Practical solutions for DSP system developers

Embedded Edge

June 2001

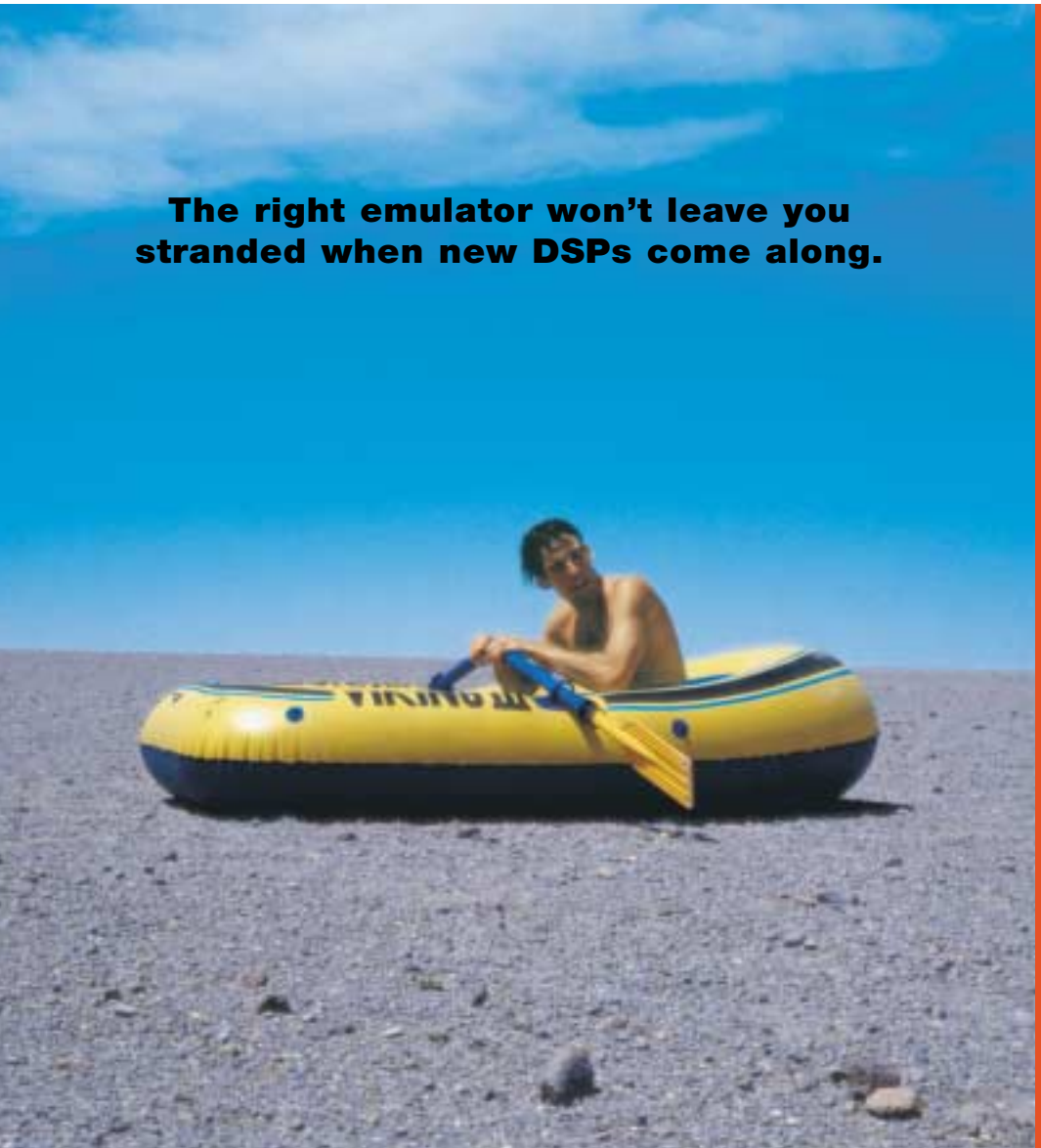
Software Radio Tunes Modem Parameters

Optimizing Soft Modems

New Tools Speed the Development of Multi-DSP Applications

SPRN154

The right emulator won't leave you stranded when new DSPs come along.



flexds With new TMS320 DSPs coming out with dizzying regularity, you need a development platform that stays up-to-date. Only the ultra-flexible FleXDS from DSP Research lets you keep up with Texas Instruments! FleXDS is a new breed of emulator – a reconfigurable platform that expands to become a complete hardware and software development system and a powerful test bed for your TMS320 applications. No one has more experience with TI DSP development than DSP Research. So when TI puts you to the test with a new DSP, look to FleXDS for answers! DSPR

