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APPLIED CONTROL LABORATORY
STUDENT PACK

PLC Programming and HMI Development for MAP-205 Automated Assembly & Disassembly System

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1. **Problem/Project Guide:**

A Programmable Logic Controller (PLC) is a digital device used to control machines and processes automatically. It replaces older control methods like relays, timers, and counters with modern electronic components such as transistors and integrated circuits. According to the National Electrical Manufacturers Association (NEMA), a PLC is an electronic system that uses a programmable memory to perform tasks like logic, sequencing, timing, and counting by receiving input and sending output signals, either digitally or through analog systems.

Before PLCs were invented, control systems used mechanical and electrical methods such as hydraulic or pneumatic systems, relay-based circuits, and hard-wired logic circuits. These older systems worked by connecting three main elements:

1. Input – Devices like sensors that detect physical conditions (such as temperature or position) and send electrical signals to the control system.

2.Control – The part that reads the input signal, processes it based on a pre-written program, and makes decisions.

3.Output – Devices like actuators that carry out actions (such as turning on a motor) based on the control system's instructions.

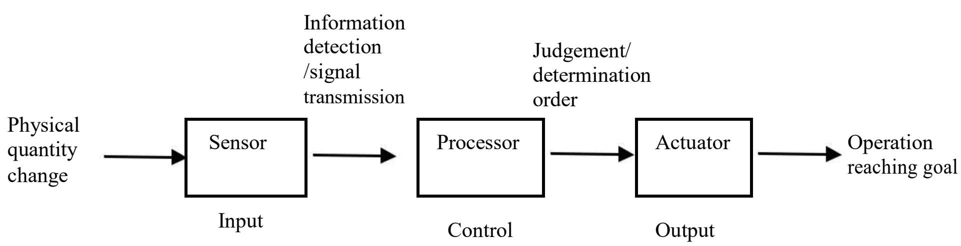


Figure 1: The correlations of the elements in the system

As it is easily programmable to accomplish a variety of control operations, it quickly gains wider applications in industry by replacing its predecessor, the electromechanical relays. The relays are now commonly used as switches and no longer as logical controllers. Logical systems are normally represented graphically by using state diagrams or other similar methodologies. The representation is then transformed to ladder logic diagrams and implemented in PLC by using its programming language which resembles the ladder logic diagram.

The purpose of this project is to control the automated assembly and disassembly process of the MAP-205 training kit using a PLC and HMI.The system includes base feeding, bearing assembly, shaft insertion, and cap placement, all managed through PLC programming and monitored via an HMI interface.

a) Problem Objectives:

- To program the MAP-205 assembly and disassembly process using CX-Programmer.
- To design an HMI for system control and monitoring using CX-Designer.

b) Problem Design:

The MAP-205 automated training kit, used for teaching assembly and disassembly processes in industrial automation, currently lacks advanced features like a fully programmed PLC sequence and interactive HMI interface. The control system is expected to simulate real industrial operations for effective training purposes.

Your team is assigned to develop a working PLC program using CX-Programmer and design a corresponding HMI interface using CX-Designer. The goal is to ensure smooth, automated control of the four stages: base feeding, bearing assembly, shaft insertion, and cap placement. The report should include the full sequence of operation, logical flow of the process, and how each phase is controlled and monitored through the HMI system.

To tackle the problem design, students are required to perform the task in c section.

c) Task :

You need to perform the task under the following conditions. Please make sure the basic wiring is connected to the system in accordance with the input & output wiring diagram, and write a PLC program to control the system, and carry out its trial run.

1) **Base Feeding**

The process begins with a "box type" or gravity feeder supplying the base. A pneumatic cylinder extracts the base, and an inductive sensor confirms extraction and monitors supply levels.

2) **Position Control**: A pneumatic cylinder checks the base's orientation by inserting a cylindrical part into its seat. Incorrect positioning is signaled to the PLC if the cylinder's run is obstructed

3) **Dislocation to the Insertion Point**: A rectangular section cylinder moves the base to the insertion point, preventing rotation of the thruster.
4) **Rejection of Incorrect Base**: If the base is incorrectly positioned, a single-acting cylinder pushes it onto a ramp, clearing the insertion zone.
5) **Mounting of Bearing**: A manipulator with a rack and pinion rotating actuator moves the bearing from the feeding point to the base. A photoelectric cell confirms the bearing's presence. An arm with a 2-finger air gripper, supported by a cog belt and pinions, ensures the bearing settles without inclination.
6) **Insertion of the Shaft**: A linear and rotary manipulator handles shaft pick-up, displacement, and insertion into the bearing. A fiber optic photoelectric cell verifies the shaft's presence at the feeding point. The arm with gripping force holds the shaft, rises, rotates 90 degrees, and descends to insert it.
7) **Positioning of the Cover**: Finally, two vacuum-held shafts collect and position the cover onto the base. This manipulator uses dual-rod air cylinders and a plate with three vacuum pads with buffers to absorb height misalignments. A vacuum ejector with a vacuum switch ensures the cover is securely fixed.
8) **Disassembly and Ejection**: After assembly, the system is capable of performing disassembly removing the components. Following the disassembly process, the ejection cylinder would then be utilized to push the box

Note: Please use the basic I/O allocation set to MAP-205 in Table 1.

