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Material Handling Robotic Arm Using PLC

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Abstract - This paper explores the development of a pick-and-place automation system utilizing a Programmable Logic Controller (PLC), emphasizing the importance of operator safety in industrial applications. The system is designed to automate the transfer of objects using a robotic arm, effectively reducing manual handling and human error. By integrating safety measures such as emergency stop features and sensors, the system ensures safe interaction between machinery and personnel. The use of PLCs enhances the overall performance in terms of precision, adaptability, and long-term reliability.

Key Words: PLC, Operator Safety, Emergency Stop, Sensors, Safety Interlocks, Ladder Logic, Real-time Monitoring, Stepper Motor, Servo Motor**.**

1. INTRODUCTION

The goal of this project is to design and implement a robotic arm system capable of performing pick-and-place operations using a Programmable Logic Controller (PLC).[2] In many industries, repetitive tasks such as material handling are not only inefficient when done manually, but also pose safety risks due to fatigue and human error. This system aims to provide a reliable automation solution that can be integrated into existing production lines to increase efficiency and reduce risk.

1.1 PROBLEM STATEMENT

Repeated material handling tasks on industrial assembly lines frequently reduce efficiency and increase the likelihood of workplace injuries. Manual handling often leads to delays, mistakes, and reduced product quality, while compromising employee safety.[3] To address these issues, this project introduces a robotic pick-and-place system controlled by a Programmable Logic Controller (PLC). The system is designed to automate operations at high speed and includes built-in safety mechanisms to avoid accidents and ensure dependable performance.[8]

2. COMPONENTS

2.1 *Delta DVP-SS2 PLC*

The **Delta DVP-SS2 PLC** is a compact and efficient programmable logic controller designed for small-scale industrial automation. It operates on a 24V DC input voltage and features 8 digital inputs and 6 transistor outputs, making it suitable for various control applications.[5][9] With a programming capacity of 8K steps, it offers highspeed performance and stable operation. The PLC supports RS-232 and RS-485 communication, allowing easy integration with other devices. Its advantages include compact design, cost effectiveness, easy programming using Delta's ISP Soft software, and expansion capabilities for additional I/O modules. The high-speed pulse output (up to 10 kHz) makes it ideal for motion control applications. Common uses include conveyor systems, packaging machines, and process automation. The reliable and durable design ensures long-term functionality in industrial environments.[3]

2. 2 Switch Mode Power Supply (SMPS)

The SMPS is an essential component that ensures the system operates at the correct voltage. It converts high-voltage AC (typically 220V) into a lower DC voltage (24V), required to power the PLC and other control units. Unlike traditional power supplies, SMPS units are more efficient due to their ability to switch at high frequencies, minimizing energy loss and heat generation. This efficiency makes them suitable for continuous operation in industrial environments.

2. 3 Stepper Motor

The NEMA 17 stepper motor is one of the most common types of stepper motors, widely used in automation, robotics, 3D printers, and CNC machines NEMA 17 stepper motors are known for their ability to provide precise control over angular position. They move in discrete steps (usually 1.8° per step, which equals 200 steps per full revolution), making them ideal for applications requiring high precision, such as in 3D printing, robotics, or CNC machinery.[7]

2. 4 Stepper Drive

A stepper motor driver is an electronic device used to control a stepper motor by providing the correct sequence of current to the motor's windings, enabling precise movement and positioning. Here's an overview of two key points about stepper motor drivers. Step motor drivers manage the current flow through the motor coils to control the rotation and torque. Many modern drivers offer micro stepping, Micro stepping improves the precision of stepper motors by reducing vibration and increasing resolution, which is crucial in applications like 3D printing, CNC, and robotics where smooth and accurate movement is required.[7]

3. OBJECTIVE

Following are the objectives of this Project:

- Increase in productivity.
- Reduction in running cost.
- Precision in control.
- Increase in speed of operation.

- Efficient operation.
- Early/predictive fault notification
- Reduce the start-up time for process.
- Complete control of manufacturing process.
- Increase in quality and consistency of the product.
- Shorten the time to market Condition.

