ADI Advances Audio Processing

By David J. Weinberg

On November 16, 2004, Analog Devices announced the ADSP-21367 and ADSP-21368—two new third-generation SHARC chips for digital signal processing. Based on ADI's press release [as is much of this information]: These two chips, with performance to 400MHz (four times that of the second-generation SHARC ADSP-2116x), deliver the audio industry's highest performance and integration for a variety of audio applications including audio/video receivers, professional mixing consoles, and digital synthesizers. ADI claims that with these new SHARC processors, manufacturers can produce competitively differentiated products for their high-end customers more quickly, easily, and cost-effectively than ever before, and can easily implement all currently available industry-standard audio decoder and post-processing algorithms, with sufficient processing headroom remaining available for customer-specific post-processing and future features.

SHARC processors (www.analog.com/processors/processors/sharc/index.html) "are based on a 32/40-bit super Harvard architecture, [and] combine a high-performance signal processing core with sophisticated memory and I/O processing subsystems. The code-compatible family portfolio extends from entry-level products priced under $10, to high-end products providing . . . signal processing performance . . . suited to applications ranging from consumer, automotive, and professional audio to industrial and medical imaging."

STRUCTURE AND ARCHITECTURE

The ADSP-21367 (aimed at upper level consumer audio/home-theater products) and ADSP-21368 (for professional audio devices) integrate a 400MHz core with large on-chip memory arrays (6MB ROM, 2MB RAM) and sophisticated audio-centric peripherals.

The on-chip ROM is factory-programmed with either industry-standard audio decoder and post-processor algorithms (ADSP-21367) or customer-specified algorithms (ADSP-21368). Thus some products can be designed using a single SHARC processor in lieu of several DSPs. The ADSP-21368 also includes support for shared memory systems, useful in multi-processor professional audio systems such as recording studio mixing consoles.

The architecture keeps the I/O bus separately controlled to allow the I/O to operate in parallel with the DSP processing without affecting processing performance.

Serial ports and S/P-DIF interfaces are commonly used in audio applications. These chips include eight full-duplex, high-bandwidth serial ports; an S/P-DIF transmitter/receiver; two signal routing units for peripheral-to-pin configuration; two UARTS; four precision clock generators; up to 34 GPIO pins; 10 hardware interrupts; two serial peripheral interface (SPI) ports; three timers; a two-wire interface; and an input data port for parallel data or additional I^2S serial channels. With these SHARCs, fewer additional chips are needed to provide those I/O connections.

The processors' high-bandwidth, efficient 32-bit external memory interface might simplify software/hardware design and speed algorithm development. The glueless interface to SRAM, FLASH, and SDRAM allows embedded-audio designers to select among several memory technologies.

These SHARCs also have an eight-channel hardware asynchronous sample-rate converter (designed under the guidance of Robert Adams, ADI Senior Design Engineer, my interview of whom was in *Multi Media Manufacturer* issue 1, January/February 2004).

PROCESSING AND DATA FORMATS

The SHARCs are based on a SIMD (Single-Instruction Multiple-Data) architecture, in which a single instruction causes multiple instances of the same operation to be carried out, each using its own input data. For instance, a SHARC LX3 can execute two multiplications, two additions, two subtractions, and two data fetches in parallel. Parallelism of this sort is common in signal processing applications.

The SHARC LX3 supports four data types: 40-bit floating point, 32-bit floating point, 16-bit floating point, and 32-bit fixed point. Complete hardware support is provided for IEEE-754 and IEEE-854 single-precision floating point format and arithmetic, and also supports the IEEE-754 and IEEE-854 single-extended precision floating point formats. Because the SHARC LX3 supports floating point arithmetic, there is no fixed/floating point data conversion necessary.

APPLICATIONS

This combination of functions and architecture enables the chips to support consumer audio features such as multi-channel decoders including lossless formats, multi-zone support, 192kHz processing, and sophisticated auto-setup routines. In many audio applications, SHARC processors provide predictable, reliable, and consistent performance while meeting other system level requirements. For example, the SHARC can process eight audio channels (such as 7.1; or a 5.1 mix plus a separate two-channel mix) and still have bandwidth left over for other tasks.

The extensive integration of functions in a single chip significantly reduces the number of external components in a product design and, hopefully, end-system costs.

The new SHARC processors have been designed to help audio product

makers reach the market more quickly with new, validated and tested, high-performance products.

