

## **Engineering Tripos Part IIA, 3B1: Radio Frequency Electronics, 2022-23**

### **Leader**

[Dr P Robertson](#) [1]

### **Lecturers**

Dr P Robertson, Dr M Crisp

### **Lab Leader**

Dr P Robertson

### **Timing and Structure**

Michaelmas term. 16 lectures, delivered in person. Lecture recordings will also be available via Panopto.

### **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 circulators.
- 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 architecture 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 digital 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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**Links**

[1] <mailto:par10@cam.ac.uk>

[2] <https://teaching.eng.cam.ac.uk/content/form-conduct-examinations>