The University Of Sheffield.

Electronic & Electrical Engineering.

EEE6224 MOBILE NETWORKS AND PHYSICAL LAYER PROTOCOLS

Credits: 15

Course Description including Aims

1. To give an overview of how cellular mobile communications networks operate, with specific examples of UK systems.
2. To describe the radio technology used over the air interface.
3. To describe physical layer protocols used in GSM, 3G and 4G networks.

Outline Syllabus

Description and demonstration of current UK cellular mobile networks with historical perspective. Antenna design for the RF interface, including handset, vehicle and base station antennas. EMC / health related issues of mobile handsets. GMSK, QPSK, QAM, OFDM modulation. GSM (incl. GPRS, EDGE etc.) protocol. WCDMA 3G UMTS (incl. HSDPA etc.) protocol. 4G LTE protocol. Propagation issues, diversity gain, Rake reception. MIMO. Link budgets. Cellular design strategies (femto, pico, micro, macro, umbrella etc.). Appreciation of metrics used in handset Engineering Field Test mode.

Time Allocation

36 hours lectures plus 12 hours additional support material.

Recommended Previous Courses

Background knowledge equivalent to EEE345 "Engineering Electromagnetics", EEE317 "Principles of Communications", EEE224 "Communication electronics"

Assessment

Examination: 3/4 questions in 2 hour written exam, plus on-line multiple choice test

Recommended Books

Redl, Siegmund M., Weber, M. K. & Oliphant M. W.	*An Introduction to GSM*	Artech House
Holma, H. & Toskala, A.	*WCDMA for UMTS*	Wiley
Stremler, F.	*Introduction to Communication Systems*	Addison Wesley
Khan F.	*LTE for 4G Mobile Broadband*	Cambridge University Press

Objectives

By the end of this module successful students will be able to

1. Understand the physical layer structure of 2G, 3G and 4G terrestrial mobile networks.
2. Understand system level components such as air interface logical payload channel and frame structures and carrier modulation techniques.
3. Contribute at a professional level to cellular planning in the enhancement and roll out of future mobile networks.
4. Show awareness of the contextual significance and constant evolution of mobile technology in society.

Detailed Syllabus

1. Historical perspective of mobile radio technology, including comparisons between analogue, GSM, 3G, 4G (Long Term Evolution).
2. GSM system architecture.
3. Cellular design strategies, including femto, pico, micro, macro and umbrella cells.
4. Handset and vehicular antennas.
5. Base station antenna arrays.
6. EMC / health issues of mobile phones. ICNIRP / HPA recommended SAR and field levels.
7. Carrier modulation techniques used in cellular systems such as GMSK and QPSK.
8. Basic Fourier theory for deriving signal spectra.
9. Spectrum of GSM mobile handset signal estimated, bursting in one timeslot per frame.
10. Intermodulation products in non linear media as an EMC / health issue.
11. The GSM protocol and burst types.
12. The random access burst and time advance, and how TA can be used for location estimate.
13. Logical channels in GSM.
14. GSM uplink and downlink channel combinations.
15. Phone Field Test Display showing GSM physical layer engineering parameters, such as frequency channels, CellId's, LAC's, neighbouring cells.
16. The professional TETRA protocol and comparisons with GSM.
17. Use of frequency diversity in mobile systems.
18. WCDMA link budget estimation.
19. 3G UMTS overview.
20. QPSK modulated downlink and I/Q BPSK uplink 3G WCDMA signals.
21. 3G logical channel and frame structures
22. WCDMA propagation characteristics. Rake reception.
23. Uplink load factor. Hard, soft and softer handovers. Power control.
24. Introduction to 4th Generation mobile systems for Long Term Evolution, WiMAX and Wi-Fi
25. OFDM, OFDMA and SC-FDMA systems
26. 4G LTE modulation techniques in OFDM - QPSK, 16QAM, 64QAM
27. 4G spectrum
28. Modulation and demodulation using FFT
29. 4G logical channel and frame structures
30. Use of advanced antenna systems - Multiple Input Multiple Output (MIMO) in 4G
31. 4G propagation characteristics

32. Integration between radio and backhaul systems
33. Packet switched vs. circuit switched networks - VoIP.
34. LTE advanced and 5G.
35. Beyond the future. Far reaching technological innovations in mobile communications.
36. Course review. Q&A.

