MARS

ROVER

Opportunity

Let's Explore the Red Planet

ABSTRACT

In an era marked by remarkable advancements in space exploration, the endeavour to explore and understand the Martian surface stands as a pinnacle of human ingenuity and scientific curiosity. The Mars Rover Project, undertaken by us, represents a pioneering effort aimed at designing and developing a robotic rover capable of traversing the challenging terrain of Mars while conducting sophisticated scientific experiments and observations.

This project encompasses multidisciplinary efforts, integrating concepts from mechanical engineering, electronics, software development, and robotics. The Mars rover is envisioned as a versatile robotic platform equipped with a suite of scientific instruments designed to investigate key aspects of Mars' geology, atmosphere, and potential habitability.

Key objectives of the Mars Rover Project include:

Designing a robust and manoeuvrable rover chassis capable of traversing diverse Martian landscapes, including rocky terrain and sandy plains.

Developing a sophisticated control system to enable autonomous navigation, obstacle avoidance, and precise manoeuvring on the Martian surface.

Implementing camera, communication systems to facilitate real-time data transmission between the rover and mission control on Earth.

Conducting comprehensive testing and validation procedures to ensure the rover's reliability and performance in simulated Martian environments.

By embarking on the Mars Rover Project, we seek to not only demonstrate technological prowess but also contribute to the broader scientific community's efforts in unravelling the mysteries of the Red Planet. Through this endeavour, we aim to inspire future generations of scientists, engineers, and space enthusiasts while advancing our understanding of Mars and its potential for harbouring life.

CONTENTS

CHAPTER-1: INTRODUCTION

1.1. INTRODUCTION TO ROVER

Rovers are robotic vehicles designed for exploration in environments where human presence is either impractical or impossible. These vehicles play a crucial role in space exploration, enabling scientists to study distant celestial bodies and their environments with a high degree of precision. Rovers are equipped with various scientific instruments and communication systems, allowing them to gather data, take images, and transmit findings back to Earth.

A Mars rover, specifically, is a robotic vehicle specially designed for exploration on the Martian surface. Since the dawn of space exploration, numerous missions have been launched to Mars, each with the goal of unraveling the planet's mysteries and understanding its geology, climate, and potential for life.

To date, several missions have successfully deployed rovers to Mars, including:

I. **Mars Pathfinder (1997):** The Mars Pathfinder mission, led by NASA, included the deployment of the Sojourner rover. Sojourner was the first rover to explore the Martian surface, conducting experiments and collecting data for over three months.

II. **Spirit and Opportunity (2004):** The Mars Exploration Rover mission, comprising the Spirit and Opportunity rovers, aimed to study the Martian surface in greater detail. Both rovers exceeded their planned mission duration, with Opportunity holding the record for the longest operational rover on Mars, lasting over 14 years.

III. **Curiosity (2012):** The Mars Science Laboratory mission deployed the Curiosity rover, a car-sized rover equipped with advanced scientific instruments. Curiosity's primary goal is to assess Mars' past and present habitability, including the potential for microbial life.

IV. **Perseverance (2021):** The Perseverance rover, part of NASA's Mars 2020 mission, is the most recent rover to land on Mars. Perseverance is tasked with searching for signs of past microbial life, collecting samples for future return to Earth, and testing technologies for future human missions to Mars.

Our project is inspired by the Opportunity rover mission, which landed on Mars as part of the Mars Exploration Rover mission in 2004. Opportunity's impressive longevity and contributions to our understanding of Mars serve as a testament to the capabilities of robotic exploration. As we embark on our own Mars rover project, we draw inspiration from Opportunity's legacy while aiming to contribute to the ongoing exploration and scientific discovery on the Red Planet.

1.2. USES OF ROVER

Mars rovers have several uses, primarily centered around scientific exploration and research on the Martian surface. Some of the key uses include:

1.2.1. Exploration

Rovers are designed to explore the Martian terrain, collecting data and samples from different locations to better understand the planet's geology, climate, and potential for past or present life.

1.2.2. Geological Analysis

Rovers analyze the composition of Martian rocks and soil to understand the planet's geological history, including factors like past water activity, volcanic activity, and the presence of minerals.

1.2.3. Studies

Rovers carry instruments to study the Martian atmosphere, measuring factors such as temperature, pressure, wind speed, and chemical composition. This helps scientists understand Mars' climate dynamics and its potential for supporting life.

1.2.4. Search for Signs of Life

Rovers are equipped with instruments to search for signs of past or present life on Mars. This includes analyzing soil and rock samples for organic molecules and studying environments that could potentially support microbial life.

1.2.5. Technology Demonstrations

Some rovers carry experimental technologies aimed at demonstrating new capabilities for future missions, such as advanced mobility systems, autonomous navigation, or in-situ resource utilization (using local resources on Mars for fuel, water, or oxygen production).

1.2.6. Communication Relay

Rovers can serve as communication relays between Earth and other robotic missions on Mars, helping to transmit data back to Earth and facilitating coordination between different spacecraft.

1.2.7. Education and Public Outreach

Rovers engage the public in space exploration by providing captivating images and data from Mars, inspiring interest in science and engineering among students and the general public.

Overall, Mars rovers play a crucial role in advancing our understanding of Mars and its potential as a destination for future human exploration.

CHAPTER-2: LITERATURE

The Mars Rover Project draws upon a rich body of literature spanning various fields including robotics, aerospace engineering, planetary science, and computer science. This section provides an overview of key literature and research that has informed and influenced the design, development, and operation of robotic rovers for planetary exploration, particularly focusing on Mars.

- **Planetary Science and Geology:** Literature in planetary science and geology provides essential insights into Mars' geological history, surface composition, and potential habitability. Research articles and textbooks covering topics such as Martian geology, mineralogy, and geomorphology serve as foundational knowledge for understanding the Martian environment.
- **Robotics and Autonomous Systems:** The field of robotics offers valuable resources on the design, control, and navigation of autonomous systems, including planetary rovers. Research papers, textbooks, and conference proceedings in robotics cover topics such as mobility systems, sensor integration, path planning, and autonomous navigation algorithms.
- **Spacecraft Design and Engineering:** Literature on spacecraft design and engineering provides guidelines and best practices for developing robotic systems capable of withstanding the harsh conditions of space and planetary surfaces. Books, journals, and technical reports on spacecraft subsystems, thermal control, power systems, and communication interfaces are essential references for rover design.
- **Previous Mars Rover Missions:** Publications and mission reports from previous Mars rover missions, such as Mars Pathfinder, Spirit and Opportunity, Curiosity, and Perseverance, offer valuable insights into mission planning, rover operations, scientific discoveries, and engineering challenges encountered during Martian exploration.
- **Computer Science and Software Engineering:** Literature in computer science and software engineering provides methodologies and techniques for developing software systems for autonomous navigation, data processing, and communication protocols in robotic platforms. Research papers, textbooks, and online resources on robotics software development, computer vision, machine learning, and communication protocols are relevant to rover design and operation.
- **Interdisciplinary Studies:** Interdisciplinary studies that integrate knowledge from multiple fields, such as astrobiology, astrogeology, and astrochemistry, offer perspectives on the search for life and habitability on Mars. Publications in astrobiology, exobiology, and related fields provide insights into the potential for past or present life on Mars and guide the selection of scientific instruments for rover missions.

