الجمهورية الجزائرية الديمقراطية الشعبية

People's Democratic Republic of Algeria

وزارة التعليم العالي والبحث العلي

Ministry of Higher Education and Scientific Research

جامعة سعد دحلب البليدة 1

University of Saad Dahleb Blida 1

قسم الألية والالكتروتقني

Department of Automation and Electrotechnics

Master's thesis

Automation branch

Specialty: Automation and Industrial Information

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Improvement and development of a supervisor for a cartoning machine (SAIDAL)

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Dedications

I dedicate this work, to my most loved ones,

to both my parents, without their love and support I would have never arrived where I am in life

to my siblings, whom I found their aid when I needed it the most

to my friends, and their emotional support throughout this journey

and finally, to you, who has taken the time to read this memoir

Acknowledgements

It is with great pleasure that I would like to express my deepest gratitude to all those who have supported and guided me throughout the process of completing this work. Without their assistance, this work would not have been possible.

First and foremost, I am extremely grateful to my Promoter, Mr. Bennila Noureddine, for their unwavering support, invaluable guidance, and expertise. Their dedication and encouragement played a crucial role in shaping my research and refining my ideas. I am also thankful to Mr. Mouloued Amine for their insightful feedback and constructive criticism, which significantly enhanced the quality of this work.

I would also like to thank the members of the jury for their valuable time, expertise, and meticulous evaluation of this thesis, hoping that they believe in my sincere gratitude and find the expression of my deep respects.

Lastly, I am immensely thankful to my family for their unwavering support, love, and encouragement throughout my academic endeavor. Their belief in my abilities and their constant motivation have been pivotal in overcoming challenges and achieving this milestone.

Résumé :

Ce travail a été réalisé sur le site de production de SAIDAL à Médéa ; son objectif est d'étudier et d'améliorer le processus de mise en carton des médicaments à l'aide d'une machine d'encartonnement en développant un nouveau système automatisé basé sur un automate programmable (PLC) Zelio Smart Relay, ainsi qu'en concevant et en programmant un superviseur sur LabVIEW.

Mots-clés : Machine de mise en carton, Système automatisé, Module Zelio SR3B261B, Zelio Soft 2, LabVIEW.

ملخص:

تمت هذه الدراسة في موقع إنتاج صيدال المدية؛ هدفها هو دراسة وتحسين عملية التعبئة في علب الأدوية باستخدام آلة تعبئة، من خلال تطوير نظام آلي جديد يعتمد على وحدة التحكم زيليو، وكذلك تصميم وبرمجة مشرف على LabVIEW.

الكلمات المفتاحية: آلة تعبئة، نظام آلي، وحدة زيليو.Zelio Soft 2, LabVIEW

Abstract:

This work has been carried out at the SAIDAL Medea production site; its aim is to study and improve on the cartoning process of medicine with a cartoning machine, by developing a new automated system based on a Zelio Smart Relay PLC, as well as designing and programming a supervisor on LabVIEW.

Keywords: Cartoning machine, Automated System, Zelio Module SR3B261B, Zelio Soft 2, LabVIEW

Table of contents

General Introduction 1

Chapter I : Overview on the SAIDAL Group and cartoning machine 2

I.1 Introduction: 3

I.2 Introduction to Automation: 3

I.3 General Presentation of the SAIDAL Group: 4

I.3.1 The SAIDAL Group: 4

I.3.2 History: 4

I.3.3 Organization: 5

I.4 Description of Cartoning Machines: 6

I.5 Presentation of the ZanasiNigris Model KA 91: 7

I.5.1 Overview: 7

I.5.2 The cartoning process: 8

I.6 Conclusion: 10

Chapter II : Study of the hardware and software utilized 11

II.1 Introduction: 12

II.2 Operative part: 12

II.2.1 Inductive Sensors: 12

II.2.2 Photoelectric Sensors: 12

II.2.3 Limit Switch Sensors: 13

II.2.4 Circuit-Breakers: 14

II.2.5 Relays: 16

II.2.6 Contactors: 17

II.2.7 Altivar 71 Variable Speed Drive: 18

II.3 actuators 19
II.3.1 GUK FA 21/4 Cartonac 68 Folding Machine: 19
II.3.2 Vacuum Pump R5 RA 0063 F: 20
II.4 Control part 22
II.4.1 General Information about PLCs: 22
II.4.2 Presentation of the ZELIO Smart Relay module: 24
II.4.3 ZELIO Module SR3B261BD 26
II.4.4 Discrete I/O extension module SR3XT141BD: 27
II.4.5 Ethernet communication extension SR3NET01BD: 28
II.5 Software: 29
II.5.1 Programming languages: 29
II.5.2 Presentation of Zelio Soft 2: 31
II.5.3 Presentation of LabVIEW: 35
II.5.4 Presentation de Virtual Serial Port Emulator: 38
II.6 Conclusion : 39
Chapter III : Programming, supervision and simulation 40
III.1 Introduction : 41
III.2 The Challenges to solve : 41
III.3 The Process: 41
III.3.1 Functioning of the cartoning machine: 41
III.4 The Program: 43
III.4.1 Purpose of using FBD: 43
III.4.2 Starting of the machine: 43
III.4.3 The cartoning process: 48
III.4.4 The Alarms: 50
III.5 The LCD Display: 52

III.5.1 Overview: 53
III.5.2 Programming of the LCD Display: 53
III.5.3 Alarms: 54
III.5.4 Mode: 55
III.5.5 Status: 55
III.5.6 Warnings/Guidelines: 55
III.6 Connecting ZELIO Soft 2 with VSPE: 56
III.6.1 Configuration of VSPE: 56
III.6.2 Configuration Zelio Soft 2: 57
III.7 Developing The supervisor in LabVIEW: 58
III.7.1 Conception of VIs: 58
III.7.2 LabVIEW add-ons needed for the project: 58
III.7.3 Planning: 59
III.7.4 Creation of the VIs: 59
III.8 Communicating between Zelio Soft 2 and LabVIEW: 66
III.9 Conclusion: 69
General Conclusion 70
Appendices 71
Bibliography 76

Table of Figures

Figure I.1 The SAIDAL Group logo 4
Figure I.2 SAIDAL's production sites 6
Figure I.3 ZanasiNigris Model KA 91 7
Figure I.4 Transportation of the vial packs while the leaflets are being added 8
Figure I.5 The conveyor belt trays 9
Figure I.6 the carton magazine and suction cups 9
Figure I.7 Tuckers pushing into the carton 10
Figure II.1 Inductive sensor 12
Figure II.2 Through-beam photoelectric sensor 13
Figure II.3 Different sizes of limit switch sensors 14
Figure II.4 circuit-breaker by Shneider 15
Figure II.5 Schematic form of a circuit-breaker 15
Figure II.6 The700-K22Z-B electromechanical relay by Allen-Bradley 16
Figure II.7 Schematic form of a three-pole relay 16
Figure II.8 The LC1DO9 contactor by schneider 17
Figure II.9 Schematic form of a contactor 17
Figure II.10 The Ativar 71 18
Figure II.11 Technical features of the Altivar 71 19
Figure II.12 The GUK FA 21/4 Cartonac 68 Folding Machine 20
Figure II.13 The R5 RA 0063/0100 F vacuum pump 21
Figure II.14 Technical specifications of the R5 RA 0063/0100 F 21
Figure II.15 Architecture of a PLC 22
Figure II.16 The MITSUBISHI FX3U-48MT/ES 23
Figure II.17 Zelio logic smart relay (front view) 24
Figure II.18 Technical specifications of zelio logic smart relay 25
Figure II.19 LCD display on the zelio smart relay 25
Figure II.20 The Zelio module SR3B261BD 26
Figure II.21 The extension module SR3XT141BD 27
Figure II.22 The ethernet communication extension SR3NET01BD 28
Figure II.23 The Zelio soft 2 logo 31

Figure II.24 The LabVIEW logo 35
Figure II.25 The Virtual Instrument's block diagram 36
Figure II.26 The Virtual Instrument with the control's palette 36
Figure II.27 The I/O server panel 37
Figure II.28 The Modbus I/O server configuration panel 37
Figure II.29 The Virtua Serial Port Emulator logo 38
Figure II.30 The VSPE interface 39
Figure III.1 Flowchart of the cartoning process 42
Figure III.2 Traffic light program in FBD 43
Figure III.3 Inputs of the starting machine part 45
Figure III.4 Outputs of the starting machine part 46
Figure III.5 Initialization of the program 46
Figure III.6 The different modes wired on an OR gate 46
Figure III.7 Wiring of the different modes of operation 47
Figure III.8 Jog and Manual mode branching 47
Figure III.9 The inputs of the cartoning process part 48
Figure III.10 The outputs of the cartoning process part 49
Figure III.11 The interconnexions of the cartoning process 50
Figure III.12 The inputs of the Alarms 51
Figure III.13 The outputs of the alarms 52
Figure III.14 The LCD Display during its operation 53
Figure III.15 The LCD Screen Display function 53
Figure III.16 Programming of the LCD Screen Display function 54
Figure III.17 No Alarms Detected 54
Figure III.18 Insertion Detected 54
Figure III.19 Blockage Detected 54
Figure III.20 No Leaflet Detected 54
Figure III.21 No Cartons Detected 54
Figure III.22 Machine is in AUTO mode 55
Figure III.23 Machine is in Jog mode 55
Figure III.24 Machine in Manual mode 55
Figure III.25 Machine is in OFF state 55

Figure III.26 Machine is in ON state 55
Figure III.27 No Warnings Triggered..... 55
Figure III.28 Shortage of leaflets detected 55
Figure III.29 Shortage of cartons detected 55
Figure III.30 Guidelines that shows up when a Shortage is Detected 55
Figure III.31 Choosing the type of virtual port..... 56
Figure III.32 Choosing the virtual port..... 56
Figure III.33 Virtual Port has been configured..... 57
Figure III.34 Connection Configuration of Zelio Soft 2..... 57
Figure III.35 LabVIEW Project of the supevisor..... 59
Figure III.36 The Main VI of the ZANASI NIGRIS supervisor..... 60
Figure III.37 The DSC add-on's image navigator 61
Figure III.38 The control file containing the customized button..... 61
Figure III.39 The block diagram of the main VI 62
Figure III.40 The front panel of the grafcet program 63
Figure III.41 The block diagram of the grafcet program 63
Figure III.42 The front panel of the tank program subVI..... 64
Figure III.43 The bock diagram of the tank program subVI 64
Figure III.44 The switch to alarms panel program..... 65
Figure III.45 The front panel of the Alarms Log VI..... 65
Figure III.46 Part of the program of the alarms log block diagram 66
Figure III.47 Selecting the I/O server option..... 67
Figure III.48 Creating new I/O server window..... 67
Figure III.49 The configuration window of I/O server 68
Figure III.50 New Modbus variable library..... 68
Figure III.51 Creating new bound variables from the library 68
Figure III.52 The variables created through the library..... 69
Figure III.53 The variables on the project window 69

Table of abreviations

PLC: Programmable Logic Circuit.

SFC: Sequential Function Chart.

ATV: Altivar

LD: Ladder language

ST: Structured Text

IL: Instruction Listed

VI: Virtual Instrument

FBD: Fuction Block Diagram

HMI: Human Machine Interface

LabVIEW: Laboratory Virtual Instrumentation Engineering Workbench

General Introduction

In recent decades, the field of industrial automation has witnessed tremendous growth and innovation, transforming manufacturing processes across various industries. With the advent of advanced technologies and the integration of robotics, industrial automation has emerged as a powerful force in optimizing efficiency, enhancing productivity, and driving economic growth.

Automation reduces the need for manual labor and speeds up production such as cartoning process. Machines can consistently and rapidly package products at a much higher rate than manual operations, leading to increased overall productivity and throughput, as well as quality and accuracy.

It is why we have proposed improving and automate the cartoning machine for vial packs at the pharmaceutical group SAIDAL. The outdated logic and hardware of the machinery has been observed to lack accuracy with high maintenance costs.

This project's objective is to revisit the machine's automation system, building a new one using a Zelio Smart Relay PLC, and also develop a supervisor to monitor the operations in real-time, to this end, this project has been organized into 3 concise chapters that can be summarized as follows:

- **Chapter 1:** Contains general information about the SAIDAL GROUP, its his story and organization structure, with an overview on cartoning machines and the machine studied.
- **Chapter 2:** In this chapter is listed all hardware used to automate the machine as well as the software utilized.
- **Chapter 3:** this chapter explores every step in the programming of the PLC and how the program functions, along with the development of the supervisor using LabVIEW and further establishing communication between the supervisor and the program.

Chapter I : Overview on the SAIDAL Group and cartoning machine

I.1 Introduction:

The objective of industrial automation is to achieve higher levels of efficiency, productivity, and profitability by eliminating manual labor, reducing cycle times, and minimizing the potential for human error. By leveraging automation technologies, manufacturers can optimize their operations to achieve higher levels of precision, accuracy, and consistency in their products and processes.

In this chapter we will present an introduction to automation with a focus of the industrial and production side, an overview of the SAIDAL group with its history, organization structure and production as well as a presentation of cartoning machine and the specific model utilized.

I.2 Introduction to Automation:

Automatism refers to the ability of a system or process to operate automatically, without human intervention. This can include anything from simple mechanical devices that perform a single task, to complex computerized systems that control entire industrial processes.

In the context of industrial automation, automatism involves the application of advanced technologies and machinery to control and optimize various stages of manufacturing and production processes. This can include the deployment of sophisticated robotic systems, sensors, programmable logic controllers (PLCs), and other automated devices to perform complex tasks such as material handling, assembly, inspection, and quality control.

Industrial automation can lead to improvements in workplace safety by minimizing the risk of accidents and injuries associated with manual labor. It can also enable manufacturers to respond more quickly and effectively to changing market demands, thereby increasing their competitiveness and enhancing their ability to innovate and grow.

I.3 General Presentation of the SAIDAL Group:

I.3.1 The SAIDAL Group:

SAIDAL is the first pharmaceutical laboratory producer of generic medicinal products in Algeria, the group was founded in 1982 in response of the growing need for a local pharmaceutical industry which guaranties and improves the availability of various medicines and enhances treatment to citizens, SAIDAL today is organized in an industrial group specialized in the development, production and commercialization of pharmaceutical products intended for human usage.

SAIDAL is a joint-stock company with a 2 500 000 000 Algerian dinars capital. Its capital is 80% state owned and 20% owned by institutional investors.

Figure I.1 The SAIDAL Group logo

I.3.2 History:

SAIDAL was created on April 1982 following the restructuring of the Pharmacie Centrale Algérienne and thus has profited from the transfer of El Harrach, Dar el Beida and Gué de Constantine's factories. It has also benefited from the 1988 transfer of Medea's Antibiotic Complex which finished building by the SNIC (Société National des Industries Chimiques).

In 1989 and following the economic reforms, SAIDAL became a public economy enterprise.

In 1993, changes had been made to the enterprise's status, making it able to participate in all industrial or commercial operations related to the corporate purpose by creating new companies or subsidiaries.

In 1997, SAIDAL has put in motion a restructuring plan which has transformed it into an industrial group regrouping 3 subsidiaries (PHARMAL, ANTIBIOTICAL and BIOTIC).

In 2009, SAIDAL increased its share in the capital of SOMEDIAL by 59%.

In 2010, it acquires 20% of IBERAL's capital and its part in the capital of TAPHCO has passed from 38,75% to 44,51%.

In 2011, SAIDAL has augmented its part in IBERAL's capital to 60%.

In January of 2014, SAIDAL has proceeded by way of absorption, to the fusing of its subsidiaries owned at 100%: PHARMAL, ANTIBIOTICAL and BIOTIC.

I.3.3 Organization:

The SAIDAL group characterizes itself by its central management entities, a research and development center, a marketing directory and medical information, multiple production units and four production subsidiaries.

❖ **The production sites (see Figure I.2):**

The SAIDAL group includes 9 production factories:

- Annaba's production site: specialized in the manufacturing of dry forms.
- Medea's production site: specialized in the manufacturing of penicillin and non-penicillin antibiotics.
- Dar El Beida's production site: this factory produces a large range of medicines in various pharmaceutical forms (sirups, solutions, tablets, ointments).
- Gué de Constantine's production sites: composed of two parties: one is for the production of pharmaceutical forms, the other is equipped with the latest technology specialized in the production of bulk solutions.
- El Harrach's production site: has four production workshops: syrups, solutions, tablets, and ointments.
- Cherchell's production site: consists of three production workshops: syrups, dry forms (tablets, sachet powder, capsules), and hemodialysis concentrate.

- Constantine’s production site: has two workshops specialized in the production of syrups, it is specialized insulin unit that produces human insulin with three types of action: rapid (Rapid), slow (Basal), and intermediate (Comb 25).
- Batna’s production site: specializes in the production of suppositories.

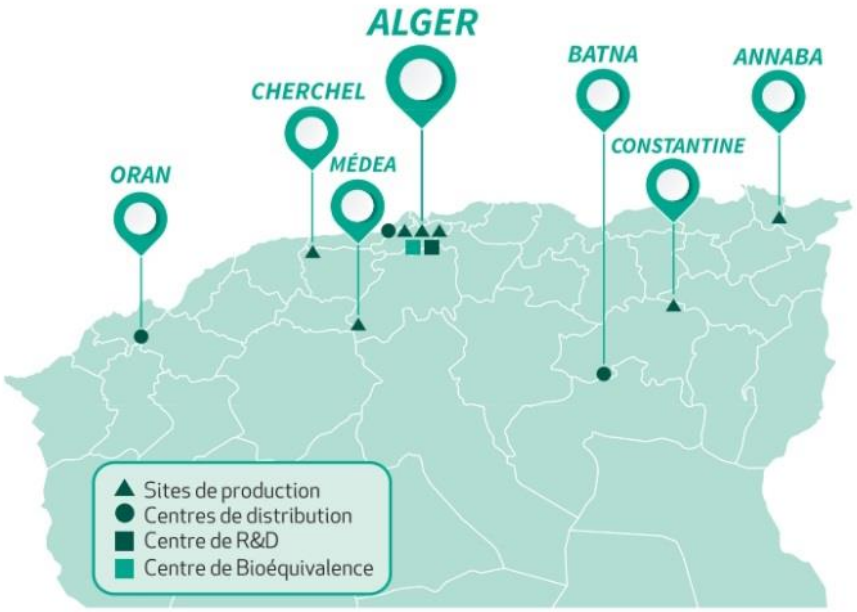


Figure I.2 SAIDAL's production sites

I.4 Description of Cartoning Machines:

A cartoning machine for medicine is a highly specialized packaging machine that is designed to automate the process of inserting blister packs or other types of individual medicine packaging into cartons or boxes. These machines are equipped with advanced mechanisms that allow for precise and efficient placement of the blister packs or other packaging into the carton, along with the insertion of any necessary leaflets or other information that must accompany the product.

the blister loading process involves the use of a specialized hopper that feeds the blister packs into the machine, which then separates and positions them for insertion into the

carton. The leaflet insertion process typically involves the use of a separate feeder that inserts the leaflets or other information into the carton along with the blister packs.

Cartoning machines are often used in large-scale pharmaceutical production facilities where high volumes of products must be packaged quickly and efficiently. These machines are designed to operate at high speeds while maintaining a high level of accuracy and precision, which helps to ensure that the products are packaged safely and securely, with all necessary information included. The use of cartoning machines for medicine packaging helps to streamline the production process, reduce waste and errors, and ensure consistent quality across all products.

I.5 Presentation of the ZanasiNigris Model KA 91:

Figure I.3 ZanasiNigris Model KA 91

I.5.1 Overview:

The ZanasiNigris Model KA 91 (Figure I.3) is a cartoning machine that was equipped to perform the sampling and forming of cartons, insertion of the product into cartons, sealing of cartons.

The KA 91 model is capable of handling a wide range of products, including blister packs, bottles, vials, and other similar products. The machine can handle up to 150 cartons per minute, depending on the size and type of the product being packed.

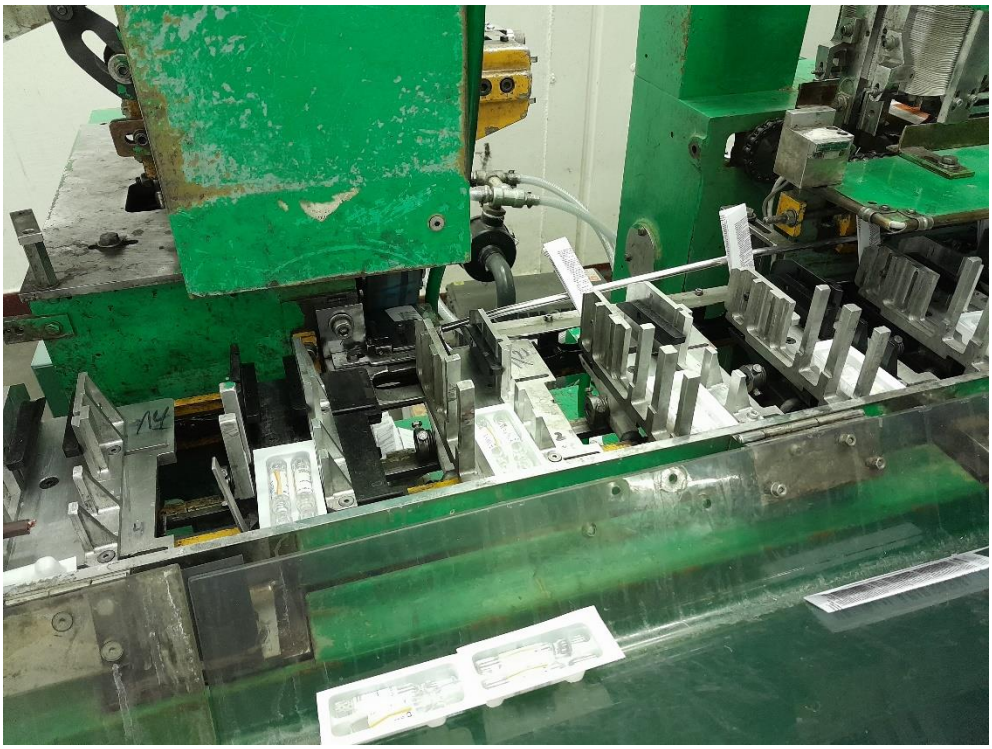


Figure I.4 Transportation of the vial packs while the leaflets are being added

The machine operates on a continuous motion principle and can be easily adjusted to accommodate different carton sizes and shapes. It can also be equipped with a range of optional features, such as automatic product feeding systems, leaflet inserters, and other customizations based on the customer's specific requirements.

the ZanasiNigris KA 91 cartoning machine is a highly versatile and efficient solution for the automatic packing of a wide range of products into cartons. It is a high-quality, reliable, and customizable machine that is designed to meet the specific needs of each customer.

