Higher National Unit Specification

General information for centres

Unit title: Power Electronics

Unit code: DN42 34

Unit purpose: This Unit has been designed to develop candidates' knowledge, understanding and skills in the characteristics and applications of a range of power electronic devices. Candidates will also study how these devices are electrically protected and cooled and will also consider a range of single phase a.c. to d.c. converter and d.c. to d.c. chopper circuits.

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

1. Analyse the characteristics and applications of power electronic devices.
2. Outline arrangements for the protection of and the dissipation of heat from power electronic devices.
3. Analyse the operation and applications of single phase converters.
4. Analyse the operation and applications of dc to dc choppers.

Credit points and level: 1 HN 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 Access 1 to Doctorates.*

Recommended prior knowledge and skills: Candidates should have a general knowledge and understanding of electronics and electrical machines. This may be evidence by possession of the following HN Units: DN46 33 Analogue Electronics: An Introduction and DN4J 34 Electrical Machine Principles. However, entry requirements are at the discretion of the centre.

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

- Written Communication (reading) at Higher
- Written Communication (writing) at Higher
- Using Number at Higher
- Using Graphical Information at Higher
- Using Information Technology at Intermediate 2
- Critical Thinking at Higher
- Reviewing and Evaluation at Intermediate 2

General information for centres (cont)

Context for delivery: This Unit has been developed for the HNC and HND Electrical Engineering awards. If the Unit is delivered as part of another 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 this Unit will consist of the following two parts:

(1) a written test covering all four Outcomes
(2) a laboratory exercise covering Outcome 3 Knowledge and/or Skills, Item 8

The written test should last one and half hours and should be conducted under controlled, supervised conditions and should be sat by candidates at the end of the delivery of the Unit.

The laboratory exercise should last no longer than one and half hours and should be conducted under supervised conditions. Candidates are required to write up a report on the laboratory exercise which should include the following details:

- Purpose of laboratory exercise
- Description of exercise
- Results
- Analysis of results including any sources of errors
- Conclusions

Higher National Unit specification: statement of standards

Unit title: Power Electronics

Unit code: DN42 34

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

Analyse the characteristics and applications of power electronic devices.

Knowledge and/or skills

- Diode
- Diac
- Thyristor
- Gate Turn-Off Thyristor
- Triac
- Power MOSFET
- Insulated Gate Bipolar Transistor
- Smart Power Devices

Outcome 2

Outline arrangements for the protection of and the dissipation of heat from power electronic devices.

Knowledge and/or skills

- Overcurrent protection (e.g. fuses, crowbar circuit)
- Overvoltage protection
- Heat transfer paths
- Thermal characteristics of heat transfer process
- Use of heatsinks

Higher National Unit specification: statement of standards (cont)

Unit title: Power Electronics

Outcome 3

Analyse the operation and applications of single phase converters.

Knowledge and/or skills

- Difference between half-wave and full-wave rectifier circuits
- Difference between no control, half control and full control converters
- One to Four Quadrant Operation
- Full-wave, half-controlled bridge circuit with resistive load
- Full-wave, half-controlled bridge circuit with inductive load and flywheel diode
- Full-wave, fully controlled bridge circuit with inductive load
- Typical applications of single phase converters
- Laboratory exercise involving a single phase converter

Outcome 4

Analyse the operation and applications of dc to dc choppers.

Knowledge and/or skills

- Step-down chopper with resistive load
- Step-down chopper with inductive load
- Typical applications of step-down chopper circuits
- Step-up chopper

Evidence Requirements for the Unit

Evidence for the knowledge and /or skills in Outcomes 1 to 4 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 the Outcomes. In any assessment of the Outcomes **four out of eight** knowledge and/or skills items should be sampled from Outcome 1, **three out of five** knowledge and/or skills items from Outcome 2, **any four out of the first seven** knowledge and/or skills items from Outcome 3 and **two out of four** knowledge and/or skills items from Outcome 4.

