

## **SQA Advanced Unit Specification**

### **General information for centres**

**Unit title:** Analogue Electronic Principles

**Unit code:** HP47 47

**Superclass:** XL

**Publication date:** August 2017

**Source:** Scottish Qualifications Authority

**Version:** 01

### **Unit purpose**

This Unit is designed to give candidates knowledge and understanding to demonstrate a wide range of discrete and integrated circuit analogue electronic devices. It will also provide candidates with the underpinning knowledge to further their studies in analogue electronics at a higher level.

On completion of the Unit the candidate should be able to:

- 1 Investigate the operation and characteristics of a range of discrete semiconductor devices.
- 2 Investigate and demonstrate applications of semiconductor diodes.
- 3 Investigate and demonstrate transistor applications.
- 4 Investigate and demonstrate linear operational amplifier characteristics and applications

### **Recommended prior knowledge and skills**

Candidates should have a basic knowledge and understanding of analogue electronic devices. Possession of a Higher in Electronics, C027 12, or some of the following NQ Units may evidence this:

D133 11 *Semiconductor Applications: An Introduction*  
E9SA 11 *An introduction to Semiconductor Applications*  
E9S2 12 *Amplification*  
D186 11/12 *Applied Electronics*

## SQA Advanced Unit Specification

### Credit points and level

2 SQA Credits at SCQF level 7: (16 SCQF credit points at SCQF level 7\*)

*\*SCQF credit points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification in the Framework is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from National 1 to Doctorates.*

### Core Skills

No Core Skills claim is made for this Unit.

### Context for delivery

This Unit was developed for the SQA Advanced Certificate/Diploma in Electronics awards. If the Unit is used in another Group Award it is recommended that it should be taught and assessed within the context of the particular Group Award.

### Assessment

The assessment of this Unit consists of a written assessment and a practical assessment.

The written assessment covers Outcomes 2, 3 and 4 only, as Outcome 1 is assessed in total by the practical assessment. The written assessment should consist of a balance of short answer restricted response and structured response questions, based on the minimum Evidence Requirements for Outcomes 2, 3 and 4. This assessment should be conducted under controlled, supervised conditions.

The practical assessment should consist of the submission of documentation, detailing four out of eight practical exercises, carried out under controlled supervised conditions. Typical examples of suitable exercises are given below and the submission must include one practical exercise for each Outcome:

- ◆ Investigate the characteristics of one diode and one transistor
- ◆ Investigate two diode applications
- ◆ Investigate two transistor applications
- ◆ Investigate two operational amplifier applications

From the above list of eight practical exercises, only the documentation of four of these, one for each Outcome is required for assessment purposes. However, all eight practical exercises should be carried out.

### Unit specification: statement of standards

**Unit title:** Analogue Electronic Principles

**Unit code:** HP47 47

The sections of the Unit stating the Outcomes, Knowledge and/or Skills, and Evidence Requirements are mandatory.

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. Candidates 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

Investigate the operation and characteristics of a range of discrete semiconductor devices

##### Knowledge and/or Skills

- ◆ Rectifier, Signal, Zener, Light-Emitting and Photo Diodes
- ◆ NPN and PNP Bipolar Junction Transistors
- ◆ N-Channel and P-Channel JFET

##### Evidence Requirements

Two practical exercises should be carried out under controlled supervised conditions. One investigating the properties and characteristics of diodes and one investigating the properties and characteristics of transistors. The submission of documentation for one of these practical exercises should be used for assessment purposes. You will be expected to carry out the practical exercises on an individual basis.

#### Outcome 2

Investigate and demonstrate applications of semiconductor diodes

##### Knowledge and/or Skills

- ◆ Rectification
- ◆ Voltage Reference Source
- ◆ Clipping
- ◆ Clamping
- ◆ Light-Emitting
- ◆ Photo Diode

##### Evidence Requirements

Written evidence for the Knowledge and/or Skills in this Outcome will be provided on a sample basis. The evidence may be presented in responses to specific questions. Each candidate will need to demonstrate that they can answer correctly questions based on a sample of the items shown above. In any assessment of this Outcome, four out of six Knowledge and/or Skills items should be sampled.

