Automation Control of Assembly-Disassembly Minicell

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Introduction

- Introduction
- Problem Statement
- Objectives
- Scope

INTRODUCTION

- **Manufacturing Evolution:** The manufacturing industry is rapidly advancing towards automation and smart systems to improve efficiency and productivity.
- **Integration of Advanced Technologies:** Modern factories are a blend of various cutting-edge technologies working seamlessly together:

  1.PLCs for precise control

  2.Sensors for real-time monitoring

  3.HMI for data acquisition and supervision

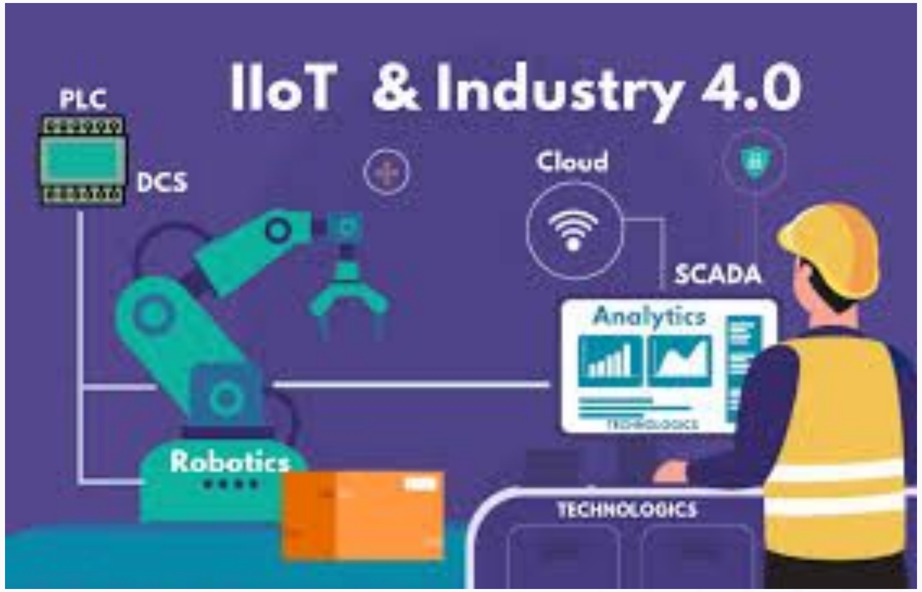
INTRODUCTION

Need for Updated Engineering Education: As industries evolve, engineering education must adapt to equip graduates with the skills required for this new era of technology-driven manufacturing.

Role of Training Systems: Training systems serve as vital tools, bridging the gap between academic learning and practical, hands-on factory experience.

Preparing Future Engineers: By incorporating training systems, universities help students gain familiarity with industrial processes, enabling a smoother transition into the workforce.

PROBLEM STATEMENT

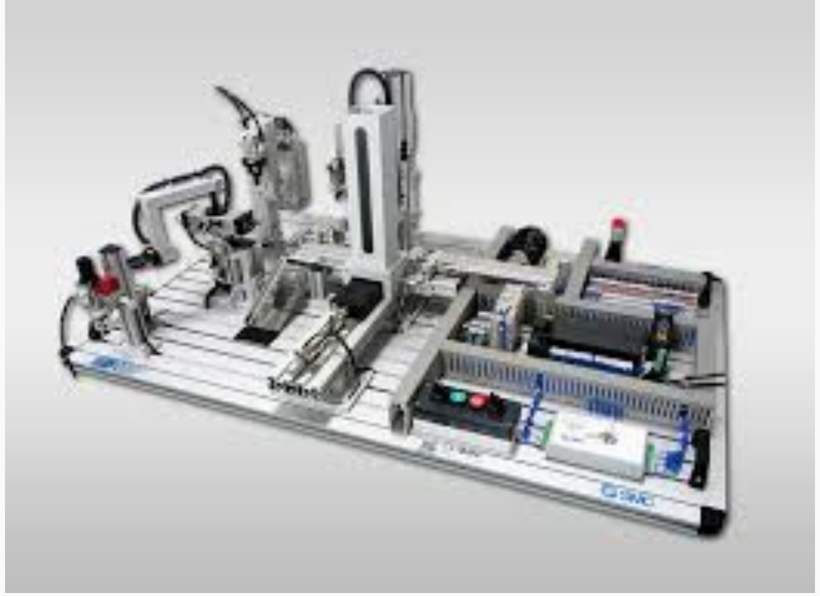


- Engineering students lack practical experience with integrated automation systems
- Current laboratory setups don't reflect real industrial environments
- Training systems often miss modern features like HMI and Scada
- Companies spend extensive resources training new graduates
- Traditional teaching methods don't prepare students for modern factory automation

OBJECTIVES

- To develop an automated system for assembly and disassembly training MAP-205.
- To integrate advanced monitoring and control features for Industry 4.0.
- To evaluate system performance and optimize efficiency for smoother operation using scan time and reduced rungs.

Project Scope



SMC MAP-205

- This project focuses on the MAP-205, an advanced automated manufacturing system. It combines sensors, actuators, and programmable logic controllers (PLCs) to create an efficient and precise mini assembly cell. The MAP-205 is designed to handle manufacturing tasks with high accuracy and adaptability, making it a key innovation in industrial automation.
- The aim of this project is to study the operations of the MAP-205, understand its processes, and document its functions using GRAFCET and ladder diagrams. This project highlights the system's capabilities and its role in improving automation in manufacturing.

