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Automated Control System for Industrial Model with S7-1200 PLC and HMI Interface on PC

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Dedication

I dedicate this work:

*To my parents, thank you for believing in me and encouraging me.
Your love and support mean the world to me.*

*To my sisters Nadia, Ibtissem and Ritadj you have been my best
cheerleaders.*

*To my friend Hana who have never left my side and supported me
throughout the process.*

*I owe so much to my whole family especially my grandparents, my
aunt Amina and my uncle Mohamed for their undying support, their
unwavering belief that I can achieve so much.*

*I want you all to know how much you matter. Without your prayers
and blessings, none of this would have been possible.*

Raouida Fatima Zahra LOUADJ

Dedication

I dedicate this project to my whole family and friends.

*To my mother **Louahem M'Sabah Ahlem** whom I owe everything to.*

*To my hard-working father **Ferdi Samir** who always had my back
emotionally and financially.*

*To my sister **Hadjer Malak Ferdi** who was always by my side.*

*To my sister **Ourida Ferdi** who always believed in me.*

*To my little brother **Ferdi Abd El-Raouf** who supported and cherish
me.*

*And last but not least my late uncle **Ferdi Mourad** who I took my
scientific thinking from.*

*To my project partner **Louadj Raouida Fatima Zahra** who would
always give me comfort when needed.*

Thank you for your constant encouragement and love.

Hana FERDI

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We would like also to extend our thanks to all the Higher school of technology and engineering – Annaba teaching team especially the EEA department that played a significant role in our education.

Abstract

This thesis provides the functionality of SMART MODULES SYSTEM 9 FESTech's training system. It consists of 9 stations for Distribution, Testing, Processing, Indexing, Handling, Buffer, Assembly, Automated Warehouse, and Sorting Station.

This work deals with the use of programmable logic controllers« SIEMENS PLC » through the use of software TIA Portal V16, which integrates various products SIMATIC such as Step 7, WinCC, that are used to develop an automation program for The Sorting Station via the S7-1200 controller. Additionally, an HMI (Human-Machine Interface) has been designed on a PC. This interface allows to efficiently monitor and control The Sorting Station.

Keywords: Programmable controllers« SIEMENS PLC »; TIA Portal; HMI; Step7; WinCC; SMS9; Sorting Station.

Résumé

Le travail présenté dans ce mémoire fournit les fonctionnalités du maquettes SMART MODULES SYSTEM 9 de FESTech. Il se compose de 9 stations pour la distribution, les tests, le traitement, l'indexation, la manutention, le tampon, l'assemblage, l'entrepôt automatisé et la station de tri.

Ce travail porte sur l'utilisation d'automates programmables « SIEMENS PLC » à travers l'utilisation du logiciel TIA Portal V16, qui intègre divers produits SIMATIC tels que Step 7, WinCC, qui sont utilisés pour développer un programme d'automatisation pour le Tri. Station via le contrôleur S7-1200. De plus, une IHM (Interface Homme-Machine) a été conçue sur un PC. Cette interface permet de surveiller et de contrôler efficacement la Station de Tri.

Mots clés: Automates programmables SIEMENS PLC; TIA Portal; IHM; STEP7; WinCC; SMS9; Station de tri.

المخلص

يوفر العمل المقدم في هذه الأطروحة وظائف نظام التدريب نظام الوحدة الذكية 9 لشركة فاستاك. وتتكون من 9 محطات للتوزيع والاختبار والمعالجة والفهرسة والمناولة والتخزين والتجميع والمستودع الآلي ومحطة الفرز. يركز هذا العمل على استخدام وحدات التحكم القابلة للبرمجة "SIEMENS PLC" من خلال استخدام برنامج TIA Portal V16 الذي يدمج منتجات SIMATIC المختلفة مثل Step 7 و WinCC والتي تستخدم لتطوير برنامج التشغيل الآلي للفرز المحطة عبر جهاز التحكم S7-1200. بالإضافة إلى ذلك، تم تصميم واجهة HMI (واجهة الإنسان والآلة) على جهاز الكمبيوتر. تنتج هذه الواجهة إمكانية مراقبة محطة الفرز والتحكم فيها بشكل فعال.

الكلمات المفتاحية: مبرمج صناعي سيمنس؛ برنامج تيا بورتال؛ واجهة المستخدم البشرية؛ ستاب 7؛ وينسيس؛ نظام الوحدة الذكية 9؛ محطة الفرز.

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General introduction

Providing effective training and high-quality education to its students is the number one priority of the Higher school of engineering and technologies Annaba, in order to cover that modern training tools must be provided, ones that are up to date to keep up with the increasing development of the targeted field.

Automation industry characterized by the use of machines and Programmable Logic controllers to assist certain tasks , is one of the eight majors at the Higher school of engineering and technologies Annaba , knowing that this field itself is a quite large field to dive into, in order to build a solid foundation, and have the necessary skills and knowledge to work with PLCs, students must receive a high-caliber training conducted professionally simulating real industrial processes in a safe real-world PLC environment, enabling learners to write and test customized scenarios using various programming languages such as structured text, GRFCET...while developing troubleshooting skills by handling common faults that can be faced to be fully prepared for careers in industrial automation.

FESTech's is a Korean company specialised in designing and producing educational training equipment. The Smart Module System FESTech's is one of the products manufactured by the company includes 9 stations: Distribution station, Testing station, Processing station, Indexing station, Handling station, Buffer station, Assembly station, Automated warehouse station, Sorting station.

The Higher school of engineering and technologies Annaba has provided the Testing and Sorting station for 4th year EEA department students as a part of their Industrial automatic subject practical work however a Human Machine Interface (HMI) to monitor and control the steps of the testing and sorting operation is not available.

The objective of this research paper is to illustrate the steps of designing an HMI screen for the Sorting station using TIA Portal V16 and WINCC to supervise the process properly.

The research paper is presented as follows:

- ✓ **Chapter 1:** Company's presentation .
- ✓ **Chapter 2:** The smart module system.
- ✓ **Chapter 3:** The sorting station.
- ✓ **Chapter 4:** Programming and Supervision.

Chapter *1* *Presentation of the Company*

Chapter 1: Company's presentation

1. Introduction:

In a world automation training systems became a crucial tool for engineering students during their technical education many companies had taken the initiative to produce this type of training systems ,in the following chapter we will spot the light at one of these companies which is FESTech that has been in the business for decades.

2. Company's presentation:

2.1 Presentation of FESTech:

Fire Engineering Science And Technology automation abbreviated as FESTech is a KOREAN company in that focuses on automation training systems. Their product line includes services such as designing and constructing automation lines, providing various resources essential for different line components, developing robotic software, and managing the maintenance and servicing of automation lines and equipment.

2.2 History:

FESTech, is a company with a rich history in Korea, was established in Gasan-dong in , Seoul in 2001. Over the years, they joined the Korea Scientific Instruments Industry Cooperative, obtained ISO 9001 certification, and registered multiple utility model patents. They expanded their presence by supplying training equipment to companies like SsangYong Motor and POSCO. FESTech also participated in events such as the World Skills International Competition and received certifications for transparent management and innovation. They further advanced into Smart Factory 4.0 technology and achieved ISO 9001:2015 recertification. [1]

2.3 The company's products:

FESTech offers a diverse line of products tailored to automation and industrial training purposes:

2.3.1 Educational Equipment:

- Pneumatics training set.
- Hydraulics training set.
- Hydraulics transparent models.
- Sensor training set.
- PLC trainer.
- FA applications.
- Motor trainer.
- Smart module system.
- Module product system.
- Flexible manufacturing system.
- Variable mechatronics system.
- Robot training set.

