Innovative Journal for Opportunities and Development in Science & Technology,
Volume 6, Issue 6, June 2026
Paper Id: – IJ2026V6I6 -8 A-D
ISSN 2582-6026

# STRUCTURAL DESIGN, FABRICATION AND PERFORMANCE EVALUATION OF AN ELECTRIC POWERED WHEELCHAIR

[1]Prof. Tarate.V.B, [2]Ajinkya Hirave, [3]Yudhishthir Kharat, [4]Pankaj Gavhane,

[1]Assistant Prof., Department of Electrical Engineering, HSBPVT's GOI Kashti,Ahilyanagar
[2]UG Scholar, Department of Electrical Engineering, HSBPVT's GOI Kashti, Ahilyanagar
[3]UG Scholar, Department of Electrical Engineering, HSBPVT's GOI Kashti, Ahilyanagar
[4]UG Scholar, Department of Electrical Engineering, HSBPVT's GOI Kashti, Ahilyanagar
ajinkyahirve2003@gmail.com

**ABSTRACT-** In this paper, an ESP32 microcontroller is used to develop and build a joystick-controlled electric wheelchair. Through simple joystick-based control, the technology is intended to give elderly or physically impaired people autonomous movement. Two geared DC motors coupled by a sprocket and chain transmission system power the wheelchair, which is constructed with a square tube frame. Each drive motor's speed and direction are managed by two BTS7960 high-current motor driver modules. The main input device is a joystick module, and control commands are also remotely sent via Wi-Fi using the Blynk program. The system is powered by a 12V 40A battery. To move the wheelchair forward, backward, left, and right, the ESP32 uses relay-controlled circuitry to detect joystick inputs and deliver the proper PWM signals to the BTS7960 motor drivers. The suggested system offers a cost-effective, dependable, and remotely controlled mobility solution appropriate for both home and rehabilitation facilities..

***Keywords-*** ESP32, Electric Wheelchair, BTS7960 Motor Driver, Geared Motor, Joystick Control, Blynk App, Relay, Sprocket Chain Drive, 12V Battery, PWM Control, IoT Mobility

## I. INTRODUCTION

Conventional manual wheelchairs require physical effort from the user or an attendant, which is not practical for people with severe limb disabilities. Motorized wheelchairs use electric drive systems that are controlled by the user through various input interfaces. Electric wheelchairs are an essential assistive technology for people with mobility impairments, offering independence and improved quality of life. Low-cost and intelligent electric wheelchairs are now possible because to the quick development of embedded systems and Internet of Things technology. The ESP32 microcontroller is the perfect platform for managing motor-driven systems because of its dual-core CPU, integrated Wi-Fi and Bluetooth, and extensive GPIO and PWM features. Strong geared DC motors in wheelchair applications are a good fit for the BTS7960 motor driver, a high-current H-bridge driver that can handle up to 43A continuous current. Using an ESP32 microcontroller, two geared DC motors, two BTS7960 motor drivers, a relay module, a joystick module, a Blynk mobile application, a sprocket-chain drive mechanism, and a 12V 40A battery, this project suggests a

Joystick Controlled Electric Wheelchair. The square tube structure offers durability and structural rigidity. Both a physical joystick and the Blynk mobile app over a Wi-Fi network may be used by the user to operate the wheelchair.

## II. OBJECTIVE

• To use an ESP32 microcontroller and BTS7960 motor drivers to design and build an electric wheelchair that can be operated using a joystick.

• Two geared DC motors with a sprocket and chain transmission system are used to power the wheelchair.

• To use PWM signals to construct joystick-based directional control (left, right, forward, and backward).

• To include the Blynk mobile application for Wi-Fi-based wireless wheelchair remote control.

• To utilize relay modules for switching and circuit protection and a 12V 40A battery as the power supply.

• To use square tube structural elements to construct a strong and lightweight wheelchair frame.

Objective To give those with physical disabilities an accessible and reasonably priced mobility option.

