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THEME

Automated Cyclone Dust Collection System Using Siemens Step 7 / WinCC and Supervision

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Dedication

As we take our final steps in university life, it's important to pause and reflect on the years we've spent within its halls, learning, growing, and being guided by dedicated professors who gave so much to shape the generation of tomorrow.

"Be a scholar. If you cannot, then be a learner. If not, then love the scholars. And if not, at least do not hate them."

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List of Abbreviations

AC	Alternating Current
AI	Analog Input
AI (Tech)	Artificial Intelligence
AO	Analog Output
CAN	Calcium Ammonium Nitrate
CP	Control Part
CP (Comm.)	Communication Processor
CPU	Central Processing Unit
DC	Direct Current
DI	Digital Input
DO	Digital Output
ERP	Enterprise Resource Planning
FM	Function Module
GUI	Graphical User Interface
HMI	Human-Machine Interface
IM	Interface Module
NC	Normally Closed
NO	Normally Open
NPK	Nitrogen, Phosphorus, Potassium Fertilizer
OP	Operative Part
PLC	Programmable Logic Controller
RPA	Robotic Process Automation
S5TIME	Siemens S5 Timer Format
SM	Signal Module
SP	Supervision Part
SSP	Simple Super Phosphate
STPP	Sodium Tripolyphosphate
UAN	Urea Ammonium Nitrate
VAT	Variable Table

Abstract

The need for effective dust collection systems in industrial settings is becoming more critical as industries face stricter environmental regulations, rising energy costs, and increasing expectations for workplace safety and operational efficiency. This study explores the design and automation of a cyclone-based dust collection system, focusing on the integration of programmable logic controllers (PLCs) to optimize performance.

Cyclone separators are widely used for their ability to remove large dust particles using centrifugal force. Although simple in design, their performance can be significantly improved when combined with smart control systems. This project integrates Siemens S7-300 PLCs and STEP 7/WinCC software to automate and monitor the dust removal process. The result is a system capable of reducing energy consumption, improving filtration efficiency, and ensuring compliance with environmental standards.

Keywords: Cyclone separator, Dust collection, PLC, Siemens S7-300, STEP 7, WinCC, Automation, Supervision.

Résumé :

Le besoin de systèmes efficaces de collecte de poussière dans les environnements industriels devient de plus en plus crucial face aux réglementations environnementales strictes, à l'augmentation des coûts énergétiques et aux exigences croissantes en matière de sécurité et d'efficacité opérationnelle. Ce mémoire porte sur la conception et l'automatisation d'un système de dépoussiérage basé sur un séparateur cyclone, en mettant l'accent sur l'intégration d'automates programmables (PLCs) pour optimiser les performances.

Les séparateurs cycloniques sont largement utilisés pour leur capacité à éliminer les grosses particules de poussière par force centrifuge. Bien que leur conception soit simple, leur efficacité peut être considérablement améliorée lorsqu'ils sont associés à des systèmes de contrôle intelligents. Ce projet intègre des automates Siemens S7-300 et les logiciels STEP 7/WinCC pour automatiser et superviser le processus de dépoussiérage. Le système obtenu permet de réduire la consommation d'énergie, d'améliorer l'efficacité de la filtration et d'assurer la conformité aux normes environnementales.

Mots-clés : Séparateur cyclone, Collecte de poussière, Automate programmable, Siemens S7-

300, STEP 7, WinCC, Automatisation, Supervision.

ملخص:

تزداد الحاجة إلى أنظمة فعالة لجمع الغبار في البيئات الصناعية نظرًا للتشريعات البيئية الصارمة، وارتفاع تكاليف الطاقة، والمتطلبات المتزايدة لضمان السلامة والكفاءة التشغيلية في أماكن العمل. يهدف هذا البحث إلى تصميم وأتمتة نظام لجمع الغبار يعتمد على فاصل إعصاري(Cyclone) ، مع التركيز على دمج أجهزة التحكم المنطقي القابلة للبرمجة (PLCs) لتحسين الأداء.

تُستخدم الفواصل الإعصارية على نطاق واسع لقدرتها على إزالة الجسيمات الكبيرة من الغبار باستخدام القوة الطردية المركزية. وعلى الرغم من بساطتها التصميمية، إلا أن فعاليتها تتحسن بشكل كبير عند دمجها بأنظمة تحكم ذكية. تم في هذا المشروع دمج أجهزة Siemens S7-300 PLCsمع برمجيات STEP 7 و WinCC لأتمتة ومراقبة عملية إزالة الغبار. وقد تم الحصول على نظام قادر على تقليل استهلاك الطاقة، وتحسين كفاءة الترشيح، وضمان الامتثال للمعايير البيئية.

الكلمات المفتاحية: فاصل إعصاري، جمع الغبار، جهاز تحكم منطقي مبرمج، سيمنس S7-300 ، STEP 7 ، WinCC الألية، الإشراف الصناعي.

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GENERAL INTRODUCTION

In contemporary industrial contexts, the control and management of airborne particulate emissions have become a paramount concern due to their implications for occupational health, environmental sustainability, and regulatory compliance. Among the various techniques employed for dust separation, cyclone separators remain a preferred solution in numerous sectors owing to their mechanical simplicity, durability, and effectiveness in removing coarse particulates from air streams.

However, with the advent of Industry 4.0, there is an increasing need for intelligent and adaptive systems that transcend the limitations of conventional mechanical designs. In this regard, the integration of automation technologies, particularly Programmable Logic Controllers (PLCs) and Human-Machine Interfaces (HMIs), offers a promising pathway to enhance the performance, reliability, and real-time control of dust collection systems.

This thesis investigates the design, implementation, and simulation of an automated cyclone dust collection system using Siemens S7-300 PLCs and WinCC supervision software. The study is situated within the operational framework of the Fertial-Annaba industrial unit, which underscores the practical relevance and industrial applicability of the project. The work is structured to provide a comprehensive understanding of cyclone operation principles, automation strategies, and supervisory control integration, culminating in the development of a responsive and energy-efficient dust control system.

The overarching objective of this research is to contribute to the advancement of sustainable industrial practices by demonstrating how the synergy between mechanical engineering and digital control technologies can lead to significant improvements in process safety, operational efficiency, and environmental performance.

CHAPTER I :

PRESENTATION OF THE FERTIAL-ANNABA UNIT

I.1 INTRODUCTION

In the era of global industrial expansion and environmental consciousness, the optimization of production processes and pollution control systems has become more than a necessity—it is a responsibility. Among the key players in Algeria's chemical and fertilizer sector stands the **Asmidal Group**, a public industrial enterprise with a crucial role in supporting the country's agricultural productivity and economic growth. Created in 1984, Asmidal has grown into a cornerstone of Algeria's chemical industry, with an extensive network of subsidiaries and industrial complexes dedicated to the manufacture of fertilizers, phytosanitary products, and various agricultural inputs.

Operating under the umbrella of **Sonatrach**, the state-owned oil and gas giant, Asmidal has successfully expanded its reach both nationally and internationally. Through its subsidiaries, including **Fertial**, the group has contributed significantly to Algeria's ambition of achieving food security, reducing dependence on imports, and enhancing the productivity of local agriculture.

Fertial's industrial site in **Annaba**, in particular, is a strategic asset that focuses on the production of ammonia and nitrogenous fertilizers—two key ingredients in modern agricultural development.

However, like many chemical and fertilizer industries around the world, Fertial's activities are not without environmental consequences. The processes involved in fertilizer production often generate large volumes of gaseous emissions and fine particulate matter, which, if not properly managed, can pose serious risks to the environment and public health. This reality has prompted Fertial and the broader Asmidal Group to invest in advanced pollution control technologies, among which **cyclone dust collection systems** play a vital role.

Cyclone separators are an essential part of Fertial Annaba's environmental management infrastructure. These systems are used to capture fine dust particles released during chemical reactions, drying processes, and material handling. By using centrifugal force to separate particulate matter from gaseous streams, cyclone collectors help reduce airborne pollution and enhance the overall cleanliness of the industrial environment. Furthermore, recovered dust can often be recycled back into the production process, contributing to resource efficiency and economic sustainability.

This chapter aims to provide an in-depth presentation of the **Asmidal Group**, with a particular focus on its **Fertial Annaba** subsidiary. It explores the company's industrial structure, operational strategies, environmental management practices, and the implementation of cyclone dust recovery systems. By understanding the role and function of Fertial within the larger framework of Algeria’s industrial and environmental policies, this chapter offers insights into how modern industries can balance productivity with sustainability. This context is particularly relevant as Algeria moves toward greener and more responsible forms of development, where industrial innovation and environmental protection go hand in hand.

I.2. HISTORY OF THE COMPANY

The origins of the Asmidal Complex trace back to Algeria's post-independence industrialization strategy, launched in the 1960s. Seeking to ensure food security and support agricultural development, the government, through the state-owned company Sonatrach, initiated the construction of major chemical and fertilizer production facilities.

In 1967, Sonatrach decided to establish a phosphate fertilizer complex in the city of Annaba. After extensive planning, production units for sulfuric acid, phosphoric acid, and various phosphate fertilizers were commissioned by 1972, marking a significant milestone in Algeria’s efforts to become self-sufficient in agrochemical production. These units were supported by several critical industrial utilities necessary for efficient operation. [1]

Responding to growing domestic and international demands, the complex expanded significantly in the 1980s. By 1982, new production units for nitric acid, ammonium nitrate, and sodium tripolyphosphate (STPP) were installed. In 1975, the construction of a nitrogen fertilizer complex began, in collaboration with major international firms such as Creusot-Loire Industrie and Krebs (France) and Kellogg (USA). This nitrogen complex became operational by 1984, and the Kellogg-designed ammonia unit commenced production in 1987.

In 1984, following the restructuring of Algeria’s public enterprises, all fertilizer production units in Annaba were unified under the newly created entity Asmidal. By 1996, Asmidal was transformed into a joint-stock company (SPA), signaling the government's intention to modernize industrial operations and open the sector to potential partnerships.

Meanwhile, a parallel facility — the Arzew Fertilizer Complex (CEA/Z) — had been established in the 1960s within the Arzew industrial zone, originally managed by Sonatrach. In September 1984, the Annaba and Arzew plants were merged administratively under the Asmidal brand by Decree 84-258, enhancing operational coherence and strategic coordination. In the context of Algeria’s economic reforms and in pursuit of increased competitiveness, Asmidal entered into a major partnership with the Spanish group Grupo Villar Mir in 2005.

This alliance resulted in the creation of FERTIAL SPA, integrating the Annaba and Arzew sites under joint management, fostering technological upgrades, and facilitating access to new markets. [2]

Today, Asmidal and its subsidiaries continue to embody Algeria's vision of an integrated, internationally competitive chemical industry, contributing significantly to national agricultural productivity and industrial diversification.

I.3 COMPLEX PRESENTATION OF ASMIDAL

The Asmidal Complex represents one of Algeria's leading industrial achievements in the chemical sector. Created to boost national fertilizer production and reduce dependence on imports, Asmidal is todaya dynamic industrial group encompassing multiple subsidiaries and activities related to the manufacture, distribution, and innovation of fertilizers and chemical products.

Following its restructuring and partnership development strategies, Asmidal founded FERTIAL SPA in 2005, as a result of a capital opening to the Spanish group Grupo Villar Mir (GVM). The new structure aimed to inject foreign investment, technology, and management practices into Algeria's fertilizer industry, while maintaining strong national ownership through Asmidal's 34% stake.

FERTIAL's share capital amounts to 17,967,000,000 Algerian Dinars, divided as follows:

- 66% owned by GVM (Grupo Villar Mir)
- 34% owned by Asmidal Group The complex's mission includes:
- The **production** of nitrogen and phosphate fertilizers.
- The **commercialization** of its products both domestically and internationally.
- The **development** of new fertilizer solutions adapted to diverse agricultural needs.

Today, Asmidal's operations extend over several specialized subsidiaries, forming an integrated industrial ecosystem:

I.3.1 FERTIAL

FERTIAL operates across two main platforms: the Eastern platform (Annaba) and the Western platform (Arzew).

A) South Zone (Annaba – Phosphate Fertilizers)

Inaugurated on March 3, 1969, through a partnership with the French company KREBS, this site began production on May 15, 1972.

Its installations include:

- **Simple Super Phosphate (SSP) Workshop**: Production of phosphate-based fertilizers essential for soil enrichment.
- **NPK Fertilizer Workshop**: Manufacturing of balanced multi-nutrient fertilizers, combining Nitrogen (N), Phosphorus (P), and Potassium (K).

B) North Zone (Annaba – Nitrogen Fertilizers)

Launched in 1975, in collaboration with Creusot-Loire, Kellogg, and Krebs, this zone became operational by 1982. Key facilities:

- **Ammonia Unit (NH_3)**: Dailyproduction capacity of 100 tons.
- **Nitric Acid Unit (HNO_3)**: Daily production capacity of 800 tons.
- **Ammonium Nitrate Unit (NH_4NO_3)**: Daily production capacityof 1,000 tons.
- **Handling and Storage Facilities**: Designed to efficiently manage large volumes of raw materials and finished products.

Central Units I and II supply essential steam, water, and energy needs to both fertilizer zones. [3]

I.3.2 KIMIAL – Production of Sodium Tripolyphosphate (STPP)

KIMIAL is a specialized industrial unit within the Asmidal Group, primarily dedicated to the manufacture of Sodium Tripolyphosphate (STPP), an essential chemical widelyused in both industrial and domestic applications.

Established to diversify Asmidal's product portfolio beyond fertilizers, KIMIAL plays a strategic role in supporting Algeria's chemical industry. The production of STPP at KIMIAL serves various markets, including:

- **Detergent manufacturing**: STPP acts as a water softener and dispersing agent, enhancing the effectiveness of detergents.
- **Water treatment**: It is used in formulations aimed at reducing water hardness and preventing scale formation in pipelines and boilers.
- **Ceramics and food industries**: STPP is utilized as a preservative and stabilizer.

The KIMIAL plant has a dailyproduction capacity of 120 tons, employing advanced chemical processes to meet both domestic and export market demands. Quality assurance and environmental compliance are integral to the unit's operations, with continuous monitoring to ensure adherence to international standards. [4]

I.3.3 SOMIAS – Industrial Maintenance Services

SOMIAS (Société de Maintenance Industrielle et d'Assistance) was established to address the complex maintenance needs of the Asmidal Group's production facilities. Over time, it evolved into a fully specialized company offering industrial maintenance services not only to Asmidal subsidiaries but also to external clients. SOMIAS's core activities include:

- **Mechanical maintenance**: Overhauling and repairing industrial machinery, turbines, compressors, and pumps.
- **Electrical and instrumentation services**: Installation, calibration, and repair of control systems, sensors, and motors.
- **Preventive maintenance programs**: Development and execution of maintenance plans to reduce downtime and increase the reliability of production equipment.
- **Emergency interventions**: Rapid deployment of technical teams to address unexpected breakdowns and ensure operational continuity.

Thanks to its expertise, SOMIAS contributes significantly to improving the productivity, safety, and longevity of industrial assets across the Asmidal ecosystem.

I.3.4 ASFERTRADE – Fertilizer Marketing and Distribution

ASFERTRADE serves as the commercial arm of the Asmidal Group, specializing in the marketing and distribution of fertilizers produced within the complex. It plays a pivotal role in connecting Asmidal's industrial output to the agricultural sector, ensuring that high-quality fertilizers reach farmers and agricultural cooperatives across Algeria. The key missions of ASFERTRADE include:

- **Market research and development**: Identifying customer needs and aligning product offerings accordingly.
- **Logistics and supply chain management**: Organizing efficient transportation, storage, and delivery of fertilizers to strategic points across the national territory.
- **Customer support services**: Providing technical assistance, training sessions, and agronomic advice to end-users, helping optimize fertilizer use.
- **Export promotion**: Supporting Asmidal's international sales efforts, particularly in Europe, Africa, and Latin America.

Byacting as the interface between production units and final customers, ASFERTRADE ensures the competitiveness, visibility, and accessibility of Asmidal's fertilizer products.

I.4 GEOGRAPHICAL LOCATION

The Asmidal Complex is strategically situated approximately 4 kilometers east of the city of Annaba, a major economic and industrial hub located in northeastern Algeria. This geographical positioning offers several operational advantages, facilitating access to essential resources and markets. [5]

Boundaries of the complex are:

- **North**: The Mediterranean Sea, providing maritime access for raw material imports and product exports through the port of Annaba.
- **East**: The district of **Sidi Salem** and the **Oued Seybouse** river, supplying vital water resources for industrial processes.
- **West**: The **Seybouse district**, connecting the complex to the city's residential and industrial zones.
- **South**: **National Road No. 44** and the **Annaba agricultural plain**, facilitating road transportation and proximity to agricultural markets.

This strategic location ensures efficient supply chain operations, rapid access to Algerian and international customers, and the logistical capacity necessary for large-scale fertilizer production and distribution. Additionally, the proximity to natural gas pipelines and phosphate mines ensures a reliable supply of key raw materials. [6]

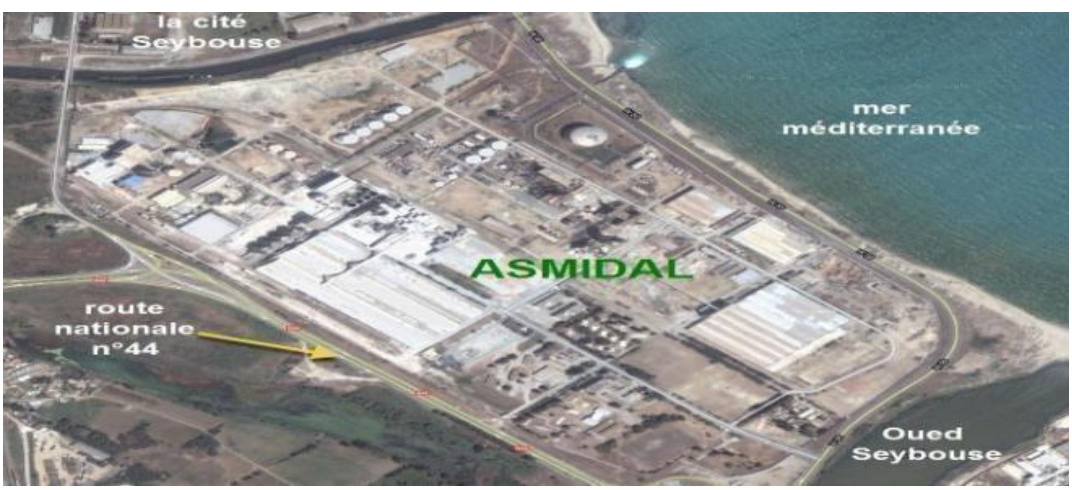


Figure I.1 : Geographical Location of the complex ASMIDAL-Annaba[25].

I.5 COMPANY ACTIVITY

The Asmidal Complex is a diversified industrial platform dedicated to the production of a wide range of chemical products, primarily focused on fertilizers essential to agriculture and food security. Covering an area of approximately 103 hectares, the Annaba plant alone employs around 500 highly qualified workers, including engineers, technicians, and administrative staff, supporting a fully integrated production process.

The company's activity is structured around two main production areas:

- **Phosphate-based Fertilizer Production Zone:** Dedicated to manufacturing phosphate fertilizers, particularly Simple Super Phosphate **(SSP)** and complex **NPK fertilizers**, by chemically treating phosphate rock with sulfuric acid and other ingredients.
- **Nitrogen-based Fertilizer Production Zone :** Focused on the production of key nitrogenous fertilizers such as Ammonia (NH_3)**,** Nitric Acid (HNO_3)**,** Ammonium Nitrate (NH_4NO_3)**,** Calcium Ammonium Nitrate (CAN)**,** and Urea Ammonium Nitrate (UAN)**.**

In addition to fertilizers, Asmidal also produces and markets a range of industrial chemicals utilized in various sectors, such as the explosives industry, metallurgy, and water treatment.

Asmidal's production units are designed to operate continuously, ensuring a steady and reliable supply of high-quality products for both the national and international markets. Production processes adhere to strict environmental standards, incorporating dust collection systems, effluent treatment facilities, and modern energy-efficient technologies.

Through its activities, Asmidal contributes significantly to Algeria's agricultural productivity, rural development, and industrial diversification, while also playing a key role in export markets. [7,8]

I.5.1 Company Objectives

Aligned with Algeria's broader economic and social development strategies, Asmidal's primary mission is to **promote and expand the fertilizer industry** as a pillar of national food security and industrial progress. The company's objectives are multifaceted and focus on sustainability, innovation, and market responsiveness.

<u>Key objectives include</u>:

- **Promotion of Agricultural Productivity:** By ensuring a continuous supply of high-quality fertilizers, Asmidal supports national efforts to increase crop yields, improve soil health, and reduce Algeria's dependence on imported foodstuffs. [10]

- **Optimization of Resources:** Efficient management of human, material, and financial resources is a central goal. This involves training personnel, modernizing facilities, and maximizing the productivity and lifespan of equipment.
- **Encouragement of Innovation and Initiative:** Asmidal fosters a corporate culture that values creativity, technological innovation, and the proactive engagement of its workforce. Research and development efforts aimto introduce new fertilizer formulations, improve process efficiency, and minimize environmental impact.
- **Diversification and International Cooperation:** To strengthen its resilience and expand its markets, Asmidal actively seeks to diversify its partnerships at the national and international levels, ensuring continuous investment and technological transfer.
- **Commitment to Sustainability:** Through investments in cleaner technologies, dust recovery systems, and sustainable production methods, Asmidal strives to align its operations with the principles of environmental responsibility.

These objectives formthe foundation of Asmidal’s strategy, ensuring its position as a competitive and responsible industrial leader in the region. [9]

I.5.2 Company Production

The Asmidal Complex boasts a significant production capacity, covering a wide array of fertilizer types to meet both domestic agricultural demands and export market requirements. The following table summarizes the principal manufactured products and their corresponding production capacities:

Table I.1: The Principal manufactured products [25].

Product	Annual Capacity (tons/year)	Daily Capacity (tons/day)
Phosphate Fertilizer (NPK)	550,000	1,000
Simple Super Phosphate (SSP)	42,000	1,200
Ammonia (NH_3)	330,000	1,000
Nitric Acid (HNO_3)	264,000	800
Ammonium Nitrate (NH_4NO_3)	330,000	1,000

This robust production capacity enables Asmidal to secure a dominant position in the Algerian market and maintain a strong presence internationally.

Export destinations for Asmidal's products are diversified, reflecting its competitiveness on the global stage. For instance:

- **Ammonia (NH_3)** is exported mainly to Spain, France, Italy, Greece, Belgium, and Cuba.
- **Nitrate products** are shipped to Tunisia and Morocco.
- **UAN (Urea Ammonium Nitrate)** solutions find markets in France, Spain, and the USA.
- **Simple Super Phosphate (SSP)** is exported to Morocco, Greece, France, Italy, and Brazil.

These export activities not only contribute to Algeria’s foreign exchange earnings but also reinforce Asmidal’s reputation as a reliable supplier in the global fertilizer industry. [1, 11]

I.5.3 Company Organization Chart

The internal organization of the Asmidal Complex is designed to ensure operational efficiency, safety, and continuous production. The company’s structure is hierarchical yet integrated, enabling clear communication and swift decision-making. The organizational structure includes:

- **Plant Manager:** Responsible for overall management, operational oversight, and strategic planning of the facility.
- **Production Department:** Oversees the operation of ammonia, nitric acid, phosphate fertilizer, and other production units, ensuring production targets and quality standards are met.
- **Maintenance Department:** In charge of preventive and corrective maintenance operations across mechanical, electrical, and instrumentation domains.
- **Utilities Department:** Manages the supply of vital utilities such as steam, water, compressed air, and energy needed for production processes.
- **Safety and Emergency Management:** Dedicated teams ensure compliance with industrial safety regulations and manage emergency response protocols.
- **Quality Control and Laboratory Services:** Responsible for monitoring product quality, conducting tests, and ensuring adherence to technical specifications.
- **Supply Chain and Logistics Department:** Coordinates raw material procurement, product storage, and delivery operations, including handling export logistics.
- **Security and Surveillance Department:** Ensures the protection of personnel, assets, and information within the complex.

- **Administrative and Support Services:** Includes human resources, finance, procurement, and information technology units.

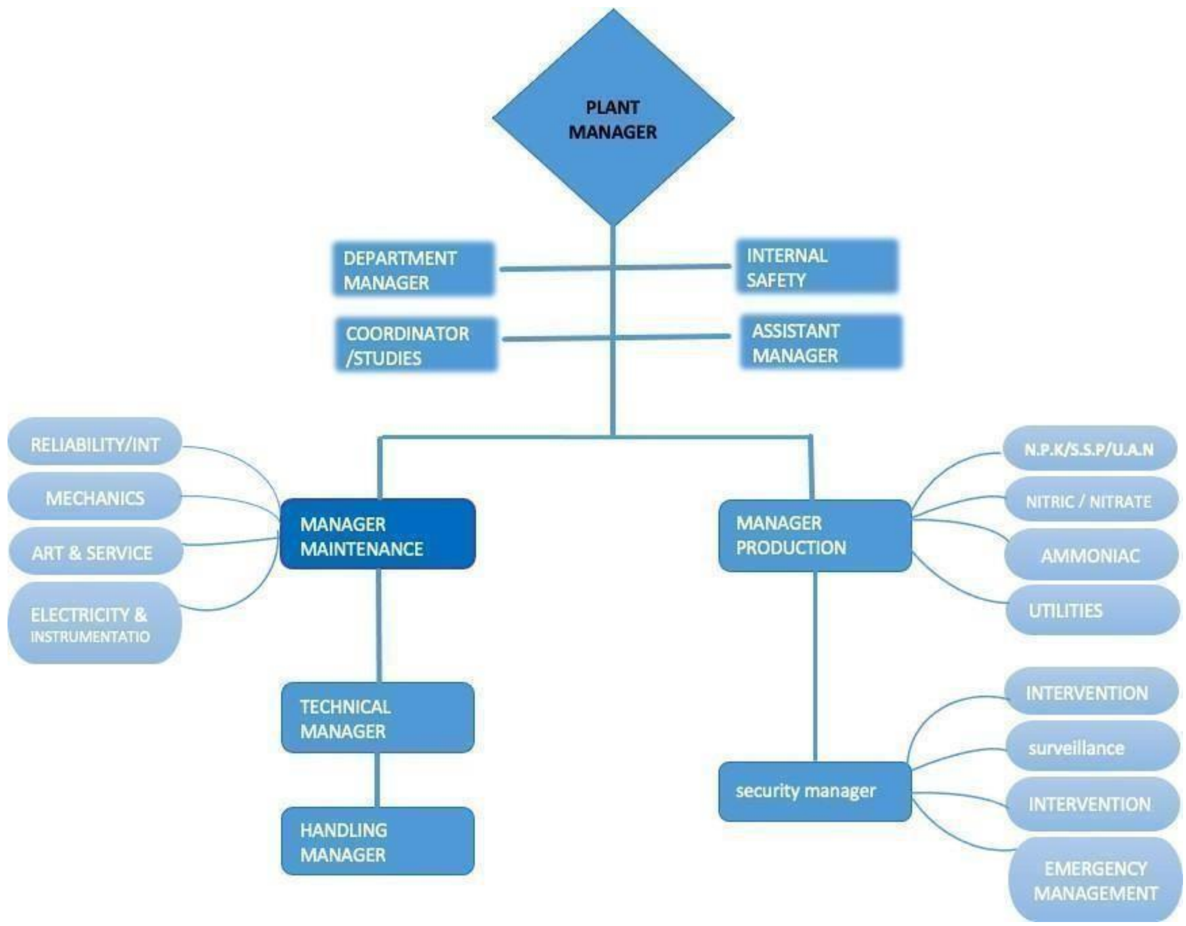


Figure I.2 : Organizational Structure Diagram.