Chapter 1: Company presentation

- Process control system.
- Electric Training Set.
- Microprocessor training kit.
- Smart factory. [2]



Figure 1 : Portable Pneumatics Trainer [2]

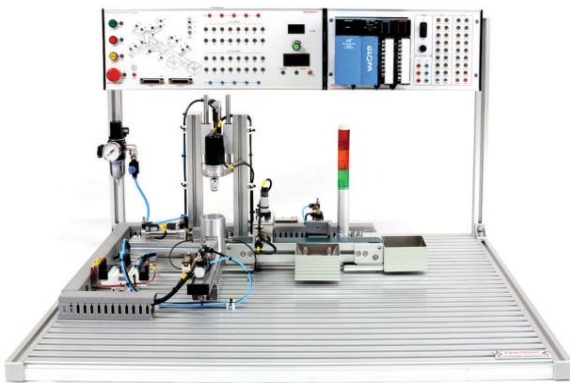


Figure 2: Mechatronics Automation System Trainer [2]

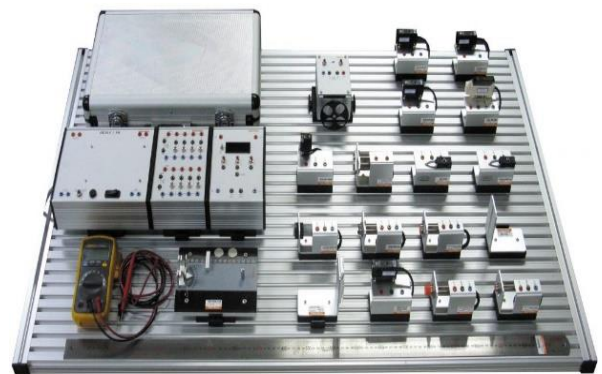


Figure 3: Mechatronics Automation System Trainer [2]

2.3.2 Industrial Equipment:

- FA(FESTECH)
- MINDMAN
- AIRTAC [3]

Chapter 1: Company's presentation



Figure 5: AIRTAC AIRUNITS [3]



Figure 4: Mindman Cylinder [3]

3 Problematic:

SMS or SMART MODULES SYSTEM 9 stations is a very interesting training system provided by THE NATIONAL HIGHER SCHOOL OF TECHNOLOGY AND ENGINEERING-ANNABA for 4th year EEA students during their 2nd semester, however the HMI (Human and machine interface) is not provided to monitor the process of the Sorting station. The upcoming chapters will be the next step to design and develop an HMI to properly supervise the Sorting station.

4 Motivation:

The points that carry the motivation for this research are as followed:

- Enhance the user's experience and increase efficiency and productivity
- Improving safety and avoiding all sort of risks
- Enable users to visualize data and remote control and monitor

5 Conclusion:

In this chapter we presented the history rich company of FESTech Korea where we tried to summarize its function and what does it actually provide for the automation training systems market.

Chapter 2

The Smart Module System

Chapter 2: The Smart Module System

1 Introduction:

The SMS is one of the products offered by FESTech Korea in the field of training that covers many automation technologies and it provides system design, assembly, installation. Its main focus is on easy learning, easy training, and easy application to industry. This chapter will flash the light on the Smart Module System, its stations and their technologies.

2 Smart Module System (SMS) 9 Stations:

SMS is composed of stations for Distribution, Testing, Processing, Indexing, Handling, Buffer, Assembly, Automated Warehouse, and Sorting Station. Each station is capable of operating separately. Any PLC type can control each module within the SMS.

2.1 Distribution station:

- Distribution station both in storing and dispensing workpieces individually.
- Workpieces are stored in the stack magazine and supervised by an optical sensor.
- The distribution cylinder splits workpieces to feeding position.
- The feeding cylinder shoves workpieces to the next station.

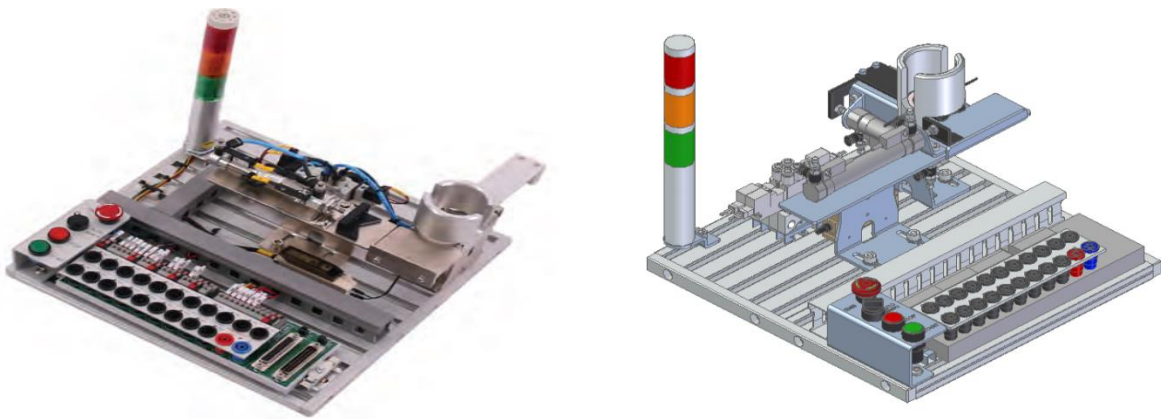


Figure 6: Distribution station [4]

2.2 Testing station:

- Testing station identifies, distinguishes the material of the work piece.
- The work piece is ejected with a solenoid actuator and transferred to next station.

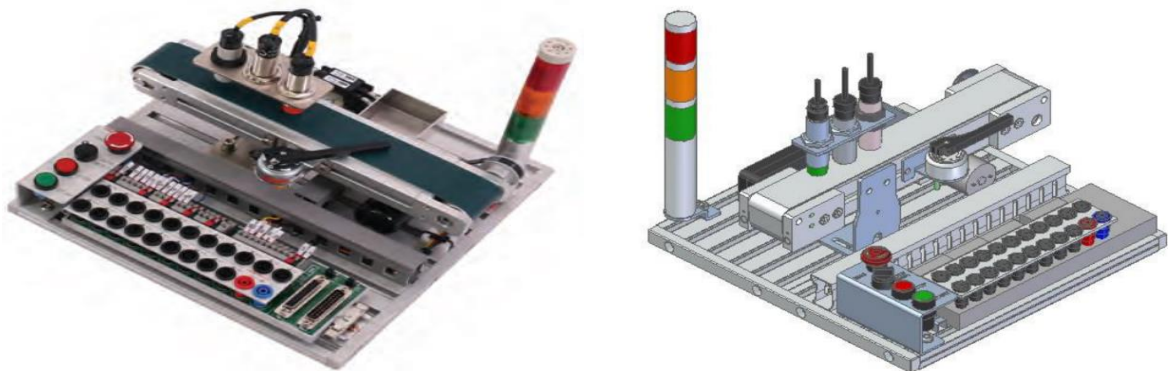


Figure 7: Testing station [4]

2.3 Processing station:

- The workpiece is detected by the optical.
- Stamping module stamps on the workpiece.
- It transfers the workpiece to next station using rotary cylinder and vacuum suction unit.

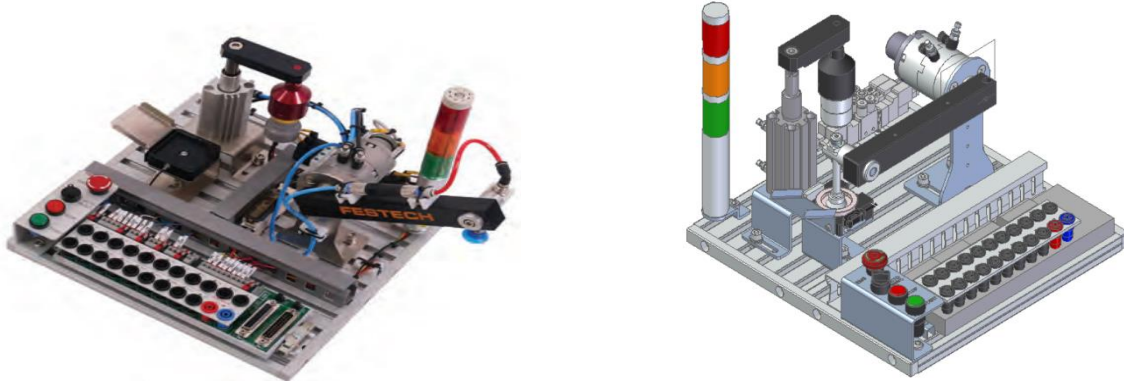


Figure 8:Processing station [4]

2.4 Indexing station:

When the work piece arrives, indexing station can store up to 6 workpieces.