UK-SPEC/IET Learning Outcomes

Outcome Code	Supporting Statement
SM1p	Historical, present and future technologies in mobile cellular communications described, to enable appreciation of evolving science and technology. Assessed using written exam
SM1m	Scientific principles relevant to mobile networks reviewed, such as antenna and signal theory. Assessed using written exam and multiple choice test
SM2m	Use of Fourier analysis to estimate GSM signal spectrum explained. Assessed using written exam and multiple choice test
SM3p	Antenna and signal process engineering involved in the course. Assessed using written exam
SM4m	Developing 4G LTE networks mentioned. Assessed using written exam and multiple choice test
SM6m	Health related issues of mobile phone usage covered. Assessed using written exam and multiple choice test
SM1fl	Scientific principles relevant to mobile networks reviewed, such as antenna and signal theory. Assessed using written exam and multiple choice test
SM2fl	Developing 4G LTE networks mentioned. Assessed using written exam and multiple choice test
SM3fl	Health related issues of mobile phone usage covered. Assessed using written exam and multiple choice test
EA1p	Engineering a mobile cellular network described. Assessed using written exam.
EA2p	Cellular system analysis described, for instance in determination of link budgets. Assessed using written exam and multiple choice test
EA2m	Cellular design strategies covered using analytical allowed propagation loss and various antenna models. Assessed using written exam and multiple choice test
EA3p / EA3m	Path loss estimates described based on quantitative evaluation of physical layer parameters. Assessed using written exam and multiple choice test
EA4p	Mobile cellular system explained in terms of engineering requirements. Assessed using written exam
EA5m	Fundamental knowledge of antennas, signal processing and modulation techniques applied to design of present and future mobile networks. Assessed using written exam and multiple choice test
D1p / D1m	The needs of mobile users versus aesthetics and the health concerns of residents addressed with regard to siting of mobile phone masts in residential areas. Assessed using written exam

D2m	Cellular coverage requirements for city, urban and rural environments defined and health and safety issues investigated. Assessed using written exam and multiple choice test
EP2p	Engineering functions of mobile handsets are discussed. Assessed using written exam and multiple choice test
ET2p / ET2m	The commercial aspects of mobile network planning and services is discussed. Assessed using written exam
ET2fl	Public perception of living close to base stations discussed. Assessed using written exam
ET5p / ET5m	The SAR safety rating provided for all mobile handsets is explained. Assessed using written exam and multiple choice test
ET5fl	HPA guidelines on exposure to electromagnetic radiation from mobile phones and base stations included. Assessed using written exam and multiple choice test
ET6p	Health implications of mobile handsets and base stations covered together with mitigation strategies. Assessed using written exam and multiple choice test
EP6m	Industry standards for the 2G and 3G protocols explained. Assessed using written exam
EP7m	QoS issues discussed with regards to link budgets, data rates and propagation. Assessed using written exam and multiple choice test
EP8m	Overlapping of cell coverage explained due to uncertainty in the extent of signal propagation in complex environments. Assessed using written exam and multiple choice test
EP9m	Limitations of 3G systems explained in context of emergent 4G networks. Assessed using written exam
EP10m	Cellular planning with regard to maximising capacity and coverage with minimum resources (e.g. base stations) discussed. Assessed using written exam and multiple choice test
EP2fl	Limitations of 3G systems explained in context of emergent 4G networks. Assessed using written exam
EP3fl	Cellular planning with regard to maximising capacity and coverage with minimum resources (e.g. base stations) discussed. Assessed using written exam and multiple choice test.