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Control Conveyor by Implementation Siemence PLC S7-1200

A Project Submitted to The Mechanical Engineering Department

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In the Partial Fulfillment of the Requirements for the Degree of

Bachelor of Science in Mechanic and Mechatronic Engineering

By

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DECLARATION

I hereby affirm that the work detailed in this report was conducted within the Department of Mechanics and Mechatronics Engineering at the University of Salahaddin, under the guidance of Dr. Chalang H.R. I solemnly declare that, to the best of my knowledge, none of the content of this report has been previously submitted, either here or elsewhere, for the purpose of obtaining a degree. Proper acknowledgment has been provided for all sources of knowledge utilized in this research endeavor.

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Aram Khalid Kaka Bra

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CERTIFICATION

This document certifies that the project titled "Controlling Conveyor through the Implementation of S7-1200 PLC", undertaken by Aram Khalid Kaka Bra, has been reviewed and deemed satisfactory in fulfilling a portion of the requirements and standards necessary for the conferral of the Bachelor of Engineering degree in Mechanical and Mechatronic Engineering from the University of Salahaldin, Erbil, Kurdistan Region of Iraq.

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Throughout the duration of our four-month research endeavor as undergraduate students at the University of Salahadin, I consider myself privileged to have collaborated with my esteemed lecturers, Dr. Chalang, Mr. Abdulla, and Eng. Shaho (From ALA Company).

Firstly, I express my gratitude to divine providence for blessing me with wisdom and the opportunity for education. I extend my heartfelt appreciation to our supervisor, Dr. Chalang, as well as to my lecturers, Mr. Abdulla, and Eng. Shaho, for their unwavering guidance, insightful ideas, encouragement, and enthusiastic support throughout the course of our research. Each interaction with them has been enriching, stimulating, and a valuable learning experience.

Furthermore, I wish to express our sincere gratitude to the University of Salahaddin and all our dedicated instructors for their invaluable contributions to our academic journey.

AIM

The scientist's daily endeavor at the Full Academy for Research involves crafting PLC programs to address challenges encountered in factories and various industrial settings. Determined to develop innovative solutions, I am committed to creating PLC programs aimed at efficiently controlling conveyors to accommodate objects of varying lengths, such as boxes, bags in airplanes, vegetable, and sets, among others. This approach enables precise control over conveyor systems, facilitating the separation of objects based on their length. Moreover, these programs can trigger the activation of subsequent conveyors to further segregate objects according to their size.

ABSTRACT

Efficient goods movement in industries hinges on controlling conveyors, which transport items from one point to another. We're honing in on the crucial aspect of adapting conveyors to the length of the items they handle, employing the Siemens S7-1200 PLC for this purpose. This approach not only facilitates length-based sorting but also enhances the overall efficiency of the process by synchronizing with other machinery. Central to our exploration are key inquiries such as devising a user-friendly sorting program, identifying cost-effective strategies, and ensuring precision without compromising speed. Through this investigation, we aim to streamline conveyor control with practical and effective solutions tailored to real-world applications.

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CHAPTER ONE

Introduction

In the world of industries and factories, managing the movement of goods efficiently is crucial. One key aspect of this is controlling conveyors, which are used to transport items from one place to another. Figuring out how to control these conveyors based on the length of the objects they carry is incredibly useful. For example, in airports, it's essential to sort luggage by size to ensure smooth loading onto planes. This kind of sorting is also valuable in other industries, such as separating fruits or boxes by size or organizing packages by length.

To address this challenge, we're turning to the Siemens S7-1200 PLC, a powerful tool for controlling machines. With this technology, we can program conveyors to operate based on the length of the items they're transporting.

Using this technology allows us to do more than just sort items by length. We can also coordinate the operation of other machinery, like activating additional conveyors or turning on lights or motors or push slender, to make the entire process more efficient.

As we delve into this topic, we have some important questions to consider:

1. How can we create a straightforward program to sort objects by their length on the conveyor?
2. What are the most cost-effective methods for achieving this?
3. How can we ensure that our sorting is highly accurate without sacrificing speed?

These questions will guide us as we explore how to control conveyors based on the length of objects, using simple program and practical solutions.

1. Introduction to PLC Control Systems and Automation

This chapter is an introduction to the world of PLCs and their evolution over the past 50 years as the top choice and most dominant among all systems available for process-control and automation applications

A programmable logic controller (PLC) is a microprocessor-based computer unit that can perform control functions of many types and varying levels of complexity. The first commercial PLC system was developed in the early 1970s to replace hardwired relay controls used in large manufacturing assembly plants. The initial use of PLCs covered automotive assembly lines, jet engines, and large chemical plants. PLCs are used today in many tasks including robotics, conveyors system, manufacturing control, process control, electrical power plants, wastewater treatment, and security applications. This chapter is an introduction to the world of PLCs and their evolution over the past 50 years as the top choice and most dominant among all systems available for process-control and automation applications.

1.1Control System Overview

A control system is a device or set of structures designed to manage, command, direct, or regulate the behavior of other devices or systems. The entire control system can be viewed as a multivariable process that has a number of inputs and outputs that can affect the behavior of the process. Figure 1 shows this functional view of control systems. This section is intended as a brief introduction to control systems.

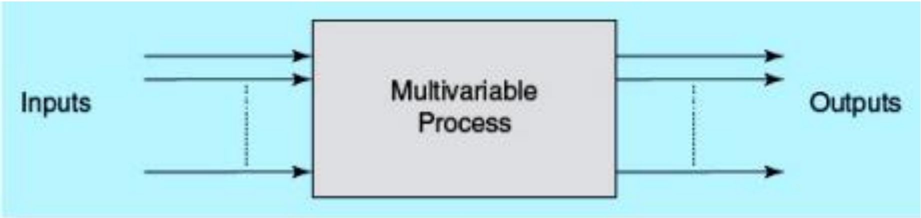


Figure 1. Control systems functional view.

1.2.1 What Is a PLC?

A programmable logic controller (PLC) is an industrial computer that receives inputs from input devices and then evaluates those inputs in relation to stored program logic and generates outputs to control peripheral output devices. The I/O modules and a PLC functional block diagram are shown in Fig. 2. Input devices are sampled and the corresponding PLC input image table is updated in real time. The user’s program, loaded in the PLC memory through the programming device, resolves the predefined application logic and updates the output internal logic table. Output devices are driven in real time according to the updated output table values.

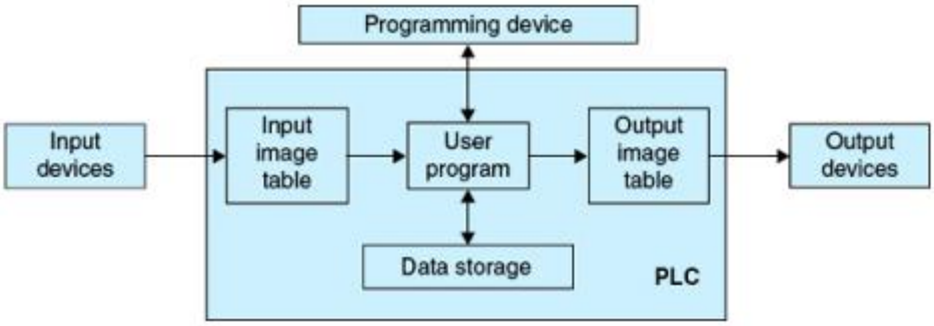


Figure 2.input-output (I/O) PLC architecture.

Standard interfaces for both input and output devices are available for the automation of any existing or new application. These interfaces are workable with all types of PLCs regardless of the selected vendor. Sensors and actuators allow the PLC to interface with all kinds of analog and ON/OFF devices through the use of digital I/O modules, analog-to-digital (A/D) converters, digital to-analog (D/A) converters, and adequate isolation circuits. Apart from the power supply input and the I/O interfaces, all signals inside the PLC are digital and low voltage.

Since the first deployment of PLCs four decades ago, old and new vendors have competed to produce more advanced and easier-to-use systems with associated user-friendly development and communications tools. Figure 1.19 shows a sample of actual industrial and popular PLCs. You should notice the diversity of sizes and obviously associated capabilities, thus not only allowing cost accommodation but also enabling the design and implementation of complex distributed control systems. Most vendors allow the integration of other PLCs as part of a networked distributed control system. It is also possible to implement extremely large system control on one PLC system with large number of interconnected chassis and modules.

Figure 3.Typical industrial PLCs.

Wikipedia states that “a programmable logic controller (PLC) or programmable controller is a digital computer used for automation of electromechanical processes, such as control of machinery on factory assembly lines, amusement rides, or light fixtures.” PLCs are used in many industries and machines. Unlike general-purpose computers, the PLC is designed for multiple input and output arrangements, extended temperature ranges, immunity to electrical noise, and resistance to vibration and impact. Programs to control machine operation are typically stored in battery-backed-up or nonvolatile memory. A PLC is an example of a hardwired real-time system because output results must be produced in response to input conditions within a bounded time; otherwise, unintended operation will result. Most of the electromechanical components needed for hardwired control relay systems are completely eliminated, resulting in great reduction in space, power consumption, and maintenance requirements. A PLC is a device that can replace the necessary sequential relay circuits needed for process control. The PLC works by sampling its inputs and, depending on their state, actuating its outputs to bring about desired changes in the controlled system. The user enters a program, usually via software, that allows control systems to achieve the desired result. Programs are typically written in ladder logic, but higher-level development environments are also available. The International Electrotechnical Commission (IEC) 1131-3 Standard (global standard for industrial control programming) has tried to merge PLC programming languages under one international standard. We now have PLCs that are programmable in function block diagrams, instruction lists, C computer language, and structured text all at the same time! Personal computers (PCs) are also being used to replace PLCs in some applications. PLCs are used in a great many real-world applications. The evolution of the competitive global economy mandated industries and organizations to commit to investments in digital process control and automation using PLCs. Wastewater treatment, machining, packaging, robotics, materials handling, automated assembly, and countless other industries are using PLCs extensively. Those who are not using this technology are wasting money, time, quality, and competitiveness. Almost all application that use electrical, mechanical, or hydraulic devices have a need for PLCs. For example, let’s assume that when a switch turns on, we want to turn on a solenoid for 15 seconds and then turn it off regardless of the duration of the switch ON position. We can accomplish this task with a simple external timer. What if our process includes 100 switches and solenoids? We would need 100 external timers to handle the new requirements. What if the process also needed to count how many times the switches individually turned ON? We’d have to employ a large number of external counters along with the external timers. All this would require extensive wiring, energy, and space and expensive maintenance requirements. As you can see, the bigger the process, the more of a need there is for PLCs. You can simply program the PLC to count its inputs and turn the solenoids on for the specified time.

1.2.2 History of PLCs

Prior to the introduction of PLCs, all production and process-control tasks were implemented using relay-based systems. Industrialists had no choice but to deal with this inflexible and expensive control system. Upgrading a relay-based machine-control production system means a change to the entire production system, which is very expensive and time-consuming. In 1960s, General Motors (GM) issued a proposal for the replacement of relay-based machines. PLC history started with an industrialist named Richard E. Morley, who was also one of the founders of Modicon Corporation in response to the GM proposal. Morley finally created the first PLC in 1977 and sold it to Gould Electronics, which presented it to General Motors. This first PLC is now safely kept at company headquarters. The website plcdev.com shows the history (reproduced in the following figures) of the development of the PLC by different manufacturers. It spans the period from 1968 to 2005. The new S7-1200 microcontroller was introduced by Siemens in 2009. It was designed to provide an easy-touse and scalable infrastructure for small and large distributed control applications. Details of the S7- 1200 and associated interfaces, including hardware, software communication, and networking, along with industrial-control application implementation using this Siemens infrastructure. Reduction in size, lower cost, larger capabilities, standard interfaces, open communication protocols, user-friendly development environment, and HMI tools are the trend in the evolution of PLCs, as shown in timeline. The history of PLCs is displayed in time categories starting from the early systems introduced from 1968 to 1971. This is followed by a span of 6 years labeled as the first PLC generation. The second generation started in 1979 and covered a period of 7 years, ending in 1986. This period showed a greater number of vendors mostly from existing U.S. companies in addition to German and Japanese firms. The early third generation started 1987 and lasted for 10 years, followed by a lasting period of continued growth and advancement in both hardware and software tools, which led to a wide deployment of PLCs in most manufacturing automation and process control activities.

1.3 Conveyors

Conveyors are like busy highways in factories and warehouses, moving goods from one place to another smoothly. They're super important for making sure things get where they need to be without any hiccups. But what's really cool is how we can control these conveyors to work just the way we want them to. Controlling conveyors is like being the conductor of an orchestra – you decide how fast they go, where they go, and when they stop. This control is crucial for making sure everything runs smoothly in factories and warehouses, and it helps save time and effort too. Over time, technology has made controlling conveyors even better. We now have smart systems called programmable logic controllers (PLCs) that help us control conveyors with precision. These controllers allow us to make quick changes to the conveyor's speed and direction, adapting to different needs and situations. With the help of sensors and smart algorithms, modern conveyors can even think for themselves! They can adjust their speed and behavior based on what's happening around them, making sure everything keeps moving smoothly. As industries embrace new technologies and ways of working, the importance of conveyor control only grows. By mastering conveyor control, factories and warehouses can become more efficient, flexible, and ready for whatever challenges come their way. It's like having a superpower for keeping things moving in the right direction. Figure 4, shown conveyor tracking which is programmed by PLC.

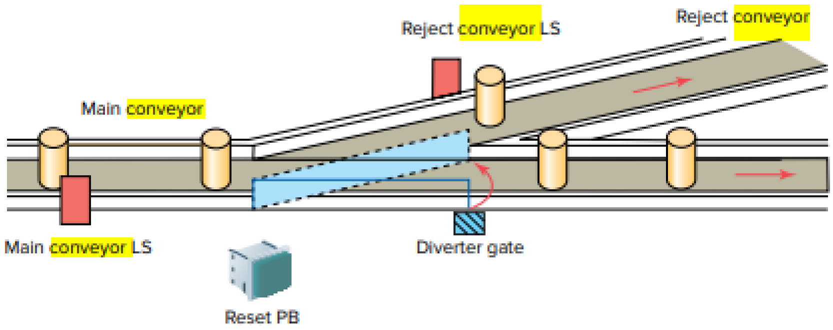


Figure 4.Conveyor parts tracking program.

