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Permissions and interlocks simulation of a three stages main air compressor motor using PCS7 V8.2

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Contents

List of figures

List of tables

Notations

AI	Analogue input
AO	analogue output
APL	Advanced process library
AQS	Algerian Qatari Steel
AS	Automation station
ASU	Air separation unit
CFC	Continuous function chart
CP	Communication Processors
DCS	distributed control system
DI	Digital input
DO	Digital output
DP	Decentralized Peripherals
DRI	Direct reduced iron
ES	Engineering station
FBD	Function block diagram
FM	Function module
HMI	Human machine interface
HW	Hardware configuration
I/O	Input/output
IL	Instruction list
IM	Interface module
Km	kilometer
KV	Kilo volt
M^3	Cubic meter

MAC	Main air compressor
Mbit/s	Megabits per second
MPI	Message passing interface
Ms	Millisecond
MVA	mega volt ampere
Nm^3/h	Normal cubic metres per hour
OLM	Optical link module
OS	Operation station
PC	Personal computer
PCS7	Process control system
PID	Proportional integral derivative
PLC	programmable logic controller
PS	Power Supply
RM	Rolling mills
SCADA	Supervisory control and data acquisition
SFC	Sequential function charts
SM	signal module
SMS	Steel melt shop
ST	Structured Text
TCP/IP	Transmission control protocol/Internet protocol
VFD	Variable frequency drive

Introduction

In the Algerian Qatari Steel (AQS) facility located El-Milia wilaya of Jijel, the conversion of the raw material into the finished products is accomplished using a great variety of processes. This is carried out by several highly automated manufacturing process units which act together efficiently. Consequently, a malfunction or mishandling could interrupt the entire facility or even do significant damage. The design of control and supervision algorithms for such an installation is a very harsh task because of all the restrictions that must be complied with in order to coordinate the operations of all the manufacturing process units. Distributed Control Systems (DCSs), from Siemens and Honeywell manufacturers, are employed in the AQS because they are generally equipped with very sophisticated configuration and development tools allowing the implementation of complex programs adapted to the constraints of the trades. Moreover, they are highly reliable and can to manage complex regulation algorithms.

The main difficulties that face automation junior engineers in AQS is how to deal with the operation conditions of a large number of highly automated systems and to acquire necessary skills to program logic of permissions and interlocks for plants working in a DCS architecture.

The main goal of this work is to use PCS7 to program permissions and interlocks and to design a Human-Machine Interface (HMI) using WinCC software for a three-stage main air compressor located in the Air Separation Unit (ASU) plant in the AQS facility.

This dissertation is organized into three chapters as follows:

The first chapter presents an overview of the AQS facility and gives a brief description of the ASU plant. Also, we state the problem statement that we worked on it during the internship.

The second chapter, in the first part, we present briefly the S7 PLC series of Siemens and we especially focus on S7-400 that it is used in the ASU plant. In the second part, we present the architecture of a typical DCS and we try to show the importance of the industrial communication protocols especially Profibus-DP.

In the last chapter, in the first part, we introduce PCS7 software which includes SIMATIC MANAGER for logic programming and the WinCC for supervision. In the second part, we provide our simulation results.

Chapter 1 An overview of the Algerian Qatari Steel complex

1.1 Introduction

The Algerian Qatari Steel Company (AQS) was created in December 2013 and it is the result of an investment partnership between the Algerian republic and the state of Qatar. With a share capital of 58,610,000,000 Algerian Dinars. It is 49% owned by Qatar Steel International (QSI), 46% by the SIDER Industrial Group and 05% by the National Investment Fund (FNI).

AQS operates in the industrial zone of Bellara, in the municipality of El-Milia, (wilaya of Jijel), located 400 km from the capital Algiers, where it operates a steel complex with a total area of 216 hectares.

Thanks to its production volume, operational reliability and technical progress, the AQS occupies an important place in the map of the national and regional steel industry.

AQS also pays great attention to human capital, as an engine of economic growth and social progress, in particular through the creation of a working environment, which encourages creativity and innovation for the benefit of its 1500 employees of different disciplines and qualifications.

The complex produces four types of products: Cold direct reduction iron, billet, wire rods and rebar.

AQS contributes to the creation of wealth and the support of the national industrial fabric by meeting the needs of the local iron market and by exporting surplus production to regional and international markets. AQS started the production and marketing of iron products at the end of 2017.

The Complex's initial production capacity is approximately 2 million tons per year of reinforcing bars and wire rods of various diameters. The second phase of the investment program will be dedicated to the production of other types of special steels used in many industries, thus bringing the production capacity to more than 4 million tons per year.

1.2 Structure of the complex

The complex is composed of many production and processing units and it is mainly structured as described below.

1.2.1 Main production units

1.2.1.1 Direct reduced iron plant

The purpose of the Direct Reduced Iron (DRI) plant to produce the iron from direct reduction of iron with a large metal content or by removing oxygen by a reducing gaz or elemental carbon produced from natural gas or coal to pouring to steel melt shop as a raw material. The production capacity is 2.5 million tons per year.

1.2.1.2 Steel melt shop (SMS)

The steel is made in this plant, impurities are removed from raw iron, and alloying elements are added to produce different grades of steel. This plant uses Electric Arc Furnace (EAF)(1650°C) steel technology, which uses scrap metal and direct reduction iron (DRI) as main material and gives us the billets as the final product. With a production capacity of 2.2 million tons per year.

1.2.1.3 Three rolling mills

In this plant we get the final products. The rolling process includes billet reheating (1050°C), rolling and forming operations. The size, shape and metallurgical properties of metal billets are changed by repeated compression of hot metal between electrically driven rollers. With production capacity of 2 million tons per year

1.2.2 Additional facilities

1.2.2.1 Water treatment plant

The purpose of the water treatment plant is to treat water from the dam to supply it to the DRI, SMS and RM cooling circuits in accordance with their quality and quantity requirements. A small part of the make-up water must be converted for drinking water and covering the water consumption of 1,200 people. The treat waste water from of DRI, SMS and RM and sewage coming from offices, changing rooms, toilets, etc. in order to comply with the characteristics imposed by Algerian law in material for final disposal of water in the river.

1.2.2.2 Main receiving substation

The plant is connected to the transport public grid at 400 kV by means of two overhead lines.

The Main receiving substation is contained in the 400 kV switchgear and four step-down transformers 120 MVA, that are converting power from 400 kV to a primary medium voltage level (33 kV) for distribution inside the plant. The primary 33 kV distribution system comprises two separate switchgear, the dirty bus bar and clean bus bar.

The dirty bus bar feed the electric arc furnace, the ladle furnace and the static var compensator, while the clean bus bar feed the steel melt shop auxiliary loads, direct reduced iron plant and rolling mills, as well as other plant package installations.

The clean bus bar feed the medium voltage distribution system through 33/6.9 kV transformers.

1.2.2.3 Air separation unit (ASU)

The ASU is the biggest plant in Africa in terms of production, it is designed to ensure the supply of AQS complex of industrial gases such as Oxygen, Nitrogen and Argon.

The ASU Plant is designed to produce industrial gases on liquid and gaseous nature as follows:

- Gaseous Oxygen (GOX): 20,450 Nm3/h.
- Gaseous nitrogen (GAN): 9,810 Nm3/h.
- Liquid Oxygen (LOX): 1,500 Nm3/h.
- Liquid nitrogen (LIN): 1,500 Nm3/h.
- Liquid argon: 100 Nm3/h.

1.2.2.4 lime plant unit

The lime production plant is used to produce both quick lime and dolomitic lime (dololime) from the corresponding raw materials using two kilns.

The products will be used primarily for steel fabrication in the SMS, a small part will be used for coating pellets in the DRI plant.

1.3 Air separation unit description

1.3.1 ASU main components

1.3.1.1 Air inlet filter

In the air inlet filter, the incoming air is cleaned from dust and other particles.

Figure 1.1 Air inlet filter

1.3.1.2 Main air compressor

The ambient air is sucked by the main air compressor up to 21 Bar via five stages, four intercoolers and one aftercooler.

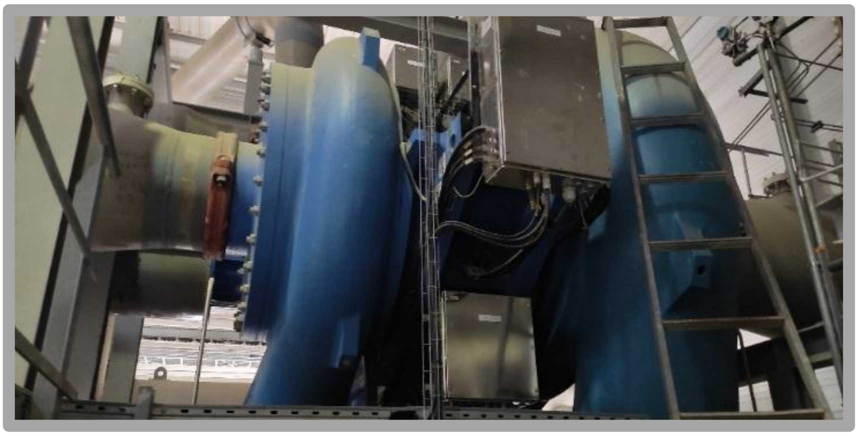

Figure 1.2 Main air compressor

1.3.1.3 Direct contact air cooler

Process air cooler: In the process air cooler there is a direct contact between the chilled water that comes from evaporation cooler and the compressed air for chilling and washing it, for removing harmful components such as SO_2, SO_3 and NH_3.

Figure 1.3 process air cooler

Evaporation cooler: The water that used in the direct contact air cooler is chilled by the evaporation cooler.

Figure 1.4 evaporation cooler

Chilled water pump: For guaranteeing the arrival of chilled water to the process air cooler the chilled water pump increases it pressure.

Figure 1.5 chilled water pump

1.3.1.4 Molecular sieve adsorbers

The remaining particles in the process air moisture, carbon dioxide and the hydrocarbons are removed by the molecular sieve adsorbers. Because each adsorber has a finite capacity to remove these components, there are two vessels to ensure the continuity of the process.

Figure 1.6 Molecular sieve adsorbers

1.3.1.5 Expansion turbine and booster

The expansion turbine compresses the dry air to the required operating pressure. Expansion of the compressed dry air delivers the necessary coldness for the rectification. [2]

Figure 1.7 Expansion turbine and booster

1.3.1.6 Main heat exchanger

The Main Heat Exchanger is used for exchanging the heat between cold liquids coming from cold-box and warm gases coming from all the processes.

Cold liquids coming from the cold box becomes gases to supply the DRI and SMS units and gases lost their temperature to reach -176 C° prior to entering the cold box. [2]

Figure 1.8 Main heat exchanger

1.3.1.7 Cold-box

For separation of gas mixtures into their pure components, the cold box contains three columns:

- Rectification column (Low-pressure column and High-pressure column) when the oxygen and nitrogen are extracted.
- Interconnection column when all the pipes between rectification column, argon column and pipes of the main heat exchanger are interconnected.
- Argon rectification column when the argon is extracted.

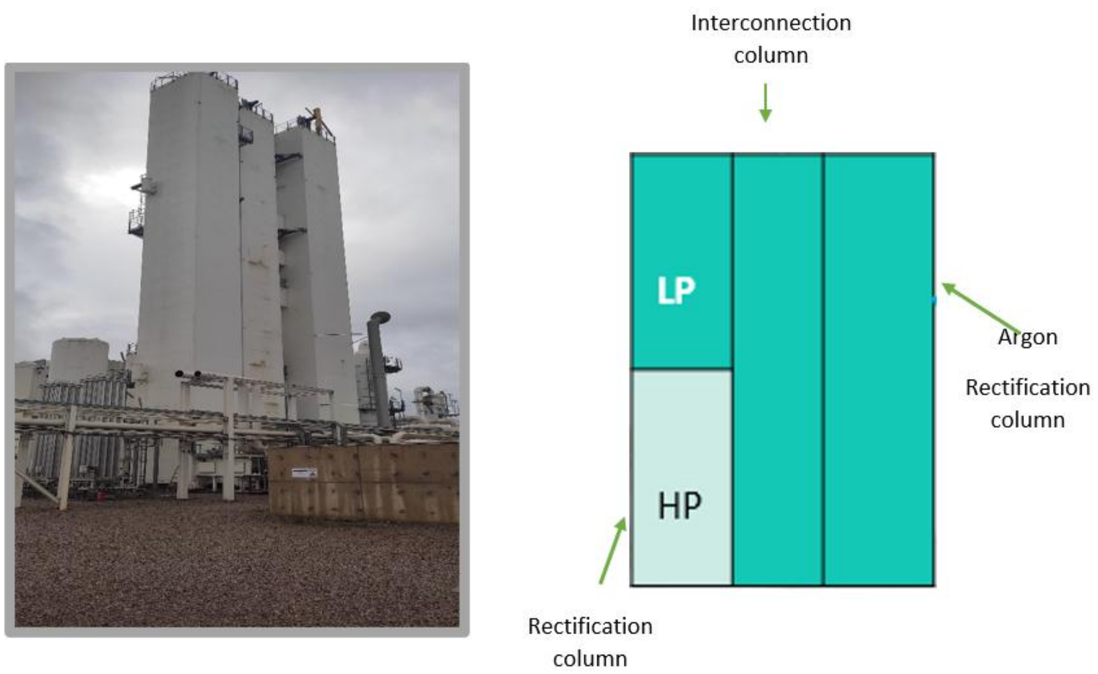

Figure 1.9 Col box and its main parts.

1.3.1.8 Cooling water system

Transfer pumps: The transfer pumps guaranteeing the required pressure by increasing the pressure of open circle cooling water.

Figure 1.10 Transfer pumps

Cooling tower: There are 3 cooling water towers in the cooling tower unit for cooling the water that return from the process.

Figure 1.11 Cooling tower

1.3.1.9 Backup system

Storage tanks: The cryogenic liquids are stored in the storage tanks. There are six tanks, three of them for liquid oxygen and the others for liquid nitrogen with a capacity of 250 M^3 each.

The system was created as a supply backup in case the unit tripped to ensure the supply of gases to all units prior to the restart of the unit [2].

Figure 1.12 Storage tanks

Evaporation system: The evaporation system is used for evaporating of cryogenic liquid for back-up purposes or to maintain a stable pressure in tanks. [2]

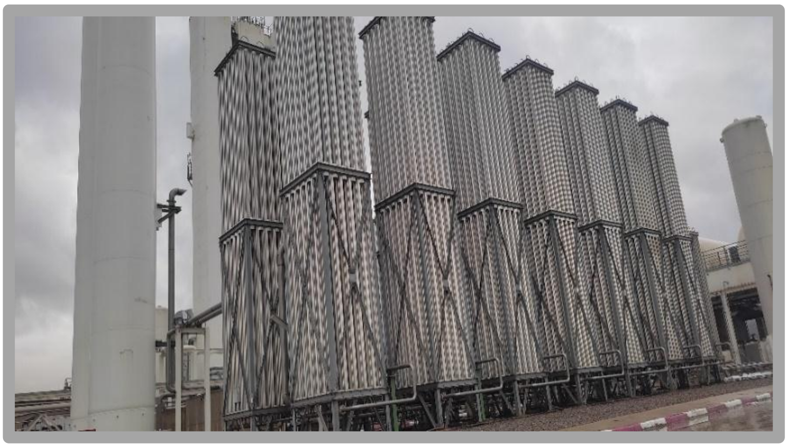

Figure 1.13 Evaporation system

1.4 Some challenges for automation engineers

In brand-new industrial facilities like ASU, there typically aren't any major issues that require stopping the process and production in order to deal with them. However, because there are many interconnected systems and complex continuous processes, a malfunction in one system could have a big impact on the overall facility and could cause:

- risks on human security,
- considerable damage of equipment,
- delay in production,
- difficulties to identify the source of the problems.

