



## COURSE DESCRIPTION CARD - SYLLABUS

Course name

Hierarchies of digital transmission systems:SDH,NG-SDH,OTH [S2EiT1-SSiU>HST]

### Course

Field of study Electronics and Telecommunications	Year/Semester 2/3
Area of study (specialization) Networks, Systems and Services	Profile of study general academic
Level of study second-cycle	Course offered in Polish
Form of study full-time	Requirements elective

### Number of hours

Lecture 30	Laboratory classes 0	Other 0
Tutorials 0	Projects/seminars 15	

### Number of credit points

4,00

### Coordinators

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### Lecturers

### Prerequisites

Students know the principles, with necessary mathematical background, theory of communication necessary to understand, analyze and evaluate the operation of analogue and digital transmission systems. Is able to extract information from Polish or English language literature, databases and other sources, is able to synthesize gathered information, draw conclusions, and justify opinions.

### Course objective

The presentation of the properties of basic hierarchies of digital transmission systems exploited in modern communication networks and used to send information between nodes of communication networks, starting from commonly used SDH hierarchy, through its newer version known as NG-SDH, and ending to OTH hierarchy, known also as OTN. To create skills necessary to evaluate utility of different transmission systems that satisfy different users" requirements concerning operation, administration and maintenance.

### Course-related learning outcomes

Knowledge:

1. Has an advanced knowledge about construction and operation of communication systems used in multimedia transmission.

### Skills:

1. Is able to design, analyze, construct and maintain technically advanced communication systems, including various devices and networks being elements of such systems. Is able to ensure required technical parameters of the designed systems.
2. Is able to select adequate methods to solve typical tasks related to analysis, design and optimization of transmission systems.

### Social competences:

1. Is responsible for the designed electronic and communication systems and knows physical and social threats that can appear as the result of irresponsible design or usage of communication systems.
2. Is aware of the necessity to approach solving technical problems with responsibility and professionalism.

## Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

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Learning outcomes are verified with a written/oral test. Test consists of 5 open questions. Answers are scored equally. Minimum number of scores to pass the exam is equal to 50%. The set of predefined subjects is sent to students by email.

Knowledge and skills gathered during the Project are assessed by written project and oral presentation of the results of this project. The final mark is the average of two marks. The assessment levels are the following: under 3 - mark 2.0, from 3 to 3.25 - mark 3.0; from 3.26 to 3.75 - mark 3.5; from 3.76 to 4.25 - mark 4.0; from 4.26 to 4.75 - mark 4.5; above 4.75 - mark 5.0.

## Programme content

During the course students learn about PDH, and its limitations, that resulted in introduction a novel digital hierarchy, called synchronous Digital Hierarchy (SDH), the origin of SDH, the layer and line model of SDH, the concept of container and virtual container, tributary unit, tributary unit group, pointer, pointer justifications, administrative unit, synchronous transport module level  $n$ , where  $n$  can be equal to 0, 1, 4, 16, 64, 256, methods of mapping bit streams into SDH containers, the concept of tandem connection, methods of protection and alarm signals, types of SDH multiplexers, SDH clocks and methods of their synchronization, topologies of SDH networks (linear, ring, mesh), protection methods offered by SDH rings, methods of interconnection of rings, methods of building hierarchical SDH network composed of many rings, examples of SDH networks in various countries. Students learn about how to introduce information into NG-SDH, virtual concatenation V-CAT, Link Capacity Adjustment Scheme (LCAS), and Generic Framing Procedure (GFC) used in NG-SDH to encapsulate data from IP networks, multiplexing in OTH (OTN), basic data structures (OPU, ODU, OTU, OCh, OCC, OCG, OTM), the concept of optical section, description of multiplexing process in OTN, the OTN frame structure, mechanism of data correction, layer model of OTN, comparison of NG-SDH and OTH (OTN). The course ends with a comparison of NG-SDH and OTH. Possible scenarios of introducing OTH (OTN) into existing networks are also described.

The goal of the Project is to prepare and implement in FPGA or SoC a chosen component of the SDH system or to design a multiring SDH network for given bit rates between neighbor nodes. Student can choose a component type or input data from prepared by the teacher or can propose his own subject, after earlier acceptance of the teacher. Among existing propositions we have: SDH multiplexer that multiplexes four STM-1 signals into one STM-4 signal; synchronization circuit for SDH multiplexer, synchronized with 2048 kb/s signal; a circuit/software for BER assessment in RSOH or MSOH or VC-4, or VC-12; phase detector for wander and jitter measurements, a circuit that can assess the power of STM-1 signal at the input of SDH multiplexer; sinusoidal jitter generator with known parameters; computer model of multiplexing four AU-4 into AU-4-4; computer model of asynchronous mapping of E1 signals into C-12 container; computer model of error detection with BIP-K, where K can assume 2, 8 or 16; header generator and visualizer for STM-1 frame.

## Course topics

The PDH Hierarchy and Its Limitations. ITU-T Multiplexing Structure.  
 Virtual Containers, Component Units, Groups of Component Units, Administrative Unit, Synchronous Transport Module.  
 Indicators and Adaptation.  
 Mapping Source Signals into Containers.  
 Functional Architecture of the Transport Network. Architectural Elements, Layering, Network and Connection Partitioning Concept.  
 The Concept of a Tandem Connection and Tandem Connection Supervision Methods.  
 Protection Methods and Alarm Signaling in SDH.  
 SDH Devices.  
 SDH Network Topologies. Linear, Ring, and Mesh Structures, Protection Methods Offered by Ring and Mesh Structures.  
 Connecting Ring Structures. Multi-Ring Networks.  
 Network Synchronization.  
 SDH Network Design.  
 NG-SDH,  
 Optical Transport Hierarchy (OTN) – Concept, Structure, and Properties. Migration of existing SDH and NG-SDH networks to OTN networks.

### Teaching methods

Lecture: Multimedia presentation.

Project: A combination of exercise and project method.

### Bibliography

Basic

1. R. K. Jain „Principles of Synchronous Digital Hierarchy”, CRC Press, Boca Raton, 2013.
2. Sławomir Kula „Systemy Teletransmisyjne”, WKŁ, Warszawa, 2004.

Additional

1. A. Valdar „Understanding Telecommunications Networks”, IET, London, 2006.
2. B.G. Lee, M. Kang, J. Lee „Broadband Telecommunications Technology”, Artech House, 2nd. Edn. Boston, 1996.
3. M. Sexton, A. Reid ”Broadband Networking, ATM, SDH, and SONET”, Artech House, Boston, 1997.

### Breakdown of average student's workload

	Hours	ECTS
Total workload	100	4,00
Classes requiring direct contact with the teacher	58	2,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	42	2,00