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TDD: Next generation access networks

Online course specification

Target audience:
This course is designed for those involved in the design, commissioning, and maintenance of copper and optical fibre access networks.

Course aim:
To describe the capabilities, components and operation of the systems that provide high-capacity broadband connections and the techniques employed to maximise data transfer rates.

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

Pre-requisites:
An appreciation of the basic principles of transmitting signals over copper wires and optical fibre. And an appreciation of the protocols that govern data communications. The PTT online courses "Signal impairments, "Transmission fundamentals", "Modulation and multiplexing" and "Data communications principles" will provide the information you need.

Course structure:
The course consists of the following 5 modules:
1. DSL principles
2. Maximising DSL performance
3. HFC broadband
4. Passive optical networks
5. Next generation PONs

Module 1: Principles of DSL broadband

Module aim: To introduce the basic principles of operation of digital subscriber line (DSL) systems and the line characteristics that can impair the performance of a broadband connection over copper wire pairs.

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

- compare the characteristics, compare the bandwidth usage, capabilities, and applications of the various versions of ADSL including ADSL2+ and, RE-ADSL.
- describe and compare the bandwidth usage, capabilities and applications of the various very high speed DSL (VDSL) profiles.
- describe the causes and effects of interference in a DSL system.
- describe and compare the cause and effects of near end crosstalk (NEXT) and far end crosstalk (FEXT) on DSL broadband performance.
- explain the basic principles of discrete multi-tone (DMT) modulation and its use in a DSL system.
- explain the role and principles of operation of rate adaptation.
- explain the role of a dynamic line management system.
- define and explain the significance of noise margin.
- define the concept and significance of contention ratio.
- describe the functions of an ATU-R, ATU-C and B-RAS.

- describe the role of the various protocols involved in the operation of a DSL connection to customer equipment.

Module 2: Maximising DSL performance

Module aim: To introduce the techniques employed to maximise the data transfer rates provided by broadband connections over copper wire pairs.

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

- describe the measures taken to minimise crosstalk between different types of digital subscriber line (DSL).
- describe the methods employed in DSL systems to correct errors with reference to FEC, interleaving, and G.INP.
- describe the role and explain the need for dynamic spectrum management (DSM).
- compare the performance benefits and operation of the techniques employed at the various levels of dynamic spectrum management.
- describe the role of vectoring with reference to the conditions necessary to adequately reduce crosstalk between lines carrying VDSL2 broadband signals.
- describe the principles of operation, capabilities, and applications of G.fast broadband connections over copper wires.

Module 3: HFC broadband

Module aim: To introduce the operation, components, and capabilities of hybrid fibre coax cable (HFC) systems and the measures that can be taken to enhance their performance.

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

- describe how coax cable systems have evolved over the years from providing analogue television services to the provision of digital TV and broadband services.
- explain that the DOCSIS standards have been developed to standardise the provision of broadband services over hybrid fibre coax (HFC) systems.
- describe how the available radio frequency spectrum of a cable system is divided up to allow bidirectional operation and the provision of several types of service.
- describe the capabilities and components of an HFC cable system.
- describe the role of the DVB-C and MPEG standards in the provision of TV services over a cable system.
- describe how upstream and downstream cable bandwidth is shared between users.
- compare the capabilities and operation of cable systems conforming to DOCSIS 3.0 and DOCSIS 3.1.
- describe methods of further improving broadband speeds including node splitting and use of DOCSIS 4.

Module 4: Passive optical networks

Module aim: To introduce the components and operation of a passive optical network (PON) and describe the factors that determine the capabilities of a PON.

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

- describe the role of the various components of a passive optical network (PON).
- describe the use of TDM and TDMA in the operation of GPON systems.
- explain the role of wavelength division multiplexing in the operation of PON systems.

- describe and compare the capabilities and characteristics of GPON, XG-PON, XGS-PON and EPON systems.
- explain the factors that determine the maximum reach of a PON with reference to receiver sensitivity and optical loss contributors.
- explain the factors that determine the architecture and split ratio employed in a PON.
- describe the frame structure of a GPON downstream signal and the role of its overheads.
- explain the role of transmission containers in assuring the appropriate quality of service.
- describe the role and operation of upstream grant allocation and ranging.
- compare the structure, equipment and benefits of FTTH, FTTC and FTTdp systems.

Module 5: Next generation PONs

Module aim: To explore and compare the capabilities and applications of second and third generation passive optical networks with reference to their compatibility with older systems.

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

- describe the techniques that later versions of passive optical network (PONJ) have employed to achieve higher capacities.
- compare the capabilities, features and basic modes of operation of the various versions of passive optical network published by the ITU and the IEEE including XGS-PON, 10G and 25G EPON, NGPON2, and 50G HSP.
- explain how the various versions of PON system can co-exist using the same infrastructure.
- give examples of the applications and benefits of a TWDM-PON (NG-PON2) in providing higher data transfer rates to more customers than even XG-PON.
- explain that employing WDM techniques requires more stable optical sources and remote tuning and describe how these objectives are achieved.
- explain that one of the drivers for higher speed PONs is providing fronthaul and backhaul connections in a 5G mobile radio access network.
- describe how passive optical networks may evolve with reference to the use of DWDM, arrayed waveguide gratings, and ring networks.

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
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