Importance of Analog in Digital World

Aabid Husain
Vice President of Marketing and Business Development
Analog, Power and Mixed Signal Technologies
Agenda

- Growth of Analog IC’s
- “Analog” in Digital World
- Analog or Multi-Technology SoC’s
- Technology Platforms and Manufacturing
- Conclusion
Semiconductor Industry

Source: WSTS
Semiconductor Industry - Maturing?

Source: WSTS

~ 7%

2~3%
Analog Market - Growing at ~7% CAGR

~ $50B (2013)
~ $60B (2015)

Source: iSuppli, GLOBALFOUNDRIES Internal Research
Some Market Drivers for Analog IC’s

Automotive

Handset

Wireless
Mega Trends that will Drive Our Economy, Technology and Semiconductors

The Cloud will cause upheaval in IT

Mobile computing will continue to converge functions and drive compute power

Internet of Things will drive mobile processing at low power with ubiquitous RF

Energy Efficiency is needed for sustainability & lower cost of ownership

Increasing Security concerns at all levels: government, enterprise and personal

Coverage and insatiable bandwidth needs will drive Next-Gen Wireless
Analog IC Market by 2015 to be $80B

**SOURCE:** McKinsey on Semiconductors, Number 2, Autumn 2012, “Finding the Next 100 Billion $’s in Semiconductor Revenues”

<table>
<thead>
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<td>Memory (Volatile)</td>
<td>-0.2</td>
<td>0.6</td>
<td>0.2</td>
<td>1.7</td>
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<td>n/a</td>
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<td>Memory (non-Volatile)</td>
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<td>0.1</td>
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<td>2</td>
<td>1.2</td>
<td>1.9</td>
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<td>3.9</td>
<td>3.5</td>
<td>5.4</td>
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<td>Analog</td>
<td>-0.8</td>
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<td>1.8</td>
<td>2.2</td>
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<td>0.1</td>
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<tr>
<td>Discretes</td>
<td>0.1</td>
<td>1.4</td>
<td>0.6</td>
<td>0.9</td>
<td>n/a</td>
<td>0.2</td>
<td></td>
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<tr>
<td>Optical</td>
<td>0.2</td>
<td>2.5</td>
<td>2.3</td>
<td>1.8</td>
<td>n/a</td>
<td>3</td>
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<tr>
<td>Sensors</td>
<td>-0.1</td>
<td>0.7</td>
<td>0.1</td>
<td>0.8</td>
<td>n/a</td>
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<tr>
<td>Total</td>
<td>5.6</td>
<td>21</td>
<td>16</td>
<td>17.3</td>
<td>1.2</td>
<td>5.6</td>
<td>66.7</td>
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Base Market + Mega Trends
$60B + $20M
Value of Analog IC in Digital Devices

- Without Analog IC
  - the Device will not turn-on
  - the Display will not work

- Many other functions won’t work!

  (in case the first two problems were not big enough!!)
Where does Analog fit in this Digital World?

Real World
- Temperature
- Pressure
- Position
- Motion
- Sound
- Video
- Light

Signal Conditioning (Analog)

Processor (Digital)

Signal Conditioning (Analog)

Ref: L. Hutter; Analog Leaders Forum, Korea 2012
Thus ……Analog is Everywhere !!
Teardown of a Common Digital Device
Smartphone (iPhone 4S)

- Analog
  - Power
  - Audio
  - Video
  - Display
  - Touch
  - Transmitters
  - Compass
  - Gyrosopes
  - Accelerometer

- Logic/Memory
  - Apps Processor + DRAM
  - NAND Flash
  - NOR Flash
  - Quad Baseband

9 Chips

4 Chips

Symposium 2013

Ref: L. Hutter; Analog Leaders Forum, Korea 2012
Difference between Digital and Analog

Digital
- Process Technology Follows ITRS Roadmap
- Major Process Differentiator is Timing & Ramp Execution
- Product Differentiation comes from Soft IP’s and Software
- Technology Development is Mainly by Foundries

Analog
- No ITRS Roadmap for Process Technology
- Process Technology Remains a Critical IP
- Silicon IP is Main Differentiator
- Historically Dominated by IDMs, but Gap is Narrowing vs. Foundries

