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Intelligent Manufacturing
By industry 4.0

Graduation Project

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Acknowledgment

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ABSTRACT

Packaged food nowadays is an important part of our daily life and under covid-19 up normal conditions our health and safty is the priority and who doesn't buy a bottle of water?! Industry 4.0 technology is used to modify the traditional production line to an automated smart one which insure more quality, less consumption and no hands touching.

This Book has been prepared to display our final year project and the documentation of each and every aspect of the theoretical and technical work done throughout the year.

Technological advancements in the industrial fields have been rapidly increasing in the past decade, with the introduction of many new trends like collaborative robotics, augmented reality and now the Industrial IoT or what is called the Industry 4.0 or IIOT. In our project we tackled the concepts behind digitalization technologies and present a technical solution to the problems facing industrial manufacturers with implementing this solution in our industrial system as a proof of concept, the chapters in this book are handling the industrial system implementation in all of its aspects and the implementation of the technical solution we can provide to any industrial manufacturer.

The book explains every part crearly with all details. The book is intdnded to be a guide for following student wants to deal with our system or working on a similar system or even need to use asimilar technology.

Contents

Table of Figures

Chapter 1
Introduction

1. INTRODUCTION

1.1. Industrial Revolution

The history of Industry 4.0 starts with the industrial revolution and follows the manufacturing industry through the digital transformation, up to the present day. As the industrial revolution developed through time, each new stage represented advances in the production process, changing the way we think and operate in the industry.

Industry 1.0 "pre-digital technology"

The First Industrial Revolution started about 1760, when the shift to newer manufacturing methods using water and steam was instituted. It had a positive impact on the whole manufacturing process, and in doing so, allowed for a higher quality of living for a greater number of people. In particular, the textile sector was affected by industrialization. Also, transportation was affected.

The availability of steam and coal as fuel sources enabled the use of machines in production, and this resulted in the concept of manufacturing with machines rapidly spreading. Machines provided quicker and more efficient manufacturing, making a host of new technologies and advances feasible.

Industry "enterprise" 2.0

Industrialization began in the middle of the 1800s and continued until the beginning of the 20th century. This is where the second industrial revolution got its start. In Britain, Germany, and the US, the "The Technological Revolution" occurred.

The introduction of improved electrical systems allowed for higher output and more advanced machinery.

Industry 3.0 "computer age"

The first computer age started it. Computers that were first built in the early 1970s were typically very basic, cumbersome, and used significant amounts of power. However, these computers paved the way for a world today that is almost impossible to picture without computers.

The Third Industrial Revolution began in the 1970s with the introduction of electronics and IT (Information Technology) in manufacturing to assist with greater automation. With internet access, connectivity, and renewable energy, manufacturing and automation advancements occurred significantly.

These more automated systems were brought on to the assembly line to help with duties formerly done by humans, e.g. using Programmable Logic Controllers (PLC). Though they had been fully automated, they still required human interaction and input.

Industry 4.0

Smart machines, storage systems, and manufacturing facilities that can share information, react, and take control of one another are characteristics of the Fourth Industrial Revolution.

The Industrial Internet of Things (IIoT) that we know today helps to facilitate this flow of information. Industry 4.0 incorporates key aspects including:

- A mechanical device that is programmed using computer algorithms
- The Internet of Things, often known as the Internet of Things (IoT), is a system of linked networks of machine equipment and vehicles with integrated computing sensors, scanners, and monitoring capabilities.
- Cloud computing is network hosting that happens remotely, as well as data backup.
- Cognitive computing – systems that use artificial intelligence to do computational tasks.

When consumers are given the ability to personalize what they want, Industry 4.0 moves to Industry 5.0."

Increasing technology breakthroughs may lead to more rapid revolutions in the near future. Our current revolutions endure only as long as industry-wide adoption completes itself. Manufacturing 5.0 is an update of 4.0, and it's essential to recognize that.

To sum it up, the advancement of Industry 5.0 is on the verge of becoming the whole fulfilment of what the Industry 4.0 builders had just hoped for as of the 2010s. The more the advancement of artificial intelligence, and industrial robots acquiring more human-like skills, the more relevant and mutually enriching the relationships between computers, robots, and human employees will become.

1.2. Industry 4.0 in More Details.

With the increasing digitalization of manufacturing, we are in the middle of a profound change for how we create goods. The transformation from Industry 3.0 to Industry 4.0 is so far-reaching that it is being referred to as Industry 4.0, in which "industry" is now defined as manufacturing. According to modern-day theories, the third industrial revolution, which began with the use of computers and automation, has been compounded with the use of smart and autonomous systems fueled by data and machine learning.

Although some people may be convinced that Industry 4.0 is just a meaningless term, the changes occurring in manufacturing need our attention.

Early uses of Industry 4.0 nowadays.

Even while some companies are still refusing to accept the effect Industry 4.0 will have on their businesses, others are already putting these changes in place and getting ready for a future where intelligent machines make things better. Consequently, these are only a handful of the many potential applications:

Determine business opportunities Included in Industry 4.0 is the potential for manufacturers to manage their operations effectively by monitoring many machines' data and discovering patterns and insights that would be almost difficult for a person to find in a reasonable amount of time. An African gold mine found an issue with the oxygen levels during leaching by utilizing sensors in their equipment. Increasing their return from its current value by 3.7% helped them save $20 million per year.

Developing and optimizing logistics and supply networks in a linked supply chain, new information given to the organization may be automatically accommodated. When a weather delay

gets in the way of cargo delivery, a connected system can anticipate that scenario and change production priorities to meet the situation.

Autonomous equipment and vehicles: The autonomous trucks and cranes used in shipping yards have allowed these companies to process shipments in less time and space, making it easier for companies to import or export merchandise.

Robots: Not previously cheap or available to big businesses, today robots are more reasonably priced and easily accessible to small and medium-sized businesses as well. Autonomous robots can rapidly and securely assist manufacturers by moving items from picking warehouses to ready-to-ship. The machines can do anything from carting items around Amazon warehouses to decreasing expenses and making better use of floor space for the e-retailer.

It has been vastly enhanced in the past decade, and now it is utilized for both prototype and mass production. As metal additive manufacturing techniques have advanced, more production options have opened up.

Industry 4.0, which is defined by linked devices through the Internet of Things, is vital to the global success of the IoT. This is advantageous for both internal operations and for optimizing equipment and operations since the cloud environment where data is kept allows data insights to be shared with others to assist each business group improve their own equipment and operations.

At this stage, Industry 4.0's potential is still unclear. Companies that are already making use of the technologies anticipate a better image in the future. As businesses strive to cope with the increased demands associated with Internet 4.0, they're facing the challenge of how to upskill their existing staff and attract new workers with the appropriate abilities. For Industry 4.0, the computerization of Industry 3.0 is optimally managed.

The introduction of computers into Industry 3.0 had a huge impact since it brought a whole new technology to the workforce. As Industry 4.0 advances, computers and robots become more interconnected and take on the role of making choices without human assistance. Industry 4.0 and the smart factory are both feasible due to the integration of cyber-physical systems, the Internet of Things, and the Internet of Systems. Our factories will become more efficient and productive as smart equipment are able to access and process more data. It is the interconnected network of these devices that provides the real power of Industry 4.0.

The Merging of the Digital and Physical Is the Next Industrial Revolution

The next industrial revolution is bringing about untold change in every industry creating massive advantages and challenges to implement. Industry 4.0 will see the merging of physical & digital systems into a cyber physical system (CPS) that mirrors the digital realm in the physical world and the physical world in the digital realm.

Advantages of Implementing Industry 4.0

The Introduction of Industrial IoT to the industrial scene has been instrumental in great improvements in the financial field and improvements in the manufacturing model and processes. The following figure shows a survey result conducted by Society of Motor Manufacturers and Traders on the effects of Digitalization on the automotive industry in the UK.

Optimization: Smart Manufacturing and Smart Factories bring with them optimizations and a growing ability to self-optimize production leading to nearly zero downtime of your machinery. Optimization will play a major role in keeping high end equipment maintained efficiently by having the right resources in the right place at the right time. Being able to utilize your production capacity constantly and consistently is better than a major down time or changeover.

***Customization*:** The interconnections of Smart Factories and the Industrial Internet of Things (IIOT) means your supply chain has shortened to a point where you must stay agile to customer demand. Communication between the customer and manufacturer will take place directly cutting out the need for manufacturers to communicate between departments internally or external providers. Smart Manufacturing allows easily scaling production up or down in relation to market demand.

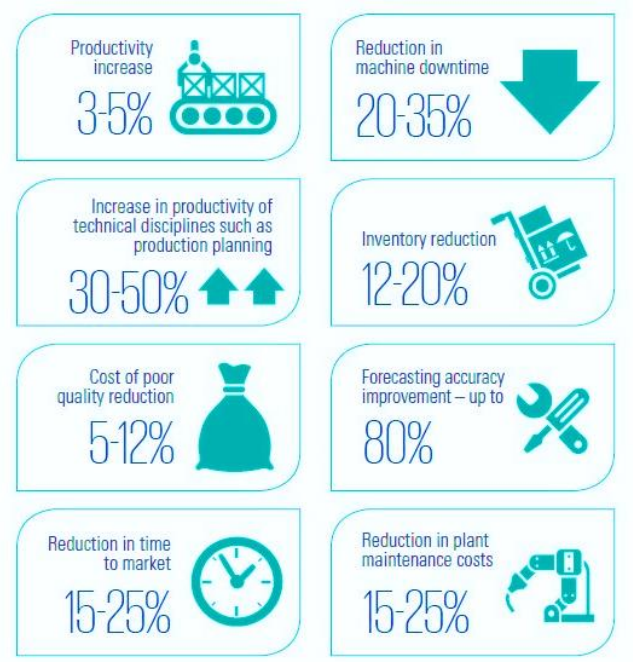


Figure 1-1: a survey result conducted by Society of Motor Manufacturers and Traders on the effects of Digitalization on the automotive industry in the UK.

ReduceCosts: Implementing smart manufacturing may have a large initial up-front cost, but if setup correctly can have a positive impact on your bottom line with the implementation of automation, systems integration, data management, and artificial intelligence all having a major role in the profitability of your business.

Helping deliver these costs savings is an improved use of resources, faster manufacturing, less machine, and production line downtime, fewer quality issues, less material & product waste and lower operating costs.

Technology: Technology is progressing exponentially and having an increasing impact on our daily lives. Self-driving cars and augmented reality seem like science fiction, but these technologies are being used today in some capacity. Volvo has been testing autonomous trucks in a shipping port environment to collect data and view the interactions with the humans working alongside autonomous vehicles.

Microsoft has developed augmented reality glasses called **HoloLens 2**, used in a variety of applications but will shine in the maintenance & construction sectors. Technology advances will create untold opportunities for consumers and manufacturers looking to disrupt markets and find new ways of doing business.

Challenges of Implementing Industry 4.0

***Cybersecurity*:** The interconnection and digitization of systems is a key feature of i4.0 meaning there are more devices connected to the Internet of Things. This represents a massive

cybersecurity challenge in terms of data protection and intellectual property. You will need to implement robust security systems to protect against hacking and unintentional data breaches.

Just like a chain, these connected cyber physical systems are only as strong as the weakest link. Policies, processes, and procedures should all be standardized to limit the amount of possible breach points in your systems.

Change Management: Embracing change is the secret to success for the majority of companies. i4.0 is changing the way we do things, merging the physical and digital together. These changes reveal a need to strategies ways to support your employees and empower them with the tools and skills needed to transition to i4.0.

Putting employees at the center of the change enables employee engagement at all stages, the human factor becomes a major lever for transitioning to i4.0. It is common for collaborators who are open to change to join the team as 'change champions' helping promote new technologies whilst helping colleagues adapt to new technologies.

Employment: i4.0 is changing the employment landscape with the need for employees to acquire different or all new skills to excel in these changing roles. Repetitive task workers will face challenges in keeping up with industry as their jobs are phased out or handled by an autonomous machine running 24/7. Education will need to transform to keep up with the demands of a rapidly changing labor market.

Capital Investment: i4.0 implementation will not be free, there will be varying degrees of cost involved from cheap IoT sensors used on existing machines or the purchase of large machinery with integrated i4.0 solutions. The capital investment needed for some of these larger projects might hurt the balance sheet in the short term but will have a multiplying effect in the long term by reducing your costs, increasing agility to market and customer satisfaction.

Do You Have an Implementation Strategy in Place?

Implementation of Industry 4.0 will cause major challenges in your business in the short term, but the advantages & benefits outweigh the challenges i4.0 will bring. You must start thinking about your Lean i4.0 strategy now or be left behind as more businesses take the lead to greater autonomy and disruption of traditional markets. TXM can help you understand where you are and where you need to be.

1.3. Project Ideation "Why are We Here?"

Every idea has a beginning, sometimes to solve a problem, to facilitate a specific work, to benefit from modern technology, or to research and develop new strategies. Therefore, we found it very important to clarify where our project started and why we are here?

"Intelligent Manufacturing" means using the combined intelligence of people, processes, and machines to impact the overall economics of manufacturing. Its purpose is to optimize manufacturing resources, improve business value, safety, and reduce waste.

"The Fourth Industrial Revolution" (Industry 4.0) marks the beginning of the imagination age, which creates a virtual copy of the physical world and make decentralized decisions to improve communication, self-monitoring, and production of smart machines that can analyze and diagnose issues without the need for human intervention and provide predictive maintenance. Therefore, our aim of this project is to implement a smart factory that uses these technologies.

1.3.1 The Problem

The industrial and manufacturing sector keep evolving and that evolution does not just happen. It is usually a direct result of overcoming the challenges that threaten the existence of the sector. So, are there any challenges that the sector is dealing with currently?

Here are some of the challenges that face the manufacturing sector;we need to overcome it:

- Difficulty with manual control of a system as complex as packing systems Which exposes workers and engineers not only to errors caused by unclear operations, but also to accidents.
- Some of the manufacturing problems in the packing when producing a product that is not good enough to be consumed so it becomes a waste.
- The asymmetry of product quantity in the produced package and making it equivalent in all packages.
- Adjust production rate according to demand.
- High levels of energy consumption due to the lack of regulation of the speed of execution of operations and the continuous working of unneeded equipment.
- The difficulty of storing a large amount of data due to the small memory of the SCADA system.
- Data transfer and exchange over long distances.
- Sudden problems that disrupt production lines.
- Supply chain systems leakage because of data leakage.

1.3.1 The Solution

Because of all mentioned and unmentioned problems that face the packaging industries, we tried to search for effective solutions to increase the quality and the rate of the production process in general

as well as decrease consumed energy over the production process:

- Using a mixed control system that combine a PLC for controlling the conveyers and the movement of the product through the whole process. HMI for ease the interaction between

workers and the machines, a SCADA system for monitoring and controlling the entire production system from one place and send data to a remote place far from the place of production by IOT server and a PID controller for the filling process and tank control.

- The use of the preproduction inspection system and the air pressure system to check the bottles (vessels) for leakages. So defective bottles (vessels) is prevented from going through the entire production process before even the production process started.
- Adjust the rate of production through the time to suit the need of the market by controlling the speed of conveyers' motors, capping motor, filling valve and packing arm.
- Adjust the quantity of the filling product by a flow meter and PID controller to make a descending gradient speed of filling, which will achieve the fastest and accurate filling process and guarantee the same level of product in all bottles (vessels).
- Using an integrated data network, recording it on the cloud, and sending it via IOT to save the data and make the process of reviewing the progress of production and make changes in plans easier.

And as we know any solution should have a business model to be applicable and our project is mush practical than theoretical, we made little business study to link our work to the market.

1.3.1. Business Study

we found that the problem of poor quality of food products packaging could be a result of many factors as following:

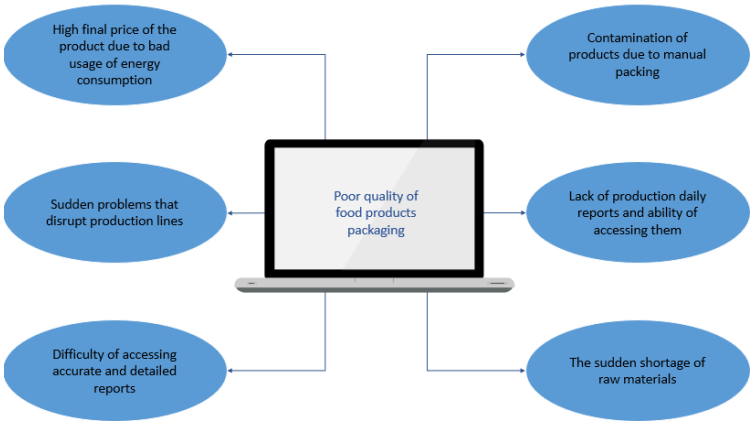


Figure 1-2: poor quality of food products packaging reasons

we know that any industry based on 3 main bases Money, Technology and Row materials, so any factor to improve or fail any product is depend on somehow and once we know the link, we can take the control.

And after this little study we can say we have two main problems one is about leakage of the electrical controllability and the other is about leakage of data collected and we will manage all by industry 4.0.

Defining your user and your customer is a very important point any study should explain to know how will be interested to use or own your solution and based on that you can work on or develop it and you know who is in your competition.

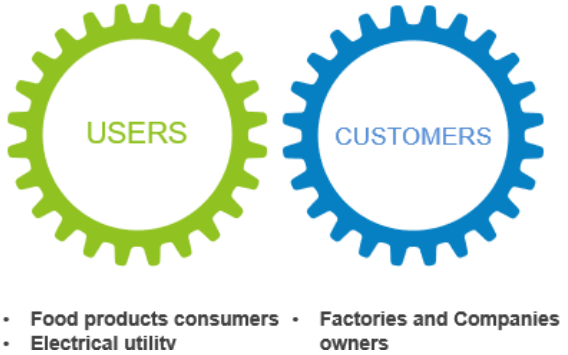


Figure 1-3: our users and customers

On user scale there are deferent interests than customer scale; for the user the most important factor while choosing the product is the price with respect to other factors like the brand

name and the product quality without forgetting caviid-19 issues which makes Less humans dealing with the product during the production cycle is a very important factor too, but for our customer there are another factors that make him interested in a project such like ours.

Our customer could be interested in using new technology which make him always updated in his market and helps him to reduce energy consumption and workers dependency at the same time gives him high quality product with high quality process and Less and predictive maintenance.

1.3.2. BMC ‘‘Business Model Canvas’’

Formal descriptions of the business become the building blocks for its activities. Many different business conceptualizations exist; coauthored 2010 book [3] propose a single reference model based on the similarities of a wide range of business model conceptualizations. With his business model design template, an enterprise can easily describe its business model.

Osterwalder's canvas has nine boxes: customer segments, value propositions, channels, customer relationships, revenue streams, key resources, key activities, key partnerships, and cost structure.[3]:16–17 Descriptions below are based largely on the 2010 book Business Model Generation.[3]:20–41

Infrastructure

- Key activities: The most important activities in executing a company's value proposition. An example for Bic, the pen manufacturer, would be creating an efficient supply chain to drive down costs.
- Key resources: The resources that are necessary to create value for the customer. They are considered assets to a company that are needed to sustain and support the business. These resources could be human, financial, physical and intellectual.
- Partner network: In order to optimize operations and reduce risks of a business model, organizations usually cultivate buyer-supplier relationships so they can focus on their core activity. Complementary business alliances also can be considered through joint ventures or strategic alliances between competitors or non-competitors.

Offering

Value propositions: The collection of products and services a business offers to meet the needs of its customers. According to Osterwalder (2004), a company's value proposition is what distinguishes it from its competitors. The value proposition provides value through various elements such as newness, performance, customization, "getting the job done", design, brand/status, price, cost reduction, risk reduction, accessibility, and convenience/usability.

The value propositions may be:

- Quantitative – price and efficiency
- Qualitative – overall customer experience and outcome

Customers

- Customer segments: To build an effective business model, a company must identify which customers it tries to serve. Various sets of customers can be segmented based on their

different needs and attributes to ensure appropriate implementation of corporate strategy to meet the characteristics of selected groups of clients. The different types of customer segments include:

  - Mass market: There is no specific segmentation for a company that follows the mass market element as the organization displays a wide view of potential clients: e.g. car.
  - Niche market: Customer segmentation based on specialized needs and characteristics of its clients: e.g. Rolex.
  - Segmented: A company applies additional segmentation within existing customer segment. In the segmented situation, the business may further distinguish its clients based on gender, age, and/or income.
  - Diversify: A business serves multiple customer segments with different needs and characteristics.
  - Multi-sided platform/market: For a smooth day-to-day business operation, some companies will serve mutually dependent customer segments. A credit card company will provide services to credit card holders while simultaneously assisting merchants who accept those credit cards.

- Channels: A company can deliver its value proposition to its targeted customers through different channels. Effective channels will distribute a company's value proposition in ways that are fast, efficient and cost-effective. An organization can reach its clients through its own channels (store front), partner channels (major distributors), or a combination of both.
- Customer relationships: To ensure the survival and success of any businesses, companies must identify the type of relationship they want to create with their customer segments. That element should address three critical steps on a customer's relationship: How the business will get new customers, how the business will keep customers purchasing or using its services and how the business will grow its revenue from its current customers. Various forms of customer relationships include:
  - Personal assistance: Assistance in a form of employee-customer interaction. Such assistance is performed during sales and/or after sales.
  - Dedicated personal assistance: The most intimate and hands-on personal assistance in which a sales representative is assigned to handle all the needs and questions of a special set of clients.
  - Self-service: The type of relationship that translates from the indirect interaction between the company and the clients. Here, an organization provides the tools needed for the customers to serve themselves easily and effectively.
  - Automated services: A system similar to self-service but more personalized as it has the ability to identify individual customers and their preferences. An example of this would be Amazon.com making book suggestions based on the characteristics of previous book purchases.
  - Communities: Creating a community allows for direct interactions among different clients and the company. The community platform produces a scenario where knowledge can be shared and problems are solved between different clients.
  - Co-creation: A personal relationship is created through the customer's direct input to the final outcome of the company's products/services.

Finances

- Cost structure: This describes the most important monetary consequences while operating under different business models.

Classes of business structures:

  - Cost-driven – This business model focuses on minimizing all costs and having no frills: e.g. low-cost airlines.
  - Value-driven – Less concerned with cost, this business model focuses on creating value for products and services: e.g. Louis Vuitton, Rolex.
- Characteristics of cost structures:
  - Fixed costs – Costs are unchanged across different applications: e.g. salary, rent.
  - Variable costs – Costs vary depending on the amount of production of goods or services: e.g. music festivals.
  - Economies of scale – Costs go down as the amount of goods are ordered or produced.
  - Economies of scope – Costs go down due to incorporating other businesses which have a direct relation to the original product.
- Revenue streams: The way a company makes income from each customer segment. Several ways to generate a revenue stream:
  - Asset sale – (the most common type) Selling ownership rights to a physical good: e.g. retail corporations.
  - Usage fee – Money generated from the use of a particular service: e.g. UPS.
  - Subscription fees – Revenue generated by selling access to a continuous service: e.g. Netflix.
  - Lending/leasing/renting – Giving exclusive right to an asset for a particular period of time: e.g. leasing a car.
  - Licensing – Revenue generated from charging for the use of a protected intellectual property.
  - Brokerage fees – Revenue generated from an intermediate service between 2 parties: e.g. broker selling a house for commission.
  - Advertising – Revenue generated from charging fees for product advertising.

Application

The Business Model Canvas can be printed out on a large surface so that groups of people can jointly start sketching and discussing business model elements with post-it notes or board markers. It is a hands-on tool that fosters understanding, discussion, creativity, and analysis It is distributed under a Creative Commons license [4] from Strategyzer AG and can be used without any restrictions for modeling businesses.

The Business Model Canvas is also available in web-based software format.

Our BMC

As we recognized the importance of BMC, we tried to make ours depending on the previous data as the following fig.1.4.

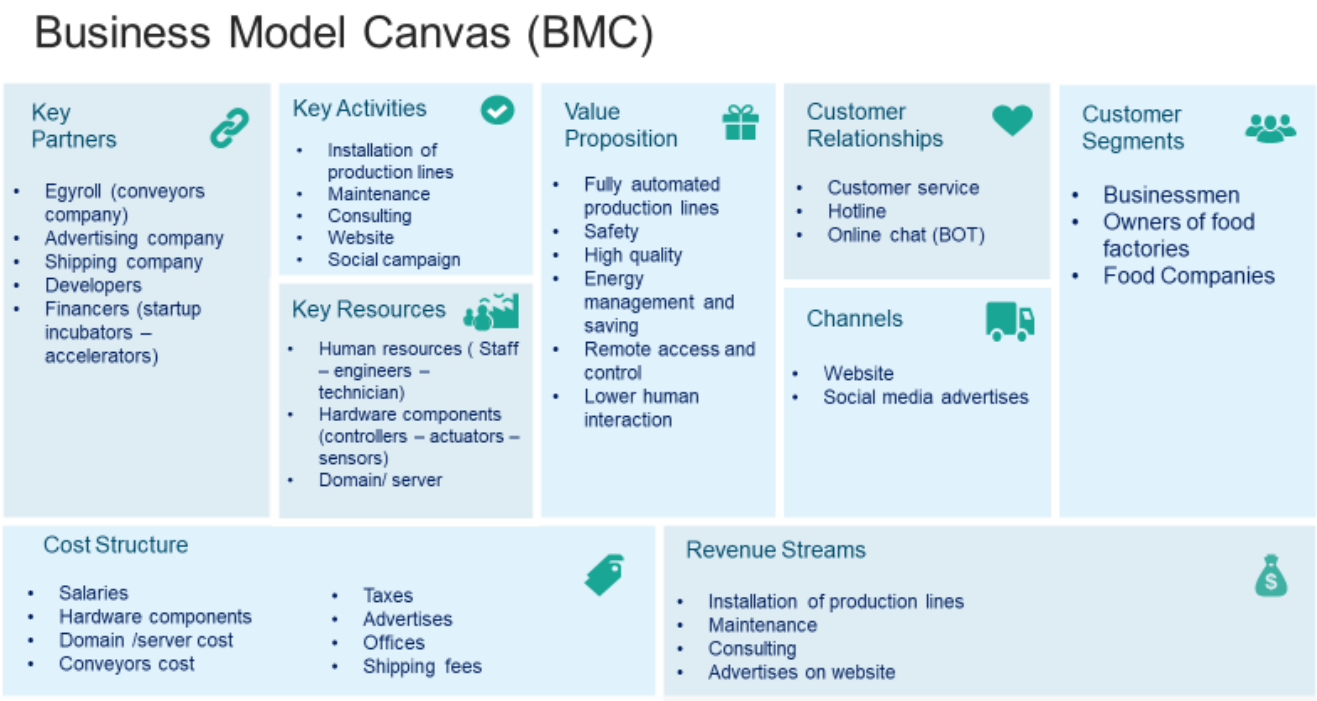


Figure 1-4: Our Business Model Canvas

1.4. Vision

"To have a high-quality system and provide the customer and the owner requirements starting from the product quality, the rate of production, with the best usage of resources and saving electrical energy."

As we know the customer doesn't pay only for the product but also he pays for the value and the process that happened until the product reach the end-user and as easier process means cheaper product, higher value means more manufacture benefits and having happy customer and satisfied manufacture makes a healthy weather for competition which leads to increase the market quality and improve the hole economic cycle.

For food products the most important values are the quality and the price, for industrial business is the income and technology without forgetting workers safety with better communicational system and for the government, the health and safety of their people is the first issue and of course the best resources consumption that enhance the national economy.

So, we choose to use industry 4.0 technology to reach integral system which provide higher quality with lower resources or energy consumption.

1.5. Objectives

What we aim to achieve through working on the concept of Industry 4.0 and working on our project can be summarized in the following points:

- Learn more about how to deal with automatic liquid bottling.
- Check the quality of the products using image possessing to improve it.
- Learn how to use SCADA system and IOT system to improve the production process and provide easier way to control the factory overall.
- Provide an automatic liquid bottling system in Egypt which uses modern developed techniques.
- Facilitating and developing the industrial process by making it fully automatic and saving operators from direct contact with machines and controlling the entire system remotely, in order to achieve the highest principles of safety.
- Know the different techniques for energy management concept.

1.6. Brief scholar

This book begins with this chapter which gives an introduction about the technology used and the project main objectives then chapter two let you know more the project main logic proses with flow charts and soled works designs, at chapter three you can have insight into our first system and all components, wiring, programming and even the problems that we faced at and at chapter four you can know more about rejection systems in general and our system specifically then at the next chapter you can see the next system that the bottle faces, at chapter six you have detailed explanation for the quality control system using image processing and its prosses then we talk about the robot and its choosing criteria, design and operation and we can't forget to mention chapter eight the panel wiring, and the you can find IoT and SCADA structure at chapter nine, finally we talked about our future work and at appendix we attach all codes used.

1.7.Sponsers

Schneider

Schneider Electric SE is a French multinational company providing energy and automation digital solutions for efficiency and sustainability. It addresses homes, buildings, data centers, infrastructure and industries, by combining energy technologies, real-time automation, software and services. Schneider Electric is a Fortune Global 500 company, publicly traded on the Euronext Exchange, and is a component of the Euro Stoxx 50 stock market index. In FY2020, the company posted revenues of €25.2 billion. Schneider Electric is the parent company of Square D, APC and others. It is also a research company. The company began in 1836 as Schneider & Cie. It was ultimately renamed Schneider Electric in May 1999.

Egy Roll

"EGYROLL" is a highly advanced Conveyors Solutions Company has been recognized it's one of the most innovative, successful, and fast-growing private companies in the Egyptian market. It offers a complete service which includes design, manufacturing, installation, commissioning and after-sales servicing of all types of Conveyors. they are able to provide movement flow for any application through expert design and production using the latest techniques with competitive prices at prompt delivery dates. Being a partner of "ABB Robotics" allows them a great privilege in producing fully integrated systems combining Robot-Solutions with Conveyor Systems. Engineering "EGYROLL" employs a fine staff of competent engineering personnel capable of providing solutions to the most complex handling problems. their Engineers are armed by the latest "Computer Aided Drawing (CAD)" software for 2D, 3D simulation and load analysis. Manufacturing their product line consists of the latest known technology "Computer Numerically Controlled (CNC)" Machines which guarantees the highest level of precision of all the manufacturing processes which consequently leads to keeping accurate delivery dates.

1.8.Project budjet

1.8.1. From Collage Fund.

Component	Quantity	Unit Price	Total Price
Limit Switch	12	10	120
Terminals	10	1	10
3D Printing	66 g	1.5	100
Row Copper 50mm	2 Kg	50	100
Pi Camera	2	295	590
Camera Acrylic Box	1	48	48
USB Cable	1	25	25
Solenoid Valve 5/2	1	71.25	71.5
Coil 24VDC	1	33.25	33.25
Exhaust Muffler	2	4.5	9
Hydraulic Terminal	1	6.5	6.5
Hose Tie	1	2	2
Hose	2 m	5	10
Pneumatic Connection	8	7	56
IR Sensor	4	250	570
Proximity Sensor	2	207.5	830
Cat 6 Cables	21 m	2.5	52. 5
Total before Taxes			2’633.75
Taxes	14%		368.725
Discount			2.475
Total			3000

1.8.2. From Schneider (Sponsor)

Component Name	Part Number	Quantity	Unit Price
PLC	TM221CE40R	1	25’500
Gateway	EGX100	1	12’250
HMI	HMIGXU3512	1	7’500
VSD	ATV320U07N4C	2	6’000
Power Supply	ABL7RE2410	1	5’750
Switch	TCSESU083FN0	1	4’500
Capacitive proximity	XT118B1PAL2	2	2’250
Pressure Transmitter	XMLG010D21	2	7500
Total			91’000

1.8.3. Other Fund Resources

Transportation from Alexanderi	1200
Lap tools	1170
Last year budget	32000
Egyroll fund	85000

Total Budget of the Project = 213’370 L.E.

Chapter 2
Hardware implementation

2. PROJECT IMPLEMENTATION

All contains in this chapter is unique, it is all our work and designs, and nothing is quoted.

Our project consists of six main phases as fig2.1, and in this chapter, we give the outer look about the whole system and tasks sequence.

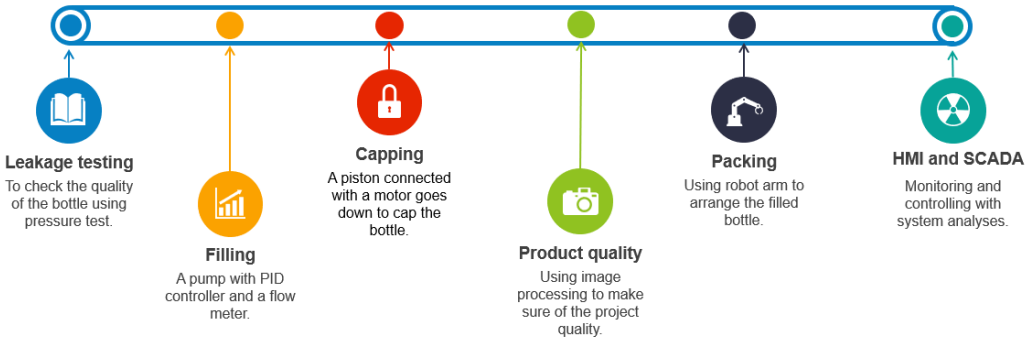


Figure 2-1: project main phases and sub systems

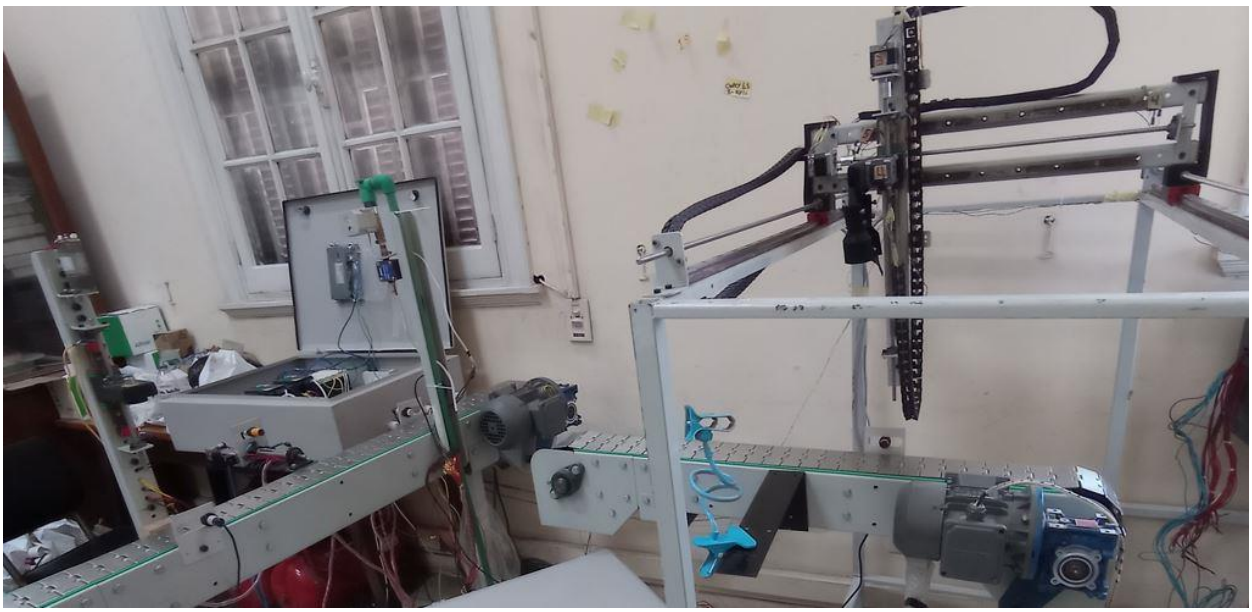


Figure 2-2:the system

2.1.Project Flowcharts

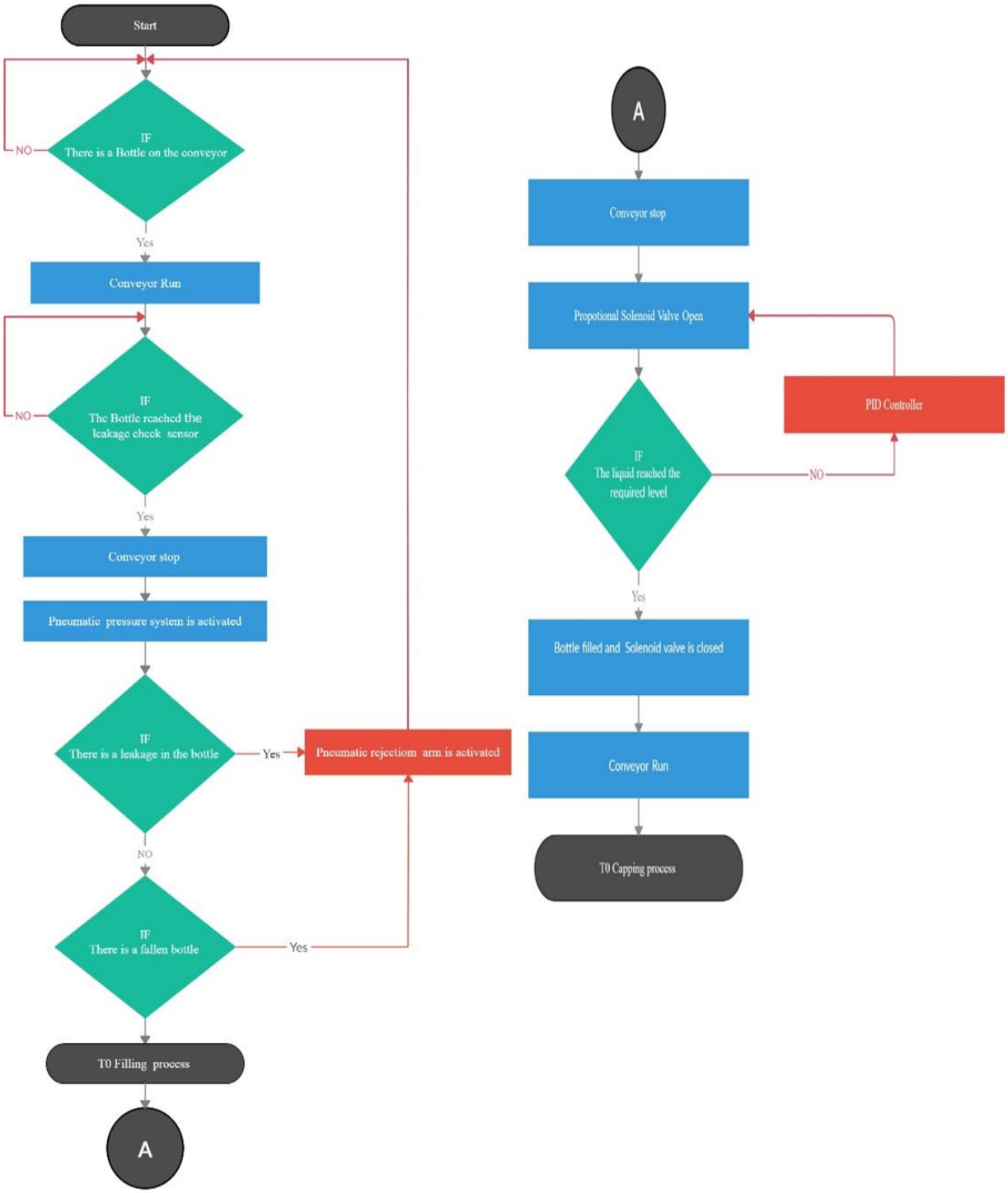


Figure 2-3:project main sequence.

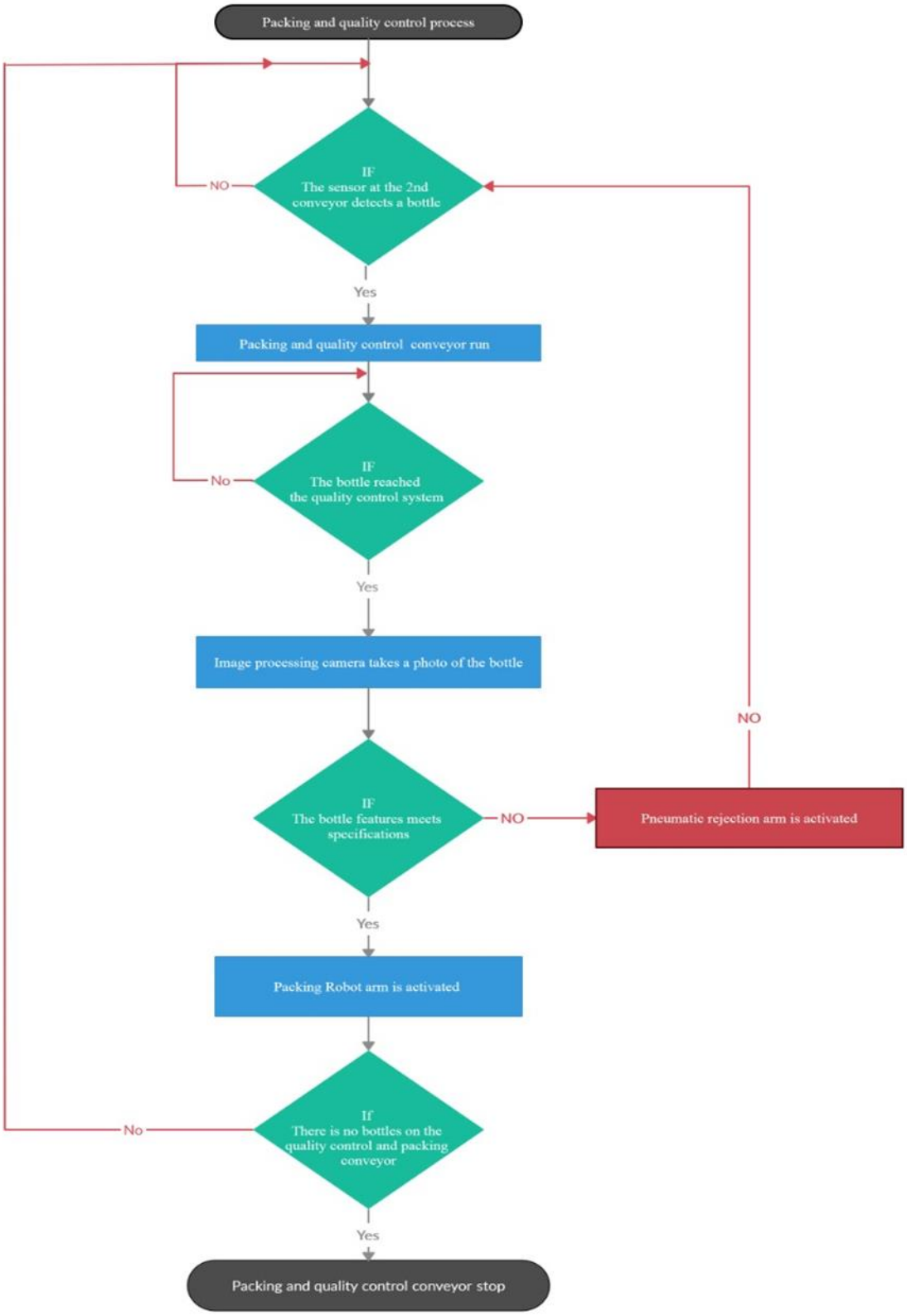


Figure 2-4: packing and quality control process system.

The system starts by the question Is there a bottle on the conveyer? Until the answer is yes there is no action taken, when the answer be yes, the conveyer motor runs until the bottle reaches leakage test system, conveyer stopes and pneumatic system start. If there is a leakage problem, pneumatic rejection system will be activated to reject the bottle and we will back to the first question in case of there is another bottle the process will continue and if there is no the motor conveyer won't run again. But if the bottle is OK and it reached the filling system we check if it stands or not, if no it will be rejected else that means the bottle is ready to be filled so the filling system mainly the valve will start to work. We use PID controller to fill the bottle, so the PID will control the valve until we reach the required level then the bottle will finish its way to capping system. After capping we have a very important phase "quality control system".

The proses start with a basic question if there is a bottle to apply the test on or not? If not, nothing will happen until there is a bottle, the second conveyer will run and once the sensor feels the bottle in its position to take the photo, it will be taken and analyzed. If the bottle passed the test the robot will package it in its position else the bottle will be rejected. Then we check if there are no other bottles the second conveyer will stop again and if there is the process will be repeated.

2.2.Designed Models

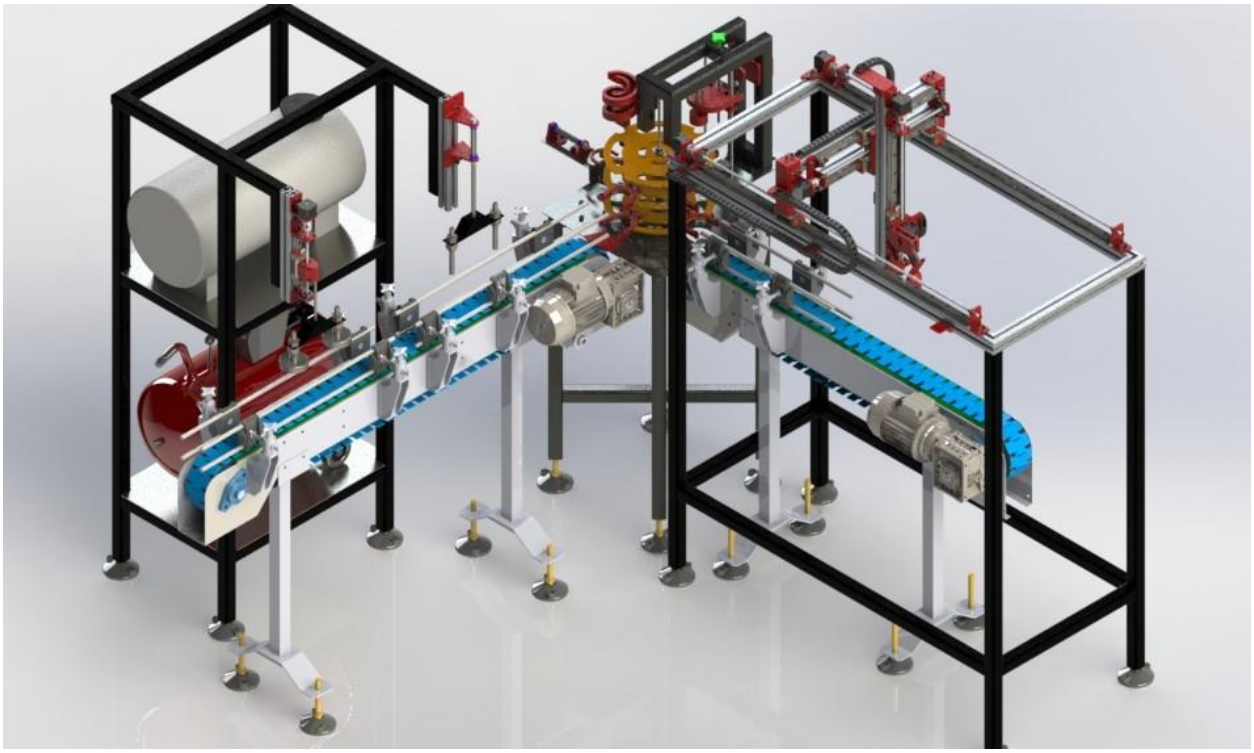


Figure 2-5: The whole system using soled works

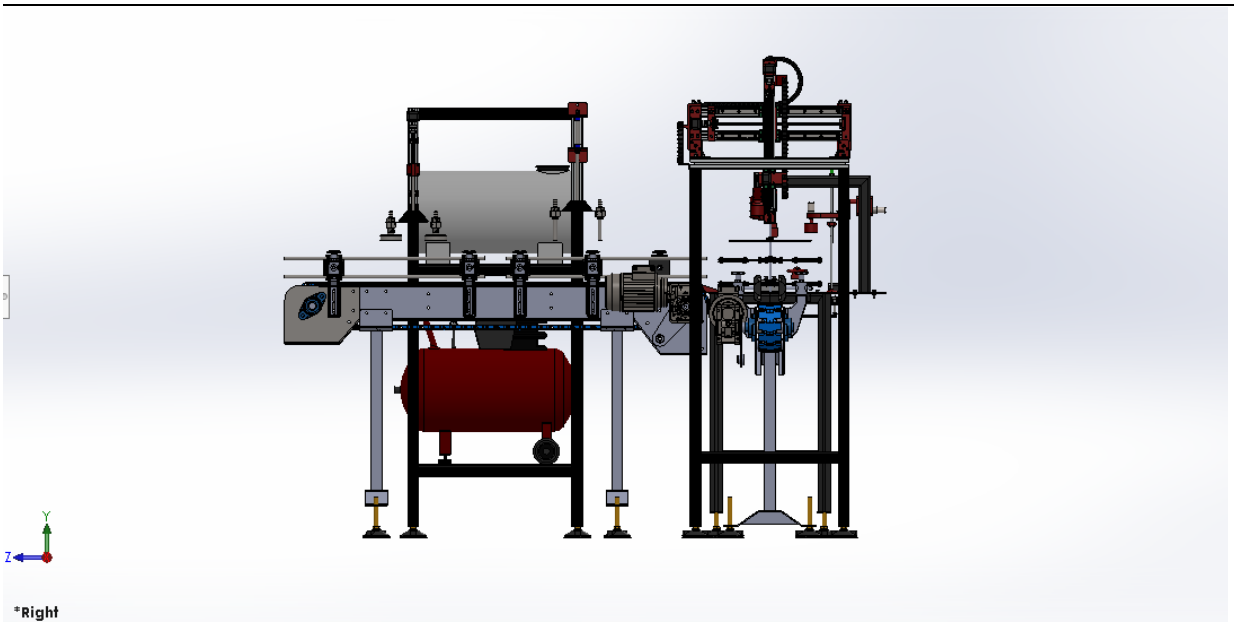


Figure 2-6: System side view.