## SQA Advanced Unit Specification

In order to ensure that candidates will not be able to foresee what items they will be questioned on, a different sample of four out of six Knowledge and/or Skills items is required each time the Outcome is assessed. Candidates must provide a satisfactory response to all four items.

Where sampling takes place, a candidate's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the candidate is able to investigate and demonstrate:

- ◆ the diode as a rectifier
- ◆ the diode as a voltage reference source
- ◆ diode clippers
- ◆ diode clampers
- ◆ a light-emitting diode
- ◆ a photo diode

Written evidence should be generated through assessment undertaken in controlled, closed-book and supervised conditions. Candidates should not be allowed to bring any textbooks, handouts or notes to the written assessment.

Two practical exercises should be carried out under controlled supervised conditions, investigating two different diode applications. The submission of documentation for one of these practical exercises should be used for assessment purposes. You will be expected to carry out the practical exercises on an individual basis.

### Outcome 3

Investigate and demonstrate transistor applications

#### Knowledge and/or Skills

- ◆ Common-Emitter Amplifier
- ◆ Common-Collector Amplifier
- ◆ Common-Source Amplifier
- ◆ Common-Drain Amplifier
- ◆ Transistor Switching

#### Evidence Requirements

Written evidence for the Knowledge and/or Skills in this Outcome will be provided on a sample basis. The evidence may be presented in responses to specific questions. Each candidate will need to demonstrate that they can answer correctly questions based on a sample of the items shown above. In any assessment of this Outcome, three of the five Knowledge and/or Skills items should be sampled.

In order to ensure that candidates will not be able to foresee what items they will be questioned on, a different sample of three of the five Knowledge and/or Skills items is required each time the Outcome is assessed. Candidates must provide a satisfactory response to all items.

Where sampling takes place, a candidate's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the candidate is able to investigate and demonstrate the transistor as:

## SQA Advanced Unit Specification

- ◆ a small-signal common-emitter amplifier.
- ◆ a small-signal common-collector amplifier.
- ◆ a small-signal common-source amplifier.
- ◆ a small-signal common-drain amplifier.
- ◆ an electronic switch.

Written evidence should be generated through assessment undertaken in controlled, closed-book and supervised conditions. Candidates should not be allowed to bring any textbooks, handouts or notes to the written assessment.

### Outcome 4

Investigate and demonstrate linear operational amplifier characteristics and applications

#### Knowledge and/or Skills

- ◆ Ideal operational amplifier characteristics
- ◆ Inverting Amplifier
- ◆ Non-inverting Amplifier
- ◆ Voltage Follower
- ◆ Summing Amplifier
- ◆ Difference Amplifier

#### Evidence Requirements

Written evidence for the Knowledge and/or Skills in this Outcome will be provided on a sample basis. The evidence may be presented in responses to specific questions. Each candidate will need to demonstrate that they can answer questions correctly based on a sample of the items shown above. In any assessment of this Outcome, four out of six Knowledge and/or Skills items should be sampled.

In order to ensure that candidates will not be able to foresee what items they will be questioned on, a different sample of four out of the six Knowledge and/or Skills items is required each time the Outcome is assessed. Candidates must provide a satisfactory response to all three items.

Where sampling takes place, a candidate's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the candidate is able to describe and demonstrate:

- ◆ ideal operational amplifier characteristics
- ◆ an inverting amplifier
- ◆ a non-inverting amplifier
- ◆ a voltage follower
- ◆ a summing amplifier
- ◆ a difference amplifier

Written evidence should be generated through assessment undertaken in controlled, closed-book and supervised conditions. Candidates should not be allowed to bring any textbooks, handouts or notes to the written assessment.

Two practical exercises should be carried out under controlled supervised conditions. Investigating two different operational amplifier applications. The submission of documentation for one of these practical exercises should be used for assessment purposes. You will be expected to carry out the practical exercises on an individual basis.

### Unit specification: support notes

#### Unit title: Analogue Electronic Principles

This part of the Unit specification is offered as guidance. The support notes are not mandatory.

