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Freescale's High-Performance StarCore DSPs for the Baseband Market

Barry Stern
Baseband DSP & SoC Product Line, Marketing Manager
Agenda

► Freescale DSP roadmap
► Freescale wireless base station – focus markets
► MSC8156/4 multicore baseband DSPs
  • MSC8156 multicore DSP – highlights
  • MSC8156/4 DSP enablement & ecosystem
► MSC8156/4 DSP - typical baseband systems
StarCore DSP Devices Roadmap

Accelerated Performance
- Base station

Available Now

Optimized Performance
- Aerospace and defense
- Test and measurement
- Medical

Next Gen

Cost Efficient Performance
- Medical
- General purpose

Next Gen

MSC8156
- 6/4 SC3850 1 GHz+ cores
- MAPLE-B Baseband Coprocessor
- Serial RapidIO, PCI Express

MSC8154

MSC8144
- 4 SC3400 1 GHz cores

MSC812x
- 4 SC1410 300-500 MHz cores

MSC8113/2
- 3/2 SC140 300-400 MHz cores

MSC711x
- 1 SC1400 266-300 MHz core

MSC8256
- 6/4 SC3850
- 1 GHz+ cores
- SRIO, PCIe

MSC8254

MSC8252
- 2/1 SC3850 1 GHz+ cores
- SRIO, PCIe

MSC8251

Available Now
2010
2011
2012

Pin for pin compatible Families:
Freescale Wireless Base Station – Focus Markets
Mobile Broadband Standards – Timelines and Challenges

Latency requirements by different Technology => Better QoS

More Sites (Macro, Micro, Pico, Femto)

More Spectrum (5 MHz to 100 MHz)

Greater Spectral Efficiency
Focus Market Segments

Wireless Access

► Multi-standard wireless base stations
  • FDD-LTE (4G)
  • HSPA+ (3.5G)
  • TDD-LTE (4G China)
  • TD-SCDMA (3G China)
  • WiMAX

► Multiple base station form factors
  • Macro
  • Micro
  • Pico

► SDR – software definable radio
  • Deploying different standard base stations by using same hardware design enabled by different underlying software

Drive for optimal programmable DSP performance density (cost, power)
Broadband Wireless Infrastructure Baseband Processor
MSC8156 Multicore DSP – Highlights
MSC8156 Industry Awards

► Industry’s highest performing programmable DSP
► Six fully-programmable DSP cores deliver 6 GHz + baseband acceleration
► Industry’s first 45 nm DSP
► Fully qualified

EN-Genius Announces 2008’s Product of the Year Winners
January 12, 2009

“Freescale has correctly identified the need for a high-capacity DSP that’s been specially tweaked for 3G wireless applications, the raw processing power and low solution cost that this new multi-core monster brings to the game should win them a fair share of business in the next generation, or two, for wireless infrastructure equipment.”

Freescale SC3850 DSP core earns highest BDTImark2000™ score to date
Freescale StarCore® SC3850 core technology used in the MSC8156 multicore DSP has garnered leading benchmark results from independent signal-processing technology analysis firm, Berkeley Design Technology, Inc. (BDTI)
MSC8156 Highlights

► Target wireless base station systems
  - 3G-LTE, TDD-LTE, WiMAX, HSPA+ and TD-SCDMA
  - Meets all leading future wireless technologies

► Multi-standard technology, Single device performance:
  - Single-sector 3G-LTE
  - Multi-sector WiMAX
  - Multi-carrier TD-SCDMA
  - Multi-sector HSPA along with external chip rate acceleration

► Highly efficient internal memory
  - Large on die low latency memory:
    ▪ 6x 512 KB of L2/M2 + 1 MB M3 = 4 MB

► MAPLE-B accelerator
  - High throughput, multi-standard compliant, re-programmable

► MSC8156 device performance
  - Optimized programmable performance
    ▪ Based on next generation SC3850 DSP core, delivers up to 48 GMACS
      - 6 GHz effective performance
  - Embedded with innovative baseband accelerators
  - High-speed standard interfaces
    ▪ 2x Serial RapidIO®, 2xSGMII, 2xDDR-3, PCI Express®
  - Highly optimized multilevel memory
  - High-speed DDR interface
MSC8156/E – Broadband Wireless DSP

► Target applications
- PHY layer processing for FDD-LTE, TDD-LTE, HSPA+, TD-SCDMA, CDMA2K and WiMAX channel cards in NodeB BTS

