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In: Automatic

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Subject:

Realization of a smart elevator using Schneider technology

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Dedications

We dedicate this work to our beloved parents, whose sacrifices, unwavering support, and heartfelt prayers have been our pillars of strength. Throughout our studies, their love and care have shaped us into who we are today. We hope this report will serve as a meaningful token of our gratitude.

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Abstract

In this work, a new solution to design smart elevators is proposed. The proposed solution is based on Schneider technology. So, **M221** Programmable Logic Controller (PLC) class has been selected. This PLC allows controlling the different functions of the smart elevator. The main functions of the elevator are reading elevator levels, door positions and data acquisition. When the operator selects a floor using the key board, the PLC reads the data and executes the desired outputs. Also, voice control is considered in the solution as a new option. Programming and management of the smart elevator is based on *EcoStruxure Machine Expert* software.

Résumé

Dans ce travail, une nouvelle solution pour concevoir des ascenseurs intelligents est proposée. Cette solution repose sur la technologie Schneider, et plus précisément sur le contrôleur logique programmable (PLC) de la classe M221. Ce PLC permet de gérer les différentes fonctions de l'ascenseur intelligent, notamment la lecture des niveaux de l'ascenseur, les positions des portes et l'acquisition de données. Lorsque l'utilisateur sélectionne un étage à l'aide du clavier, le PLC lit les données et exécute les sorties correspondantes. De plus, le contrôle vocal est envisagé comme une nouvelle option dans cette solution. La programmation et la gestion de l'ascenseur intelligent sont réalisées à l'aide du logiciel *EcoStruxure Machine Expert*.

الملخص

في هذا العمل، تم اقتراح حل جديد لتصميم المصاعد الذكية. يعتمد هذا الحل على تكنولوجيا شنايدر، وبالتحديد على المتحكم المنطقي القابل للبرمجة (PLC) من الفئة .M221 يتيح هذا المتحكم إدارة الوظائف المختلفة للمصعد الذكي، بما في ذلك قراءة مستويات المصعد، وضعية الأبواب، واكتساب البيانات. عند قيام المستخدم باختيار طابق معين باستخدام لوحة المفاتيح، يقوم المتحكم بقراءة البيانات وتنفيذ المخرجات المطلوبة. بالإضافة إلى ذلك، تم أخذ التحكم الصوتي بعين الاعتبار كخيار جديد في هذا الحل. تعتمد برمجة وإدارة المصعد الذكي على برنامج *EcoStruxure Machine Expert*.

General introduction

The world today is in continuous development in various scientific, industrial, mechanical, electronic and information fields. Today there are many automated systems that play an important role in the industrial field. The automated system always consists of a control part and an operating part. The control part is the one that gives orders and receives information from the outside, while the operating part is the part of the automated system that executes instructions.

The elevator is one of the lifting mechanisms that can be used to transport people, goods and patients in buildings, hospitals and other. Integration of new options in elevator technology is the objective of this work.

The organization of this work is given as follow

In chapter one the state of the art about elevators is presented. Hardware and software description is explained in chapter two. Design, realization, simulation and practical tests have been discussed in chapter three. In addition, results and discussions are given. Finally, a conclusion is given.

CHAPTER 1

STATE OF THE ART OF ELEVATORS

I.1 Introduction

Since ancient times, man has sought to improve the vertical movement of loads,It was in 1853 that the concept of the modern elevator was truly born; in the 1950s, the elevator was not very common and was considered a luxury item of equipment.

Indeed, in March 1857, Otis installed the first elevator for public use serving a 5-story building with a speed of 0.2m/s.

Since then, the technology used in building elevators has continued to develop, and indeed the field of elevators has witnessed a great development today and has become safer and more reliable.

I.2 Definition of an elevator

An elevator is a mechanical device used for transporting people or goods between different floors of a building. It typically consists of a cabin or platform that moves vertically along a shaft, controlled by a system of pulleys, cables, or hydraulic mechanisms.

I.3 Exploitation domains and types of elevators

Many people search for types of electric elevators and wonder what are the best types of elevators. There are many different types of elevators. The goal of using an elevator is always to provide comfort to residents or workers in the property, and ease and speed of transporting various goods and foodstuffs.[1]

Among these domains we mention:

Passenger elevator, Service elevator , Freight elevator, Dumbwaiter .

I.3.1 Passenger elevator

A passenger elevator is any elevator intended for the transport of people through a building. These elevators can vary drastically in terms of size, speed, and interior options depending on the use of the elevator. Figure I.1 present the passenger elevator[1]

Figure I.1. Passenger elevator

I.3.2 Service elevator

In industrial, residential, and commercial buildings, service elevators are often standard passenger elevator packages modified for service use. [15]

Figure I.2 present the service elevator

Figure I.2. Service elevator

I.3.3 Freight elevator

Usually classed as general freight loading, motor vehicle loading, industrial truck, or concentrated loading elevators. General freight loading elevators may be electric drum type or traction or hydraulic elevators. [15]

Figure I.3 present the freight elevator.

Figure I.3. Freight elevator

I.3.4 Dumbwaiter

A dumbwaiter is a small freight elevator. It is often used for the transport of food in restaurants. However, they can be found in both commercial and private buildings.

Figure I.4 present the Dumbwaiter

Figure I.4. Dumbwaiter

- Elevators are powered by different kinds of mechanisms. Here are the 4 most common models:

I.3.5 Traction Elevators

In traction elevators the cabin is moved using ropes that pass over a wheel, powered by a motor which is housed in the machine room, located above the elevator shaft. In order to limit the strain placed on the electric motor, a counter weight is used to exert an opposite force, making the lifting process more efficient. The advantages of traction elevators lies in the speed and high capacity potential they offer.[2]

Figure I.5 present the traction elevator

Figure I.5. Traction elevator

I.3.6 Machine Room-less (MRL) Elevators

The MRL elevator has become a popular choice for low-rise to mid-rise buildings. Whilst the elevator still works on a traction mechanism, the machine room is replaced by an override space at the top of the shaft which houses the machinery. The advantages of this system include the creation of a more usable space, 80% less energy usage than hydraulic systems, and an oil-free operating system.[2]

Figure I.6 present the MRL elevator

Figure I.6. MRL elevator

I.3.7 Hydraulic Elevators

The hydraulic elevator uses a piston mechanism to push the passenger cabin up and down in response to control buttons being pressed. The piston is powered by an electric motor which pumps hydraulic fluid into the piston as it ascends; the lift descends as the fluid is released. This elevator tends to be used in low-rise buildings, as it has limited reach and can only operate at low speeds.[2]

Figure I.7 present the Hydraulic elevator

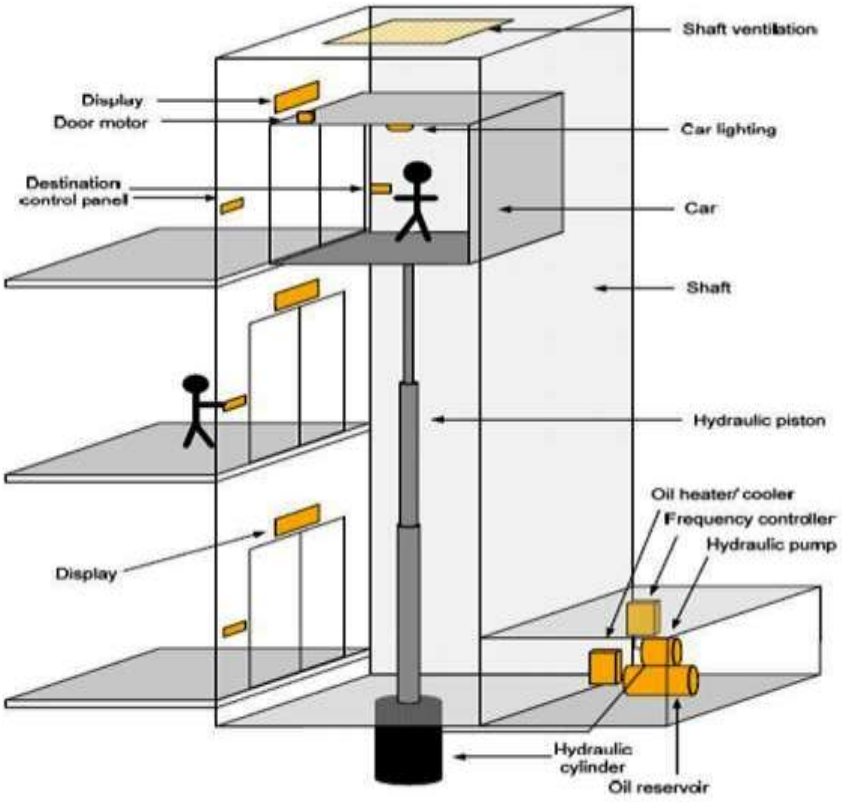


Figure I.7. Hydraulic elevator

I.3.8 Pneumatic Elevator

This kind of elevator is powered by a vacuum placed above the passenger cabin and a valve positioned at the apex of the shaft. The valve is closed to pull the cab upwards, and opened to allow the cabin to descend. The vacuum pump turbine in round which determines the pneumatic elevator design, and the shaft is made of acrylic. This kind of elevator can only carry 1-3 passengers at a time.[2]

Figure I.8 present the pneumatic elevator

FigureI.8. Pneumatic elevator

I.4 Electric elevator components

The components of the electric elevator are many and work as one unit to ensure the proper operation of the elevator, and these are the most important components:

- **Cabin**

The cabin is the enclosed space inside the elevator where people or goods are transported. It's the part you stand in when you ride the elevator. [5]

- **Ropes**

These are strong cables that are attached to the elevator cabin and looped over a sheave (a pulley) at the top. The ropes are what move the elevator up and down. [5]

- **Over speed Governor**

The over speed governor is a safety device that prevents the elevator from moving too fast.

- **Traction Machine**

In an elevator system with ropes, a traction machine is needed to pull the cabin up and down. With the power of the contention machine.[4]

➢ Drive Unit

The drive unit is also known as the control system of the elevator. It is a system that controls up and down movement. It is usually located in the elevator machine room. [4]

➢ Hoist way

The hoist way is used for the up-and-down movement of the elevator. This elevator component is important because it has gaps between the walls and floors, and the elevator can move safely in this way.

➢ Cabin Buffer

Buffers are an apparatus designed to protect the people inside the elevator from a possible accident and are located at the bottom of the elevator.[4]

➢ Counter weight

Elevator cars are balanced by heavy counter weight that weigh the same amount as a car when it's loaded about 50%. This helps put less strain on the cables which makes the elevator safer to operate. [6]

➢ Safety Systems

elevators are very safe vehicles, especially for passengers, because they are designed with a number of safety systems. These systems, which are activated in extraordinary situations, generally have an accident-preventing role. For example, If the cabin has received a load greater than its capacity, the overload protection is activated. This protection system automatically detects that the elevator is overloaded and stops working. Also, there is an emergency communication system inside the elevator, and this system is used for any breakdown. [4]

I.5 The importance of elevators

- Facilitates the movement of people and goods between different floors.
- Accessibility for people with special needs and the elderly.
- Improves the usability of buildings for everyone.
- Save time, energy and space and maximise comfort, security and possibility for users.

