**Nazwa przedmiotu:**

Signals, Systems and Modulations

**Koordynator przedmiotu:**

dr hab. inż. Przemysław Dymarski

**Status przedmiotu:**

Obowiązkowy

**Poziom kształcenia:**

Studia I stopnia

**Program:**

Computer Science

**Grupa przedmiotów:**

Technical Courses

**Kod przedmiotu:**

ESISM

**Semestr nominalny:**

4 / rok ak. 2015/2016

**Liczba punktów ECTS:**

6

**Liczba godzin pracy studenta związanych z osiągnięciem efektów uczenia się:**

lecture attendance 15 x 2h = 30 h
tutorials (attendance) 15 h
laboratories (attendance) 13 x 2.33 = 30 h
preparation to lectures and tutorials 30 h
preparations for the exams 20 h
preparations for the laboratories 25 h
sum: 150 h

**Liczba punktów ECTS na zajęciach wymagających bezpośredniego udziału nauczycieli akademickich:**

30 (lecture) + 15 (tutorials) + 30 (laboratories) = 75 h
75/25 = 3 ECTS

**Język prowadzenia zajęć:**

angielski

**Liczba punktów ECTS, którą student uzyskuje w ramach zajęć o charakterze praktycznym:**

laboratories: 30 h (attendance) + 25 h (preparations) = 55 h
i.e. 2 ECTS

**Formy zajęć i ich wymiar w semestrze:**

|  |  |
| --- | --- |
| Wykład:  | 30h |
| Ćwiczenia:  | 15h |
| Laboratorium:  | 15h |
| Projekt:  | 0h |
| Lekcje komputerowe:  | 0h |

**Wymagania wstępne:**

This is the first course of telecommunications, so only bases of signal processing (e.g. Fourier series and transform), bases of analog and digital systems are required. These topics are included in Circuits and Signals (ECIRS) course.

**Limit liczby studentów:**

28

**Cel przedmiotu:**

Students become acquainted with signals used in telecommunications, the basic transmission link, analog and digital modulations, signal reception in presence of noise. Digital transmission of speech is studied and bases of signal compression are introduced.
Short summary:
General model of communication link (modulator – channel - demodulator) is introduced as well as criteria of its performance. Analog and digital modulations are described and compared. Digital transmission of analog signals is studied (based on the example of the G.711 PCM) as well as bases of signal compression. The time- and frequency domain methods of signal representation are developed (DFT, DCT) as well as the bases of adaptive filtering (for prediction and noise suppression)

**Treści kształcenia:**

Lecture:
Signals in telecommunications (2h): Examples, properties and mathematical models of signals in telecommunication. General model of communication link (modulator – channel - demodulator). Analog and digital modulations, multiplexing (TDM, FDM). Criteria used for comparing modulations: bandwidth, bit rate, signal to noise ratio, immunity to channel noise.
Limits of transmission (2h) Maximum baud rate (Nyquist theorem). Channel capacity – Shannon theorem and its consequences.
Analog modulations (3h): Amplitude modulations (DSB-SC, DSB, SSB, VSB) and angle modulations (FM, PM): spectra of modulated signals, bandwidth, detection methods, immunity to channel noise.
Digital modulations and transmission codes (2h): Transmission codes and their spectra (unipolar code, bipolar code, AMI, etc.). Basic digital modulations: ASK, FSK, PSK – spectra of the modulated signals. Mixed modulations: AM-PM, QAM. Differential coding: DPSK.
Reception of digital signals (3h): Channel with additive gaussian noise. Optimal reception of binary signals: unipolar, bipolar, PSK, FSK. The quadrature receiver for M-ary PSK and AM-FM signals. Coherent and noncoherent reception of DPSK signals. Comparison of digital modulations.
Digital transmission of analog signals (4h): Quantization, quantization error, SNR. Nonuniform quantizers, logarithmic quantizers. ITU-T standard PCM 64kbit/s – channel bandwidth, SNR, influence of channel noise.
Discrete signals and systems (8h) Sampling of the baseband and passband signals. Z-transform and inverse Z-transform. Discrete Fourier Transform. Discrete systems: impulse response, frequency response, stability conditions.
Introduction to adaptive filtering: (4h) A problem of signal prediction, noise suppression, echo cancellation. The Wiener filter, adaptive filters.
Introduction to signal compression (2h): Problem of source coding, lossless and lossy compression. Example of a lossy compression – the Huffman code. Lossy compression: using a predictor, digital transforms (DFT, DCT).

