Reed Electronics Group

MICROPROCESSOR REPORT

www.MPRonline.com

THE INSIDER'S GUIDE TO MICROPROCESSOR HARDWARE

PHILIPS DEBUTS MEDIA PROCESSOR

Nexperia PNX1700 Has Award-Winning TriMedia TM5250 Core

By Tom R. Halfhill {4/18/05-02}

Philips Semiconductor is only weeks away from receiving silicon samples of the first Nexperia media processor based on the TriMedia TM5250 processor core. The new high-performance chip—dubbed the Nexperia PNX1700 Connected Media Processor—is designed for streaming digital-media applications, such as video decoding for high-definition television (HDTV).

Microprocessor Report readers may recall that the TriMedia TM5250 won the *MPR* Analysts' Choice Award as the Best Media Processor of 2003. (See *MPR 2/9/04-14*, "Best Media Processor: TriMedia TM5250," and *MPR 2/9/04-13*, "Media Processors Poised to Pounce.") The TM5250, code-named Spitfire, is a 32-bit synthesizable processor core based on the TriMedia VLIW architecture, which first appeared in 1994. Philips has patterned several processor cores on this pioneering architecture, with varying degrees of success. In 2000, Philips tried to spin off TriMedia as a separate company and license the architecture to other companies. Unfortunately, the tech bubble was bursting, and it wasn't a good time to launch new technology ventures. In 2002, Philips reabsorbed TriMedia into the parent company and has continued to design new TriMedia cores and chips.

Nexperia is Philips's all-encompassing brand name for programmable digital-media processors, whether they are based on TriMedia or other architectures. (Some Nexperia chips use ARM, MIPS, or DSP architectures.) Devices with TriMedia cores are the highest-performance members of the Nexperia family, and the TM5250 is currently the most powerful TriMedia core available. It's a superpipelined design (11 to 16 stages deep, depending on the type of operation) with a staggering array of 30 function units. It can maintain an equal number of instructions in flight, and the variable-length VLIW bundles may contain up to five operations for parallel execution. By every measure, the TM5250 is a significant improvement over the previous TM3260 core, which is the foundation for the current Nexperia PNX1500 media processor. (See *MPR 11/3/03-01*, "Philips Powers Up for Video.")

When Philips unveiled the TM5250 at Microprocessor Forum 2003, the company expected to announce the first TM5250-based chip in early 2004. That schedule turned out to be optimistic. Although the PNX1700 announcement is coming a year late, Philips is confident that production will begin in 3Q05 at the target clock frequency of 500MHz. The first silicon samples are due back from the fab in three to five weeks. Favored partners will get sample chips soon afterward. Software developers have been working with a cycle-accurate simulator for more than a year.

On-Chip Features Same As PNX1500

To keep its first TM5250-based chip relatively simple, Philips dropped the new core into the existing PNX1500 system-on-chip (SoC) design. The PNX1700 has the same lineup of peripherals and I/O interfaces that the PNX1500 has, including a 200MHz 16/32-bit DDR-1 memory controller (effectively 400MHz), which provides 1.6GB/s of peak bandwidth. As a result, the new chip is pin compatible with the PNX1500. Because both chips can run at the same voltage, some customers can use the PNX1700 in their existing PNX1500 system designs with little or no modification.

One significant difference is that the PNX1700 has a 128KB L2 cache on chip; the PNX1500 has none. The rest of the cache hierarchy is unchanged: both chips have a 64KB L1 instruction cache and 16KB L1 data cache. The big L2 cache keeps the PNX1700 from becoming memory bound when chewing larger amounts of data. A faster or wider memory interface might have achieved the same goal, but at the cost of pin-compatibility with the PNX1500. However, customers that don't currently use the PNX1500 may question whether the larger die required for the L2 cache is a worthwhile trade-off for the compatibility Philips preserved by sticking with the same memory interface. Figure 1 shows a block diagram of the PNX1700.

Philips refers to the PNX1700 as a Connected Media Processor because it can accept digital-media streams from a network or broadband modem via the on-chip Ethernet controller, as well as from traditional sources. For video processing, the 32-bit-wide video input accepts up to 10-bit YUV 4:2:2 digital video in a CCIR656-compatible stream or a YUV stream with separate horizontal and vertical synchronization. Before storing this data in memory, the PNX1700 can crop, scale, and convert the video to other pixel formats. If the video is a TV broadcast, the PNX1700 can also send data transmitted during the vertical blanking interval to a different region of memory for separate processing. Alternatively, programmers can reassign the video-input pins to capture and double-buffer any parallel datastream up to 32 bits wide.