Literature Review

Literature Review

Author	Title	Objectives	Limitations
YanYue and Chen Yinjun (2024)	Design and Application of Automatic Material Sorting System Based on PLC Control	• To create an automatic sorting system that efficiently processes and sorts materials. • To develop a user-friendly Human-Machine Interface (HMI) for monitoring operations. • To ensure the system operates effectively and meets control requirements.	• **No IoT Features**: The system does not include Internet of Things (IoT) capabilities for remote monitoring and control. • **Basic HMI**: The Human-Machine Interface lacks advanced features like customizable dashboards and remote access. • **Limited Performance Evaluation**: There is no detailed assessment of system performance or strategies for optimization.
ZuXun Wang (2022)	Design of Gas Drainage Monitoring System Based on Siemens S7-1500 PLC and WinCC	• Develop an automated system for monitoring gas drainage in coal mines. • Integrate advanced features for monitoring and control, such as HMI, SCADA, and IoT. • Evaluate system performance to optimize efficiency and ensure smooth operation.	• **No IoT Features**: The system does not include Internet of Things (IoT) capabilities, which are important for real-time monitoring and remote control. • **Limited HMI and SCADA Functions**: While the system uses Siemens WinCC for monitoring, it lacks advanced monitoring, it lacks advanced Human-Machine Interface (HMI)

Literature Review

Author	Title	Objectives	Limitations
Lv Huimin (2023)	Design and Implementation of the Automatic Sorting System Based on PLC	• To create an automatic sorting system that improves efficiency in production lines. • To design a control system using PLC technology for better operation management. • To ensure the system operates reliably and meets sorting accuracy requirements.	• **Basic Features**: The system lacks advanced capabilities like SCADA and IoT integration, limiting real-time monitoring. • **Different PLC Brands**: The Omron CP1H offers advanced features such as built-in Ethernet communication, which enhances system integration compared to the Mitsubishi FX2N, making it more suitable for complex automation tasks. • **Limited Advanced Features**: The Mitsubishi FX2N lacks the advanced features of the Omron CP1H, such as integrated motion control, which can limit flexibility in

Literature Review

Author	Title	Objectives	Limitations
Chang Wang and Xujie Hou (2022)	Design of Intelligent Book Sorting System Based on PLC Control	• To create an intelligent book sorting system using PLC and touch screen technology. • To improve the sorting and classification of returned books in libraries. • To enhance the efficiency and accuracy of book handling processes.	• **No IoT Features**: The system does not include Internet of Things (IoT) capabilities, which limits its ability to connect and communicate in real-time. • **Lacks Advanced Monitoring**: It does not utilize advanced monitoring tools like SCADA, which are important for overseeing operations and data management. • **Limited Real-World Application**: The design may not fully represent the complexities of actual industrial environments, reducing practical training opportunities for students.

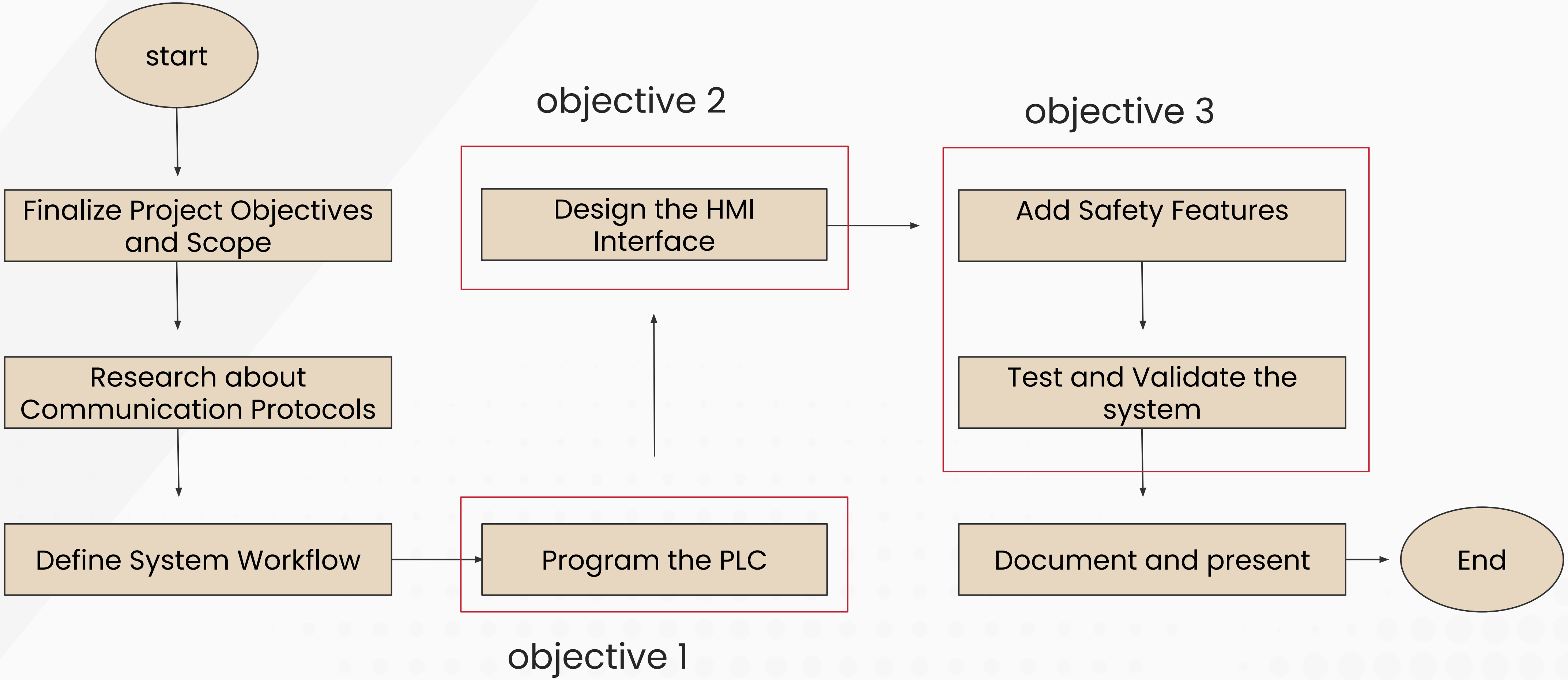
Literature Review Summary

Category	Analysis
Basic HMI and SCADA Features	Existing systems only provide basic HMI and SCADA functionalities, with limited visualization, user interaction, and no advanced dashboards.
Limited Data Analysis Capabilities	Current systems lack advanced monitoring features such as predictive maintenance, performance optimization, and automated reporting.This restricts the ability to track system performance, identify issues proactively, and optimize operations effectively.
Specific Application Focus	Most designs cater to niche applications (e.g., gas drainage or book sorting) and are not adaptable for versatile industrial automation tasks.

Methodology

- Project Flow
- Flowchart
- System Architecture

PROJECT FLOW



SYSTEM ARCHITECTURE

ACTUATORS

Output devices for physical operations , Pneumatic cylinders , Vacuum systems and Rotary actuators

PLC CP1H

input devices for system monitoring,Position sensors Presence detection and Pressure sensors

SENSORS

Human-Machine Interface,Real-time monitoring,Process control,Alarm management and User authentication

HMI

DESIGN SPECIFICATION

LIMITATIONS

- Current systems only provide basic **Human-Machine Interface (HMI) and SCADA** functionalities, which limit user interaction and reduce operational efficiency.
- Many designs focus solely on **specific applications**, making them less adaptable to broader industrial automation needs.