By synthesizing insights from diverse literature sources, the Mars Rover Project aims to leverage existing knowledge and expertise to design, develop, and operate a capable and scientifically valuable robotic rover for exploration on the Martian surface.

CHAPTER-3: COMPONENTS REQUIRED AND DESCRIPTION

3.1. Components Required

RECEIVER		
Sr. No.	**Components**	**Quantity**
I.	L298N Motor Driver Module	1
II.	DC Geared Motor (150 rpm)	6
III.	ESP32 (Wi-fi / BL Module)	1
IV.	Li – ion Battery (5200 mAh)	1
V.	CP Plus Camera	1
VI.	Wheel	6
VII.	Jumper Wires	As per requirement
VIII.	Ply Board	As per requirement
IX.	PVC Pipes	As per requirement
TRANSMITTER		
Sr. No.	**Components**	**Quantity**
I.	ESP32 (Wi-fi / BL Module)	1
II.	Analog Joystick	1
III.	LED	1
IV.	Switch	1
V.	Battery	3
VI.	Micro USB Connector	1
VII.	Battery Cell Holder (3 Cells)	1
VIII.	Jumper Wires	As per requirement
IX.	Ply Board	As per requirement
X.	Screw & Hinges	As per requirement

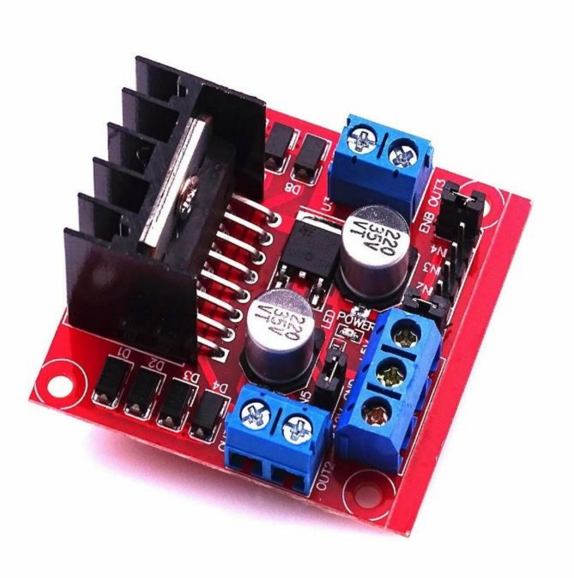
List of Items

3.2. Components Description

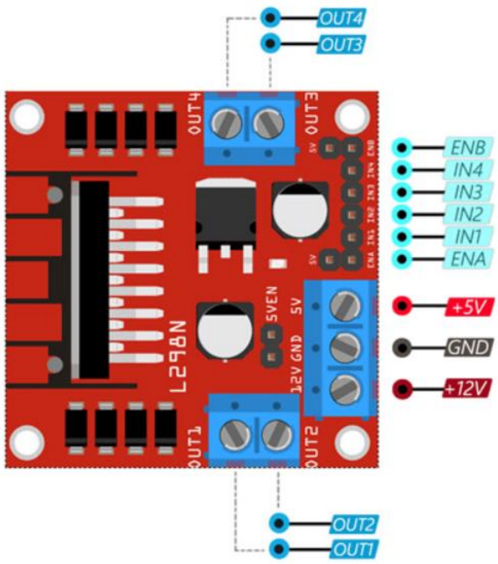
3.2.1. Receiver

3.2.1.1. *L298N Motor Driver Module*

This L298N Motor Driver Module is a high-power motor driver module for driving DC and Stepper Motors. This module consists of an L298 motor driver IC and a 78M05 5V regulator.



L298N Motor Driver Module



L298N Motor Driver Module Pinout

PIN Name	Description
IN1 & IN2	Motor A input pins. Used to control the spinning direction of Motor A
IN3 & IN4	Motor B input pins. Used to control the spinning direction of Motor B
ENA	Enables PWM signal for Motor A
ENB	Enables PWM signal for Motor B
OUT1 & OUT2	Output pins of Motor A
OUT3 & OUT4	Output pins of Motor B
12V	12V input from DC power Source
5V	Supplies power for the switching logic circuitry inside L298N IC
GND	Ground pin

L298N Motor Driver Module Pinout Configuration

Features & Specifications:

- Driver Model: L298N 2A
- Driver Chip: Double H Bridge L298N
- Motor Supply Voltage (Maximum): 46V
- Motor Supply Current (Maximum): 2A

- Logic Voltage: 5V
- Driver Voltage: 5-35V
- Driver Current:2A
- Logical Current:0-36mA
- Maximum Power (W): 25W
- Current Sense for each motor
- Heatsink for better performance
- Power-On LED indicator

Brief about L298N Module:

The L298N Motor Driver module consists of an L298 Motor Driver IC, 78M05 Voltage Regulator, resistors, capacitor, Power LED, 5V jumper in an integrated circuit.

78M05 Voltage regulator will be enabled only when the jumper is placed. When the power supply is less than or equal to 12V, then the internal circuitry will be powered by the voltage regulator and the 5V pin can be used as an output pin to power the microcontroller. The jumper should not be placed when the power supply is greater than 12V and separate 5V should be given through 5V terminal to power the internal circuitry.

ENA & ENB pins are speed control pins for Motor A and Motor B while IN1& IN2 and IN3 & IN4 are direction control pins for Motor A and Motor B.

Application:

- Drive DC motors.
- Drive stepping motors
- In Robotics

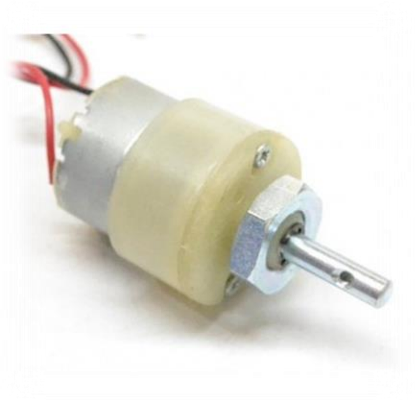
3.2.1.2. DC Geared Motor

Description:

DC Motor – 150RPM – 12Volts geared motors are generally a simple DC motor with a gearbox attached to it. This can be used in all-terrain robots and variety of robotic applications. These motors have a 3 mm threaded drill hole in the middle of the shaft thus making it simple to connect it to the wheels or any other mechanical assembly.

