Engineering Tripos Part IA, 1P3: Analysis of Circuits and Devices, 2024-25

Course Leader

Prof T D Wilkinson [1]

Lecturer (Analsys of Circuits)

Prof T D Wilkinson [1]

Lecturer (AC Power)

Prof S Goetz [2]

Timing and Structure

Weeks 3-8 Michaelmas term and weeks 1-3 Lent term. 22 lectures, (16 on AC circuits (TW), 4 on AC power (FU), 2 lectures/week, in Michaelmas term, 3/week in Lent term.

Aims

The aims of the course are to:

- Teach students how electrical and electronic circuits are analysed, how field effect transistors and amplifiers operate, how real and reactive power flows in a.c. circuits, and to teach basic transformer theory.

Objectives

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

- Ohm's law, ideal voltage and current sources, Thevenin and Norton theorems and Kirchhoff's laws in DC circuit analsys (Lectures 1-2)
- Power is transferred from a source to a load and how any network can be represented by a Thevenin or a Norton source.(Lecture 3).
- Complex numbers in the analysis of AC circuits leading to impedance. Resonance, Q-factor in electronic circuits.(Lectures 4-5).
- Analyse AC circuits including gain, frequency response, and impedances of AC circuits.(Lectures 6).
- Introduce the amplifier model to determine gain, input and output impedance. Bode plots and frequency response (7-8)
- Understand how doped semiconductors can produce p-type and n-type, introduce the p-n junction diode. (Lecture 9)
- Know the principles of operation of the Metal Oxide Semiconductor Field Effect Transistor (MOSFET).(Lecture 10)
- Know how an equivalent circuit for a MOSFET can be used to determine the small-signal performance of the circuits.(Lectures 11-13).
- Introduction to ideal operational amplifiers (Op Amps) and examples of useful circuits (Lectures 14-26).
- The concepts of real, reactive and apparent power, and power factor, power factor correction of AC loads (FU Lectures 1-2)
- The principles of the transformer, and the development and use of its equivalent circuit. (FU Lectures 3-4)

Content

- Mesh and nodal analysis *(1) 34 - 39*
- Thevenin's and Norton's theorems, superpositions. *(1) 50 - 57*
- Alternating current circuits:
- Techniques, impedance and complex analysis. *(1) 151-163 (1) 263- 264*
- Circuits containing R,L and C. Resonance. *(1) 220-231*
- Power in resistive loads, r.m.s. quantities. *(1) 79*
- D.C. characteristics of:
- Diodes *(1) 340 - 348 (2) 36 - 41*
- Field effect transistors (MOSFET) *(1) 362 - 367 (2) 62 - 66*
- Operating point, load line and graphical analysis of common source amplifier. *(1) 556 - 559 (2) 48 52*
- Amplifiers as building blocks, decibels, mid-band gain, bandwidth, multistage amplifiers and coupling. *(1) 630 - 632 (2) 1 - 22*
- Linearised model of the MOSFET. *(1) 591 - 595 (2) 52 - 54*
- Common source amplifier *(2) 54 - 60*
- Operational amplifiers, ideal characteristics, inverting and non-inverting configurations. *(1) 518 - 53 (2) 114 - 137*
- A.C. Power Flow *(1) 205-213 (3) 7-12*
- Real power (Watts), reactive power (VARs), apparent power, power factor and its correction.
- Use of power and reactive power to solve a.c. circuits.
- Single-phase Transformers *(1) 690 - 710 (3) 67-78*
- Principles of operation.
- Development and use of transformer equivalent circuit.

INTEGRATED ELECTRONICS PROJECT (IEP)

The lecture course is run in conjunction with the integrated electronics project (IEP) series of practical exercises. A kitset of components will be provided along with a PicoScope which will allow experiments to be run in parallel with lectures and examples sheets. These will also tie in with LTSpice simulations and experiments performed in the lectures.

See the IEP Moodle page [3]

REFERENCES

(1) AHMED, H. & SPREADBURY, P.J. ANALOGUE AND DIGITAL ELECTRONICS FOR ENGINEERS
(2) BRADLEY, D. BASIC ELECTRICAL POWER AND MACHINES
(3) HOROWITZ, P & HILL, W. THE ART OF ELECTRONICS
(4) SMITH, R.J. & DORF, R.C. CIRCUITS, DEVICES AND SYSTEMS
(5) WARNES, L.A.A. ELECTRONICS AND ELECTRICAL ENGINEERING

Examples papers

- 3/1 on Lectures 1-4
- 3/2 on Lectures 5-8
- 3/3 on Lectures 9-12 (lectures 9 & 10 are before Christmas, 11 & 12 are after Christmas)
- 3/4 on Power lectures
- 3/5 on Lectures 13-18

Booklists

Please refer to the Booklist for Part IA Courses for references to this module, this can be found on the associated Moodle course.

Examination Guidelines

Please refer to Form & conduct of the examinations [4].

UK-SPEC

This syllabus contributes to the following areas of the UK-SPEC [5] 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.

E4

Understanding of and ability to apply a systems approach to engineering problems.

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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[5] https://teaching24-25.eng.cam.ac.uk/content/uk-spec