While the exact time allocated to this Unit is at the discretion of the centre, the notional design length is 80 hours.

#### Guidance on the content and context for this Unit

This Unit has been written in order to allow candidates to develop their knowledge, understanding and skills in the following areas:

- ◆ investigate the operation and characteristics of a range of discrete semiconductor devices
- ◆ investigate and demonstrate applications of semiconductor diodes
- ◆ investigate and demonstrate transistor applications
- ◆ investigate and demonstrate linear operational amplifier characteristics and applications

This Unit has been developed as a stand-alone topic in Analogue Electronics within the mandatory section of the new SQA Advanced Certificate/Diploma in Electronics Awards. This is a double credit Unit at SCQF level 7 (16 SCQF credit points at SCQF level 7).

In designing this Unit, a range of topics have been identified which lecturers are expected to cover. Recommendations have also been given as to how much time should be spent on each Outcome. This has been done to help lecturers to decide what depth of treatment should be given to the topics attached to each of the Outcomes. Whilst it is not mandatory for centres to use this list of topics it is strongly recommended that they do so to ensure continuity of teaching and learning, and because the assessment exemplar pack for this Unit is based on the Knowledge and/or Skills and list of topics in each of the Outcomes.

One practical exercise will only be assessed for each Outcome but candidates are expected to carry out eight practical and simulation exercises on a wide range of circuits.

A list of topics is given below. The suggested times exclude assessment.

#### **Investigate the operation and characteristics of a range of discrete semiconductor devices (17 hours)**

- ◆ Operation of rectifier and signal diode: forward bias, reverse bias and depletion region.
- ◆ Operation of zener diode including two types of reverse breakdown, avalanche and zener breakdown.
- ◆ Basic operation of LED when forward-biased.
- ◆ Basic operation of Photo-Diode when reverse biased.
- ◆ Basic transistor operation of NPN and PNP transistors including forward and reverse bias and direction of currents.
- ◆ Operation of n- and p-channel JFETs, reverse biased gate-source region, depletion-mode operation.
- ◆ Forward and reverse I/V characteristics of rectifier and signal diode indicating and explaining regions of importance such as forward and reverse blocking, forward and

## SQA Advanced Unit Specification

reverse conduction, forward voltage drop and reverse breakdown voltage, slope resistance.

- ◆ Forward and reverse I/V characteristics of zener diode.
- ◆ Forward characteristic of LED.
- ◆ Reverse characteristic of Photo-Diode.
- ◆ Data sheets of diodes to determine important parameters.
- ◆ Input and output characteristics of bipolar transistors.
- ◆ Data sheets of bipolar transistors to determine important parameters.
- ◆ Transfer and drain characteristics of JFETs.
- ◆ Data sheets of JFETs to determine important parameters.

### Investigate and demonstrate applications of semiconductor diodes (17 hours)

- ◆ Use of rectifier diode in half- and full-wave rectifier circuits.
- ◆ Use of zener diode as a voltage reference source.
- ◆ Use of signal diode in clipping and clamping circuits.
- ◆ Use of infrared and indicator LEDs.
- ◆ Use of Photo-Diodes.
- ◆ Circuit calculations of voltage, current and resistance where appropriate.
- ◆ Computer simulation and practical assignments on some of the above circuits.
- ◆ Areas for practical assignments should include, but are not limited to the following:
  - half and full wave rectification with resistive load
  - zener diode circuit as a voltage regulator
  - diode clipper and/or clamper circuit

### Investigate and demonstrate transistor applications (20 hours)

- ◆ Common-emitter amplifier to include bias as a Class-A amplifier using potential divider bias with resistive load and emitter resistor stabilisation of the operating point. Calculation of circuit voltages, given component values. Calculation of circuit components.
- ◆ Common-collector amplifier: voltage gain, current gain, power gain, input and output impedance.
- ◆ Frequency response of AC coupled amplifier.
- ◆ Common-source amplifier with self-bias and resistive load. Calculation of circuit components for mid-point bias.
- ◆ Common-drain amplifier: voltage gain and input impedance.
- ◆ Class A amplifiers.
- ◆ Transistor switching using Bipolar Junction Transistors, JFETs and MOSFETs.
- ◆ Computer simulation and practical assignments on transistor amplifier circuits.
- ◆ Areas for practical assignments should include, but are not limited to the following:
  - common-emitter amplifier
  - common-source amplifier
  - transistor switching