This structured organization enables Asmidal to operate in a highly efficient, safe, and responsive manner, sustaining its competitive edge in the fertilizer and chemical industries.

I.6 RESEARCH AND DEVELOPMENT EFFORTS

The Asmidal Complex places a growing emphasis on **research and development (R&D)** to maintain its competitiveness in an evolving global market. Innovation initiatives focus on:

- **Development of New Fertilizer Formulations:** Research centers work on producing specialized fertilizers adapted to different soil types and climatic conditions, particularly to support sustainable agriculture in arid and semi- arid regions.
- **Process Optimization:** R&D projects aim to improve chemical process efficiencies, minimize raw material consumption, and reduce energy usage across production lines.

- **Environmental Protection Technologies:** Investments are directed towards developing technologies for dust recovery, effluent treatment, and emissions reduction, contributing to Asmidal's environmental stewardship.

Through collaboration with universities, research institutes, and international partners, Asmidal strengthens its technological base and enhances its capacity for industrial innovation.

I.7 IMPORTANCE OF DUST RECOVERY IN THE ASMIDAL INDUSTRIAL ENVIRONMENT

The Asmidal Complex, through its extensive production of fertilizers and industrial chemicals, generates significant quantities of particulate matter during various manufacturing processes. These particulates, if not properly managed, can lead to several critical issues, including:

- **Air pollution** inside and outside production facilities.
- **Health risks** to employees due to inhalation of fine dust particles.
- **Product loss** as valuable materials can be carried away in the gas streams.
- **Regulatory non-compliance**, given strict environmental standards imposed by Algerian law and international frameworks.
- **Operational inefficiencies**, as dust can clog equipment and reduce system performance.

Sources of dust emission at ASMIDAL

Several key stages of fertilizer and chemical production at Asmidal are known to generate large volumes of dust-laden gases, including:

- **Phosphate fertilizer production** (e.g., Simple Super Phosphate (SSP), NPK granulation): Crushing, drying, and conveying operations create large amounts of fine phosphate dust.
- **Nitric acid and ammonium nitrate production:** Reaction and neutralization processes release dust-laden steam and air streams containing nitrogen-based residues.
- **Ammonia production units:** Though less dust-prone, indirect dust generation can occur during solid material handling.
- **Material handling and storage:** Transfer of raw materials such as phosphates, sulfur, and finished fertilizers leads to fugitive dust emissions.

Given the volume and diversity of dust sources, effective dust recovery systems are indispensable for maintaining a safe, sustainable, and efficient industrial environment at Asmidal.

I.8 CYCLONE SEPARATORS AS A SOLUTION FOR DUST RECOVERY AT ASMIDAL

Cyclone dust separators provide a robust, cost-effective, and low-maintenance solution to the dust emission challenges faced by Asmidal's fertilizer and chemical plants. Cyclone technology is particularly well-suited for Asmidal's processes because:

- It operates efficiently in environments with high particle loads typical of fertilizer production.
- It is capable of separating medium to large dust particles (typically greater than 5-10 microns) which are abundant in crushing, drying, and material handling processes.
- It requires no moving parts, making it ideal for industrial sites aiming to minimize maintenance costs and maximize equipment reliability.
- It can be integrated easily into existing exhaust and ventilation systems at Asmidal's production lines.

Specific applications within Asmidal include:

- Dust extraction from granulators and dryers in NPK fertilizer production.
- Emission control at phosphate rock crushing units.
- Dust removal from air streams exiting ammonium nitrate prilling towers.
- Air cleaning in bagging, storage, and transportation areas.

The implementation of cyclone dust collectors not only enhances **air quality** within production halls but also contributes to **environmental compliance** and **material recovery**, reducing waste and improving overall operational efficiency.

I.9 STRATEGIC IMPORTANCE OF DUST RECOVERY FOR ASMIDAL

By integrating dust recovery technologies such as cyclones into its production systems, Asmidal achieves several strategic advantages:

- **Environmental compliance**: Meeting increasingly strict national and international air quality regulations.
- **Health and safety improvement**: Protecting workers from dust-related respiratory illnesses.
- **Operational efficiency**: Preventing dust accumulation that could damage sensitive equipment or reduce process efficiency.
- **Economic gain**: Recovering valuable raw materials (phosphate particles, fertilizer dust)

that would otherwise be lost, translating into material savings.

- **Corporate image enhancement**: Strengthening Asmidal’s reputation as a responsible and modern industrial actor.

Thus, cyclone dust separators are not simply optional equipment; they are **integral elements** of Asmidal’s broader strategy for sustainable, efficient, and compliant fertilizer production**.**

I.10 CONCLUSION

The Asmidal Complex, through its historical evolution, diversified activities, and strategic organizational structure, has emerged as a **key player** in Algeria's industrial landscape.
Originally founded to meet the country's growing demand for agricultural inputs, Asmidal has progressively expanded its scope to become a fully integrated chemical and fertilizer producer, capable of competing on both national and international markets.

Its structure, composed of specialized subsidiaries like FERTIAL, KIMIAL, SOMIAS, and ASFERTRADE, enables it to control the entire value chain — from production to distribution — while maintaining high standards of quality, innovation, and environmental responsibility. The strategic geographic location of its facilities, combined with robust production capacities and a well-organized industrial ecosystem, positions Asmidal as a cornerstone of Algeria’s economic diversification efforts.

Furthermore, the group's focus on research and sustainable development highlights its proactive approach to the challenges of globalization, environmental preservation, and technological advancement.

Thus, the Asmidal Complex not onlyembodies the industrial ambitions of Algeria but also stands as a model of resilience, adaptability, and strategic vision in the face of changing economic and environmental realities.
This strong foundation paves the way for the following chapters, where we will explore specific technological processes — notably the cyclone dust recovery system — that reflect Asmidal's ongoing commitment to operational excellence and sustainable industrial practices.

CHAPTER II:

THEORETICAL AND TECHNICAL BACKGROUND OF THE AUTOMATED CYCLONE DUST COLLECTION SYSTEM

II.1 INTRODUCTION

The control of airborne particles in industrial environments is a crucial factor in ensuring both equipment reliability and operator safety. Chapter 2 introduces one of the most widely used technologies in dust separation: the cyclone dust separator. Known for their simplicity, durability, and efficiency in separating relatively large dust particles from an air stream, cyclone separators are an essential component in many industries including cement, pharmaceuticals, chemicals, agriculture, and metal processing.

This chapter explores the fundamental working principles of cyclone separators, which rely on the centrifugal force generated by a spiral flow within a conical chamber. As dust-laden air enters the chamber tangentially, the vortex formed causes larger and denser particles to be flung outward and down into a collection chamber, while cleaner air exits from the top. Although efficient for larger particles, cyclones are less effective at capturing smaller particulates, which must be considered in system design.

In addition to basic operation, the chapter examines performance characteristics, such as separation efficiency, pressure drop, and flow rate, as well as the influence of design parameters like inlet velocity, cyclone diameter, and cone angle. These factors significantly impact the performance and energy consumption of the system.

Understanding these principles is vital for engineers and designers aiming to create effective dust control systems. This chapter serves as the theoretical foundation for further integration of cyclone systems with automated controls discussed in subsequent sections.

II.2 CYCLONE SEPARATORS —THEORY OF OPERATION

Relative to powder system operations, a cyclone separator is a device used to separate powder particles from an incoming air stream within a conical cylinder, using the principle of centrifugal acceleration. (See Figure 1) The air stream is injected at high velocities into the inlet pipe, which is positioned tangentially to the body of the cyclone. The shape of the cone induces the high velocity air stream to spin, thus creating a vortex within the conical cylinder. The larger particles within the air stream are forced outward toward the wall of the cyclone, where the drag of the spinning air and ensuing gravitational forces cause them to fall down the sides of the cyclone into an outlet at the base of the cyclone. Simultaneously, the smaller, lighter particles are captured within the center of the spiral-like air stream and are drawn out or discharged through an outlet at the top of the cyclone [26].

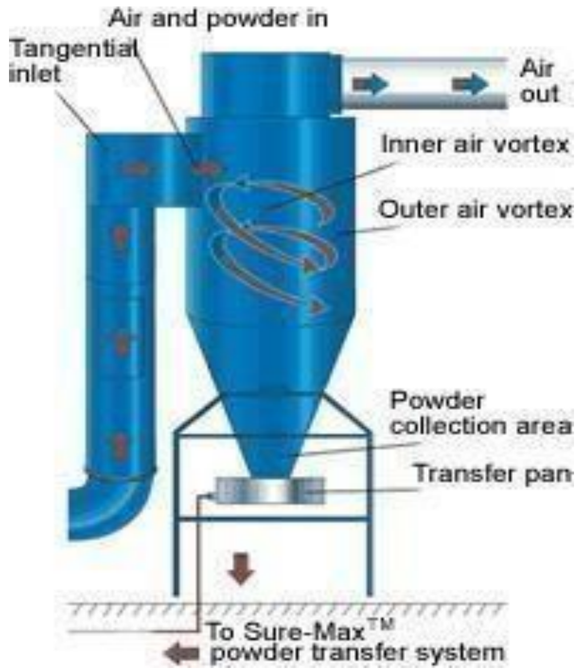


Figure II.1: Conventional Cyclone Separator Theoryof Operation [26].

II.3 CYCLONES: SIMPLE YET POWERFUL DUST SEPARATORS

II.3.1 Operating principle

Cyclones operate on a relatively simple, single-stage mechanism. When a gas stream enters the cyclone tangentially, it is forced into a spiral motion [27]. This rotational movement generates centrifugal forces that expel dust particles towards the outer walls of the cyclone. When these particles collide with the walls, they lose their momentum and fall into a collection chamber, while the cleaned gas is discharged from the top. This efficient design enables cyclones to efficiently handle large volumes of dust-laden air with minimal maintenance requirements.

II.3.2 Efficiency

Despite their efficient design, cyclones are mainly suitable for separating larger particles, generally those larger than 10 microns. Their efficiency decreases considerably with finer particles, particularly those measuring less than 5 microns. Byexploiting the centrifugal forces generated bytheir design, cyclones are ideal for operations where dust particles are larger and less demanding in terms of filtration.

II.3.3 Factors affecting performance

Cyclone performance depends on several key factors:

- **Particle size:** Larger particles experience stronger centrifugal forces, making them easier to separate fromthe gas stream, while smaller particles tend to require more sophisticated methods for effective capture.
- **Inlet velocity:** The speed at which gas enters the cyclone can influence separation efficiency. Higher inlet velocities generally improve the separation process, but also contribute to higher pressure drop and energy consumption.
- **Design features:** Dimensions such as cyclone diameter and height have a direct impact on cyclone performance. Smaller diameters can improve particle capture efficiency, but can increase energy costs if not properly managed.

II.4 POWDER COATING AND DUST COLLECTION PROCESS

Most of the manufacturing industry faces significant challenges in the control of dust to ensure the continued sustainable operation and to meet emissions regulations and goals. The methods for controlling dust emissions can either lie in the prevention of dust emissions or in the removal of dust once it has become airborne.

Though the concept for the dust collection system seems simple, many things can go wrong if don’t pay careful attention to the design details. Dust control systems involve multiple engineering decisions, including the efficient use of available space, the length of duct runs, the ease of returning collected dust to the process, the necessary electrical requirements, and the selection of optimal filter and control equipment.

Further, key decisions must be made about whether a centralized or multiple system are best for the circumstances. Critical engineering decisions involve defining the problem, selecting the best equipment for each job and designing the best dust collection system for the needs of an operation. Well-designed dust collection systems need to consider not onlythe dust as a potential contaminant but also the attributes of the dust capturing system.

There are four key components in a dust collection system is very important like exhaust hood, ductwork, dust collector and the air mover/fan. This project helps to understand as a design guide which provides information that will help to achieve optimum performance and energy efficiency in commercial dust collection systems byproperly selecting and sizing of exhaust hoods, duct, dust collector and air blower or fan. A well-designed dust collection system has multiple benefits resulting in a dust-free environment that increases productivity, complywith emission regulations, and improve industry employee morale.

This paper also illustrates design analysis and the best selection of a dust collection system for various kinds of manufacturing industries who are facing dust emission and unable to control as well as can also help to control odor, moisture, and other undesirable environmental conditions. [28]

This diagram shows the 7 main components used in the powder coating and dust collection process. These parts work together to help move the material, reduce dust in the system, and recover some of the powder that can be reused .

Figure II.2: Main Components of a Powder Coating and Dust Collection System [29].

Process Description

- **Raw material preparation:** Prepare dry, impurity-free resins, pigments, fillers and additives according to the formula [29].
- **Premixing:** Before hot melting, use a mixer to premix the raw materials to ensure that the additives and pigments are evenly distributed.
- **Melt extrusion:** Melting base material/curing agent, mixing additives, wetting pigments, and completing through an extruder.
- **Fine grinding:** Use a grinder to grind the molten material to a specified particle size.

- **Dust collection and collection:** Use side filters or cyclone separators to collect fine powders. The device selection depends on the output and coating type.
- **Screening and packaging:** Use mechanical vibration screening or airflow screening to remove unqualified particles. Choose bagging, barreling or automatic packaging according to needs.
- **Powder recovery (optional):** Use a multi-cyclone systemto recover powder during the spraying process and classify it for use.

II.5 INPUT/OUTPUT COMPEMNTS

II.5.1 TOR sensors

II.5.1.1 Technology selection method

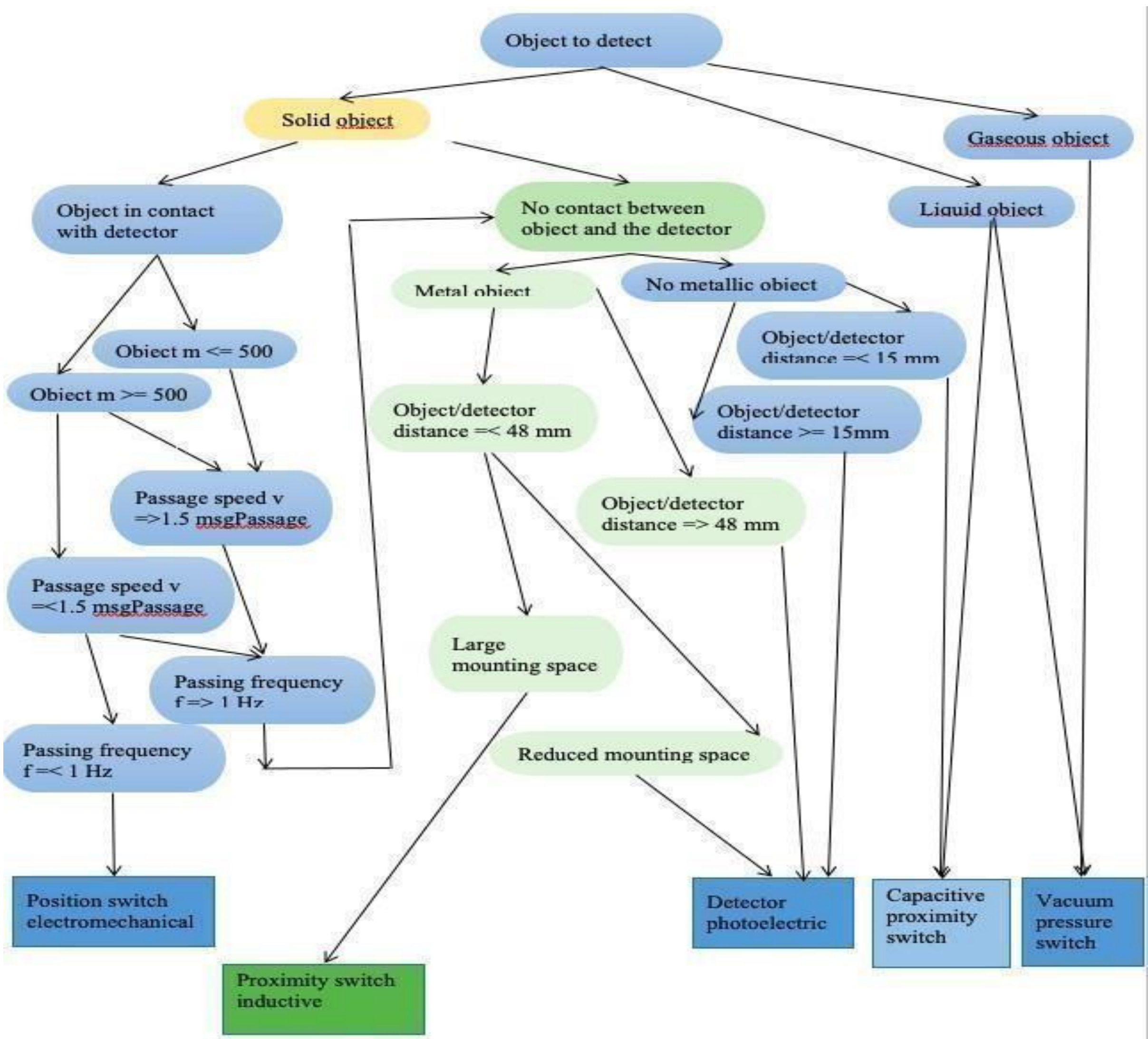
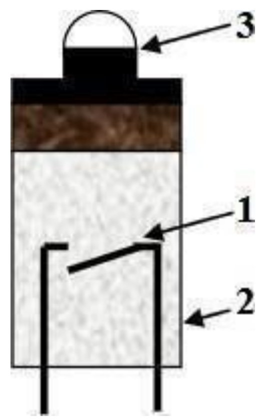


Figure II.3: Method for selecting appropriate technomogie [30].

II.5.1.2 Mechanical position switches

Operating Principle:

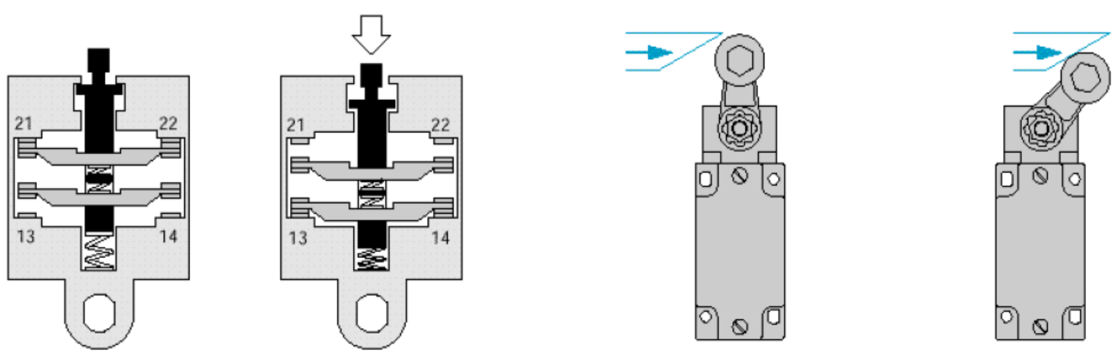
Position switches are made up of three basic components.



1. An electrical contact
2. A body
3. A control head with driver

Figure II.4: Basic compements of a mechanical position switch [30].

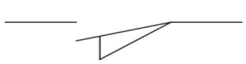
Presence detection takes place when the object to be detected comes into contact with the control head at its actuator. The movement generated on the drive head causes the electrical contact in the sensor body to close.



Mouvement rectiligne   Mouvement angulaire

Figure II.5 : Movement type [30].

General Specifications :

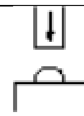
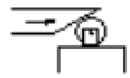
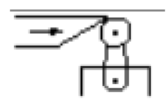
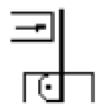
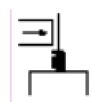
Symbol: 

Nominal range: Direct contact.

Supply voltage: 240 V AC; 250 V DC max.

Selection criteria:

Table II.1 : Recommended limit switch actuator types based on application characteristics

Application features	**recommended cammande head and attack device**
Presence of object in mechanical stop	 Rectilinear with push-button
30° cam Precise guidance <1 mm linear path	 Rectilinear with roller lever or roller tappet
30° cam Imprecise guidance ~5 mm	 Angular roller lever
Target with flat or cylindrical face linear or angular trajectory imprecise guidance ~10mm	 Angular rod
Target of anyshape multidirectional trajectory guidance >10mm	 Multi-directional

Applications:

They can be used on many systems to detect rigid materials. to detect presence or passage.

- **Stop:** end of stroke, presence of part on machining support.
- **Cam:** passage of a cylinder or carriage on a rail. Multidirectional: joystick.

II.5.1.3 Reed switches (ILS)

A reed switch consists of a body(2) inside which is placed a flexible metal electrical contact (1) sensitive to magnetic fields.

When a magnetic field (4) is directed onto the sensor's sensitive face (3), contact is established between the sensor's two terminals.

This type of sensor is often mounted directlyon cylinder bodies as a limit switch (in this type of installation, the cylinder piston is magnetized).

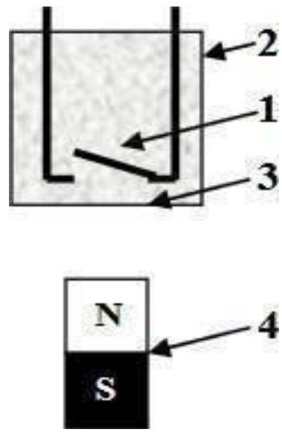
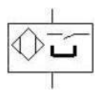


Figure II.6: Structure and operation of a reed switch (ILS) [30].

General specifications:

- **Symbol:** 
- **Nominal range:** Depends on the amplitude of the magnetic field of the object to be detected.
- **Supply voltage:** 10 to 30 VDC .

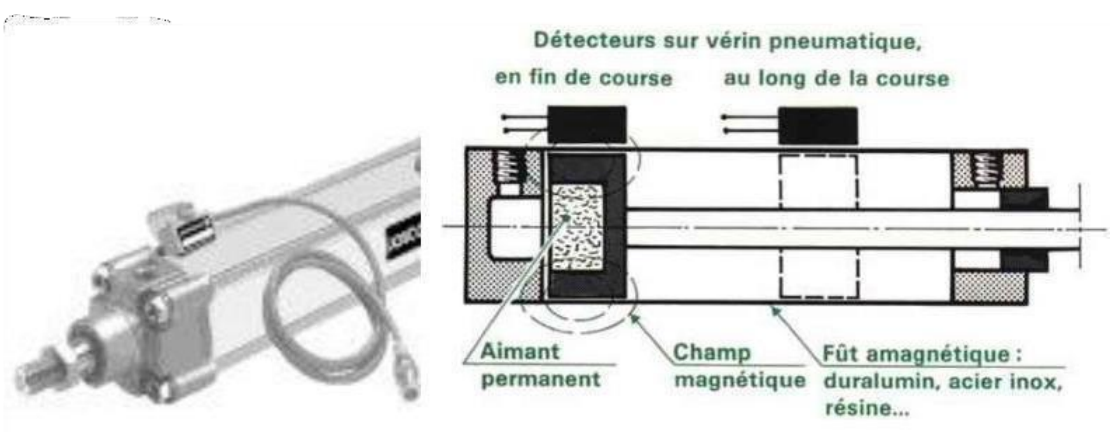


Figure II.7: Integration of magnetic sensors on pneumatic actuators [30].

II.5.1.4 Inductive proximity switches

Operating principle:

- An inductive proximity switch detects all objects made of conductive materials without contact.
- From its active face (3), the inductive proximityswitch generates alternating

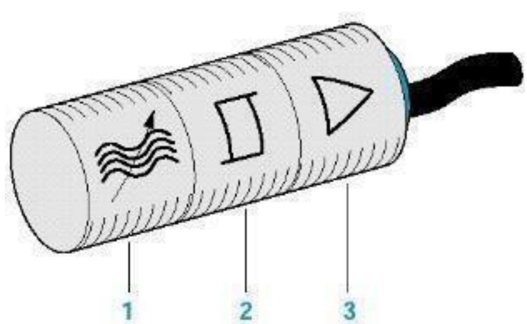
electromagnetic fields.

- Approaching a conductive material (6) causes these magnetic fields to change magnetic fields, and the sensor delivers a signal.

1. Cable.
2. Threaded body.
3. Active face.
4. LED display.
5. Fastening nuts.
6. Conductive object to be detected.

Figure II.8 : External Components of an inductive proximity switch [30].

<u>Composition of the inductive proximity switch :</u> An inductive sensor detects only metal objects. It consists essentially of an oscillator whose windings formthe sensitive face. An alternating magnetic field is created in front ofthis face.



1. Oscillator.
2. Shaping stage.
3. Output stage.

Figure II.9: Internal of an inductive proximity sensor [30].

<u>Metal object detection:</u> When a metal screen is placed in the detector's magnetic field, induced currents cause the oscillations to stop. After shaping, an output signal corresponding to an electrical contact is generated.

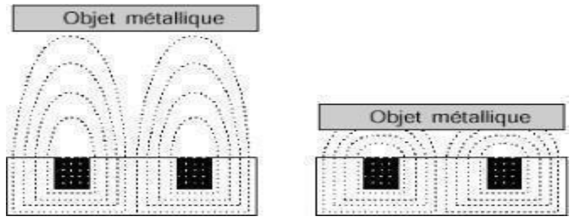
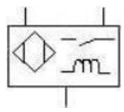
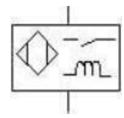


Figure II.10: Principe of metal object detection [30].

General specifications:

- **Symbol:**  3-wire or 2-wire 
- **Nominal range:** From a few mm to 40 mm for the most efficient (2 to 5 mm for the most common).
- **Supply voltage:** 20 to 264 VAC; 10 to 30 VDC .
- **Nominal range (Sn):** Range used to designate the device, which does not take into account dispersions (manufacturing, temperature, voltage).
- **Actual range (Sr):** Actualrange is measured at supply voltage (Un) and ambient temperature (Tn). The actual range is between 90% and 110% of the nominal range (Sn).

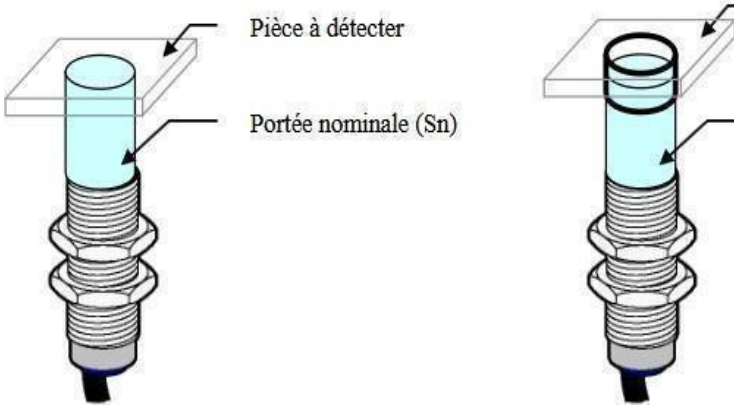


Figure II.11: Comparison between nominal range and actual range [30].