The PNX1700 can decode MPEG2, Windows Media 9 (WM9), and DivX video streams at HD resolution, up to 1,280 × 720 pixels at 24 frames per second. It can encode and decode standard-definition (SD) video streams in MPEG2, MPEG4, DivX, H.264, and WM9 formats. Because it can simultaneously encode and decode MPEG2 and MPEG4 video, it's suitable for personal video recorders (PVR) that allow users to view and record a TV program at the same time, with live pause. The PNX1700 can perform numerous transformations on the video, including edge-dependent deinterlacing, scaling, aspect-ratio conversions, and anti-flicker filtering.

For video output, the PNX1700 supports two video planes (allowing a picture-in-picture window) or one video plane plus a graphics plane (for superimposed graphics, such as a GUI or a web browser). It can apply gamma equalization, adjust brightness and contrast, sharpen the luminance layer, correct skin tones, and perform numerous other transformations in real time. It supports CCIR656, YUV, and RGB formats with progressive or interlaced scan modes at resolutions up to 1,920 × 1,080 pixels at 60Hz. An integrated TFT LCD controller supports resolutions up to 1,280 × 1,024 pixels, also at 60Hz. Alternatively, programmers can reassign the video-output pins to carry any parallel datastream that doesn't require video processing.

Audio I/O is equally flexible. The PNX1700 has dual I^2S interfaces for connecting to external analog-to-digital and digital-to-analog converters, and they support up to eight channels of stereo audio. A two-way Sony/Philips Digital Interface (SPDIF) can send and receive digital-audio streams to and from external sources, such as DVD players, and it supports standard two-channel stereo or 5.1-channel surround sound. Miscellaneous I/O interfaces include a 32-bit, 33MHz PCI/XIO master/slave controller (which supports IDE hard drives and NAND/NOR flash memory), I^2C for connecting to other chips in the system, and 16 dedicated general-purpose I/O (GPIO) pins.

CE Developers Want Turnkey Solutions

The TM5250 processor core supports nine new instructions, which together with the existing 226 instructions constitute the TriMedia TMA3 instruction-set architecture (ISA). These previously undisclosed instructions, documented in the latest version of the user manual (revision 1.1), fill some gaps in the ISA and are useful for accelerating H.264-standard video and other codecs. In addition, the new ISA enhances some existing load/store instructions to access data not aligned on 32-bit memory boundaries.

Customers aren't required to use the new instructions, and the PNX1700 is source compatible with the PNX1500, so recently written software will run after recompilation. However, to take advantage of the PNX1700's new features, customers must either rewrite their code with the new instructions or use an updated codec supplied by Philips or a third party. Programmers must explicitly invoke the new instructions in their C/C++ source

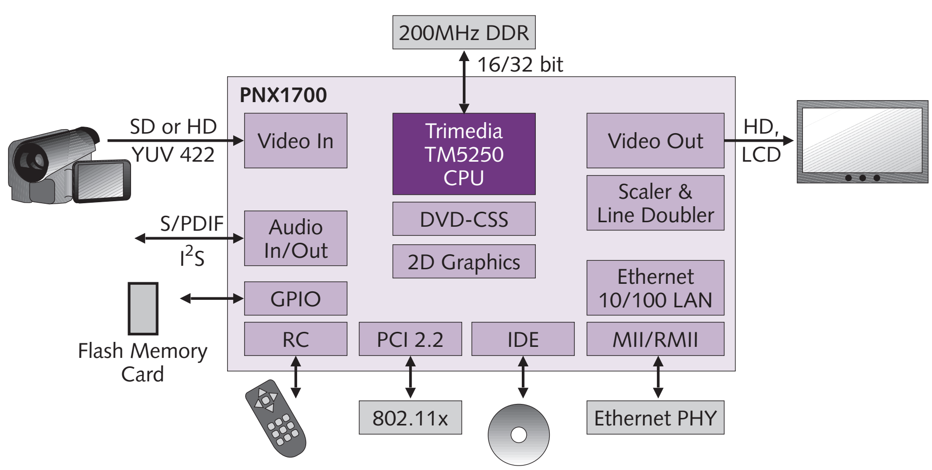

Figure 1. The Philips Nexperia PNX1700 substitutes the new TriMedia TM5250 core for the older TM3260 core in the existing PNX1500. Philips also added a 128KB on-chip L2 cache. Otherwise, the two media processors are virtually identical. Thanks to its new core, however, the PNX1700 will debut at 500MHz and deliver significantly more throughput. The PNX1500 hits the wall at 350MHz.

code, because the compiler has a limited ability to exploit the wide parallel-processing potential of the TriMedia VLIW architecture. Table 1 lists the new instructions.

