Outline

• Strategic Thinking
• Smartphone Partition and Challenges
• Tear Down: iPhone5 and iPad3 4G
• Miniaturization Approach
Package vs. Module; Design Rule vs. Design Case

• Generic Package
  – For IC of a Wide Range of Industries
  – May Need to Qualify for the Conjunction of All Applicable Requirement
  – Comprehensive Design Rule to Accommodate Versatile Applications

• Specialized Module
  – For IC of Specific Industries
  – These Industries Often Have Similar System Requirement
  – Just Need to Qualify for the Intended Application Requirement
  – Single Point Design Case for Specific Application
From Multi-Die Integration to System in Package

Design for Manufacture & Performance!!
Multi-Die Integration: Cost Up or Down

• Cost-up Factors
  – New CAPEX
  – Cost of Yield: $\prod (1-x_n)$ or $1-\sum (x_n)$ or in Between
  – Volume: Customized vs. Standard
  – Fluctuation of Commodity Pricing

• Cost-down Factors
  – Less Package and Testing
  – Less Material
  – Design Cycle: Rule Based to Case Based
  – Less Overall System Cost
Who Owns the Multi-Die Integration

- Die Vender #1? Die Vender #2? …
- Module Maker? Device Owner?
- What about GM?
Typical Partitions in Smartphone

- Antenna Switch
- Front End Components
- RF Transceiver
- Communication Processor
  - Memory
  - POP Memory
  - Wi-Fi
  - GPS
  - BT
- Application Processor
  - Codec
  - Sensing
- Out Side of CMOS Node
  - PMU
  - POP Memory
  - Sensors
  - Wi-Fi
  - GPS
Challenges at 3G/4G Modem
## 3G and 4G Bands

<table>
<thead>
<tr>
<th>LTE</th>
<th>FDD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Band</strong></td>
<td><strong>Frequency</strong></td>
</tr>
<tr>
<td><strong>2100</strong></td>
<td>1920 - 1980</td>
</tr>
<tr>
<td><strong>1900</strong></td>
<td>1700 - 1775</td>
</tr>
<tr>
<td><strong>1700</strong></td>
<td>1745 - 1755</td>
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<td><strong>1695</strong></td>
<td>1710 - 1755</td>
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<tr>
<td><strong>2600</strong></td>
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### Operating Band
- **Frequency Band**: MHz
- **Common Name**: MHz
- **DL Frequencies**: MHz
- **UL Frequency**: MHz
- **Band**: MHz
- **UL Band**: MHz
- **DL Band**: MHz
- **Country**: MHz
- **Region**: MHz

### Channel Number
- **UL (UARFCN)**
- **DL (UARFCN)**

### More Are Coming!
Challenges at the Connectivity

- Connectivity 2.4GHz, 5GHz, 60GHz
- WiFi, BT, GPS, FM, NFC, ...
- Co-existence with LTE
- Mobile and WiFi Digital Integration
Challenge on PCB Area

Side View (from Bottom)

Phone T: 7.1mm vs. 7.6mm

Moto Droid Razr

Apple iPhone5

<table>
<thead>
<tr>
<th></th>
<th>Moto Droid Razr (4G LTE)</th>
<th>iPhone4s (3G)</th>
<th>iPhone5 (4G LTE)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LCD</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.3&quot;</td>
<td>3.5&quot;</td>
<td>4&quot;</td>
</tr>
<tr>
<td><strong>Phone Size</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L(mm)</td>
<td>130.7</td>
<td>115.2</td>
<td>123.8</td>
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<tr>
<td>W(mm)</td>
<td>68.9</td>
<td>58.6</td>
<td>60.1</td>
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<tr>
<td>T(mm)</td>
<td>7.1</td>
<td>9.3</td>
<td>7.6</td>
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<tr>
<td>Area(mm^2)</td>
<td>9005.2</td>
<td>6750.7</td>
<td>7442.2</td>
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<tr>
<td><strong>Battery</strong></td>
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<tr>
<td>Capacity (Whr)</td>
<td>1780mAh</td>
<td>3.7V/5.3Whr (1420mAh)</td>
<td>3.8V/5.45Whr</td>
</tr>
<tr>
<td>L(mm)</td>
<td>94.5</td>
<td>82.0</td>
<td>87.5</td>
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<tr>
<td>W(mm)</td>
<td>56.0</td>
<td>33.3</td>
<td>33.3</td>
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<tr>
<td>T(mm)</td>
<td>2.3</td>
<td>4.0</td>
<td>3.75</td>
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<tr>
<td>Area(mm^2)</td>
<td>12171.6</td>
<td>10922.4</td>
<td>10922.4</td>
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<tr>
<td><strong>PCBA</strong></td>
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</tr>
<tr>
<td>L</td>
<td>94.5</td>
<td>92.0</td>
<td>79.1</td>
</tr>
<tr>
<td>W</td>
<td>56.0</td>
<td>18.0</td>
<td>19.5</td>
</tr>
<tr>
<td>T</td>
<td>2.2</td>
<td>4.0</td>
<td>3.75</td>
</tr>
<tr>
<td>Area(mm^2)</td>
<td>5292.0</td>
<td>3312.0</td>
<td>3084.4</td>
</tr>
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iPhone5 Example
**iPhone 5 Example (Continue)**

- Skyworks 77352-15 GSM/GPRS/EDGE power amplifier module
- SWUA 147 228 RF antenna switch module
- Triquint 666083-1229 WCDMA / HSUPA PA/ duplexer module for UMTS bands
- Avago AFEM-7813 dual-band LTE B1/B3 PA+FBAR duplexer module
- Skyworks 77491-158 CDMA power amplifier module
- Avago A5613 ACPM-5613 LTE band 13 power amplifier
- Qualcomm PM8018 RF power management IC
- Hynix H2JTDG2MBR 128 Gb (16 GB) NAND flash
- Apple 338S1131 dialog power management IC*
- Apple 338S1117 Cirrus Logic device (second image)
- STMicroelectronics L3G4200D (AGD5/2235/G8SBI) low-power three-axis
- Murata/USI 339S0171 Wi-Fi module
iPhone5 Example (Continue)

- STMicroelectronics LIS331DLH (2233/DSH/GFGHA) ultra low-power, high performance, three-axis linear accelerometer
- Texas Instruments 27C245I touch screen SoC
- Broadcom BCM5976 touchscreen controller
- Apple A6 application processor
- Qualcomm MDM9615M LTE modem
- Qualcomm RTR8600 Multi-band/mode RF transceiver
iPAD3 4G Example
• Texas Instruments CD3240 driver device
• Broadcom BCM4330 802.11a/b/g/n MAC/baseband/radio with integrated Bluetooth 4.0+HS and FM transceiver
• 2 x 4Gb Elpida LP DDR2 = 1 GB DRAM in separate packages in a 64-bit configuration
• Fairchild FDMC 6683
• Broadcom BCM5973 I/O controller
• Broadcom BCM5974 microprocessor
• Apple 338S0987 (Cirrus Logic audio codec)

• Apple A5X processor
• Apple 343S0561 - This IC looks like an updated version of the 343S052 that we found in the iPad 2, and is used for power management.
• The NAND, part number THGVX1G7D2GLA08 is a 16 GB 24 nm MLC Flash from Toshiba
• Qualcomm MDM9600 - 3G and 4G wireless modem
• Skyworks 77469
• Avago A7792
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