I.6 Conclusion

In this chapter, we have provided a brief overview of what an elevator is. We have also provided its most common uses and components, and we have added its advantages.

CHAPTER 2

SOFTWARE AND HARDWARE PRESENTATION

II.1 Introduction

In this chapter, we'll dive into the essential software and hardware components that make up the smart elevator system. After exploring the state of art of elevator technology in Chapter 1, it's time to focus on the tools and technologies we're using to bring this system to life. The M221 Schneider controller is at the core, handling all the main processes that control the elevator's movement and functionality. Alongside it, the Arduino Uno plays a key role in facial recognition, which adds a layer of security and personalized access. We're also using a Human-Machine Interface (HMI) to simulate the entire process, making it easy to monitor the system and manage security features in real-time.

Additionally, sensors and actuators, like motors and position detectors, are used to ensure the elevator runs smoothly and safely. Each of these components is carefully chosen to work together, creating a fully automated and secure system. This chapter will explore each component's functionality, interaction, and the software required to manage them, providing a comprehensive understanding of the system's architecture.

II.2 Schneider M221controller 16 IO transistor PNP Ethernet

II.2.1Controller description

The Schneider Electric Modicon M221 programmable logic controller (PLC) is a compact and cost-effective solution for controlling, automating small to medium-sized machines and processes like our process of the smart elevator. The PLC provides reliable performance and flexibility in a compact form factor. The M221 PLC is designed to be energy-efficient, helping to reduce power consumption and operational costs in processes and industrial automation applications and that's one of our objectives. Concerning programming it can be easy to configure it using Schneider Electric's use EcoStuxure MACHINE EXPERT software, which offers a user-friendly interface for creating and editing logic control. Figure II.1 shows M221 PLC [10].

Figure II.1. Schneider M221 controller [10]

II.2.2M221 controller Characteristics:[10]

1. Product Overview

Model	M221CE16T
Series	Modicon M221
Type	Programmable Logic Controller (PLC)
Mounting Type	DIN rail or panel mounting
Processor	32-bit

Tab II.1. Product Overview

2. Power Supply

Voltage	24V DC

Tab II.2. Power Supply

3. I/O Configuration

Total I/O	16
Digital Inputs	9
Digital Outputs	7 (Transistor) 2 fast outputs

Tab II.3. I/O Configuration

4. Communication Ports

Ethernet	1x RJ45 (10/100 Mbps)
Serial Ports	1x RS232/RS485
USB Port	1x Mini-B (for programming)

Tab II.4. Communication Ports

5. Supported Programming Languages

- Ladder Diagram (LD)
- Function Block Diagram (FBD)
- Structured Text (ST)
- Instruction List (IL)
- Sequential Function Chart (SFC)

6. Memory

Program Memory	256 KB
Data Storage	64 KB
Flash Memory	Non-volatile (for program storage)

Tab II.5. Memory

7. Performance

Cycle Time	0.2 ms per instruction (approx.)
Maximum I/O Expansion	Supports up to 7 TM3 modules

Tab II.6. Performance

8. Environmental Specifications

Operating Temperature	-10°C to +55°C
Storage Temperature	-40°C to +70°C
Protection Rating	IP20

Tab II.7. Environmental Specifications

9. Special Features

Embedded Web Server	For remote monitoring and control
Built-in Real-Time Clock	
Compact Design	Ideal for small automation tasks
Expandability	Compatible with Modicon TM3 expansion modules

Tab II.8. Special Features

10. Certifications

- CE
- UL
- Other international standards

II.2.3 Characteristics

Compact Size	Suitable for space-constrained applications.
Ethernet Communication	Easy connectivity and integration with other devices.
High Performance	Fast processing speeds for quick response times.
Modular Design	Expandable and customizable with additional I/O modules.
Built-in Functions	Digital and analog I/O, high-speed counters, and pulse outputs.

Tab II.9. Characteristics

II.2.4 Cabling:

- **Power Supply:** Connect a 24VDC power source to the PLC's power input terminals.
- **Inputs and Outputs:** Connect sensors, actuators, and other devices to the digital and analog input/output terminals as required.
- **Ethernet Communication:** Connect the PLC to an Ethernet network using a standard Ethernet cable.
- **Programming**: we use EcoStuxure MACHINE EXPERT software to program the PLC and configure the communication settings.

By following these cabling instructions and utilizing the features and characteristics of the Schneider Electric Modicon M221 PLC, we can effectively control and automate our smart elevator.

II.2.5 Smart Elevator control using M221 Controller

In the smart elevator system, the **M221 Schneider Controller** is responsible for managing the system functioning, ensuring that all system operations are executed easy and efficiently. The controller coordinates the actions of the elevator's motors, sensors, and actuators, ensuring precise movement between floors and handling safety mechanisms.

The M221 interacts directly with the GTO2310 HMI, allowing the operator to monitor and adjust the elevator's settings through the HMI interface. It also processes data from the facial recognition system (handled by the Arduino Uno), managing access control and ensuring that the elevator responds appropriately to authorized users.

Additionally, the M221 controls the elevator's speed, door operations, and floor selection, making it central to the system's automation. Its ability to handle inputs from sensors (such as position detectors) and execute real-time instructions ensures a safe and efficient operation. With its scalability and communication capabilities, the M221 ensures that the elevator is flexible, responsive, and easy to manage.

II.3 Human Machine Interface GTO2310 HMI

II.3.1 Description of the GTO2310 HMI:

The **GTO2310 Human-Machine Interface (HMI)** is a highly versatile and user-friendly interface designed for industrial control systems. It allows operators to interact with machines, monitor system parameters, and manage processes in real-time. The GTO2310 model stands out for its high-resolution display, compact design, and easy integration with a wide range of controllers. Its touchscreen capability makes it intuitive, providing operators with a seamless experience when controlling or configuring systems.

This HMI is designed with a focus on both durability and clarity, ensuring that it can handle demanding industrial environments while offering a clear, responsive interface for users. [10]

Whether used for simple control tasks or more complex process management, the GTO2310 is reliable and adaptable to various needs.

II.3.2 GTO2310 HMI Datasheet:

Key specifications of the **GTO2310 HMI** include:

- **Display Size**: 7.5 inches, TFT LCD with 800x480 resolution.
- **Touchscreen**: Resistive type, supporting easy and precise input.
- **Communication Interfaces**: RS232, RS422/485, Ethernet, USB for peripheral connections.
- **Memory**: 128 MB Flash, 64 MB RAM, ensuring smooth operation and enough storage for configurations.
- **Operating Temperature**: -10°C to +50°C, suitable for a wide range of industrial environments.
- **Ingress Protection**: IP65 front panel, ensuring protection against dust and water, which is essential for durability in harsh conditions.
- **Power Supply**: 24V DC, making it compatible with most industrial power setups.
- **Certifications**: CE, UL, and RoHS compliant, ensuring it meets global safety and environmental standards.[10]

These specs underline the GTO2310's capability to handle high-performance tasks in an industrial setting while maintaining reliability and ease of use.

Figure II.2 present the GTO2310 HMI

Figure II.2. GTO2310 HMI

II.3.3 Applications of the GTO2310 HMI

The **GTO2310 HMI** finds use in a variety of industrial applications, from manufacturing processes to automation in different sectors. Its ability to connect seamlessly with controllers like PLCs (Programmable Logic Controllers) makes it an essential tool in monitoring and controlling automated systems.

In manufacturing, it can be used to monitor machine performance, set parameters, and quickly respond to system alerts. In energy management systems, it helps visualize power flows and control energy distribution. The GTO2310 is also commonly used in transportation systems,

building automation, and industrial safety systems, offering an intuitive and centralized control interface.

II.3.4Cabling for the GTO2310 HMI

1. **Power Supply**: The HMI operates on **24V DC**, requiring properly rated **2-wire shielded cables** (typically 1.5mm² or 16 AWG) for reliable power.
2. **Communication**:
   - **Ethernet**: Use **CAT5e/CAT6 Ethernet cables** for high-speed communication with the M221 controller or network.
   - **RS232/RS422/485**: Use **shielded serial communication cables** for direct serial communication, ensuring the proper pin configuration (TX, RX, GND).
   - **USB**: For programming or peripherals, use standard **USB 2.0 cables**.
3. **Grounding and Shielding**: Proper grounding and shielding of cables are necessary to prevent electrical noise and ensure reliable data transmission.

II.3.5 Role of the GTO2310 in Our Smart Elevator Process:

In our smart elevator system, the **GTO2310 HMI** plays a pivotal role in providing both simulation and real-time control. It serves as the primary interface for operators to monitor the system's status, visualize the elevator's movements, and manage security features such as facial recognition. The HMI enables easy access to system parameters, floor selection, and fault detection, ensuring that the elevator operates smoothly and safely.

The touchscreen interface allows for quick configuration of system settings, making it simple to adjust operational parameters or respond to issues. By integrating the HMI with the M221 Schneider controller, the GTO2310 ensures that the elevator's movements are coordinated effectively, offering a clear and responsive interface for both simulation and live control. This integration greatly enhances the elevator's user-friendliness and security management, making it an indispensable part of the overall system.

II.4 EcoStruxure Machine Expert Software

II.4.1Software description [10]

(Formerly known as SoMachine) is an advanced software platform developed by Schneider Electric for the programming, configuration, commissioning, and maintenance of industrial automation systems, particularly those using **Modicon PLCs**, **HMI**, **drives**, and **servo systems**. It is designed to support all phases of a machine's lifecycle, from design and engineering to operation and maintenance, within a single integrated environment.[10]

Figure II.3 present the EcoStruxure MACHINE EXPERTsoftware Interface

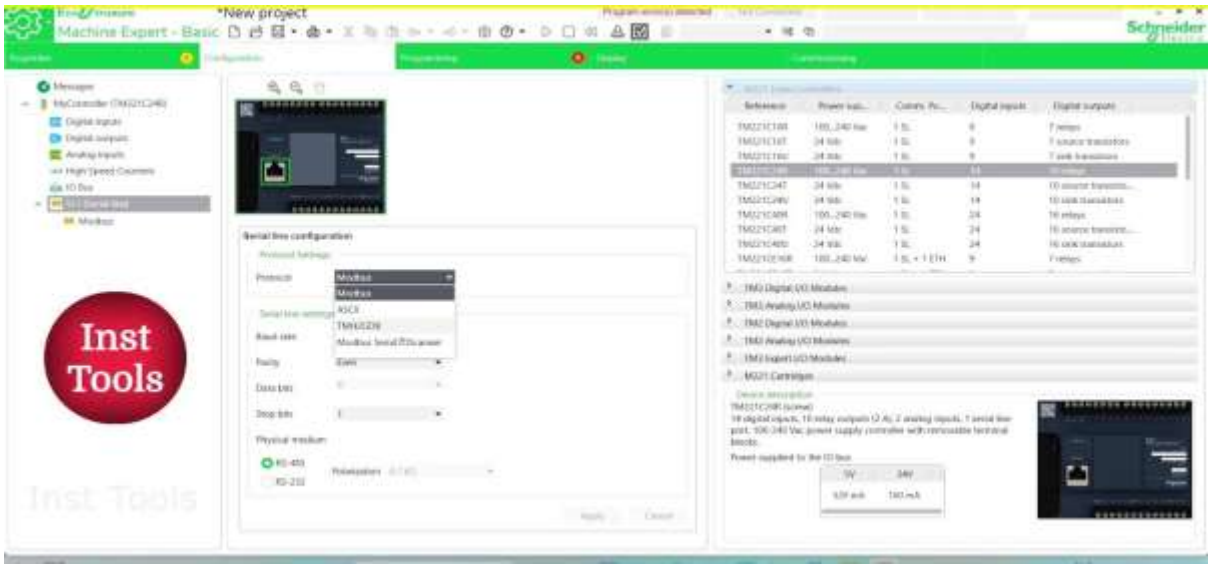


Figure II.3. EcoStruxure MACHINE EXPERT software Interface

II.4.2 Key Features [10]