► Key advantages
- Industry’s highest performance DSP, outperforms competitors’ highest performing multicore DSP by more than double
- Featuring six fully-programmable 1GHz DSP cores delivering 6 GHz of DSP processing power plus innovative, multi-standard baseband specific accelerators
- Supports at least 3G-LTE 10 MHz sector, UL+DL including MIMO in a single device

► The MSC8156 DSP has been qualified on advanced 4 5nm process technology
MSC8154/E – Broadband Wireless DSP

► Target applications
  • PHY layer processing for FDD-LTE, TDD-LTE, HSPA+, TD-SCDMA, CDMA2K and WiMAX channel cards in NodeB BTS

► Key advantages
  • Featuring four fully-programmable 1 GHz DSP cores delivering 4 GHz of DSP processing power plus innovative, multi-standard baseband specific accelerators
  • Enables pico/micro base stations

► The MSC8154 DSP has been qualified on advanced 45 nm process technology
SC3850 DSP Core

► SC3850 core advantages
- 1 GHz at 45nm
- High performance for deep pipeline architecture – advanced branch prediction
- Control code efficiency - hardware support for stack, many control-oriented instr.
- Easy programming - interlocked pipeline, backward compatible with all SC devices
- Intrinsic MAC functionality (Vs. MPY + ADD) – 8 GMAC per core
- Multicore support - semaphore support (read-modify-write)

► SC3850 subsystem advantages
- Memory management unit (MMU)
  - Flexible memory protection - Easier debug, faster time to market
  - Address translation
  - Better MTBF (mean time between errors)
- L1 data and instr. caches – 2*32 KB, 8 way, hardware and software pre-fetch
- Private L2 cache – 512 KB, unified data/Instr., dynamically defined as M2
- Debug and profiling - smart breakpoints, non intrusive profiling capabilities
SC3850 core BDTI Scores Update – Jan 2010
MAPLE-B Block Diagram

PSIF : Programmable System Interface
TVPE : Turbo/Viterbi Processing Engine
FFTPE : FFT Processing Engine
DFTPE : DFT Processing Engine
CRCPE: CRC processing Engine

**MAPLE-B Block Diagram**

- **PSIF**
  - MAG2DRAM
  - System DMA Engine
  - Local DMA/CRC PE x2
  - IRAM 16kB
  - RISC 0 Core
  - RISC 1 Core
  - IRAM 16kB
  - PIC
  - CE Slave
  - Arbitration and switching

- **TVPE**
  - FFTPE
  - DFTPE

- **FFTPE**
  - I/O Data Buffer
  - Radix 2 Cells
  - Radix 4 Cells

- **DFTPE**
  - I/O Data Buffer
  - Radix 2 Cells
  - Radix 4 Cells

- **CRCPE**
  - Radix 3 Cells
  - Radix 5 Cells

**Notes:**
- **PSIF config**:
- **Interrupts**
MAPLE-B Baseband Acceleration – Benefits

Cost

FPGA

MAPLE

Hardware/ASIC

Flexibility

Flexibility:
• Technologies/standards modifications
• Algorithmic modifications
• Architecture options
• Solution scalability

Cost:
• Power dissipation
• Silicon area

Programmable System Interface (PSIF)
• 1-4 RISC controllers
• 1-12 Processing Elements
• 1-4 System DMA’s & internal DMA’s

Processing Engines

• Multistandard support
• High throughputs
• From Macro to Femto
• Adaptable to multiple standards
• Mix and match different PE’s for various solution scalability and derivatives
### MAPLE-B Accelerator - Performance and Standards Compliance

<table>
<thead>
<tr>
<th>MAPLE-B (MSC8156)</th>
<th>3GPP TS 36.212 FEC and CRC</th>
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<tbody>
<tr>
<td><strong>3GLTE FDD/TDD Systems</strong></td>
<td></td>
</tr>
<tr>
<td>Turbo Decoding</td>
<td>&gt; 200 Mbps (6 iterations)</td>
</tr>
<tr>
<td>Optional support for sub-block de-interleaving</td>
<td></td>
</tr>
<tr>
<td>Viterbi Decoding</td>
<td>&gt; 100 Mbps (Tail-biting multi-iteration)</td>
</tr>
<tr>
<td>Optional support for periodic de-puncturing</td>
<td></td>
</tr>
<tr>
<td>FFT/IFFT/DFT/IDFT</td>
<td>&gt; 280 Msps FFT using FFTPE</td>
</tr>
<tr>
<td>Optional support for guard bands insertion</td>
<td>&gt; 175 Msps DFT using DFTPE</td>
</tr>
<tr>
<td>CRC, Insertion for downlink and check for uplink</td>
<td>&gt; 10 Gbps, CRC24A, CRC24B</td>
</tr>
</tbody>
</table>

