

## SQA Advanced Unit Specification

### General information for centres

**Unit title:** Programmable Logic Controllers: Advanced

**Unit code:** HV6G 48

**Unit purpose:** This Unit is designed to enable candidates to gain knowledge and understanding of using a programmable logic controller (PLC) to perform proportional, integral and derivative (PID) control and to generate shutdown trips. The Unit will also allow the candidate to develop knowledge and skills about networked systems that incorporate PLCs.

On completion of the Unit candidates should be able to:

- 1 Apply a PLC to perform PID control of a process loop.
- 2 Apply a PLC to generate shutdown trips in a process control system.
- 3 Explain the component parts of a networked system that includes PLCs.
- 4 Design a PLC system for a given specification.

**Credit points and level:** 1 SQA Credit at SCQF level 8: (8 SCQF credit points at SCQF level 8\*).

*\*SCQF credit points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification in the Framework is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from National 1 to Doctorates.*

**Recommended prior knowledge and skills:** Access to this Unit will be at the discretion of the centre and the following recommendations are for guidance only. Candidates should have a wide knowledge of Measurement and Control Engineering. This could be evidenced by the possession of the SQA Advanced Units: HV63 47 Distributed Control Systems and HV67 47 Measurement Systems 1. There could also be the advantage of possessing or working towards the SQA Advanced Units HT1K 47 Applications of Programmable Logic Controllers, HT9X 47 Process Control, HV60 48 Process Control by Computer.

**Core Skills:** There are opportunities to develop the Core Skills of Written Communication (Writing), Written Communication (Reading), Working with Others and Problem Solving (Critical Thinking) at SCQF level 5 in this Unit, although there is no automatic certification of Core Skills or Core Skills components.

**Context for delivery:** If this Unit is delivered as part of a Group Award, it is recommended that it should be taught and assessed within the subject area of the Group Award to which it contributes.

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**Assessment:** Outcome 1 in this Unit should be assessed by an assignment that asks candidates to write a programme that will perform PID control of a process loop, enter the programme into the PLC and demonstrate the operation of the programme. Candidates should complete the assignment in five hours.

Outcome 2 in this Unit should be assessed by an assignment that asks candidates to write a programme that will generate shutdown trips in a process control system, enter the programme into the PLC and demonstrate the operation of the programme. Candidates should complete the assignment in four hours.

Outcome 3 in this Unit should be assessed by a question paper that should last one hour and thirty minutes. The assessment paper should be composed of a suitable balance of restricted response and structured questions. The assessment should be conducted under controlled supervised conditions.

Outcome 4 in this Unit should be assessed by an assignment that asks candidates to design a PLC system. Candidates should complete the assignment in five hours including class time.

The assessments for Outcomes 1, 2, 3 and 4 in this Unit should be carried out at the end of the delivery of each Outcome.

It should be noted that candidates must achieve all the minimum evidence specified for each Outcome in order to pass the Unit.

## **Unit specification: statement of standards**

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The sections of the Unit stating the Outcomes, knowledge and/or skills, and evidence requirements are mandatory.

Where evidence for Outcomes is assessed on a sample basis, the whole of the content listed in the knowledge and/or skills section must be taught and available for assessment. Candidates should not know in advance the items on which they will be assessed and different items should be sampled on each assessment occasion.

### **Outcome 1**

Apply a PLC to perform PID control of a process loop

#### **Knowledge and/or skills**

- ◆ Loop components required for PID control of a process loop by a PLC
- ◆ Interconnection of loop components
- ◆ PLC programme to perform PID control
- ◆ PLC programme entry
- ◆ PID control loop tuning
- ◆ Operation of a PID programme

#### **Evidence Requirements**

This is a practically based Outcome and all of the knowledge and/or skills items above should be assessed. The evidence should be presented in response to a practical assignment in which the candidate is set the task of explaining about the loop components required to generate PID control with a PLC and to apply a PLC to generate PID control of a process.

A candidate's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the candidate is able to:

- ◆ explain, with the aid of a sketch, the loop components that are required to perform PID control of a process with a PLC
- ◆ connect the external hardware to the PLC
- ◆ produce a well commented PLC programme that will perform PID control of a process loop
- ◆ enter the PLC programme into the PLC
- ◆ tune the PID control loop
- ◆ demonstrate the correct operation of the PLC programme

Evidence should be generated through an assignment in which candidates should have access to relevant programming notes and textbooks. If the candidate's programme does not function properly then the candidate should be allowed to correct the faults and retest the operation of the programme. Centres should make every reasonable effort to ensure that the control solution is the candidate's own work.

