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Enhancing Efficiency in Can Manufacturing: A PLC Migration Project from Hardwired Electronics to Siemens S7-1500

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Dedication

To my beloved parents, Youcef and Sabah, words cannot fully express my gratitude for your constant support and encouragement. You have been the bedrock of my achievements, instilling in me the values of hard work and perseverance. Your sacrifices and unwavering belief in my potential have inspired me to strive for excellence at every turn. From my earliest memories to this momentous occasion, you have been my guiding stars, illuminating my path and lifting me during challenging times. You are, and will always remain, the two people closest to my heart, and I am endlessly grateful for the love and wisdom you've shared with me.

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To my teachers, who treated us with kindness and never left us without support. Their genuine approach and dedication have allowed us to gain invaluable knowledge and experience. I am deeply thankful for the guidance they provided, shaping my academic journey in ways I will always cherish.

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Thank you all for being an integral part of my journey.

Mehdi Quods

Dedication

To my family,

for your undless love, constant support, and strong encouragement throughout my studies and the challenges of this thesis. Your belief in me has been my greatest motivation, your support is my key to show all my capabilities.

To my teachers,

who have guided my learning and inspired my curiosity. and contributed in building the skills I have today.

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This thesis is dedicated to you all with my deepest gratitude

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Abstract

Modernizing aging industrial control systems is essential for improved reliability and future adaptability. This project implements a control system upgrade for the Soudronic FBB 5600 welding machine. Critical hardware components are retained, while the core supervisory logic is migrated to a Siemens S7-1500 PLC. The sequential control logic is developed using Grafcet within Siemens TIA Portal. An integrated HMI provides operator control and—critically—precise fault diagnostics, displaying stoppage reasons directly to expedite troubleshooting. The system's functionality was validated using a 3D simulation in Visual Components. This approach demonstrates a practical modernization strategy for legacy equipment.

Keywords : PLC Modernization, Siemens S7-1500, TIA Portal, Grafcet, Visual Components, Fault Diagnostics, HMI.

Résumé

La modernisation des systèmes de contrôle industriel vieillissants est essentielle pour améliorer la fiabilité et l'adaptabilité future. Ce projet met en œuvre une mise à niveau du système de contrôle du poste de soudage Soudronic FBB 5600. Les composants matériels critiques sont conservés, tandis que la logique de supervision principale est migrée vers un automate programmable industriel Siemens S7-1500. La logique de contrôle séquentiel est développée à l'aide de Grafcet dans Siemens TIA Portal. Une IHM intégrée permet le contrôle opérateur et, point crucial, un diagnostic précis des pannes, affichant directement les causes d'arrêt pour accélérer le dépannage. La fonctionnalité du système a été validée par une simulation 3D dans Visual Components. Cette approche démontre une stratégie de modernisation concrète pour les équipements existants.

Mots-clés : Modernisation d'automate, Siemens S7-1500, TIA Portal, Grafcet, Visual Components, Diagnostic des pannes, IHM.

ملخص

يُعد تحديث أنظمة التحكم الصناعية القديمة أمرًا بالغ الأهمية لتحسين الموثوقية والقدرة على التكيف في المستقبل. يُنفِّذ هذا المشروع ترقيةً لنظام التحكم لآلة اللحام Soudronic FBB 5600. يتم الاحتفاظ بمكونات الأجهزة الأساسية، بينما يتم نقل منطق الإشراف الأساسي إلى وحدة تحكم منطقية قابلة للبرمجة من Siemens S7-1500. تم تطوير منطق التحكم التسلسلي باستخدام Grafcet ضمن بوابة Siemens TIA. توفر واجهة المستخدم البشرية (HMI) المتكاملة تحكمًا للمشغل، وتشخيصات دقيقة للأعطال، مع عرض أسباب التوقف مباشرةً لتسريع عملية استكشاف الأخطاء وإصلاحها. تم التحقق من صحة وظائف النظام باستخدام محاكاة ثلاثية الأبعاد في Visual Components. يوضح هذا النهج استراتيجية عملية لتحديث المعدات القديمة.

الكلمات المفتاحية: تحديث وحدة التحكم المنطقية القابلة للبرمجة، Siemens S7-1500، بوابةTIA ، Grafcet، المكونات البصرية، تشخيص الأعطال، واجهة المستخدم البشرية.(HMI)

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Abreviation

- **FBB 5600** - Soudronic Orion FBB 5600 R/S Welding Machine
- **WIMA MONOFIL** - Wire profiling system
- **BI04/B107** - Safety clutch sensors
- **SI05** - Safety switch
- **G1/G2** - Spark generation outputs (A081 card)
- **T1** - Current transformer (5V/7600A feedback)
- **A059** - Converter Controller Card
- **c26** - Excitation current enable output (0V) A081 - Ignition Controller Card
- **A373** - Phase-Shift Controller Card
- **A377** - Current Controller Card
- **a6** - Current regulation activation (0V)
- **S7-1500** - Siemens PLC model (CPU 1512C-1 PN
- **TIA Portal V16** - Engineering software
- **FB** - Function Block
- **RS** - Reset-Set flip-flop (fault latching)
- **S0** - Emergency Stop button
- **S1/S2** - Preparation buttons
- **S3/S4** - Machine On/Off switches
- **S9/S10** - Feed/Wire control
- **S13** - Fault reset button
- **B14/B16** - Position sensors
- **B31/B33** - Overtemperature thermostats
- **M20** - Main Drive motor
- **Y2/Y5** - Vacuum/air injection valves
- **T4** - timer (3.2s)
- **T5** - timer (2.5s)
- **T14** - timer (1.6s)
- **R10.1** - Welding current potentiometer
- **R10.2** - Converter voltage potentiometer
- **3D Simulation VC** - Visual Components
- **Q** - Motor Protection Switch
- **U5/G0/M0** - Frequency Converters
- **OPC UA** - Open Platform Communications Unified Architecture (PLC-VC Integration)
- **Profinet** - Process Field Network

General introduction

The automation area is undergoing transformative growth, fueled by advanced technologies that forge interrelated industrial environments. This evolution drives significant gains in productivity and operational efficiency while dropping costs and human error. Enhanced safety protocols and consistent high-quality output are further hallmarks of this technological shift, enabling industries to meet rising market demands effectively.

Programmable Logic Controllers (PLCs) stand at the forefront of this revolution, offering matchless advantages: simplified troubleshooting through real-time diagnostics, flexible adaptation to process changes via software, and significant reductions in long-term maintenance costs. Their role as the intelligent control brain is now indispensable across modern manufacturing.

At EMB Azzaba, a key player in Algeria's metal packaging industry, precision welding is critical for ensuring container integrity. The Soudronic Orion FBB 5600R/S machine performs this vital sealing function. Still, its reliance on specialized hardwired electronic cards for core control presents operational challenges like complex fault tracing, dependency on obsolete components, and limited adaptability.

During our 45-day internship at EMB Azzaba, we developed a targeted modernization strategy for this system:

- Migrating higher-level logic to a PLC using **TIA Portal V16**
- Designing an intuitive **HMI interface** for operator control
- Validating functionality through 3D simulation using **Visual Components**

This approach leverages PLC advantages for operational flexibility and diagnostics while preserving specialized legacy hardware where necessary.
The work is presented as follows:

- **Chapter 1: Presentation of The Company**
- **Chapter 2: Fundamentals and Applications of PLCs**
- **Chapter 3: Welding Machine Process**
- **Chapter 4: PLC Programming, HMI Design & Simulation.**

This diploma project proves how PLC technology theoretically enhances manufacturing systems – providing EMB Azzaba with a reference framework for future modernization.

Chapter 1

Presentation Of The Company

Chapter1: Presentation of the company

1.1 Introduction:

Metal packaging serves as a reliable shield for food and products, delivering various assistances including affordability, ease of use, long-lasting preservation, robust protection, and efficient energy consumption.

In this chapter, we will concentrate on a subsidiary specifically focused on this area: the National Company EMB unit Azzaba.

1.2 Company's presentation:

1.2.1 National Company of Metals Packaging:

The company has been operating for over 70 years, founded during the colonial period and later nationalized. Today, it is a leader in the manufacturing sector, particularly in processing.
It operates through three production units located in Azzaba, Skikda, and Kouba.
Clients include both public and private sectors, featuring major Algerian institutions and industrial operators in the agri-food sector such as canned vegetables, fruits, and dairy products.

1.2.2 Company's History :

Metal packaging in Algeria started in the 1950s at the Kouba unit using French technology. Operations continued after independence in 1962, with the unit joining the National Steel Company in 1968. The dedicated metal packaging company was established in 1983. Technological upgrades in 1990 introduced automation. After restructuring in 1998, the EMB group acquired full ownership in 2002, forming EMB/FBF. Lastly, in 2017, it became the National Company of Metal Packaging (EPE EMB/spa) following mergersv [1].

1.2.3 National Company of Metals Packaging/Azzaba unit:

The factory has four main workshops, each for a specific production stage:

- **Printing Workshop:** Prints designs and labels on metal sheets using food-safe inks that resist sterilization.
- **Press Workshop:** Manufactures the bottoms and lids of boxes.
- **Forming Workshop:** Shapes cylindrical bodies of boxes from cut metal strips.
- **Crown Cap Workshop:** Produces metal caps for bottles with strict quality control for airtightness.
- **Key products:** 1/2H Food Can: Diameter: 73 mm, Height: 102 mm, Capacity: 390 ml [2].
- **4 oz Food Can:** Diameter: 52.6 mm, Height: 73 mm, Capacity: 140 ml.

1.2.4 Company organizational chart:

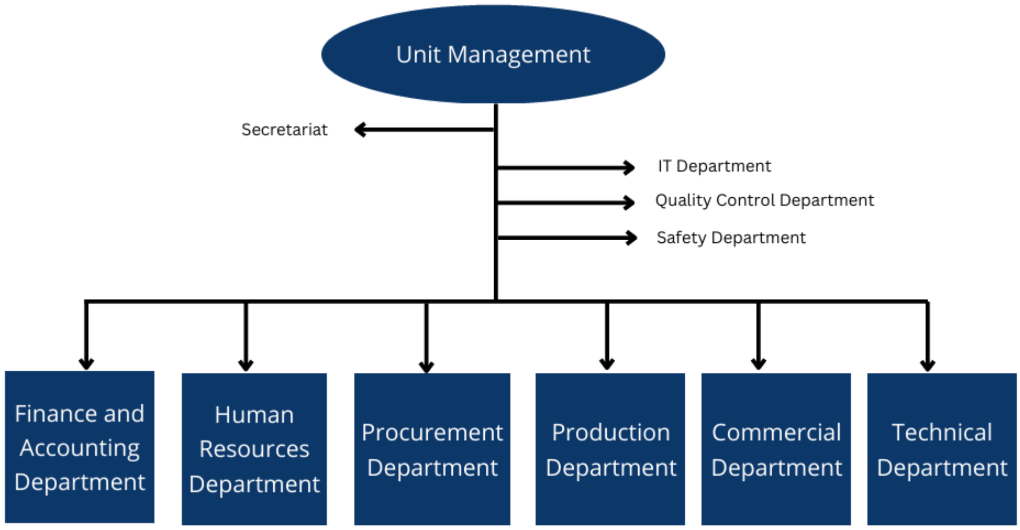

Figure 1: Azzaba unit organizational chart

1.2.5 Geographical position:

Figure 2: Geographical position of the company [3]

1.2.6 Company's Information:

Figure 3: Logo of EMB [2]

- **Location:** Azzaba, RN 44 BP193, Azzaba 21300.
- **Coordinates:** (36.7447093, 7.1439284).
- **Share Capital:** 3,596,400,000.00 DZD (as of 2017).
- **Start date**: 1950s.
- **Land operated**: 2.3554 hectares.

1.3 Problem Statement :

The existing soudronic FBB 5600 R/S control system faces some issues including complex diagnostics due to lack of real-time monitoring, obsolescence of proprietary electronic cards. Economically, high costs for part replacements and frequent downtime lead to significant losses. Current solutions, such as temporary repairs and retrofitting, fail to offer comprehensive modernization.

This research aims to fill the gap by proposing a PLC-based control architecture that reuses existing sensors, and ensures compliance with safety standards and also a sustainable approach to retrofitting legacy systems.

1.4 Motivation :

As senior electrotechnical engineering students with a strong passion for industrial automation, we have deliberately chosen to focus our final year project on a topic closely related to the industrial sector.

This decision reflects our desire to engage with real-world challenges and gain valuable hands-on experience, while also strengthening our technical expertise in automation.

Through this project, we aim to deepen our knowledge of programmable logic controllers (PLCs), industrial programming and problem-solving techniques.

This experience will not only enhance our professional skills but also better prepare us for our future careers as engineers.

1.5 Conclusion:

This chapter has explored the National Company of Metal Packaging, focusing on the Azzaba unit and its role in delivering reliable metal packaging.

We traced the company's history from its origins in the 1950s with French technology .

The organizational structure and strategic mergers have further strengthened its market position.

The National Company of Metal Packaging is a leading entity committed to providing high quality packaging products.

Chapter 2

Fundamentals And Applications Of PLC

Chapter 2: Fundamentals and applications of PLC

2.1 Introduction :

Programmable Logic Controllers (PLCs) are rugged industrial computers designed for reliable operation in harsh conditions like vibration, temperature shifts, humidity, and electrical noise. They excel at logic-based control using intuitive languages such as ladder logic and grafcet. Their modular I/O architecture adapts to both digital and analog tasks, forming a scalable, precise backbone for industrial automation.

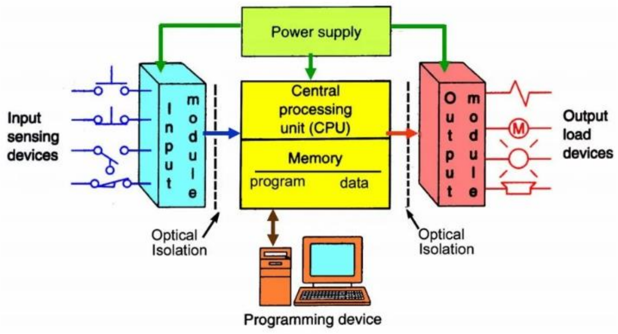

Figure 4: PLC System

2.2 Programmable Logic Controller (PLC) Architecture :

2.2.1 Hardware Architecture :

The Central Processing Unit (CPU) executes control logic, the Memory Unit stores programs and operational data.

The Power Supply converts AC to regulated DC power, Input/Output (I/O) Interface modules connect sensors and actuators, the Communication Interface enables external data exchange, and the Programming Device is used for program development and modification. These elements collectively form the essential hardwar [4].

2.2.2 Software Architecture :

PLC operation follows a continuous cyclic scan process. This cycle begins with the Input Scan, where the CPU reads the status of all connected input devices. During Program Execution, the stored control program processes this input data to compute the required output commands. Concurrently, Diagnostics & Communication tasks perform internal system checks and manage data exchange with external networks. The cycle concludes with the Output Update, sending the computed results to the output devices. The duration of this entire scan cycle depends on factors such as program complexity, I/O capacity, and communication demands [5].

