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Automation and supervision of an industrial process with programmable Logic controller s7-300 GICA Group palleizer application

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Dedication

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ملخص

ركز هذا المشروع على أتمتة العمليات الصناعية والإشراف عليها باستخدام وحدة التحكم المنطقية القابلة للبرمجة والتغليف أكياس الأسمنت في مصنع ECDE "GICAلتحميل.

كان الهدف من هذا العمل هو تصميما نظام للتحكم والإشراف في الوقت الفعلي على جميع مراحل العملية التي تشمل 9 محطات مختلفة. يتيح نظامنا إدارة عدد الطبقات على البالتة حسب الحاجة، وضبط درجة الحرارة والضغط أثناء الانقلاب عند الضرورة. تم إنشاء منصة تمثلا المشغلات والمستشعرات المختلفة للعملية للتحقق من صحة عملنا. تم تأكيد التزامن بين المنصة وواجهة المستخدم البشرية و كما تمت إضافة إشارات الإنذار للأحداث المحددة.

Abstract

This project focused on the automation and supervision of industrial processes using the Siemens S7-300 programmable logic controller (PLC) for the palletizing and packaging platform of cement bags at the ECDE "GICA" factory.The purpose of this work was to design a control and real-time supervision system for all phases of the process, which has 9 different stations. Our system allows for managing the number of layers on a pallet as needed, adjusting temperature and pressure during inversion when necessary. A platform representing the different actuators and sensors of the process was created to validate our work. The synchronization between the platform and the HMI was also confirmed, and alarm signals were added for specific events.

Résumé

Ce projet a porté sur l'automatisation et la supervision des processus industriels en utilisant l'automate programmable Siemens S7-300 (PLC) pour la plateforme de palettisation et d'emballage des sacs de ciment à l'usine ECDE "GICA".Le but de ce travail était de concevoir un système de contrôle et de supervision en temps réel de toutes les phases du processus, qui comporte 9 postes différents. Notre système permet de gérer le nombre de couches sur une palette selon les besoins, d'ajuster la température et la pression lors de l'inversion si nécessaire. Une plateforme représentant les différents actionneurs et capteurs du processus a été créée pour valider notre travail. La synchronisation entre la plateforme et l'IHM a également été confirmée, et des signaux d'alarme ont été ajoutés pour des événements spécifiques.

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Abbreviations and Notations:

AC: Alternative Current

AI: Analog Input

AO: Analog Output

API: Industrial Programmable Controller

CPU: Processing Unit

DB: Data Bloc

DC: Direct Current

DI: Digital Input

DO: Digital Output

EEPROM: Electrically Erasable Programmable Read Only Memory

FB : Fonctionnel Bloc

FC : Fonction

FM : Function Module

HMI : Human-Machine Interface

INT : Integer

LIST : Le langage de liste d’instructions

LOG : LOGigramme

OB : Organisationnel Bloc

PC : Personnal Computer

PLC: Programmable Logic Controller

PROFIBUS: Process Field Bus

MPI: Multi-Point Interface.

PROM: Programmable Read Only Memory

RAM: Random Access Memory

ROM: Read Only Memory

SIMATIC: Siemens Automatic

SM: Signal Module

S7: Step 7

TOR: All or Nothing

TIA PORTAL: Totally Integrated Automation Portal

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General introduction

General introduction

The industrial sector has seen rapid expansion in recent years largely driven by the integration of automation within production facilities .Across various markets such as agri-food, automotive telecommunications. And household appliances, consumer demand for products continues to rise. As result, there has been a critical need to introduce advanced industrial methods and technique to keep pace with this demand. Looking forward, it is increasingly evident that developing a production system without leveraging diverse automation technologies will pose significant challenges in the near future[1].

The automation of production systems has led to the elimination of certain tiring and repetitive manual tasks; speed in production with an increase in quantity and reduction in product costs are the characteristics of an automatic production system. Industrial companies are obliged to follow technological development and the continuous change of automation equipment[1].

The ECDE, belonging to the <GICA>group, is one of the leading companies in our region. it employs a strategy of direct truck filling on-site, which is effective for local markets however this approach proves insufficient when the company focuses on exports. The need for storage on protected pallets arises, hence the use of palletizer .effective automation is crucial for managing this process, enabling real-time control and supervision of pallets, especially since the company recently introduced a new production line.

Our Objective is to automate the palletizer using a Siemens S7-300 PLC and a pc based supervision system.This setup enables real-time control and monitoring of the palletizing process, including adjusting parameters like layer count, temperature, and pressure references. the plc manages sensors and actuators, while the pc system provides operators with an interface to oversee operations, detect faults ,and optimize performance .this integrated automation solution ensures efficient palletizing to meet dynamic production needs effectively so to reach our objective, we will explain:

In Chapter I, we will discuss the palletizer in general and provide a description of the ECDE <GICA> system citing the breakdown of the overall process into two phases, each comprising a certain number of tasks.

In Chapter II, we will discuss the tools we need to achieve our objective, providing a general description of PLCs, TIA Portal, and the HMI system.

In chapter III, clarify the applied part: we will describe the specification document, then the programming using TIA Portal software. Next, we will show the implementation steps in a PLC and illustrate the simulation and implementation results on supervision board and supervision software.

At the end, we'll mention a summary of the work we have done in as well as talk about conclusions and points of view that we believe can open the door for our project to be improved in the general conclusion, and then provide some information necessary to understand our work that we used in our thesis in the appendix.

ChapterI:

System Description

I.1 Introduction

Palletization is one of the most developed handling systems in the world. Over the last three decades. It consists of grouping a certain number of packages on a support: the pallet; the grouping operation is carried out by a palletizer.

Palletization having developed in all sectors of industrial activity, the diversity of products, the quantities produced and the ways of producing them very quickly led to a multitude of types of palletizes [1].

In this chapter, we'll presented palletizer in general and stations of the ECDE palletizer.

I.2 Palletizing

Palletizer is the logistics process which consists of grouping goods on a pallet in order to unify the load and facilitate its transport by different handling equipment. There pallet is a horizontal platform made of boards which serves as a base for the products so that the forks of a forklift or pallet truck can pick up and move the entire load at the same time.

Palletization aims, in addition to facilitating transport, to protect the merchandise from the moment it is palletized until its destination, maintaining the product in perfect condition until its next logistical process or until its arrival to the customer final. In order to ensure the stability of the goods, the choice of the type of pallet is fundamental, It will therefore be necessary to take into account not only the material from it is made there has wooden, plastic or metal pallets, but also its dimensions .Palletizers can be categorized into several types based on their functionality and level of automation:

1. Manual Palletizers: Operators manually place items onto pallets.

2. Semi-Automatic Palletizers: Combine manual input with automated machinery to assist in placing items on pallets.

3. Automatic Palletizers: Fully automated systems that do not require human intervention during the palletizing process.

4. Robotic Palletizers: Use robotic arms to handle and place items onto pallets with high precision [1].

III.2.1 Types of Palletizers

1. Conventional Palletizers: These use layer-forming techniques where products are arranged in layers on a conveyor before being transferred onto a pallet.

2. Robotic Palletizers: Utilize robotic arms to pick and place products onto pallets. They offer high flexibility and can handle complex palletizing tasks.

3. Mixed-Load Palletizers: Designed to handle different types of products simultaneously, creating mixed pallets that are common in distribution and retail settings.

III.2.2 Role of Palletizers in the Palletizing Process

1. Efficiency and Speed: Palletizers significantly increase the speed of the palletizing process compared to manual methods. They can handle high volumes of products quickly, which is essential for industries with large-scale production and shipping requirements.

2. Consistency and Precision: Automated palletizers ensure that products are stacked uniformly and securely. This consistency reduces the risk of pallet instability and product damage during transportation and storage.

3. Labor Savings: By automating the palletizing process, companies can reduce the need for manual labor. This not only lowers labor costs but also minimizes the risk of workplace injuries associated with repetitive lifting and stacking tasks.

4. Versatility: Palletizers can handle a wide range of products, including boxes, bags, bottles, and other packaging types. They can be programmed to create different pallet patterns and configurations to optimize space utilization and stability.

5. Integration with Production Lines: Palletizers can be integrated seamlessly into existing production and packaging lines. This integration allows for continuous and streamlined operations, where products are automatically transferred from the production line to the palletizing system.

6. Improved Safety: Automation of the palletizing process enhances workplace safety by reducing the need for workers to perform physically demanding and repetitive tasks. It also minimizes the risk of accidents related to manual palletizing.

7. Flexibility and Scalability: Modern palletizers are designed to be flexible and scalable. They can be adjusted to accommodate different product sizes and pallet patterns, making them suitable for a variety of applications and industries [1].

III.2.3 Advantages of Using Palletizers over Manual Palletizing

1. Speed and Efficiency

High Throughput: Automated palletizers can handle a much higher volume of products per hour compared to manual methods. They can operate continuously without the need for breaks, maintaining a steady flow of production.

Consistent Operation: Palletizers maintain a constant speed and can work around the clock, significantly increasing overall productivity.

2. Accuracy and Precision

Consistent Stacking: Automated systems ensure products are stacked uniformly and precisely, reducing errors and inconsistencies that are common with manual palletizing.

Pattern Accuracy: Palletizers can follow pre-programmed stacking patterns exactly, ensuring optimal use of pallet space and stability of the load.

3. Safety

Reduced Risk of Injury: Automation eliminates the need for workers to perform repetitive, heavy lifting tasks, which are common causes of workplace injuries such as strains and sprains.

Enhanced Workplace Safety: Palletizers include safety features such as sensors and emergency stops that minimize the risk of accidents.

4. Cost Savings

Labor Cost Reduction: By automating the palletizing process, companies can significantly reduce labor costs associated with manual stacking.

Less Product Damage: Precise handling and stacking reduce the likelihood of product damage, leading to lower costs associated with damaged goods.

5. Quality and Reliability

Consistent Quality: Automated palletizers provide consistent quality in stacking, which enhances the reliability of the pallet loads during transportation and storage.

Minimized Human Error: Automation eliminates the variability and potential for error that comes with manual labor.

6. Flexibility and Adaptability

Handling Various Products: Modern palletizers can handle a wide range of product sizes, shapes, and weights, making them versatile for different packaging needs.

Quick Changeover: Automated systems can quickly adapt to different products and pallet patterns with minimal downtime, increasing flexibility in production lines.

7. Space Optimization

Optimal Pallet Use: Automated palletizers can create highly optimized pallet patterns that maximize the use of pallet space, leading to more efficient storage and transportation.

Improved Load Stability: By precisely arranging products, palletizers enhance the stability of the pallet load, reducing the risk of shifting or toppling during transport.

8. Data and Monitoring

Real-Time Monitoring: Palletizers often come with software that allows real-time monitoring and data collection, helping to track performance and identify areas for improvement.

Traceability: Automated systems can provide detailed logs and records of palletizing operations, useful for quality control and traceability.

III.2.4 The advantages of Palletization:

The introduction of the pallet as a standard in the warehouse allowed:

- Faster loading and unloading of goods.The use of pallets allows operators or automatic loading docks tooled and unload goods from the truck more quickly, since the equipment Handling can stack products and thus reduce the number of trips.

-More speed in the flow of goods from the warehouse Goods, stacked on pallets, move easily through the warehouse, while respecting the steps assigned to each product.

-Greater safety for operators and stored products: The pallets prevent the operator from moving loads one by one, which offers more safety both for the goods and for himself.

-Inventory management: Loading on pallets allows stricter control of each reference. As the warehouse manager knows the volume of products stacked on each pallet, he can already get an idea of the stock level of each product at a glance.

-Optimization of the storage area: When we talk about pallets, one of the key concepts is stacking. The different systems of storage, whether conventional or automatic, make the most of storage space storage, each of course with its advantages and disadvantages

-Overall structure of a pallet: The pallets can be equipped with a superstructure the lower floor, or sole, which is in contact with the ground. The upper floor, which will support the merchandise. Finally the rafters, when it comes to boards which will be the entire length, or the cubes [2]. Figure I.1.

Figure I.1: The popular palette.

III.2.5 Typical composition of a palletizing system

A typical palletizing system is a comprehensive setup designed to automate the process of stacking products onto pallets efficiently and accurately. The system includes various components and subsystems that work together seamlessly. Here’s an overview of the typical composition of a palletizing system:

1. Feeding Conveyor System

Function: Transports products from the production line to the palletizing area Components**:**Belt or Roller Conveyors: Moves products towards the palletizing station.

Product Guides: Ensures products stay on track and are correctly aligned.

Sensors: Detects the presence and position of products, providing data to the control system.

2. Product Orientation and Sorting System

Function: Ensures products are correctly oriented and sorted before palletizing Components**:**

Orientation Devices: Such as rotators and turners, adjust the position of products.

Sorting Mechanisms: Like pushers and diverters, route products to the correct lanes.

Scanners (Barcode/RFID): Identify and verify products.

3. Layer Formation Area

Function: Arranges products into specified patterns or layers before stacking Components:

Layer Forming Tables/Conveyors: Organize products into the desired configuration.

Layer Forming Devices: Use pushers or sweepers to position products.

Sensors and Vision Systems: Ensure accurate placement and pattern formation.

4. Pallet Dispenser

Function: Supplies empty pallets to the palletizing system Components:

Pallet Magazine: Stores a stack of empty pallets.

Automated Pallet Dispenser: Releases one pallet at a time.

Conveyor to Move Pallets: Transfers empty pallets to the palletizing station.

5. Robotic Arm or Palletizing Mechanism

Function: Stacks products onto pallets in a specific pattern Types:

Robotic Palletizers: Use articulated arms to pick and place products.

Conventional Palletizers: Use mechanical devices like gantries or layer pushers.

Robotic Arm/Gantry System: Provides the motion and control for stacking.

End-of-Arm Tooling (EOAT): Customizable tools like grippers or suction cups designed for specific products.

Control System: Programs and directs the movements of the robot or mechanism.

6. Pallet Conveyor System

Function: Moves loaded pallets from the palletizing area to the next stage (e.g., wrapping, storage) Components:

Roller or Chain Conveyors: Transport loaded pallets.

Turntables: Rotate pallets for proper orientation.

Pallet Lifts or Elevators: Adjust the height of pallets as needed.

7. Stretch Wrapper or Pallet Wrapper

Function: Secures the stacked products on the pallet with stretch wrap for stability during transport and storage Components:

Stretch Wrapping Machine: Applies stretch film around the pallet.

Film Dispenser: Feeds and controls the stretch film.

Wrapping Arm or Turntable: Rotates the pallet or moves around it to apply the film.

8. Control System

Function: Manages and coordinates the entire palletizing process. Components:

Programmable Logic Controllers (PLCs): Execute the programmed instructions for the system.

Human-Machine Interface (HMI): Allows operators to monitor and control the system.

Sensors and Feedback Systems: Provide real-time data to ensure accuracy and detect issues.

9. Safety Systems

Function: Ensures the safety of operators and equipment Components:

Safety Guards and Enclosures: Prevent unauthorized access to moving parts.

Emergency Stop Buttons: Allow immediate shutdown in case of an emergency.

Light Curtains and Safety Sensors: Detect the presence of personnel and halt operations if necessary.

10. Additional Components (Optional)

Labelling Systems: Apply labels to products or pallets for identification and tracking.

Vision Systems: Inspect and verify product placement and quality.

Weighing Systems: Check the weight of products or pallets to ensure they meet specifications [2].

I.3 Palletization process of the CHLEF cement plant company

Among the companies in our region using the palletizing process we find the cement company which belongs to the GICA group. Known under the name “ECDE”, CHLEF’s cement and Derivatives Company is one of the nationally important companies for the production and marketing of cement. It uses the Palletization process to facilitate the storage, transportation and protection of the goods from the moment they are palletized to their destination. This process is to carried out in two phases. The first phase allows to organize the cement bags by layer in a specific form. The second phase allows the pallet to be prepared for storage[3].

III.3.1 First phase: the first phase which is composed of three stations.

I.3.1.1 Feeding station:

The first station is responsible for feeding the system with cement bags and delivering them to the next station, it usedfor correcting the shape and straightness of the bag so that it is ready for the next stage the figure 1.2.

Figure I. 2: preparation of cement bags.

I.3.1.2 Second post: organization of the product (cement bag)

This station is used to organize the cement bags in a certain shape.(Figure 1.3), the process of preparing and organizing the cement bags continues until we obtain the number of layers whose was entered in the first stage. The odd layer consists of five bags of cement, three vertical and two horizontal, the even layer which also consists of five bags of cement opposite the odd layer in order, tree of them are horizontal and two are vertical, and the last layer (special layer) must consist of four bags two horizontal on sides, and two vertical inside theme.

Figure I. 3: organization of cement bags.

I.3.1.3 Third station: pallet evacuation

This station is responsible for evacuating the layer that has been prepared from the preparation table to the pallets. It is also responsible for counting the number of layers that have been prepared, which must be prepared in order to be equal to the number of layers desired (figureI.4).


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Figure I. 4: pallet loaded with layers of cement bags.

I.3.2 second phase Preparation stations :

The secondphase which is composed of five stations.This station is responsible for feeding the second stage with pallets and transporting them to the next station to be packed.

I.3.2.1.Packing station: This station is responsible for wrapping the pallets and closing them well so that they are completely ready to be heated in the next station.

I.3.2.2Heating station:

This station is responsible for heating at a calculated temperature that was enteredearler so that the cover adheres to the pallet tightly. It is then taken out to the next station after a period of time sufficient for the cover to warm sufficiently.

I.3.2.3Cooling station:

This station is responsible for two basic tasks: first, cooling the pallets for a sufficient period of time so that the coating regains its hardness, and the second task is to correct the straightness and shape of the pallets so that they will be evacuated to the next station.

I.3.2.4Reversal station:

This station is responsible for turning the pallets upside down, so that the special layer is at the bottom and the first layer is at the top. The role of this layer is to facilitate the loading process (Clark). Finally form we obtain packages as illustrated in figure 5.

Figure I. 5: the final form of cement bags.

I.4 Conclusion

The automation of palletizing systems through advanced technologies and integrated control mechanisms significantly enhances industrial efficiency, accuracy, and safety. The detailed examination of the palletizer stations at the ECDE underscores the critical role of each component in achieving seamless and effective palletizing operations. The shift towards automation in industrial management not only streamlines processes but also provides a scalable, flexible, and safe environment, essential for modern manufacturing and logistics operations.

The following section devoted to the description of automates programmable controllers and the TIA portal software the powerful Human Machine Interface (HMI) system, WinCC.

ChapterII:

Automation tools

II.1 Introduction

In light of the advancements in industry and rapid technological transformations, Programmable Logic Controllers (PLC) have become indispensable for achieving efficiency and precise control in industrial processes. Siemens stands out as a leader in this field, offering robust and flexible PLC solutions that cater to a wide range of industrial needs. The TIA Portal (Totally Integrated Automation) system, provided by Siemens, exemplifies a prominent solution that integrates seamlessly with PLCs and enhances the capabilities of industrial automation systems.. It includes the powerful Human Machine Interface (HMI) system, WinCC.

The aim of this chapter is to explore the fundamentals of PLC and the TIA Portal technology, and how they are utilized to achieve automation and logical operation in industrial processes. We will analyze the tools within the TIA Portal, including WinCC, and how they are used to effectively create, operate, and monitor industrial processes.

By understanding how PLC works and its integration with the HMI system in the TIA Portal environment, we will be able to leverage technology more effectively to improve productivity, quality, and achieve precise control in industrial processes[4].

II.2Programmable controllers:

II.2.1 Definition:

A Programmable Logic Controller (PLC) is a specialized computing device extensively used in industrial automation to control electromechanical processes. Unlike general-purpose computers, PLCs are purpose-built for real-time control tasks in manufacturing environments, where they regulate the operation of machinery, production lines, and other industrial processes.

PLCs are engineered to withstand harsh industrial conditions, featuring robust construction and reliability to ensure continuous operation in demanding environments. They typically consist of a central processing unit (CPU), input and output modules (I/O), memory, and a programming interface.

The programming of PLCs involves creating logic sequences, timers, and other control functions through specialized software. This allows operators to define the behavior of the PLC based on input from sensors, switches, and other devices. PLC programming languages, such as ladder logic, function block diagrams, or structured text, provide a structured approach to designing control algorithms [4].

II.2.2 Components of the PLC Unit

The PLC unit consists of the following main components:

II.2.2.1 Input Module

PLC input modules are components of a Programmable Logic Controller (PLC) system responsible for interfacing with external devices to receive input signals. These input signals typically originate from sensors, switches, or other field devices located within the industrial environment.

Input modules are designed to convert various types of input signals, such as digital or analog signals, into a format that the PLC's central processing unit (CPU) can interpret and process. They provide isolation and protection for the PLC system against electrical noise and voltage fluctuations commonly encountered in industrial environments.

Input modules are characterized by their number of input channels, signal types supported, and compatibility with different sensor types and communication protocols. They play a crucial role in the overall functionality of a PLC system by enabling it to monitor and respond to changes in the external environment, thus facilitating automated control of industrial processes [4].

II.2.2.2 Central Processing Unit (CPU)

It is a microprocessor that contains the memory of the system and is also the decision-Making center of the PLC unit and performs the following Obtaining and analyzing logical signals received from the input unit make the necessary Decisions in accordance with the program's memory-stored instructions. Issuing control Commands to the output unit in accordance with the program instructions stored in memory, And the CPU unit carries out a variety of tasks such timing counting, data comparison, Sequential operations, and displacement in addition to transferring the program instructions Stored in memory [4].

II.2.2.3 Memory Unit

There are two main types of memory in a PLC:

1. Random Memory RAM

Which is the memory to which data can be entered directly from any address, and data Can be written and read from this memory, which is temporary memory, meaning when power is lost, all data stored in it will be lost, for this a battery is installed to avoid data loss in the event of the main power operating it.

2. ROM

Memory from which data can be read. This memory is used to protect the data or Programs stored in it from erasure, and it is permanent memory, and this means that the data stored in it will not be lost in the event of loss of electrical energy. There are two main types of memory in a PLC: As well as the transfer of program instructions stored in memory. In the event of loss of the main power operating it. This memory is divided into two types:

The programmable and erasable read-only memory (EPROM) is a read-only memory,but data can be erased from it by exposing it to ultraviolet rays to make it ready to receive newdata, Erasable and electronically programmable read-only memory (EEPROM), It is read only,but the data stored in it can be erased[4].

II.2.2.4 Output Module

PLC output modules are integral components of a Programmable Logic Controller (PLC) system responsible for controlling external devices based on output signals generated by the PLC's central processing unit (CPU). These output signals typically drive actuators, motors, valves, or other devices to perform specific actions within an industrial process.

Output modules receive control signals from the PLC's CPU and convert them into output signals compatible with the requirements of external devices. These signals may be in the form of digital signals (on/off) or analog signals (continuous), depending on the type of device being controlled.

Similar to input modules, output modules provide isolation and protection for the PLC system against electrical noise and voltage fluctuations. They are designed to deliver reliable and precise control signals to ensure the accurate operation of external devices in various industrial applications.

Output modules are characterized by their number of output channels, the type of signals supported, and compatibility with different types of actuators and communication protocols.

They play a critical role in the automation of industrial processes by enabling the PLC system to execute control commands and interact with the physical environment effectively [4].

II.2.2.5.Interface Module (IM): This is a coupler that allows the multi-row configuration and ensures the connection between the frames and coupling between the different units.

II.2.2.6.Function module (FM): Provides heavy calculation tasks as well as special functions such as positioning, regulation, counting, and digital control….etc.

II.2.2.7.Communication processor (CP): The communication processor allows controllers to communicate with each other and facilitates human-machine connections via various interfaces of communication such as point-to-point, profibus and industrial Ethernet.

II.2.3 Criteria for choosing a PLC:

The choice of a programmable controller is first and foremost the choice of:

• **Number of inputs/outputs:** the number of cards can have an impact onThe number of racks as soon as the number of necessary inputs/outputs becomesPupil.

• **Processor type:** memory size, processing speed and functionsSpecial offers offered by the processor allow the choice in a wide range.

• **Special functions or modules:** certain cards (axis control, weighing, etc.)Make it possible to “relieve” the processor and must offer the characteristicsdesired (resolution, etc).

• **Communication functions:** the automaton must be able tocommunicate with other control systems and offer communication possibilities with standards standardized(Profibus) PROFIBUS (Process Field BUS) is an open communication system accepting devices from various manufacturers. The PROFIBUS field bus makes the connection between the automation system, peripheral modules and field devices[4].

II.2.4 Presentation of Siemens PLC

There are several SIMATIC ranges. We find the SIMATIC S7

In the S7 range there are five main families of programmable industrial controllers Described in these following paragraphs.

II.2.4.1 PLC S7-200

The S7-200 is a range of programmable logic controllers (PLCs) from Siemens designed for small to medium-sized automation tasks. Here are the maincharacteristics of the S7-200 PLC:

A-Compact Design: Space Efficiency: The S7-200 has a compact design, making it suitable for installations where space is limited. Its small size does not affect its functional capabilities.

B-Integrated Capabilities: Built-in Functions: It includes built-in inputs and outputs as well as integrated communication ports, simplifying installation and reducing the need for additional hardware.

C-Performance: Adequate Processing Power: Although less powerful than the S7-300 and S7-400 series, the S7-200 offers sufficient processing power for small to medium-sized automation tasks.

D-Communication: Communication Ports: The S7-200 includes communication ports such as RS-232 and RS-485, supporting the PPI (Point-to-Point Interface) for networking multiple S7-200 PLCs.

E-Programming and Diagnostics: STEP 7-Micro/WIN: It is programmed using the STEP 7-Micro/WIN software, which is user-friendly and provides essential programming and diagnostic tools.

F-Modularity and Expandability: Expansion Options: Despite its compact size, the S7-200 can be expanded with additional input/output modules and specialized function modules, such as analog I/O modules, positioning modules, and communication modules.

G-Memory: Adequate Memory: The S7-200 has enough memory to handle programs and data for typical small to medium-sized automation projects.

H-Speed: Fast Execution: It provides fast instruction execution times, ensuring efficient processing of control tasks[5].Figure □.1.

FigureII.1: PLC S7-200.

II.2.4.2 PLC S7-300

The S7-300 is a range of programmable logic controllers (PLCs) from Siemens designed for a wide variety of automation tasks in industrial environments. Here are the main features and characteristics of the S7-300 PLC:

A-Performance: Processing Power: The S7-300 provides robust processing capabilities suitable for medium to large automation tasks. It offers a range of CPUs with different performance levels to match application needs.

B-Fast Response Time: Capable of fast response times, making it suitable for time-critical applications.

C-Communication: Integrated Communication: Supports multiple communication protocols, including MPI (Multi-Point Interface), PROFIBUS, and Industrial Ethernet, for seamless integration into various industrial networks.

Communication Modules: Additional communication processors are available for expanded networking capabilities, supporting protocols like AS-Interface, CAN, and DeviceNet.

D-Programming and Diagnostics: STEP 7 Software: Programmed using Siemens' STEP 7 software, which provides a comprehensive suite of programming, configuration, and diagnostic tools.

User-Friendly Interface: The software includes an intuitive user interface, making it easier to develop, test, and troubleshoot control programs.[5] Figure. □ .2.

Figure□.2: PLC S7-300.

II. 2.4.3PLC S7-400

The S7-400 is a family of programmable logic controllers (PLCs) from Siemens, used primarily in complex industrial automation applications. Here are the main characteristics of the PLC S7-400:

A-Modular architecture: The S7-400 is designed with a modular architecture, which allows for high flexibility and expandability. Modules can be added or replaced without affecting the entire system.

B-High performance: It offers high performance in terms of processing speed and memory capacity, making it suitable for demanding applications requiring rapid data processing and high reliability..

C-Communication: The S7-400 supports a wide range of communications protocols, including Profibus, Profinet, Industrial Ethernet, and others, facilitating integration into complex industrial networks.

D-Multiple interfaces: It has multiple interfaces for connecting devices and networks, including MPI (Multi-Point Interface), Profibus DP, and Ethernet interfaces for communicating with other devices and systems.

E-Processing capacity: The S7-400 can handle many tasks in parallel, thanks to its powerful processors and multitasking capabilities. This enables efficient management of complex processes.

F-Programming and diagnostics: The S7-400 is programmed using SIMATIC STEP 7 software, which offers advanced programming tools as well as diagnostic and debugging capabilities.

G-Expansion modules: There are a variety of expansion modules available for the S7-400, including input/output modules, communications modules, and special function modules for specific applications [5].FigureII.3.

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FigureII.3: PLC S7-400.

