

IoT Based Motorized Hydraulic Jack for Vehicle Lifting

Dr. Shah Fateh Azam¹, Anshuman Singh², Harsh Yadav³, Pappu Prajapati⁴, Aman Srivastava⁵

¹Assistant Professor and HOD, Department of Mechanical Engineering ^{2,3,4,5}Undergraduate Researchers,
Department of Mechanical Engineering
KIPM College of Engineering and Technology, Gorakhpur Uttar Pradesh, India

Abstract: This research paper presents the design and development of an IoT-based motorized hydraulic jack system for vehicle lifting applications. In the modern era, automation has become an essential part of engineering to improve efficiency, accuracy, and ease of operation. Traditional hydraulic jacks require significant manual effort and are time-consuming, which makes them inconvenient, especially during emergency situations or for physically weak users.

The proposed system integrates mechanical, electrical, and IoT technologies to develop a smart lifting mechanism. It uses an ESP32 microcontroller, relay module, DC motor, and hydraulic pump. The ESP32 enables wireless communication through Wi-Fi, allowing users to control the system remotely via a mobile application or web interface.

The working principle of the system is based on Pascal's law, where pressure applied to a confined fluid is transmitted equally in all directions. The DC motor drives the hydraulic pump, which creates pressure inside the cylinder, resulting in the upward movement of the piston and lifting of the vehicle.

This system significantly reduces human effort, saves time, and improves operational efficiency. It also enhances safety and convenience, making it highly suitable for automobile workshops, service centers, garages, and roadside assistance. The project demonstrates the practical implementation of IoT in mechanical systems and highlights its potential for future smart automation solutions.

Keywords: IoT, Hydraulic Jack, ESP32, Automation, Vehicle Lifting, Smart System

1. Introduction

Vehicle lifting is an essential process in automobile maintenance, repair, and servicing operations. In workshops, garages, and service centers, hydraulic jacks are commonly used to lift vehicles for inspection and repair work. However, traditional hydraulic jacks require significant manual effort and time, which can be inconvenient and physically demanding for users.

With the rapid advancement of technology, automation has become a key aspect of modern engineering systems. The integration of IoT (Internet of Things) with mechanical devices provides new opportunities for developing smart, efficient, and user-friendly systems. IoT enables remote monitoring and control, reducing the need for manual intervention.

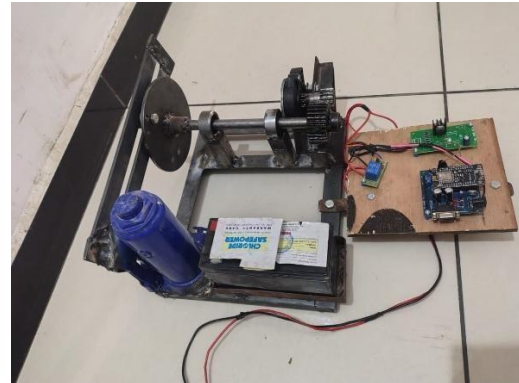
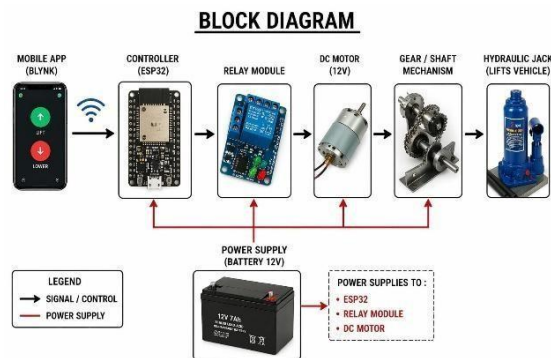
This project focuses on the design and development of an IoT-based motorized hydraulic jack system. The system combines mechanical components with electronic control using an ESP32 microcontroller. The ESP32 allows wireless communication via Wi-Fi, enabling the user to operate the system remotely using a mobile interface or web application.

The motorized mechanism replaces manual effort with electrical operation. A DC motor is used to drive the hydraulic pump, which generates pressure in the fluid. According to Pascal's law, this pressure is transmitted equally, causing the piston to move upward and lift the vehicle.

