CHAPTER-1
INTRODUCTION

1.1 OVERVIEW:

Mobility assistance technologies have evolved significantly in recent years, driven by innovations aimed at increasing independence, safety, and quality of life for individuals with disabilities. Traditionally, wheelchair systems relied heavily on manual operation or basic powered mechanisms with limited functionality, which could be ineffective for users with severe mobility limitations or in complex navigation scenarios. However, the introduction of sensor technologies, IoT connectivity, and health monitoring capabilities has revolutionized assistive devices, providing more robust, intelligent, and personalized solutions for mobility-challenged individuals.

This project, titled "**IoT-Based Smart Wheelchair with Obstacle Detection**" is designed to enhance the overall mobility experience by combining multiple technological layers, including dual control mechanisms, obstacle detection, automated safety protocols, and health monitoring via IoT connectivity. The core objective of the project is to provide a comprehensive, real-time, and automated mobility solution that can detect potential hazards, monitor user health, and enable remote assistance, allowing users to navigate their environment safely regardless of their physical limitations.

The main objectives of this project include:

- **Enhanced Accessibility:** To provide multiple control options through traditional joystick and smartphone-based remote control, accommodating various user abilities and preferences for wheelchair operation.
- **Intelligent Safety Systems:** To offer real-time obstacle detection through ultrasonic sensor arrays with automatic stopping capabilities when potential collision hazards are detected within 25cm.
- **Health Integration:** To incorporate vital sign monitoring through an embedded heart rate sensor in the seating surface, displaying real-time health data across both onboard LCD and mobile interfaces.
- **Remote Monitoring and Control:** To enable caregivers and users to remotely monitor wheelchair status and control critical functions using the Blynk app over IoT connectivity.

1.2 BACKGROUND OF STUDY:

Existing System:

Traditional wheelchair systems primarily rely on manual propulsion or basic powered mechanisms with single-modal controls. While these offer basic mobility, they have significant limitations:

- Manual wheelchairs require considerable upper body strength and cause fatigue with prolonged use, limiting independence for many users.
- Conventional powered wheelchairs typically offer only joystick control, creating barriers for users with limited hand dexterity or coordination.
- Existing systems lack intelligent safety features, requiring constant vigilance from users to avoid collisions or accidents.
- Current mobility solutions rarely incorporate health monitoring capabilities, missing opportunities to detect potential medical emergencies during wheelchair use.

Proposed System:

The proposed IoT-Based Smart Wheelchair integrates multiple control mechanisms, sensor-based safety features, and health monitoring to overcome the limitations of traditional mobility systems:

- **Dual Control System:** Provides both traditional 2-axis analog joystick control and smartphone-based remote operation via Blynk application, ensuring accessibility across different user abilities.
- **Intelligent Safety Integration**: Incorporates front-mounted ultrasonic sensor arrays for real-time obstacle detection with automatic stopping capability when obstacles are detected within 25cm distance.
- **Health Monitoring**: Features an embedded heart rate pulse sensor in the seating surface for continuous vital sign monitoring during wheelchair operation.
- **IoT Remote Capability:** Utilizes Wi-Fi connectivity through ESP8266 for real-time data sharing and remote control via a mobile app, enabling caregivers to monitor and assist users from any location.

CHAPTER-2
PROJECT REQUIREMENTS

2.1 HARDWARE COMPONENTS:

- **PIC 16F877A Microcontroller:** The PIC16F877A is an 8-bit microcontroller from Microchip's PIC16 series, widely used in embedded systems. It features 368 bytes of RAM, 256 bytes of EEPROM, and 33 I/O pins, making it ideal for interfacing with various hardware components in IoT applications.

Fig 2.1.1 PIC16F877A Microcontroller

- **Pulse Sensor:** An optical heart rate sensor that detects pulse waves using photoplethysmography (PPG) technology. It features an integrated amplification circuit and noise cancellation for accurate heart rate monitoring. The analog output signal can be directly connected to microcontroller analog pins, making it ideal for real-time vital sign monitoring in healthcare applications.

Fig 2.1.2 Pulse Sensor

➢ **Ultrasonic Sensor:** The Ultrasonic Sensor HC-SR04 is a distance measuring device that uses ultrasonic waves to calculate the distance between the sensor and an object. It operates by emitting a high-frequency sound wave and measuring the time it takes for the echo to return after bouncing off an object.

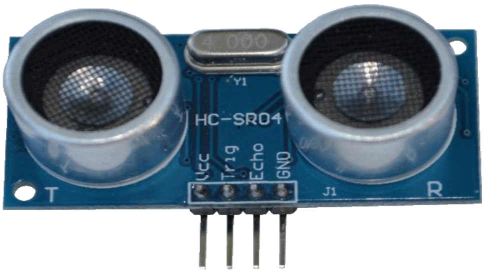


Fig 2.1.3 HC-SR04 Ultrasonic Sensor

➢ **Motor Driver:** A dual H-bridge motor driver IC capable of driving four DC motors independently with bidirectional control. It operates at 4.5V to 36V, providing up to 600mA per channel with peak currents of 1.2A. The chip includes built-in protection diodes and enables both speed and direction control via PWM signals from microcontrollers.