II. 2.4.4 PLC S7-1200

The S7-1200 is a range of programmable logic controllers (PLCs) from Siemens designed for small to medium-sized automation tasks. Here are the main features and characteristics of the S7-1200 PLC:

A-Compact Design: Space Efficiency: The S7-1200 has a compact design, making it suitable for installations where space is limited. Its small footprint is ideal for tight spaces without compromising functionality.

B-Integrated Capabilities: Built-in I/O: It includes integrated digital and analog inputs and outputs, which simplifies the design and reduces the need for additional I/O modules.

Communication Ports: Integrated PROFINET interface for communication with HMI devices, other controllers, and SCADA systems.

C-Performance: Processing Power: The S7-1200 offers a powerful CPU with various performance levels, making it suitable for a wide range of automation tasks, from simple control tasks to more complex applications.

D-Communication:

1-PROFINET: Integrated PROFINET interface for real-time communication with other devices.

2-Additional Protocols: Supports Modbus TCP/IP, and can be expanded with communication modules for other protocols like PROFIBUS, AS-Interface, and others.

E-Programming and Diagnostics:

1-TIA Portal: Programmed using Siemens' TIA (Totally Integrated Automation) Portal software, which provides advanced programming, diagnostics, and simulation tools. The software supports ladder logic, function block diagrams, and structured text programming languages.

2-Web Server: Integrated web server for remote diagnostics and monitoring.

F-Modularity and Expandability:

Expansion Modules: The S7-1200 can be expanded with a wide variety of signal modules, communication modules, and technology modules (for tasks such as high-speed counting, positioning, and more).

Flexibility: This modular approach allows customization and scalability based on specific application requirements.

G-Memory: Sufficient Memory: The S7-1200 offers ample memory for user programs and data, supporting complex automation tasks and data-intensive applications.

H-Speed: Fast Processing: Provides fast execution times, ensuring efficient and timely processing of automation tasks [5].Figure Ⅱ.4

FigureII.4: PLC S7-1200.

II.2.4.5 PLC S7-1500

The S7-1500 is a range of advanced programmable logic controllers (PLCs) from Siemens, designed for high-performance industrial automation applications. Here are the main features and characteristics of the S7-1500 PLCFigureⅡ .5:

A-High Performance:

Processing Speed: The S7-1500 offers very high processing speeds, with fast instruction execution times, making it suitable for complex and time-critical automation tasks.

High Data Throughput: Supports high-speed data processing and communication, ensuring efficient performance in demanding applications.

B-Integrated System Functions: Web Server Integrated web server for remote diagnostics and monitoring, accessible through standard web browsers.

Data Logging: Built-in data logging capabilities for recording process data and events.

Trace Function: Advanced trace functionality for real-time analysis and debugging of control programs.

C-Modular and Scalable:

Flexible Configuration: Modular design allows flexible configuration and scalability, with a wide range of CPUs, I/O modules, and communication modules to choose from.

Seamless Integration: Easily integrates with other Siemens automation components and systems within the TIA (Totally Integrated Automation) framework.

D-Communication:

Profinet and Profibus: Supports Profinet and Profibus communication protocols for seamless integration with field devices and other automation systems.

Multi-Protocol Support: Can communicate using various protocols, including Ethernet/IP, Modbus TCP/IP, and OPC UA, enhancing interoperability with third-party devices and systems.

E-Advanced Diagnostics:

System Diagnostics: Comprehensive system diagnostics with detailed error messages and status information, accessible via the TIA Portal and the integrated web server.

User-Friendly Interface: Intuitive diagnostics interface within the TIA Portal simplifies troubleshooting and maintenance.

F-Security: Built-in Security Features Includes robust security features such as access protection, encrypted communication, and secure user authentication to safeguard against unauthorized access and cyber threats.

G-Motion Control:

Integrated Motion Control: Advanced motion control capabilities for applications involving positioning, speed control, and synchronization of multiple axes.

Redundancy and High Availability:

Redundant Configurations: Supports redundant configurations to ensure high availability and reliability in critical applications.

Fault Tolerance: Designed to maintain operation and recover quickly from hardware or software failures.

H-Safety Integrated: Safety functions are integrated into certain models, allowing for the control of safety-related applications compliant with international safety standards (e.g., SIL and PL).

I-Memory and Storage:

High Capacity Memory: Offers substantial program and data memory to handle large and complex automation tasks.

Retentive Memory: Retentive memory areas for storing critical data that must be preserved during power cycles.

J-User-Friendly Programming:

TIA Portal: Programmed using the TIA Portal software, which provides an integrated environment for programming, configuration, and diagnostics with user-friendly tools and interfaces.

Programming Languages: Supports multiple programming languages, including ladder logic, function block diagram, structured text, and SCL (Structured Control Language) [5].

FigureII.5: PLC S7-1500.

II.2.5 Description of the Components of a SIMATIC S7-300 PLC

The SIMATIC S7-300 from Siemens is an industrial programmable logic controller (PLC) used to automate industrial processes. Its modular design allows for great flexibility and scalability, making it a popular choice for many industrial applications. Here is a description of the main components of the S7-300:

II.2.5.1Central Processing Unit (CPU)

Processor: The core of the PLC, where the control program execution takes place. It processes instructions from the program and manages data exchanges between different modules.

Memory: The CPU contains several types of memory:

RAM: For temporary storage of data being processed.

ROM: Contains the firmware and system program.

Flash Memory: For permanent storage of the user program.

Communication: CPUs may include integrated communication interfaces such as MPI (Multi-Point Interface), Profibus, and Ethernet for communication with other devices and systems.

II.2.5.2Input/output (I/O) Modules

Digital Input Modules: Capture signals from various sensors and switches. Convert these signals into data that the CPU can process.

Digital Output Modules: Convert control signals from the CPU into physical actions, such as turning on lights or actuating relays.

Analog Input Modules: Measure analog signals from sensors (such as temperatures, pressures) and convert them into digital data.

Analog Output Modules: Convert digital data from the CPU into analog signals to control devices like frequency converters.

II.2.5.3 Communication Modules

Function: Facilitate communication between the CPU and other devices or control systems. They support various industrial communication protocols.

Types of Modules:

Profibus: For communication with field devices.

Profinet: For real-time communication over industrial Ethernet networks.

MPI: Primarily used for communication between multiple Siemens PLCs and HMI devices.

II.2.5.4 Special Function Modules

High-Speed Counter Modules: For applications requiring precise counting such as encoders.

Positioning Modules: For controlling servo motors and other precise positioning systems.

PID Modules: For process control applications (temperature, flow, pressure, etc.).

II.2.5.5 Power Supply

Function: Provides the necessary power for the CPU and I/O modules.

Types: Different power supply modules are available to suit installation needs (24V DC, 230V AC, etc.).

II.2.5.6 Chassis or Rack

Function: Physical support for the S7-300 modules, ensuring their electrical connection and internal communication via the backplane bus.

Extension: Allows for the addition of more modules to expand the system's capabilities.

II.2.5.7 Expansion Modules

Function: Enable additional capabilities to the base system by adding more I/O modules, extra communication interfaces, or special function modules.

Connection: Modules are connected to the CPU via bus cables or special connectors[6].

II.2.6Advantages of PLC S7-300

A compact and modular construction, free from configuration constraints. A rich range of modules adapted to all market needs and usable in centralized or decentralized architecture, which greatly reduces t1he stock of parts spare. A wide range of CPUs adapted to all performance demands forbeing able to obtain a short machine cycle time, some being equipped with functions integrated technologies such as counting, regulation or positioning.

Engineering savings using application-oriented and standardized IEC 1131- tools3 such as advanced SCL languages or technology-oriented executive software for movement control.

II.2.7Programming languages:

In the context of programmable logic controllers (PLCs), several programming languages are commonly used to create control logic and automation sequences. These languages are tailored to the needs of industrial automation and vary in their syntax, structure, and application. Here are the main programming languages used in PLC programming:

II.2.7.1 Ladder Logic (LAD/LD):

-Ladder Logic is one of the most widely used programming languages in PLCs.

-It uses graphical symbols to represent logical and arithmetic operations, similar to relay logic diagrams.

-Ladder Logic is particularly intuitive for electricians and technicians familiar with traditional relay-based control systems.

II.2.7.2 Function Block Diagram (FBD):

-Function Block Diagram is a graphical programming language that represents control logic as a network of interconnected function blocks.

-Function blocks encapsulate specific functions or operations, such as timers, counters, mathematical operations, and input/output (I/O) functions.

-FBD is often used for complex control algorithms and modular programming.

II.2.7.3 Structured Text (SCL):

-Structured Text is a high-level programming language based on structured programming concepts.

-It resembles traditional programming languages like Pascal or C, using textual syntax with structured constructs such as loops, conditional statements, and functions.

-ST offers more flexibility and expressiveness compared to graphical languages like Ladder Logic and FBD, making it suitable for complex algorithms and mathematical operations.

II.2.7.4 Sequential Function Chart (SFC):

-Sequential Function Chart is a graphical programming language used to represent sequential control logic.

-It consists of steps, transitions, and actions organized in a structured manner to model the sequential behaviour of a process or machine.

-SFC is particularly useful for defining complex sequences of operations with well-defined states and transitions.

II.2.7.5 Instruction List (IL):

-Instruction List is a low-level programming language similar to assembly language.

-It uses mnemonic instructions to represent basic operations such as logic, arithmetic, and data manipulation.

-IL is rarely used directly by programmers but is generated by some programming environments from higher-level languages for optimization purposes[6].

II.2.8 Programming software:

Siemens offers several programming software options for its programmable logic controllers (PLCs), each with its own features and capabilities. Here's an overview of some of the key programming software offered by Siemens:

II.2.8.1 STEP 7 (TIA Portal):

STEP 7 is the primary programming software for Siemens PLCs, part of the Totally Integrated Automation (TIA) Portal engineering framework.

Features: It provides a comprehensive suite of tools for PLC programming, configuration, simulation, and diagnostics.

Programming Languages: Supports multiple programming languages including ladder logic (LAD), function block diagram (FBD), structured text (ST), and sequential function chart (SFC).

Integration: Integrates seamlessly with other TIA Portal software components for HMI (Human Machine Interface) design, motion control, and drive configuration.

Compatibility: Supports a wide range of Siemens PLC families including S7-1200, S7-1500, S7-300, and S7-400.

II.2.8.2STEP 7 Micro/WIN:

STEP 7 Micro/WIN is lightweight programming software primarily used for Siemens S7-200 PLCs.

Features: It offers essential programming and configuration tools in a user-friendly interface, suitable for small to medium-scale automation projects.

Programming Languages: Supports ladder logic (LAD) programming language.

Ease of Use: Designed for ease of use, with simple drag-and-drop programming and configuration features.

II.2.8.3SIMATIC Manager:

SIMATIC Manager is the legacy programming software used for Siemens S7-300 and S7-400 PLCs.

Features: Provides programming, configuration, and diagnostic capabilities for S7-300 and S7-400 PLCs.

Programming Languages: Supports ladder logic (LAD), function block diagram (FBD), and structured text (ST) programming languages.

Integration: Integrates with other Siemens engineering tools for system configuration and visualization.

II.2.8.4WinCC (TIA Portal):

WinCC is Siemens' HMI (Human Machine Interface) software, part of the TIA Portal engineering framework.

Features: Offers powerful tools for designing, configuring, and monitoring HMI applications.

Integration: Integrates seamlessly with STEP 7 for PLC programming, allowing for unified project engineering.

Visualization: Supports dynamic graphics, alarms, trends, and data logging for advanced visualization of industrial processes.

II .2.9.Presentation of the softwareTIA portal:

The TIA Portal (Totally Integrated Automation Portal) development platform Siemens enables significant time savings when developing systems automation.

It is an all-in-one platform featuring Step 7 software for programming Of PLCs and WinCCFlexible for human-machine interfaces. This platform is very architected offering HMI sections for interfaces, networks and Motion for control of motors and variators. Thanks to PLCSim, we can intuitively simulateour project before deploying it on a controller.

A. Characteristic:

The TIA portal software allows you to have:

• Programming a PLC,

• Several programming languages,

• Easy-to-use documentation.

B. Type of blocks:

TIA portal offers the following user blocks for structured programming:

➢ Organization block (OB):

The organization blocks constitute the interface between the operating system and theuser program. They are called by the operating system for start-up or tocyclical processing of the program.

➢ Function block (FB):

The FB is a block with memory. An instance data block is associated with eachcall from FB. The parameters transmitted to the FB, as well as the static variables aresaved in the instance data block.

➢ Function (FC):

A function is a block of code without memory. Temporary variables of a functionare saved in the local data stack. This data is lostthe completion of the function.

➢ Data block (DB):

Data blocks are blocks used by blocks of code in your program user to save values. There are two categories of data blocks:

• **Global DBs:** where all OBs, FBs and FCs can read data recorded and write data to the BD themselves.

• **DB instances:** are assigned to a defined FB [7].

II.2.9.1.Portal view and project view

When you launch TIA Portal, the working environment is divided into two types of view

- The portal view: focused on the tasks to be performed and is very quick to use.

- The project view: includes a tree structure with the different elements of the project. Required editors open according to the tasks to be carried out. Data, settings and editors can be viewed inone and the same view.

II. 2.9.2 Portal view

Each portal allows you to process a category of task (actions).

The window displays the list of actions that can be performed for the selected task.

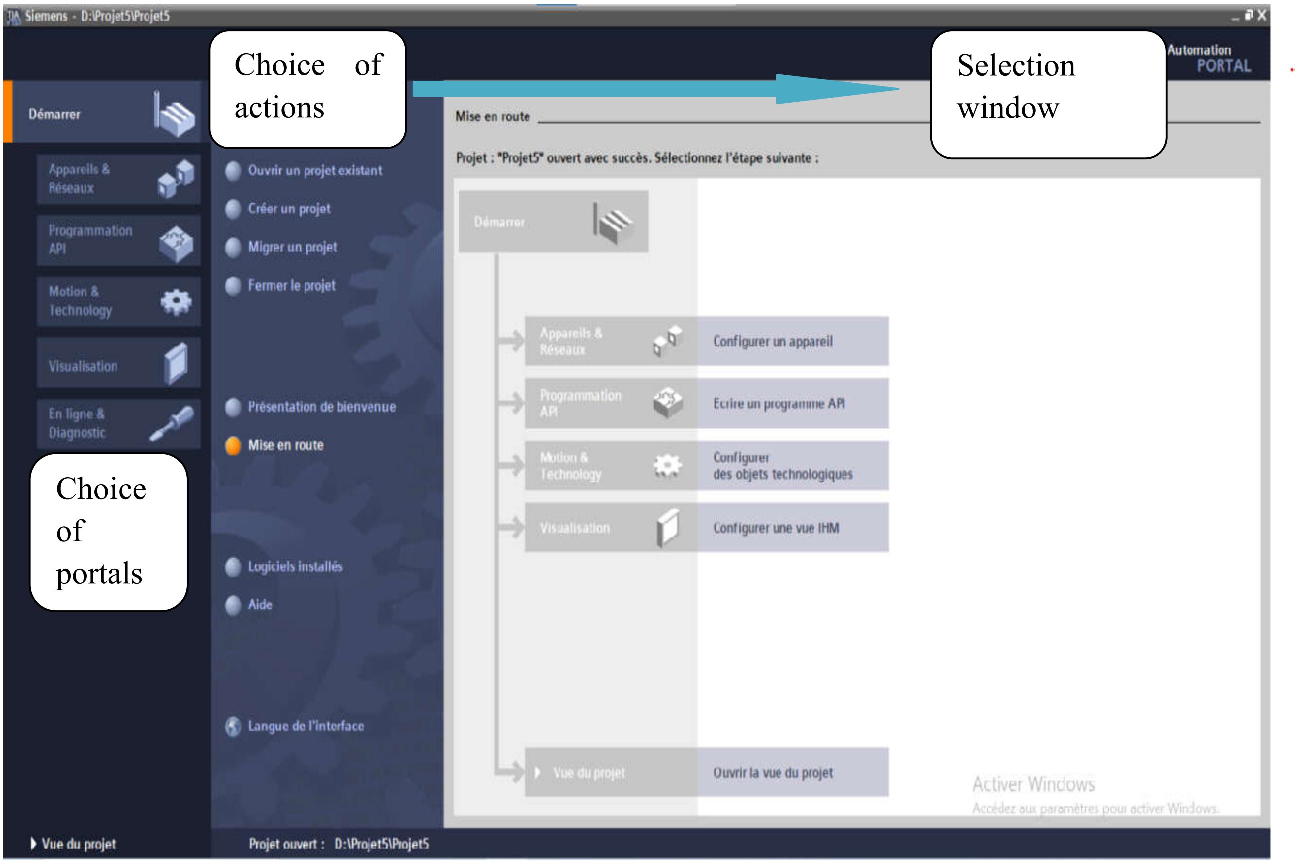


Figure II.6: View of the portal.

The "Project" element contains all the elements and data necessary to implement the desired automation solution.

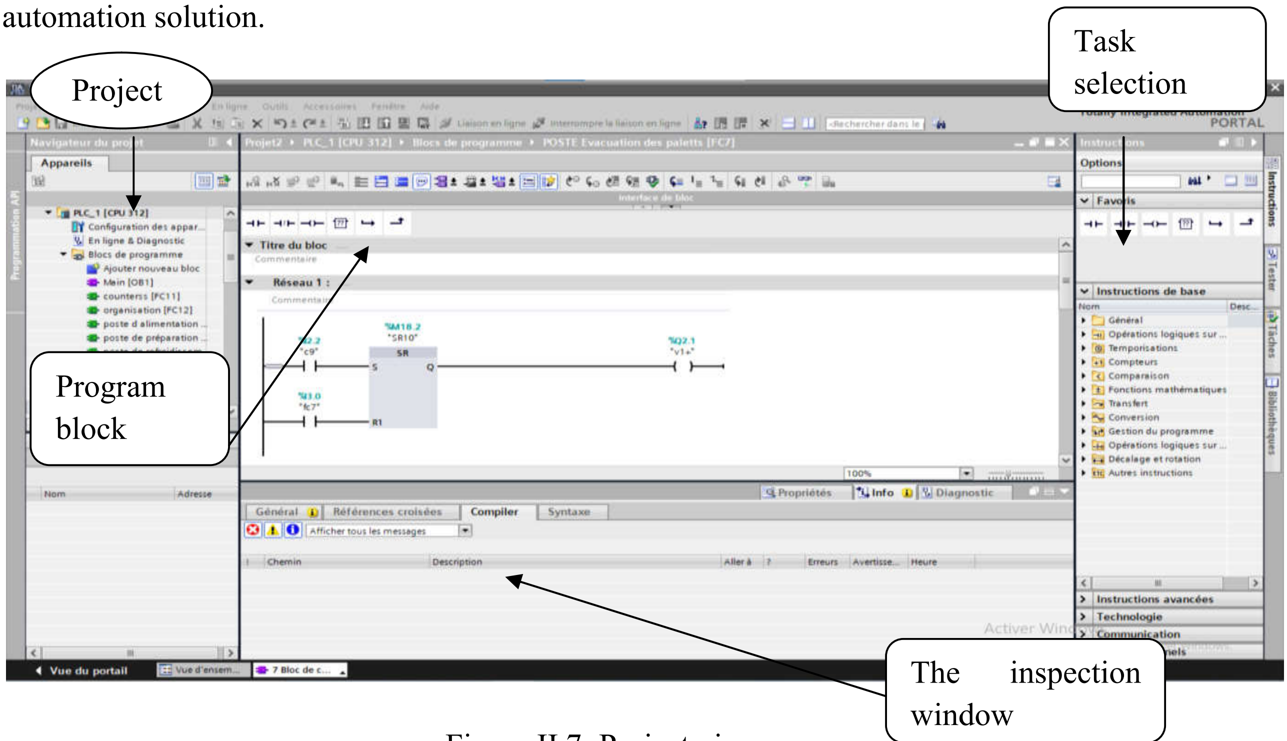


Figure II.7: Project view.

• **The working window:** allows you to view the objects selected in the project toBe treated. These may include hardware components, program blocks, tables of variables, HMI, ..

• **The inspection window:** Allow you to view additional information on selected object or on the actions currently being executed (hardware property selected, error message when compiling program blocks, etc.)

• **Task selection tabs:** have content that varies depending on the subject selected (hardware configuration, component libraries, block of program, programming instruction).

This work environment contains a lot of data. It is possible to hide or minimize some of these windows when you don't have them. It is also possible to resize, reorganize, undock the different Windows.

II.3.1 Definition of industrial supervision:

Supervision is an evolved form of Human-Machine dialogue. She presents several advantages for industrial production processes. It facilitates the operator monitoring the operating state of a process as well as its Remote control.

It allows, thanks to views created and configured beforehand using WINCC flexible 2008 supervision software, to integrate and visualize in real time all the steps necessary for the process. It also helps detect problems which may occur during operation.

The functions of supervision are numerous, we can cite a few:

• Ensure communication between automation equipment and tools IT scheduling and production management.

• Coordinate the operation of a set of chained machines constituting a production line, ensuring the execution of common orders (start, stop, etc.) meet needs generally requiring processing power important.

• Assist the operator in diagnostic and maintenance operation [8].

II.3.2The advantages of supervision:

• Allows you to visualize the process and design the graphical interface intended for the operator.

• Allows the operator to monitor the process. To do this, the process is visualized by a graphic on the screen. As soon as a state of the process evolves, the display is updated.

• Allows the operator to control the process.

• When a process state becomes critical, an alarm is triggered automatically. The screen displays an alarm if a threshold is crossed defined.

• Alarms and process values can be printed out and archived on electronic media. This makes it possible to document the progress of the process and to have future access to past production data.

• Ensure communication between automation equipment and tools IT scheduling and production management.

• Coordinate the operation of a set of chained machines constituting a production line, ensuring the execution of common orders (walking, stop,...etc.)

• meet needs generally requiring processing power important.

• Assist the operator in diagnostic and maintenance operations[8].

II. 3.1Creation of a supervision system:

Most supervision systems consist of a central engine (software), to which data from the equipment (PLC) is attached.

The supervision software ensures the display, data processing, archiving and communication with other devices. Viewing modules:

It makes it possible to obtain and make available to operators the elements evaluation of the process by its volumes of instantaneous data.

A-Archiving modules:

It stores data (alarms and events) for a long time and it allows the exploitation of data for specific applications for the purposes of maintenance or production management.

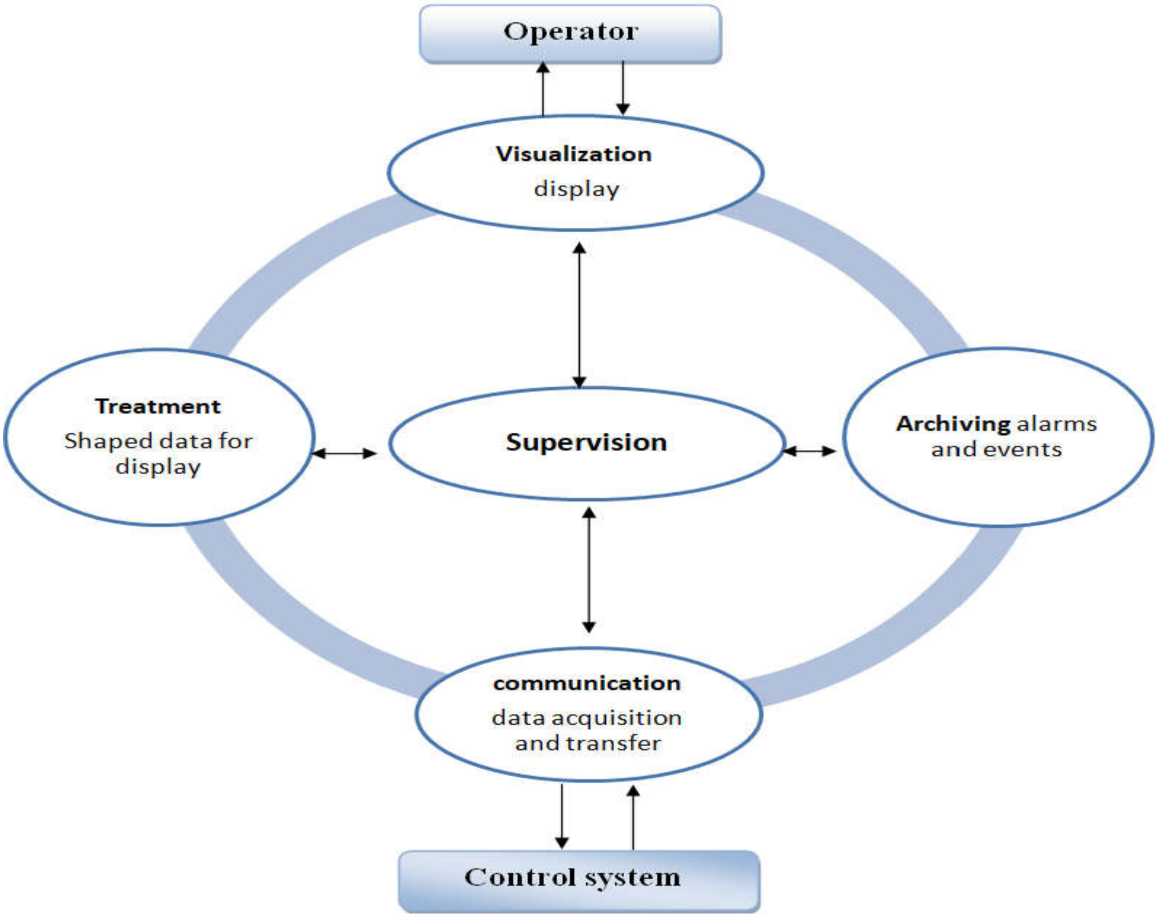
B-Processing modules:

It allows you to format the data in order to present it via the module. Visualization to operators in a predefined form.

C-Communication module:

Ensures the acquisition and transfer of data and manages communication with industrial programmable logic controllers and other peripherals.

The following figure represents the different constituents of a supervision system.



FigureII .8: Constituents of a supervision system.

II.3.2Structure of a supervision system:

In order to achieve communication between a PLC and a PC, exchange mechanisms have been developed in this sense to ensure the acquisition and data transfer between the supervision PC and a programmable controller.

The supervision PC exchanges data through the PLC which manages the entire process. A supervision network is often made up of:

•PC used as an operator station, allows data acquisition, display of synoptic and management of the unit.

•PC as an engineer station, dedicated to system administration and configuration of the application.

•Industrial Ethernet type acquisition network, connecting operator stations to the automaton [8].

II.4 Conclusion

In this chapter, we presented an overview of the automaton industrial programmable that we adopted to control our system, as well as its TIA portal programming software and supervision.

The SIMATIC S7-300 modular programmable controller is the basic element of the control system that directly controls manufacturing processes. He replaces advantageously hardwired logic systems in most applications industrial.

The following section of our note will explain about our project and how we use these programs after we have explained and listed the programs that we used to create it, arranged them sequentially, and addressed some special information about them. We then explain the project's practical component.

ChapiterIII:

Realisation part

III.1 Introduction

In this chapter, we focus on programming and monitoring the palletizer system using Siemens automation technology, specifically TIA Portal V15. We begin by examining the specifications of each station, laying the foundation for understanding the system's specific requirements and functionalities. Next, we dive into detailed discussions on programming strategies, providing insights into methodologies and approaches used to ensure optimal system performance and functionality. Additionally, we showcase practical examples of these strategies through selected program extracts from various stations. We also describe the realization process of deploying this system in real-world applications. Finally, we conclude by presenting the results achieved from implementing the palletizer system and outlining our future development and advancement goals.

III.2 Stations Specifications

In these points, we will explain in detail how each station works from a technical standpoint and the components of each station. The entire system operates when we press the Start button and stops when we press the Stop button. The addresses of these buttons are mentioned in (Table III.1).

item	Input/output	address	Description
Start	Input	I1.2	Turn on the system
Stop	Input	I2.6	Turn off the system

Table III.1 : main buttons

III.2.1 Feeding station

The feeding stations consist of 4 conveyor belts (T1, T2, T3, and T4) and a vibrator, all these components (Table III.2) are activated by pressing the "Start" button.T1 stops when the "Stop" button is pressed or when bags are simultaneously detected by detectors C1 and C2. Subsequently, T2, T3, and the vibrator stop when the "Stop" button is clicked. Additionally, T4 stops either by pressing the "Stop" button or when the push actuator is activated during its operation.The addresses of these buttons are mentioned in (Table III.2).

item	Input/output	Address	Description
T1	Output	Q2.5	Electric motor transmits movement for T1
T2	Output	Q2.6	Electric motor transmits movement for T2
T3	Output	Q2.7	Electric motor transmits movement for T3
T4	Output	Q3.0	Electric motor transmits movement for T4
Vibrator	Output	Q3.1	Electric motor generate movement for Vibrator
C1	Input	I1.4	The bag is at the entrance of T1
C2	input	I1.5	The bag is at the entrance T2

Table III.2: Feeding Station components

III 2.2 organization station

The organizing stations allow organizing bags in a specific form and consist of Orientation cylinder 1, Orientation cylinder 2, Push cylinders (Single-Acting), along with detectors C3, C4, C5, C6, C7, C8, C9, and FC5. Initially, after receiving the number of layers as a reference in HMI, during odd-numbered layers (Figure III.1), three horizontal bags are prepared without any intervention from the Orientation cylinders. The bags pass over the obstacle and trigger detector C4, which counts the horizontal bags.Subsequently, the bags proceed to 'Preparation Table 1', where detectors C6, C7, and C8 detect their presence. The Push cylinder extends to C9 to evacuate Preparation Table 1 after preparing three horizontal bags.After preparing three horizontal bags, Orientation cylinder 1 extends to prepare a line of two vertical bags. It retracts once the two bags touch C5, allowing them to move to 'Preparation Table 1'. This cycle repeats for each detection of bags in Preparation Table 1.When both lines of layers are prepared, FC5 detects the presence of a complete layer at 'Preparation Table 2'.

