NEW YORK CITY COLLEGE OF TECHNOLOGY
THE CITY UNIVERSITY OF NEW YORK

DEPARTMENT:	Electrical and Telecommunications Engineering Technology
SUBJECT CODE AND TITLE:	TCET2102 Analog and Digital Telephony
COURSE DESCRIPTION: **Required Course**	This course is an introduction to modern telephone networks and interfaces. Telephone sets, the central office and the Public Switched Telephone Networks are discussed in detail. Private (PBX) and public switches both digital and analog are discussed, with emphasis on features, signaling and technology. This course also concludes the transmission of audio signals through different networks. Laboratory experiments supplement the course and expose students to the fundamentals of analog and digital telephony.
PREREQUISITE:	TCET1100
COREQUISITES:	EET2140, EET2162, PHYS 1433
TEXTBOOKS:	1. Robert Boylestad, *Introductory Circuit Analysis*, 13th edition, Pearson Prentice Hall Publishers, 2016 ISBN-13: 978-0133923605 ISBN-10: 9780133923605 2. Warren Hioki, *Telecommunications*, Prentice Hall Publishers, ISBN 0-13-020031-X 3. Class notes and handouts.
COURSE OBJECTIVES/ COURSE OUTCOMES: (ETAC/ABET Criteria 3, Program Criteria)	Upon completion of the course the students will be able to: 1. Characterize electrical networks with respect to gain and loss in terms of dBs and dBms. (ABET Criteria 3a, 3b, 3c, 3e, PCa) 2. Describe the basic design of resistor attenuator networks using insertion loss techniques. (ABET Criteria 3a, 3b, 3c, 3e, 3f, PCa, PCb) 3. Analyze transmission lines in terms of characteristic impedance, propagation constant, phase velocity and line loading. (ABET Criteria 3a, 3b, 3c, 3d, 3e, 3f, PCa, PCb) 4. Discuss how central offices process analog and digital telephone calls via the SLIC circuit. (ABET Criteria 3a, 3b, 3c, 3d, 3g, 3h, 3i, PCa)
TOPICS:	Course topics include how to classify electrical networks (T and Pi) in terms of their open-circuit z-parameters and ABCD parameters; design of their respective values; transmission line parameters which include topics in

insertion loss; SLIC circuit equivalency; analog and digital transmission characteristics.

CLASS HOURS:	**3**
LAB HOURS:	**3**
CREDITS:	**4**
PREPARED BY:	Professor Sunghoon Jang, Fall 2013
COURSE COORDINATOR:	Professor Zory Marantz, email: zmarantz@citytech.cuny.edu

Descriptive details for laboratory coursework:
The laboratory exercises essentially follow the course curriculum: characterization of networks in terms of easy parameters such as dBs and dBms; how to design simple networks in terms of insertion loss parameters and propagation constants; students are required to set up all experiments in group fashion and learn to use telephony equipment. One experiment involves the use of MATLAB® Multisim® applications to study the characteristics of a transmission from the point of the standard transmission line equation and loss vs. frequency curves.

Contribution of course to meeting the requirements of Program Criteria:
TCET 2102 meets criterion 5 by providing students with a strong foundation of theoretical principles and practical laboratory skills needed to analyze and understand analog and digital telephony systems with the ability to utilize statistics/probability in traffic engineering and transforms methods. Academic benchmarks, course outcomes, and assessment requirements have been established to ascertain student comprehension of concepts and proper usage of test equipment. By also fostering critical thinking, communications, and team work, students develop the skills needed to solve problems in a classroom and laboratory environment which will later serve them in the work place.

GRADING POLICY:

Attendance	10%
Laboratory Report	30%
Midterm Exam	30%
Final Exam	30%

SCORE AND GRADES:

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 3 outcomes (3a, 3b, 3c, 3d, 3e, 3f, 3g, 3h, 3i, PCa, PCb).

Upon completion of the course the student should be able to:	Evaluation methods and criteria Students will be assessed based on their ability to:
1. Characterize electrical networks with respect to gain and loss in terms of dBs and dBms.	1. Given a network, use electronic calculators to solve dBs and dBms operations.
2. Describe the basic design of resistor attenuator networks using insertion loss techniques.	2. Use appropriate equations that support the given information to solve for the transfer constant and insertion loss.
3. Analyze transmission lines in terms of characteristic impedance, propagation constant, phase velocity and line loading.	3. Use the given transmission line constants of R, L, G, and C to solve for the characteristics impedance Z_O and propagation constant γ.
4. Discuss how central offices process analog and digital telephone calls via the SLIC circuit.	4. Describe in details the applied transmission technology used at the central office.

