COMP ENG 4TL4:

# Digital Signal Processing

Notes for Lecture #1

Friday, September 5, 2003

# Instructor:

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Office Hours: TBA

# Teaching Assistants:

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Office Hours: TBA

# Web Site:

http://www.ece.mcmaster.ca/~ibruce/courses/COE4TL4_2003.htm

# Course mailing list:

coe4tl4@mail.ece.mcmaster.ca

- This mailing list will be used as a primary means of communication for this course — please make sure that you check your email regularly!
- Only for instructor and TA use
- If you are not currently on this mailing list, please email me with your name, student number and email address.

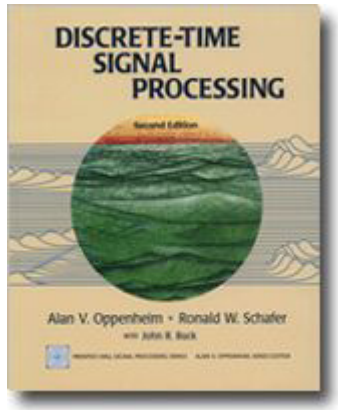
# Proposed Course Content:

- Introduction to DSP
- Time-Domain Analysis of Discrete Signals and Systems
- Frequency-Domain Analysis Using Fourier and *z*-Transforms
- Fast Fourier Transform (FFT) Processing
- Design of FIR and IIR Digital Filters
- Random Signal Analysis
- DSP Processors
- Adaptive Filtering and Adaptive Signal Processing
- Spectral Analysis and Signal Compression

*(subject to change!)*

# Textbooks:

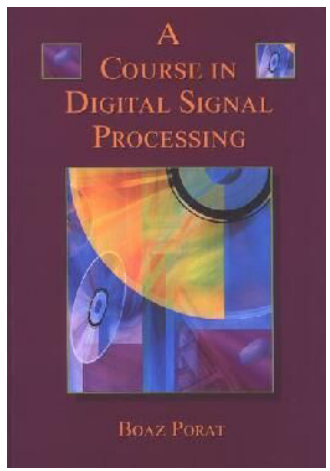
**Recommended text:**
A. Oppenheim and R. Schafer, *Discrete-Time Signal Processing*, Prentice-Hall, 2nd Edition, 1998. (ISBN 0-13-754920-2)




Errata

(Some copies should soon be available at Titles Bookstore.)

**Secondary reference:**
B. Porat, *A Course in Digital Signal Processing*, John Wiley and Sons, 1997. (ISBN 0-471-14961-6)



# Prerequisites:

**Must have passed:**

- EE3TQ4 (or equivalent *Probability and Random Processes* course)

**Should have done well in:**

- EE3TQ4 (or equivalent)
- EE3TP4 (or equivalent *Signals and Systems* course)

# Assessment:

- 5 Homework Assignments (15%)
- 5 Labs (15%)
- Midterm exam (30%)
- Final exam (40%)

**Rules for Students Missing the Midterm Exam:**

- Students without a valid excuse will get zero points for the midterm, i.e., will lose 30% of their possible total grade.
- Students with a valid excuse approved by the Associate Dean's office will have an **oral** deferred midterm exam.

# Lectures:

There will be ≤35 one-hour lectures (3 per week) in **BSB-236** on:

**Tuesdays, Wednesdays and Fridays**
**12:30-1:20pm.**

Note: no lecture on Tuesday, September 16th and Friday, November 14th

Lecture notes in PDF format will be posted on the course web site before each lecture.

(*Acknowledgment: Lecture notes are based on notes from previous years, created by Dr. Alex Gershman.*)

# Tutorials:

There will be 1 one-hour tutorial per week.

The class is split into two sections for tutorials:

**Section T1** is in **KTH-104** on
Thursdays 8:30-9:20am

**Section T2** is in **GS-219** on
Tuesdays 1:30-2:20pm

# Labs:

There will be 5 three-hour labs in **T13-111** every second week, beginning the week of September 15.

Lab descriptions will be made available on the web site in advance.

Lab reports are to be submitted one week from the date of your assigned lab.

# Labs (cont.):

Currently you are assigned to 8 (!!) lab sections:

- Monday, Tuesday, Wednesday & Friday afternoons on alternating weeks, with students working alone.

Proposed re-sectioning:

- 3 sections, working in pairs.
- New Sections L1 & L2 in T13-111 on one day of the week (Wednesdays?), alternating weeks.
- New Section L3 to complete labs on your own computer and in your own time, with demo of results to Jeff Bondy during his office hours.

# Homework:

There will be 5 homework assignments.

Homework assignments will be posted on the web site.

2 weeks will be given to complete each assignment.

