Higher National Unit specification

General information

Unit title: Electronics (SCQF level 8)

Unit code: H93M 35

Superclass: RC

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Unit purpose

This Unit is designed to enable learners to understand key aspects of electronics. The Unit is suitable for learners studying at HND level, and will provide the necessary underpinning knowledge and skills to enable progression to further study of electronics at degree level or to seek employment in science based industries.

Outcomes

On successful completion of the Unit the learner will be able to:

1 Perform calculations related to the analysis of direct and alternating current circuits.
2 Explain and apply the principles of active components and related circuits.
3 Apply Boolean algebra and logic to aspects of combinational digital logic.
4 Perform a practical experiment related to microcontrollers.

Credit points and level

1 Higher National Unit credit at SCQF level 8: (8 SCQF credit points at SCQF level 8)

Recommended entry to the Unit

Entry is at the discretion of the centre, however it is recommended that learners should have completed the HN Unit H93L 34 *Electricity and Magnetism* or equivalent, or have experience of Physics and Mathematics at Higher level.

Higher National Unit specification: General information (cont)

Unit title: Electronics (SCQF level 8)

Core Skills

. Achievement of this Unit gives automatic certification of the following Core Skills component:

Complete Core Skill	None
Core Skill component	Critical Thinking at SCQF level 6 Using Number at SCQF level 6

There are also opportunities to develop aspects of Core Skills which are highlighted in the Support Notes of this Unit specification.

Context for delivery

If this Unit is delivered as part of a Group Award, it is recommended that it should be taught and assessed within the subject area of the Group Award to which it contributes.

The Assessment Support Pack (ASP) for this Unit provides assessment and marking guidelines that exemplify the national standard for achievement. It is a valid, reliable and practicable assessment. Centres wishing to develop their own assessments should refer to the ASP to ensure a comparable standard. A list of existing ASPs is available to download from SQA's website **www.sqa.org.uk/sqa/46233.2769.html**.

Equality and inclusion

This Unit specification has been designed to ensure that there are no unnecessary barriers to learning or assessment. The individual needs of learners should be taken into account when planning learning experiences, selecting assessment methods or considering alternative evidence.

Further advice can be found on our website **www.sqa.org.uk/assessmentarrangements**.

Higher National Unit specification: Statement of standards

Unit title: Electronics (SCQF level 8)

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.

Where evidence for Outcomes is assessed on a sample basis, the whole of the content listed in the Knowledge and/or Skills section must be taught and available for assessment. Learners should not know in advance the items on which they will be assessed and different items should be sampled on each assessment occasion.

Outcome 1

Perform calculations related to the analysis of direct and alternating current circuits.

Knowledge and/or Skills

- Branch and mesh analysis
- Power transfer and dissipation in alternating current circuits
- Transient response of an inductor-capacitor (LC) circuit
- Transient responses of resistor-inductor-capacitor (RLC) circuits
- Resonance, bandwidth and Q-factor

Outcome 2

Explain and apply the principles of active components and related circuits.

Knowledge and/or Skills

- Diodes: junction, Schottky, Zener, tunnel
- Bipolar Junction Transistor (BJT)
- Field Effect Transistor (FET)
- Operational amplifiers
- Mechanics of solid state transducers

Outcome 3

Apply Boolean algebra and logic to aspects of combinational digital logic.

Knowledge and/or Skills

- Logic operations
- Binary number system
- Boolean algebra
- De Morgan's Theorems
- Karnaugh Maps
- Logic circuit design

Higher National Unit specification: Statement of standards (cont)

Unit title: Electronics (SCQF level 8)

Outcome 4

Perform a practical experiment related to microcontrollers.

Knowledge and/or Skills

- Microcontrollers experiment(s)
- Working safely, within current health and safety regulations
- Consistent and accurate results
- Recording observations and results
- Evaluation skills
- Result analysis and conclusions

Higher National Unit specification: Statement of standards (cont)

Unit title: Electronics (SCQF level 8)

Evidence Requirements for this Unit

Written and/or oral recorded evidence for Outcomes 1−4 should be assessed using a holistic closed-book assessment under supervised conditions. The assessment will use a sampling approach to the Knowledge and/or Skills as detailed below. It is recommended that the assessment be completed within 90 minutes. Learners can only have access to the *SQA Databook for HN Physics* or any suitable replacement when sitting the assessment.

