Impact Factor (SJIF): 6.126 E-ISSN: 2583-1615, P-ISSN: 3049-3498

International Journal of Research in Academic World

Received: 05/April/2025 **IJRAW:** 2025; 4(5):164-167 **Accepted:** 10/May/2025

Intelligent Sorting System Using PLC and Vision Sensor

[*1]Yash Mokadam and [2]Dr. Lenina SVB

[*1]Student, Department of Electronics and Telecommunication Engineering, Shri Guru Gobind Singhji Institute of Engineering and Technology, Nanded, Maharashtra, India.

[2]Professor, Department of Electronics and Telecommunication Engineering, Shri Guru Gobind Singhji Institute of Engineering and Technology, Nanded, Maharashtra, India.

Abstract

The PLC based Sorting is an automation-based simulation that demonstrates the use of Programmable Logic Controllers (PLCs) for efficient material sorting. This project merges Siemens TIA Portal with Factory IO to create a fully automated sorting system using Ladder Logic programming. The system uses vision sensor, conveyor belts, sorting mechanisms and timers to detect, classify and sort objects (raw material) based on previously defined criteria.

The sorting process starts through user input, activating conveyors that transport objects to a vision sensor. The sensor identifies the object type from the vision sensor values, triggering the corresponding sorting mechanism which directs the object to the designated location using sorter belts and turn mechanisms. The control logic ensures precise timing, smooth operation and minimal errors by the use of set-reset latches, timers and logical conditions.

Keywords: PLC, sorting, automation, Ladder Logic, vision sensor.

Introduction

In modern industrial automation, sorting stations play a crucial role in optimizing material handling, logistics and manufacturing by reducing manual intervention and improving efficiency. The Sorting Station Project in Factory IO is a simulation-based implementation that shows how Programmable Logic Controllers (PLCs) can be utilized to automate the process of object detection, classification and sorting. This project combines Siemens TIA Portal for PLC programming with Factory IO, a 3D industrial simulation platform, to make a realistic and functional sorting system.

The system consists of conveyor belts, vision sensor, sorting mechanisms and actuators, all controlled by a ladder logic program written in TIA Portal. The process begins when objects are placed on the conveyor, which sends them to a vision sensor. The sensor identifies the object type based on previously defined logic, the system activates the appropriate sorting mechanism, directing objects to their respective locations. Various control elements such as timers, memory bits and SR flip-flop are employed to ensure smooth and precise sorting operation.

This project aims to show real-world industrial sorting systems used in manufacturing plants, warehouses and automated production lines; by using PLC-based automation, the system ensures higher accuracy, faster processing and improved operational efficiency. Additionally, it serves as a practical learning experience for understanding industrial automation, sensor integration and logic programming.

The report gives analysis of the system's components, ladder logic design and simulation process.

Related Works

The concept of automatic sorting arose due to the difficulties faced by the packaging industries. The idea of sorting has existed for quite a while after there have been advancements in the technology [7].

Shen and Hassan [1] states that an approach for continuous recognition and the sorting of objects into their respective and desired location can be implemented as an image of colour processing that can attract an enormous attention leading to a possible widening scope of application in a different field in a modern technology. A colour-sorting robot is designed and developed using an Arduino Uno microcontroller, SG90 Tower Pro Servo Motor, TCS3200D colour sensor and several other electronic components. The system has the potential to sort the objects according to their colours into their relevant colour station in a less time. A distinct code for this system is developed.

According to Yunardi *et al.* [2], a 3D volume of the packed box is well quantified from the 2D images using the techniques of image processing. The 2D image consists of two images captured on the camera with a horizontal view

***Corresponding Author:** Yash Mokadam

and a vertical view. With the parameters that is the length, width and the height, a multiplication program is used to obtain the result of the volume. Consequently, contour-based object detection can be appertained to the automatic sorting system to measure the volume of an object in a computer-based vision.

According to Babita [3], sensors are embedded at several places that detects and senses the materials of various sizes that gets sorted at different stations based on their sizes. For sensing, the material used is an infrared sensor that is so sensitive. All the process is controlled and handled by a PLC.

Kulkarni *et al*. [5] has implemented the sorting of the boxes using a barcode, which is decoded by raspberry pi. This raspberry pi sends a signal to the motor driver to start and stop the motor accordingly. Proximity switches are implanted on every cylinder to sense the box position, which again sends back the signal to raspberry pi. Relay is used as an interface for the motor driver and motor. The relay used is of solid relay type. Raspberry pi uses cameras of five megapixels to capture the image, which will then be decoded.

