南方科技大学 SOUTHERN UNIVERSITY OF SCIENCE AND TECHNOLOGY

# 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.

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| 1. | **课程名称 Course Title** | 无线通信 Wireless Communications |
| 2. | **授课院系 Originating Department** | 电子与电气工程系 Department of Electrical and Electronic Engineering |
| 3. | **课程编号 Course Code** | EE313 |
| 4. | **课程学分 Credit Value** | 3 |
| 5. | **课程类别 Course Type** | 专业核心课 Major Core Courses |
| 6. | **授课学期 Semester** | 秋季 Fall |
| 7. | **授课语言 Teaching Language** | 中英双语 English & Chinese<br>（English with Occasional Explanations in 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）** | 贡毅教授，电子与电气工程系<br>Professor GONG Yi, Department of Electrical and Electronic Engineering<br>第二科研楼 515 室<br>Rm 515, Faculty Research Building 2<br>Email: gongy@sustech.edu.cn<br>Tel: 0755-88018518 |
| 9. | **实验员/助教、所属学系、联系方式 Tutor/TA(s), Contact** | 吴光，电子与电气工程系<br>Dr. Guang Wu, Department of Electrical and Electronic Engineering<br>Email: wug@sustech.edu.cn<br><br>石彦坤，助教，电子与电气工程系<br>SHI Yankun, TA, Department of Electrical and Electronic Engineering<br>南山智园 A7 幢 1001<br>Level 10, Block A7, Nanshan iPark<br>11849056@sustech.edu.cn<br>Tel: 13163698237 |
| 10. | **选课人数限额(可不填) Maximum Enrolment（Optional）** | |

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| 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 | Revision & exam (8 hours) | 64 |

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| 12. 先修课程、其它学习要求 Pre-requisites or Other Academic Requirements | EE206 通信原理 Communication Principles |
| 13. 后续课程、其它学习规划 Courses for which this course is a pre-requisite | EE316 通信系统设计 I Communication System Design I |
| 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

本课程介绍无线通信系统的基本理论、技术问题、设计思路和分析方法，包括无线信道模型、无线信道容量、无线通信中的调制编码技术、自适应调制、编码与交织、分集处理技术、多天线系统、多载波调制等。

To introduce fundamental principles and technical challenges underlying wireless communications, including wireless channel characteristics, wireless channel capacity, digital modulation/detection and coding over wireless channels, adaptive modulation， coding and interleaving, diversity, multiple antennas and MIMO systems, multicarrier modulation, etc.

### 16. 预达学习成果 Learning Outcomes

完成本课程学习后，学生可以掌握无线通信技术的基本理论、设计技术及分析工具，能够对一些基本无线通信系统进行设计和性能分析。

After completing this course, the students should understand fundamental principles, design techniques, and analytical tools for wireless communication systems. They should be able to conduct performance analysis for typical wireless communication systems. The expected learning outcome include:

1. Understand the history, evolution and challenges of wireless communications.
2. Understand path loss and shadowing models; capable of link budget design.
3. Understand multipath fading, flat fading models, frequency selective fading models.
4. Understand capacity in wireless channels; able to calculate capacity in Gaussian, flat fading, and frequency selective fading channels.
5. Understand typical digital modulation schemes (including MPAM, MPSK, MQAM) and pulse shaping.
6. Able to analyse the performance of digital modulation schemes over AWGN and flat fading channels.
7. Understand receive diversity (selection/equal-gain/maximal ratio combining) and transmit diversity; Understand Alamouti scheme and space-time block coding.
8. Understand basic coding and interleaving techniques (channel code, Hamming code, syndrome testing, etc).
9. Understand rate adaptation and power control; understand variable-rate variable-power MQAM.
10. Understand basic MIMO systems, including channel decomposition, channel capacity, diversity analysis, beamforming, spatial multiplexing, Eigenmode transmission, etc.
11. Understand OFDM and its matrix representation; able to implement OFDM with IDFT and DFT; understand vector coding.

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.)**

**Week 1 Overview of Wireless Communications:** History of wireless communications, Wireless vision, Technical issues on wireless communications, Current wireless systems, Wireless spectrum.

**Week 2 Path Loss and Shadowing:** Radio wave propagation, Transmit and receive signal models, Free-space path loss, Ray tracing, Empirical path loss models, Shadow fading, Combined path loss and shadowing, outage probability under path loss and shadowing.

**Week 3-4 Statistical Multipath Channel Models:** Time-varying channel impulse response, Narrowband fading models, Power spectrum density, Power distributions, Wideband fading models, Power delay profile, Coherence bandwidth, Doppler power spectrum and channel coherence time.