Outcome 1

The assessment will sample 3 of the 5 Knowledge and/or Skills items. Learners will not have prior knowledge of which items are being assessed. Those items which are not sampled must be covered in the alternative (re-sit) assessment.

Where an item is sampled, a learner's response will be judged satisfactory where the evidence shows that the learner can:

- Apply branch or mesh analysis to determine the potentials across a DC resistor network.
- Apply an intermediate application of the maximum power transfer theorem to calculate the power dissipation within an AC circuit.
- Apply Kirchhoff's Loop Rule to derive the differential equation for time-dependent current in an LC circuit and state a solution, explaining any arbitrary constants used.
- Determine the mode of dampening, under/over/critical, for a given RLC circuit.
- Perform calculations to determine the resonant frequency, bandwidth and Q-factor of a parallel or series RLC circuit.

Outcome 2

The assessment will sample 3 of the 5 Knowledge and/or Skills items. Learners will not have prior knowledge of which items are being assessed. Those items which are not sampled must be covered in the alternative (re-sit) assessment.

Where an item is sampled, a learner's response will be judged satisfactory where the evidence shows that the learner can:

- Identify a diode type, either Schottky, Zener or tunnel, within a circuit and explain the principles and applications of its primary characteristics.
- Define the alpha (α) and beta (β) parameters of a BJT, deriving α in terms of β and apply towards the calculation of the collector voltage and current for a given BJT circuit.
- Apply the equations describing current flow through a given JFET or MOSFET for a given circuit.
- Describe mathematically the function of either an integrating, differentiating or instrumentation amplifier and calculate its output voltage.
- Explain the principles behind the piezoelectric, thermoelectric or Hall Effect, giving an example of how the effect is applied in electronics.

Higher National Unit specification: Statement of standards (cont)

Unit title: Electronics (SCQF level 8)

Outcome 3

The assessment will sample 4 of the 6 Knowledge and/or Skills items. Learners will not have prior knowledge of which items are being assessed. Those items which are not sampled must be covered in the alternative (re-sit) assessment.

Where an item is sampled, a learner's response will be judged satisfactory where the evidence shows that the learner can:

- ♦ Apply the definitions of logic operations to fill-in the truth tables for two logic gates.
- ♦ Convert integers between binary, hexadecimal and decimal number systems.
- ♦ Derive the function of a combinational logic circuit as a Boolean equation.
- ♦ Apply De Morgan's Theorems to reduce Boolean equations.
- ♦ Apply the technique of Karnaugh Maps to derive Boolean expressions from a set of requirements.
- ♦ Apply a set of Boolean equations to their logic gate counterparts for the design of a logic circuit.

Outcome 4

Learners will perform a minimum of one practical experiment, the content of which will be related to microcontrollers and their applications in physical measurement. A learner's response will be judged satisfactory where the evidence shows that the learner can achieve all of the following:

- ♦ Design, construct and program a microcontroller based system to read, display and operate on sensory input.
- ♦ Work in a safe manner regarding current health and safety regulations.
- ♦ Achieve consistent and accurate results.
- ♦ Record experimental observations clearly and accurately.
- ♦ Evaluate validity of results in terms of sources of and values of experimental error.
- ♦ Analyse results correctly and state valid conclusions.

An assessor observation checklist will be used to record the learner's performance of the practical work in line with given instructions and health and safety requirements.

Learners could complete a laboratory diary throughout the practical experiment. Learners may report results either by production of a full laboratory report, or by completion of an appropriate pro forma. Where a pro forma approach is deployed, the pro forma will not present information or assistance to the learners on how to correctly perform calculations, analyse experimental results or experimental errors. Learners will be expected to perform such activities independently on the basis of the experimental data.

Where a learner does not perform an assessed practical experiment to the required standard, they will be given the chance to either reattempt the same practical experiment, or to undertake a different practical experiment of similar complexity. Where a report or pro forma does not meet the required standard, then the learner will be given a single opportunity to re-draft. If the required standard is still not attained, then an alternative practical experiment will be set.

Evidence could be generated via one assessed practical experiment or via multiple assessed practical experiments.

Higher National Unit Support Notes

Unit title: Electronics (SCQF level 8)

Unit Support Notes are offered as guidance and 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 Unit is intended as part of the framework for HND Applied Sciences, but may be suitable for inclusion in other HN Science awards. It is designed to develop the theoretical aspects of electronics introduced in the HN Unit H93L 34 *Electricity and Magnetism* while introducing new and transferrable theories of linear dynamics, solid state physics and programmable systems.