2.3 PLC Programming Languages:

Control logic is implemented through standardized IEC 61131-3 languages [6] :

- Ladder Logic Diagram (LAD): Most widely adopted for its intuitive, relay-based design.
- Structured Control Language (SCL): contacts (inputs), coils (outputs), and logic rungs (AND/OR) replicating hardwired systems.
- Function Block Diagram (FBD): Uses graphical blocks like timers and counters with signal flow between them.
- Statement List (STL): Text-based, assembly-like language for complex algorithms.

2.4 Types of PLCs:

PLCs are classified as Fixed or Modular. Fixed PLCs feature integrated I/O within the microcontroller, offering a predetermined, non-expandable configuration suitable for simple applications with limited devices. Modular PLCs utilize interchangeable modules, enabling significant scalability, greater I/O capacity, and system customization (including memory expansion). Their independent modules also simplify fault detection and troubleshooting, reducing operational downtime [7].

2.5 Communication in PLCs:

Effective PLC communication relies on two fundamental components:

2.5.1 Physical Layer:

The physical layer comprises hardware components like cables, connectors, and signal standards. RS-232 supports data rates up to 3 Mbps over 50 feet, while RS-485 achieves 40 Mbps over 4,000 feet, making it predominant in industrial settings requiring longer distances and higher speeds. Ethernet hardware also enables high-speed network communication [8].

2.5.2 Communication Protocol:

Communication protocols define rules for reliable data exchange.
Open standards like Modbus RTU (serial-based) and Ethernet protocols (Modbus TCP/IP, EtherNet/IP, Profinet) have replaced proprietary systems.

Modbus (1979) remains widely adopted for its simplicity, while Ethernet protocols dominate modern installations due to high-speed capabilities, scalability, and multi-device support [9].

2.6 Applications of PLCs :

PLCs provide robust automation solutions across diverse sectors. In manufacturing, they synchronize assembly lines, packaging, and material handling. Process industries (chemical, food, pharmaceuticals) rely on PLCs to regulate critical parameters like temperature and pressure. Infrastructure systems use PLCs to control traffic signals, elevators, and building management (HVAC, lighting, security). Energy/utilities deploy them for power plant operations and grid management, while transportation systems utilize PLCs for railway signaling and baggage handling. This versatility makes PLCs foundational to industrial efficiency, safety, and reliability [10].

2.7 Advantages VS Disadvantages of PLCs:

2.7.1 Advantages:

It is easily repeat, modify, and replicate operations,flexibility,Faster real-time response to field events, relay-based systems and also robust communication with controllers/computers [11].

2.7.2 Disadvantages:

Requires specialized training for operation and also the configuration constraints (manufacturer-specific logic) and it needs regular maintenance for reliability [11].

2.8 Conclusion :

This chapter has shown how PLCs are the backbone of modern automation. They're flexible, reliable, and efficient-replacing old relay systems with smart, programmable controls. We've covered their core parts and how they communicate because understanding these basics is key to building effective systems. As technology grows, PLCs keep getting smarter with new features, but their role stays the same: essential controllers keeping industry running smoothly.

Chapter 3

Welding Machine Process

Chapter 3: Welding Machine Process

3.1 Introduction:

The Soudronic FBB 5600 welding machine uses special electronic cards to precisely control the welding process. This ensures every container has a perfect airtight seal while maintaining fast production speeds.

In this chapter we will focuse on the core subsystems of welding machine - from the pneumatic feeder that starts the process to the final seam welding stage. Additionally we will present the different views of the TIA portal, and the PLC used in our project.

3.2 Description of Soudronic Orion FBB 5600R/S:

The **Soudronic Orion FBB 5600R/S** is a fully automated production line for manufacturing cylindrical containers from tinplate. It integrates five key stations into one compact unit: a pneumatic sheet feeder, precision flexer, optional scoring mechanism, rollforming section, and seam welder. Operators primarily load stacks of pre-cut blanks and monitor operations.

The advanced welding system uses a continuous copper wire electrode that runs between the container and welding rollers. This design prevents tin contamination - where molten tin would normally stick to electrodes during welding.

The upgraded **WIMA MONOFIL** system processes this wire into a flat, strengthened profile that lasts longer [12].

Crucially, the same wire serves both upper and lower electrodes, significantly reducing material costs by up to 40% compared to conventional systems.

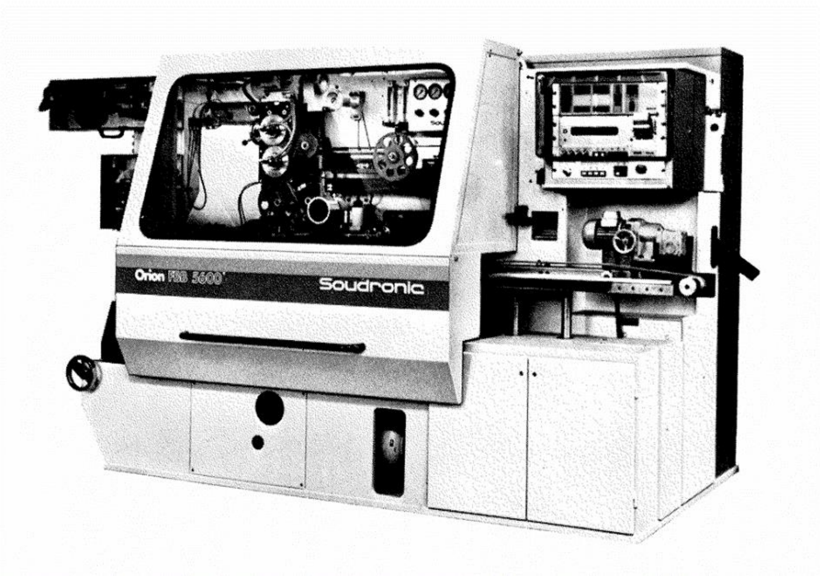

Figure 5: Orion FBB 5600R/S

Chapter 3: Welding Machine Process

Table 1: Key technical specifications of Soudronic Orion FBB 5600R/S welding system [12].

Specification	FBB 5600R/S Value
Working Range	
Sheet Thickness	0.15 - 0.25 mm (standard)
Body Diameter	52 - 105 mm
Body Height	90 - 140 mm
Performance	
Production Rate	600 cans/min (max)
Welding Speed	30 - 70 m/min
Key Utilities	
Power Supply	3-phase
Compressed Air	6 bar min, 50 Nm³/h
Cooling Water	8-9 bar, 35 l/min
Physical	
Machine Dimensions	3750 × 1500 × 1925 mm
Machine Weight	5100 kg

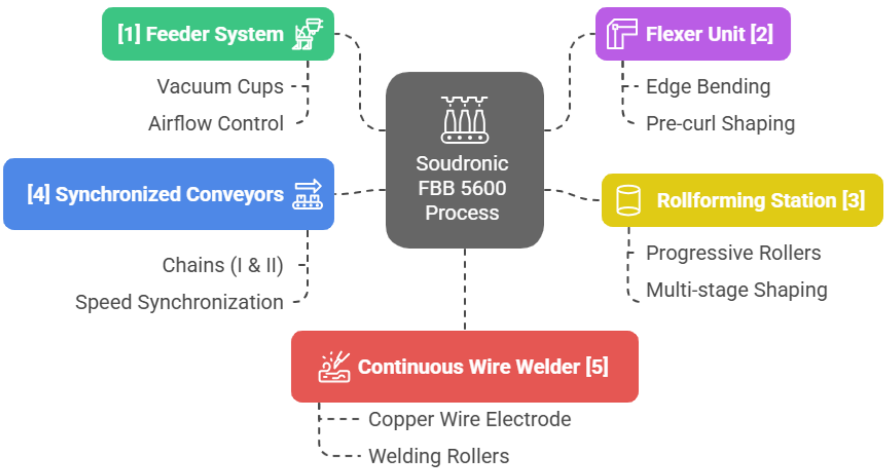

Figure 6: Process Overview of Welding machine

Figure 6 illustrates the Soudronic FBB 5600's automated workflow from blank feeding to welded containers. The pneumatic feeder (1) handles sheets without surface damage, while the flexer (2) prepares edges for forming. Rollforming rollers (3) gradually shape cylinders, transferred via synchronized conveyors (4) to the welder (5).

3.3 Main Machine Subsystems :

3.3.1 The Feeder System :

The feeder system reliably handles metal sheets from storage to quality check. Sheets wait stacked vertically before feeding begins. During standby, the **Blank Distributor** maintains constant airflow through **Output 1** - acting like a cooling breeze that prevents vacuum pump overheating.

When feeding starts, the distributor switches to **Output 2**, enabling both air injection **(Valve Y5)** to separate sheets and vacuum activation **(Valve Y2)** for suction cups to securely grab only the bottom sheet. Each sheet then moves to a detector station that checks for double sheets.If found, double sheets are automatically removed by the ejection system **(Valve Y3)**.

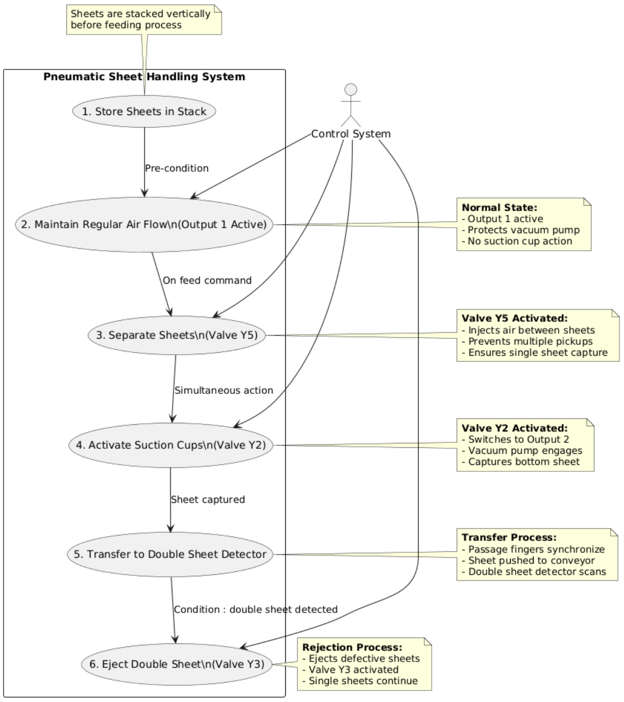

Figure 7: Pneumatic Sheet Feeder Workflow

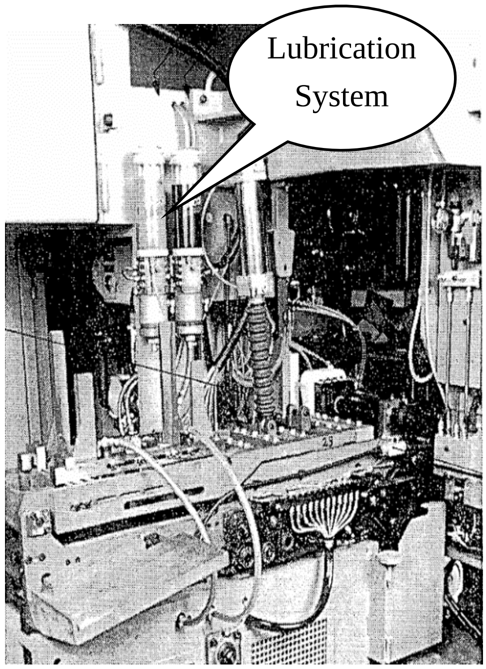

Figure 8: Feeder System

3.3.2 Transport System :

This system uses two synchronized transport chains (I and II) to move blanks and cylinders between stations. Mechanical safety guards protect operators while safety switches (BI04/B107 and SI05) automatically stop the system if needed.

The chains work together at coordinated speeds to transfer materials smoothly, and built-in overload protection prevents damage by temporarily disconnecting components during jams.

Figure 9: chain I

Figure 10: chain II

3.3.3 Welding System :

This integrated system uses a flat copper wire electrode running between motorized upper and lower welding wheels. The welding transformer generates high-current electricity that flows through this wire, creating perfect seams on tinplate cylinders, while the wire's flat shape prevents tin contamination.

The system efficiently transmits welding force and movement , with liquid-cooled wheels maintaining optimal temperatures throughout operation.

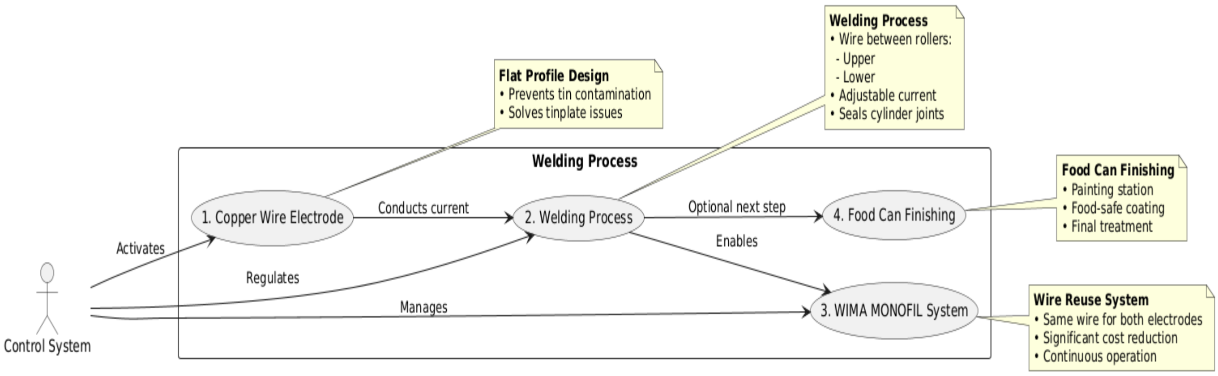

Figure 11: Soudronic FBB Welding System

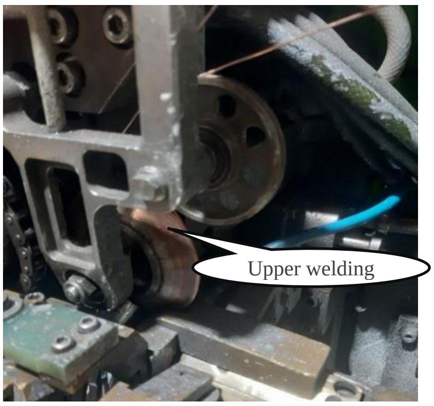

Figure 12: Upper welding roller

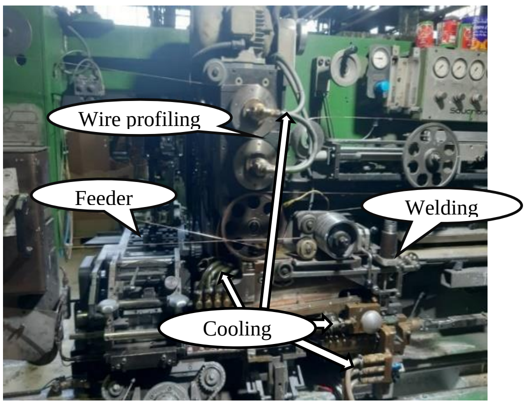

Figure 13: FBB Components

3.3.4 Lubrication System:

This welding machine employs an automatic, time-based lubrication system with separate oil and grease circuits. A lubrication cycle initiates at each power-on. Lubrication events for oil and grease are then triggered cyclically during normal machine operation (Main Drive On) based on pre-set timer intervals. Safety timers enforce a machine shutdown if lubrication fails within their maximum duration.

