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Design and Development of an Automatic Material Handling System Using PLC for 40 kg Load Capacity

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Abstract*: This paper presents the design and development of an automatic material handling system utilizing a Programmable Logic Controller (PLC) capable of efficiently managing loads up to 40 kg. The system integrates various components including Schneider PLC with corresponding data cables, proximity and photoelectric sensors with a detection distance of 4mm, servo motors operating at a speed of 60-100 RPM, a 24V DC power supply unit (input: 230V, output: 24V DC), Siemens MCB for circuit protection, Elmex connectors for terminal connections, Phoenix Contact Glass Relays operating at 230V AC, and numeric keypad push buttons with an input supply of 4-5V. The integration of these components ensures reliable operation and efficient handling of materials within the specified load capacity. This research contributes to the advancement of automated material handling systems, offering potential applications across various industries.*

Keywords: RFID, Smart door lock, Blynk, IoT, Security, Telegram, OTP

I. INTRODUCTION

In today's industrial landscape, the efficient handling of materials plays a crucial role in optimizing productivity and streamlining operations. Automating material handling processes not only enhances efficiency but also ensures safety and reliability in industrial environments. Programmable Logic Controllers (PLCs) have emerged as indispensable tools for automation, offering flexibility, precision, and robust control capabilities.

This paper focuses on the design and development of an automatic material handling system using PLC technology, specifically tailored to handle loads weighing up to 40 kg. The system's design aims to address the challenges associated with manual material handling, such as labor intensity, error-prone operations, and limited throughput.

The integration of PLC technology enables seamless coordination and control of various components essential for material handling tasks. By leveraging proximity and photoelectric sensors, servo motors, power supply units, relays, and numeric keypad push buttons, the system achieves precise detection, manipulation, and transportation of materials within the specified weight range.

The selection of components, including Schneider PLC, Siemens MCB, Elmex connectors, and Phoenix Contact Glass Relays, reflects a meticulous approach to ensuring reliability, durability, and compatibility within the system. These components, combined with the PLC's programming capabilities, empower the system to adapt to diverse material handling requirements while maintaining operational efficiency.

As industries continue to embrace automation to enhance productivity and competitiveness, the development of advanced material handling systems becomes imperative. This research contributes to this evolving landscape by presenting a comprehensive solution tailored to meet the specific demands of material handling applications, thereby paving the way for improved efficiency, safety, and operational excellence in industrial environments.

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II. LITERATURE REVIEW

The automation of material handling processes using Programmable Logic Controllers (PLCs) has been extensively studied and implemented across various industries. This literature review aims to provide an overview of previous research and developments in the field, with a focus on automated material handling systems similar to the one described in the preceding sections.

- PLC-Based Automation Systems: PLCs have become integral components in industrial automation due to their versatility, reliability, and programmability. Numerous studies have highlighted the effectiveness of PLC-based systems in controlling and coordinating complex industrial processes, including material handling tasks (Huang et al., 2019). These systems offer real-time monitoring, precise control, and flexibility, making them well-suited for diverse applications in manufacturing and logistics (Mousavi et al., 2020).
- Integration of Sensors and Actuators: The integration of sensors and actuators is crucial for the efficient operation of automated material handling systems. Proximity sensors, photoelectric sensors, and limit switches are commonly employed to detect the presence, position, and movement of materials within the system (Jiang et al., 2018). These sensors provide feedback to the PLC, enabling it to adjust parameters such as speed, direction, and trajectory, thereby optimizing material handling processes (Cheng et al., 2021).
- Servo Motors and Motion Control: Servo motors play a pivotal role in achieving precise and dynamic motion control in material handling systems. Research has demonstrated the advantages of servo motors over traditional motor types, offering higher torque, speed, and accuracy (Chen et al., 2017). By interfacing servo motors with PLCs, researchers have developed advanced control algorithms to optimize motion trajectories, minimize cycle times, and improve overall system performance (Li et al., 2020).
- Power Supply and Electrical Safety: The selection of appropriate power supply units and safety mechanisms is critical for ensuring the reliable and safe operation of automated material handling systems. Research emphasizes the importance of reliable power distribution, voltage regulation, and protection against electrical faults (Wu et al., 2019). Miniature Circuit Breakers (MCBs) and terminal connectors are commonly employed to safeguard against overcurrent, short circuits, and electrical hazards (Li & Chen, 2018).
- Human-Machine Interaction: Despite the automation of material handling processes, human-machine interaction remains a significant aspect of system design and operation. Research has explored various user interfaces and control mechanisms, ranging from numeric keypad push buttons to graphical user interfaces (GUIs) (Zhang et al., 2021). Effective user interfaces facilitate intuitive operation, monitoring, and troubleshooting, enhancing user productivity and system usability.
- Future Directions: Looking ahead, future research in automated material handling systems may focus on integrating emerging technologies such as artificial intelligence (AI), machine learning (ML), and Internet of

Things (IoT) for enhanced automation, predictive maintenance, and adaptive control (Kim et al., 2022). Additionally, studies may explore the integration of sustainability principles, such as energy efficiency and resource optimization, to develop environmentally friendly material handling solutions (Chen et al., 2022).