This system is particularly useful in emergency situations, roadside assistance, and for individuals who may find manual lifting difficult. It improves efficiency, reduces human effort, and enhances operational safety.

The project demonstrates how IoT technology can be effectively integrated with mechanical systems to create innovative

and practical solutions for real-world problems. It also opens the door for further advancements in smart automation systems in the automobile sector.



2. Problem Statement

Traditional hydraulic jacks are widely used in automobile workshops, garages, and service stations for lifting vehicles during maintenance and repair work. Although these jacks are simple in design and commonly available, they have several limitations that reduce their efficiency and usability in modern applications. One of the major drawbacks of traditional hydraulic jacks is that they require significant manual effort to operate. The user has to continuously apply force to lift the vehicle, which can be physically exhausting and time-consuming.

In real-life situations, especially during roadside emergencies such as vehicle breakdowns or tire punctures, using a manual jack becomes even more difficult. The user may not have enough strength or proper conditions to operate the jack efficiently. This creates inconvenience and delays in handling emergency situations. Moreover, traditional jacks are not suitable for elderly people or individuals who are physically weak, making them less user-friendly.

Another major limitation is the absence of automation and remote-control functionality. Conventional hydraulic jacks require direct human interaction for operation, which increases effort and reduces convenience. In today's world, where automation and smart systems are becoming increasingly popular, there is a strong need for advanced solutions that minimize human intervention and improve ease of use.

Safety is also a significant concern when using manual hydraulic jacks. Improper handling, uneven surfaces, or sudden pressure release can lead to accidents such as slipping of the jack or instability of the lifted vehicle. This can cause damage to the vehicle as well as serious injury to the user. The lack of safety features in traditional systems makes them unreliable in certain conditions.

Additionally, traditional jacks do not provide any monitoring or control mechanism to ensure safe operation. The user must rely completely on manual judgment, which may not always be accurate. This increases the risk of operational errors.

Therefore, there is a strong need to develop an advanced and efficient system that reduces human effort, improves safety, and provides remote control capability. The integration of IoT (Internet of Things) with a motorized hydraulic mechanism can offer a smart solution to these problems. Such a system can automate the lifting process, allow remote operation through a mobile interface, and enhance overall performance and reliability. This project aims to address these issues by developing an IoT-based motorized hydraulic jack system.

3. Objectives

The primary objective of this project is to design and develop an efficient and user-friendly IoT-based motorized hydraulic jack system for vehicle lifting. The system aims to reduce manual effort, improve safety, and enhance the overall performance of conventional lifting mechanisms.

One of the main objectives is to automate the vehicle lifting process by replacing manual operation with a motorized mechanism. This will help in reducing the physical effort required by the user and make the system more convenient and accessible for all individuals, including elderly and physically weak users.

Another important objective is to integrate IoT (Internet of Things) technology into the system. By using an ESP32 microcontroller, the system can be connected to a Wi-Fi network and controlled remotely using a mobile interface or web application. This will allow users to operate the hydraulic jack from a safe distance, improving convenience and safety.

The project also aims to improve the efficiency and speed of the lifting operation. The use of a DC motor and hydraulic pump ensures smooth and controlled movement of the piston, resulting in faster lifting compared to manual methods.

Enhancing safety is another key objective of this system. By providing controlled motor operation through a relay module, the risk of sudden movements or accidents can be minimized. The system is designed to provide stable and reliable lifting under proper conditions.

In addition, the project focuses on developing a cost-effective solution that can be easily implemented in real-life applications such as automobile workshops, garages, and roadside assistance services. The system should be simple design, easy to maintain, and reliable in operation.

Finally, the project aims to demonstrate the practical application of IoT technology in mechanical systems and highlight the potential for future advancements in smart automation systems for the automobile industry.

4. Methodology

The methodology of this project involves the integration of mechanical, electrical, and IoT-based systems to develop a smart vehicle lifting mechanism. The system is designed to automate the lifting process using a motorized hydraulic jack controlled through wireless communication.

