RF SYSTEMS AND CIRCUIT DESIGN - 2024/5

Module code: EEEM044

Module Overview

IMPORTANT: The second assessment pattern is only applicable to the MSc Short Course Students

Expected prior learning: EEE3033 – RF and Microwave Fundamentals, or equivalent learning.

Module purpose: Advanced communications systems and radar operate at RF and microwave frequencies. The design principles and circuit operation, underlying these systems, are quite different from those of electronics used in signal processing at baseband frequencies. This module will cover the key elements of RF and microwave system design as well as analysis concepts for a range of commonly used active circuits, including: oscillators, frequency synthesisers, amplifiers and mixers. The module will also cover the circuit design and operation of non-linear devices used in active circuits together with deployment considerations. This module will include and build on many of the concepts studied in EEE3033 RF and Microwave Fundamentals and address further advanced features of non linear RF devices and system optimisation. It is complementary to EEEM064 Microwave Design Techniques and also EEEM006 Antennas and Propagation.

Module provider

Computer Science and Electronic Eng

Module Leader

BROWN Tim (CS & EE)

Number of Credits: 15

ECTS Credits: 7.5

Framework: FHEQ Level 7

Module cap (Maximum number of students): N/A

Overall student workload

Independent Learning Hours: 59

Seminar Hours: 7

Tutorial Hours: 7

Laboratory Hours: 11

Guided Learning: 21

Captured Content: 45

Module Availability

Semester 1

Prerequisites / Co-requisites

None.

Module content

Indicative content includes the following:

- Revision of prerequisite background material, including: S-parameters, decibel scale, transmission line theory, smith charts.
- Functionality and structure of RF non-linear circuit components, including: diodes, and field effect transistors.
- RF power amplifier performance, analysis, and design, including: amplifier classes, amplifier stability, non-linearity, intermodulation distortion, adjacent channel interference.
- Oscillator circuit design and operation, including: feedback loops, frequency synthesis, phase noise.
- Single balanced and double balanced active and passive mixer circuit design.
- Role of mixers in RF systems, including up conversion, down conversion.
- RF system considerations, including: dynamic range, link budget analysis, and noise figure calculations.
- Microwave integrated circuits; role, applications, and technology overview.
- RF test and measurement, including: spectrum analysers and network analysers.
- Computer aided RF circuit design laboratories.

Assessment pattern

Assessment type	Unit of assessment	Weighting
Practical based assessment	Laboratory	20
Examination	Examination - 2 hours	80

Alternative Assessment

N/A

Assessment Strategy

Assessment Strategy

The **assessment strategy** for this module is designed to provide students with the opportunity to demonstrate their competence in using fundamentals of RF electronics and applying them to real life problem solving scenarios. This is achieved in part through a computer aided design laboratory (CAD) assessment which the student is required to document in a professional manner.

Thus, the **summative assessment** for this module consists of the following.

- A computer aided design (CAD) laboratory assignment, which follows three weeks of preparation in supervised laboratory sessions.
- Open book written examination, where students can bring one sheet of paper to the exam with their own notes.

Any deadline given here is indicative. For confirmation of exact date and time, please check the assessment calendar issued to you.

- NB: For those studying the 1P version of the module on MSc Electronic Engineering (by short course), the open book written examination, is weighted as 100% of the final mark.

Formative assessment and feedback

For the module, students will receive formative assessment/feedback in the following ways:

- During lectures, by question and answer sessions.
- During lectures, by peer instruction (subject to a large enough class size).
- During tutorials/tutorial classes.
- During supervised computer laboratory sessions.
- Via assessed coursework.

Module aims

- To provide a foundation of knowledge and understanding in the area of active microwave circuit and systems design.
- The module also aims to provide opportunities for students to learn about the Surrey Pillars listed below.

Learning outcomes

Ref		Attributes Developed	
001	Demonstrate knowledge of how to apply RF systems and circuit design concepts in existing and future radio technologies, including use of S-parameters and the decibel scale.	KC	M1, M6
003	Be able to design and analyse circuits containing active non-linear components most commonly used in active RF devices.	CPT	M5
004	Understand how to use and apply data measured with RF test and measurement equipment including network analysers and spectrum analysers.	CPT	M4, M12
002	Recognise commonly used active RF devices and know how to integrate them into systems.	KC	M2, M6
005	Apply circuit and system design within a computer aided design (CAD) simulation and report the outcomes in written form.	KCPT	M3, M16, M17

Attributes Developed

C - Cognitive/analytical

K - Subject knowledge

T - Transferable skills

P - Professional/Practical skills

Methods of Teaching / Learning

The learning and teaching strategy is designed to achieve the following aims:

- To build on and extend knowledge of measurement parameters used in radio frequency (RF) electronics including scattering parameters, link budgets, the decibel scale and amplifier characteristics.

