IMA-PG India Pvt Ltd

Plot No. R-677, M.I.D.C, T.T.C Indl. Area, Thane Belapur Road, Rabale, Mumbai, Maharashtra 400701

WINTER INTERNSHIP PROJECT REPORT

DECEMBER 2023

PROJECT TITLE
AUTONOMOUS BOTTLE FILLING AND CAPPING USING PLC

COLLEGE NAME
VIVEKANAND EDUCATION SOCIETY'S INSTITUTE OF TECHNOLOGY (VESIT)

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DECLARATION

We, the undersigned, hereby declare that the contents of this internship report entitled “Autonomous Bottle Filling and Capping Using Plc” are the collective efforts and original work of our group during our tenure at IMA-PG Pvt Ltd. This report has been prepared based on our experiences, observations, and learnings acquired throughout the internship period.

We affirm that all information presented in this report, including project descriptions, methodologies, results, conclusions, and acknowledgments, is genuine, accurately documented, and does not infringe upon any proprietary information or intellectual property rights of IMA-PG Pvt Ltd or any other entity.

Furthermore, we acknowledge and attribute any external sources, references, or materials utilized during the internship project, appropriately citing them within the report as per academic and ethical guidelines.

We understand that any misrepresentation, plagiarism, or falsification of information in this report would violate the principles of academic integrity and professional ethics. Therefore, we affirm the authenticity and originality of our contributions to this internship report.

ADITYA AYARE

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MAYUR MISTRY

Supervisor:

Date:

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CHAPTER 01

ACKNOWLEDGEMENT

We extend our heartfelt gratitude to the collective efforts of the team involved in the successful completion of this internship project.

We express our deepest appreciation to Mr. Ashok Kumar Singh and Mr. Kaustubh Kulkarni, our mentor and guide, for their unwavering support, valuable insights, and continuous encouragement throughout this endeavour. Their expertise and guidance were pivotal in navigating the intricacies of industrial automation, enabling us to comprehend PLCs, HMIs, and sensor integration comprehensively.

Our profound gratitude goes to the entire team at IMA-PG India Pvt Ltd. for granting us the opportunity to immerse ourselves in practical applications of automation technologies. Their generosity in sharing knowledge, resources, and experiences significantly enriched our learning journey.

We extend our thanks to each of our fellow interns and colleagues for their collaborative spirit, collective efforts, and shared enthusiasm. Together, we fostered a conducive learning environment, making this experience both enriching and enjoyable.

Acknowledgment is also due to the academic faculty at Vivekanand Education Society's Institute of Technology (VESIT) for equipping us with the theoretical foundation and academic rigor necessary to understand industrial automation principles.

Lastly, we express our gratitude to our families and friends for their unwavering support, understanding, and encouragement throughout this academic pursuit and internship experience.

The collective support, guidance, and encouragement from all these entities were instrumental in shaping our learning, growth, and overall experience during this collaborative internship project.

CHAPTER 02

INFORMATION ABOUT THE COMPANY

Ima-Pg India Private Limited is an unlisted private company incorporated on 23 March, 1961. It is classified as a private limited company and is located in Navi Mumbai, Maharashtra. Its authorized share capital is INR 2.00 cr and the total paid-up capital is INR 1.79 cr.

Ima-Pg India Private Limited's operating revenues range is INR 100 cr - 500 cr for the financial year ending on 31 December, 2020. It's EBITDA has decreased by -73.38 % over the previous year. At the same time, it's book net worth has increased by 7.65 %.

The company is a manufacturer of rotary motion vacuum forming, blister packaging machines for the pharmaceutical blister packaging machine etc.

Ima-Pg India Private Limited's Corporate Identification Number is (CIN) U27100MH1961PTC011958 and its registration number is 11958.Its Email address is secretarial@imapg.com and its registered address is PLOT NO. R-677, M.I.D.C., T.T.C. INDUSTRIAL AREA, THANE BELAPUR ROAD, RABALE, NAVI MUMBAI MH 400701 IN.

CHAPTER 03

INFORMATION ABOUT THE INTERNSHIP POSITION

Internship Position: Industrial Automation Intern

Company: IMA-PG India Pvt Ltd

Internship Focus:

Automation Technologies:
Working with Programmable Logic Controllers (PLCs), Human-Machine Interfaces (HMIs), sensors (inductive and capacitive), and actuators.
Project: Designing and implementing an autonomous bottle filling machine.

Tasks Involved:

- Developing PLC logic using Siemens TIA Portal for bottle filling, capping, and fill level verification.
- Designing HMI interfaces for operator control and system monitoring.
- Integrating and calibrating sensors for bottle detection and fill level verification.
- Testing, validation, troubleshooting, and optimization of the automation system.
- Documenting the project process and preparing a comprehensive report.

Key Skills and Learnings:

- Proficiency in PLC programming, particularly using Siemens TIA Portal.
- Understanding of sensor integration, calibration, and automation system synchronization.
- Experience in HMI design and interfacing for industrial control.
- Troubleshooting, optimization, and testing methodologies in industrial automation.
- Project documentation and reporting skills.

CHAPTER 04

DESCRIPTION OF INTERNSHIP EXPERIENCE

During our collective internship at IMA-PG India Pvt Ltd, our team delved into the intricate world of industrial automation, where theory met practical application. Tasked with exploring the functionalities of Programmable Logic Controllers (PLCs), Human-Machine Interfaces (HMIs), and sensor integration, our primary objective revolved around the design and implementation of an autonomous bottle filling machine. This immersive experience provided us with a platform to translate theoretical knowledge acquired from our academic pursuits into tangible solutions within an industrial setting, fostering proficiency in PLC programming using Siemens TIA Portal, sensor calibration techniques, HMI interface design, and the orchestration of sequential operations inherent in industrial automation.

