Integrated Communications Processors

Modular AdvancedMC™ Platform for WiMAX Base Stations
A New Generation of WiMAX Base Stations

WiMAX is an emerging standard under development by the WiMAX Forum (www.wimax.org) to deliver next-generation broadband wireless technology for wide area networks. WiMAX targets higher throughput, lower latency and efficient IP backhaul compared to previous wireless network technologies. It offers a new mass deployable wireless network technology which should herald a new age of rich multimedia and real-time services.

Platform Benefits

- “Jump starts” time to market
- Accelerates prototyping and development time
- Helps to lower cost of ownership
- Offers portable C-based software baseline for low latency, high throughput systems

OEM Availability

The Rapid System Development reference platform, including both hardware and software, is specifically targeted for use by OEM customers developing base station equipment solutions. The individual AdvancedMC™ platform hardware components are widely available from a combination of Freescale and Freescale Alliance Partners, and the software is available under license to OEMs.

Turning Vision into Reality with Freescale's Rapid System Development Platform

As the WiMAX market evolves from Wave1 and Wave2 towards future 802.16m standards, Freescale has developed a comprehensive hardware and software reference package which enables OEMs to quickly plug together their own systems for evaluation and development. The Rapid System Development Platform delivers a modular, programmable base station reference platform based on:

- Industry-leading processors, including networking communication processors built on Power Architecture™ technology and DSPs based on StarCore® technology
- PCI Industrial Computers Manufacturing Group (PICMG®) standard AdvancedMC (AMC)
- Layer 1 and 2 baseband enablement software for base station developments on Freescale processors

Rapid System Development Platform Ingredients

<table>
<thead>
<tr>
<th>Function</th>
<th>Component</th>
<th>Content/Deliverables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Platform base</td>
<td>MicroTCA™ chassis Part #11850-013 (Schroff®)</td>
<td>• Industry-standard MicroTCA development chassis</td>
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<tr>
<td></td>
<td></td>
<td>• Available direct from Schroff</td>
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<tr>
<td>Baseband Layer 2</td>
<td>MPC8548 AMC (PowerQUICC® processor-based AMC) Part #CWH-PPC-854N-VE (Freescale)</td>
<td>• Board with user documentation</td>
</tr>
<tr>
<td>processor board</td>
<td></td>
<td>• Linux® board support package (BSP)</td>
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<td></td>
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<td>• Optional schematics, OrCAD originals, Gerber files, layout files</td>
</tr>
<tr>
<td>Baseband Layer 1</td>
<td>MSC8144 StarCore® DSP AMC Part # MSC8144AMC-S (Freescale)</td>
<td>• Board with user documentation</td>
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<tr>
<td>processor board</td>
<td></td>
<td>• SmartDSP-OS board support package</td>
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<tr>
<td></td>
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<td>• Optional schematics, OrCAD originals, Gerber files, layout files</td>
</tr>
<tr>
<td>Layer 2 software</td>
<td>L2 Software</td>
<td>• Object library, source code, GCC build environment</td>
</tr>
<tr>
<td>package (under OEM</td>
<td></td>
<td>• Test harness</td>
</tr>
<tr>
<td>license)</td>
<td></td>
<td>• Documentation</td>
</tr>
<tr>
<td>Layer 1 software</td>
<td>L1 Software</td>
<td>• Object library, source code, CodeWarrior® build environment</td>
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<tr>
<td>package (under OEM</td>
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<td>• Test harness</td>
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<tr>
<td>license)</td>
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<td>• MATLAB® models</td>
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<tr>
<td></td>
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<td>• Documentation</td>
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AMC Hardware Platform Details

The broadband wireless baseband processing reference hardware is based on multiple modular PICMG defined AMC modules plugged into a compact MicroTCA™ chassis. The ability to use AMC modules directly, without the need for an AdvancedTCA® or a custom carrier, enables substantial reductions in size, cost and power. The modular approach also enables individual components of the system to be upgraded or even cost reduced, as newer hardware becomes available over time. This accelerates developer timelines and streamlines support. The baseline platform focuses on the Baseband Layer 1/Layer 2 processing, but the same system can be extended by adding control, network interface and FPGA cards to provide a WiMAX “Base Station-in-a-Box” solution. The baseline hardware platform components available are shown to the right.

