SQA Advanced Unit Specification

General information for centres

Unit title: Applications of Power Electronics in Electrical Motor Drive Systems

Unit code: HV50 48

Unit purpose: This unit has been designed to develop candidates' knowledge, understanding and skills in a range of power electronic circuitry used in electrical motor speed and torque control. More specifically candidates will study three-phase converters, AC to AC regulators and inverters particularly as these are applied to motor speed control. Candidates will also be provided with an opportunity to consolidate their knowledge, understanding and skills in power electronics and electrical motor speed control by undertaking an investigation into the operation and performance of an electronically controlled motor speed control system.

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

1. Explain the operation of single-phase converters and DC choppers
2. Explain the operation of three-phase converters, AC to AC regulators and inverters
3. Investigate the operation and performance of an electronically controlled motor speed control system

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: Candidates should have a knowledge and understanding of power electronics and electrical machines. This may be evidence by possession of the following SQA Advanced Units: HT83 47 Electrical Machine Principles and HT7M 48 Electrical Motor Drive Systems. However, entry requirements are at the discretion of the centre.

Core skills: There may be opportunities to gather evidence towards the following listed core skill components in this unit, although there is no automatic certification of core skills or core skills components.

- Written Communication (reading) at SCQF level 6
- Written Communication (writing) at SCQF level 6
- Using Number at SCQF level 6
- Using Graphical Information at SCQF level 6
- Using Information Technology at SCQF level 6
- Problem Solving at SCQF level 6

Context for delivery: This unit has been developed as an optional unit within the SQA Advanced Diploma in Electrical Engineering. If the unit is delivered as part of another group award(s), it is recommended that it should be taught and assessed within the subject area of the group award(s) to which it contributes.

Assessment: The assessment for this unit is in two parts. First, a written test lasting one and a half hours, which should be conducted under controlled, supervised conditions and should follow after the delivery of Outcomes 1 and 2. Second, following the written test, an investigation into the operation and performance of an electronically controlled motor speed control system. Candidates will be expected to produce a report of between 1000 – 1200 words plus diagrams and appendices on the operation and performance of the system.

SQA Advanced Unit specification: statement of standards

Unit title: Applications of Power Electronics in Electrical Motor Drive Systems

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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

Explain the operation of single-phase converters and DC choppers.

Knowledge and/or skills

- Single-phase converters (half-wave controlled and full-wave controlled rectifier circuits)
- Application of single-phase converters in the speed control of DC motors
- DC chopper circuits
- Application of DC chopper circuits in the speed control of DC motors

Outcome 2

Explain the operation of three-phase converters, AC to AC regulators and inverters.

Knowledge and/or skills

- Three-phase convertors (three-phase diode bridge, half-controlled three-phase bridge converter, full-controlled three-phase bridge converter)
- AC to AC regulators (phase control, burst firing)
- Application of AC to AC converters in the speed control of a universal motor
- Inverters (voltage source, current source, PWM, DC link)

Evidence requirements

Evidence for the knowledge and/or skills in Outcomes 1 to 2 will be provided on a sample basis. The evidence may be presented in responses to specific questions. Each candidate will need to demonstrate that she/he can answer correctly questions based on a sample of the items shown under the knowledge and skills items in both outcomes. In any assessment of the

Outcomes **two out of four** knowledge and/or skills items should be sampled from Outcome 1, and **two out of four** knowledge and/or skills items from Outcome 2.

In order to ensure that candidates will not be able to foresee what items they will be questioned on, a different sample of two out of four knowledge and/or skills items from Outcome 1, and two out of four knowledge and/or skills items from Outcome 2 are required each time the unit is assessed. Candidates must provide a satisfactory response to all 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:

Outcome 1

- describe, with the aid of a circuit diagram and waveform diagram(s), the operation of a half-wave or full-wave controlled single-phase converter
- explain the application of a half or full-wave single-phase converter in the speed control of a DC motor
- describe, with the aid of a circuit diagram and waveform diagram(s), the operation of one type of DC chopper circuit
- explain the application of a DC chopper circuit to the speed control of a DC motor

