Next Generation Higher National Unit Specification

Electrical Engineering Principles (SCQF level 7)

Unit code: J6CW 47

SCQF level: 7 (24 SCQF credit points)

Valid from: session 2024 to 2025

Prototype unit specification for use in pilot delivery only (version 3.0) 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 3.0)

Unit purpose

This unit provides learners with the knowledge, skills and understanding required to analyse electrical circuits, including electrical theorems, covering:

- DC principles
- single-phase AC principles
- three-phase principles
- electrostatics and electromagnetics

It gives them the opportunity to expand their knowledge of electrical engineering into other areas. It also provides knowledge to support their progression to the Electrical Power and Drive Systems unit at SCQF level 7.

The target group for this unit is learners who want to develop knowledge and skills in using electrical theories and concepts, to support a career in electrical engineering.

Entry is at your centre's discretion. However, we recommend that learners have knowledge and understanding of electrical circuits and/or mathematical concepts before they begin.

This unit provides learners with suitable knowledge and skills to progress to employment in a wide range of engineering jobs requiring electrical knowledge, technical apprenticeships, or further study.

Unit outcomes

Learners who complete this unit can:

1 demonstrate knowledge and understanding of DC principles
2 demonstrate knowledge and understanding of single-phase AC principles
3 demonstrate knowledge and understanding of three-phase principles
4 demonstrate knowledge and understanding of electrostatics and electromagnetics

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 three of the five required items:

- Solve electrical engineering problems using Ohm's and Kirchhoff's laws.
- Solve electrical engineering problems using Thevenin's and Norton's theorems in DC circuits.
- Solve electrical engineering problems using superposition theorem.
- Solve electrical engineering problems using maximum power transfer theorem in DC circuits.
- Demonstrate an understanding of DC transients for CR and LR circuits.

Outcome 2

Sample any three of the five required items:

- Analyse RL, RC and RLC electrical circuits using complex notation.
- Solve power factor improvement problems.
- Solve electrical engineering problems using Thevenin’s and Norton’s theorems in single-phase AC circuits.
- Solve electrical engineering problems using maximum power transfer theorem in single-phase AC circuits.
- Solve problems involving resonating passive circuits.

Outcome 3

Sample any four of the six required items:

- Describe the construction of a three-phase generator.
- Explain the advantages of using a three-phase system.
- Solve electrical engineering problems for balanced star-connected loads and balanced delta-connected loads.
- Draw phasor diagrams for balanced three-phase loads.
- Solve electrical engineering problems for unbalanced star-connected loads and unbalanced delta-connected loads.
- Demonstrate an understanding of power in three-phase systems.

Outcome 4

Sample any three of the four required items:

- Demonstrate an understanding of electrostatic fields.
- Solve electrical engineering problems for capacitor networks.
- Demonstrate an understanding of magnetic fields.
- Solve electrical engineering problems for self and mutual inductance.

Knowledge and skills

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

Knowledge	Skills
Outcome 1 Learners should understand: ♦ Ohm's and Kirchhoff's laws ♦ Thevenin's and Norton's theorems ♦ superposition theorem ♦ maximum power transfer theorem ♦ DC transient effects of CR and LR circuits	**Outcome 1** Learners can: ♦ solve DC problems using Kirchhoff's laws ♦ solve DC problems using Thevenin's and Norton's theorems ♦ solve DC problems using superposition theorem ♦ solve DC problems using maximum power transfer theorem ♦ demonstrate an understanding of DC transients for CR and LR circuits
Outcome 2 Learners should understand: ♦ RL, RC and RLC circuits ♦ AC power ♦ power factor improvement ♦ resonating passive circuits	**Outcome 2** Learners can: ♦ solve AC electrical problems involving RL, RC and RLC using complex notation and drawing phasor diagrams ♦ solve AC electrical problems of power factor improvement ♦ solve AC electrical problems using Thevenin's and Norton's theorems ♦ solve AC electrical problems using maximum power transfer theorem ♦ solve AC electrical problems of resonating passive circuits

