ELECTRONIC DESIGN

FOR ENGINEERS AND ENGINEERING MANAGERS - WORLDWIDE

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JUNE 9 1997

Super Chip Is The First To Get The Cable Modem Down To Size p. 67

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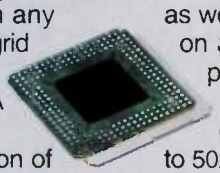

Advanced materials and multilayer capabilities enable *Super*BGA to handle signal speeds beyond 1.0 GHz. Direct attachment of the die to a built-in heat spreader substantially increases power handling capabilities while providing EMI/RFI shielding. Moisture sensitivity exceeds JEDEC level 2 requirements.

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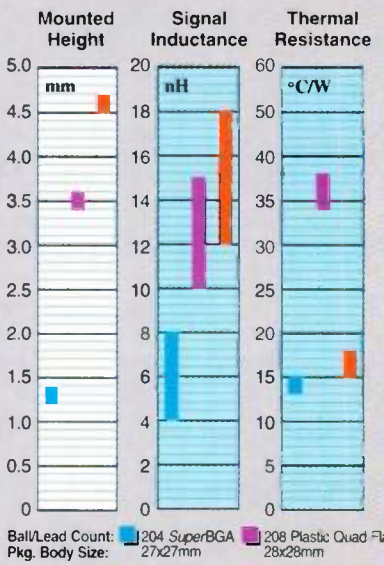

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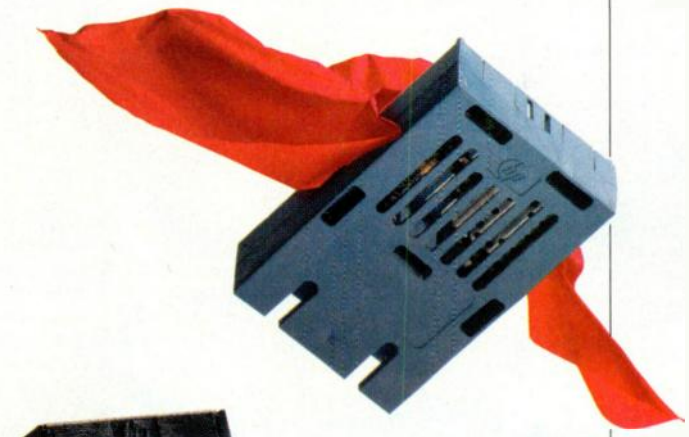

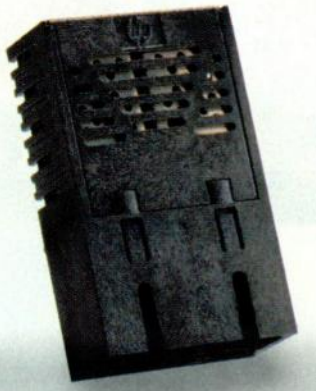

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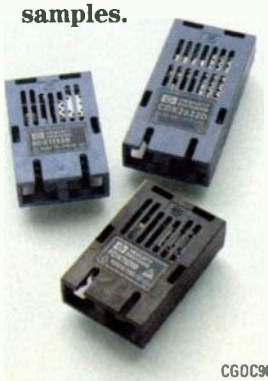

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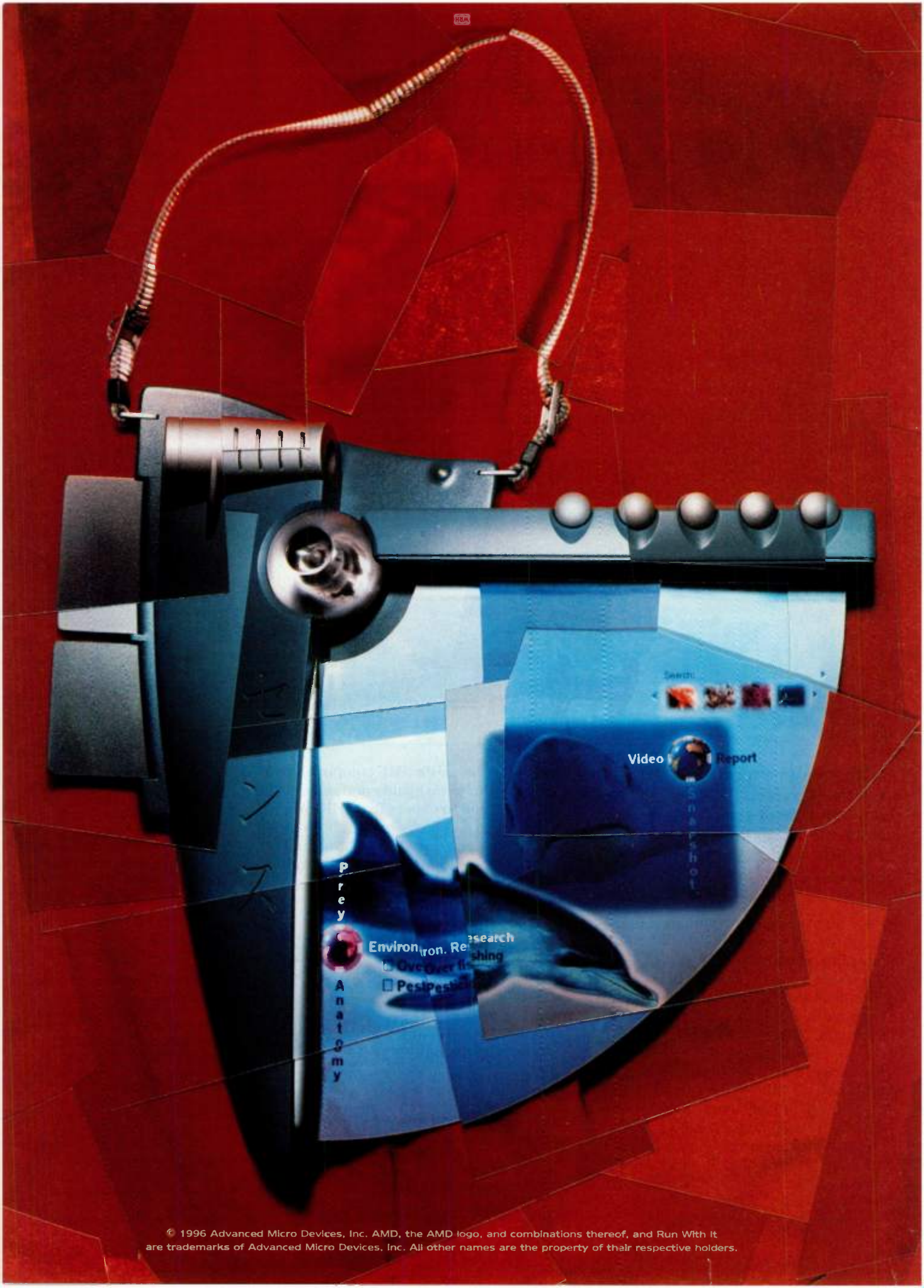

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ERA-3	DC-3000	20.8	12.1	3.8	24.0	35	2.10
ERA-3SM	DC-3000	20.2	11.5	3.8	25.0	35	2.15
ERA-4	DC-4000	13.5	▲17.0	5.5	▲32.5	65	4.15
ERA-4SM	DC-4000	13.5	▲16.8	5.2	▲33.0	65	4.20
ERA-5	DC-4000	18.8	▲18.4	4.5	▲33.0	65	4.15
ERA-5SM	DC-4000	18.5	▲18.4	4.3	▲32.5	65	4.20
ERA-6	DC-4000	11.3	▲18.5	8.4	▲36.5	70	4.15
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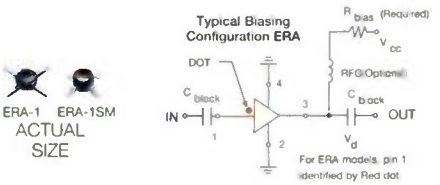
120x60	.002, .047, .068, .1 µf



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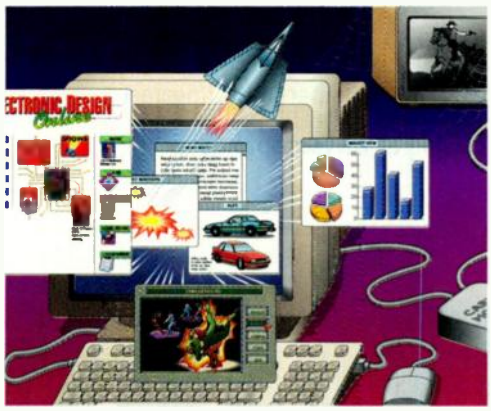

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ELECTRONIC DESIGN

June 9, 1997 Volume 45, Number 12

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QUICKLOOK

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Jesse H. Neal Editorial Achievement

1967 First Place Award	1978 Certificate of Merit
1968 First Place Award	1980 Certificate of Merit
1972 Certificate of Merit	1986 First Place Award
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ELECTRONIC DESIGN

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JUNE

IEEE Power Electronics Specialist Conference (PESC 97), June 22-27. Regal Riverfront Hotel, St. Louis, MO. Contact Philip T. Krein, University of Illinois, 1406 W. Green St., Urbana, IL 61801; (217) 333-4732; e-mail: krein@uipesl.ece.uiuc.edu.

IEEE International Symposium on Information Theory, June 29-July 4. Ulm, Germany. Contact Han Vinck, Institute of Experimental Mathematics, University of Essen, Ellernstr. 29, 45326 Essen, Germany; (49) 201 3206458; fax (49) 201 3206425.

JULY

Fifth USENIX TCL/TK Workshop, July 14-17. Tremont House Hotel, Boston MA. Contact USENIX Conference Office, 22672 Lambert St., Suite 613, Lake Forest, CA 92630; (714) 588-8649; fax (714) 588-9706; e-mail: conference@usenix.org; Internet: http://www.usenix.org.

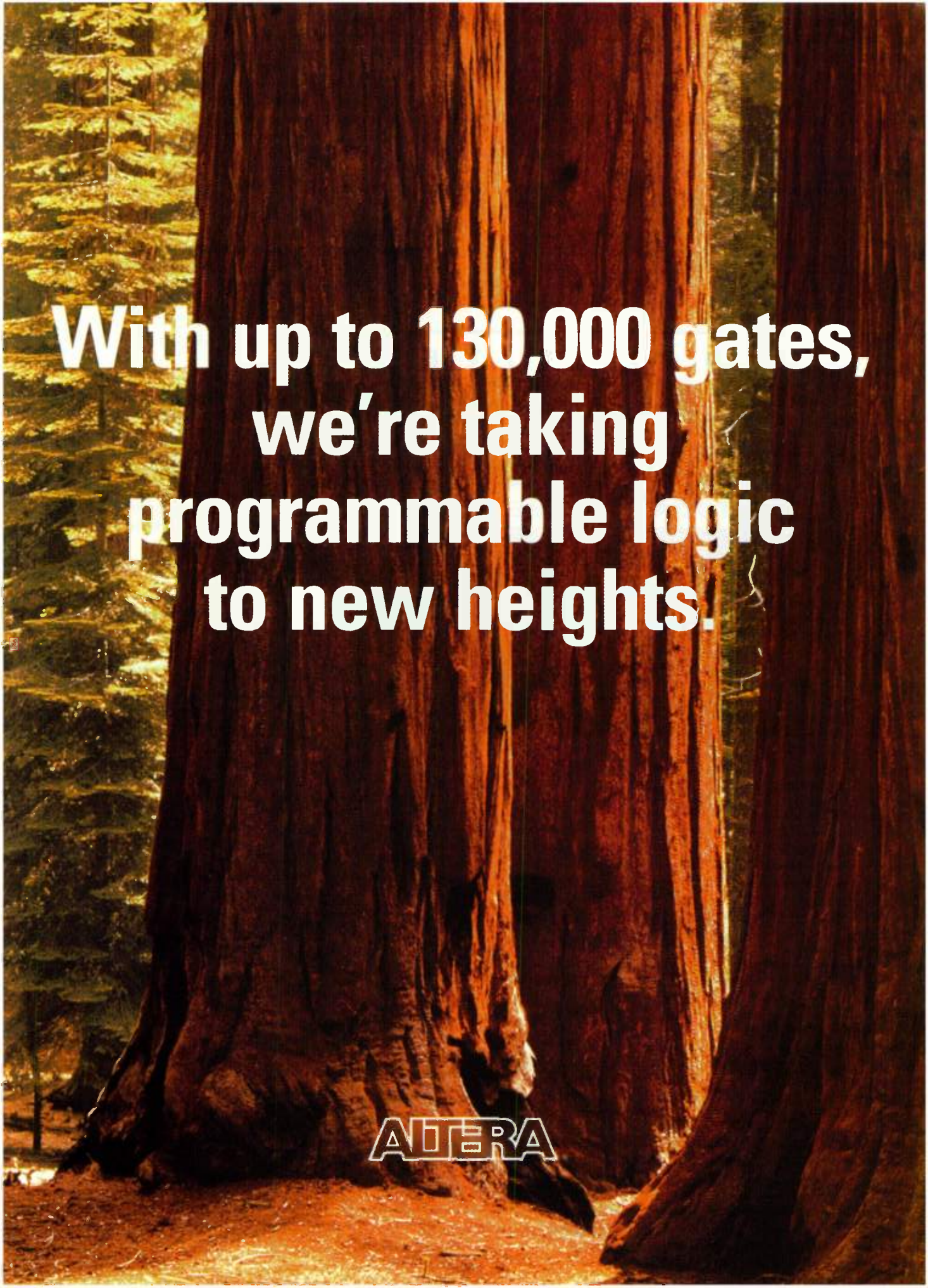
IEEE Power Engineering Society Summer Meeting, July 20-25. Intercontinental Hotel, Berlin, Germany. Contact Executive Office, IEEE Power Engineering Society, P.O. Box 1331, Piscataway, NJ 08855-1331; (908) 562-3864; fax (908) 981-1769.

IEEE Signal Processing Workshop on Higher Order Statistics, July 21-23. Banff Centre for Conferences, Banff, Alberta, Canada. Contact Keh-Shin Lii, Department of Statistics, University of California, Riverside, 900 University Ave., Riverside, CA 92521; (909) 787-3836; fax (909) 787-3286; e-mail: ksl@ucrstat.ucr.edu.

IEEE Nuclear & Space Radiation Effects Conference (NSREC '97), July 21-25. Snowmass Conference Center, Snowmass, CO. Contact Dennis B. Brown, Naval Research Laboratory, Code 6612, Washington, DC 20375; (202) 767-5453; fax (202) 404-8076; e-mail: dbbrown@ccfnrl.nvy.mil.

AUGUST

40th Midwest Symposium on Circuits and Systems, Aug. 2-6. Hyatt Regency Hotel, Sacramento, CA. Contact Sharon Baumgartner, Department of E & CE, University of California, Davis, CA 95616; (916) 754-6216; fax (916) 752-8428; e-mail:mwscas97@ece.ucdavis.edu.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IEEE International Geoscience & Remote Sensing Symposium (IGARSS '97), August 4-8. Singapore International Convention Exhibition Centre, Suntec City, Singapore. Contact Kwoh Leong Keong, CRISP, National University of Singapore, Faculty of Science, Lower Kent Ridge Rd., S 119260 Singapore; (65) 7727838.

Memory Technology, Design, & Test Workshop, Aug. 11-12. San Jose, CA. Contact F. Lombardi; (409) 845-5464; e-mail: lombardi@cs.tamu.edu.

USENIX Windows/NT Workshop, Aug. 11-13. Sheraton Hotel, Seattle, WA. Contact USENIX Conference Office, 22672 Lambert St., Suite 613. Lake Forest, CA 92630; (714) 588-8649; fax (714) 588-9706; e-mail: conference@usenix.org.

Large-Scale Systems Administration of NT Workshop, Aug. 14-16. Sheraton Hotel, Seattle, WA. Contact the USENIX Conference Office, 22672 Lambert St., Suite 613, Lake Forest, CA 92630, (714) 588-8649; fax (714) 588-9706; e-mail: conference @usenix.org.

IEEE International Symposium on Electromagnetic Compatibility (EMC '97), Aug. 18-22. Contact John Osburn, EMC Test Systems LP., 2205 Kramer Lane, Austin, TX 78758; (512) 835-4684 ext. 669; fax (512) 835-4729.

SEPTEMBER

Telecom Interactive '97, Sept. 8-14. Geneva, Switzerland. Contact (703) 907-7736.

Fifth European Congress on Intelligent Techniques and Soft Computing (EUFIT '97), Sept. 8-12. Aachen, Germany. Contact Promenade 9, 52076 Aachen, Germany; (49) 2408 6969; fax (49) 2408 94582; e-mail: eufit@mitgmbh.de; Internet: http://www.mitgmbh.de/elite/elite/-eufit.html.

ICSPAT/DSP WORLD 1997, Sept. 14-17. San Diego Convention Center, San Diego, CA. Contact Denise Chan, Miller Freeman Inc. (415) 278-5231; e-mail: dsp@exporeg.com.

MCM Test Workshop, Sept. 14-17. Napa Valley, CA. Contact Y. Zorian, (408) 453-0146 ext. 227; e-mail: zorian@lvision.com.

International Conference on Solid State Devices and Materials (SSDM), Sept. 16-19. Act City Hamamatsu, Hamamatsu, Japan. Contact Secretariat of SSDM '97, % Business Center for Academic Societies Japan, 5-16-9 Honkomagome, Bunkyo,Tokyo 113, Japan; (81) 3 5814 5800; fax (81) 3 5814 5823; e-mail: confg3@bcasj.or.jp.

Thermionic Workshop, Sept. 21-23. Cannes, France. Contact B. Courtois; (33) 35 76 7 46 15; e-mail: bernard.courtois@imag.fr.

AUTOTESTCON '97, Sept. 22-25. Disneyland Hotel, Anaheim, CA. Contact Robert C. Rassa, Hughes Aircraft, P.O. Box 92426, MS R07/P553, Los Angeles, CA 90009-2426; (310) 334-4922; fax (310) 334-2578; e-mail: rcrassa@ccgate.hac.com.

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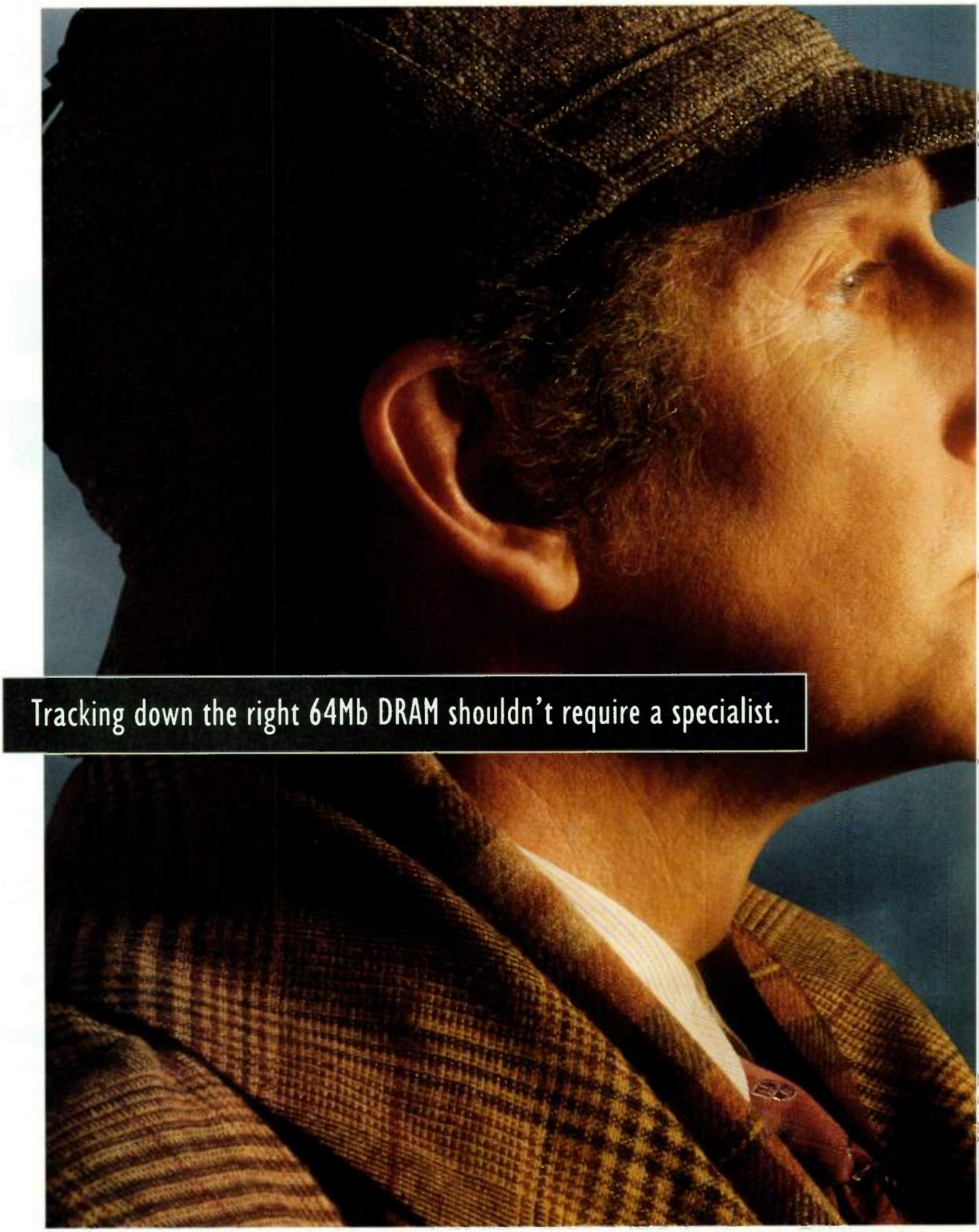
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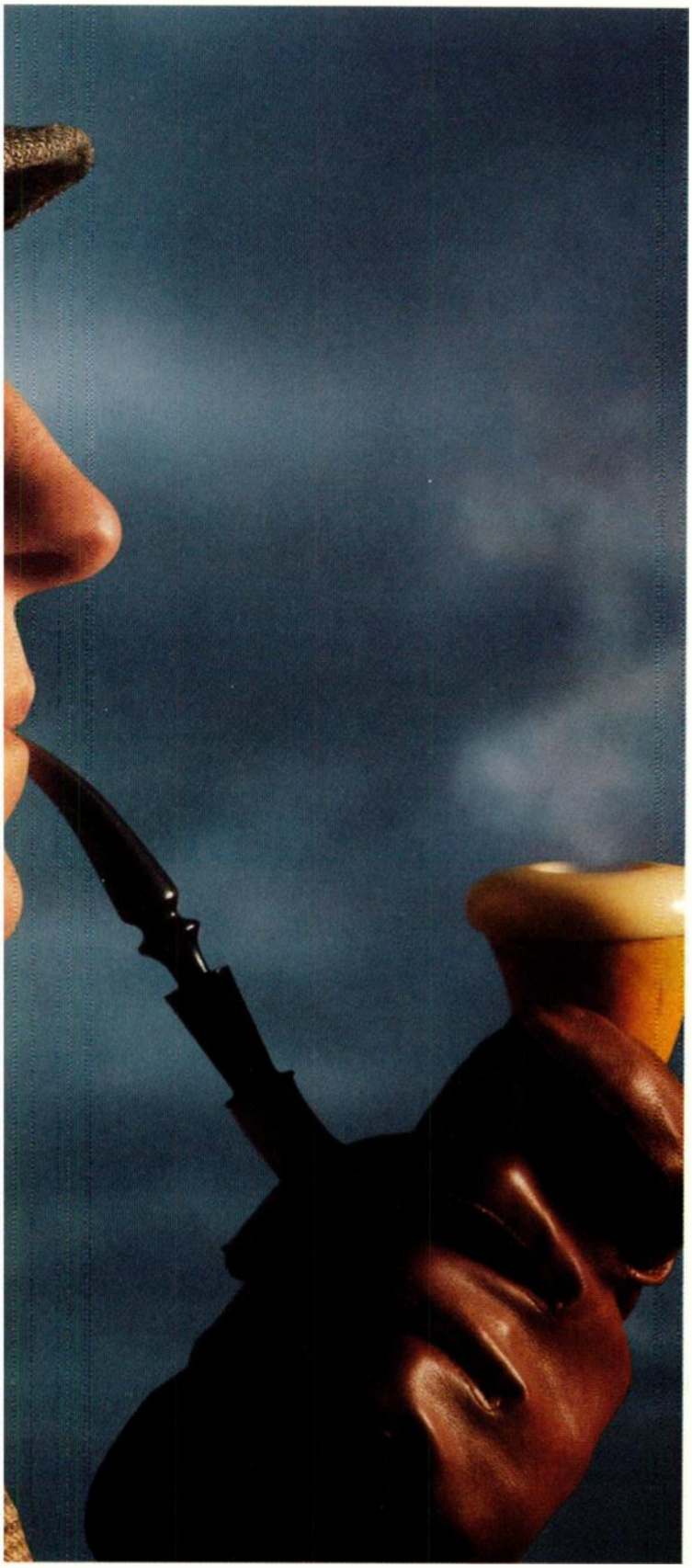

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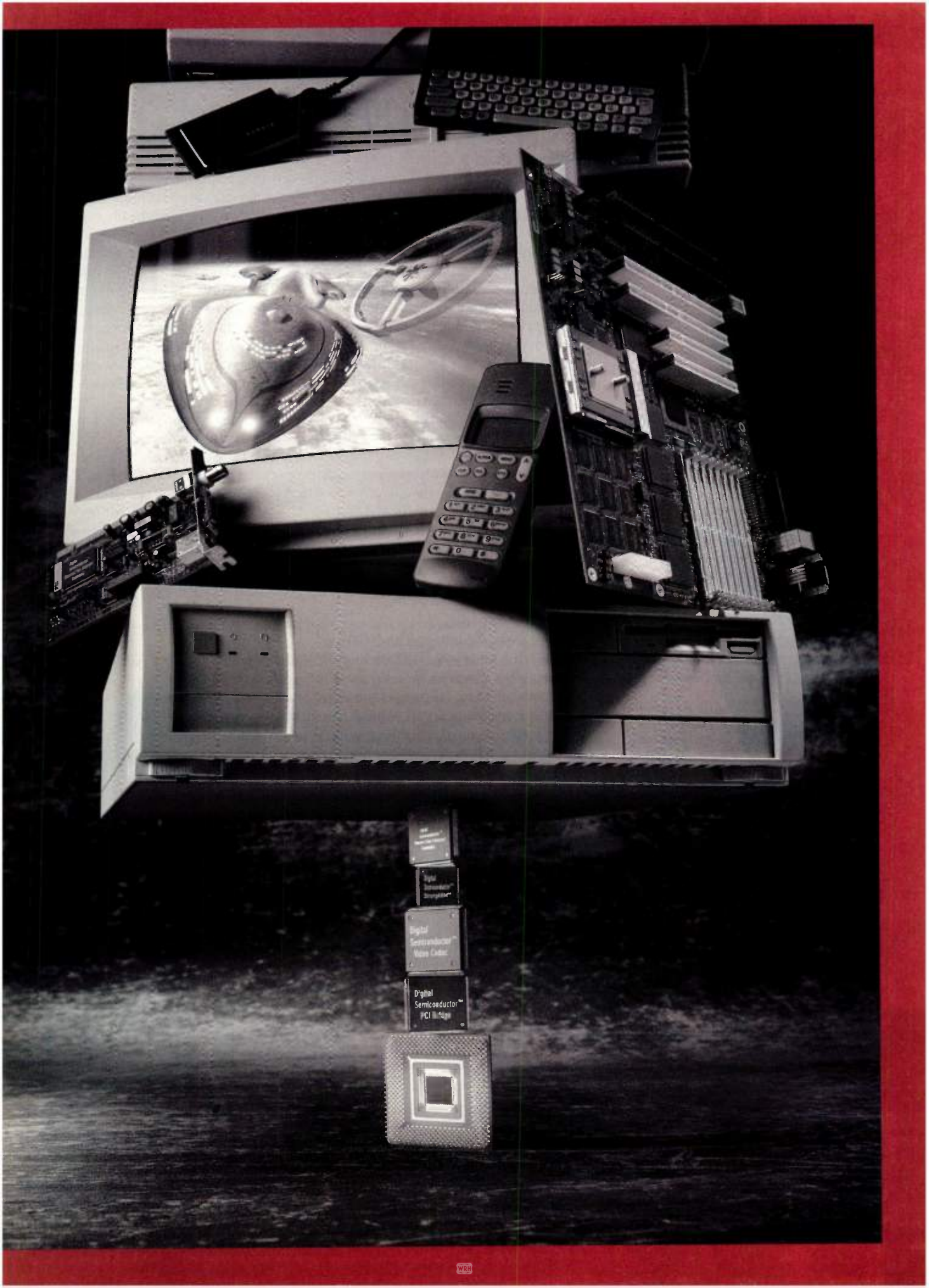
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EDITORIAL

The Year 2000 And Beyond

The worldwide demand for electronics products and technologies is surpassing even the most optimistic forecasts and predictions from industry experts. By the year 2000, the global electronics industry will top one *trillion* dollars in revenue. And there appear to be no obstacles in sight for continued growth well into the millennium.