## III. LITERATURE SURVEY

According to S. Tamura et al., their work on electric wheelchair control systems demonstrates the use of joystick interfaces for intuitive directional control and highlights the importance of speed regulation in motorized mobility aids. [1]

According to R. A. Ramlee and M. R. Arshad, their research on microcontroller-based wheelchair control systems proposes the use of PWM motor control techniques to achieve smooth and precise wheelchair manoeuvring. [2]

According to A. Kumar and P. Singh, their study on IoT-enabled assistive devices demonstrates the integration of the Blynk platform with ESP32 for wireless control of rehabilitation equipment, enabling remote operation via smartphones. [3]

According to B. Patel and N. Shah, their paper on motor driver selection for electric vehicles highlights the BTS7960 H-bridge driver as a cost-effective and high-performance solution for driving high-current DC motors in mobility systems. [4]

According to V. Kumar et al., their work on gear-driven electric vehicle frames discusses the advantages of sprocket and chain drives in terms of torque transmission efficiency and reliability in low-speed, high-load applications such as wheelchairs. [5]

According to M. Zubair and A. Hamid, their research on ESP32-based IoT applications for assistive technology demonstrates the effectiveness of the ESP32 in real-time sensor data acquisition and wireless communication, making it an ideal controller for smart wheelchair systems. [6]

| Sr. No. | Author / Year | Technique Used | Main Contribution | Limitations |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| 1 | S. Tamura et al. (2012) | Joystick Control | Joystick interface for directional control; speed regulation in mobility aids | Limited to wired control |
| 2 | R. A. Ramlee & M. R. Arshad (2014) | PWM Motor Control | Smooth and precise wheelchair manoeuvring using PWM | No wireless integration |
| 3 | A. Kumar & P. Singh (2020) | IoT / Blynk Platform | Blynk + ESP32 for wireless rehabilitation equipment control | Dependent on Wi-Fi availability |
| 4 | B. Patel & N. Shah (2018) | BTS7960 H-Bridge Driver | Cost-effective high-current DC motor driving solution | Limited to specific current range |
| 5 | V. Kumar et al. (2017) | Sprocket-Chain Drive | Efficient torque transmission for low-speed high-load applications | Requires periodic chain maintenance |
| 6 | M. Zubair & A. Hamid (2021) | ESP32 IoT | Real-time sensor data and wireless comms for smart wheelchair | Requires stable Wi-Fi infrastructure |
| 7 | Proposed Work | ESP32 + BTS7960 + Blynk + Joystick + Chain Drive | Affordable dual-control wheelchair with real-time app monitoring and structural evaluation | Prototype-level implementation |

**Block diagram**

The block diagram of the Joystick Controlled Electric Wheelchair consists of the following main blocks: 12V 40A Battery (Power Supply), ESP32 Microcontroller (Central Controller), Joystick Module (Primary Input), Blynk Mobile Application (Wireless Input via Wi-Fi), Relay Module (Circuit Switching), Two BTS7960 Motor Drivers (Motor Control), Two Geared DC Motors (Drive Mechanism), Sprocket and Chain Drive (Power Transmission), and Square Tube Frame (Mechanical Structure). The joystick and Blynk app provide directional commands to the ESP32, which processes the input and generates PWM signals to the BTS7960 motor drivers to control motor speed and direction.

Innovative Journal for Opportunities and Development in Science & Technology,
Volume 6, Issue 6, June 2026
Paper Id: – IJ2026V6I6 -8 A-D
ISSN 2582-6026