Selection criteria:

- No physical contact with the object (no wear), possibilityof detecting the presence of freshly painted objects or fragile surfaces.
- Highoperating speeds, perfectly matched to electronic modules or automation systems

- High attack speeds for short-term information processing.
- Fullyresin-coated products, for excellent resistance to aggressive industrial environments.
- Static products (no moving parts) for a lifetime independent of the number of operating cycles.
- Output status display.

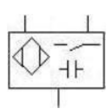
Areas and types of use: These sensors are found in the machine-tool, robotics, fine chemicals and food industries, as well as in machining, handling, assembly and conveying applications...

Applications: This type of sensor can be used to detect room presence and proximity. There is therefore a notion of distance. These sensors are veryreliable and are often used to count or detect metal objects. The drawback is their short range.

II.5.1.5 Capacitive proximity switches Operating principle

– A capacitive proximityswitch detects, without contact, all objects made of conductive or insulating materials with a permitivity >1.
– A capacitive proximityswitch consists mainly of an oscillator, with capacitors on the sensitive side.

General characteristics:

Symbol: 

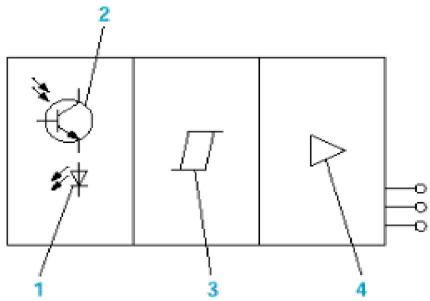
Nominal sensing range: 2; 5; 10; 15 or 20 mm.
Supply voltage: 20 to 264 VAC; 10 to 30 VDC .

Applications: Same detection capability as an inductive sensor, but with greater range. It also detects non- metallic objects: Detection of water level, cardboard presence....

II.5.1.6 Photoelectric sensors

A photoelectric detector essentially consists of a light emitter (light-emitting diode) associated with a receiver sensitive to received light (phototransistor).

A light-emitting diode emits light when an electric current is passed through it. Detection occurs when the target enters the light beam emitted bythe detector and modifies the light received by the receiver to cause a change of state of the output.



1. Light emitter
2. Light receiver
3. Shaping stage
4. Output stage

Figure II.12 : Block diagram and operating princioale of a photoelectric sens [30]

II.5.2 Manual timer blocks (general)

II.5.2.1 Timer contacts

Timed contacts have the propertyof opening or closing after the contactor has been switched on or off. There are two types of timer **[31]**:

- **ON** delay(on action), generally blue in color
- **OFF** delay(on release), generally black in color.

For each type of time delay, contacts can be normallyopen (NO), or normally closed (NC).

II.5.2.2 Symbolization

The timer function is indicated bya semicircle connected bytwo lines to the timed contact.

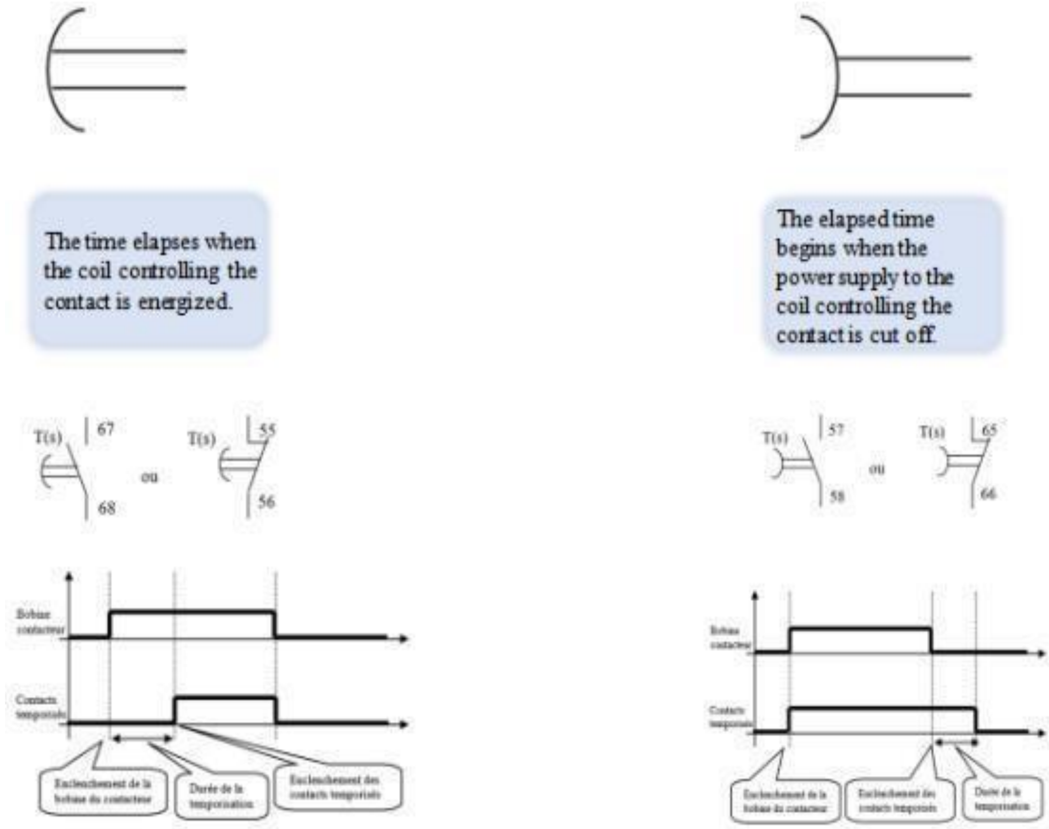


Figure II.13: Timing diagrams of delay on and delay off relay contacts [31].

II.5.2.3 Timers SIEMENS S7

<u>Tempo: T from 0 to 255</u>

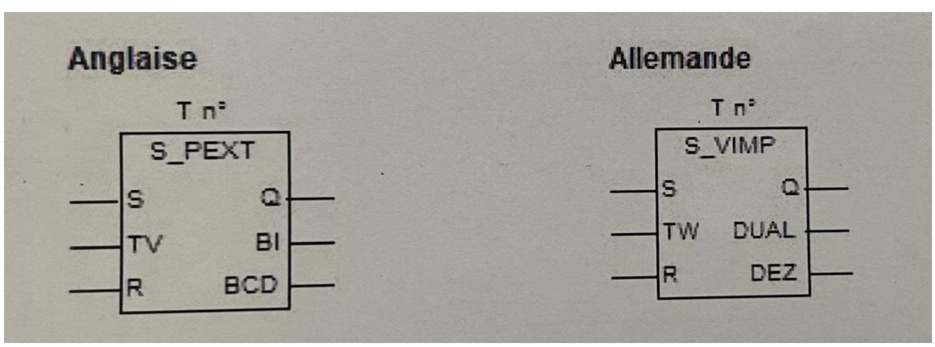


Figure II.14: Timer simens S-VIMP **[32].**

Table II.2: Timer parameters and data types in STEP 7 programming.

English parameter	allmande parameter	data types	memory area	description
T n °	**T n °**	**TIMER**	**T**	timer identification number. range depends on CPU
S	**S**	**BOOL**	**E,A,M,L,D**	start-up input
TV	**TW**	**S5TIME**	**E,A,M,L,D**	preset time value
R	**R**	**BOOL**	**E,A,M,L,D**	reset entryto ZERO
BI	**DUAL**	**WORD**	**E,A,M,L,D**	remaining time value (binary format)
BCD	**DEZ**	**WORD**	**E,A,M,L,D**	remaining time value (DCB format)
Q	**Q**	**BOOL**	**E,A,M,L,D**	status of temporesation

Description of operation [logiciel step7]

S_VIMP (set and start timer as long pulse)

This operation starts the specified timer on a rising edge at start input S . a change in signal state is always required to activate a timer . the time value indicated at input TW continues to run even if the signal state at input S changes to 0 before the time expires . As long as the timer is running, the signal state at output Q equals 1 . the timer is restarted with the preset time value if the signal state at input S changes from 0 to 1 while the timer is running.

If the reset input R changes from 0 to 1 while the timer is running, it is reset to zero. The current time value and the time base are then also set to 0.

The current time value can be read in binary format at the DUAL output and in binary coded decimal format at the DEZ output. The current time value corresponds to the initial value in TW minus the time value that has elapsed since the timer started.

Chronogram

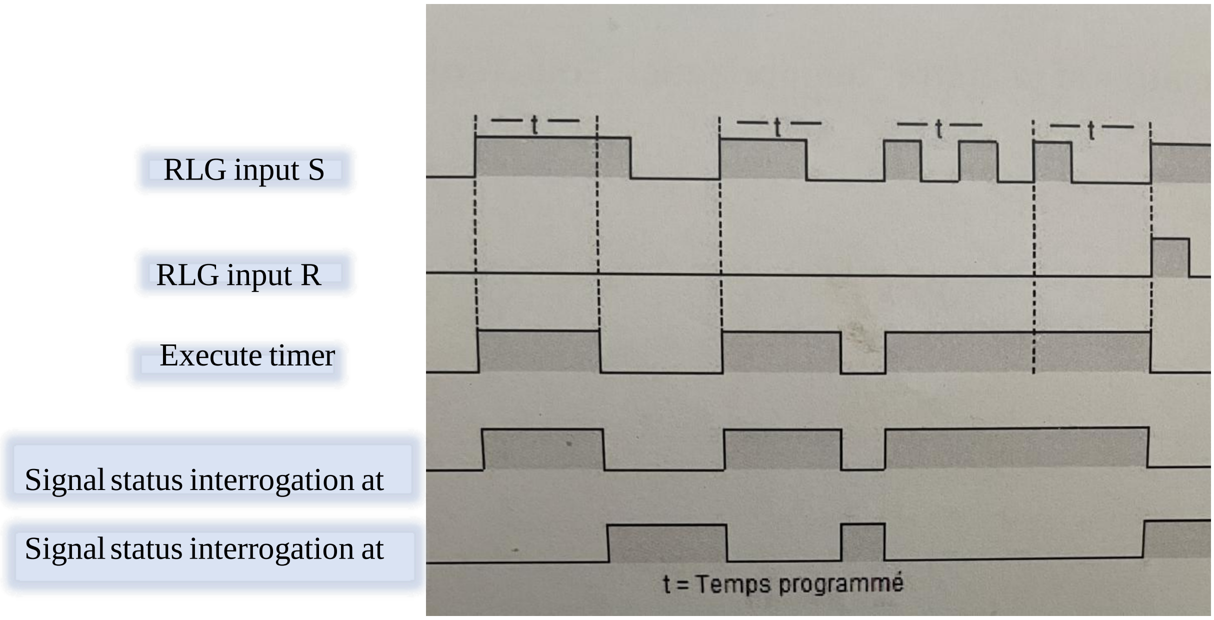


Figure II.15: Chronogram of Timer Operation in PLC.

II.5.3 Actuators

An actuator is a component used to set machine parts in motion in response to electrical commands. This is achieved by converting an input energy (electrical, hydraulic or pneumatic...) into an output energy (mechanical). The most commonly used actuators are : [33]

II.5.3.1 Pneumatic actuators

Pneumatic actuators use compressed air at ~6 bar. The air is supplied by a compressor, which often supplies the entire workshop, and distributed to all machines. They are supplied by distributors, following an electrical command. They are mainly used for low-force movements (20 to 50,000 N).

Widespread pneumatic actuators include cylinders (linear and rotary) and rotary motors. Vacuum suction cups are also used to grip objects (these are gripping elements using a vacuum generator with venturi effect).

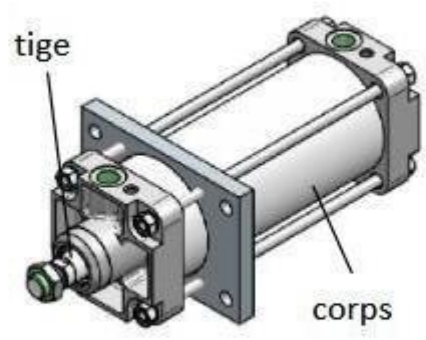


Figure II.16 : Pneumatic Actuators : function components and application [33].

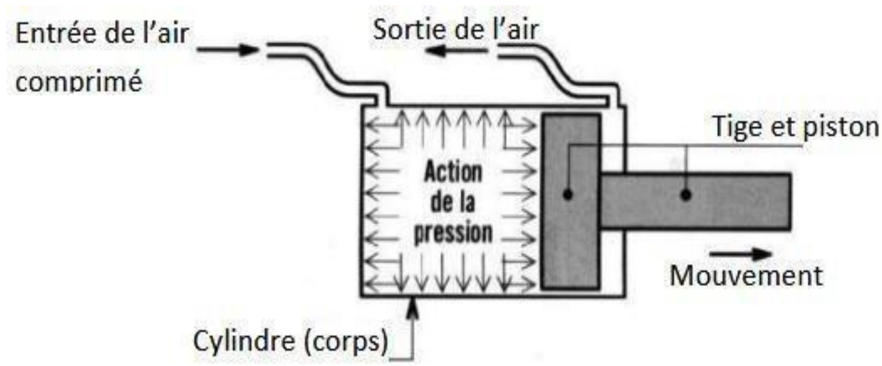


Figure II.17 : Operating principle of a single-acting pneumatic cylinder [33].

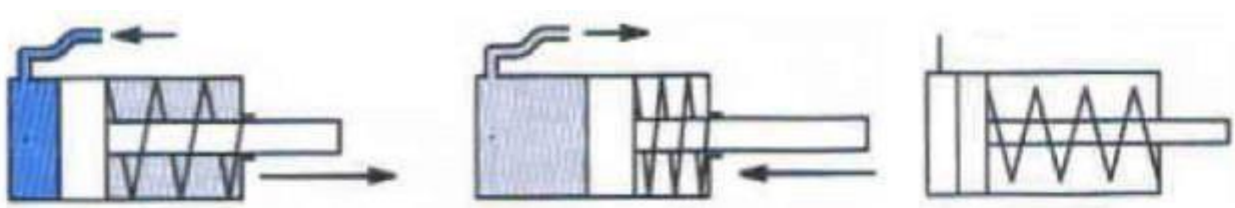


Figure II.18 : Single-acting cylinder [33].

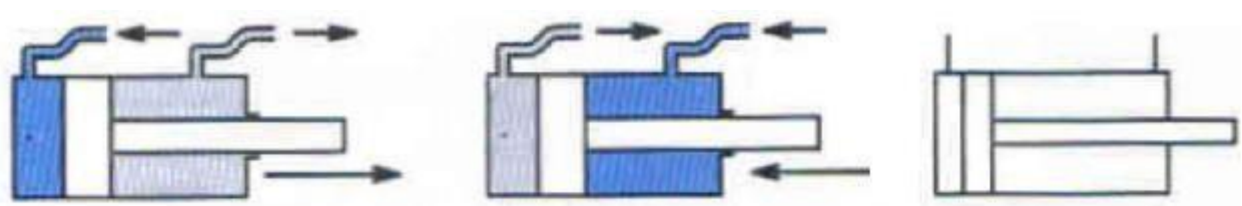


Figure II.19 ***:*** Fig: Double-acting cylinder [33].

This photo was taken during an industrial visit, where this type of actuator is used to operate a dust cleaning system using compressed air. The choice of this actuator was based on its reliability, ease of control, and its ability to produce linear motion in both directions.

Figure II.20 : Cylinder double effet.

During field testing, it was observed that when the air pressure dropped to 5 bar, the double-acting cylinder failed to operate. This suggests that the minimum required operating pressure for proper cylinder function is higher than 5 bar. Maintaining a stable pressure above this threshold is essential to ensure reliable actuation in the dust recovery system.

Figure II.21: Pressure Sensor (Transmitter).

II.5.4 Pre-actuators

Pre-actuators act as energy interfaces between the control and operating parts. The Control Unit is generally incapable of directly distributing the energy required by the actuator.[33]

II.5.4.1 Distributors (pneumatic pre-actuators)

A directional control valve consists of a fixed part and a moving part (the spool):

- The fixed part is fitted with ports connected to the energy source (compressed air, etc.), the actuator and the exhaust.
- The movable spool, sliding in the fixed part, is fitted with pipes allowing fluid to pass between the various ports and the fixed part.

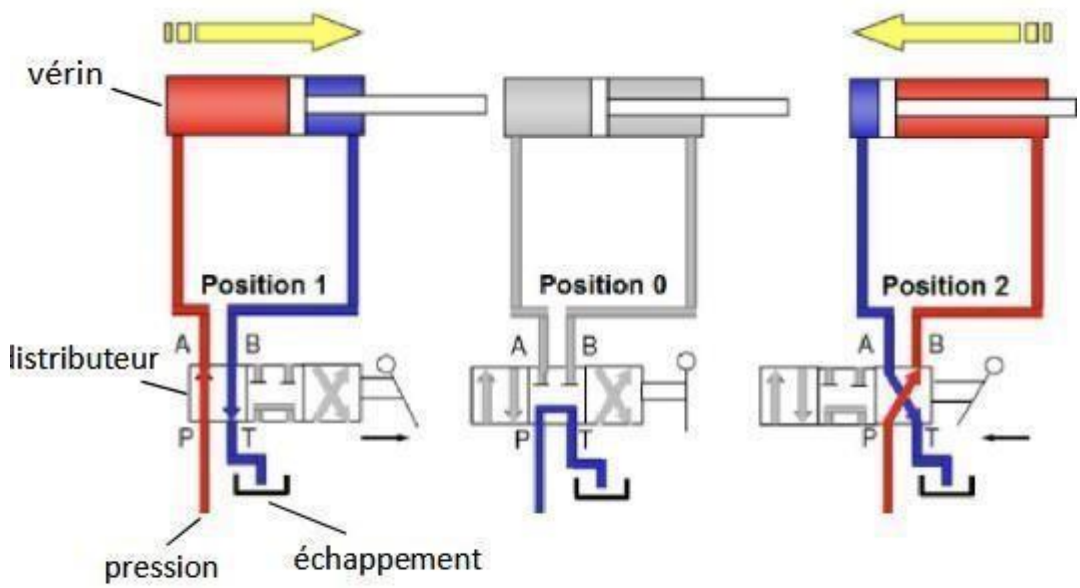


Figure II.22: Distributor operating principle [33]

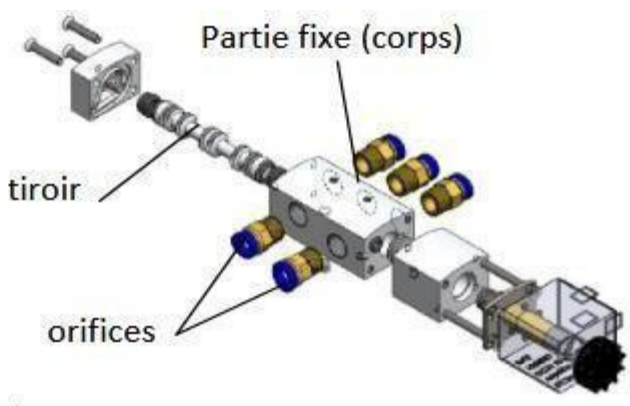


Figure II.23 : Distributor components [33].

The pneumatic distributor shown in **Figure II.23** is another essential component used in the dust recovery system I studied.

It was observed during an industrial site visit and is responsible for directing the flow of compressed air to the appropriate side of the double-acting cylinder. This enables the actuator to move back and forth efficiently. The use of such a distributor ensures precise control of the pneumatic system and contributes to the overall automation of the cleaning process.

Figure II.24 : Distributor

Among the pre-actuator components used in this system, the filter-regulator unit plays a crucial role. It is responsible for cleaning the compressed air and regulating its pressure before it reaches the distributor and actuator. This ensures reliable operation and protects pneumatic components from damage caused by impurities or pressure fluctuations.

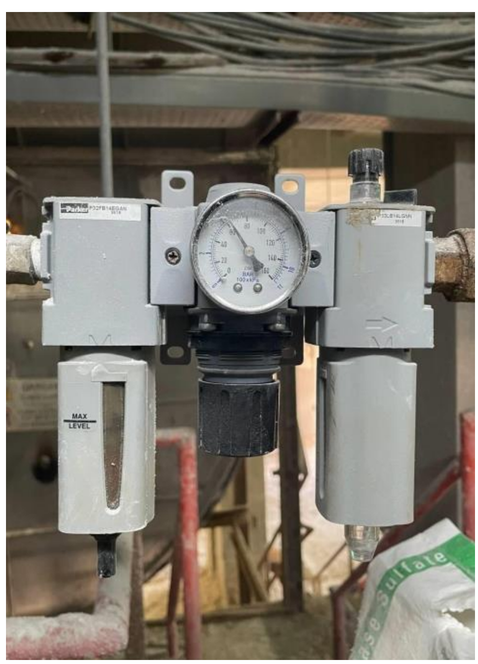


Figure II.25 : Real filter-regulator unit observed in the industrial site.

This photo was taken during the field visit and shows the actual air preparation unit used in the system.

II.6 CONCLUSION

In conclusion, cyclone dust separators remain a fundamental element in industrial dust control due to their cost-effectiveness, mechanical simplicity, and ability to handle high dust loads without clogging. Their operating principle, based on centrifugal force, makes themparticularly effective in removing large particles from gas streams with minimal energy input.

However, their limitations in capturing fine particles necessitate a careful evaluation of application context, especially when regulatory standards require stringent particulate removal. Factors such as cyclone dimensions, inlet velocity, pressure drop, and particle size distribution must be optimized to ensure satisfactoryperformance. In some cases, cyclone separators are used in tandem with secondary filtration systems, such as baghouses or electrostatic precipitators, to achieve higher overall efficiency.

Moreover, while the mechanical design of cyclones is straightforward, their operation can benefit greatly from enhanced monitoring and control. Variations in flow rate, particle load, and system wear over time can reduce effectiveness if not properly managed. These challenges can be addressed through automation, which allows for real-time system diagnostics, automated maintenance alerts, and adaptive control of process parameters.

This chapter has laid the essential groundwork in understanding the mechanical and operational aspects of cyclone dust collection. The next logical step is to explore how automation can elevate the performance and reliability of such systems—topics that will be discussed in Chapter 3.

CHAPTER III :

S7-300 PLC 7 SOFTWARE

AND SUPERVISION

III.1 INTRODUCTION

As industrial processes become more complex and efficiency-driven, the need for automated control systems has become increasingly apparent. Chapter 3 presents the concept of industrial automation with a specific focus on its application in cyclone dust collection systems. Automation is not only about replacing manual operations with machines but also about improving the precision, responsiveness, and adaptability of the entire system.

At the heart of this automation strategy lies the Programmable Logic Controller (PLC), a digital computer used to automate electromechanical processes. PLCs can be programmed to control machinery, monitor sensors, and execute complex sequences of operations. In the context of dust collection, they are used to control fans, monitor pressure differentials, detect filter conditions, and adjust system parameters in real time.

The chapter explores various types of automation—from fixed and programmable to flexible and intelligent automation—and the benefits each offers. It also explains the architecture of automated systems, including the operative part (mechanical system), the control part (PLCs and programs), and the supervision part (human-machine interfaces and monitoring tools).

By integrating automation, industries can enhance system efficiency, reduce energy consumption, lower operational costs, and ensure compliance with increasingly strict environmental standards. The implementation of PLCs in dust collection processes not only automates routine tasks but also enables predictive maintenance and system diagnostics.

This chapter sets the stage for understanding how automation transforms traditional systems into intelligent, high-performance solutions tailored for modern industrial challenges.

III.2 AUTOMATION

Automation consists of making operations automatic that previously required human intervention. In the industry, automation has become indispensable as it allows for the daily execution of the most tedious, repetitive, and dangerous tasks. Sometimes, these automated processes are so rapid and precise that theyaccomplish actions impossible for a human being. Automation, therefore, is synonymous with productivity and safety.

Automation consists of the study of industrial systems control. Automation techniques and methods are continuously evolving, incorporating technologies such as electromechanics, electronics, pneumatics, and hydraulics. Automation is present in all sectors of activity, including carpentry, textiles, food, automobile, and more [34].

III.2.1 Intelligent automation

Intelligent automation is a more advanced form of automation that combines artificial intelligence (AI), business process management, and robotic process automation capabilities to streamline and scale decision-making across organizations [35].

III.2.2 The advantages of automation

In complex environments like Command and Control (C2) where human errors may have tragic consequences, intelligent automated systems are essential. With the increasing number of information to be processed, the human information processing capability becomes rapidly overloaded. In addition, with these numerous sources of information, the tempo and the complexity of the environment is also increased with the development of the technology. High stake environments such as C2 produce a considerable amount of stress that affects the human performance.

The performance is also affected by the level of fatigue felt by the human. All these factors may produce variability in the performance contribute for human errors and the miss achievement of the task. The automation can be seen as a potential solution to these problems. Several cognitive benefits can be attributed to the automation. Among them, are: [36]

- The reduction of the operator’s workload.
- With automated systems, operator’s attentional resources can be allocated to other tasks executed concurrently.
- The reduction of the stress factor induced by the stakes of the situation.
- The reduction of the fatigue factor.
- Automated systems provide a certain level of stability in the execution of a task.
- Automated systems can significantly reduce the occurrence of human errors.

In addition to these benefits, automation includes improved accuracy, reliability, and productivity, as well as enhanced employee morale. These advantages are illustrated in the figure below.

Figure III.1: Benefits of automation [37].

III.2.3 Types of Automation

- Fixed Automation : Often used in manufacturing, this involves using machineryto perform repetitive tasks.[38]
- Programmable Automation : Programmable automation is employed when production needs vary, requiring machinery to be reprogrammed or adjusted for different tasks.
- Flexible Automation : Flexible automation allows equipment to switch between different tasks with minimal reprogramming or setup changes.
- Software Automation : Software automation involves using software applications to automate tasks that would otherwise be performed manually on a computer.
- Robotic Process Automation (RPA) : Uses software robots to mimic human actions on computer.
- Artificial Intelligence (AI) Automation :Uses AI technologies like machine learning and natural language processing to performcomplex tasks that typically require human intelligence.

Figure III.2: Types of automation [38].

III.2.4 Objectives of automation

Automating the cyclone dust recovery process aims to enhance operational efficiency, reduce operating costs, and ensure compliance with environmental standards. The key objectives of automation in this field include : [38]

- Increase system productivity (quantityof products manufactured within a given time).
- Improve production flexibility.
- Enhance product quality.
- Adapt to specific contexts:
  - Hostile environments for humans.
  - Hard tasks that require physical or intellectual effort for humans.
- Enhance safety.

