National Unit Specification: general information

UNIT Direct Current Machines (SCQF level 6)

CODE F5HC 12

SUMMARY

This Unit is designed for candidates with a basic knowledge and understanding of electrical motors but who wish to enhance their knowledge and understanding of direct current (dc) machines. This Unit is particularly suitable for those candidates training to be electrical technicians, but may also be studied by candidates following alternative engineering technician routes.

The aim of this Unit is to provide candidates with the opportunity to develop their knowledge and understanding of the construction, principles of operation, characteristics and applications of dc generators, dc motors and brushless dc motors. Candidates will also develop knowledge and understanding of dc motor starting and speed control methods.

This Unit may form part of a National Qualification Group Award but may also be offered on a free standing basis.

OUTCOMES

1 Explain the construction, principles of operation, characteristics and applications of dc generators.
2 Explain the construction, principles of operation, characteristics and applications of dc motors.
3 Explain dc motor starting and speed control methods.
4 Explain the construction, principles of operation, characteristics and applications of a brushless dc motor and compare with its brushed equivalent.

Administrative Information

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National Unit Specification: general information (cont)

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RECOMMENDED ENTRY

While entry is at the discretion of the centre, candidates would normally be expected to have attained one of the following, or equivalent:

- Standard Grade Physics — Credit level
- Standard Grade Technological Studies — Credit level

CREDIT VALUE

1 credit at SCQF level 6 (6 SCQF credit points at SCQF level 6).

**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.*

CORE SKILLS

There is no automatic certification of Core Skills in this Unit.

This Unit provides opportunities for candidates to develop aspects of the following Core Skill:

- Numeracy (SCQF level 6)

These opportunities are highlighted in the Support Notes of this Unit Specification.

National Unit Specification: statement of standards

UNIT Direct Current Machines (SCQF level 6)

Acceptable performance in this Unit will be the satisfactory achievement of the standards set out in this part of the Unit Specification. All sections of the statement of standards are mandatory and cannot be altered without reference to SQA.

OUTCOME 1

Explain the construction, principles of operation, characteristics and applications of dc generators.

Performance Criteria

(a) Identify accurately the main constructional features of a dc generator.
(b) Describe correctly the principles of operation of a dc generator.
(c) Explain correctly, with the aid of appropriate graph(s), the main characteristics of dc generators.
(d) State correctly applications of dc generators.

OUTCOME 2

Explain the construction, principles of operation, characteristics and applications of dc motors.

Performance Criteria

(a) Identify accurately the constructional features of a dc motor.
(b) Describe correctly the principle of operation of a dc motor.
(c) Explain correctly, with the aid of appropriate graph(s), the main characteristics of dc motors.
(d) State correctly the applications of dc motors.

OUTCOME 3

Explain dc motor starting and speed control methods.

Performance Criteria

(a) Explain correctly the operation of a face plate starter for a dc motor.
(b) Explain correctly a conventional method of controlling the speed of a dc motor.
(c) Carry out correctly calculations to determine the additional resistance in field or armature circuit required to reduce/increase the speed of a dc motor.
(d) Explain correctly an electronic method of controlling the speed of a dc motor.

National Unit Specification: statement of standards (cont)

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OUTCOME 4

Explain the construction, principles of operation, characteristics and applications of a brushless dc motor and compare with its brushed equivalent.

Performance Criteria

(a) Identify accurately the main constructional features of a brushless dc motor.
(b) Explain correctly the principles of operation of a brushless dc motor.
(c) Explain correctly, with the aid of appropriate graph(s), the main characteristics of a brushless dc motor.
(d) State correctly applications of a brushless dc motor.
(e) State correctly advantages and a disadvantage of a brushless dc motor over a brushed dc motor.

EVIDENCE REQUIREMENTS FOR THIS UNIT

Evidence is required to demonstrate the candidates have achieved all Outcomes and Performance Criteria.

Written and/or recorded oral evidence should be produced to demonstrate that the candidate has achieved all the Outcomes and Performance Criteria.

Outcomes may be assessed on an individual basis, as combinations of Outcomes (eg Outcomes 1 and 2 together and Outcomes 3 and 4 together) or as a single, holistic assessment covering all four Outcomes. The total time taken for assessment(s) must not exceed 2 hours and 30 minutes. Assessment must be conducted under supervised, closed-book conditions in which candidates may use reference materials provided by the centre but are not allowed to bring their own notes, handouts, textbooks or other materials into the assessment. Candidates may use a scientific calculator during assessment.

With regard to Outcomes 1, 2 and 4

- candidates can either be asked to sketch and label a diagram of a dc generator, a dc motor and a brushless dc motor **or** can be provided with a diagram of the generator and motors and be asked to label the main parts

With regard to Outcome 1

- candidates must explain the characteristics of any two of the following generator types: separately excited, shunt, series or compound. Speed/Current and Torque/Current graphs for both generator types should be included with the explanation.
- candidates should state one application of any two of the following generator types: separately excited, shunt, series or compound.

National Unit Specification: statement of standards (cont)

UNIT Direct Current Machines (SCQF level 6)

With regard to Outcome 2

- candidates should explain the characteristics of any two of the following motors types: separately excited, shunt, series or compound. Speed/Current and Torque/Current graphs for both motor types should be included with the explanation.
- candidates should state one application of any two of the following motor types: separately excited, shunt, series or compound.

