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INTEGRATION

www.ti.com/sc/9805

the power of pin-out tool set architecture

The 1600-MIPS TMS320C6201 and now the 1-GFLOPS 'C6701

With last year's introduction of the TMS320C6201 fixed-point digital signal processor (DSP), Texas Instruments turned up the heat on providing developers with more performance for sophisticated applications. This year the push continues with the disclosure of the TMS320C6701 floating-point DSP, the first product from TI's 'C67x floating-point DSP generation.

The new DSP is both pin- and code-compatible with the industry-leading fixed-point 'C62x DSP, creating a fixed- and floating-point universal platform, which enables 100 percent reuse of fixed-point code for faster time-to-market. In addition, a new TI mixed-signal data converter connects to the DSP, providing an advanced DSP solution.

TI's TMS320C6000 architecture recently captured EDN's 1997 Innovation of the Year Award, an honor that recognizes outstanding products in the electronics industry.

Please see 'C6701 on page 3

New development technology opens a window into real-world performance

The start-and-stop debugging process system developers know all too well can become a task of the past because of Real-Time Data Exchange (RTDX™), new digital signal processing (DSP) analysis technology developed by Texas Instruments.

RTDX provides a window into real-world performance, allowing designers to transmit and receive data between a host computer and DSP devices without stopping their applications to evaluate results. Just as modern medical diagnostic equipment provides a real-time, ongoing analysis of the way a patient's body is functioning, RTDX allows designers to continually monitor their systems and gain real-time insight into their running applications.

This innovative technology, which further extends TI's leadership in DSP Solutions, will be incorporated as a standard capability in many future TMS320 DSP development tools, adding significant value and powerful functionality at no additional cost to users.

The continuous window into the world of TMS320 DSP applications — such as telecommunications, mass storage and digital control systems — equips customers with essential development building blocks to increase ease-of-use, productivity and time-to-market. TI expects its third parties to use the RTDX capability as a foundation for their products, freeing them to focus on creating application-specific development tools.

Easy analysis

TI's RTDX capability will allow easy analysis for a variety of current and emerging DSP systems.

- Wireless telecommunication designers will be able to capture the output of their vocoder algorithms to check

Please see RTDX on page 2

DSP SOLUTIONS

A new age of networking and global communications

By Jim Adams, Member of the Board of Directors and Former Chairman

Imagine a 200-lane expressway being built over a one-lane, heavily traveled road. It's every commuter's dream but practically impossible, unless you're talking about the information superhighway.

The limited, often-bottlenecked route to the Internet is about to undergo major construction, thanks to new technology called Digital Subscriber Line (DSL). Asymmetric DSL — the first version likely to hit the market — will give consumers up to 100 times the download speeds of current modems over existing phone lines and add a new dimension of functionality to the PC. That graphic that takes more than three minutes to download with today's fastest modem will happen in a blink with ADSL.

This technology will present tremendous opportunities for consumers and equipment makers, and it will help telephone companies, or telcos, open new avenues for data communications. It is cost effective and can become a showcase service in any company's package of communications services. ADSL is a competitive advantage in the rapidly growing demand for greater bandwidth, and TI will help deliver it to a world entering a new age of networking and global communications. *(See ADSL chipset article on page 4)*

Ideas to realities

Broadband is changing data communications to information communications. Once broadband is in the home, a whole new class of information services will become available. Incredible applications like real-time video will move beyond ideas to realities.

TI is committed to being an ADSL technology provider. The recent acquisition of Amati Communications — a world leader in DSL — underscores that commitment. TI's goal is to combine its industry-leading TMS320 digital signal processors (DSPs) and mixed-signal products with Amati's expertise to provide the world's best and most flexible DSL technology.

Digital signal processing, the technology best suited to developing ADSL, is an area dominated by TI, and programmable DSPs offer valuable flexibility for the emerging market. One factor that will help accelerate the rollout of ADSL is the ability to upgrade first-generation ADSL when improvements or code features are developed. For that, software — not just a silicon hardware solution — is needed. That points to a strength only DSPs can deliver.

Window of opportunity

The window of opportunity for ADSL is opening more quickly than anticipated, and telcos are in prime position to benefit. Customer demand and competition are driving the need for this technology.

The number of people using the Internet is exploding. About 40 million customers will have Internet access by the year 2000, according to one estimate. Telecommuting is growing, and thus far, has attracted more than 30 million people.

Telcos are operating in a new competitive environment. They have new freedoms and will be able to package services they once were prohibited from providing. On the flip side, the local loop is now open to competition from cable companies, long distance providers and others — all of whom will be pursuing the premium customers.

Cable is out of the gate fast, but telcos with ADSL will have advantages, one of which is the ubiquity of the copper network and being able to use the established network for data. It goes everywhere; cable doesn't. Cable has coaxial or fiber, neither of which is inferior to copper, but ADSL is faster. Telephony is designed for two-way service, cable isn't. And as more cable users come on-line in a neighborhood, everyone's throughput will be lower — several users on a cable system would have to compete for the same bandwidth, potentially diminishing data rates for each user. That's not a problem with ADSL.

Market forces

But what drives the market is not just technology — it's economics. Customers don't buy a product because of the technology. They buy it because of the applications. They buy it because it adds value for them. And the hot application today is the Internet.

Internet content providers know that narrow bandwidth is their Achilles heel. As the World Wide Web becomes the World Wide Wait, customers become frustrated and the promises of the information superhighway grow dim. Users are growing tired of watching the hourglass icon on their screens as they wait for data to be downloaded. Service providers are rushing to find a cost-effective way to meet this demand.

ADSL is the answer. It provides the bandwidth needs customers crave over the already-built copper network. Capital requirements — a digital modem in the central office and one more on the customer's end — are minimal. Plus, the software programmability of DSPs eliminates some of the telco concern about investing in this technology. The threat of technical obsolescence, a big telco concern, is lessened.

TI plans to work closely with telcos to remove risks and speed implementation. TI's already established Networking Lab is just one way we can bring laboratory solutions to real-world applications much faster than before.

