



ROBOTICS AND APPLIED ARTIFICIAL INTELLIGENCE LABORATORY (6 DOF)



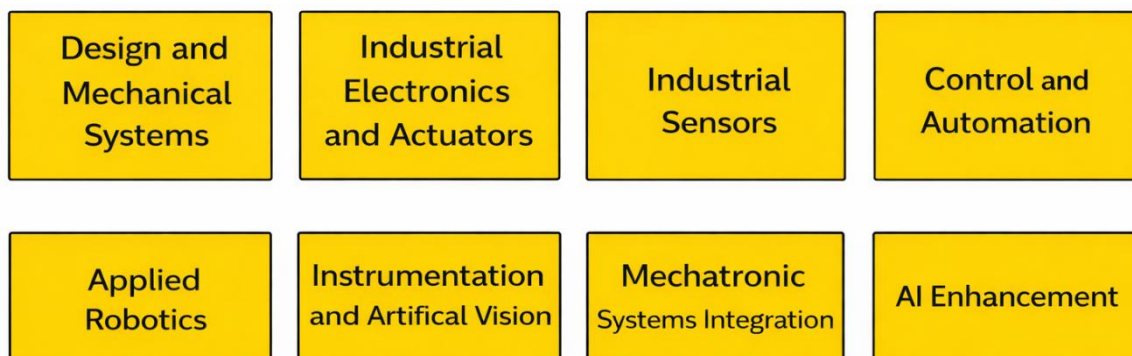
DL XM-AI-PLC

INTRODUCTION

The Robotics and Visual Inspection Didactic Station with PLC is a compact training system designed to teach applied mechatronics in a fully industrial environment. It integrates a six-axis robot, an automated conveyor belt, industrial sensors, a parts dispenser, and a Siemens S7-1200 controller with HMI, enabling hands-on practice in assembly, synchronization, and diagnostics.

Designed with a fully didactic approach, this station transforms theory into practice. Students learn mechanics, electronics, and control while integrating vision and robotics, developing key competencies to operate and implement real automated manufacturing cells in Industry 4.0.

AREAS COVERED BY THE LABORATORY





DIDACTIC APPROACH

The pedagogical approach of the station is based on experiential learning and progressive skill development, where students build technical competencies by integrating mechanics, electronics, control, and programming through hands-on practice on a functional industrial system. The trainer promotes analytical skills, problem-solving abilities, and systems thinking.

The teaching model is supported by three principles:

- 1. Learning by Construction (Learning by Doing):**
Knowledge emerges from assembly, wiring, programming, adjustment, and real-time troubleshooting, replicating the work of an industrial integrator.
- 2. Integrated Competencies (Applied Mechatronics):**
Students do not study isolated areas; instead, they experience how robotics, PLCs, vision systems, and sensors interact to bring an automated cell to life, fostering interdisciplinary reasoning.
- 3. Real-World Problem Solving (Industrial Projects):**
Practical activities are designed around real industrial challenges: sorting parts, synchronizing conveyor and robot, implementing visual inspection, or improving cycle times-promoting performance-based decision-making.

Overall, this approach prepares students to perform as technicians or integration engineers, capable of understanding, implementing, and improving smart manufacturing systems within Industry 4.0 environments.

Simulated Industry Challenges:

- Automatic classification based on features.
- Robot–conveyor synchronization.
- Robot–PLC–sensor integration.
- Visual inspection and decision-making.
- Workflow optimization.
- Functional safety implementation.
- Intelligent product handling.

Main Didactic Concepts:

- Applied mechatronics.
- Industrial robotics.
- PLC-based automation.
- Machine vision and inspection.
- AI and decision-making.
- Systems integration (Industry 4.0).
- Industrial safety.

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SYSTEM COMPONENTS: Detailed Description of the System Elements.

1) 6DOF Didactic Robot: Compact robotic arm designed for pick & place tasks, sorting, and repetitive handling. It enables teaching basic kinematics, trajectory programming, and coordinating systems, as well as safe interaction with other equipment. Its precision and speed make it the central element of the process, operating according to PLC instructions and vision system decisions.

2) Siemens S7-1200 PLC Controller: Main control unit of the station, responsible for coordinating conveyor movement, parts dispensing, sensor signals, and safety logic. It enables industrial programming practices using timers, counters, logic blocks, ProfNet communication, and sequential control. It serves as the link between robotics, vision, and actuators.

3) Touch HMI for Operation and Diagnostics: Industrial graphical interface that allows the user to operate the cell through buttons, alarms, parameters, and production statistics. It facilitates understanding of the automated cycle and teaches students to design professional screens for real processes: automatic mode, manual mode, maintenance stop, alarms, and monitoring of robot and conveyor status.

4) Automated Conveyor Belt: Transport mechanism that moves parts along the station. Controlled by the PLC, it simulates real feeding processes for a robotic cell. It enables practice in robot–conveyor synchronization, sensor detection, speed control, cycle time tracking, and moving-part logistics.

5) Automatic Parts Dispenser: Mechanical and pneumatic system controlled by the PLC to release parts in a regulated manner onto the conveyor. It simulates continuous feeding processes used in industrial lines. It allows programming of dispensing cycles, frequency regulation, and event handling to prevent jams or material depletion.

6) Industrial Sensors: Includes industrial-grade sensors strategically placed to detect product presence, passage, or position. These sensors function as PLC input signals and as triggers for the vision system. They enable learning of industrial instrumentation principles, wiring, fault diagnostics, and response times.

7) Vision System with Microcomputer: Camera connected to an embedded processor (microcomputer) that runs machine vision or AI algorithms to analyze the moving part. It sends information to the PLC or robot to classify, accept, reject, or trigger specific actions. It enables practical work with OpenCV, basic neural networks, camera calibration, and coordinating transformation.

8) Auxiliary Actuators (Electrical / Pneumatic): Solenoid valves, solenoids, and vacuum gripper that complement the function of the robot and conveyor. These actuators allow students to learn principles of power systems, driver control, circuit protection, preventive maintenance, and logical activation from the PLC or the robot itself.

9) Structure, Control Panel, and Didactic Connections: Mechanical base with industrial profiles and a control panel equipped with protections, labeling, and accessible connection points for rewiring practice. It includes terminal blocks, fuses, switches, relays, and didactic terminals. It enables students to wire, configure, measure, troubleshoot, and validate electrical safety, just as performed in industrial environments.