Engineering Tripos Part IB, 2P5: Analysis of Circuits and Devices, 2018-19

Lecturers

Prof Tim Wilkinson [1]

Timing and Structure

10 lectures, 2 lectures/week weeks 1-5

Aims

The aims of the course are to:

- Understand the operation of the bipolar transistor as a linear amplifier.
- Understand the principle of negative feedback and the effects of its application.
- Understand the concept and practical realization of an operational amplifier and be familiar with the use of operational amplifiers in feedback circuits.
- Appreciate the special considerations involved in output stages which are required to supply appreciable power.
- Understand how oscillators can be realized using linear circuits and other means.

Objectives

As specific objectives, by the end of the course students should be able to:

- Know how to bias a bipolar transistor to a suitable operating point for linear amplification and how to construct a load line through the operating point.
- Be familiar with the small signal equivalent circuit for the bipolar transistor and be able to use it to determine gain, bandwidth and input and output impedances for the common emitter and emitter follower (common collector) circuit configurations.
- Be able to analyse the long-tailed pair circuit and to understand its importance in practical differential and operational amplifiers.
- Know how to apply negative feedback to an operational amplifier and calculate the effects on gain, bandwidth and input and output impedances.
- Be able to relate the departures from ideality of practical operational amplifiers to the use of the long-tailed pair circuit.
- Know how to use operational amplifiers to make simple circuit elements, namely difference amplifiers, adders, integrators and differentiators.
- Be able to configure a simple oscillator using a linear amplifier and a feedback network.
- Understand how a hysteresis switch and a timing network can be used to make a relaxation oscillator.
- Be able to set up a basic complementary emitter follower, or source follower, output stage for a power amplifier
- Know the conditions for class A, AB and B operation of a power amplifiers, and the effect on efficiency and linearity.

Content

Bipolar Transistor - Device & Circuits (2L)

- Biasing & load lines. *(1) 83-91 (2) 560-565*

- Small signal equivalent circuit. *(1) 91-100 (2) 600-601*
- Emitter (source) follower. *(1) 100-104, 60-62 (2) 642-644*
- Input & output impedance of CE and CC configurations. *(1) 96-98, 100-104*

Operational Amplifier Circuits (5L)

- The long-tailed pair as an input circuit to an OpAmp (both FET and BJT)
- Differential gain and common mode rejection ratio (long-tailed pair). *(1) 140-146 (2) 536-538*
- Negative feedback theory, gain = A/1+AB. *(1) 164-181 (2) 636-641*
- Input & output impedance with & without feedback. *(1) 121-126 (2) 528-529*
- Stabilisation of gain, increasing bandwidth and reducing distortion.
- Revision of Ideal operational amplifiers *(1) 114-128, 526 (2) 518-520*
- Effects of input bias and offset currents, offset voltages. *(1) 146-151 (2) 528-539*
- The non-ideal OpAmp
- Voltage follower, adding, integrating & differentiating amplifiers. *(1) 128-132 (2) 526-529*

Oscillators (1.5L)

- Instability, AB = -1, positive feedback.
- Oscillators using linear circuits. (2) 574-576
- Relaxation oscillators

Power Amplifier Stages (1.5L)

- Emitter or source follower, power output and efficiency. *(2) 574-576*
- Complementary transistor output stage.
- Classes A, AB and B.

REFERENCES

(1) AHMED, H. & SPREADBURY, P.J. ANALOGUE AND DIGITAL ELECTRONICS FOR ENGINEERS
(2) SMITH, R.J. & DORF, R.C. CIRCUITS, DEVICES AND SYSTEMS

Booklists

Please see the Booklist for Part IB Courses [2] for references for this module.

Examination Guidelines

Please refer to Form & conduct of the examinations [3].

UK-SPEC

This syllabus contributes to the following areas of the UK-SPEC [4] standard:

Toggle display of UK-SPEC areas.

GT1

Develop transferable skills that will be of value in a wide range of situations. These are exemplified by the Qualifications and Curriculum Authority Higher Level Key Skills and include problem solving, communication, and working with others, as well as the effective use of general IT facilities and information retrieval skills. They also include planning self-learning and improving performance, as the foundation for lifelong learning/CPD.

IA1

Apply appropriate quantitative science and engineering tools to the analysis of problems.

IA3

Comprehend the broad picture and thus work with an appropriate level of detail.

KU1

Demonstrate knowledge and understanding of essential facts, concepts, theories and principles of their engineering discipline, and its underpinning science and mathematics.

KU2

Have an appreciation of the wider multidisciplinary engineering context and its underlying principles.

E1

Ability to use fundamental knowledge to investigate new and emerging technologies.

E2

Ability to extract data pertinent to an unfamiliar problem, and apply its solution using computer based engineering tools when appropriate.

E3

Ability to apply mathematical and computer based models for solving problems in engineering, and the ability to assess the limitations of particular cases.

P1

A thorough understanding of current practice and its limitations and some appreciation of likely new developments.

P3

Understanding of contexts in which engineering knowledge can be applied (e.g. operations and management, technology, development, etc).

US1

A comprehensive understanding of the scientific principles of own specialisation and related disciplines.

US3

An understanding of concepts from a range of areas including some outside engineering, and the ability to apply them effectively in engineering projects.

US4

An awareness of developing technologies related to own specialisation.

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Links
[1] mailto:tdw13@cam.ac.uk
[2] https://www.vle.cam.ac.uk/mod/book/view.php?id=364081&chapterid=43731
[3] https://teaching18-19.eng.cam.ac.uk/content/form-conduct-examinations
[4] https://teaching18-19.eng.cam.ac.uk/content/uk-spec