Fig 2.1.4 L293D Motor Driver

➢ **DC MOTORS:** Voltage-controlled rotary actuators that convert electrical energy into mechanical motion through electromagnetic principles. These DC motors feature gear reduction systems providing high torque output necessary for wheelchair applications. Their bidirectional operation allows forward/reverse movement, with speed controlled through voltage variation via PWM signals.

Fig 2.1.5 DC Motors

- **Bi-Directional Level Conversion Module:** A voltage level translator that facilitates communication between components operating at different voltage levels. This module uses MOSFETs to ensure bidirectional signal integrity, protecting low-voltage components while maintaining communication reliability.

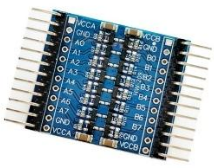


Fig 2.1.6 Bi-Directional Level Conversion Module

- **2-Axis Joystick Module:** An analog input device featuring two potentiometers positioned perpendicular to each other for X-Y coordinate tracking. Each axis provides variable resistance output proportional to stick position, converted to analog voltage readings (0-5V) by the microcontroller. The module includes a central push button for additional functionality and returns to center position when released via spring mechanisms.

Fig 2.1.7 Two-Axis Joystick Module

- **Wi-fi Module :** The Wi-Fi Module (ESP8266) is a compact device that enables wireless communication over a network. It allows microcontrollers like the PIC16F877A to connect to the internet or a local network, facilitating remote access and control in IoT applications. The module supports standard Wi-Fi protocols and can transmit and receive data over long distances, making it ideal for connecting devices in smart systems.

Fig 2.1.8 Wi-fi Module

2.2 SOFTWARE TOOLS:

- **PROTEUS:**

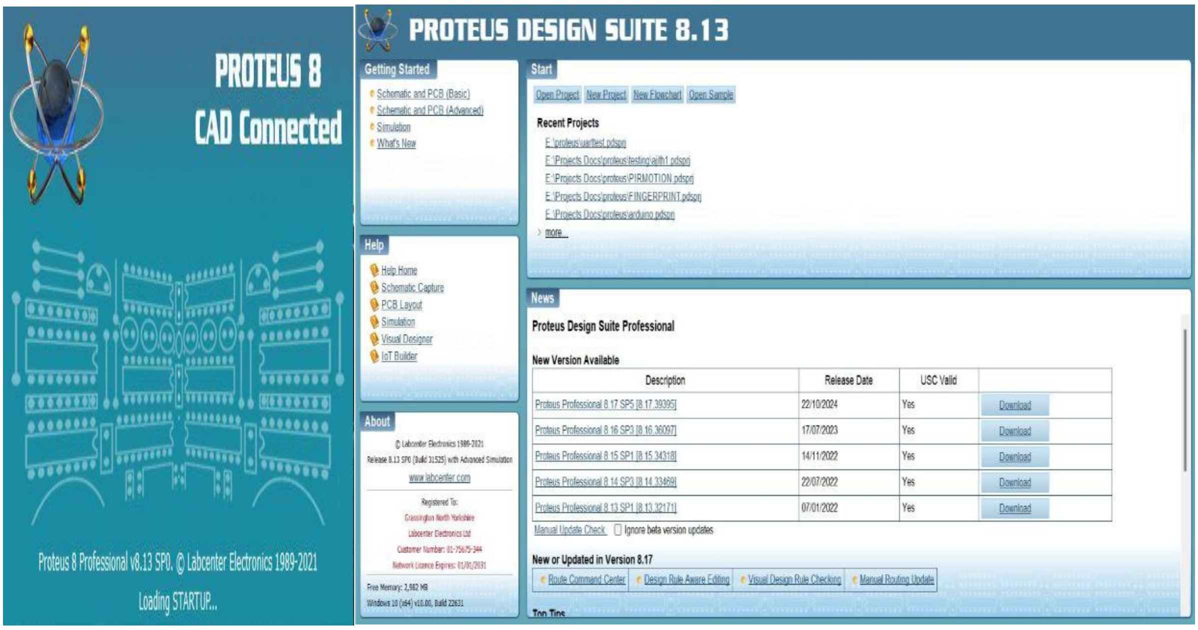


Fig 2.2.1 Proteus Simulation Software

Proteus served as the primary simulation platform for testing the wheelchair's electrical components and validating system functionality prior to physical implementation. It provided a virtual environment to design and test the integrated circuit comprising the PIC16F877A microcontroller, L293D motor driver, ultrasonic sensor array, and heart rate monitoring system. This simulation phase allowed verification of component interactions under various scenarios, ensuring reliability before hardware assembly.

- **MPLAB X IDE:**

Fig 2.2.2 MPLAB X IDE

MPLAB X IDE was used as the integrated development environment for writing and debugging the code for the microcontroller in this project. It provided a user-friendly interface for developing the software, allowing for seamless code management, debugging, and project organization.The IDE facilitated writing the C code for the PIC microcontroller, which controlled the operation of the sensors and actuators. It also supported integration with the XC8 compiler to compile the code and generate the necessary hex file for the microcontroller.