SOLUTIONS

- Develop a user-friendly **HMI and SCADA** system with improved visualization and interaction to ensure better operational management.
- Create a versatile system design adaptable to **various** industrial automation applications, enhancing usability and scalability.

GRAFCETS

AUTOMATIC OPERATION

- **Automated Cycle:** The PLC controls an automatic cycle for assembling and disassembling a turning mechanism using parts like the body, bearing, shaft, and cover.
- **Operation Mode:** The cycle starts in AUTO mode with the Start button and stops anytime with the Stop button. It repeats every time the Start button is pressed.
- **Initial Conditions:** All actuators are in standby, the vacuum ejector is off, and the manipulator must be preloaded. A blinking red light indicates the system is not ready to start.

MANUAL OPERATION

- **Manual Mode Activation:** The "MAN/AUTO" switch is set to **MAN** to enable manual mode.
- **Step-by-Step Operation:** The system performs **each step with a pause**, and transitions to the next step only when the **Start button** is pressed.
- **Cycle Completion:** After completing assembly and disassembly, the system **returns to the initial position and stops**, ready to repeat when the Start button is pressed again.

Gantt Chart of FYP1

Task	Description	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	**Project Planning**															
	Finalize project idea															
	Literature review															
	Study MAP-205 manual															
2	**PLC Development**															
	Research PLC programming															
	Plan system workflow & sequence															
	Basic I/O testing															
	Develop PLC program															
	Testing & debugging															
3	**Presentation and Report**															
	Presentation Slides															
	Thesis Report writing															

Gantt Chart for FYP2

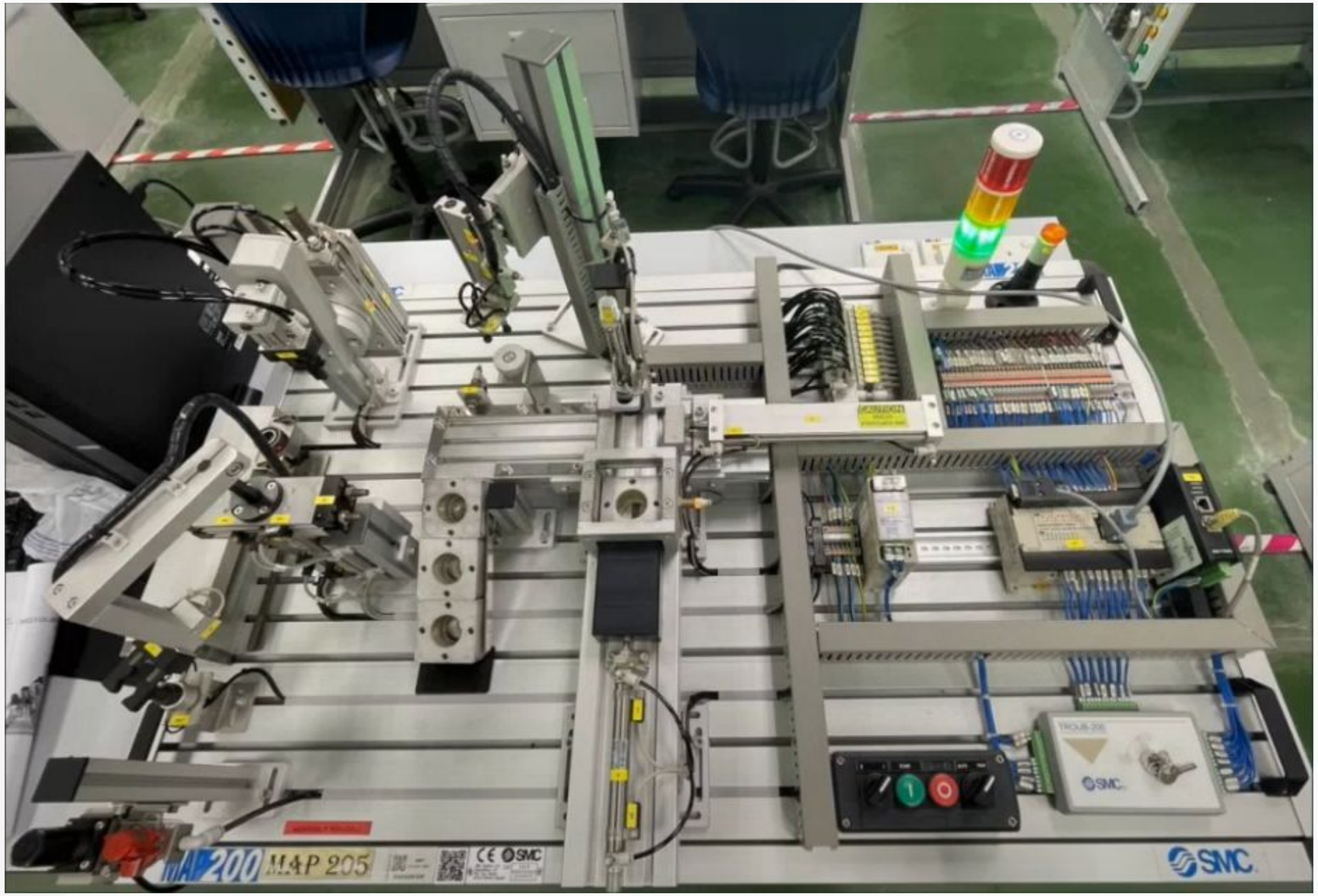
Task	Description	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	**HMI Development**															
	HMI research & planning															
	Implement HMI controls															
	Test HMI-PLC communication															
2	**HMI Integration**															
	SCADA system planning															
	Implement SCADA system															
	Data logging setup															
3	**HMI Implementation**															
	CX-DESIGNER setup															
	Dashboard development															
	System integration testing															
4	**Presentation and Report**															
	Complete system testing															
	Slide and Thesis Report writing															

