



International Journal of Innovative Research in Science Engineering and Technology (IJIRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 8.699

Volume 15, Issue 1, January 2026

Pick and Place Robotic Arm

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ABSTRACT: Automation in industrial and academic environments has become essential for improving productivity, accuracy, and safety. This paper presents the design and implementation of a pick and place robotic arm using an ESP32 microcontroller and servo motors. The system is capable of picking objects from one location and placing them at another with high precision. Servo motors are used to control the base, shoulder, elbow, wrist, and gripper movements of the robotic arm. The ESP32 provides efficient processing and reliable control capabilities. The proposed system is cost-effective, compact, and suitable for small-scale industrial automation, laboratories, and educational applications. Experimental results demonstrate smooth operation, accurate positioning, and reliable object handling.

I. INTRODUCTION

Robotic automation plays a vital role in modern manufacturing and material handling processes. Pick and place robotic arms are widely used in industries for repetitive tasks such as sorting, assembling, and packaging. Manual handling of such tasks is often time-consuming, error-prone, and unsafe.

The objective of this project is to design a simple and efficient pick and place robotic arm using an ESP32 microcontroller and servo motors. The proposed system reduces human effort and increases accuracy in object manipulation. Due to its low cost and flexible design, the robotic arm is suitable for educational institutions and small-scale automation applications.

II. LITERATURE SURVEY

Several researchers have developed pick and place robotic arms using microcontrollers such as Arduino Uno, Arduino Mega, and Raspberry Pi. Earlier systems mainly focused on wired control and DC motor-based mechanisms, which limited precision and flexibility.

Recent studies have demonstrated the effectiveness of servo motor-based robotic arms due to their accurate angular control and ease of implementation. Advanced controllers such as ESP32 have gained popularity due to their performance and flexibility.

III. METHODOLOGY

The pick and place robotic arm system consists of integrated hardware and software components that work together to achieve precise movement and object handling.

The hardware includes an ESP32 microcontroller, multiple servo motors, a mechanical arm structure, and an external power supply. The ESP32 is programmed using Arduino IDE to generate PWM signals for controlling servo motors. Predefined angles are used to perform pick and place operations smoothly and accurately.

1. System Design Methodology

The system design methodology for a pick and place robotic arm includes requirement analysis, system architecture design, mechanical and actuator selection, sensor integration, control and software development, system integration, testing and validation, performance optimization, and documentation for reliable and efficient operation.

2. Hardware Methodology

1. Selection of robotic arm structure and materials
2. Determination of degrees of freedom (DOF)

3. Selection of suitable servo/stepper motors
4. Design and installation of end effector (gripper)
5. Selection of microcontroller or controller unit
6. Integration of motor drivers and control circuits
7. Selection and installation of sensors (proximity, limit switches)
8. Design of power supply and voltage regulation
9. Electrical wiring and component mounting
10. Hardware testing and fault checking

3. Software Methodology

1. Definition of software requirements and task sequence
2. Definition of software requirements and task sequence
3. Based on the command, Arduino generates appropriate signals for the motor driver.
4. Sensor data acquisition and processing.

4. Working Methodology

1. System power-on and initialization of controller and sensors
2. Detection of object at the pickup location
3. Movement of robotic arm to the pickup position
4. Activation of gripper to grasp the object
5. Lifting of the object safely
6. Servo motors rotate in the desired direction, resulting in robotic arm movement.
7. When the STOP command is received, the motors immediately stop.