III.2.5 Structure of an automated system

Automated systems, used in the industrial sector, have an identical basic structure. Theyconsist of several more or less complex parts linked together: [38]

- **Operative Part (OP):** the process to be controlled
- **Control Part (CP):** the control system
- **Supervision Part (SP):** the operator (monitoring, start/stop) increasingly integrated into the control part

Anyautomated system can be decomposed according to the following diagram:

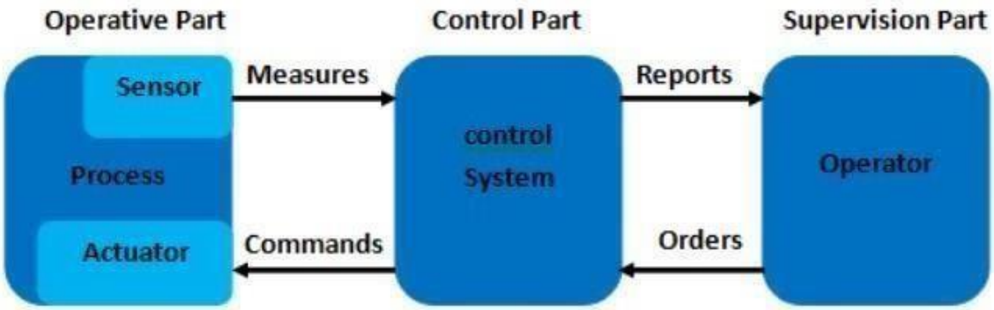


Figure III.3: Structure of an automated system [38].

- **Operative part :** Also known as the power part, it is the visible part of the system (body). It acts on the raw material to give it added value. The actuators (motors, cylinders) and pre-actuators (distributors and contactors) act onthe mechanical part of the system, which, in turn, acts on the raw material. Sensors are used to acquire various states of the system. To carryout movements, it is necessary to supply energy (electrical, pneumatic, and hydraulic) to the OP
- **Control part :** It gives operating orders to the operative part. It is considered the "brain" of the system.The command part replaces the operator, the operator's know-how is translated into a program. It gives orders to the operative part according to:
  a) Program it contains.
  b) Information received by the sensors.
  c) Instructions given by the user.
- **Supervision part :** Comprising control panels and signaling consoles, it enables the operator to control the system (start, stop, cycle start, etc.). It also provides visualization of various system states through indicators, dialogue terminals, or human-machine interfaces (HMI).

III.2.6 Communication and Interaction Between the Control System, the Operative Part, and the Operator

The communication between the operative part and the control system relies on a continuous exchange of measurement and control signals to ensure smooth and precise operation. At the same time, the interaction between the operator and the control system is facilitated through advanced human-machine interfaces, which act as an intermediary by interpreting and converting signals from both sides. This ensures that commands from the operator are accurately transmitted to the system while real-time feedback from the system is clearly presented to the operator, allowing for effective monitoring, decision-making, and adjustments as needed.

III.3 PROGRAMMABLE LOGIC CONTROLLERS (PLC)

III.3.1 Definition of programmable logic controllers

PLCs have many definitions. In simple terms, however, theycan be regarded as industrial computers with specially designed input/output interfaces and functions.

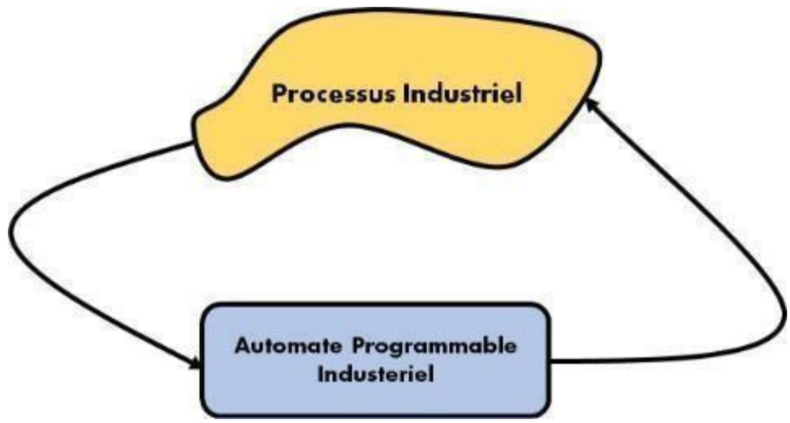


Figure III.4: PLC-Based system diagram[39].

Also, it can be defined as a special form of microprocessor that uses a programmable memory to store instructions and implement functions such as logic, sequencing, timing, counting and solving arithmetic operations as well as the communication function in order to control industrial machines and processes.

PLC designers have pre-programmed PLCs so that the control program can be entered in a simple, rather intuitive form of language. The system's inputs (sensors such as switches, etc.) and outputs (motors, valves, etc.) are connected to the PLC, each identified by its own address.

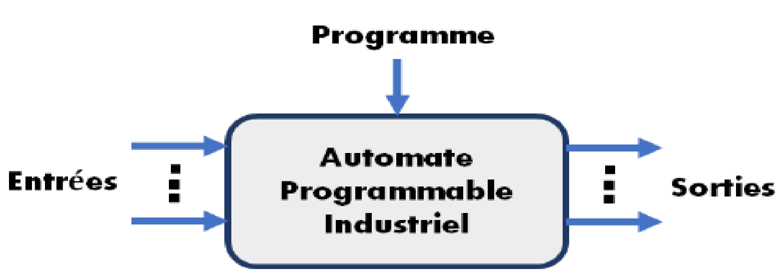


Figure III.5 : Automate programmable industeriel [39].

The operator then enters sequences of instructions, a program, into the PLC's memory. memory. The PLC then monitors inputs and outputs according to the and executes the control rules for which it has been programmed.

III.3.2 Architecture of programmable logic controllers

A PLC generally consists of modules arranged side by side, such as a power supply, a central processing unit (CPU) based on a microprocessor with a memory card, input and output interfaces, communication interfaces, special cards, and a programming device. It can indeed be considered as a unit containing a large number of relays, counters, timers, and separate data storage units (usually EEPROM). The following figure shows the basic layout of a PLC

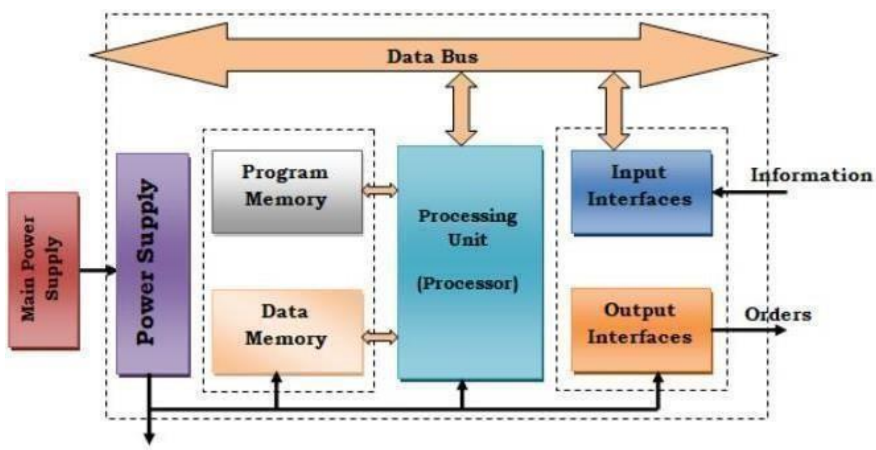


Figure III.6 : Internal structure of PLC [39].

- **Power supply module :** The Power Supply(PS) is required to convert the AC input voltage (220 V) from the mains into the DC voltage (24V,48V...) necessary for the processor and input/output interface module circuits. Power supplies vary from one PLC to another, requiring currents ranging from 2A to 50A, depending on the number of I/O interfaces powered by the supply.

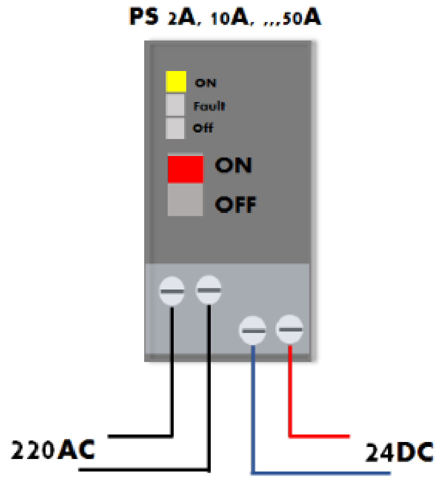


Figure III.7: Power supply module [39].

- **Central Processing Unit (CPU):** The CPU module is the unit containing the microprocessor. This unit interprets input signals and executes control actions according to the program stored in its memory, communicating decisions in the form of action signals to the outputs. This module also contains a programming interface for communicating with the programming console according to a specific protocol (e.g. TCP/IP, MPI-bus...etc.).

  Program memory is where the stored program containing the control actions to be executed by the microprocessor is stored, usually in an electrically erasable memory (EEPROM) with a capacity ranging from 4KB to 50KB.

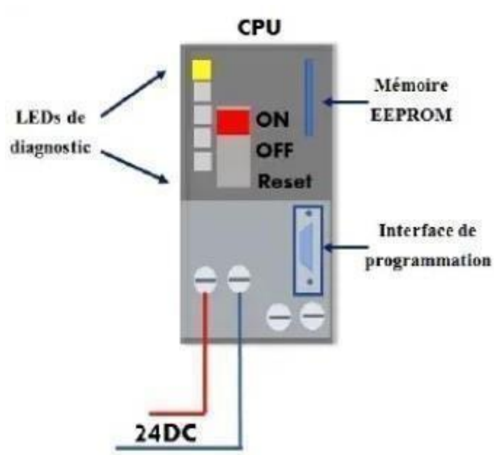


Figure III.8: Central processing unit (CPU) [39].

- **Input/output interfaces :** I/O boards enable the processor to receive information from external peripherals (sensors) and communicate it to external peripherals (preactuators and actuators). Generally speaking, there are two types of I/O: On/Off (DI/DO) and analog (AI/AO). In addition to these modules, there are special I/O modules (PID cards, high-speed counter cards, etc.), this type of card with microprocessors, to simplify tasks and relieve the CPU module.

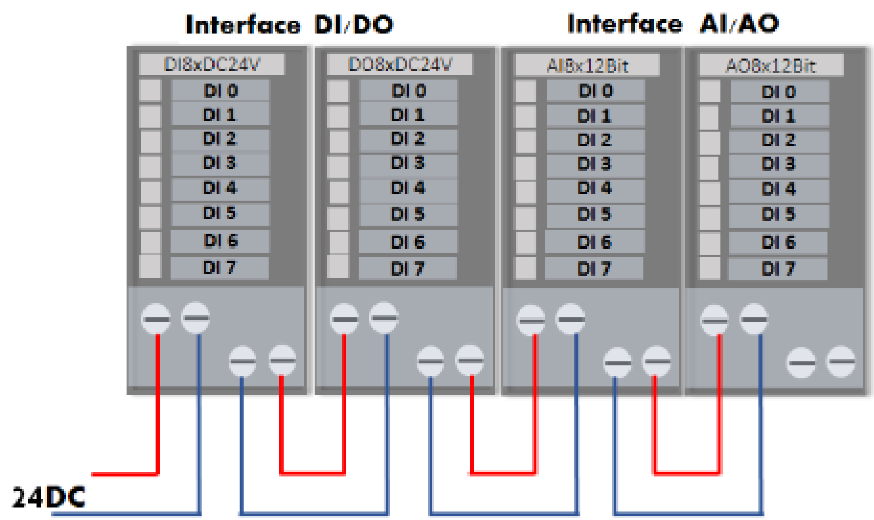


Figure III.9: Input/Output interfaces [39].

- **Programming console :** The programming device is used to enter the desired program into the programmable memory. Typically, the program is developed on a PC or a special a special console supplied by the manufacturer, then transferred to the CPU memory via a suitable communication cable (MPI-bus, TCP/IP, etc.).

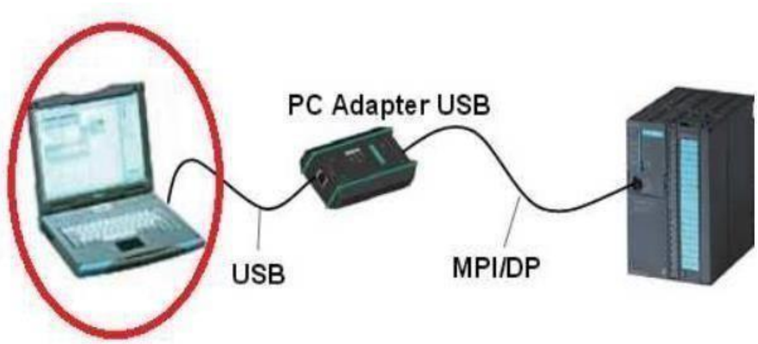


Figure III.10 : Programming console **[39].**

Communication Module : The communication interface is used to receive and transmit data over communication networks from or to other remote systems such as PLC, SCADA F&G, HMI, OPC server ...etc.. It covers actions such as device verification, data acquisition, synchronization between systems and connection management.

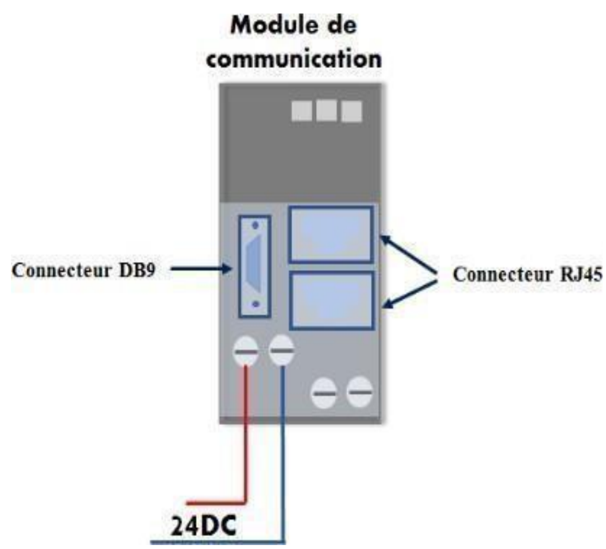


Figure III.11: Communications modules [39].

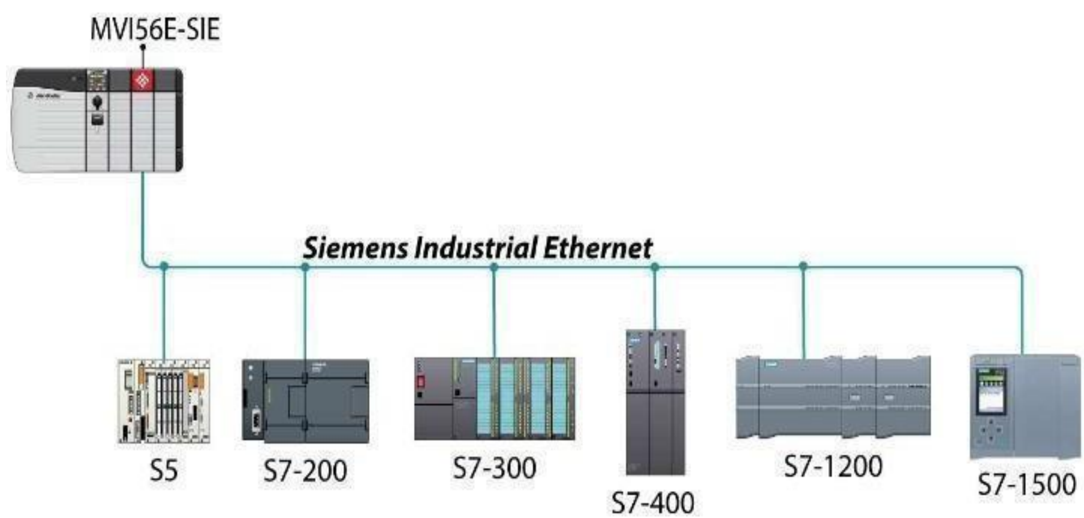


Figure III.12: Industrial communication networks [39].

III.3.3 Areas of use of PLC

Programmable logic controllers (PLCs) are used in all industrial sectors for controlling machines (conveyors,packaging, etc.) or production lines (automotive, agri-food, etc.). They can also perform process regulation functions (metallurgy, chemistry, etc.). Furthermore, they are increasingly used in the building sector (commercial and industrial) for controlling heating, lighting, security, and alarms [34].

III.3.4 Nature of the information processed by the PLC

The information can be of the type:

On/Off : The information can only take two states (true/false, 0 or 1, etc.). This is the type of information delivered by a detector, a push-button, etc.

Analog: The information is continuous and can take a value within a specific range. This is the type of information delivered by a sensor (pressure, temperature, etc.).

Digital: The information is contained in coded words in binaryor hexadecimal form. This is the type of information delivered by a computer or an intelligent module [34].

III.3.5 Criteria for choosing a PLC

Several criteria exist for the choice of a PLC, citing, for example:

- Quality/Price ratio.
- Ease of programming that offers a language intended for the automation engineer following the IEC 61131standard.
- Simulation and visualization capabilities that provide the user with effective support for development and operation, for example, S7-PLCSIM from SIEMENS.
- Processing power and a set of specialized cards allowing easydevelopment of specific applications: communication, axis control, regulation, etc.
- Expansion possibilities in terms of inputs and outputs.
- Standardization of communication protocols.[34]

III.3.6 Introduction to the S7-300 PLC

III.3.6.1 Overview and Definition of Siemens PLC S7-300

Siemens PLC S7-300 as modular controller is designed for innovative system solutions in manufacturing, because Siemens PLC S7-300 has appropriate supporting modules for system performance and application complexity. Power and efficiency combine with safety technology and motion control can be integrated with standard automation into this universal modular controller. Siemens PLC S7-300 has A wide range of controllers' modules based on space, the task at hand and specification system you set up. For better performance guarantee, Siemens has completed this controller with appropriate supporting device from CPUs, Signal modules, Function modules until Communication [40].

Figure III.13: SIMATIC S7-300 Overview [41].

III.3.6.2 Components

The SIMATIC 7-300 is a modular programmable controller comprising the following components: [42]

1. **Power supply (PS):** Provides the internal supply voltages
2. **Central processing unit (CPU):** Stores and processes the user program
3. **Interface modules (IMs):** Connect the racks to one another
4. **Signal modules (SMs):** Adapt the signals from the system to the internal signal level or control actuators via digital and analog signals
5. **Function modules (FMs):** Execute complex or time-critical processes independently of the CPU
6. **Communications processors (CPs):** Establish the connection to subsidiary networks (subnets)
7. Simulation modules (SM 374) :
8. **Racks:** Accommodate the modules and connect them to each other
9. **Subnets :** Connect programmable controllers to each other or to other devices

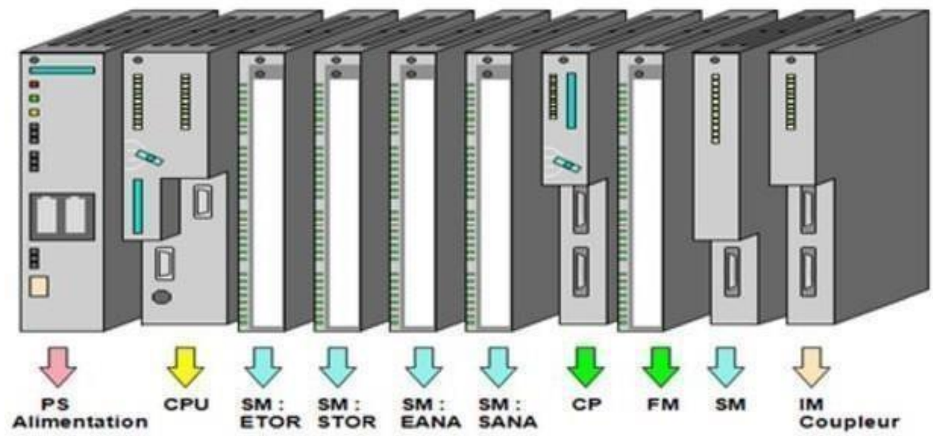


Figure III.14: S7-300 PLC Modules [42].

Support profiles or racks are the basic mechanical elements of the SIMATIC S7 - 300, fulfilling the following functions:

- Fixing of modules or mechanical assemblyof modules.
- Voltage distribution.
- routing the backplane bus to the individual modules.

In the S7 - 300, modules are fixed in sequence, and their number is limited, i.e the support profile in the S7 - 300 contains a maximum of 11 slots [47].

1. **Power supply module**

   The power supply module converts mains (or network) voltage into a voltage (24V, 48V, 120V or 230V) to power the PLC, sensors and actuators.

   - It also performs monitoring and signalling functions via LEDs.
   - It enables RAM memory contents to be backed up by means of a back-up battery or an external power supply

2. **Central processing units (CPU)**

The CPU is the brain of the PLC, enabling it to

- Read input signal states.
- Execute user programs and control outputs.
- Set start-up behavior and diagnose faults via LEDs.

The S7 - 300 features a wide range of CPUs at different performance levels, including include the following versions:

- CPUs for standard users: CPU 313, CPU 314, CPU 315 and CPU 316.
- CPUs with integrated functions: CPU 312 IFM and CPU 314 IFM

- CPU avec interface PROFILBUS DP (CPU 315 - 2 DP, CPU 316 - 2 DP CPU 318 2DP).

3. **Coupler (IM)**

Couplers are electronic boards that ensure communication between I/Os (peripherals or other) and the CPU. Information is exchanged between the CPU and I/O modules I/O modules via an internal bus (coded parallel link). Couplers connect one or more chassis to the base chassis. For the S7 - 300 PLC, the available couplers available are :

- IM 365: for couplings between chassis up to one meter apart.
- IM 360 and IM 361: for coupling distances of up to 10 meters.

4. **Communication module (CP)**

Communication modules are designed for serial communication tasks. transmission. They can also be used to establish point-to-point links with :

- Robot controllers.
- Communication with operator panels.
- SIMATIC S7, SIMATIC S5 and other manufacturers' PLCs.

5. **Function modules (FM)**

These modules reduce the CPU's processing load by performing heavy computational tasks, calculation tasks. They include the following modules:

- FM 354 and FM 357: Axis control module for servomotors.
- FM 353: Positioning module for stepper motor.
- FM 355: Regulation module.
- FM 350 - 1 and FM 350 - 2: Counting module.

6. **Signal modules (SM)**

Signal modules establish the link between the S7-300 CPU and the controlled process. There are several signal modules.

- digital input/output module
- analog input/output module

7. **Simulation modules (SM 374)**

The SM 374 simulation module is a special module that enables the user to test his program during commissioning and operation. In the S7 - 300, this module is fitted in place of a digital input or output module. It provides several functions, such as:

- Simulation of sensor signals by means of switches.
- LED status indication of output signals. [43]

III.4 STEP7 SOFTWARE

III.4.1 Introduction

STEP 7, also known as SIMATIC Manager, is a powerful software tool developed by Siemens for configuring and programming automation systems, specifically for the Siemens S7 series PLCs. It supports various automation tasks, including hardware configuration, communication setup, testing, and diagnostics.STEP 7 is available in different versions [44]:

- STEP 7 Basic is a cost-effective option for basic tasks like programming controllers and configuring HMIs.
- STEP 7 Professional provides advanced capabilities for more complex automation systems
- Step7 offers the following functions: [45]
    - Project creation and management.
    - Program creation.
    - Configuration and parameterization ofcommunication protocols.
    - Mnemonic management.
    - Test the automation system.
    - Diagnosis of system faults.
    - Documentation and archiving.

III.4.2 Description of programming blocks

1. **Organization block for cyclic program processing (OB1) :** Cyclic program processing is a normal process for programmable logic controllers. The operating systemcyclically calls OB1, which triggers cyclic processing of the user program.[45]
2. **Function (FC) :** Blocks of code with no memory, i.e. no static data, functions enable parameters to be passed into the user program.
3. **Database (DB) :** A data block (DB) is a data area in the user program which contains user data. All code blocks (functions) have access to the global data block, as does the instance data block associated with a specific function block call. Unlike all other blocks, data blocks contain no instructions.
4. **Function block (FB) :** A function block is a block of code with memory, i.e. with static data. It is used to transfer parameters to the user program. Function blocks are therefore suitable for programming complex, repetitive functions, such as control and operating mode selection.

III.4.3 S7-PLCSIM

The S7-PLCSIM module simulation application enables us to test and run our simulated programs on the PC or programming console. Since the simulation is carried out entirely within STEP7, there's no need to establish a connection to the PLC hardware. PLC-SIM features a simple interface for viewing and forcing the various parameters used bythe program, such as the variable table (VAT).[45]

III.4.4 CPU operating states

- **Running state (RUN-P) :** While the program is running, the CPU allows the program and its parameters to be modified, enabling S7 applications to be used.
- **Running state (RUN) :** When the CPU is in running state, objects can be loaded into it, and data requested bythe program can be modified via windows created in S7-PLCSIM.
- **Stop state (STOP) :** Although the CPU does not execute the program, it does not prevent it from being loaded; as the outputs do not take on predefined values, they retain the state theywere in when the stop state was entered.
- **CPU indicators :** The CPU window features a series of indicators which correspond to the signal lights on a real CPU:
  - ➢ VSF (system error) warns us that the CPU has detected a system error resulting in a change of operating state;
  - ➢ DP (decentralized periphery or remote I/O) indicates the state of communication with the I/O;
    - ❖ DC (power supply) indicates whether the CPU is on or off; ∟∟ RUN indicates that the CPU is in the run state;
    - ❖ STOP indicates that the CPU is in the stop state.

III.4.5 Different programming languages

There are several types of programming language for PLCs:

- Programming language where we have used a logigram (instruction list);
- Programming language based on a GRAFCET.
- Contact (Ladder) language;

III.4.6 Contact (Ladder) language

The contact language, also known as the Ladder language, is based on a graphical representation for Boolean data manipulation. It is based on Boolean equations that combine contacts (inputs) and relays (outputs). The graphic symbols associated with this language are organized in a diagram that resembles an electrical schematic with contacts. Ladder diagrams are delimited by power bars on the left and right. This language makes it possible to perform complex logic operations using intuitive visual elements, simplifying programming and understanding of logic circuits.

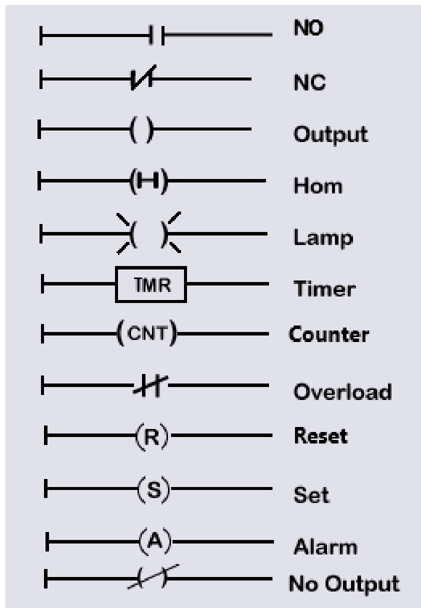


Figure III.15: The basic graphic components of an LD diagram [46].

III.4.6.1 The concept of NO and NC

1 **NC:** The Normally Close is the default state of a circuit that makes electrical contact with the circuit. It means the circuit is in ON state. [46]

0 **NO:** The Normally Open is the state of a circuit that makes no electrical contact with the circuit. It means the circuit is in the OFF state. It opens the terminal of the circuit to interrupt the flowing current. The NO button turns NC when it is pressed. It means, when the input is 1, NO turns NC. It means the current can pass through .