Outcome 1 — Perform calculations related to the analysis of direct and alternating current circuits

Define Kirchhoff's Junction (current) and Loop (voltage) Rules. Define sign conventions for EMFs and resistors. Apply DC branch current analysis by identifying a node within a circuit and applying Kirchhoff's and Ohm's Laws to derive simultaneous equations for its unknown currents. The solutions, when used with Ohm's Law, allow the calculation of potential across any component. In a similar fashion, apply DC mesh current analysis by identifying loops within a circuit and applying Kirchhoff's Loop Rule to arrive at a similar system of equations for unknown current, the treatment of which follows from branch analysis.

Express voltage and current as complex numbers with magnitude and phase. Introduce phase diagrams for the purpose of electronics. Generalise Ohm's Law in terms of impedance with real and imaginary parts of resistance and reactance respectively. Derive expressions for the impedance of resistors, capacitors and inductors. Prove the maximum power transfer theorem for DC circuits and state for the case of reactive AC circuits.

From Kirchhoff's Loop Rule, the zero sum of the potentials across the capacitor and inductor, in terms of charge, forms the homogenous second order differential equation:

$$V_L = L\frac{di(t)}{dt}, V_C = \frac{Q(t)}{C} : i(t) = \frac{dQ(t)}{dt} \Rightarrow \frac{d^2i(t)}{dt^2} + \frac{1}{LC}i(t) = 0$$

Where $\frac{1}{LC}$ simplifies to ω_0^2, thus:

$$\frac{d^2i(t)}{dt^2} = -\omega_0^2 i(t)$$

Which has the general solution of:

$$i(t) = aSin(\omega_0 t) + bCos(\omega_0 t)$$

Evaluate general solution at initial conditions to arrive at function for time dependent current:

$$i(t) = I_0 Sin(\omega t + \phi)$$

Derive the second order homogenous differential equation for charge in an RLC circuit from Kirchhoff's Loop Rule, where:

$$\frac{d^2 i(t)}{dt^2} + \Gamma \frac{di(t)}{dt} + \omega_0^2 Q(t) = 0, \frac{R}{L} = \Gamma, \frac{1}{\sqrt{LC}} = \omega_0$$

The dampening coefficient (Γ) and resonant frequency (ω_0) are substituted.

Assuming exponential form of solution, substitute charge with complex variable *Z*(t) such that:

$$Z(t) = Ae^{\alpha t} \Rightarrow \frac{dZ(t)}{dt} = \alpha t \Rightarrow \frac{d^2 Z(t)}{dt^2} = \alpha^2 t$$

Substitute into initial differential equation and factorize to yield the auxiliary equation:

$$\alpha^2 + \Gamma \alpha + \omega_0^2 = 0$$

Solve as a quadratic expression, considering cases of a negative, positive and zero discriminant.

$$\alpha = \frac{-\Gamma \pm \sqrt{\Gamma^2 - 4\omega^2}}{2}, \Delta = \Gamma^2 - 4\omega^2$$

Provided that:

$$\Delta > 0 \Rightarrow Q(t) = ae^{pt} + be^{qt} : p, q \in \mathbb{R}\ are\ roots\ of\ \alpha$$

$$\Delta < 0 \Rightarrow Q(t) = e^{-\frac{\Gamma t}{2}} [aCos(\omega t) + bSin(\omega t)]$$

$$\Delta = 0 \Rightarrow Q(t) = e^{-\frac{\Gamma t}{2}} (a + bt)$$

Each give distinct general cases for over, under and critically dampened electrical oscillations, evaluating at initial conditions to define constants.

Define resonance as the measure of response of a system to a given frequency with the greatest response being at the natural — or resonant — frequency (ω_0). In an electrical circuit, this corresponds to maximum power transfer. Given the maximum amplitude at ω_0, define the half power frequencies ω_1, ω_2 as those which occur either side of ω_0 at half the maximum amplitude, such that bandwidth is defined as $\Delta\omega = \omega_2 - \omega_1$ where the Q-factor is given as $Q = \frac{\omega_0}{\Delta\omega}$. Examine cases where high and low Q-factors are desired.

Unit title: Electronics (SCQF level 8)

Outcome 2 — Explain and apply the principles of active components and related circuits

Review solid state model of semiconductor conduction via transfer of holes and electrons across the n and p regions, as applied in the junction diode to achieve signal rectification. General uses of the p-n diode such as inductive load protection and demodulation should also be highlighted.

