SYLLABUS

1. Program information

1.1 Higher education 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 Study program / Qualification	Telecommunications Technologies and Systems/ Engineer
1.7 Form of education	IF – full-time education

2. Course information

2.1 Course title	Modulation Techniques			Course code		TST-E34.00
2.2 Course coordinator	*Eng. Anghel BOTOS, Ph.D. - Anghel.Botos@com.utcluj.ro*					
2.3 Seminar/ laboratory coordinator	*Eng. Anghel BOTOS, Ph.D. - Anghel.Botos@com.utcluj.ro*					
2.4 Year of study	3	2.5 Semester	5	2.6 Type of assessment		E
2.7 Course status	Formative category					DS
	Optionality					DOB

3. Estimated total time

3.1 Hours per week	5	of which:	3.2 Lecture	2	3.3 Seminar	1	3.3 Laboratory	2	3.3 Project	-	3.3 Practical training	-
3.4 Hours per semester	70	of which:	3.5 Lecture	28	3.6 Seminar	14	3.6 Laboratory	28	3.6 Project	-	3.3 Practical training	-

3.7 Time distribution (hours per semester) for individual study and assessment:	
(a) Assessment	6
(b) Study using textbook, course materials, bibliography, and notes	28
(c) Additional documentation in the library, on specialized electronic platforms, and in the field	0
(d) Preparation for seminars/laboratories, assignments, reports, portfolios and essays	19
(e) Tutoring	2
(f) Other activities	0
3.8 Total hours of individual study and assessment (sum of (3.7(a)...3.7(f))	55
3.9 Total hours per semester (3.4+3.8)	125
3.10 Number of credits	5

4. Prerequisites (where applicable)

4.1 curriculum	Signal theory, Digital integrated circuits
4.2 competencies	Basic knowledge of signal theory; basic knowledge of digital circuits

5. Requirements (where applicable)

5.1. for the development of the lecture	Cluj-Napoca, Downloading of the lecture notes -available on the course's website
5.2. for the development of the seminar/ laboratory/ project	Cluj-Napoca, Downloading and study of some laboratory notes and set of proposed problems - available on the course's website

6. Specific competencies acquired

Professional competencies	**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 competencie	N/A

7. Expected learning outcomes

Knowledge	**K4.** The student/ graduate describes, identifies, summarizes concepts and elementary methods of signal acquisition, analysis and processing, implemented in systems with general-purpose processors or signal processors and their application in concrete problems

Skills	**S13.** The student/graduate uses specific methods and tools for the characterization of signals in the time domain and in the frequency domain, performs the acquisition, analysis and digital processing of analog signals. **S14.** The student/ graduate designs, measures, evaluates the performance, diagnoses and troubleshoots functional blocks of low/medium complexity for digital signal analysis and processing, using dedicated simulation environments (Matlab, Python, etc.). **S15.** Develop and plan ICT networks, such as a wide area network and a local area network, that connect equipment via wired or wireless connections and allow them to exchange data and assess their capacity requirements.
Responsibility and autonomy	**R9.** The student/ graduate demonstrates initiative and takes action to update their professional, economic, and organizational culture knowledge.

8. Course objectives (based on the grid of specific competencies acquired)

8.1 General objective of the course	Development of professional competences in the area of employment, design, simulation and performance evaluation of the studied modulation techniques in transmission systems.
8.2 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

9. Contents

9.1 Lecture	**No. of hours**	**Teaching methods**	**Remarks**
1. Linear Modulations LM (I). Types of LM. Quadrature Amplitude Modulation QAM. Expression and spectra of the LM signals. Modulation methods of LM signals.	2	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	2		
3. Frequency Modulation. Expression and spectrum of the FM signal. Modulation methods. Demodulation methods. SNR performance of the FM	2		
4. Base-band Data Transmissions BB (I). BB Codes. Definitions. Spectral properties. Encoding-decoding of the BB codes. SNR performance of BB codes. Applications.	2		
5. Base-band Data Transmissions BB (II). Elementary notions on PLL circuits. Digital methods for fast and dynamic bit-clock synchronization	2		
6. Pulse-Amplitude Modulation PAM. Definition. Spectrum. SNR performance. Filtering the Data Signals. Defining the ISI. The RC and RRC filtering characteristics.	2		