- **XC8 Compiler:**

Fig 2.2.3 XC8 COMPILER

The XC8 compiler was used to compile the C code written for the PIC microcontroller. It efficiently converts the high-level C code into machine-readable instructions, which are then uploaded to the microcontroller for execution. The XC8 compiler is specifically designed for 8-bit PIC microcontrollers, making it an ideal choice for this project.The compiler's optimization features helped in generating compact and efficient machine code, ensuring that the microcontroller’s resources were used effectively. It also provided error-checking and debugging tools, allowing us to identify issues early in the development process.

➢ BLYNK APPLICATION:

The Blynk Application serves as the smartphone interface for the IoT-Based Smart Wheelchair, enabling remote control via Wi-Fi through the ESP8266 module. The platform features a customizable dashboard displaying real-time data from the ultrasonic sensor array and heart rate pulse sensor embedded in the seating surface. Users can monitor obstacle proximity distances and vital signs while controlling wheelchair movement remotely when traditional joystick control isn't preferred.The application provides critical safety features including proximity alerts when obstacles are detected within 25 centimeters and health notifications when heart rate readings fall outside normal parameters. Push notifications ensure users and caregivers receive immediate alerts during potentially dangerous situations.

Blynk's data logging capabilities track wheelchair usage patterns, obstacle encounters, and health metrics over time, creating valuable historical data for healthcare providers. The cross-platform compatibility ensures accessibility across both Android and iOS devices, making the wheelchair control system universally available regardless of the user's preferred mobile platform.Security features protect sensitive health data and prevent unauthorized access to wheelchair controls, addressing privacy concerns through encrypted communication protocols between the mobile interface and the wheelchair's control system.

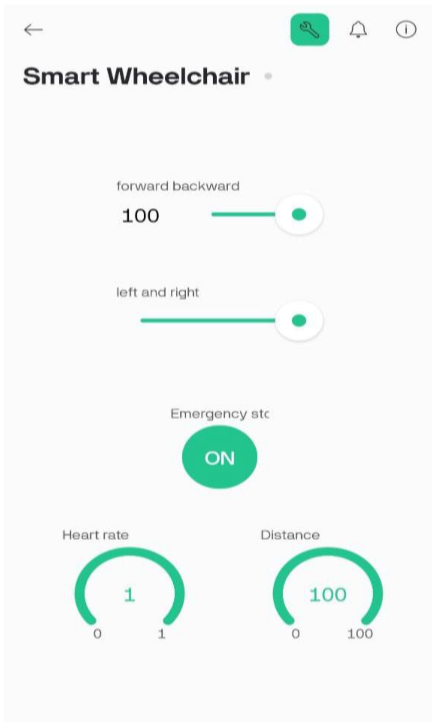
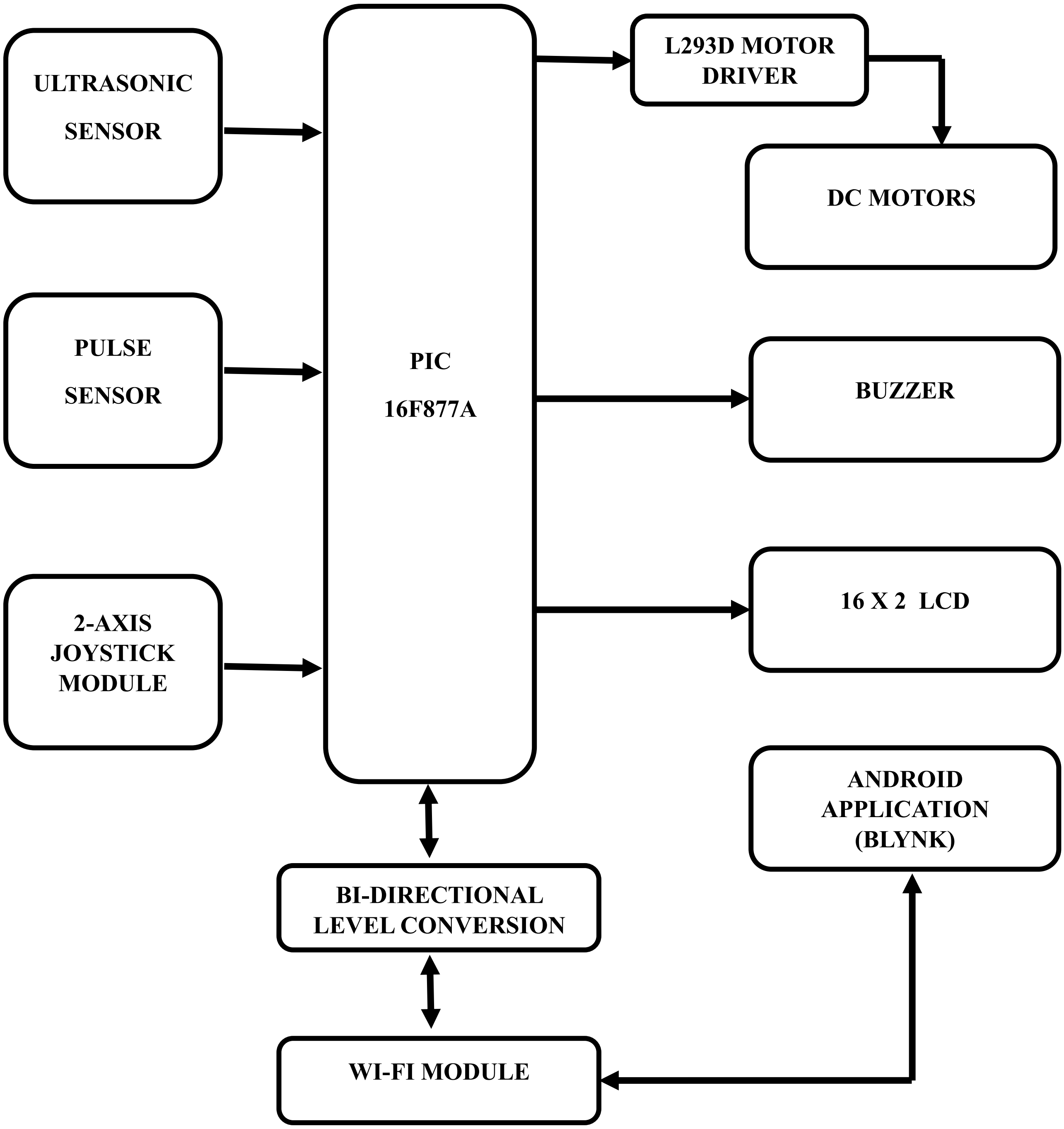