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◆ Mark Mattson, Texas Instruments marketing manager

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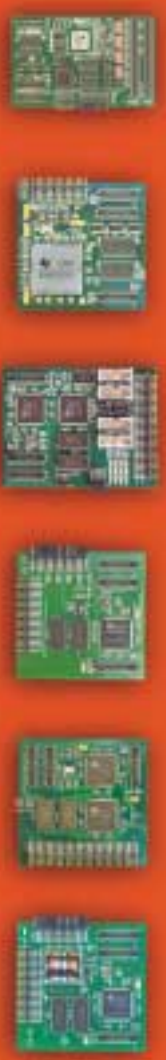

Key FleXDS Features:

- PCI-based in-circuit emulator
- JTAG POD with detachable cable and diagnostic LEDs
- DSP and I/O Expansion modules for TI's C6000, C5000 and more
- More than 15 modules available
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The Power of Cheese

We've all seen the commercial: A precocious waif leaves a plate of cheese for Santa instead of milk and cookies, and lo and behold, Santa leaves behind a roomful of luxury goods, ranging from top-line cars to high-tech electronics. The commercial concludes with the punch line rolling across the screen: "Behold the power of cheese."

Clever, the American Dairy Associations. Too bad the semiconductor industry doesn't have the equivalent to similarly promote DSPs, for the power of DSP capabilities can produce equally startling wonders.

Take modems for wireless Internet devices—a technical challenge if there ever was one. But base wireless functions on digital signal processing and all of the advantages of the digital domain accrue, and new algorithms eager to exploit those advantages are appearing.

Basically, the design challenge is to achieve robust communications at high data rates—10 to 100 Mb/s wouldn't be unusual—and decent spectral efficiency. Naturally, minimal setup time, low maintenance, and a competitive price go along, and provision for emerging frequency bands.

Those goals are achievable, says Andrew Bateman, the author of our cover story. Indeed, the power of modern DSP devices and software can comfortably embrace source and channel coding, pulse shaping, modulation, demodulation, quadrature frequency translation, power amplifier linearization, receiver dynamic range extension, calibration of the in-phase and quadrature signal components, automatic power and frequency control, and direct digital synthesis. Unfortunately, there isn't enough room inside to focus on everything, but you'll get a good idea of how DSPs and software can be tapped for pulse shaping, demodulation, and PA linearization.

Are you more interested in using C-coded reference modems? Want to stuff as many as possible onto a single chip without assembly coding? Ah, the power of Code Composer Studio's optimizing compiler for DSP platforms, especially when it's tickled to up the density. How dense? According to Commetrex, which went through the optimizing process, C-baseline modems can soar from 6 per 200-MHz DSP chip to 28 in four short project phases. Need even more? A fifth phase can take the number of channels to 48 per DSP. Get the details from Ghassan Farah, who shows you exactly how to go about it yourself.

