www.ptt.co.uk

MJC: 4G and 5G radio access networks

Online course specification

Target audience:
This online course is designed for those who are, or intend to be, involved in planning or commissioning LTE and 5G mobile systems.

Course aim:
This course introduces the features, structure, and operation of LTE (4G) and 5G radio access networks.

Course level: Advanced
An explanation of PTT course levels is given at the end of this document

Pre-requisites:
You will get the most out of this course if you already understand the principles of mobile communications. Therefore, familiarity with the material in the PTT courses "Introduction to mobile systems" and "Mobile radio communications" is desirable.

Course structure:
The course consists of the following 4 modules:

1. Building for the future
2. The air interface
3. Radio access networks
4. Heterogeneous networks

Module 1: Building for the future

Module aim: To explain the need to further improve the performance of mobile systems beyond that offered by LTE and explain how 5G systems will meet the requirements of new applications and services in the years to come.

After completing this module, a trainee will be able to:

- explain the drivers for mobile system evolution in terms of higher expectations of users, more efficient use of limited radio spectrum, reduction in system costs, and meeting the requirements of new applications.
- describe the role and special requirements of enhanced mobile broadband (eMBB) and ultra reliable low latency communications (uRLLC)
- describe the special requirements of massive machine type communications (mMTC) and give examples of possible applications.
- describe and compare the characteristics of high definition voice services available with LTE and 5G systems.
- describe and compare the structure and basic operation of LTE and 5G radio access networks.
- explain that the 5G air interface can be tailored to gain the maximum benefit from operation at higher carrier frequencies.
- explain the principles and benefits of network function virtualisation (NFV) as employed in 5G core networks.

- describe the role, principles, and possible applications of network slicing with reference to the role of NFV in its implementation in 5G systems.
- Describe the role, principles, benefits, and possible applications of mobile edge computing with reference to the role of NFV in its implementation in 5G systems.

Module 2: The air interface

Module aim: To explain the techniques employed to provide reliable, high speed communications by radio in LTE and 5G mobile systems.

After completing this module, a trainee will be able to:

- explain the role, principles and advantages of the use of OFDM.
- state that LTE can use either Frequency Division Duplex (FDD) or Time Division Duplex (TDD) and explain the advantages of each.
- explain how radio resources are shared between LTE mobile users with reference to the concepts of radio resource blocks, subframes, slots and transmission time intervals.
- describe and compare the role of logical, transport and physical channels.
- describe the role of the PDCP, RLC and MAC protocols at the air interface and explain the relationship between them.
- describe the role of the various radio channels on the uplink and downlink.
- state that the 5G air interface has been designed to provide both ultra low latency and enhanced mobile broadband.
- explain that the role, principles, and benefits of the use of scalable OFDM in 5G systems.
- explain how radio resources are shared between 5G mobile users with reference to the role, principles, and benefits of minislot operation, pre-emptive scheduling, and slot aggregation.
- explain the error correction techniques Hybrid ARQ (HARQ), Incremental Redundancy (IR) and Adaptive Modulation and Coding (AMC) as employed in LTE and 5G systems.
- describe how HARQ techniques has been modified for use in 5G systems to minimise latency.

Module 3: Radio access networks

Module aim: To describe the architecture and role of components of LTE ad 5G radio access networks, and the techniques employed to maximise data transfer rates over the air interface.

After completing this module, a trainee will be able to:

- describe the architecture of LTE and 5G radio access networks (RANs) with reference to the role of base stations and the connections between them.
- explain how initially 5G services may be provided as a non standalone (NSA) service that relies on existing LTE infrastructure, giving examples of different NSA configurations.
- explain the principles and benefits of dual connectivity as used in an NSA implementation.
- describe the use of carrier aggregation in LTE and 5G RANs to increase data transfer rates.
- describe Multiple-In Multiple-Out (MIMO) multi-antenna techniques and their uses on downlinks and uplinks to improve radio link performance and throughput.
- describe the concept, role, and applications of Massive MIMO aerial arrays with reference to the constraints on its use.
- explain the benefits of distributing the functions of a base station with some functions located at a centralised location.
- explain how the use of network function virtualisation (NFV) in a distributed base station architecture in 5G RANs enhances the provision of mobile edge computing.
- describe the principles, benefits, and applications of Integrated access and backhaul (IAB).

Module 4: Heterogeneous networks

Module aim: To explain the methods employed to minimise inter cell interference and improve radio reception in an environment where cells of various sizes and operating frequency bands co-exist.

After completing this module, a trainee will be able to:

- explain the need for, and methods of, power output control.
- describe the concept, benefits, and applications of a heterogeneous radio access network.
- describe methods of minimising interference between cells in a heterogeneous RAN including ICIC and Enhanced ICIC.
- describe the role and principles of Coordinated Multipoint transmission and reception.
- explain that the practicality of employing CoMP depends on the architecture of the existing radio access network.
- describe the benefits, challenges, and applications of employing unlicensed spectrum for mobile communications.
- describe and compare the operation of LTE Licensed Assisted Access (LAA) and 5G New Radio-Unlicensed (NR-U) services.
- explain that the evolution of mobile systems is a continuous process marked periodically with 3GPP Releases and that different generations do not evolve in isolation and will co-exist in the years to come.

Course access requirements:
To access the course, a computer running a browser such as Google Chrome, Safari etc is required. The computer should have Internet access. A screen resolution of at least 1024x768 is necessary.

Learning facilities:
This online course employs interactive simulations, hypertext links to an online glossary and multiple-choice question sessions to fully involve the trainee in the learning experience. Each module provides revision links to previously studied, relevant topics. A record of progress and level of achievement is recorded for each trainee. Once studied as a structured, assessed course, the content can be browsed for revision or reference.

PTT course levels:
PTT online courses are categorised by one of three levels according to the depth of treatment they provide:

1. **Introductory:**

   PTT Introductory courses are designed for those with no previous experience or knowledge of telecommunications. These courses provide an overview of telecommunications or discuss the fundamentals of electronic communications. The study of general science at secondary (high) school is a typical pre-requisite for PTT Introductory courses.
   PTT Introductory courses are suitable for those joining the telecommunications sector particularly those in an apprenticeship programme.

2. **Intermediate:**

   PTT Intermediate courses are designed for technicians and engineers requiring an understanding of a certain aspect of telecommunications. Those planning to study an Intermediate course should have an understanding of the basic principles of electronic communications.
   The depth of treatment provided by Intermediate courses is typically equivalent to level 3 of a UK national vocational qualification (NVQ). PTT Intermediate courses can be used to support the attainment of a Communications Technology NVQ at level 3.

3. **Advanced:**

   PTT Advanced courses are designed for those who require an in-depth treatment of a certain aspect of telecommunications. Such courses are suitable for system designers as well as those who will be responsible for the maintenance of the system described in the course.
   Those planning to study a PTT Advanced course should have a background in telecommunications, and an understanding of telecommunications fundamentals and the principles of the type of telecommunications system described in the course.

PTT
December 2022