The operation of the system begins with the user interface, which can be a mobile application or a web-based platform. The user sends a command such as ON or OFF through the interface. This command is transmitted via a Wi-Fi network to the ESP32 microcontroller, which acts as the central control unit of the system.

The ESP32 receives the signal and processes it according to the programmed instructions. Based on the received command, the ESP32 sends a control signal to the relay module. The relay acts as an electrically operated switch that allows the low-power signal from the ESP32 to control the high-power DC motor.

When the relay is activated, it completes the circuit and allows current to flow to the DC motor. The motor starts rotating and drives the hydraulic pump. The hydraulic pump pushes oil into the cylinder, creating pressure within the system.

According to Pascal's law, the pressure applied to a confined fluid is transmitted equally in all directions. This pressure causes the piston inside the hydraulic cylinder to move upward. As the piston moves upward, the jack lifts the vehicle smoothly and steadily.

The entire process is controlled remotely, which reduces manual effort and increases convenience. The system ensures smooth operation by maintaining proper synchronization between electrical and mechanical components.

In addition to the basic work, the system also ensures controlled and safe operation through proper coordination between all components. The relay module plays a crucial role in maintaining safety by controlling the switching of the motor. It prevents direct high current flow through the microcontroller, thereby protecting the system from electrical damage.

The power supply unit provides the necessary electrical energy required for the operation of the ESP32, relay module, and DC motor. A stable and reliable power source is essential to ensure smooth functioning of the system. Any fluctuation in power can affect the performance of the motor and the lifting mechanism.

The IoT-based control system enhances the usability of the project by allowing remote access. The user does not need to be physically present near the jack to operate it. This feature is particularly useful in emergency situations where quick action is required.

The system also allows easy ON and OFF control of the motor, which directly affects the lifting and lowering of the vehicle. When the motor is turned OFF, the hydraulic pressure gradually releases, and the piston moves downward, lowering the vehicle safely.

The design of the system is kept simple to ensure ease of use and maintenance. All components are connected in a structured manner to achieve efficient performance. The combination of mechanical and electronic systems makes the project innovative and practical.

This methodology demonstrates how modern technology such as IoT can be integrated with traditional mechanical systems to improve efficiency, safety, and user convenience. It provides a strong foundation for further advancements in automation and smart vehicle maintenance systems.