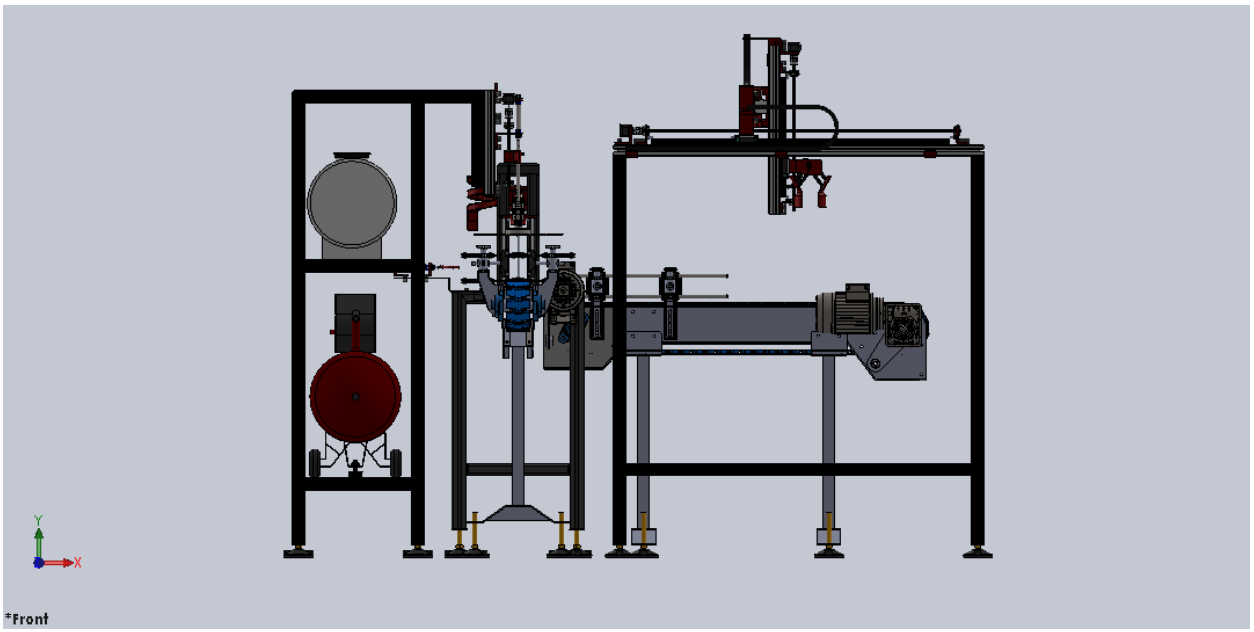


Figure 2-7: system front view.

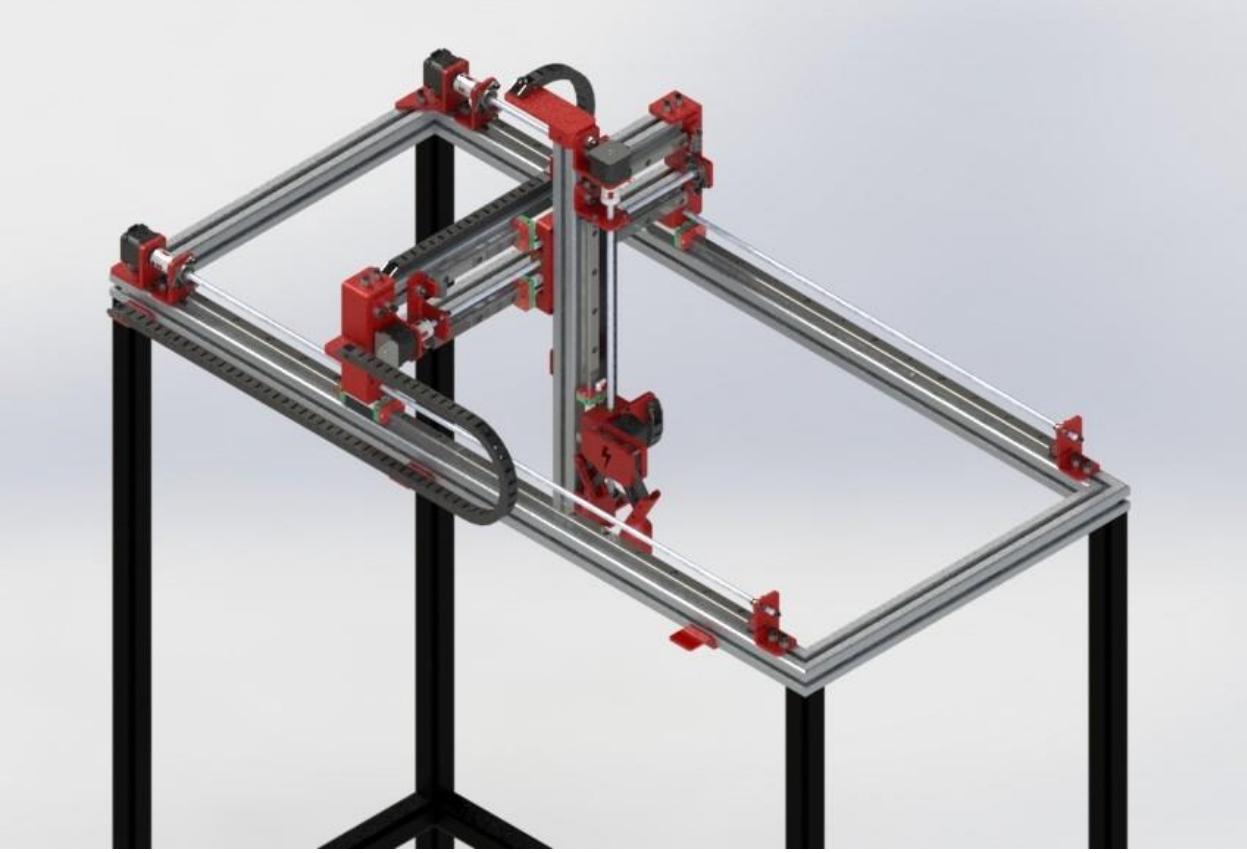


Figure 2-8: The Cartesian robot arm

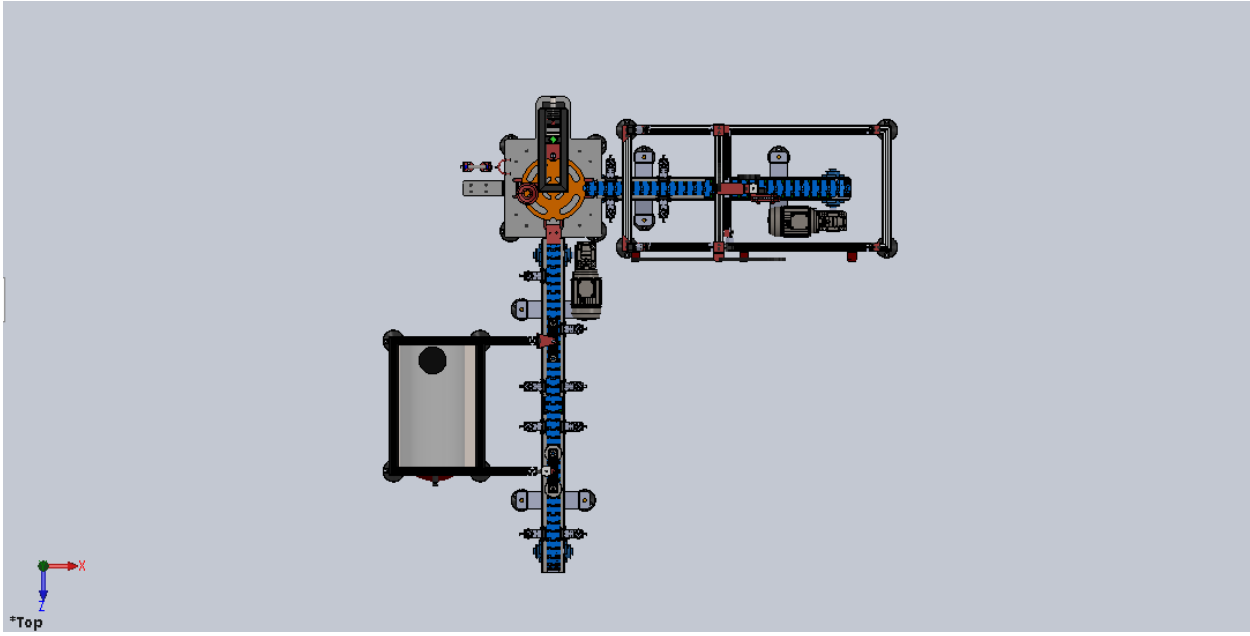


Figure 2-9: System Top view.

Chapter 3
Project Components

3. PROJECT COMPONENTS

<u>This chapter includes the whole devices used in our project and its characteristics.</u>

3.1.Conveyer Motor

Model Number	AGM 71 4b B35
Approximate Price	1000 L.E.
Rated Power	0.37 KW
Rated Speed	1390 rpm
Voltage (Δ/Y)	230/400 V
Frequency	50Hz
Rated Current	1.15 A
Rated Torque	2.5 N.m
Rated Power Factor	0.68
Starting Current	4.3 A (3.7*rated)
Starting Torque	5.5 N.m (2.2*rated)
Breakdown Torque	6.3 N.m (2.5*rated)
Noise Level	46 dB/A
Number of Poles	4 poles
Frame	Aluminum
Operation Type	S1
Protection Class	IP55
Insulation Class	F (155°)
Engine Efficiency	68.1%
Efficiency Class	IE-
Temperature Rise Class	B (80K)
Mounting Design	B35

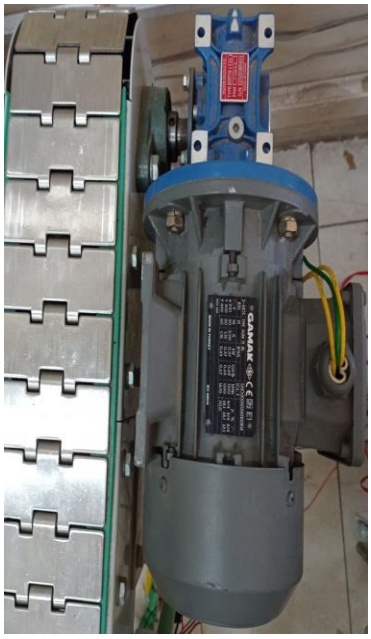


Figure 3-1:conveyer motor

Figure 3-2:name plate

3.2. Capacitive Proximity Sensor

Model Number	CR18-8DN
Approximate Price	415 L.E.
Type	DC 3-wire
Sensing Distance	8mm
Operating Voltage	10-30 VDC
Max Current	15 mA
Max Hysteresis	20% of Sensing dist.
Standard sensing target	50x50x1mm (iron)
Setting distance	0-5.6mm
Response frequency	50Hz
Max Residual Voltage	1.5V
Affection by Temp.	Max ±20% @ 20°C
Max Control Output	200mA
Insulation Resistance	500MΩ

Figure 3-3:capacitive sensor

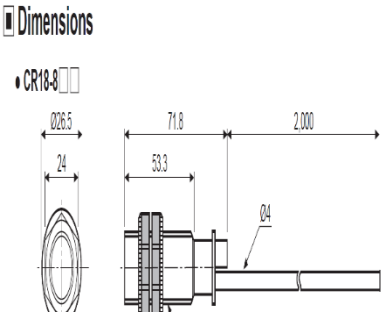


Figure 3-4:dimensions

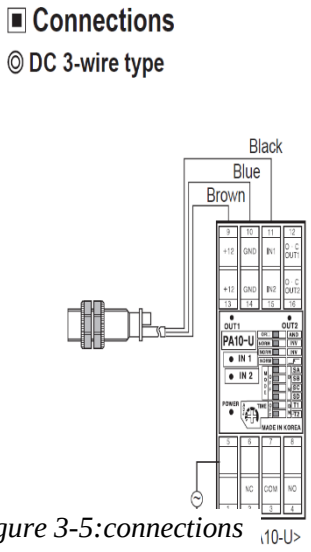


Figure 3-5:connections

3.3.Infrared Diffuse Sensor

Model Number	SN-E18-B03N1
Approximate Price	125 L.E.
Type	NPN - Three wires
Voltage	6-36 VDC
Current	< 300 mA
Sensing distance	0-30 cm

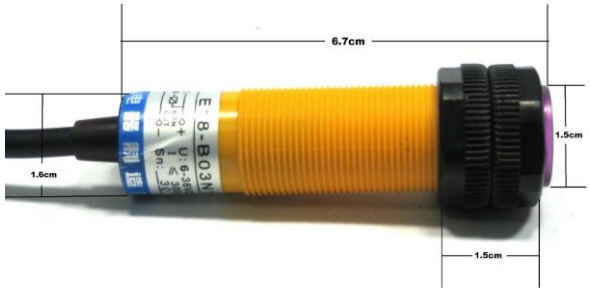
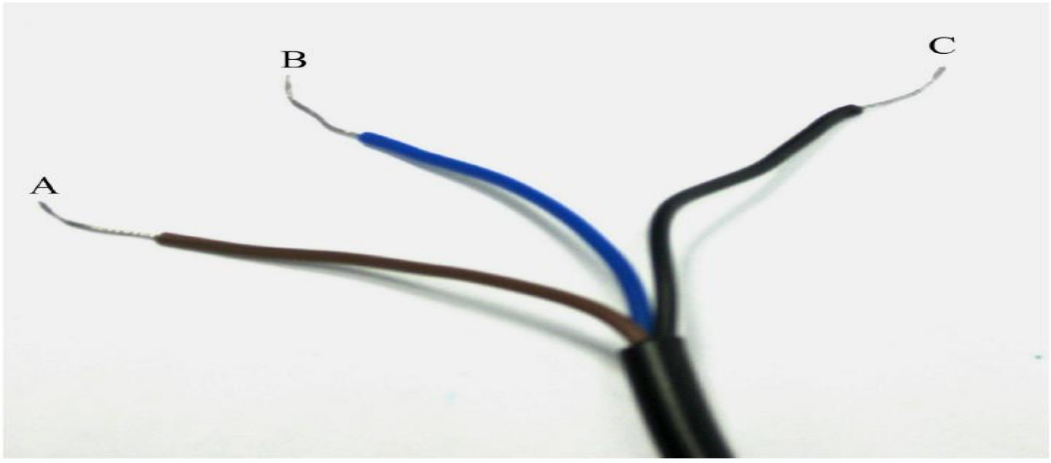


Figure 3-6:infrared diffuse sensor



Label	Color	Function
A	Brown	Connect VCC(+)
B	Blue	Connect GND(-)
C	Black	Connect Output Signal (S)

Figure 3-7: connection

3.4.Pressure Transmitter

Model Number	XMLG010D21
Approximate Price	1750 L.E.
Voltage	12/24 VDC
Output	4-20 mA
Vmin - Vmax	8 - 33
R	(Vmin -8)/0.02A
Measuring range	0-10 Bar
Degree of protection	IP66 – IP67
Permissible overpressure	22 Bar
Rupture pressure	25 Bar
Materials in contact with the fluid	AISI 303 + FPM
Ambient air temperature and fluid	-15°C / +85°C

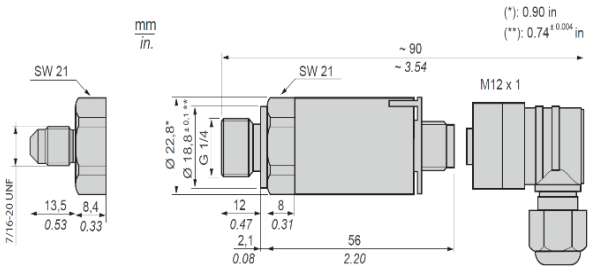


Figure 3-9:dimension

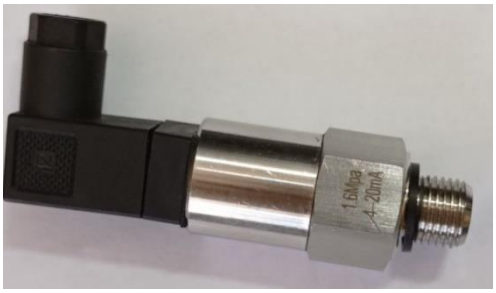


Figure 3-8:pressre transmitter

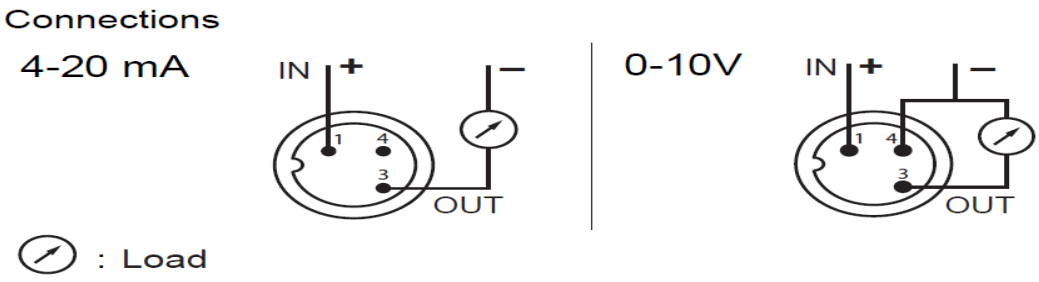


Figure 3-10:connection

3.5.Geared DC Motor

Model Number	JGA25-370
Approximate Price	750 L.E.
Voltage	6 – 12
No Load Speed	190 – 350 rpm
No Load Current	0.2 – 0.1 A
Max. Eff. Speed	133 – 245 rpm
Max. Eff. Current	0.5 – 0.65 A
Max. Eff. Power	1.1 – 2.4 W
Blockage Torque	4 – 5.2 Kg.cm
Blockage Current	2.1 – 2.2 A

Figure 3-11:DC motor

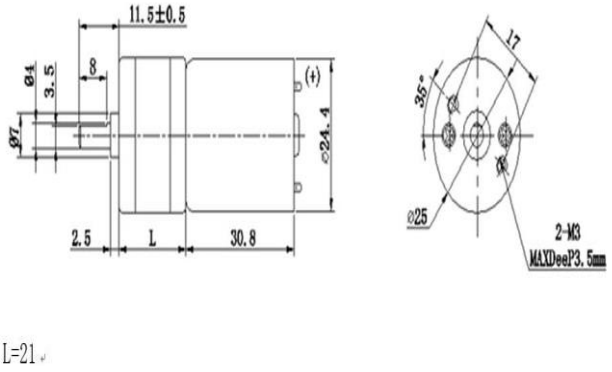


Figure 3-12:dimension

3.6.Solenoid Valve

Model Number	4V210-08
Approximate Price	150 L.E.
Model	5/2 Way
Valve Type	Single Solenoid
In/Out Port size	1/4 inch
Exhaust Port size	1/8 inch
Voltage	24VDC ±10%
Operating Pressure	0.15-0.8 MPa
Max. Pressure	1.2 MPa
Fluid	Air (to be filtered by 40µm filter element)
Temperature	-20°C / +70°C
Material of Body	Aluminum Alloy
Max. Frequency	5 Cycle/sec
Weight	220 gm
Lubrication	Not Required
Power Consumption	3 W
Protection	IP65
Temperature Class	B Class
Coil Activating time	50 mSec and below
Electrical entry	Terminal

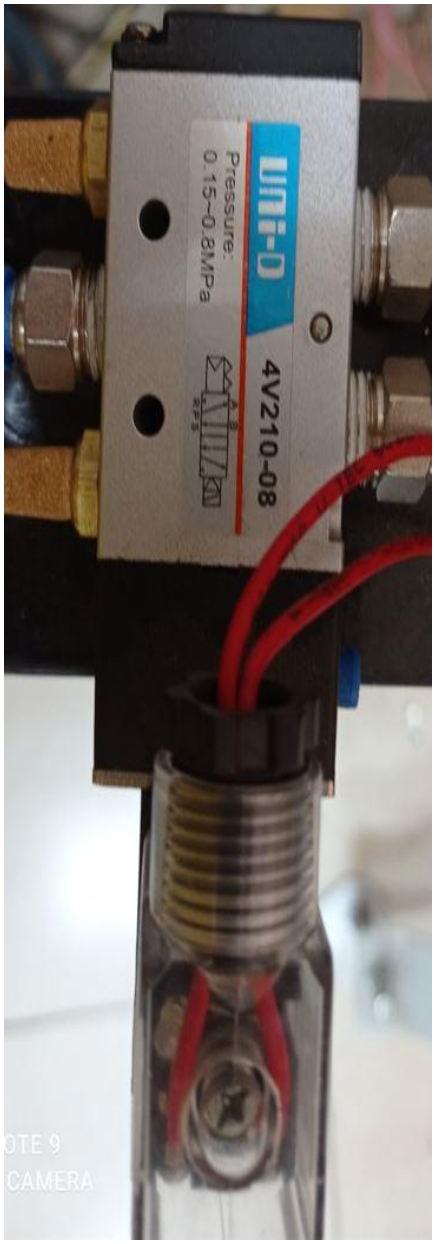


Figure 3-13:solenoid valve

3.7.Compressor

Figure 3-14:compressor

MODEL	CODE	PUMP	C F	dB(A) LWA	VOLT/HZ	KW - HP	l/min - c.f.m.	bar - p.s.i	R.P.M.	cm.	kg
PEOPLE 24	55898878	XD200	24	76 - 90	230/50	1,5 - 2	190 - 6,7	8 - 116	2850	61 x 27 x 60	25

Figure 3-15: specs

Figure 3-16: name plate

3.8. Water Pump

Model	Brushless Motor Submersible Water Pump
Approximate Price	480 L.E.
Voltage	12 VDC
Power	19 W
Water Flow	800 L/hr
Water Lift	5 m
Weight	10 gm
Material	ABS
Max. Rated Current	1 A
Ambient Temp.	+1°C / +60°C
Max. Water Temp.	100°C
Noise	<40dB

Figure 3-17: water pump

3.9.Flow Sensor

Model	DIGITEN G3/8
Brand	Digiten 3.6
Flow range	1-30L/min.
Voltage	DC 3V-12V
Accuracy	±0.5%.
Size	Gear 3/8" flow sensor for hose
Connection	3/8" quick connect
Output signal	pulse signal, 2.5mL/P
Max operation pressure	0.8Mpa with fluid temperature of +20℃
Ambient operating temperature	-10 to 70℃ (freezing must be avoided)
Wiring	Red---Power+; Black---GND; Yellow---Pulse signal
Applications	Fuel, oil, gasoline, diesel, milk, water liquid, thick liquid, etc

Figure 3-18: flow sensor

3.10. Motorized Valve

Model Number	A20-M10-B2-C
Approximate Price	450 L.E
Working Voltage	5-24 VDC
Max. Working Current	15mA “@5VDC”
Flow Rate Range	1-60 L/min
Load Capacity	≤ 10 mA “@5VDC”
Operating Temp	≤80°C
Liquid Temp	≤120°C
Operating Humidity	35-90% RH
Water Pressure	≤2 MPa

Figure 3-19: motorized valve

3.11. Stepper Motor

Model Number	17PM-K406-11V
Approximate Price	250 L.E
Step Angle	1.8°
Drive Sequence	Bipolar
Rated Current/Wdg	1.4 A
Winding Resistance	2.4 Ω
Holding Torque	5 Kg.cm
Inductance	5.7 mH
Rotor Inertia	0.08 Kg.cm^2
Detent Torque	150 gm.cm
Weight	350 gm
Type	Laminated Stack
Construction	Phase Hybrid
Step Accuracy	±5%
Temperature Rise	80°C Max
Ambient Temp Range	-20°C / +50°C
Insulation Resistance	100MΩ Min. 500VDC
Dielectric Strength	500VAC 1min

Figure 3-20:stepper motor

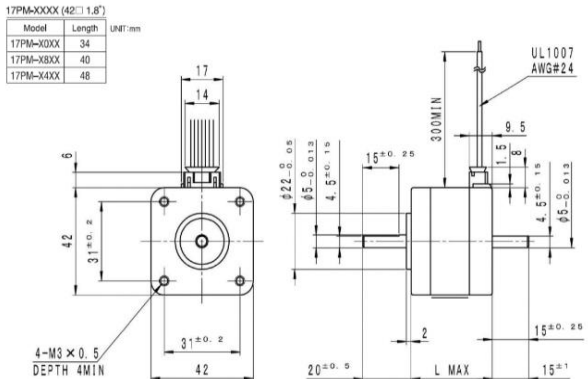


Figure 3-21:dimension

3.12. Stepper Drive

Model Number	TB6600
Approximate Price	250 L.E
Input Current	0~5.0 A
Output Current	0.5~4.0 A
Power (Max)	160 W
Micro Step	1, 2/A, 2/B, 4, 8, 16, 32
Temperature	-10 ~ 45°C
Humidity	No Condensation
Weight	0.2 kg
Dimension	96*56*33 mm

Power Supply:

- VCC VCC (DC9-42V)
- GND GND

Wiring instructions

There are three input signals in all:

- Step pulse signal PUL +, PUL-
- Direction signal DIR +, DIR-
- off-line signal EN +, EN-

The driver supports common-cathode and common-anode circuit you can select one according to your demand.

Wiring

Signal Input:

- PUL+ Pulse +
- PUL- Pulse –
- DIR+ Direction +
- DIR- Direction –
- EN+ Off-line Control Enable +
- EN- Off-line Control Enable –

Motor Machine Winding:

- A+ Stepper motor A+
- A- Stepper motor A-
- B+ Stepper motor B+
- B- Stepper motor B-

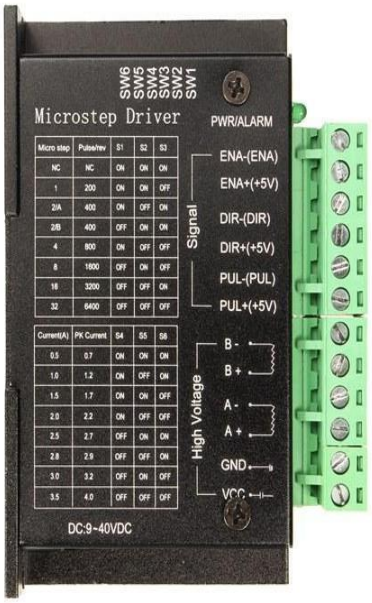


Figure 3-22: stepper driver

3.13. PLC

Model Number	TM221CE40R
Approximate Price	25’500 L.E
# Digital Inputs	24
# Relay Outputs (2 A)	16
# Analog Inputs	2
# Serial Line Port	1
# Ethernet Port	1
Power Supply	100-240 Vac

Figure 3-23

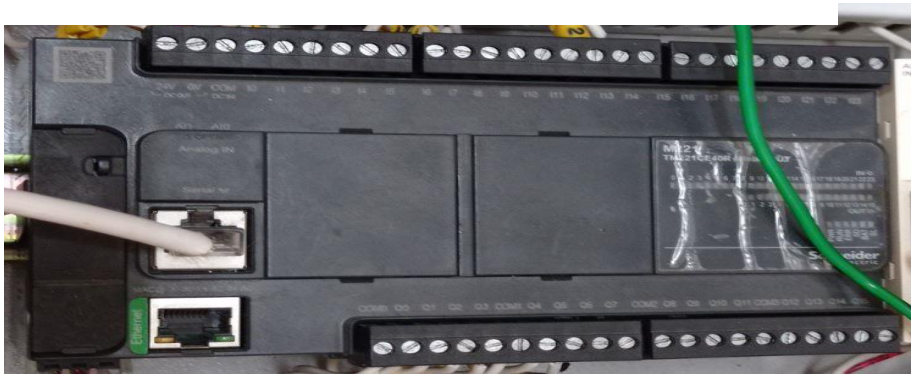


Figure 3-24

3.14. Analog Module

Model Number	TM2AMI2HT
Approximate Price	3’150 L.E

Figure 3-25

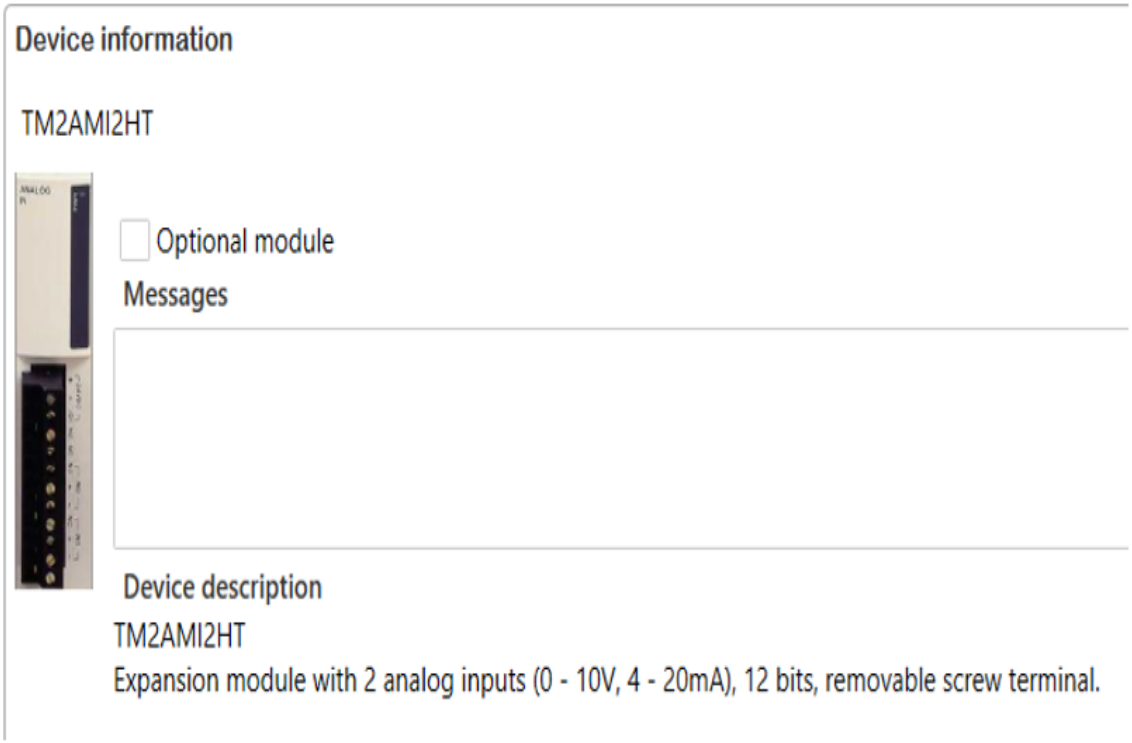
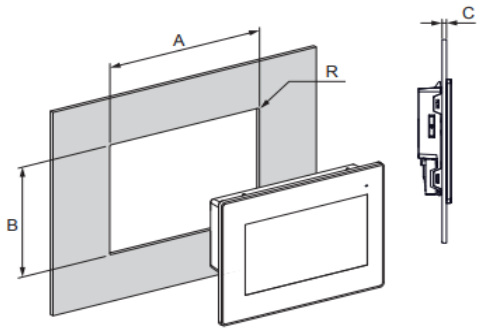


Figure 3-26:description

3.15. HMI

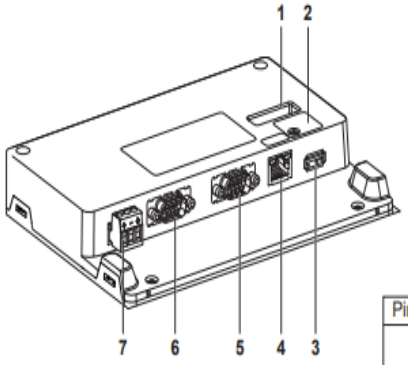
Model Number	HMIGXU3512
Approximate Price	7’500 L.E



Model / 型号	A	B	C (Panel thickness / 安装面板厚度)	R
HMI GXU35●●	190±1 mm (7.48±0.04 in)	137±0.7 mm (5.31±0.03 in)	1...5 mm (0.04...0.19 in)	3 mm (0.12 in) max.
HMI GXU55●●	255±1 mm (10.04±0.04 in)	185+1 mm (7.28+0.04 in)	1...5 mm (0.04...0.19 in)	3 mm (0.12 in) max.

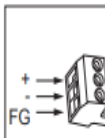
Figure 3-27::dimension

D INTERFACE AND WIRING / 接口和接线说明

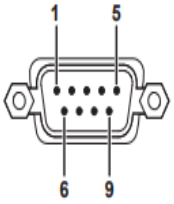


1. USB mini B downloading port / USB mini B 下载接口
2. USB Type A extension port locker for HMIGXU3512 and HMIGXU5512
   USB Type A 扩展口紧固锁扣仅HMIGXU3512和HMIGXU512具备
3. USB Type A Extension port for HMIGXU3512 and HMIGXU5512
   USB Type A 扩展口仅HMIGXU3512和HMIGXU512具备
4. Ethernet port for HMIGXU3512 and HMIGXU5512
   以太网接口仅HMIGXU3512和HMIGXU5512具备
5. Serial Interface RS-422/485 / 串行口 RS-422/485
6. Serial Interface RS-232C for HMIGXU3512 and HMIGXU5512
   串行口 RS232C 仅HMIGXU3512和HMIGXU5512具备
7. Power supply connector / 电源端子

NOTE : Use only the SELV (Safety Extra-Low Voltage) circuit to connect the COM, USB, and LAN interfaces.
注：只使用安全特低电压 (SELV) 电路连接 COM、USB 和 LAN 接口。

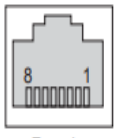


Connection	Wire
+	24 Vdc
-	0 Vdc
FG ⏚	Grounded terminal connected to the panel chassis.



Male

Pin Connection	Pin	RS-232	RS-422/RS-485
	1	CD	RDA
	2	RD(RXD)	RDB
	3	SD(TXD)	SDA
	4	ER(DTR)	-
	5	SG	SG
	6	DR(DSR)	-
	7	RS(RTS)	SDB
	8	CS(CTS)	-
	9	Reserved	-
	Shell	FG	FG



Female

Pin Connection	Pin	Signal
	1	TD+
	2	TD-
	3	RD+
	4	–
	5	–
	6	RD-
	7	–
	8	–

SG: Signal Ground
FG: Functional Ground

Tighten the mounting screws using the defined torque: 0.5 N•m *(4.42 lb-in)*.
Wherever possible, use wires that are 0.75 to 2.5 mm² *(AWG 18 - 12)* for the power cord, and twist the wire ends before attaching the terminals.
以定义的扭矩拧紧安装螺钉：0.5 N•m *(4.42 lb-in)*。
请尽可能使用 0.75 至 2.5 mm² *(AWG 18 - 12)* 规格的电线用作电源线，并且在连接到设备之前，请先把电缆末端绞合。

Figure 3-28:connection

3.16. VSD

Model Number	ATV320U07N4C
Approximate Price	6’000 L.E

Main

Range of product	Altivar Machine ATV320
Product or component type	Variable speed drive
Product specific application	Complex machines
Variant	Standard version
Mounting mode	Wall mount
Communication port protocol	Modbus serial CANopen
Option card	Communication module, CANopen Communication module, EtherCAT Communication module, Profibus DP V1 Communication module, Profinet Communication module, Ethernet Powerlink Communication module, Ethernet/IP Communication module, DeviceNet
[Us] rated supply voltage	380...500 V - 15...10 %
Nominal output current	2.3 A
Motor power kW	0.75 kW heavy duty
EMC filter	Class C2 EMC filter integrated
IP degree of protection	IP20

Figure 3-30:specs

Figure 3-29:vsd

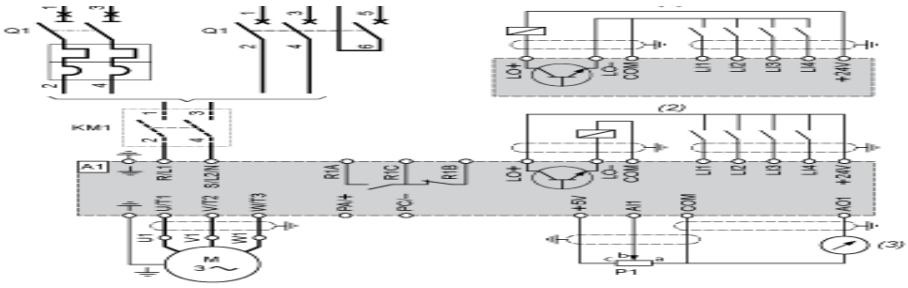


Figure 3-31:connection

3.17. Gateway

Model Number	EGX100
Approximate Price	12’250 L.E

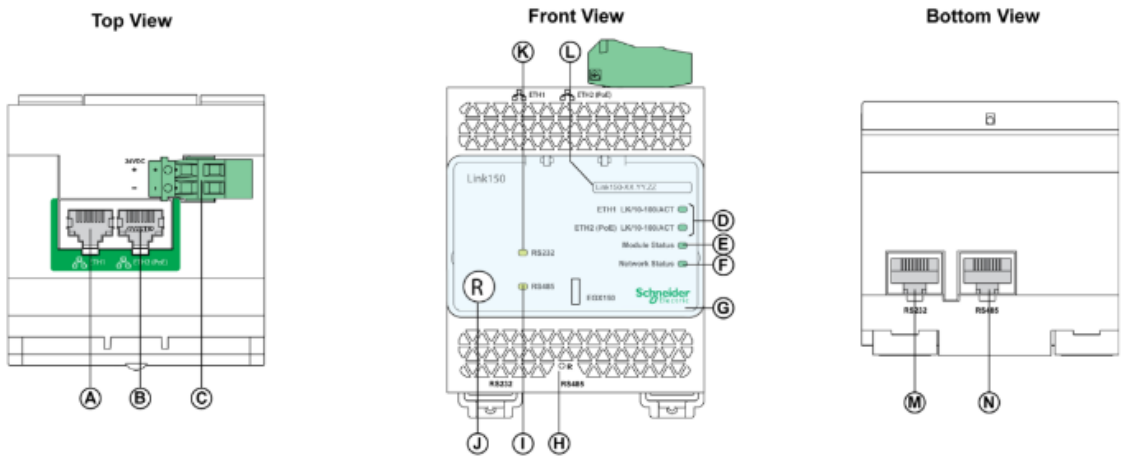


Figure 3-32:gateway

A: ETH1: Ethernet 1 communication port

B: ETH2: Ethernet 2 (Power over Ethernet) communication port

C: 24 Vdc power supply terminal block

D: Ethernet communication LEDs

E: Module status LED

F: Network status LED

G: Sealable transparent cover

H: IP reset pin

I: RS485 traffic status LED

J: Device soft restart button (Accessible through closed cover)

K: RS232 traffic status LED

L: Device name label

M: RS232 port

N: RS485 port

3.18. Switch

Model Number	TCSESU083FN0
Approximate Price	4’500 L.E

SPECIFICATION | TECHNICAL INFORMATION (2) | MULTIMEDIA

Manufacturer	SCHNEIDER ELECTRIC
Type of industrial module	switch Ethernet
Kind of module	unmanaged
Number of ports	8
Mounting	DIN
Kind of connector	RJ45
IP rating	IP30
Data transfer rate	10Mbps, 100Mbps
Width	35mm
Depth	121mm
Height	138mm
Manufacturer series	ConneXium
Operating temperature	0...60°C

Supply voltage

- 9.6...32V DC

Additional information

- Gross weight: 244 g

Figure 3-34:specs

Figure 3-33:switch

3.19. Circuit Breaker (3 Pole)

Figure 3-35:CB(3P)

Main Features			
Range of Product	Acti9 iC60	Article No.	A9F44363
EAN	3606480513473	Sale per Indivisible Quantity	1
Number of poles (total)	3	Over voltage category	4
Rated voltage	415	Suitable for flush-mounted installation	No
Degree of protection (IP)	IP20	Rated short-circuit breaking capacity Icn EN 60898 at 400 V	6
Rated short-circuit breaking capacity Icu IEC 60947-2 at 230 V	20	Width in number of modular spacings	3
Connectable conductor cross section solid-core	1-35	Concurrently switching N-neutral	No
Built-in depth	44.5	Number of protected poles	3
Current limiting class	3	Rated current	63
Release characteristic	C	Rated impulse withstand voltage Uimp	6
Frequency	50-60	Connectable conductor cross section multi-wired	1-25
Pollution degree	3	Rated short-circuit breaking capacity Icn EN 60898 at 230 V	NA
Voltage type	AC/DC	Rated insulation voltage Ui	500
Rated short-circuit breaking capacity Icu IEC 60947-2 at 400 V	10	Additional equipment possible	Yes
Ambient temperature during operating	35-70		

Figure 3-36:specs

3.20. Circuit Breaker (2 Pole)

Main

Range	Acti 9
Product name	Disbo iC60
Product or component type	Miniature circuit-breaker
Device short name	IC60N
Poles description	2P
Number of protected poles	2
[In] rated current	20 A
Network type	AC/DC
Trip unit technology	Thermal-magnetic
Curve code	C
Breaking capacity	6 KA Icu at 100...133 V DC conforming to EN/IEC 60947-2 6000 A Icn at 415 V AC 50/60 Hz conforming to EN/IEC 60898-1 36 KA Icu at 12...133 V AC 50/60 Hz conforming to EN/IEC 60947-2 20 KA Icu at 220...240 V AC 50/60 Hz conforming to EN/IEC 60947-2 10 KA Icu at 380...415 V AC 50/60 Hz conforming to EN/IEC 60947-2 6 kA Icu at 440 V AC 50/60 Hz conforming to EN/IEC 60947-2
Utilisation category	Category A conforming to EN/IEC 60947-2

Figure 3-37:CB(2P)

3.21. Power Supply 24VDC

Model Number	ABL7RE2410
Approximate Price	5’750 L.E

Figure 3-38:power supply

Manufacturer: SCHNEIDER
Type: MODICON POWER SUPPLY
Model: ABL7RE2410
Replaced with: ABL8RPS24100

Input:
Voltage: 100 ... 240 VAC
Frequency: 50/60 Hz
Rated Current: 5 / 2.5 A

Output:
Voltage: 24 VDC
Rated Current: 10 A
Power: 240 W

Degree of Protection: IP20
Ambient Air Temperature for Storage: -40...70 °C
Weight: 2.58 Kg

Figure 3-39:specs

3.22. Limit Switch

Figure 3-40:limit switch

3.23. Power Supply 12VDC

Figure 3-41:power supply(12)

3.24. Relay(24VDC)

Figure 3-42:relay

3.25. Arduino mega

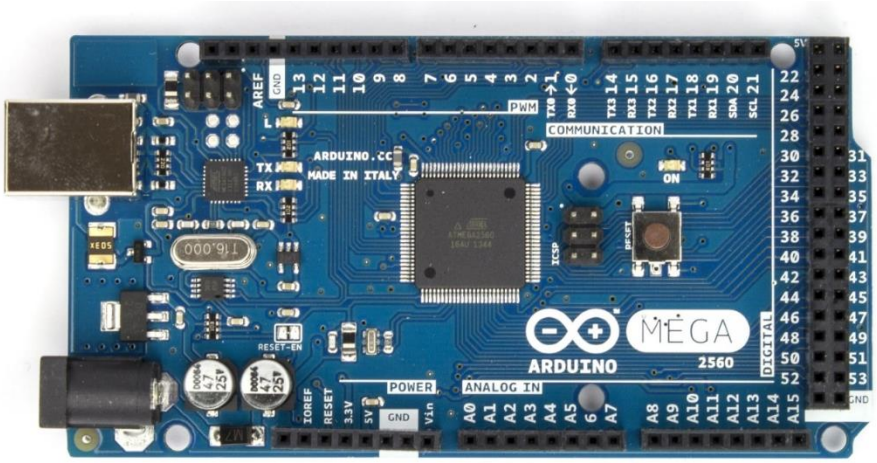


Figure 3-43:arduino

Microcontroller	ATmega2560
Operating Voltage	5 V
Input Voltage (recommended)	7 – 12 V
Input Voltage (limits)	6 – 20 V
Digital I/O Pins	54 (of which 14 provide PWM output)
Analog Input Pins	16
DC Current per I/O Pin	40 mA
DC Current for 3.3 V Pin	50 mA
Flash Memory	256 KB of which 8 KB used by bootloader
SRAM	8 KB
EEPROM	4 KB
Clock Speed	16 MHZ

3.26. 3D Printed Parts

part	% Infill	Q	item	#
Capping	30	2	Bearing Compartment	1
Back Stage	50	1	Anti-Backlash Nut Housing Leakage test	2
Cartesian Robot	50	8	Bearing Holder	3
Capping	50	8	bottle holder lower	4
Capping	50	8	bottle holder lower	5
Capping	50	1	Capper Holder	6
Cartesian Robot	50	1	Gripper Bracket	7
Cartesian Robot	50	2	Limit Switch Holder	8
Capping	50	1	Motor Leveler	9
Conveyer	50	1	slider	10
Cartesian Robot	50	1	x-dir Anti Backlash Nut Housing Left	11
Cartesian Robot	50	1	x-dir Anti Backlash Nut Housing Right	12
Cartesian Robot	50	1	x-dir Motor Bracket Left	13
Cartesian Robot	50	1	x-dir Motor Bracket Right	14
Cartesian Robot	50	2	y-dir Bearing Holder	15
Cartesian Robot	50	1	y-dir ANti Backlash Nut Holder	16
Cartesian Robot	50	1	y-dir Motor Bracket	17
Cartesian Robot	50	2	z-dir Motor Bracket	18
Capping	80	1	Capping Rear Motor	19
Cartesian Robot	80	2	Gripper Finger	20
Back Stage	80	1	piston holder1	21
Back Stage	80	1	piston holder2	22
Cartesian Robot	80	1	Gripper Driven Gear	23
Cartesian Robot	80	1	Gripper Driving Gear	24
Cartesian Robot	80	2	Gripper Supporter	25
Capping	80	1	Gear 12 T	26
Capping	80	1	Gear 48T	27
Capping	80	1	Gt2 60T.stl	28
Cartesian Robot	50	1	Gripper Hand Cover	29
Back Stage	50	1	Rear Motor Holder	30
Back Stage	50	1	Rear Motor Holder	31
Back Stage	30	1	Capper.	32

Chapter 4
Project Processes

4. PROJECT PROCESSES

4.1.Motion System

This system consists of two 3 phase induction motors driven by variable speed drives (ATV320)

We established Modbus Serial network between PLC and VFD to read the motor (speed – current – voltage – power – torque) & write speed reference setpoint

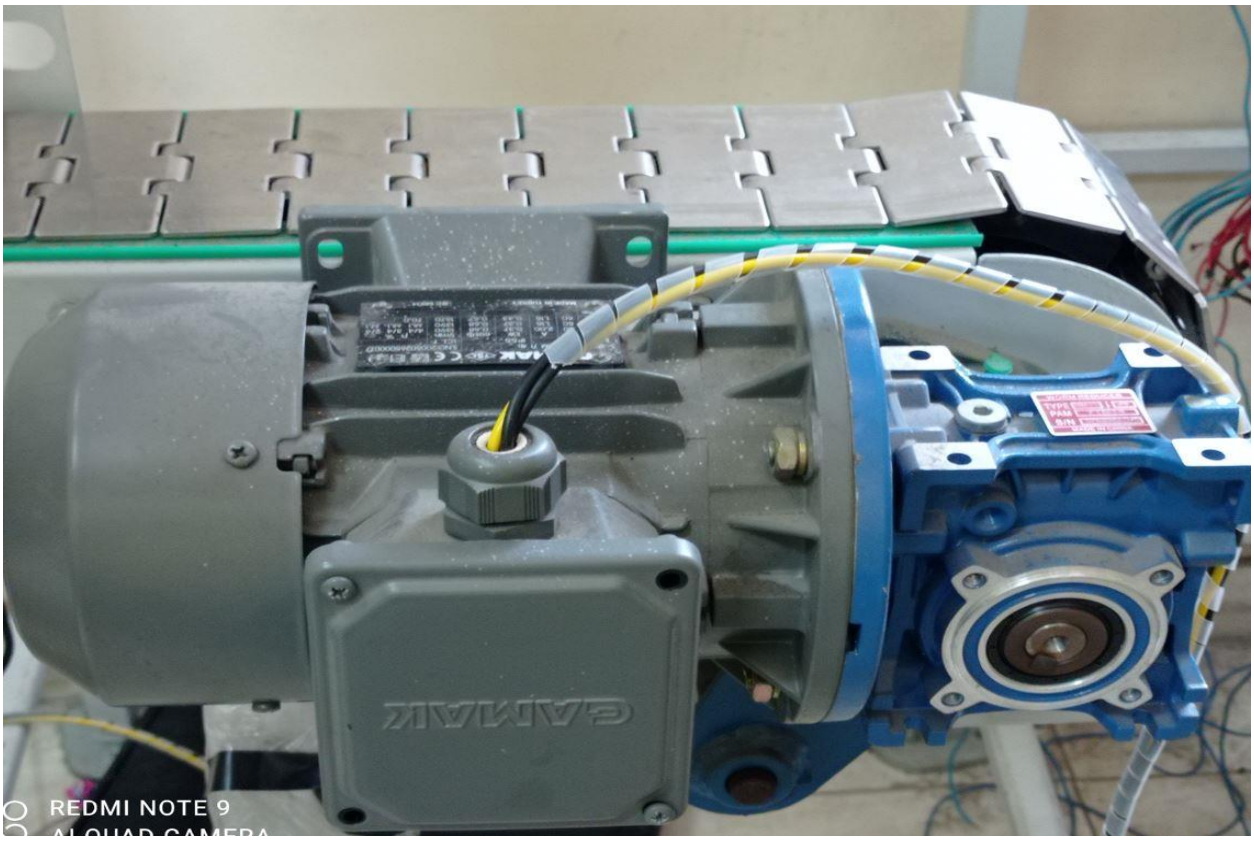


Figure 4-1:conveyer motor

4.2.Leakage System

This system aims to distinguish between healthy bottles and leaked bottle.

Sensors	Actuator
Capacitive Proximity Sensor	DC Motor
Limit Switch	Compressor
Analog Pressure Transmitter	

Process description

- If the bottle reached the proximity sensor, stop the conveyor.
- Energize the DC motor in down direction, until it reaches the lower limit switch.
- At the same instance, energize the compressor.
- Read the pressure value of the tested bottle from the pressure transmitter after 15 sec.
- If the pressure greater than 3 bar, the bottle is healthy & has no leakage.
- If the pressure less than 3 bar, the bottle is unhealthy & must be rejected.
- Energize the DC motor in up direction, until it reaches the upper limit switch.
- Deenergize the compressor & start the conveyor again.