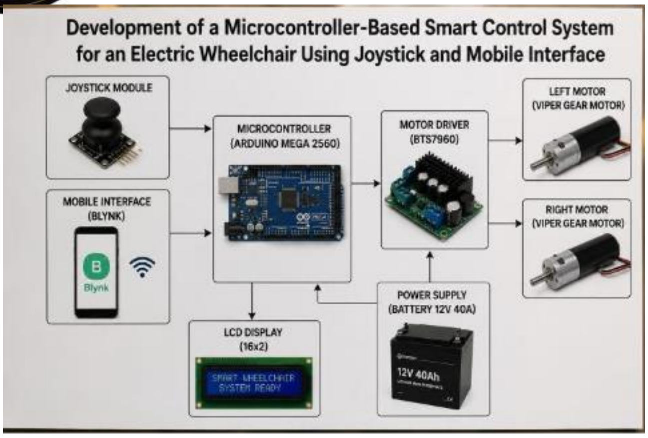



Fig.1- Block diagram

## IV. WORKING

On power-up, the ESP32 initializes the joystick module, connects to the Wi-Fi network, and initiates communication with the Blynk application. Relay-controlled circuits in the 12V 40A battery power the entire system. The Joystick Controlled Electric Wheelchair functions on the differential drive control principle. Two analog output signals that correspond to the joystick handle's X and Y axes are provided by the joystick module. The ESP32 uses its ADC channels to read these analog signals. The ESP32 decides whether to move forward, backward, left, or right based on the deflection of the joystick. The two BTS7960 motor driver modules receive corresponding PWM signals.

One geared DC motor is controlled by each BTS7960 module. Differential steering is achieved by individually controlling the speed and direction of both motors by adjusting the PWM duty cycle and direction pins of the BTS7960 drivers. Smooth and effective torque distribution is made possible by the two geared motors' transmission of power to the back wheels via sprocket and chain drives .The Blynk mobile application allows the user to simultaneously operate the wheelchair electronically. The ESP32 receives virtual button orders from the Blynk app over Wi-Fi, interprets them, and then activates the motors appropriately. In addition to controlling the primary power supply to the motor drivers, the relay module offers further circuit protection.

### 4.1 ESP32 Microcontroller

Espressif Systems created the ESP32, a powerful, inexpensive, dual-core microcontroller. It has a 240 MHz Xtensa LX6 dual-core processor, several ADC channels, PWM output capabilities, integrated Wi-Fi and Bluetooth connection, and an extensive array of digital I/O ports. The ESP32 serves as the system's central controller, receiving analog data from the joystick, establishing Wi-Fi communication with the Blynk server, and producing PWM control signals for the BTS7960 motor drivers.

### 4.2 BTS7960 Motor Driver (x2)

A fully integrated H-bridge motor driver, the BTS7960 can continuously control DC motors with currents up to 43A. It has current sensing feedback, over-temperature protection, short-circuit protection, and PWM input control. In order to provide independent bidirectional speed control of both wheels, this project uses two BTS7960 modules, one for each geared drive motor. Each

BTS7960 module's RPWM, LPWM, R_EN, and L_EN pins are driven by the ESP32 to regulate motor speed and direction.

### 4.3 Geared DC Motors (x2)

The wheelchair's main driving actuators are two geared DC motors. Wheelchair users' weight must be supported on a variety of surfaces, and geared motors offer great torque at low speeds. These motors are rated to take the current provided by the 12V 40A battery via the BTS7960 drivers, and they run on 12V DC. Through the sprocket and chain drive arrangement, each motor powers one of the wheelchair's back wheels.

### 4.4 Relay Module

The relay module functions as an electrically driven switch that enables the ESP32 to regulate the motor driver circuit's primary power source. The relay can switch high-current DC loads from the 12V 40A battery and runs on a low-power control signal from the ESP32. It guarantees that the motor circuit may be de-energized when necessary without removing the battery thanks to its safety disconnect mechanism.

### 4.5 12V 40A Battery

The wheelchair system's main power source is a 12V 40A lead-acid or lithium-based rechargeable battery. The battery, which has a 40Ah capacity at 12V, has enough energy to power the ESP32, relay, motor drivers, and geared motors for prolonged operation. The wheelchair frame contains the battery, which is linked to the system via the relay module.