Considering that the first commercial microprocessor made its debut less than 25 years ago, the trillion dollar milestone is a remarkable achievement for the electronics industry. But along with this amazing worldwide demand for electronics products comes pressure on the design engineers and engineering managers whose job it is to design, build, and manufacture next-generation electronics products. Global competition, coupled with consumer and business demand for cutting-edge products, has created an environment where engineers and managers are under the gun to move their products to market first—defect-free and competitively priced.

Not an easy task. But there is no one in the industry who isn't excited about the creative opportunities that the chip, hardware, and software technologies are fostering in R&D labs around the world. And the enthusiasm does not stem so much as to how far the industry has progressed in such a short period of time, but rather where the industry is *going* that is creating the most excitement.

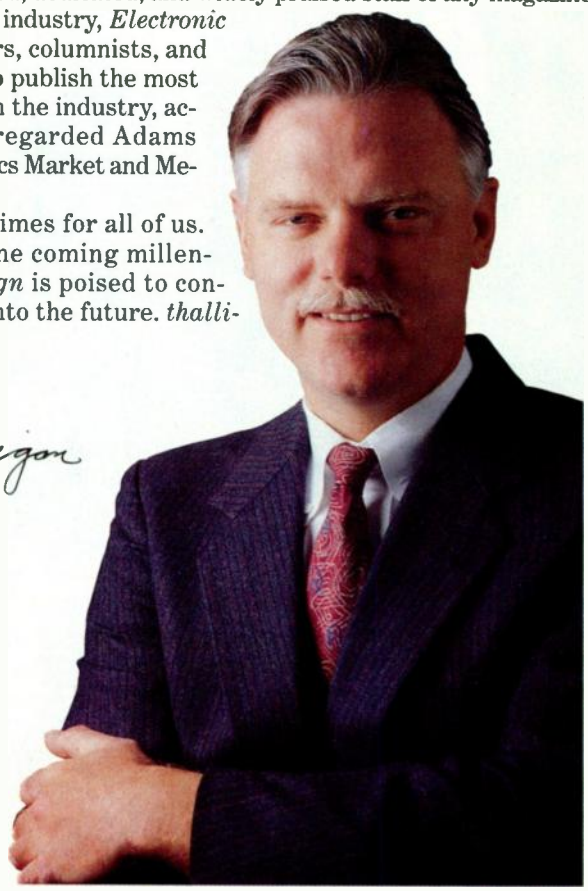
The same holds true for the writers and editors here at *Electronic Design* who cover the electronics industry. We are not only equally excited about where the electronics industry is going, but we also are inspired by the advanced technology that has emerged for the publishing industry in recent years. Not only can we deliver to you a better and more timely magazine because of advanced computer and communications technology, but CD-ROM and the Internet also will allow us to deliver to you more comprehensive, extended, pertinent, and even customized information and data.

With the most seasoned, dedicated, and widely praised staff of any magazine covering the electronics industry, *Electronic Design*'s writers, editors, columnists, and contributors continue to publish the most widely read magazine in the industry, according to the highly regarded Adams Company 1996 Electronics Market and Media Report.

These are exciting times for all of us. And as we approach the coming millennium, *Electronic Design* is poised to continue its mission well into the future. *thalligan@penton.com*

Tom Halligan

Editor-in-Chief



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Heavy Weather Ahead

I woke up to find the drifts piling up outside the windows and knew it was going to be a rough morning. Catherine made coffee while I tackled the stuff closest to the house. I ditched the junk mail, piled up the magazines and journals, sorted the faxes, and scanned the rest of the pile for anything resembling a personal letter or a bill. Over a cup of coffee, I logged on to find that the blizzard was worse than the experts had predicted.

Forecasters at *www.stormwatch.com* badly underestimated the situation although they called for heavy overnight accumulations of four to six megabytes, with severe avalanche warnings for later in the afternoon. Somehow, they missed the torrent of information, press releases, and general hype emanating from a rapidly developing squall line of trade shows stretching from Las Vegas to San Francisco. When I got to my PC, it was already buried. The disk drive struggled for traction, but could barely find its boot sectors under the weight of 350 e-mail messages and dozens of video clips delivered overnight along with an assortment of news, trivia, and chat-group proceedings. When I finally dug out and got to work, a flash data flood had overwhelmed our servers, bringing them to their knees. So much for "push" media at the office!

Sound familiar? Seems like everyone I talk to is up to their eyeballs in information, and none the better for it. Beyond a certain point, too much data is as bad as not enough. The information revolution has its benefits, but how much time is now spent sorting through the mountains of stuff that thunders across our desks, phones, and computers each day?

LEE GOLDBERG
COMMUNICATIONS

Instant access to information has raised our expectations to unrealistic levels, resulting in a frenzied treadmill existence where the boundaries between work and the rest of our lives become increasingly blurred. We're now all so afraid of MISSING SOMETHING that we can't waste a nanosecond of time to daydream.

Our technology is now sufficiently advanced to give us overwhelming amounts of information on virtually any topic, but it still can't help us figure out what the heck to do with it. Unfortunately, most of the schedulers, search engines, groupware, PDAs, palmtops, and other gadgets I've tested out seem to increase my workload and confusion levels rather than decrease them. In the long run, a wired planet will probably be a good thing, but it might to be a hellish couple of decades as we wait for the technology to mature and society to adapt.

What might ease this transition would be technology based on "knowledge" rather than "data." At the risk of being strung up by the academics, here's a working definition of knowledge: "The framework of relationships between individual pieces of data that establishes its significance within a given context." If designed properly, a knowledge-processor would buffer much of the raw data in our lives by digesting, prioritizing, and putting it into the context of what we already know in relation to our current activities. Their function might be akin to how an automatic transmission lets you forget about shifting to concentrate more on driving.

Knowledge processing will likely take many forms, including intelligent agents, integrated data managers, and ways of using visual displays that are closer to the way humans really think, instead of the tired "Windows" paradigm. A fresh approach will take creative thinking and input from nontraditional places. Sociologists, artists, neuro-psychologists, and science fiction writers might help to develop ways for us to interact with the devices we create and the information that they manipulate. Maybe there will be more than one "right" way to use a knowledge-based device, depending on your particular cognitive style.

This new generation of "knowledge-management technology" could be a gold mine for the electronics industry, with opportunities for products to navigate the growing ocean of data. Without them, the information revolution could stall as people become data-bound, trapped by the stuff they produce. *leeg@class.org*

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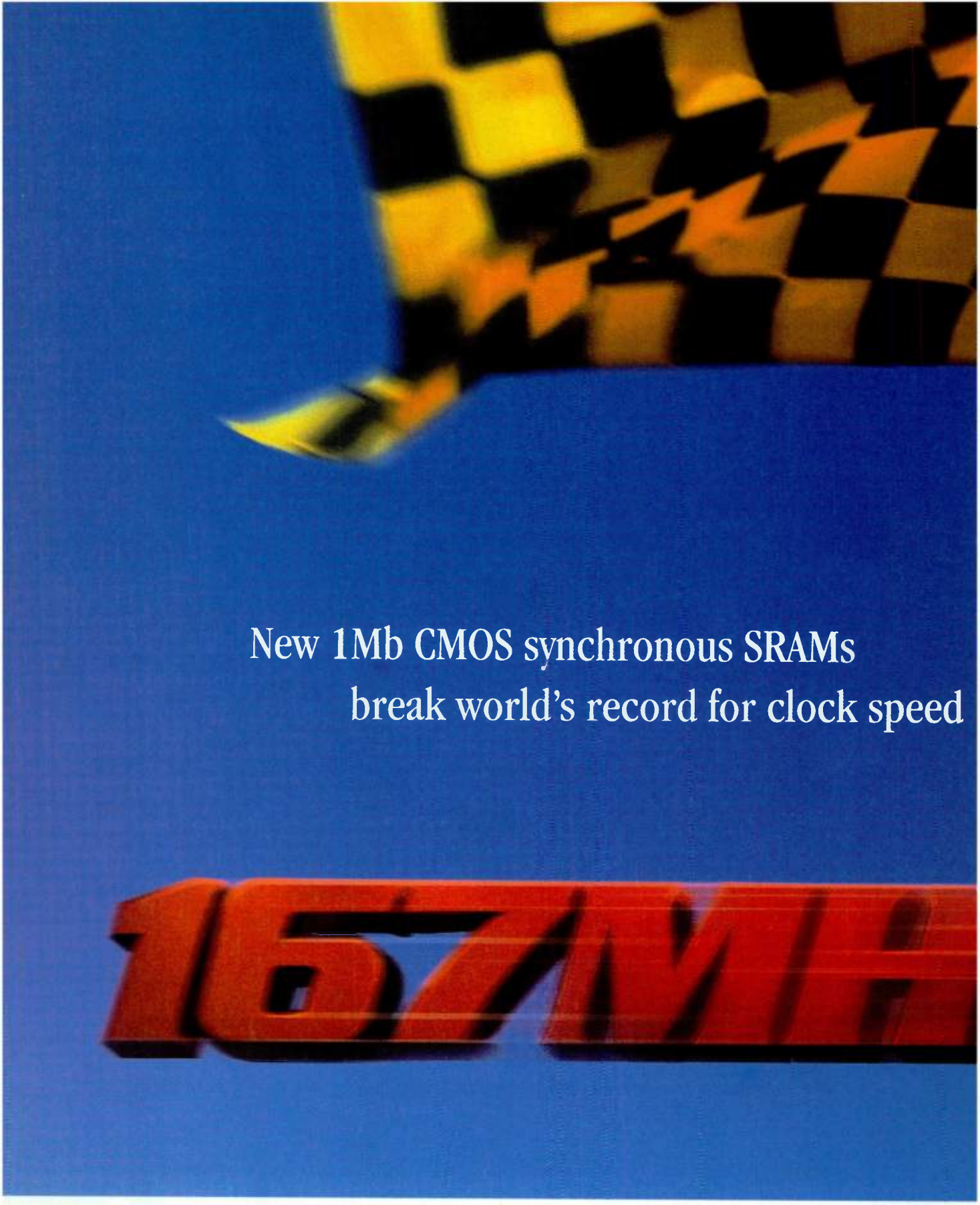

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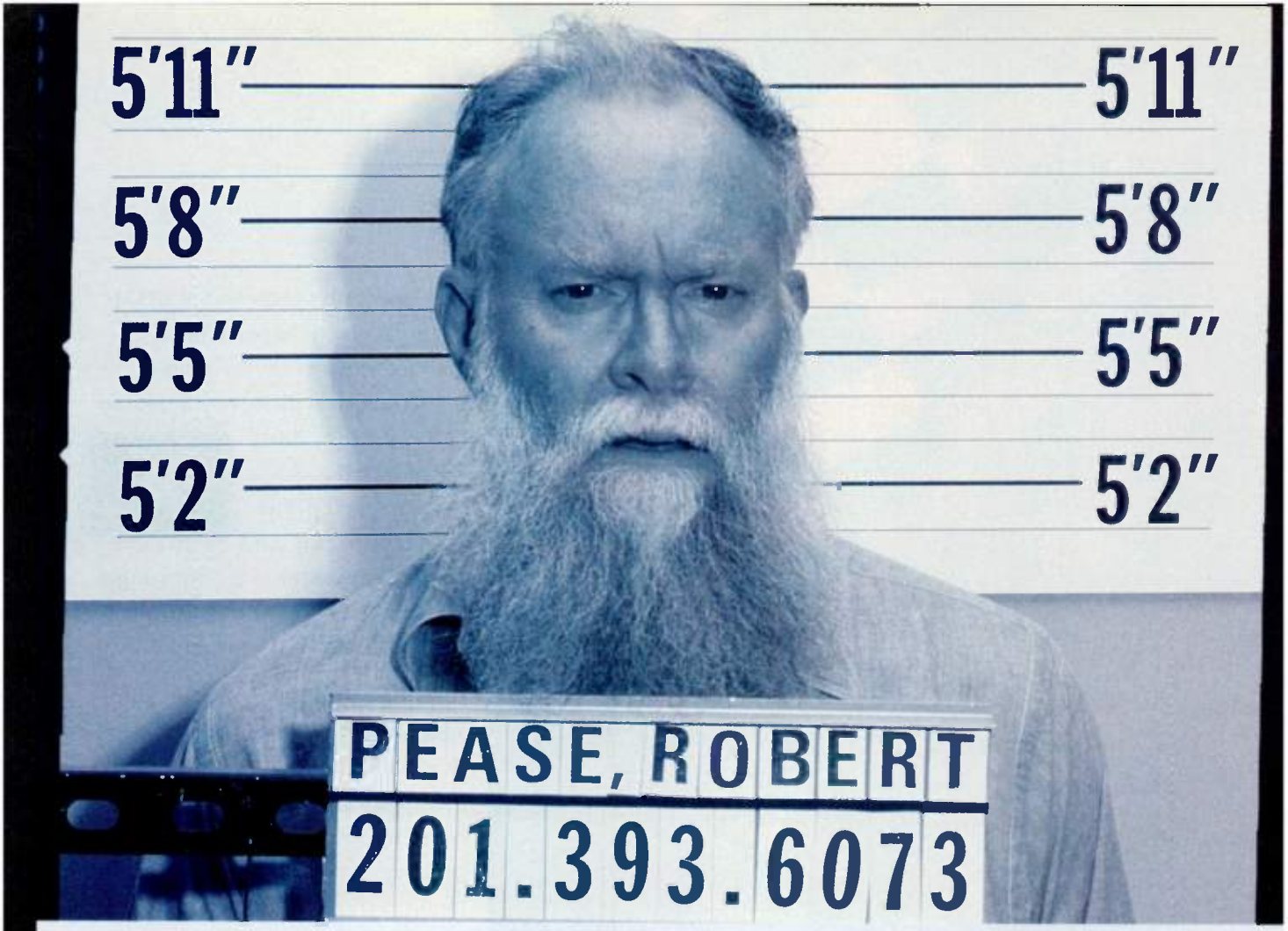

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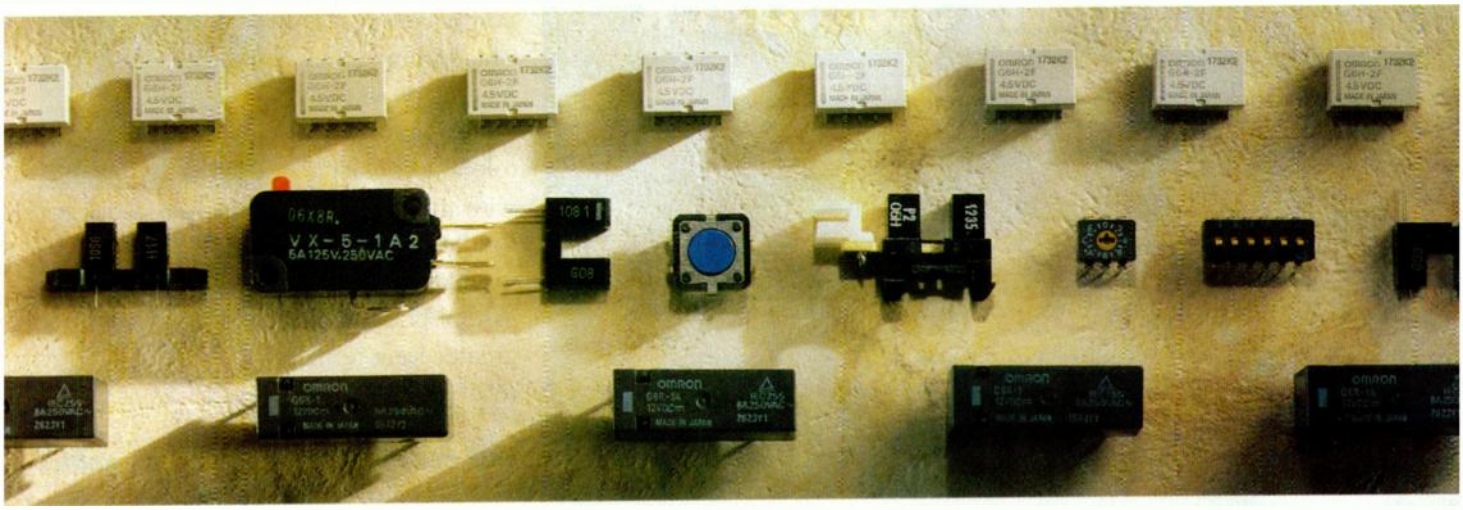

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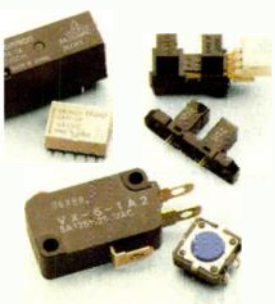

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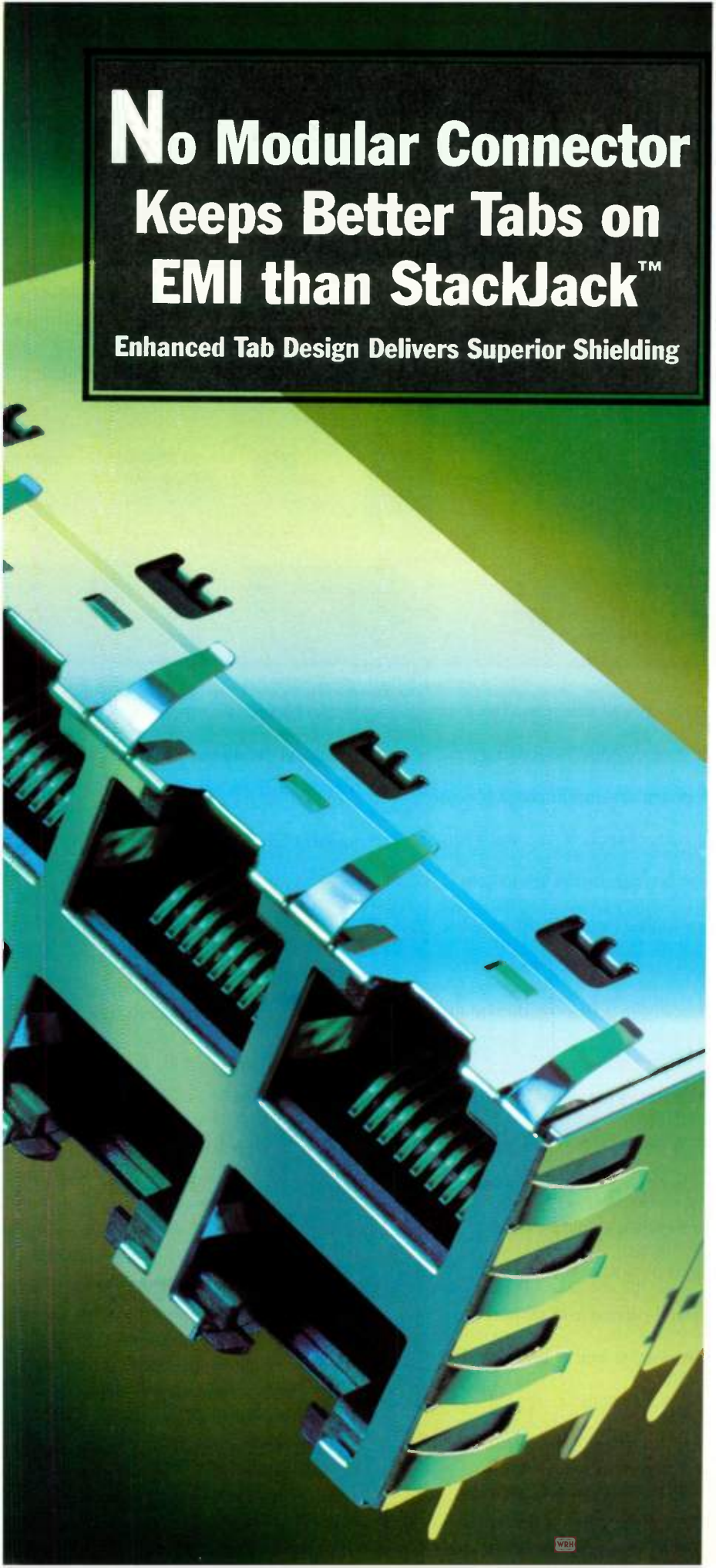

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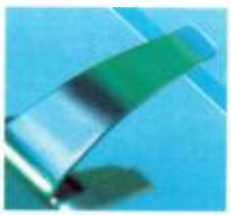

The spring-action of the StackJack enhanced tabs provides superior shielding, producing fast, interference-free network performance.

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Thanks to the only selectively gold-plated, wire-formed contacts in the industry, you get constant normal force and low-contact resistance. All this adds up to high performance and reliability. And if you're looking for higher hub density, specify StackJack in the industry's lowest profile, with up to 16 ports in a two-row configuration. And if you don't need shielding, try our unshielded StackJack modular connectors.

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Software Labor Demand Of Millennia Proportions

Two unusual problems are heating up the heavy demand for computer programmers for the next few years. First, there's the decision to combine together for a common currency in the EU (European Union), producing one of the most non-trivial costs in upgrading business and government computers to handle the sheer volume of computer codes needed. The second is the often-quoted millennia problem, with programs installed in the last decades turning back, like Cinderella's carriage, into useless pumpkins at the stroke of midnight on December 31, 1999.

The reasoning behind the millennia problem is that the early computers had limited and expensive memory; storing years data with just the last two digits seemed reasonable (but remarkably short-sighted!). A simple example of the problem is that interest on a loan due in 20XX would change into a dividend payable to the borrower! Few companies, government agencies, and nonprofit institutions have started to determine how the problem could affect their business, and fewer still have started to work on fixing it, according to Stanford University's Computer Industry Project, funded by the Alfred P. Sloan Foundation.

At a meeting of information systems departments leaders in April, it was reported that some companies believe they can fix all of their problems by the start of the century. However, the general feeling was that they could only fix some, which will be done randomly rather than prioritizing and fixing the ones that are most important first.

Potential problems were identified years ago but people were slow to act. Computer programming is idiosyncratic: A programmer trying to fix Year 2000 problems at an insurance company told the Wall Street Journal that he had come across fields named after song lyrics, flowers, programmers' sweethearts, and members of the Beatles. The European Monetary Union switch to a single currency forebodes an upheaval that could be as critical as the Year 2000 problem. According to the U.K. publication *Computer Weekly*, a survey of British firms had begun to tackle the currency problems because of political uncertainty as to whether it would happen at all. *PMcG*

TIA Updates Interim Standards For TDMA Cellular/PCS Systems

The Telecommunications Industry Association (TIA) has published three documents that update the operating standards for IS-136-type TDMA handsets and base stations operating in both the cellular and personal-communications-services (PCS) bands. The technical requirements in these documents form a compatibility standard for PCS and cellular phone services. These ensure that a mobile unit can obtain service in any PCS/cellular system that is compliant to them.

Published in 1996, a core group of four documents comprise the specification for developing IS-136-based products; IS-136.1 (DCCH - Digital Control Channel), IS-136.2 (a modified TIA/EIA 627 standard), IS-137 (a modified TIA/EIA 628 standard) and IS-138 (a modified TIA/EIA 629 standard).