# Policy Reminders:

**"The Faculty of Engineering is concerned with ensuring an environment that is free of all adverse discrimination. If there is a problem, that cannot be resolved by discussion among the persons concerned, individuals are reminded they should contact the Departmental Chair, the Sexual Harassment Officer or the Human Rights Consultant, as soon as possible."**

**"Academic dishonesty consists of misrepresentation by deception or by other fraudulent means and can result in serious consequences, e.g. the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: 'Grade of F assigned for academic dishonesty'), and/or suspension or expulsion from the university.**

**"It is your responsibility to understand what constitutes academic dishonesty. For information on the various kinds of academic dishonesty please refer to the Academic Integrity Policy, specifically Appendix 3, located at http://www.mcmaster.ca/senate/academic/ac_integrity.htm**

**"The following illustrates only three forms of academic dishonesty:**

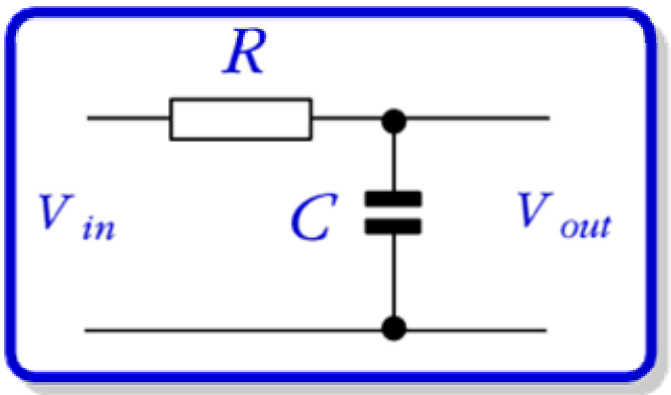
1. **Plagiarism, e.g. the submission of work that is not one's own or for which other credit has been obtained.**
2. **Improper collaboration in group work.**
3. **Copying or using unauthorized aids in tests and examinations."**

# 1. INTRODUCTION TO DSP

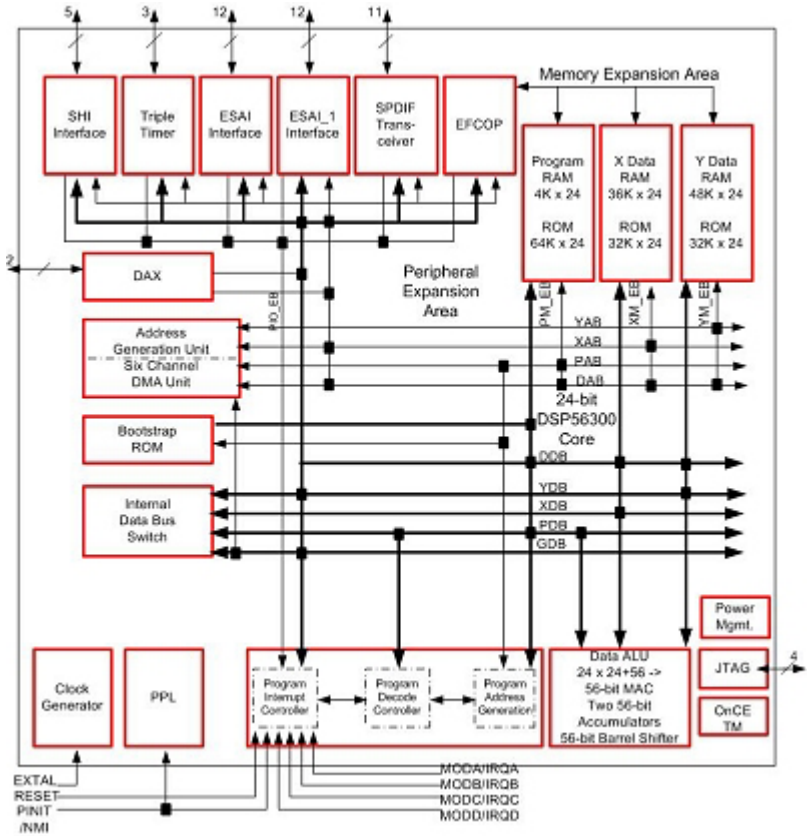
## 1.1 The purpose and scope of DSP

"*That discipline which has allowed us to replace a circuit previously composed of a capacitor and a resistor with two antialiasing filters, an A-to-D and a D-to A converter, and a general purpose computer (or array processor) so long as the signal we are interested in does not vary too quickly.*" – Thomas P. Barnwell, 1974