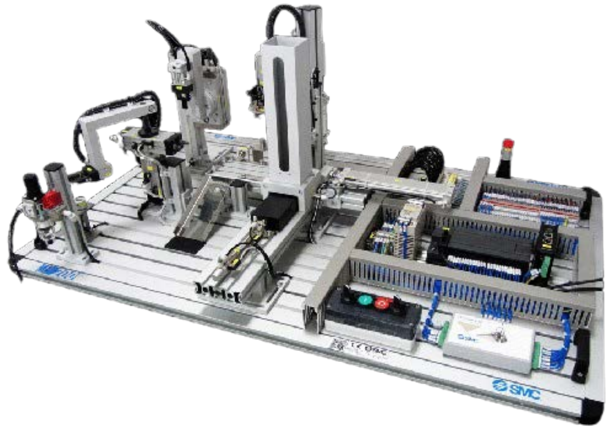


Figure 2: MAP-205 Assembly-Disassembly Minicell

A report supported with the experiment result is expected to be produced at the end of the task. The collected data and analysis should be well presented and discussed in detail in the report.

d) Problem-solving Time-line

Activities	Week 1	Week 2	Week 3
1. Briefing, PLC exercises, brainstorming, oral interview, submission of proposal	■■■		
2. Design/programming/experiments, oral interview, individual report		■■■	
3. Analysis, oral interview, demonstration of final designed			■■■

e) Proposal write-up

You are expected to submit a handwritten project proposal on one page of paper + attachments (e.g. a flowchart for software based project). Each write-up is to be submitted as teamwork on the **first week** of the laboratory. Please ensure that each team member is responsible enough to contribute in completing the work. Your proposal may include the following information:

- title
- objective
- problem statement
- methodology (flow chart/block diagram/list of equipment, materials)
- expected outcome

f) Report writing

A group report needs to be submitted in the **post week** after the third week of laboratory session. Your report should follow the general guide by the Laboratory Coordinator such as abstract, introduction, methodologies etc.

Other than the general guide, your report for this laboratory may also include:

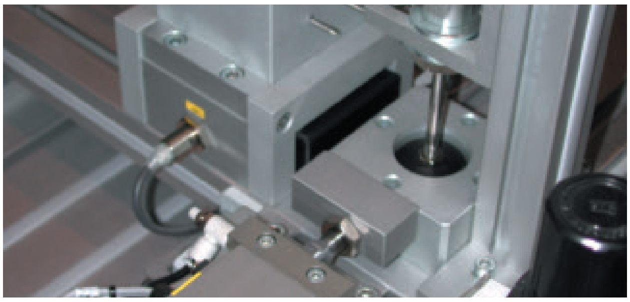
- Review and circuit diagrams
- Data and graph as a results
- Photographs of the actual circuit construction
- Photographs of your group members

g) Questions That Can Help You Tackle The Problem

1) How does the MAP-205 training kit simulate real industrial assembly and disassembly processes?
2) What are the inputs and outputs of the system?