Collaborating closely, our team navigated the complexities of industrial automation by spearheading a project aimed at creating an autonomous system capable of seamlessly detecting, filling, capping, and verifying bottle fill levels. Each of us actively contributed to the development of PLC logic, meticulously crafting sequences for bottle filling, capping procedures, and precise fill level verification. Embracing challenges collectively, we engaged in troubleshooting, optimization, and rigorous testing to ensure the flawless operation of the automated system. This collaborative experience not only deepened our understanding of automation technologies but also honed our collective problem-solving skills, emphasizing the pivotal role of meticulous planning and iterative refinement in the realm of industrial automation.

4.1 INTRODUCTION TO PROJECT

In today's industrial landscape, the pursuit of efficient and reliable manufacturing processes is paramount. Automation plays a pivotal role in achieving these goals, and the utilization of Programmable Logic Controllers (PLCs) and Human-Machine Interfaces (HMIs) stands at the forefront of modern industrial automation.

This report documents an immersive internship experience at IMA-PG Pvt Ltd., focusing on the design, development, and implementation of an autonomous bottle filling machine employing PLC and HMI technologies. The project's primary objective was to engineer a seamless and intelligent system capable of accurately filling and capping bottles while ensuring precise fill levels through sensor-based monitoring.

The project was executed in three main stages: the filling stage, capping stage, and fill level verification stage. At the filling stage, the arrival of bottles on the conveyor belt was detected by an inductive sensor, triggering the commencement of the bottle filling process. Subsequently, the bottle, post-filling, was identified by another inductive sensor to initiate the capping procedure. Finally, a capacitive sensor verified the fill level before the bottle's exit from the conveyor belt.

The implementation of this intricate process was achieved through ladder programming on the PLC, orchestrating the interaction between sensors, actuators, and the bottle filling mechanism. Furthermore, the system's interface and control were facilitated via the Human-Machine Interface (HMI), providing an intuitive platform for monitoring, control, and diagnostics.

Throughout the project, a series of challenges were encountered and addressed, enriching the learning experience and enhancing problem-solving capabilities. Troubleshooting complexities in sensor integration, refining the timing and coordination of sequential processes, and optimizing system responsiveness were among the key challenges encountered and overcome during the project's development.

4.2 METHODOLOGY FOR PROJECT

1. Understanding Requirements:

Gathered detailed specifications and requirements for the bottle filling machine, including the desired functionalities, sensors needed, filling and capping mechanisms, and system behaviour.

2. Research and Conceptualization:

Conducted research on PLC programming principles, HMI interface design, sensor functionalities, and automation concepts relevant to bottle filling systems.

Developed a conceptual design outlining the system architecture, sensor placements, actuator requirements, and the overall workflow of the autonomous bottle filling machine.

3. Hardware Acquisition and Setup:

Procured necessary hardware components including PLC, HMI, sensors (inductive and capacitive), actuators, conveyor belts, and other supporting equipment.

Set up the hardware components in the laboratory or workshop environment, ensuring proper connections and functionality.

4. PLC Programming:

Utilized Siemens TIA Portal to write the PLC program, implementing ladder logic to control the bottle filling, capping, and fill level verification processes.

Tested and refined the PLC logic to ensure accurate and sequential operation of the machine.

5. HMI Interface Development:

Designed the HMI interface using Siemens WinCC within the TIA Portal, creating screens for operator control, system monitoring, and diagnostics.

Integrated the HMI with the PLC program to enable seamless communication and control between the operator interface and the automation system.

6. Sensor Integration and Calibration:

Installed and calibrated inductive sensors for bottle detection along the conveyor belt.

Configured and calibrated capacitive sensors to verify the fill level of bottles accurately.

7. Testing and Validation:

Conducted extensive testing to validate the functionality of the autonomous bottle filling machine.

Evaluated the system's performance, ensuring accurate bottle detection, filling, capping, and fill level verification.

8. Troubleshooting and Optimization:

Addressed any encountered issues or discrepancies in the system's operation through troubleshooting methodologies.

Optimized the system's efficiency and responsiveness by refining PLC logic, HMI interfaces, and sensor calibrations.

4.3 HARDWARE / SOFTWARE REQUIRED

HARDWARE:

1. **Programmable Logic Controller (PLC):** The brain of the automation system, responsible for controlling the entire process. Common brands include Siemens, Allen-Bradley, Mitsubishi, etc.

2. **Human-Machine Interface (HMI):** A graphical interface allowing operators to monitor and control the system. Brands like Siemens, Pro-face, Red Lion, etc., offer HMIs.

3. **Sensors:**
- **Inductive Sensors:** Detecting the presence of metallic objects, used for bottle detection along the conveyor belt.
- **Capacitive Sensors:** Detecting non-metallic materials like liquids or plastics, used for verifying bottle fill levels.

4. **Power Supply Units**: Providing power to the various components of the system.

5. **Wiring and Connectors:** Ensuring proper connections between different components.

6. **Tower Lamp:** A tower lamp is an industrial signalling device with stacked lights used to visually indicate machinery status or alerts through color-coded illumination.

7. **Ethernet or Communication Modules:** Facilitating communication between the PLC, HMI, and other devices.

8. **Emergency Stop Buttons or Safety Components:** Ensuring the system can be halted in case of emergencies or faults.