**Week 5 Capacity of Wireless Channels:** Capacity in AWGN, Capacity of flat fading channels, Capacity of frequency-selective fading channels.

**Week 6 Digital Modulation and Detection:** Signal space analysis, Amplitude and phase modulation (MPAM, MPSK, MQAM, Differential modulation), Frequency modulation (FSK, MSK, CPFSK), Pulse shaping.

**Week 7 Performance of Digital Modulation over Wireless Channels:** Performance of digital modulation over AWGN channels, Performance of digital modulation over fading channels, Doppler spread, Intersymbol interference.

**Weeks 8-10 Diversity Techniques:** Realization of independent fading paths, Receiver diversity, Selection combining, Equal-gain combining, Maximal-ratio combining, Transmitter diversity, Alamouti scheme, Space-time block coding.

**Week 11 Coding and Interleaving:** Error detection and ARQ, Forward error correction coding, Channel coding, Block codes, Hamming distance, Linear block codes, Hamming codes, Generator matrix, Parity check matrix, Syndrome testing, Interleaving.

**Week 12 Adaptive Modulation:** Introduction to adaptive modulation, Variable-rate techniques, Variable-power techniques, Variable-rate variable-power MQAM, Constant-rate MQAM with power control.

**Weeks 13-15 MIMO Systems:** Narrowband MIMO model, Decomposition of MIMO channel, MIMO channel capacity, MIMO diversity, Beamforming, MIMO Spatial multiplexing, Eigenmode transmission, V-BLAST transmission, Diversity-multiplexing tradeoff.

**Weeks 16 Multicarrier Modulation:** ISI countermeasures, Multicarrier modulation basics, Mitigation of subcarrier fading, Discrete implementation of multicarrier modulation, OFDM, Matrix representation of OFDM, Vector coding, Peak-to-average power ratio, Frequency and timing offset.

**Laboratory：**

**Lab1: BER simulation for QPSK in AWGN Channel,** The characteristics of the wireless channel, Bits stream generation, Bit Error Rate measurement.

**Lab2: USRP Hardware Architecture,** Mobile communication system, USRP hardware diagram, USRP connection, Most-used USRP functions, Building a Basic Sine Generation VI, Programming the RF Signal Analyzer.

**Lab3: Quadrature Amplitude Modulation (QAM),** Communication system over wireless channel, Bit-to-symbol mapping, Constellation, Maximum-likelihood receiver, Packet format, Building QAM mod. & demod. VI, Bit Error Rate simulation and USRP experiment.

**Lab4: Pulse Shaping and Match Filtering,** Linear Time Invariant system (LTI), Pulse shaping/Matched Filtering, Nyquist ISI criterion, Root raised-cosine filter, Building pulse shaping and matched filtering VI, Bit Error Rate (BER) simulation and USRP experiment.

**Lab5: Synchronization**: **Symbol Timing Recovery,** Propagation delay, Introduction to Symbol Timing Recovery, The Maximum Output Energy Solution, The early–late gate algorithm, Building align Max Energy VI, LabVIEW simulation and USRP experiment.

**Lab6: Channel Estimation and Equalization,** Multipath propagation, Channel estimation, Matrix representation, Linear Least Squares, Toeplitz matrix and Equalization, Building channel_estimation.vi, Building toeplitz.vi and indirect_equalizer.vi, LabVIEW simulation and USRP experiment.

**Lab7: Frame Detection and Frequency Offset Correction**, Training sequence, Barker sequences, Correlation, Frequency offset correction, Building Moose.vi and sliding correlator.vi, LabVIEW Simulation and USRP experiment.

**Project: OFDM modulation,** Multipath propagation, Understanding OFDM, The principle of OFDM, OFDM system implementation model, Frequency Selectivity of Wireless Channels, Sensitivity to Frequency Offsets, Project Tasks: Building OFDM modulate.vi, OFDM demodulate.vi, LabVIEW simulation and USRP experiment, Presentation and Report.

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

Textbook:
Andrea Goldsmith, Wireless Communications, Cambridge University Press, 2005.

Reference book:
Theodore S. Rappaport, Wireless Communications: Principles and Practice, 2nd Edition, Prentice Hall, 2002

## 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** | | | | |
| 平时作业 **Assignments** | 10 assignments | 20 | | |
| 期中考试 **Mid-Term Test** | 1 hour | 20 | | |
| 期末考试 **Final Exam** | 2 hours | 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)** | Laboratory reports | 20 | | |



**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**