1.4 Literature review

1. "Automated Conveyor Control System Using PLC" by Arun Prakash, Alok Kumar Pandey, Pankaj Patel (2016), In this article, Prakash and his team talk about how they made a system to control conveyor belts using a special computer called a PLC. They explain how they connected sensors and machines to the PLC to make the conveyor belts move smoothly and sort items accurately. This article is helpful for anyone who wants to understand how to use PLCs to control conveyor belts.

2. "Design and Development of a PLC-Based Automatic Object Sorting Conveyor System" by Shahid Ali, Haider Raza, Asghar Hayat, Asif Iqbal (2017), Ali and his colleagues discuss how they created a system to automatically sort objects using a conveyor belt controlled by a PLC. They explain the parts they used and how they programmed the PLC to make the system work. This article is great for people who want to learn about making conveyor belts sort things on their own.
3. "Implementation of PLC for Conveyor Belt Control" by Praveen Kumar Yadav, Virendra Singh Yadav, Shubham Bhadoria, Ashish Yadav (2018), Yadav and his team explain how they used a PLC to control a conveyor belt in a factory. They talk about the different things they connected to the PLC and how they wrote special instructions for the PLC to control the conveyor belt safely and efficiently. This article is useful for understanding how PLCs are used in factories to control conveyor belts.

4. "PLC Based Conveyor Control System" by Prof. A. P. Bangale, Prof. R. V. Kshirsagar, Prof. A. A. Dabade, Prof. M. D. Shende (2019), Bangale and his colleagues discuss how they designed a system to

control conveyor belts using a PLC. They explain the steps they took to choose the right parts and program the PLC to make the conveyor belts move smoothly and safely. This article is helpful for anyone who wants to learn about controlling conveyor belts with PLCs.

5. "Development of PLC-Based Control System for Conveyor Belt" by Himanshu Sharma, Vikash Kumar, Vipul Shrivastava, Chetan Kumar, Rohit Nandanwar (2020), Sharma and his team explain how they built a system to control conveyor belts using a PLC. They talk about the different sensors and machines they connected to the PLC and how they programmed it to control the conveyor belts efficiently. This article is great for understanding how PLCs are used in real-world settings to control conveyor belts.

CHAPTER TWO

Methodology

In this section, an extensive examination will be conducted to explore the myriad parameters essential for effectively controlling a conveyor using the PLC S7-1200, encompassing both hardware and software components, as well as the development of a sophisticated weighing program through ladder diagram programming. This discussion will particularly focus on controlling the conveyor based on the length of objects, a crucial aspect with practical applications ranging from separating bags in airplane luggage handling to sorting fruits in various industrial settings requiring object separation based on length. Through an in-depth analysis of these parameters, including their conceptualization, implementation, and practical implications, this chapter aims to provide comprehensive insights into the intricacies of conveyor control systems driven by the PLC S7-1200 platform.

2.1 PLC Hardware

The S7-1200 PLC provides the flexibility and power to control a wide variety of devices in support of automation needs. The compact design, flexible configuration, and powerful instruction set combine to make the S7-1200 a perfect solution for controlling a wide variety of applications. The central processing unit (CPU) combines a microprocessor, an integrated power supply, input circuits, and output circuits in a compact housing to create a powerful PLC. After downloading the program, the CPU contains the logic required to monitor and control the devices in the application. The CPU monitors the inputs and changes the outputs according to the logic of the user program, which can include Boolean logic, counting, timing, complex math operations, and communications with other intelligent devices.

2.1.1 S7-1200 Processor

The CPU provides a PROFINET port for communication over a PROFINET network. PROFINET uses the Ethernet network protocol as in offices and information technology (IT) departments. However, its capabilities have been enhanced to meet the far-tougher conditions encountered in factory automation, process automation, and other industrial applications. Figure 2.1 shows a typical Siemens S7-1200 processor. The SIMATIC S7-1200 system comes in three different models: CPU 1211C, CPU 1212C, and CPU 1214C.

The following five areas are pointed out:

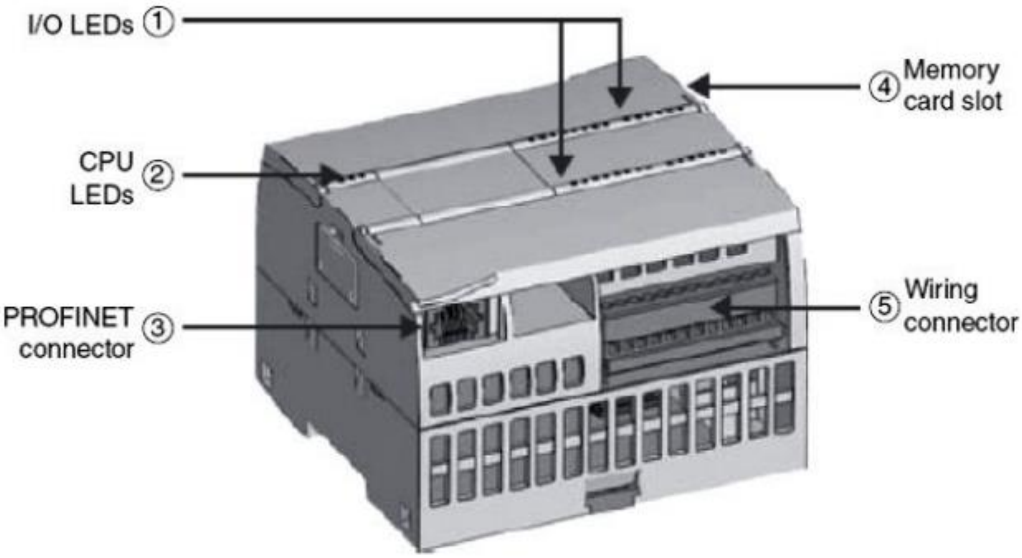


Figure 5.Typical S7-1200 processor.

1. Status light-emitting diodes (LEDs) for the onboard input-output (I/O)
2. Status LEDs for the operational state of the CPU
3. PROFINET connector
4. Memory card slot (under door)
5. Removable user wiring connector

2.1.2.1 Operating Modes of the CPU

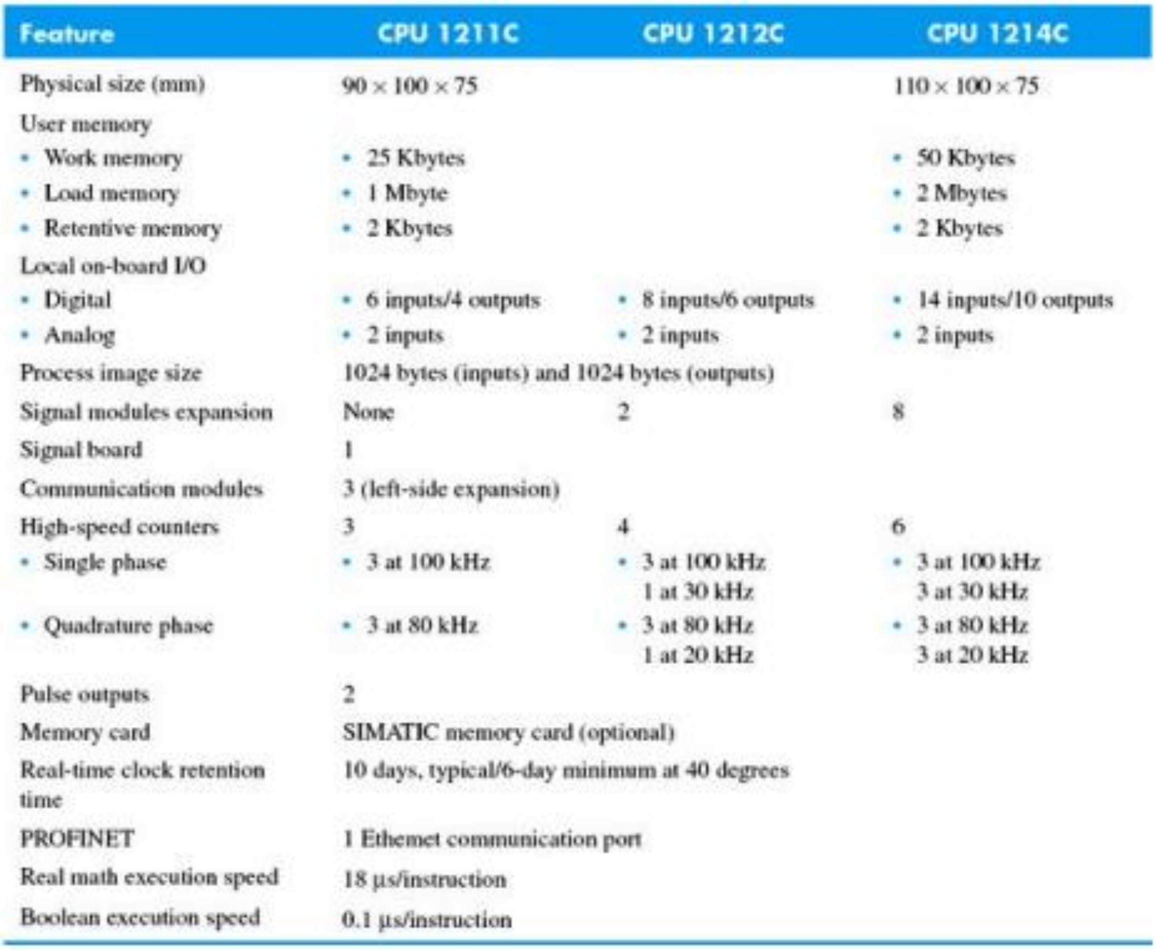
The CPU has three modes of operation: STARTUP, STOP, and RUN. The following are the characteristic of each of the three CPU modes:

- In STOP mode, the CPU is not executing the program. Projects cannot be executed in this mode.
- In STARTUP mode, the startup organizational blocks (OBs) are called by the operating system. OBs (if present) are executed once and usually contain setup instructions. Interrupt events are not processed during the startup phase.
- In RUN mode, the scan cycle is executed repeatedly in the processor memory, and outputs are activated according to the implemented program logics. The program cannot be downloaded in this mode.

2.1.2.2 S7-1200 PLC Memory Organization/Specifications

The S7-1200 PLC is designed to be a microcontroller with compact size, limited resources, and excellent capabilities. Table 1. shows the specification and capabilities of the S7-1200.

Table 1.S7-1200 PLC Specifications.



Feature	CPU 1211C	CPU 1212C	CPU 1214C
Physical size (mm)	90 × 100 × 75		110 × 100 × 75
User memory			
• Work memory	• 25 Kbytes		• 50 Kbytes
• Load memory	• 1 Mbyte		• 2 Mbytes
• Retentive memory	• 2 Kbytes		• 2 Kbytes
Local on-board I/O			
• Digital	• 6 inputs/4 outputs	• 8 inputs/6 outputs	• 14 inputs/10 outputs
• Analog	• 2 inputs	• 2 inputs	• 2 inputs
Process image size	1024 bytes (inputs) and 1024 bytes (outputs)		
Signal modules expansion	None	2	8
Signal board	1		
Communication modules	3 (left-side expansion)		
High-speed counters	3	4	6
• Single phase	• 3 at 100 kHz	• 3 at 100 kHz 1 at 30 kHz	• 3 at 100 kHz 3 at 30 kHz
• Quadrature phase	• 3 at 80 kHz	• 3 at 80 kHz 1 at 20 kHz	• 3 at 80 kHz 3 at 20 kHz
Pulse outputs	2		
Memory card	SIMATIC memory card (optional)		
Real-time clock retention time	10 days, typical/6-day minimum at 40 degrees		
PROFINET	1 Ethernet communication port		
Real math execution speed	18 µs/instruction		
Boolean execution speed	0.1 µs/instruction		

2.1.3 Power Supply

The main function of the power supply is to convert the 120/220-Vac input to the 24 Vdc required for the PLC operation. The power supply has three main components: line conditioner, rectifier, and voltage regulator. The line conditioner purifies the input ac voltage waveform to a smoothed sine wave. The rectifier converts the stepped-down input ac voltage to the required dc voltage level, as shown in Fig. 2. The voltage regulator maintains a constant dc output voltage level by filtering and reducing existing ripples.

Figure 6.S7-1200 power supply.

2.1.4 PROFINET and Ethernet Protocol

The S7-1200 CPU has an integrated PROFINET port that supports both Ethernet and direct connections. Direct communication is used when using a programming device, HMI, or another CPU that can still connect to a single CPU. Network communication is used when two or more devices are connecting (e.g., CPUs, HMIs, programming devices, and non-Siemens devices). Figure 3. shows a programming terminal connected to an S7-1200 PLC. In a direct connection, it is possible to connect a programming device to an S7-1200 CPU, an HMI to an S7-1200 CPU, and an S7-1200 CPU to another S7-1200 CPU. Multiple PLCs/HMIs can be configured and connected to the same network, each with a unique network address identifier.

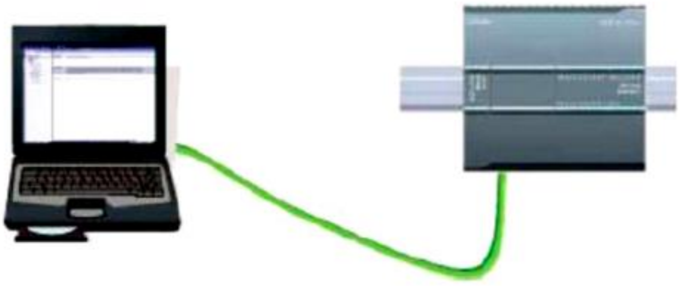


Figure 7.Programming terminals and S7-1200 PLC connection.

2.1.5 Electromagnetic Control Relays

the PLC's original purpose was the replacement of electromagnetic relays with a solid-state switching system that could be programmed. Although the PLC has replaced much of the relay control logic, electromagnetic relays are still used as auxiliary devices to switch I/O field devices. The programmable controller is designed to replace the physically small control relays that make logic decisions but are not designed to handle heavy current or high voltage (Figure 4). In addition, an understanding of electromagnetic relay operation and terminology is important for correctly converting relay schematic diagrams to ladder logic programs.