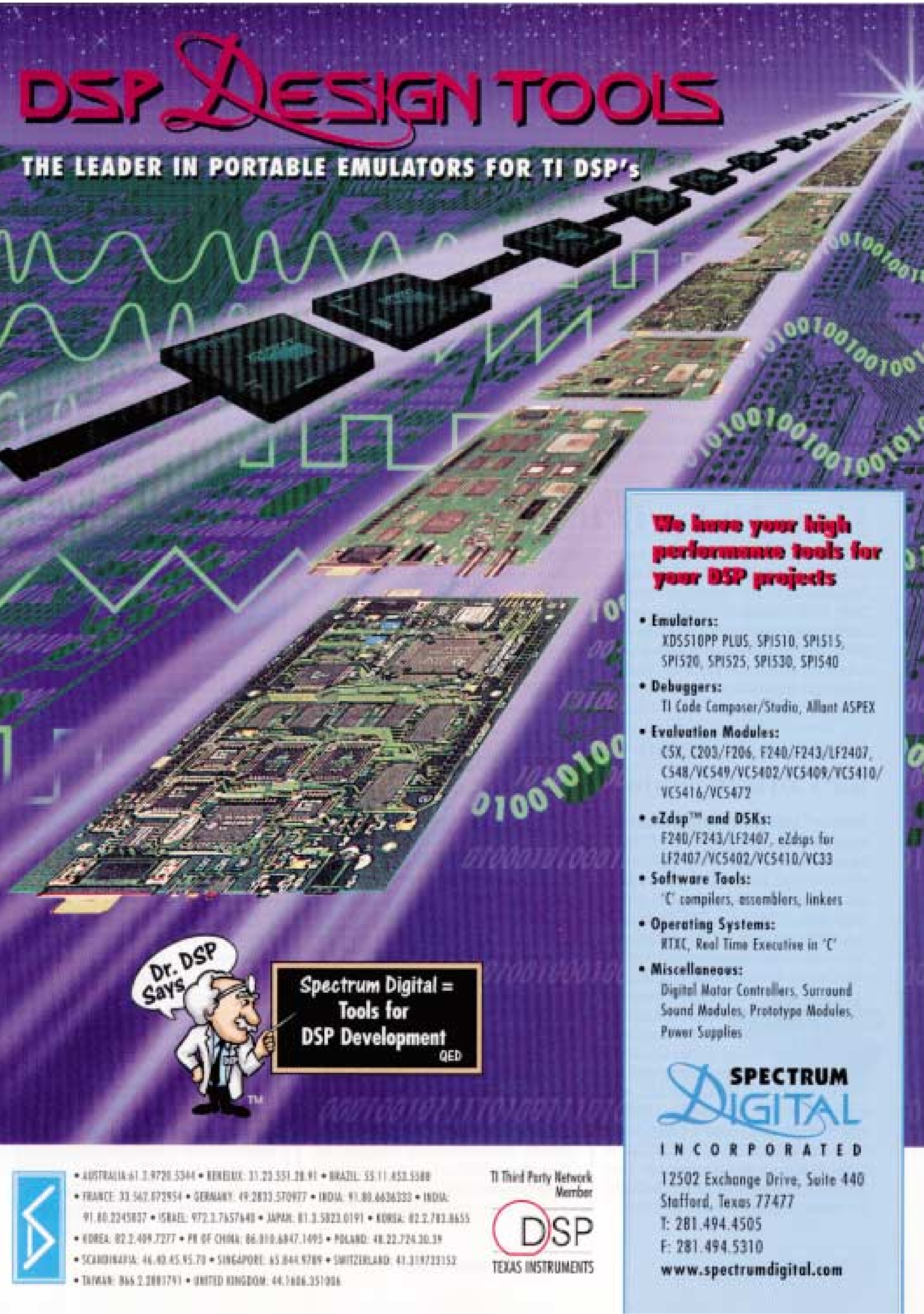
As powerful as DSP chips are, bring them together and stand back—your application is liable to take off on you. OK, not quite, but new software tools—frameworks—for multiprocessor DSP systems promise much faster development of application software, plus a slew of other benefits.

Each one has its own claim to fame, but generally the tools are aimed at sorting out some common challenges with multiprocessors—partitioning of the problem and its data, processor communications and synchronization, simulation, and debugging. Fiona Culloch, from 3L, describes the two types of frameworks—ones based on writing C code and graphical development environments, with examples, and details how the former work.

While you're beefing up your DSP muscle, you could deploy a software-based statistical real-time profiler to dramatically boost the performance of your application even more. According to Konstantin Merkher and Jacob Bridger, of Surf Communication Solutions, optimizing code to boost performance is one of the greatest challenges in writing real-time DSP code. But if you write a real-time profiler, you can do it—to the tune of several orders of magnitude. Learn how inside.

More power to DSPs!

—Stan Runyon
testman2@earthlink.net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eXpressDSP Compliance for Sound, Speech Techs

WOW audio enhancement technology from SRS Labs, Inc. (Santa Ana, Calif.; www.srslabs.com) has passed eXpressDSP compliance testing on the TMS320C54x and TMS320C55x DSPs. The technology, which is embedded in Microsoft's Windows Media Player 7, improves the dynamics and bass performance of stereo audio played through small speakers and headphones. The announcement follows a similar one regarding SRS Labs' Voice Intelligibility Processor (VIP) technology, which raises the quality and intelligibility of speech in voice communications equipment and speech synthesis equipment, such as conventional and cellular phones, VoIP devices, headsets, and digital radios. VIP's small footprint fits easily on top of existing voice coder or processor applications.

Linux kit for TI DSPs debuts

RidgeRun, Inc. (Boise, Idaho; www.ridgerun.-com) has unveiled the DSPLinux Software Development Kit (SDK) for the OMAP1510 and TMS320DSC21 processors from Texas Instruments, which combine an ARM7 or ARM9 core with the TMS320C5000 DSP platform. Now available in beta, the kit includes a 2.4 version of the Linux operating system optimized for embedded devices, standard GNU development tools, and the Desktop Simulation Environment.

