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Simulation of a product packaging system by FACTORY I/O and TIA Portal V13 softwares

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الجمهورية الجزائرية الديمقراطية الشعبية
République Algérienne Démocratique et Populaire
وزارة التعليم العالي و البحث العلمي
Ministère de l'enseignement Supérieur et de la recherche scientifique



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Thème

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FACTORY I / O and TIA Portal V13 softwares**

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Présenté par : SOLTANI Khaled

Dirigé par : MESSAOUDI Abdelhamid

Résumés (Anglais et Arabe)

Summary

This work carried out within the Biskria Cement Plant presents the study of an automated production system (palletizer), and the realization of a program that ensures the start-up of this machine. For this, we have used a program under the environment of the TIA Portal V13 software for the SIMENS S7-1200 PLC to ensure the proper functioning of this machine. The TIA Portal V13 contains a SIEMENS PLC simulator such as the S7-1200. We used this simulator in our project to simulate programs and make the communication even with the absence of the real automaton. For supervision, we used the FACTORY I/O software.

الملخص

في هذا العمل الذي تم انجازه في مصنع بسكرية، قمنا بدراسة الآلة التي تقوم بشحن وتكديس اكياس الاسمنت. قمنا أيضا بإعداد وتصميم برنامج يضمن تشغيل هذه الآلة. من اجل هذا قمنا باستعمال برنامج TIA Portal V13 الذي يضمن تشغيلها آليا لهذه الآلة. برنامج TIA Portal V13 يحتوي على برنامج محاكاة الآلي مثل المبرمج S7-1200 . قمنا باستعمال هذا الاخير في مشروعنا هذا من أجل اجراء محاكاة للبرامج وعمل التوصيل نظرا لغياب المبرمج الآلي الحقيقي ومن أجل المراقبة استعمالنا البرنامج FACTORY I/O.

Dedications

to the memory of my father,

HOCINE

who inspired scientific thinking in my life;

to my mother,

who provided unflagging patience and

support;

to my sister,

a person who is there when you need her;

To my brothers and all my family;

To All my friends.

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*I thank Allah Almighty who gave me the strength and the will to do
this modest work.*

*I would like to thank first and foremost Dr. A. MESSAOUDI
for agreeing to be my supervisor during this work, and for the trust
she has given me and her valuable advice.*

*My thanks also go to the jury members for agreeing to judge my work.
Dr. BENCHABANE and Dr. GUETTAF*

*I thank the factory workers Biskria Cement, which opened their doors
and give me the opportunity to realize this project and more
particularly Mr. Mohamed, Mr. Walid, and to all those who helped me
during my practical training.*

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always
supported me morally and financially during all my long years of
study.*

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GENERAL INTRODUCTION

If we consider rapid technological changes and the growing presence of emerging economies in the global manufacturing market, companies are feeling pressure on many fronts. For this, companies at all levels of the value chain have the opportunity to position themselves to drive growth through their solid manufacturing experience, a robust innovation engine, a reputation for quality and innovation.

In order to improve each country's competitive position and increase its long-term viability, it is essential to consider changes to manufacturing methods. This leads us to think about plans that can benefit from advances in the manufacturing sector and other major emerging trends in the industry.

Nowadays, the use of automated machines in the industry where research is increasingly important. Indeed, the automation of the systems allows a faster and safer design than some works. In the field of research, we note that the use of automated machines is constantly changing, because it allows to handle with much precision and therefore more safely various products or objects, neutral or dangerous. In addition, automated machines can help human in difficult, repetitive and painful tasks. It constitutes the dream of substituting the human by the machine for these tasks. It is the reason for choosing the case of the exquisite company where the integration of a palletizer for a palletizing application and automated warehouse for storage is proposed.

It is from this that the initiation BISKRIA cement is taking the challenge of improving this performance, by proposing corrective solutions of the state, almost textbook, aimed to double the production capacity of the factory [1].

It is in this direction that our end of study project topic has been oriented. The objective of this work is to implement the automation of a line of cement component

palletizer system, while ensuring the maximum production and the minimum of failures with a reduced waiting time.

The new generation of operating room simulation software developed recently for learning automation, allows an easily and quickly design our production line by simple assembly of subsystems available in the library provided by these programs [1].

To achieve our goal, we used the TIA PORTAL V13 programming software provided by SIEMENS. The TIA PORTAL V13 contains a SIEMENS PLC Simulator such as the S7 1200, while for supervision we used the FACTORY I/O software.

Our project will consist of three chapters:

The first chapter is devoted to the understanding of Cement Manufacturing Process and Automated Production System.

The second chapter consists in the presentation of Programmable PLCs and the TIA PORTAL V13 and FACTORY I/O softwares.

Finally in the third chapter, we presented the different structures that make up the studied systems and the way in which their work silting up. Then we did the simulation on the software FACTORY I/O. The latter will be linked with the TIA PORTAL V13 software.

We end this work with a general conclusion.

CHAPTER I:
Cement Manufacturing Process and
Automated Production System

I.1 Introduction

As part of my final project study, which consisted in the study and the automation of the cement manufacturing process, in the Cement factory in Biskra, this chapter is intended to explain Cement manufacturing process and theoretical study Automated production systems.

I.2 Cement manufacturing process

I.2.1 Definition of cement

Cement is an industrial product made by grinding and mixing clinker and additions of other products (gypsum or others).

The clinker which is the main constituent of the cements is a semi-finished product obtained by cooking a mixture of raw materials (usually limestone and clay) with high temperature (1450°C). This mixture of raw materials is finely ground before cooking to obtain a 'raw feed' or 'kiln feed' which must contain certain components (chemical elements) in well-defined proportions [1].

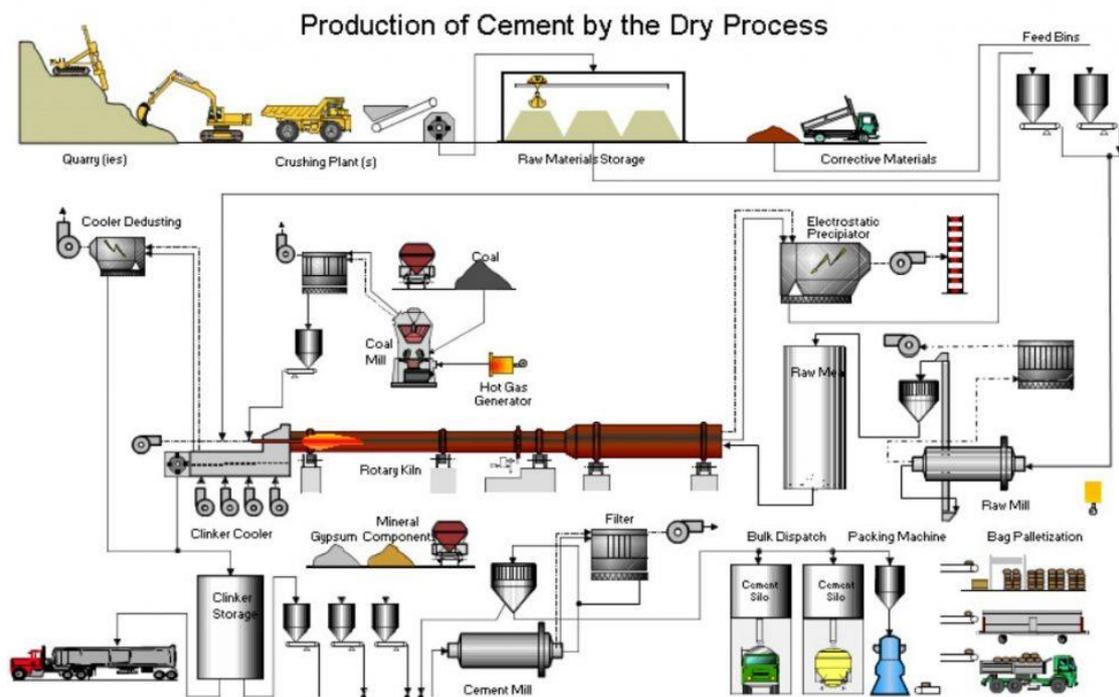


Figure I.1: Cement manufacturing cycle.

To produce the cement, the following steps must be considered (Figure I.1):

I.2.2 First Steps: Preparation of raw materials

I.2 .2.1 Raw Material Extraction

It provides two essential raw materials, limestone and clay, they are extracted like rocks and that by method of blasting (Figure I.2), and then the raw materials are dumped into trucks that will bring its rocks up to workshop crushing (Figure I.3). other materials are needed for the manufacture of cement such as sand, iron ore and gypsum. But, unlike limestone and clay, they are bought [1].



Figure I.2: Quarry.



Figure I.3: Extraction of raw material for cement making

I.2.2.2 Crushing

The purpose of the crushing operation is to reduce stone blocks by fragments of weak (Figure I.4), this operation is provided by a hammer crusher these are the most used in cement works [1].



Figure I.4: Hammer crusher.

I.2.2.3 Storage

After these three basic constituents crushing operation a particle size of 0 to 25 mm is obtained the component are in chimneys to the plant covered by treadmill and then stored in s two homogenization pre halls: a hall with a circular storage (Figure I.5) for limestone and a linear storage (Figure I.6) hall for clay and sand and iron ore [1].



Figure I.5: circular storage.



Figure I.6: linear storage.

I.2.3 Step 2: raw dosing and grinding

I.2.3.1 Dosage

The raw material and consisting of a mixture of raw materials of correction in proportion that are defined according to the values of the raw chemical modules (Figure I.7), in general the raw material consists of 70% of limestone, 20% clay and

10% between sand and iron ore, four feeders are installed under hoppers, limestone and clay and iron ore and sand are respectively extracted by these dosers, each doser is systematized in an automatic manner [1].



Figure I.7: Dosing Workshop.

I.2.3.2 Crushing of raw

After the dosing operation, the extracted raw materials are loaded onto a single belt conveyor and then transported to the raw mill (Figure I.8).

Most grinders in the Biskra Cement Plant are 2-chamber horizontal ball mills. The first has a role of crushing and the second has a role of finisher. In the case of wet materials to be treated, there is a drying chamber [1].



Figure I.8: Raw mill.

I.2.4 Step 3: Clinker production

Clinker is a dark grey nodular material made by heating ground limestone and clay at a temperature of about 1400 °C - 1500 °C. The nodules are ground up to a fine powder to produce cement (Figure I.9) with a small amount of gypsum added to control the setting properties [1].

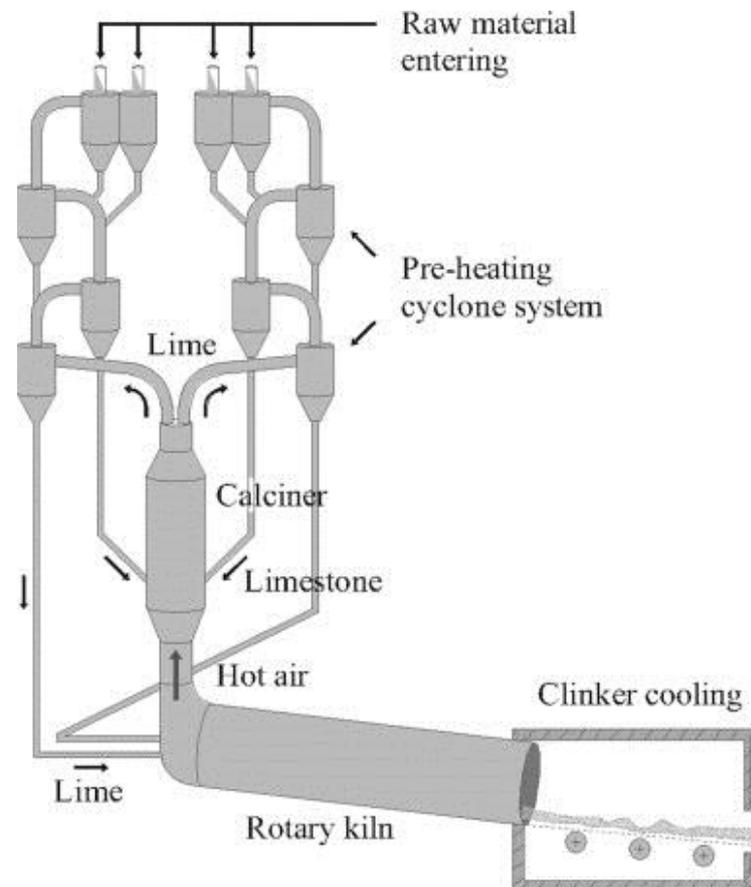


Figure I.9: Production stages of clinker.

I.2.4.1 Homogenization and preheating

Then, the raw is transported in the homogenization silo. In the bottom of this silo, the mixing chamber homogenizes the material that is sent directly into the tower preheating through an elevator (Figure I.10). The preheating tower is equipped with five stages of cyclones that allow the material to be preheated to around 800 °C, to dehydrate it flour (another name given to the material) falls by gravity while the gases go up the tower for move towards the filter [1].



Figure I.10: Preheater or cyclones.

I.2.4.2 Rotary kiln

The ovens are designed systems for the cement plant, to meet the requirements chemical process during which the raw material is transformed into clinker. The rotary kiln is a steel cylinder resting on rolling stations; it is lined internally by refractory products. During cooking, the rotary kiln (Figure I.11) is animated by a movement of rotation; the sloping arrangement of the furnace allows the movement of the raw material which is injected from the other end with respect to the heating flame. During this trip, the matter turns into baking while advancing from its initial state until it become clinker at the temperature of 1450°C [1].

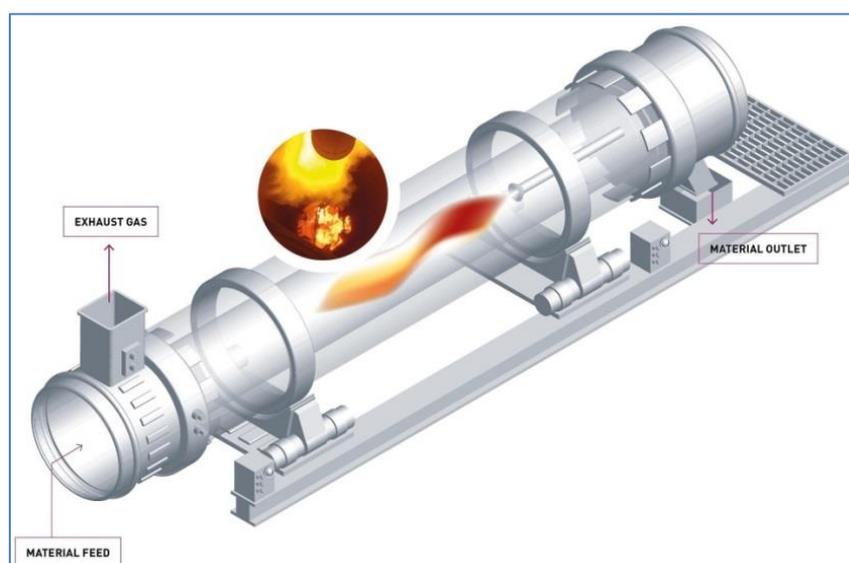


Figure I.11: Rotary kiln.

I.2.4.3 Cooler

At the outlet of the oven, the clinker is introduced into a cooler with balloons or grids where it is cooled to a temperature of 120 ° C (Figure I.12). the role of chillers is to guarantee the quenching of the clinker to have a mineralogical structure and dimensions of favorable crystals. Chillers also lower the clinker temperature to facilitate handling up to storage silos [1].



Figure I.12: Grid Cooler.

I.2.4.4 Storage of clinker

Once cooled, the clinker is then stored in silos which, on the one hand, confer the cement grinding shop (next step) [1].

I.2.5 Step 4: Cement production

I.2.5.1 Grinding Cement

The clinker goes to the cement hoppers and then crushed by adding the gypsum and limestone with different amounts depending on the qualities of the desired cement.

This type of crusher that allows the grinding of clinker by adding additions is called "CEMENT CRUSHER" [1].

I.2.5.2 Storage and shipping of cement

At the end of the mill, the cement is transported to large capacity silos which subsequently feed the bagging workshops for bagged shipping, or devices loading and delivery in BULK. So shipments include cement storage, its packing (bagging) in case of delivery by sacks or via a bulk and its loading on the transport tool (truck). This is the interface of the factory with the customer (Figure I.13) [1].

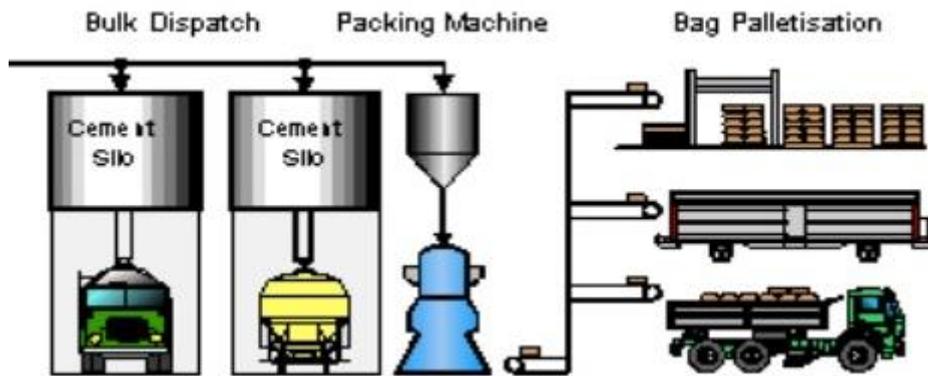


Figure I.13: The Cement Expedition.

I.3 Newtec bag palletizing

I.3.1 presentation of the machine

Bag palletizers for a rate of 4000 bags/hour (Figure I.14). this range is especially designed for high palletizing throughputs in the building materials sector. Bags are oriented by a removable stop. Layers are built row by row with respect to the bag shape. Each layer is squared and pressed to optimize pallet geometry. The components of NEWTEC's bag palletizers are carefully chosen to take the abrasiveness of the products into account [1].

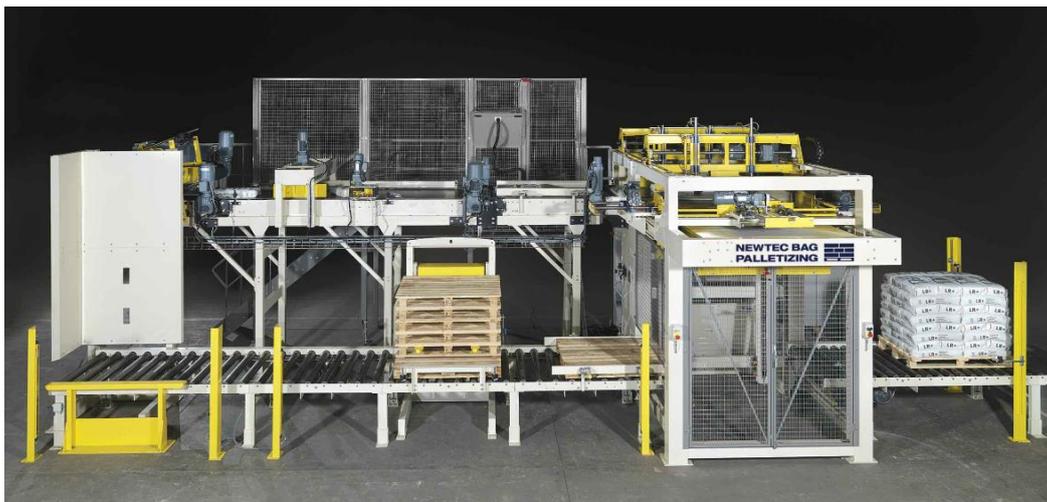


Figure I.14: Newtec bag palletizing model 4000.

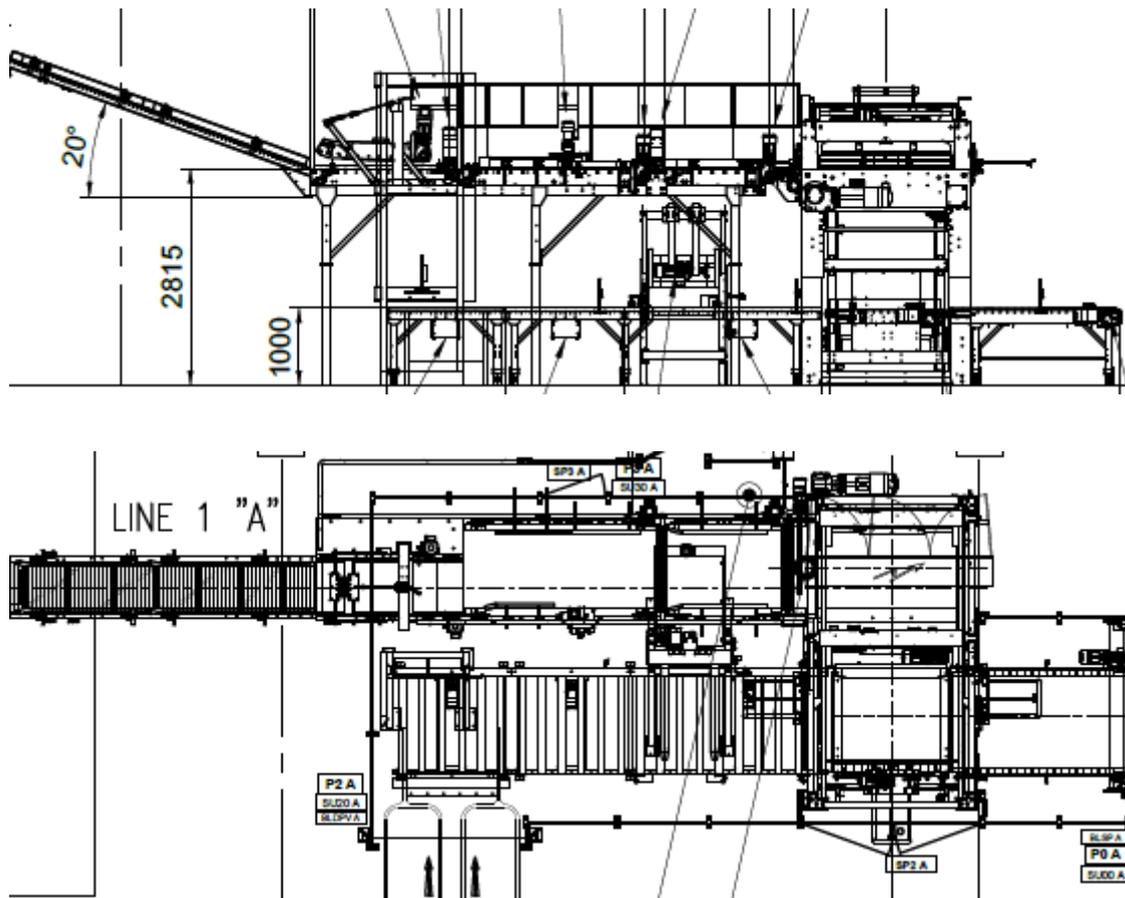


Figure I.15: Installation plan.

I.3.2 Principle of operation

The purpose of the machine is to automatically build stacks of full bags from a production line of customer, arranging them and depositing them layer by layer on empty pallets supplied by the customer.

- **Bag conveyor:**
It carries bags from the customer's belt to the top of the palletizer.
- **Bag flattener, with or without lifting:**
The bag flattener, with rollers or tape, reduces the thickness of the bag. The lift, manual or motorized, distributes the product in the bag.
- **Conveyor for bag orientation:**
The orientation of the bags is done using a turning stopper, without deformation, on an orientation conveyor. The programming directs the orientation of the bag 90 ° to the left, 90 ° to the right, 180 ° or will let the bag

go straight. This method allows the seams or valves to be oriented inside the stack.

- **Stacking** :
- The formation of the stacking:
 - the grouping band prepares the rows of bags;
 - the row pusher transfers the rows on the false pallet to form the layer;
 - after conformation on the four sides of the layer, the false pallets deposit it on the pallet;
 - The pallet elevator ensures the stacking and pressing of each layer down as you go the removal of the layers.
- **Embedded roller conveyor:**
It receives the empty pallet and evacuates the full pallet.
- **Motorized roller conveyor feeding empty pallets:**
It conveys empty pallets to the frame.
- **Motorized roller conveyor evacuation full pallets:**
A modular range of standard elements makes it possible to adapt the conveying and storage of the following full pallets the implementation and the needs of the client [1].

I.4 Industrial Automation

I.4.1 the Industrial Control System

Every industrial production process consists of a series of simple or complicated machines that, through the combination of raw materials, undergo a sequential transformation and integration in order to produce a final product. The term “machine” denotes every kind of electromechanical device on the industrial floor, e.g., from a simple motor (such as a drilling or a cutting machine) up to a complicated chemical machine (e.g., a chemical combustion machine). The whole set of machines (namely non-homogeneous machines), which are being integrated and combined in an industrial production process, will be referred to as an integrated machine” [2].

I.4.2 Definition of an automated system

An automated system is a collection of devices working together to accomplish tasks or produce a product or family of products. Industrial automated systems can be one

machine or a group of machines. Devices include those that actually produce the product and that provide support, Control, and feedback to the system. The four basic types of devices in a cell are production, support, Control, and feedback [3].

I.4.3 Purpose of an automated system

A fundamental motivation for the automation of an industrial process is that the viability of the enterprise, and particularly business profit, can be achieved through the following objectives:

- Production increase.
- Cost reduction, mainly due to the reduction of human-related cost.
- Improvement of the raw material utilization (reduced loss in materials).
- Reduction of energy consumption [2].

I.4.4 Structure of an automated system

The automation system is broadly divided into three subsystems: instrumentation, control, and human interface. They are interconnected, as illustrated in Figure I.16 [4].

