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SZA: Synchronous transmission

Online course specification

Target audience:
This course is designed for technicians and engineers involved in the design, commissioning and maintenance of synchronous transmission networks. This course is a useful primer for the subsequent study of the PTT courses: “SDH principles” and “Optical transport networks”.

Course aim:
This course explains the principles of synchronous transmission and time division multiplexing with reference to their role in the networks that provide high capacity national and international connections for telecommunications services.

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

Pre-requisites:
An understanding of the characteristics of digital signals. It is recommended that the PTT online courses “Analogue and digital signals" and “Signal impairments” are studied before attempting this "Synchronous transmission" course.

Course structure:
The course consists of the following four modules:
1. Time division multiplexing
2. Signal transport
3. Synchronisation
4. Transmission networks

Module 1: Time division multiplexing

Module aim: To introduce the principles of time division multiplexing.

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

- explain the principles of time division multiplexing (TDM) with reference to byte interleaving and the concept of timeslots.
- describe the advantages of employing TDM in wide area networks with reference to the characteristics of TDM connections.
- give examples of the types of networks and applications that employ TDM including fixed line and mobile services.
- explain the principles of frame alignment with reference to the role of the frame alignment word.
- describe and compare the characteristics and applications of synchronous, asynchronous, and plesiochronous transmission.

Module 2: Signal transport

Module aim: To describe the transport of signals over TDM networks with reference to the synchronous digital hierarchy and optical transport networks.

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

- describe the basic frame structure of a 2 Mbit/s E1 synchronous signal conforming with ITU-T recommendations.
- describe the purpose of overheads in a TDM network.
- describe the role of terminal mux equipment.
- compare the multiplexing capabilities of terminal mux in a network employing the synchronisation digital hierarchy (SDH) with those in an optical transport network (OTN).
- describe and compare the hierarchy of SDH and OTN transport signals.
- describe the role of, and relationship between, optical channel carriers (OCCs) and optical transport units (OTUs) in an OTN.
- describe the basic frame structure of SDH and OTN transport signals.
- explain the concepts and role of SDH containers and OTN optical data units.
- explain how an SDH multiplexer allows for small variations in the bit rate of multiplexed signals.

Module 3: Synchronisation

Module aim: To introduce the principles of synchronisation and the hierarchical distribution of timing signals.

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

- explain the need for stable timing control of synchronous transmission networks and mobile networks.
- describe the causes and effects of jitter.
- describe the hierarchical structure of a timing distribution network.
- describe the roles of, and relationship between, primary and secondary timing sources with reference to their respective timing stabilities.
- give examples of the types of clock that can be used as a timing reference including atomic clocks and GNSS satellite receivers.
- describe the role of synchronisation supply units (SSUs).
- describe methods of adapting to changes in timing of a transported signal relative to the transporting signal.
- explain that timing can be distributed by, and extracted from, a synchronous signal.
- explain the need for, and methods of, signalling the status of the clock controlling a transmitted signal.
- explain how an optical transport network (OTN) can transport synchronous signals while avoiding the need for a primary reference clock.

Module 4: Transmission networks

Module aim: To describe the provision of resilient, constant bit rate connections over TDM-based networks and the distribution of timing references over synchronous and asynchronous networks.

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

- explain how networks employing TDM provide low latency, constant bit rate connections.
- describe the role and basic operation of add and drop multiplexers (ADM) and cross-connect equipment.
- explain that optical transport networks (OTNs) employ optical add drop multiplexing (OADM) giving the advantages over SDH ADM.

- describe the role, basic operation, and types of automatic protection switching.
- explain that Ethernet networks can operate asynchronously or synchronously with reference to the applications of synchronous Ethernet (SyncE).
- describe timing and clock status distribution in a synchronous Ethernet network.
- compare frequency, phase, and time synchronisation with reference to their applications.
- describe the role and operation of the precision time protocol (PTP) in providing time synchronisation over asynchronous networks.
- describe a method of distributing timing references to a radio access network using a combination of SyncE, PTP, and a Global Navigation Satellite System (GNSS) with reference to the PTP clock hierarchy.

Course access requirements:
To access the course, a computer/tablet running a browser such as Chrome, Safari, Edge etc is required. The device should have an active Internet connection and a screen resolution of at least 1024x768.

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 digital technology. Those planning to study an Intermediate course should understand the basic principles of computing or 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 level 3 digital apprenticeships.

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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