ANALOG ELECTRONICS-I (EC207)

PROJECT FILE

H-BRIDGE MOTOR DRIVER

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

Submitted To:

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CANDIDATE'S DECLARATION

I, PRAKHAR AGRAWAL (23/EC/153) student of B. Tech. (Electronics and Communication Engineering), hereby declare that the project Dissertation titled "H-Bridge Motor Driver" which is submitted by us to the Department of Electronics and Communication Engineering - Delhi Technological University, Delhi in partial fulfillment of the requirement for the award of the degree of Bachelor of Technology, is original and not copied from any source without proper citation. This work has not previously formed the basis for the award of any Degree, Diploma Associateship, Fellowship or other similar title or recognition.

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CANDIDATE'S DECLARATION

I, PIYUSH ATRAS (23/EC/150) student of B. Tech. (Electronics and Communication Engineering), hereby declare that the project Dissertation titled "H-Bridge Motor Driver" which is submitted by us to the Department of Electronics and Communication Engineering - Delhi Technological University, Delhi in partial fulfillment of the requirement for the award of the degree of Bachelor of Technology, is original and not copied from any source without proper citation. This work has not previously formed the basis for the award of any Degree, Diploma Associateship, Fellowship or other similar title or recognition.

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CERTIFICATE

I hereby certify that the Project Dissertation titled “H- BRIDGE MOTOR DRIVER USING BJT” which is submitted by PIUSH ATRAS (23/EC/150), PRAKHAR AGRAWAL (23/EC/153) student(s) of B.Tech. (Electronics And Communication Engineering), Delhi Technological University, Delhi in partial fulfillment of the requirement for the award of the degree of Master of Technology/Bachelor of Technology, is a record of the project work carried out by the students under my supervision. To the best of my knowledge this work has not been submitted in part or full for any Degree or Diploma to this University or elsewhere

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(Supervisor)

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ABSTRACT

An H-bridge is a common circuit configuration that allows bidirectional control of a DC motor. It consists of four transistors (typically BJTs or MOSFETs) arranged in a bridge-like structure. By switching these transistors on and off, we can control the direction and speed of the motor. Reference circuit is given below:

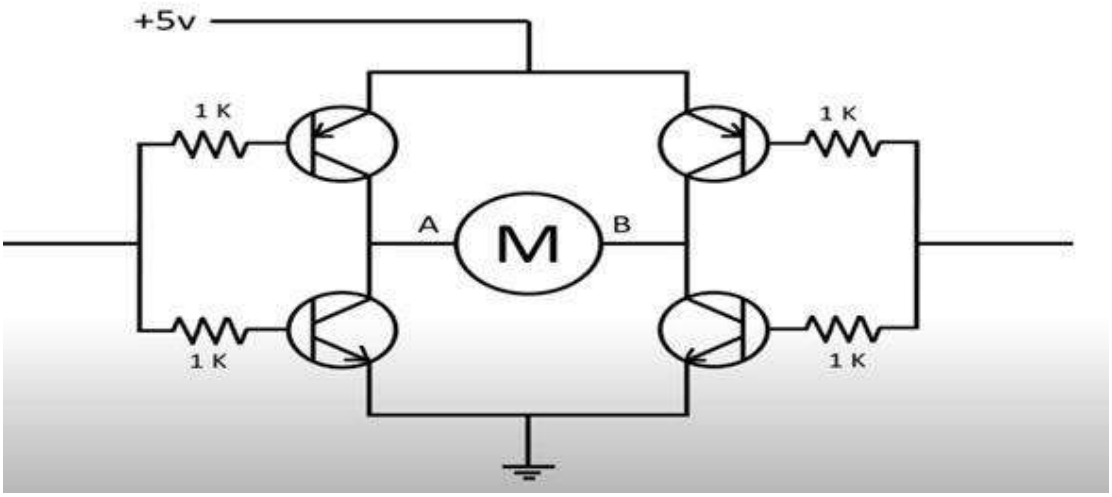


Fig.1. H-Bridge Motor Driver Using BJT

Methodology

- Circuit Design: Designing the H-bridge circuit on a breadboard with the transistors, diodes, and resistors according to the circuit diagram. Connecting the motor terminals to the appropriate nodes of the H-bridge.
- Power Supply: Custom 4 V DC power Supply will be used.
- Testing and Calibration: Carefully testing the circuit to ensure it works correctly. Implementing safety measures to protect the circuit and the motor from damage.