The Zener Effect occurs when a sufficient reverse voltage causes a breakdown of valence bonds, liberating accelerated electrons which in turn, enable an avalanching increase of further breakdowns. The Zener diode makes use of this effect which enables it to operate as a voltage regulator or limiter.

Introduce the tunnel diode as a direct application of electron tunnelling (a quantum phenomenon where an electron may permeate a potential barrier of greater energy; a result ordinarily invalid by classical physics) where an electron has a finite probability to cross — or tunnel — through the p-n depletion layer, moving from the n-region conduction band to the p-region valence band. The tunnel diode has the distinct property of negative resistance, allowing it to oscillate and amplify microwave RF. Examples of the microwave spectrum in telecommunications can help to enforce the practical significance.

Schottky barrier formed from a metal/semiconductor (typically n-type silicon) junction. Employed in the Schottky diode, it exhibits a very low voltage drop (~ 0.3V), as compared to a conventional p-n junction diode. This means that the Schottky diode has a high switching speed and greater rectifying efficiency. Schottky junctions are also used in 74S series TTL logic devices.

Explanation of Bipolar Junction Transistors (BJTs) using established p-n junction model. Define types; npn and pnp. Introduce terminology; base, emitter, collector. Describe the process of current flow through emitter and collector, ie small controlling current applied to base allows large controlled current through emitter and collector. Relate operation to input/output characteristic graphs for common base and common emitter modes. Discuss load lines by examining voltage/current responses for linear and non-linear components of diode and/or transistor based circuits. Actual examples may be used in the case of published component data sheets. Examine the BJT in the context of a solid state switch and low frequency voltage amplifier.

Overview of conductivity in Field Effect Transistors (FETs). Comparison between junction and metal oxide semiconductor FETs. Examine usages of FETs based on their characteristic low power consumption, high input impedance, cost and relative size.

Beginning with the ideal operational amplifier (op amp), discuss the requirements for usage (large voltage gain and high (relative to feedback components) input impedance) and practical component values (resistors typically in the kΩ range). Compare characteristics of the ideal and a practical op amp, examining published component data sheets in the case of the latter. Discussions based on the consideration of particular practical op amps can be made, highlighting the aspects of design choices in electronics. Examine designs of integrating and differentiating op amps, identifying the RC component in each and its significance in the output voltage given. Compare with mathematical definitions of integration and differentiation. Examine designs of instrumentation amplifier, noting that at the component level, it is often formed from 3 op amps with multiple feedback stages, however, is commercially available as a single IC. Define voltage gain for basic instrumentation amplifier.

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Briefly revise the conservation of energy and reversible processes. Discuss the conversion between electrical energy and mechanical stress, heat and magnetism.

Examine solid state model of crystals, discussing atom placement and symmetry. For a non-centrosymmetric structure, a mechanical deformation will result in an internal generation of electric charge. The process is reversible, hence the application of an electric field will induce mechanical strain. This allows the piezoelectric effect to produce both current and vibrations. Applications include electric ignition for combustibles (gas cooker, butane lighter) and sound output (alarm systems, ultrasonic sensors).

Discuss the use of semiconductors and metals in the production of thermocouples. The thermoelectric effect mediates the reversible conversion between heat and electrical current, arising from the diffusion of charge carriers across a temperature gradient to produce an EMF. Conversely, application of an EMF to a thermocouple will result in a heating or cooling effect, depending on polarity. Examples include temperature measurement, refrigeration/heating and electrical generation using heat sources (plutonium thermoelectric generators used in space probes, for example). Consideration should be given to the relatively low efficiencies of the thermoelectric effect but also the advantageous size and reliability which thermoelectric components offer.

Define the Hall Effect as the production of an EMF in a conductor crossed by a magnetic field. In the presence of a non-parallel magnetic field, charge carriers within a conductor undergo displacement via the Lorentz Force resulting in a separation of charge which in turn establishes an electric field. Examine the Hall Effect in semiconductors leading to its implantation as Hall probes, often applied as magnetometers. The Hall probe has the advantage of contactless measurement of current (employed in clamp style multimeters) but its naturally small output signal often requires amplification. This can be tied in with the transistor amplifier circuit (although most commercial sensors have an on-board amplifier).