The recently issued revisions to the IS-136 standard are: "TIA/EIA/IS-136.1-A, TDMA Cellular/PCS - Radio Interface - Mobile Station - Base Station Compatibility - Digital Control Channel," TIA/EIA/IS-136.1-A-1 (Addendum No. 1), and "TIA/EIA/IS-136.2-A, TDMA Cellular/PCS - Radio Interface - Mobile Station - Base Station Compatibility - Traffic Channels and FSK Control Interface." Copies of the main body of the standard, as well as the revisions, may be obtained from Global Engineering Documents at (800) 854-7179, or at http://www.global.ihs.com. *LG*

RTL Interoperability Standard First Draft Is Finalized

A first draft of a register-transfer level (RTL) interoperability standard, known as the VHDL RTL Synthesis Subset Standard, has been completed by VHDL International's (VI), Santa Clara, Calif., VHDL Synthesis Interoperability Working Group. The draft standard is built on synthesis subsets donated by a number of EDA vendors including Cadence Design Systems, IBM, Mentor Graphics and Synopsys.

Work on the standard has been divided into two parts, Levels 1 and 2. Level 1, similar to the current de facto industry standard, entails everything included in the current draft. Level 2 will address a larger subset and include standards for synthesis constraints. Work on this part of the standard will begin in the second quarter of this year. Also, in the same time frame, the current draft standard is to be presented to the EDA industry Council Project Technical Advisory Board (PTAB) for ratification and approval by EDA Council member companies. At this stage, it will be submitted to an IEEE Working Group for formal standardization. The standard RTL subset is intended to support the need for a more portable and reusable design specification for the entire EDA industry.

The draft of the VHDL RTL Synthesizable Subset standard is now available for use by VI and its members, and can be viewed or downloaded from http://vhdl.org/vhdlsynth/siwg. VHDL International also is working with Open Verilog International and The EDA Industry Council's PTAB to ensure that the synthesizable RTL subsets will meet industry needs for both VHDL and Verilog HDL. For more information concerning VHDL International, contact Mahendra Jain at (408) 492-9806, e-mail: jainm@vhdl.org, or visit their web site at http://www.vhdl.org/vhdl_intl. *CA*

Cycle-Based-Simulation Standard Proposal Submitted to OVI

One of the major challenges facing today's designer involves verification, and one of the technologies being touted as a solution to this challenge is cycle-based simulation (CBS). To help lay the foundation for developing a CBS standard, Quickturn Design Systems Inc., Santa Clara, Calif., has submitted a strawman proposal to the Open Verilog International (OVI) Cycle-Based Simulation Technical Sub-Committee.

The proposal, which outlines an industry standard for cycle-based simulation (CBS), comes from the company's three year history of CBS technical expertise stemming from its development of the SpeedSim product. The proposal specifically addresses six areas of interest related to CBS technology. These areas include general modeling guidelines, general modeling restrictions, timing and data updating, main event loops, procedural interfaces for C-based compiled models, and programming language interface subsets (PLI). It assumes that the Verilog subset for CBS consists of the synthesizable subset described in the standard proposal under consideration by OVI's Cycle-Based Simulation Technical Subcommittee.

This proposal is significant because it allows the standards process to start from a workable specification as opposed to starting from ground zero. It's hoped that the standardization of CBS technology will speed its rapid deployment into future verification methodologies. To obtain additional information, contact the company at (415) 967-3300; e-mail: info@quickturn.com; or through the company's web site at http://www.quickturn.com. *CA*

Committee Formed To Define Digital A/V Bus Standard

The Consumer Electronics Manufacturers Association (CEMA) Advanced Television (ATV) Interface Subcommittee is launching a project to define a digital A/V bus standard. It will be based on IEEE 1394, the Internet Protocol (IP), and the CEMA/EIA Common Applications Language (CAL). The new standard will provide for carriage and control of high-speed digital transport protocols, such as MPEG and JPEG, among digital consumer electronic products, including high-definition TVs, digital video disks (DVDs), TV/PCs, and PC theaters.

IEEE 1394 provides the high speed needed to deliver quality pictures and sound, as well as the protocol to prevent different data streams from interfering with each other. The IP also holds the promise of easy access to external networks. CAL is an object-oriented command language used in the CEBus home-automation standard. In fact, many consumer electronic-product commands have already been created using CAL.

Two working groups, the first on new applications led by Thomson Multimedia, and the second on transport, led by Intel, will provide any additional standards to allow the bus to work smoothly. Call CEMA at (703) 907-7674, fax (703) 907-7690, to get the latest details. *RE*

Just-Released Library Format Speeds ALF Standard Effort

Open Verilog International (OVI), Santa Clara, Calif., is at work developing a standard for ASIC library modeling formats, known as the Advanced Library Format (ALF), which all EDA tools could use. To aid this effort, Mentor Graphics, Wilsonville, Ore., has released the library format used by its design-for-test (DFT) tools. Already being used by a majority of leading semiconductor companies, the library format will assist in accelerating ALF development in the areas of functionality definition and test capability. Furthermore, it will increase the availability of effective design-for-test libraries

Mentor's proprietary ASCII library format was originally developed for use by DFT tools to retrieve and specify critical functionality information of ASIC designs. Other applications that rely on functional information, such as cycle-based simulation, formal verification, and synthesis, can easily leverage this format for optimal performance. For further information, contact the company's web site at http://www.mentorg.com. *CA*

National Awareness Campaign To Focus On ITS Benefits

While many in industry understand the potential benefits of Intelligent Transportation Systems (ITS), the general public has yet to be convinced. This is due, in part, to the fact that most companies working in ITS-related areas have focused on technology development and not consumerization of ITS products. In an attempt to increase public understanding and awareness of the benefits of ITS-related products and services, ITS America, Washington D.C., a public-private partnership representing advanced surface transportation interests across the U.S. and abroad, has launched a multi-year National Awareness Campaign.

The first stage of the campaign will focus on identifying current industry and consumer attitudes about transportation and ITS. Information obtained through industry polling, focus groups, surveys in various metropolitan areas, and related industry studies will then be used to develop a national campaign that will target selected audiences. For additional information, contact the Intelligent Transportation Society of America at (202) 484-4847; http://www.itsa.org. *CA*

Edited by Roger Engelke

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Electrical Overstress/Electrostatic Discharge Symposium, Sept. 23-25. Santa Clara Convention Center, Santa Clara, CA. Contact ESD Association, 7902 Turin Rd., Suite 4, Rome, NY 13440-2069; (315) 339-6937; fax (315) 339-6793.

Fifth China International Electronics Exhibition (CIEE '97), Sept. 24-28. China International Exhibition Centre, Beijing. Contact Gu Jinjing, CEIEC, P.O. Box 140, Beijing, 100036 China; (011) 8610 6822 3909; fax (011) 8610 6821 3348.

Eastern Regional Conference on Crystal Growth & Epitaxy, ACCGE/East-97, Sept. 28-Oct. 1. Bally's Park Place Hotel & Casino, Atlantic City, New Jersey. Contact Louis G. Casagrande, (516) 346-6379; fax (516) 346-3670; e-mail: Lou_Casagrande@atdc.grumman.com, or contact Ed Porbansky, Conference Secretariat, 163 Carson Dr., Colonia, New Jersey 07067; (908) 382-1806.

Embedded Systems Conference, Sept. 29-Oct. 3. San Jose Convention Center, San Jose, CA. Contact Miller Freeman Inc. (415) 278-5231; e-mail: esc@exporeg.com.

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OEMed Northeast, Oct. 1-2. Bayside Expo Center, Boston, MA. Contact Exposition Excellence Corp., 112 Main St., Norwalk, CT 06851; (203) 847-9599; fax (203) 854-9438.

OEM Electronics Northeast, Oct. 1-2. Bayside Expo Center, Boston, MA. Contact Exposition Excellence Corp., 112 Main St., Norwalk, CT 06851; (203) 847-9599; fax (203) 854-9438.

PCI Plus Europe, Oct. 1-2. The International Conference Center (ICC), Messe Berlin, Germany. Contact Active Exhibitions Europe at P.O. Box 2114, 5300 CC Zaltbommel, The Netherlands. (31) 418 512999; fax (31) 418 515115; e-mail: active@ots-group.nl: http/aexpo.com or Annabooks, 11838 Bernardo Plaza Court, San Diego, CA 92128; (800) 462-1042; fax (619) 673-1432; e-mail: 73204.3405@compuserve.com; http://www.annabooks.com.

IEEE Ultrasonics Symposium, Oct. 7-10. Marriott Hotel, Toronto, Canada. Contact Stuart Foster, Dept. of Medical Biophysics, Room S-658, Sunnybrook Health Science Ctr., 2075 Bayview Ave., Toronto, Ontario, M4N 3M5, Canada; e-mail: stuart@owl.sunnybrook.utoronto.ca.

Sixth IEEE International Conference on Universal Personal Communications, Oct. 12-16. Hotel del Coronado, San Diego, California. Contact Gail Weisman, IEEE Communications Society, 345 E. 47th St., New York, NY 10017; (212) 705-7018; fax (212) 705-7865; e-mail: g.weisman@ieee.org.

Sixth IEEE International Conference on Universal Personal Communications (ICUPC '97), Oct. 13-15. Contact Tony Acampora, MC 0409, Bldg EBU1, UCSD, 9500 Gilman Dr., La Jolla, CA 92093-0409; (619) 534-5438; fax (619) 534-2486; e-mail: acampora@ece.ucsd.edu.

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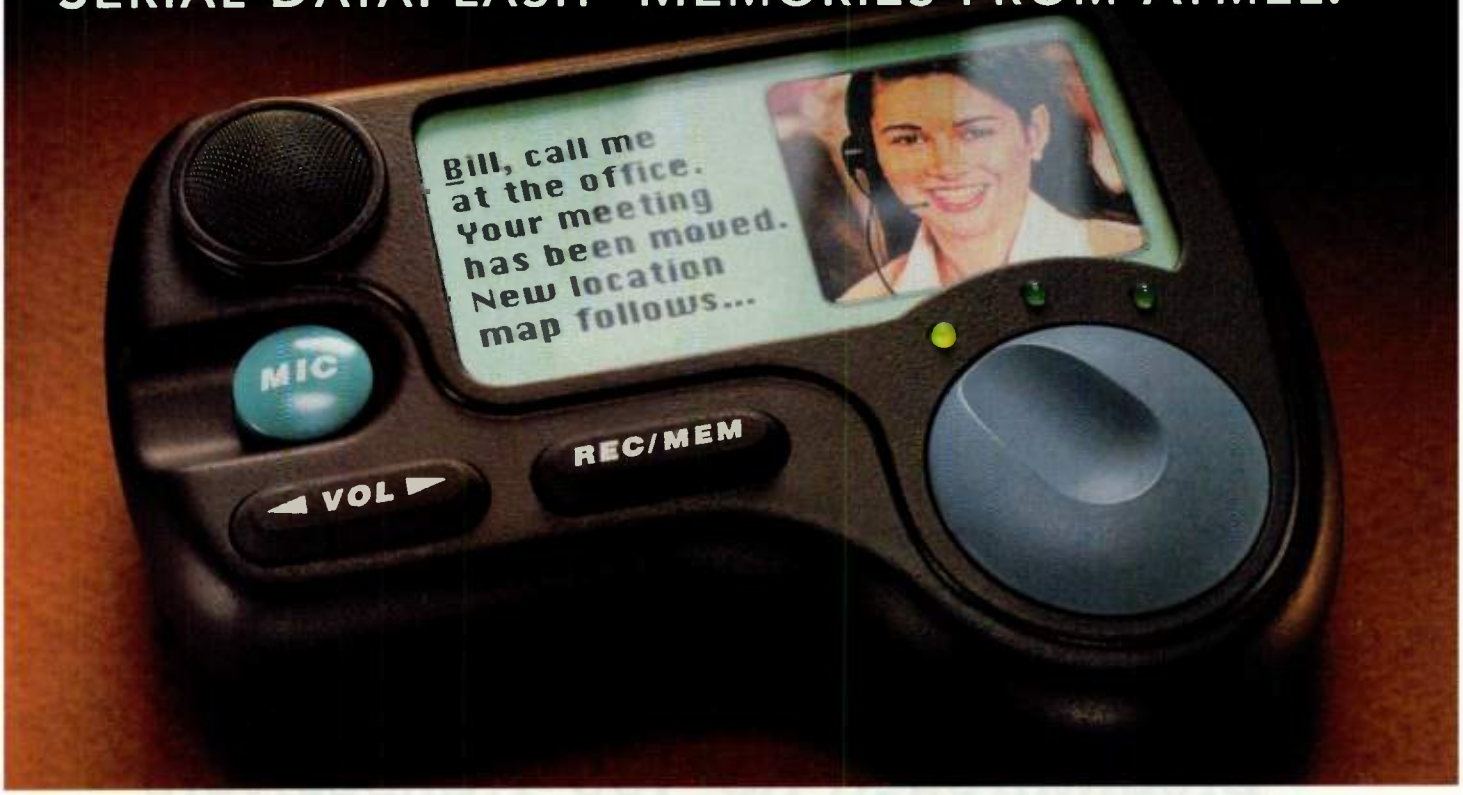

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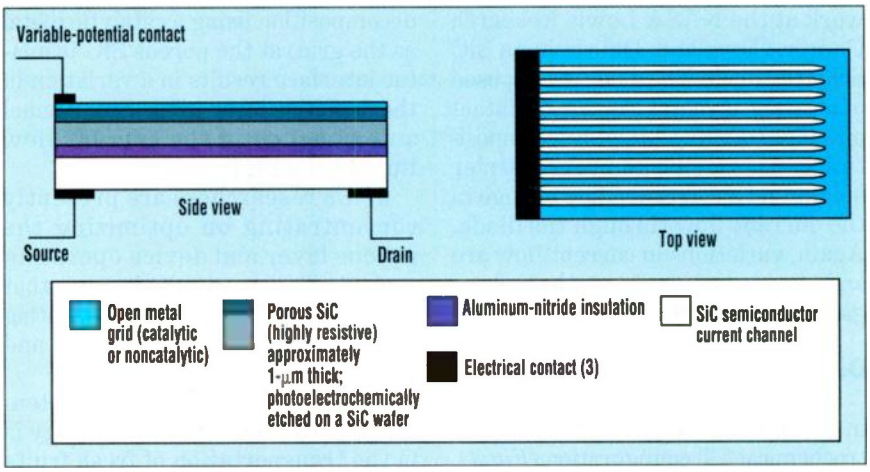
Tiny Single-Chip Sensors Based On Silicon-Carbide Technology Show Promise For Detecting Hydrocarbons In The PPM Range

If researchers at the Jet Propulsion Laboratories can obtain the necessary funding, we may very well see a new generation of single-chip sensors that can detect and distinguish among classes of hydrocarbon gases in the ppm range. Based on silicon-carbide (SiC) technology, a wide-bandgap material, the tiny sensors, less than 1 cm^2, have been fabricated and successfully tested.

Such a sensor has wide applications in automotive, industrial, commercial, and space applications. And if it can be produced inexpensively, it could have an even bigger future. "We're talking about a tiny sensor that can be produced for less than $20," claims Dr. Virgil B. Shields, one of three scientists at JPL working on the project. "With the right funding, it can be produced in one to one and a half years," he adds. The other two scientists are Dr. Margaret A. Ryan, and Dr. Roger M. Williams.

The JPL microsensor works by dissociation or electrochemical reaction of hydrocarbons at temperatures in excess of 200°C, in a thin layer of porous SiC. Such temperatures are beyond the electrical operational range of narrow-bandgap semiconductors such as silicon. Thermal excitations of charges at temperatures near and above 300°C results in excessive noise and failure of the switching abilities of silicon electronic devices.



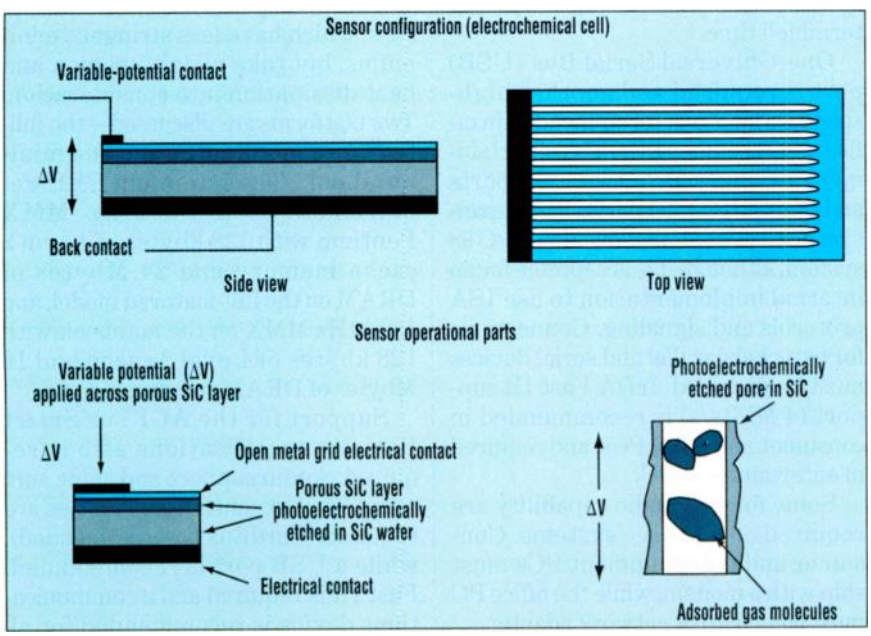
2. Experimental SiC-based hydrocarbon gas sensor, developed at JPL, in the FET configuration.

To detect minute concentrations of hydrocarbon gases, the sensor absorbs or adsorbs the gases in an electrochemically prepared nanoporous SiC layer. This thin layer is highly resistive, and is etched on top of a SiC substrate. A noncatalytic contact metal is placed on the backside of the SiC substrate while an open-grid metal contact is placed on the top of the nanoporous layer. Hydrogen gases are adsorbed inside the nanoporous SiC layer through the openings of the grid.

A varying voltage potential is placed across the layer between the grid and back contacts. Detected hydrocarbon gases are electrochemically dissociated on (or in) the surfaces of the pores. The potential at which this decomposition occurs varies for different classes of hydrocarbon gases as a function of the bond in the hydrocarbon molecule.

The voltage sweep and the resulting threshold changes make the sensor act like a spectrograph for different classes of hydrocarbon gases. Thus, besides being able to detect hydrocarbon gas concentrations, the JPL sensor also can distinguish between the types and classes of hydrocarbon gases.

There are at least two other SiC efforts underway developing a hydrocarbon-gas SiC sensor. But unlike the JPL effort, the other two use catalytic decomposition instead of electrochemical dissociation. One of these efforts involves work at Linkoping University, Sweden. Their sensor is composed of a metal-oxide semiconductor capacitor formed from a catalytic metal layer on top of a SiO_2 layer on SiC. Catalytic decomposition causes an ion buildup at the metal-oxide interface which changes the applied-



1. Experimental SiC-based hydrocarbon gas sensor, developed at JPL, in the electrochemical cell configuration.

voltage difference across the capacitor. The voltage variation is an indicator of varying hydrocarbon gas concentrations.

The other development involves work at the NASA Lewis Research Center, Cleveland, Ohio using a SiC Schottky diode. The diode is composed of a catalytic metal electrical contact on a layer of SiC. Catalytic decomposition causes a charge in the barrier height and a corresponding change in the current flow through the diode. Again, variations in current flow are an indication of varying hydrocarbon-gas concentrations.

Different Configurations

JPL's microsensor can be fabricated in one of two configurations: an electrochemical cell configuration *(Fig. 1)*, or a MIS-FET transistor configuration *(Fig. 2)*, where the nanoporous layer (with the open grid on top) forms the device's gate on top of an insulating layer. This insulating layer separates the gate from a SiC current channel in the FET. Ionic buildup due to electrochemical dissociation (possibly with the enhancement of catalytic decomposition using a catalytic metal as the grid) at the porous SiC-insulator interface results in a variation in the depletion layer in the SiC channel and a change in the current flow through the FET.

JPL's researchers are presently concentrating on optimizing the porous layer and device operating regimes. To date, results indicate that the sensor will be capable of operating at temperatures as low as 200°C and and as high as 500°C.

One of the more interesting potential applications of this technology is in the transportation of fresh fruits and vegetables. Fresh produce normally releases ethylene, a hydrocarbon gas, as it decays. Using an inexpensive microsensor like the JPL device placed among the food will allow produce vendors to monitor the condition of fruits and vegatables while in transit and know when they are no longer fresh.

Besides the obvious automotive application of detecting exhaust gases, another application is in the remote measurement of the degradation of industrial lubricants.

Still another application can be found in remote sensing of the health of human environments on Earth or in space. In fact, the original intent of this sensor was to remotely monitor conditions on space craft.

Presently, there are no commercial microsensors capable of detecting hydrocarbon gases. Only large and costly mass spectrometers and gas analyzers are available to do the job.

For more information, contact JPL's Dr. Shields at (818) 354-9506; e-mail: virgil.shields@jpl.nasa.gov.

Roger Allan

PC 98 Specification Provides Hardware Design Guides For Building Consumer, Office, And Entertainment PCs

At the recent Windows Hardware Engineering Conference (WinHEC), Intel and Microsoft released details of the PC 98 specification. According to the draft document, "The goal of the PC 98 specification is to provide hardware design guidelines that will result in a positive user experience, particularly when used with the Windows family of operating systems." Specifically, it refers to the upcoming releases of the Windows NT 5.0 and Memphis operating systems (Memphis is the code name for the follow-up to Windows 95).

Three types of systems are defined in the proposal—the consumer PC, the office PC, and the entertainment PC. In all three platforms, the minimum CPU performance level is a 200-MHz Pentium processor with MMX technology, a 256-kbyte secondary cache memory, and 32 Mbytes of system DRAM (64 Mbytes is recommended). Support for the Advanced Configuration and Power Interface (ACPI) and OnNow initiative is required. ACPI enables the operating system to invoke power-savings features. An OnNow-enabled PC is ready for use immediately when the user presses the "on" button. In the "off" mode, the PC is perceived to be off but is still capable of responding to wake-up events, such as a telephone ringing or software that has requested the PC to wake up at a predetermined time.

One Universal Serial Bus (USB) port is required and another high-speed serial bus is recommended in office and consumer PCs. The entertainment PC must have two USB ports and two IEEE 1394 ports. ISA expansion devices are not allowed in a PC 98 system, although it is acceptable for an internal implementation to use ISA protocols and signaling. Connections for external parallel and serial devices must be provided. IrDA Fast IR support (4 Mbits/s) is recommended in consumer and office PCs, and required in entertainment PC.

Some form of audio capability are required on all three systems. Consumer and entertainment PCs must ship with a modem, while the office PC must come with a network adapter.

The minimum display capabilities on all systems is 1024 by 768 pixels at 16 bits/pixel. NTSC or PAL TV output is recommended on consumer and office PCs and required on entertainment PCs. DVD-Video and MPEG-2 playback capabilities are required on all PCs.

There's a special section for mobile PCs, which have less stringent minimums, but take weight, power, and heat dissipation into consideration. Two platforms are discussed—the full-featured mobile PC, and the mini-notebook. The minimum CPU requirement is a 166-MHz MMX Pentium with 128 kbytes of Level 2 cache memory and 24 Mbytes of DRAM on the full-featured model, and 120-MHz MMX on the notebook with 128 kbytes of Level 2 cache and 16 Mbytes of DRAM recommended.

Support for the ACPI or Smart Battery specifications also is required. Audio support and some sort of external expansion capabilities are required (CardBus is recommended), while a USB port is recommended. Fast IR is required and a communications device is recommended for all portables. Minimum display capabilities on the full-featured model are 800

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by 600 pixels at 16 bits/pixel or 1024 by 768 pixels at 8 bits/pixel. The notebook model demands 640 by 480 pixels at 8 bits/pixel. MPEG-2 and DVD-Video support is recommended but not required. There also are a host of docking-station specifications.

More information on the PC 98 specification, including guides with technical clarifications and answers to frequently-asked questions can be found on the Internet at: *http://www.microsoft.com/hwdev/deguid/* or *http://developer.intel.com/pc98/*.

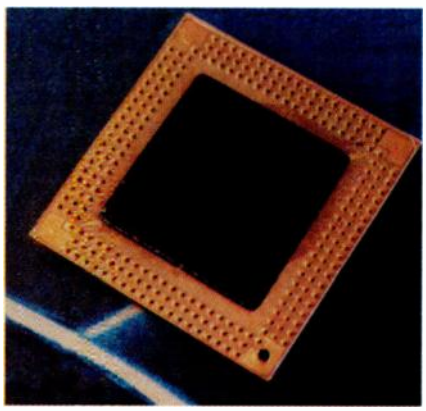
Richard Nass

Advanced IC Packaging Technology Uses Polymer For Pins And Housing

Pin density, heat-dissipation ability, and price are the major factors chip manufacturers considerwhen deciding the IC package in which to house a device.Traditional lead-frame-based packages with peripheral I/O pads are in the process of reaching their technological limits. That's why engineers at Imec/Belgium (Leuven, Belgium) and Siemens Laboratories (Oostkam, Belgium) set out to develop a new type of area array package with significant advantages over traditional package construction.

The new housing not only offers a higher packaging density, but delivers major price advantages while providing good thermal capabilities. At first glance, the Polymer Stud Grid Array (PSGA) package looks like a cross between a conventional ball-grid array (BGA) and a pin-grid array (PGA). However, the PSGA consists of a plastic-injection molded body *(see the figure)* with a cavity for chip mounting, in which the die is mounted face down toward the printed-circuit board (pc board). The pins, which make contact with the pc-board substrate, are made of a polymer/metal combination, where the metal is just a coating. Because these pins are less metallic and more plastic they are called studs. The studs measure 400 µm in diameter, are 500 µm long, and have and a pitch of 1 mm.

