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PAD: Modulation and multiplexing

Online course specification

Target audience:
This course is designed for those who require an introduction to the fundamental technical concepts that underpin modern telecommunications. The course is suitable for those joining the industry in a technical role especially those in an apprenticeship.

Course aim:
To introduce the methods employed in telecommunications systems to maximise the traffic carrying capacity of transmission media.

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

Pre-requisites:
An understanding of the basic properties of analogue and digital signals, the effects of signal impairments, and the characteristics of various transmission media. It is recommended that the PTT courses “Analogue and digital signals”, “Signal impairments” and “Transmission media” are studied before attempting this course.

Course structure:
The course consists of the following four modules:
1. Modulation
2. Introduction to multiplexing
3. Time division multiplexing
4. Line and block codes

Module 1: Modulation

Module aim: To describe the principles, capabilities and applications of various types of modulation technique.

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

- explain the role of modulation in the transmission of data over both wired and wireless links.
- describe the relationship between bit rate, available bandwidth and signal to noise ratio as defined by Shannon’s law
- explain the principles of amplitude modulation (AM) and describe the characteristics of an AM wave in terms of the occupied bandwidth and effects of noise.
- explain the principles of Frequency Shift Keying (FSK) and describe the characteristics of an FSK wave in terms of the occupied bandwidth and effects of noise.
- explain the principles of Phase Shift Keying (PSK) with reference to the relationship between the number of permitted states, the maximum achievable data transfer rate and immunity to noise.
- explain the principles of Quadrature Amplitude Modulation (QAM) with reference to the relationship between the number of permitted states, the maximum achievable data transfer rate and immunity to noise.
- give examples of the applications of AM, FSK, PSK, and QAM.

Module 2: Introduction to multiplexing

Module aim: To explain the role and principles of the various types of multiplexing used in modern telecommunications networks.

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

- describe the role of multiplexing in telecommunications systems.
- explain the basic principles of time division multiplexing.
- explain the principles of operation of statistical multiplexing
- compare the roles of TDM and statistical multiplexing, giving examples of the applications of each.
- explain the principles of frequency division multiplexing with reference to its use in mobile communications.
- explain the basic principles of Wave Division Multiplexing (WDM), giving examples of its use.
- describe the role of TDMA and FDMA in allowing mobile users to share access to a cell.
- describe how WDM allows bi-directional operation over a single fibre and the sharing of a fibre by several traffic streams.
- describe the principles and applications of orthogonal frequency division multiplexing (OFDM) for both line and radio communications.

Module 3: Time division multiplexing

Module aim: To explain the principles of operation of transmission links using Time Division Multiplexing (TDM) and describe the capabilities of TDM signals as used in modern telecommunications networks.

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

- explain the operation of TDM with reference to frames, timeslots and the role of a Frame Alignment Word (FAW).
- compare the benefits and drawbacks of TDM with those of packet switching.
- describe the structure and payload capability of an E1 primary multiplex frame.
- explain the benefits of the Synchronous Digital Hierarchy (SDH) in terms of the multiplexing flexibility and the availability of a comprehensive set of ITU recommendations.
- explain that TDM-based networks are synchronous in operation and depend on the distribution of timing signals from a centralised clock.
- describe the role of TDM in national networks.
- list and compare the bit rates and payload capabilities of European SDH and North American SONET aggregate signals.
- explain that SDH signals can carry both encoded voice and data.

Module 4: Line and block codes

Module aim: To describe the role, characteristics and format of the various types of signal transmitted over copper and optical cable systems.

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

- explain the purpose of a line code with reference to the bandwidth efficiency and dc component of a transmitted signal, and the requirement for timing extraction and error checking.
- describe methods of improving timing extraction including the use of zero (RZ) signals.
- explain the advantages of bipolar line codes with reference to error checking and the reduction in the DC component of a signal.
- explain that a multi-level line code reduces the bandwidth requirement of a signal but also reduces its noise immunity.
- describe examples of line codes including Manchester encoding, CMI, MLT-3 and PAM-5, giving applications and benefits of each.

- explain the basic principles of block coding with reference to error checking, bandwidth requirement, and applications.
- give examples of the use of block codes in combination with a line code.

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 and be running Adobe Flash. 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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