Mentor, TI Team for Coverification

Mentor Graphics Corp. (Wilsonville, Ore.; www.mentor.com) and Texas Instruments, Inc. (Dallas, Texas; www.ti.com) have agreed to deliver coverification Processor Support Packages (PSPs) for TI's DSPs and microcontrollers. The PSPs are based on TI's present instruction set simulators and connect to Mentor Graphics' Seamless Co-Verification Environment through an adapter layer. PSPs included in the agreement model the TMS320C27x, C54x, C55x, and C2000 DSPs, as well as the ARM925 microcontroller core. They work with all popular logic simulation platforms and are compatible with Mentor's library of PSPs offered by for use in multiprocessor systems.

Blue Wave Systems to Join Motorola's Computer Group

Blue Wave Systems (Carrollton, Texas; www.bluews.com), a long-standing TI DSP Third Party Network member, and Motorola, Inc. (Schaumburg, Ill.; www.motorola.com) have signed a definitive merger agreement in which Blue Wave will join the telecommunications business of Motorola's Computer Group (Tempe, Ariz.; www.motorola.com/computer).

Best known for its ComStruct software environment, which includes the use of DSP/BIOS as well as integrated eXpressDSP-compliant algorithms, Blue Wave will continue its operations in Carrollton and Loughborough, U.K.

I-Logix Plots Software Component Strategy

I-Logix, Inc. (Andover, Mass., www.ilogix.com) has rolled out a three-phase plan to build a comprehensive development platform for writing and reusing seamless, component-based embedded software. The strategy, which will unfold during the course of the year, will let developers snap existing software components into their designs, similar to the way that IP building blocks are assembled to construct systems on chip and other ICs.

The first phase, available now in Rhapsody 3.0, lets developers "componentize" and reuse legacy software modules that can be viewed within the UML graphical model. The second phase will equip Rhapsody with an intuitive visual metaphor for assembling model-based executable code components into embedded real-time applications.

In the third phase, the company will provide a Web-based structure to organize and catalogue software components, encouraging the exchange of design information. As part of the plan, I-Logix will also integrate iNOTION product life-cycle technology into its existing products. The technology, acquired in March from KLA-Tencor (San Jose, Calif.; www.kla-tencor.com), will let embedded development teams store, support, and maintain design components in a central repository.

More Breakpoints on page 33

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PRODUCT TRIALS ONLINE

MATLAB and Code Composer Studio.

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- Data transfer
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The leaders in DSP development now work together. With the new Developer's Kit for Texas Instruments DSP from The MathWorks, you can execute Code Composer Studio™ functions in MATLAB to interactively debug applications, analyze real-time data, and automate testing on TI DSPs. And you can streamline implementation by generating real-time prototypes and Code Composer Studio projects from Simulink.

The Developer's Kit for TI DSP works with C5000™ and C6000™ platforms.

Demos, tutorials, and trials are available online.

See the fastest way to develop, test, verify, and implement DSP software. Visit www.mathworks.com/eme.

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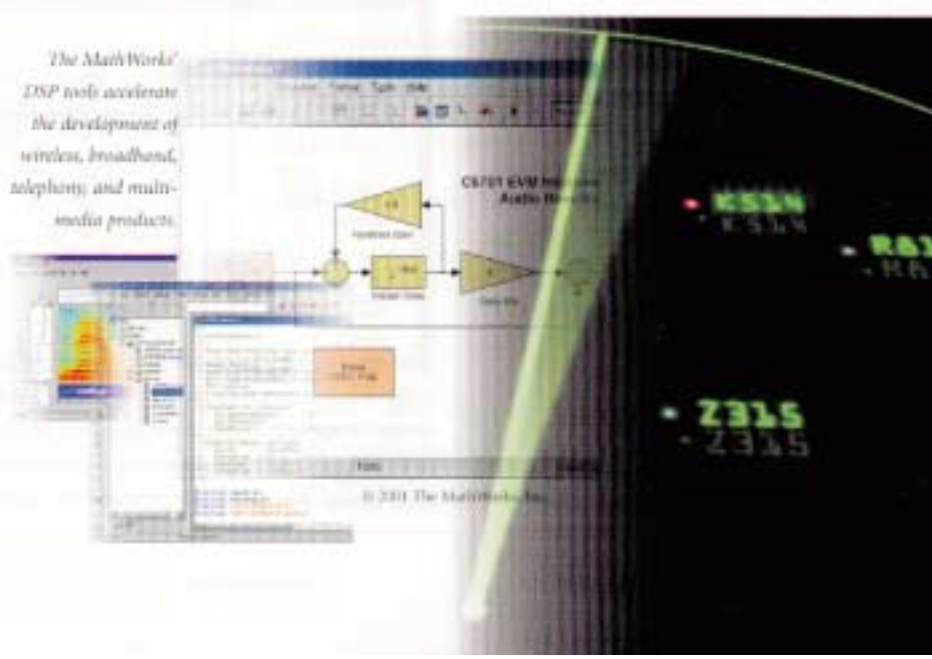