Outcome 3 — Apply Boolean algebra and logic to aspects of combinational digital logic

Define the basic logic operations NOT, AND, OR and XOR, followed by their negated counterparts NAND, NOR and XNOR using truth tables of high and low inputs and outputs. Represent pictorially using distinctive shape and rectangular outline symbols, corresponding to ANSI/IEEE standards respectively.

Definition of what is meant by a number system in terms of its base (2, 6 and 10: binary, hexadecimal and decimal respectively). The reasoning behind using binary number systems, relating high and low voltage states to binary digits. The weighting structure of binary numbers, least and most significant bits and counting in binary using 4 bits. Conversion of binary numbers to decimal and decimal to binary. Construction of 4-bit Gray code. Similar treatment for the discussion of hexadecimal numbers, giving examples of colour space and character encoding.

Definition of Boolean operations and the equivalency to logic operations. The commutative, associative and distributive axioms of variables for Boolean algebra followed by the basic rules of Boolean algebra.

Formal definition of De Morgan's Theorem to demonstrate the equivalency of Boolean expressions to simplify digital systems using ICs in order to reduce the number of ICs needed, signifying the importance of simplification when it comes to the optimisation and economics of physical systems.

Use Karnaugh Maps to formulate Boolean equations for a set of desired behaviours.

Implement Boolean equations as systems of logic gates, abstractly in terms of gates or with respect to the 7400 series TTL ICs. Design should show aspects of optimisation and planning, for example, using the least amount of gates/ICs.

Outcome 4 — Perform a practical experiment related to microcontrollers

Guidance on suitable practical experiments for assessment purposes is given elsewhere in this document. However, it is envisaged that learners will also participate in a range of other practical experiments which will both develop their laboratory skills and support the theory covered in Outcomes 1−3.

In carrying out such activities, learners should follow Good Laboratory Practice (GLP) and carry out or be familiar with the risk and Control of Substances Hazardous to Health (COSHH) assessments on all procedures undertaken. Opportunities should be taken to develop awareness of the sources of experimental error and of the accuracy of measurements, with quantification of errors where possible.

Guidance on approaches to delivery of this Unit

It is suggested that Outcomes 1−4 are delivered in order.

Outcome 1 intends to build on the theories learnt in the HN Unit H93L 34 *Electricity and Magnetism* but will quickly adopt a greater level of complexity in the theories encountered and mathematical analysis they require. Kirchhoff's Laws should formalise learners' past experience of DC circuit analysis before applying this to mesh and branch analysis. In the case of a resonant circuit, the mathematical aspects of dynamic systems can be introduced or used to supplement understanding. In the case of the latter, general solutions to ODEs may be given without much derivation to avoid repetition. Browser-based open source mathematical software such as SAGE can assist the learner in mathematical computations while offering an introduction in programming.

Outcome 2 will detail the fundamental mechanics and also implementation of active semiconductor and other solid state electrical components. Looking at specific component variants, a significant aspect of Outcome 2 will be the justification of design choices in electronic circuits based on the merits of the device. This can be achieved through a detailed examination of the physical principles behind each component and offers many opportunities to reference theories from across physics and other disciplines in natural science, potentially enriching prior learning. Computer simulation software such as SPICE or MultiSim could be considered at this point.

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Outcome 3 will introduce learners to digital logic. The mathematical components of this Outcome should be presented as a supplement to learners' existing knowledge of algebra. Outcome 3 has the potential to introduce practical experiments, especially when designing a logic circuit. Learners may use computer software to design and test prototypes before implementing on breadboards using integrated circuits and miscellaneous electrical components. Suitable practical experiments may include the construction of a logic probe, experimentally determining truth tables for IC gates and using NAND and NOR ICs to build other equivalent gates.

Outcome 4 will introduce learners to the application of microcontrollers through a series of practical experiments. The nature of the practical experiments will focus on sensory data acquisition and the associated theories and practices regarding system integration and programming, all towards being able to build and program a microcontroller based system to read sensory data for analysis, display as an output and operate on as part of a control sequence.

It is envisioned that learners progress independently through a laboratory manual containing the backgrounds and methods of practical experiments while recording all actions and observations made in a laboratory diary. The practical experiments will provide the learner with the knowledge and skills needed for Outcome 4 but could also relate to topics encountered previously. At the end of each practical experiment, the learner will be required to draw conclusions and provide written discussions in response to questions asked in the laboratory manual before proceeding. For example, the learner could complete a practical session on using an accelerometer or rotary sensor to measure the mechanical vibrations of a pendulum, relating it to the theory of simple harmonic oscillation from Outcome 1. The learner might then need to briefly explain the process of acquiring data from an analogue sensor, making reference to analogue/digital conversion and discussing the relevance to Shannon's Sampling Theorem.