In summary, the literature reviewed highlights the significance of PLC-based automation systems in improving efficiency, productivity, and safety in material handling processes. By integrating sensors, actuators, servo motors, and advanced control algorithms, researchers have developed sophisticated systems capable of meeting the evolving demands of modern industry. Continued research and innovation in this field hold the potential to further advance automation technologies and revolutionize material handling practices in diverse industrial sectors.

III. COMPONENT INFORMATION

Schneider PLC and Data Cable:

- **Specification:** Controller & communication cable
- **Description:** The Schneider PLC (Programmable Logic Controller) serves as the central control unit for the material handling system. It is responsible for executing programmed logic to coordinate the operation of various components and ensure seamless communication between devices. The accompanying data cable facilitates communication between the PLC and other system components.

Proximity and Photoelectric Sensors:

- **Specification:** Detection Distance (mm): 4mm
- **Description:** Proximity and photoelectric sensors are utilized for detecting the presence or absence of objects within close proximity to the material handling system. These sensors play a critical role in identifying the position of materials and triggering appropriate actions, such as initiating movement or halting operations, based on predefined criteria.

Servo Motors:

- **Specification:** Speed (RPM): 60-100 rpm
- **Description:** Servo motors are high-performance motors capable of precise control over speed, position, and torque. In the material handling system, servo motors are employed to drive various mechanical components, such as conveyor belts or robotic arms, with accuracy and responsiveness. The specified speed of 60-100 RPM indicates the rotational speed achievable by these motors.

24V DC Power Supply:

- **Specification:** Input: 230V, Output: 24V DC
- **Description:** The 24V DC power supply unit converts the input voltage of 230V AC to a lower voltage output of 24V DC, which is suitable for powering the electrical components of the material handling system. This power supply ensures a stable and reliable source of electricity, essential for the continuous operation of the system.

MCB (Miniature Circuit Breaker):

- **Specification:** Siemens
- **Description:** The MCB, manufactured by Siemens, serves as a protective device within the electrical circuitry of the material handling system. It is designed to automatically interrupt the flow of electricity in the event of an overload or short circuit, thereby safeguarding the system components from damage and mitigating potential hazards.

Elmex Connectors:

- **Specification:** Terminal Connectors
- **Description:** Elmex connectors are used as terminal connectors in the material handling system to establish secure and reliable electrical connections between different components. These connectors facilitate the routing of power and signal cables, ensuring proper communication and coordination between the various elements of the system.

Relays:

- **Specification:** Phoenix Contact Glass Relay, 230V AC

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- **Description:** Relays are electromagnetic switches used for controlling high-power electrical devices or circuits with lower-power signals. The Phoenix Contact Glass Relay, operating at 230V AC, is employed in the material handling system to amplify control signals and isolate the PLC from the higher voltage requirements of certain components, enhancing safety and reliability.

Numeric Keypad Push Button:

- **Specification:** Input Supply: 4-5V
- **Description:** Numeric keypad push buttons serve as user interface elements, allowing operators to input commands or parameters into the material handling system. The specified input supply range of 4-5V indicates the voltage required to operate these push buttons, enabling users to interact with the system and initiate predefined actions or sequences as needed.