SOFTWARE:

Siemens TIA Portal:
Siemens Totally Integrated Automation (TIA) Portal is an engineering framework that integrates various automation software tools into one environment, facilitating PLC programming, HMI design, commissioning, and diagnostics within a single software suite.

INDUCTIVE SENSOR

An inductive sensor is a type of proximity sensor that detects the presence or absence of an object based on its ability to generate an electromagnetic field. Inductive sensors work on the principle of electromagnetic induction. When an object enters the sensor's electromagnetic field, it induces a current in the sensor coil, triggering a response. These sensors are particularly sensitive to metallic objects. The presence or absence of a conductive material (usually metal) within the sensing range affects the sensor's output.

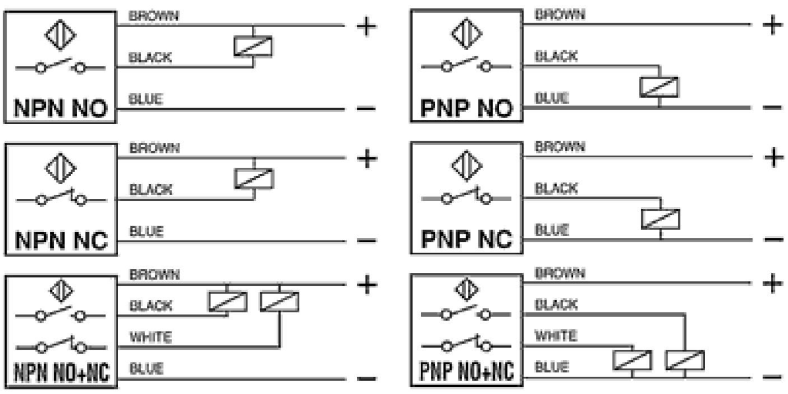
Applications:

- Object detection and positioning in industrial automation.
- Sorting and counting in manufacturing processes.
- Proximity detection in machinery to prevent collisions.
- Conveyor belt systems to control the flow of materials.

Advantages:

- Reliable and durable in harsh environments.
- Resistant to dirt, dust, and other environmental factors.
- Fast response times. Around 2 milli seconds.
- They are non contact sensor, hence suitable for applications where contact may not be feasible or could lead to wear and tear.
- Disadvantages:
- Limited sensing range compared to some other sensor types, only 60 mm
- Can be affected by non-metallic or non-conductive materials.

Wiring & Symbol:



CAPACITIVE SENSOR

A capacitive sensor is a type of proximity sensor that detects the presence or proximity of objects based on changes in capacitance. Capacitive sensors operate on the principle of capacitance change. When an object enters the sensor's electric field, the capacitance between the sensor and the object changes, leading to a measurable effect.

Applications:

- Touchscreens: Used in smartphones, tablets, and other touch-sensitive devices.
- Proximity Sensors: Detect the presence of objects without direct contact.
- Object Detection: Identify the presence or absence of materials in manufacturing.
- Liquid Level Sensing: Detect the level of liquid in containers.

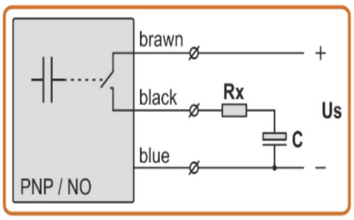
Advantages:

- Can detect both conductive and non-conductive materials.
- High sensitivity and precision.
- Suitable for various environmental conditions.
- They are non contact sensor, hence suitable for applications where contact may not be feasible or could lead to wear and tear.

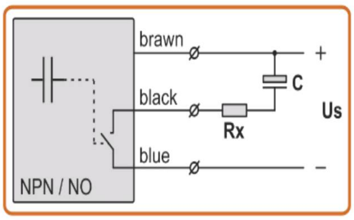
Disadvantages:

- Sensitivity to environmental factors like humidity.
- Limited sensing range compared to some other sensor types. Around 40 mm.
- Performance can be affected by certain materials and environmental conditions.

Wiring & Symbol:



Connection of capacitive load to PNP type sensor



Connection of capacitive load to NPN type sensor

TOWER LAMP

A tower lamp, also known as a signal tower, is a visual signaling device used in industrial settings to convey information about the status of a machine, process, or system. Tower lamps are equipped with multiple lights of different colors, typically stacked vertically. Each color represents a specific status or condition. Tower lamps can have both flashing and steady modes for each color, providing additional information about the nature of the status or condition.

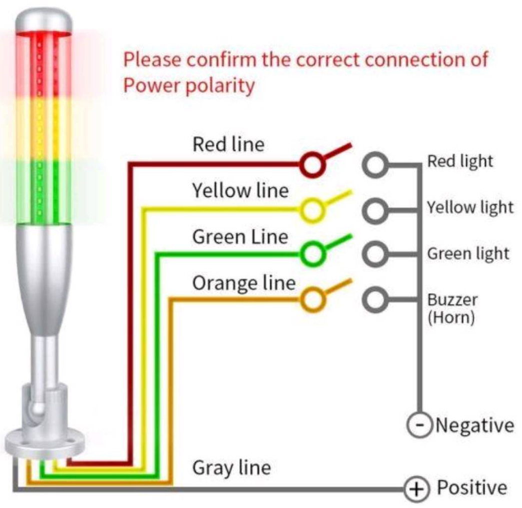
Common Colors and Meanings:

- Red indicates an alarm, error, or critical condition.
- Green represents normal operation or a positive status.
- Yellow indicates a caution or warning state.
- Blue is used for to signify a specific event.