Instruction	Description	Notes
alloc_d set	Allocate cache block and set to value	Fills block in L1 data cache with a 32-bit value specified in operand; useful for inverse discrete cosine transforms
clsame	Count leading same bits	Result equals amount of leading bits that are the same in the two source operands; useful for Huffman coding
dualaddsub	Dual signed arithmetic domain expansion	Adds or subtracts two 16-bit signed integers, depending on whether first operand is greater than or less than zero
dualiadd	Dual signed add	Adds two 16-bit signed integers; useful for inverse discrete cosine transforms
dualimax	Dual signed maximum	Finds maximum value of 16-bit signed integers packed in operands; useful for motion-compensated deinterlacing
dualimin	Dual signed minimum	Finds minimum value of 16-bit signed integers packed in two operands
dualisub	Dual signed subtract	Subtracts two 16-bit signed integers without overflow or underflow detection
duallsr	Dual logical shift right	Performs two logical shift-right operations on 16-bit unsigned integers
swapbits	Swap bits	Reverses the bit pattern of the 32-bit source operand; useful for addresses of results in fast-Fourier transforms

Table 1. The new TM5250 processor core in the PNX1700 introduces nine new instructions to the TriMedia TMA3 ISA. These instructions address some shortcomings and help accelerate software codecs for popular video standards. The new ISA also has enhanced load/store instructions (not shown) for accessing unaligned data in memory.

Philips says few of the consumer-electronics companies that are likely customers for the PNX1700 care much about new machine-level instructions these days, because they rarely write low-level software. Instead, they prefer to license off-the-shelf software codecs from Philips or third-party intellectual-property (IP) vendors. It's up to Philips and the IP vendors to optimize their codecs for the latest architectural improvements. In fact, consumer-electronics developers are becoming so harried (or lazy, depending on your point of view) that they're demanding complete hardware and software reference designs for popular product categories. By modifying the reference designs and buying prewritten software, developers can churn out new products faster than ever—although differentiation may suffer.

This industrywide trend toward turnkey solutions explains why your local electronics store has piles of me-too products. It also means that vendors like Philips cannot ship a new media processor without simultaneously releasing a boatload of software codecs for popular audio and video standards. Otherwise, even the best media processor on the planet would be snubbed by its intended customers. Consequently, programmers at Philips and allied IP vendors have been using a cycle-accurate software simulator of the TM5250 for more than a year in advance of the first silicon. Even so, there hasn't been enough time to optimize all the codecs for the new ISA. Table 2 lists the codecs that will be available for the PNX1700 and compares them with codecs for the existing PNX1500.

In addition to offering hardware reference designs, Philips has a growing catalog of application software kits, which include almost all the low- and high-level software needed to design a trendy consumer-electronics product. These kits are available for designing PVRs, Internet-protocol set-top boxes, H.264 videophones, wireless media streamers, and digital media adapters. Essentially, all the customer must add is the user interface.

New Core Boosts Performance

To reduce risks, Philips decided against making a transition to a new fabrication process concurrently with the transition to a new core. Therefore, Philips will manufacture the PNX1700 in the same 0.13-micron CMOS process used for the existing PNX1500. Despite the trailing-edge technology, Philips still

Codecs	Philips Nexperia PNX1700	Philips Nexperia PNX1500
Video		
MPEG1	Simultaneous D1 encode/decode; 720p HD decode	D1 encode; 480p decode
MPEG2	Simultaneous D1 encode/decode; 720p HD decode	D1 encode; 480p decode
MPEG4	Simultaneous D1 encode/decode; SP, MVP, ASP decode	D1 encode; SP, MVP, ASP decode
DivX	Standard encode; 3/4/5/6/HD decode	Standard encode; 3/4/5/6 decode
WM9	Standard encode; 720p decode	Cannot encode; SD decode
H.264	Simultaneous 1/2 D1 encode/decode; Main Profile D1 decode	Simultaneous CIF encode/decode; Baseline D1 decode
DV	Standard encode/decode	Standard encode/decode
H.32x	Standard encode/decode	Standard encode/decode
H.263	Standard encode/decode	Standard encode/decode
Audio		
MP3	Standard encode/decode	Standard encode/decode
AAC	Standard encode/decode	Standard encode/decode
Dolby AC-3	Standard encode/decode	Standard encode/decode
Dolby Pro Logic	Standard encode/decode	Standard encode/decode

Table 2. Philips and third-party IP vendors will offer these video and audio codecs when the PNX1700 media processor ships later this year. Some PNX1700 codecs will be recompiled versions of existing PNX1500 codecs, but others will be optimized for new features in the TM5250 processor core. Key differences are the PNX1700's abilities to support HD video and to simultaneously encode and decode some video streams. (D1 resolution: 720 × 576 pixels or 720 × 480 pixels. SD: standard definition. HD: high definition. SP: simple profile. ASP: advanced simple profile. MVP: multiview profile.)

