Engineering Tripos Part IIB, 4B29: Wireless Communication, 2026-27

Module Leader

Prof OB Akan [1]

Timing and Structure

Lent term. 75% exam / 25% coursework

Prerequisites

3B2 and 3F4 useful

Aims

The aims of the course are to:

- Provide an in-depth understanding of wireless communication systems, covering both fundamental principles and advanced methodologies, including the challenges and demands faced by modern wireless communication technologies.
- Explore the evolution of wireless communication, from traditional systems to advanced technologies like 6G, and examine how wireless communication has transformed society, influencing how people live, work, and interact through ubiquitous networks such as
- Equip students with the tools to understand key concepts in wireless systems, such as signal propagation, channel models, and path loss, establishing a strong foundation to evaluate and design complex wireless systems.
- Delve into statistical channel analysis, diversity techniques, and advanced methods for optimizing communication e?ciency. This includes applying techniques such as Maximal Ratio Combining (MRC), Equal Gain Combining (EGC), and OFDM, and focusing on optim
- Investigate multicarrier systems, including the application of OFDM, NOMA, and spread spectrum techniques, and explore their use in modern wireless communications, preparing students for the latest trends such as 6G technologies, Integrated Sensing and Co
- Prepare students to design, analyze, and optimize wireless systems by providing a comprehensive understanding of wireless communication technologies. This enables students to address real-world challenges through practical applications of OFDM, MIMO, and

Objectives

As specific objectives, by the end of the course students should be able to:

- Develop a strong foundation in wireless communication systems, focusing on concepts such as signal propagation, channel models, path loss, and shadowing e?ects. Understand how these principles apply to the design and evaluation of communication systems an
- Analyze wireless channel models, including statistical models for Narrowband fading, Markov channels, and wideband channels. Assess the impact of delay spread, Doppler shift, and capacity in various channel conditions (e.g., AWGN, flat fading, and frequen
- Explore diversity techniques such as MRC, EGC, adaptive modulation and coding, and Alamouti coding. Implement these techniques to improve system reliability and data transmission rates, while also understanding their performance in diverse channel conditi
- Master multiple-antenna systems, including MIMO, massive MIMO, and beamforming techniques, essential

for modern communication systems. Apply these techniques to improve signal reception, transmission e?ciency, and system capacity.
- Investigate advanced techniques, such as OFDM, NOMA, and spread spectrum techniques (DSSS, FHSS), to optimize wireless communication systems. Apply the knowledge of OFDM in multicarrier systems to handle high-data-rate wireless transmission, particularly
- Understand emerging wireless technologies such as ISAC, Reconfigurable Intelligent Surfaces (RIS), Terahertz communications, and gain insights into how these technologies will be integrated into next-generation networks like 6G.
- Apply these concepts in practical scenarios through coursework that focuses on the design and implementation of systems like OFDM and basic communication technologies for real-world applications. This hands-on approach will provide students with valuable

Content

Introduction to Wireless Communications & Channel Models (2L)

- Overview of wireless communications and channels
- Signal propagation
- Tx/Rx signal models
- Path loss models and shadowing e?ects
- Combined path loss/shadowing models
- Coverage area in cellular systems

Statistical Channel Models and Capacity (2L)

- Statistical wireless channel models
- Narrowband fading models
- Markov channel
- Wideband channel models
- Delay spread and Doppler
- Capacity of wireless channels: capacity in AWGN, flat and FS fading channels

Diversity Techniques (2L)

- Diversity techniques overview
- MRC and EGC diversity
- Transmit diversity
- Adaptive modulation and coding

Multiple-Antenna Systems and Beamforming (2L)

- Multiple-antenna wireless communications
- MIMO channel capacity and diversity
- Massive MIMO
- Beamforming
- mmWave Beamforming

Multi-carrier Systems & Spread Spectrum Techniques (2L)

- Time, Frequency, and Code Division Multiple Access (TDMA, FDMA, CDMA)
- Multicarrier Systems, OFDM, and other multi-carrier waveforms
- NOMA System
- Frequency domain equalization
- Spread spectrum techniques (DSSS, FHSS)
- RAKE receivers

Advanced Topics and Applications (2L)

- Multi-user systems and Cellular Systems

- 6G roadmap and key technologies
- Integrated Sensing and Communications (ISAC)
- Reconfigurable Intelligent Surfaces (RIS)
- Terahertz (THz) wireless
- Space communications

Examples papers

Two example papers will be issued with an example class for each example paper.

Coursework

For the coursework there will be a design exercise worth 25%. Since the coursework will assess OFDM design, OFDM design will not be assessed in the end of year examination.

Advanced OFDM System Design, CFO Estimation and Correction for 5G and Beyond Wireless Communications

In this project, you will design and implement an OFDM-based communication system for 5G wireless networks, with a specific focus on Carrier Frequency O?set (CFO) estimation and correction. The project will be conducted in two phases: first, simulating the OFDM system and CFO estimation/correction techniques in MATLAB/Python, followed by real-time transmission and performance evaluation using the ADALM Pluto SDR platform. You will investigate the impact of CFO on system performance and develop optimization strategies to improve signal quality and system reliability in real-world conditions. Through this coursework, you will gain valuable insights into how advanced synchronization techniques enhance the robustness and e?ciency of wireless communication systems. Additionally, this project will provide a foundation for understanding the critical role of synchronization in future 6G networks, where addressing challenges such as CFO will be essential for supporting massive device connectivity and ensuring seamless communication in complex environments.

Learning objectives:

- Simulate a 5G OFDM with key physical layer parameters (subcarrier spacing, FFT size, cyclic prefix, and modulation schemes) in MATLAB/Python.
- Configure and operate the ADALM Pluto SDR for real-time transmission and reception of OFDM signals.
- Implement Carrier Frequency O?set (CFO) estimation and correction techniques on real-world IQ data captured from the SDR platform.
- Evaluate system performance by measuring Bit Error Rate (BER), Signal-to-Noise Ratio (SNR), and throughput before and after CFO correction under AWGN, Rayleigh fading, and Doppler shifts in a hardware-in-the-loop environment.
- Develop a comprehensive understanding of synchronization challenges and mitigation strategies in SDR-based 5G wireless communication systems.

Format

The report should be no more than 10 sides of A4 with minimum font size of 11. Individual report anonymously marked.

Due date & marks

Wednesday of Week 9, [15/60].

Examination Guidelines

Please refer to Form & conduct of the examinations [2].

Last modified: 05/06/2026 10:39

Source URL (modified on 05-06-26): https://teaching26-27.eng.cam.ac.uk/content/engineering-tripos-part-iib-4b29-wireless-communication-2026-27

Links
[1] mailto:oba21@cam.ac.uk
[2] https://teaching26-27.eng.cam.ac.uk/content/form-conduct-examinations