Unit 4033: Programmable Logic Controllers

Unit Code: T/651/0760

Level: 4

Credits: 15

Introduction

The programmable logic controller (PLC) has revolutionised the automation industry. Since Richard Morley's Modicon invention at General Motors in the 1970s, the PLC has been the standard solution for industrial automation. Today PLCs can be found in everything from manufacturing equipment to vending machines, and PLC system development for automated systems is a highly specialised and demanding area of engineering.

The aim of this unit is to enable students to understand the rationale behind the use of programmable logic controllers and their applications in industry. The unit combines practical skills and knowledge in developing PLC applications from real scenarios with theoretical principles, such as communication and networking protocols.

On successful completion of this unit students will have developed an understanding of the evolution, types and applications of PLCs. They will know how to select and develop a PLC system, integrate features of functional safety based on their understanding of risk management, and evaluate the wide range of communication technologies available on modern PLCs.

Learning Outcomes

By the end of this unit students will be able to:

LO1 Describe the design, operation and selection of PLC systems

LO2 Explore Functional Safety within PLC systems

LO3 Develop a PLC program for an automated process system

LO4 Review how PLCs exchange information and process signals with other devices.

Essential Content

LO1 Describe the design, operation and selection of PLC systems

PLC architecture and operation:

central processing unit (CPU), data memory, program memory, speed, scan time, power supply, output current rating

Input/output (I/O) interface: digital, analogue, relay, transistors, TRIACs, opto-coupling.

PLC types and selection:

Compact, modular and rack-mounted

Distributed control systems and programmable automated controllers

PLC manufacturers

Latest PLC case studies.

LO2 Explore Functional Safety within PLC systems

Functional Safety standards:

Evolution of Safety and Risk management

IEC61508 (Electrical, Electronic and Programmable Equipment)

IEC61131 (PLCs), IEC61131-3 (Languages)

IEC61511 (Process Control) IEC62061 (Machinery)

Hazard and risk assessment

Hazard and operability analysis (HAZOP)

Failure modes and effects analysis (FMEA)

Fault tree analysis (FTA)

Safety integrity levels, redundancy (back-up or failsafe).

LO3 **Develop a PLC program for an automated process system**

Logic control circuits:

AND, OR, NAND, NOR, XOR, combinational logic, latching circuits.

Number systems:

Binary, decimal, hexadecimal, octal number representation and conversion

Memory: bits, bytes, nibbles, word, long/double

Signed and unsigned values.

PLC programming:

Industrial Standard IEC61131; PLC software tools

Ladder logic operation: rungs, input, process, output

Variables: Boolean, integer, floating point

Inputs, outputs, delay functions, timers, counters, latches, registers, comparison blocks, math operators, function blocks, simulation, debugging, hardware testing, fault finding

Peer review of programming activities (e.g., design, code, test plan), program demonstration and profession discussion including good practice.

Documentation:

Requirements and specification, flow chart, functional chart, sequence table, input/output or allocation list, wiring diagram, test data.

LO4 **Review how PLCs exchange information and process signals with other devices**

Digital communication basics:

Digital versus analogue communication: analogue to digital conversion (ADC), digital to analogue conversion (DAC)

Sampling rate, resolution, errors

Noise: decoding, encoding, pulse code modulation (PCM)

Elements of a digital communication system; digital communication medium.

PLC communication and networking:

Fieldbus, profibus, modbus, ethernet, profinet

OSI model, RS232, RS485, USB, parallel, serial

Controlled area network (CAN)

Supervisory control and data acquisition (SCADA)

Remote terminal unit (RTU)

Human–machine interface (HMI).

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Describe the design, operation and selection of PLC systems		
P1 Describe the architecture and operation of programmable logic controllers. **P2** Compare the design and applications of Compact, modular and rack-mounted PLCs. **P3** Describe the range of input/output devices and PLC interface techniques.	**M1** Analyse the suitability of programmable logic controllers (PLCs) with programmable automation controllers (PACs) for given applications.	**D1** Justify the selection of a programmable logic controller for a given application.
LO2 Explore Functional Safety within PLC systems		
P4 Explore the requirement of functional safety within industrial PLC systems. **P5** Compare the range of IEC6113-3 languages and their applications.	**M2** Apply functional safety analysis on a PLC based automated process system.	**D2** Evaluate functional safety and its integration into PLC systems to minimise hazards and risks.

Pass	Merit	Distinction
LO3 Develop a PLC program for an automated process system		
P6 Translate a digital logic control circuit into an equivalent PLC program. **P7** Produce design and planning documentation associated with the preparation of a PLC program. **P8** Design and develop a functionally safe PLC program for an automated process system.	**M3** Apply methods of testing and debugging hardware and software in PLC systems.	**D3** Evaluate the PLC program for an automated process system and make justifiable modifications.
LO4 Review how PLCs exchange information and process signals with other devices.		
P9 Describe the characteristics and methods of digital data communication for PLCs. **P10** Review common communication technologies available on a range of PLCs.	**M4** Assess the use and integration of SCADA and HMI's with PLCs in industry.	**D4** Evaluate fieldbus and Ethernet technologies for industrial manufacturing applications.

Recommended Resources

Note: See HN Global for guidance on additional resources.

Print Resources

Bolton W. (2015) *Programmable Logic Controllers*. 6th Ed. Elsevier.

Dawkins N. (ed.) (2014) *Automation and Controls: A guide to Automation, Controls, PLCs and PLC Programming*.

Johnson Jr C.H. and Sanusi A.L. (2022) *PLC Programming from Novice to Professional: Learn PLC Programming with Training Videos (Paperback)*. Ojula Technology Innovations.

Manesis S. and Nikolakopoulos G. (2018) *Introduction to Industrial Automation.* 1st Ed. Routledge, Taylor and Francis Group.

Perez A. E. (2012) *Introduction to PLCs: A beginner's guide to Programmable Logic Controllers*.

Petruzella F. (2023) *Programmable Logic Controllers.* 6th Ed. McGraw Hill.

Stewart G.R. (2021) *Siemens Plc Programming For Beginners: [Step-by-Step Instructions] How Can I Quickly and Easily Learn PLC Programming at Home?* Independent publication.

White M.T. (2023) *Mastering PLC Programming: The software engineering survival guide to automation programming (Paperback)*. Packt Publishing Limited.

Journals

Note: Example journals listed below provide a broad range of articles related to unit content and those relevant for the qualification. Staff and students are encouraged to explore these journals and any other suitable journals to support the development of academic study skills, and subject specific knowledge and skills as part of unit level delivery.

Automation and Remote Control

Automation

Electrical, Electronics and Communications Engineering (Applied Sciences)

IFAC Journal of Systems and Control

IEEE Journal on Robotics and Automation

IEEE Potentials (Programmable Logic Controllers)

International Journal of Automation and Control (IJAAC)

International Journal of Innovative Research in Technology & Science

Journal of AI, Robotics and Workplace Automation

Journal of Automation and Intelligence

Programmable Logic Controllers (Special issue)

Links

This unit links to the following related units:

Unit 4015: Automation, Robotics and Programmable Logic Controllers (PLCs)

Unit 4016: Instrumentation and Control Systems

Unit 4030: Industry 4.0

Unit 4068: Industrial Robots

Unit 5009: Further Programmable Logic Controllers (PLCs)

Unit 5021: Further Control Systems Engineering.