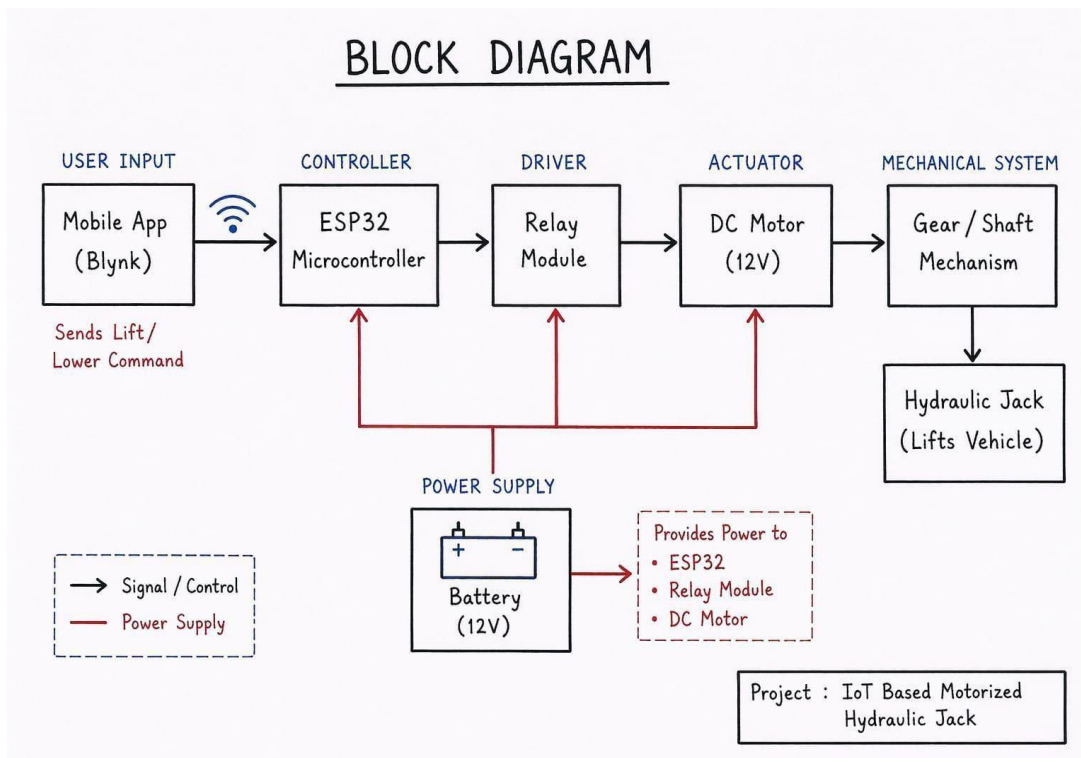


Fig 1: Block Diagram of IoT Based Hydraulic Jack System

5. Hardware Components

The hardware components used in this project play a vital role in the proper functioning of the IoT-based motorized hydraulic jack system. Each component is carefully selected to ensure efficiency, reliability, and smooth operation of the system. The integration of these components enables the system to perform automated lifting with minimal human effort.

The main component of the system is the ESP32 microcontroller. It acts as the brain of the system and is responsible for controlling all operations. The ESP32 has built-in Wi-Fi capability, which allows it to receive commands from a mobile application or web interface. It processes these commands and sends signals to other components accordingly.

Another important component is the DC motor. The motor is responsible for converting electrical energy into mechanical energy. It drives the hydraulic pump, which generates pressure required for lifting the vehicle. The performance of the system largely depends on the efficiency and power of the motor used.

The relay module is used to control the operation of the DC motor. It acts as a switching device that allows the low-power signal from the ESP32 to control the high-power motor circuit. This ensures safe and efficient operation without damaging the microcontroller.

The hydraulic pump is a key mechanical component that creates pressure in the fluid. It pushes oil into the hydraulic cylinder, which results in the movement of the piston. This movement is responsible for lifting the vehicle. The proper functioning of the pump is essential for smooth lifting operation. A stable power supply is required to provide electrical energy to all components. The system requires consistent voltage and current to operate effectively. Any fluctuation in the power supply can affect the performance and reliability of the system.

The metal frame provides structural support to the entire setup. It ensures stability and strength while lifting the vehicle. The design of the frame is important to maintain balance and prevent accidents during operation. All these hardware components work together in coordination to achieve the desired output. The combination of electronic and mechanical components makes the system efficient, reliable, and suitable for real-world applications.

HARDWARE COMPONENTS



Fig 2: Hardware Components Used in System

6. Software and IoT Implementation

The software and IoT implementation play a crucial role in making the hydraulic jack system smart and automated. The integration of software with hardware components allows the system to be controlled remotely and efficiently. In this project, Arduino IDE is used as the primary software platform for programming the ESP32 microcontroller.

The ESP32 is programmed using embedded C language through Arduino IDE. The code includes instructions for receiving signals from the Wi-Fi network and controlling the relay module accordingly. The microcontroller continuously monitors incoming commands and executes actions based on user input.

IoT functionality is achieved through a web-based interface or mobile application. The ESP32 connects to a Wi-Fi network using predefined credentials such as hotspot name and password. Once connected, it communicates with the user interface through the internet. The user can open a web link or mobile dashboard to control the system.

When the user presses the ON button on the interface, a signal is sent to the ESP32. The microcontroller processes this signal and activates the relay, which in turn starts with the DC motor. Similarly, when the OFF button is pressed, the motor stops, and the lifting operation is halted or reversed.

The use of IoT technology allows real-time control and monitoring of the system. It eliminates the need for manual operation and provides convenience to the user. The system can be operated from a safe distance, reducing the risk of accidents.

Another advantage of using ESP32 is its fast-processing speed and built-in Wi-Fi capability, which makes it suitable for IoT-based applications. The software is designed to be simple and efficient, ensuring smooth communication between all components.

