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Modeling and Simulation of an industrial automaton (Oil shipping pump)

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Dedication

I thank God for giving me the courage and the will. As well as the consciousness of having been able to complete my studies.

I dedicate this modest work :

to those who have trusted, supported, and encouraged me throughout my life.

I dedicate my work to my dear parents for their encouragement, support and patience.

To my brothers, my sisters and all my family

To all who love me and I love them...

To everyone who knows me, and loves me, I say thank you.

To anyone who directly or indirectly contributed to the completion of this work.

Thanks

We would like to express our gratitude and appreciation to Dr. Abi Mouloud, Lecturer at the University of Ouargla, who led this work, for his support, for his sympathy towards us and for the freedom of research. He was kind enough to guide us,

We extend our sincere thanks to M. Lecturer at the University of Ouargla for giving us the honor of chairing the jury.

We extend our sincere thanks to Mr. Lecturer at the University of Ouargla for agreeing to be a member of the arbitration committee for our thesis.

Abstract

The research we conducted during the period of this thesis aims to design a computer application for HMI panel to control a pump station unit via the virtual industrial programmable logic controller that reproduces by simulation the operation of the real automation at lower cost and without risk.

The purpose of our application is to make it easier for the operator to work, to ensure material and personal safety, with the least amount of manpower, and to avoid pump outages and shipping delays with the lowest cost possible.

As part of our project, we needed automation and supervision software. It is in this sense that we decided to use the new Totally Integrated Automation (TIA) software, which combines both SIMATIC STEP 7 and WINCC.

Key-Words: Simatic, TIA PRTAL, WinCC, Step7, Plcsim, PLC, Ladder, HMI, Supervision

Résumé

Les recherches que nous avons menées durant la période de cette thèse ont pour objectif de concevoir une application informatique pour panneau IHM permettant de contrôler une unité de station de pompage via l'automate programmable industriel virtuel qui reproduit par simulation le fonctionnement de l'automatisme réel à moindre coût et sans risque.

Le but de notre application est de faciliter le travail de l'opérateur, d'assurer la sécurité matérielle et personnelle, avec le moins de main d'œuvre possible, et d'éviter les pannes de pompes et les retards d'expédition au moindre coût possible.

Dans le cadre de notre projet nous avions besoin d'un logiciel d'automatisation et de supervision. C'est dans ce sens que nous avons décidé d'utiliser le nouveau logiciel Totally Integrated Automation (TIA), qui combine à la fois SIMATIC STEP 7 et WINCC.

Mots-clés : Simatic, TIA PRTAL, WinCC, Step7, Plcsim, PLC, Ladder, HMI, Supervision

ملخص

يهدف البحث الذي قمنا به خلال فترة هذه الأطروحة إلى تصميم تطبيق حاسوبي للوحة HMI تسمح بالتحكم في وحدة محطة الضخ عبر وحدة التحكم الصناعية الافتراضية القابلة للبرمجة والتي تستنسخ عن طريق محاكاة تشغيل الأتمتة الحقيقية بتكلفة أقل وبدون مخاطرة.

الهدف من تطبيقنا هو تسهيل عمل المشغل، وضمان السلامة المادية والشخصية، بأقل قدر ممكن من العمالة، وتجنب أعطال المضخة وتأخير الشحن بأقل تكلفة ممكنة.

كجزء من مشروعنا كنا بحاجة إلى برامج الأتمتة والإشراف. ومن هذا المنطلق قررنا استخدام برنامج الأتمتة المتكاملة بالكامل (TIA) الجديد، والذي يجمع بين كل من SIMATIC STEP 7 و WINCC.

الكلمات الرئيسية: سيماتيك، TIA PRTAL، WinCC، Step7، Plcsim، PLC، سلم، HMI، الإشراف

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General Introduction

1-1- Introduction

The oil and gas industry is considered one of the largest industries in the world, and relies heavily on a number of automated processes to maintain production efficiency and ensure the safety of workers and the environment. Among these automatic processes, the petroleum pump is one of the most important devices used in this industry.

A simulation model for an automatic industry that includes a petroleum pump can be designed with the aim of simulating the process of producing and transporting oil and gas accurately and efficiently. This model is used to develop and test new processes and procedures before implementing them on the ground. It enables errors to be corrected and overall production performance to be improved.

An automatic petroleum pump manufacturing simulation model typically includes stages such as raw material preparation, pump operation and pressure adjustment, data logging and performance monitoring. These models also include multiple factors such as ambient temperature and pressure, the efficiency of machinery and equipment, as well as the effect of weather and environmental conditions on the production process.

Drawing on this model, engineers and technicians in the oil and gas industry can analyze and improve various processes and implement changes or improvements to increase productivity and improve overall process efficiency. The model can also be used to train workers to use equipment and apply security procedures correctly and effectively [1].

1-2- Technological trend

Today, technological trend is moving towards the development of industrial companies with automated production units with the aim of providing technological infrastructure for technological applications .This is in order to increase production efficiency, improve product quality and reduce cost. Automated petroleum station technology is considered an important innovation in the oil and gas industry, as it contributes to improving oil extraction and manufacturing processes in a more effective and safe manner.

By modernizing and improving the techniques of using mechanisms in petroleum pumping stations, companies can achieve many advantages, such as reducing human factors in pumping operations, reducing the risk of accidents and improving the quality of extracted products. Therefore, modern technology can contribute to increasing productivity and improving the overall efficiency of the oil and gas industry.

Therefore, governments must pay attention to developing and strengthening the technology sector in the oil and gas industry by supporting companies and providing the necessary infrastructure, to enhance the development of this sector and push it towards innovation and continuous improvement.

1-3- Thesis Context

It is essential for the company to ensure that these automated processes better good operation of the process where deployed software is operable and performance due to a glitch temporarily lowers production. Research work was carried out during this phase but in order to propose a solution which is an information application concept with an human machine interface)HMI(to drive a pumping station unit via a programmable automation that can handle .these pumps remotely

1-4- Problematic

Many pumps in the pump house, their operations and manual : on/off and from observing the level of the tanks are less secure.

The pump safety system is ensured by a chain of contacts linked to relays which receive their states via sensors which give the state of the four (4) parameters to be monitored (vibration, temperature, packing leak, and low flow rate **of water).**

This starting system is very old, complex and presents many difficulties during intervention, which leads to poor functionment.

For greater security and to ensure the proper functioning of the pump, we proposed to design a computer application for an HMI console to control a pumping station unit via the industrial programmable controller which could lead to manipulating these pumps remotely.

1-5- Objectives and contributions

Our objective is to design and model a computer application for an HMI console to control a pumping station unit via the programmable industrial controller which can lead to manipulating these pumps remotely. We take a fresh look at existing pumps. This new vision adopts new approaches to discover routes satisfying certain criteria to ensure proper functioning.

We made the following contributions :

• Study the different industrial automation systems and establish a comparative study according to several classification criteria.

• We proposed the TIA (Totally Integrated automation portal) Siemens redefines engineering. The new TIA Portal development environment brings together the automation software tools namely **:** SIMATIC STEP 7, WinCC and SINAMICS Start-Drive in a common environment [02]. With its intuitive user interface, efficient navigation and proven technology, the TIA Portal stands out in many ways. It constitutes a milestone for the software development of the future

1-6- Thesis structure

The structure of this manuscript consists of three chapters, organized in a manner consistent with :

- **Chapter One:**

  A general introduction of automated systems in the industry and their importance of increasing the productivity and efficiency of manufacturing processes.

- **Chapter Two:**

  This chapter will be devoted to presenting the description of the oil shipping pump as well as the instruments used and giving a short description of the current system and its functional stages.

- **Chapter Three:**

  In this chapter we present the different tools that we choose to design our system, we use the TIA Portal development environment to model the operation of PLC, and the Ladder language which represents the deployment platform of the PLC program.

Furthermore, we present our work which is part of a global perspective consisting of designing a virtual industrial programmable controller, which allows to resume and simulate the operation of real controller with an HMI panel to control a pumping station unit via PLC and to develop a computer application to control and supervise a pumping station.

Chapter I: Study of current systems

2-1- Introduction

This chapter will be devoted to presenting the description of the oil shipping pump as well as the instruments used in this process and give a short description of the current system and its functional steps.

2-2- Description of pumps

2-2-1- Definition of pumping

The crude shipping pump house is an industrial installation for pumping and transporting crude oil from production sites to refining or storage sites. It may consist of pumps, pipes, tanks and other equipment necessary to transfer the oil.

