-SQA-SCOTTISH QUALIFICATIONS AUTHORITY

HIGHER NATIONAL UNIT SPECIFICATION

GENERAL INFORMATION

Unit Number	**D3PG 04**
Unit Title	ANALOGUE CIRCUITS
Superclass Category	XL
Date of publication (month and year)	
Originating Centre for Unit	Cleveland Open Learning Unit

DESCRIPTION

GENERAL COMPETENCE FOR UNIT:

Applying circuit theory to the operation and design of analogue circuits.

OUTCOMES:

1. evaluate the performance of operational amplifiers;
2. design, construct and test operational amplifier circuits;
3. investigate applications of analogue integrated circuits;
4. compare methods of analogue-to-digital and digital-to-analogue conversion.

CREDIT VALUE: 2 HN Credits

ACCESS STATEMENT:

Access to this unit is at the discretion of the Centre. It would, however, be beneficial if the student had competence in mathematics, circuit theory and basic electronics. This may be evidenced by possession National Certificate Module 'Applied Electronics 1' and HN Units 'Mathematics for Engineers' and 'Engineering Principles (Electrical)' or similar qualifications and experience.

Additional copies of this unit can be obtained from: The Administrative Services Unit, SQA, Hanover House, 24 Douglas Street, Glasgow G2 7NQ (Tel: 0141-242 2166).

At the time of publication, the cost is £2.50 (minimum order £5.00)

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STATEMENT OF STANDARDS

Unit number:

Unit title: ANALOGUE CIRCUITS

Acceptable performance in this Unit will be the satisfactory achievement of the standards set out in this part of the specification. All sections of the statement of the standards are mandatory and cannot be altered without reference to SQA.

OUTCOME

1. EVALUATE THE PERFORMANCE OF OPERATIONAL AMPLIFIERS

PERFORMANCE CRITERIA

(a) Operational amplifier characteristics are correctly interpreted in relation to practical circuit applications.
(b) The circuit elements of an integrated circuit operational amplifier are correctly related to the device's operation and fabrication.
(c) Estimations of the frequency and pulse response of an operational amplifier are correct in terms of bandwidth, frequency compensation, slew rate and rise time.

RANGE STATEMENT

Characteristics:	input offset voltage; input bias current; input offset current; differential voltage amplification; maximum peak output voltage swing; input resistance; output resistance; common mode rejection ratio; rise time; overshoot; slew rate; unity gain bandwidth; settling time; phase margin; gain margin; open-loop voltage gain.
Circuit elements:	input stage; differential amplifier; long-tail pair; current mirror; buffer stage (e.g. emitter follower); intermediate high gain stage; push-pull class AB output stage; short-circuit protection; over-voltage protection; active loads; compensation.

EVIDENCE REQUIREMENTS

PC (a) Written evidence that the student can identify the significance of each of the range of characteristics.
PC (b) Written or oral evidence that the student can identify the function of each of the circuit elements from a manufacturer's schematic diagram of an op-amp.
PC (c) Calculations to show that the student can predict the frequency and pulse response of an op-amp given the appropriate data.

OUTCOME

2. DESIGN CONSTRUCT AND TEST OPERATIONAL AMPLIFIER CIRCUITS

PERFORMANCE CRITERIA

(a) Analysis of the effects of feedback upon an amplifier's properties are correct.
(b) Operational amplifier circuits are constructed and their measured performance compared to that predicted by design.
(c) Sallen and Key filters are constructed and their measured performance compared to design predictions in terms of bandwidth, gain and Q-factor.
(d) Wein bridge and phase-shift (RC ladder) oscillator circuits are constructed and their measured performance is compared to design predictions in terms of frequency of operation and the gain of the amplifier.
(e) The performance of operational amplifier circuits is predicted by software simulation.

RANGE STATEMENT

Operational amplifier circuit:	summing; difference; inverting; integrating; level shifting; non-inverting; logarithmic; precision rectifier; comparitor with hysteresis; window comparitor; current-to-voltage converter; voltage-to-current converter; voltage regulator; oscillator; filter.
Amplifier's properties:	operating points; transfer function; voltage gain; current gain; gain/frequency response; phase/frequency response; stability; gain margin; phase margin; gain-bandwidth product; input impedance.
Filters:	high, low; band pass filters.

EVIDENCE REQUIREMENTS

PC (a)	Written evidence that the student can apply mathematical analysis to an amplifier circuit to derive quiescent conditions, d.c. and a.c. transfer functions and apply mathematical or graphical techniques to ascertain the stability of an amplifier possessing at least two breakpoints.
PC (b)	Written evidence to show that the student can predict the performance of the range of circuits. Performance evidence that the student can successfully build and test examples of the circuits given in the range.
PC (c)	Performance evidence that the student can obtain the gain/frequency response of filters in the range and compare gain, bandwidth and Q-factor with that predicted from theory.
PC (d)	Written and performance evidence that the student can analyse, construct and measure the performance of each type of oscillator.
PC (e)	Performance evidence that the student can simulate the behaviour of two of the constructed circuits (amplifier, filter or oscillator) by means of a software emulation package.