I.5.2 The cartoning process:

While the conveyor belt is advancing, vial packs are being put in the trays which are specialized containers that hold the products put on the conveyor belt that can be adjusted according to the size of the product.

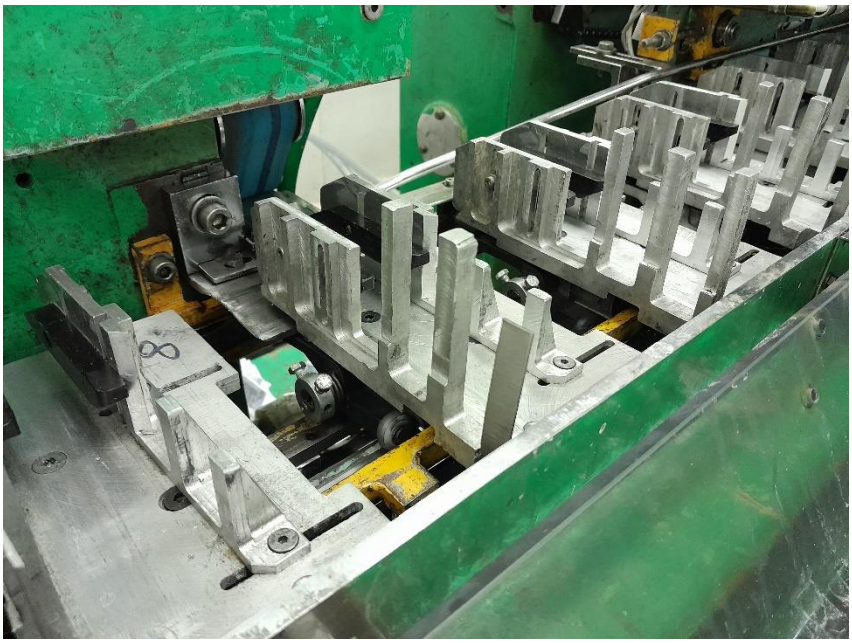


Figure I.5 The conveyor belt trays

The vial packs will eventually pass through a sensor, when it does the folding machine GUK FA 21/4 Cartonac 68 will release a folded leaflet from its magazine into the trays and this for each vial pack.

After the leaflet coupled with the vial pack get detected by the next photo-electric sensor one carton will be deployed and opened by suctions cups powered by the vacuum pump R5 RA 0063 F and is readied for filling

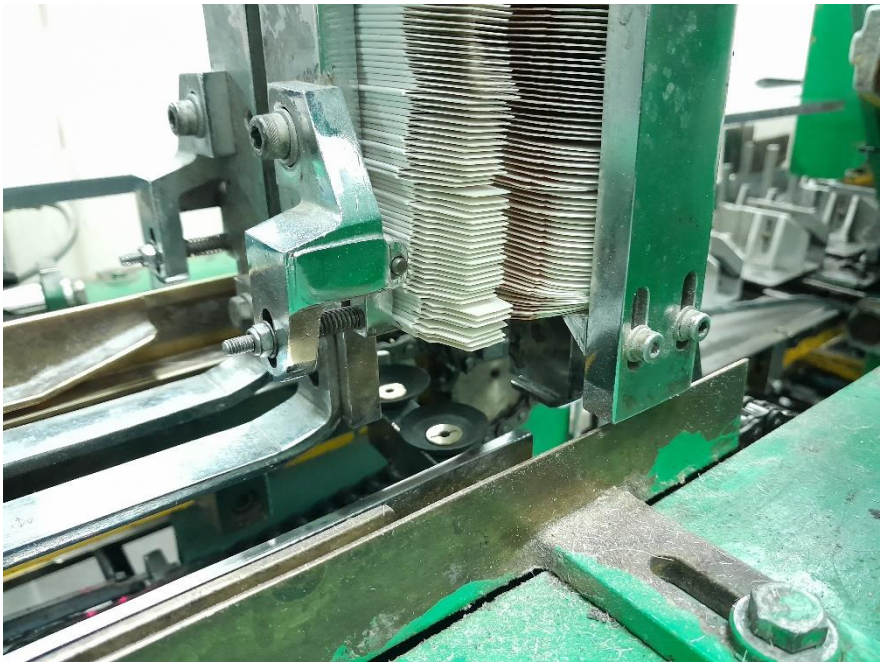


Figure I.6 the carton magazine and suction cups

Finally, special apparatuses called tuckers push the product together with the leaflet into the cartons when they meet at the end of the conveyor belt, the cartons are then sealed and proceed to the next step of production on another machine.

Figure I.7 Tuckers pushing into the carton

I.6 Conclusion:

This chapter has provided a look at the concept of automation and its impact on the industry, a review of the SAIDAL Group including its history, organizational structure, and production processes, and a overview of the ZanasiNigris model KA 91 with its production process.

Chapter II : Study of the hardware and software utilized

II.1 Introduction:

Automated systems are composed of multiple elements, essentially divided into two major parts, that being the hardware part and the software part.

This chapter will explore each part in detail, going through the operative and control part and also the software used on this project.

II.2 Operative part:

II.2.1 Inductive Sensors:

An inductive sensor is an electronic apparatus that has the capability to sense ferrous metal targets without requiring physical contact.

In addition, inductive sensors are also capable of detecting non-ferrous metal targets such as aluminum, brass, and copper. However, the utilization of non-ferrous metal targets reduces the sensing range of an inductive sensor. (See Figure II.1)

These sensors were used as replacements for the alarms that use limit-end switches as improvement on the machine since these types of sensors are more reliable

Figure II.1 Inductive sensor

II.2.2 Photoelectric Sensors:

A Photoelectric Sensor is a robust and versatile apparatus that utilizes light beams to identify the presence or absence of an object in industrial settings.

With their wide-ranging applicability, these sensors are deployed in a variety of ways and across diverse industrial sectors. Notably, they are instrumental in detecting objects or the spatial orientation of objects on production lines, accurately counting items, and safeguarding against hazardous situations by halting automatic doors from closing.

Figure II.2 Through-beam photoelectric sensor

There are three types of photoelectric sensors:

- Through-beam photoelectric sensors: Consists of a transmitter and receiver unit placed opposite to each other and detects the presence of an object by measuring the amount of light blocked by it. (see Figure II.2)
- Retro-reflective photoelectric sensors: Uses a reflective surface to bounce the light back to the sensor, and detects the presence of an object by measuring the amount of light reflected back to the receiver unit. This is the type of sensor that is used to check on the presence of cartons on the conveyor belt to activate the electromagnets.
- Diffuse reflective photoelectric sensors: Uses the reflection of light from an object to detect its presence and measures the amount of light reflected back to the receiver unit, without the need for a separate transmitter unit.

II.2.3 Limit Switch Sensors:

Limit switches (see Figure II.3) are mechanical devices that are used to detect the presence or absence of an object or to detect a certain position of a moving object. They

are typically composed of a mechanical actuator and electrical contacts that are activated when the actuator is triggered.

When the actuator is triggered by a physical object, it pushes the contacts together or pulls them apart, completing an electrical circuit or interrupting it. The electrical signal generated by the switch can then be used by a control system to stop or start a machine, or to trigger an alarm or warning signal.

Figure II.3 Different sizes of limit switch sensors

Limit switches are used in a wide range of industrial applications where precise position detection is required. Some common applications of limit switches include Machine Tool Limit Switches which are used to detect the end of a travel range for a spindle, table, or other moving component or Conveyor Belt Limit Switches that are used to detect the presence of objects on the conveyor or to trigger a stop or warning signal when the conveyor reaches the end of its travel range.

In the machine studied, these sensors are used on the CAMs to check for a full rotation0

II.2.4 Circuit-Breakers:

Circuit breakers are electrical devices used to protect electrical circuits and equipment from overloads and short circuits.

Circuit breakers (see Figure II.4) offer a manual method for controlling the flow of electricity in a circuit by enabling or disabling it. In contrast to fuses that require replacement upon activation, circuit breakers can be reset once the excessive current

issue has been resolved. By pushing the handle to the "OFF" position and subsequently returning it to the "ON" position, the circuit is restored.

Figure II.4 circuit-breaker by Shneider

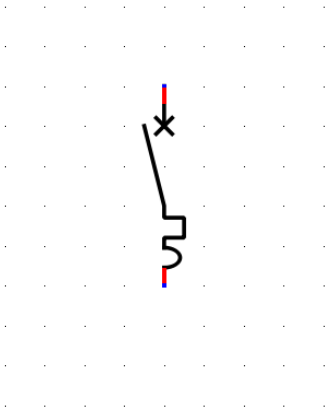


Figure II.5 Schematic form of a circuit-breaker

There are different types of circuit breakers, including:

- Thermal Circuit Breakers: These function by utilizing heat as the operating principle. When there is an excessive current, a bimetallic strip deflects and triggers the circuit breaker.
- Magnetic Circuit Breakers: These employ an electromagnet to trip the circuit breaker in response to the presence of a high current in the circuit.
- Thermal-Magnetic Circuit Breakers: These integrate both thermal and magnetic mechanisms to provide improved protection against electrical faults.

II.2.5 Relays:

Relays are electro-mechanical devices responsible for regulating the passage of electric current within an electrical circuit. Functioning as switches, they enable a small electrical signal to govern a larger current or voltage. Relays find extensive utility across diverse domains, such as industrial control systems, automotive electronics, and various other applications.

Figure II.6 The700-K22Z-B electromechanical relay by Allen-Bradley

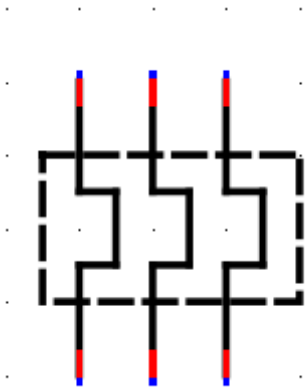


Figure II.7 Schematic form of a three-pole relay

There are different types of relays available, each designed for specific applications:

Electromechanical Relays: These relays employ electromagnetic principles to activate the contacts. They possess versatility, reliability, and the ability to switch both AC and DC circuits. (see Figure II.6)

Solid-State Relays (SSRs): SSRs utilize semiconductor switching elements like thyristors or transistors to regulate the circuit. They provide rapid response times, high switching

frequencies, and eliminate the presence of mechanical parts, leading to silent operation and an extended lifespan.

Time Delay Relays: These relays incorporate a delay in time between energizing the coil and the subsequent switching of the contacts. They find utility in applications where precise timing functions are necessary, such as motor control or sequential operations.

II.2.6 Contactors:

A contactor is an electrical switching device that is used to control the flow of electrical power in industrial and commercial applications.

Figure II.8 The LC1DO9 contactor by schneider

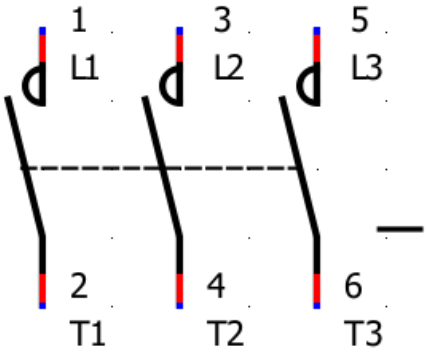


Figure II.9 Schematic form of a contactor

Its function is comparable to that of a relay, but unlike relays, It is designed to handle high-current and high-voltage circuits, making it suitable for switching heavy loads such as motors, lighting circuits, heaters, and power distribution systems.

II.2.7 Altivar 71 Variable Speed Drive:

Altivar 71 is a range of variable speed drives (VSDs) manufactured by Schneider Electric (see Figure II.10), a French multinational corporation specializing in energy management and automation solutions.

Figure II.10 The Ativar 71

The Altivar 71 range of VSDs is designed to provide energy-efficient motor control and improve the performance of a wide range of industrial and commercial applications, such as pumps, fans, compressors, and conveyors.

These drives feature advanced motor control algorithms, including flux vector control and sensorless vector control, which provide precise speed and torque control for the connected motor. They also offer a variety of communication options, including Ethernet, Modbus, and CANopen, which enable easy integration with a variety of automation systems.

Altivar 71 VSDs are available in a range of power ratings, from 0.37 kW to 630 kW, and can operate at a wide range of voltages and frequencies. They also offer a range of built-in safety features, including short-circuit protection and overload protection, to ensure safe and reliable operation.

In addition, the Altivar 71 range of VSDs is designed for easy installation, operation, and maintenance. They are equipped with a range of features that simplify commissioning

and operation, including an intuitive keypad and graphical display, and a range of diagnostic tools that enable rapid fault diagnosis and troubleshooting.

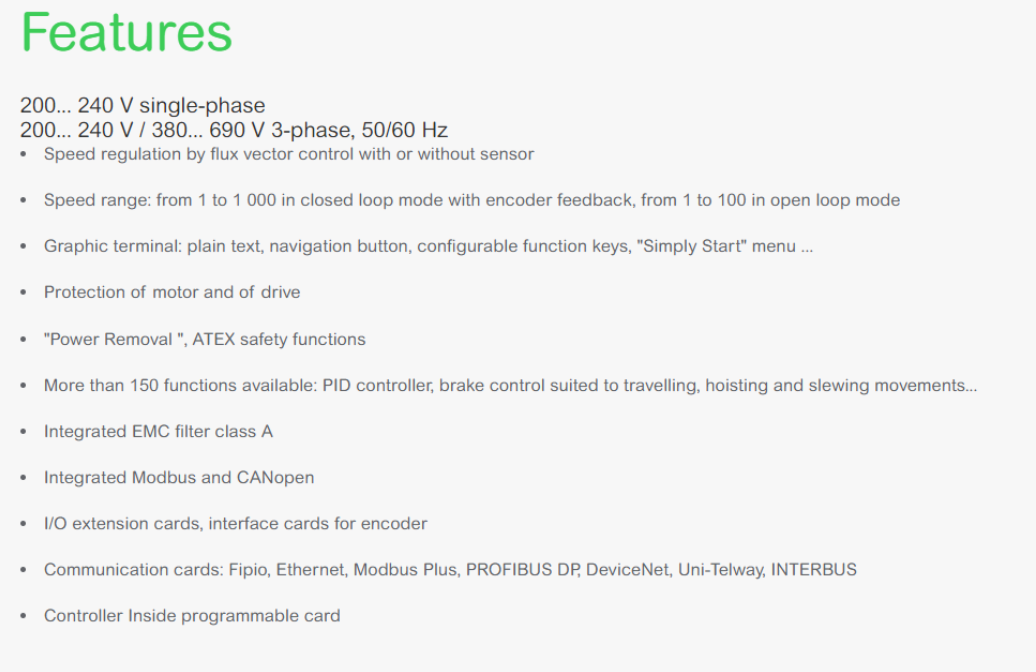


Figure II.11 Technical features of the Altivar 71

The variable sped drive in this project is used to control the speed and direction of rotation of the conbeyor belt to avoid damage on the machine and the product.

II.3 actuators

II.3.1 GUK FA 21/4 Cartonac 68 Folding Machine:

The GUK FA 21/4 Cartonac 68 (see Figure II.12) is a folding machine manufactured by GUK-Falzmaschinen GmbH, a company based in Germany that specializes in the production of folding machines, delivery systems, and peripheral equipment for the printing industry.

The machine is designed for the folding of paper and cardboard materials, and is particularly suited for the production of pharmaceutical leaflets and package inserts. It features high-precision folding technology, as well as advanced automation and control systems to ensure efficient and reliable folding operations.

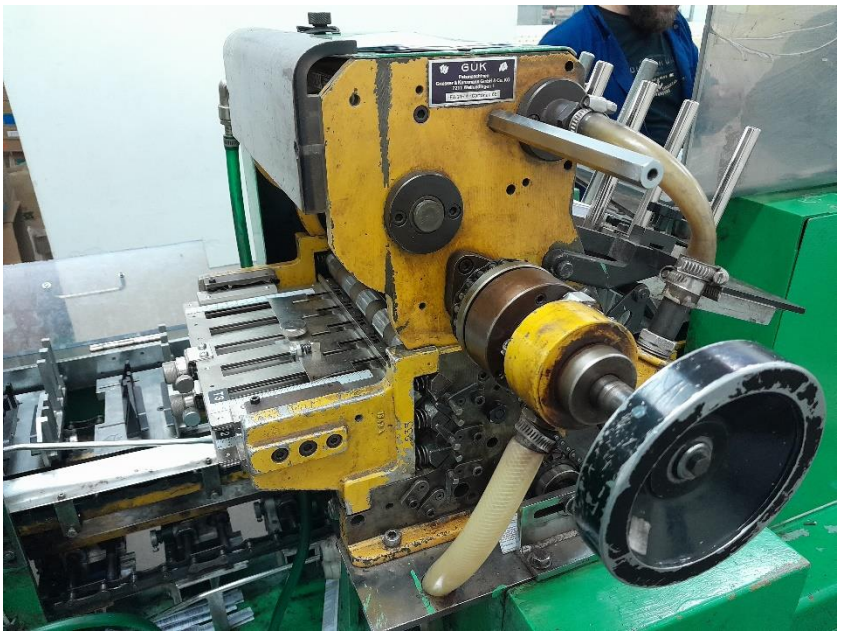


Figure II.12 The GUK FA 21/4 Cartonac 68 Folding Machine

II.3.2 Vacuum Pump R5 RA 0063 F:

The R5 RA 0063/0100 F (see Figure II.13) vacuum pump is a product manufactured by Busch Vacuum Solutions, a company based in Germany that specializes in vacuum pumps and systems.

The R5 series is a line of rotary vane vacuum pumps that are designed for a wide range of industrial applications. The RA 0063/0100 F model is a specific type of R5 vacuum pump that is designed to operate at an absolute pressure of 0.1 mbar, and a maximum pumping speed of 76 cubic meters per hour.

This vacuum pump features an oil-lubricated rotary vane design that ensures reliable and efficient operation, even in harsh industrial environments. It is equipped with a gas ballast valve that allows it to handle small amounts of moisture and condensable gases, which can prolong the life of the pump.

The R5 RA 0063 F vacuum pump is suitable for a variety of industrial applications, including packaging, plastics processing, printing, and many others. It is known for its high efficiency, low noise level, and ease of maintenance, making it a popular choice for many different industries.

Figure II.13 The R5 RA 0063/0100 F vacuum pump

TECHNICAL DATA	R5 RA 0063 F	R5 RA 0100 F
Nominal pumping speed	76 m^3/h	120 m^3/h
Ultimate pressure	0.1 hPa (mbar)	0.1 hPa (mbar)
Nominal motor rating	2.4 kW	3.4 kW
Nominal motor speed	1800 min^{-1}	1800 min^{-1}
Power consumption at 100 mbar	1.5 kW	2.4 kW
Power consumption at ultimate pressure	0.8 kW	1.5 kW
Noise level (ISO 2151)	67 dB(A)	68 dB(A)
Oil capacity	2 l	2 l
Weight approx.	55 kg	73 kg
Dimensions (L x W x H)	627 x 406 x 290 mm	701 x 406 x 290 mm
Gas outlet	G 1¼"	G 1¼"
Gas inlet	G 1¼"	G 1¼"

Figure II.14 Technical specifications of the R5 RA 0063/0100 F

II.4 Control part

II.4.1 General Information about PLCs:

A programmable logic controller (PLC) is a type of controller that is microprocessor-based and utilizes programmable memory for storing instructions to perform various functions such as sequencing, timing, counting, arithmetic, and logic. PLCs are commonly used to control machines and processes. These controllers are designed in such a way that they can be operated by engineers who may have limited knowledge of computers and computing languages.

II.4.1.1 PLC architecture:

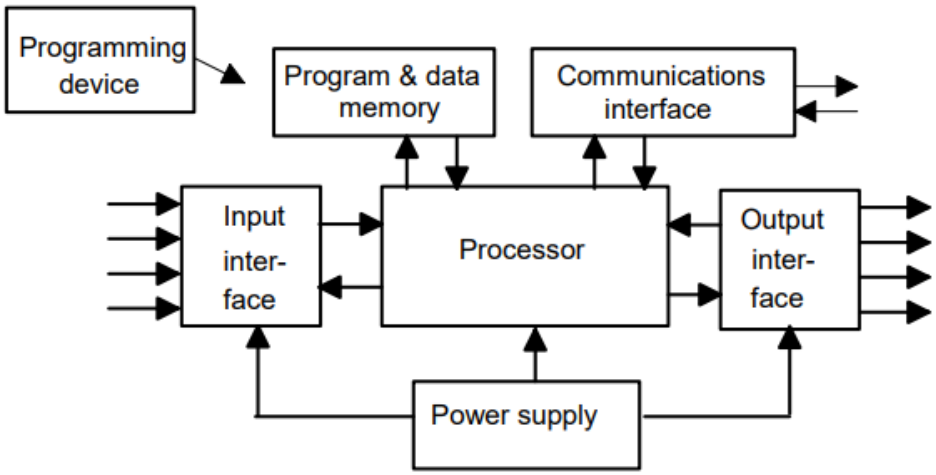


Figure II.15 Architecture of a PLC

- The CPU, also known as the processor unit, comprises the microprocessor responsible for interpreting input signals and executing control actions as per the program stored in its memory. It then transmits the decisions as action signals to the outputs.
- The power supply unit is an essential component that converts the mains a.c. voltage into low d.c. voltage (5V) necessary for the processor and circuits in the input and output interface modules.
- The programming device is utilized to input the required program into the memory of the processor. The program is developed in the device and then transferred to the memory unit of the PLC.

