Next Generation Higher National Unit Specification

Applications of Programmable Logic Controllers (SCQF level 7)

Unit code: J7GP 47

SCQF level: 7 (8 SCQF credit points)

Valid from: session 2023–24

Prototype unit specification for use in pilot delivery only (version 1.0) August 2023

This unit specification provides detailed information about the unit to ensure consistent and transparent assessment year on year.

This unit specification is for teachers and lecturers and contains all the mandatory information required to deliver and assess the unit.

This edition: August 2023 (version 1.0)

Unit purpose

This unit introduces learners to programmable logic controllers (PLCs) and helps them understand how PLCs are applied to control industrial processes. Learners develop the necessary knowledge and skills to understand the basic construction and operation of PLCs.

It also gives learners the opportunity to develop practical programming skills, enabling them to apply a PLC to simulate control of a specified industrial process.

The target group for the unit is learners who want to develop their knowledge of using PLCs to support a career in an engineering field such as:

- electrical engineering
- mechanical engineering
- systems engineering
- manufacturing engineering
- measurement and control engineering

Entry to the unit is at your centre's discretion. However, we recommend that learners have one or more of the following:

- basic knowledge and understanding of electrical and mechanical principles, and combinational logic, as well as knowledge of digital systems and programmable systems
- relevant, equivalent workplace experience

The unit is also aimed at those who want to develop the practical, personal and professional skills required for a successful career as an engineering technician. At SCQF level 7, it provides learners with suitable knowledge and skills for progression or articulation to further study.

Unit outcomes

Learners who complete this unit can:

1 explain and classify PLC hardware
2 describe the operation of PLC software
3 simulate the safe control of an industrial process by applying PLC technology

Evidence requirements

All outcomes are assessed holistically using written and/or oral recorded evidence. Learners must generate evidence under unsupervised, open-book conditions and produce a portfolio of evidence.

To achieve the unit, learners must provide a sample of evidence from the 'Knowledge and skills' section.

Even though the evidence requirements are assessed on a sample basis, you must teach all content in the 'Knowledge and skills' section and it must be available for assessment. Learners should not know which items they will be assessed on in advance. You must use a different sample for each assessment occasion.

Outcome 1

You must collect evidence for the knowledge and skills in this outcome on a sample basis. Learners can provide evidence in response to specific questions, based on a sample of three of the following items:

- Draw an annotated block diagram of a PLC showing the element parts and arrows indicating the flow of information between elements.
- Describe the function of the element parts of a PLC.
- Explain three possible causes and the corresponding consequences of failure in a PLC control system.
- Describe two examples of how PLC systems can be classified in terms of memory capacity, number of input/output (I/O) terminals and availability of advanced features, and give examples of practical applications.
- State four advantages of PLC control compared to traditional hard-wired relay control systems and conventional computer control systems.

Evidence must meet the requirements for all three items.

You must use a different sample each time you assess this outcome, so that learners don't know what items they are being questioned on.

Outcome 2

You must collect evidence for the knowledge and skills in this outcome on a sample basis. Learners can provide evidence in response to specific questions, based on a sample of the following items:

- State the function of a PLC timer and describe the operation of a simple ladder diagram containing a timer.
- State the function of a PLC counter and describe the operation of a simple ladder diagram containing a counter.
- State the function of a PLC latch contact and describe the operation of a simple ladder diagram containing a latch.
- State the function of a PLC shift register and describe the operation of a simple ladder diagram containing a shift register.
- State the function of a PLC auxiliary relay and give two examples of special functions that could be performed by PLC auxiliary relays.
- Describe the operation of a small given PLC program.
- Describe how a user program is executed in a PLC (learners should make reference to mass I/O copying).

The sample must include four out of the seven knowledge and skills items, and evidence must meet the requirements for all four items.

You must use a different sample each time you assess this outcome, so that learners don't know what items they are being questioned on.

Outcome 3

This is a practical outcome. Learners must meet the requirements for all of the following knowledge and skills items:

- Design software that is valid and simulates the safe control of the industrial process.
- Correctly allocate PLC input and output addresses.
- Correctly enter the program into the PLC.
- Edit the PLC program.
- Demonstrate effective testing procedures.
- Demonstrate the correct operation of the PLC program through the PLC-indicating LEDs or an existing mimic panel.
- Produce a report that includes the following:
  - a description of the process to be controlled
  - allocation of PLC inputs and outputs
  - a ladder diagram of the PLC program
  - an instruction code listing (where applicable)
  - an explanation of the operation of the program
  - an explanation of the safety features that have been incorporated in the application of the PLC

Learners must present evidence in response to a practical assignment where they apply a PLC to simulate the safe control of an industrial process.

The control problem in this assignment should be based on an industrial process, but the physical process should not be controlled. You can mimic operating the program by either using I/O LEDs on the PLC or by connecting the PLC to an existing mimic panel. However, if a real or simulated process is available at your centre, you should encourage learners to test their final program by connecting to the hardware.

Learners must have access to relevant programming notes, textbooks and reference manuals for the PLC. If their programs do not function properly, they should be allowed to correct the faults and retest the operation of the program. You must make every reasonable effort to ensure that control solutions are learners' own work.