1. **Integrated Development Environment (IDE)**
   - Provides a unified platform for programming, debugging, and configuration, supporting various Schneider Electric devices like Modicon PLCs, HMIs, and servo drives.
2. **Multi-Programming Language Support**

   Conforms to **IEC 61131-3** standards, allowing programming in multiple languages:

   - Ladder Diagram (LD)
   - Structured Text (ST)
   - Function Block Diagram (FBD)
   - Instruction List (IL)
   - Sequential Function Chart (SFC)
3. **Device Configuration**:
   - Simplifies the configuration of different components (PLCs, HMIs, drives) using predefined libraries and templates.
4. **Automation Libraries**:
   - Offers a wide range of pre-built function blocks and libraries to speed up development, including safety libraries and motion control modules.
5. **Graphical User Interface**:
   - Intuitive and user-friendly, allowing for easier project navigation, component selection, and system visualization.
6. **Simulation & Diagnostics**:
   - Provides simulation tools for offline testing of the program before deployment and offers powerful diagnostic tools for troubleshooting and monitoring system performance.
7. **Fieldbus& Communication Protocols**:

- Supports multiple industrial communication protocols, such as Modbus TCP/IP, Ethernet/IP, CANopen, and PROFIBUS, ensuring interoperability with a wide variety of devices.

8. **Version Control & Project Management**:
   - Integrates version control systems to track changes and manage project revisions efficiently, offering collaboration capabilities across teams.
9. **Scalability**:
   - Suitable for a range of applications, from simple standalone machines to more complex, interconnected systems with multiple devices.
10. **EcoStruxure Integration**:
    - As part of Schneider Electric's **EcoStruxure architecture**, it allows seamless integration with the larger EcoStruxure platform for IIoT (Industrial Internet of Things), offering cloud connectivity, data analytics, and remote monitoring.

II.4.3 Applications:

- Used in machine automation projects for sectors like packaging, material handling, robotics, and general manufacturing.
- Optimized for creating highly efficient, flexible, and connected machines with enhanced diagnostics and remote access.

II.5 Vijeo Designer 6.2 SP13Software

II.5.1 Software description:[14]

Vijeo Designer 6.2 SP13 is a powerful software tool used for developing Human-Machine Interface (HMI) applications, commonly in industrial automation. It provides a user-friendly environment for designing, configuring, and simulating operator interfaces that control machines or processes. The software is part of Schneider Electric's EcoStruxure suite, designed to integrate with various hardware like the M221 controller that we are using in our smart elevator project.

II.5.2 Key Features of Vijeo Designer 6.2 SP13[14]

1. **User Interface Design**: Vijeo Designer allows the creation of custom HMI screens with interactive components such as buttons, indicators, gauges, and alarms. These can be used to monitor the real-time state of the elevator system, such as its current floor, door status, and error alerts.
2. **Controller Communication**: Vijeo Designer seamlessly integrates with the M221 Schneider PLC, facilitating smooth data exchange between the controller and HMI. In our smart elevator, this means that the PLC can send sensor and actuator data to the HMI, and operators can input commands via the HMI, such as floor selection or maintenance mode activation.
3. **Alarm Management**: The software supports advanced alarm monitoring, which can be useful for your smart elevator system. Alarms can be configured for various system states like door malfunctions, overload, or power failures. These alerts can be displayed on the HMI, allowing operators to respond quickly.
4. **Data Logging and Trending**: It offers tools for logging operational data and displaying trends over time. In the context of your smart elevator system, this feature

can be used to track usage patterns, monitor performance, and troubleshoot issues based on historical data.

5. **Simulation and Debugging**: Vijeo Designer provides simulation capabilities, allowing you to test and debug the elevator HMI without deploying it on the actual hardware. This is particularly helpful in refining the user interface and ensuring that all controls and indicators behave as expected before integrating with the M221 controller.
6. **Remote Access**: With the Vijeo Web Server feature, operators can monitor and control the elevator system remotely through a web browser. This can be useful for maintenance personnel who may need to check the system's status without being physically present.

Figure II.4 present the Vijeo Designer 6.2 SP13 Interface

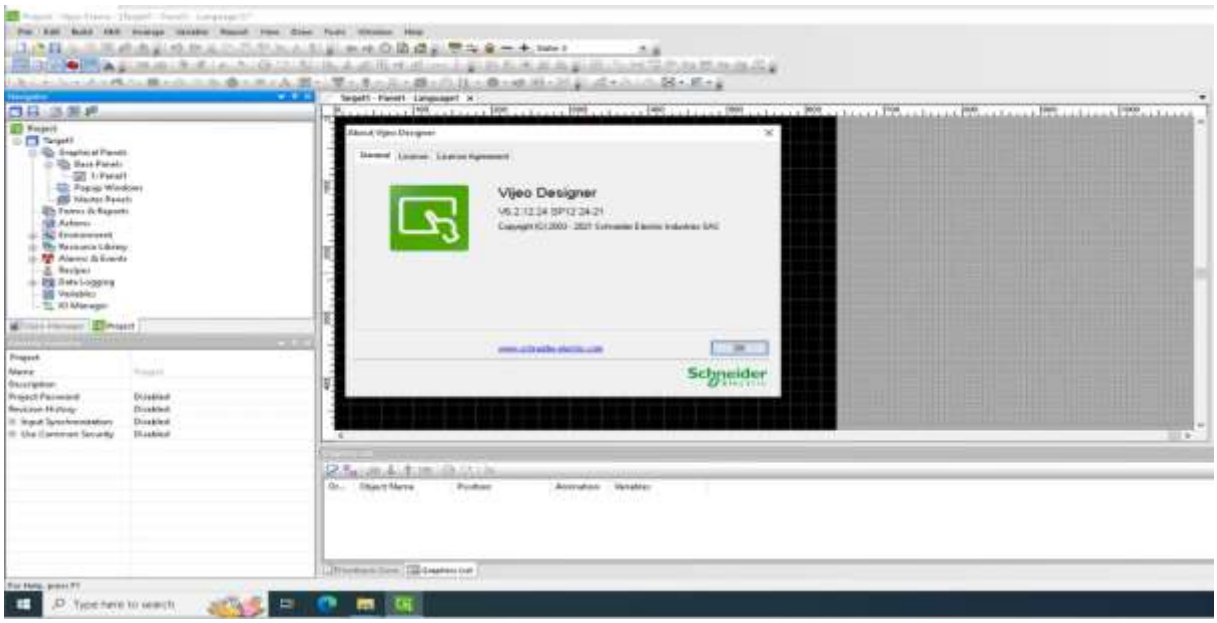


Figure II.4. Vijeo Designer 6.2 SP13 Interface

II.5.3 Application in our Smart Elevator Project

Vijeo Designer 6.2 SP13 is specialized software used for programming Human-Machine Interfaces (HMIs). In our smart elevator project, we are utilizing this software to design and program the interface that will display and manage the elevator’s functions.

In our project, Vijeo Designer 6.2 SP13 serves as the bridge between the operator and the underlying control system (M221 + Arduino). It allows for the creation of a user-friendly interface that visually represents the real-time state of the elevator. we can display floor levels, facial recognition statuses from the Arduino system, and the overall system's health. The HMI can also provide critical system feedback to users, including error messages or system warnings, enhancing the elevator's security and operational efficiency.

II.5.4Other components and accessories

- **WM07C Brushed Motor [7]**
  - The world's first standard front wiper module that uses a 4-pole brushed wiper motor.
  - Regarded as the world's top class compact wiper module because of the optimization of the electromagnetic circuit of the motor and the highly efficient deceleration mechanism

In our elevator system, the **WM07C motor** is repurposed to handle the movement mechanism. Leveraging the motor's torque output and durability, it operates as the main drive to lift or lower the elevator cab between floors. By integrating the WM07C with the M221 Schneider controller, the motor's motion is precisely managed, ensuring controlled, consistent movement and stopping at each floor. Figure II.5 present the WM07C Brushed Motor

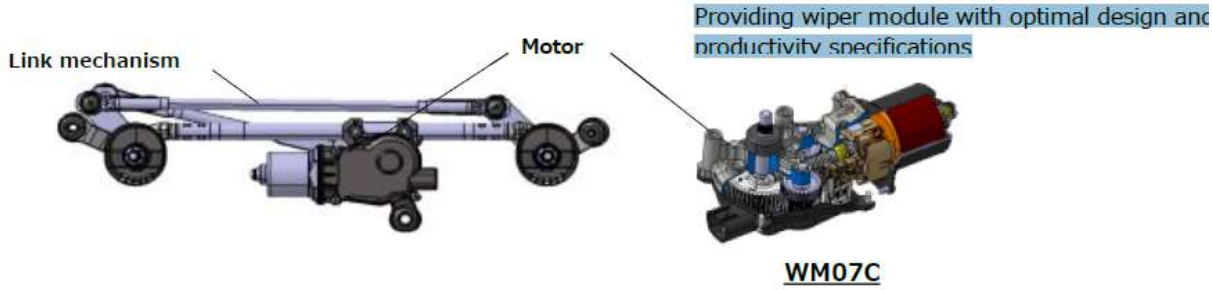


Figure II.5. WM07C Brushed Motor

- **V-152-1C25 LIMIT SWITCH [8]**

Contact Type	SPDT 1NO 1NC
Actuator Type	Push Button
Max. Overload Current	15A 250VAC
Switch Body Size (Each)	4 x 2.3 x1.1cm/1.6" x 0.9" x 0.43"(L*W*T)
Fixing Holes Diameter	3.5mm / 0.14"

Tab II.10. V-152-1C25 LIMIT SWITCH Data sheet

Figure II.5 present the V-152-1C25

Figure II.6. V-152-1C25

The **V-152-1C25 limit switch** plays an essential role in controlling and safeguarding our elevator system. Here's a breakdown of its function:

The V-152-1C25 limit switch can act as a position sensor within the elevator mechanism, helping the system detect specific points, like the top and bottom limits of the elevator's travel. When the elevator reaches a floor or end position, the switch can trigger a response, either stopping the elevator or reversing its direction.

