SQA Advanced Unit Specification

General information for centres

Unit title: Engineering Systems Interfaced with Programmable Logic Controllers

Unit code: HV39 47

Unit purpose: This Unit is designed to enable candidates to develop knowledge and understanding of interfacing engineering systems with programmable logic controllers (PLCs) and writing programmes to operate the interfaced engineering systems. The Unit also provides candidates with the opportunity to examine the use of programmable logic controllers as a tool to aid fault finding in industrial systems.

On completion of the Unit the candidate should be able to:

1 Identify basic requirements of interfacing devices to PLCs.
2 Develop programmes to operate a variety of engineering systems interfaced to a PLC.
3 Develop a programme to operate a sequential system with a minimum of three actuators interfaced to a PLC.
4 Investigate the benefits of PLC programmes to aid fault finding.

Credit points and level: 1 SQA Credit at SCQF level 7: (8 SCQF credit points at SCQF level 7*).

**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: It would be an advantage for candidates to have a basic knowledge and understanding of the programmable controllers. This can be evidenced by possession of the following NQ Units: Programmable Logic Controllers, Combinational logic or Boolean Algebra.

Core Skills: There are opportunities to develop the Core Skills of Written Communication, Critical Thinking and Reviewing and Evaluating 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.

Assessment: The assessment for Outcomes 1 and 4 in this Unit should be combined together into one assessment paper. This paper should be taken by candidates at one single assessment event that should last one hour. The assessment should be conducted under controlled, supervised conditions (closed book).

The assessment for Outcomes 2 and 3 is in the form of Practical assignments.

Centres should make every reasonable effort to ensure the assignment solution is the candidate's own work. Where copying or plagiarism is suspected candidates may be interviewed to check their knowledge and understanding of the subject matter. A checklist should be used to record oral evidence of the candidate's knowledge and understanding.

SQA Advanced 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

Identify basic requirements of interfacing devices to PLCs

Knowledge and/or skills

- Sensors
  - simple switches
  - light sensing devices
  - metal sensing devices
  - non-metal sensing devices
- Actuators
  - hydraulic cylinders and motors
  - pneumatic cylinders and motors
  - relays
- Safety Relays for guarding (all output off)

Evidence Requirements

Evidence for the knowledge and or skills in this Outcome will be provided on a sample basis. The evidence may be presented in response to specific questions. Each candidate will need to demonstrate that she/he can answer questions correctly based on a sample of the items shown above. In any assessment of this Outcome **two out of three** knowledge and/or skills items should be sampled.

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

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

- Briefly describe the connecting of two of the following sensing devices to the PLC
  - simple switch
  - light sensing device
  - metal sensing device
  - non-metal sensing devices

- Briefly describe the connecting of two of the following actuating devices to the PLC
  - hydraulic cylinder or motor
  - pneumatic cylinder or motor
  - felays (used to step up voltage, power and three phase systems)

- Briefly describe the use of Safety Relays for guarding systems on machines and equipment that is interfaced with PLCs.

Assessment guidelines

The assessment for Outcomes 1 and 4 in this Unit should be combined together into one written paper. This paper should be taken by candidates at one single assessment event that should last one hour. The assessment should be conducted under controlled, supervised conditions (closed book).

Outcome 2

Develop programmes to operate a variety of engineering systems interfaced to a PLC

Knowledge and/or skills

- Process Flow and input/output address allocations
- Programmes for interfaced engineering systems
- Programme Verification

Evidence Requirements

Evidence for the knowledge and or skills in this Outcome will be provided on completion of all skills and knowledge.

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

- produce process diagrams and address allocations for engineering systems interfaced to PLCs
- develop a variety of ladder logic programmes systems
- run and verify the programmes

The programmes above must have at least six of the nine functions listed below, which would operate at least two different systems such as small mechanical mechanisms, conveyor systems, component placement systems, lever systems, hoist systems.

