Higher National Unit Specification

General information for centres

Unit title: Active Electronic Circuits

Unit code: DG2W 35

Unit purpose: This Unit is designed to enable candidates to build on the knowledge of Analogue Electronic Principles with regard to further understanding electronic circuits. It will allow the candidate to gain an understanding of feedback and to develop this understanding with regard to a specified list of electronic amplifiers, filters and oscillator circuits. In addition candidates will design a second order filter using a reference table provided. The candidates will be required to perform practical tests on a selection of circuits from the list.

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

1. Analyse the effects of positive and negative feedback.
2. Analyse the circuits and properties of common Operational Amplifier Circuits.
3. Outline the properties of filters.
4. Outline the operation of electronic oscillator circuits.

Credit value: 1 HN Credit at SCQF level 8: (8 SCQF credit points at SCQF level 8*)

**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 Access 1 to Doctorates.*

Recommended prior knowledge and skills: Candidates should have a good knowledge of electronic devices and amplifiers. This may be evidenced by possession of credit for the HN Unit Analogue Electronic Principles.

Core skills: There may be opportunities to gather evidence towards core skills in this Unit, although there is no automatic certification of core skills or core skills components.

Context for delivery: This Unit was developed for the HNC/HND Electronics award. If this Unit is used in another group award(s) it is recommended that it should be taught and assessed within the context of the particular group award(s) to which it contributes.

Assessment: The assessments for all four Outcomes in this Unit are combined into one assessment paper taken at a single assessment event lasting two hours. The assessment paper could be composed of a suitable balance of short answer, restricted response and structured questions. Assessment should be conducted under controlled, supervised conditions. It should

be noted that candidates must achieve the minimum evidence specified for each Outcome in order to pass the Unit.

Higher National Unit Specification

General information for centres (cont)

The practical content of this Unit must be assessed by evidence of one exercise from either Outcomes 2, 3 or 4, appropriately logged and reported. The practical exercise should be allocated a maximum of 2 hours, with the writing of the report to be done in the candidate's own time. The practical exercises should be tackled on an individual candidate basis and each candidate should generate distinct reports.

Higher National Unit specification: statement of standards

Unit title: Active Electronic Circuits

Unit code: DG2W 35

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

Analyse the effects of positive and negative feedback

Knowledge and/or skills

- Recognise four amplifier feedback configurations
- The effects of feedback on amplifier properties:
  - gain
  - input and output impedance
  - stability
  - frequency response
  - distortion
  - noise
- Calculations involving feedback effects

Evidence requirements

Evidence for the knowledge and skills in this Outcome will be provided on a sample basis. The evidence may be presented in response to specific questions. In any assessment of this Outcome sampling should be based on:

- identify two out of four amplifier feedback configurations
- calculate all 7 properties for one of these identified configurations

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:

- explain the concepts of positive and negative feedback
- identify the feedback derived from an amplifier as voltage or current

- identify the feedback applied to an amplifier as series or shunt
- recognise and classify feedback in operational amplifier circuits
- understand and explain the effects of the above feedback on amplifier properties:
  - gain
  - input impedance
  - output impedance
  - frequency response
  - stability
  - distortion
  - noise

Evidence should be generated through assessment undertaken in controlled, supervised conditions. Assessment should be conducted under closed book conditions and as such candidates should not be allowed to bring any textbooks or notes to the assessment. Candidates will be permitted to use scientific calculators during the assessment.

Assessment guidelines

Questions used to elicit candidate evidence may take the form of an appropriate balance of short answer, restricted response and structured questions.

The assessment of this Outcome should be combined with Outcomes 2, 3 and 4 to form a single assessment paper, details of which are given under Outcome 4.

Outcome 2

Analyse the circuits and properties of common Operational Amplifier Circuits

Knowledge and/or skills

- Integrator
- Exponential amplifier
- Logarithmic amplifier
- Piece-wise linear function generator
- Voltage controlled current source
- Current controlled voltage source
- Instrumentation amplifier

Evidence requirements

Evidence for the knowledge and/or skills in this Outcome will be provided on a sample basis. In any written assessment two out of seven circuits should be sampled. Each candidate will need to demonstrate that they can answer correctly questions based on a sample of the items shown above.

