Engineering Tripos Part IA, 1P3: Analysis of Circuits and Devices, 2018-19

Lecturers

Prof T D Wilkinson, Dr F Torrisi, Prof F Udrea [1]

Timing and Structure

Weeks 3-8 Michaelmas term and weeks 1-3 Lent term. 22 lectures, (18 on linear circuits (CD), 4 on power flow (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:

- Know how Ohm's law, the concepts of ideal voltage and current sources, and Thevenin's and Norton's theorems are used by electrical engineers to calculate currents and voltages in d.c. and a.c. circuits. To explain Kirchhoff's voltage and current laws and
- Know how power is transferred from a source to a load and how any network can be represented by a Thevenin or a Norton source.(Lecture 4).
- Understand how semiconductors can be doped to produce p-type and n-type semiconductors, introduce the p-n junction diode. (Lectures 5 & 6).
- Know the principles of operation of the Field Effect Transistor (FET).(Lectures 6 - 8)
- Use complex numbers in the analysis of a.c. circuits and keep track of amplitude and phase simultaneously. Understand the importance of resonance and resonant frequency in electronic circuits.(Lectures 9-12).
- Know how an equivalent circuit for an FET can be used in transistor circuits to determine the small-signal performance of the circuits.(Lectures 13-14).
- Calculate the gain, frequency response, and input and output impedances of amplifier circuits.(Lectures 15-16).
- Introduction to operational amplifiers (Op Amps), and understand how feedback can be used in amplifier circuits to improve frequency response, gain stability and output and input impedances. (Lectures 17-18).
- Understand the concepts of real, reactive and apparent power, and power factor, the importance of power factor correction of a.c. loads, the principles of operation of the transformer, and the development and use of its equivalent circuit.

Content

- Mesh and nodal analysis *(1) 34 - 39*
- Thevenin's and Norton's theorems, superpositions. *(1) 50 - 57*
- 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*

- Alternating current circuits:
- Techniques, impedance, admittance, phasors, mutual inductance. *(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*
- Amplifiers as building blocks, decibels, mid-band gain, bandwidth, multistage amplifiers and coupling. *(1) 630 - 632 (2) 1 - 22*
- Linearised models of F.E.T. *(1) 591 - 595 (2) 52 - 54*
- Common source amplifier *(2) 54 - 60*
- Operational amplifiers, characteristics, feedback, 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.

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 see the Booklist for Part IA Courses [2] for module references.

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.

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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[2] https://www.vle.cam.ac.uk/mod/book/view.php?id=364071&chapterid=41981
[3] https://teaching.eng.cam.ac.uk/content/form-conduct-examinations
[4] https://teaching.eng.cam.ac.uk/content/uk-spec