2-2-2- The role of pumps

- Transfer degassed crude oil from RD to RS via 30 inch pipe.
- Increasing the suction pressure of shipping pumps
- Shipping crude from RS to the storage terminal
- Evacuation of settled water from RD and RS to API basin
- Sending oil to the new refinery
- Increase freight productivity to HEH

It is made up of three main parts :

- RD degassing tanks.
- Pumps (transfer, decanting, nutrition, shipping).
- RS storage tanks.

2-2-3- The different pumping system equipments

➢ **Pipeline :**

Characterize by different diameters

- 6“diameter line
- 16“diameter line
- 20“diameter line
- 24“diameter line
- 30“diameter line

➢ **Storage :**

The storage section consists of two floating roof bins with a capacity of 12,000 m3 each. These storage tanks serve as reserve buffers for the pumping station. Each storage bin consists of :

- motorized inlet valve on the drain and purge network.
- motorized inlet/outlet valve on the crude oil inlet network. Level transmitter. High level detection switch.
- Low level detection switch.
- These storage tanks are filled either from the crude inlet network (main network), or from the drain and purge network (secondary network). The bins do not
- can only be drained through the main network.

2-3- The role of storage

Hydrocarbon storage is a very important step in exploitation of hydrocarbons for various reasons .The storage of energy resources is necessary to compensate for supply fluctuations due to all kinds of hazards during the production, transportation and refining

- It is necessary to cope with the fluctuation due to variations in the consumption, which depends in particular on weather conditions.
- It is also strategic to ensure a minimum of energy autonomy of the consumer country.

2-3-1- Characteristics of storage bins

- Height 18 m
- Filling height 16 m
- Diameter 30,480 m
- Volume 13,345 m3
- Filling volume 12000 m3
- Thickness at the base 16.32 mm
- Thickness at the top 6.32 mm

2-3-2- Storage bins

We have two types of bins :

A. RD

Are horizontal cylindrical type tanks with fixed roof. The main role is to store the crude arriving from the last separation stage ; the volume of each one is 2500 m3. (Figure 2.3) [01].

(Figure 2.1) : Example of Fixed Roof Tank

B. RS

These tanks are horizontal cylindrical types with a floating roof with a volume of 1560 m3. Their role is to receive crude oil coming from the RD.

Each tank assembles the inlet and outlet (inlet pipe is the same as the outlet pipe)

❖ **Fi Bin equipment**

- **The dress:** It is a vertical wall made of sheets curved to the diameter of the reservoir.
- **The ferrule:** It is a ring made up of sheets whose succession gives the dress.
- **The bowl:** It is a compartment built around a tray or asset of bins intended to receive the contents of the bin or set of bins in the event of an accidental leak.
- **The bottom:** This is the base of the tank; it is also made of a set of sheets.
- **The base:** This is the foundation on which the tank rests. Figure 2.4: Example of floating roof containers

2-3-3- Bins

Certain security measures must be put in place for the safety of the bins :

- Isolation by manual valves follows regulations.

- Presence for very low level and very high level alarm tanks (LALL/LAHH).
- Pressure alarms.
- Presence of vibration and pressure sensor.
- Non-return valve on the reception and delivery lines,
- Sizing of vents taking into account the possibility of transfer accidental.
- Watering crowns (water and/or foam).
- Lightning protection (ground braid).
- Tanks with watertight retention.
- Regular monitoring by the Inspection of all equipment

2-4- Pump models

2-4-1- Transfer pumps

Transfer pumps are used to move crude from storage tanks (RS) to distribution tanks (RD). Their role is to efficiently pump crude through pipelines to ensure rapid and continuous transfer.

These pumps help to ensure a consistent supply of crude oil to processing and refining facilities, thereby helping to maintain the production and distribution of petroleum products

2-4-2- Feeder pumps (boosters)

They are connected to the 30“ pipes, their role is to increase the pressure of the crude oil drawn off to reach a pressure equal to 5 bar, which is the pressure that must be at the entrance to the main pump network.

2-4-3- Shipping Pumps

Which are used to ship liquids at high pressure. These pumps are designed to be robust and reliable to operate efficiently in harsh conditions.

2-4-4- Decanting pumps

They are used to pump waste water, sludge and other liquids into systems of waste water collection .Their role is to purge the water collected from the RD and RS.

2-4-5- Draining pump

Their role is to empty the collected quagmire of RD and RS.

	Nombre	Débit N	Press.Ref.	Vitesse
Transfert	03	1090 m^3/h	3 à 3.5 bars	975 T/m
Feeder	02	725 m^3/h	3.5 bars	
Decanting	04	190 m^3	3 à 3.5 bars	
Shipping	03	1450 m^3/h	15 bars	1485T/m
Draining	02	370 m^3/h	3 à 3.5 bars	

(Tab.2.1): The different types of pumps

2-5- The Vannes TOR Pump

The main security measures that must be put in place to reduce risks of leakage and their consequences :

- Presence of manual isolation valves on suction and discharge.
- Presence of non-return valves on discharge for centrifugal pumps.
- Systematic monitoring of all pumps by Maintenance (vibrations, noises, general condition).
- Permanent visual surveillance by operators

All-or-nothing automatic valves (or TOR) are automated equipment whose role is to interrupt or allow the passage of a fluid (gas or liquid) in a pipe.

(Figure 2.2) : The van TOR pump.

2-6- Instrumentation

Any industrial installation is equipped with a set of sensors and actuators whose usefulness consists of controlling the main physical parameters, namely, level, Flow, pressure, temperature, vibrations, etc.

Therefore we will present the different sensors and actuators used in the transfer and shipping pumps as well as their connection.

2-6-1- Level detector :

Level detection on the bins is ensured by this system : The ENRAF system : The servo gauge is a very reliable, versatile and precise automatic instrument with a minimum of moving parts.

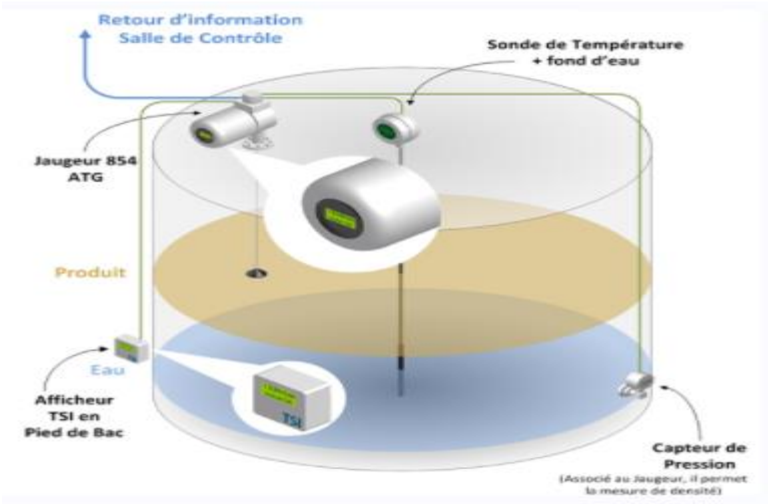
(Figure 2.3) : Slave gauge view

2-6-2- The local TSI indicator

Is a compact digital device which allows data from the gauges of the ENRAF remote gauging system to be read safely at ground level (Figure 2.4)

(Figure 2.4) : The local TSI indicator

An optional keypad allows the user to send commands to the gauge (and scroll through detailed density, interface level and other useful tank data. The TSI features an easy-to-read display which immediately presents with great precision the measurements of liquid level, temperature, and the status of the tank and the product (Figure 2.6)



(Figure 2.5) : Installation of level gauge.

The system used is a simple and advantageous system intended for monitoring rotating machines (fans, pumps, etc.) it provides a signal in the case of the presence of vibrations. The system consistsof a sensor (CA 220 or CA 201), the monitor and a relay. For each pump there are two vibration probes, one is installed on the front bearing and the second on the rear bearing

(Figure 2.6) : Vibration detector.

2-6-3- Temperature detector

PT100 temperature probes are sensors commonly used in industry. Their principle is based on the variation in temperature resistance of a conductor according to known and stable electrical characteristics. The name of the most common model pt100 means that the sensor has a resistance of 100ohm at 0°c. They can be used in temperature ranges going beyond -200°C to 800°C.

The variation in resistance is almost linear as a function of temperature. In the pump room there are seven temperature detectors on each pump installed as follows :

(Figure 2.7) : Temperature detector probe pt 100.

2-6-4- Pump seal leak detector

They can be used to detect leaks in various industrial applications such as storage tanks, process vessels, heat exchangers, etc. When the liquid level reaches the detector, the floatrises activates an electrical contact which can trigger an alarm or stop the process if a leak is detected. These detectors can also be integrated into a remote monitoring system for early detection of leaks and rapid response.

Due to their robust design and reliability, MAGNETROLE liquid level detectors are widelyused in oil and gas industry, chemical industry, food industry, etc. to guarantee the safety of installations and prevent leaks of dangerous liquids. (Figure 2.8)

(Figure 2.8) : Pump seal leak detector.