With this type of stud, the mechanical strain caused by the thermal mismatch between the package and the board is relieved. In other words, the coefficient of expansion of a mostly plastic stud more closely matches that of the pc board than a metal pin so there is less stress between the board and package that could break the connection between them. In contrast to a BGA, no solder-ball attachment step is required even though a PSGA has similar characteristics. Furthermore, a PSGA is able to automatically correct a placing misalignment of up to 250 µm when it is placed onto a pc board.



Fabricated mainly from polymer material, this Polymer Stud Grid Array (PSGA) integrated circuit package offers higher density and better thermal handling capabilities than conventional pin-grid array and ball-grid array packages.

For evaluation purposes, the package design team created a PSGA package measuring 25 mm by 25 mm. The package offers 232 I/O studs at a pitch of 1 mm in three rows around the cavity. The size of the cavity to hold the die is 13 mm by 13 mm. Currently, the studs may be arranged in up to four rows at a 1-mm pitch, while a five-row configuration is under investigation. The biggest PSGA size which can be realized at the moment is a bit smaller than 40 mm by 40 mm with up to 500 I/Os arranged in four rows. Assuming a 150-µm bond pitch, the maximum die size would be about 19 mm by 19 mm. A bond pitch of 200 µm would allow cavity sizes almost up to 25 mm by 25 mm. The package is realized using chip-in molded-interconnect-service (CIMID) technology. This technology allows for low cost fabrication of the device because only a small number of steps are required. Additionally, injection-molding processes for polymers are a lot cheaper than the production steps needed for making a ceramic package like the PGA or BGA.

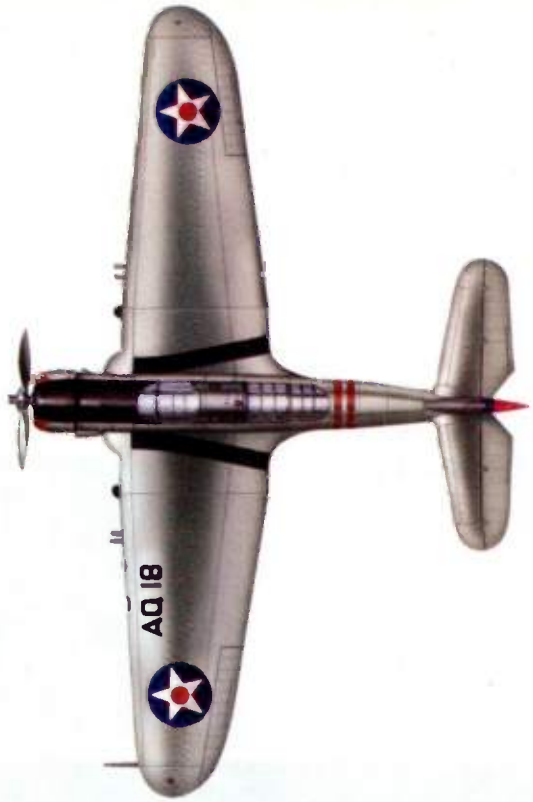
In terms of the process flow for manufacturing this package there are a number of steps. First, the package body is created in an injection-molding process that allows the use of different types of thermoplastic materials. Then the metallization of the plastic body is performed by applying a wet-chemical process. The third step is the patterning of a metal-resist layer by means of a high-speed 3D-laser process (Nd-YAG laser). For the evaluation package described above, positioning and patterning of the entire package only took eight seconds. After a wet-chemical etching process of the copper metallization in the fourth step, comes an electroless deposition of a NiP layer which is followed by a thin flash of gold to make up the fifth and last step.

The NiP/Au finish offers good solder and wire bond properties, enabling both ultrasonic Al bonding and thermosonic Au ball-wedge bonding. After the chip is mounted in the cavity, it may be protected by using a simple glob-top encapsulation process. As the cavity of the PSGA forms a natural barrier for the encapsulation liquid, a low-viscosity encapsulant may be used enabling a wide process window and minimizing the amount of encapsulation material needed.

Because the chip is mounted in a cavity of the PSGA, the overall thickness of the PGA-to-board assembly can be very small, typically about 1.5 mm to 2 mm. The flat, metallized backside distributes the heat from the chip quite well. These thermal characteristics may be significantly improved by using a metal slug molded in the package. This slug then forms the bottom of the cavity to which the die is mounted.

For additional material on PGSA packaging, contact Marcel Herman, c/o Siemens LPT, Oostkamp, Belgium; (011) 32 (50) 832550; fax: (011) 32 (50) 832553; e-mail: Marcel.Herman@pt.Oost.Siemens.Net or Eric Beyne c/o Imec, Leuven, Belgium; (011) 32 (76) 287267; fax (011) 32 (76) 287507; e-mail: Beyne@ IMEC.BE.

Alfred Vollmer



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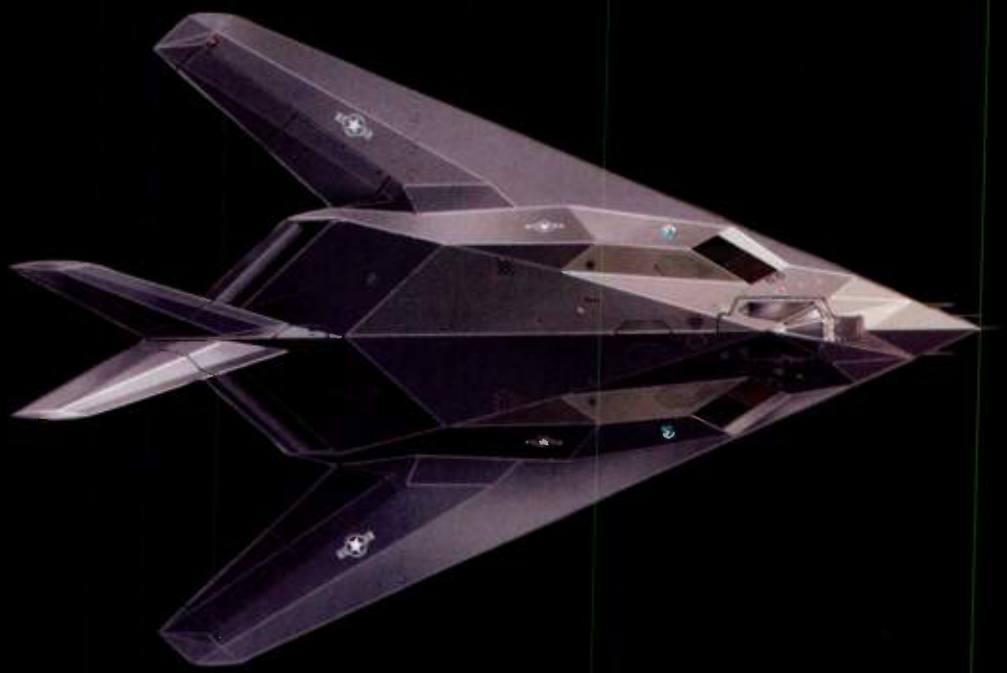

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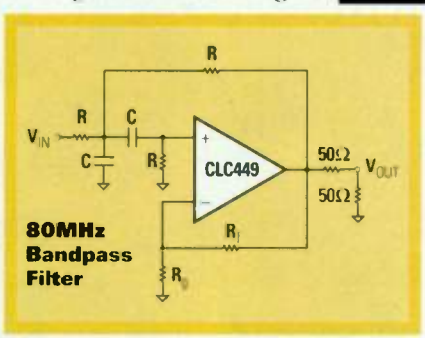

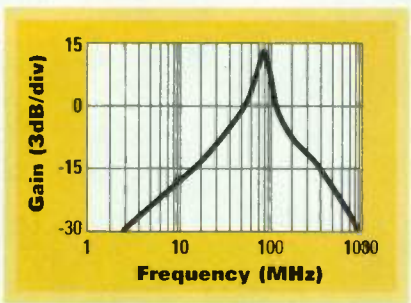

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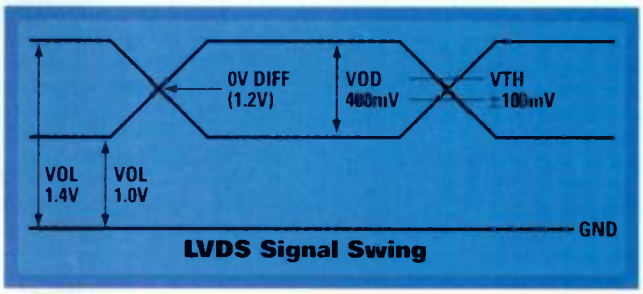

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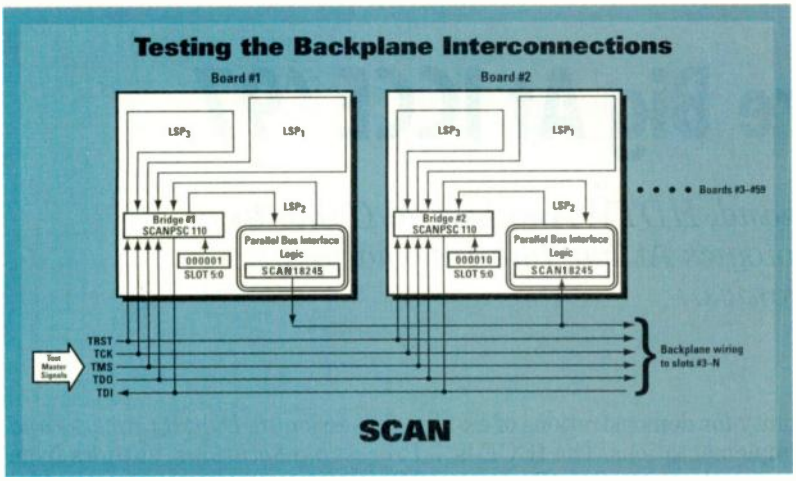

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CONFERENCE PREVIEW

Video, PCS Score Big At ICCE '97

Interactive Video, Video-On-Demand, HDTV, And Digital Cameras Are Among The Featured Technologies At The 16th International Conference On Consumer Electronics.

By John Novellino

The rapidly growing—and changing–consumer electronics industry will pause for a moment for its annual exchange of information on new technologies as the 16th International Conference on Consumer Electronics (ICCE) gets underway in Chicago, Ill. In addition to traditional topics like audio, video, HDTV, displays, recording, and multimedia, this year's paper sessions include new topics like DVD, digital cameras, video servers, and personal communications, according to conference organizers.

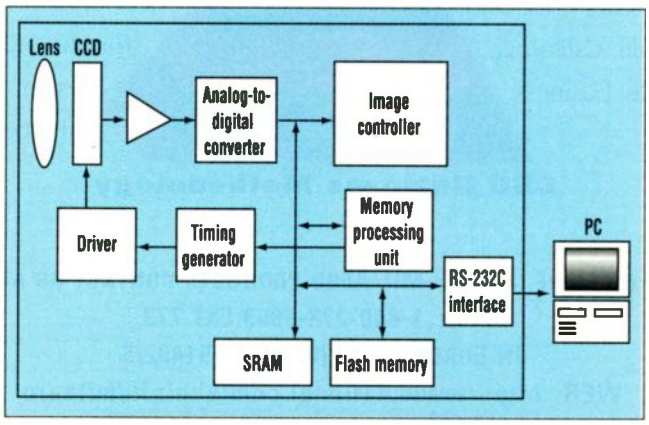
A total of 195 papers were selected out of 296 submitted for presentation in the 24 paper and three poster sessions. "I'm delighted that 1997 provided us with a record number of paper submissions," says Werner Wedam, director of Sharp Laboratories of America and this year's technical program chairman. "Because of this, we are in a position to provide an extremely high-quality program at a time when emerging technologies are becoming increasingly important to the consumer electronics industry."

The conference's technical sessions and the accompanying exhibits are scheduled for June 11-13 at the Westin Hotel O'Hare *(see the Table)*. Additionally, eight tutorial sessions are scheduled for Monday evening, June 9, and all day Tuesday, June 10. The poster sessions will be held in a new setting that allows an opportunity for demonstrations of example implementations. The ICCE is sponsored by the Consumer Electronics Society of the IEEE.

On Thursday evening, a panel discussion, led by Stuart Lipoff of Arthur D. Little Inc., Cambridge, Mass., will delve into "Electronic commerce and consumer Internet services." The panel will include representatives from manufacturers, service providers, content producers, and third-party firms performing clearing house and financial services. The discussion will revolve around questions like which transport services will grow and prosper, will the Internet "melt down" under the expected heavy load, and what are the trends and directions in the development of unique local and consumer-based content. Other issues include security and privacy problems and solutions.

In session 18, *Digital Cameras and Processing Solutions*, authors from Mitsubishi Electric Corp., Nagaokakyo City, Kyoto, Japan, describe how they developed "Credit card-sized digital still cameras (CDSC)." Their camera measures only 62 by 107 by 8.5 mm (lens closed, 12.3 mm with lens open). The project included writing new signal-processing software to ensure high-quality images.

The camera uses a CCD whose output is initially stored in SRAM *(Fig. 1)*. A memory processing unit transfers the signals from SRAM to a 2-Mbyte flash memory. The camera stores up to 15 images in the form of cyan + white, yellow + green, cyan + green, and yellow + white signals from the CCD. The user transfers these signals to a PC through a serial interface. There, the new software converts the images to RGB signals.



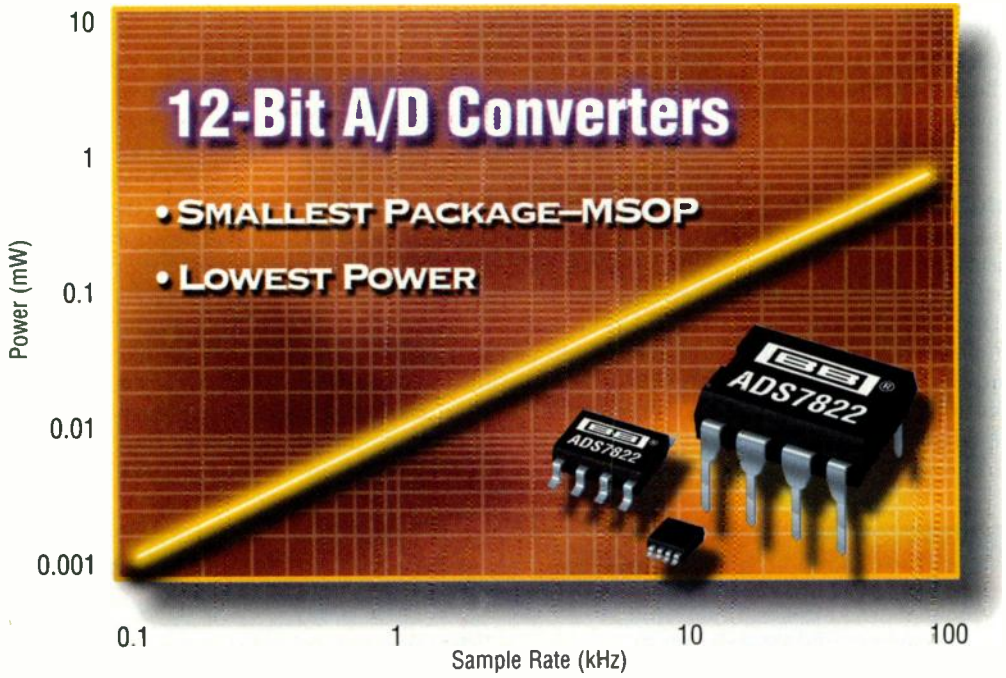
1. A credit-card-size digital camera stores 15 images in flash memory for transfer via a serial port to a PC, where specially written signal processing software converts the data to an RGB picture.

To improve resolution, the software uses a two-dimensional interpolating process. The signals are interpolated by using other color signals from adjacent pixels and multiplying by a correlative ratio of the low-frequency component of those color signals. The RGB signals are calculated from the resulting signals. The authors say this technique allows for a doubling of the apparent number of sampling points vertically and horizontally for each color filter.

The software also handles a

microPOWER

AND THE PRECISION YOU EXPECT



ADS7822—12-Bit, 60µW at 7.5kHz Sample Rate

When smaller is better and performance is essential, **ADS7822** is your solution for a high speed 12-bit, micro power sampling A/D converter. With guaranteed specifications over a 2.7V to 3.6V supply range, ADS7822 requires very little power even when operating at the full 75kHz rate. Its high speed allows the device to remain in power down mode most of the time—dissipation is less than 60µW at 7.5kHz—great for battery operated systems. ADS7822 also features 2V to 5V operation, synchronous serial interface, and differential input. ADS7822's low cost also makes it ideal for simultaneous multi-channel systems and remote data acquisition modules.

Key Specifications

Micro Power.....0.54mW at 75kHz
0.06mW at 7.5kHz

Supply Voltage 2.7V

Power Down.....3µA

Packages: 8-Pin DIP, SOIC, MSOP

Pricing is **$4.64** in 1000s

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Products	Resolution (Bits)	INL (LSB)	NMC* (Bits)	Sample Rate (kHz)	Power (mW)	SINAD (dB)	THD (dB)	FAX*LINE#*	Reader Service #
ADS7816	12	±1	12	200	1.9	72	–84	11355	81
ADS7817	12	±1	12	200	2.3	71	–83	11369	82
ADS7822	12	±0.75	12	75	0.54	71	–82	11358	83
ADS1286	12	±1	12	20	1	72	–85	11335	84

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problem inherent in CCD cameras using complementary color filters. In these systems, the saturation level of each color is different, causing color distortion in a bright environment. The software looks for saturation and makes corrections to reduce false colors.

Using this external software allowed the team to minimize the number of components needed in the camera, thus making it smaller. The camera weighs 75 g, without its lithium-ion battery. It offers quarter-VGA resolution (320 by 240) with 24-bit color.

Delivering Interactive Video

Interactive video has been a favorite topic for some time. Before it can be widely implemented, however, a transmission medium must be selected. Candidates include hybrid fiber-coax, fiber-to-the-curb, and fiber-to-the-home, according to David Mark Harrison, Thomson Multimedia R&D, and Jean-Charles Point, Thomson Broadcast Systems, France. The per-subscriber costs of these alternatives are high, especially early on when subscribers are few. In fact, "last mile" connections typically represent over 80% of the cost of a cable system, they note.

Instead, Harrison and Point propose a 40-GHz microwave multipoint distribution system (MMDS) in Session 3. Their architecture employs an optical fiber network backbone to carry signals between the supplier and local broadcast facilities. At that point, the microwave system makes the final connection to the subscriber. Rain attenuation at 40 GHz limits the range of a practical system to less than 5 km, but that shouldn't prevent implementation, say the authors.

The European Conference of Postal and Telecommunications Administrations has already allocated a 40.5- to 42.5-GHz band for MMDS use, and the Digital Video Broadcast Group is preparing European transmission standards for interactive services using 40-GHz MMDS. The paper reviews these standards and their effect on the proposed system.

The authors also compare two possible modulation schemes: direct optical modulation at 40 GHz and intermediate frequency (1 to 5-GHz) modulation. A proposed low-cost architecture for a subscriber unit is detailed. The authors say that for subscription rates of up to 70%, the hybrid fiber-wireless network still costs significantly less than a hybrid fiber-coax network.

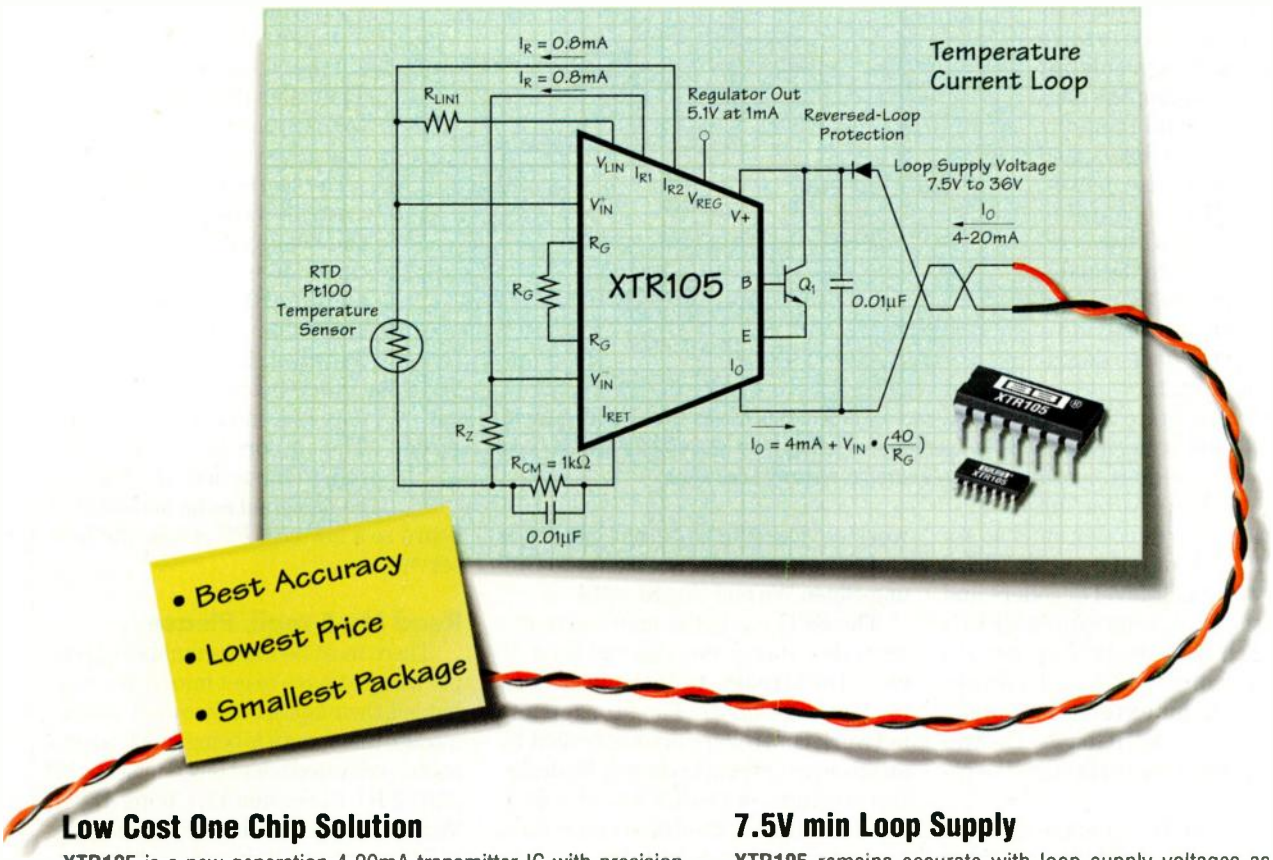
HDTV should be a reality in the U.S. within the next year now that the FCC has approved a digital standard for implementation. Since the agency also ruled that the old analog standard will eventually be dropped, there will be a huge market for new TV components over the next several years. A group of authors from Lucent Technologies' Bell Laboratories, Murray Hill, N.J., and Mitsubishi in Japan and

1997 ICCE TECHNICAL SESSIONS

Monday, June 9					
6:00-9:30 p.m.	**MPM-1** Overview of ATSC standards (Tutorial)		**MPM-2** Digital video disc–How it works (Tutorial)		
Tuesday, June 10					
8:00-11:30 a.m.	**TUAM-3** Fundamentals of digital video (Tutorial)		**TUAM-4** Digital mobile communications (Tutorial)		
1:00-4:30 p.m.	**TUPM-5** Basics of MPEG video and audio compression (Tutorial)		**TUPM-6** Digital broadcast communications (Tutorial)		
6:00-9:30 p.m.	**TUPM-7** MPEG-2 transport (Tutorial)		**TUPM-8** Introduction to object-oriented technology (Tutorial)		
Wednesday, June 11					
8:30-11:45 a.m.	**WAM-1** Software platforms and architectures	**WAM-2** Non-MPEG compression: Quality improvement	**WAM-3** DBS and MMDS	**WAM-4** Digital video recording	
2:30-5:40 p.m.	**WPM-5** Video servers and networks	**WPM-6** Non-MPEG compression: Algorithms and implementations	**WPM-7** Terrestrial, cable, and satellite modulation systems	**WPM-8** Optical disc system and coding	
Wednesday, June 12					
8:30-11:45 a.m.	**THAM-9** Multimedia: Components and applications	**THAM-10** MPEG codec algorithms	**THAM-11** RF techniques	**THAM-12** Audio coding and applications	**P-1** Compression algorithms (Poster)
2:00-5:40 p.m.	**THPM-13** Multimedia: Algorithms and methodologies	**THPM-14** MPEG codec ICs	**THPM-15** RF LSI technology	**THPM-16** Audio signal processing	**P-2** Video processing and new television applications (Poster)
8:00 p.m.	**Evening Panel Session** Electronic commerce and consumer Internet services				
Friday, June 13					
8:30-11:45 a.m.	**FAM-17** Home network applications	**FAM-18** Digital cameras and processing solutions	**FAM-19** RF techniques	**FAM-20** Personal communications I: Systems technology	**P-3** Consumer applications
1:15-4:15 p.m.	**FPM-21** Displays and related circuits	**FPM-22** Video signal processing	**FPM-23** High-speed ADC and DAC	**FPM-24** Personal communications II: Implementations	

4-20mA

New Generation Transmitter IC



Low Cost One Chip Solution

XTR105 is a new generation 4-20mA transmitter IC with precision on-board linearization circuitry. Its low-drift instrumentation amplifier input stage beats bulky discrete op amp circuits. Laser trimmed performance eliminates troublesome adjustments and reduces your manufacturing costs. Versatile excitation current sources (two, 800µA) are suited to a wide range of sensors including RTDs, bridges, potentiometers and others.

RTD Linearization

Simple on-board circuitry corrects the nonlinearity of platinum RTD temperature sensors for highest overall accuracy. XTR105 is simply your best and lowest cost solution for 4-20mA loop transmitters.

Power for External Circuits

XTR105 even has a 5.1V regulated output—great for powering external circuitry. Up to 1mA is available for signal pre-conditioning circuitry or sensor excitation.

7.5V min Loop Supply

XTR105 remains accurate with loop supply voltages as low as 7.5V, allowing plenty of headroom for diode reversed-loop protection. A complete 4-20mA current loop can easily be run from a standard 12V PC supply.