Overall, the software and IoT implementation enhance the functionality of the system by providing automation, remote access, and improved user experience. It demonstrates how modern technology can be used to improve traditional mechanical systems.

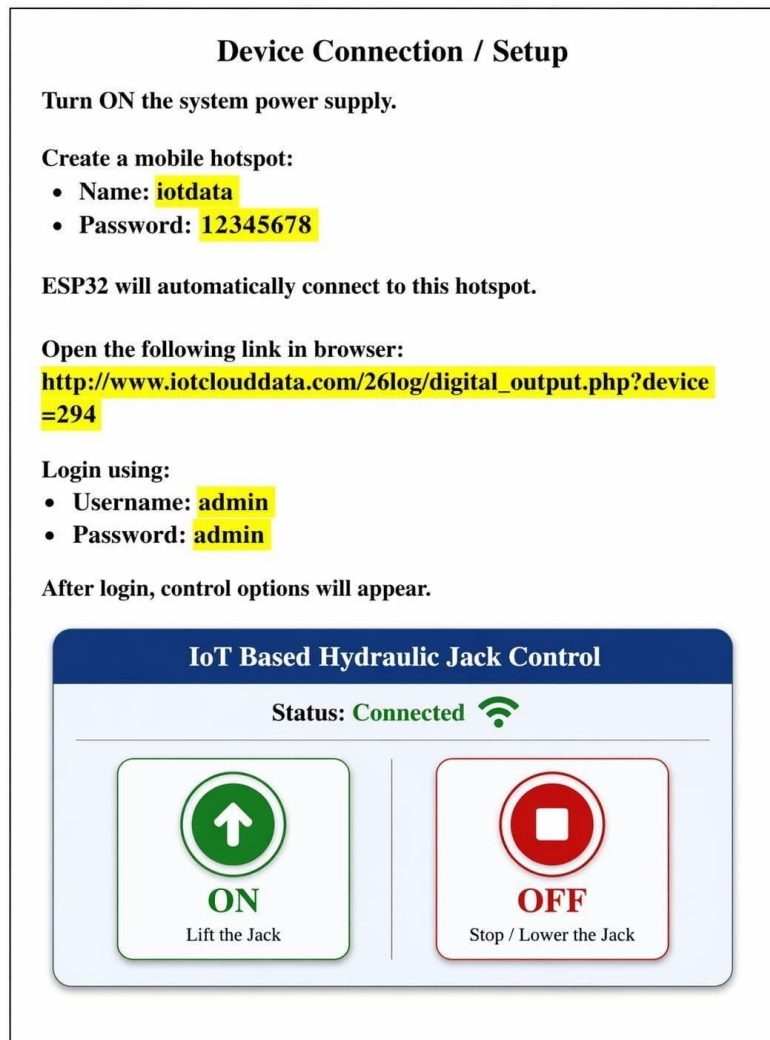


Fig 3: IoT Control Interface for Hydraulic Jack System

7. Motorized Mechanism

The motorized mechanism is one of the most important parts of the IoT-based hydraulic jack system. It is responsible for converting electrical energy into mechanical energy and driving the hydraulic system to lift the vehicle. This mechanism replaces the traditional manual effort with an automated and efficient process.

In this system, a DC motor is used to drive the hydraulic pump. When the user sends a command through the IoT interface, the ESP32 microcontroller processes the signal and activates the relay module. The relay then allows current to flow to the DC motor, causing it to rotate.

The rotating motor shaft is connected to the hydraulic pump. As the motor rotates, it drives the pump, which pushes hydraulic oil into the cylinder. This creates pressure inside the cylinder, which acts on the piston. According to Pascal's law, the pressure applied to the fluid is transmitted equally in all directions, resulting in the upward movement of the piston.

As the piston moves upward, the hydraulic jack lifts the vehicle smoothly and steadily. The motor ensures continuous and controlled motion, which makes the lifting process faster and more efficient compared to manual operation.

When the user stops the motor using the OFF command, the hydraulic pressure is gradually released, and the piston moves downward. This allows the vehicle to be lowered safely without sudden jerks or instability.