This is why in AQS a high-level architecture based on the DCS of Siemens is used to deal with this complexity, minimize dangers, give employers security, improve production and return the diagnostic easier. When we talk about DCS, we are at the second level in the automation pyramid. Linde automation engineers make something called permission and interlock in the program for organizing all signals and give more flexibility to the process.

For better understanding, signals of permissions and interlocks come from sensors and transmitters. Permission is all conditions that have to be verified before starting the process, for example a permission of a motor: when the power is good, the temperature is not over 40° c and the connection is good, the program must check all these conditions before starting the motor. An interlock is a condition that happens when the process is working and necessitate its stopping. For example, when the temperature of a motor reaches 80° c or its speed attains 3500 RPM, the motor is stopped.

1.5 Conclusion

In this chapter we have seen a brief description of the AQS complex and its main plants in the first part. In the second part, we present the ASU plant, its main components and we explained the process of the plant to give to the reader a clear idea in the upcoming chapters.

Finally, we ended up with a brief explanation of permissions and interlocks which we worked on it in our internship.

Chapter 2 Programmable Logic Controllers and Distributed control systems

2.1 Introduction

The first section of this chapter will discuss some automation components, notably the S7-400 high range PLC used in the ASU facility. The design of a typical DSC utilized in modern industry, as well as its key elements—most notably, the communication protocol used in Siemens' DCS—will be attempted to be explained in the second section.

2.2 Programmable logic controller

2.2.1 What is a PLC

The National Electrical Manufacturing Association (NEMA) defines a programmable controller as follows: *“A programmable controller is a digital electronic apparatus with a programmable memory for storing instructions to implement specific functions, such as logic, sequencing, timing, counting, and arithmetic to control machines and processes.”* [16]

More specifically, a PLC can be considered as an industrial computer that is especially designed for use in industrial, rugged environments. It performs the following functions:

- Receives and interprets the signals from various input switches and sensors.
- Implements the control logics designed in the form of programs.
- Outputs the control signals to activate the power devices such as motor starters, contactors, etc. [16]

2.2.2 Some History on PLC

The inception of PLCs resulted from the necessity and the emergence of computer technology. Electromechanical relays that provide logic controls for industrial systems had been successfully implemented for many generations. The main problems with those hard-wired, relay-based systems include:

- Lack of flexibility of reprogramming.
- Limit to relay types of applications.
- Difficulty of trouble shooting.
- Limited to small-to-medium size of control systems.
- Costly to implement when the size of control systems increases. [16]

GM's Hydromatic Division realized the need for using a solid-state system with computer flexibility to replace hard-wired relay control panels, which were huge, costly, and inflexible. In 1968, Hydromatic defined the design specifications for the first programmable logic controller. Some of the initial specifications are outlined below:

- The new control system had to be a solid-state device with the flexibility of a computer.
- The system had to sustain an industrial environment (vibration, heat, dirt, etc.).
- The system had to be reprogrammable and reusable for other tasks.
- The input and output interfaces had to be easily replaceable.
- The system had to be easily programmed and maintained by plant electricians and technicians.
- The system had to be cost competitive with the use of hard-wired relay systems. [16]

GM solicited interested companies to develop a system that met the above design specifications. Richard E. Morley, founder of the Modicon Corporation, built the first practical PLC in 1969. Since then, PLC technology has steadily advanced, in both hardware and software, with the computer technology. [16]

2.3 Siemens PLC series

2.3.1 S7-200

The S7-200 is used for small applications, actually it is no more available for sale. The supply voltage is on 24 VDC or 120VAC -230 VAC and it has two communication interfaces RS-485 and PROFIBUS. We can program it with S7 Micro/WIN32 software and STEP 7 is not required. [17]

Figure 2.1 PLC SIEMENS S7-200

2.3.2 S7-300

The S7-300 came with additional data processing tasks to give us the individual solution for fast process and automation tasks, it is high-performance, fast, versatile and future-proof. It can be networked with Multipoint Interface (MPI), PROFIBUS and Industrial Ethernet, we can program it using STEP 7 V5.5, STEP 7 Professional 2010 or STEP 7 Professional in the TIA Portal. [17].

Figure 2.2 PLC SIEMENS S7-300

2.3.3 S7-1200

To deal with the control task in machine and plant construction, the S7-1200 was designed. It can be networked with PROFIBUS or PROFINET. For slot rules we have CM on the left of the CPU and SM on the right of the CPU, the basic panels the small controllers offer a perfect interaction and STEP 7 basic in TIA Portal is the only software that can be used to program it [17].

Figure 2.3 PLC SIEMENS S7-1200

2.3.4 S7-1500

The new SIMATIC S7-1500 controller sets new standards in productivity with its many innovations. It can be networked with PROFINET. SIMATIC S7-1500 is perfectly integrated with the TIA Portal for maximum efficiency [17].

Figure 2.4 PLC SIEMENS S7-1500

2.3.5 S7-400

The S7-400 is the best PLC that SIEMENS has designed until now. It is fast, robust, and strong in communication, has been proven as a controller in the upper performance range of factory automation and can be found in plants for process automation as well. Similar to the S7-300, for engineering, the established STEP 7, STEP 7 Professional in the TIA Portal or in the mighty, process-oriented PCS7 can be used for its programming. It can be networked with Multipoint interface (MPI), PROFIBUS and Industrial Ethernet [17].

Figure 2.5 PLC SIEMENS S7-400

2.3.5.1 **S7-400 modules**

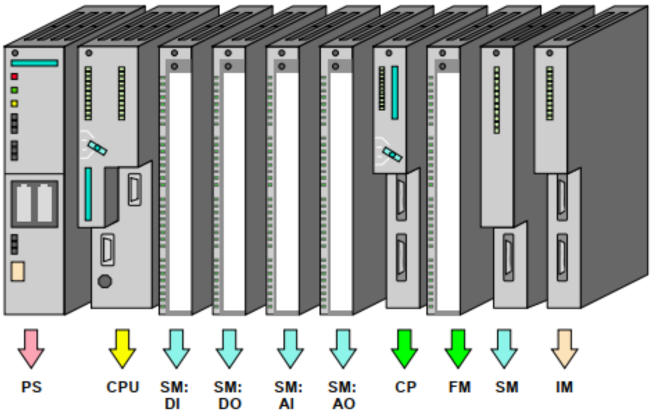

Figure 2.6 S7-400 modules

Signal modules:

- Digital input modules.
- Digital output modules.
- Analog input modules.
- Analog output modules.

Interface modules:

- UR1 (Universal Rack) with up to 18 modules.
- UR2 (Universal Rack) with up to 9 modules.
- ER1 (Expansion Rack) with up to 18 modules.
- ER2 (Expansion Rack) with up to 9 modules.

Function Modules: *Perform* "special functions" such as counting and positioning.

Communication Processors (CP): Provide the following networking facilities:

- Point-to-Point connections.
- PROFIBUS.
- Industrial Ethernet.

2.4 Distributed control system (DCS)

The term DCS has evolved from the original description for the acronym as a **"Distributed Control System"** to the use of the term **"Decentralized Control System"** and they seem to be somewhat interchangeable nowadays. Regardless of which description is used, we are discussing a structure that, at the high-level view, is a system that coordinates and supervises an entire plant of many varying processes. When PLC was invented, it relied good at handling single processes and was primarily used for repetitive, discrete control. The advent of the DCS was for controlling many autonomous controllers that handled many continuous operations, mainly using analog control.

PLCs, traditionally, were used for single batch or high-speed control, have a relatively simple, low-cost design, and are the core of the system. A DCS is used for continuous, complex controls, have an integrated control center much like a SCADA, which is the core of the system versus the processors in a PLC system. The DCS has a number of predefined functions that come ready to customize and deploy for various applications.

DCS also have a claim that when safety is a top priority, it is the most reliable system. The reason for this is because the manufacturer supplies both the control and supervisory equipment as an integrated package, the risks of integration errors are greatly reduced.

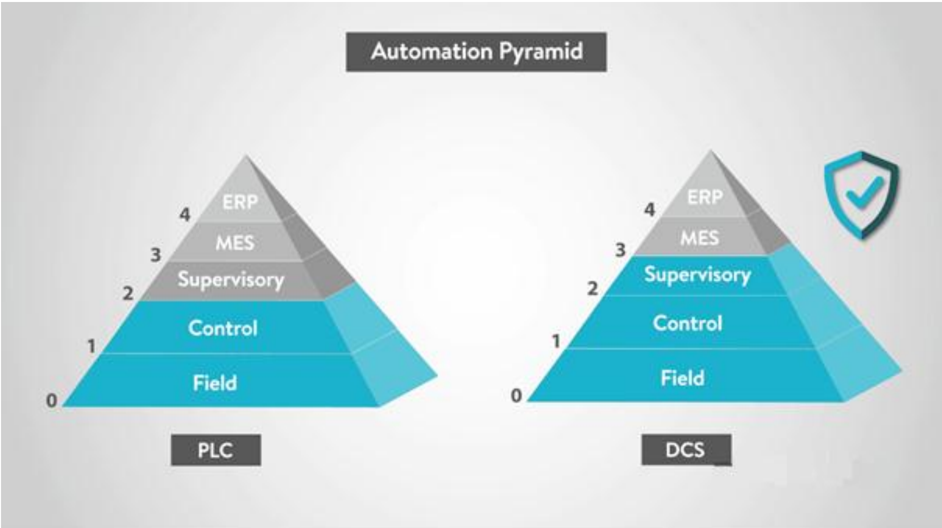

Figure 2.7 DCS rank in the Automation Pyramid

There are indeed scenarios in which a PLC system would be the best option such as smaller sized processes where you could employ redundant components to negate the possibility of process shutdowns.

The use of DCS would be for larger, more complex processes that require a lot of interaction between many processors. [14]

2.4.1 **Basic components of a typical DCS network**

The basic elements comprised in a DCS include engineering workstations, archiving computers operating station or HMI, servers, automation station, and communication system.

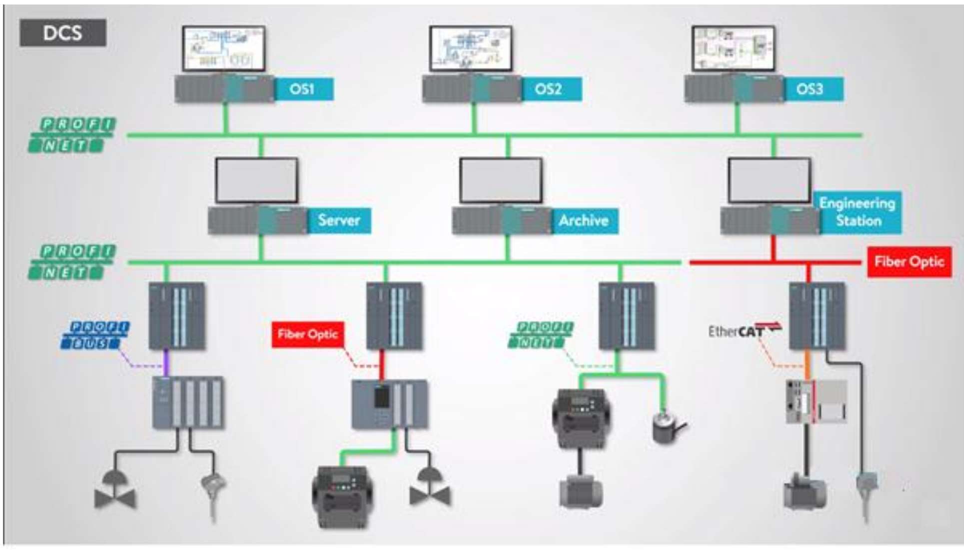

Figure 2.8 Typical DCS Network

2.4.1.1 **Operation station**

The operation station is the heart of the system, it is a centralized operator control center, at this level the type of communication is Ethernet. The operation station gives to operators the possibility to observe the processes of the plant, warnings, alarms, monitoring and more.

2.4.1.2 **Servers**

Servers are the responsible for the collection of data and manage the moving of it between the automation station and operation station.

2.4.1.3 **Archiving computers**

That task of archiving computers is storing data for using it later when we need.

2.4.1.4 **Engineering stations**

The engineering station gives us the possibility to create and modifying projects when the processors run, in which we can configure hardware and doing logic tasks, also the graphical displays for operation station, from the engineering station we download the projects to automation station and graphical displays to the operation station.

2.4.1.5 Automation station

In automation station the logic is executed, it is also the responsible for providing the data to servers. Automation station is located in the control room, it is a master controller that supervises remote I/O modules such as ET200M. Generally, in SIEMENS' DCS, Ethernet is used to connect AS and OS, and Profibus-DP is used to connect AS to I/O modules.

2.4.1.6 Field Devices

In this level we find sensors and actuators such as transmitters, remote I/O modules, valves and motors. The communication between them can be of any type such as Ethernet, Profibus-DP and optical fiber.

2.5 Connecting the distributed process I/O via a fieldbus

Generally, in a factory there are two areas: the control room where we find industrial computers, and the factory floor where we find sensors. Obviously, we find sensors monitored by a PLC and located everywhere in the factory. A problem rises is if the PLCs' I/O are individually connected to each sensor and actuator. In this case, we have to deal with a large quantity of cables between the factory floor and the control room and because this method is expensive and not efficient, the best solution is to use an industrial network such as Profibus-DP to ensure a successful monitoring of all factory sensors.

2.5.1 Profibus DP

With the Profibus-DP we make an electrical cabinet and connect all sensors to it where we find a remote I/O module, and the connection between remote I/O module and PLC is made by using a single RS-485 cable. By that method the Profibus-DP reduces the massive quantity of cables and return the connection of cables easier and more efficient also it is far cheaper.

The **DP** stands for **Decentralized Peripherals**. Before Profibus-DP, the I/O, or peripherals as they are also known, were centralized in the control room. But by moving them to the factory floor next to the sensors, we **decentralize** these I/O or the, hence the DP designation. [14]

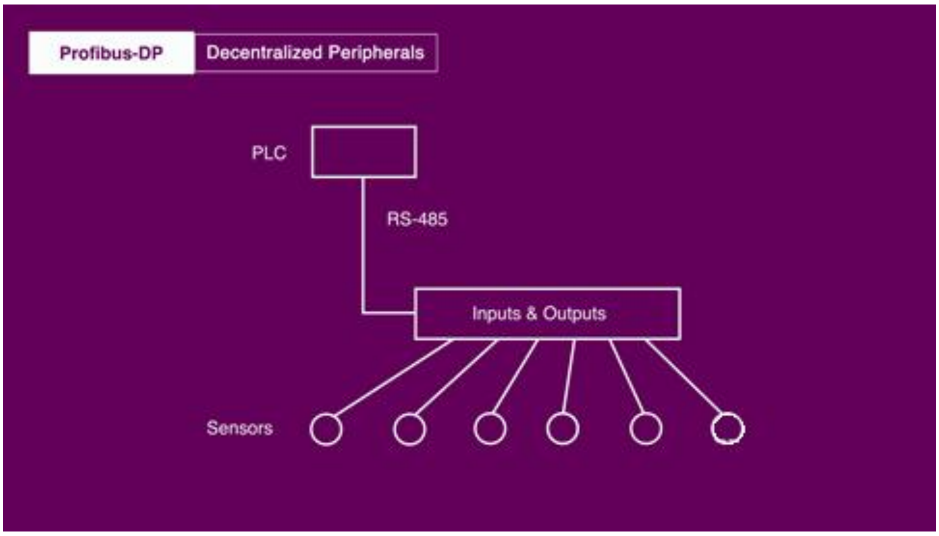

Figure 2.9 Profibus connection between PLC and remote I/O

2.5.1.1 **Feature**

- Transfer medium: - Shielded, twisted two-wire cable.
  - Glass or plastic fiber-optic cable.
- Access procedure: token passing with master/slave.
- Transmission speed 9.6 Kbit/s to 12 Mbit/s
- Length: - Up to 9 km with a two-wire cable.
  - Up to 90 km with glass fiber-optic cable.
- Maximum of 127 nodes.
- Response times down to 1 ms.
- Topology Line, tree, ring, star.