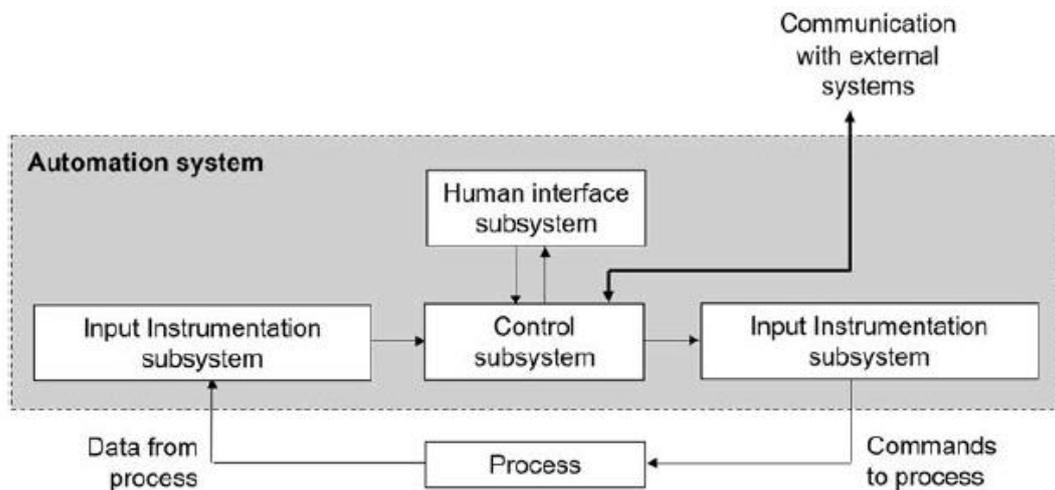


Figure I.16: Basic structure of automation system.

I.4.4.1 Instrumentation

The instrumentation is the branch of engineering that deals with the measurement and control of process parameters. An instrumentation device measures the physical variable and/or manipulates it to produce an output in an acceptable form for further

processing in the next stage device. Instrumentation devices are not normally intelligent and are not capable of making decisions.

The instrumentation subsystem primarily works in two directions: one on the input side of the control subsystem and the other on the output side. Hence the instrumentation subsystem can be further divided into input and output subsystems to explain the flow of data in the order they are received from a process, processed in the control subsystem, and sent to a process for actions:

1. **The input instrumentation subsystem (Sensors):** interfaces with the process to acquire data on the behavior of the process (measurement of process parameters) and sends them to the control subsystem in an acceptable form .
2. **The output instrumentation (Actuators):** subsystem interfaces with the process to send the command received from control subsystem to the process in an acceptable form, to change the behavior of the process (control of process parameters) [4].

a) Actuators

An actuator is a device that uses some type of energy and produces the required force, either providing motion to an object or actuating something. Actuators (independently of their shape, form, and size) produce the mechanical movements required in any physical process in a factory .types of actuators in industrial automation (Figure I.17): (a) servo motor, (b) DC motor,(c) stepper motor, (d) linear motor, (e) pneumatic cylinder, (f) solenoid actuator[2].



Figure I.17: Types of actuators in industrial automation.

b) Sensors

The sensors provide the necessary feedback information for the conduct of the process by capturing the movements of the actuators or the result of their actions on the process. They can detect positions, pressures, temperatures, and flow rates....

I.4.4.2 Human Interface

The human interface subsystem presents information to the operator or user on the state of the process and facilitates implementing the operator's control instructions to the process. The human interface subsystem is also called the human-machine interface, man-machine interface, human-system interface, and so forth. The human interface subsystem is a facility for the user or operator to interact directly with the process, via the control subsystem, for:

- Direct monitoring of process parameters to know what is happening inside the process (monitoring of process behavior);
- Direct control of process parameters by forcing a change, if required, by issuing manual commands (controlling of process behavior) [4].

I.4.4.2 Control

The control subsystem is a mechanism or device for automatically manipulating the output of a process and for managing, commanding, directing, or regulating the behavior of the process to achieve the desired result. The control subsystem is the heart of the automation system. It is an intelligent device capable of making decisions.

The control subsystem manages data flow to/from the instrumentation subsystems for process monitoring and control, and to/from the human interface subsystem for direct interaction with the process; it can exchange data directionally with other external compatible systems if required [4].

I.5 Conclusion

This chapter gives an overview of the different areas of the Biskra cement production plant and the different phases of cement manufacturing. First, we introduced the process of making cement factory and explaining the operation of the main areas, then we presented an overview of the automated systems of production, the following chapter will be devoted to the description of programmable logic controllers, in general, especially PLCs Siemens S7-1200 with TIA Portal V13 software and monitoring software Factory I/O.

CHAPTER II:
**Cement Manufacturing Process and
Automated Production System**

II.1 Introduction

In this chapter we will talk about the description of the PLCs in a more general way and in a more detailed way of the S7-1200 PLC, as well as the programming software TIA Portal V13, which is basic software for the configuration. Afterwards an overview of Factory IO will be presented.

II.2 Generality on the programmable logic controller

II.2.1 Definition

Programmable logic controllers (Figure II.1) are now the most widely used industrial process control technology.

A programmable logic controller (PLC) is an industrial grade computer that is capable of being programmed to perform control functions. The programmable controller has eliminated much of the hardwiring associated with conventional relay control circuits. Other benefits include fast response, easy programming and installation, high control speed, network compatibility, troubleshooting and testing convenience, and high reliability.

The PLC is designed for multiple input and output arrangements, extended temperature ranges, immunity to electrical noise, and resistance to vibration and impact. Programs for the control and operation of manufacturing process equipment and machinery are typically stored in battery-backed or nonvolatile memory. A PLC is an example of a real-time system since the output of the system controlled by the PLC depends on the input conditions [5].



Figure II.1 : Programmable logic controller.

II.2.2 Types of programmable logic controller

There are two ways in which I/Os (Inputs/Outputs) are incorporated into the PLC: compact and modular.

- **Compact PLC** (Figure II.2) is typical of small PLCs that come in one package with no separate, removable units. The processor and I/O are packaged together, and the I/O terminals will have a fixed number of connections built in for inputs and outputs. The main advantage of this type of packaging is lower cost. The number of available I/O points varies and usually can be expanded by buying additional units of fixed I/O. One disadvantage of fixed I/O is its lack of flexibility; you are limited in what you can get in the quantities and types dictated by the packaging. Also, for some models, if any part in the unit fails, the whole unit has to be replaced [5].

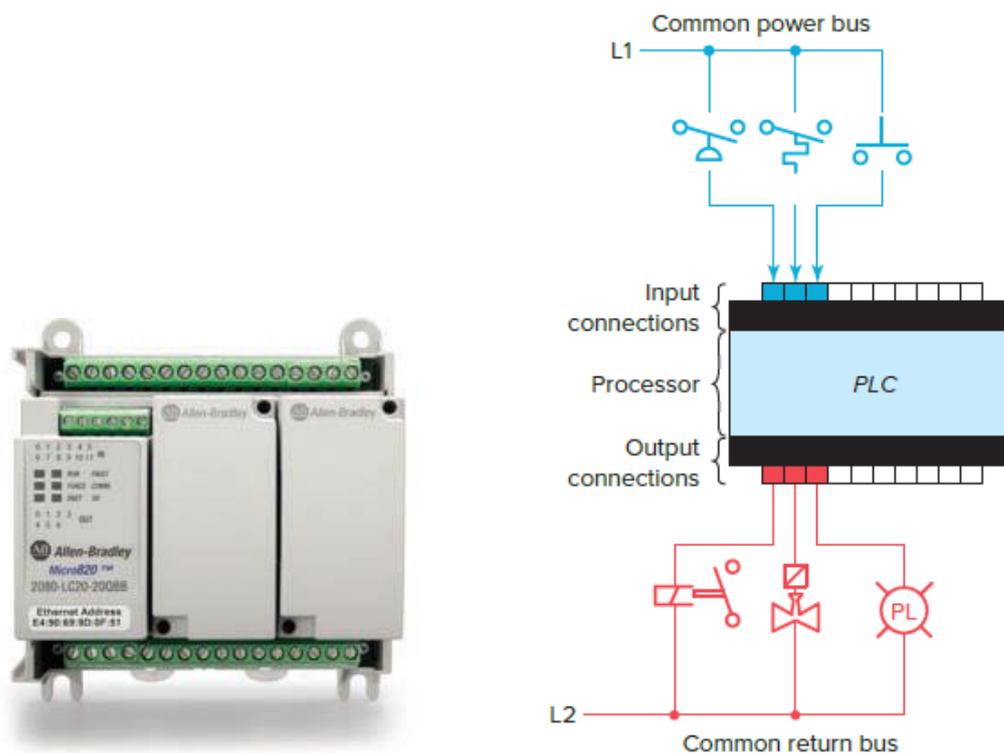


Figure II.2: PLC compact.

- **Modular PLC** (Figure II.3) is divided by compartments into which separate modules can be plugged. This feature greatly increases your options and the unit's flexibility. You can choose from the modules available from the manufacturer and mix them any way you desire. The basic modular controller consists of a rack, power supply, processor module (CPU), input/output (I/O

modules), and an operator interface for programming and monitoring. The modules plug into a rack. When a module is slid into the rack, it makes an electrical connection with a series of contacts called the backplane, located at the rear of the rack. The PLC processor is also connected to the backplane and can communicate with all the modules in the rack.

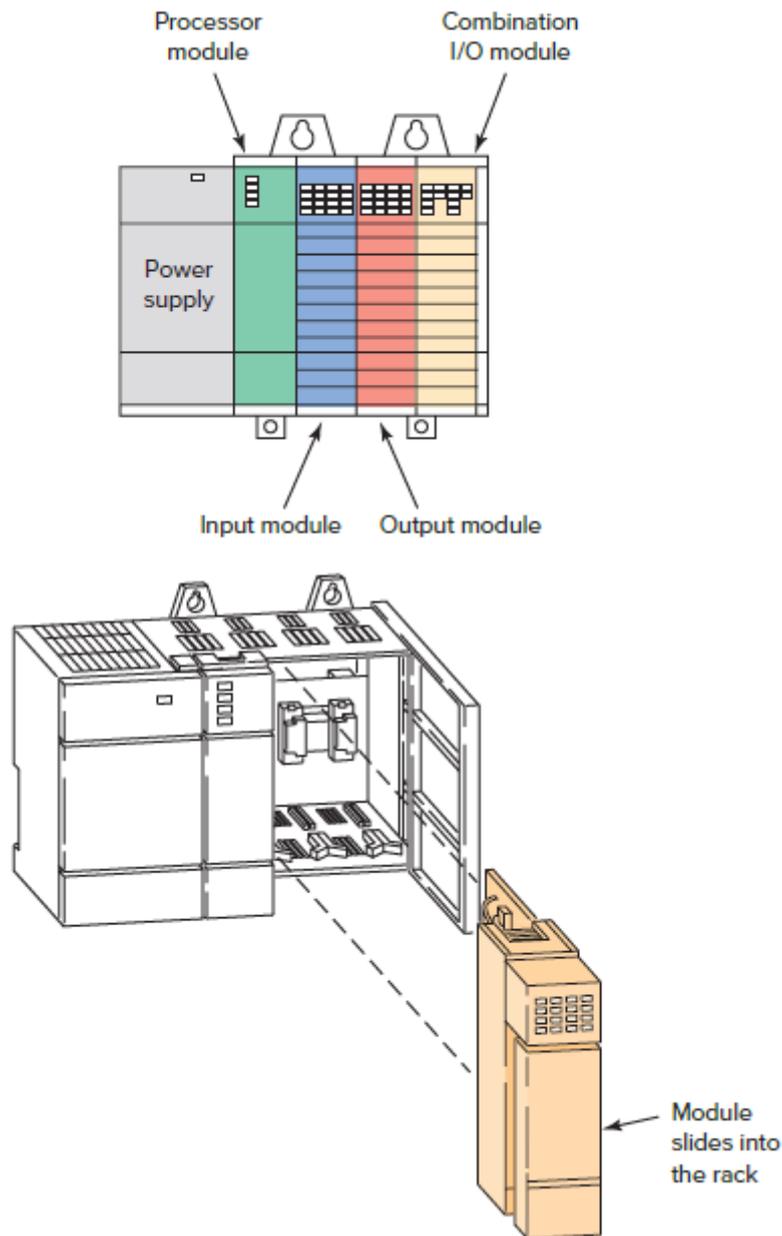


Figure II.3: Modular PLC.

II.2.3 Hardware

Typically, a PLC system has the basic functional components of processor unit, memory, power supply unit, input/output interface section, communications interface, and the programming device. Figure 1.7 shows the basic arrangement [5].

- **The processor unit or central processing unit (CPU)** (Figure II.4) is the unit containing the microprocessor. This unit interprets the input signals and carries out the control actions according to the program stored in its memory, communicating the decisions as action signals to the outputs.



Figure II.4: Typical PLC processors.

- **The power supply unit** is needed to convert the mains AC voltage to the low DC voltage (5 V) necessary for the processor and the circuits in the input and output interface modules.
- **The programming device** is used to enter the required program into the memory of the processor. The program is developed in the device and then transferred to the memory unit of the PLC.
- **The memory unit** is where the program containing the control actions to be exercised by the microprocessor is stored and where the data is stored from the input for processing and for the output.
- **The I/O system** forms the interface by which field devices are connected to the controller (Figure II.5). The purpose of this interface is to condition the various signals received from or sent to external field devices.

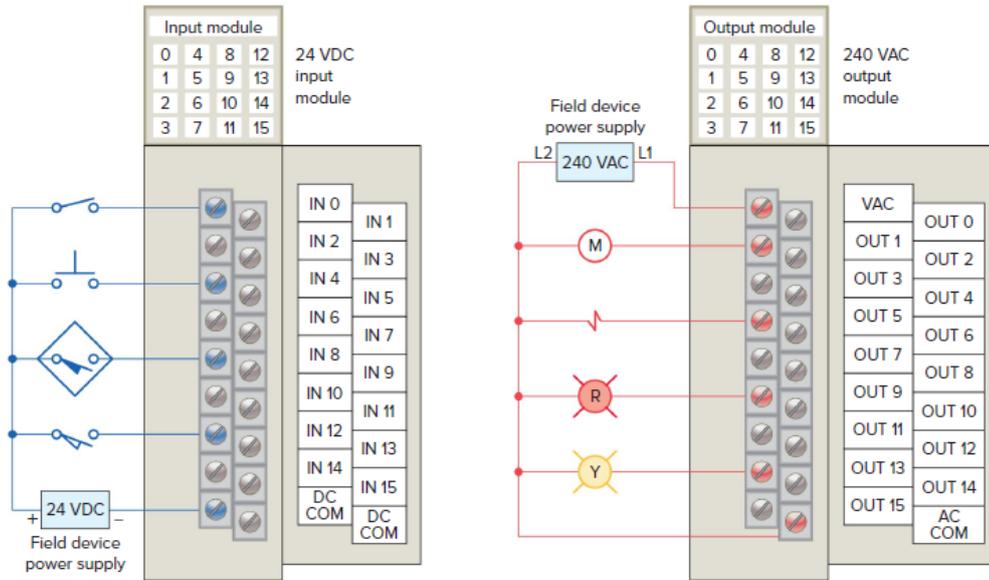


Figure II.5: Typical PLC input/output (I/O) system connections.

Input devices such as pushbuttons, limit switches, and sensors are hardwired to the input terminals. Output devices such as small motors, motor starters, solenoid valves, and indicator lights are hardwired to the output terminals. To electrically isolate the internal components from the input and output terminals, PLCs commonly employ an optical isolator, which uses light to couple the circuits together [5].

- **The communications interface** is used to receive and transmit data on communication networks from or to other remote PLCs (Figure II.6 to II.7). It is concerned with such actions as device verification, data acquisition, synchronization between user applications, and connection management [6].

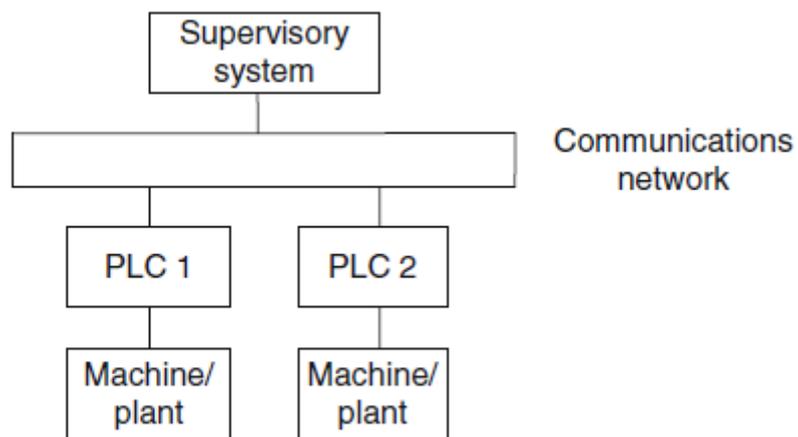


Figure II.6: Basic communications model.

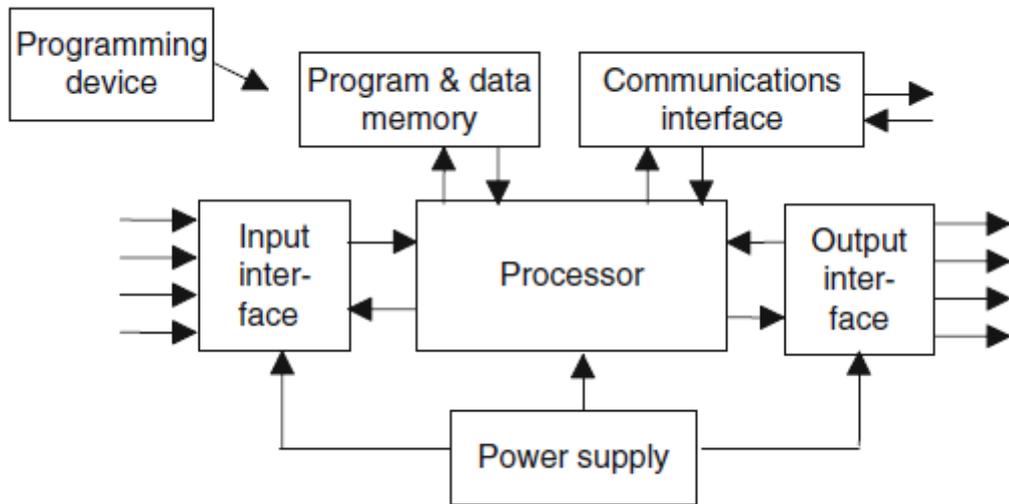


Figure II.7: The PLC system.

II.2.4 Principles of Operation

The CPU controls all PLC activity and is designed so that the user can enter the desired program in relay ladder logic. The PLC program is executed as part of a repetitive process referred to as a scan (Figure II.8). A typical PLC scan starts with the CPU reading the status of inputs. Then, the application program is executed. Once the program execution is completed, the status of all outputs is updated. Next, the CPU performs internal diagnostic and communication tasks. This process is repeated continuously as long as the PLC is in the run mode [5].

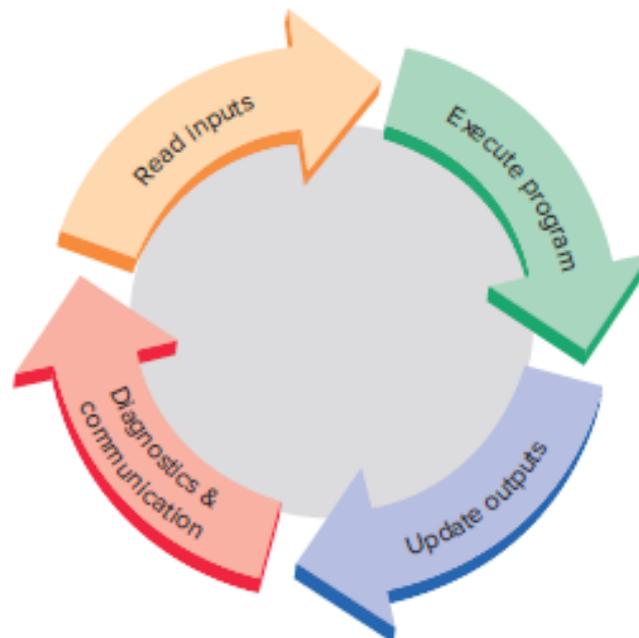


Figure II.8: Typical PLC scan cycle.

II.2.5 Modifying the Operation

One of the important features of a PLC is the ease with which the program can be changed. For example, assume that the original process control circuit for the mixing operation must be modified as shown in the relay ladder diagram of Figure II.9. The change requires that the manual pushbutton control be permitted to operate at any pressure, but not unless the specified temperature setting has been reached [6].

If a relay system were used, it would require some rewiring of the circuit shown in Figure II.9 to achieve the desired change. However, if a PLC system were used, no rewiring would be necessary. The inputs and outputs are still the same. All that is required is to change the PLC ladder logic program as shown in Figure II.10 [5].

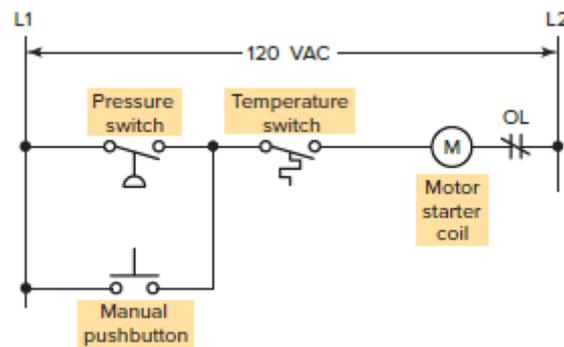


Figure II.9: Relay ladder diagram for the modified process.

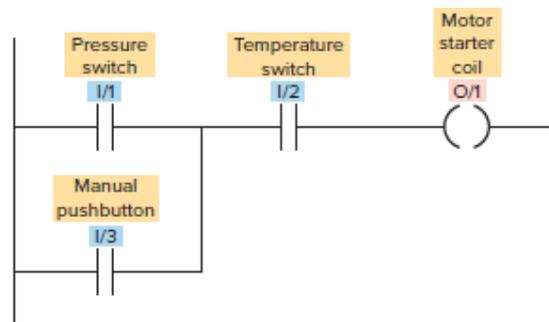


Figure II.10: PLC ladder logic program for the modified process.

II.2.6 PLC Programming Languages

The term PLC programming language refers to the method by which the user communicates information to the PLC. The standard IEC 61131 (Figure II.11) was established to standardize the multiple languages associated with PLC programming by defining the following five standard languages:

- **Ladder Diagram (LD):** a symbolic depiction of instructions arranged in rungs similar to ladder formatted schematic diagrams [5].

- **Function Block Diagram (FBD):** a graphical depiction of process flow using simple and complex interconnecting blocks [5].
- **Sequential Function Chart (SFC):** a graphical depiction of interconnecting steps, actions, and transitions [5].
- **Instruction List (IL):** a low-level, text-based language that uses mnemonic instructions [5].
- **Structured Text (ST):** a high-level, text-based language such as BASIC, C, or PASCAL specifically developed for industrial control applications [5].

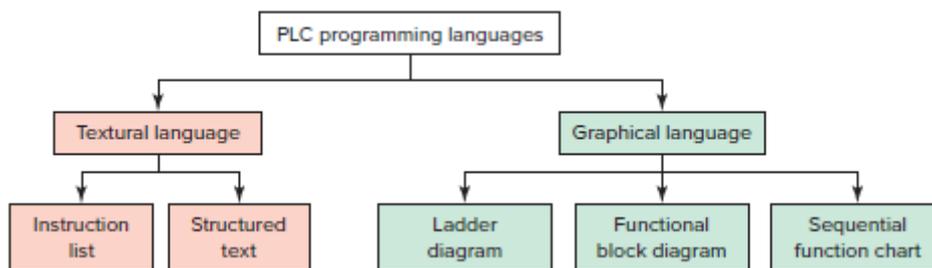


Figure II.11: Standard IEC 61131 languages associated with PLC programming.

II.3 GRAFCET

The GRAFCET is a graphical tool that describes the operation of a sequential automation. It can be used to represent automation in all phases of the design: from the definition of the specifications, to the implementation (programming of an industrial PLC, use of sequencers or other technologies) through the study of the modes of marches and stops.

The GRAFCET is based on the use of precise instructions, the use of a well-defined vocabulary, the respect of a rigorous syntax and the use of rules of evolution. It allows, among other things, to adopt a progressive approach in the development of automation. It describes the relationships between the outputs and the Boolean inputs of the control system.

The GRAFCET is an alternate representation of steps and transitions. Only one transition must separate two steps [7].

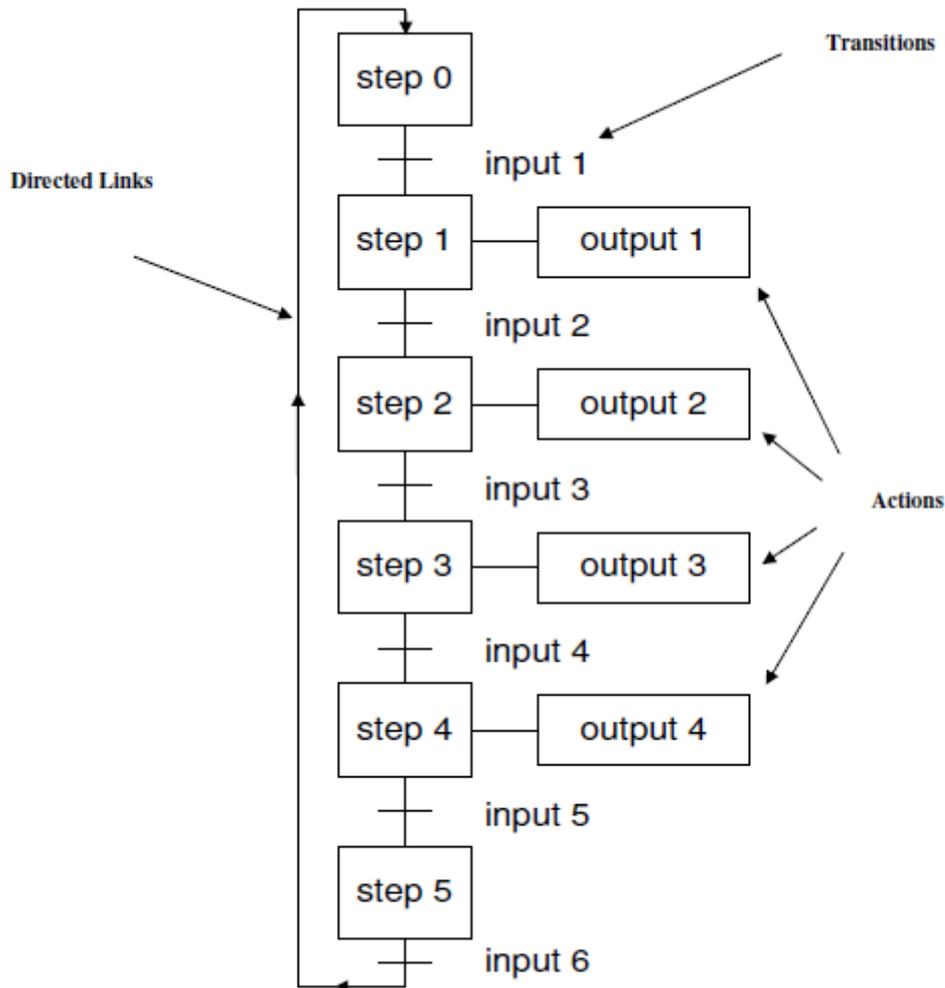


Figure II.12: Typical GRAFCET.