Applications:

- Communicates the operating status of machines.
- Indicates the status of different stages in a manufacturing process.
- Provides visual alerts for alarms or critical events.
- Used to indicate safe or unsafe conditions.
- Tower lamps can e automated as well as manually controlled.
- Built-in buzzers provide an audible alert in addition to the visual signals.

Wiring & Symbol:



HMI SCREEN

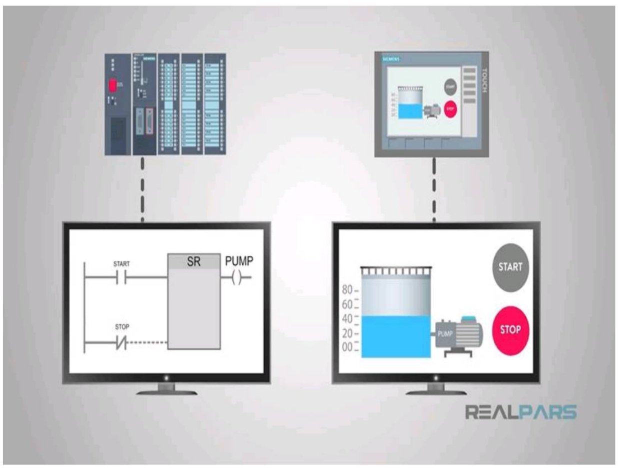
An HMI, or Human-Machine Interface, screen is a graphical interface that allows users to interact with and monitor machines, processes, and systems in various industries.

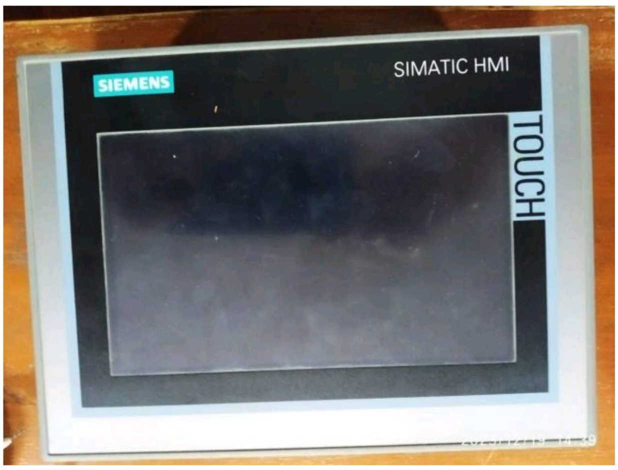
Advantages:

- HMI screens have graphical elements such as buttons, icons, images, graphs, pie charts, animations etc.
- Many modern HMIs use touchscreen technology which enhances user experience and simplifies navigation.
- HMIs provide data such as temperature, pressure, total production, power consumption, total run time of machine etc
- The system can display error messages or warnings to prompt corrective actions incase of abnormal conditions.
- HMI can log and display historical data trends, enabling users to analyze past performance and identify patterns or issues.
- HMI includes security measures such as user authentication, access levels, and encryption to ensure that only authorized personnel can access and control critical systems.

Applications:

- Controlling and monitoring production lines.
- Monitoring and controlling power generation and distribution.
- Managing HVAC systems, lighting, and security.
- Overseeing complex industrial processes.
- Monitoring and controlling vehicle systems.
- Wiring & Symbol:





PNEUMATIC ACTUATOR

A pneumatic actuator is a device that converts energy from compressed air into mechanical motion. It is widely used in various industrial applications to control the movement of valves, dampers, and other mechanical components.

Advantages:

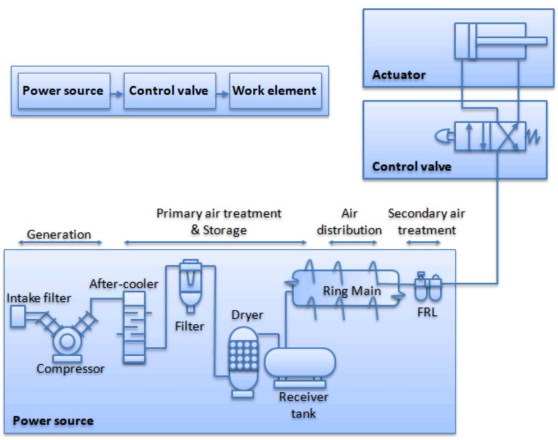
- Pneumatic actuators allow for precise and controlled motion.
- Pneumatic systems are known for their quick response times.
- Pneumatic actuators often have a fail-safe design, meaning that in the event of a loss of air pressure, they default to a safe position
- They are compact & lightweight compared to other actuators
- Compressed air is more cost-effective than other power sources.

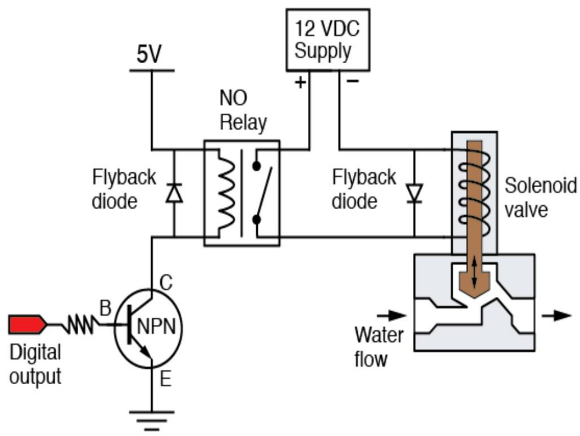
Applications:

- Controlling the opening & closing of valves in industrial processes.
- Adjusting the flow of air or other gases in ventilation systems.
- Controlling the movement of components on conveyor belts.
- Powering certain movements in pneumatic robotic systems.