WEEK	TOPICS	READING ASSIGMENT	HOMEWORK PROBLEMS
1	**Introduction:** Review of voice delivery options today: Traditional PSTN, Internet telephony, cable-TV voice, and cellular telephony.	Cole: Chapter 1; Introduction to Telecommunications. Thru Sect. 1.7 & 1.11 Chapter 5; The Medium Sect. 5.15 thru 5.20	Cole: Chapter 1: Review questions. 1, 5, 7 thru 16. Chapter 5:10 & 11
2	**Logarithms**: base 10, 2 and e (Ln). **Decibels**: dB (current and voltage vs power, gain Vs loss); • dBW, dBm; • dB as the difference in dBm values; • dBm0 (referenced to 0-TLP); • dBrn (referenced to –90 dBm noise), C-message & Psophometric weighting and Notch filtering), dBrnC0,S/N; • dBs (referenced to 0.0002 microbars). **Instrumentation:** calibration references (775mv & 600Ω), dBm measurement corrections (actual load & voltage scale). Continued in Lab. **session #1**	Boylestad: Chapter 21; thru sect. 3 Cole: Appendix B sect. B.14 thru B.17 Instructor's Handout: dB and dBm	1 thru 16 and 18 Instructor's Handout: dB,dBm,dBm0 & dBrnC0 problems.
3-4	**Basic analog circuit concepts related to Telephonic Communications Circuits:** • Two-Port Networks (Open-ckt z parameter matrix & Cascade ABCD parameter matrix); • Equivalent Ckts.(T, PI & Lattice), T in terms of two-port parameters and open & short ckt values; • Impedance matching (Image and Iterative) and Transfer Functions; • Equivalent T circuit & input & output impedances (in terms of image and hyperbolic functions; • Attenuation and Insertion Loss networks and minimum loss L-Pads; Continued in Lab. **session #2 and 3**	Boylestad: Chapter 26; sect. 1, 2&6 Instructor's Handouts: Two-Port Circuits (pages 1, 2, 5-8), Hyperbolic Functions (pages 1-4, 3-8), Supplementary notes Attenuation & Insertion loss.	Instructor's Handout: Two-Port, Equiv. Circuit & Image-matched networks.
5	**Transmission Lines in the telephone voice frequency band:** • L, C & Z_0 formulas (comparison of using Log_{10} & Ln); • Lossless line traveling wave solution, Reflections & TDR • AC steady state solution, Characteristic Impedance, and Propagation, Attenuation & Phase Constants (complex No. solutions & algebraic approximation formulas), - Distortion-less criteria, - Phase Velocity & Wavelength, - Distortions (variations with frequency graphs); Continued in Lab. **session #4**	Young: Chapter 14; thru sect. 2. Instructor's Handout: Transmission Line Parameters & Distortion. (pages 1-7, 9-11)	Young: Chapter 14; 1, 3, 4, 8, 9, 10, 11 d, e & 12
6	**Transmission Lines continued:** - Solving V(t, x) & V_{load} with no reflections, - V_{load} & Insert. Loss Formulas with reflections, - Input impedance formula, - T equivalent & Short length approximation, • Loading coils (concept of Campbell's formula, modification of Propagation Constant, Cut-Off freq., Coil spacing); • Line Impairments, Atten. & Envelope Delay distortions, Conditioning. Continued in Lab. **session #4**	Instructor's Handout: Transmission Lines Parameters & Distortion. (pages 4, 8, 9, 11-17) Cole: Appendix B: Sect. B.9 & B.10 Chapter 5: The Medium Thru sect. 14.	Instructor's Handout: Additional Transmission Line Problems-1a, c, d, e, 3 thru 6 Cole: Chapter. 5: 1, 3, 4, 9, 12 thru 15

