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OMA: Optical fibre principles
Online course specification

Target audience:
Those responsible for the installation and maintenance of optical fibre links.

Course aim:
To explain the basic principles of optical fibre transmission, describe the main components of optical links, appreciate the hazards of optical sources, and describe the factors that limit the transmission distance and data transfer rate of a link.

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

Pre-requisites:
This course assumes a basic understanding of digital transmission and the use of decibels. It is recommended that the PTT online courses “Analogue and digital signals” and “Transmission fundamentals” are studied before attempting this course.

Course structure:
The course consists of the following five modules:
1. Optical communications
2: Optical loss
3: Causes and effects of dispersion
4: Types of optical fibre and cable
5: Optical links

Module 1: Optical communications

Module aim: To introduce the benefits, applications, and basic principles of optical fibre communications, and the safety precautions necessary working with optical systems.

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

- list the advantages of the use of optical fibre with reference to its bandwidth, physical flexibility, and immunity to harsh environments and electrical interference.
- give examples of the applications of optical fibre.
- explain why wavelengths in the near infrared are employed in optical fibre communications.
- describe the function of an optical fibre's core, cladding and primary coating.
- explain the significance of the acceptance angle of a fibre and the effect of an increase in core diameter on that parameter.
- compare the characteristics of a semiconductor laser and a light emitting diode giving examples of their applications.
- describe the precautions that are necessary when working with optical equipment with reference to the IEC classification of optical sources according to the hazard they present.

Module 2: Optical loss

Module aim: To explain the various causes of optical loss produced by an optical fibre and ancillary components and describe how such losses affect the choice of operating wavelength.

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

- explain the cause of scattering loss in an optical fibre and the reduction in loss as the operating wavelength increases.
- explain that impurities in optical fibre can create peaks in the loss versus wavelength characteristics of a fibre due to absorption.
- explain the choice of operating wavelength in terms of the loss versus wavelength characteristics of a fibre and the cost of appropriate optical sources.
- describe how bending loss occurs and describe the significance of the minimum bending radius of an optical cable.
- define the terms "insertion loss" and "return loss" giving typical values for demountable connectors.
- explain how the loss introduced by demountable connectors and fusion splices can be minimized.
- describe how the total loss of a link of a given length is dependent on average fibre loss, connector loss and splice loss.
- define the term "receiver sensitivity" with reference to the acceptable error performance of an optical link.
- calculate the maximum acceptable loss of a link for a given launched power and receiver sensitivity.

Module 3: Causes and effects of dispersion

Module aim: To introduce the effects, causes, and methods of reducing dispersion in optical fibres.

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

- explain how dispersion limits the maximum bit rate that can be achieved over an optical fibre.
- explain the cause of multimode dispersion and describe how it can be minimised.
- describe the cause of chromatic dispersion and describe how it can be minimised.
- describe how polarisation mode dispersion is produced and describe the situations where it may be introduced.
- State that the minimum chromatic dispersion for standard fibre occurs at a wavelength of 1300 nanometers.
- State that special types of fibre are available where the wavelength of minimum dispersion occurs at the low loss window at 1550 nanometers.

Module 4: Types of optical fibre and cable

Module aim: To describe the characteristics and applications of the various types of optical fibre used in communications systems.

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

- describe the structure and characteristics of multimode, step index fibre
- describe the structure, advantages and applications of multimode graded index fibre
- describe the structure, advantages, and applications of singlemode step index fibre
- describe the characteristics and applications of dispersion free, dispersion shifted and non zero dispersion shifted fibre.
- describe the main characteristics and applications of the six fibre categories specified in the ISO/IEC specifications.

- explain that the ITU has published recommendations for various types of optical fibre for use in long haul systems and access networks, giving examples.
- explain how the types of protection layer included in optical cables depend on the environment they are designed for.
- describe the role of the various protection layers in internal, external and submarine cables.

Module 5: Optical links

Module aim: To describe the functions of the components of an optical link, methods of increasing the capacity of a link, and the parameters which are considered when calculating whether an optical link will provide an acceptable performance.

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

- describe the functions of optical line terminal equipment.
- give examples of the various types of optical line terminal.
- describe the basic principles, benefits, and applications, of optical amplifiers.
- describe the role and main components of an optical distribution shelf.
- describe the principles of wavelength division multiplexing (WDM).
- compare wideband WDM, course WDM and dense WDM giving examples of their applications.
- describe the purpose of the dispersion penalty when determining the minimum acceptable received power for a link.
- describe the purpose of the system margin when determining the minimum acceptable received power for a link.
- calculate whether a link will provide an acceptable performance taking into account launched power, dispersion penalty, system margin, loss contributors, and receiver sensitivity.

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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