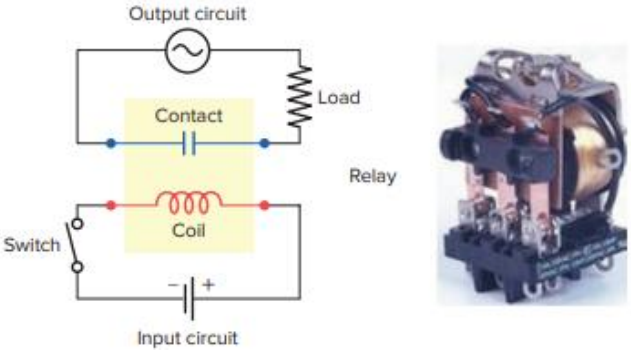


Figure 8.Electromechanical control relay.

An electrical relay is a magnetic switch. It uses electromagnetism to switch contacts. A relay will usually have only one coil but may have any number of different contacts. Figure 5 illustrates the operation of a typical control relay.

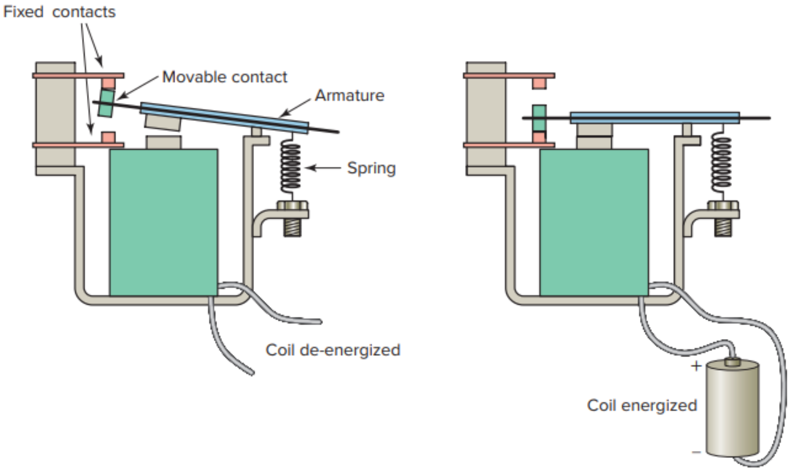


Figure 9.Relay operation.

control relay. With no current flow through the coil (de-energized), the armature is held away from the core of the coil by spring tension. When the coil is energized, it produces an electromagnetic field. Action of this field, in turn, causes the physical movement of the armature. Movement of the armature causes the contact points of the relay to open or close. The coil and contacts are insulated from each other; therefore, under normal conditions, no electric circuit will exist between them. The symbol used to represent a control relay is shown in Figure 6. The contacts are represented by a pair of short parallel lines and are identified with the coil by means of the letters. The letter M frequently indicates a motor starter, while CR is used for control relays. Normally open (NO) contacts are defined as those contacts that are open when no current flows through the coil but that close as soon as the coil conducts a current or is energized. Normally closed (NC) contacts are closed when the coil is de-energized and open when the coil is energized. Each contact is usually drawn as it would appear with the coil de-energized. A typical control relay used to control two pilot lights is shown in Figure 7. The operation of the circuit can be summarized as follows:

- With the switch open, coil CR is de-energized.
- The circuit to the green pilot light is completed through the normally closed contact, so this light will be on.
- At the same time, the circuit to the red pilot light is opened through the normally open contact, so this light will be off.

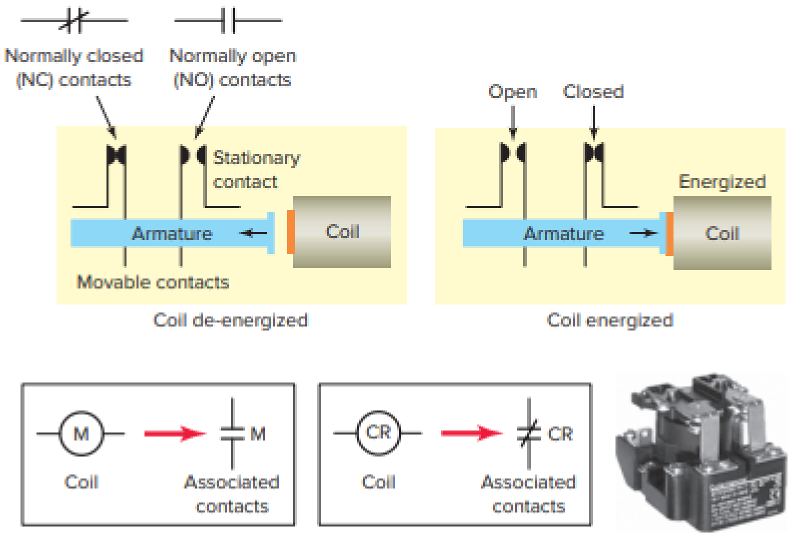


Figure 10.Relay normally open and normally closed contacts.

- With the switch closed, the coil is energized.
- The normally open contact closes to switch the red pilot light on.
- At the same time, the normally closed contact opens to switch the green pilot light off.

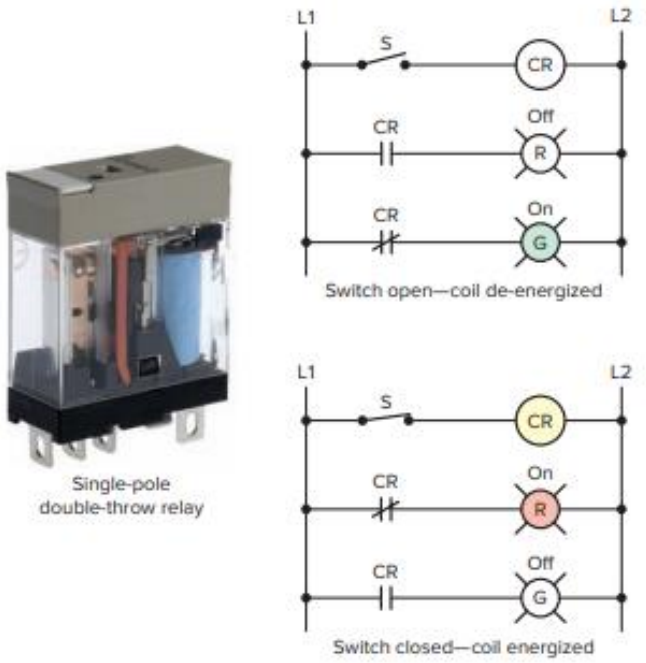


Figure 11.Control relay used to control two pilot lights.

Control relay coils and contacts have separate ratings. Coils are rated for the type of operating current (DC or AC) and normal operating voltage. Contacts are rated in terms of the maximum amount of current the contacts are capable of handling at a specified voltage level and type (AC or DC). Control relay contacts generally are not designed to carry heavy currents or high voltages. The contacts are usually rated between 5 and 10 Amp, with the most common rating for the coil voltage being 120 VAC.

2.1.6 Sensors

Sensors are used for detecting, and often measuring, the magnitude of something. They convert mechanical, magnetic, thermal, optical, and chemical variations into electric voltages and currents. Sensors are usually categorized by what they measure, and they play an important role in modern manufacturing process control.

2.1.6 Light Sensors

The photovoltaic cell and the photoconductive cell, illustrated in Figure 8, are two examples of light sensors. The photovoltaic or solar cell reacts to light by converting the light energy directly into electric energy. The photoconductive cell (also called a photo resistive cell) reacts to light by change in the resistance of the cell. A photoelectric sensor is an optical control device that operates by detecting a visible or invisible beam of light and responding to a change in the received light intensity.

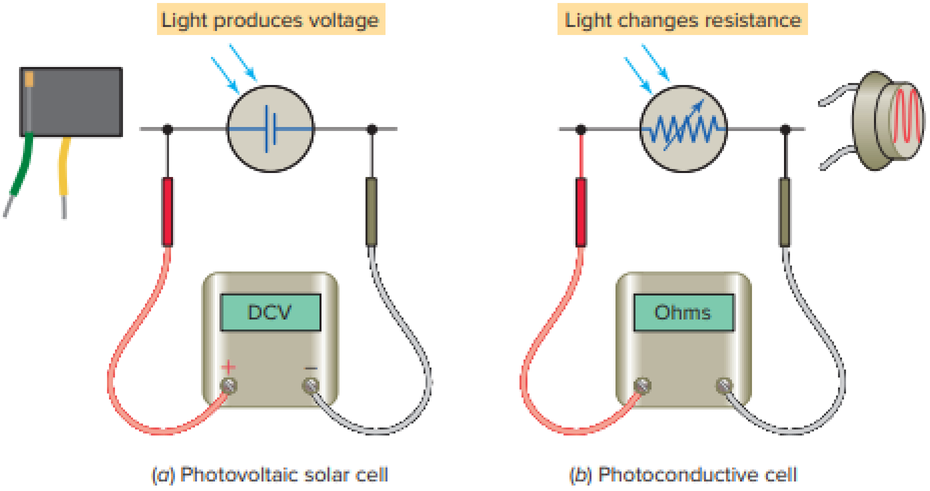


Figure 12.Photovoltaic and photoconductive light cells.

Photoelectric sensors are composed of two basic components: a transmitter (light source) and a receiver (sensor), as shown in Figure 9. These two components may or may not be housed in separate units.

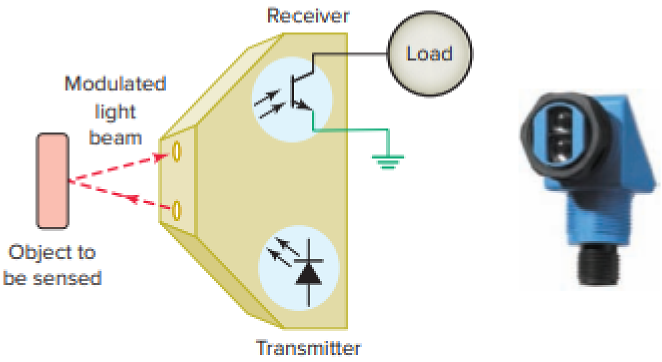


Figure 13.Photoelectric sensor.

The basic operation of a photoelectric sensor can be summarized as follows:

- The transmitter contains a light source, usually an LED along with an oscillator.
- The oscillator modulates or turns the LED on and off at a high rate of speed.
- The transmitter sends this modulated light beam to the receiver.
- The receiver decodes the light beam and switches the output device, which interfaces with the load.
- The receiver is tuned to its emitter's modulation frequency and will amplify only the light signal that pulses at the specific frequency.
- Most sensors allow adjustment of how much light will cause the output of the sensor to change state.
- Response time is related to the frequency of the light pulses. Response times may become important when an application calls for the detection of very small objects, objects moving at a high rate of speed, or both.

The scan technique refers to the method used by photoelectric sensors to detect an object. The through-beams can technique (also called direct scan) places the transmitter and receiver in direct line with each other, as illustrated in Figure 10. Because the light beam travels in only one direction, through-beam scanning provides long-range sensing. Quite often, a garage door opener has a through-beam photoelectric sensor mounted near the floor, across the width of the door. For this application the sensor senses that nothing is in the path of the door when it is closing.

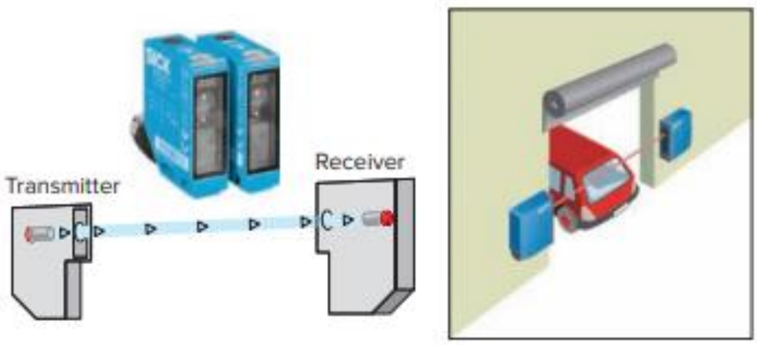


Figure 14.Through-beam scan.

In a retroreflective scan, the transmitter and receiver are housed in the same enclosure. This arrangement requires the use of a separate reflector or reflective tape mounted across from the sensor to return light back to the receiver. The retroreflective scan is designed to respond to objects that interrupt the beam normally maintained between the transmitter and receiver, as illustrated in Figure 11. In contrast to a through-beam application, retroreflective sensors are used for medium range applications. Fiber optics is not a scan technique, but another method for transmitting light. Fiber optic sensors use a flexible cable containing tiny fibers that channel light from emitter to receiver, as illustrated in Figure 12. Fiber optic sensor systems are completely immune to all forms of electrical interference. The fact that an optical fiber does not contain any moving parts and carries only light means that there is no possibility of a spark. This means that it can be safely used even in the most hazardous sensing environments such as a refinery for producing gases, grain bins, mining, pharmaceutical manufacturing, and chemical processing. Bar code technology is widely implemented in industry to enter data quickly and accurately. Bar code scanners are the eyes of the data collection system. A light source within the scanner illuminates the bar code symbol; those bars absorb light, and spaces reflect light. A photodetector collects this light in the form of an electronic-signal pattern representing the printed symbol. The decoder receives the signal from the scanner and converts these data into the character data representation

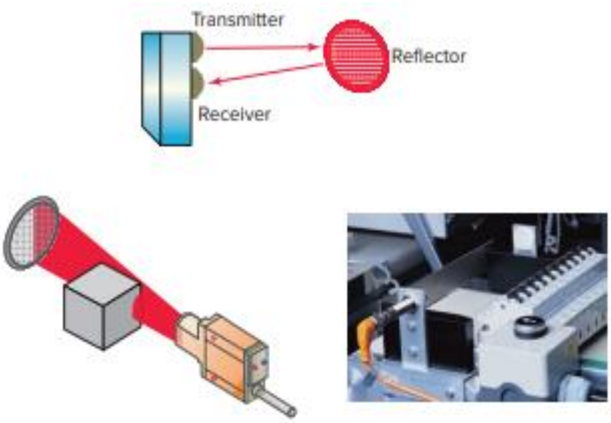


Figure 15.Retroreflective scan.

