MATRIX | INDUSTRIAL MAINTENANCE

Teachers Notes for

CP2388 – PLC Fundamentals for Maintenance Engineers

MATRIX

CP2388

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INTRODUCTION

This Teacher Notes document is designed to support delivery of the CP2388 PLC Fundamentals for Maintenance Engineers curriculum, mapped to T Level and EAL industrial maintenance units. The program is aimed at students and apprentices who are new to PLC-controlled systems and industrial automation.

The PLC Fundamentals Trainer uses real-world components, including a Siemens S7-1214 PLC, Unified Basic HMI, industrial sensors, relays, and actuators, to provide hands-on experience with typical control panel hardware. Lessons are structured around practical tasks such as wiring inputs and outputs, understanding safety circuits, using indicator LEDs, and observing motor and relay behaviour.

No prior programming experience is required. Each worksheet introduces a specific component or concept, gradually building learner confidence in system wiring, signal tracing, and interpreting PLC and HMI feedback.

This document gives you as the instructor:

- Clear learning objectives for each worksheet
- Suggested teaching strategies and pacing
- Safety guidance for practical sessions
- Mapped answers to all worksheet tasks
- Notes on differentiation and flexible lesson delivery (guided, scenario-based, or self-paced)

Whether you are working with complete beginners or those developing existing skills, this course provides a foundation in industrial automation that prioritises hands-on learning, diagnostic thinking, and readiness for real-world maintenance roles.

INSTRUCTOR GUIDE

TEACHING STRATEGY

Scaffolded, Hands-On Learning

- Begin each topic with a short demonstration using the PLC Fundamentals Trainer.
- Move quickly from theory to practical application: after introducing a component or concept (e.g., relay operation, NO/NC contacts), have learners immediately locate, wire, and test it on the hardware.
- Use the HMI interface to visualise system states, reinforcing how physical actions affect control logic.

Structured Worksheets with Instructor Guidance

- Assign worksheets sequentially, ensuring learners follow the intended progression from simple to more complex tasks.
- For each worksheet:
    - Start with a group walk-through of the first task or question.
    - Then set learners to work in pairs or individually, encouraging them to explore, test, and observe system responses.
    - Rotate around the classroom to provide guidance, clarify misconceptions, and ensure safety protocols are followed.

Emphasis on Diagnostic and Troubleshooting Skills

- Regularly prompt learners to explain the purpose of each device, wiring choice, or PLC response.
- Incorporate “what if?” scenarios: for example, ask what would happen if a wire was disconnected, or a button was stuck.
- Use the status LEDs, HMI fault pages, and visible wiring to develop students’ ability to trace and diagnose faults.

Real-World Context and Safety

- Link every practical task to real-world industrial scenarios (e.g., emergency stop circuits, relay-driven actuators, sensor testing).
- Reinforce electrical safety and correct isolation before any changes to the hardware.

Teaching Strategy

- Discuss best practices for documentation, test point verification, and use of multimeters.

Ongoing Assessment and Reflection

- Use worksheet answers, observed practical competence, and informal questioning to monitor progress.
- At the end of each lesson, run a short recap or Q&A, asking students to summarise key concepts or demonstrate correct operation.

This strategy ensures students build confidence and competence step by step, with every session reinforcing both practical and theoretical skills essential for industrial maintenance roles.

Learning Objectives

LEARNING OBJECTIVES

By the end of the PLC Fundamentals curriculum, learners will be able to:

1. Identify and explain the function of common industrial control panel components, including push buttons, selector switches, relays, motors, indicator lights, and sensors.
2. Demonstrate correct wiring and testing of both digital and analogue input and output devices to a Siemens PLC and HMI.
3. Apply safe working practices by using isolation devices, emergency stops, and status indicators during system operation.
4. Distinguish between digital and analogue signals, explain how PLCs process each type, and apply scaling to interpret sensor values.
5. Monitor and interpret PLC and HMI feedback, including I/O activity, fault states, and process conditions, to support troubleshooting.
6. Understand how PLC logic controls outputs, including sequencing, latching, and PWM motor speed control.
7. Follow structured worksheets to build practical confidence in tracing signals, testing circuits, and verifying safe system operation.
8. Describe how a PLC processes basic on/off inputs to control outputs, using push buttons and indicator LEDs.
9. Explain sequencing and latching logic, and demonstrate how a PLC can manage multi-step processes with start/stop conditions.
10. Interpret HMI displays to monitor live I/O states, process steps, and alarms, and explain their role in operator interaction.
11. Demonstrate safe isolation using a dual-channel emergency stop and reset circuit, and explain its role in industrial safety.
12. Recognise how system status indicators show healthy, fault, and stop states, and explain their use in diagnostics.
13. Distinguish between normally open (NO) and normally closed (NC) inputs, interpret their states on the HMI, and explain why both are used in control circuits.
14. Connect and test an inductive proximity sensor, and describe its application in detecting objects and ensuring safe operation.
15. Use a potentiometer to generate a 0–10 V analogue signal, and explain how PLCs scale and process analogue inputs.
16. Measure and interpret readings from a PT100 RTD with transmitter, and explain how analogue scaling converts raw values into real temperatures.
17. Operate PLC-driven outputs such as LEDs, relays, and motors, and explain how digital logic activates actuators.