Higher National Unit specification: statement of standards (cont)

Unit title: Active Electronic Circuits

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:

- identify the operational amplifier circuit
- explain the function of the circuit
- identify the components which affect the operation and range
- identify suitable applications

Evidence for the above should be generated through assessment undertaken in controlled, supervised conditions. Assessment should be conducted under closed book conditions and as such candidates should not be allowed to bring any textbooks or notes to the assessment. Candidates will be permitted to use scientific calculators during the assessment.

Evidence of the practical assessment should include:

- circuit name and circuit function, operation and application
- the properties to be tested or measured
- any simulation results and the package used
- record of results and appropriate waveforms from the practical circuit
- conclusions

Assessment guidelines

Questions used to elicit candidate evidence may take the form of an appropriate balance of short answer, restricted response and structured questions.

The assessment of this Outcome should be combined with Outcomes 1, 3 and 4 to form a single assessment paper, details of which are given under Outcome 4.

For the practical exercise: Centres are recommended to develop and use appropriate checklists to monitor candidate's progress.

Outcome 3

Outline the properties of filters

Knowledge and/or skills

- Explain the signal requirements of filter types:
  - low pass
  - high pass
  - band pass
  - band stop
  - notch
  - all pass

- Identify the following parameters of a filter:
  - critical frequency
  - order
  - roll-off rate
  - bandwidth
  - quality factor
- Explain the benefits of active filters
- Recognise the Butterworth flat pass band and Chebychev rapid roll-off characteristics
- Use a tabular method to design, simulate and build a second order active filter

Evidence requirements

Evidence for the knowledge and/or skills in this Outcome will be provided on a sample basis. Written assessment of the filter circuits should show that the candidate:

- identifies four out of the six filter types
- identifies three out of five of the filter parameters listed
- explains the benefits of active filters
- recognises Butterworth and Chebychev characteristics
- uses a tabular method to design a second order active filter

Assessment guidelines

This mandatory written assessment would employ an appropriate balance of short answer, restricted response and structured questions. The assessment of this Outcome should be combined with Outcomes 1, 2 and 4 to form a single assessment paper, details of which are given under Outcome 4.

The practical assessment should include appropriate points as previously listed:

- circuit name, function, operation and application
- the properties to be tested or measured
- any simulation results and the package used
- record of results and appropriate waveforms from the practical circuit
- appropriate calculations
- conclusions

Higher National Unit specification: statement of standards (cont)

Unit title: Active Electronic Circuits

Outcome 4

Outline the operation of electronic oscillator circuits

Knowledge and/or skills

- Understand the conditions necessary to sustain oscillation
- Identify the operational amplifier configurations and properties of the following oscillators:
  - Hartley
  - Wien Bridge
- Identify the frequency determining components and oscillator applications

Evidence requirements

Evidence for the knowledge and/or skills in this Outcome will be provided on a sample basis.

Written assessment of the oscillator circuits should show that the candidate:

- explains the conditions necessary to sustain oscillation
- identifies one out of the two specified oscillators
- identifies the oscillator frequency-determining components and specifies the gain factor for the chosen oscillator
- identifies a suitable application for the chosen oscillator

The evidence of a practical assessment should include:

- circuit name, function, operation and application
- the properties to be tested or measured
- any simulation results and the package used
- record of results and appropriate waveforms from the practical circuit
- appropriate calculations
- conclusions

Assessment guidelines

The assessment of this Outcome should be combined with those for Outcomes 1, 2 and 3 to form one assessment paper for the Unit. The single assessment paper will be taken at a single assessment event lasting two hours and carried out under supervised, controlled conditions. Such a paper could be composed of an appropriate balance of short answer, restricted response and structured questions.

Administrative Information

Unit code: DG2W 35

Unit title: Active Electronic Circuits

Superclass category: XL

Date of publication: May 2004

Version: 01

Source: SQA

Higher National Unit specification: support notes

Unit title: Active Electronic Circuits

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 40 hours.

