Next Generation Higher National Unit Specification

Electrical Power and Drive Systems (SCQF level 7)

Unit code: J6D2 47

SCQF level: 7 (24 SCQF credit points)

Valid from: session 2024 to 2025

Prototype unit specification for use in pilot delivery only (version 2.0) August 2024

This unit specification provides detailed information about the unit to ensure consistent and transparent assessment year on year.

This unit specification is for teachers and lecturers and contains all the mandatory information required to deliver and assess the unit.

This edition: August 2024 (version 2.0)

Unit purpose

This unit develops the knowledge and skills required to explain, model, analyse and evaluate electrical power and drive systems. It provides knowledge and skills to support progression to the Electrical Engineering: Practical Skills unit at SCQF level 7 and further study at SCQF level 8.

Entry to this unit is at your centre's discretion. However, we recommend that learners have one or more of the following:

- foundational knowledge and understanding of electrical concepts and theorems at SCQF level 6, for example Electrical Principles
- relevant, equivalent workplace experience or SCQF level 6 qualifications, for example Higher Physics or a National Certificate (NC) in Electrical Engineering

Learners with SCQF level 6 qualifications can enhance their foundational knowledge by studying the Electrical Engineering Principles unit at SCQF level 7 before or at the same time as this unit.

Unit outcomes

Learners who complete this unit can:

1 explain the structure and operation of electrical power systems
2 describe the construction, operation and characteristics of a range of electrical motors
3 explain protection, starting and control methods for a range of electrical motors
4 analyse the performance of electrical machines under a range of load conditions
5 apply electrical engineering principles to provide a solution for a given real-world engineering problem

Evidence requirements

All outcomes can be assessed holistically using product, written and/or oral recorded evidence. Learners generate evidence under controlled or supervised, open-book conditions, and it must be authenticated as being all their own work. The evidence must contain a mix of knowledge and skills items that matches the evidence requirements of the unit, and include various forms of evidence, such as:

- assignments
- case studies
- reports
- essays
- simulations
- structured controlled tests
- practical evidence
- other relevant sources of evidence

Where sampling is indicated, you must teach all content in the ‘Knowledge and skills’ section and it must be available for assessment. Learners should not know which items they will be assessed on in advance. You must use a different sample for each assessment occasion.

Outcome 1

Sample any six of the eight required items:

- Produce a single line schematic diagram describing the structure of a national electrical power network.
- Explain the operation of a national electrical power network in terms of the function of generation, transmission and distribution network infrastructure and associated apparatus.
- Describe the construction of synchronous generators, transformers, switchgear and protective devices.
- Describe the characteristics and operation of synchronous generators, transformers, switchgear and protective devices.

- State three harmonic sources.
- Describe one method of harmonic filtering.
- State at least four types of power system faults.
- Discuss the impact smart grid technology may have on power network operations.

Outcome 2

Sample any three items:

- Describe the constructional features of a range of electrical motors:
  - three-phase AC induction motor
  - three-phase AC synchronous motor
  - single-phase AC induction motors (split-phase, capacitor start, capacitor start-run, shaded pole, universal, servo)
  - DC motors (shunt, series and universal, compound, permanent magnet, brushless, switched reluctance, servo, stepper)

Sample any three items:

- Explain the principle of operation of a range of electrical motors:
  - three-phase AC induction motor
  - three-phase AC synchronous motor
  - single-phase AC induction motors (split-phase, capacitor start, capacitor start-run, shaded pole, universal, servo)
  - DC motors (shunt, series and universal, compound, permanent magnet, brushless, switched reluctance, servo, stepper)

Outcome 3

- Explain the need for isolation and earthing.
- Explain the need for circuit protection (overcurrent, overvoltage, thermal, surge).
- Describe a range of starting methods for DC, single- and three-phase motors:
  - reduced voltage starting methods (rotor/stator resistance, autotransformer)
  - electronic starting (soft starter, variable frequency drive)
  - positional and speed control (variable frequency drive, servo controller, stepper controller)

Outcome 4

Sample any two of the three required items:

