NEW YORK CITY COLLEGE OF TECHNOLOGY
The City University of New York

DEPARTMENT: Electrical and Telecommunications Engineering Technology

SUBJECT CODE AND TITLE: TCET3202/TC620 Analog and digital Communications II

COURSE DESCRIPTION: Theory and practice of transmission and filtering of analog and digital signals are covered. Fundamental parameters of digital communication systems, various modulation techniques such as Pulse Code Modulation (PCM) and Delta Modulation (DM) and their performance in terms of bandwidth efficiency and signal to noise ratio (SNR), line coding and pulse shaping are analyzed. Introduction to information theory and error correcting codes such as block coding and convolutional coding. Emerging technologies. Software simulation and hard wired experiments dealing with PCM, DM, and line coding are parts of laboratory exercises.

PREREQUISITES: TCET3102/TC500, TCET3120/TC520

TEXTBOOK:
1. Modern Digital and Analog Communications Systems
   B.P.Lathi , 3rd Ed. Oxford University Press
2. Laboratory Manual: Part I developed by Prof. M. Kouar
   Part II from Emona Technologies, LLC (TIMS)
3. Reference: Digital and Analog Communication Systems
   Leon W. Couch, Prentice Hall, 1997 5th Ed.

COURSE OBJECTIVES/ COURSE OUTCOMES:

Upon completion of this course students will posses the ability to:

1. Apply Fourier analysis to study analog communications systems.(ABET Criteria 2a, 2b, 2k)
2. Describe and analyze the mathematical techniques of analog modulation and demodulation.(ABET Criteria 2a, 2b, 2k)
3. Convert analog signals to digital format using sampling and quantization techniques.(ABET Criteria 2a, 2b, 2k)
4. Define and evaluate the performance of digital communications systems.(ABET Criteria 2c, 2k)
5. Describe digital signaling schemes and determine their properties.(ABET Criteria 2a, 2b, 2k)
6. Explain the basic types of digital carrier systems (ASK, FSK, PSK) and evaluate their effective bandwidths. .(ABET Criteria 2a, 2b, 2k)
7. Design source coding schemes based on the Huffman/Shannon-Fano and Lempel-Ziv algorithms. .(ABET Criteria 2a, 2d, 2k, 2m)
8. Understand, analyze and develop error correcting codes using the latest techniques in communications. .(ABET Criteria 2a, 2b, 2k)
9. Develop hands-on experience by analyzing, and implementing PCM and DM systems using CAD and hardware experiments. .(ABET Criteria 2a, 2b, 2e, 2k, 2l, 2m, 2n)

10. Describe and discuss the emerging digital communications technologies and demonstrate awareness of professional, ethical and social responsibilities. .(ABET Criteria 2g, 2h, 2i, 2k)

TOPICS:
_Fourier Transform, Energy Spectral Density, Power Spectral Density
_Analog Modulation/Demodulation revisited.
_Sampling Theorem, Aliasing, Quantization.
_PCM, DPCM, DM, ADM.
_Line Coding, Pulse Shaping.
_Information Theory, Source Encoding.
_Error Detection and Correction Codes.

CLASS HOURS: 3
LAB HOURS: 3
CREDITS: 4

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Descriptive details for laboratory coursework:
Laboratory exercises include using MATLAB to process sine and sound signals, producing echo effects, simulating and analyzing quantization for uniform case and μ-law, using predictive coding on a sampled signal. Hardware experiments cover implementation of natural sampling and sample-and-hold, pulse code modulation (PCM) linear and non-linear, delta modulation (DM) and demodulation, adaptive delta modulation (ADM). Line coding and amplitude shift keying (ASK) complete the hands-on exercises which efficiently support the theory part.