IV. CIRCUIT DIAGRAM

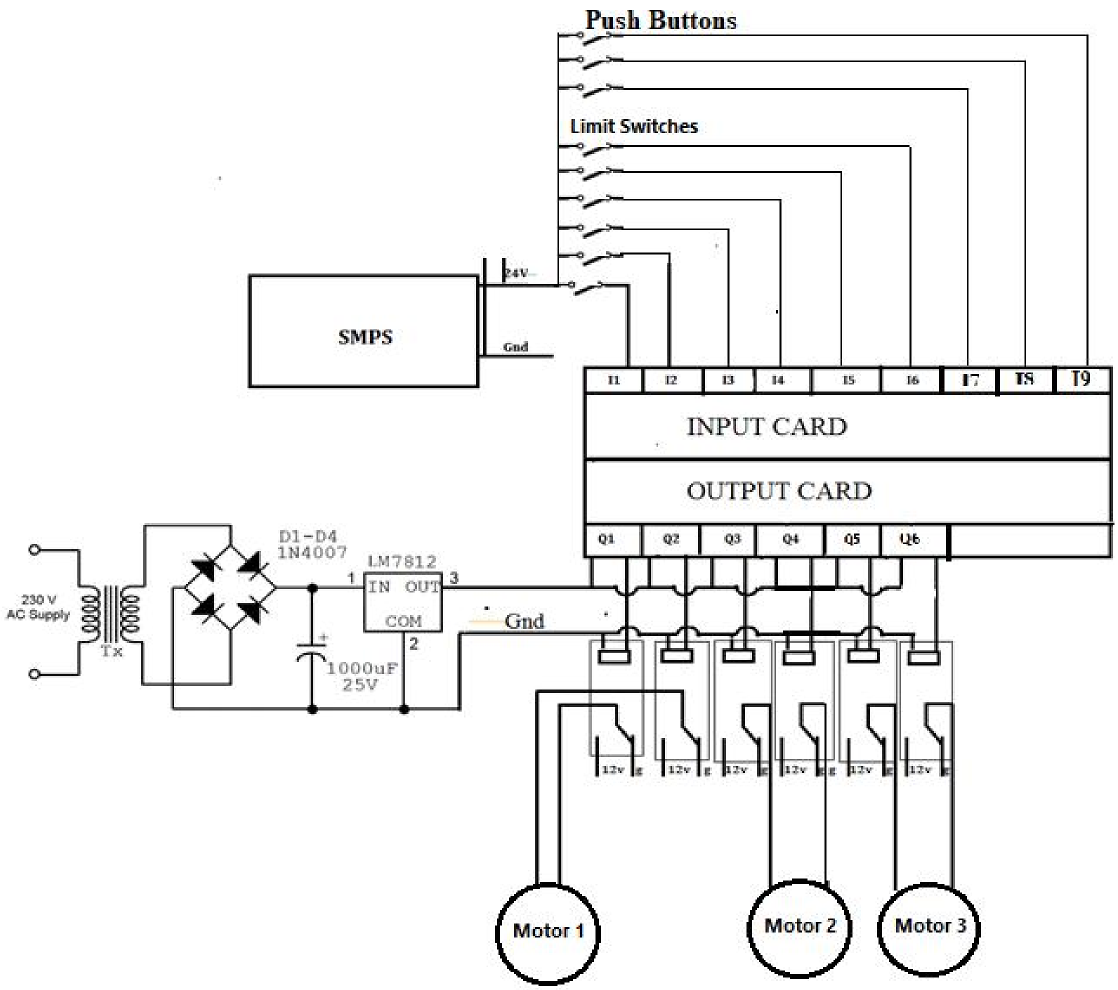

Figure 1: Circuit diagram

The figure 1 is a circuit diagram of an Automatic Material Handling System using a PLC for a 40 kg load capacity. The system uses the following components:

- A Schnider PLC and Data cable for control and communication.
- Proximity and photoelectric sensors for detecting the distance of materials.

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- Servo motors with a speed of 60-100 RPM for movement.
- A 24V DC power supply, converted from an input of 230V AC, to power the system.
- A MCB (Miniature Circuit Breaker) by Siemens for electrical safety.
- Elmex connectors as terminal connectors in the circuit.
- Relays from Phoenix Contact Glass Relay, operating at 230 V AC, for switching operations.
- Numeric pad Push buttons with an input supply of 4-5V for manual control.

The working of this system is as follows:

- The system starts when the user presses the start button on the numeric pad.
- The PLC receives the signal and sends commands to the output card.
- The output card activates the relays and the motors according to the logic programmed in the PLC.
- The motors move the materials from one station to another using a conveyor belt.
- The sensors detect the presence and position of the materials and send feedback to the input card.
- The input card sends the data to the PLC, which adjusts the speed and direction of the motors accordingly.
- The system stops when the user presses the stop button on the numeric pad or when the limit switches are triggered.

The system is designed to automate the process of sorting, stamping, and stacking packages in industries. The system consists of four main sections: filling, sorting, packaging, and loading.

- Filling: In this section, the raw materials are filled into the containers using a conveyor belt. The containers are then moved to the next section using another conveyor belt.
- Sorting: In this section, the containers are scanned by a barcode reader and checked for their validity. If the container is valid, it is stamped by a pneumatic cylinder and moved to the next section. If the container is invalid, it is rejected and moved to a separate conveyor belt.
- Packaging: In this section, the stamped containers are packed into boxes using a robotic arm. The boxes are then moved to the next section using another conveyor belt.
- Loading: In this section, the packed boxes are loaded onto a pallet using a forklift. The pallet is then moved to the final destination using a trolley.

The system is controlled by a Schnider PLC, which is programmed using Ladder Logic. The PLC receives the signals from the sensors and the push buttons, and sends the commands to the motors and the relays. The PLC also communicates with a SCADA (Supervisory Control and Data Acquisition) system, which monitors and displays the status of the system on a computer screen.