This switch enhances safety by preventing the elevator from moving beyond intended points, which could lead to mechanical damage or unsafe conditions. It effectively helps ensure that the elevator motor only operates within a specified range, acting as a failsafe in case of control errors. In automated control systems, the V-152-1C25 limit switch provides feedback to the PLC (like the M221 Schneider controller) about the elevator's position, enabling coordinated actions such as opening and closing doors only when the elevator is properly aligned with a floor.

- **4 Pole ice cube relay [13]**

Poles	4
Pins	14
Coil Voltage	24VDC
Termination	Plug-in
Ambient Temperature	-40°F - 158°F (-40°C - 90°C)
Outline Dimensions	28.0mm x 21.3mm x 35.2mm

Tab II.11. 4 Pole ice cube relay Data sheet

Figure II.7 present the 4 Pole ice cube relay

Figure II.7. 4 Pole ice cube relay

In our elevator system, the **4-pole ice cube relay** acts as a critical component for managing and isolating electrical signals within different parts of the control system. Here's a quick breakdown of its role:

1. **Signal Isolation and Switching**: The 4-pole relay can isolate multiple electrical signals, providing a safe way to control high-power circuits using low-power signals from the M221 controller or other components. Each pole (or contact) can manage a separate circuit, allowing for multi-functional control.
2. **Multi-Point Control**: The relay can operate multiple devices simultaneously (up to four circuits) with a single input, which is useful in systems requiring coordinated actions, such as opening and closing elevator doors, activating safety locks, or controlling indicator lights.
3. **Safety and Fault Protection**: Ice cube relays provide a reliable way to handle power surges or faults, adding an extra layer of safety. If there's a failure in one section, the relay can isolate the problem to prevent it from affecting other parts of the system.

This relay is compact, versatile, and often easy to replace, making it ideal for industrial applications like elevators where space is limited but reliable control is essential.

- **HC-05 -Bluetooth Module [11]**

  HC-05 module is an easy-to-use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. Serial port Bluetooth module is fully qualified Bluetooth V2.0+EDR (Enhanced Data Rate) 3Mbps Modulation with complete 2.4GHz radio transceiver and baseband. It uses CSR Bluecore 04-External single chip Bluetooth system with CMOS technology and with AFH(Adaptive Frequency Hopping Feature). It has the footprint as small as 12.7mmx27mm. Hope it will simplify your overall design/development cycle. Specifications.[11]

Figure II.8 present the HC-05 -Bluetooth Module

FigureII.8. HC-05 -Bluetooth Module

1. **Hardware features**

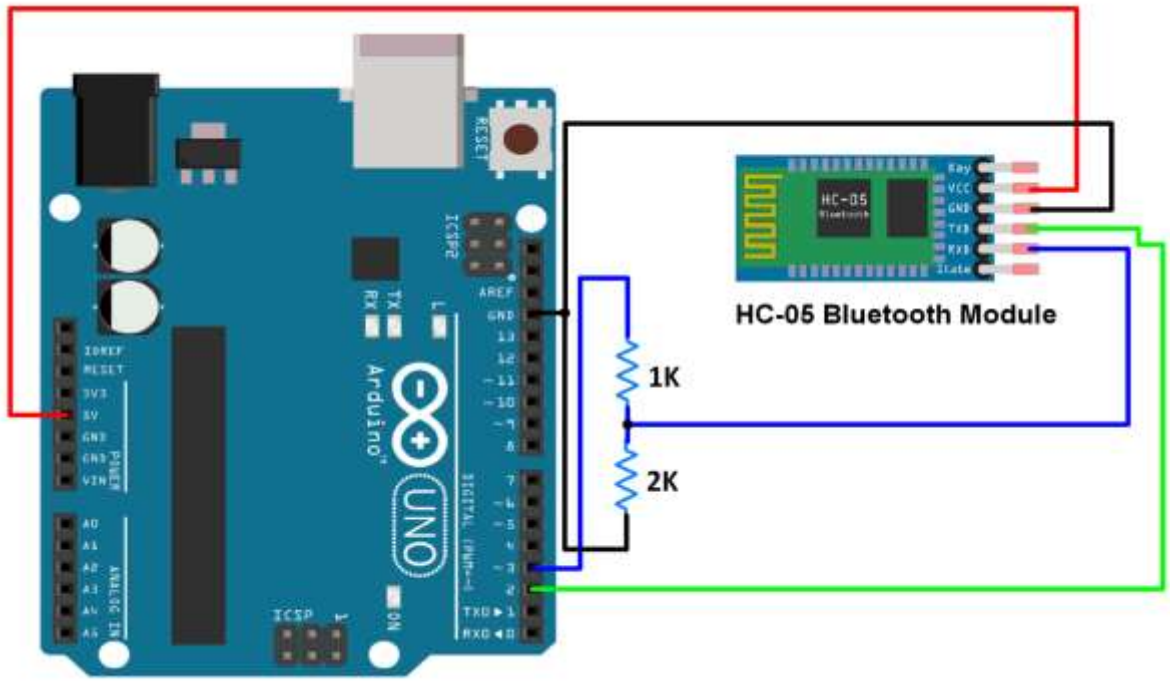
   - Typical -80dBm sensitivity
   - Up to +4dBm RF transmit power
   - Low Power 1.8V Operation ,1.8 to 3.6V I/O
   - PIO control
   - UART interface with programmable baud rate
   - With integrated antenna with edge connection

2. Role and Arduino communication

With the addition of voice commands, the HC-05 Bluetooth module in our smart elevator project serves as a wireless communication link between the Arduino and external devices, enhancing interaction and accessibility. Through the HC-05, we can connect via Bluetooth, allowing voice commands (e.g., “go to floor 2” or “open door”) to be sent from a smartphone or compatible device to the Arduino. The Arduino processes these commands and communicates them to the M221 controller or directly activates outputs like moving the elevator to a specified floor or opening doors.

This functionality provides a hands-free operation option, which is especially valuable for accessibility. Additionally, with the HC-05, real-time data exchange becomes possible; for instance, the Arduino could relay voice command feedback through the HMI, confirming actions like "floor selected" or "door opening." This feature makes the elevator more interactive, secure, and user-friendly.

Figure II.9 present the Communication HC-05 with Arduino uno



FigureII.9. Communication HC-05with Arduino uno [11]

- **2 Channel 5V Relay Module**

This is a LOW Level 5V 2-channel relay interface board, and each channel needsa15-20mA driver current. It can be used to control various appliances and equipment with large current. It is equipped

with high-current relays that work under AC250V10A or DC30V 10A. It has a standard interface that can be controlled directly by micro-controller.[12]

Figure II.10 present the 2 Channel 5V Relay Module

FigureII.10. 2 Channel 5V Relay Module

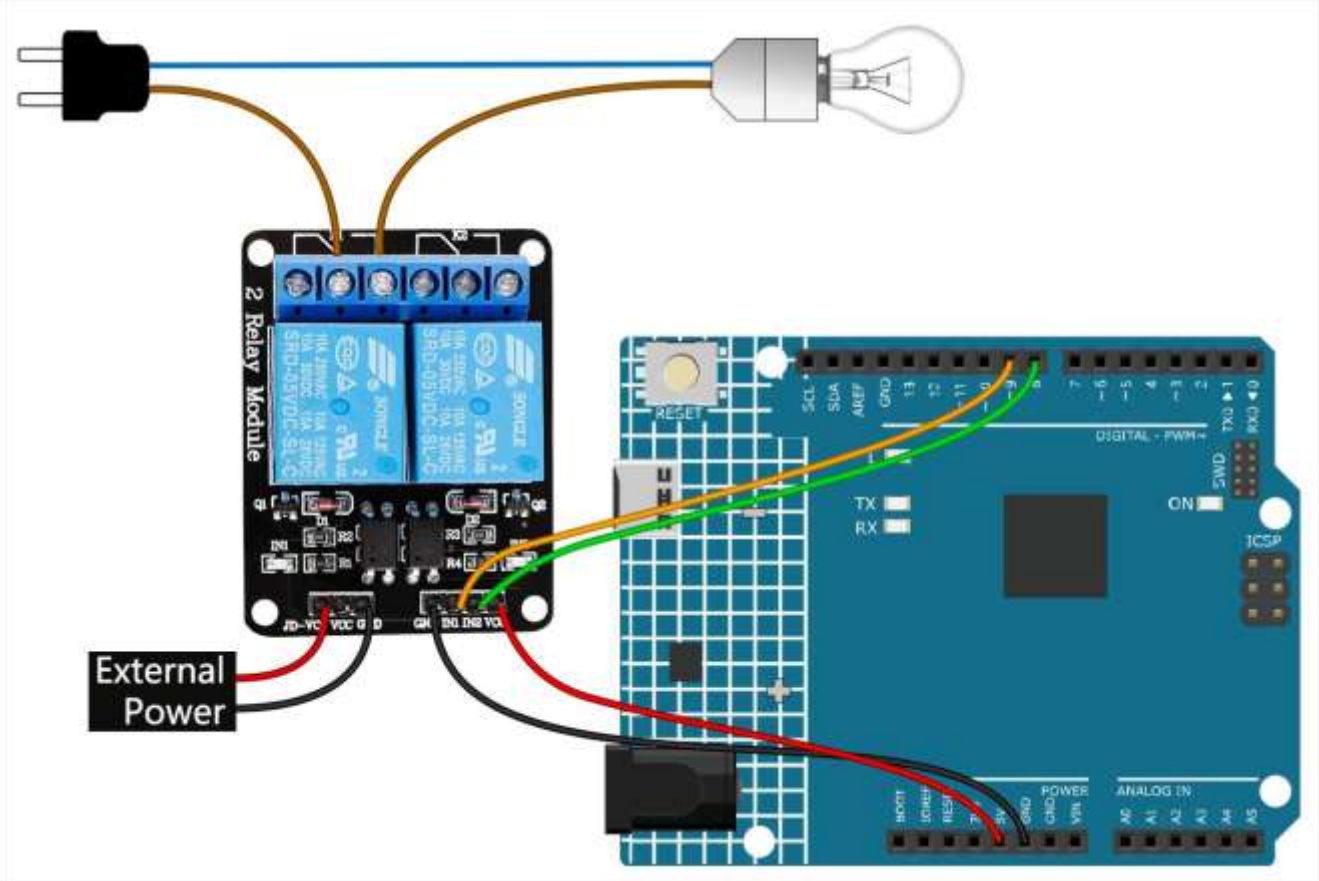
- **Role and Arduino communication**

The 2 Channel 5V Relay Module in our smart elevator system, together with the HC-05 Bluetooth module, enables the Arduino to control high-power components such as door locks or cabin lighting remotely and safely, while the M221 controller oversees the core elevator operations. Here's how they interconnect:

- **Command Reception and Execution**: Through the HC-05 module, users can send voice commands (e.g., "open door" or "turn on light") via Bluetooth to the Arduino. The Arduino interprets these commands and, using the 2 Channel 5V Relay Module, controls the appropriate components (like activating the door lock relay or toggling cabin lights) while keeping users informed.
- **M221 Controller as Central Monitor**: The M221 Schneider controller monitors the elevator's primary status and receives information from the Arduino on specific command actions. For example, when a door is opened via voice command, the Arduino signals the M221 controller. This keeps the M221 aware of all high-power component activities managed through the relays, maintaining a consistent record of operations.
- **Safety and Coordination**: The M221 ensures that commands executed by the Arduino do not conflict with the elevator's primary functions. For instance, it can prevent doors from opening if the elevator is between floors, or ensure lights are activated only during specific operation times.