GRADING POLICY:

EXAMS (2)	**35%**
LAB REPORTS	**25%**
FINAL	**40%**

Letter Grade	Numerical Grade Range	Quality Points
A	93-100	4.0
A-	90-92.9	3.7
B+	87-89.9	3.3
B	83-86.9	3.0
B-	80-82.9	2.7
C+	77-79.9	2.3
C	70-76.9	2.0
D	60-69.9	1.0
F	59.9 and below	0.0

Assessment The following assessment techniques are correlated to the course objectives as follows: In addition, each assessment technique incorporates one or more of the following ABET Criterion 2 outcomes (2a, 2b, 2c, 2d, 2e, 2f, 2g, 2h, 2i, 2k, 2l, 2m, 2n).	
Course Objectives	**Assessment**
	Students will exhibit skills in class, labs, and all homework assignments, laboratory reports, quizzes, and exams. Students will be able to:
1. Apply Fourier analysis to study analog communications systems.	1.1 Use Fourier Transform to determine spectra of common communications signals. 1.2 Compute correlation integral for signal comparison 1.3 Perform convolution operation to determine system output.
2. Describe and analyze the mathematical techniques of analog modulation and demodulation	2.1 Describe and analyze the block diagram of different types of analog communications systems. 2.2 Calculate the required bandwidth for each type.
3. Convert analog signals to digital format using sampling and quantization techniques	3.1 Determine the minimum sampling frequency (Nyquist frequency) for a given analog signal. 3.2 Apply pulse code modulation (PCM) and delta modulation (DM) to produce a digital signal.
4. Define and evaluate the performance of digital communications systems.	4.1 Calculate the signal to noise ratio (SNR) for PCM and DM. 4.2 Determine the required number of bits for achieving a given SNR in PCM. 4.3 Compute the maximum voice signal amplitude for no slope overload in DM.
5. Describe digital signaling schemes and determine their properties.	5.1 Analyze a line code spectrum to determine some desirable properties (DC null, not excessive bandwidth, etc…). 5.2 Apply various transmission codes to a digital data. 5.3 Explain the use of pulse shaping to eliminate inter symbol interference (ISI).
6. Explain the basic types of digital carrier systems (ASK, FSK, PSK) and evaluate	6.1 Define and describe amplitude shift keying (ASK), phase shift keying (PSK),

their effective bandwidths.	and frequency shift keying (FSK). 6.2 Explain the multiplexing scheme of North American Digital Hierarchy.
7. Design source coding schemes based on the Huffman/Shannon-Fano and Lempel-Ziv algorithms.	7.1 Determine the optimum entropy source code using Huffman and Shannon-Fano methods. 7.2 Apply Lempel-Ziv algorithm for data compression. 7.3 Evaluate code performance quantities such as efficiency.
8. Understand, analyze and develop error correcting codes using the latest techniques in communications.	8.1 Explain block and convolutional codes. 8.2 Compute Hamming distance. 8.3 Design a systematic block code by generating parity check bits. 8.4 Demonstrate error detection and correction using the syndrome vector. 8.5 Construct convolutional codes. 8.6 Apply Viterbi's algorithm.
9. Develop hands-on experience by analyzing, and implementing PCM and DM systems using CAD and hardware experiments.	9.1 Develop the ability to compare and contrast the strengths and weaknesses of communications systems. 9.2 Use MATLAB to quantize a sampled signal using Uniform and μ-law. 9.3 Use predictive coding on the sampled signal of DM and ADM. 9.4 Implement PCM encoding and Decoding. 9.5 Practice with line coding and amplitude shift keying (ASK) modulation and demodulation.
10. Describe and discuss the emerging digital communications technologies and demonstrate awareness of professional, ethical and social responsibilities.	10.1 Discuss the recent developments in communications technologies. 10.2 Comment on some case studies dealing with ethics such as the Challenger etc… 10.3 Define and Comprehend IEEE code of ethics.