Baseline Hardware Platform Components

<table>
<thead>
<tr>
<th>Function</th>
<th>Category</th>
<th>Specifications/Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Platform base</td>
<td>MicroTCA™ Chassis</td>
<td>• Schroff® MicroTCA development chassis</td>
</tr>
<tr>
<td>Baseband Layer 2 processor</td>
<td>AMC</td>
<td>• Processor: MPC8548 up to 1.3 GHz with integrated Serial RapidIO® and Gigabit Ethernet (GbE)</td>
</tr>
<tr>
<td>Baseband Layer 1 PHY processor</td>
<td>AMC</td>
<td>• Processor: 4 x MSC8144 StarCore® DSPs up to 1.0 GHz with integrated Serial RapidIO and GbE</td>
</tr>
</tbody>
</table>

**Modular AdvancedMC™ Mezzanine Hardware Platform Diagram**

- **RF PA**
- **RF Small Sign**
- **U/D Conv.**
- **Network Interface Card**
- **Radio Layer 2 Processing Card**
- **Radio Layer 1 Processing Card**
- **FPGA Card**
- **MPC8568**
- **MPC8548**
- **MSC8144**
- **FPGA/Fiber to RH Antenna**

- **PowerQUICC® Processor**
- **Control**
- **Radio L1 Physical Layer**
- **Radio L2 MAC Layer**
- **Network Interface**

- **Modular AdvancedMC Platform**
  - Processors built on Power Architecture™ technology
  - Digital Signal Processors built on StarCore® technology

- **MicroTCA™ Chassis**
**System Architecture Partitioning**

The base station system architecture is cleanly partitioned between separate network, Radio Layer 2 and Radio Layer 1 processors as shown above. It should be noted that for lower scale solutions—like micro-base stations—it is practical to consolidate these functions into fewer components, but the baseline reference design addresses the scaling needed for multi-sector macro-base station solutions, where each sector delivers high throughput and optimum range.

**Major Architectural Block Responsibilities**

**Layer 1—Physical**
Performs the Physical Layer Radio User, Frequency and Time processing as well as processing of ranging data and MIMO multiple antenna techniques ready to carry the logical radio transport channels and higher layers over the air interface.

**Layer 2—Medium Access Control**
Performs the MAC-CPS and Scheduler components that controls the base station and subscriber access to air interface resources. Resources are scheduled according to Quality of Service (QoS) requirements, using packet fragmentation/packing and retransmission via automatic repeat request (ARQ).

**Network Interface**
Performs network backhaul transport and interworking with internal interfaces. This includes processing the MAC-CS, which includes functions such as classification and header compression.

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**Layer 1 PHY**
- Frequency Process
- PUSC, Ranging Eq., MRC, STC

**Layer 2 MAC**
- User Processing
- FEG, QAM Modulation
- Scheduler
- MAC -CPS
- MAC -CS

**Network Interface**
- WiMAX
- IP or ATM/TDM

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  - Performs network backhaul transport and interworking with internal interfaces. This includes processing the MAC-CS, which includes functions such as classification and header compression.
Layer 1 and Layer 2 Radio Software Architecture

Layer 1/Layer 2 real-time software subsystems combine together to offer several key baseband ingredients for an air interface conduit to mobile subscribers. The Layer 1/Layer 2 real-time software subsystems can operate in concert, through a commonly defined architecture and Layer 1/Layer 2 interface. This interface can not only ensure efficient inter-operation of the two, but also enables advanced features and scheduling algorithms between them. The effort in the system and interface definition should translate into time to market savings for the developer, and can be considered as a baseline Layer 1/Layer 2 solution for OEMs to add differentiating intellectual property.

Layer 2—Data Plane Module Software

Freescale provides a set of OS independent modules covering the Layer 2 processing that is executed in real time. All software is delivered as a set of modules for MAC-CS, MAC-CPS and scheduler that can be ported to any RTOS. Designed for maximum real-time throughput, several optimized hardware specific software drivers can be included for optimum performance. All software is developed in ANSI-C, fully documented, flexible and extensible in design, with an emphasis on the scheduler architecture. As a design aid, the software can be delivered as an application running under User Mode Linux®. Further details are listed to the right.