### Investigate and demonstrate linear operational amplifier characteristics and applications (18 hours)

- ◆ Ideal and practical characteristics of operational amplifier including open-loop voltage gain, input impedance, output impedance, slew rate, CMRR and bandwidth.
- ◆ Ideal operational amplifier as an inverting amplifier, closed-loop voltage gain, virtual earth concept.
- ◆ Ideal operational amplifier as a non-inverting amplifier, closed loop voltage gain.

## SQA Advanced Unit Specification

- ◆ Operational amplifier as a voltage follower, closed loop voltage gain, input impedance and output impedance.
- ◆ Ideal operational amplifier as a summing amplifier with a maximum of three inputs, unity-gain summing amplifier, gain greater than unity, averaging amplifier and scaling amplifier
- ◆ Ideal operational amplifier as a difference amplifier.
- ◆ The operation of all the above amplifiers can be described using a mathematical model.
- ◆ Computer simulation and practical assignments on operational amplifier circuits.
- ◆ Areas for practical assignments should include, but are not limited to the following:
  - Inverting amplifier
  - Non-inverting amplifier
  - Voltage follower
  - Summing amplifier
  - Difference amplifier

### Guidance on the delivery of this Unit

This Unit has been designed as a stand alone Unit for the SQA Advanced Certificate in Electronics candidates and as a first year Unit for the SQA Advanced Diploma in Electronics candidates. The Unit should provide SQA Advanced Certificate candidates with sufficient knowledge, understanding and skills related to analogue electronic components and circuits. For SQA Advanced Diploma students, it should provide them with the underpinning knowledge that will allow them to further their studies in analogue electronics. It is recommended that Unit be delivered towards the start of the course.

### Guidance on the assessment of this Unit

This Unit has been designed to incorporate sufficient time to allow lecturers to teach the entire analogue electronic principles contained in the Unit. There is also sufficient time for candidates to practice what they have learnt through appropriate formative assessment exercises, computer simulation and practical laboratory work. Some of the practical work will be assessed as stated under Evidence Requirements and Assessment Guidelines for each Outcome in the SQA Advanced Unit specification: statement of standards section. The practical assessments should take place after completion of the relevant Outcome. Some of the practical assignments could be integrated with the Electronic Testing Skills Unit assessments.

### Assessment Guidelines

Written evidence should consist of questions used to elicit candidate evidence taking the form of restricted response and structured questions.

The written assessment of this Outcome can be combined with Outcomes 2 and 3 to form a single assessment paper.

The documentation required for the practical exercise should include the task undertaken, equipment used, results achieved and relevant conclusions. This document should show that the candidate has investigated and demonstrated the chosen operational amplifier application.



## **SQA Advanced Unit Specification**

### **Outcome 1**

The documentation required for the practical exercise should include the task undertaken, equipment used, results achieved and relevant conclusions. This document should show the candidate has investigated the operation and characteristics of the chosen device.

Candidates who do not meet the Evidence Requirements should be re-assessed using a practical exercise based on a different type of device.

### **Outcome 2**

Written evidence should consist of questions used to elicit candidate evidence taking the form of restricted response and structured questions.

The written assessment of this Outcome can be combined with Outcomes 3 and 4 to form a single assessment paper.

Re-assessment of candidates who do not meet the Evidence Requirements should be carried out using a different sample of Knowledge and/or Skills items.

The documentation required for the practical exercise should include the task undertaken, equipment used, results achieved and relevant conclusions. This document should show that the candidate has investigated and demonstrated the chosen diode application.

### **Outcome 3**

Written evidence should consist of questions used to elicit candidate evidence taking the form of restricted response and structured questions.

