TI Developer Conference
February 28-March 2, 2006 • Dallas, TX

New Communications Curriculum With TI DSP Hardware at the University of Toronto

Bruno Korst

Comm. Syst. Engineer

University of Toronto
bkf@comm.utoronto.ca

SPRP410

Agenda

- **Mandate**
  - Create the facility tailored for the courses
- **The Communications Lab**
  - Workstations, Experiments, Design Projects
  - Demonstrations, Summer Intern, DEEP (High School)
  - Student Feedback
- **Future Goals**
- **Demo**

Mandate

- **Develop lab components for communications / DSP courses**
  - Communication Principles
  - Digital Communications
  - Digital Signal Processing
  - Multimedia & Image Processing

Mandate

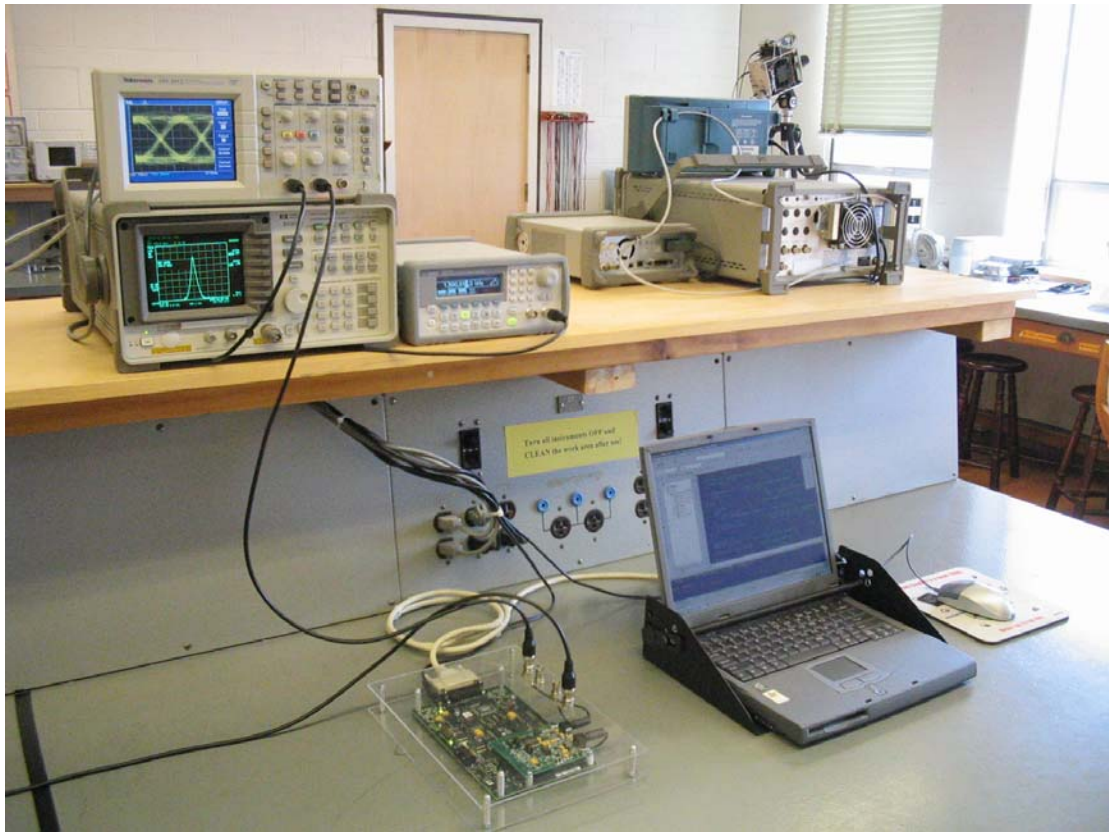
- **Provide students with superior learning experience**
  - Large number of stations
    - Flexible lab hours, teaching material and guidance provided
  - State of the art hardware using TI platforms
    - TMS320C6713 for design projects
  - Exposure to latest industry software tools
    - Code Composer Studio™ IDE (with or without Simulink®/Matlab®)
  - Opportunity to develop projects on latest hardware available to the industry