	TC620 OUTLINE		
WEEK	**TOPIC**	**READING ASSIGNMENT**	**HOMEWORK PROBLEMS**
1	Overview of course contents. Review of Fourier series. Energy and power signals. Useful signal operations. Unit impulse function. Correlation.	Chapter 2 pages14-60	2.1-1, 2.1-8, 2.4-1, 2.4-2, 2.6-1
2	Fourier transform revisited. Properties of Fourier transform.	Chapter 3 pages 71-101	3.3-10, 3.4-1, 3.3-6
3	Signal transmission through a linear system. Convolution. Ideal and practical filters.	Chapter 3 pages 101-110	3.2-1, 3.8-4
4	Analog modulation revisited: AM, DSB, SSB, VSB, FM, PM.	Chapter 4 pages 151-188 , Chapter 5 pages 208-228	4.2-1, 4.2-4, 4.2-8, 4.2-9, 4.3-1, 4.5-1, 4.5-5, 5.2-1, 5.2-2, 5.2-3
5-6	Sampling theorem. Antialiasing filter. Maximum information rate. Pulse code modulation (PCM).Quantizing. Compander. Transmission bandwidth and Output signal to noise ratio. EXAM # 1	Chapter 6 pages 251-281	6.1-1, 6.1-2, 6.1-4, 6.2-2
7	Delta Modulation (DM). Threshold of coding and overloading. Adaptive delta modulation (ADM). Signal to noise ratio (SNR).	Chapter 6 pages 281-288	6.2-3, 6.2-5, 6.2-9, 6.4-1
8	Digital data transmission: Line coding, pulse shaping, regenerative repeaters. Digital carrier systems. Digital multiplexing.	Chapter 7 pages 294-329, 337-348	7.3-1, 7.3-3, 7.9-1, 7.9-2. 7.9-3.
9	Introduction to information theory. Memoryless source. Entropy of a source. Source Encoding. Compact codes. Classification of codes.	Chapter15 pages 679-685	15.1-1, 15.1-2, 15.1-3.
10	Entropy coding. Huffman coding. Shannon-Fano coding. Code efficiency. Redundancy. Lempel-Ziv coding. Channel capacity.	Chapter 15 pages 686-693	15.2-1, 15.2-2, 15.2-3, 15.2-4, 15.2-5.
11	Introduction to error correcting codes. Code efficiency. Hamming codes. Hamming distance. Binary symmetric channel. Linear block codes. Systematic codes. Parity check bits. Syndrome. Generator matrix.	Chapter 16 pages 728-737	16.2-2, 16.2-3, 16.2-4, 16.2-6, 16.2-9

	TC620 OUTLINE (continued)		
WEEK		**READING ASSIGNMENT**	**HOMEWORK PROBLEMS**
12-13	Cyclic codes. BCH codes. Burst-error detecting and correcting codes. Convolutional coding. Code tree. Viterbi's decoding. EXAM # 2	Chapter 16 pages 737-755	16.2-11, 16.3-1, 16.6.-1, 16.6-2
14	Emerging digital communications technologies. Define Engineering ethics Professional and codes of ethics Workplace responsibilities Class discussion of IEEE code of Ethics.	Chapter 8 pages 354-400 Handouts	8.1-2, 8.1-3, 8.1-5
15	Review and Final Exam		

Weekly Schedule for TC 620 Experiments

Week #	EXPERIMENT
1-2	VOICE AND AUDIO SAMPLIND, PROCESSING, AND PLAYBACK
3-4	SPEECH AND AUDIO SIGNAL COMPRESSION
5	THE SAMPLING THEOREM
6	SAMPLING WITH SAMPLE & HOLD
7	PCM ENCODING
8	PCM DECODING
9	DELTA MODULATION
10	DELTA DEMODULATION
11	LINE CODING
12	AMPLITUDE SHIFT KEYING
13-14	SPEECH MODELING, PREDICTION, AND SYNTHESIS
15	DIGITAL SONAR FOR LOCALIZATION AND SIGNALING