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

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Presentation Overview

• Background
• Industry-University Partnership
• Center Overview
• Operational Details
• Project Examples
• Conclusion
<table>
<thead>
<tr>
<th>Year Range</th>
<th>Position / Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1979-1983</td>
<td>A.B. Engineering, Dartmouth College</td>
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<tr>
<td>1983-1986</td>
<td>Design Engineer, Analogic Corp.</td>
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<tr>
<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-pres</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 third-oldest technological university
- Located in Worcester, Massachusetts
  - ~ 1 hour from Boston
- Full-time enrollment:
  - ~ 3500 Undergrad, ~ 1500 Grad (~220 FT Faculty)
  - Small size, 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
## Background: Curriculum

<table>
<thead>
<tr>
<th>Undergraduate: &quot;Technological Humanist&quot;</th>
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<tbody>
<tr>
<td>– Prepare students for entire career and life path</td>
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<tr>
<td>– Projects: Close collaboration with faculty mentor</td>
</tr>
<tr>
<td>• Humanities: Creativity in nontechnical fields</td>
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<tr>
<td>• Interdisciplinary: Optional global sites</td>
</tr>
<tr>
<td>• Disciplinary Project: Capstone design</td>
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<tr>
<td>– Professional-level design experience</td>
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<tr>
<td>– Integrate, apply knowledge</td>
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<tr>
<td>– Solve “real-world” problems</td>
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<table>
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<tr>
<th>Graduate: Disciplinary Specialization</th>
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<tbody>
<tr>
<td>– M.S., Ph.D. research</td>
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- Background
- Industry-University Partnership
  - Goals
  - Traditional Research Model
  - Collaborative Design Center
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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
## Industry / University Partnership: Models

<table>
<thead>
<tr>
<th>Model</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undergraduate Project</td>
<td>2 – 3 student project team $15K, 3 – 8 months</td>
</tr>
<tr>
<td>Graduate Project</td>
<td>1 MS or PhD student $60K/yr, 1.5 – 4 years</td>
</tr>
<tr>
<td>Collaborative Design Center</td>
<td></td>
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</tbody>
</table>
Traditional Research Model

• Targeted
  – Support single 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
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  - Organization
  - Benefits for Students
  - Benefits for Sponsors
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Center Overview

• The Center for Analog and Mixed Signal Design at WPI conducts graduate research and undergraduate projects in all aspects of mixed signal circuit and system design.

• These activities are conducted in an environment that supports the complete "real world" design process.

• The Center is supported by contributions from member companies, who help to determine the direction of Center research.
### Design Center Overview: Organization

- **Membership:** $35,000 annual fee
- **Student / faculty participation (average):**
  - 15 students/year: 4 capstone teams, 3-5 grad
  - 4-5 faculty involved
- **Advisory Board**
  - Representatives from member companies
  - Half-day meetings in fall, spring
  - Review progress, choose future projects
  - Direct interaction with students
- **Project Ideas**
  - Proposed by companies, faculty
  - Sponsors select (Advisory board vote)
Benefits to Students

• 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, grad students
- Better evaluation of engineering competence
  - Lab vs. interview situation
- Increase pool of students with mixed signal design experience
- More awareness of engineering opportunities at sponsoring 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
<table>
<thead>
<tr>
<th>Recruiting Students</th>
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</table>
| • Two words: FREE FOOD  
  – Student recruiting event after Fall meeting |
| • Two more words: OPEN HOUSE  
  – Invite students in ECE to presentations  
  – See ongoing projects; cool place to work |
| • Presence in microelectronics courses at all levels  
  – Frequently mention related, high quality, sponsored projects  
  – Lecture examples from industry / project work |
| • Most important: Student word-of-mouth, positive peer "buzz" |
| • Interviews: 12 selected from pool of 20 to 30  
  – Excellent student quality |
### 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
  – Graduate
• Conclusion
Efficient Wall Adapter

- Undergraduate: Barschdorf, Kernan (2007)
- Application: Reduce standby power of wall transformer
- Sense load impedance; disconnect power if current below threshold
Efficient Wall Adapter

- Results: 90% power reduction in standby mode

Figure 5-14: Plot of power consumption for both our solution and the unmodified adapter versus the inverse of the attached load resistance.
14b Pipeline ADC Design in 0.25µm CMOS

- Undergraduate: Goluguri, Nair (2007)

- Presented at IEEE International Symposium on Circuits and Systems, 2007
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 transient current source test load with pulse timing, rise time program, and constants current program.
50A 1µs Transient Current Source Test Load

Fig. 7. Measurement configuration.

- Presented at IEEE Instrumentation and Measurement Conf, 2000
Class D Audio Amplifier

- Undergraduate: Morey, Vasudevan, Woloschin (2008)
- Application: High Efficiency Audio Power Amplifier
- H-bridge power stage; 3-level $\Sigma-\Delta$ modulation

Plot for Efficiency of Input Signals at $f = 1\text{kHz}$
Solar Panel Peak Power Tracker

- Application: Control duty cycle of boost converter
- Track optimum point in panel V-I curve

Figure 6-7: Indoor Solar Panel Testing Set-up
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
- Output buffers
- Address bus
- Reset SHAs
- Source follower pixel buffer
- Test pixels
- Test photodiodes
- 128 pixel array
- Control Units
- Signal SHAs
- Pixel buffers
Digital Baseband Predistortion For RF Power Amp Linearization

- Undergraduate: Ahmad, Gupta (2006)

Figure 17: Digital baseband predistorter schematic.
Digital Baseband Predistortion For RF Power Amp Linearization

- Undergraduate: Ahmad, Gupta (2006)
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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, grad students
  - Increase pool of experienced students
  - Improved awareness of opportunities at sponsor among all students in ECE
  - Influence direction of research