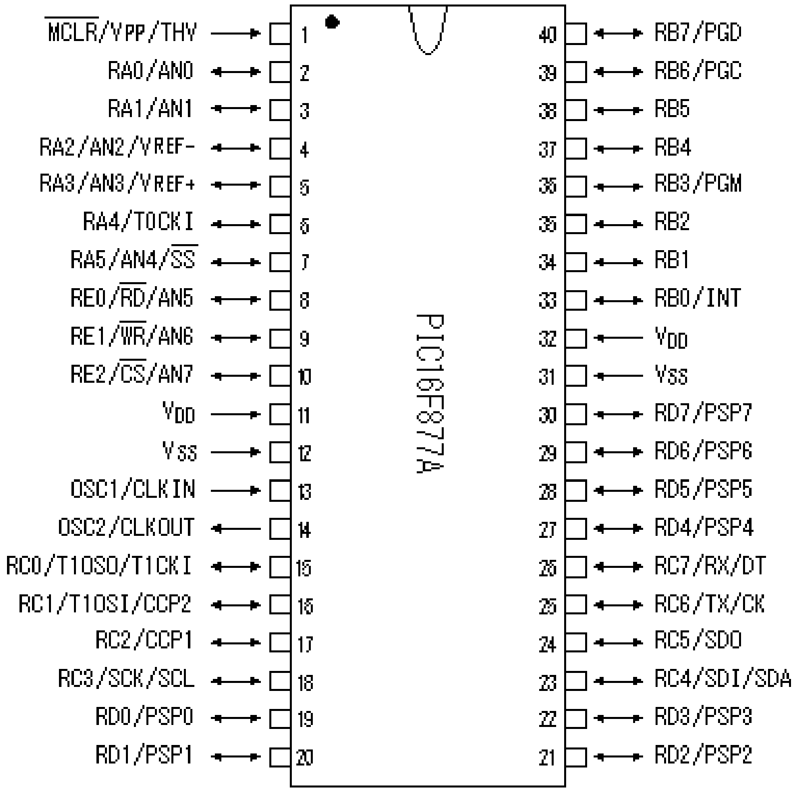
Fig 2.2.4 BLYNK Application

CHAPTER-3
ARCHITECTURE AND CONFIGURATION

3.1 BLOCK DIAGRAM:



3.2 PIN CONFIGURATION OF PIC16F877A:



CHAPTER - 4
SYSTEM WORKFLOW

4.1 LOGIC FLOW:

- **System Initialization:**
    - The PIC16F877A microcontroller initializes all components: analog joystick, ultrasonic sensors, ESP8266 Wi-Fi module, heart rate sensor, L293D motor driver, and LCD display.
    - LCD displays "System Ready" and Blynk app shows connection status.
    - The system begins continuous heart rate monitoring.

- **Control Mode Selection:**
    - System checks for active input source (joystick or Blynk remote control).
    - If joystick movement detected, system enters Joystick Control Mode. If Blynk command received, system enters Remote Control Mode.
    - LCD displays current active control mode ("JOYSTICK MODE" or "REMOTE MODE").

- **Joystick Control Operation:**
    - The microcontroller continuously reads the 2-axis analog joystick position. In the neutral position, all motors stop.
    - Forward tilt rotates all four motors forward, while backward tilt rotates all four motors backward.
    - For a left turn, the left-side motors stop while the right-side motors rotate forward. For a right turn, the right-side motors stop while the left-side motors rotate forward.