Guidance on the content and context for this Unit

This Unit has been written in order to increase candidate's knowledge of electronic circuits, including the use of operational amplifiers, in respect to: -

1. Application of feedback.
2. Operational Amplifier applications.
3. Filters.
4. Oscillators.

This Unit is a core Unit of the HND Electronics award.

In designing this Unit the Unit writers have identified the range of topics they would expect to be covered by lecturers. The writers have also given recommendations 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.

Most of the circuits identified should be simulated on an appropriate simulator, using any available software package. The simulations will not be formally assessed.

At least one circuit in each of Outcomes 2, 3 and 4 should be constructed and tested, although only one of the three will be assessed.

The following notes should be considered along with the assessment exemplar pack to give lecturers a clear indication of the standard of achievement expected of candidates.

1. Analyse the effects of positive and negative feedback (6 hours)

- Candidates will understand the concepts of positive and negative feedback; series and shunt applied feedback; and voltage and current derived feedback.
- Feedback will be classified and equations given with respect to a block diagram and applied to operational amplifier circuits related to the block diagrams.
- Useful examples could include followers, phase-splitters and circuits from Analogue Electronic Principles. Applications will arise in Outcomes 2, 3 and 4.

- Candidates will understand the effects of feedback on gain, impedance, stability, frequency response, distortion and noise and calculate the new values.
- Examples could include, high gain operational amplifier stabilisation and gain reduction, stabilisation, gain, input and output impedance of follower circuits, transistor linearity improvement.
- Candidates will examine given circuit diagrams for properties and calculations and could simulate them to verify predictions and to consider suitable applications.
- The simulations and any practical results will not be required for assessment.

2. Analyse the circuits and properties of common operational amplifier circuits (10 hours)

- Candidates will be able to describe the Operational Amplifier Circuits listed below, identify circuits and properties and suitable applications.
  - ***Integrator…*** output is the integral of input, constant current charging a capacitor, charging rate, scale factor, time constant, its relation to appropriate signal pulse width, mathematical and signal examples, solving differential equations.
  - ***Piecewise linearisation circuit…*** **n**on-mathematical functions or waves are produced a piece at a time with the new operation of the circuit occurring in some voltage controlled fashion such as when a diode bias changes-over.
  - ***Logarithmic amplifier…*** **o**utput is the natural logarithm of the input
  - ***Exponential amplifier…*** **o**utput is the exponential or inverse logarithm of the input
  - ***Voltage to current converter…*** virtual earth principle, input voltage produces current in input resistor and feedback resistor, power supply maintains the output current and output voltage
  - ***Current to voltage converter…*** virtual earth principle, input current produces voltage across feedback resistor and thus controls the output voltage
  - ***Instrumentation amplifier…*** two input amplifiers control the gain, differential output amplifier removes common mode component, thus high gain, high common mode rejection ratio (cmrr)

  Each example in the list should be simulated to verify its properties and at least one circuit constructed and tested with results recorded (as specified in the Statement of Standards) for possible assessment verification.

Higher National Unit specification: support notes (cont)

Unit title: Active Electronic Circuits

3. Outline the properties of filters (10 hours)

- Understand filters by type: low pass, high pass, bandpass, bandstop, notch, all pass.
- Discuss how R C circuits can act as signal filters and know what is meant by filter order.
- Explain how follower or low gain operational amplifiers improve the filter properties listed above. Properties such as critical frequency, roll-off rate, bandwidth and quality factor of these simple filters to be verified by electronic simulation.
- Candidates will become familiar with the characteristics of Butterworth and Chebychev filters.
- Tables will be used to design second order filters (Sallen and Key) and these filters realised first on an electronic simulator then constructed and tested. The tables to be made available to all candidates and may be used in closed book assessments.
- Records from circuit constructed should include the list of items specified in the Statement of Standards.

4. Outline the operation of electronic oscillator circuits (10 hours)

Use the feedback equation from learning Outcome 1 to establish the criteria for oscillation and show how the oscillator circuits listed fit the feedback conditions using frequency dependent feedback to produce oscillations of a single designed frequency.