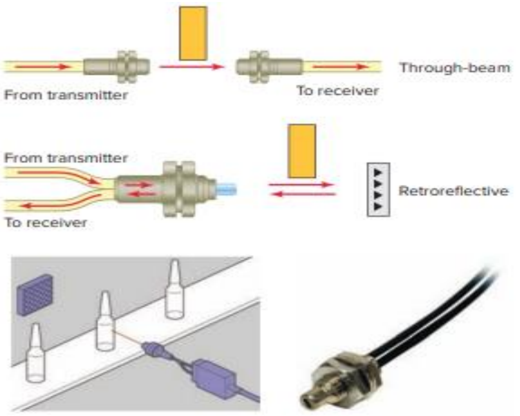


Figure 16. Fiber optic sensors.

of the symbol's code. Figure 13. illustrates a typical PLC application which involves a bar code module reading the bar code on boxes as they move along a conveyor line. The PLC is then used to divert the boxes to the appropriate product lines according to the data read from the bar code.

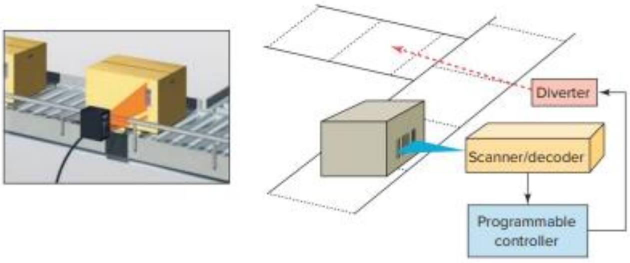


Figure 17.PLC bar code application.

2.2.1 PLC ladder programming

A very commonly used method of programming PLCs is based on the use of ladder diagrams. Writing a program is then equivalent to drawing a switching circuit. The ladder diagram consists of two vertical lines representing the power rails. Circuits are connected as horizontal lines, i.e. the rungs of the ladder, between these two verticals. In drawing a ladder diagram, certain conventions are adopted:

1. The vertical lines of the diagram represent the power rails between which circuits are connected. The power flow is taken to be from the left-hand vertical across a rung.
2. Each rung on the ladder defines one operation in the control process.
3. A ladder diagram is read from left to right and from top to bottom, Figure 14. showing the scanning motion employed by the PLC. The top rung is read from left to right. Then the second rung down is read from left to right and so on. When the PLC is in its run mode, it goes through the entire ladder program to the end, the end rung of the program being clearly denoted, and then promptly resumes at the start. This procedure of going through all the rungs of the program is termed a cycle. The end rung might be indicated by a block with the word END or RET for return, since the program promptly returns to its beginning.

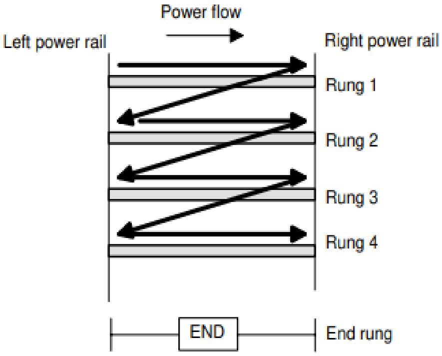


Figure 18.Scanning the ladder program.

4. Each rung must start with an input or inputs and must end with at least one output. The term input is used for a control action, such as closing the contacts of a switch, used as an input to the PLC. The term output is used for a device connected to the output of a PLC, e.g. a motor.
5. Electrical devices are shown in their normal condition. Thus, a switch which is normally open until some object closes it, is shown as open on the ladder diagram. A switch that is normally closed is shown closed.
6. A particular device can appear in more than one rung of a ladder. For example, we might have a relay which switches on one or more devices. The same letters and/or numbers are used to label the device in each situation.
7. The inputs and outputs are all identified by their addresses, the notation used to depend on the PLC manufacturer. This is the address of the input or output in the memory of the PLC.

Figure 15. shows standard IEC 1131-3 symbols that are used for input and output devices. Some slight variations occur between the symbols when used in semi-graphic form and when in full graphic. Note that inputs are represented by different symbols representing normally open or normally closed contacts. The action of the input is equivalent to opening or closing a switch. Output coils are represented by just one form of symbol.

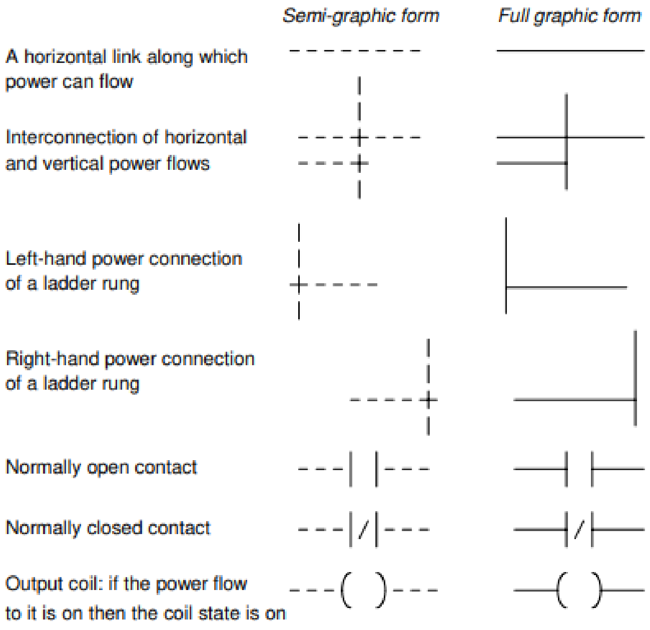


Figure 19.Basic symbols.

To illustrate the drawing of the rung of a ladder diagram, consider a situation where the energizing of an output device, e.g. a motor, depends on a normally open start switch being activated by being closed. The input is thus the switch and the output the motor. Figure 16. (a) shows the ladder diagram.

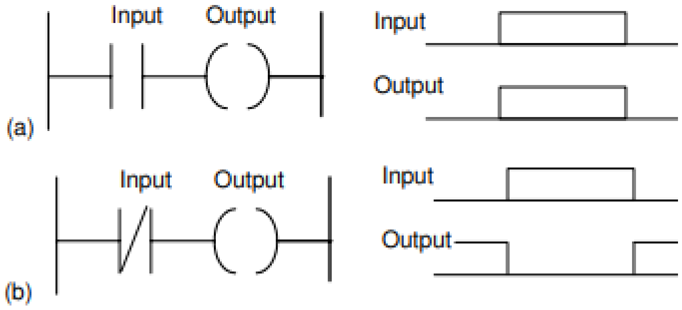


Figure 20.A ladder rung.

Starting with the input, we have the normally open symbol | | for the input contacts. There are no other input devices and the line terminates with the output, denoted by the symbol ( ). When the switch is closed, i.e. there is an input, the output of the motor is activated. Only while there is an input to the contacts is there an output. If there had been a normally closed switch |/| with the output (Figure 16. (b)), then there would have been an output until that switch was opened. Only while there is no input to the contacts is there an output. In drawing ladder diagrams the names of the associated variable or addresses of each element are appended to its symbol. Thus Figure 17. shows how the ladder diagram of Figure 5.5(a) would appear using (a) Mitsubishi, (b) Siemens, (c) Allen-Bradley, (d) Telemecanique notations for the addresses. Thus Figure 17. (a) indicates that this rung of the ladder program has an input from address X400 and an output to address Y430. When wiring up the inputs and outputs to the PLC, the relevant ones must be connected to the input and output terminals with these addresses.

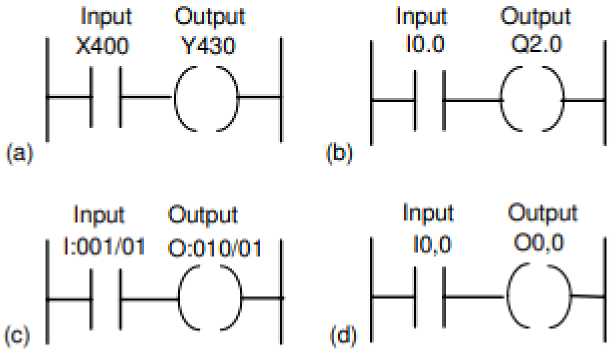
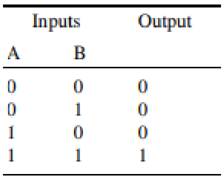


Figure 21.difference type of ladder programming in plc.

2.2.2 AND

Figure 18. (a) shows a situation where an output is not energized unless two, normally open, switches are both closed. Switch A and switch B have both to be closed, which thus gives an AND logic situation. We can think of this as representing a control system with two inputs A and B (Figurec18. (b)). Only when A and B are both on is there an output. Thus, if we usec1 to indicate an on signal and 0 to represent an off signal, then for there to be a 1 output we must have A and B both 1. Such an operation is said to be controlled by a logic gate and the relationship between the inputs to a logic gate and the outputs is tabulated in a form known as a truth table. Thus, for the AND gate we have:



Inputs		Output
A	B	
0	0	0
0	1	0
1	0	0
1	1	1

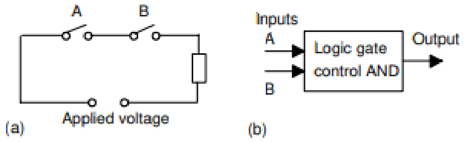


Figure 22. (a) AND circuit, (b) AND logic gate.

An example of an AND gate is an interlock control system for a machine tool so that it can only be operated when the safety guard is in position and the power switched on. Figure 19. (a) shows an AND gate system on a ladder diagram. The ladder diagram starts with | |, a normally open set of contacts labelled input A, to represent switch A and in series with it | |, another normally open set of contacts labelled input B, to represent switch B. The line then terminates with O to represent the output. For there to be an output, both input A and input B have to occur, i.e. input A and input B contacts have to be closed (Figure 19. (b)). In general: On a ladder diagram contacts in a horizontal rung, i.e. contacts in series, represent the logical AND operations.

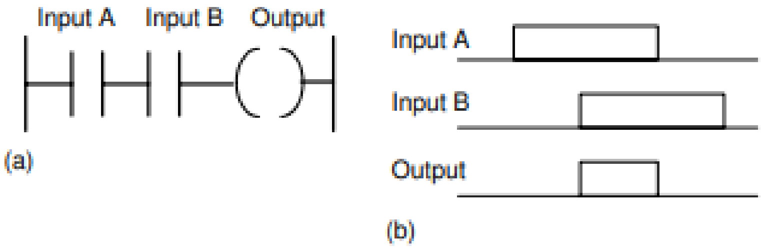


Figure 23.AND gate with a ladder diagram rung.

2.2.3 OR

Figure 20. (a) shows an electrical circuit where an output is energized when switch A or B, both normally open, are closed. This describes an OR logic gate (Figure 20. (b)) in that input A or input B must be on for there to be an output. The truth table is:

Inputs		Output
A	B	
0	0	0
0	1	1
1	0	1
1	1	1

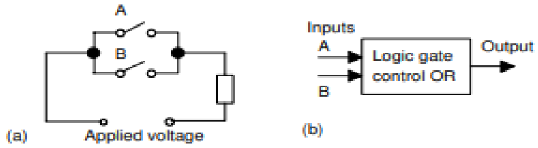


Figure 24.(a) OR electrical circuit, (b) OR logic gate.

Figure 21. (a) shows an OR logic gate system on a ladder diagram, Figure 21. (b) showing an equivalent alternative way of drawing the same diagram. The ladder diagram starts with | |, normally open contacts labelled input A, to represent switch A and in parallel with it | |, normally open contacts labelled input B, to represent switch B. Either input A or input B have to be closed for the output to be energized (Figure 21. (c)). The line then terminates with O to represent the output. In general: Alternative paths provided by vertical paths from the main rung of a ladder diagram, i.e. paths in parallel, represent logical OR operations.

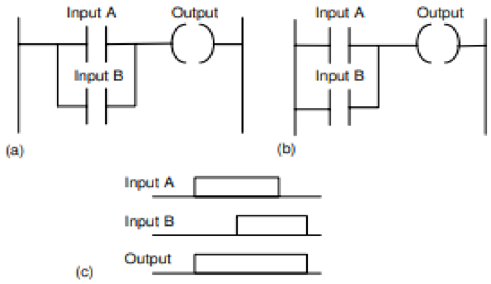


Figure 25.OR gate.

An example of an OR gate control system is a conveyor belt transporting bottled products to packaging where a deflector plate is activated to deflect bottles into a reject bin if either the weight is not within certain tolerances or there is no cap on the bottle.

2.2.4 NOT

Figure 22. (a) shows an electrical circuit controlled by a switch that is normally closed. When there is an input to the switch, it opens and there is then no current in the circuit. This illustrates a NOT gate in that there is an output when there is no input and no output when there is an input (Figure 22. (c)). The gate is sometimes referred to as an inverter. The truth table is:

Input A	Output
0	1
1	0

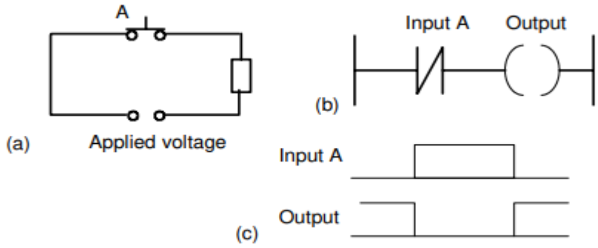
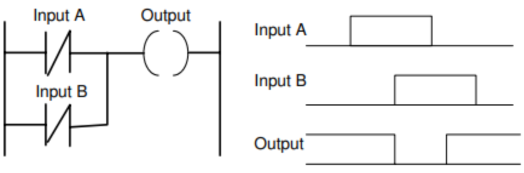


Figure 26.NOR gate.

Figure 22. (b) shows a NOT gate system on a ladder diagram. The input A contacts are shown as being normally closed. This is in series with the output ( ). With no input to input A, the contacts are closed and so there is an output. When there is an input to input A, it opens and there is then no output. An example of a NOT gate control system is a light that comes on when it becomes dark, i.e. when there is no light input to the light sensor there is an output.

In the field of digital logic, various types of gates such as NAND, XOR, and NOR gates exhibit complexities in their utilization. Shown in Figures (23,24,25).



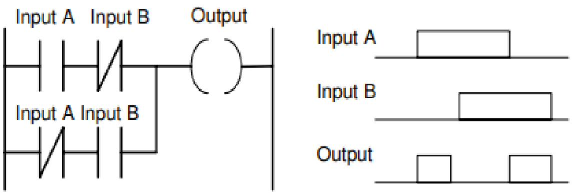


Figure 28. NAND gate.

Figure 27.XOR gate.