AND function
OR function
Inverse AND or OR Function
Latch
Counters
Timers
Shift register
Jump commands
Simultaneous outputs

Assessment guidelines

The preference is for the assignments to be carried out on practical interfaced engineering systems; but where this not available a computer simulated system can be used. The type of practical interfaced engineering systems that are selected to be controlled by PLCs may reflect the candidate's own employment background and engineering systems available at delivering centres. Centres must prepare a checklist to confirm that practical fault finding activity is the candidate's own work. The assessment for Outcome 2 may be combined with parts of that for Outcome 3.

Outcome 3

Develop a programme to operate a sequential system with a minimum of three actuators interfaced to a PLC

Knowledge and/or skills

- Programme Development
- Programme Verification
- System documentation and fault finding procedure

Evidence Requirements

All knowledge and/or skills items should be assessed in this Outcome.

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

- develop a programme to operate a sequential system with a minimum of three actuators
- verify the operation of the programme on the engineering system
- produce system documentation and a faultfinding procedure for a minimum of two faults

Assessment guidelines

The preference is for the assignment to be carried out on a practical pneumatic or hydraulic or electrical system but where this not available a computer simulated system can be used. The type of pneumatic or hydraulic circuit selected for the fault finding exercise may reflect the candidate's own employment background. Centres may wish to prepare a checklist to confirm that practical fault finding activity is the candidate's own work. The assessment for Outcome 3 may be combined with parts of that for Outcome 2. Centres may wish to issue candidates with suitable guidance notes giving advice on the best way to structure their documentation. The documentation should include:

- process flow diagram
- ladder diagram
- description of program operation relating to the interfaced system
- description of fault finding procedure for a minimum of two faults

Outcome 4

Investigate the benefits of PLC programmes to aid fault finding

Knowledge and/or skills

- Major faults
- Programmable fault display devices
- Programme modification to extend the functionality

Evidence Requirements

Evidence for the knowledge and or skills in this Outcome will be provided on a sample basis. The evidence may be presented in response to specific questions. Each candidate will need to demonstrate that she/he can answer questions correctly based on a sample of the items shown above. In any assessment of this Outcome **two out of three** knowledge and/or skills items should be sampled.

In order to ensure that the candidates will not be able to foresee what items they will be questioned on, a different sample of two from three knowledge and/or skills items is required each time the Outcome is assessed.

- identify major faults conditions that occur on systems controlled by PLCs
- briefly describe the use of Programmable fault display devices that can be attached to PLCs to indicate fault conditions
- modify an existing program to extend the functionality

Assessment guidelines

The assessment for Outcomes 1 and 4 in this Unit should be combined together into one written paper. This paper should be taken by candidates at one single assessment event that should last one hour. The assessment should be conducted under controlled, supervised conditions (Closed book).

Administrative Information

Unit code: HV39 47

Unit title: Engineering Systems Interfaced with Programmable Logic Controllers

Superclass category: VE

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History of Changes:

Version	Description of change	Date

Source: SQA

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.

SQA Advanced Unit Specification: support notes

Unit title: Engineering Systems Interfaced with Programmable Logic Controllers

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

The purpose of this Unit is to provide candidates with an opportunity to acquire knowledge and understanding of programming PLCs to control mechanical systems and develop an understanding of PLCs as an aid to fault finding systems.

Outcome 1 — The aim of this Outcome is to introduce the student to interfacing of sensors, actuators, relays and safety relays. Connection of sensors will involve physical connection to the PLC and also placement of the sensor in the mechanical system so that the correct sensing distance is achieved to sense the component depending on the component material and manufacturers' instructions.

Centres will have various makes and models of PLCs with different output arrangement it is anticipated that at least one PLC is set aside to connect input and output devices to the PLC. Other centres may have quick connection systems to allow all the Sensors that are expected to be covered in this Unit are simple switches two wire on/off devices.

- Sensors
  - simple switches (microswitches, stop start buttons)
  - light sensing devices (infrared, visual light)
  - metal sensing devices (Inductive proximity devices)
  - non-metal sensing devices (capacitive devices)

The input sensors should be compatible with the PLCs interfacing requirements (24v and PNP devices). This will allow a basic knowledge of interfacing to be taught, other factor can be discussed as additional knowledge such as PNP/NPN (sink and source connection techniques), but it is not anticipated that these would be assessed.