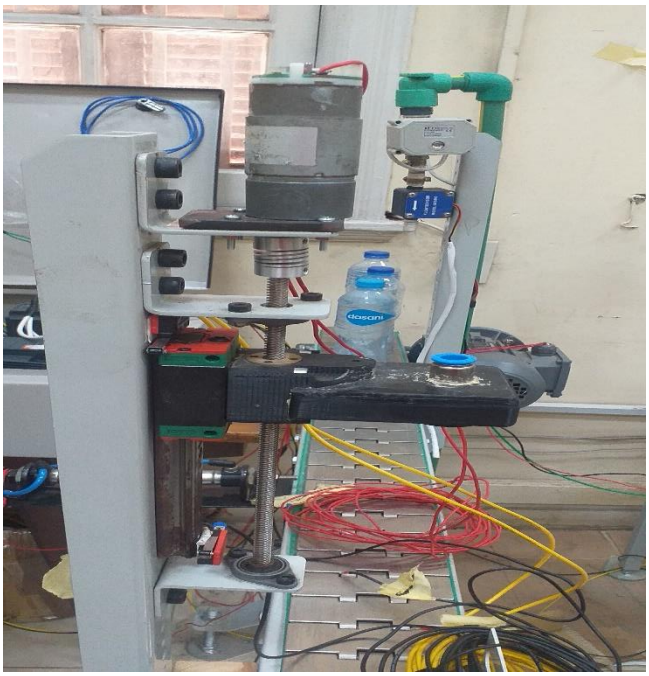


Figure 4-2:leakage system

4.3.Rejection System

This system aims to reject the leaked bottles

Sensors	Actuator
Digital Infrared Sensor (diffuse)	Solenoid Valve
	Compressor

Process description

- Check (manually) that the compressor is charged enough before initiating the system.
- In case of the leaked bottle reaches the diffuse Sensor, energize the solenoid valve to active the rejection piston.
- In case of the healthy bottle, do nothing.

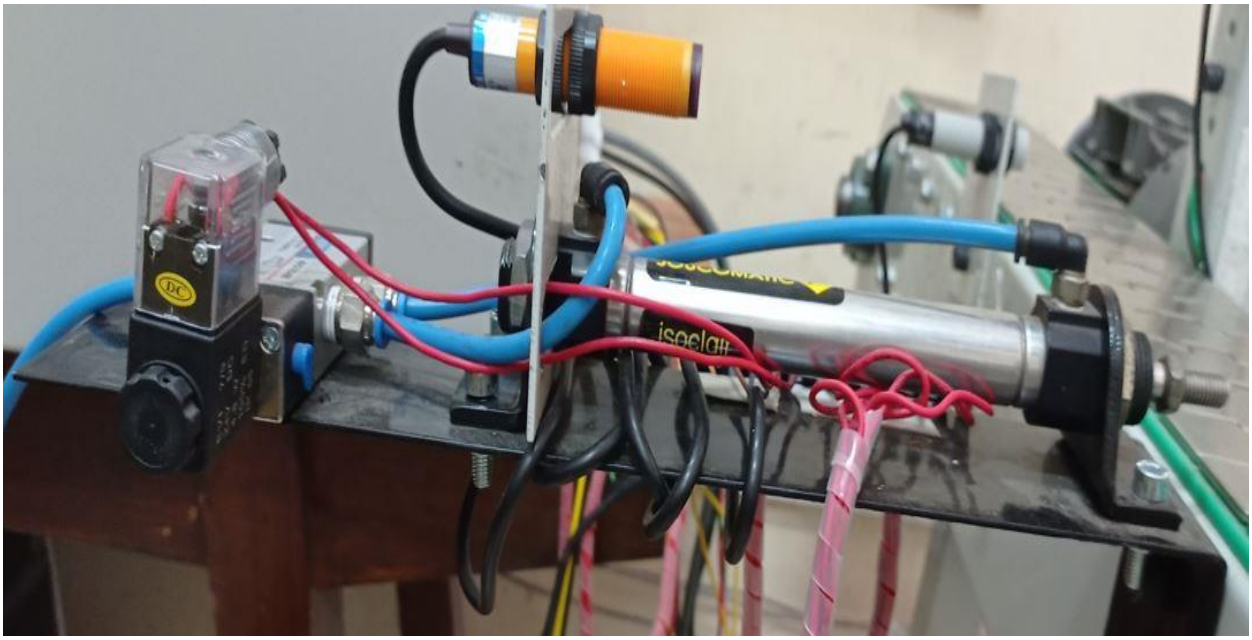


Figure 4-3:rejection system

4.4.Filling System

This system aims to fill the bottle automatically with t-set amount of liquid.

Sensors	Actuator
Capacitive Proximity Sensor	Water Pump
	Motorized Valve

Process description

- If the bottle reached the proximity sensor, stop the conveyor.
- Energize the water pump & motorized valve for 2 sec.
- Start the conveyor again.

Figure 4-4:filling system

4.5. Capping System

This system has 3 main functions:

1. Transfer the bottle from the first conveyor to the second conveyor.

2. put the cap on the bottle.

3. capping it.

** this system has mechanical problems and needs to be designed again from scratch to overcome the high inertia of the moving parts.

this part starts to work when the sensor on the end of the first conveyer “the filling conveyer” sense there was a bottle reached its position, the bottle inters the disk hole, the stepper motor will start to rotate the desk with angle 90 degree, then the cap will fall at the bottle, and after another 90 degree another small DC Motor with larger DC motor for linear motion will press the cap at the bottle top, then the second conveyer will start to run.

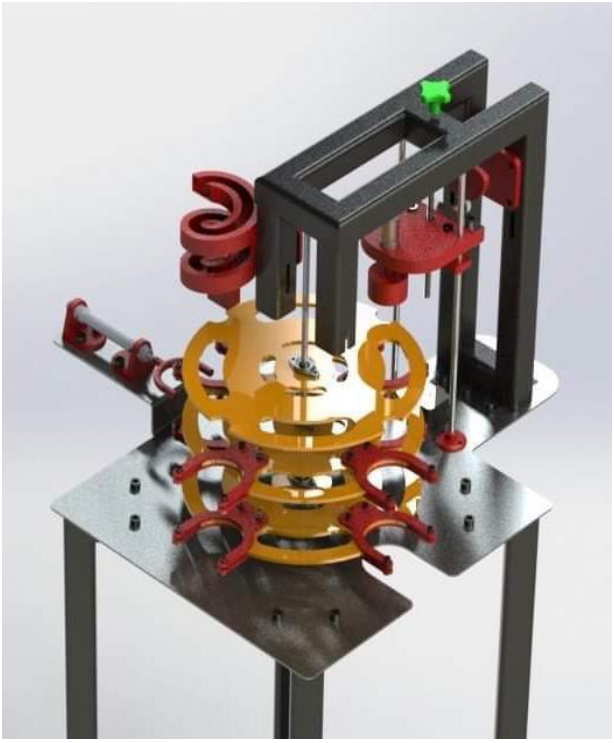


Figure 4-5:capping system

Chapter 5
Software implementation

5. Software implementation

<u>This chapter aims to help anyone to create the whole project from scratch.</u>

5.1.PLC programming(Eco Structure Machine Expert Basic)

1- Install and setup the software package

2- Open the software and follow the following steps

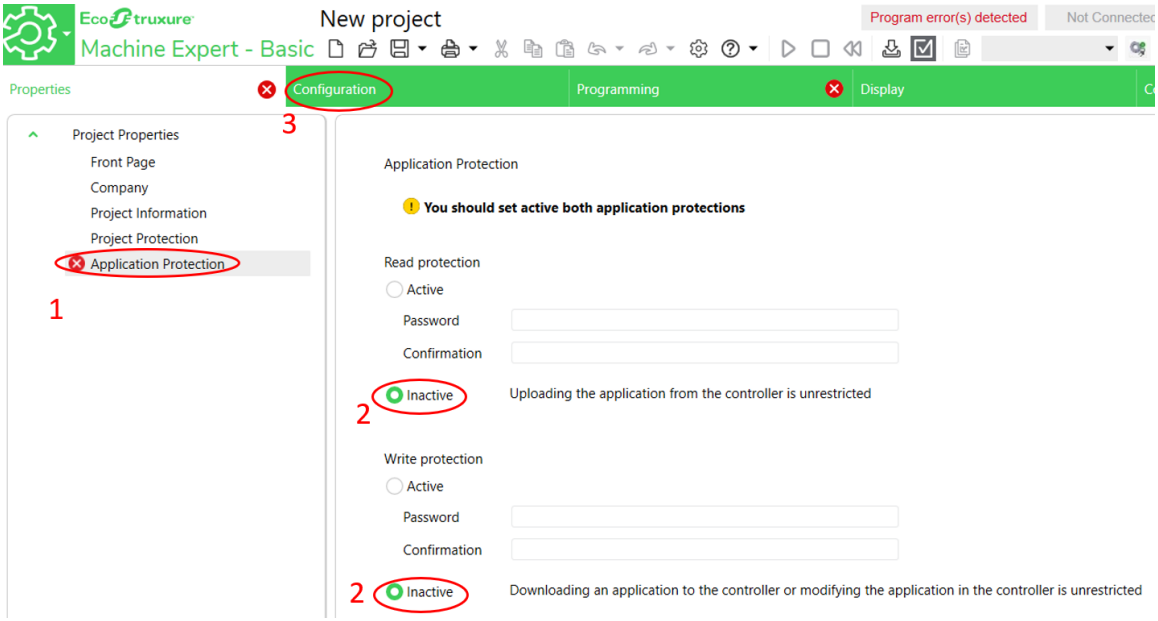


Figure 5-1

3- Configure the PLC Model

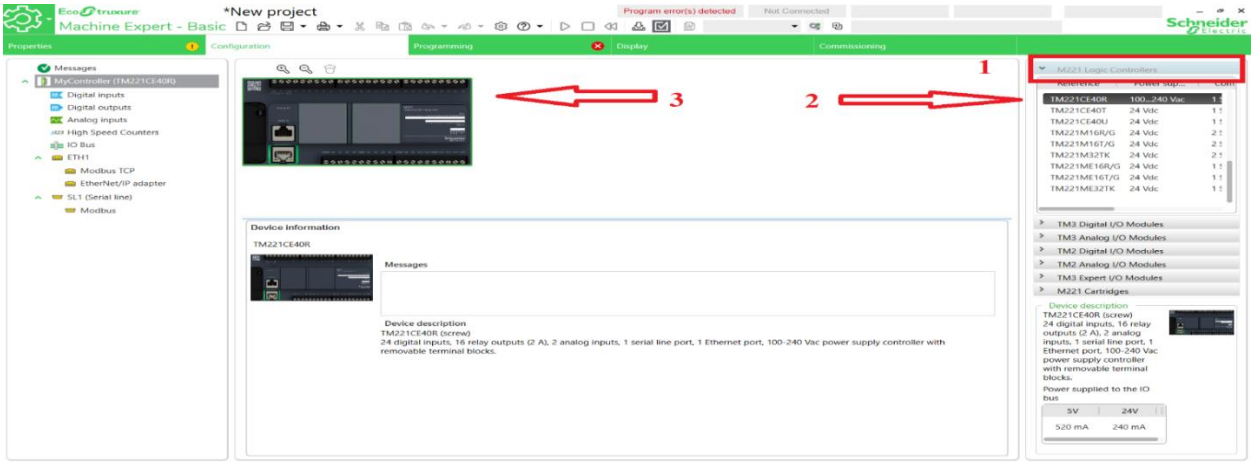


Figure 5-2

4- Configure the Ethernet port

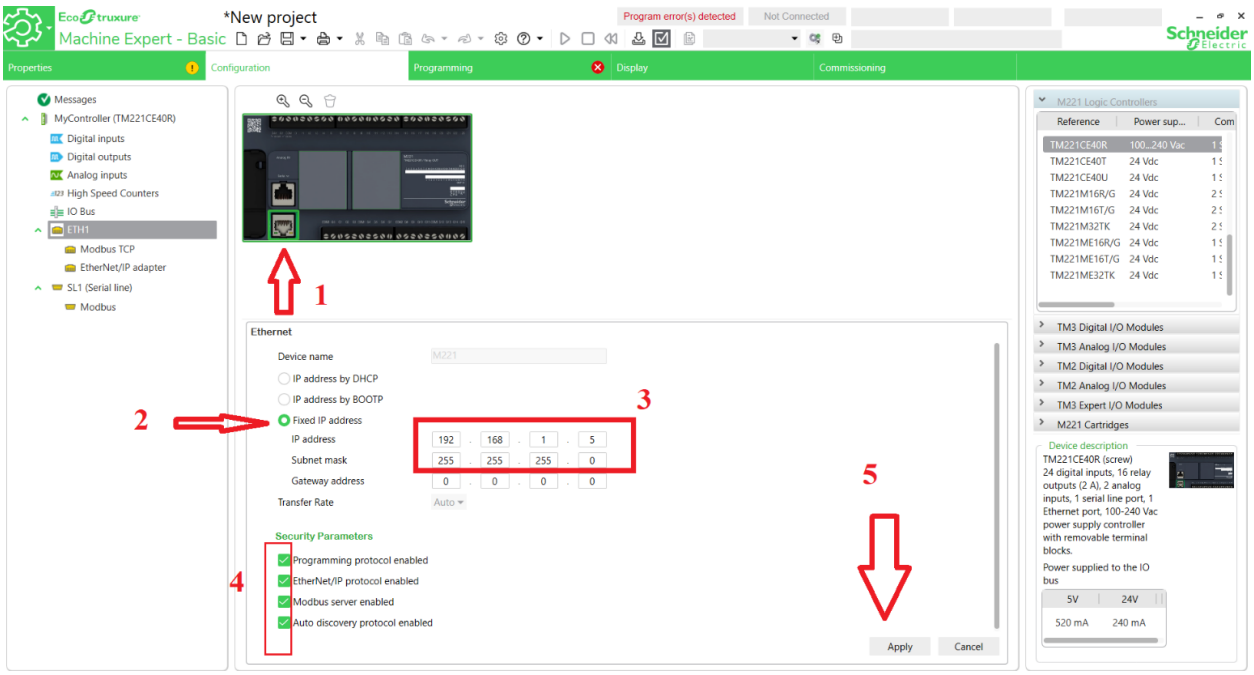


Figure 5-3

5- Configure the Serial port

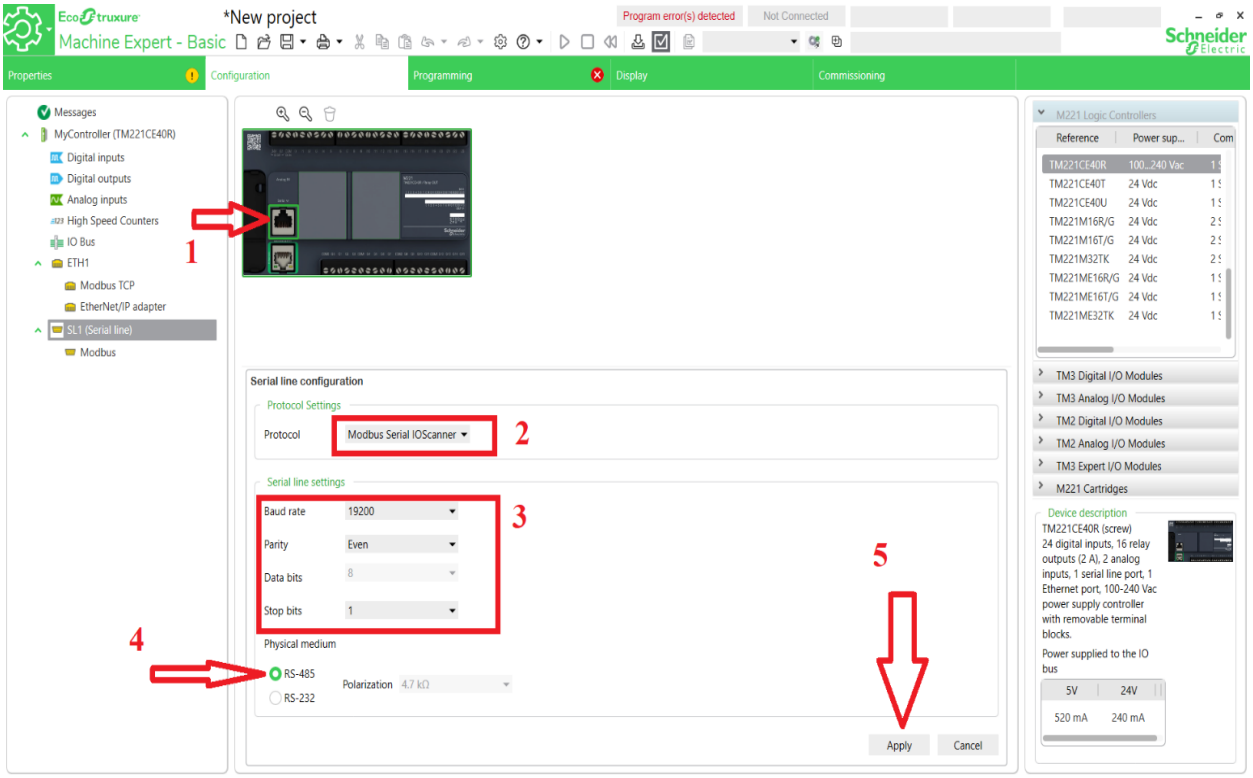


Figure 5-4

6- Add 2 variable speed drives

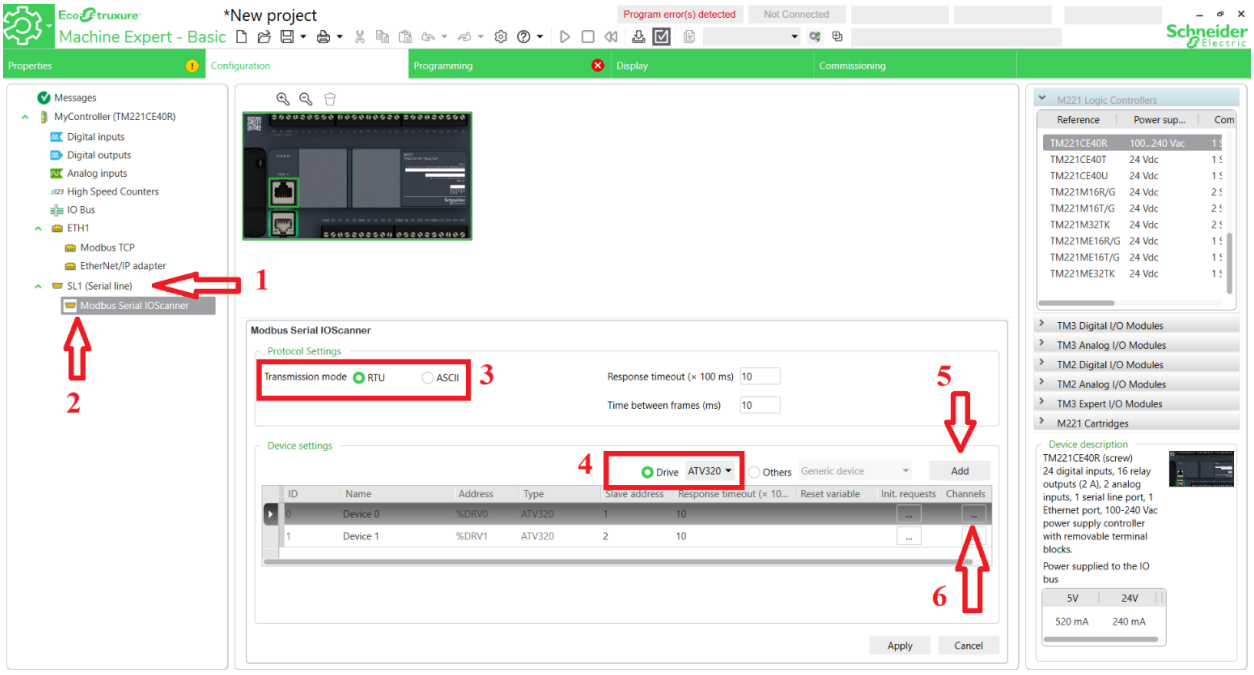


Figure 5-5

7- Establish a serial communication link to read the motor (speed – current – voltage – power – torque) & write speed reference setpoint

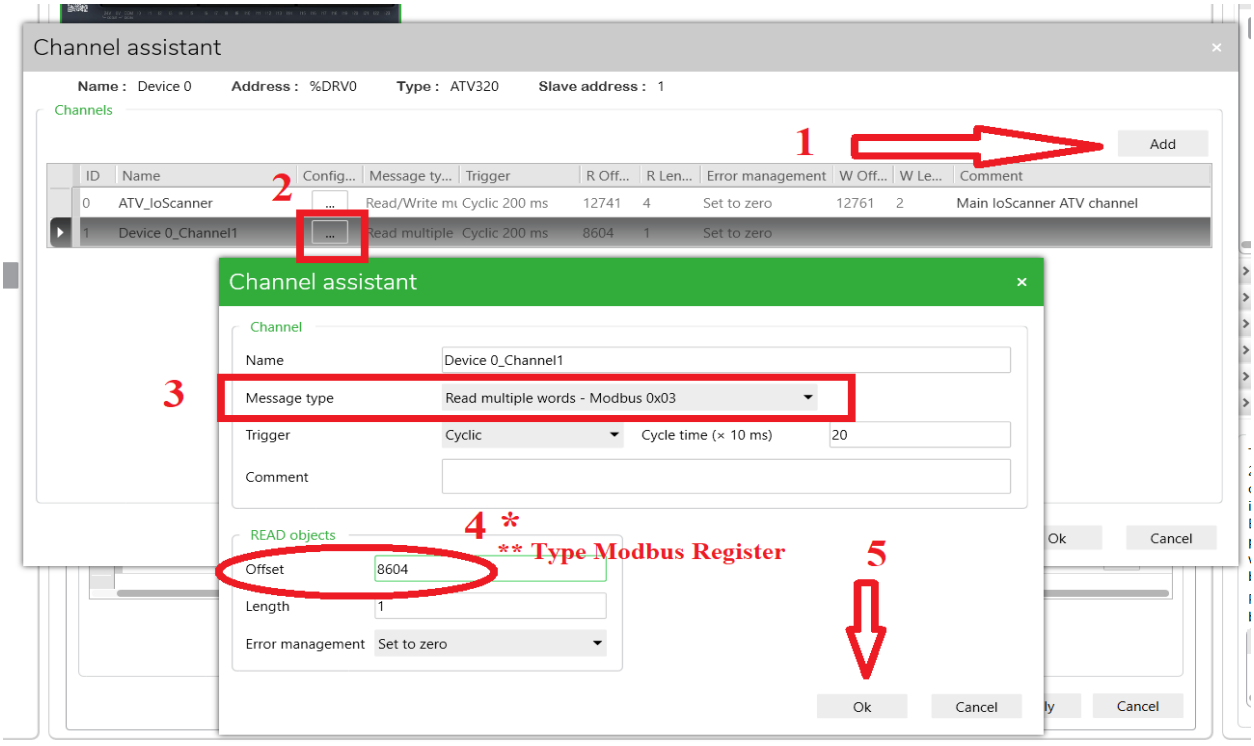
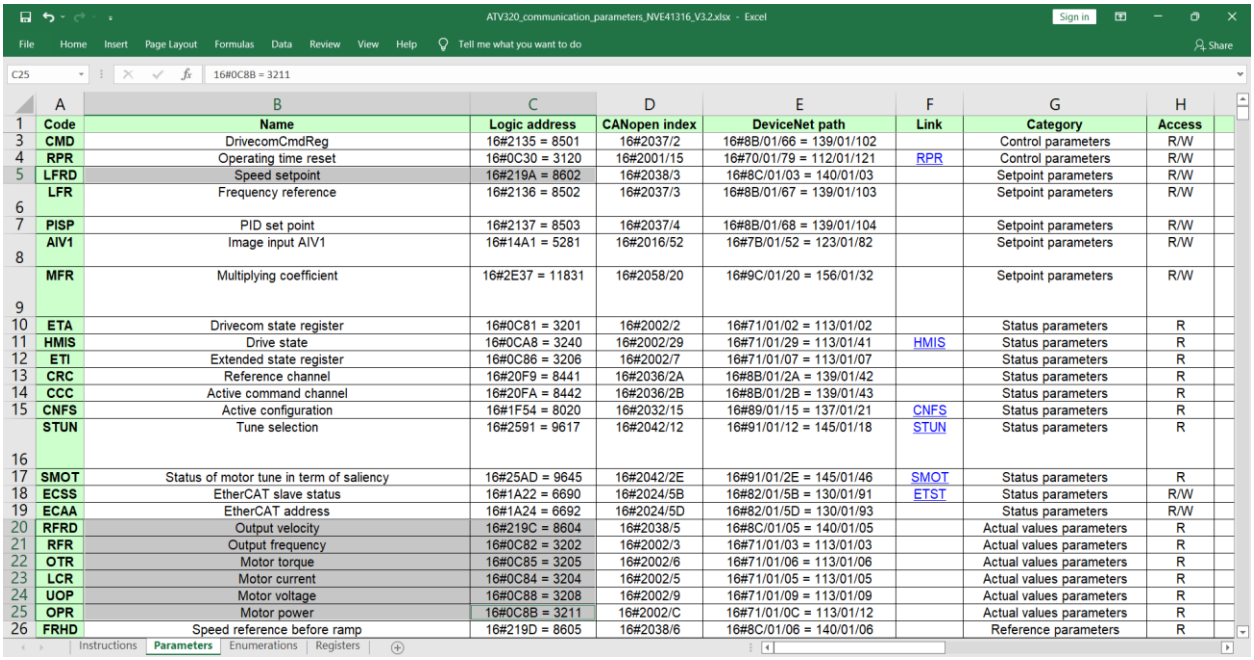


Figure 5-6

** Modbus registers for required quantities



ATV320_communication_parameters_NVE41316_V3.2.xlsx - Excel

C25 | 16#0C8B = 3211

	A	B	C	D	E	F	G	H
1	Code	Name	Logic address	CANopen index	DeviceNet path	Link	Category	Access
3	CMD	DrivecomCmdReg	16#2135 = 8501	16#2037/2	16#8B/01/66 = 139/01/102		Control parameters	R/W
4	RPR	Operating time reset	16#0C30 = 3120	16#2001/15	16#70/01/79 = 112/01/121	RPR	Control parameters	R/W
5	LFRD	Speed setpoint	16#219A = 8602	16#2038/3	16#8C/01/03 = 140/01/03		Setpoint parameters	R/W
6	LFR	Frequency reference	16#2136 = 8502	16#2037/3	16#8B/01/67 = 139/01/103		Setpoint parameters	R/W
7	PISP	PID set point	16#2137 = 8503	16#2037/4	16#8B/01/68 = 139/01/104		Setpoint parameters	R/W
8	AIV1	Image input AIV1	16#14A1 = 5281	16#2016/52	16#7B/01/52 = 123/01/82		Setpoint parameters	R/W
9	MFR	Multiplying coefficient	16#2E37 = 11831	16#2058/20	16#9C/01/20 = 156/01/32		Setpoint parameters	R/W
10	ETA	Drivecom state register	16#0C81 = 3201	16#2002/2	16#71/01/02 = 113/01/02		Status parameters	R
11	HMIS	Drive state	16#0CA8 = 3240	16#2002/29	16#71/01/29 = 113/01/41	HMIS	Status parameters	R
12	ETI	Extended state register	16#0C86 = 3206	16#2002/7	16#71/01/07 = 113/01/07		Status parameters	R
13	CRC	Reference channel	16#20F9 = 8441	16#2036/2A	16#8B/01/2A = 139/01/42		Status parameters	R
14	CCC	Active command channel	16#20FA = 8442	16#2036/2B	16#8B/01/2B = 139/01/43		Status parameters	R
15	CNFS	Active configuration	16#1F54 = 8020	16#2032/15	16#89/01/15 = 137/01/21	CNFS	Status parameters	R
16	STUN	Tune selection	16#2591 = 9617	16#2042/12	16#91/01/12 = 145/01/18	STUN	Status parameters	R
17	SMOT	Status of motor tune in term of saliency	16#25AD = 9645	16#2042/2E	16#91/01/2E = 145/01/46	SMOT	Status parameters	R
18	ECSS	EtherCAT slave status	16#1A22 = 6690	16#2024/5B	16#82/01/5B = 130/01/91	ETST	Status parameters	R/W
19	ECAA	EtherCAT address	16#1A24 = 6692	16#2024/5D	16#82/01/5D = 130/01/93		Status parameters	R/W
20	RFRD	Output velocity	16#219C = 8604	16#2038/5	16#8C/01/05 = 140/01/05		Actual values parameters	R
21	RFR	Output frequency	16#0C82 = 3202	16#2002/3	16#71/01/03 = 113/01/03		Actual values parameters	R
22	OTR	Motor torque	16#0C85 = 3205	16#2002/6	16#71/01/06 = 113/01/06		Actual values parameters	R
23	LCR	Motor current	16#0C84 = 3204	16#2002/5	16#71/01/05 = 113/01/05		Actual values parameters	R
24	UOP	Motor voltage	16#0C88 = 3208	16#2002/9	16#71/01/09 = 113/01/09		Actual values parameters	R
25	OPR	Motor power	16#0C8B = 3211	16#2002/C	16#71/01/0C = 113/01/12		Actual values parameters	R
26	FRHD	Speed reference before ramp	16#219D = 8605	16#2038/6	16#8C/01/06 = 140/01/06		Reference parameters	R

Instructions | Parameters | Enumerations | Registers

Figure 5-7

8- Configure the analog input module

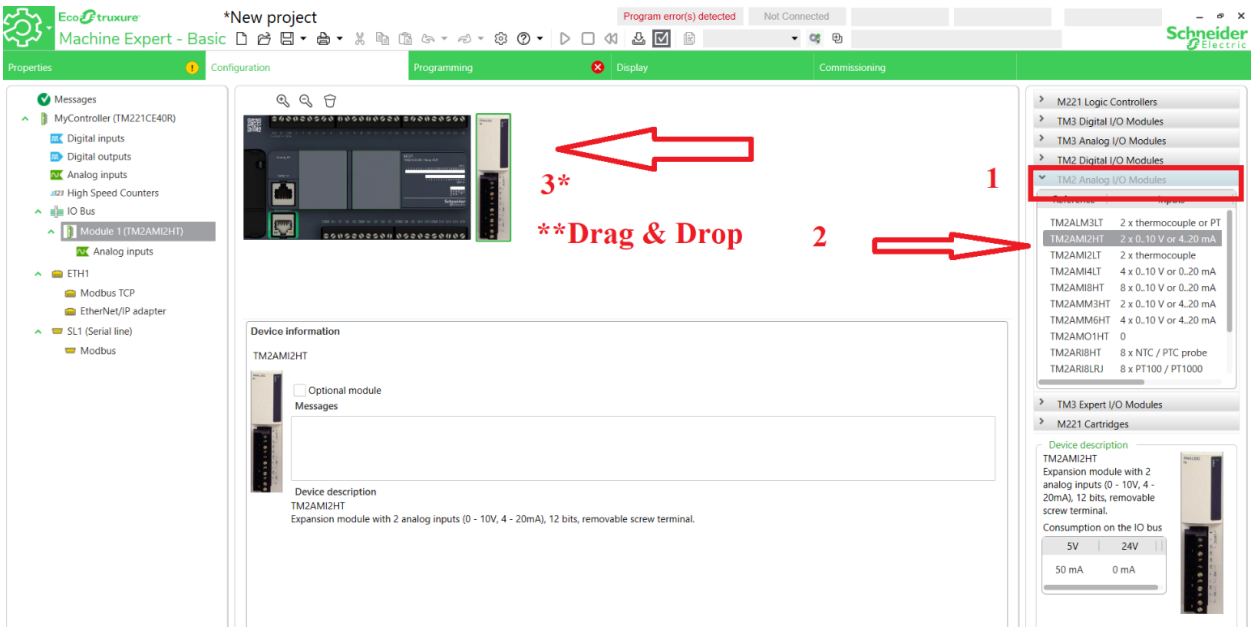


Figure 5-8

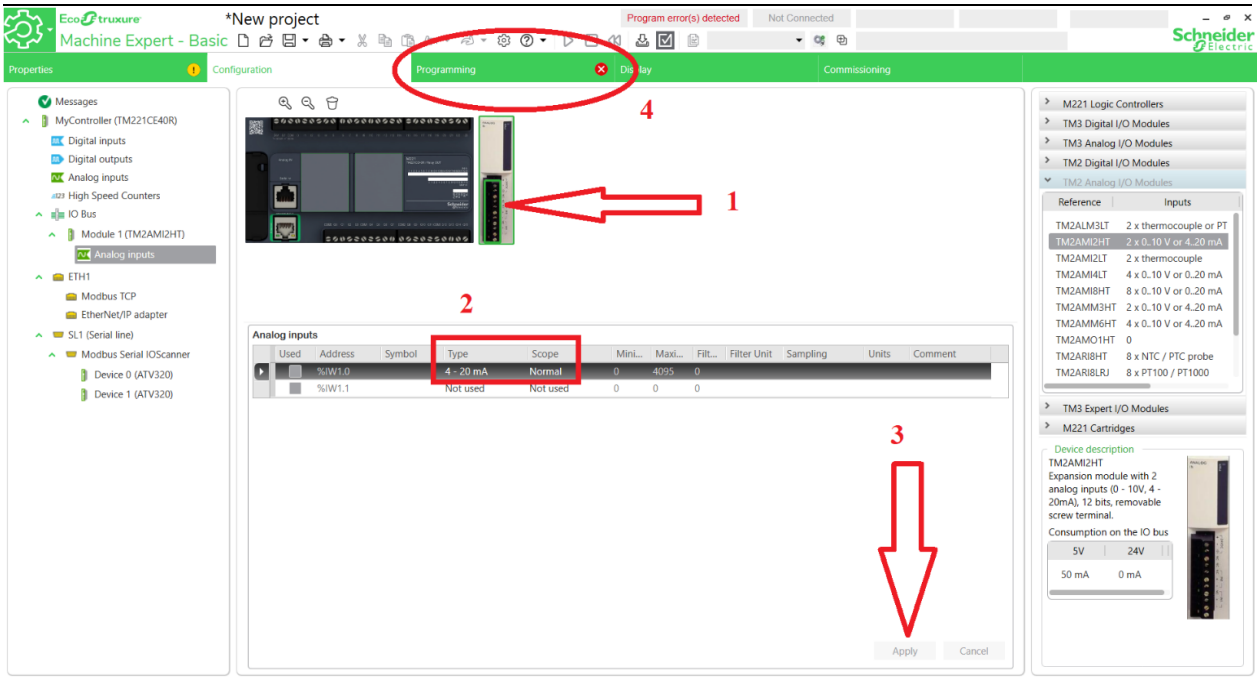


Figure 5-9

** Now start writing your PLC Code

9- After finishing, download the code to PLC

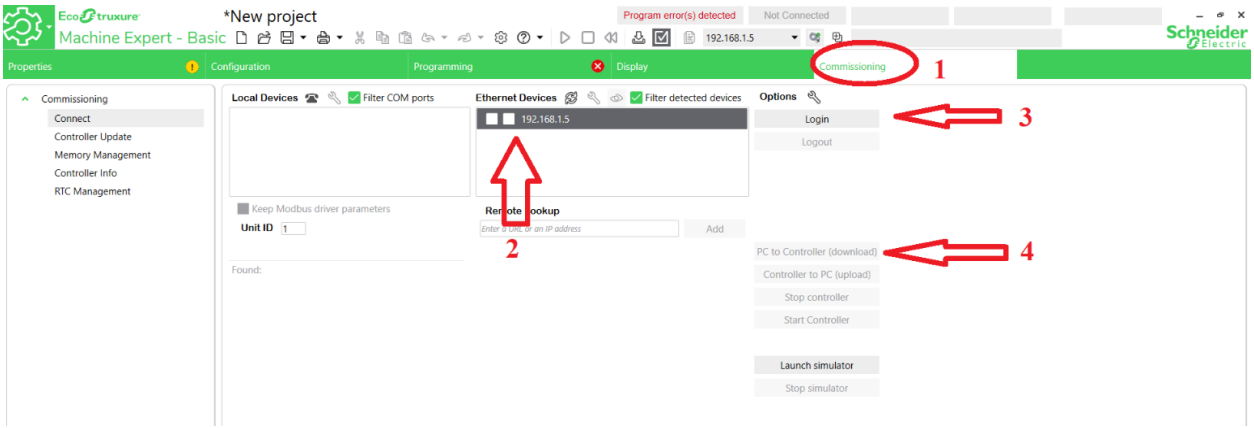


Figure 5-10

5.2. HMI programming using (Vijeo Designer Basic 1.1)

1- Install and setup the software package

2- Create New Project

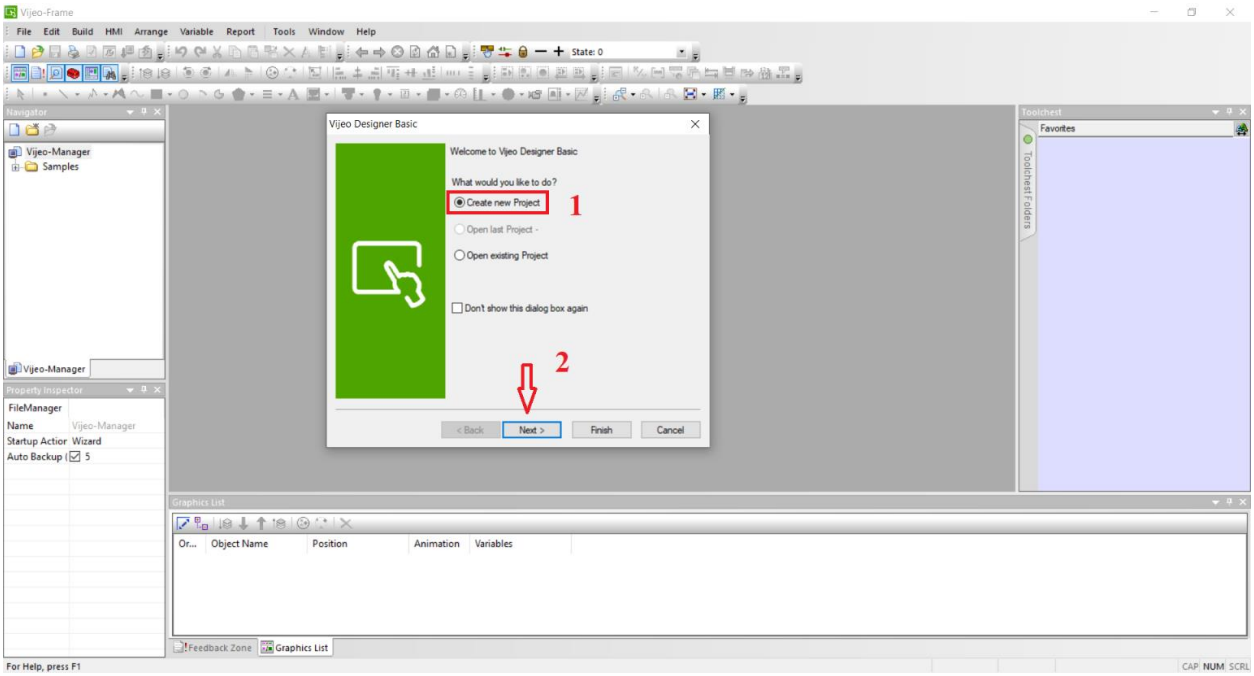


Figure 5-11

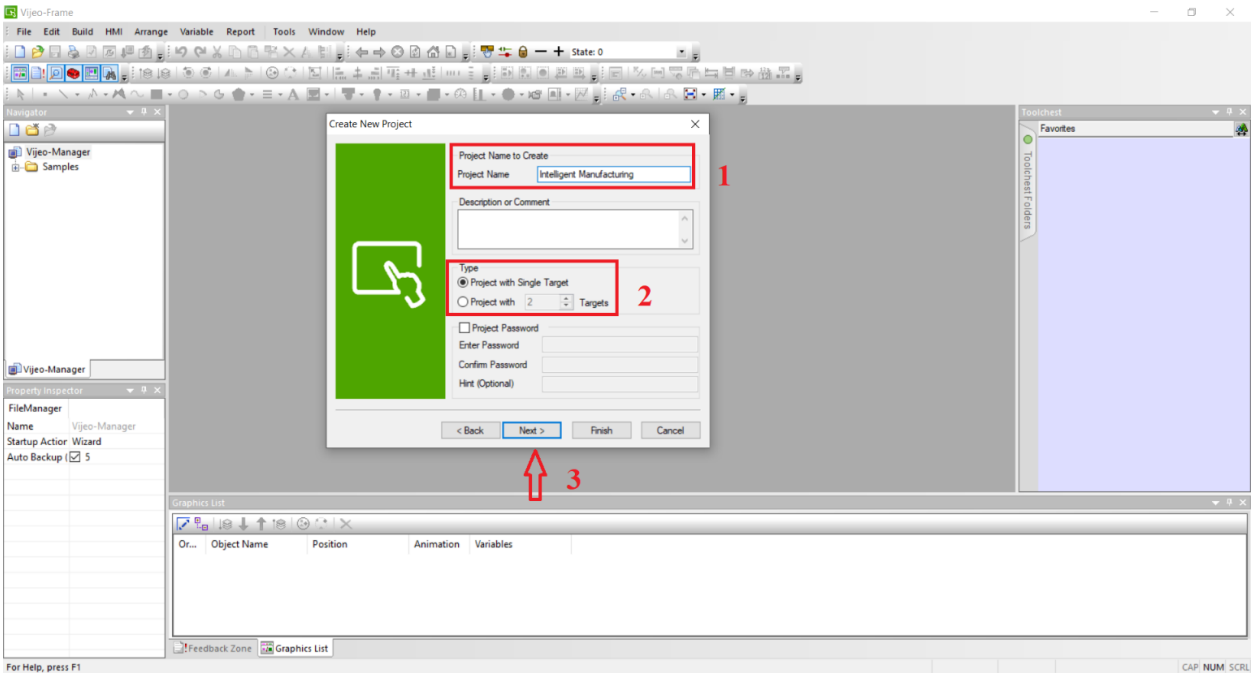


Figure 5-12

3- Select HMI Model

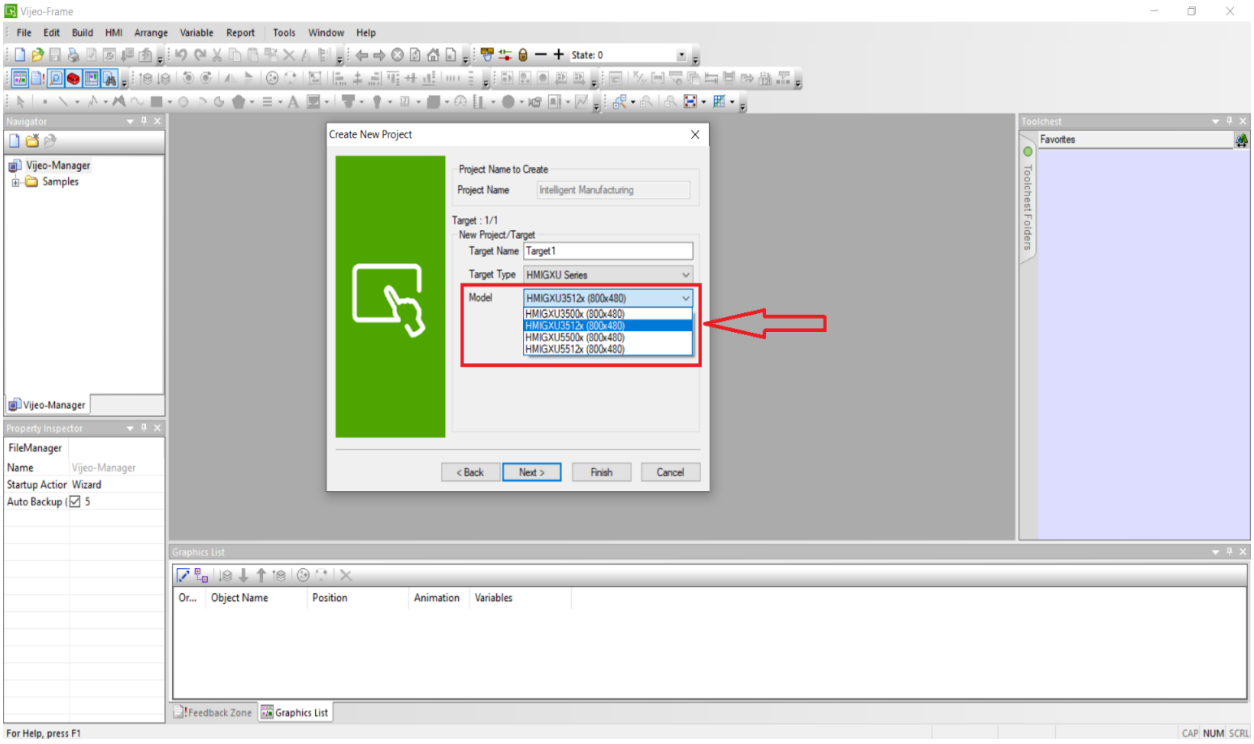


Figure 5-13

4- Configure HMI Ethernet port

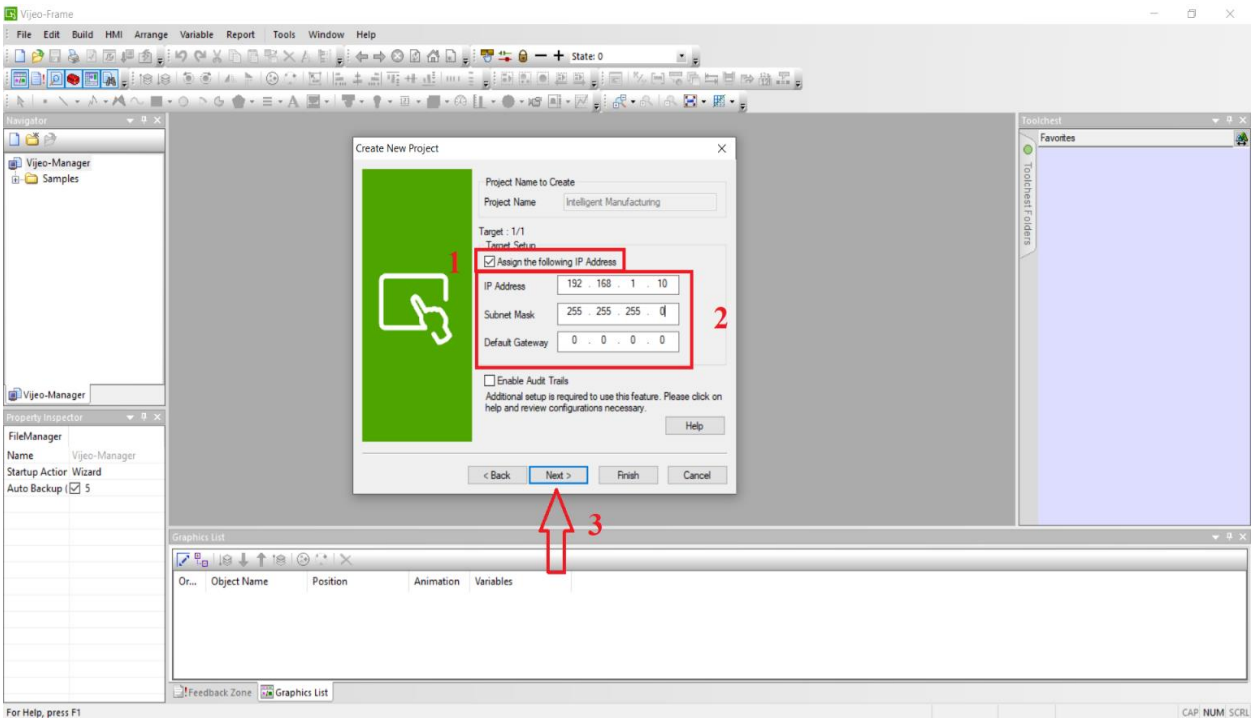


Figure 5-14

5- Add Modbus TCP/IP Driver

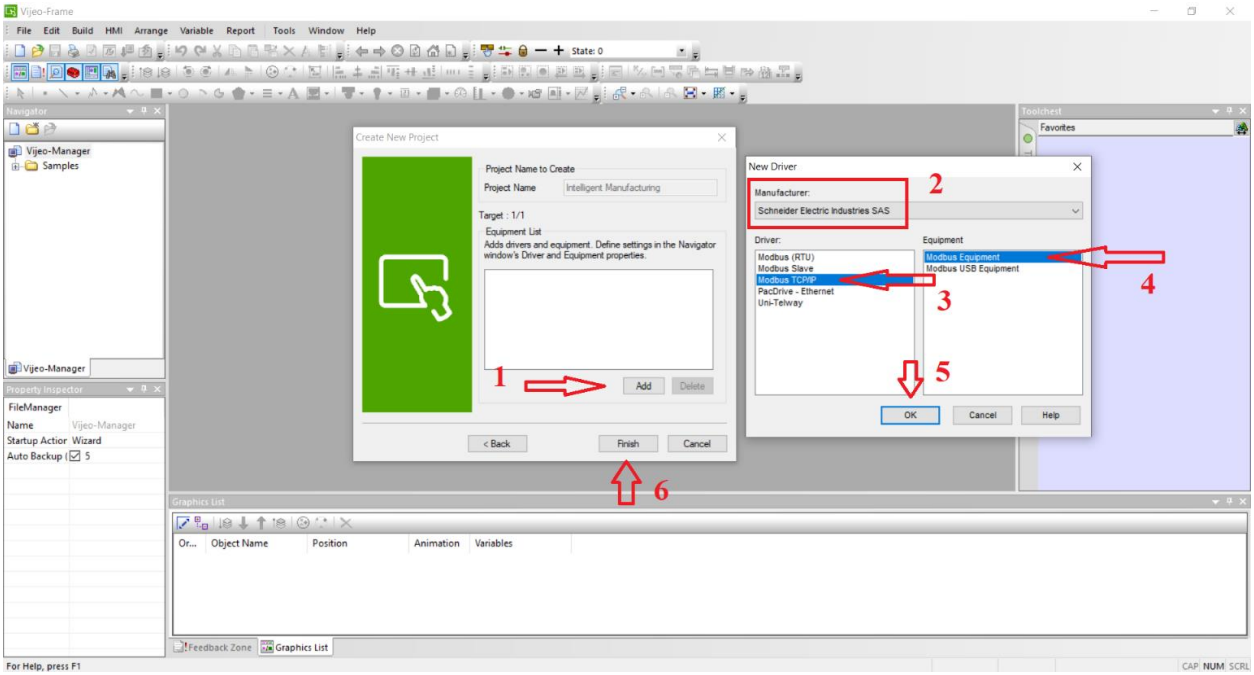


Figure 5-15

6- Configure the added driver

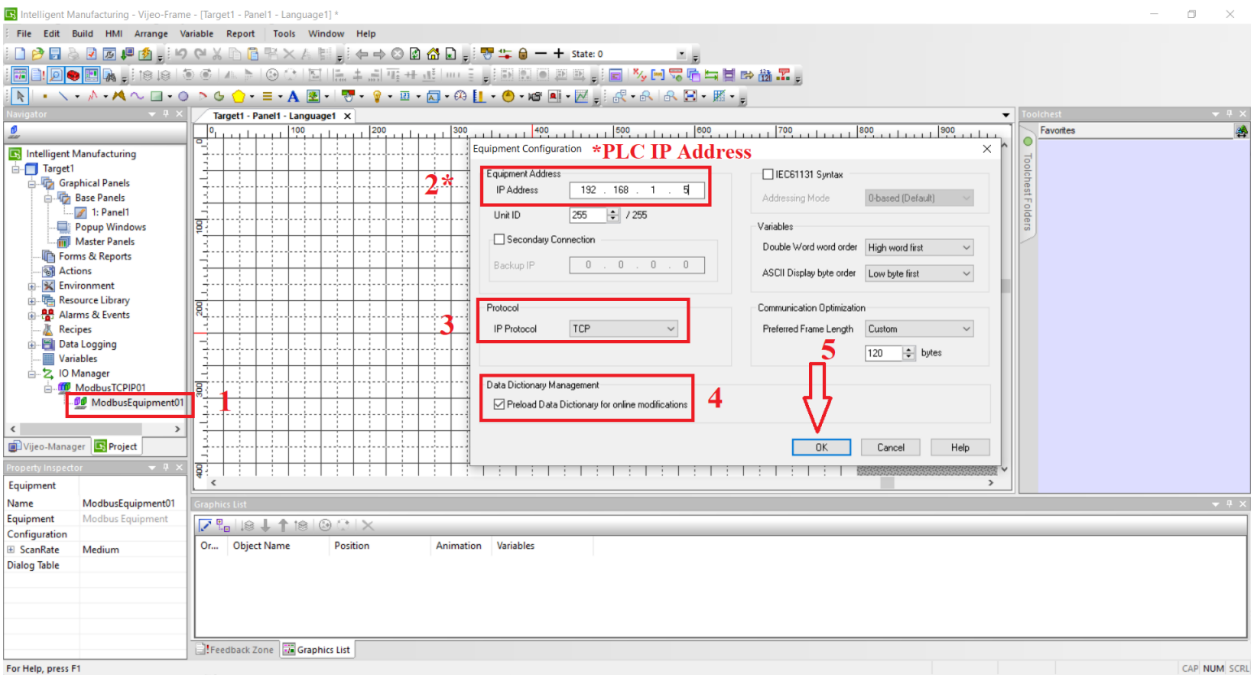


Figure 5-16

Now you can start to design the layout of your HMI program.

