Next Generation Higher National Unit Specification

Analogue Electronics: Theory and Applications (SCQF level 7)

Unit code: J751 47

SCQF level: 7 (24 SCQF credit points)

Valid from: session 2023–24

Prototype unit specification for use in pilot delivery only (version 1.0) April 2023

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: April 2023 (version 1.0)

Unit purpose

This unit provides learners with knowledge and skills specific to electronics engineering.

They learn about the principles underlying analogue electronics, including:

- circuit analysis using Kirchhoff's, Thevenin's and Norton's theorems, superposition theorem, and mesh analysis
- the operation and characteristics of semiconductor diodes, and their use in circuits
- the operation and characteristics of bipolar and field effect transistors, and their use in circuits
- the operation and characteristics of operational amplifiers, and their use in circuits
- the operation and characteristics of passive filters

The target learner group for this unit is learners who want to develop their core electronic engineering skills to support a career in electronic engineering.

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

- broad knowledge and understanding of electronics concepts and theorems; for example, an SCQF level 6 qualification in Electronics Principles, Higher Physics or a National Certificate in an engineering discipline
- relevant, equivalent workplace experience

The unit provides learners with suitable knowledge and skills to progress to further study, or employment in a wide range of engineering industries.

Unit outcomes

Learners who complete this unit can:

1 apply knowledge and skills of circuit theorems to direct current (DC) and alternating current (AC) circuits
2 apply knowledge and skills of semiconductor diodes' operation and characteristics to diode circuit applications
3 apply knowledge and skills of bipolar and field effect transistors' operation and characteristics to transistor circuit applications
4 apply knowledge of operational amplifiers' operation and characteristics to operational amplifier circuit applications
5 apply knowledge of filters' operation and characteristics to passive filter applications

Evidence requirements

You can assess this unit holistically using a portfolio of evidence that learners generate. Learners must produce a reflective report for each outcome, evaluating the knowledge and skills they have gained.

Evidence should principally consist of written and/or oral recorded evidence. Learners generate evidence under unsupervised, open-book conditions.

You can find further information in the 'Additional guidance' section.

Outcome 1

Circuit theorems

1a Use Kirchhoff's current and voltage laws, and mesh circuit analysis to calculate current and voltage in one AC circuit. The circuit should include at least three current loops, one or more voltage and current sources, resistors, capacitors, and inductors.

1b Use Thevenin's theorem and mesh current analysis to calculate current and voltage in one DC circuit. The circuit should include at least three current loops, one or more voltage and current sources, and resistors.

1c Use Norton's theorem and mesh current analysis to calculate current and voltage in one AC circuit. The circuit should include at least three current loops, one or more voltage and current sources, capacitors, inductors, and resistors.

1d Use the superposition theorem to calculate current and voltage in one DC circuit. The circuit should include at least three current loops, one or more voltage and current sources, and resistors.

Outcome 2

Semiconductor diodes

2a Describe the characteristics and operation of each of the following diodes:

- PN junction diode
- Zener diode
- Schottky diode
- light-emitting diode
- photodiode

2b Analyse the operation of each of these circuits:

- rectifier circuit
- voltage reference source
- clipping circuit
- clamping circuit
- light-emitting diode circuit
- photodetection circuit

2c Simulate and evaluate the operation of a minimum of two of these circuits:

- rectifier circuit
- voltage reference source
- clipping circuit
- clamping circuit
- light-emitting diode circuit
- photodetection circuit

2d Build, test and evaluate the operation of a minimum of two of these circuits:

- rectifier circuit
- voltage reference source
- clipping circuit
- clamping circuit
- light-emitting diode circuit
- photodetection circuit

2e Document 2c and 2d, ensuring that documentation includes evidence of self-management, social intelligence, innovation and the use of technical data sheets.

Outcome 3

Transistors

3a Describe the characteristics and operation of:

- NPN and PNP bipolar junction transistors
- N-channel and P-channel junction field effect transistors (JFETs)
- enhancement and depletion mode metal oxide semiconductor field effect transistors (MOSFETs)

3b Analyse the operation of each of the following transistor circuits:

- common emitter amplifier circuit
- common collector amplifier circuit
- common source amplifier circuit
- common drain amplifier circuit
- transistor switching circuit

3c Simulate and evaluate the operation of a minimum of two of these circuits:

- common emitter amplifier circuit
- common collector amplifier circuit
- common source amplifier circuit
- common drain amplifier circuit
- transistor switching circuit

3d Build, test and evaluate the operation of a minimum of two of these circuits:

- common emitter amplifier circuit
- common collector amplifier circuit
- common source amplifier circuit
- common drain amplifier circuit
- transistor switching circuit

3e Document 3c and 3d, ensuring that documentation includes evidence of self-management, social intelligence, innovation and the use of technical data sheets.