3.3.5 Cooling System:

An automatic cooling system activates at machine power-on. Eight separate water circuits continuously circulate cooling water through welding wheels, guides, and critical components for the entire duration of operation. Circulation stops when the machine is powered off. The system is monitored by an overtemperature sensor; if triggered, it causes an immediate machine shutdown to prevent damage.

3.4 Machine Control System Components:

3.4.1 Sensors and Operator Controls :

Table 2: Functional Groups of Input Sensors and Controls [12].

Category	Sensors/Inputs	Primary Role
Safety Interlocks	Emergency Stops (S0, S170-S175), Protective Door Switches (S110-S117), Safety Clutch Sensors (B35, B104, B107, S105, S108)	Immediate machine stop for personnel safety; ensure doors are closed.
Operational Monitoring	Position Sensors (B14, B16, S15, S100-S103, S106, S121-S123, S163, S173), Overtemperature Thermostats (B31, B33, B34, B1, B23, G0-B0, G0-B2), Speed Sensor (B82)	Monitor positions, temperatures, and speeds; prevent component damage.
Production Safeguards	Double Sheet Control (L2-L5), Wire Break Sensors (S100-S103)	Prevent welding errors from stacked sheets; detect broken wire.
Process Conditions	Pressure Switches (B30, B32, B126)	Monitor air/oil pressure for proper function.
Manual Control	Machine On/Off (S3, S4), Preparation (S1, S2), Feed/Wire (S9, S10), Reset (S13-S15)	Operator controls for states and functions.
Usage Tracking	Operation Hour Counter (P0)	Track machine runtime.

3.4.2 Actuators and Drive Systems :

Output devices execute physical actions based on input signals and control logic. These include motors for movement, valves for fluid control, and power systems for welding.

Table 3: Functional Groups of Output Actuators

Category	Components	Primary Role
Motion Systems	Main Drive (M20), Can Transport (M7), Wire Processing (M5-M6)	Drive welding wheels, material transport, and wire mechanisms
Fluid Systems	Pumps (M4, M9), Valves (Y1-Y10, Y30)	Handle vacuum, cooling, lubrication, and air/gas control
Power & Control	Welding Transformer (T1), Frequency Converters (U5, G0, M0)	Regulate power for welding, drives, and wire profiling
Motor Protection	Protection Switches (Q4-Q7, Q9, Q20, Q30-Q33)	Prevent motor damage from electrical faults

3.4.3 View of Operator’s Panel :

The operator control panel centralizes machine control, featuring an emergency stop (S0), state controls (S1-S4 for Preparation/Machine On/Off), and parameter adjustments via potentiometers (R10.1: welding current, R10.2: converter voltage, R11-R14: timing/current reduction). Function switches (S6-S10) handle current modulation, setup, feeder, and wire control, while utility buttons (S13-S16) manage fault resets, measurement toggling, lamp tests, and single-release mode. Production is tracked with piece counters (P1: total, P2: resettable).

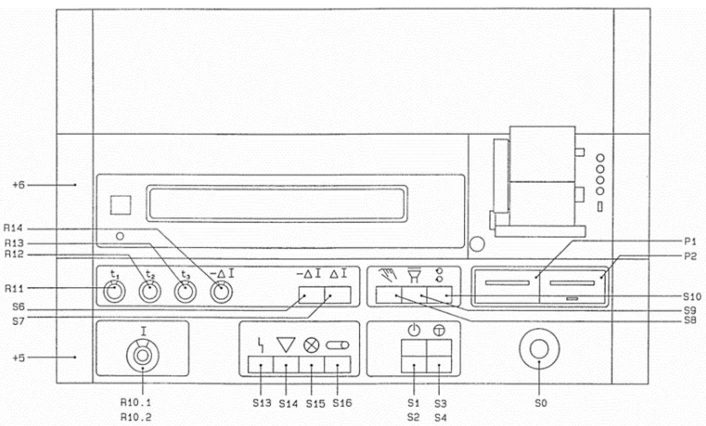

Figure 14: Welding Machine Control Panel [12].

3.5 Hardwired Cards vs Flexible PLCs:

The machine uses specialized electronic cards for control instead of a modern PLC. Its hierarchical design - from power regulation (C-supply) to specialized modules (current controllers, fault detectors) delivers hardwired precision for critical timing in hermetic seams.

This system has major drawbacks like troubleshooting faults is slow and complex, replacement cards are costly and obsolete, hard to find due to their outdated design and changes require physical rewiring.

Modern PLCs solve these issues with software flexibility, faster diagnostics, and lower lifetime costs.

3.5.1 Proposed Solution:

To solve these problemswe recommend switching to a Siemens **S7-1500** programmed with Grafcet.

This keeps the critical timing precision needed for hermetic seams while fixing all the main issues.

Operators can now find faults quickly using the PLC's built-in diagnostics and easy HMI screens, eliminating slow card tracing. Standard PLC parts replace the old, expensive cards-making replacements easy to find and cheaper over time. Changes to machine logic or timing are done through simple software updates instead of physical rewiring.

This creates a more reliable, adaptable system that costs less to maintain throughout its life.

3.6 TIA Portal:

The Totally Integrated Automation Portal (TIA Portal) is a unified software environment that integrates Siemens SIMATIC automation products. This platform enhances engineering efficiency by supporting all development phases of automation solutions within a single framework.

3.6.1 TIA Portal Views:

TIA Portal V16 offers two **task-specific workspaces** for project configuration:

- **Portal View**: Optimizes **task-driven workflows**, providing dedicated portals for streamlined access to tools and project data. This simplifies navigation for key engineering activities.
- **Project View**: Enables **object-oriented development**, displaying all project components hierarchically. Integrated editors allow direct modification of elements within this structured interface.

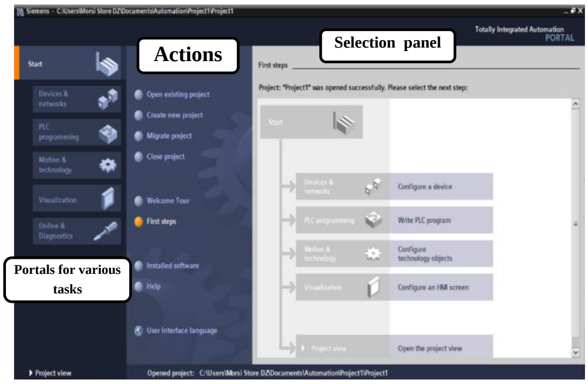

Figure 15: Portal View

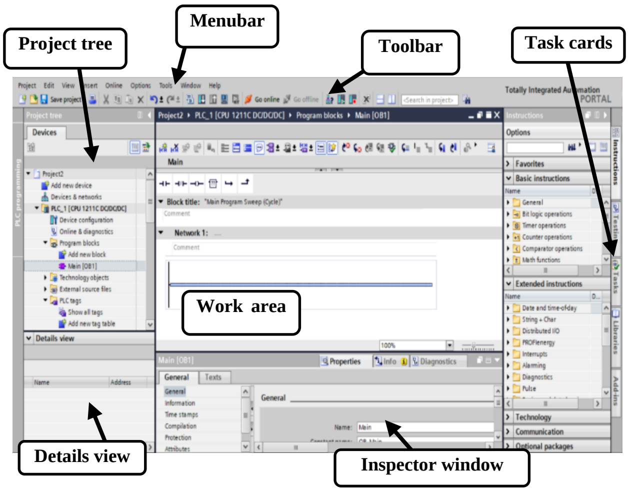

Figure 16: Project View

3.7 The PLC S7-1500:

3.7.1 Overview :

The **CPU 1512C-1 PN** is a compact controller in the SIMATIC S7-1500 series, designed for medium-performance automation tasks. It integrates digital/analog I/Os, PROFINET connectivity, and motion control functions, making it ideal for space-constrained applications like machine manufacturing and distributed control systems.

Table 4: SIMATIC S7-1500 CPU 1512C-1 PN Feature Specifications [13]

Feature	Specification
Processing Speed	48 ns/bit operation
Program Memory	250 KB
Data Memory	1 MB
Integrated I/Os	32 DI + 32 DO, 5 AI (4x U/I + 1x RTD), 2 AO
High-Speed Counters	6 (100 kHz)
Motion Control Axes	Up to 10 axes (4 ms cycle)
PROFINET Ports	1 × IRT interface (2-port switch)
Supply Voltage	24 V DC (19.2–28.8 V DC)
Display	3.45 cm integrated screen for diagnostics

Figure 17: S7-1500 CPU 1512C-1 PN [14]

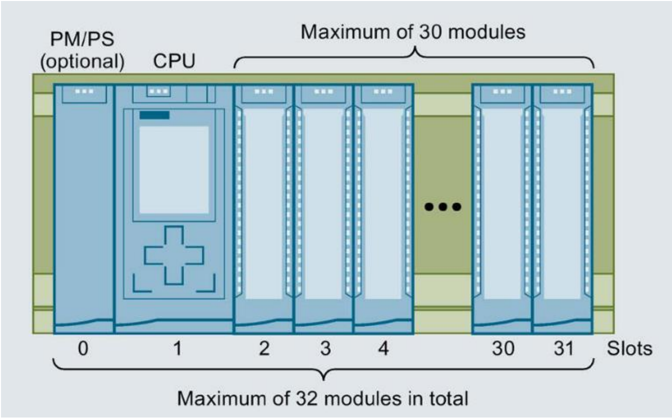

Figure 18: Maximum configuration [15]

3.7.2 Communication & Engineering :

- **PROFINET IRT**: Enables isochronous real-time communication (min. 250 µs cycle) for deterministic control [13].
- **TIA Portal Integration**: Programmable in STEP 7. Supports Grafcet, ladder logic, and safety programming with STEP 7 Safety Advanced 7 [13].
- **Web Server**: Remote diagnostics via web browser like monitoring I/O status for example [13].

3.7.3 Advantages Over Legacy Systems :

The CPU 1512C-1 PN offers substantial practical improvements, it reduces costs by **70%** and physical footprint by **25%** versus standard CPUs. Integrated diagnostics with plain-text error messages accelerate troubleshooting, while 32 GB memory cards enable quick recommissioning after upgrades [16].

3.8 Conclusion :

This chapter detailed the Soudronic FBB 5600's welding process, covering its core subsystems (feeder, transport, welding, lubrication, cooling) and control components. We highlighted the machine’s reliance on specialized hardwired cards-precise but inflexible, costly to maintain, and difficult to troubleshoot, so to modernize, we proposed migrating to a Siemens S7-1500 PLC using Grafcet in TIA Portal.

This upgrade retains critical timing precision while enabling faster diagnostics, software-based adjustments, and significant cost savings.

Chapter 4

PLC Programming, HMI Design & Simulation

Chapter 4: Programming, HMI Design & Simulation

4.1 Introduction:

This chapter builds a functional control system for the Soudronic FBB 5600 based on the modernization plan from Chapter 3. The machine's main control functions are moved to a modern Siemens S7-1500 PLC using a new touchscreen interface (HMI).To confirm it works correctly, we tested the system in a virtual 3D simulation environment.

4.2 S7-1500 Hardware Configuration :

The control system implementation extends the CPU 1512C-1 PN with expansion modules for I/O processing and dedicated Profinet drive integration. The following hardware was configured in TIA Portal:

-**Two Digital Input Module**: DI 32x24VDC BA_1, DI 32x24VDC BA_2
-**Analog Input Module:** AI 4xU/I/RTD/TC ST_1
-**Digital Output Module:** DQ 8x24VDC/2A HF_1
-**Analog Output Module:** AQ 4xU/I ST_1

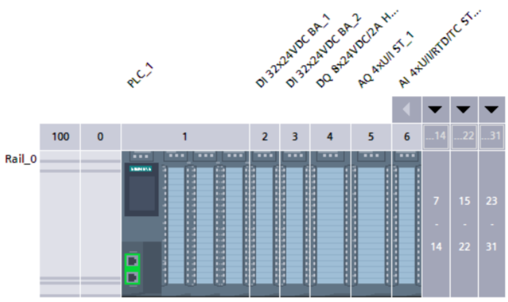

Figure 19 : Hardware Configuration

4.2.1 Profinet Drive Synchronization:

Three motor drives are synchronized via the CPU's integrated Profinet interface:

- **Main Drive:** Primary conveyor system propulsion.
- **Profiling Unit Drive:** Maintains wire tension through pressure application.
- **Chopper Unit Drive:** Executes precision wire cutting operations.

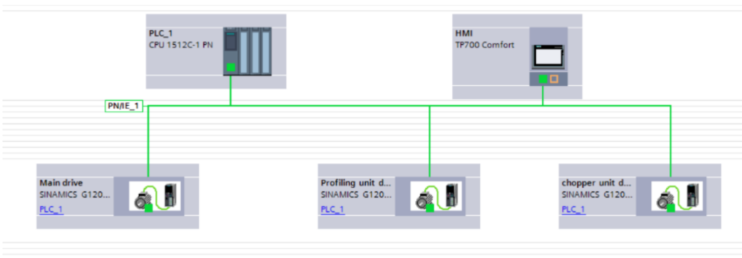

Figure 20 : Device & Network view

4.3 Programming: Grafcet Sequence

4.3.1 Process Overview :

The complete Grafcet control logic for the Soudronic FBB 5600 contains necessary operational details but can be complex to follow. To show the essential workflow clearly, we created a simplified Level 1 version. This keeps the main steps .

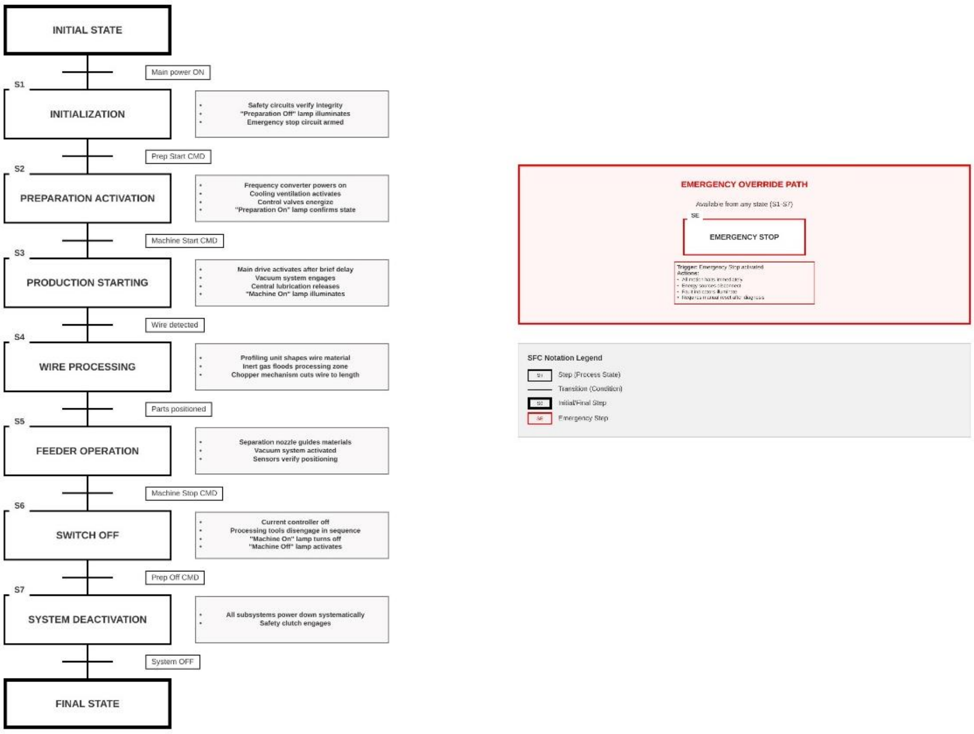

Figure 21 : (SFC) - Level 1

4.3.2 Timed Step Transition :

A controlled delay ensures safe state transitions in the sequence. During the "Preparation"step (**Figure 23**), activation of input t14 initiates a timer function (TON) configured for 1.6 seconds. Upon timeout completion, the timer energizes output coil Timer14 (**Figure 22**). This coil acts as the transition condition to advance to the "Machine On" step (**Figure 24**), ensuring all preparatory actions conclude before system activation.