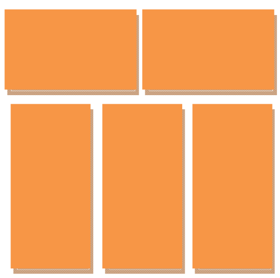


Figure III.1: odd layer form

During even-numbered layers(Figure III.2), the process starts with two vertical bags. Orientation Unit 1 extends upon detecting bags through C3 and prepares two vertical bags, which are counted by detectors C5 before retracting.After the bags are evacuated by the Push cylinder, the process repeats for the three horizontal bags, similar to the odd-numbered layers (Figure III.1).

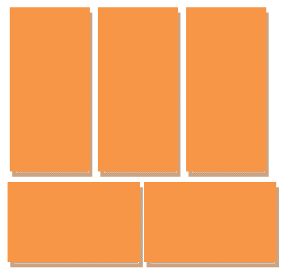


Figure III.2: even layer form

In the special layer(Figure III.3), a horizontal bag is prepared upon detection by C4. Orientation cylinder 1 extends to prepare a vertical bag upon detection by C5, while Orientation cylinder 2 extends to prepare another distant vertical bag. Both Orientation Units retract after counting three bags in the special layer, concluding the special layer with a horizontal bag.The addresses of these buttons are mentioned in (Table III.3).

Figure III.3: special layer form

Item	Input/output	Address	Description
ORI 1	Output	Q3.3	Responsiblefor horizontal bags
ORI 2	Output	Q3.4	Responsible for far horizontal bags
PUSH	Output	Q3.2	Unloading the preparation table1
C3	Input	I1.6	The bag at the entrance of orientation unit
C4	Input	I1.7	used for counting vertical bags
C5	Input	I2.0	The bags are at the exit of orientation unit
C6	Input	I2.1	The bags on the preparation table 1
C7	Input	I2.4	The bags on the preparation table 1
C8	Input	I2.5	The bags on the preparation table 1
C9	Input	I2.2	PUSH arm exit to the maximum
FC5	Input	I2.3	Attend a full layer

Table III.3: organization station components

III2.3 Evacuation stations:

The evacuation station facilitates the movement of the layer from Preparation Table 2 (upper level) to T8 (lower level) and is composed of Evacuation cylinder 1, Evacuation cylinder 2 (double-acting), and detectors FC5, FC6, FC7, FC8, and FC9 (Table III.4).

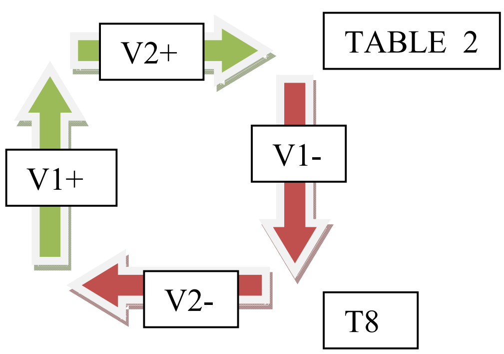


Figure III.4 : evacuation path

After detecting the presence of a complete layer at Preparation Table 2 by FC5, Evacuation cylinder 1 extends up to FC7. Subsequently, Evacuation cylinder 2 extends up to FC9. Afterward, Evacuation cylinder 1 retracts until FC6, followed by Evacuation cylinder 2 retracting until FC8. This sequence repeats for each detection by FC5.

item	Input/output	address	Dicreption
V1+	Output	Q2.1	Upward movement
V1-	Output	Q2.2	Downward movement
V2+	Output	Q2.3	Right movement
V2-	Output	Q2.4	Left movement
Fc5	Input	I2.3	Attend a full layer
Fc6	Input	I2.7	Cylinder 1 fully retract
Fc7	Input	I3.0	Cylinder 1 fully extend
Fc8	Input	I3.1	Cylinder 2 fully extand
Fc9	Input	I3.2	Cylinder 2 fully retract

Table III4 : Evacuation station components

III 2.4preparation station:

The preparation station consists of conveyor belts T8 and T9, and detectors P1 and D17. When the layer count matches the reference number, and Fc8 detects it, conveyor belt T8 moves until pallet presence is detected by P1. Then, conveyor belt T9 starts operating. Both T8 and T9 stop when detected by D17 at the packing station.

item	Input/output	address	Description
T8	Output	Q0.0	Electric motor transmits movement for T8
T9	Output	Q0.1	Electric motor transmits movement for T9
P1	Input	I0.0	Pallet at T9
D17	Input	I0.1	Pallet at packing station

Table III.5 : preparation station components

III 2.5 Packing station:

The packaging station is responsible for packaging pallets in preparation for the next phase. The single-acting cylinder "VER" starts in the up position when idle. When the pallet reaches conveyor belt "T9" and sensor "D17" detects its presence, conveyor belt "T9" stops. The VER cylinder then lowers until the packaging process is finished, as indicated by "FC1". If the packaging bag detector D18 is active during this time, the cylinder remains in the down position for 3 seconds to perform the welding operation "SUD". Afterwards, conveyor belts T10 and T9 start simultaneously upon the front door of the next station opening.

item	Output/input	address	Description
VER	Output	Q0.2	Packing cylinder
SUD	Output	Q0.3	Welder
Fc1	Input	I0.4	Cylinder VER fully extend
D18	Input	I0.2	Presence of packing bags

Tabel III.6 : Packing station components

III 2.6 Heating station :

The heating station is used to warm the packaging (bag) to adhere it to the pallet and prepare it for the next process. When the pallet enters the furnace via conveyor belt T10 and sensor D19 detects its presence, conveyor belts T10 and T9 stop rolling, and the front door closes. Heating begins to bring the temperature to a set value. If it doesn't reach this value, the heating process continues to operate. After 15 seconds of reaching the set value, the rear door opens, and conveyor belts T11 and T10 operate to evacuate the pallet towards the next station.

Item	Output/input	Address	Description
Front door	Output	Q0.5	The front door of the furnace
Rear door	Output	Q0.6	The rear door of the furnace
Chauff	Output	Q1.0	Heating action in The furnace
T11	Output	Q0.7	Electric motor transmits movement for T11
T10	Output	Q0.4	Electric motor transmits movement for T10
D19	Input	I0.3	Detect the presence of the pallet in the furnace
Temp capt	Input	IW4	Temperature sensor

Tabel III 7: heating station components

III 2.7 Cooling station :

The cooling station allows for the cooling of the packing bag and consists of conveyor belt T12, forming cylinder VForm, fan 'Venti', and detectors FC2 and D20.When detection D20 stops conveyor belts T10 and T11, it triggers the extension of forming cylinder 'VForm' until FC2 is detected, where it remains extended. After FC2 detection, the fans initiate cooling for 10 seconds. The forming actuator 'VForm' then retracts, and conveyor belts T12 and T11 start rolling until D21 at the next station.

Item	Output/input	Address	Description
T12	Output	Q1.3	Electric motor transmits movement for T12
Vform	Output	Q1.1	Forming cylinder
Venti	Output	Q1.2	Electric motor transmits movement for the fan
D20	Input	I0.5	Detect the presence for the pallet in the cooling station
Fc2	Input	I1.0	Cylinder VFORM fully extend

Tabel III 8 : cooling station components

III 2.8 Reversing station :

The inversion station is necessary for preparation of pallets to be evacuated by the forklift comprises SERR+, SERR-, INV+, INV-, T13, D21, D22, FC3, FC4, and pressure capture. Upon reaching detector D21, conveyor belts T11 and T12 stop rolling, and SERR+ extends until it reaches the set pressure value. Once this is achieved, INV+ starts rolling for 3 seconds until it reaches FC3. Following this, SERR- retracts until FC4 is detected. Subsequently, conveyor belts T12 and T13 begin rolling until D22 is reached. After the pallet is evacuated from the lifting area, the reverser INV- returns to its initial position.

Item	Output/input	Address	Description
SERR+	Output	Q1.4	Extending side of the double acting cylinder SERR
SERR-	Output	Q1.5	retracting side of the double acting cylinder SERR
INV+	Output	Q1.60	Electric motor transmits movement for INV+
INV-	Output	Q1.7	Electric motor transmits movement for INV-
T13	Output	Q2.0	Electric motor transmits movement for T13
Item	**Output/input**	**Address**	**Description**
D21	Input	I0.6	Detect the presence of the pallet in the reversing

			station
D22	Input	I0.7	Detect the presence of the pallet in the finish line
FC3	Input	I1.1	INV did a half lap
FC4	Input	I1.3	SERR- fully retract
PERSS CAPT	Input	IW8	pressure sensor

Tabel III 9 : Reversing station components

III.3 Palletizer Programming:

According to the title of this work, we are supposed to program the automatic operation of the palletizer by a SIEMENS-type PLC. To do this, we chose the PLC that can be found in our laboratory and it responds to our needs like the number of the inputs/outputs digital and analog. The SIMATIC S7-300 312-1AE13-0AB0 is chosen.We used LADDER as a programming language in this project because it's easy for technicians to use. Our programming strategy involved dividing the system into stations and implementing independent programming for each station using FC blocks, while ensuring consistency across stations by programming common functionalities. In the MAIN block, we integrated the call to these FC blocks and programmed other system-wide functionalities such as start and stop buttons. Additionally, we utilized FC blocks for programming counters.Here are examples from some of these blocks.

III.3.1 Main:

In this block, we will discuss the network**(**Figure III.5), responsible for turning on the entire system through a memory controlled by two buttons, Start and Stop, and a SR bascule. when the Start button is pressed, the entire system is turned on, and when the Stop button is pressed, the entire system is turned off. By changing the memory M126.4 of SR bascule, stop is NC button so it's represent differently of start button ,stop hmi is a soft button activate in hmiapplication

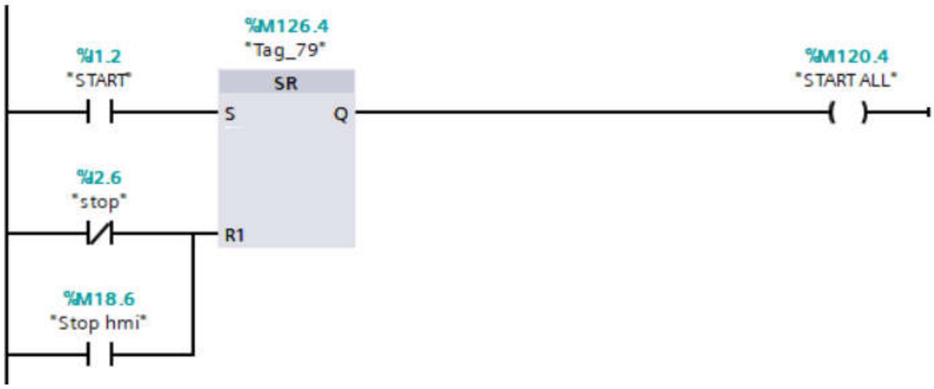


Figure III.5 : main start network

III.3.2 Counters :

In this block, we will see the network(Figure III.6), responsible for calculating vertical bags ,we have used a CTU counter with a database because we need ascending counting. C4 denotes a detector that emits an impulse signal with each detection of a vertical bag. Fc5 signifies another detector which triggers an impulse every time the system completes a layer. the Stop3 a Boolean variable that transitions to 1 once the counter reaches a count of 3

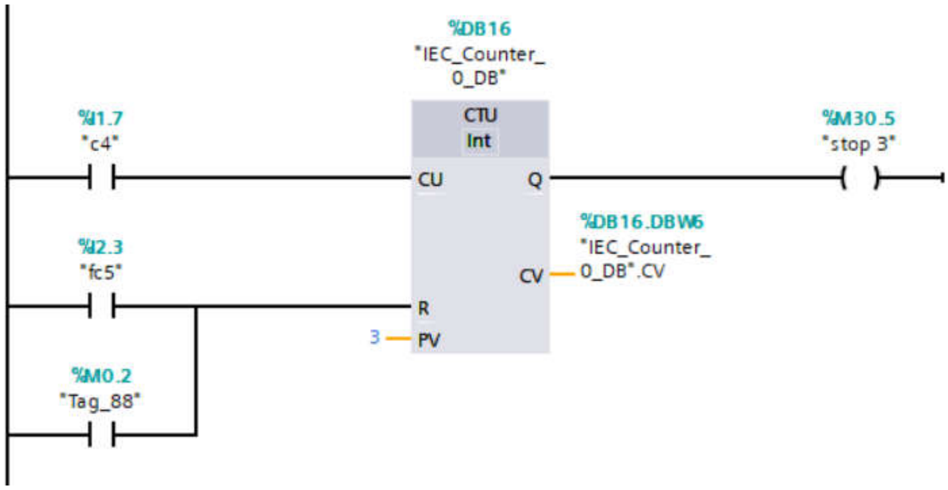


Figure III.6: counting network

III.3.2 Feeding station:

In this block, we will examine the network(Figure III.7), responsible for controlling T1, which supplies bags to the entire system. The "Start all" function sets a variable to 1 when the start button is pressed and remains active until the stop button is pressed. Meanwhile, C1 and C2 simultaneously monitor traffic at T1 and T2. Conversely, the "Stop all" function sets a variable to 1 when the stop button is pressed, and it remains active until the start button is pressed again.

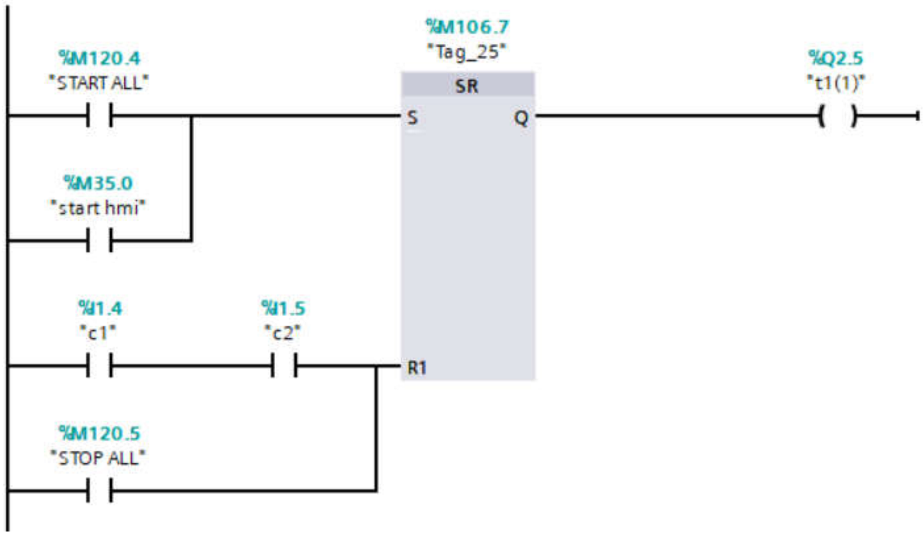


Figure III.7: feeding station T1 network

III 3.3 organizationstation:

In this block, we will see the network**(**Figure III.8), responsible for controlling ORI 2, which is responsible for routing the third bag in the special layer.Spyr.cv represents a variable that tracks the number of bags accumulated in the special layer , the Stop sp involves a Boolean variable that switches to 1 once three bags have been prepared in the special layer, signalling completion of the layer's assembly process. Urg denotes another Boolean variable that activates in urgent cases.

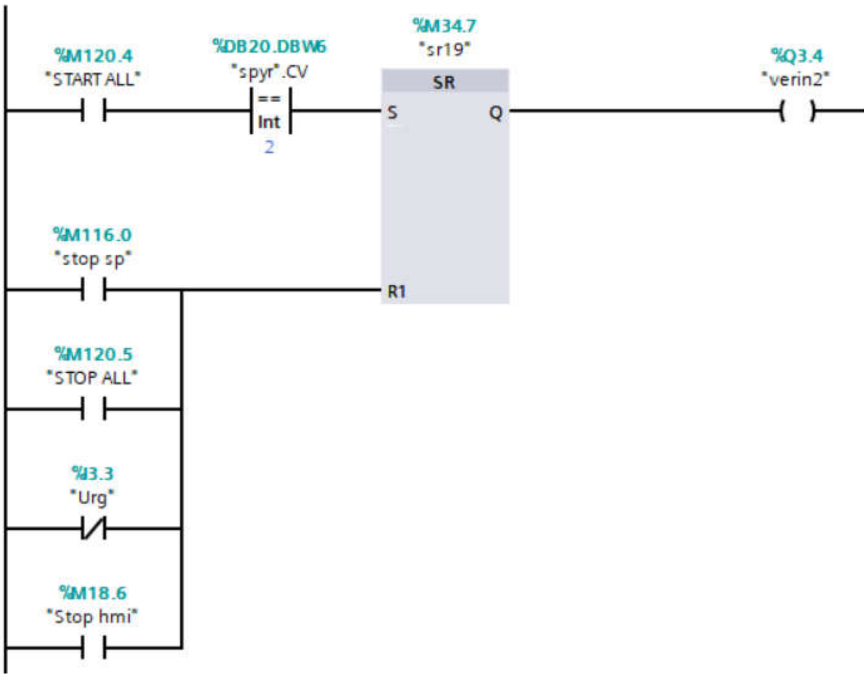


Figure III.8: organization station verin2 network

III 3.4 Heating station :

In this block, we will discuss the networkthat controls the heating action(Figure III.9), in the furnace system . D19 is an input variable that transitions to 1 upon the entry of a pallet into the furnace, Tag-69 captures the temperature value immediately after the scaling process, providing real-time data on the current operational temperature, TEMP REFF denotes the reference temperature , representing the targeted temperature level for the system's operations.

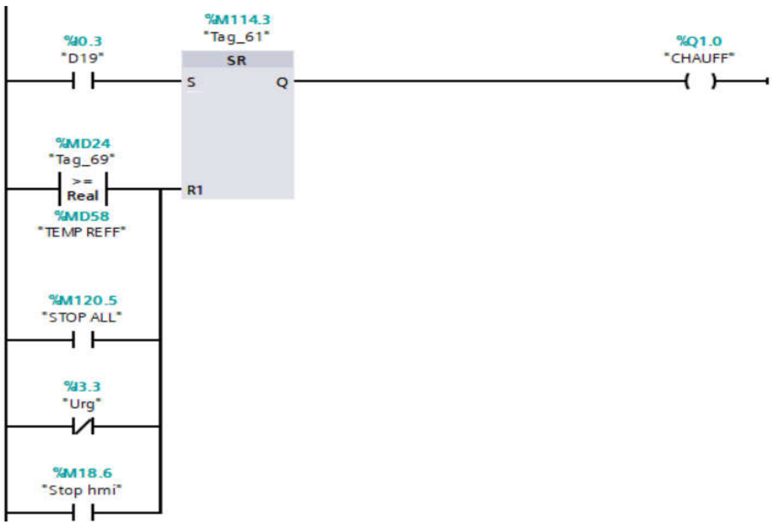


Figure III.9: heating station chauf network

III 3.5 Cooling station :

In this block, we will see the network responsible for controlling VFORM(Figure III.10), which is responsible for correcting the shape of the pallets. D20 is an input variable that switches to 1 upon a pallet entering the cooling station, Tag-74 is a Boolean variable that toggles to 1 with every falling edge of VENTI,

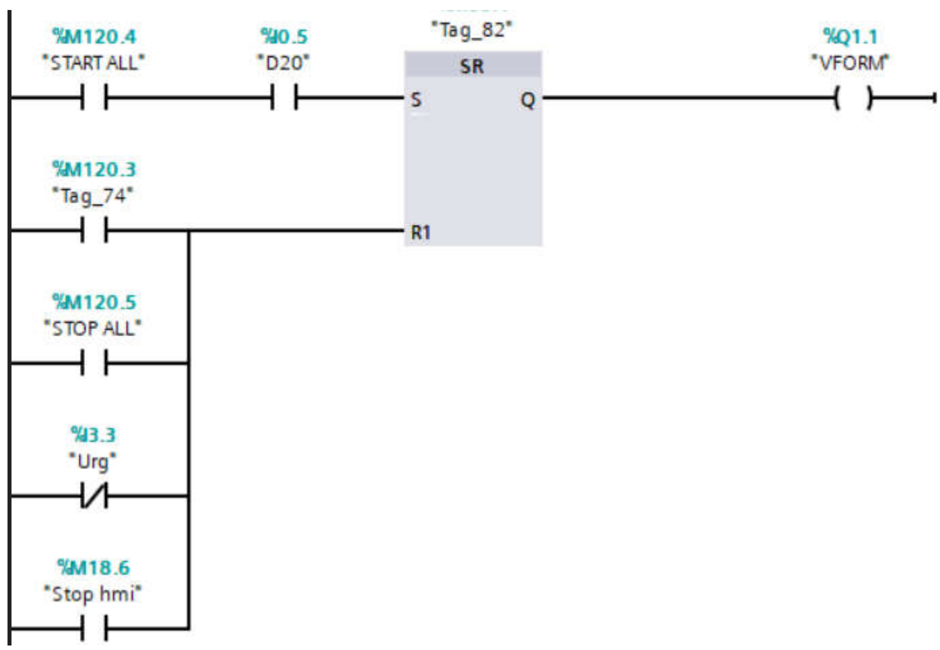


Figure III.10 : cooling station VFORM network

III 3.6Reversingstation:

In this block, we will see the network responsible for controlling the serr+(Figure III.11), which is responsible for pressing the pallets individually according to theirset value before reversing them.D21 operates as an input variable that transitions to 1 upon a pallet entering the reversing station, 'Press' captures the pressure value immediately after scaling, providing real-time data on the current operational pressure. Additionally, 'Press reff' denotes the reference pressure, representing the targeted pressure level for the system's operations.

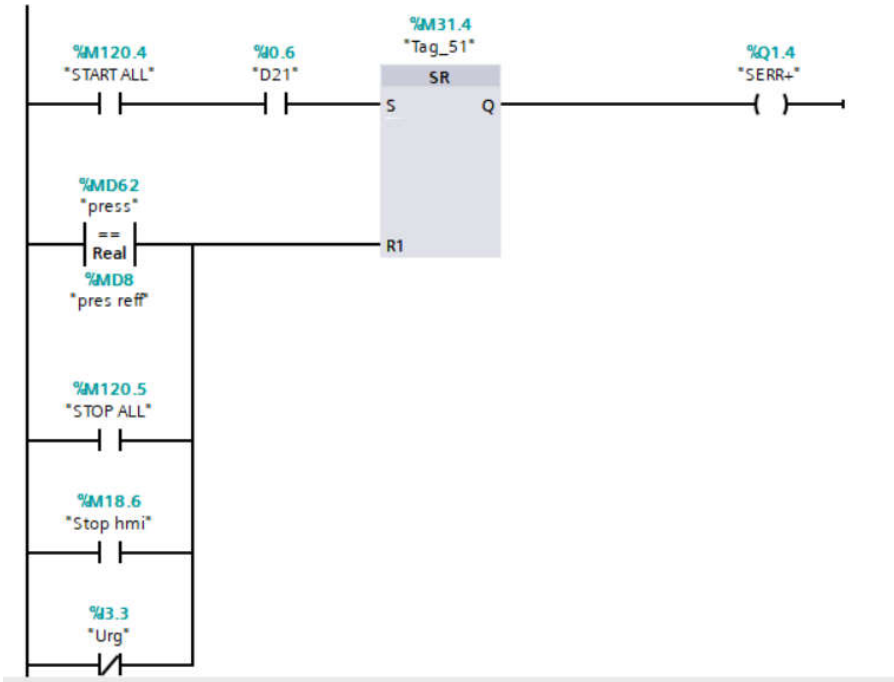


Figure III.11: reversing station SERR+ network

After the representation of some programme network ,we build a monitoring system in order to controland supervised the palitizer in real time

III.4 Monitoring of our system in WinCC TIA PORTAL V15 :

To ensure the smooth operation of this system, we have attached an HMI interface to facilitate system monitoring and the communication with the system. This interface can provide information to the user about the status of outputs and inputs, and also allows the user to provide reference set information to the system through the interface, the steps of building of this interface are shown in details on the appendix here we focus onlyin the functionalities

III.4.1 The different views of our control panel :

In this interface, we have used three views, the home view, first phase view, and second phase view

- **Home view :** It's a project presentation view(Figure III.12) , it allows access to navigate between the different views developed in this supervision solution through a set of buttons configured on it. By clicking on each button, we'll have access to the corresponding view.

Figure III.12: home view

- **First phase view :**In this view, we encounter the schematic diagram depicting of the first part of the system(figure III.13), accompanied by a panel designated for in putting reference information such as temperature , pressure, and the quantity of layers intended for processing

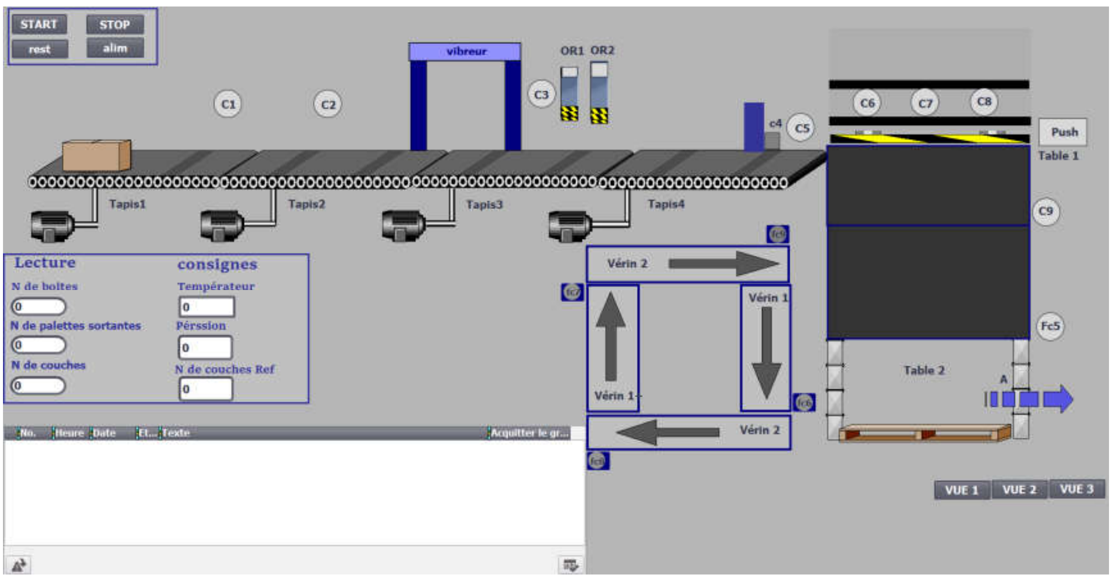


Figure III.13: first phase view

- **Second phase view:**in this view we find the schematic representation of part two(Figure III.14), and some gadgets to show the real values of temperature, pressure in real time.