Knowledge	Skills
Outcome 3 Learners should understand: ♦ a three-phase generator ♦ the advantages of using a three-phase system ♦ star and delta loads ♦ balanced and unbalanced loads ♦ measuring power in a three-phase load	**Outcome 3** Learners can: ♦ solve problems for balanced star-connected loads ♦ solve problems for unbalanced star-connected loads ♦ solve problems for balanced delta-connected loads ♦ solve problems for unbalanced delta-connected loads ♦ draw phasor diagrams for balanced three-phase loads for star and delta ♦ demonstrate an understanding of power in three-phase systems
Outcome 4 Learners should understand: ♦ electrostatic fields ♦ magnetic fields	**Outcome 4** Learners can: ♦ demonstrate an understanding of electrostatic fields ♦ solve problems with parallel plate capacitors in series and parallel network ♦ demonstrate an understanding of electrostatic fields ♦ demonstrate an understanding of magnetic fields ♦ solve problems for self and mutual inductance

Meta-skills

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

Self-management

Learners develop their focusing, adapting and initiative skills as they study the course material. They can provide evidence of these in their reflective reports.

Social intelligence

Learners develop their communication skills while producing technical reports. They also develop collaboration skills while working with other learners on lab exercises.

Innovation

Learners develop their curiosity, sense-making and critical thinking skills when conducting their learning activities and projects either individually or in groups.

Literacies

Learners develop core skills in the following literacies:

Numeracy

Learners develop their numeracy skills through performing calculations when analysing DC and AC circuits.

Communication

Learners develop their communication skills by studying the course material and engaging with fellow learners, and their teacher or lecturer.

Digital

Learners develop digital literacy by accessing the course material through a virtual learning environment (VLE), if applicable.

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.

The notional design length is 120 hours, however, the amount of time you allocate to each outcome is at your centre's discretion. We suggest the following distribution of time, including assessment:

Outcome 1 — Demonstrate knowledge and understanding of DC principles (30 hours)
Outcome 2 — Demonstrate knowledge and understanding of single-phase AC principles (30 hours)
Outcome 3 — Demonstrate knowledge and understanding of three-phase principles (30 hours)
Outcome 4 — Demonstrate knowledge and understanding of electrostatics and electromagnetics (30 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 they need to support a career in electrical engineering.

Demonstrate knowledge and understanding of DC principles (outcome 1)

Introduces learners to circuit techniques to analyse DC circuits. You could start with knowledge and understanding of resistance, capacitance, inductance, voltage, current and power and their relationship in series and parallel, including ohms law and Kirchhoff's law. Following this, you could introduce more complex analysis theorems in superposition, such as Thevenin's, Norton's and maximum power transfer.

Demonstrate knowledge and understanding of single-phase AC principles (outcome 2)

This helps learners apply their knowledge from outcome 1 to AC principles. You should cover inductive reactance, capacitive reactance and impedance to help them understand AC circuits. Support learners with complex notation so they can analyse RL, RC and RLC circuits before you introduce apparent, active and reactive power. You should continue with power factor correction. If you combine AC circuits with the theorems from outcome 1 (Thevenin's, Norton's and maximum power transfer), this gives learners good knowledge and understanding of analysing AC circuits. Finally, cover knowledge and understanding of resonating passive circuits, including resonating frequency, dynamic impedance, bandwidth, Q-factor impedance/frequency and current/frequency graphs for RL, RC and RLC circuits.

