Dolby MS11 Decoder for DesignWare ARC Audio Processors

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With many new broadcast standards incorporating the latest audio standards, integrated circuit manufacturers need to support an increasingly wide range of audio formats for applications such as digital TV and set-top boxes. Dolby's MS11 Multistream Decoder is an integrated solution that supports simultaneous decoding, mixing, and post-processing of multiple audio formats including Dolby® Digital, Dolby Digital Plus™ and Dolby Pulse (HE AAC and all AAC streams). This article highlights the key benefits of Synopsys' optimized Dolby MS11 software for the DesignWare® ARC™ audio processors that enables designers to implement a certified solution for their next-generation multimedia system-on-chip (SoC) designs.

High-Definition Audio is Everywhere

High-quality audio is everywhere. It is not just in the theater or on a DVD, but TV audio is broadcast with clear, digital audio as well. We are seeing more formats and standards today than in the past, and many of them utilize specific codecs. Often these include one or more Dolby formats, such as Dolby Digital, Dolby Digital Plus or Dolby Pulse. Additionally, a second (referred to as a secondary or an associated) audio stream can be applied to the simultaneous transmission of, for example, director commentary in a movie or audio services for hearing impaired people.

SoC manufacturers that design chips for products such as digital TVs, set-top boxes and home cinema receivers for consumer markets need to support all these audio standards. Since these products are often not just used for broadcast, but also for playback of media content from the internet or local media storage devices, this trend may become a challenge for system designers.

Dolby MS10 and MS11 Decoders

Traditionally designers have had to integrate many different Dolby components into a small decoding subsystem themselves. With Dolby Multistream 10 and 11 (MS10 and MS11) Decoders, Dolby Laboratories provides a solution that reduces this integration effort. Dolby MS10 and MS11 decoders can simultaneously decode and encode multiple Dolby audio streams, such that with a single solution, device makers can be sure their products will meet market requirements.

If we look in more detail, we find that a Dolby Multistream Decoder is a small decoding system on its own (Figure 1). Compared to Dolby MS10, the MS11 decoder provides more inputs and outputs plus, optionally, Dolby Volume.

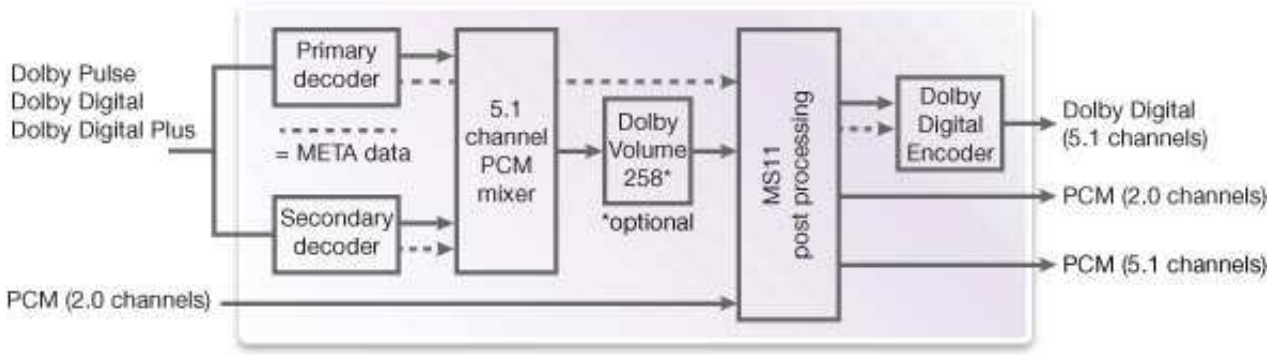

Figure 1: DesignWare ARC Audio Dolby MS11 decoding system

Dual decoding capabilities are provided for simultaneous processing of both the main and associate channel. For TV broadcast reception, the associate, or secondary, channel could contain additional audio. For example, audio descriptions (AD) for visually impaired people, special audio services for hearing impaired people or simply another language. Playback of a movie on DVD or from a USB network drive can provide 5.1 surround audio on the main channel, and, at the same time, the director's comments on the scenes can be viewed on the associated channel.

The decoders support a wide range of audio formats, including Dolby Digital, Dolby Digital Plus, Dolby Pulse (which is HE AAC v2 with additional embedded metadata) up to 5.1 channels (front left, front right, center, surround left, surround right,

and 'subwoofer'). Metadata is information derived from the broadcast streams and is used in various stages in the decoding system, including mixing and post-processing functions like dialog normalization and dynamic range control.