Components:

- Piston & Cylinder
- Solenoid direction control Valve
- Air Compressor
- Magnetic Head Sensor
- Primary air treatment unit
- Secondary air treatment unit





CONVEYOR

Conveyor belts are a fundamental component in manufacturing industries, providing a means of efficiently moving materials, products, or packages from one point to another within a facility

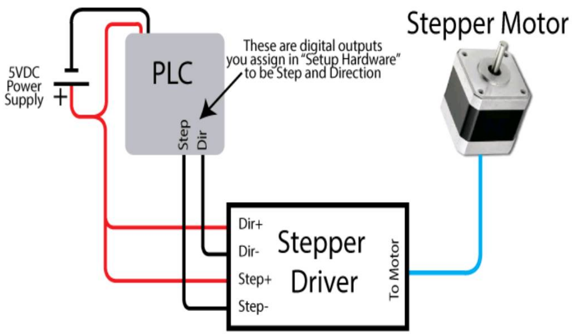
Advantages:

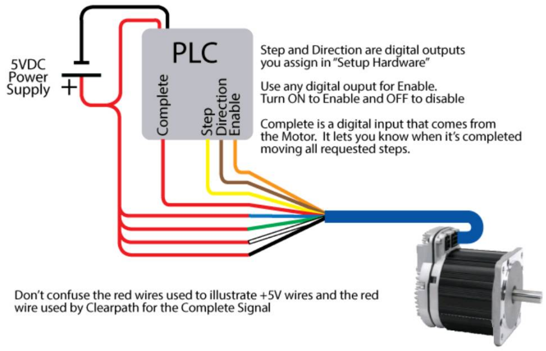
- They operate continuously which is benficial for mass production.
- Conveyor belts can handle a wide variety of materials, including bottles, cartons, boxes.
- Conveyor can be categorisedon the basis of belt width, length, speed, & the addition of features like inclines, declines, or curves.
- They contribute to increased efficiency, reduced manual handling, & minimized production delays.
- common applications are transporting raw materials to processing areas, moving finished products to packaging stations, or facilitating the loading and unloading of goods.

Components:

- Belt: It is a continuous loop made of rubber, fabric etc.
- Pulleys: Pulleys are used to change the direction of the belt or to provide tension. They consist of a drum or cylinder around which the belt wraps.
- Motor: The motor converts electrical energy into mechanical power to drive the conveyor. It controls direction and speed of conveyor.
- Support Structure: also called as conveyor frame, includes legs, brackets, and other structural elements that keep the conveyor in place and properly aligned.

Wiring:





CONTACTOR

A contactor is an electrical relay designed to control the flow of electric current in a high-power circuit. It typically consists of a set of contacts that open and close to allow or interrupt the electrical power to a load. When the coil is energized, it creates a magnetic field that attracts the contacts, closing the circuit. When the coil is de-energized, the contacts return to their normal state, opening the circuit.

Applications:

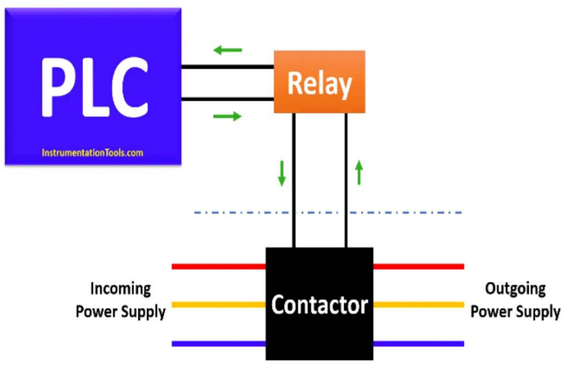
- Contactor are used to control the power supply to electric motors, allowing for the start, stop, and reversal of motor rotation.
- Contactors control the power supply to heating elements in appliances such as furnaces, ovens, and water heaters.
- Contactors are employed in lighting systems to switch high-power lighting loads.

Advantages of Contactor over Relay:

- We use contactor instead of relay due to the following reasons
- Voltage and current ratings of a relay are very small.
- A relay cannot handle a large load like a motor.
- Relays generally do not have three phase connection.
- Helps to control motors by PLC in a safe manner.
- Relay have short life span & less durability.

Wiring:

- L1, L2, L3 are inputs of 3 phase power supply
- T1, T2, T3 are outputs of 3 phase power supply
- A1, A2 are energising contacts
- NO, COM are auxiliary contacts