❖ **basic models are available :**

– External chamber with flange.
– Welded outer chamber.

In hundreds of industrial applications in power generation, petrochemical production and petroleum refining, these detectors have demonstrated their value through reliable and repeatable service

2-6-5- Cooling Water Flow Detector

MAGNETROL flow detectors are extremely reliable instruments that detect the presence or absence of liquid in horizontal pipes. The disc actuated detector is used for gas or liquid flow applications in pipes 2”; and larger (Figure 2.9).

(Figure 2.9) : Cooling water presence detector

Pressure Switch : they are placed before and after the shipping pumps, they are intended to indicate low pressure in the pipes on the suction side or high pressure on the discharge side to keep the pumps running.

The pumps are started, if Pressure Switch indicates a low suction pressure or a high discharge pressure, a pump shutdown is planned.

The control panel : the storage unit has a control system grouped on an independent local panel designed specifically for alarms and different indicators.

2-7- Pump start-up loan conditions

For the pump to be ready for start-up, some conditions must be verified.

These conditions are :

- No high temperature.
- No vibration.
- Presence of cooling water.
- No gasket leaks.
- No low suction pressure.
- No high discharge pressure.

2-8- System Description

The crude is separated in several separation stages, it is then desalinated, stabilized then stored before being shipped) storage terminal. The part of the stabilized crude is processed on site in the TOPPING unit to obtain finished products such as diesel, gasoline, lampant and butane which are stored in the finished products storage yard.

2-9- Operation of pumping

This is done in two phases:

2-9-1- The first phase: transfer

This phase is done after filling the RDs and to start the transfer operation the operator must open one of the transfer valves A, B, Neck D since each RD has its own transfer valve with the corresponding RS, the transfer process begins at the end of the operator's task. The means of transfer are pumps called GA1103 A/B/S via the 16 “lines.

2-9-2- The second phase: The expedition

This operation comes after the transfer phase. The shipment passes through valves A, B, C or D which are crossed by the crude generated with GA1102 A/C/B shipping pumps these pumps suck up the crude from pipeline 16“and 30“at a pressure of 5 bar and discharges it to 20 bar.The fact that both pressures are important, two pumps are placed to feed the suction of the shipping pumps to achieve the desired suction pressure. The two GA1101 pumps called feeder pumps.

2-9-3- The pump ON/OFF system

The two phases are manually controlled to see the level of the tank, if it is full or at low level or to open the tank drain valve. So, the pump on/off system is manual.

2-10- Conclusion

After our presentation of the curent systems of pumping and the instruments of control used, a more devlopped and sofisticated system is requested to ensure security and facilitate the control.So in the next chapter we propose an automated solution to address these issues .

Chapter II : PLC Programming and simulation

3-1- Introduction

In this chapter, we present the different tools that we choose to design our system. We needed automation and supervision software. It is with this in mind that we decided to use the new Totally Integrated Automation (TIA) software which includes both SIMATIC STEP 7 and WIN CC. Totally Integrated automation provides an optimal response to all requirements and offers an open concept with regard to international standards and third-party systems.

3-2- Why TIA?

Due to the availability of the Siemens automaton and its technology as well as the various information available on the internet, we have relied on SIMATIC STEP 7 which is the exellent programming software for the Siemens automaton.

With the TIA (Totally Integrated automation portal) Siemens redefines engineering. The new TIA Portal development environment brings together the automation software tools namely : SIMATIC STEP 7, WinCC and SINAMICS Start-Drive in a common environment. With its intuitive user interface, efficient navigation and proven technology, the TIA Portal stands out in many ways. It constitutes a milestone for the software development of the future.

Totally Integrated automation from Siemens is an automation architecture with clearly defined characteristic system properties :

- Engineering
- Communication
- Diagnosis
- Operational safety (Safety)
- Data security
- Robustness

TIA Portal also has the following advantages :

Intuitive : simple to learn, simple to use Due to task-oriented, intelligent and intuitive editors.

Efficient : Due to a consistent engineering framework for all automation tasks. Sustainable : reuse of existing automation solutions and integration of future software products into the TIA Portal engineering Framework

3-3- SIMATIC STEP 7 TIA Portal

3-3-1- General description

SIMATIC STEP 7 is the most famous programming software in the world and the most used in the field of industrial automation .It is intended for programming of s7 1200, s7 1500 PLCs and s7 300 and s7 400 CPUs. Among its different applications include :

3-3-2- PLC programming

It allows :

- Configuration and programming of controllers SIMATIC S7-1200, S7-300, S7-400 and the new S7-1500 :
- Device and network configuration for the entire chain automation.
- Online diagnostic for the entire project.
- Motion and Technology for integrated Motion features.
- Simulation and visualization of the project. In our project, we used TIA PORTAL V16, which has many new features:
- Automatic marking of multi-use objects.
- Offline work possible with multi-user engineering.
- Improved recording and commenting functions project server with extensive revision history and editing functions recovery

3-3-4- Ladder Diagram (LD)

Ladder language or ladder diagram is a graphical language very popular with automation Engineers for programming industrial programmable logic controllers. It looks a bit like electrical diagrams, and is easily understandable, Ladder is the English word for ladder.

Language components:

There are 3 types of language element:

- The inputs (or contacts), which allow you to read the value of a Boolean variable;
- The outputs (or coils) which allow you to write the value of a Boolean variable;
- The functional blocks which allow advanced functions to be carried out entries (or contacts), there are two types of contact: The normally open (NO) contact (en: NO normally open)

3-3-5- The advantages of the TIA portal software

- **Intuitive and fast programming:**
  - With programming editors newly developed SCL, LAD, LOG, LIST and GRAPH.
- **Increased efficiency Due to the linguistic innovations of STEP 7:**
  - Uniform symbolic programming, Calculate Box, adding blocks during Operation, and much more.
- **Increased performance thanks to integrated functions:**
  - Simulation with PLCSIM, remote maintenance with Teleservice and consistent system diagnostics.
- **Flexible technology:**
  - Scalable and efficient motion control functionality for S7-1500 and S7-1200 controllers.
- **Secrete accrue avec Security Integrated:**
  - Know-how protection, copy protection, access protection and protection against falsification.
  - Common configuration environment with HMI panels and drives in the TIA Portal engineering environment.

3-4- SIMATIC WinCC

SIMATIC WinCC is a powerful software for all HMI applications, ranging from simple operation solutions with Basic Panels to SCADA applications on PC-based multi-user systems. It offers efficient engineering combined with powerful archiving and maximum data security.

WinCC supports international standards and native script and programming interfaces, allowing integration of special requests. With options and add-ons, WinCC can be expanded for technological and industry-specific solutions.

The system then generates all the necessary settings, such as connection, HMI variables, view object. Finally, a comfortable selection window makes it easy to select the desired object. The configuration via selection windows is present throughout the TIA Portal. This eliminates the need for incorrect, manual or multiple entries of object names. Strong points :

- Scalable run-time functionality from Basic Panels to distributed SCADA applications. Innovative configuration interface based on cutting-edge software technologies.
- Comprehensive library concept for freely definable objects and faceplates.
- Intelligent tools for graphic configuration and mass data processing

3-5- Designing a program with TIA PORTAL V16

The strategy to follow when designing a program using TIA PORTAL V16 platform is :

1) The creation of a new project ;
2) Hardware configuration ;
3) Compiling and loading the configuration ;
4) The creation of the mnemonics table ;
5) Program development ;
6) Simulation with the software ;
7) Program status visualization (test).

The design of an automation solution is done through two alternatives, either started with programming or hardware configuration. In our case we started with configuration

3-5-1- Portal view and project view

(Figure 3.1): TIA Portal V16.