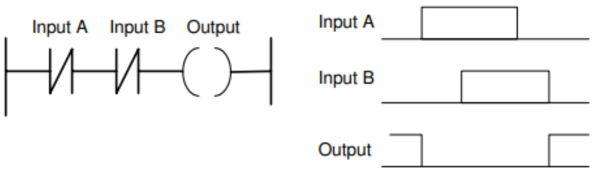


Figure 29.NOR gate.

2.2.5 Latching

There are often situations where it is necessary to hold an output energized, even when the input ceases. A simple example of such a situation is a motor which is started by pressing a push button switch. Though the switch contacts do not remain closed, the motor is required to continue running until a stop push button switch is pressed. The term latches circuit is used for the circuit used to carry out such an operation. It is a self-maintaining circuit in that, after being energized, it maintains that state until another input is received. An example of a latch circuit is shown in Figure 26. When the input A contacts close, there is an output. However, when there is an output, another set of contacts associated with the output closes. These contacts form an OR logic gate system with the input contacts. Thus, even if the input A opens, the circuit will still maintain the output energized. The only way to release the output is by operating the normally closed contact B.

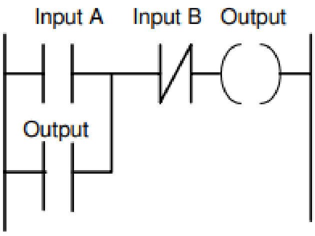
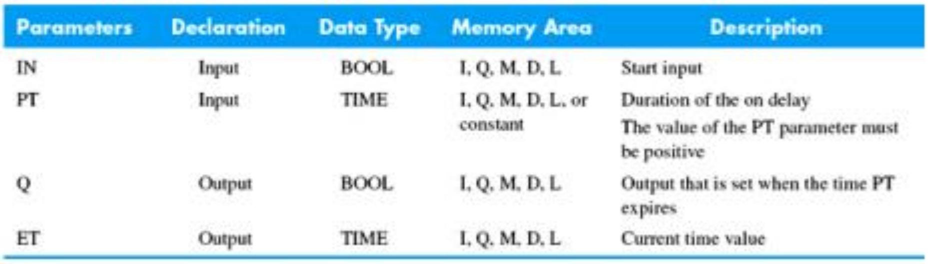


Figure 30.Latched circuit.

2.3 Timer Fundamentals

Siemens S7-1200 timers are available in four different forms: generate ON-DELAY (TON), generate OFF-DELAY (TOF), time accumulator (TONR), and generate pulse (TP). Table 2. shows the parameters for the TON, TOF, and TONR timers. Timer instruction preset/accumulated value uses the M (2 words, 16 bits), D (double words, 32 bits), or L (long, 64 bits) memory area, as shown in the data table.

Table 2.TON, TOF, and TONR Parameters.



Parameters	Declaration	Data Type	Memory Area	Description
IN	Input	BOOL	I, Q, M, D, L	Start input
PT	Input	TIME	I, Q, M, D, L, or constant	Duration of the on delay The value of the PT parameter must be positive
Q	Output	BOOL	I, Q, M, D, L	Output that is set when the time PT expires
ET	Output	TIME	I, Q, M, D, L	Current time value

2.3.1 ON-DELAY Timers (TONs)

This timer's main function is to delay the rising edge of output Q by the predefined period of the preset time (PT). The timer block is shown in Fig. 27. with appropriate tag names assigned. In the figure, these tags are displayed between double quotes. All timer-required variables are displayed using the standard system labels, which start with the percent (%) character. Timer preset-time (PT) input can be defined as displayed or as a constant value.

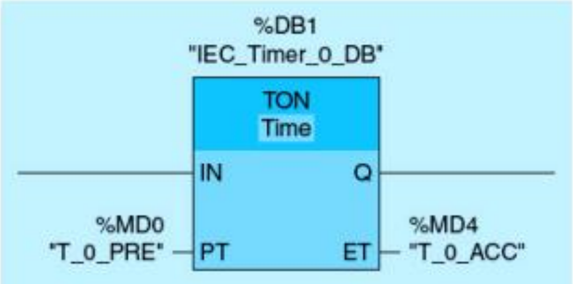


Figure 31. ON-DELAY timer (TON).

If rung input (IN) is TRUE, the timer accumulated value with tag name T_0_ACC will increment. When timer accumulated value is equal to the defined preset value with tag name T_0_PRE, the output Q will change status to ON, and the timer will stop timing. Figure 3.2 illustrates the timer timing diagram. Notice that the delay action applies to timer output Q. It turns ON after the prespecified preset time from the point where the timer input is enabled. If the timer enable input is lost before the prespecified preset time, the Q output will not turn ON. The timer input must stay ON during the entire preset time in order for the output to turn ON. The timer output will turn OFF once the input goes OFF.

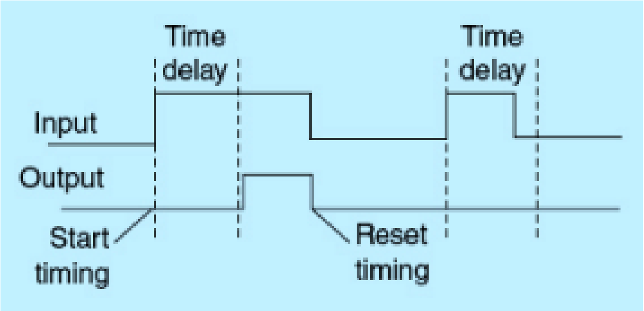


Figure 32.ON-DELAY timing diagram.

2.3.2 OFF-DELAY Timers (TOFs)

This timer's main function is to delay the falling edge of output Q by the predefined period of the preset time (PT). If the input to the instruction (IN) is TRUE, the output Q is set true. When input turns OFF, the timer starts timing. It resets the output Q when the timer accumulated value ET with tag name T_0_ACC is equal to the timer preset value PT with assigned tag name T_0_PRE. Figure 29. shows the timer, and Fig. 30. illustrates the TOF timing diagram. Please refer to the book's website for an interactive simulator illustrating the operation of this timer.

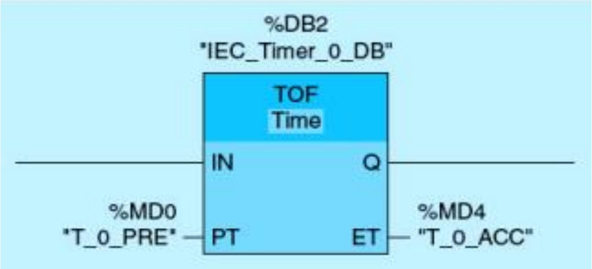


Figure 33. OFF-DELAY timer (TOF).

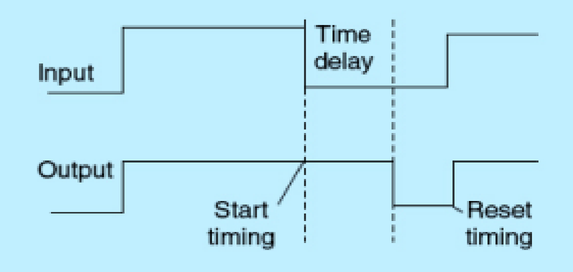


Figure 34.OFF-DELAY timing diagram.

2.3.3 Retentive/Time-Accumulator Timers (TONRs)

The time-accumulator timer (TONR) works exactly the same as the ON-DELAY timer except that the accumulated value is retained while the timer instruction is inactive. To reset the accumulated value to zero, a positive pulse-input instruction is required at the reset input (R). Figure 31. shows the timer, and Fig. 32. illustrates the timer timing diagram. Please refer to the book's website for an interactive simulator illustrating the operation of this timer.

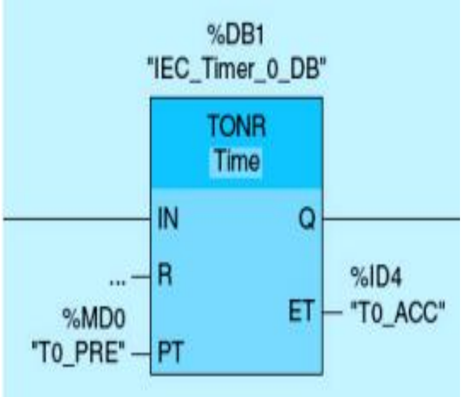


Figure 36.Retentive/time-accumulator timer (TONR).

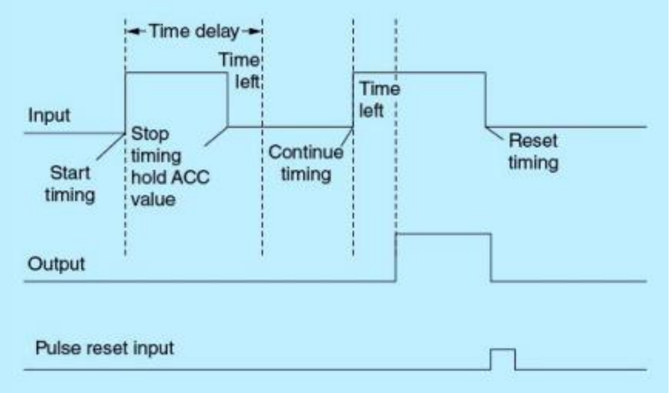
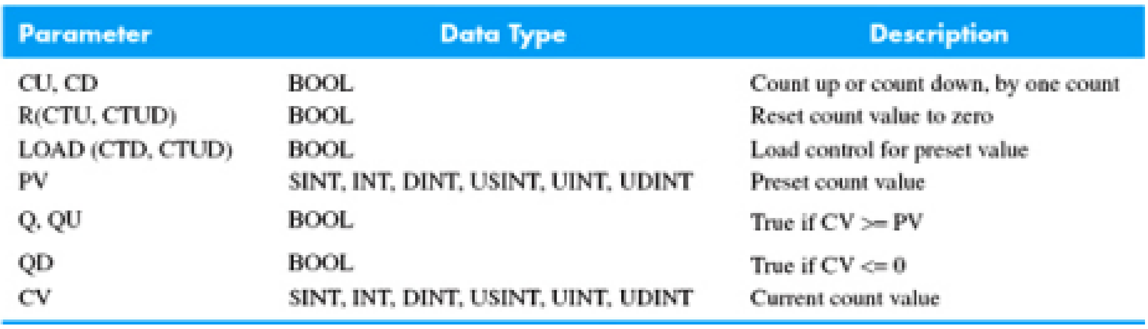


Figure 35.TONR delay timing diagram.

2.4 Counters Fundamentals

Siemens S7-1200 Counters are available in three different forms: count up (CTU), count down (CTD), and count up and count down counter (CTUD). Table 3.3 shows the basic parameters for the CTU, CTD, and CTUD.

Table 3.CTU, CTD, and CTUD Parameters.



Parameter	Data Type	Description
CU, CD	BOOL	Count up or count down, by one count
R(CTU, CTUD)	BOOL	Reset count value to zero
LOAD (CTD, CTUD)	BOOL	Load control for preset value
PV	SINT, INT, DINT, USINT, UINT, UDINT	Preset count value
Q, QU	BOOL	True if CV >= PV
QD	BOOL	True if CV <= 0
CV	SINT, INT, DINT, USINT, UINT, UDINT	Current count value

2.4.1 Count Up Counters (CTU)

The count up counter's main function is to increment the current value each time the input to the counter transitions from 0 to 1. If the current count value (CV) is equal to the preset value (PV), the output Q is set. When reset input (R) is TRUE, the accumulated value resets to 0. Counter preset input can be defined as a tag name or a constant value. The counter block is shown in Fig. 3.23 with appropriate tag names assigned. These tags are displayed between double quotes in the figure. All counter-required variables are displayed using the standard system labels, which start with the percent (%) character. Counter preset input can be defined as a tag name or a constant value. Figure 3.24 provides the timing diagram for this counter.

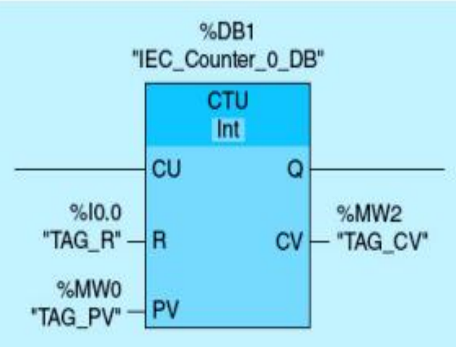


Figure 38.Counter block.

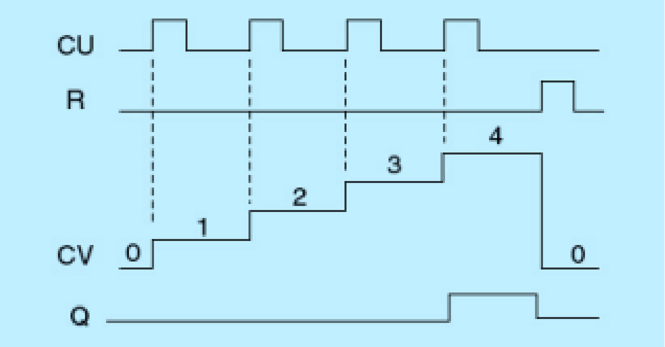


Figure 37. CTU timing diagram with PV = 4.

2.4.2 Count Down Counters (CTD)

The countdown counter's main function is to decrement the current value (CV) each time the input to the counter transitions from 0 to 1. If the current value is equal to or less than 0, the counter output Q is set. The value at the CV is set to the value of the PV parameter when the signal state at the LD input changes to 1. As long as the LOAD input has signal state 1, the signal state at the CTD input has no effect on the instruction. Figure 35. shows the CTD counter block, and Fig. 36. provides the timing diagram.

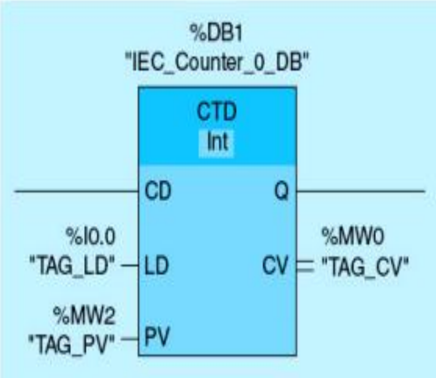


Figure 40.CTD counter block.