WEEK	TOPICS	READING ASSIGMENT	HOMEWORK PROBLEMS
7	**Midterm Exam: weeks 1 to 6**		
8-9	**Traditional PSTN:** • PSTN architecture and operation • Central office and local loop • Long distance transmission • Switching in PSTN • Signaling in PSTN • PBX and LANs **The Local Loop, Telephone Set & Signaling:** • Description of Central Office (CO) loop-trunk interface (battery, ballast resistors, pickup relay & coupling transformer), SLIC, BORSCHT; • Loop-Start current, loop resistance & length; • Telephone Set functional block Diagrams (Bell 500 vs electronic telephone); • Hybrid coil & Sidetone; • Signaling: Address (pulse dialing, DTMF); Progress Tones (dial, busy, ring back, congestion & off-hook); Alerting (ringing & call waiting); Continued in Lab. **session # 5 and 6**	Cole: Chapter 3; Thru sect. 3.21. Chapter 4; Thru sect. 4.12 Chapter 7; Thru sect. 7.5 Chapter 10; Thru sect. 10.10. Instructor's Handout: PSTN, Telephones, Local Loop & SLI Circuits	Cole: Chapt.3: 1, 2,4, 6, 7, 11, 12, 13, 38. Chapt. 4 2, 4, 5, 17 thru 20. Chapt. 7: 9, 10, 18 & 19 Chapt. 10: 1, 5, 6& 8
10	**Traffic:** • Definitions: busy hour, arrivals, holding time & traffic (offered, carried & lost); • Formulas: traffic probabilities & blocking (GOS); • Units: Erlang's & CCS; • Mathematical models & tables: Poisson arrivals distribution formula, Poisson or Molina blocking formula and tables for Lost Call Held systems, Erlang's lost-call probability formula; • Erlang B formula & tables for lost calls cleared (LCC). Continued in Lab. **session #7**	Reference: Flood Chapter 4; Thru sect. 4.6 Instructor's Handout: Traffic.	Instructor' Handout
11	**Switching:** • Concentration, Distribution (Routing), & Expansion general trunking diagram & definitions. • Switching fabrics: - Analog space division & Digital time & space divisions; - Circuit & Pocket switching; - Access Blocking (output to input ports or data ratio), Evaluation of various configurations; - Direct Progressive Control; - Common Control (Crossbar); - Stored Program Control. Continued in Lab. **session #8**	Cole: Appendix G; Thru sect. G.10 Chapter 3; Sect. 3.22 thru 3.32. Chapter 8; Sect. 8.13. Reference: telecommunications, Switching, Traffic and Networks by Flood.	Cole: Chapter 3; 15, 16, 21, 24, 26, 27, 29, 31-33, 35-38. Instructor's Handout
12	**ADSL:** • Introduction, Modulation (CAP & DMT), ADSL Standards, Service Providers. **FTTP:** • Active FTTP and Passive Optical Network (PON)	Cole: Chapter 9; Sect. 9.22 thru 9.28. Instructor's Handout:	Cole: Chapter 9:21-25. Instructor's Handout

	architectures, Service providers; Verizon (FiOS) and AT&T (U-Verse). **Cable-TV Telephony:** • Introduction, Architectures, Cable Modems, Cable Modem Termination Systems, Other Cable-based Services, Service Providers. Continued in Lab. **session #9**		
13	**Internet Telephony:** • VoIP-Operation, hardware and protocols; ARPANET, Functionality, Mobility, and Drawbacks • Other developments in Internet telephony; • Skypes and similar systems; **Cellular Telephony:** • Operation; Analog and Digital Technologies • Network Technologies; 2G (FDMA, TDMA, GSM,CDMA) and 3G (CDMA2000, WCDMA, TD-SCDMA) • Switching and Signaling; Transceiver, Mobile Telephone Exchange Continued in Lab. **session #10**	Cole: Chapter 12; Thru sect. 12.11 Chapter 13; Thru sect. 13.11 Instructor's Handout:	Instructor's Handout
14	**Modern Trends:** • Internet Telephony; • iPhones by Apple; • Other means of delivery; • Voice delivery will be integrated into data deliverywhich means end as a separate branch of telephone industry; Continued in Lab. **session #11 and 12**	Instructor's Handout:	Instructor's Handout
15	**Final Examination**		

Weekly Schedule for TCET 2102 Experiments

Week	Experiment
1-2	DB measurements for a Loaded Low Pass RC Filter – First Order Butterworth
3-4	Two-Ports and Decibels – Attenuator, Insertion Loss, and Impedance Matching Networks
5	Introduction to MATLAB
6-7	Attenuation and Insertion Loss of Telephone Transmission Lines with and without Loading Utilizing Computer Simulations
8	Telephone DC Local Loop with TLS
9	AC and Tone Local Loop Signaling Characteristics
10	Voice, Sound, Noise, and AC Impedance
11	Local Signal and Digital Switch Principles Assignments
12	Digital switch Operation and Line Scan Assignments
13	Call Records, Line Records, and Line Maps Assignments
14	State Transitions, Call Progress, and Manual Control Assignments
15	Testing and Traffic Assignments & **Final Examination**