Outcome 2

- describe, with the aid of a circuit diagram and waveform diagram(s), the operation of a half-controlled, three-phase bridge converter or a full-controlled, three-phase bridge converter
- describe, with the aid of a circuit diagram and waveform diagram(s), an AC to AC regulator using either phase control or burst firing
- explain the application of an AC to AC regulator to the speed control of a universal motor
- define the different types of inverter and explain, with the aid of a circuit diagram and waveform diagram(s), the operation of one type of inverter

The assessment for Outcomes 1 and 2 should be combined together to form one assessment paper. This single assessment paper should be taken at a single assessment event lasting one and a half hours and carried out under supervised, controlled conditions. The assessment should be conducted under closed book conditions and as such candidates should not be allowed to bring any textbooks, handouts or notes to the assessment. Candidates will be permitted to use scientific calculators during the assessment.

Assessment guidelines

The assessment paper should be composed of an appropriate balance of short answer, restricted response and structured questions.

Outcome 3

Investigate the operation and performance of an electronically controlled motor speed control system

Knowledge and/or skills

- Block diagram of the system
- Description of system operation
- Waveforms
- Key performance characteristics
- Starting and braking
- Protection

All knowledge and/or skills items in Outcome 3 should be assessed. The evidence should be presented in response to an assignment in which the candidate is set the task of investigating the operation and performance of an electronically controlled motor speed control system. Such a system can be based around either a DC or AC motor.

Evidence requirements

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

- draw a block diagram of the motor speed control system
- describe the operation of the system
- draw important waveforms
- evaluate key performance characteristics
- explain the way in which starting and braking are achieved in the system
- explain all forms of protection that are available in the system

The assignment should be based on a real industrial or commercial situation in which a motor is used for precision speed control purposes.

Candidates should have access to course notes, relevant textbooks, instruction manuals and suppliers' catalogues while doing the assignment.

Evidence for this outcome should be gathered by the candidate preparing a report which covers the knowledge and skills items in outcome 3. The report should be between 1000 – 1200 words plus diagrams, appendices etc.

Assessment guidelines

Centres may wish to issue candidates with suitable guidance notes giving advice on the best way to structure their reports.

Administrative information

Unit code: HV50 48

Unit title: Applications of Power Electronics in Electrical Motor Drive Systems

Superclass category: XL

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For further information, please 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: Applications of Power Electronics in Electrical Motor Drive Systems

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 their knowledge, understanding and skills in the following areas:

1. explaining the operation of single-phase converters and DC choppers
2. explaining the operation of three-phase converters AC to AC regulators and inverters
3. investigating the operation and performance of an electronically controlled motor speed control system

This unit has been developed to provide SQA Advanced Diploma in Electrical Engineering candidates with knowledge, understanding and skills of power electronics particularly as relevant to the speed control of industrial electrical motor drive systems. It is a 1-credit unit at SCQF Level 8 (8 SCQF credit points at SCQF Level 8). It is included within the optional section of the SQA Advanced Diploma in Electrical Engineering framework. The unit can be offered on a free-standing basis, but can also be combined with the Power Electronics Unit and specialist electrical machines units such as Three-Phase Induction Motors and Synchronous Machines to form a study of electrical motors including speed control.

This unit has been developed in conjunction with the Power Electronics unit and it is strongly recommended that candidates study that unit before commencing this one.

In designing this unit, the unit writer has identified the range of topics expected 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 to 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 strongly recommended that they do so to ensure continuity of teaching and learning. The list of topics is shown as follows and lecturers are advised to study this list of topics.

Outcome 1 (6 hours)

Explain the operation of single-phase converters and DC choppers

- Review single-phase converters circuits as covered in the Power Electronics unit
- Explain the application of single-phase converters in the speed control of DC motors (use basic motor equations such as $E = V - I_aR_a$, $E = k_1N\Phi$ and $M = k_2\Phi I_a$ and waveform diagrams to assist explanation)
- Review the work on DC chopper circuits in the Power Electronics unit
- Consider the application of DC chopper circuits to the speed control of DC motors (use basic motor equations such as $E = V - I_aR$, $E = k_1N\Phi$ and $M = k_2\Phi I_a$ and waveform diagrams to assist explanation)

Outcome 2 (21 hours)

Explain the operation of three-phase converters, AC to AC regulators and inverters.