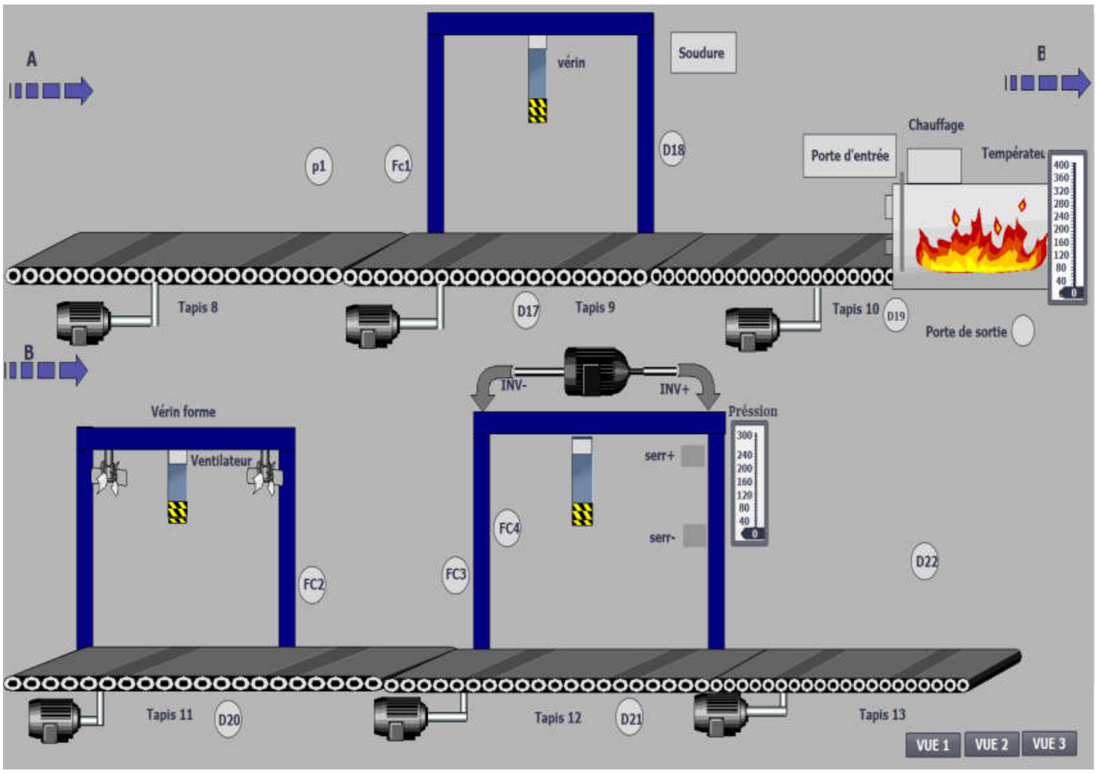


Figure III.14: second phase view

III.5Implementation session:

Our project consists of three main components: the SIEMENS PLC found in our laboratory, the monitoring screen, and the platform used to represent the real factory (Figure III.15).

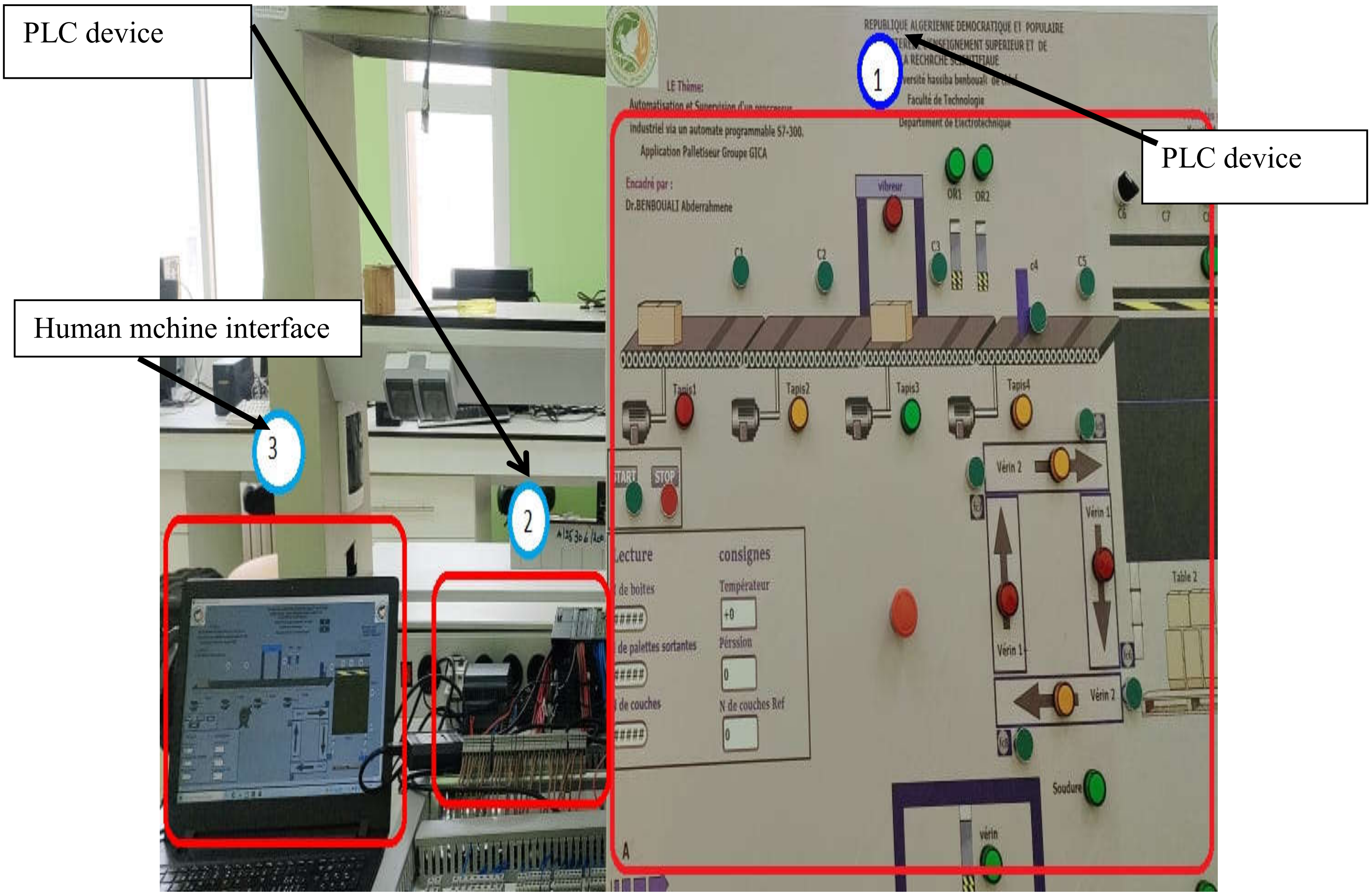


Figure III.15: project realisation

III.5.1 Palitizersystem:

In the process of creating this system(Figure III.16), we followed some strategies to implement it. We used lamps to indicate the status of the outputs instead of the ones commonly used in the factory. Additionally, we used push buttons instead of end-of-stroke sensors, and switches for proximity sensors. As for analogical sensors, we utilized variable resistors.

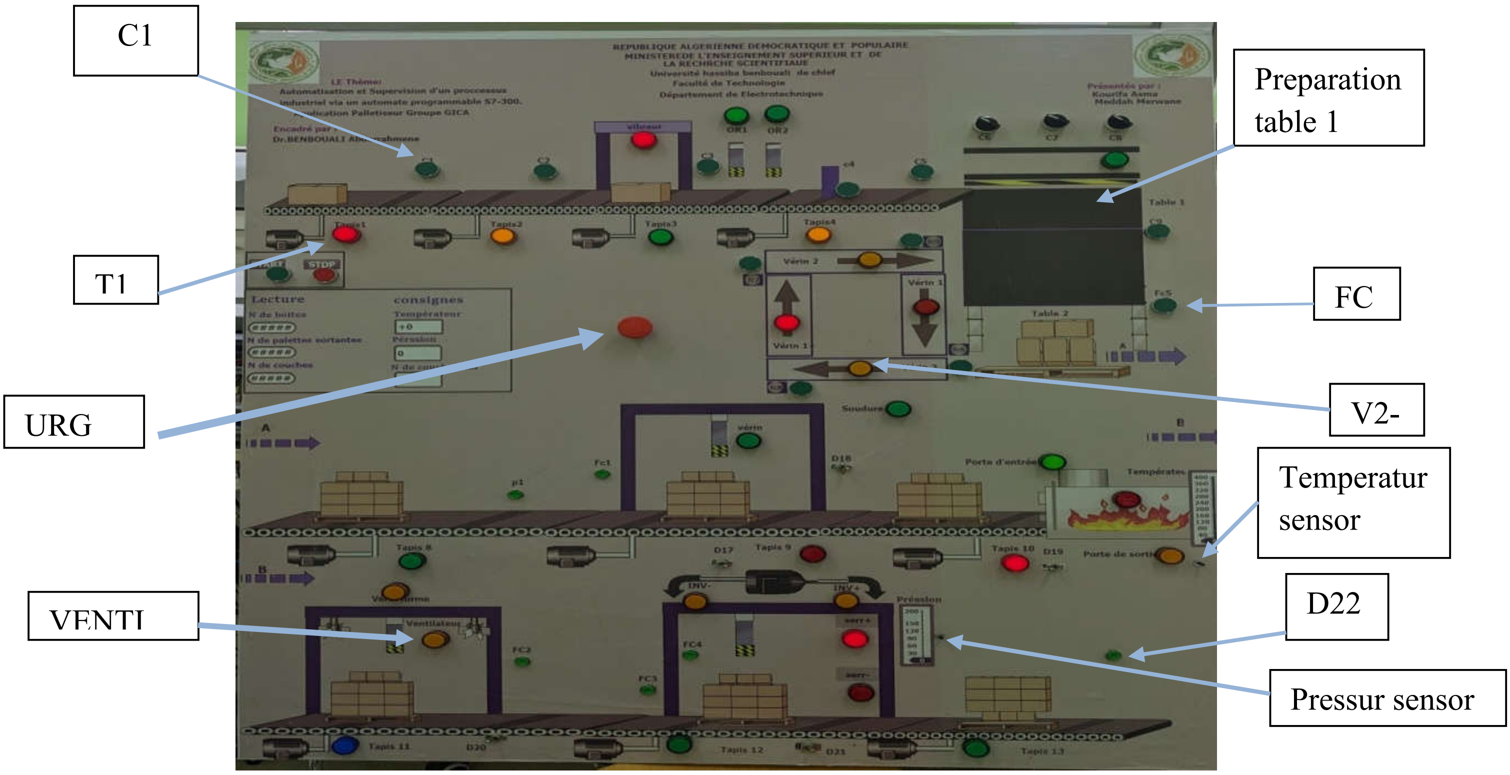


Figure III.16:palitizer system

III.5.2 PLCdevice:

We used the PLC(Figure III.17), available in our universityThe SIMATICS7-300 CPU 312-1AE13-0AB0. With a digital input module DI 32Xdc 24V 321-1BL00-0AA0 , and a digital out put module DO 32XDC 24v/0.5A 322-ABL00-0AA0 , and analogical input/output AI/AO 02x8BIT 334-CE01-0AA0 ,and made some modifications to it, such as increasing the number of available inputs and outputs for use. We also added some tools to facilitate its integration with other systems.

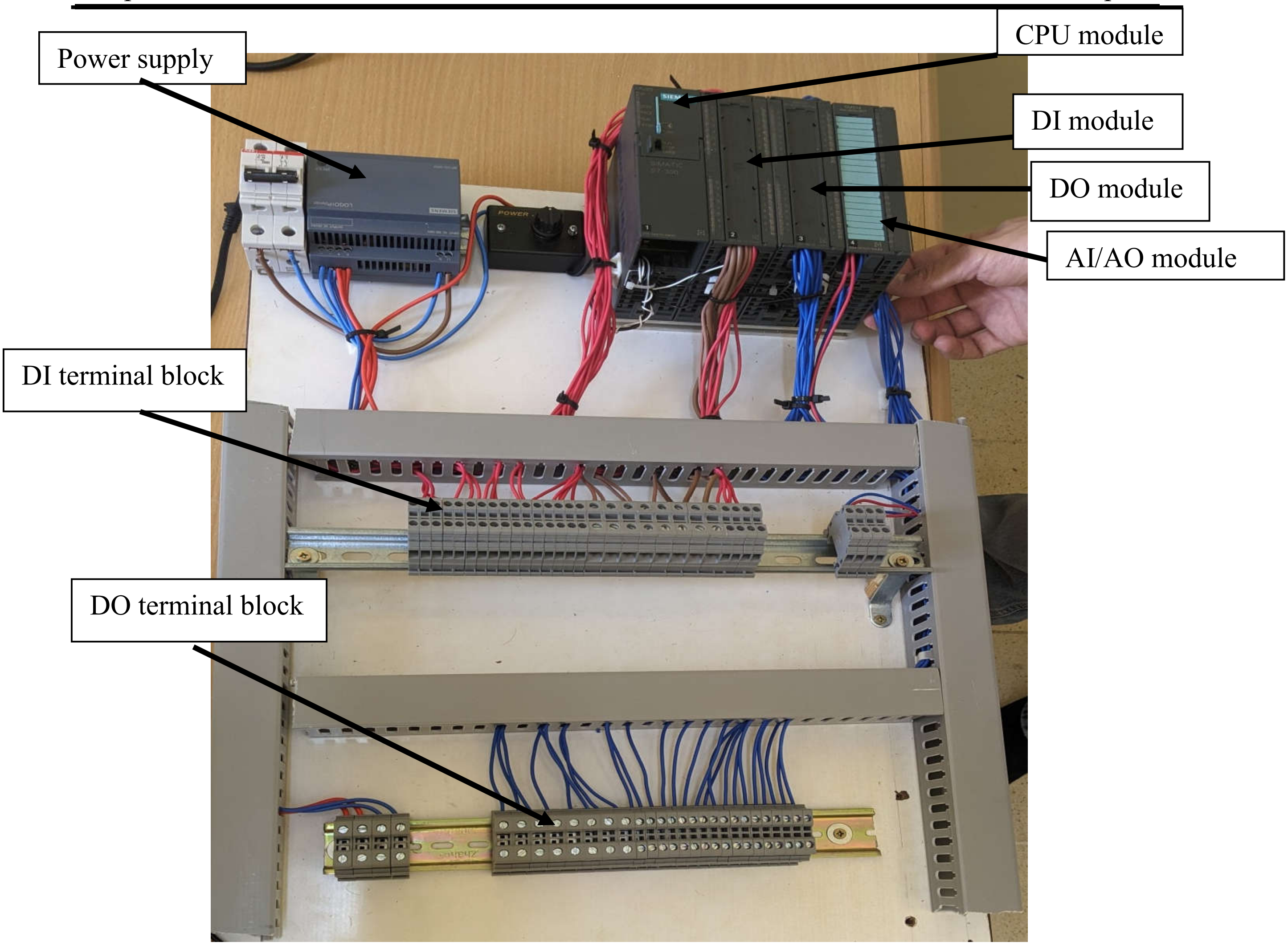


Figure III.17: PLC device

III.5.2 Human Machine Interface (HMI):

We used a PC station as a gateway for monitoring through a computer screen(Figure III.18), connected via an MPI cable.

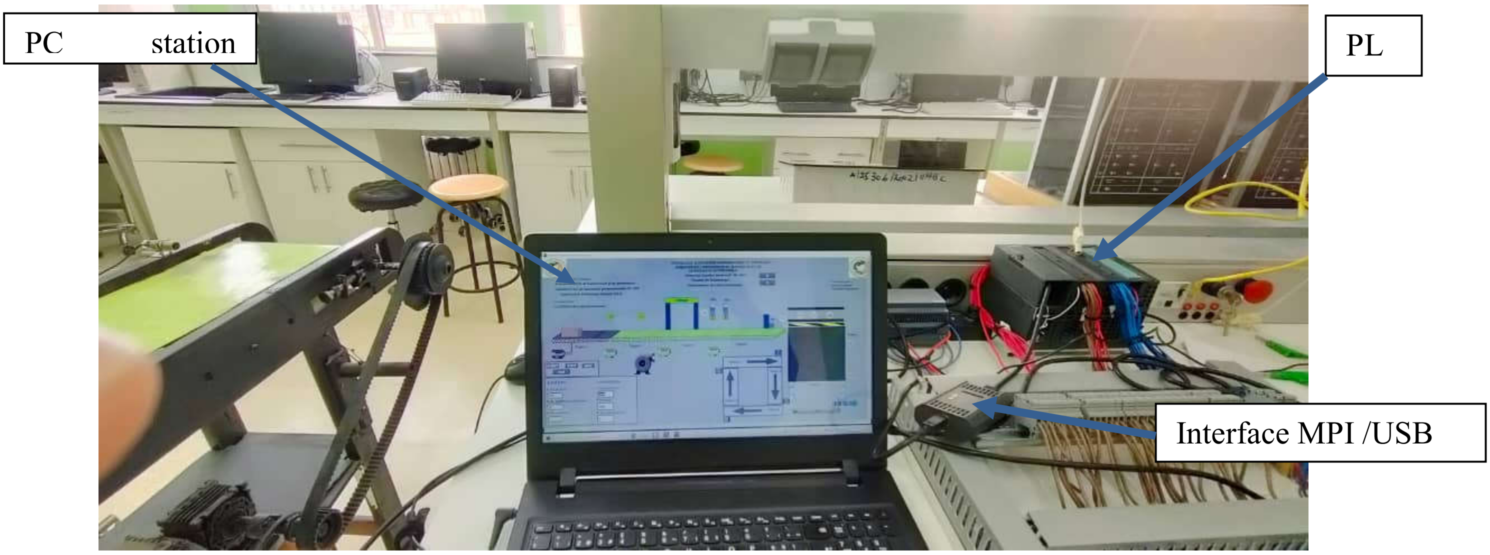


Figure III.18:human machine interface

III.6 Results and discussion:

At this point, we will discuss some of the results obtained in some situations from both the platform and software .

III.6.1 feeding station example:

In this case(Figure III.19), we notice that buttons C1 and C2 are pressed simultaneously as mentionedpreviously this action resulting in the shutdown of T1. We also observe the same outcome on the monitoring screen

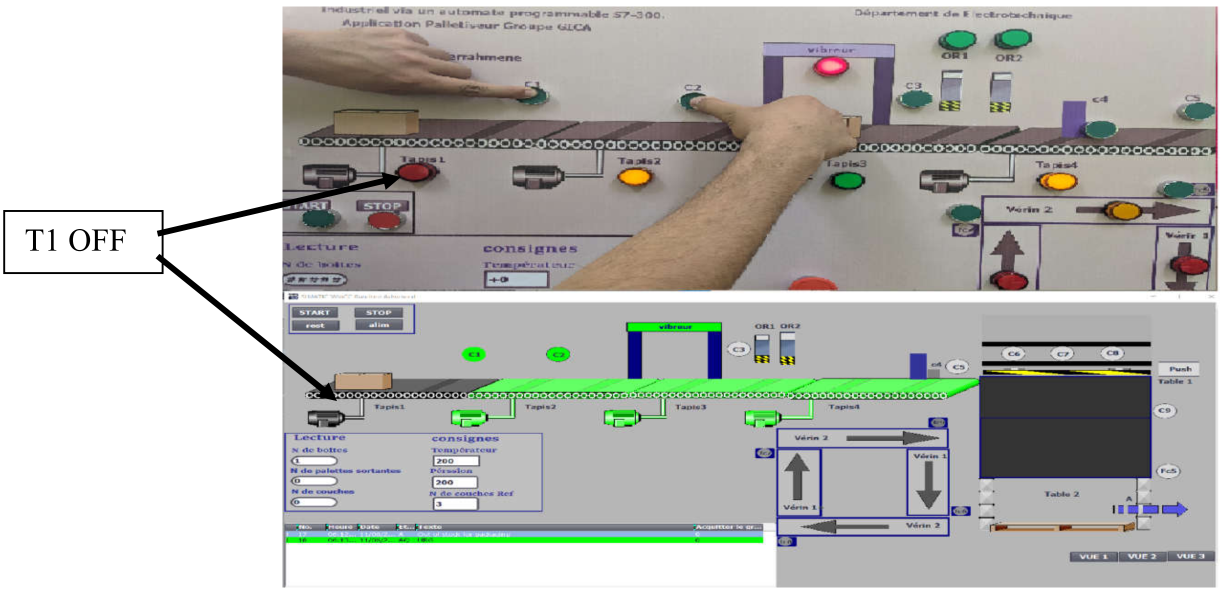


Figure III.19 : Feeding station exampel

III.6.2 organization station example:

In this case(Figure III.20), we observe the illumination of the two indicator lamps indicating the exit of ORI 1 and ORI 2, which occurs when two bags pass through the special layer in preparation for the third bag to reach its destination. Simultaneously, we observe the same results on the monitoring screen.(Figure III.20)

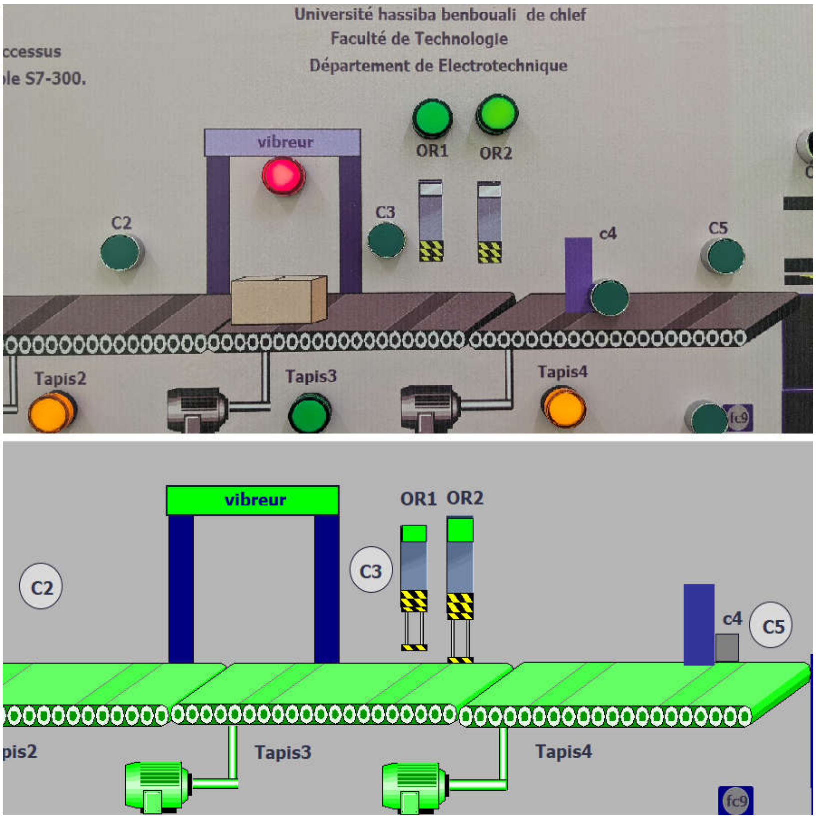


Figure III.20:organization station example

III.6.3 packing station example:

In this scenario, the position of D18 signifies the availability of packing bags, while D17 indicates the presence of pallets at the packing station, asdictated by the program. Consequently, cylinder pneumatic V1 is activated as confirmed by both system operation and the monitoringscreen (figure III.21).

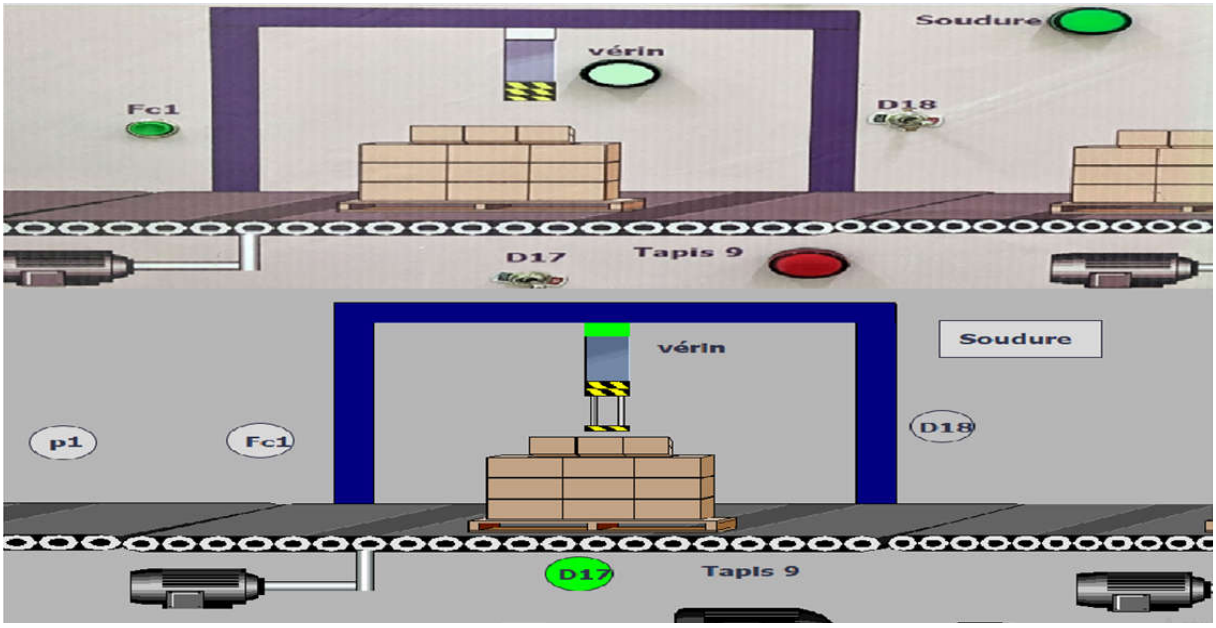


Figure III.21:packing station example

In the same situation if the position of D18 signifies the unavailability of packing bags ,it wil trigger an alarm message(figure III.22)

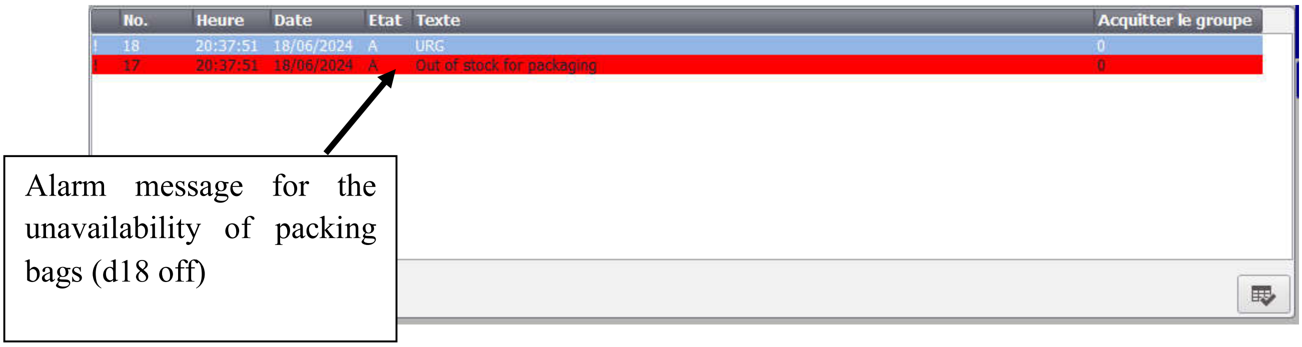


Figure III.22: D18 alarmexample

III.6.4 Heating station example:

In this case(Figure III.23), we observe a glowing of D19 indicating the presence of a pallet inside the furnace, along with a temperature of 0 degrees. According to the program, it is necessary to close both the front and rear doors and turn off T10 and the most important the beginning of heating with the CHAUFF. This is what we observe in both the system and the monitoring screen.