### 4.6 Joystick Module

In this system, the X-axis output controls lateral turning (left/right) and the Y-axis output controls forward/backward motion. The ESP32 ADC reads the analog outputs and maps them to PWM duty cycles for the motor drivers. The joystick module is a dual-axis analog input device that provides proportional X and Y axis voltage outputs corresponding to the direction and magnitude of the joystick deflection. It also has a push-button switch that is activated by turning the joystick knob.

### 4.7 Blynk App

Using a smartphone, the Blynk mobile application offers a wireless remote control interface for the wheelchair. The ESP32 receives directional commands (forward, backward, left, right, stop) via virtual buttons set up on the Blynk dashboard over a Wi-Fi network. In addition to the actual joystick, this capability enables the user or a caregiver to operate the wheelchair remotely.

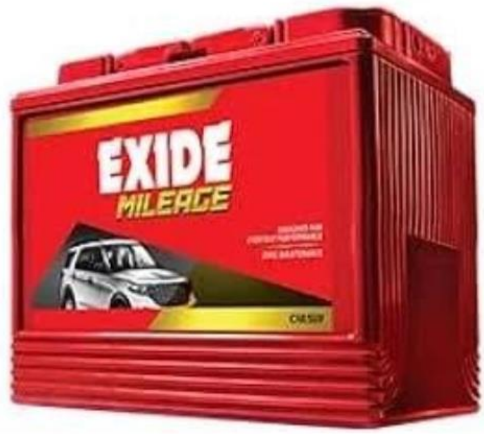
### 4.8 Sprocket and Chain Drive

The wheelchair's back wheels get the rotational power of the geared motors through the sprocket and chain drive system. Compared to direct drive or belt drive systems, this drive method offers effective torque multiplication, mechanical dependability, and simple maintenance. The motor torque, wheel size, and intended wheelchair speed are taken into consideration while choosing the chain and sprocket.

### 4.9 Square Tube Frame

The sprocket and chain drive system transfers the rotational power of the geared motors to the wheelchair's rear wheels. This drive type provides efficient torque multiplication, mechanical reliability, and easy maintenance in contrast to direct drive or belt drive systems. When selecting the chain and sprocket, the motor torque, wheel size, and intended wheelchair speed are taken into account.






## V. STRUCTURAL DESIGN

Load-bearing capacity, compactness, and ergonomics are given top priority in the structural design of the electric powered wheelchair. The frame is made of 25 mm x 25 mm mild steel (MS) square hollow section tubes with a wall thickness of 2 mm, which were selected for their high strength-to-weight ratio and ease of welding. The overall frame dimensions are roughly 900 mm (length) x 600 mm (width) x 900 mm (height), which provides sufficient room for the seat, battery, and drivetrain components. The seat height is set at 480 mm from the ground, which is in line with standard wheelchair ergonomics.

### 5.1 Frame Geometry and Load Analysis

In addition to the self-weight of about 25 kg (battery, motors, controllers, and frame), the frame is built to support a static load of up to 120 kg (user weight). Two 300 mm-diameter rear driving wheels and two 150 mm-diameter front caster wheels make up the four-wheel setup. Sprocket-chain drives are used to directly connect the rear wheels to the geared motors. The combined user and wheelchair system's center of gravity was assumed to be at seat level for the static load study, which produced a load distribution of around 65% on the rear axle and 35% on the front casters.

### 5.2 Drivetrain and Motor Mounting

Innovative Journal for Opportunities and Development in Science & Technology,
Volume 6, Issue 6, June 2026
Paper Id: – IJ2026V6I6 -8 A-D
ISSN 2582-6026

Every geared DC motor is installed on a specific motor bracket that is welded to the frame's rear lower cross-member. Chain tension may be adjusted thanks to the bracket's slotted slots. With a 3:1 gear reduction with a 36-tooth driven sprocket on the wheel axle and a 12-tooth driver sprocket on the motor shaft, the sprocket-chain drive increases torque at the wheel. To ensure alignment and reduce friction, flanged ball bearings are press-fitted into bearing housings that are welded to the frame side members to support the wheel axle.