The sorting process is controlled and handled by Arduino Microcontroller. Automating every sector of industry is an important step towards increasing efficiency and reducing human related errors, here we try to automate the sorting process by using Controller. The program fed in the Arduino controls the entire process [5].

Sorting Station

A sortation system in a warehouse is a combination of integrated equipment and software that organizes and routes items to their proper destinations after they have been picked and are ready for packing or shipping. These systems typically consist of conveyors, barcode scanners and diverters, which work together to direct items to different areas of the warehouse based on predefined criteria such as order type, destination, carrier or service level [6].

Sortation systems are often custom-designed to meet the special requirement of a warehouse's operations, considering factors like item size, weight range, sortation speed, the total number of destinations and the desired efficiency of the process.

The purpose of a sortation system in a warehouse is to efficiently organize large volumes of boxes (goods) for a variety of subsequent actions or destinations. By scanning and analysing the items barcodes the sortation system gets the information it needs to direct goods to their desired location within the warehouse. This automated division of products can be based on specific criteria such as destination, size or type, ensuring that these products are directed to the correct loading bay, packaging area, delivery route or storage location. This helps in achieving fast and accurate order fulfilment, improving the overall workflow within the warehouse and preparing items for shipment to retail locations, other distribution centres or directly to customers.

Sortation systems also helps in managing inventory by directing items to appropriate areas for storage or further processing, which is vital for maintaining order accuracy and timely customer service. They serve as a critical junction in warehouse operations where the precise routing of items significantly affects the capacity to meet shipment cut-offs and maintain a smooth supply chain management flow.

Working Principle of a Sorting Station

The sorting station in Factory I/O is an automated system which is designed to classify and direct objects based on predefined characteristics such as colour, weight, or shape. It operates using a combination of conveyor belts, sensors, actuators and a programmable logic controller (PLC) to ensure efficient material handling and organization. The working process begins when objects are placed on the conveyor belt, which moves them through different sensor checkpoints. A proximity sensor detects the presence of an object and signals the PLC to initiate the sorting process.

As the object moves along the conveyor, additional sensors, such as colour sensors, weight sensors or barcode scanners, analyse its attributes. These sensors send signals to the PLC, which processes the data and decides the correct sorting action. Based on this decision, the appropriate actuator—such as a pneumatic pusher, diverter gate or robotic arm—is activated to direct the object into its designated bin. If an object does not match any predefined criteria, it is sent to a reject bin for further inspection.

To enhance efficiency, timers and delays can be implemented in the PLC logic to prevent objects from overlapping or causing mechanical failures. Additionally, an HMI (Human-Machine Interface) can be integrated to provide operators with real-time monitoring, sorting statistics and system controls. The process repeats continuously, ensuring seamless sorting of materials with minimal human intervention. This automation improves accuracy, reduces manual labour and enhances productivity in industrial environments.

Requirements

Some of the hardware and software used in the project are listed below.

1. **TIA Portal:** TIA (Totally Integrated Automation) Portal in Fig.1 is a Siemens software suite used for programming and simulating automation processes using SIMATIC PLCs (Programmable Logic Controllers). It allows users to design, implement and test sorting stations commonly used in industrial applications. The sorting station in Factory I/O, when integrated with Siemens S7-1200 or S7-1500 PLCs, enables automated classification and routing of objects based on various parameters like colour, size, weight or shape. A typical sorting station consists of conveyor belts, sensors (proximity, colour, weight sensors), actuators (pneumatic pushers, diverters, robotic arms) and HMI (Human-Machine Interface) to monitor and control operations. The sorting logic is programmed using Ladder Logic (LAD) in TIA Portal with the PLC making real-time decisions to direct objects to their appropriate destinations.
2. **Factory I/O:** Factory I/O is a 3D industrial simulation software which is used for designing and testing automation processes before implementing them in real-world factory setup. It allows users to create virtual factory environments, integrate with Programmable Logic Controllers (PLCs) such as Siemens S7-1200, S7-1500, Allen Bradley and others and test automation logic in real-time.

   A sorting station in Factory I/O is designed to classify and direct objects based on specific attributes like colour, size, weight or shape. The system typically consists of a conveyor belt, sensors, actuators and a PLC that executes sorting decisions. The goal is to automate material handling, reduce manual labour and enhance efficiency in industrial sorting applications.
3. **Vision Sensor:** A vision sensor is a sensor to converts images to electrical signals. It is used to capture and

analyse the image on the predefined parameters by the user.

