University of Macau

Faculty of Science and Technology

Department of Electrical and Electronics Engineering

Part A: Course Outline

Course Title:	Introduction to Radio-Frequency Circuits and Systems		
Course Code:	ECEB366	Year of Study:	3
Compulsory/Elective:	Elective		
Course Prerequisites:	none		
Prerequisite Knowledge	Circuit analysis, analog integrated circuits, basic MOSFET operation		
Class/Laboratory Schedule:	2-hour lecturer, and 2-hour tutorial and/or laboratory per week		
Duration	One semester	Credit Units	3
Text Books and References:	Behzad Razavi, RF Microelectronics, 2nd Edition, Prentice Hall, 2011 [ISBN-10: 0137134738; ISBN-13: 978-0137134731]		
Course Description:	This course covers the circuit and system design of modern CMOS radio-frequency (RF) receivers and transmitters. The system performance metrics, circuit performance metrics and figure-of-merits are introduced. Design examples from practical applications such as GSM, WCDMA, WLAN or GPS are included. The course includes design and simulation projects with CMOS technologies. Students will gain the basic understanding of RF integrated circuits design as well as familiar with the necessary design and simulation tools.		
Topics Covered	Introduction to RF and wireless technology, basic concepts in RF design, communication concepts, transceiver architectures and circuits such as low-noise amplifiers, mixers, etc.		
Course Objectives:	1. To educate students fundamental RF circuit and system design skills [a, e, k] 2. To introduce students the basic RF electronics utilized in the industry and how to build up a complex RF system from basis [a, e, k] 3. To offer students experience on designing and simulating RF circuits in computer [a, b, c, d, e, k]		
Course Assessment:	Quiz : 20% Simulation project: 30% Final Exam : 50%		
Relationship to Program Objectives and Outcomes	This course primarily contributes to ECE program outcomes that develop students abilities to: a. Ability to apply knowledge of mathematics, science and engineering. e. Ability to identify, formulate and solve engineering problems. k. Ability to use the techniques, skills and modern engineering tools necessary for engineering practice. This course secondarily contributes to ECE program outcomes that develop students abilities to:		

<table>
<tr><td></td><td>b. Ability to design and conduct simulations and experiments.
c. Ability to design a system, component or process to meet desired needs.
d. Ability to function on multidisciplinary teams.</td></tr>
<tr><td>Course Contents and Relationship to Program Criteria:</td><td>
<table>
<tr><th>Week no.</th><th>Topics</th><th>Program Criteria</th></tr>
<tr><td>1</td><td>Introduction to RF and wireless technology
The big picture of wireless industry, the history and state-of-the-art wireless circuits in wide type of electronics systems, the fundamental challenges of systematic circuit design in CMOS technologies,</td><td>ES</td></tr>
<tr><td>2.5</td><td>Basic Principles in RF Design
Units in RF Design, Time Variance, Nonlinearity, Effects of Nonlinearity, Harmonic Distortion, Gain Compression, Cross Modulation, Intermodulation, Cascaded Nonlinear Stages, AM/PM Conversion, noise, sensitivity and dynamic range, S parameters, analysis of nonlinear dynamic systems</td><td>ES, PS</td></tr>
<tr><td>3</td><td>Communication Concepts
A General Considerations, Analog Modulation, Digital Modulation, Inter-symbol Interference Signal Constellations, Orthogonal Frequency Division Multiplexing, Spectral Regrowth, Mobile RF Communications, Multiple Access Techniques, Wireless Standards</td><td>ES, CS</td></tr>
<tr><td>2.5</td><td>Transceiver Architectures
General Considerations, Receiver Architectures, Transmitter Architectures</td><td>ES</td></tr>
<tr><td>2</td><td>Low Noise Amplifiers
General Considerations, Problem of Input Matching, LNA Topologies, Gain Switching, Band Switching, High-IP2 LNAs, Differential LNAs Other Methods of IP2 Improvement, Nonlinearity Calculations, Degenerated CS Stage, Undegenerated CS Stage, Differential and Quasi-Differential Pairs, Degenerated Differential Pair.</td><td>ES</td></tr>
<tr><td>2</td><td>Mixers
General Considerations, Performance Parameters, Mixer Noise Figures, Single-Balanced and Double-Balanced Mixers, Passive Downconversion Mixers, Active Downconversion Mixers, Active Mixers with High IP2, Active Mixers with Low Flicker Noise, Upconversion Mixers, Performance Requirements, Upconversion Mixer Topologies.</td><td>ES</td></tr>
<tr><td>1</td><td>Tutorial on RF Integrated Circuit Design Software
To provide a tutorial to the Professional RF Integrated Circuit Design Software – Cadence with SpectreRF, which is widely used in industry. The simulation projects are also based on Cadence.</td><td>ES, CS</td></tr>
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</td></tr>
<tr><td>Contribution of Course to meet the professional component:</td><td>This course educates students with basic RF circuits and systems design skills related with wide types of CMOS electronics. Students should be able to design apposite RF circuits for different applications and apply knowledge of mathematics and engineering, identify formulas, build up simulation netlists to simulate RF electronic circuits</td></tr>
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Course Instructor(s):	Prof. Pui-In Mak
Prepared by:	Prof. Pui-In Mak