## VI. FABRICATION

The fabrication process of the electric powered wheelchair was carried out in sequential stages, beginning with raw material preparation and ending with system integration and wiring.

### 6.1 Frame Fabrication

An angle grinder and hacksaw were used to cut MS square tubes to the necessary lengths, and all joints were prepared by grinding the tube ends to form tight-fitting butt joints. MIG welding (GMAW) was carried out using ER70S-6 wire at a current setting of 120–140 A to ensure full penetration at each joint. Following welding, all welds were visually inspected, and the frame was checked for squareness using a steel square and diagonal measurement technique. The finished frame was cleaned with wire brushing and coated with a red oxide primer coat to prevent corrosion.

### 6.2 Mechanical Assembly

M8 bolts and spring washers were used to secure the geared DC motors to the welded motor brackets. A key and locking collar were used to secure the 12-tooth driving sprockets that were press-fitted onto the motor output shafts. The flanged bearing housings were fitted with the rear wheel axles, each of which had a 36-tooth driven sprocket. Between each motor sprocket and wheel sprocket, roller chains (#35 standard chain) were installed. The motor brackets were pushed into the slotted mounting holes to adjust the chain tension until the chain sag was less than 3 mm. M10 pivot bolts with nylon lock nuts were used to secure the front caster wheels to the front fork brackets. Bolted to the frame seat support rails were the seat and backrest, which were made of 18 mm plywood with foam cushioning and vinyl upholstery.

### 6.3 Electrical Wiring and Integration

To maintain a low center of gravity, the 12V 40A battery was installed in a lockable battery tray at the base of the frame. To manage the high-current requirement, all power cables connecting the battery, relay module, and BTS7960 motor drivers were rated at 10 AWG (5.26 mm2). To avoid interference, conduit was used to transport the signal cables between the ESP32 and the BTS7960 drivers. Within a vented ABS enclosure fastened to the rear frame cross-member, the ESP32 controller board and relay module were installed on a DIN rail. The electrical harness was fastened to the frame with cable ties and adhesive cable clamps spaced 150 mm apart, and all connections were crimped using insulated ferrule terminals.

## VII. PERFORMANCE EVALUATION

Performance evaluation of the fabricated electric wheelchair was conducted through a series of controlled tests to assess speed, range, turning radius, load capacity, and control responsiveness. Tests were performed on a flat concrete surface with an 80 kg test load placed on the seat to simulate real-world operating conditions.

### 7.1 Speed and Range Test

The wheelchair was timed over five runs while being pushed at maximum joystick deflection around a 20-meter track. The average maximum speed that was observed was 4.8 km/h, which is within the safe operating range of 4-6 km/h that is advised for indoor powered wheelchairs. The wheelchair was driven continuously at half speed (50% PWM duty cycle) with an 80 kg load until the battery voltage fell to 10.8 V (the cut-off threshold) in order to evaluate the battery drain. For normal inside and brief outdoor use situations, the measured range of about 12 km per charge was adequate.

Fig.2 - Speed and Range Test

### 7.2 Turning Radius and Maneuverability

By propelling one motor forward and the other backward at identical speeds, the differential drive design permits zero-radius turning, or spin-in-place. In order to get through typical 850 mm doorways, the minimum turning radius measured during the testing was around 350 mm from the wheelchair's geometric center. The average time to execute a full 360-degree in-place rotation at maximum speed was 3.2 seconds, indicating good agility in small interior areas.

### 7.3 Load Capacity and Structural Integrity

A 120 kg dead weight was placed on the seat for 30 minutes as part of a static load test. The welded MS square tube frame's sufficient structural integrity for the intended user weight range was confirmed by the absence of permanent deformation, weld cracking, or fastener loosening. During straight-line driving and turning maneuvers, dynamic load testing at 80 kg and 100 kg revealed no unusual vibration or frame flex. After testing, every welded joint passed a visual and tap-hammer examination, showing no evidence of fatigue cracking.