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<tr>
<th>MAPLE-B (MSC8156)</th>
<th>IEEE® 802.16 Rev2</th>
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<tr>
<td><strong>UMTS – WCDMA, HSPA+</strong></td>
<td></td>
</tr>
<tr>
<td>Turbo Decoding</td>
<td>&gt; 165 Mbps (6 iterations)</td>
</tr>
<tr>
<td>Viterbi Decoding</td>
<td>&gt; 115 Mbps (Zero tail, K=9)</td>
</tr>
<tr>
<td>Optional support for periodic de-puncturing</td>
<td></td>
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<tr>
<td>FFT/IFFT</td>
<td>&gt; 350 Msps FFT using FFTPE and DFTPE</td>
</tr>
<tr>
<td>CRC, Insertion for DL and check for UL</td>
<td>&gt; 10 Gbps, CRC24</td>
</tr>
</tbody>
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<tr>
<th>MAPLE-B (MSC8156)</th>
<th>3GPP TS 25.212 (FDD) FEC &amp; CRC</th>
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<tr>
<td><strong>WiMAX Systems</strong></td>
<td></td>
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<tr>
<td>Turbo Decoding</td>
<td>&gt; 195 Mbps (6 iterations)</td>
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<td>Optional support for sub-block de-interleaving</td>
<td></td>
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<tr>
<td>Viterbi Decoding</td>
<td>&gt; 100 Mbps (Tail-biting multi-iteration)</td>
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<tr>
<td>Optional support for periodic de-puncturing</td>
<td></td>
</tr>
<tr>
<td>FFT/IFFT</td>
<td>&gt; 350 Msps using 2 units (FFTPE, DFTPE)</td>
</tr>
<tr>
<td>Optional support for guard bands insertion</td>
<td></td>
</tr>
<tr>
<td>CRC, Insertion for DL and check for UL</td>
<td>&gt; 10 Gbps, CRC16 (PDU)</td>
</tr>
</tbody>
</table>
MSC8156 Other Building Blocks

- Security engine acceleration – enabling data protection for MAC/L2 processing
- Dual Serial RapidIO® – x4 at 3.125G => 20 Gbps, high throughput interfaces connecting to antenna, L2/MAC processor and other DSPs on channel card
- Dual Gigabit Ethernet – control path
- PCI Express® – x4 at 2.5G, high throughput interface connecting to L2/MAC processor or ASIC/FPGA
- Dual DDR 2/3 64b 800 MHz – high throughout memory interfaces
MSC8156/4 DSP Enablement and Ecosystem
CodeWarrior Development Studio for StarCore v10.0
A complete development environment under Eclipse

► Eclipse IDE
  • Configuration wizards
  • Plug-in architecture
  • Third-party community

► StarCore Build Tools
  • C/C++ optimizer compilers

► Software Simulators
  • Multicore functional accurate simulator
  • Core platform cycle accurate simulator
  • MAPLE integrated into multicore simulator

► SmartDSP - Operating Systems
  • Pre-emptive, high performance, field deployed, networking stacks
  • Royalty-free

► StarCore Debugger
  • Multicore and multi-DSP
  • MSC8144, MSC8156, MSC8154 targets

► Trace and Profile
  • Profiler
  • Trace data offload via Ethernet using SmartDSP HEAT technology
# 3G-LTE Reference Software/Hardware

<table>
<thead>
<tr>
<th>Item</th>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1 Software</td>
<td>3GPP TS 36.211/12/13/14</td>
<td><strong>Software kernels sources for MSC8156:</strong>&lt;br&gt;- ANSI-C source for channel estimation SISO/MIMO&lt;br&gt;- UL MU-MIMO&lt;br&gt;- DL MIMO&lt;br&gt;- MMSE modulation demapping&lt;br&gt;- UL / DL HARQ&lt;br&gt;- Turbo encoder&lt;br&gt;- RACH&lt;br&gt;- PDSCH, PUSCH&lt;br&gt;- ULSCH, DLSCH</td>
</tr>
<tr>
<td>L2/L1 Interworking</td>
<td>3GPP TS 36.300</td>
<td>- Well defined L2/L1 interface&lt;br&gt;- Reuse possible across devices</td>
</tr>
<tr>
<td>Board</td>
<td>AMC</td>
<td><strong>Multi-standard baseband AMC platform</strong>&lt;br&gt;- Sample quantities as development reference&lt;br&gt;- Cards available to decrease time-to-market</td>
</tr>
<tr>
<td>Platform</td>
<td>3GPP TS 36.201</td>
<td><strong>Quick Start integrated reference platform</strong>&lt;br&gt;- Running L1/L2 multicore system software</td>
</tr>
</tbody>
</table>
MSC8156 Application Development System (MSC8156ADS)

