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	Professor Vasile Bota, Ph.D., Vasile.Bota@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	I	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	28
Supplementary study in the library, online specialized platforms and in the field	0
Preparation for seminars / laboratories, homework, reports, portfolios and essays	19
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	Amphitheatre, Cluj-Napoca; Downloading of the lecture notes -available on the course's website

5.2. for the seminars / laboratories	Amphitheatre, Laboratory; 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
Cross 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 employment, 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 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

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		laboratory site
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: 1. 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 Laboratory	Teaching methods	Notes
1. Introduction. Basic notions of signals' theory - revision	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
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.		
8.3. Seminar	Teaching methods	Notes
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 V. Bota, A. Botos, Sets of problems, available on the laboratory site http://users.utcluj.ro/~dtl/TM/seminar_tm.html V. Bota, M. Varga, A. Botos, Set of laboratory works, available on the laboratory site http://users.utcluj.ro/~dtl/TM/laboratoare_tm.html		

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

The acquired competences would be useful for employment in the following jobs, according to COR: Transmission engineer, Electronics engineer, Telecommunications engineer, R&D Electronics engineer, Communications design engineer, Sales support engineer, Network operation engineer, Communications systems testing engineer, Project manager, Consultant in communications systems

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 Consisting of problems and theory (11-12 questions)	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 the mean 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 $E \geq 5$ and $P \geq 5$. If either $E \leq 5$ or $P \leq 5$, the final mark N will be computed by rounding the weighted score P to the closest integer smaller than 5.
- ✓ Conditions to pass the exam: $P \geq 5$ and $E \geq 5$.

Date of filling in:	Responsible	Title First name SURNAME	Signature
28.09.2020	Course	Professor Vasile BOTA, Ph.D.	
	Applications	Eng. Anghel BOTOȘ, Ph.D.	
		Professor Vasile BOTA, Ph.D.	

Date of approval in the Department of Communications 30.09.2020	Head of Communications Department Prof. Virgil DOBROTA, Ph.D.
Date of approval in the Council of Faculty of Electronics, Telecommunications and Information Technology 30.09.2020	Dean Prof. Gabriel OLTEAN, Ph.D.