- The memory unit is responsible for storing the program used for control actions executed by the microprocessor, as well as the data collected from input and output for processing and outputting, respectively.
- The input and output sections serve as the channels through which the processor obtains information from external devices and transmits information to them.

II.4.1.2 Types of PLCs:

PLC systems are designed in two common mechanical types: the single box and the modular/rack types (see Figure II.16). Small programmable controllers typically use the single box type, also known as the brick, which comes in a compact package containing a power supply, processor, memory, and input/output units. Such PLCs usually have 6, 8, 12 or 24 inputs, 4, 8 or 16 outputs, and a memory that can store around 300 to 1000 instructions.

Figure II.16 The MITSUBISHI FX3U-48MT/ES

On the other hand, modular PLCs are designed to fit in racks and are suitable for systems with a larger number of inputs and outputs. They consist of separate modules for power supply, processor, etc., which are usually mounted on rails inside a metal cabinet. The rack type can be used for PLCs of all sizes, and functional units are packaged in individual modules that can be plugged into sockets in a base rack. The user can decide the mix of modules required for a particular purpose and plug them into the rack. This makes it easy to expand the number of input/output connections by adding more input/output modules or to expand the memory by adding more memory units.

II.4.2 Presentation of the ZELIO Smart Relay module:

II.4.2.1 Overview:

Zelio Logic smart relays offer a cost-effective and user-friendly solution for managing uncomplicated automation systems, providing a viable alternative to cabled logic or specific cards-based solutions.

With two available ranges, Zelio Logic offers the choice between Compact versions that come with fixed configurations, and Modular versions that can be extended with additional modules. These smart relays also include a PID function that makes them suitable for HVAC applications, as well as a 2G/3G modem communication ability.

For small applications, Zelio Soft, the configuration software for Zelio Logic, offers a simplified tool-free programming experience in Ladder or FBD and SFC languages. This software can be downloaded free of charge from our website.

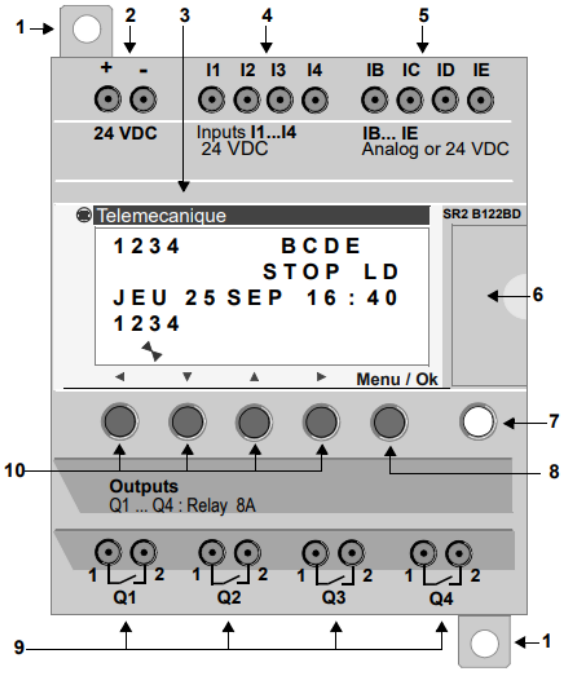


Figure II.17 Zelio logic smart relay (front view)

Prompt	Element
1	Retractable mounting feet.
2	Screw terminal block for the power supply.
3	LCD display, 4 lines, 18 characters.
4	Screw terminal block for discrete inputs.
5	Screw terminal block for analog inputs. 0-10 Volts, usable as discrete inputs depending on the reference.
6	Slot for backup memory or PC connection cable.
7	**Shift** key (white).
8	**Menu/OK** key (green) for selection and confirmation.
9	Relay output screw terminal block.
10	Navigation keys (gray) or, alternatively, can be configured as Z keys.

Figure II.18 Technical specifications of zelio logic smart relay

II.4.2.2 Purpose of choosing ZELIO:

Zelio PLCs are designed to be compact, user-friendly, and versatile, making them a good choice for small to medium-sized control applications.

Compared to other PLC brands, Zelio PLCs may be more affordable and easier to program, especially for users who are new to PLC programming. They also offer a range of programming options, including ladder logic and function block diagram which can be helpful in creating complex control sequences.

II.4.2.3 LCD Display:

Some Zelio modules come with an LCD display (see Figure II.19), which provides useful information about the module's status and operating parameters.

The illustration below presents an example of LCD display elements when displaying the INPUT/OUTPUT screen:

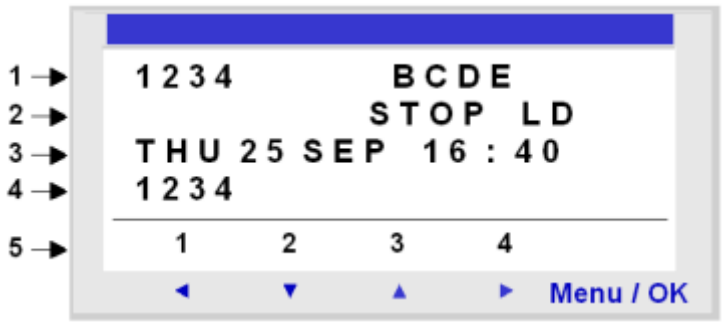


Figure II.19 LCD display on the zelio smart relay

II.4.3 ZELIO Module SR3B261BD

For this project, the Zelio module SR3B261BD has been chosen for the programming of the machine (see Figure II.20):

Figure II.20 The Zelio module SR3B261BD

Some key features of the SR3B261BD module include:

- 26 I/O points, including 16 digital inputs and 10 digital outputs
- Analog inputs for temperature and pressure sensors
- Programming via ladder logic or function blocks using the Zelio Soft software
- Modbus RTU communication protocol for easy integration with other devices
- LED indicators for power, communication, and I/O status
- Compact size and easy mounting on a DIN rail

II.4.4 Discrete I/O extension module SR3XT141BD:

Figure II.21 The extension module SR3XT141BD

The SR3XT141BD is a discrete input/output extension module manufactured by Schneider Electric, designed to be used with the Zelio Logic smart relay family. It provides additional I/O points, allowing for greater flexibility and customization in small to medium-sized automation tasks.

II.4.4.1 Purpose of using the extension module SR3XT141BD:

When used with a Zelio module SR3B261BD, the SR3XT141BD extension module can provide additional I/O points, allowing for greater flexibility and customization in automation tasks. The SR3B261BD module itself provides 26 I/O points, including 16 digital inputs and 10 digital outputs. However, in some cases, the system may require additional I/O points beyond what the SR3B261BD can provide.

The SR3XT141BD module can be easily connected to the SR3B261BD using the RJ45 connector and cable, and the additional 8 digital inputs and 6 digital outputs can be programmed using the Zelio Soft software. This can significantly expand the functionality of the automation system, allowing for more complex tasks to be performed.

II.4.5 Ethernet communication extension SR3NET01BD:

The SR3NET01BD module (see Figure II.22) enables the Zelio Logic smart relay to communicate via the Modbus TCP/IP protocol. It allows the smart relay to exchange data with other devices, such as programmable logic controllers (PLCs), human-machine interfaces (HMIs), supervisory control and data acquisition (SCADA) systems, or other compatible devices on the same network.

Figure II.22 The ethernet communication extension SR3NET01BD

The communication module features support for 10/100BASE-T Ethernet communication port. It is equipped with an RJ45 connector for establishing the electrical connection.

II.5 Software:

II.5.1 Programming languages:

II.5.1.1 Ladder Logic (LD):

Ladder Logic is a graphical programming language that is widely used in PLCs. With the introduction of basic PLCs, ladder logic programming was developed to emulate the layout of relay-based circuits. This programming language, ladder logic, is still widely used today due to its simplicity and was among the first PLC programming languages to be introduced. LD is used primarily for discrete control applications such as on/off control of machines, lights, motors, and other devices.

II.5.1.2 Function Block Diagram (FBD):

Function Block Diagram is a graphical programming language that uses blocks to represent various functions and logic operations. These blocks are connected to form a program that controls the operation of a PLC. FBD enables users to generate a graphical representation and flow of the process, complete with suitable transitions between instructions. The visual editor in FBD is known for being user-friendly, intuitive, and creates a natural workflow for implementing specific processes. The graphical nature of FBD makes it easy to understand and analyze complex chemical processes, and is widely used in the field of process control and automation. FBD is used for complex control applications that require mathematical calculations, signal processing, and other advanced functions.

II.5.1.3 Structured Text (ST)

Structured Text is a popular programming language for Programmable Logic Controllers (PLCs) that closely resembles C or assembly language. In Structured Text programming, the user inputs lines of code that execute sequentially, evaluate specific functions, perform boolean checks, and energize the appropriate outputs of the PLC. This language provides a straightforward transition into PLC programming for those who have experience in traditional programming languages such as C, C++, Java, or Python.

One of the key advantages of Structured Text is that it can be easily manipulated in text processors, making it quick and easy to implement without the need for any specialized hardware. Its text-based format also makes it highly portable and easily transferable between different systems. These benefits have made Structured Text a popular choice for PLC programming in a wide range of industrial applications.

II.5.1.4 Sequential Function Chart (SFC):

Sequential Function Chart is a programming language that excels in handling subsequent processes. In SFC, the process steps are executed in a sequence, with each step having defined start conditions, and flow as the process would run in the production facility. While it is possible to implement this process in ladder logic using an SQI/SQO instruction, a more efficient approach would be to utilize SFC.

SFC provides a graphical representation of the process that is easy to understand and follow, with each step clearly defined and sequenced. This makes it an ideal choice for managing complex production processes that require precise sequencing and control. Additionally, SFC allows for a high degree of flexibility in designing the process flow, enabling the programmer to easily modify and update the process as needed. Overall, SFC is a powerful tool for managing subsequent processes and ensuring efficient production operations.

II.5.1.5 Instruction List (IL):

Instruction Lists are sometimes confused with Structured Text due to their similar editors. However, there are some differences between the two languages. Like Structured Text, Instruction Lists specify each line of code, including instructions, conditions, and outcomes. However, Instruction Lists are more similar to ladder logic programs in terms of program flow, while Structured Text is closer to traditional programming languages like C or Java.

II.5.2 Presentation of Zelio Soft 2:

II.5.2.1 Overview:

Zelio Soft 2 (Figure II.23) programming software is specifically designed for programming the logic modules of the Zelio Logic range. The software provides users with a variety of options including selecting programming languages, displaying program and parameter data, loading and downloading applications, and printing application documentation. This powerful programming tool allows for easy customization of Zelio Logic modules to meet specific automation needs.

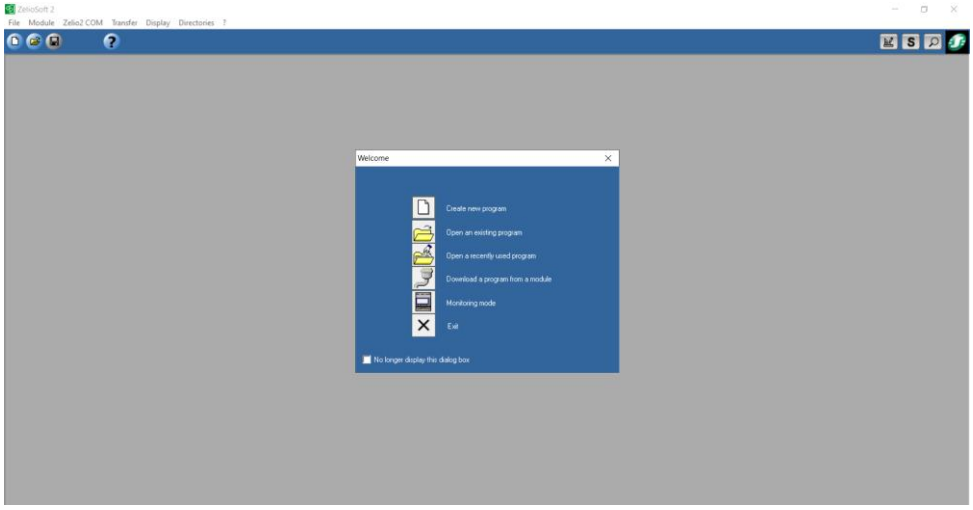
Figure II.23 The Zelio soft 2 logo

II.5.2.2 Characteristics:

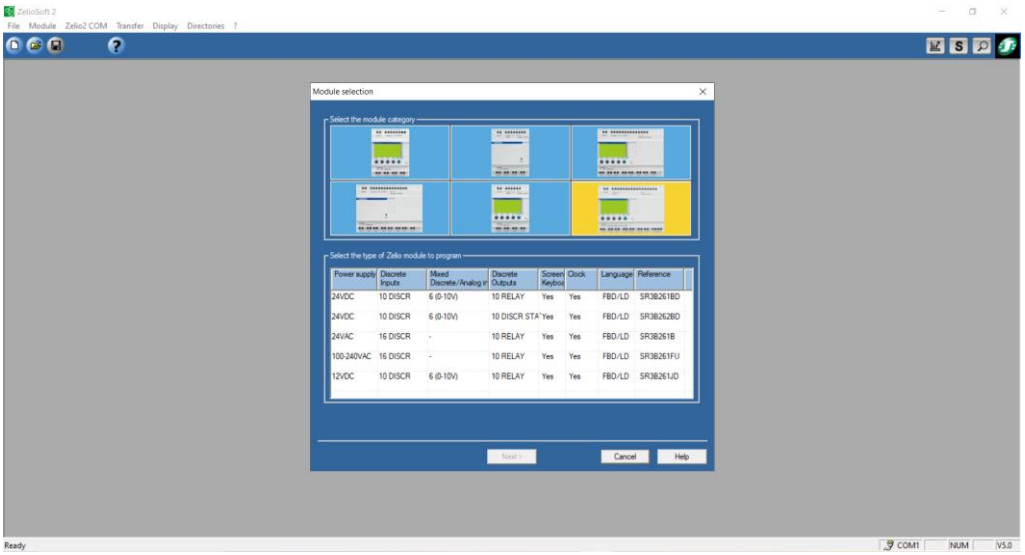
- supports both LADDER logic and Sequential Function Chart (FBD).
- has a simulation function to do a live simulation of the program.
- Intuitive and user-friendly interface.
- Free to download and use.

II.5.2.3 How to Use:

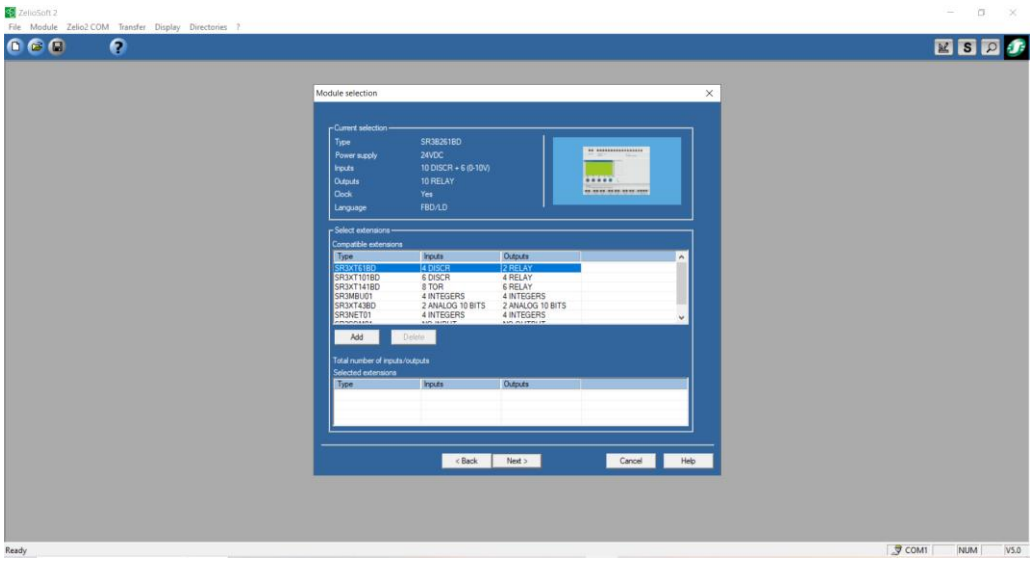
- First launch ZELIO soft 2:



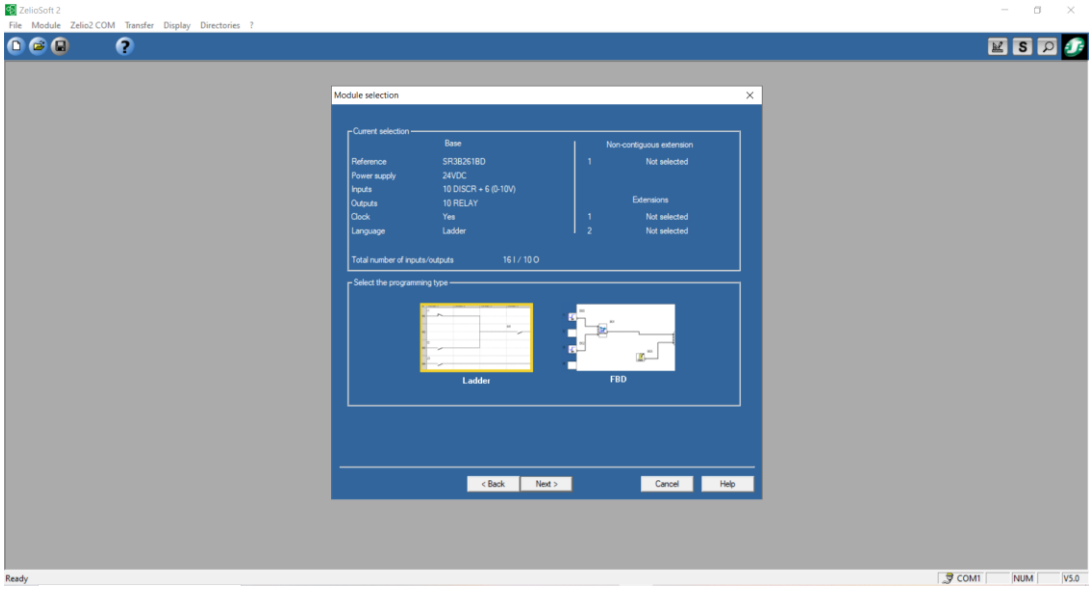
- the above window will appear, choose Create new program.



- Now choose the module most suited for the project.

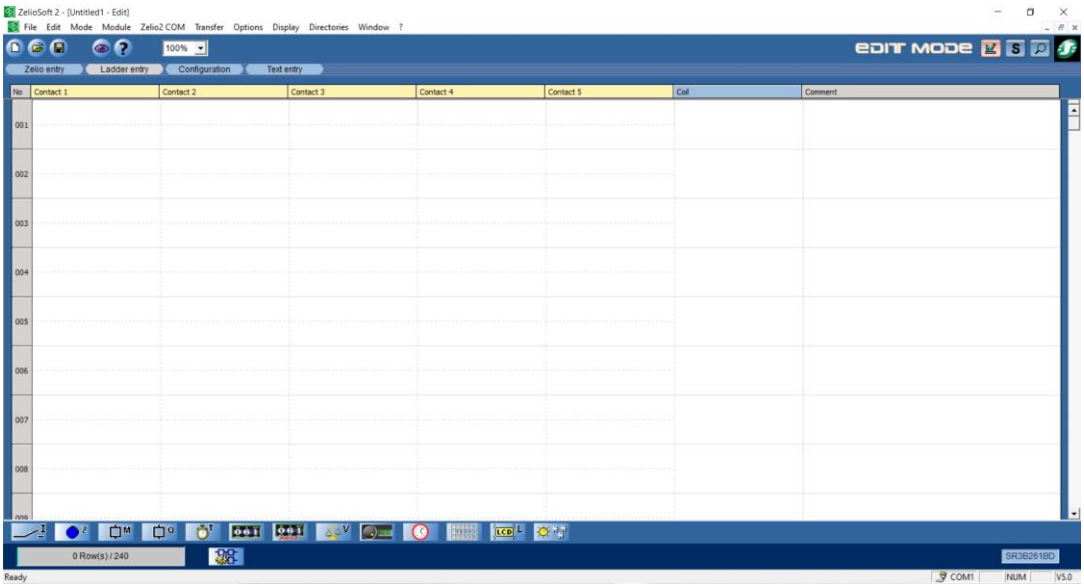


- Here multiple extensions can be chosen.

