

FACTORY CONTROL

Applied Programmable Logic Controllers
ACDA6000

Rebecca Coles

2218001

Electrical & Electronic Engineering

Table of Contents

Abstract	2
Introduction	2
Task 1.....	3
Task 2.....	12
Task 3.....	14
Task 4.....	14
Task 5.....	16
References.....	17

Abstract

In this assignment we were required to design and control a factory system which would sort 4 different packages based on size and weight. We used a programme called Factory I/O and siemens ladder logic. The design of the system had to include 4 conveyor belts, 2 pushers, 1 conveyor scale, 2 diffuse sensors, 1 emergency stop, 2 push buttons, 1 siren, 1 warning light and 2 stack lights.

Introduction

This report focuses on the design and control of a factory system that sorts four different types of packages using Factory I/O. The sorting process is based on the size and weight of the packages.

The system incorporates essential components such as four conveyor belts, two pushers, a conveyor scale, and two sensors for size and weight detection. To enhance safety and operation, the system is equipped with an emergency stop, buttons for manual control, a siren, a warning light, and stack lights for status indication.

This report explains how the system works, the safety and alarm features, and the logic used to control the Factory I/O. The design aims to create a reliable, efficient, and user-friendly sorting system.

Task 1

Programmable Logic Controllers (PLCs) are specialised computers used in various industries to automate, control, and monitor processes. They play an important role in managing tasks such as assembly lines, machinery operations, and other complex systems. PLCs are designed to be reliable, durable, and capable of working in harsh environments.

There are several PLC brands available on the market, each with its own set of features and advantages, as well as disadvantages. These brands offer different models to suit a wide range of industrial needs, from small machines to large complex systems. Some PLCs focus on providing advanced processing power, while others provide a ease of use, energy efficiency, or integration with other automation equipment[1].

Below, we will review some of the most widely used PLCs in industry today focusing on their advantages and disadvantages.

Allen Bradley

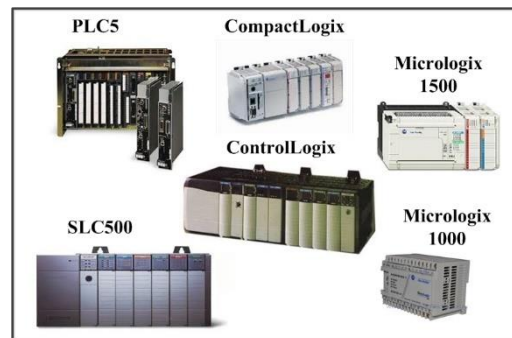


Fig.1

Allen Bradley PLCs are made by Rockwell Automation. They are popular for their scalability and performance. Allen Bradley PLC's include models like MicroLogix, CompactLogix and ControlLogix, these PLC's are able to adapt from small, medium and large automation systems. These models are displayed in Fig.1. Allen Bradley are known for their fast processing and advanced features for handling complex tasks. Allen Bradley are user friendly and use software's like RSLogix or Studio 5000, this includes tools for diagnostics and troubleshooting. Allen Bradley PLC's also support multiple communication protocols such as EtherNet/IP ensuring smooth connectivity with other devices[2]. Below are some of the advantages and disadvantages of Allen Bradley PLC's.

Advantages

- Scalability & flexibility –
 - Allen-Bradley PLCs are modular, meaning they can easily be expanded and customized as systems grow or change.
- Easy integration –
 - These PLCs work seamlessly with other products, making it easier to design and manage large systems.
- User friendly software –
 - The programming software is designed to be easy to use, even for beginners, with tools for programming and troubleshooting.
- Technical support –
 - Allen-Bradley offers excellent customer support, with training resources and a large distributors to assist end users.
- Durable & reliable –
 - Allen-Bradley PLCs are built to last in tough environments, withstanding things like temperature changes, vibration, and electrical interference.
- Strong communication features –
 - These PLCs support various communication, e.g., Ethernet/IP which is useful for connecting many devices in complex systems.
 -

Disadvantages

- Cost –
 - Allen-Bradley PLCs are expensive both in terms of hardware and software, which may be a challenge for smaller businesses with limited budgets.
- Software –
 - The programming software requires purchasing licenses, which can add to the overall cost.
- Configuration –
 - For larger systems setting up Allen-Bradley PLCs can be complicated and time-consuming.

Allen-Bradley PLCs are powerful and reliable, making them ideal for large and more complex automation systems. However, they can be expensive and complicated on configuration. Overall they are good when used for large-scale, high-performance applications, particularly in industries[3].

Siemens



Fig.2

Siemens PLCs like the SIMATIC S7-1200, S7-1500 and many others are known for their high performance and fast processing. Siemens PLC's are programmed using TIA Portal, which simplifies programming and integration. Siemens also support communication protocols like PROFINET and Modbus making them versatile and easy to connect with other devices. They are suitable for small to large systems[4].

Below are some of the advantages and disadvantages of using Siemens PLC's.

Advantages

- Performance & speed –
 - Siemens PLCs are known for their fast processing capabilities, making them ideal for high-performance applications where speed and precision are critical.
- Easy to use software –
 - The TIA Portal software integrates all tools, e.g. programming, configuration, diagnostics into one place, making it a much simpler system setup.
- Simpler communication –
 - Siemens PLCs support many communication protocols like PROFINET, Ethernet/IP, and Modbus which makes them easy to connect with other devices and systems.
- Scalability –
 - These PLCs can be used for small, medium or large systems allowing for growth and changes as needed.
- Support –
 - Siemens offers support, along with training resources and detailed documentation making it easier to troubleshoot systems.

Disadvantages

- Cost –
 - Siemens PLC's can be more expensive than other brands, which might be a concern for smaller businesses or simpler applications.
- Set up time –
 - Setting up Siemens PLCs, especially for complex systems, can take more time and effort compared to simpler PLCs.

- Resource –
 - Siemens PLC's require more processing power and memory which may not be necessary for smaller and simpler systems.

Overall Siemens PLCs are fast, reliable and flexible making them a great choice for large or complex automation projects. Siemens offer excellent communication, but may be expensive and harder for beginners to use[5].

Mitsubishi



Fig.3

Mitsubishi offer a range of series within the PLC's like the FX Series, Q Series, and iQ-R Series are reliable and affordable making them ideal for small and medium systems. They are easy to programme through software and are known for their compact design and durability. Mitsubishi PLC's support communication protocols like CC-Link and Modbus. They are user friendly and provide good performance for general applications[6]. Listed below are some of the advantages and disadvantages of Mitsubishi PLC's.