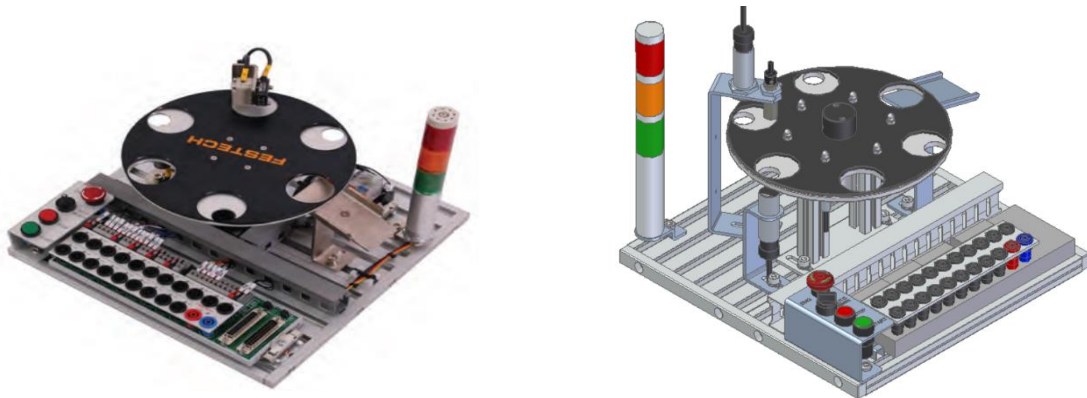


Figure 9:Indexing station [4]

2.5 Handling station:

Convey workpiece with the help of pneumatic rod less cylinder and vacuum suction handling unit.

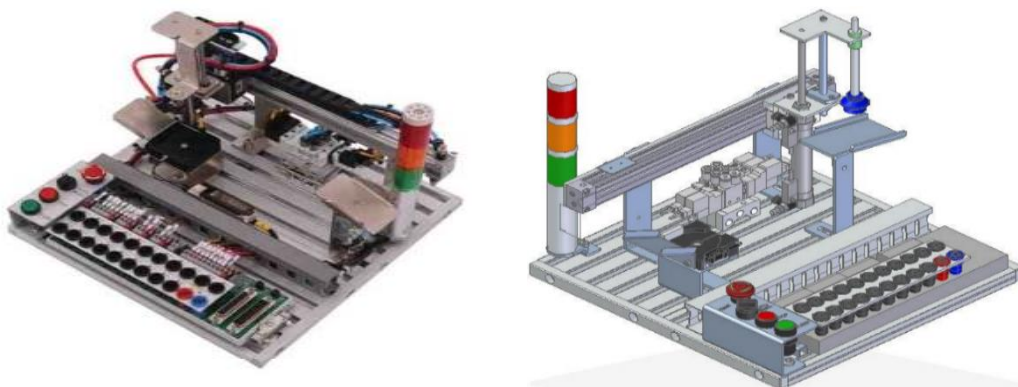


Figure 10:Handling station [4]

2.6 Buffer station:

- Buffer station is used in the combination of intermediate stations.
- When the operation is concluded the work piece is transferred to next station.

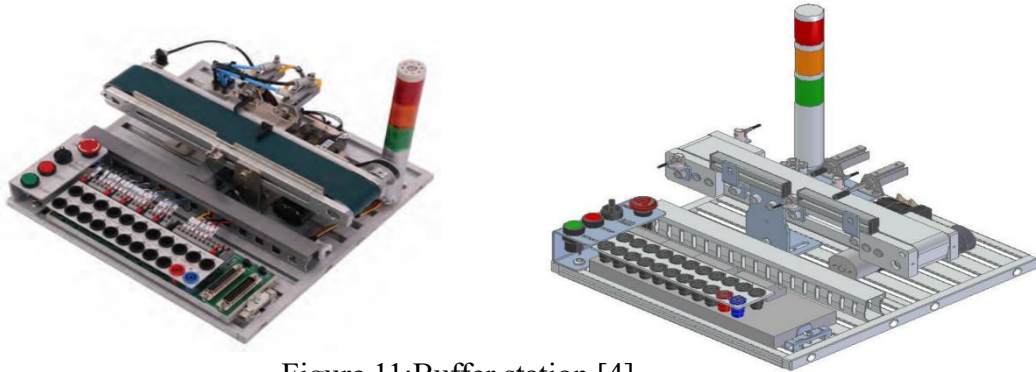


Figure 11: Buffer station [4]

2.7 Assembly station:

- Supply the workpiece via rotary disc unit and assemble the workpiece with the press unit.
- Move the assembled workpiece to the next station via conveyor belt.



Figure 12: Assembly station [4]

2.8 Warehouse station:

- Automated warehouse station is capable of storing and releasing a work piece. It has storage of 3rd floor and stacker crane.



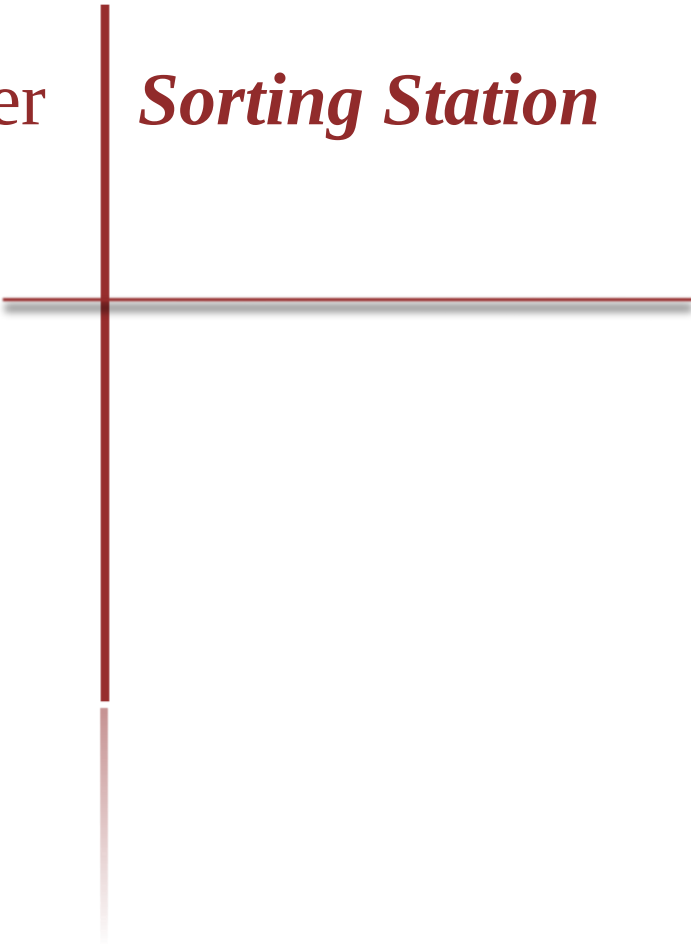
Figure 13: Warehouse station [4]

3 Conclusion:

This chapter focused on the SMS (SMART MODULE SYSTEM) 9 stations where we presented the 8 stations briefly, In the 3rd chapter we will be seeing the Sorting station individually as it is our case of study.

Chapter 3

Sorting Station



Chapter 3: Sorting Station

1 Introduction:

Sorting stations play a pivotal role in various industrial operations, these are manufactured to meticulously organize items or materials based on certain specifications and characteristics.

In this chapter we will take a closer look on the sorting station designed by FESTECH Korea which is a part of the SMS.

2 Sorting Station:

2.1 Function:

- Classify workpieces into three categories according to their type.
- The sorting actuator module stores the workpiece using a sorting slide.

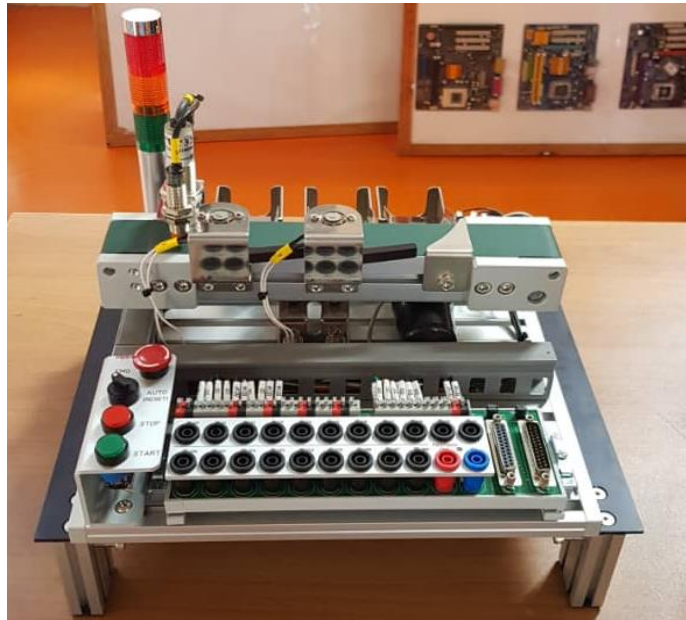


Figure 14 : Sorting station

2.2 Components:

- **Control switch module:**

START, STOP, AUTO (RESET), EMERGENCY.