With regard to Outcome 3

- for Outcomes 3, pc (a), pc (b) and (d) candidates should be provided with a suitable diagram(s) to assist their explanation
- candidates should explain either a field regulator in a dc shunt motor method or a controller in series with the armature method
- the additional resistance may be calculated for either a shunt or series motor
- candidates should explain a simple thyristor system of speed control or dc chopper speed control in series motors or other suitable methods

With regard to Outcome 4

- candidates should draw Speed/Current and Torque/Current graphs to aid their explanation of the main characteristics of a brushless dc motor
- candidates should state two applications of brushless dc motors

Candidates should state two advantages of brushless dc motors over brushed dc motors.

National Unit Specification: support notes

UNIT Direct Current Machines (SCQF level 6)

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 is an optional Unit within the National Qualification Group Award in Electrical Engineering at SCQF level 6, but may also be offered on a free standing basis.

This Unit is one of three NQ electrical machines Units. The other two Units are entitled:

- *Rotating Electrical Machines* at SCQF level 5
- *Single and Three Phase Induction Motors* at SCQF level 6

The Unit, Rotating Electrical Machines has been designed to provide a foundation level of knowledge and understanding on electrical machines. As such it provides a suitable entry Unit for the two SCQF level 6 electrical machines Units.

There is also an NQ Unit on static electric plant at SCQF level 6 entitled: *Transformers*.

The aim of the Unit Direct Current Machines is to allow candidates to develop knowledge and understanding of the construction, principles of operation, characteristics and applications of dc generators, dc motors and brushless dc motors. Candidates will also develop knowledge and understanding of dc motor starting and speed control methods.

The list below shows a suggested range of topics which may be delivered to candidates to support and underpin the requirements set out in the Outcomes, Performance Criteria and Evidence Requirements.

DC generators

- main constructional features of dc generators
- principles of operation of dc generators
- commutation including problems arising from this process
- $V = E - I_aR_a$
- main dc generator winding configurations, ie
  — separately excited
  — shunt
  — series
  — compound
- main characteristics and applications of separately excited, shunt, series and compound wound dc generators
- simple calculations involving dc generators

National Unit Specification: support notes (cont)

UNIT Direct Current Machines (SCQF level 6)

DC motors

- main constructional features of dc motors
- principles of operation of dc motors
- $V = E + I_aR_a$
- main dc motor winding configurations, ie
  — separately excited
  — shunt
  — series
  — compound
- main characteristics of separately excited, shunt, series and compound wound dc motors
- applications of different dc motor types
- calculations involving dc motors including changing the speed of dc motors using additional resistance in the field or armature circuits

Starting and speed control of dc motors

- DC motor starting considerations
- face plate starter
- $N = V/k\ \Phi$
- traditional methods of controlling the speed of a dc motor (eg field regulator in shunt wound motor, controller in armature circuit etc)
- electronic methods of controlling the speed of a dc motor (eg thyristor system, chopper control etc)

Brushless dc motor

- constructional features of brushless dc motors
- principles of operation of brushless dc motors
- characteristics of brushless dc motors
- applications of brushless dc motors (relate to power rating of motor)
- advantages and disadvantage of brushless dc motors over brushed dc motors

GUIDANCE ON LEARNING AND TEACHING APPROACHES FOR THIS UNIT

It is recommended that the Unit is delivered in the same sequence the Outcomes are presented in the National Unit Specification: statement of standards section of the Unit. This Unit may be delivered by a combination of lectures, tutorial work, investigations using paper based and electronic sources and practical exercises which may include candidates disassembling different types of generators and motors to study their constructional features. Centres may also wish to allow candidates to perform experiments on generators and motors to investigate some of their performance characteristics.

Centres should ensure that candidates receive appropriate induction in safety before undertaking any disassembly and/or experimental work. It should be noted that the Internet contains a rich source of information on the construction, principles of operation and applications of dc generators, dc motors, brushless dc motors and dc motor starting and speed control methods.

Well annotated wall charts of generator and motor constructional features can also act as an important source of learning.

OPPORTUNITIES FOR CORE SKILL DEVELOPMENT

As they demonstrate understanding of the principles underlying the operation of direct current machines candidates work with a number of complex concepts. Candidates will have to interpret, calculate, apply and produce data in numerical and graphic formats. Numeracy skills will be naturally enhanced, with the focus on the practical use, application and presentation of number and graphics. Formative activities could be designed to develop accuracy and confidence in working in electrical engineering contexts.

GUIDANCE ON APPROACHES TO ASSESSMENT FOR THIS UNIT

Opportunities for the use of e-assessment

E-assessment may be appropriate for some assessments in this Unit. By e-assessment we mean assessment which is supported by information and communications technology (ICT), such as e-testing or the use of e-portfolios or e-checklists. Centres which wish to use e-assessment must ensure that the national standard is applied to all candidate evidence and that conditions of assessment as specified in the Evidence Requirements are met, regardless of the mode of gathering evidence. Further advice is available in *SQA Guidelines on Online Assessment for Further Education (AA1641, March 2003), SQA Guidelines on e-assessment for Schools (BD2625, June 2005).*

Formative assessment exercises in writing answers to questions about dc generators, dc motors and brushless dc motors, and calculations involving generators and motors should be used to reinforce candidate learning.

Outcomes 1 and 2 — may be assessed by a single assessment paper taken at a single assessment event lasting 1 hour and 15 minutes. The assessment paper may comprise of a balance of short answer, restricted response and structured questions.

Outcomes 3 and 4 — may be assessed by a single assessment paper taken at a single assessment event lasting 1 hour and 15 minutes. The assessment paper may comprise of a balance of short answer, restricted response and structured questions.

CANDIDATES WITH DISABILITIES AND/OR ADDITIONAL SUPPORT NEEDS

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. Further advice can be found in the SQA document *Guidance on Assessment Arrangements for Candidates with Disabilities and/or Additional Support Needs* **(www.sqa.org.uk)**.