Tutorials
Calculation of Fourier Transform repetition (2h)
Reception of AM and FM signals: calculation of signal and noise power in a synchronous detector, envelope detector and frequency discriminator. Analysis of a phase modulator for SSB. Comparison of analog modulations. (2h).
Optimal reception of digital signals: Evaluation of BER for binary transmission in the channel with AWGN. (2h)
Quantization: Evaluation of a SNR for the uniform and nonuniform quantizer. Comparison of the PCM with analog modulations (channel bandwidth ,influence of the channel noise on the output signal quality, etc.). (2h).
Discrete in time signals and systems (review): Calculation of Z-transforms and inverse Z-transforms. Calculation of a frequency response of a system, given its transfer function in Z domain. Stability of discrete systems. (4h)
Adaptive filtering: Evaluation of an echo canceller or noise suppression algorithm (2).

Laboratory
Transmission codes (2h). Hardware part: comparison of the bipolar code receivers. Software part: construction of decision algorithms for binary baseband transmission
Digital modulations (2h) Comparison of binary and M-ary modulations, the quadrature receiver, coherent and noncoherent reception of DPSK.
Quantization and ADPCM (2h). Presentation of the PCM and DPCM: sampler, quantizer, predictor. SNR for an uniform, nonuniform and adaptive quantizers. Measurement of prediction gain in ADPCM.
Discrete transforms (2h).
Discrete filters (2h).
Adaptive filtering (2h).

**Metody oceny:**

During the lab exercises it is possible to score up to 30 points (5 pts per one session)
Maximum score for the exam is 70 points. There are also up to 10 points to get during the tutorials.
The final result is based on the following pattern:
• 5.0: 91-110 points
• 4.5: 81-90 points
• 4.0: 71-80 points
• 3.5: 61-70 points
• 3.0: 51-60 points
• 2.0: 0 -50 points

**Egzamin:**

tak

**Literatura:**

K. Sayood Introduction to Data Compression, Morgan Kauffman (IT library)
L.W. Couch Digital and Analog Communication Systems Prentice Hall (IT library)
I.A. Glover Digital Communications (IT library)
S.Haykin Communication Systems, Wiley 2001

**Witryna www przedmiotu:**

https://studia.elka.pw.edu.pl, www.tele.pw.edu.pl/esism

**Uwagi:**

## Efekty przedmiotowe

### Profil ogólnoakademicki - wiedza

**Efekt ESISM\_W01:**

General model of communication link, criteria of its quality

Weryfikacja:

exam

**Powiązane efekty kierunkowe:** K\_W13

**Powiązane efekty obszarowe:** T1A\_W03, T1A\_W07

**Efekt ESISM\_W02:**

Digital and analog modulations and transmission codes

Weryfikacja:

exam

**Powiązane efekty kierunkowe:** K\_W06, K\_W13

**Powiązane efekty obszarowe:** T1A\_W02, T1A\_W03, T1A\_W03, T1A\_W07

**Efekt ESISM\_W03:**

Reception of digital signals

Weryfikacja:

exam

**Powiązane efekty kierunkowe:** K\_W06, K\_W13

**Powiązane efekty obszarowe:** T1A\_W02, T1A\_W03, T1A\_W03, T1A\_W07

**Efekt ESISM\_W04:**

Bases of analog to digital conversion and compression

Weryfikacja:

exam, exercises

**Powiązane efekty kierunkowe:** K\_W06, K\_W13, K\_W14

**Powiązane efekty obszarowe:** T1A\_W02, T1A\_W03, T1A\_W03, T1A\_W07, T1A\_W03, T1A\_W07

### Profil ogólnoakademicki - umiejętności

**Efekt ESISM\_U01:**

Comparison of modulations

Weryfikacja:

tutorials, exam

**Powiązane efekty kierunkowe:** K\_U13

**Powiązane efekty obszarowe:** T1A\_U14, T1A\_U15, T1A\_U16

**Efekt ESISM\_U02:**

Analysis of signal reception methods

Weryfikacja:

tutorials, laboratory

**Powiązane efekty kierunkowe:** K\_U08, K\_U09

**Powiązane efekty obszarowe:** T1A\_U08, T1A\_U09, T1A\_U08, T1A\_U09

**Efekt ESISM\_U03:**

Analysis and comparison of basic signal compression methods

Weryfikacja:

tutorials, laboratory

**Powiązane efekty kierunkowe:** K\_U08, K\_U09

**Powiązane efekty obszarowe:** T1A\_U08, T1A\_U09, T1A\_U08, T1A\_U09

### Profil ogólnoakademicki - kompetencje społeczne

**Efekt ESISM\_K01:**

team work in a laboratory

Weryfikacja:

laboratory exercises

**Powiązane efekty kierunkowe:** K\_K04

**Powiązane efekty obszarowe:** T1A\_K03, T1A\_K04