150 RPM 12V DC geared motors widely used for robotics applications. Very easy to use and available in standard size. Also, you don’t have to spend a lot of money to control motors with a compatible board. The most popular L298N H-bridge module with onboard voltage regulator motor driver can be used with this motor that has a voltage of between 5 and 35V DC or you can choose the most precise motor diver module from the wide range available in our Motor divers’ category as per your specific requirements.

Nut and threads on the shaft to easily connect and internally threaded shaft for easily connecting it to the wheel. DC Geared motors with robust metal gearbox for heavy-duty applications, available in the wide RPM range and ideally suited for robotics and industrial applications. Very easy to use and available in standard size. Nut and threads on the shaft to easily connect and internally threaded shaft for easily connecting it to the wheel.



DC Geared Motor

Features:

- It comes with Good Quality Gears.
- The metal gears have better wear and tear properties.
- Gearbox is sealed and lubricated with lithium grease and requires no maintenance.
- Although motor gives 150 RPM at 12V, motor runs smoothly from 4V to 12V and gives the wide range of RPM, and torque.
- The shaft has a hole for better coupling.

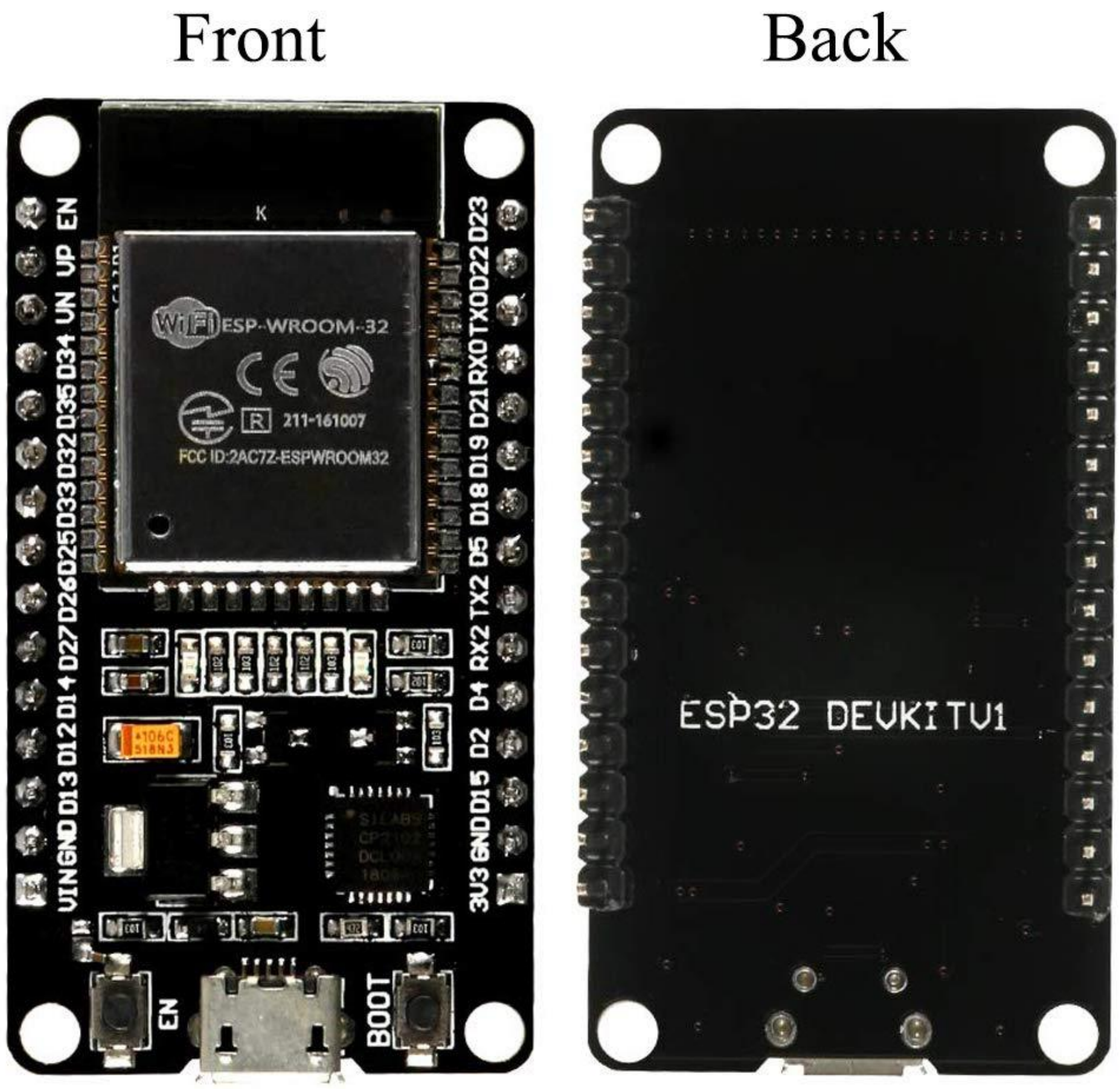
3.2.1.3. ESP32 (Wi-fi / BL Module)

Description:

The ESP8266 started a small revolution by bringing WiFi to a small and cheap package that also had enough processing power and enough pins to get small things done. Now get ready to take your bite-sized WiFi capabilities to the next level with the ESP-WROOM-32 WiFi / Bluetooth Classic / BLE Module!

According to Espressif, the Espressif ESP32 Development Board with Wifi and Bluetooth is a powerful, generic WiFi-BT-BLE MCU module that targets a wide variety of applications ranging from low-power sensor networks to the most demanding tasks such as voice encoding, music streaming and MP3 decoding.

