Unit 5014: Analogue Electronic Systems

Unit Code: **M/651/0868**

Level: **5**

Credits: **15**

Introduction

Analogue electronic systems are still widely used for a variety of very important applications and this unit explores some of the specialist applications of this technology.

The aim of this unit is to further develop students' understanding of the application of analogue devices in the design of electronic circuits. Students will investigate the design and testing of electronic systems based on a sound theoretical knowledge of the characteristics of electronic devices supported by Electronic Computer Aided Design (ECAD) tools, and then construct and test sample physical circuits. Students will be able to explain the characteristics of analogue and digital subsystems and the representation and processing of information within them.

Upon completion of this unit students will be aware of techniques employed in the design and evaluation of analogue subsystems used in the development of complete electronic systems.

Learning Outcomes

By the end of this unit a student will be able to:

LO1 Analyse single stage analogue amplifier circuits to predict and measure, by simulation, the gain, frequency response and input and output resistances

LO2 Develop functional subsystems through an understanding of the characteristics of operational amplifiers

LO3 Assess techniques for the conversion of signals between analogue and digital formats

LO4 Design electronic circuits using physical components.

Essential Content

LO1 **Analyse single stage analogue amplifier circuits to predict and measure, by simulation, the gain, frequency response and input and output resistances**

Bipolar Junction Transistor models:

The theory of operation of the Bipolar Junction Transistor (BJT), together with DC biasing conditions of BJT for linear amplifier applications

Characteristics of common emitter, common collector and common base amplifier configurations

DC h_{FE} and small signal common emitter h-parameter model and the common emitter hydrid-π model of the BJT

Show g_m =~ I_C/26mV for silicon BJT at room temperature.

Bipolar Junction Transistor small signal amplifiers:

Four-resistor BJT common-emitter amplifier analysis and its predicted DC and AC voltage gain

ECAD tools to be used to determine the mid-band voltage gain and input and output resistances.

The effect of input, output and emitter decoupling capacitors and tuned L-C collector load.

Bipolar Junction Transistor large signal amplifiers:

Class A, B, AB, C and D amplifiers and applications

Use of ECAD to investigate the characteristics of a sample power amplifier circuit to include frequency response.

Field Effect Transistor models:

The theory of operation of the Field Effect Transistor (FET) and the Metal Oxide Semiconductor FET (MOSFET)

Application of FETs and MOSFETs in switching circuits and linear amplifiers, including complementary MOSFET stages

Apply FET AC equivalent circuit models

Examples of specific applications of FET that have been developed for specialist applications

Use of ECAD tools, to simulate and analyse the behaviour of switching and linear amplifier circuits.

LO2 **Develop functional subsystems through an understanding of the characteristics of operational amplifiers**

Operational amplifier:

Components and characteristics

Circuit configuration and operation

Ideal operational amplifier model, specifications of practical operational amplifiers

Characteristics of the operational amplifier with negative feedback applied.

Operational amplifier applications:

Description of a range of subsystems, including the voltage comparator, linear voltage regulator, switched mode voltage regulator, differentiator, integrator, active filters, Schmitt trigger and Schmitt oscillator

Sub-system specifications and evaluations in time and frequency domains, as appropriate

Use of ECAD tools to simulate and analyse the behaviour above listed circuits.

LO3 **Assess techniques for the conversion of signals between analogue and digital formats**

The characteristics of information represented electronically:

Comparison of the implications of capturing, processing and storing information represented by analogue signals and by digital data, including amplitude range, frequency range, accuracy, resolution, linearity, drift, noise and signal-to-noise ratio.

Digital to analogue convertors (DAC) and analogue to digital converters ADC):

Evaluation and comparison of digital to analogue converters using calculations and simulation based on the binary weighted resistor, the R/2R ladder network techniques, successive approximation, segmented configuration, to also include an introduction to delta-sigma convertor

Evaluate and compare of analogue to digital converters based on the single ramp, successive approximation and parallel comparator (flash) techniques, sigma-delta and delta-sigma

Examples of commercially available converters and the implementation of analogue input and output ports to digital processing devices found within embedded systems.