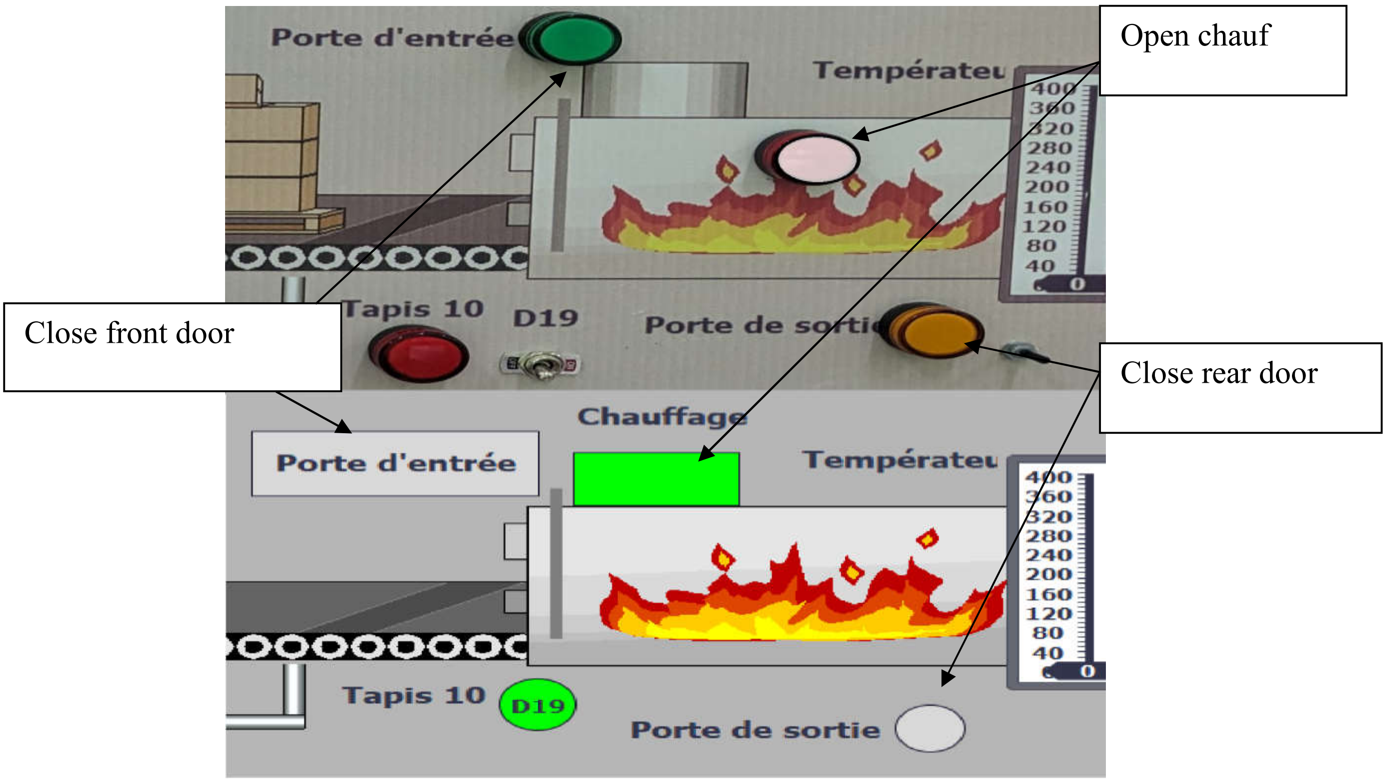


Figure III.23: heating station example

III.6.5 Emergency example:

In this case when the URG button is pressed, whatever the situation an alarm message will be triggered (figure III.24), and all the system shutdown

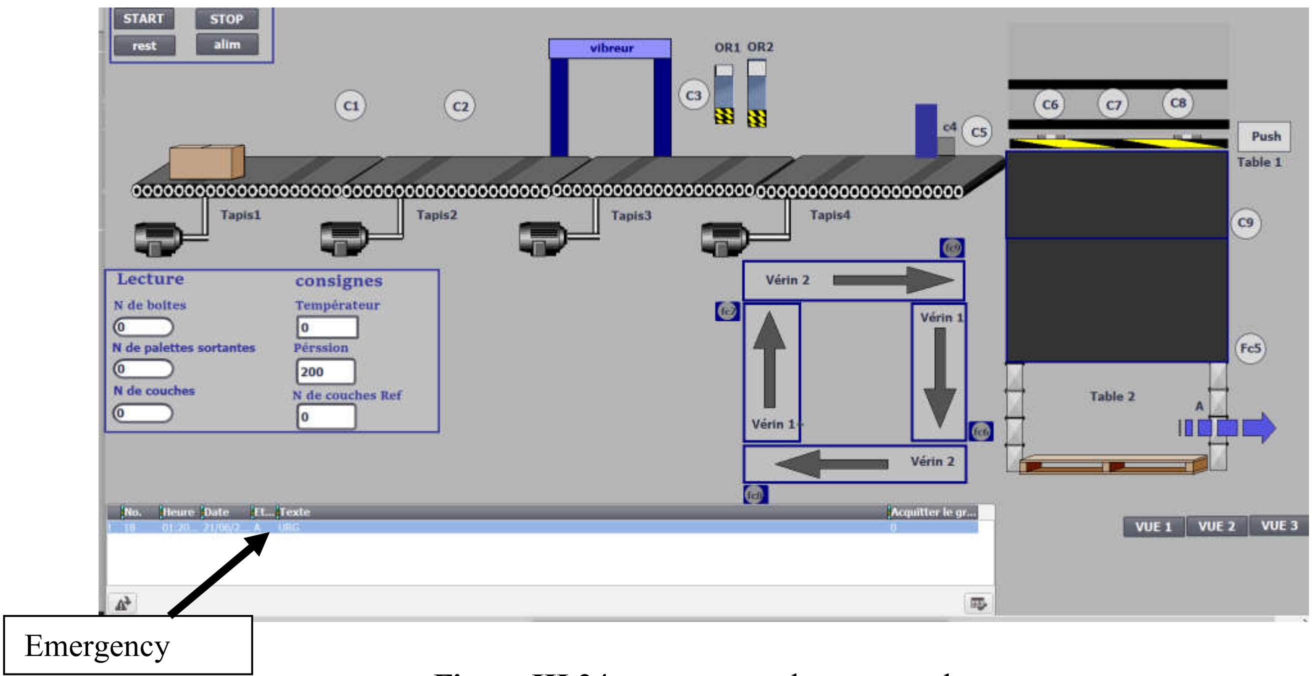


Figure III.24: emergency alarm example

III.7 Conclusion

In conclusion, our chapter has provided a detailed exploration of palletizer system programming and operation using Siemens automation technology via TIA Portal V15. We've examined each station's specifications, components, and operational processes, showcasing meticulous programming strategies and practical realizations. Through the integration of a SIMATIC S7-300 PLC and WinCC TIA Portal V15 for monitoring, we've achieved a robust and efficient system. Our results demonstrate seamless operation across all stations, setting the stage for future advancements. This chapter serves as a comprehensive guide, showcasing both the intricacies of palletizer system implementation and the potential for ongoing innovation in automation technology

General conclusion

General conclusion

Automation is the use of computers and devices based on processors or controllers and software in various industrial, commercial, and service sectors to ensure the correct and automated execution of procedures and to work with as few errors as possible .

Automation is the art of making procedures and machines operate automatically. The objective of this project is to automate and supervise an industrial process within the ECDE factory using a Siemens S7-300 programmable controller. More specifically, this project aims to automate the factory's palletizer in order to improve production efficiency, reduce manual labour, and optimize operational costs. By integrating a powerful supervision system, we also seek to provide real-time monitoring and control capabilities to enable rapid adjustments and continuous optimizations of the production process.

This project aims to position the factory to meet future challenges and seize growth opportunities, thus ensuring its long-term success in the industry.

While working, we faced some technical problems such as: In the context of programming organization block, we encountered some difficulties using the "JUMP" instruction, which only jumps to networks that follow it, not those before it. Therefore, we had to use another instruction, which is the "mod" instruction, to process the command for the number of reference layers and the number of completed layers. The alarm device, since it only accepted INT and WORD, we had it in URG (BOOL) and we converted it from BOOL to INT using data block.

Despite these problems and of course many others, we were able to achieve our objective. This work allowed us to learn several tools and techniques in automation such as learning the advanced features of the Siemens S7-30, developing logic programs to automate specific tasks, Configuring inputs/outputs for effective integration with machines. Using the TIA Portal software programming, configuration, and commissioning of the PLC. Projects, deploying programs, and diagnosing faults. And developing user interfaces to monitor and control the process in real-time Using touch screens to improve operator-machine interaction. And add the alarm signals for specific events.

For the continuation of this work, we suggest applying this program to the actual process installed at the factory. We also recommend extending the use of this system via the web while integrating security

Appendix

-This appendix is dedicated to configuring a device, we will show the different steps of device configuration. Figure I.1.

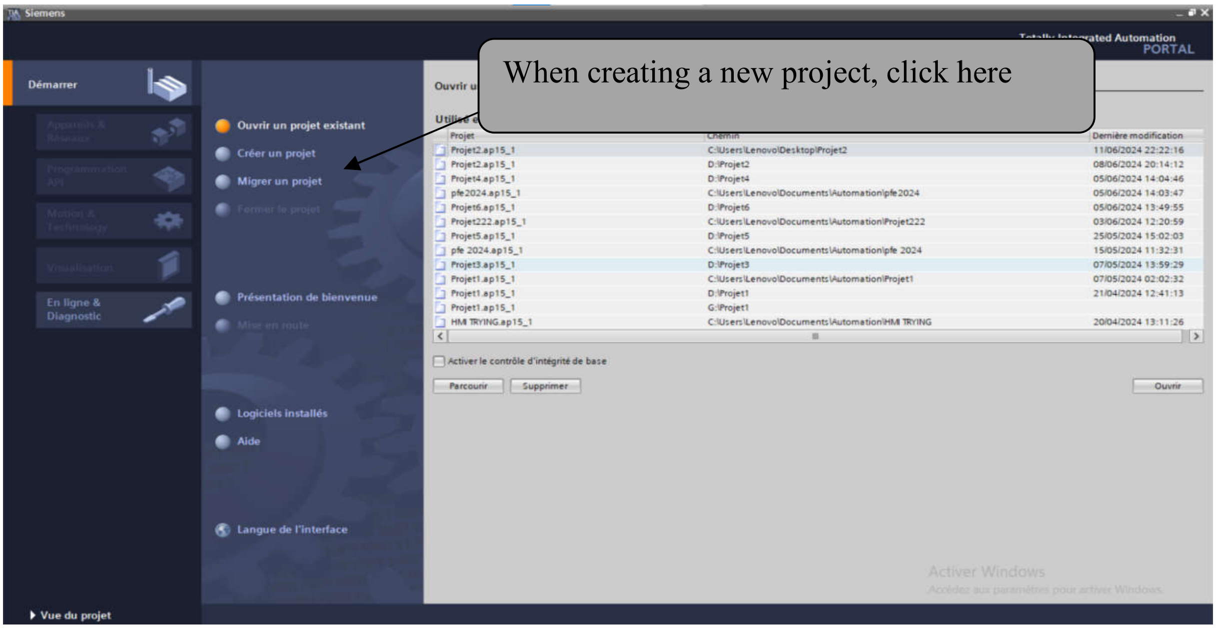


Figure I.1.: Creation of a project.

-The first step is to define the existing hardware. To do this, you have to go through the Project view and click “add device” in the project browser. Figure I.2.

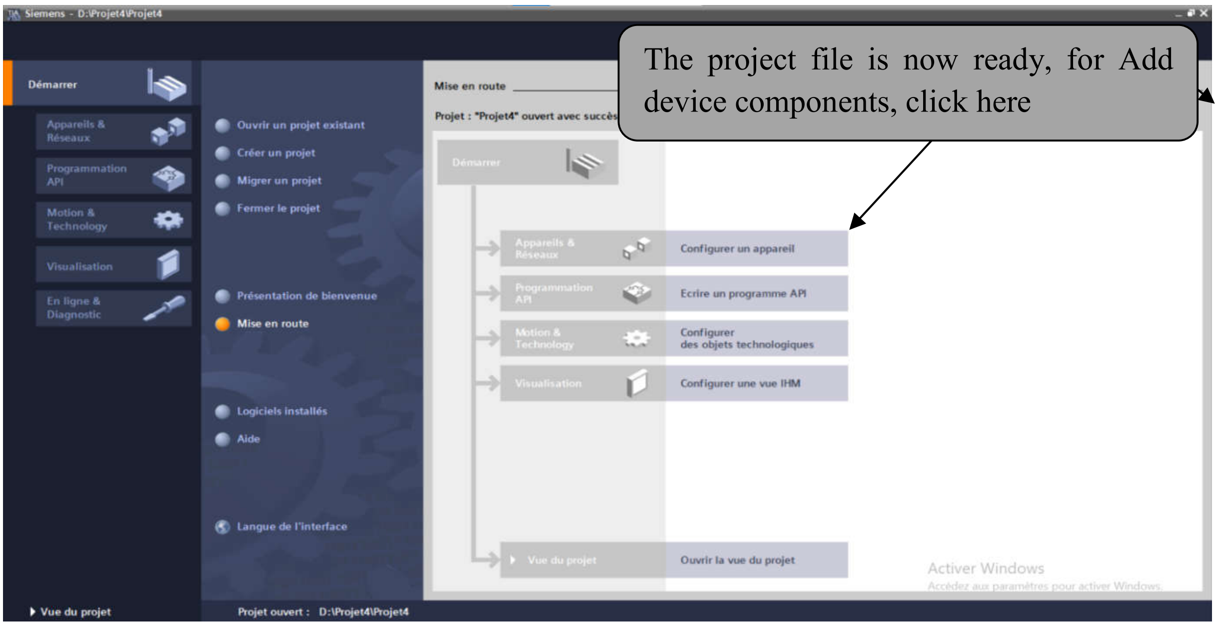


Figure I.2: device configuration.

-The lists of elements that can be added are (PLC, HMI, and PC system). All first you have to choose the CPU and then add the additional modules. Figure I.3.

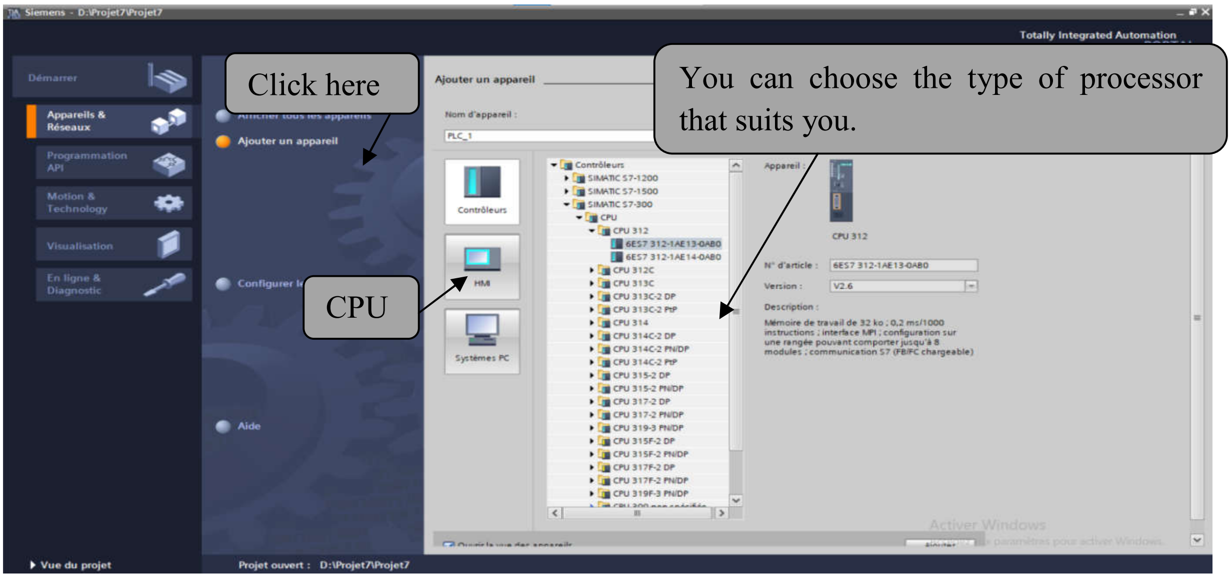


Figure I.3:Hardware configuration.

-API add-ons can be added using the catalog. Figure I.4.

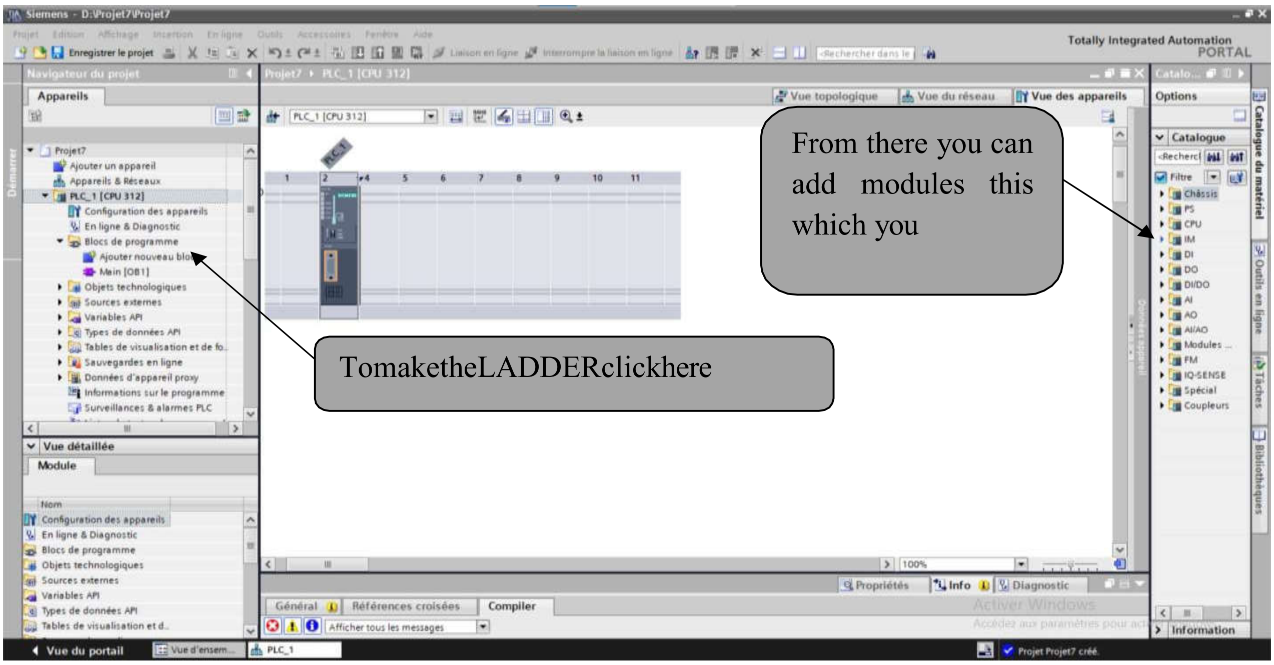


Figure I.4: CPU configuration

-For this program block Figure I.5.

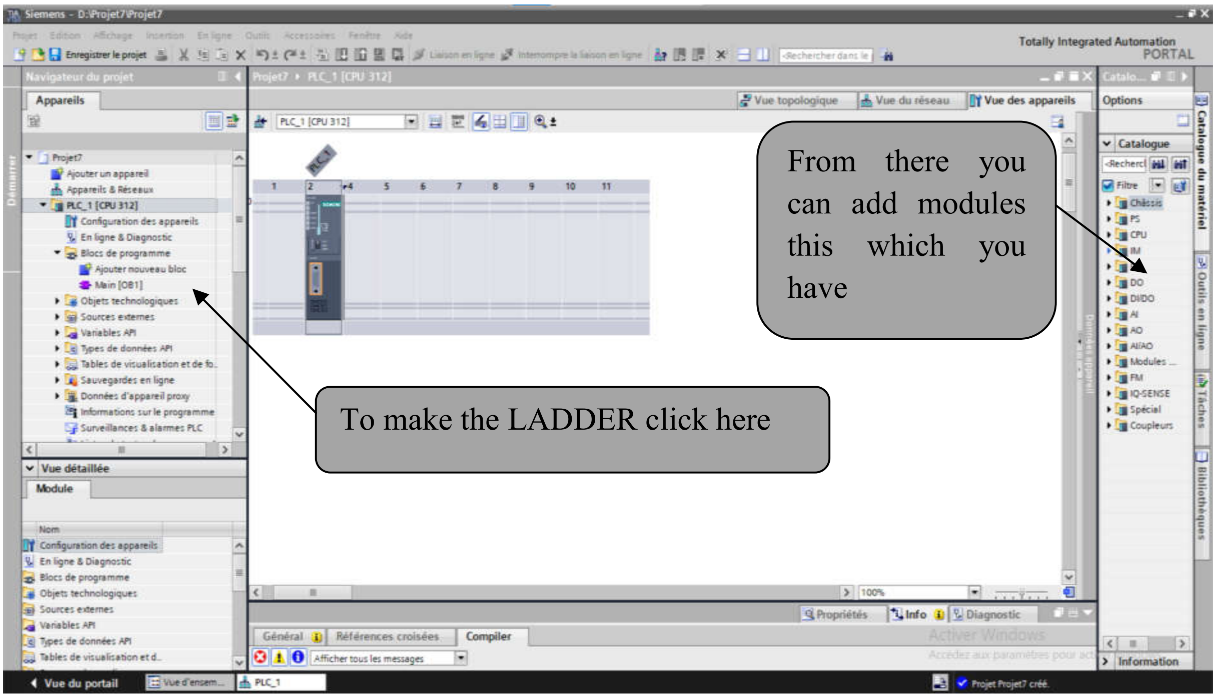


Figure I.5: program block.

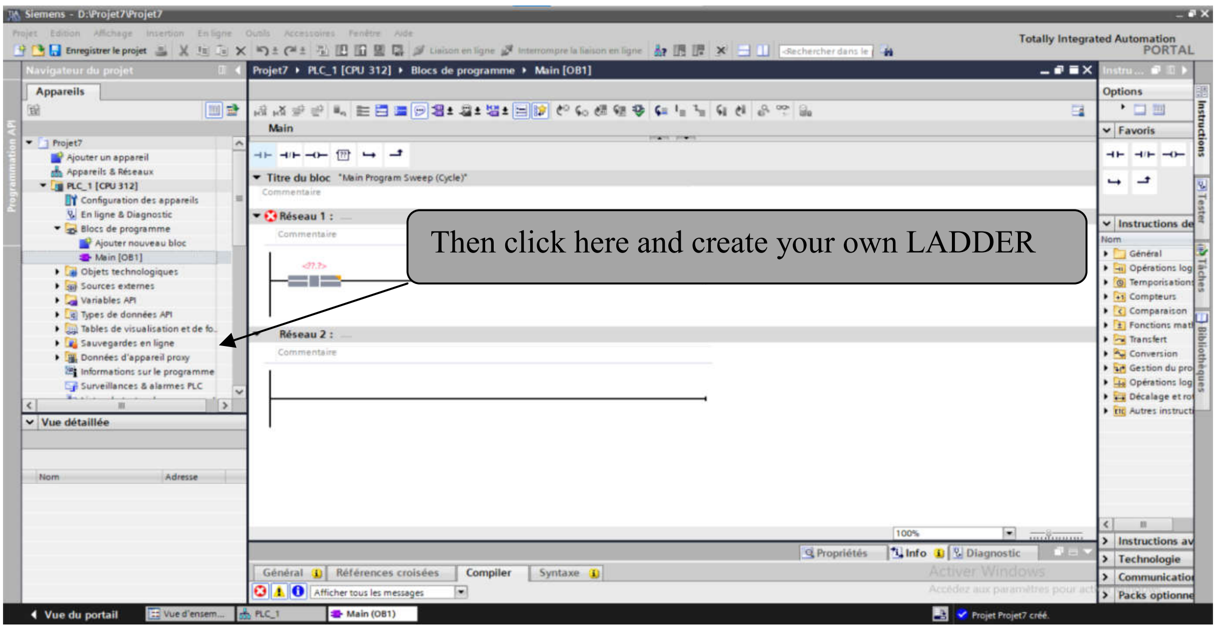


Figure I.5: Main [OB1].

B-1 Establish a connection.

This appendix is dedicated to configureWinccadvanced; we will show the different steps of device configuration. Figure I I.1.

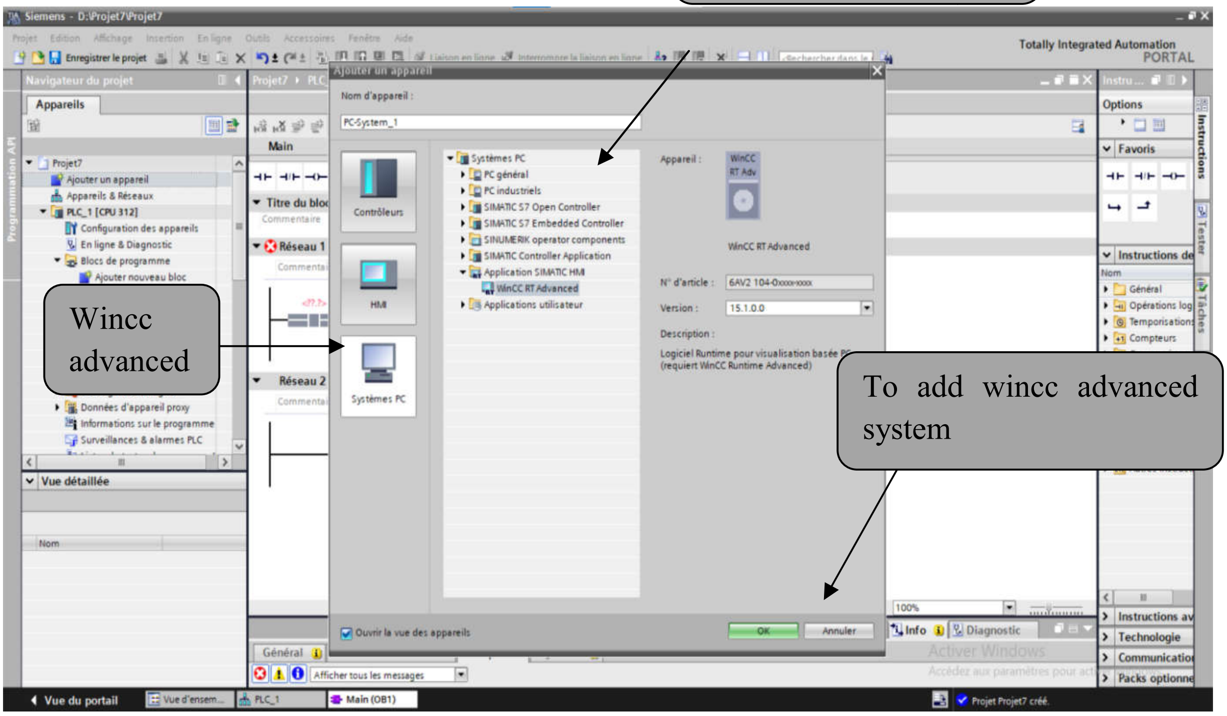


Figure I I.1: add Wincc advanced.

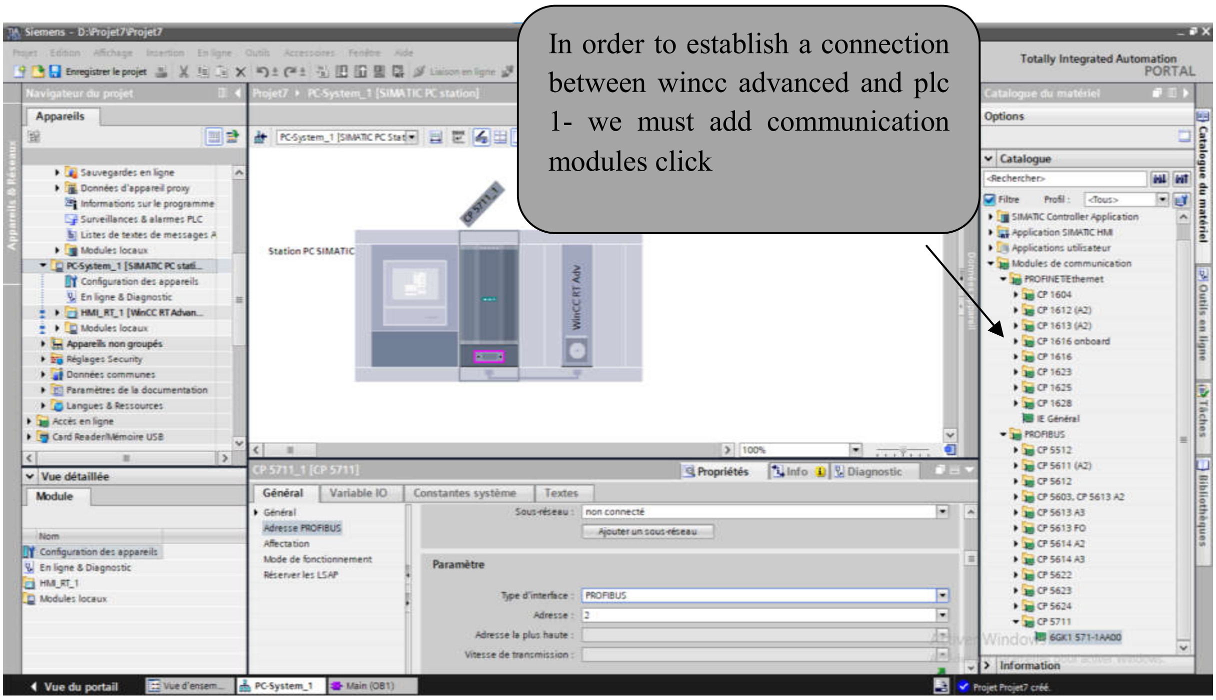


Figure I I.2: configure Wincc advanced.

-add Protocole de Communication Industrielle. Figure I I.3.