Parameter	PLC	Microcontroller
Quality	Superior	Moderate
Efficiency	High	Limited
Accuracy	High Precision	Lower Precision
cost	More Expensive	Cost-Effective

Table-1: Comparison Table Between PLC and Microcontroller

3.1 BLOCK DIAGRAM

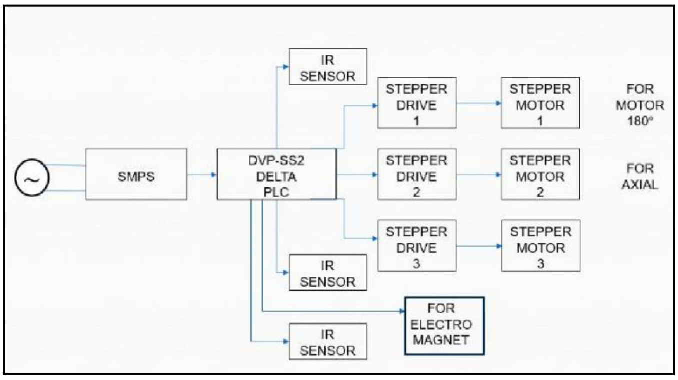

Fig 1: Block diagram of system

This project automates the pick-and-place process while prioritizing operator safety using sensors and emergency shutdown systems. The setup is managed using a Delta DVP-SS2 PLC, which serves as the central controller for the entire process. As the PLC operates on 24V DC, an SMPS is integrated into the system to convert the standard 220V AC input into 24V DC output. To control movement across three axes, three stepper motors are utilized, each of which is connected through dedicated drivers to the PLC. These drivers are necessary because the PLC cannot directly drive the motors. To ensure a safe working environment and prevent accidents, the system includes infrared sensors that constantly monitor for human presence and can immediately stop operations if needed.[5][7]

3.3 METHODOLOGY

The proposed methodology for the Pick and Place Robotic Arm controlled by a PLC begins with the system initialization, where the process starts by pressing a start push button. Once activated, the arm goes towards the predefined position. The electromagnet positioned at the robotic arm is powered on by the PLC to pick up the metallic object. The arm then moves, adjusting its height with the up down motor and rotating in specified increments (90°, 180°, 270°, 360°) through the rotation of stepper motor. The arm places the object at the desired location, and the PLC controls the timing of each movement through its internal timers to ensure precision. After placing the object, the electromagnet is deactivated to release the object, and the arm returns to its home position and repeats the operation as per our requirement, additionally infrared sensors are used for human safe operation.[6][8]

4. FLOWCHART

The flowchart represents the sequence of operations in a PLC-controlled pick-and-place robotic arm system designed with a focus on human safety. The process begins with the system initialization, triggered by pressing the START push button. Once initiated, the robotic arm moves to a predefined location where the object is to be picked. The PLC then activates an electromagnet mounted on the arm to securely grasp the object. After successfully picking up the object, the arm adjusts its position through vertical and rotational movements, which are handled by stepper motors controlled by the PLC.[2][6]

