Trends in RF/Mixed-Signal Design and Its Implications on Computer Aided Design

by Henry Chang, Ken Kundert

9/22/05
Bridging the GAP

Digital

# of gates

The classic EDA “gap”

Creativity
Function
Performance

Analog

The analog CAD “gap”
Outline

• Design Drivers
• Design Challenges
• Addressing Challenges
  – Design Teams
  – Methodology and CAD
• Conclusions
The Morning Paper

Friday’s Fry’s Electronics circular - 8 pages of the electronics We Make!!!
With “Cool” Mixed-Signal Chips

PROGRESSIVE SCAN DVD PLAYER
- Plays DVD, DVD±RW, CD, CD-R/-RW, CD+G, VCD, SVCD, MP3
#4493246

KEYCHAIN DIGITAL CAMERA
- Built in Memory
- Store up to 80 Images
#4220204

120GB INTERNAL HARD DRIVE for Only
$39.99 19.99
*Best Buy and CompUSA ads also
Latest and More Expensive

5.4" PORTABLE DVD PLAYER WITH CAR MOUNTING KIT
$79.99

LMD-2548
#4366795

Maximize the speed and range of your network with this Smart Antenna Wireless g MIMO Router. (DI-624M) 6960238

*Best Buy and CompUSA ads also

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New Technology Premium

600% Premium!!!!

Fry’s Electronics HAS ALL THE

10/100Mbps PCI NETWORK CARD

NO REBATE REQUIRED

Limit 2 Per Customer
#4276294

99¢

WORKING NEEDS!

AirLink™

GIGABIT PCI NETWORK ADAPTER CARD

NO REBATE REQUIRED

Limit 2 Per Customer
#3887837

5.99

800%
Could Be Worse

Software

Free
Bright Spot
Not Just Cost

Power is everything!

Functionality

Performance
One Device, Do Everything

- 3D Video Games
- Streaming Video
- MP3 Player
- Bluetooth
- Mobile Web
- 1.3MP Camera
- Video Camera
- Speakerphone
- Voice Dial
- Mini SD Card
- Address Book
- Speed Dial

4 oz, 4 hour talk, 1 week standby
Fierce Competition

End Products

Prototypes

ICs

Selection

“Design In”

No margin for error!
Outline

• Design Drivers
• Design Challenges
• Addressing Challenges
  – Design Teams
  – Methodology and CAD
• Conclusions
Design Challenges

- Functionality
  - Many standards
  - Adaptable to different end products
- Performance
  - Specifications and exceeding them
  - Low power
- Cost
  - High yield
  - Small die area
- All before the holidays!
  - Design productivity
  - Design quality
  - Fast ramp to volume
- Repeatable
Complexity

- # of transistors (functionality)
- modes
- modes/standard
- # of standards
- countries
- power modes
- circuit modes
- many products
- experiments
- test

algorithmic circuits
(performance)

more digital

calibration

process scaling

at test
at power-up
during operation

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# Performance

<table>
<thead>
<tr>
<th>Disk Drive (RPM)</th>
<th>Wireless Networking</th>
<th>Video</th>
<th>Digital Camera (Pixels)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Next Generation</td>
<td></td>
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</tr>
<tr>
<td>15,000 10Gb/s</td>
<td>802.11b</td>
<td></td>
<td>QUXGA 13M</td>
</tr>
<tr>
<td>10,000 1Gb/s</td>
<td>802.11g</td>
<td></td>
<td>QSXGA 8M</td>
</tr>
<tr>
<td>7,200 100BaseT</td>
<td>802.11</td>
<td></td>
<td>QXGA 6M</td>
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<tr>
<td>5,400 10BaseT</td>
<td>Appletalk</td>
<td></td>
<td>UXGA 4M</td>
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<tr>
<td>4,500 RS-232</td>
<td>Appletalk</td>
<td></td>
<td>SXGA 3M</td>
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<td>3,600</td>
<td>RS-232</td>
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<td>XGA</td>
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<tr>
<td>Mainstream</td>
<td>Increasing</td>
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<tr>
<td>Obsolete</td>
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<td>15,000</td>
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<td></td>
<td>XGA</td>
</tr>
</tbody>
</table>

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CICC 2005 Examples

A Discrete Time Quad-band GSM/GPRS Receiver in a 90nm Digital CMOS Process [1]

