SAULT COLLEGE OF APPLIED ARTS AND TECHNOLOGY
SAULT STE. MARIE, ONTARIO

COURSE OUTLINE

Course name:	DIGITAL COMMUNICATIONS
Code No.:	ELN 305-6
Program:	ELECTRONIC TECHNOLOGY
Semester:	SIX
Date:	January 5, 1996
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Approved: ____________________ Dean   96-01-15 Date

Digital Communication ELN-305

Total credit hours 96

Prerequisites ELN-245, ELR-309

I. PHILOSOPHY/GOALS

This course provides an in-depth frequency domain analysis of analog and digital communications signals. Another objective is the study of the widespread telephone network and the applications of the most recent digital communications schemes.

II. STUDENT PERFORMANCE OBJECTIVES

Upon successful completion of this course, the student will be able to

1. Perform the spectral analysis of arbitrary waveforms and operate a radio frequency spectrum analyzer.

2. Understand the concept of frequency division and time division multiplexing of voice signals, and the essentials of data communication concepts.

3. Apply the principles of analog pulse modulation and digital modulation to simplex, duplex and multi-channel communication systems.

4. Understand the terminology and principles of information theory.

III. TOPICS TO BE COVERED

1. Voice and data communication.
2. Spectral analysis.
3. Pulse and digital modulation.
4. Information theory.

IV. LEARNING ACTIVITIES

	REQUIRED RESOURCES
<u>BLOCK 1: VOICE AND DATA COMMUNICATION OVER ANALOG SYSTEMS</u>	TEXT: Digital, Analog, and Data Communication.
Upon successful completion of this unit, the student will be able to:	ACTIVITIES: Study pp. 1-38, Chapter 1.
1.1 Recall and be familiar with: - the block diagram of a basic communication system. - psophometric and C-message weighting curves. - the characteristics and bandwidth of voice. - FDM and TDM concepts. - Simplex and Duplex communication.	Solve problems 1 to 30.
1.2 Have a good understanding of the: - telephone network. - the 500 type telephone set. - DTMF telephones. - subscriber to trunk circuit interfacing. - touch tone decoders. - characteristic impedance and propagation constant. - standard CCITT groups. - types of trunk circuits. - concepts of centralized switching. - four wire terminating set. - network stability, noise, distortion, crosstalk. - group delay, delay equalizers, dynamic compandors.	Study pp. 42-104, Chapter 2. Solve problems 1 to 20. Study pp.106-141, Chapter 3. Solve problems 1 to 19.

1.3 Recall and understand Data Communication concepts, as follows:

- the Seven-Layer OSI architecture.
- RS-232-C, RS-422-A, RS-423-A, RS-449 interface standards.
- the "bit rate = baud rate x bits per baud".
- calculate the Information Rate = $(1/T)\log_2 n$ for n bits.
- balanced and unbalanced lines and generators.
- differential and unbalanced receivers.
- 20 mA current-loop interfaces.
- 8251 USART.

Study pp.144-172, Chapter 4.

Solve problems 1 to 57.

1.4 Recall and understand the essentials of MODEM theory:

- line losses caused by skin effect, proximity effect and radiation.
- line drivers, limited distance modem and modem eliminator.
- modem modulation techniques: ASK, FSK, PSK, DPSK, QAM.
- CCITT and Bell standard modems.
- frequency spectrum of FSK and PSK modems.
- FSK, BPSK, DPSK and Four-Phase modulators and demodulators.
- phasor diagram of modem signals.

Study pp.181-211, Chapter 5.

Solve problems 1 to 28, 39 to 42, 44 to 46, 55 to 57, 72.

BLOCK 2: SPECTRAL ANALYSIS

Upon successful completion of this unit, the student will be able to:

TEXT: Van Valkenburg, Network Analysis, Chapter 15 and 16, provided by teacher.

2.1 Write the mathematical form of time functions of electric waves or electronic signals such as: square wave, rectangular pulses, sawtooth, AM, SSB, FM signals, etc.

ACTIVITIES:
Study pp.452-513. Selected problems will be assigned.

2.2 Recall the definition or the application of:

- periodic functions.
- odd and even functions.
- Dirichlet conditions.
- Fourier series.
- truncated series.
- amplitude and phase spectrum.
- the sin/cos form, the amplitude-phase form and the exponential form of the Fourier series.
- the (sin x)/x function.

2.3 Calculate the Fourier series coefficients for each form of the series.

2.4 Plot the amplitude and phase spectra. (Single sided and two sided).

2.5 Sketch the spectrum envelope for recurring pulses.

2.6 Generate the waveform of a signal from the Fourier series.

Use MathCad to solve Fourier analysis problems.

BLOCK 3: PULSE AND DIGITAL MODULATION

3.1 Recall the principles of Analog Pulse Modulation:

- time sampling and sampling theorem.
- natural and flat-top (sample and hold) sampling.
- aliasing and aperture distortion.
- Chebyschev, Butterworth, Bessel and Cauer filter characteristics.
- Time Division Multiplexing of PAM signals.
- PAM-TDM System block diagram and waveforms.
- PAM, PDM and PPM modulators and demodulators.
- Pulse Edges Only modulators.

TEXT: Digital, Analog, and Data Communication.

ACTIVITIES:

Study pp.268-298, Chapter 6.

Solve problems 1 to 14.