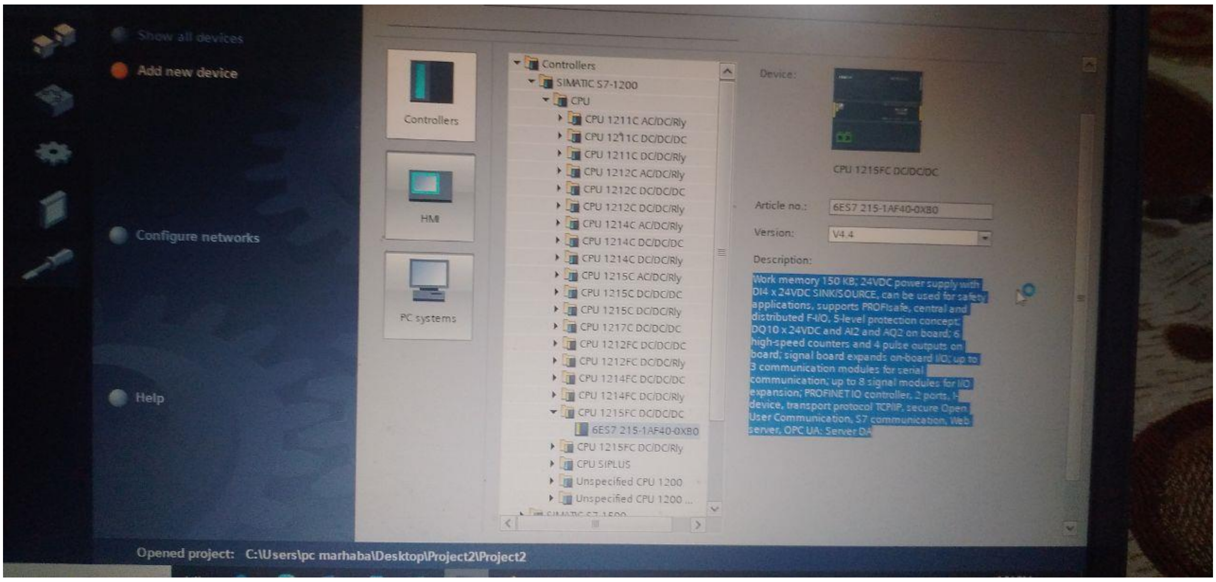
When you launch TIA Portal, the working environment is divided into Two view types :

❖ **The portal view:**

It is focused on the tasks to be performed and is very easy to use and fast.

❖ **The project view:**

It includes a tree structure with the different elements of the project. The required editors open depending on the tasks to be carried out : data, Settings and editors.3 They can be viewed in a single 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, the figure below represents a view of the portal.



(Figure 3.2) : Working window.

3-5-2- CPU chosen

SIMATIC S7-1200, CPU 1212C carecterised by:

- Compact CPU, DC/DC/DC, with 100 KB memory work, onboard I/O: 8 DI 24 V DC; 6 DO 24 V DC (8 digital inputs/6 digital outputs),
- 2 AI 0-10 V DC, power supply : DC 20.4-28.8 V DC.
- Number of modules per system: max. 3 comm. modules, 1 signal board, 2 signal modules
- PROFINET Ethernet interface, RJ45, with 01 port switch, integrated power supply.

(Figure 3.3) : CPU 1212C

3-5-3- Power module

The power supply module (6ES7307-1BA00-0AA0) independent of the PLC programmable, ensures the distribution of energy to the different modules. Our module power supply has a power of 25W and powered at 24V DC. The image shown in Figure 3.4 represents the power supply module (SP) that we have chosen.

(Figure 3.4) : the power supply module (SP)

3-5-4- I/O modules

Illustrates the input and output modules which associate the automaton Industrial programmable, that we will program it.

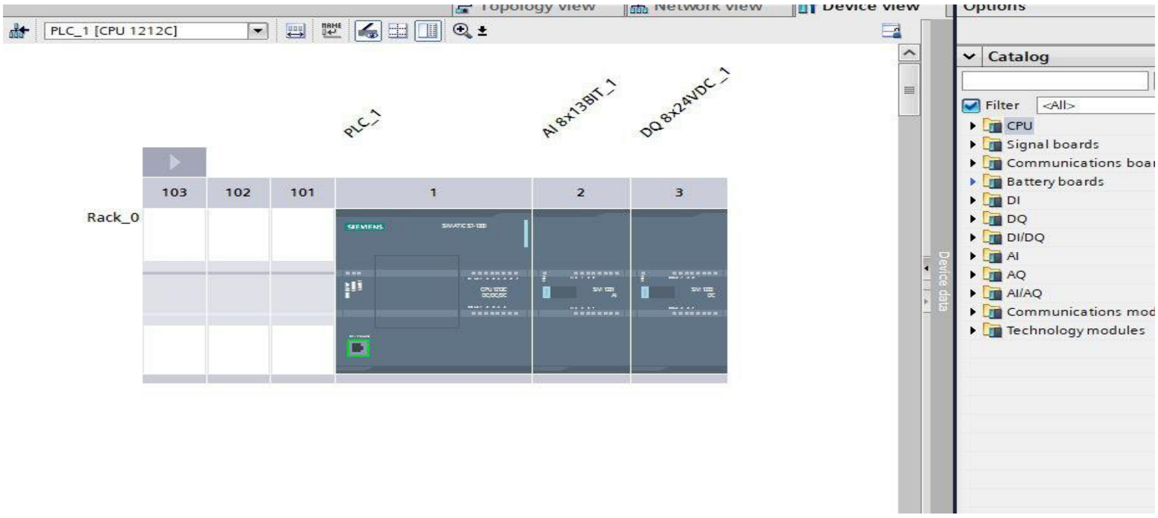
- The digital input module used in our program is reference 6ES7521-1BL00-0AB0,
- The output module chosen in this project is reference 6ES7522-1BL10- 0AA0,
- The chosen analog input module is reference 6ES7531-7KF00-

(Figure 3.4): DI 8x24VDC BA

(Figure 3.5): DQ 8x24VDC/0,5A BA

(Figure 3.6): AI 8x13 bit_1

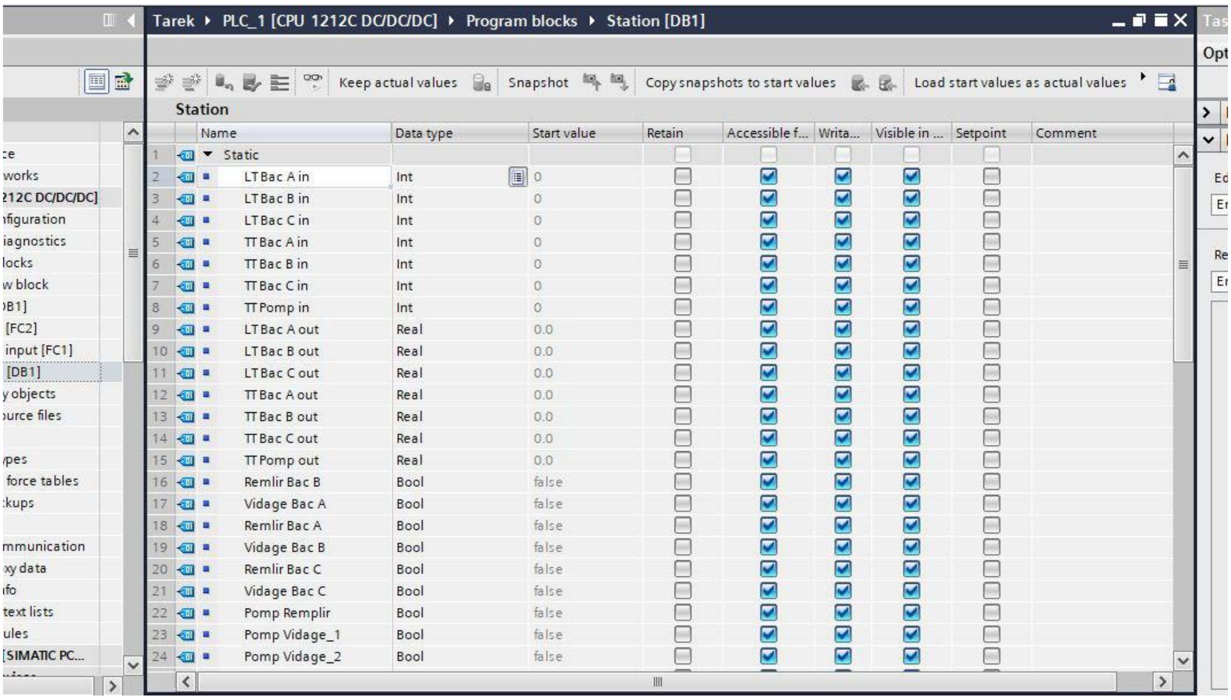
The modules of our API (PS power supply module, processing module, DO digital output modules and an 8-input AI analog input module



(Figure 3.7) : CPU 1212C

3-5-5- Table of Variables

After having chosen the PLC modules we will create a table of variables which contains inputs, outputs and internal variables, like the following image



	Name	Data type	Start value
1	Static		
2	LT Bac A in	Int	0
3	LT Bac B in	Int	0
4	LT Bac C in	Int	0
5	TT Bac A in	Int	0
6	TT Bac B in	Int	0
7	TT Bac C in	Int	0
8	TT Pomp in	Int	0
9	LT Bac A out	Real	0.0
10	LT Bac B out	Real	0.0
11	LT Bac C out	Real	0.0
12	TT Bac A out	Real	0.0
13	TT Bac B out	Real	0.0
14	TT Bac C out	Real	0.0
15	TT Pomp out	Real	0.0
16	Remlir Bac B	Bool	false
17	Vidage Bac A	Bool	false
18	Remlir Bac A	Bool	false
19	Vidage Bac B	Bool	false
20	Remlir Bac C	Bool	false
21	Vidage Bac C	Bool	false
22	Pomp Remplir	Bool	false
23	Pomp Vidage_1	Bool	false
24	Pomp Vidage_2	Bool	false

(Figure 3.8) : Table of variables.