The recent formation of a DSL industry group, in which TI participates as a technology provider, should speed adoption of industry standards. The lineup of companies involved in this program is impressive, but it will be up to technology providers such as TI to make it happen — and we are prepared for that challenge. ■

TELECOM

'C549 meets need for power efficiency

TI's TMS320C549 is meeting the need for power-efficient performance in the demanding telecommunications market.

The 'C549 offers 100 MIPs of high performance, extremely low power dissipation, ultra-small packaging, 32K words of on-chip SRAM and low cost. All of these features make it a powerful choice for manufacturers of high-performance telecommunications end equipment.

According to independent industry reports, the 'C549 has some of the most efficient MIPS of any fixed-point digital signal processor (DSP) offered in the industry. The MIPS efficiency is equivalent to that of a 24-bit DSP, but without the extra cost of interfacing to 24-bit memories. The 'C549 architecture enables other tasks, traditionally handled by ASICs or microcontrollers, to be integrated onto the DSP, thus lowering overall system cost.

The combination of an enhanced Harvard architecture, parallel bus structure and optimized core empowers a sophisticated instruction set, which uses many single-cycle and parallel instructions.

The 'C549 DSPs dissipate only 0.45 mA/MIPS for their core supply. Therefore, a 100-MIPS 'C549 operating at 2.5 V would dissipate less than 115 mW using on-chip resources. The 'C549 has three power-down modes — IDLE1, IDLE2 and IDLE3 — that enable the power dissipation to be reduced much further than the active power. For instance, in IDLE3 power-down mode the 'C549 has a current draw of less than 1 uA. The 'C549 features 32K words of on-chip RAM and 16K of ROM. This large amount of on-chip memory will enable designers to bring software functions from multiple DSPs together onto a single chip. In addition, the 'C549 can address up to 8M words of code. With such a large address space, the 'C549 can reconfigure itself in operation to run a wide variety of software algorithms available to it off-chip, using an enormous external memory pool.

Targeted at manufacturers of high-performance telecommunications end equipment, the 'C549 is an optimum solution for applications such as voice processing, Internet telephony, modems, wireless voice/data communications and dedicated subsystems. Applications that are power-sensitive, space-constrained, cost-limited and yet performance-driven can take full advantage of the 'C549 benefits.

TI is shipping 100-MIPS 'C549 samples with full qualification for all speeds (66/80/100 MIPS) planned for 3Q98. ■

TMS320C549	144-pin TQFP	$25
	144-pin ultra-small MicroStar BGA™ (12mm X 12mm X 1.4mm)	$25

Suggested resale in U.S. dollars in 10K quantity.
MicroStar BGA is a trademark of Texas Instruments.

➔ **For complete information, order: 'C54x Product Bulletin (SPRT121D). See page 8.**

RTDX

Continued from page 1

the implementations of speech applications.

- Embedded control systems will benefit, and hard disk drive applications can be tested without improper signals to the servo motor crashing the drive.
- Engine control designers will be able to analyze changing conditions like heat and environmental factors while the control application is running.

In all cases, users can select visualization tools for these applications in the way it is most meaningful for them. RTDX enables live and saved data display through an easy-to-use, object linking and embedding (OLE) application program interface (API) that easily connects to industry-standard, third-party application-specific or customized visualization packages.

The technology is based on communication between TI's extended development system (XDS) emulator hardware and software and a very small procedural library that TI will make available on future TMS320 DSPs. Developers use C or DSP assembly code to address an internal data exchange library, which in turn makes use of a scan-based emulator to move data on and off chip via the IEEE 1149.1 (JTAG) serial test bus.

The emulation logic built into TI DSP cores allows the host to transmit data to and receive it from the DSP while the target application is running at full speed. Initially, the RTDX capability will support data transfer rates at least 8 kilobytes per second, sufficient for running control, servo and audio applications at full speed. Future transfer rates will increase by a factor of 10 or more as emulation logic

RTDX key benefits

- Provides industry's first continuous, real-time code visibility into running applications
- Significantly shortens development time
- Is viewable on industry-standard, application-specific or customer-developed visualization packages
- Is well suited for full-speed control, servo and audio applications
- Will be standard element of many new TI DSPs and other processors

➔ **For complete information, order: RTDX White Paper (SPRY012). See page 8.**

MASS STORAGE

Best of both worlds

TI's latest DSP architecture combines the best features of MCUs and DSPs, delivering system-on-a-chip performance to mass storage.

The flexibility, ease-of-use and cost-efficiency of microcontrollers (MCUs) and the high-performance of digital signal processors (DSPs) are now available in a single architecture to meet the demands of the mass storage industry.

The new 100-MIPS TMS320C27x fixed-point DSP core from Texas Instruments will allow designers of hard disk drives and other high-density storage products such as digital video disks (DVD) and high-density floppies to realize the dream of creating no-compromise uniprocessor solutions for drive electronics.

The 'C27x, designed for embedded systems containing DSPs and general-purpose processors like microcontrollers, is a key addition to TI's customizable DSP (cDSP™) library. It's the first DSP core on the market to address all aspects of storage system requirements for integrated uniprocessor design. The 'C27x provides the highly efficient C compiling, linear address space and real-time control capabilities of an advanced MCU. It also permits development of a range of specialized integrated peripherals such as buffer management, multiplexers, bus interfaces, servo control logic and read channels.

Redefined DSP

DSP calculating capabilities serve to position recording heads more accurately on media surfaces, while at the same time controlling more precisely the speed of media rotation. In addition, the processor accommodates the enhanced partial response, maximum likelihood (EPRML) signal processing techniques employed in today's read channels.

technology evolves.

RTDX represents a fundamental new approach to system debug and offers significant advantages over methods currently used. Sometimes developers slow down their systems to obtain dynamic readings, but the resulting slow-motion version does not always reflect the true conditions of full-speed operation.

Alternatively, DSPs and other components can integrate in-circuit emulation (ICE) structures to perform real-time monitoring. Adding an ICE structure to the target component makes it a variant of the production component; therefore, the emulation may not be definitive in the results it yields. RTDX eliminates the time and cost involved in creating an extra version of a chip that includes ICE structures. Because the relatively small test structures on-chip that RTDX addresses are part of the production device and not an ICE add-on, developers obtain results identical to those of the finished product and know they will not require an additional version of the chip for debugging.