LO4 **Design electronic circuits using physical components**

Sub-system design, implementation, and evaluation:

Examples of electronic subsystems

Development of specifications to achieve a predefined function Design the circuits to achieve this function including components selection (resistors, capacitors, inductors, transistors, diodes, op-amps, sensors, and connectors) as well as input and output signals to be used for circuit testing in simulation and bench testing

Simulation of design using ECAD tools

Implementation, integration, and evaluation aspects

Building of circuits as designed, application of a range of appropriate bench tests to evaluate its operation, and comparing its actual operation to the design specifications and the simulation results.

Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Analyse single stage analogue amplifier circuits to predict and measure, by simulation, the gain, frequency response and input and output resistances</td><td rowspan="2">D1 Propose and implement justified and operable recommendations for changes to the specifications of the circuits and repeat the simulation to produce improved results.</td></tr>
<tr><td>P1 Analyse key aspects of single stage amplifier circuits through calculations and simulation to produce input and output waveforms.</td><td>M1 Discuss assumptions and discrepancies between simulation results and circuit calculations.</td></tr>
<tr><td colspan="2">LO2 Develop functional subsystems through an understanding of the characteristics of operational amplifiers</td><td rowspan="2">D2 Communicate to specialist audiences the use of manufacturers’ data sheets, including critical parameters for component selection in practical circuits design.</td></tr>
<tr><td>P2 Develop the key components of an operational amplifier configuration with negative feedback.

P3 Determine the operation of subsystems from the ideal model of the operational amplifier and by simulation for a range of input signals.</td><td>M2 Design operational amplifier subsystems simulated in time and frequency domains.

M3 Critically analyse simulation results with reference to the expected results.</td></tr>
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Pass	Merit	Distinction
LO3 Assess techniques for the conversion of signals between analogue and digital formats		
P4 Assess the limitations of representing information in both analogue and digital form. **P5** Specify the technical characteristics of converters in terms of meeting a given set of requirements.	**M4** Evaluate the characteristics and the limitations of specific converter topologies and their example applications.	**D3** Create a given range of DAC circuit simulations to critically evaluate the implications of resolution and conversion time on accuracy and noise.
LO4 Design electronic circuits using physical components		
P6 Design an electronic circuit supported by a written description. **P7** Simulate a working electronic circuit using a set of chosen components. **P8** Construct and test the design on the bench with a justification of the testing method.	**M5** Critically analyse design equations, simulation, and bench test results ensuring discrepancies are recorded and explained using graphical representation.	**D4** Present circuit designs to specialist audiences, showing the variation of circuit function in simulations as a result of design changes or component tolerances.

Recommended Resources

Note: See HN Global for guidance on additional resources.

Print Resources

Bird Jo. (2022) *Bird's Electrical Circuit Theory and Technology*. 7th Ed. Routledge

Bishop 0 (2021) *Electronics: A First Course*. 3rd Ed. Routledge.

Bugg D.V. (2021) *Electronics: Circuits, Amplifiers and Gates*. 2nd Ed. CRC Press.

Makarov S., Ludwig, R. and Bitar, SJ. (2019) *Practical Electric Engineering.* 2nd Ed. Springer

Lathi B.P. and Zhi D. (2009) *Modern Digital and Analog Communications Systems. Oxford Series in Electrical and Computer Engineering.* 4th Ed. Oxford University Press.

Storey N. (2013) *Electronics: A Systems Approach*. 5th Ed. Pearson.

Journals

Note: Example journals listed below provide a broad range of articles related to unit content and those relevant for the qualification. Staff and students are encouraged to explore these journals and any other suitable journals to support the development of academic study skills, and subject specific knowledge and skills as part of unit level delivery.

Analogue Design Journal

Analog Integrated Circuits and Signal Processing

IEEE Transactions on Circuits and Systems II

Links

This unit links to the following related units:

Unit 4019: Electrical and Electronic Principles

Unit 4022: Electronic Circuits and Devices

Unit 5019: Further Electrical, Electronic and Digital Principles.