Key Specifications

- Loop Supply Voltage.....7.5V to 36V
- Offset Voltage Drift .....0.4µV/°C
- Dual Current Sources For Sensor Excitation 800µA
- Packages .....SO-14 Surface-Mount, 14-Pin DIP
- $3.75 in 1000s

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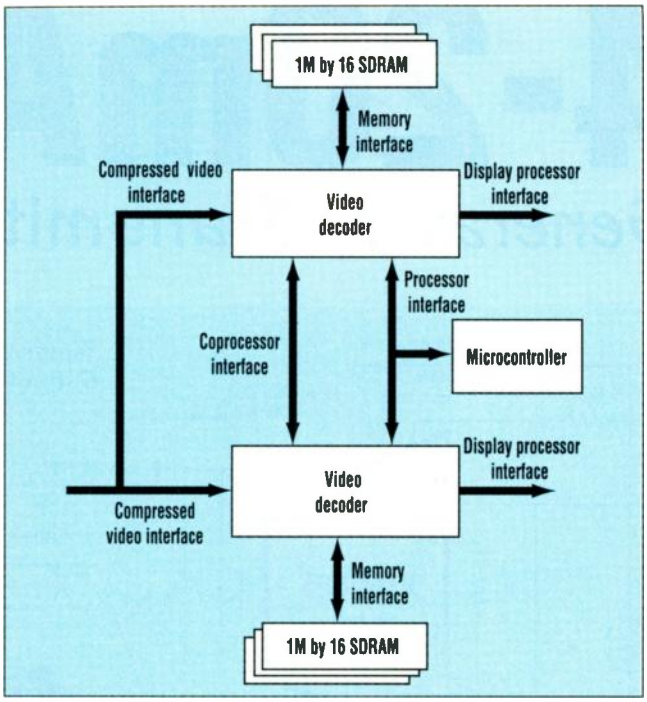
Somerset, N.J., describe one contender in their paper, "An HDTV video decoder IC for ATV receivers," (Session 14).

The chip decodes MPEG-2 main-profile, high-level video such as 1920 by 1088 interlaced at 60 fields/s, 1920 by 1152 interlaced at 50 fields/s, and 1280 by 720 progressive at 60 frames/s. A dual-decoder architecture was used to solve three key design problems: The 62,668,800-sample/s data rate, the external memory bandwidth of 6.5 Gbits/s, and the need to keep size, power, and cost within acceptable consumer limits. With this architecture, two identical decoders, external SDRAM, and a microcontroller provide a complete HDTV video decoding solution *(Fig. 2)*.



2. A dual-decoder architecture allows this video decoder IC to meet HDTV specifications calling for a 62,668,800-sample/s data rate and 6.5-Gbit/s external memory bandwidth.

The IC can operate in a single- (31,334,400 samples/s) or dual-decoder mode (for full HDTV resolution). At the full HDTV rate, the decoder runs at six times the rate of current MPEG-2 main-profile, main-level decoders and 24 times the processing rate of MPEG-1 units. Each of the dual units processes and outputs one-half of each picture and supports an external memory bandwidth of about 3.5 Gbits/s. The two decoders communicate through the coprocessor interface.

The decoder IC incorporates 1.5 million transistors and is fabricated in Mitsubishi's 0.35-µm CMOS ECA process. It operates at 3.3 V and dissipates 3 W in a 225-pin plastic BGA package. The device is one of six in the Mitsubishi/Lucent Technologies ATV decoder chip set.

Another hot video topic is video-on-demand, a capability that will require storing and handling of very large amounts of digital video. Two authors from the Computer Communication Research Labs at ITRI, Hsinchu, Taiwan, describe a generic video access device called a stream-pumping engine (SPE) that can serve as a basic building block for digital multimedia systems. The SPE integrates both the storage and network controllers on one board, allowing more efficient connection of storage devices like SCSI hard disk drives and digital tapes, as well as network devices like Ethernet interfaces and EtherSwitches, according to Chiung-Shien Wu and Gin-Kou Ma.

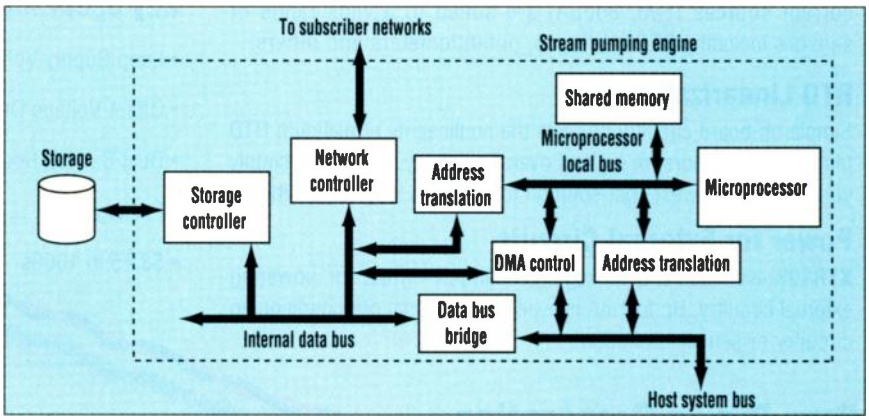
The SPE reads the media streams from the storage devices and then directs the streams to the subscribers' networks *(Fig. 3)*. The storage and network controllers are controlled by an on-board microprocessor. Basically, the storage controller has the SPE read a block of media stream data from the storage device, through the internal bus, and to the shared memory, which acts as a buffer. The network controller reads the data from the shared memory to the subscriber's network. These steps can be repeated as often as necessary for continuous access and playing.

The authors say the SPE can handle several subscribers running the media streams interactively, and multiple SPEs can be connected to form a media server host, which can accommodate a larger number of subscribers simultaneously. They also describe an interconnection structure for such a larger system.

The shared memory and two controllers are connected to the host system bus so they can be accessed by the host or another SPE located on the same host. This function is handled by the data bus bridge between the internal data bus and host system bus. The authors say the host will be a PCI bus and the SPE will be designed as an add-on PCI board so a low-cost PC can be the host server.

Read My E-mail, Please

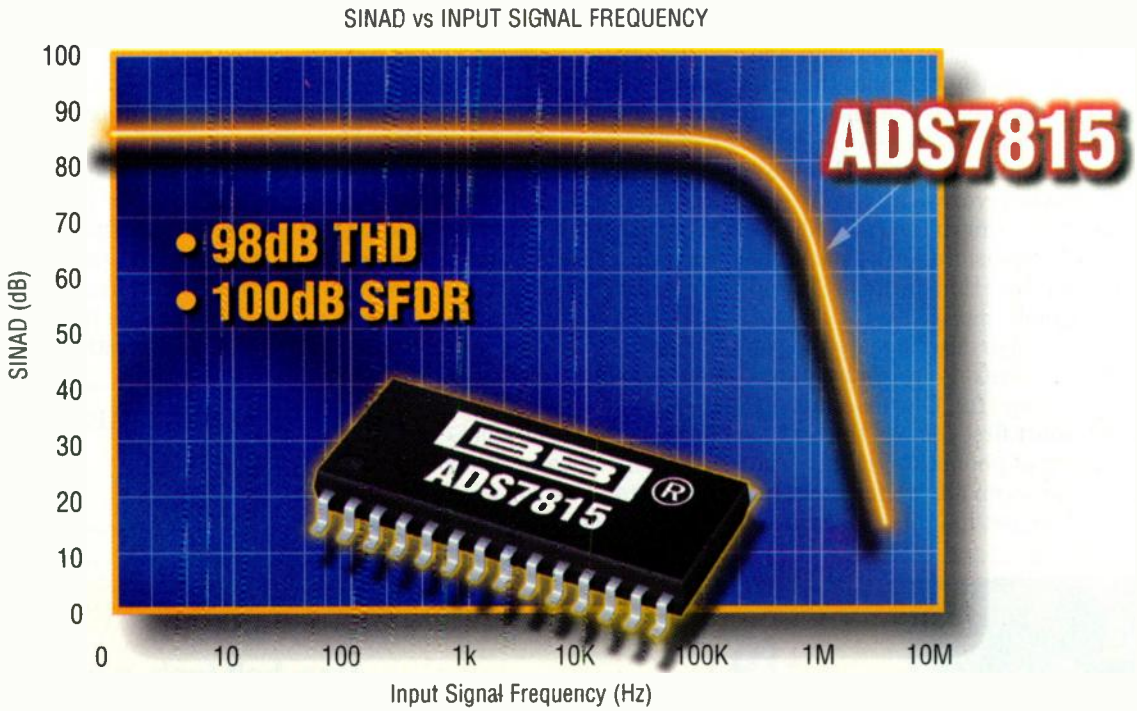
There must be a large number of people who just have to get into their e-mail but left their laptops at home. To accommodate them, work is being reported on a speech-activated telephony e-mail reader (SATER). In Session 17, Chung-Hsien Wu and Jau-Hung Chen of the Institute of Information Engineering at the National Cheng Kung University, Tainan, Taiwan, describe a system combining speaker verification, network, and text-to-speech conversion. The system



3. A stream-pumping engine for video applications includes both storage and network controllers on the board, which allows more efficient connection of both storage and network devices.

250kHz

Fastest 16-Bit A/D On The Market



ADS7815—Fast, 16-Bit A/D Samples at 250kHz

ADS7815 is a 16-bit monolithic capacitor-based SAR A/D converter complete with S/H, precision reference, clock, µprocessor interface, and 3-state output drivers. With typical specifications of 98dB THD and 100dB SFDR, ADS7815 offers outstanding AC performance—ideal for multi-channel data acquisition systems. Its ±2.5V input range allows development of precision systems using only ±5V supplies. ADS7815 is your solution of choice for ATE, wireless base stations, and CCD applications.

Key Specifications

- SINAD at 100KHz ..... 84dB min
- THD at 100KHz 98dB
- Full Power B/W 1MHz
- Full Parallel Data Output w/Latches
- Internal or External Reference
- 28-Lead SOIC
- Priced from $20.00 in 1000s.

Products	INL (LSB)	NMC* (Bits)	Sample Rate (kHz)	Power (mW)	SINAD (dB)	THD (dB)	Resolution (Bits)	FAX*LINE* Number	Reader Service #
ADS7813	±2	16	40	30	87	–96	16	11302	85
ADS7815	±4(Typ)	15	250	250	84	–96	16	11364	86
ADS7821	±3	16	100	100	86	–94	16	11323	87
ADS7825	±2	16	40	50	86	–90	16	11304	88

*No Missing Codes. *For Technical Information: http://www.burr-brown.com/Ads/ADS7815-Ad.html*

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would allow a registered subscriber to listen to e-mail through any telephone.

To use the system, the subscriber first states his or her e-mail address and password. The SATER then asks the user to speak his pre-assigned ID number, which is encoded using error-control coding techniques in order to tolerate recognition errors. For increased security, the SATER then reads the user a digit string randomly selected from a list of 20 strings the user has previously read into the system. If the readback is a match, the SATER server retrieves the subscriber's e-mail in Post Office Protocol (POP3) Mail Server via a TCP/IP link. An anti-speaker model and prosodic information representing the speaking style and intonation of the user help protect against improper use.

In the system described by the paper, the e-mail text is an arbitrary Big-5 code string (for Chinese) so the SATER must first convert the text to a sequence of phonetic symbols. The conversion even allows for emotion markers (anger, happiness, sadness, fear, disgust, and grief) that the e-mail sender can tag in the original text. The conversion subsystem first analyzes the text for punctuation, Arabic numerals, and Chinese characters. It then performs a dictionary lookup of word pronunciation and rules for exceptions and unusual cases. The final synthesized speech includes varied prosodic and spectral characteristics from a large, single-speaker database.

Battery life is always a major concern when designing portable systems, especially cellular phones and PCS units. A new modulation scheme and RF architecture can potentially extend battery life significantly. The technique is described in Session 20 by Yanpeng Guo of the Department of Electrical and Computer Engineering at the University of Missouri-Columbia/Kansas City.

Guo notes that conventional constant-envelope modulation techniques offer good system power efficiency, but they generally have a low spectrum efficiency, another very important parameter for wireless systems. Instead, he proposes introducing controlled cross-correlation to the I and Q channels in an offset QPSK system and using modified baseband filtering techniques. The result is a much smaller envelope-fluctuation factor and so a more efficient power amplifier can be used, according to the paper. Guo reports that his technique improves power efficiency by 4 to 7 dB compared to conventional QPSK.

The author evaluated bit error rate and the error floor characteristic of the system in nonlinear-amplified Rayleigh fading channels corrupted by co-channel interference and delay spreading. Based on this evaluation, he also analyzed system capacity and throughput. Other topics discussed are hardware implementation, measured results, and how to optimize the technique for a range of PCS and mobile communication applications.

How Valuable	Circle
Highly	540
Moderately	541
Slightly	542

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ADS1212/ADS1213

A Winning Solution for IPC Applications

ADS1212 and **ADS1213** are complete, wide dynamic range, 22-bit delta-sigma converters operating from a single +5V supply. ADS1212 is a single channel A/D; ADS1213 is a 4-channel multiplexed version. Both include a flexible synchronous serial interface which is SPI compatible, and a 2-wire mode for low-cost isolation. Burr-Brown's proprietary "Turbo" modulator mode of operation allows the ADS1212 and ADS1213 to achieve effective resolutions of 16 bits at a sample rate of 1kHz. Effective resolution of 22 bits is achieved by using a low-noise input amplifier at conversion rates up to 10Hz. V_{BIAS} generated from V_{REF} allow drift characteristics to track over temperature thus providing high accuracy for the complete application over temperature extremes found in industrial environments.

Key Specifications

- Differential Inputs
- Internal or External Reference
- 20 Bits Effective Resolution at 10Hz: 16 Bits at 1kHz
- Package Options:
  ADS1212—18-pin DIP, 18-lead SOIC
  ADS1213—24-pin DIP, 24-lead SOIC, 28-lead SSOP
- ADS1212 is priced from **$7.25** in 1000s;
  ADS1213 from **$8.15** in 1000s

Model	INL (%FSR)	DNL (Bits)	Resolution (Bits at 10Hz)	Resolution (Bits at 1kHz)	Power Dissipation (mW)	FAX*LINE*#	Reader Service #
ADS1210	±0.0015	No Missing Codes	24	20	26	11284	89
ADS1211	±0.0015	No Missing Codes	24	20	26	11284	90
ADS1212	±0.0015	No Missing Codes	22	16	1.4	11360	91
ADS1213	±0.0015	No Missing Codes	22	16	1.4	11360	92

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Just like a CRT, our new screen gives you full color and gray-scaling because it offers all-analog signal processing from input to driver. Images are exceptionally bright with a luminance of 200cd/m^2. With pixel arrays of 1,024 x 768, our screen features multi-scan capability. The 14.1" screen measures 330 x 255 x 22.5mm. It weighs 1,200g and consumes 17W.

NEC also offers smaller analog LCD modules for monitor applications. Our 13" module has 1,280 x 1,024 pixels; and the 12.1" screen has 1,024 x 768 pixels. If you want to make your monitor a star, add value, character and performance with an analog LCD module from NEC.

The right components to build your reputation

just imagine
NEC MULTIMEDIA

NEC

READER SERVICE 167

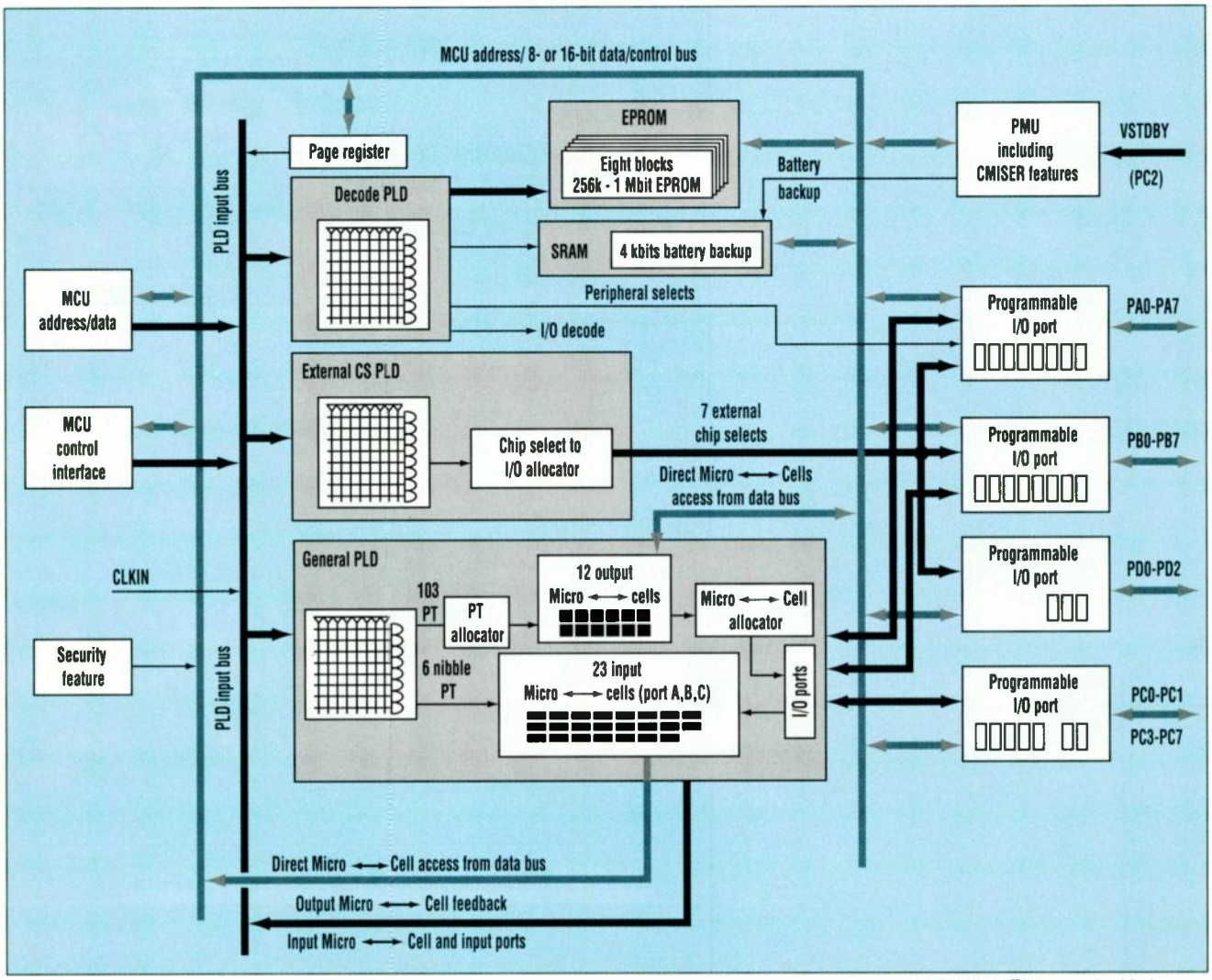
Programmable Chip Extends MCU Memory And Logic

System Support Gains Flexibility By Merging Programmable Logic, SRAM, EPROM, And An MCU Interface On One Chip.

Dave Bursky

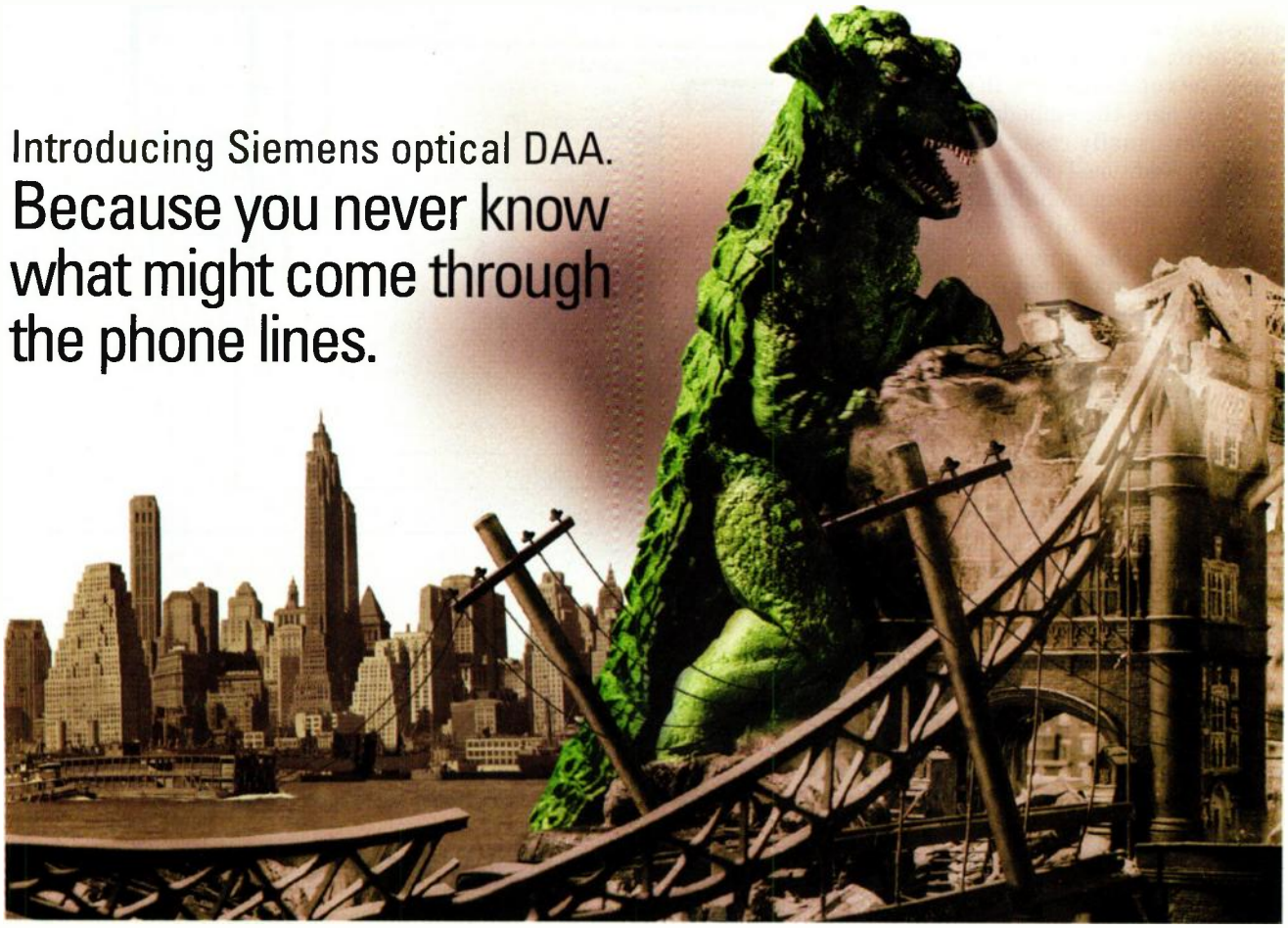
Systems that employ embedded processors often try to take advantage of highly integrated, single-chip microcontrollers to reduce component count and cost. When such chips don't provide a good match for the application, microcontrollers and support chips (memory and logic that provide either multiple standalone functions or a custom support chip) allow the designer build the desired system solution.

However, custom support chips can turn out to be costly if production volumes are low. Furthermore, employing multiple, commodity support chips can result in too many components. It also could mean excessive total power consumption. Both alternatives provide a fixed-function solution that cannot be updated if system functionality changes, forcing costly system redesigns.



1. The PSD6xx family of programmable chips from WSI offer designers a veritable kitchen sink of resources for microcontrollers or embedded processors. Each device provides designers with EPROM for program storage (32, 64, or 128 kbytes), SRAM (512 bytes) for scratchpad memory, 2500 gates of programmable logic for customized interfaces or support functions, and 26 programmable I/O lines.

SIEMENS



Introducing Siemens optical DAA.
Because you never know what might come through the phone lines.

Features	DAA2000	DAA2100
10 Hz—4KHz Bandwidth	✓	✓
Transhybrid	✓	✓
Integrated Ring Detect	✓	✓
Hook Switch Control	✓	✓
Caller ID	✓	
Snoop Mode	✓	
Line Sense	✓	
Voltage/Frequency Converter	✓	✓
Power Mgmt.	✓	✓
Wake on Ring	✓	✓
Thermal Protection	✓	✓

The opto solution that shrinks interface/isolation problems.

Today's increasing modem speeds and decreasing device sizes can make the traditional transformer and circuitry solution seem like an unwieldy monster. Now the leader in optocoupler technology breaks through the transformer barrier with the new DAA2000 and DAA2100.

Smaller size. Giant capability.

The Siemens DAA2000 is ideal for applications in PC modem cards with multimedia capabilities and extremely tight real estate requirements. The DAA2100 is the lower-cost solution for internal and stand-alone modems where space is not an issue. The DAA2000 utilizes two 24-pin TSSOPs, while the 2100 uses two 24-pin SOICs. And both kits include two 8-pin Slimline IL388 linear optocouplers, with specifications to easily assemble the DAA function directly onto the mother board.

Special features tame distortion and power management.

The DAA2000 and DAA2100 are all-analog solutions, operating down to 2.7 V on the modem side, with distortion numbers flat across the whole band. And both include built-in ring detect and hook-switch control. In addition, the DAA2000 offers extra features such as snoop mode and built-in overcurrent/thermal limiting. So whether you have a tight space or a tight budget, with Siemens DAA2000 and DAA2100 you'll find a perfect fit.