The actuators that are expected to be covered in this unit are as follows:

- Hydraulic cylinders and motors
- Pneumatic cylinders and motors
- Relays (used to step up voltage, power and 3 phase systems)

Centres will have various makes and models of PLCs with different input/output arrangements, where power supplies and systems are already connected/interfaced into the delivering centres' PLC training rigs/equipment the basics input/output requirements will still need to be explained. In this case it is anticipated that at least one PLC could be set aside to allow connect input and output devices to the PLC.

Safety relays guarding systems (all output off) are external devices interfaced to the PLCs and should not be confused with internal programming of the PLCs and watchdog timers which is often used to protect processes, tooling and equipment. External safety relays are required to protect the safety of the personnel by shutting down the system/process when any guard door is opened or an emergency stop button is pressed.

Outcome 2 — The aim of this outcome is to develop the students' skills in programming of PLC in the first instance with prewritten programmes. The students are then is encouraged to develop programmes for themselves for a variety of engineering systems and verify their programmes on the engineering systems.

It is envisaged that the variety of engineering systems are small systems which cover a wide range of features that the PLCs and systems the delivery centre have, cover the majority of the following features below:

Features that development programmes and hardware should include for interfaced engineering systems are as follows:

- pulse
- latch
- timers
- flag/marker (internal output)
- start position checks
- step up/down relays
- other features that may be added include spring return cylinders and
- normally open and Normally closed switches external to PLCs
- latch on switches (run switches) and (spring return switches) single step switches
- shift registers
- jump commands

Depending upon the type of PLCs individual centres have for training (manufacturer and model) some commands will be simple to programme other commands may be complex to achieve for example; shift register, jump commands and even timer and counters have a wide variance when programming them. It is anticipated that the commands that are used suit the PLC that the students will be programming.

Outcome 3 — The aim of this outcome is to interface three actuators with a PLC and then programme a set sequence for the system. The students can develop skill by first programming one actuator, then programme a few sequences for two actuators and then inserting counters and timers into the sequences. It is envisaged that the final sequence would include three actuators, at least one timer and one counter, latch or use of the pulse function.

Examples of typical systems could be as follows:

- a pick and place unit
- an assembly system
- a position, clamp and drill unit
- a two level conveyor system with hoist lifting/lowering components between levels

Centres will have their own interfaced engineering system that they will train and assess the students with so the above list is for guidance where individual centres have systems of equivalent degree of complexity these systems can be used to assess students.

In Outcome 3 the skills and knowledge covered in Outcome 2 are to be reinforced and documentation of the process of development of programming cover by use of flow diagrams, process block diagrams or other methods of structuring programmes.

Input and output address allocations should be given or assigned to processes or equipment.

Documentation that a manufacturers would supply to aid faultfinding should be covered by showing students examples, discussing the advantages it brings to aiding improved fault finding and by the students producing appropriate faultfinding documentation themselves.

This includes an explanation of how the interfaced systems to PLC operate in terms of input to output address allocation programme logic operations, field device actions as shown in the following example:

Example: input x1 and input x2 go high, and function to output y1 to start conveyor belt component on conveyor passes IR beam input x3, which activates output y2 pneumatic cylinder to push component off the conveyor belt.

The Fault finding procedures covered in Outcome 3 of this unit could take the form of: -

Fault a pneumatic cylinder does not extend forward.

Typical procedure:

- Safety first (personal and process requirements)
- Check inputs to outputs
- Are sensor x1 and x2 high?
  - — if no - isolate power — check with appropriate test equipment (multimeter) — replace sensor if necessary
  - — if yes — isolate system and check cylinder operation if OK, then check programme and hardware integrity of PLC
- Is the fault repaired? Yes/no
  - — if no — carry out further faultfinding until fault is corrected
  - — if yes — check system position in terms for the process (reset or continue process from where it stopped
- Check safety
- Restart process

Centres may wish to issue candidates with suitable guidance notes giving advice on the best way to structure their documentation. The documentation should include:

- Process Flow Diagram
- Ladder Diagram
- Description of program operation relating to the interfaced system
- Description of fault finding procedure for a minimum of two faults

Outcome 4 — The aim of this outcome is to develop the students understanding of fault finding on engineering systems using PLCs. This will be the major task that students will deploy PLCs in industry when working in the maintenance.