In summary, the HC-05 and relay module allow for controlled, high-power interactions through the Arduino, while the M221 controller safeguards and coordinates these actions within the elevator's primary functions for secure, seamless operation.

Figure II.11 present the Communication of 2 Channel 5V Relay with Arduino uno



FigureII.11. Communication of 2 Channel 5V Relay with Arduino uno[12]

II.6 Conclusion

In conclusion, Chapter 2 has detailed the essential components and technologies powering our smart elevator system. With the M221 Schneider controller as the central processor, coordinating the elevator's core movements and safety features, and the Arduino Uno managing security through facial recognition, each element plays a vital role in the system's functionality. The HMI, programmed with Vijeo Designer 6.2 SP13, provides a user-friendly interface for real-time monitoring and control, while a network of sensors, actuators, and relays ensures the system operates seamlessly and securely.

With a comprehensive understanding of these hardware and software elements in place, we now turn to Chapter 3, where we will delve into the testing and design phases. This next chapter will explore the testing protocols, conception strategies, and iterations that will bring our integrated components together into a fully functional, smart elevator system, ensuring reliability, safety, and optimal performance.

CHAPTER 3

REALIZATION, SIMULATION AND PRACTICAL TESTS

III.1 Introduction

This chapter demonstrates the developed prototype of the elevator and some operating tests. Also, the main parameters of control are discussed to show the system performances. This section introduces the design and implementation of a smart elevator control system. The system shows advanced programming techniques to optimize the efficiency and safety of elevator operations. By utilizing EcoStruxure Machine Expert software. Also, we will develop a comprehensive control program using two graphical programming languages Ladder Diagram (LD) and GRAFCET (SFC). These languages will be used to define the control logic, which will then be integrated into the system's API for seamless operation. Additionally, simulation will be conducted to validate the system's performances.

III.2 General description of the elevator prototype

The smart elevator system is designed to optimize efficiency and safety by utilizing automated control mechanisms. The entire operation is managed through a program using EcoStruxure Machine Expert software, basing on graphical programming languages like Ladder Diagram and GRAFCET.

Initially all doors of the elevator are securely closed. Once this condition is ensured, passengers can request the elevator by pressing the corresponding button for their desired floor. The cabin can move either up or down, depending on the request, and continues until it reaches the selected floor. As the elevator approaches its target, the motor gradually slows down, and precise floor position sensors (CP-ET1, CP-ET2) are activated to bring the cabin to a smooth stop. Upon reaching the designated floor, the sensors trigger the Programmable Logic Controller (PLC) to open the doors. These doors will remain open for a set period of 5 seconds, allowing passengers to safely enter or exit the cabin. Once this time has elapsed, the doors close automatically. After the doors have closed, an additional sensor checks for any new requests. If no new request is detected within a 5-second window, the system switches into a standby mode, ready to promptly respond to any subsequent passenger inputs. The integration of automated sensors, efficient programming, and reliable control systems ensures that the elevator operates smoothly and safely, providing a seamless experience for users.

Next, Figures **III.1 III.2 III.3** present the real realization of this elevator, and shows the cabin, the floors and motor, on the front side and the back side.

Figure III.1 shows the realized prototype of the front side of this elevator, and it presents 2 floors and their buttons.

Figure III.1. Front side of the elevator.

Figure III.2 shows the real realization of the back side of this elevator, it presents the cabin with the weight sensor, also the PLC and the limit switch of two doors.

Figure III.2. Back side of the elevator

Figure III.3 presents the real picture of the motor before any process with the programmable logic controller **(PLC).**

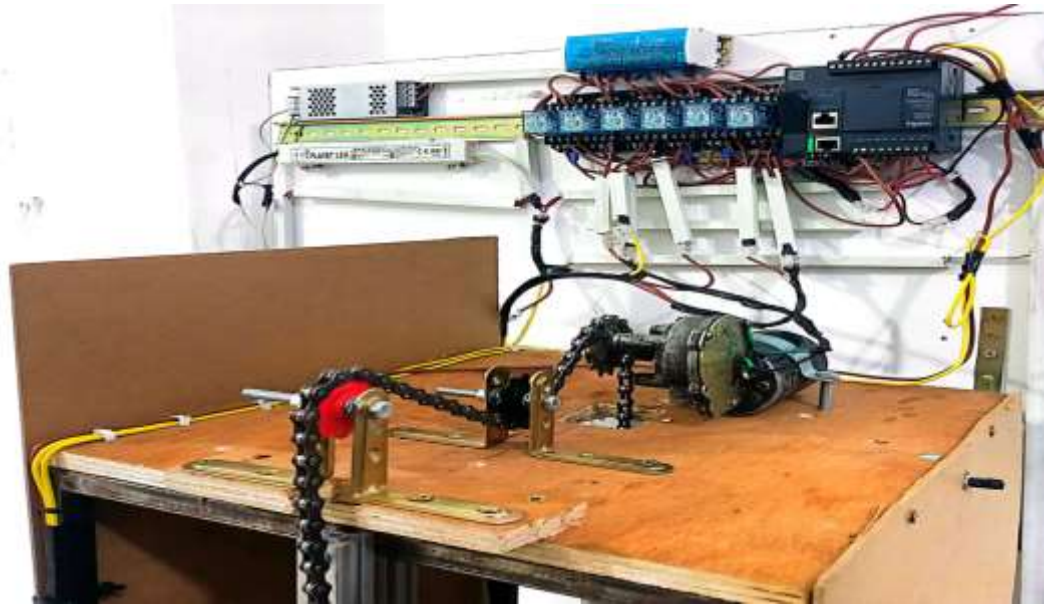


Figure III.3. The motor before any process

III.3 Program development using EcoStruxure machine expert

To program the control system for our elevator, we will be using EcoStruxure Machine Expert by Schneider Electric. This software provides powerful tools to assist in all stages of automation development, from creation to configuration. In addition to the commonly used CONT language, EcoStruxure Machine Expert also supports LIST and LOG programming languages. This flexibility allows us to seamlessly switch between different representations, enabling more efficient and intuitive programming of the control blocks.

III.3.1 Elevator programming using Ladder language

Tab III.1 shows the digital input variables

Variable Symbols	Adress	comment
PB1	**%I 0.0**	**Request 1st floor**
FCDO1	**%I 0.1**	**The 1st floor door open**
FCFC1	**%I 0.2**	**The 1st floor door closed**
FPC	**%I 0.3**	**1st floor photocell**
P1	**%I 0.4**	**1st floor position**
PB2	**%I 0.5**	**Request 2ndfloor**
FCDO2	**%I 0.6**	**The 2nd floor door open**
FCFC2	**%I 0.7**	**The 2nd floor door closed**
P2	**%I 0.8**	**2ndfloor position**

Tab III.1. Digital input variable

TabIII.2 present the digital output variables

Variable Symbols	Adress	Comment
OD1	%Q 0.0	Opening the 1st floor door
ETOD1	%Q 0.1	End of 1st floor door opening time
CD1	%Q 0.2	Closing the 1st floor door
OD2	%Q 0.3	Opening the 2nd floor door
CM	%Q 0.4	Engine mounted
CD	%Q 0.5	Downhill motor
CD2	%Q 0.6	Closing the 2nd floor door

TabIII.2. Digital output variables

Tab III.3 shows the memory variables

Variable Symbols	Address	Comment
ETCD2	%M0	End of door closing time of floor 2
ETOD2	%M1	End of door opening time of floor 2
ETCD1	%M2	End of door closing time of floor 1
WCH	%M3	The weight is checked
PB1	%M4	Request floor 1
PB2	%M5	Request floor 2

Tab III.3. memory variables

Figure III.4 shows the request 1st floor.

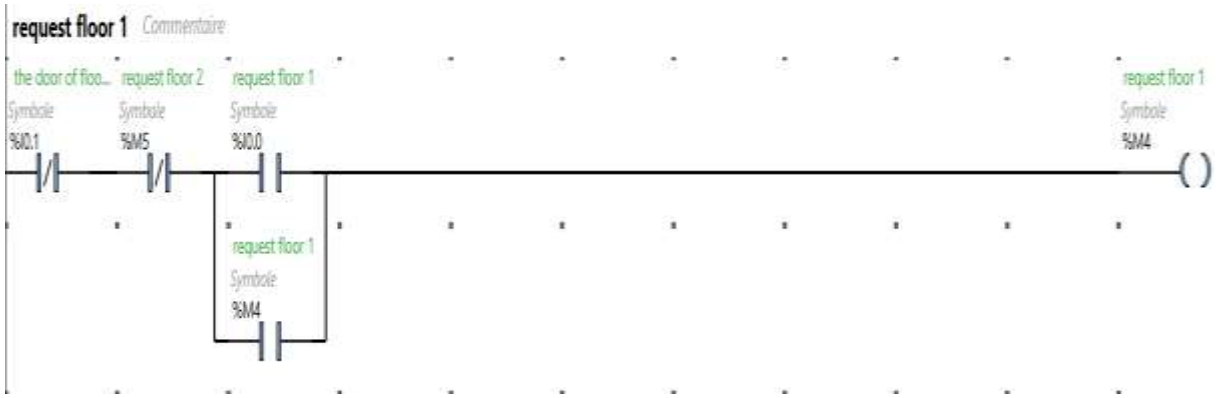


Figure III.4. Request of the 1st floor.