Outcome 4

Operational amplifiers

4a Describe ideal and practical operational amplifier characteristics including:

- open-loop gain
- input impedance
- output impedance
- slew rate
- common mode rejection ration (CMRR)
- operating bandwidth

4b Analyse the operation of the following circuits using ideal operational amplifier assumptions:

- inverting amplifier
- non-inverting amplifier
- voltage follower
- summing amplifier
- difference amplifier

4c Simulate and evaluate the operation of a minimum of two of these circuits:

- inverting amplifier
- non-inverting amplifier
- voltage follower
- summing amplifier
- difference amplifier

4d Build, test and evaluate the operation of a minimum of two of these circuits:

- inverting amplifier
- non-inverting amplifier
- voltage follower
- summing amplifier
- difference amplifier

4e Document 4c and 4d ensuring that documentation includes evidence of self-management, social intelligence, innovation and the use of technical data sheets.

Outcome 5

Filters

5a Identify the following filter parameters:

- critical frequency
- filter order
- roll-off rate
- bandwidth
- quality factor

5b Analyse the operation of the following filters:

- a low or high pass passive filter
- a band pass or band stop passive filter
- an RLC notch filter

5c Simulate and evaluate the following circuit:

- a two-pole passive filter

5d Build, test and evaluate the operation of two of these filters:

- a band pass filter
- an RLC notch filter
- a two-pole passive filter

5e Document 5c and 5d, ensuring that documentation includes evidence of self-management, social intelligence, innovation and the use of technical data sheets.

Knowledge and skills

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

Knowledge	Skills
Outcome 1 Learners should understand: ♦ the operation and characteristics of: — PN junction diodes, Schottky diodes, Zener diodes, light-emitting diodes and photodiodes — circuits containing diodes for rectification, voltage reference sources, clipping, clamping, light emission and photo detection	**Outcome 1** Learners can: ♦ apply Kirchhoff's current and voltage laws to analyse DC and AC circuits ♦ apply Thevenin's and Norton's theorems to analyse DC and AC circuits ♦ apply superposition theorem to DC ♦ apply mesh analysis to DC ♦ analyse circuits containing diodes for rectification, voltage reference sources, clipping, clamping, light emission and photo detection ♦ simulate, using software, then build, test and evaluate a range of diode circuits for rectification, voltage reference sources, clipping, clamping, light emission or photo detection
Outcome 2 Learners should understand: ♦ the operation and characteristics of: — NPN and PNP bipolar transistors — N-channel and P-channel JFETs — enhancement and depletion mode MOSFETs — circuits containing bipolar transistors for common emitter amplifiers, common collector amplifiers, common source amplifiers and transistor switching — circuits containing field effect transistors for common drain amplifiers and transistor switching	**Outcome 2** Learners can: ♦ analyse circuits containing NPN and PNP bipolar transistors for common emitter amplifiers, common collector amplifiers, common source amplifiers and transistor switching ♦ analyse circuits containing JFETs and MOSFETs for common drain amplifiers and transistor switching ♦ simulate, using software, then build, test and evaluate a range of bipolar transistor circuits for common emitter amplifiers, common collector amplifiers, common source amplifiers or transistor switching ♦ simulate, using software, then build, test and evaluate a range of field effect transistor circuits for common drain amplifiers or transistor switching

Knowledge	Skills
Outcome 3 Learners should understand: ♦ the operation and characteristics of operational amplifiers	**Outcome 3** Learners can: ♦ analyse circuits containing operational amplifiers ♦ simulate circuits containing operational amplifiers ♦ build, test and evaluate circuits containing operational amplifiers
Outcome 4 Learners should understand: ♦ the operation and characteristics of passive filters	**Outcome 4** Learners can: ♦ analyse circuits containing passive filters ♦ simulate circuits containing passive filters ♦ build, test and evaluate circuits containing passive filters
Outcome 5 Learners should understand: ♦ the operation and characteristics of passive filters	**Outcome 5** Learners can: ♦ analyse circuits containing passive filters ♦ simulate circuits containing passive filters ♦ build, test and evaluate circuits containing passive filters

Meta-skills

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

Self-management

Learners develop the meta-skills of focusing, adapting and initiative as they study the course material.