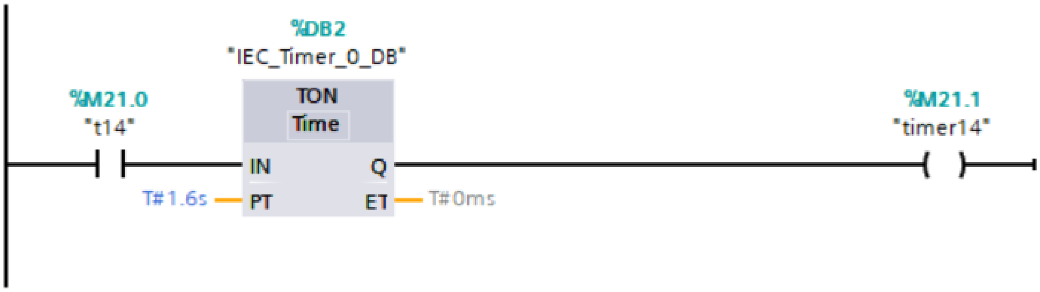

Figure 22 : Main Program Timer Handling Function

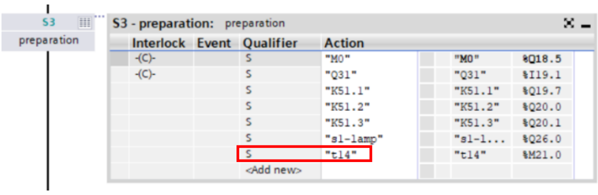

Figure 23 : t14 Activation in Preparation Step

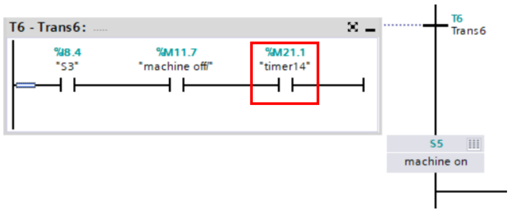

Figure 24 : Transition Condition to Machine On

4.3.3 Fault Monitoring:

The Grafcet design incorporates universal fault monitoring at every operational step. Two parallel transitions branch from each step:

- **Normal Progression Path:** Proceeds to the next step when all fault groups (Emergency Stop and Stop) are inactive (condition=1).
- **Immediate Safety Path:** Diverts to the Stop step if any fault group activates (Fault Active=1).

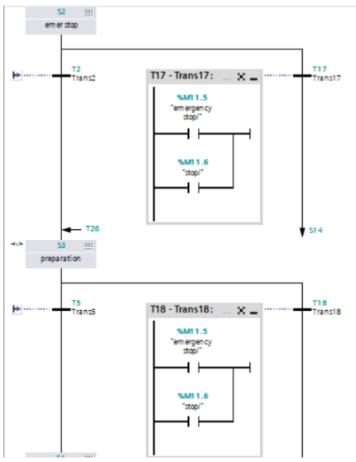

Figure 25 : Transition Branching Step

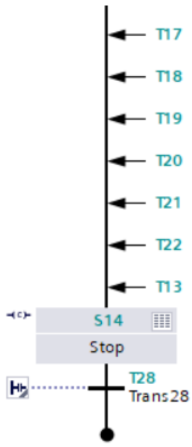

Figure 26 : Transition arrows to Stop step

4.4 Critical Card Functions and PLC Integration Sequence:

The welding process requires specialized analog circuits for high-speed control, so we retain four critical cards:

- **A059 (Converter Controller)**
- **A081 (Ignition Controller)**
- **A373 (Phase-Shift Controller)**
- **A377 (Current Controller)**

The PLC-managed Grafcet sequence interfaces directly with two of these cards-A059 and A377-through dedicated outputs.

The sequence initiates with wire handling motor activation, immediately starting the T4 delay (3.2s) for wire tension stabilization. Upon T4 expiration, the PLC sets A059/c26=0V, enabling excitation current in the converter and powering the A081 ignition card with 24V DC - this primes thyristors but prevents triggering until circuit completion. During the 3.2s-5.7s, the A373 card sends phase-synchronized pulses (0-180°) to A081, which generates 50µs sparks via G1/G2 outputs only during can contact, closing the circuit. Finally, at t=5.7s (T4+T5), the PLC sets A377/a6=0V, activating closed-loop current regulation and initiating real-time feedback processing from the current transformer (T1) to maintain precise secondary current (5V/7600A).

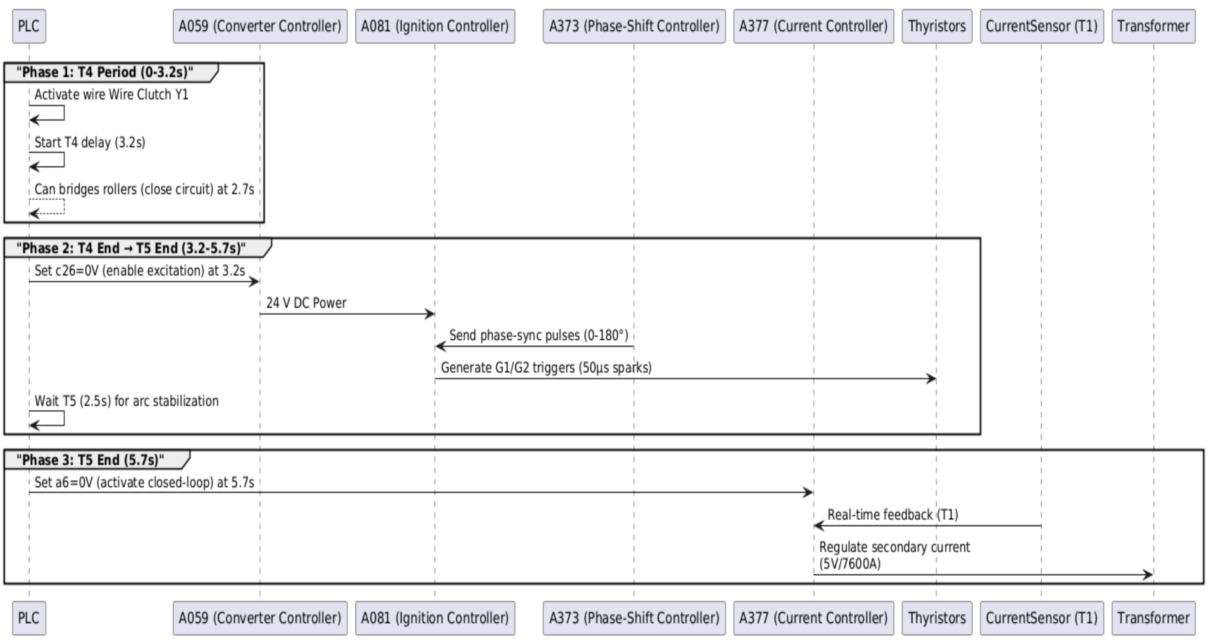

Figure 27 : Welding Control Sequence

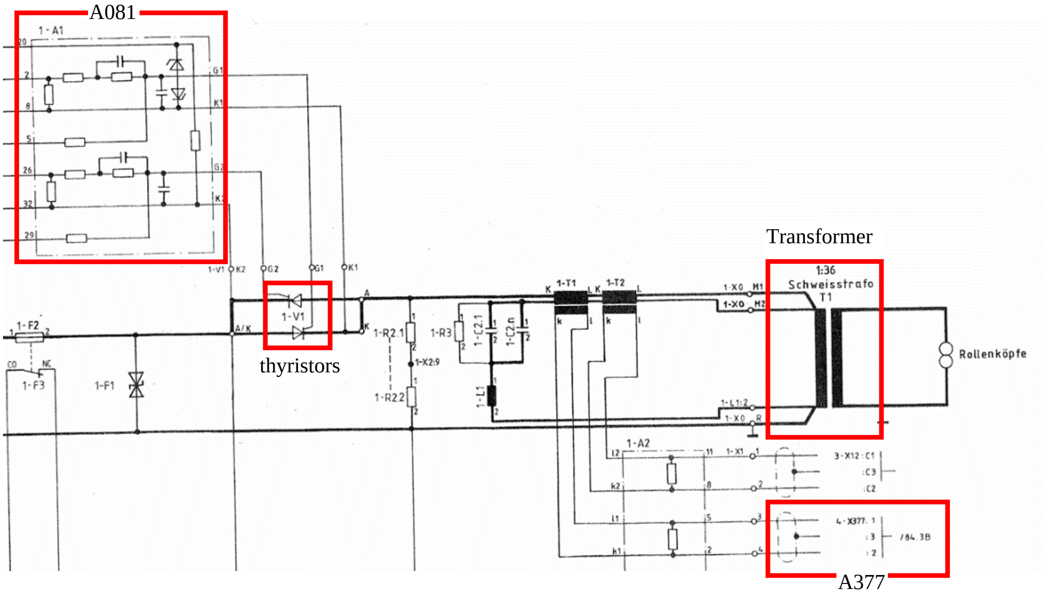

Figure 28 : Welding Power Stage Control Scheme (A081 & A377)

This system ensures energy flows only during can contact, with each card performing specialized functions.

4.5 Multi-Drive Speed Synchronization System:

The speed synchronization system for the can production line was implemented in Structured Control Language (SCL) within Siemens TIA Portal. This control logic employs a feed-forward with Proportional (P) feedback trim strategy to maintain precise synchronization between the main drive, profiling unit, and chopper.

The diagram simplifies the control architecture to clearly illustrate how synchronization is

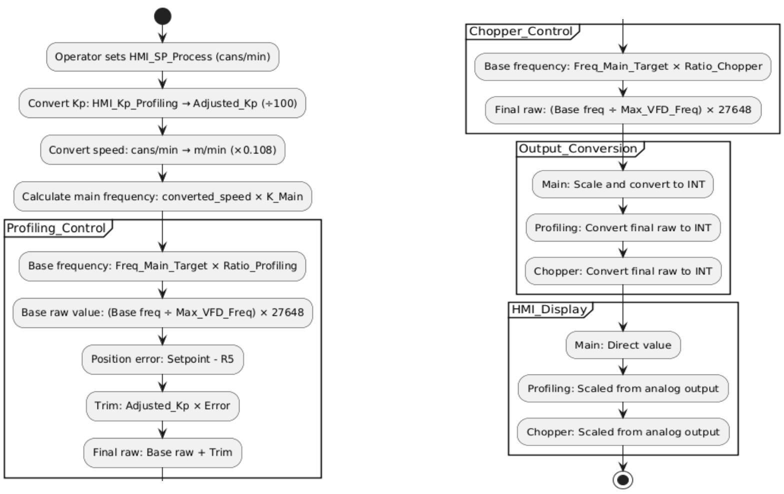

Figure 29 : Automated Drives Control Flow

4.6 HMI Interface:

The Human-Machine Interface (HMI) system comprises four specialized screens designed for operational clarity:

- **Home**: Drive frequencies, time, status lamps (Preparation/Start), and navigation.
- **Control**: Switch buttons for machine states and speed adjustment (cans/minute).
- **Alarm**: Auto-displays fault details during errors.
- **Status**: Fault reset (S13) and state of Sensors.
- **Configuration**: System monitoring of Delays and Kp Profiling.

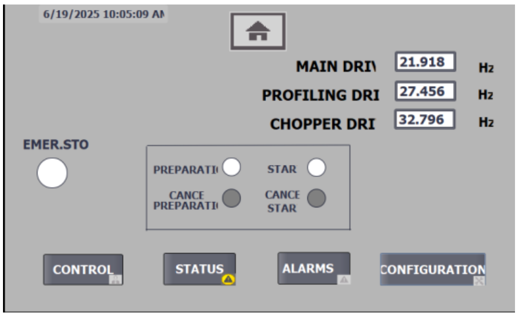

Figure 30 : Home Screen

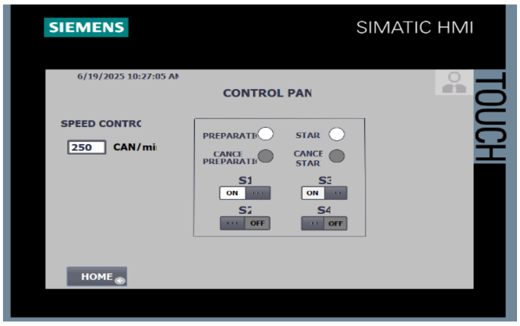

Figure 31 : Control Screen

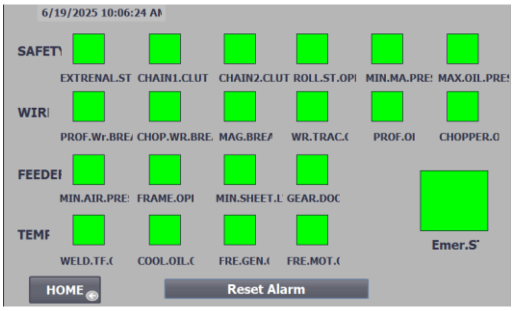

Figure 32 : Status Screen

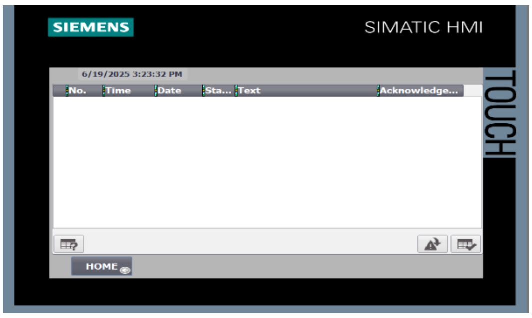

Figure 33 : Alarms Screen

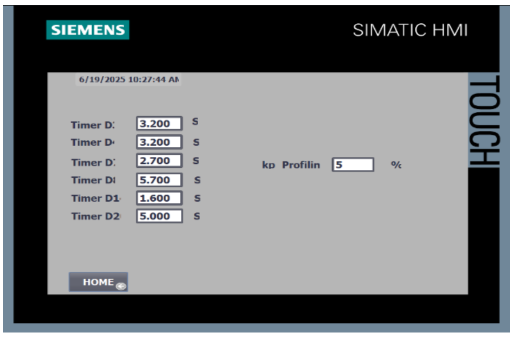

Figure 34 : Configuration Screen

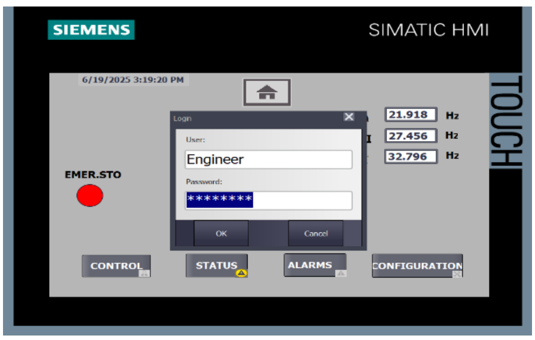

Figure 35 : Password For Configuration Screen

4.7 3D Simulation,Visual Components :

Visual Components is a 3D manufacturing simulation platform that enables creation of functional digital twins through physics-based modeling and real-time PLC integration via OPC UA. It validates mechanical kinematics, control logic, and production workflows before physical implementation [16].