3.2 Be able to mathematically interpret the sampling theorem, and

- observe that the sampled waveform can be expressed as:

  $Sam(t)=m(t).S(t)$

- multiply the Fourier series expansion of the sampling function by the frequency spectrum of the message, to obtain the frequency spectrum of the sampled message.
- plot the line spectrum of the switching function.
- plot the frequency spectrum of the natural sampled waveform.
- plot the frequency spectrum of a sample-and-hold signal.
- plot the frequency spectrum of a single pulse.
- calculate the aperture time.

3.3 Recall the applications, definition and properties of two of the most common type of Digital Modulation: CVSD and PCM.

- sketch the block diagram and explain the functioning of a delta encoder and decoder.
- given the maximum rate of rise of a signal, and the step size a, calculate the maximum amplitude times modulating frequency product: $A \cdot fm = a \cdot fs/2\pi$
- understand slope overload, tracking and idling conditions of a delta modulator.
- recall the functions of a PCM: sampling, quantizing and encoding.
- understand the block diagram of a PCM terminal.
- calculate the S/N ratio of a signal encoded by an 8 bit code.

TEXT: Digital, Analog, and Data communication.

Study pp.301-348, Chapter 7.
Solve problems 1 to 37.

- for a message with a maximum rate of change and for a maximum aperture uncertainty "a", calculate the maximum aperture time of the A/D converter:

$$\tau = 1/(2^n-1)\pi f$$

- understand and apply the μ law.
- be able to determine the 8 bit code of a sample of the message.
- be able to decode the signal Y from the digit pattern.
- recall the functioning of parallel, serial and hybrid encoders and the weighted current source and ladder decoders.
- explain the advantage of the monolithic integrated circuit CODEC
- sketch and explain qualitatively a 24 channel PCM system frame alignment and time slot assignment.
- recall the types of line coding: RZ, NRZ, AMI, unipolar and polar.
- justify the bandwidth requirements of the above line codes.
- recall and be able to calculate the fundamental frequency of a 24 channel PCM system, using RZ unipolar code.
- recall the North American PCM multiplex hierarchies.
- draw the block diagram of a quantization noise measurement system.

ACTIVITIES:
Study the specifications of the INTEL 2910A Codec. INTEL documentation available in the laboratory.

BLOCK 4: INFORMATION THEORY

4.1 Apply the principles of Information Theory, as follows:

- recall that the basic unit of information is the bit.

- be able to calculate the information content for n alternatives: $H = \log_2 m$
- recall that the information content varies directly with the message length: $H = \log_2 m^n$
- calculate the information capacity from the information content over a time period, as $C = (n \cdot \log_2)/T$
- recall that the number of pulses transmitted per second, relate linearly to the bandwidth, expressed as $C = 2 \cdot BW \cdot \log_2 m$

4.2 Analyze pulse transmission over bandlimited systems:

- be able to interpret the Fourier series of a pulse train.
- graphically show the effect of filtering on a periodic bit stream.

3.3 Understand coding for communications.

- recall the essentials of the BCD, EBCDIC, ASCII, HOLLERITH and NUMERIC codes.
- recall the two basic error control methods: retransmission and forward acting.
- use geometrical models to illustrate the Hamming distance.
- recall the error detecting mechanism of Cyclic and Hamming codes.
- graphically represent the line spectra of typical line codes: RZ, NRZ, AMI, HDB3.
- recall that Manchester coding uses the phase of a square wave and collisions are detected by monitoring the dc component.

TEXT: Analog, Digital, and Data Communication.

ACTIVITIES: Selected topics from Chapter 8, 9, and 10 will be presented.

V. ADMINISTRATIVE AND EVALUATION PROCEDURES

TESTING

a) Written tests based upon theory objectives will occur following the completion of each theory block and with about a week of advance notice. Short written quizzes may occur at any time without advance notice

b) Testing of lab objectives will occur concurrent with the specific lab activity.

GRADING

a) Grading is done using the following definitions:
- Consistently outstanding performance.....A+ (90 -100)%
- Outstanding performance..................A (80 - 90)%
- Above average performance................B (70 - 80)%
- Satisfactory performance.................C (55 - 70)%
- Unsatisfactory performance...............R (0 - 55)%

b) The grading of laboratory type objectives will be in two parts: The demonstrated ability to perform a skill function, e.g. use an instrument in a specified role or trouble shoot a circuit, will be graded "C". Failure to demonstrate the skill function will be graded "R". Subjective evaluation of lab reports, supporting theory, deportment, housekeeping etc., will be used to modify the skill function grade upward, where applicable.

c) Lab reports are due one week after the experiment was scheduled to be completed. Late reports are penalized 5% per day.

d) The grading weight will be 30% for the lab and 70% for the theory.

e) A final overall accumulated mark of 55% is the minimum requirement for course credit with the added restriction that neither the theory or the lab part of the course can be less then 55%. e) A failing grade on more then half of the theory tests during the semester leads directly to an "R" grade, regardless of the theory average.

f) Failing one third of the semesters theory tests excludes a final "A" grade, regardless the theory average.

UPGRADING

a) No upgrading tests will take place during the semester.

b) The method of upgrading is at the teachers discretion. It may consist of the rewriting of block tests, the writing of comprehensive examination, repeating laboratory experiments or repeating the course.

c) The highest mark obtainable in any make-up test is "Sufficient".

ATTENDANCE

a) Attendance for laboratory classes is compulsory.

b) Attendance at all theory classes will be recorded. Attendance is highly recommended but not mandatory.

c) Anyone with an accumulated attendance record of less then 80% at the end of the semester, and who is also in a failing condition, can expect to have to repeat the course, with no right to write a make-up test.