Advantages

- Cost –
 - Mitsubishi PLC's are affordable, making them a good choice for small to medium sized applications.
- Reliability –
 - Mitsubishi are known for their reliability and performance in various industries.
- Programming –
 - The software is user-friendly and simple to learn for beginners.
- Compact –
 - Mitsubishi PLC's are designed to be compact, saving space in control panels.

Disadvantages

- Limited capability –
 - Mitsubishi PLC's may not be as capable as other brands like Siemens or Allen-Bradley for larger and more complex systems.

In conclusion Mitsubishi PLCs are cost-effective and reliable for small to medium applications. They are easy to program and work well, but may not be ideal for large and complex systems due to their limited capability[7].

Schneider



Fig.4

Schneider Electric PLC's such as the Modicon M221, M241 and M580 are known for their flexibility and easy use. They are suitable for small to medium automation systems and are programmed using EcoStruxure software. These PLC's support common communication protocols like Modbus and Ethernet making them easy to integrate with other devices. Schneider PLC's are affordable, reliable and designed for efficient control in industrial applications[8].

Below is a short list of advantages and disadvantages of Schneider PLC's.

Advantages

- Cost –
 - Schneider PLC's offer a good performance at a lower cost, making them a good option.
- User friendly –
 - The programming software is user-friendly and easy to learn for beginners.
- Flexible –
 - Schneider PLC's are flexible and can be scaled to meet the needs of small and large systems.
- Wide range –
 - Schneider offers a variety of PLC models to suit different applications, from simple tasks to more complex systems.

Disadvantages

- Features –
 - Schneider PLC's may not have as many features compared to other brands like Siemens or Allen-Bradley.
- Software –
 - Occasional compatibility issues with older software or hardware when upgrading.

To sum up Schneider PLC's are a cost effective, easy to use and are suitable for a variety of applications[9].

ABB

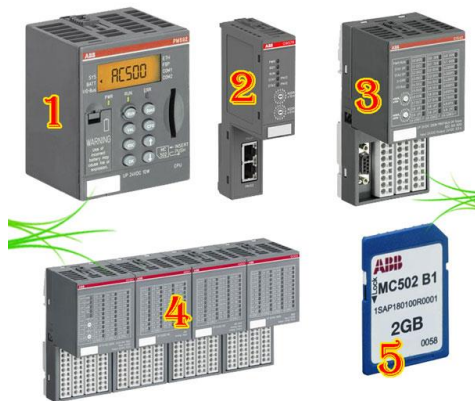


Fig.5

ABB PLC's include the AC500 and AC800M series are designed for both small and large automation systems. They offer high performance, reliability and are programmable using the Automation Builder software. ABB support communication protocols like Ethernet/IP and Modbus, this allows easy integration with various devices. ABB PLC's are known for their energy efficiency and suitability of complex systems. These PLC's are able to provide a large scale of scalability, making them a good choice for a wide range of applications[10]. Listed below are the advantages and disadvantages of ABB PLC's.

Advantages

- Reliability –
 - ABB PLCs are known for their reliability and can perform well in tough industrial environments.
- Flexible –
 - ABB PLCs can be used for both small and large systems, making them adaptable to various applications.
- Integration/communication –
 - ABB PLCs have good communication protocols, ensuring easy integration with other systems.
- User friendly –
 - The software is easy to use and suitable for both beginners and experienced users.
- Efficient –
 - ABB PLCs are designed to help reduce energy consumption, making them an environmentally friendly option.

Disadvantages

- Cost –
 - ABB PLCs can be expensive than some other brands.

All in all ABB PLC's are reliable, flexible and energy-efficient in a variety of industrial applications. However ABB PLC's can be more expensive than other brands[11].

PLC Comparison table

PLC Brand	Allen Bradley	Siemens	Mitsubishi	Schneider	ABB
Cost	Expensive	Expensive	Affordable	Affordable	Expensive
Scalability	Suitable for large systems	Suitable for both small and large systems	Not as suitable for larger systems	Suitable for small and medium systems	Suitable for small to large systems
Software	User friendly, requires learning time	TIA portal, requires learning time	Easy to use, especially for beginners	Easy to use	Easy to use, but can be difficult first time
Performance	Suitable for complex tasks	Suitable for time sensitive systems	Suitable for small and medium tasks	Moderate, general application	Reliable for demanding systems
Integration	Strong compatibility	Flexible	Limited	Flexible	Good, but maybe complex to configure
Technical support	Good support	Good Support	Limited support	Good support	Limited support
User Friendly	Difficult to learn for new users	Easy to use, but got to learn how to use TIA portal	Easy to programme	Easy to programme	Can be complex for beginners

Table.1

PLCs play a critical role in modern industrial automation and there are several top brands to choose from, each with their own strengths and weaknesses. Allen-Bradley is known for its reliability and technical support but is often an expensive system. Siemens offers advanced features and flexibility but requires more time when configuring. Mitsubishi PLCs are affordable and reliable but aren't as suitable and designed for the large systems. Schneider are cost-effective and have easy to use software but lack some features comparing to others. ABB PLCs are durable and energy efficient but can be costly and complex to configure.

From the comparison table above the choice of PLC depends on the specific needs of the application. These can include factors like system complexity, scalability, budget and technical support.

After a thorough comparison of available options, Siemens PLC's have been selected as the preferred choice for this project. The decision is based primarily on familiarity with Siemens systems. Siemens PLC's have a user friendly interface. Additionally, their robust performance and versatility make them a reliable option for automation tasks.

However, during the research phase, ABB PLC's were identified as a strong alternative. ABB PLC's offer several notable advantages. This includes high durability, energy efficiency and integration capabilities, particularly for demanding industrial environments.

For this project, Siemens PLCs remain the practical choice due to their accessibility and the familiarity.

Task 2

Task 2 involves designing a factory process using Factory I/O to sort packages based on their size and weight. The system will sort four different types of packages, each requiring different sorting criteria's. By using various components such as conveyor belts, sensors, and pushers, the system will efficiently detect package characteristics and sort them accordingly. This design will aim to ensure smooth, safe and accurate sorting whilst counting each package entering the conveyor to each one being on and leaving the conveyor.

Factory I/O is an effective tool for designing and testing automation systems. It uses a 3D simulation of a factory processes, allowing users to create and test systems without the need for physical equipment. The software is user friendly, making it easy for both beginners and experienced. Factory I/O integrates with real world PLC's, enabling users to test their programs before applying them to actual machines. It is cost effective, making it ideal for learning, prototyping, and educational purposes. Its flexibility allows it to be used for both simple and complex automation systems.

Below is an overview of the system that was created using factory I/O.