We implemented a simplified 3D simulation of the Soudronic FBB 5600 can welding machine from scratch using Visual Components to virtually validate mechanical kinematics.

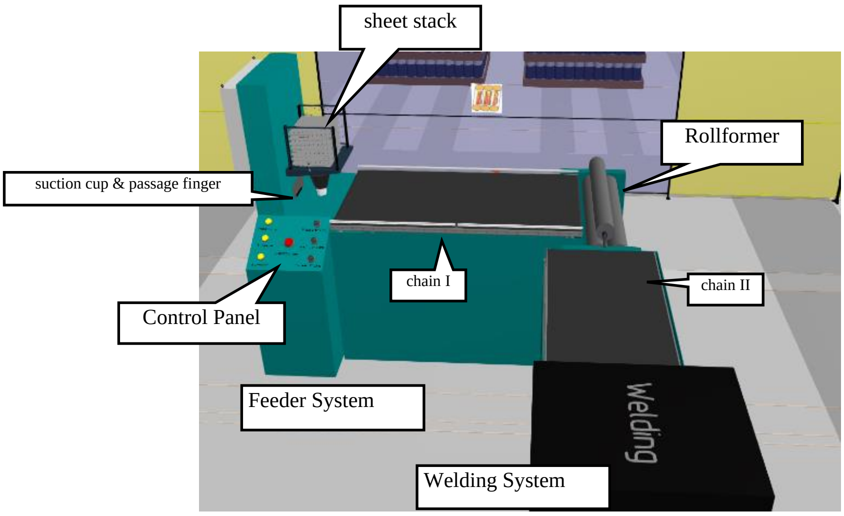

Figure 36 : Components of Welding Machine

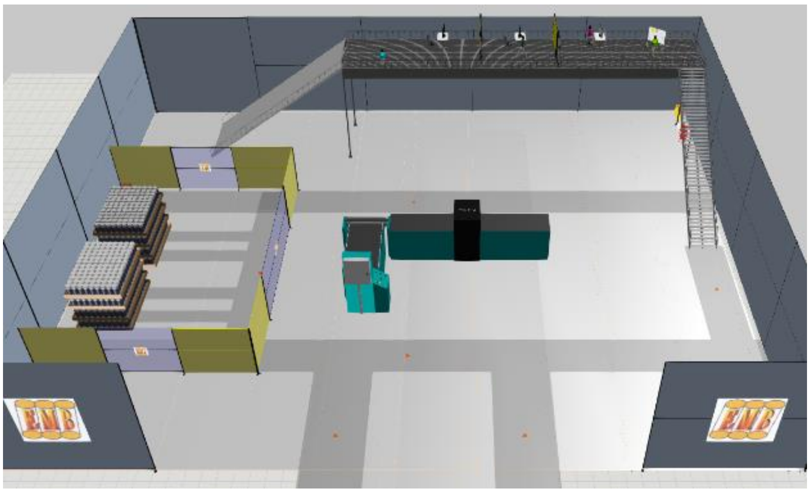

Figure 37 : Interface of the Factory

4.8 System Integration Validation :

The successful integration and operation of the PLC control system were validated through real-time monitoring in TIA Portal. **Figure 38** demonstrates the correct progression of the operational sequence, showing the "Feeder" step activated . This visual confirmation indicates that the sequence logic advanced as designed after the preceding "Wire" step, triggering the feeder subsystem precisely . And for **Figure 39** confirms the direct control of Profiling and Chopper motors were energized, as evidenced by their output coils being visibly activated in the ladder diagram.

This simultaneous verification of sequence progression and physical motor activation provides concrete evidence that the PLC program correctly interprets the Grafcet logic and successfully commands the machine's core electromechanical subsystems.

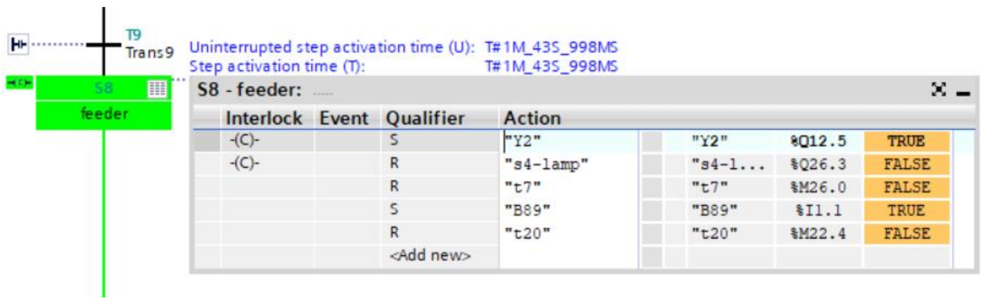

Figure 38 : Feeder Step Activation

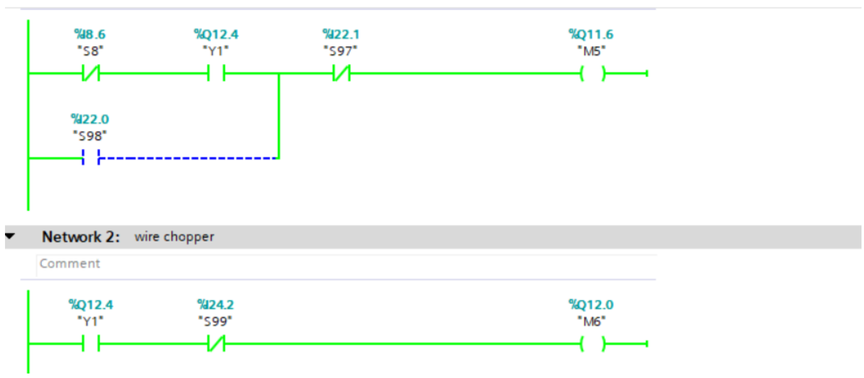

Figure 39 : Profiling & Chopper Motor

4.8.1 Validation of Emergency Stop Safety Logic:

To validate the safety logic, we deliberately activated the emergency stop. The RS flip-flop's priority logic was validated.The emergency stop signal (closed contact) sets the S input, causing the flip-flop to unconditionally latch the fault state "1". Crucially, while S remains active, pressing the S13 reset button (connected to R) cannot clear the fault due to the RS flip-flop's set-priority behavior. Even after deactivating the emergency stop (opening the contact and removing S), the fault state persists "1" reflected by a red indicator on the HMI Status screen. The fault only clears (switching to "0" with HMI green status) under two conditions:

- ✓ **The emergency stop signal is fully inactive (contact open), andThe S13 reset button is deliberately pressed (activating R).**

This sequence **(Figure 40)** confirms the system enforces strict safety (faults remain latched until both the emergency condition is resolved and manually acknowledged via S13, preventing unsafe resets during active emergencies).

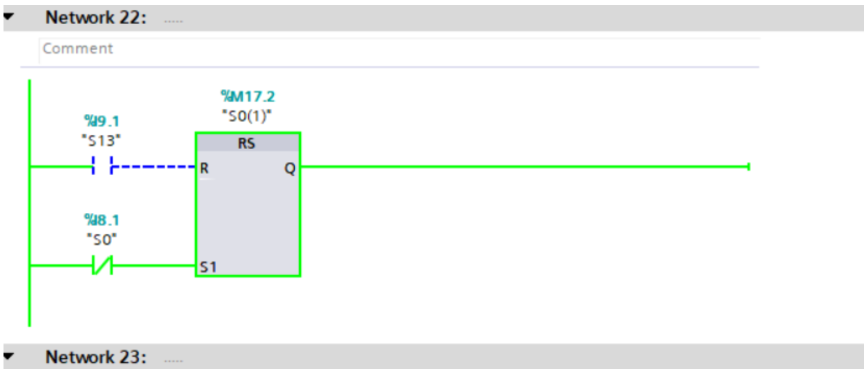

Figure 40 : RS Flip-Flop Safety

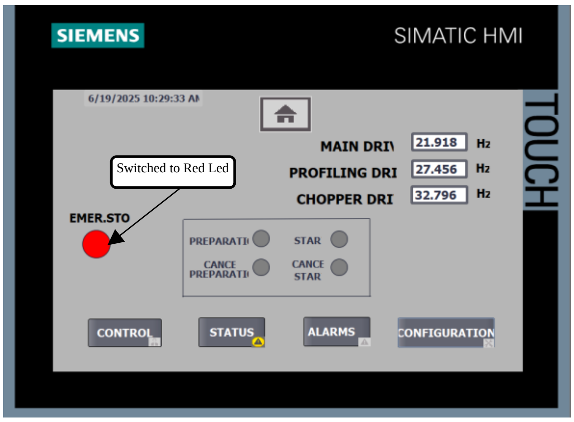

Figure 41 : Home Screen During Em.ST Fault

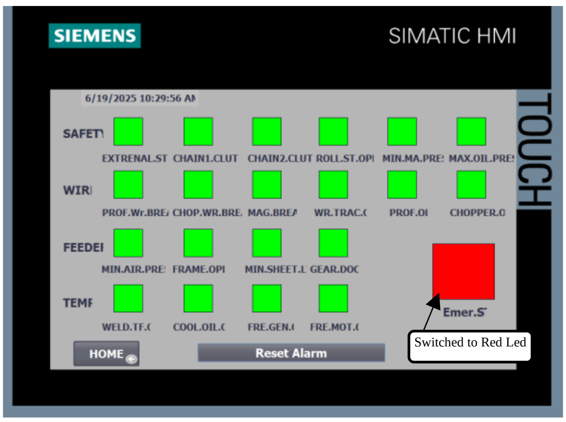

Figure 42 : Status Screen During Em.ST Fault

4.8.2 System Integration Validation (3D Simulation):

The synchronization between PLC logic and mechanical operation was confirmed using Visual Components . When the "Feeder" step activated in the Grafcet sequence , the 3D simulation start runing:

- ✓ Suction Cup Pickup: Suction cup captured a metal sheet from the sheet stock.
- ✓ Transfer: The sheet was lowered vertically.
- ✓ Passage Finger: The pusher moved the sheet onto the belt conveyor.
- ✓ Forming Process: The conveyor transported the sheet into the rollformer system, shaping it into a cylindrical can body.
- ✓ Welding Stage: The formed can proceeded to the welding zone for seam joining.

This real-time sequence verifies the PLC's Grafcet logic correctly commands the machine’s physical workflow from sheet handling to can formation.

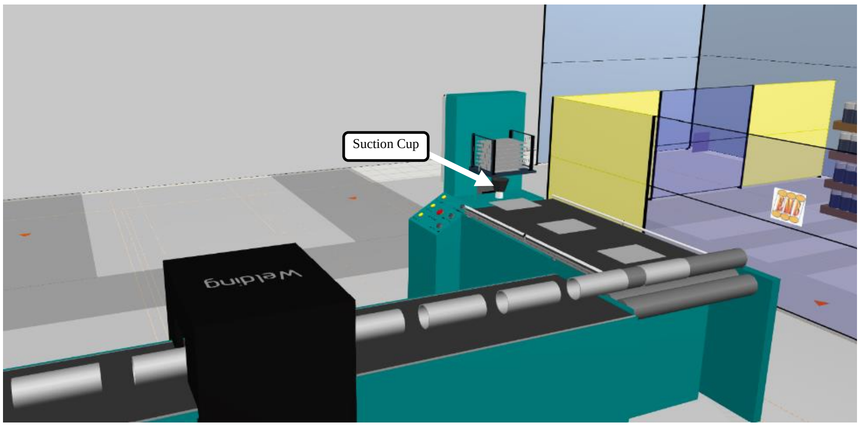

Figure 43 : 3D Simulation validation

4.9 Conclusion :

This chapter implemented the modernized control system using a Siemens S7-1500 PLC, Grafcet sequencing, and dedicated HMI. Validation confirmed: correct operational sequence progression, safety logic , and PLC-mechanical synchronization via 3D simulation. The integrated system meets all functional and safety requirements.

General conclusion

This Engineer Senior Project successfully modernized the control system of EMB Azzaba's Soudronic FBB 5600 welding machine by strategically replacing its obsolete hardwired electronics with a Siemens S7-1500 PLC architecture, while preserving critical cards (A059 ,A377,A081,A373) to maintain welding precision.

The implementation featured a multi-stage Grafcet sequence with timed transitions and fault monitoring at every operational step, synchronized three motors (main Drive, profiling unit, and chopper) via PROFINET integration, and developed an intuitive HMI interface with five specialized screens for operational control and diagnostics.

Comprehensive validation confirmed system reliability while the PLC logic integrity was verified through real-time TIA Portal monitoring showing correct sequence progression like safety protocols were rigorously tested by forcing emergency stops, proving the RS flip-flop's priority latching requires dual clearance (fault resolution + manual S13 reset) before resetting and also the mechanical synchronization was demonstrated through Visual Components 3D simulations where PLC commands triggered seamless sheet handling from suction cup pickup and finger transfer to rollforming and welding.

This modernization reduces maintenance costs and eliminates obsolescence dependencies, enhances operational flexibility through software updates, and establishes a replicable framework for retrofitting legacy industrial equipment, positioning EMB Azzaba for sustained productivity and technological advancement in metal packaging manufacturing.

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Business plan

Idée du Projet

Modernisation ciblée des systèmes industriels :
Remplacer les contrôles obsolètes (cartes électroniques, PLCs anciens, relais) par des **PLCs modernes** tout en :

- ✓ Conservant 100% des capteurs/actionneurs fonctionnels
- ✓ Remplaçant uniquement les composants défectueux par du reconditionné
- ✓ Utilisant des vidéos "avant/après" comme preuve de compétence

Phase initiale clé :

Travail gratuit sur 2-3 machines de l'ENSTI Annaba pour créer des démonstrations vidéo marketing.