- Explanation, with the aid of circuit and waveform diagrams, of the following three- phase converter circuits:
  - Three-phase diode bridge
  - Half-controlled, three-phase bridge
  - Full-controlled, three-phase bridge
- Calculations involving converter average voltages, average currents, rms currents and power
- Explain AC to AC voltage regulation
- State the two principles methods as phase control and burst fire
- Use simple block diagram to explain Triac Phase Controller
- With the aid of suitable diagrams illustrate the impact of resistive and inductive loads on Triac Phase Controller
- Equations for V_{rms} and I_{rms} for phase control circuit
- Application of Phase Control to the speed and torque control of a universal motor
- With the aid of a block diagram explain burst firing
- With the aid of circuit and waveform diagrams explain the operation of an inverter
- Explain the principle of operation behind voltage source, current source and PWM inverters
- Inverter performance in terms of parameters such as frequency range, efficiency and cost
- Application of three-phase inverters to the control of three-phase induction motors

Written Test – 1 hour 30 minutes

Outcome 3 (11.5 hours)

Investigate the operation and performance of an electronically controlled motor speed control system.

- The content for this outcome is fully specified under Outcome 3 in the SQA Advanced Unit Specification: statement of standards section

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Guidance on the delivery and assessment of this unit

This unit has been designed to incorporate sufficient time to allow lecturers to teach all of the power electronics and electrical motor speed control content contained in the unit. There is also sufficient time for candidates to practice what they have learned through appropriate formative assessment exercises and practical laboratory work. With regard to practical work, it is strongly recommended that candidates are allowed to undertake a practical laboratory on at least some of the power electronic circuitry identified in the outcomes. This will help candidates relate theory to practice. The use of computer simulation software, either along with the practical laboratory work, or on its own will also assist candidate learning. Visits to industrial or commercial premises, where power electronics is used as part of an electrical motor drive system, will also be of value to candidate learning.

Information on evidence requirements and assessment guidelines is given after Outcomes 2 and 3 in the SQA Advanced Unit Specification: statement of standards section. The written assessment should take place after Outcomes 1 to 2 have been delivered and the assignment should follow the written test.

Open learning

This unit could be delivered by distance learning, which may incorporate some degree of online support. It is advisable that candidates come into centres to do any practical laboratory work. 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.

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: Applications of Power Electronics in Electrical Motor Drive Systems

The widespread use of power electronics in industry, commerce and even the home has led to the precision control of speed and torque on a range of electrical motors. This unit has been written in conjunction with the Power Electronics unit to provide you with a comprehensive study of power electronics and motor speed control at SQA Advanced level. In this unit you will have an opportunity to study some of the circuits used to achieve electrical motor speed and torque control. In the first part of the unit you will review what you learned in the Power Electronics unit before going on to consider three-phase converters, AC to AC regulators and inverters. You will have an opportunity to study how these circuits are used to control the speed and torque of different motors. Finally you will be provided with an opportunity to consolidate your knowledge, understanding and skills of power electronics and motor speed control by undertaking an investigation into the performance of an electronically controlled motor speed control system.

By its very nature this subject does involve some theory and you may find that the centre where you are studying this unit will ask you to undertake a number of laboratory exercises and computer simulations. These exercises will help you to understand how the theory you are learning relates to practice.

The assessment for this unit will comprise firstly of a written test lasting one and half hours, which will be conducted under controlled, supervised conditions and will follow the delivery of Outcomes 1 and 2. Secondly, following this written test you will be asked to undertake an investigation into the operation and performance of an electronically controlled motor speed control system. You will be expected to produce a report of between 1000 – 1200 words plus diagrams and appendices on the system.