II.3.1 Construction rules of a grafcet

A grafcet is graph which is composed of steps and transitions, connected between them by connections or directed arcs (see Figure II.12) [7].

II.3.1.1Steps:

A Step (Figure II.13) is represented by a square to which a unique number is associated, step can be initial (represented by a double square) and it is either active or inactive.

The whole of active steps (called situation) entirely defines the state of the system. We specify for each step, the actions to be executed. These actions are executed only when the corresponding step is active. We can associate a condition to those actions, the action is then executed only if the step is active and the condition is performed [7].

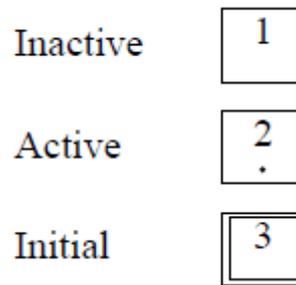


Figure II.13: Type of steps.

II.3.1.2 Transitions

A transition is represented by a horizontal line and represents a possibility of change of the compartment of the system. This change of compartment (the passage from one step to the following) corresponds to the crossing of a transition.

A transition is validated when all previous steps are active. The logical proposal which conditions the transition calls the receptivity [7].

II.3.1.3 Directed arcs

Each directed arc links a step to a transition or a transition to a step: there is always strict alternation: step-transition. When this connection is directed upwards, we show the direction by an arrow upwards [7].

II.3.1.4 Convergences and divergences

When the directed arcs start from several steps (known as steps downstream) and arrive on the same transition or when directed start from the same transition and arrive on several steps (known as steps upstream) then these regrouping are represented by two horizontal parallel lines respectively called convergence and divergence “in and” (Figure II.14) [7].

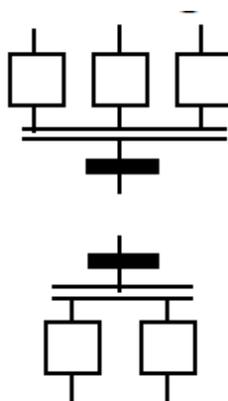


Figure II.14: In and.

When separation is in the direction from several transitions to a common step (respectively from a step to several transitions), we name them convergences (respectively divergence) “in or”. Their representation is done by dividing the directed connections (Figure II.15) [7].

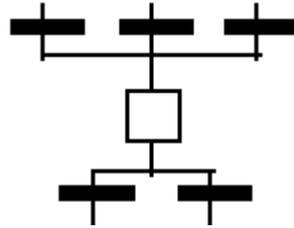


Figure II.15: In or.

II.3.2 Rules of evolution of a grafcet

The evolution of a grafcet is subject to five rules:

Rule 1: Initial situation

The initial situation of a grafcet characterizes the initial behavior of the control part with respect to the operative part, to the operator and/or to the external elements. It corresponds to the active steps at the beginning of operation: those steps are the initial steps.

Rule 2: Crossing a transition

A transition is validated when all immediately preceding steps connected to this transition are active. The crossing of the transition occurs:

- when the transition is validated,
- AND when the receptivity associated with this transition is true.

Rule 3: Evolution of activated steps

The crossing of a transition involves simultaneously the activation of all immediately following steps and the inactivation of all immediately preceding steps.

Rule 4: Simultaneous evolution

Several simultaneously crossable transitions are simultaneously crossed.

Rule 5: Simultaneous activation and inactivation

If during operation same step is simultaneously activated and inactivated, it remains active [7].

II.4 SIMATIC S7-1200 automation system

II.4.1 S7-1200 station components

A complete programmable controller including all I/O modules is referred to as a “station”. This also includes distributed I/O modules connected to the CPU via a bus system.

An S7-1200 station comprises at least the CPU. Depending on the version, it has digital and analog input/output channels and can be fitted with additional input/output channels using a signal board (SB).

Depending on the type of CPU, up to eight signal modules can be plugged in which expand the station by digital and analog input/output channels. A two-tier design is possible using a 2-meter long extension cable.

The programming device is connected over Industrial Ethernet. Industrial Ethernet can also be used to connect further SIMATIC stations or HMI devices to the CPU. Up to three communication modules take over the connection to additional bus systems or to a point-to-point link.

Integral technological functions for measuring and counting tasks, closed-loop control, and motion control allow the CPU 1200 (Figure II.16) to be used in many complex machine controls.

The SIMATIC Memory Card can be used to download configuration data, as an external load memory, or for a firmware update [8].



Figure II.16: S7-1200 station with CPU S7-1214, two SMs (right) and one CM (left).

II.4.2 S7-1200 CPU modules

There are four types of CPU (CPU 1211, CPU 1212, CPU 1214, and CPU 1215), available in each case in the versions DC/DC/DC (Figure II.17), AC/DC/RLY, DC/DC/RLY. The first item of data refers to the module power supply (DC = 24 V direct current, AC = 120/230 V alternating current). The middle item of data refers to the operating voltage of the onboard digital inputs (DC = 24 V direct current) [8].

The last item of data refers to the type of digital outputs (DC = 24 V direct current electronic, RLY = up to 30 V direct current or up to 250 V alternating current with relay) [8].



Figure II.17: CPU 1214C DC/DC/DC.

II.4.2.1 Integrated I/O

The digital inputs (DI) on the CPU module work with an operating voltage of 24 V DC. Different numbers are available depending on the CPU version. The status of the input signals is displayed by means of LEDs.

The digital outputs (DQ or DO) are available in electronic form (24 V DC and 0.5 A output current with a resistive load of 5 W) and as relay outputs (up to 30 V DC and 2 A output current with a resistive load of 30 W or up to 250 V AC and 2 A output current with a resistive load of 200 W). Different numbers of digital outputs are available depending on the CPU version. The status of the output signals is displayed by means of LEDs.

Each CPU has two analog input channels (AI) for 0 to 10 V. The resolution is 10 bits. The analog value can be processed in the user program in the numerical range from 0 to 27 648. The CPU 1215 has two additional analog output channels (AO) for 0 to 20 mA. The resolution is 10 bits. The analog value can be processed in the user program in the numerical range from 0 to 27 648 [8].

II.4.2.2 PROFINET connection

The CPU is connected to an Ethernet network over the PROFINET interface (Figure II.18). The connection (port) takes the form of an RJ45 socket. The protocols Transmission Control Protocol (TCP) in accordance with RFC 793, ISO Transport over TCP (ISO-on-TCP) in accordance with RFC 1006, and User Datagram Protocol (UDP) in accordance with RFC 768 are supported. The connection is able to automatically recognize a transmission rate of 10 or 100 MBit/s (autosensing). Either a standard Ethernet cable or a crossover cable can be used for the network [8].



Figure II.18: PROFINET connection.

II.4.2.3 Status LEDs

The current operating mode of the CPU is indicated by LEDs on the front of the module (Figure II.19):

RUN/STOP:

- Continuous yellow light in STOP mode.
- Continuous green light in RUN mode.
- Flashing light in STARTUP mode.

ERROR:

- Flashing red light in event of error.
- Continuous red light if hardware is faulty.

MAINT:

- Continuous yellow light with maintenance request.

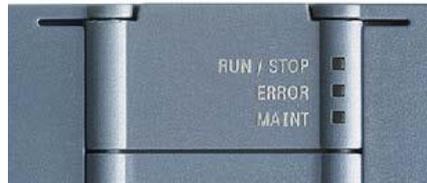


Figure II.19: LED displays on the CPU.

After switching on, the CPU is in STARTUP mode. It runs through test routines, carries out parameter settings, and executes the startup program. The CPU then changes to the RUN status and executes the user (main) program – this is the “normal” operating status. The CPU returns to the STOP mode if it detects a “serious” error, if it executes a corresponding program statement, or if it is specifically set to this state e.g. by the programming device. The user program is not executed in the STOP mode, but the CPU is still able to communicate, facilitating downloading of parts of the user program, for example [8].

The ERROR LED flashes when an error has been detected. It lights up permanently if the hardware is faulty. The MAINT LED lights up continuously to indicate that a previously configured maintenance request is now present. All LEDs flash if the firmware of the CPU module is faulty [8].

II.4.2.4 SIMATIC Memory Card

The SIMATIC Memory Card (Figure II.20) can be used as a program card, a card for transferring data, or as a data medium for firmware updates. As a program card it is required for runtime operation of the CPU, in the other cases it is not required for operation.

There are two versions of the SIMATIC Memory Card: with a storage capacity of 2 MB or 24 MB. It has a special ID which is necessary for use in a CPU 1200 [8].



Figure II.20: SIMATIC Memory Card

II.4.2.5 Expansions of the CPU

A **signal board (SB)** expands the onboard I/O without changing the dimensions of the CPU. The associated slot is located on the front of the CPU (Figure II.21) [8].



Figure II.21: Signal Board 1223.

A **Communication Board (CB)** expands the communication connections without changing the dimensions of the CPU. The associated slot is located on the front of the CPU [8].

With the **Battery board (BB)** 1297 battery board, the buffered runtime of the real-time clock can be extended from a typical 10 days to up to one year, without changing the dimensions of the CPU. The associated slot is located on the front of the CPU [8].

II.4.3 Signal modules (SM)

Signal modules are input/output modules which extend the integrated I/O. Depending on the CPU version, either none, two or eight modules can be plugged onto the right of the CPU [8].

A two-tier design is possible using a 2-meter long extension cable. But the number of modules which can be used is not changed as a result [8].

II.4.3.1 Digital I/O modules

Digital modules (Figure II.22) are signal converters for binary process signals. The CPU can use input modules to scan operating modes of the machine or plant, and output modules for intervention [8].



Figure II.22: SM 1221 DI16 signal module.

Input modules convert external signals of 24 V DC into signals with an internal level. Output modules convert the internal signal level into 24 V DC (electronic outputs) or are designed as relay outputs. Using direct current, a relay can switch maximum 30 W, while with alternating current it can switch 200 W. There are signal modules with one or two bytes corresponding to 8 or 16 signals [8].

II.4.3.2 Analog input/output modules

Analog modules (Figure II.23) are signal transducers for analog process signals. The CPU can use these modules to process analog variables when these have been converted by analog input modules into digital values. The CPU can also continuously supply actuators with analog set points which have been generated from the specified digital values by analog output modules [8].

One “channel” is occupied on the module by each analog value (e.g. measured value or set point). Analog modules are available with 2, 4 or 8 channels corresponding to 4, 8 or 16 bytes. A digitized analog value is represented internally as a 16-bit fixed-point number (data type INT). Analog modules can output diagnostic data concerning the module status or when limit values are reached [8].



Figure II.23: SM 1234 AI/AO signal module.

II.4.4 Communication modules (CM)

The communication modules (CM) support the CPU in communication tasks. They establish the physical connection to a communication partner, take over establishment of the connection and data transport on this, and provide the required communications services for the operating system of the CPU and the user program [8].



Figure II.24: CM 1241 RS485 communication module.

The communication modules (Figure II.24) are plugged onto the CPU from the left, seen from the front. Operation of up to three communication modules is possible for all CPUs [8].

II.5 TIA Portal V13

II.5.1 SIMATIC S7-1200 automation system

The SIMATIC S7-1200 automation system is a modular microcontroller system for the lower performance range. A comprehensive range of modules is available to optimally adapt the system to the automation task. The S7 controller consists of a power supply and a CPU with integrated inputs and outputs or additional input and output modules for digital and analog signals.

If necessary, communication processors and function modules are also used for special tasks such as stepper motor control. The programmable logic controller (PLC) uses the S7 program to monitor and control a machine or process. In doing so, the IO modules are scanned in the S7 program using input addresses (%I) and addressed using output addresses (%Q) [9].

II.5.2 STEP 7 Basic V13 (TIA Portal V13) programming software

The STEP 7 Basic V13 (TIA Portal V13) software is the programming tool for the following automation systems:

- SIMATIC S7-1200;
- Basic Panels.

STEP 7 Basic V13 provides the following functions for automation of a system:

- Configuration and parameter assignment of the hardware;
- Specification of the communication;
- Programming;
- Testing, commissioning and servicing with operational/diagnostic functions;
- Documentation;
- Creation of visualizations for SIMATIC Basic Panels using the integrated WinCC Basic software;
- Support is provided for all functions through detailed online help [9].

II.5.2.1 Project

To implement a solution for an automation and visualization task, you create a project in the TIA Portal. A project in the TIA Portal contains the configuration data for the configuration and internetworking of devices as well as the programs and the configuration of the visualization [9].

II.5.2.2 Hardware configuration

The hardware configuration includes the configuration of the devices, consisting of the hardware of the automation system, the field devices on the PROFINET bus system and the hardware for visualization. The configuration of the networks specifies the communication between the various hardware components. Individual hardware components are inserted in the hardware configuration from catalogs [9].

The hardware of SIMATIC S7-1200 automation systems comprises the controller (CPU), the signal modules for input and output signals (SMs), the communication modules (CMs) and other special-purpose modules [9].

The signal modules and the field devices connect the input and output data of the process to be automated and visualized to the automation system.

The hardware configuration enables the downloading of automation and visualization solutions to the automation system and access to the connected signal modules by the controller [9].

II.5.2.3 Planning the hardware

Before you can configure the hardware, you must plan it (hardware planning). In general, you begin by selecting which controllers are needed and how many. You then select the communication modules and signal modules. The selection of signal

modules is based on the number and type of inputs and outputs needed. As the final step, a power supply that ensures the necessary power supply must be selected for each controller or field device [9].

II.5.2.4 TIA Portal – Project view and portal view

The TIA Portal has two important views. When started, the TIA Portal displays the portal view by default. This view makes getting started easier, especially for beginning users.

The portal view provides a task-oriented view of the tools for working on the project. Here, you can quickly decide what you want to do and open the tool for the task at hand. If necessary, a change to the project view takes place automatically for the selected task.

Figure II.25 shows the portal view. At the bottom left, there is an option to switch between this view and the project view [9].

The project view, as shown in Figure II.26, is used for hardware configuration, programming, creation of the visualization and many other tasks.

By default, the project view displays the menu bar with the toolbars at the top, the project tree with all components of a project on the left and the so-called "task cards" with instructions and libraries, for example, on the right [9].

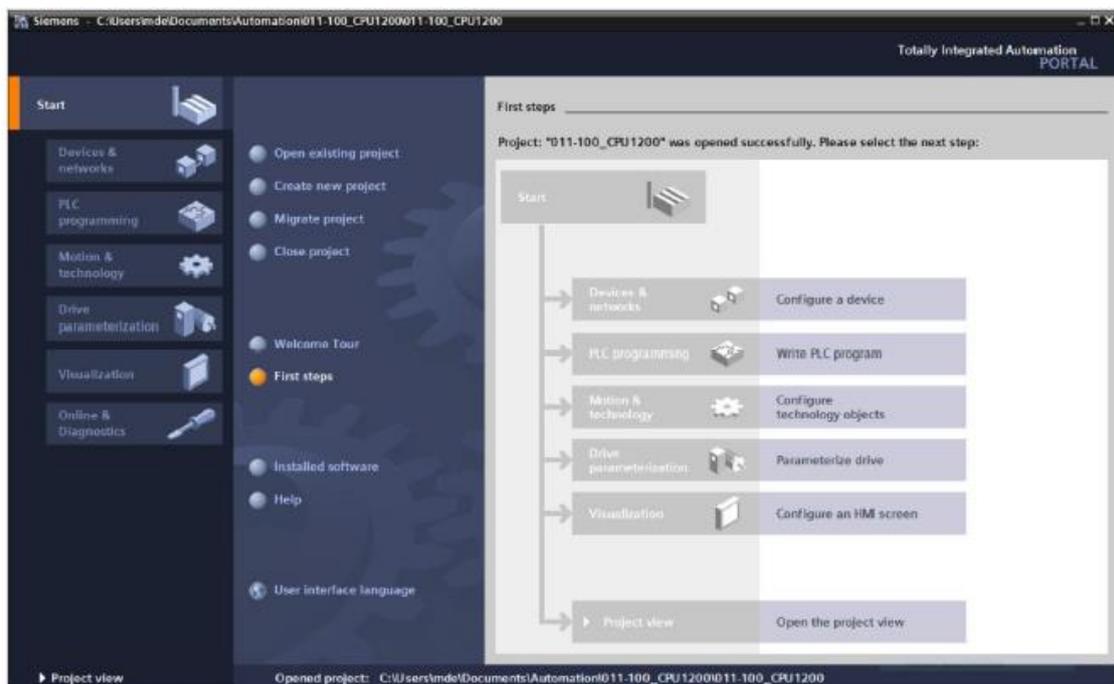


Figure II.25: Portal view.

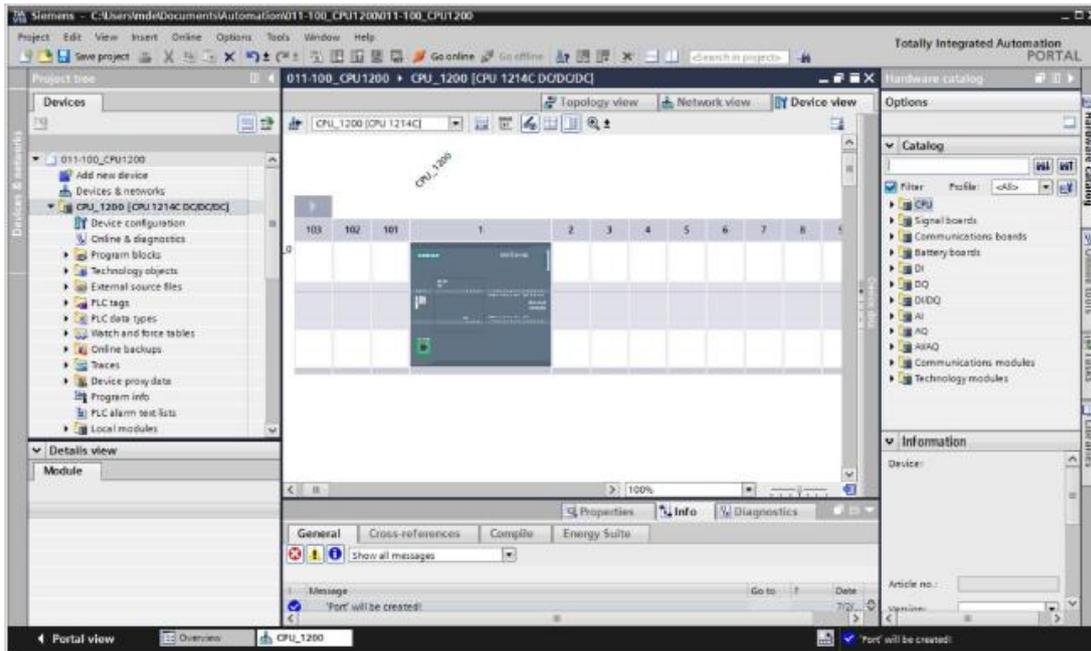


Figure II.26: Project view.

If an element (for example, the device configuration) is selected in the project tree, it is displayed in the center and can be worked on there [9].

II.5.3 Structured step-by-step instructions

II.5.3.1 Create a new project

→ Select the Totally Integrated Automation Portal (Figure II.27) for this, which is opened here with a double-click (→ TIA Portal V13).



Figure II.27: Icon TIA Portal V13.

→ in the portal view under the "Start" menu (Figure II.27), select the command → "Create new project".

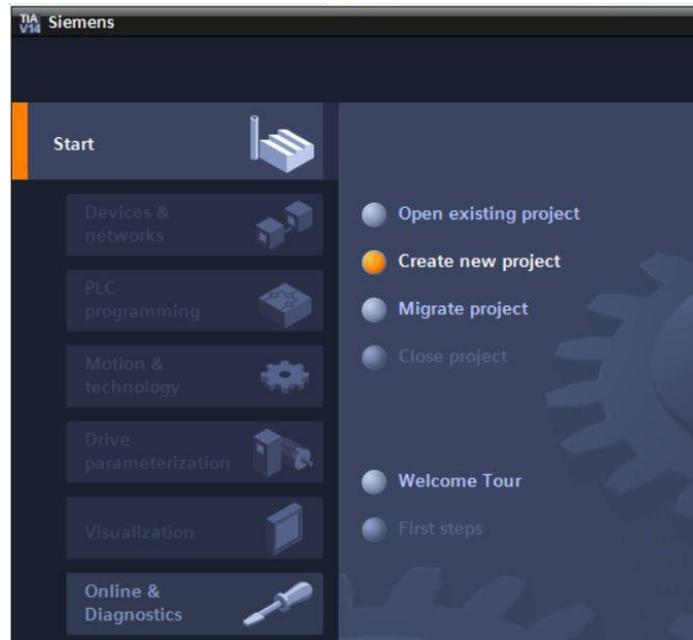


Figure II.28: Start menu.

→ Modify Project name (Figure II.29), Path, Author and Comment as appropriate and click → "Create".

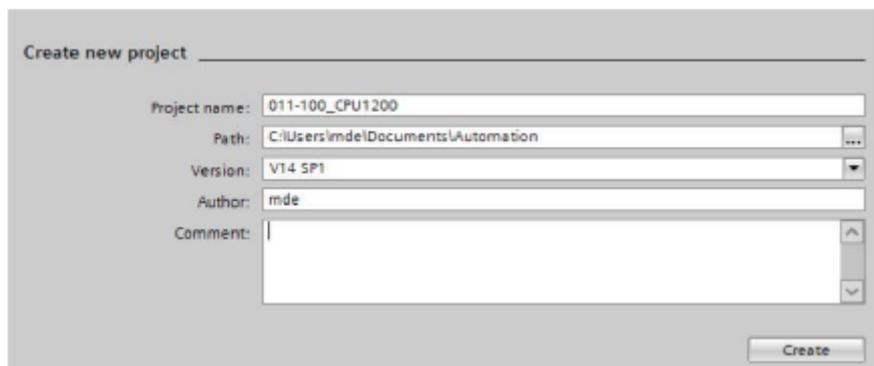


Figure II.29: Modify Project name.

→ the project will be created and opened and the menu "Start", "First steps" will open automatically [9].

II.5.3.2 Read the hardware of SIMATIC S7-1200

→ In the ® "Start" portal, select → "First steps" → "Devices & Networks" → "Configure a device" (see Figure II.25).

→ The "Show all devices" menu opens in the "Devices & Networks" portal.

→ Switch to the "Add new device" menu (see Figure II.30).

→ Create a new CPU. Use an unspecified model of the S7-1200 CPU with order number 6ES7 2XX-XXXXX-XXXX for this [9].

- (Controllers ® SIMATIC S7-1200 → CPU → Unspecified CPU 1200 ® 6ES7 2XX-XXXXXXXX → V4.2)
- Assign a device name (Device name → "CPU_1200").
- Select "Open device view".
- Click "Add".
- The TIA Portal now switches automatically to the project view and displays a notice there that this device is not specified. In order to have the hardware configuration automatically detected, start detection by clicking "detect" in the yellow information box (→ detect).
- Select the type of your PG/PC interface (→ Type of the PG/PC interface: PN/IE).
- You can now select the network adapter you want to use to establish an Ethernet connection with the PLC (→ PG/PC interface: Intel(R) Ethernet Connection (4) I219-LM).
- The search for devices in the network must be started by clicking the button [9].

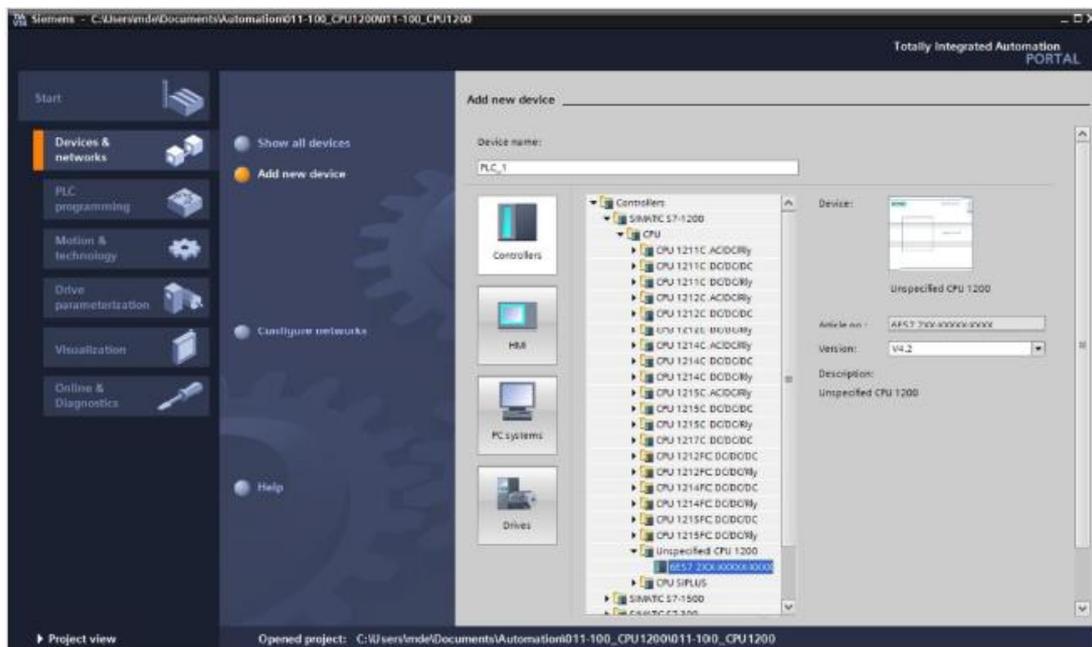


Figure II.30: PLC View.

