Unit 47: Analogue Electronic Systems

Unit code F/615/1515

Unit level 5

Credit value 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 and digital 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 and digital subsystems used in the development of complete electronic systems.

Learning Outcomes

By the end of this unit students will be able to:

1. Design single stage analogue amplifier circuits to predict and measure, by simulation, the gain, frequency response and input and output resistances.
2. Develop functional subsystems through an understanding of the characteristics of operational amplifiers.
3. Examine the characteristics of information represented in analogue and digital format to assess techniques for the conversion of signals between analogue and digital formats.
4. Design electronic circuits using physical components.

Essential Content

LO1 **Design 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 and its predicted AC voltage gain

ECAD 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:

Examples of class A, B, AB, C and D large signal amplifiers

Use of ECAD to investigate the characteristics of sample power amplifier circuits

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

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

Operational amplifier components:

Circuit configuration and the operation of the long-tailed pair differential amplifier, current mirror and class AB amplifiers and relate these to circuits of operational amplifiers published in manufacturers' data sheets

Operational amplifier characteristics:

Characteristics of practical operational amplifiers, including open loop gain, input offset voltage, common mode input range, saturated output levels, slew rate and gain-bandwidth product

Describe the ideal operational amplifier model and relate these to the 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, inverting and non-inverting amplifier, summing amplifier, differential amplifier, linear voltage regulator, switched mode voltage regulator, differentiator, integrator, filters, sinusoidal oscillator, Schmitt trigger and Schmitt oscillator

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

Use of ECAD tools

LO3 **Examine the characteristics of information represented in analogue and digital format to 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 and analogue to digital converters:

Evaluation and comparison of digital to analogue converters based on the binary weighted resistor and the R/2R ladder network techniques

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

Advantages of using non-linear conversion curves in communications applications. Techniques for multichannel operation using multiplexing and de-multiplexing techniques applied to both digital and analogue channels

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 useful function and design of circuits to achieve this function

Simulation of design using ECAD tools

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

Pass	Merit	Distinction
LO1 Design single stage analogue amplifier circuits to predict and measure, by simulation, the gain, frequency response and input and output resistances		**D1** Critically analyse the relationship between the circuit design and simulation results, making justified and operable recommendations for changes to the specifications of the circuits
P1 Design single stage amplifier circuits and measure key aspects by simulation	**M1** Relate simulation results to circuit designs and analyse discrepancies	
LO2 Develop functional subsystems through an understanding of the characteristics of operational amplifiers		**D2** Communicate circuit designs to specialist audiences The implications of manufacturers' data sheets are understood so that practical designs can be produced
P2 Present the key components of operational amplifiers **P3** Determine the operation of subsystems from the ideal model of the operational amplifier and by simulation results	**M2** Design operational amplifier subsystems simulated in time and frequency domains **M3** Critically analyse simulation results with reference to the expected results	

Pass	Merit	Distinction
LO3 Examine the characteristics of information represented in analogue and digital format to assess techniques for the conversion of signals between analogue and digital formats		**D3** Critically evaluate the implications of resolution, conversion time and non-linear conversion curves on accuracy and noise
P4 Examine the limitations of representing information in both analogue and digital form **P5** Specify the technical characteristics of converters to meet a given set of requirements	**M4** Critically evaluate the characteristics and the limitations of converter topologies and their specific applications	
LO4 Design electronic circuits using physical components		**D4** Communicate circuit designs to specialist audiences, showing variation of circuit function in simulations as a result of design changes or component tolerances
P6 Design an electronic circuit **P7** Simulated construct and test the design on the bench	**M5** Critically analyse design equations, simulation and bench test results, ensuring discrepancies are recorded and explained	

Recommended Resources

Textbooks

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.

Links

This unit links to the following related units:

Unit 19: Electrical and Electronic Principles