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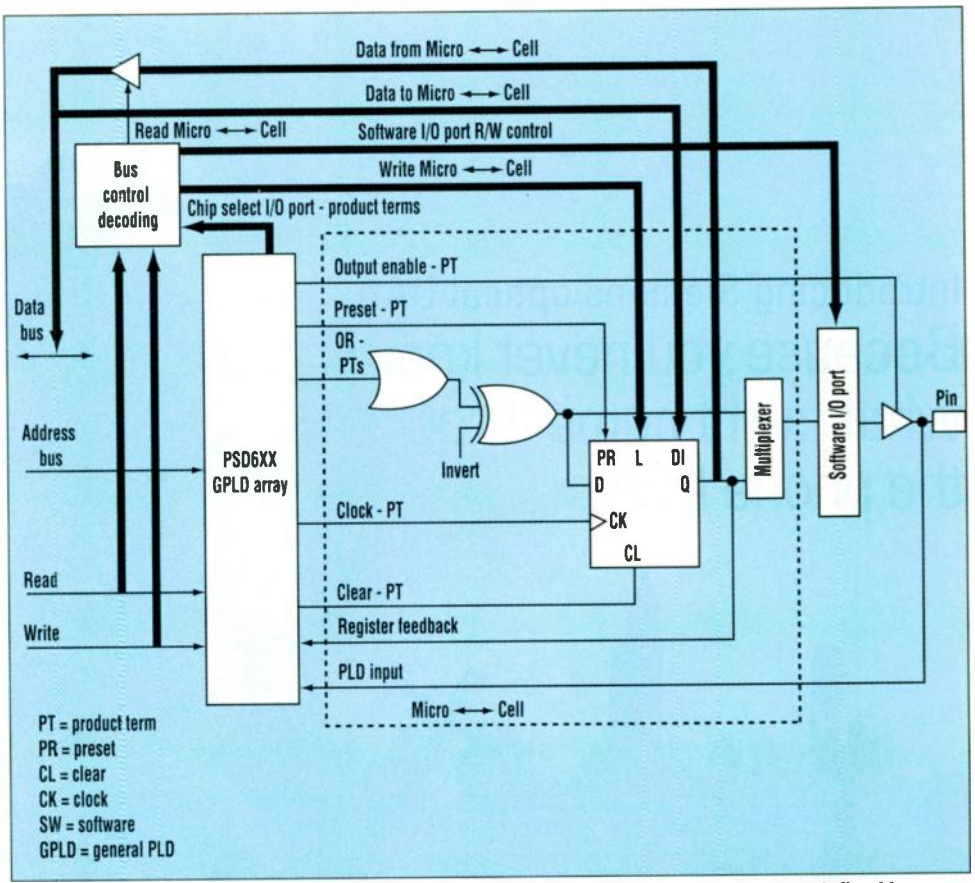
Large field-programmable gate arrays also could be used, but they typically offer only on-chip SRAM and logic. Any EPROM storage would require a separate chip. FPGAs that offer a lot of memory would be too expensive in a system where the embedded controller usually costs less than $10. Additional cost is incurred in having to build an MCU-to-FPGA interface. Connecting the microcontroller to the macrocell flip-flops is silicon-intensive, often requiring more logic resources than the peripheral function.

By taking the same multiple-functions-on-a-chip approach used for its programmable system devices (PSDs), WSI has crafted a new class of programmable circuit, the field-programmable microcontroller peripheral. Expected to sell for less than $5 each in large quantities, the circuits are designed to support most 8- or 16-bit microcontrollers and embedded processors. Like their previous PSD products, the PSD6xxE1 family includes EPROM, SRAM, programmable logic, multiple dynamically configurable I/O ports, and a programmable MCU interface, all integrated together on one chip *(Fig.1)*. But, unlike the previous PSDs, the new PSD6xx family offers an innovative programmable logic architecture that provides a direct connection between the PLD flip-flops and the MCU address/data bus.

The direct MCU-to-flip-flop connection saves as many as 32 product terms and 38 macrocells, which would have been required with conventional programmable logic to establish the address bus, data bus, and read/write connections necessary to implement serial ports, counters, shift registers, and dual-processor interfaces. In all, the programmable-logic portion of the PSD6xx family provides 63 inputs and 129 product terms.

The first chip in the family (the PSD6x3E1) will pack 1 Mbit of EPROM, 4 kbits of SRAM, about 2500 gates of programmable logic, and 26 I/O pins that can serve as additional microcontroller I/O lines. Also included on the chip are latched address outputs, programmable logic I/O lines, or special-function I/O lines.



2. The internal programmable Micro⇔Cell packs a configurable flip-flop, bus-routing control, flexible product-term allocation, and a direct interface to the microcontroller bus. These features give designers plenty of resources and flexibility when implementing custom interface or support logic.

There will be two additional parts in the initial family—the PSD6x1E1 and PSD6x2E1, which differ only in their amounts of on-chip EPROM. The 6x1E1 packs 256 kbits and the 6x2E1 packs 512 kbits. All three versions have two pinout options, with the "x" in the part number turning into a "0" for versions that have a user-selectable data bus width of 8 or 16 bits. The "x" turns into a "1" for versions that have a fixed, 8-bit-wide data bus interface.

The programmable logic on all the 6xx chips is actually distributed across three blocks. The first is a programmable decoder that can be used to scramble the address lines to the EPROM and SRAM blocks, making it harder to decode the memory contents. The second programmable block allows designers to configure the chip's seven external chip-select output lines that go to the programmable I/O ports. And, the third programmable block contains some general-purpose programmable logic with 12 output Micro⇔Cells and 23 input Micro⇔Cells *(Fig. 2)*.

The EPROM array on the chips provides extra storage for program code (32, 64, or 128 kbytes), the SRAM provides some scratchpad memory that can be backed up with an external battery (512 bytes), and the programmable logic provides flexible I/O support. The the Micro⇔Cells, the seven external chip selects, and the 26 I/O lines allow designers to efficiently implement a variety of logic functions to supplement the resources of the microcontroller or microprocessor.

A 4-bit page register on the chip expands the address range of the processor 16 times. The paged address can be used as part of the address space to access external memory and peripherals, or the internal EPROM, SRAM, or I/O lines.

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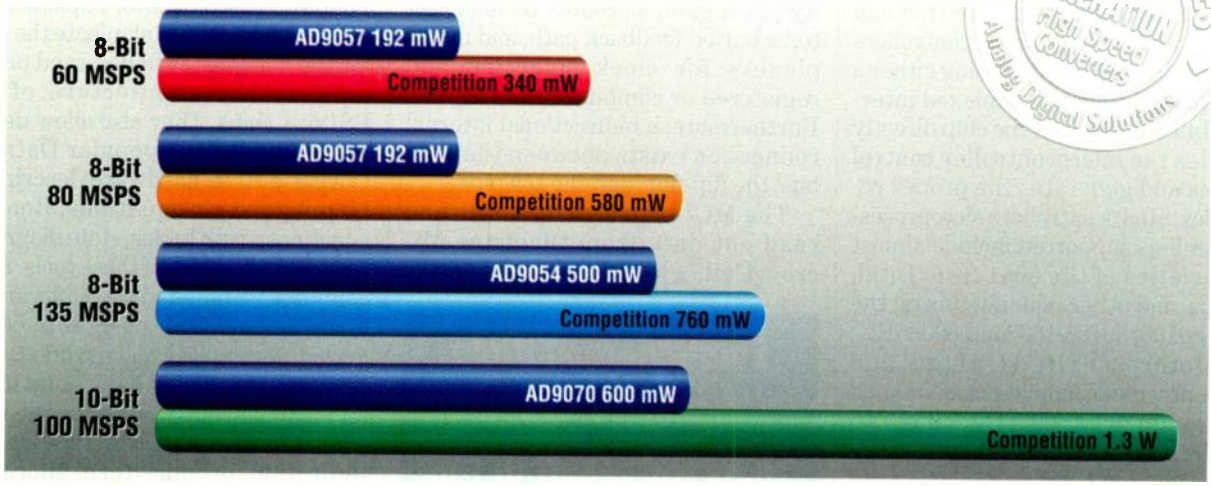

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The logic could be used to create state machines, address decoders, special counters, timers, and interrupt controllers, for both internal and external control. More complex functions such as a dual-processor interface, a stepper-motor controller, serial data controllers, timing synchronization functions, and many others also can be implemented.

The PSD600xx series gives designers a programmable device that can connect to 8- or 16-bit microcontrollers or microprocessor buses using either a multiplexed or nonmultiplexed interface. Internal logic on the chip directly decodes the microcontroller control signals and generates the proper responses. Microcontroller/microprocessor families supported include almost all varieties of the 8051 from Intel, Philips, and other manufacturers; the Intel 80196, 80186/188, and 80386EX; the Motorola 68HC11, 16, 12, and 683xx processor families; the National Semiconductor 16000; the Zilog Z80 and Z8; and the Neuron 3150.

The on-chip logic also is internally power-managed. A power-management unit included on the chips reduces the circuit's current drain to just 25 µA when the devices go into their standby mode. When the devices are in their active mode, the PLD, EPROM, and SRAM sections of the chip each consume about 2 mA/MHz when powered by a 5-V supply.

The slowest version has a total access time of 90 ns, including address decoding. Operating in a multiplexed mode, this translates into a maximum system frequency of 22 MHz. The faster 70-ns version supports a top system speed of 28 MHz when used in the multiplexed-bus mode.

Unlike previous programmable-logic solutions that tie into the microcontrollers through programmable logic cells, the PSD6xx family provides a direct path from the microcontroller bus to the PLD macrocell for read and write operations. Thus, the microcontroller sees the macrocell in the chip as a decoded location in the address map

That design enhances the dual-bus connectivity and reduces logic-path delays, improving response times. The simplified diagram of one of the 12 Micro⇔Cells has a special block that decodes the bus data, and will allow the address and data bus signals to bypass the logic in the Micro⇔Cell and feed directly to the software configurable I/O port.

Each of the Micro⇔Cells includes a programmable AND array with global and dedicated product-term clocks that are directly routed to a configurable flip-flop (D, T, R-S, or J-K). The cells also include an OR gate with up to nine product terms, a polarity select gate, a product term allocator, a buried feedback path, and multiplexers for clock selection and registered or combinatorial outputs. Furthermore, a bidirectional internal connection exists between the data bus, the flip-flop, and the I/O pin.

The MCU can load data into and read out data from the same Micro⇔Cell, while leaving that cell's product terms available for logic operations. The product-term allocator can then allocate the terms to another cell. That setup allows the logic in the cell to be used even if the pin is dedicated to another function, such as microcontroller I/O. In previous designs, two PLD macrocells were required, and all the product terms in those cells were lost.

Employing multiple commodity support chips can result in too many components. It could also mean excessive total power consumption.

Complementing the logic Micro⇔Cells are 26 bidirectional I/O ports, which can be software-controlled to operate as inputs or outputs. When configured as an output, they can function just like a microcontroller's output line, providing three-state operation. On the other hand, they can play a variety of roles, configured as a PLD I/O port, an open-drain output, a latched-address output, an input Micro⇔Cell, or a nonmultiplexed data port.

As an input Micro⇔Cell, the port consists of a flip-flop that can be configured as a latch, register, or direct input to the programmable logic. When configured as a latch, an address-latch-enable signal will latch the input address. When configured as a register, a clock-input-product term will store the data.

To ease the design of systems, WSI also has developed the PSDsoft suite of Windows-based tools for implementing a design. These tools eliminate the need for the designer to understand or manipulate the architecture of the PSD6xx chips. They also allow design capture using the popular Data I/O Corp.'s AHDL hardware description language, logic equations, Boolean equations, truth tables, state diagrams, or any combination of these tools. A decompiler included in the software allows previous PSD designs to be uploaded, decompiled, and modified.

The software can automatically and transparently optimize the logic so that functions such as flip-flop configuration, product-term allocation between Micro⇔Cells, and Micro⇔Cell allocation to I/O pins results in the most efficient utilization of the silicon. Next, the software maps the MCU code and the logic into the PSD6xx, ensuring that there are no overlaps of address locations. PSDsoft uses Data I/O's ABEL software for logic design, and SimuCAD's SILOS III Verilog simulator for full-chip simulation.

Price And Availability

The PSD6xx programmable microcontroller peripherals are housed in 52-lead ceramic and plastic leaded chip carrier packages. Samples are immediately available. In lots of 100,000 units, prices for the one-time programmable version of the circuits start at $4.99 per piece for the PSD611E1-15 (the 8-bit bus version with 256 kbits of EPROM, 4 kbits of SRAM, and 26 I/O lines). Windowed, reprogrammable versions also are available. The PSDsoft design tool suite sells for $495, and a full tool suite that includes the PSDsilos Verilog simulator sells for $1295.

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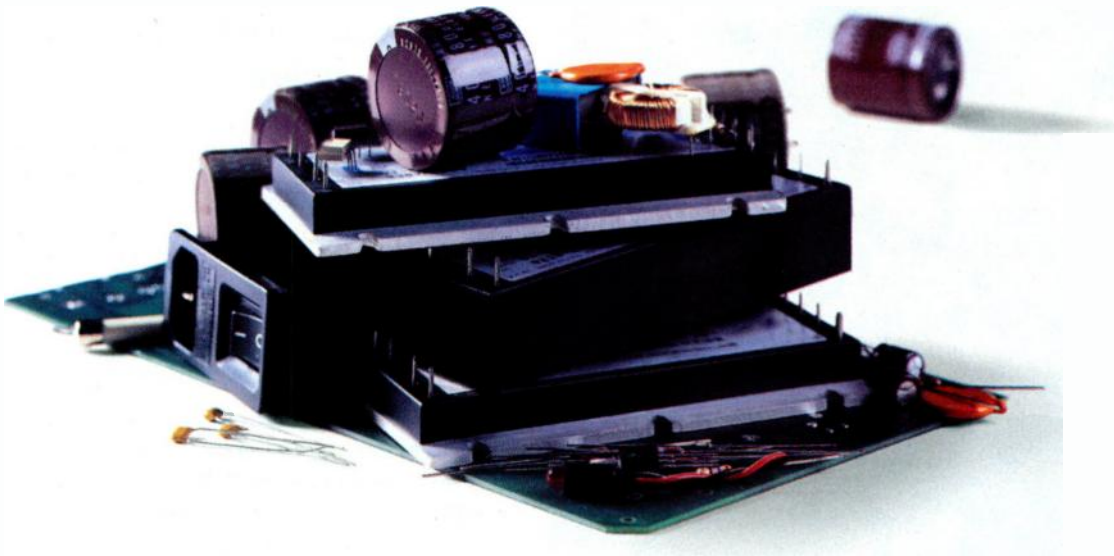

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PRODUCT FEATURE

Data sheets on products like these can be found at www.penton.com/ed/

Visual Tools Speed Development Of Device Drivers For Embedded Systems

An innovative graphical, point-and-click software tool helps automate the development of complex device drivers for embedded systems. The DriveWay Device Driver Design Environment (3DE) provides an interactive data sheet and a graphical interface that lets driver developers select peripheral functions from lists of options rather than by writing code to set registers. The results are automatically generated and documented driver code.

In today's complex embedded systems, writing device drivers is an ever more demanding skill. It not only requires programming ability, but also intimate knowledge of the hardware (i.e. the particular microcontroller and its on-chip peripherals) and the implementation environment—the external buttons, sensors, actuators, etc., controlled by the MCU. What's done by hand, usually with assembler programming (a combination of C and assembler), can bog down a project.

While the complexity of 32-bit microcontrollers is dense enough, the major problem becomes the sheer volume of data that the developer must understand and coordinate. For example, for a given controller, the designer must understand the register map, the capabilities of the chip's peripherals, and which bits control which functions in which peripherals. Then one must know the instructions that are used to set bits in the registers. This will initialize the microcontroller for operation.

Using knowledge of the MCU, the designer then has to design, code, and debug the drivers, taking into consideration initialization sequences, normal operations, and error handling. The debugging process can be particularly difficult because there is often no way to run the code if actual hardware is not available.

The major components of DriveWay 3DE are the chip explorer, the API definition window, the peripheral configuration window, the code tiler, and the on-line documentation. The chip explorer displays a tree-like list of chip resources. A peripheral or parts of peripheral to work on can be selected. The same also goes for peripheral configurations.

Double clicking on a peripheral from the tree opens the driver API definition window. For each peripheral. the desired type of functional object can be selected. For example, a timer might function as a 16-bit timer, or as a cascade timer to a second 16-bit timer to perform as a 32-bit timer. Selecting the 16-bit timer option will display a number of setup options for that object. A 16-bit timer can be defined as edge detection, edge detection and capture, and so on.

After selecting the characteristic of the peripheral, a list of the functions

PRODUCT FEATURE

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that object definition is capable of performing can be displayed. The highlighted functions (e.g, timer init) are the ones most in demand.

Once the functions are chosen, selecting peripheral configurations from one or more dialog boxes can complete the driver. For example, you could select whether to capture interrupts on the rising or falling edge, what clock source to use, and which timer signal pins to use as input or output.

Context-sensitive help is available for each dialog box and the tool checks for errors or inconsistencies in a configuration. For example, the edge-detection timer box can't be chosen without selecting an edge to detect. When it comes time to generate code, the system checks all files to be generated for completeness.

Code is generated from modules specifically written, pre-tested, and documented for each peripheral. Debugging should be a matter of checking that the configuration objects are set correctly and whether the application code is calling the driver functions correctly. Code can be modified to implement special conditions, such as logging when a peripheral is accessed.

In addition to the context-sensitive help, DriveWay 3DE includes a complete on-line manual for each microcontroller. The manual is implemented as a hyperlinked, knowledge-based data sheet. Clicking on a block diagram of the microcontroller will take you to the appropriate section from which there are further links to pertinent information.

DriveWay 3DE products support Motorola's MPC860, MC68360, and MC68302; Philips' XA; and AMD's E186-EM. Other DriveWay products support the 8-bit 80C51 family, the AMD E186-ES, and the Microchip PIC16/17 family.

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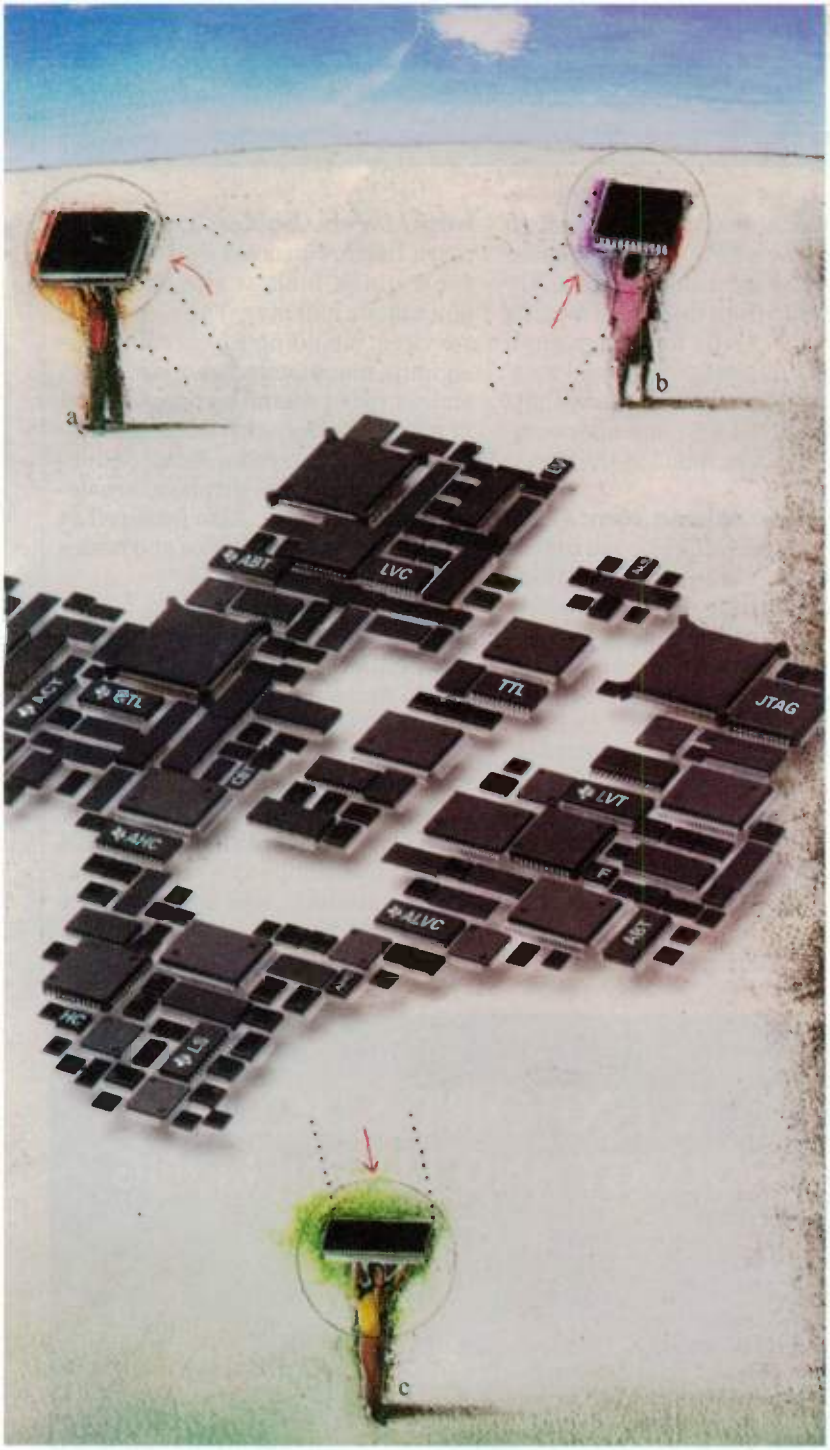

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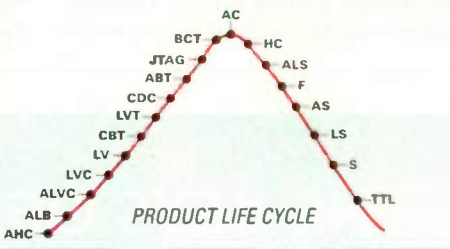

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http://www.ecliptek.com: Drop in on Ecliptek's recently redesigned site to find a part number generator for standard and custom products, application notes, corporate information, distributor locator, and price and delivery requests. Query responses can be obtained within 24 hours. The company's crystals, inductive products, and oscillators are all described here.

The ABC's Of CPD

A new video tape library entitled "Concurrent Product Development" has been developed by Goldense Group Inc. (GGI), Cambridge, Mass., in cooperation with The Gordon Institute of Tufts University. The video series is a nine-hour, eight-tape course covering all the essentials of concurrent product development (CPD).

The overriding concept behind CPD is a well-defined, team-driven new product development process that is consistently applied to accomplish the product planning, product definition, design engineering, manufacturing engineering, test engineering, field service engineering, and quality engineering activities involved in the design, development, and manufacturing of new products.

GGI notes that if concurrent product development approaches are successfully applied, the result will be the production of high-quality products in 30% to 60% less time and cost. In addition, these new products should be able to meet and/or exceed customer expectations and previous development accomplishments.

Concurrent engineering approaches support TQM initiatives. If properly implemented, they will satisfy most ISO 9000 certification requirements in the product development and manufacturing areas.

The term Concurrent Engineering (CE) implies a scope that is focused on the engineering function in a company. What CE actually focuses on is the involvement of all business areas in a given company that have a stake in new product development. In addition to improving the concurrency between the different engineering disciplines, the relative emphasis is on involving the nonengineering product development functions—the right roles at the right points in time. Second, having established the organization-wide nature of concurrent practices, selecting a term that is attractive to all departments and persons involved in developing new products is prudent.

The video tape series covers:

- Definitions and driving forces for speed
- Baselining changes with metrics
- Designing concurrent processes
- Selecting products effectively
- Creating CPD teams
- Defining products
- Reviewing designs
- Creating replicatable environments

Simply put, what the tapes attempt to get across to viewers is that the concepts of CPD and CE will not have any meaning unless the engineering and nonengineering factions of a company decide to work in unison to develop and produce the best possible products.

The eight-tape set is priced at $1600. Individual tapes are priced at $250. For more information, contact GGI, 6 Bigelow St., Cambridge, MA 02139; (617) 876-6776; fax (617) 876-6766.—*MS*

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LVR-1	1 watt	.01Ω-100mΩ	Axial, Molded
WSR-2	2 watt	.005Ω-1Ω	SMD, Molded
LVR-3	3 watt	.005Ω-200mΩ	Axial, Molded
LVR-5	5 watt	.005Ω-300mΩ	Axial, Molded

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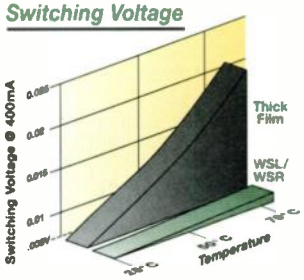

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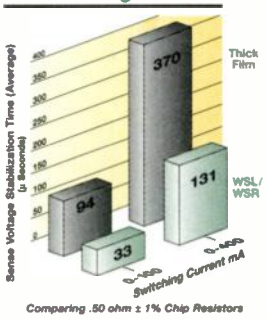
Total Response Time vs. Switching Current



Comparing .50 ohm ± 1% Chip Resistors

Tight Resistance Tolerance — A tight tolerance (± 1%) provides the designer with a narrow resistance window and aids in specifying the sensing voltage. A wide tolerance reduces circuit's response time and contributes to excessive energy loss.

Low Thermal EMF — A low thermal EMF is required when the circuit is in an inactive mode. The thermal effects caused by the connection of dissimilar metals must be minimized to provide component accuracy.

Type	EMF
WSL	< 1μV/°C
WSR	< 1μV/°C

Fast Response — Power Metal Strip technology resistors stabilize their sensing voltage more than 2.5 times faster than comparable thick film chip resistors. The result is improved voltage sense accuracy and enhanced battery life.

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READER SERVICE 121

HP, Fluke Sign Marketing Agreement

It seems like a case for the old adage that war makes strange bedfellows. But officials at Hewlett-Packard Co. (H-P) and Fluke Corp. say that's not so. Instead, the reciprocal distribution and marketing agreement just signed by the companies is a natural outgrowth of an evolution that has seen their product lines become more complementary and less competitive over the last few years.

The agreement allows customers to buy H-P's Basic Instruments line from selected distributors of Fluke products. H-P, through its direct sales force and H-P Direct program, will sell seven of Fluke's handheld instruments and a number of accessories. The agreement is in effect in the U.S., and similar programs in other countries will be phased in as details are ironed out.

"This contract responds to customers' desires for the additional convenience of buying H-P Basic Instruments from distributors," said Larry Potter, H-P vice president and general manager of the Test and Measurement Organization's worldwide field operations. "Equally important is that this contract allows H-P to augment its traditional, bench test and measurement equipment with Fluke's handheld test tools, addressing the new need of a large segment of H-P's customers–research and development engineers–for portable, multifunction test tools."

