SYLLABUS

1. Data about the program of study

1.1 Institution	Technical University of Cluj-Napoca
1.2 Faculty	Faculty of Electronics, Telecommunications and information Technology
1.3 Department	Communications
1.4 Field of study	Electronic Engineering, Telecommunications and Information Technologies
1.5 Cycle of study	Bachelor of Science
1.6 Program of study / Qualification	Telecommunications Technologies and Systems/Engineer
1.7 Form of education	Full time
1.8 Subject code	TST-E34.00

2. Data about the subject

2.1 Subject name	Modulation Techniques						
2.2 Subject area	Theoretical area Methodological area Analytic area						
2.3 Course responsible	Eng. Anghel BOTOS, Ph.D. - Anghel.Botos@com.utcluj.ro						
2.4 Teacher in charge with seminar / laboratory / project	Professor Vasile BOTA, Ph.D. - Vasile.Bota@com.utcluj.ro Eng. Anghel BOTOS, Ph.D. - Anghel.Botos@com.utcluj.ro						
2.5 Year of study	III	2.6 Semester	5	2.7 Assessment	E	2.8 Subject category	DS/DI

3. Estimated total time

3.1 Number of hours per week	5	of which: 3.2 course	2	3.3 seminar / laboratory	3
3.4 To Total hours in the curriculum	70	of which: 3.5 course	28	3.6 seminar / laboratory	42

Distribution of time	hours
Manual, lecture material and notes, bibliography	35
Supplementary study in the library, online specialized platforms and in the field	0
Preparation for seminars / laboratories, homework, reports, portfolios and essays	12
Tutoring	2
Exams and tests	6
Other activities:	0

3.7 Total hours of individual study	55
3.8 Total hours per semester	125
3.9 Number of credit points	5

4. Pre-requisites (where appropriate)

4.1 curriculum	The courses on Signal's theory and the courses on Digital integrated circuits
4.2 competence	Basic knowledge of signal theory; basic knowledge of digital circuits

5. Requirements (where appropriate)

5.1. for the course	Downloading of the lecture notes -available on the course's website
5.2. for the seminars / laboratories	Downloading and study of some laboratory notes and set of proposed problems - available on the course's website

6. Specific competences

Professional competences	**C4. Design, implementation and operation of data, voice, video and multimedia services. This is based on the understanding and the application of fundamental concepts in telecommunications and transmission of information** C4.1 Identification of the fundamental concepts regarding the transmission of information and analog and digital communications C4.2 Solving practical problems using general knowledge of multimedia techniques C4.4 Use of the main specific parameters in evaluations based on the concept of quality of service in communications **C5. Selecting, installing, configuring and operating fixed or mobile telecommunications equipment. Equipping a site with usual telecommunications networks** C5.1 Defining the principles of the main technologies for fixed and mobile telecommunications, through various transmission media C5.2 Explanation and interpretation of the technologies and of fundamental protocols for integrated fixed and mobile communications systems **C6. Solving specific problems of the broadband communications networks: propagation in different environment, circuits and equipment for high frequencies (microwaves and optical).** C6.2 Explaining the specific methods for implementation of the communications techniques C6.5 Development of low/ medium complexity projects regarding the transmission and receiving equipment
Transversal competences	N/A

7. Discipline objectives (as results from the key competences gained)

7.1 General objective	Development of professional competences in the area of emplyment, design, simulation and performance evaluation of the studied modulation techniques in transmission systems.
7.2 Specific objectives	1. Assimilation of theoretical knowledge regarding the structure, design, simulation, performance evaluation and applicability of the modulation techniques studied 2. Acquiring the skills and abilities to use transmission measuremnt and analysis equipment. 1. 3. Acquiring the elementary skills and abilities to implement and evaluate the performance of the modulation techniques by using advanced simulation tools

8. Contents

8.1 Lecture (syllabus)	Teaching methods	Notes
1. Linear Modulations (LM) I. Types of LM. Quadrature Amplitude Modulation (QAM). Expression and spectra of the LM signals. Modulation methods of LM signals.	Exposition, discussions	Video-projector, employment of the lecture notes available on the laboratory site
*2. Linear Modulations (LM) **II.*** LM receivers. Demodulation methods of the LM signals. Carrier recovery methods. Properties of Gaussian noise. SNR performance of the LMs		
3. Frequency Modulation. Expression and spectrum of the FM signal. Modulation methods. Demodulation methods. SNR performance of the FM		
4. Base-band Data Transmissions (BB) I. BB Codes. Definitions. Spectral properties. Encoding-decoding of the BB codes. SNR performances of BB codes. Applications.		
5. Base-band Data Transmissions (BB) II. Elementary notions on PLL circuits. Digital methods for fast and dynamic bit-clock synchronization		
6. Pulse-Amplitude Modulation (PAM). Definition. Spectrum. SNR performance. Filtering the Data Signals. Defining the ISI. The RC and RRC filtering characteristics.		
7. Amplitude Shift Keying (ASK). Definition. Spectrum. Modulation-demodulation. SNR performance. QAM with digital modulating signals. Definition. Spectrum. Modulation-demodulation		
8. Phase Shift Keying (PSK) I. Expression of the PSK signal. Signal constellations. QAM-based generation of the PSK and DPSK signals. Spectra and filtering of the DPSK signals. Structure of the DPSK transmitter.		
9. Phase Shift Keying (PSK) II. QAM-based DPSK demodulators. Carrier and symbol-clock recovery and synchronization. Structure of the DPSK receiver.		
10. Phase Shift Keying (PSK) III. SNR performance of the DPSK modulation. Variants of QPSK–OQPSK, π/4-QPSK. Applications.		
11. A+PSK (QAM) Modulation I Definitions. A+PSK constellations. Bit-mapping and generation of the invariant constellations. Modulating the A+PSK constellations. Filtering the A+PSK signals. Structure of the A+PSK transmitter.		
12. A+PSK (QAM) Demodulation II The A+PSK Demodulator (the LPF- variant). Carrier Recovery (the DDCR method). Structure of the A+PSK receiver. SNR performance of the A+PSK modulations. Comparison to the SNR performance of DPSK and ASK. Applications of A+PSK .		