- All accessible nodes are found and listed (Figure II.31). If you have selected the correct CPU, the corresponding CPU and all the connected modules will be detected when you click "detect".

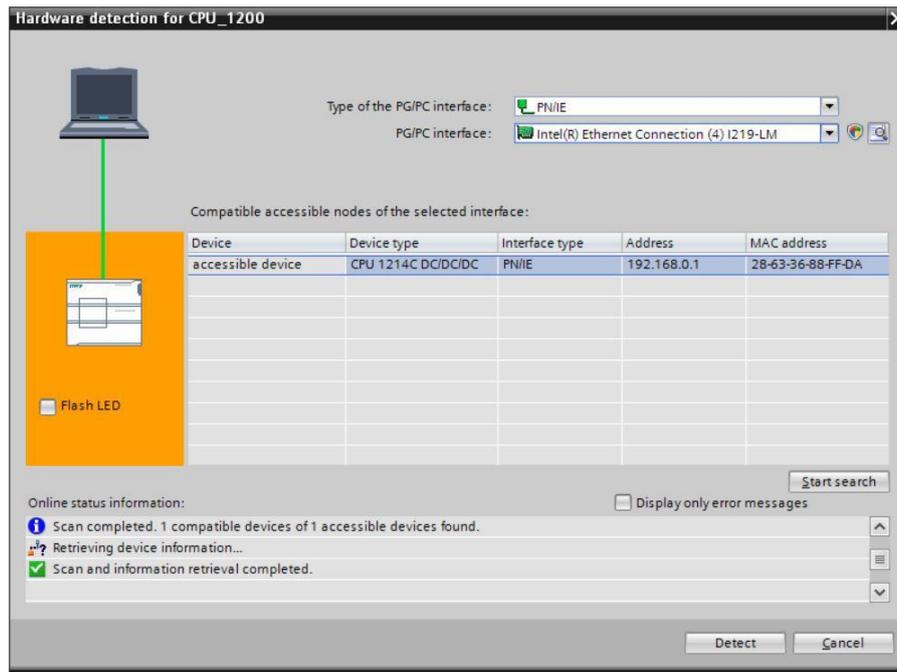


Figure II.31: Hardware detection.

II.5.3.3 Configure the address areas

→The next step is to check the address areas (Figure II.32) of the inputs and outputs and adapt them if necessary. DI/DO should have an address area of 0...1 and AI/AO should have an address area of 64...67 and 64...65, respectively. (→ Device overview → DI 14/DQ 10_1 → I address: 0...1 → Q address: 0...1 → AI 2_1 ® I address: 64...67 → AQ 1x12BIT_1 → Q address: 64...65) [9].

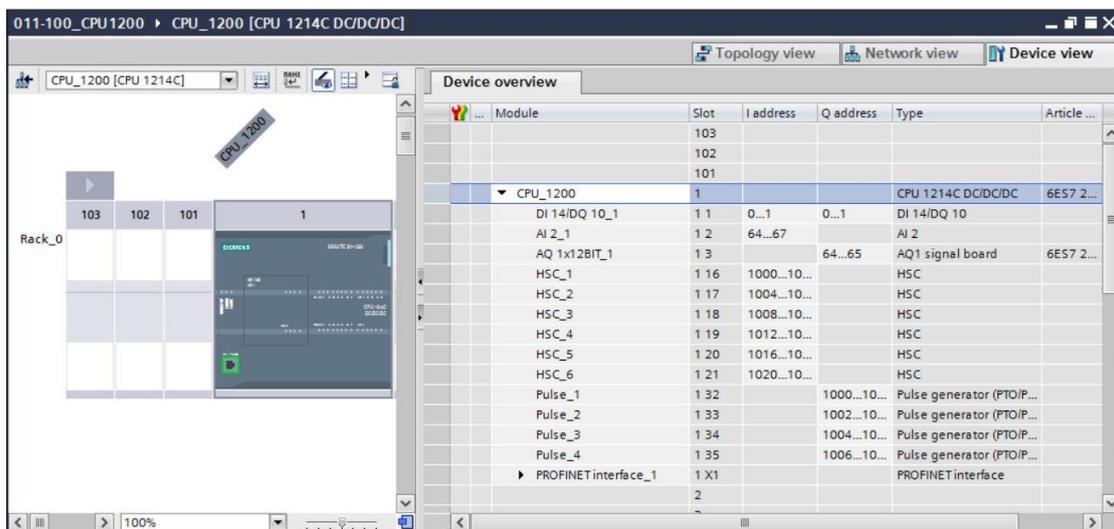


Figure II.32: Address areas.

II.5.3.4 Save and compile the hardware configuration

→ before you compile the configuration, you should save your project by clicking the →

“Save project” Button (Figure II.33). To compile your CPU with the device configuration, first select the →"CPU_1200 [CPU1214C DC/DC/DC]" folder and click the → "Compile" icon [9].

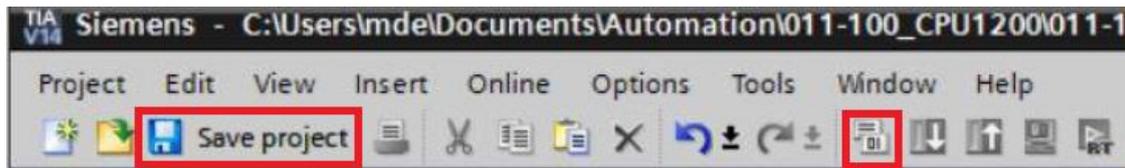


Figure II.33: Menu Bar.

II.5.3.4 Download the hardware configuration to the device

→ to download your entire CPU, select the → "CPU_1200 [CPU1214C DC/DC/DC]" folder and click the “Download” icon.

→ the manager for configuring the connection properties (extended download) opens.

→ First, the interface must be correctly selected. This happens in three steps.

→ Type of the PG/PC interface ® PN/IE → PG/PC interface ® here: Intel(R) Ethernet Connection I217-LM.

→ the "Show all compatible devices" check box must be selected (se Figure II.34).

The search for devices in the network is started by clicking the →start search button.

→If your CPU is shown in the "Compatible devices in target subnet" list, you must select it. The download can then be started (® CPU 1214C DC/DC/DC → "Load").

→ You first obtain a preview. Confirm the prompt → "Overwrite all" and continue with → "Load" [9].

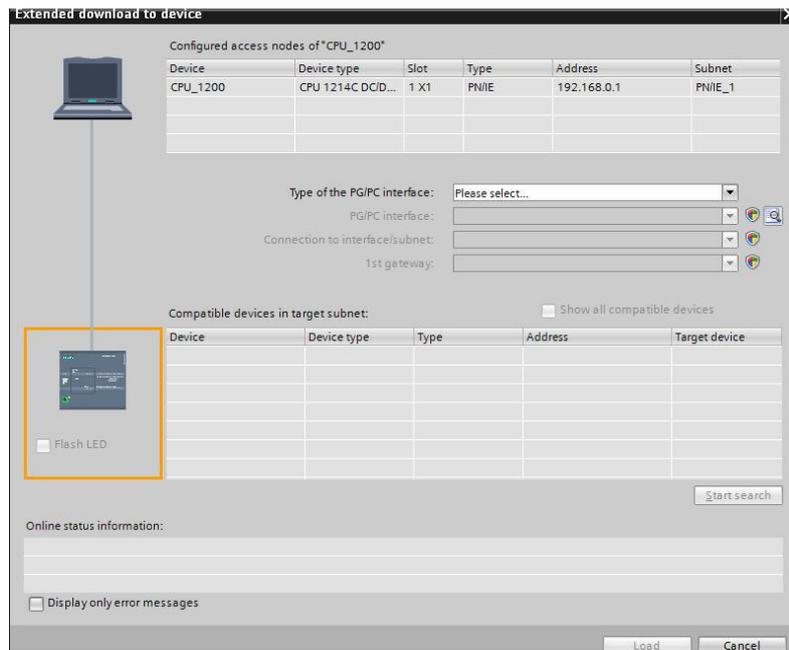


Figure II.34: Extended download.

→ The “Start all” option will be selected next before the download operation can be completed with →"Finish" (see Figure II.35) [9].

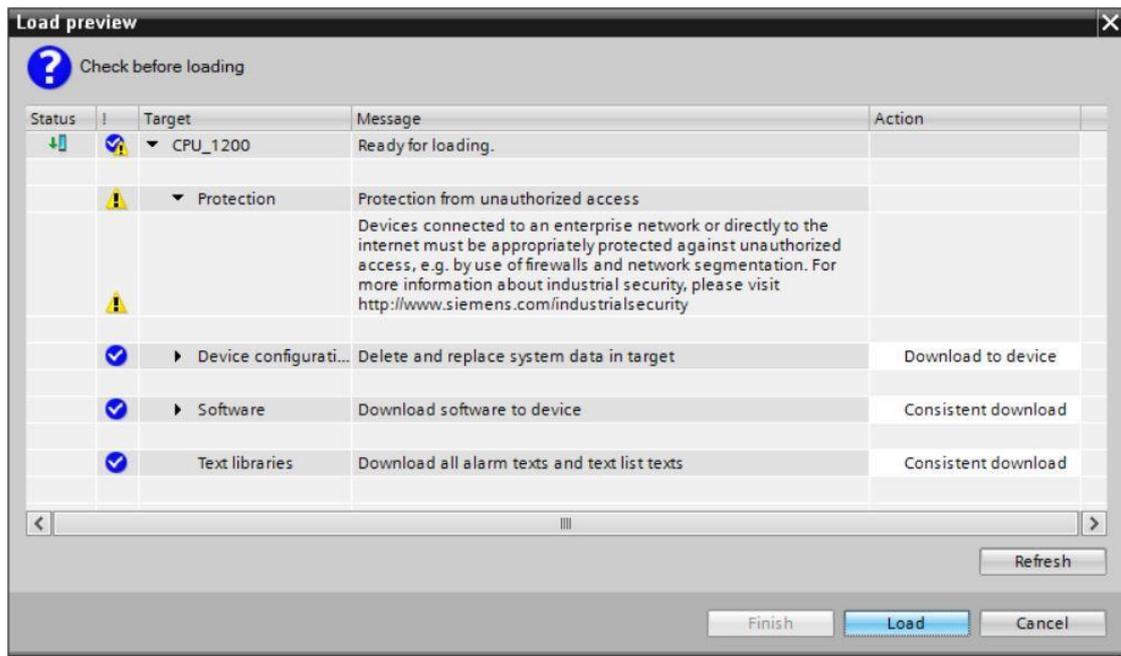


Figure II.35: Load preview.

→ after a successful download, the project view will open again automatically. A loading report appears in the information field under "General". This can be helpful when troubleshooting an unsuccessful download [9].

II.6 Factory I/O

II.6.1 Overview

Factory I/O simulation software (Figure II.36) is available in 7 versions or editions: the starter edition, the Allen Bradley Edition for Allen Bradley PLCs, the Siemens Edition for Siemens PLCs, the Modbus and OPC Edition for Modbus and OPC communications, the MHJ Edition for the WinSPS-S7 virtual controller and the Siemens WinPLC-Engine PLC simulator, the Automgen Edition for the connection with the Automgen software, the Ultimate Edition which is the complete version including an SDK for the developments communication drivers [10].

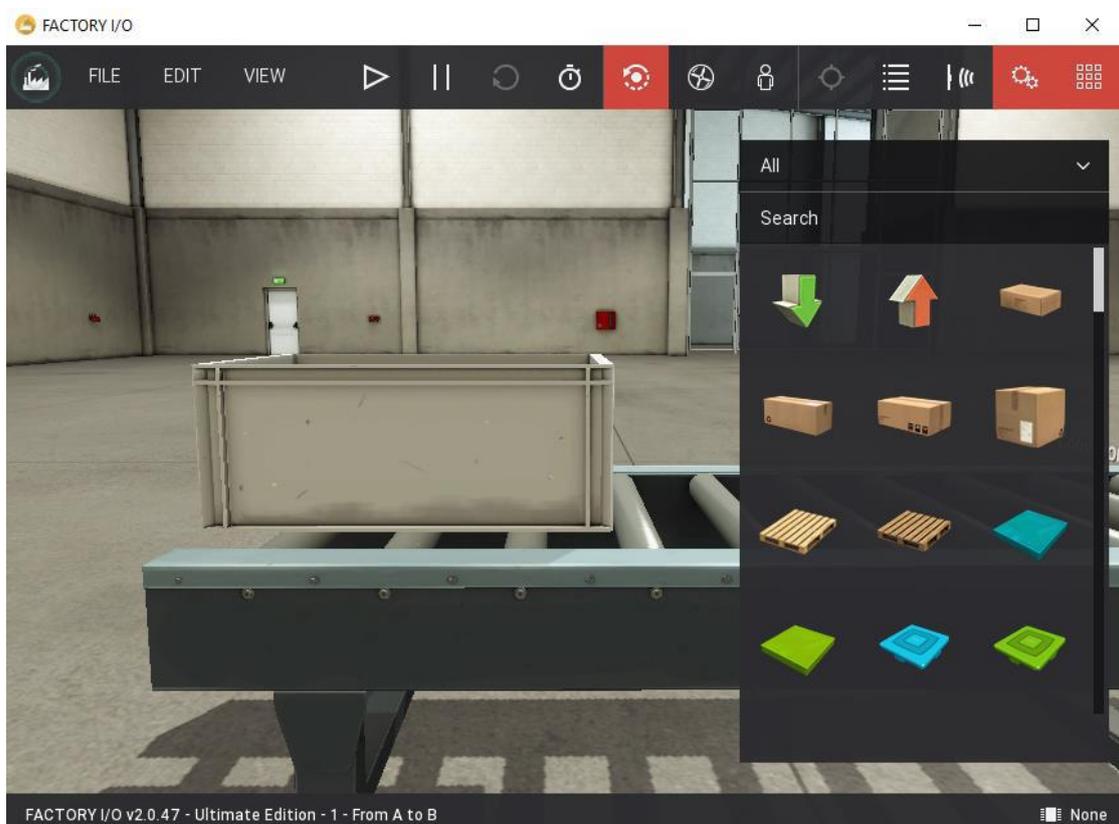


Figure II.36: Factory I/O.

II.6.2 The software interface

The interface of the software is quite simple and has 3 menus (Figure II.37) and several buttons to manage the cameras, to display the palette, to display the sensors, to display the actuators, to perform a simulation etc...

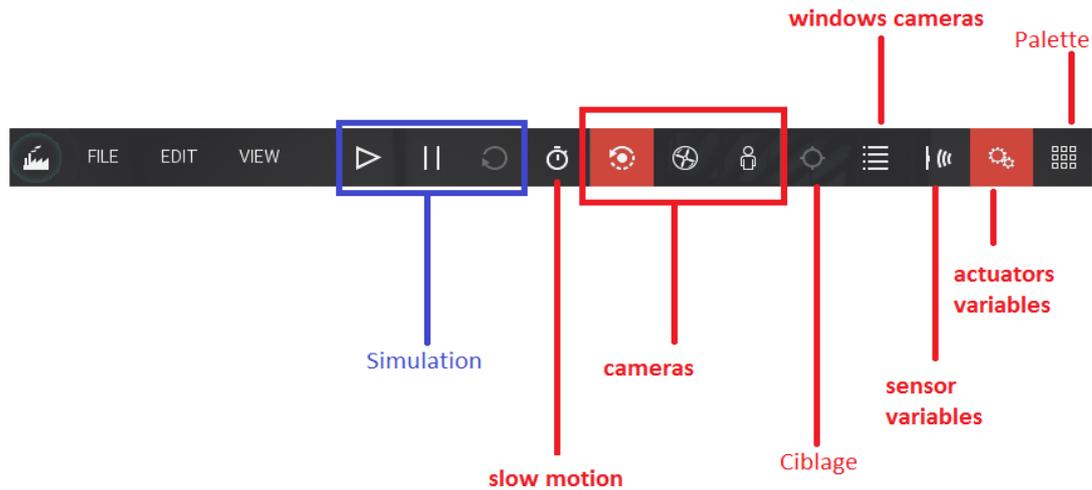


Figure II.37: Menu bar.

II.6.3 Cameras

There are mainly 3 cameras:

- The Fly camera
- The Orbit camera
- The first-person camera

To manipulate these different cameras, you will have to use the two buttons of your mouse, the wheel and the keys directions of your keyboard. To be comfortable with the different cameras, you will have to practice [10].

II.6.4 The palette

At the level of the pallet are the different components allowing to design brick by brick your automated system (Figure II.38). At the pallet we can find treadmills, push buttons, lights etc.

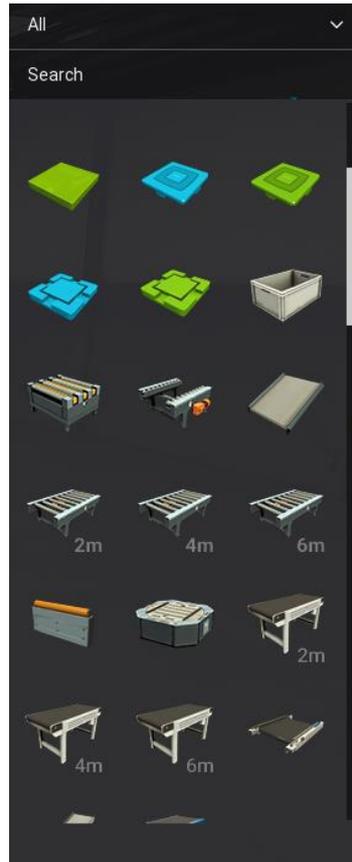


Figure II.38: Menu palette.

Your imagination will be your only limit; you can design several types of systems by simply dragging and dropping the component into the editing interface [10].

II.6.5 the drivers

The drivers are used to control the automated system designed via the editing interface. There are several types of drivers: drivers for Siemens PLCs, Schneider, Rockwell etc., also the driver Connect I/O which is the controller software built into factory I/O. To activate a given driver, click on the lower right corner of the software [10].

You can choose from the list of available drivers (see Figures below).



Figure II.39: Drivers bar.

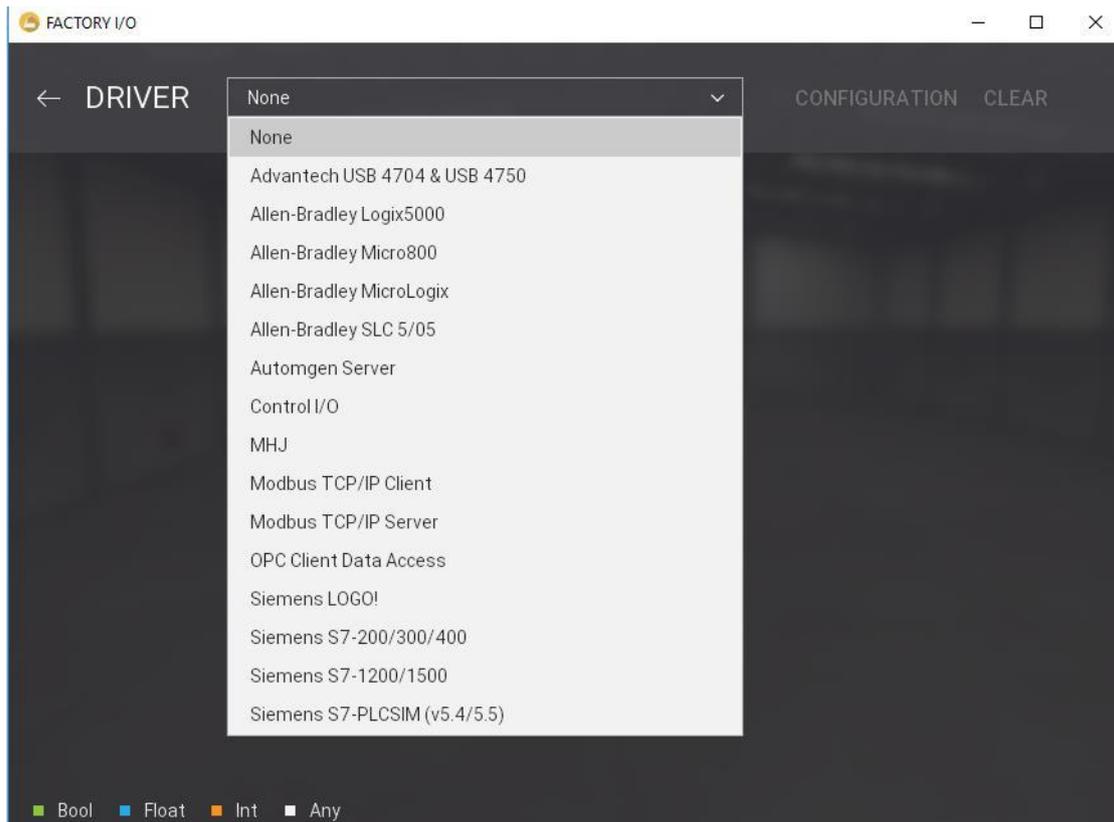


Figure II.40: Driver menu.

II.7 Conclusion

In this chapter we have seen a description of the S7-1200 programmable logic controller, TIA Portal V13 programming software and the Factory I / O software, after which we have detailed the steps of the creation and configuration of a project. At the end, a description of Step7 and Factory I / O presented. In the next chapter, we will present the description of our machine as well as the development steps of our automated control system.

CHAPTER III:
**Description and automation of a product
packaging system**

III.1 Introduction

The simulation part of our work involves the modeling and automation of product packaging system. We start with a general description of product packaging system. We will then detail the specifications of our application by GRAFCET. Finally, it is converted into a control program of our system in real time using the TIA Portal V13 programming software. We will finish this chapter by exposing the supervision part with Factory I/O.

III.2 The specifications

The palletizer is composed of three conveyors, two at the bottom (to enter and exit the pallets) and the other at the top for the boxes; they are connected by an elevator. The elevator carries pallets to the stacking table. The conveyor which is at the top transfers the boxes to the loading belt.

First, a row is formed consists of two boxes, they are then pushed to the stacking table. We will repeat this process until we have three rows of boxes on the stacking table, then open the sliding door to put the boxes on the pallet. Then the elevator goes down one step, and then closes the sliding door. Now we have a layer of boxes consisting of three rows in each row two boxes.

Second, the second layer of boxes consists of two rows in each row three boxes.

To do this process we take out the rotating arm to change the position of the box on the loading belt, we enter three boxes, and the number of boxes is determined by the sensor located at the end conveyor boxes. After forming a row of three boxes they are then pushed towards the stacking table. We repeat this process until we have two rows of boxes on the stacking table, then open the sliding door to put the boxes on the pallet.

If we get the desired number of layers then the elevator goes down to the pallet exit conveyor, then we transfer the pallet by the exit conveyor to the Chain Transfer. This system is used to transfer to right the first pallet to the conveyor at the end of the first line, then transfer Second pallet either to the conveyor at the end of the Second line.

III.3. Control panel

III.3.1 Definition

The displays and indicators required for monitoring the machine are grouped together on a control panel, generally associated with the different controls of the machine.

A control panel is also a device, usually wall mounted, in a facility, industrial or other, grouping the various displays (counters, screens, indicators and various indicators ...) for monitoring its operation. It is usually located in a control room, grouped with devices to regulate this operation and control operations. This room also includes the means of communication with the outside.

III.3.2 Control panel structure

The control panel consists of several different buttons shown in Table III.1. Figures III.1 show the images of the control panel structure.

Table III.1: Control panel.

Description	Type
Emergency button	Emergency stop push button
Switch	Selector switch Auto \ C / C
Start button	Pushbutton
Bouton Stop	Pushbutton



Figure III.1: Control panel.

III.4. Product packaging system

System consists of two parts as the following figure shows.

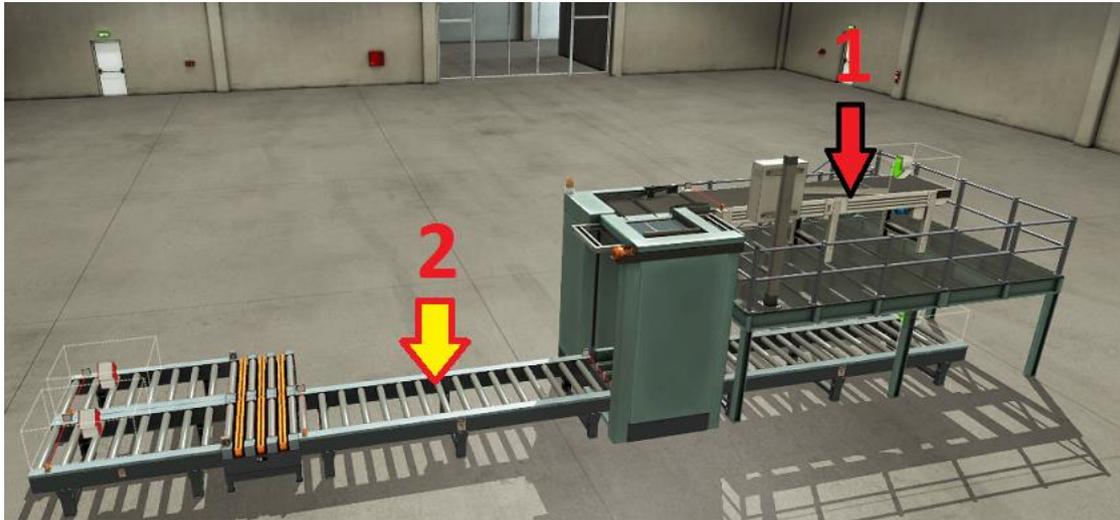


Figure III.2: Product packaging system.

III.4.1 First part (palletizer)

a) Sensors

The Palletizer system has eight sensors, shown in Table III.2. Figures III.3 to III.4 show the photos the sensors.

