Next Generation Higher National Unit Specification

Electronics in Practice: Skills and Techniques (SCQF level 7)

Unit code: J750 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 develops learners' knowledge of electronic circuits and their practical skills in circuit construction, simulation, electronic testing and fault finding.

The unit provides learners with knowledge of common electronic components and their corresponding symbolic representation for use in analogue and digital circuits. Learners develop skills in drawing circuit schematic diagrams and using software to simulate and test the operation of alternating current (AC) and direct current (DC) circuits. They gain practical skills in circuit construction including prototyping, soldering and printed circuit board (PCB) design and manufacture. Practical electronic testing of AC and DC analogue and digital circuits provide learners with opportunities to gain practice in basic fault-finding techniques.

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; for example, Higher Engineering Science at SCQF level 6, or NQ units such as Electronic Test Equipment and Measurement, or Electrical Testing and Measurement at SCQF level 6
- relevant, equivalent workplace experience

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

Unit outcomes

Learners who complete this unit can:

1 identify electronic components and use their corresponding circuit symbols to draw schematic circuit diagrams for AC and DC circuits
2 simulate the test and operation of passive and active linear circuits and combinational logic digital circuits
3 safely construct AC and DC circuits using a range of different substrates, such as protoboards, stripboards and PCBs
4 perform measurements, circuit testing and fault finding safely and accurately on analogue and digital circuits

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.

To successfully achieve the unit, learners must provide evidence that they can do the following:

Outcome 1

Circuit components

1a Accurately identify International Electrotechnical Commission (IEC) and American National Standards Institute (ANSI) electronic components from given schematic circuit diagrams. You should present learners with two or more circuit diagrams containing a minimum of 20 components, including but not limited to: resistors, capacitors, inductors, diodes, transistors, integrated circuits, transformers, transducers, connectors, voltmeters, ammeters, ohm meters, direct and alternating power supplies, signal generators, and oscilloscopes.

1b Accurately interpret a physical electronic circuit containing at least 10 components from the list in 1a and correctly draw the corresponding circuit schematic diagram using IEC and ANSI circuit component symbols.

Outcome 2

Circuit simulation

2a Simulate, using appropriate software, three types of circuit: passive circuits, active linear circuits and combinational logic circuits containing gates and input and output devices. The schematic circuit diagrams that learners simulate should contain a minimum of eight components or logic functions that must be simulated.

2b Demonstrate the use of circuit simulation software to check the circuit function of circuits simulated in 2a and measure a selection of circuit parameters for AC, analogue DC and digital DC circuits. You should provide learners with a list of required measurements.

2c Document in an electronic portfolio with diagrammatic and descriptive evidence the simulated circuits with their test results and parameter measurements.

Outcome 3

Circuit construction

For the following evidence requirements, learners must manufacture a minimum of one AC, one analogue DC and one combinational logic circuit.

3a Demonstrate practical skills in circuit prototyping. Given a schematic circuit diagram, learners:

- design component layouts suitable for protoboards
- manufacture a functional circuit on a protoboard and evidence through documentation the appropriate selection of components by type and parameter for the given circuit
- construct circuits containing passive and active linear components
- test a circuit's operation

3b Demonstrate practical skills in circuit construction. Given a schematic circuit diagram, learners:

- design component layouts suitable for stripboards
- manufacture a functional circuit on a stripboard and evidence through documentation the appropriate selection of components by type and parameter for the given circuit
- safely manufacture a circuit with a minimum of eight components using wire stripping and preparation (solid and stranded wire), component preparation, soldering, and crimping

3c For a given circuit, use appropriate engineering software to design the layout artwork master suitable for the manufacture of a bare PCB. Learners provide evidence of design choices, such as number of layers, component location, track widths, clearances and copper fills, and consideration of manufacturing and environmental issues.

3d Produce a PCB and perform visual inspection and electrical testing for assembly faults. Learners populate the PCB with correctly located and oriented components to produce a functioning PCB circuit. Learners provide evidence of their knowledge of the PCB fabrication and assembly processes and safety requirements and perform in-circuit component testing to validate the operation and function of the given circuit.

3e Evidence items 3a to 3d by producing a technical report to include both technical achievement evidence and meta-skills evidence. Technical evidence should include descriptive evidence and diagrammatic evidence (where appropriate) of understanding:

- different circuit construction approaches
- safety and environmental considerations
- PCB manufacturing processes
- the difference between surface mount and through-hole technology
- basic circuit testing and inspection techniques

Learners should document evidence of the meta-skills of self-management, social intelligence and innovation.

Outcome 4

Circuit testing

For the following evidence requirements, learners must perform tests on a minimum of one AC, one analogue DC and one combinational logic circuit.

4a Generate evidence of their ability to use test instruments safely and accurately in a series of practical laboratories. Learners should provide evidence of the correct use of the following instruments: digital multimeters, oscilloscopes, function generators and frequency meters.