Social intelligence

Learners develop the meta-skills of communicating, collaborating and leading as they build and test circuits together.

Innovation

Learners develop the meta-skills of curiosity, creativity, sense-making and critical thinking as they analyse, test and evaluate circuits.

Literacies

Learners develop core skills in the following literacies:

Numeracy

Learners develop their numeracy by using Kirchhoff’s current and voltage laws, Thevenin’s and Norton’s theorems, and mesh circuit analysis, to calculate currents and voltages.

Communication

Learners develop their communication skills by analysing circuits, and presenting and evaluating test results.

Digital

Learners develop digital literacy by using a broad range of engineering software and testing equipment.

Delivery of unit

This unit is part of HNC Engineering. The framework includes mandatory and optional units, and you can tailor the selected combination of units to specific engineering pathway needs. You can deliver this unit alongside, and use it to support, the SCQF level 7 unit, Electronics in Practice: Skills and Techniques.

While the exact time allocated to this unit is at your centre's discretion, the notional design length is 120 hours.

The amount of time you allocate to each outcome is also at your discretion. We suggest the following distribution of time, including assessment:

Outcome 1 — Apply knowledge and skills of circuit theorems to DC and AC circuits (20 hours).
Outcome 2 — Apply knowledge and skills of semiconductor diodes' operation and characteristics to diode circuit applications (25 hours).
Outcome 3 — Apply knowledge and skills of bipolar and field effect transistors' operation and characteristics to transistor circuit applications (25 hours).
Outcome 4 — Apply knowledge of operational amplifiers' operation and characteristics to operational amplifier circuit applications (25 hours).
Outcome 5 — Apply knowledge of filters' operation and characteristics to passive filter applications (25 hours).

Additional guidance

The guidance in this section is not mandatory.

Content and context for this unit

This unit provides learners with knowledge of analogue electronic circuit theorems, electronic components and devices; and skills in circuit design, simulation, build and testing. It supports learners who want to pursue a career in electronics engineering.

Apply knowledge and skills of circuit theorems to DC and AC circuits (outcome 1)

Learners develop fundamental knowledge of circuit analysis theorems. This knowledge prepares them to analyse AC and DC circuits and calculate relevant circuit parameters.

Apply knowledge and skills of semiconductor diodes' operation and characteristics to diode circuit applications (outcome 2)

Learners develop knowledge and skills in the design, operation and application of diodes in electronic circuits. They gain digital literacy skills by using engineering software or websites to simulate circuit operation and function. Learners also develop circuit simulation skills for passive circuits using different types of diodes for voltage rectification; clipping and clamping circuits; and light generation and detection using diode devices. They apply and develop their knowledge by constructing and investigating circuits that utilise diodes.

Apply knowledge and skills of bipolar and field effect transistors' operation and characteristics to transistor circuit applications (outcome 3)

Learners develop knowledge and skills in the physical operation and application of transistors in electronic circuits. They cover the operating principle and characteristics of bipolar junction transistors, JFETs and MOSFETs. Learners also develop digital literacy skills using engineering software to simulate circuit operation and function. They develop circuit simulation skills for active circuits using different types of transistors, NPN and PNP bipolar junction transistors, P-channel and N-channel JFET and MOSFETs for AC and DC amplifiers, and switching circuits. Learners apply and develop their knowledge by constructing and investigating circuits that utilise transistors.

Apply knowledge of operational amplifiers' operation and characteristics to operational amplifier circuit applications (outcome 4)

Learners develop knowledge and skills regarding the operation, characteristics and application of operational amplifiers. They also learn about the appropriate use of ideal operational amplifier assumptions to simplify circuit analysis. Learners develop digital literacy skills using engineering software to simulate circuit operation and function. They apply and develop their knowledge by constructing and investigating circuits that utilise transistors.

Apply knowledge of filters' operation and characteristics to passive filter applications (outcome 5)

In outcome 5, learners develop knowledge and skills in the design of passive filter circuits. Learners develop knowledge of how resistors and capacitors can be combined to filter the frequency content of signals. Properties such as filter order, roll-off rate, bandwidth and quality factor are defined. Learners develop digital literacy skills using engineering software to simulate passive circuit operation and function. Learners apply and develop their knowledge by constructing and investigating filter circuits.