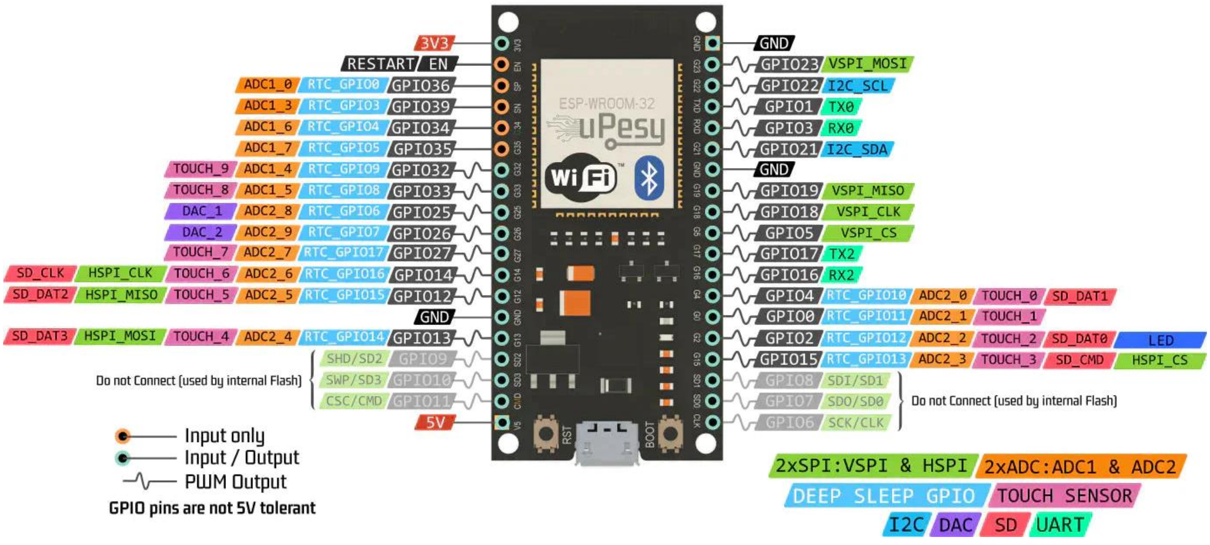
NodeMCU ESP32 Development Board WIFI Bluetooth is a low-footprint, minimal system development board powered by the latest ESP-WROOM-32 module and can be easily inserted into a solderless breadboard.The ESP32-DevKitC contains the entire basic support circuitry for the ESP-WROOM-32, including the USB-UART bridge, reset- and boot-mode buttons, LDO regulator and a micro-USB connector.



ESP WROOM 32 (Wi-fi / Bluetooth Module)

<u>Features:</u>

- Integrated 520 KB SRAM.
- Hybrid Wi-Fi & Bluetooth.
- High level of integration.
- Ultra-low-power management.
- 4 MB Flash.
- On-board PCB antenna.



ESP32 Pinout

Specifications:

Processor	Single or Dual core Tensilica Xtensa 32-bit LX6
Operating voltage (V)	2.3 ~ 3.6
Operating current (mA)	80
Clock Frequency (MHz)	80 ~ 240
Flash memory (MB)	4
Data Rate (Mbps)	54
SRAM Memory (KB)	512
Length (mm)	49.5
Width (mm)	26.5
Height (mm)	11.5
Weight (gm)	10

Specification of ESP32 Wi-fi / BL Module

3.2.1.4. Li – ion Battery (5200 mAh)

Lithium Ion Battery of 5200 mAh and of 12 V Supply is used to provide the power to rover. It is rechargeable.

Li-ion Battery 5200 mAh (12V)

3.2.1.5. CP Plus Camera

Camera is used for recording the content. It is 2MP 1080p Full HD Smart Wi-fi CCTV camera. It has 360° pan tilt and can support SD Card of up to 128 GB. It has features like Motion detection and Night Vision.

CP Plus Camera

3.2.1.6. Wheel

Wheels are attached for movement. There are 6 Wheels attached with Motors for 6 Legs of the Rover

3.2.1.7. Jumper Wires / Ply Boards / PVC Pipes

Jumper Wires are used to make the connections between two components.

Ply Boards are used to make the body of the Rover.

PVC Pipes are used to make the legs.

3.2.2. Transmitter

3.2.2.1. ESP32 (Wi-fi / BL Module)

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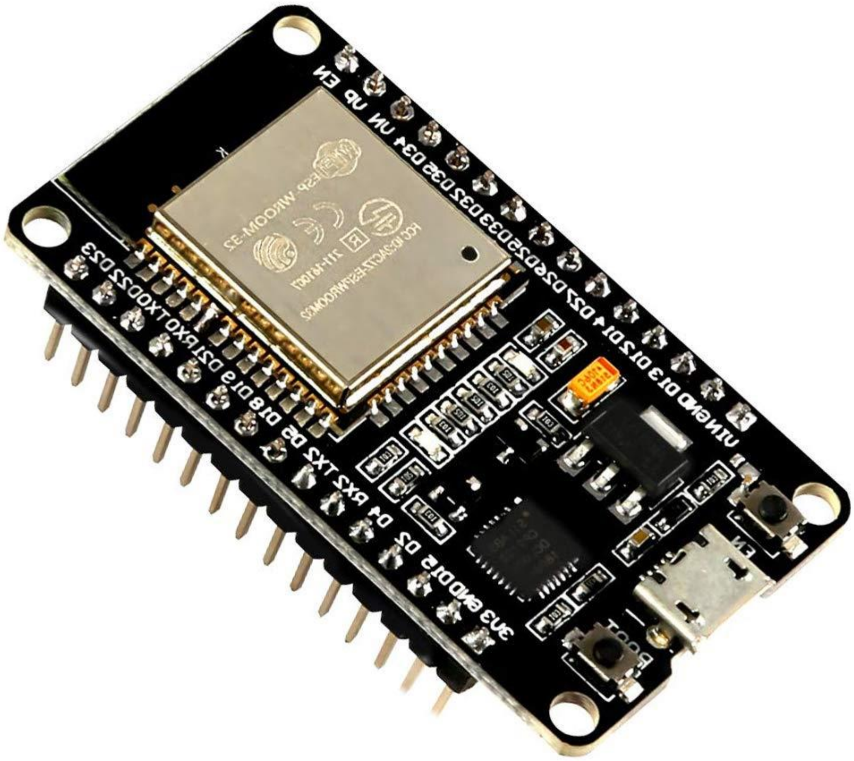

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Length (mm)	49.5
Width (mm)	26.5
Height (mm)	11.5
Weight (gm)	10

Specification of ESP32 Wi-fi / BL Module

3.2.2.2. Analog Joystick

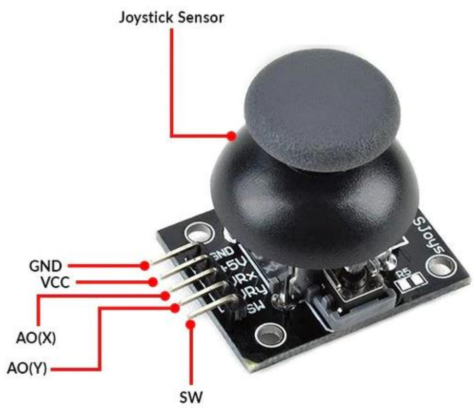
Description:

This is a dual axis high quality Joystick Module. It can be used to sense movements in 2 directions(axes). It also has an inbuilt switch which can be activated by pressing the stick. Directional movements are simply two potentiometers - one for each axis. Pots are ~10k each.

With the help of this Joystick Module, you can measure position coordinates on the X and Y axis by moving the "hat". It also contains a switch that is press-able by pushing the "hat". It also contains a switch that is press-able by pushing the "hat" down. Similar to the XBOX controller.