In addition, the two decoders Dolby MS11 also provides an input for 2.0 channels of Pulse-code Modulation (PCM) data. Furthermore, Dolby MS11 provides up to 5.1 channels PCM output versus 2.0 channels in MS10.

Dolby Volume can be integrated into an MS11 decoding system. It provides an algorithm that allows the end-user (a consumer watching TV) to set the volume at a desired level after which the software will ensure that a constant volume level is maintained despite variations in volume between scenes, such as a change from a movie to a commercial break, or when the channel is changed.

Dolby MS11 provides up to 5.1 channels Dolby Digital encoded output. This can be used to stream the decoded audio from the TV receiver or set-top box (STB) via a digital S/PDIF link to a home-cinema system.

Dolby MS11 also provides PCM output, which can be used to directly connect a digital-to-analog converter (DAC) for headphone or speakers connections. It can also be used as input to additional post-processing software such as Dolby Virtual Speaker.

	Dolby MS10	Dolby MS11	Benefits of MS11
PCM input	-	2.0 channels	Mixing audio effects or external decoders
PCM output	2.0 channels	5.1 channels	Enable additional post-processing (e.g. Dolby Virtual Speaker)
Dolby Volume	-	Optional	Avoid large (unwanted) volume fluctuations

Table 1: Dolby MS11 benefits

Benefits of Scalability using Multi-core ARC Audio Processors

The more complex the audio software is, the higher the load will be on the processor. When multiple software components are running on a single-core processor, the processor clock frequency will need to go up. But why run a processor at hundreds of MHz's if this is not needed?

Often a dual-core processor that can execute the same amount of software, but at a much lower frequency is the preferred choice. Since the clock frequency of a core is the sum of the (MHz) load of the individual software functions running on the core, a dual-core processor can run at a much lower clock frequency (as the functions are spread over two cores).

Synopsys provides SoC designers a scalable solution. Depending on their application designers can either use a single or a dual-core audio processor. For light-weight portable applications, a single core may be used, whereas in high-performance applications such as a set-top box, a dual-core could be an optimal solution. All the audio software works on either platform, allowing system architects to design for growth (for example a roadmap of products with both single and dual-core ARC processors).

Using Synopsys' dual-core ARC AS221BD audio processor, designers can configure the processor to perfectly meet their needs. In the case of MS10 and MS11 users can balance the software load of the decoding system to their requirements, see the example in figure 2.