- **Tower lamp module:**

Give an output signal through the color of the lamp.

GREEN, YELLOW, RED

- **Relay module.**

- **Conveyor module:**

The conveyor operated by DC motor, transfers the workpiece vertically. Relay is used to control conveyor.

Chapter 3: Sorting Station

- **Sorting actuator module:**
Sort the workpiece using 2 rotary solenoid
- **Storage module:**
Store the workpiece fallen from the conveyor.
actuators. [4]

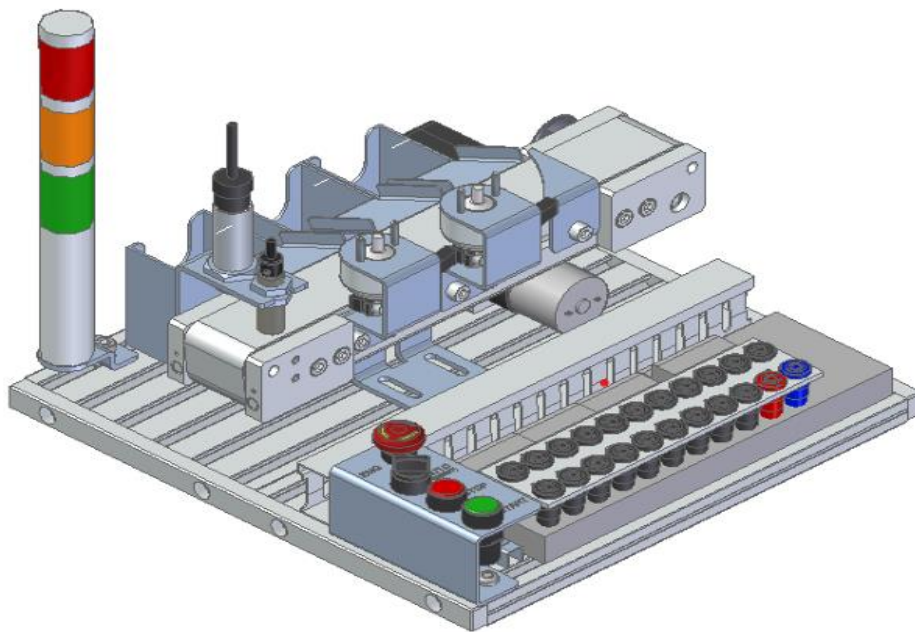


Figure 15 3D illustration of sorting station [4]

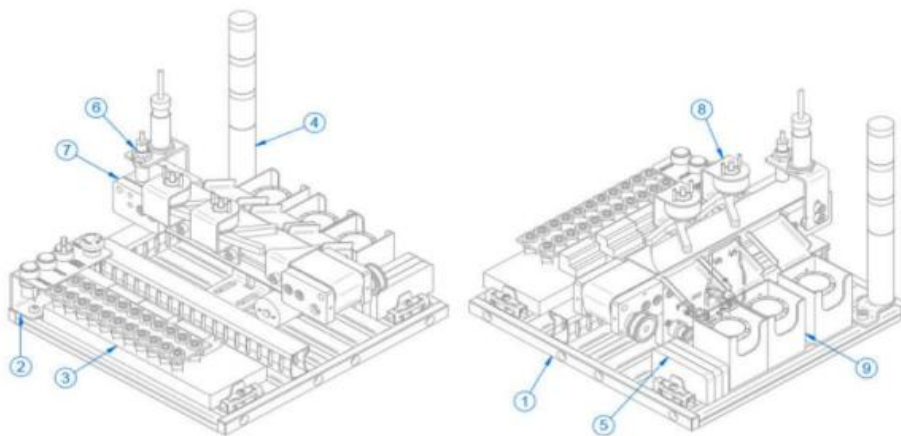


Figure 16 : Components of sorting station [4]

Chapter 3: Sorting Station

Sorting Station		
Seq.	Components	Q'ty
1	Aluminum profile panel	1
2	Control switch module	1
3	SMS IN/OUT terminal unit	1
4	Tower lamp module	1
5	Relay module	1
6	Testing module	1
7	Conveyor module	1
8	Sorting actuator module	2
9	Storage module	3

Table 1: Table of components [4]

2.3 Operation:

Initial condition

- Conveyor shuts down
- Solenoid actuator shuts down

Start condition

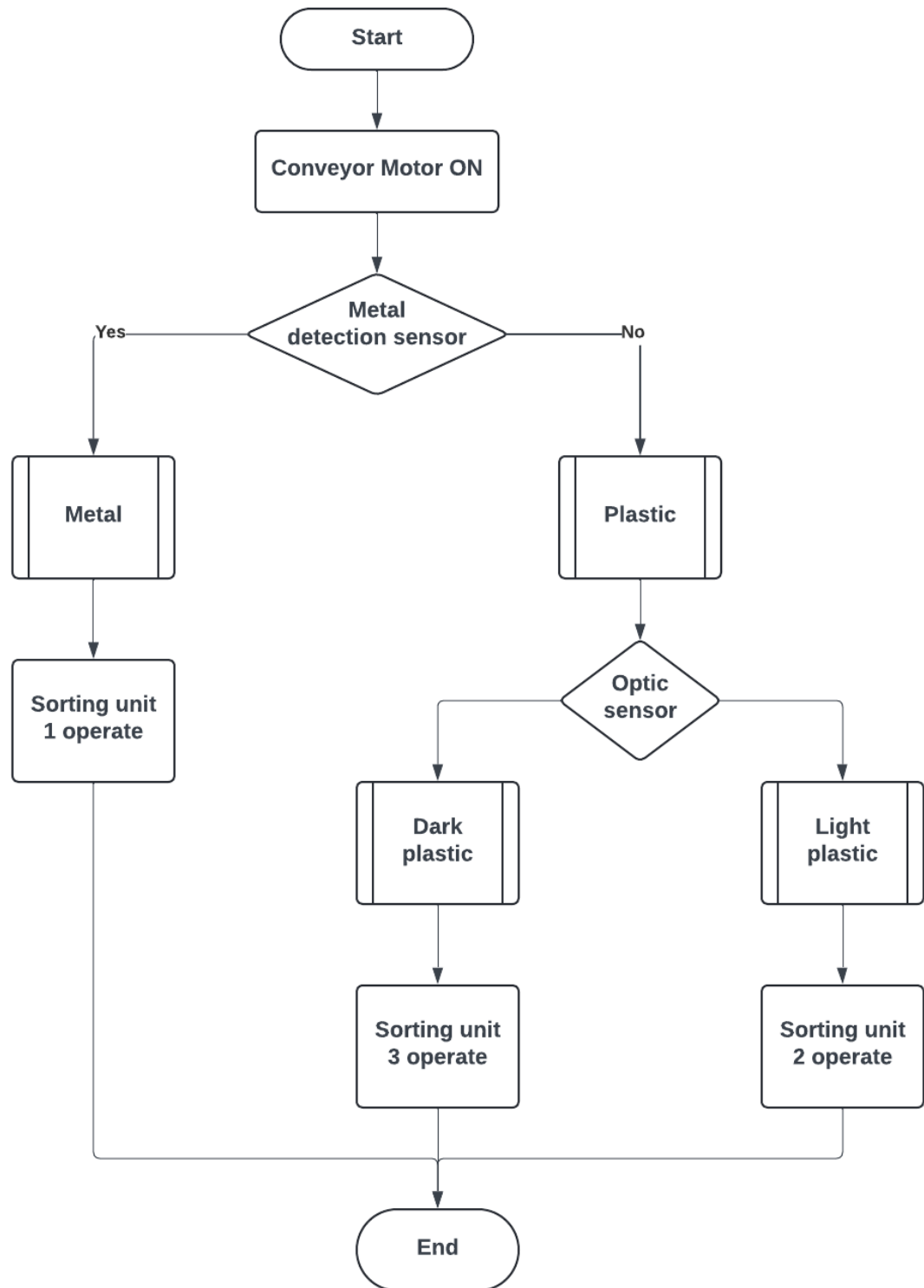
- All condition Initialization
- The conveyor must not have any workpiece on it
- No workpiece should be present on the slide