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Continued from page 6

DSP Helps Kodak With Upgradable Product

A TMS320DSC21 DSP from Texas Instruments, Inc. (Dallas, Texas; www.ti.com) sits at the heart of Kodak's mc3, a multifunction consumer imaging and audio product that captures video, still images, and audio. The chip lets Kodak customers upgrade the product, via software downloads from the Web, with the latest audio and video compression formats. The mc3 can record video at 20 frames/s for the highest resolution or 10 frames/s for virtually unlimited recording to removable memory cards. It also captures still color images having VGA resolution and can store up to 90 minutes of MP3 music on a 64-MB CompactFlash memory card.

TI Launches On-line DSP Newsletter

Texas Instruments, Inc. (Dallas, Texas; www.ti.com) has started an on-line monthly newsletter called e-Tech Innovations, Digital Signal Processing Edition. Readers can subscribe at www.ti.com/sc/docs/dsps/etechdsp.htm for an easy way to keep informed of the latest DSP news and trends from TI.

PCTEL and Groupe SAGEM Collaborate

PCTEL, Inc. (Milpitas, Calif.; www.pctel.com) has formed a strategic alliance with Groupe SAGEM (Paris, www.sagem.com), France's second-largest telecommunications equipment maker. The aim of the deal is to develop a reference design for use in digital TV set-top boxes. The design will feature PCTEL's Solsis embedded modem for accessing the Internet and include the TMS320C5000 DSP platform. The set-top boxes will be sold or licensed to European television service providers, like France's Canal+, which will then sell or rent them to customers.

Experts Answer Your Questions

Using Code Composer, can I debug a target board containing two DSPs of different platforms in a single JTAG scan path?

In this case, you'll need to launch two separate instances of Code Composer to support each of the DSP platforms. Two separate directories should be created for Code Composer files; the set-up utility will need to be run in each of these directories, and the DSP not being targeted in one instance of Code Composer should be bypassed. Do the same for the remaining DSP. Bypassing DSPs and scan chain devices is discussed in Chapter 1, "Setting Up Code Composer," of *Code Composer User's Guide.*

Should I use the interrupt keyword when implementing an interrupt service routine in a DSP/BIOS application?

You can't use the C compiler's interrupt keyword in DSP/BIOS programs. DSP/BIOS interrupt routines must be written in assembly language and must use the HWI_enter and HWI_exit macros. The C6000 version of DSP/BIOS has an interrupt dispatcher that allows you to write interrupt routines in C. You can also write a C interrupt service routine by making a small .asm file that includes just HWI_enter, call cfxn, and HWI_exit.

Can I define my own linker command (.cmd) file instead of one created by the DSP/BIOS configuration tool?

Since the Code Composer Studio build tool allows only a single linker command file per project, the best approach is to list the DSP/BIOS linker command file at the top of the user-defined linker command file. To list the DSP/BIOS linker command file in the user defined CMD, add the following line to the top of the file (replacing it with the actual design name):

```
-l yourappcfg.cmd
```

Can DSP/BIOS run on the simulator?

Yes, DSP/BIOS runs on the simulator. The simulators currently do not contain a timer interrupt source, so the clock (CLK) and the periodic function (PRD) are effectively disabled.

What is the relationship between CIO's malloc/free and MEM_alloc and MEM_free?

DSP/BIOS overrides the standard malloc and free functions with calls to MEM_alloc and MEM_free. The segment allocated by malloc is controlled by the segment for malloc()/free() inside the MEM Manager properties.

How much memory does the memory management system require?

As long as no heaps are defined, no memory is used by the MEM Module. If your application requires dynamic memory allocation, a small number of words are required for each heap defined. Beyond that, only memory defined as a heap is required.