2.5.1.2 **Remote I/O systems ET200M**

In practice, there is a lot of remote distributed and modular process I/O in the field area and each protocol has its own suitable remotes. In the field area based on PROFIBUS DP the ET 200 M is highly recommended.

Figure 2.10 ET 200M distributed I/O system

2.5.2 Profinet

Profinet is based on Ethernet and expands Profibus technology for applications requiring high-speed data communication via Ethernet networks. There are some similarities in the engineering concepts and in the use of GSD (General Station Description) files to describe the properties and functions of Profinet devices [24]. Profinet ensures that real-time communication is not disrupted by standard TCP/IP-based communication and that time requirements are met reliably. This flexibility offers a great advantage over other Ethernet real-time systems [23].

2.5.2.1 Feature

- Transfer medium: - Double-shielded coaxial cable.
  - Glass fiber-optic cable.
- Access procedure: TCP/IP.
- Transmission speed 10/100 Mbit/s.
- Length: - Up to 1.5 km with a two-wire cable.
  - Up to 4.5 km with glass fiber-optic cable, 200 km using switches.
- Over 1000 nodes.
- Topology Line, tree, ring, star

2.5.3 Use of fiber optics

The fiber optics are insensitive to electromagnetic interference but is more expensive than RS-485. The Optical Link Modules (OLM) permits the connection between fiber optics and Profibus DP. The length that gives us fiber optics is up to 2000 m.

2.6 Some field devices used the ASU

2.6.1 SAMSON Valves

SAMSON is Germany company operates wherever there is controlled flow of oils, gases, vapors or chemical substances. it is specialized in control valve engineering. It had had a considerable impact on the evolution of valves from analog components to smart control valves [9]. In ASU plant in AQS complex, we find different valves from SAMSON.

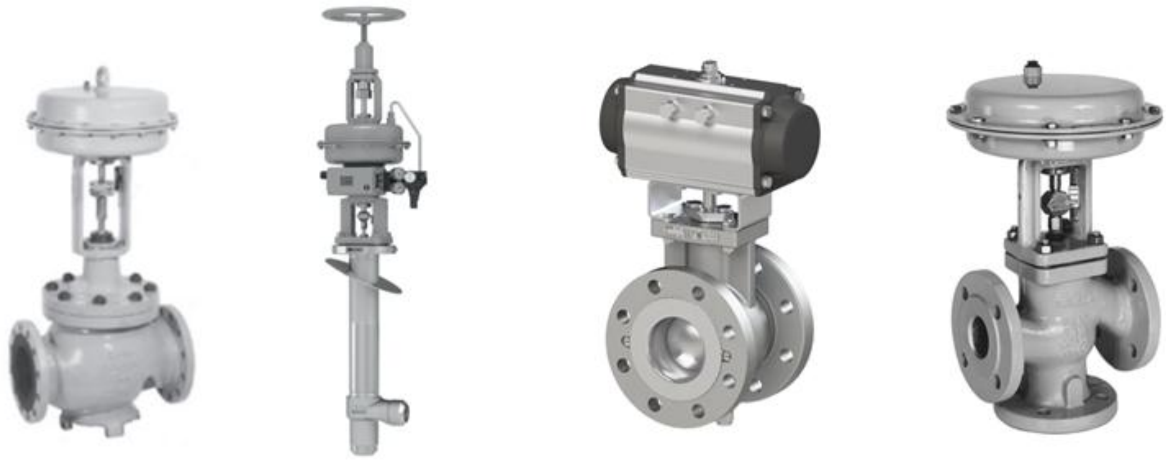

Figure 2.11 Some types of SAMSON Valves used in the AQS.

2.6.2 Siemens' transmitters

Siemens AG is a German multinational conglomerate corporation and the largest industrial manufacturing company in Europe headquartered in Munich with branch offices abroad.

In ASU plant in AQS complex, there are different types of transmitters such as the SITRANS P DS III series. We also find digital pressure transmitters for measuring gauge pressure, absolute pressure, differential pressure, flow and level. Even the standard devices offer comprehensive diagnostics and simulation functions with high reliability.

The pressure transmitter can be programmed locally using the 3 control buttons or externally via HART or PROFIBUS PA or FOUNDATION Fieldbus interface [7].

Figure 2.12 Pressure, flow and level transmitters from Siemens (1-plastic cover as access to the input keys. 2- screw cover with viewing pane. 3-digital display. 4- locking screw for preventing the measuring cell from rotating. 5- sensor. 6-screw cover with viewing pane (TAG). 7-the rating plate with the Article No. 8- the inlet for the electrical connection is located either on the left or right side. 9- process covers for vertical differential pressure lines. 10- remote seal).

2.6.3 Endress + Hauser transmitters

Endress+Hauser is a global leader in measurement instrumentation, services and solutions for industrial process engineering. They provide process solutions for flow, level, pressure, analytics, temperature, recording and digital communications, optimizing processes in terms of economic efficiency, safety and environmental impact[8]. AQS uses Endress+Hauser technology for measurement of pressure, level and flow, for liquids, pastes and gases.

Figure 2.13 Some Endress+Hauser transmitters (from left to right: Vibronic Point-Level detection Liquiphant FTL5, Proline Promag E 100 electromagnetic flowmeter, Proline Prowirl R 200 vortex flowmeter).

2.7 Conclusion

In this chapter we have presented Siemens's PLCs families, DSC architecture and components, some industrial communication protocols, and finally some field devices. The objective is to provide the main automation components that are used in ASU plant in AQS complex.

Chapter 3 Design of a logic of permissions and interlocks for a three-stage main air compressor in the ASU plant using PCS 7

3.1 Introduction

In this chapter is dedicated to present our work on programming a logic of permissions and interlocks for a three-stage main air compressor in the ASU plant of the AQS complex and its associated HMI.

Firstly, we present PCS7, the software that allows us to make this project, Simatic manager and WinCC. We also give an overview of PLC programming languages. Then we show how to perform a multi-project configuration for a DCS. Finally, we end up with the results of simulation of permission and interlock of 3 stage main air compressor motor.

3.2 PCS7 description

PCS 7 is an integrated, full-feature scalable DCS control system based on the latest technology from Siemens. PCS7 builds upon the Siemens SIMATIC hardware platform and integrates seamlessly into the totally integrated automation software platform.

PCS7 can be consider as a hybrid control system: characteristics of both DCS and PLC, it has the power of a DCS and the flexibility of PLC. The CPU at the heart of the system is an S7-400 advanced controller. In the PCS7 structure, this processor is referred to as the AS-400, for automation system controller.

The diagram in Figure 3.1 shows a general representation of a Siemens PCS7 system, it includes the major component levels that most PCS7 systems will have.

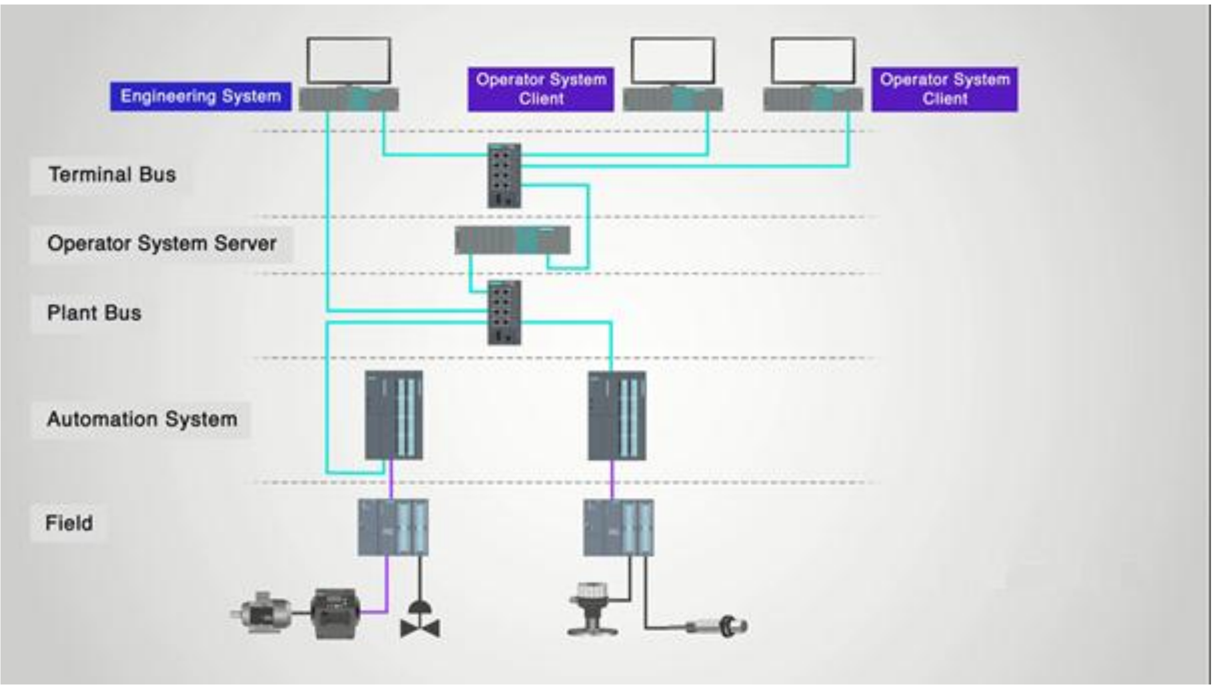

Figure 3.1 Siemens DCS

At the top level a PC-Based Engineering Station and Operator system clients are connected directly to an operator system server, to access graphics and field data values. These Engineering and Operator Stations and servers are connected via Ethernet or Profinet through a common network switch or Terminal Bus. The terminal Bus is separated from the plant Bus, on which the plant's controllers and field devices reside, in order to provide a high speed of communication and to segment the functions requiring higher band width.

The plant bus network is connected via a separated network switch from the Terminal Bus and connects to the operator system server PC.

Field data is collected at the operator system server PC and used for populating graphic displays, storing as historical data, and many other functions. The connection to the terminal bus at the operator system server PC allows interaction of the operator switch graphics.

The Engineering Station also has a connection to the plant bus as well as the Terminal Bus, this allows the ES to configure and download and monitor control programs in the AS controllers via the Plant Busas well as develop and download operator graphics to the operator graphics to the operator system server PC via the Terminal Bus.

The AS controllers provide the platform for solving logic, monitoring the process sensors and devices, driving outputs, VFDs, control valves, and distributed I/O the most common used in PCS7 is the ET-200 family of I/O.

The basic PCS7 software platform includes the ”AS-OS Engineering Station” software called SIMATIC Manager a modified version of the STEP 7 software, The HMI software is based on WinCC Professional.

3.2.1 SIMATIC Manager

The SIMATIC Manager manages all the data that belong to an automation project. It is the basic application for configuring and programming. One can perform the following functions in the SIMATIC Manager:

- Set up projects.
- Configure and assign parameters to hardware.
- Configure hardware networks.
- Program blocks.
- Debug and commission your programs.
- Access to the various functions is designed to be object-oriented, and intuitive and easy to learn.

We can work with the SIMATIC Manager in one of two ways [18]:

- Offline, without a programmable controller connected.
- Online, with a programmable controller connected.

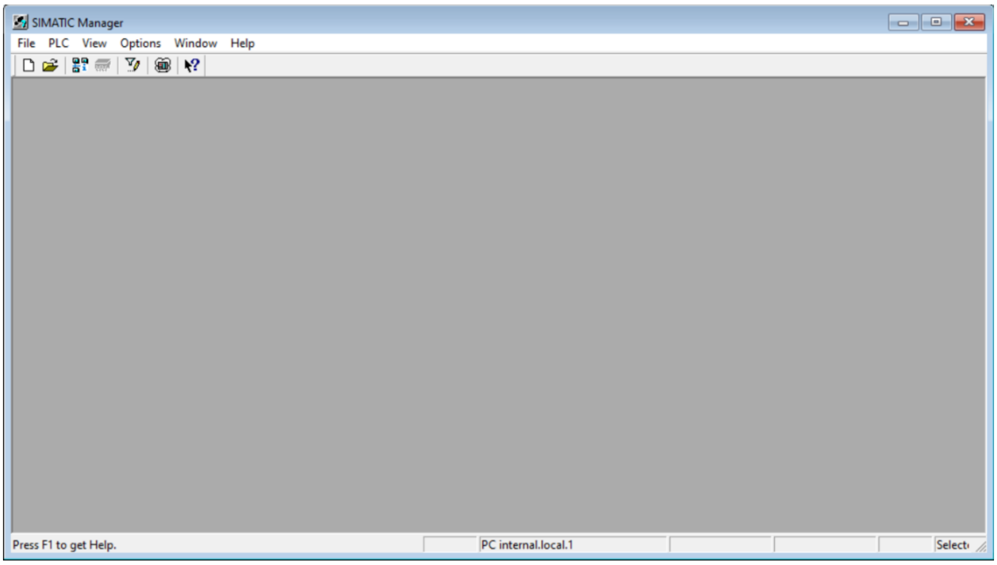

Figure 3.2 SIMATIC Manager window

STEP 7 is the standard software package used for configuring and programming SIMATIC programmable logic controllers. It is part of the SIMATIC industry software.

3.2.2 PLC programming languages

There are 5 languages that are all a part of the IEC (International Electrotechnical Commission) Section 61131-3 Standard. This IEC Standard allows some ground rules that standardize PLC's and their languages [14]. In this subsection, we take a look into all these popular PLC programming languages.

3.2.2.1 Ladder diagram (LD)

The name Ladder diagram is inspired from the electromechanical relays that were controlled automatic systems. It is the easiest language and most engineers and technicians understand ladder logic also and it is often the way the engineer presents the logic in their specifications anyway. Its principle is simple because it modeled from relay logic there is the electrical connection represent by two vertical rails and between its there is horizontal rungs where we put inputs, outputs and other conditions.