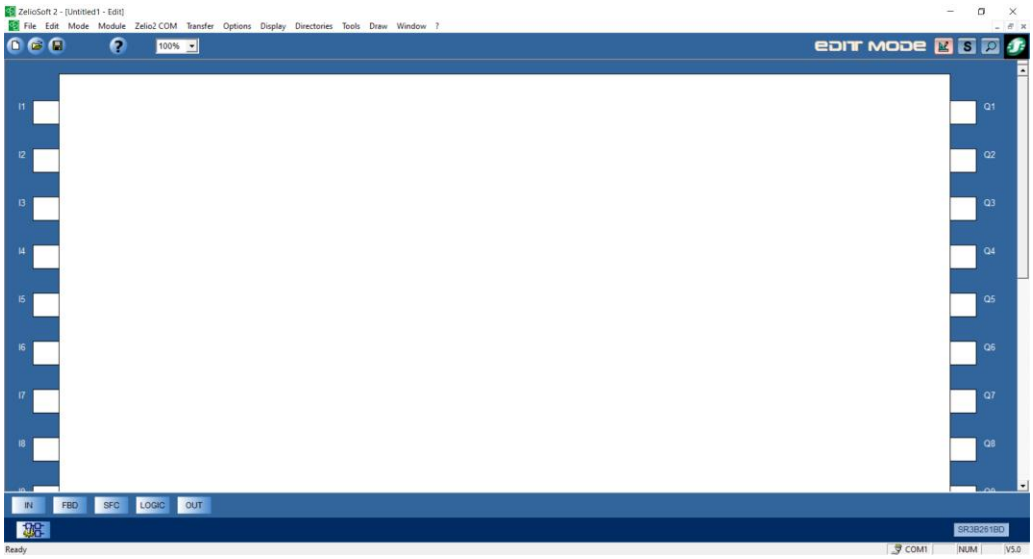


- In this window there is a choice between choosing LADDER logic or Function Block Diagram

  - In the case of LD:



  - In the case of FBD:



II.5.3 Presentation of LabVIEW:

Unlike TIA Portal, Zelio Soft 2 doesn't come with an integrated environment to build a visual user interface, and so an external software has been chosen to design a supervisor for this project.

II.5.3.1 Overview:

LabVIEW, short for Laboratory Virtual Instrument Engineering Workbench (see Figure II.24), is a graphical programming language and development environment created by National Instruments (now NI) in 1986.

Figure II.24 The LabVIEW logo

LabVIEW offers a visual programming paradigm where users can create programs by connecting icons or blocks, called "virtual instruments" (VIs), on a block diagram.

Since its inception, engineers and scientists globally have benefited from the adoption of NI LabVIEW, in various stages of the product design process. This adoption has resulted in enhanced quality, reduced time to market, and increased efficiency in engineering and manufacturing. Leveraging the integrated LabVIEW environment, users can seamlessly interface with real-world signals, analyze data to extract valuable insights, and easily share their findings.

II.5.3.2 Characteristics:

LabVIEW is made of multiple key features, including:

- Graphical programming: LabVIEW uses a dataflow model, where the flow of data determines the execution of the program. This approach allows for parallel execution and easy visualization of data flow.

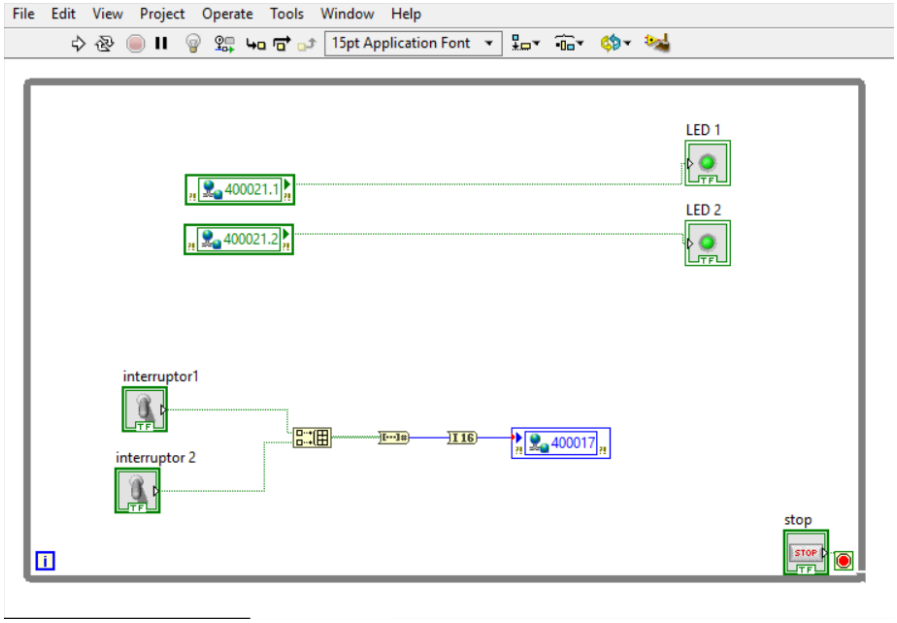


Figure II.25 The Virtual Instrument's block diagram

- User interface design: LabVIEW empowers users to develop user interfaces that are intuitive and interactive for their applications (see Figure II.26). The drag-and-drop interface design tools provided by LabVIEW make it straightforward to create personalized user interfaces. Additionally, LabVIEW facilitates real-time data visualization, enabling users to effectively visualize and interpret data as it is being generated.

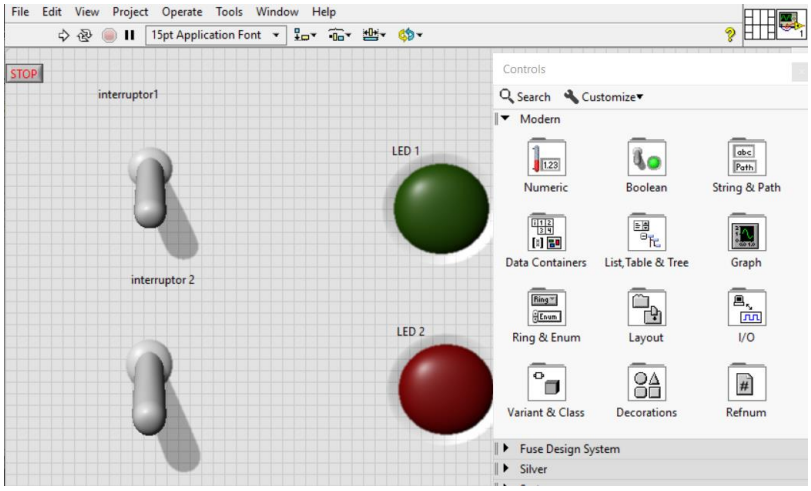


Figure II.26 The Virtual Instrument with the control's palette

- Connectivity and communication: LabVIEW supports various communication protocols, such as TCP/IP, UDP, serial, and Ethernet (see Figure II.27), enabling seamless integration with other software systems and devices. It also offers web publishing capabilities to create web-based interfaces for remote monitoring and control.

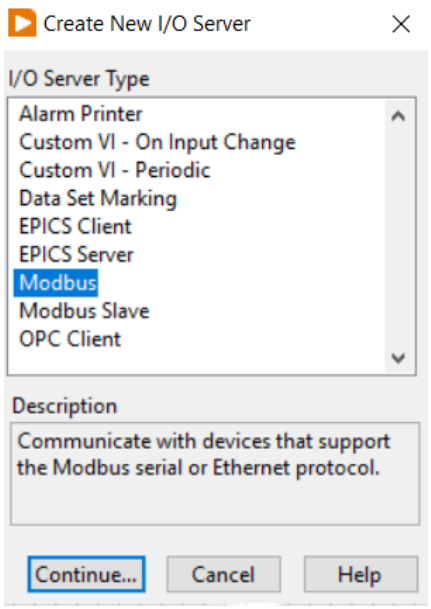


Figure II.27 The I/O server panel

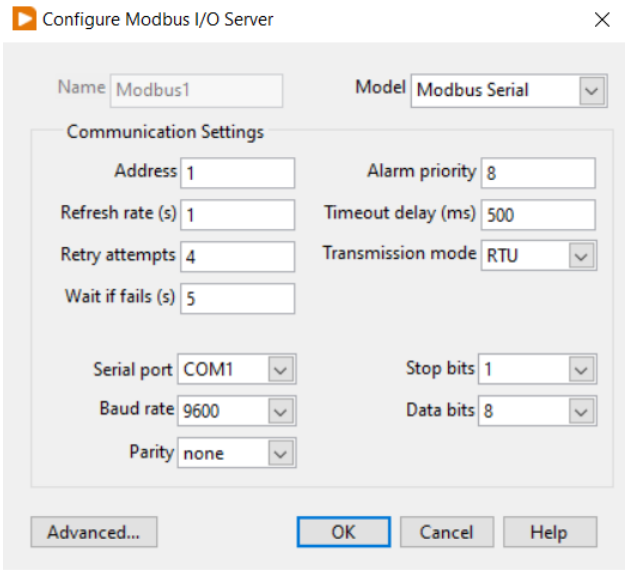


Figure II.28 The Modbus I/O server configuration panel

II.5.4 Presentation de Virtual Serial Port Emulator:

To initiate Zelio Soft 2's monitoring mode to monitor the behavior and status of the program in real-time, additional virtual ports are needed, the use of VSPE has been opted to tackle the issue.

II.5.4.1 Overview:

Virtual Serial Ports Emulator (VSPE) is a valuable tool designed to assist engineers and developers in the creation, debugging, and testing of applications that rely on serial ports. It enables the creation of virtual devices that can transmit and receive data. Virtual devices possess unique capabilities that differentiate them from regular serial ports. For instance, they can be simultaneously accessed by multiple applications, offering increased flexibility and utility in various scenarios.

Figure II.29 The Virtua Serial Port Emulator logo

II.5.4.2 Purpose of use:

VSPE is commonly used in situations where a physical serial port is not available or when there is a need to simulate multiple serial port connections. It can be utilized for testing and debugging serial communication protocols, developing software.

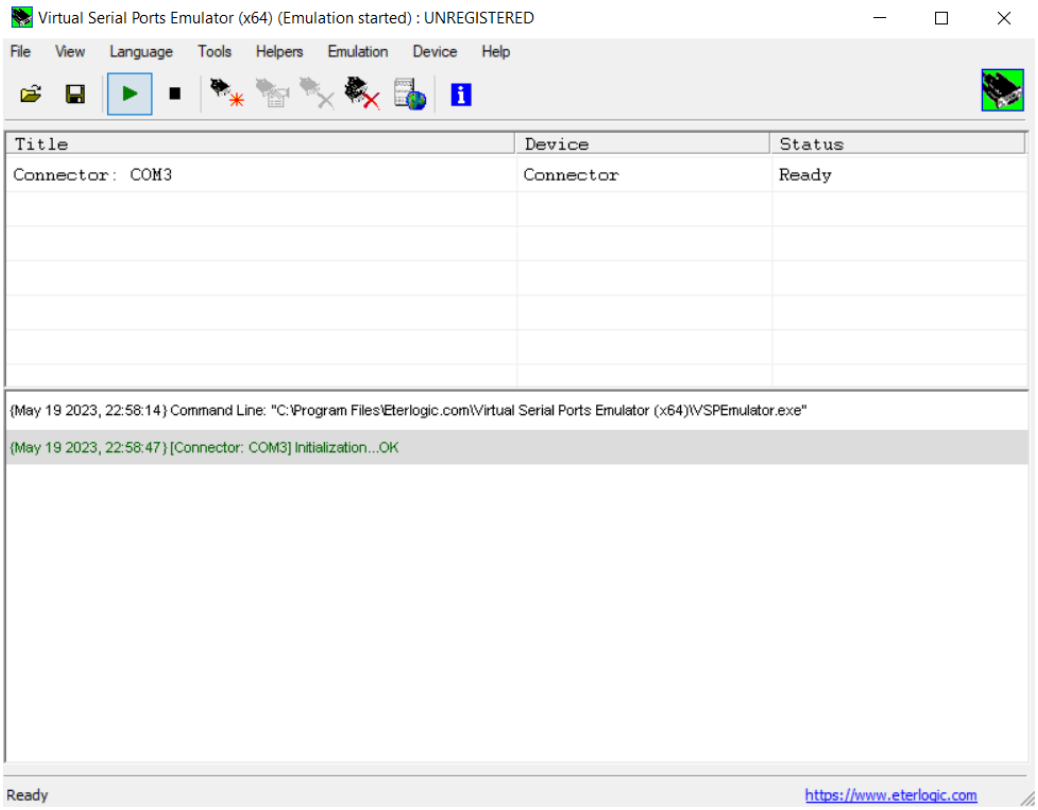


Figure II.30 The VSPE interface

II.6 Conclusion :

In this chapter we have gone through the operative part including the sensors and circuit-breakers, the control in which we covered programable logic controllers and presentation of zelio smart relays with the module and extention used in this project, as well as every software used from zelio soft 2 for programing the plc to LabVIEW for developing the supervisor.

Chapter III : Programming, supervision and simulation

III.1 Introduction :

After exploring the hardware such as the sensors and Zelio Smart Relay, as well as the software used, the next step is to delve into the programming and simulation of the project.

This chapter will explore every step of the programming in Zelio Soft 2 and the design and programming of the supervisor in LabVIEW.

III.2 The Challenges to solve :

The cartoning machine was built on hardwired logic, which makes it less precise and is hard to do maintenance on, the machine also lacks a supervisor, making it impossible to actively survey the cartoning process.

The solutions proposed: Develop a program in Zelio Soft 2 destined to be implemented in a Zelio Smart Relay, make use of lcd screen of the PLC to display the machine's status, alarm and warnings and finaly developing a supervisory program in LabVIEW to aid in real-time monitoring and control of the machine.

III.3 The Process:

III.3.1 Functioning of the cartoning machine:

To really understand the program developed, this flowchart has been put together to get a better comprehension of the machine's cartoning process (see Figure III.1):

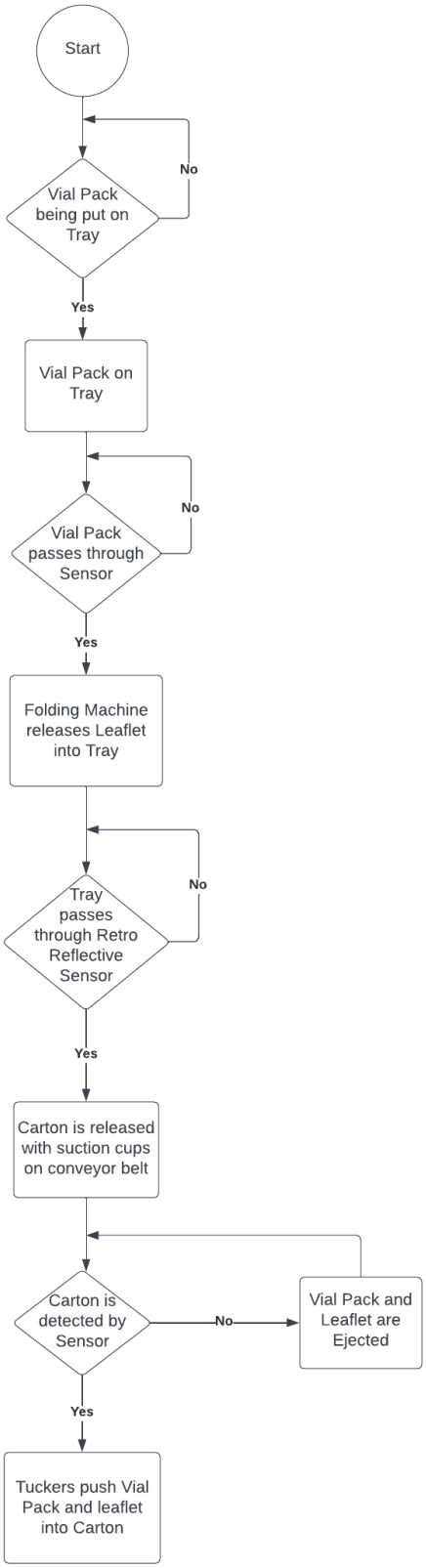


Figure III.1 Flowchart of the cartoning process

III.4 The Program:

The program, made for the machine, has been fashioned in Zelio Soft 2 in the Function Block Diagram (FBD) programming language, and is essentially composed of three parts: starting of the machine, the cartoning process and the alarms.

III.4.1 Purpose of using FBD:

FBD was chosen as the programming language for this project, for its graphical style of programming (Figure III.2 Traffic light program in FBD, where the code is represented by interconnected blocks and wires.

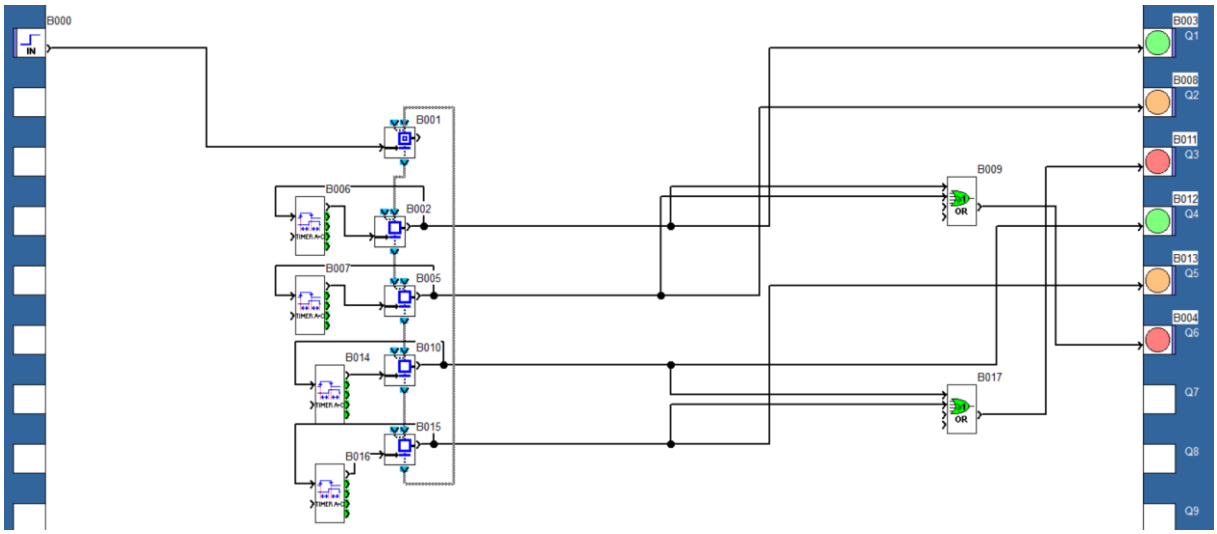


Figure III.2 Traffic light program in FBD

This visual representation enhances clarity and facilitates easier comprehension of intricate control systems by offering a simplified and comprehensible way to understand and analyze them.

III.4.2 Starting of the machine:

Here's an overview of how the starting of the machine works:

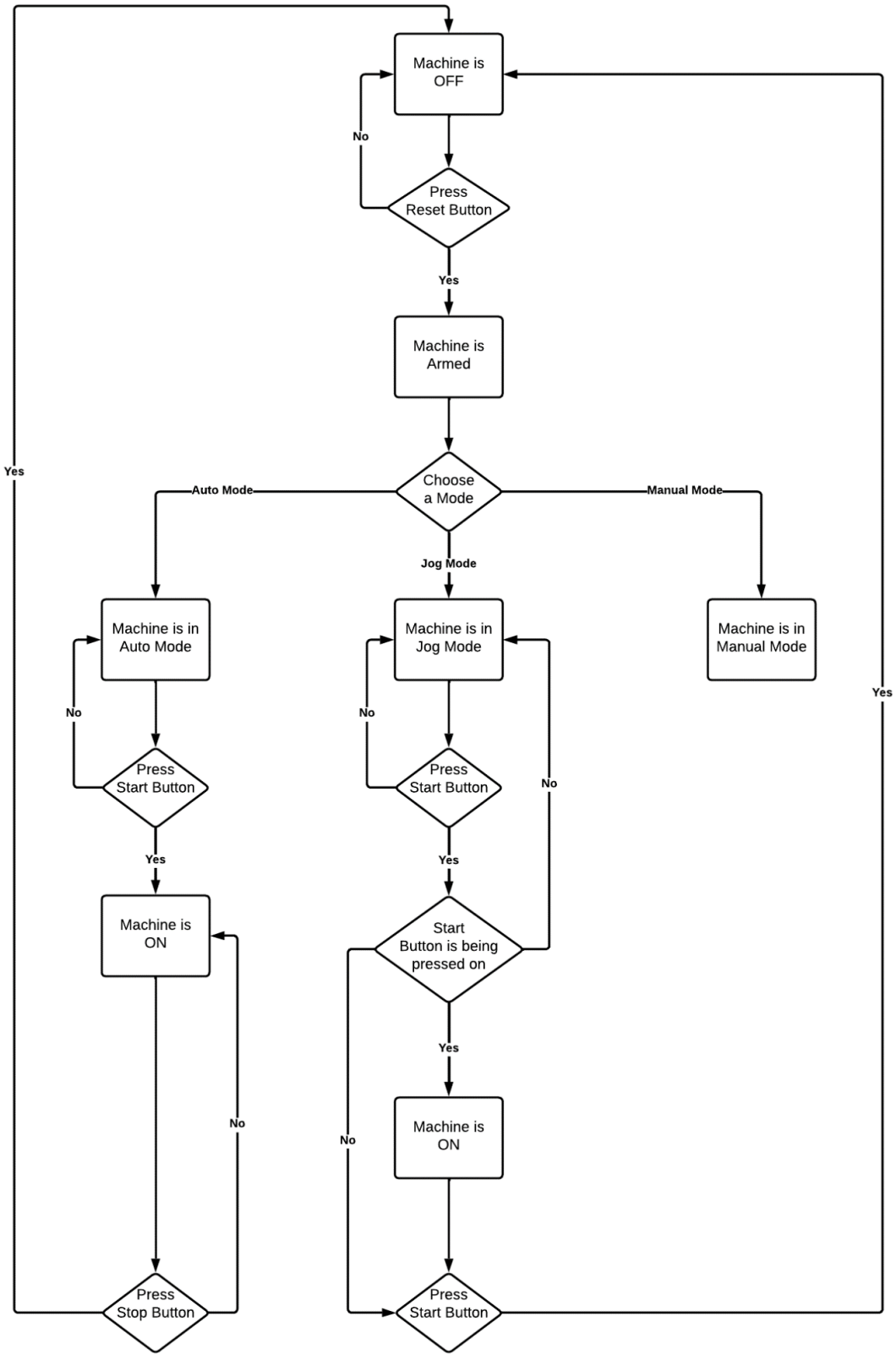


Figure III.3 Flowchart for the startup sequence

III.4.2.1 The Inputs:

The inputs used here are the following (see Figure III.4):

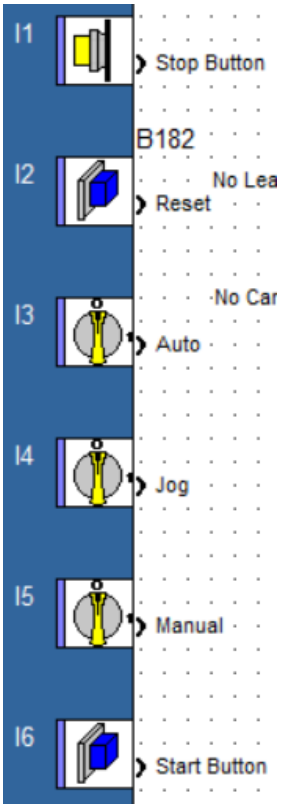


Figure III.4 Inputs of the starting machine part

- **Stop Button**: Serves as an emergency stop, pressing it will stop the machine immediately.
- **Reset**: When the machine stops its operations, whether by an alarm or a press of the stop button, this button needs to be pressed in order to rearm the machine.
- **Auto**: enables the auto mode.
- **Jog**: enable the jog mode.
- **Manual**: enables the manual mode.
- **Start mode**: After choosing a mode, this button is pressed to start the machine.

