Opportunities for University-Industry Collaboration: The Center for Analog and Mixed Signal Integrated Circuit Design at WPI

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## Background: Personal

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<th>Year</th>
<th>Position</th>
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<tr>
<td>1979-1983</td>
<td>A.B. Engineering, Dartmouth College</td>
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<td>1983-1986</td>
<td>Design Engineer, Analogic Corp.</td>
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<td>1986-1990</td>
<td>Design Engineer / Engineering Manager, AOA</td>
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<td>1990-1991</td>
<td>MSEE, University of Rochester</td>
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<tr>
<td>1991-1994</td>
<td>PhD, Boston University</td>
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<tr>
<td>1994-2004</td>
<td>Assistant / Associate Professor, WPI</td>
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<tr>
<td>2002-2003</td>
<td>Research Sabbatical, Analog Devices</td>
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Background: WPI

- Founded 1865
  - USA's 3rd-oldest technological university
- Located in Worcester, Massachusetts
  - ~1 hour from southern NH
- Full-time enrollment:
  - ~2700 Undergrad, ~500 Grad (~220 FT Faculty)
  - Small size allows close faculty interaction
- University with core focus on science, engineering, and management of technology
- Grants bachelor's, master's and doctoral degrees in 30+ disciplines
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<td><strong>Background: Curriculum</strong></td>
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<tr>
<td>• <strong>Undergraduate: &quot;Technological Humanist&quot;</strong></td>
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<tr>
<td>– Prepare students for entire career and life path</td>
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<td>– Projects: Close collaboration with faculty mentor</td>
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<tr>
<td>• Humanities: Creativity in nontechnical fields</td>
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<td>• Interdisciplinary: Optional global sites</td>
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<tr>
<td>• Disciplinary Project: Capstone design</td>
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<td>– Professional-level design experience</td>
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<td>– Integrate, apply knowledge</td>
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<td>– Solve “real-world” problems</td>
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<tr>
<td>• <strong>Graduate: Disciplinary Specialization</strong></td>
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<tr>
<td>– M.S., Ph.D. research</td>
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<td>– Goals</td>
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<td>– Traditional Research Model</td>
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<td>– Collaborative Design Center</td>
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Industry / University Partnership: Goals

- Industry
  - Technical
    - Stay current with "cutting edge" research
    - Explore / develop "back burner" ideas
  - Human Resources
    - Identify good engineers to hire!
- University
  - Intellectual Mission (Research)
    - "Create knowledge"
  - Customer Service (Education)
    - Instruction, research relevant to needs of student, industry constituencies
Traditional Research Model

- **Targeted**
  - Support 1 graduate student or project team
  - Single project

- **Disadvantages:**
  - High cost
  - Lost opportunity
Collaborative Design Center

- Take advantage of common interests
- Share information, contact among members
- Pooling resources allows reduced entry cost

- Current members:
  - Analog Devices
  - Allegro Microsystems
  - Texas Instruments
Presentation Overview

- Background
- Industry-University Partnership
- Center Overview
  - Organization
  - Benefits for Students
  - Benefits for Sponsors
- Operational Details
- Project Examples
- Conclusion
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<td>• The Center for Analog and Mixed Signal IC Design at WPI conducts graduate research and undergraduate projects in all aspects of mixed signal IC design.</td>
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<td>• These activities are conducted in an environment that supports the complete &quot;real world&quot; integrated circuit design process.</td>
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<td>• The Center is supported by contributions from member companies, who help to determine the direction of Center research.</td>
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<td>Design Center Overview: Organization</td>
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<tr>
<td>• Membership: $35,000 annual fee</td>
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<td>• Student / faculty participation:</td>
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<tr>
<td>– 16 students / year: 4 capstone</td>
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<td>teams, 4 MS</td>
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<td>– 4 faculty involved</td>
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<tr>
<td>• Advisory Board</td>
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<td>– Representatives from member</td>
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<tr>
<td>companies</td>
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<td>– One-day meetings in fall, spring</td>
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<td>– Review progress, choose future</td>
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<td>projects</td>
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<td>– Direct interaction with students</td>
</tr>
<tr>
<td>• Project Ideas</td>
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<tr>
<td>– Proposed by companies, faculty</td>
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<tr>
<td>– Sponsors select (Advisory board</td>
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<tr>
<td>vote)</td>
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## Benefits to Students