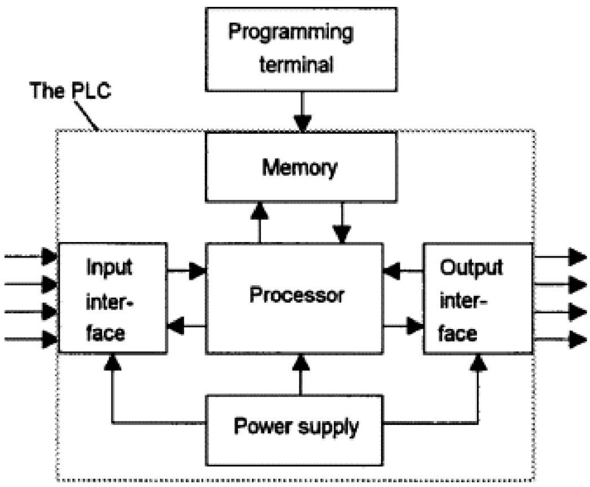


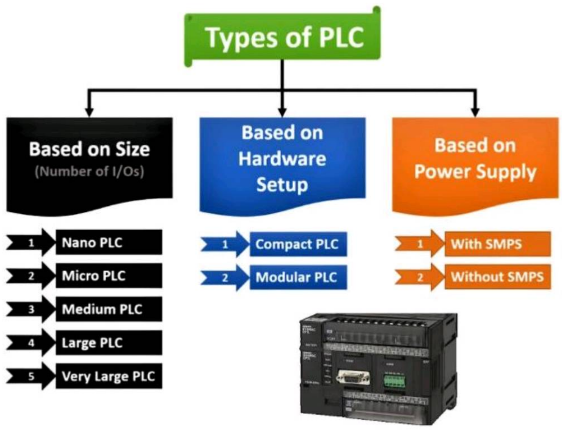
PLC (PROGRAMMABLE LOGIC CONTROLLER)

A Programmable Logic Controller (PLC) is a digital computer used for automation of electromechanical processes in industries. PLCs monitor and control various industrial processes by processing input data, executing a stored program, and producing output signals. They are instrumental in automating repetitive tasks. PLCs interface with sensors to receive input signals and control actuators to produce desired outputs. Sensors are devices that detect and convert physical quantities (such as temperature, pressure, or proximity) into electrical signals. Sensor can be of 2types digital & analog.

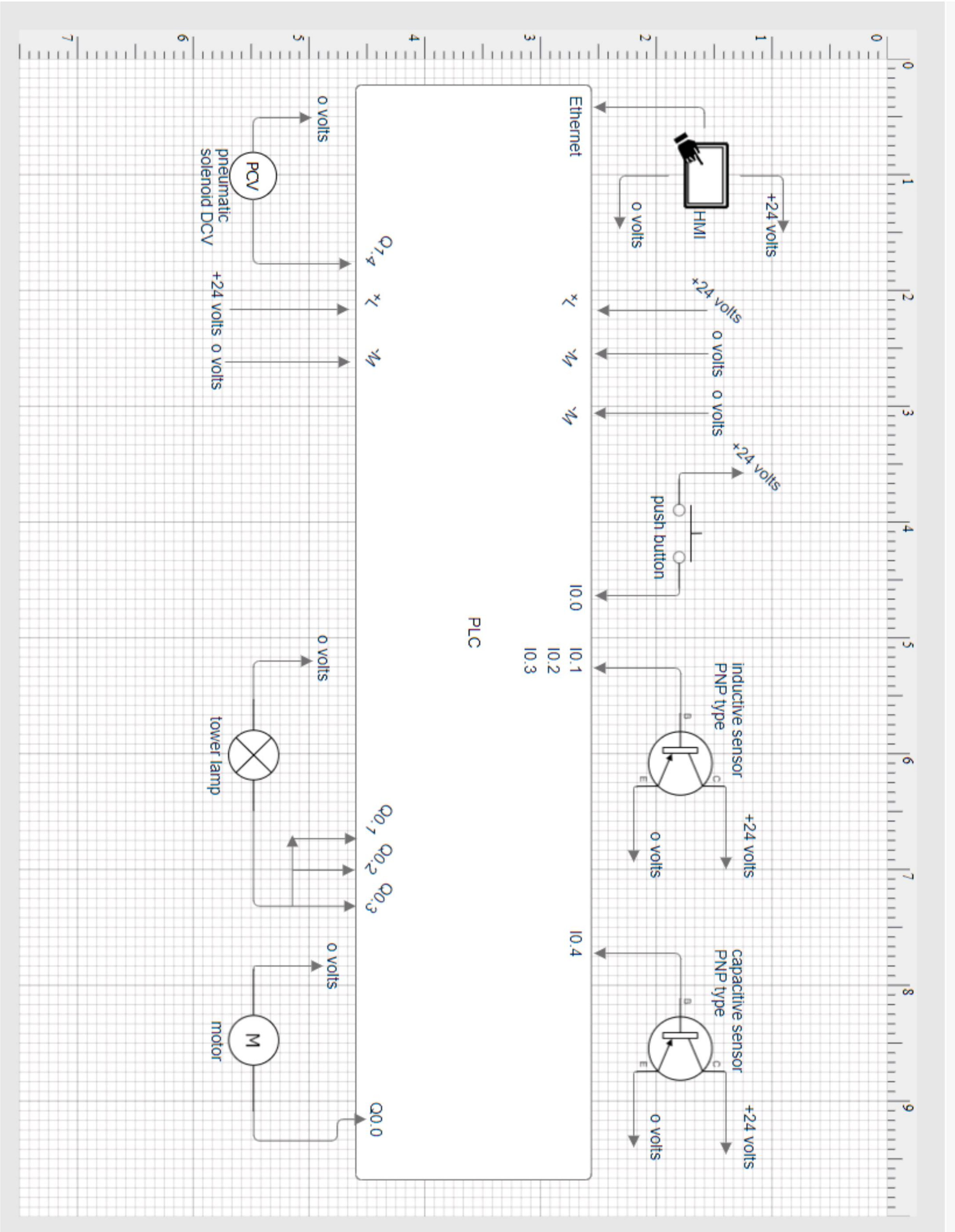
Components of PLC:

- CPU (Central Processing Unit): The brain of the PLC, responsible for executing the control program.
- Input Modules: Receive signals from sensors and switches in the field. Input pins can be digital as well as analog.
- Output Modules: Control devices such as motors, valves, and lights. Output pins can be digital as well as analog.
- Power Supply: Provides the necessary power for the PLC's operation.
- PLCs have two main types of memory: RAM (Random Access Memory): Used for storing data and the program currently being executed. ROM (Read-Only Memory): Stores the firmware and operating system of the PLC.
- PLCs often have communication ports for connecting to other devices, networks, or supervisory systems. Common communication protocols include Ethernet, Profibus, Modbus.