❖ **Variables can be of type:**

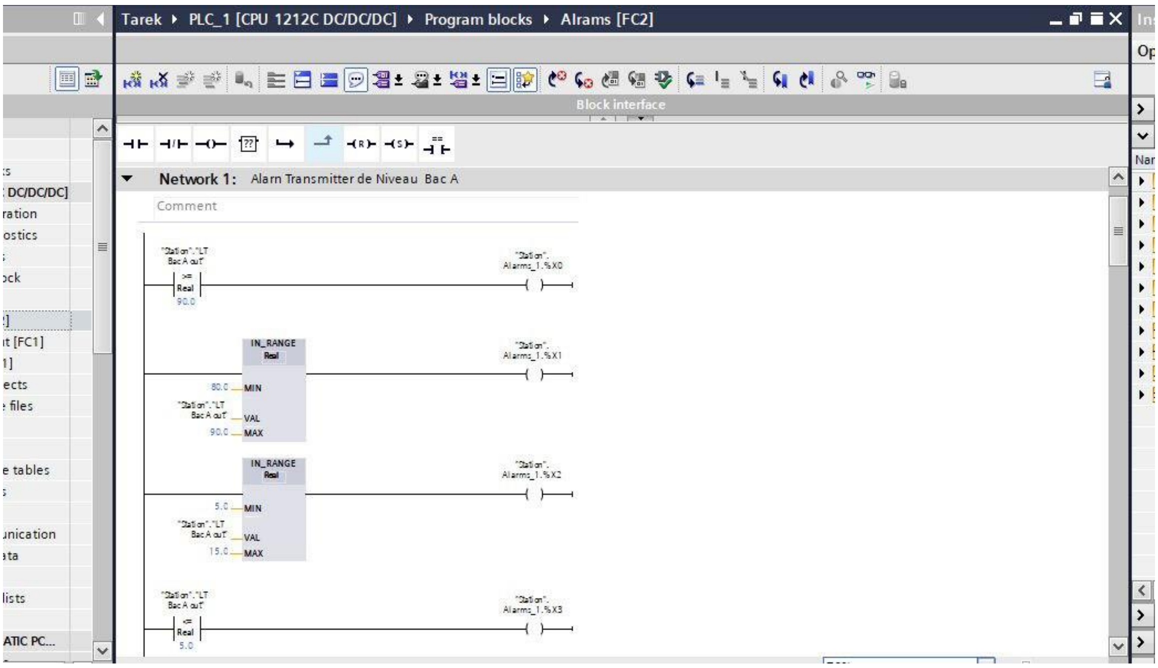
1) 1 Starters to know the status and progress of the process, the automation collects information from Of the installation and this via PLC inputs which are connected to the various sensors and Installation buttons to process them and generate the command.
2) 2 Exits After processing the input data and to control the installation, the automation must generate and send signals through these outputs. The PLC outputs are connected to the various valves, pumps and actuators of the installation.
3) 3 Internals (memo) Memory area in the system memory of a CPU. It is possible to access it for writing and reading (by bit, byte, word and double word). The memory area allows the use

3-6- The programming

3-6-1- Main program

In order to create the table of variables we will start programming. The MAIN OB1 block (Figure 4.13) contains the main program and the other function blocks (Alarms_Level_A (FC1), Alarms_Temp (FC2), Alarms_Temp_Pumps (FC3), digital_alarms_block (FC4), Pump_Drain_G_SCL (FC5), Pump_Drain_F_LIST (FC8) and the Alarms (DB1) and Thresholds (DB8) data blocks) represent the subroutines for the different operations (Pumps operations, Opening, Closing of valves, choosing Modes and scenario, alarms, timing and indication).SCALE function

Adds SCALE type functions which process the analog values recorded by the level sensors mounted on the tanks



(Figure 3.9) : SCALE function for Bac A level

3-6-2- Block programming (LD programming language)

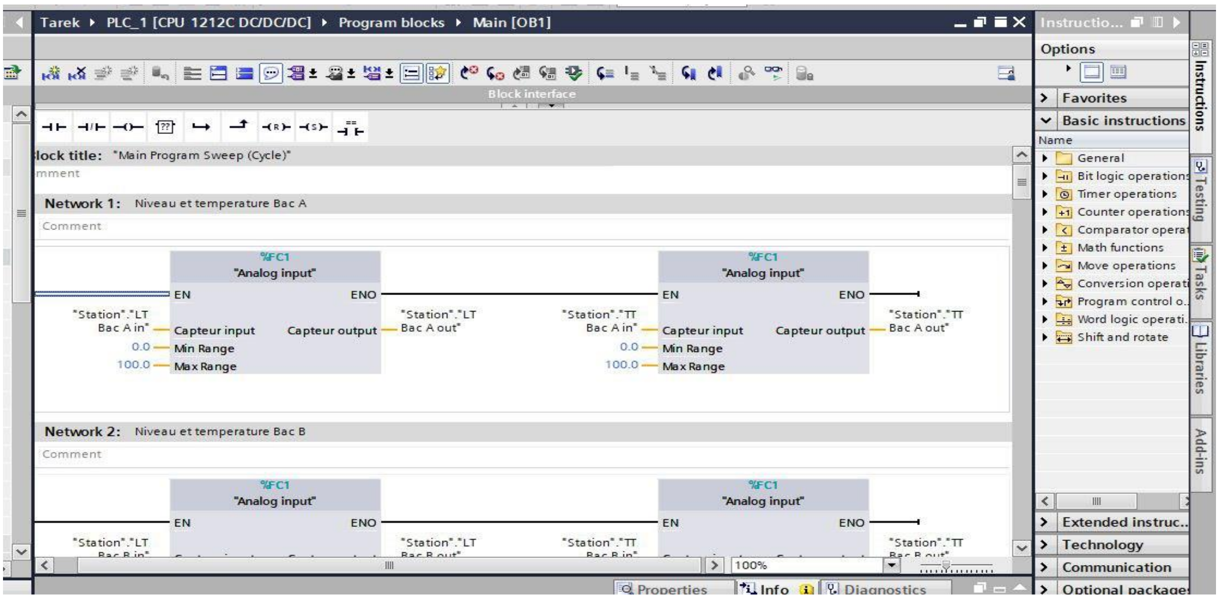
Function Blocks :

1) The FC1 function block (Alarms_Level) which contains four comparators :
   If the level exceeds the very high level threshold value (90.0) in one of the level sensors a LAHH (Very High Level) alarm will be triggered.
2) If the level exceeds the high level threshold value (80.0) in one of the level sensors an LAH (High Level) alarm will be triggered. This memory will be used later as a condition for starting the pumps
3) If the level exceeds the lower limit of the very low level threshold value (15.0) in one of the level sensors an LAL (Low Level) alarm will be triggered.
4) If the level exceeds the lower limit of the low level threshold value (5.0) in one of the level sensors a LALL (Very Low Level) alarm will be triggered. This memory will be used subsequently as a condition for stopping the pumps.
5) The memory addresses LAH, LAHH, LAL and LALL are output parameters in the function, the memory address Level represents the input parameter.
6) The Threshold.LAL and Threshold. LALL are constants which respectively take the real value 80.0, 90.0,15.0 and5.0.