13. Frequency Shift Keying (FSK) I. Parameters and spectrum of FSK signals. Digital FSK modulators. Filtering the FSK signal. Structure of the FSK transmitter.		
14. Frequency Shift Keying (FSK) II. Demodulation of the FSK signals. Bit-clock synchronization. Structure of the FSK receiver. SNR performance. Applications.		
Bibliography 1. Proakis, J.G., Digital Communications, 4th edition, McGraw-Hill 2. Fuqin Xiong, Digital modulation Techniques, Artech House Internet teaching materials: 3. V. Bota, M. Varga, Modulation Techniques. Lecture Notes (in English), Universitatea Tehnică din Cluj-Napoca, http://users.utcluj.ro/~dtl/TM/cursuri_tm.html		
8.2 Seminar / laboratory	Teaching methods	Notes
Laboratory	Configuration of advanced simulators, performing measurements and interpretation of the results obtained. Case studies.	Computers, advanced software simulation tools, experimental laboratory circuits, specific measuring equipment
1. Introduction. Basic notions of signals' theory - revision		
2. Linear Modulations I. Spectral composition. Transmission.		
3. Linear Modulations II. Demodulation. Carrier recovery. SNR performance.		
4. Frequency Modulation. Modulation. Demodulation. SNR performance.		
5. Base-band Data Transmissions I. BB codes.		
6. Base-band Data Transmissions II. Digital synchronization of the bit-clock		
7. Filtering of data signals.		
8. PAM. ASK		
9. PSK I. Transmitter. Receiver.		
10. PSK II. Error performance of PSK		
11. A+PSK I. Transmitter. Receiver.		
12. A+PSK II. Local carrier synchronization. Error probability of A+PSK. Comparison to the performance of PSK.and ASK		
13. FSK.I Spectrum. Transmitter..		
14. FSK II Receiver. Bit-clock synchronization. Bit-error probability.		
Seminar		
1. Linear modulations	Solving problems. Case studies	Sets of problems available on the laboratory site
2. Frequency modulation		
3. Baseband transmissions		
4. PAM, Data Filtering and ASK		
5. PSK		
6. A+PSK		
7. FSK		
Bibliography 4. V. Bota, M. Varga, Modulation Techniques. Problems, Technical University of Cluj-Napoca, http://users.utcluj.ro/~dtl/TM/seminar_tm.html		

9. Bridging course contents with the expectations of the representatives of the community, professional associations and employers in the field

The discipline content and the acquired skills are in agreement with the expectations of the professional Competences acquired will be used in the following COR occupations (Electronics Engineer; Telecommunications Engineer; Electronics Design Engineer; System and Computer Design Engineer; Communications Design Engineer) or in the new occupations proposed to be included in COR (Sale Support Engineer; Multimedia Applications Developer; Network Engineer; Communications Systems Test Engineer; Project Manager; Traffic Engineer; Communications Systems Consultant).

10. Evaluation

Activity type	10.1 Assessment criteria	10.2 Assessment methods	10.3 Weight in the final grade
10.4 Course	The level of acquired theoretical knowledge and analysis and synthesis abilities.	Written examination Solving 4-5 issues (problems + theory)	75%
10.5 Seminar/ Laboratory	The level of acquired knowledge in the laboratory and seminar classes	Evaluation during the semester by means of three laboratory tests	25%
10.6 Minimum standard of performance			

Qualitative level:

Minimal knowledge:

- ✓ Basic knowledge of the operating principles of the studied modulation techniques.
- ✓ Basic knowledge of performance provided by the studied modulation techniques

Minimal competences:

- ✓ Elaboration of the block structure of the transmission equipment using the studied modulation techniques.
- ✓ Basic knowledge of the evaluation of the performance provided by the modulation techniques in a given simple transmission environment

Quantitative level:

- ✓ Execution of all laboratory works and attendance to the seminaries
- ✓ The final mark (N) is composed of the exam score (E) and the arithmetic average of the lab tests' scores (L). The final mark N will be computed by rounding the weighted score P = 0.75*E+0.25*L, to the closest integer, if P ≥ 5 and E ≥ 5.
- ✓ Conditions to pass the exam: P ≥ 5 and E ≥ 5.

Data of filling in:	Responsible	Title First name SURNAME	Signature
20.06.2023	Course	Eng. Anghel BOTOS, Ph.D.	
	Applications	Professor Vasile BOTA, Ph.D.	
		Eng. Anghel BOTOS, Ph.D.	

Date of approval in the Council of the Communications Department 11.07.2023	Head of Communications Department Prof. Virgil DOBROTA, Ph.D.
Date of approval in the Council of the Faculty of Electronics, Telecommunications and Information Technology 12.07.2023	Dean Prof. Ovidiu POP, Ph.D.