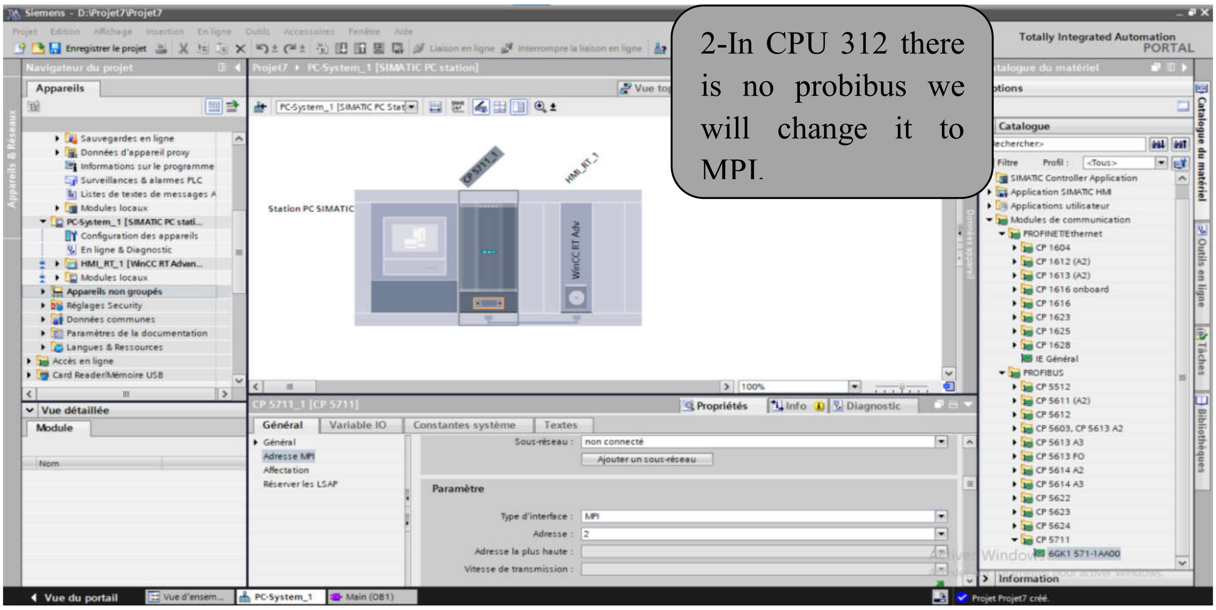


Figure I I.3: Protocole de Communication MPI.

-Connections between plc and pc system Figure I I.4.

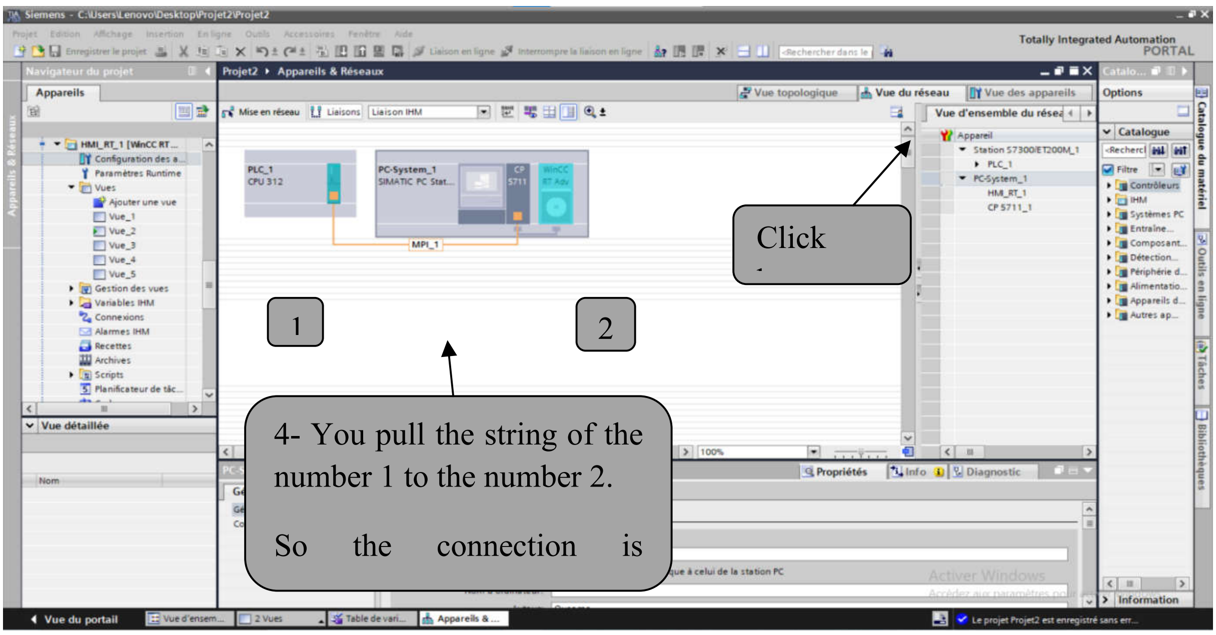


Figure I I.4:connections HMI.

B.2 introduce HMI variables.

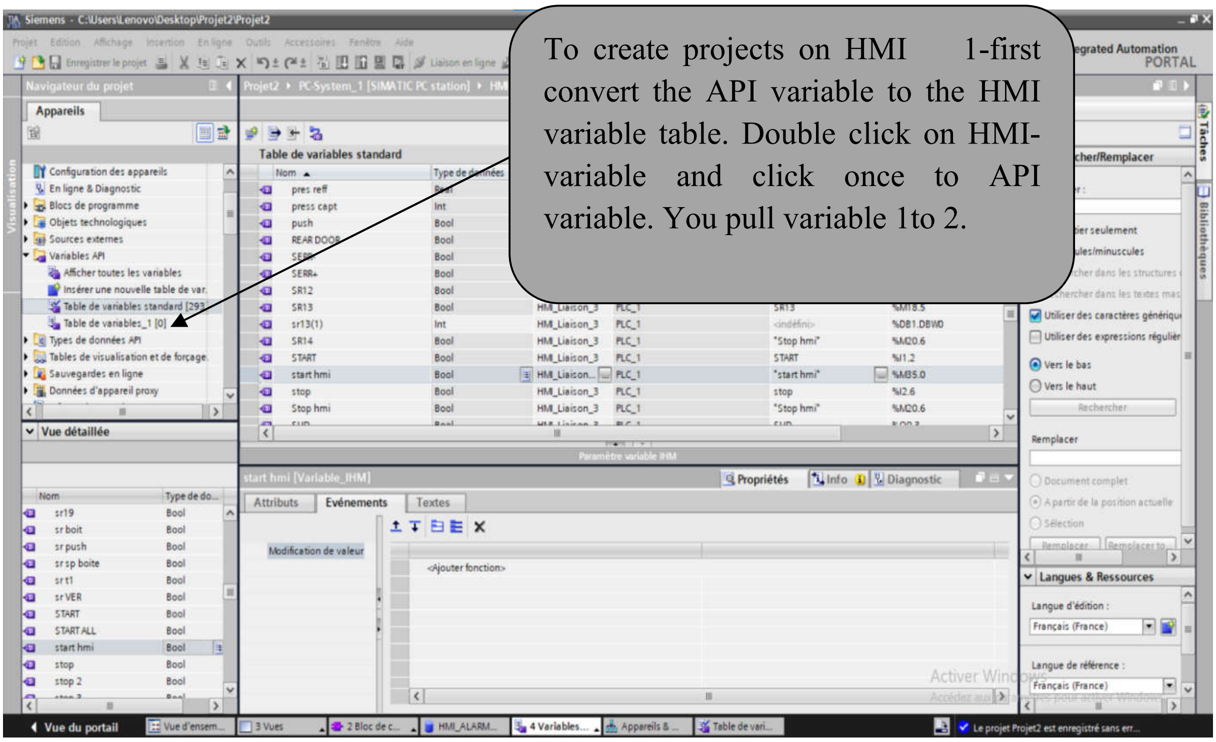


Figure I I.4: HMI variable table.

-Add screen and the items you will have needed for your project.

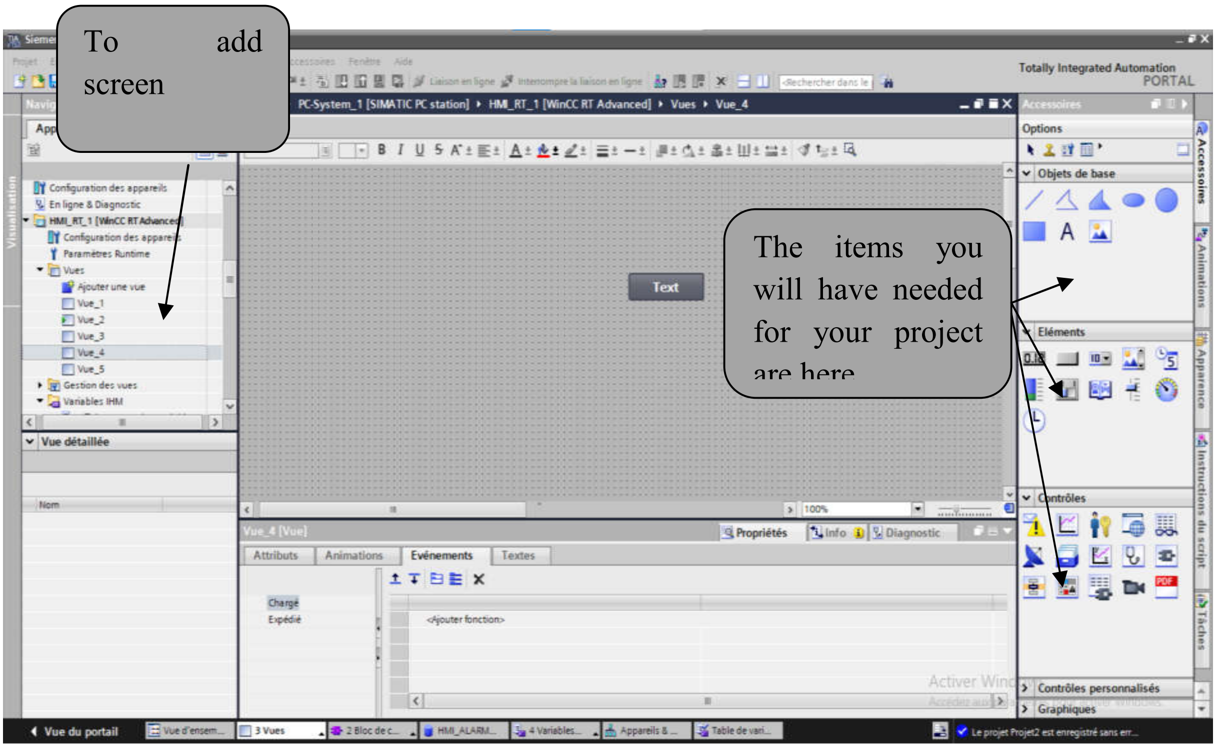


Figure I I.5: Add screen.

-B.2 general properties of button.

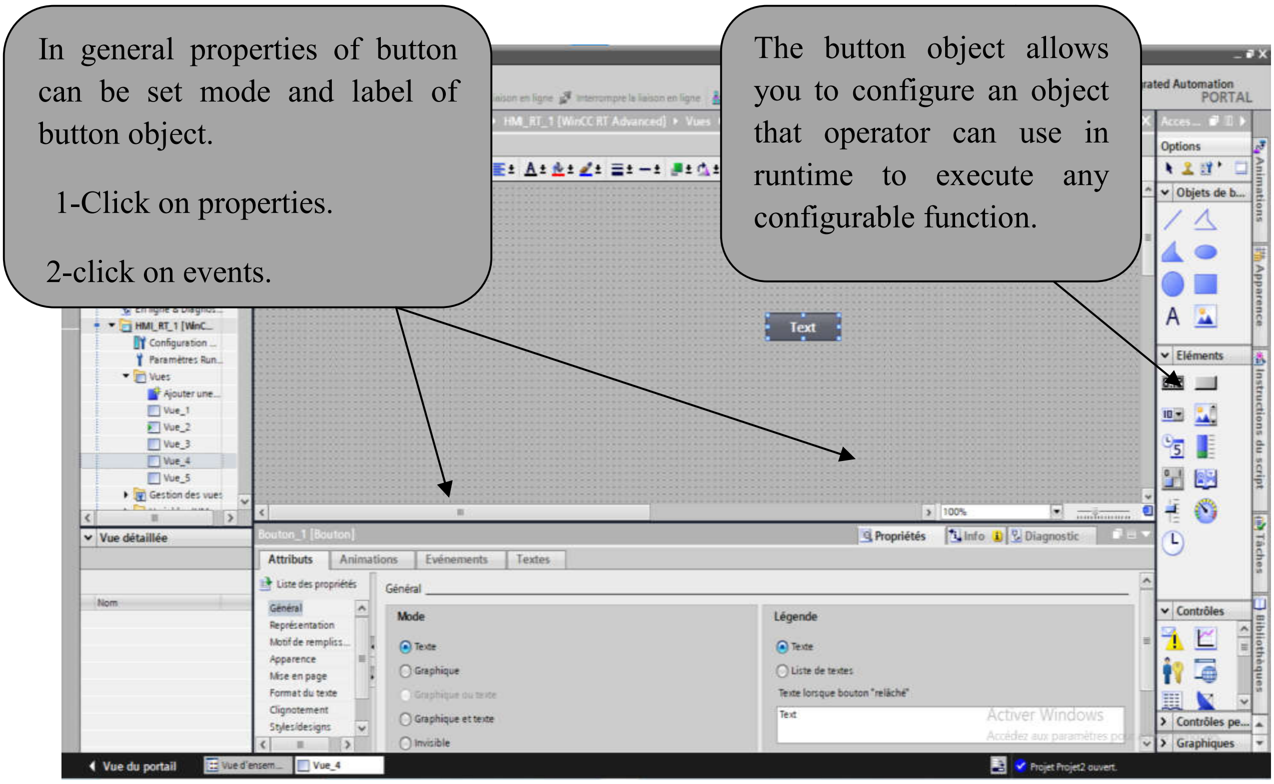


Figure I I.6: The button object

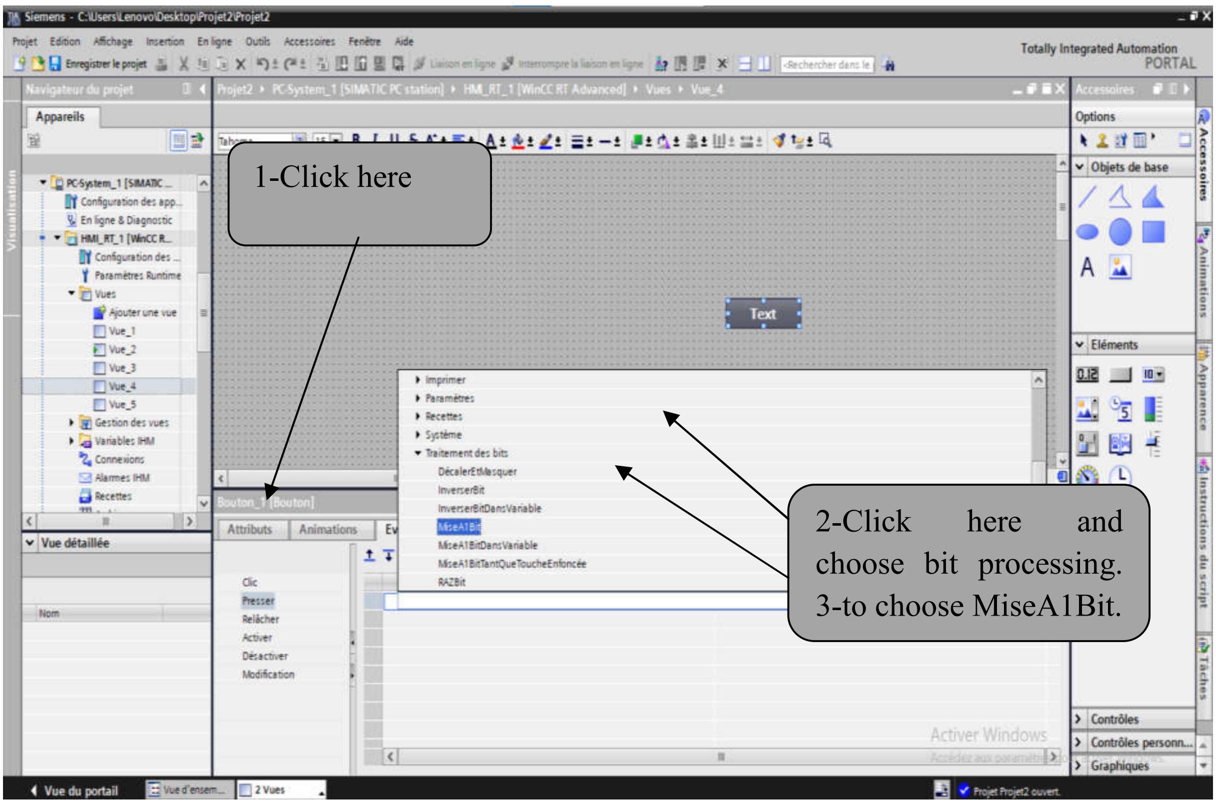


Figure I I.7: events of button.

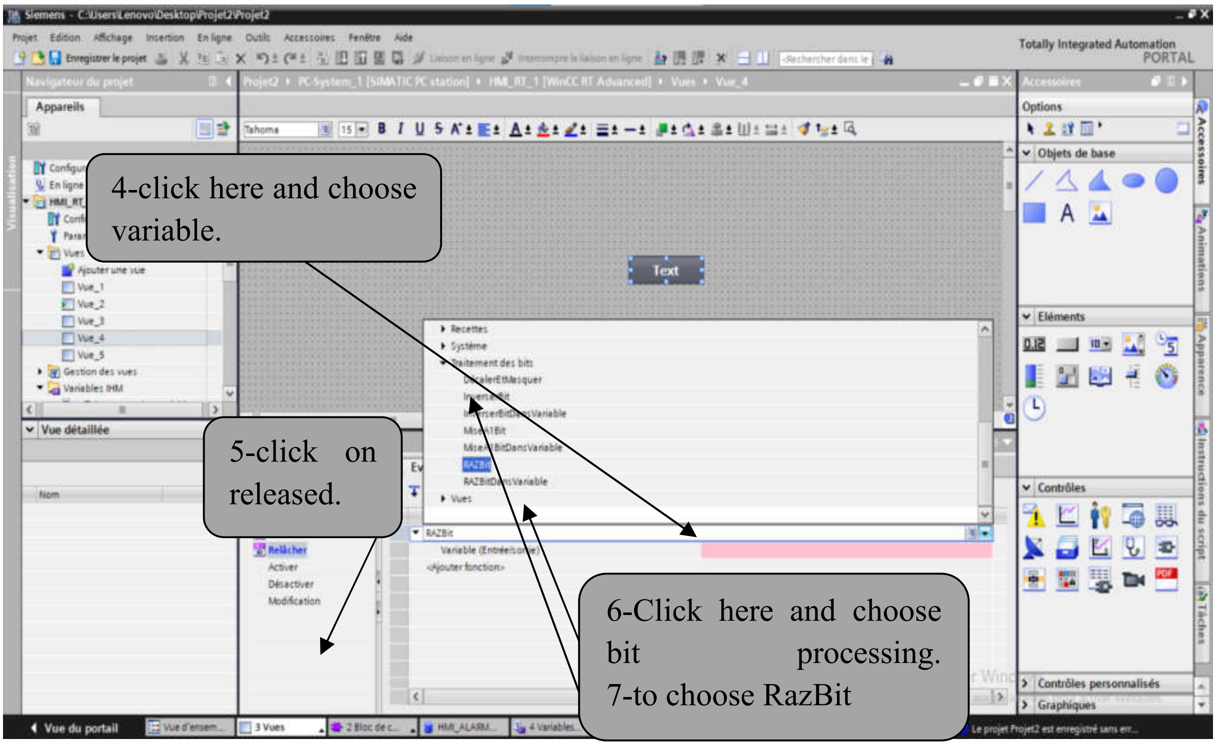


Figure I I.7: Set button mode.

B-3 Make Animation using movement.

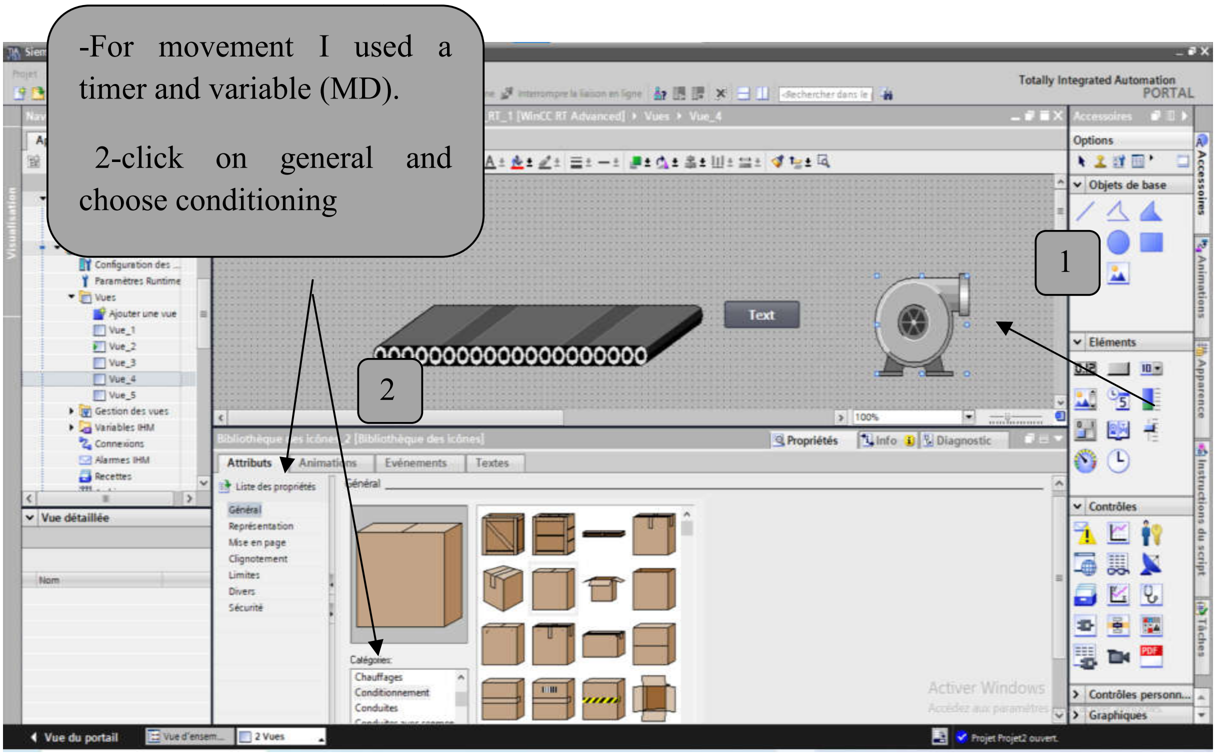


Figure I I .9:animation general.

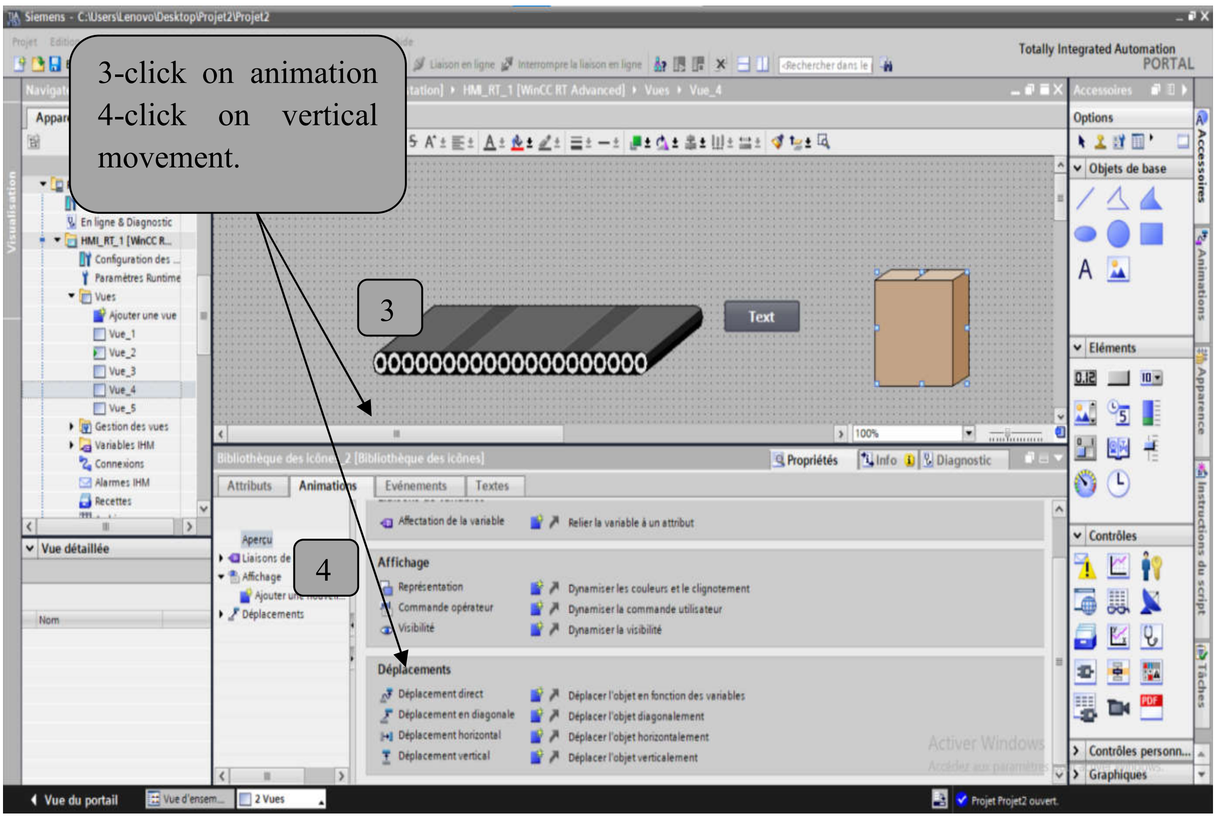


Figure I I .10: Animation for HMI.

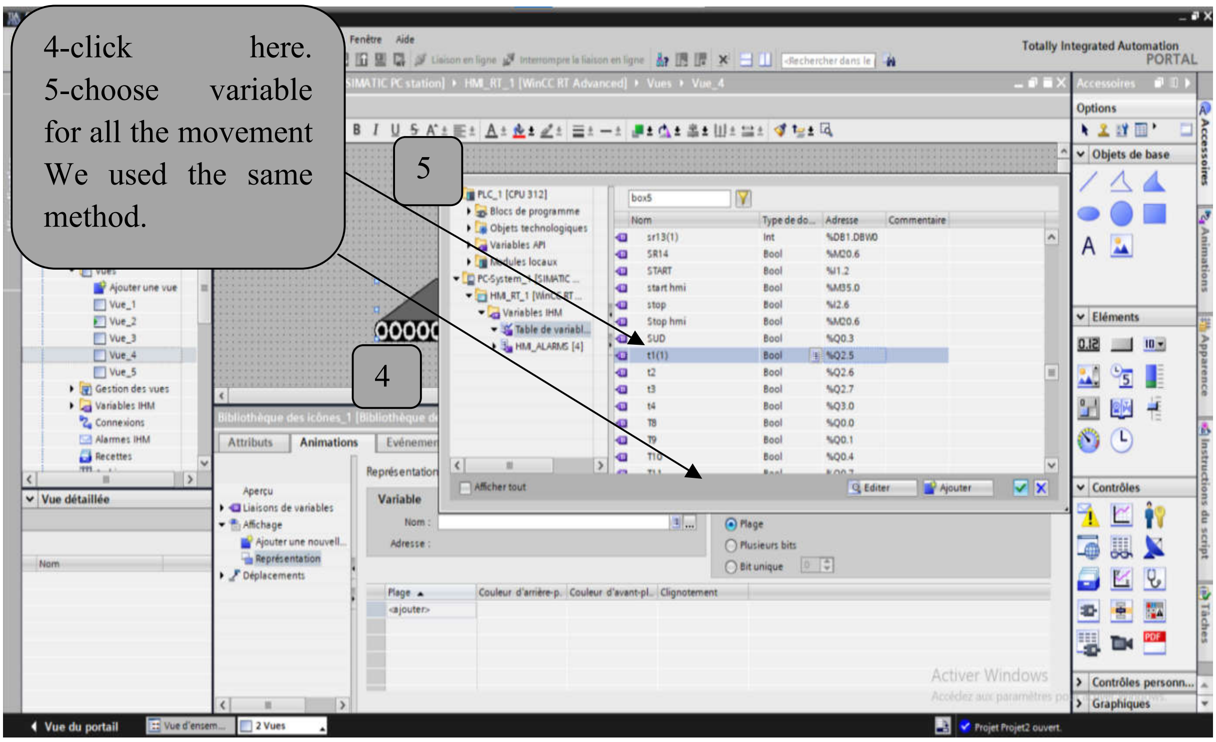


Figure I I.11: variable for movement.