You must provide learners with details of the required report format, which should include (as a minimum) the items listed in the final bullet point of the knowledge and skills items. They can use software packages to produce documentation for their reports. Although learners are not required to produce their reports under controlled, supervised conditions, you should make every reasonable effort to ensure that reports are learners' own work.

Knowledge and skills

The following table shows the knowledge and skills covered by the unit outcomes:

Knowledge	Skills
Learners should understand: ♦ architecture of a PLC ♦ functions of the element parts of a PLC ♦ causes and consequences of failures within a PLC-controlled system ♦ classification of PLC systems (in terms of memory capacity, number of input and output terminals, complexity of programming functions, and typical application) ♦ benefits of PLC control systems ♦ function and operation of a timer within a PLC program ♦ function and operation of a counter within a PLC program ♦ function and operation of a latching circuit within a PLC program ♦ function and operation of a shift register within a PLC program ♦ function and operation of auxiliary relays within a PLC program ♦ interpretation of PLC programs ♦ method of program execution	Learners can: ♦ prepare a PLC program to simulate safe control of an industrial process ♦ allocate PLC inputs and outputs ♦ enter a program into a PLC ♦ edit a PLC program ♦ verify correct operation of a PLC program ♦ demonstrate the operation of a PLC program ♦ document control strategy and software

Meta-skills

Throughout the unit, learners develop meta-skills to enhance their employability in the engineering sector.

Self-management

Learners develop their self-management skills when completing the practical project in outcome 3.

Social intelligence

Learners enhance their social intelligence skills by developing the safety aspects required for the practical project in outcome 3.

Innovation

Learners develop problem recognition when explaining the problem given in outcome 3 and generating ideas for solutions. They develop holistic and logical thinking when making sense of the problem and critically thinking of solutions.

Literacies

Learners develop core skills in the following literacies:

Numeracy

Learners develop their numeracy skills by performing engineering calculations.

Communication

Learners develop their communication skills by reporting and presenting results for all outcomes.

Digital

Learners develop their digital literacy by using research methods. They use project management software and engineering applications, and digitally present their results for outcome 3.

Delivery of unit

This unit is part of the Higher National Certificate (HNC) in Engineering. The framework includes mandatory and optional units, and you can tailor the selected combination of units to specific engineering pathway needs.

The notional design length is 40 hours; however, the amount of time you allocate to each outcome is at your discretion. We suggest the following distribution of time, including assessment:

Outcome 1 — Explain and classify PLC hardware
(4 hours)

Outcome 2 — Describe the operation of PLC software
(6 hours)

Outcome 3 — Simulate the safe control of an industrial process by applying PLC technology
(30 hours)

Additional guidance

The guidance in this section is not mandatory.

Content and context for this unit

We strongly recommend you use the following list of topics to ensure continuity of learning and teaching, and that learners are prepared for assessment.

Explain and classify PLC hardware (outcome 1)

The following topics are general in nature — you should put them into context by referring to the specific PLC available at your centre:

- purpose of a PLC
- examples of the use of PLCs in industrial control
- basic architecture of a PLC, shown in block diagram format — the diagram should include the following:
  - control unit
  - program memory
  - work memory
  - input module
  - output module
  - power supply unit
  - programming device

Learners should be able to describe the functions carried out by the following hardware elements:

- control unit — scanning input states, executing program steps, setting or clearing the internal relays and outputs in response to program logic, and managing timers, counters and other special functions
- program memory — ROM for operating system; ROM, EPROM, EEPROM or battery-backed RAM for user's program
- work memory — partially battery-backed RAM to store auxiliary relay states, timers and counters states, I/O states, and arithmetic and logic calculation results
- input modules with opto-isolation
- output modules with:
  - opto-isolation and solid-state switches
  - electromechanical relays
- power supply unit and battery back-up of certain PLC auxiliary relay contacts and program memory, where this is in volatile RAM
- programming devices — for example hand-held programmer or host computer

- hardware failures:
  - within the PLC, for example input and output circuits, internal power supply, processor, and memory
  - outwith the PLC, for example sensors and actuators
- environmental failures — for example dust, vibration, temperature and electrical interference
- failures owing to programming errors
- consequences of the various types of failures within a PLC-controlled system
- memory capacity, number of I/O ports and availability of advanced features — for PLCs that are classified as:
  - micro
  - small
  - medium
  - large
- typical applications of micro, small, medium and large PLCs
- advantages of PLC control compared to traditional hard-wired relay control systems and conventional computers

Describe the operation of PLC software (outcome 2)

The following topics are general in nature — you should put them into context by referring to the specific PLC available at your centre:

- normally open contacts
- normally closed contacts
- output relays
- timers
- counters
- latching circuits
- shift registers
- auxiliary relays, including those with special functions
- ladder diagrams
- statement lists or logic symbols — whichever is appropriate for the specific PLC available
- principles of program execution, including:
  - input scan
  - program execution
  - output scan

Simulate the safe control of an industrial process by applying PLC technology (outcome 3)

Learners should carry out the following using the specific PLC that is available at your centre:

- safety aspects, including fail-safe conditions, guards for machines, and the use of emergency stops and watchdog timers
- designing software to control a process
- allocating PLC inputs and outputs
- entering a program into the PLC
- editing a program
- effective testing procedures to verify a program is operating correctly
- using any diagnostic tools in the PLC — for example, monitor, and trace and search
- demonstrating correct operation of a program through PLC-led indicators or supplied mimic panel
- relevant documentation — including I/O charts, program listing, ladder diagram and description of program operation
- demonstrating relevant software packages that can be used to produce documentation of programs

They should also study a range of industrial-related control problems.