Results and Discussion

- Current Obtained Results

SYSTEM FLOW

MAP-205 SAI-1125

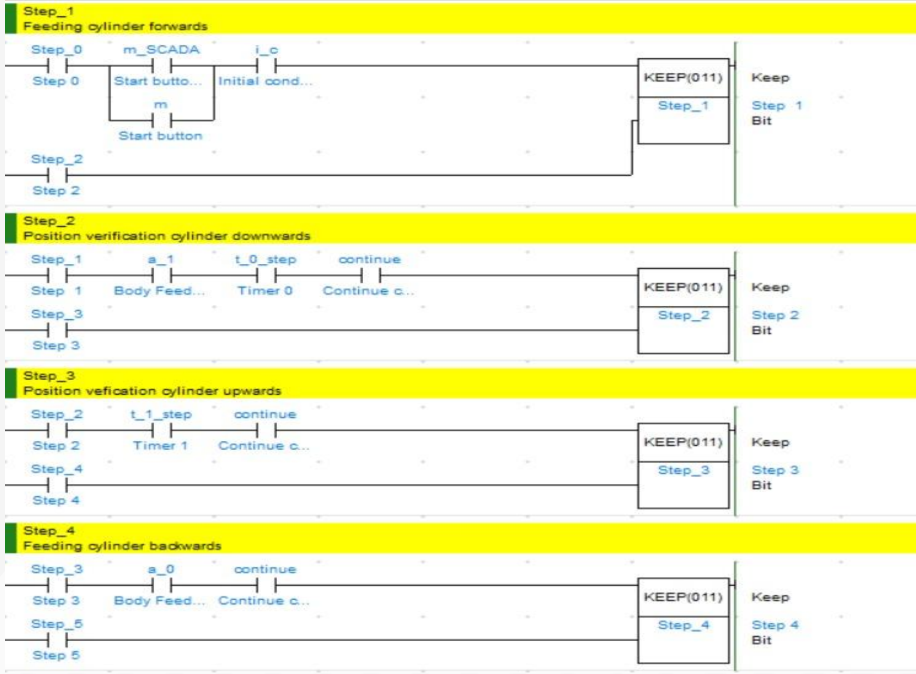


Phases:

- Feeding the base
- Assembling the bearing
- Inserting the shaft
- Placing the Cap

Step No.	Objective/Operation	Input/Component	Output/Result	Conditional Path/Notes
ASSEMBLY PROCESS 1	Feed the base component and ensure correct positioning.	Base components (from hopper/vibratory feeder)	Base on conveyor/indexing table, positioned.	-
2	Verify the alignment of the base (Position Verification).	Positioned Base	Feedback signals to controller.	IF True (Position Verified): Proceed to Bearing Insertion. IF False Send to Rejection Cylinder.
3	Insert the bearing with precision into the verified base (Bearing Insertion).	Bearing (from hopper/feeder)	Base with inserted Bearing.	Robotic arm/pneumatic pick-and-place unit used.
4	Insert the shaft into the bearing and base assembly (Shaft Insertion).	Shaft (from magazine/loader)	Base-Bearing-Shaft assembly.	Quality checks for proper insertion.
5	Complete the assembly by placing and securing the cover (Cover Placement).	Cover (from stacker/conveyor)	Fully Assembled Product.	Secured using clips, screws, or press-fit mechanism.
6	Integration of all previous modules to perform complete assembly .	All components assembled	Completed product, ready for next stage/disassembly.	This marks the end of the assembly sequence.
DISASSEMBLY 7	Systematically remove the cover from the assembled product	Assembled Product	Product with Cover Removed.	Reverses cover placement operation.
8	Systematically remove the shaft from the assembly .	Product with Cover Removed	Product with Cover & Shaft Removed.	Reverses shaft insertion operation.
9	Systematically remove the bearing from the assembly.	Product with Cover & Shaft Removed	Product with Cover, Shaft & Bearing Removed (Base remaining).	Reverses bearing insertion operation.
10	Systematically remove the base, completing the disassembly .	Base (remaining)	Disassembled components (Base, Bearing, Shaft, Cover separated).	Reverses base feeding operation (conceptually).

SYSTEM FLOW



Components Involved:

- Feeder mechanism
- Sensors for base detection
- Actuator for positioning the base

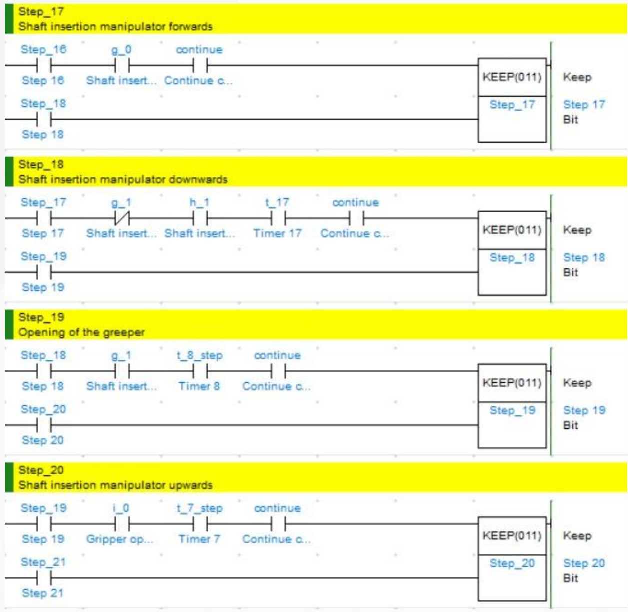
Process:

- The feeder mechanism loads the base onto the assembly station.
- Sensors confirm the base's presence on the station.
- The actuator adjusts the base into its correct position for further processing.

Assembling the bearing

objective 1

SYSTEM FLOW

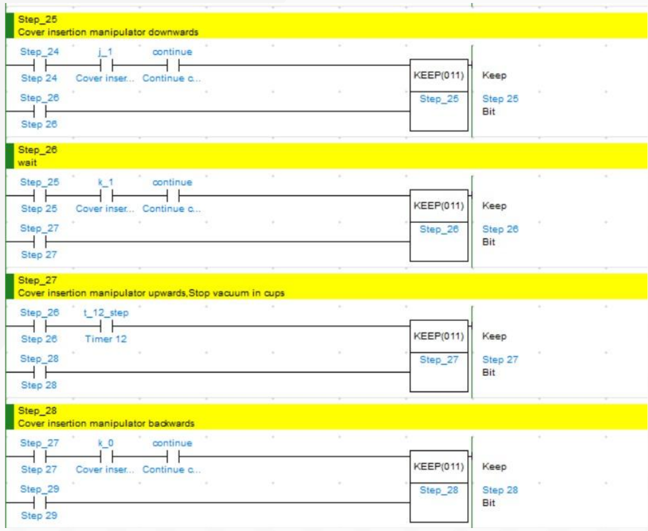


- **Components Involved**:
  - Bearing feeder
  - Gripper mechanism or actuator
  - Sensors for alignment
- **Process**:
  - Bearings are loaded into the feeder.
  - The gripper picks up a bearing and places it onto the base.
  - Sensors check the alignment of the bearing on the base.