RTDX support in TMS320C54x development tools is expected to be available in mid-1998, with support of other leading TMS320 DSPs available in 1998 and beyond. ■

RTDX is a trademark of Texas Instruments.

Offering at least twice the performance of the most advanced DSPs currently in use for servo/spindle control, the 'C27x can accommodate future requirements brought on by new technologies such as microactuators, very high-speed motors and 6x or greater DVD.

"The new 'C27x core redefines the meaning of DSP in the storage world," said Briant Regan, TI mass storage marketing manager for DSP. "Not only is it a calculation engine, it is truly an optimized data storage processor."

Balanced architecture

The 'C27x architecture combines DSP high-speed multiply-and-accumulate (MAC) operations with the intensive I/O operations characteristic of MCUs. The result is that one device can provide the high-speed number crunching needed for real-time signal processing with the fast context switch and data manipulation capabilities required for control tasks.

To take advantage of the balanced 'C27x architecture, TI has developed an efficient C compiler that can produce compiled code denser than that of MCUs. Approaching the architecture's native assembly code in density, compiled code for the 'C27x requires half as much memory as equivalent compiled code for earlier DSPs. For the first time, designers will be able to implement completely the most demanding real-time applications in a high-level language.

The 'C27x is code compatible with the widely used TMS320 DSP family to provide a migration path for TI's existing DSP customers. Within its hardware is Real-Time Data Exchange (RTDX™) technology, an important innovation for system debug and development of highly integrated devices. *(See article on page 3)* Used in conjunction with an integrated JTAG port, RTDX enables 'C27x developers to isolate software bugs quickly and produce higher quality code in a shorter time.

Support

TI is making a major commitment to shorten time-to-market for 'C27x customers by developing more complete solutions called integration platforms. These platforms include a collection of macro cells required to meet a popular configuration, complete with fully tested firmware for both servo/spindle and controller operations.

Highly focused field and factory technical support is critical in the development of customized embedded processor solutions, and TI offers customers a mass storage dedicated firmware and hardware technical staff, each with long experience in storage processor solutions.

Availability

Most DSP solutions using the 'C27x core will be customized devices, with final pricing depending on the complexity of a particular design. TI has working silicon in .35-micron technology and is engaged with several mass storage customers today. Design models for .25 micron and denser process nodes will be available later this year. Contact your dedicated TI storage products sales office for more details. ■

cDSP and RTDX are trademarks of Texas Instruments.

➔ **For complete information, order: Technology Fact Sheet (SPRT157). See page 8.**

'C6701

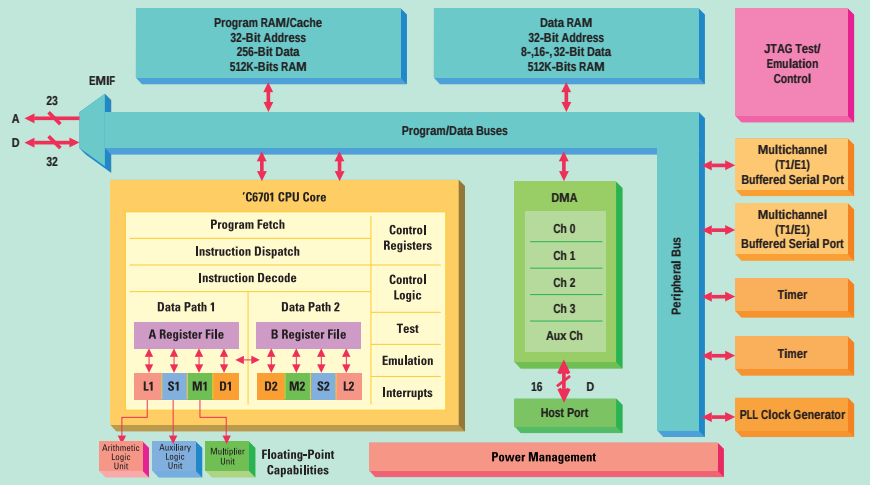
Continued from page 1

"A code-compatible fixed- and floating-point architecture will provide our customers with a universal platform for DSP application design," said Mike Hames, Semiconductor Group vice president and worldwide DSP manager. "A single development team can now create both fixed- and floating-point designs using the same tool set, the same code and even the same socket. Thanks to this flexibility, developers can achieve faster time-to-market and greater development cost savings while leveraging the highest performance DSPs on the market for product innovation."

1-GFLOPS performance

Operating at 1 billion floating-point operations per second (1-GFLOPS) at 167 MHz, the 'C6701 DSP provides up to 10 times the performance of today's floating-point DSPs. This high performance level will allow manufacturers to reduce system chip count from as many as 10 DSP chips down to a single 'C6701.

The 'C6701 performance will enable faster speed, precision and dynamic range in next-generation applications such as wireless local loop and beamforming base stations, virtual reality 3-D graphics, speech recognition, audio,



radar, industrial control and imaging such as fingerprint recognition, CAT scan, ultrasound and magnetic resonance imaging (MRI).

The 'C6701 is the first product based on the TMS320C67x 32-bit, floating-point core TI announced last October. All peripherals on the 'C6701 are 100 percent compatible with the fixed-point TMS320C6201, which is now in volume production. This allows designers currently developing with the 'C6201 to get 100 percent reusable hardware for a true drop and go transition. TI plans to triple the performance of the 'C67x to 3 GFLOPS by the end of the decade and offer low-cost and multiprocessor 'C67x products.

The 'C67x product line extends the advanced Very Long Instruction Word (VLIW) VelociTI(tm) architecture TI developed for its industry-leading 'C62x fixed-point DSPs. The first 'C62x product, the 'C6201, can execute 1600 million instructions per second (MIPS), up to 10 times the performance of other fixed-point DSPs.

Useful tools

The 'C6000 architecture is complemented by an ultra-efficient C compiler that supports both fixed- and floating-point and cuts development time in half by allowing programmers to write high-performance code in a familiar high-level language. Since the 'C67x instructions are a superset of the 'C62x instructions, developers can write and test programs on fixed-point 'C6201 devices, knowing that the same code will run successfully on the 'C6701. Conversely, when 'C6701 devices become available, developers can write and test programs on floating-point design, then easily migrate their systems to more cost-efficient, fixed-point solutions.