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<th>Details</th>
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| Better Project Quality, Definition | - Project credibility  
- "Customer" = Easier to motivate students |
| Real World Constraints | - Compete with sponsor's competitors  
- Students live with real cost / budget constraint |
| Networking | - Talk to “real engineers”  
- Better exposure in hiring process |
| Grad-Undergrad Interaction | - "Analog Lab" environment |
## Benefits to Corporate Sponsors

- Access to graduating seniors, M.S. students
- Better evaluation of engineering competence
  - Lab vs. interview situation
- Increase pool of students with mixed signal IC design experience
- More awareness of sponsor's company among all students in ECE
- Influence direction of research
- Awareness of and access to new technologies
- Influence curriculum development
- Networking
Presentation Overview

• Background
• Industry-University Partnership
• Center Overview
• Operational Details
  – Communication
  – Recruiting Students
  – Intellectual Property Policy
• Project Examples
• Conclusion
Communication: Fall Meeting

- Poster presentations: Status of work in progress
  - Graduate projects
    - Progress: 6 months
    - "Critical design review"
  - Undergraduate projects
    - Progress: 1 month
    - Feedback, "course correction"

- Determining General Research, Project Priorities
  - Input from members, faculty
  - General research direction
  - Specific project proposals for recruiting students
Communication: Spring Meeting

- Poster presentations: Completed work
  - Direct sponsor interaction with students
  - Assess technical, communication skills
  - Open to all students (recruiting)

- Choosing Research/Projects for Upcoming Year
  - Faculty
    - Present proposed projects for coming year
    - Provide results of recruiting, student interest
  - Advisory Board
    - Vote on which projects will be carried out
Recruiting Students

- **Two words: FREE FOOD**
  - Student recruiting event after Fall meeting

- **Two more words: FREE CLOTHING**
  - Analog Lab T-shirts

- **Another two words: OPEN HOUSE**
  - Invite students in department to presentations
  - See ongoing projects; cool place to work

- **Presence in microelectronics courses**
  - Frequently mention related, high quality, sponsored projects
  - Lecture examples from industry / project work

- **Most important: Student word-of-mouth, positive peer "buzz"**
# Intellectual Property Policy

- Research results equally available to all members
  - Consortium NOT for proprietary research!
- Members may request nominal delay in publication of results
- Ownership of discoveries, inventions, etc.
  - Whoever pays for patent expenses
  - WPI and/or subset of interested sponsors
- All members entitled to non-exclusive, royalty free license
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  - Undergraduate
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CMOS Image Sensor (Kumar)

CMOS Image Sensor (Kumar)

- 0.4µm 1P4M CMOS
- Die Area 5mm²
- 3.3V Supply
- 84 pin PLCC

Chip Microphotograph

Single column test block

Pixel buffers
Signal SHAs
Control Units

Output buffers
Address bus
Reset SHAs

128 pixel array
Test pixels
Test photodiodes

Source follower pixel buffer
Jitter / Phase Noise in IC VCOs (Toh)

Fig. 5. Chip micrograph.

· M.S. thesis, 2002
Jitter / Phase Noise in IC VCOs (Toh)

- Predict jitter in 1.3 GHz VCO
Trimmable Bandgap Voltage Reference in CMOS

- Undergraduate: Foreman, Solitro, Wolfertz (1999)
  - Bipolar devices in CMOS process for bandgap reference function

Figure 4.3.3.2: Layout of PNP Device
Trimmable Bandgap Voltage Reference in CMOS

Figure A6: Links blown using power supply at 200X

• Implemented link fuses for bandgap voltage trim
50A 1µs Transient Current Source Test Load

- **Undergraduate:** Lawler, Levesque, Ruiter (2000)
- **Application:** Test microprocessor power supply
- **Programmable current:** to 50A, 1µs rise time

![Diagram of the 50A 1µs Transient Current Source Test Load](imageURL)
**50A 1µs Transient Current Source Test Load**

Fig. 7. Measurement configuration.

- **Presented at IEEE**
  **Instrumentation and Measurement Conf, 2000**

Top: $I_{\text{out}}$ at 20A/div  
Middle: $V_S$ at 50mV/div  
Bottom: $V_{S+}$ at 50mV/div

Horizontal scale: 1µs/div
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Conclusion

• Collaborative Center
  – Serves needs of constituencies: Students, Sponsors, Faculty
• Analog / Mixed Signal Research Lab
  – "Real World" design environment
  – Attracts best students
• Benefits
  – Access to graduating seniors, M.S. students
  – Increase pool of experienced students
  – Improved awareness of BAE among all students in ECE
  – Influence direction of research