The First Communications Lab Facility

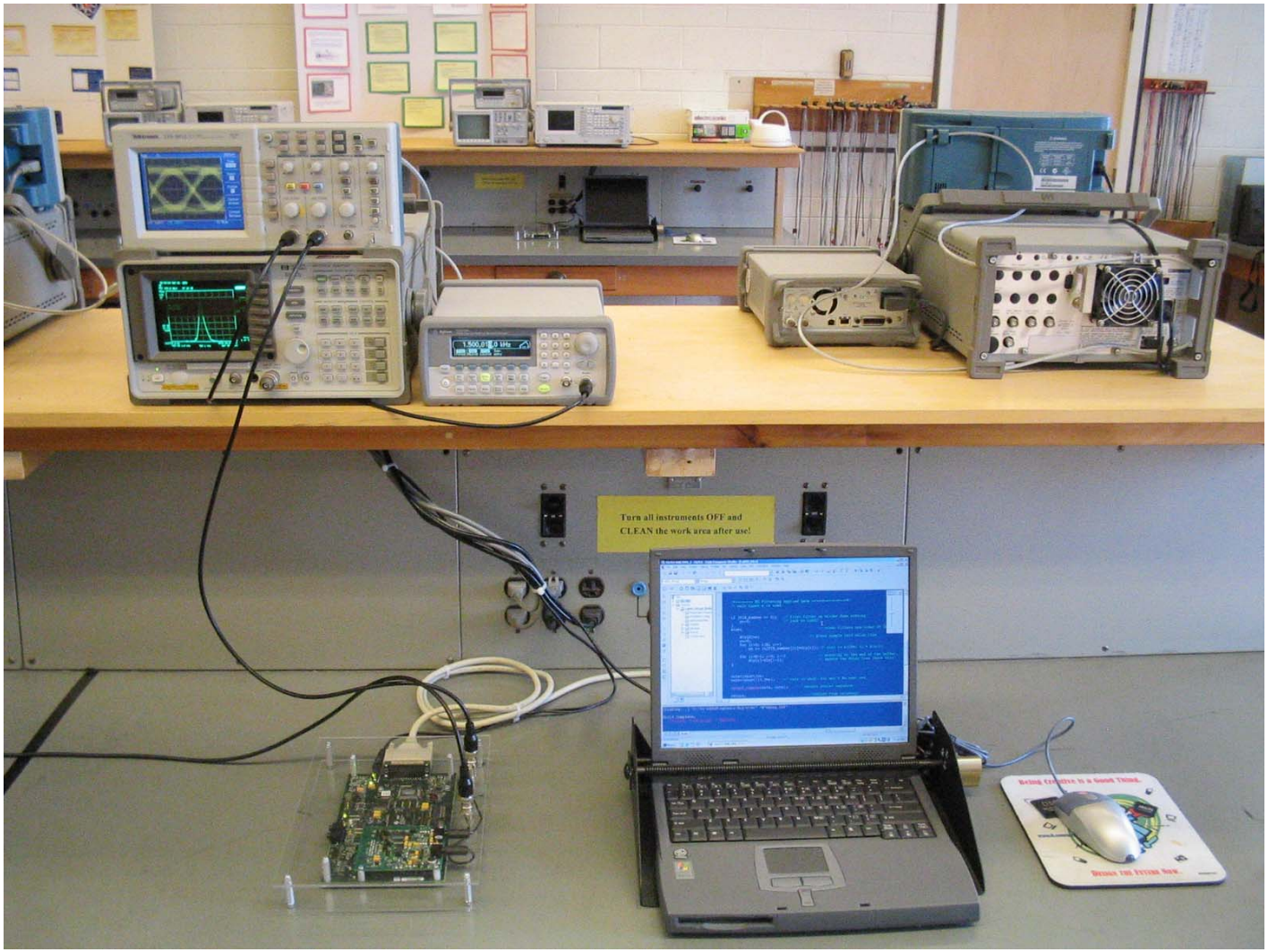
- 16 workstations
- 32 students per session

