected, loop step 2}
```

If (current_time – T1) > T(2 sec) AND front_wall > threshold voltage{
    Gap detected, jump to step 1}

If push right == 1{
    Touched the left wall, jump to step 3;}

Good.
Score for question 5: 2 out of 2.

Question 6 – Inclusivity and Diversity

Introduction:
In this section of the report, we will examine the Mamut copper mine located in Malaysia, Sabah and explore different aspects of the Mamut copper mine, including its history, current state, how it generates revenue and benefits to the local society. The Mamut copper mine is an open-pit quarry mine where various minerals can be mined, including copper, gold and silver. Due to the major environmental harm it caused, the mine ceased operations closed in 1999.

History of Mamut Copper Mine: (Dylan Lim)
Mamut copper mine was first established in the late 1960s, and its production first started in 1975. The origins of the mine could be traced back to the end of the Pacific War when Japan found itself in a position where it needed to find other Asian countries to become joint venture partners and supply its raw materials needs. The involvement of Japanese investors in Mamut copper mining began after Japanese Mitsubishi Metal Corporation (JMMC) established Overseas Mineral Resources Development Tokyo (OMRDT), which consisted of 7 Japanese companies [1]. As a result, the Mamut Copper Mine was formed and grew to be a company that holds a monopoly on copper production in Malaysia throughout its lifespan.

In 1999, the Mamut Copper mine ceased its operations due to the environmental catastrophe it caused, which can be attributed to acid mine drainage (AMD). This is a highly acidic, metal-contaminated leachate which is a toxic waste product produced during the post-mining phase. During its operation from 1975 to 1999, it left behind a total of 20.6 million cubic meters of untreated AMD in a 4800-acre wasteland[3] that continually poses a hazard to the surrounding communities.

However, despite the environmental risks this abandoned mine posed to the public, the government of Sabah, through Chief Minister Chong Kah Kiat tried attracting investors into a resort development project surrounding the mine for tourism attraction[4]. This bold decision can be attributed to the location's interesting topography and its scenic view of Mount Kinabalu. Despite this, no further deals are realized.

More than a decade later, in 2016, Sabah Deputy Chief Minister Joseph Pairin Kitingan announced that local authorities are looking into the prospect of treating the 20.6 million cubic meters of acidic water to help ease the water shortages issue caused by drought. This proposal was also dropped after experts conducted a study and determined that doing so would be unfeasible.[5]

Current State of Mamut Copper Mine: (Sihan Chen)
Today, the Mamut Copper Mine has undergone a transformation from an active running operation to a cultural and educational site which offers visitors a unique opportunity to

learn about the history of the mine, the mining industry in the region, and the environmental challenges associated with copper mining.

The museum features a range of exhibits and displays that showcase the mining history of the Mamut Copper Mine. Visitors can explore various artifacts, mining equipment, and photographs that depict the mining operations and even the lives of the workers. In addition, the museum provides insights into the mining process and techniques used to extract copper ore and the procession of these into copper concentrate. Also, it provides a valuable opportunity for searching natural acid neutralization process and mine rehabilitation because of its unusual geochemical features and unique biological features.

Benefits to the local society: (JianXiang Hao)

Prior to its closure in 1999, the Mamut copper mine (MCM) opened up a large number of employment opportunities to the surrounding locals. In the early stages of the mining development, an estimated 94% of all employees are Sabahans, and 64% of them are from the Ranau district alone[1]. In addition to this, the MCM company also opened up part-time positions to high school students, with priority given to children of existing workers. This gave the local communities the opportunity to engage in mining activities, speeding up the industrialization process of the local area, which primarily focused on agriculture. All these factors contributed to the increased employment rate and sped up the economic development of the surrounding area, which raised the living standards of the local communities.

How it generates revenue: （Jingyi He）

The Mamut copper mine has many avenues for revenue. First and foremost, the sale of copper concentrate accounts for its largest portion of revenue. Copper concentrate is produced by processing copper ore, which yields copper concentrate consisting of high levels of copper. Mamut copper mine then sells this to smelters or refiners, who further process these into copper products. It was estimated that the copper mine had exported a total of over 21 million kilograms of minerals worth 11.5 million dollars exported overseas, primarily Japan, given that Japan is the largest investor in Mamut Copper Mine.[2]

Conclusion: (Alexander Zhang)

In conclusion, the Mamut Copper Mine ceased operations after more than 2 decades of mining due to the environmental risk it posed to the surrounding area. It serves as a cautionary tale of the environmental harm mining has to the ecosystem, proving that proper handling of toxic waste is imperative to operating a copper mine.

References:

[1] ADNAN, N. (2021). MAMUT COPPER MINE: DEVELOPMENT AND SOCIAL IMPACT ON SABAH SOCIETY 1960-1990. Quantum Journal of Social Sciences and Humanities, 2(2), 1–10. https://doi.org/10.55197/qjssh.v2i2.65 ✓

[2] The First Production of The Copper Mine In Mamut, Sabah -. (2019, August 28). Web.archive.org. Should add accessed date. https://web.archive.org/web/20190828075543/http://hids.arkib.gov.my/en/peristiwa/-/asset_publisher/WAhqbCYR9ww2/content/pengeluaran-pertama-lombong-tembaga-di-mamut-sabah/pop_up?_101_INSTANCE_WAhqbCYR9ww2_viewMode=print

[3] Being Human: Can the rehabilitation of Mamut transcend survival politics? (n.d.). The Edge Malaysia. Retrieved May 17, 2023, from https://theedgemalaysia.com/article/being-human-can-rehabilitation-mamut-transcend-survival-politics

[4] "Investors urged to develop abandoned Mamut Copper Mine". Chief Minister Department (Press release). Government of Sabah. 9 August 2001

[5] "Contaminated water in mining pool too costly to treat". Free Malaysia Today. 31 March 2016.

Formatting of reference needs to be checked.

Well-written.
Score for question 6: 1.5 out of 2.