Ref: L. Hutter; Analog Leaders Forum, Korea 2012
Scaling of Digital and Analog

Analog & Power Scale Slower  
Not Much Digital on a Typical Analog ICs

Ref: L. Hutter; Analog Leaders Forum, Korea 2012
And … Analog Scaling will be Even Slower

- Litho-Based Analog Scaling Will Slow
- Targeted Device Scaling Will Occur

Ref: L. Hutter; Analog Leaders Forum, Korea 2012
Hence… Mixed-Technology SoC’s

**Applications**
- Audio
- Display
- Power Management
- Others………..

**Technologies**
- 180nm – mainstream
- 130nm – leading edge
- 55nm – bleeding edge
PMIC for Samsung GALAXY – S3 Smartphone
Mixed Technologies for Analog SoC’s

- Innovation and Differentiation is “In-Silicon”
- “Analog-Mind-Set” for Manufacturing
Strategy must be Centered on Modular Technology Platforms

Customizable
- Options for customer specific devices

Modular
- Add or Subtract mask-layers / devices
- Replace devices (e.g. 5V with 3.3V OR 1.8V with 2.5V)
- Add different type of isolation (e.g. DTI)

Portabe IP
- One Set IP’s for Platform
- IP’s can be developed by customer

Benefits
- **Flexibility**
  - Innovate in Silicon
  - Create value for both Customer\Foundries
- **Scalability**
  - Multiple technologies
  - Modular and extendable
  - Multiple markets/applications
Modular Technology Platform for Analog SoC’s

- eFlash
- Low Voltage Logic + OTP
  - 12V & 16V LDMOS
  - 20V & 24V LDMOS
  - 7V & 10V LDNMOS
- 30V LDMOS
- HRes Poly Resistor
- MIM Cap
- Zener Diode
  - with VNPN, VPNP, Schottky Diode, MOS Caps, Varactors and LDMOS
- 5V Baseline Process
## Benefit of Modular Platform – An Example

### Availability of 5V and 6V CMOS

<table>
<thead>
<tr>
<th>Parameters</th>
<th>5V CMOS</th>
<th>6V CMOS</th>
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<tbody>
<tr>
<td></td>
<td>NMOS</td>
<td>PMOS</td>
</tr>
<tr>
<td>VT [V]</td>
<td>0.72</td>
<td>0.77</td>
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<tr>
<td>$I_{dsat}$ [µA/µm]</td>
<td>540</td>
<td>280</td>
</tr>
<tr>
<td>$B_{Vdss}$ (min) [V]</td>
<td>7.5</td>
<td>7.5</td>
</tr>
<tr>
<td>$I_{off}$ (typ) [pA/µm]</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>$R_{dson}$ [mohm-mm$^2$]</td>
<td>2.02</td>
<td>6.03</td>
</tr>
</tbody>
</table>
Chip size:
Height  1.5~1.8mm
Length  22~24mm
Requirements for HD Display Drivers

- **Voltages**
  - TFT: 1.2V; 6V and 32V
  - AMOLED: 1.2V; 8V and 20V

- **OTP**
  - Configurable Parameter for Picture Quality w/ High Reliability

- **SRAM**
  - Smallest SRAM cell Implemented for High Density Memory

- **Embedded -Flash**
  - Allows Integration of Display Driver and Touch Panel Controller
HD Display Driver Technology Platform

- **32 V HV device**
- **20V HV device**
- **OTP**
- **6V Analog CMOS**
- **8V Analog CMOS**
- **Standard Cells I/O with ESD Cell**
- **SRAM with smallest bit cell**
- **MOM & MiM**
- **Poly Res 1K & 2K**
- **VNPN & LPNP**
- **1.2V CMOS Baseline Process**
## Design Infrastructure to Support Analog SoC's