- Hartley
- Wien Bridge
- Frequency selective components should be identified and tuning discussed.
- Appropriate frequency ranges should be considered leading to suitable applications. Operational amplifier and single stage bipolar of field-effect transistor circuit versions should be discussed.
- Examples of the oscillators should be simulated and at least two real circuits tested. Records from circuit tested should include the items specified in the Statement of Standards.

Unit Assessment (maximum 4 hours)

Higher National Unit specification: support notes (cont)

Unit title: Active Electronic Circuits

The four Outcomes will be assessed at one single written assessment event lasting two hours, and by one practical assessments lasting a maximum of two hours. The conditions for these are stated under General Information for Centres.

Guidance on the delivery and assessment of this Unit

This Unit has been designed with sufficient time built in for candidates to practice what they have learnt through appropriate formative assessment exercises. The assessment guidelines under each Outcome in the Higher National Unit specification: statement of standards section should be read carefully before assessing candidates. An assessment exemplar pack will be available.

In this Unit it is strongly recommended that Outcome 1 be completed first since it supports the other Outcomes, which could be tackled in any order.

Throughout the Unit calculations should include appropriate complex notation.

This Unit has also been designed to incorporate time for some practical experimental work and computer simulations so that candidates do have some practical laboratory work to gain knowledge of the circuits and the use of test and measuring equipment.

Elements of the practical work will form a separate practical assessment covering one Outcome from Outcomes 2, 3 or 4. This should be performed as appropriate within the Unit delivery.

The written assessment is one holistic assessment instrument, which takes place at the end of the Unit delivery time, under controlled, supervised conditions. The time allowed for the written test will be 2 hours.

Open learning

This Unit could be delivered by distance learning, which may incorporate some degree of on-line support, to include an electronic circuit simulation program.

With regard to assessment, planning would be required by the centre concerned to ensure the sufficiency and authenticity of candidate evidence. Arrangements would be required to ensure that assessment whether done at a single or multiple events were conducted under controlled, supervised conditions.

Higher National Unit specification: support notes (cont)

Unit title: Active Electronic Circuits

Arrangements would have to be made for candidates to attend the centre to do the practical work and assessment.

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)*.

Special needs

This Unit specification is intended to ensure that there are no artificial barriers to learning or assessment. Special needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments or considering special alternative Outcomes for Units. For information on these, please refer to the SQA document *Guidance on Special Assessment Arrangements* (SQA, 2001).

General information for candidates

Unit title: Active Electronic Circuits

This Unit has been designed to allow you to develop your knowledge and understanding of Active Electronic Circuits such as Amplifiers, Oscillators and Filters. This Unit is a core Level 8 Unit for the HND Electronics but could be used as a stand alone Unit for candidates with appropriate entry who wish to broaden their knowledge and understanding of Analogue Electronics.

Upon completion of this Unit, you should be competent in recognising the circuit diagrams of a wide range of active electronic devices. You will be familiar with their main features and the components, which establish or control these features, and be able to test the circuits for correct behaviour. 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 enable you to recognise and analyse common electronic feedback applied in electronics, and know its effects on the circuit's behaviour. Calculations will involve complex notation.

Outcome 2 will familiarise you with a selection of Operational Amplifier Circuits used in electronics identifying the feedback applied and the properties and applications of these. Most of the circuits will be demonstrated by simulation but at least one example should be tested to show or measure its properties using appropriate test equipment.

Outcome 3 will introduce filter types and characteristics. A tabular method of filter design will be employed to simulate and build a Second Order Filter of given characteristics and it will be tested.

Outcome 4 explains how Positive Feedback can produce oscillation and studies a selection of oscillator circuits popular as signal generators, identifying their main properties. Each oscillator should be simulated and at least one built and tested.

This Unit will be assessed by both a written and a practical part. The written part will take place at one assessment event, which will take place at the end of this Unit. It will consist of one assessment paper lasting two hours and will be conducted under closed book, controlled and supervised conditions. You will be allowed to use a scientific calculator and may have approved tables and data provided.

The practical assignment, which will be drawn from Outcomes 2 or 3 or 4 will take place under supervised conditions and should be properly logged.