The First Communications Lab Workstations

- **16 Workstations**
  - 1 Notebook PC
  - 1 TI c6711 DSK
    - Audio daughtercard
  - 1 Oscilloscope
  - 1 Signal Generator
  - 1 Spectrum Analyzer
- **Software**
  - Matlab / Simulink
    - TI interface
  - Code Composer Studio



The First Communications Lab Workstations



Communications Lab
New Facility

- New room for 20 workstations

The Communications Lab
Experiments

- **Five experiments per course**
  - One experiment every two weeks
- **Format: Preparation and Outline/Report**
  - Preparation done at home
    - Background math and design of block diagrams
  - Results reported in the lab
    - Results obtained from system which students designed in their preparation.
- **Always Simulation & Implementation**
  - Simulink with some Matlab code
  - Implementation automatic or on code provided

The Communications Lab
Experiments

- **Reports prepared during experiment**
  - 90% of the session time spent on simulation/implementation
  - 10% remaining reporting results
  - TAs may ask questions (and mark them) during the session. Most TAs prefer to give the marks at the end of every session
- **Maximum of 2 students per station**
  - Large groups (>2) for the workstations utilized are unproductive

The Communications Lab Experiments

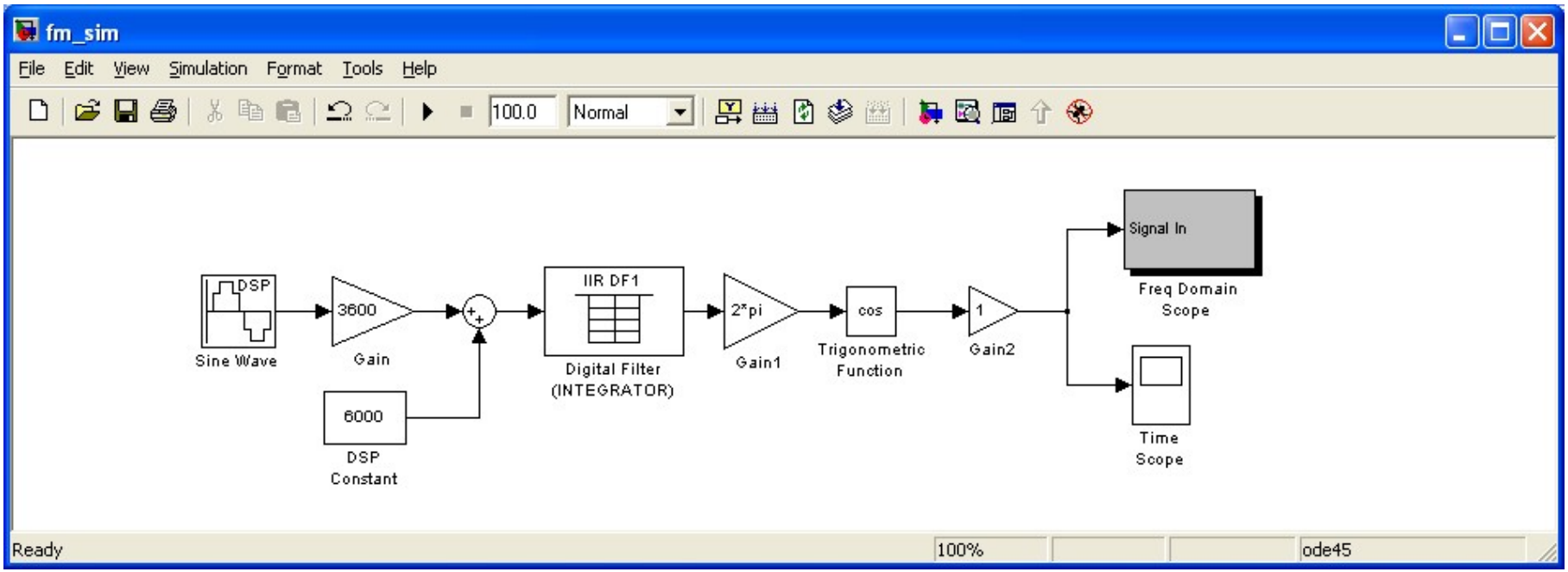
- **Course: Introduction to Communication Systems**
  - Code Composer Studio and Simulink
    - Initial exposure to software / hardware tools
  - Introduction to Digital Filters
    - “look at it as a band-limited channel”
  - Amplitude Modulation
    - Modulation and demodulation (prototype board)
  - Frequency Modulation
    - Modulation and demodulation (PLL on DSP platform)
  - Uniform PCM (sampling and quantization)