Key Components:

- **Transistors (BJTs)**
- **Resistors**: Used to limit the base current of the transistors.
- **Power Supply**: A DC power supply to provide the necessary voltage for the motor.

Fig.2. 4V Lead Acid Rechargeable Battery

Expected Result:

1. To be able to control the direction of motor by the designed circuit.
2. To learn how transistors, diodes etc. are used in day-to-day practical applications.

PART 1: INTRODUCTORY CHAPTER

1. Introduction

- **Overview of H-Bridge Circuits**:
  The H-Bridge is a circuit configuration used to control the direction of a DC motor. It consists of four switches (transistors in this project) that can control the flow of current through the motor. By toggling these switches, the circuit can reverse the polarity of the motor voltage, allowing bidirectional motor control.
- **Importance of Motor Drivers in Practical Applications**:
  Motor drivers are essential in robotics, industrial machinery, and everyday appliances. They enable precise control of motor speed and direction, making them crucial for automation and electromechanical systems.
- **Objective of the Project**:
  This project aims to design, build, and test an H-Bridge motor driver using BJTs. The focus is on understanding component behavior and developing practical skills in analog electronics.

2. Background

- **Basics of BJTs and Motor Control**:
  Bipolar Junction Transistors (BJTs) act as switches in the H-Bridge circuit. Their ability to rapidly switch between on and off states is utilized to control motor operation. Diodes protect the BJTs from back EMF generated by the motor.
- **Review of Existing Motor Driver Designs**:
  While MOSFETs are commonly used in motor drivers due to lower power loss, BJTs are chosen for their cost-effectiveness and suitability for low-power applications.

- **Justification for Using BJTs**:
  BJTs are ideal for this educational project as they provide a hands-on understanding of transistor switching characteristics and their practical applications in circuit design.

3. Scope and Objective

- **Project Goals**:
  1. To design and implement a functional H-Bridge motor driver.
  2. To enable bidirectional motor control with reliability and safety.
- **Expected Outcomes**:
  1. A working prototype that demonstrates motor direction control.
  2. Enhanced understanding of transistor and diode applications in practical circuits.

Part 2: Chapters Developing Main Theme

1. Circuit Design

- **Explanation of H-Bridge Configuration:**

  The circuit consists of four BJTs arranged in an H-like shape. Switching diagonally opposite transistors allows current to flow in different directions through the motor.

- **Circuit diagram:**

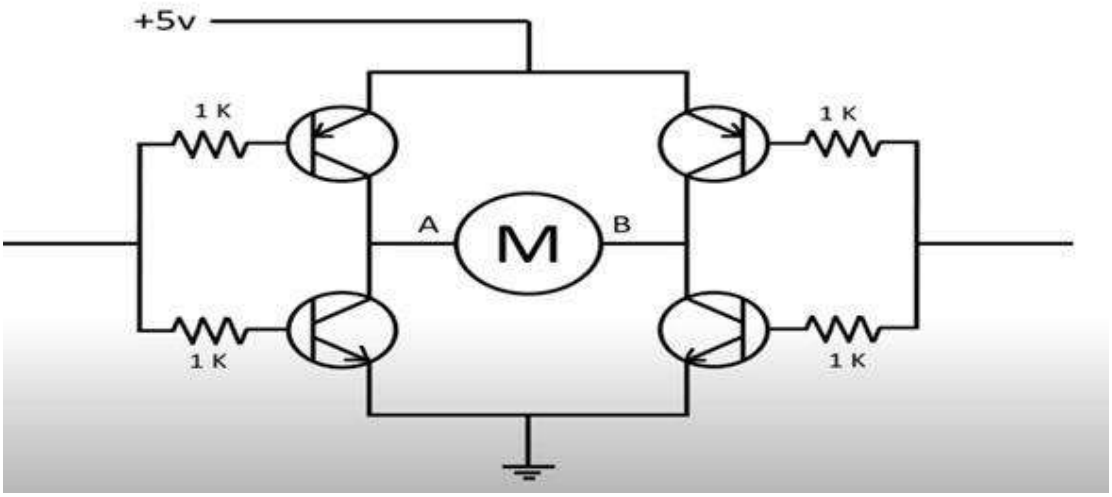


Fig.3: Circuit Diagram

1. Transistor Pairs (Q1, Q2, Q3, Q4):

- The circuit uses four transistors arranged in an H-Bridge configuration:
  - Q1 and Q3 (BD139): These are NPN transistors connected on the UPPER side of the bridge.
  - Q2 and Q4 (BD140): These are PNP transistors connected on the LOWER side of the bridge.
- Their arrangement allows current to flow through the motor in either direction, enabling bidirectional control.