Inserting the Shaft

objective 1

SYSTEM FLOW



Components Involved:

- Shaft feeder or magazine
- Actuator for insertion
- Sensors to detect insertion depth

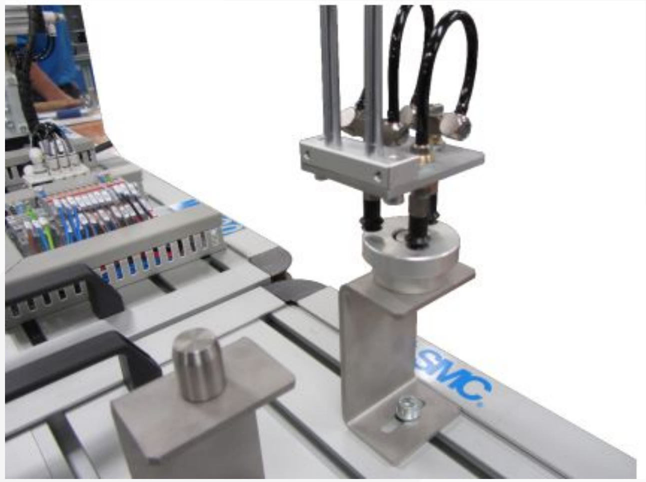
Process:

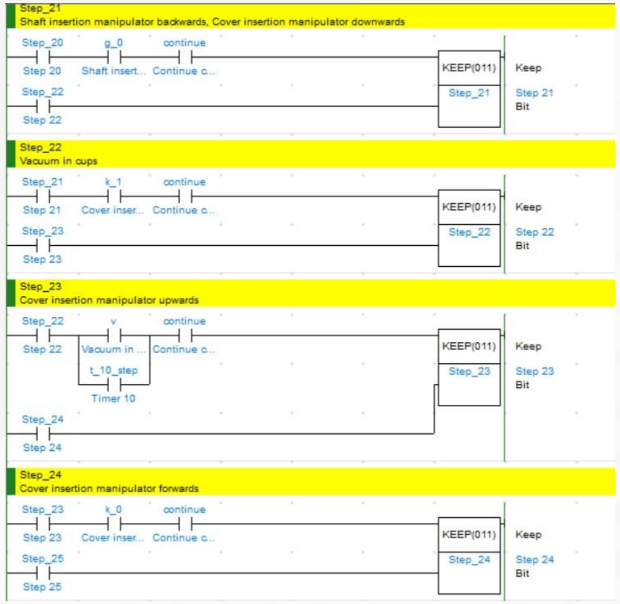
- A shaft is loaded and positioned by the feeder or magazine.
- The actuator inserts the shaft into the bearing.
- Sensors confirm that the shaft is inserted correctly to the required depth.

Placing the Cap

objective 1

SYSTEM FLOW





Components Involved:

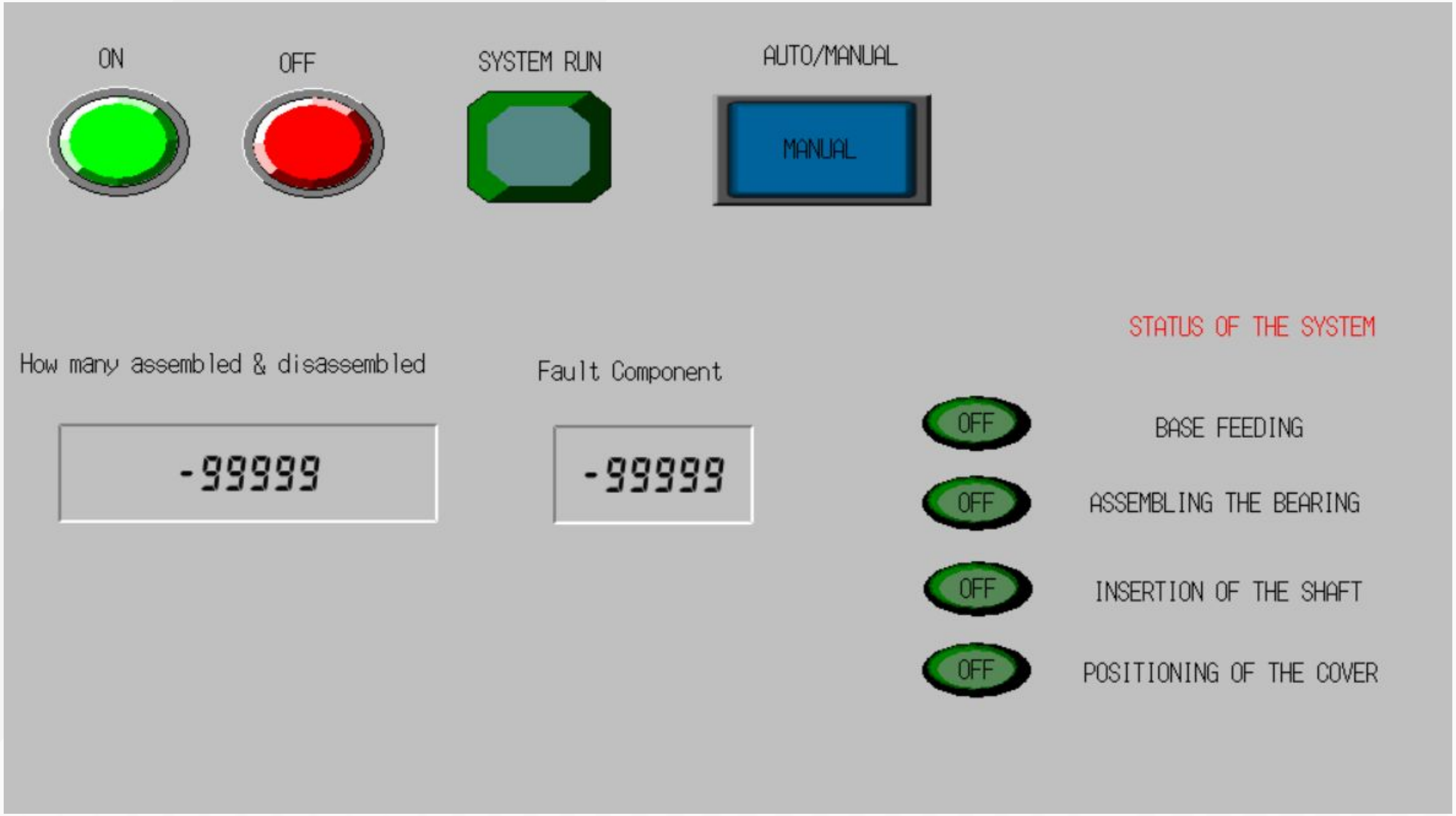
- Lid feeder mechanism
- Gripper or robotic arm
- Sensors to verify placement