<table>
<thead>
<tr>
<th>Dataplane Module Software Features</th>
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<tbody>
<tr>
<td><strong>Category</strong></td>
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<tr>
<td>Design approach</td>
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<td>RTOS support</td>
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<td>API</td>
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<tr>
<td>1. Medium Access Control Convergence Sub-layer (MAC-CS)</td>
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<td>2. Medium Access Common Part Sub-layer (MAC-CPS)</td>
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<tr>
<td>3. L2/L1 interface</td>
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<td>4. Framework</td>
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Layer 1—Real-Time Software Subsystem

The LTE Layer 1 software includes physical baseband channel processing and radio transport channel functions as defined in the 802.16d/e standards. Freescale provides a comprehensive set of kernel modules covering the Layer 1 processing for User Processing, Frequency Processing and Time Processing. The kernels are further combined into uplink and downlink chains which run real time using the SmartDSP real-time operating system as a reference. All software is developed as ANSI-C callable and fully documented.

In brief, the physical layer processing functions include:

- Modulation
- Channel coding
- Transmission schemes
- Ranging
- Channel estimation
- Equalization

Further details are listed on the following page.
## Real-time Software Subsystem Features

<table>
<thead>
<tr>
<th>Category</th>
<th>Specifications/Features</th>
</tr>
</thead>
</table>
| **Design approach** | • Layered API software approach enables multi-level reuse eases integration with custom and IP  
• Modular C software modules for all subsystems—includes C wrapper for optimized real-time assembly modules  
• Algorithm verification with floating and fixed point simulation system  
• Multi-core framework allows for efficient inter-core communication and task partitioning |
| **Features** | • User Processing  
  ◦ DL. Encoding  
  ◦ Modulation  
  ◦ UL Decoding  
• Frequency Processing  
  ◦ PUSC and FUSC Physical Mapping and De-Mapping  
  ◦ STC  
  ◦ Channel Equalizer  
  ◦ MRC Combining  
  ◦ Ranging  
• Time Processing  
  ◦ FFT, IFFT, Scaling  
• Modular design with well defined interfaces and module interactions  
  ◦ e.g. Downlink  
    ◦ IF11x: L1/L2 logical interface  
    ◦ IF2Tx: User to frequency processing interface  
    ◦ IF3Tx: Frequency to time domain processing—remaps IFFT signal generation onto FPGA  
    ◦ IF4Tx: Baseband I/Q sample interface towards the antenna FPGA  
  ◦ Message based configuration and runtime control  
• 3rd Party enhancements are available for all aspects of the PHY solution |
| **RTOS support** | • SmartDSP OS: Integrates real-time kernels and drivers |
| **API** | • Full software abstraction through well-defined and documented APIs  
  ◦ SBL1 API structure for reuse on function level  
  ◦ Framework API for reuse of higher level, complete processing chains  
  ◦ Complete subsystem reuse possible for channel types |
| **Validation/Test** | • Software tested on  
  ◦ Unit level (individual modules)  
  ◦ Integration level (module interaction)  
  ◦ System level (system operation, performance)  
• Software test environment is part of the software delivery package |
| **Standards reference** | Compatible to IEEE® 802.16e standard |
| **Layer 1 software packages** | • Signal Processing Library: contains WiMAX Layer 1 signal processing chains and kernel library functions. The signal processing kernels are the basic processing units and the signal processing manager is the chain integration of a set of kernels which includes:  
  ◦ Randomizer, FEC encoder and symbol mapper  
  ◦ Slot mapping logical to physical mapping for PUSC and FUSC modes  
  ◦ IFFT/FFT, frequency guard and CP management  
• MATLAB® Model Package  
  ◦ Delivers:  
    ◦ UL/DL Loopback, CC and CTC, QPSK, 16QAM, 64QAM (DL only), BER Testbench, Ranging and Fast Feedback Decode  
    ◦ Enables test vector generation  
• Functional integration of uplink/downlink chains on multi-core MSC8144  
  ◦ Uses SmartDSP OS real-time operation |