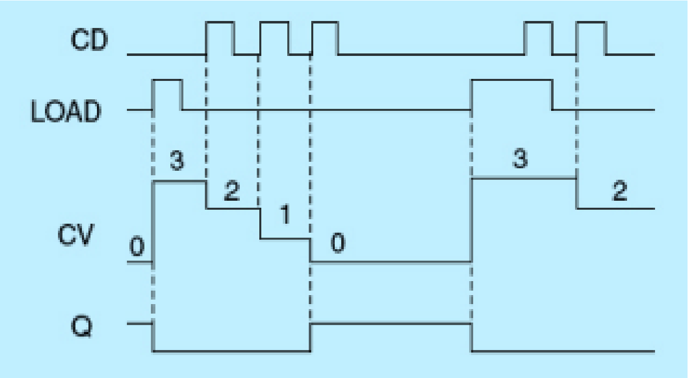


Figure 39. CTD timing diagram with PV = 3.

2.5 Comparison Instructions

The most commonly used comparison instructions are powerful: 'in range' and 'out of rang'.

2.5.1 IN RANGE Instruction (Fig. 37)

If TAG_IN is TRUE, the IN-RANGE instruction is executed. If the value TAG_VALUE is within the value range specified by the current values of TAG_MIN and TAG_MAX, that is, MIN <= VALUE or VALUE <= MAX, then output value of TAG_IN_RANGE is set.

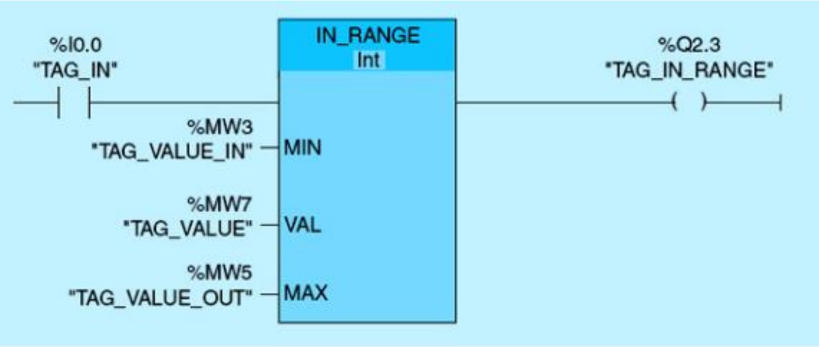


Figure 41.IN RANGE instruction block.

2.5.2 OUT RANGE Instruction (Fig. 38)

If TAG_IN is TRUE, the OUT-RANGE instruction is executed. If the value of TAG_VALUE is outside the value range specified by the current values of TAG_MIN and TAG_MAX, that is, VALUE < VAL or VAL > MAX, then the output value TAG_OUT_RANGE is set.

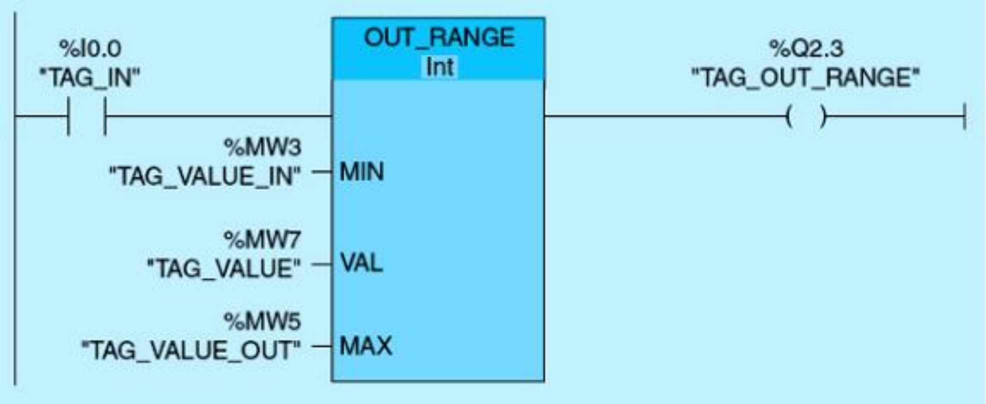


Figure 42.OUT RANGE instruction block.

2.6 Conveyor system

A conveyor system is a fast and efficient mechanical handling apparatus for automatically transporting loads and materials within an area. This system minimizes human error, lowers workplace risks and reduces labor costs — among other benefits. They are useful in helping to move bulky or heavy items from one point to another. A conveyor system may use a belt, wheels, rollers, or a chain to transport objects.

Typically, conveyor systems consist of a belt stretched across two or more pulleys. The belt forms a closed loop around the pulleys so it can continually rotate. One pulley, known as the drive pulley, drives or tows the belt, moving items from one location to another. The most common conveyor system designs use a rotor to power the drive pulley and belt. The belt remains attached to the rotor through the friction between the two surfaces. For the belt to move effectively, both the drive pulley and idler must run in the same direction, either clockwise or counterclockwise. While conventional conveyor systems such as moving walkways and grocery store conveyors are straight, sometimes, the unit needs to turn to deliver the items to the proper location. For the turns, there are unique cone-shaped wheels or rotors which allow the belt to follow a bend or twist without getting tangled. Figure 39 shown conveyor.

Figure 43.Conveyor.

2.7 Control Process

In the industrial world, the word process refers to an interacting set of operations that lead to the manufacture or development of some products. In the chemical industry, process means the operations necessary to take an assemblage of raw materials and cause them to react in some prescribed fashion to produce a desired end product, such as gasoline. In the food industry, process means to take raw materials and operate on them in such a manner that an edible product result. In each use, and in all other cases in the process industries, the end product must have certain specified properties that depend on the conditions of the reactions and operations that produce them. The word control is used to describe the steps necessary to ensure that the conditions produce the correct properties in the product. A process, as shown in Fig. 40, can be described by an equation. The process has m variables v1 to vm. Suppose that we let a product be defined by a set of properties P1, P2 ,, Pn . Each of these properties must have a certain value for the product to be correct. Examples of properties are things such as color, density, chemical composition, and size.

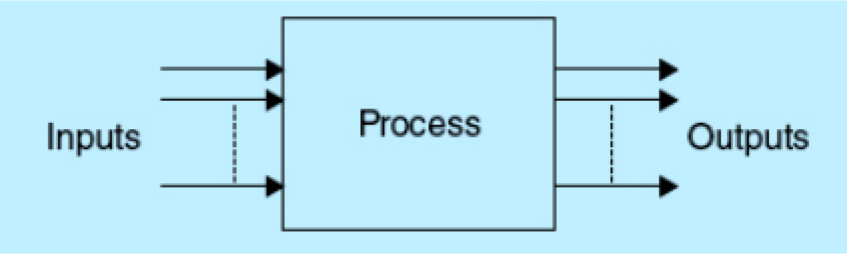


Figure 44.Process block diagram.

$$P_i = f(v_1, v_2, \ldots, v_m, t)$$

where Pi is the ith property and t is time.

CHAPTER THREE

3.1 Theoretically

The precise separation of objects on conveyors is a critical aspect for many industries, including manufacturing plants and airports. In airports, for instance, it ensures bags are sorted efficiently, while in fruit processing industries, it aids in segregating fruits based on their length. The theoretical and practical validation of this concept involves testing its efficacy and then developing a simple program to execute the sorting process.

The separation of objects is achieved by detecting their length using sensors installed along the conveyor. This process relies on two main factors: the frequency of sensor activations and the velocity of the conveyor. By monitoring these variables, the system can accurately determine the lengths of objects and subsequently sort them accordingly.

The theoretical basis for this operation involves an equation to calculate the time taken for objects of varying lengths to pass through the sensor array [($T = \frac{60\,D}{2\pi n r}$) when D is distance of object, n is RPM of conveyor motor and r is outer dimeter of conveyor roll]. Additionally, encoders may be employed to measure changes in conveyor velocity. However, if the velocity remains constant, encoders are unnecessary.

Developing a simple program entails using logical operations such as retentive timers, up counters, and range checks. This program can effectively organize the sorting process based on the lengths of detected objects, ensuring efficient separation and throughput on the conveyor.

3.2 Practically

Through some simple tests outlined in this section, we can determine the amount of time the check sensor remains active when objects are present under different cases.

3.2.1 Procedure

- Y-0030 S7-1200 PLC TEST SET.
- Y–0042 CONVEYOR TRAINING KIT.
- TIA portal software on desktop.
- PROFINET to connection between laptop and PLC module.

- Writing a simple program using a retentive timer to determine the duration of sensing in different cases on bidirectional conveyor.
- Writing a complete program utilizing a retentive timer, up counter, In range check to facilitate the separation of various cases using an additional unidirectional conveyor.

3.2.2 Y-0030 S7-1200 PLC TEST SET

PLC training set is designed for study applications with required simulation components. The set is suitable for using alone or with various application modules.

Siemens S7-1200 series CPU 1214C model PLC is used on training set. All PLC outputs can be used directly or over relay. Also led and simulation keys are used for all inputs.

1. TECHNICAL QUALITIES OF Y-0030 S7-1200 PLC TEST SET

Figure 45.PLC Test Set Units.

1. Roller/without Roller Numerical Outputs (8+2 bit)
2. Key/Keyless Numerical Inputs (8+6 bit)
3. Analogue Unit (2 inputs, 1 output)
4. 2x multi tour potentiometer (10 Kohm)

5. 10V DC Power Plant

6. Test Set Open/Close Light Key

7. 24V DC Power Plant

8. Function Generator

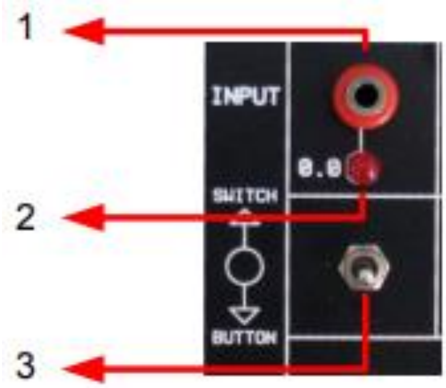


Figure 46. PLC training set input structure.

1. Numerical Output Display Led
2. Direct PLC output with 4 mm socket (24V max 0.5 A)
3. Output signal (PLC/Roller) selection key

Figure 47.PLC training set output structure.

1. Numerical output display led
2. Direct PLC output with a 4 mm socket (24V max 0.5 A)

3. Roller selection key
4. Output roller
5. 4 mm N.O. Normally open roller contact (Dry contact)
6. 4 mm C Common tip roller contact (Dry contact)
7. 4 mm N.C. Normally closed roller contact (Dry contact)

2. TECHNICAL QUALITIES OF S7-1200 CPU 1214C PLC

Siemens S7-1200 CPU 1214C type PLC used in the training set has 10-bit numerical output, 14-bit numerical input and 2 analogue inputs as a standard. In CPU 1214C DC/DC/DC model the whole numerical outputs have been driven with MOSFETs.

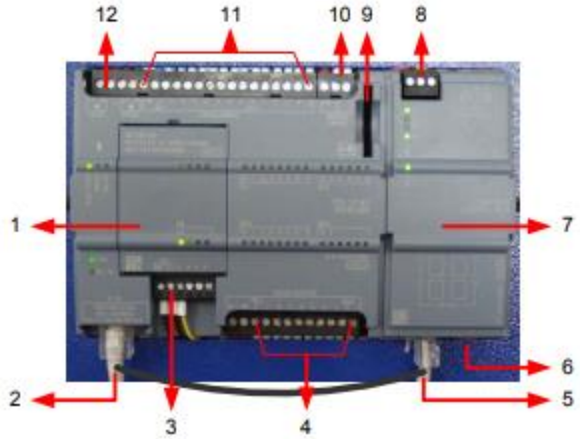
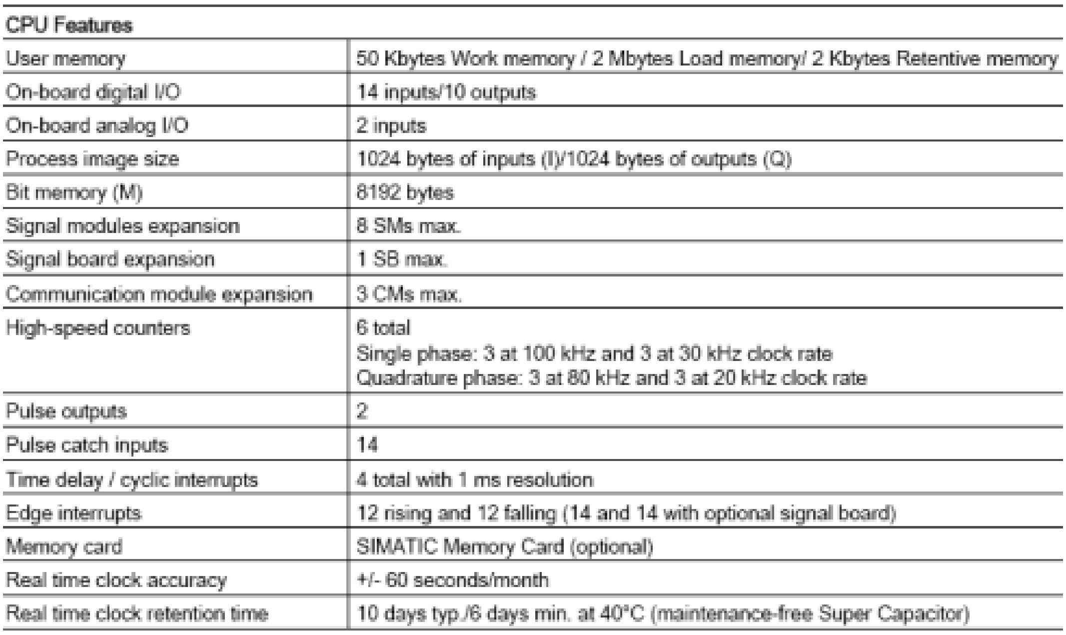


Figure 48.PLC (S7–1200 CPU 1214C) and Switch (CSM1277).

1. SB1232 (Signal Board) 12Bit Analogue Output Board
2. RJ45 Ethernet input
3. SB1232 signal output connectors of signal board
4. Digital signal outputs of CPU1214C (8 bit+2 bit)
5. CSM Switch module RJ45 inputs (CPU has been connected)
6. This input of Switch is used in the connection with the computer.
7. CSM 1277 Switch module
8. CSM 1277 power line connection clip
9. Memory input (MMC card)

10. CPU Onboard Analogue IN input clips (ANI0, ANI1)
11. Digital signal inputs of CPU1214C (8 bits+6 bit)
12. CPU power input connection clip

Table 4. Technical Qualities Belonging to S7-1200 CPU 1214C type PLC.