III.4.2.2 The Outputs:

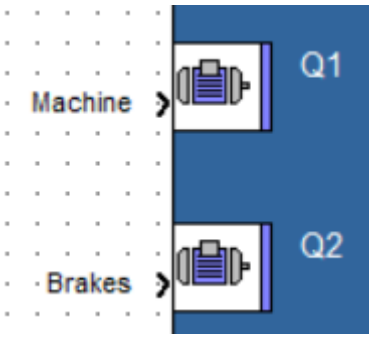


Figure III.5 Outputs of the starting machine part

- **Machine**: This output represents the machine's operations.
- **Brakes**: the motor's brakes.

III.4.2.3 The Interconnexions:

This part of the program is built on an independent chart of FBD's Sequential Function Chart (SFC) functions

❖ **Initialization:**

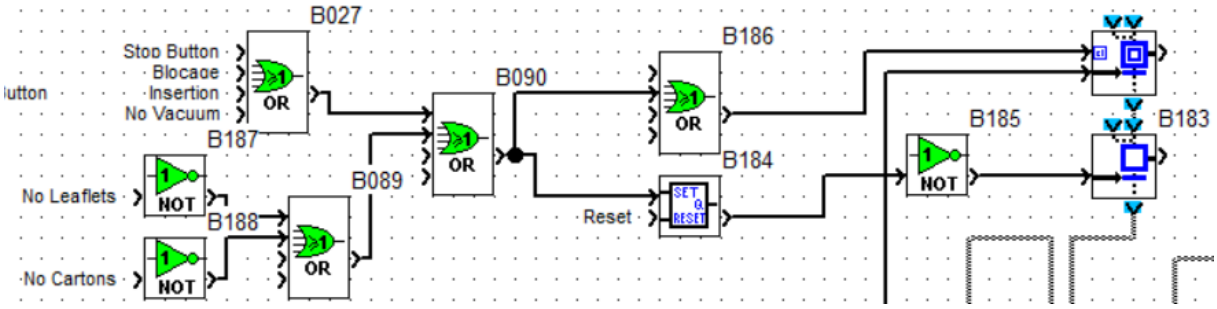


Figure III.6 Initialization of the program

As seen in Figure III.6, the independent chart starts with a resettable initial step, with its reinitialized plug being wired to every sensor linked to an alarm along with the Stop Button, and its transition wired with every mode input which are all wired to an OR function (see Figure III.7).

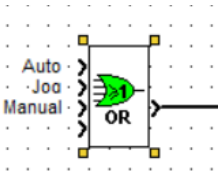


Figure III.7 The different modes wired on an OR gate

Next is the Reset Button, which is set up with a RS Switch wired in the step that follows.

❖ **The Modes:**

The divergence to OR step that follows the initialization steps, starts the branching between the modes, one transition is wired to an AND function with Auto and Start Button inputs, while the other is wired to an OR function with the Jog and Steering Wheel inputs (see Figure III.8).

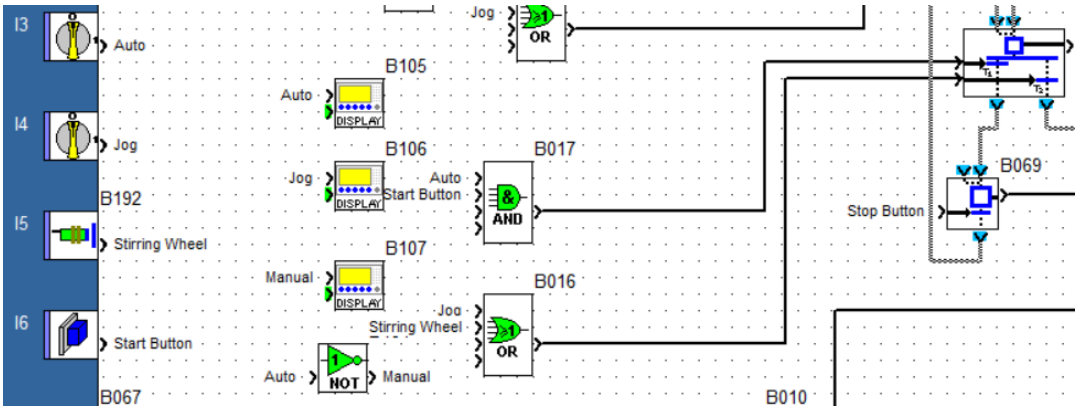


Figure III.8 Wiring of the different modes of operation

The former is used to start the machine in Auto mode by passing to the next step, which is wired to the Machine and Brakes outputs, and its transition wired to the Stop Button to reinitialize the program when needed, and the latter is used to go to the next divergence that branches between the Jog mode and Manual mode (see Figure III.9).

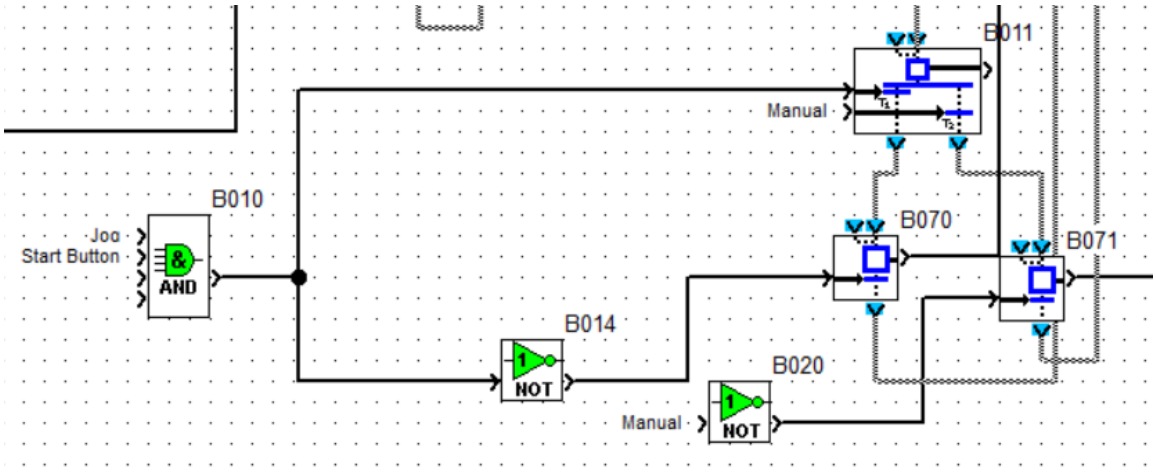


Figure III.9 Jog and Manual mode branching

In this second divergence to OR step, one of the transitions is wired to an AND function with the Jog and Start Button inputs, this is the one that starts the machine in Jog mode by taking you to the step below that is wired to the Machine and Brakes outputs, and has its transition wired to the same AND function but through a NOT gate, this insures that upon switching off either the Jog input or Start Button input, the step will transition back to the former divergence, so to maintain the Machine and Brakes inputs ON, both inputs need to be continually ON.

The other transition is directly wired to the Manual input, which is the Auto input passed through a NOT function, and by switching it ON, starts the machine in Manual mode that initiates the Brakes output only.

III.4.3 The cartoning process:

III.4.3.1 The Inputs:

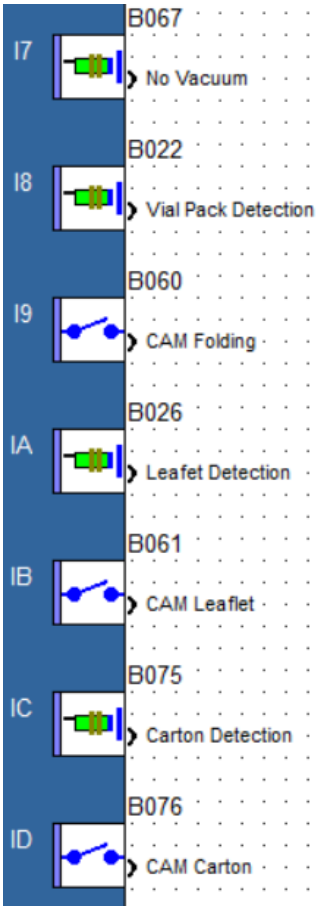


Figure III.10 The inputs of the cartoning process part

- **No Vacuum:** This is an alarm, but is necessary for the comprehension of this part, when this input is OFF, it means there is vacuum generated by the pump.
- **Vial Pack Detection:** This input represents an end-limit switch which detects when a vial pack enters at the very start of the process.
- **CAM Folding:** The CAM related to the folding machine.
- **Leaflet Detection:** Represents a photoelectric sensor that detects leaflets to engage the deployment of cartons.
- **CAM Leaflet:** The CAM related to the Vacuum Pump.
- **Carton Detection:** Represents a photoelectric sensor that detects cartons to activate the electromagnets.
- **CAM Carton:** The CAM related to the electromagnets.

III.4.3.2 The Outputs:

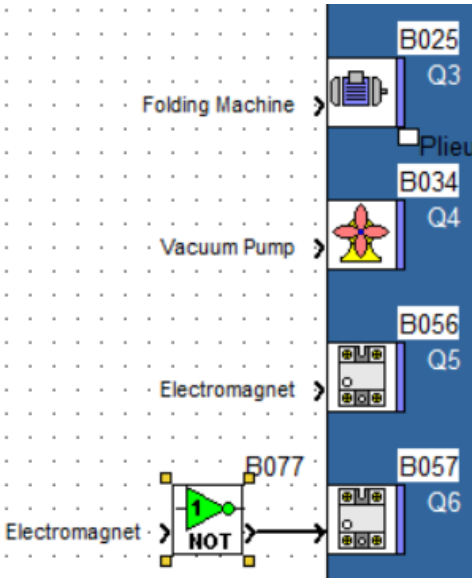


Figure III.11 The outputs of the cartoning process part

- **Folding Machine:** The output that represents the Folding Machine.
- **Vacuum Pump:** Represents the Vacuum Pump.
- **Electromagnets:** Both represent the two electromagnets.

III.4.3.3 The Interconnexions:

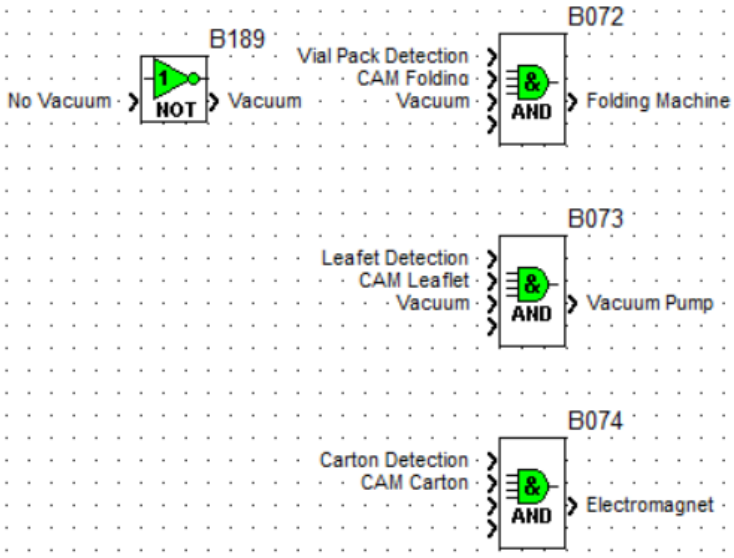


Figure III.12 The interconnexions of the cartoning process

For the different outputs to switch ON, each require a different set of conditions to be met (see Figure III.12):

For the Folding Machine, the Vial Pack Detection, CAM Folding and No Vacuum which is being connected through a NOT function, have to be simultaneously triggered.

The Vacuum Pump needs the Leaflet Detection, CAM Leaflet and Vacuum (NOT No Vacuum) triggered.

The Electromagnet, that controls whether the tuckers activate or not, need the Carton Detection and CAM Carton triggered at the same time.

III.4.4 The Alarms:

Since the input points of the SR3B261BD module don't suffice, the SR3XT141BD has been implemented to add the additional inputs needed (see Figure III.13):

III.4.4.1 The Inputs:

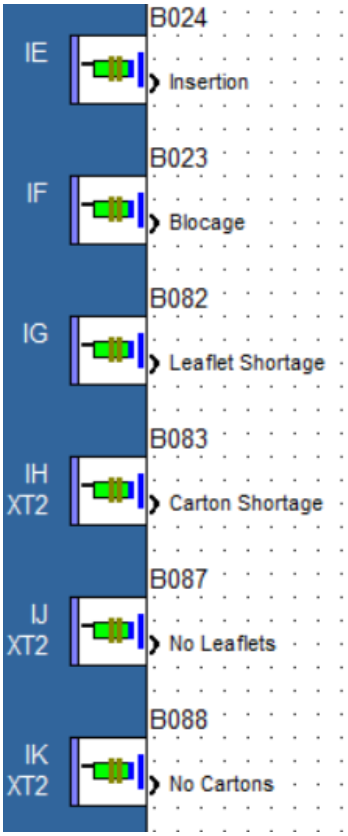


Figure III.13 The inputs of the Alarms

- **Insertion:** Input that represents a limit-end switch and a machine-stopping alarm, it checks if there is an error in the insertion of the vial pack and leaflet into the carton.
- **Blockage:** A limit-end switch sensor and a machine-stopping alarm, checks if the carton is slotted properly on the conveyor belt.
- **Leaflet Shortage:** This input represents a photoelectric sensor and a warning which detects if there is a shortage of leaflet of the folding machine's magazine.
- **Carton Shortage:** This input represents and a warning a photoelectric sensor which detects if there is a shortage of cartons of the magazine.
- **No Leaflets:** A photoelectric sensor that detects if there are no leaflets(alarm).
- **No Cartons:** A photoelectric sensor that detects if there are no cartons(alarm).

III.4.4.2 The Outputs:

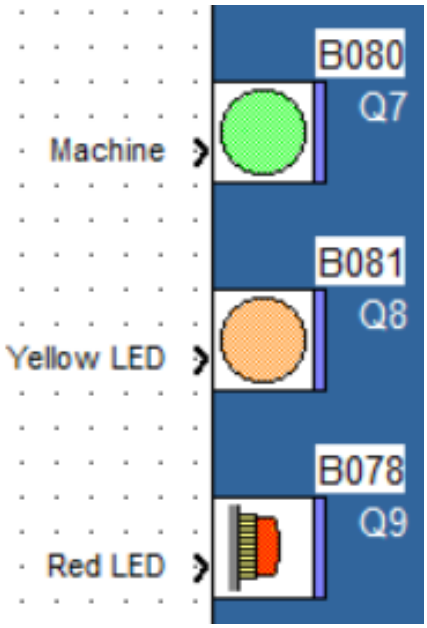


Figure III.14 The outputs of the alarms

- **Green LED:** This LED is an output that lights on when the machine is operating.
- **Yellow LED:** This LED is an output that lights on when a warning is ON.
- **Red LED:** This LED is an output that lights on when a machine-stopping alarm is ON.

III.5 The LCD Display:

The LCD display has been programed to show the machine status, alarms, warnings and guidelines in real-time throughout the machine's operations.

III.5.1 Overview:

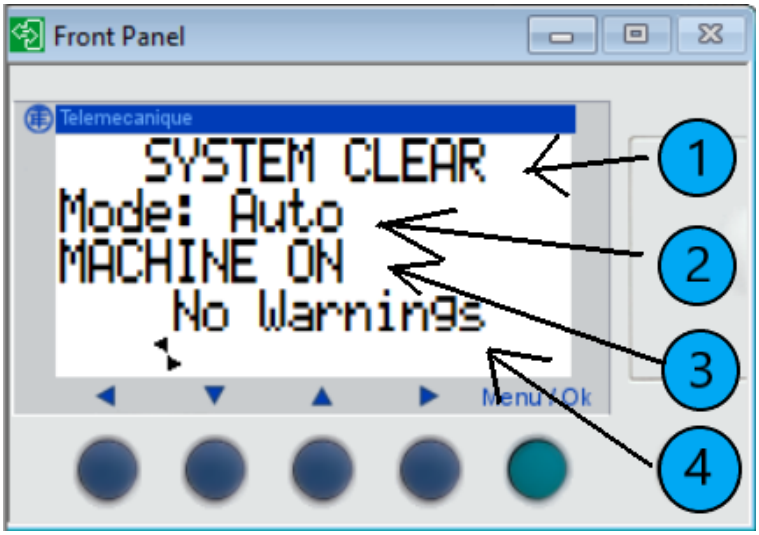


Figure III.15 The LCD Display during its operation

The LCD screen has been split into 4 parts (see Figure III.15):

1. **Alarms:** this is where alarms will show up when occurring.
2. **Mode:** this is where the machine's mode during operation will be displayed.
3. **Status:** will show the machine's current status.
4. **Warnings/Guidelines:** the place where warnings will be displayed.

III.5.2 Programming of the LCD Display:

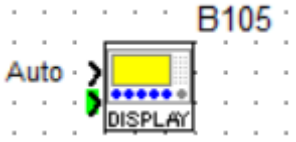


Figure III.16 The LCD Screen Display function

The LCD Screen Display function is used to program the LCD screen, each alarm, mode, status and warning needs a separate function on its own.

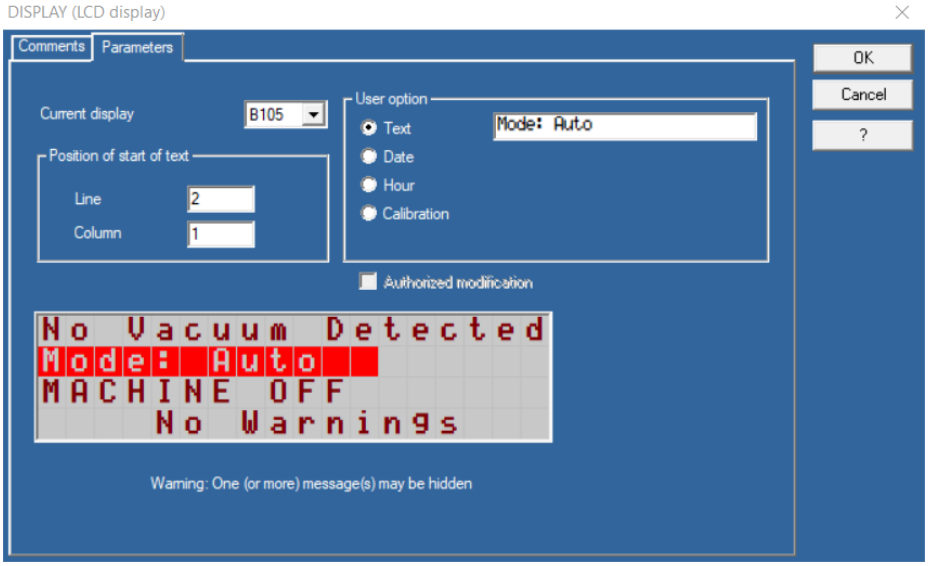


Figure III.17 Programming of the LCD Screen Display function

III.5.3 Alarms:

When triggered, the appropriate alarm will show up in its section on screen.

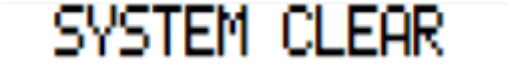


Figure III.18 No Alarms Detected

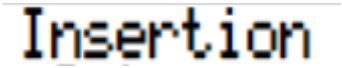


Figure III.19 Insertion Detected

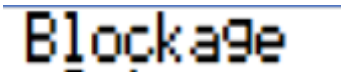


Figure III.20 Blockage Detected

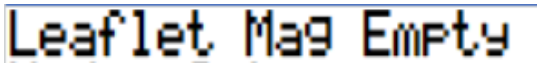


Figure III.21 No Leaflet Detected

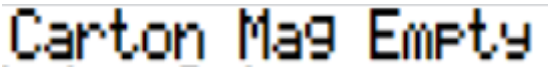


Figure III.22 No Cartons Detected

III.5.4 Mode:

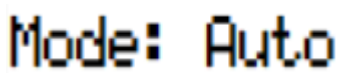


Figure III.23 Machine is in AUTO mode

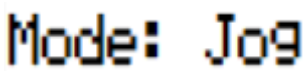


Figure III.24 Machine is in Jog mode

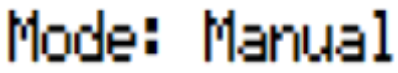


Figure III.25 Machine in Manual mode

III.5.5 Status:

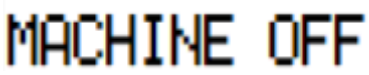


Figure III.26 Machine is in OFF state

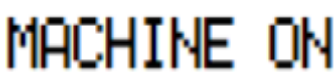


Figure III.27 Machine is in ON state

III.5.6 Warnings/Guidelines:

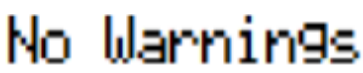


Figure III.28 No Warnings Triggered

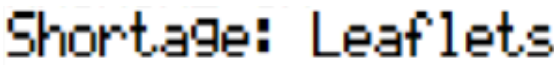


Figure III.29 Shortage of leaflets detected

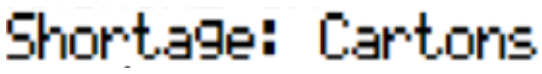


Figure III.30 Shortage of cartons detected

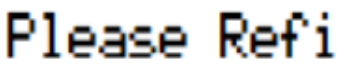


Figure III.31 Guidelines that shows up when a Shortage is Detected

When a warning is triggered, the warning message will flash and switch between it and its guideline.