- Model the operation of a range of electrical machines:
  - one DC machine (series, shunt or compound)
  - one single-phase AC machine (split-phase, capacitor start or start-run)

  - one three-phase machine
- Analyse the performance of range of electrical machines:
  - one DC machine (series, shunt or compound)
  - one single-phase AC machine (split-phase, capacitor start or start-run)
  - one three-phase machine
- Evaluate the performance of a range of electrical machines
  - one DC machine (series, shunt or compound)
  - one single-phase AC machine (split-phase, capacitor start or start-run)
  - one three-phase machine

Outcome 5

- Describe the real-world problem.
- Investigate solutions to the problem.
- Evaluate solutions to the problem.
- Choose and justify a single practical solution to the problem.
- Prepare documentation supporting the proposed solution.
- Present the proposed solution.

Knowledge and skills

The following table shows the knowledge and skills covered by the unit outcomes:

Knowledge	Skills
Outcome 1 Learners should understand how to: ♦ describe the structural features of a national electrical power network ♦ explain the operation of a national electrical power network ♦ describe the constructional features of synchronous generators ♦ describe the constructional features of power, voltage and current transformers ♦ explain the operating principle of synchronous generators ♦ explain the operating principle of power, voltage and current transformers ♦ explain the operating principle and characteristics of switchgear and protective devices ♦ state harmonic sources ♦ explain methods of harmonic filtering ♦ state types of power system faults ♦ describe the impact smart grid technology may have on power network operations	**Outcome 1** Learners can: ♦ create and interpret single line schematic diagrams illustrating electrical transmission and distribution systems ♦ identify the main functional parts of a synchronous generator ♦ identify different transformers by their symbol on a circuit diagram
Outcome 2 Learners should understand how to: ♦ describe the constructional features of a range of electrical machines ♦ explain the principle of operation of a range of electrical motors	**Outcome 2** Learners can: ♦ identify the main functional parts of a range of electrical machines

Knowledge	Skills
Outcome 3 Learners should understand how to: ♦ explain the need for isolation and earthing ♦ explain the need for circuit protection (overcurrent, overvoltage, thermal, surge) ♦ describe starting methods for DC, single and three-phase motors ♦ describe positional and speed control methods	**Outcome 3** Learners can: ♦ identify different protective devices by their symbol on a circuit diagram ♦ physically identify different protective devices ♦ identify different starters from circuit diagrams
Outcome 4 Learners should understand how to: ♦ model the operation of electrical machines using equivalent circuits or simulations ♦ analyse the performance of electrical machines using practical tests or simulations	**Outcome 4** Learners can: ♦ model the operation of a range of electrical machines using equivalent circuits or simulations ♦ analyse the performance of a range of electrical machines using practical tests or simulations
Outcome 5 Learners should understand how to: ♦ research and investigate solutions ♦ write technical documents ♦ present technical information to a specific audience	**Outcome 5** Learners can: ♦ explain the problem ♦ research and investigate solutions to the problem ♦ select and justify a single practical solution to the real-world problem ♦ examine and explain the importance of the solution's safety, quality and reliability ♦ write technical documentation supporting the proposed solution ♦ present the proposed solution

Meta-skills

Throughout the unit, learners develop meta-skills to enhance their employability in the engineering sector.

Self-management

Learners develop their focusing skills as they work on case studies and projects. They also develop adaptability through team working compromises, and take initiative with their responsibility in ensuring successful team outcomes.

Social intelligence

Learners develop empathy with their team members. They build relationships and collaboration skills through team working, and while leading team sessions to influence and inspire their team co-workers. Learners also develop communication skills while working in a team and presenting solutions to real-world problems.

Innovation

Learners develop problem recognition when they explain problems and generate ideas for solutions. They also develop holistic and logical thinking when making sense of problems and critically thinking when finding solutions.

Literacies

Learners develop core skills in the following literacies:

Numeracy

Learners develop their numeracy skills by performing engineering calculations.

Communication

Learners develop communication skills by:

- working in a team
- producing documentation
- presenting solutions

Digital

Learners develop digital skills and computer literacy by:

- using research methods
- using software for project management
- simulating and modelling engineering applications
- preparing documents and results for presentation

Delivery of unit

This unit is part of the Higher National Certificate (HNC) in Engineering. The framework includes mandatory and optional units, and you can tailor the selected combination of units to specific engineering pathway needs.