How can I control in what memory sections DSP/BIOS objects are placed?

The DSP/BIOS Configuration tool lets you place all the objects in different memory locations declared in the Memory Manager through each manger module.

Can DSP/BIOS run in extended memory on C54x processors?

Yes, the DSP/BIOS Configuration tool allows you to select the appropriate library under Global Setting. DSP/BIOS requires that the bios, .sysinit, and .vect sections be placed on the overlay (OVLY=1) section of memory (0x000000[EN]0x008000). These sections contain wrappers to support extended memory and are expected in the start-up sequence. All other sections and objects can be placed anywhere in memory. For more information on extended memory with DSP/BIOS, go to www.ti.com/sc/docs/apps/dsp/tms320c5000app.html and locate document SPRA599.

High-Density G.726 Vocoder

Available for TMS320C54x and C6000 DSPs, G.726 vocoder software compresses 64-kb/s packet voice data for 40-, 32-, 24-, or 16-kb/s rates. It can implement 20 channels on a C5400 using 5 MIPS and up to 190 channels on a 300-MHz C6203. The vocoder is available in versions that comply with the TMS320 DSP Algorithm Standard or MSP Consortium M.100, as well as on the company's MSP Media Gateway DSP boards. Licensing fees are $20,800 for the object code and $26,000 for limited-use source code. ***Commetrex Corporation,*** Norcross, Ga.; (770) 449-7775, www.commetrex.com

eXpressDSP-Based Library

Version 5 of SigLib, a highly portable ANSI-C source DSP library, touts compatibility with the TMS320 DSP Algorithm Standard. It includes many of the low-level routines used in today's telecommunications algorithms and accommodates many of the fundamental telecom operations found in modems, mobile phones, and other network access devices. It comes with comprehensive examples and documentation and sells for $350. ***Numerix, Ltd.,*** Leicestershire, U.K.; +44 (0)-7050-803996, www.numerix-dsp.com

DSP Development Kit

The Developer's Kit for Texas Instruments Digital Signal Processing combines MATLAB 6 and Simulink 4 with eXpressDSP Real-Time Software Technology to simulate, generate, and validate designs build around TMS320C6000 and C5000 DSPs. Features include MATLAB links for Code Composer Studio and Real-Time Data Exchange and Simulink targets for CCS and the TMS320C6701 EVM. The kit is available for Windows 95, 98, and NT and works with CCS version 1.2. Prices start at $1,000 for an individual PC license. *The* ***MathWorks, Inc.,*** Natick, Mass.; (508) 647-7589, www.mathworks.com

DSP Imaging Evaluation Kit

A tool for building real-time audio and video compression applications, the Imaging Evaluation Kit addresses four phases of development: evaluating available technologies, assessing a DSP platform's suitability for an application, functional prototyping, and bringing redesigned systems to market quickly. A basic version sells for $2,995 and includes a TMS320C6111-based board and drivers, sample algorithms, and Code Composer Studio. Another version, which adds a camera, microphone, and speakers, sells for $6,495. ***A.T.E.M.E.,*** Velizy, France; +33-1-46-01-55-72, www.ateme.com

USB Emulator for TMS320C54x

The SB-USB, a self-powered high-

l emulator, connects to a PC's USB port to debug systems built around one or more TMS320C54x DSPs. Featuring two programmable counter-timers, it occupies a 4- x 2.5-in. circuit board and operates seamlessly with Code Composer Studio. The emulator sells for $3,000 and includes cables, software drivers, and a user manual. Custom versions are available. ***Domain Technologies,*** Plano, Texas; (972) 578-1121, www.

NFO Evaluation Board

An evaluation board that operates with a three-phase induction motor takes advantage of the natural-field-oriented (NFO) control algorithm stored in the flash memory of TMS320LF2406A 40-MIPS DSPs. The algorithm gives accurate, sensorless torque control over a wide speed range. The board can work in a stand-alone mode, with speed or position sensors feeding on-board control loops, or connected to a PC through an optically coupled serial link. Available in July and bundled with a Labview user interface that controls the motor and modifies motor and control parameters, it sells for $500. ***NFO Control AB,*** Lund, Sweden; +46-46-286-29-26, www.nfo.se