Part B: General Course Information and Policies

Instructor: Prof. Pui-In Mak Office: E11-3053
Office Hour: Thursday 3:30~5:30 p.m. or by appointment Phone: 8794
e-mail: pimak@umac.mo

Programme Educational Objectives

1. **Problem Solving**: Graduates have the ability to think in a critical and evaluative manner and to consider a broad perspective, in order to solve technical and nontechnical problems.

2. **Leadership and Communication**: Graduates will provide effective leadership, act in an ethical manner and skills will include the ability to communicate well and to work successfully within diverse groups.

3. **Market Acceptance**: Graduates will have successful careers in the academic environment, industrial and government organizations.

4. **Technical Competence**: Graduates will be technically competent and have a thorough grounding in the fundamentals of math and science in electrical and computer engineering and experience in engineering design. They will be able to use modern engineering techniques, skills, and tools to fulfill societal needs.

Scale: 1 (Highest) to 4 (Lowest)

	Problem Solving	**Leadership and Communication**	**Market Acceptance**	**Technical Competence**
Circuit Analysis	1	3	1	1

Remark:
Objective for "Problem Solving" can be achieved by assignments, quizzes, project, and final exam.

Objective for "Leadership and Communication" can be achieved by report writing. However, leadership training is not given by this course.

Objective for "Market Acceptance" can be achieved by the course contents that are required in industries.

Objective for "Technical Competence" can be achieved by using fundamentals of math and science in electrical and computer engineering and experience in computer simulation.

Program Criteria Policy:

Course VS Program Criteria

Scale: 1 (Highest) to 4 (Lowest)

Course	PS	DIC	BS	CS	ES	DE	LA	CV	DM
Introduction to Radio-Frequency Circuits and Systems	2	2	2	3	1	3		4	

Terms:

Probability and Statistics (PS), Differential and Integral Calculus (DIC), Basic Science (BS), Computer Science (CS), Engineering Science (ES), Differential Equation (DE), Linear Algebra (LA), Complex Variables (CV), Discrete Mathematics (DM)

Relationship of course to Programme Outcomes:

Course VS Course Outcomes

	Program Outcomes											
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**
Introduction to Radio-Frequency Circuits and Systems	T	P	TP		P						P	P

***T – TEACH; P – PRACTICE; M – MEASURED**

The outcomes of electrical and computer engineering program are:

a. Ability to apply knowledge of mathematics, science and engineering.

b. Ability to design and conduct experiments.

c. Ability to design a system, component or process to meet desired needs.

d. Ability to function on multidisciplinary teams.

e. Ability to identify, formulate and solve engineering problems.

f. Understanding of professional and ethical responsibility.

g. Ability to communicate effectively.

h. Broad education necessary to understand the impact of engineering solutions in global and societal context.

i. Recognition of the need for and an ability to engage in life-long learning.

j. Knowledge of contemporary issues.

k. Ability to use the techniques, skills and modern engineering tools necessary for engineering practice.

l. Ability to use the computer/IT tools relevant to the discipline along with an understanding of their processes and limitations

Curriculum Detail

ECEB366 Introduction to Radio-Frequency Circuits and Systems

Timetabled work in hours per week			No of teaching weeks	Total hours	No /Duration of exam papers	Max marks available from:	
Lecturer	Tutor	Practice				Exams	Course
2	0	2	14	56	2/5 hours	50	50

Term: 6th

Hours			Percentage content of					
Lecturer	Lab/tut	Other	Maths	Basic Science	Engineering Science	Engineering Design and Synthesis	Complementary Studies	Computer Studies
28	24/4	0	20	0	40	35	0	5

Design Elements

% of Design Content	Design Content in Course Work	Design Project	Design Content in Laboratories
35%	X	X	X

Course Assessment Policy:

- 2-3 Quizzes will be held during the semester.
- 1 to 2 simulation projects will be performed during the semester. 2-3 students form one group and group report should be handed up.
- 1 final exam with 3 hours.