Figure III.5 shows the request 2nd floor

Figure III.5. Request 2nd floor

Figure III.6 shows the cabin amount to floor 1

Figure III.6. the cabin amount to floor 1

Figure III.7 shows the cabin amount to floor 2

Figure III.7. the cabin amount to floor 2

Figure III.8 shows the 1st floor door closing

Figure III.8. 1st floor door closing

Figure III.9 shows the 2nd floor door closing

Figure III.9. 2nd floor door closing

Figure III.10 shows the 1st floor door opening

Figure III.10. 1st floor door opening

Figure III.11 shows the 2nd floor door opening

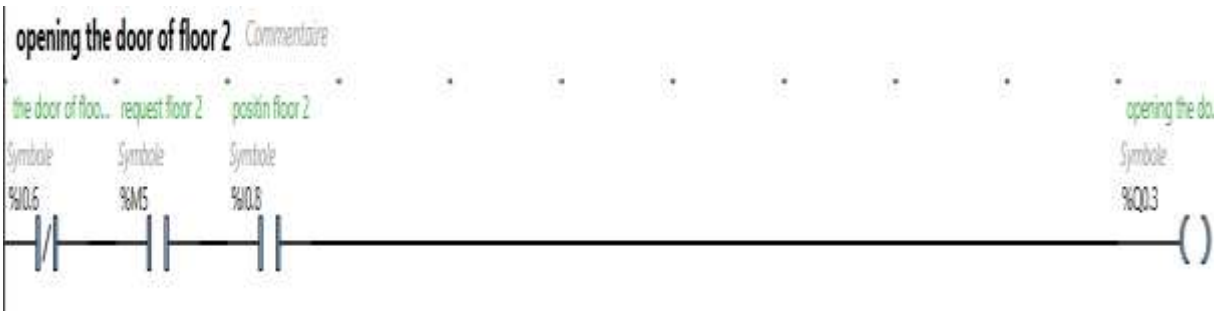


Figure III.11. 2nd floor door opening

Figure III.12 shows the 5s timer to close door 1 floor

Figure III.12. 5s timer to close door 1 floor

Figure III.13 shows the 5s timer to close the 2nd floor door

Figure III.13. 5s timer to close the 2nd floor door

Figure III.14 shows the 5s timer for cabin returns to standby

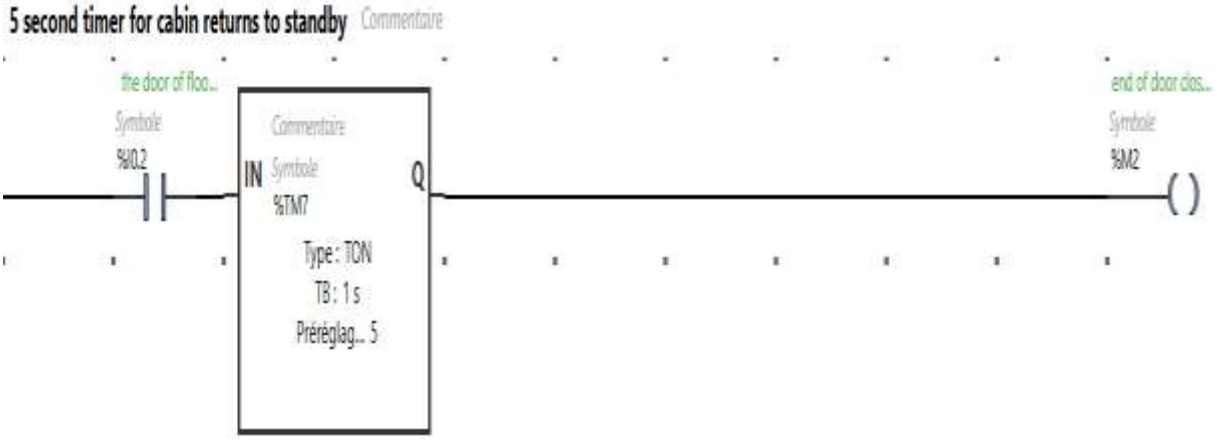


Figure III.14. 5s timer for cabin returns to standby

Figure III.15 shows the 5s timer for cabin returns to standby

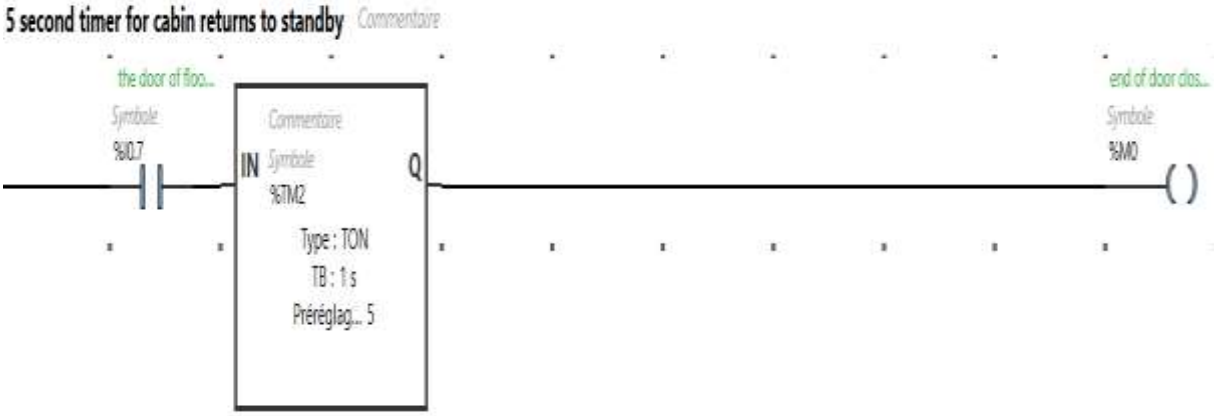


Figure III.15. 5s timer for cabin returns to standby

III.3.2 Elevator programming using GRAFCET

Figure III.18 shows the elevator GRAFCET program

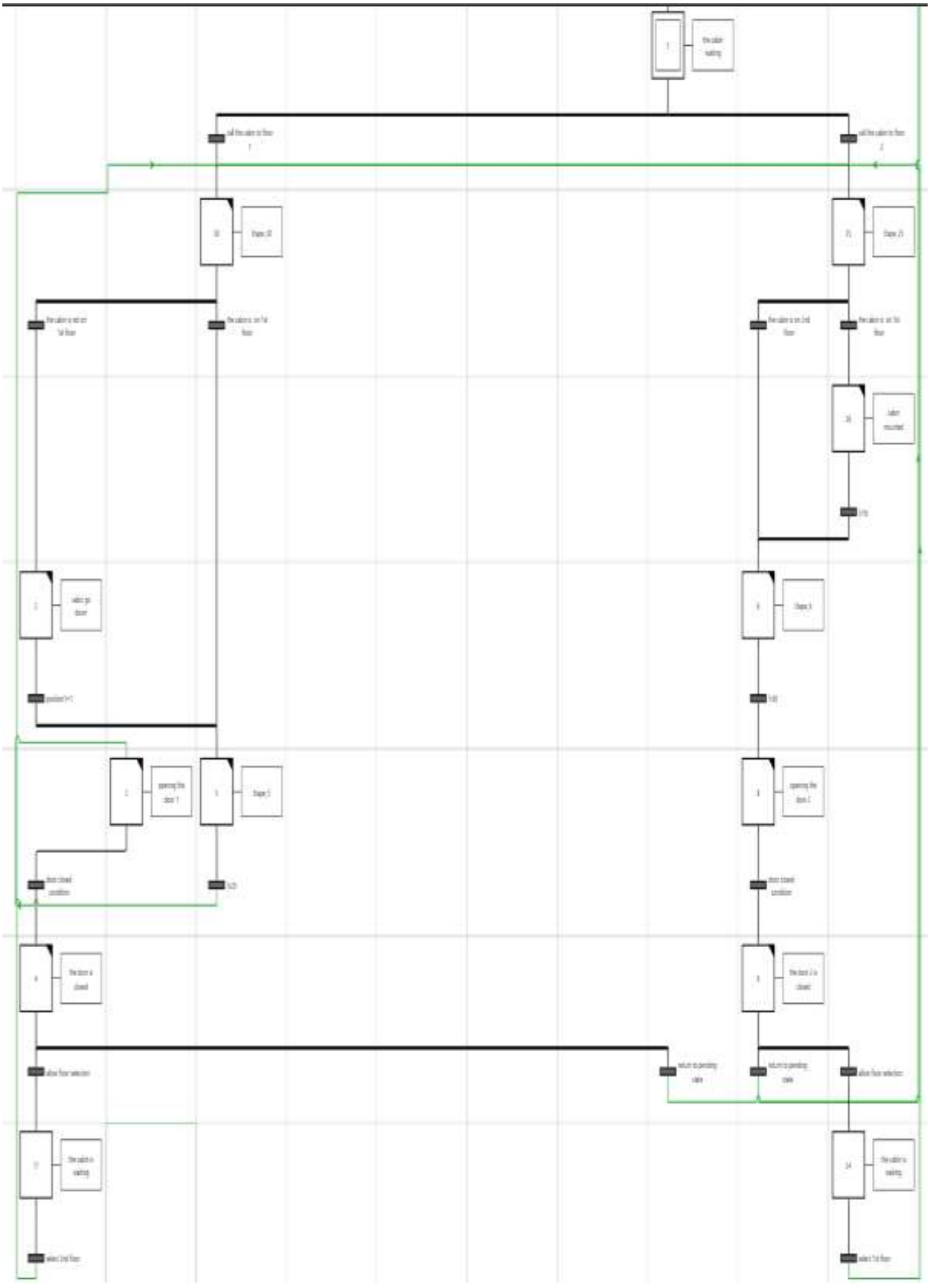


Figure III.16. the elevator operation GRAFCET

III.3.3 Simulation tests using EcoStruxure machine expert

- **Get off the cabin on the 1st floor**
  - If the starting conditions (closed doors) are met and the call button is pressed, the cabin descends to the 1st floor as shown in the figure

Figure III.19 shows descend from the cabin to the 1st floor

Figure III.17. descend from the cabin to the 1st floor

- **Cabin stop**
  - If the cabin touches the limit switch of floor 1 makes a stop

Figure III.20 shows cabin stop

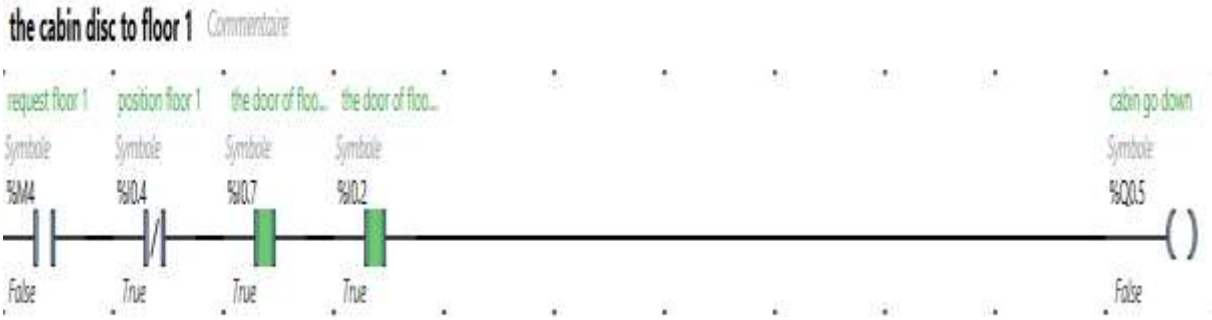


Figure III.18. cabin stop

- **Opening the 1st floor door**
  - If the cabin stops on the 1st floor the door will open

Figure III.21 shows the real picture of opening the 1st floor door

Figure III.19. real picture of opening the 1st floor door

Figure III.22 shows the opening the 1st door floor

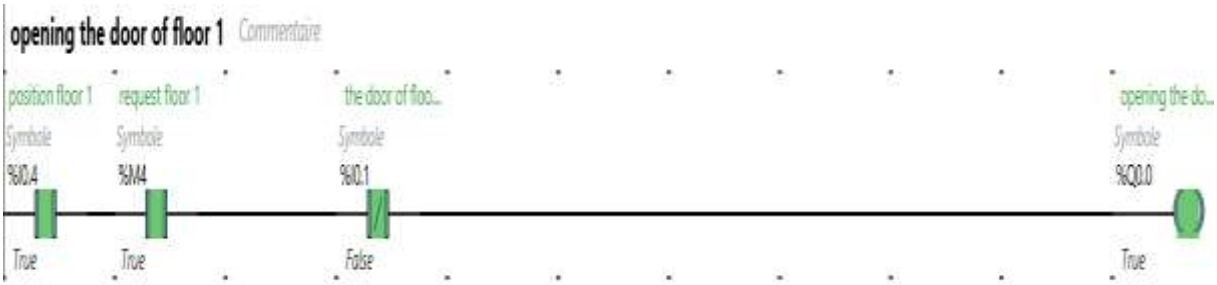


Figure III.20. opening the 1st door floor

- **1st floor door opening delay**
  - If the open door touches a limit switch, this limit switch triggers a 5 second timer.