- By using knowledge of measurement parameters, to then determine the capabilities of RF devices in how they support better efficient sustainable systems, while showing actively how to use such knowledge in circuit and system design as real life problem solving.

- To gain competence in RF simulation and test and measurement through which demonstration of knowledge and its use will be evidenced in the assignment tasks set from completing the laboratories.

Learning and teaching methods include the following:

EEEM044 – Short Course Version

- Short course delivery

- Distance learning study, materials provided after course.
- Ad-hoc tutorials to be arranged in person or online with module leader.

EEEM044 – Standard Version

- Seminars
- Tutorials
- Laboratory demonstrations
- Taught material online is provided for each of the weeks where the seminars and laboratory demos occur
- Computer based laboratory sessions. The computer based laboratory sessions will provide an opportunity for the students to learn how to use computer aided design (CAD) software

Indicated Lecture Hours (which may also include seminars, tutorials, workshops and other contact time) are approximate and may include in-class tests where one or more of these are an assessment on the module. In-class tests are scheduled/organised separately to taught content and will be published on to student personal timetables, where they apply to taken modules, as soon as they are finalised by central administration. This will usually be after the initial publication of the teaching timetable for the relevant semester.

Reading list

https://readinglists.surrey.ac.uk
Upon accessing the reading list, please search for the module using the module code: EEEM044

Other information

Sustainability – The design of RF power amplifiers to be efficient and cost effective in their increasingly dense deployment for communications is essential. Students will study the different classes of amplifier and how they can improve efficiency in digital communication systems to support sustainable cities and communities. Overall system efficiency can provide opportunities for self sustaining radio deployments forming usage of cleaner energy solutions.

Digital capabilities – RF engineering requires competence in using design simulators. In this module there are laboratories dedicated to using the Advanced Design System (ADS) which is a state of the art RF design tool. Students will have opportunity to learn the detail of optimising both passive and active circuits and using the Smith chart, as an important design tool for RF engineers used here in a digital form within the simulator.

Employability – Students will learn competencies in many important parameters and ‘bread and butter’ that is applicable to RF test and measurement including use of the decibel scale, scattering parameters, Smith charts and phase noise in order to quantify them on a spectrum analyser. These are key competences for any proficient RF engineer in an employment setting while also this will link together with an ability to apply knowledge of the circuit design of RF active devices to system design and evaluation.

Resourcefulness and resilience – Students will build competence in the knowledge of RF systems and circuits in order to apply these to design and problem solving in the assessment. The written exam will be set specific design tasks both in RF circuits and systems. The assignment will require successful completion of simulations in the laboratories, which will then involve using important complex parameters to interpret system performance and compliance. Advanced learning of the module will enable students to interpret how or why an RF system may or will go wrong and by what means.

Programmes this module appears in

Programme	Semester	Classification	Qualifying conditions
5G and Future Generation Communication Systems MSc	1	Optional	A weighted aggregate mark of 50% is required to pass the module
Electrical and Electronic Engineering MEng	1	Optional	A weighted aggregate mark of 50% is required to pass the module
Electronic Engineering MEng	1	Optional	A weighted aggregate mark of 50% is required to pass the module
Electronic Engineering MSc	1	Optional	A weighted aggregate mark of 50% is required to pass the module
Electronic Engineering with Nanotechnology MEng	1	Optional	A weighted aggregate mark of 50% is required to pass the module
Electronic Engineering with Space Systems MEng	1	Optional	A weighted aggregate mark of 50% is required to pass the module
RF and Microwave Engineering MSc	1	Compulsory	A weighted aggregate mark of 50% is required to pass the module
Satellite Communications Engineering MSc	1	Optional	A weighted aggregate mark of 50% is required to pass the module
Space Engineering MSc	1	Optional	A weighted aggregate mark of 50% is required to pass the module