Operation Sequence

- Conveyor running
- Detect the workpiece with a sensor
- The sorting solenoid actuator functions

Chapter 3: Sorting Station

2.4 Workflow:

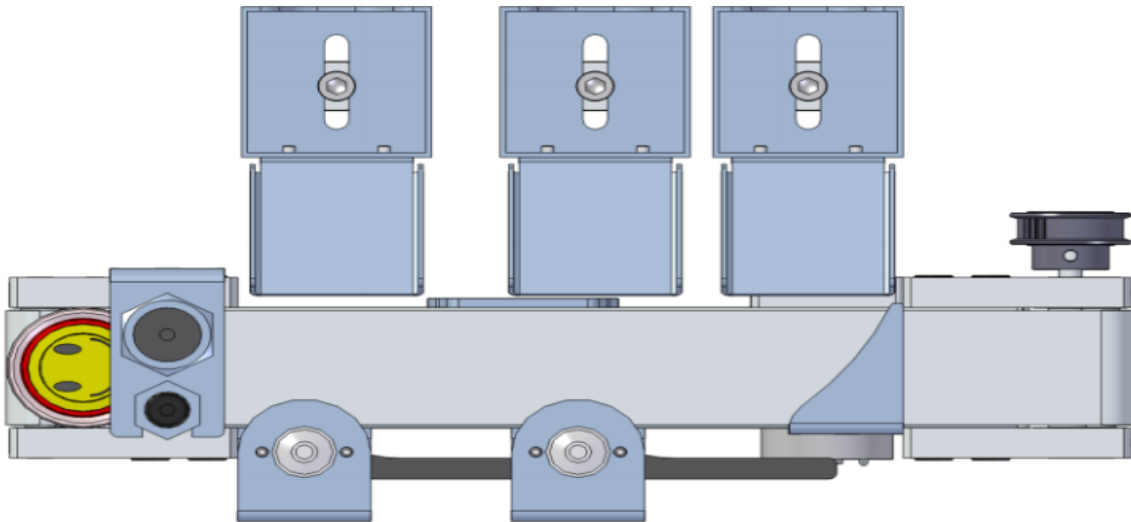


Chapter 3: Sorting Station

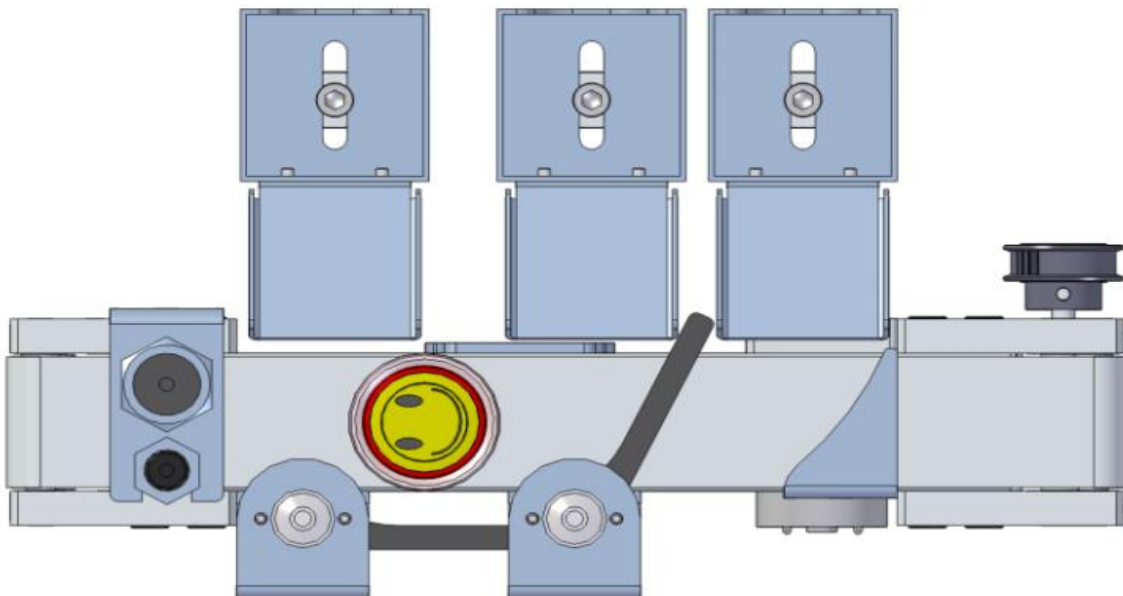
2.5 Operational Steps of the Sorting Station:

the following figures shows the steps of the sorting station functions [4]:

a) Detection: Workpiece is detected.

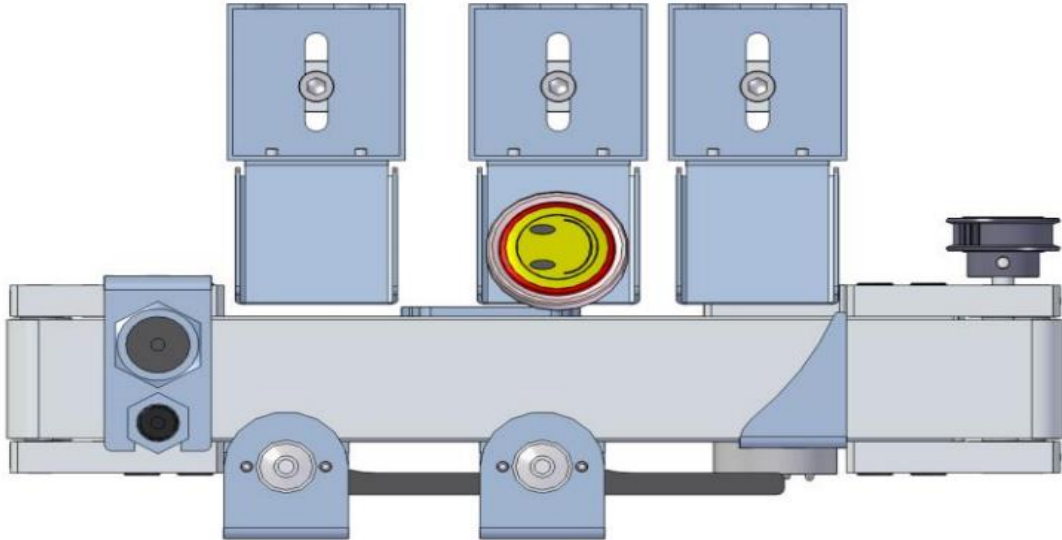


b) Distinguished by sorting solenoid actuator.



Chapter 3: Sorting station

c) Distinguished by sorting end bracket



2.6 Installation requirements:

In order for the 9 stations within the SMS to operate properly, some other components are required:

2.6.1 PLC Trainer:

A learning tool that contains hardware components resembling to those found in the industrial settings designed for students or learners in general in the field of PLCs, it supplies a simulated environment where they can develop their skills while practicing PLC programming and testing in a safe environment.



Figure 17 : PLC Trainer

Chapter 3: Sorting station

2.6.2 IAN (industrial automation network) cable:

IAN are used to transmit and exchange data between different components such as PLCs, HMIs...etc



Figure 18: IAN cable

2.6.3 Ethernet Hub:

a network hardware device that connects multiple Ethernet devices, allowing them to function as a single network segment.



Figure 19: Ethernet Hub

3. Conclusion:

In this chapter we presented our case of study the Sorting station within the SMS, we took a look at its components and design, explained the sorting process of the workpieces and the elements required for its installation.

Chapter 4 *Programming and Supervision*

Chapter 4: Programming and supervision

1 Introduction :

The Totally Integrated Automation Portal (TIA portal) is a software application for configuring and programming SIEMENS automation systems. It integrates various SIMATIC products, such as STEP 7, WINCC flexible, and WINCC professional.

A common automation solution includes:

- A PLC that controls the process with the help of the program.
- An HMI device that operates and visualizes the process.