7- Link PLC variables with HMI

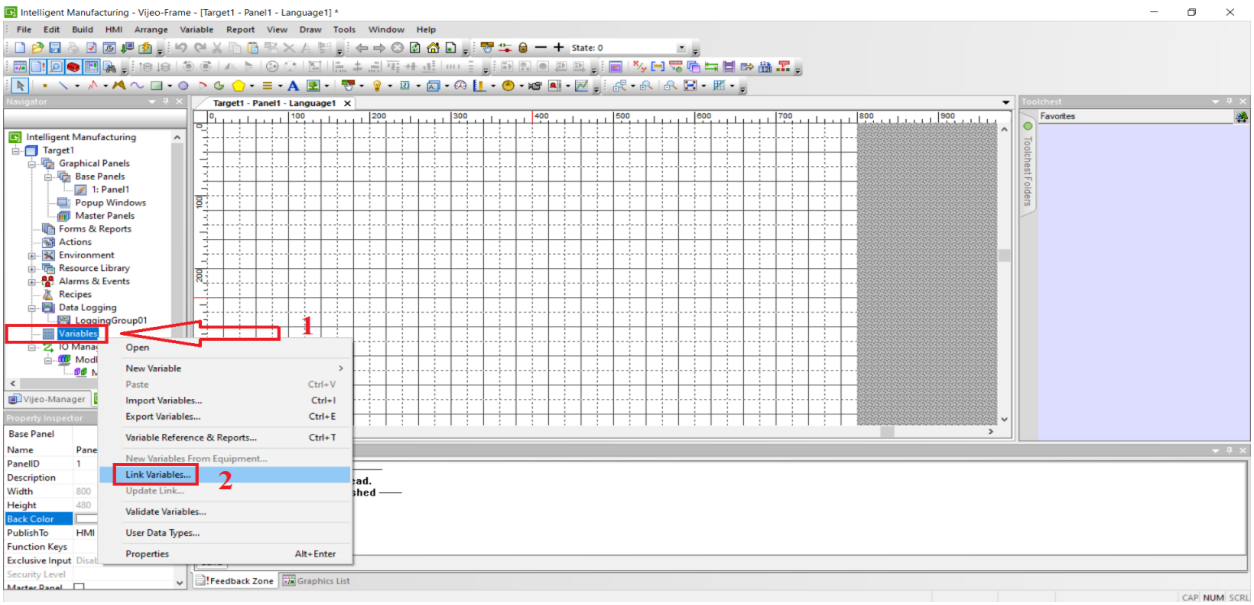


Figure 5-17

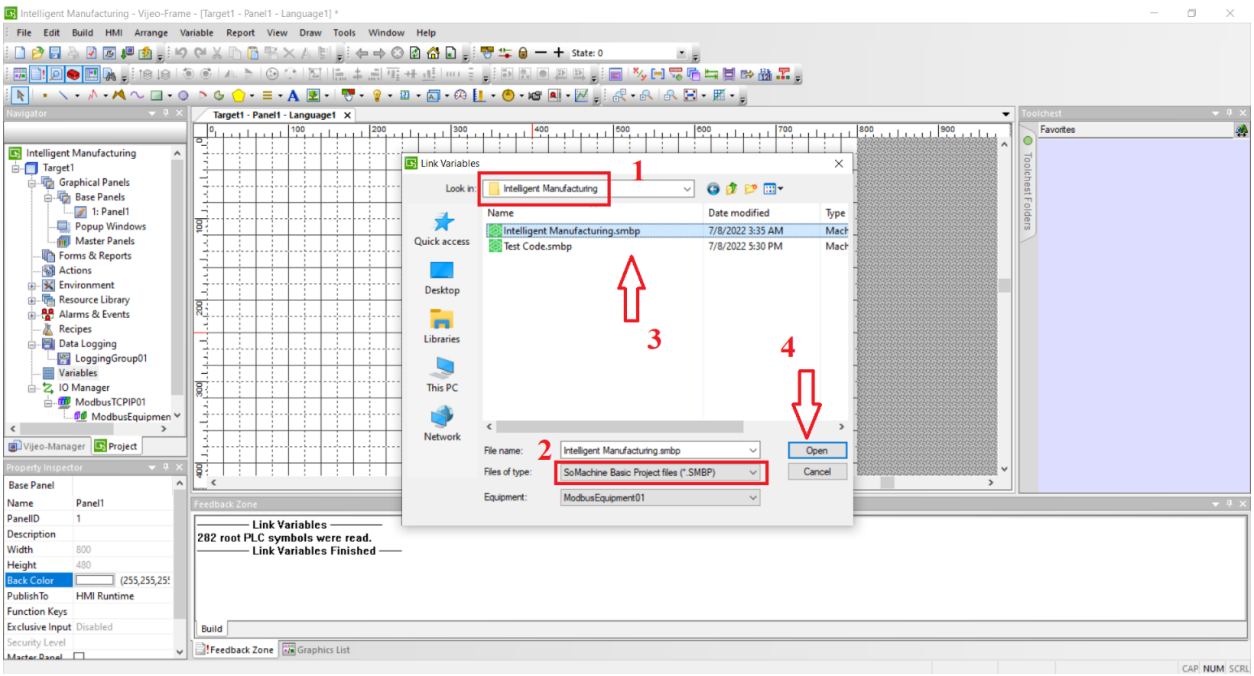


Figure 5-18

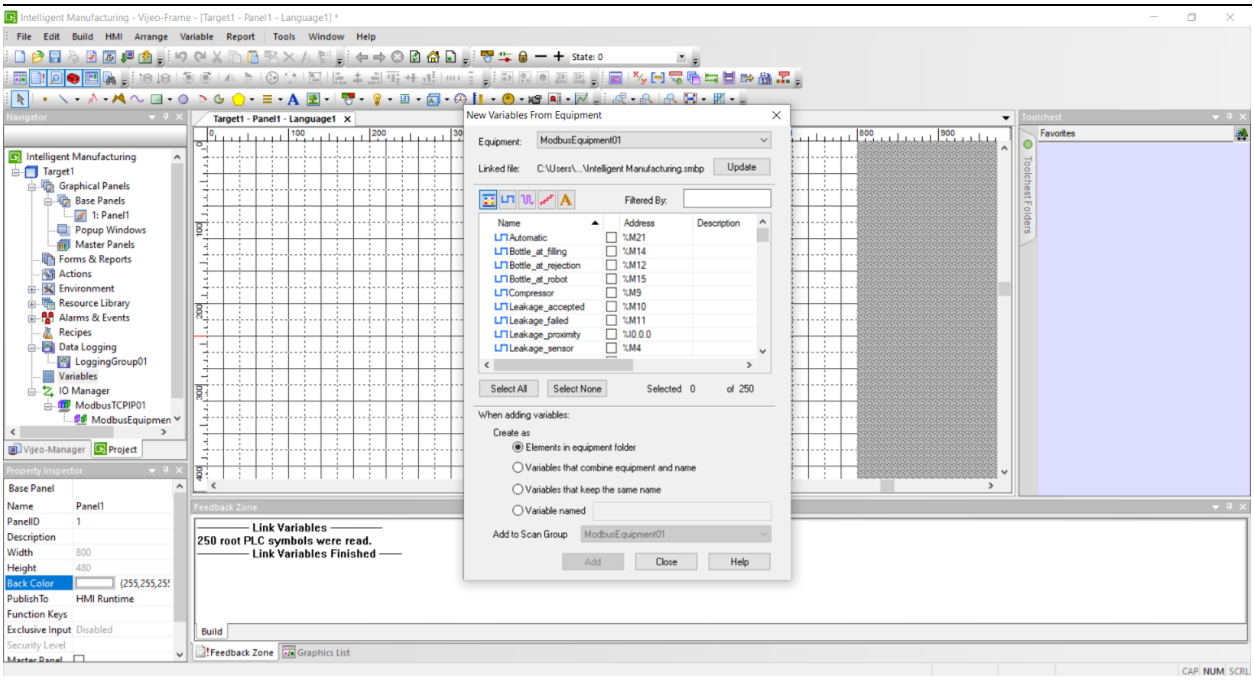

New Variables From Equipment
Equipment: ModbusEquipment01
Linked file: C:\Users\...\Intelligent Manufacturing.smbp
Update
Filtered By:
Name
Address
Description
Automatic %M21
Bottle_at_filling %M14
Bottle_at_rejection %M12
Bottle_at_robot %M15
Compressor %M9
Leakage_accepted %M10
Leakage_failed %M11
Leakage_proximity %I0.0.0
Leakage_sensor %M4
Select All
Select None
Selected 0 of 250
When adding variables:
Create as
Elements in equipment folder
Variables that combine equipment and name
Variables that keep the same name
Variable named
Add to Scan Group ModbusEquipment01
Add
Close
Help
Link Variables
250 root PLC symbols were read.
Link Variables Finished

Figure 5-19

5.3. SCADA programming using (Machine SCADA Expert 2020)

1- Install and setup the software package

2- Create New Project

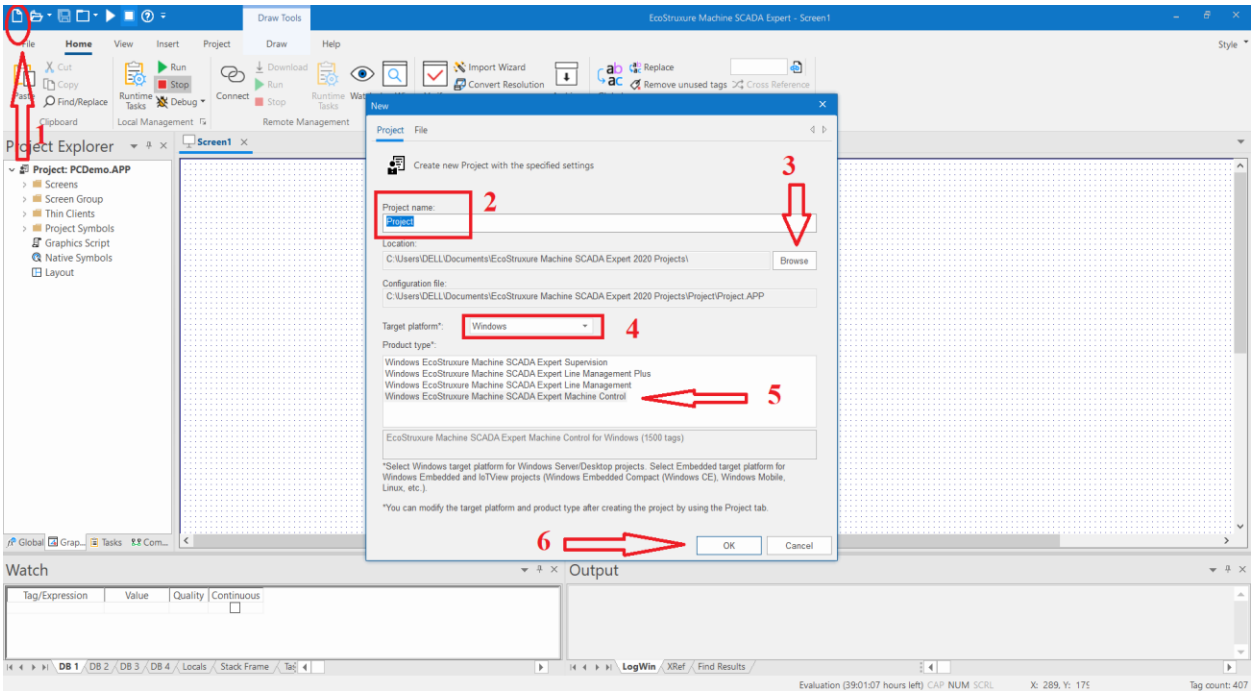


Figure 5-20

3- Determine Window Size

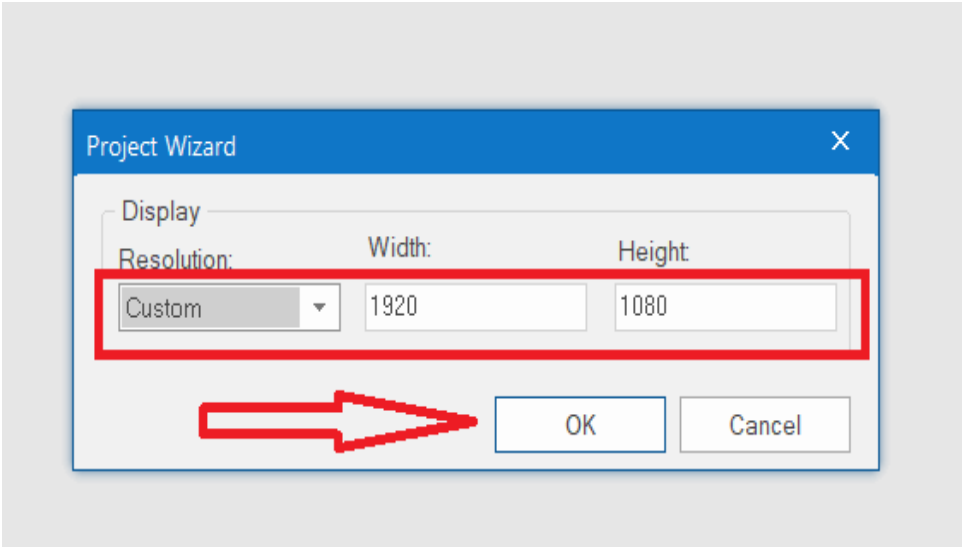


Figure 5-21

4- Configure Security

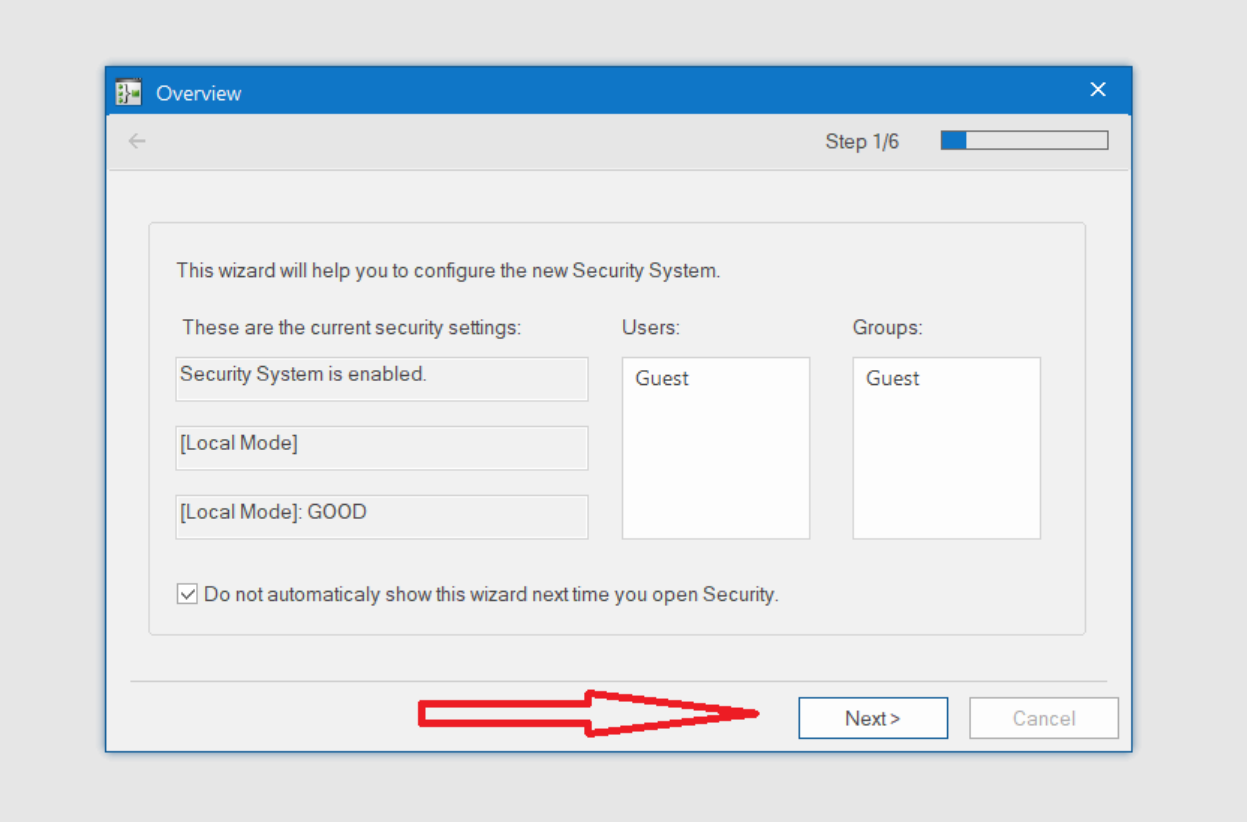


Figure 5-22

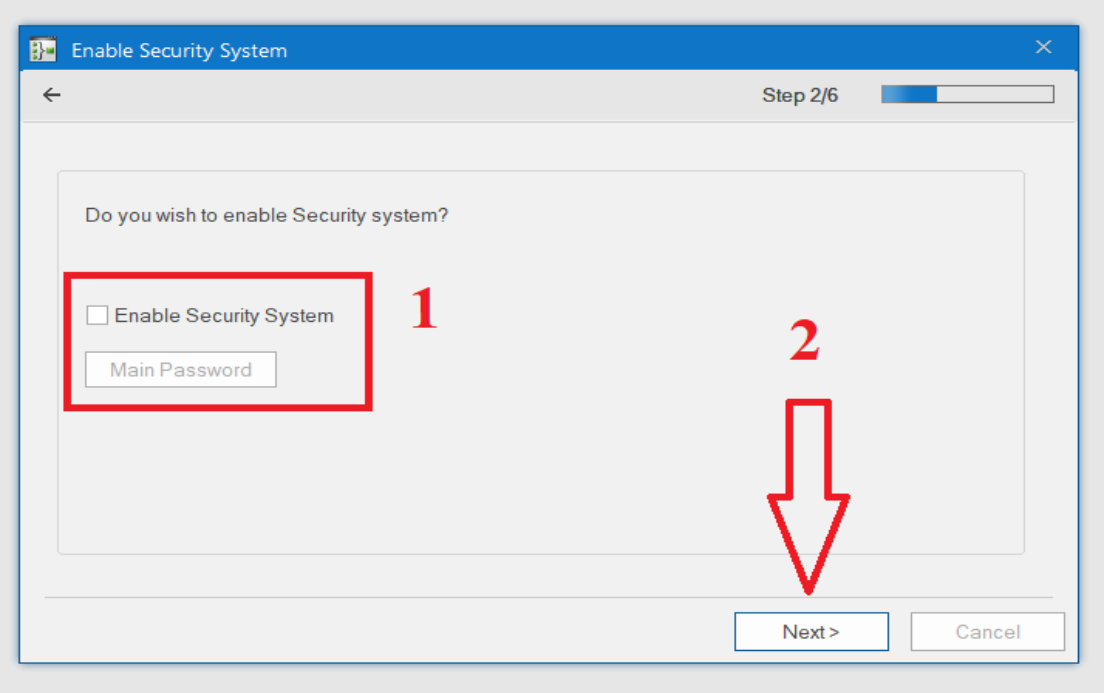


Figure 5-23

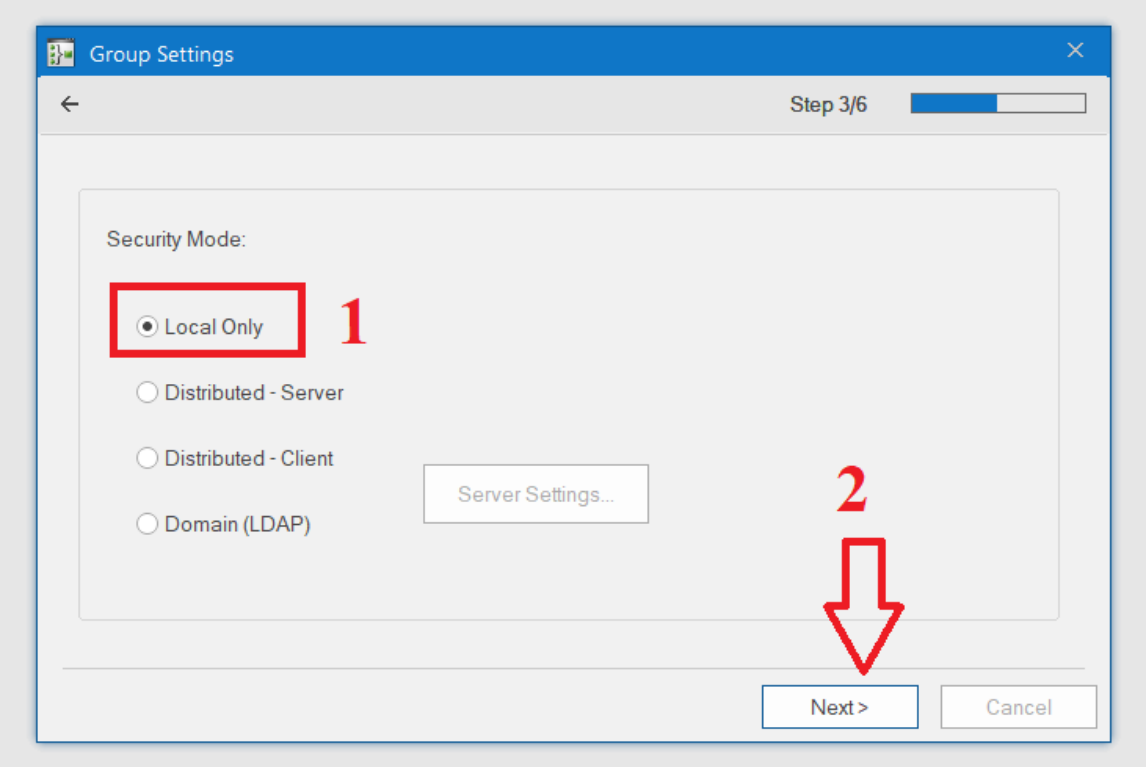


Figure 5-24

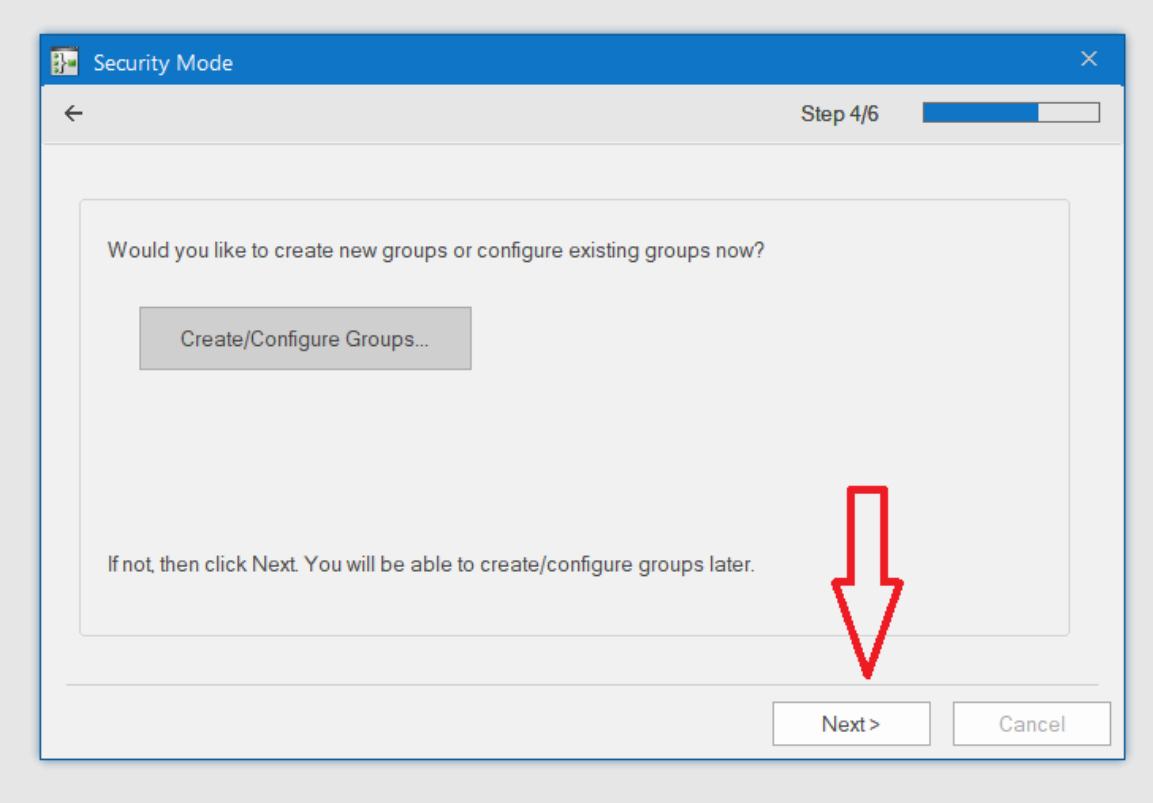

Security Mode
Step 4/6
Would you like to create new groups or configure existing groups now?
Create/Configure Groups...
If not, then click Next. You will be able to create/configure groups later.
Next >
Cancel

Figure 5-25

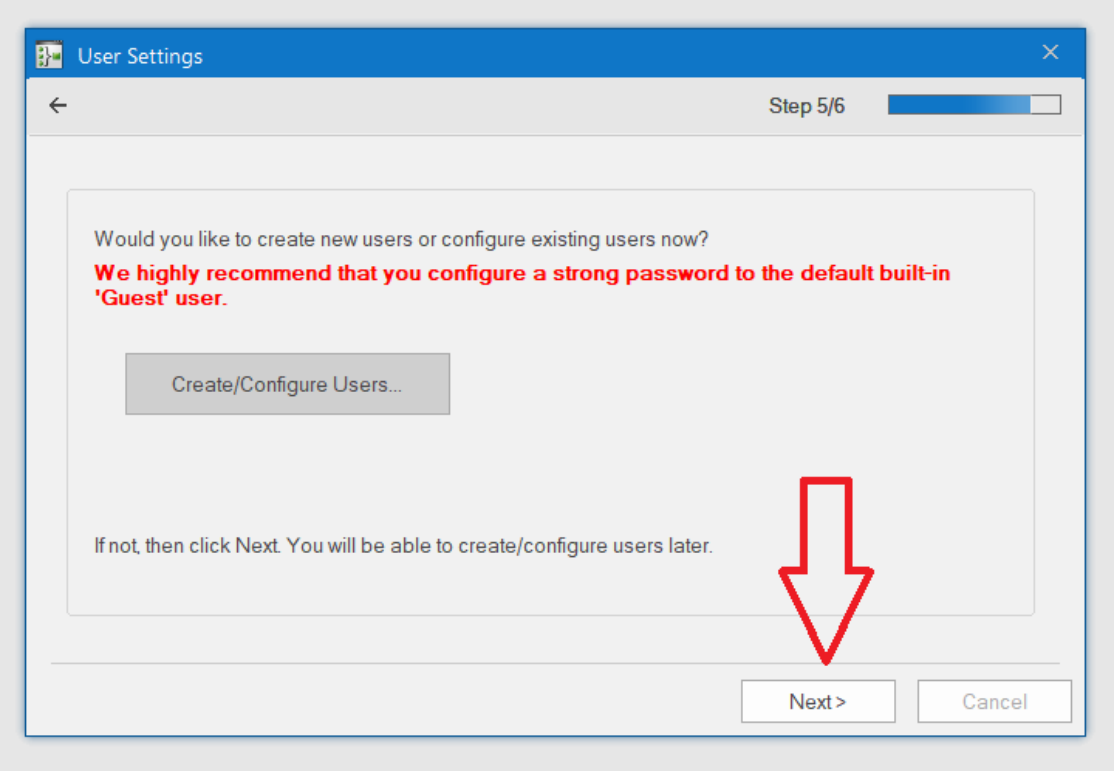

User Settings
Step 5/6
Would you like to create new users or configure existing users now?
We highly recommend that you configure a strong password to the default built-in 'Guest' user.
Create/Configure Users...
If not, then click Next. You will be able to create/configure users later.
Next >
Cancel

