

FINAL STATE EXAM RANGE of ISSUES

IN MASTER DEGREE PROGRAMME: TELECOMMUNICATION TECHNOLOGY

Final state exam subjects in 2019/2020 academic year:

- I. **Information and Communication Technology** (2 questions)
- II. **Telecommunication technology**
(2 questions from branch chosen by student during diploma thesis)
 - A. Branch: **TELECOMMUNICATIONS**
 - B. Branch: **OPTICAL COMMUNICATIONS**
 - C. Branch: **RADIO COMMUNICATIONS**

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I INFORMATION AND COMMUNICATION TECHNOLOGY

1. Telecommunication and computer networks

- a. OSI reference model (OSI model layers description).
- b. Signaling in digital systems and networks (subscriber DSS1, network SS7 signaling).
- c. Queueing theory (queueing system parts, Kendall classification, offered load and carried load modelling - Erlang B, Erlang C).
- d. LAN, WAN and transport networks (Ethernet, Frame Relay, SDH, DWDM).
- e. Access networks (xDSL, DOCSIS, PON variants, FTTx concept, WLAN, Bluetooth, Zigbee, WiMAX 2.0).
- f. Mobile radio networks from 1 to 4 generation (frequency ranges, cell principles, NMT architecture, GSM, WCDMA/UMTS, LTE/SAE, GPRS/EDGE system, HSPA, PRB concept, OFDM).
- g. TCP/IP protocols family (TCP/IP model architecture, relation to OSI model, examples and usage of protocols in particular layers).
- h. Active network elements in computer networks and its functions - hub, switch, router (Detail description of functions of the elements, functions definition related to the OSI model, collision domain).
- i.

2. Digital signal processing

- a. Definition of Signals and Systems; Basic Types and Operations with Signals. Frequency and Spectrum of Signal.
- b. Analog and discrete signal spectrum – Fourier series expansion, Fourier transform, discrete Fourier transform, FFT and its properties. Spectrum of Basic types of signals. (Dirac impulse, unit impulse, harmonic signal, rectangular signal).
- c. Typical DSP system (sampling, quantization, coding and signal reconstruction), sampling theorem, aliasing, leakage.
- d. Cross-correlation and its meaning, autocorrelation and its meaning, convolution and its relation to LTI systems. Relation of correlation and convolution with Fourier transform and z-transform.
- e. Linearity, stability, time invariance, causality of systems. Ideal filter, causal filter.
- f. IIR and FIR filters. Typical properties and usage areas, IIR and FIR comparison.

3. Communication Network Practice II

- a. Monitoring and maintenance of communication networks (data logging, SNMP protocol, RRDtool graphing tool, Netflow protocol).
- b. AAA problematic – authentication, authorization and accounting in communication networks (LDAP protocol, Radius, Kerberos, SSO Single Sign-on Systems, SAML).
- c. Communication tools (IRC communication, IM Instant Messaging, XMPP protocol, WebRTC communication via web browser).

I INFORMATION AND COMMUNICATION TECHNOLOGY

4. Optical communication

- a. Principle of optical fiber operation, Single-mode and Multi-mode fibers and difference between them, Attenuation and dispersion in optical fibers, Splicing of optical fibers, Attenuation measurements.
- b. Light sources for optical communications, principle of LED and LASER diode operation, LED and LD difference, Properties of LASER radiation.
- c. Receivers for optical communications, Photodetector principle, Photodetector with PN junction, PIN, APD photodetectors, Catalog parameters of detectors.

5. Radio communications

- a. Radio waves propagation (types and properties of radio waves, Frequency spectrum allocation, Fresnel zone, Doppler Effect, Diversite reception).
- b. Radiocommunication chain (particular blocks description, modulation with carrier waves, capacity of radio channel).
- c. Mobile cellular systems 1 – 5th generations (basic architecture– differences, frequency band allocation, transmission rate).
- d. Technology for the Internet of Things Networks.

II TELECOMMUNICATION TECHNOLOGY

Branch: TELECOMMUNICATIONS

1. VoIP

- a. RTP (codecs and their parameters, RTP stream requirements calculation, security of RTP, packetization and de-jitter buffer).
- b. H.323 (H.323 standard elements, RAS signaling, Fast Connect a H.245 tunneling, DRC a GRC model).
- c. SIP (SIP elements, transactions and dialogs, methods and answers, SDP and offer/answer model, usage of SUBSCRIBE/NOTIFY methods, establishing call scenarios, ENUM).
- d. VoIP Quality (speech quality evaluation approach, specific problems of IP telephony and its solutions, speech quality evaluation via E-model).