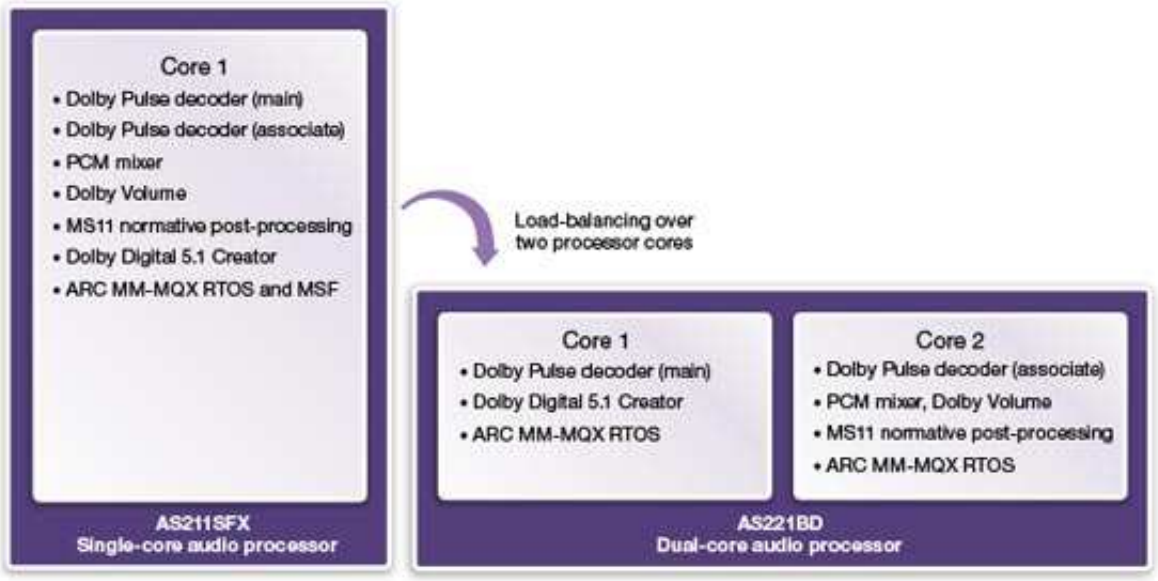

Figure 2: Designers can choose to balance their MS11 application over two cores

When benchmarking performance requirements of software on a processor (a lower MHz number is good), designers always take into account the most important dependency in their system, which is latency from and to the main system memory (often DDR). Often performance requirements are quoted at 0 cycles, but most multimedia designs have between100 to 200 cycles latency. The majority of processors will require a lot of extra processor cycles if the latency increases. Others, such as the ARC single- and dual-core audio processors are more robust to the impact to memory latency. Their XY memory architecture [3] implements a smart pre-fetching mechanism that enhances performance, especially at high latencies (>50 cycles).

	Competing Audio Processor [2]			Synopsys AS211SFX		
Performance Requirements (MHz) of Dolby MS10/11 use-cases	memory latency = 0 cycles	memory latency = 100 cycles	memory latency = 200 cycles	memory latency = 0 cycles	memory latency = 100 cycles	memory latency = 200 cycles
Dolby Pulse (main) + Dolby Pulse (associated)	223	340	**457**	243	314	**388**

Table 2: Processor performance requirements impact of memory latency (a smaller number is better!)

From table 2 it is clear that designers can achieve a lower processor load (388 instead of 457 MHz) and make their designs more robust to the impact of memory latency by using ARC audio processors (that benefit from their XY memory architecture).

When using a dual-core audio processor instead of a single-core processor, the impact of memory latency is further reduced. If the clock frequency of a dual-core processor can, for example, be made half that of the required frequency of a single-core processor, e.g. two cores running at 200 MHz instead of a single core running at 400 MHz, the relative memory latency is also reduced by a factor of two (of course the absolute latency (in ns) does not change, but the processor observes approximately 50% lower latency (in cycles). A lower memory latency results in less wait cycles, which reduces the MHz load on the processor.

	Competing Audio Processor [2] @400MHz		AS211SFX Audio Processor (single-core) @400 MHz		AS221BD Audio Processor (dual-core) @200MHz	
Performance Requirements (MHz)	memory latency = 0 cycles (0 ns)	memory latency = 200 cycles (500 ns)	memory latency = 0 cycles (0 ns)	memory latency = 200 cycles (500 ns)	memory latency = 0 cycles (0 ns)	memory latency = 100 cycles (500 ns)
MS10/MS11 Dolby Pulse 5.1 48 kHz (main) + Dolby Pulse 5.1 48 kHz (associated)	223	457 (note: does not fit in 400MHz)	243	388	146	179
MS11 Dolby Digital Plus 5.1 48 kHz (main) + Dolby Digital Plus 5.1 48 kHz (associated)	Not available	Not available	166	277	111	147

Table 3: Benefits of using ARC Audio processors for Dolby MS11

Table 3 shows designers can further reduce their processor clock frequency (e.g. from 388 to only 179 MHz) by selecting a dual-core ARC audio processor (that can balance the load over its two cores).

Audio Software Integration

Traditionally, DSP suppliers provide SoC designers with an audio processor and software codec IP. The SoC designers have to take up all the integration effort to build a working system, starting with a framework in which all the software components can be connected together. Synopsys provides its customers a lightweight Real-Time Operating System (RTOS) with a Media Streaming Framework (MSF), called MM-MQX. It allows designers to instantiate audio software components and create use cases (audio graphs) on either a single-, or dual-core ARC audio processor. Examples of functions in an audio graph include decoding, up/down sampling, virtual surround creation, post-processing and encoding. The ARC MM-MQX makes software integration on a dual-core processor as easy as on a single-core processor. The RTOS manages all software tasks including cross-core communication: a dual-core implementation behaves functionally the same as a single core. The DesignWare ARC Audio Dolby MS11 decoder comes with a reference design for the DesignWare ARC Audio MM-MQX, and allows users to configure and tailor the decoding system to their needs.