The motorized mechanism improves the overall performance of the system by providing smooth operation, reducing human effort, and increasing efficiency. It also enhances user convenience by enabling remote control and eliminating the need for manual pumping.

Proper selection of the motor is important to ensure sufficient torque and power for lifting heavy loads. The system is designed to operate within safe limits to prevent overheating or damage to the motor. Overall, the motorized mechanism plays a crucial role in making the system automated, reliable, and user-friendly.

8. IoT Control Workflow

The IoT control workflow describes the complete process through which the user interacts with the system and controls the hydraulic jack remotely. This workflow plays a crucial role in ensuring smooth communication between the user interface and the hardware components of the system.

The process begins when the user turns ON the system power supply. Once the system is powered, the ESP32 microcontroller initializes and starts searching for the predefined Wi-Fi network. In this system, a mobile hotspot is created with a specific name and password. The ESP32 automatically connects to this hotspot using the programmed credentials stored in its memory.

After successfully connecting to the network, the user opens a web browser on their mobile device or computer and enters the specified URL. This URL redirects the user to a control interface that allows interaction with the system. The interface includes a login page where the user must enter valid credentials such as username and password to access the control panel.

Once logged in, the control options are displayed on the screen. These options include buttons such as ON and OFF that control the operation of the hydraulic jack. When the ON button is pressed, a signal is transmitted over the internet to the ESP32 microcontroller. The ESP32 processes this signal and activates the relay module, which allows current to flow to the DC motor. As a result, the motor starts and drives the hydraulic pump, lifting the vehicle.

Similarly, when the OFF button is pressed, the signal is sent to stop the motor. The relay module turns OFF, cutting the power supply to the motor. The hydraulic pressure is gradually released, and the piston moves downward, lowering the vehicle safely.

This workflow ensures reliable and efficient communication between the user and the system. It eliminates the need for manual operation and enhances safety and convenience. The IoT control workflow makes the system modern, efficient, and suitable for real-world applications.

9. Advantages

The IoT-based motorized hydraulic jack system offers several advantages over traditional manual hydraulic jacks. One of the major advantages is the reduction in human effort. The system eliminates the need for manual pumping and allows the user to operate the jack using a mobile interface.

Another important advantage is time efficiency. The motorized mechanism enables faster lifting of vehicles compared to manual operation. This is particularly useful in emergency situations where quick action is required.

The system also provides remote control functionality through IoT technology. The user can operate the system from a safe distance, which improves convenience and reduces the risk of accidents.

Improved safety is another key benefit of the system. The controlled operation of the motor through a relay module ensures smooth lifting and lowering of the vehicle. This reduces the chances of sudden jerks or instability.

The system is user-friendly and easy to operate. Even individuals with less technical knowledge can use the system without difficulty. The simple interface makes it accessible to a wide range of users.

In addition, the system is suitable for various applications such as automobile workshops, garages, service centers, and roadside assistance. It can also be used in smart garage systems for automated vehicle maintenance. Overall, the system enhances efficiency, safety, and convenience, making it a better alternative to traditional hydraulic jacks.

10. Limitations

Despite its advantages, the IoT-based motorized hydraulic jack system has certain limitations that need to be considered. One of the major limitations is the requirement of a continuous power supply. The system depends on electrical energy to operate the motor and control components. In the absence of power, the system cannot function.

Another limitation is the dependence on internet connectivity. Since the system uses IoT technology, it requires a stable Wi-Fi connection for communication between the user and the ESP32 microcontroller. Poor network connectivity can affect the performance of the system.

The system currently lacks advanced safety features such as automatic load detection and emergency cut-off mechanisms. This means that manual monitoring is still required during operation to ensure safety.

The cost of the system is higher compared to traditional manual hydraulic jacks. The inclusion of electronic components such as ESP32, relay module, and motor increases the overall cost. This may limit its adoption in low-budget applications.

Additionally, the system requires proper maintenance of both mechanical and electronic components. Any failure in the components can affect the performance of the system.

Despite these limitations, the system provides a strong foundation for future improvements and can be enhanced with additional features to overcome these challenges.

