**Questions of the entrance exam on speciality 05.12.04**

**‘RADIO ENGINEERING, INCLUDING SYSTEMS AND DEVICES OF RADIO NAVIGATION, RADIOLOCATION AND TELEVISION’.**

**2.1. Statistical radio engineering**

**2.1.1. Methods of mathematical description of messages, signals and disturbances**

Deterministic and random signals. Classification of random and deterministic processes: continuous and discrete, deterministic and nondeterministic, stationary and nonstationary, ergodic and non-ergodic. Integral representations of signals. Fourier and Hilbert transforms. Decomposition of a signal by a given system of functions. Harmonic analysis of signals. Spectra of periodic and non-periodic signals. Kotelnikov's theorem of samples in the frequency domain. Discrete signals and their analysis. Discrete Fourier and Hilbert transforms and their properties. Z-transform. Messages, signals and interference. Radio signals. Radio signals with amplitude and angular (frequency and phase) modulation and their spectra. Envelope, phase and frequency of a narrowband signal. Analytical signals. Noise and interference as random processes. Probability distribution densities, characteristic functions and distribution functions of random processes. Energy characteristics of random processes. Moment functions. Autocorrelation and mutual correlation functions. Properties of correlation functions. Spectral density. Wiener-Khinchin theorem. Stationarity and ergodicity of random processes. Gaussian random process and its characteristics. Poisson and Rayleigh random processes, white noise. The concept of Markov random processes and methods of their description. Additive and multiplicative disturbances.

**2.1.2 Fundamentals of the theory of analysing linear and nonlinear circuits and devices**

Linear circuits and devices with constant parameters. Methods of analysing linear circuits. Active linear circuits. Amplifiers and their characteristics. Passage of signals and disturbances (deterministic and random oscillations) through linear circuits with constant parameters.

Nonlinear circuits and devices. Methods of analysing nonlinear circuits. Frequency multipliers. Amplitude limiters. Detectors. Oscillation frequency converters. Oscillation generators. Auto oscillating systems. Oscillation modulators. Discrete linear systems. Methods of analysis and synthesis of discrete radio engineering devices. Structural schemes of tracking systems: automatic regulation (gain, automatic frequency adjustment, phase auto-tuning, etc.). Statistical characteristics of discriminators.

**2.1.3. Optimal methods of reception.**

The main tasks of reception theory: detection, differentiation, parameter estimation and filtering of signals. The concept of optimal processing devices. Criteria of optimality. Functional schemes of optimal receivers for signals with amplitude, frequency and phase modulation. Elements of the theory of optimal statistical solutions. Bayes formula A priori and a posteriori probabilities. Likelihood function, principles of maximum likelihood and maximum posterior probability. Two-alternative decision theory. Decision errors. Decision functions and loss functions. Neumann-Pearson and Kotelnikov-Siegert optimality criteria. Optimal distinction of binary signals on the background of Gaussian and correlated noise. Methods of solving the problem of estimating the parameter of signals received against the background of noise. Methods of estimation. Limit accuracies of measurement of signal parameters. Estimation of time lag and Doppler frequency shift of received radio signals. Formulation and methods of solving the problem of signal filtering on the background of interference. Criteria of filtering quality Optimal linear filtering by the criterion of maximum signal-to-interference ratio. Matched filters and their properties. Optimal linear and nonlinear filtering by the criterion of minimum RMS error. Principles of adaptive reception at unknown parameters of useful signals or unknown characteristics of interference.

**2.1.4 Digital methods of signal processing**

Time discretisation of signals and level quantisation. Analogue-to-digital converters (ADC) and selection of code parameters. Digital multibit signals, methods of their formation. Methods of synthesis of algorithms and devices for digital signal processing. Digital filtering and digital filters. Quantisation and rounding errors. Recursive and non-recursive digital filters. Physical feasibility and stability of digital filters. Transfer function, impulse response and frequency response of digital filters. Spectral analysis. Discrete Fourier transform. Fast Fourier transform. 2.2. Theory of information transfer Applications and problems of information transfer. Measure of information quantity (Hartley, K. Shannon). Entropy of information source and its properties. Redundancy. Performance. Bandwidth of a communication channel. Shannon's formula. Basic theorem of coding. Notion of information coding: code, alphabet, code base and significance. Methods of constructing an effective code. Principles of constructing error-detecting and error-correcting codes. Theories of potential noise immunity of V.A. Kotelnikov. Criterion of noise immunity of reception of continuous messages. Gain and generalised gain with respect to message (signal) noise. Algorithm of optimal demodulation of continuous messages under weak interference. Types of modulation in the transmission of continuous messages. Noise power at the output of the demodulator and its energy spectrum. Application of AM, BM, OPM, FM and FM, their comparison in terms of gain and physical explanation. The cost of increased noise immunity in FM and HF. Digital methods of transmission of continuous messages. Pulse-code modulation (PCM). Differential ICM and delta modulation. Application of complex noise-like signals. Methods of reception of binary signals in channels with constant parameters. Digital modulation methods. Reception of binary signals. Radiolines. Range of radio waves in information transmission systems. Types of radio information transmission systems: communication, television, telemetry and command. Communication channel and its characteristics. Channel capacity. Characteristics and parameters of transmitted information. Structure of radio signals. Modems and codecs.

**2.3 Radio engineering devices and systems**

**2.3.1 Signal generation and shaping devices**

Generators and autogenerators. Self-excitation modes, their peculiarities. Frequency stability and methods of its increase. Stabilisation by means of high-frequency oscillating systems (resonators). Quartz generators. Frequency multipliers. Frequency synthesisers.

**2.3.2 Signal reception and conversion devices**

Basic types of radio receiving devices. Signal frequency converters, mixers and heterodynes. Signal detectors: amplitude, frequency and phase. Amplifiers of various frequency ranges. Automatic adjustments in radio receivers. Features of television and communication radio receivers.

**2.3.3 Radio-television systems**

Range of radio waves for television. Frame, lines and picture elements, synchronisation. Television signal format. Television signal standards. Peculiarities of construction of television transmitters. Transmission of radio signal image and sound, synchronisation and colour code of the signal. Features of television antennas. Principles of construction of nodes of television receivers. Principles of digital television.

**2.3.4 Radio communication systems.**

Evolution of radio communication systems. Mobile communication systems. Cellular communication systems. Satellite communication systems.

2.4 Additional individual programme in the chosen scientific field:

1. Interference control in SBN search systems.

2. Joint nonlinear filtering of signal parameters.

3. Time-frequency distributions.

4. Digital signal processing.

5. Filtering of multilevel signals.

6. Software-defined radio.

7. Cognitive radio.

8. Wireless networks.

**List of references**

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