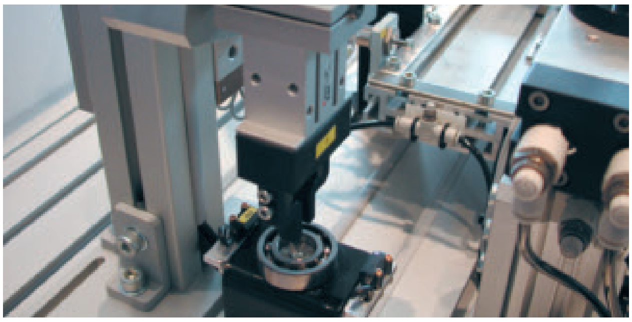
	3) How is the PLC (Omron CP1H) programmed using CX-Programmer to control the sequence of operations? 4) What is: a. Timer b. Counter c. Single/ double acting cylinder d. holding circuit e. limit switch f. capacitive/ inductive sensor 5) How does the HMI (created using CX-Designer) interact with the PLC to display system status and receive user inputs?
2.	**Equipment list:**
	(a) MAP-205 Assembly & Disassembly minicell (b) PLC OMRON CP1H
3.	**Components list:**
	(a) Sensors (b) Actuators (c) Push buttons
4.	**Software:**
	(a) PLC programming software: CX- Programmer (b) HMI Development software:CX-Designer
5	**Additional resources:**
	Materials related to the project can include user manuals, datasheets, programming guides, and training materials to assist in understanding the system operation and software tools. Below are examples of helpful references for this project: (a) MAP-205 Training Kit – User Manual (SMC Corporation) (b) CX-Programmer Programming Guide – For programming Omron PLCs (CP1H) (c) CX-Designer User Manual – For creating Human-Machine Interfaces (HMI) (d) SMC Pneumatic Circuit Exercises – For understanding actuator and sensor interactions (e) Wiring and I/O Configuration Examples – Refer to lab guides or technical PLC handbooks (f) Figures of the MAP-205 System – Used for hardware reference and troubleshooting during lab sessions

Modules included in the equipment:



Base feeder.

The bases are housed in a gravity part feeder. The process starts by extracting a base and verifying that the position is correct. If it is not in the correct position, it is pushed towards the evacuation ramp. If it is in the correct position, it is moved to the insertion point.



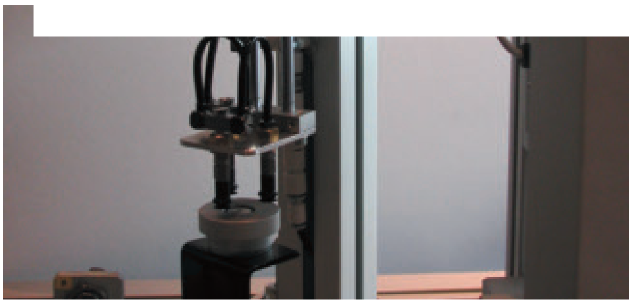
Bearing assembly.

By using a rack and pinion type revolving handling device, which detects an angle of 180º, a bearing is inserted inside the base coming from the previous module.

The presence of the bearing in the initial position is verified by a miniature photocell. If affirmative, the gripper arm attached to the handling device holds the bearing and inserts it into the base.

Insertion of the shaft

A rotolinear handling device is used during this phase of the process, having verified the presence of the part by using a fiber optic photocell. The moving of the part is carried out using a gripper attached to the rotolinear handling device.



Positioning of the lid

The last assembly operation is carried out using a handling device consisting of two shaft-shaped cylinders with a plate fitted with three vacuum pads.

Once the lid is positioned, the assembly process will be completed.

Table 1: Basic I/O allocation set to the MAP-205

Variable	Address	Description
m	0.00	Start button
p	0.01	Stop button
atm	0.02	Auto/Manu selector
a_0	0.03	Body Feeder backward
a_1	0.04	Body Feeder forward
b_1	0.05	Body transfer cylinder forward
c_1	0.06	Position verification cylinder downward
e_0	0.07	Rotary actuator backward
e_1	0.08	Rotary actuator in the middle position
e_2	0.09	Rotary actuator forward
g_0	0.10	Shaft insertion manipulator upward
g_1	0.11	Shaft insertion manipulator downward
h_0	1.00	Shaft insertion manipulator backward
h_1	1.01	Shaft insertion manipulator forward
i_0	1.02	Gripper opened
i_1	1.03	Gripper closed
j_0	1.04	Cover insertion manipulator backward
j_1	1.05	Cover insertion manipulator forward
k_0	1.06	Cover insertion manipulator upward
k_1	1.07	Cover insertion manipulator downward
v	1.08	Vacuum in cups
dp1	1.09	Body detector
dp2	1.10	Bearing detector
dp3	1.11	Shaft detector

Variable	Address	Description
APLUS	100.00	Feeder cylinder forwards
BPLUS	100.01	Body transfer cylinder forwards
CPLUS	100.02	Position verification cylinder downwards
DPLUS	100.03	Rejection cylinder forwards
EPLUS	100.04	Rotary actuator forwards
EMINUS	100.05	Rotary actuator backwards
FPLUS	100.06	Opening of the gripper of the rotary actuator
GPLUS	100.07	Shaft insertion manipulator downwards
HPLUS	101.00	Shaft insertion manipulator forwards
IPLUS	101.01	Gripper closure
JPLUS	101.02	Cover insertion manipulator forwards
JMINUS	101.03	Cover insertion manipulator backwards
KPLUS	101.04	Cover insertion manipulator downwards
VPLUS	101.05	Vacuum in cups
FM	101.06	Error light on