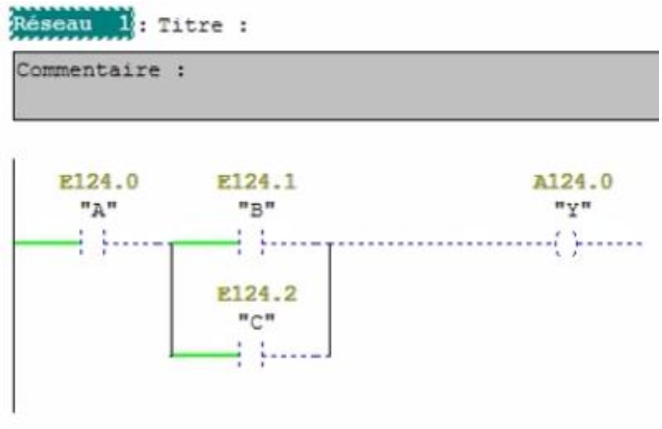

Figure 3.3 LADDER language

3.2.2.2 **Structured Text (ST)**

ST is a high-level language and textual based language, it is easier for people who had some experience with languages like C or C++. It allows by exploiting algorithms and function to realize complex tasks that other language cannot offer instructions to do it. On the other hand, it is difficult to edit online.

```
FUNCTION CARRE : INT

 VAR_INPUT
  valeur : INT;
 END_VAR

 BEGIN
   IF valeur <= 181 THEN
       CARRE := valeur * valeur; //Calcul de la valeur de la fonction
   ELSE
       CARRE := 32_767; // Fournir la valeur maximale en cas de

   END_IF;
END_FUNCTION
```

Figure 3.4 ST language

3.2.2.3 **Sequential Function Charts (SFC)**

The SFC is similar to flow charts, it is a graphical programming language based on binary Petri nets. SFC is designed specifically to handle stepwise, sequential operations. It is based on steps and transitions until to get to the final results. Steps equal function in a program and transition equals condition for moving from one step to another if the condition is satisfied.

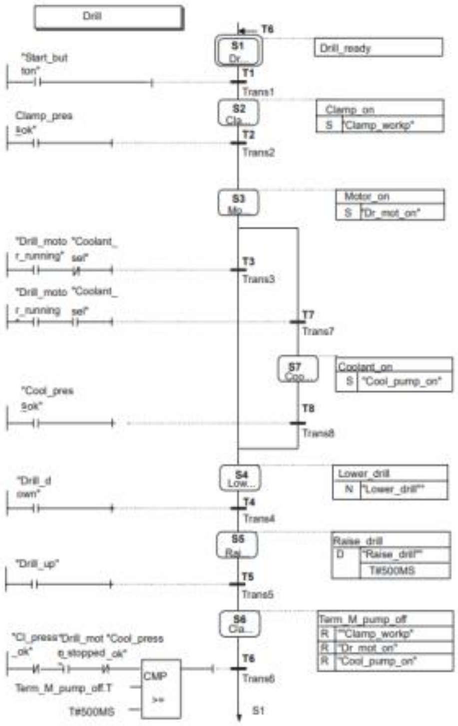

Figure 3.5 SFC language

3.2.2.4 Instruction List (IL)

The instruction list is also a textual based language is like Assembly Language where we use in each line one instruction. Since it is a low-level language, it is more suitable when we need speed for the program execution. Nowadays, it is not a common language in comparison with other languages because of its difficulties.

```
Réseau  1 : Titre :
Commentaire :

      L     #SPAN                          #SPAN
      L     #ZERO                          #ZERO
      -R
      L     #MAX_PULSE                     #MAX_PULSE
      ITD
      DTR
      /R
      L     #PULSE                         #PULSE
      ITD
      DTR
      *R
      L     #ZERO                          #ZERO
      +R
      T     #VALUE                         #VALUE
```

Figure 3.6 IL language

3.2.2.5 **Function Block Diagram (FBD)**

This language is a graphical type, each function is represented by a block and the connection lines between blocks represent the I/O variables. The connection is orientated, which means that the associated data is transmitted along the line from left to right. The connection line's left and right ends must be of the same kind. In the program we have sheets from A to Z and each sheet divided to six parts that contains function blocks. Generally, FBD language is used in continuous processes that need a DCS.

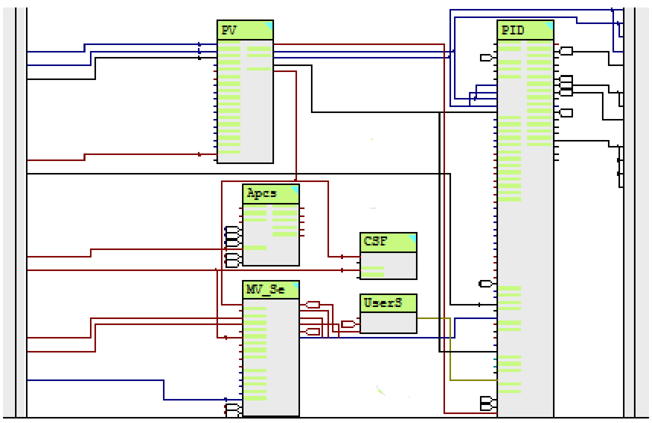

Figure 3.7 FBD language

3.2.3 Advanced Process Library (APL)

The APL is offered as a standard feature of SIMATIC PCS 7. It includes preconfigured and pre-tested function blocks, faceplates and block icons for simplified, graphically based control of all process equipment. APL’s comprehensive and flexible range of modules includes options for mathematical operations, control logic, motors, valves, field devices, monitoring, diagnostics and more [19].

3.2.4 Continuous Function Chart (CFC)

CFC is an editor with a graphical user interface, an extension based on the STEP 7 software package. It is used to create the entire software structure of the CPU and uses preconfigured blocks. The editor lets you insert blocks into function charts, assign block parameters and interconnect blocks.

Interconnecting means that values can be transferred from one output to one or more inputs during communication between the blocks or other objects [20].

3.2.4.1 Component view and plant view

Component view: In the component view we find all data is assigned to physical stations and component.

Plant view: In the plant view we find all data are organized like in folder and subfolder as the plant is divided.

3.2.4.2 Charts

Each chart has a unique name, at least contains one block and represent them with a graphic user interface (the CFC editor).

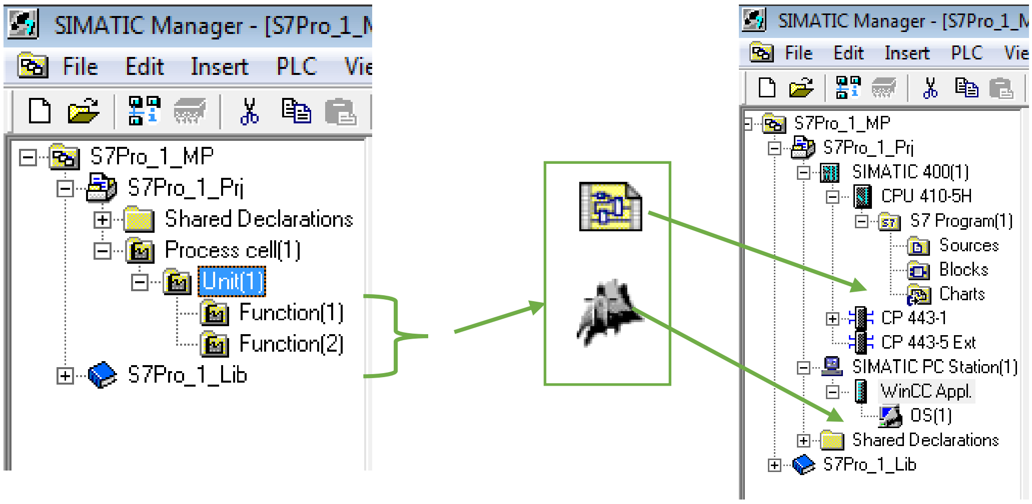

Figure 3.8 Component view and plant view

Element bar in the CFC editor

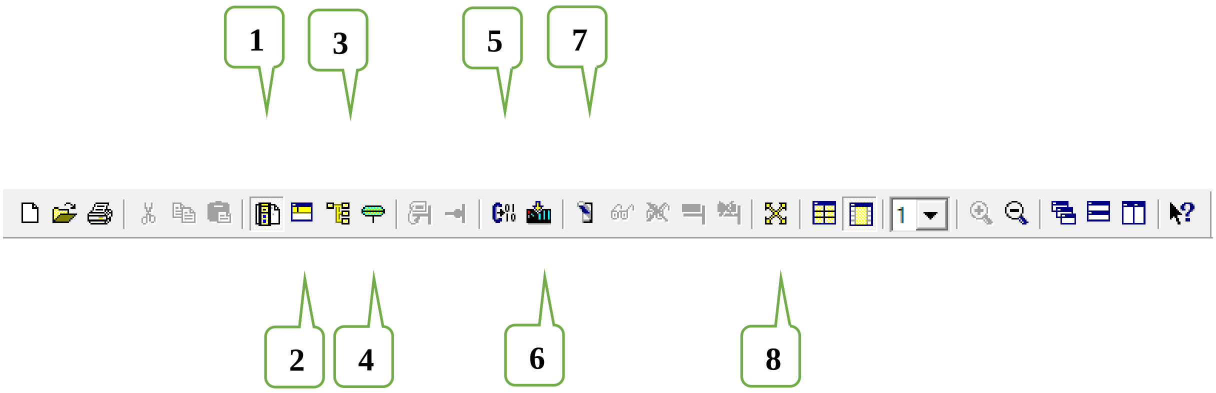

Figure 3.9 CFC element bar (1-Display of the CFC catalog. 2-Display of the chart I/Os, 3-display of the Runtime editor, 4-Display of the technological I/Os , 5-Compile charts, 6-Download the S7 program, 7-Change to the CFC test mode 8-Open the chart reference data).

Overview: The chart is divided to 6 sheets and each sheet consists of up to 26 chart for A to Z.

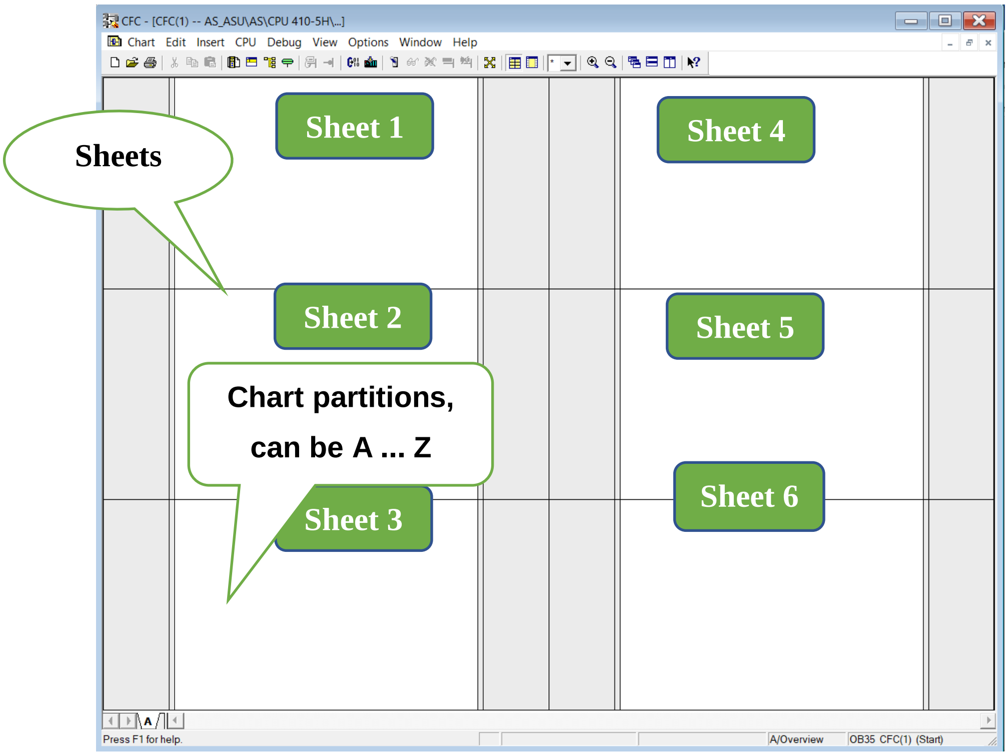

Figure 3.10 CFC chart

3.2.5 **WinCC**

WinCC is a high-performance HMI system for use under Microsoft Windows 7, Windows 8.1, Windows 10, Windows Server 2008 R2 and Windows Server 2012. HMI stands for "Human Machine Interface", i.e. the interface between the person and the machine. WinCC allows the operation and observance of the processes that run in a machine. The communication between WinCC and the machine takes place via an automation system [21].

There are two basic components of WicCC, the configuration software (CS) where the entire project structure is displayed and administered via the WinCC Explorer editor, And the runtime software (RT) which executes the project and allows the operation and observation of the processes.

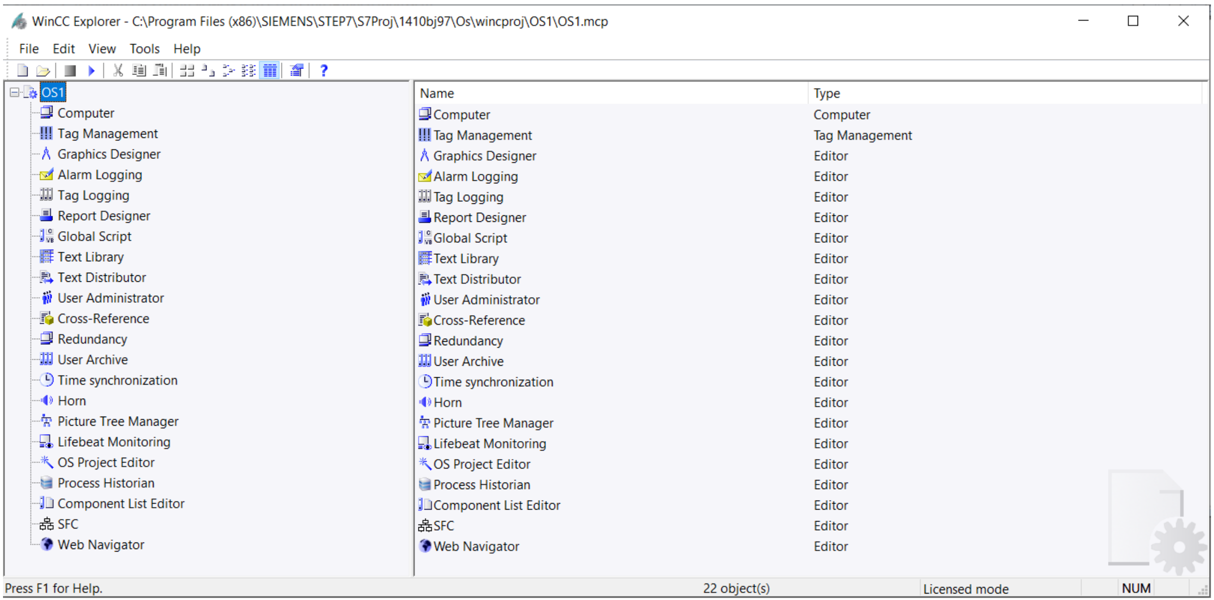

Figure 3.11 WinCC front view

3.2.6 **S7-PLCSIM**

With the optional software package PLC Simulation, one can run and test his program on a simulated programmable controller that exists on your computer or programming device. As the simulation is realized completely by the STEP 7 software, we do not require any S7 hardware (CPU or signal modules). Using the simulated S7 CPU we can test and troubleshoot programs for S7-300 and S7-400 CPUs.

This application provides a simple user interface for monitoring and modifying the various parameters that are used in the program. we can also use the various applications in the STEP7 software while the program is being processed by the simulated CPU. For example, we can monitor and modify variables with the variable table [18].