Process:

- Lids are loaded into the feeder.
- The gripper picks up a lid and places it on the assembled component.
- Sensors ensure the lid is properly positioned.

ASSEMBLY AND DISASSEMBLY-HMI

objective 2



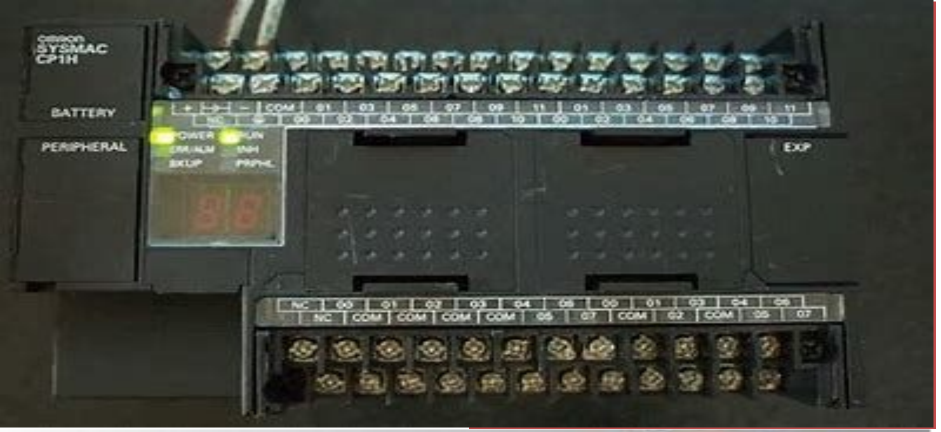
MAP-205 OPTIMIZATION RESULTS

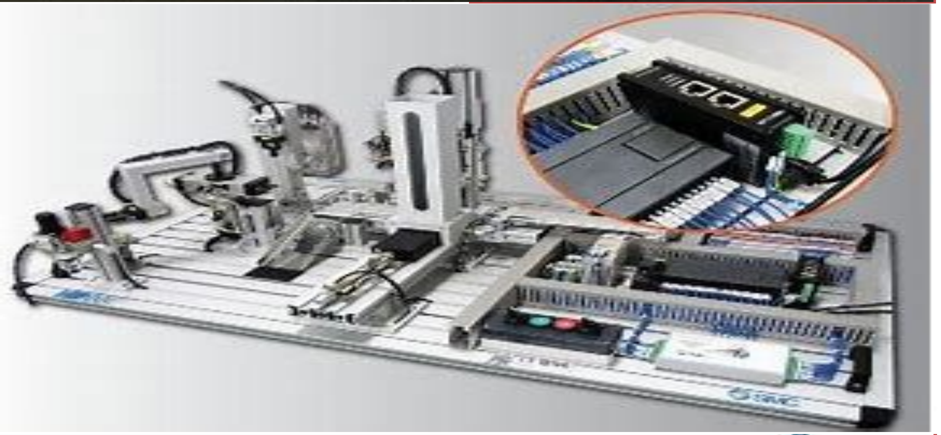
objective 3

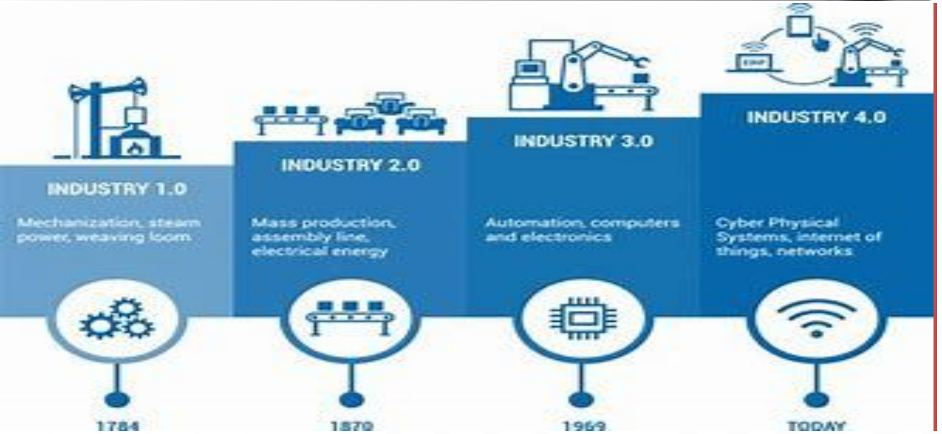
RESULTS	OPTIMIZATION	HOW I DID IT
37% reduction in ladder rungs (247 → 156 rungs)	Combined multiple single-bit operations into word operations	Replaced individual coil operations with MOVE and KEEP operations for multiple outputs simultaneously
36% faster sensor-to-actuator response (12.6ms → 8.1ms)	Reduced network I/O scanning	Grouped I/O operations and used local variables for intermediate calculations
Auto Mode 69% faster throughput (214 vs 127 units/hour)	Eliminated human reaction delays	Programmed direct sensor-to-actuator logic without operator confirmation steps
36% improvement in scan time (4.2ms → 2.7ms)	Eliminated redundant calculations	Created memory variables to store calculated values instead of recalculating in multiple rungs

future work

- **IoT Features and opencv:**: Add cloud-based connectivity for remote monitoring and control, enhancing system accessibility and functionality.