Prototyping Daughterboards

Two prototyping daughterboards, ProtoPlus and ProtoPlus Lite let developers construct a prototype circuit that plugs into the TMS-320C2000 and C6000 DSP platforms, the C54x, and the DSK and EVM development systems. The boards give access to all signals and power rails. They accept external ±12-V power. The ProtoPlus Lite, a two-layer board, sells for $125. The ProtoPlus, a six-layer board, has separate ground, and 3.3- and 5-V planes; it sells for $225. ***DSP Global, Inc.,*** Warwick, R.I.; (401) 737-9900, www.dspglobal.com

Single-Board Media and Signaling Gateway

SuperSpan II is a completely integrated single-board embedded hardware and software platform for implementing carrier-class media gateway, SS7 signaling gateway, cellular infrastructure, and unified messaging systems. Included are octal T1/E1 network access ports, i860 signaling controller, PowerPC 750 protocol controller, high-density DSP resource mezzanine board, and embedded software for convergent voice and data applications. Besides sporting VoIP, wireless, V.90, and G3 fax software for the TMS320C5000 DSP platform, SuperSpan II embeds H.323, MGCP, SIP, TCP/IP, SS7, and TCAP/ISUP signaling stacks and internetworking functions. Prices start at $3,000. ***Voiceboard Corporation,*** Oxnard, Calif.; (805) 985-6200, www.voiceboard.com

Assistant Enhances Development Tools

Development Assistant for C works independently or alongside Code Composer Studio. The assistant uses an ActiveX interface to communicate with Code Composer Studio and debugger commands. Among its features are an editor with structured and nonstructured flowcharts, start debugger commands for Code Composer Studio, symbol browser, call- and type-hierarchy graph, makefile generator, software metrics, interface to version control systems, project manager, and static code analyzer. Starting prices range from $295 to $660 each, depending on the target DSP. ***RistenCASE GmbH,*** Wallisellen, Switzerland; +41-1-883-35-70, www.ristancase.ch

IP Phone Chip

The IP Phone, a chip built around a 100-MHz TMS320C549, delivers the features of a standard PBX-based phone, including call transfer and caller ID. Accompanying software includes G.723 and G.729 voice compression and automatic echo cancellation algorithms, as well as IP, UDP, RTP, and DHCP

network protocols; SIP signal protocol; and DES encryption. Prices start at $300 each. ***ADtech,*** Boncelles, Belgium; +32-4-338-13-30, www.adtech.com

Low Data-Rate AMBE+2 Vocoder

A low-data-rate AMBE+2 vocoder operates at 2.0 to 9.6 kb/s for applications where low bandwidth and high-quality speech performance are high priorities. Its model-based multiband excitation algorithm carries distinct advantages over conventional CELP-based vocoders, including higher mean opinion scores. The software runs on the TMS320C5000 DSP platform. The price depends on customer specifications. ***Digital Voice Systems, Inc.,*** Burlington, Mass.; (781) 272-5606, www.dvsinc.com

Ada Suite Teams Up with TI DSPs for Military Service

The 83/95 Ada Compiler, an Ada software suite that targets Texas Instruments' SMJ32C6000 DSP platform for military applications, includes a full Ada symbolic debugger and Ada run-time options that include tight integration with the DSP/BIOS kernel. The suite fits tightly into Code Composer Studio. It works with SMJ32C6000, SMJ-32C6201, and SMJ32C6701 DSPs and runs on Windows 95, 98, 2000, and NT machines. The 83/95 Ada Compiler costs $25,000 for the first seat and $20,000 per seat thereafter. A maintenance program costs $5,000 annually. ***Irvine Compiler Corporation,*** Irvine, Calif.; (949) 250-1366, www.irvine.com

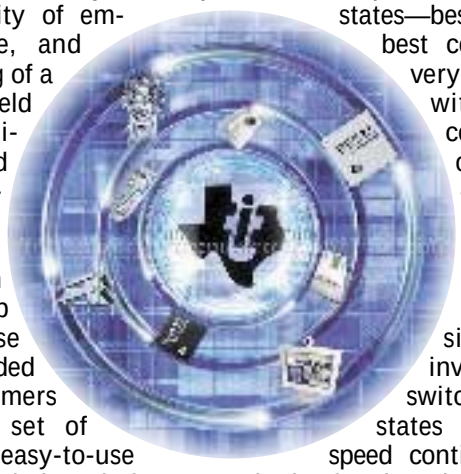
Libraries Tuned to C6000 DSP Platform

The GD-100 DSP vector library for the TMS320C6000 DSP platform comprises over 100 functions and macros, including transforms, filters, and vector operations. The GD-200 math library for the C67x consists of algebraic and trigonometric functions and utilities. They sell for $3,500 and $2,450 respectively. *Kane Computing,* Cheshire, U.K.; +44 (0) 1606 351006, www.kanecomputing.com