Table III.2: List of Sensors.

sensors	Description	Type
Pen	Pallet at entry	Photoelectric
Pld	Pallet loaded	Capacitive (Proximity)
Pex	Pallet at exit	Photoelectric
Em	Indicates the elevator is moving	Inductive (Proximity)
Clamped	Clamper reached the front limit	Inductive(Proximity)
Pshl	Pusher is at front/back limit	Inductive(Proximity)
Cap p6	Plate is closed	Inductive(Proximity)
Cap p7	box at entry	Photoelectric

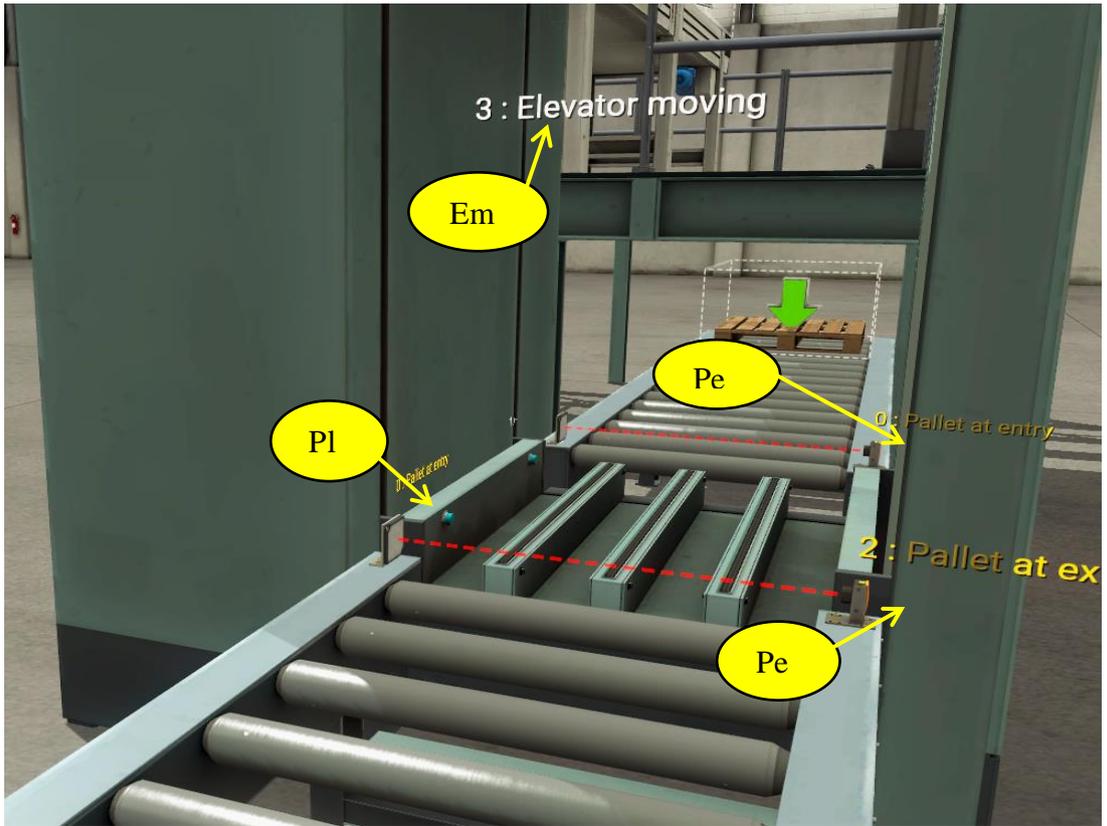


Figure III.3: Position of the sensors in the palletizer at the bottom.

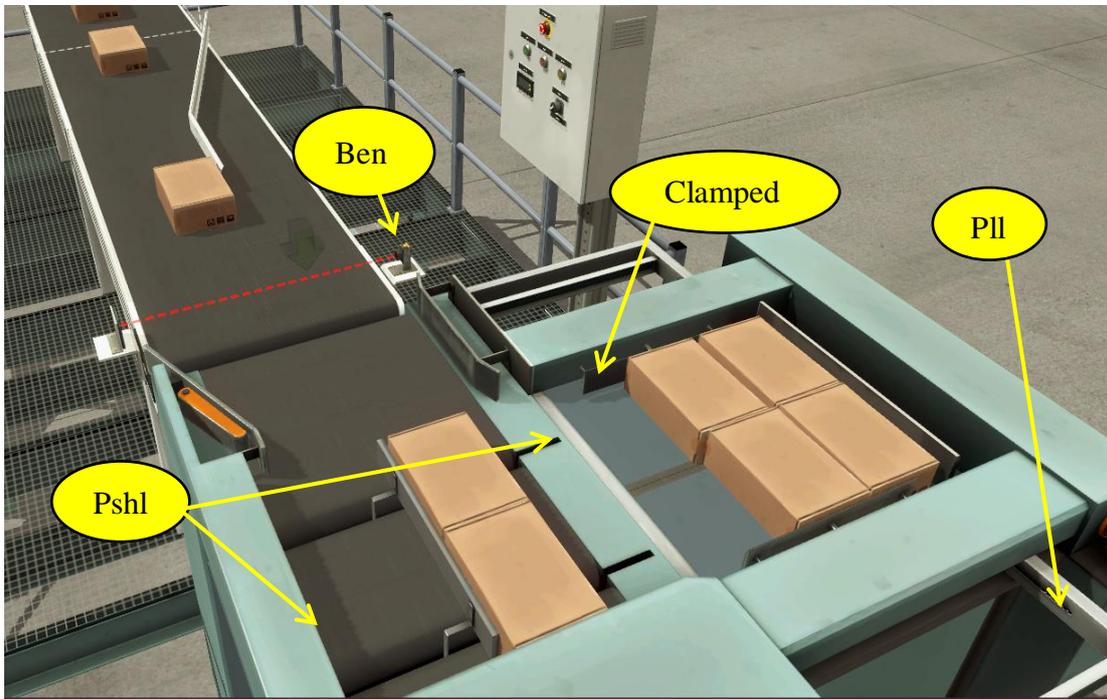


Figure III.4: Position of the sensors in the palletizer at the top.

b) Actuators

For the actuators, the system has eleven actuators as shown in Table III.3, Figures III.5 to III.6 show the photos the actuators.

Table III.3: List of actuators.

Actuators	Description	Type
Pf	Pallet feeder	Motor
Lp	Load pallet at elevator	Motor
Ex	Exit conveyor	Motor
Eup	Moves the elevator up by step	Motor
Ed	Moves the elevator down by step	Motor
Bf	Box feeder	Motor
Turn	Turn flipper (used to rotate boxes by 90°)	Single acting cylinder
Lb	The loading belt	Motor
Push clamp	Move pusher	Single acting cylinder
Op	Opens the plate	Motor

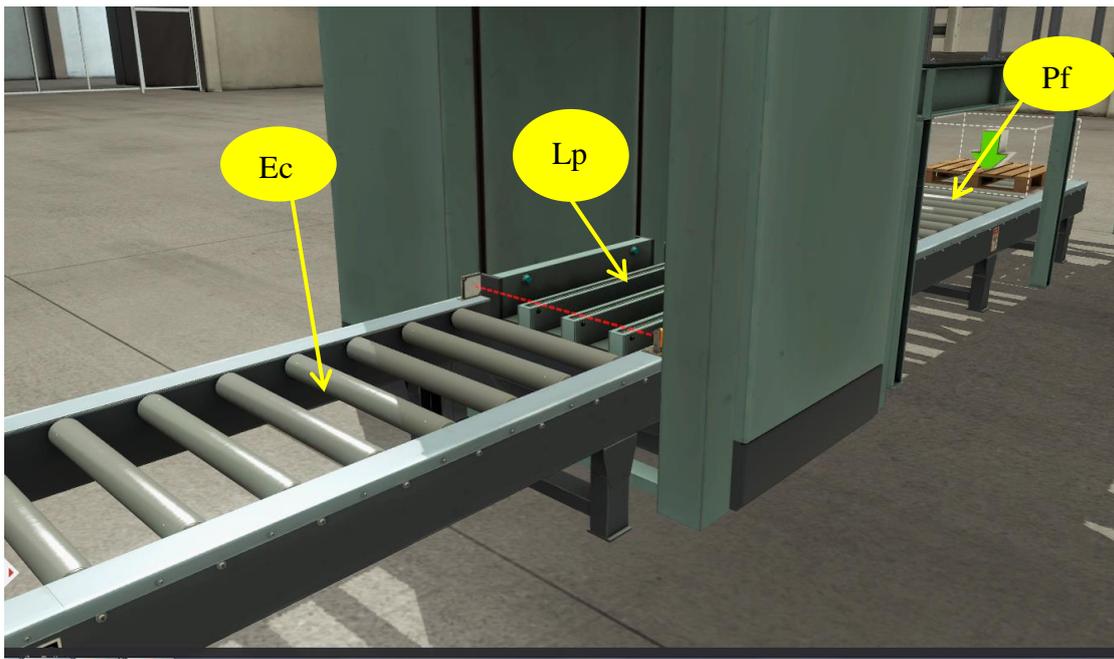


Figure III.5: Position of the actuators in the palletizer at the bottom.

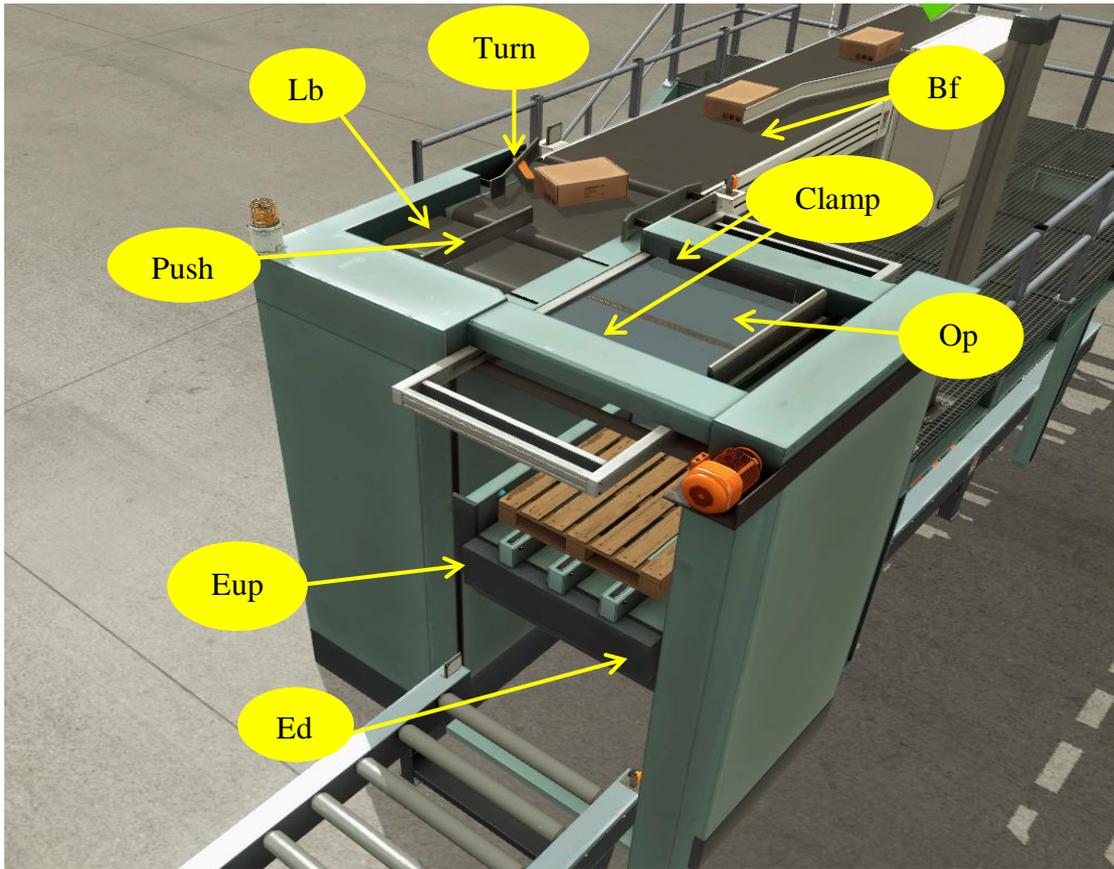


Figure III.6 Position of the actuators in the palletizer at the top.

III.4.2 Second part (Chain Transfer)

a) Sensors

The Chain Transfer system has five sensors, shown in Table III.4. Figure III.7 show the photo the sensors.

Table III.4: List of Sensors.

sensors	Description	Type
Cp1	Detection of pallet at entry	Photoelectric
Cp2	Pallet loaded in chain Transfer 1	Capacitive (Proximity)
Cp3	Pallet loaded in chain Transfer 2	Capacitive (Proximity)
CP4	Pallet at the end of the first line	Photoelectric
Cp5	Pallet at the end of the second line	Photoelectric



Figure III7: Position of the sensors in the Chain Transfer.

b) Actuators

For the actuators, the system has eleven actuators as shown in Table III.5, Figures III.8 show the photos the actuators.

Table III.5: List of actuators.

Actuators	Description	Type
Load1	Load or discharge pallet at chain transfer 1	Motor
Load2	Load or discharge pallet at chain transfer 2	Motor
Ttr1	Transfer pallet to right of chain 1	Motor
Ttr2	Transfer pallet to right of chain 2	Motor
C1	conveyor at the end of the first line	Motor
C2	conveyor at the end of the second line	Motor
Rem1	Remove pallet at the end of the first line	Motor
Rem2	Remove pallet at the end of the second line	Motor

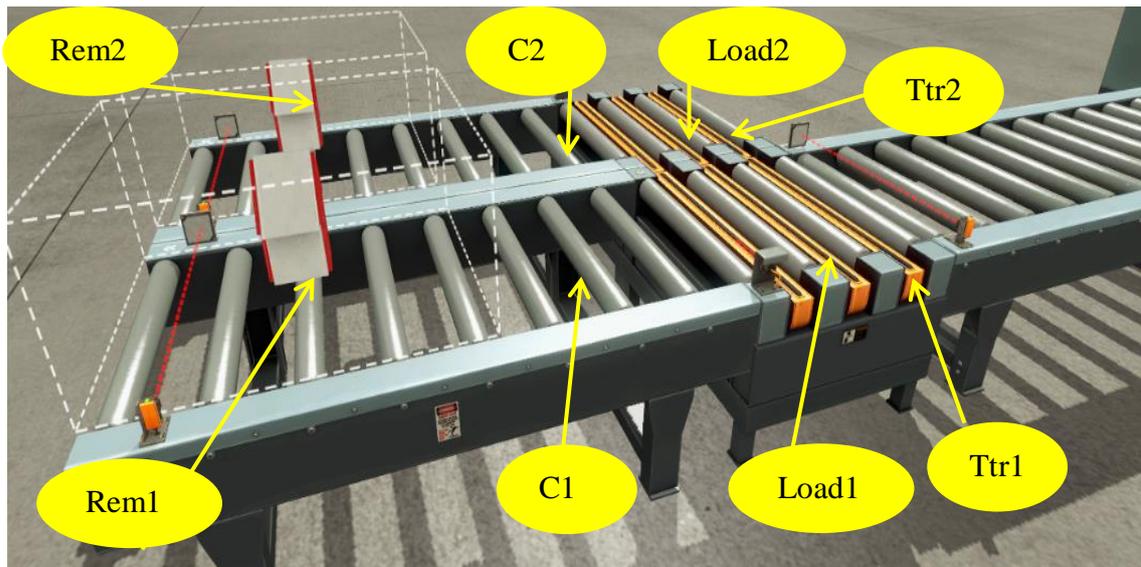


Figure III.8: Position of the actuators in the Chain Transfer.

III.5 Programming system

III.5.1 GRAFCET

A normally open start and normally closed stop pushbuttons are used to start and stop the process in automatic or C/C mode. Upon starting the pallet conveyors will load a pallet onto the elevator.

The elevator will move the pallet to the top of the elevator where it will be loaded with layers of boxes. Boxes are staggered on the each layer so that they will interlock with themselves. This will provide a more stable skid.

A turn device is utilized to orientate the boxes on every other layer. A pusher is used to move the rows of boxes to the plate.

Once the last row is pushed on the plate, a clamp will be used to square up the layer of boxes. The plate will then open putting the layer of boxes onto the pallet. The elevator will then move down to allow the plate to close. The next layer then can be assembled on the plate.

When the layers of boxes have been obtained, the elevator will move all the way to the bottom. This will align with the exit conveyor. The finished pallet will then move onto the exit conveyor. An empty pallet is then moved onto the load conveyor and the process will continue again.

Chapter III: Description and automation of a product packaging system

The grafcet consists of 4 networks shown in Figure III.9 to III.10.

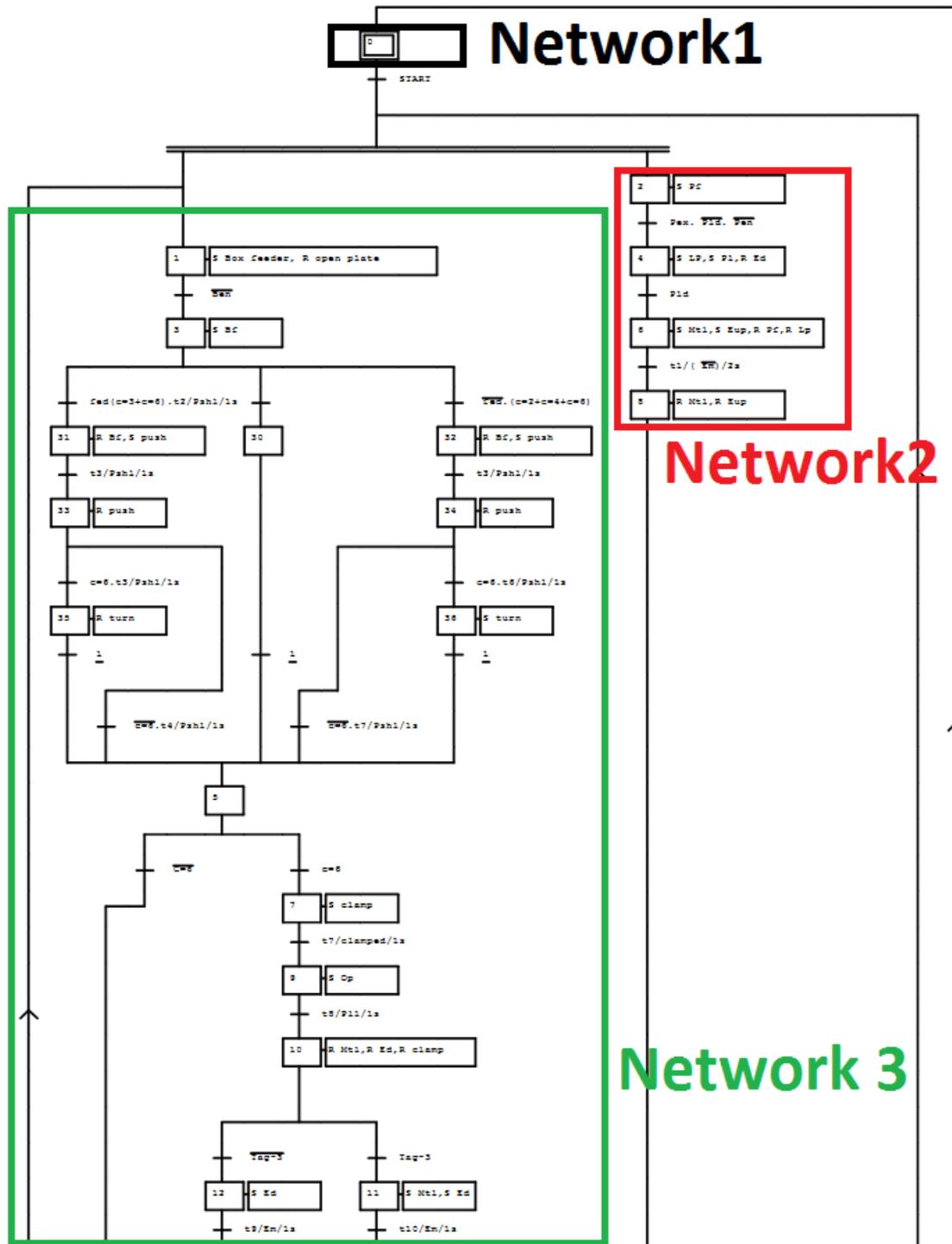


Figure III.9: GRAFCET of a product packaging system1/2.

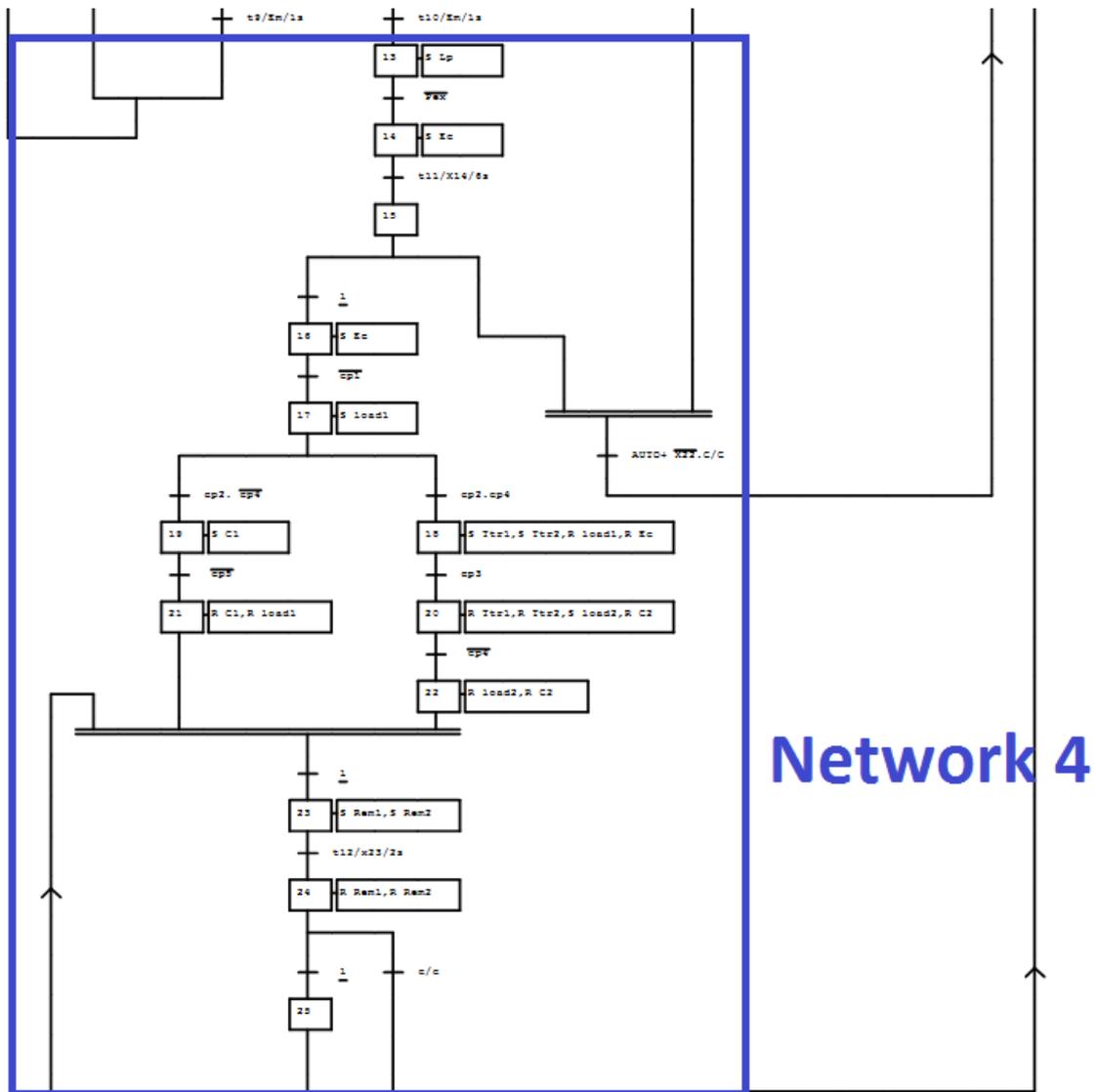


Figure III.10: GRAFCET of a product packaging system2/2.

III.5.2 Programming on TIA Portal V13

III.5.2.1 Hardware configuration

The creation of a surTIA Portal V13 project begins by defining a hardware configuration, whose interest is to specify the supply, input and output modules for the project, in order to connect it with the Corresponding CPU at the PLC, hardware shown in figure Figure III.9.