PACKAGING AND AVAILABILITY

The ADSP-21367 is offered in two packages—a 208-lead MQFP and a 256-ball SBGA, while the ADSP-21368 is offered only in the 256-ball SBGA. Commercial, industrial, and automotive temperature ranges are also supported via selection during production testing.

The SHARC ADSP-21367 and ADSP-21368 will be sampling in Q1 2005, and will be available in quantity during Summer 2005 at $30 and $35, respectively, for 10,000 pieces.

BEYOND THE OBVIOUS

I spoke with ADI representatives about these new chips. Those of us familiar with computer hardware and programming understand that raw clock speed is a poor measure of ultimate application performance. Factors such as the number of clock cycles each instruction requires, bus speed, peripheral processing speed, efficiency of the code and the compiler, plus others, all substantively affect real-world performance. In light of this I requested explanation for their claims of high performance at such a relatively low clock speed (for example, as compared with the much higher raw clock speeds of Pentium processors), with this response:

Comparing Pentium with SHARC architecture is akin to matching a jackhammer against a hammer. Each tool can be very effective, but only performing the particular tasks for which it is targeted. The Pentium architecture offers significantly higher raw speed, but this doesn't come for free: the Pentiums' higher price points and power consumption, as well as their non-deterministic interrupt response time, prevent Pentium processors from operating as effective signal processing engines, especially in the very cost-sensitive consumer and professional audio markets where the SHARC ADSP-21367 and ADSP-21368 are targeted. Also, it's clear that the number of channels in a home, professional, or automotive audio system will not stop at eight; the 400MHz performance offered by the newest SHARC processors enables them to handle twice this number of channels, with headroom for product-differentiating features to be added by the equipment manufacturer.

Clock frequency could be thought of as analogous to a car engine's rpm. Just as the rpm alone does not reveal the speed and comfort of travel, clock speed alone does not guarantee the overall power and performance for a given application, especially when comparing dissimilar processor architectures.

On top of this, the characteristics of a DSP system are somewhat different from those of a general-purpose computing machine. Many DSP systems are subject to real-time constraints, where it is important to reliably and consistently respond to a stimulus within a specified amount of time.

The architecture of a general-purpose processor such as the Pentium is quite complex, and there are no good tools to help predict code execution times, so predicting time-dependent behavior is almost impossible. SHARC processors have a straightforward architecture, and well-developed tools that enable quite reliable and accurate prediction of code execution times.

Audio applications are sensitive to performance, circuit board real estate, power dissipation, and cost. The ADSP-21367/8 offer trade-offs among performance, power, and price. As a signal processor used for specific code-compact applications, the newest SHARC processors provide a number of benefits compared with the Pentium.

SUPPORT SOFTWARE

Recognizing that programming chips for applications has become quite complex and specialized, ADI offers an assortment of development, testing, and user application support tools.

ADI's SHARC processor development tools include the CrossCore family (www.analog.com/processors/resources/CrossCore/index.html), which encompasses the VisualDSP++ integrated software development environment, EZ-KIT Lite evaluation systems and emulators for on-chip debugging.

In addition, ADI has expanded its support for audio systems developers who use ADI chips, including its SHARC processors, with its VisualAudio design and development environment (www.analog.com/epHSProd/0,,VisualAudio,00.html; $2k per site license), which plugs into the VisualDSP++ integrated development and debugging environment (IDDE). Used this way, VisualAudio generates MIPS- and memory-optimized product-ready code by leveraging SIMD operations, without requiring users to possess specialized knowledge of digital signal processing or audio algorithms.

VisualAudio includes a GUI environment, a customizable software framework, a large library of optimized audio modules, a host communication and tuning interface, plus support for a range of audio decoders, along with much of the other software that is common to most audio products (see

www.analog.com/processors/tools for additional capabilities). In this way, it is designed to shorten the time, cost, and risk required to bring more-optimized audio products to market by enabling developers to focus on the features that will differentiate their products. For example, VisualAudio assists system developers to more easily design custom post-processing networks, generate product-ready code and dynamically tune output via real-time tweaking of digital signal processing modules such as delay, reverb, equalizers, and tone controls.

For the user: Auto Room Tuner (ART) technology is integrated into the latest SHARC Melody Platform (www.analog.com/processors/platforms/sharcMelody/) based on the recently introduced third-generation SHARC processors. ART technology is a software algorithm for audio calibration and equalization that makes it easier, faster, and more convenient for consumers to match surround-sound receiver settings for their speakers to the acoustics of the space in which they install their home theater or music system. M³

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