Fig. 6

The figure shows a system with six conveyor belts that manage the sorting process. A main diff sensor is placed at the start to count the number of boxes entering the system. Each conveyor belt also has its own diff sensor to detect the size of the boxes and the quantity of the boxes, as seen in Figures 7 and 8.

Two pushers are used to direct the boxes to their correct destinations and on this occasion used as counter for the quantity of boxes. Additionally, a weighing scale is included to separate the remaining boxes into two categories based on weight, as shown in Figure 9. These components work together to sort the boxes efficiently by size and weight.

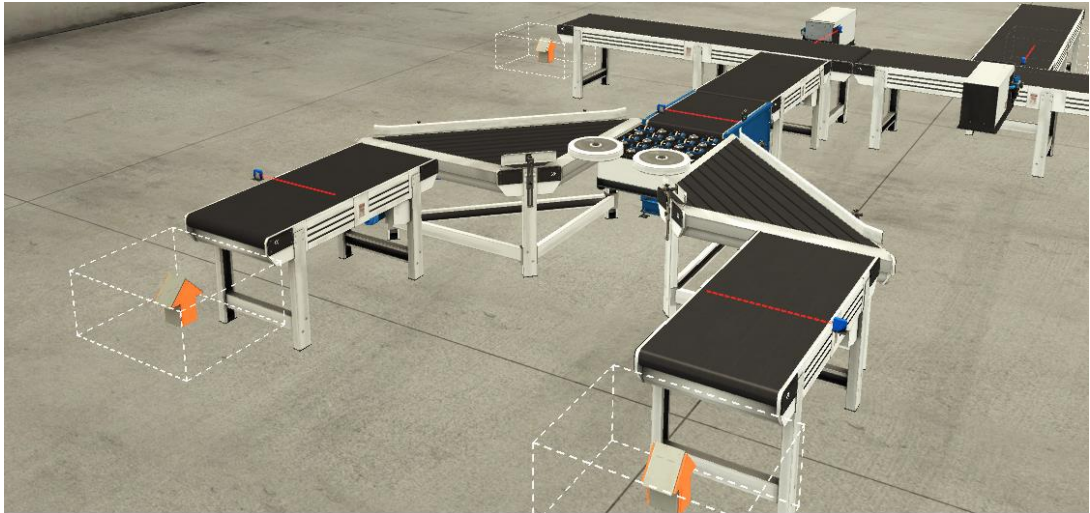


Fig.7

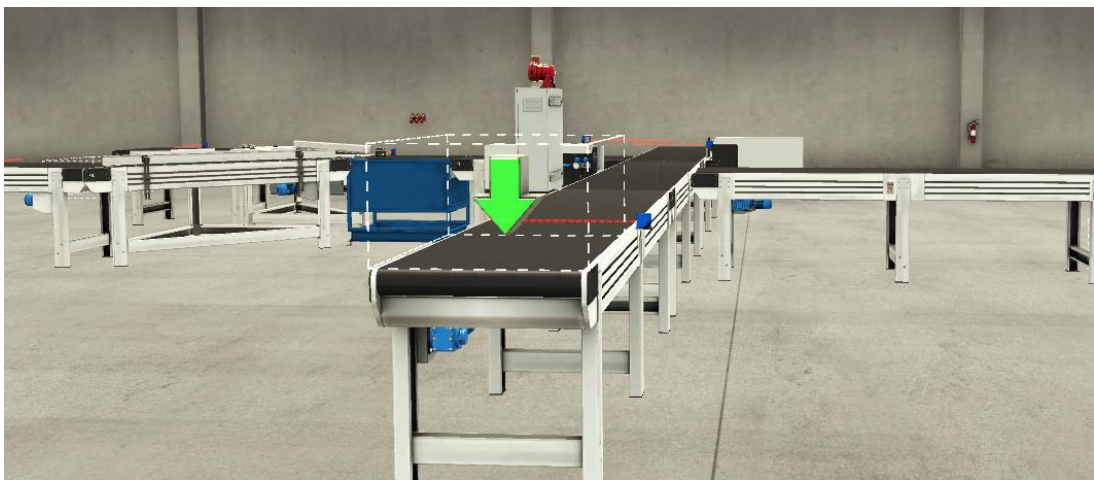


Fig.8

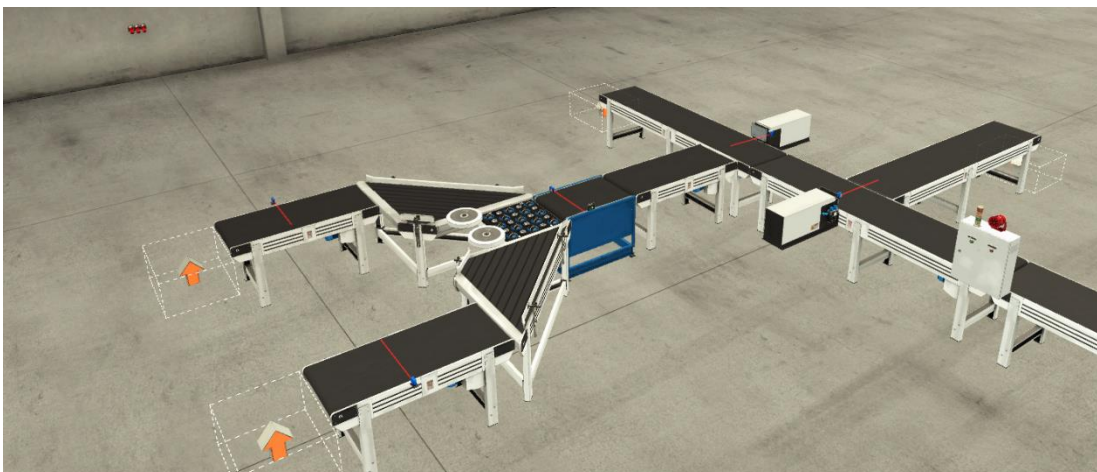


Fig.9

Task 3

Task 3 involves creating a ladder logic program to control the factory sorting process. The program will manage the operation of components such as conveyor belts, sensors, pushers and the weighing scale to ensure accurate sorting of packages by size and weight. It will include safety features like emergency stop, stop buttons and alarms. The system will include warning lights to immediately alert operators to any errors, ensuring awareness and response to potential issues.

Each network within the Siemens PLC program has been clearly labelled and thoroughly explained to detail the functionality of each logic line.

Task 4

Task 4 focuses on integrating a Human Machine Interface (HMI) into the factory system to enhance operator interaction and control. The HMI will provide a interface for monitoring and managing the sorting process.