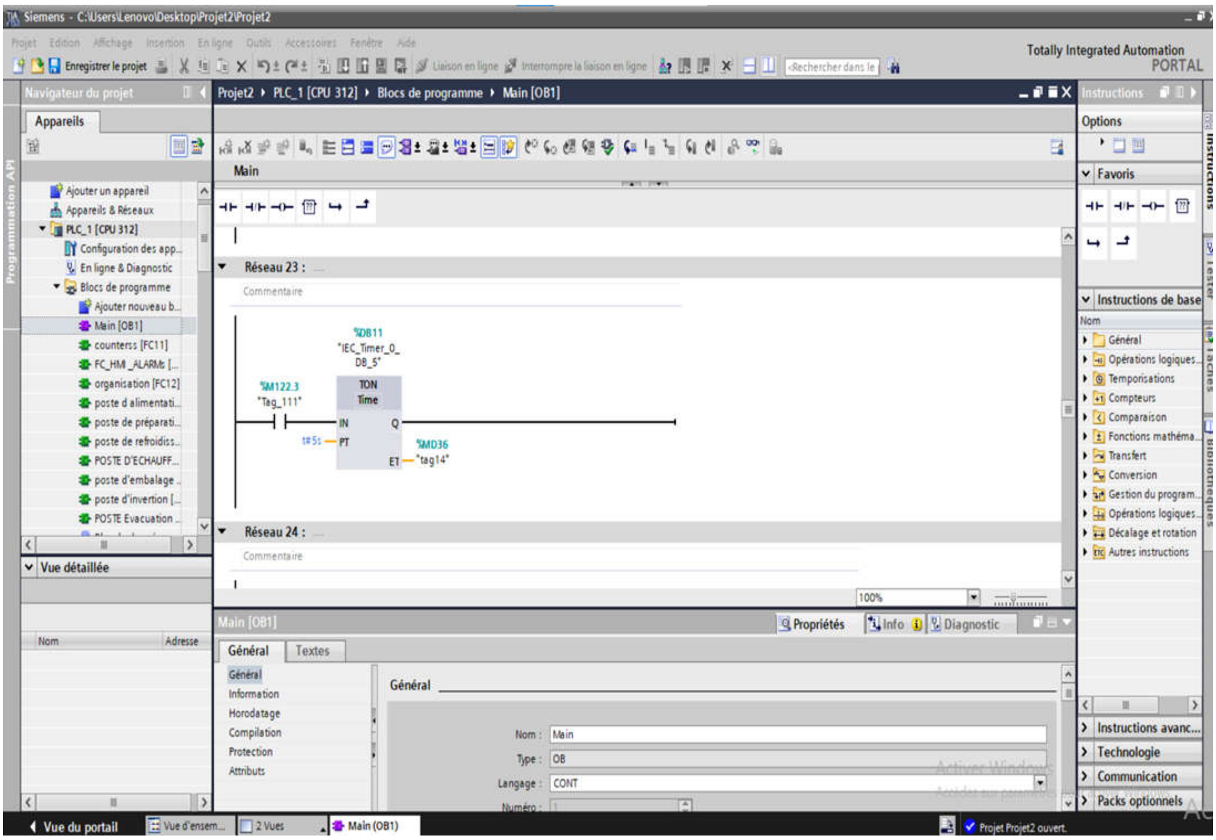


Figure I I.12: timer for movement.

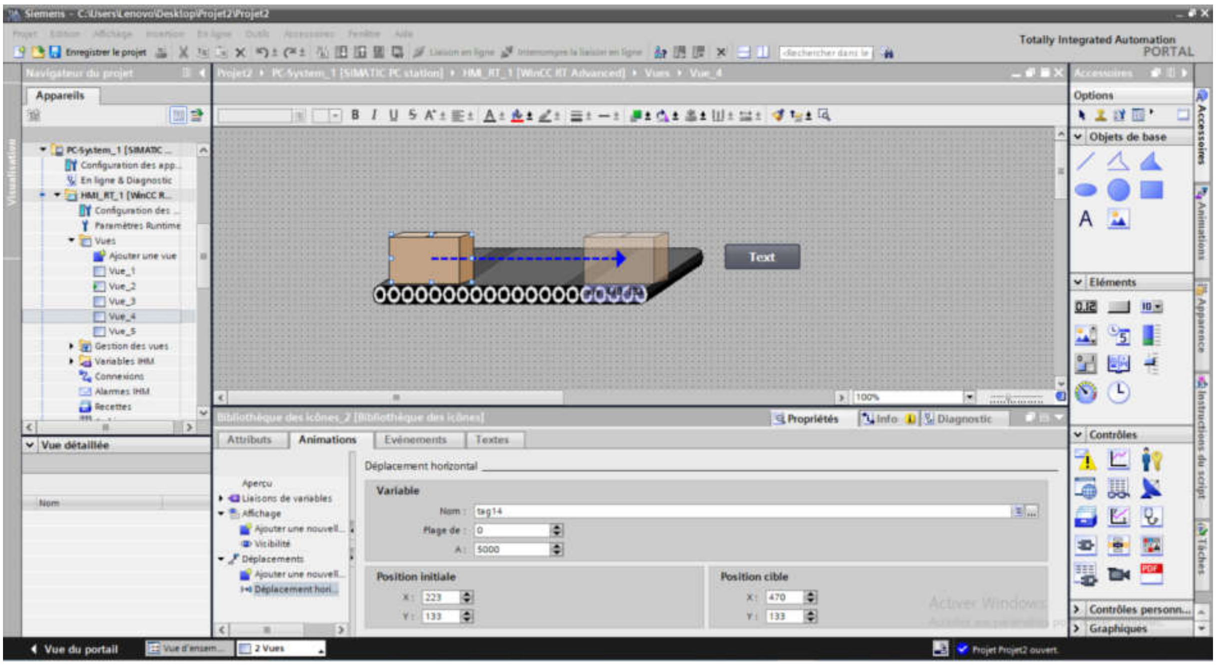


Figure I I.13: animation for movement.

B-4. Make animation using visibility.

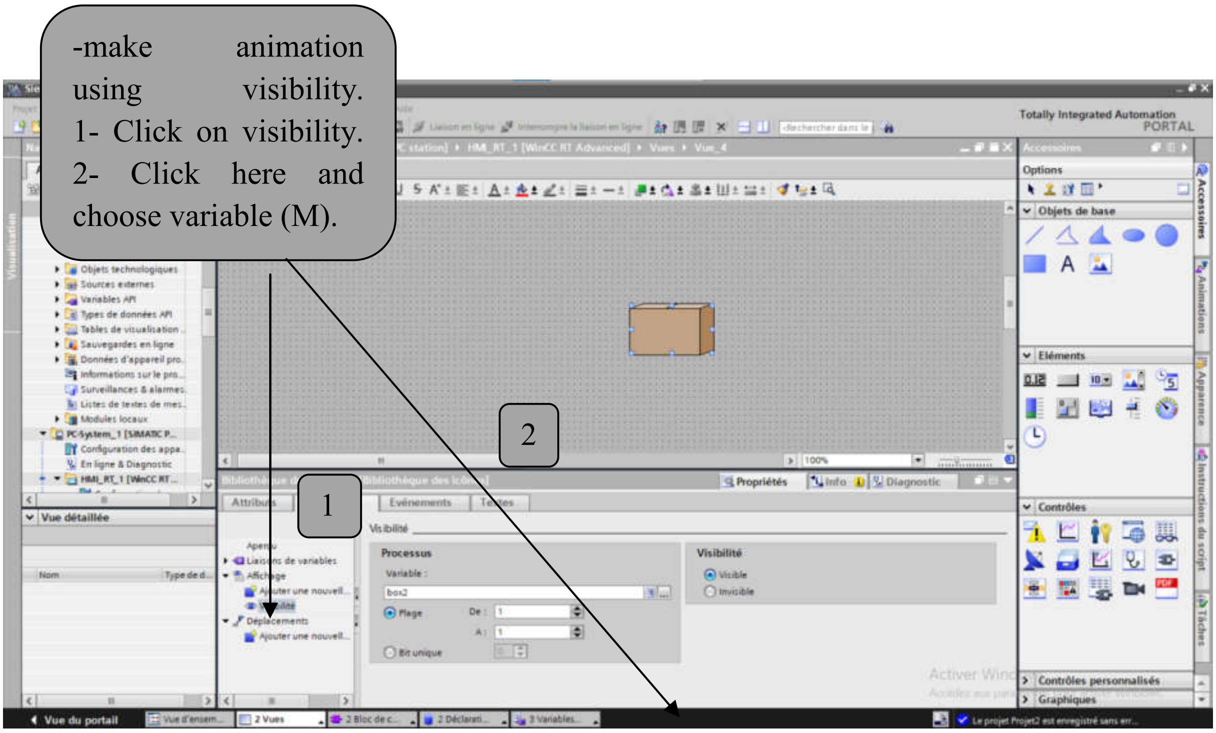


Figure I I.13: Animation for visibility.

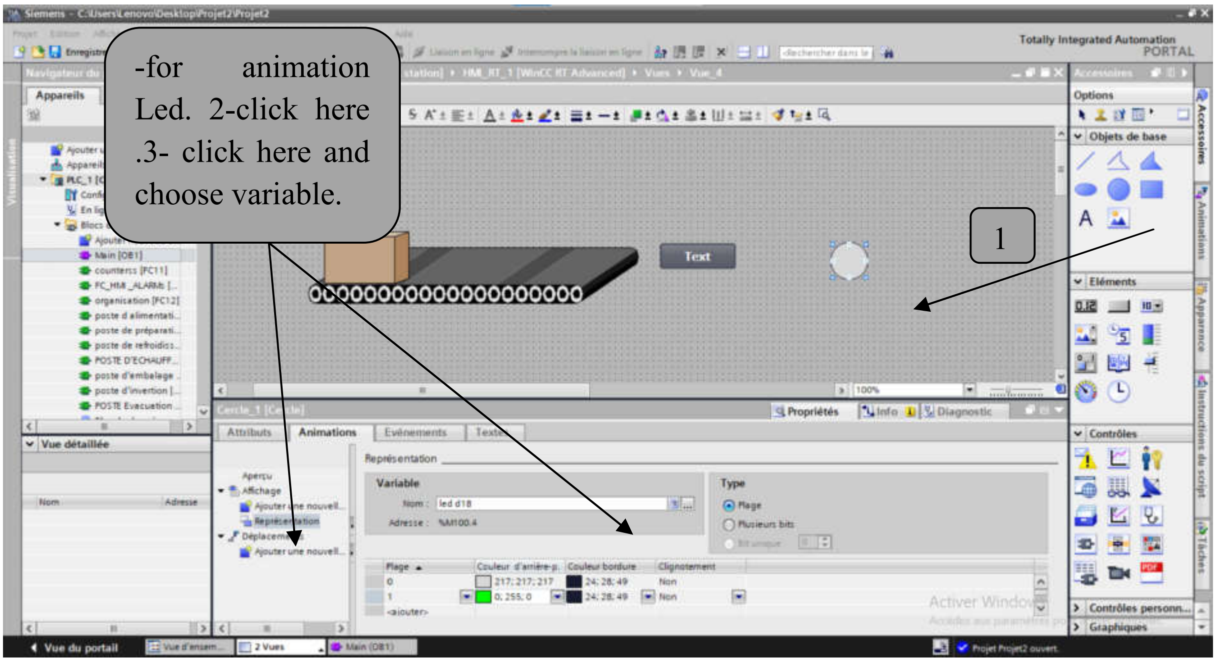


Figure I I.14: Animation for appearance.

B-6 In order to write a sentence.

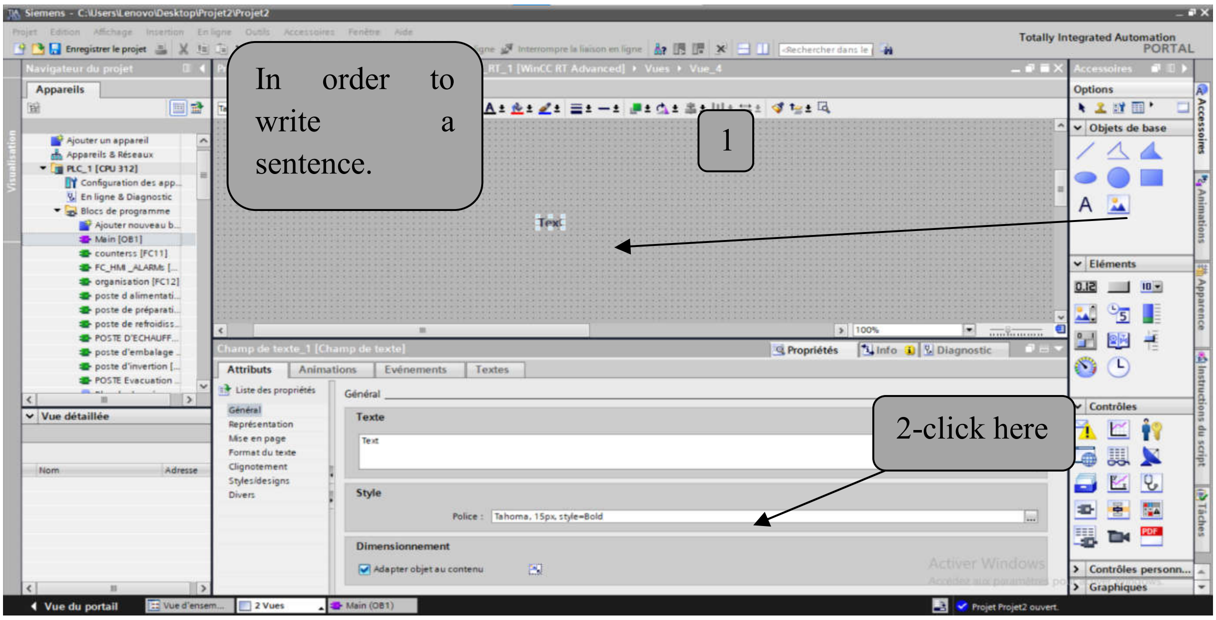
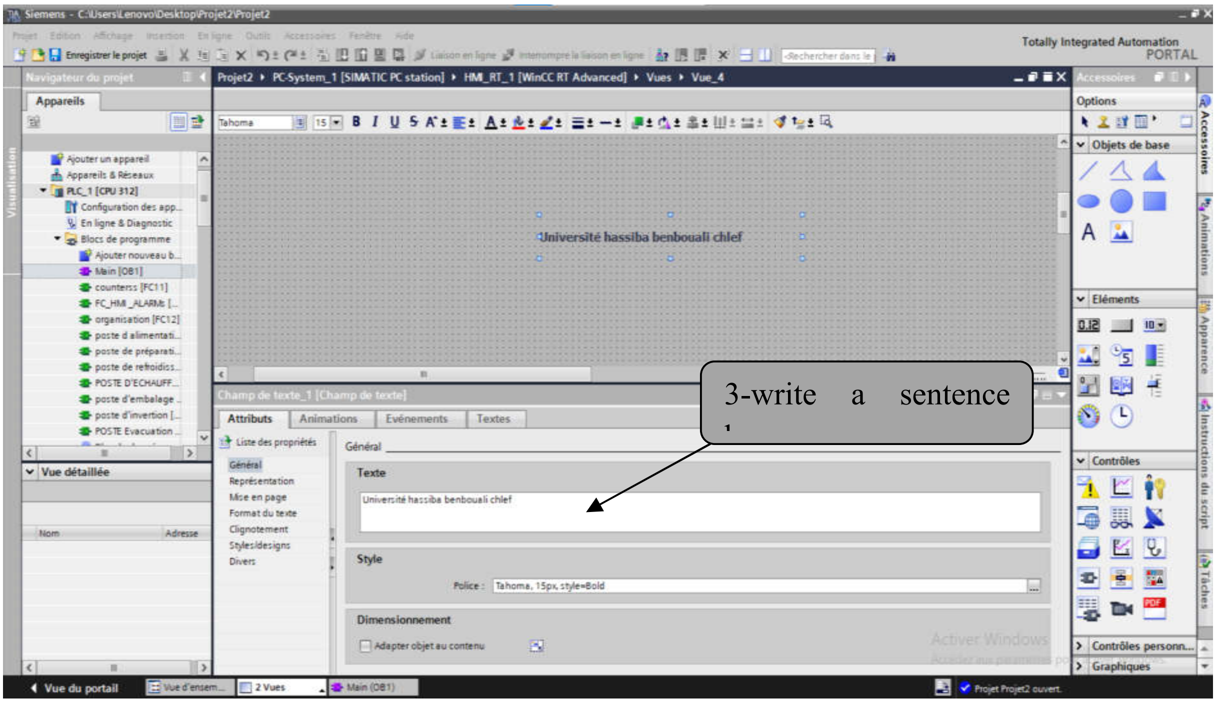


Figure I I.19: write a sentence.



B-7 make input analogiaue

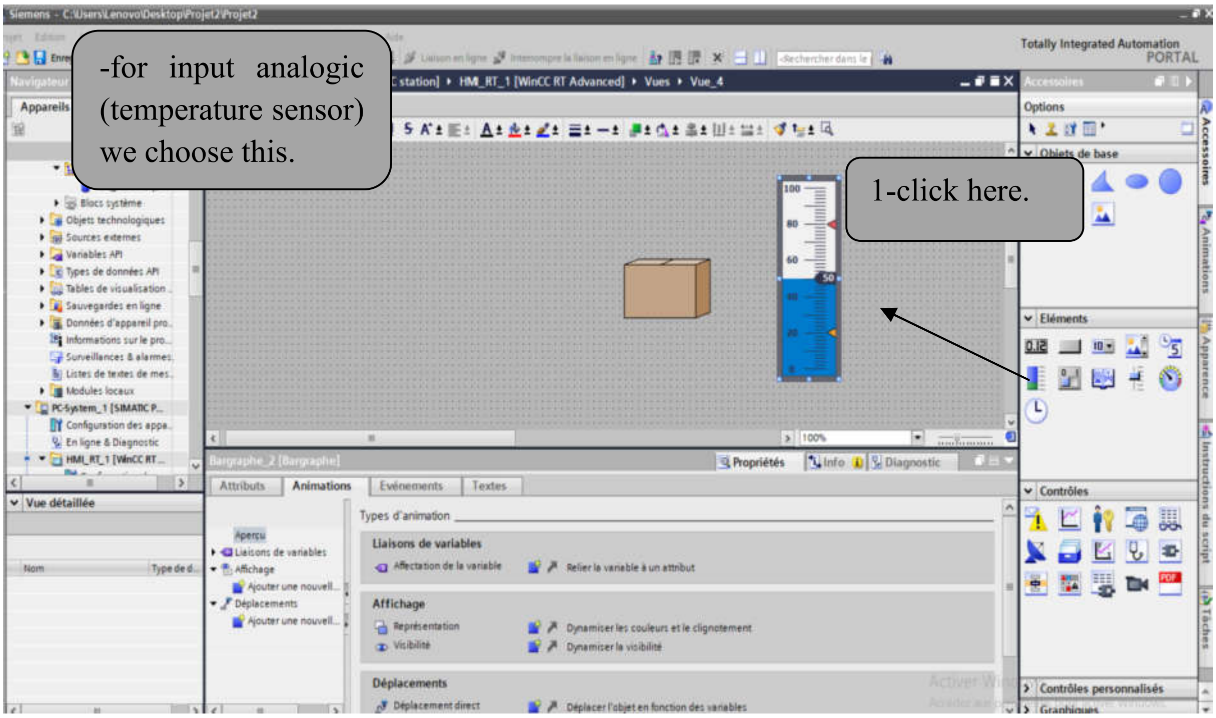


Figure I I.20: input analogique for HMI.

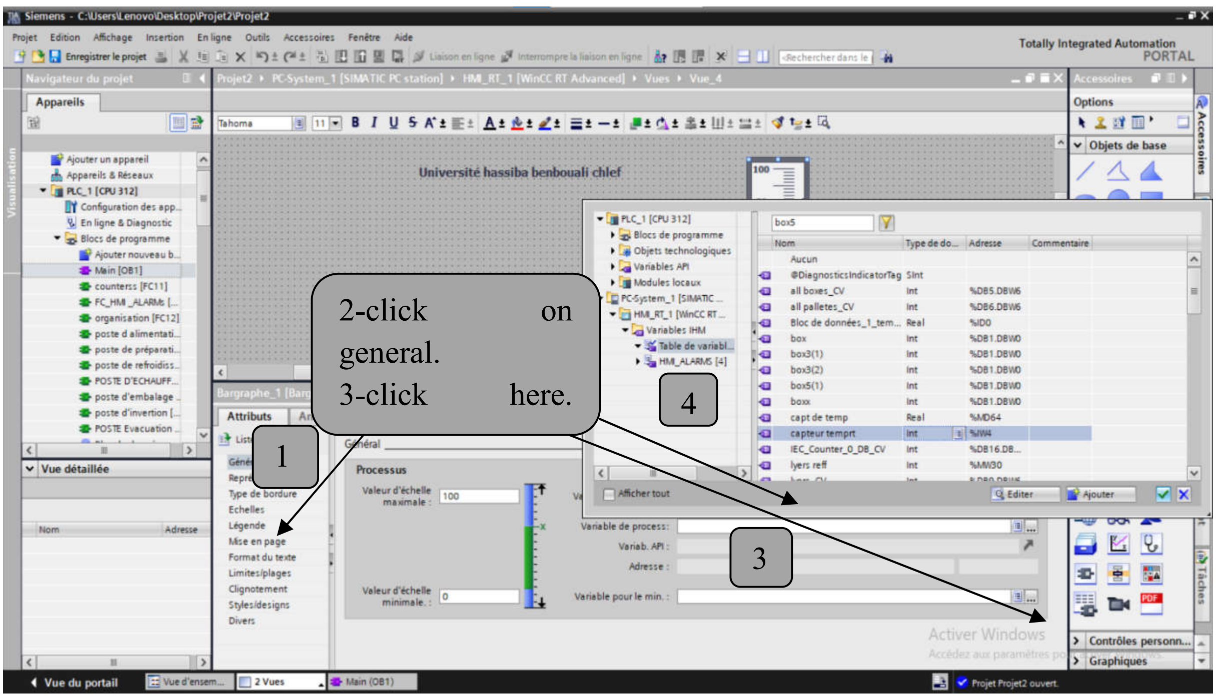


Figure I I.20: variable input analogic for HMI.

B-8 make enter infomation

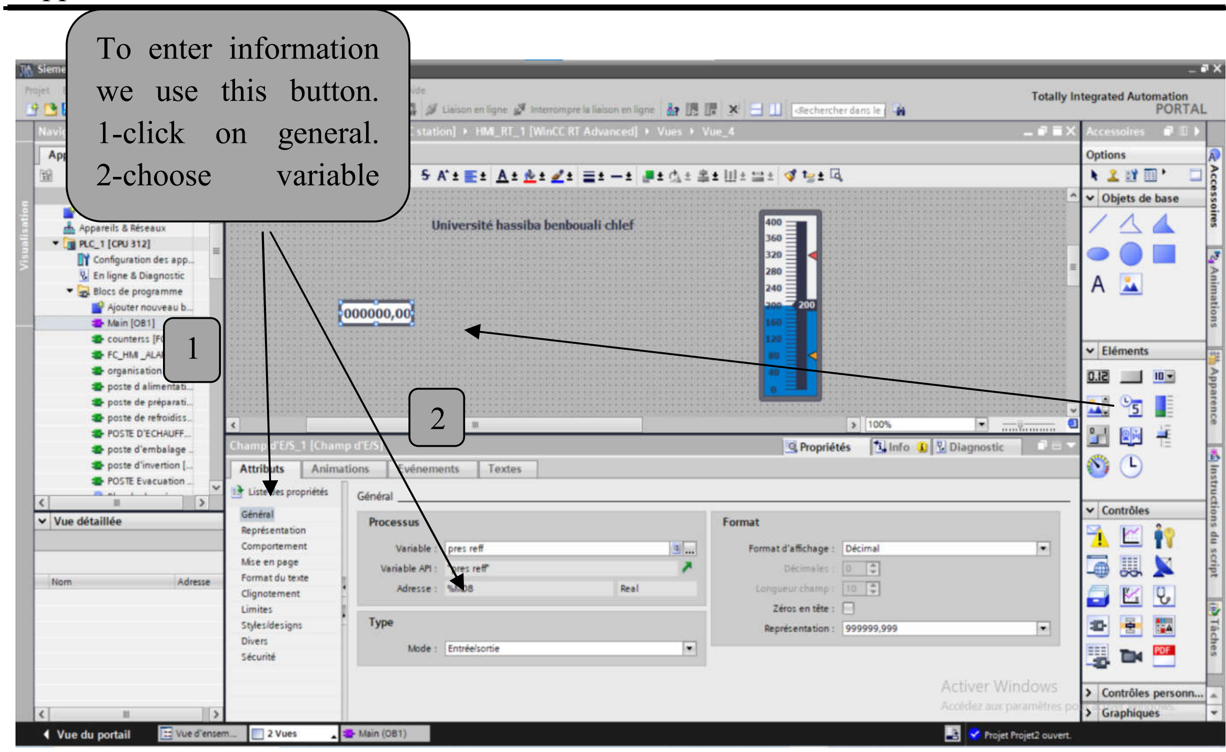


Figure I I.20: button of information.

B-9 In order to move from one screen to another.

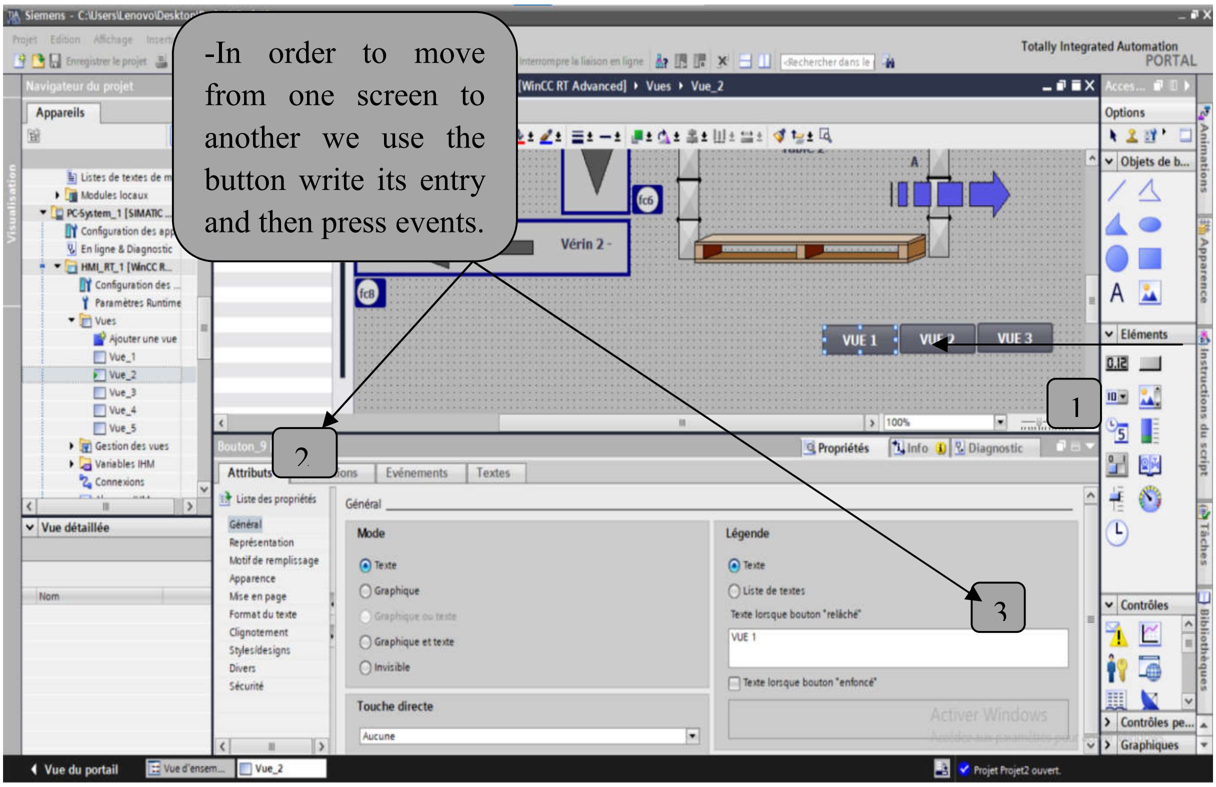


Figure I I.20: button of screen.