The new floating-point DSP complements TI's existing floating-point product lines, the TMS320C3x and TMS320C4x, which represent the largest floating-point DSP customer base in the world. TI plans to offer a software translation assistant for existing floating-point customers who want more performance for their 'C3x and 'C4x designs.

TI also offers the 'C62x EVM, which incorporates a 'C6201 DSP and a 10-bit, 20-MSPS analog-to-digital converter (the TLC876). In addition to TI's tools, other support is available to simplify development and speed time-to-market. Developers can turn to the world's largest network of DSP third parties for software and hardware tools and design support. To date, 19 TI DSP third parties have started development to support the 'C6701 product.

Availability

Sampling of the 'C6701 floating-point DSP is planned for the second half of 1998. Volume production is planned for the first half of 1999. Once in volume, the device will be available in a 352-pin ball grid array (BGA), with pricing planned at $196 (U.S.) each in quantities of 25,000. Military versions are planned in a 429-pin ceramic BGA.

The 'C62x EVM costs $995 (U.S.). Customers who purchase it now through Oct. 15, 1998, will receive a free set of 'C6000 code generation tools valued at $1,495 (U.S.). A floating-point version of the EVM is scheduled to be available in the second half of 1998.

The TMS320C6201 fixed-point DSP, now in volume production, is packaged in a 352-pin BGA.

The TMS320C6000 Release 2.00 toolset is available and being shipped to registered 'C62x and 'C67x customers.

All products are available from TI and authorized distributors. ■

VelociTI is a trademark of Texas Instruments.

➔ **For complete information, order: 'C67x Product Bulletin (SPRT158) and the 'C62x EVM Product Bulletin (SPRT159). See page 8.**

NETWORKING

The faster track

DSP-based ADSL products to provide quicker access to the Internet

A new family of asymmetric digital subscriber line (ADSL) chipsets now available from Texas Instruments will help meet the demand for faster Internet access.

The ADSL products, designed to offer home and business users high-speed Internet access 100 times the performance of today's analog modem technology, are the leading industry solutions that deliver the performance and programmability necessary to support evolutionary versions of DSL. They will give consumers the flexibility to upgrade their modems to the new DSL technology by simply downloading new software.

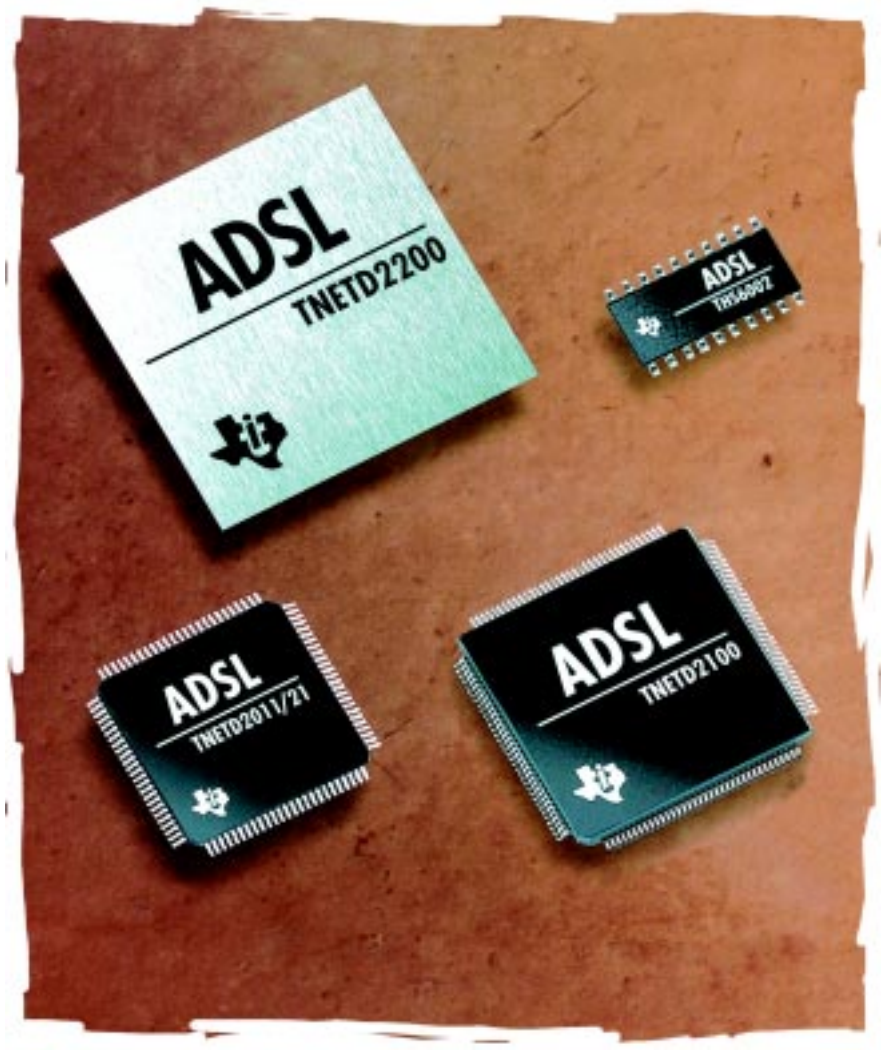
The product family includes three chipsets that leverage a fully programmable DSP ADSL transceiver. The TNETD2000P and TNETD2000R client-side solutions and TNETD2000C central office chipset each includes the ADSL transceiver based on the powerful, industry-leading TMS320C6x DSP core, a digital interface, codec and line driver. The chipsets provide DSP solutions for both ends of the Internet access local loop, and they can execute the fast and extremely complex calculations required for high-speed DSL because they are based on TI's DSP core technology.

Suitable applications

The ADSL products are suited for use in new, high-speed PC modems and service provider equipment such as digital subscriber line access mutiplexers (DSLAMs), digital loop carriers (DLCs) and central office cards. They also are compliant with American National Standards Institute (ANSI) TI.413 Issue 2 and support up to 8 megabits per second (Mbps) rates for downstream communications and 800 kilobits per second (Kbps) rates for upstream communications. The TNETD2000C central office side chipset is the only solution that can support multiple lines via the ADSL transceiver.