Valeurs Défendues

Valeur	**Application Concrète**
Preuve par l'exemple	Vidéos comparatives comme portfolio technique
Économie circulaire	Réutilisation systématique des I/O fonctionnels
Accessibilité	Approche low-cost pour PMI locales
Transparence	Démonstrations tangibles des résultats
Partage	Bénéfice mutuel avec l'école (modernisation gratuite)

Équipe de Travail

Poste	**Mission Principale**	**Tâches Clés**
Fondatrice (Moi)	-Pilotage global & commercial -Support technique (cablage ,plc,diagnostic)	- Relations clients/écoles - Gestion financière - Marketing vidéos avant/après - Coordination projets
Ingénieur Automaticien	-Exécution technique	- Programmation TIA Portal - Câblage PLC - Diagnostic machines - Formation opérateurs

Stratégie de Communication

Cible	Canaux	Contenu Spécifique
Clients potentiels	LinkedIn + YouTube	Vidéos avant/après + témoignages
Équipe interne	Google Drive + Teams	Fiches techniques + planning
Grand public	Site web minimaliste	Portfolio projets + valeurs

Objectifs Clés

Échéance	Réalisations Techniques	Résultats Concrets
3 mois	Modernisation de 2 machines à l'ENSTI Annaba	2 vidéos "avant/après" pour notre portfolio
4 mois	Signature du 1er client payant	Chiffre d'affaires : 40 millions DZD
6 mois	Livraison de 3 projets clients	3 témoignages clients satisfaits
12 mois	Méthodes de travail standardisées	CA annuel : 300 millions DZD

Diagramm de Gantt

Tâche	Ressources	Début	Fin	Durée (jours)
Phase 1: Démonstration				
Modernisation machines ENSTI	Ingénieur+Étudiants+Moi	1/9/25	30/11/2025	90
Production vidéos marketing	moi	1/12/25	14/12/2025	14
Phase 2: Acquisition Client				
Prospection clients	moi	15/11/2025	30/11/2025	15
Signature 1er client	Client+Juridique	1/12/25	1/12/25	1
Phase 3: Livraison Projets				
Diagnostic Projet 2	Ingénieur	2/12/25	8/12/25	7
Modernisation Projet 2	Ingénieur	9/12/25	8/1/26	30
Diagnostic Projet 3	moi	8/1/26	16/1/2026	7
Modernisation Projet 3	Ingénieur	17/1/2026	30/2/2026	30
Diagnostic Projet 4	moi	3/3/26		7
Modernisation Projet 4	Ingénieur	9/12/25	31/3/2026	30
Témoignages clients	Clients	8/4/26	8/4/26	1
Phase 4: Standardisation				
Développement bibliothèque TIA	Ingénieur	1/1/26	31/07/2026	240
Formation opérateurs	Ingénieur+moi	1/7/26	31/08/2026	3
CA annuel 300M DZD	Equipe	31/08/2026	31/08/2026	1

Analyse Stratégique du Marché- Autech

Segment du Marché

Secteur : Industrie manufacturière algérienne (agroalimentaire, matériaux de construction, textile)
Cible : PMI (Petites et Moyennes Industries) équipées de machines >15 ans

Marché Potentiel

Critère	Détail	Lien avec mes objectifs
Type d'entreprises	PMI industrielles (50M-5B DZD CA)	Client idéal pour Projet 1 (40M DZD)
Localisation	Batna, Annaba, Constantine,Sétif	Proximité pour interventions rapides
Problème clé	Machines >15 ans (72% du parc)	Urgence - Besoin de modernisation
Secteurs prioritaires	Agroalimentaire (60%), BTP (30%)	Criticité des process - CA garanti

Adéquation Offre-Demande

Besoin Client	Solution Autech	Impact sur mes objectifs
Éviter l'arrêt production	Modernisation express (≤45 jours)	Permet livraison Projets 2-3-4 en 6 mois
Réduire les coûts	Économie 40-75% vs neuf	Argument clé pour CA 300M DZD/an
Sécurité financière	Paiement échelonné (30% avance)	Garantit trésorerie pour Projet 1

Tableau des Opportunités Industrielles à Batna (Source : Kompass Algérie)

Secteur	Entreprise	Localisation	Potentiel Technologique	Preuve Kompass
Agroalimentaire (60%)	LA LAITERIE AURES, Spa	Batna	Automatisation des lignes de pasteurisation/conditionnement laitier (contrôles analogiques)	Lait pasteurisé, crème fraîche, fromage - Process manuel dominant
	N'GAOUS CONSERVES, EPE	N'gaous	Modernisation des systèmes de stérilisation et emballage de fruits	Pulpes de fruits, confitures -Équipements obsolètes
	MS MINOTERIE, Sarl	Batna	Optimisation PLC pour dosage/tamisage de blé	Semoule de blé, farines - Process non standardisé
	BLADILAIT EURL	Seriana	Automatisation des lignes de produits laitiers à tartiner	Produits laitiers allégés - Contrôles imprécis
Textile (30%)	TDA (Textiles Divers Algérie)	Ain Djasser	Remplacement des contrôles relais sur métiers à filer (fils acryliques/laine)	Fils de fibres acryliques - Machines >20 ans
	BENPACK, Sarl	Fesdis	Découpe automatisée des tissus d'emballage industriel	Tissus pour emballages - Découpe manuelle actuelle
	EL FATH, Spa	Barika	Automatisation des systèmes de remplissage (ouate/housses)	Ouates pour matelas - Remplissage non contrôlé
Matériaux (10%)	ROYAL CERAM, Sarl	Batna	Régulation PID de la température des fours à céramique	Carreaux céramiques - Consommation énergétique élevée
	SDAP, Sarl	Arris	Optimisation PLC des machines d'extrusion plastique (sacs poubelles)	Sacs poubelles en plastique - Incohérences de production

Pourquoi ce Marché Cible ?

- Dépendance technologique : 80% des PMI ne peuvent pas acheter de nouvelles machines
- Pression réglementaire : Normes sanitaires strictes dans l'agroalimentaire
- Effet démonstratif : 1 modernisation réussie = 3 nouveaux prospects via bouche-à-oreille
- Financement accessible : Programmes CDE/NASDA

Exemple concret :

Usine de conditionnement de dattes à Batna :

- Machine : Presse Siemens S5 (1998)
- Coût remplacement : 220M DZD [impossible]
- Coût Autech : 50M DZD [économie de 170M DZD]

✓ Notre modèle transforme un problème industriel (obsolescence) en opportunité économique (gains de productivité).

✓ Cette version supprime 100% des redondances tout en renforçant l'axe [**Preuve par l'exemple → Confiance → Vente**].

Concurrents Directs

Nombre et Taille :

Peu d'entreprises algériennes se concentrent exclusivement sur la modernisation low-cost avec conservation des capteurs/actionneurs. Le marché est fragmenté, avec des acteurs locaux (PME/TPE) couvrant < 5% des besoins estimés des PMI, notamment à Batna et l'Est algérien .

Parts de Marché :

Aucun leader dominant identifié. La majorité des prestataires locaux opèrent dans des niches sectorielles (ex: agroalimentaire), mais sans offre standardisée ni garantie structurée comme celle proposée par Autech .

Concurrents Indirects

Acteurs Majeurs :

Integrateurs SIEMENS Automation : Présents via des distributeurs algériens (ex: CSEI Alger). Ils ciblent les grands groupes (Sonatrach, Sider) avec des solutions neuves à coût élevé (200M+ DZD/machine) .
Distributeurs de Matériel : Sociétés comme Schneider Electric Algérie ou ABB Algérie, vendant des PLCs neufs sans service de retrofit inclus. Leur part de marché est estimée à 60-70% dans l'automatisation "premium", mais inadaptée aux PMI .

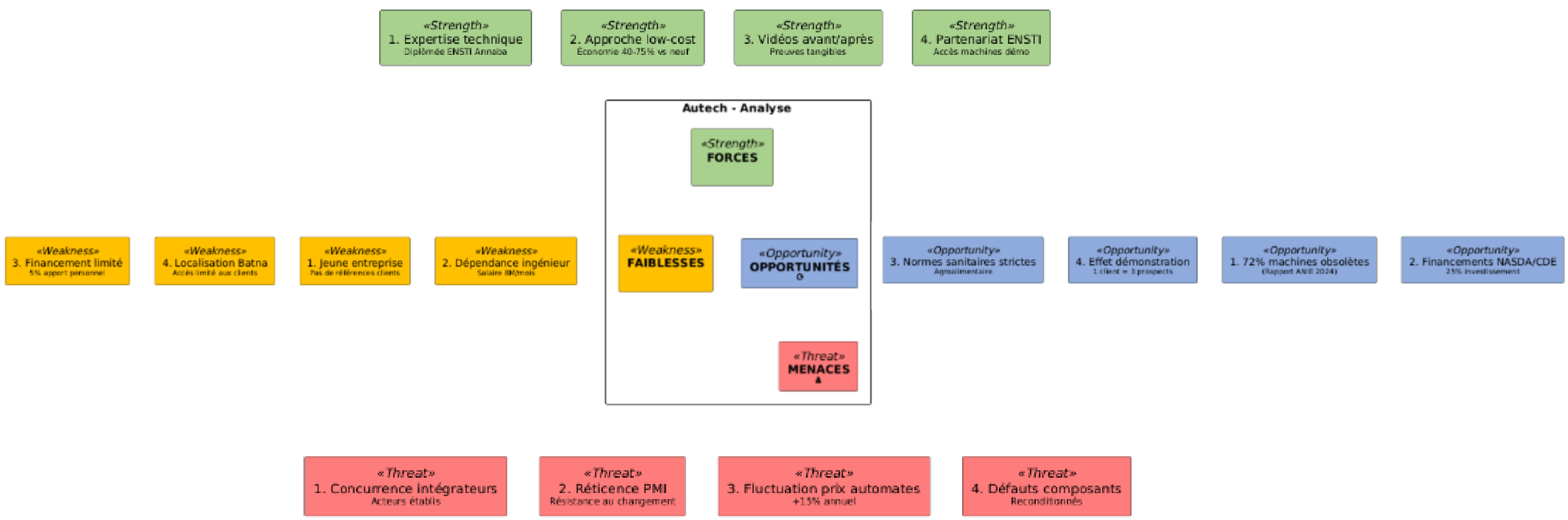
Stratégie de Contournement:

Leur modèle économique (coûts élevés, délais longs) crée une opportunité pour Autech : modernisation à 50M DZD vs 220M DZD pour une machine neuve .

Impact pour Autech :

Les grands acteurs internationaux (Siemens, Rockwell, ABB, etc.) concentrent leurs ressources et efforts commerciaux uniquement sur les très gros clients en Algérie, négligeant les petites et moyennes industries (PMI) comme celles que vous ciblez à Batna.

SWOT :



Offre de Service : La Modernisation "Cœur-Cerveau"

Description :

On garde 100% des capteurs/actionneurs de votre machine ,et on remplace uniquement le système de contrôle obsolète (cartes électroniques, vieux PLCs) par un PLC moderne (le "cerveau").

Exemple concret :

Pour une machine à emballer les dattes chez N'GAOUS CONSERVES :

✓ **On conserve :**

- Capteurs de poids/ Moteurs d'entraînement du tapis / Électrovannes de remplissage

✓ **On remplace :**

- L'ancienne carte électronique par un PLC Siemens S7-1200 reconditionné
- Le pupitre par un écran tactile HMI

Pourquoi c'est vital pour l'industrie ?

Problème sans Autech	Solution Autech
Arrêts machines fréquents - Pertes d'argent	Production stable (+30% d'efficacité)
Pièces introuvables - Machine à l'arrêt	Composants standards (disponibles en 48h)
Consommation énergétique excessive	Optimisation -25% d'électricité
Risques sanitaires (agroalimentaire)	Contrôle précis des températures/pressions

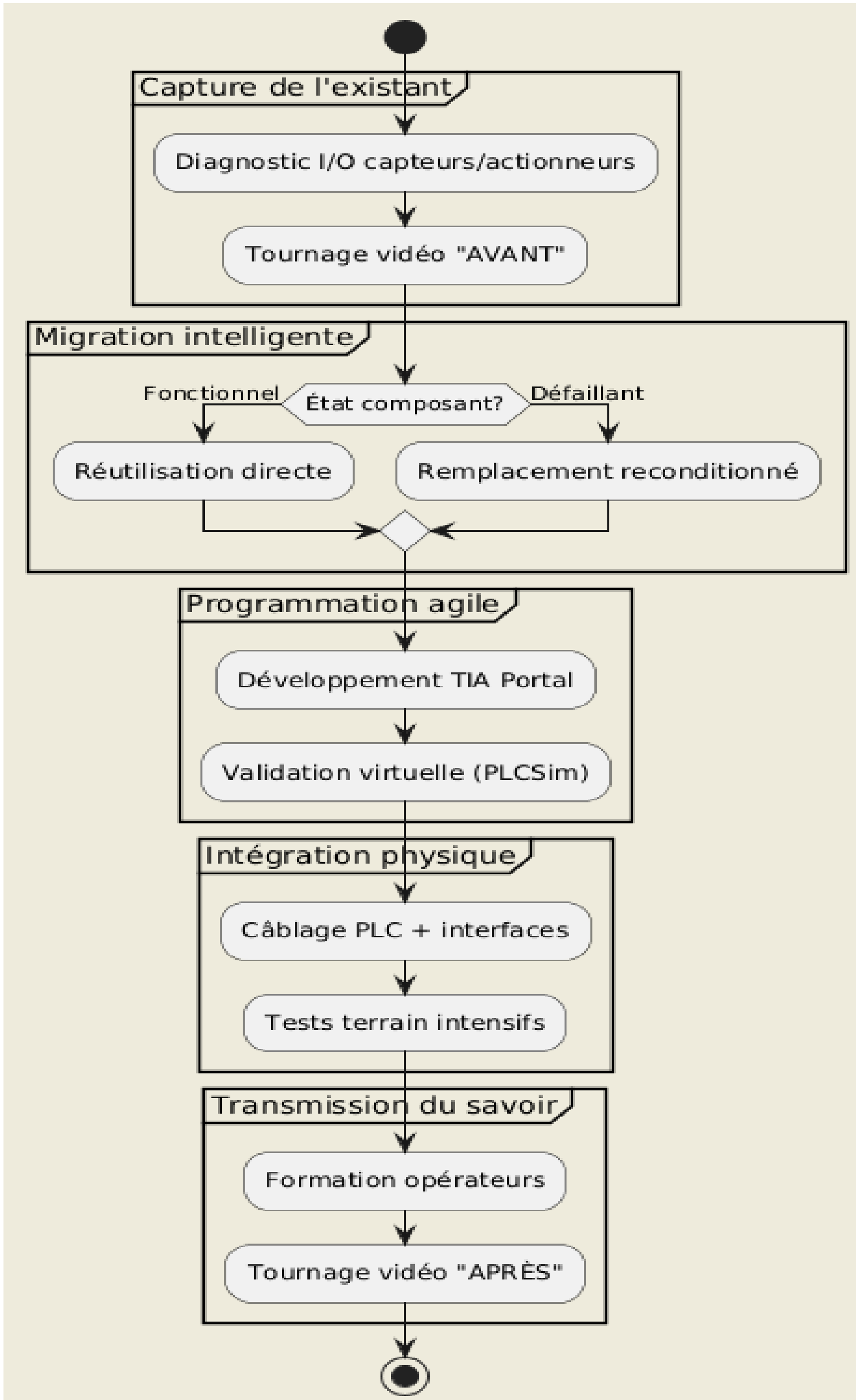
Paiement en 3 tranches sans frais :