It will also allow operators to start, stop and reset the system from the HMI display. The display will also show fault or warning indicators for quick troubleshooting.

By programming the HMI to communicate with the PLC the system will ensure seamless operation, improve efficiency and enhance overall usability.

HMI devices are essential in industrial automation as they provide a platform for operators to monitor and control systems. They display real time data such as system status, production counts and fault alerts, this then enables quick responses to changes or issues.

Totally Integrated Automation Portal

Project 1 / PLC_1 [CPU 1214C DC/DC/DC] / Program blocks

Main [OB1]

Main Properties

General

Name	Main	Number	1	Type	OB	Language	LAD
Numbering	Automatic						

Information

Title	"Main Program Sweep (Cycle)"	Author		Comment		Family	
Version	0.1	User-defined ID					

Main

Name	Data type	Default value	Comment
▼ Input			
Initial_Call	Bool		Initial call of this OB
Remanence	Bool		=True, if remanent data are available
Temp			
Constant			

Network 1: Main programme

%FC9000

"MHJ-PLC-Lab-Function-S71200"

EN

ENO

Network 2: Switch on

In Network 2, the main program operates, and the master alarm is triggered. This alerts users that the belts are about to start. This will stay operated until someone prresses the stop button or emergency button.

%I16.0

"Start Button"

%I16.1

"Stop Buttom"

%M151.7

"master alarm"

%M100.0

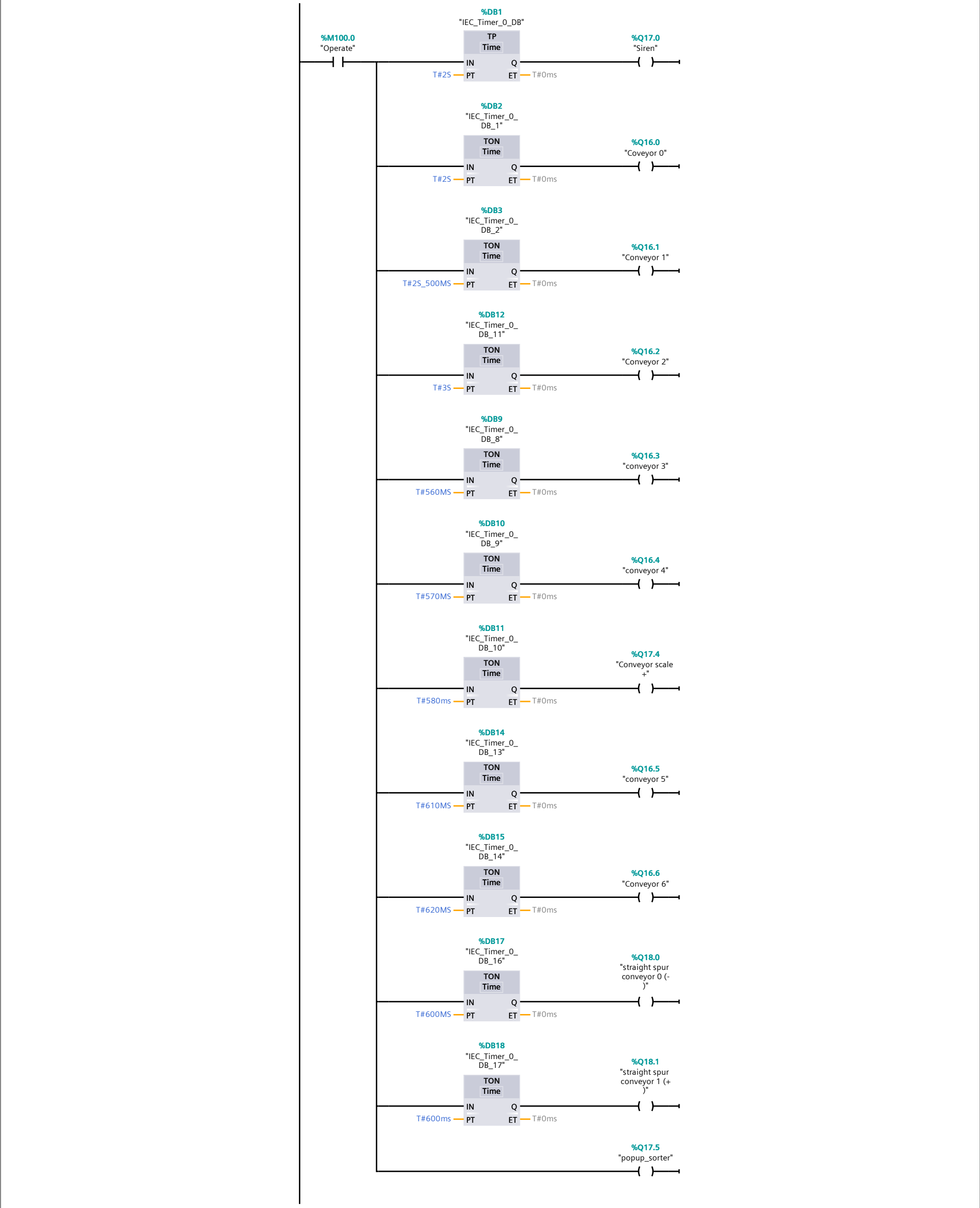
"Operate"

%M100.0

"Operate"

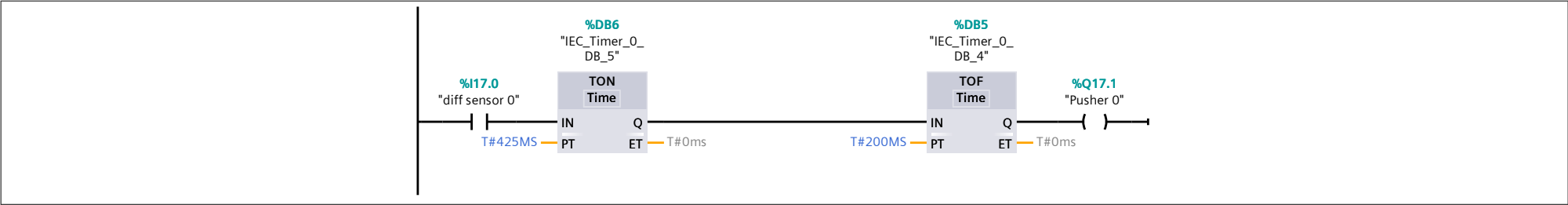
Network 3: Operate/start - sirens/Conveyor belts

In Network 3, the siren sounds for 2 seconds to warn users that the belts are about to start. Conveyors 1 to 6, along with both spur conveyors and the pop sorter, are then activated until signalled otheriwse.