The hardware and software requirements are as follows:

- SIMATIC S7-1200
- CPU : CPU 1214C DC/DC/DC
- DI/DQ : DI 16/DQ 16x24VDC

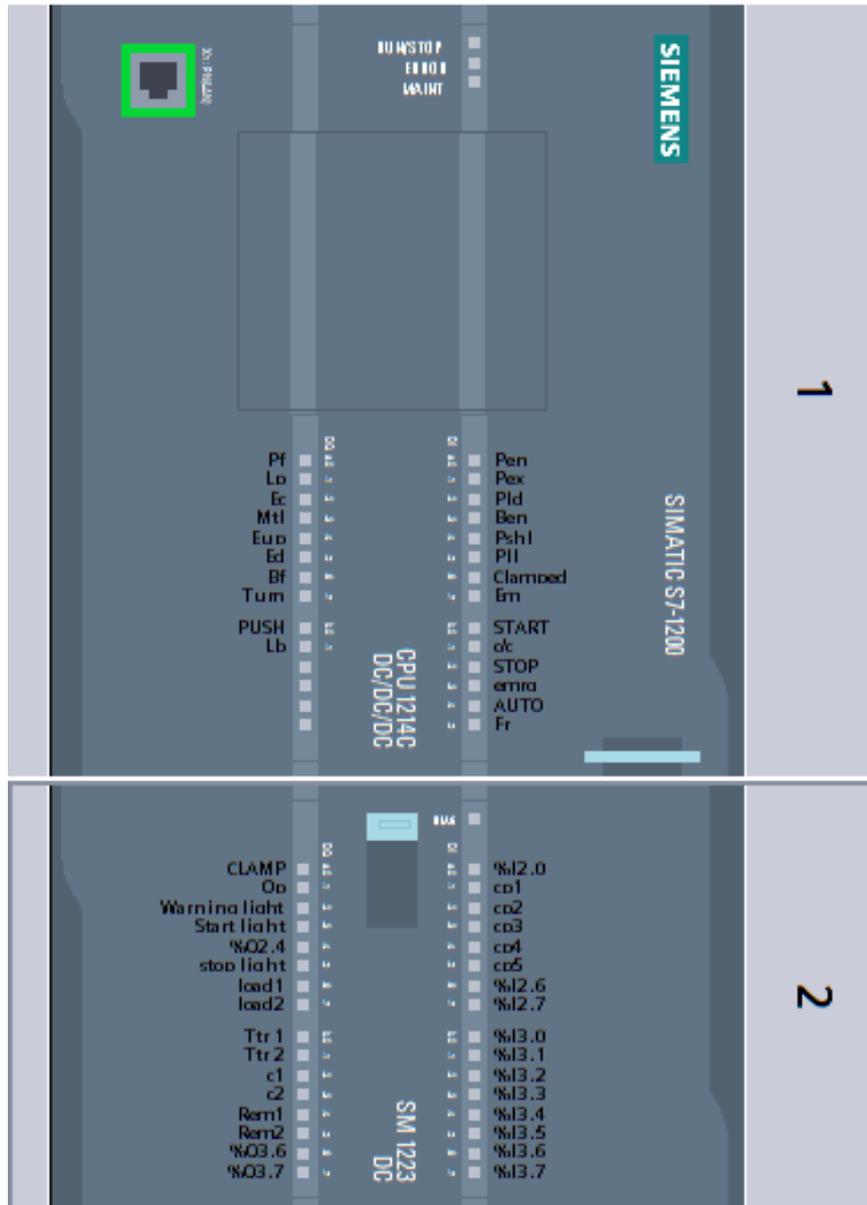


Figure III.11: Hardware configuration

III.5.2.2 PLC tags

The program blocks creation follows the hardware configuration phase where the choice of the language used is made and the definition of the variables at the level of PLC tags table, it's shown in Table III.6 to III.8.

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Table III.6: PLC tags 1/3.

Name	Data type	Address	Comment
Pen	Bool	%I0.0	Pallet at entry
Pex	Bool	%I0.1	Pallet at Exit
Pld	Bool	%I0.2	Pallet loaded
Ben	Bool	%I0.3	Box at entry
Pshl	Bool	%I0.4	Pusher is at front/back limit.
Pll	Bool	%I0.5	Plate is closed.
Clamped	Bool	%I0.6	Clamper reached the front limit.
Em	Bool	%I0.7	Indicates the elevator is moving.
START	Bool	%I1.0	push button (green)
c/c	Bool	%I1.1	Cycle by Cycle mode
STOP	Bool	%I1.2	push button (red)
emrg	Bool	%I1.3	Emergency stop activated.
AUTO	Bool	%I1.4	Automatic mode
Fr	Bool	%I1.5	Factory running
cp1	Bool	%I2.1	Detection of pallet at entry
cp2	Bool	%I2.2	Pallet loaded in chain Transfer 1
cp3	Bool	%I2.3	Pallet loaded in chain Transfer 2
cp4	Bool	%I2.4	Detection of pallet at the end of the first line
cp5	Bool	%I2.5	Detection of pallet at the end of the second line

Table III.7: PLC tags 2/3.

Name	Data type	Address	Comment
Pf	Bool	%Q0.0	PALLET FEEDER
Lp	Bool	%Q0.1	load pallet in the elevator
Ec	Bool	%Q0.2	Exit conveyor
Mtl	Bool	%Q0.3	the elevator should move to the limit
Eup	Bool	%Q0.4	Moves the elevator up.
Ed	Bool	%Q0.5	Moves the elevator down.
Bf	Bool	%Q0.6	Box feeder
Turn	Bool	%Q0.7	Turn flipper (used to rotate boxes by 90°).
PUSH	Bool	%Q1.0	Move pusher
Lb	Bool	%Q1.1	load box in belt
CLAMP	Bool	%Q2.0	Move clamper.
Op	Bool	%Q2.1	Opens the plate.
Warning light	Bool	%Q2.2	Rotating lamp
Start light	Bool	%Q2.3	Green light
stop light	Bool	%Q2.5	Red light
load1	Bool	%Q2.6	load pallet in Chain Transfer 1
load2	Bool	%Q2.7	load pallet in Chain Transfer 2
Ttr 1	Bool	%Q3.0	transfer the pallet to right 1
Ttr 2	Bool	%Q3.1	transfer the pallet to right 2
c1	Bool	%Q3.2	the conveyor at the end of the first line
c2	Bool	%Q3.3	the conveyor at the end of the second line
Rem1	Bool	%Q3.4	Remove pallet at the end of the first line
Rem2	Bool	%Q3.5	Remove pallet at the end of the second line

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Table III.8: PLC tags 3/3.

Name	Data type	Address	Comment
X0	Bool	%M0.0	Step 0 (initial step)
X1	Bool	%M1.0	Step 1
X2	Bool	%M0.2	Step 2
X3	Bool	%M1.1	Step 3
X4	Bool	%M0.4	Step 4
X5	Bool	%M2.1	Step 5
X6	Bool	%M0.6	Step 6
X7	Bool	%M1.4	Step 7
X8	Bool	%M0.7	Step 8
X9	Bool	%M1.5	Step 9
X10	Bool	%M1.6	Step 10
X11	Bool	%M1.7	Step 11
X12	Bool	%M2.0	Step 12
X13	Bool	%M0.1	Step 13
X14	Bool	%M0.3	Step 14
X15	Bool	%M0.5	Step 15
X16	Bool	%M4.6	Step 16
X17	Bool	%M5.6	Step 17
X18	Bool	%M6.0	Step 18
X19	Bool	%M5.7	Step 19
X20	Bool	%M6.2	Step 20
X21	Bool	%M6.1	Step 21
X22	Bool	%M6.3	Step 22
X23	Bool	%M6.4	Step 23
X24	Bool	%M6.5	Step 24
X25	Bool	%M6.6	Step 25
X30	Bool	%M1.2	Step 30
X31	Bool	%M2.2	Step 31
X32	Bool	%M2.3	Step 32
X33	Bool	%M2.4	Step 33
X34	Bool	%M2.5	Step 34
X35	Bool	%M2.6	Step 35
X36	Bool	%M2.7	Step 36
fed	Bool	%M3.0	Feedback of Turn flipper
c=1	Bool	%M3.2	Box counter = 1
c=2	Bool	%M3.7	Box counter = 2
c=3	Bool	%M4.0	Box counter = 3
c=4	Bool	%M4.1	Box counter = 4
c=5	Bool	%M4.2	Box counter = 5
c=6	Bool	%M4.3	Box counter = 6
Tag_3	Bool	%M4.4	Layer counter
XX	Bool	%M6.7	Emergency Stop

III.5.2.3 The PLC program

Number of layers on the pallet is done with counter (see Figure III.10).

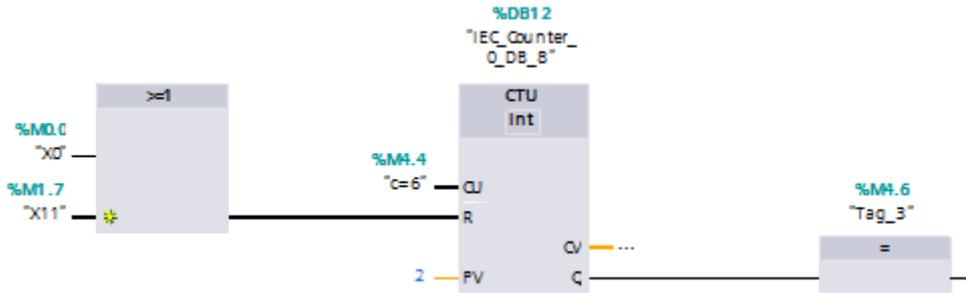


Figure III.12: Counter of layers.

The boxes are staggered on the layer. Counter is set up for the number of boxes in the row and the number of rows on the layer.

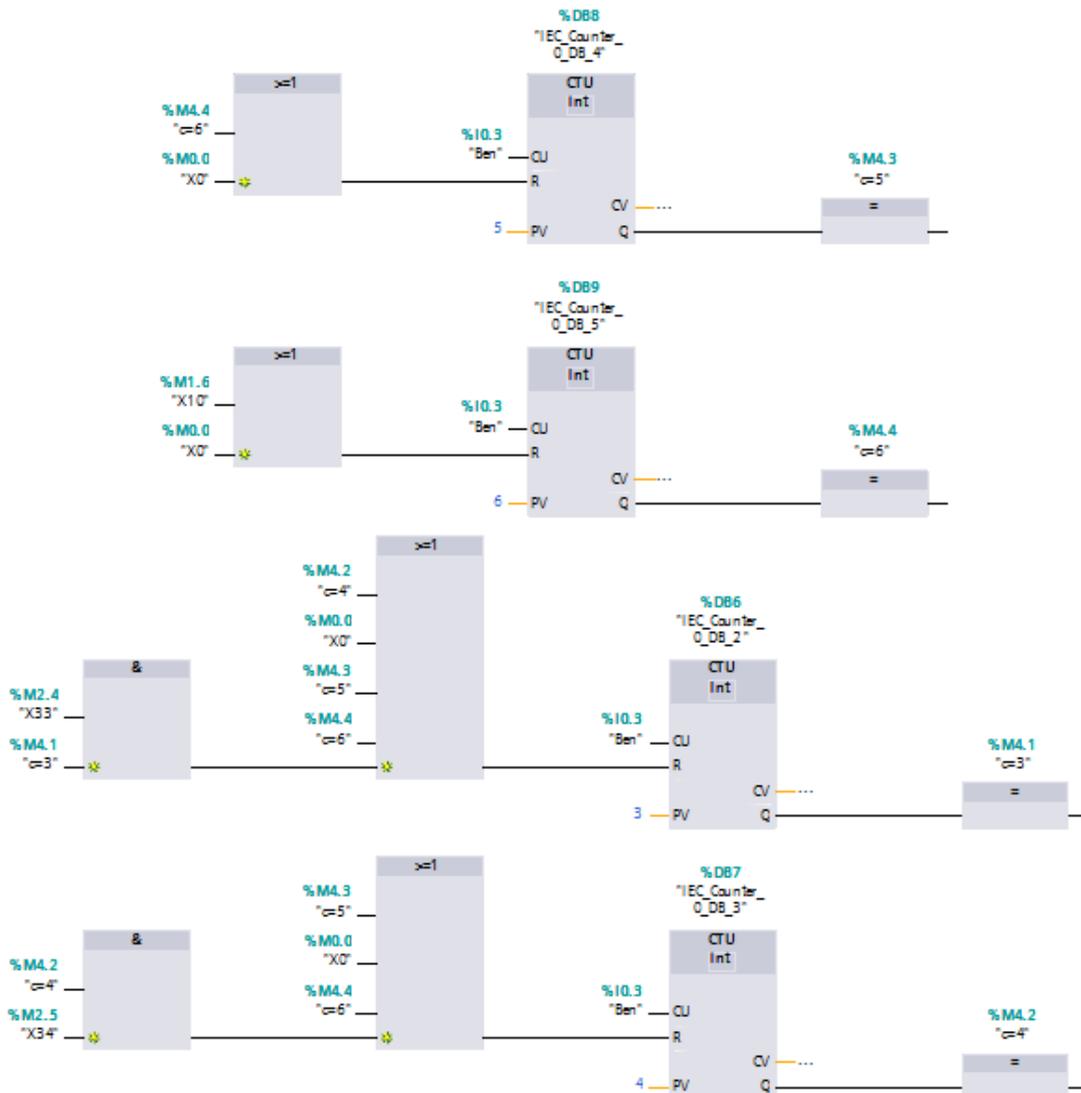


Figure III.13: Counter of The boxes 1/2.

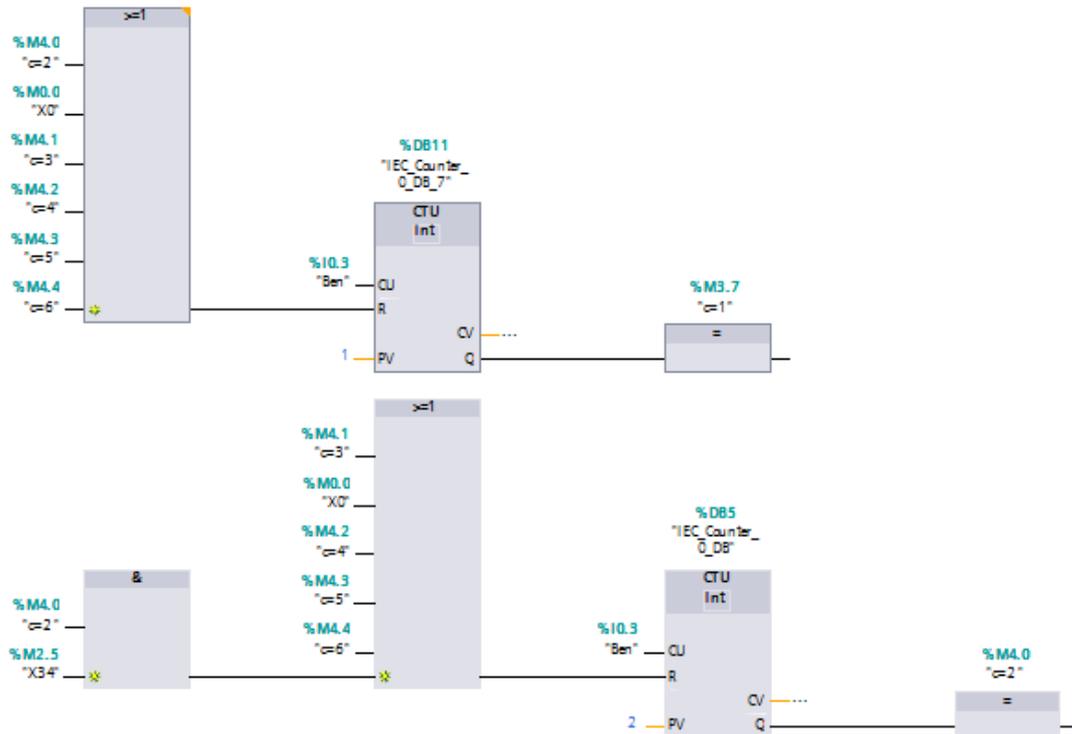


Figure III.14: Counter of The boxes 2/2.

Network 1 (initial step) is the first thing in our program.

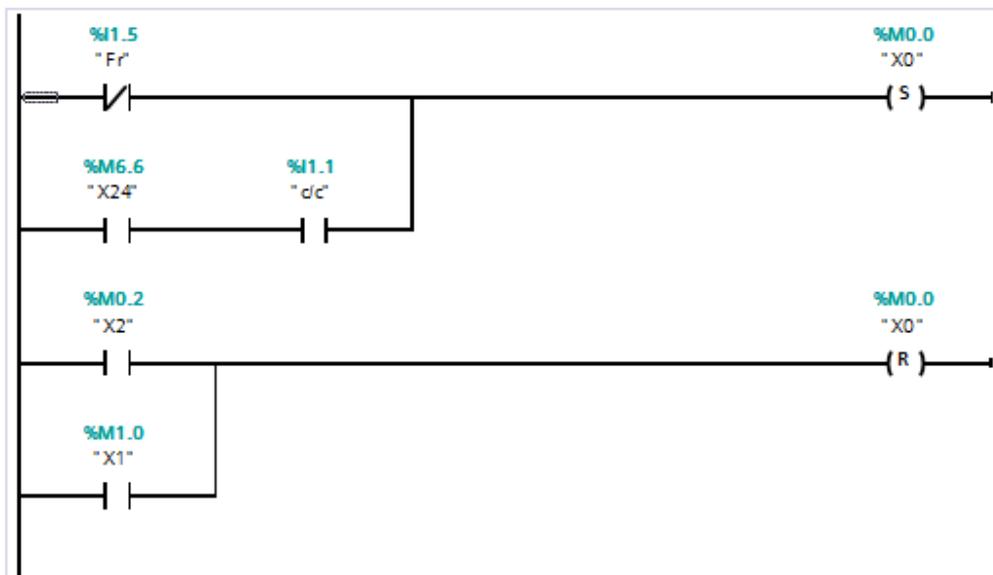


Figure III.15: Network 1 (initial step).

Network 2 (empty pallet): This is the logic of loading the empty platforms in the elevator and going up to the top, and these Figure show that.

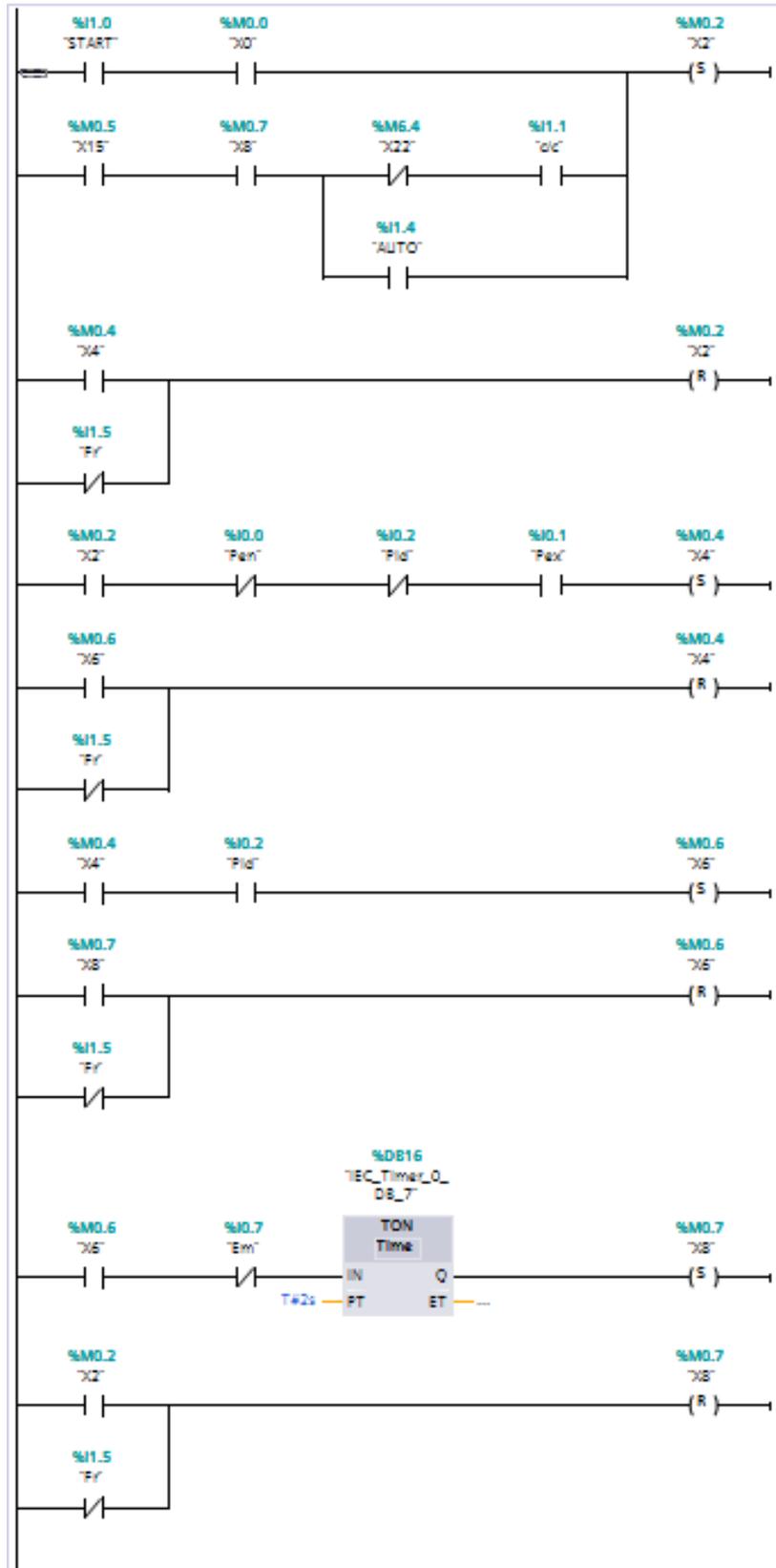


Figure III.16: Network 2 (empty pallet).

Network 3 (layers of boxes): This is the logic for organizes the layer of boxes, the figures below shows the network 3.

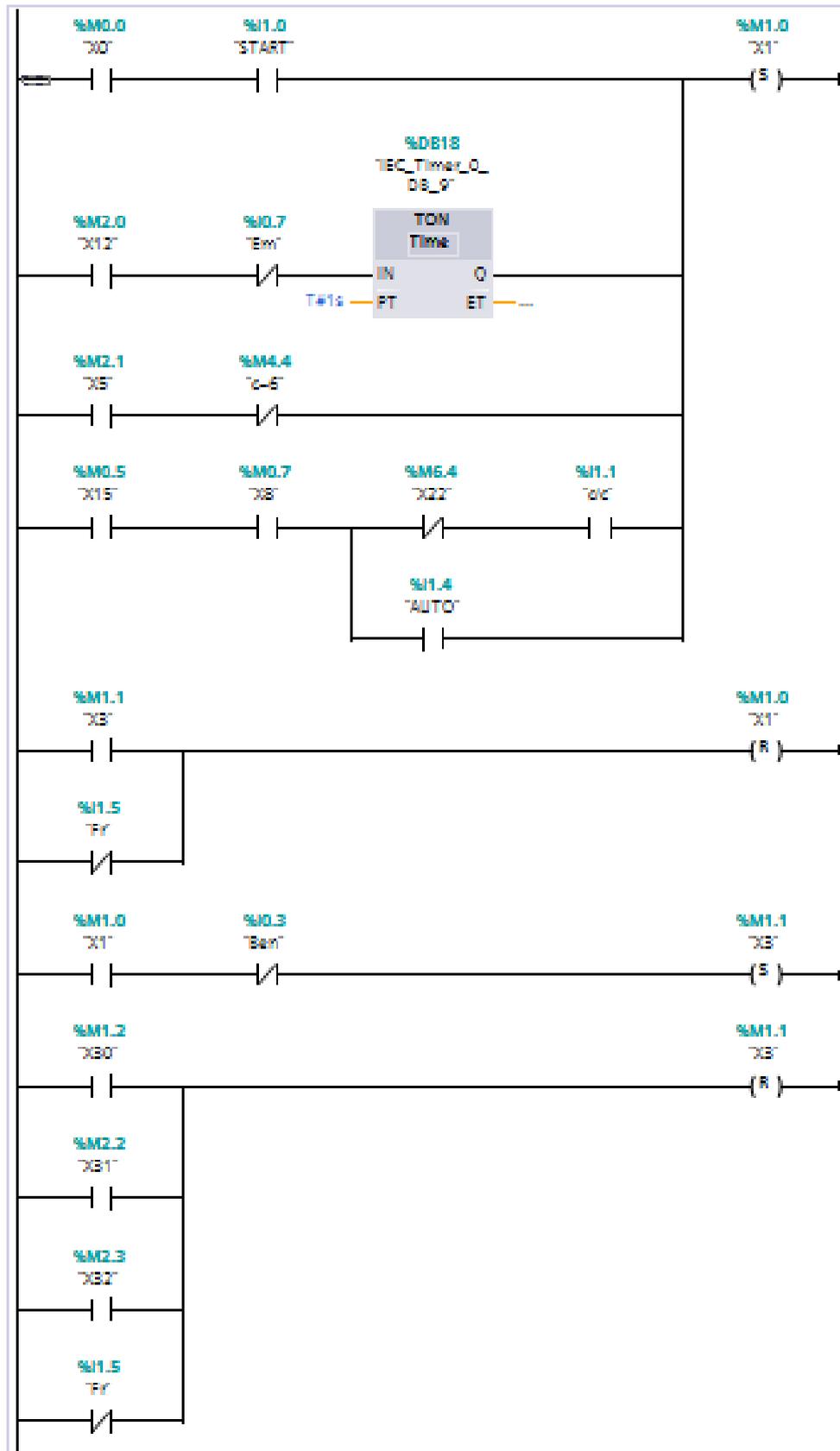


Figure III.17: Network 3 (layers of boxes) 1/5.