3-6-3- Calling the Function Block from the main program block

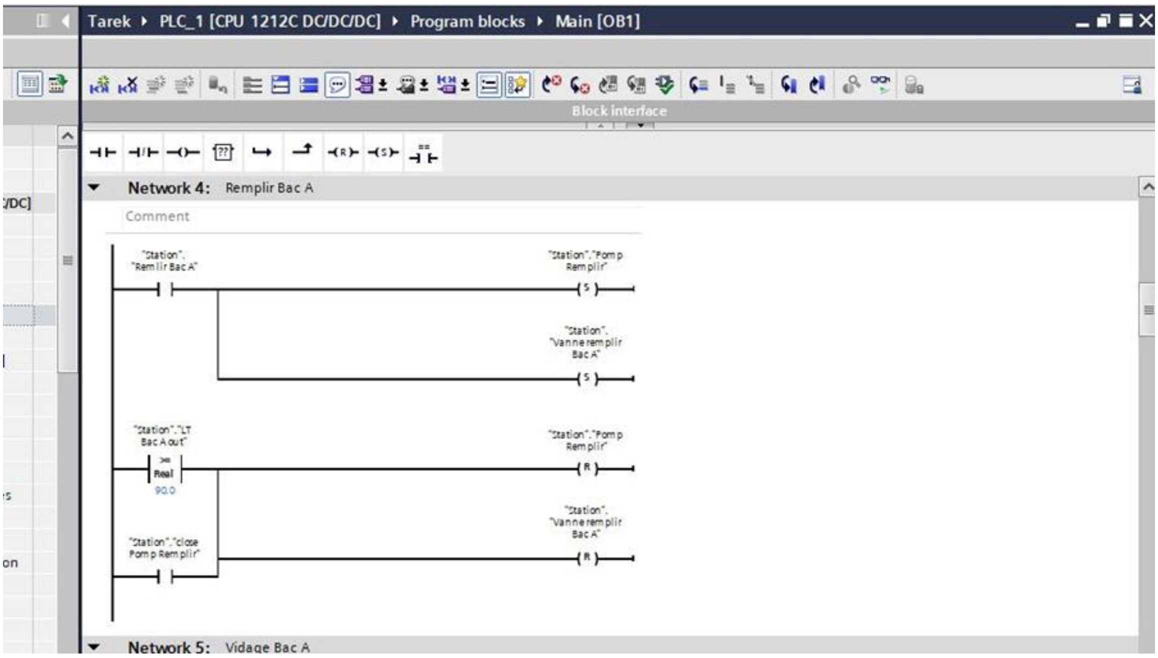
For the PLC to execute the program, the function block FC1 (Alarms_Level) containing the comparators must be called from the main program block.

Adding the function block is simply done by dragging the functional program block into the main program block



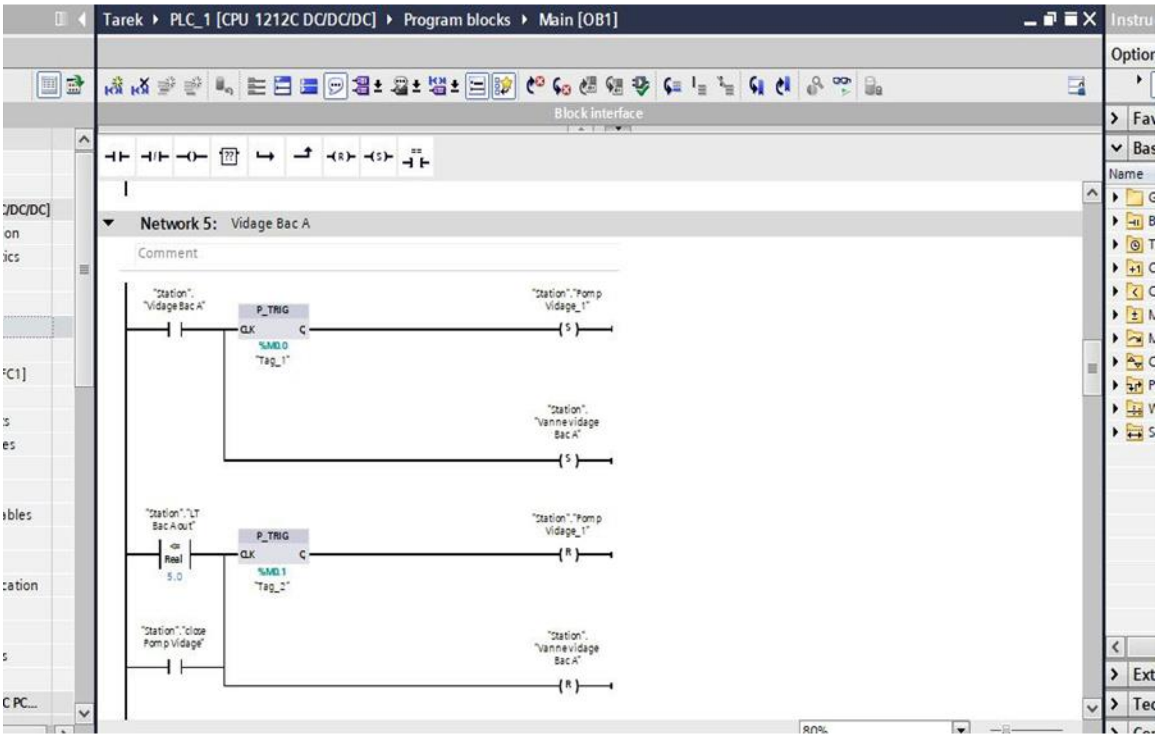
(Figure 3.10) : Calling the Function Block from the main program bloc

- **Filling Bac A :**



(Figure 3.11) : LD program of filling Bac A

- **Emptyng Bac A :**



(Figure 3.12) : LD program of emptyng Bac A

3-7- Supervision and Simulation

3-7-1- Introduction to supervision

Supervision consists of monitoring the evolution and control of the automated system using a computer. For this, a supervision program carried out with the TIA PORTAL software (WinCC flexible) is carried out on a PC which supports the general view of the process.

To properly control the process, the operator needs to have maximum transparency, which allows him to properly supervise and control the installation, this is possible with the human machine interface (HMI). Process control is provided by the automation system.

Once the console is connected to the network, it allows :

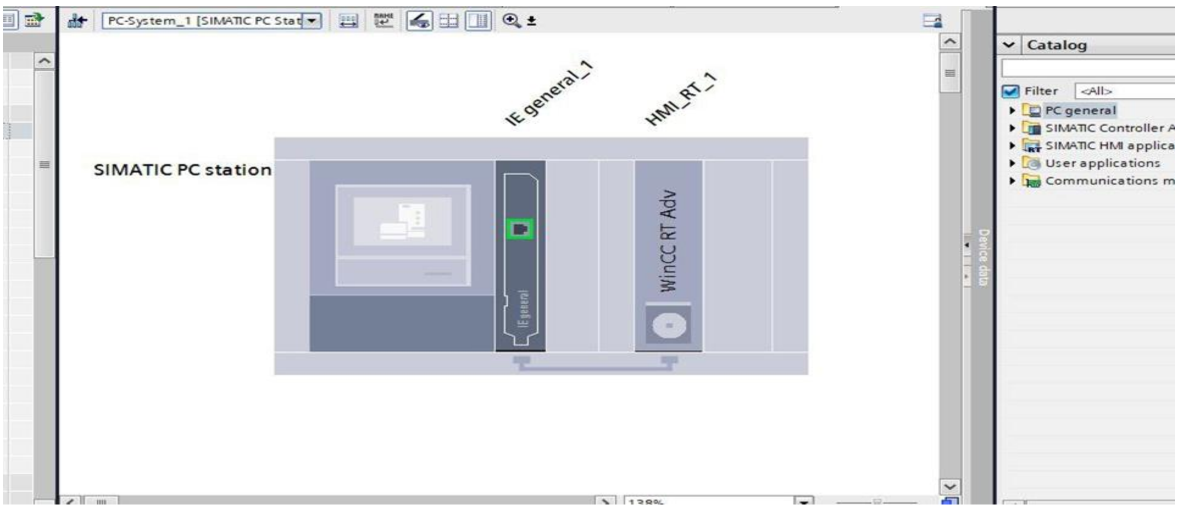
- View the status of actuators (pumps, valves) and sensors (pressure, level, temperature, start).
- Display faults and alarms.
- To act on pumps and valves.