Figure III.23 shows the 1st floor door opening delay

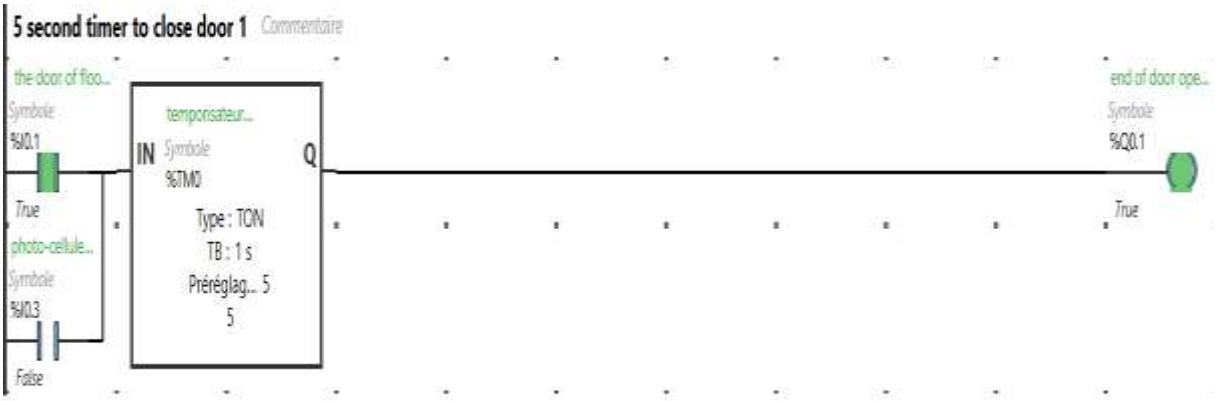


Figure III.21. 1st floor door opening delay

- **1st floor door closing**
  - If the timer finishes counting for 5 seconds it triggers the output (Q0.1) and closes the door

Figure III.24 shows the 1st floor door closing

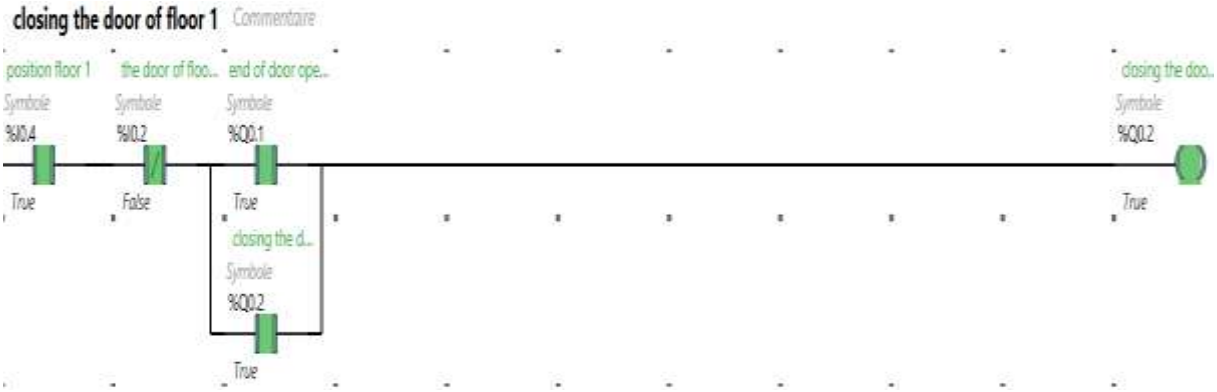


Figure III.22. 1st floor door closing

- **1st floor door closing time delay**
  - If the door is closed it touches the limit switch, this limit switch starts the timer

Figure III.25 shows the 1st floor door closing time delay

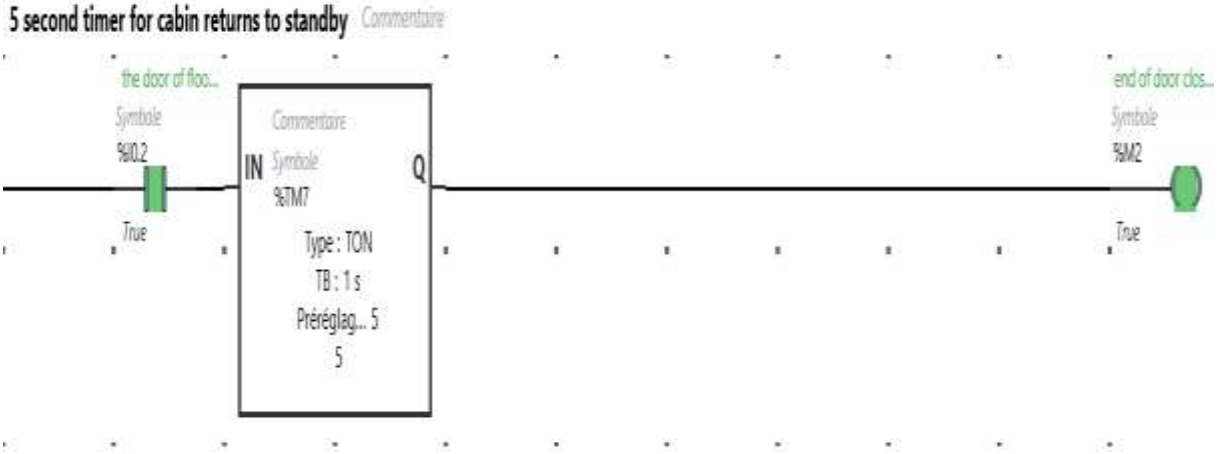


Figure III.23. 1st floor door closing time delay

- **Return to the pending state**
  - If the operator does not make any request before the timer (%TM7) triggers the output (%M2) the cabin returns to the waiting state.

Figure III.24 shows the GRAFCET which displays calling the cabin to the 1st floor

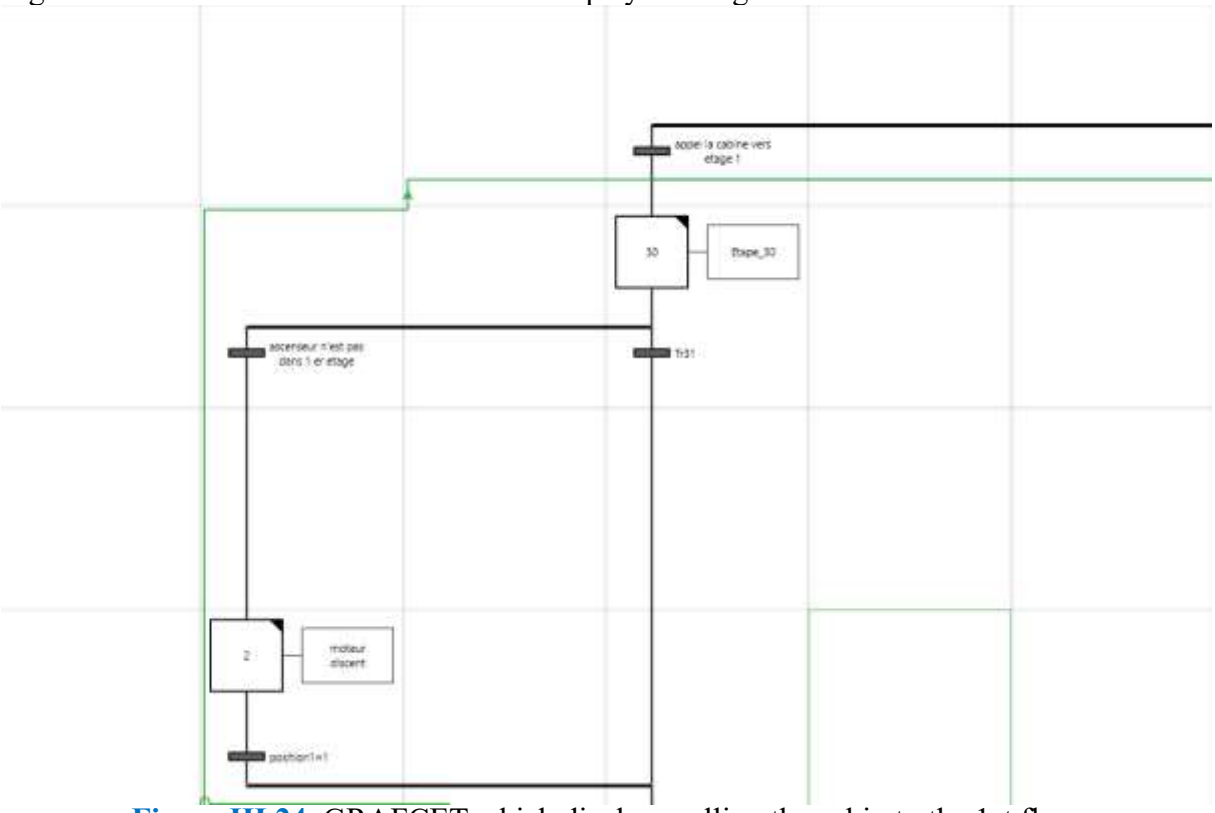


Figure III.24. GRAFCET which displays calling the cabin to the 1st floor

Figure III.25 shows the GRAFCET which displays calling the cabin to the 1st floor

