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

Unit Code: M/651/0731

Level: 4

Credits: 15

Introduction

The word automation was not used until the 1940s and it originated in the automotive manufacturing sector as a method designed to reduce labour costs and improve the quality, accuracy and precision of the finished products. We are all now very familiar with the sight of dancing robots, not only in the production of cars but in everything from washing machines to pharmaceuticals. As a result of this technology the products we purchase may have never been touched by human hands and we all benefit from a reduction in costs and improvement in quality.

The aim of this unit is for students to investigate how Programmable Logic Controllers (PLCs) and industrial robots can be programmed to successfully implement automated engineering solutions.

Among the topics included in this unit are: PLC system operational characteristics, different types of programming languages, types of robots and cell safety features.

On successful completion of this unit students will be able to learn about programming PLCs and robotic manipulators to implement a set of activities, different types and uses of PLCs and robots available, writing PLC programs using a language of their choice, and program industrial robots with straightforward commands and safety factors.

Learning Outcomes

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

LO1 Describe the design and operational characteristics of a PLC system

LO2 Design a PLC program by considering function requirements, PLC information, programming and communication techniques

LO3 Program industrial robots using commands to perform a given task with the knowledge of the key elements and their functions

LO4 Investigate the design and safe operation of a robot within an industrial application.

Essential Content

LO1 **Describe the design and operational characteristics of a PLC system**

System operational characteristics:

Modular, unitary and rack mounted systems

Characteristics, including speed, memory, scan time, voltage and current limits

Input and output devices (digital, analogue)

Interface requirements

Communication standards (RS-232, RS-422, RS-485, Ethernet)

Industrial communication networks at Supervisory (e.g. Ethernet), Cell (e.g. PROFINET/PROFIBUS) and Field (e.g. AS-Interface) levels; industrial networks configuration and commissioning; installation, application and operational aspects

Industrial Communication Protocols (e.g., Profinet, EtherNet/IP, Powerlink)

Internal architecture

Different types of programming languages (IEC 61131-3)

Programmable Logic Controllers (PLC), Variable Speed Drives (VSD), Human Machine Interface (HMI) and Supervisory Control and Data Acquisition (SCADA).

LO2 **Design a PLC program by considering function requirements, PLC information, programming and communication techniques**

Programming language:

Signal types

Number systems (binary, octal, hexadecimal)

Allocation lists of inputs and outputs

Communication techniques

Network methods

Logic functions (AND, OR, XOR)

Associated elements (timers, counters, latches)

PLC, HMI & SCADA configuration, and programming

Modern context of PLC programming and Automation

Test and debug methods:

Systematic testing and debugging methods

Proper application of appropriate testing and debugging methods

LO3 **Program industrial robots using commands to perform a given task with the knowledge of the key elements and their functions**

Element considerations:

Types of robots

Mobile robotics

Sensors, tools and end effectors

Programming methods

Key functions/commands and application in designing and implementing robot tasks

Robotics hardware and software tools, configuration, calibration, programming, and fault finding

Robot manipulators (kinematics, design, dynamics and control, vision systems, user interfaces, instrumentation configuration and calibration); effective use of data collection tools/systems and data formats for inputs/outputs within the context.

Impact of Industry 4.0:

Automation, robots, PLCs, smart factories using Industry 4.0 based technologies (e.g., data and digital technologies/systems)

Performance optimisation

Documentation control processes and procedures such as format, location, access, authorisation

Integration and impact on organisations.

LO4 **Investigate the design and safe operation of a robot within an industrial application**

Safety:

Health and safety policies, procedures and regulations, potential hazards, risk assessment and mitigation

Cell safety features

Operating envelope

Operational modes

User interfaces

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Describe the design and operational characteristics of a PLC system		
P1 Describe the key differences of PLC types and configurations, and their typical applications. **P2** Determine the types of PLC input and output devices available. **P3** Describe the different types of communication links used with PLCs.	**M1** Explain the different types of PLC programming languages available.	**D1** Analyse the internal architecture of a typical PLC to determine its operational applications.
LO2 Design a PLC program by considering function requirements, PLC information, programming and communication techniques		
P4 Design key elements that have to be considered in the preparation of a PLC program. **P5** Explain how communication connections are correctly used with the PLC.	**M2** Integrate methods used for testing and debugging PLC hardware and software.	**D2** Create a fully functional PLC design for a given industrial task, with performance analysis.
LO3 Program industrial robots using commands to perform a given task with the knowledge of the key elements and their functions		
P6 Using a selection of commands, program an industrial robot to perform given task. **P7** Explain the types of robot tools, sensors, and end effectors available and their applications.	**M3** Investigate a given industrial robotic system and make recommendations for improvement.	**D3** Produce a fully working robotic program for a given industry task, with an illustrated scope for further improvements to achieve complex tasks.
LO4 Investigate the design and safe operation of a robot within an industrial application		
P8 Investigate the safety systems used within an industrial robotic cell.	**M4** Analyse how the systems in place ensure safe operation of a given industrial robotic cell.	**D4** Design a safe working plan for an industrial robotic cell in a given production process, including a full risk assessment.

Recommended Resources

Note: See HN Global for guidance on additional resources.

Print Resources

Auat F., Prieto P. and Fantoni G. (Editors) (2022) *Rapid Roboting: Recent Advances on 3D Printers and Robotics − Intelligent Systems, Control and Automation: Science and Engineering 82* (Hardback). Springer.

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

Bozek P., Krenický T. and Nikitin Y. (Editors) (2022) *Automation and Robotics: Latest Achievements, Challenges and Prospects* (Hardback). Mdpi AG.

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*.

Kumar K. and Babu B.S. (Editors) (2023*) Industrial Automation and Robotics − Techniques and Applications*. 1st Ed. CRC Press.

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.