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

DEPARTMENT: Electrical and Telecommunication Engineering Technology

SUBJECT CODE AND TITLE: TCET 4202/TC 800 – Advanced Telecommunications

COURSE DESCRIPTION: Discrete time signals are studied in time and frequency domains using Z-Transform. The properties of the DFT are studied as well as its applications. Linear convolution and circular convolution are presented. The FFT is covered. Up sampling, down sampling, and up/down sampling are considered in both time and frequency domains as well as for filter requirements. Basic FIR and IIR discrete filters are studied. Software simulation is used to supplement the theory, augmented by Digital Signal Processing and its applications in telecommunications.

PREREQUISITES: TCET 3202/TC 620, TCET 4140/TC 740

COREQUISITE: TCET 4220/TC 870

TEXTBOOKS: DSP First, A Multimedia Approach,
By McLellan, Schaefer, and Yoder
Publisher: Prentice Hall 1998,
ISBN: 0-13-243171-8

REFERENCE:

1. Signal Processing First,
   By McClellan, Schafer, and Yoder.
   Publisher: Prentice Hall 2003,
   ISBN: 0-13-090999-8

2. Advanced Electronic Communications Systems
By Wayne Tomasi,
Publisher: Prentice Hall 2000,
ISBN 0-13-022126-0

COURSE OBJECTIVES: Upon the completion of this course, the students should be able to:
COURSE OBJECTIVES
1. Understand basics in representation of digital signals: sampling rate, bandwidth, bit rate, fidelity. Understand the functions of digital components in the modern telecommunication system.
(ABET Criterion 2a, 2b, 2c, 2d, 2f)

2. Represent discrete time invariant system by using block diagram, difference equation, and Z transform.
(ABET Criterion 2a, 2b, 2d, 2e, 2f)
3. Understand the purpose of using the Z transform. Know the difference for processing signal in the time domain and frequency domain.
(ABET Criterion 2a, 2b, 2d, 2e, 2f)
4. Choose filter structures according to their performance characteristics: sensitivity, complexity, delay, etc. Analyze and design filters based on pole/zero placement.
(ABET Criterion 2a, 2b, 2c, 2d, 2f)
5. Design IIR and FIR filters from given specifications. Learn the MATLAB filter design functions from DSP toolbox.
(ABET Criterion 2a, 2b, 2c, 2d, 2f)
6. Design filters using MATLAB and exploit more sophisticated design tools in MATLAB.
(ABET Criterion 2a, 2b, 2d, 2f)
7. Analyze signal spectra using DFT/FFT, Apply FFT to filtering applications.
(ABET Criterion 2a, 2b, 2c, 2d, 2f)

TOPICS: Discrete Signals, Linearity and Difference equations, The Z transform and linear systems, System representation by using difference equation, block diagram, and Transfer function, Filter specifications, MATLAB design of Digital Filters, comparison between IIR filters and FIR filters, Multilevel filters, IIR Digital filter design basic approaches, Channel Filters, Filter bank, The frequency spectrum, Spectrum Analysis, The Discrete Fourier Transform (DFT), The Fast Fourier Transform (FFT), FFT operation count, The Spectrogram, Filtered Speech.

CLASS HOURS: 2

LAB HOURS: 3

CREDITS: 3

PREPARED BY: PROFESSOR X. WEI
Fall 2006

COURSE COORDINATOR: **Professor Xinzhou Wei**
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DESCRIPTIVE DETAILS FOR LABORATORY COURSEWORK:

Laboratory exercises include the representation of analog and discrete signals; MATLAB Symbolic Math toolbox; Convolution operation analysis of a Linear Time Invariant (LTI) system; Z transform and Inverse Z transform; Zeros and Poles on the Z plane; Digital filter design methods; Comparison between FIR and IIR system; General design methods for IIR filters; Eight window filters; Filter Design Graph User Interface sptool; Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT) and their applications; Spectrum analysis.

GRADING POLICY:

QUIZ:	10%
MIDTERM:	25%
LABORATORY EXECISES:	30%
FINAL EXAM:	35%

Letter Grade	Numerical Grade Ranges	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, 2f, 2k).

COURSE OBJECTIVES	ASSESSMENT:
By the end of the course, the student will be able to:	Evaluation Methods and Criteria:
1. Understand basics in representation of digital signals: sampling rate, bandwidth, bit rate, fidelity. Understand the functions of digital components in the modern telecommunication system.	Students will demonstrate comprehension of the digital signal concepts by using hardware components and software codes demos. MATLAB functions will be used in the lab to plot the digital signals.
2. Represent discrete time invariant system by using block diagram, difference equation, and Z transform.	Students will illustrate how to use different methods to represent same system. The symbolic math toolbox in MATLAB will be used in the projects and homework.
3. Understand the purpose of using the Z transform. Know the difference for processing signal in the time domain and frequency domain.	Students will learn to process the signal in the time domain by using convolution method. The network communication application of noise reduction will be given in the lab.
4. Choose filter structures according to their performance characteristics: sensitivity, complexity, delay, etc. Analyze and design filters based on pole/zero placement.	Students will find zeros and poles of a given system and analyze the stability of the system. From the lab and assignment, students should know how to plot the zeros and poles on the Z plane.
5. Design IIR and FIR filters from given specifications. Learn the MATLAB filter design functions from DSP toolbox.	Students will show the skills for using MATLAB tools to design both IIR and FIR filters. Students will display competency for choosing the correct filters according to the given specification.
6. Design filters using MATLAB and exploit more sophisticated design tools in MATLAB.	Students will illustrate skills for using the GUI tools to design different discrete systems for a given project.
7. Analyze signal spectra using DFT/FFT, Apply FFT to filtering applications.	Students will illustrate skills for applying the FFT method in the different applications by using MATLAB DSP toolbox. Students will show the comprehension of Spectrogram.