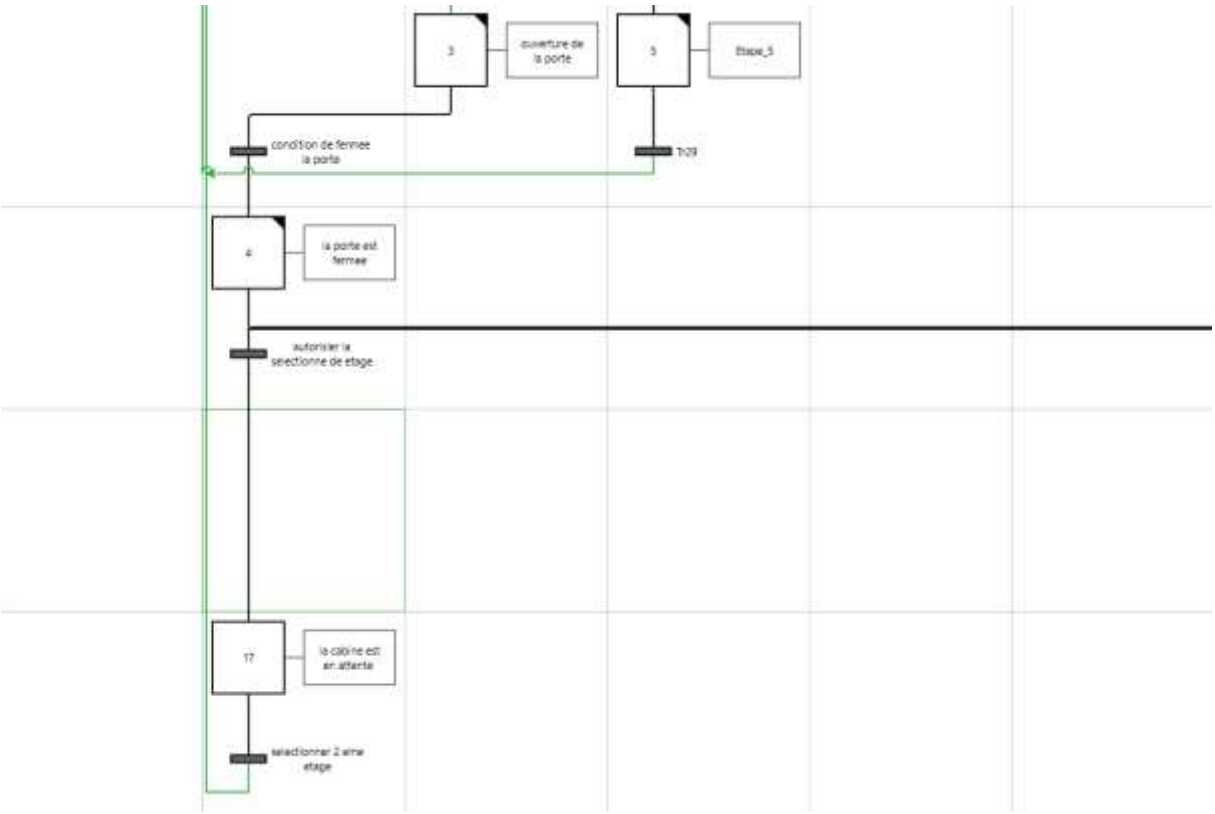


Figure III.25. GRAFCET which displays calling the cabin to the 1st floor

Figure III.26 shows the GRAFCET which displays calling the cabin to the 2nd floor

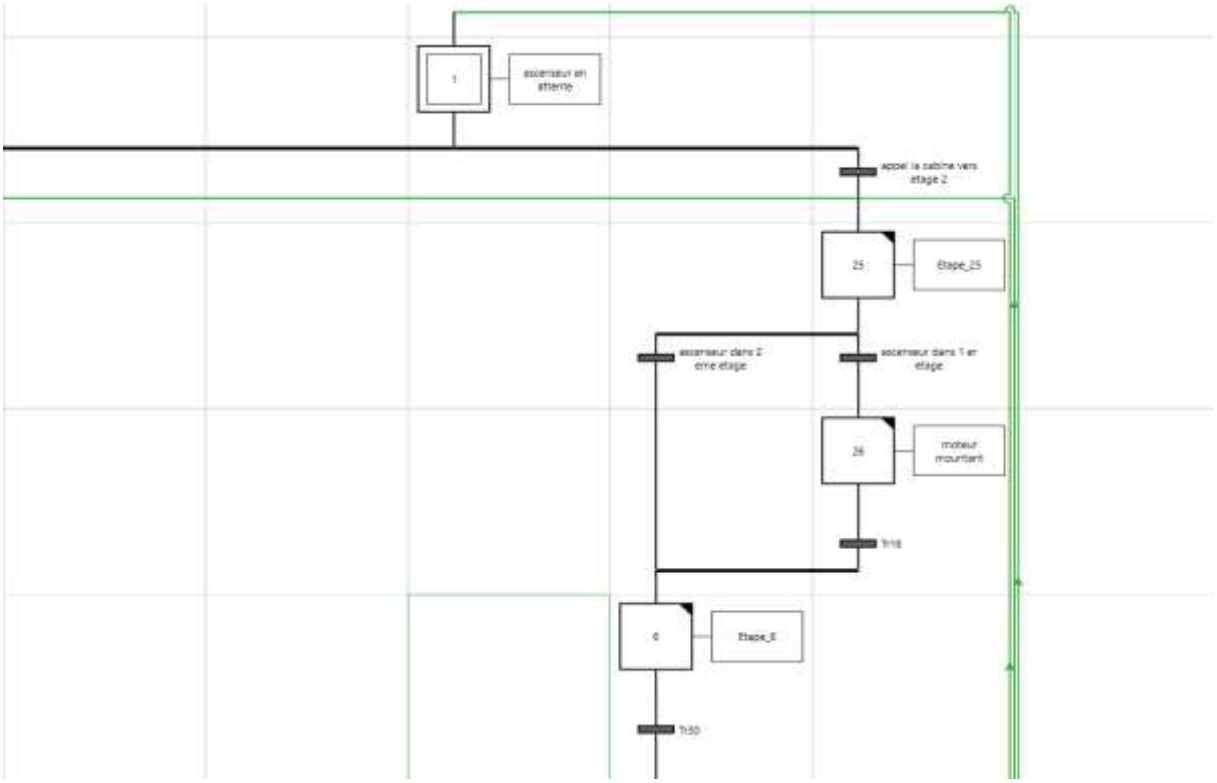


Figure III.26. GRAFCET which displays calling the cabin to the 2nd floor

Figure III.27 shows the GRAFCET which displays calling the cabin to the 2nd floor

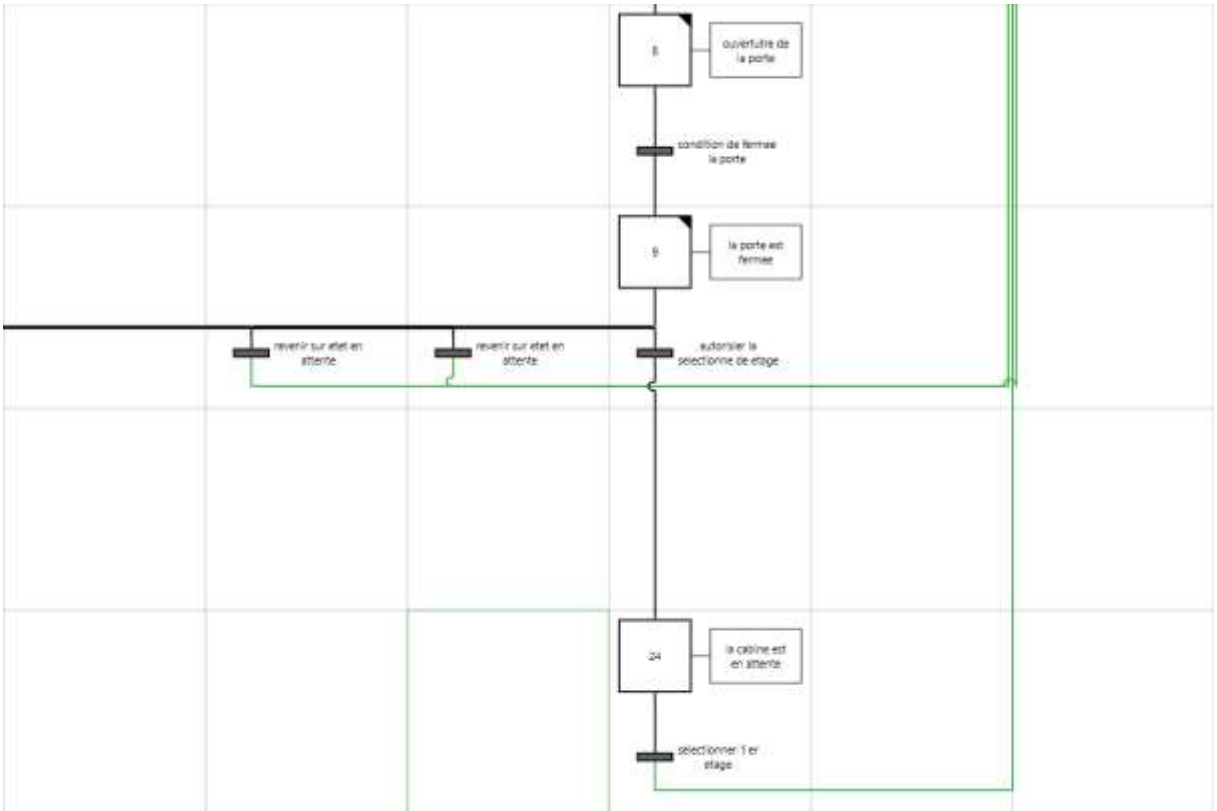


Figure III.27. GRAFCET which displays calling the cabin to the 2nd floor

III.4 Conclusion

In this chapter, we have presented the developed prototype, and operating principle of the elevator. Also, programming of the PLC using EcoStruxure machine expert software is realized. Two types of programming languages are used ladder and GRAFCET language. By the end we presented an example of simulation of the elevator.

General Conclusion

IV. General Conclusion

The objective of this work is to realize a smart elevator using Schneider technology. This technology is based on EcoStruxuture machine expert software. Two types of programming languages are used Ladder and GRAFCET.

This project has allowed us to gain new knowledge and get an idea of the field. This training has allowed us to deepen our theoretical and practical knowledge.

First, we gave an overview of elevators and their definitions, then we mentioned the areas in which the elevator is used and the places where it is found. After that, we mentioned its types and the principle of operation of each type, and finally we mentioned the advantages of the elevator in daily life and why it should be used.

The creation of the control program requires a perfect knowledge of the device to be controlled, so we studied the elevator in a global way: its technical characteristics, its operating principle, the possible risks and the safety devices that are required.

The choice of this system was beneficial and very interesting, since the creation of this type of automated system calls upon several technical fields, in addition, it is a means of transport that is widely used and increasingly widespread, especially since it helped us in the knowledge and mastery of new control and automation software.

The results obtained by simulation showed us the correct functioning of our system.

We can confirm that the objective, set at the beginning, could be achieved and our work meets the requirements determined at the beginning.

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Appendix

Appendix

This figure Present the Arduino code of the voice controller HC-05 which is connect with Bluetooth

```
#include <SoftwareSerial.h>
SoftwareSerial BT(2,3); //TXD, RXD respetively
char voice ;
String test="\0";
void setup()
{
  Serial.begin(9600);         //Sets the data rate in bits per second (baud) for serial data transmissio
  BT.begin(9600); //Lancement du bluetooth
  //configuration des leds
  pinMode(13, OUTPUT);        //Led rouge
  pinMode(12, OUTPUT);     //led verte
}
void loop()
{
  while(BT.available()>0)
  {
    voice = BT.read();
    delay(10);
    test += voice;
    Serial.print(test);
    Serial.print("\n");
  }
    if (test.length() > 0)
    {
      if (test == "Premiere étage")          //Checks whether value of data is equal to 1
      {
        test="\0";
        digitalWrite(13, HIGH); //Allumez Led Rouge
       digitalWrite(12, LOW); //Eteindre Led Verte
      Serial.println("Premiere étage");
      Serial.print("\n");}
    else if (test == "Deuxième étage")      //Checks whether value of data is equal to 0
      {
```