The Communications Lab
Experiments

- **Course: Digital Communications**
  - Non-Uniform PCM (u-Law / A-Law)
  - Noiseless Pulse Transmission
    - The role of Matched Filters
  - Noisy Pulse Transmission
    - The role of the Square Root Raised Cosine filter
  - QAM (16-QAM)
    - Eye Diagram and Constellation Diagram
  - Error Control Codes
    - BER, generator matrix/syndrome

The Communications Lab Experiments

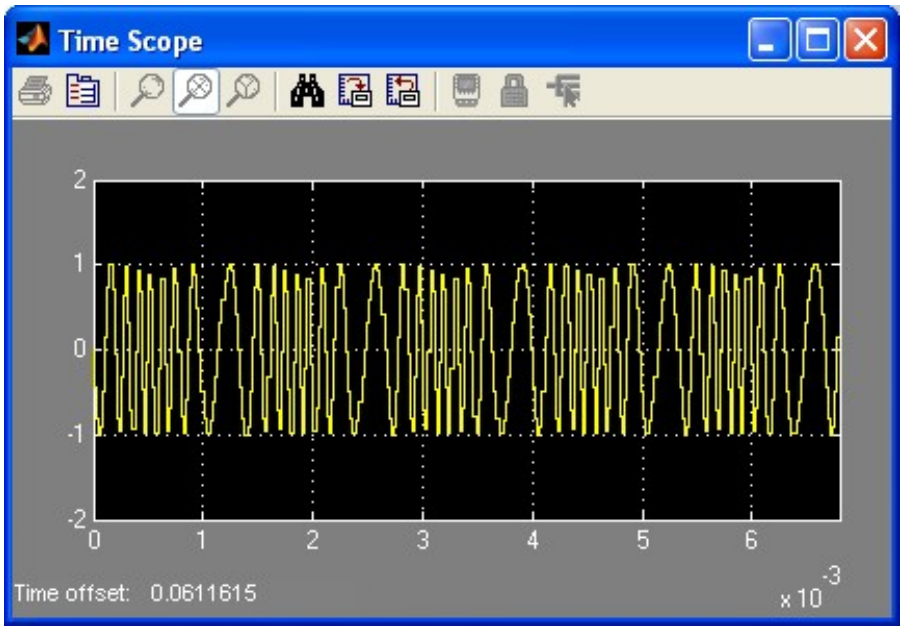
- **Sample: Frequency Modulation – Simulation**

