

课程详述

COURSE SPECIFICATION

以下课程信息可能根据实际授课需要或在课程检讨之后产生变动。如对课程有任何疑问，请联系授课教师。

The course information as follows may be subject to change, either during the session because of unforeseen circumstances, or following review of the course at the end of the session. Queries about the course should be directed to the course instructor.

1.	课程名称 Course Title	CMOS 射频集成电路设计 Design of CMOS Radio Frequency Integrated Circuits
2.	授课院系 Originating Department	深港微电子学院 School of Microelectronics
3.	课程编号 Course Code	SME313
4.	课程学分 Credit Value	3
5.	课程类别 Course Type	专业选修课 Major Elective Courses
6.	授课学期 Semester	春季 Spring
7.	授课语言 Teaching Language	中英双语 English & Chinese
8.	授课教师、所属学系、联系方式 (如属团队授课, 请列明其他授课教师) Instructor(s), Affiliation & Contact (For team teaching, please list all instructors)	刘小龙, 助理教授, 深港微电子学院 Xiaolong LIU, Assistant Professor, School of Microelectronics Email: liuxl@sustech.edu.cn
9.	实验员/助教、所属学系、联系方式 Tutor/TA(s), Contact	待公布 To be announced
10.	选课人数限额(可不填) Maximum Enrolment (Optional)	

11. 授课方式 Delivery Method	讲授 Lectures	习题/辅导/讨论 Tutorials	实验/实习 Lab/Practical	其它(请具体注明) Other (Please specify)	总学时 Total
学时数 Credit Hours	32		32		64
12. 先修课程、其它学习要求 Pre-requisites or Other Academic Requirements	SME307 CMOS 模拟集成电路设计 SME307 CMOS Analog Integrated Circuit Design				
13. 后续课程、其它学习规划 Courses for which this course is a pre-requisite					
14. 其它要求修读本课程的学系 Cross-listing Dept.					

教学大纲及教学日历 SYLLABUS

15. 教学目标 Course Objectives

本课程是从事 CMOS 射频集成电路设计方向的入门课程，其讲授内容是深港微电子学院课程 SME307 的延伸和进阶。本课程主要任务是让学生掌握 CMOS 射频集成电路设计中的基本概念、基本分析与设计方法；培养学生使用 EDA 工具设计和仿真射频集成电路关键模块的基本技能，培养学生根据具体性能指标，设计射频集成电路的基本能力，为以后从事集成电路设计领域的工程技术工作、科学研究工作以及开拓新技术领域奠定基础。本课程介绍以下几大方面的知识：

1. 通信系统介绍
2. 射频电路中的基本概念
3. 射频收发机结构
4. 基本模块（低噪声放大器、混频器、功率放大器、振荡器）
5. 锁相环与频率综合器

This course is a major course for the senior undergraduates majoring in microelectronics. It is the extension of SME307 in analog and radio frequency (RF) integrated circuits design. The main task of this course is to let students understand the basic concepts, basic analysis and design methods of CMOS RF integrated circuits design; train students to use EDA tools to design and simulate the critical CMOS RF modules. According to specifications, students analyze and design the RF integrated circuits. This will lay the foundation for future engineering and scientific research in the field of integrated circuits design. This course introduces the following major areas of knowledge:

1. Communication concepts
2. Basic concept in RF design
3. Transceiver architectures
4. Basic building blocks (LNA, Mixer, PA, Oscillator)
5. Phase-locked loop and frequency synthesizer

16. 预达学习成果 Learning Outcomes

本课程通过理论课教学和实验，使学生掌握

1. CMOS 射频集成电路的基本分析方法与设计过程
2. CMOS 射频集成电路的基本概念
3. 关键模块（LNA、Mixer、PA、Oscillator）的工作原理、分析与设计方法
4. 训练学生如何分析设计指标，通过针对设计指标选择和设计合适的电路，巩固和加深所学到的理论知识
5. CMOS 射频集成电路的计算机辅助设计和仿真分析的方法，培养基本的 CMOS 射频集成电路设计能力
6. 通过实践教学环节不仅要培养学生基本的电路设计能力，还要培养学生良好的科学素养

This course enables students to understand

1. Basic analysis ideas and design methods of CMOS RF integrated circuits
2. Basic concepts of CMOS RF integrated circuits
3. Principles, analysis and design methods of critical building blocks, including LNA, Mixer, PA, and Oscillator
4. Train students how to analyse the design specifications, and consolidate and deepen the theoretical knowledge they have learned through choosing and designing an integrated circuit that meet the specifications

5. Master the computer-aided design and simulation analysis methods of CMOS RF integrated circuits, and cultivate basic CMOS RF integrated circuits design capabilities
6. Through the practice teaching link, not only the basic circuits design ability of students should be cultivated, but also the good scientific literacy of students should be cultivated

17. 课程内容及教学日历（如授课语言以英文为主，则课程内容介绍可以用英文；如团队教学或模块教学，教学日历须注明主讲人）

Course Contents (in Parts/Chapters/Sections/Weeks. Please notify name of instructor for course section(s), if this is a team teaching or module course.)