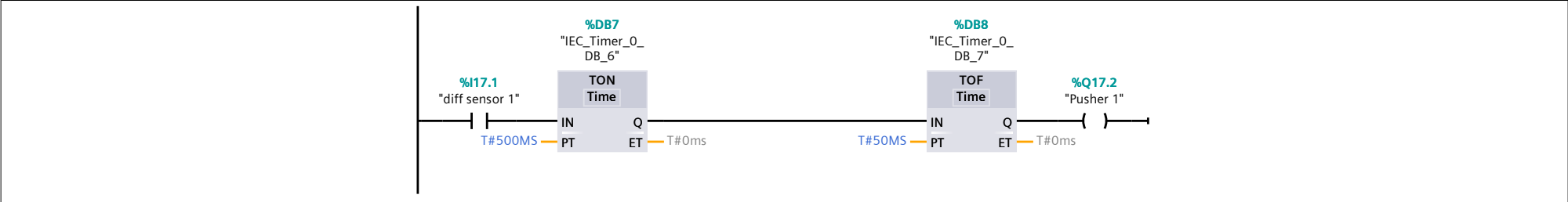
Network 4: Operate pusher, when diff sensor 0 has been activated

In Network 4, sensor 0 is activated, triggering a delay on a timer, this then operates Pusher 0. This action pushes specific boxes onto one of the conveyor belts, this is dependant on size. Other boxes entering the conveyor may pass this without triggering diff sensor 0.



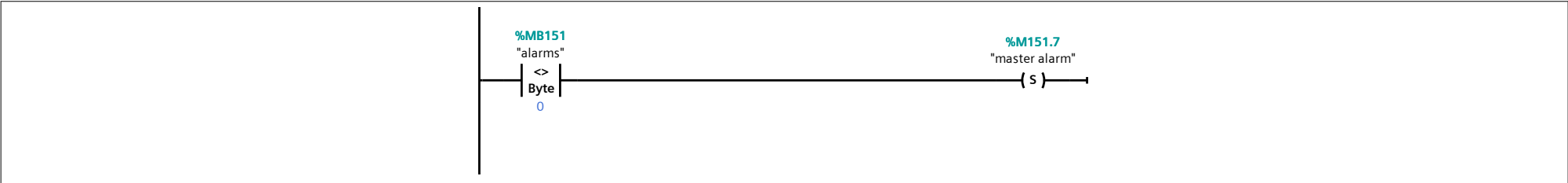
Network 5: Operate pusher 1, when diff sensor 1 has been activated

Network 5 is a resemblance of network 4. In Network 5, when sensor 1 is triggered, it initiates a timer delay that activates Pusher 1. This then pushes designated boxes onto a different conveyor belt. This again is dependant on size. Again some boxes may bypass diff sensor 1 without being detected.



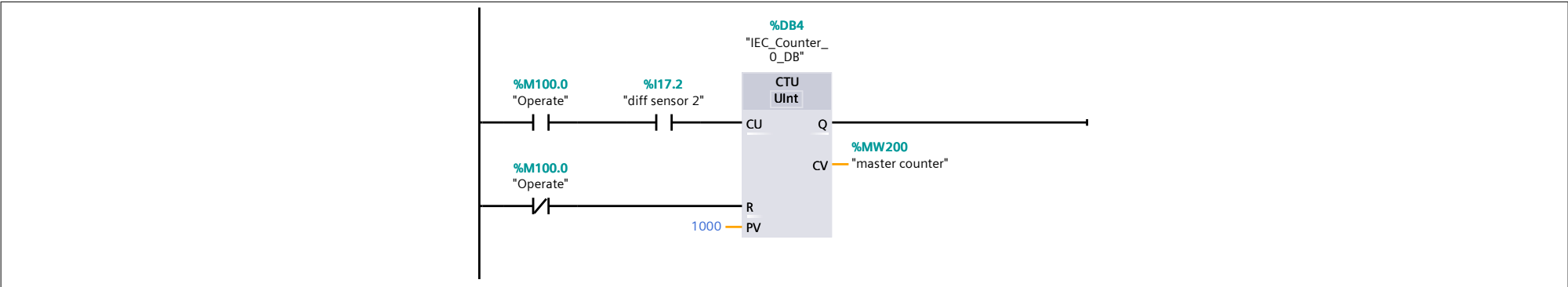
Network 6: Maser alarm

Network 6 sets the master alarm.



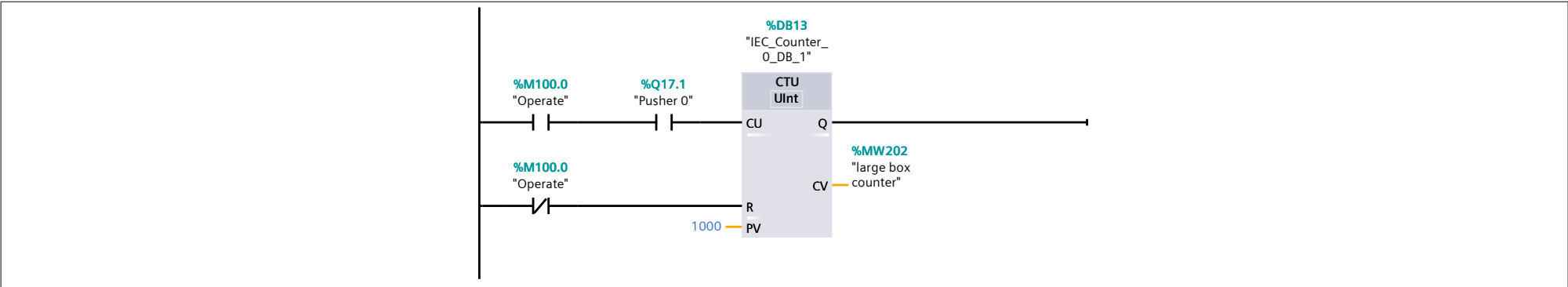
Network 7: Operate master counter - main counter for all the boxes

Network 7 controls the master counter, which tracks the number of boxes entering the conveyor belt. It uses Sensor 2, located at the conveyor's start, to count the boxes, effectively serving as the total counter.



Network 8: Operate large box counter

Network 8 tracks the number of boxes on a specific conveyor belt by using a counter linked to Pusher 0. Each time Pusher 0 pushes a box down the conveyor, the counter increases the total count by 1, providing an accurate count of the large boxes on the belt.