In addition, the last bullet point (Knowledge/skills Item 8) in Outcome 3, involving a laboratory exercise on a single phase converter, must be assessed each time the Unit is delivered. A different single phase converter must be used in the laboratory exercise each time the assessment is offered.

Higher National Unit specification: statement of standards (cont)

Unit title: Power Electronics

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 eight knowledge and/or skills items from
Outcome 1, three out of five knowledge and/or skills items from Outcome 2, any four out of the first seven knowledge and/or skills items from Outcome 3 and two out of four knowledge
and/or skills items from Outcome 4 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 appropriate diagrams, the characteristics and applications of four of the following:

- Diode
- Diac
- Thyristor
- Gate Turn-Off Thyristor
- Triac
- Power MOSFET
- Insulated Gate Bipolar Transistor
- Smart Power Devices

Outcome 2

- describe the main overcurrent protection arrangements in power electronic circuits
- describe the main overvoltage protection arrangements in power electronic circuits
- identify the main heat transfer paths in power electronic devices
- describe, with the aid of a graph, the thermal characteristics of the heat transfer process in power electronic devices
- explain the use of heatsinks with power electronic devices

Outcome 3

- explain the difference between half-wave and full-wave rectifier circuits
- explain the differences between no control, half controlled and full-controlled converter circuits
- explain what is meant by one, two, three and four quadrant operation in converter circuits
- explain, with the aid of circuit and waveform diagrams, the operation of a full-wave, half-controlled bridge circuit with resistive load
- explain, with the aid of circuit and waveform diagrams, the operation of a full-wave, half-controlled bridge circuit with inductive load and flywheel diode
- explain, with the aid of circuit and waveform diagrams, the operation of a full-wave, fully-controlled bridge circuit with inductive load
- explain one domestic or industrial application of a single-phase converter

Higher National Unit specification: statement of standards (cont)

Unit title: Power Electronics

Outcome 4

- explain, with the aid of circuit and waveform diagrams, the operation of a step-down chopper circuit with resistive load
- explain, with the aid of circuit and waveform diagrams, the operation of a step-down chopper circuit with inductive load
- explain one domestic or industrial application of a step down dc-dc chopper
- explain, with the aid of circuit and waveform diagrams, the operation of a step-up chopper

The assessment for Outcomes 1 to 4 should be combined together to form one assessment paper. This single assessment paper should be taken at a single assessment event lasting one and half hours and carried out under supervised, controlled conditions. 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.

In addition, candidates are required to undertake one laboratory exercise on a single phase converter from the selection of converters shown in the knowledge and/or skills items in Outcome 3. A different single phase converter must be used in the laboratory exercise each time the assessment is offered. The laboratory exercise should last no longer than one and half hours and should be conducted under supervised conditions. Candidates are required to write up a report on the laboratory exercise, in their own time, which should include the following details:

- Purpose of laboratory
- Description of laboratory exercise
- Results
- Analysis of results including any sources of errors
- Conclusions

Centres should make every reasonable effort to ensure that the laboratory report 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.

Assessment guidelines for the Unit

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

Centres may wish to develop a laboratory report checklist to assist in the accurate and consistent assessment of reports.

Administrative Information

Unit code: DN42 34

Unit title: Power Electronics

Superclass category: XL

Date of publication: May 2005

Version: 01

Source: SQA

SQA acknowledges the valuable contribution that Scotland's colleges have made to the development of Higher National qualifications.

Additional copies of this Unit specification can be purchased from the Scottish Qualifications Authority. Please contact the Customer Contact Centre for further details, telephone 0845 279 1000.

Higher National Unit specification: support notes

Unit title: Power Electronics

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. Analysing the characteristics and applications of power electronic devices.
2. Outlining arrangements for the protection of and the dissipation of heat from power electronic devices.
3. Analysing the operation and applications of single phase converters.
4. Analysing the operation and applications of dc to dc choppers.