The X and Y axes are two 10k potentiometers which control 2D movement by generating analog signals. When the module is in working mode, it will output two analog values, representing two directions. This module uses the 5V power supply, and value, when reading through analog input, would be about 2.5V, a value will increase with joystick movement and will go up till maximum 5V; the value will decrease when the joystick is moved in other direction till 0V.

Analog Joystick



Analog Joystick Pinout

Specifications:

- Operating Voltage: 5V
- Internal Potentiometer value: 10k
- 2.54mm pin interface leads
- Operating temperature: 0 to 70 °C

Applications:

- Camera Pan/Tilt Control.
- Game Input/Control.
- Robot Control.
- Widely use in DIY projects.

3.2.2.3. LEDs

RGB LED (Light Emitting Diode) was used as an indicator to indicate either the rover is in ON condition or OFF condition.

RGB LED

3.2.2.4. Switch

Switch is a two-pin device that is use to OPEN or CLOSE the circuit.

Switch

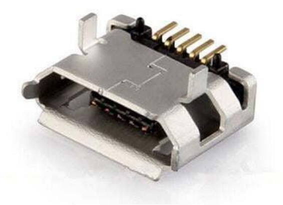
3.2.2.5. Battery

Battery (Cell) is used for providing the DC power supply to the transmitter.

Battery

3.2.2.6. Micro USB Connector

Micro USB Connector is an electronics component that is used to connect the Micro USB. If a Micro USB Connector is used in any circuit board, then by using that Micro USB can be connected to it for power supply or data feeding.



Micro USB Connector

3.2.2.7. Battery Cell Holder

Battery Cell Holder

Battery Cell Holder is a case that can hold multiple batteries and supply the power all the cells together.

3.2.2.8. Jumper Wires / Ply Board / Screw / Hinges

Jumper Wires are used to make the connections between two components

Ply Boards are used to make the body of the transmitter

Screw and Hinges

Jumper Wires

Screw and Hinges are used to attach the ply boards and make it moveable respectively. Making the box moveable ensures that the transmitter box can be opened any time according to the work needed.

CHAPTER-4: METHODLOGY

4.1. Assembly of the Parts

4.1.1. Receiver

Step I: Firstly, we have assembled the PVC pipes and Ply Board together to make the skeleton of the Rover.

Step II: PVCs were attached in such a way that it could make the legs of the Rover through screws.

Step III: Motors were attached to the legs of the Rover with screws and hinges. Further Wheels were attached to the motors.

Step IV: Motors were attached to Motor Driver (L298N Motor Driver) through jumper wires.

Step V: Li – Ion Battery (5200 mAh, 12V) was attached to the Motor Driver for supply.

Step VI: ESP32 Wi-fi Module was attached to the Motor Driver and Battery for controlling the Motor Driver efficiently

Step VII: ESP32 Wi-fi Module receives an additional power supply of +5V from Motor Driver for the purpose of receiving the signal from ESP32 Module that is used in Transmitter (Controlling Remote).

Step VIII: LED was used on the top surface of the Rover to indicate that is it ON or OFF.

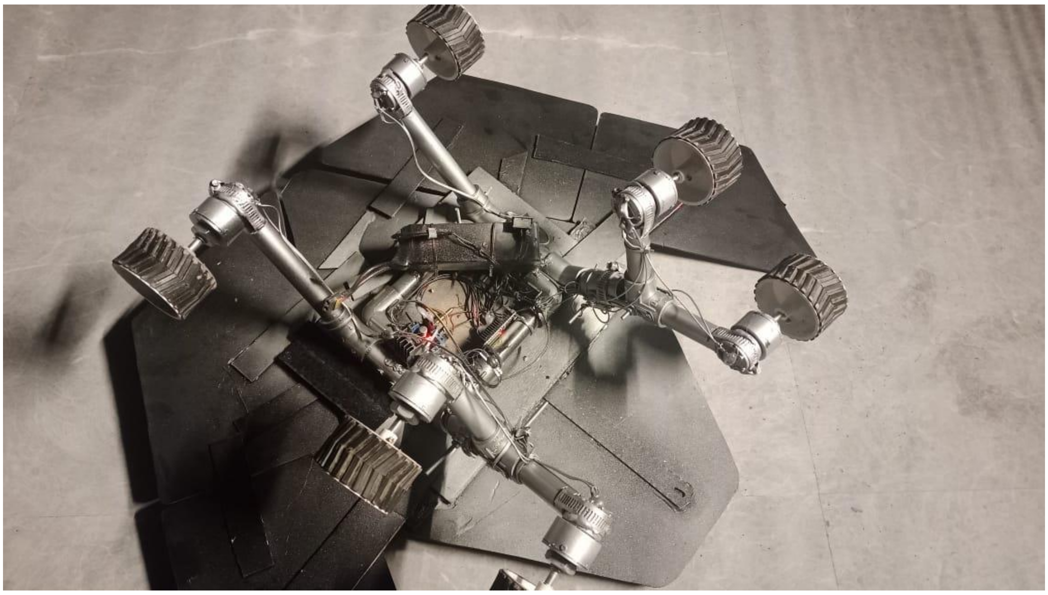
Step IX: Ply Boards were used to make the upper surface of the Rover. Additional Ply Boards were used on the top to provide the design of Solar Plates.

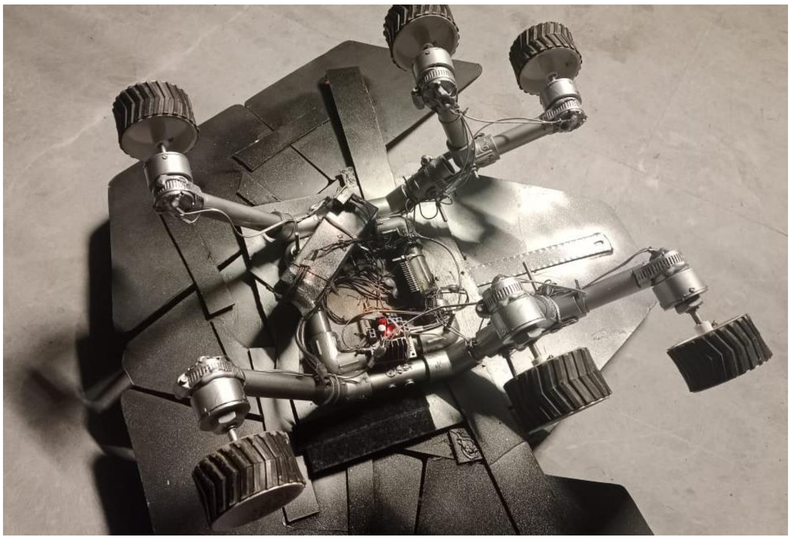
Step X: CP Plus Camera was mounted on the top of the Rover for recording and navigating purpose.