OUTCOME

3. INVESTIGATE APPLICATIONS OF ANALOGUE INTEGRATED CIRCUITS

PERFORMANCE CRITERIA

(a) The investigation of the use of two specialised analogue integrated circuits in practical applications is accurate and complete in terms of the given specifications.
(b) Design calculations for the two specialised analogue integrated circuits are correct with respect to given parameters and data sheet formulae.
(c) Construction and testing of a simple system based on each of the analogue integrated circuits is complete and correct in terms of the given specification.
(d) Calculations involving power gain in a cascaded system are correct in terms of absolute and relative logarithmic power levels.

RANGE STATEMENT

The range for this outcome is fully expressed in the performance criteria.

EVIDENCE REQUIREMENTS

It is intended that the student selects or is given two specialised analogue integrated circuits to investigate.

PC (a) Written evidence to demonstrate the student's understanding of how the principles of operation of each of the two devices relate to its application.
PC (b) A correct solution for each device.
PC (c) Performance evidence that the student can construct and test circuits involving each device.
PC (d) Written evidence to demonstrate competence in the use of logarithmic units of power (relative and absolute).

OUTCOME

4. COMPARE METHODS OF ANALOGUE-TO-DIGITAL AND DIGITAL-TO-ANALOGUE CONVERSION

PERFORMANCE CRITERIA

(a) Comparisons of the distinguishing features of the principal types of converter are correct in terms of the device's principle of operation.
(b) Terminology is accurately explained and applied.
(c) Selection of a converter type is appropriate for a given application.

RANGE STATEMENT

Analogue-to-digital converter:	single slope; dual slope; successive approximation; flash.
Terminology:	conversion time; conversion rate; conversion code; resolution; settling time; quantization error; nominal full-scale output; missing codes.

EVIDENCE REQUIREMENTS

Written or written and oral evidence to demonstrate the candidate’s understanding of the criteria across the ranges of PCs (a), (b) and (c).

MERIT

To gain a pass in this unit, a candidate must meet the standards set out in the outcomes, performance criteria, range statements and evidence requirements.

To achieve a merit in this unit, a candidate must demonstrate a superior or more sophisticated level of performance. In this unit this might be shown in the following ways:

(a) Demonstrating an ability to use a number of different performance criteria in an integrative way (e.g. to solve problems that are more complex than are necessary to demonstrate the achievement of the individual performance criteria).

(b) Using the individual performance criteria in a creative way to solve unfamiliar problems, (i.e. is able to transfer a competence gained in one situation to be related but unfamiliar situation).

(c) Demonstrating a critical awareness of the significance of the practical exercise to the theory and development of the subject.

ASSESSMENT

In order to achieve this unit, candidates are required to present sufficient evidence that they have met all the performance criteria for each outcome within the range specified. Details of these requirements are given for each outcome. The assessment instruments used should follow the general guidance offered by the SQA assessment model and an integrative approach to assessment is encouraged. (See references at the end of support notes.)

Accurate records should be made of the assessment instruments used showing how evidence is generated for each outcome and giving marking schemes and/or checklists, etc. Records of candidates' achievements should be kept. These records will be available for external verification.

SPECIAL NEEDS

Proposals to modify outcomes, range statements or agreed assessment arrangements should be discussed in the first place with the external verifier.

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SUPPORT NOTES

Unit Number

Unit Title ANALOGUE CIRCUITS

SUPPORT NOTES:

This part of the unit specification is offered as guidance. None of the sections of the support notes is mandatory.

NOTIONAL DESIGN LENGTH:

SQA allocates a notional design length to a unit on the basis of time estimated for achievement of the stated standards by a candidate whose starting point is as described in the access statement. The notional design length for this unit is 80 hours. The use of notional design length for programme design and timetabling is advisory only.

CONTENT/CONTEXT

Corresponding to the outcomes:

1. (b) The 741 op amp is a good model.

2. (a) The standard feedback equation is . $A_f = \frac{A_f}{1 + AB}$

As a function of frequency it becomes $A_f(\omega) = \frac{A_f}{1 + \frac{\omega}{\omega_c}}$

Where A is the open loop gain, A_f the closed-loop gain and ω_c a system parameter.

The simplification $A_f = \frac{1}{B}$ should be justified and applied to practical circuits.

Gain and phase/frequency responses should be plotted for the complex equation and it should be demonstrated that gain can be traded for bandwidth.

The conditions required for positive and negative feedback identified.

Manufacturers' supply evaluation copies of emulation software on CD-ROM or on the internet.

3. Possible example of specialised integrated circuits include timers, phase-locked loops, multipliers, comparators, instrumentation amplifiers, audio amplifiers and pre-amplifiers, rf amplifiers, sample and hold amplifiers, multiplexer amplifiers, voltage-to-frequency and frequency-to-voltage converters, waveform generators,

4. An analysis of the operation of the R-2R ladder DAC should be given. A simple block diagram treatment of ADC techniques should include counter-ramp comparator, dual-ramp integration, successive-approximation and flash conversion.

REFERENCES

1. Guide to unit writing.
2. For a fuller discussion on assessment issues, please refer to SQA's Guide to Assessment.
3. Information for centres on SQA's operating procedures is contained in SQA's Guide to Procedures.
4. For details of other SQA publications, please consult SQA's publications list.