Conclusion

The MAP205 trainer is an excellent tool for learning and practicing industrial automation processes. Its step-by-step operations help users understand how cylinders, sensors, and timers interact within a system. This trainer simplifies complex tasks such as part assembly, component insertion, and completing automated processes. By utilizing the MAP205, users can gain a deeper understanding of automation workflows and develop the skills needed to manage real-world industrial systems efficiently.

An important outcome of this project is the preparation of a comprehensive lab sheet for students, which will serve as a reference guide to help them understand and operate the MAP-205 trainer effectively.

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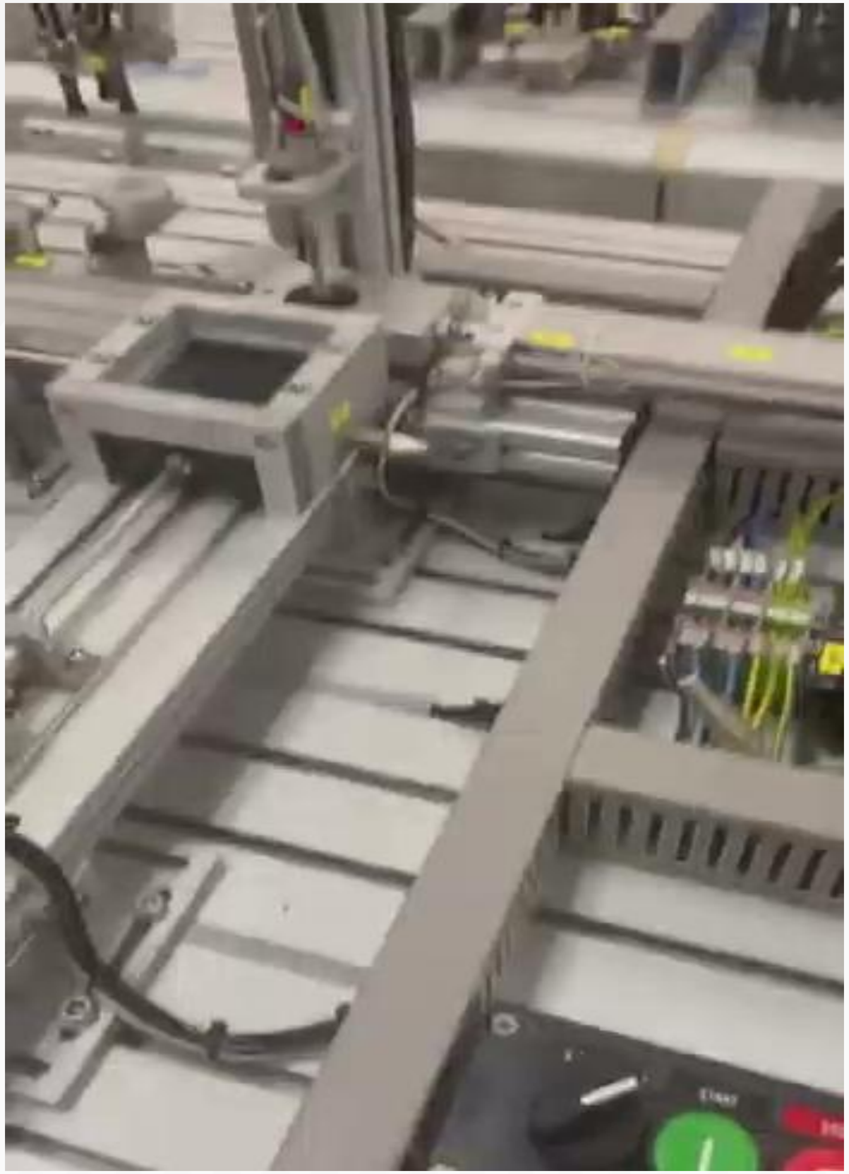
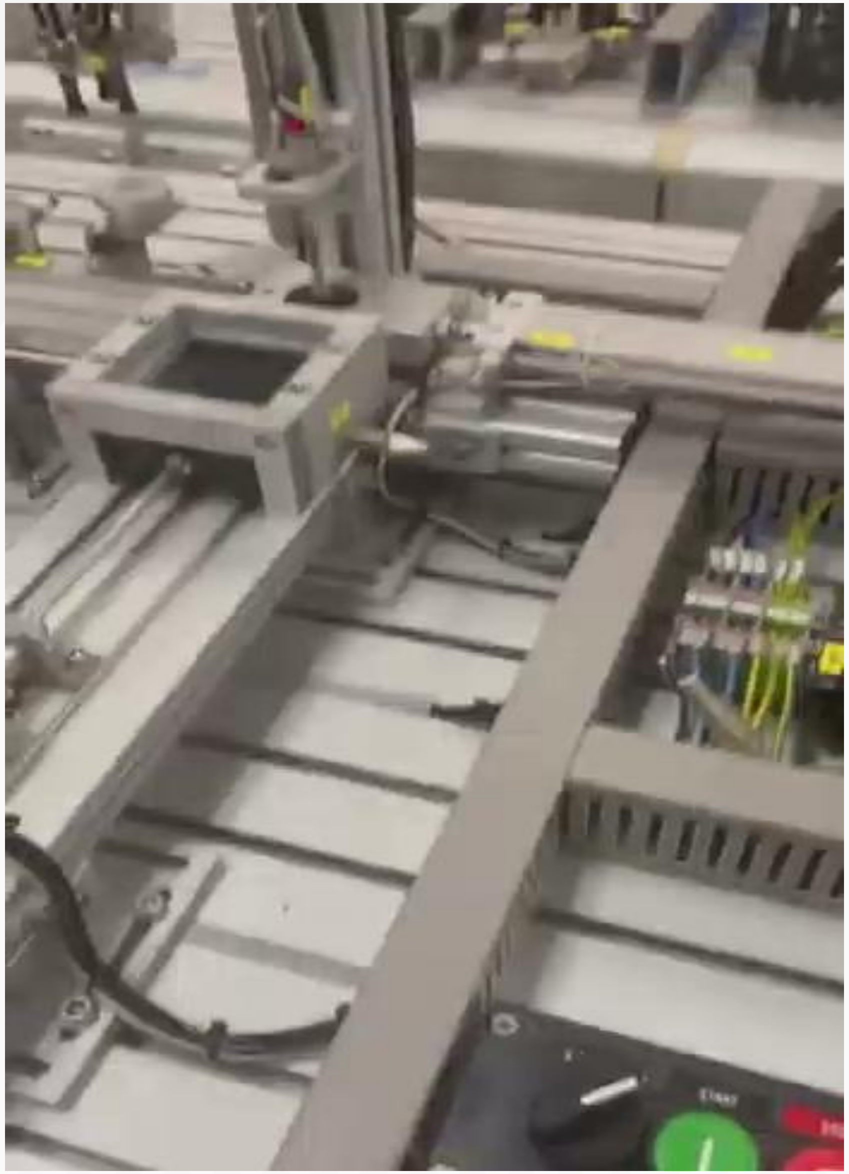
DEMO