2. Advanced Network Technologies

- a. MPLS Technology - basic characteristics. (label, LSP, LDP, LIB, LFIB)
- b. MPLS VPN, MPLS – Traffic Engineering, AToM. (VRF, VPNv4, RT, tunnel label and virtual circuit label).
- c. Differentiated Services, Priority marking of transferred data. (DSCP, IP precedence, ToS, CoS, Assured Forwarding).
- d. Packet queueing methods, Traffic Shaping, Traffic Policing, WRED. (CBWFQ, LLQ, Traffic Shaping, WRED).

3. Security in communications

- a. Secure communication basics (Steganography, cryptography, Kerckhoffs's principle, aims and methods of cryptography).
- b. Modern cryptography systems (Symmetric and asymmetric cryptography, one-way functions and digital signatures, modular arithmetic, DH algorithm and RSA).
- c. Block cyphers and stream cyphers characteristics (Stream and block cyphers, operate modus ECB, CBC, OFB, CFB and CTR).
- d. Computer network security (typical attacks, packet filters, stateful firewall, IPS/IDS, VPN, IPsec, SSL/TLS a SSH).
- e. Security in IP telephony (SRTP, SIPS, ZRTP, security risks in VoIP and their elimination).

Branch: OPTICAL COMMUNICATIONS

1. Optical communications I-III

- a. Description of light – geometrical, electromagnetic and quantum optics. Description of ray, Planar wave, Photon, energy of a photon. Fermat's principle, Snell law of refraction, Coherence, Polarization and light interference.
- b. Optical fibers - History, Materials; Principle of light transmission through optical fiber; Critical acceptance angle definition, Numerical aperture. Effects causing attenuation in optical fibers. Dispersion in optical fibers – modal, chromatic, polarization modal.

II TELECOMMUNICATION TECHNOLOGY

- c. Light sources for optical communications – LED, LASER – physical principles, Mutual properties and differences of LED and LASER diodes. Spontaneous and stimulated emission of radiation, Inversion of population, Excitation.
- d. Detectors for optical communications – photodiode, PIN, Avalanche photodiode – physical principles; SNR a BER.
- e. Attenuation and dispersion measurements in optical links (insertion loss method, cut back method, reflectometry method), BER measurements.
- f. Wave equation and its solution for cylindrical fibers, Phase and group velocity of wave propagation, Modes in cylindrical waveguide, Normalized frequency.
- g. Special materials and optical fiber structures, Fiber with shifted dispersion characteristic, Bending insensitive fibers, Bragg fibers, Microstructure optical fibers, Fiber optical sensors.
- h. Nonlinear effects in optical fibers, Raman and Brillouin scattering, Four wave mixing, Self-phase modulation, Solitons, Cross-phase modulation.
- i. WDM systems – EDFA and semiconductor amplifiers, Filters, Splitters, Chromatic dispersion compensation.
- j. Optical fiber and cables fabrication.
- k. Optical fiber connections – mechanical connections, splicing, demountable connections.
- l. Fiber optic sensors, Division of FOS, Used principles, Point, integrated, distributed and quasi-distributed sensors.
- m. Free space communications, Atmosphere characteristics, Types of free space networks, free space networks elements.

Branch: RADIO COMMUNICATIONS

1. Radio networks, Radio communication technology

- a. Radio waves propagation (radio waves types, fading, dispersion, refraction, reflection and diffraction of waves, frequency spectrum allocation, Fresnel zone, Doppler Effect, diversity reception, equalization, energy-balance of radio link).
- b. Signal processing in radio networks (source coding, channel coding, interleaving, modulation, MIMO technology, OFDM).
- c. Basic functions and concepts of radio communication systems (multiple access, duplex, cellular structure, frequency band utilization increasing of network capacity, handover).
- d. Antennas (basic division, types and properties; Yagi-Uda antenna, Impedance matching, Standing Wave Ratio, RF feeders, and connectors).
- e. WLAN (components of WiFi network, network types, spectrum technics, standards, frequency bands/radio channels).
- f. Digital Video and Audio broadcasting (advantages/disadvantages, SFN networks, frequency bands).
- g. GSM and UMTS system (frequency bands, system architecture, GPRS / EDGE technology, HSPA).

II TELECOMMUNICATION TECHNOLOGY

- h. LTE / SAE system (frequency bands, system architecture, OFDM and PRB unit, Cyclic Prefix).
- i. 5G NR system (frequency bands, fundamental differences from LTE / SAE).
- j. Base station of the mobile system (base station parts, limits, legislation, optimization).