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

DEPARTMENT: Electrical and Telecommunications Engineering Technology

SUBJECT CODE AND TITLE: TCET2102/TC320
Analog and Digital Telephony

COURSE DESCRIPTION: 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. Concludes with the transmission of audio signals through different networks. Laboratory experiments supplement the course and expose students to the fundamentals of telephony.

PREREQUISITE: TCET1100/TC100,

COREQUISITES: EET2140/ET313, EET2162/ET382, PHYS 1433/SC433

TEXTBOOKS:
1. Robert Boylestad, *Introductory Circuit Analysis*,11th edition, Pearson Prentice Hall Publishers, ISBN 0-13-173044-4
2. Marion Cole, *Introduction to Telecommunications,* Prentice Hall Publishers, ISBN 0-13-060890-4
3. Class notes and handouts.

COURSE OBJECTIVES/ COURSE OUTCOMES: 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 2a, 2b, 2c, 2f, 2k, 2l, 2m)
2. Describe the basic design of resistor attenuator networks using insertion loss techniques. (ABET Criteria 2a, 2b, 2d, 2k)
3. Analyze transmission lines in terms of characteristic impedance, propagation constant, phase velocity and line loading. (ABET Criteria 2a, 2b, 2d, 2k, 2l)
4. Discuss how central offices process analog and digital telephone calls via the SLIC circuit. (ABET Criteria 2a, 2b, 2d, 2k)

Electrical and Telecommunications Engineering Technology-TCET2102/TC320

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 Sheldon Rosenberg, Fall 2006
Revised by Professor Mohammed Kouar, Fall 2006

COURSE COORDINATOR: Professor Sunghoon Jang, email: sjang@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.

GRADING POLICY:

Laboratory part	25%
Quizzes	25%
Final Exam	50%

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

COURSE OBJECTIVES Upon completion of the course the student should be able to:	**ASSESSMENT** 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	**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 & 600 Ω), 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.
2	**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 #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.
3	**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);	Young: Chapter 14; thru sect. 2. Instructor's Handout: Transmission Line Parameters & Distortion. (pages 1-7,9-11)	Young: Chapter 14; 1,3,4,8,9,10,11d,e & 12
4	**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.	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

Electrical and Telecommunications Engineering Technology-TCET2102/TC320

WEEK	TOPICS	READING ASSIGMENT	HOMEWORK PROBLEMS
5	TEST 1: weeks 1 to 3	Cole: Chapter 1; Introduction to Telecommunications. Thru Sect. 1.7 & 1.11 Chapter 5; The Medium Sect. 5.15 thru 5.20	Cole: Chapt. 1: Review questions. 1,5,7 thru 16. Chapt. 5: 10 & 11
6	**2 to 4 Wire Conversion:** • Maximum Power Available & Mismatch Factor in dBm & db; • Anti-sidetone Ckts., 1-2 & 2-2 Repeater; • Hybrid Transformer (description of current flow, voltage transformations & power losses), Calculations for Talker to Listener power, BRL, Echo, Singing & Gain Margin. **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 # 6	Reference: Boylestad: Chapter 25; Transformers. Reference: Flood Chapt. 2: Sect. 2.3 Cole: Chapter 3; Thru sect. 3.21. Chapter 4; Thru sect. 4.10 Chapter 7; Thru sect. 7.5 Instructor's Handout: Telephones, Local Loop & SLI Circuits	Instructor's Handout: Anti-sidetone circuit & 2 to 4 wire problems. 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
7	**Fiber Optics:** • Snell's law, Numerical Aperture (N.A.), Reflectance; • Losses (NA, area, alignment, Rayleigh, absorption, reflectivity); • Modes of propagation and normalized frequency (V); • F.O. types (single-mode, multimode step-index, Graded-index); • Dispersions (Pulse Spread)-Intermodal, Material, or chromatic, Waveguide; • Light Sources & Detectors.	Young: Chapter 18; Sect. thru 3, 6 (skip couplers) Sect. 7 start at paragraph. for Bandwidth/Data Rate to end of sect. 7. (Skip example 18-8) Sect.4 (only LEDs, Lasers & Fiber Amps) Sect. 5	Young: Chapter 18; 2a,5,6,7b,9,14a,b,24, 25a,b, 11,12.

8	**Traffic:** • Definitions: busy hour, arrivals, holding time & traffic (offered, carried & lost); • Formulas: traffic probabilities & blocking (GOS); • Units: Erlang's & CCS; • Measurements: PC, ATB & ATH; • 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),	Reference: Flood Chapter 4; Thru sect. 4.6 Instructor's Handout: Traffic.	 Instructor' Handout
9	**Switching:** • Concentration, Distribution (Routing), & Expansion general trunking diagram & definitions. • Switching fabrics: -Analog space division & Digital time & space divisions; -Access Blocking (output to input ports or data ratio) vs Cross-point contacts, Evaluation of various configurations; -Direct Progressive Control (SXS-Strowger); -Common Control (Crossbar); -Stored Program Control.	Cole: Appendix G; Thru sect. G.10 Chapter 3; Sect. 3.22 thru 3.32. Reference: telecommunications, Switching, Traffic and Networks. by Flood. Chapter 3	Cole: Chapt. 3; 15,16,21-24,26,27,29, 31-33,35-38. Instructor's Handout
	Final Examination		