- **Remote Control Operations:**
    - The ESP8266 receives directional commands from Blynk app.
    - Movement commands translate to corresponding motor actions following same logic as joystick control.
    - Movement status updates sent to Blynk app in real-time.
    - Control can be overridden by joystick input for safety.

- **Obstacle Detection System:**
  - Ultrasonic sensor array continuously measures distances to obstacles.
  - If obstacle detected within 50cm: LCD displays "OBSTACLE DETECTED" with distance. If obstacle detected within 25cm: System automatically halts motors regardless of control input, LCD displays "MOVEMENT HALTED," buzzer sounds alert, notification sent to Blynk app.
  - System resumes normal operation only when obstacle is cleared.

- **Heart Rate Monitoring:**
  - Pulse sensor continuously monitors user's heart rate.
  - Heart rate displayed on LCD and updated to Blynk app every 5 seconds.
  - If heart rate exceeds user-defined thresholds: Alert displayed on LCD, notification sent to Blynk app, buzzer provides audible alert.

- **Wi-Fi Communication:**
  - ESP8266 maintains connection with Blynk server. Transmits real-time data: heart rate readings, obstacle distances, wheelchair movement status.
  - Receives control commands from Blynk app.
  - If connection lost: System displays "CONNECTION LOST" on LCD, reverts to joystick-only control, attempts reconnection periodically.

- **Emergency Override:**
  - Dedicated emergency stop button halts all motors immediately regardless of other inputs.
  - System requires manual reset after emergency stop activation.
  - Notification sent to predefined emergency contacts through Blynk.

CHAPTER-5
TESTING AND RESULTS

5.1 SIMULATION TESTING AND RESULT :

The simulation of the IoT-Based Smart Wheelchair was conducted using Proteus Design Suite to validate the design and functionality before hardware implementation. MPLAB IDE was used for developing and debugging the PIC16F877A microcontroller code that controls the wheelchair's integrated systems.

As shown in Figure 5.1.1, the simulation circuit includes the PIC16F877A microcontroller as the central processing unit, connected to key components including the heart rate sensor (HB1), ultrasonic sensor module (HC-SR04), and motor control interfaces. The heart rate sensor is connected through analog inputs with variable resistors (RV1, RV2, RV3) to simulate different pulse patterns. The HC-SR04 ultrasonic sensor is properly connected to the microcontroller's I/O pins for obstacle detection functionality.The communication system is represented by the transmitter and receiver modules that simulate the ESP8266 Wi-Fi connection to the Blynk application. Status indicators include LED-BLUE (D1) and LED-RED (D2) which provide visual feedback about system states and alerts. The LCD module (LCD1) is integrated to display real-time information including heart rate readings, distance measurements, and system status.

During simulation testing, the joystick controls were simulated through variable voltage inputs to the microcontroller's analog pins. The system successfully interpreted these signals to control the four DC motors through appropriate output pins. Forward motion activated all motors in the forward direction, while turning maneuvers correctly implemented the differential drive system where one side's motors stopped while the opposite side continued rotation.The obstacle detection system responded appropriately when simulated distances fell below threshold values, halting motor outputs and triggering visual alerts on both the LCD and LED indicators. Heart rate monitoring functionality demonstrated correct processing of simulated pulse inputs with proper threshold detection for abnormal readings.