2. Resistor Connections (R1, R2, R3, R4):

- R1 and R2 (1 kΩ):
  - These resistors are connected to the base terminals of Q3 and Q4 respectively.
  - They limit the base current to prevent damage to the transistors during switching.
- R3 and R4 (1 kΩ):
  - These resistors are connected to the base terminals of Q1 and Q2 respectively.
  - Their purpose is to control the base current for these transistors and ensure proper switching.

3.Power Supply (Top Node):

- A regulated +4V DC power supply is connected to the upper terminals of the H-Bridge.
- This supplies the required voltage for the motor and the switching circuit.

4. Motor Connection:

- The motor is connected between the collector terminals of Q1 and Q2.
- Current flow through the motor is determined by the combination of active transistors:

When Q1 and Q4 are active, the current flows in one direction.

- When Q2 and Q3 are active, the current flows in the opposite direction.

5.Switching Logic:

- To operate the motor in different directions:
  1. Activate Q1 and Q4: The current flows from Q1 through the motor and exits via Q4. The motor rotates in one direction.
  2. Activate Q2 and Q3: The current flows from Q3 through the motor and exits via Q2. The motor rotates in the opposite direction.

2. Component analysis

• Detailed component selection

1. Choice of BJTs Over MOSFETs

For this H-Bridge circuit, **BJTs (Bipolar Junction Transistors)** were chosen over **MOSFETs** for the following reasons:

- **Ease of Driving:**
  - BJTs require a base current to switch, whereas MOSFETs need a specific gate voltage.
  - In low-power applications, BJTs can be driven directly by microcontrollers or switches without additional driver circuitry.
- **Cost and Availability:**
  - BJTs such as BD140 and BD139 are inexpensive and widely available compared to MOSFETs, making them suitable for small-scale projects.
- **Low Power Requirement:**
  - The circuit is designed for small DC motors (low current and voltage), which are well within the capabilities of BJTs like BD140 (rated for 100mA) and BD139.
- **Voltage and Current Ratings:**
  - **BD139 (NPN) and BC140 (PNP)**:
    - Maximum Collector Current (Ic): 100mA
    - Maximum Collector-Emitter Voltage (Vce): 45V
    - These ratings are sufficient for the motor used in this circuit, which operates at 5V and draws less than 100mA.
  - MOSFETs are typically preferred for high-power applications due to their efficiency at high currents, but for this low-power setup, BJTs are a more practical choice.

- **Role of Each Component**

1. Transistors (BD140 and BC139)

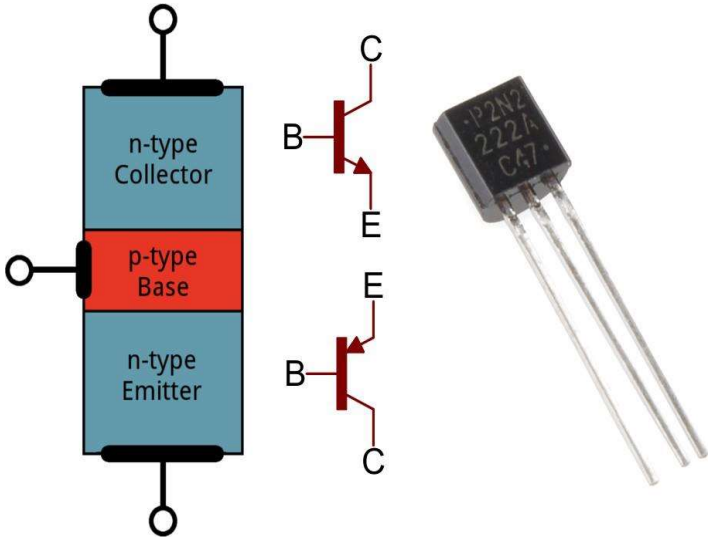


Fig.4: Bipolar Junction Transistor

- **Function:**
  - Act as electronic switches to control the flow of current through the motor.
  - In the H-Bridge configuration, transistors operate in complementary pairs:
    - **Q1 and Q4**: Direct current in one direction (clockwise motor rotation).
    - **Q2 and Q3**: Direct current in the opposite direction (counterclockwise motor rotation).
- **Why BJTs?**
  - They are chosen for their simplicity in driving circuits, especially in low-power setups.
  - They enable efficient switching by toggling their base current.
- **Specifications for Use:**
  - The **BD139 (NPN)** and **BD140 (PNP)** are general-purpose transistors.
  - Their current rating of 100mA is sufficient for the motor's load.