There are opportunities to integrate how you teach and assess this unit with the following units:

- Professional Practice in Engineering (SCQF level 7)
- Electrical Engineering Principles (SCQF level 7)
- Electrical Engineering: Practical Skills (SCQF level 7)

The notional design length is 120 hours, which you should deliver in a physical or virtual learning space, however, the exact time you allocate to this unit is at your centre's discretion. We suggest the following distribution of time:

Outcome 1 — Explain the structure and operation of electrical power systems
(12 hours)

Outcome 2 — Describe the construction, operation and characteristics of a range of electrical motors
(20 hours)

Outcome 3 — Explain protection, starting and control methods for a range of electrical motors
(8 hours)

Outcome 4 — Analyse the performance of electrical machines under a range of load conditions
(40 hours)

Outcome 5 — Apply electrical engineering principles to provide a solution for a given real-world engineering problem
(40 hours)

Additional guidance

The guidance in this section is not mandatory.

Content and context for this unit

This unit gives learners some of the knowledge and skills required to support a career in electrical engineering. It uses a project-based, team working approach to develop their professional skills and meta-skills, which are in high demand for industry careers.

Explain the structure and operation of electrical power systems (outcome 1)

Introduces learners to the electricity power system. This knowledge provides them with a foundational overview of the electrical power system that will support further specialised study of electrical power engineering.

Describe the construction, operation and characteristics of a range of electrical motors (outcome 2)

Introduces learners to a wide range of electrical machines. This gives them a firm understanding of the operating principles of DC and AC machines.

Explain protection, starting and control methods for a range of electrical motors (outcome 3)

Introduces learners to starting, protection and control methods used with DC and AC machines.

Analyse the performance of electrical machines under a range of load conditions (outcome 4)

Provides learners with the opportunity to model, analyse and evaluate the performance of a range of electrical machines. You should introduce them to equivalent circuit models and encourage them to investigate through simulations and practical laboratory work where practical. The range of electrical machines analysed should include:

- synchronous generators and motors
- transformers
- single- and three-phase induction motors
- various DC motors

The performance characteristics analysed may include:

- voltage
- current
- input and output power
- power factor
- speed
- slip
- torque
- efficiency

Apply electrical engineering principles to provide a solution for a given real-world engineering problem (outcome 5)

Provides learners with the opportunity to apply the knowledge and skills developed throughout this unit in a real-world context by solving real-world problems. Proposal documents could include:

- design calculations
- wiring diagrams
- technical specifications for electrical machines
- circuit protection and safety
- starting and control methods
- models
- analysis
- evaluations

There are no specific resources required for this unit other than information and communication technology (ICT), but if you use the recommended delivery approach of practical experimentation, you need suitable engineering design software, laboratory facilities and equipment.

Approaches to delivery

We suggest a learner-centred problem or project-based-learning (PBL) approach using case studies and projects. You should deliver the unit using a variety of holistic methods, as this provides opportunities to develop meta-skills following the interconnected nature of electrical engineering.

You should principally deliver all outcomes in a learning space or virtual learning environment. We recommend you use a holistic approach to delivery, where learning occurs in the context of a few overarching complex engineering scenarios. You can achieve this by delivering outcomes 4 and 5 concurrently with outcomes 1, 2 and 3.

For example, when learners investigate potential solutions to a real-world problem in outcome 5, you should encourage them to model, analyse and evaluate the performance of electrical drives in outcome 4, and develop a deeper knowledge of the machine starting and operation covered in outcomes 2 and 3.

Use practical experimentation to help conceptual understanding, supported by self-directed research to investigate and learn about the relevant quantities and concepts.

Approaches to assessment

You can assess learners in a variety of ways, mainly using reports, work products, reflective accounts and presentations, generated by learners in open-book, unsupervised and untimed conditions. Learners should collate all evidence in their individual portfolio.