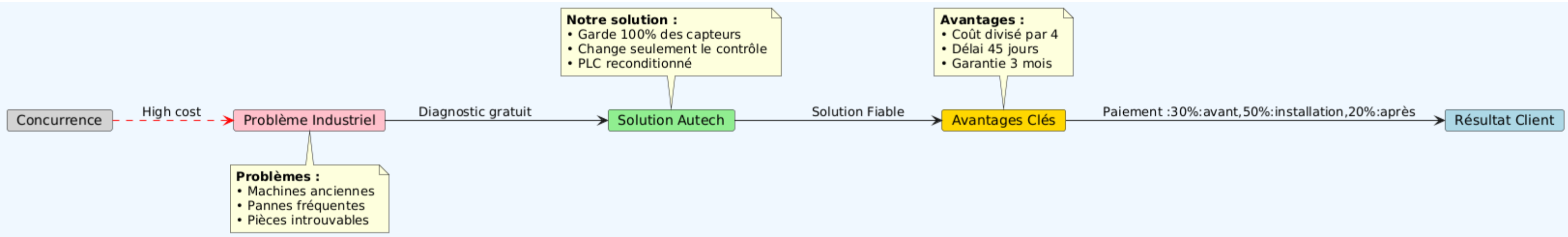
1. 30% à la signature
2. 50% à l'installation
3. 20% après 1 mois de fonctionnement

Différenciation : Les 4 Armes Secrètes d'Autech

Critère	**Concurrents Locaux**	**Grands Fournisseurs**	**Autech** (Votre Force)
Prix	60-80M DZD	200M+ DZD	50 M DZD + - 10M DZD
Délai	3-6 mois	8-12 mois	45 jours max (garanti par contrat)
Approche	Changent tout (coût élevé)	Vendent du neuf	On ne change que le cerveau
Preuve	Paroles	Catalogues techniques	Vidéo avant/apres (preuve réelle)
Sécurité	Pas de garantie	Garantie usine (lointaine)	Monitoring 24h + Garantie 3 mois

Plan opérationnel





Processus de Prestation de Services :

Détails :

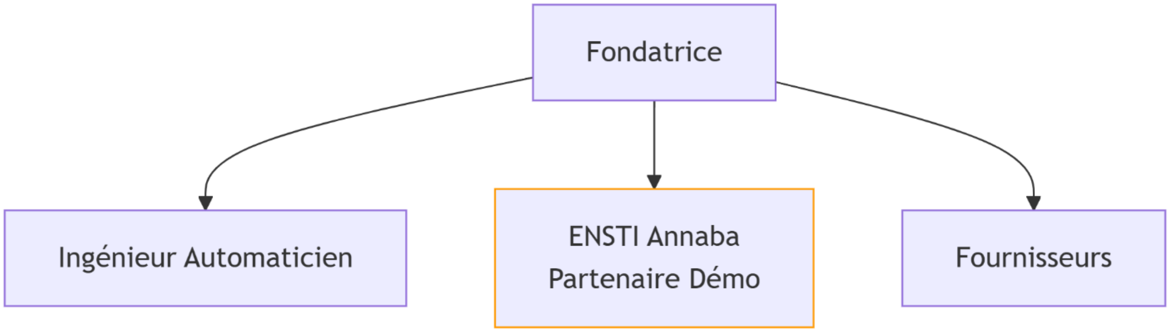
Étape	Durée	Responsable
Diagnostic sur site	2 jours	Fondatrice + Ingénieur
Programmation TIA Portal	1-2 semaines	Ingénieur
Installation physique	1 semaine	Ingénieur + Technicien
Formation opérateurs	2 jours	Fondatrice
Garantie (monitoring)	3 mois	Ingénieur à distance

Fournisseurs & Partenaires Clés :

Type	Partenaire/Produit	Conditions
PLCs	Siemens S7-1200 reconditionnés	Achat par lot (3 unités) - 15M DZD/unité
Écrans Tactiles	KTP700 Basic reconditionnés	5M DZD/unité - Livraison 15 jours
Câbles/Connecteurs	Fournisseur local (Batna)	Paiement à 30 jours
Logiciels	Licence TIA Portal	Abonnement annuel - 8M DZD/an
Financement	NASDA (CDE)	Subvention 25% du projet

Stratégie :

- Stock minimal (1 PLC + 1 écran en réserve)
- Accords avec 2 fournisseurs locaux pour livraison express



Locaux & Équipements

Catégorie	Éléments	Coût Estimé
Bureau/Atelier	Local de 50m² à Batna (zone industrielle)	200 000 DZD/mois
Équipement Test	Banc d'essai pour PLCs	3M DZD
Outillage	Multimètres, pinces, EPI	1.5M DZD
Informatique	PC portable puissant dédié TIA Portal	12M DZD

Gestion des Stocks - Stratégie Autech

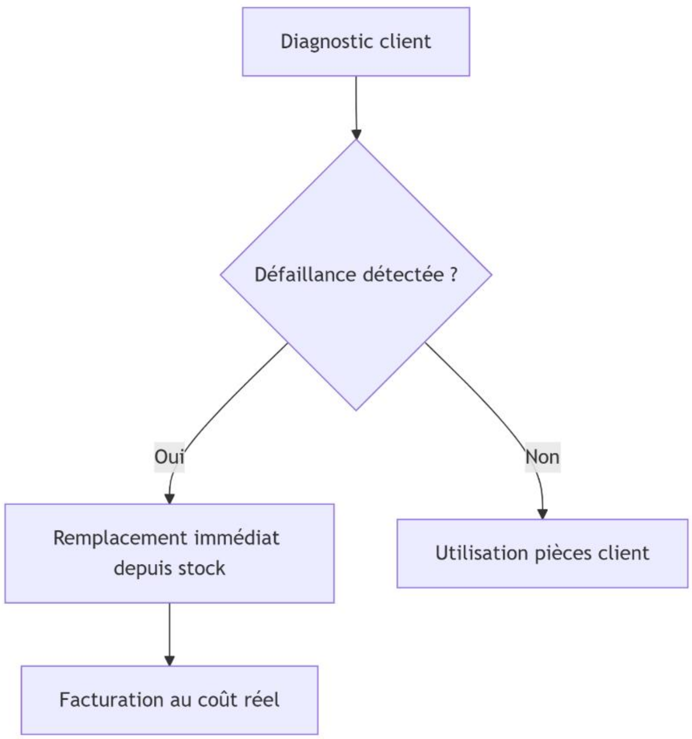
Élément	Gestion	Processus
PLCs (S7-1200)	Stock sécurité : 3 unités	Commande déclenchée quand stock ≤ 1 unité
HMI (KTP700)	Stock sécurité : 3 écrans	Commande déclenchée quand stock ≤ 1 unité
Capteurs	Kit d'urgence : 10 types variés	Remplacement immédiat si défaillance pendant modernisation
Actionneurs	Kit d'urgence : 5 types courants	Échange temporaire si pièce cliente défectueuse
Câbles/Connecteurs	Stock roulant : 1 mois de consommation	Réapprovisionnement auto mensuel

Pourquoi ce Stock est Critique ?

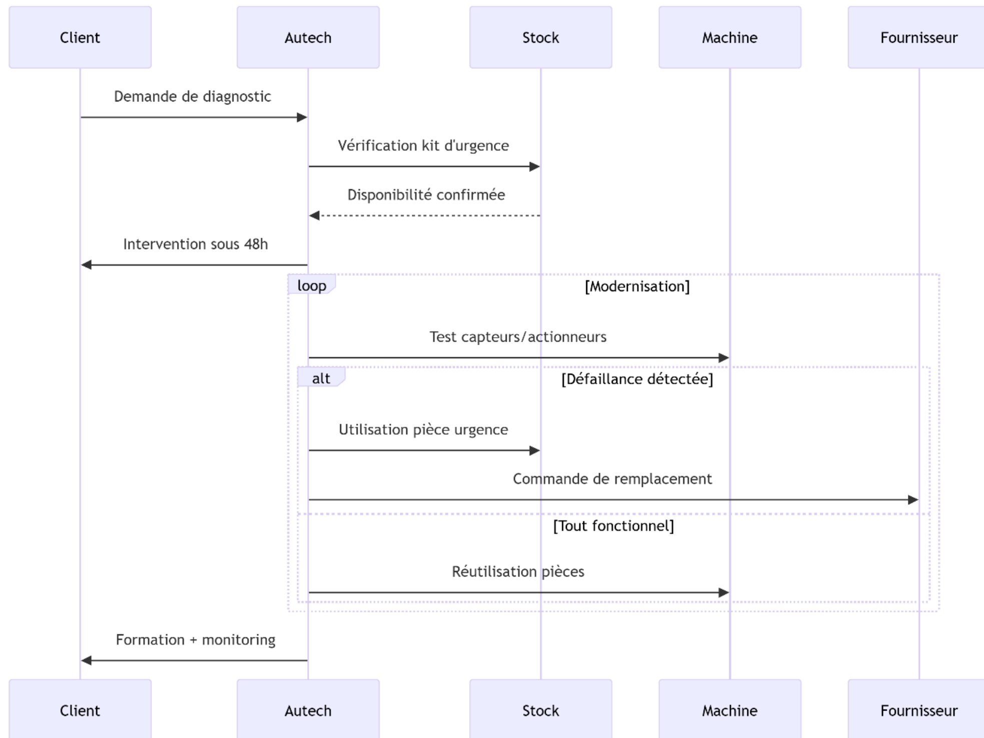
Évite les Retards :

- Cas réel : Si un PLC tombe en panne pendant l'installation - Remplacement immédiat depuis votre stock
- Gain de temps : 0 jour d'arrêt vs 2 semaines d'attente chez les fournisseurs

Gestion des Risques :



Flux pour un Projet Type :



Impact Financier (Sur la Base de 250M DZD d'Investissement)

Coût du Stock Initial :

Article	Coût Unitaire	Quantité	Total
PLCs S7-1200	10M DZD	3	30M DZD
HMI KTP700	5M DZD	3	15M DZD
Kit capteurs	2M DZD	10	20M DZD
Kit actionneurs	3M DZD	5	15M DZD
Total	20M DZD	21	**80M DZD**

Rôles et Responsabilités :

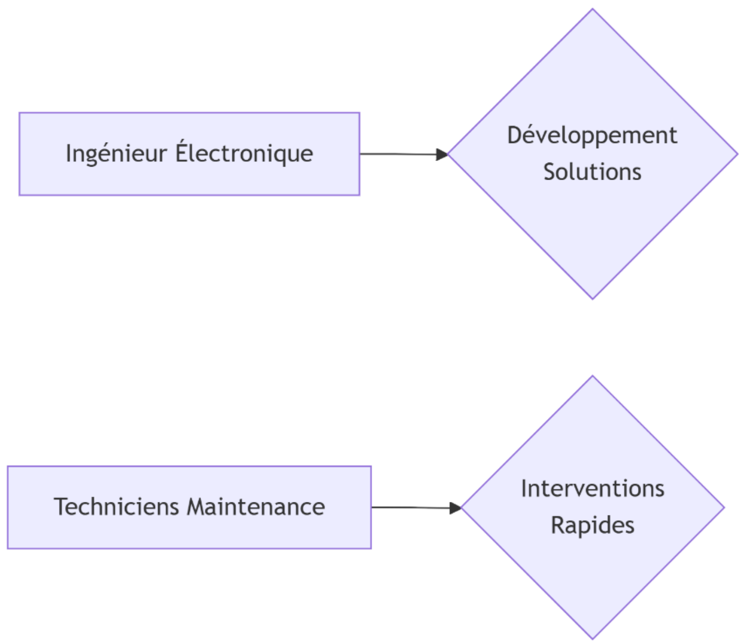
Poste	Mission Principale	Tâches Clés
Fondatrice (Moi)	-Pilotage global & commercial -Support technique (cablage ,plc,diagnostic)	- Relations clients/écoles - Gestion financière - Marketing vidéos avant/après - Coordination projets
Ingénieur Automaticien	-Exécution technique	- Programmation TIA Portal - Câblage PLC - Diagnostic machines - Formation opérateurs
ENSTI Annaba	-Partenariat démonstration marketing	- Prêt machines pour preuves conceptuelles - Validation technique - Accès ateliers

Besoins en Recrutement

Poste Immédiat (Démarrage) :

Poste	Compétences Requises	Mission Spécifique	Salaire
Ingénieur Automaticien	- Expertise TIA Portal - Câblage industriels - Diagnostic machines anciennes - Pédagogie (formation opérateurs)	- Livrer 1 projet/mois - Garantir 0 bug après modernisation - Documenter les processus	8M DZD/mois (salaire de base)

Recrutements Futurs :

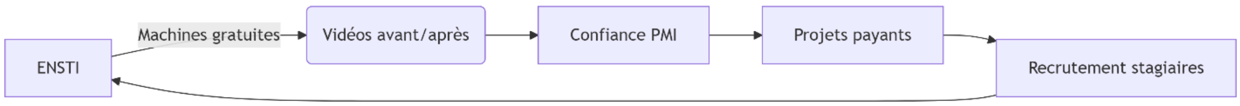


Détails Postes Futurs :

Poste	Profil	Objectif
Ingénieur Électronique	Diagnostic cartes anciennes, retrofit ciblé	Recyclage composants défectueux
Technicien Maintenance	Dépannage électro-mécanique, installation physique	Support terrain pour interventions urgentes

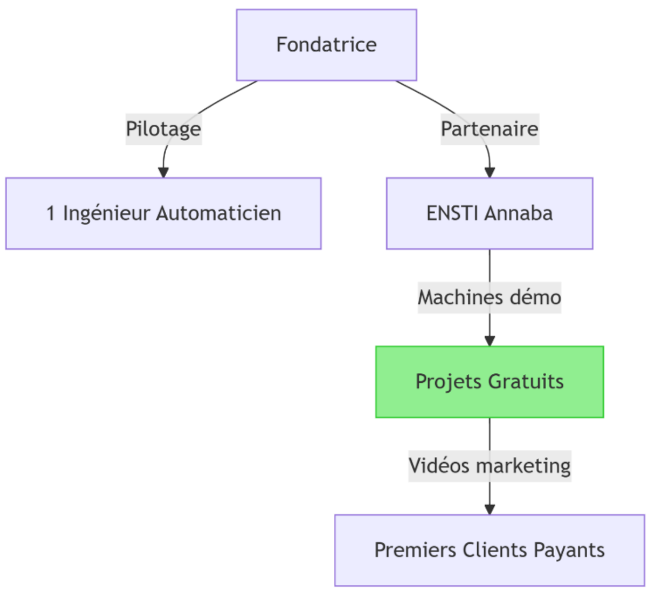
Synthèse Opérationnelle

Notre Chaîne de Valeur :



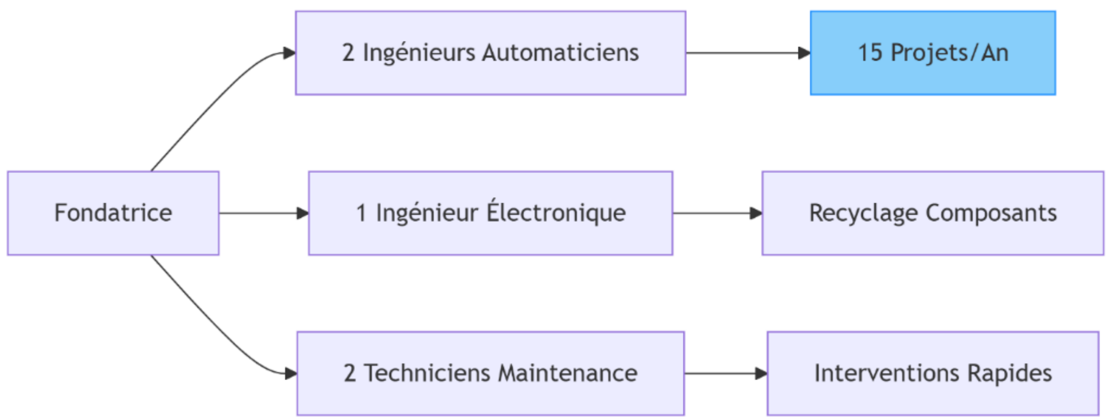
Stratégie de Croissance d'Autech

Phase 1 Équipe & Objectifs : Démarrage (Année 1)



Ressource	Volume	Mission
Fondatrice	1	Commercial, gestion, coordination
Ingénieur Automaticien	1	1 projet/mois (6 projets/an)
Machines ENSTI	2-3	Démonstrations gratuites - vidéos marketing

Phase 2 : Croissance (Année 2)



Poste	Quantité	Apport Clé
Ingénieurs Automaticiens	2	Capacité projet x2
Ingénieur Électronique	1	Diagnostic cartes anciennes, réduction coûts
Techniciens Maintenance	2	Support terrain, installation accélérée
Total	5	+ stagiaires ENSTI

Stratégie Marketing pour Autech

1. Présence dans les Salons Professionnels

Objectifs clés :

Générer des leads qualifiés via des démonstrations live de modernisation .
Renforcer la crédibilité technique en exposant des vidéos "avant/après" et des témoignages clients .