4b Provide written evidence of knowledge of instrument specifications and operations.

4c Provide written evidence of knowledge of circuit loading effects of test instruments on circuits, and the impact of different output impedance configurations of function generators on circuit operation.

4d Generate evidence of their ability to test digital circuits safely and accurately using logic probes, pulse generators and multimeters in a series of practical laboratories.

4e Correctly identify the open circuit and short circuit faults in different test circuits. Learners must provide written evidence of measurements taken for each faulty circuit and should include evidence of logical and critical thinking. Assessment should be carried out under supervised conditions. Learners should use a variety of circuits of a similar nature to those used previously, and faults should not be visible.

Knowledge and skills

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

Knowledge	Skills
Learners should understand how to: ♦ identify common electronic components and their corresponding circuit symbols as defined by appropriate electrical standards ♦ simulate analogue and digital circuits in software and use virtual test instrumentation to verify their operation and extract circuit parameters ♦ design circuit layouts for construction on protoboard, stripboard and PCBs ♦ describe and discuss construction techniques for PCBs ♦ explain the circuit loading effects of digital multimeters and other test instruments, such as logic probes, oscilloscopes and function generators ♦ analyse circuit operation and apply systematic troubleshooting processes to identify common circuit faults	Learners can: ♦ use software to build and simulate electronic circuits ♦ use software to investigate and test operation of electronic circuits ♦ lay out circuits for construction on protoboards, stripboards and use an electronic design software package for PCB layouts ♦ construct analogue and digital circuits on suitable circuit substrates, including the manufacture and component population of PCBs ♦ perform tests on electronic circuits safely and accurately, using digital multimeters, oscilloscopes, function generators and frequency meters ♦ develop analytical problem-solving skills to troubleshoot circuit operation ♦ perform tests on digital circuits using a logic probe, pulse generator and multimeter ♦ identify short circuit and open circuit faults in simple electronic circuits

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. Designing, constructing, troubleshooting and testing electronic circuits provides an environment where learners must focus, filter information and develop a growth mindset to adapt and take the initiative to solve problems.

Social intelligence

Learners develop the meta-skills of communicating orally and collaborating as they work in groups to design and construct circuits. They develop written communication skills as they prepare documentation and report their findings.

Innovation

Learners develop the meta-skills of creativity, curiosity, sense-making and critical thinking. They create circuit layouts for different types of circuit substrates, experimenting and making observations of circuit function as they do so. They develop the meta-skill of curiosity through questioning expected and unexpected circuit behaviour. Learners also develop the meta-skill of sense-making through analysis of and troubleshooting circuits. Fault finding in circuits enables learners to develop their critical thinking skills by deconstructing the problem and applying logical thinking to determine faults.

Literacies

Learners develop core skills in the following literacies:

Numeracy

Learners develop their numeracy through circuit design calculations, and observing and recording physical parameters.

Communication

Learners develop their communication skills by working with peers and workshop technicians, where appropriate, to design and construct circuits. Additionally, they use oral and written communication to formally report their circuit designs, test results and performance.

Digital

Learners develop digital literacy by using industry-relevant software packages to simulate circuits, and design and lay out PCBs. Learners develop digital literacy in general applications by producing technical formal reports and generating circuit schematic figures, tables of results, report layouts and presentations.

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. The unit provides opportunities to integrate the simulation, construction and testing of analogue and digital circuits to help meet learning outcomes in the SCQF level 7 units, Digital Electronics: Theory and Applications, and Analogue Electronics: Theory and Applications.

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 — Identify electronic components and use their corresponding circuit symbols to draw schematic circuit diagrams for AC and DC circuits (10 hours).
Outcome 2 — Simulate the test and operation of passive and active linear circuits and combinational logic digital circuits (25 hours).
Outcome 3 — Safely construct AC and DC circuits using a range of different substrates such as protoboards, stripboards and PCBs (60 hours).
Outcome 4 — Perform measurements, circuit testing and fault finding safely and accurately on analogue and digital circuits (25 hours).

Additional guidance

The guidance in this section is not mandatory.

Content and context for this unit

This unit helps develop learners' practical electronics engineering skills. You should deliver this unit predominantly using practical exercises that allow learners to learn and develop safe working practices. Practical work allows learners to develop a range of skills appropriate to electronic engineering, including:

- circuit simulation and testing
- circuit prototyping and construction techniques
- efficient testing skills using standard electronic instruments

Learners should gain experience in testing circuits in both simulated and actual circuit environments to experience the advantages and limitations of each method. You can integrate the unit with units in which learners build and investigate circuits to help reinforce theoretical understanding.

Identify electronic components and use their corresponding circuit symbols to draw schematic circuit diagrams for AC and DC circuits (outcome 1)

Learners develop fundamental knowledge and awareness of international conventions by identifying circuit components and their corresponding circuit symbols using IEC and ANSI standards. They develop skills in component recognition, circuit reading and translation to schematic circuit diagrams.