CPU Features	
User memory	50 Kbytes Work memory / 2 Mbytes Load memory/ 2 Kbytes Retentive memory
On-board digital I/O	14 inputs/10 outputs
On-board analog I/O	2 inputs
Process image size	1024 bytes of inputs (I)/1024 bytes of outputs (Q)
Bit memory (M)	8192 bytes
Signal modules expansion	8 SMs max.
Signal board expansion	1 SB max.
Communication module expansion	3 CMs max.
High-speed counters	6 total Single phase: 3 at 100 kHz and 3 at 30 kHz clock rate Quadrature phase: 3 at 80 kHz and 3 at 20 kHz clock rate
Pulse outputs	2
Pulse catch inputs	14
Time delay / cyclic interrupts	4 total with 1 ms resolution
Edge interrupts	12 rising and 12 falling (14 and 14 with optional signal board)
Memory card	SIMATIC Memory Card (optional)
Real time clock accuracy	+/- 60 seconds/month
Real time clock retention time	10 days typ./6 days min. at 40°C (maintenance-free Super Capacitor)

3.2.3 Y–0042 CONVEYOR TRAINING KIT

It is a 2-axis model designed for training purposes for the conveyors used in factory automation systems. The control and separation of the materials processed/will be processed on the production lines while transferred from one point to another can be formed. Belt conveyor training kit is concordant with such a scenario due to its design. There is input/output control module conforming to control with PLC.

Table 5. Content of Y-0042 KIT.

Conveyor Training Kit System Introduction
A. Conveyor Training Kit (Y-0042) System Components
B. Conveyor Training Kit Control Card Input/Output Points
Optical Sensor
D. Conveyor Training Kit Input/Output Points and Connections

A. Conveyor Training Kit (Y–0042) System Components

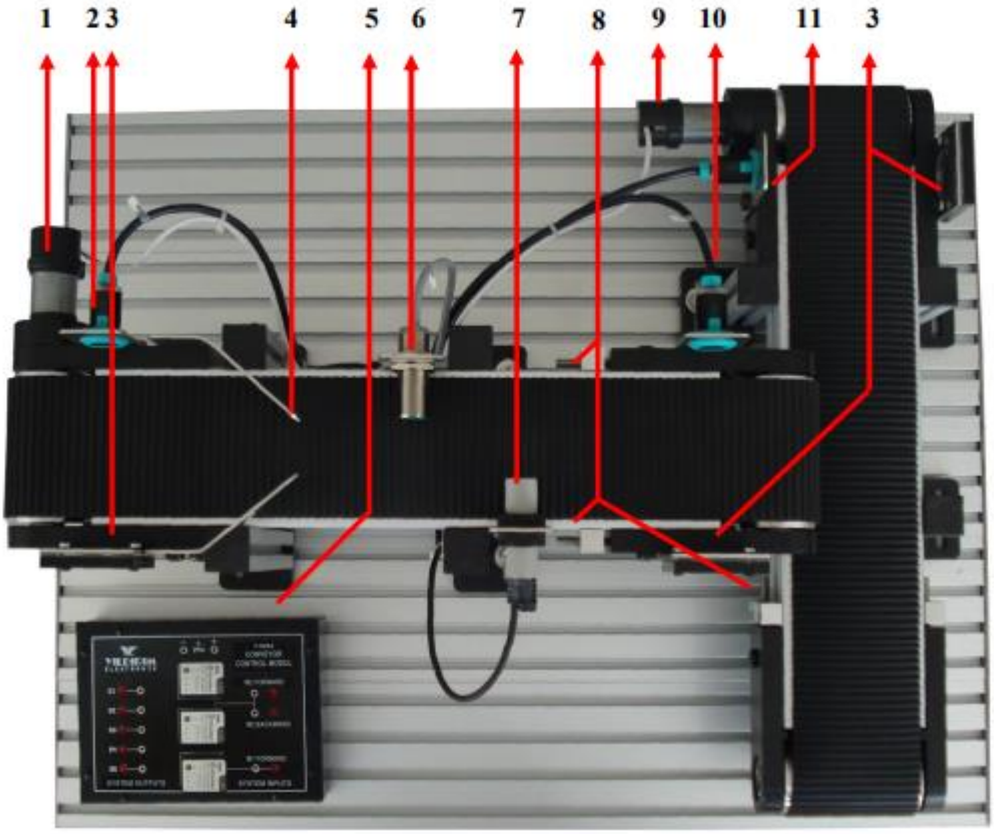


Figure 49.Conveyor training kit components.

1. DC motor with Reducer (M1)
2. Reducer Reverberatory Optical Sensor (S2)
3. Reflectors (3 pieces)
4. Material mean wings
5. Conveyor Control Module
6. Inductive (Metal) Sensor (S3)
7. Capacitive sensor (S4)
8. Tape set points
9. DC motor with Reducer (M2)
10. Reducer Reverberatory Optical Sensor (S5)
11. Reducer Reverberatory Optical Sensor (S1)

B. Conveyor Training Kit Control Card Input/Output Points.

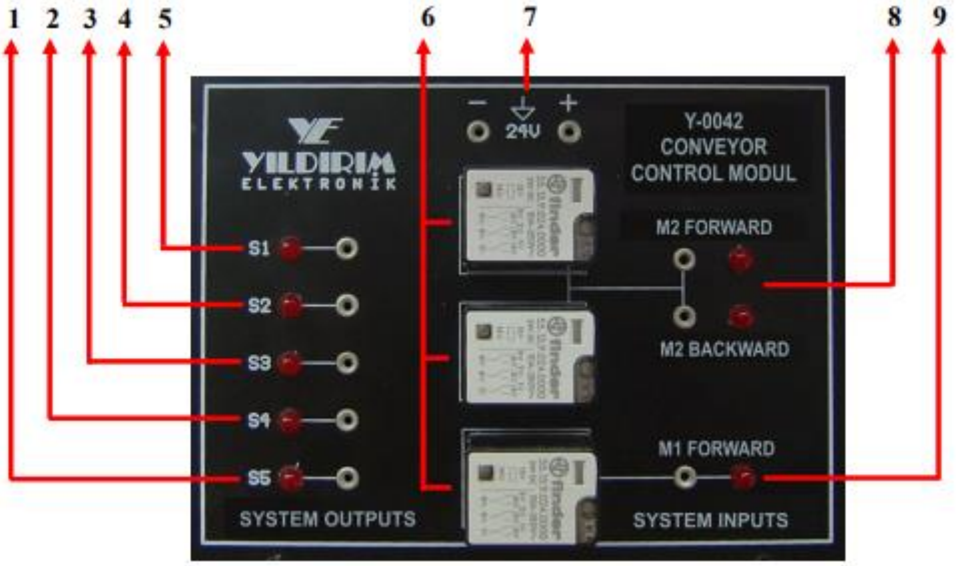


Figure 50.Conveyor training kit input/output connection points.

1. S5 Optical Sensor Signal Output (+24V)
2. S4 Capacitive Sensor Signal Output (+24V)
3. S3 Inductive Sensor Signal Output (+24V)
4. S2 Optical Sensor Signal Output (+24V)
5. S1 Optical Sensor Signal Output (+24V)
6. Motor Control Driver Relays
7. T Tape Power Input (24V DC)
8. Motor2 (M2) Control (Forward/Backward) Signal Inputs (+24V)
9. Motor1 (M1) Control (Forward) Signal Input (+24V)

IMPORTANT NOTE:

SYSTEM OUTPUTS point on the control card are the Sensor (Inductive, Capacitive, Optical) +24V signal output points. The voltage must certainly not to be applied to these points.

I our test we use only one optical sensor so that is enough to do the test.

Introduction of System Components

Optical Sensor: Through the Optical Sensor the presence of the objects, passing on the tape, can be understood. The electrical connection diagram, belonging to the Optical Sensor, is seen in the Figure 2. BN (4), BU (-) are the supply tips and work with 10.30 VDC voltage. BK is normally open and WH is normally closed output tips. The other tip of the load to be connected to this PNP type sensor outputs is connected to (-) minus. The sensor outputs in the conveyor training kit are selected as N.O. (Normally open).

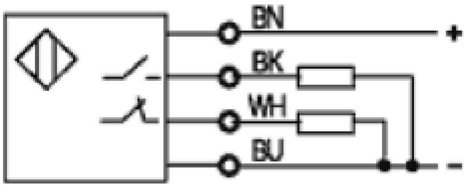


Figure 51.The electrical connection diagram of optical

Sensor works on the basis of the principle, whether the reflector, placed in front of it, and light that it has sent (660 nm red light) return or not. When an object ranks among the sensor and reflector, the sensor will produce signal, because the ray sent will not be reflected by the object well. But high gloss objects can affect the working of this sensor.

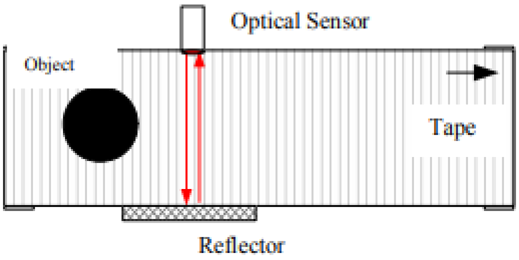


Figure 53.The working of the Optical sensor on the system.

D. Conveyor Training Kit Input/Output Points and Connections

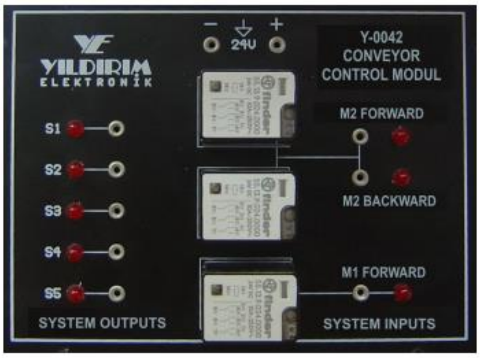


Figure 53. Conveyor training kit input/output connection points.

If the Conveyor Training Kit is desired to work in accordance with the coming demo software, PLC (Siemens S7–1200) input/output and system input/outputs and the points indicated in the table with the sign of (X) should be connected with the 2 mm test cables given. In addition, the Control card interface should be supplied with 24V DC and 500mA power source.

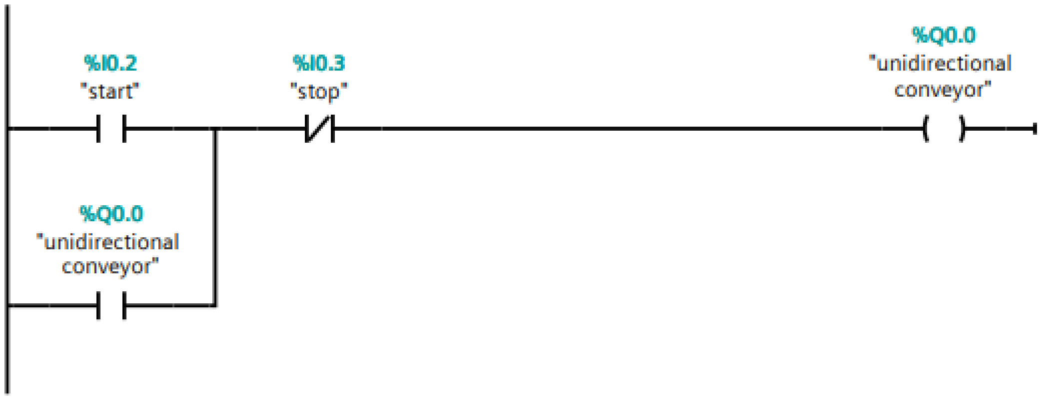
Table 6. input & output selections.

PLC out put siemens (S7-1200)	System
Q0.0	M1 Forward
Q0.1	Maximum case
Q0.2	M2 Forward
Q0.3	M2 Backward
Q0.4	Reset of Timer
PLC input siemens(S7-1200)	
I0.0	S2-Check sensor
I0.1	Reset (Test)
I0.2	Start
I0.3	Stop

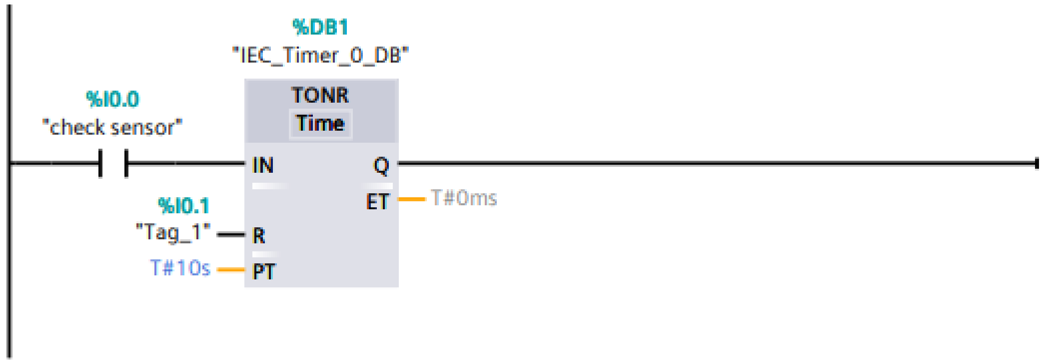
3.4 Test

The duration of the program depicted in steps below allows us to derive the results presented in Table 4. Subsequently, we can develop a preparatory program for case separation on TIA portal software.

Network 1: Start conveyor



Network 2: Test



Through the test, we were able to determine the duration of different cases ten times with certainty to accurately determine the correct range.

Table 7. measuring length of objects for three cases.

Case 1	Case 2	Case 3
1188	851	350
1180	845	488
1185	847	486
1180	852	490
1197	851	492
1165	850	492
1190	855	489
1187	842	490
1171	855	492
1166	852	490

Through the measurement test for determining the lengths of objects, we can ascertain the three ranges corresponding to the three lengths outlined in Table 5.

Table 8.Max.&Min. range of cases.

	Case 1	Case 2	Case 3
Max.	1197	855	492
Min.	1165	842	350

To minimize errors in the test, we employed a wide range of cases shown in Table 6.

Table 9.Max.&Min. selected range of cases.