Price & Availability

Philips plans to begin sampling the PNX1700 in 2Q05 and commence production in 3Q05. The target clock frequency for initial devices is 500MHz. The company will announce pricing later. For more information, see *www.semiconductors.philips.com/products/nexperia/*.

expects the PNX1700 to handily outperform the PNX1500 and other Nexperia media processors, thanks to the TM5250's enhancements.

Philips says the PNX1700 will easily reach 500MHz (worst case) while running on the same 1.2V core supply as the PNX1500, which peaks at 350MHz. The PNX1700's higher clock frequency is mainly attributable to the TM5250's deeper pipeline. However, Philips's decision to stick with a 0.13-micron process for the PNX1700, instead of moving to a lower-voltage 90nm process, eliminates the opportunity to reduce power consumption at the same time—especially since the PNX1700 is a much larger design that has more logic gates and cache memory. On the other hand, the PNX1700 dodges the current-leakage problems of 90nm. Bottom line: Philips expects the PNX1700 to consume about 3.0W at 500MHz compared with 2.5W for a 350MHz PNX1500.

That's only 20% more power for 43% more clock speed, a worthwhile trade-off. One would expect the actual improvement in performance to be greater than the difference in clock speed, because the PNX1700 has the enhanced TM5250 core and integrated L2 cache. According to Philips's internal MediaStone benchmarks, a 500MHz PNX1700 is about twice as fast as a 300MHz PNX1500 and 2.3 times as fast as a 200MHz PNX1300. (The 350MHz PNX1500 is a new speed grade that wasn't available when Philips ran the benchmarks.) However, the PNX1700 isn't markedly more clock-efficient than its predecessors. Clock for clock, it's only 8.5% faster than the PNX1500 and is actually 15% slower than the PNX1300.

Of course, clock efficiency isn't everything. Ultimately, throughput is what matters. The deeper-pipelined TM5250 core allows the PNX1700 to reach a 43% higher clock frequency than the fastest PNX1500 when both chips are manufactured in the same 0.13-micron process and supplied with the same voltage, so the new core is definitely an advantage. The PNX1500 and PNX1300 simply can't reach the same clock frequency as the PNX1700, so they can't match the new processor's throughput.

The new core also holds more promise for the future. According to software simulations, the TM5250's MediaStone performance scales at a virtually linear rate, with clock frequency up to 900MHz. The integrated L2 cache is crucial in this regard because it keeps the processor from becoming memory bound as its clock speed increases. If the simulations are accurate, the PNX1700 would greatly benefit from a process shrink to 90nm, which Philips suggests is a possibility. In contrast, the older TM3260 pipeline in the PNX1500 is only five stages deep, severely limiting its clock-frequency headroom in a smaller process. And without an integrated L2 cache, the PNX1500 becomes memory bound at higher frequencies.

To provide another indicator of actual performance, Philips has published certified EEMBC benchmark scores for the TM5250 core in simulation. Extrapolated for its target clock speed of 500MHz, the TM5250's out-of-the-box score in the EEMBC 1.0 ConsumerMark suite was 51.3, and its optimized ConsumerMark 1.0 score was 284.6. Those were high-ranking scores when Philips ran the EEMBC benchmarks in 2003, and they're still near the top of the charts today. Although several processors beat the TM5250's out-of-the-box (unoptimized) score, its optimized score is surpassed only by Tensilica's Xtensa V (ConsumerMark 525.9), a configurable-processor core that was heavily customized for the benchmarks. Perhaps in the future, Philips will test the TM5250 with EEMBC's new DENbench suite, which has much better kernels for evaluating digital audio and video performance. (See *MPR 2/22/05-01*, "EEMBC Expands Benchmarks.")

When customers consider all factors in the PNX1700's favor—higher throughput, simultaneous video encoding and decoding, HD video, only 500mW more power than the fastest PNX1500, a pin-compatible footprint, backward compatibility with TriMedia software, new video codecs, application-software kits, and hardware reference designs—they will probably find the new processor an attractive choice for their next-generation consumer-electronics products. ◇