- CODING AND HMI

ASSEMBLY AND DISASSEMBLY-AUTO



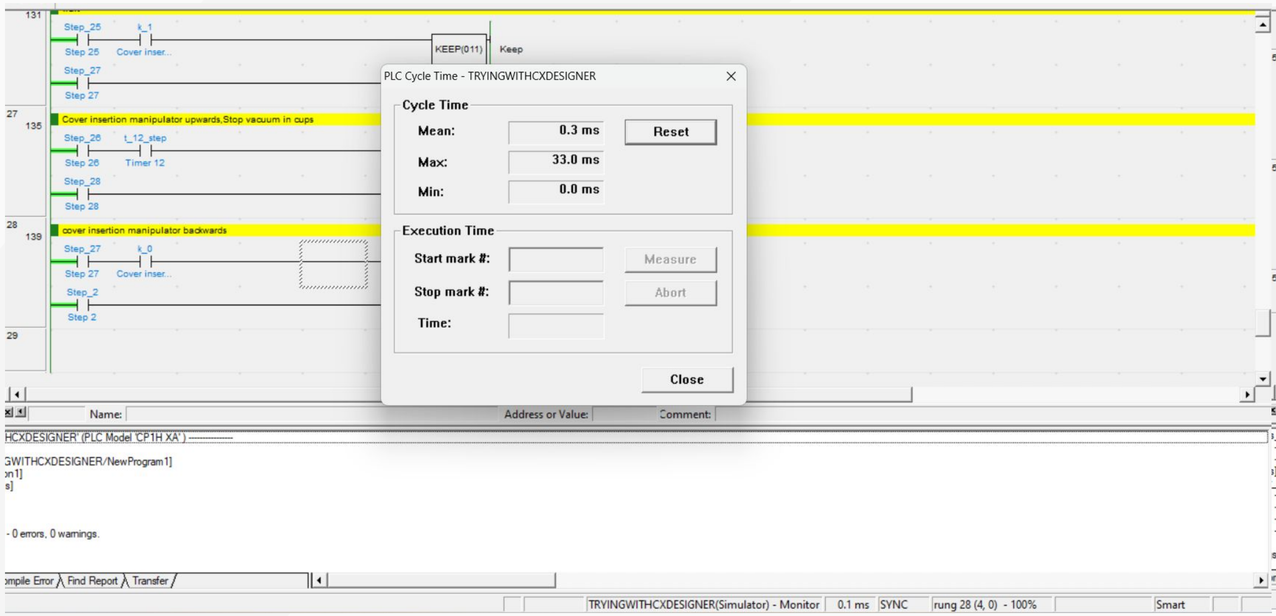
ASSEMBLY AND DISASSEMBLY-FAULT ORIENTATION



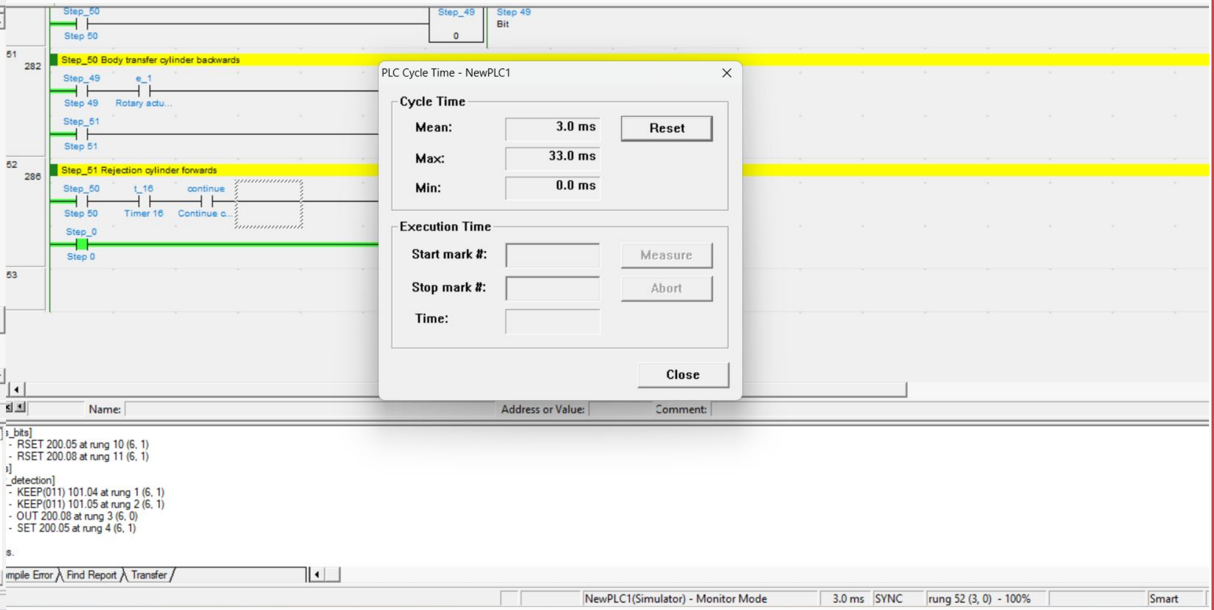
ASSEMBLY AND DISASSEMBLY-MANUAL

HMI

objective 3



PLC Cycle Time - TRYINGWITHCXDESIGNER
Cycle Time
Mean: 0.3 ms
Max: 33.0 ms
Min: 0.0 ms
Reset
Execution Time
Start mark #:
Stop mark #:
Time:
Measure
Abort
Close
TRYINGWITHCXDESIGNER(Simulator) - Monitor



PLC Cycle Time - NewPLC1
Cycle Time
Mean: 3.0 ms
Max: 33.0 ms
Min: 0.0 ms
Reset
Execution Time
Start mark #:
Stop mark #:
Time:
Measure
Abort
Close
NewPLC1(Simulator) - Monitor Mode