	Case 1	Case 2	Case 3
Min.	1140	830	330
Max.	1220	870	520

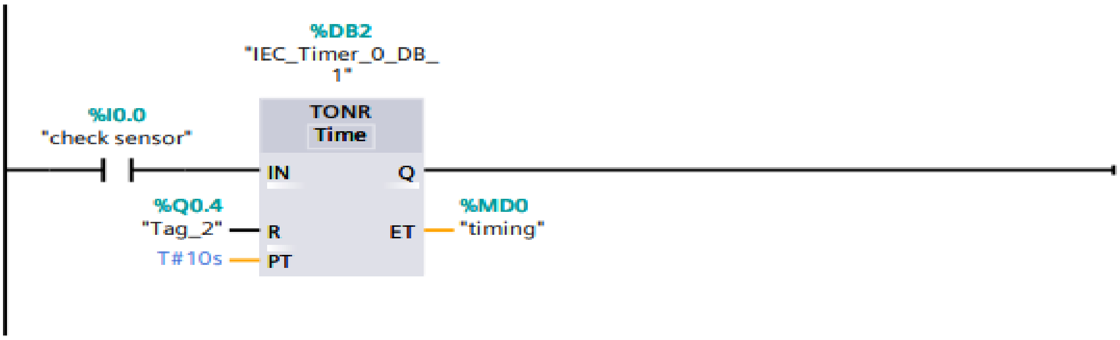
3.5 Program

Finally, we developed a straightforward program to control the two conveyors using retentive timers, up-counters, and IN range instructions to separate every three cases by several network shown below.

Network 1: Start unidirectional conveyor

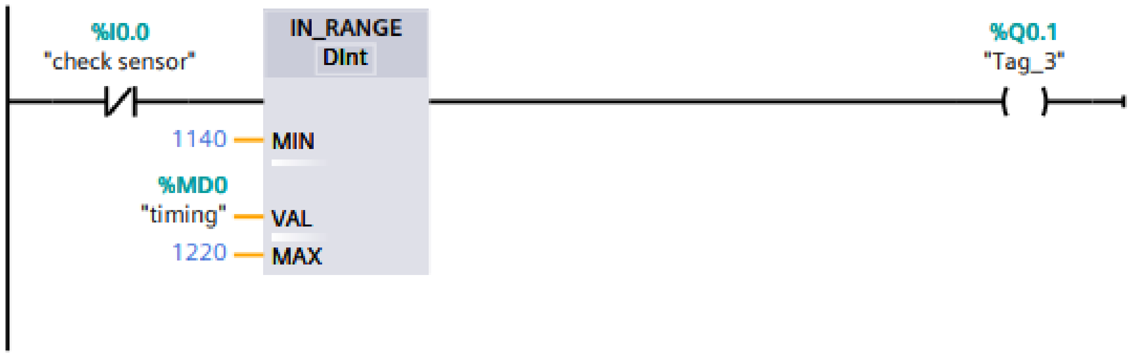
This network used to start and stop a unidirectional conveyor using two push buttons, where the start push button required normally open (NO) contacts and the stop push button required normally closed (NC) contacts. Additionally, it featured a self-latching mechanism for starting the conveyor.

Network 2: Check sensor



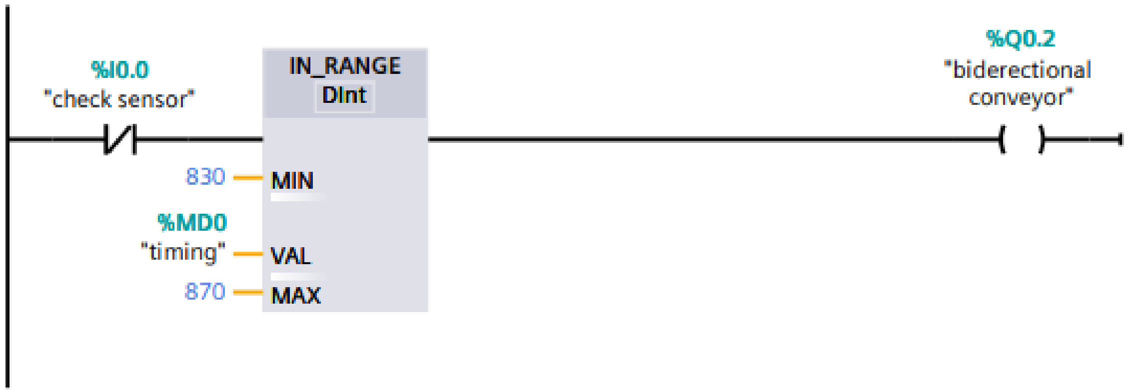
In network two, we used pin I0.0 to connect to a photoelectric sensor for checking the cases via a normally open (NO) contact. Subsequently, we employed a retentive timer to determine the time taken for each case, utilizing the accumulating value of the timer for analysis.

Network 3: Case 1



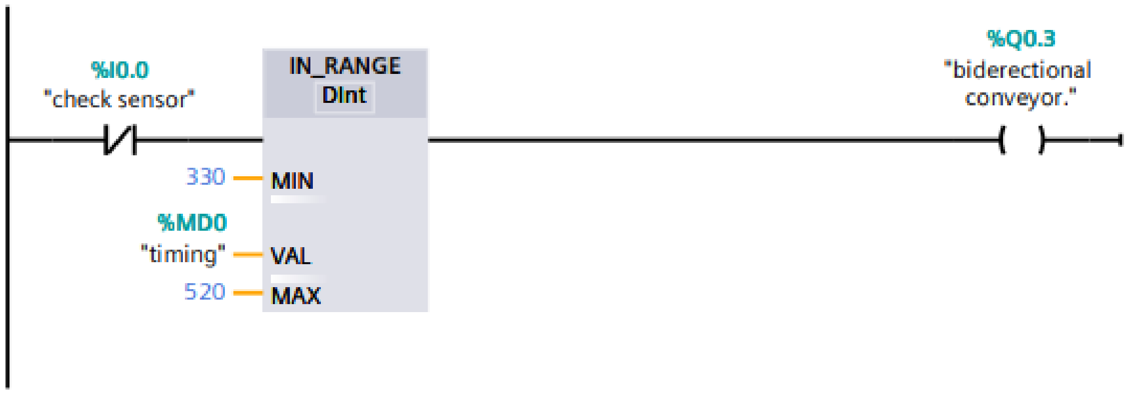
In network three, we specialize in selecting the range of length time for case one using the IN-range instruction. However, it's crucial to remember to include the check sensor contact (NC) because if a larger case passes through without activating the check sensor, it may prevent the output for smaller cases from activating.

Network 4: Case 2



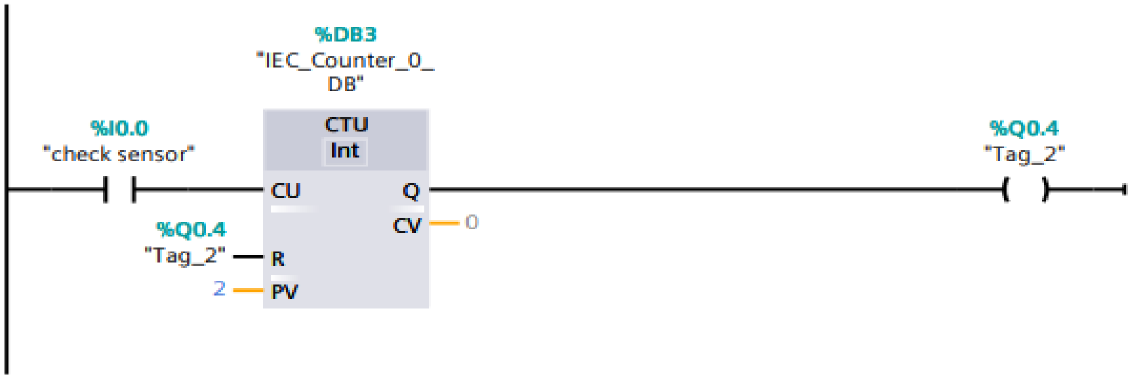
Network four is utilized for selecting the range of medium-sized cases using the IN-range case instruction with the (NC) contact of the check sensor. It activates the bidirectional conveyor, rotating it in the anticlockwise direction.

Network 5: Case 3



Setting the minimum and maximum range for the smallest case and integrating the accumulating value into the IN-range instruction activates the bidirectional conveyor in the clockwise direction, utilizing the (NC) contact for the check sensor.

Network 6: Reset Timer and Counter

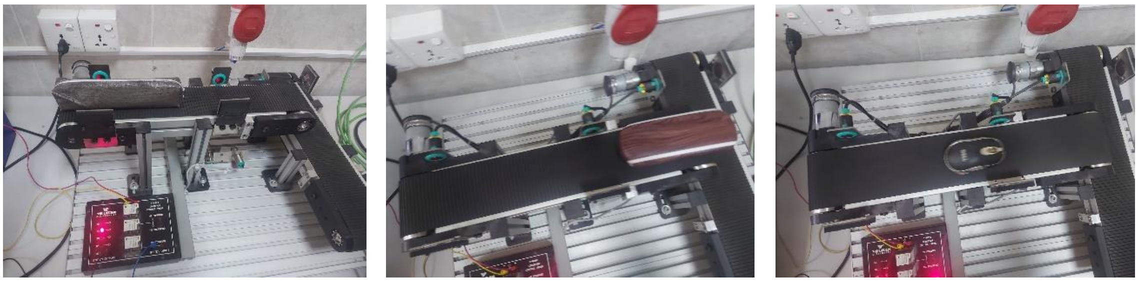


Using the (NO) contact of the check sensor for counting, the counter goes up until resetting the retentive timer and itself, ensuring a reset for any subsequent cases.

CHAPTER FOUR

4.Results and Discussion

During the project, a simple program was developed to segregate objects on a conveyor belt by adjusting the sensing time range of a photoelectric sensor. Three different scenarios were tested: in the shortest scenario, the bidirectional conveyor rotated clockwise; in the medium scenario, it rotated counterclockwise; and in the longest scenario, the bidirectional conveyor stopped altogether. Due to space constraints, these scenarios were simulated using two pencil pouches and a laptop's webcam mouth. The sensor placements were strategically organized within the compact conveyor kit, as depicted in Figure 1.



(a) (b) (c)

Figure 54. (a) longest case 1, (b)medium case 2 and (c) smallest case 3.

An encoder was not utilized to monitor the conveyor speed, as it remained constant throughout the experiments. However, for situations where speed variability is a factor, integrating an encoder would enhance the accuracy of the separation process. Nonetheless, the process yielded high precision.

The successful implementation involved crafting a straightforward program using Ladder diagram logic in Siemens S7-1200 PLC, employing retentive timers, counters, and the 'in range' instruction. Retentive timers were deliberately chosen over clock Hertz timing due to the limited granularity of the smallest Hertz unit (0.2 Hz) in the PLC S7-1200, equating to 5 pulses per second, as detailed in Table 1. Consequently, to achieve precise length readings, retentive timers capable of generating 1000 pulses per second were employed. This approach significantly enhanced the length measurement accuracy.

Table 10. Clock memory frequency.

Bit number	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Tag name								
Period (s)	2.0	1.6	1.0	0.8	0.5	0.4	0.2	0.1
Frequency (Hz)	0.5	0.625	1	1.25	2	2.5	5	10

Moreover, efficiency was optimized by effectively utilizing the 'in range' instruction to define ranges and minimize errors. Additionally, employing counters to reset retentive timers and progress through subsequent scenarios further streamlined the process.

This project not only demonstrated the feasibility of improving efficiency in various industries but also hinted at potential cost and time savings. By accurately measuring and segregating objects based on length, applications such as baggage sorting at airports, boxes handling in logistics, and fruit sorting in agricultural settings could benefit significantly. Figure 2, shown some application of the project.

(a) (b)

(c)

Figure 55. (a)boxes, (b)fruits and (c)bags.

CHPTER FIVE

5.Conclusion and Recommendations

In conclusion, this project has demonstrated the feasibility and effectiveness of developing a simple yet robust program for object segregation on conveyor belts. Through meticulous experimentation and strategic implementation of sensor adjustments, the system exhibited high precision and adaptability across various scenarios.

While the absence of an encoder to monitor conveyor, speed did not hinder immediate success, future iterations would benefit from its integration, particularly in scenarios with variable speeds. This enhancement would bolster the system's accuracy and reliability, ensuring consistent performance under diverse operational conditions.

The successful implementation of a straightforward program using Ladder diagram logic in Siemens S7-1200 PLC, coupled with the utilization of retentive timers, counters, and the 'in range' instruction, underscores the project's technical proficiency. The deliberate choice of retentive timers over clock Hertz timing significantly enhanced length measurement accuracy, while strategic parameter adjustments optimized system efficiency.

Looking ahead, future developments could focus on expanding the system's functionality to encompass more complex industrial applications. By incorporating features such as solenoid or cylinder activation for object separation based on length, the system would offer enhanced versatility and utility across diverse industrial settings, like figure 1.

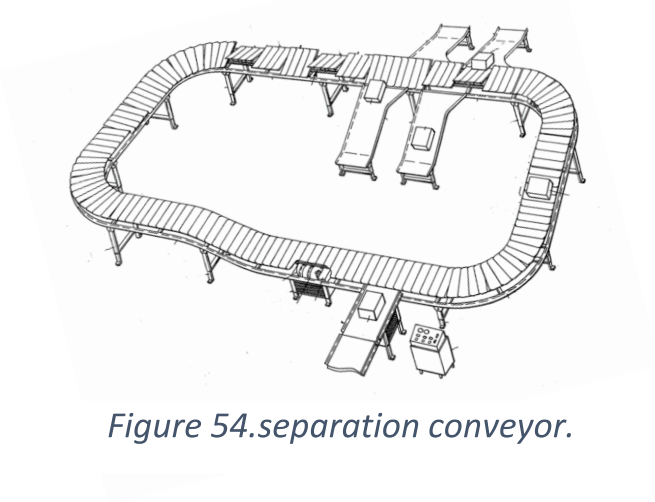


Figure 54.separation conveyor.

Continuous refinement and optimization of program logic, sensor placements, and operational parameters are essential for maximizing system performance and adaptability. Collaboration with industry stakeholders and rigorous real-world testing will ensure the seamless integration and validation of the segregation system within industrial workflows.

In summary, by incorporating these recommendations and maintaining a commitment to innovation and collaboration, future iterations of the segregation system can further advance industrial efficiency and contribute to the optimization of logistics and manufacturing processes, ultimately driving tangible benefits in terms of cost savings, time efficiency, and operational productivity.

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