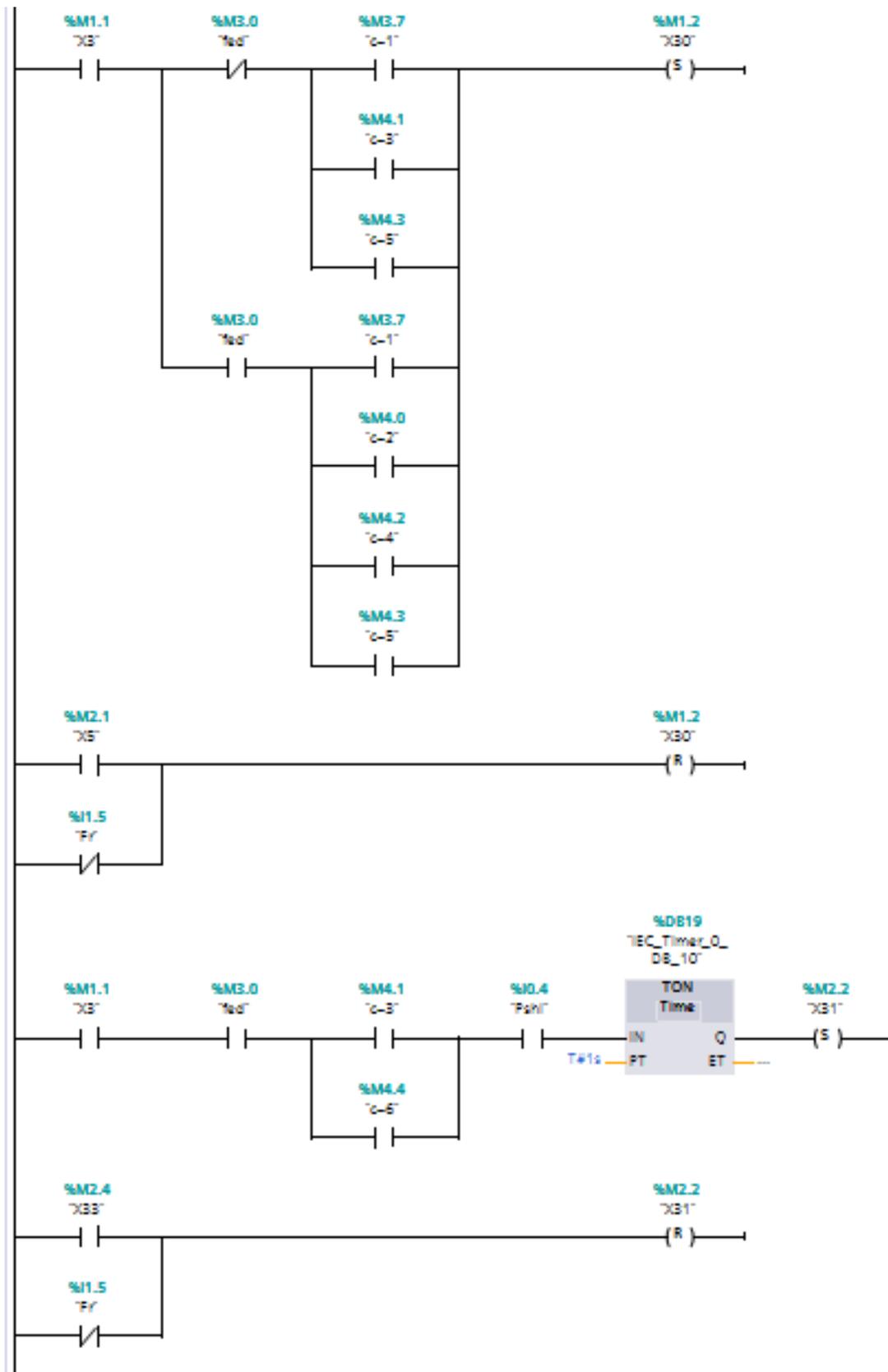


Figure III.18: Network 3 (layers of boxes) 2/5.

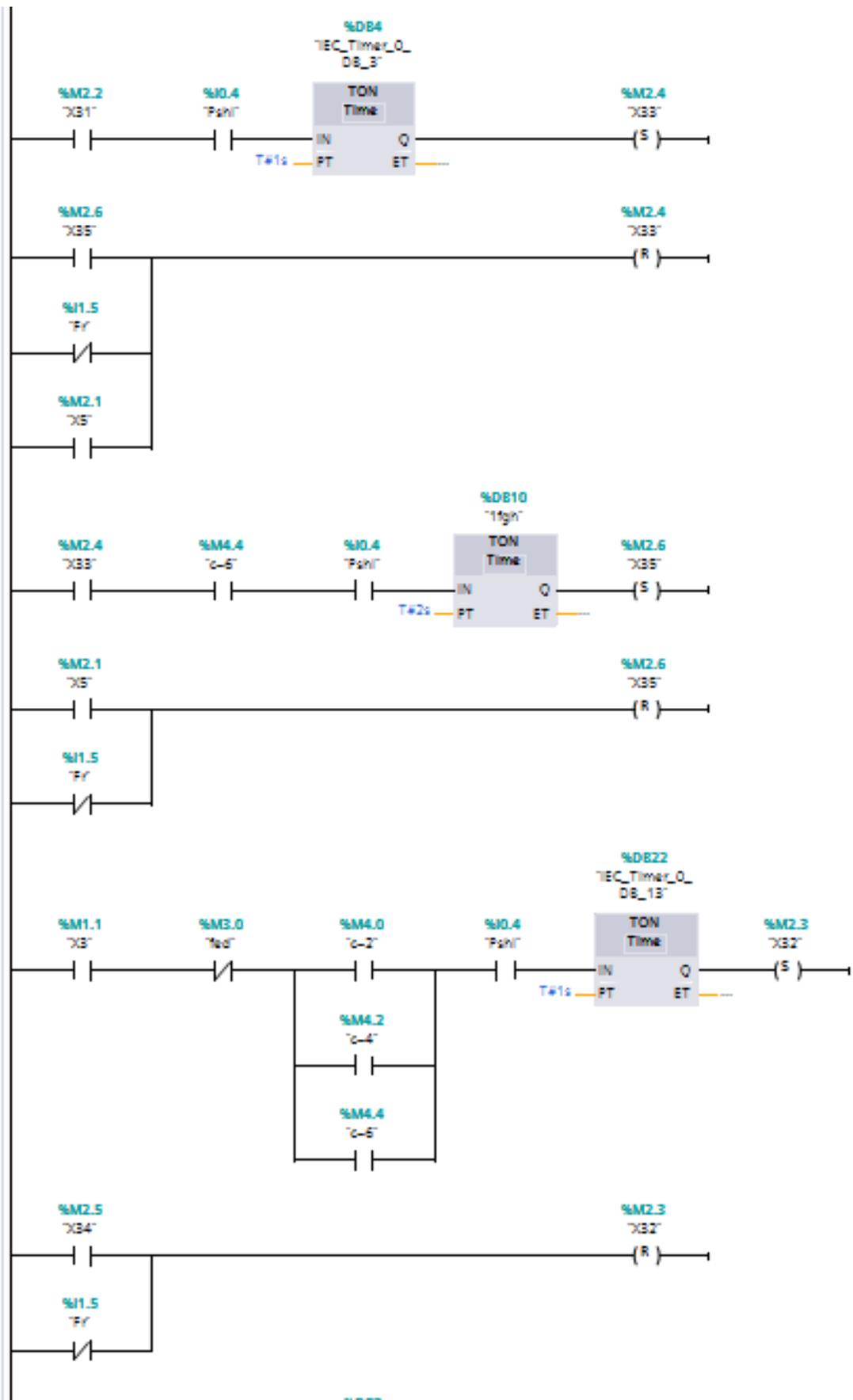


Figure III.19: Network 3 (layers of boxes) 3/5.

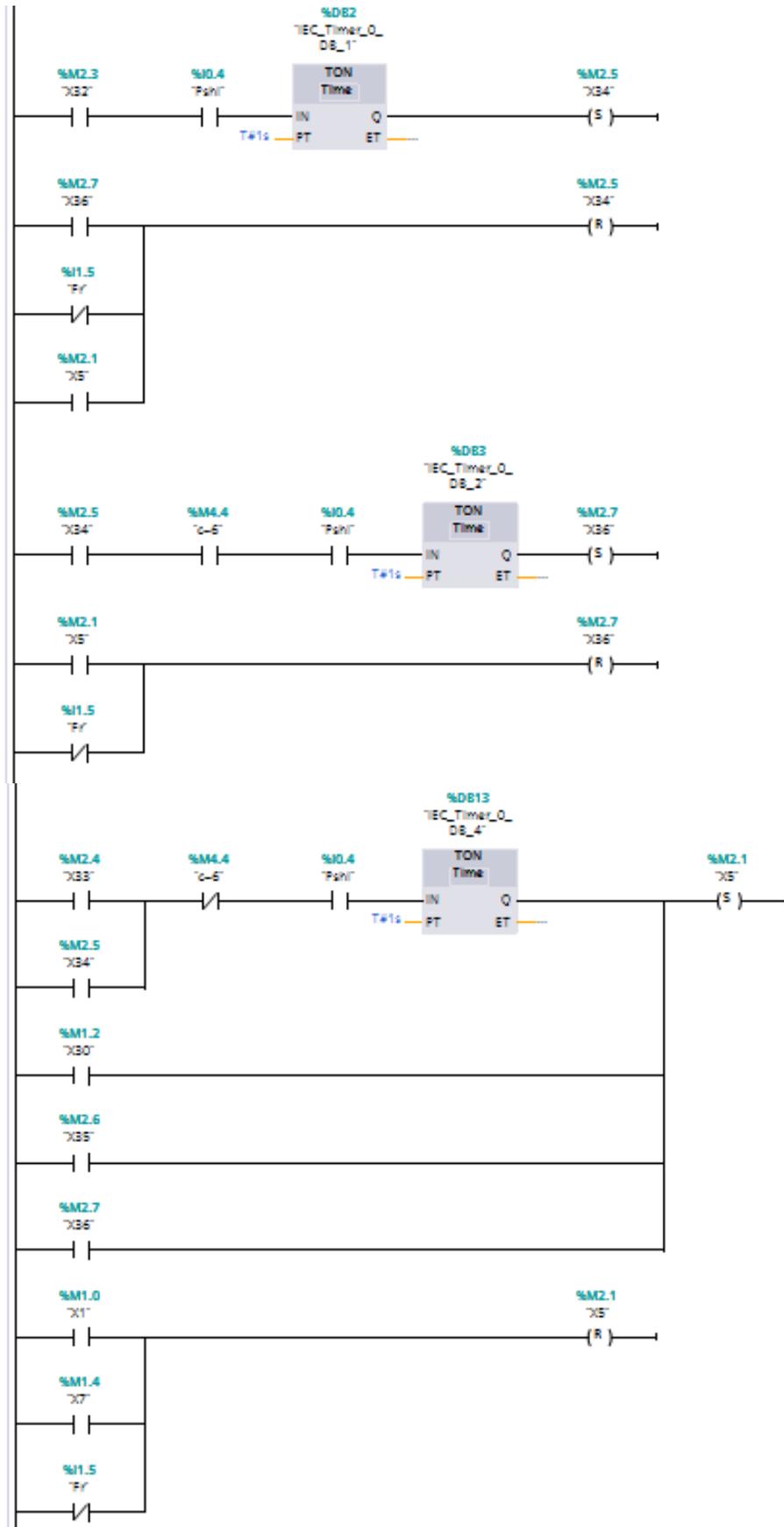


Figure III.20: Network 3 (layers of boxes) 4/5.

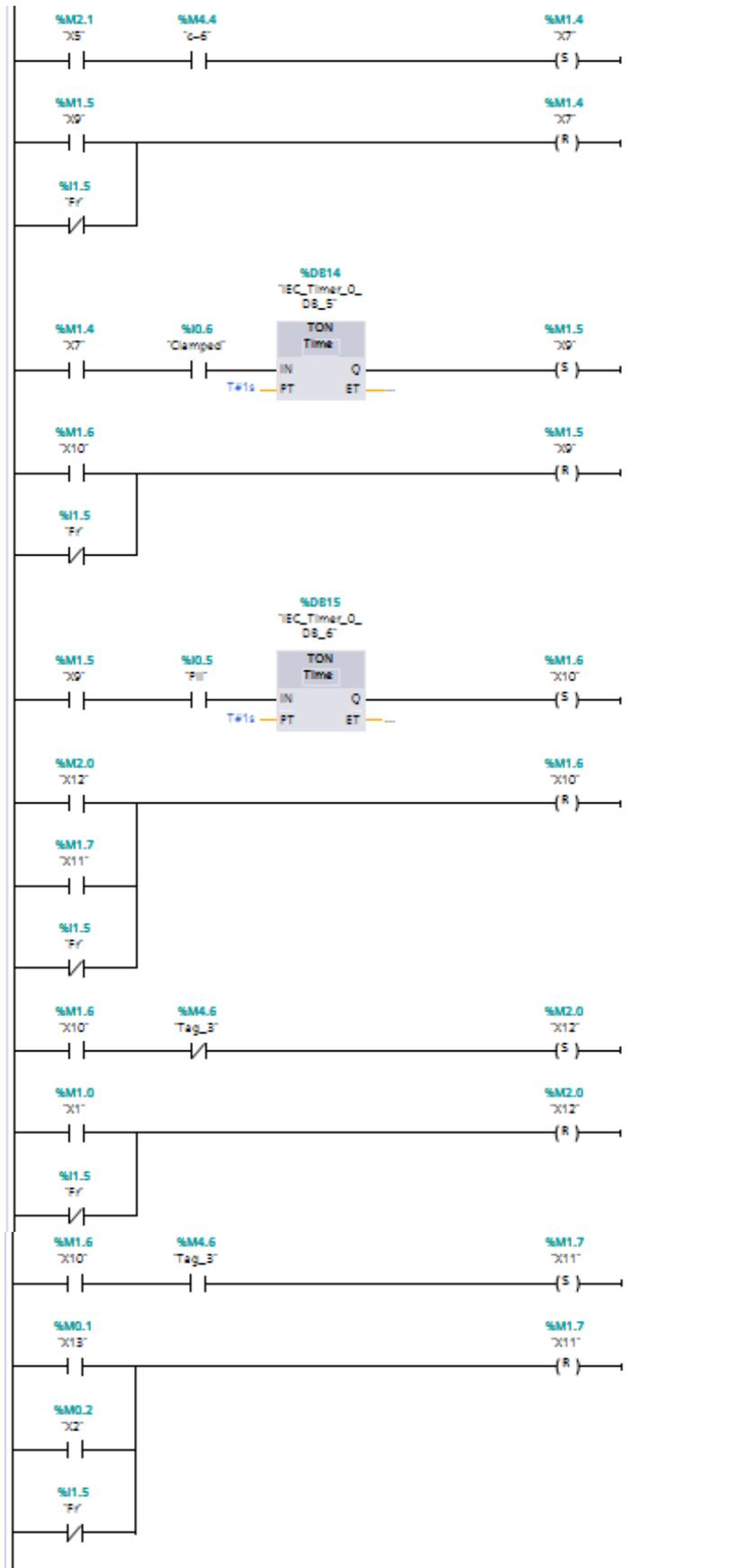


Figure III.21: Network 3 (layers of boxes) 5/5.

Chapter III: Description and automation of a product packaging system

Network 4 (Exit full pallet): This is the logic for unloading of the full pallets and sends it to the conveyor at the end of the line, the figures below shows the network 4.

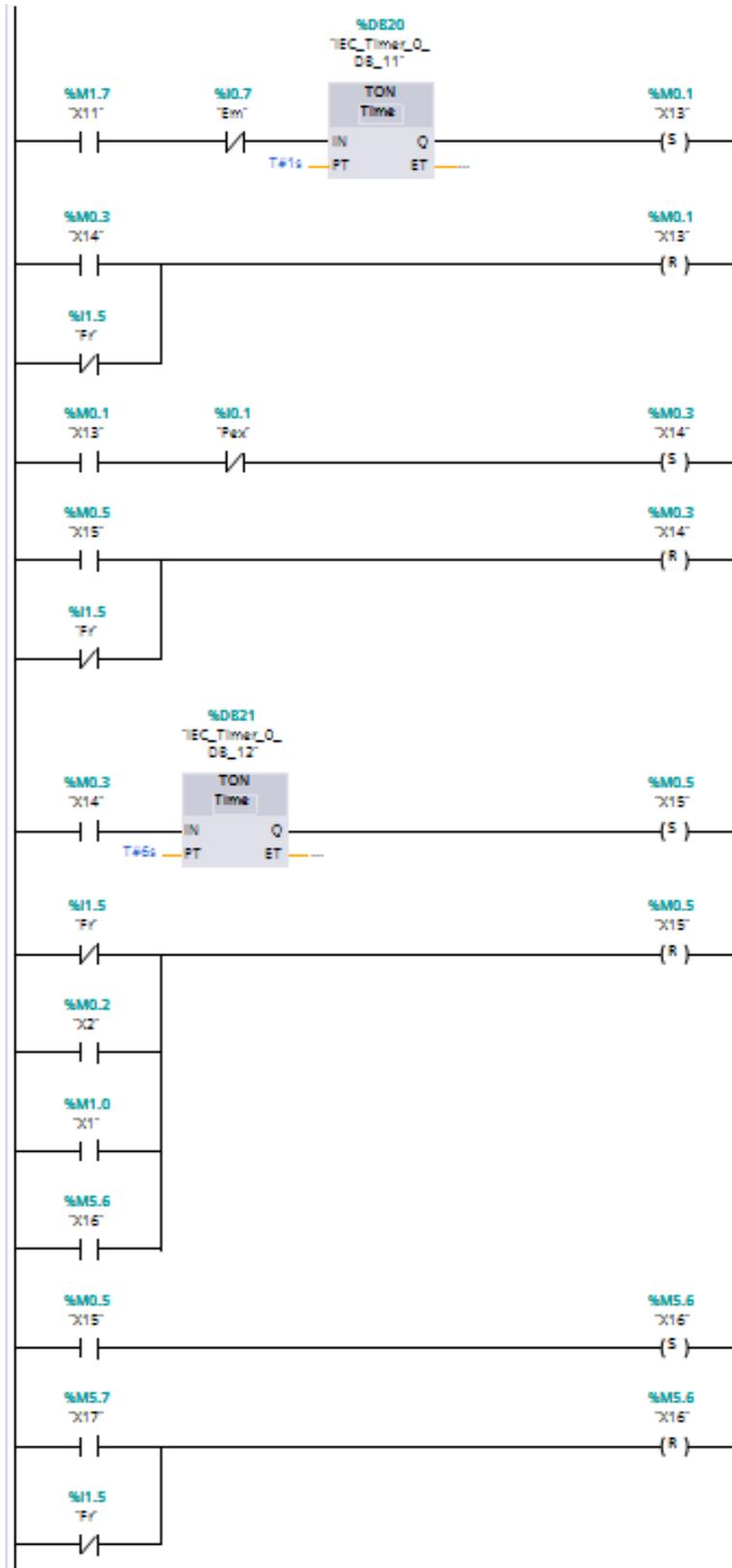


Figure III.22: Network 4 (Exit full pallet) 1/3.

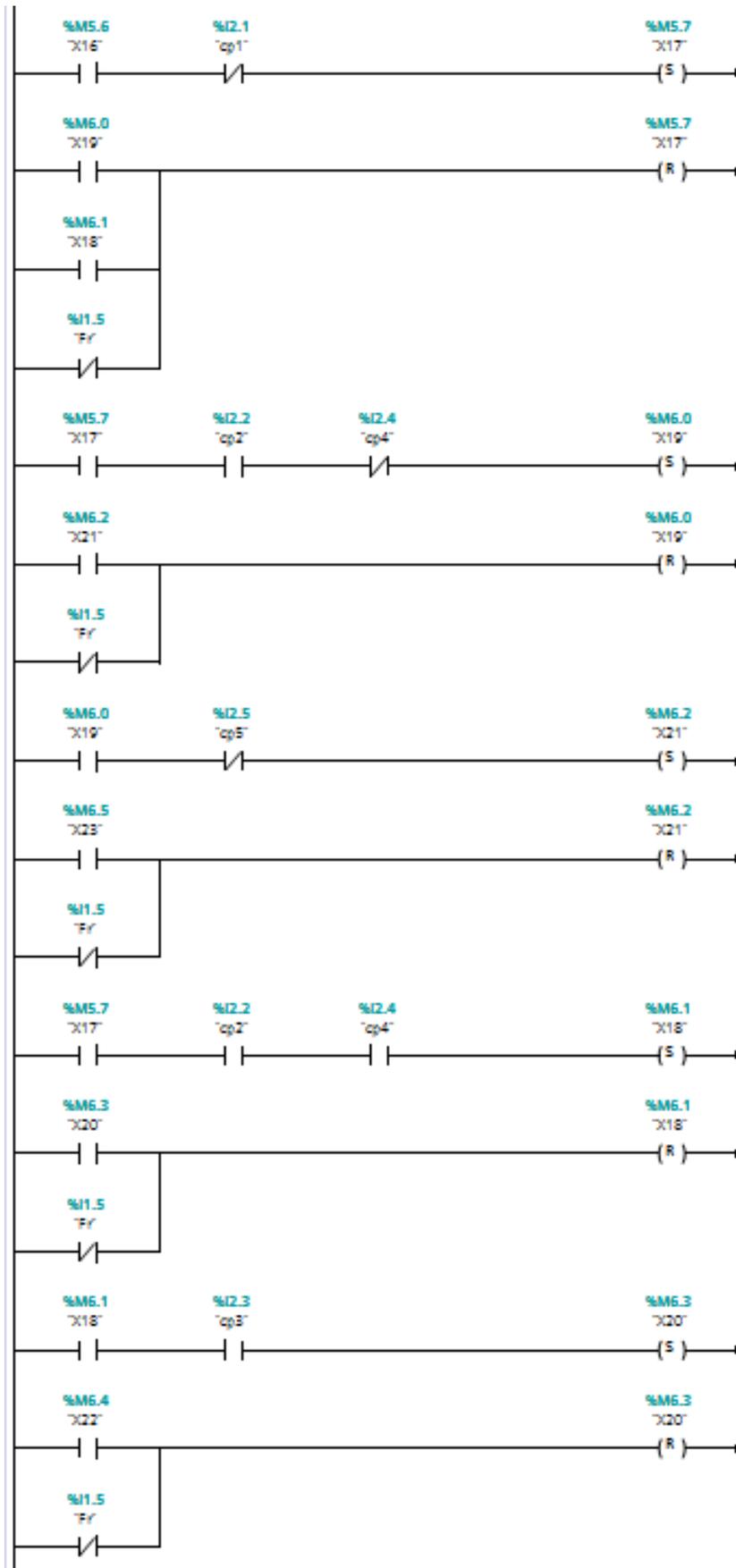


Figure III.23: Network 4 (Exit full pallet) 2/3.

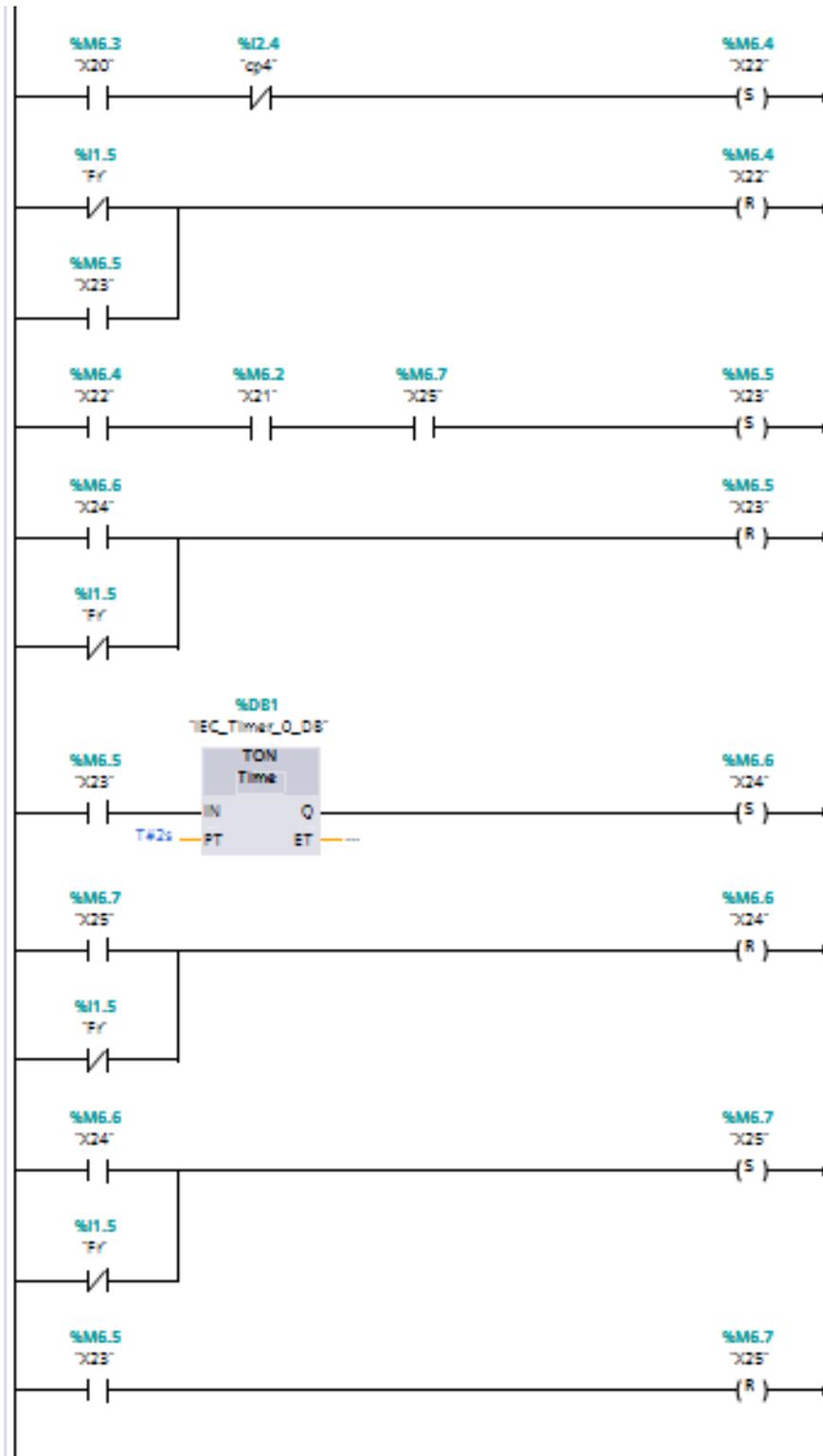


Figure III.24: Network 4 (Exit full pallet) 3/3.

Network 5(Output): This is the logic to connect the steps with their outputs, the figures below shown that.