With these new products, end-equipment manufacturers can now quickly deliver low-cost, high-performance ADSL modems to the consumer market. Service providers can deploy ADSL services rapidly and cost-effectively for a competitive advantage. Programmability, a key benefit provided for both client-side and central office solutions, addresses evolving versions of DSL that will target residential applications of discrete multi-tone based (DMT)-based ADSL such as splitterless technology. This is especially important since splitterless is a version of DSL with the potential to reduce installation costs and accelerate market acceptance.

DSP programmability will also create a time-to-market advantage for TI's customers while its flexible architecture will enable faster development of new, tailored solutions for specific market segments. Also, the scalability of the architecture allows modem designs to support bit rates less than 1 Mbps and up to 8 Mbps so manufacturers can address both consumer and business markets.



TNETD2000R/ TNETD2000P

➔ Designed for use in client-side modems, the TNETD2000R chipset provides the core solution for both external and network termination box modems. The TNETD2000P delivers the industry's most comprehensive solution for internal peripheral component interconnect (PCI) adapter cards. The '2000P chipset includes an asynchronous transfer mode (ATM) host interface controller and robust Microsoft Windows drivers. Complete adapter card production reference designs based on the '2000P also will be offered. These designs will help PC and modem vendors bring their products to market faster.

TNETD2000C

➔ The first and only chipset on the market to support multiple ADSL lines via a single transceiver, the TNETD2000C ADSL chipset addresses critical central office design concerns. The chipset's multi-line architecture increases port densities, lowers power consumption and reduces cost-per-line. Capable of supporting two full-rate ADSL modems, the '2000C is also standards-compliant, assuring telecommunications manufacturers that their designs will be fully compatible with complementary ADSL equipment. As these standards evolve, the programmability of the TNETD2000C chipset ensures that the designs will stay both standard-compliant and interoperable.

Technology and expertise

All three ADSL chipsets combine TI's TMS320C6x core, the world's fastest DSP, and precision mixed-signal components with DMT echo cancellation technology from Amati Communications. Recently acquired by TI, Amati has been the pioneer and leading ADSL developer as well as a significant contributor to ANSI and International Telecommunications Union (ITU) standards.

Collectively, TI now holds elected positions in the TI.413 Issue 2 standards body, G.DMT and European Telecommunications Standards Institute (ETSI). TI also will leverage the field trials in the United States, Canada, Europe and Asia started by Amati in 1995. Additionally, TI is a core technology provider to the Universal ADSL Working Group (UAWG), a consortium organized by Microsoft, Intel and Compaq to promote interoperability of DSL consumer products.

Availability

TI's ADSL chipsets are available now in sample quantities. Evaluation kits are expected to be available in the second quarter of 1998 while volume production and TNETD2000P reference designs are planned for the third quarter. ■

TNETD2000C	$95
TNETD2000P	$76
TNETD2000R	$65

Suggested resale pricing in U.S. dollars in 25K quantity.

➔ **For complete information, order: Product Bulletin — ADSL Client Modem Solution for the PC (SPAT006), Product Bulletin — ADSL Modem Solution for Central Office(SPAT007) and DSL Image Brochure (SPAT005). See page 8.**

Industry leaders to conduct ADSL interoperability testing

Alcatel, Analog Devices and Texas Instruments plan interoperability testing among their asymmetric digital subscriber line (ADSL) silicon solutions. This initiative will accelerate ADSL service deployment worldwide by creating an open market place for equipment manufacturers through multiple sources of standards-based silicon that work together across silicon platforms.

As a result of this effort, service providers will be able to deploy with confidence central office equipment that will interoperate with a variety of customer premises equipment. Customers will benefit because they can make purchasing decisions on equipment and services without worrying about the type of equipment used in the telephone network.

The interoperability project will allow the three silicon vendors to validate interoperability based on discrete multi-tone (DMT) at the physical layer and will concentrate on link and network layer interoperability based on asynchronous transfer mode (ATM) transport.

This initiative is based on the American National Standards Institute (ANSI) standard T1.413 Issue 2 status as of the March meeting of ANSI. The joint testing will create more momentum to ensure that a wide range of equipment — both central office and customer premise equipment — will interoperate.

The three companies will conduct interoperability testing independently and will migrate, when interoperability is proven, to a neutral testing facility where DMT vendors can do interoperability testing with their equipment. ■

ON THE WEB

Order more information about products in *Integration* through our site on the World Wide Web. Check it out at www.ti.com/sc/9805

Resource Guide

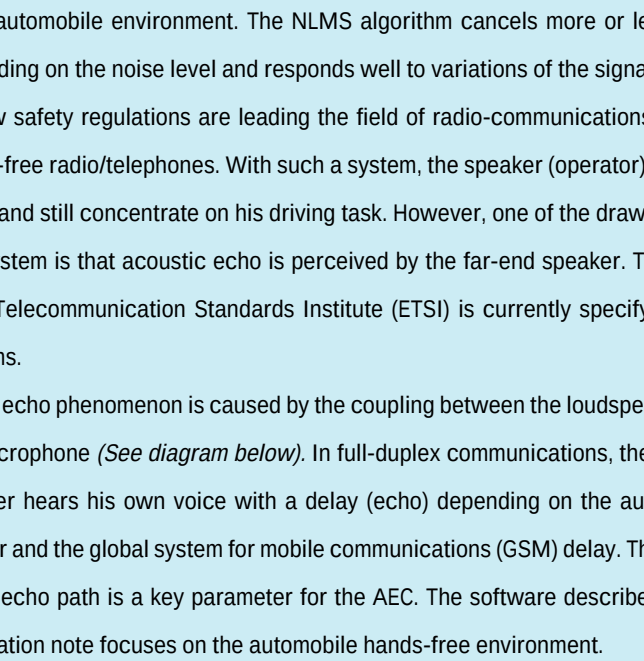
APP REPORT

■ Acoustic-echo cancellation software for hands-free wireless systems: This note describes the DSP implementation of a full-duplex acoustic-echo cancellation (AEC) software. This software is based on the normalized least mean square (NLMS) algorithm. The algorithm includes active-channel and double-talk detection. This software was implemented on a TMS320C54x digital signal processor (DSP) in assembly language. It requires few resources in terms of million instructions per second (MIPS), random-access memory (RAM) and read-only memory (ROM). AEC achieves 30 dB of attenuation in an automobile environment. The NLMS algorithm cancels more or less echo depending on the noise level and responds well to variations of the signal level.