Block Diagram

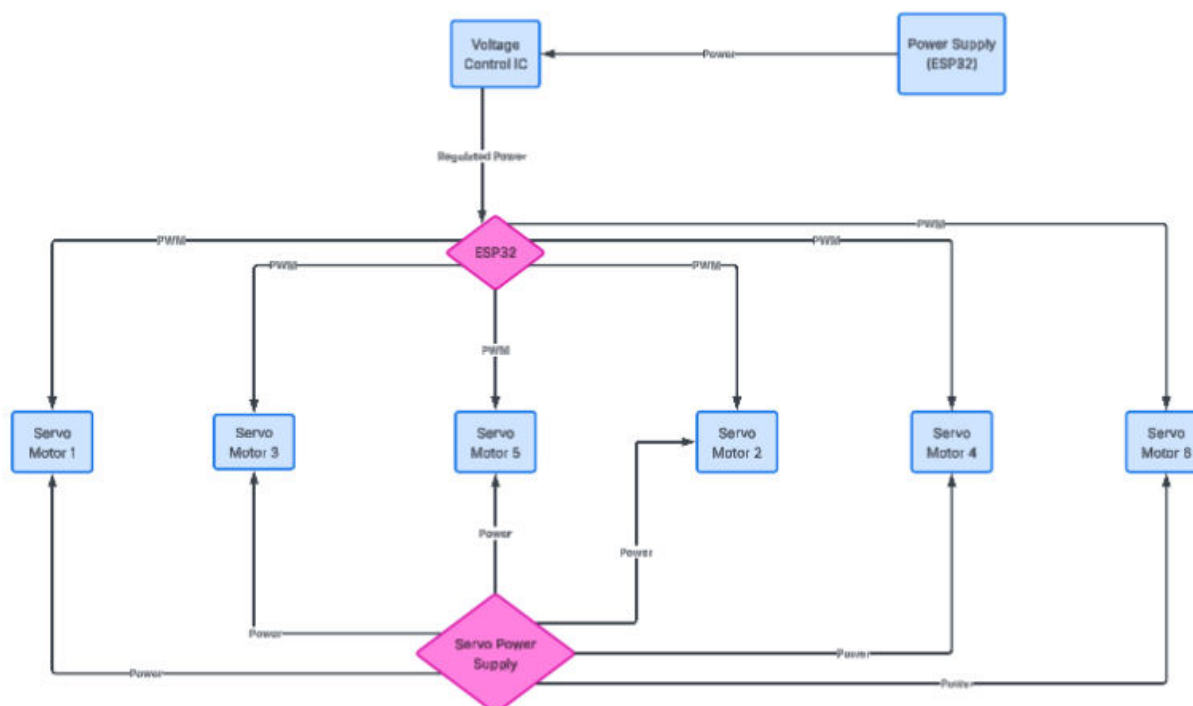


Fig. Pick and Place Robotic Arm

CIRCUIT DIGRAM

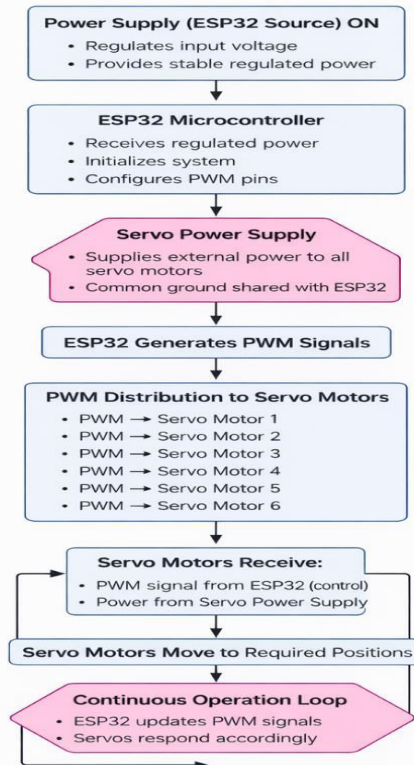
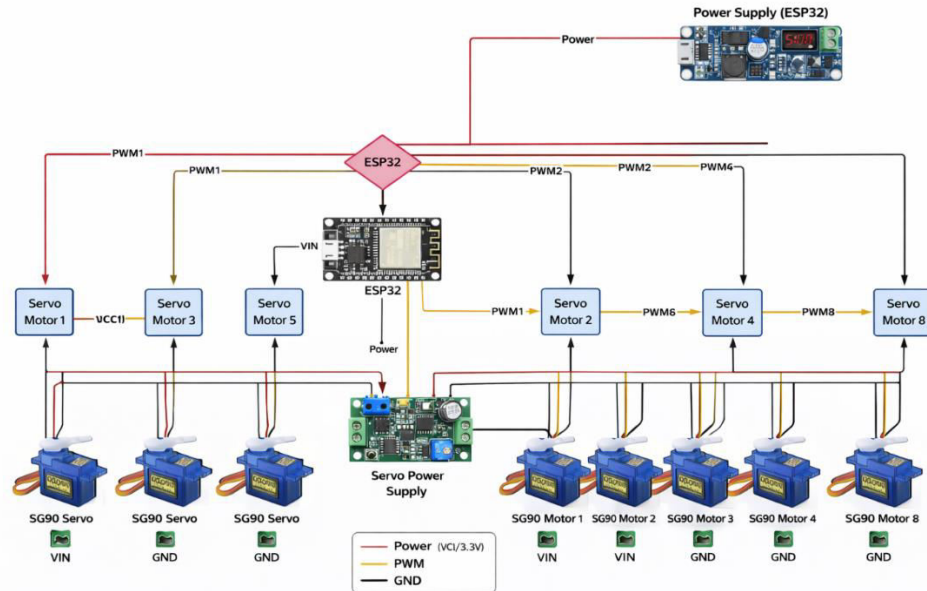
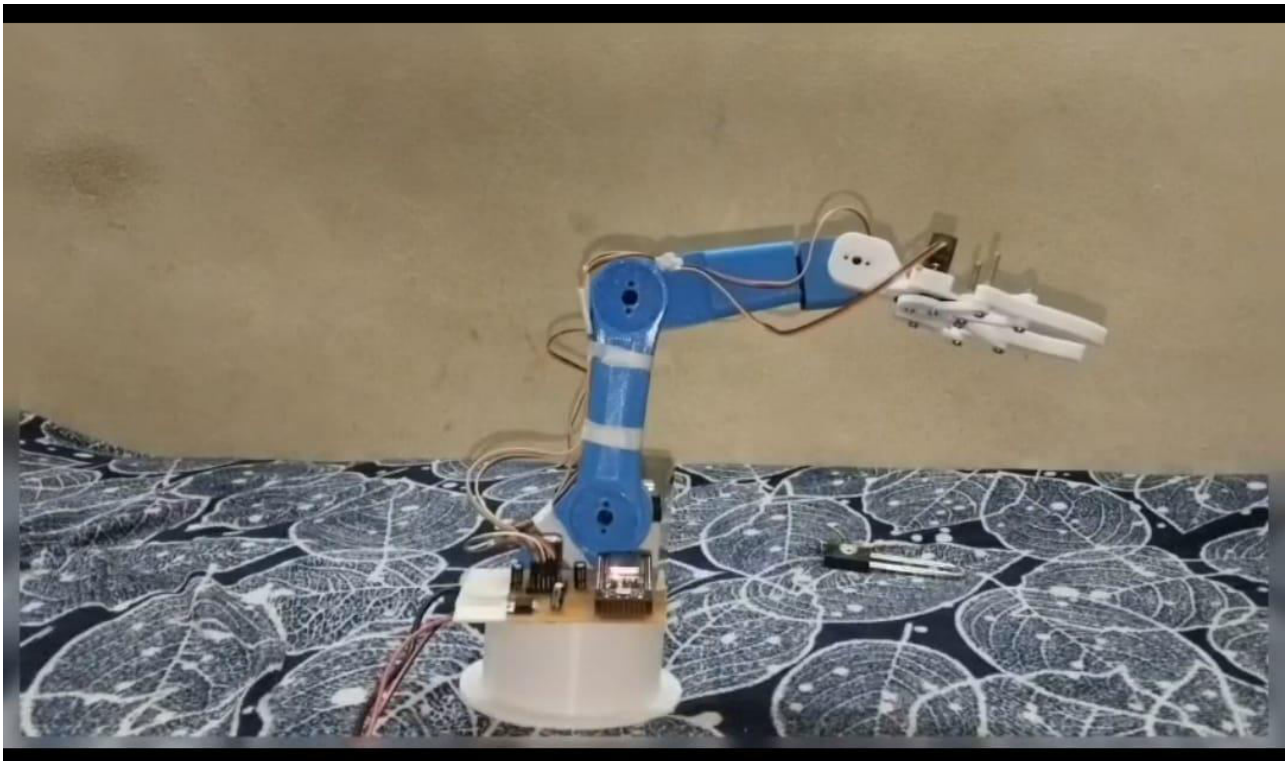


Fig. Flow Chart

IV. EXPERIMENTAL RESULTS

The pick and place robotic arm prototype was experimentally tested to evaluate its performance, accuracy, and reliability. The system was tested using objects of different shapes and light weights. Servo motors demonstrated accurate angular positioning with smooth motion. The gripper successfully picked and placed objects without slippage. The system remained stable during continuous operation, confirming its reliability.



V. CONCLUSION

This paper presents the design and implementation of a pick and place robotic arm using an ESP32 microcontroller and servo motors. The proposed system performs pick and place operations with good accuracy and smooth control. The system is cost-effective, reliable, and suitable for small-scale automation and educational applications. Future enhancements may include sensor integration, object detection, and IoT-based monitoring.

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