3-7-2- WinCC RT Advanced configuration

Befor testing our program, we must create a Human/Machine interface device, Siemens offers us several types of HMI. We choose the HMI Pc System of type WinCC RT Advanced and reference 6AV2 104-Oxxxx-xxxx

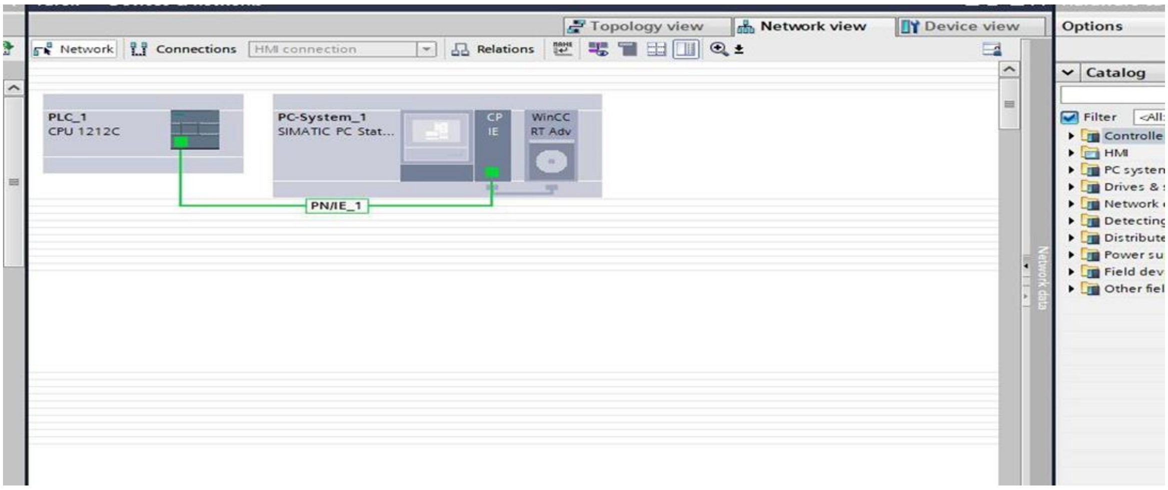
❖ **Communication port configuration**

In this step we need to add an IE General communication port between PC and CPU. **(Figure 3.13)**



(Figure 3.13) : Configuration IE General port of communication for establishing an HMI connection

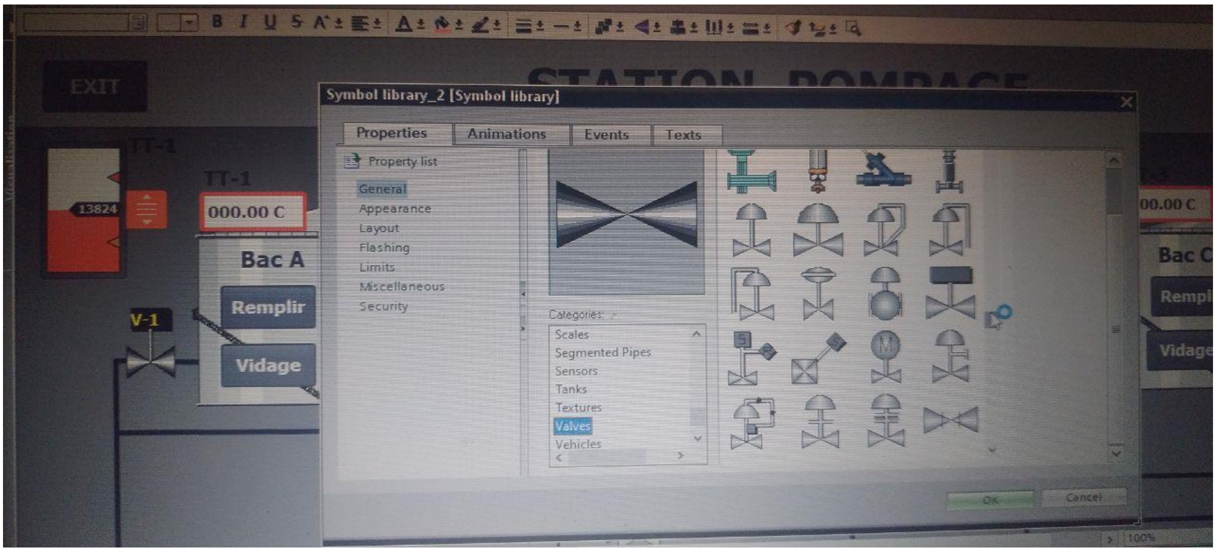
We must first create an HMI link between the CPU and the HMI, in order to be able to read the data that is in the automaton. **(Figure 3.14)**



(Figure 3.14) : HMI Link(PLC-PC System)

❖ **Creating views:**

After choosing the device, we can now create the synoptic views from the large WINCC library of 'SIEMENS'. The following figure represents the overall view of the Human/Machine interface. We can add other views for different process operations. To each view you can add elements (objects) by pressing on the chosen object then dragging it onto the view.

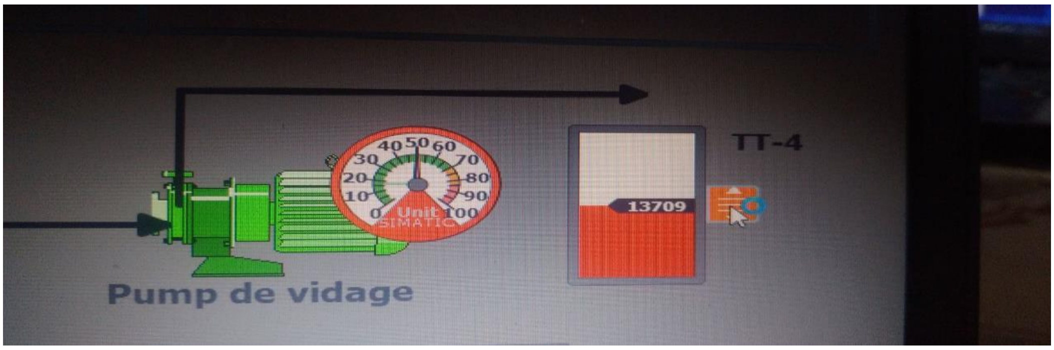


(Figure 3.15) : Configuring view elements

❖ **Pump configuration:**

Animation : Each pump is associated with a PLC output, when the output variable is at “0” the pump is represented in red (pump off), when the variable is at “1” the pump is in green (pump running).

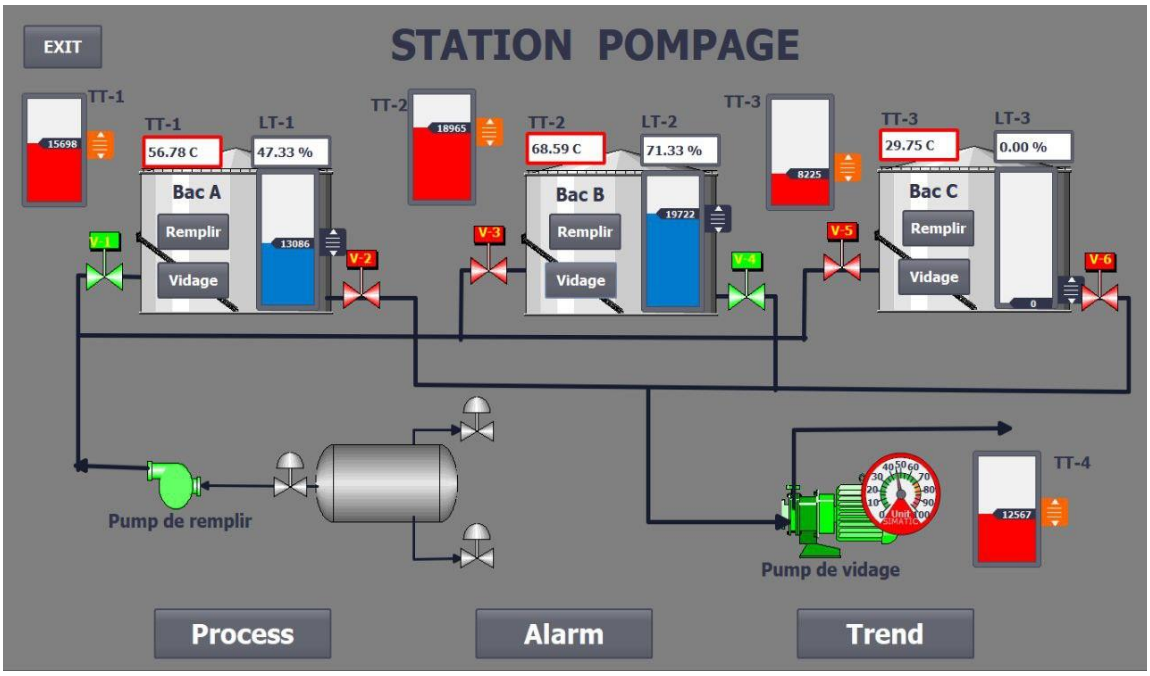
Right-click on the chosen object "Properties>Animation>Display>Representation". Assign it a variable that, based on its value, and let's choose the colors red for value 0 and green for value 1



(Figure 3.16) : Configruring pumps

❖ **General Interface:**

This is the general view of the project, it allows us to visualize the state of the actuators and gives the state of each pump (on or off) as well as the positions of the valves (open/closed), the level of the tanks and it also gives us the possibility of controlling the start of the pumps and the manipulation of operations on the valves. From this view the operator can access the different views of the project



(Figure 3.17) : General Interface

❖ **Bins:**

It is a detailed view it represents the 3 tanks and gives us the status of each tank the level (% and in mm) the volume in (m3) and the temperature in (°C) and display all the level alarms and temperature in these tanks.