This Unit has been developed to provide HNC and HND Electrical Engineering candidates with a knowledge, understanding and skills in the characteristics and applications of a range of power electronic devices. It also includes studies in electrical protection and cooling methods associated with power electronic devices and the operation and application of some single phase converter and dc chopper circuits. The Unit is a 1 credit unit at SCQF Level 7 (8 SCQF credit points at SCQF Level 7). The Power Electronics Unit is an optional Unit within the HNC Electrical Engineering award but is part of the core Principles and Technology section within the HND Electrical Engineering award. It can be offered on a free standing basis, but also provides a foundation level Unit for the more specialist Unit in the HND Electrical Engineering award entitled Applications of Power Electronics in Electrical Motor Drive Systems. In fact, the two Units were developed together to provide a comprehensive course in power electronic devices, circuits and applications at Higher National level.

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. Whilst 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, and because the assessment exemplar pack for this Unit is based on the knowledge and/or skills and list of topics in each of the Outcomes.

A list of topics is given below. Lecturers are advised to study this list of topics in conjunction with the assessment exemplar pack so that they can get a clear indication of the standard of achievement expected of candidates in this Unit.

Higher National Unit specification: support notes (cont)

Unit title: Power Electronics

Outcome 1 (6-hours)

Analyse the characteristics and applications of power electronic devices.

In this section the lecturer should outline the main constructional features, key characteristics (using, for example, I/V curves) and applications of the range of power electronic devices listed under the Knowledge and/or Skills items in Outcome 1. The emphasis should be on identifying the key operating characteristics particularly as they may be used in different types of power electronic control circuits.

It may be helpful to set the study of power electronic devices within the context of a block diagram of a typical power electronic system (consisting, say, of a power source, power conditioner, load, control and filter (in some power electronic circuits only). The block diagram could be used as the basis to introduce ideal versus practical switching, power switching including choice of power switching devices and different types of power conditioners (e.g. a.c. to d.c. controlled rectifiers, d.c. to d.c. choppers and d.c. to a.c inverters)

Candidates may be encouraged to study the operation and applications of specific devices in more depth during, for example, directed study time.

It should be noted that a Smart Power Device combines logic and control elements alongside power switching devices either on a same chip or as part of a hybrid circuit. Such Smart Device possess the functionality to monitor and control their own operation and generate status reports on system behaviour.

Outcome 2 (3-hours)

Outline arrangements for the protection of and the dissipation of heat from power electronic devices.

- Identify the need for overcurrent and overvoltage protection with power electronic devices
- Detail the main forms of overcurrent protection (e.g. fuses, crowbar circuitry – include circuit diagram)
- Detail the main forms of overvoltage protection (e.g. non-linear surge suppressor plus snubber circuit)
- Identify main heat transfer paths in power electronic devices as: from internal junction to the case of the device; from the case to a heat transfer system such as fin and from this heat transfer system to ambient temperature heat sink
- Explain the heat transfer process under both steady state and transient conditions. Equivalent electrical circuit representation and temperature versus time graph. Steady state versus transient condition. **Non-mathematical treatment**
- Explain the use of heatsinks in the cooling of power electronic devices

Higher National Unit specification: support notes (cont)

Unit title: Power Electronics

Outcome 3 (19-hours)

Analyse the operation and applications of single phase converters.