New safety regulations are leading the field of radio-communications toward hands-free radio/telephones. With such a system, the speaker (operator) can talk freely and still concentrate on his driving task. However, one of the drawbacks of this system is that acoustic echo is perceived by the far-end speaker. The European Telecommunication Standards Institute (ETSI) is currently specifying AEC systems.

The echo phenomenon is caused by the coupling between the loudspeaker and the microphone *(See diagram below).* In full-duplex communications, the far-end speaker hears his own voice with a delay (echo) depending on the automobile interior and the global system for mobile communications (GSM) delay. The length of the echo path is a key parameter for the AEC. The software described in this application note focuses on the automobile hands-free environment.

Adaptive filtering (and more precisely, the NLMS algorithm) is one of the most common solutions to the problems of AEC. The NLMS algorithm offers a good trade-off between computational load and performances. Other problems with AEC are double-talk (DT) conditions, where both operators are speaking at the same time. If not detected, DT can cause divergence of the adaptive algorithm. The AEC software utilizes the NLMS algorithm to cancel the echo and is implemented in 'C54x DSP assembler. ■



Overview of an AEC system

The system includes the AEC software implemented on a TMS320C54x DSP, a loudspeaker and a microphone.

➔ **For complete information, order: Application Report (SPRA162).**
See Page 8.

THIRD-PARTY NEWS

CD-ROM and Internet provide easier access to DSP information

To get the latest information from TI's third-party network, all you need is your computer.

The TI DSP Third-Party Application Software & Development Guide is now available on CD-ROM, and an online resource guide is also available through the Internet.

The CD contains hardware and software development support information from the most extensive third-party network in the industry. It's a comprehensive, fully searchable collection of DSP information, including technical data sheets, directories of third-party software and developer resources, training documents and newsletter and magazine archives.

The online resource guide allows you to search for products in two ways: by using keywords, product category and company names and by browsing listings with complete product summary tables.

For more information about the third-party online resource guide or how to receive your free CD-ROM, please visit www.ti.com/sc/dsp_3pguide. ■

➔ **For complete information, order: Third-Party Guide CD-ROM (SPRC013A).**
See page 8.

SUPPORT FROM PIC

To maintain and increase its level of commitment to customers, TI's Semiconductor Product Information Center (SCPIC) delivers efficient, cost-effective technical and non-technical assistance. The SCPIC was established in 1991 to supplement TI's sales force by providing product information, first-level application support, literature and sample fulfillment services.

TI SCG Home Page	www.ti.com/sc
TI Distributors	www.ti.com/sc/docs/distmenu.htm

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News Briefs

Audio amplifiers

A new single-chip audio solution for stereo systems and two low-voltage, low-power audio amplifiers are the latest additions to TI's analog technology portfolio. The devices have been designated the TPA0202, TPA301 and TPA311, respectively.

The TPA0202 is the first 2-W stereo audio amp to feature integrated depop circuitry for applications with low-impedance speakers such as desktop and notebook computers, portable multimedia systems and speakerphones. The device is capable of delivering 2 watts of continuous average power to each of two 3-ohm speakers in a 5-V system and 800 mW in a 3-V system. Ultra-low distortion, measuring less than 0.05 percent THD+N at 2 watts and into 3-ohm loads, guarantees clear, crisp sound. An integrated switch configures the amp to operate in single-ended (SE) mode for headphones or in bridge-tied load (BTL) mode for speakers, reducing device count, board space and system cost.

The TPA301 and TPA311 are designed for applications such as cellular phones and personal communications systems (PCS), voice pagers, personal digital assistants (PDAs), battery-powered toys and point-of-sale (POS) terminals. Each device is fully specified for 3.3- and 5-V operation, and each is capable of delivering 250 mW to an 8-ohm speaker from a 3.3-V power supply or 350 mW from a 5-V supply. The TPA301 is streamlined for BTL operation only. The TPA311 features depop and an integrated SE/BTL switch for products that use both speakers and headphones.

The TPA0202, TPA301 and TPA311 are available now from TI. ■

TPA0202PWPR	24-pin TSSOP PowerPAD™	$2.83
TPA301D	8-pin SOIC	$0.67
TPA311D	8-pin SOIC	$0.85

Suggested resale pricing in U.S. dollars in 1K quantity. PowerPAD is a trademark of Texas Instruments.

➔ **For complete information, order: TPA0202 Data Sheet (SL0S205), TPA301 Data Sheet (SLOS208) and TPA311 Data Sheet (SLOS207). See Page 8.**

TPA0202 features

- Depop circuitry eliminates speaker noise
- Integrated switch configures amp to SE or BTL mode
- Ultra-low distortion guarantees clear sound
- Stereo multiplexer can switch amplifier inputs between two sets of pins

TPA301/TPA311 features

- Fully specified for 3.3-V and 5-V operation
- Offers harmonic distortion of less than one percent
- Shutdown mode reduces power consumption (TPA301)
- Provides integrated depop circuitry (TPA311)

Dual line driver/receiver

TI's new THS6002 dual line driver/receiver provides the high-output current often needed to drive data over standard telephone lines with extremely low signal distortion.

This 200-MHz device can be used to design a wide range of communications systems, but it is particularly well suited to asymmetrical digital subscriber line (ADSL) applications, including central office switches and multiplexers. It is part of TI's newly introduced ADSL chipset *(See article on page 4),* which features an advanced programmable DSP, digital interface and analog front end.