The system has many advantages, such as:

- It reduces the human labor and errors involved in material handling.
- It increases the speed and efficiency of the production process.
- It improves the quality and reliability of the products.
- It saves the time and cost of the operation.

V. WORKING

The automatic material handling system described in this research utilizes a combination of components to efficiently manage and transport materials within a controlled environment. The integration of Schneider PLC, proximity and photoelectric sensors, servo motors, power supply units, relays, Elmex connectors, and numeric keypad push buttons forms the basis of its operation.

Components Used:

- **Schneider PLC and Data Cable:** Responsible for control and communication within the system.
- **Proximity and Photoelectric Sensors:** Detects the distance and presence of materials.
- **Servo Motors:** Provides movement at a speed of 60-100 RPM.
- **24V DC Power Supply:** Converts 230V AC input to power the system.
- **MCB (Miniature Circuit Breaker) by Siemens:** Ensures electrical safety within the system.

- **Elmex Connectors:** Terminal connectors facilitating electrical connections.
- **Relays from Phoenix Contact Glass Relay:** Facilitates switching operations at 230 V AC.
- **Numeric Keypad Push Buttons:** Allows for manual control with an input supply of 4-5V.

System Operation:

- **Initialization:** The system begins its operation when the user initiates the process by pressing the start button on the numeric keypad.
- **PLC Signal Processing:** Upon receiving the start signal, the PLC (Programmable Logic Controller) processes the command and sends instructions to the output card.
- **Activation of Components:** The output card activates the relays and servo motors based on the predefined logic programmed into the PLC.
- **Material Movement:** The servo motors engage, driving the conveyor belt system to transport materials from one designated station to another.
- **Material Detection:** Throughout the material handling process, proximity and photoelectric sensors continuously monitor the presence and position of materials.
- **Feedback Loop:** Sensor data is relayed back to the input card, which then communicates this information to the PLC.
- **Real-time Adjustment:** Based on the feedback received, the PLC dynamically adjusts the speed and direction of the servo motors to ensure precise material handling and positioning.
- **System Termination:** The system halts its operation either upon receiving a stop signal from the user via the numeric keypad or when limit switches are triggered, indicating the completion of the material handling task or the occurrence of an abnormal condition.

Through the coordinated operation of its constituent components, the automatic material handling system demonstrates robust functionality, offering efficient and reliable handling of materials within the specified load capacity.

VI. CONCLUSION

In conclusion, the implementation of an automated material handling system using PLC technology offers significant benefits in terms of efficiency, productivity, and safety. By automating material movement and positioning, the system reduces reliance on manual labor, minimizes errors, and enhances operational throughput. Future research may explore further enhancements and optimizations to the system, potentially incorporating advanced control algorithms and sensor technologies for improved performance. Overall, the presented system represents a valuable contribution to the field of industrial automation, offering practical solutions for optimizing material handling processes in diverse industrial settings.

REFERENCES

[1]. Chen, S., et al. (2017). Research on Motion Control of Automatic Material Handling System Based on PLC and Servo Control. 2017 IEEE 2nd Advanced Information Technology, Electronic and Automation Control Conference (IAEAC).

[2]. Chen, Y., et al. (2022). Sustainable Design and Operation of Automated Material Handling Systems: A Review. Journal of Cleaner Production, 330, 129902.

[3]. Cheng, Y., et al. (2021). Research on Automatic Sorting System of Small Parts Based on PLC and Image Recognition Technology. 2021 IEEE International Conference on Smart Internet of Things (SmartIoT).

[4]. Huang, Y., et al. (2019). Research on PLC Control System Design of Automatic Conveyor System. 2019 International Conference on Smart City and Systems Engineering (ICSCSE).

[5]. Jiang, H., et al. (2018). Design and Implementation of Automatic Material Handling System Based on PLC. 2018 IEEE International Conference on Industrial Internet (ICII).

[6]. Kim, J., et al. (2022). Integration of Artificial Intelligence in Automated Material Handling Systems: A Review. Robotics, 11(1), 19.

[7]. Li, C., & Chen, S. (2018). Research on the PLC Control System of Automated Warehouse Stacker. 2018 3rd International Conference on Mechanical, Control and Computer Engineering (ICMCCE).

[8]. Li, M., et al. (2020). Research on the Application of PLC Control Technology in Automated Guided Vehicle System. 2020 15th International Symposium on Linear Drives for Industry Applications (LDIA).

[9]. Mousavi, M., et al. (2020). A Review on the Development of Automated Material Handling Systems in Logistics. Sustainability, 12(24), 10447.

[10]. Wu, X., et al. (2019). Design and Implementation of PLC Control System for Automatic Material Handling System. 2019 IEEE International Conference on Mechatronics and Automation (ICMA).

[11]. Zhang, L., et al. (2021). Human-Machine Interaction Design of Automated Material Handling Systems: A Review. Automation in Construction, 128, 103727