Required resources

The resources each learner requires are:

- electronic simulation software
- circuit breadboards
- general hand tools for electronic circuit construction
- electronic components
- electronic test instrumentation such as: digital multimeter, signal generator, oscilloscope, frequency meter

Approaches to delivery

You should deliver outcome 1 first and outcome 5 last. You can deliver outcomes 2, 3 and 4 in any order, but we recommend that you deliver outcome 2 before outcome 3 to allow a better understanding of diode behaviour before introducing transistors. You can combine aspects of the practical work to investigate circuits with diodes, transistors, operational amplifiers and filters.

You should deliver the unit in a physical learning space or virtual learning environment (VLE). Using the holistic teaching format of active learning encourages learners to consider the deeper context of the theory.

This unit is best suited for on-campus delivery and would benefit from technician support to set up equipment, and resolve equipment and hardware failure. However, you can deliver it remotely if learners are well supported with software, hardware, health and safety requirements, and online synchronous lecturer time. You should take care to ensure equitable experience. Cloud computing applications can benefit simulation, as they allow lecturers, learners and peers to share designs with each other.

Approaches to assessment

In line with the approach to delivery, you should take a holistic approach to assessment. You should use formative assessment of practical and written work in all outcomes to develop a learning cycle of assessment and feedback.

You can assess outcomes individually; however, if you take a project-based delivery approach, assessments are likely to be more authentic and closer to real-life applications. Learners should record diagrammatic and written documentation in their individual portfolio.

This should also include reflective accounts evaluating their meta-skills development. You should use summative assessment of practical and written work to assess knowledge and skills across all outcomes. This could be individual assessments or integrated together; for example as a final technical report.

Checklists or rubrics may be useful to ensure learners have achieved all knowledge and skills required by the learning outcomes, as well as meta-skills and literacies.

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 projects and coursework, making use of oral questioning, and using originality-checking software.

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.

There are a number of opportunities for e-assessment; for example,
in outcome 1, where learners can apply circuit theory to different examples. You could assess this through online quizzes in your VLE. In outcomes 2, 3, 4 and 5, you could use online quizzes to assess fundamental knowledge, circuit recognition and circuit design calculations.

Learners can use electronic portfolios to document circuit diagrams and circuit operation from electronic simulation software.

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

Analogue Electronics: Theory and Applications (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 is part of HNC Engineering. The unit focuses on analogue electronics and provides a wide range of knowledge and skills relevant to electronics engineering.

It helps develop your fundamental knowledge of electronic circuits and relevant circuit theory to allow you to design and analyse circuits.

Unit outcomes

On completing the unit, you are able to:

1 apply knowledge and skills of circuit theorems to direct current (DC) and alternating current (AC) circuits
2 apply knowledge and skills of semiconductor diodes' operation and characteristics to diode circuit applications
3 apply knowledge and skills of bipolar and field effect transistors' operation and characteristics to transistor circuit applications
4 apply knowledge and skills of operational amplifiers' operation and characteristics to operational amplifier circuit applications
5 apply knowledge of filters' operation and characteristics to passive filter applications

In outcome 1, you learn Kirchhoff's voltage and current laws, Thevenin and Norton's theorems, and mesh analysis, and apply them to DC and AC circuits.

In outcome 2, you learn about a range of diode components, their characteristics, and how to design, simulate and build circuits using diodes.

In outcome 3, you learn about active devices including transistors and operational amplifiers. Transistors can be used to design a range of circuits, and you learn about transistor amplifier configurations, their characteristics, and how to simulate and build circuits using transistors.

Operational amplifiers are an important active device used to achieve a variety of circuit functions such as voltage amplification, addition, subtraction and buffering. In outcome 4, you learn about the ideal and practical characteristics of these devices, how to simulate circuits, and how to build and test circuits using operational amplifiers.

Finally, in outcome 5, you learn about different circuits to filter AC signals. You learn about filter characteristics, how to simulate and evaluate filter performance, and how to build and test filter circuits to achieve different functions such as a low pass filter, high pass filter, band pass filter or band stop filter.

You are assessed holistically, meaning your knowledge and skills of the unit content are assessed in one or more engineering scenarios. A variety of assessment approaches are used to assess both practical work and written work, and this includes completing project work. You should record all evidence for the unit in your individual portfolio.

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 meta-skills of focusing, adapting and initiative as you test and modify circuits and software.

Social intelligence

You develop communicating and collaboration meta-skills as you work with others to design and build circuits, and report your completed work through technical project reports.

Innovation

You develop the meta-skills of curiosity, sense-making and critical thinking as you troubleshoot and investigate the function of your circuits.

Administrative information

Published: April 2023 (version 1.0)

Superclass: XL

History of changes

Version	Description of change	Date

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