

Synopsys and Texas Instruments Storage Products

Synthesis-Based Design Enables Fastest Read Channel Chip, Fast Time to Market and Easier Integration

Texas Instruments set a record for performance with their SP4140 500-Mbit-per-second read channel chip. They did it using a new all-synthesis design methodology that makes the read channel integrated circuit more easily integrated, and enables Texas Instruments to move more quickly to evolving semiconductor processes. To accelerate the transition to the new design methodology, Texas Instruments brought in expertise from Synopsys Professional Services.

“We chose Synopsys for assistance because they are the market leader in digital systems and for their expertise in synthesis processes, synthesis algorithms, and timing analysis for large digital CMOS designs.” Mark McQuilkin, Texas Instruments, Mixed Signal Computing Systems Manager

Storage

Issues

- Shorten development cycle for increasingly complex disk-drive integrated-circuit designs
- Lead the disk drive industry in integration
- Improve read channel performance

Solution

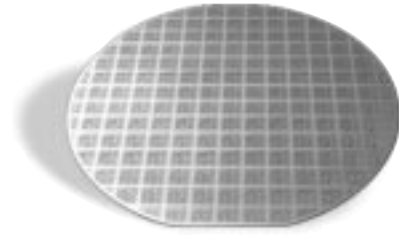
- Synopsys Professional Services rapid synthesis-based design methodology
- Synopsys PowerMill® simulator and PrimeTime® static timing analysis tools

Benefits

- Easier integration of digital components
- Easier migration to improved semiconductor processes
- First pass, full speed, full function silicon
- Real-time knowledge transfer

Business

Texas Instruments Storage Products is a leading designer and manufacturer of advanced semiconductors for mass storage applications and is composed of Silicon Systems, Inc., Intersect Technologies, Inc. and the mass storage unit of Texas Instruments.



Texas Instruments Storage Products Group serves the mass storage market by providing advanced semiconductors for high performance, desktop and mobile hard disk drives as well as removable drives.

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A New Process and A New Design Methodology

No one feels the relentless pressures of increasing design complexity and shorter product life cycles more acutely than disk drive integrated circuit (IC) suppliers like Texas Instruments (TI). Disk drive product life cycles will soon be down to 12 months with capacity increases of 60 percent a year. To simplify and speed up their design cycle, disk drive manufacturers, such as Seagate, Maxtor and Quantum, are demanding more highly integrated components.

To meet these challenges, TI changed how it makes read channel chips, the component that recovers data from the spinning platters coated with magnetic media. Improving the performance of the read channel is key to increasing data-storage density and disk drive capacity.

Stan Chapski, Director of the TI Bay Area Design Center, explains the basic read channel function. "Transitions of current create magnetic fields that

represent data bits, which are written onto the media. When density is increased, the transitions become distorted. The read channel function uses sophisticated signal processing techniques to quickly and accurately recover the signal." TI's job, Chapski explains, is to create signal-processing hardware that allows disk drive manufacturers to offer high density drives at the lowest possible cost. That's why, for the SP4140 read channel family, TI

shifted from bi-complementary metal oxide semiconductor (CMOS) to all-CMOS technology, and from custom schematic-capture design techniques to a repeatable synthesis-based design methodology. "This was our first CMOS read channel solution," says Chapski. "CMOS offers us high-performance at low power."

The Key to the Future

Synthesis-based design offers TI a number of compelling advantages as well. Chapski cites four:

1. Design modifications can be made more rapidly.
2. A high level of automated test is supported.
3. Other digital functions can be integrated more easily.
4. And next-generation CMOS process improvements can be easily accommodated.

"We're able to describe the logic of our circuits at an abstract level and use Synopsys tools to implement the gates automatically," Chapski explains.

"Changing to a different semiconductor process is simply a matter of telling the tools which library to use to regenerate the gates. The methods of timing verification stay the same; only the library changes."

Using the new synthesis methodology, the 500-Mbit/second SP4140 became the fastest design ever produced by TI. However, for TI this 500-MHz read channel design is just the beginning. It paves the way for development of highly integrated CMOS superchips, the next step in mass storage technology.

The superchip integrates the read channel, a digital signal processor (DSP) or micro-processor, and application-specific integrated circuit (ASIC) logic. "If we win with this CMOS read channel, and we begin an integration path, we could find ourselves in three years doing in the disk drive market what we did in cellular, where we've won the integration war at Nokia, Ericsson and Motorola. If we hit a home-run, it's the fastest growth area we have in TI," says Tom Engibous, Chairman, President and CEO, Texas Instruments.