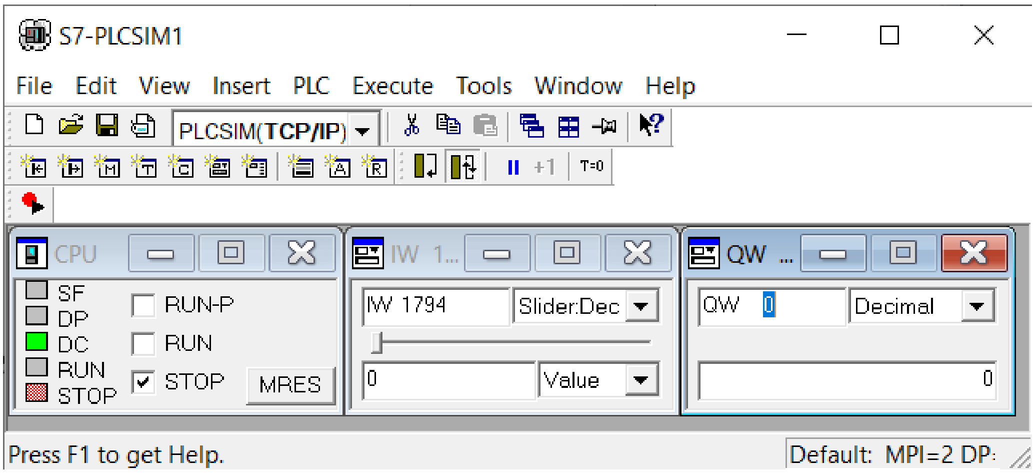

Figure 3.12 S7-PLCSIM

3.3 Process specifications

The process specifications consist of two chapters, the first for air filter and the second for the main air compressor motor as described in the following subsections.

3.3.1 Air Filter S1146

The differential pressure between the inlet and the outlet of the MAC filter S1146 should be measured by differential pressure indicator transmitter PDIT1101, the MAC stage one suction differential Pressure is measured by PDI1113_1. Also, the MAC stage one suction pressure is measured by Pressure indicator transmitter PI1113, and the Mac stage one suction temperature is measured by temperature indicator transmitter TI1113.

3.3.2 Main Air Compressor

The MAC is drived by a motor HS1181_1 which has the following permissions and interlocks.

Permissions: The unit ready YL1161_6 consist of two groups. Under group one there are MAC stage one, two and three Condensate Levels LAH1119, LAH1129 and LAH 1139. Under group two there is MAC antisurge Valve Position FZLL1110, which should be inactive.

In order to increase the outlet pressure of the MAC, we would like to insert the valve FV1110 controlled by FIC1110.

The EL ready MAC Motor M1181 should be inactive, and if EM-stop local HL1161_2 is pushed that means there is no permission to start the motor.

Interlocks: The interlock involves two inputs condition stop and trip. the YL1161_9 MAC emergency stop feedback is under stop condition and each of MAC stage 2 suction temp , MAC 3 suction Temp and MAC 3 Outlet Temp TI1123, TI1133 and TI1143 all of them under trip condition.

HS1110 25 Unload / Load : When start the MAC the Drive Ready to load OS1181_13 is matching. During the MAC is OFF an alarm is triggered in the HMI and it hides when the MAC is ON. When the E-stop Fb is active the HS1110 25 will go to unload and the MAC will stop directly.

Permissions	*TAGs*
Condensate level in each stage	LAH1119, LAH1129 and LAH 1139
MAC antisurge valve should be open	FZLL1110
Emergency stop local should be not pushed	HL1161_2
MAC electrical ready	EL1181_6
Ready to load	EL1181_7

Table 1 Permission and their TAGs table

Interlocks	*TAGs*
Tempertures in each stage	TI1123,TI1133 and TI1143
Emergency stop feedback for unload	YL1161_9

Table 2 Interlocks and their TAGs table

3.4 Creation a multiproject folder with PCS 7 wizard new project

At the desktop we find the icon of SIMATIC Manager after double click on it the principal windows appear. Then, on click on file -> ‘new project’ Wizard -> next.

In the windows “Witch CPU are you using in your project?” we can choose which the CPU you need (1) and your bundle (2) also the number of communication modules (3).

In the window of “Which objects do you still use” we can choose the number of Plant hierarchy that means the organization of folder and subfolder in the Plant view. For adding OS objects, we click on (1) the PCS OS and chose the type of station system.

The option of Preview gives us the structure of Plant hierarchy before generating the new project

The final window “where do you want to store the multiproject” give us information about our new project. When we click on “Finish” the following object will be created automatically: Multiproject, project and master data library.

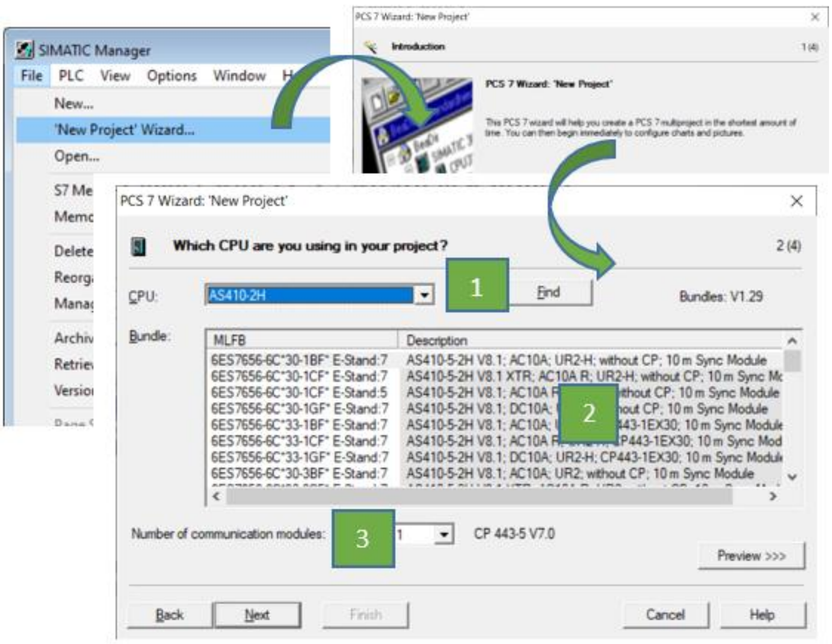

Figure 3.13 PCS7 Wizard new project.

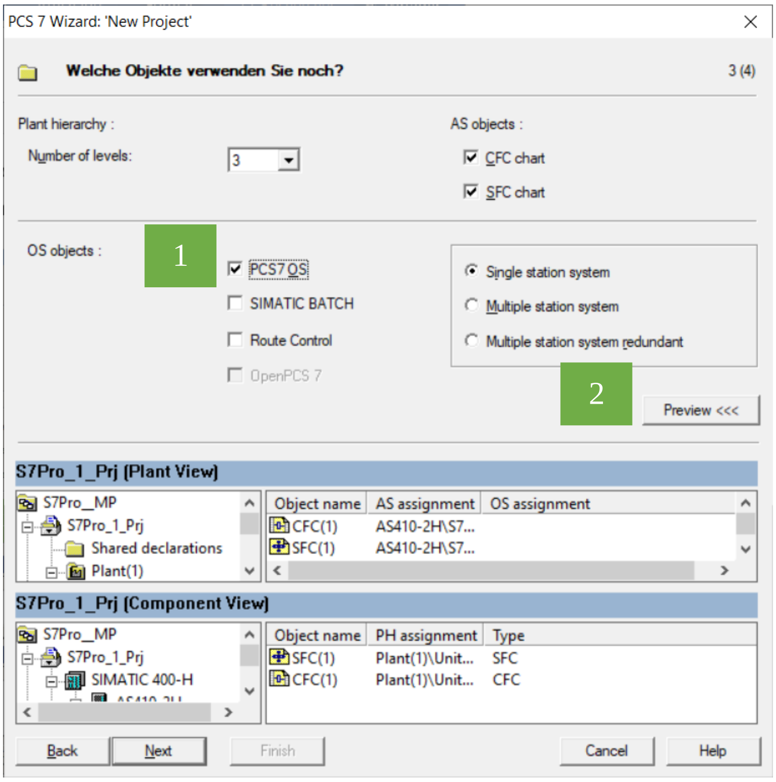

Figure 3.14 objects in wizard new project.

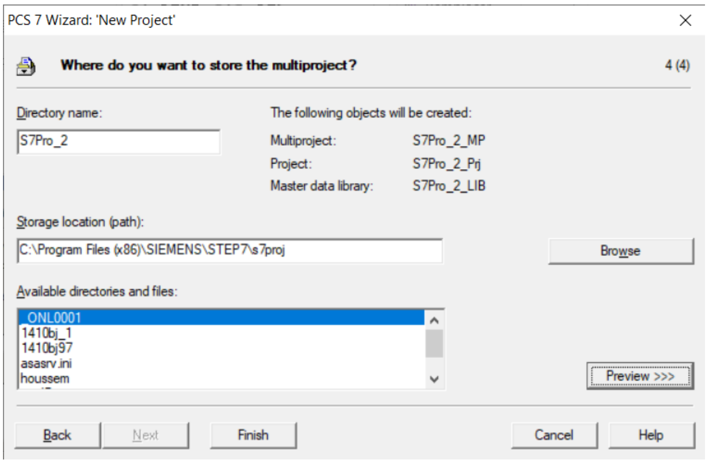

Figure 3.15 Final window in new project wizard.

3.5 Configuration of a remote I/O Profibus DP

The first step is to create a Profibus network. To do that, we go to the hardware configuration and we do the following steps : AS -> SIMATIC 400 -> hardware -> DP -> right click -> add master system.

Secondly on the right windows we find a catalogue, then we choose: PROFIBUS DP -> ET 200M -> IM 153-2 HF and drag it to the network.

Now, when we click on the device IM 153-2 the configuration table appears on the bottom of the windows, on the right of the windows we can add signal modules by dragging it to the configuration table.

After saving, compiling, and putting the PLC in MODE RUN. To check that the Module is connected by observing the operating mode of the CPU (1) in Module information we should to choose the ONLINE MODE (2).

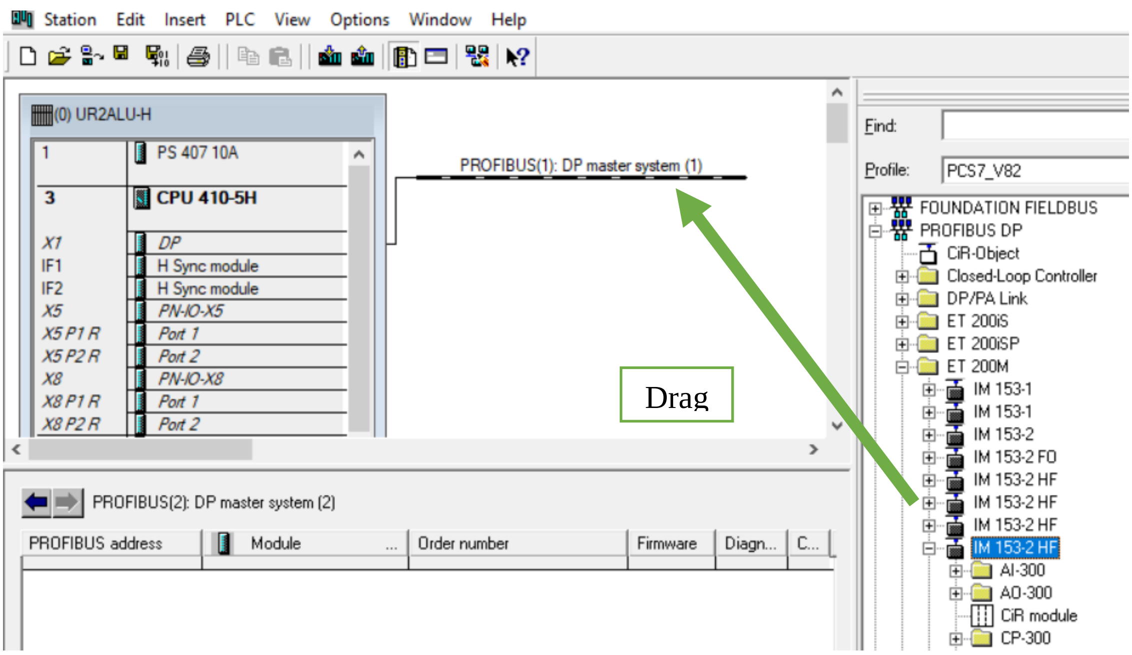

Figure 3.16 Hatdware configuration window

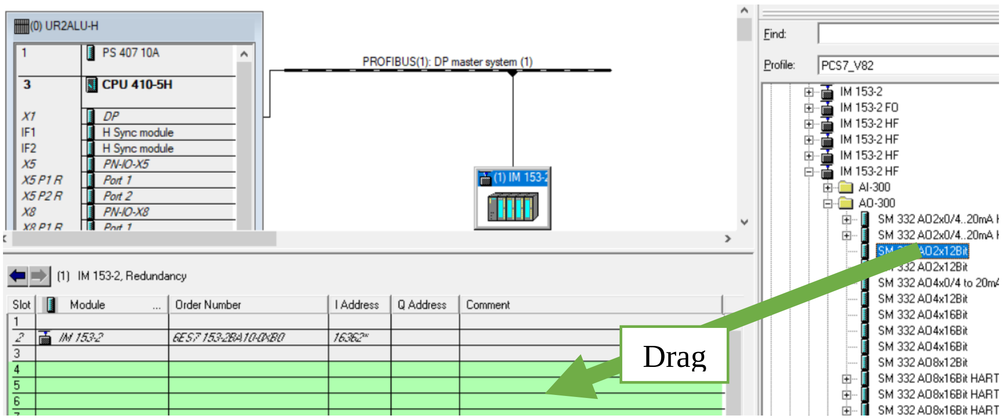

Figure 3.17 Adding modules in HW

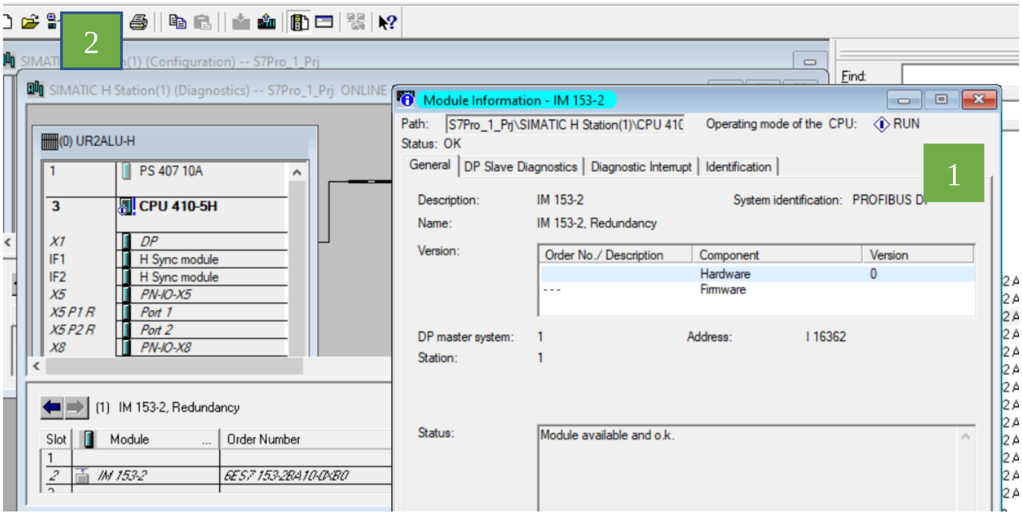

Figure 3.18 Module information in Online mode

3.6 How to add a chart

To add a chart, we follow the step presented in the figure 3.19.