Approaches to delivery

You should deliver this unit referring to the specific PLC available at your centre, ensuring that the technical and programming manuals for the PLC are readily available to learners.

If you deliver the unit as part of a group award, you should teach and assess it within the group award's subject area.

Approaches to assessment

Learners must meet all the minimum evidence specified for each outcome to achieve the unit.

Outcomes 1 and 2

You could combine assessment for these outcomes. Learners produce a portfolio for these two outcomes where the number of inputs and outputs required in the PLC program should be limited to:

- inputs — minimum 2, maximum 3
- outputs — minimum 3, maximum 4

Outcome 3

You should assess this outcome using a practical assignment. Learners could complete a series of tasks allowing them to apply a PLC to simulate the safe control of a specified industrial process. The assignment tasks should involve:

- devising the control strategy
- writing PLC software
- programming the PLC
- verifying correct operation of the program
- documenting the final solution

Learners should be able to complete the assignment in 8 hours. They should have access to a PLC and be allowed to use any relevant course notes, textbooks and reference material for the PLC. We recommend that you develop checklists to support the assessment requirements for each of the knowledge and skills items.

You must ensure that evidence generated is learners' own work. You can give each learner a different process to simulate, or you can give them the same one. If they use different process specifications, then the degree of difficulty for each one should be equal. If they use the same process specification, each learner must interpret it and offer a unique design solution.

Opportunities for e-assessment

Assessment that is supported by information and communication technology (ICT), such as e-testing or the use of e-portfolios or social software, may be appropriate for some assessments in this unit.

If you want to use e-assessment, you must ensure that you apply the national standard to all evidence and that conditions of assessment (as specified in the evidence requirements) are met, regardless of the mode of gathering evidence.

Equality and inclusion

This unit is designed to be as fair and as accessible as possible with no unnecessary barriers to learning or assessment.

You should take into account the needs of individual learners when planning learning experiences, selecting assessment methods or considering alternative evidence.

Guidance on assessment arrangements for disabled learners and/or those with additional support needs is available on the assessment arrangements web page: www.sqa.org.uk/assessmentarrangements.

Information for learners

Applications of Programmable Logic Controllers (SCQF level 7)

This information explains:

- what the unit is about
- what you should know or be able to do before you start
- what you need to do during the unit
- opportunities for further learning and employment

Unit information

This unit provides you with the knowledge and skills you need to understand the basic construction and operation of programmable logic controllers (PLCs).

You develop practical skills that enable you to enter and edit programs within a PLC. You gain hands-on experience of operating and programming a PLC, and by the end of the unit, you should be able to apply a PLC to simulate safe control of an industrial process.

Before starting the unit, we recommend that you have one or more of the following:

- basic knowledge and understanding of electrical and mechanical principles, and combinational logic, as well as knowledge of digital systems and programmable systems
- relevant, equivalent workplace experience

You study PLC hardware and software, and you learn to write programs that could be used to control simple industrial processes.

Formal assessment for this unit consists of knowledge questions and a practical assignment.

Your practical skills are assessed by an assignment. You must complete a series of tasks that allows you to apply a PLC to safely control a specified industrial process. You are given a description of an industrial process and you must then:

- design software that could be used in the PLC to safely control the process
- enter and edit your program in the PLC
- demonstrate the correct operation of your program
- submit a report documenting your assignment

You should be able to complete the assignment in 8 hours. Your centre provides you with access to a PLC and any relevant course notes, textbooks and reference manuals for the PLC.

On completion of the unit, you can:

- explain and classify PLC hardware
- describe the operation of PLC software
- simulate the safe control of an industrial process by applying PLC technology

The unit is aimed at those who want to develop the practical, personal and professional skills required for a successful career as an engineering technician. At SCQF level 7, it provides you with suitable knowledge and skills for progression or articulation to further study.

Meta-skills

Throughout the unit, you can develop meta-skills to enhance your employability in the engineering sector.

Meta-skills include self-management, social intelligence and innovation.

Self-management

You develop your self-management skills when completing the practical project in outcome 3.

Social intelligence

You enhance your social intelligence skills by developing the safety aspects required for the practical project in outcome 3.

Innovation

You develop problem recognition when explaining the problem given in outcome 3 and generating ideas for solutions. You develop holistic and logical thinking when making sense of the problem and critically thinking of solutions.

Administrative information

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Superclass: XL

History of changes

Version	Description of change	Date

Note: please check SQA's website to ensure you are using the most up-to-date version of this document.