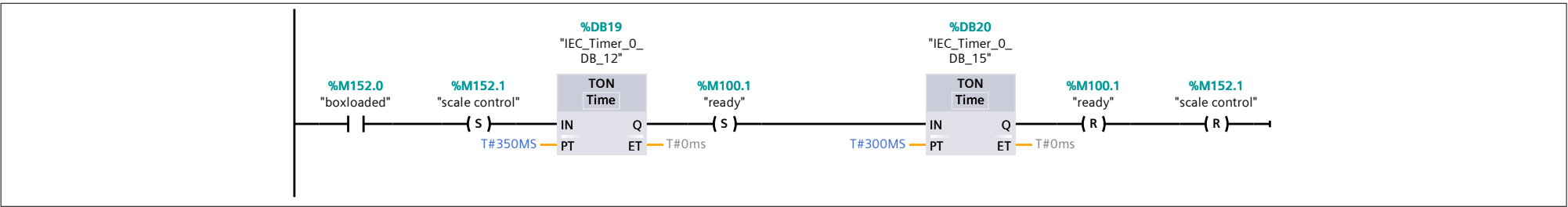
Network 9: Operate weigh scales

Network 9 operates the weigh scales.



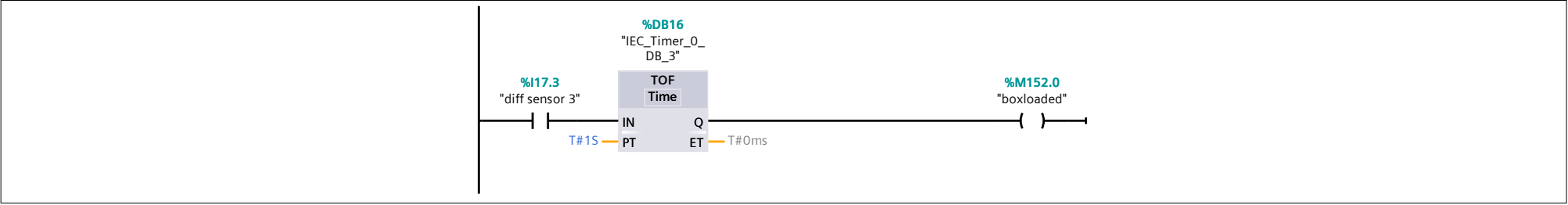
Network 10: Weigh control

Network 10 is responsible for weighing the boxes. The box enters the weigh scale control, where it sits briefly using a timer, whilst the boxes weight is being calculated. This will then help to seperate boxes further from just size.



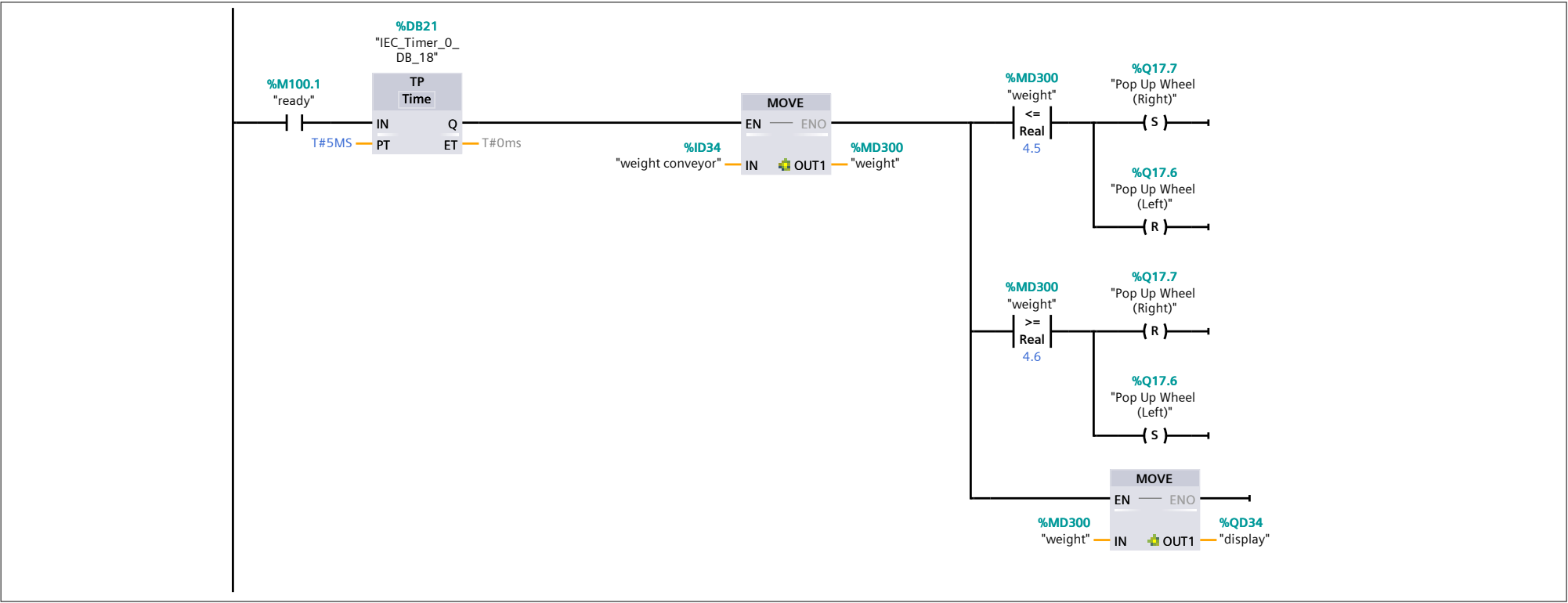
Network 11: Diff sensor 3 operates when box is loaded

Network 11 controls sensor 3, which is activated when a box is placed onto the weigh scale. Diff sensor 3 is also used to count the total boxes enetering the weigh scale, this will help identify and separete the boxes from the master counter.



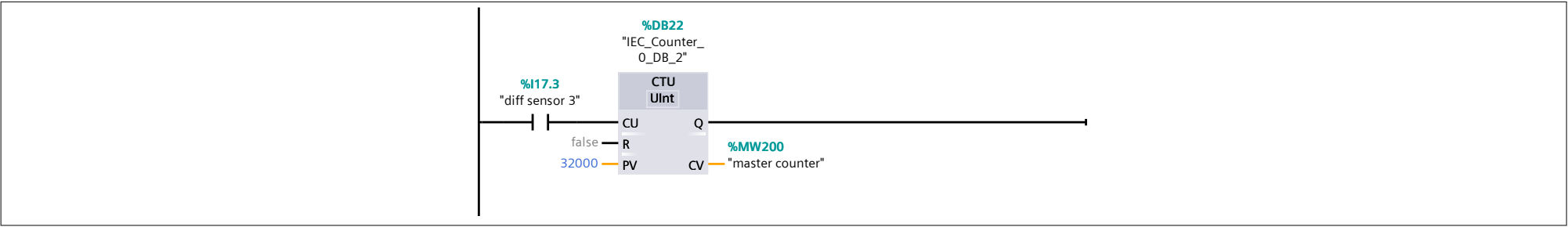
Network 12: Weigh control/pop up control

Network 12 manages the entire weight control process. After a box is weighed, a short timer is used whilst the boxes weight is calculated. The boxes are then classified into two categories. Any box weighing 4.5 or less is directed to the right conveyor, with the pop-up mechanism shifting to guide the box accordingly. For boxes weighing 4.6 or more, the pop-up shifts to the left, sending them to the left conveyor.