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### Assessment guidelines

The assessment of this Outcome should take the form of an assignment. The recommended time allocation for the assignment is five hours. It is recommended that centres develop checklists to support the assessment requirements.

It is essential that centres ensure that evidence generated is the candidate's own work.

### Outcome 2

Apply a PLC to generate shutdown trips in a process control system

#### Knowledge and/or skills

- ◆ Alarms
- ◆ Trips
- ◆ PLC programme to provide shutdown facilities
- ◆ PLC programme entry
- ◆ Operation of a PLC programme that generates shutdown

#### Evidence Requirements

This is a practically based Outcome and all of the knowledge and/or skills items above should be assessed. The evidence should be presented in response to a practical assignment in which the candidate is set the task of explaining about alarms and trips and applying a PLC to generate PID control of a process.

A candidate's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the candidate is able to:

- ◆ explain the need for alarms in relation to plant safety
- ◆ explain the need for trips in relation to plant safety
- ◆ produce a well commented PLC programme that will provide shutdown facilities
- ◆ enter the programme into the PLC
- ◆ demonstrate the correct operation of the PLC programme

Evidence should be generated through an assignment in which candidates should have access to relevant programming notes and textbooks. If the candidate's programme does not function properly then the candidate should be allowed to correct the faults and retest the operation of the programme. Centres should make every reasonable effort to ensure that the control solution is the candidate's own work.

### Assessment guidelines

The assessment of this Outcome should take the form of an assignment. The recommended time allocation for the assignment is four hours. It is recommended that centres develop checklists to support the assessment requirements.

It is essential that centres ensure that evidence generated is the candidate's own work.

### Outcome 3

Explain the component parts of a networked system that includes PLCs

#### Knowledge and/or skills

- ◆ Digital communication standards
- ◆ Network cables
- ◆ Network topologies
- ◆ Network protocols
- ◆ Hierarchical control
- ◆ Network standards

#### Evidence Requirements

Evidence for the knowledge and/or skills in this Outcome will be provided on a sample basis. The evidence may be provided in response to specific questions. Each candidate will need to demonstrate that they can answer questions based on a sample of the items shown above. In any assessment of this Outcome four out of six knowledge and/or skills items should be included.

In order to ensure that candidates will not be able to foresee what items they will be questioned on, a different sample of four out of six knowledge and/or skills items is required each time the Outcome is assessed. Candidates must provide a satisfactory response to all four items.

Where sampling takes place, a candidate's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the candidate is able to:-

- ◆ explain RS232C, RS422 and RS485 digital communication standards
- ◆ explain twisted pair, coaxial and fibre optic types of network cables
- ◆ explain bus, star and ring types of network topologies
- ◆ explain CSMA/CD (Carrier Sense, Multiple Access/Collision Detection) and token ring types of network protocols
- ◆ explain hierarchical control of a PLC based system
- ◆ explain ISO/OSI (International Standards Organisation/Open Systems Interconnection) and MAP (Manufacturing Automation Protocol) network standards

Evidence should be generated through assessment undertaken in controlled, supervised conditions. Assessment should be conducted under closed-book conditions and as such candidates must not be allowed to bring handouts, notes or textbooks to the assessment.

#### Assessment guidelines

Questions used to elicit candidate evidence should take the form of an appropriate balance of short answer, restricted response and structured questions.

This Outcome should be assessed by a question paper that should last one hour and thirty minutes. The assessment should be conducted under controlled supervised conditions.

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### Outcome 4

Design a PLC system for a given specification

#### Knowledge and/or skills

- ◆ Component parts of a networked PLC system
- ◆ Individual PLCs that can be used in a networked PLC system
- ◆ PLC network

#### Evidence Requirements

In this Outcome all of the knowledge and/or skills items above should be assessed. The evidence should be presented in response to an assignment in which the candidate is set the task of designing a networked PLC system to suit the given application.

A candidate's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the candidate is able to:

- ◆ design a networked PLC system with a minimum of three PLCs that will suit the given specification and produce a sketch of the system which clearly identifies the component parts
- ◆ justify the suitability of the individual PLCs to perform their tasks in terms of the following features
  - input and output requirements
  - processing speed
  - memory capacity
  - methods of programming, editing and monitoring program performance
  - range of programming functions
- ◆ justify the suitability of the network in terms of the following features
  - network configuration
  - transmission speed of data transfer
  - protocols for data transfer
  - network cabling

Evidence should be generated through an assignment in which candidates should have access to manufacturers' data sheets and textbooks.