The computer programming part of Outcome 4 is intended to act as an introduction to the field of computational science by introducing the learner to new terms and concepts before detailing the generalised processes involved in computer programming, ie define a task, identify the steps to perform the task (algorithm), implement algorithm as code. To facilitate learning, learners may attempt to reverse engineer premade code to fulfil different parameters.

Guidance on approaches to assessment of this Unit

Evidence can be generated using different types of assessment. The following are suggestions only. There may be other methods that would be more suitable to learners.

Outcomes 1−3 could be assessed by a single holistic closed-book assessment with an appropriate cut-off score that covers the sampling requirements as detailed in the Evidence Requirements. Assessments should be carried out in supervised conditions, and it is recommended that the assessment be completed within 90 minutes. Learners can only have access to the *SQA Databook for HN Physics* or any suitable replacement when sitting the assessment.

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Where evidence of Outcomes 1−3 is assessed by sampling, the whole of the content listed in the Knowledge and/or Skills must be taught and available for assessment. Learners should not know in advance the items on which they will be assessed, and different items should be sampled on each assessment occasion. Any items not sampled in the first assessment must be included in the alternative (re-sit) assessment.

In Outcome 4 learners are required to undertake a minimum of one assessed practical experiment, the content of which will be related to microcontrollers and their applications in physical measurement. Examples of suitable experiments are given below. However, this list is not prescriptive, and other practical experiments of similar complexity may be used by the centre.

Suitable practical experiments for Outcome 4 are:

- Programming output states of a microcontroller.
  - Blinking an LED with a certain frequency.
  - Using pulse width modulation to control motor speed.

This will introduce the learner to the fundamental aspects of microcontrollers; the software interface (internal development environment IDE) and basic programming and the hardware interface; identifying the correct elements of the microcontrollers board and integrating it with electrical circuits.

- Assembling and applying sensory circuits to measure radiative, thermal, mechanical or electromagnetic physical quantities.
  - Radioactivity via GM tube
  - Light intensity via phototransistor
  - Force/pressure using resistive bridge
  - Rotation via a rotary encoder
  - Temperature via thermocouple
  - Magnetic field intensity using a Hall Effect sensor

At this stage, the learner will be assembling electronic sensory circuits designed to give a voltage output proportional to some physical measurand. The experiment should relate to theoretical aspects already encountered.

- Assembling and programming a microcontroller based circuit to read sensory input(s).

- Real time interpretation and output of sensory data, ie programming microcontroller to convert input into a formatted and readable state. For example, experimentally derive a function for temperature in terms of the potential across a thermistor, thermocouple, etc, incorporate into microcontroller's programming and print the temperature on screen with appropriate units.

- Further methods of data output.
  - Real time computer displays using line graphs, gauges etc.
  - Programming a microcontroller to drive segmented LED displays, eg 7-segment display to output numbers, bar displays to output normalised or absolute magnitudes.

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Topics in digital logic may be expanded upon in the case of binary encoders driving segmented displays.

- Applications of sensory input, ie controlling an output state as a function of some input.
  - Make a red LED blink when radioactivity exceeds a certain threshold.
  - Control motor speed as a function of temperature.
  - LED brightness as a function of light intensity.

The exact method and nature of the measurement is second to the process of obtaining it electronically.

The assessed practical experiment will usually be performed individually. However, there may be some experiments that are suitable to be undertaken in pairs or small groups. If this is the case then the assessor should ensure that all participants are actively involved and are able to adequately demonstrate the required skills.

An exemplar instrument of assessment with marking guidelines has been produced to indicate the national standard of achievement at SCQF level 8.

Centres are reminded that prior verification of centre-devised assessments would help to ensure that the national standard is being met. Where learners experience a range of assessment methods, this helps them to develop different skills that should be transferable to work or further and higher education.

Opportunities for 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 Communication Technology (ICT), such as e-testing or the use of e-portfolios or social software. Centres which wish to use e-assessment must ensure that the national standard is applied to all learner evidence and that conditions of assessment as specified in the Evidence Requirements are met, regardless of the mode of gathering evidence. The most up-to-date guidance on the use of e-assessment to support SQA’s qualifications is available at **www.sqa.org.uk/e-assessment**.