Figure 5-26

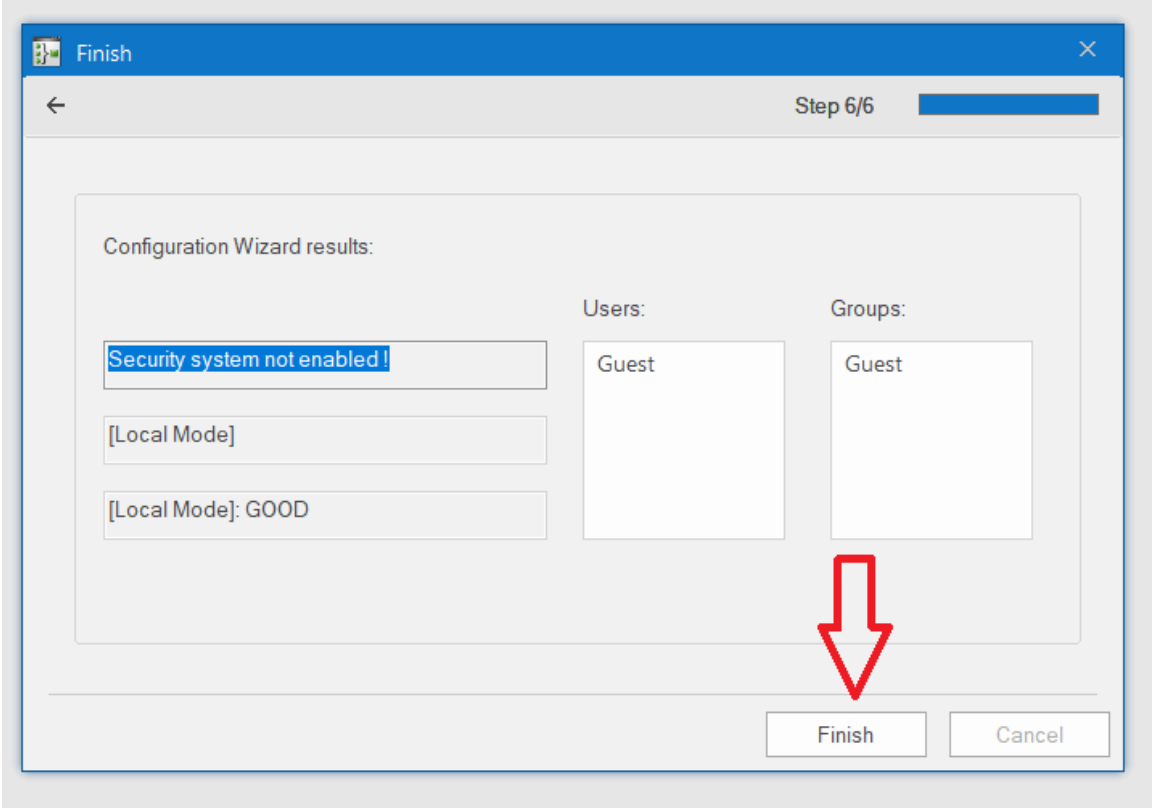


Figure 5-27

5- Add SCADA Tags

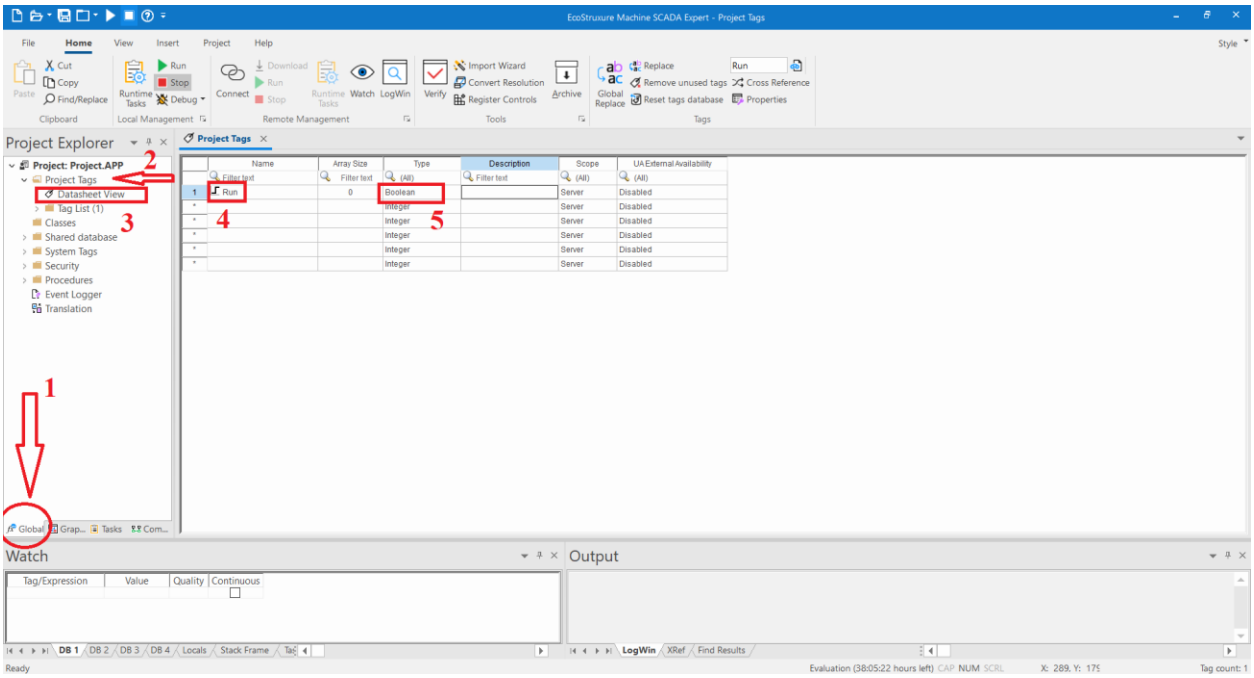


Figure 5-28

6- Configure Communication Driver

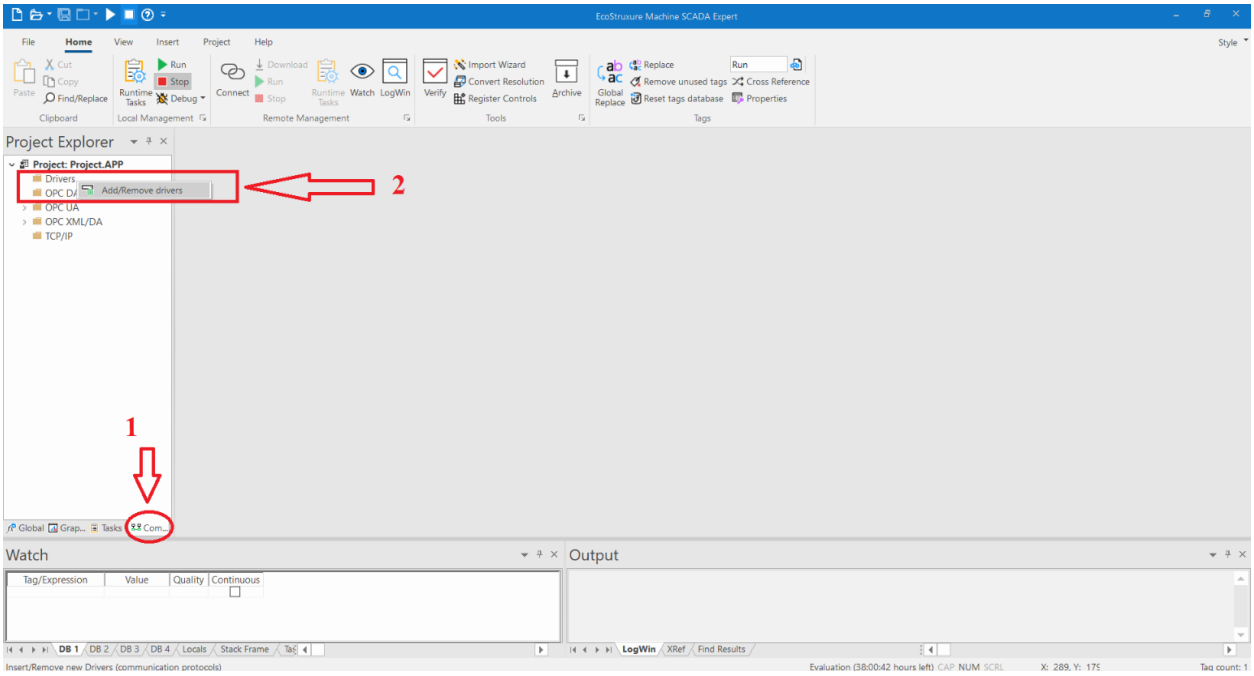


Figure 5-29

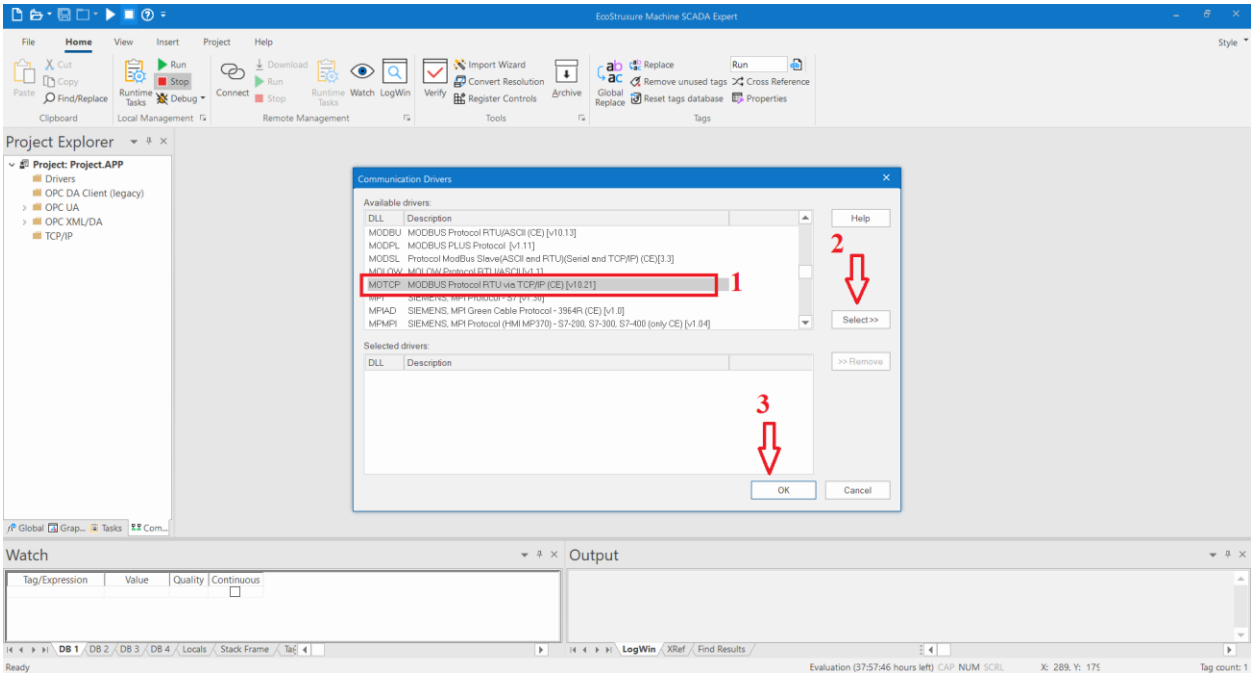


Figure 5-30

7- Link SCADA variables with PLC

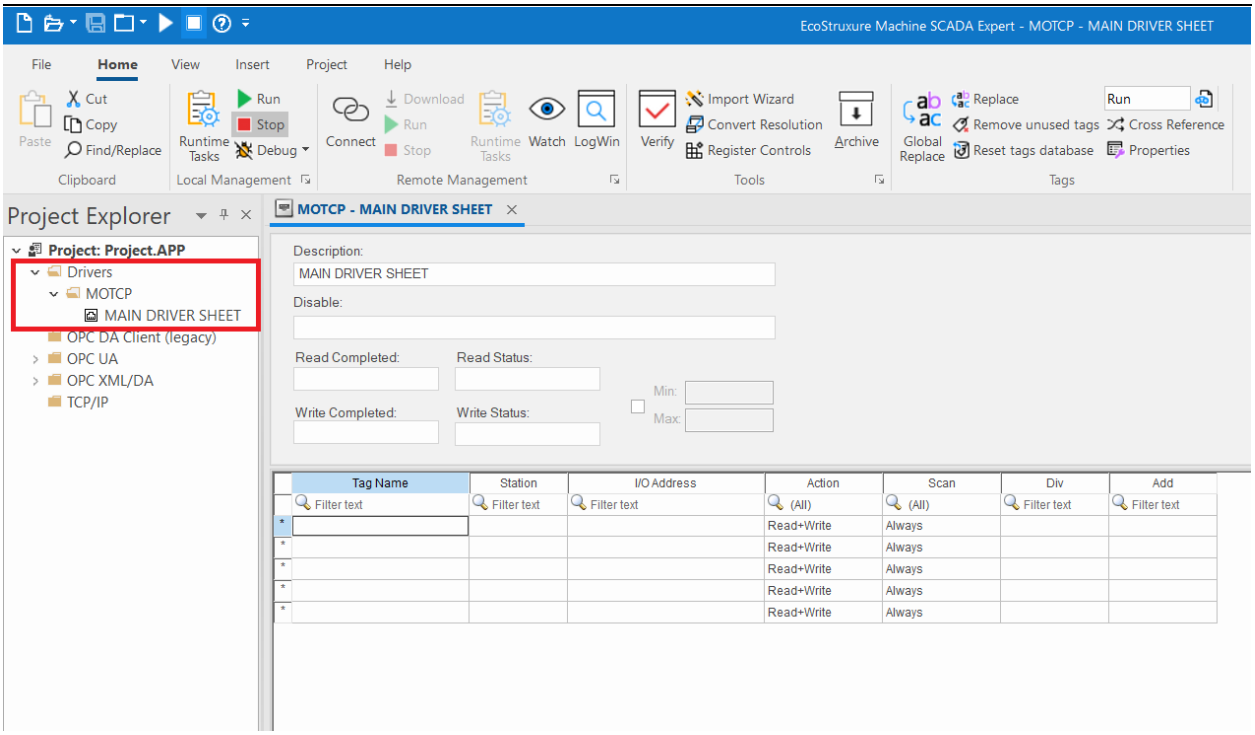


Figure 5-31

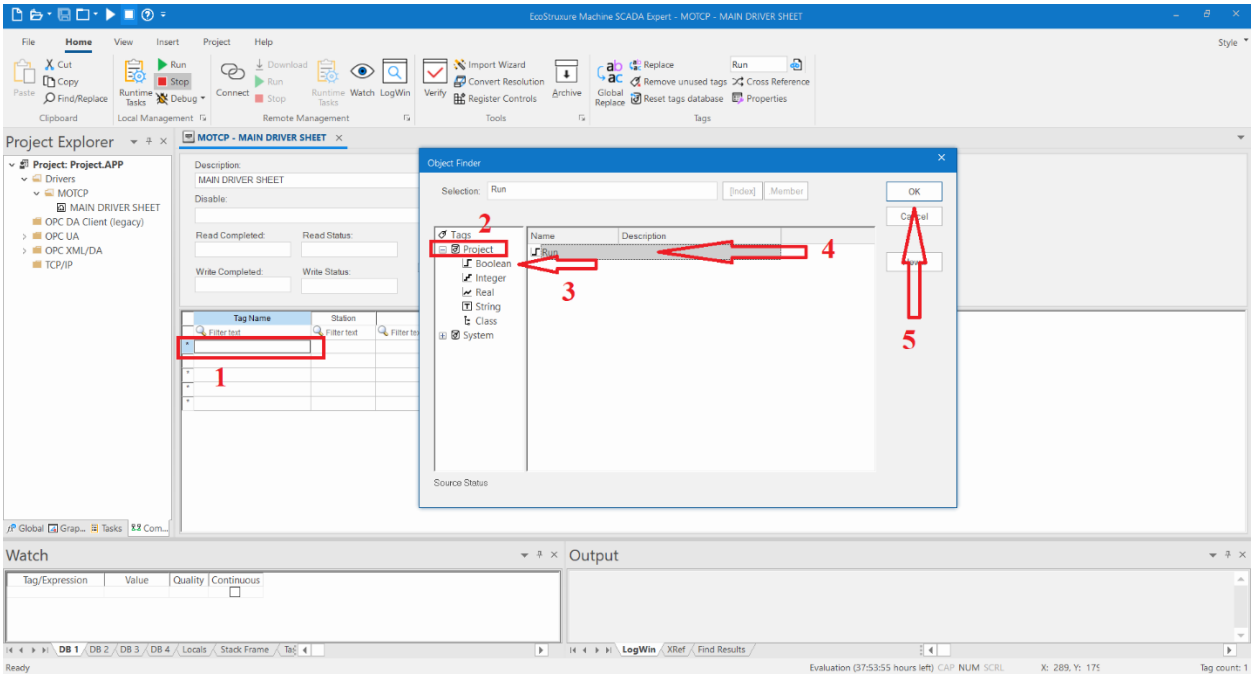


Figure 5-32

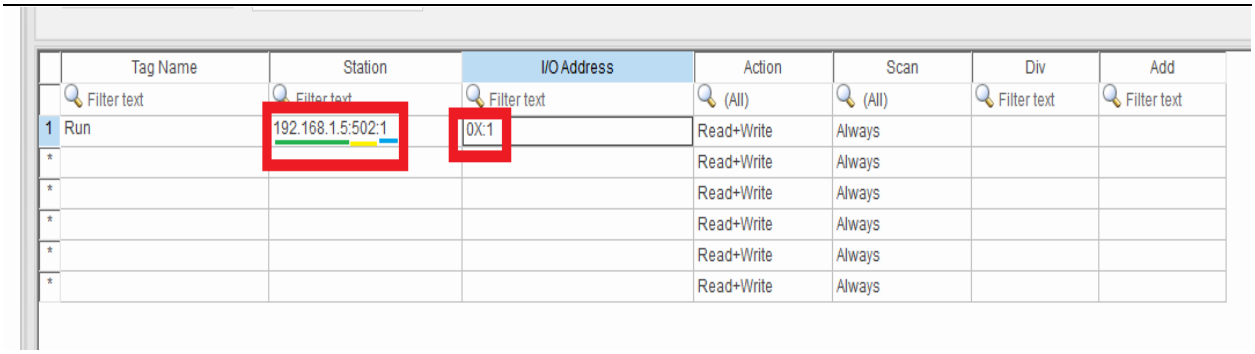


Figure 5-33

** 0X → Boolean Type ** 4X → Word Type

8- Start to design your screen

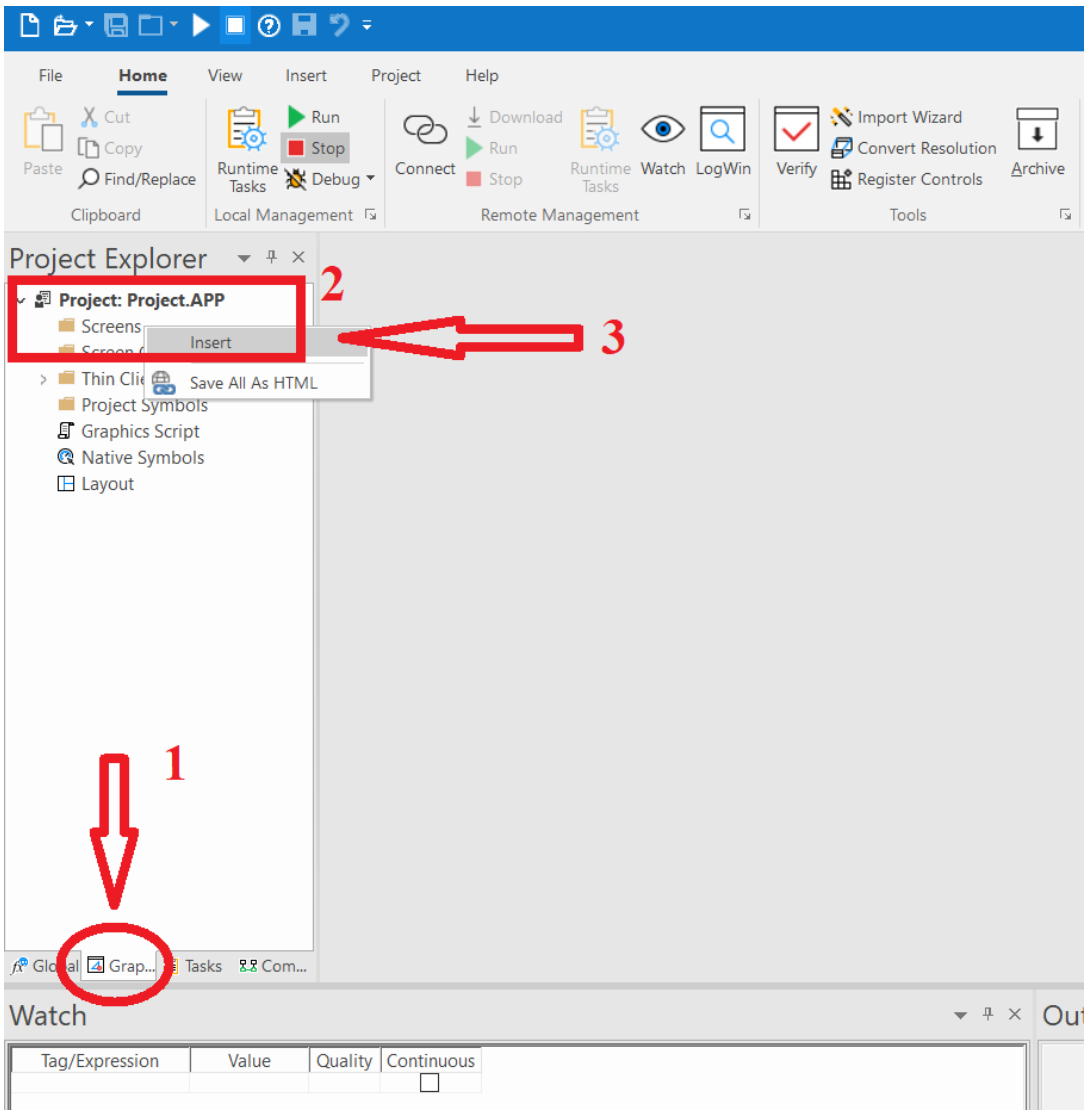


Figure 5-34

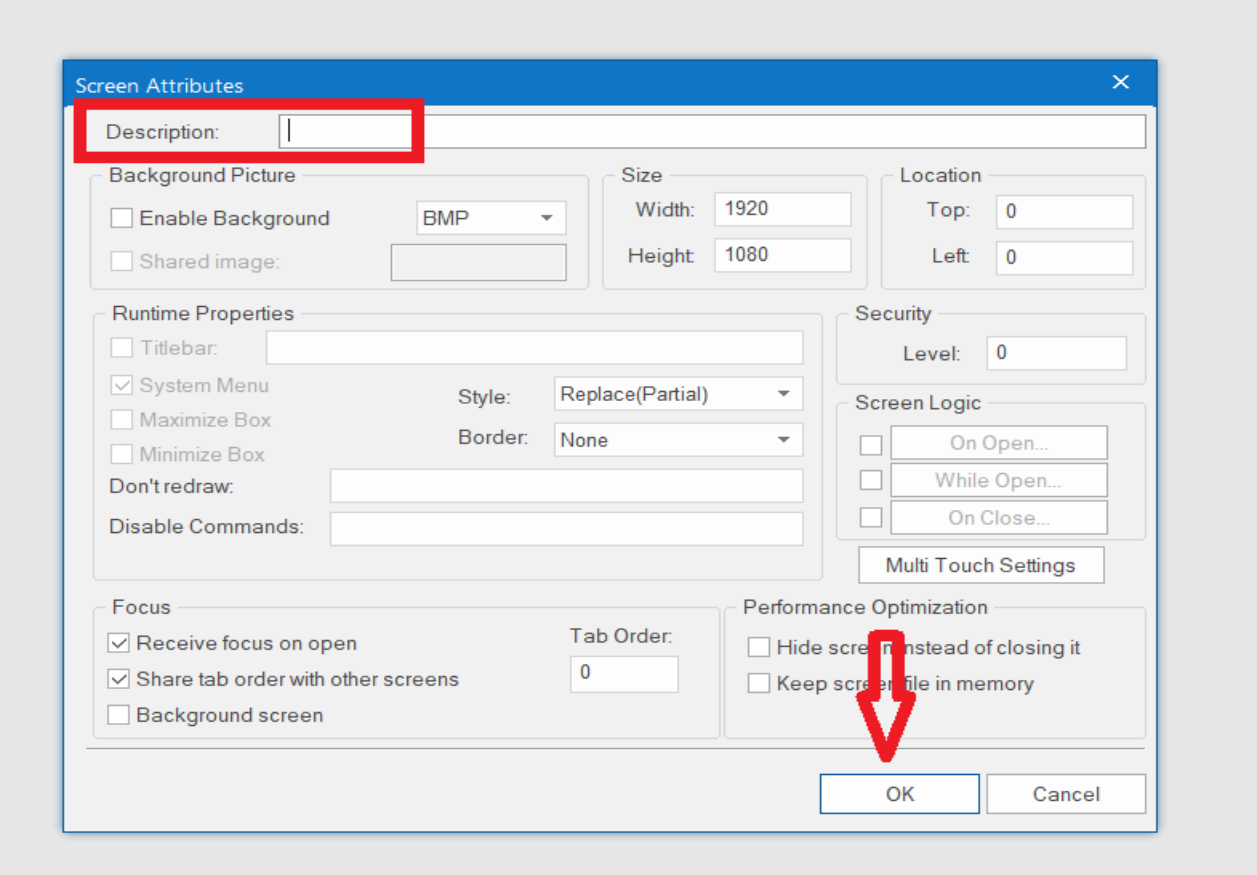


Figure 5-35

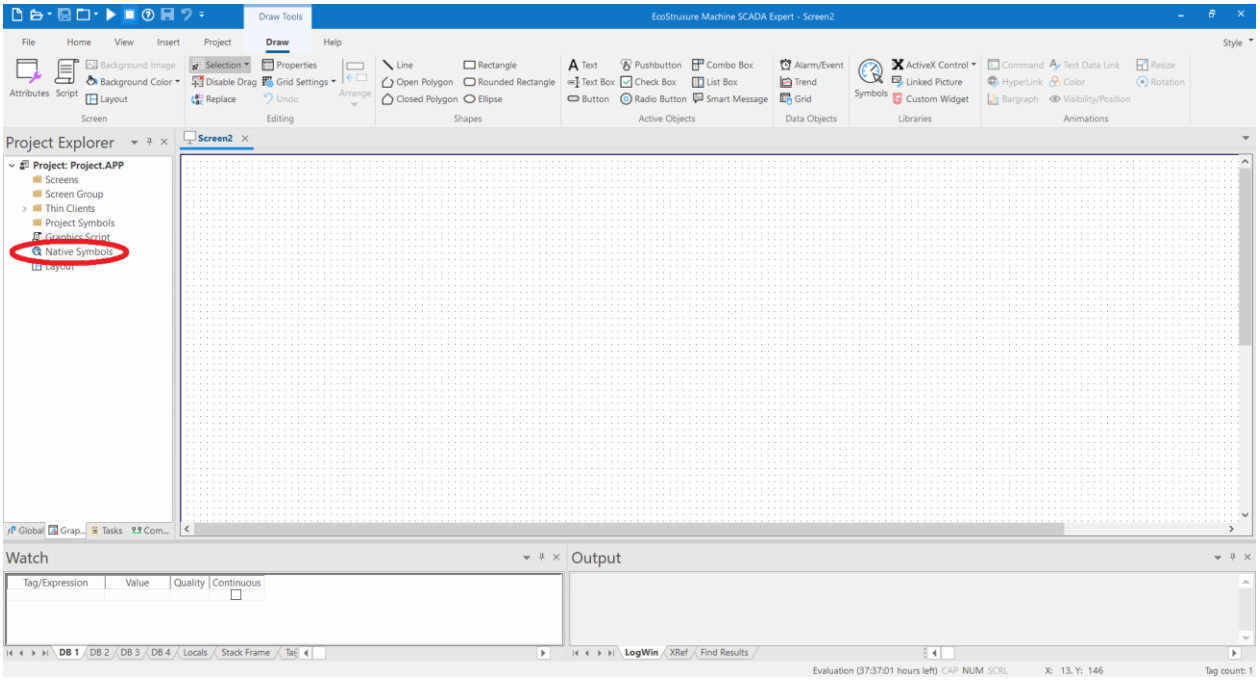


Figure 5-36

Chapter 6
Quality Control

6. QUALTIY CHECK SYSTEM “COMPUTER VISION”

6.1.Introduction

Computer vision is a field of computer science that works on enabling computers to see, identify and process images in the same way that human vision does, and then provide appropriate output. It is like imparting human intelligence and instincts to a computer. Computer vision is closely linked with artificial intelligence, as the computer must interpret what it sees, and then perform appropriate analysis or act accordingly.

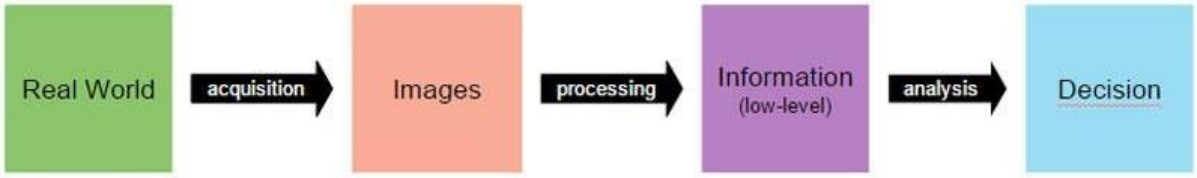


Figure 6-1

Image processing-based quality checking is one of the most popular technologies employed in manufacturing process nowadays, as it reduces both the human errors and the man power requirement. The purpose of this project is to identify the external defects of the bottle which is manufactured in an industry and to eliminate such products to assure the quality of the final products. Main objective of this project is to identifying the defective objects which arrive through conveyer line using a camera which is controlled by a PC. Image processing using LabVIEW is used for processing the images which is very user friendly. The bottle moves through a conveyor. A proximity sensor will sense the object. Then the image of the object will be taken by the camera and compare the image with the already stored template image using LabVIEW. Object that falls within the prescribed tolerance level be regarded as good object. The conveyor will take the bottle to the packing section and others will discarded. Defective bottle will be removed with the help of a solenoid piston.

Usually in factories they check the quality of each part alone which means more systems and higher cost and this operation usually done by humans which cause lower accuracy but we use one technology solution that reduce time, cost and the probability of error.

6.1.1. Classifications:

There are three software can be used image processing:

- Python
  - Open source
  - Has a specific library for image processing
  - Needs hardware
- MATLAB
  - User friendly
  - Closed source
  - Complex to create image processing function
  - Needs strong processor
- LabVIEW

- Light software
- Simple
- Specifically designed for image processing
- Has graphical user interface

So we choose to use Python.

In this system we check the state of the bottle if it's capped or not using an AI model which is built by google tenser flow.

Computer vision using python, OpenCV and TensorFlow

We are going to build an AI model with these libraries to identify the quality of the bottle.

First of all, we download the libraries

- https://www.python.org/downloads/ link for downloading python
- After downloading python open your command prompt and write pip install OpenCV-python to download OpenCV
- To install tensor flow, write pip install TensorFlow

6.2.Building the model:

After preparing everything, now we will build the model

First, we have to build the dataset that we use to train the model.

We made dataset of 2500 images to train the model as shown in the figures

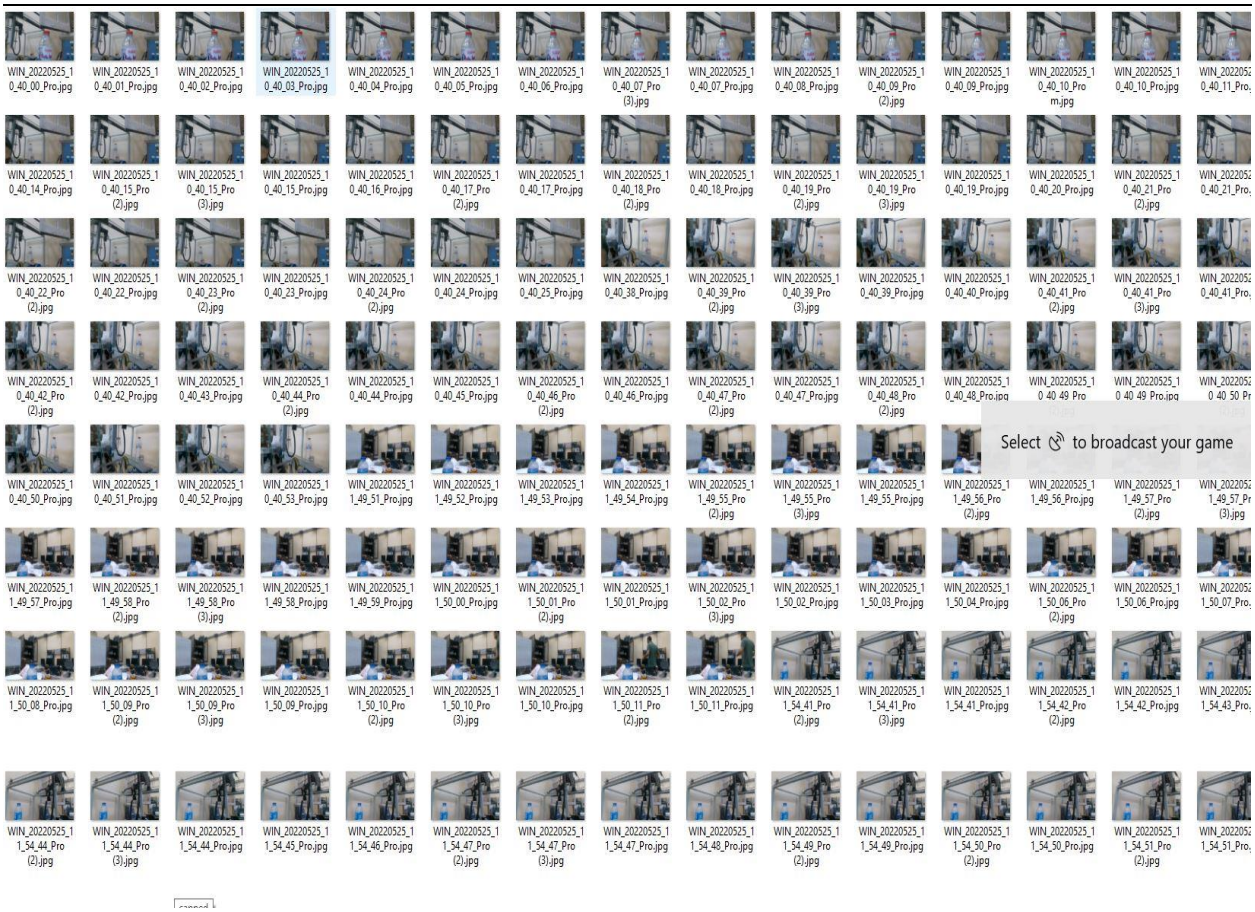


Figure 6-2

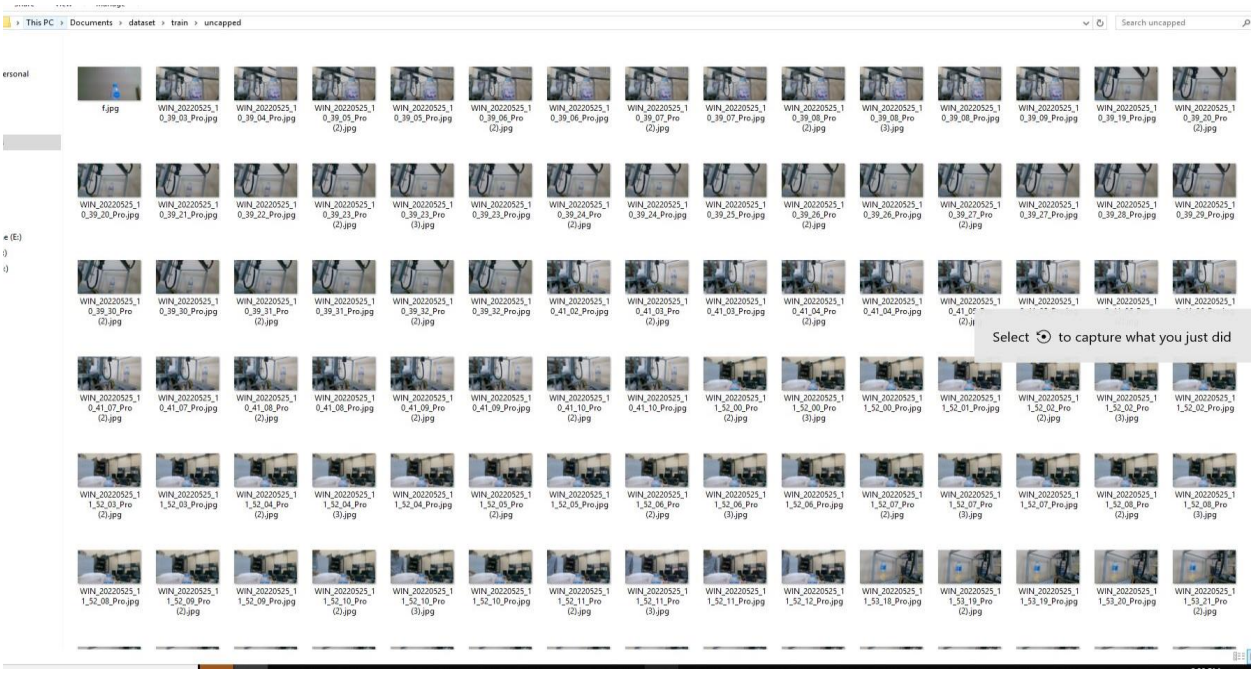


Figure 6-3

Now we build and train the model using TensorFlow. We will use neutral network.

In normal human's Neural Networks every cell learns something then passes it to all cells eventually every cell has all the information from other cells.

In artificial neural network every cell receives many inputs then they all summed through Sigmoid Function to get one output

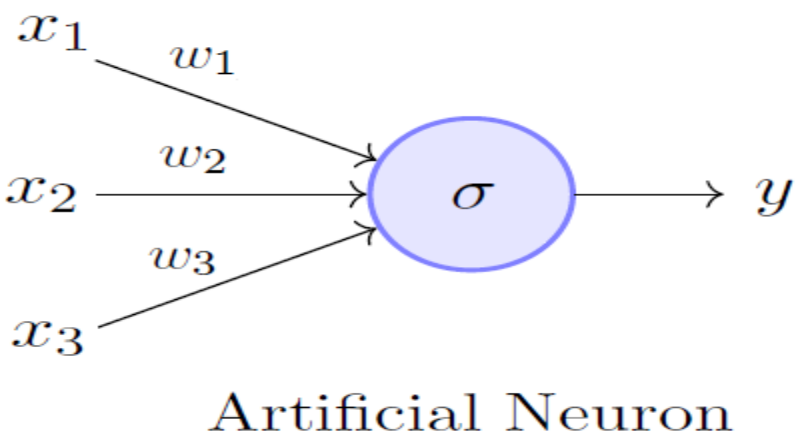


Figure 6-4

The training of the model took about 8-10 hours

With Starting Accuracy 60%

With final Accuracy 95.62%

```
Epoch 96/100
150/150 [==============================] - 170s 1s/step - loss: 0.0905 - accuracy: 0.9529 - val_loss: 0.0506 - val_accuracy:
0.9740
Epoch 97/100
150/150 [==============================] - 174s 1s/step - loss: 0.0849 - accuracy: 0.9575 - val_loss: 0.0277 - val_accuracy:
0.9896
Epoch 98/100
150/150 [==============================] - 85s 569ms/step - loss: 0.0745 - accuracy: 0.9558 - val_loss: 0.0282 - val_accurac
y: 0.9844
Epoch 99/100
150/150 [==============================] - 88s 584ms/step - loss: 0.1127 - accuracy: 0.9546 - val_loss: 0.0491 - val_accurac
y: 0.9792
Epoch 100/100
150/150 [==============================] - 101s 674ms/step - loss: 0.0781 - accuracy: 0.9562 - val_loss: 0.0244 - val_accurac
y: 0.9844
```

Figure 6-5

6.3. Code Sequence**:**

The first step we open live camera using web cam

Figure 6-6

When the bottle passes through the camera the camera detects it using library called YOLO it's AI created by Google to detect the objects and identify them

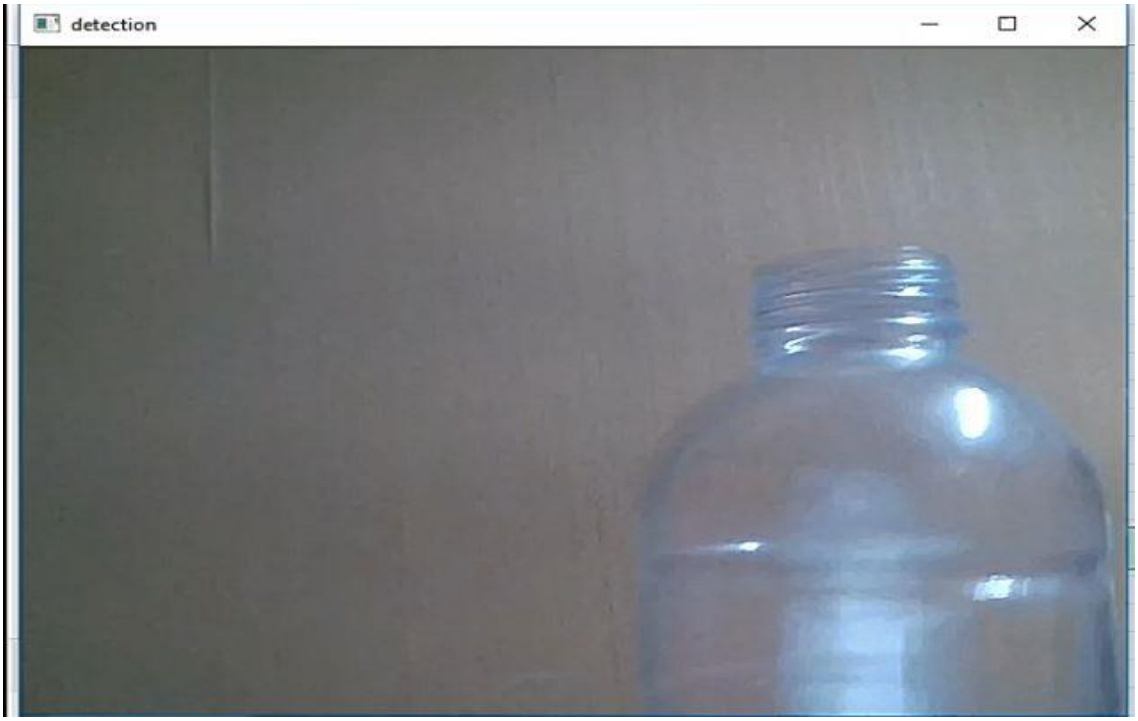


Figure 6-7

After Detection the model we built it used to determine the bottle if it's capped or not then sends to node red 0 or 1

- 0 means it's capped
- 1 means it's uncapped

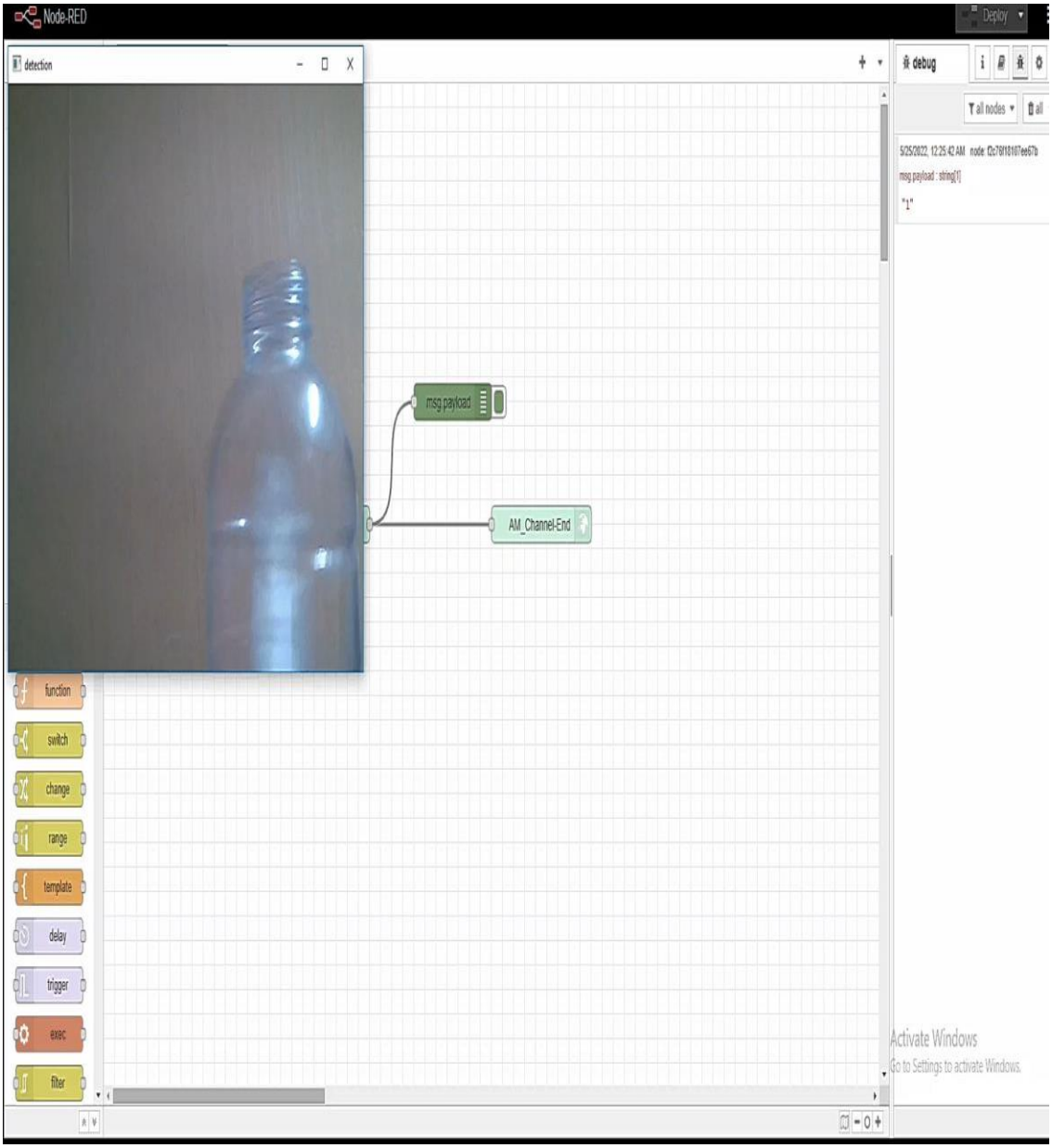


Figure 6-8

In this figure when the bottle is uncapped we send to node red 1

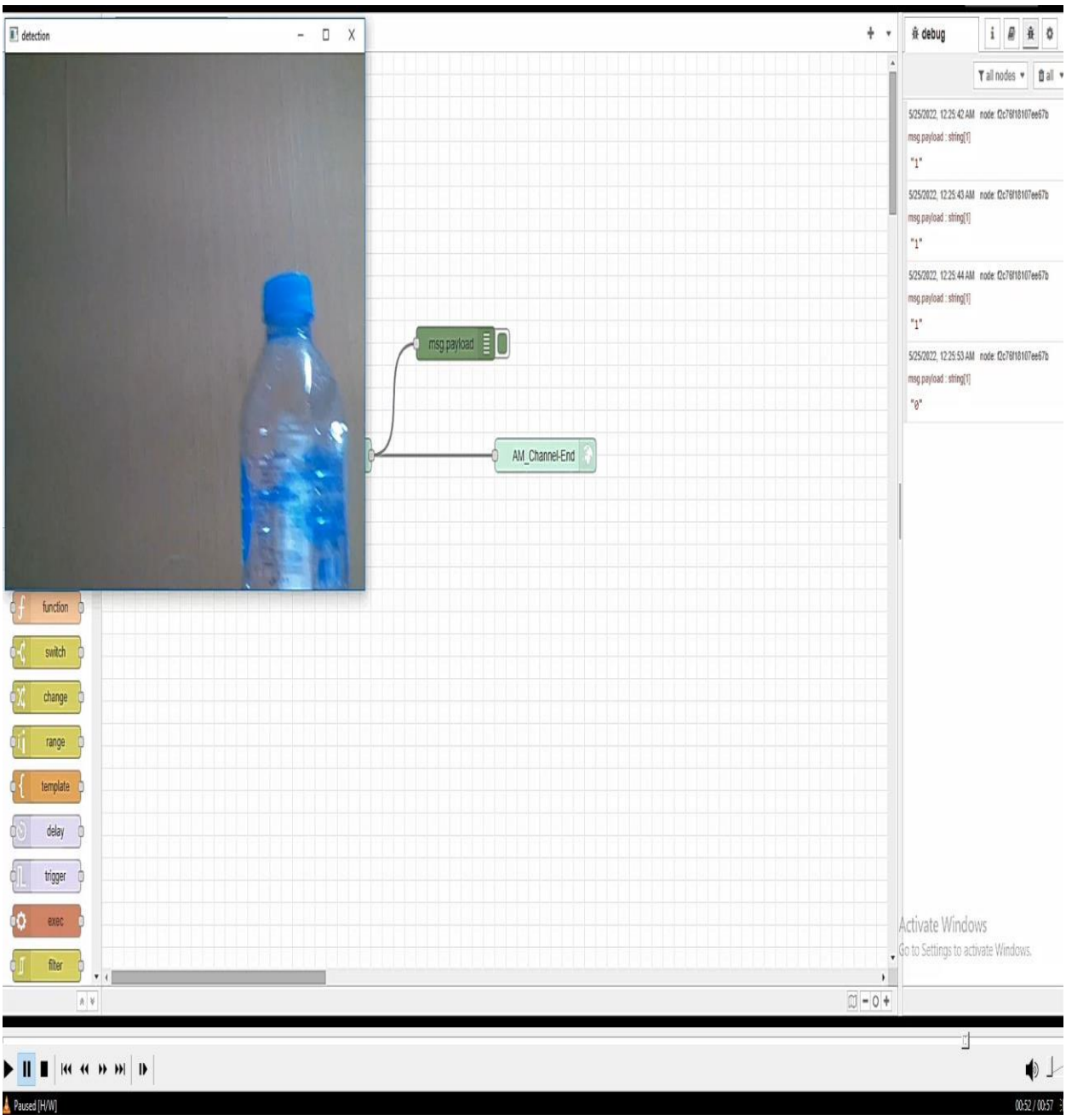


Figure 6-9

In this figure when the bottle is capped we send to node red 0

The model is trained by more than 2500 photo.

Chapter 7
Robot & Packing system

7. ROBOT AND PACKING SYSTEM

7.1.Principle of work:

When the Cartesian robotic arm system is ordered to pack the tested bottle into the box, the robot will take the bottle to be packed. At the other hand when the robot is ordered to throw-out the faulty bottle, it will throw it away out of the box of packing.

7.2.Solid works design:

All System

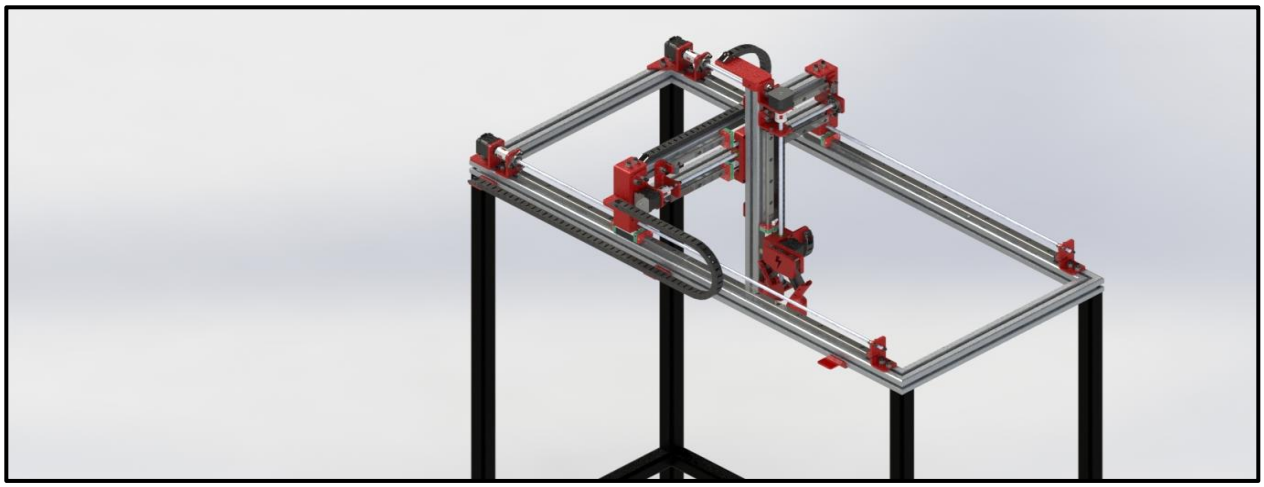


Figure 7-1

Gripper

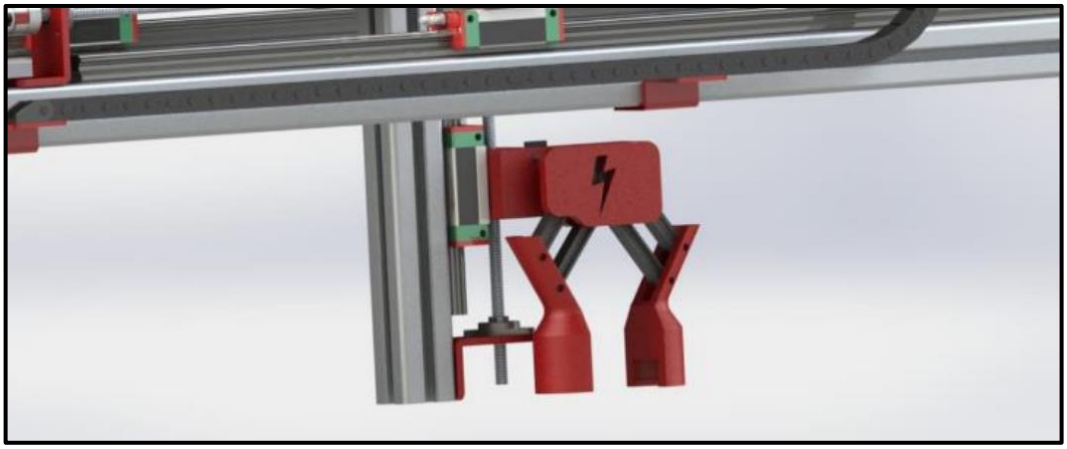


Figure 7-2

7.3.Hardware Implementation:

All System

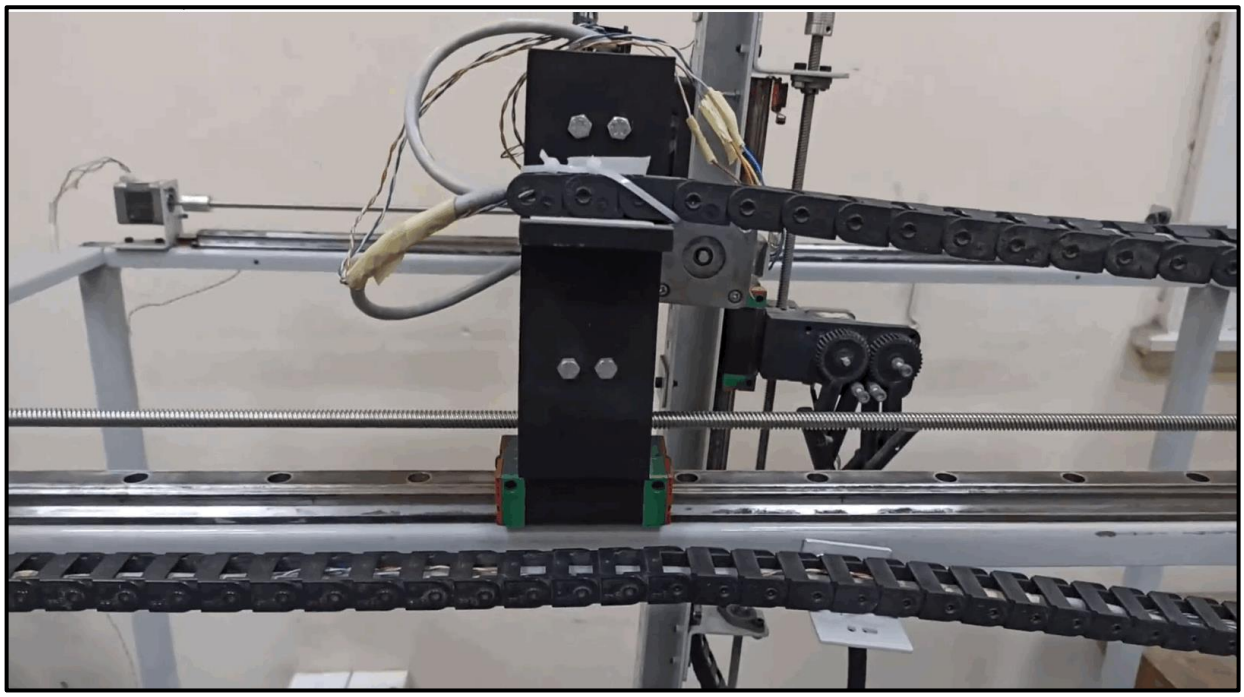


Figure 7-3

Figure 7-4

Gripper

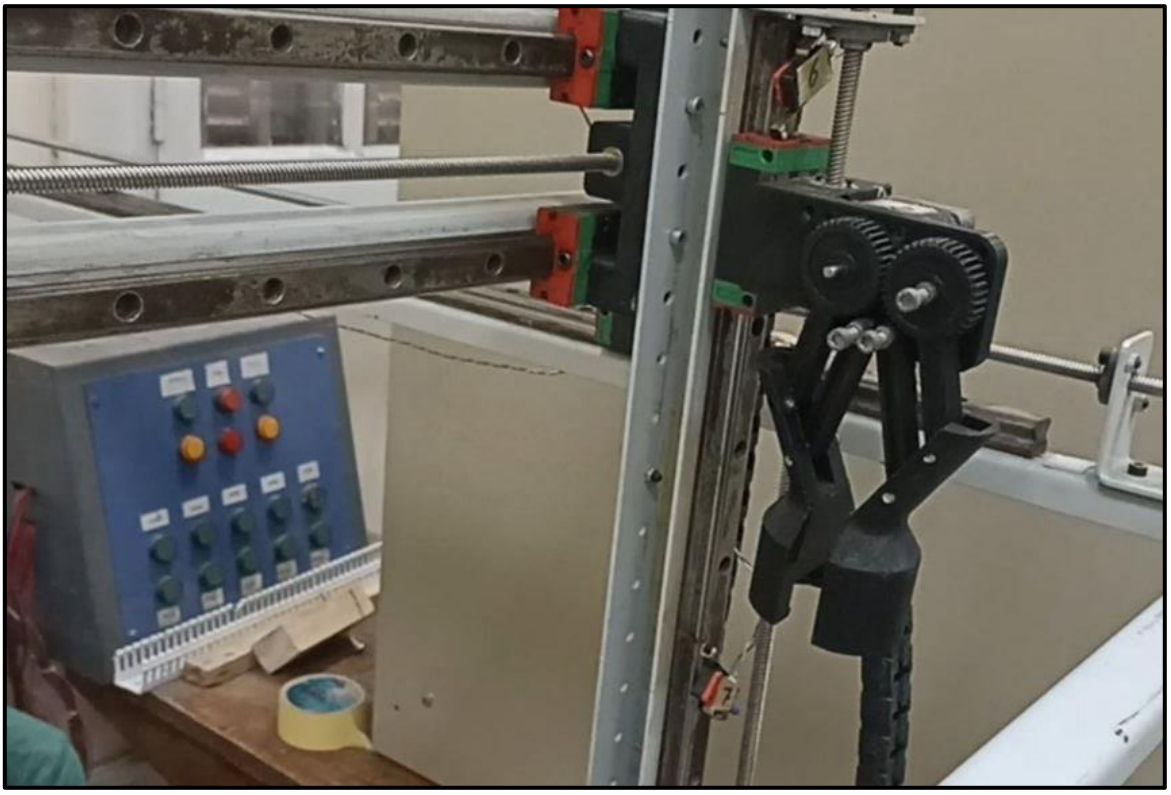


Figure 7-5

7.4. Components:

1- Linear Motion Mechanism – (Mechanical component):

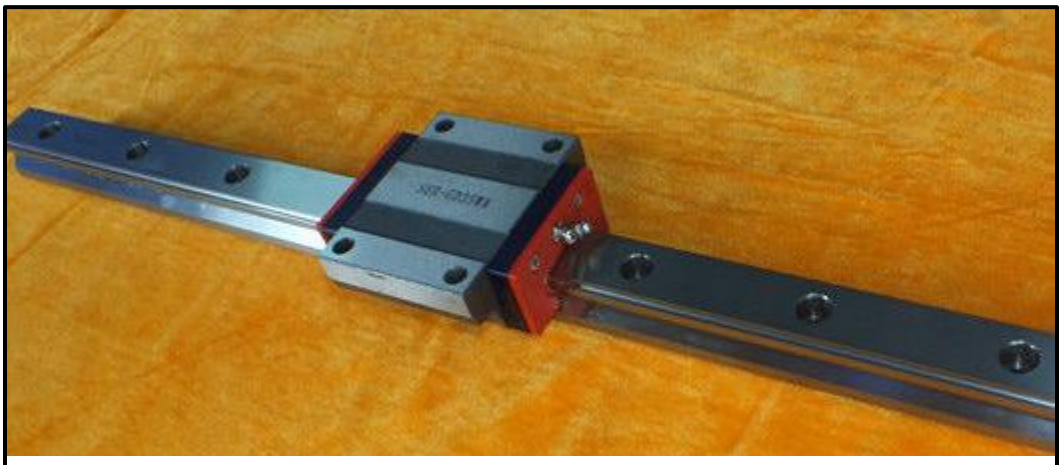


Figure 7-6

2- Limit Switches – (Electrical component):

Used to give the limit indication on the trip of X-axis, Y-axis or Z-axis.

Figure 7-7

3- Stepper Motors Drives – (Electrical Component):

Four drives are used to derive the motion in x, y, z and the Gripper

4- Stepper Motors – (Electrical Component):

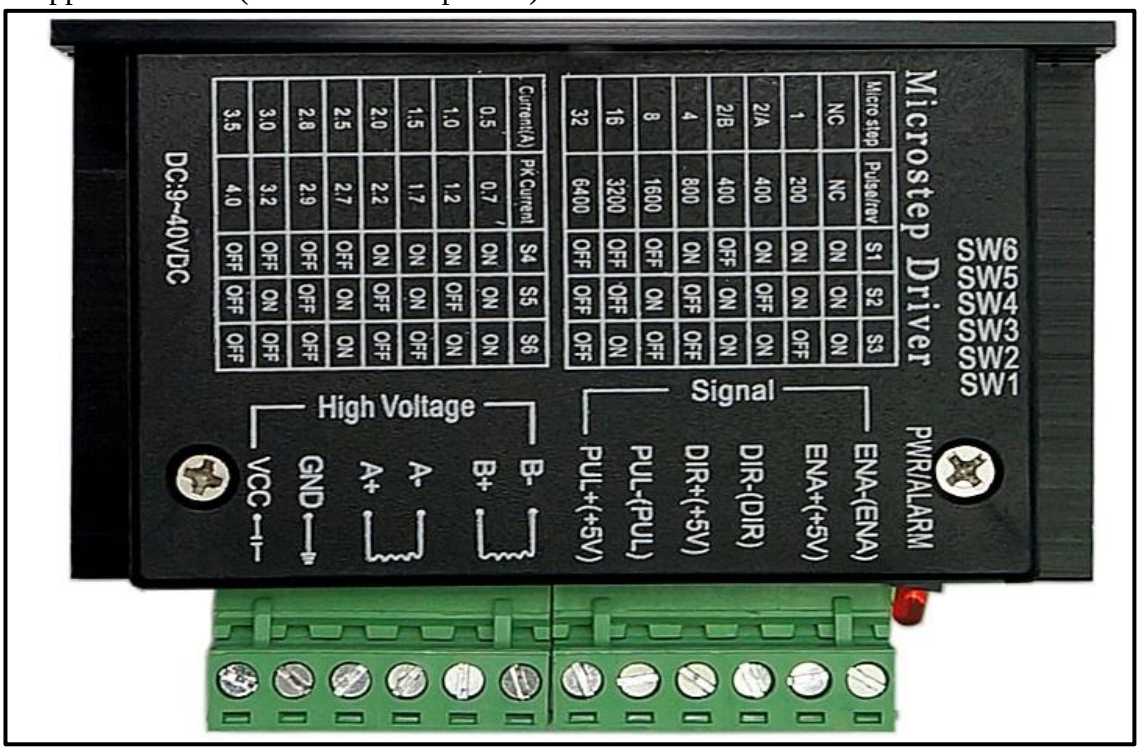


Figure 7-8

Five Steppers are used to derive the motion of the robot system.