III.6 Connecting ZELIO Soft 2 with VSPE:

Since a Zelio Smart Relay isn't being used, there is no communication port being detected by Zelio Soft 2, the VSPE software is used to solve the serial port issue.

III.6.1 Configuration of VSPE:

First, we configurate the virtual communication port in VSPE:

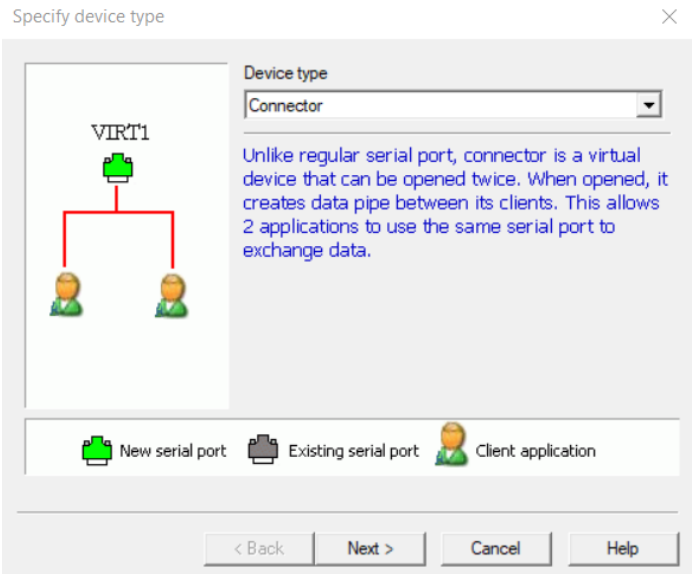


Figure III.32 Choosing the type of virtual port

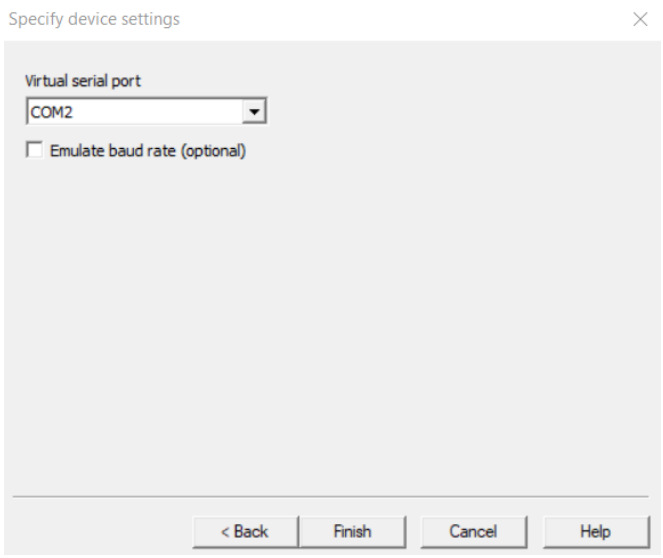


Figure III.33 Choosing the virtual port

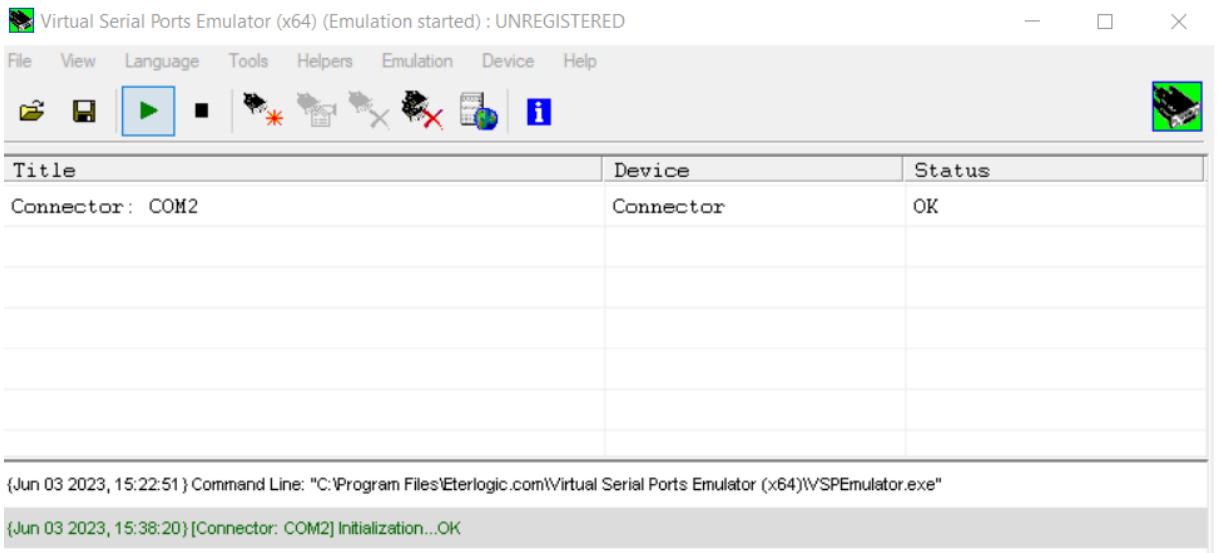


Figure III.34 Virtual Port has been configured

III.6.2 Configuration Zelio Soft 2:

Second, we configure Zelio Soft 2 through its communication configuration by setting the Com Port to the configured virtual port (in this case COM 2) as seen in Figure III.35:

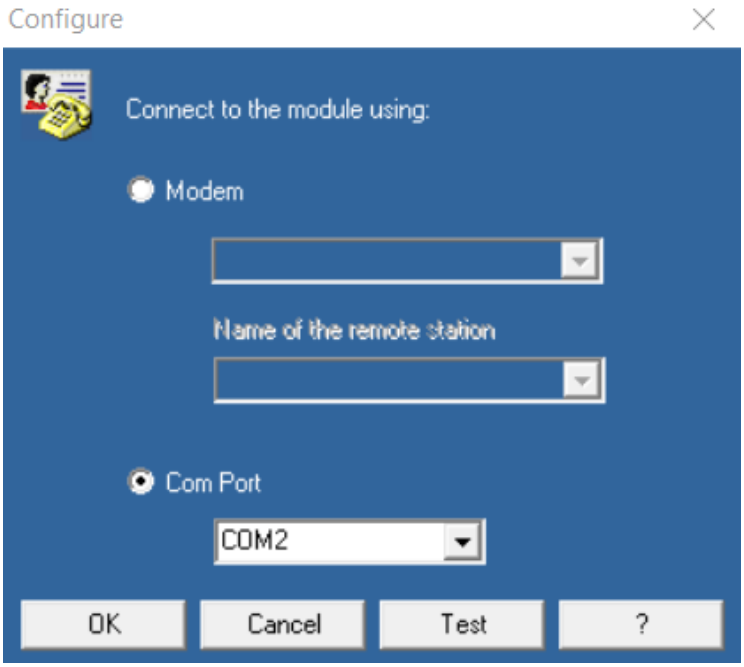


Figure III.35 Connection Configuration of Zelio Soft 2

III.7 Developing The supervisor in LabVIEW:

Supervisors are made up of multiple visual screens, in LabVIEW, screens can be developed inside Visual Instruments (VI).

III.7.1 Conception of VIs:

Visual Instruments are made of two parts:

- **The Front Panel:** The visual part of VIs and where the design of the graphical elements happens.
- **The Program Block:** The programming part of Visual Instruments and where the logic of how each screen is made.

In VI's, UI elements are usually comprised in three categories:

- **Controls:** interactive elements that allow users to provide input to a program. They are typically used to change the value of a variable or parameter (buttons, knobs, text boxes…etc.).
- **Indicators:** used to display the values of variables or parameters during program execution. They provide real-time feedback or output information to the user (text, tanks…etc.).
- **Constants:** used to define fixed values that do not change during program execution (value, reference number…etc.).

III.7.2 LabVIEW add-ons needed for the project:

LabVIEW doesn't come with dedicated HMI tools that come with the base software, to design user interfaces in VIs, the Datalogging and Supervisory Control (DSC) add-on can be used to customize controls and indicators as required for the supervisor.

The DSC add-on comes with a range of UI components, including buttons, sliders, graphs, and alarms, which can be utilized to create a user-friendly interface.

In addition, the Grafcet Designer add-on was used to program the VIs in a sequential manner for easier and better readability.

III.7.3 Planning:

Here's the steps needed to design the VIs:

- **Create a project:** the project will hold all Vis, subVIs and components of the project.
- **Design and program:** construct the logic of the VI to track the machine's status in real-time.
- **Navigation:** Plan how to navigate between the different VIs.

III.7.4 Creation of the VIs:

III.7.4.1 Making the project:

Here's the project containing the components of the supervisor:

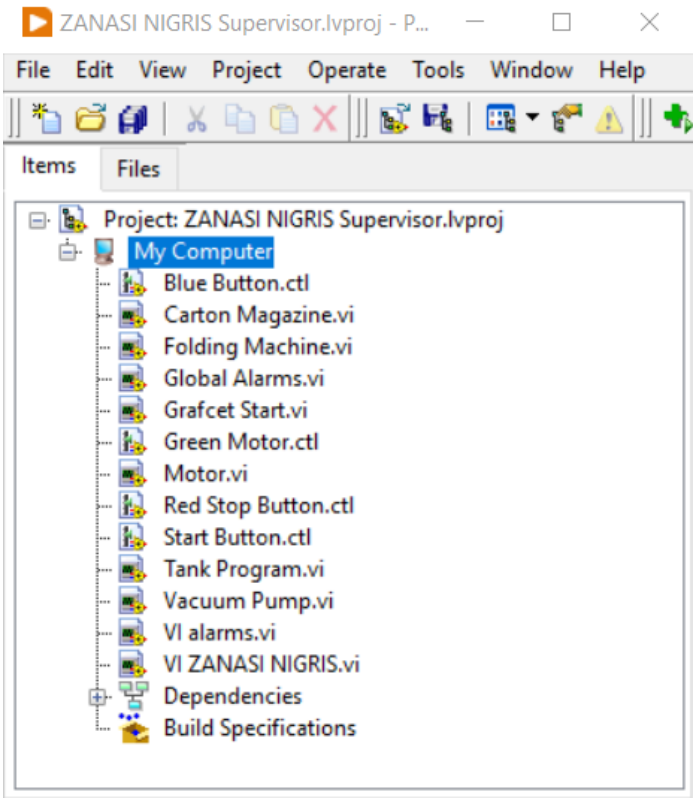


Figure III.36 LabVIEW Project of the supevisor

As shown in Figure III.36, the project possesses mainly two kinds of files, the .vi files which are the VI acting as the screens for the supervisor, and the .ctl files, these are default inputs and objects that are customized and used on the VIs.

III.7.4.2 The Main VI:

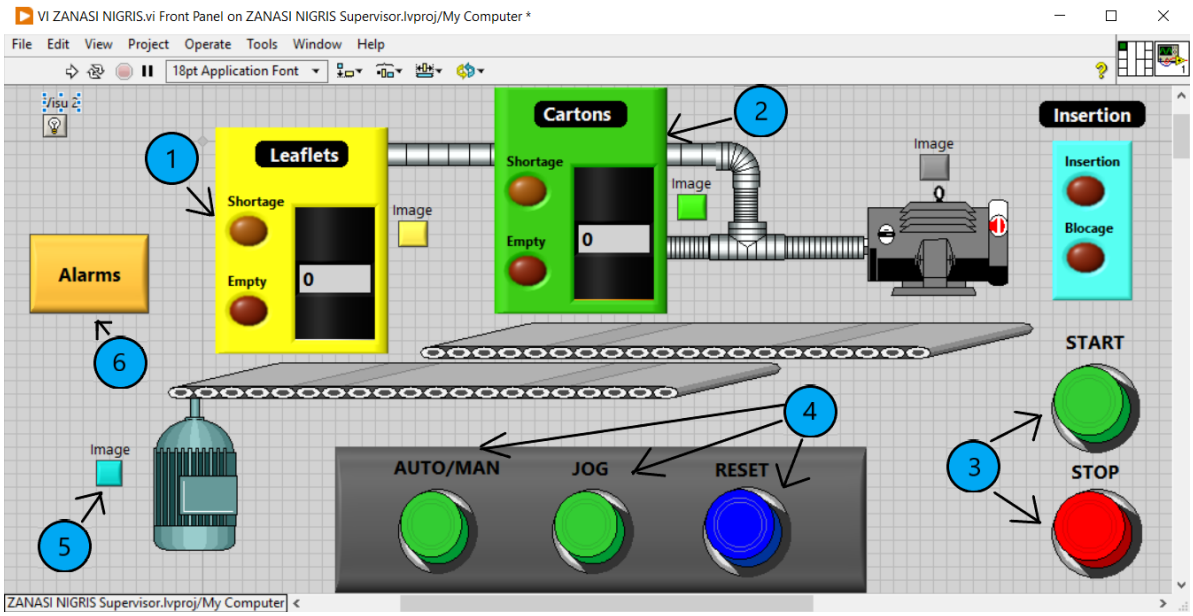


Figure III.37 The Main VI of the ZANASI NIGRIS supervisor

The main VI monitors different parts of the machine:

Both the leaflets and carton's magazine (respectively (1) and (2), refer to Figure III.37), are represented by tank indicators that display the amount remaining in each magazine with LEDs for the sensors, specifically shortage (yellow LED) and empty (red LED) which will light up when the level in each tank drops to a certain amount.

The Start and Stop buttons (3) serve to, respectively, start the machine and stop it and so after choosing the mode of operation.

The AUTO/MAN and JOG buttons (4) are used to choose the mode the machine will operate on, as for the RESET button, it rearms the machine which is necessary after an alarm sensor is triggered or the STOP button is pressed. Note that these buttons, as well as the START and STOP buttons were fashioned using the DSC add-on:

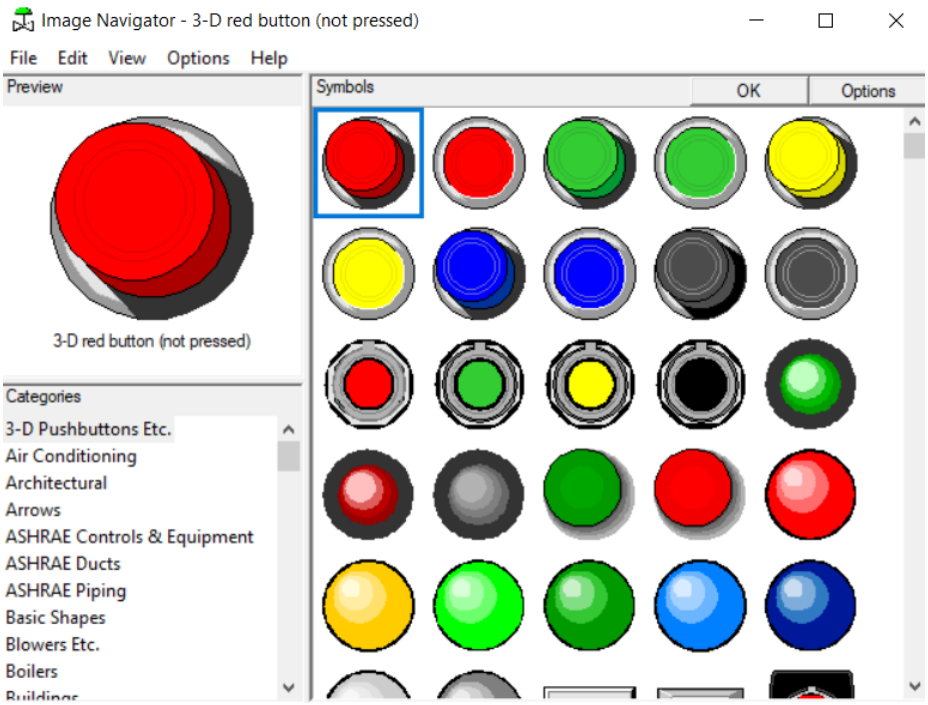


Figure III.38 The DSC add-on's image navigator

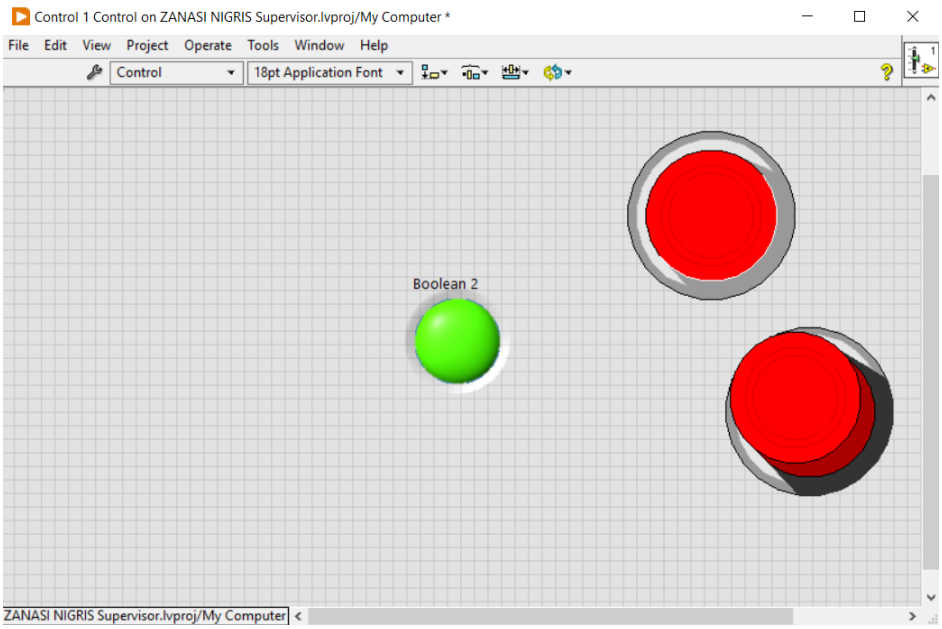


Figure III.39 The control file containing the customized button

Upon pressed, the Image buttons (5) will open an image of the part of the that is associated with it.

Finally, the alarms button (6), will open the alarms log panel.

On the Block Diagram:

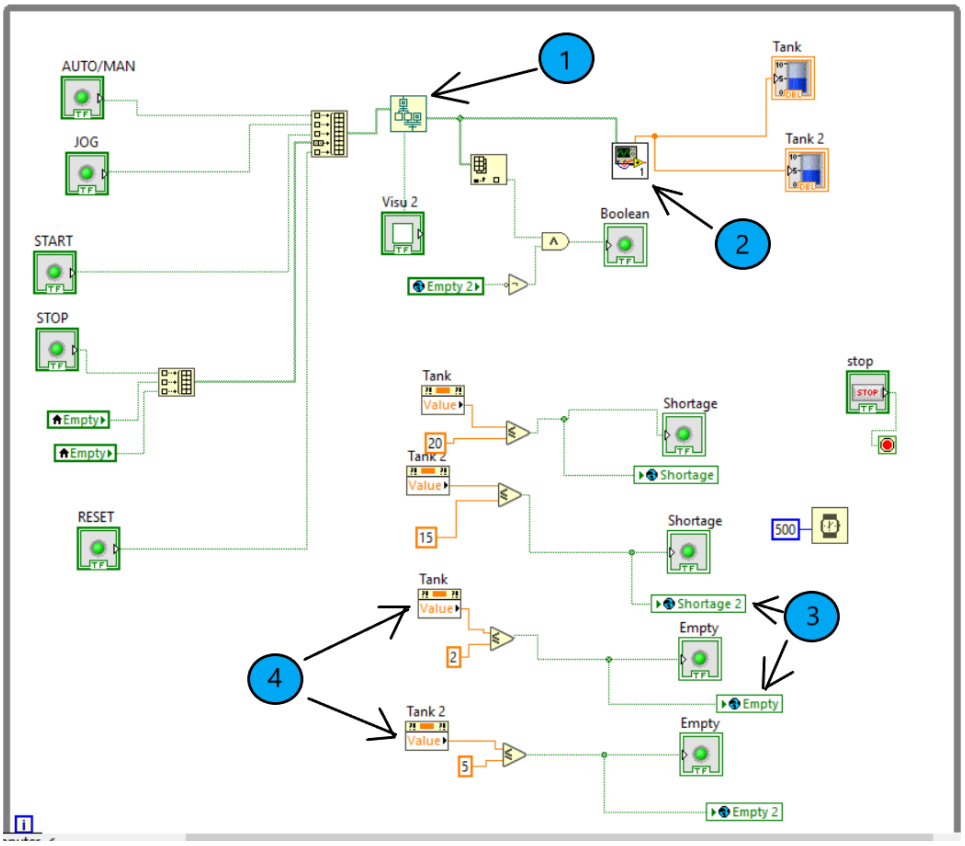


Figure III.40 The block diagram of the main VI

The grafcet program (1), written with the Grafcet Designer add-on, as well as the program that governs the logic behind the magazines (2), are contained into subVIs.

SubVIs allow you to encapsulate a portion of code or a set of instructions into a modular and reusable block, it is essentially a VI that can be called and used as a single customizable node within another VI.