Learning Objectives

18. Demonstrate how PWM control varies motor speed, and relate duty cycle percentage to motor performance.
19. Explain and test the function of relays in isolating PLC outputs from loads, and describe their importance in industrial control circuits.

Suggested Delivery & Pacing

SUGGESTED DELIVERY & PACING

The following table provides a recommended delivery and pacing plan for the PLC Fundamentals Trainer curriculum, mapped to 12 weeks. Each week focuses on one worksheet, giving learners the time to deeply explore each core concept and practical activity.

Delivery Modes

- **Discovery:** Learners are encouraged to investigate, experiment, and record their observations independently or in pairs.
- **Guided:** The instructor leads the session step-by-step, providing demonstrations and direct explanations.

Week	Focus / Topic	Worksheet	Mode	Notes
1	Introduction & Safety	Introduction, Safety Note	Discovery	Course overview, system demo, safety briefing
2	Simple PLC Systems	Worksheet 1	Discovery	Hands-on with push buttons and indicator LEDs
3	Complex PLC Systems	Worksheet 2	Discovery	Sequencing, latching, real-world system behaviour
4	HMIs	Worksheet 3	Guided	Instructor demonstrates HMI use and process navigation
5	Emergency Stops	Worksheet 4	Discovery	E-Stop, reset logic, safety system exploration
6	Status LED	Worksheet 5	Discovery	System status indication, fault and run states
7	Normally Open vs Normally Closed	Worksheet 6	Discovery	Contact types, input states, diagnostic thinking
8	Proximity Switch	Worksheet 7	Guided	Teacher-led sensor setup, alignment, fault finding
9	Potentiometer	Worksheet 8	Discovery	Analogue input, scaling, real-time testing

Suggested Delivery & Pacing

10	Temperature Sensor	Worksheet 9	Discovery	RTD, transmitter, scaling and sensor faults
11	Digital Outputs & Motor PWM	Worksheet 10, Worksheet 11	Discovery	Outputs, output mapping, PWM and speed control
12	Relays & Review	Worksheet 12, Review/Assessment	Discovery	Relay wiring, output switching, end-of-course review

SAFETY BRIEFING

Before any practical work begins, instructors should review the following key safety points with learners:

Isolation Procedure

Always isolate power using the circuit breaker (MCB1) before adjusting or removing any hardware wiring. No wire changes should be made while the system is powered.

Low Voltage Operation

The trainer operates at 24 V DC only. Never allow connection to mains voltage. Use only the supplied power adapter.

Emergency Stop Limitations

The E-Stop is simulated in software and does not disconnect electrical power. Instruct students that for any real emergency, the MCB must be switched off and the power supply unplugged.

Pre-Session Checks

Inspect the trainer before each session for loose wires, damaged cables, or signs of tampering. Do not use the unit if any issues are found.

Supervision of Moving Parts

Always supervise students and instruct them to keep fingers, hair, and loose clothing away from moving parts.

No Unauthorised Modification

Students must not modify internal wiring, connect external devices, or open the enclosure. Only qualified staff should carry out internal work.

Component Handling

Ensure all controls (buttons, switches, potentiometer, sensors) are used as instructed. Prevent misuse or forced operation of any component.

Faults and Troubleshooting

If the system shows a fault or behaves unexpectedly, stop the session and investigate. Do not permit unsupervised troubleshooting or resets.

Safety Briefing

Classroom Management

Maintain clear walkways and safe workspace around each trainer. Limit the number of students per unit to ensure effective supervision.

Communication of Safety Procedures

Remind students regularly about safe working practices, isolation steps, and emergency shutdown procedures.

STANDARD FAULT LIST

The system monitors several core faults which cannot be bypassed in software. If any are detected, the system will stop or prevent operation until the fault is resolved and reset.

Here's a simple breakdown of each fault:

- **Emergency Stop Fault:** Checks if the dual-channel E-Stop circuit is open or if the Emergency Stop is pressed.
- **Worksheet 7 Proxy Fault:** Detects issues with the proximity sensor used in Worksheet 7 (such as a missing or stuck target).
- **High Temperature:** Triggered if the measured temperature exceeds the configured upper safety limit.
- **Low Temperature:** Triggered if the measured temperature drops below the configured lower limit.
- **Temp Disconnected:** Indicates the temperature sensor is not detected (e.g., disconnected wiring or sensor fault).
- **AI0 Out of Bounds:** Detects if Analogue Input 0 (AI0) is outside the valid range (e.g., wiring error or sensor fault).
- **AI1 Out of Bound:** Detects if Analogue Input 1 (AI1) is outside the valid range.
- **Switch I4/I5 Damaged:** Checks for faults in the 3-position selector switch (inputs I4/I5), such as both signals being active at once or neither responding.

These faults ensure safety and prevent damage, and they always trigger when detected.

VERSION CONTROL

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