Two Steppers motors are used for X-axis

One for Y-axis

One for Z-axis

The last is for the Gripper

Figure 7-9

7.5.Hardware Specs & Settings:

Stepper motor used model specs:

Model Specifications

Model Number	Step Angle	Drive Sequence	Rated Current/Wdg	Winding Resistance	Holding Torque	Inductance	Rotor Inertia	Detent Torque	Weight
	Degrees		Amps	Ohms	Nm (kg-cm)	mH	kg-cm²	Nm (g-cm)	g
17PM-K406V	1.8°	BIPOLAR	1.4	2.4	0.490 (5.0)	5.7	0.080	0.0147 (150)	350

Figure 7-10

Stepper Drive used model Specs:

Input Current	0~5.0A
Output Current	0.5-4.0A
Power (MAX)	160W
Micro Step	1, 2/A, 2/B, 4, 8, 16, 32
Temperature	-10～45℃
Humidity	No Condensation
Weight	0.2 kg
Dimension	96*56*33 mm

Figure 7-11

Stepper Drive used model Settings:

Micro Step	Pulse/Rev	S1	S2	S3
NC	NC	ON	ON	ON
1	200	ON	ON	OFF
2/A	400	ON	OFF	ON
2/B	400	OFF	ON	ON

Current (A)	S4	S5	S6
0.5	ON	ON	ON
1.0	ON	OFF	ON
1.5	ON	ON	OFF

Figure 7-12

7.6. Configurations:

Common-Cathode Stepper Driver Configuration

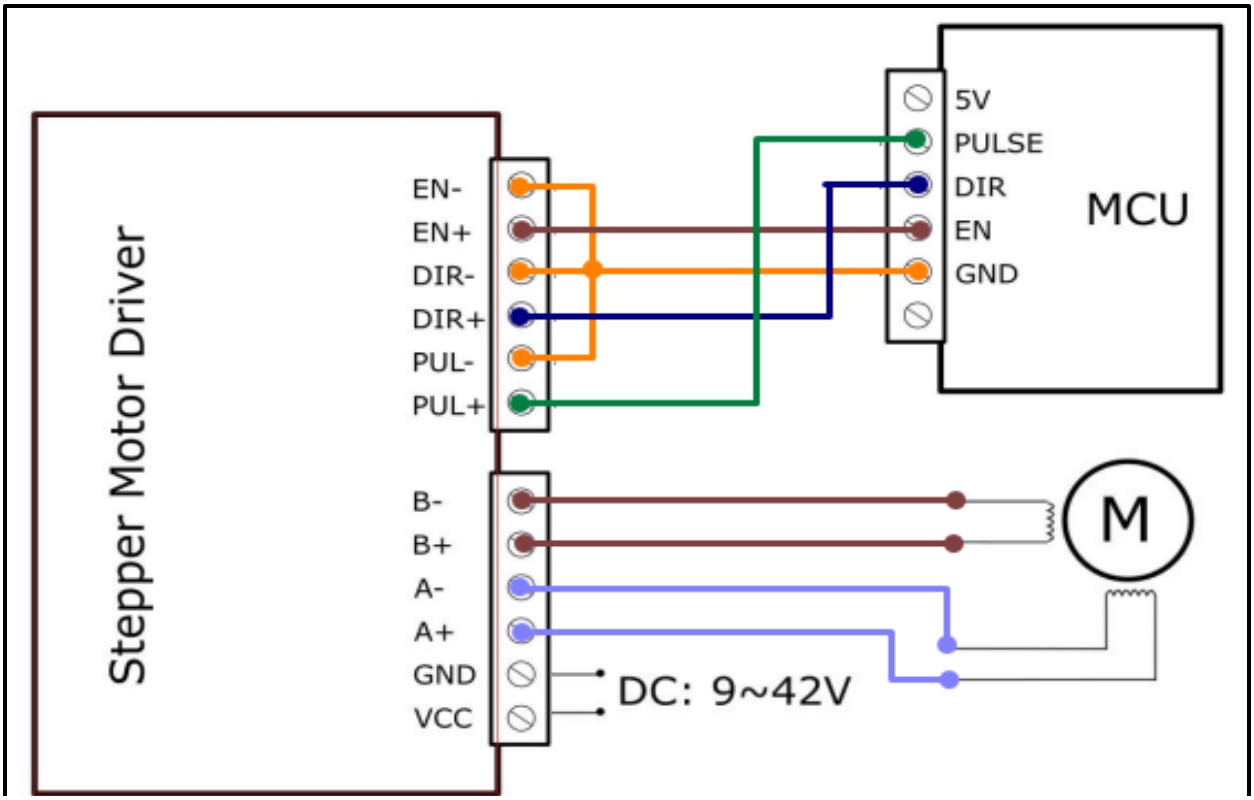


Figure 7-13

Robot-System Configuration Sketch

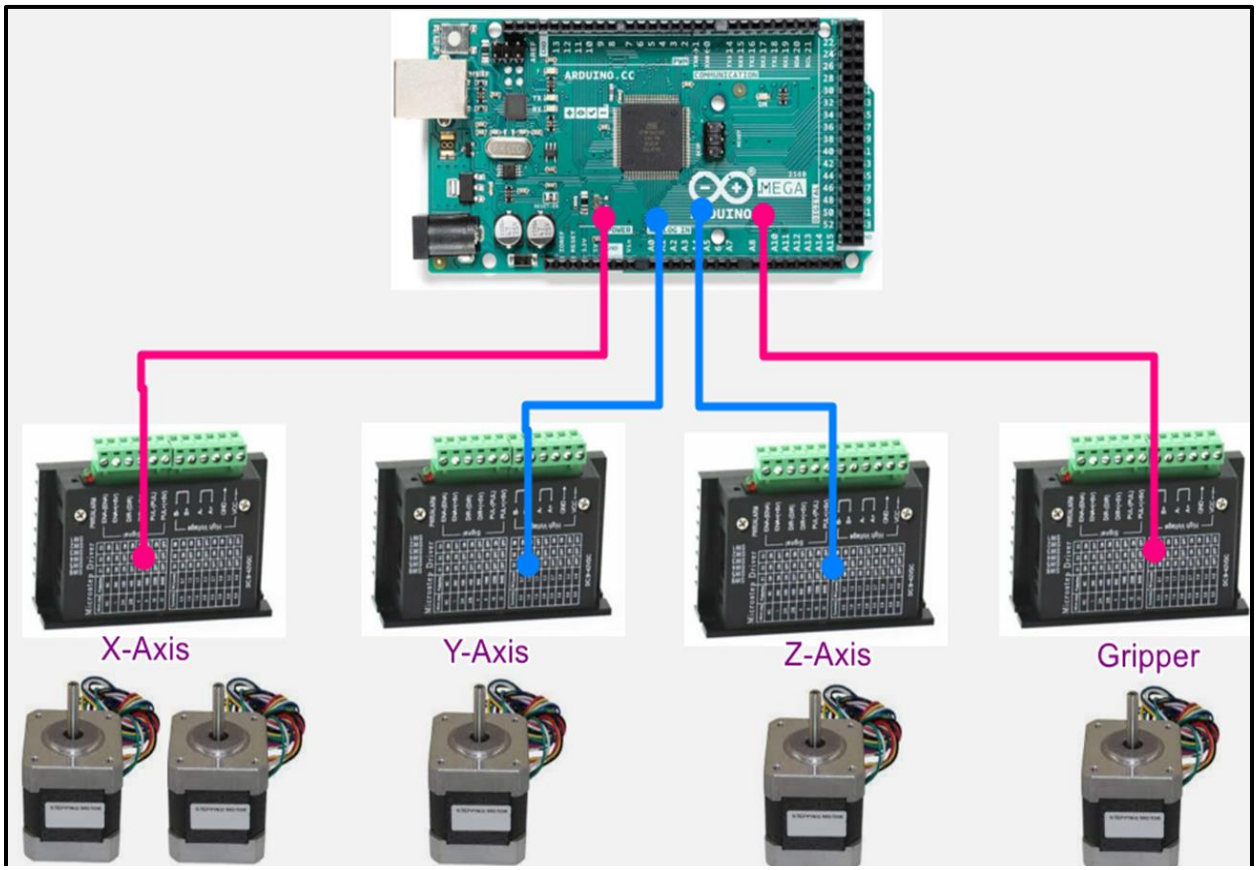


Figure 7-14

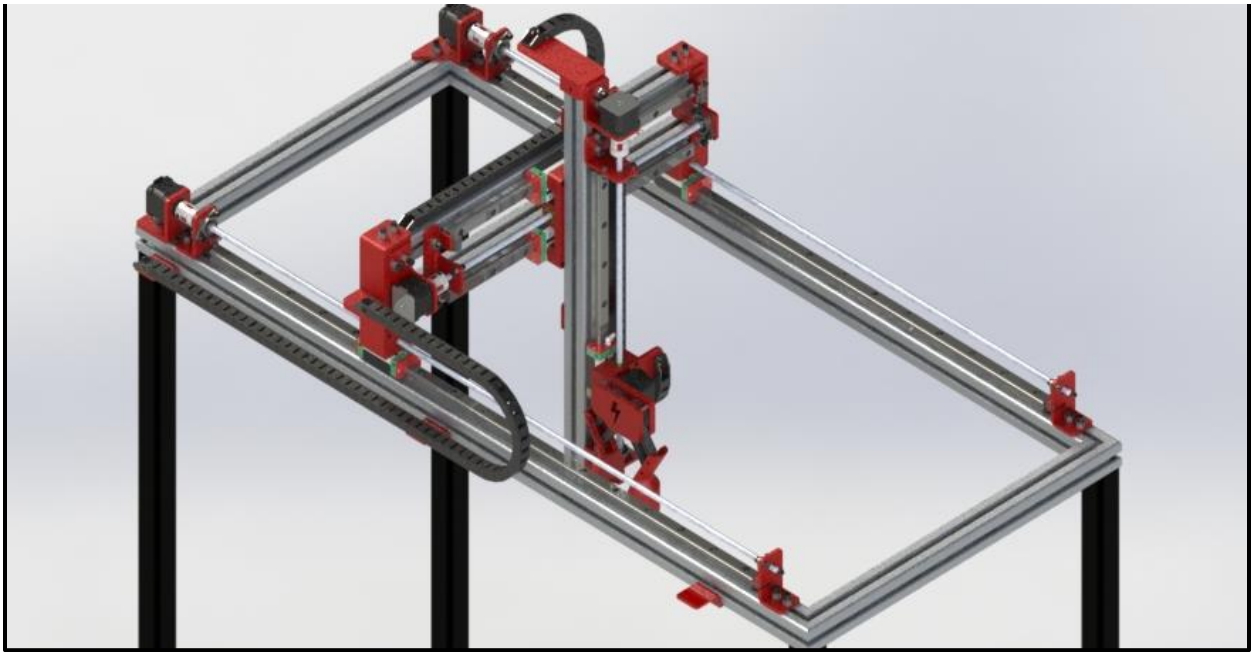


Figure 7-15

7.7.Robot sub-system control panel

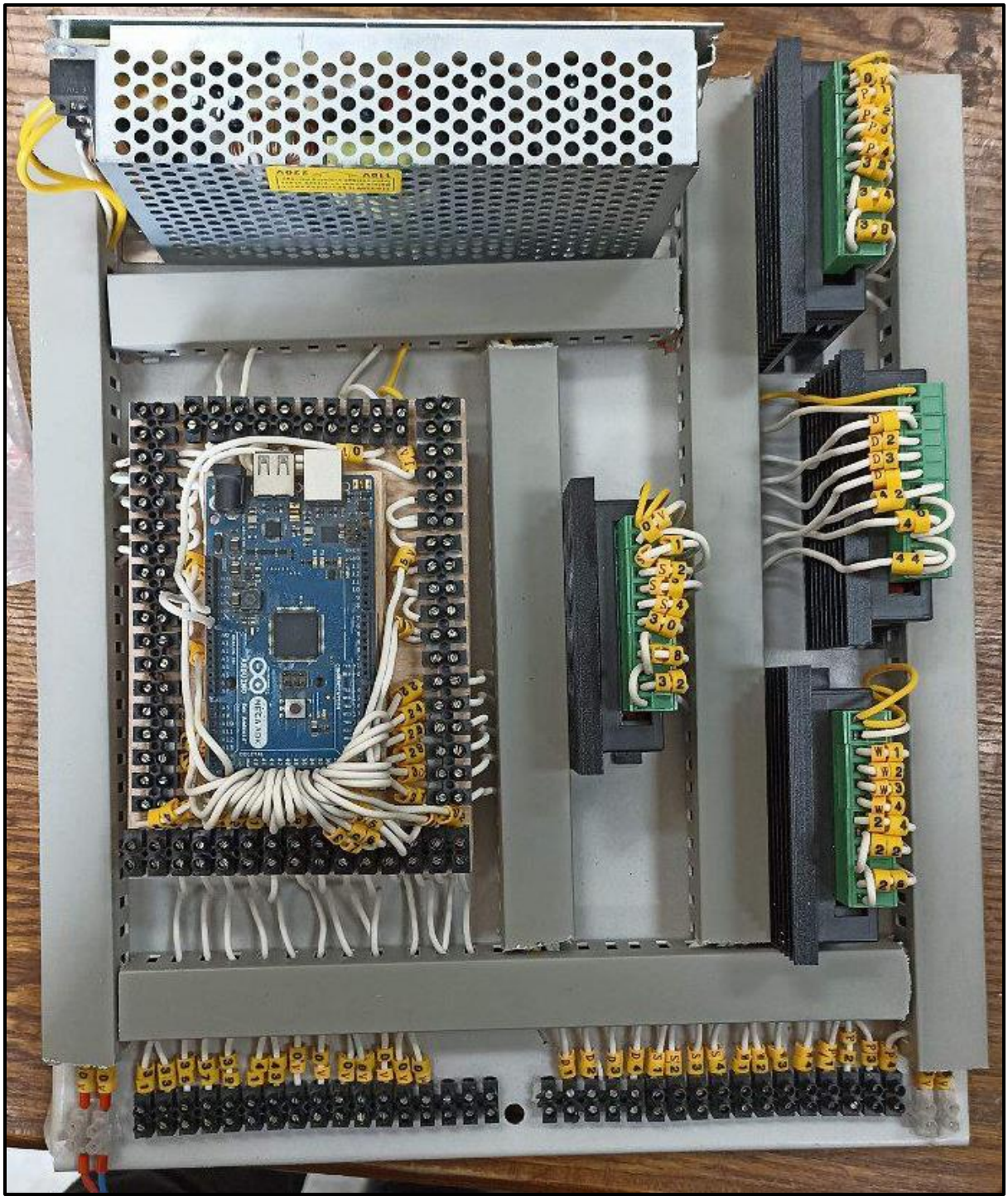


Figure 7-16

See pin configuration in the code section.

7.8. Code Implementation:

7.8.1. Code Expected Sequence (Simple Mapping):

1. Begin serial communication at baud rate 9600.
2. Panel and Arduino Pins configuration setup.
3. Ready for the next step:
    1. Loop required function:
        1. Read the limit switches states.
        2. Listen to the serial command:
            1. Check X-axis mismatch.

                To check that the car on the x-axis is not slipped means that the Two horizontal limit switches are triggered not one is triggered and the other not.
            2. Go Home Command.

                To make the system to go the zero-position at the new bottle to be taken for the new trip.
            3. Start Packing Command.

                To take the intact (covered or not [image processing]) bottle into the box.
            4. Throw the faulty bottle away Command.

                To throw the faulty bottle away out of the box.
            5. Manual control commands.

                (Specific command for specific route motion)
        3. Send every new event into the serial communication for Node-RED to read the status of the whole system.

7.8.2. Coding part – using VS-Code:

Code Files

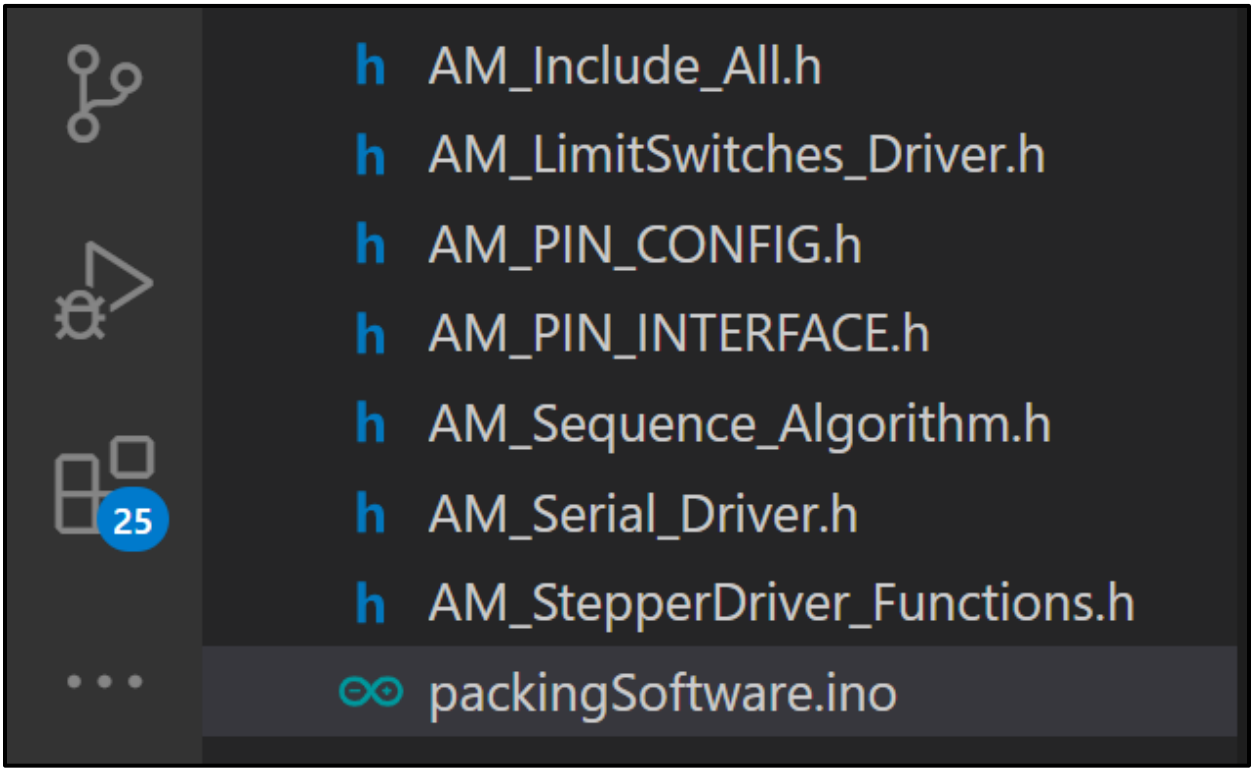


Figure 7-17

We have separated the code into these files to make the code easier to be understood and to increase the reliability of the code and also to lessen the mistakes number. Of course, every file here has a specified role that the simple concept of separation.

In the next phase we will show every single file in detail.

Code Files - AM_PIN_CONFIG.h:

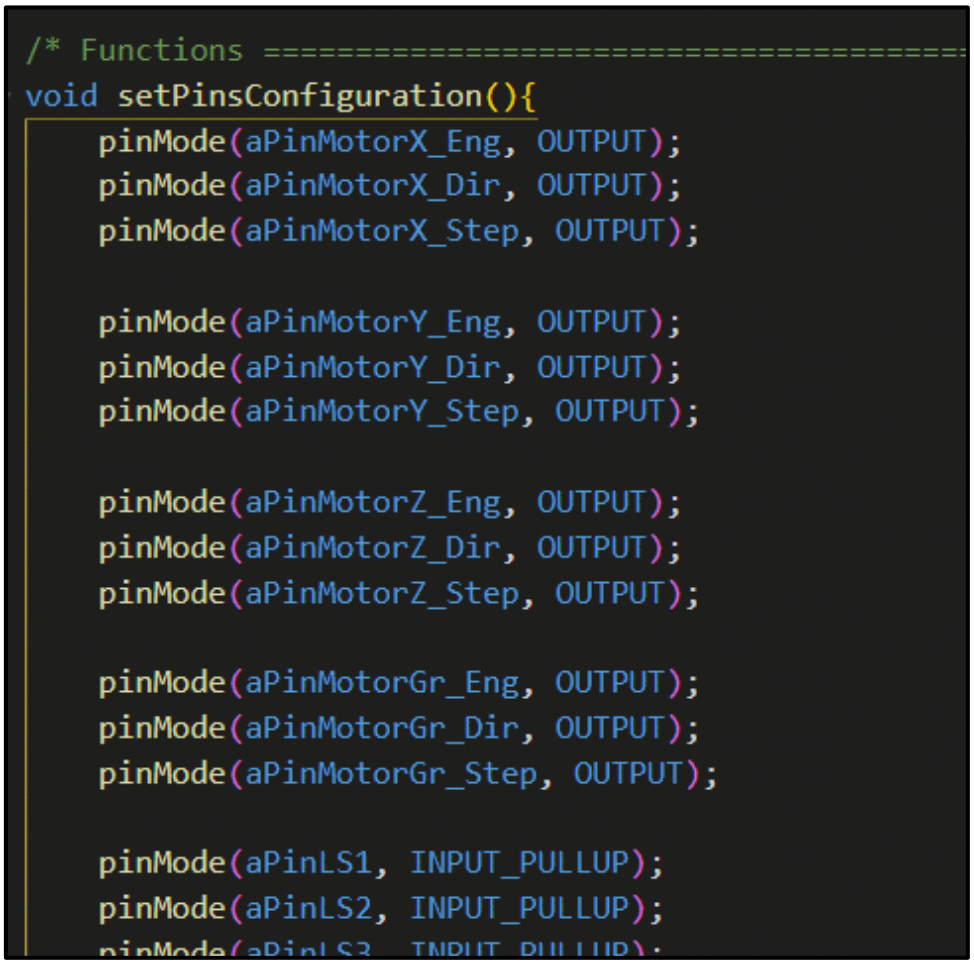
```
 9  #ifndef AM_PIN_CONFIGURATION
10  #define AM_PIN_CONFIGURATION
11
12      #define aPinMotorX_Dir              28
13      #define aPinMotorX_Step             30
14      #define aPinMotorX_Eng              32
15
16      #define aPinMotorY_Dir              22
17      #define aPinMotorY_Step             24
18      #define aPinMotorY_Eng              26
19
20      #define aPinMotorZ_Dir              34
21      #define aPinMotorZ_Step             36
22      #define aPinMotorZ_Eng              38
23
24      #define aPinMotorGr_Dir             40
25      #define aPinMotorGr_Step            42
26      #define aPinMotorGr_Eng             44
27
28      #define aPinLS1                     31
29      #define aPinLS2                     33
30      #define aPinLS3                     35
31      #define aPinLS4                     37
32      #define aPinLS5                     39
33      #define aPinLS6                     41
34      #define aPinLS7                     43
35
36  #endif
```

Figure 7-18

Pin configuration figure

This file shows the pin numbers and specify every single integer to a specified name to deal easier with the code.

Code Files - AM_PIN_INTERFACE.h:



```
/* Functions ========================================
void setPinsConfiguration(){
    pinMode(aPinMotorX_Eng, OUTPUT);
    pinMode(aPinMotorX_Dir, OUTPUT);
    pinMode(aPinMotorX_Step, OUTPUT);

    pinMode(aPinMotorY_Eng, OUTPUT);
    pinMode(aPinMotorY_Dir, OUTPUT);
    pinMode(aPinMotorY_Step, OUTPUT);

    pinMode(aPinMotorZ_Eng, OUTPUT);
    pinMode(aPinMotorZ_Dir, OUTPUT);
    pinMode(aPinMotorZ_Step, OUTPUT);

    pinMode(aPinMotorGr_Eng, OUTPUT);
    pinMode(aPinMotorGr_Dir, OUTPUT);
    pinMode(aPinMotorGr_Step, OUTPUT);

    pinMode(aPinLS1, INPUT_PULLUP);
    pinMode(aPinLS2, INPUT_PULLUP);
    pinMode(aPinLS3, INPUT_PULLUP);
```

Figure 7-19

This file has functions related to pins Setup (initial setup functions)

Like setPinsConfiguration Method

Code Files - AM_LimitSwitches_Driver.h:

```
#ifndef AM_LimitSwitches_Driver
#define AM_LimitSwitches_Driver


int LS1;
int LS2;
int LS3;
int LS4;
int LS5;
int LS6;
int LS7;

void limitSwRead()
{
    LS1 = digitalRead(aPinLS1);
    LS2 = digitalRead(aPinLS2);
    LS3 = digitalRead(aPinLS3);
    LS4 = digitalRead(aPinLS4);
    LS5 = digitalRead(aPinLS5);
    LS6 = digitalRead(aPinLS6);
    LS7 = digitalRead(aPinLS7);
}

#endif
```

Figure 7-20

In this file we wrote a drive for the limit switches declaring some global variables that within you can read the status of any limit switch just every time you need to get the status of anyone Call limitSwRead () function and call LS1 or LS2 or whatever you want.

Code Files - AM_StepperDriver_Functions.h:

```
30  void motorX_Until_Limit(bool direction){
31    digitalWrite(aPinMotorX_Eng, LOW);
32    digitalWrite(aPinMotorX_Dir, direction);
33    while((direction && LS1) | (!direction && (LS2 && LS3)))
34    {
35      digitalWrite(aPinMotorX_Step, HIGH);
36      delayMicroseconds(700);
37      digitalWrite(aPinMotorX_Step, LOW);
38      delayMicroseconds(700);
39      limitSwRead();
40    }
41    digitalWrite(aPinMotorX_Eng, HIGH);
42  }
```

Figure 7-21

For the stepper driver code file this responsible for the motion in each axis.

Code Files - AM_Sequence_Algorithm.h:

In this file we wrote the compact algorithms of motion.

Like Go Home method.

```
#ifndef AM_Sequence_Algorithm
#define AM_Sequence_Algorithm

#include "AM_StepperDriver_Functions.h"
#include "AM_LimitSwitches_Driver.h"

void goHome(bool openGripper = true){

    if (openGripper)
    {
        Serial.println(46);     // Gripper indication (Open)
        motorGripper(150, true);   // open Gripper
    }

    Serial.println(45);     // Moving indication (Z-)
    motorZ_Until_Limit(false);  // Z up (Z-)

    Serial.println(40);     // Moving indication (X-)
    motorX_Until_Limit(false);   // X -

    Serial.println(42);     // Moving indication (Y-)
    motorY_Until_Limit(false);   // Y -

    Serial.println(49);     // Ready for the new command
}
```

Figure 7-22

Code Files - AM_Serial_Driver.h:

```
#ifndef AM_Serial_Driver
#define AM_Serial_Driver

#include "AM_StepperDriver_Functions.h"

void listenToSerialCommand()
{
    u8 cmd = Serial.read();
    switch (cmd)
    {
    case 'A': // X-Axis Right
        Serial.println("Motor_X-Axis Starts to move right");
        // motorX(2000, true);
        motorX_Until_Limit(true);
        Serial.println("Motor_X-Axis Finished moving");
        break;

    case 'B': // X-Axis Left
        Serial.println("Motor_X-Axis Starts to move left");
```

Figure 7-23

This file is a driver for the serial communication and has functions like listenToSerialCommand ().

This file responsible with dealing serial and sending data or receiving data also or commands.

Code Files – Main File:

```
#include "Arduino.h"
#include "AM_Include_All.h"

void setup()
{
  Serial.begin(9600);
  /*==============[Settings of Pins]===============*/
  setPinsConfiguration();
}

void loop()
{
  listenToSerialCommand();
  limitSwRead();
  delay(100);
}

```

Figure 7-24

The main file appears simple because of code organizations and file separation.

Just the required from this file is to import other files and use their functions and methods.