Step XI: Extra Battery was used for Camera.

Step XII: For Designing of Rover, spray paints color was used.

Step XIII: Finally, the Receiver end i.e., THE ROVER was ready.





Internal look of Rover (Receiver)

4.1.2. Transmitter

Step I: Firstly, to make the outer controlling box, ply boards were used.

Step II: Analog Joystick was attached in the box for providing 2D motion instructions.

Step III: ESP32 Wi-fi Module was used for controlling the Analog Joystick. ESP32 Module also transmits the signal for receiver.

PS2 - Analog Joystick Module

Step IV: For providing DC supply +5V to ESP32 Module, Batteries were used. Battery Holder (4 Cell) was also used to keep the batteries mounted.

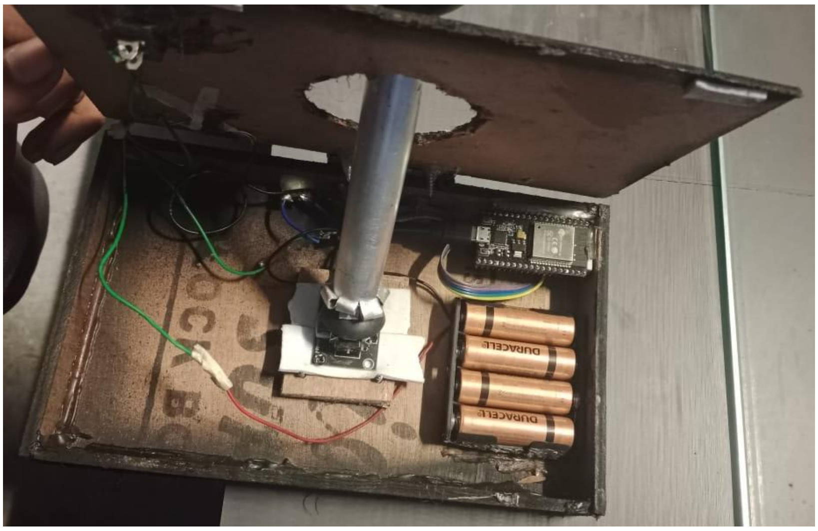
Step V: If the Battery is fully used then in this condition, we can also provide the power through AC Extensions by using Mirco USB and Adapter (it should be of 5V). For this a Micro USB Connector is present in the Controller Box.

Step VI: For switching purpose, switch was used.

Step VII: RGB LED was connected to the controller box to ensure that the controller is either ON of OFF.

Step VIII: For designing purpose, colors were added.

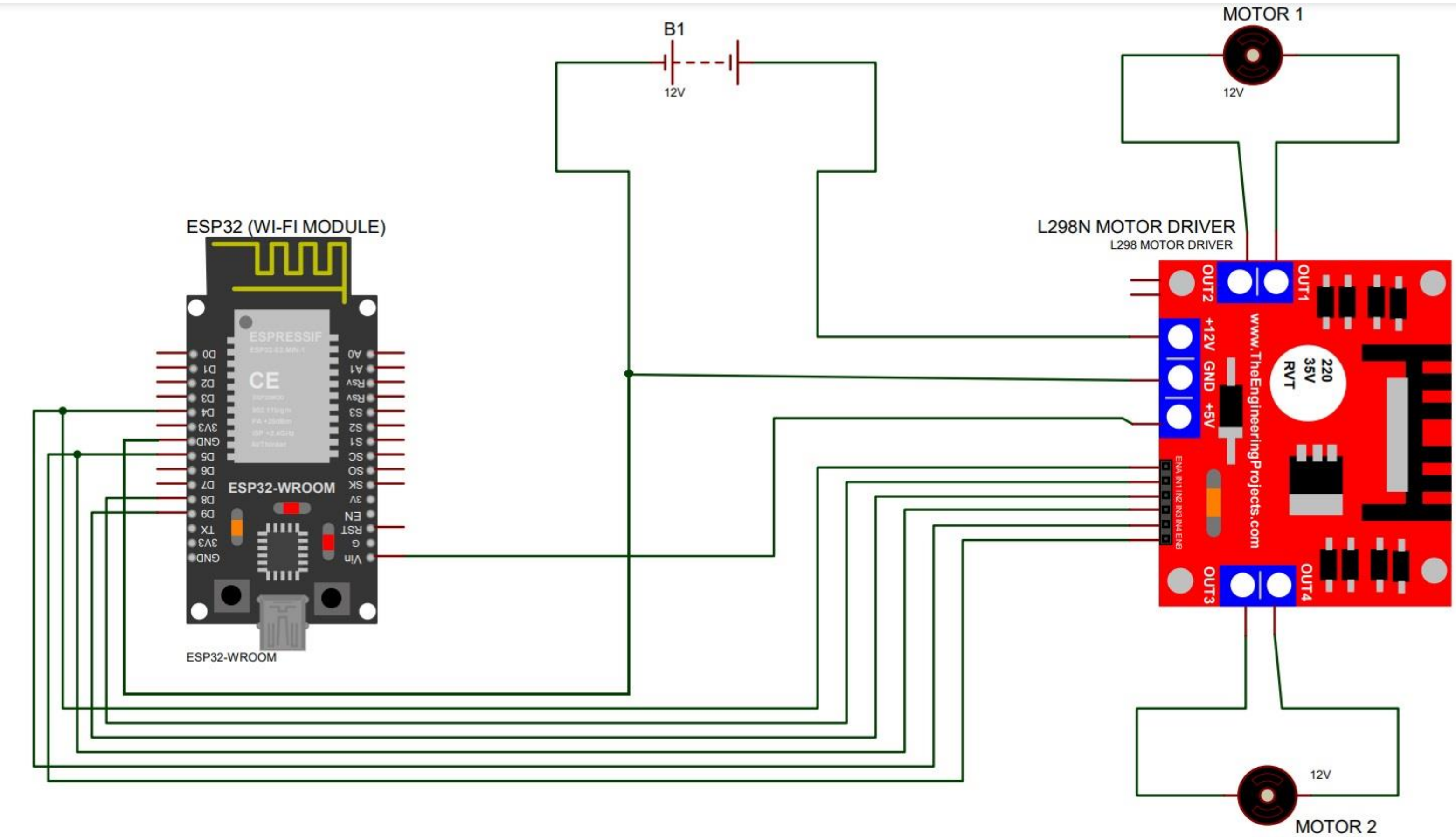
Step IX: Finally, the Transmitter end i.e., The Controller was ready.