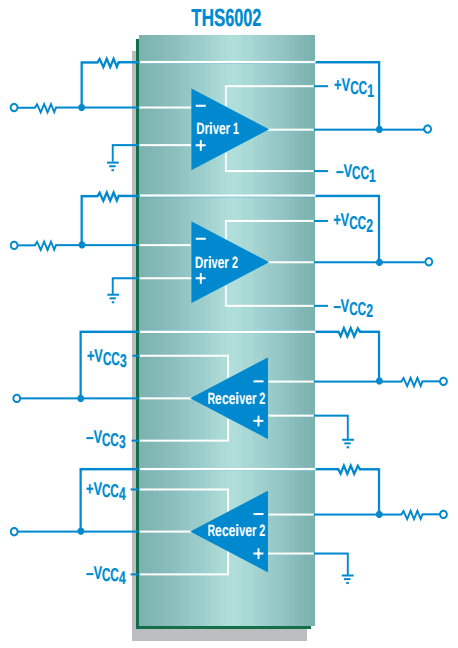
The new line driver/receiver features four amplifiers — two designed to perform the task of line drivers, while the other two feature the performance characteristics of receivers. All four amplifiers carry a slew rate of 1,000 volts per microsecond, assuring very low levels of total harmonic distortion (THD). A high slew rate minimizes distortion by allowing the output of a line driver/receiver to follow more closely the rise and fall of the input signal. The THS6002's output drive of more than 400 milli-amps is ideal for driving low-impedance lines the two to three miles required by the telephone network's local loop.

The THS6002 is expected to be available during the first half of 1998 from TI and authorized distributors. ■

THS6002	20-pin SOIC PowerPAD™	$5.67

Suggested resale pricing in U.S. dollars in 1K quantity. PowerPAD is a trademark of Texas Instruments.

➔ **For complete information, order: Data Sheet (SLOS202B). See Page 8.**



Motor control devices offer enhanced functionality, lower cost

TI's TPIC43T01 is a monolithic device designed to provide precision RPM control to a three-phase DC brushless motor. The controller is the industry's first to feature an EEPROM programmable digital filter providing increased flexibility and minimized design efforts.

The TPIC43T01's gate drive outputs are designed to drive six external discrete N-channel power FETs or an integrated driver such as the new Power+ Arrays™ TPIC1310. As a chipset, the TPIC43T01 and TPIC1310 offer enhanced functionality and lower cost, which makes it an attractive solution for high-performance motor control applications. The chipset is well suited for other applications such as printers, copiers, fax machines, scanners, plotters, fans and robotics.

In addition, TI provides a PC-based Windows™ compatible software package to input the motor and system characteristics and select the digital filter coefficients to stabilize the system. The software program outputs control parameters to a JEDEC compatible file to program the TPIC43T01 through a third-party device programmer.

The TPIC43T01 provides a variable reluctance speed sensor interface and a Hall-effect position interface. The speed interface receives an external sinusoidal signal and converts it to a digital speed input for lock detect. The control circuit's core is a hardware implementation of a digital signal processing algorithm consisting of a digital integrator and filter. User programmable filter coefficients set compensation pole and zero to stabilize the system response. Programmable parameters are stored in an internal EEPROM.

The TPIC1310 is a monolithic gate-protected power DMOS array that consists of six electrically isolated N-channel enhancement-mode DMOS transistors configured as a three-half H-bridge. When used with the TPIC43T01 controller, the TPIC1310 gives the customer the ability to optimize the current switching capability of the output stage. ■

TPIC43T01	38-pin TSOP surface mount	$2.08
TPIC1310	15-pin through-hole PowerFLEX™	$1.98
	15-pin surface mount PowerFLEX	$1.98

Suggested resale pricing in U.S. dollars in 1K quantity. Power+ Arrays and PowerFLEX are trademarks of Texas Instruments. Windows is a trademark of Microsoft Corp.

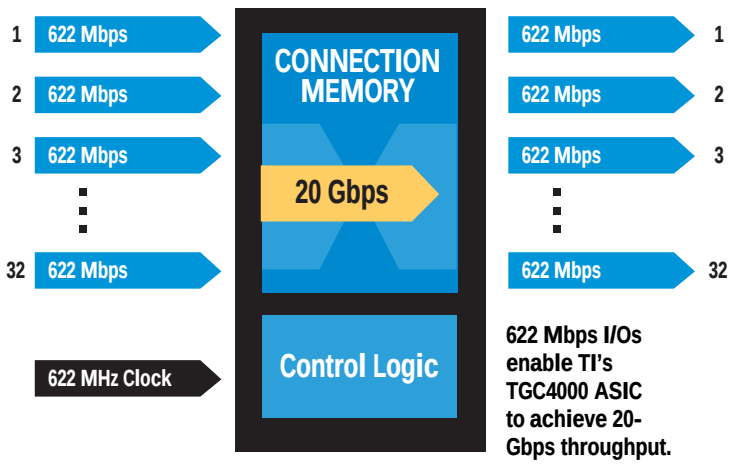
➔ **For complete information, order: Data Sheets (SLIS081 and SLIS071). See Page 8.**

TPIC43T01 features/benefits

- **Digital control:**
  - — One main feedback loop to simplify design of phase-lock-loop response
  - — No external control loop compensation components to reduce parts count
  - — PWM power conversion for high efficiency
- **User programmable:**
  - — Frequency divide by select to set motor target RPM
  - — External speed control input for real-time select of fast/slow RPM
  - — Improved precision allowing lower-tolerance external discrete components to reduce cost
- **On-board functions and protection for enhanced performance and improved reliability:**
  - — Under-voltage lockout protection
  - — Power-up clear
  - — Shutdown logic
  - — Charge pump

TPIC1310 features/benefits

- Low rDS(on) of 0.25 ohms for minimized power dissipation
- 30-V capability for extended voltage operation
- 3-A continuous current for increased motor drive
- Input transient and ESD protection for increased reliability



622 Mbps I/Os enable TI's TGC4000 ASIC to achieve 20-Gbps throughput.

20-Gbps throughput ASIC

Texas Instruments is shipping in volume a CMOS application specific integrated circuit (ASIC) that uses multiple 622 Mbps interfaces and achieves 20-Gbps bandwidth. The TGC4000 ASIC device replaces expensive BiCMOS chips and is working in production telecommunications equipment. It allows designers of high-speed telecommunications and networking systems to reduce overall system cost, size and power consumption.