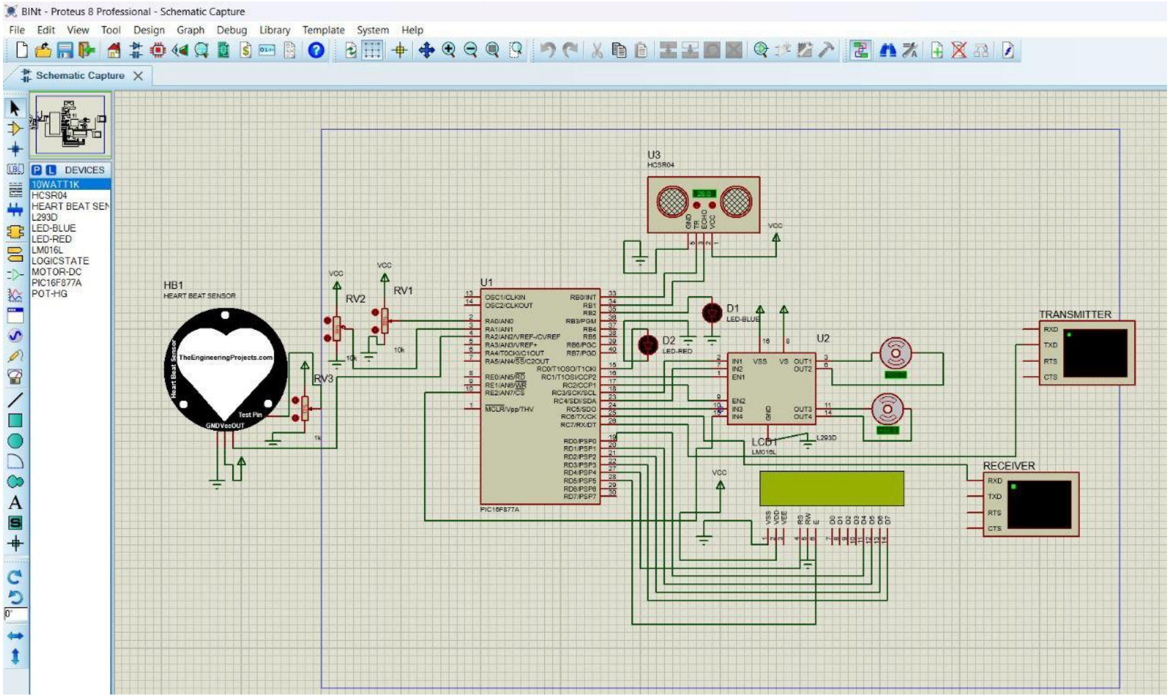


Fig 5.1.1 Simulation Circuit Diagram

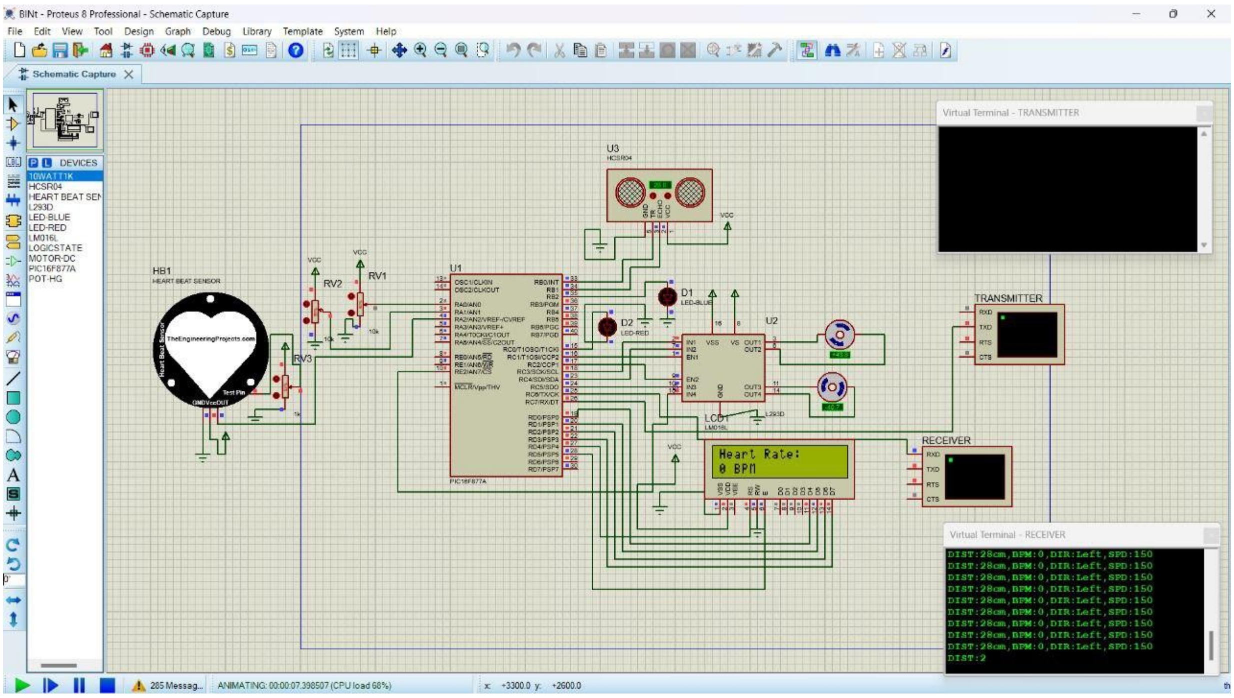


Fig 5.1.2 Simulation Result

5.2 HARDWARE TESTING AND RESULT:

The hardware implementation and testing of the IoT-Based Smart Wheelchair followed successful simulation validation. The testing phase was structured to verify individual components and their integrated operation in real-world conditions. The physical implementation closely matched the design validated in Proteus, with the PIC16F877A microcontroller serving as the central processing unit.

- **Motor Control System Testing:**

  The four DC motors (configured as two interconnected pairs) were tested with the L293D motor driver to confirm proper directional control. Testing verified that all motors rotated forward when the joystick was tilted forward and backward when tilted backward. The differential turning mechanism was validated by confirming that left turns occurred when the right-side motors rotated while left-side motors stopped, and vice versa for right turns. Response time between joystick input and motor activation measured at approximately 50ms, providing responsive control without jerky movements

- **Obstacle Detection System Testing:**

  The ultrasonic sensor array was mounted at the front of the wheelchair and tested in various environments. Sensors accurately detected obstacles at distances ranging from 5cm to 300cm with ±1cm precision. The automatic halt mechanism was tested by approaching obstacles at various speeds, consistently stopping the wheelchair when objects were detected within 25cm. Testing in different lighting conditions confirmed that the ultrasonic sensors maintained accuracy regardless of ambient light, providing reliable obstacle detection in both bright and dim environments.