Internal look of Controller (Transmitter)

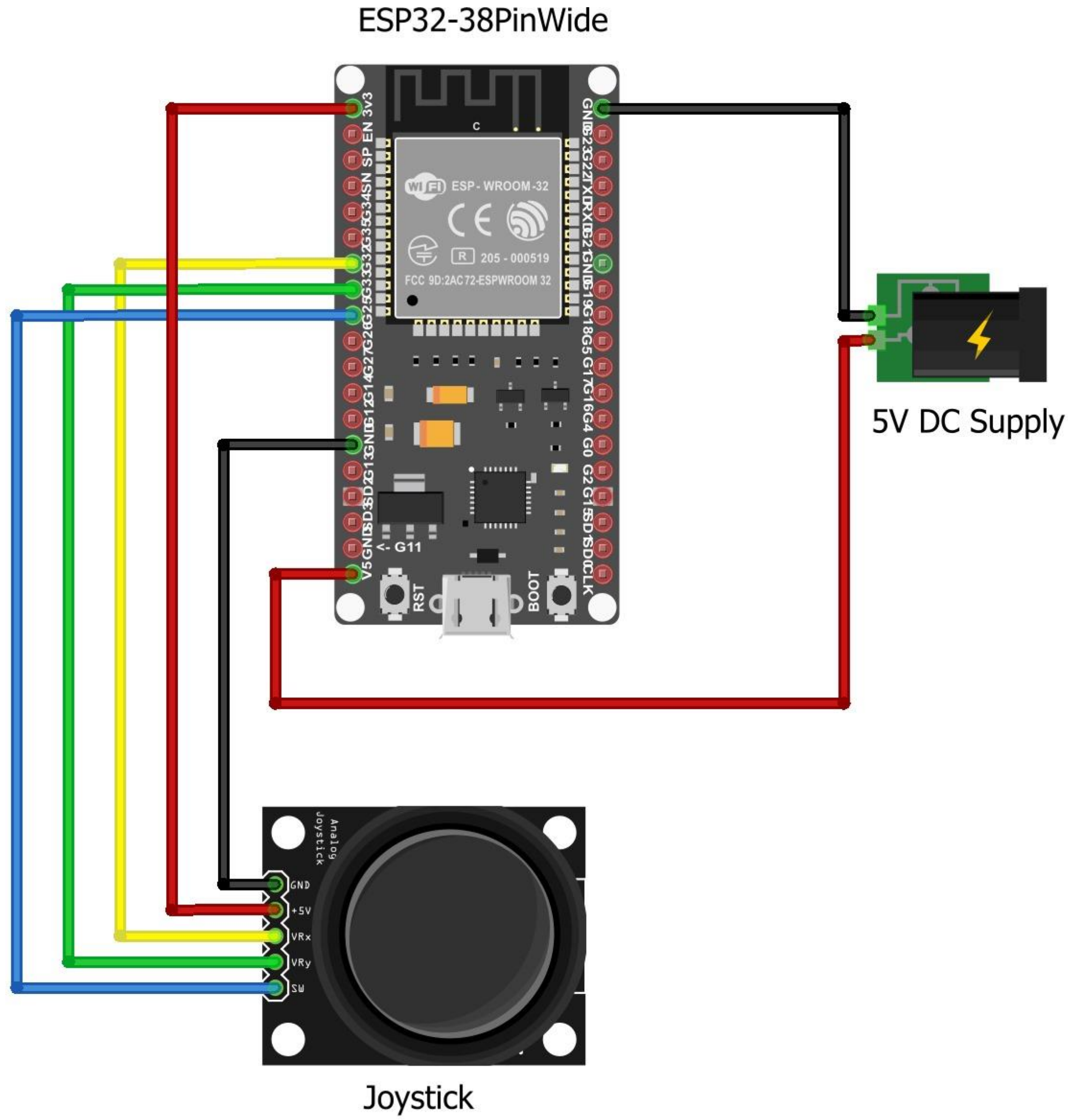
4.2. Schematic Design

4.2.1. Receiver



Schematic of Receiver End (Rover)

4.2.2. Transmitter



Schematic of Transmitter End (Controller)

4.3. Programming

4.3.1. Receiver

```
#include <esp_now.h>
#include <WiFi.h>

// Define a data structure
typedef struct struct_message {
  int joystickXValue;
  int joystickYValue;
} struct_message;
```

```
// Create a structured object
struct_message myData;

// Motor control pins
int enableRightMotor = 32;
int rightMotorPin1 = 25;
int rightMotorPin2 = 26;
int enableLeftMotor = 33;
int leftMotorPin1 = 12;
int leftMotorPin2 = 13;

// Maximum motor speed
const int MAX_MOTOR_SPEED = 230;

// PWM settings
const int PWMFreq = 1000;
const int PWMResolution = 8;
const int rightMotorPWMSpeedChannel = 4;
const int leftMotorPWMSpeedChannel = 5;

// Signal timeout
#define SIGNAL_TIMEOUT 1000
unsigned long lastRecvTime = 0;

// Callback function executed when data is received
void OnDataRecv(const uint8_t *mac, const uint8_t *incomingData, int len) {
  memcpy(&myData, incomingData, sizeof(myData));

  // Print received values
  Serial.print("Joystick X-axis Value: ");
  Serial.print(myData.joystickXValue);
  Serial.print(", Joystick Y-axis Value: ");
  Serial.println(myData.joystickYValue);

  // Motor control based on joystick values
  int throttle = map(myData.joystickYValue, 0, 4096, -MAX_MOTOR_SPEED,
MAX_MOTOR_SPEED);
  int steering = map(myData.joystickXValue, 0, 4096, -MAX_MOTOR_SPEED,
MAX_MOTOR_SPEED);

  int rightMotorSpeed = throttle + steering;
  int leftMotorSpeed = throttle - steering;

  rightMotorSpeed = constrain(rightMotorSpeed, -MAX_MOTOR_SPEED,
MAX_MOTOR_SPEED);
  leftMotorSpeed = constrain(leftMotorSpeed, -MAX_MOTOR_SPEED,
MAX_MOTOR_SPEED);
```

```
  rotateMotor(rightMotorSpeed, leftMotorSpeed);

  // Reset signal timeout
  lastRecvTime = millis();
}

void setUpPinModes() {
  pinMode(enableRightMotor, OUTPUT);
  pinMode(rightMotorPin1, OUTPUT);
  pinMode(rightMotorPin2, OUTPUT);
  pinMode(enableLeftMotor, OUTPUT);
  pinMode(leftMotorPin1, OUTPUT);
  pinMode(leftMotorPin2, OUTPUT);

  // Set up PWM for motor speed
  ledcSetup(rightMotorPWMSpeedChannel, PWMFreq, PWMResolution);
  ledcSetup(leftMotorPWMSpeedChannel, PWMFreq, PWMResolution);
  ledcAttachPin(enableRightMotor, rightMotorPWMSpeedChannel);
  ledcAttachPin(enableLeftMotor, leftMotorPWMSpeedChannel);

  rotateMotor(0, 0);
}

void setup() {
  // Set up Serial Monitor
  Serial.begin(115200);

  // Set ESP32 as a Wi-Fi Station
  WiFi.mode(WIFI_STA);

  // Initialize ESP-NOW
  if (esp_now_init() != ESP_OK) {
    Serial.println("Error initializing ESP-NOW");
    return;
  }

  // Register callback function
  esp_now_register_recv_cb(OnDataRecv);

  // Set up motor control pins
  setUpPinModes();
}

void loop() {
  // Check signal timeout
  unsigned long now = millis();
  if (now - lastRecvTime > SIGNAL_TIMEOUT) {
    rotateMotor(0, 0);
```

```
  }
}

void rotateMotor(int rightMotorSpeed, int leftMotorSpeed) {
  // Motor control logic
  if (rightMotorSpeed > 0) {
    digitalWrite(rightMotorPin1, LOW);
    digitalWrite(rightMotorPin2, HIGH);
  } else if (rightMotorSpeed < 0) {
    digitalWrite(rightMotorPin1, HIGH);
    digitalWrite(rightMotorPin2, LOW);
  } else {
    digitalWrite(rightMotorPin1, LOW);
    digitalWrite(rightMotorPin2, LOW);
  }

  if (leftMotorSpeed > 0) {
    digitalWrite(leftMotorPin1, LOW);
    digitalWrite(leftMotorPin2, HIGH);
  } else if (leftMotorSpeed < 0) {
    digitalWrite(leftMotorPin1, HIGH);
    digitalWrite(leftMotorPin2, LOW);
  } else {
    digitalWrite(leftMotorPin1, LOW);
    digitalWrite(leftMotorPin2, LOW);
  }

  ledcWrite(rightMotorPWMSpeedChannel, abs(rightMotorSpeed));
  ledcWrite(leftMotorPWMSpeedChannel, abs(leftMotorSpeed));
}
```