### 7.4 Control Responsiveness

PWM-based speed control was confirmed throughout the entire duty cycle range (0-100%), confirming smooth and proportionate motor speed variation without dead zones or jerky transitions. The average response latency for joystick control was 85 ms, which is imperceptible to the user in normal operation. Blynk app control introduced an additional average latency of 220 ms over a local Wi-Fi network, which remained within acceptable limits for low-speed wheelchair operation.

### 7.5 Performance Summary

The following is a summary of the main performance metrics noted during the assessment: maximum tested static load of 120 kg, minimum turning radius of 350 mm, maximum speed of 4.8 km/h, operating range of around 12 km per charge, joystick control latency of 85 ms, and Blynk app control latency of 220 ms over local Wi-Fi. These findings verify that the manufactured wheelchair satisfies the desired performance standards for applications involving indoor assisted mobility.

## XIII. ADVANTAGES

- Provides independent and intuitive mobility control for physically disabled individuals using a joystick.
- Dual control modes (joystick and Blynk app) offer flexibility for both the user and caregiver.
- BTS7960 motor drivers deliver high-current performance with built-in protection features.
- Sprocket and chain drive ensures efficient and reliable torque transmission to drive wheels.
- Square tube frame provides a sturdy, lightweight, and cost-effective structural solution.
- 12V 40A battery provides long operational endurance between charges.
- Wi-Fi-based Blynk control allows remote monitoring and operation via smartphone.
- Low cost and ease of assembly make it accessible and replicable for rehabilitation applications.

## IX. CONCLUSION

The ESP32 microcontroller was used to create the Joystick Controlled Electric Wheelchair, which effectively illustrates a practical and reasonably priced motorized mobility option for those with physical disabilities. Using BTS7960 high-current motor drivers, the system efficiently combines a joystick module with the Blynk mobile application to offer dual-mode control of two geared DC motors. The square tube frame offers the required structural stability, while the sprocket and chain drive system guarantees dependable power transfer to the driving wheels.

The relay module offers circuit safety, and the usage of a 12V 40A battery provides enough energy for prolonged operation. The ESP32's integrated Wi-Fi allows for easy connection with the Blynk platform, providing smartphone-based remote control features. The project may be made into a complete smart wheelchair solution for assistive technology applications by adding obstacle detection sensors, an automatic braking system, or voice control using the ESP32's Bluetooth functionality.

## REFERENCES

1. S. Tamura, H. Seki, and M. Hirose, "Joystick-Based Electric Wheelchair Control System," IEEE Transactions on Neural Systems and Rehabilitation Engineering, 2012.

2. R. A. Ramlee and M. R. Arshad, "Microcontroller-Based Electric Wheelchair with PWM Speed Control," International Journal of Advanced Robotics and Automation, 2014.

3. A. Kumar and P. Singh, "IoT-Enabled Assistive Devices Using ESP32 and Blynk Platform," International Journal of Engineering Research and Technology, 2020.

4. B. Patel and N. Shah, "BTS7960 H-Bridge Motor Driver for Electric Vehicle Applications," Journal of Power Electronics, 2018.

5. V. Kumar, R. Mehta, and A. Sharma, "Sprocket-Chain Drive Analysis for Low-Speed High-Torque Mobility Systems," International Journal of Mechanical Engineering, 2017.

6. M. Zubair and A. Hamid, "ESP32-Based IoT System for Assistive Technology," Journal of Embedded Systems and IoT, 2021.

7. Espressif Systems, "ESP32 Technical Reference Manual," Version 5.1, 2023.

8. Infineon Technologies, "BTS7960 Motor Driver Datasheet," Rev. 1.1, 2020.

9. R. S. Khurmi and J. K. Gupta, "Theory of Machines," S. Chand Publications, 2014.

10. B. L. Theraja and A. K. Theraja, "A Textbook of Electrical Technology," S. Chand Publications, 2014.