- Identify typical d.c. voltage levels required in industry/commerce
- Explain the difference between half and full-wave rectifier circuits
- Explain what is meant by a converter circuit
- Explain the difference between no control, half control and full controlled converter circuits
- Simple thyristor firing circuits
- Describe, with the aid of circuit and waveform diagrams, the operation of a single phase half-wave, controlled bridge circuit with resistive load
- Equations for V_{av}, I_{av}, V_{rms} I_{rms} (not derived).
- Calculations involving these quantities
- Explain one, two, three and four quadrant operation
- Describe, with the aid of circuit and waveform diagrams, the operation of a single phase full-wave, half-controlled bridge circuit with resistive load
- Equations for V_{av}, I_{av}, V_{rms} I_{rms} (not derived).
- Calculations involving these quantities
- Describe, with the aid of circuit and waveform diagrams, the operation of a single phase full-wave, half-controlled bridge circuit with inductive load and flywheel diode
- Describe, with the aid of circuit and waveform diagrams, the operation of a single phase full-wave, half-controlled bridge circuit with resistive load
- A typical application may involve the speed control of a separately excited d.c. motor (use motor equations $E = V - I_aR$, $E = k_1N\Phi$ and $M = k_2\Phi I_a$ to explain principles behind this form of speed control)
- Practical laboratory work

Outcome 4 (9-hours)

Analyse the operation and applications of dc to dc choppers.

- Explain the purpose of a d.c. to d.c. chopper
- Describe, with the aid of circuit and waveform diagrams, the operation of a step-down chopper circuit with resistive load
- Equations for V_{av}, I_{av}, V_{rms} I_{rms} and periodic time (not derived)
- Calculations involving these quantities
- Explain, with the aid of circuit and waveform diagrams, the operation of a step-down chopper circuit with inductive load
- One application may involve a d.c. series motor
- Explain, with the aid of circuit and waveform diagrams, the operation of a step-up chopper (analogy to d.c. transformer)
- Practical laboratory work

Assessment Paper – One and a half hours

Laboratory exercise for Outcome 3 Knowledge/skills, Item 8 – One and a half hours

Higher National Unit specification: support notes (cont)

Unit title: Power Electronics

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 devices, circuits and applications subjects contained in the Unit. There is also sufficient time for candidates to practice what they have learnt through appropriate formative assessment exercises and computer simulation and practical laboratory exercises. With regard to computer simulation and laboratory work there are software packages available which can be used to illustrate the operation of different power electronic circuits and it is certainly recommended that lecturers use such packages to consolidate learning. However, it is also important that candidates get exposure to power electronic devices and are able to perform tests on practical power electronic circuits, such as single phase converters and d.c. choppers, so that they get a realistic sense of the types of devices and circuits that are used in industrial and commercial applications.

Information on Evidence requirements and Assessment guidelines is given after Outcome 4 in the Higher National Unit specification: statement of standards section. The written assessment should be taken at the end of the delivery of the Unit, while the practical laboratory exercise can be done during the delivery of Outcome 3.

Open learning

This Unit could be delivered by distance learning, which may incorporate some degree of on-line support. It is advisable that candidates come into centres to do any computer simulation or 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.

Candidates with additional support needs

This Unit specification is intended to ensure that there are no artificial barriers to learning or assessment. The additional support needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments or considering alternative Outcomes for Units. For information on these, please refer to the SQA document *Guidance Assessment Arrangements for Candidates with Disabilities and/or Additional Support Needs,* which is available on the SQA website www.sqa.org.uk.

General information for candidates

Unit title: Power Electronics

Power Electronics devices and circuits are used extensively throughout industry and commerce for control purposes in a range of different equipment (e.g. the control of speed and torque in electrical motors). In this Unit you will be provided with the opportunities to learn about the characteristics and applications of a range of modern power electronic devices. You will also learn about how such devices are electrically protected and cooled and you will consider the practical application of some of these devices by studying a range of single phase converter and d.c. chopper circuits.

The centre where you study this Unit is likely to provide you with opportunities to consolidate your knowledge and understanding of power electronic devices and circuits by allowing you to use computer software to simulate the operation of circuits and by undertaking practical laboratory exercises on devices and/or circuits.

Assessment for this Unit will comprise of one written test paper and one laboratory exercise. The written test will last one and half hours and will be taken under controlled, supervised conditions. You will take this test at the end of Unit delivery. You are likely to undertake the practical laboratory during the delivery of Outcome 3. Ask your lecturer for more details of when you will do the laboratory exercise.