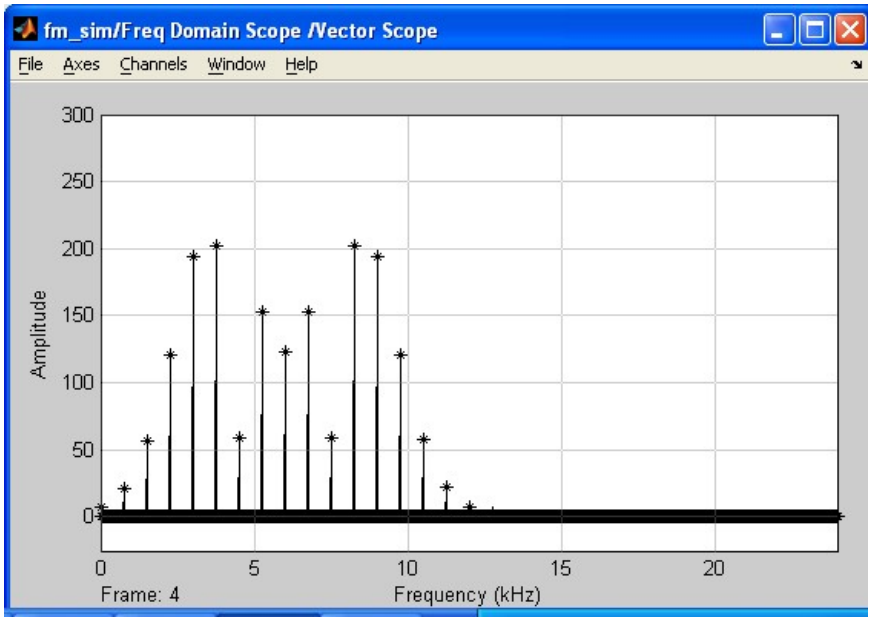


Challenge: rework the FM equation to implement it

The Communications Lab Experiments

- **Sample: FM – results from simulation**





(implementation on c6713 DSK demo at the end)

The Communications Lab
Experiments

- **Sample: Eye Diagram – Constellation (simulation)**

The Communications Lab
Experiments

- **Course: Digital Signal Processing**
  (under development)
  - Sampling and Quantization
  - Finite Impulse Response
  - Infinite Impulse Response
  - Fast Fourier Transform
  - Introduction to Image Processing

The Communications Lab
Experiments

- **Course: Multimedia & Image Processing**
  (under development)
  - Sampling and Quantization
  - Colour Image Processing
  - Discrete Cosine Transform
  - Wavelets I
  - Wavelets II

The Communications Lab Design

- **A variety of projects have been supported**
  - Loudspeaker Linearization
  - CAP Modem Design
  - Optimal Reception in Multiuser Environment
  - Phase Correction Algorithm for Power Circuits
  - Head-Related Transfer Function Implementation
- **TI Hardware (DSK) and guidance is provided**

Other Activities

- **Demonstrations on demand**
  - Courses which do not have a lab component require in-class demos:
    - Sampling and Quantization (Uniform)
    - Pulse Transmission (noisy and noiseless)
    - 16 QAM – eye diagram and constellation
  - Visitations from academia / industry
  - Open-house – prospective students

Other Activities

- **Summer Student Intern**
  - Every summer a student/volunteer is recruited
    - 3rd year student (paid) or 2nd year volunteer
  - Student tasks:
    - Assist in the preparation of future experiments
    - Work on a particular project of interest
      - **Efficient Implementation of Head Related Transfer Function**
  - Work provides early exposure to TI platform/programming environment

Other Activities

- **Da Vinci Engineering Enrichment Programme**
  - Geared towards Senior High School students
  - Projects are primarily related to audio and acoustics
    - Very first exposure to “real” DSP programming
    - Math is kept to a minimum. Ex: Echo/Delay, FIR filtering
  - Intention to use TI High School material in the future

Student satisfaction

- **Surveys with > 100 students**
  - Introduction to Communication Systems Course
  - Lab Setting
    - Setting was considered very adequate
    - Students appreciate groups of two
  - Teaching Methodology
    - “Lab Outline / Report” is an all-time favourite
      - **TAs and students prefer marking in the lab**
    - Avg 15 students per TA is desireable

Student Satisfaction

- **Surveys with > 100 students (cont'd)**
  - Relevance of Experiments
    - Students indicate their appreciation for lab experiments synchronized with topic studied in the theory
    - Experiments helped significantly their understanding of the topic (meaning: better marks in exams)
  - Perception of future use
    - By working with HW used in the industry, students experience a "closer to reality" lab.
    - They appreciate becoming familiar with a useful tool for their professional practice.

Future Goals

- Achieve full compatibility with latest TI development platform
- Add dedicated hardware components to specific courses: image processing, audio processing, telephony, etc.
- Expand towards project-only courses
- Offer industry-oriented courses

Demo

- **FM Modulator**
- **Platform: TI TMS320C6713 DSK**
- **SW: Simulink with TI interface, Code Composer Studio.**
- **Details**
  - Students should work out the math to design the block diagram and simulate it.
  - Students should realize the limitations of the CODEC and account for that.

New Communications Curriculum With TI DSP Hardware at the University of Toronto

Bruno Korst

Communication Systems Engineer
University of Toronto
bkf@comm.utoronto.ca

SEE THE FUTURE

CREATE YOUR OWN