Both companies' product lines have evolved independently in the past five years to the point where many products are now complementary, said company officials. "We don't compete in as many areas as people think we do," says Bill Parzybok, Fluke's chairman and chief executive officer.

"When two companies with complementary products team up, customers are better served because they have a broader selection of products available from their preferred sources," said Parzybok. "Both companies will increase their market presence, and distributors can provide a greater selection of products to their customers."

Potter noted that the two companies have had a lot in common over the years. While H-P is a major player in the benchtop instrument arena, Fluke is known for its handheld, high-performance, multifunction tools, which H-P will sell under the initial agreement, including the Models 105B and 123 ScopeMeters; Models 863 and 867 Graphical MultiMeters; Models 164, 164H, and 164T multifunction counters; and various accessories.

Fluke will sell H-P's E2310A LogicDart advanced logic probe, 54600 series digital oscilloscopes, 34970A standalone data-acquisition system, 34401A digital multimeter, 53131A and 53132A universal counters, 53181A RF counter, E3600 series dc power supplies, 33120A function/arbitrary waveform generator, 34810-34812A BenchLink series, and accessories for scopes and digital multimeters.

John Novellino

"Stop Noise Two Ways"

Most people know that a pacifier will stop noise, sometimes very quickly, other times it takes a little longer. The method, however, works. Add a little sweetness and it works even faster. And for certain applications the pacifiers come in different shapes and sizes.

Conec Filter Connectors stop noise as well. Noise created by EMI/RFI in today's high speed digital systems. And just like pacifiers, Conec Filter Connectors come in different configurations - industry standard d-sub, high density d-sub, filltered adapters, modular jacks and combo d-sub, with power filtering and signal filtering. We don't add any sweeteners. What we do add is our patented planar filters. The technology with a proven track record, combined with the industry's best connectors—ours. Both technologies fully integrated, for best results in filtering.

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READER SERVICE 118

JUST 4 THE KIDS

Putting Around

No, this isn't going to be about golf, greens, putters, woods, or the like. Actually, it's about a talking purple roadster, Putt-Putt, and his dog Pep. Putt-Putt is appearing on a new CD-Rom from Humongous Entertainment called "Putt-Putt Travels Through Time."

In the time-traveling adventure game, the happy little car guides kids through a search to find his dog, calculator, history report, and Smokey the Fire Engine lunch box. The designers at Humongous placed different items that the kids need to complete the game throughout time. To keep it interesting, the designers programmed the items to pop up in different places each time the kids play the game.

The game challenges kids' math skills, encourages creativity, teaches about shapes, and tests memory skills. All of the characters in the time travels share facts about what their lives are like and what the world around them is like during that time period, giving kids a wider perspective of history. The characters range from the dinosaur age to the future. The hybrid CD-ROM is available for Windows 95 and Macintosh platforms for $39.95 retail.

For more information, contact Humongous Entertainment, 16932 Woodinville-Redmond Rd. NE, Woodinville, WA 98072; (206) 486-9258; fax (206) 486-9494; Internet: http://www.humongous.com.—*DS*

S.W.A.K.

Fan mail, schman mail. Bottom line is we need your input so that we can give you the best QuickLook we can. If you were our bosses (which, in the empirical sense, you are, but let's not quibble about semantics here), what would you suggest we start including? What would you want us to banish forever from the face of QuickLook? If you'd like to fill us in on your recommendations, our e-mailboxes are: Mike Sciannamea at **mikemea@class.org,** or Deb Schiff at **debras@csnet.net**. Another quick way to reach QuickLook is by fax: (201) 393-0204. Readers with an old-fashioned style of correspondence may address their envelopes to: QuickLook, *Electronic Design*, 611 Route 46 West, Hasbrouck Heights, NJ 07604.

Y2K UPDATE

A new trend emerging in the Year 2000 Date Change (Y2K) arena is the rush to patent software solutions. Just a refresher course for those not in the know about Y2K: Because many of the legacy systems out there in corporation land only have date fields with two digits instead of four, those computers will mistake 2000 for 1900 in their date-related applications. Of course, that's an extremely simplistic view of the problem, but if you're really interested in some history, try the Year 2000 Information Center: **http://www.year2000.com.**

CODE CONVERTER

One of the companies on the path to patent-holding status is Progestic International. Their offering is called the DVR 2000 system refurbishment process. Of the more outstanding features of DVR 2000 is the price point. At a cost of $0.34 per line of code, the process blows away other projects using the same sliding-window and date-definition-expansion scheme that are carrying price tags of $1.10 to $1.70 per line of code.

Progestic's conversion system is based on a simple mathematical algorithm that works through the cyclical nature of the Gregorian calendar. Slimming down the logic changes that are found in most conversion systems, DVR 2000's robust and highly intelligent date routine simplifies the testing procedure. All of the time-saving elements of DVR 2000, in addition to the cost savings make this process inviting to those who may just be at the beginning (unfortunately) of their conversion cycle.

Flexibility is always important when it comes to any tool. DVR 2000 can support any language and can be used with any automated conversion tool. And, there's talk of Progestic teaming with major tool providers to further automate the DVR 2000 process further.

Progestic initiated their work on DVR 2000 when they saw that companies who where planning to spend millions on their conversion investment were left broke when it came to capital for designing or implementing new technologies.

For more information on DVR 2000, contact Progestic International Inc., 222 Queen St., Suite 400, Ottawa, Ontario, Canada K1P 5V9; (613) 230-7522; fax (613) 230-5739; Internet: http://www.progestic.com.

PARTS OF A WHOLE

Another enterprise in the patent process is Computer Horizons Corp. (CHC). Their application has been filed for the Signature Time Engineer software, a component of the Signature 2000 solution.

Also going for the highly automated, process-driven approach CHC's Time Engineer dynamically slides or windows dates within a one-century window. The process is designed to minimize potential for fraud, reduce conversion effort and complexity, and drain fewer resources than other correction software.

A unique feature of Time Engineer is its ability to age test data in real time. This aging allows the testing of future dates without the Y2K manager having to create a test bed of aged data. To test downstream applications, the software also will create the needed aged data.

The Signature 2000 solution is a five-phase system of Y2K compliance tools and processes. The first phase, Discovery, takes an exhaustive inventory and analysis of all of an enterprise's applications. This task is accomplished through the use of Signature Analyzer and Navigator.

Signature Analyzer accesses source code files, databases, JCL, sorts, reports, screens, call modules, and copy members. The automated software also identifies potential business process failure points. After the analysis is performed, the company is outfitted with a set of customizable reports specifically detailing all of the applications that will be hit by Y2K. The Discovery Study document includes the reports and recommendations on how to handle the various impact points. The software uses a syntactic and semantic parser to seek out and report all the potential Y2K issues throughout the company's systems.

Next comes the Impact Analysis phase, which is really where the enterprise and CHC hunker down and decide what the priorities are, and develop a true understanding of what's ahead of them. The Signature Navigator is used here to analyze the data flow of both batch and on-line files in the company's applications. The analysis is done through schedulers and CICS control tables.

The third phase of the Signature 2000 solution is the Construction phase. At this point, CHC's Signature Replacer automates the changes to the impacted objects that had been identified during the Impact Analysis phase. The changes are made by interpreting the modification rules defined in the Replacer script language. Each line of code is stored within the Signature Repository and analyzed by Replacer.

The fourth phase, probably the most important of all the phases, is the Testing phase. The modifications made by Time Engineer and Replacer, along with Data Migrator (creates programs required to migrate and interface data) are all validated during this stage in the process. This phase of the Signature 2000 solution runs concurrent with the Discovery and Analysis phases. All of the applications must be tested through production parallel cycles, which are daily, weekly, monthly, quarterly, annually. After all the parallel production processing has been wrapped up, CHC starts in on the Y2K simulation testing.

And, finally, the fifth phase is Implementation. The goal of this part of the solution is to bring the now-compliant applications into production. Before production with the Y2K compliant systems begins, data interface procedures in the JCL, file, and database declarations must be completed. Additionally, all the data migration programs must be executed to create the Y2K data structures.

More information on Signature Time Engineer, as well as the Signature 2000 solution can be obtained from Computer Horizons Corp., 490ld Bloomfield Ave., Mountain Lakes, NJ 07046-1495; (201) 402-7400; fax (201) 402-7985; Internet: http://www.chccorp.com.—*DS*

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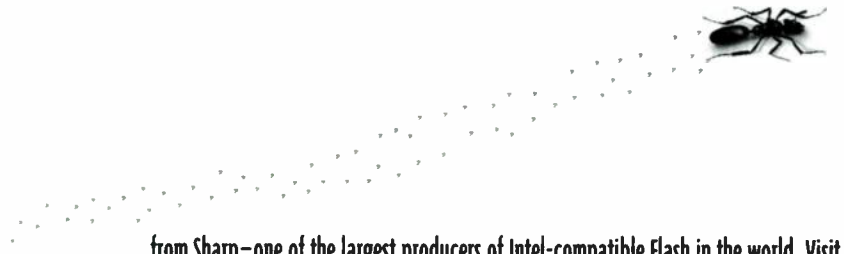

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TRUDEL TO FORM

JOHN D. TRUDEL
CONTRIBUTING EDITOR

Young people ask the best questions. "Why is the sky blue?" A staffer to a newly-elected member of Congress asked, "Why are people trying to destroy the U.S. patent system?"

The Great Patent Sell Out is back with a vengeance. The Patent Wars, which I have written about in these pages, have flared up again. Like a video-game monster, you keep shooting it and it keeps coming back. A new bill, H.R. 400, is being rushed through Congress. U.S. Rep. Dana Rohrabacher calls it the "Steal American Technology Act" because it legalizes technology theft and industrial espionage.

The societal issue is high-wage U.S. jobs for you and your kids. If you weaken patent protection, jobs move offshore faster, and wages fall. The business issue here is profit margins. Why innovate if anyone can steal from you? But if you don't innovate, your products become commodities with razor-thin margins. To prevent this, write Congress now!

I spent an hour trying to educate this young person about products, innovation, and international business. By the end I felt very old and tired. She kept asking why those pushing for a sell out persisted. My cynical answer, "Money," just did not compute for her.

I reflected on our conversation. I dimly remembered that those selling out our system once had used rallying cries like "world harmonization" and "submarine patents." Still, these PR fictions were long ago crisped into cinders under the glaring light of testimony.

Why does the onslaught persist? The timing is bad. Bloodhounds are hot on the trail of foreign "donations." Each week sees a major new scandal, and criminal investigations are starting.

H.R. 400 is a cookie-cutter copy of last year's H.R. 3460, which was disowned by those it claimed to benefit. HR 3460 never even made it to a vote, and the authors were not reelected.

Still, Bruce Lehman, Assistant Secretary of Commerce and Honorable Commissioner of Patents, remains. Lehman signed the original letters of agreement with Japan to sell out our patent system. He is a politically correct icon, well defended, and far enough down in the bureaucracy that Congress does not have a good shot at him. He knows this and exploits it.

Lehman's discreet Japanese fund raising has so far escaped the notoriety of the Indonesian and Chinese funds that flowed in down the hall. Compared to Whitewater, Donorgate, and other such odoriferous events, his money is relatively "clean."

If H.R. 400 passes, Lehman stands to gain personally. If the Patent Office is privatized (critics say "piratized") he would run it, and "gifts" to patent office officials, like him, would be legalized. Let's see—if I could run a private tollgate through which all U.S. technology must flow, could I make a lot of money? Yes, I probably could. Lehman also is on record, strangely, as viewing his job as the "regulation" of technology.

A new global survey from ACME (Association of Management Consulting Firms) says that 88% of clients indicate that growth is more important than cost cutting. How can you grow? If a U.S. firm, return to innovation. If a foreign firm, seek cheap access to U.S. technology. That dynamic makes Mr. Lehman a dangerous individual. Perhaps he is why the sell out persists?

John D. Trudel, CMC, provides business innovation consulting to selected clients. Lectures, keynotes, and workshops also are available. He is the author of "High Tech with Low Risk." The Trudel Group, 33470 Chinook Pl., Scappoose, OR 97056; (503) 640-5599; fax (503) 543-6361; e-mail: jtrudel@gstis.net; Internet: http://www.trudelgroup.com.

OFF THE SHELF

Cypress Information Resources has released the latest edition of its "*Intellectual Property Company Profiles Report.*" The report covers chip technologies available for license from chip design houses, semiconductor companies, and research organizations. Over 1000 companies are profiled that offer intellectual property (IP) technology in either Core Cell formats, ASIC library cells, chip portable software algorithms, or as completed chip products. The report includes licensable technology in chip technology areas such as digital audio broadcasting, micromachining and sensors, superconductivity, and wireless LANs. The 500-page report is priced at $1495. Contact Cypress Information Resources, 15466 Los Gatos Blvd., #109-285, Los Gatos, CA 95032; (408) 354-4887; fax (404) 354-5058.

"*Simulation of Communications Systems*" provides readers with in-depth coverage of computer simulation for communications systems. Detailed are the theoretical foundations, techniques, and methodologies of simulation. The book has been tailored toward those readers who are now developing a simulation of a communication system, using simulation programs for the design or analysis of a communication system, or considering the application of these tools to their own design and analysis problems. The 731-page book is priced at $125. Contact The Penton Institute, 100 Superior Ave., Cleveland, OH 44114; (800) 223-9150; fax (216) 696-6023; Internet: http://www.penton.com.

"*How to Program Delphi (Latest Version)*" aims to enable developers to create components with Delphi, one of the fastest growing RAD tools, that are compatible with Active documents and ActiveX materials that can be used in any application. It also allows developers to create bridges between the Microsoft and Netscape worlds. The book includes a CD-ROM with the full source code of the Routine Library. The 450-page book is priced at $40. Contact Macmillan Computer Publishing USA, 201 W. 103rd St., Indianapolis, IN 46290; (800) 428-5331; Internet: http://www.mcp.com/mcp.

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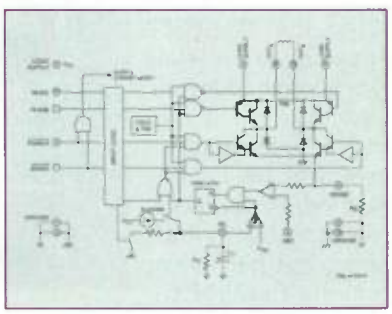

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READER SERVICE 95

HOT PC PRODUCTS

Since most of us are connected to the Internet, it's becoming increasingly important to find unique tools that can handle our needs. A new software tool from Infinitron allows users to compress all kinds of digital images down to manageable sizes for optimum downloading from the Internet.

Lightning Strike Compressor 3.0 for Windows is based on wavelet technology. According to Infinitron, Lightning Strike 3.0 speeds images to users five times as fast as JPEG. Sticklers for numbers will note that most graphics can be viewed with Lightning Strike in two to four seconds, compared to JPEG viewers that download at a rate of 10 to 20 seconds.

In addition to converting JPEG files, Lightning Strike works with GIF and PNG files, as well as other formats. Two different encoding mechanisms can be selected by users depending on their needs. Other settings allow users to control the size of their image files or the speed of viewing.

Unique compression options also featured in Lightning Strike are Region of Interest Focusing, Split and Merge, Post Reconstruction Filters, Transparency, and Progressive Decompression. With Region of Interest Focusing, outstanding portions of images can keep their detail through selective compression, while the user compresses the entire image to the smallest possible size.

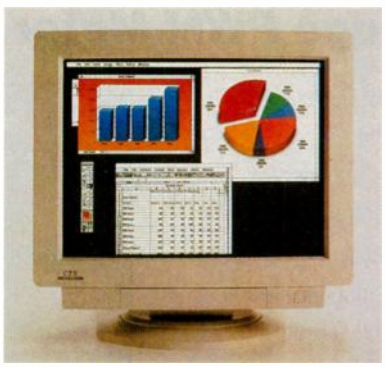
Split and Merge is used for very large images that have to be split into smaller images for individual compression. Able to enhance images after decompression, Post Reconstruction Filters also are included.

Used in showing background colors through an image, the Transparency feature allows designers to set pixels to a transparent mode. Finally, Progressive Decompression, found with most browsers, shows decompressed images first at lower resolution, then progressively sharper over viewing time.

Lighting Strike Compressor 3.0 licenses cost about $3000 per server, with additional charges per visit. Trial versions are available for $149.

For more information, contact Infinitron Inc., 1199 W. Hastings, 10th Fl., Vancouver, British Columbia, Canada V6E 3T5; (604) 688-9789; fax (604) 688-9798; Internet: http://www.infinitron.com.

The Executive (EX) Series of large-screen, high-resolution monitors from CTX International are offered in 17-in., 20-in., and 21-in. sizes. The CRT manufacturer is responding to a market demand that dictates a move to larger screens with more features.



Using electron guns with dynamic focus and astigmatism control, the EX Series features advanced tube technology. The new monitors use an antiglare, antistatic, and antireflection coating known as the Invar Shadow Mask. The Mask reduces doming distortion and improves heat resistance.

The new line allows users to control the geometry, color temperature, and individual RGB color calibration all within the on-screen display feature. The digital controls facilitate higher levels of color purity, screen linearity, balance, and uniformity.

All of the EX Series monitors comply with Energy Star power consumption and MPR-II radiation guidelines, in addition to the European TCO standards. Plug-and-play specifications for Windows 95 also are met. Additionally, EX Series monitors are backed by a three-year, point-of-purchase warranty on parts and labor.

The EX900 displays a 0.28 mm diagonal dot pitch within a 21-in., flat-square CRT. At 68 Hz, the maximum resolution is 1600 by 1200. The monitor's recommended resolution of 1280 by 1024 is obtainable at 80 Hz. The horizontal frequency range is 30 to 85 KHz, and the vertical frequency runs 50 to 120 Hz. The EX900 weighs 68.7 lb., and measures 20.2 in. by 20 in. by 20.3 in.

The 20-in. EX800 also displays a fine 0.28 mm dot pitch, and has the same recommended and maximum resolutions as the EX900. Operating horizontal and vertical frequencies also are the same. The monitor's footprint is the same, but weighs 63.5 lb.

The EX700, on the other hand, is based on a high-contrast 17-in. CRT from Hitachi. It displays a tight 0.26 mm diagonal dot pitch and a 0.22 mm horizontal dot pitch. Both flicker-free resolution of 1280 by 1024 and recommended resolution of 1024 by 768 can be obtained at an 80 Hz refresh rate. It reaches a maximum resolution of 1600 by 1200 at 68 Hz. It measures 16.5 in. by 17.2 in. by 17.5 in., and weighs in at 41.9 lb.

The EX900 is priced at $1549, the EX800 runs $1129, and the EX700 carries a list price of $689.

For more information, contact CTX International, 748 Epperson Dr., City of Industry, CA 91748; (818) 839-0500; fax (818) 810-6703; Internet: http://www.ctxintl.com.

Packard Bell and NEC brand PCs will now be featuring 56-kbits/s modem chip sets from Texas Instruments that carry U.S. Robotics' x2 technology. Currently, over 400 Internet service providers are adopting the x2 technology to offer higher speeds to their customers.

The particular chip set used is the TMS320x2. It is outfitted with Texas Instruments' digital signal processing formulation of the x2 technology. According to Texas Instruments, the new technology allows customers to upgrade their modems via software, to comply with evolving communications advances.

Texas Instruments has shipped over 20 million modem chip sets with the digital signal processing upgradeable solution since 1995.

Contact Packard Bell NEC, 1 Packard Bell Way, Sacramento, CA 95826; (800) 733-5858; Internet: http://www.packardbell.com.

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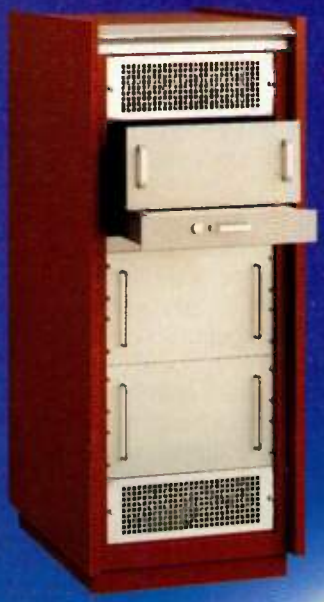

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READER SERVICE 108

INTERNET NEWS

If you find yourself struggling in your efforts to sell someone on the virtues of electronic commerce (e-commerce), you might want to try a new approach. A hefty, new report from Computer Technology Research Corp., "Electronic Commerce: The New Business Platform for the Internet," takes the tack of teaching organizations how to build the ultimate e-commerce strategy.

The key is to look at what information the company is lacking. Does it know the benefits of e-commerce? Do managers know the challenges they'll face in implementing the new technology? How will the company design the web site for a diverse audience? What are the demographics of the electronic marketplace? How will the the success of the e-commerce strategy be determined? What kind of steps can be taken to ensure the security of the on-line transactions? Where do managers find information on e-commerce regulatory issues? All of these questions and more are answered in the new report.

Computer Technology Research Corp. also looks at the challenges that businesses already in this marketplace face, and what kind of hopes these companies have for the future of the medium.

The 245 page report, by Debra Cameron, an internationally recognized Internet consultant, is priced at $295 per copy.

For more information, contact Computer Technology Research Corp., 6 North Atlantic Wharf, Charleston, SC 29401-2115; (803) 853-6460; (803) 853-7210; Internet: http://www.ctrcorp.com.

In the U.S. today, one of the fastest growing businesses is the Internet Service Provider (ISP). Of the many major decisions ISPs need to make, one of the biggest is what kind of platform to choose. ISPs such as OzEmail (the largest in Australia) and Sprint Internet Passport use the Portal Information Network's Portal Infranet as their standard software platform for building and managing their Internet offerings.

Infranet allows ISPs to manage their subscribers' entire lifecycle. The software allows subscribers to register on-line in real time. ISPs can set up their authentication, access, customer event tracking, rating, and billing policies on the platform.

Infranet's event-rating engine lets ISPs create custom billing rates for all kinds of service from enterprise to microtransactions. The parallel-processing architecture enables enormous scalability to many millions of subscribers.

Protected by a three-layer security system, the software allows secure credit-card transactions. Infranet uses multiple paths, providing high reliability in accessing data.

For more information, contact The Portal Information Network, 20863 Stevens Creek Blvd., Suite 200, Cupertino, CA 95014; (408) 343-4400; fax (408) 343-4401; e-mail: johnw@corp.portal.com.

When it comes to issues that plague Internet users, one of the constant occupiers of the top positions is connectivity. An interesting approach to the challenge of connectivity is the Token-Ring. One company now shipping an ICA-based Windows thin-client device that features Token-ring connectivity is Wyse Technology.

Using 10Base-T Ethernet connectivity and PPP for Internet connectivity, the company's new Winterm 2000 SE family also features a slot for PC cards. The new card slot is a direct reflection of the importance of the higher level of security that's been driving the market. Not only does the user benefit from the protection of this security attribute, but network administrators and MIS directors enjoy a greater flexibility in doing their work .

Typical applications of Token-ring networks are large corporate structures, healthcare organizations, and financial institutions.

The Winterm 2300SE comes in two different configurations: Modular and integrated. The modular variety includes a keyboard and mouse and is capable of connecting to any WYSEvision or VESA-standard monitor. The integrated version of the system is outfitted with a 15-in., low-emission monitor, keyboard, and mouse.

Both the modular and integrated Winterm 2300SE units start below $1000.

For more information, contact Wyse Technology, 3471 N. First St., San Jose, CA 95134; (800) GET-WISE; fax(408) 473-12222; Internet: http://www.wyse.com.

Another important, and often controversial, element of Internet and intranet security is the firewall. Most enterprises prefer the ready-to-use software solutions that may not necessarily be the right tool for their needs. Addressing the niche market of the small business or departmental firewall, Technologic and DynaLab have teamed to produce Interceptor Internet.

The new out-of-the-box firewall solution now comes preinstalled on a Pentium-based PC. In addition, DynaLab is providing localized versions of Interceptor.

But the feature that really makes the hardware/software system stand out is the fact that it's available in nine languages. Given the worldwide nature of enterprises, the multiple-language feature of the system makes it ideal for companies with international partners. The naming conventions differ depending on the language. The English language version is named Interceptor and the non-English version is called United Nations (UN) Interceptor. The Chinese (traditional and simplified), French, German, Korean, Japanese, Portuguese, and Spanish languages are included in UN Interceptor.

The appliance can protect data at various physical locations, and segmenting departments via multiple firewalls. Entire security appliances can be configured and managed from one local or remote desktop.

Interceptor and UN Interceptor units are available in configurations supporting 32, 256, 4096, and unlimited simultaneous network connections. Pricing begins at $3495.

For more information, contact Dyna Lab Inc., 2880 Lakeside Dr., Suite 237, Santa Clara, CA 95054; (408) 490-4224; fax (408) 490-2233; Internet: http://www.dynalab.com.