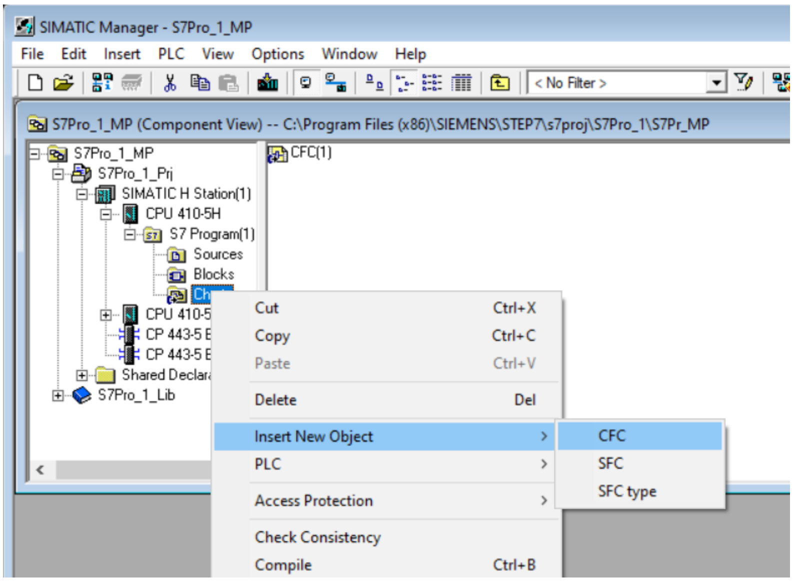

Figure 3.19 Adding a chart in CFC editor

3.7 Integration of WinCC with PCS7

The first step is to create a SIMATIC PC station. In a Multiproject we can add SIMATIC PC station with AS in one project or in a separate project and to choose it in our project we should create a new project in Multiproject. Then we add a SIMATIC PC station in the subproject.

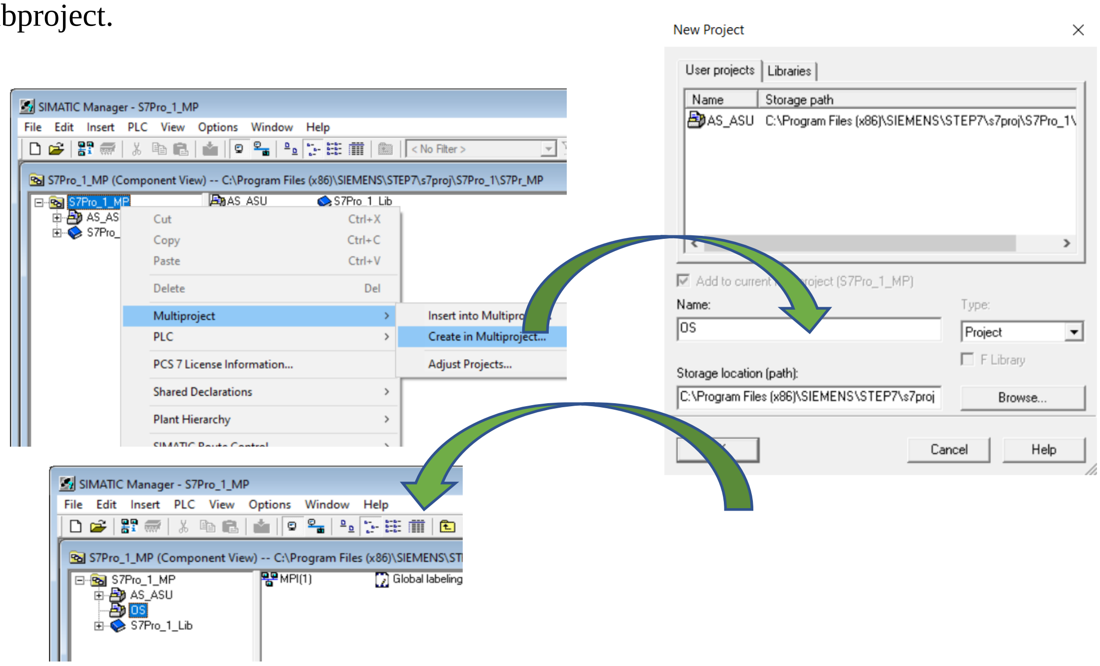

Figure 3.20 Insering an Multiproject for Operation Station.

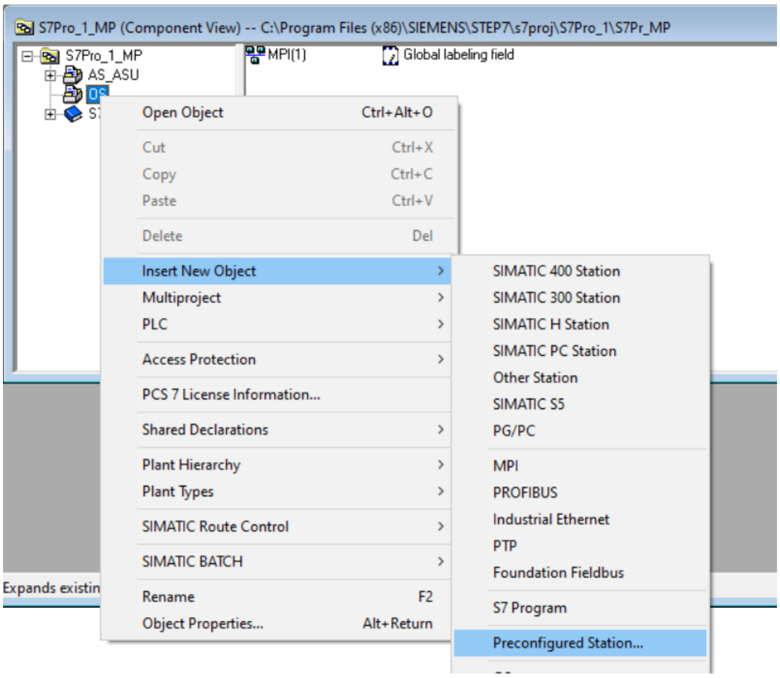

Figure 3.21 Adding a SIMATI PC station.

Now we go to hardware configuration of SIMATIC PC station to configure it with the AS, the CP must be choosen according to the protocol that we want to use. in our project we choose the Ethernet.

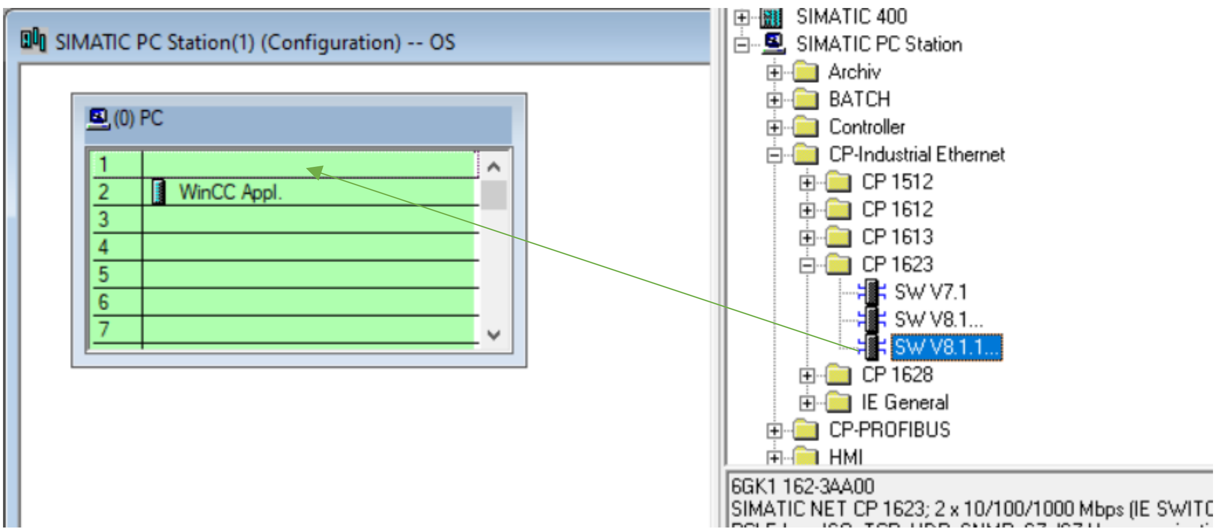

Figure 3.22 HW configuration for SIMATC PC station

Now we have to network the AS with SIMATIC PC station via the NetPro, because each project has its proper network. We should muddle them in one wide profinet to connect AS with the SIMATIC PC station. To do that, we go to the in Multiproject: adjust properties-> Ethernet ->Execute -> add all subnets in Ethernet-wide ->OK ->close->yes.

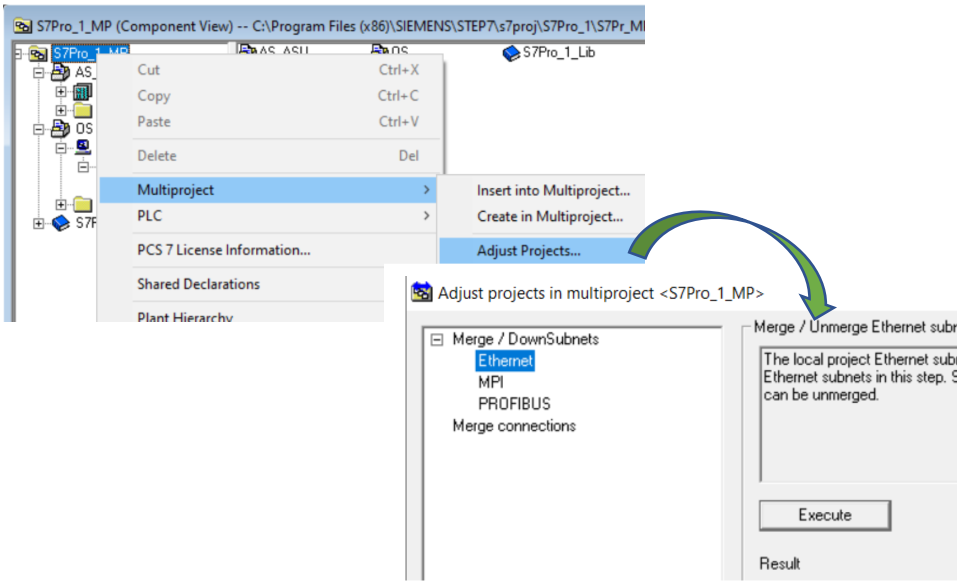

Figure 3.24 Marging all subnet in wide.

Now for integrating the WinCC project, we only open object and the integration will occurs automatically.

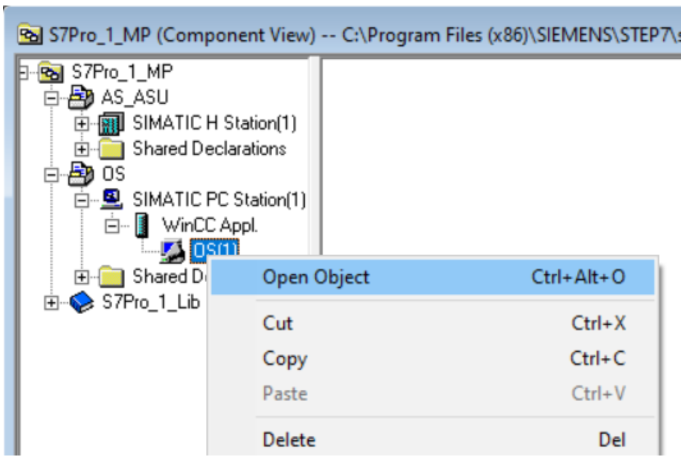

Figure 3.25 Integration WinCC project.

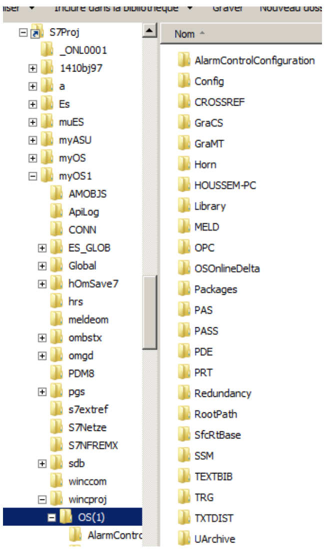

Figure 3.26 WinCC project integrated.

The last step is sharing data and variables between AS and SIMATIC PC station, for that we should compile SIMATIC PC station.

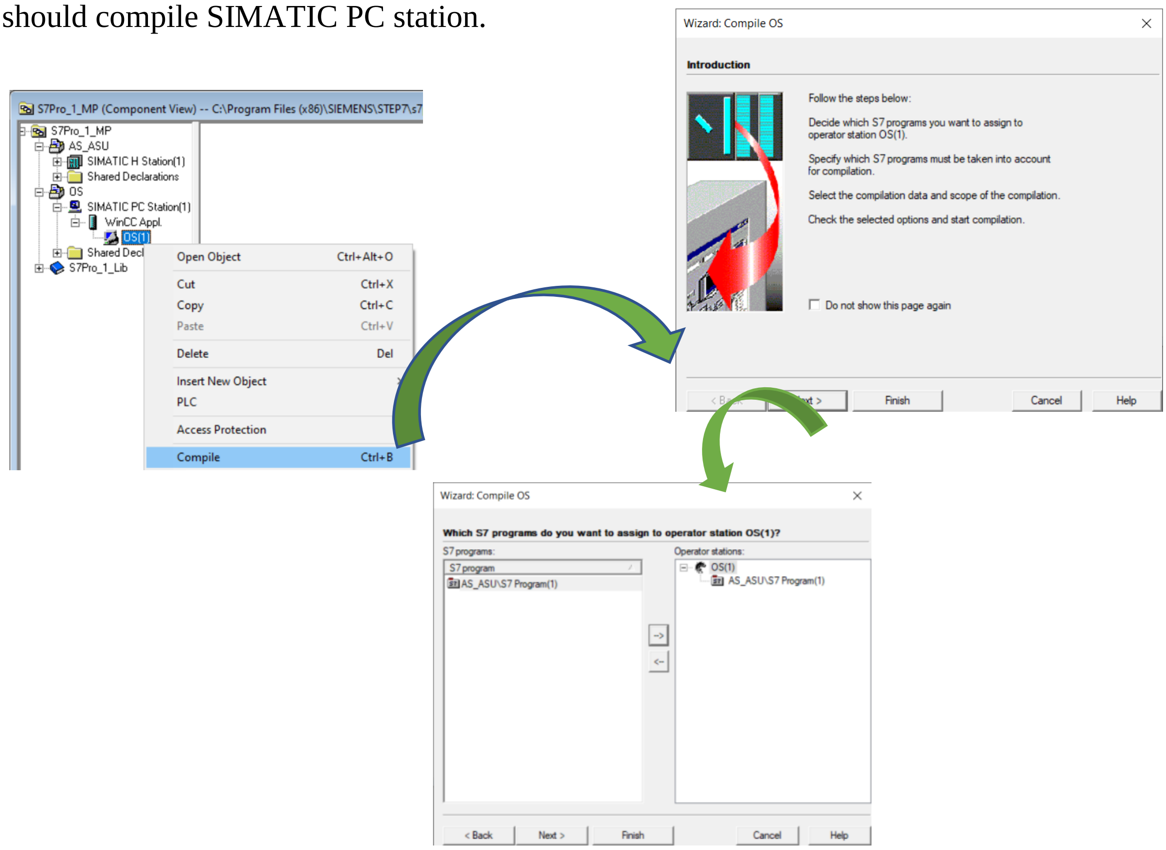

Figure 3.27 Compilation of the SIMATIC PC station

3.8 Main program

3.8.1 Brief description of used blocks

PCS7AnIn block

This block reads the raw analog value and converts it to its physical value.