III.4.7 Flexible WinCC software and supervision

III.4.7.1 WinCC flexible software

WinCC Flexible is a vital software tool used for programming and configuring Siemens's legacy HMI panels such as the popular OP and TP series. You can create graphical interfaces that interact with your PLC programs and monitor them. These interfaces play a crucial role in industrial automation, allowing operators to interact with and control machinery. [47] To support this, the following tools and components are commonly involved in industrial automation projects :

- Programmable Logic Controllers (PLC);
- Input-output modules of PLC;
- Hand-Held Terminals (HHT);
- PLC software;
- Communications networks in the industrial environment byusing PLC;
- Sensors – inductive and capacitive sensors, optical sensors, etc.;
- Impulse water meters;
- And others.[48]

III.4.7.2 WinCC Runtime Professional Features and Extensions

The following possible extensions are available for WinCC Runtime Professional:

- WinCC Client (standard client for structuring multi-station systems)
- WinCC Server (supplements WinCC Runtime to include server functionality)
- WinCC Recipes (recipe system, formerly WinCC / UserArchives)
- WinCC WebNavigator (Web-based operator control and monitoring)
- WinCC DataMonitor (display and evaluation of process states and historical data)
- WinCC ControlDevelopment (extension by means of customer-specific controls)
- WebUX (platform and browser-independent operation and monitoring via the Web)
- SIMATIC Information Server 2014 (Web-based and browser-independent analysis and reports of historic process data)
- SIMATIC Process Historian 2014 (plant-wide archive server for messages and process data);
- Industrial Data Bridge (configurable connections to databases and IT systems)
- Redundancy(increased availability due to redundant server)

- SIMATIC ProDiag (machinery and plant diagnostics and SIMATIC HMI) [50].

III.4.8 Overview of Human-Machine Interface (HMI) in Industrial Applications

A Human-Machine Interface (HMI) is a user interface or dashboard that connects a person to a machine, system, or device. While the term can technically be applied to any screen that allows a user to interact with a device, HMI is most commonly used in the context of an industrial process.

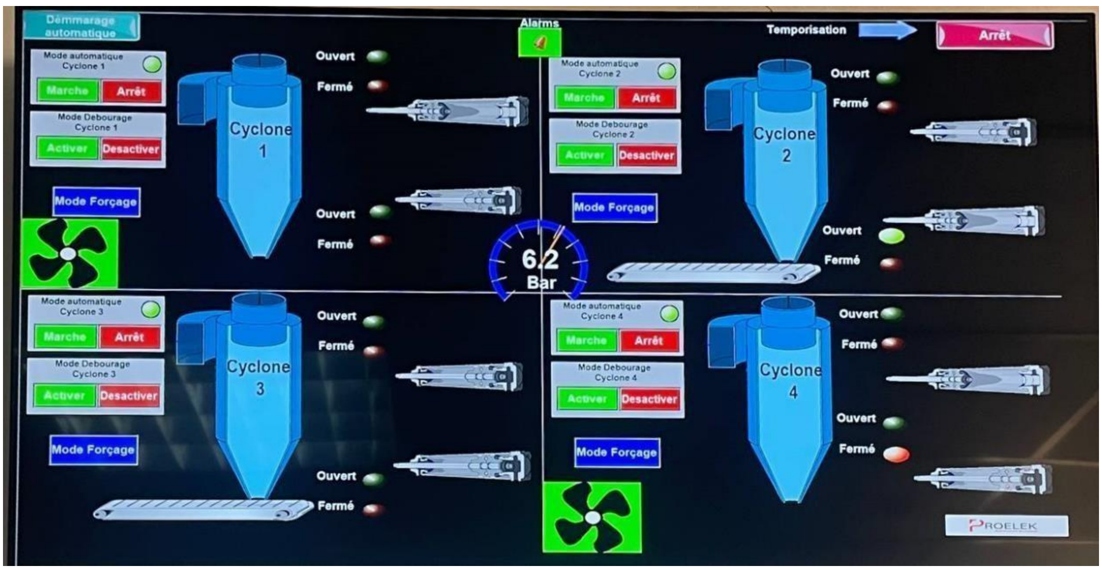


Figure III.16 : Cyclone network animation.

HMIs are similar in some ways to Graphical User Interfaces (GUI) but theyare not synonymous; GUIs are often leveraged within HMIs for visualization capabilities.

In industrial settings, HMIs can be used to:

- Visually display data
- Track production time, trends, and tags
- Oversee KPIs
- Monitor machine inputs and outputs
- And more

III.5 DEFINITION OF SUPERVISION

The term "supervision" generally refers to the act of overseeing, managing, or directing the activities of individuals or processes. It involves providing guidance, support, and monitoring to ensure that tasks or activities are carried out effectively and efficiently. supervision refers to the monitoring and control of a PLC system's operation. It involves overseeing the functioning of the PLC system, monitoring its inputs and outputs, and ensuring that the programmed logic and automation processes are running as intended. [51]

III.5.1 Constitution of a Supervision System

In this section, we will delve into the constitution of a supervision system, focusing on four essential modules: the visualization module, archiving module, processing module, and communication module. These modules play crucial roles in enabling effective monitoring, data management, analysis, and communication within the supervision system:

1. **Visualization Module:**

The visualization module is responsible for creating an intuitive and user-friendly interface for operators to interact with the supervision system. It involves designing graphical displays, screens, and controlpanels that provide real-time visualization of process variables, alarms, and status indicators. This module utilizes the capabilities of the WinCC Flexible software to create visuallyappealing and informative displays that enable operators to monitor the automation glance system.

2. **Archiving Module**

The archiving module is responsible for storing and managing historical data generated bythe ,automation system. It allows for the collection, storage, and retrieval of process data over time which can be valuable for analysis, troubleshooting, and compliance purposes. The archiving module in the supervision system utilizes the capabilities of the WinCC Flexible software to configure data logging parameters, set up storage locations, and define data retention periods.

3. **Processing Module**

The processing module is responsible for performing data processing and analysis tasks within supervision system. It enables the extraction of valuable insights from the collected data, the generating reports, performing statistical analysis, and detecting trends or anomalies. The such as processing module utilizes the computational capabilities of the WinCC Flexible software to implement algorithms and calculations that transform raw data into actionable information for decision-making

4. **Communication Module**

The communication module enables seamless data exchange and integration between the supervision system and other components of the automation system. It establishes connections through with field devices, programmable logic controllers (PLCs), and other control systems various communication protocols such as Profibus, Profinet, or OPC. The communication ensures real-time data synchronization, remote monitoring capabilities, and the ability to module control commands to the automation system send by integrating these four modules – the visualization module, archiving module, processing module, and communication module – the constitution of a supervision system using WinCC. Flexible provides a comprehensive solution for effective monitoring, data management, analysis and communication within the automation environment. This integrated approach empowers operators and decision-makers to make informed decisions, optimize processes, and enhance overall system performance.

III.5.2 The benefits of supervision

The implementation of a supervision system brings numerous benefits to the automation environment. In this section, we will discuss four key benefits: remote process monitoring and control, fault detection, diagnosis and processing of alarms, and data processing.

- **Remote Process Monitoring and Control:** One of the primary advantages of a supervision system is the ability to remotely monitor and control the process. Operators can access the system from a central control room or even through mobile devices, allowing them to keep an eye on the process parameters and make adjustments as needed. This remote access capability enhances flexibility and efficiency by reducing the need for physical presence on-site and enabling faster response times to changing conditions or emergencies.
- **Fault Detection:** Supervision systems are equipped with advanced monitoring capabilities that enable the detection of faults or abnormal conditions in the automation system. Bycontinuously monitoring process variables, alarms, and equipment statuses, the system can identify deviations from normal operation and raise alerts. Early fault detection helps prevent potential failures, minimize downtime, and ensure the smooth operation of the process.
- **Diagnosis and Processing of Alarms:** Supervision systems provide powerful tools for diagnosing and processing alarms. When an alarm is triggered, the system can provide detailed information about the cause, location, and severity of the issue. This information enables operators to quickly assess the situation, take appropriate actions, and resolve the

problem effectively. The system can also prioritize alarms based on their criticality, allowing operators to focus on the most significant issues first.

- **Data Processing:** Supervision systems play a crucial role in data processing within the automation environment. They collect, store, and analyze large volumes of data generated by the process and the associated equipment. By applying advanced algorithms and statistical techniques, the system can extract valuable insights, detect patterns, and identifytrends. This data processing capability enables operators and decision-makers to optimize processes, improve efficiency, and make data-driven decisions to enhance overall performance.

The implementation of a supervision system offers significant benefits to the automation environment. It enables remote process monitoring and control, facilitates fault detection, enhances diagnosis and processing of alarms, and empowers data processing for improved decision-making. These benefits contribute to enhanced efficiency, reliability, and productivity, ultimately leading to optimized operations and improved outcomes in industrial processes.

III.6 CONCLUSION

In summary, the integration of automation into cyclone dust collection systems marks a significant advancement in industrial process control. Through the use of programmable logic controllers (PLCs), systems can operate with greater accuracy, flexibility, and consistency. PLCs offer the capability to monitor critical parameters such as airflow, pressure, temperature, and dust concentration, and to adjust system behavior dynamically based on real-time data.

The benefits of automation extend beyond performance improvements. By reducing manual intervention, the system minimizes the risk of human error, ensures consistent operation, and enhances worker safety. Furthermore, automation facilitates compliance with environmental standards by maintaining optimal operating conditions and triggering alerts when thresholds are exceeded.

The use of supervisory systems, such as WinCC, enhances the value of automation by providing real-time visualization, historical data analysis, and remote-control capabilities. Operators gain a deeper understanding of system behavior, can respond faster to anomalies, and are empowered to make data-driven decisions that improve process outcomes.

As industries continue to embrace digital transformation, the role of automation in dust collection systems will only grow. Future advancements may include machine learning-based predictive controls, remote diagnostics, and seamless integration with enterprise resource planning (ERP) systems. This chapter has demonstrated how PLCs and automated supervision elevate traditional dust control into a smart, adaptive, and future-ready solution.

CHAPTER IV : PROGRAMING AND SUPERVISION

IV.1 INTRODUCTION

In the rapidly evolving landscape of industrial operations, automation has emerged as a cornerstone of efficiency, safety, and precision. This chapter delves into the application of automation in the context of cyclone dust collection systems, highlighting the transformative role of programmable logic controllers (PLCs), supervisory systems, and intelligent sensors. It explores the core principles, structural components, and integration of automation technologies that enable real-time monitoring, control, and optimization of industrial processes. By bridging mechanical systems with digital intelligence, the chapter provides a comprehensive framework for implementing modern automation solutions tailored to enhance operational performance and environmental compliance.

IV.2 PROJECT CREATION AND MAIN INTERFACE OVERVIEW

Let’s start by looking at how to create projects in Simatic Manager. First, start the Simatic Manager software. To do this, open your Start menu, browse the “Siemens Automation” folder, and click “SIMATIC manager.”

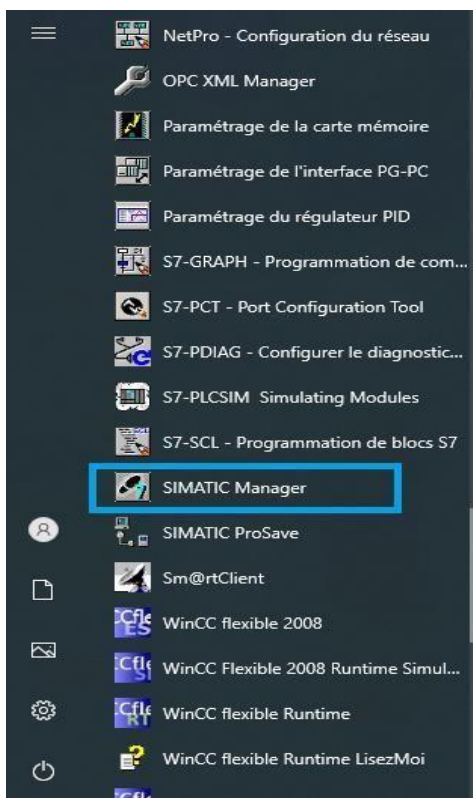


Figure IV.1 : Siemens SIMATIC Manager STEP7 PLC Programming | Opening SIMATIC Manager

When the software opens, we must create a new project. Click on the “New project” button symbolized by a white page icon.

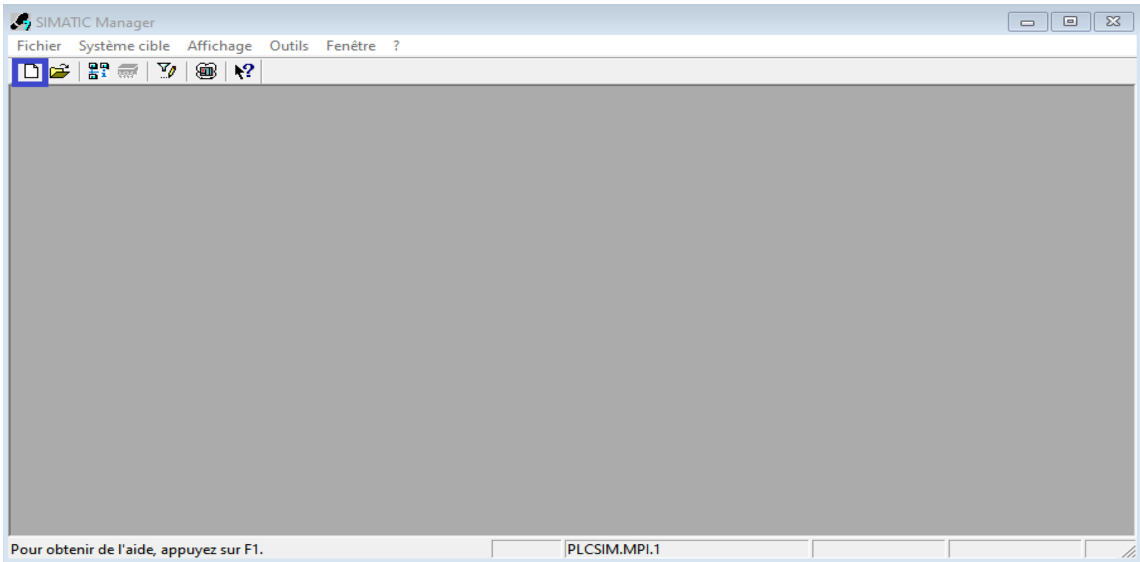


Figure IV.2 : Siemens SIMATIC Manager STEP7 PLC Programming | Creating a new project

A small “New Project” window will appear where you can define the project’s name, the project’s type, and the storage location of the project.

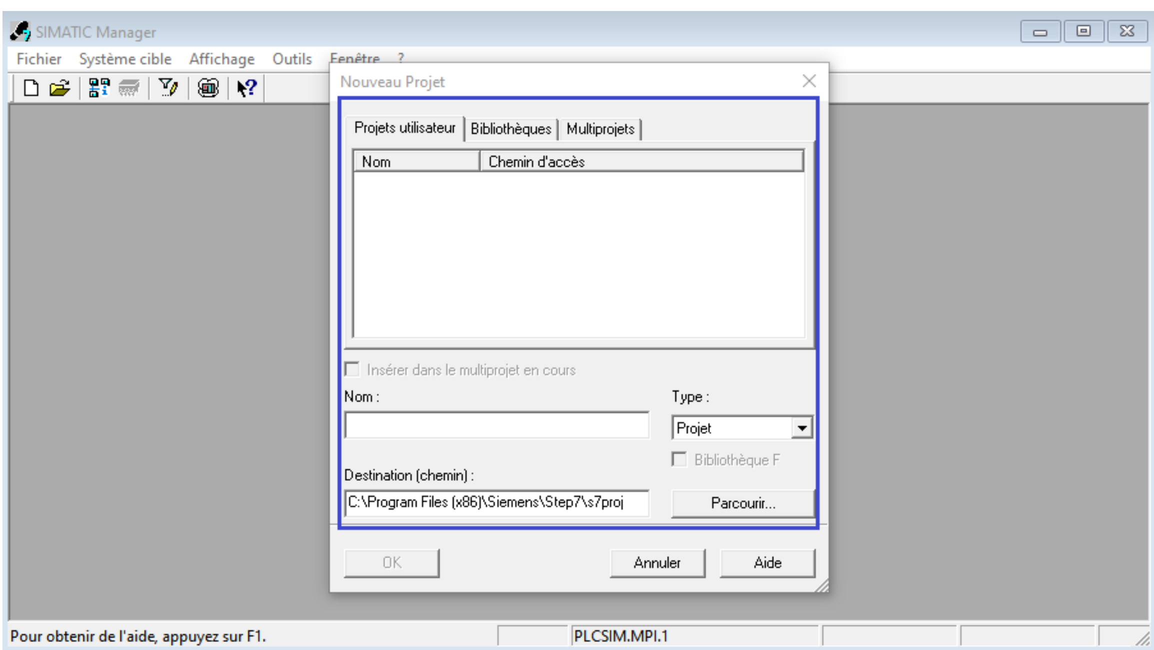


Figure IV.3 : Siemens SIMATIC Manager STEP7 PLC Programming | New project.

Configuration Give the project a name, keep the type at “Project,” and click on “OK.”

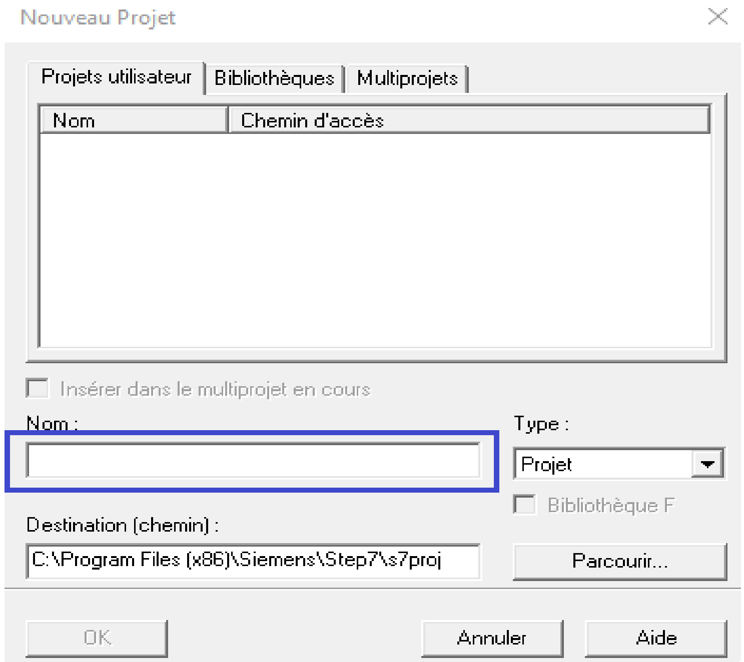


Figure IV.4 : Siemens SIMATIC Manager STEP7 PLC Programming / Giving the project a name.

Wait for the project creation to finish. Once done, the project interface appears. Before covering the interface, let’s quickly look at how to open projects. To do this, click on the “Open Project” button symbolized with a yellow folder icon.

This will open a small “Open Project” window where you can find a list of all your projects. You should find the newly created project in this list.

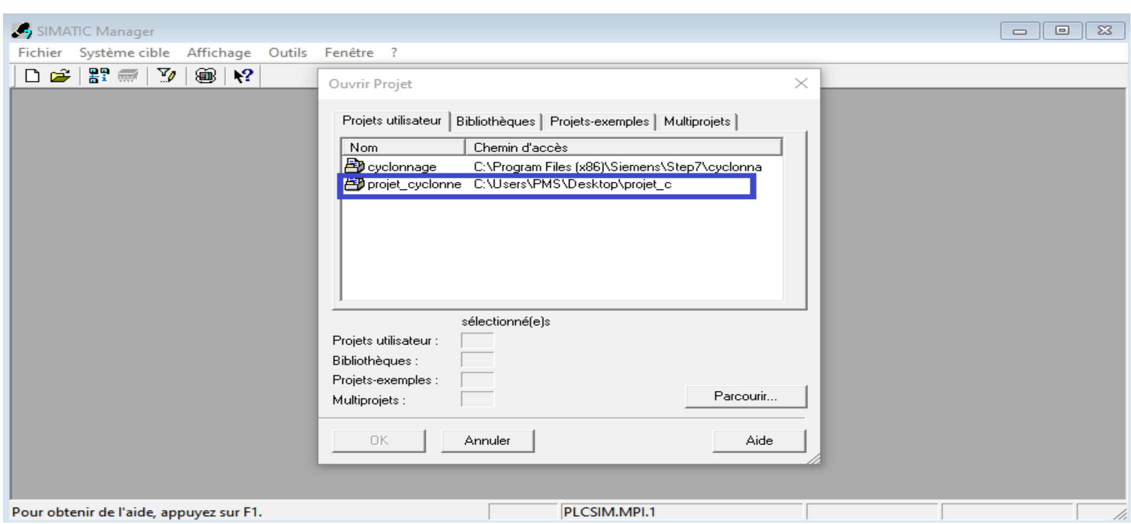


Figure IV.5 : Siemens SIMATIC Manager STEP7 PLC Programming | Opening a project.

Now, you can close the "Open Project" window to come back to the main project interface, which is divided into three sections:

1. Toolbox: Here, you can find various tools such as creating/opening a project, loading the project in a PLC, opening the network management, enabling the simulator, viewing options….etc
2. Project tree: Here, you can find an exploded view of each component, offering quick access to any part of the project.
3. Workspace: Here, you can find a more detailed view of the selected section of the project where you can find all the components included inside and interact with them.

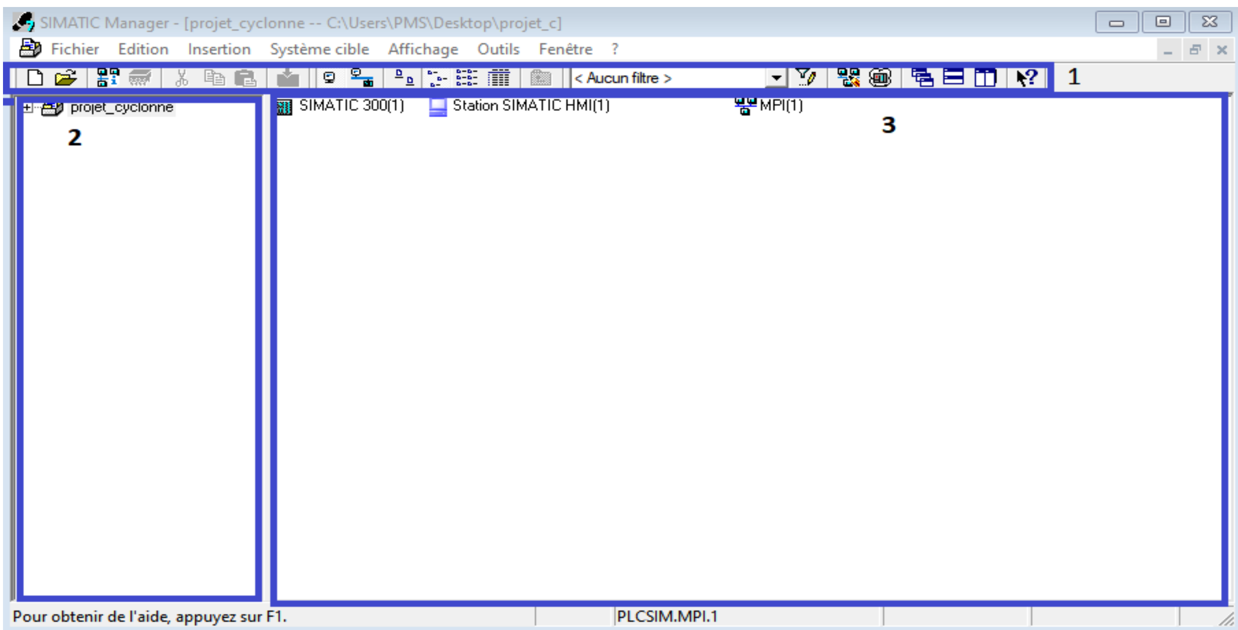


Figure IV.6 : Siemens SIMATIC Manager STEP7 PLC Programming | Interface description

IV.3 HARDWARE CONFIGURATION

We need to create a PLC station in the project. We will add an S7-300 PLC station to the project. To do this, open the "Insert" menu, select "Station," and click on "SIMATIC 300 Station."

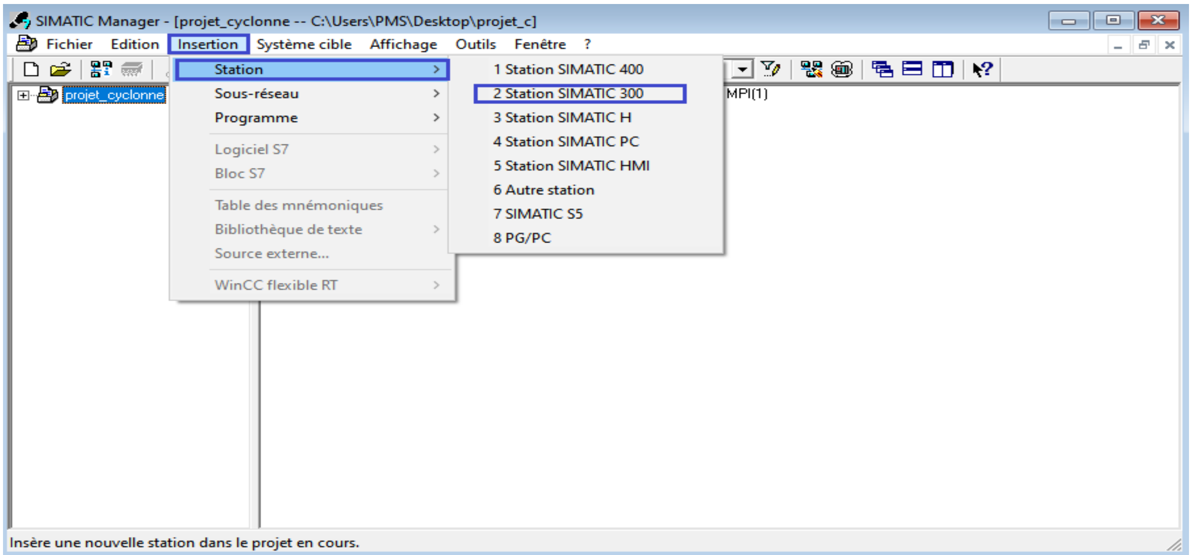


Figure IV.7: Siemens SIMATIC Manager STEP7 PLC Programming | Adding a new 300 station.

The hardware configuration opens in a new window. Here, you can configure the actual hardware used in your station using a catalog that contains all the various Siemens PLC components (CPUs, modules… etc.) for the 300s . The components are added to replicate their physical layout (Modules positions in the rack).