→ The above code is used to build the connections so that receiver can receive the instruction signal from transmitter and work accordingly.

4.3.2. Transmitter

```
#include <esp_now.h>
#include <WiFi.h>

// It will transmite all the function to C8:F0:9E:7A:C1:78
// C8:F0:9E:7A:C1:78
uint8_t receiverAddress[] = {0xC8, 0xF0, 0x9E, 0x7A, 0xC1, 0x78}; //

// Define a data structure
typedef struct struct_message {
  int joystickXValue;
  int joystickYValue;
```

```
} struct_message;

// Create a structured object
struct_message myData;

// Peer info
esp_now_peer_info_t peerInfo;

// Callback function called when data is sent
void OnDataSent(const uint8_t *mac_addr, esp_now_send_status_t status) {
  Serial.print("\r\nLast Packet Send Status:\t");
  Serial.println(status == ESP_NOW_SEND_SUCCESS ? "Delivery Success" :
"Delivery Fail");
}

void setup() {
  // Set up Serial Monitor
  Serial.begin(115200);

  // Set ESP32 as a Wi-Fi Station
  WiFi.mode(WIFI_STA);

  // Initialize ESP-NOW
  if (esp_now_init() != ESP_OK) {
    Serial.println("Error initializing ESP-NOW");
    return;
  }

  // Register the send callback
  esp_now_register_send_cb(OnDataSent);

  // Register peer
  memcpy(peerInfo.peer_addr, receiverAddress, 6);
  peerInfo.channel = 0;
  peerInfo.encrypt = false;

  // Add peer
  if (esp_now_add_peer(&peerInfo) != ESP_OK) {
    Serial.println("Failed to add peer");
    return;
  }
}

void loop() {
  // Read analog joystick values
  int joystickXValue = analogRead(32);
  int joystickYValue = analogRead(33);
```

```
  // Set joystick values
  myData.joystickXValue = joystickXValue;
  myData.joystickYValue = joystickYValue;

  // Send the data via ESP-NOW
  esp_err_t result = esp_now_send(receiverAddress, (uint8_t *)&myData,
sizeof(myData));

  if (result == ESP_OK) {
    Serial.println("Sending confirmed");
  } else {
    Serial.println("Sending error");
  }

  delay(200);
}
```

→ The above code helps to program the transmitter such that it can transmit the signal according to the movement of joystick.

CHAPTER-5: TESTING AND APPLICATION

The Mars Rover is in working condition. All the components are working according to their functions. The rover is moving according to commands provided by the controller. The program which was fed into ESP32 Wi-Fi modules of rover and controller are producing, transmitting and receiving the signals from the transmitter and receiver very precisely. The camera is also recording video in good quality.

→ The Mars Rover is in motion according to the commands given by the controller.

→ The rover can move smoothly on rocky surfaces and can cross craters (like real surface conditions of Mars).

→ The rover can cross small hurdles and objects present in its path.

→ Camera records the video in Full HD resolution.

→ Camera can also perform live recording.

→ The Controller of the rover can be used either by applying batteries or by connecting the controller directly to switch boards through adapter (5V) and micro-USB cable.

CHAPTER-6: CONCLUSION

In conclusion, the Mars Rover Project represents a significant achievement in our exploration of the Red Planet. Through our collective efforts and dedication, we have designed, developed, and operated a robotic rover capable of traversing the Martian surface and conducting scientific experiments.

Our rover builds upon the successes of previous Mars missions, drawing inspiration from the Spirit, Opportunity, Curiosity, and Perseverance rovers. By studying the Martian terrain, analyzing soil and rock samples, and studying the atmosphere, our rover contributes valuable data to our understanding of Mars and its potential for life.

While our project marks the culmination of months or even years of hard work, it also serves as a starting point for future exploration. As we continue to push the boundaries of space exploration, our rover paves the way for new discoveries and insights into the mysteries of Mars.

We extend our gratitude to all those who have supported and contributed to this project, including team members, advisors, mentors, and collaborators. Together, we have demonstrated the power of teamwork, innovation, and determination in advancing our knowledge of the cosmos.

As we look towards the future, we remain committed to furthering our exploration of Mars and beyond, unlocking the secrets of the universe and inspiring future generations to reach for the stars.

CHAPTER-7: FUTURE SCOPE

In the future, our Mars Rover Project could be expanded to include:

Enhancing rover capabilities for more advanced scientific analysis.

Integrating new technologies for improved mobility and navigation on Mars.

Collaborating with international space agencies for joint missions and data sharing.

Exploring new regions of Mars to uncover additional insights about the planet's history and potential for life.

Engaging in outreach activities to inspire and educate the next generation of scientists and engineers about space exploration.

By pursuing these avenues, our project can continue to contribute to humanity's quest to understand and explore the Red Planet.