WEEK	TOPICS	READING ASSIGNMENTS, HOMEWORK & LAB EXERCISES
1	Introduction: The Communication Models, Functions of Physical Layer in OSI Model, Mathematical representation of signals and systems. Time and frequency representations of analog signals. Analog and digital signals	Signal representation by using MATLAB. P1- P8, Class handout, MATLAB tutorial material. Lab #1 **Introduction of Analog and Discrete Systems** HWK: Plot the different discrete signals according to the questions on the handout.
2	Sinusoidal Signals, Complex Exponential Signals, Magnitude and phase spectrums of analog signals. Complex Exponentials and Phasors.	Symbolic tool boxes, using MATLAB. P 10- P42 Lab #2 Analog and Discrete Time Signals. Sampling and plotting Sinusoids. HWK: Calculate the total area from the homework sheet.
3	The spectrum of a Sum of Sinusoids, Periodic waveforms, Square wave, Triangle wave, Non-periodic signal.	Symbolic toolboxes (Part 2). P48-P77. Lab #3 Signal generation and plotting.
4	The Sampling Theorem, Aliasing, Folding, Interpolation, Discrete Signals, Linearity and Difference equations.	P83-P109. Lab #4 Signal processing in the time domain, convolution, noise reduction, filters examples. HWK: calculate the output of a discrete system according to the given input on the homework sheet
5	The Z transform and linear systems, Properties of the Z transform, The L- point running sum filter.	Z transform by using MATLAB Symbolic toolbox, The L- point running sum filter. P 202-P 219 Lab #5 Class notes HWK: Use MATLAB Symbolic toolbox calculate the Z-transforms on the homework sheet.
6	The Z plane and the Unit circle, Zeros and Poles of Z transform, Factoring Z polynomials, converting difference equation to Z transfer function.	Review/Problem Solving, Homework from handout. P220-P242.
7	Region of convergence, Inverse Z transform, Review and **Midterm-Exam**	Class handout. HWK: Calculate the inverse of Z transform on the homework sheet by using MATLAB Symbolic function iztrans().
8	Transfer functions: Analog vs. discrete system, block diagram of system, Delay Unit, Multiplier, Adder, Signal flow chart, System representation by using difference	P272-300 Inverse Z transform, A general procedure for Inverse Z transformation for first order and second order system. Lab #6 Representation of transfer function in

	equation, block diagram, and Transfer function.	MATLAB, filter functions in MATLAB. HWK: Calculate the inverse of Z transform on the homework sheet by using residuez() function from MATLAB.
9	The Synthesis process. Analog vs. Digital. Stability Analysis, Filters design and prototypes, Frequency Scaling, Magnitude Scaling.	P250-268 Class handout Lab #7 **Analog Filters using DSP/MATLAB**
10	MATLAB design of filters, (type I, II), Butterworth, elliptic filters, Frequency response of filters, Attenuation plots of the filters.	Class handout. Lab #8 Digital Filters using DSP MATLAB HWK: Compare 5 types of filters learned in the class with order N= 5, 10, and 15. Plot each filter with different order.
11	Filter specifications, MATLAB design of Digital Filters, comparison between IIR filters and FIR filters, Multilevel filters.	P 269-272 Lab #9 **Testing Filters and Stability, Filter applications in the industry.**
12	IIR Digital filter design basic approaches, Bilinear transform, commonly used window filters characteristics, Introduction of window functions in MATLAB.	Class handout. Lab #10 Window filters design and applications. HWK: Plot all 8 windows in one figure and analyze them according to the data given in the lecture.
13	Channel Filters, Filter bank, The frequency spectrum, Spectrum Analysis. MATLAB GUI sptool.	Design filters by using MATLAB GUI sptool. Class handout. Lab #11 MATLAB filter examples, Applications of bandpass filter, and bandstop filter. HWK: Design both FIR and IIR filters according to the specification on the lab handout.
14	The Discrete Fourier Transform (DFT). The Fast Fourier Transform (FFT), FFT operation count, The Spectrogram, Filtered Speech,	P320 - 368 Lab #12 **Multilevel Digital Filters and Spectrograms.**
15	Course review and **Final Exam**	