Chapter 8
The Electrical panel

8. THE ELECTRICAL PANEL

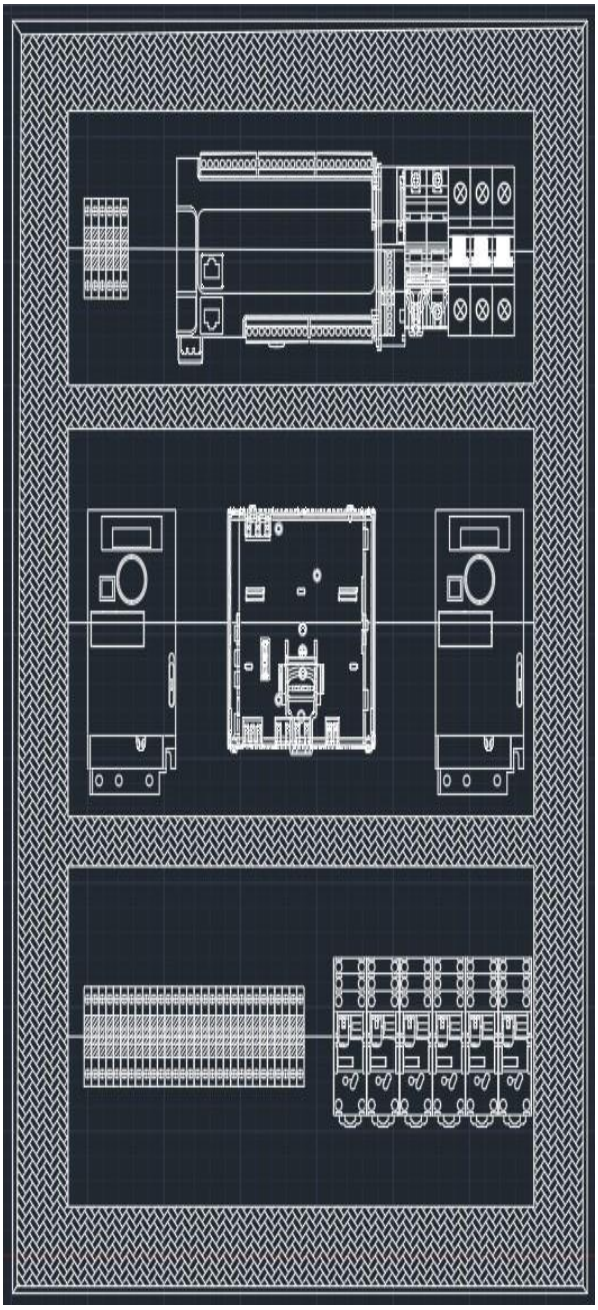


Figure 8-2

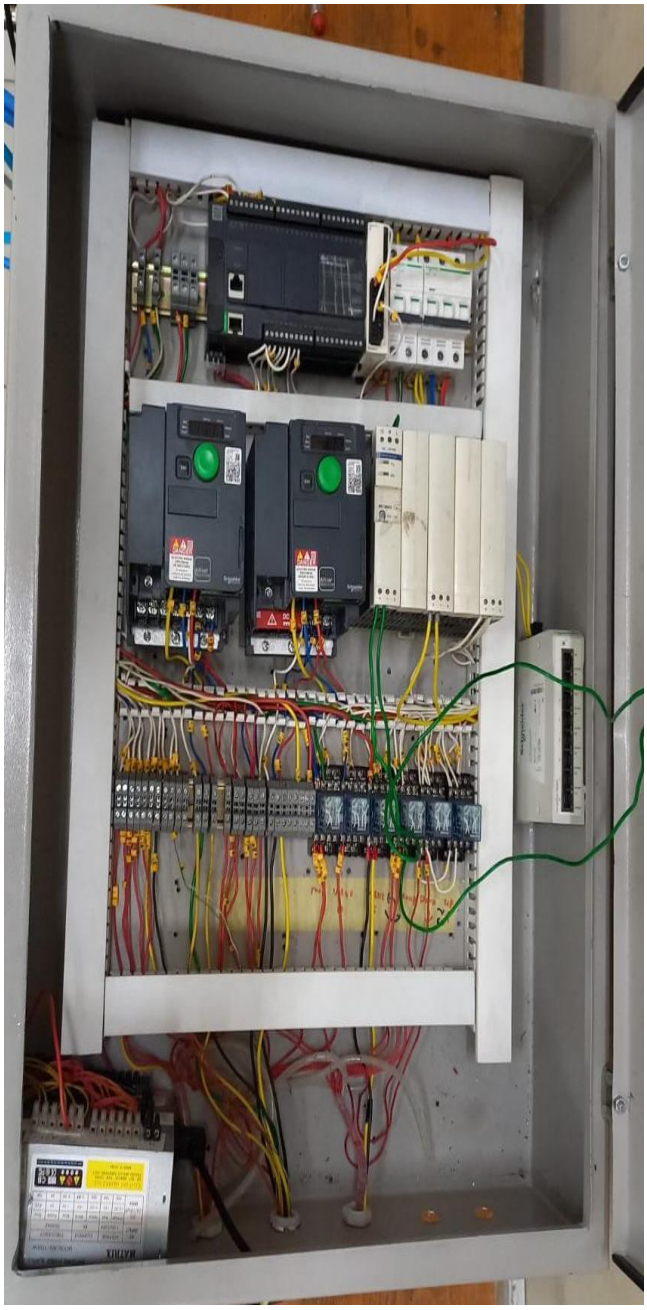


Figure 8-1

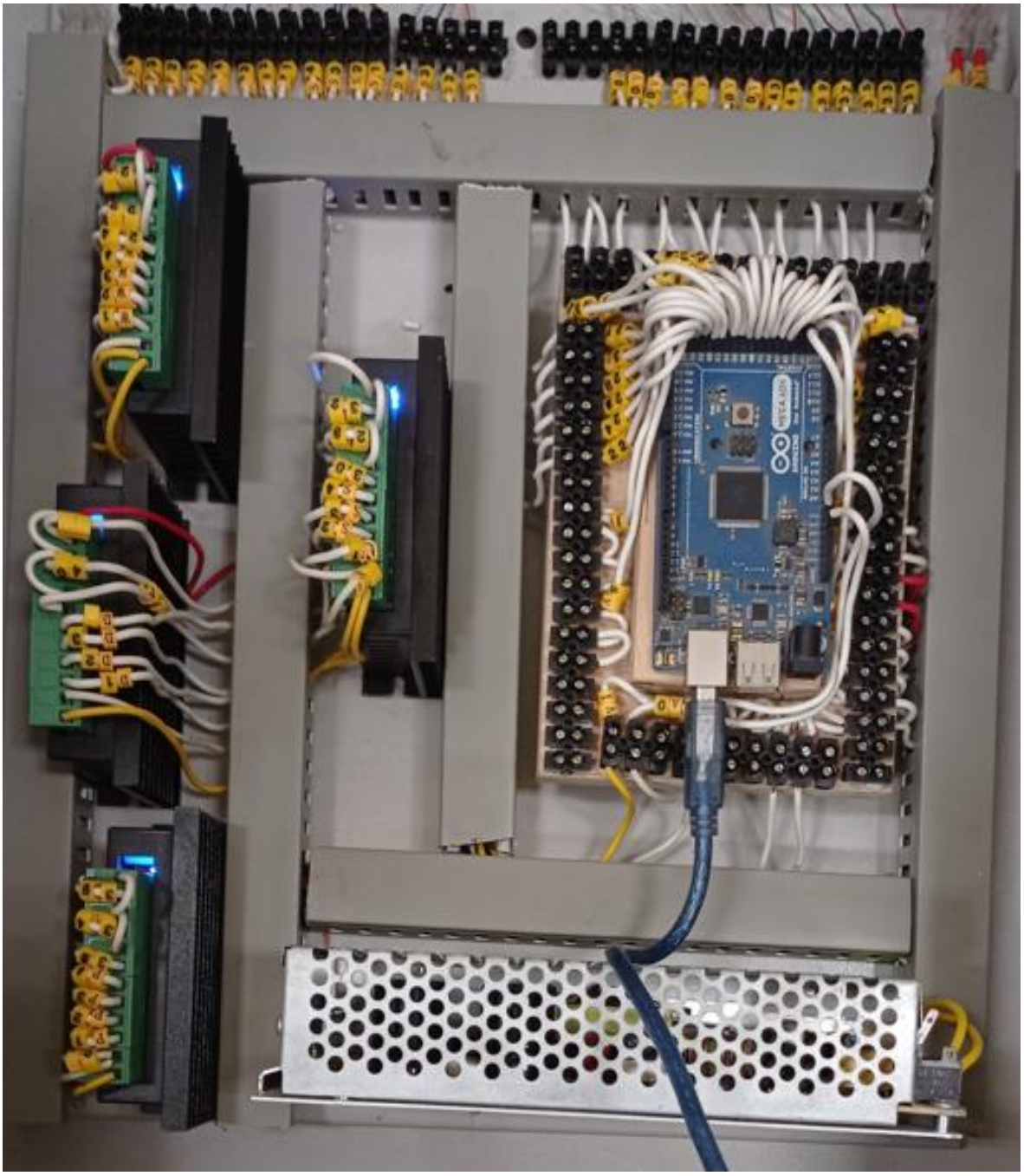


Figure 8-3

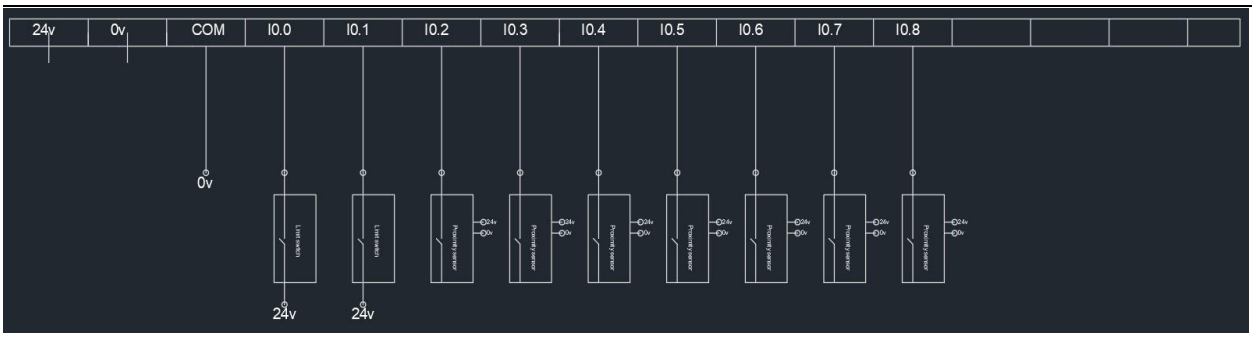


Figure 8-4

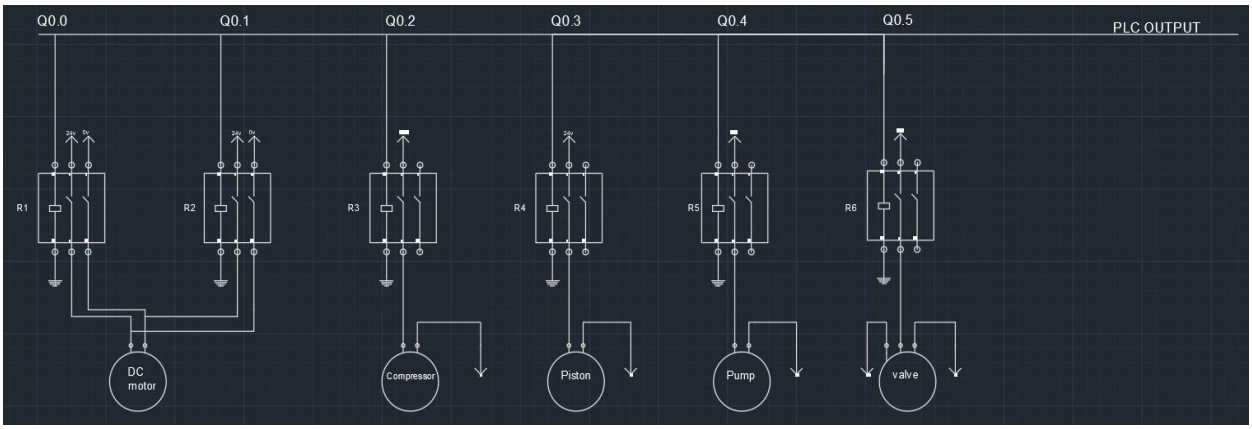


Figure 8-5

Chapter 9
Visualization

9. VISUALIZATION

9.1.HMI

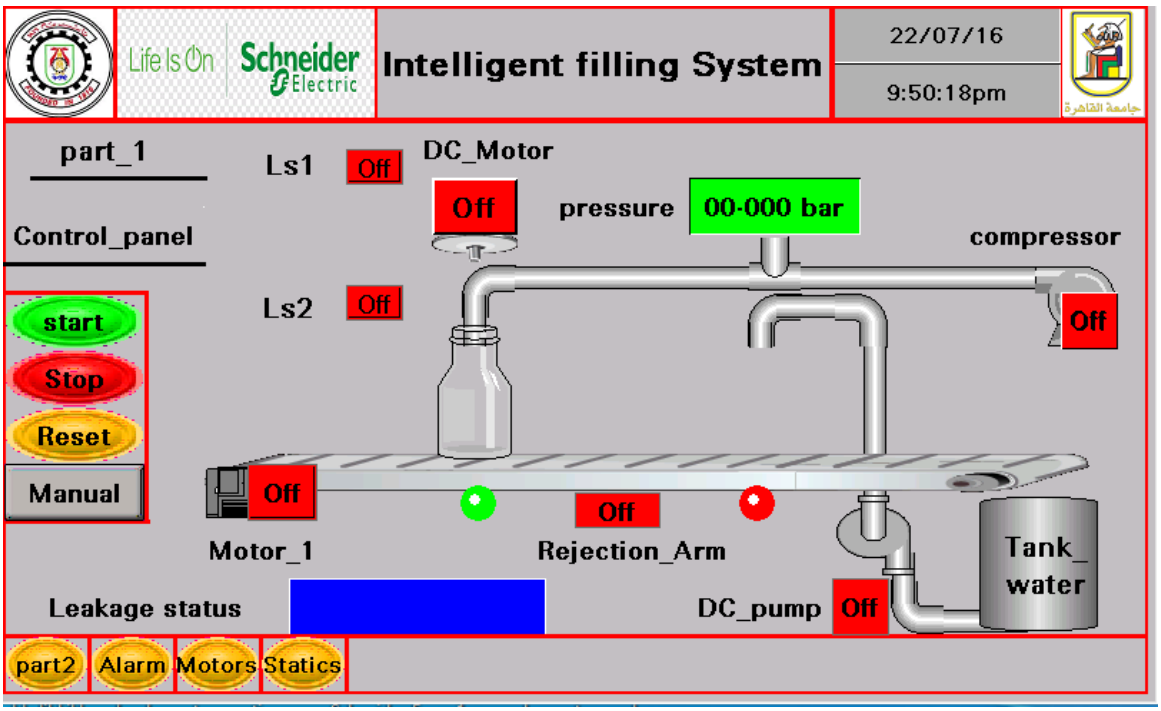


Figure 9-1

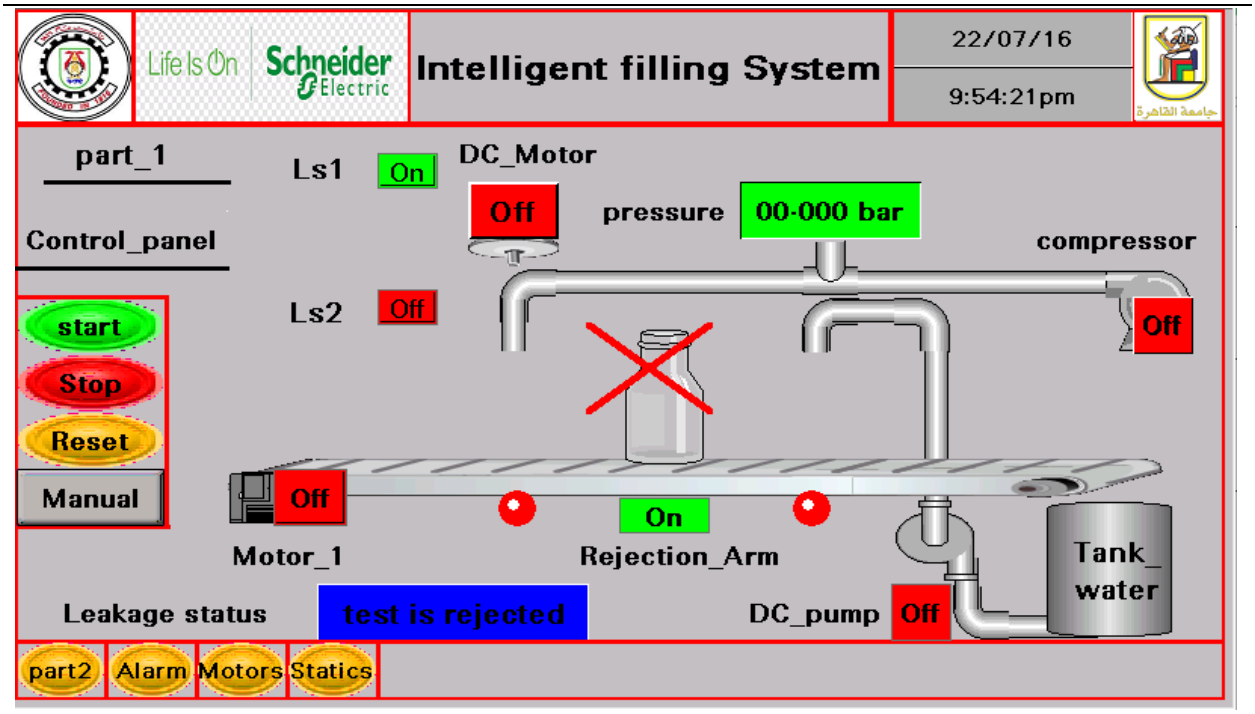


Figure 9-2

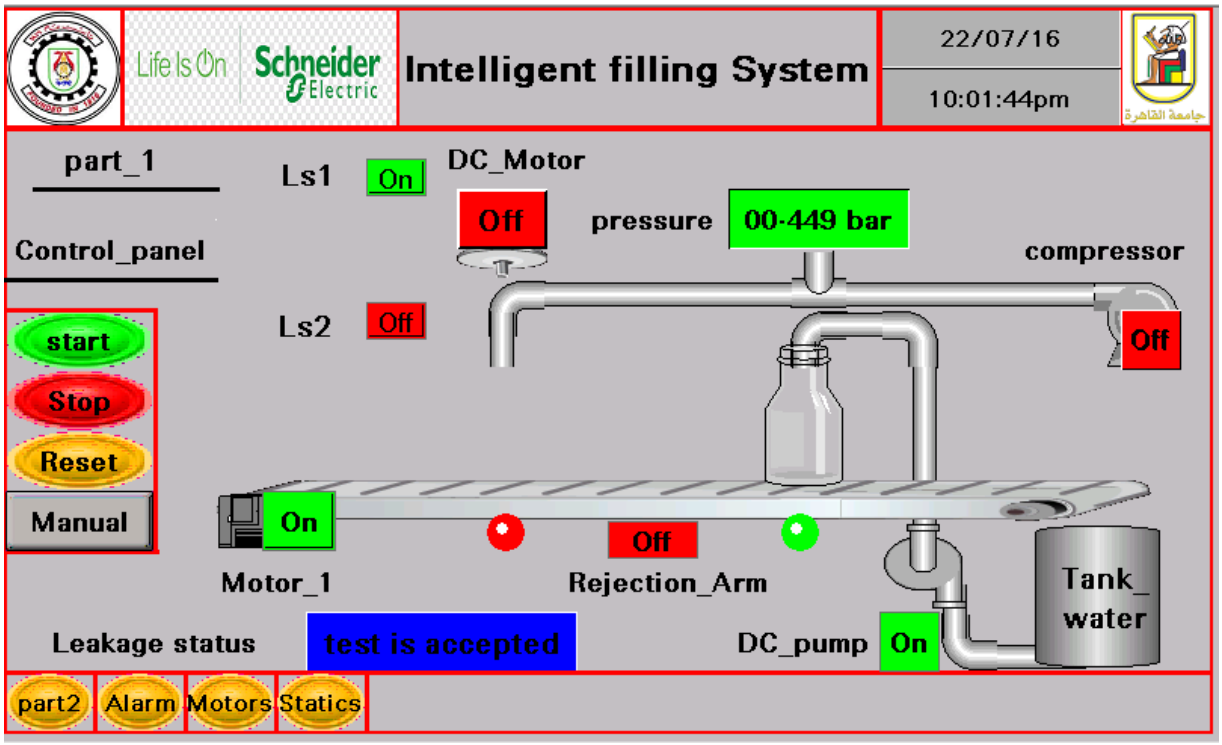


Figure 9-3

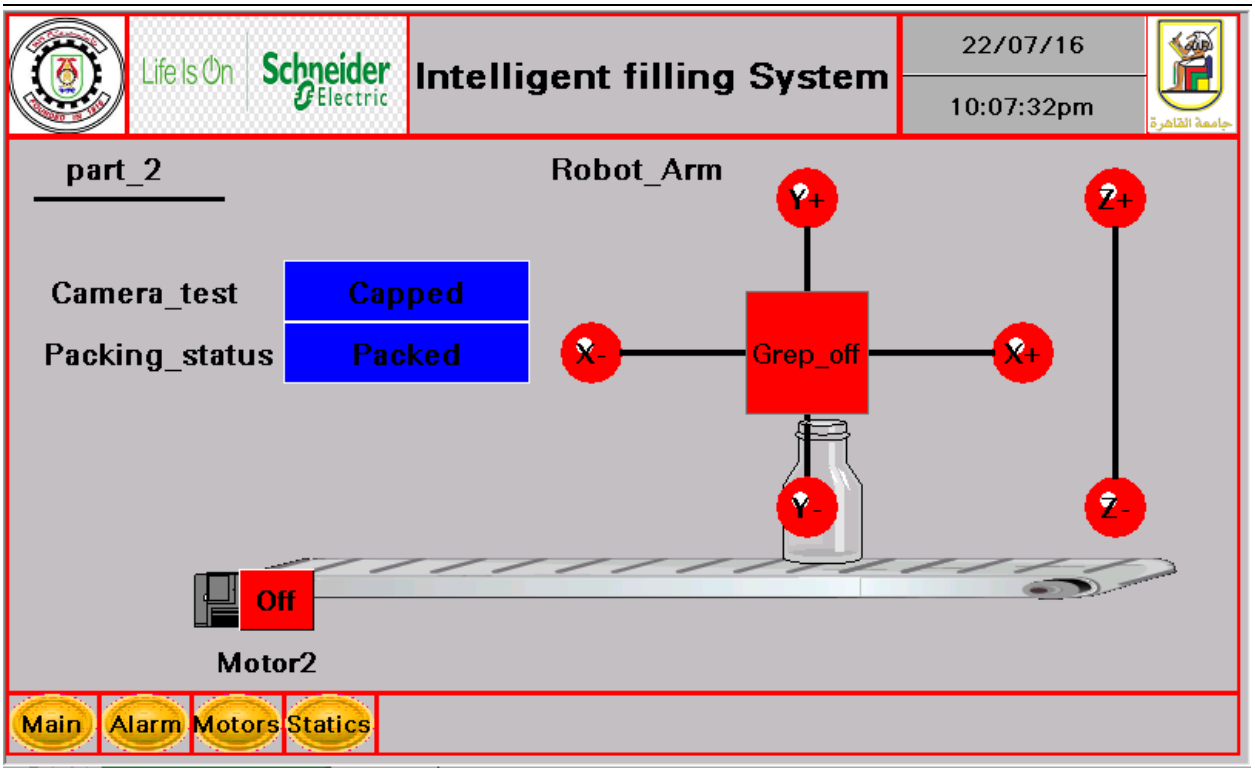


Figure 9-4

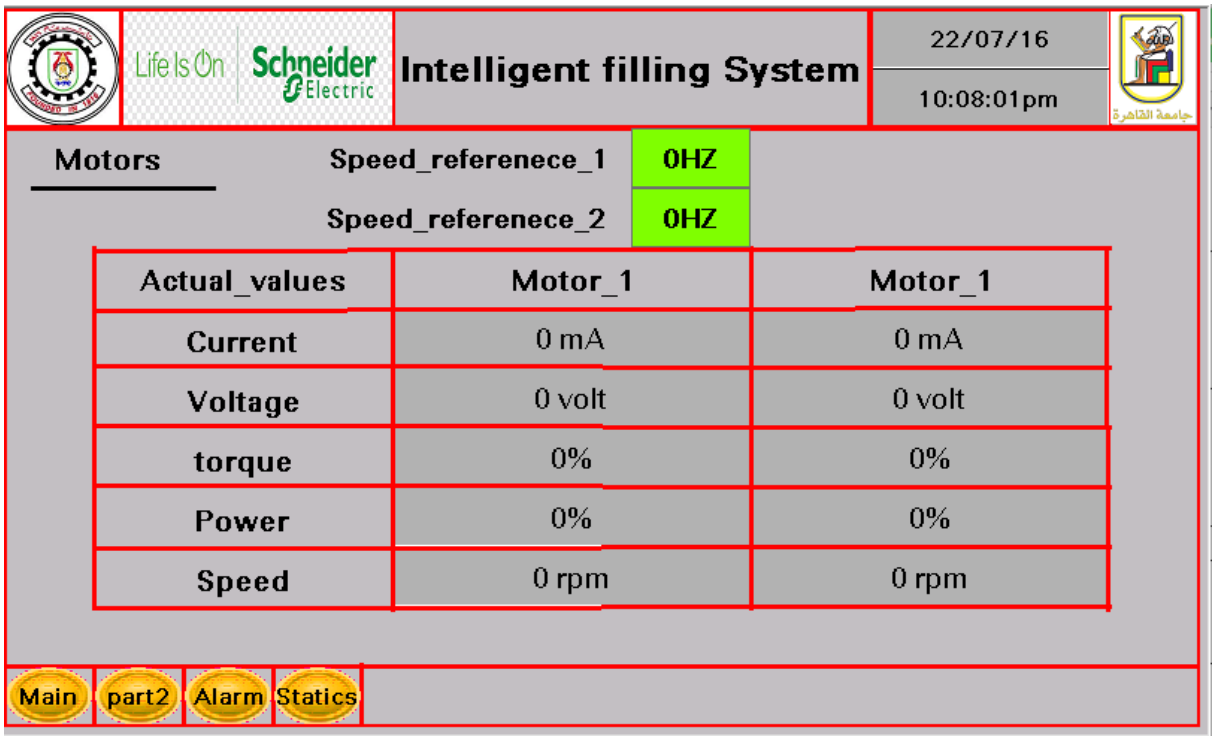


Figure 9-5

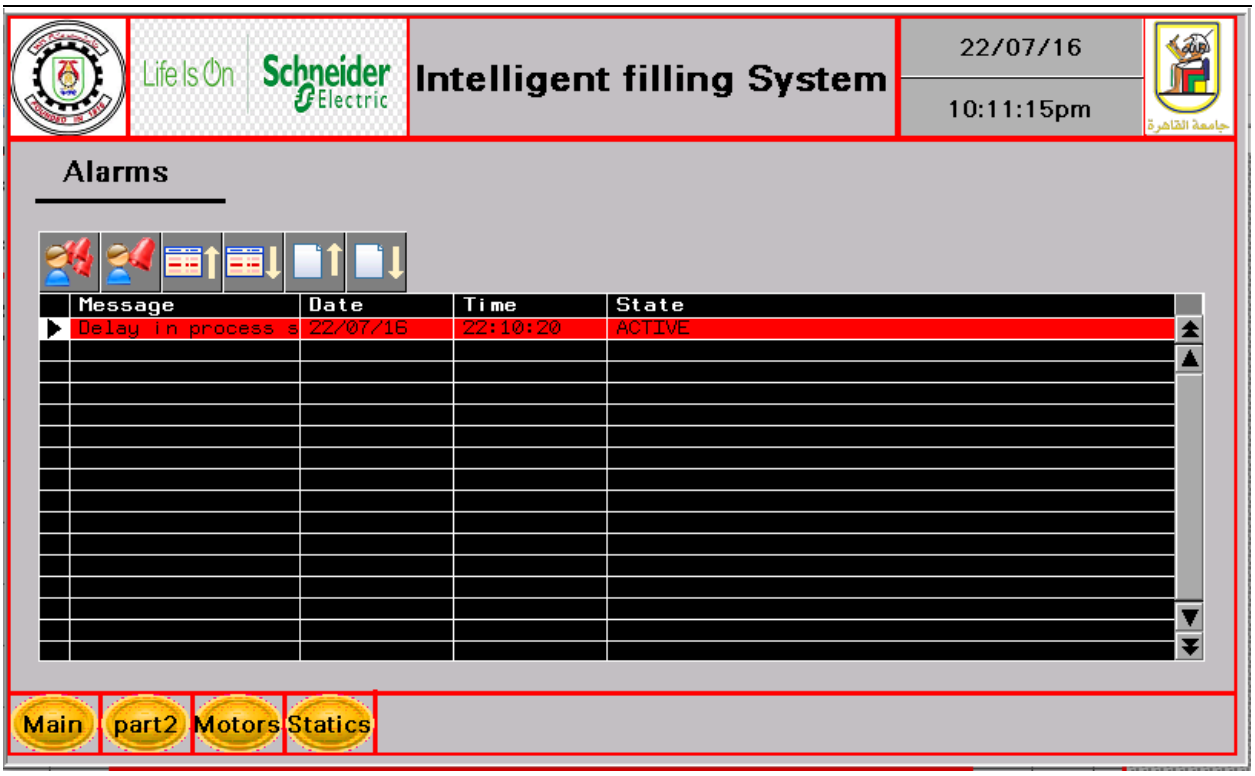


Figure 9-6

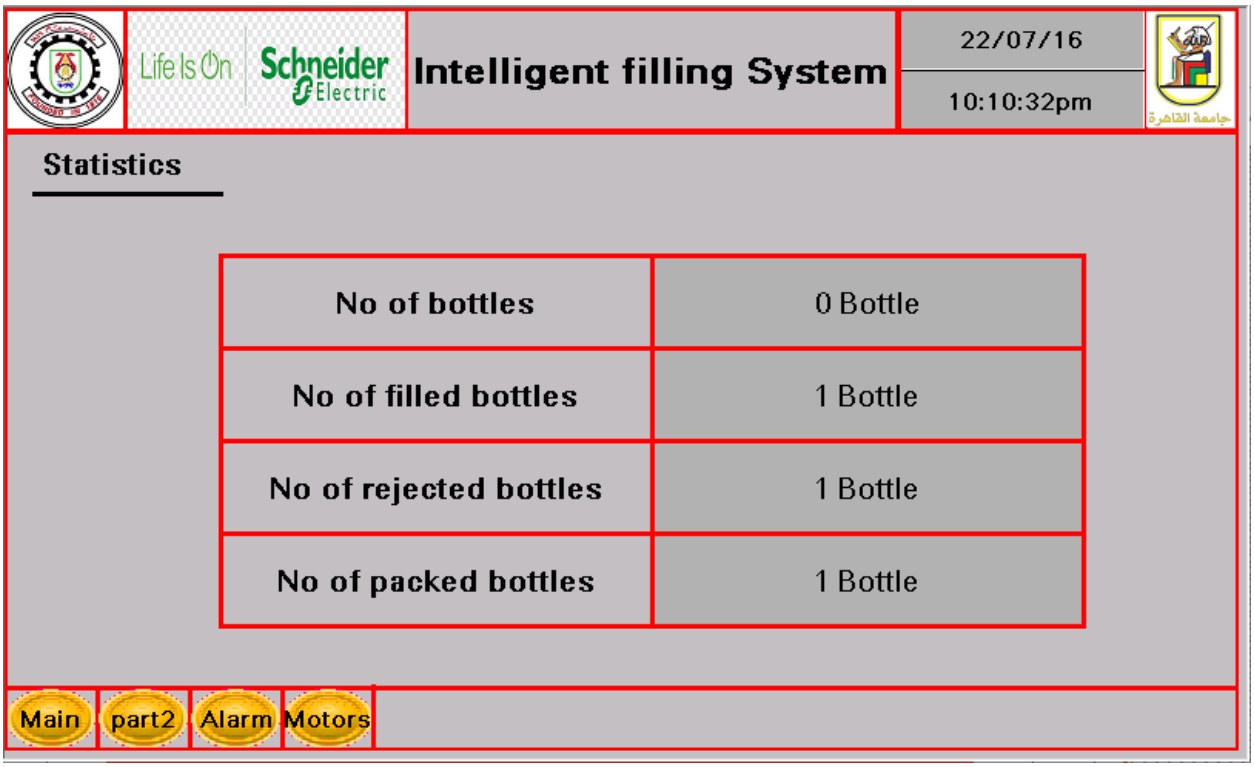


Figure 9-7

9.2.SCADA screens

Figure 9-8

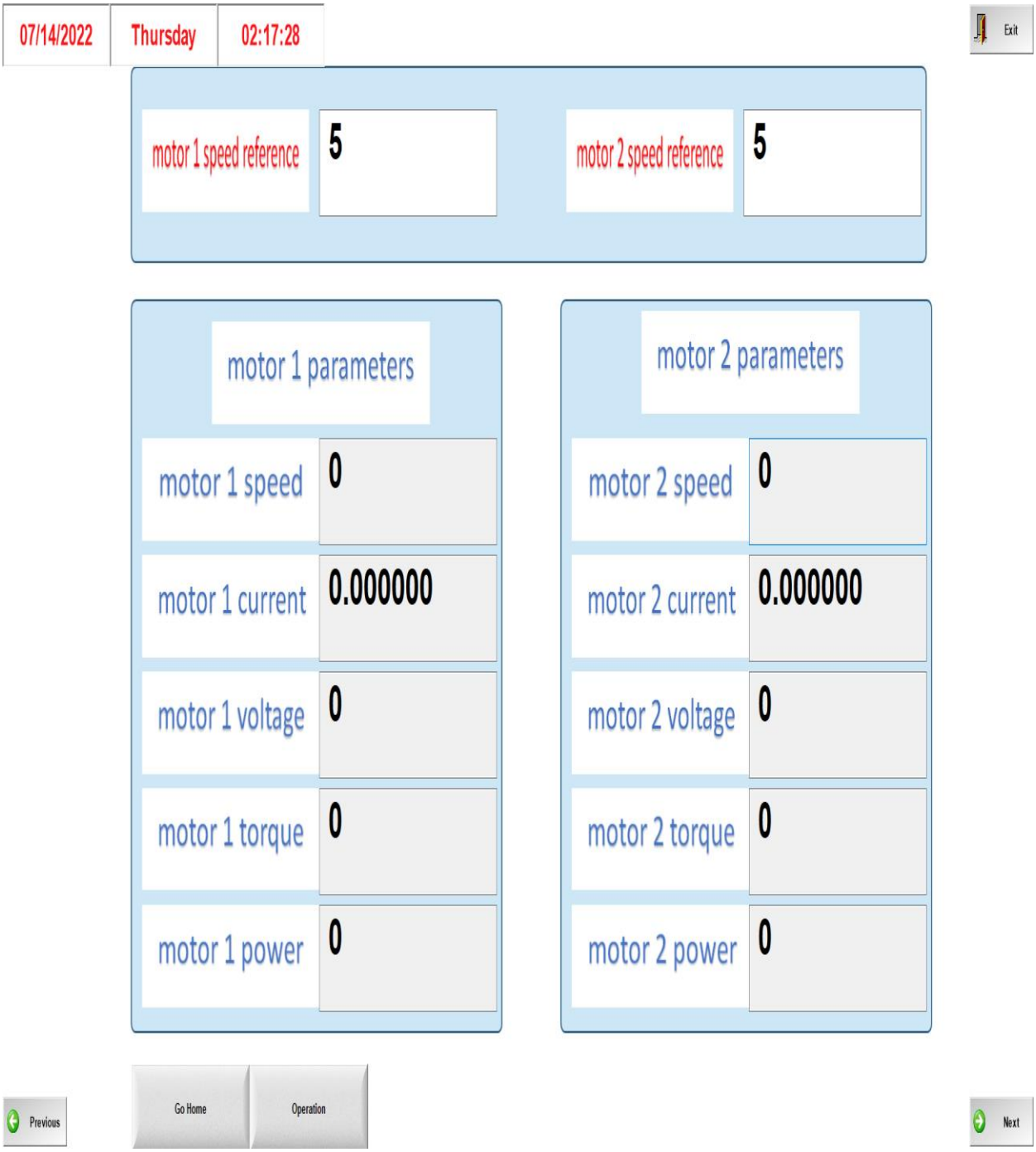

07/14/2022
Thursday
02:17:28
Exit
motor 1 speed reference
5
motor 2 speed reference
5
motor 1 parameters
motor 1 speed
0
motor 1 current
0.000000
motor 1 voltage
0
motor 1 torque
0
motor 1 power
0
motor 2 parameters
motor 2 speed
0
motor 2 current
0.000000
motor 2 voltage
0
motor 2 torque
0
motor 2 power
0
Previous
Go Home
Operation
Next

Figure 9-9

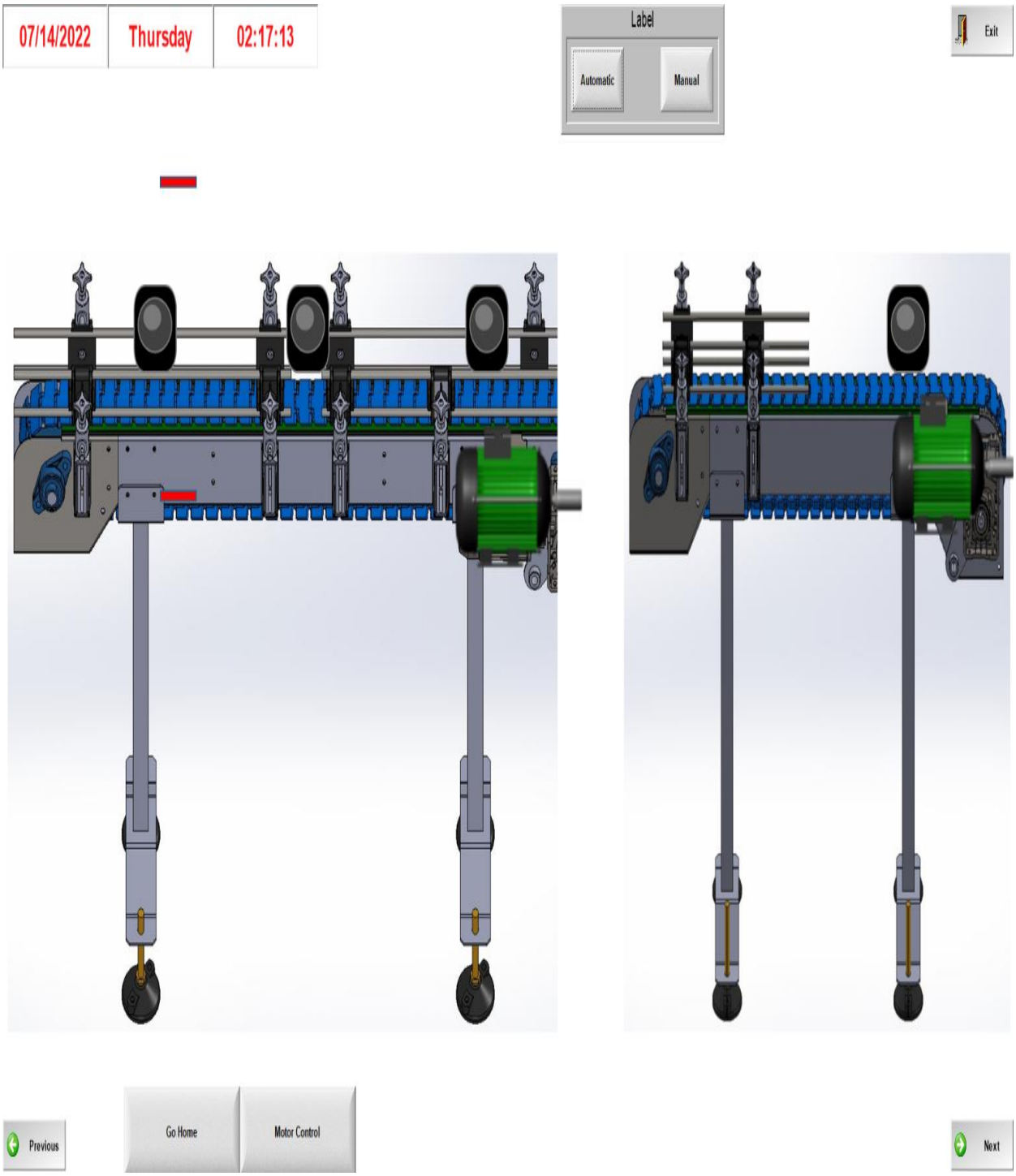

07/14/2022
Thursday
02:17:13
Label
Automatic
Manual
Exit
Previous
Go Home
Motor Control
Next

Figure 9-10

9.3.Dashboard

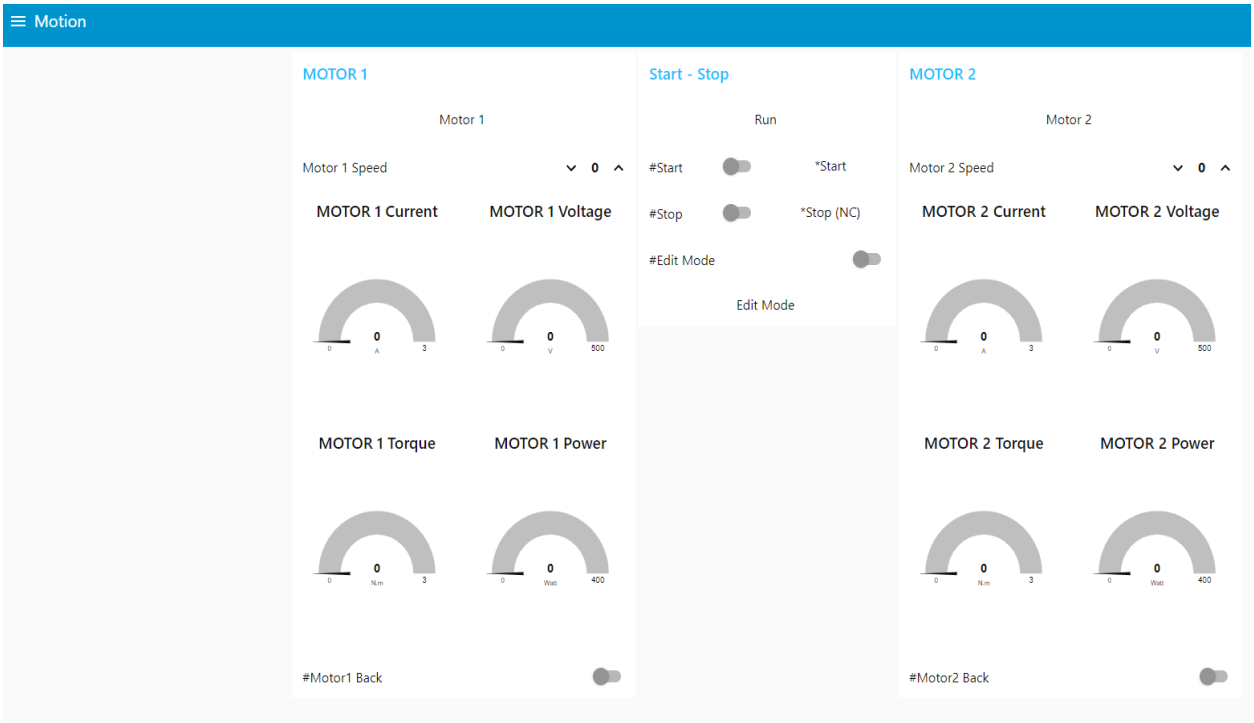


Figure 9-11

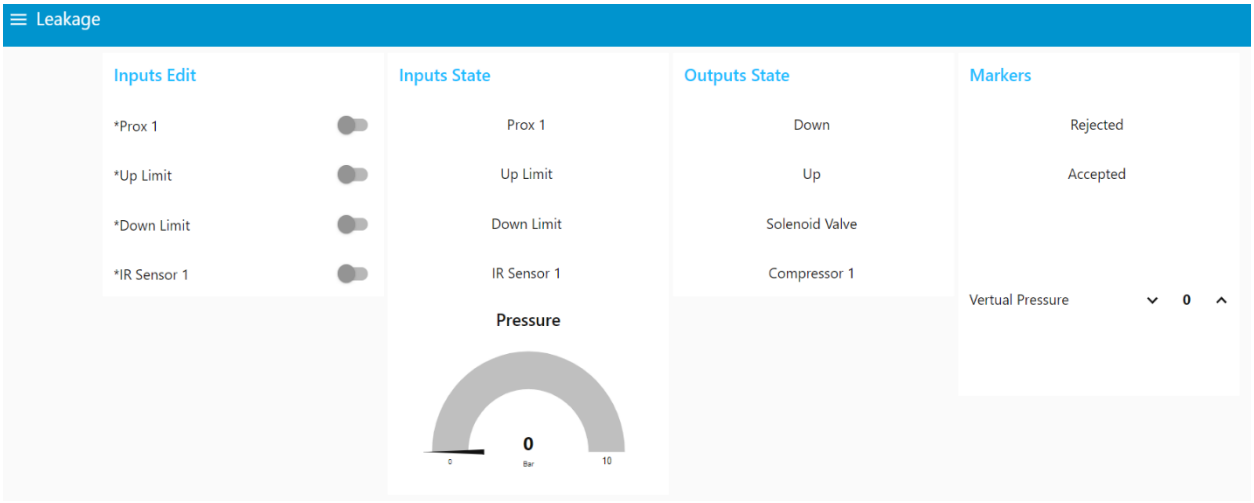


Figure 9-12

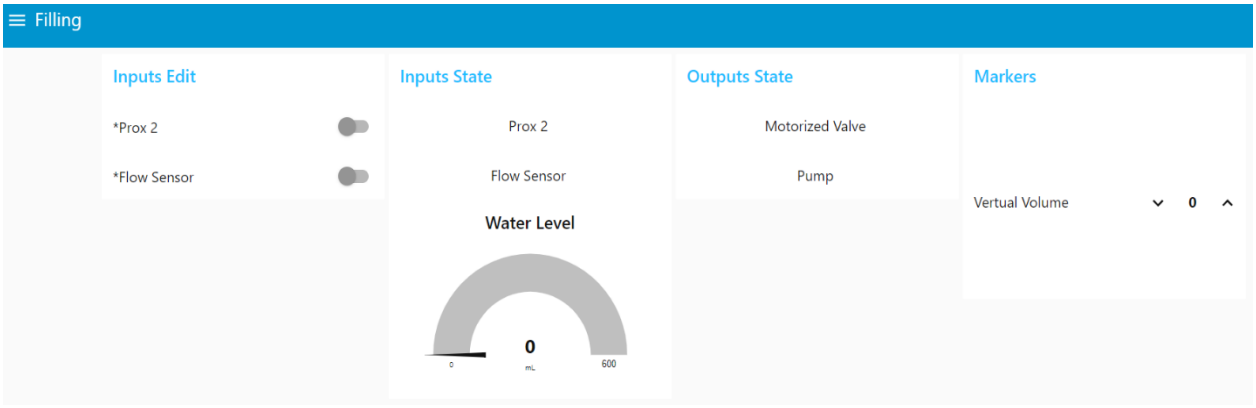


Figure 9-13

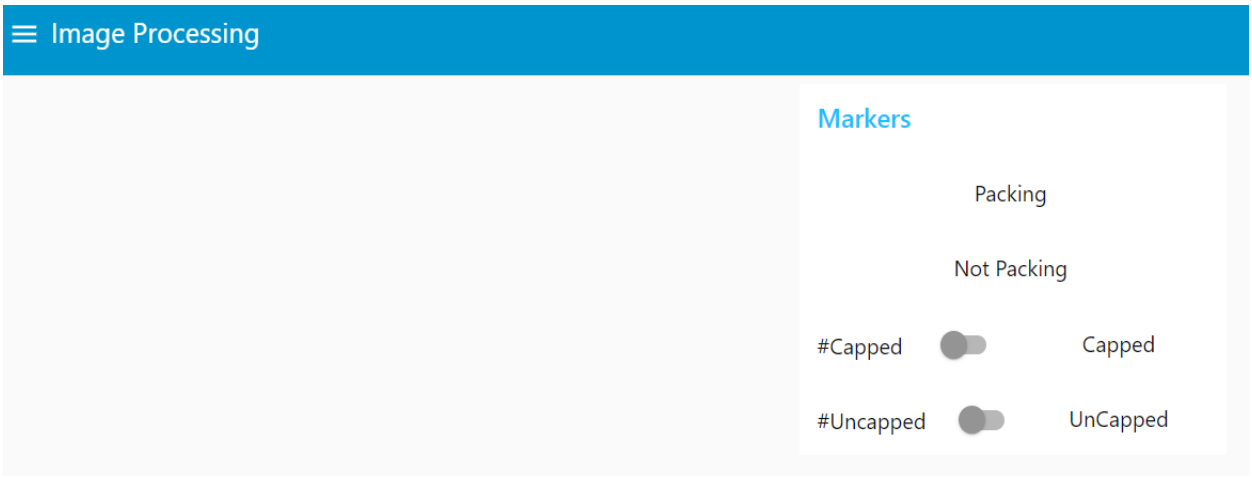


Figure 9-14

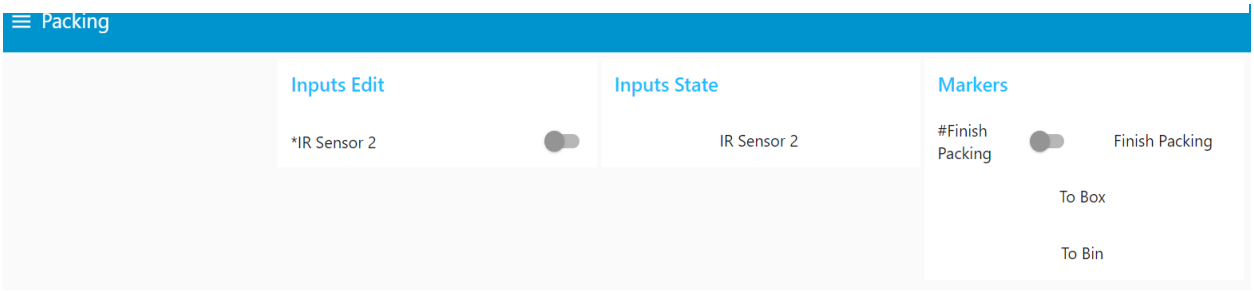


Figure 9-15

9.4.Mobil application (IOT)

9.4.1. Remote Red App

To log in Dashboard you can use remote red mobile application (googel play store) and remote red node .

Figure 9-16

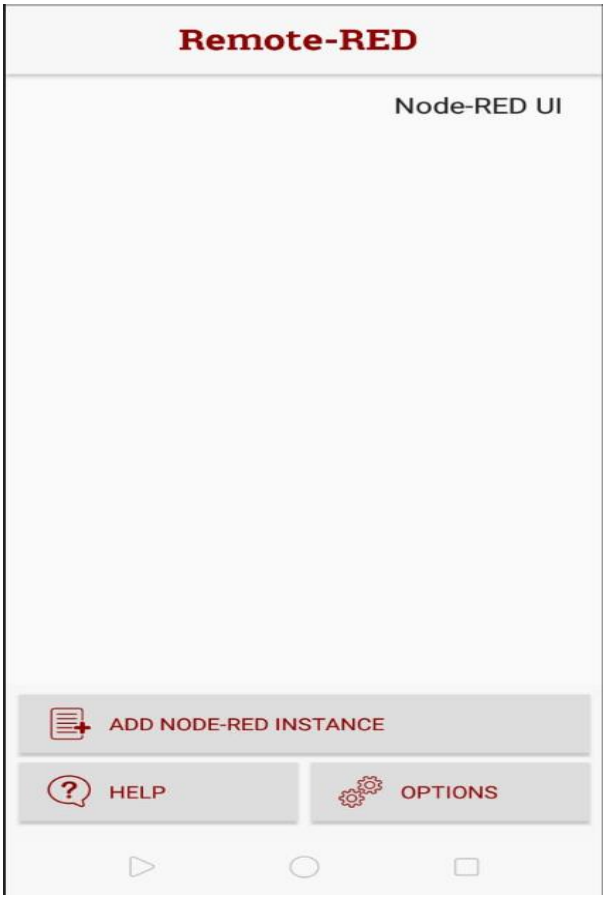


Figure 9-18

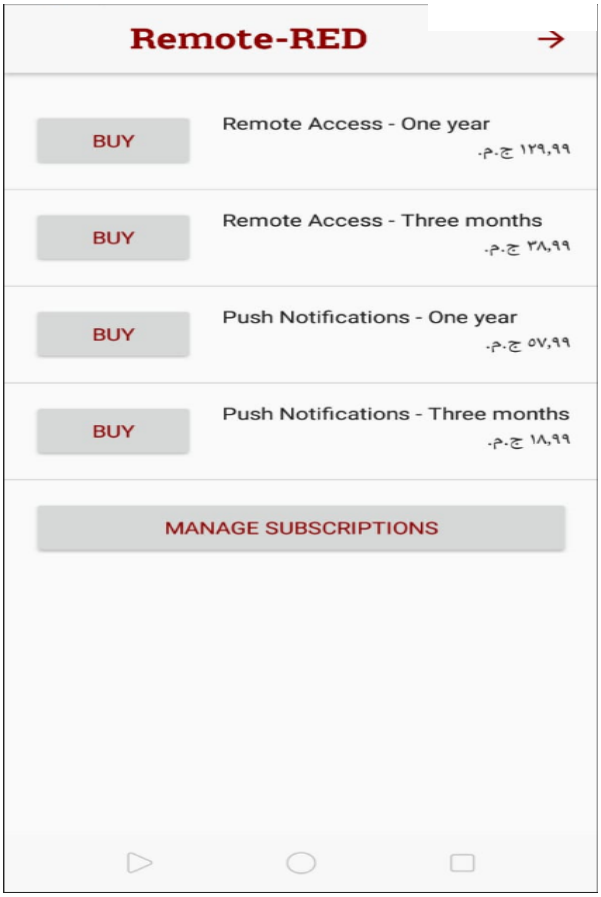


Figure 9-17

9.4.2. Mobile Application (Flutter)

1.Welcome Screen

Figure 9-19

2. Home Page

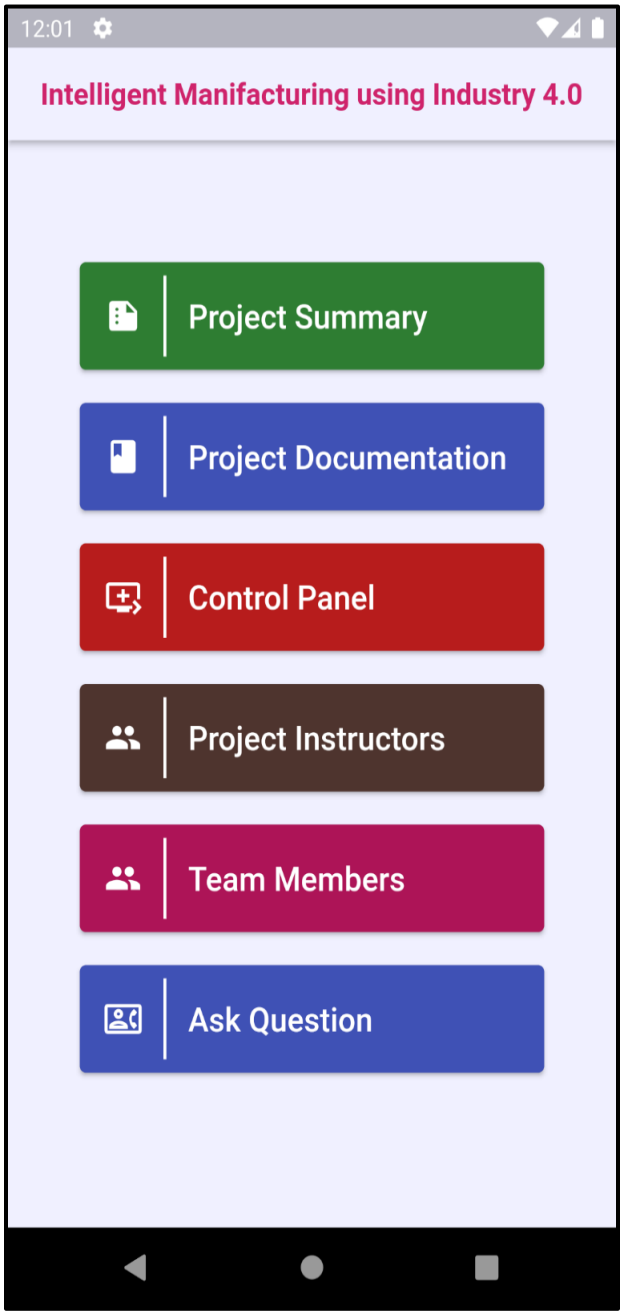


Figure 9-20

3. Control Panel Page

1. Remote Server

Run the Public-RED application on the PC that has the Node-RED.