The written assessment of this Outcome can be combined with Outcomes 2 and 4 to form a single assessment paper.

Re-assessment of candidates who do not meet the Evidence Requirements should be carried out using a different sample of Knowledge and/or Skills items.

The documentation required for the practical exercise should include the task undertaken, equipment used, results achieved and relevant conclusions. This document should show that the candidate has investigated and demonstrated the chosen transistor application.

### **Outcome 4**

Written evidence should consist of questions used to elicit candidate evidence taking the form of restricted response and structured questions.

The written assessment of this Outcome can be combined with Outcomes 2 and 3 to form a single assessment paper.

Re-assessment of candidates who do not meet the Evidence Requirements should be carried out using a different sample of Knowledge and/or Skills items.

The documentation required for the practical exercise should include the task undertaken, equipment used, results achieved and relevant conclusions. This document should show that the candidate has investigated and demonstrated the chosen operational amplifier application.

### Online and Distance Learning

This Unit could be delivered by distance learning, which may incorporate some degree of on-line support. However, with regards to assessment, planning would be required by the centre concerned to ensure the sufficiency and authenticity of candidate evidence. Arrangements would be required to be put in place to ensure that assessment, whether done at a single or multiple events, was conducted under controlled, supervised conditions.

Arrangements would have to be made for the candidates to do the two practical assessments at the centre.

To keep administrative arrangements to a minimum, it is recommended that a single assessment paper taken by candidates at a single assessment event be used for distance learning candidates.

For information on normal open learning arrangements, please refer to the SQA guide *Assessment and Quality Assurance of Open and Distance Learning* (SQA 2000).

### Opportunities for developing Core Skills

Although there is no automatic certification of core skills in this unit, there may be opportunities to develop the core skills of Numeracy and Problem Solving.

### 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](http://www.sqa.org.uk/assessmentarrangements).

## Administrative information

Version	Description of change	Date

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SQA acknowledges the valuable contribution that Scotland's colleges have made to the development of SQA Advanced Qualifications.

**FURTHER INFORMATION:** Call SQA's Customer Contact Centre on 44 (0) 141 500 5030 or 0345 279 1000. Alternatively, complete our [Centre Feedback Form](#).

### General information for candidates

#### Unit title: Analogue Electronic Principles

This Unit has been designed to allow you to develop your knowledge, understanding and skills in analogue electronic devices and circuits so that you can further your studies with more advanced Units in analogue electronics. The Unit can be used as a stand-alone Unit in analogue electronics for candidates who do not wish to advance their studies beyond SCQF level 7 (SQA Advanced Certificate). Other engineering students who wish to broaden their knowledge can also use it.

SQA Advanced Certificate/Diploma candidates will have the opportunity to improve their knowledge, understanding and skills of discrete and integrated circuit semiconductor devices that are widely used in electronic circuits. By the completion of the Unit you should be competent in the understanding of a wide range of analogue electronic devices and be able to interpret data sheets and gain practical skills in the handling and testing of components and circuits.

You should also be able to recognise the relationship between the theoretical knowledge gained and the practical assignments undertaken. The use of computer simulation will allow you to analyse circuit operation before carrying out the practical work.

Outcome 1 will introduce you to a wide range of discrete semiconductor devices used in electronic circuits. At the end of the Outcome you will have knowledge and understanding about the operation of these devices. Outcomes 2 and 3 allow you to understand the practical applications of the discrete devices studied in Outcome 1. You will also gain valuable experience by carrying out some computer simulation and practical work.

In Outcome 4 you will learn about the operational amplifier, which is widely used in analogue linear circuits to perform mathematical operations including addition and subtraction.

The written assessments for this Unit may consist of one assessment paper lasting two hours. The assessment will be conducted under closed-book, controlled and supervised conditions. You will not be allowed to take notes or textbooks into the assessment but you will be allowed to use a scientific calculator.

The practical assessment will consist of four submitted assignments (one for each Outcome) out of eight completed assessments (two for each Outcome). The practical assessments will take place under controlled and supervised conditions. You will be expected to carry out the practical assessments on an individual basis.