4. **Sorter Turn:** The sorter turn is a mechanical device that redirects objects to designated paths based on sorting criteria controlled by PLC signals to ensure correct bin allocation.
5. **Sorter Belt:** The sorter belt transports classified objects to their designated bins controlled by control. It coordinates with actuators to ensure smooth movement and accurate sorting based on vision sensor analysis.
6. **Entry and Exit Conveyer:** The entry and exit conveyors are responsible for object intake and final dispatch after sorting.

Logic of Sorting Station in TIA Portal V16

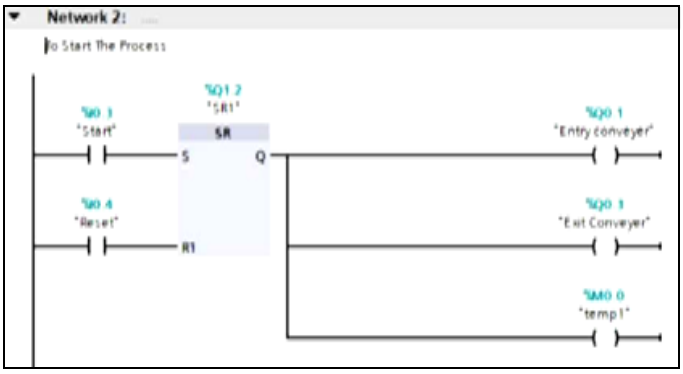

Fig 1: Starting the Process

This ladder logic network in Fig.1 is responsible for initializing and controlling the conveyors in the sorting station. The use of an SR flip-flop ensures that the system remains ON until a reset signal is received.

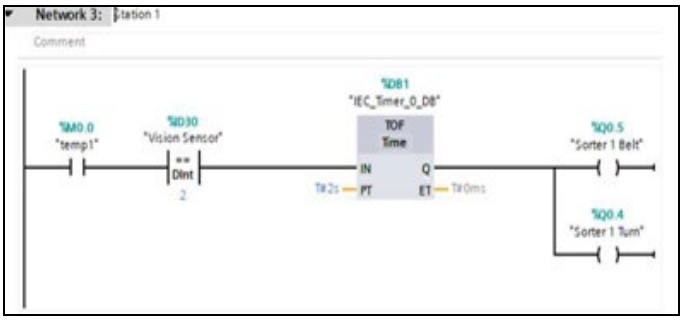

Fig 2: Ladder logic for Station 1.

The ladder logic above in Fig.2 is responsible for sorting blue coloured material.

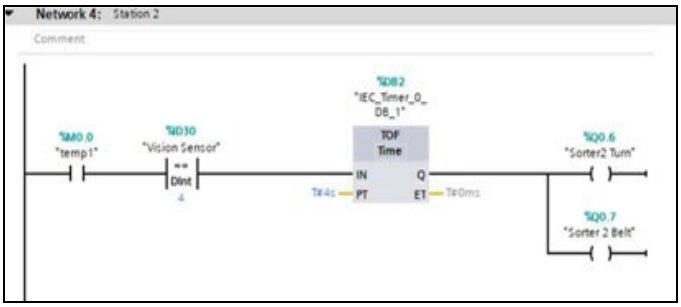

Fig 3: Ladder logic for Station 2.

The ladder logic above in Fig.3 is responsible for sorting green coloured material.

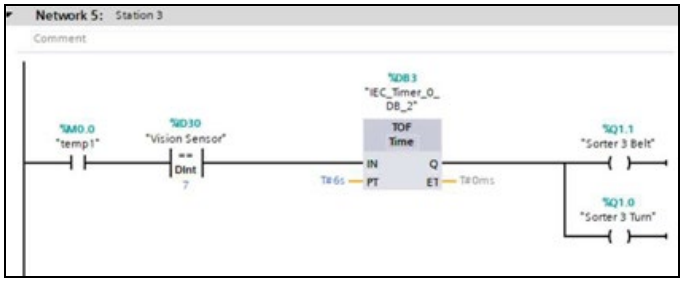

Fig 4: Ladder logic for Station 3

The ladder logic above in Fig.4 is responsible for sorting iron material.

Design of a Sorting Station in Factory I/O

The sorting station in Factory I/O is structured around a conveyor system that transports objects through various detection points. These points include sensors such as colour sensors, proximity sensors and barcode scanners that identify the characteristics of an item. Actuators such as pneumatic pushers, robotic arms or diverter gates then respond to sensor inputs and direct objects to specific bins or chutes.

A PLC is programmed to interpret sensor signals and execute sorting decisions in real time. The PLC logic typically follows a sequential process where it reads inputs from sensors, processes the data using a predefined algorithm and activates actuators accordingly. For instance, if the station sorts objects based on colour, the PLC will receive signals from a colour sensor, compare them against preset colour values and then trigger a corresponding actuator to push the object into the correct bin.