In this chapter we will develop an automation program for The Sorting Station via the S7-1200 controller, Additionally, an HMI (Human-Machine Interface) will be developed on a PC to provide a smooth interaction between the user and the machine. This interface will allow the monitoring and the control of the Sorting Station.

2 Visualisation configuration (HMI interface) :

An HMI stands for Human-Machine Interface. it allows the interface between the user and the process, the operation is controlled by the PLC, the user utilize the operator panel to monitor processes or intervene during the ongoing process.

2.2 Win CC:

Machine-level visualization software WinCC in the (TIA Portal) is part of a new integrated engineering concept that offers a homogeneous engineering environment for programming and configuring control, visualization and monitoring solutions. training.

SIMATIC WinCC in TIA Portal integrates WinCC Basic for configuring basic panels, WinCC Comfort for more sophisticated panels and WinCC Advanced for engineering PC-based HMI systems.

2.3 HMI: Supervision screen:

TIA PORTAL enables the configure a various range of SIEMENS supervision screens, offering options in screen size, communication type, and interface type, including both touchscreens and keyboard-operated screens.

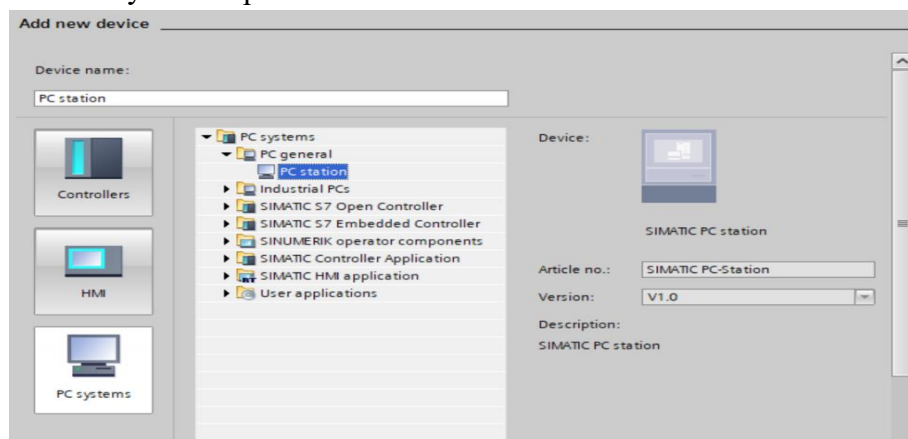


Figure 20: The HMI screen catalog

Chapter 4 : Programming and supervision

2.4 Graphical Programming:

The TIA Portal allows for the creation of operating and monitoring screens for machines and plants. It offers predefined objects to build these screens, which are used to simulate machines, display processes, and define process values. The operator panel's functions dictate the visualization of the project in the HMI and the functional scope of the graphic objects. These objects include all elements used for project visualization in the HMI, such as texts, buttons, diagrams, and graphics.

Graphic objects:

Objects are graphic elements used to create the views for our project. The tool window displays different palettes depending on the currently open editor. When the "Views" editor is open, the tool window offers the following palettes:

- **Simple Objects:** this palette contains the fundamental graphical objects as "line", "circle", "Text Field" or "Graph View".
- **Elements:** Elements are fundamental control elements, such as "I/O Field", "Button" or "Needle Instrument".
- **Controls:** They represent process sequences much like the curve view and the recipe view.
- **Graphics:** This palette contains industrial equipment like pumps, valves, etc.

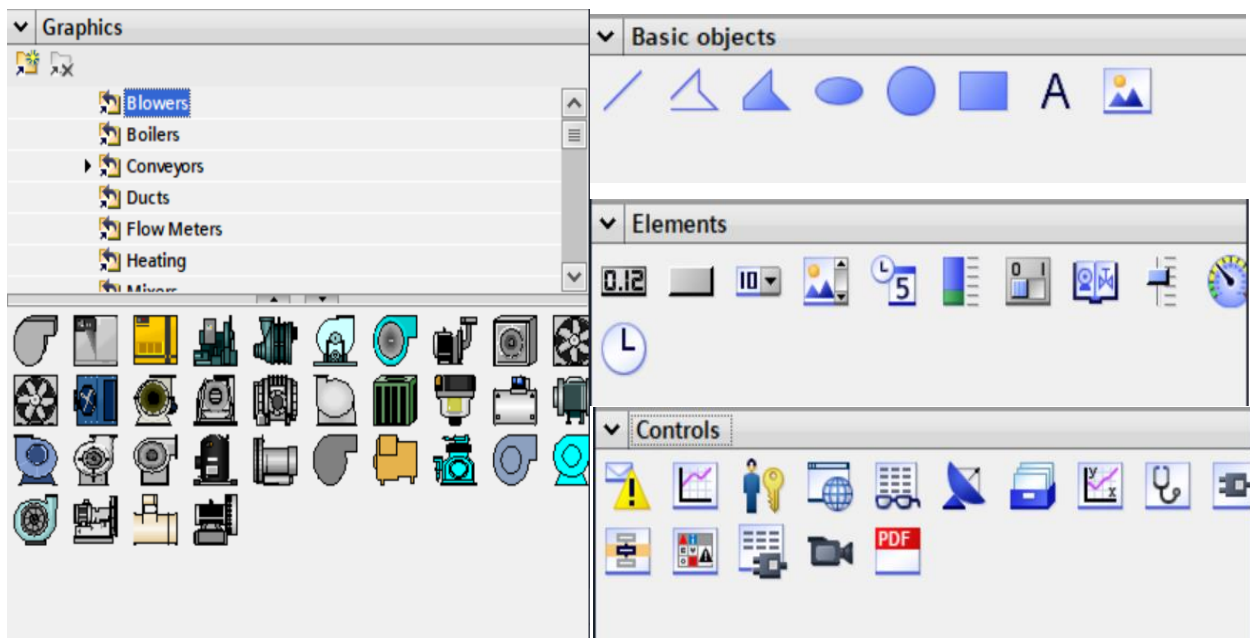


Figure 21:Graphic objets

Chapter 4 : Programming and supervision

3 The Sorting operation

3.1 The operation

The sorting process begins with items placed on a conveyor belt which move them through the sorting station.

- **Metal detection:**

The item passes the inductive sensor that detects whether the item is made of metal, if it is made of metal solenoid actuator number 1 is activated in order to transfer the item to the storing storage 1.

- **Light / Dark plastic detection:**

After moving past the inductive sensor and being acknowledge as Non-metallic item the plastic piece, passes the optic sensor to detect its colour, if the piece is a light plastic solenoid actuator number 2 is activated to direct the piece to the storing storage 2, in case the piece turns out to be dark plastic the conveyor transports the piece to storing storage 3.



Figure 22: Sorting station installation



Figure 23: Solenoid

Chapter 4 : Programming and supervision

3.2 Sorting station sensors:

- **Inductive sensor:**

When an object approaches within the detection range of the sensor, it emits an electromagnetic field for detecting the object. The sensor then analyzes the returning signal to search for any changes. If an object is detected, the returning signal becomes shorter compared to when there is no object present.

- **Optic sensor:**

A color sensor functions by emitting light towards an object and analyzing the light reflected back. It assesses the intensity of red, green, and blue wavelengths in the reflected light to determine the object's color. Subsequently, the sensor transmits a signal indicating the identified color, enabling accurate color detection and differentiation.

4. Programming and Supervision :

4.1 Programming:

4.1.1 Tag table :

In every program, it's essential to establish a list of variables that will be utilized during programming. The tag table enables the definition of the variable list for programming purposes.