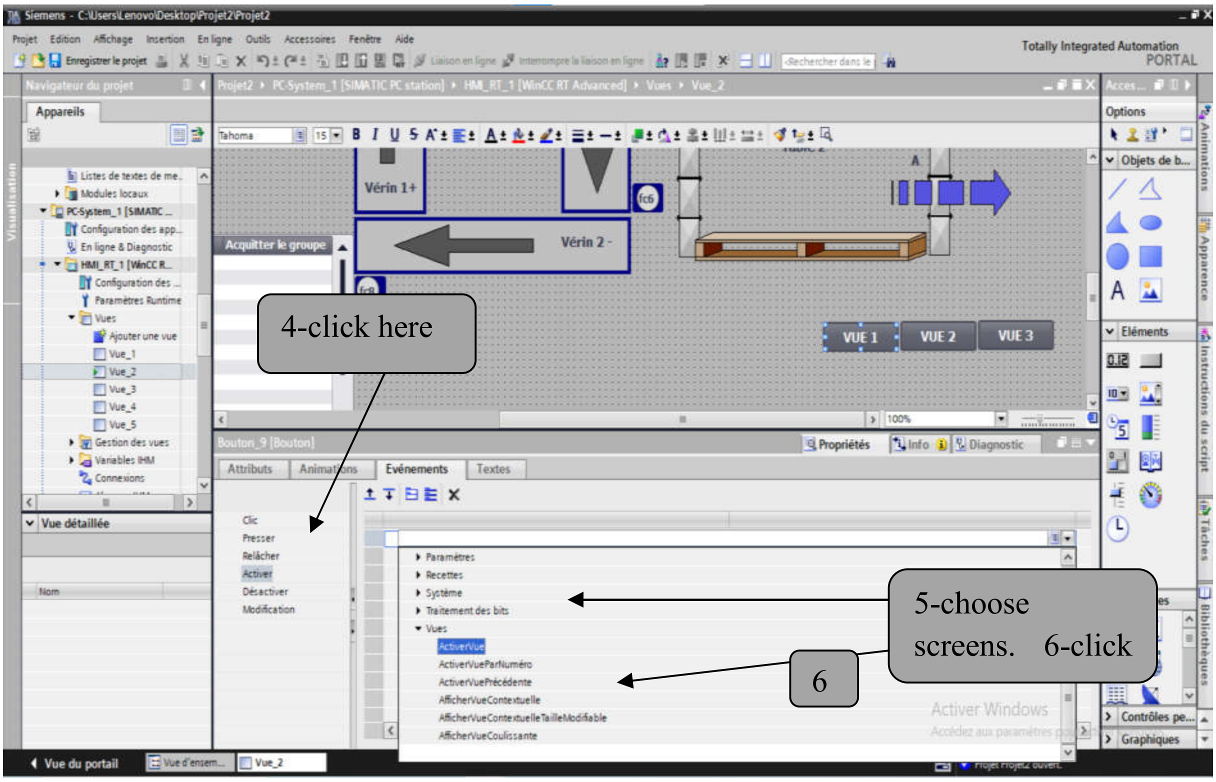


Figure I I.22: general screen.

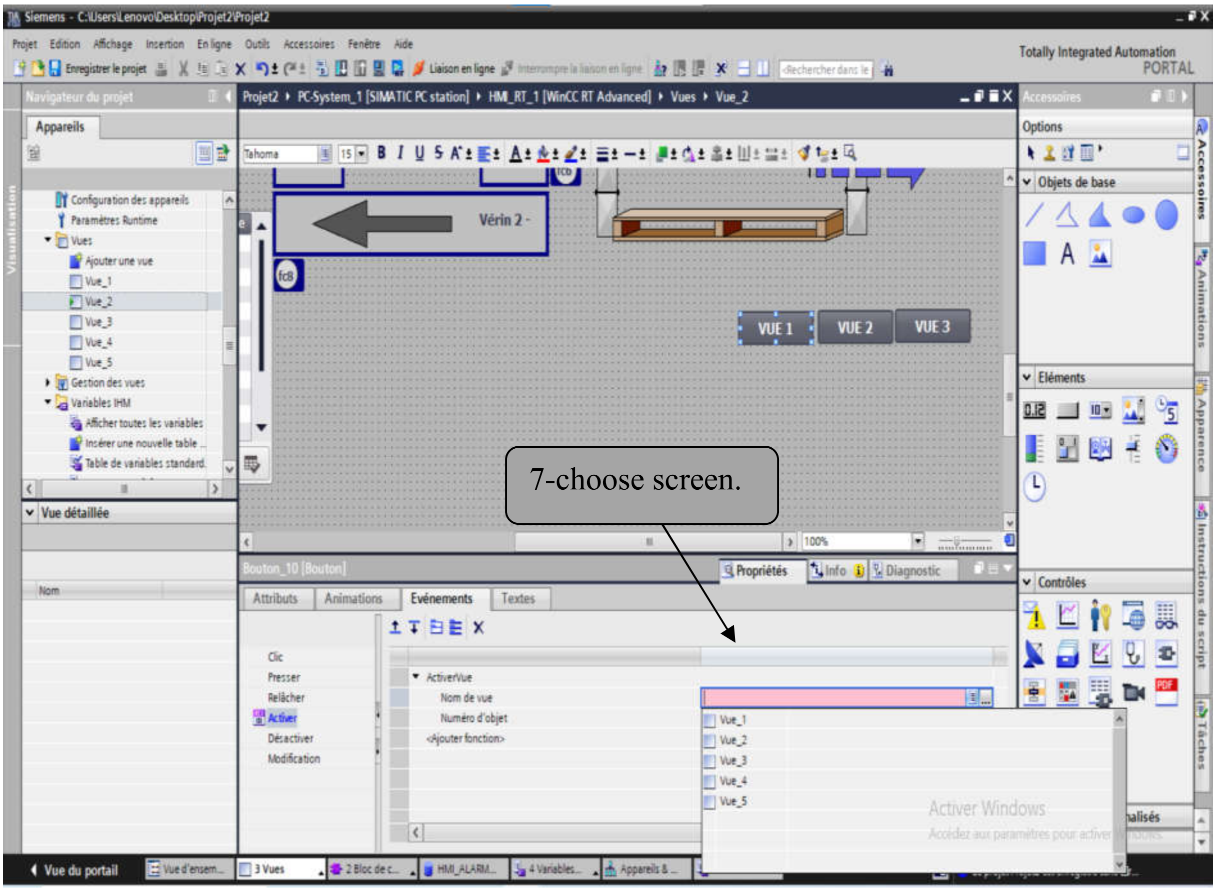


Figure I I.23: Enable screen.

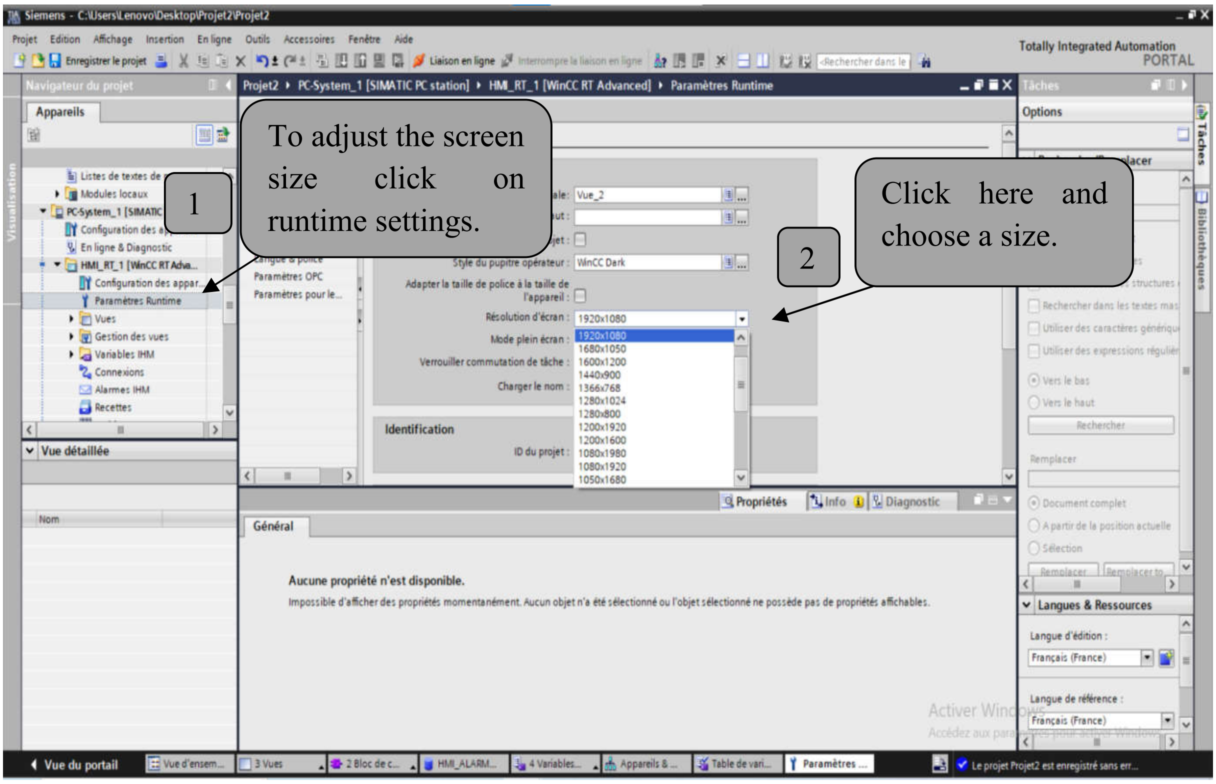


Figure I I.24: adjust the screen.

B-9 add data block.

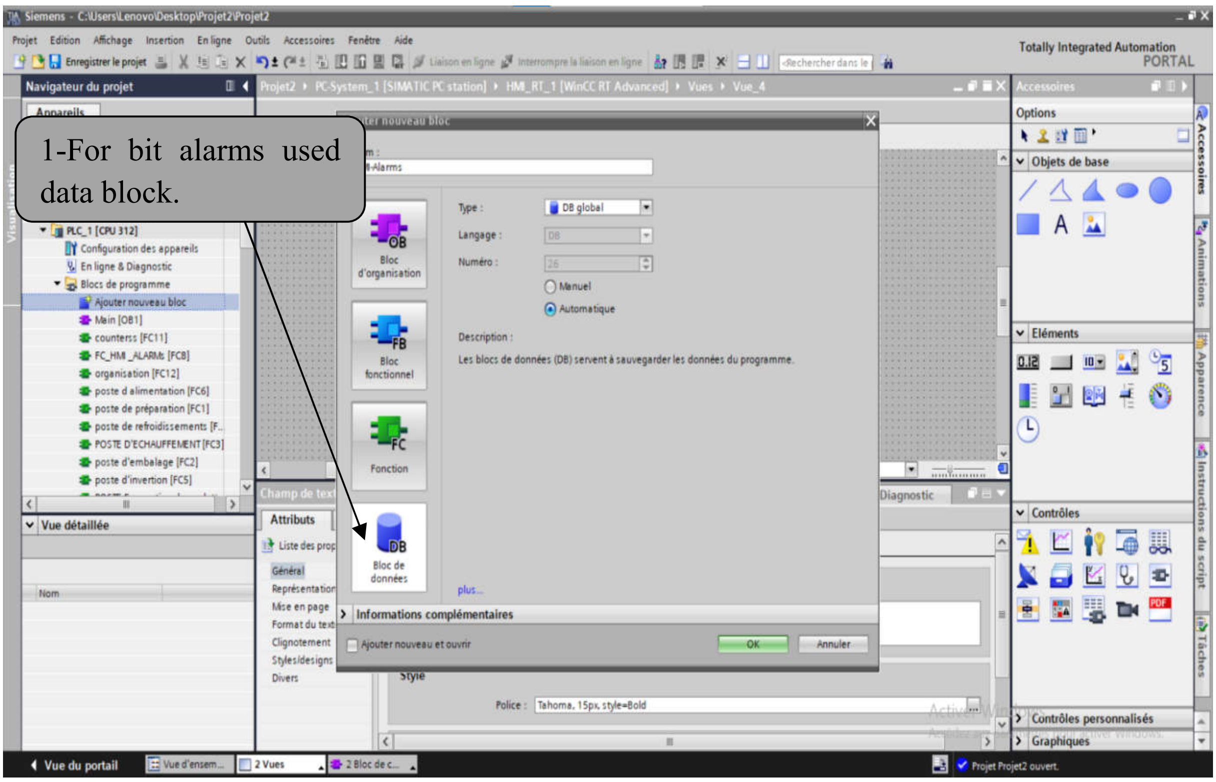


Figure I I.25: data block.

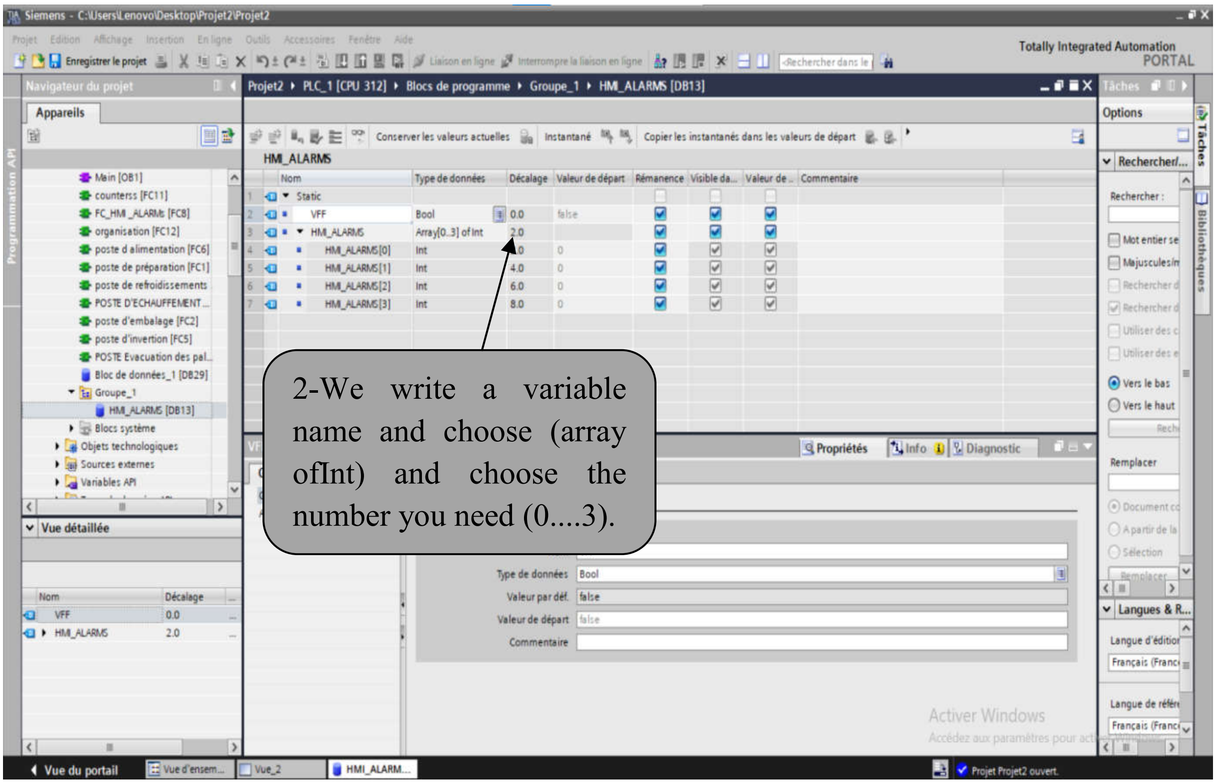


Figure I I.26: variable data block.

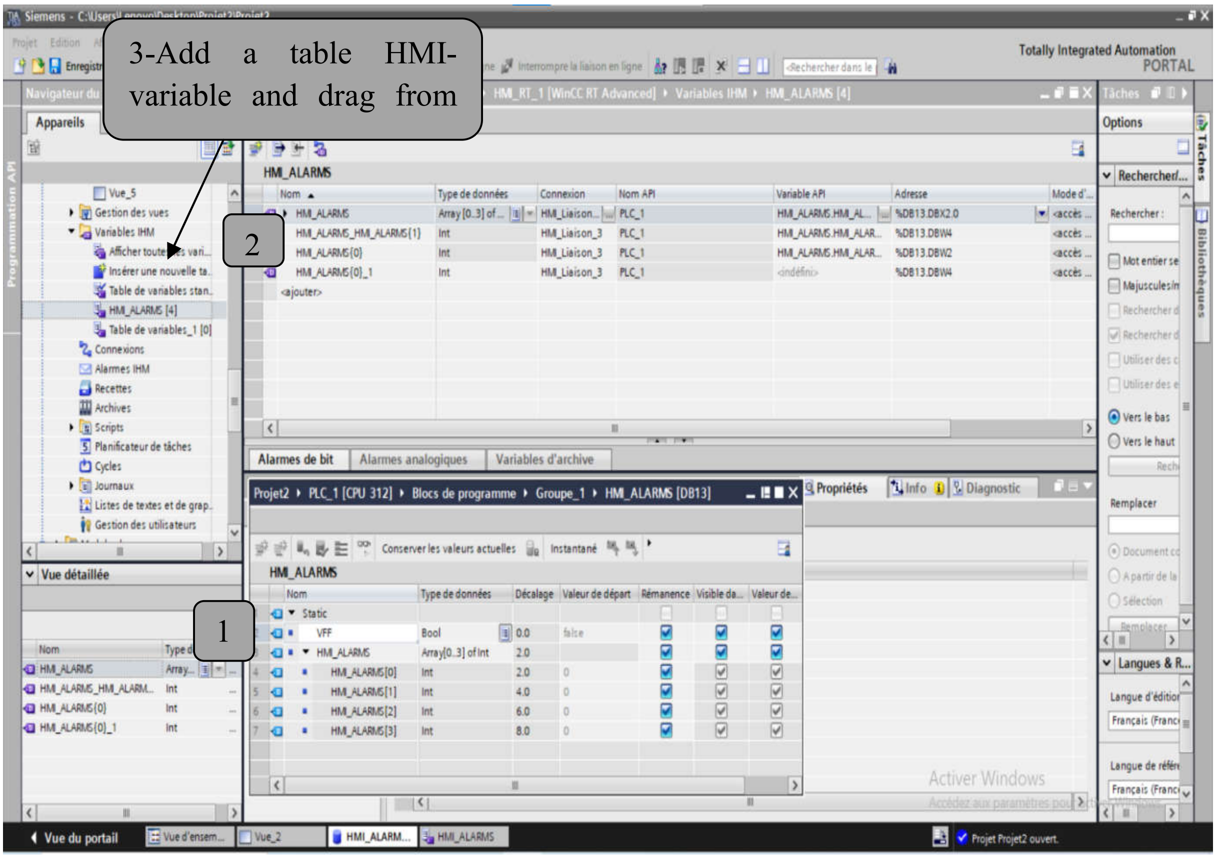


Figure I I.27: variable data block for HMI.

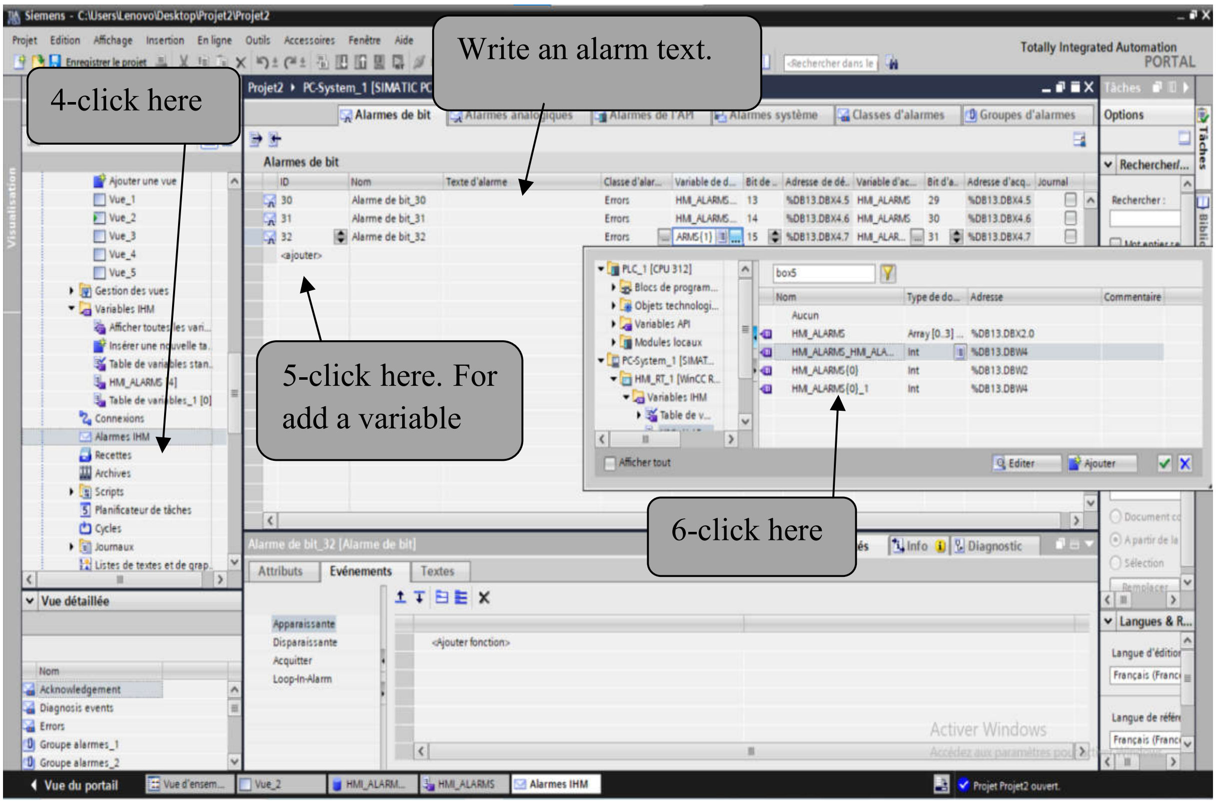


Figure I I.28: HMI alarm.

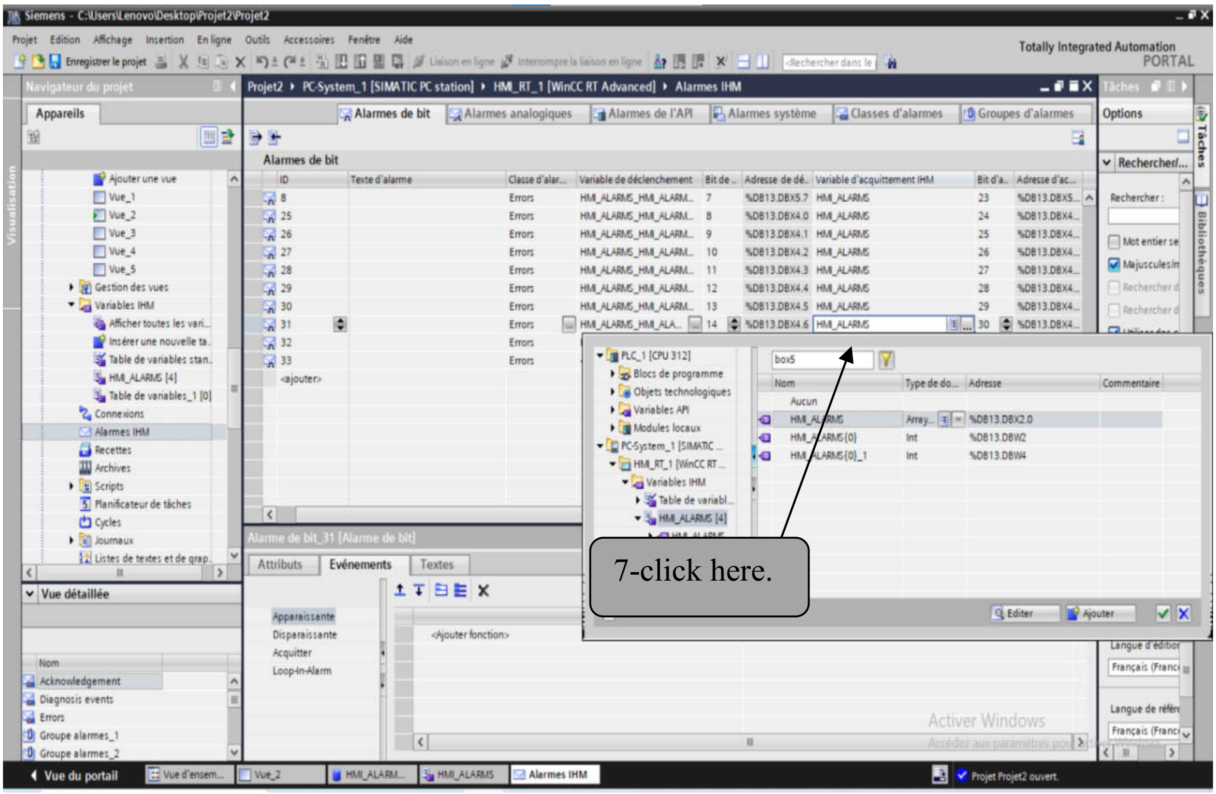


Figure I I.29: variable HMI alarm.

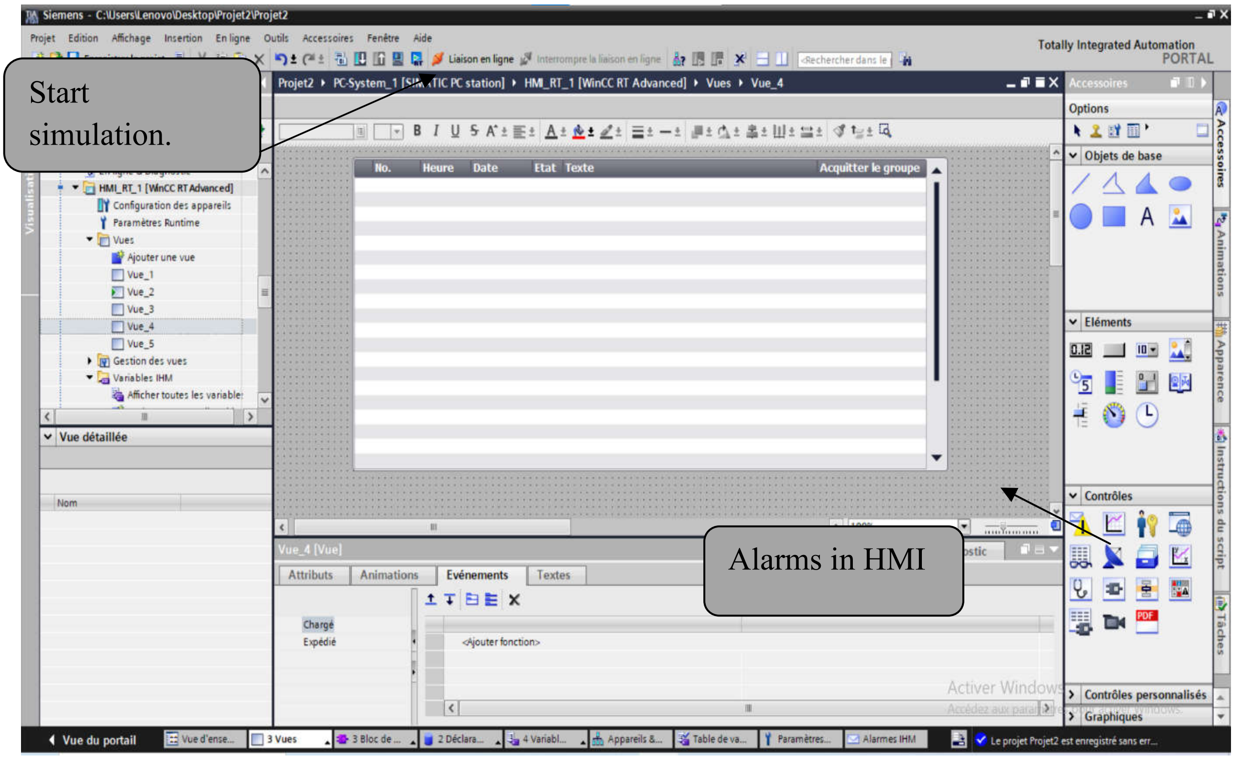


Figure I I.30: alarm of HMI.

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