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When It's This Important, Work With the Best

At the start of SP4140 read channel project, this was the challenging situation:

- A new process-CMOS.
- A new design methodology-full synthesis.
- A strategic product.

TI had two parallel objectives:

1. Rapid synthesis of their first CMOS read channel IC
2. A repeatable design methodology for follow-on projects.

"We knew what methodology we wanted to use, but didn't have the full complement of skills on board," recalls Chapski. "We're experts in disk drive applications and read channel technology,

but we needed to augment our skills in the synthesis methodology and learn to use the full capabilities of the Synopsys tools." The natural place to go for the skills was Synopsys Professional Services.

Mark McQuilkin, Manager of TI's Mixed Signal Computing Systems says, "We chose a synthesis-based approach for the digital logic design because it gives us greater flexibility for future design changes and a migration path for faster process technologies. And we chose Synopsys for assistance because they are the market leader in digital systems and for their expertise in synthesis processes, synthesis algorithms, and timing analysis for large digital CMOS designs."

The Quickest Way to an Accelerated Design Methodology

To meet their objectives, TI incorporated Synopsys Professional Services consultants into the team from the beginning and tapped their expertise throughout the project.

The project was conducted at five TI facilities throughout the United States, including Arizona, Texas, New Jersey and two in California. At the beginning of the engagement, Synopsys consultants visited each site for in-depth discussions with TI designers and the verification

and integration teams to understand the scope of the project and identify areas needing specific attention. "We needed very focused expertise in specific areas, such as timing analysis," says McQuilkin. "Synopsys Professional Services provided that expertise."

A Synopsys consultant was paired with the TI designer for each of the 12 logic blocks in the read channel architecture. This one-on-one relationship promoted the quick transfer of skills to the TI counterpart while keeping the project on a fast track. As members of the design

team, the Synopsys consultants helped ensure that the best synthesis strategy was used for each block to achieve the overall timing requirements, as well doing some of the hands-on work.

They introduced tools into the methodology, such as PrimeTime for static timing analysis and PowerMill to dramatically increase simulation speed. The SP4140 is a digital analog mixed signal solution, and PowerMill helped TI reduce simulation time on the analog digital converter block from more than two days to about two hours.

Synopsys Professional Services also helped TI generate a web-based tracking system for each logic block design, including metrics for worst negative slack, total negative slack, number of violations, and many others. The tracking system helped the development teams focus on design elements needing the most attention, and provided an excellent project overview of the work being conducted at multiple sites.

McQuilkin sums up the Synopsys contribution. "Synopsys Professional Services helped us develop methodologies for very high speed synthesis-based design. They advised us how to write RTL for high-speed design and provided consultants to write the scripts and help conduct the synthesis."

As the project progressed into phase two, Synopsys' role evolved to include architecture review for timing improvement,

dedicated tool assistance, layout strategies, and library improvement. Chapski commends Synopsys Professional Services for flexibility in responding to evolving issues. "The high speed of the SP4140 design meant we were pushing the edge of all the tools. Synopsys Professional Services proved their mastery of those tools by quickly analyzing and solving complicated problems."

Conclusion

The SP4140 CMOS read channel IC gives TI a number of competitive advantages. Not only is it one of the fastest read channel ICs available, offering outstanding performance as a standalone part, but it is positioned for integration with other digital components into the superchip. "Using the Synopsys synthesis methodology, we can describe circuit logic at an abstract level with RTL and use the synthesis tools to implement gates in a more automated way to quickly modify a design," said Chapski. "This gives us a high degree of agility over full custom processes."

When the SP4140 project began, the TI design team had never used an RTL synthesis methodology for a CMOS read channel design. When the project was done, they delivered full speed, fully functional silicon for testing. Without help from Synopsys Professional Services, "We wouldn't have taped out as soon as we did," says McQuilkin. "Synopsys helped us accelerate our development cycle, and that's a key competitive advantage in the marketplace."

Chapski adds, "With the rapid pace of technology development in the disk drive IC industry, we must continue to improve our methodologies, and we look to Synopsys to help us achieve that improvement."

"Synopsys Professional Services helped to develop methodologies for very high speed synthesis-based design and provided consultants to write the scripts, advised us on how to write RTL for high speed design and helped conduct the synthesis."

Stan Chapski, Texas Instruments,
Bay Area Design Center Director

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