#### Assessment guidelines

The assessment of this Outcome should take the form of an assignment. The recommended time allocation for the assignment is five hours including class time. It is essential that centres ensure that evidence generated is the candidate's own work.

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### Administrative information

<b>Unit code:</b>	HV6G 48
<b>Unit title:</b>	Programmable Logic Controllers: Advanced
<b>Superclass category:</b>	VE
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### History of Changes:

Version	Description of change	Date

**Source:** SQA

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SQA acknowledges the valuable contribution that Scotland's colleges have made to the development of SQA Advanced Qualifications.

**FURTHER INFORMATION:** Call SQA's Customer Contact Centre on 44 (0) 141 500 5030 or 0345 279 1000. Alternatively, complete our [Centre Feedback Form](#).

### Unit specification: support notes

#### Unit title: Programmable Logic Controllers: Advanced

This part of the Unit specification is offered as guidance. The support notes are not mandatory.

While the exact time allocated to this Unit is at the discretion of the centre, the notional design length is 40 hours.

#### Guidance on the content and context for this Unit

This Unit has been written in order to allow candidates to develop knowledge, understanding and skills in the following areas:

- 1 Apply a PLC to perform PID control of a process loop.
- 2 Apply a PLC to generate shutdown trips in a process control system.
- 3 Explain the component parts of a networked system that includes PLCs.
- 4 Design a PLC system for a given specification.

This Unit is at SCQF level 8 and has been devised as a mandatory Unit within the new SQA Advanced Diploma in Measurement and Control Engineering award. However this does not preclude the use of this Unit in other awards where award designers feel this to be appropriate.

In designing this Unit, the Unit writer has identified the range of topics that they would expect to be covered by lecturers. The writer has also given recommendations as to how much time should be spent on each Outcome. This has been done to help lecturers decide what depth of treatment should be given to the topics attached to each of the Outcomes. While it is not mandatory for centres to use this list of topics, it is recommended that they cover them.

A list of topics for each Outcome is given below.

#### Outcome 1

Apply a PLC to perform PID control of a process loop (12 hours)

- ◆ Loop components required to perform PID control of a process including
  - the process
  - transmitter
  - PLC that is capable of generating PID control
  - regulator (typically control valve)
  - converter devices (typically I/P converter)
- ◆ Connection diagram for the loop components
- ◆ Connecting a PLC to analogue input devices
- ◆ Connecting a PLC to analogue output devices
- ◆ PLC programme code to read in and scale an analogue signal
- ◆ PLC programme code to write out a value to an analogue device
- ◆ PLC programme code to generate PID control
- ◆ Writing a PLC programme to generate PID control
- ◆ Entering the programme into the PLC
- ◆ Editing the programme
- ◆ Adding comments to a programme



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- ◆ Tuning a PLC that is used to perform PID control
- ◆ Testing procedures for the PLC programme

### Outcome 2

Apply a PLC to generate shutdown trips in a process control system (10 hours)

- ◆ The need for alarms in a process control system
- ◆ Hardware and software trips
- ◆ The need for shutdown trips in a process control system in relation to the effects on the following
  - plant
  - personnel
  - production
  - environment
- ◆ PLC programme code to detect an alarm condition
- ◆ PLC programme code to detect a shut down trip condition
- ◆ Writing a PLC programme to generate shutdown in the event of a trip condition
- ◆ Entering the programme into the PLC
- ◆ Editing the programme
- ◆ Adding comments to the programme
- ◆ Testing procedures for the PLC programme

### Outcome 3

Explain the component parts of a networked system that includes PLCs (8 hours)

- ◆ Types of digital communication including
  - RS232C
  - RS422
  - RS485
- ◆ Types of network cable including
  - twisted pair
  - coaxial
  - fibre optic
- ◆ Types of network topologies including
  - bus
  - star
  - ring
- ◆ Types of network protocols including
  - CSMA/CD
  - token ring
- ◆ Hierarchical control that covers from plant instrumentation up to the top level of computer
- ◆ Types of network standards including
  - ISO/OSI
  - MAP

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### Outcome 4

Design a PLC system for a given specification (10 hours)