The hardware configuration interface splits into three parts:

1. Workspace: In this section, you can define a rack and add modules to it.
2. Detail view: Here, you can find a detailed view of all the components in the rack.
3. Hardware catalog: Here, you can find a list of all the different CPUs, modules, and devices that you can add to your rack. Contains only devices compatible with the S7-300

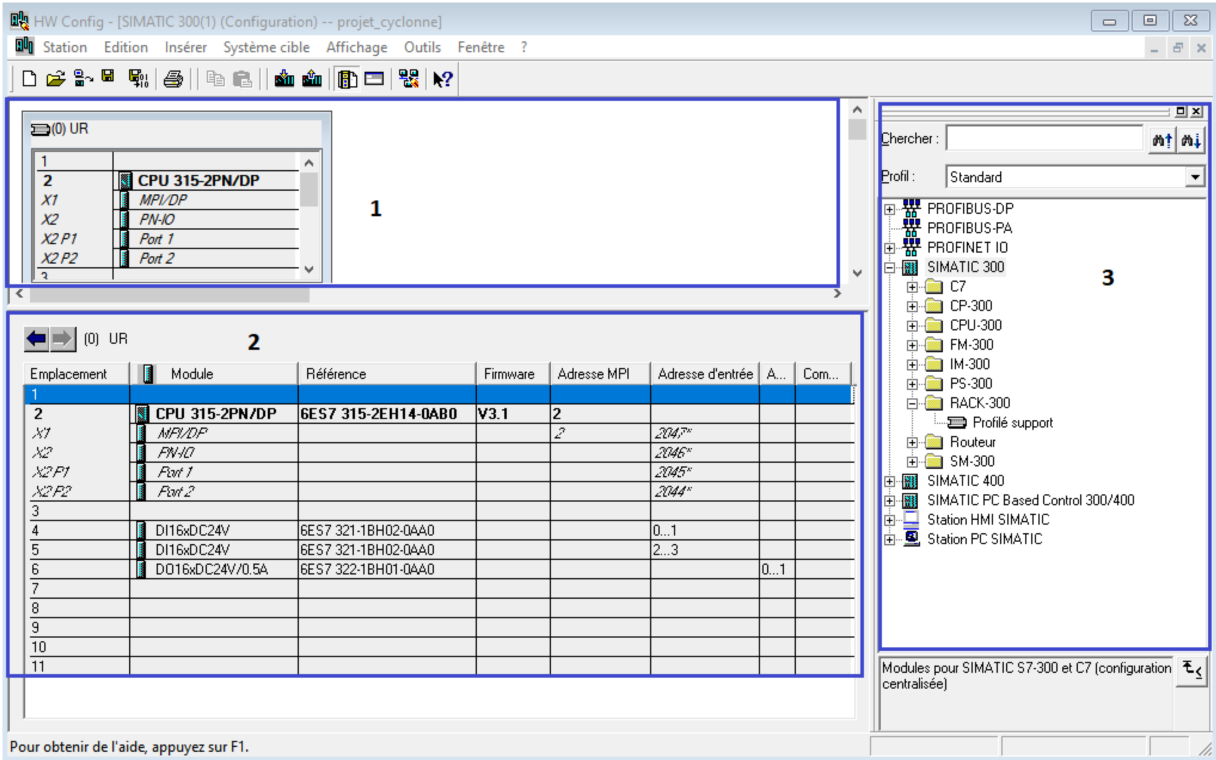


Figure IV.8 : Siemens SIMATIC Manager STEP7 PLC Programming | Hardware configuration interface.

The first thing to do is to add a rack. Open the ”SIMATIC 300” folder in the catalog. Here, you will find all the components available for the S7-300 PLCs. After that, open the “RACK 300” folder, where you will find the Rail component.

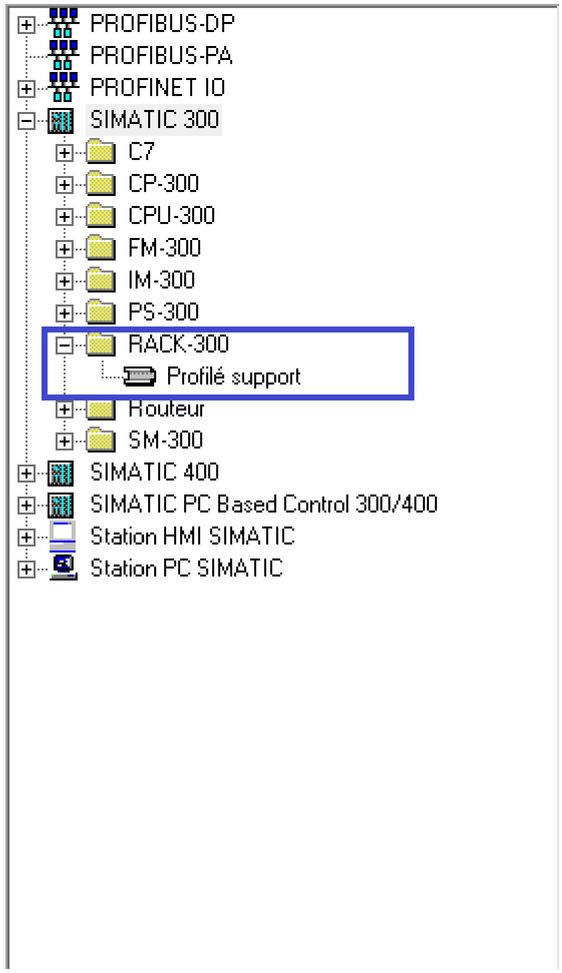


Figure IV.9: Siemens SIMATIC Manager STEP7 PLC Programming | Adding a rail

That we have added a rail, we can start adding modules. For this example, we will add an S7 315-2 PN/DP CPU, one of the most popular CPUs in the S7-300 series. To do this, open the CPU 300 folder. Here, you will find all the available S7 300 CPU models. Next, open the "CPU 315-2 PN/DP" folder. Three versions are available for this module, displayed with their order number.

Select the last one and open it. You will find two available firmware versions for this CPU; select the highest and drag it to the rail. You will notice that only slot two highlights in green indicate that it's the only slot. The first three rail slots are reserved as follows: 1- Power supply. 2- CPU. 3- Interface module (For multi-rack systems). Add the CPU to the second slot of the rail.

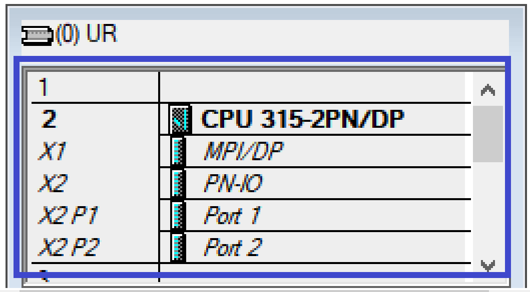


Figure IV.10 : Siemens SIMATIC Manager STEP7 PLC Programming | Adding a CPU

IV.4 NETWORK COMMUNICATION (PROFIBUS)

In cases where your CPU is connected to other devices through a fieldbus, such as PROFIBUS and PROFINET, we need to configure the network. Let’s configure a slave device connected to the CPU through PROFIBUS. To do this, double-click on the “MPI/DP” interface of the CPU in the hardware configuration.

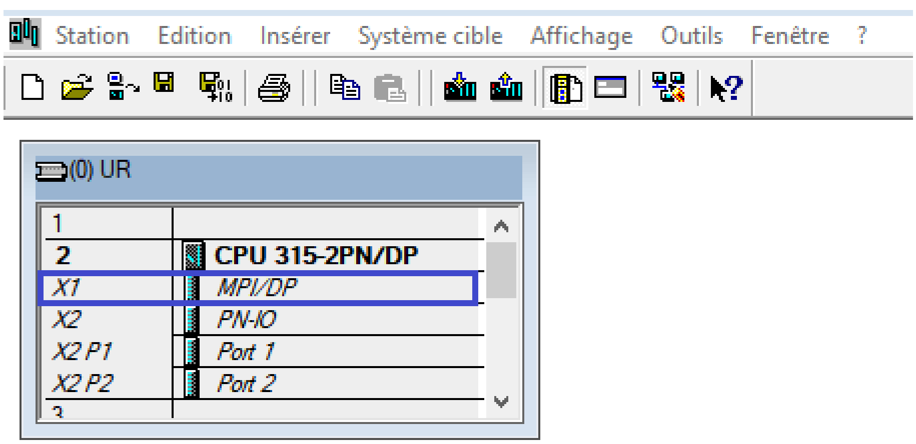


Figure IV.11 : Siemens SIMATIC Manager STEP7 PLC Programming | Accessing the MPI/DP interface

Check that your devices (CPU and ET200) are connected to the PROFIBUS network in the network manager. If not, you can connect them using the graphic interface by selecting the device’s interface (red square) and dragging it to the PROFIBUS network.

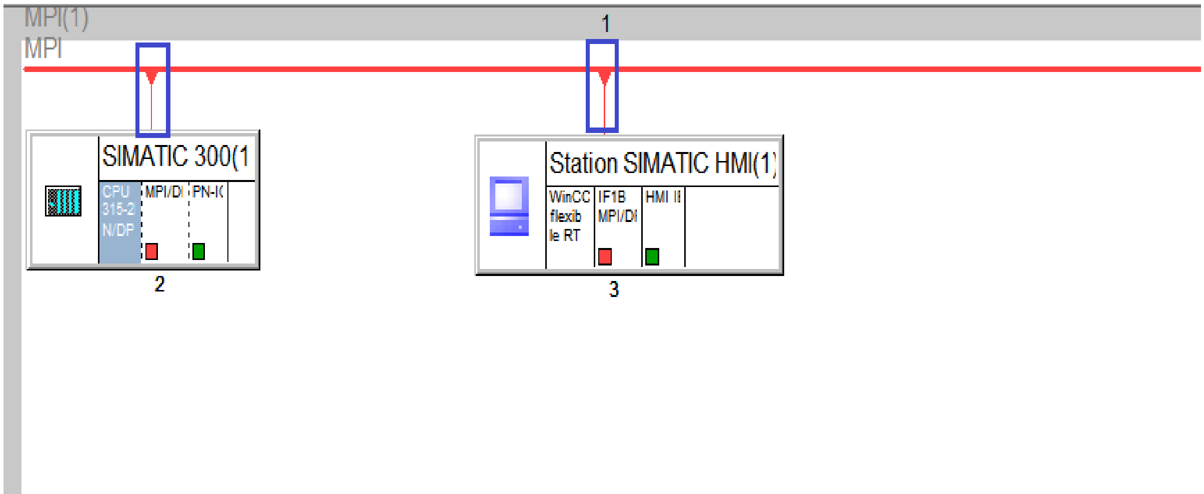


Figure IV.12: Siemens SIMATIC Manager STEP7 PLC Programming | Network manager

IV.5 CREATING PROGRAM BLOCKS

We are now done configuring the station. We can head to the program blocks management. As a reminder, PLC programs are split into different segments called “blocks.” You can program these blocks and link them together to build automation applications.

There are four types of program blocks:

1. Organization blocks (OB): These blocks are the most essential blocks of a PLC program. They define the sequence and timing of program execution. OBs determine when and how often certain sections of the program are executed. They typically handle tasks like program startup, cyclic program execution, and fault handling.
2. Functions (FC): These blocks are predefined or user-defined routines that perform specific tasks or calculations. Functions encapsulate and modularize certain operations, making the code readable and reusable. They can perform mathematical calculations, data manipulation, and other tasks.
3. Data Blocks (DB): These blocks store and manage data such as variables, arrays, and structured data types. It allows you to organize and store data in a structured manner, making it easier to manage and access data throughout the program. They are commonly used to store process data, configuration settings, and input/output (I/O) data.
4. Function Blocks (FB): These blocks are reusable program modules that encapsulate a specific control or automation function. They consist of a Function (FC) associated with

a Data Block (DB). They can represent complex control algorithms like PID controllers, motor control, or communication protocols.

You can create, edit, and manage these blocks in the “Blocks” section in the “S7 Program” folder of your CPU.

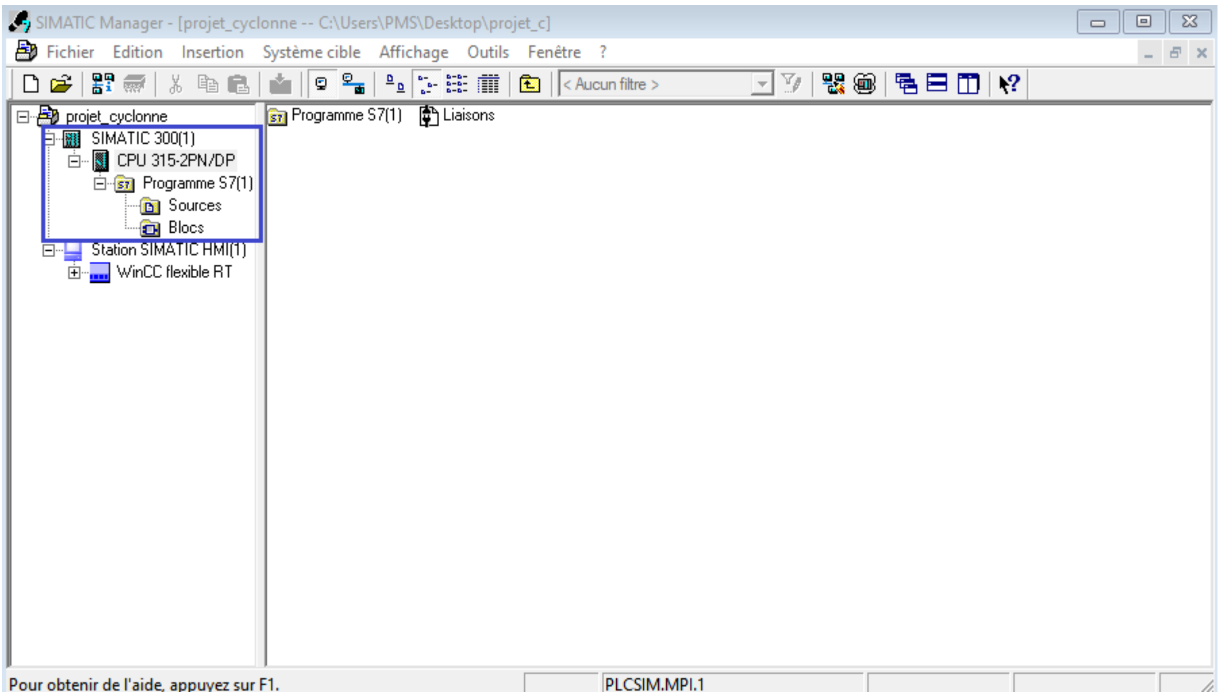


Figure IV.13: Siemens SIMATIC Manager STEP7 PLC Programming | Accessing the station’s program block

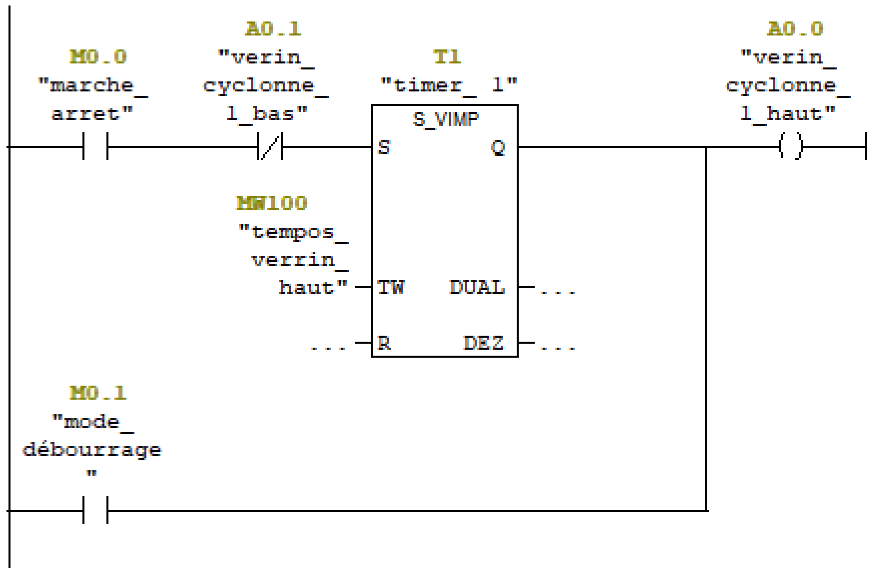
IV.5.1 Organization Block 1

Organization Block 1 (OB1) contains several networks (Networks) which control the pneumatic cylinders responsible for opening and closing the cyclone's top and bottom flaps. Each network performs a specific action depending on the conditions defined (run mode, unclogging mode, cylinder position, etc.).

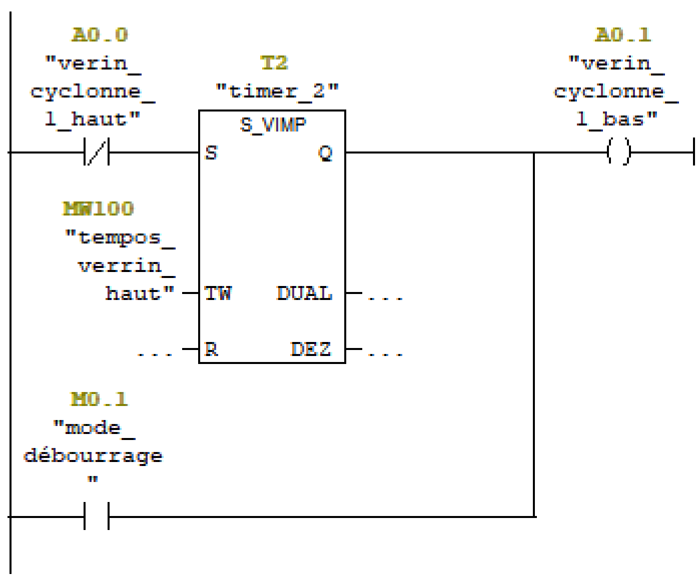
For example, when the unclogging mode is activated and the bottom flap is closed, a timer is triggered to automatically open the top flap for a given time.

This program enables cyclic, automatic and safe operation of the cyclone cleaning system.

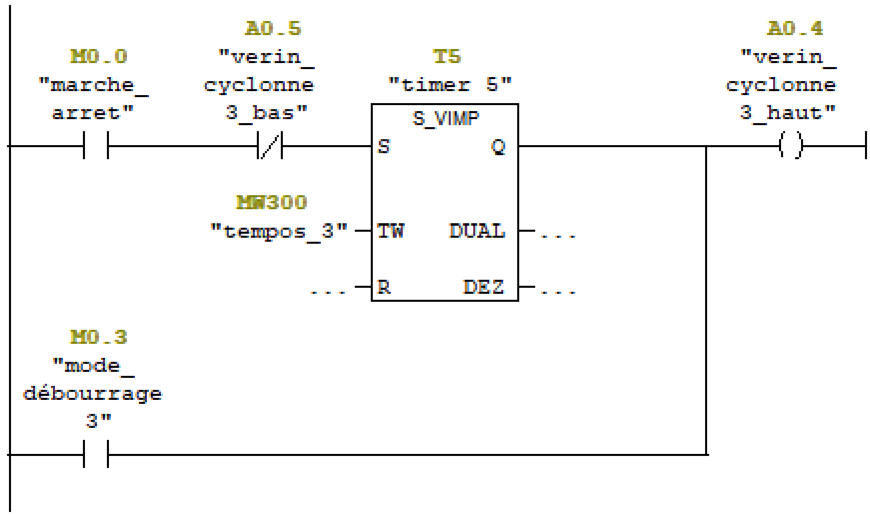
Réseau 1 : cyclonne n°1 clapet_haut



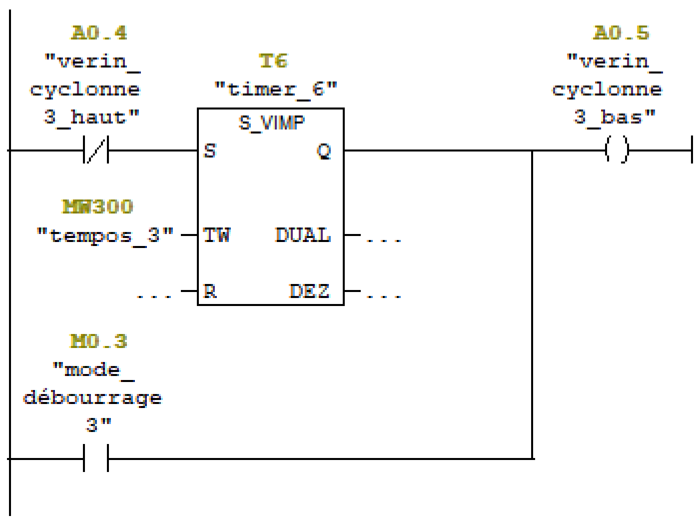
Réseau 2 : cyclone n° 1 clapet bas

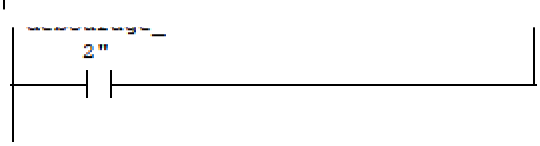


⊟ Réseau 5 : cyclone n°3 clapet_haut

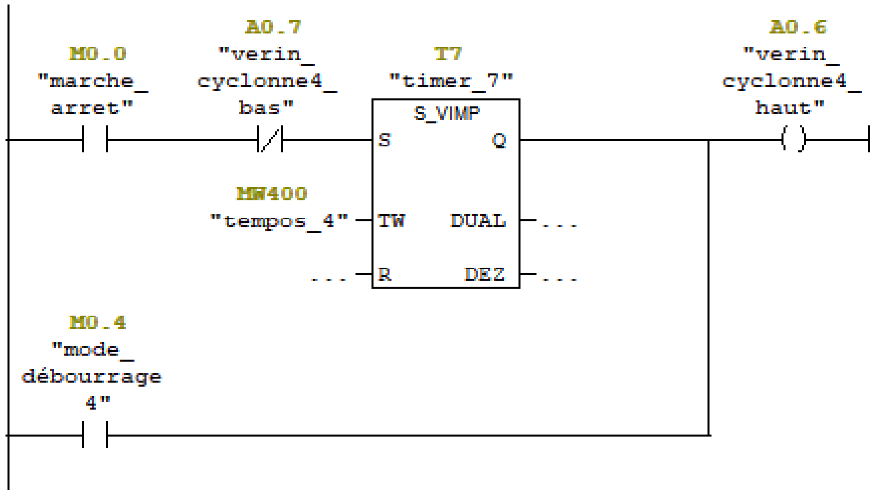


⊟ Réseau 6 : cyclone n°3 clapet_bas

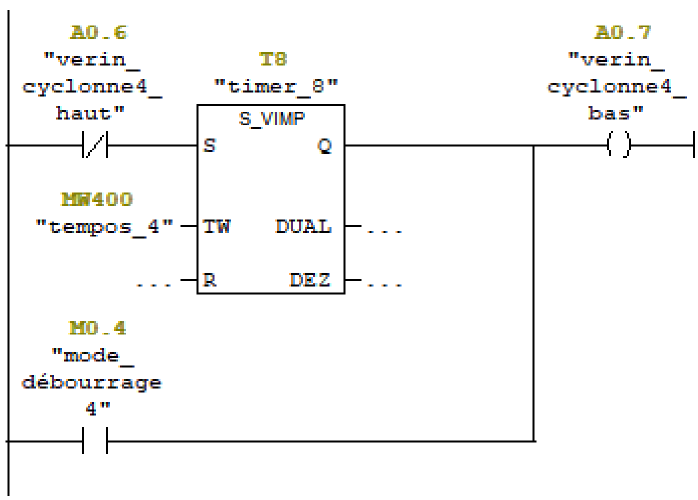




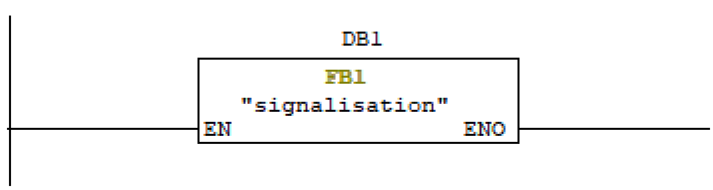
⊟ Réseau 7 : cyclone n°4 clapet_haut



⊟ Réseau 8 : cyclone n°4 clapet_bas



⊟ Réseau 9 : signalisation_cyclonne 1_2_3_4



⊟ Réseau 10 : tempos cyclone_ 1_2_3_4

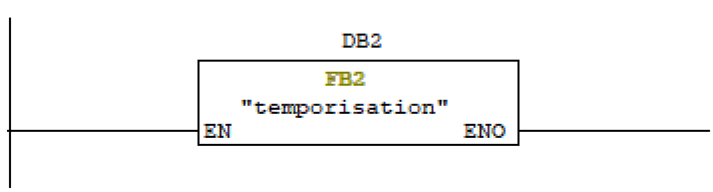


Figure IV.14 : Siemens SIMATIC Manager STEP7 PLC Programming | Program blocks

IV.5.2 Function Block 1

We've created a function block (FB1) to control the cyclone system used for dust recovery. This block comprises several ladder language networks, each representing a specific operating situation.

Digital inputs from sensors are used to trigger outputs that control equipment such as fans or valves.

The main aim of this programming is to guarantee automatic, reliable system operation, by reacting precisely to signals detected in the field. After testing, the unit proved to be stable and responsive to a wide range of operating conditions

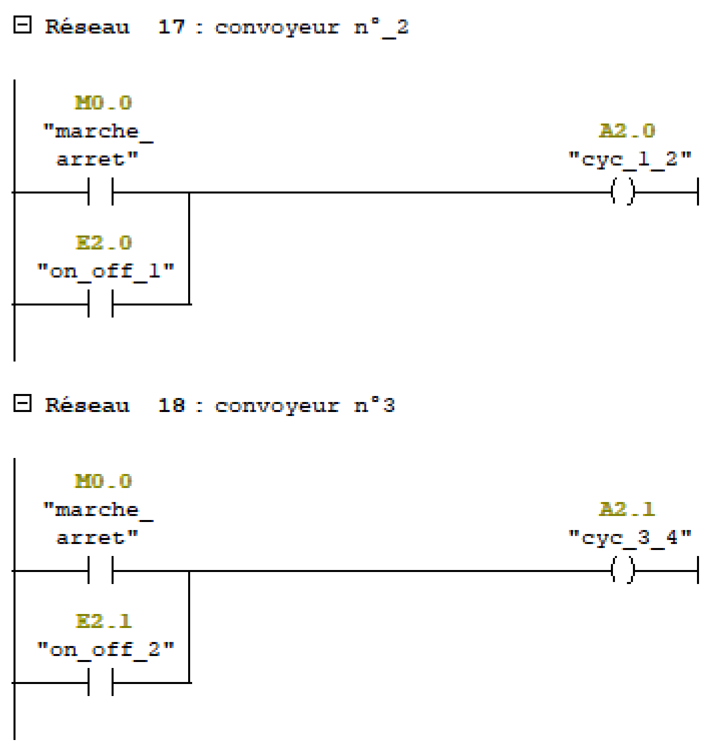


Figure IV.15: Siemens SIMATIC Manager STEP7 PLC Programming | Adding a Function Block 1

IV.5.3 Function Block 2

Here , we programmed four networks (one for each cyclone) using a Programmable Logic Controller (PLC) to control the operation time of each cyclone in the dust recovery system. For each cyclone, we applied the same programming logic:

1. Read the desired time (in seconds) from a specific memory address (e.g., MW500,

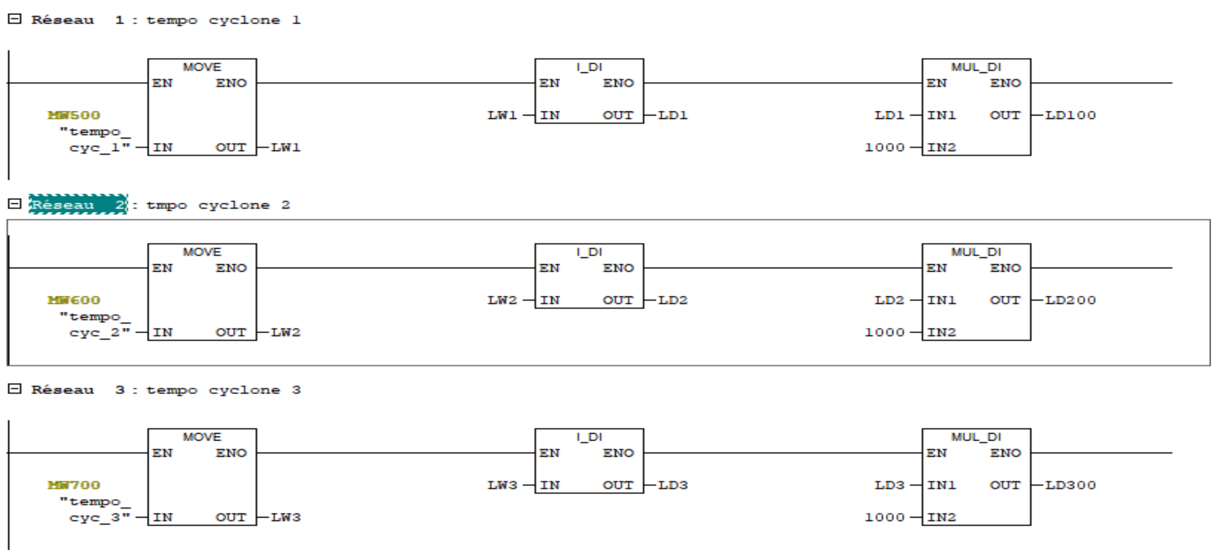
MW600, etc.).