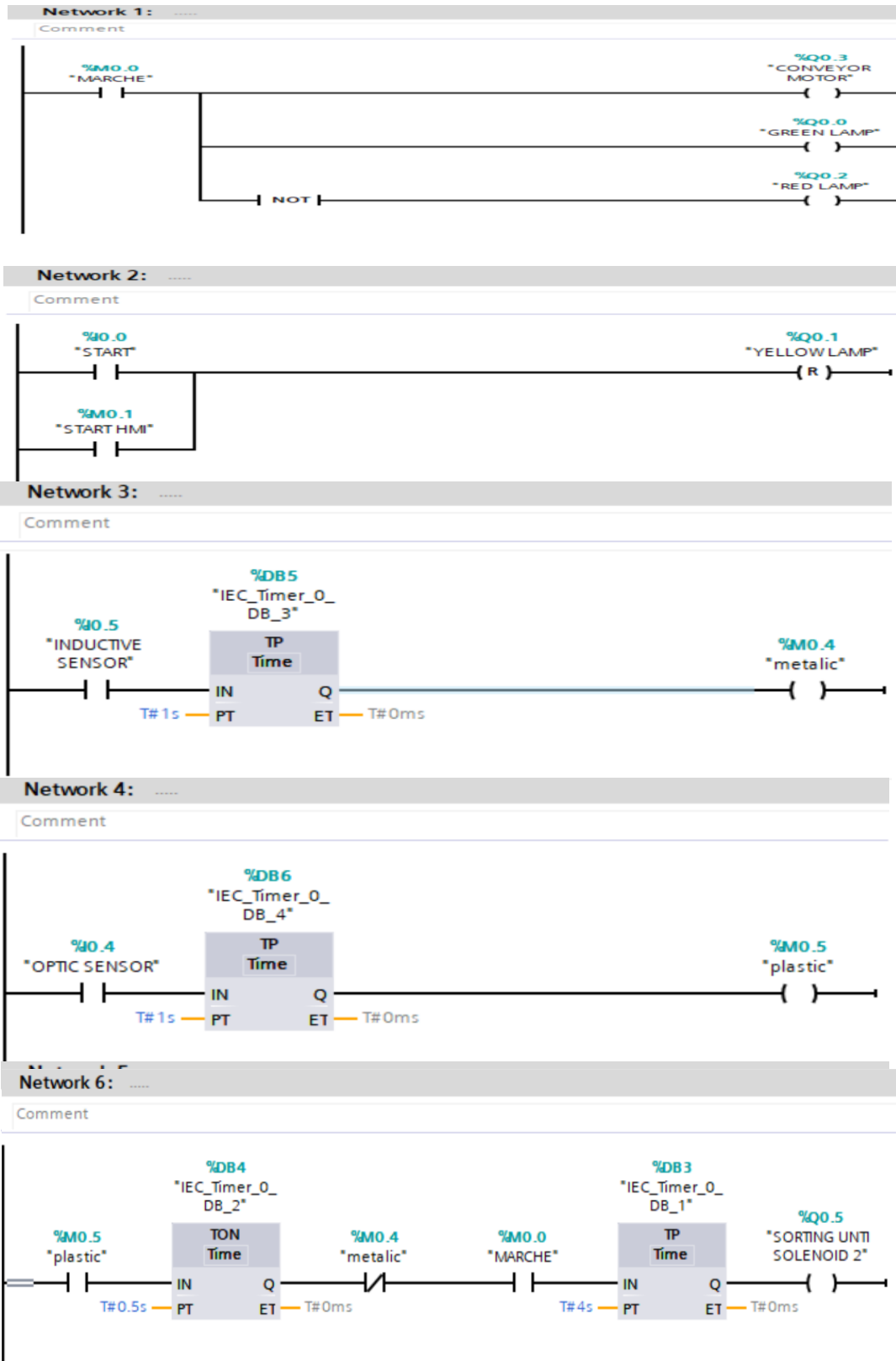
Tag table_1									
	Name	Data type	Address	Retain	Acces...	Writa...	Visibl...	Comment	
1	START	Bool	%I0.0	☐	☒	☒	☒		
2	STOP	Bool	%I0.1	☐	☒	☒	☒		
3	RESET	Bool	%I0.2	☐	☒	☒	☒		
4	OPTIC SENSOR	Bool	%I0.4	☐	☒	☒	☒		
5	INDUCTIVE SENSOR	Bool	%I0.5	☐	☒	☒	☒		
6	GREEN LAMP	Bool	%Q0.0	☐	☒	☒	☒		
7	YELLOW LAMP	Bool	%Q0.1	☐	☒	☒	☒		
8	RED LAMP	Bool	%Q0.2	☐	☒	☒	☒		
9	CONVEYOR MOTOR	Bool	%Q0.3	☐	☒	☒	☒		
10	SORTING UNIT SOLENOID 1	Bool	%Q0.4	☐	☒	☒	☒		
11	SORTING UNIT SOLENOID 2	Bool	%Q0.5	☐	☒	☒	☒		
12	MARCHE	Bool	%M0.0	☐	☒	☒	☒		
13	METAL COUNTER	Int	%MW2	☐	☒	☒	☒		
14	LIGHT PLASTIC COUNTER	Int	%MW4	☐	☒	☒	☒		
15	DARK PLASTIC COUNTER	Int	%MW6	☐	☒	☒	☒		
16	START HMI	Bool	%M0.1	☐	☒	☒	☒		
17	STOP HMI	Bool	%M0.2	☐	☒	☒	☒		
18	RESET HMI	Bool	%M0.3	☐	☒	☒	☒		
19	Tag_1	Word	%MW10	☐	☒	☒	☒		

Figure 24: Tag table

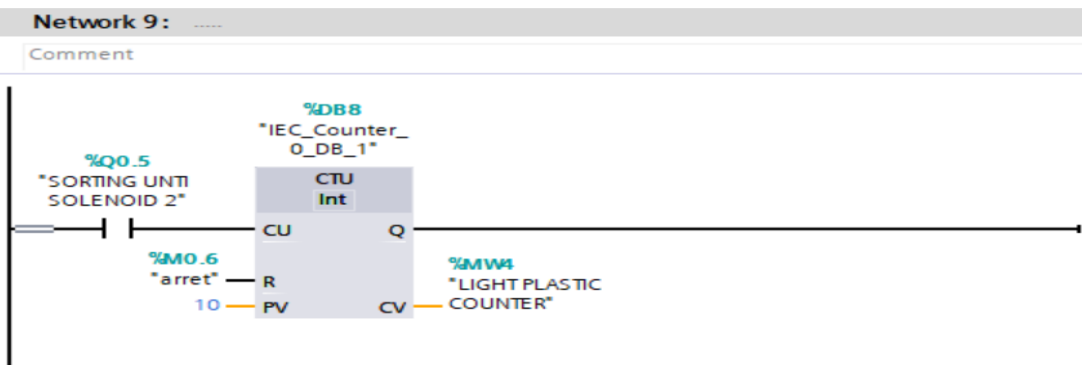
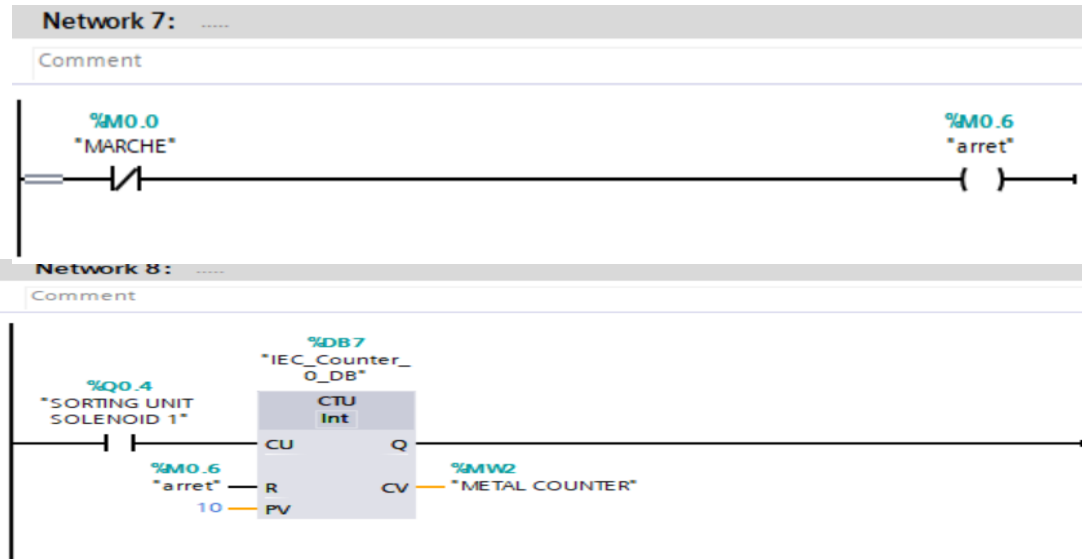
Chapter 4 : Programming and supervision

4.1.2 FB functional blocks:

we developed the sorting station program using ladder language. The figure below represents the FB1 block for sorting station program.