In line with the approach to delivery, you should take a holistic approach to assessment to demonstrate evidence of all knowledge and skills items in the context of a few overarching complex engineering scenarios.

Learners could keep a linear reflective account to measure their meta-skills, digital literacies, professional skills and wider employer-desired skills, and record this in their personal portfolio.

You should provide learners with support, guidance and feedback on areas of development, and signpost developmental opportunities.

Opportunities for e-assessment

Assessment that is supported by information and communication technology (ICT), such as e-testing or the use of e-portfolios or social software, may be appropriate for some assessments in this unit.

If you want to use e-assessment, you must ensure that you apply the national standard to all evidence and that conditions of assessment (as specified in the evidence requirements) are met, regardless of the mode of gathering evidence.

Equality and inclusion

This unit is designed to be as fair and as accessible as possible with no unnecessary barriers to learning or assessment.

You should take into account the needs of individual learners when planning learning experiences, selecting assessment methods or considering alternative evidence.

Guidance on assessment arrangements for disabled learners and/or those with additional support needs is available on the assessment arrangements web page: www.sqa.org.uk/assessmentarrangements.

Information for learners

Electrical Power and Drive Systems (SCQF level 7)

This information explains:

- what the unit is about
- what you should know or be able to do before you start
- what you need to do during the unit
- opportunities for further learning and employment

Unit information

This unit gives you the opportunity to develop some of the knowledge and skills required to support a career in electrical engineering. It forms part of the Higher National Certificate (HNC) in Engineering, which is for learners who want to become engineering technicians.

Before starting this unit, we recommend that you have foundational knowledge and understanding of electrical concepts and theorems.

For this project-based unit, you need to work as part of a small project team to develop and evaluate solutions to real-world engineering problems. You learn about the electrical supply system and the application of DC and AC machines to solve real-world problems.

Unit outcomes

On completion of this unit, you can:

1 explain the structure and operation of electrical power systems
2 describe the construction, operation and characteristics of a range of electrical motors
3 explain protection, starting and control methods for a range of electrical motors
4 analyse the performance of electrical machines under a range of load conditions
5 apply electrical engineering principles to provide a solution for a given real-world engineering problem

Outcome 1 — introduces you to the structure and operation of an electricity power system. This knowledge provides you with a foundational overview of the electrical power system that will support further specialised study of electrical power engineering.

Outcome 2 — introduces you to a wide range of electrical machines. This gives you a firm understanding of the construction and operating principles of DC and AC machines.

Outcome 3 — introduces you to starting, protection and control methods used with DC and AC machines.

Outcome 4 — provides you with the opportunity to model, analyse and evaluate the performance of a range of electrical machines. The range of electrical machines you analyse includes:

- synchronous generators and motors
- transformers
- single- and three-phase induction motors
- various DC motors

The performance characteristics you analyse may include:

- voltage
- current
- input and output power
- power factor
- speed
- slip
- torque
- efficiency

Outcome 5 — gives you the opportunity to apply the knowledge and skills developed throughout this unit in a real-world context, by solving real-world problems.

You are assessed in various ways, mainly consisting of reports, work products, reflective accounts and presentations, generated in open-book, unsupervised and untimed conditions.

Meta-skills

Throughout the unit, you develop meta-skills to enhance your employability in the engineering sector.

Meta-skills include self-management, social intelligence and innovation.

Self-management

You develop your focusing skills as you work on case studies and projects. You also develop adaptability through team working compromises, and take initiative with a responsibility to ensure successful team outcomes.

Social intelligence

You develop empathy with your team members. You build relationships and collaboration skills through team working, and while leading team sessions to influence and inspire your team co-workers. You also develop your communication skills while working in a team and presenting solutions to real-world problems.

Innovation

You develop problem recognition when you explain problems and generate ideas for solutions. You also develop holistic and logical thinking when making sense of problems and critically thinking when finding solutions.

Administrative information

Published: August 2024 (version 2.0)

Superclass: VE

History of changes

Version	Description of change	Date
02	Evidence requirements updated to clarify sampling and conditions of assessment.	August 2024

Note: please check SQA's website to ensure you are using the most up-to-date version of this document.