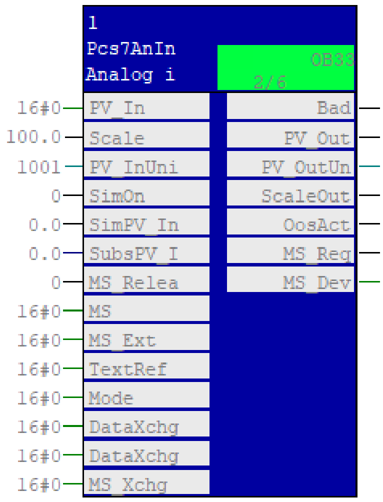

Figure 3.28 Channel BlockPCS7AnIn

parameter	Description	type
PV_In	Process value (raw value)	WORD
PV_InUnit	Unit of measure for process value	INT
SimOn	1 = Simulation on	STRUCT
SimPV_In	Process value used for SimOn = 1	STRUCT
Bad	1 = Process value is not valid	STRUCT
PV_Out	Standard value (physical variable)	STRUCT
PV_OutUnit	Unit of the process value	INT

Table 3 Main inputs and outputs of PCS7AnIn

MonAn block

This blocks is made by Linde there is no way to know its characteristics. It is used for monitoring an analog process tag and the corresponding limits. The block generates and outputs corresponding messages if limits are violated.

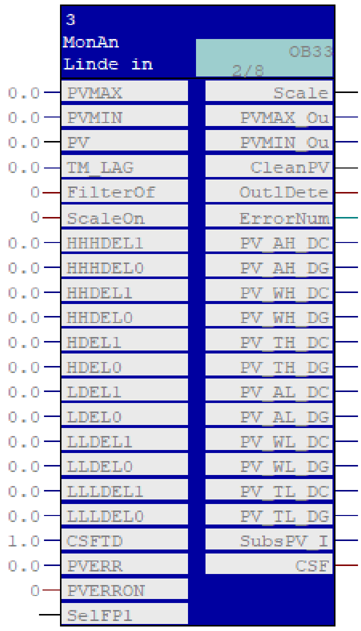

Figure 3.29 Monitoring analog block

parameter	description	type
PVMAX	Process value high range	REAL
PVMIN	Process value low range	REAL
PV	Process value	STRUCT
PVERR	Process value error	REAL
PVERRON	1 = Process value error on	BOOL
ENO	1 = Block algorithm completed without errors	BOOL
CSF	1 = External error (control system fault)	STRUCT

Table 4 Main inputs and outputs of MonAn

MonAnL

It is used for monitoring an analog process tag and the corresponding limits. The block generates and outputs corresponding messages if limits are violated.

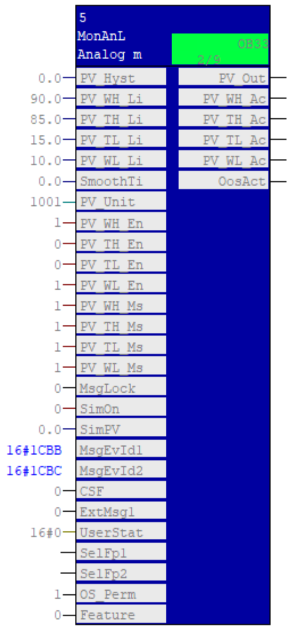

Figure 3.30 Monitoring analog large block

parameter	description	type
PV_WH_Lim	Limit PV warning (high)	REAL
PV_TH_Lim	Limit PV tolerance message (high)	REAL
PV_TL_Lim	Limit PV tolerance message (low)	REAL
PV_WL_Lim	Limit PV warning (low)	REAL
PV_InUnit	Unit of measure for process value	INT
PV_WH_En	1 = Enable PV warning limit (high)	BOOL
PV_TH_En	1 = Enable PV tolerance limit (high)	BOOL
PV_TL_En	1 = Enable PV tolerance limit (low)	BOOL
PV_WL_En	1 = Enable PV warning limit (low)	BOOL

MsgLock	1 = Suppress process messages	STRUCT
SimOn	1 = Simulation on	STRUCT
SimPV_In	Process value used for SimOn = 1	STRUCT
CSF	1 = External error (control system fault)	STRUCT
SelFp1	1 = Call a block saved in this parameter as an additional faceplate in the standard view	ANY
PV_WH_Act	1 = PV warning (high) active	STRUCT
PV_TH_Act	1 = PV tolerance message (high) active	STRUCT
PV_TL_Act	1 = PV tolerance message (low) active	STRUCT
PV_WL_Act	1 = PV warning (low) active	STRUCT

Table 5 Main inputs and outputs of MonAnL

PCS7DiIn

The block cyclically processes all channel-specific signal functions of a digital input module.

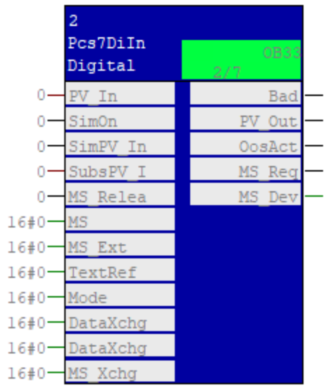

Figure 3.31 Channel Block PCS7DiIn

parameter	Description	type
PV_In	Process value (raw value)	BOOL
SimOn	1 = Simulation on	STRUCT
SimPV_In	Process value used for SimOn = 1	STRUCT
Bad	1 = Process value is not valid	STRUCT
PV_Out	Standard value (physical variable)	STRUCT

Table 6 Main inputs and outputs of PCS7DiIn

MonDiL

The block is used for Monitoring a digital process tag.

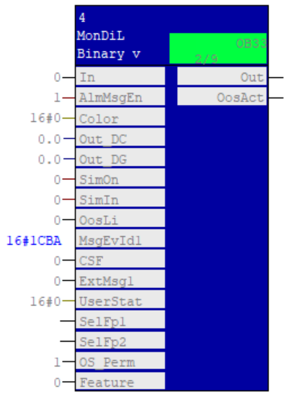

Figure 3.32 Monitoring digital large block

parameter	Description	type
In	Digital input value	STRUCT
AlmMsgEn	1 = Alarms are output	BOOL
SimOn	1 = Simulation on	STRUCT
SimPV_In	Process value used for SimOn = 1	STRUCT
CSF	1 = External error (control system fault)	STRUCT
Out	Output	STRUCT

Table 7 Main inputs and outputs of MonDiL

3.8.2 Edit address and symbols in the HW

Before beginning our program, we should assign addresses in the HW, for that we choose the address that we want in ET200M, then we go to the slot digital or analogic. After that we right click and choose Edit Symbols, and finally we can put our information.

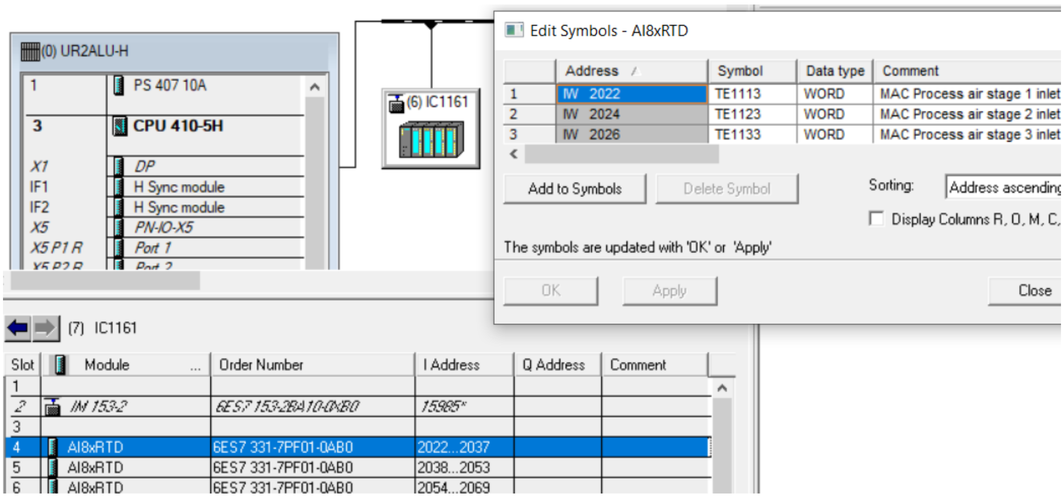

Figure 3.33 Edits addresses and symbols in the HW.

3.8.3 Transmitter program

This is the chart of the transmitter program at the right side of MonAnL we have an interconnection to the right sheet bar that conduct to a permission or an interlock block.

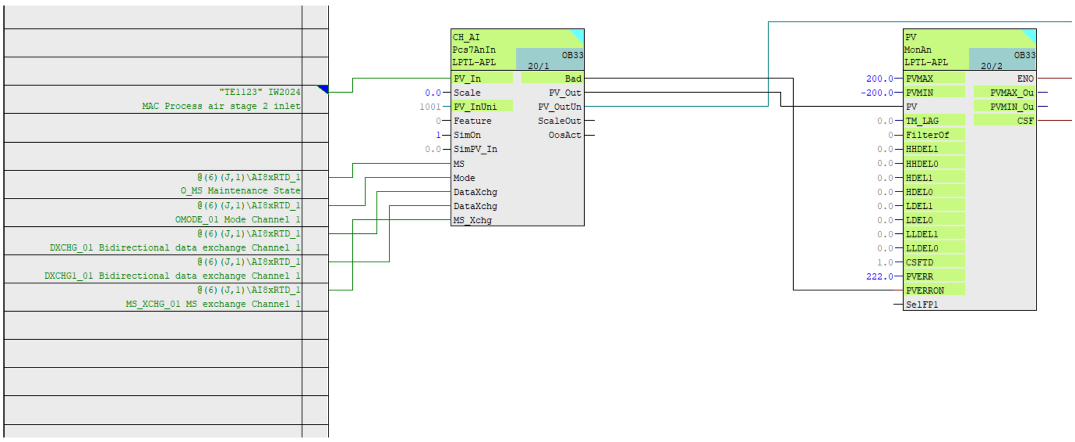

Figure 3.34 Transmitter program part1.

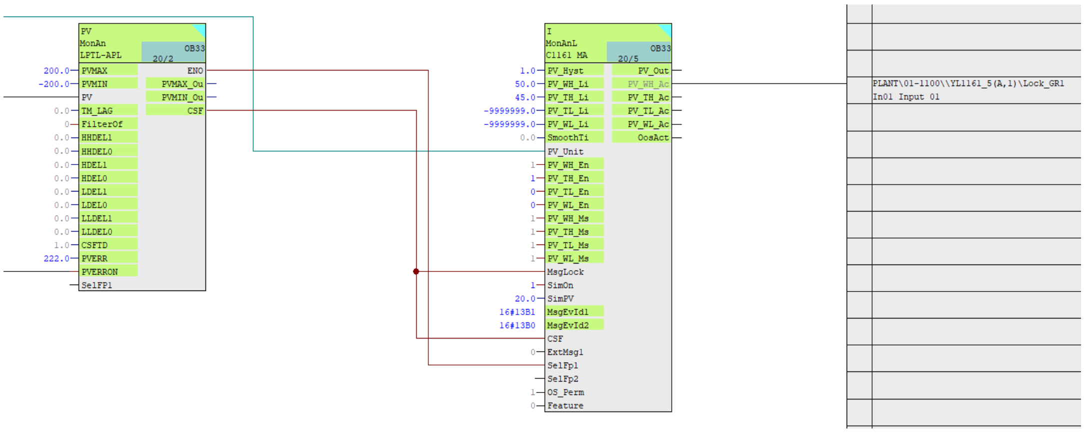

Figure 3.35 Transmitter program part2.

3.8.4 **Digital sensor program**

This is the chart of a digital sensor program.at the right side of MonDiL we have an interconnection to the right sheet bar that bring us to a permission or an interlock block.

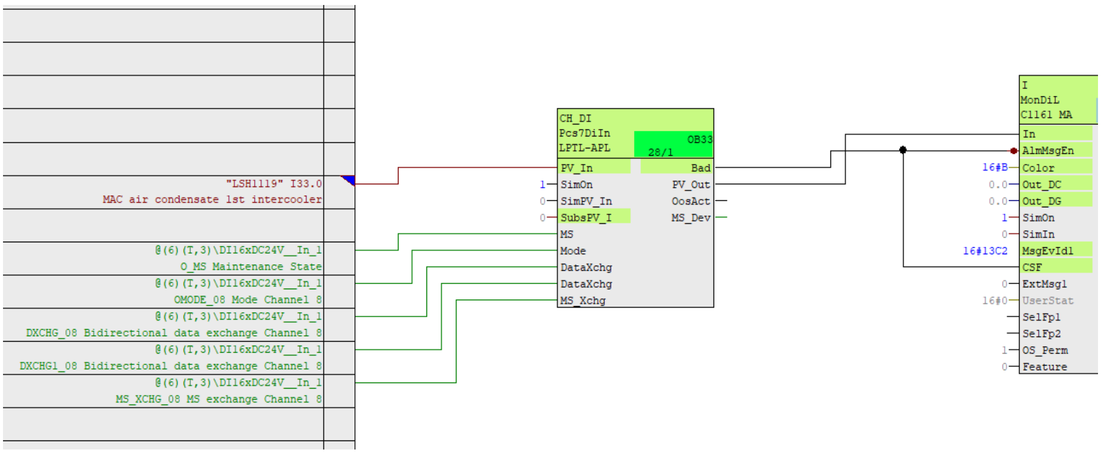

Figure 3.36 Digital sensor program part1.

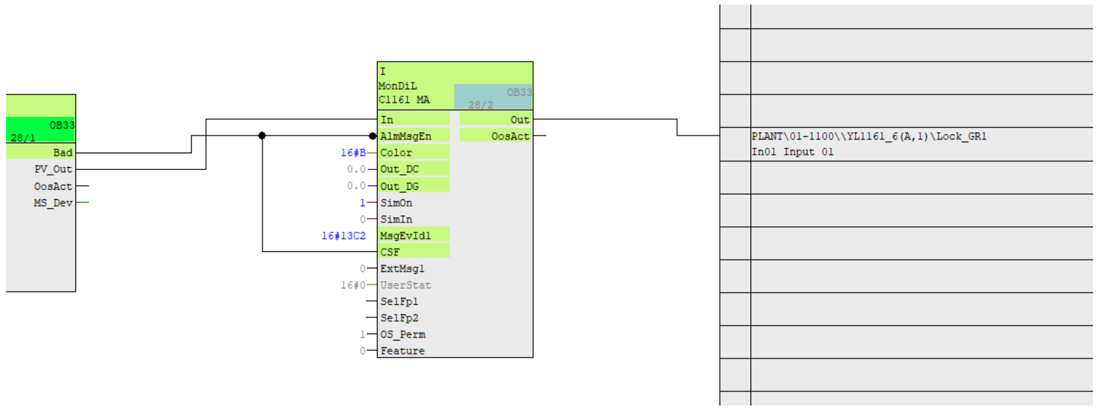

Figure 3.37 Digital sensor program part2.

3.8.5 Permission and Interlock block

As we have seen in the transmitter program, the interconnection from MonAnL is interconnected to one of the right inputs of the interlock block, the output of the block can go to another interlock block, we use multiple blocks to classify and organize permission and interlock. the out also can go to the motor block.