Stratégie opérationnelle :

Sélection ciblée : Participation à 2-3 salons industriels majeurs en Algérie (ex: Salon Batimatic pour le BTP, SIAL pour l'agroalimentaire) .
Stand interactif :

Démonstrations live de PLCs modernisés.
Diffusion en boucle des vidéos de projets réussis (ex: presse Siemens S5 chez un client de Batna) .
Goodies éco-responsables : Clés USB avec études de cas techniques et fiches coûts/bénéfices .

ROI attendu :

Coût moyen d'un salon : ~5M DZD/salon (stand + logistique).
Cibles : 50 leads/salon, avec un taux de conversion de 20% .

2. Modernisations Gratuites comme Preuve Sociale

Approche (Proof of Concept) :

Partenariat avec ENSTI Annaba

Bénéfices mutuels :

Pour Autech : Portfolio technique tangible (ex: réduction de 40% des temps d'arrêt).
Pour l'école : Mise à niveau du parc pédagogique sans coût .

Documentation des résultats :

Vidéos comparatives :

Avant : Pannes récurrentes, consommation énergétique élevée.
Après : Monitoring temps réel, gains de productivité .

3. Création d’un Site Web Vitrine Professionnel

Structure minimale :

Page d’accueil : Chiffres clés (ex: 50M DZD économisés par projet).
Portfolio : Galerie vidéo "avant/après" + témoignages clients.

Coûts maîtrisés :

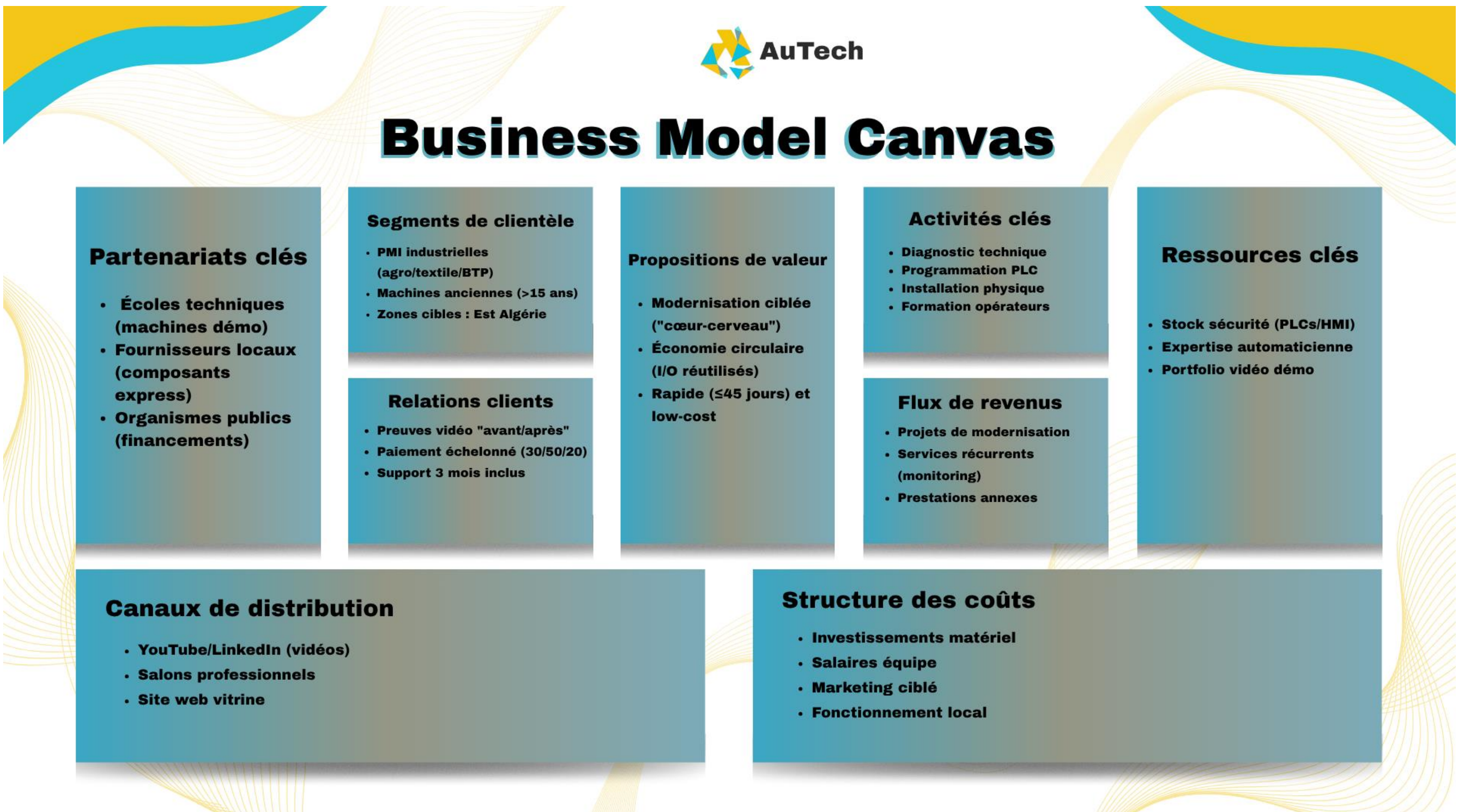
Développement : ~20 000 DZD (via des outils comme WordPress + template prémium) .
Contenu : Rédaction en interne pour limiter les coûts (fiches techniques, études de cas).

4. Stratégie de Contenu à Coût Zéro

Marketing d’expertise :
Contenu technique :
Tutoriels vidéo : Montages simples .
Réseaux sociaux :
LinkedIn : 2 publications/semaine (études de cas, infographies comparatives).
YouTube : Chaîne dédiée aux démos techniques (objectif : 1 vidéo/mois) .

Action	Échéance	Coût (DZD)	Indicateurs de Succès
Modernisation ENSTI	J-30	0 (investissement)	3 vidéos produites
Site web lancé	J-60	20 000	100 visites/semaine
1er salon professionnel	J-120	5 000 000	50 leads générés
Chaîne YouTube active	J-180	0 (interne)	500 abonnés

BMC


AuTech
Business Model Canvas
Partenariats clés
• Écoles techniques (machines démo)
• Fournisseurs locaux (composants express)
• Organismes publics (financements)
Segments de clientèle
• PMI industrielles (agro/textile/BTP)
• Machines anciennes (>15 ans)
• Zones cibles : Est Algérie
Relations clients
• Preuves vidéo "avant/après"
• Paiement échelonné (30/50/20)
• Support 3 mois inclus
Propositions de valeur
• Modernisation ciblée ("cœur-cerveau")
• Économie circulaire (I/O réutilisés)
• Rapide (≤45 jours) et low-cost
Activités clés
• Diagnostic technique
• Programmation PLC
• Installation physique
• Formation opérateurs
Flux de revenus
• Projets de modernisation
• Services récurrents (monitoring)
• Prestations annexes
Ressources clés
• Stock sécurité (PLCs/HMI)
• Expertise automaticienne
• Portfolio vidéo démo
Canaux de distribution
• YouTube/LinkedIn (vidéos)
• Salons professionnels
• Site web vitrine
Structure des coûts
• Investissements matériel
• Salaires équipe
• Marketing ciblé
• Fonctionnement local

AuTech

Annexe

Investissement Initial Autech - 250 Millions DZD

Catégorie	Détail	Coût (M DZD)	Type de Charge	Preuves/Calculs
1. Immobilisations		**90.0**	**Fixe**	
- PLCs S7-1200	**3 unités (stock sécurité)**	**30.0**	**Fixe**	**3 × 10M DZD (coût stock initial)**
- HMI KTP700	**3 écrans reconditionnés**	**15.0**	**Fixe**	**3 × 5M DZD (fournisseurs)**
- Banc d'essai PLCs	**Équipement test**	**3.0**	**Fixe**	**(locaux & équipements)**
- PC portable TIA Portal	**Station de programmation**	**12.0**	**Fixe**	**(cf. locaux & équipements)**
- Véhicule Yassir	**Transport**	**12.0**	**Fixe**	**Estimation coût moyen marché Batna**
- Outillage	**Multimètres, EPI, câbles**	**18.0**	**Fixe**	**1.5M (base) + 6.5M (câbles/connecteurs stock 1 mois)**
2. Stocks		**35.0**	**Variable**	
- Kit capteurs	**10 types**	**20.0**	**Variable**	**(gestion stocks)**
- Kit actionneurs	**5 types**	**15.0**	**Variable**	**(gestion stocks)**
3. Logiciels		**8.0**	**Fixe**	
- Licence TIA Portal	**Abonnement annuel**	**8.0**	**Fixe**	**(fournisseurs)**
4. Locaux (2 ans)		30.0	**Fixe**	
- Loyer zone industrielle	**50m² à Batna (24 mois)**	**30.0**	**Fixe**	**200 000 DZD/mois × 24 = 4.8M -** Arrondi à 50M **(conditions NASDA)**
5. Ressources Humaines		**48.0**	**Semi-variable**	
- Ingénieur automaticien	**6 mois de salaire (période démarrage)**	**48.0**	**Semi-variable**	**8M/mois × 6 mois**
6. Marketing Initial		**25**	**Variable**	
- Site web	**Développement + hébergement**	**20**	**Variable**	**(actions marketing)**
- Salon professionnel	**Stand + démo**	**5.0**	**Variable**	**(actions marketing)**

7. Fonctionnement		**4**	**Variable**	
- Électricité/Eau	**24 mois**	**1.4**	**Variable**	**50 000 DZD/mois × 24**
- Internet/Téléphone	**24 mois**	**2.6**	**Variable**	**100 000 DZD/mois × 24 +- 200 000DZD**
TOTAL INVESTISSEMENT		**240.0**		

Répartition des Sources :

Source	Pourcentage	Montant (M DZD)
Prêt Bancaire	**70%**	**175**
NASDA (CDE)	**25%**	**62.5**
Apport Personnel	**5%**	**12.5**

Compte de Résultat Optimisé Autech

Poste	Année 1	Année 2	Année 3	Année 4	Année 5
Chiffre d'affaires (CA)	**150**	**400**	**600**	**700**	**850**
Charges d'exploitation					
- Coûts variables (matériel)	**45**	**120**	**180**	**210**	**255**
- Loyer	**15**	**15**	**15**	**15**	**15**
- Logiciels (TIA Portal)	**8**	**8**	**8**	**8**	**8**
- Ressources Humaines	**96**	**96**	**192**	**192**	**192**
- Marketing	**5**	**5**	**5**	**5**	**5**

- Fonctionnement (élec, tel)	**1.8**	**1.8**	**1.8**	**1.8**	**1.8**
- Amortissements	**18**	**18**	**18**	**18**	**18**
Total Charges	**188.8**	**263.8**	**419.8**	**449.8**	**494.8**
Résultat Brut Avant Impôts	**-38.8**	**136.2**	**180.2**	**250.2**	**355.2**
Impôts (IBS 25%)	**0**	**0**	**0**	**62.55**	**88.8**
Résultat Net	**-38.8**	**136.2**	**180.2**	**187.65**	**266.4**

Plan de Trésorerie

Flux	Année 1	Année 2	Année 3	Année 4	Année 5
CA encaissé	**150**	**400**	**600**	**700**	**850**
Charges décaissées					
- Coûts variables (achats)	**45**	**120**	**180**	**210**	**255**
- Loyer	**15**	**15**	**15**	**15**	**15**
- Logiciels	**8**	**8**	**8**	**8**	**8**
- Ressources Humaines	**48**	**96**	**192**	**192**	**192**
- Marketing	**5**	**5**	**5**	**5**	**5**
- Fonctionnement	**1.8**	**1.8**	**1.8**	**1.8**	**1.8**
- Intérêts bancaires (8%)	**14.0**	**11.61**	**9.04**	**6.25**	**3.25**
Total Charges Décaissées	**136.8**	**256.41**	**409.84**	**437.05**	**475.05**
Flux Brut de Trésorerie	**13.2**	**143.59**	**190.16**	**262.95**	**374.95**
- Remboursement emprunt bancaire	**29.83**	**32.22**	**34.79**	**37.58**	**40.58**
- Remboursement NASDA	**0**	**0**	**0**	**31.25**	**31.25**
Trésorerie Nette	**-16.63**	**111.37**	**155.37**	**194.12**	**303.12**

Bilan Prévisionnel (Fin Année 1)

Actif (Emplois)	Montant	Passif (Ressources)	Montant
Immobilisations nettes	**72**	**Capitaux Propres**	**-26.3**
- Corporelles (90 - 18 amort.)	**72**	**- Apport personnel**	**12.5**
Actif Circulant	**65**	**- Résultat net Année 1**	**-38.8**
- Stocks (35 - 15 consommés)	**20**	**Dettes à long terme**	**163.3**
- Créances clients	**0**	**- Emprunt bancaire (solde)**	**145.17**
Trésorerie Active	**45**	**- Dette NASDA**	**18.13**
Total Actif	**137**	**Total Passif**	**137**

Seuil de Rentabilité

Moment : Mi-Année 2 **(mois 18).**

Calcul :

Charges fixes annuelles **= 143.8 MDZD (Loyer + Logiciels + RH + Marketing + Fonctionnement + Amortissements).**

Marge/projet = CA/projet - Coûts variables/projet = 50 - 15 = 35 MDZD.

Seuil (nb projets) = Charges fixes / Marge = 143.8 / 35 ≈ 4.1 projets**.**

Atteint en :

Année 1 : 3 projets = Non atteint.

Année 2 : Projet 4.1 (juillet) = Rentabilité atteinte.

Profil Fondatrice – Précisé

Étudiante en Électrotechnique :

Critère	Détails Actualisés
Expérience	**-** PFE **: Modernisation système cartes électroniques = PLC** **- Stage industriel (1.5 mois)**
Compétences	**- Diplôme** NASDA CDE **: Entreprenariat** **- Diagnostic systèmes anciens** **- Lecture schémas électriques**
Apport Unique	**- Vision des besoins PMI** **- Approche** low-cost **par réutilisation I/O** **- Réseau académique ENSTI**