9.1 Lecture	No. of hours	Teaching methods	Remarks
7. Amplitude Shift Keying ASK. Definition. Spectrum. Modulation-demodulation. SNR performance. QAM with digital modulating signals.	2		
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.	2		
9. Phase Shift Keying PSK (II). QAM-based DPSK demodulators. Carrier and symbol-clock recovery and synchronization. Structure of the DPSK receiver.	2		
10. Phase Shift Keying PSK (III). SNR performance of the DPSK modulation. Variants of QPSK– OQPSK, π/4-QPSK. Applications.	2		
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.	2		
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 .	2		
13. Frequency Shift Keying FSK (I). Parameters and spectrum of FSK signals. Digital FSK modulators. Filtering the FSK signal. Structure of the FSK transmitter.	2		
14. Frequency Shift Keying FSK (II). Demodulation of the FSK signals. Bit-clock synchronization. Structure of the FSK receiver. SNR performance. Applications.	2		

References:

1. J. Proakis, M. Salehi, *Digital Communications*, 5th Edition, McGraw-Hill, 2007
2. F. Xiong, *Digital Modulation Techniques*, 2nd Edition, Artech House, 2006

Online references:

3. V. Bota, M. Varga, *Modulation Techniques. Lecture Notes (in English),* Technical University of Cluj-Napoca, 2026, https://users.utcluj.ro/~dtl/TM/cursuri_tm.html

9.2 Laboratory	No. of hours	Teaching methods	Remarks
1. Introduction. Basic notions of signals' theory - revision	2	Configuration of advanced simulators, performing measurements and interpretation	Computers, advanced software simulation tools, experimental laboratory
2. Linear Modulations I. Spectral composition. Transmission.	2		
3. Linear Modulations II. Demodulation. Carrier recovery. SNR performance.	2		
4. Frequency Modulation. Modulation. Demodulation. SNR performance.	2		
5. Base-band Data Transmissions I. BB codes.	2		

9.2 Laboratory	No. of hours	Teaching methods	Remarks
6. Base-band Data Transmissions II. Digital synchronization of the bit-clock	2	of the results obtained. Case studies.	circuits, specific measuring equipment
7. Filtering of data signals.	2		
8. PAM. ASK	2		
9. PSK I. Transmitter. Receiver.	2		
10. PSK II. Error performance of PSK	2		
11. A+PSK I. Transmitter. Receiver.	2		
12. A+PSK II. Local carrier synchronization. Error probability of A+PSK. Comparison to the performance of PSK and ASK	2		
13. FSK I. Spectrum. Transmitter.	2		
14. FSK II Receiver. Bit-clock synchronization. Bit-error probability.	2		
On-line references: 1. V. Bota, M. Varga, A. Botos, *Set of laboratory works, available on the laboratory site*, Technical University of Cluj-Napoca, 2026, https://users.utcluj.ro/~dtl/TM/laboratoare_tm.html			

9.3 Seminar	No. of hours	Teaching methods	Remarks
1. Linear modulations	2	Solving problems. Case studies	Sets of problems available on the laboratory site
2. Frequency modulation	2		
3. Baseband transmissions	2		
4. PAM, Data Filtering and ASK	2		
5. PSK	2		
6. A+PSK	2		
7. FSK	2		
On-line references: 1. V. Bota, A. Botos, *Sets of problems, available on the seminar site*, Technical University of Cluj-Napoca, 2026, https://users.utcluj.ro/~dtl/TM/seminar_tm.html			

10. Alignment of the course contents with the expectations of the epistemic community, professional associations, and representative employers in the field related to the program

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).

11. Assessment

Activity type	11.1 Assessment criteria	11.2 Assessment methods and type of assessment: continuous/ summative)	11.3 Weight in 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 knowledge acquired in the laboratory and seminar classes	Evaluation during the semester by means of three laboratory tests	25%

11.6 Minimum performance standard

Qualitative point of view

Minimal knowledge:

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

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 each simple transmission environment

Quantitative level:

- ✓ Execution of all laboratories' work and attendance at 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 $E \geq 5$.

Completion date:	Course coordinators	teaching rank, title First name LAST NAME	Signature
16.06.2026	Course	*Eng. Anghel BOTOS, Ph.D. - Anghel.Botos@com.utcluj.ro*	
	Applications	*Eng. Anghel BOTOS, Ph.D. - Anghel.Botos@com.utcluj.ro*	

Approval of the Head of the Department coordinating the course, only if this differs from the department organizing the study program	Head of Department

Date of approval by the Council of the Communications Department 19.06.2026	Head of Communications Department Prof. Virgil DOBROTA, Ph.D.
Date of approval by the Council of the Faculty of Electronics, Telecommunications and Information Technology 30.06.2026	Dean, Prof. Ovidiu-Aurel POP, Ph.D.