Module Code	EEU44CRF / EEP55CRF
Module Name	RF Engineering
ECTS credit weighting	5 ECTS
Semester taught	Semester 2
Module Coordinator/s	Justin King
Module Learning Outcomes with embedded Graduate Attributes	On successful completion of this module, students should be able to: LO1: Explain the theoretical principles and limitations of lumped-circuit analysis and the need for distributed-circuit analysis in the context of RF engineering. [PO1(i)] LO2: Analyse, describe, and evaluate a wide range of RF components, circuits, and systems using the appropriate mathematical principles, and apply these principles to ill-defined engineering problems. [PO2(ii), PO2(iii)] LO3: Design complex RF circuits and systems considering the constraints of noise, power budget, efficiency, bandwidth and regulatory requirements. [PO3(i), PO3(iv)] LO4: Design and conduct RF experiments and simulations, applying appropriate standards and calibration procedures, and analyse and interpret the resulting data to draw evidence-based conclusions. [PO3(v), PO4(ii)] LO5: Critically evaluate contemporary research challenges, apply and adapt emerging technologies where appropriate, and develop novel insights into state-of-the-art RF systems design. [PO1(iv), PO2(iv), PO3(i), PO4(iii), PO4(v)]
Module Content	This module introduces students to radio-frequency (RF) engineering with particular emphasis on RF communication systems. Students are introduced to distributed circuit and system analysis from a circuit-theoretic perspective, and how such systems can be engineered to solve RF communication challenges that satisfy specifications relating to return loss, bandwidth, efficiency, noise margin, link budget and power consumption. The fundamental concepts of one-, two- and N-port networks are introduced allowing for the introduction of the scattering parameter (*S*-parameter) formalism

which leads nicely on to the Smith chart nomograph and vector network analysers and their associated calibration.

RF transceivers are introduced using the FM broadcast radio system as an example and motivation for the superheterodyne architecture. Direct conversion (zero-IF) receivers are also discussed. Other key constraints and limiting factors are discussed such as noise, harmonic and intermodulation distortion. Software defined radios are introduced, using the RTL-SDR as an example.

RF transceiver architectures are subsequently explored at the circuit level, with emphasis on the practical implementation of key building blocks.

Contemporary research topics in transistor modelling and simulation are examined, providing students with exposure to emerging developments in the field.

1. Distributed circuits: Transmission Lines, Impedance Matching
2. RF measurement: S-parameters, Smith chart, Vector Network Analysers (VNAs) and Calibration
3. RF systems: Radio Receivers, Radio Transmitters, Distortion, Noise, Software-Defined Radios (SDRs)
4. RF circuits: PLLs, oscillators, RF transistors, Low-Noise Amplifiers, Power Amplifiers.
5. Modelling and Simulation: Introduction to contemporary research topics.

Teaching and Learning Methods

This module will be delivered through lectures, tutorials, and laboratory sessions.

Assessment Details[1]
Please include the following:

- **Assessment Component**
- **Assessment description**
- **Learning Outcome(s) addressed**
- **% of total**
- **Assessment due date**

Assessment Component	Assessment Description	LO Addressed	% of total	Week due
Written Examination	In-person examination	LO1-5	80	Examination Period
Continuous Assessment	Practical Exercises and Laboratory Reports.	LO2, LO4	20	During the semester

Reassessment Requirements

Reassessment Examination.

Contact Hours and Indicative Student Workload[2]

Contact hours:
40 including lectures, tutorials and laboratories.

[1] https://www.tcd.ie/CAPSL/resources/assessment
[2] TEP Guidelines on Workload and Assessment

	Independent Study (preparation for course and review of materials): 60 hours
	Independent Study (preparation for assessment, incl. completion of assessment): 25 hours
Recommended Reading List	RF Circuit Design: Theory and Applications [Second Edition], R. Ludwig and G. Bogdanov, Upper Saddle River, 2009. Microwave Engineering [Fourth Edition], D. Pozar, Wiley, 2012.
Module Pre-requisite	Electronic Analysis (KVL, KCL, RLC circuits, phasor analysis, filters e.g. EEU11E06 and EEU22E06). Electronic Circuits (amplifiers, small-signal analysis e.g. EEU33C13). Communication Theory (modulation, AM / FM spectra, e.g. EEU33C05). Digital Communications (e.g. EEU44C18/EEP55C28) would be an advantage but is not required.
Module Co-requisite	
Module Website	
Are other Schools/Departments involved in the delivery of this module?	
Module Approval Date	
Approved by	Prof. Naomi Harte
Academic Start Year	September 2026
Academic Year of Date	2026/27