(Taken from p. 1 of *Porat.)*


R
V in
C
V out

versus


Memory Expansion Area
SHI Interface
Triple Timer
ESAI Interface
ESAI_1 Interface
SPDIF Trans-ceiver
EFCOP
Program RAM 4K x 24
ROM 64K x 24
X Data RAM 36K x 24
ROM 32K x 24
Y Data RAM 48K x 24
ROM 32K x 24
DAX
Peripheral Expansion Area
Address Generation Unit
Six Channel DMA Unit
Bootstrap ROM
Internal Data Bus Switch
24-bit DSP56300 Core
YAB
XAB
PAB
DAB
DDB
YDB
XDB
PDB
GDB
Clock Generator
PPL
Program Interrupt Controller
Program Decode Controller
Program Address Generation
Data ALU 24 x 24+56 -> 56-bit MAC Two 56-bit Accumulators 56-bit Barrel Shifter
Power Mgmt.
JTAG
OnCE TM
EXTAL
RESET
PINIT
/NMI
MODA/IRQA
MODB/IRQB
MODC/IRQC
MODD/IRQD

Examples of analog signals appearing in nature:

- *electrical signals*: voltages, currents, fields
- *acoustic signals*: mechanical vibrations, sound waves
- *mechanical signals*: displacements, velocities, forces, moments

Analog processing may include the following operations:

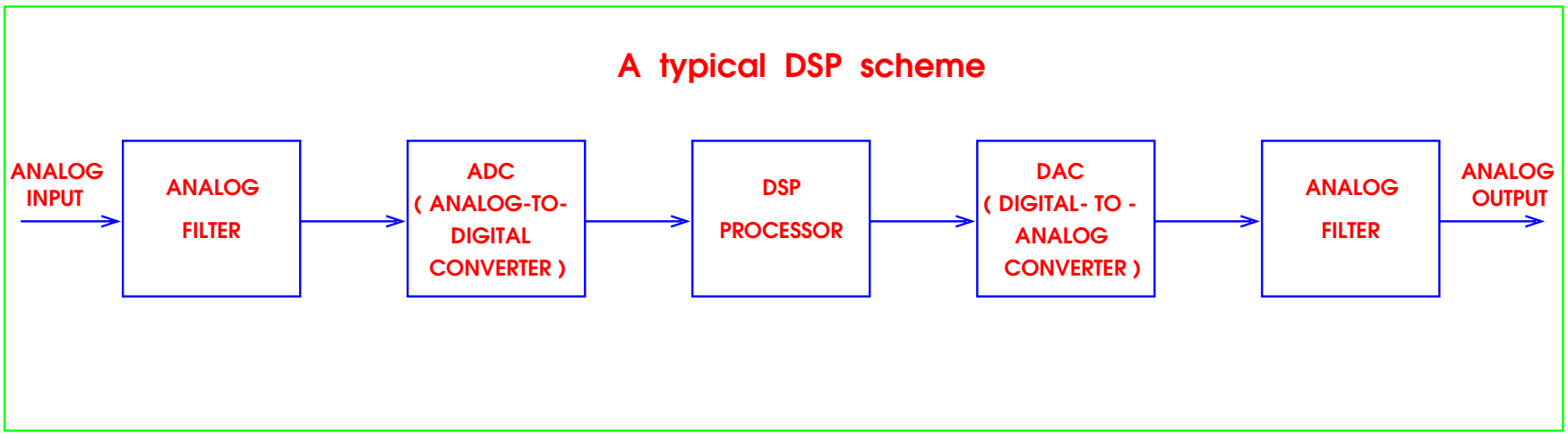
- *linear*: amplification, filtering, integration, differentiation
- *nonlinear*: squaring, rectification, inversion

## Limitations of practical analog processing:

- restricted accuracy (e.g., component variations with time, temperature, etc.)
- restricted dynamic range
- sensitivity to noise
- inflexibility to alter or adjust the processing functions
- problems in implementing accurate nonlinear and time-synchronized operations
- high cost of data storage and transmission
- limited speed of operation

# DSP operations:

- converting analog signals into a digital (usually binary) sequence
- performing all signal processing operations in the digital form
- if necessary, converting the digital information back to analog signal



# Advantages of DSP:

- digital data storage and transmission is much more effective than in the analog form
- flexibility: processing functions can be altered or adjusted
- possibility of implementing much more complicated processing functions than in analog devices
- efficient implementation of fast algorithms and matrix-based processing
- speed of digital operations tends to grow rapidly with the years of technical progress
- a very high accuracy and reliability is possible to achieve
- dynamic range can be increased
- signal multiplexing: simultaneous (parallel) processing

## Some application areas of DSP:

- Music: recording, playback, mixing, synthesis, storage
- Speech: recognition, synthesis, noise reduction, coding
- Communications and multimedia: signal generation, transmission, modulation and compression, data protection via error-correcting signal coding
- Radar: filtering, detection, feature extraction, localization, tracking, identification
- Image processing: 2-D filtering, enhancement, compression, pattern recognition
- Biomedicine: diagnosis, patient monitoring, neural and neuromuscular prostheses, assistive devices
- Control: automation of electrical, chemical and mechanical plants, robotics