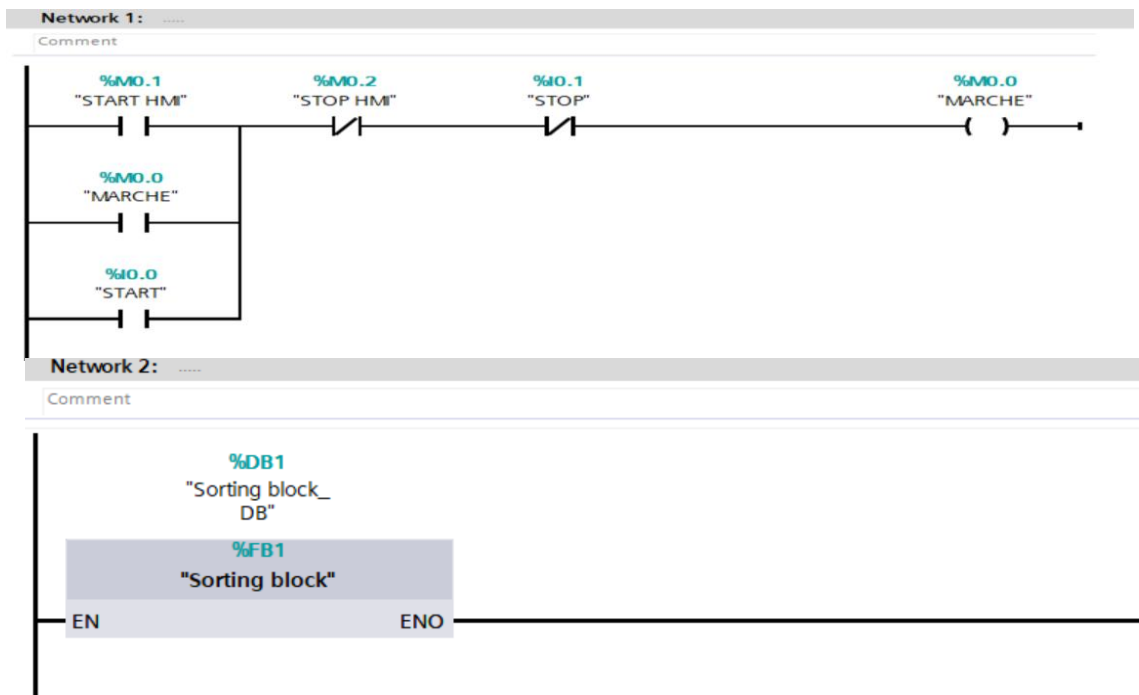


Chapter 4 : Programming and supervision



4.1.3 Organization block OB1:

The OB1 block was used to call the functional block (FB) that we needed.



Chapter 4 : Programming and supervision

4.2 Station supervision under WinCC:

4.2.1 The view description:

In the HMI we previously designed we implemented:

- 1) START BUTTON
- 2) STOP BUTTON
- 3) RESET BUTTON
- 4) EVENT LIGHT FOR THE solenoid actuators
- 5) EVENT LIGHT for the system
- 6) Two counters set to count how many pieces are there in the storage units

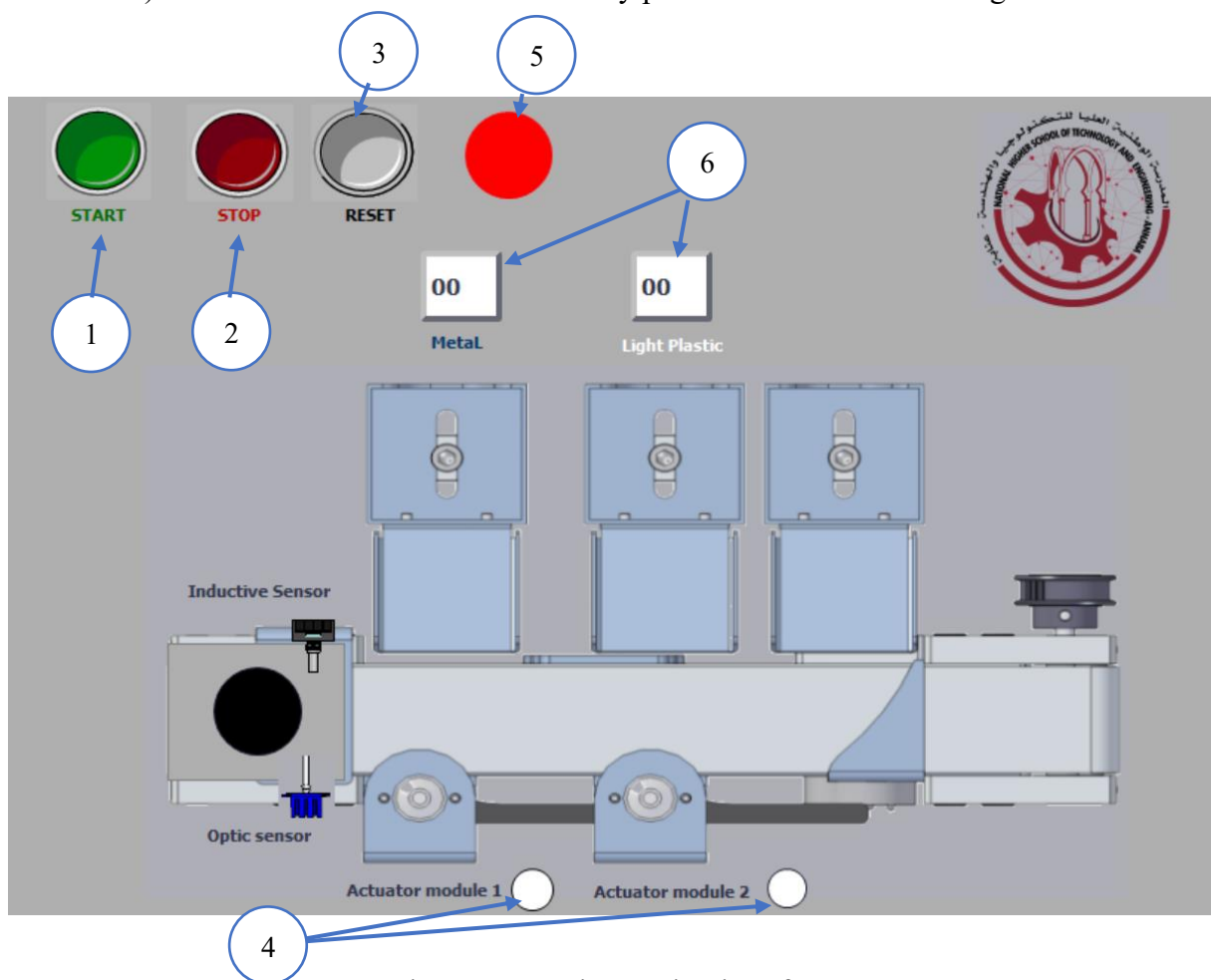


Figure 25: sorting station interface

5. Conclusion:

In this chapter, we laid out the steps of designing and developing the Human machine interface (HMI) for the sorting station using WinCC. Additionally we showcased the code developed in TIA Portal v16 alongside providing a comprehensive explanation of the working principle of the sorting station and its sensors.

Genral conclusion

An HMI (HUMAN MACHINE INTERFACE) serves as a bridge between humans and machines providing a safe environment for the users to control and monitor different processes and potential emergencies, communicate with machines, making complex systems easier to operate.

In this research paper we detailed the process of developing a Human machine interface for the sorting station manufactured by FESTech, while briefly presenting the company FESTech its function, and products.

The first phase focused on displaying the Smart Module System components and functionalities, while the second phase spotted the light on the sorting station explaining the sorting process and the overall system.

Furthermore, this diploma work sought to design a user-friendly interface accessible and reliable aiming to provide operators with clear, real time visualisations of the sorting process.

Finally, we outlined the development of the code for the sorting station using TIA Portal v16, this part also showcased the detailed networks of the ladder logic using different instructions such as timers and counters.

Providing a pleasing HMI that is easy to use while ensuring its accessibility and efficiency was he objective of this project to furnish the user with a consistent experience to enhance the human-machine interaction.

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