本课程涵盖射频集成电路的基本概念、射频集成电路系统和关键模块的相关内容，介绍以下几大方面的知识：

1. 通信系统介绍
2. 射频电路中的基本概念
3. 射频收发机结构
4. 基本模块（低噪声放大器、混频器、功率放大器、振荡器）
5. 锁相环与频率综合器

本课程由理论教学和课程实验两部分组成，其中理论授课学时为 32 学时，课程实验学时为 32 学时

本课程理论课的教学日历如下：

课程内容	学时分配
第 1 章 无线通信系统概论 无线通信系统 通信电路	2
第 2 章 射频电路的基本概念 射频电路中的非线性 射频电路中的噪声 无源 RLC 网络和阻抗匹配 传输线基础	6
第 3 章 射频收发机结构 接收机系统结构 发射机系统结构 收发机系统介绍	4
第 4 章 低噪声放大器 基本性能指标 低噪声放大器的基本结构 低噪声放大器的设计过程 低噪声放大器的非线性计算	4
第 5 章 混频器 描述混频器的性能参数 有源混频器 无源混频器	2
第 6 章 功率放大器 基本性能指标 基本功率放大器类型 高效率功率放大器 大信号阻抗匹配 先进发射机结构	4
第 7 章 振荡器 振荡器的振荡条件	4

反馈型振荡器 负阻振荡器 压控振荡器 相位噪声	
第 8 章 锁相环和频率综合器 锁相环的基本工作原理 锁相环的数字模型和稳定性分析 电荷泵型锁相环 锁相环型频率综合器的设计过程	6

本课程实验课的教学日历如下：

实验项目	学时分配
熟悉 Cadence Virtuoso 的设计环境	2
无源器件仿真和阻抗匹配	2
低噪声放大器仿真	2
混频器仿真	2
功率放大器仿真	2
振荡器仿真	2
锁相环行为级仿真	2
接收机行为级仿真	2
课程项目	16

This course covers the basic knowledge of RF integrated circuits, the related content of the RF transceiver systems and critical building blocks, and introduces the following major aspects of knowledge:

1. Introduction of wireless communication systems
2. Basic concepts of RF integrated circuits
3. Transceiver architectures
4. Basic modules (LNA, Mixer, PA, Oscillator)
5. PLL and frequency synthesizer

This course is composed of two parts: theory teaching and course experiment. The theoretical teaching hours are 32 hours, and the course experiment hours are 32 hours.

The teaching calendar of the theoretical lessons of this course is as follows:

Course Content	Class Allocation
Chapter 1 Introduction to Wireless Communication Systems Wireless communication systems Communication circuits	2
Chapter 2 Basic Concepts in RF Design Effects of nonlinearity Noise Passive impedance transformation Transmission line	6

Chapter 3 Transceiver Architectures Receiver architecture Transmitter architecture Transceivers	4
Chapter 4 Low Noise Amplifier General considerations LNA topologies Design method of LNA Nonlinearity calculation	4
Chapter 5 Mixer General considerations Active Mixers Passive Mixers	2
Chapter 6 Power Amplifier General considerations Classification of power amplifiers High-efficiency power amplifiers Large-signal impedance matching Advanced transmitter topologies	4
Chapter 7 Oscillators Basic principles Feedback-based oscillators Negative-transconductance oscillators Voltage-controlled oscillators Phase noise	4
Chapter 8 Phase-Locked Loops and Frequency Synthesizers Basic concepts Model and state analysis Charge-pump PLLs PLL-based frequency synthesizer design	6

The teaching calendar of the Lab of this course is as follows:

Lab Items	Class Allocation
Familiar with Cadence Virtuoso Simulation Environment	2
Passive Simulation and Impedance Matching	2
Low Noise Amplifier Simulation	2
Mixer Simulation	2
Power Amplifier Simulation	2
Oscillator Simulation	2
PLL Behavioral Simulation	2
Receiver Behavioral Simulation	2
Course Project	16

18. 教材及其它参考资料 Textbook and Supplementary Readings

教材 Textbooks:

1. RF Microelectronics, Second Edition, Behzad Razavi, Prentice Hall, 2011.
2. The Design of CMOS Radio-Frequency Integrated Circuits, Second Edition, Thomas H. Lee, Cambridge University Press, 2003.
3. CMOS 射频集成电路分析与设计, 池保勇编著, 清华大学出版社, 2006.

参考杂志和会议 Reference Journals and Conferences:

1. IEEE Journal of Solid-State Circuits (JSSC)
2. IEEE Transactions on Microwave Theory and Techniques (TMTT)
3. IEEE Transactions on Circuits and Systems I: Regular Papers (TCAS-I)
4. IEEE International Solid-State Circuits Conference (ISSCC)
5. IEEE Symposium on VLSI Circuits (VLSI)
6. IEEE Radio Frequency Integrated Circuits Symposium (RFIC)
7. IEEE Custom Integrated Circuits Conference (CICC)
8. European Solid-State Circuits Conference (ESSCIRC)
9. Asian Solid-State Circuits Conference (A-SSCC)

课程评估 ASSESSMENT

19. 评估形式 Type of Assessment	评估时间 Time	占考试总成绩百分比 % of final score	违纪处罚 Penalty	备注 Notes
出勤 Attendance				
课堂表现 Class Performance				
小测验 Quiz				
课程项目 Projects		40		
平时作业 Assignments		20		
期中考试 Mid-Term Test				
期末考试 Final Exam		40		
期末报告 Final Presentation				
其它 (可根据需要 改写以上评估方 式) Others (The above may be modified as necessary)				

20. 记分方式 **GRADING SYSTEM**

- A. 十三级等级制 **Letter Grading**
 B. 二级记分制（通过/不通过） **Pass/Fail Grading**

课程审批 **REVIEW AND APPROVAL**

21. 本课程设置已经过以下责任人/委员会审议通过

This Course has been approved by the following person or committee of authority