2. Move the value to a temporary variable (LW) to use it in calculations without modifying the original input.

3. Convert the value from seconds to milliseconds by multiplying it by 1000, since PLC timers usually operate in milliseconds.

4. Store the result in a register (e.g., LD100, LD200, etc.) to be used later by the timers.

This approach allows us to accurately control the activation duration of each cyclone as needed, improving dust removal efficiency and ensuring continuous system performance without clogging.



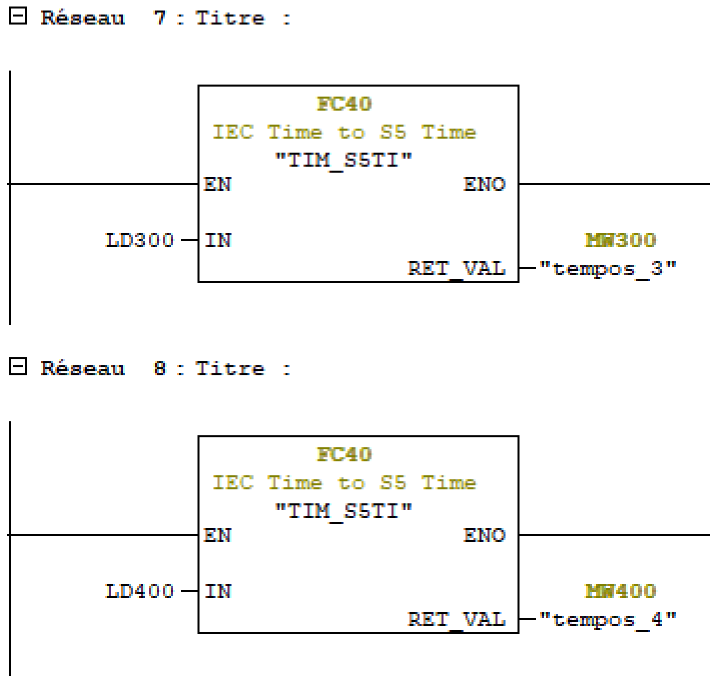


Figure IV.16 : Siemens SIMATIC Manager STEP7 PLC Programming | Adding a Function Block 2.

IV.6 DOWNLOADING AND UPLOADING THE PROGRAM

We have so far covered the primary steps when creating an automation project. After that, the last step would be to transfer the project containing the programs to the PLC. We need to have a physical or virtual PLC connected to this. I am using a virtual PLC (PLCSim) in the background to enable the downloading. The SIMATIC Manager simulation tutorial provides more information about the virtual PLC. Select the station in the project tree and click the "Download" button.

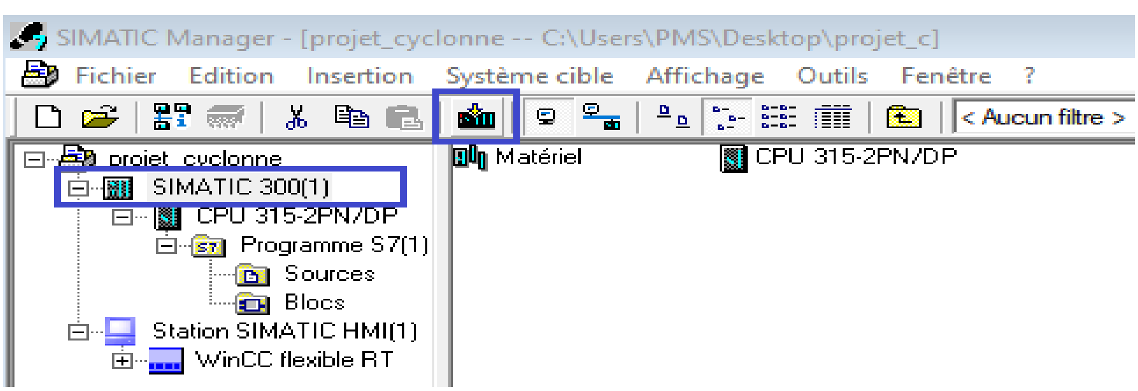


Figure IV.17: Siemens SIMATIC Manager STEP7 PLC Programming | Downloading the station.

IV.7 MNEMONIC TABLE

When programming in Step7, we worked with operands such as I/O, mementos, counters, timers, data blocks and functions. We can address these absolutely in the program, but we can also improve the readability and clarity of a program considerably, by using mnemonics instead of absolute addresses, as shown in the figure below.

Vue_1 | Variables

VARIABLES

Nom	Nom d'affichage	Connexion	Type de données	Mnémonique	Adresse	Eléments du ta...	Cycle d'acquisi...	Commen
captd_cyc1_h...		Liaison_1	Bool	captd_cyc1_haut_o	I 0.0	1	1 s	
cyc_1_2		Liaison_1	Bool	cyc_1_2	Q 2.0	1	1 s	
cyc_3_4		Liaison_1	Bool	cyc_3_4	Q 2.1	1	1 s	
d_c1_bas_f		Liaison_1	Bool	d_c1_bas_f	I 0.3	1	1 s	
d_c1_bas_o		Liaison_1	Bool	d_c1_bas_o	I 0.2	1	1 s	
d_c2_bas_f		Liaison_1	Bool	d_c2_bas_f	I 0.7	1	1 s	
d_c2_bas_o		Liaison_1	Bool	d_c2_bas_o	I 0.6	1	1 s	
d_c2_haut_f		Liaison_1	Bool	d_c2_haut_f	I 0.5	1	1 s	
d_c2_haut_o		Liaison_1	Bool	d_c2_haut_o	I 0.4	1	1 s	
d_c3_bas_f		Liaison_1	Bool	d_c3_bas_f	I 1.3	1	1 s	
d_c3_bas_o		Liaison_1	Bool	d_c3_bas_o	I 1.2	1	1 s	
d_c3_haut_f		Liaison_1	Bool	d_c3_haut_f	I 1.1	1	1 s	
d_c3_haut_o		Liaison_1	Bool	d_c3_haut_o	I 1.0	1	1 s	
d_c4_bas_f		Liaison_1	Bool	d_c4_bas_f	I 1.7	1	1 s	
d_c4_bas_o		Liaison_1	Bool	d_c4_bas_o	I 1.6	1	1 s	
d_c4_haut_f		Liaison_1	Bool	d_c4_haut_f	I 1.5	1	1 s	
d_c4_haut_o		Liaison_1	Bool	d_c4_haut_o	I 1.4	1	1 s	
d_cyc1_bas_f		Liaison_1	Bool	d_cyc1_bas_f	I 0.1	1	1 s	
l_c1_bas_f		Liaison_1	Bool	l_c1_bas_f	M 1.3	1	1 s	
l_c1_bas_o		Liaison_1	Bool	l_c1_bas_o	M 1.2	1	1 s	
l_c2_bas_f		Liaison_1	Bool	l_c2_bas_f	M 1.7	1	1 s	
l_c2_bas_o		Liaison_1	Bool	l_c2_bas_o	M 1.6	1	1 s	
l_c2_haut_f		Liaison_1	Bool	l_c2_haut_f	M 1.5	1	1 s	
l_c2_haut_o		Liaison_1	Bool	l_c2_haut_o	M 1.4	1	1 s	

Vue_1 | Variables

VARIABLES

Nom	Nom d'affichage	Connexion	Type de données	Mnémonique	Adresse	Eléments du ta...	Cycle d'acquisi...	Commen
d_c2_haut_f		Liaison_1	Bool	d_c2_haut_f	I 0.5	1	1 s	
d_c2_haut_o		Liaison_1	Bool	d_c2_haut_o	I 0.4	1	1 s	
d_c3_bas_f		Liaison_1	Bool	d_c3_bas_f	I 1.3	1	1 s	
d_c3_bas_o		Liaison_1	Bool	d_c3_bas_o	I 1.2	1	1 s	
d_c3_haut_f		Liaison_1	Bool	d_c3_haut_f	I 1.1	1	1 s	
d_c3_haut_o		Liaison_1	Bool	d_c3_haut_o	I 1.0	1	1 s	
d_c4_bas_f		Liaison_1	Bool	d_c4_bas_f	I 1.7	1	1 s	
d_c4_bas_o		Liaison_1	Bool	d_c4_bas_o	I 1.6	1	1 s	
d_c4_haut_f		Liaison_1	Bool	d_c4_haut_f	I 1.5	1	1 s	
d_c4_haut_o		Liaison_1	Bool	d_c4_haut_o	I 1.4	1	1 s	
d_cyc1_bas_f		Liaison_1	Bool	d_cyc1_bas_f	I 0.1	1	1 s	
l_c1_bas_f		Liaison_1	Bool	l_c1_bas_f	M 1.3	1	1 s	
l_c1_bas_o		Liaison_1	Bool	l_c1_bas_o	M 1.2	1	1 s	
l_c2_bas_f		Liaison_1	Bool	l_c2_bas_f	M 1.7	1	1 s	
l_c2_bas_o		Liaison_1	Bool	l_c2_bas_o	M 1.6	1	1 s	
l_c2_haut_f		Liaison_1	Bool	l_c2_haut_f	M 1.5	1	1 s	
l_c2_haut_o		Liaison_1	Bool	l_c2_haut_o	M 1.4	1	1 s	
l_c3_bas_f		Liaison_1	Bool	l_c3_bas_f	M 2.3	1	1 s	
l_c3_bas_o		Liaison_1	Bool	l_c3_bas_o	M 2.2	1	1 s	
l_c3_haut_f		Liaison_1	Bool	l_c3_haut_f	M 2.1	1	1 s	
l_c3_haut_o		Liaison_1	Bool	l_c3_haut_o	M 2.0	1	1 s	
l_c4_bas_f		Liaison_1	Bool	l_c4_bas_f	M 2.4	1	1 s	
l_c4_bas_o		Liaison_1	Bool	l_c4_bas_o	M 2.6	1	1 s	
l_c4_haut_f		Liaison_1	Bool	l_c4_haut_f	M 2.5	1	1 s	

Nom	Nom d'affichage	Connexion	Type de données	Mnémonique	Adresse	Eléments du ta...	Cycle d'acquisi...	Commen
d_c4_bas_f		Liaison_1	Bool	d_c4_bas_f	I 1.7	1	1 s	
d_c4_bas_o		Liaison_1	Bool	d_c4_bas_o	I 1.6	1	1 s	
d_c4_haut_f		Liaison_1	Bool	d_c4_haut_f	I 1.5	1	1 s	
d_c4_haut_o		Liaison_1	Bool	d_c4_haut_o	I 1.4	1	1 s	
d_cyc1_bas_f		Liaison_1	Bool	d_cyc1_bas_f	I 0.1	1	1 s	
l_c1_bas_f		Liaison_1	Bool	l_c1_bas_f	M 1.3	1	1 s	
l_c1_bas_o		Liaison_1	Bool	l_c1_bas_o	M 1.2	1	1 s	
l_c2_bas_f		Liaison_1	Bool	l_c2_bas_f	M 1.7	1	1 s	
l_c2_bas_o		Liaison_1	Bool	l_c2_bas_o	M 1.6	1	1 s	
l_c2_haut_f		Liaison_1	Bool	l_c2_haut_f	M 1.5	1	1 s	
l_c2_haut_o		Liaison_1	Bool	l_c2_haut_o	M 1.4	1	1 s	
l_c3_bas_f		Liaison_1	Bool	l_c3_bas_f	M 2.3	1	1 s	
l_c3_bas_o		Liaison_1	Bool	l_c3_bas_o	M 2.2	1	1 s	
l_c3_haut_f		Liaison_1	Bool	l_c3_haut_f	M 2.1	1	1 s	
l_c3_haut_o		Liaison_1	Bool	l_c3_haut_o	M 2.0	1	1 s	
l_c4_bas_f		Liaison_1	Bool	l_c4_bas_f	M 2.4	1	1 s	
l_c4_bas_o		Liaison_1	Bool	l_c4_bas_o	M 2.6	1	1 s	
l_c4_haut_f		Liaison_1	Bool	l_c4_haut_f	M 2.5	1	1 s	
l_cyc1_bas_f		Liaison_1	Bool	l_cyc1_bas_f	M 1.1	1	1 s	
l_cyc1_haut_o		Liaison_1	Bool	l_cyc1_haut_o	M 1.0	1	1 s	
marche_arret		Liaison_1	Bool	marche_arret	M 0.0	1	100 ms	
mode_débour...		Liaison_1	Bool	mode_débourage_2	M 0.2	1	1 s	
mode_débourr...		Liaison_1	Bool	mode_débourrage	M 0.1	1	1 s	
mode_débourr...		Liaison_1	Bool	mode_débourrage 3	M 0.3	1	1 s	

Nom	Nom d'affichage	Connexion	Type de données	Mnémonique	Adresse	Eléments du ta...	Cycle d'acquisi...	Commen
mode_débourr...		Liaison_1	Bool	mode_débourrage 3	M 0.3	1	1 s	
mode_débourr...		Liaison_1	Bool	mode_débourrage 4	M 0.4	1	1 s	
on_off_1		Liaison_1	Bool	on_off_1	I 2.0	1	1 s	
on_off_2		Liaison_1	Bool	on_off_2	I 2.1	1	1 s	
tempo_cyc_1		Liaison_1	Word	tempo_cyc_1	MW 500	1	1 s	
tempo_cyc_2		Liaison_1	Word	tempo_cyc_2	MW 600	1	1 s	
tempo_cyc_3		Liaison_1	Word	tempo_cyc_3	MW 700	1	1 s	
tempo_cyc_4		Liaison_1	Word	tempo_cyc_4	MW 800	1	1 s	
tempos_3		Liaison_1	Word	tempos_3	MW 300	1	1 s	
tempos_4		Liaison_1	Word	tempos_4	MW 400	1	1 s	
tempos_cyclon...		Liaison_1	Word	tempos_cyclonne_n°2	MW 200	1	1 s	
tempos_verrin...		Liaison_1	Word	tempos_verrin_haut	MW 100	1	1 s	
timer _3		Liaison_1	Timer	timer _3	T 3	1	1 s	
timer 5		Liaison_1	Timer	timer 5	T 5	1	1 s	
timer_ 1		Liaison_1	Timer	timer_ 1	T 1	1	1 s	
timer_2		Liaison_1	Timer	timer_2	T 2	1	1 s	
timer_4		Liaison_1	Timer	timer_4	T 4	1	1 s	
timer_6		Liaison_1	Timer	timer_6	T 6	1	1 s	
timer_7		Liaison_1	Timer	timer_7	T 7	1	1 s	
timer_8		Liaison_1	Timer	timer_8	T 8	1	1 s	
verin_cyclonn...		Liaison_1	Bool	verin_cyclonne 3_bas	Q 0.5	1	1 s	
verin_cyclonn...		Liaison_1	Bool	verin_cyclonne 3_haut	Q 0.4	1	1 s	
verin_cyclonn...		Liaison_1	Bool	verin_cyclonne_1_bas	Q 0.1	1	1 s	
verin_cyclonn...		Liaison_1	Bool	verin_cyclonne_1_haut	Q 0.0	1	100 ms	

Nom	Nom d'affichage	Connexion	Type de données	Mnémonique	Adresse	Eléments du ta...	Cycle d'acquisi...	Commen
tempo_cyc_2		Liaison_1	Word	tempo_cyc_2	MW 600	1	1 s	
tempo_cyc_3		Liaison_1	Word	tempo_cyc_3	MW 700	1	1 s	
tempo_cyc_4		Liaison_1	Word	tempo_cyc_4	MW 800	1	1 s	
tempos_3		Liaison_1	Word	tempos_3	MW 300	1	1 s	
tempos_4		Liaison_1	Word	tempos_4	MW 400	1	1 s	
tempos_cyclon...		Liaison_1	Word	tempos_cyclonne_n°2	MW 200	1	1 s	
tempos_verrin...		Liaison_1	Word	tempos_verrin_haut	MW 100	1	1 s	
timer _3		Liaison_1	Timer	timer _3	T 3	1	1 s	
timer 5		Liaison_1	Timer	timer 5	T 5	1	1 s	
timer_ 1		Liaison_1	Timer	timer_ 1	T 1	1	1 s	
timer_2		Liaison_1	Timer	timer_2	T 2	1	1 s	
timer_4		Liaison_1	Timer	timer_4	T 4	1	1 s	
timer_6		Liaison_1	Timer	timer_6	T 6	1	1 s	
timer_7		Liaison_1	Timer	timer_7	T 7	1	1 s	
timer_8		Liaison_1	Timer	timer_8	T 8	1	1 s	
verin_cyclonn...		Liaison_1	Bool	verin_cyclonne 3_bas	Q 0.5	1	1 s	
verin_cyclonn...		Liaison_1	Bool	verin_cyclonne 3_haut	Q 0.4	1	1 s	
verin_cyclonn...		Liaison_1	Bool	verin_cyclonne_1_bas	Q 0.1	1	1 s	
verin_cyclonn...		Liaison_1	Bool	verin_cyclonne_1_haut	Q 0.0	1	100 ms	
verin_cyclonn...		Liaison_1	Bool	verin_cyclonne4_bas	Q 0.7	1	1 s	
verin_cyclonn...		Liaison_1	Bool	verin_cyclonne4_haut	Q 0.6	1	1 s	
verrin_cyclonn...		Liaison_1	Bool	verrin_cyclonne2_bas	Q 0.3	1	1 s	
verrin_cyclonn...		Liaison_1	Bool	verrin_cyclonne2_haut	Q 0.2	1	1 s	

Figure IV.18: Siemens SIMATIC Manager STEP7 PLC Programming | mnemonic table.

IV.8 TEST TRANSFER OF PROGRAM INTO S7-PLCSIM (SIMULATION)

After programming the system, we tested its operation using S7-PLCSIM, which simulates the S7- 300 PLC controller. The program was uploaded to the CPU 315-2 PN/DP and run in RUN-P mode. During the simulation:

- We activated digital inputs and outputs and monitored the status changes. Timers were observed to ensure each cyclone operated for the correct duration. We verified the correct transfer of values between variables and outputs.
- We ensured that the cyclones activated in the proper sequence as programmed.

The simulation confirmed that the program functions efficiently and without logical errors, allowing us to proceed confidently to real-world implementation.

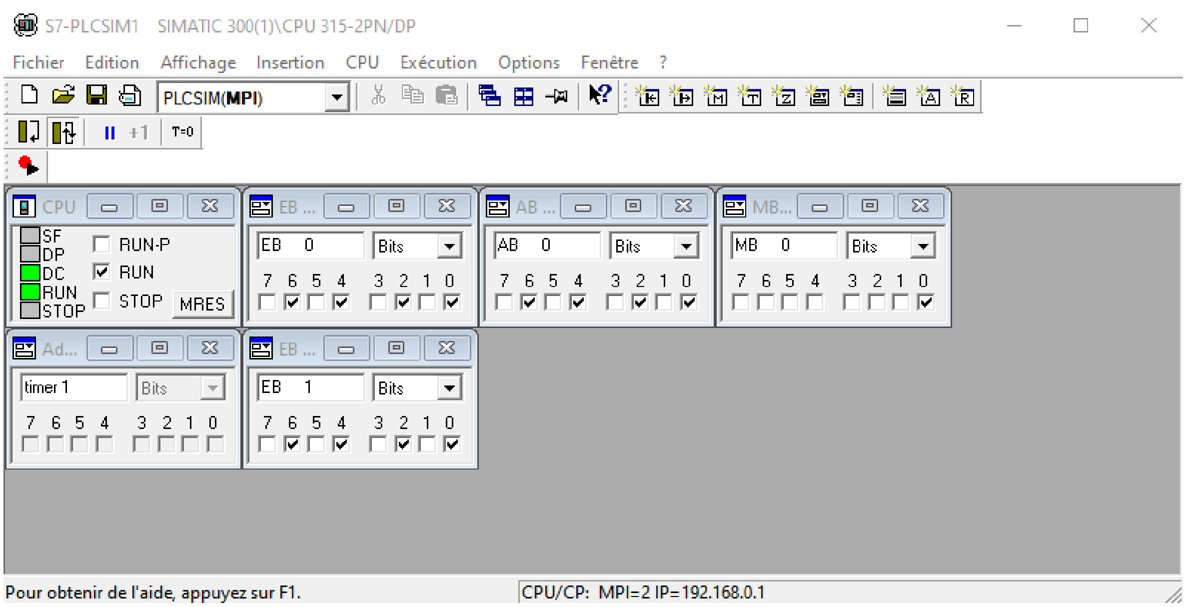


Figure IV.19: Flexible WinCC supervision.

IV.9 SUPERVISION (WINCC FLEXIBLE)

IV.9.1 View components

A supervision interface was developed using WinCC Flexible to monitor and control the dust recovery process through four cyclone units. Interface Description:

- Vue_1: The main screen shows a graphical representation of the cyclones, with indicator LEDs displaying the operational status of each unit and an alarm button.
- Vue_2: The settings screen allows the operator to: Set the timer (temporisation) for each cyclone.

- Choose the cleaning mode (mode de débourrage): manual or automatic.

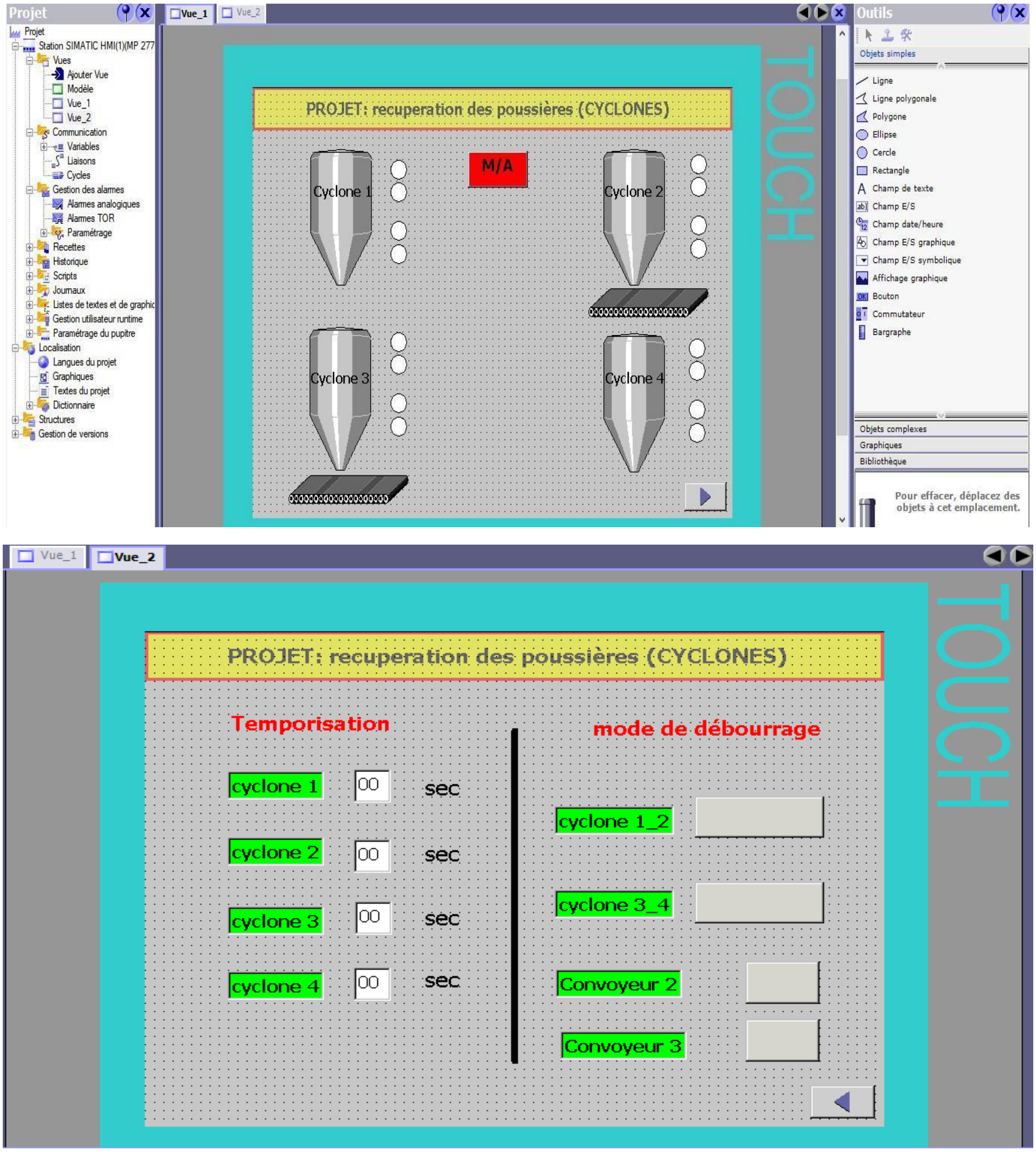


Figure IV.20: Flexible WinCC project creation.

IV.9.2 Operation Mode

The image shows the system in operation mode, where all cyclones are running and the green indicators confirm their active status. On the right, a section of the PLC program in Ladder language is displayed, where the control logic is executed using a timer to manage the movement of the upper and lower pistons for each cyclone.