► DSP - MSC8156 multicore DSP

► Memories –
  DDR2&3 1 GB each

► Ethernet Switches –
  SGMII and RGMII

► SGMII/RGMII PHY

► TDM – 2x E1/T1 framers and PTMC
  • AdvancedMC™ connector
  • Dual 1000BaseX
  • Dual Serial RapidIO® x4 / PCI Express® x4
  • TDM

► Board form factor –
  dual-width AMC

► Availability – now

► Price - $3900
MSC8156AMC – Reference Development System

► High-density DSP platform
  - 3x MSC8156 multicore DSP – each with:
    - 6x SC3850 StarCore DSP cores at 1 GHz + MAPLE-B baseband accelerator
    - 2x 512 MB of 64-bit DDR3 memory

► Connectivity
  - Four 3.125 GB Serial RapidIO® (x4) interfaces from backplane to DSP farm via Serial RapidIO switch
  - Two 1000 Base-X Gigabit Ethernet interfaces from backplane to DSP farm via Ethernet switch

► Module Management Controller (MMC)
  - Hot swapping
  - Board control

► Target applications
  - 3G-LTE, WCDMA, WiMAX base stations and media gateway systems
  - Design reference and enablement platform for customers and third parties

► Form factor
  - Single-width AMC

► Availability – Now

► Price - $6000
3G-LTE eNodeB – Capacity and Software Processes Mapping

► 3G-LTE FDD/TDD:
  - Single sector 20 MHz, 2x4 MIMO UL, 4x4 MIMO DL
  - Up to 300 Mbps DL, Up to 150 Mbps UL

► WiMAX TDD:
  - 3 sectors 10 MHz
  - Up to 50 Mbps/Sector DL
  - Up to 13 Mbps/Sector UL
MSC8154 Picocell System

► 3G-LTE FDD/TDD -
  • Single sector 10 MHz
  • 100 Mbps DL, Up to 50 Mbps UL
  • 2x2 MiMO
P2020-MSC8156/4 AdvancedMC™ Reference Design
For 3G-LTE Picocell

P2020+MSC8156 Combined Channel Card

LTE Reference Software

- Frequency Processing
- User Processing
- Scheduler
- MAC
- RLC
- PDCP (Encrypt)
- IP Security
- IP
- IP Security
- IP

Layer 1

MSC8156 AMC

Layer 2/3

P2020 AMC
Freescale’s Value Add Base Station Solutions

► Freescale DSPs enable OEMs the opportunity to take full advantage of LTE capabilities
  • 6 GHz raw performance with fully programmable cores
  • Embeds the unique Freescale MAPLE-B technology that accelerates Turbo and Viterbi, MiMO, CRC, Fast Fourier Transform (FFT), Inverse Fast Fourier Transform (IFFT), Discrete Fourier Transform (DFT), Inverse Discrete Fourier Transform (IDFT) operations currently performed in FPGA/ASIC custom devices, contains configurable RISC engines which can be reprogrammed in the future to accommodate updates
  • Supports legacy 3G technologies as well as the newest wireless standards to enable using same DSP for multiple technologies or in a multi-standard base stations

► Manufactured at most advanced process technology
  • Helps to significantly increase performance and design energy efficient solution while integrating functionality compared to previous generations process technologies
  • Help OEMs deliver cost-effective solution, to design small form factor channel cards that take up less space, increased functionality and consumes less power giving the opportunity to provide differentiated and competitive solutions for their customers

► High speed and standard interfaces pertinent to different board topologies
  • Meet required throughputs
  • Equipped with off-the-shelf ecosystem

► Cost-optimized solutions
  • Reduces channel card BOM by reducing chip count and eliminates the need to externally attach costly, customized and power hungry devices
  • Enabling common hardware platform cross multiple air interfaces saving CAPEX and OPEX

► Future roadmap
  • Already addressing the need for highly optimized 3G-LTE Macro and Pico base stations
  • Forward looking for cost optimized 3G-LTE and advanced-LTE eNB solutions
The embedded market needs long-term product support.

Freescale has a longstanding track record of providing long-term production support for our products.

Freescale offers a formal product longevity program for the market segments we serve:

- For the automotive and medical segments, Freescale will make a broad range of program devices available for a minimum of 15 years.
- For all other market segments in which Freescale participates, Freescale will make a broad range of devices available for a minimum of 10 years.
- Life cycles begin at the time of launch.

A list of participating Freescale products is available at: www.freescale.com/productlongevity