- They switch on when the base-emitter voltage exceeds 0.7V, making them easy to control with simple input signals.

2. Resistors

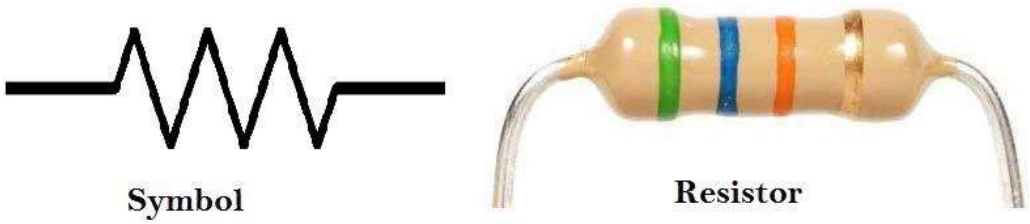


Fig.5: Resistor

- **Function:**
  - Limit the base current to transistors, ensuring proper switching without damage.
  - Resistors also prevent excess current draw from the control inputs (switches or microcontroller).
- **Placement:**
  - **1kΩ resistors** (R1, R2, R3 and R4) are connected to the base of the transistor to limit their base current.

3. Motor

Fig.6: DC MOTOR

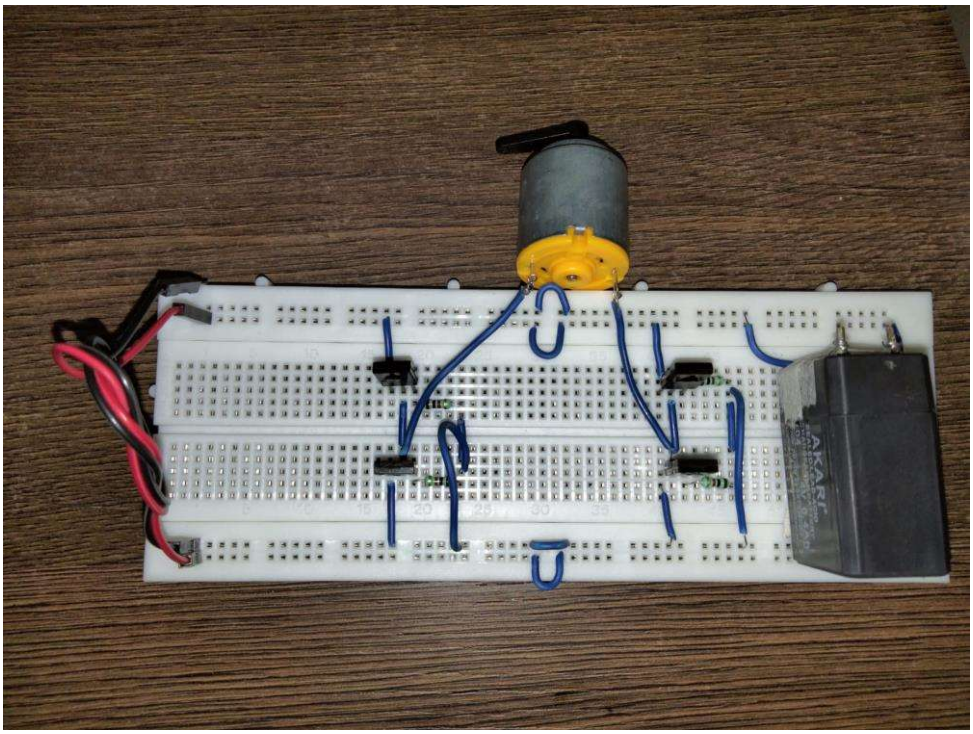
- **Function:**
  - The motor is the load being controlled by the H-Bridge circuit.
  - It converts electrical energy into mechanical energy, driving a mechanical system.
- **Role in the Circuit:**
  - The H-Bridge allows the motor to operate in both forward and reverse directions, controlled by the transistors.
  - Current through the motor determines its direction, and the magnitude of the current affects its speed.
- **Specifications:**
  - A low-power DC motor operating at 4V is suitable for this circuit.
  - The motor's current draw should not exceed the maximum current rating of the transistors (100mA in this case).