The 20-Gbps throughput is achieved with 64 signals (32 inputs and 32 outputs), each communicating at a speed of 622 Mbps. The 0.35-micron gate array design contains 1.4 million transistors and forms the heart of an OC-192 public telecommunications system.

The key to the device's throughput capability lies in a high-performance current mode logic (CML) interface designed to operate at more than 850 Mbps. This technology also supports other high-speed interfaces, including 850 Mbps emitter coupled logic (ECL) type and 622 Mbps low voltage differential swing (LVDS). Supporting functions such as clock recovery and bit phase aligners are also available.

Integrating these high-performance interfaces eliminates the need for power-hungry and expensive gallium arsenide (GaAs), Bipolar or BiCMOS devices that historically have been required for high-speed interface applications. This integration capability also simplifies board design, resulting in significantly reduced system development costs.

First-pass design success was achieved with the device, and the well-established 0.35 micron process made the TGC4000 a very cost-effective solution.

TI offers even higher performance in its latest 0.18 micron TGC6000 ASIC. Interfaces capable of speeds up to 2.5 Gbps will be supported. Power consumption also will drop at least 70 percent in the core, leading to chip power dissipation savings of greater than 50 percent. The smaller size, higher speed and lower power of TI's 0.18 micron technology will save system costs by further reducing the number of chips required in a system.

TI is offering designers a TGC4000 test chip and test board to evaluate high-speed interfaces and macros in their system designs. TI has accepted design engagements and is executing designs using the TGC6000 technology. ■

➔ **For complete information, see: www.ti.com/sc/9805.**

Stereo audio codec

A new stereo audio codec providing higher-quality audio and reduced power is now available from Texas Instruments. The TLC320AD90 is fully compliant with the Audio Codec (AC) '97 specification, providing PC motherboard and add-in card vendors an audio solution that exceeds the parameters affecting true audio quality.

The device, which also provides an integrated 600-ohm power amplifier not specified in the standard, is well-suited for applications such as video and audio conferencing, musical instruments and high-end video cards.

The 'AD90 provides CD-quality conversion, analog mixers, volume control and has a pseudo-differential CD input to offer improved CD-ROM analog performance. Additional features include a 5-V or 3.3-V digital interface, allowing the device to interface to 5-V or 3.3-V controllers, and a power-down mode to conserve power.

The TLC320AD90 is now available from TI and authorized distributors. ■

TLC320AD90	64-pin TQFP	$4.31

Suggested resale pricing in U.S. dollars in 1K quantity.

➔ **For complete information, order: Product Bulletin (SLAT089). See page 8.**

GET YOUR COPY

The SC Package Outlines Reference Guide

The 1998 Texas Instruments Semiconductor Package Outlines Reference Guide is now available. The guide contains outline drawings and information for packages currently offered by TI. To get your free copy, order: TI Semiconductor Package Outlines Reference Guide (SSYU001D).

See page 8.

BUSINESS NEWS

TI ships 10 millionth DSP to Maxtor

Texas Instruments has shipped its 10 millionth customizable Digital Signal Processor (cDSP) to Maxtor Corp, which develops, manufactures and markets high-performance information storage products for desktop computer systems.

The two companies have worked together since 1994 to develop DSP architectures, resulting in significantly reduced IC component counts and improvements in the quality, reliability and cost-effectiveness of Maxtor's storage products. All Maxtor products introduced since late 1996 have shipped with TI cDSPs, and Maxtor is TI's fastest-growing DSP Solutions customer.

TI's Storage Products provides advanced semiconductors for high-performance, desktop and mobile hard disk drives and removable drives. Its industry-leading read channels and DSP solutions are complemented by its servo/spindle, interface, preamp and ASIC solutions. These solutions are designed and manufactured for hard disk drives, tape drives, high-density floppy disk drives, optical disk drives and digital video disk products.

Maxtor is a subsidiary of Hyundai Electronics America with headquarters in Milpitas, Calif. ■

TI acquires Spectron Microsystems

Texas Instruments has acquired Spectron Microsystems, a Santa Barbara, Calif.-based software development company specializing in real-time operating systems (RTOS) and software products that ease digital signal processing (DSP) development and eliminate some low-level programming tasks.

The acquisition further enhances TI's extensive offering of DSP Solutions, enabling its customers to shorten their time-to-market and to focus on features that differentiate their products. TI will extend its leadership in DSP Solutions by providing the most complete development environment, simplifying DSP development and making its DSP Solutions even more attractive for a broad range of fast-growing markets.

Two key software development products include SPOX™ and BIOSuite™. SPOX is an RTOS for DSP applications. BIOSuite products provide implementations of the TI DSP/BIOS open software application programming interface (API) standard. The DSP/BIOS API defines a common set of function calls that improves overall code quality and shortens development time.

Spectron, formed in 1987, had been a wholly owned subsidiary of Dialogic Corp. since 1995. Now it has become TI-Santa Barbara. ■

SPOX and BIOSuite are trademarks of Texas Instruments.

IDT and TI to serve as alternate sources for 3.3-V logic families

Texas Instruments and Integrated Device Technology Inc., leading suppliers of high-performance bus interface CMOS logic, will serve as alternate sources for two 3.3-V 16/18/20-bit logic interface families. These include TI's and IDT's low voltage CMOS (LVC/LVCH) and advanced low voltage CMOS (ALVC/ALVCH) logic families.

Both LVC and ALVC products from TI and IDT have the same pin definitions, perform the same logic functions and have identical electrical specifications. The companies will work together to define and standardize new products, functions and families.

The LVC family is a 5-V tolerant, 3.3-V family with functions boasting a maximum propagation delay of 6.5ns. The ALVC family is a 3.3-V family designed for optimized speeds. Members of this family boast a 3.0ns maximum propagation delay.

Both families offer multiple functions, including buffers, registers, latches and transceivers, with a variety of input and output configurations. The products are specified for 3.3-V and 2.7-V operation and function in an industrial temperature range of -40 C to +85 C.

LVC and ALVC products from IDT and TI are currently available. ■

➔ **For complete information, order: Sample Pack (SCAP079). See page 8.**