System Integration Made Easier

Synopsys' DesignWare SoundWave Audio Subsystem provides designers a 'drop-in' solution for audio (Figure 3). It includes both user-configurable audio processors as well as digital and analog audio IP interfaces. The SoundWave Audio Subsystem provides system designers everything necessary to quickly integrate the subsystem into their design. Its software infrastructure includes the very small, efficient MM-MQX RTOS, which creates the foundation for the software stack running on the processor. Users can select either a single- or dual-core audio processor. Depending on the application, multiple input/output configurations can be selected, as well as software for decoding, encoding, and post-processing. In addition to the proprietary MM-MQX API, a GStreamer audio plug-in is included that makes all the software functions, like Dolby Digital Plus decoding in the MSF easily available on the host-processor. Software developers can simply instantiate the audio graph into their application that is running on the host-processor, and all the audio processing is transparently off-loaded to the ARC audio processor inside the SoundWave Audio Subsystem.

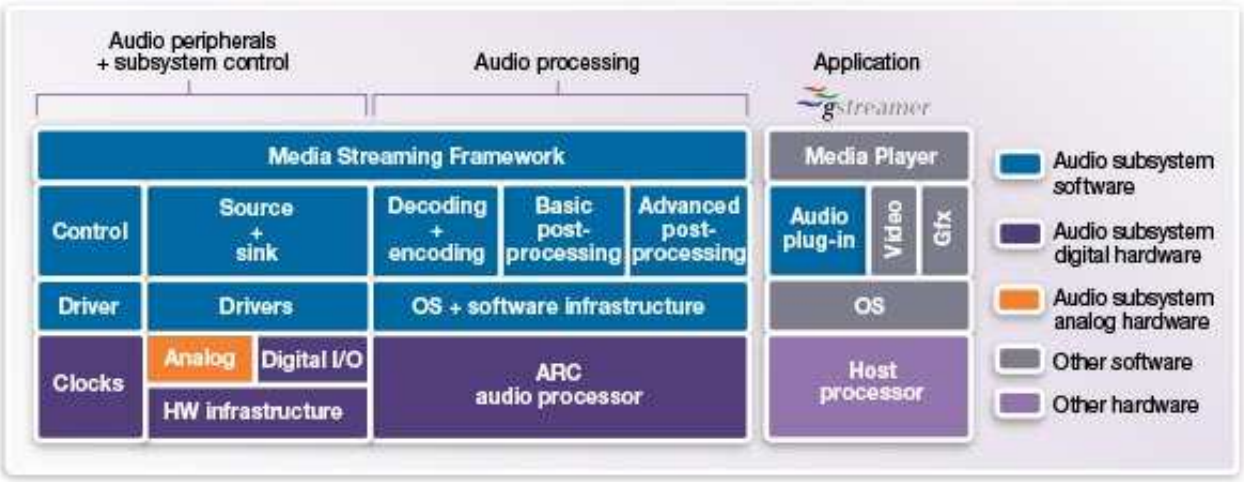

Figure 3: DesignWare SoundWave Audio Subsystem architecture

Summary

SoC designers need to support more audio standards in their products, and these standards are becoming increasingly processor-intensive (simultaneous decoding of multiple streams). Integration of various Dolby audio software components into a decoding subsystem is made simpler by Dolby's new MS11 decoder technology.

In order to get the best SoC performance, designers can use DesignWare ARC audio processors, which requires a much lower clock frequency compared to other processors. Performance improvements and further clock frequency reduction can be achieved by using the dual-core DesignWare ARC AS221BD audio processor.

Synopsys' DesignWare SoundWave Audio Subsystem enables designers to quickly configure and build complete Dolby MS10 and MS11 audio solutions for digital TVs, set-top boxes and other multimedia consumer devices.

References

[1] Logic + memory area, dynamic + leakage power, nominal voltage TSMC 40G

[2] http://www.tensilica.com/uploads/pdf/Audio_Israel_Seminar%2011-17-2011.pdf

[3] http://www.synopsys.com/dw/ipdir.php?ds=arc_xy_adv_dsp

More Information

- DesignWare ARC Audio Dolby MS11 Decoder
- DesignWare ARC Audio Dolby Volume
- DesignWare ARC Audio Dolby Virtual Speaker
- DesignWare ARC Audio Solutions
- DesignWare SoundWave Audio Subsystem

About the Author

Mike Thompson is the Sr. Manager of Product Marketing for the DesignWare ARC Processors at Synopsys where he is responsible for the microprocessor cores and subsystem solutions, and the development tools used with them. Mike has more than 30 years experience in both design and support of microprocessors, microcontrollers, IP, and the development of embedded applications and tools working previously for Virage Logic, Actel, MIPS, ZiLOG, Philips/Signetics, and AMD. Mike is also the primary author for Configurable Thoughts, a blog that discusses everything to do with microprocessors. He has a BSEE from Northern Illinois University and an MBA from Santa Clara University.

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