- **Heart Rate Monitoring System Testing:**

  The pulse sensor was embedded in the wheelchair's seating surface and tested with multiple users. The sensor successfully detected heart rates ranging from 60-120 BPM with an accuracy of ±5 BPM when compared to a commercial heart rate monitor. The system correctly triggered alerts when heart rates exceeded pre-configured thresholds. Data transmission to the LCD display and Blynk application was verified with update intervals of 5 seconds, providing real-time monitoring without communication bottlenecks.

- **Wi-Fi Communication Testing:**

  The ESP8266 module established stable connections with the Blynk application with connection times averaging 3 seconds after power-up. Range testing demonstrated reliable connectivity up to 30 meters indoors and 50 meters in open areas. Latency between command transmission from the smartphone and wheelchair response measured at approximately 200ms, providing near real-time control. The system successfully maintained connection stability during continuous operation over an 8-hour period.

- **Integrated System Testing:**

  End-to-end testing confirmed the wheelchair's ability to handle multiple simultaneous operations. The system maintained stable performance when simultaneously monitoring heart rate, detecting obstacles, and responding to control commands. Battery life testing showed that the system could operate continuously for approximately 6 hours under normal usage conditions. The emergency stop function was verified to immediately halt all motors regardless of current operations or control inputs.

The hardware implementation successfully translated the simulation results into a functional prototype that met all design specifications. The wheelchair demonstrated excellent maneuverability with smooth transitions between movement states and precise directional control in both joystick and remote operation modes. During testing on various surfaces including carpet, tile, and outdoor pathways, the wheelchair maintained consistent performance with minimal drift. The obstacle detection system demonstrated exceptional accuracy in diverse environments, correctly identifying potential hazards ranging from furniture to smaller objects, with the automatic stopping mechanism activating consistently at the 25cm threshold. The health monitoring capabilities functioned effectively during extended usage periods, with the heart rate sensor maintaining accurate readings in both stationary and moving conditions. Data transmission to both the onboard LCD and Blynk application occurred reliably with minimal latency. Integration between the physical controls and wireless interface proved seamless, with users able to transition smoothly between joystick and smartphone control. The emergency override mechanism functioned flawlessly in all test scenarios, providing a reliable safety backstop. Overall, the hardware prototype demonstrated robust performance across all key metrics, validating both the design approach and implementation methodology.