<table>
<thead>
<tr>
<th>EDA/IP Solutions</th>
<th>0.18µm BCDlite™</th>
<th>0.13µm BCDlite™</th>
</tr>
</thead>
</table>
| **Standard Cells** | 1.8V: ARM-SAGE-9T  
1.8V: RM-Metro-7T | 1.5V: ARM-SAGE-9T |
| **Standard Cells** | (5V&6V): ARM -9T | -- |
| **Memory Compiler** |  |  |
| SP SRAM | Synopsys | ARM |
| DP SRAM | Synopsys | ARM |
| ROM | Synopsys | ARM |
| **I/O** | 1.8V ARM | -- |
| **5V I/O** | GLOBALFOUNDRIES | GLOBALFOUNDRIES |
| **OTP** | eMemory | eMemory |
| **eFuse** | GLOBALFOUNDRIES | GLOBALFOUNDRIES |
| **eFlash** | -- | SST |
| **Spice Model** | BSIM4.5 | BSIM4.5/HiSIM (for HV) |
| **PDKs** | Cadence | Cadence |
| **DRC/LVS** | Mentor | Mentor |
| **RCX** | Mentor / Synopsys / QRC | Mentor / Synopsys |
| **ESD Library** | GLOBALFOUNDRIES | GLOBALFOUNDRIES |
## Analog Companies with Internal Manufacturing

<table>
<thead>
<tr>
<th>&gt; 0.35um</th>
<th>180nm</th>
<th>130nm</th>
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</thead>
<tbody>
<tr>
<td>Analog Devices</td>
<td>Atmel</td>
<td>Fujitsu</td>
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<tr>
<td>Atmel</td>
<td>Bosch</td>
<td>Infineon</td>
</tr>
<tr>
<td>Bosch</td>
<td>Freescale</td>
<td>Samsung</td>
</tr>
<tr>
<td>Diodes – Fairchild Semiconductor</td>
<td>Fujitsu</td>
<td>ST Microelectronics</td>
</tr>
<tr>
<td>Freescale</td>
<td>IBM Corporation Burlington</td>
<td>Texas Instruments</td>
</tr>
<tr>
<td>Fujitsu</td>
<td>Infineon</td>
<td>Texas Instruments</td>
</tr>
<tr>
<td>IBM Corporation</td>
<td>Maxim</td>
<td>Toshiba</td>
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<tr>
<td>Infineon</td>
<td>NXP</td>
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<tr>
<td>Intersil</td>
<td>Panasonic Semiconductor</td>
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<tr>
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<td>Renesas Electronics</td>
<td>Toshiba</td>
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<tr>
<td>Maxim</td>
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<td>Samsung</td>
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<tr>
<td>Microchip Technology</td>
<td>Seiko Epson</td>
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<tr>
<td>Mitsumi Electric</td>
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<tr>
<td>Renesas Electronics</td>
<td>Toshiba</td>
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</table>
Foundries Serving Analog IC Manufacturing

- Altis
- AMS
- ASMC
- GLOBALFOUNDRIES
- Grace
- MagnaChip
- Micrel
- OKI
- PowerChip Technology
- Silterra
- Sekio Epson
- SMIC
- TowerJazz
- TSMC
- UMC
- Vanguard
- Yamaha
- X-Fab

- > 0.35um
- 180nm
- 130nm

GLOBALFOUNDRIES
PowerChip Technology
SMIC
TSMC
UMC
Manufacturing Scalability for Analog Products

GLOBALFOUNDRIES Manufacturing in Singapore

- 200mm:
  - 0.18um GLOBALFOUNDRIES modular platforms
  - MEMS Manufacturing

- 300mm:
  - 0.13um GLOBALFOUNDRIES modular platforms
  - 55nm GLOBALFOUNDRIES modular platform
  - 40nm GLOBALFOUNDRIES modular platform
The Analog Mindset

**Silicon Accuracy**
- Rich Component Set
- Tight Parametric Distributions
- Exhaustive Device Characterization
- 2\(^n\)d Order Effects – Noise, Matching, …

**Simulation Accuracy**
- Thorough PDK That Works
- SPICE Models That Match Silicon
- Robust ESD Solutions
- Proven IP Blocks for Key Functions

**Manufacturability**
- Electrical Failure Analysis, ESD Reviews
- Zero Defects, DPPM Focus
- Flexibility – Handle Unusual Requests
- Eco-System
Conclusion

- Analog IC is a Growth Market
- Analog is Everywhere!
- Analog - SoC's are here....
- "Analog Mindset" for Manufacturing
THANK YOU

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