- ◆ Different PLC manufacturers
- ◆ Small, medium and large scale PLCs
- ◆ Digital and analogue inputs and outputs
- ◆ Memory capacity of the PLC
- ◆ Processing speed of the PLC
- ◆ Range of programming functions
- ◆ Redundant PLC systems including
  - fault tolerant
  - fail safe
- ◆ Methods of programming, editing and monitoring the PLC programme (eg hand held programmer, computer with appropriate software)
- ◆ Network configurations
- ◆ Type and size of data to be transferred over the network
- ◆ Protocols for data transfer
- ◆ Network cabling

### Unit assessment

Assignment for Outcome 1	5 hours
Assignment for Outcome 2	4 hours
Question paper for Outcome 3	1 hour and 30 minutes
Assignment for Outcome 4	5 hours

## Guidance on the delivery and assessment of this Unit

This Unit has been designed to incorporate sufficient time to allow the lecturer to teach, in a student centred way, how a PLC can be used to perform PID control and generate shutdown trips. It will also allow candidates to learn about networked PLC systems.

The programming part of this Unit should be carried out using any suitable model of PLC that is available within the centre.

In the delivery of this Unit, candidates should be provided with the opportunity to gain as much “hands-on” experience as possible.

Details on approaches to assessment are given under evidence requirements and assessment guidelines under each Outcome in the SQA Advanced Unit specification: statement of standards section. It is recommended that these sections be read carefully before proceeding with assessment of candidates.

### *Opportunities for developing Core Skills*

There are opportunities to develop the Core Skills of Written Communication (Writing), Written Communication (Reading) and Problem Solving (Critical Thinking) at SCQF level 5 and Problem Solving (Planning and Organising) at SCQF level 6 in this Unit.

### Open learning

This Unit could be delivered by distance learning, which may incorporate some degree of on-line support. With regard to assessment, planning would be required of the centre concerned to ensure the sufficiency and authenticity of candidate evidence. Arrangements would be required to be put in place to ensure that written assessment was conducted under controlled, supervised conditions. Arrangements would also need to be made to ensure that the candidate could practically demonstrate the operation of his/her solution to the practical assignment required as assessment evidence. This could involve the candidate attending the Centre or utilising video conferencing. Alternatively, special arrangements could be made for the candidate to demonstrate the practical work to a designated, responsible person local to the candidate.

For information on open learning, please refer to *SQA guide assessment and quality assurance of open and distance learning (A1030, Feb 2001)*.

### Equality and inclusion

This Unit specification has been designed to ensure that there are no unnecessary barriers to learning or assessment. The individual needs of learners should be taken into account when planning learning experiences, selecting assessment methods or considering alternative evidence. Further advice can be found on our website [www.sqa.org.uk/assessmentarrangements](http://www.sqa.org.uk/assessmentarrangements).

### General information for candidates

#### **Unit title:** Programmable Logic Controllers: Advanced

This Unit has been designed to provide you with the knowledge and skills that will enable you to write PLC programs that will perform PID control and generate shutdown trips. You will also learn about networked PLC systems.

In Outcome 1 you will learn about how a PLC can be programmed to perform PID control. You will gain “hands-on” experience of writing a program to perform PID control, entering the programme into the PLC and demonstrating that the programme satisfactorily performs PID control.

In Outcome 2 you will learn about how a PLC can be programmed to generate shutdown trips. You will gain “hands-on” experience of writing a program to generate shutdown trips, entering the programme into the PLC and demonstrating that the programme satisfactorily performs shutdown functions.

In Outcome 3 you will learn about the component parts of a network system that contains PLCs.

In Outcome 4 you will learn about how to design a networked PLC system that will suit a given industrial specification.

The formal assessment for this Unit will consist of two practical assignments for Outcomes 1 and 2, a written assessment for Outcome 3 and a written assignment for Outcome 4.

The assignment for Outcome 1 should normally be completed in five hours. The assignment for Outcome 2 should normally be completed in four hours. The assessment paper for Outcome 3 should normally be completed in one hour and 30 minutes. The assignment for Outcome 4 should normally be completed in five hours.

You will be allowed access to any relevant notes, manufacturers’ data and text books when carrying out the assignments for Outcomes 1, 2 and 4. The assessment for Outcome 3 will be carried out under closed-book conditions in which you will not be allowed to take notes, handouts, textbooks, etc into the assessment.

Your centre will provide you with access to a suitable PLC and programmer to carry out the practical parts of the assignments for Outcomes 1 and 2.

Each of the assessments will normally be carried out at the end of the delivery of the Outcome.