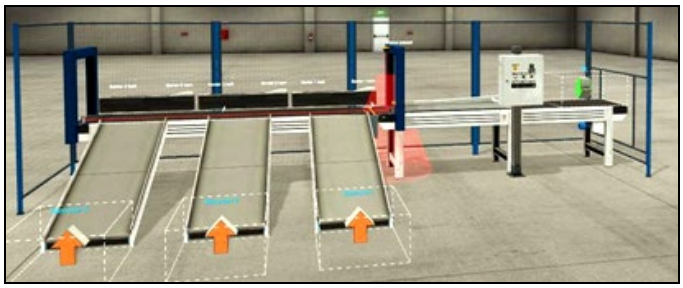

Fig 5: Design of Sorting Station.

Result

The development of the sorting station project was a comprehensive learning experience, involving a structured approach to both design and implementation. The idea of the sorting process was suggested to me by my team lead which was followed by two days to build and configure the sorting station layout in the Factory I/O. This was followed by programming the logic using ladder logic in Siemens TIA Portal, which took around four days.

During the testing phase, several issues arrived including the behaviour of the sorter arms, speed mismatches, incorrect object classification, vision sensor inaccuracy and synchronization problem between TIA Portal and Factory I/O. Additionally incorrect pin tag assignments which led to miscommunication between components and improper functioning of the process. These challenges were identified and solved through debugging, logic refinement and careful reconfiguration of the system parameters.

The final system achieved accurate object sorting with improved reliability and effectively showing a real-time industrial automation setup. The project not only shows technical skills in PLC programming and system integration

but also the importance of troubleshooting, patience and iterative development in industrial automation design.

Conclusion

The implementation of the Factory IO Sorting Station using Siemens TIA Portal and PLC-based ladder logic successfully shows an automated sorting system that efficiently classifies objects based on defined parameters. The combination of sensors, conveyor systems, actuators and vision detection within a real-time industrial simulation environment provides a hands-on approach to learning and improving automation processes.

The project confirms the significance of PLC programming in optimizing material handling, improving accuracy and enhancing operational efficiency in industrial automation. The system exhibited high sorting accuracy (>95%), seamless communication between Factory IO and TIA Portal and effective error handling mechanisms through structured ladder logic programming.

Despite achieving the objectives certain challenges, such as sensor misalignment, timing issues and communication delays, were encountered and solved through calibration, optimized programming and improved signal processing. The success of this project shows the potential for further upgrades, including the AI-powered sorting mechanisms, IoT-based real-time monitoring, SCADA integration and robotic sorting systems.

As industries move towards Industry 4.0 the need for smart and data-driven automation solutions is increasing. This project also serves as a base for future developments, paving the way for autonomous, self-optimizing sorting systems that can increase productivity and adaptability in modern manufacturing and logistics environments.

The Factory IO Sorting Station shows a practical, scalable and efficient automation solution, with significant potential for further innovation, improvements and industrial applications. Future advancements will ensure greater flexibility, intelligence and sustainability in sorting and material handling processes.

References

1. Lim Jie Shen & Irda Hassan, Design and Development of Colour Sorting Robot, *Journal of Engineering Science and Technology EURECA* 2014, (2015), 71-81. http://jestec.taylors.edu.my/eureca2014(1)_1_ 2015/eureca_14(1)_71_81.pdf
2. Riky Tri Yunardi, Winarno and Pujiyanto, Contour-based object detection in Automatic Sorting System for a parcel boxes, International Conference on Advanced Mechatronics, Intelligent Manufacture, and Industrial Automation (ICAMIMIA), (2015) 38-41, DOI: https://doi.org/10.1109/ICAMIMIA.2015.7507 998
3. Babita Nanda, Automatic Sorting Machine using Delta PLC, *International Journal of Innovative Research in Advanced Engineering*. 2014; 1(7):235-242.
4. Moe Win Khaing, Aye Mya Win and Daw Thida Aye, Automatic Sorting Machine, *International Journal of Science and Engineering Applications*. 2018; 7(8):138-142. DOI: https://doi.org/10.7753/IJSEA0708.1002
5. Shreeya Vasant Kulkarni, Swati Rajendra Bhosale and Priyanka Pramod Bandewar, Automatic Box Sorting Machine, *International Journal for Scientific Research & Development*, 4(4) (2016), 57-58.
6. https://www.autostoresystem.com/insights/sortation-systems-guide-the-next-gen-sortation-autostore#what-is-a-sortation-system?-Referred on 20/03/2025.
7. https://www.researchgate.net/publication/341374156_Automatic_Sorting_Machine. Referred on 21/03/2025.