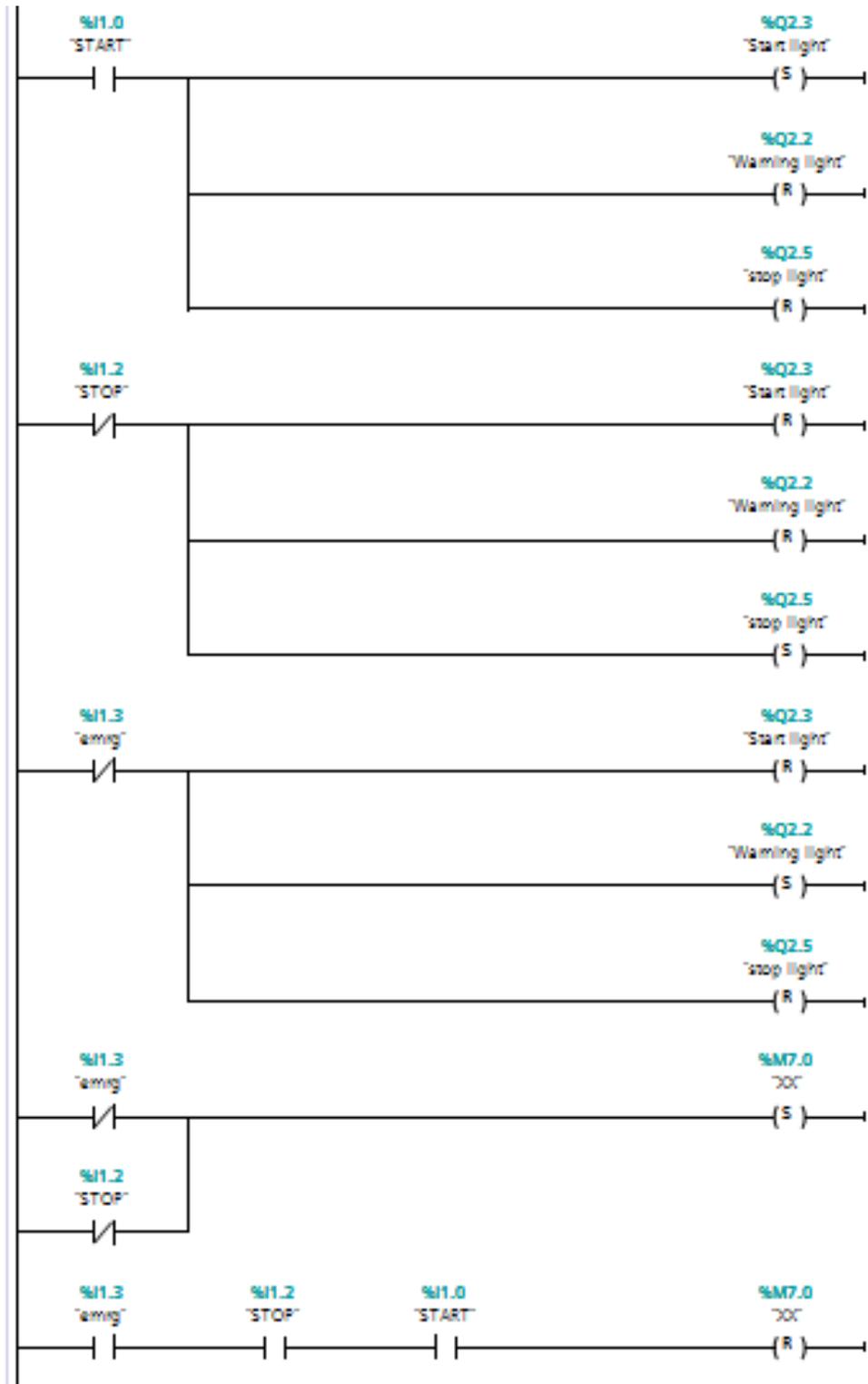


Figure III.25: Network 5(Output) 1/6.

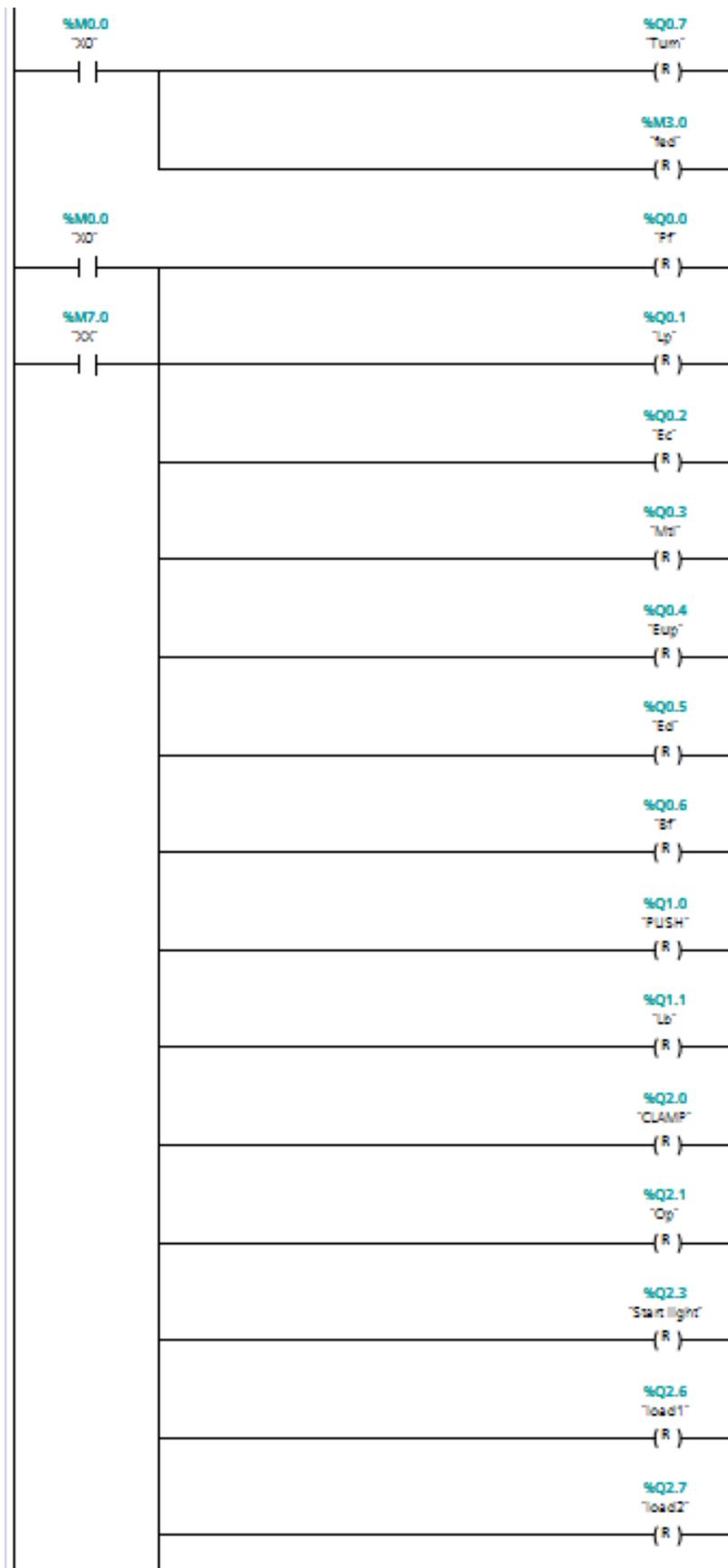


Figure III.26: Network 5(Output) 2/6.

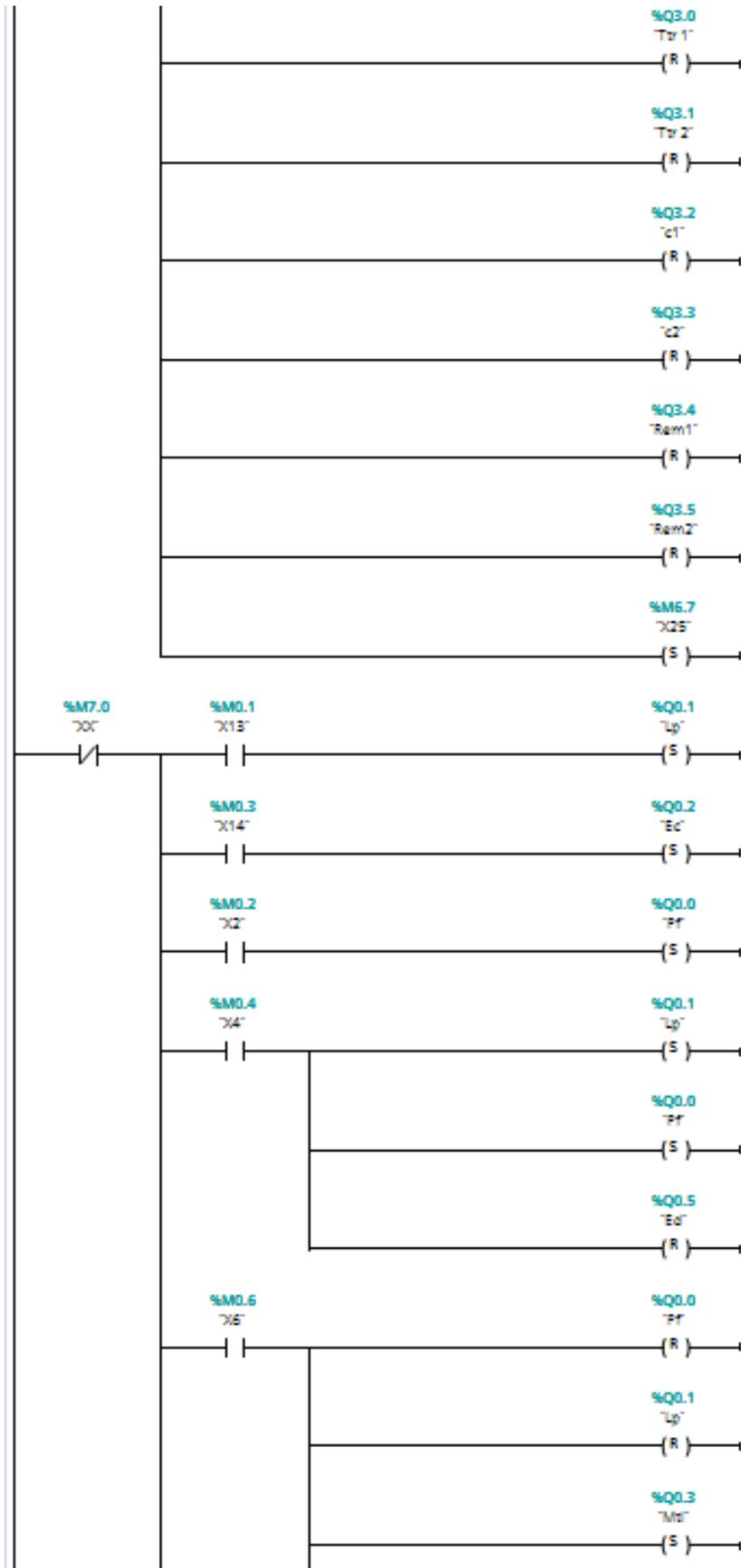


Figure III.27: Network 5(Output) 3/6.

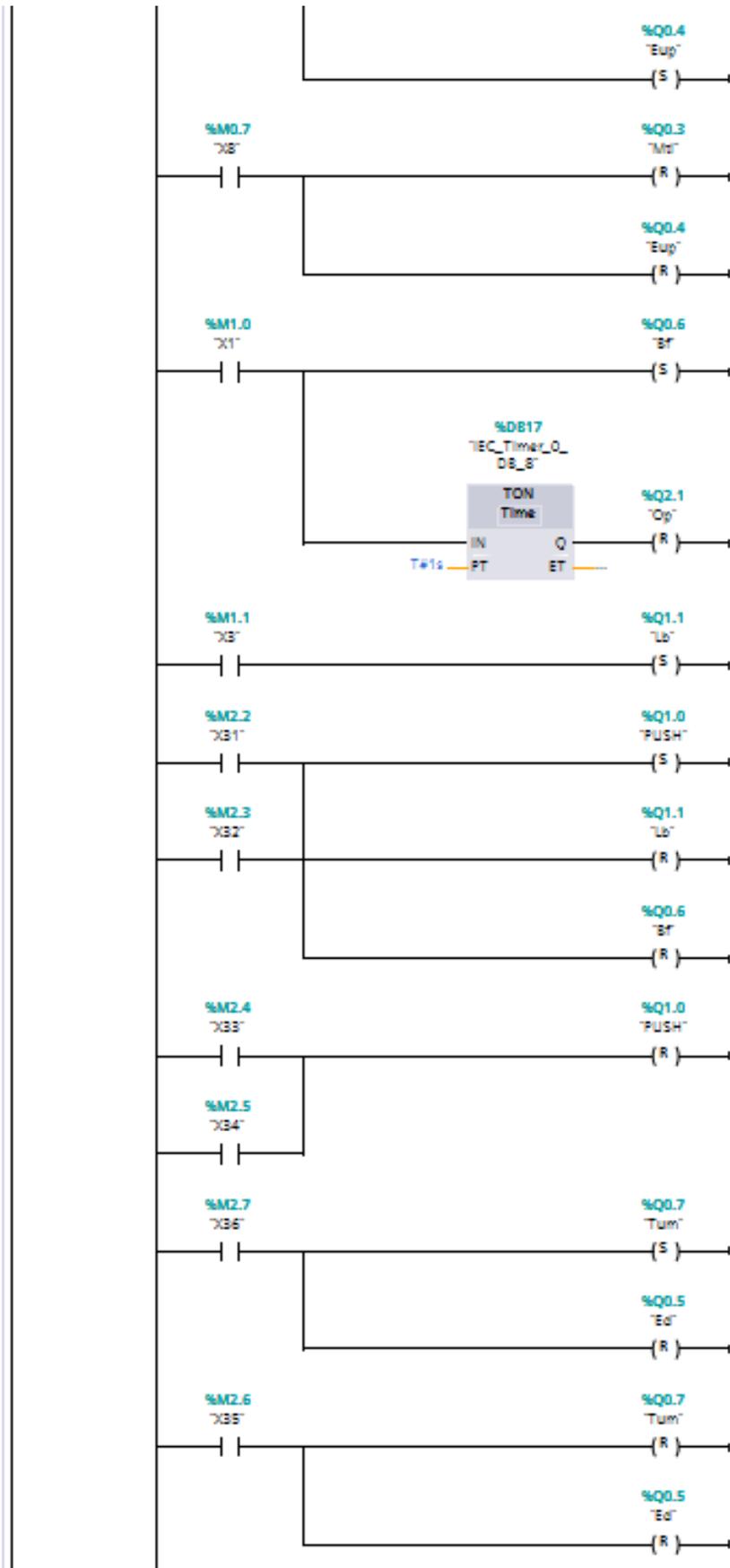


Figure III.28: Network 5(Output) 4/6.

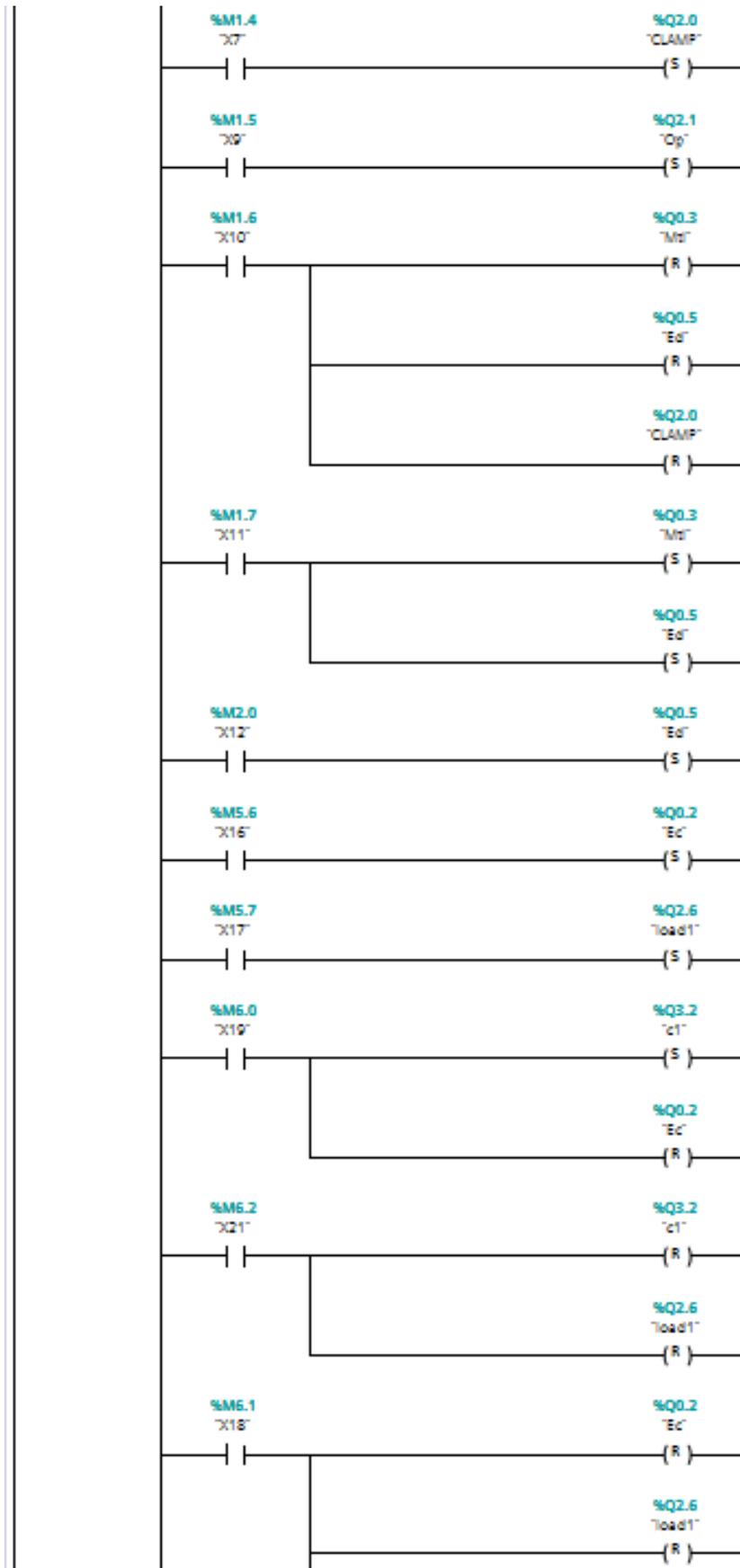


Figure III.29: Network 5(Output) 5/6.

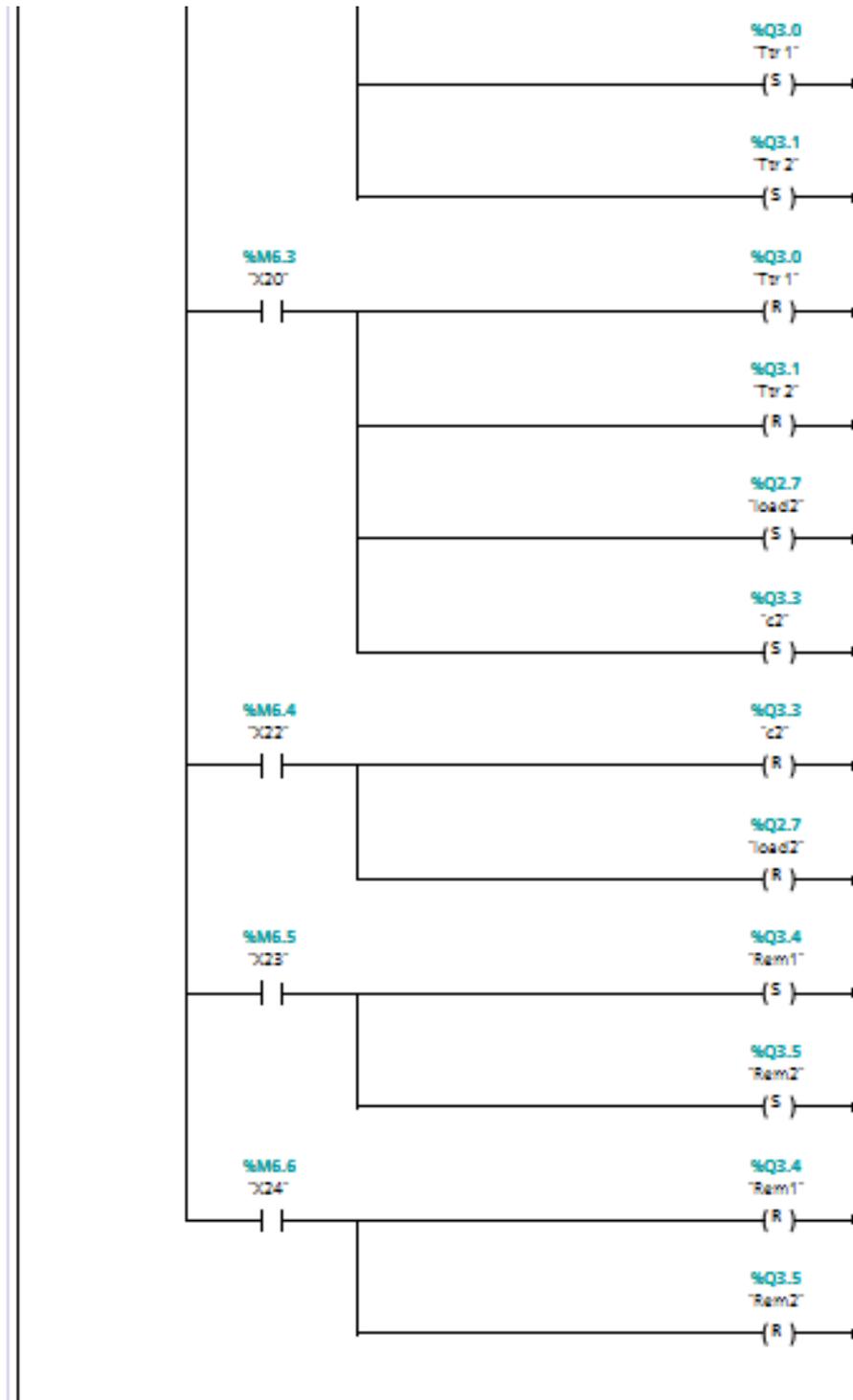


Figure III.30: Network 5(Output) 6/6.

III.5.2.4 Factory I/O

We will now add the inputs and outputs to our program for communication to our scene in Factory IO. The output coils from Factory IO will set the actual input addresses in our PLC, the figure below shows that.

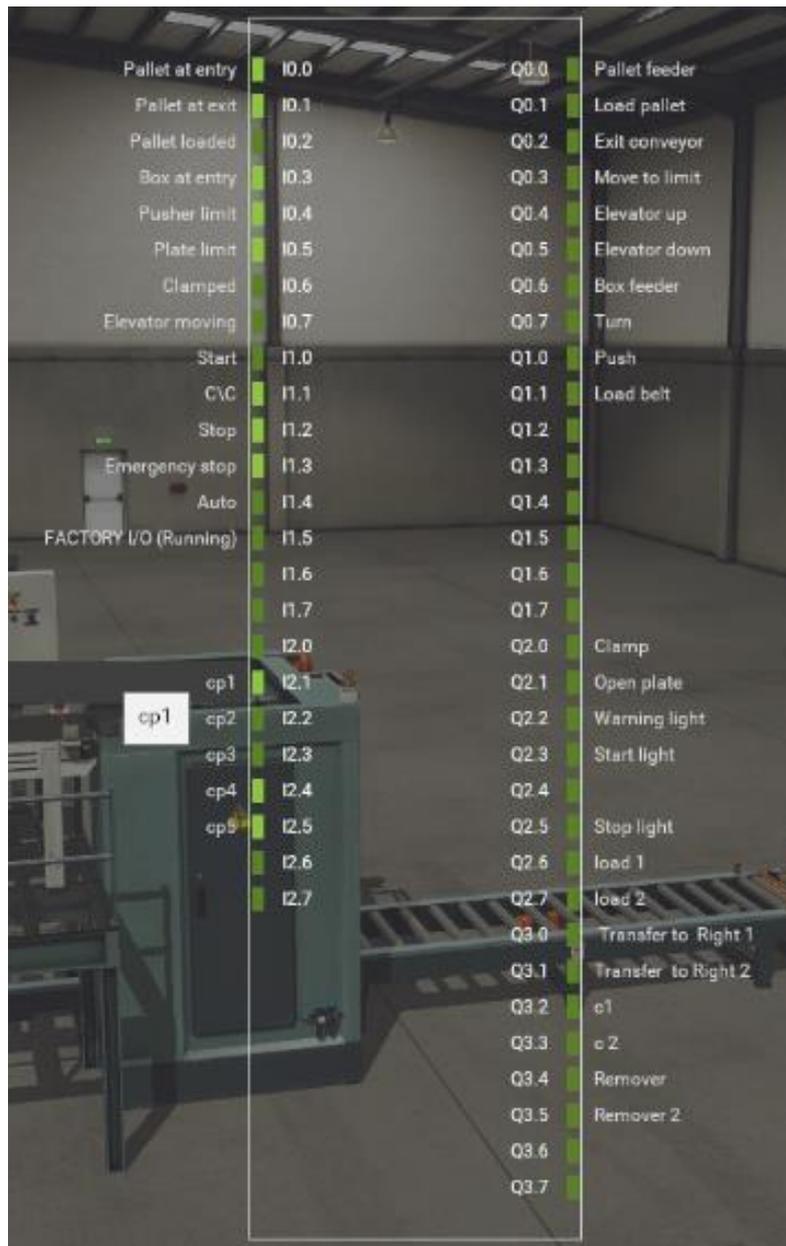


Figure III.31: Factory I/O.

III.6 Conclusion

The automation of any system requires good modeling ensuring the proper functioning of this system as well as control and supervision, among the various existing systems we find the palletizer and the automated warehouse which is a means of 'increase production in factories.

In this chapter we first made a general presentation of palletizer and the automated warehouse on the FACTORY I /O simulation software, we then programmed this system using the Tia Portal V13 software.

OVERALL CONCLUSION AND PERSPECTIVES

The automation is the scientific and technological domain that executes and controls technical tasks by machines operating without human intervention, or by means of a reduced intervention. The automation has become widespread in all production activities, both in industry and service activities. Whatever, its field of application and the techniques it uses, automation has constantly developed with the sole aim of reducing the arduousness of human work and improving the productivity of work.

The chapter I is the result of an internship at BISKRIA Cement SPA, as part of this internship; we have detailed the steps of the manufacturing of Cement.

In the chapter II, we have given a detailed functional study on the automated production system. On other words, we have increase our knowledge of PLCs and in particular, the SIEMENS PLC.

In the chapter III, we have developed an automation program of a product packaging system using the TIA PORTAL V13 programming software.

The realized project proposes an automated solution using the SIMATIC programming TIA PORTAL V13 and FACTORY I/O Simulation softwares.

In the light of the results obtained, many perspectives are envisaged such:

- ✓ A simulator that allowing programmable solutions.
- ✓ The assurance of the maximum production of the machine and the minimum of breakdowns with a reduced waiting time.

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ANNEXES