Global Variables (3), are front panels without block diagrams that can contain inputs and outputs to be used in multiple VIs at the same time. In this instance, a global variable contains the LEDs of the alarms and so, data can be shared with the Alarms log VI.

The Property Node of type Value (4) returns the real-time value of its associated tank, it can be used as both an input and an output.

❖ **The Grafcet subVI:**

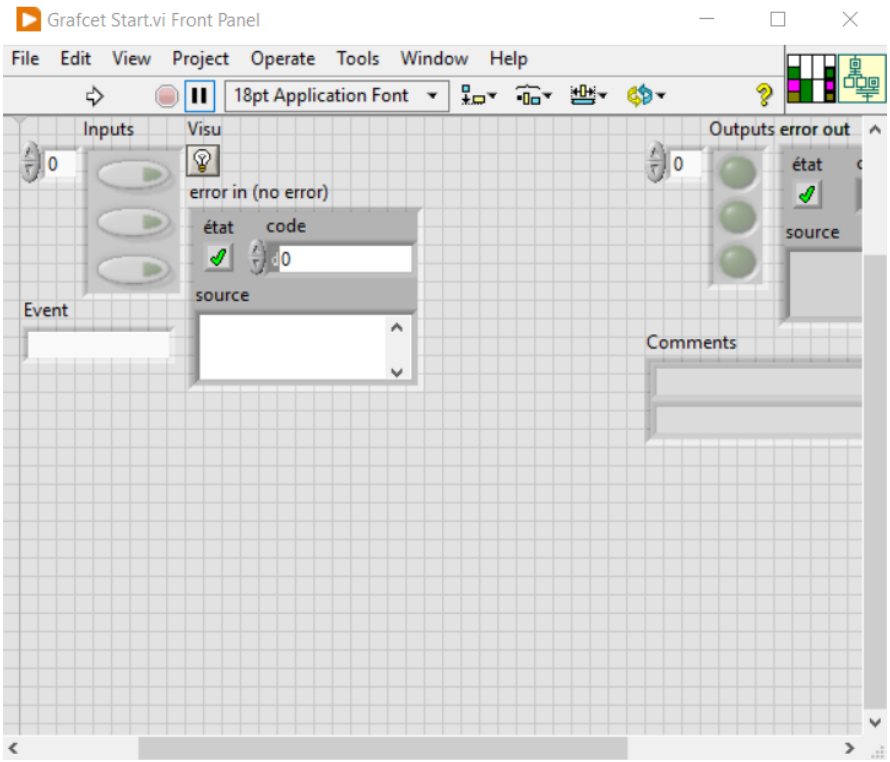


Figure III.41 The front panel of the grafcet program

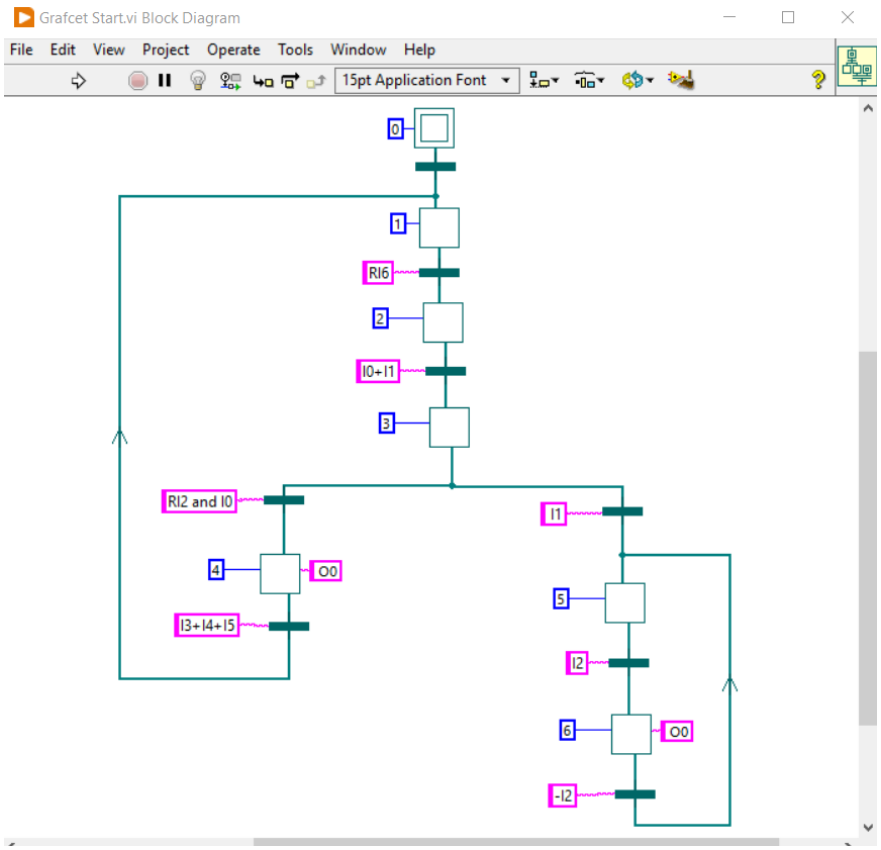


Figure III.42 The block diagram of the grafcet program

The steps (O0) run the tank subVI, while the transitions (from I0 to I6) are triggered by the main VI front panel buttons.

❖ **The Tank Program subVI:**

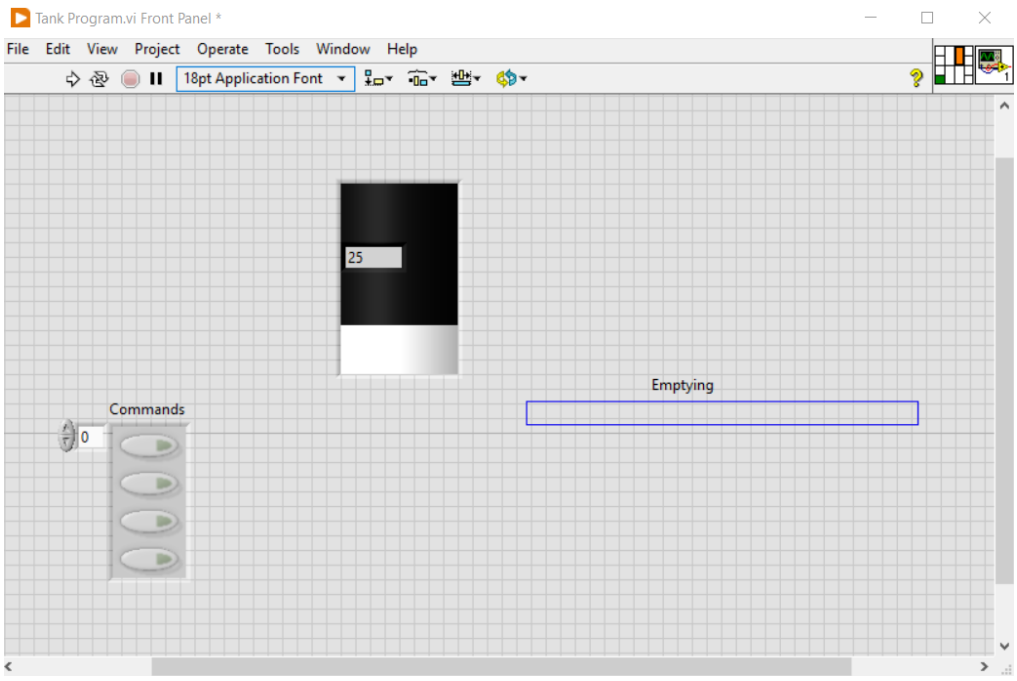


Figure III.43 The front panel of the tank program subVI

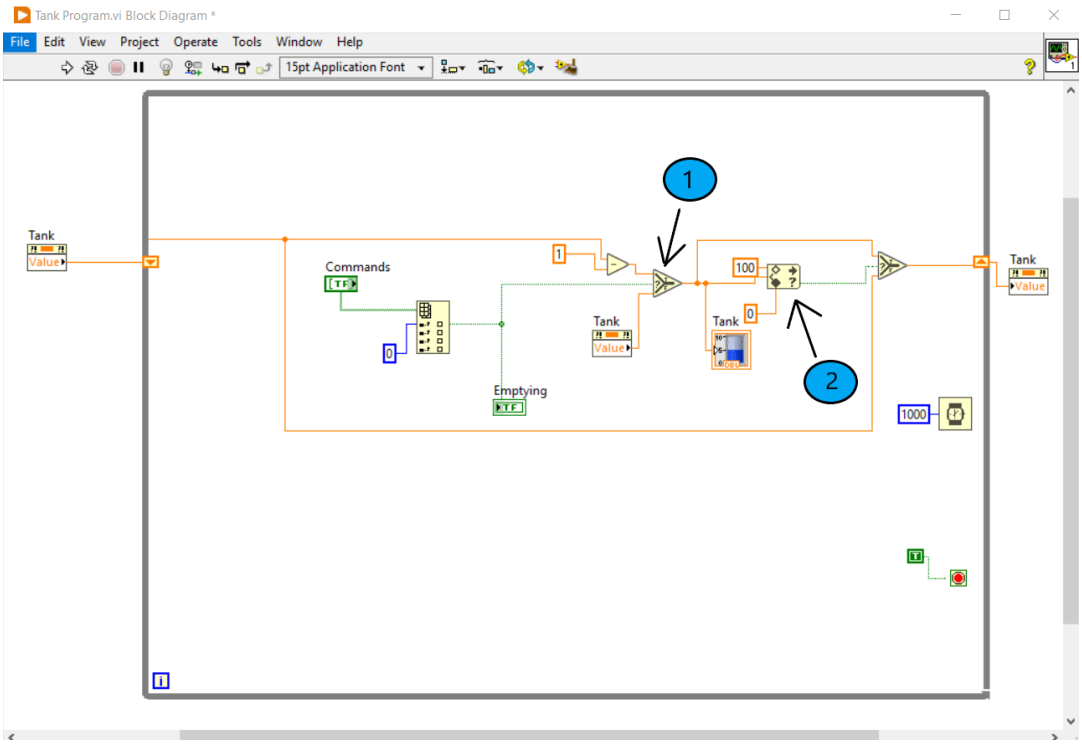


Figure III.44 The bock diagram of the tank program subVI

The Select function (1), checks the state of the commands input, if TRUE, the program will subtract from the tank, if FALSE, it will show you the current value of the tank through a property node, the In Range or Coerce function (2) serve to cap the value of the tank.

❖ **The alarms button program:**

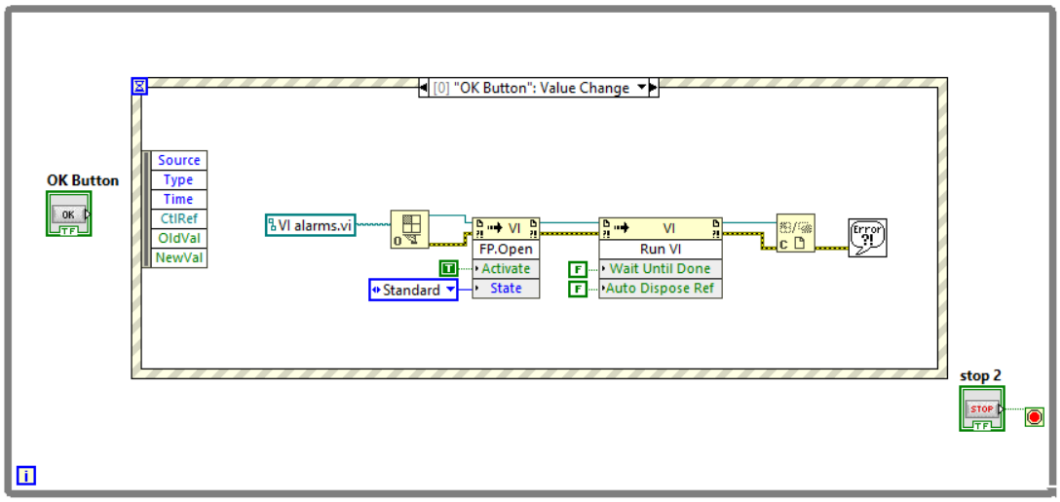


Figure III.45 The switch to alarms panel program

This Event Structure waits for the button input, after which it will open and run the called VI, in this case the alarms VI, with the Invoke Nodes FP.Open and Run VI.

III.7.4.3 The Alarms Log VI:

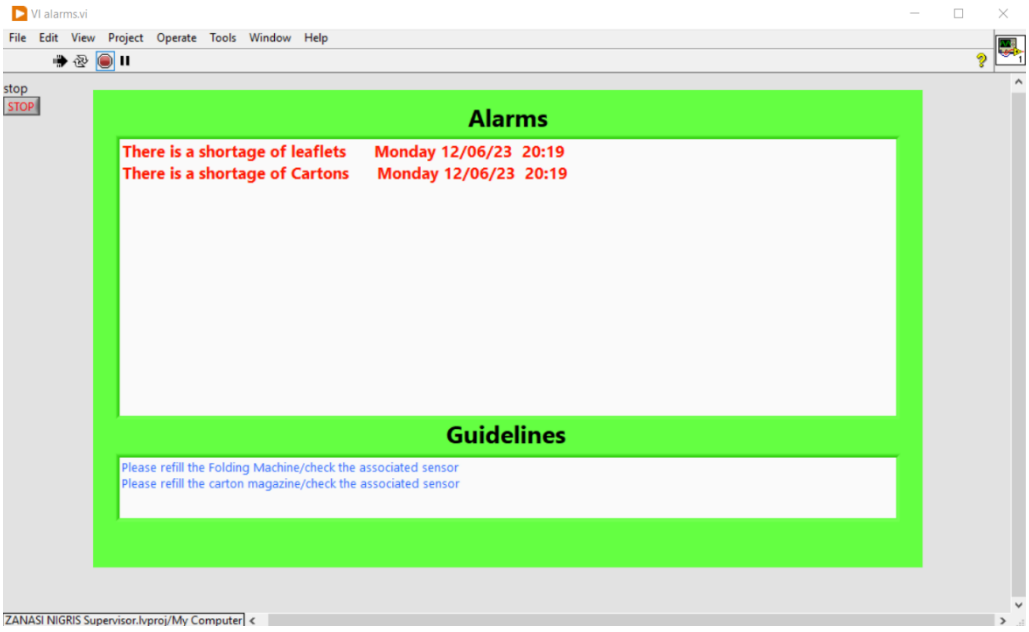


Figure III.46 The front panel of the Alarms Log VI

This Vi is mainly comprised of two string text indicators (see Figure III.46):

- **Alarms:** This section will show a message, as well as the time and date when an alarm is triggered, the message will disappear when the cause of the alarm is solved.
- **Guidelines:** This section will show the guideline associated with triggered alarm.

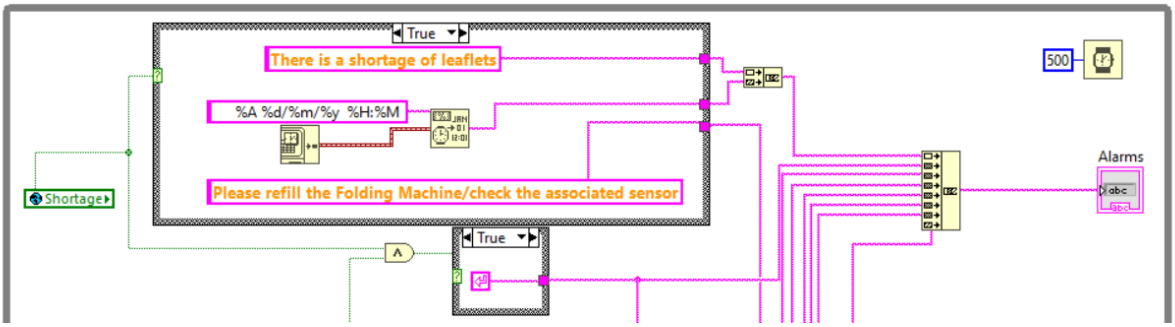


Figure III.47 Part of the program of the alarms log block diagram

In the block diagram, case structures wait for the input from global variables and if TRUE, returns string constants representing the alarm and its guideline.

III.8 Communicating between Zelio Soft 2 and LabVIEW:

To share data between the program in Zelio Soft 2, and the supervisor made in LabVIEW, the DSC add-on of LabVIEW may be used, it provides the software with a OPC server.

An OPC server is a widely accepted standard for data exchange software component that enables communication between different industrial automation systems.

LabVIEW's OPC server allows its applications to communicate with other OPC-compliant devices and systems.

Here's how to set the OPC server up:

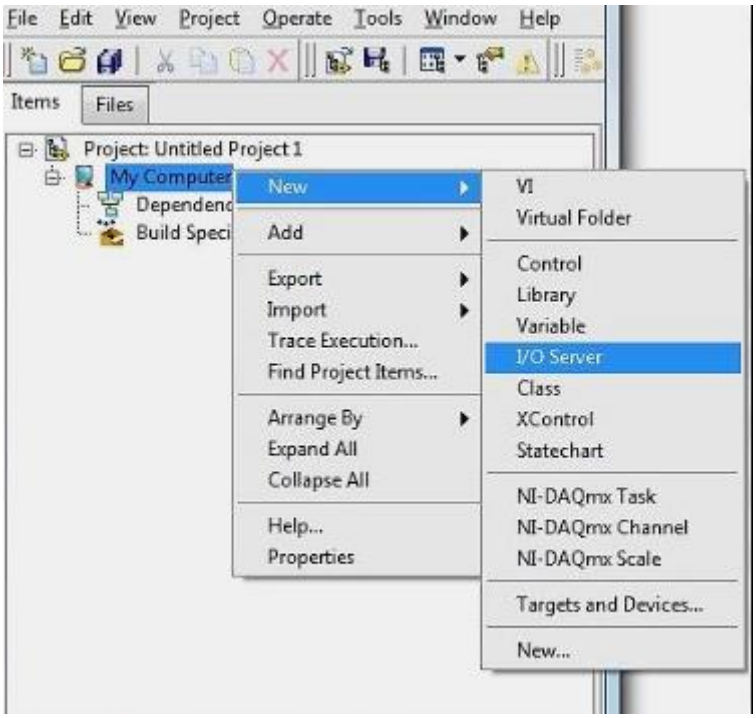


Figure III.48 Selecting the I/O server option

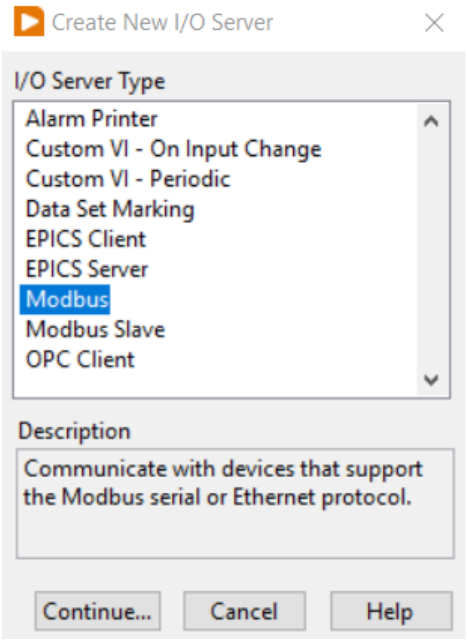


Figure III.49 Creating new I/O server window

Choosing the Modbus protocol will allow communication with the Zelio module extension SR3NET01BD (as seen in Figure III.49).

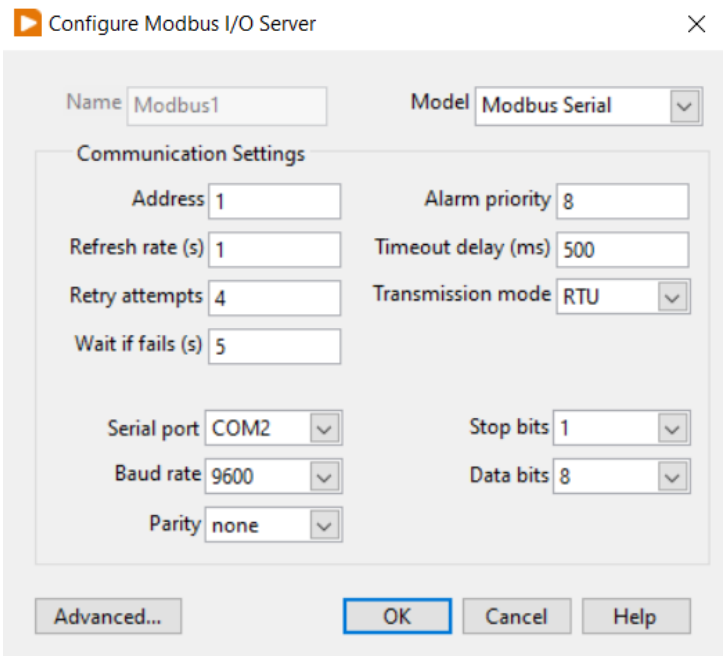


Figure III.50 The configuration window of I/O server

In the configuration window (Figure III.50), we make sure to choose the appropriate serial port we set up previously on VSPE.

After confirmation, a new variable library has been successfully created (Figure III.51).