Opportunities for developing Core and other essential skills

The delivery and assessment of this Unit will provide learners with the opportunity to develop the Core Skills of *Numeracy, Problem Solving* and *Information and Communication Technology (ICT)* at SCQF level 6.

Numeracy — **Using Number at SCQF level 6**

Learners will be required to use additional mathematical definitions and operations to arrive at a solution, transpose equations containing multiple terms, apply complex algebra on problems related to impedance, substitute differentials into equations involving time-dependant current and solve as functions of time.

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***Problem Solving* — Reviewing and Evaluating at SCQF level 6**

Learners will be required to design electronic circuits within a set specification in order to fulfil a given function. For example, identifying from a given set of components, design an RC circuit with a specific time constant, an LC circuit with a specific resonant frequency or a logic circuit with a specific function. In the case of the latter, learners may also be restricted on the number of gates or ICs used.

***Information and Communication Technology (ICT)* — Providing/Creating Information at SCQF level 6**

Learners may make appropriate use of ICT packages to write programs designed to instruct a microcontroller, and design and test electronic circuits using specialist programs. Packages used will likely include word processing, spreadsheets, and specialist simulation and development software.

This Unit has the Critical Thinking components of Problem Solving and Using Number components of Numeracy embedded in it. This means that when candidates achieve the Unit, their Core Skills profile will also be updated to show they have achieved Critical Thinking at SCQF level 6 and Using Number at SCQF level 6.

History of changes to Unit

Version	Description of change	Date
02	Core Skills Components Critical Thinking and Using Number at SCQF level 6 embedded	28/07/2015

Additional copies of this Unit specification can be purchased from the Scottish Qualifications Authority. Please contact the Business Development and Customer Support team, telephone 0303 333 0330.

General information for learners

Unit title: Electronics (SCQF level 8)

This section will help you decide whether this is the Unit for you by explaining what the Unit is about, what you should know or be able to do before you start, what you will need to do during the Unit and opportunities for further learning and employment.

This is a 1 credit Unit at SCQF level 8, which you are likely to be studying as part of the second year of a HND Science programme. Before progressing to this Unit it would be beneficial to have completed the HN Unit H93L 34 *Electricity and Magnetism*. There will be an emphasis on the foundations of electronics derived from physical theory, the calculus of dynamic systems and computer simulation and programming.

On completion of the Unit, you should be able to:

1 Perform calculations related to the analysis of direct and alternating current circuits.
2 Explain and apply the principles of active components and related circuits.
3 Apply Boolean algebra and logic to aspects of combinational digital logic.
4 Perform a practical experiment related to microcontrollers.

Outcome 1

In this Outcome you will learn the rules, equations and laws regarding direct and alternating current circuit analysis. You will be able to apply mesh and nodal analysis to evaluate complex component networks, use complex algebra to generalise Ohm's Law for reactive components, and derive and solve the differential equations for current within an oscillating circuit.

Outcome 2

In this Outcome, you will take a detailed look at the different varieties of diodes, transistors and amplifiers used in electronics.

Outcome 3

In this Outcome you will be introduced to the theories of combinational logic and its applications in digital electronics. You will learn the mathematical definitions of logic operations and you will be introduced to Boolean algebra, count and convert binary numbers and derive Boolean expressions using Karnaugh Maps. You will learn how to apply conditional logic into digital electronics by means of logic gates or TTL ICs and you will design your own circuits to fulfil various conditions.

Outcome 4

In this Outcome you will undertake a practical experiment, based on the content of microcontrollers and their applications in physical measurement.

During this practical work, you will be expected to develop good laboratory practices as well as improve your skills of manipulation, observation and measurement. You will be encouraged to develop safe working practices and to strive constantly to improve the accuracy and reliability of your results. The reporting and analysis of experimental data is an important aspect of the practical sessions.

General information for learners (cont)

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You will be introduced to the operation and applications of microcontrollers and the theories and skills required to program a microcontroller and integrate it into a system of sensors designed to collect and analyse data.

Assessment

For Outcomes 1 to 3 you will take a closed-book, end of Unit assessment.

Outcome 4 will be assessed after you have learned the necessary practical skills, and will take the form of one practical experiment, for which you will report your results either in a full laboratory report, or by completion of a pro forma report.

Core Skills

You will have opportunities to develop the Core Skills of *Numeracy*, *Problem Solving* and *Information and Communication Technology (ICT)* at SCQF level 6.