Engineering Tripos Part IIA, 3B1: Radio Frequency Electronics, 2020-21

Leader

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Lecturer

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Lab Leader

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Timing and Structure

Michaelmas term. 16 lectures.

Aims

The aims of the course are to:

- Give an introduction to circuit architecture, operation and design techniques used for signals ranging from the audio range up to microwave frequencies ie. kHz – GHz.
- Introduce some material on antenna operation and design, which form a key part of radio systems.

Objectives

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

- Understand the various characteristics of transistors including high frequency effects and circuit techniques which exploit them.
- Explain the Miller effect and how it influences the frequency response.
- Design basic multiple transistor circuits and to calculate their output and input impedances.
- Know the disadvantages and advantages of positive feedback.
- Explain how to make single and variable frequency oscillators.
- Design simple RF impedance matching circuits including the use of Smith charts.
- Understand the architecture and circuits used in radio applications and be able to design simple functional blocks.

Content

Modern communication products such as radios, mobile ‘phones and GPS receivers utilise circuitry which operates at very high frequencies; this module will introduce circuit architecture, operation and design techniques used for signals ranging from the audio range up to microwave frequencies ie. kHz – GHz.

- Transistor characteristics and circuit design: JFET, MOSFET and Bipolar devices. High frequency performance and the Miller Effect, input and output impedances.

- Multiple transistor circuits: cascaded amplifiers, current sources and differential amplifiers.
- Filters: operational amplifier VCVS filters, resonant circuits, gyrators, ceramic.
- Oscillators: relaxation, Wein Bridge, resonant – negative impedance, Colpitts, quartz crystal, voltage controlled oscillators, phase locked loop.
- Impedance matching: LC circuits, transformers, transmission line.
- Radio architecture: 'crystal set', Superhet, digital radio.
- Mixer circuits: simple diode, Gilbert cell, diode ring, dual gate MOSFET.
- Modulation and demodulation schemes: AM, FM, PSK, FSK and circuits: F-V, V-F, diodes, multipliers, PLL.
- Microwave circuit techniques: microstrip and stripline, characteristic impedance, s & z parameters, Smith chart.
- Directional couplers and cirulators.
- Antenna principles and design: dipole, microstrip patch, helical, array antennas.

Coursework

The module is accompanied by the lab experiment: 'Superhet radio' situated in the Electrical and Information Engineering Teaching Laboratory (EIETL).

Superhet Radio Experiment

Learning objectives:

- To how key elements of the superheterodyne radio architeture operate by characterising them individually
- Appreciate how the circuit blocks are connected and how the radio operates
- To gain further experience of using laboratory equipment and instruments
- See how the performance of a superhet architecture compares to that of a tuned RF circuit, as made in the IEP

Practical information:

- Sessions will take place in the EIETL, during week(s) 1-8.
- This activity involves a little bit of preliminary work (15 mins.) reading through the lab. sheet before the session.
- Bring a digitial camera / phone along to the lab. to record oscilloscope traces etc. for your report.

Full Technical Report:

Students will have the option to submit a Full Technical Report.

Booklists

Please refer to the Booklist for Part IIA 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 [2].

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