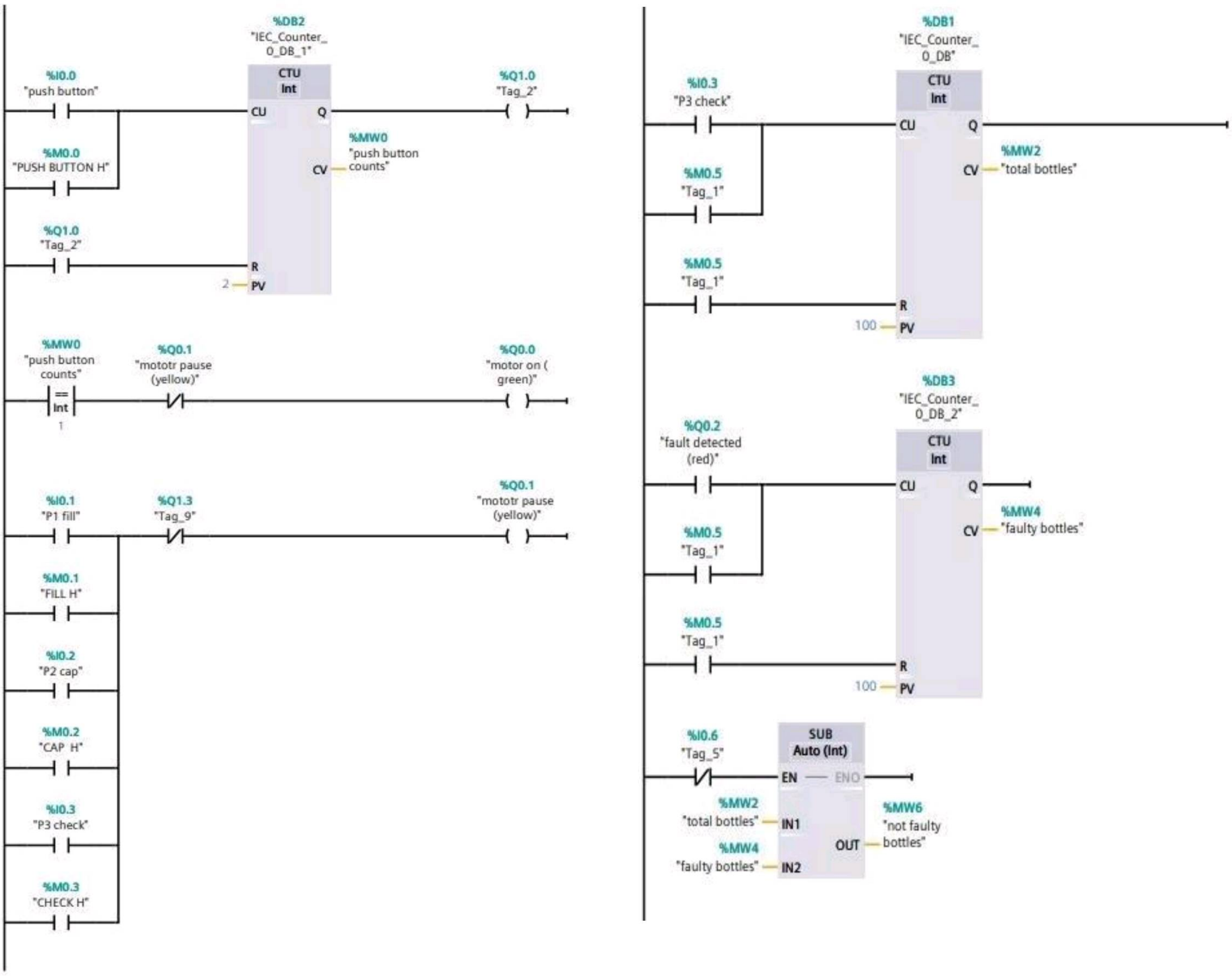


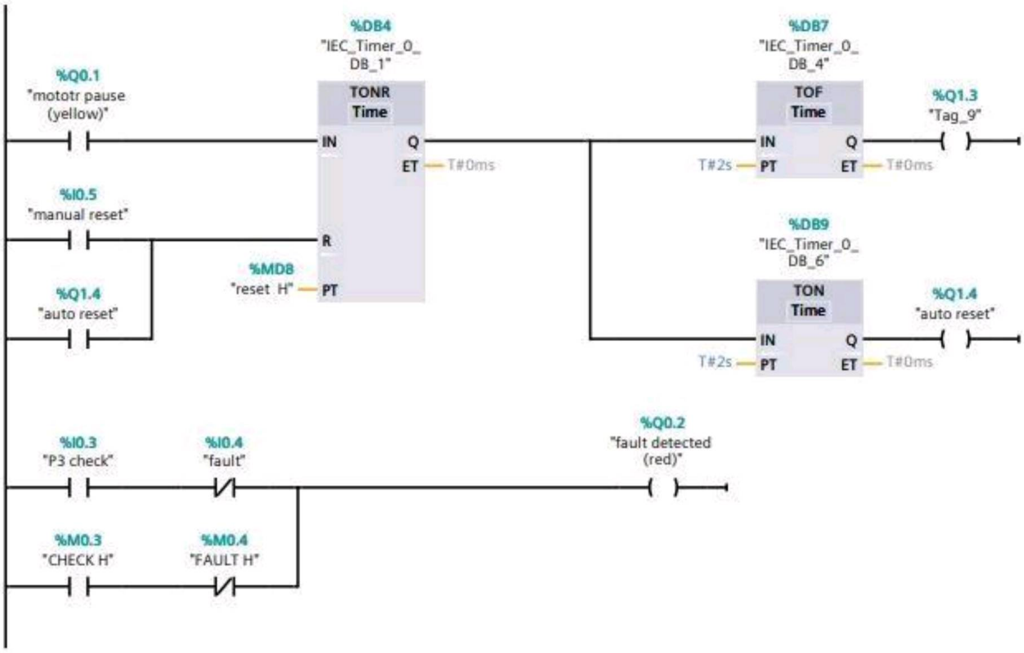


4.4 ELECTRICAL DIAGRAM



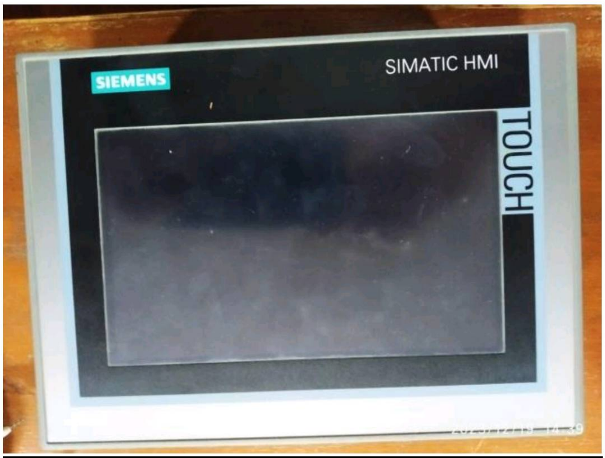
4.5 LADDER DIAGRAM FOR PLC

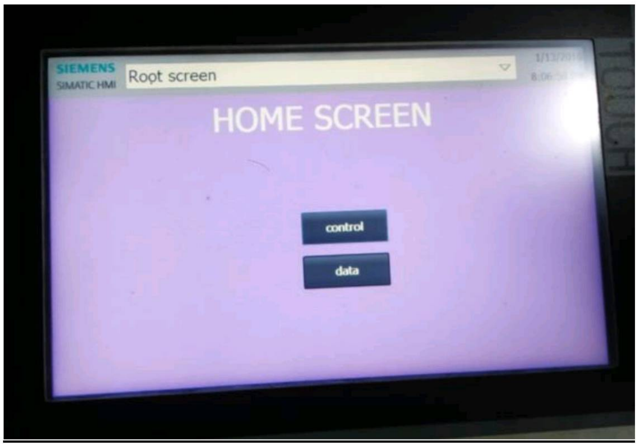




4.6 PICTURES OF PROJECT

HMI SCREENS





PROJECT

4.7 RESULT AND OUTCOMES

Functional Autonomous Bottle Filling Machine:
Successfully developed and implemented an autonomous bottle filling machine capable of performing sequential operations including bottle detection, filling, capping, and fill level verification.

PLC Logic Implementation:
Demonstrated proficiency in PLC programming using Siemens TIA Portal, creating robust ladder logic to control the entire bottle filling process with precise sequencing and control.

HMI Interface Integration:
Developed an intuitive Human-Machine Interface (HMI) using Siemens WinCC within TIA Portal, enabling operators to monitor and control the system efficiently.

Sensor Integration and Validation:
Integrated inductive sensors for bottle detection and capacitive sensors for fill level verification, ensuring accurate and reliable sensor functionalities throughout the process.

System Testing and Validation:
Conducted thorough testing and validation procedures to verify the functionality and performance of the autonomous bottle filling machine. Results indicated accurate bottle detection, precise filling, successful capping, and reliable fill level verification.

Optimization and Efficiency:
Identified and addressed system inefficiencies and discrepancies through troubleshooting and optimization techniques, resulting in an enhanced and responsive automation system.

Documentation and Project Report:
Prepared comprehensive documentation including hardware specifications, PLC and HMI programming details, sensor configurations, testing results, challenges faced, solutions implemented, and a detailed project report summarizing the entire internship experience and project outcomes.

CHAPTER 05

CONCLUSION

The internship experience at IMA-PG India Pvt Ltd. provided an invaluable opportunity to delve into the realm of industrial automation through the development of an autonomous bottle filling machine. The successful execution of this project underscored the integration of Programmable Logic Controllers (PLCs), Human-Machine Interfaces (HMIs), and sensor technologies to orchestrate a seamless and efficient automation process.

The utilization of Siemens TIA Portal for PLC programming and HMI interface design proved instrumental in creating a robust system capable of accurately detecting, filling, capping, and verifying bottle fill levels. The convergence of theoretical knowledge acquired through academic pursuits with practical application in an industrial setting provided a comprehensive understanding of automation principles and their real-world implications.

The challenges encountered during the project, including sensor calibration, sequencing precision, and optimization, served as invaluable learning experiences, fostering problem-solving skills and enhancing the ability to troubleshoot complex automation systems. The successful resolution of these challenges further fortified the skill set required in the field of industrial automation.

In conclusion, this internship project not only facilitated the application of theoretical knowledge but also cultivated practical skills crucial in navigating the intricacies of industrial automation systems, laying a solid foundation for future endeavours in this dynamic field.