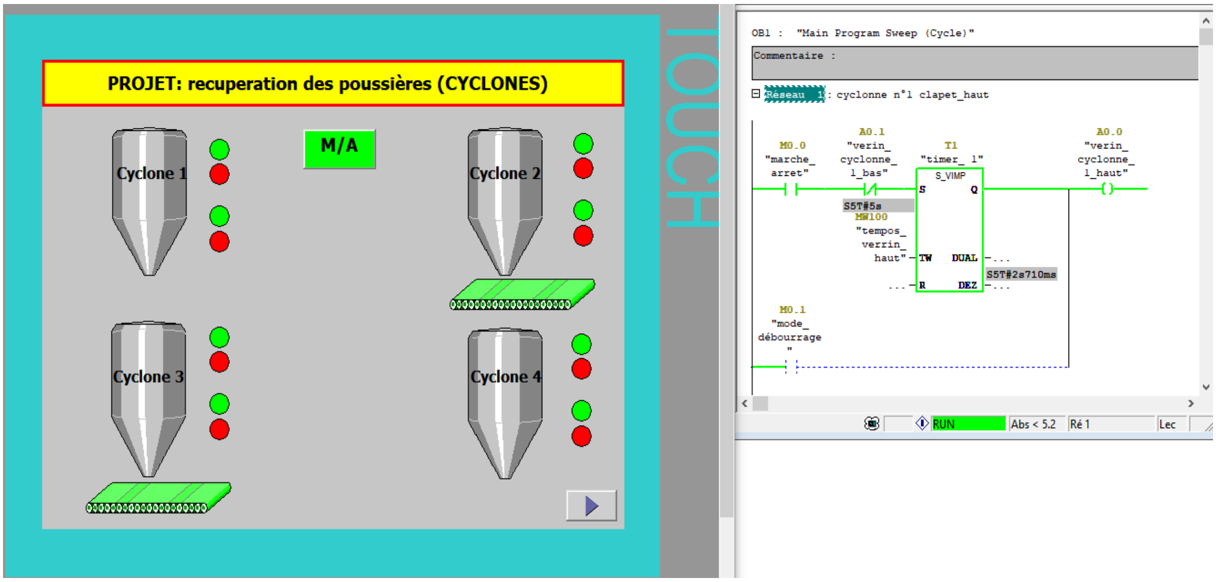


Figure IV.21: Cyclone Dust Recovery System in Operation Mode.

IV.10 CONCLUSION

In conclusion, the integration of automation technologies into cyclone dust collection systems represents a significant advancement in industrial process control. Through the use of PLCs, HMIs, and intelligent sensor networks, industries can achieve higher levels of efficiency, reliability, and environmental stewardship.

This chapter has presented a detailed overview of the key components, programming environments, and communication architectures that support such systems. As industries continue to prioritize smart manufacturing and sustainability, automation will remain an essential tool in optimizing performance and ensuring regulatory compliance across various sectors.

GENERAL CONCLUSION

This research has presented the conceptualization, development, and implementation of an automated dust collection system based on cyclone separation and supervised control, tailored to the operational needs of the Fertial-Annaba industrial facility. By integrating Siemens S7-300 PLCs with WinCC supervision tools, the proposed system enhances the efficiency of dust removal, enables precise process control, and supports real-time monitoring and fault detection.

The study has demonstrated that automation not only improves the operational reliability of cyclone systems but also contributes to compliance with environmental regulations and occupational safety standards. The implemented solution exemplifies how classical mechanical systems can be transformed into intelligent units capable of self-regulation and adaptive behavior in response to process dynamics.

Moreover, the methodology adopted in this project offers a replicable framework for other industrial applications seeking to modernize their environmental control systems. The use of standard industrial automation tools ensures scalability, interoperability, and ease of maintenance, thereby extending the system's applicability beyond the specific case of Fertial.

In conclusion, this thesis contributes to the field of industrial automation by showcasing the practical benefits of integrating programmable control and supervision technologies in environmental management systems. Future research directions may include the incorporation of advanced sensing technologies, data analytics, and machine learning algorithms to further optimize system performance and support predictive maintenance strategies.

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List of Annexes

Annex 1

SIEMENS

Data sheet **6ES7321-1BL00-0AA0**

SIMATIC S7-300, Digital input SM 321, Isolated 32 DI, 24 V DC, 1x 40-pole

Supply voltage	
Load voltage L+	
▪ Rated value (DC)	24 V
▪ permissible range, lower limit (DC)	20.4 V
▪ permissible range, upper limit (DC)	28.8 V
Input current	
from backplane bus 5 V DC, max.	15 mA
Power loss	
Power loss, typ.	6.5 W
Digital inputs	
Number of digital inputs	32
Input characteristic curve in accordance with IEC 61131, type 1	Yes
Number of simultaneously controllable inputs	
horizontal installation	
— up to 40 °C, max.	32
— up to 60 °C, max.	16
vertical installation	
— up to 40 °C, max.	32
Input voltage	
▪ Type of input voltage	DC
▪ Rated value (DC)	24 V
▪ for signal "0"	-30 to +5 V
▪ for signal "1"	13 to 30V
Input current	
▪ for signal "1", typ.	7 mA
Input delay (for rated value of input voltage)	
for standard inputs	
— parameterizable	No
— at "0" to "1", min.	1.2 ms
— at "0" to "1", max.	4.8 ms
— at "1" to "0", min.	1.2 ms
— at "1" to "0", max.	4.8 ms
Cable length	
▪ shielded, max.	1 000 m
▪ unshielded, max.	600 m
Encoder	
Connectable encoders	
▪ 2-wire sensor	Yes
— permissible quiescent current (2-wire sensor), max.	1.5 mA
Interrupts/diagnostics/status information	

Alarms	No
Diagnostics function	No
Alarms	
▪ Diagnostic alarm	No
▪ Hardware interrupt	No
Diagnostics indication LED	
▪ Status indicator digital input (green)	Yes
Potential separation	
Potential separation digital inputs	
▪ between the channels	No
▪ between the channels, in groups of	16
▪ between the channels and backplane bus	Yes; Optocoupler
Isolation	
Isolation tested with	500 V DC
connection method	
required front connector	40-pin
Dimensions	
Width	40 mm
Height	125 mm
Depth	120 mm
Weights	
Weight, approx.	260 g

Annex 2

SIEMENS

Data sheet **6ES7322-1BL00-0AA0**

SIMATIC S7-300, Digital output SM 322, isolated, 32 DO, 24 V DC, 0.5A, 1x 40-pole, Total current 4 A/group (16 A/module)

Supply voltage	
Load voltage L+	
▪ Rated value (DC)	24 V
▪ permissible range, lower limit (DC)	20.4 V
▪ permissible range, upper limit (DC)	28.8 V
Input current	
from load voltage L+ (without load), max.	160 mA
from backplane bus 5 V DC, max.	110 mA
Power loss	
Power loss, typ.	6.6 W
Digital outputs	
Number of digital outputs	32
Short-circuit protection	Yes; Electronic
▪ Response threshold, typ.	1 A
Limitation of inductive shutdown voltage to	L+ (-53 V)
Controlling a digital input	Yes
Switching capacity of the outputs	
▪ on lamp load, max.	5 W
Load resistance range	
▪ lower limit	48 Ω
▪ upper limit	4 kΩ
Output voltage	
▪ for signal "1", min.	L+ (-0.8 V)
Output current	
▪ for signal "1" rated value	0.5 A
▪ for signal "1" permissible range for 0 to 40 °C, min.	5 mA
▪ for signal "1" permissible range for 0 to 40 °C, max.	0.6 A
▪ for signal "1" permissible range for 40 to 60 °C, min.	5 mA
▪ for signal "1" permissible range for 40 to 60 °C, max.	0.6 A
▪ for signal "1" minimum load current	5 mA
▪ for signal "0" residual current, max.	0.5 mA
Output delay with resistive load	
▪ "0" to "1", max.	100 µs
▪ "1" to "0", max.	500 µs
Parallel switching of two outputs	
▪ for uprating	No
▪ for redundant control of a load	Yes; only outputs of the same group
Switching frequency	
▪ with resistive load, max.	100 Hz
▪ with inductive load, max.	0.5 Hz

• with inductive load (acc. to IEC 60947-5-1, DC13), max.	0.5 Hz
• on lamp load, max.	10 Hz
Total current of the outputs (per group)	
horizontal installation	
— up to 40 °C, max.	4 A
— up to 60 °C, max.	3 A
vertical installation	
— up to 40 °C, max.	2 A
Cable length	
• shielded, max.	1 000 m
• unshielded, max.	600 m
Interrupts/diagnostics/status information	
Alarms	No
Diagnostics function	No
Alarms	
• Diagnostic alarm	No
Diagnoses	
• Diagnostic information readable	No
• Wire-break	No
• Short-circuit	No
• missing load voltage	No
Diagnostics indication LED	
• Rated load voltage PWR (green)	No
• Fuse OK FSG (green)	No
• Group error SF (red)	No
• Status indicator digital output (green)	Yes; per channel
• Channel fault indicator F (red)	No
Potential separation	
Potential separation digital outputs	
• between the channels	Yes
• between the channels, in groups of	8
• between the channels and backplane bus	Yes; Optocoupler
Isolation	
Isolation tested with	500 V DC
connection method	
required front connector	40-pin
Dimensions	
Width	40 mm
Height	125 mm
Depth	120 mm
Weights	
Weight, approx.	260 g

Annex 3

SIEMENS

Data sheet **6ES7315-2EH14-0AB0**

SIMATIC S7-300 CPU 315-2 PN/DP, Central processing unit with 384 KB work memory, 1st interface MPI/DP 12 Mbit/s, 2nd interface Ethernet PROFINET, with 2-port switch, Micro Memory Card required

General information	
HW functional status	01
Firmware version	V3.2
Product function	
▪ Isochronous mode	Yes; Via PROFIBUS DP or PROFINET interface
Engineering with	
▪ Programming package	STEP 7 V5.5 or higher
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	20.4 V
permissible range, upper limit (DC)	28.8 V
external protection for power supply lines (recommendation)	2 A min.
Mains buffering	
▪ Mains/voltage failure stored energy time	5 ms
▪ Repeat rate, min.	1 s
Input current	
Current consumption (rated value)	750 mA
Current consumption (in no-load operation), typ.	150 mA
Inrush current, typ.	4 A
I^2t	1 $A^2 \cdot s$
Power loss	
Power loss, typ.	4.65 W
Memory	
Work memory	
▪ integrated	384 kbyte
▪ expandable	No
Load memory	
▪ Plug-in (MMC)	Yes
▪ Plug-in (MMC), max.	8 Mbyte
▪ Data management on MMC (after last programming), min.	10 a
Backup	
▪ present	Yes; Guaranteed by MMC (maintenance-free)
▪ without battery	Yes; Program and data
CPU processing times	
for bit operations, typ.	0.05 µs
for word operations, typ.	0.09 µs
for fixed point arithmetic, typ.	0.12 µs
for floating point arithmetic, typ.	0.45 µs
CPU-blocks	

Number of blocks (total)	1 024; (DBs, FCs, FBs); the maximum number of loadable blocks can be reduced by the MMC used.
DB	
▪ Number, max.	1 024; Number range: 1 to 16000
▪ Size, max.	64 kbyte
FB	
▪ Number, max.	1 024; Number range: 0 to 7999
▪ Size, max.	64 kbyte
FC	
▪ Number, max.	1 024; Number range: 0 to 7999
▪ Size, max.	64 kbyte
OB	
▪ Size, max.	64 kbyte
▪ Number of free cycle OBs	1; OB 1
▪ Number of time alarm OBs	1; OB 10
▪ Number of delay alarm OBs	2; OB 20, 21
▪ Number of cyclic interrupt OBs	4; OB 32, 33, 34, 35
▪ Number of process alarm OBs	1; OB 40
▪ Number of DPV1 alarm OBs	3; OB 55, 56, 57
▪ Number of isochronous mode OBs	1; OB 61
▪ Number of startup OBs	1; OB 100
▪ Number of asynchronous error OBs	6; OB 80, 82, 83, 85, 86, 87 (OB83 only for PROFINET IO)
▪ Number of synchronous error OBs	2; OB 121, 122
Nesting depth	
▪ per priority class	16
▪ additional within an error OB	4

Counters, timers and their retentivity	
S7 counter	
▪ Number	256
Retentivity	
— adjustable	Yes
— preset	Z 0 to Z 7
Counting range	
— adjustable	Yes
— lower limit	0
— upper limit	999
IEC counter	
▪ present	Yes
▪ Type	SFB
▪ Number	Unlimited (limited only by RAM capacity)
S7 times	
▪ Number	256
Retentivity	
— adjustable	Yes
— preset	No retentivity
Time range	
— lower limit	10 ms
— upper limit	9 990 s
IEC timer	
▪ present	Yes
▪ Type	SFB
▪ Number	Unlimited (limited only by RAM capacity)
Data areas and their retentivity	
Retentive data area (incl. timers, counters, flags), max.	128 kbyte
Flag	
▪ Size, max.	2 048 byte
▪ Retentivity available	Yes; MB 0 to MB 2 047
▪ Retentivity preset	MB 0 to MB 15
▪ Number of clock memories	8; 1 memory byte
Data blocks	
▪ Retentivity adjustable	Yes; via non-retain property on DB

▪ Retentivity preset	Yes
Local data	
▪ per priority class, max.	32 768 byte; Max. 2048 bytes per block
Address area	
I/O address area	
▪ Inputs	2 048 byte
▪ Outputs	2 048 byte
of which distributed	
— Inputs	2 048 byte
— Outputs	2 048 byte
Process image	
▪ Inputs	2 048 byte
▪ Outputs	2 048 byte
▪ Inputs, adjustable	2 048 byte
▪ Outputs, adjustable	2 048 byte
▪ Inputs, default	128 byte
▪ Outputs, default	128 byte
Subprocess images	
▪ Number of subprocess images, max.	1; With PROFINET IO, the length of the user data is limited to 1600 bytes
Digital channels	
▪ Inputs	16 384
— of which central	1 024
▪ Outputs	16 384
— of which central	1 024
Analog channels	
▪ Inputs	1 024
— of which central	256
▪ Outputs	1 024
— of which central	256

Hardware configuration	
Number of expansion units, max.	3
Number of DP masters	
▪ integrated	1
▪ via CP	4
Number of operable FMs and CPs (recommended)	
▪ FM	8
▪ CP, PtP	8
▪ CP, LAN	10
Rack	
▪ Racks, max.	4
▪ Modules per rack, max.	8
Time of day	
Clock	
▪ Hardware clock (real-time)	Yes
▪ retentive and synchronizable	Yes
▪ Backup time	6 wk; At 40 °C ambient temperature
▪ Deviation per day, max.	10 s; Typ.: 2 s
▪ Behavior of the clock following POWER-ON	Clock continues running after POWER OFF
▪ Behavior of the clock following expiry of backup period	the clock continues at the time of day it had when power was switched off
Operating hours counter	
▪ Number	1
▪ Number/Number range	0
▪ Range of values	0 to 2^31 hours (when using SFC 101)
▪ Granularity	1 h
▪ retentive	Yes; Must be restarted at each restart
Clock synchronization	
▪ supported	Yes
▪ to MPI, master	Yes
▪ on MPI, device	Yes
▪ to DP, master	Yes; With DP slave only slave clock

▪ on DP, device	Yes
▪ in AS, master	Yes
▪ in AS, device	Yes
▪ on Ethernet via NTP	Yes; As client
Digital inputs	
Number of digital inputs	0
Digital outputs	
Number of digital outputs	0
Analog inputs	
Number of analog inputs	0
Analog outputs	
Number of analog outputs	0
Interfaces	
Number of industrial Ethernet interfaces	1; 2 ports (switch) RJ45
Number of PROFINET interfaces	1; 2 ports (switch) RJ45
Number of RS 485 interfaces	1; Combined MPI / PROFIBUS DP
Number of RS 422 interfaces	0
1. Interface	
Interface type	Integrated RS 485 interface
Isolated	Yes
Interface types	
▪ RS 485	Yes
▪ Output current of the interface, max.	200 mA
Protocols	
▪ MPI	Yes
▪ PROFIBUS DP master	Yes
▪ PROFIBUS DP device	Yes
▪ Point-to-point connection	No
MPI	
▪ Transmission rate, max.	12 Mbit/s
Services	
— PG/OP communication	Yes
— Routing	Yes
— Global data communication	Yes
— S7 basic communication	Yes
— S7 communication	Yes
— S7 communication, as client	No; but via CP and loadable FB
— S7 communication, as server	Yes
PROFIBUS DP master	
▪ Transmission rate, max.	12 Mbit/s
▪ max. number of DP devices	124
Services	
— PG/OP communication	Yes
— Routing	Yes
— Global data communication	No
— S7 basic communication	Yes; I blocks only
— S7 communication	Yes
— S7 communication, as client	No
— S7 communication, as server	Yes
— Equidistance	Yes
— Isochronous mode	Yes; OB 61; isochronous mode can only be used alternatively on PROFIBUS DP or PROFINET IO
— SYNC/FREEZE	Yes
— activation/deactivation of DP devices	Yes
— max. number of DP devices that can be activated/deactivated at the same time	8
— Direct data exchange (slave-to-slave communication)	Yes; as subscriber
— DPV1	Yes
Address area	
— Inputs, max.	2 kbyte

— Outputs, max.	2 kbyte
PROFIBUS DP slave	
▪ Transmission rate, max.	12 Mbit/s
▪ automatic baud rate search	Yes; only with passive interface
▪ Address area, max.	32
▪ User data per address area, max.	32 byte
Services	
— PG/OP communication	Yes
— Routing	Yes; Only with active interface
— Global data communication	No
— S7 basic communication	No
— S7 communication	Yes
— S7 communication, as client	No
— S7 communication, as server	Yes; Connection configured on one side only
— Direct data exchange (slave-to-slave communication)	Yes
— DPV1	No
Transfer memory	
— Inputs	244 byte
— Outputs	244 byte
2. Interface	
Interface type	PROFINET
Isolated	Yes
automatic detection of transmission rate	Yes; 10/100 Mbit/s
Autonegotiation	Yes
Autocrossing	Yes
Change of IP address at runtime, supported	Yes
Interface types	
▪ RJ 45 (Ethernet)	Yes
▪ Number of ports	2
▪ integrated switch	Yes
Protocols	
▪ MPI	No
▪ PROFINET IO Controller	Yes; Also simultaneously with IO-Device functionality
▪ PROFINET IO Device	Yes; Also simultaneously with IO Controller functionality
▪ PROFINET CBA	Yes
▪ PROFIBUS DP master	No
▪ PROFIBUS DP device	No
▪ Open IE communication	Yes; Via TCP/IP, ISO on TCP, and UDP
▪ Web server	Yes
▪ Media redundancy	Yes
PROFINET IO Controller	
▪ Transmission rate, max.	100 Mbit/s
Services	
— PG/OP communication	Yes
— Routing	Yes
— S7 communication	Yes; With loadable FBs, max. configurable connections: 14, max. number of instances: 32
— Isochronous mode	Yes; OB 61; isochronous mode can only be used alternatively on PROFIBUS DP or PROFINET IO
— IRT	Yes
— Shared device	Yes
— Prioritized startup	Yes
— Number of IO devices with prioritized startup, max.	32
— Number of connectable IO Devices, max.	128
— Of which IO devices with IRT, max.	64
— of which in line, max.	64
— Number of IO Devices with IRT and the option "high flexibility"	128
— of which in line, max.	61
— Number of connectable IO Devices for RT, max.	128
— of which in line, max.	128

— Activation/deactivation of IO Devices	Yes
— Number of IO Devices that can be simultaneously activated/deactivated, max.	8
— IO Devices changing during operation (partner ports), supported	Yes
— Number of IO Devices per tool, max.	8
— Device replacement without swap medium	Yes
— Send cycles	250 µs, 500 µs,1 ms; 2 ms, 4 ms (not in the case of IRT with "high flexibility" option)
— Updating time	250 µs to 512 ms (depending on the operating mode, see Manual "S7-300 CPU 31xC and CPU 31x, technical Data" for more details)
Address area	
— Inputs, max.	2 kbyte
— Outputs, max.	2 kbyte
— User data consistency, max.	1 024 byte
PROFINET IO Device	
Services	
— PG/OP communication	Yes
— Routing	Yes
— S7 communication	Yes; With loadable FBs, max. configurable connections: 14, max. number of instances: 32
— Isochronous mode	No
— IRT	Yes
— PROFIenergy	Yes; With SFB 73 / 74 prepared for loadable PROFIenergy standard FB for I-Device
— Shared device	Yes
— Number of IO Controllers with shared device, max.	2
Transfer memory	
— Inputs, max.	1 440 byte; Per IO Controller with shared device
— Outputs, max.	1 440 byte; Per IO Controller with shared device
Submodules	
— Number, max.	64
— User data per submodule, max.	1 024 byte
PROFINET CBA	
▪ acyclic transmission	Yes
▪ cyclic transmission	Yes
Open IE communication	
▪ Number of connections, max.	8
▪ Local port numbers used at the system end	0, 20, 21, 23, 25, 80, 102, 135, 161, 443, 8080, 34962, 34963, 34964, 65532, 65533, 65534, 65535
▪ Keep-alive function, supported	Yes
Protocols	
PROFIsafe	No
Redundancy mode	
Media redundancy	
— Switchover time on line break, typ.	200 ms; PROFINET MRP
— Number of stations in the ring, max.	50
Open IE communication	
▪ TCP/IP	Yes; via integrated PROFINET interface and loadable FBs
— Number of connections, max.	8
— Data length for connection type 01H, max.	1 460 byte
— Data length for connection type 11H, max.	32 768 byte
— several passive connections per port, supported	Yes
▪ ISO-on-TCP (RFC1006)	Yes; via integrated PROFINET interface and loadable FBs
— Number of connections, max.	8
— Data length, max.	32 768 byte
▪ UDP	Yes; via integrated PROFINET interface and loadable FBs
— Number of connections, max.	8
— Data length, max.	1 472 byte
Web server	
▪ supported	Yes
▪ User-defined websites	Yes
▪ Number of HTTP clients	5

communication functions / header	
PG/OP communication	Yes
Data record routing	Yes
Global data communication	
▪ supported	Yes
▪ Number of GD loops, max.	8
▪ Number of GD packets, max.	8
▪ Number of GD packets, transmitter, max.	8
▪ Number of GD packets, receiver, max.	8
▪ Size of GD packets, max.	22 byte
▪ Size of GD packet (of which consistent), max.	22 byte
S7 basic communication	
▪ supported	Yes
▪ User data per job, max.	76 byte
▪ User data per job (of which consistent), max.	76 byte; 76 bytes (with X_SEND or X_RCV); 64 bytes (with X_PUT or X_GET as server)
S7 communication	
▪ supported	Yes
▪ as server	Yes
▪ as client	Yes; via integrated PROFINET interface and loadable FB or via CP and loadable FB
▪ User data per job, max.	See online help of STEP 7 (shared parameters of the SFBs/FBs and of the SFCs/FCs of S7 Communication)
S5 compatible communication	
▪ supported	Yes; via CP and loadable FC
communication functions / PROFINET CBA (with set target communication load) / header	
▪ Setpoint for the CPU communication load	50 %
▪ Number of remote interconnection partners	32
▪ number of master/device functions	30
▪ total of all master/device connections	1 000
▪ data length of all incoming master/device connections, max.	4 000 byte
▪ data length of all outgoing master/device connections, max.	4 000 byte
▪ Number of device-internal and PROFIBUS interconnections	500
▪ Data length of device-internal und PROFIBUS interconnections, max.	4 000 byte
▪ Data length per connection, max.	1 400 byte

performance data / PROFINET CBA / remote interconnection / with acyclic transfer / header	
— Sampling interval, min.	500 ms
— Number of incoming interconnections	100
— Number of outgoing interconnections	100
— Data length of all incoming interconnections, max.	2 000 byte
— Data length of all outgoing interconnections, max.	2 000 byte
— data volume / as user data for remote interconnections / in the case of acyclic transmission / with PROFINET CBA / per connection / maximum	1 400 byte
performance data / PROFINET CBA / remote interconnection / with cyclic transfer / header	
— Transmission frequency: Transmission interval, min.	10 ms
— Number of incoming interconnections	200
— Number of outgoing interconnections	200
— Data length of all incoming interconnections, max.	2 000 byte
— Data length of all outgoing interconnections, max.	2 000 byte
— data volume / as user data for remote interconnections / with cyclical transfer / with PROFINET CBA / per connection / maximum	450 byte
performance data / PROFINET CBA / HMI variables via PROFINET / acyclic / header	
— Number of stations that can log on for HMI variables (PN OPC/iMap)	3; 2x PN OPC/1x iMap
— HMI variable updating	500 ms
— Number of HMI variables	200
— Data length of all HMI variables, max.	2 000 byte
performance data / PROFINET CBA / PROFIBUS proxy functionality / header	

— supported	Yes
— Number of linked PROFIBUS devices	16
— Data length per connection, max.	240 byte; Slave-dependent
Number of connections	
▪ overall	16
▪ usable for PG communication	15
— reserved for PG communication	1
— adjustable for PG communication, min.	1
— adjustable for PG communication, max.	15
▪ usable for OP communication	15
— reserved for OP communication	1
— adjustable for OP communication, min.	1
— adjustable for OP communication, max.	15
▪ usable for S7 basic communication	14
— reserved for S7 basic communication	0
— adjustable for S7 basic communication, min.	0
— adjustable for S7 basic communication, max.	14
▪ usable for S7 communication	14
— reserved for S7 communication	0
— adjustable for S7 communication, min.	0
— adjustable for S7 communication, max.	14
▪ total number of instances, max.	32
▪ usable for routing	X1 as MPI: max. 10; X1 as DP master: max. 24; X1 as DP slave (active): max. 14; X2 as PROFINET: 24 max.
S7 message functions	
Number of login stations for message functions, max.	16; Depending on the configured connections for PG/OP and S7 basic communication
Process diagnostic messages	Yes
simultaneously active Alarm-S blocks, max.	300
Test commissioning functions	
Status block	Yes; Up to 2 simultaneously
Single step	Yes
Number of breakpoints	4
Status/control	
▪ Status/control variable	Yes
▪ Variables	Inputs, outputs, memory bits, DB, times, counters
▪ Number of variables, max.	30
— of which status variables, max.	30
— of which control variables, max.	14
Forcing	
▪ Forcing	Yes
▪ Forcing, variables	Inputs, outputs
▪ Number of variables, max.	10
Diagnostic buffer	
▪ present	Yes
▪ Number of entries, max.	500
— adjustable	No
— of which powerfail-proof	100; Only the last 100 entries are retained
▪ Number of entries readable in RUN, max.	499
— adjustable	Yes; From 10 to 499
— preset	10
Service data	
▪ can be read out	Yes
Ambient conditions	
Ambient temperature during operation	
▪ min.	0 °C
▪ max.	60 °C
configuration / header	
Configuration software	
▪ STEP 7	Yes; V5.5 or higher
configuration / programming / header	

▪ Command set	see instruction list
▪ Nesting levels	8
▪ System functions (SFC)	see instruction list
▪ System function blocks (SFB)	see instruction list
Programming language	
— LAD	Yes
— FBD	Yes
— STL	Yes
— SCL	Yes
— CFC	Yes
— GRAPH	Yes
— HiGraph®	Yes
Know-how protection	
▪ User program protection/password protection	Yes
▪ Block encryption	Yes; With S7 block Privacy
Dimensions	
Width	40 mm
Height	125 mm
Depth	130 mm
Weights	
Weight, approx.	340 g