Demonstrate knowledge and understanding of three-phase principles (outcome 3)

Develops learners' knowledge and understanding of three-phase generators, including:

- the advantages of using three-phase over single-phase
- the relationship between phase and line voltage and current for star and delta configuration
- calculating phase and line voltages and currents for star and delta configuration in both balanced and unbalanced loads
- calculating the current in the neutral wire of an unbalanced load supplied by three-phase four wire supply
- calculating the potential difference between the load star point and the supply star point for an unbalanced star-connected load supplied by a three-phase three wire supply
- knowledge and understanding of active, reactive and apparent power and power factor in a three-phase system
- knowledge and understanding of measuring power including one-, two- and three-watt meter methods

Demonstrate knowledge and understanding of electrostatics and electromagnetics (outcome 4)

Introduces electrostatics, to give learners knowledge and understanding of:

- charge
- electromotive force
- electric field strength
- electric flux density
- capacitance

By continuing with electromagnetics, this gives them knowledge and understanding of:

- mmf
- flux
- reluctance
- induced EMF and current
- leakage
- magnetic losses
- pulsating and rotating EMFs
- self and mutual inductance

Approaches to delivery

We suggest learners complete outcomes 1 and 2 first. They can do this in order or concurrently, as some of the theorems apply to DC and AC. You can deliver outcomes 3 and 4 in any order.

You should deliver the outcomes in a learning space or VLE and primarily use problem-based learning (PBL) techniques, such as case studies and mini projects, supported by other methods. The holistic format of PBL encourages learners to consider the deeper context of the theory.

Approaches to assessment

In line with the approach to delivery, you should take a holistic approach to assessment. This consists of a review of case study reports and mini projects. Learners should generate evidence under open-book conditions and collate it in their individual portfolio.

They should demonstrate evidence of all knowledge and skills in the context of one or more overarching complex electrical engineering scenarios.

For case studies and mini projects, you can assess knowledge and skills through coursework exercises. Learners must produce product evidence (for example, in the form of a coursework report), that they compile under open-book, unsupervised and untimed conditions.

They 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.

Because of the open-book nature of the assessment, you must take care to ensure authenticity. You could do this by using variable values in the coursework, making use of oral questioning and using originality-checking software, as appropriate.

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 Engineering Principles (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 provides you with knowledge and skills specific to electrical engineering. It is part of the HNC in Engineering, which is for learners who wish to become engineering technicians.

Before starting this unit, we recommend that you have knowledge and understanding of electrical circuits and/or mathematical concepts. For example, you may have achieved:

- National Certificate (NC) in Electrical Engineering (SCQF level 6)
- Higher Physics
- Electrical Principles unit at SCQF 6

In outcomes 1 and 2, you cover the basic concepts of DC and AC circuits before moving on to more complex analysis techniques. You also learn how to solve electrical problems of AC circuits using complex notation. In outcome 3 you are introduced to three-phase systems, where you learn the reasons why industry prefers these, before you analyse star and delta configurations. In outcome 4 you look at electrostatics, covering capacitors and charge in an electrical circuit. Finally, you move on to electromagnetics, which helps you to understand transformers content covered in the Electrical Power and Drive Systems unit at SCQF level 7.

You are assessed in different ways, including the review of case study reports and mini projects. You should collate all evidence in your individual portfolio.

There is a holistic approach to assessment, where you demonstrate evidence of all knowledge and skills in the context of one or more overarching electrical engineering scenarios.

On completion of this unit, you can:

- demonstrate knowledge and understanding of DC principles
- demonstrate knowledge and understanding of single-phase AC principles
- demonstrate knowledge and understanding of three-phase principles
- demonstrate knowledge and understanding of electrostatics and electromagnetics

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 the skills of focusing, adapting and initiative as you study the course material.

Social intelligence

You develop your communication and collaboration skills as you work with other learners on activities.

Innovation

You develop the skills of curiosity, sense-making and critical thinking when carrying out learning activities and projects either individually or in groups.

Administrative information

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Superclass: XJ

History of changes

Version	Description of change	Date
2.0	♦ Additional wording in 'Evidence requirements' to clarify sampling. ♦ 'Ohm's law' added to outcome 1 evidence requirements. ♦ Changed 'section' to 'information' in 'Information for learners' section for consistency across units. ♦ Recommend entry requirements in 'Information for learners' section amended for clarity and accuracy.	August 2023
3.0	Additional wording to clarify 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.