Part 3: Results, Discussion, and Conclusion

TESTING AND RESULT

The circuit was thoroughly tested to ensure proper functionality. The circuit was assembled on a breadboard following the provided circuit diagram. A multimeter was used to measure voltages at key points and to check for any potential short circuits.

The motor could reliably switch between forward and reverse directions based on the input signals provided to the BJTs.



DISCUSSION

Evaluation Against Objectives

The project successfully achieves its stated objectives, as outlined below:

1. **Control of Motor Direction**:
   The primary goal was to construct an H-bridge motor driver that enables bidirectional control of a DC motor. The circuit achieves this through the strategic use of BJTs, which act as switches, and the configuration of these transistors in the H-bridge topology. By carefully toggling the transistors, the circuit allows the motor to run forward or in reverse, demonstrating a clear understanding of the switching behavior of BJTs.
2. **Educational Value**:
   This project serves as an excellent learning experience for understanding basic electronic components and their roles in practical applications:
   - **Transistors**: Gained insights into their switching properties and application in motor control.
   - **Resistors**: Understood their role in limiting current and safeguarding sensitive circuit elements.
   - **Circuit Design**: Provided hands-on exposure to designing, testing, and troubleshooting circuits, fostering critical thinking and problem-solving skills.
3. **Cost-Effectiveness**:
   The project employs readily available and low-cost components like BJTs, resistors. This ensures affordability without compromising functionality.
4. **Relevance to Real-World Applications**:
   The H-bridge motor driver is a foundational circuit in robotics and automation, making this project a stepping stone for advanced motor control techniques.

Practical Insights

1. **Behavior of Transistors in Switching Applications**:
   The project provided a deeper understanding of how transistor operate as switches.

Scope for Improvement

1. **Replacing BJTs with MOSFETs**:
   While BJTs are effective, MOSFETs could enhance the circuit's efficiency by offering lower power losses and faster switching speeds. Their high input impedance reduces the base drive requirement, making the circuit more energy-efficient and compact.
2. **Integration of a PWM Controller**:
   Adding a Pulse Width Modulation (PWM) controller would enable precise speed regulation of the motor. This would expand the circuit's capabilities, making it suitable for more complex applications such as robotics or variable-speed drives.
3. **Improved Heat Management**:
   BJTs can generate significant heat during operation, especially under high current conditions. Incorporating heat sinks or switching to more efficient components like MOSFETs can address this limitation.

CONCLUSION

- In this project, we successfully designed and implemented an H-Bridge motor driver using transistors, demonstrating a practical and efficient method for controlling DC motors. The H-Bridge configuration allows for precise bidirectional control of motor direction and speed, which is essential in numerous applications such as robotics, electric vehicles, and industrial automation. The circuit involves the use of BD139 and BD140 transistors coupled with simple components such as resistors and a power supply that makes it suitable for controlling motors with minimal complexity.

- This project demonstrates the basic principles of transistor switching, circuit design, and motor control using the versatile H-Bridge in a real-world application. With the ability to drive motors in both directions, this circuit can be easily adapted for various use cases, making it an important building block in modern electronic and robotic systems.

APPENDICES

Appendix A: Key Circuit Components

- Transistors (BJTs): Act as switches to control motor direction.
- Diodes: Protect the circuit from voltage spikes caused by the motor's inductive load.
- Resistors: Limit base current and ensure stable transistor operation.
- Power Supply: 4V DC power supply for powering the motor and circuit components.

Appendix B: Circuit Diagram

(Refer to the main report or project documentation for the detailed schematic of the H-bridge motor driver using BJTs.)

Appendix C: Testing and Calibration Procedures

1. Connection Check: Verify connections against the circuit diagram.
2. Continuity Testing: Ensure there are no shorts or open connections.
3. Power On: Apply the 4V DC supply and monitor the circuit behavior.
4. Switching Test: Toggle the transistor inputs and observe the motor's directional changes.

Appendix D: Observations

- Motor successfully switches direction as intended.
- BJTs exhibit expected behavior, though heat management is necessary during prolonged use.

Appendix E: Suggested Improvements

1. Use MOSFETs for greater efficiency and reduced power loss.
2. Add a PWM controller for motor speed regulation.
3. Enhance thermal management with heat sinks or active cooling.