Simulate the test and operation of passive and active linear circuits and combinational logic digital circuits (outcome 2)

Learners develop digital literacy skills using engineering software or websites to simulate circuit operation and function. Learners develop circuit simulation skills for passive circuits, active linear circuits and combinational logic circuits containing gates and input and output devices. Simulation and testing of AC, analogue DC and digital circuits develops learners' knowledge of different test instruments, their operation and limitations. Learners develop meta-skills in self-management, social intelligence and innovation through focusing on tasks, working collaboratively to troubleshoot simulation errors. They develop curiosity through questioning observed measurements.

Safely construct AC and DC circuits using a range of different substrates such as protoboards, stripboards and PCBs (outcome 3)

Learners develop a wide range of practical skills to develop circuits from conception, through prototyping and testing, to producing a final functioning circuit on a PCB. Learners develop awareness of safety hazards and risk mitigation, and develop safe working practices. Learners develop an appreciation of different circuit construction approaches and different component forms using surface mount and through-hole technology components. A significant component of this outcome focuses on the design and manufacture of PCBs that are used extensively in electronics engineering. In designing, simulating and manufacturing

functional circuits, learners develop meta-skills in innovation, logical thinking, focus and self-management.

Perform measurements, circuit testing and fault finding safely and accurately on analogue and digital circuits (outcome 4)

Learners develop knowledge and understanding of the specifications and operation of test instrumentation including digital multimeters, oscilloscopes and logic probes. Learners develop skills to configure the test instrumentation appropriately based on its function to perform safe and accurate measurements. In particular, they learn about effective resistance of digital voltmeters, voltage drop of digital ammeters, lead and terminal resistances, which all contribute to circuit loading effects under test. To work safely, learners perform continuity testing on circuits with no power and learn to electrically isolate components for resistance testing. Learners develop skills testing AC, analogue DC and digital circuits.

Required resources

The resources each learner requires are:

- electronic simulation software
- PCB design software
- circuit protoboards, stripboards
- general hand tools for electronic circuit construction
- soldering tools for through-hole and surface mount components
- desoldering tools
- PCB fabrication facilities
- circuit drilling facilities
- general electronic components
- electronic test instrumentation such as digital multimeter, signal generator, oscilloscope, frequency meter and logic probe

Approaches to delivery

You should deliver outcomes 1 and 2 in order; however, you can deliver outcomes 3 and 4 in parallel with circuit testing applied to the different circuits under construction.

The unit is suitable for teaching holistically through project-based work where learners develop practical skills, academic knowledge and meta-skills. The chosen circuits for simulation and construction can be individual, or you could incorporate collaboration by having learners work on a project where the overall circuit function is broken down into sub-parts and each part is constructed by an individual or small group. The overall successful integration of the sub-parts requires learners to work together and communicate.

The unit is best suited for on-campus delivery and would benefit from technician support to set up equipment, and resolve equipment and hardware failure. 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. Formative assessment of an interim technical report would allow learners to develop their knowledge and understanding, as well as their technical communication skills.

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.

Evidence of circuit fault-finding skills should be in the form of a practical summative assessment conducted under supervised conditions.

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, you could assess component and circuit symbol identification through online quizzes in a virtual learning environment (VLE). In outcomes 2, 3 and 4, you could use online quizzes to record and assess test data measured by learners for simulated or practical circuits. You could use e-assessment to assess learners' skills in measuring; for example, period, frequency or phase shift from oscilloscope traces.

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

Electronics in Practice: Skills and Techniques (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 developing your practical skills to design, simulate, build and test electronic circuits.

It helps you develop practical skills in electronic circuit construction.

Unit outcomes

On completing the unit, you are able to:

1 identify electronic components and use their corresponding circuit symbols to draw schematic circuit diagrams for AC and DC circuits
2 simulate the test and operation of passive and active linear circuits and combinational logic digital circuits
3 safely construct AC and DC circuits using a range of different substrates such as protoboards, stripboards and PCBs
4 perform measurements, circuit testing and fault finding safely and accurately on analogue and digital circuits

You are also able to use a range of test instruments, including digital multimeters, oscilloscopes, frequency meters and logic probes.

In outcome 1, you learn how to draw electronic circuits showing how electronic components are connected using a schematic circuit diagram.

In outcome 2, you learn how to use electronic simulation software to draw circuits and simulate how the circuit will behave. This is an important step in designing circuits.

After designing and simulating circuits in software, in outcome 3 you learn about the different stages of prototyping a physical circuit on a protoboard or circuit breadboard. These allow you to quickly and easily test your physical circuit. You then develop your skills in circuit construction using soldering and stripboards. Finally, you learn about the different stages of producing a PCB and you design, lay out and build a function circuit on your own PCB.

In outcome 4, you learn about different electronic test instruments and how to use them safely to make accurate measurements about your circuit.

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 collaborating 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.