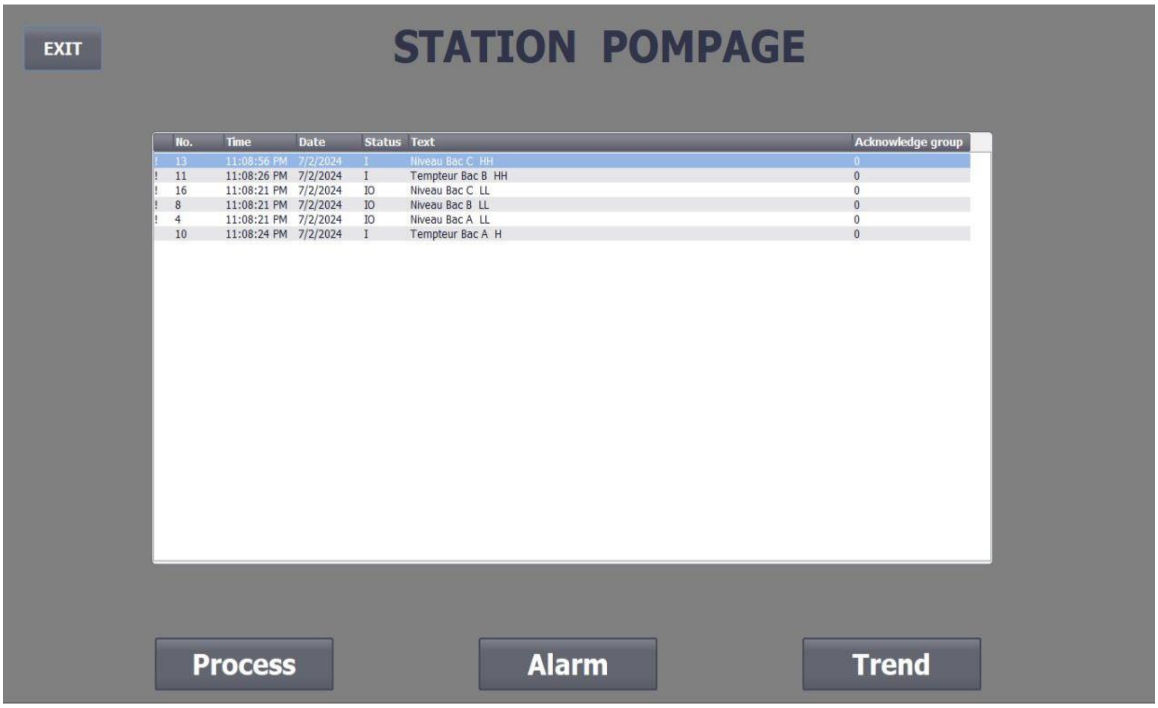
From this view you can return to the initial view or go to the other views you want

❖ **Valves**:

- It gives us the state of the valves of each tank and can also manipulate the various operations on these valves such as:
- Choose the tray system mode (Auto / Manu) using a switch associated with the PLC variable.
- Select the tank (a valve) if the tank system mode is Manu.
- Choose the working mode of the valve (Auto / Manu) using buttons associated with the automaton variable.
- Control the opening and closing of the valve in Manu mode.

❖ **Alarms:**

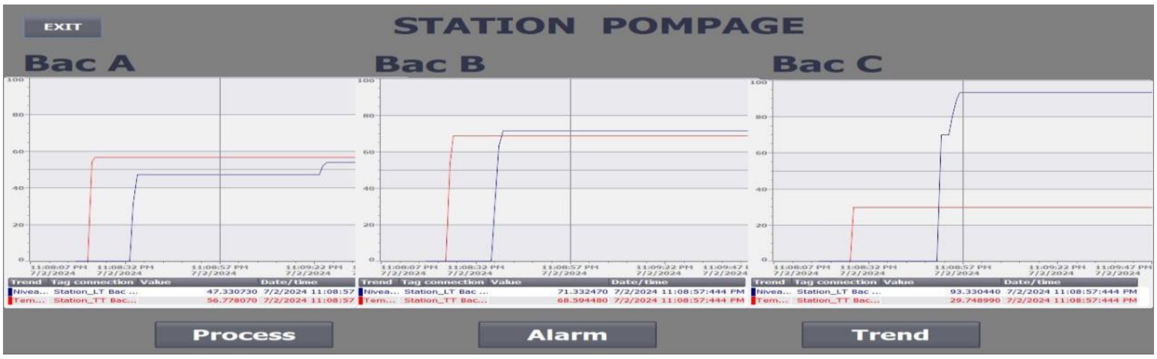
It allows us to display all analog and digital alarms (TOR), such as temperature (high, very high), level (low, very low, high, very high), vibrations, gasket leak, water start, and water stop 'emergency



(Figure 3.18) : Alarms

❖ **Bacs and pumps curves** :

Allows you to display the level and temperature history of each tank and pumps in the form of a curve.

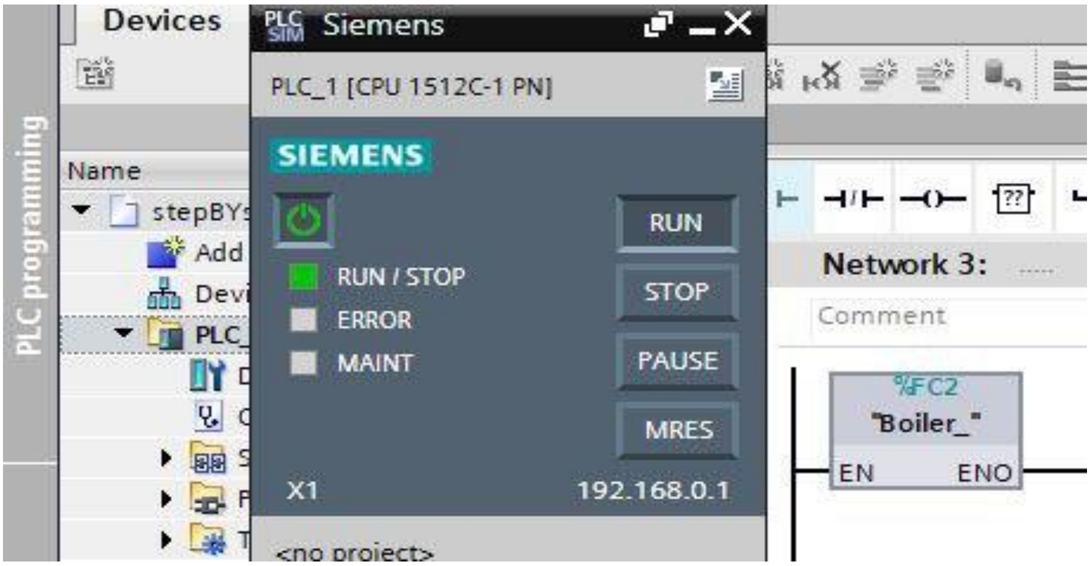


(Figure 3.19) : Bacs and pumps level curves of each one.

3-8- Test and Simulation

- **API Simulation**

In this part, we will test the response of our API using the PLCSIM window (PLC simulator). We can see in the following figures (Figure 5.26), the variation of the output signals with the variation of the inputs and time. The state of the input can be varied by immediate forcing of the bit, and the value of the level and temperature sensors can also be varied by variation of the corresponding address value



(Figure 3.20) : The S7-PLCSIM window interface (PLC simulator).

3-9- Management

In this view we will have the management of TIA. HMI man-machine users to describe how to manage the different users.

There are several types of user groups (roles) on our project which are detailed below.

❖ **Users:**

These are users who only have ordering rights.

❖ **Administrators:**

These are users who have control and command rights.

❖ **Supervisors:**

This user class has full powers over the administrative part of our project, they have all rights ; User Management ; control (parameter configuration) and command.

3-10- Conclusion

In this chapter, we configured the HMI interfacing device to create synoptic views. Next, we tested the PLC and HMI program. And finally, we tested and simulated the response of each case.

General Conclusion

The automation of industrial systems significantly contributes to development by improving safety,robustness ,productivity, and quality.This neccessitates the evolution of programmable controllers designed for industrial environments.

The application of programmable controllers as a basic production tool in the industrial environment has helped the evolution of automated systems given their flexibility and easy integration.

Our work is based on the automation of a pumping station to facilitate the shipping of crude oil. CPU Configuration and Programming allowed us to have a general idea of the field of systems automation, and to understand the different steps to follow for such automation, from study to implementation.

The objective of our application is to make it easier for the operator and to garantee material and personnel safety, using as little man power as possible, and avoids pump breakdowns and shipping delays with the lowest cost possible.

At the end of our project we believe that this work will be a platform for other possible automation and realization of some miniature projects in order to participate in the renovation of shipping pumps and help in the understanding of modern technologies and to follow their evolution.

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