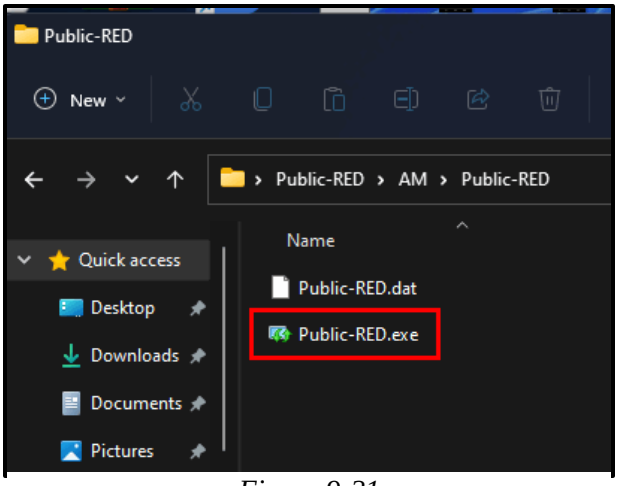


Figure 9-21

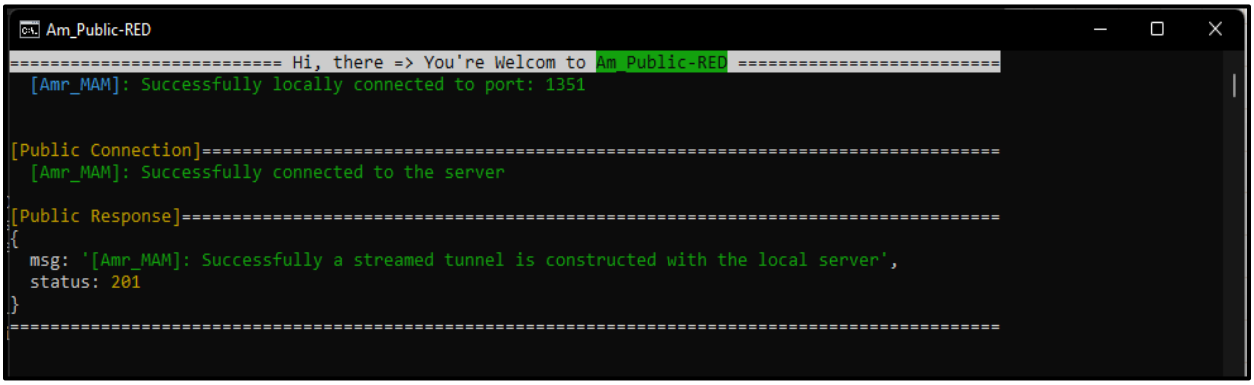


Figure 9-22

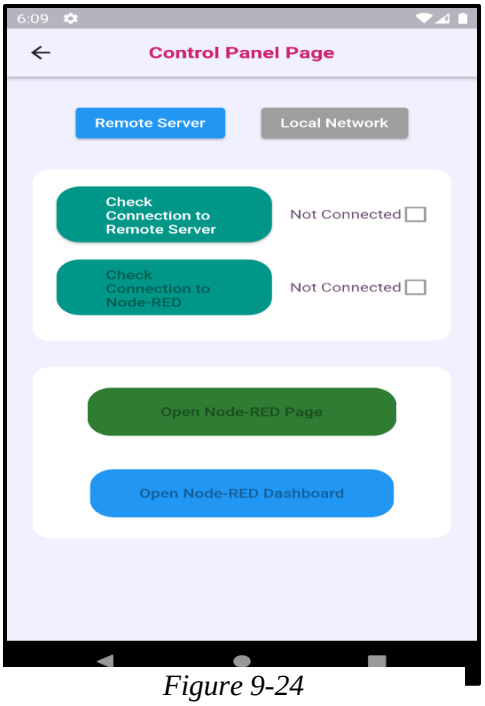


Figure 9-24

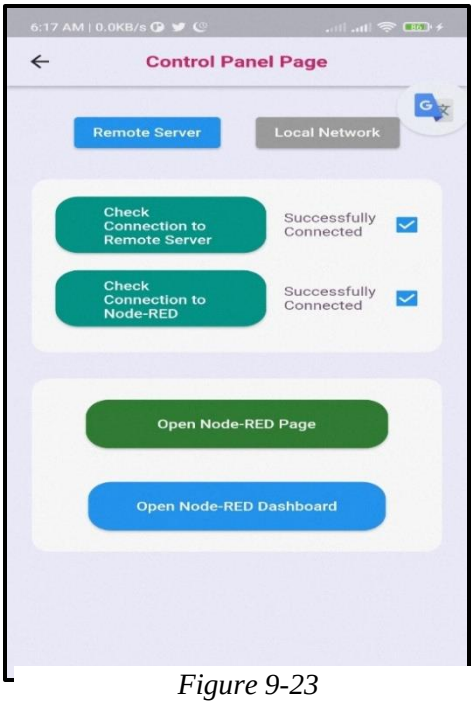


Figure 9-23

2. For Local Connection

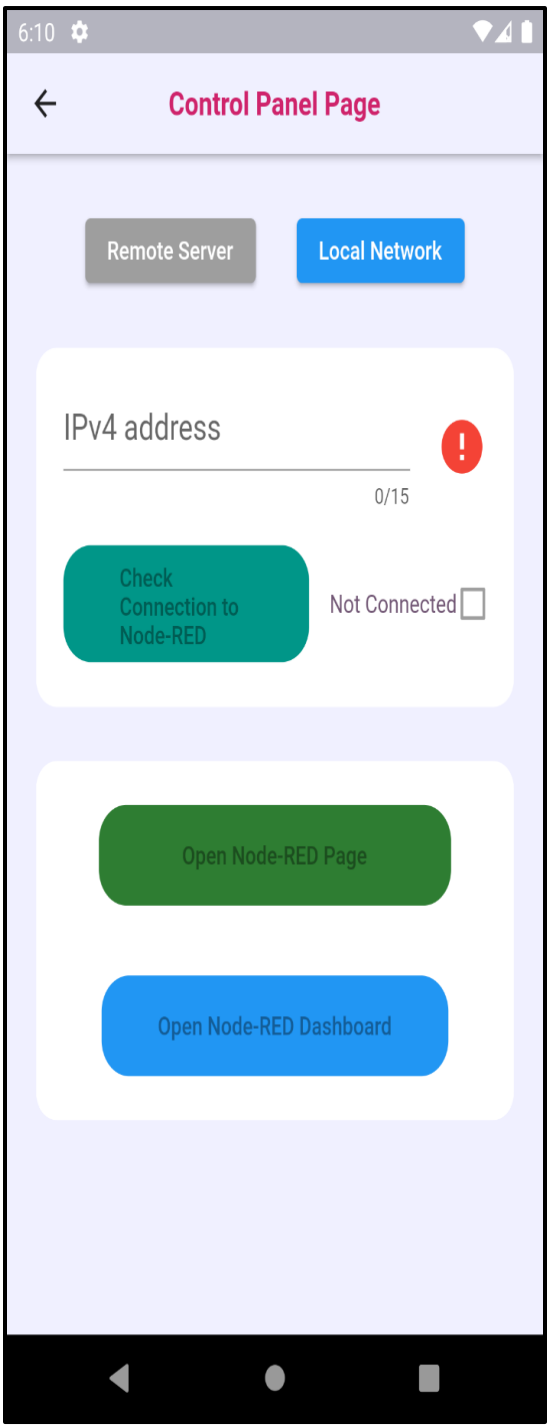


Figure 9-25

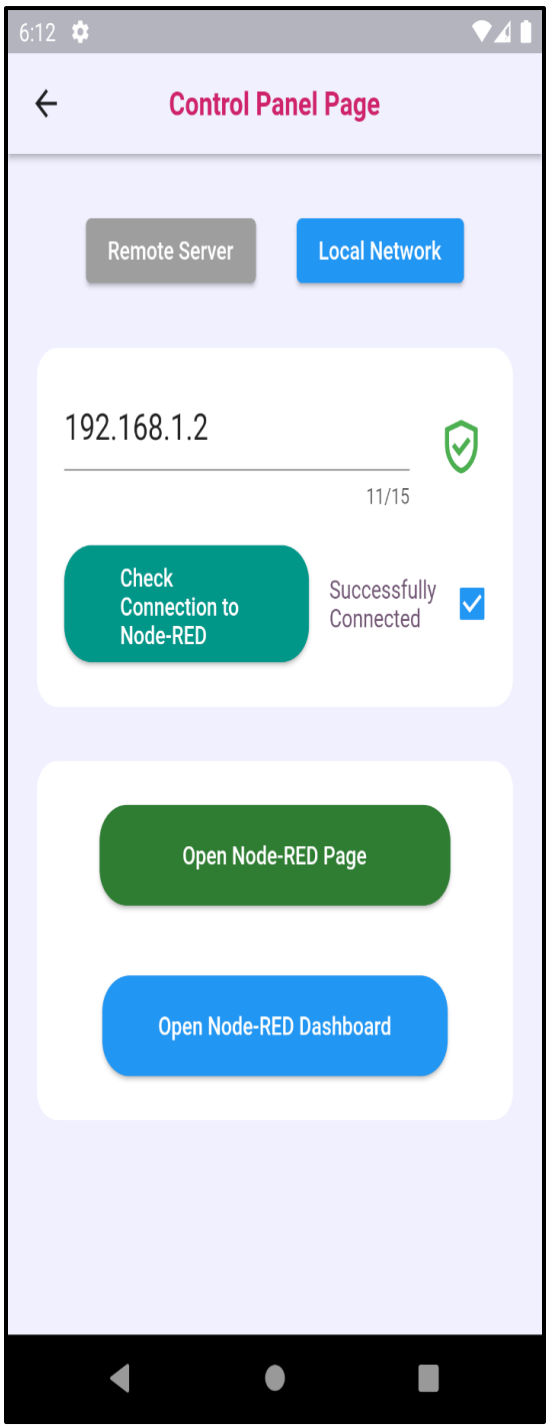


Figure 9-26

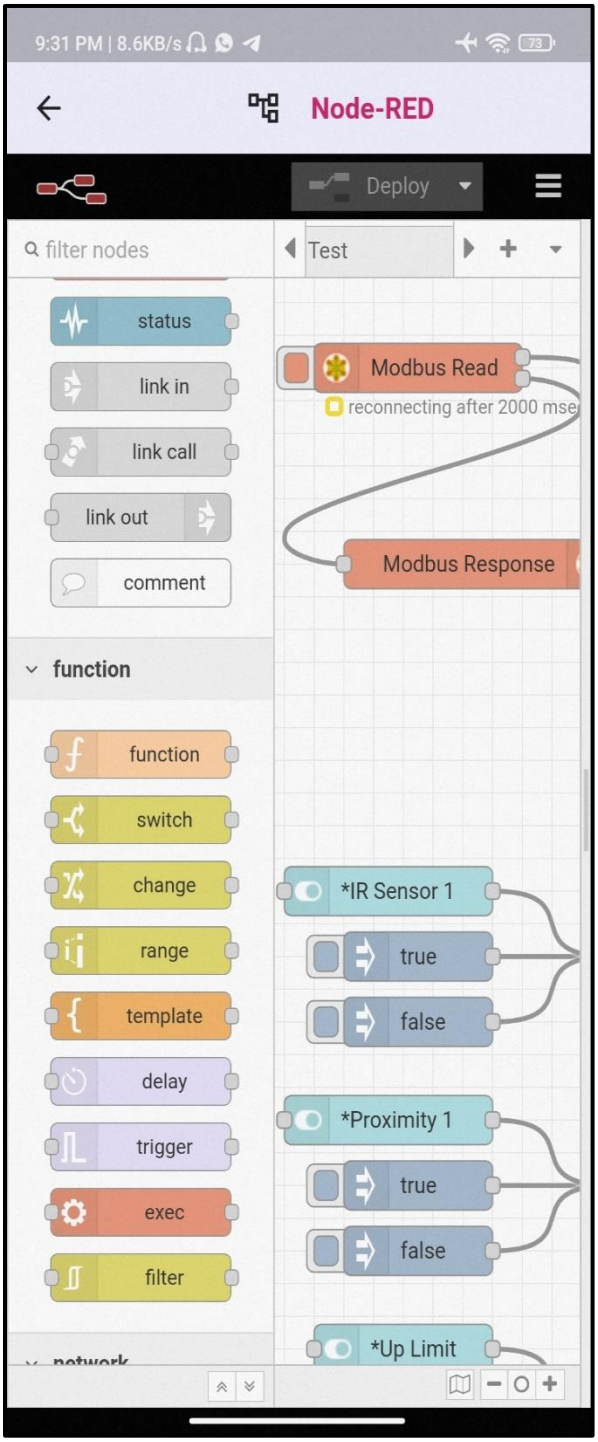


Figure 9-27

Figure 9-28

5. Team member Page (click to see the cv):

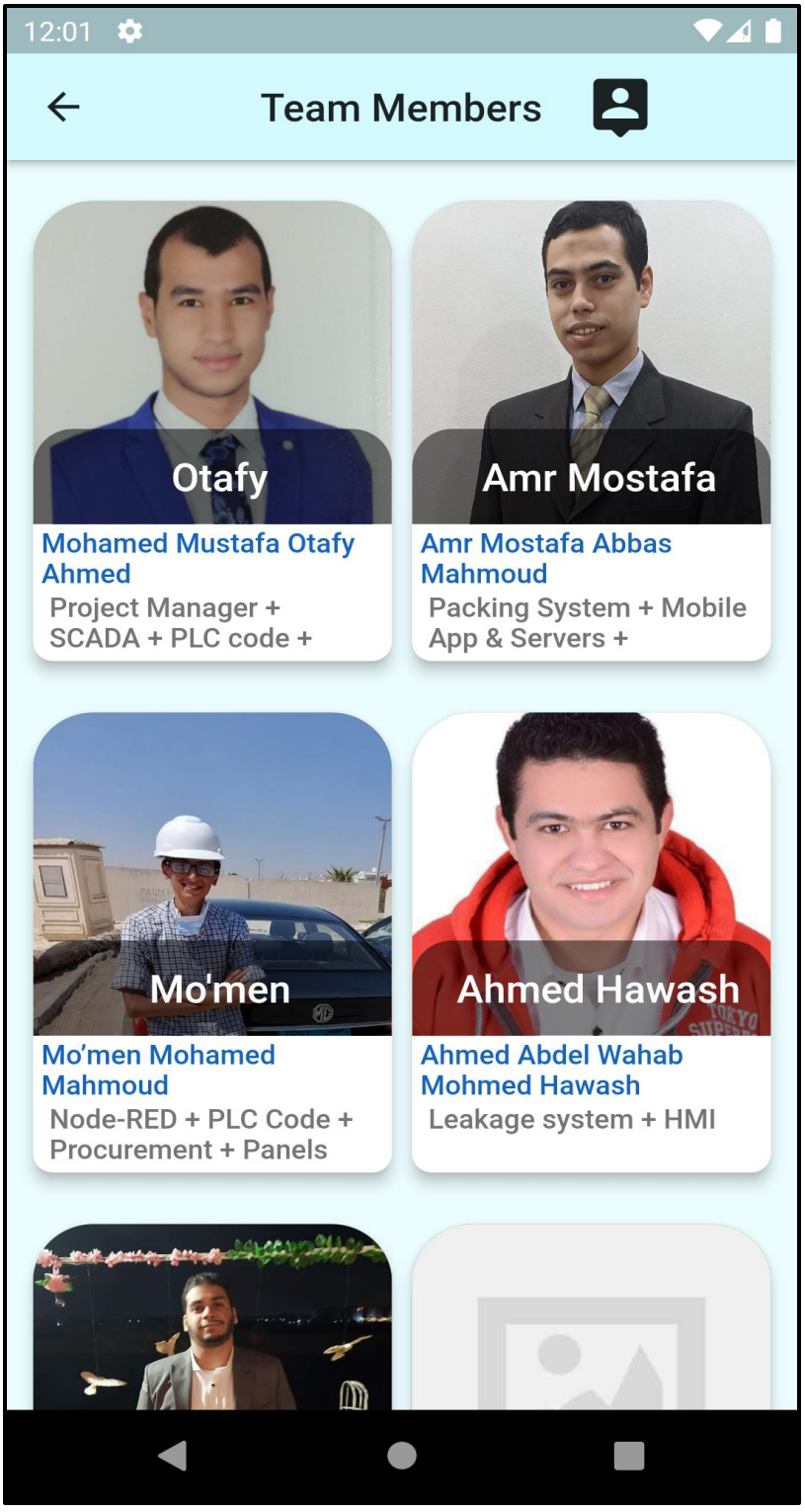


Figure 9-29

6. Project instructors Page

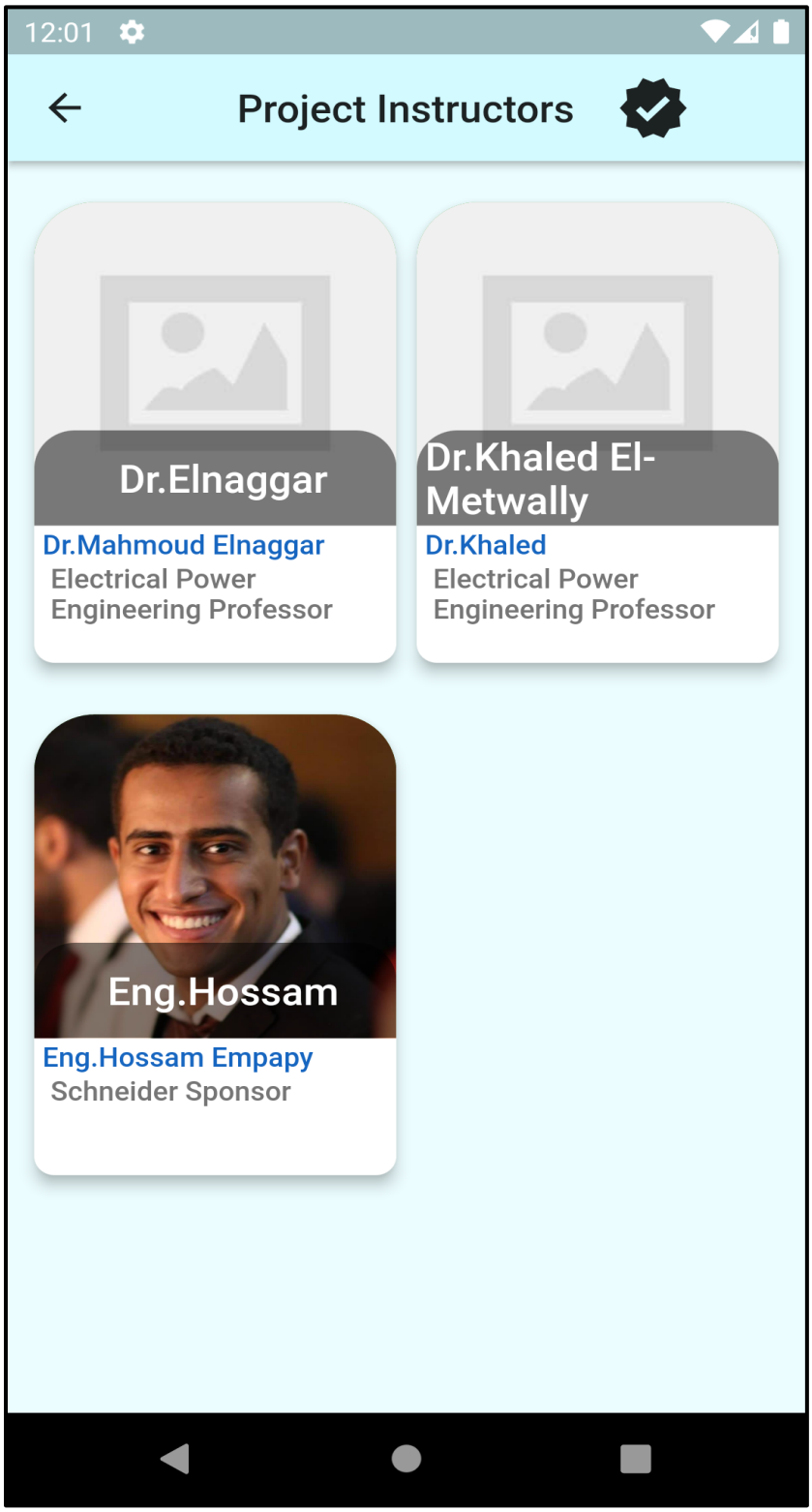


Figure 9-30

7. Ask Question Page

these Message will reach us in Telegram

Note: the phone no must have WhatsApp or Telegram

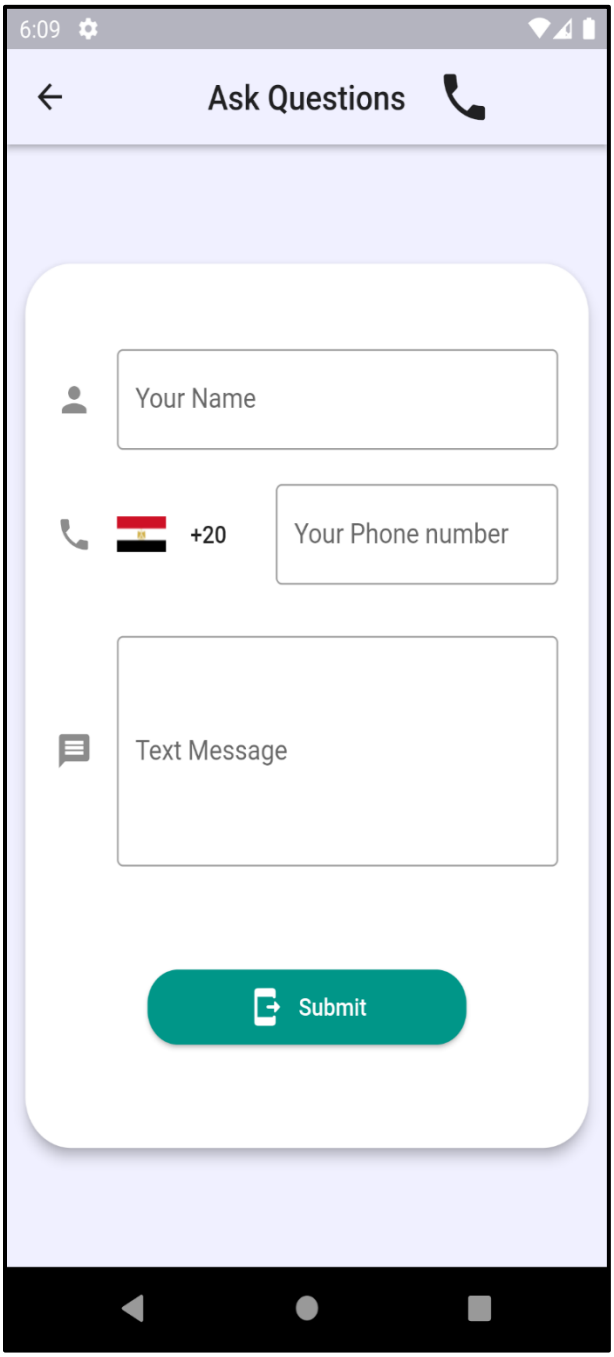


Figure 9-31

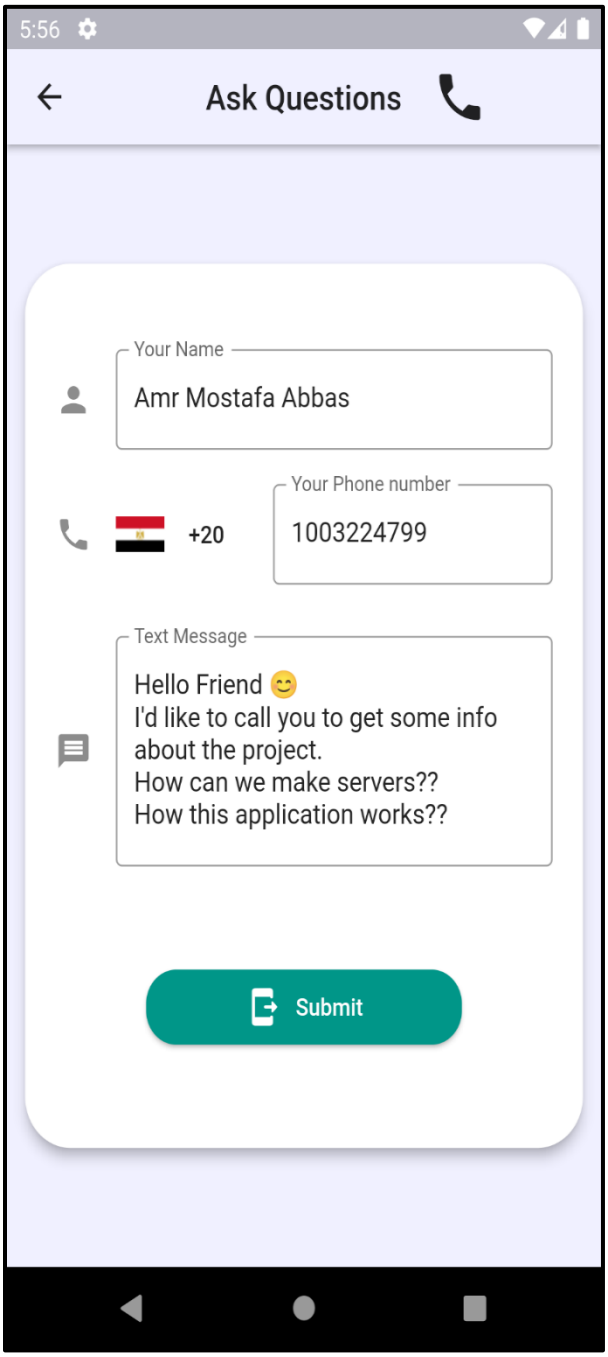


Figure 9-32

8. The message reached Telegram

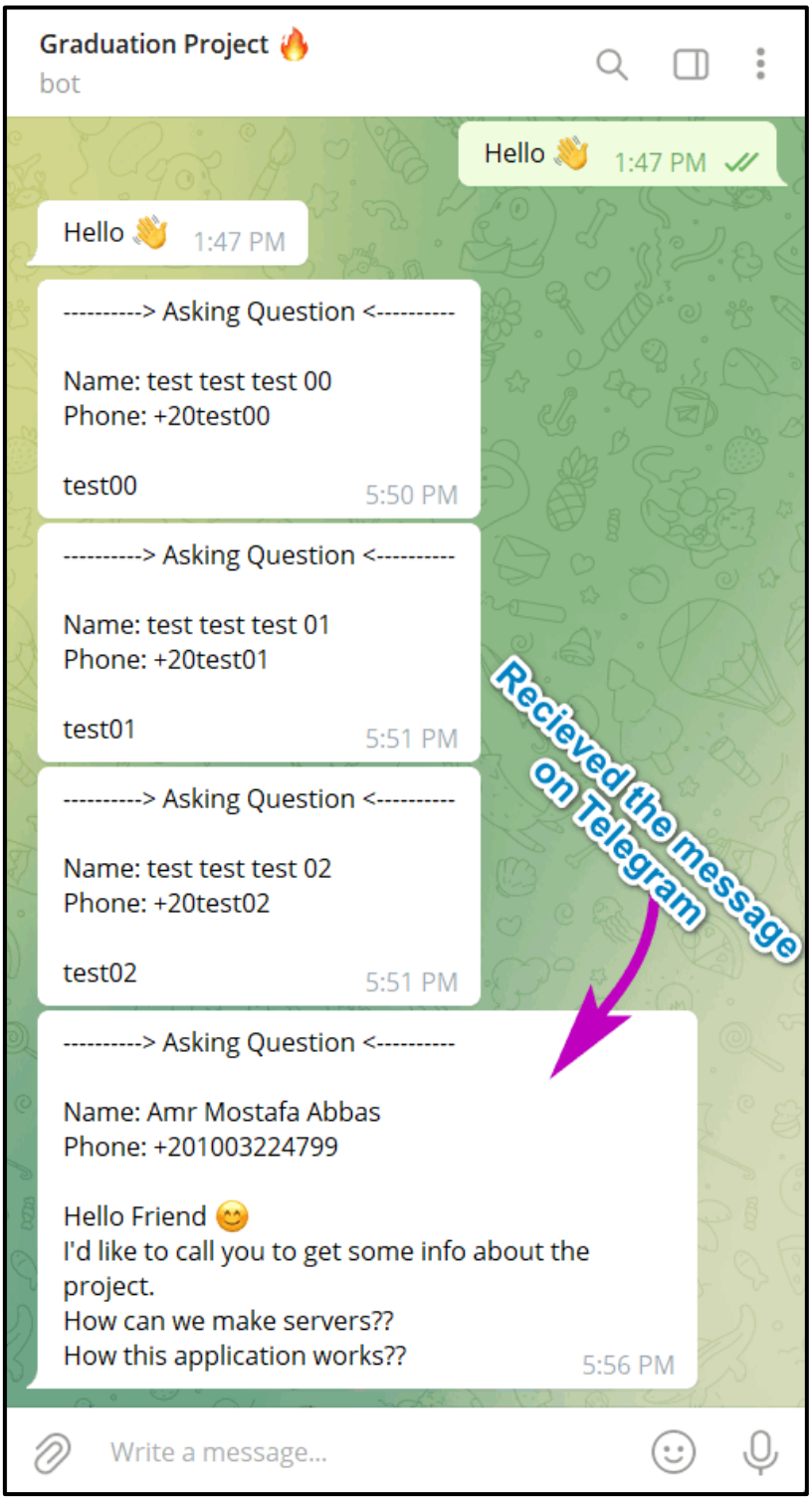


Figure 9-33

Chapter 10
Communication

10. COMMUNICATION

In this chapter we explain the used method to connect the project devices (PLC – VFD – HMI – SCADA – Mobile)

10.1. introduction

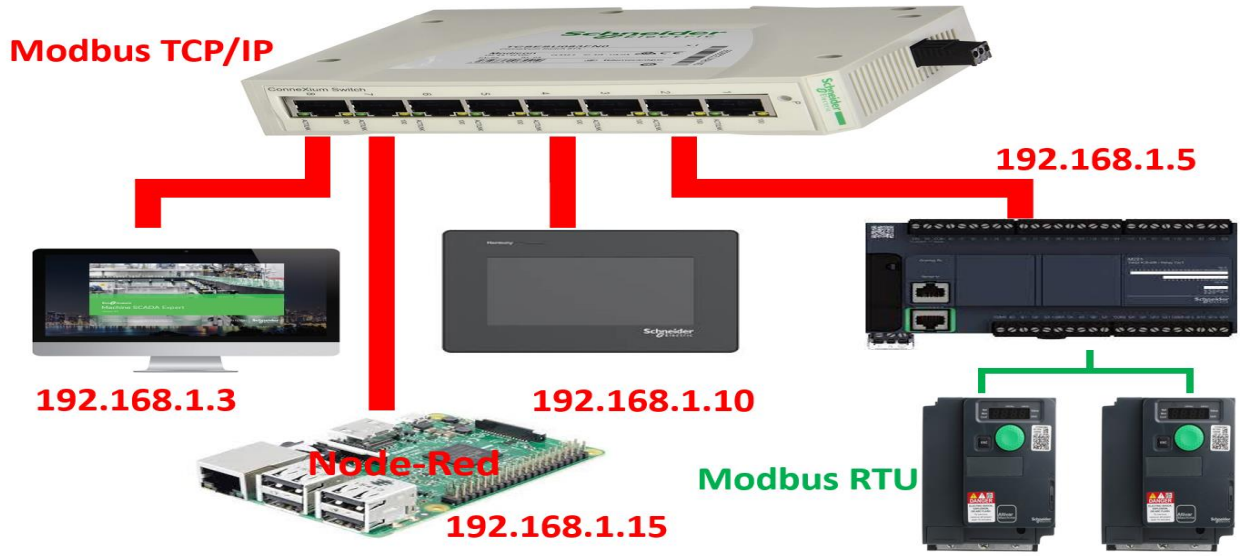


Figure 10-1

At first

We established a Modbus Serial RS485 network to connect PLC (Master Device) with 2 VFD (Slave 1 – Slave 2)

Then

We established a Modbud TCP/IP Ethernet network to connect PLC (ipv4: 192.168.1.5) , HMI (ipv4: 192.168.1.10) , SCADA (ipv4: 192.168.1.3) & Node-Red (ipv4: 192.168.1.15).

Hint : the selected ip addresses must be in the same domain

The node-red is conciderd as a system gateway to the cloud connection

10.2. Node-red

Installation & Get Started

Step 1: Download Node.js

https://nodejs.org/en/download/

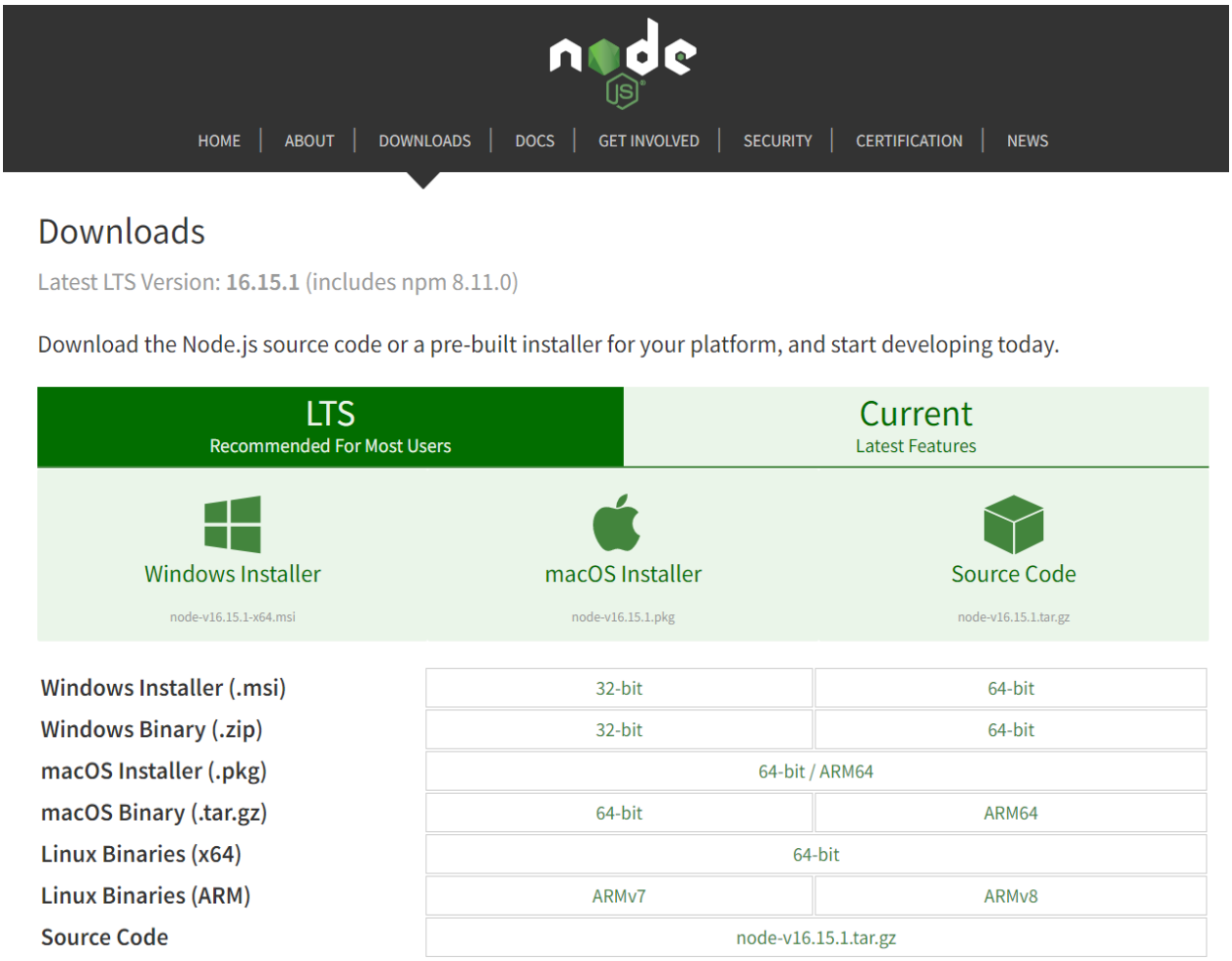


Figure 10-2

Step 2: Installing with npm

Open **cmd** then write **`npm`**

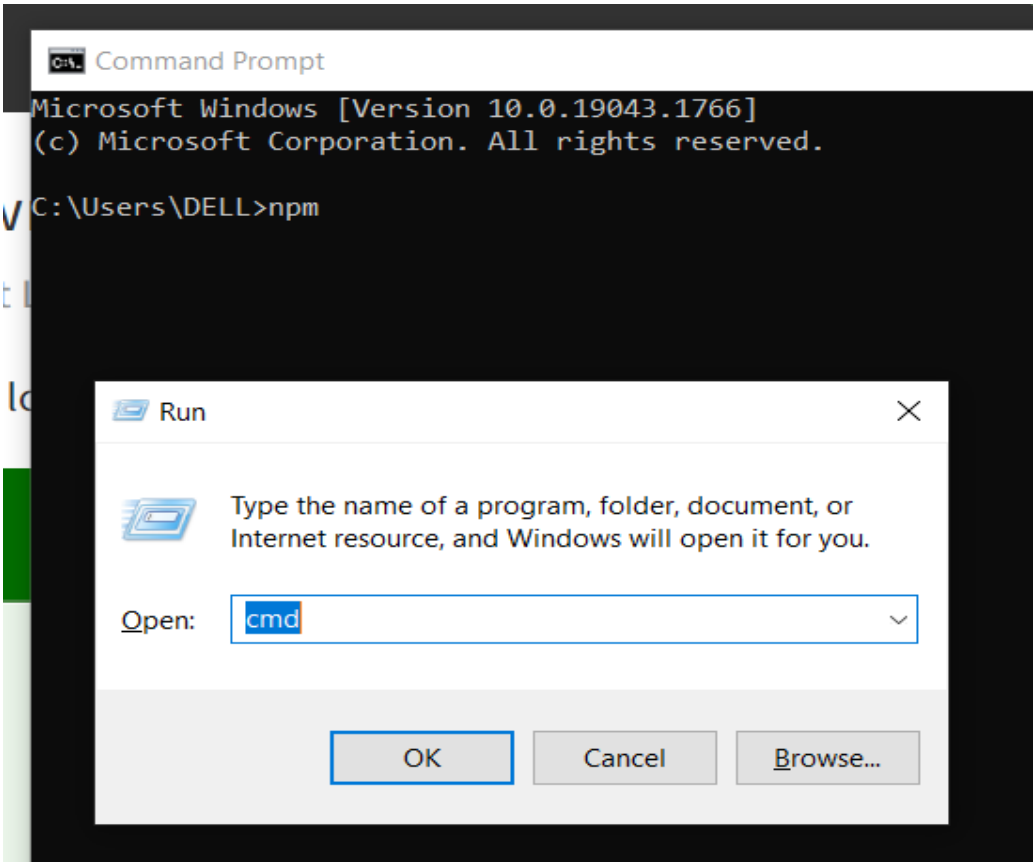


Figure 10-3

Step 3: Install Node-Red

Open **cmd** then write

`npm install -g --unsafe-perm node-red`

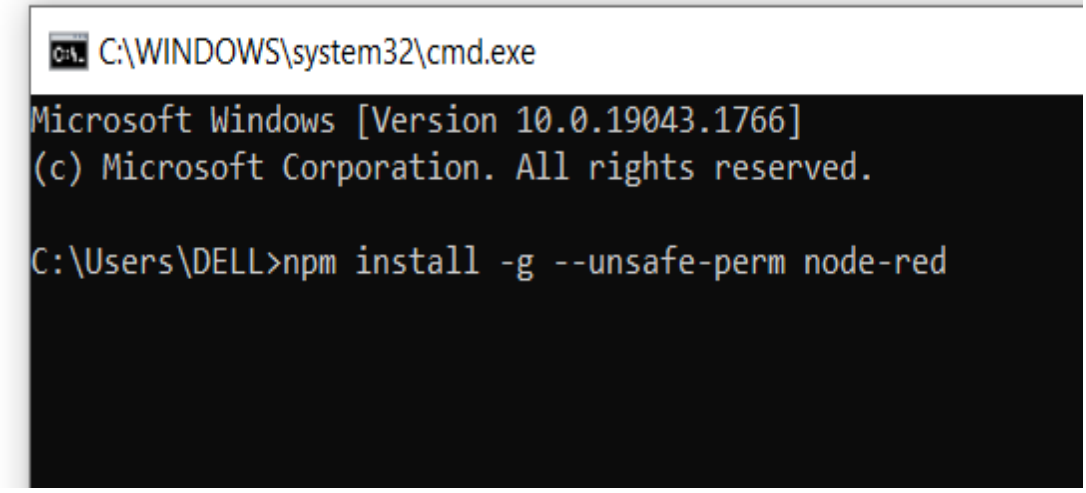


Figure 10-4

Step 4: Run Node-Red

Open **cmd** then write

`node-red`

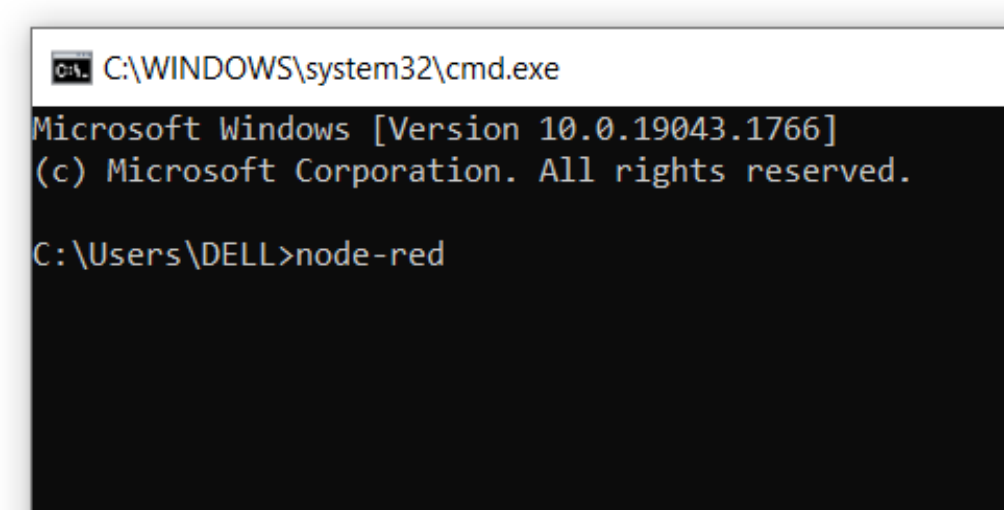


Figure 10-5

Step 5: Get Your Server IP

Copy Server IP, then Paste it in any browser

***Note:** DON'T Close cmd While Using Server

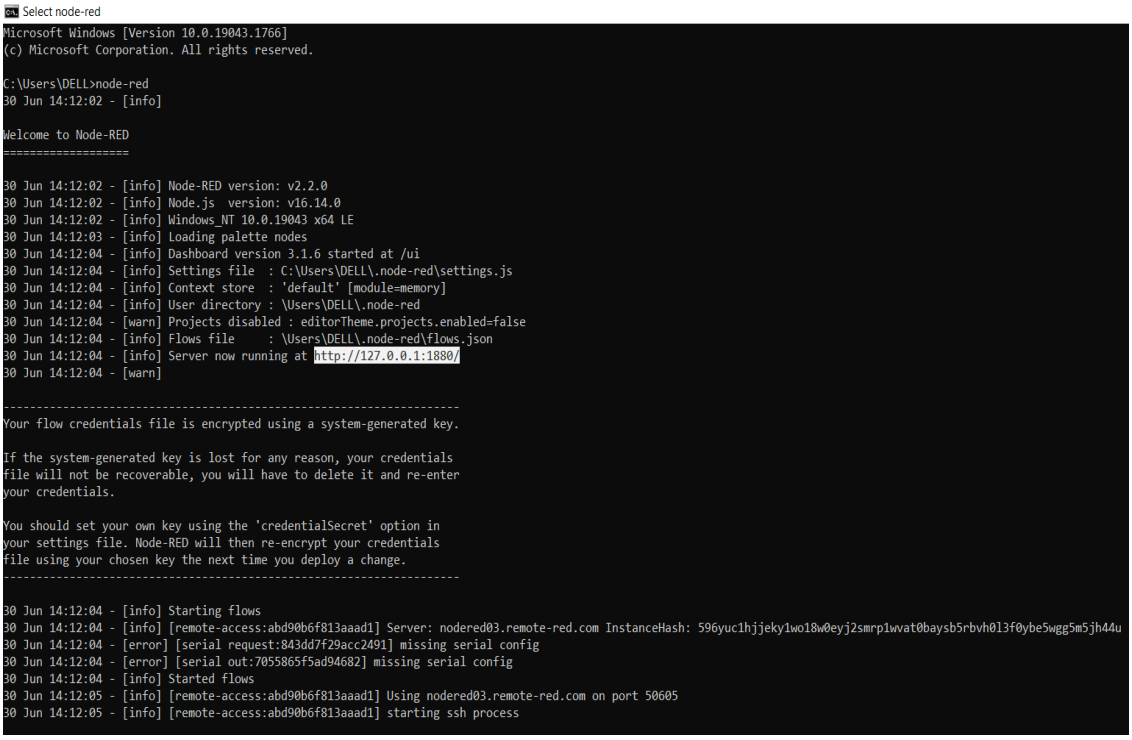


Figure 10-6

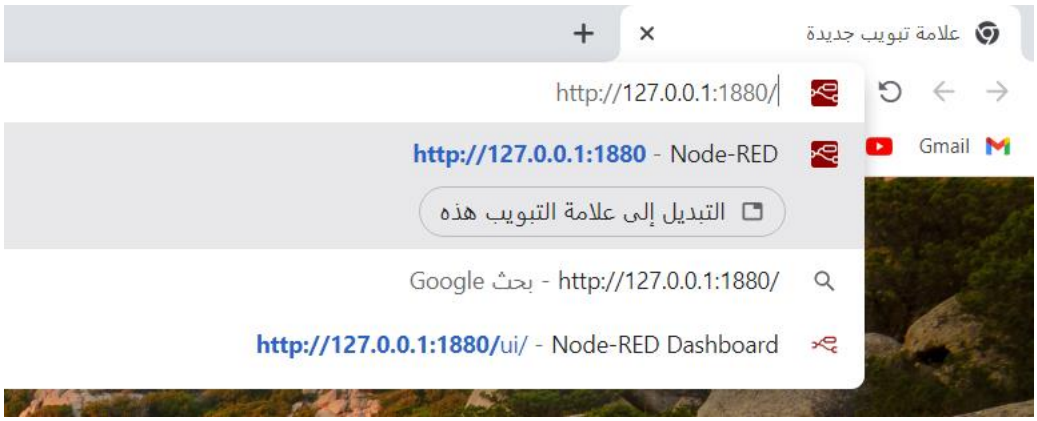


Figure 10-7

Step 6: Download any Necessary Palettes “Optional”

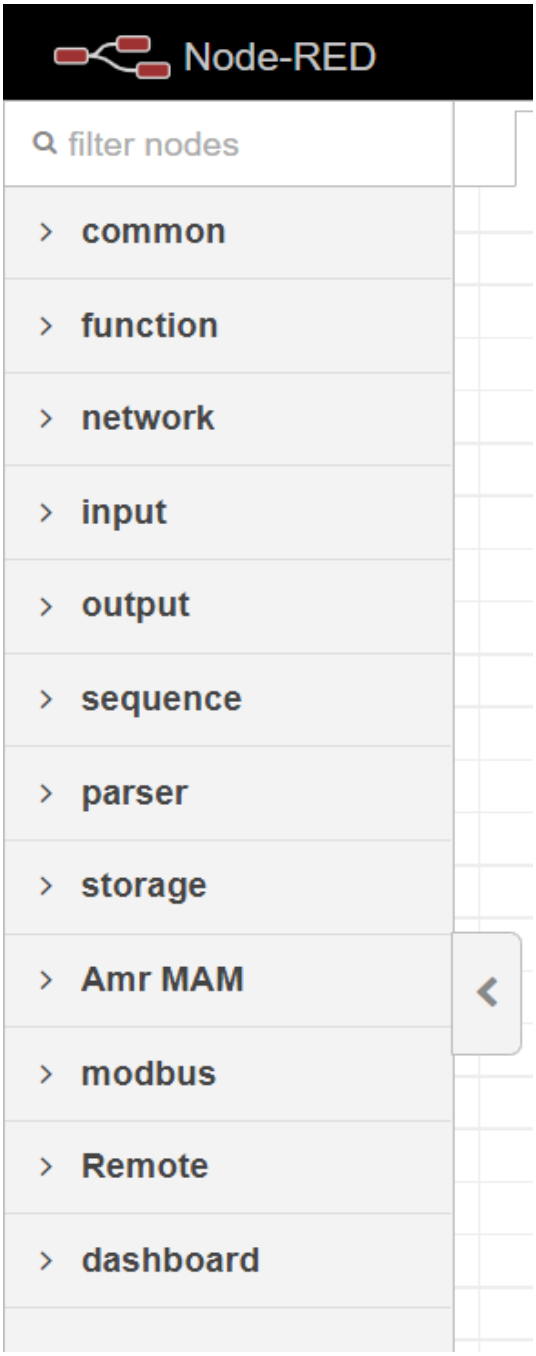


Figure 10-8

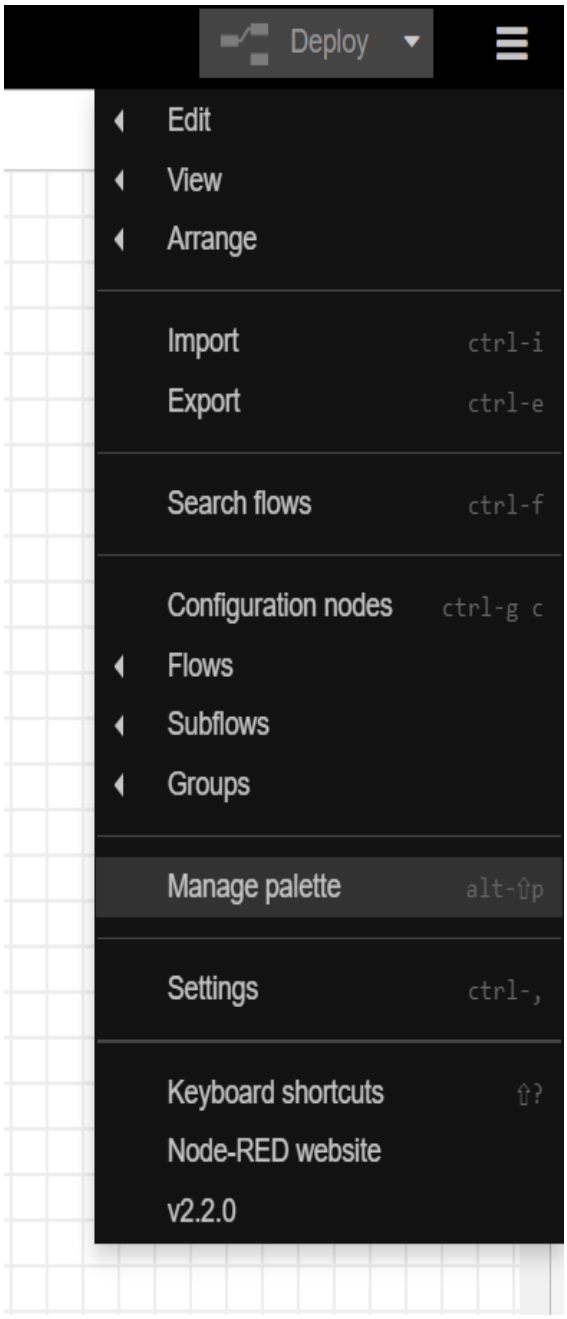


Figure 10-9

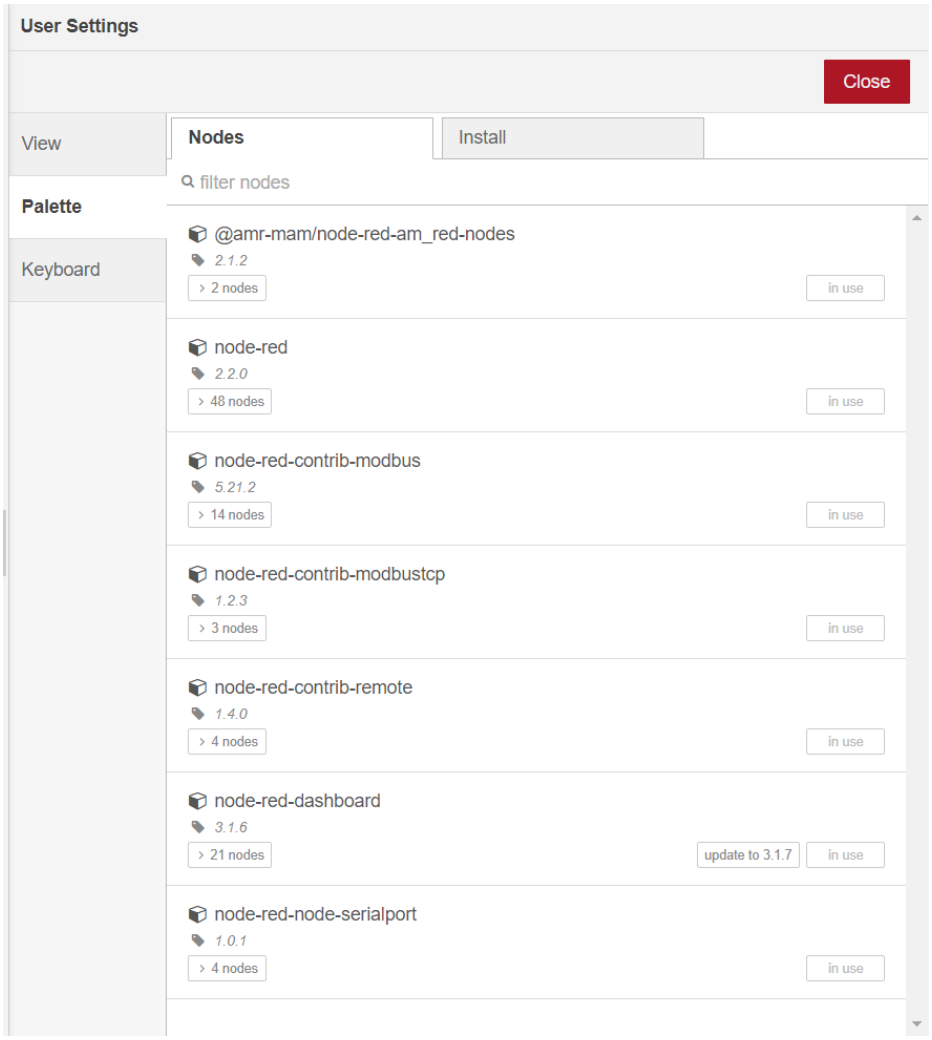

User Settings
Close
View
Palette
Keyboard
Nodes
Install
filter nodes
@amr-mam/node-red-am_red-nodes
2.1.2
2 nodes
in use
node-red
2.2.0
48 nodes
in use
node-red-contrib-modbus
5.21.2
14 nodes
in use
node-red-contrib-modbustcp
1.2.3
3 nodes
in use
node-red-contrib-remote
1.4.0
4 nodes
in use
node-red-dashboard
3.1.6
21 nodes
update to 3.1.7
in use
node-red-node-serialport
1.0.1
4 nodes
in use

Figure 10-10

10.3. Making connection between Node-RED & Python:

10.3.1. am_red-nodes (Node-RED nodes library)

it opens a channel between the two nodes and the channel will have an ID

you can use python to send and receive data through this ID.

1. Installation:
   From Manage palette → install tap → search for am_red-nodes → then install.

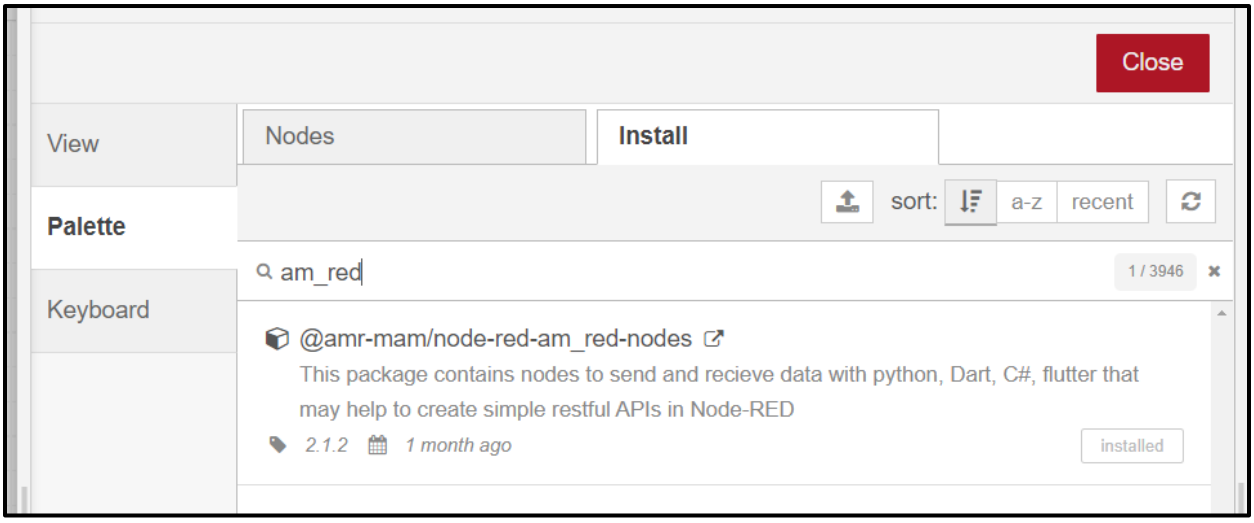


Figure 10-11

2. How to use:

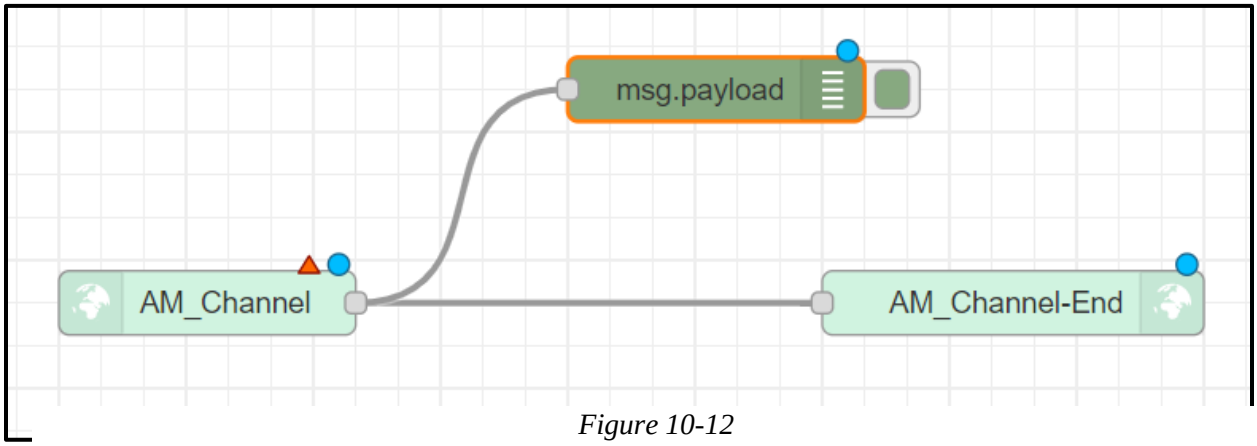


Figure 10-12

Select ID for the AM_Channel node

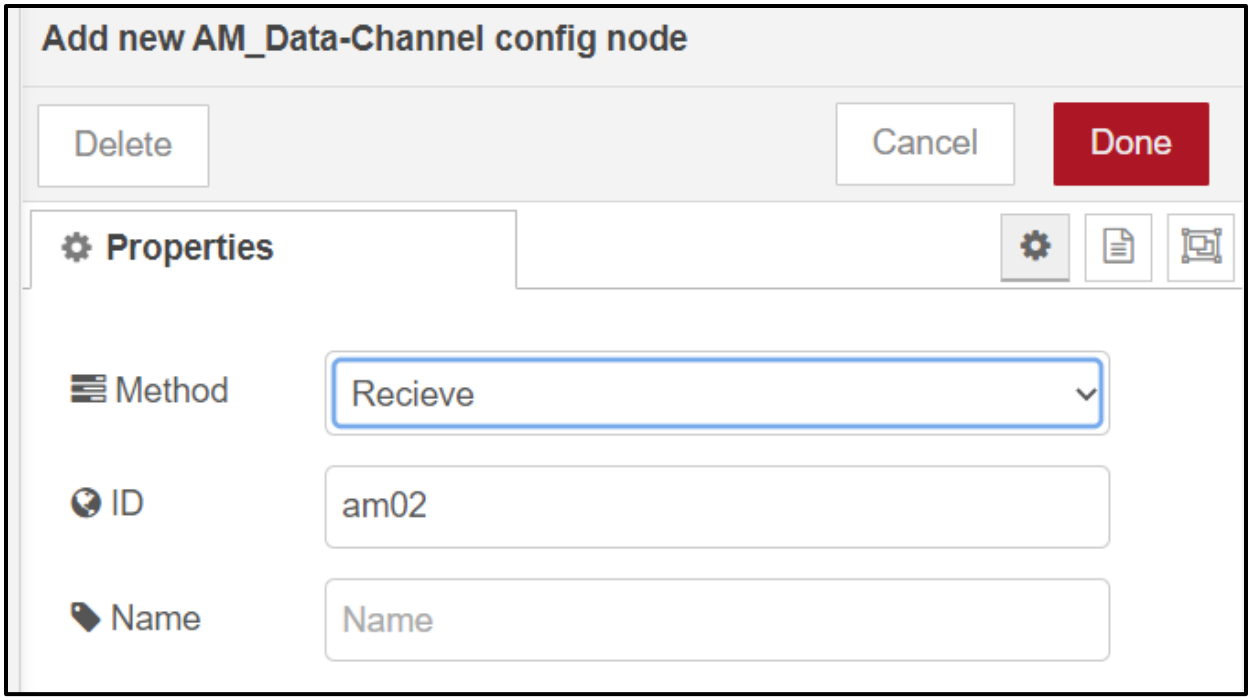


Figure 10-13

Follow the next phase to Configure python also to send data.

10.3.2. am-red-channel (Python library):

it is used to send data to Node-RED throw specified channel with specified id.

3. Installation:

In CMD write → "python -m ensurepip" → then write "python -m pip install am-red-channel"

4. Simple Code (how to use):

```
main.py
1
2   import am_red_channel as channel
3
4   channel.AM_SendDataSameDevice(id='am02', data="Hello Friend")
5
6   channel.AM_SendData(id='am02' , node_red_url= 'http://192.168.1.2:1880', data="Hello There")
```

Figure 10-14

5. Node-RED result:

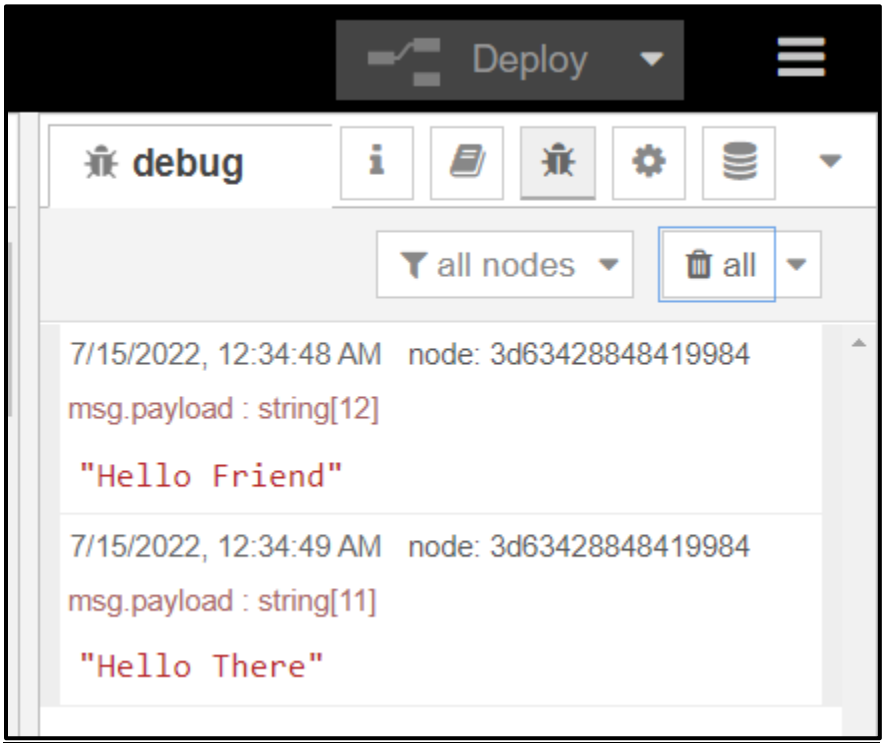


Figure 10-15

Chapter 11
Conclusion

11. CONCULTION AND FUTHER WORK

11.1. Recommendations

- Investing longer time in component selection that will save more time and money.
- Choosing a team is the most important thing to do to have a suitable people to work with.
- Choosing cheaper component may Couse damage in system and wase money.
- Data collecting is the topic of interest of the new business.

11.2. Future improvements

The industrial field is one of the most important fields globally and economically and it is being developed continuously not only every day but every hour. SO, we have to work harder to provide the highest technology possible that give us the ability to achieve customer requirements and drive our economy to be among the greatest economies in the world, so:

- Developing energy saving techniques to provide the least resources consumption for not only electricity but also raw materials.
- Getting the best product quality by reducing production defects using the huge data from the image processing and save it in cloud using IOT to analyses it later.
- Developing data server security using high security system for saving the database safely, so no one can hack or data can't be destroyed.
- Developing the ordinary control room to a modern control that works on a huge amount of data and information which facilitates and make the process of production and decision-making easier and accurate.
- Detect faults, their causes, and the causes of weakness in production faster by using data analysis to provide higher accuracy and greater efficiency for the production process.
- Using the huge database that will be provided due to IOT system in data analyses and machine learning researches to provide AI system in our production process.
- Using AI systems connected with the cloud to be able not only to take more accurate decisions faster but also to make a self-developed system.

11.3. Benefits of the project to other following students

- Provide hardware model to help student to deal with a practical mechanical system.
- Illustrate energy management concept (study the techniques of energy efficiency).
- To know the difference between system performance with VFD and without it (with results).
- Deal with drives and how to control motor performance.
- Learn more about IOT technology.
- Deal with HMI and SCADA system.

11.4. Steps for Future improvement

- Replace control panel by a larger one.
- Installing a mechanical track.

- Show capping system to mechanical experts to assess the suitability of the design to perform the task.
- Buying a New capper.
- Transform the machine from semi-automatic state to a fully automatic state.

Chapter 12
References.

12. REFERENCES

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[5]https://drive.google.com/drive/folders/1Vn3vJ8JSHjGeXvCiCwLo3y7u4fni3Mey?usp=sharing

[6]https://www.se.com/eg/ar/

[7]http://egyroll.com/

Chapter 13
Appendix.

13. APPENDIX

https://drive.google.com/drive/folders/1Vn3vJ8JSHjGeXvCiCwLo3y7u4fni3Mey?usp=sharing

Figure 13-1: QR Code

13.1. App A “ PLC Code”

13.2. App B “Arduino Code”