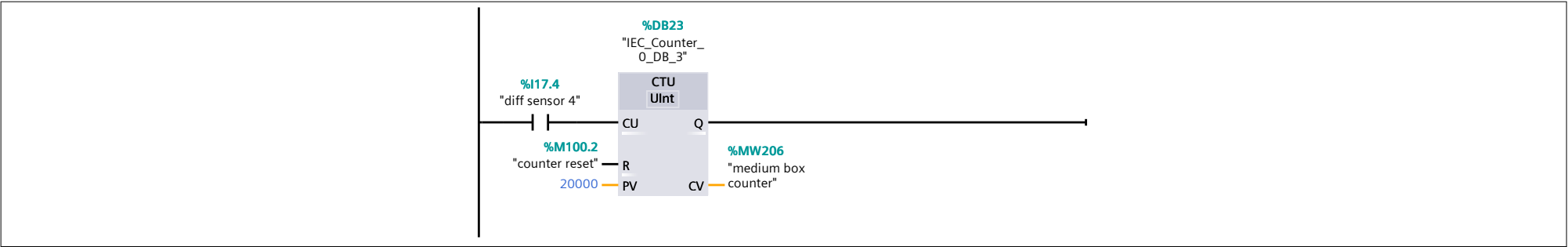
Network 13: Diff sensor 3 - boxes entering the weigh control

Network 13 uses sensor 3 to count the total number of boxes entering the weigh control. In theory, this serves as the master counter for the boxes on this conveyor belt. This will help identify for any error or how many boxes are on this conveyor.



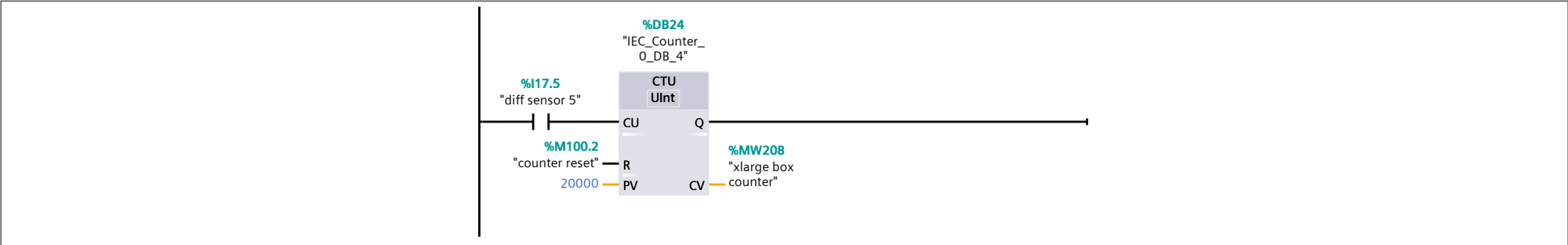
Network 14: Diff sensor 4 counts all medium sizes boxes

Network 14 uses sensor 4 to count the medium sized boxes, which in theory those weighing 4.5 or less entering the right side of the conveyor. This provides a total count of the boxes on that conveyor.



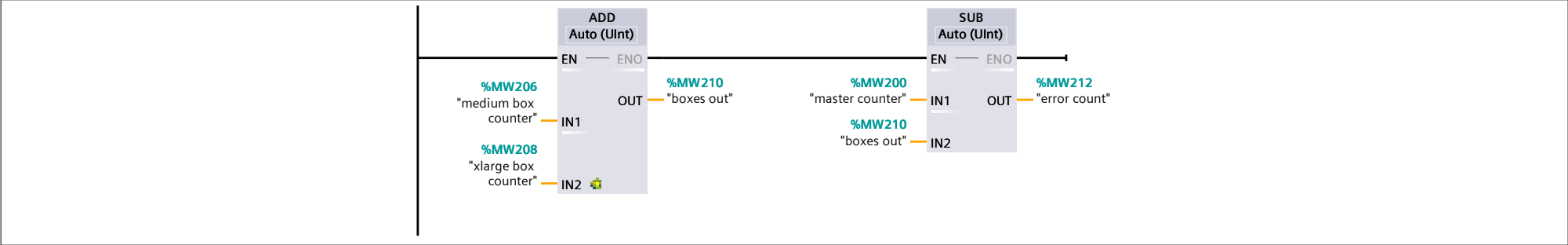
Network 15: Diff sensor 5 counts all xlarge boxes

Network 15 operates similarly to network 14 but tracks a different category of boxes. Sensor 5 counts boxes weighing 4.6 or more as they enter the left conveyor, providing a total count for this group of boxes.



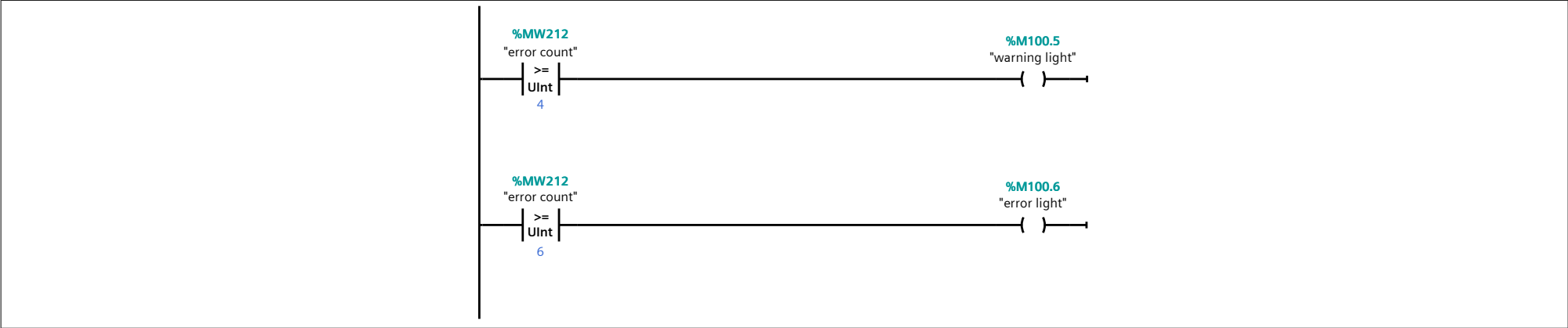
Network 16: Error checking

Network 16 performs error checking for the boxes entering the main conveyor. The master counter keeps track of the total number of boxes entering the belt and monitors the counts from other conveyor belts. This allows the system to compare the incoming and outgoing boxes, detecting any discrepancies or errors.