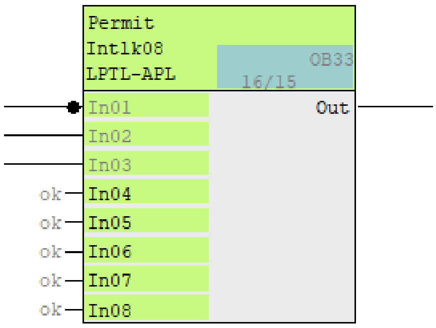

Figure 3.38 Permission and interlock block.

parameter	Description	type
In	input	STRUCT
Out	Output	STRUCT

Table 8 Main inputs and outputs of Intlk08

3.8.6 **Motor**

In the right of the motor block, we have to inputs Permit and Interlock. all permissions and interlocks met in two inputs to give us a permission or an interlock.

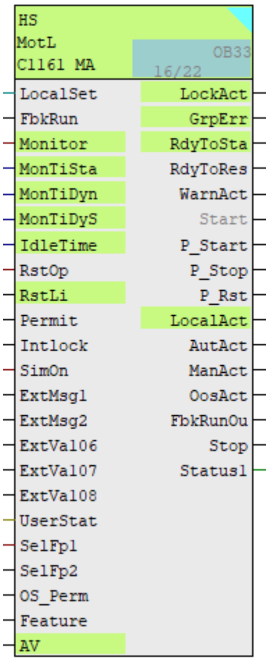

Figure 3.39 Motor Block.

parameter	**Description**	**type**
Permit	1 = OS activation enable for motor 0 = No OS release for energizing motor	STRUCT
Intlock	0 = Interlocking without reset is active; you can operate the block without reset once the interlocking condition has disappeared 1 = Interlock not activated	STRUCT

Table 9 Main inputs and outputs of MotL

3.9 Simulation

Main faceplate

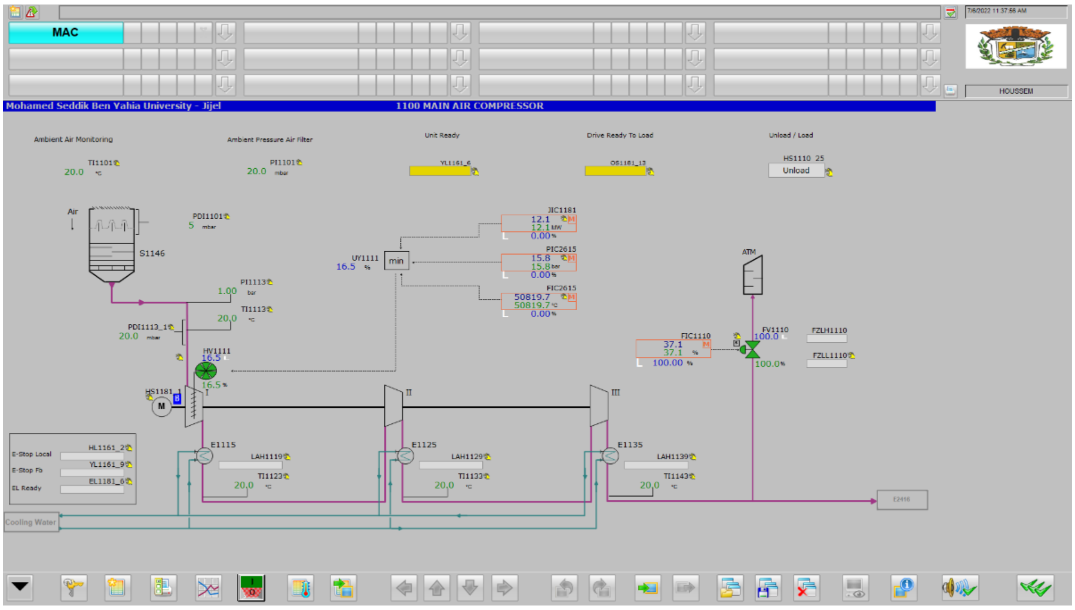

Figure 3.40 Faceplate of program.

Manipulated faceplate

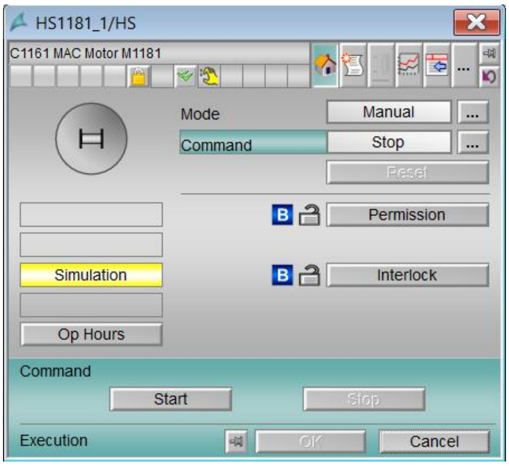

Figure 3.41 Manipulated faceplate 1

This plate for example is for MAC motor, we can start or stop it, and from it we can move on to another face plate until we get to transmitter faceplate.

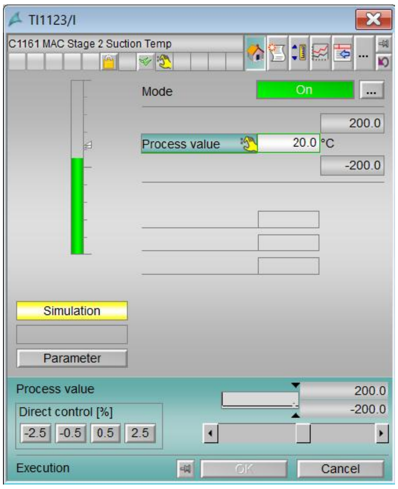

Figure 3.42 Manipulated faceplate 2

This faceplate is for a temperature transmitter, it gives us the possibility to change value for our simulation.

motor running faceplate

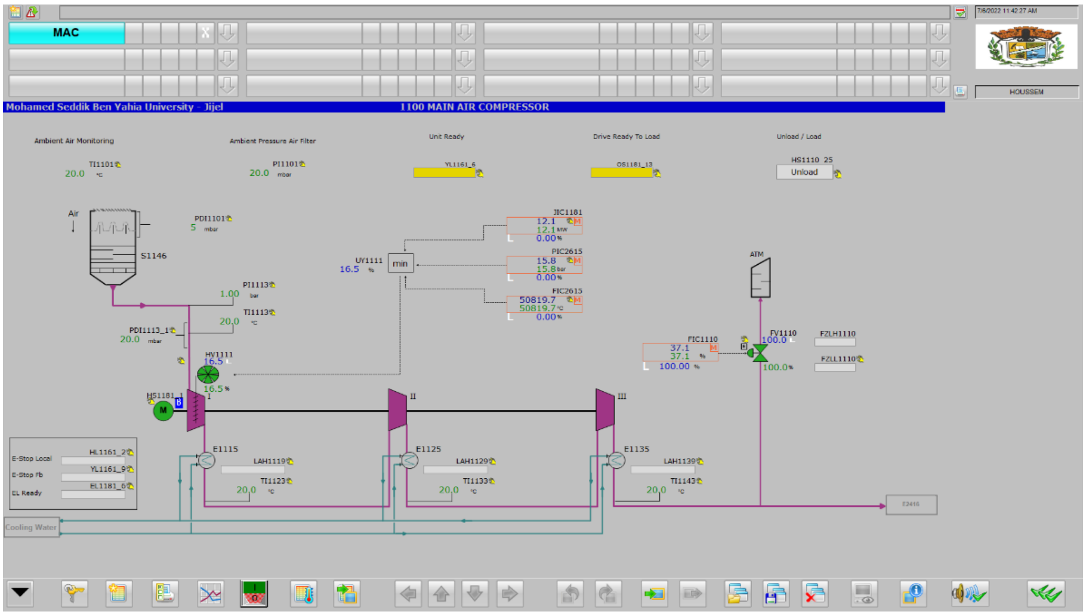

Figure 3.43 Simulation when motor running

The purple color in the faceplate indicate that motor is work.

Trip faceplate

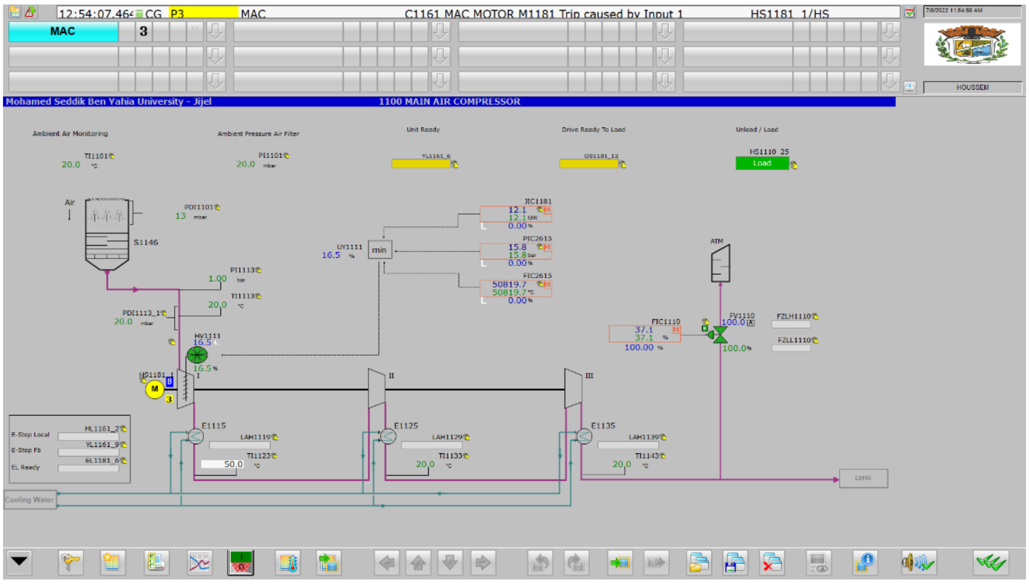

Figure 3.44 Simulation of an interlock

When we have an interlock, we notice that the purple color disappears, and a yellow color appears, also we have a message of alarm on the top of the faceplate.

Alarm faceplate

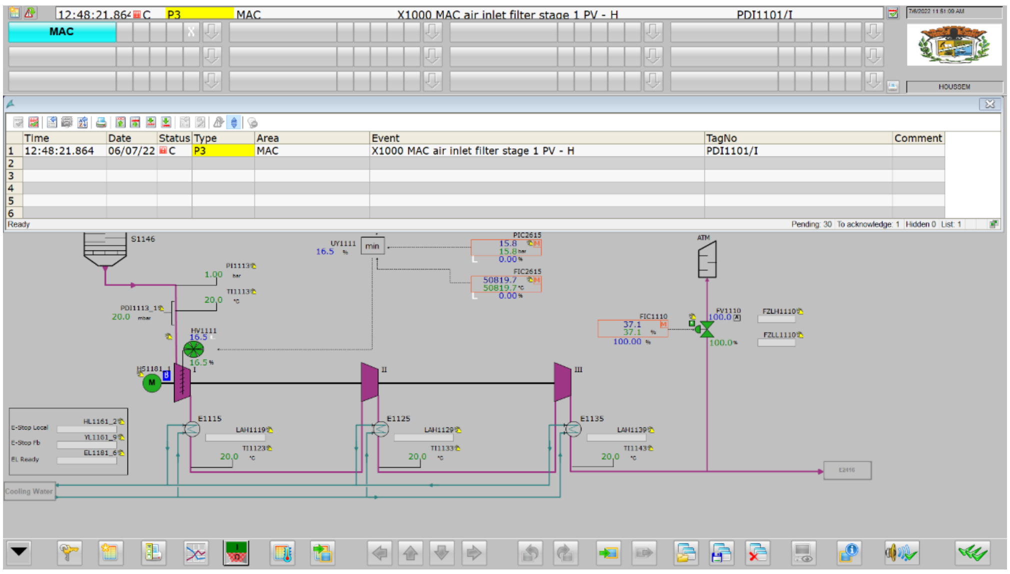

Figure 3.45 Simulation of an alarm.

In Figure 3.39, we see a small faceplate for alarms, each interlock and alarms are archived here.

3.10 Conclusion

In this chapter we achieve to our goal by making a simulation of permission and interlock of a real MAC motor by PCS7. In the first step we make the logic for a transmitter (analogue) and a digital sensor after that its permission and interlock that go to motor block by SIMATIC MANAGER. In the second step we made the simulation of this logic to supervise on the control room by WinCC.

General conclusion

In this dissertation, we are interested in programming permissions and interlocks for a three-stage main air compressor of the ASP unit located in AQS complex of Bellara using PCS7 software. The project consists of making the logic programming and an HMI interface for the supervision of the process using the S7-400-5H PLC of Siemens under SIMATIC MANAGER and WinCC.

Firstly, we presented the various plants in the AQS complex and the process of the ASU plant. Then, we made an overview of the different PLC controllers of Siemens and the main component of S7-400. We also presented the typical DCS architecture that is used in industry and some of its communication protocols. In the last chapter, we presented the PCS7 software and the logic program of our project with a supervision faceplate allowing monitoring the evolution of the process in real time. The obtained simulation results validate our program as well as the proposed supervision interface.

Finally, concerning the perspectives, we propose the implementation of a PID regulator in the antisurge valve adopt to the pressure in the outlet of the MAC motor.

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Abstract

The aim of this work is to make permissions and interlocks for a three-stage main air compressor motor using PCS7 in the AIR SEPARATION UNIT in the ALGERIAN QATARI STEEL complex. This work is mainly composed of three parts: in the first one, we present all the tools and concepts that we used to achieve this project, as well as the needed hardware and software. The second part involves using SIMATIC MANAGER to create a logic for permissions and interlocks. Finally, in the third part, we make a human-machine interface for visualization by WinCC.

Keywords: permissions, interlocks**,** PLC, DCS, PCS7, Air Separation Unit, SIMATIC MANAGER, CFC, WinCC, Algerian Qatari Steel.

Résumé

Le but de ce travail est de faire des permissions et des verrouillages d'un moteur de compresseur d'air principal à trois étages en utilisant PCS7 dans l'UNITÉ DE SÉPARATION D'AIR du complexe ALGERIAN QATARI STEEL. Ce travail se constitue principalement de trois parties : dans la première, nous présentons tous les outils et les concepts que nous avons utilisés pour réaliser ce projet, ainsi que le matériel et les logiciels nécessaires. La deuxième partie consiste à faire le programme des permissions et des verrouillages par SIMATIC MANAGER. Enfin, la dernière partie consiste à réaliser une interface homme-machine pour la visualisation par WinCC.

Mots clés: autorisations, verrouillages**,** API, DCS, PCS7, Unité de Séparation d’Air, SIMATIC MANAGER, CFC, WinCC, Algerian Qatari Steel.

ملخص

الهدف من هذا العمل هو عمل تصاريح وإغلاقات لمحرك ضاغط الهواء الرئيسي بثلاث مراحل باستخدام PCS7 في وحدة فصل الهواء في مجمع الفولاذ القطري الجزائري. ينقسم هذا العمل بشكل أساسي إلى ثلاثة أجزاء: في الجزء الأول نقدم جميع الأدوات والمفاهيم التي استخدمناها في إنجاز هذا المشروع، وكذلك الأجهزة والبرامج اللازمة. الجزء الثاني هو عمل كود للتصاريح و الإغلاقات بواسطة SIMATIC MANAGER. الجزء الأخير عمل واجهة المراقبة بواسطةWinCC .

الكلمات المفتاحية: التصاريح، الإغلاقات،PCS7 ،PLC ، DCS، وحدة فصل الهواء ،SIMATIC MANAGER،CFC ، WinCC،الجزائرية القطرية للصلب.