Programmable Fault Display Devices are attached to the PLC to read the data at the inputs and outputs. When a production system that is interfaced to a PLC develops a fault during operation a message is displayed in English on the output screen of the **Programmable Fault Display Devices** to guide the maintenance towards expected interfaced system fault using the PLC's input and output data at the instant of system breakdown.

Typical output messages could include:

- no power to motor No. 2
- faulty inductive input sensor No. 5 (component sensor)
- faulty photovoltaic input sensor No. 5 (Box on conveyor sensor)

Guidance on the delivery and assessment of this Unit

This Unit should be delivered by a combination lecturing, class and group discussions.

In order to make the subject as interesting as possible centres are encouraged to use practical examples that model industrial systems wherever possible.

It is envisaged that centres will use the programmable logic controllers and equipment that suits the needs of local industry and resources within the centres. The aim of this unit is to provide students with the skills and knowledge to allow them to fault find industrial systems controlled by PLCs and allow them to write or modify small PLC programmes. Advanced programming would require development of the students' skills and knowledge.

Assessment of Outcomes 1 and 4 is by a written paper but if is expected that each student should have an opportunity to carry out interfacing of actuators and sensors practically and where feasible correct faults on interfaced systems. This will depend on available resources at the delivering centres.

Assessment of Outcomes 2 and 3 is by completion of practical assignments where the students have to produce documentation at the end of each assignment and evidence the correct operation of the interfaced systems. (Appropriate documentation and a checklist of systems that operated of correctly would suffice.)

Opportunities for developing Core Skills

There are opportunities to develop the Core Skills of Written Communication, Critical Thinking and Reviewing and Evaluating at SCQF level 5 in this Unit, although there is no automatic certification of Core Skills or Core Skills components.

Open learning

This Unit could be delivered by distance learning, which may incorporate some degree of on-line support. However, with regards to assessment, planning would be required by the centre concerned to ensure the sufficiency and authenticity of candidate evidence. Arrangements would be required to be put in place to ensure that assessment, whether done at a single or multiple events, was conducted under controlled, supervised conditions.

To keep administrative arrangements to a minimum, it is recommended that for distance learning candidates the assessment paper is taken at a single assessment event.

Outcomes 1 and 4 in this Unit could be delivered on an Open, Flexible or Distance learning basis, which may incorporate some degree of online support.

However, with regard to assessment, planning would be required by the centre concerned to ensure the sufficiency and authenticity of candidate evidence. Arrangements would be required to be put into place to ensure that the assessment papers for Outcomes 1 and 4, which is required to be sat at a single event, was conducted under controlled conditions

Outcomes 2 and 3 involving programming of programmable logic controllers plus the preparation of documentation requires to be taken at a centre or in an industrial location.

The use of simulation software can supplement but cannot fully replace the practical element of the experiment.

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.

General information for candidates

Unit title: Engineering Systems Interfaced with Programmable Logic Controllers

This Unit has been designed to allow you to develop knowledge and understanding about the function of PLCs as a programmable device to control industrial systems and also to aid fault finding within these industrial systems.

The Unit commences with diagrams and instructions of how to interface sensors, actuators, relays and safety relays to the PLC unit. Relays external to the PLCs are used to step up voltage, power and interface three phase systems, whereas safety relays are used for guarding systems.)

The aspect of guarding is outlined by discussing the use of a safety relay using the all outputs off function external to the PLC. These guarding systems provide safety personnel operating and maintaining industrial systems.

In the middle part of the unit small programmes are used to interface a variety of mechanical mechanisms to the PLC. This will develop programming skills by using various logic function, counters timers, pulse, latch and where appropriate shift registers and other specialised functions.

The Unit continues with the programming of pneumatic and/or hydraulic cylinders. At least three cylinders should be programmed as this would replicate most applications in industry.

The end of the unit deals with fault finding, where sufficient skills should be developed to realise the potential of PLCs as a programming device and as a tool to assist the maintenance technician to fault find industrial systems. The major faults developed in systems controlled by PLCs are identified. The devices that can be attached to PLCs to improve diagnosis of faults are discussed.