Needed: New Compilation Tools to Help Optimize Embedded Code

By Alan S. Ward

For embedded software programmers, the performance of code generated from a high-level language is becoming increasingly important. At the same time, code size is often a critical concern. Three trends—the leaps in the capability of embedded processors, the significantly greater complexity of embedded software, and the mushrooming of a variety of handheld devices—are driving a huge and rapidly expanding need for tools to help automate programming. In order to keep up with these changes, embedded software programmers clearly need a set of accessible and easy-to-use tools to optimize their code for performance and size demands.



Many embedded compilation tools already possess the sophistication to highly optimize applications. The difficulty is extracting that capability from the tools. Consider the task of scheduling code for a VLIW DSP that supports eight parallel instructions per cycle. Applying "parallelism-generating" transformations results not only in faster code, but also in a larger code size. In the embedded environment, though, programmers are usually limited by real-time and cost constraints—that is, by cycle counts and code size.

Because of these conflicting constraints, most compilers for embedded processors contain some mechanism for controlling the optimizations that affect size versus speed. However, simply managing this mechanism can be a daunting challenge. Given the simplified situation of a compiler switch with two states—best performance or best code size—and a very small application with 20 units of code (such as a file or function), 2^{20}—or roughly 1 million—combinations would exist.

A more realistic situation would involve a compiler switch with many states along a size-to-speed continuum and hundreds of code units. Obviously, programmers can't search the entire solution space for the optimum mapping of options to code units. Instead, they typically use the 80/20 rule, which states that 80 percent of an application's cycle requirements are in 20 percent of the code. The exact percentages can be debated, but the premise is usually true. Using this rule and knowledge of the application, programmers can quickly prune much of the solution space. Indeed, such a manual, iterative process is still used to determine a satisfactory solution. What's more, this problem is only one example; developing production-quality embedded code with old compilation tools involves many trial-and-error processes.

Fortunately, compiler tools are appearing that address this level of interaction between the tools and their users. A profile-based compiler uses criteria supplied by the programmer to automatically build and profile multiple sets of options for coding all the software's key functions; then it plots the most favorable option combinations on a curve that represents different trade-off values between performance and code size. Using the graph, programmers can select the right trade-off for the design's requirements, like the tightest code for a given cycle count or the fastest execution at a given memory size. Thus this type of compiler can save weeks of effort and assure developers that they have the best solution for reconciling performance with code size.

Other examples of new or upcoming compilation tools include ones that structure code sequences to better map to the underlying processor and ones that experiment with the memory layout of code or data to utilize on-chip memory or cache most effectively.

Alan Ward is the C6000 DSP compiler tools manager and a distinguished member of the technical staff at Texas Instruments, Inc. in Houston.

xICE* Multi-Target Emulator

DSP/RISC Debugging

In the past emulators provided a physical and software link between a ***single*** scan chain target DSP/RISC and a host computer, running a Debugging Interface Program.

Until now, multi-processor systems have required that devices be daisy chained into the one scan path. The longer scan path does not allow full scan rates because of scan path delays through the respective processors (switching in and out of bypass) and PCB-processor interconnects.

*xICE** Solution

The ***xICE*** Multi-Target Emulator is capable of emulating multiple DSPs/RISCs on separate scan paths **simultaneously**. This is particularly useful for parallel processing applications employing multiple DSPs and/or RISCs, such as image processing, radar/sonar systems, and processor arrays.

The ***xICE*** consists of one PCI host card and multiple pods, one for each of the separate scan paths. This enables a number of DSPs / RISCs, each on separate scan paths, to be debugged from one PCI slot, all at full scan rates upto 30MHz, all at the same time.

Softronics Emulators

- xICE* -> PCI Bus **Multi-Target** Emulator
- nICE -> **100baseT Ethernet** Emulator
- DspIce* -> **PCI** Bus Emulator
- Ice*Pack -> **ISA** (16 bit) Bus Emulator
- Mice*Pack -> **Parallel Port** Emulator

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- ARM7 <> ARM9 <>TMS470 <> TMS320CAVxxx
- Flash Programming Support <> RTDX <>DSPBios

Software Support

- TI Code Composer Studio
- ARM Aspex
- Eonic Virtuoso

xICE*

Multi-target DSP/RISC

eXpressDSP Real-Time Software Technology from TI.

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