A 0.8-1.3V 16-channel 2.5Gb/s High-speed Serial Transceiver in a 90nm Standard CMOS Process [2]

A Highly-Integrated CMOS Analog Baseband Transceiver with 180MSPS 13b Pipelined CMOS ADC and Dual 12b DACs [3]
Outline

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Design Levels
# Design Teams

<table>
<thead>
<tr>
<th>Design Level</th>
<th>Designer/Team</th>
<th>Cause of Sleepless Nights</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analog Block</td>
<td>Analog Designer</td>
<td>Function, Performance</td>
</tr>
<tr>
<td>Analog IP</td>
<td>Design Lead</td>
<td>Architecture, Function, Performance, IP Packaging</td>
</tr>
<tr>
<td>Chip</td>
<td>System Designer</td>
<td>Architecture, Performance</td>
</tr>
<tr>
<td></td>
<td>Implementation</td>
<td>Schedule, Integration, Function</td>
</tr>
<tr>
<td></td>
<td>Verification Engineer</td>
<td>Function (Performance)</td>
</tr>
<tr>
<td>ASSP</td>
<td>Production Engineer</td>
<td>Design for Test, Yield</td>
</tr>
<tr>
<td></td>
<td>Business Owner</td>
<td>Schedule, Customer Relationship</td>
</tr>
<tr>
<td>End Product</td>
<td>“Customer”</td>
<td>System “Bring Up”</td>
</tr>
</tbody>
</table>

Own concerns *plus* communicating with others
Complex Communication

• Geography / time zone / language
• Different concerns
• Different design domains
• Different design languages
The Problem

- System Design
- Design Entry
- Design Tuning
- Floorplanning
- Layout
- Extraction
- Parasitic Management
- Functional Verification
- Performance Verification
- Yield
- Substrate Noise
- DRC/LVS
- Data Management
Verification Issues

• Chip Functional Verification
• IP Functional Verification
• IP Performance Verification
• Block Performance Verification
Outline

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Top-Down Verification

• Verification planning
• Shared design representations
• Verification of each design change
• Continual refinement w/quick initial iteration
• Executable models and scripts used daily
Flow

Flow

Verification Plan → Modeling Plan → HDL -A -AMS Test-benches → Regression Tests

Must be owned by design team and be an integral part of design process
Navigating the Details

- Verilog vs. VHDL?
- Verilog vs. Verilog-A vs. Verilog-AMS?
- When mixed-level? When mixed-mode?
- Level of model? How many levels?
- How to verify models?
- Verification vs. design models?
- Effort to invest?
- Build generic models?
- How to integrate with design?
- Who writes models?
- Purpose of each model? Concerns? What to model?
- Customer of model?
- Spice transient vs. timing simulator?
- Where does Matlab fit in?
- How to help design not impact design?
Design vs. Verification

**Design**
- Scratch Pad
- Excel, Matlab, Models
- Parametric Selection

**Verification**
- Full functional verification
- Full performance verification
- Regression Testing
- Monte Carlo / Corners Analysis

Are the same models used?
Same person for both tasks?
Analog Verification Engineer

• Modeling expert (digital and analog)
• Paired with analog IP design lead
• Understands top-down verification
• Understands simulation technologies
• Focuses on verification and delivering models to customers (internal and external)
The Real Issues

• Work jointly with designers
• Talk to designers
• Test ideas with them
• Read about what they are struggling with

http://www.designers-guide.org/
Conclusions

• Fierce competition driving design
• Analog design is multi-dimensional
• Analog verification changing
• New methodologies required
• Analog behavioral modeling has new roles to play
Portable Music

- First AM/FM “walkman”
  - 25 years ago
  - $285 (adjusted for inflation)
  - 4 x AA batteries
  - Stereo
- FM/MP3 Player
  - $60
  - 1 x AAA battery
  - CD Quality
  - < 20% of the weight
Buyer's Remorse

TAKE THE MUSIC WITH YOU!

NO REBATE REQUIRED!

128MB MP3 PLAYER

- 128MB Built-in Memory for WMA and MP3 Playback
- PC and MAC Compatible
- LED Indicator for Play/pause Modes
- USB 2.0/1.1 Compatible

$19.99

#4456946 Limit 1 Per Customer
References