11. Results

The developed IoT-based motorized hydraulic jack system was successfully tested under various conditions to evaluate its performance and reliability. The system demonstrated efficient and smooth operation during the lifting and lowering of the vehicle.

The motorized mechanism effectively reduced the manual effort required for lifting. The DC motor was able to drive the hydraulic pump smoothly, generating sufficient pressure to lift the vehicle without any difficulty. The lifting process was faster compared to traditional manual methods.

The IoT control system also performed well during testing. The ESP32 microcontroller successfully connected to the Wi-Fi network and responded accurately to the commands sent by the user. The ON and OFF controls worked as expected, providing reliable operation.

The system showed good stability and control during operation. There were no sudden jerks or instability observed while lifting or lowering the vehicle. The relay module ensured safe switching of the motor, preventing electrical issues.

Overall, the results indicate that the system is efficient, reliable, and suitable for practical applications. It successfully meets the objectives of reducing human effort, improving efficiency, and enabling remote control operations.

12. Cost Analysis

The cost analysis of the IoT-based motorized hydraulic jack system is an important aspect to evaluate its feasibility and practical implementation. The project is designed to be cost-effective while maintaining good performance and reliability. The components used in the system are easily available in the market and are reasonably priced.

The major component of the system is the ESP32 microcontroller, which costs approximately ₹300. It is a low-cost yet powerful device with built-in Wi-Fi capability, making it suitable for IoT applications.

The DC motor used in the system costs around ₹800. The motor plays a crucial role in driving the hydraulic pump and providing the necessary mechanical power for lifting the vehicle.

The hydraulic system, which includes the hydraulic jack and pump, is one of the most expensive components, costing approximately ₹1500. It is responsible for generating the pressure required for lifting the vehicle.

Other components such as the relay module, connecting wires, power supply, and supporting materials cost around ₹300. These components are essential for proper electrical connections and system stability.

The total cost of the system is approximately ₹3000 to ₹4000. This makes the system affordable compared to advanced automated lifting systems available in the market.

Overall, the project demonstrates that an efficient and automated hydraulic lifting system can be developed at a reasonable cost. With further optimization and large-scale production, the cost can be reduced even more, making it accessible for wider applications.

13. Future Scope

The IoT-based motorized hydraulic jack system has great potential for future development and improvement. Although the current system performs efficiently, there are several enhancements that can be implemented to make it more advanced and reliable.

One of the major improvements that can be made is the addition of safety sensors. Sensors such as load sensors and position sensors can be used to monitor the lifting process and prevent overloading or unsafe conditions. This will significantly improve the safety of the system.

Another important improvement is the development of a fully automatic system. The current system requires user input to operate, but it can be upgraded to perform automatic lifting and lowering based on predefined conditions. This will further reduce human intervention.

The system can also be integrated with solar power to make it energy-efficient and environmentally friendly. This will allow the system to operate in areas where electricity supply is limited.

Voice control is another feature that can be added to the system. By integrating voice recognition technology, the user can control the system using voice commands, making it more convenient and modern.

The system can also be developed into a smart garage system where multiple devices are interconnected and controlled through IoT. This will enable automation of various vehicle maintenance operations.

Overall, the future scope of this project is vast, and with further research and development, it can be transformed into a highly advanced and intelligent system.

14. Conclusion

The IoT-based motorized hydraulic jack system is an innovative solution that combines mechanical and electronic technologies to improve vehicle lifting operations. The system successfully reduces manual effort and provides a convenient method for lifting vehicles using remote control.

The integration of IoT technology allows the user to operate the system from a distance, enhancing safety and ease of use. The motorized mechanism ensures smooth and efficient lifting, while the hydraulic system provides the necessary force to lift heavy loads.

The project demonstrates how traditional mechanical systems can be improved using modern technology. It highlights the importance of automation in engineering and its role in increasing efficiency and safety.

The results obtained from the project show that the system is reliable, efficient, and suitable for real-world applications. It meets the objectives of reducing human effort, saving time, and improving user convenience.

Overall, the project is a successful implementation of an IoT-based automation system in the field of mechanical engineering. It provides a strong foundation for future advancements in smart vehicle maintenance systems.

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