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DLA: ADSL principles
Online course specification

Target audience:
Those involved in implementing, installing and maintaining access networks.

Course aim:
To describe the characteristics and structure of access networks based on the use of copper wires and explain the principles of the technologies that provide access to broadband services over those wires.

Course level: Intermediate
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 have a basic understanding of analogue and digital transmission. The PTT online courses "Analogue and digital signals" and "Transmission fundamentals" will provide the information you need. We suggest, therefore, that you complete these before continuing this course.

Course structure:
The course consists of the following 7 modules:

1. Course introduction
2. Digital access over the last mile
3. Limitations of the local loop
4. Modulation techniques
5. Error correction
6. ADSL principles
7. ADSL and VDSL versions

Module 1: Course introduction

Module aim: To summarise the aims of each module and introduce the navigation and learning facilities provided by the course.

Module 2: Digital access over the last mile

Module aim: To describe the structure of the local access network and explain how this existing infrastructure can be exploited to provide broadband access to the Internet.

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

- describe the characteristics of a conventional telephone connection between a customer's premises and the local exchange.
- describe the role of the various components of a local access network using copper wire including the main distribution frame (MDF), cross-connect points and remote line unit (RLU).
- describe the structure and physical components of a multipair cable and its use in a local access network.

- explain the effect of the length of a copper-wire connection on its characteristics and the services that it can support.
- explain that a band of higher frequencies not used by a conventional telephone service can provide high speed access to the Internet.
- describe the role of a splitter in an exchange.
- compare the typical capabilities of various types of digital subscriber line (DSL) services in terms of their reach and data transfer rates.

Module 3: Limitations of the local loop

Module aim: To describe the cause and effects of the various impairments on the last mile that limit the performance of DSL service.

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

- describe how the loss of a copper wire connection varies with its length and the diameter of the wires.
- describe the cause and effect of crosstalk and describe how near end crosstalk (NEXT) and far end crosstalk (FEXT) are measured.
- describe the role of loading coils and explain how their presence prevents the provision of a digital subscriber line (DSL) service.
- explain bridged taps and explain how these can degrade the service provided by a DSL connection.
- explain the cause of various types of noise and interference and the effect of these impairments on a DSL service.
- explain the cause of impedance mismatch and its effect on a DSL service.
- summarise the factors that determine whether a copper-wire connection will allow the provision of a DSL service with acceptable performance.

Module 4: Modulation techniques

Module aim: To explain the principles, role and characteristics of the various modulation techniques used in DSL systems.

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

- explain the role of line codes and other multi-level modulation techniques in a DSL system.
- explain the principles of pulse amplitude modulation (PAM).
- explain the principles of phase shift keying (PSK).
- explain the principles of quadrature amplitude modulation (QAM).
- describe the relationship between the number of allowed carrier states and the bandwidth requirement and noise immunity of a carrier modulated by a data signal.
- explain that a rate adaptive DSL system varies the number of permitted QAM states according to the signal to noise ratio of the transmission line.

Module 5: Error correction

Module aim: To explain the principles, role and characteristics of the various error correction systems used in DSL systems.

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

- explain the role of, and requirement for, error correction in a DSL system.
- explain the principles, role of, and limitations of parity checking.
- explain the term Hamming space in relation to the number of errors in a data block that can be corrected.

- explain the role of the cyclic redundancy checksum (CRC) in relation to error checking and forward error correction (FEC).
- explain the relationship between the length of the CRC, the error correction capabilities of an FEC system and the bandwidth requirement of a signal for a given data transfer rate.
- describe the principles and role of interleaving in a DSL system.
- explain that trellis coding combines multi-level modulation and error correction to provide high data transfer speeds over noisy lines.

Module 6: ADSL principles

Module aim: To explain the basic principles and operation of an ADSL system and describe the functions of its components.

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

- explain the basic principles of discrete multi-tone (DMT) modulation and its use in an ADSL system.
- explain why upstream traffic has a lower and narrower DMT frequency allocation than downstream traffic with reference to the effect of near end crosstalk (NEXT).
- describe how certain ADSL systems use a modified form of DMT to allow the provision of ADSL and ISDN over the same line.
- describe the various sub-systems in a functional block diagram of an ADSL termination unit - remote (ATU-R).
- explain the differences in function and performance of a “Fast channel” and an “Interleaved channel”.
- explain the principles and role of rate adaptive ADSL.
- explain the role of dynamic line management.
- describe the function of a splitter at the customer’s premises and at the exchange.
- describe the use of microfilters to avoid the cost of installing a splitter at the customer’s premises.

Module 7: ADSL and VDSL versions

Module aim: To describe and compare the characteristics, performance and applications of various types of DSL systems.

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

- compare the performance of an ADSL2 system with the first version of ADSL in terms of data transfer rates.
- list and describe the extra facilities offered by an ADSL2 system.
- explain how reach extended ADSL (RE-ADSL) provides a better service for customers who are furthest away from an exchange.
- compare the DMT spectrum of an ADSL2+ system with that of an ADSL2 system.
- compare the performance of an ADSL2+ system with that of an ADSL2 system for connections of various lengths.
- explain that the ITU has produced recommendations for various profiles of very high speed DSL (VDSL2) system with each profile suited to a particular application.
- compare the data transfer rates of a VDSL2 system with that of ADSL2 for a selection of profiles for connections of various lengths**.**
- describe the role of VDSL2 in a fibre to the cabinet (FTTC) system.
- explain how G.fast over copper wires can provide a cost-effective alternative to a fibre to the premises service.

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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