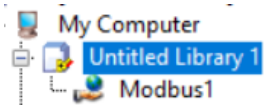


Figure III.51 New Modbus variable library

From the new library, we create new bound variables:

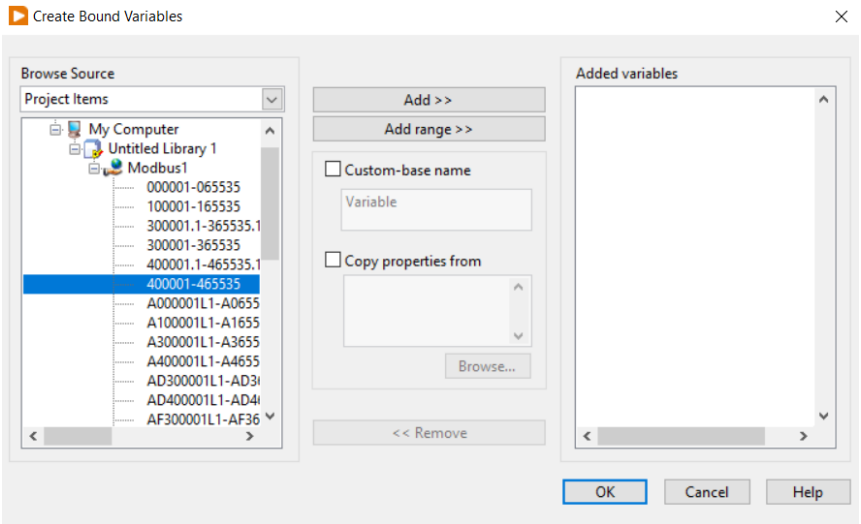


Figure III.52 Creating new bound variables from the library

Multiple Variable Editor

	Path	Name	Var Type	Data Type	Network-Published: Buffering	Network-Published: Buffer Size	Network-Published: Bind to Source	Network-Published: Access Type
400017	.../My Computer/Untitled Library 1/	400017	Network-Publis...	UInt16	☑	50	☑	read/write
400018	.../My Computer/Untitled Library 1/	400018	Network-Publis...	UInt16	☑	50	☑	read/write
400019	.../My Computer/Untitled Library 1/	400019	Network-Publis...	UInt16	☑	50	☑	read/write
400020	.../My Computer/Untitled Library 1/	400020	Network-Publis...	UInt16	☑	50	☑	read/write
400021	.../My Computer/Untitled Library 1/	400021	Network-Publis...	UInt16	☑	50	☑	read/write
400022	.../My Computer/Untitled Library 1/	400022	Network-Publis...	UInt16	☑	50	☑	read/write
400023	.../My Computer/Untitled Library 1/	400023	Network-Publis...	UInt16	☑	50	☑	read/write
400024	.../My Computer/Untitled Library 1/	400024	Network-Publis...	UInt16	☑	50	☑	read/write
400025	.../My Computer/Untitled Library 1/	400025	Network-Publis...	UInt16	☑	50	☑	read/write
400026	.../My Computer/Untitled Library 1/	400026	Network-Publis...	UInt16	☑	50	☑	read/write
400027	.../My Computer/Untitled Library 1/	400027	Network-Publis...	UInt16	☑	50	☑	read/write
400028	.../My Computer/Untitled Library 1/	400028	Network-Publis...	UInt16	☑	50	☑	read/write
400029	.../My Computer/Untitled Library 1/	400029	Network-Publis...	UInt16	☑	50	☑	read/write
400030	.../My Computer/Untitled Library 1/	400030	Network-Publis...	UInt16	☑	50	☑	read/write

Figure III.53 The variables created through the library

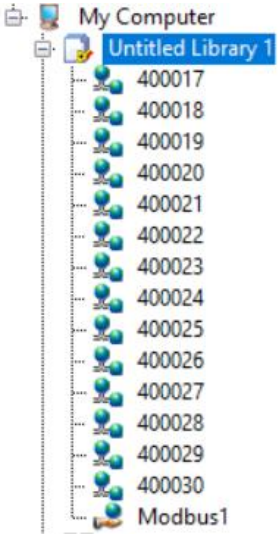


Figure III.54 The variables on the project window

Finally, these variables will enable communication between Zelio Soft 2 programmed inputs and outputs and LabVIEW.

III.9 Conclusion:

In this chapter, we have tackled the main steps of how the program, in Zelio Soft 2, was written in the FBD programming language, a deep dive in the development, designing and programming of the supervisor in LabVIEW and lastly arranging communication between the Zelio program and LabVIEW applications.

General Conclusion

This project addresses the study of improving, automating and supervising of the ZANASI NIGRIS cartoning machine, throughout my internship within the SAIDAL GROUP at the Medea production plant, I have gathered valuable insight and generated significant knowledge in the industry as well as in the field of industrial automation.

For the realization of this project, it first required extensive research on the necessary hardware to improve the machine's capabilities, this meant a complete overhaul of the machine's outdated hardwired logic, and replacing it with a more efficient programmed logic, based on the Zelio Smart Logic module SR3B261BD.

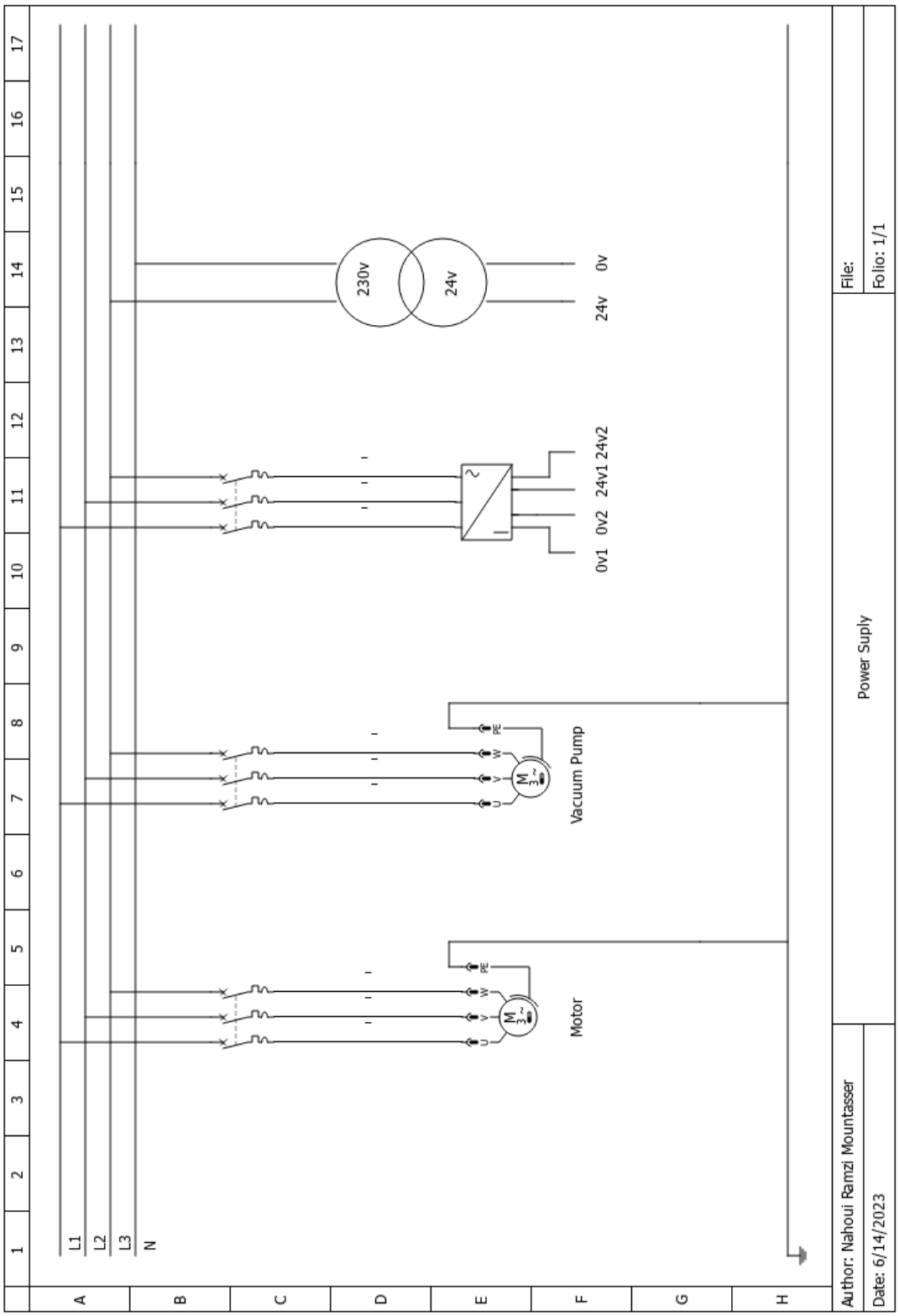
The programming of the module as well as the supervisor also demanded the right software, so Zelio Soft 2 was used as it is the dedicated programming software for Zelio Smart Relays, and for the supervision LabVIEW was opted for its ease of use and accessibility.

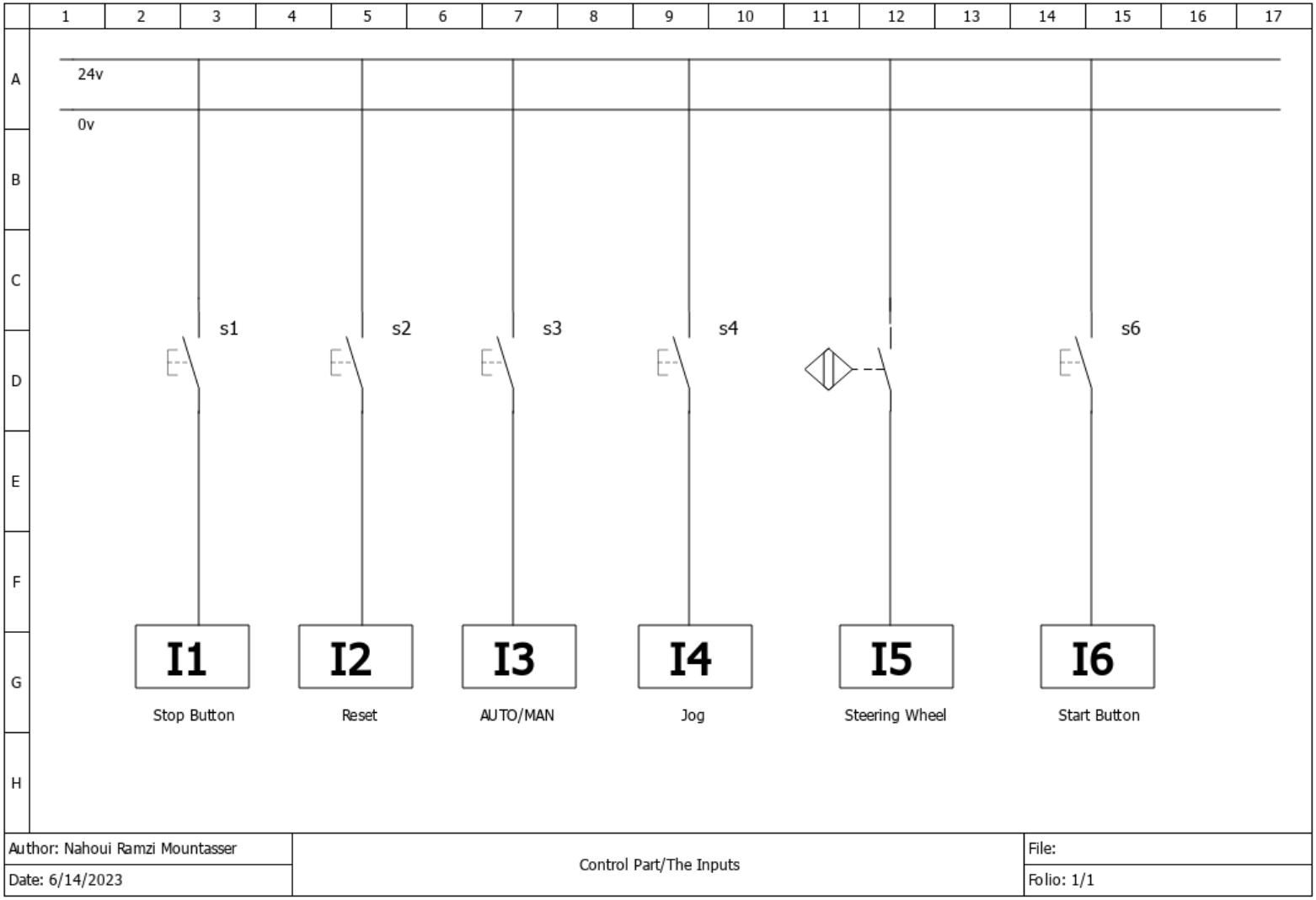
While the results from the project were overall positive, it is crucial to acknowledge the limitations inherent to this study. Since a Zelio Smart Relay SR3B261BD was not obtainable within the scope of this project, because Zelio Soft 2 relies on there being a module to download the program into to utilize its real-time monitoring feature, communication between Zelio Soft 2 and LabVIEW couldn't virtually be achieved. Recognizing these limitations, we can identify avenues for future research, such as:

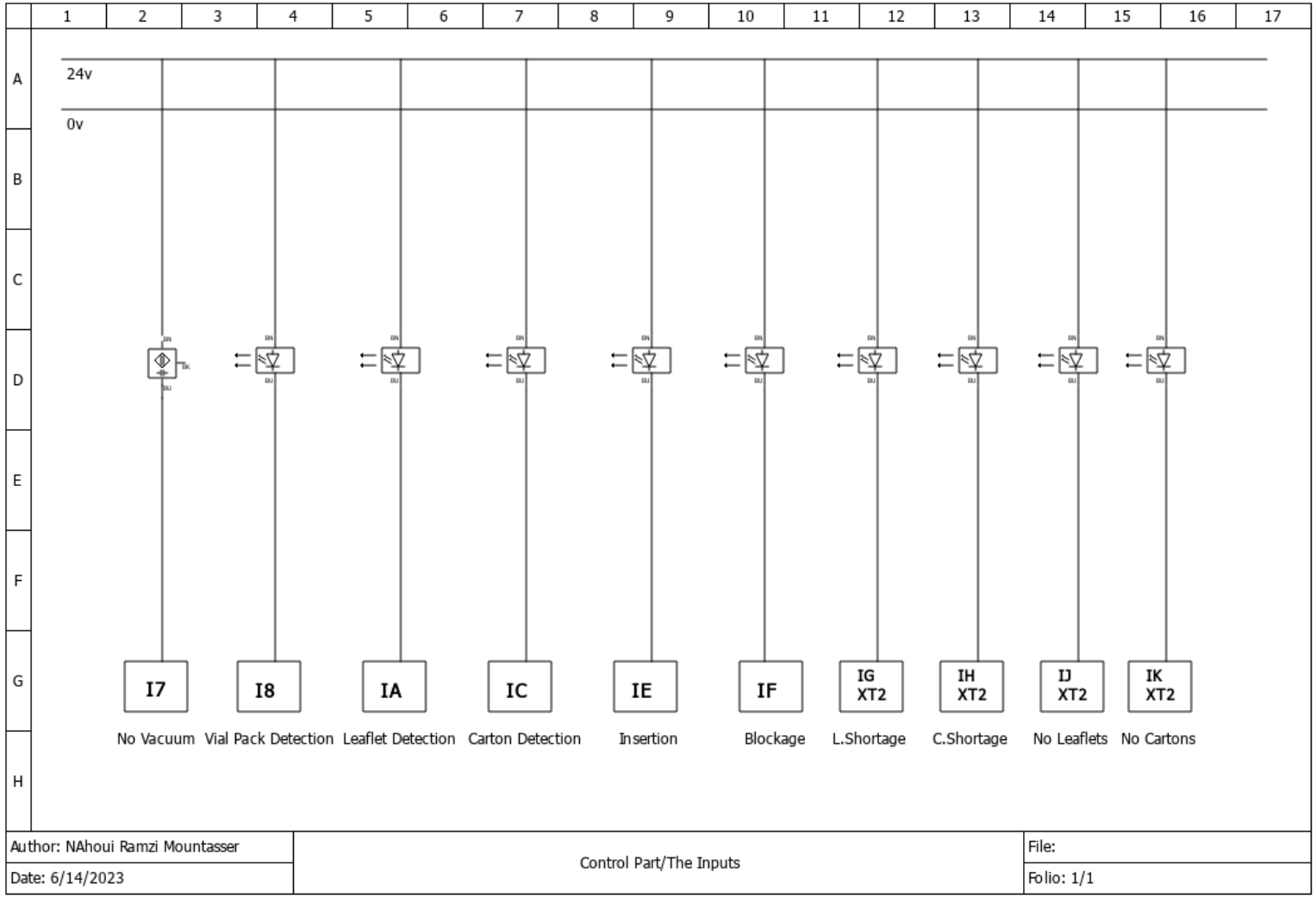
- Implementing a physical Zelio Smart Relay so that communication can be established between both Zelio Soft 2 and LabVIEW.
- Improving on the supervisor made in LabVIEW by adding more features.

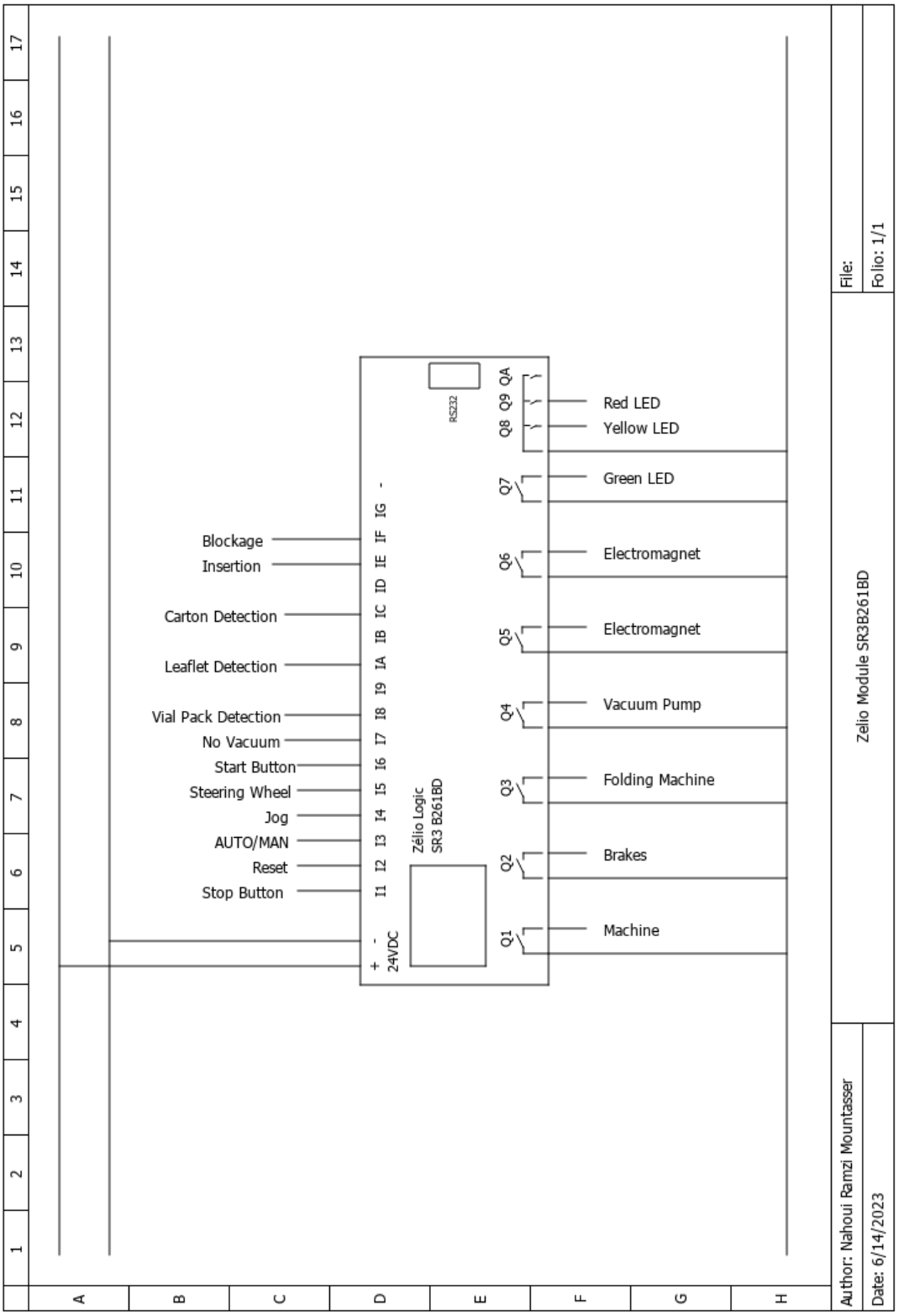
In conclusion, this study has provided valuable understanding, by summarizing the results, highlighting their implications, and acknowledging the limitations and future research directions, we have established the significance and relevance of this work. I hope that these findings will inspire further innovation, and positive change in the field of industrial automation.

Appendices


L1
L2
L3
N
230v
24v
0v
24v
0v1
0v2
24v1
24v2
Vacuum Pump
Motor
PE
W
V
U
Power Suply
File:
Folio: 1/1
Author: Nahoui Ramzi Mountasser
Date: 6/14/2023


1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
A B C D E F G H
24v
0v
s1
s2
s3
s4
s6
I1
I2
I3
I4
I5
I6
Stop Button
Reset
AUTO/MAN
Jog
Steering Wheel
Start Button
Author: Nahoui Ramzi Mountasser
Date: 6/14/2023
Control Part/The Inputs
File:
Folio: 1/1


1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
A B C D E F G H
24v
0v
I7
I8
IA
IC
IE
IF
IG XT2
IH XT2
IJ XT2
IK XT2
No Vacuum
Vial Pack Detection
Leaflet Detection
Carton Detection
Insertion
Blockage
L.Shortage
C.Shortage
No Leaflets
No Cartons
Author: NAhoui Ramzi Mountasser
Date: 6/14/2023
Control Part/The Inputs
File:
Folio: 1/1


Zelio Module SR3B261BD
Author: Nahoui Ramzi Mountasser
Date: 6/14/2023
File:
Folio: 1/1
Zélio Logic
SR3 B261BD
RS232
24VDC
Blockage
Insertion
Carton Detection
Leaflet Detection
Vial Pack Detection
No Vacuum
Start Button
Steering Wheel
Jog
AUTO/MAN
Reset
Stop Button
Red LED
Yellow LED
Green LED
Electromagnet
Electromagnet
Vacuum Pump
Folding Machine
Brakes
Machine

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