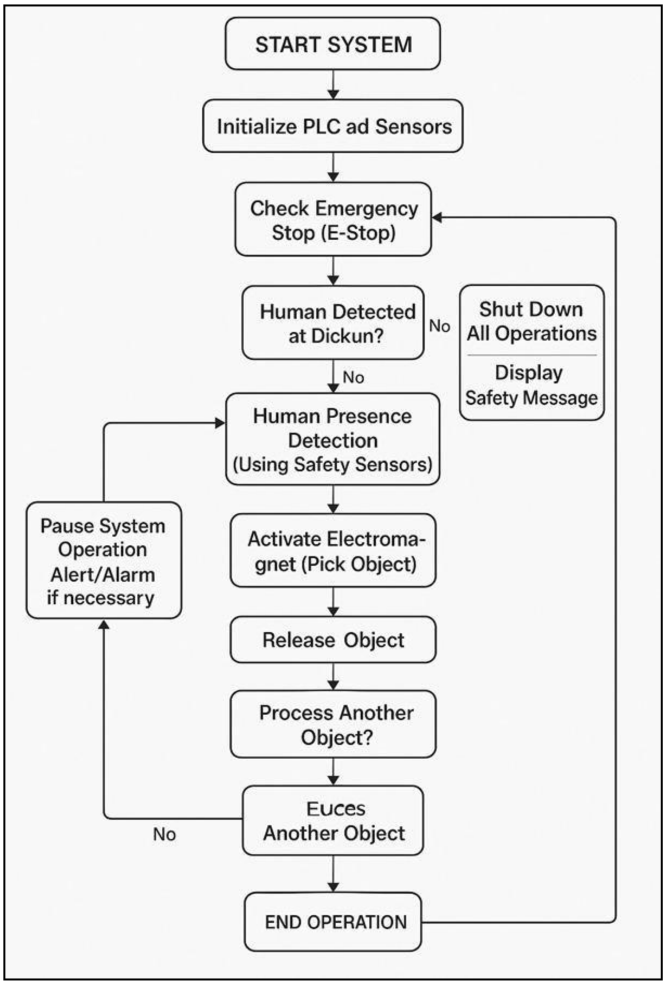

Fig 2: Flow chart of PLC control program

These movements allow the arm to orient and reach the designated placement area. Once in position, the PLC deactivates the electromagnet, releasing the object precisely at the intended location.[9]

5. CONCLUSION

The integration of Programmable Logic Controllers (PLCs) with comprehensive safety protocols in robotic material handling marks a significant advancement in industrial automation. This project successfully showcased how automation can enhance operational efficiency, reduce human errors, and create a safer workplace environment. By employing PLCs, the system was able to deliver precise control and real-time monitoring of material handling tasks, ensuring reliable and consistent performance. Safety mechanisms such as emergency stops, sensors, and interlocks were incorporated to maintain safe operating conditions, protecting both machinery and personnel from potential hazards.

A detailed circuit diagram illustrating all connections between the servo driver and servo motor was designed using AutoCAD software. Pulse calculations for the stepper motor were performed to accurately drive the 3-
axis robotic arm, and the ladder logic was developed and programmed using ISPSoft software. After each operation, the robotic arm returns to its home position, ready for the next cycle. Infrared (IR) sensors continuously monitor the workspace to detect any human interference, automatically triggering emergency stops when necessary. Additionally, the system includes a manual STOP push button, allowing operators to halt the process at any time and maintain full control over the automation system.

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REFERENCES

[1] Robot arm control with arduino by abdellatif baba.

[2] Design, Manufacturing and Analysis of Robotic Arm with SCARA Configuration Kaushik Phasale1, Praveen Kumar2, Akshay Raut3, Ravi Ranjan Singh4, Amit Nichat5 1,2,3,4Students, 5Assitant Professor, Department of Mechanical Engineering, JSPM's Bhivarabai Sawant Institute of Technology & Research, Wagholi, Pune, Maharasthra, India.

[3] Object detection and recognition for a pick and place Robot by Rahul Kumar ; Sunil Lal ; Sanjesh Kumar ; Praneel Chand published in AsiaPacific World Congress on Computer Science and Engineering.

[4] GUI Based Pick and Place Robotic Arm for Multipurpose Industrial Applications by Rasika Yenorkar ; U. M. Chaskar in 2018 Second International Conference on Intelligent Computing and Control Systems(ICICCS).

[5] Motion Control of Robotic Arm for Micro- Positioning in Industrial Application by Prachi. P. Sonawane ; Gayatri M. Phade published in 2018 International Conference On Advances in Communication and Computing Technology (ICACCT).

[6] Safdar, B. (2015). "Theory of Robotics Arm Control with PLC." Saimaa University of Applied Sciences, Faculty of Technology, Mechanical Engineering and Production Technology.

[7] Jagan, R., Singh, P.R., Ashirvadam, C.H., & Navitha, K. (2017). "Auto & Manual Control of Robotic Arm Using PLC." International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, 6(8).

[8] Högskoleingenjör, F.A. (2017). "Application and Control of Robotic Manipulator through PLC." Luleå tekniska universitet, Institutionen för teknikvetenskap och matematik.

[9] Global Journals (2017). "PLC based Robot Manipulator Control using Position based and Image Based Algorithm." Global Journal of Researches in Engineering, XVII(I).