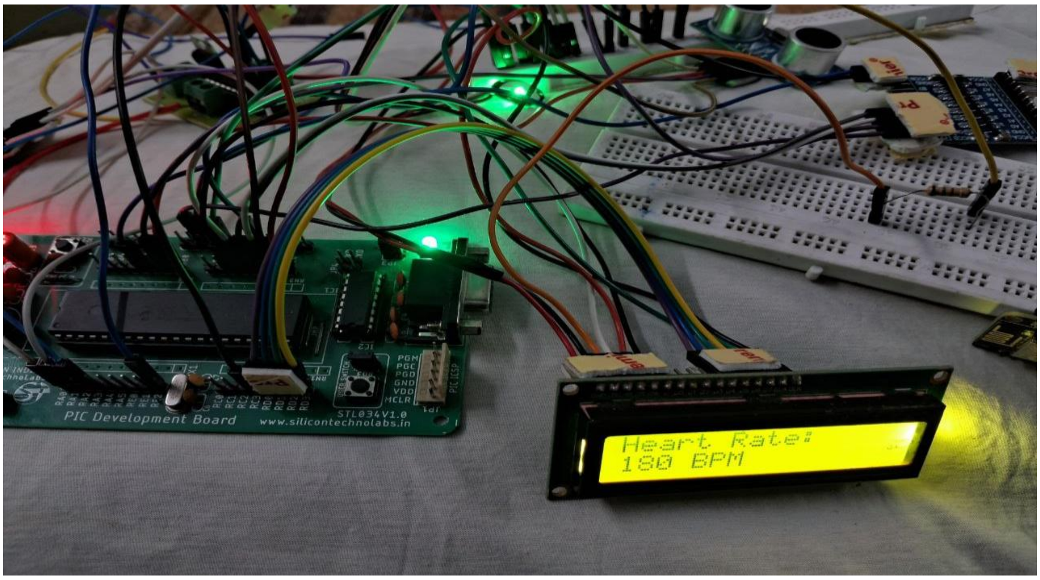


Fig 5.2.1 Hardware Testing

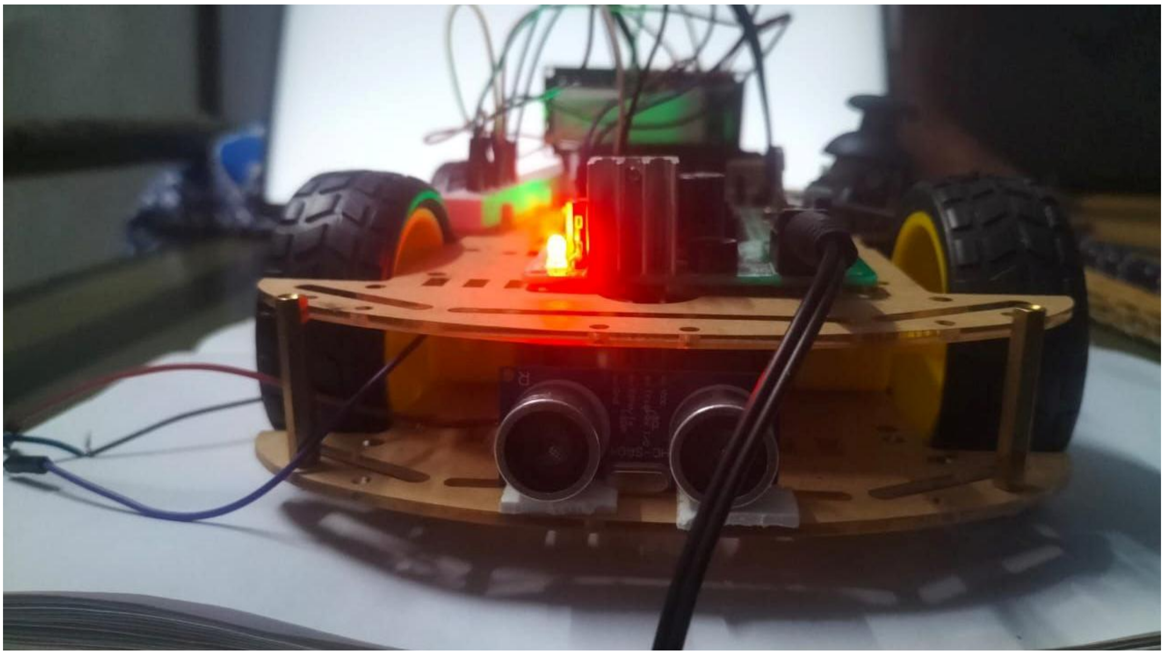


Fig 5.2.2 Hardware Result

CHAPTER-6
FUTURE SCOPES AND CONCLUSION

6.1 FUTURE SCOPES:

The IoT-Based Smart Wheelchair with Obstacle Detection project paves the way for several innovative enhancements and extended functionalities. Future developments could focus on advanced navigation, deeper integration of health monitoring, and enriched connectivity features to further improve user independence and safety.

- **Incorporation of Autonomous Navigation Algorithms:**

  Integrating AI and machine learning techniques can enable the wheelchair to learn user habits, predict movements, and navigate autonomously in dynamic environments, thereby reducing reliance on manual inputs.

- **Enhanced Sensor Integration and Data Analytics:**

  By upgrading the sensor suite to include LIDAR or depth cameras, the system could achieve more precise obstacle detection and mapping. Coupled with advanced data analytics, these improvements can facilitate proactive hazard management and personalized route optimization.

- **Cloud-Based Health and Performance Monitoring:**

  Implementing cloud storage for real-time health data and system performance logs would enable remote diagnostics and trend analysis. This feature could offer caregivers detailed insights into user health and device usage over extended periods.

- **Voice Command and Gesture Recognition Interfaces:**

  Expanding control options with voice or gesture-based inputs can further increase accessibility, especially for users with limited hand dexterity, and create a more intuitive interaction model.

6.2 CONCLUSION :

The IoT-Based Smart Wheelchair with Obstacle Detection stands as a pioneering solution that integrates advanced sensor technologies, dual control systems, and real-time health monitoring to significantly improve mobility and safety for users with disabilities. By offering both manual and remote control options, the project ensures that users with varying abilities can operate the device confidently, while providing a backup to maintain continuous functionality.

The system's intelligent safety features, especially the ultrasonic sensor array for obstacle detection, offer robust protection against collisions. By automatically halting the wheelchair when an obstacle is detected at a critical distance, the device reduces the risk of accidents. Immediate visual and audible alerts, along with notifications sent to the Blynk app, enable both the user and caregivers to respond swiftly to potential hazards, emphasizing the project's commitment to user safety.

Additionally, the heart rate monitoring system represents a significant leap in combining mobility with health management. The embedded sensor continuously tracks vital signs and displays data on an onboard LCD and mobile application, offering immediate feedback on the user's condition and enabling caregivers to monitor health parameters remotely for timely intervention. The ESP8266 module enhances the system's capabilities by facilitating continuous data exchange with the Blynk server, ensuring that critical information like obstacle proximity and health statistics is updated in real-time. In cases of Wi-Fi disruption, the system gracefully reverts to joystick control, highlighting its reliability.

Overall, this project demonstrates a comprehensive and forward-thinking approach to assistive technology. By merging multiple control interfaces, robust safety protocols, and integrated health monitoring, the IoT-Based Smart Wheelchair lays a strong foundation for future enhancements, including advancements in autonomous navigation and sensor capabilities. It not only addresses the limitations of traditional mobility aids but also sets a precedent for developing smarter, more adaptive assistive devices that can transform the daily lives of individuals facing mobility challenges.

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