Network 17: Error warning light

Network 17 controls the warning and error lights. The warning light illuminates if there is a discrepancy of more than 4 boxes between what is entering and what is on or leaving the conveyor. The error light activates if the difference exceeds 6 boxes.



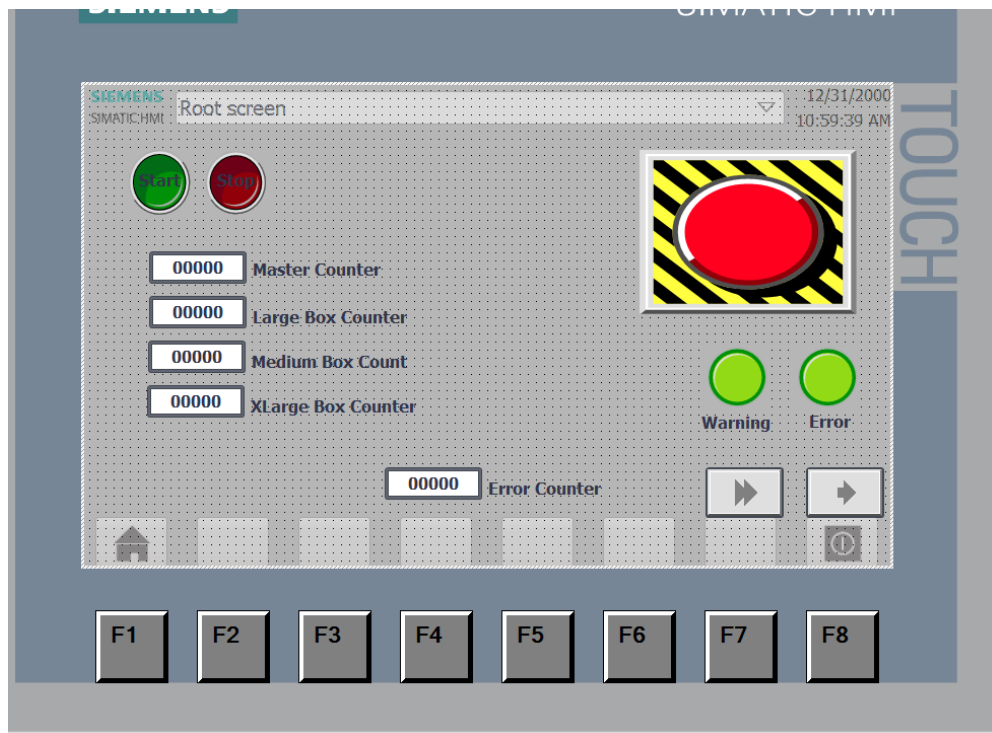


Fig. 10

The figure above displays the HMI interface designed for the sorting system. The HMI includes a master counter that tracks the total number of boxes entering the conveyor belt. It also features a large box counter, which increments when boxes are directed onto the large box conveyor by the pusher. Additionally, there are separate counters for medium and xlarge boxes. This gets calculated when boxes pass through the weigh scale and are sorted accordingly. The HMI interface also includes two indicator lights, a warning light and an error light. The warning light activates when there is a discrepancy of four boxes between the number of boxes entering the conveyor and those on the conveyor. The error light illuminates if this discrepancy exceeds six boxes, signalling an issue. The display also provides essential control buttons for starting, stopping, and activating the emergency stop for the system.

Task 5

This report summarizes the design, implementation and analysis of an automated sorting system using Factory I/O. The tasks are structured as follows:

Task 1: Reviews of PLC's

A detailed review of several PLC's commonly used in the industry was conducted, including Allen-Bradley, Siemens, Mitsubishi, Schneider Electric and ABB. The review evaluated the features, advantages and disadvantages of each brand to determine their suitability for industrial automation. A comparison table of pros and cons was also provided to highlight their unique strengths and challenges.

Task 2: Factory design using I/O

Using Factory I/O a system was designed to sort packages into four categories based on size and weight. The system consists of six conveyor belts, two pushers, a weighing scale and diff sensors to measure box size and track quantities. Safety and operation features such as emergency stops, warning lights and alarms were included to enhance safety and reliability.

Task 3: Ladder logic

A ladder logic program was created to control the factory's operations. The programme controls conveyor sequence, box detection, sorting via pushers or weigh scale and box counting using diff sensors. Safety features including emergency stop and alarms were also programmed. The logic ensures smooth, reliable sorting while checking for any potential errors. Each network of the ladder was explained with its specific function and relevance to the system.

Task 4: Integration of the HMI Display

A HMI display was integrated into the factory system to enhance user operation and control. The HMI includes counters to track the total number of boxes and the sorted categories. It features warning and error indicators to alert operators of discrepancies in box counts, control buttons for starting, stopping and emergency stops were also used.

This report covers an automated sorting system using Factory I/O. From evaluating PLC options to designing the factory process, creating ladder logic and integrating a HMI display. The detailed report shows the integration and technology a control system required to meet industrial automation needs effectively.

References

- [1] <https://www.sciencedirect.com/science/article/abs/pii/S1364032116000551>
- [2] <https://www.rockwellautomation.com/en-gb/products/hardware/allen-bradley/programmable-controllers.html>
- [3] <https://www.siemens.com/global/en/products/automation/systems/industrial/plc/s7-1200.html>
- [4] <https://www.plctable.com/allen-bradley-plc/>
- [5] <https://www.mitsubishielectric.com/fa/products/cnt/plc/>
- [6] <https://www.dmcinfo.com/latest-thinking/blog/id/9877/advantages-disadvantages-of-siemens-tia-openness>
- [7] <https://www.se.com/uk/en/product-subcategory/3910-plc-programmable-logic-controllers/>
- [8] https://pl.mitsubishielectric.com/en/news-events/releases/local/2016/1221-a/161221-a_local_en_pl.pdf
- [9] <https://www.plctable.com/schneider-plc/>
- [10] <https://new.abb.com/plc>
- [11] https://www.plctable.com/abb-plc/#google_vignette