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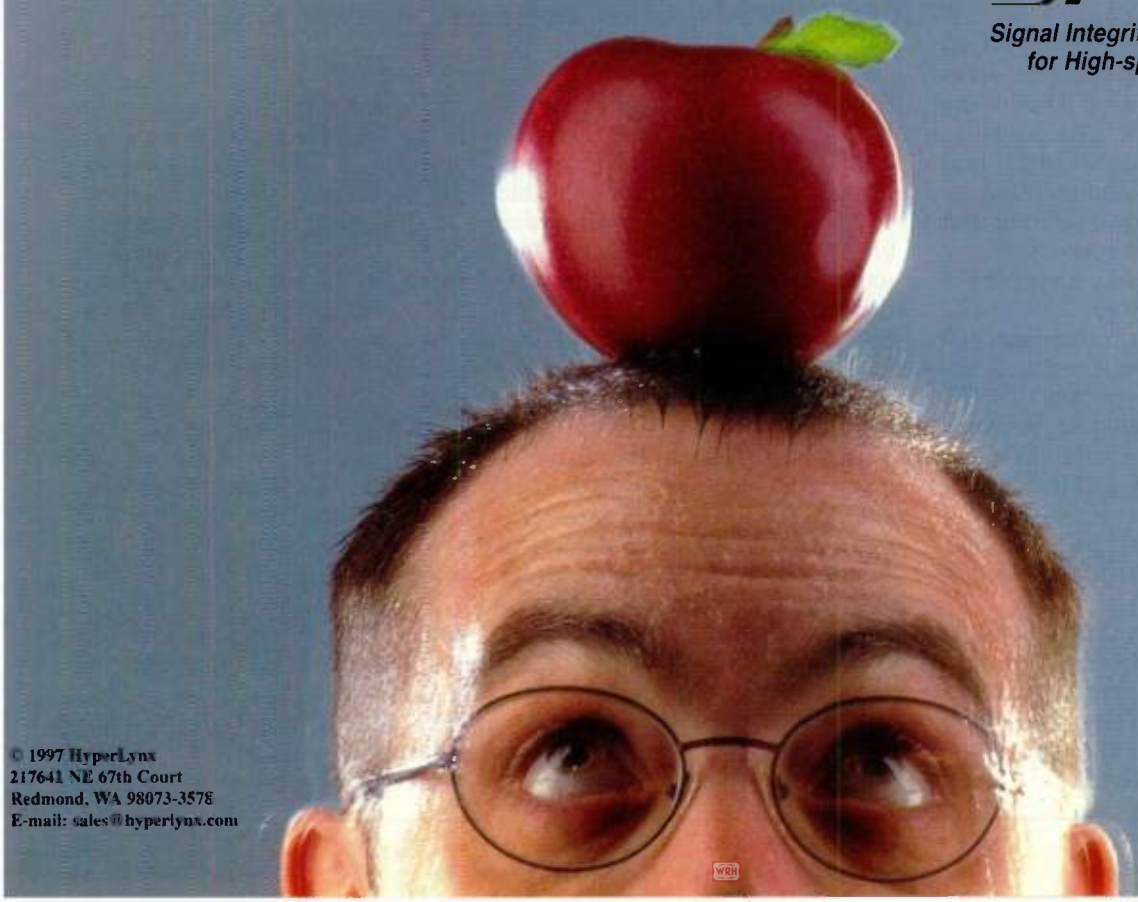

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QUICK NEWS

EZ As One, Two, Three—Providing a way for executives to bring their laptops into meetings to access workgroup files and sever-based data, OTC Telecom's new AirEZY2400 offering provides users with a high-performance wireless Ethernet networking solution.

The roaming network solution runs at 2.4 GHz, with an effective data rate of 2 Mbits/s. Although it can already connect up to six users in a workgroup without cables, combined with AirEZY2400-AP (Access Point), the system connects up to 64 users to any Ethernet environment.

Unique to the AirEZY2400 is its two adapter units. The adapters eliminate the requirement for expensive receiving equipment to link users to the network. One unit is installed at the server or hub, while the other is installed at the workstation. Peer-to-peer networking, temporary working environments, or client/server workgroup applications can now be handled easily without the cumbersome wiring that's associated with other products.

The multichannel central access point, AirEZY2400-AP, raises the effective data rate to 6 Mbits/s in the 64-connection scenario.

Performing in any Ethernet environment, the solution connects workstations at the network layer of the OSI protocol stack. The wireless LAN adapter needs no additional software drivers or configuration because it's designed to be Plug and Play. It literally just connects to any RJ-45 on the Ethernet adapter or PC card and it's ready to go.

The LAN adapter transmits at 100 mW by using an omnidirectional antenna to reach a range of 300 ft. to 500 ft. The AirEZY2400-AP permits users to access three, 2-Mbit/s channels simultaneously, and it also supports automatic channel selection.

The Air EZY2400 is priced at $699, and the AirEZY2400-AP is priced at $1699.

Additional information on these products can be obtained from OTC Telecom, 2036 Bering Drive, San Jose, CA 95131; (408) 245-6888; fax (408) 245-8886; Internet: http://www.ezylink.com.

Building A Better Board—PLX Technology is betting that its new PCI 9080 Peripheral Component Interconnect bus master chip, I_2O (Intelligent I/O) Manager messaging software, and OEM development kits will inspire embedded systems manufacturers to adopt the I_2O architecture. The technology is designed to work independently of the processor and operating system.

The high performance of the I_2O architecture is gained through redirecting the I/O processing to a subsystem known as the "I/O Processor." An embedded CPU (i960, PowerPC, or 410, to name a few), the I_2O Manager software, and the 9080 chip combine to provide the interface and I_2O messaging protocol between the PCI bus, I/O subsystem, and the host microprocessor.

Because the host microprocessor no longer needs to process I/O, memory and system buses can perform other functions, thus raising total performance.

For more information, contact PLX Technology Inc., 390 Potrero Ave., Sunnyvale, CA 94086; (408) 328-3502; fax (408) 774-2169; Internet: http://www.plxtech.com.

Adapting To A New Addition—AdvanSys has added the ABP940-UW, priced at $195, to its line of ultra-wide SCSI host adapter boards. The SuperSCSI line is based on an intelligent software-based SCSI installation problem analyzer.

The adapter works by using SuperInstall to automatically sense and adapt to the correct hardware environment and to configure and install itself. Through SuperView, an interactive graphical-user interface, the ABP940-UW lets users examine the status of all devices in the SCSI chain.

The ABP940-UW comprises 8 Kbytes of internal RAM (expandable to 72 Kbytes), and AdvanSys' dedicated RISC processor, which frees up the host system of I/O duties, and minimizes drain on the CPU. It accommodates up to 15 SCSI-1, SCSI-2, and SCSI-3 devices such as hard drives and removable storage devices.

Contact AdvanSys, 1150 Ringwood Ct., San Jose, CA 95131; (408) 383-9400; fax (408) 383-5793; Internet: http://www.advansys.com.

Low Prices For Pump Lasers—By focusing its energies on bringing down engineering and manufacturing costs, Ortel Corp. has been able to lower the cost of its high-power 980 nm pump laser module. The unit's output power ranges from 90 mW to 120 mW for erbium-doped fiber amplifier applications. The reduction in price represents a 20% drop from the market range in comparable devices.

In the company's initiative to lower its pump laser costs, the Tactical Technology Office of the Defense Advanced Research Projects Agency (DARPA) has been a source of funding. DARPA, via the IFOG Flexible Manufacturability Program sponsored, in part, Ortel's cost reduction efforts.

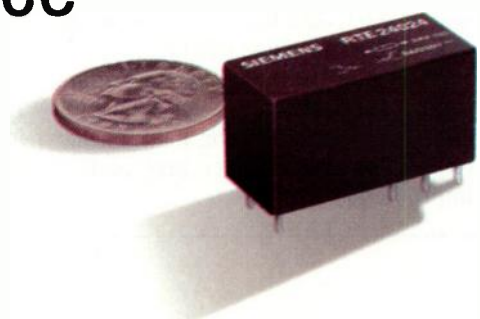
Used in fiberoptic gyroscopes, the 980 nm lasers are continuous-wave optical pump sources for erbium-doped fiber amplifier systems operating at 1550 nm wavelengths. They also can be found in in-line optical repeaters, optical preamplifiers, and power-booster amplifiers. As far as device reliability goes, the lasers achieve theirs through a proprietary nonabsorbing window structure.

Ortel's pump lasers have been qualified at up to 200 mW facet power levels. The advanced chip technology has demonstrated fewer than 500 FITs during lifetests. And, the package design is of the hermetic-laser-welded variety.

For pricing information and availability, contact Ortel Corp., 2015 W. Chestnut St., Alhambra, CA 91803-1542; (800) 362-3891; fax (818) 281-8231; Internet: http://www.ortel.com.

SIEMENS

RT series relays are small in size, but deliver big performance



RT series relays rise only 0.62" (15.7mm) above the PC board, but they switch up to 16A at 240VAC. And they provide 8mm spacing between contacts and coil for more than 5kV isolation. That's a level of performance you might not expect from a relay this small.

The RT doesn't sacrifice life expectancy, either. Life at various loads is appropriate for appliances, HVAC systems, industrial controls, and computer peripherals.

Check out these features:

- Silver-nickel 90/10 contacts
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READER SERVICE 181

A Clearer Vision Of Automation

As is the case with many of the intertwined markets in the electronics industries, if the semiconductor, electronic, or automotive industries grow, so does the machine vision industry. Given the number of enterprises moving to more automated processes, it's no surprise that this market is seeing gains. According to a new report from the Automated Imaging Association, "The Machine Vision Market: 1996 Results and Forecasts to 2001," the North American machine vision market reached $1.3 billion in 1996.

The figure represents a 13% growth throughout the year. Despite the fact that the market has slowed since its 54% leap in 1995, last year's growth is respectable enough to keep the machine vision industry alive and kicking into the next millennium.

Of the $1.3 billion in revenues the industry saw in 1996, $802 million comes from application-specific machine vision systems. Making up the second largest sector of the market were general purpose machine vision products, totaling $192 million in sales. The remainder comprises sales of image-processing boards and value-added by system integrators and OEMs.

Projections for the future look rosy for the machine vision market. By year's end, the market is expected to top $1.5 billion, growing to $1.7 billion in 1998. Right before the turn of the century, the North American machine vision market will be looking at $1.9 billion in revenues. Automated Imaging estimates the market will hit $2 billion by 2000. Finally, by the end of 2001, $2.5 billion will be spent in the machine vision market.

The force driving the North American machine vision market will be increased capital spending for capacity expansion, productivity, and quality improvements.

The research, conducted by Nellow Zuech of Vision Systems International, also points out some interesting facets of the marketplace and who's playing in it. The study asserts that of the North American machine vision market revenues of 1996, over 51% belonged to the electronic and semiconductor industries, and over 46% of those revenues were derived from exports of their products. In addition, the average price of a machine vision system slipped 8.4%, opening up more options for startups.

The Automated Imaging Association represents 140 companies in the machine vision supplier, system integrator, end users, and research firm sectors. The organization promotes the use of image capture and analysis technology for industrial and scientific imaging.

For more information, contact The Automated Imaging Association, P.O. Box 3724, Ann Arbor, MI 48106; (313) 994-6088; fax (313) 994-3338; Internet: http://www.automatedimaging.com.

—DS

Have Your Old MOVs Worn Out Their Welcome?

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With today's constant quest to provide quality, fail-safe products, over-voltage protection is more important than ever before. So it's probably time to retire old, slow devices like MOVs, which can allow pesky transient voltages to sneak right through.

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Your old MOVs might be effective against low-level transients, but they're slow and degrade over time. Conversely, TransAX™ reacts instantly, withstands voltage spikes to 6000V, and provides a virtually transient-proof device.

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1996 EE Product News PRODUCTS OF THE YEAR AWARD

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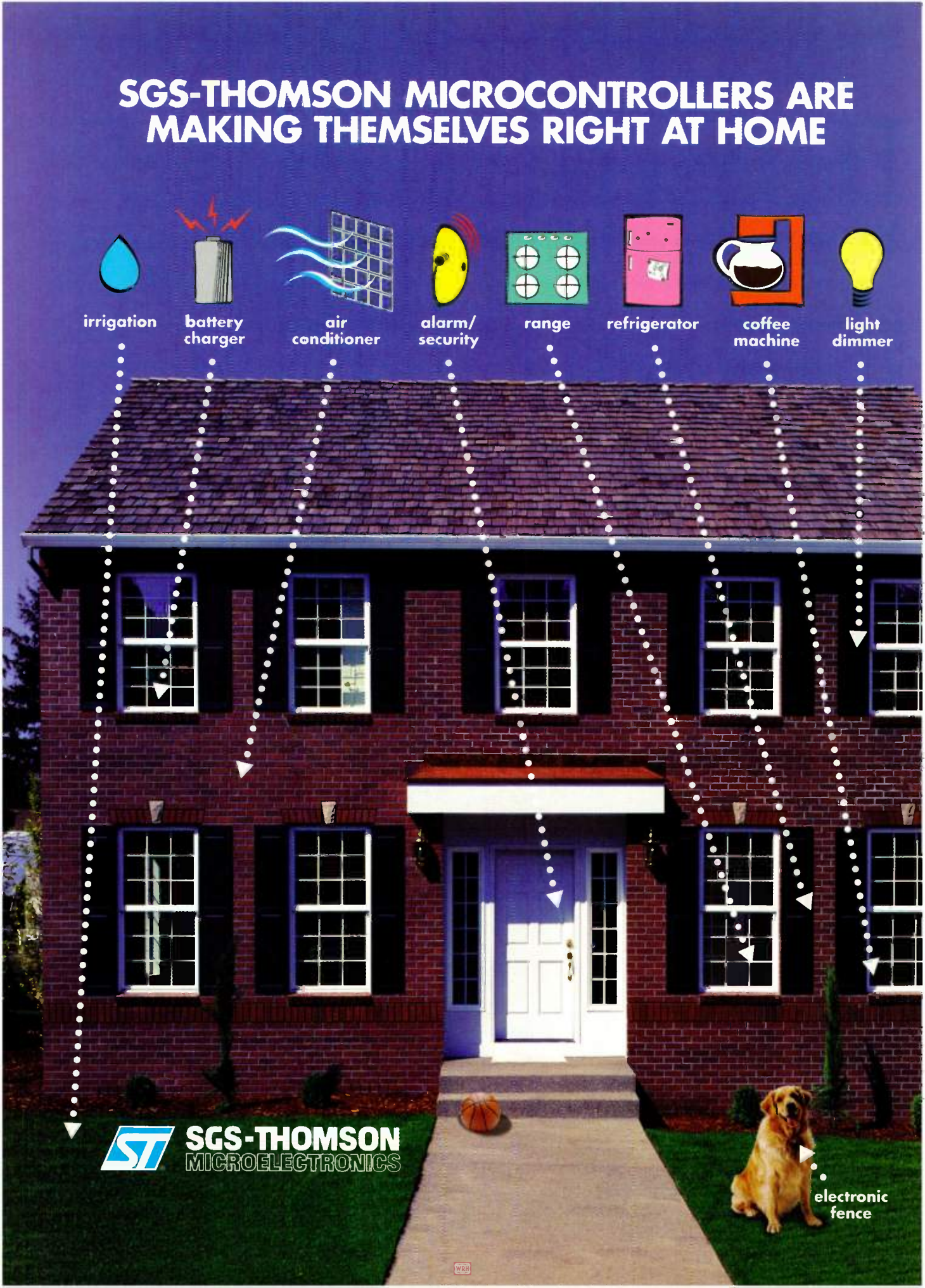
SGS-THOMSON MICROCONTROLLERS ARE MAKING THEMSELVES RIGHT AT HOME



LET OUR MICROS MAKE YOUR PRODUCT A HOUSEHOLD WORD

The reason SGS-THOMSON's 8-bit ST62 family of MCUs is making itself at home in so many household appliances can be summed up in one word: *Value.* ST62 devices deliver more performance in less space for less money. Even the core is optimized for cost-effective operation. Add ESD protection and unmatched noise immunity and you begin to understand why the ST62 is opening doors to consumer applications that remain closed to ordinary MCUs.

Additional ST62 MCU Applications

- washing machine
- power tool
- heater
- UPS
- thermostat
- scale
- programmable timer
- vacuum cleaner
- home bus

All ST62s contain ROM, RAM, an 8-bit timer with 7-bit programmable prescaler and multifunctional individually programmable I/O ports. Also available: Devices with high-current buffers to directly drive LEDs or TRIACs, along with a wide range of peripherals such as PWM and LCD drivers. A wide operating voltage range and robust design allow ST62 microprocessors to be powered directly from a battery or the main with minimum external components.

In addition to the extensive ST62 family, SGS-THOMSON offers other 8-32 bit micro solutions such as ST7, ST9, ST10 and ST20 families. All of these products are fully supported with extensive development tools including C compilers for most families. So why not let our micros help make your product a household word. To find out more fax 617-259-9442, write SGS-THOMSON, 55 Old Bedford Road, Lincoln, MA 01773, or e-mail: info@stm.com. And visit our web site at **http://www.st.com**

ST6
The 8-bit MCUs of choice in automotive and industrial as well as consumer applications. Instruction set and addressing modes maximize code efficiency.

ST7
Powerful industry standard 8-bit core, surrounded by numerous advanced peripherals. 3K to 48K of ROM with different RAM sizes. Choose EPROM and OTP versions for proto-typing. On-chip EEPROM is also available for integrated data storage.

ST9
8/16-bit micro family fills requirements of most advanced computer, consumer, telecom, industrial and automotive applications.

Service and Technology

For More Info Turn Page

OUR 8-BIT MICROS ARE BECOMING HOUSEHOLD WORDS

	DEVICE	PROGRAM MEMORY	RAM	EEPROM	A/D INPUTS	TIMERS	SERIAL INTERFACE	I/O's	PACKAGE	OTHER FEATURES
*	ST6200	1K ROM	64		4x8-Bit	1x8-Bit		9	DIP/SO16	LED or TRIAC driver
*	ST6201	2K ROM	64		4x8-Bit	1x8-Bit		9	DIP/SO16	
*	ST6203	1K ROM	64			1x8-Bit		9	DIP/SO16	
*	ST6208	1K ROM	64			1x8-Bit		12	DIP20/SO20	
*	ST6209	1K ROM	64		4x8-Bit	1x8-Bit		12	DIP20/SO20	
*	ST6210	2K ROM	64		8x8-Bit	1x8-Bit		12	DIP20/SO20	
*	ST6215	2K ROM	64		16x8-Bit	1x8-Bit		20	DIP28/SO28	
*	ST6220	4K ROM	64		8x8-Bit	1x8-Bit		12	DIP20/SO20	
*	ST6225	4K ROM	64		16x8-Bit	1x8-Bit		20	DIP28/SO28	
	ST6240	8K ROM	216	128	12x8-Bit	2x8-Bit	SPI	16	QFP80	LCD driver (segment) + LED or TRIAC driver, 32KHz oscillator
	ST6242	8K ROM	152		6x8-Bit	1x8-Bit	SPI	10	QFP64	
	ST6245	4K ROM	140	64	7x8-Bit	2x8-Bit	SPI	11	QFP52	
*	ST6253	2K ROM	128		7x8-Bit	2x8-Bit		13	DIP20/SO20	auto-reload timer + LED or TRIAC driver + PWM
*	ST6260	4K ROM	128	128	7x8-Bit	2x8-Bit	SPI	13	DIP20/SO20	
*	ST6263	2K ROM	128	64	7x8-Bit	2x8-Bit		13	DIP20/SO20	
*	ST6265	4K ROM	128	128	13x8-Bit	2x8-Bit	SPI	21	DIP28/SO28	
	ST6280	8K ROM	320	128	12x8-Bit	2x8-Bit	SPI, UART	22	QFP100	LCD driver (dot matrix) + auto-reload timer + LED or TRIAC driver
	ST6285	8K ROM	288		8x8-Bit	1x8-Bit	SPI, UART	12	QFP80	
	ST7291	8/16/24K ROM	256/384			1x16-Bit		19	DIP28/SO28	wake-up function + power saving & standby modes + power supply monitor
	ST7294	6K ROM	224	256		1x16-Bit		22	DIP28/SO28	wake-up function + power saving & standby modes + WDG
	ST9036	16K ROM	224+256		8x8-Bit	2x16-Bit	SPI+SCI	56	LCC68	WDG + handshake + Direct Memory Access
	ST9040	16K ROM	224+256	512	8x8-Bit	2x16-Bit	SPI+SCI	56	LCC68	
	ST90R50		224		8x8-Bit	3x16-Bit	SPI+2xSCI	56	LCC84	WDG + 2 handshakes + Direct Memory Access + 16 M Bit address
	ST90R52		224		8x5-Bit	3x16-Bit	SPI+2xSCI	52	QFP80	

Abbreviations:

ADC = Analog to Digital Converter
SCI = Serial Communications Interface
WDG = Watchdog
SPI = Serial Peripheral Interface
USART = Universal Synchronous/ AsynchronousReceiver/Transmitter

Packages:

DIP = Dual In Line
QFP = Quad Flat Pack
S = Shrink
LCC = Leaded Chip Carrier
SO = Small Outline

Also check out our new ST62 REALIZER

The ST62 REALIZER is a user-friendly tool that assists designers in developing applications based on the ST62 family. A graphical schematic description of the application is used to automatically generate the executable code for the ST62 and to run simulations for verification of the program function. The complete tool set runs under Microsoft WINDOWS® environment.

*More Gold Standard devices available from ST (OTP versions only)

For more information fax 617-259-9442
Complete product information at http://www.st.com

SGS-THOMSON MICROELECTRONICS

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FEBRUARY 1998

IEEE Applied Power Electronics Conference and Exposition (APEC '98), Feb. 15-19. The Disneyland Hotel, Anaheim, CA. Contact Pamela Wagner, Courtesy Associates, 655 15th St., N.W., Suite 300, Washington, DC 20005; (202) 639-4990; fax (202) 347-6109; e-mail: pwagner@courtesyassoc.com.

MARCH 1998

Sixth Annual Embebbed Systems Conference East, Mar. 31-Apr. 2. Chicago's Navy Pier Festival Hall, Chicago, IL. Contact Miller Freeman Inc., 600 Harrison St., San Francisco, CA 94107; (415) 905-2354; fax (415) 905-2220; Internet: http://www.embedsyscon.com/.

APRIL 1998

Southeastcon '98, Apr. 10-15. Hyatt Regency, Orlando International Airport, Orlando, FL. Contact Parveen Ward, ECE Dept., University of Central Florida, Orlando, FL 32816; (407) 823-2610; fax (407) 823-5835; e-mail: pfw@ece.engr.ucf.edu.

MAY 1998

IEEE International Conference on Evolutionary Computation, May 3-9. Ankorage, AK. Contact Patrick K. Simpson, Scientific Fishery Systems Inc., P.O. Box 242065, Anchorage, AK 99524; (907) 345-7347; fax (907) 345-9769; e-mail: scifish@akaska.net.

IEEE International Conference on Neural Networks (ICNN '98), May 3-9. Anchorage, AK. Contact Patrick K. Simpson, Scientific Fishery Systems Inc., P.O. Box 242065, Anchorage, AK 99524; (907) 345-7347; fax (907) 345-9769; e-mail: scifish@akaska.net.

IEEE World Congress on Computational Intelligence, May 3-9. William A. Egan Civic and Convention Center, Anchorage, AK. Contact Patrick K. Simpson, Scientific Fishery Systems Inc. P.O. Box 242064, Anchorage, AK 99524; (907) 345-7347; fax (907) 345-9769; e-mail: scifish@alaska.net.

Seventh IEEE International Fuzzy Systems Conference, May 3-9. Anchorage, AK. Contact Patrick K. Simpson, Scientific Fishery Systems Inc., P.O. Box 242065, Anchorage, AK 99524; (907) 345-7347; fax (907) 345-9769; e-mail: scifish@alaska.net.

IEEE/IAS Industrial & Commercial Power Systems Technical Conference (I&CPS), May 4-7. Edmonton, Alberta, Canada. Contact Marty Bince, Modicon Canada Ltd., 5803 86th St., Edmonton, Alberta T6E 2X4, Canada; (403) 468-6673; fax (403) 468-2925.

IEEE International Conference on Acoustics, Speech & Signal Processing (ICASSP '98), May 12-15. Seattle Convention Center, Seattle, Washington. Contact Les E. Atlas, Dept. EE(FT 10), University of Washington, Seattle, WA 98195; (206) 685-1315; fax (206) 543-3842; e-mail: atlas@ee.washington.edu.

JUNE 1998

IEEE/MTT-S International Microwave Symposium (MTT 98), June 7-12. Baltimore Convention Center, Baltimore, MD. Contact Steven Stitzer, Westinghouse Electric Corp., P.O. Box 1521, MS 3T15, Baltimore, MD 21203; (410) 765-7348; fax (410) 993-7747.

USENIX 1998 Technical Conference, June 13-17. Marriott Hotel, New Orleans, Louisiana. Contact USENIX Conference Office, 22672 Lambert St., Suite 613, Lake Forest, California 92630; (714) 588-8649; (714) 588-9706; e-mail: conference@usenix.org; Internet: http://www.usenix.org.

JULY 1998

IEEE International Geoscience & Remote Sensing Symposium (IGARSS '98), July 6-10. Sheraton Seattle, WA. Contact Tammy I. Stein, IGARSS Business Office, 2610 Lakeway Dr., Seabrook, TX 77586-1587, (281) 291-9222; fax (281) 291-9224; e-mail: tstein@phoenix.net.

IEEE Power Engineering Society Summer Meeting, July 11-17. Sheraton Hotel, San Diego, California. Contact Terry Snow, San Diego Gas & Electric, P.O. Box 1831, San Diego, California 92112; (619) 696-2780; fax (619) 699-5096.

IEEE Power Engineering Society Summer Meeting, July 12-16. Sheraton San Diego Hotel & Marina, San Diego, CA. Contact Terry Snow, San Diego Gas & Electric, P.O. Box 1831, San Diego, California 92112; (619) 696-2780; fax (619) 699-5096; e-mail: t.snow@ieee.org.

IEEE Nuclear & Space Radiation Effects Conference (NSREC '98), July 20-24. Newport Beach, California. Contact Jim Schwank, Sandia National Laboratories, Post Office Box 5800, MS-1083, Albuquerque, New Mexico 87185-1083; (505) 844-8376; fax (505) 844-2991; e-mail: schwanjr@sandia.gov.

AUGUST 1998

AUTOTESTCON '98, Aug. 24-27. Salt Palace Convention Center, Salt Lake City, UT. Contact Robert Myers, Myers/Smith Inc., 3685 Motor Ave., Suite 240, Los Angeles, CA 90034; (310) 287-1463; fax (310) 287-1851; e-mail:bob.myers@ieee.org.

OCTOBER 1998

IEEE International Conference on Systems, Man, & Cybernetics, Oct. 12-14. Hyatt Regency La Jolla, La Jolla, CA. Contact M.A. Jafari, Dept. of Industrial Engineering, Rutgers University, P.O. Box 909, Piscataway, NJ 08855; (908) 445-3627; (908) 445-5467; e-mail: jafari@gandalf.rutgers.edu.

NOVEMBER 1998

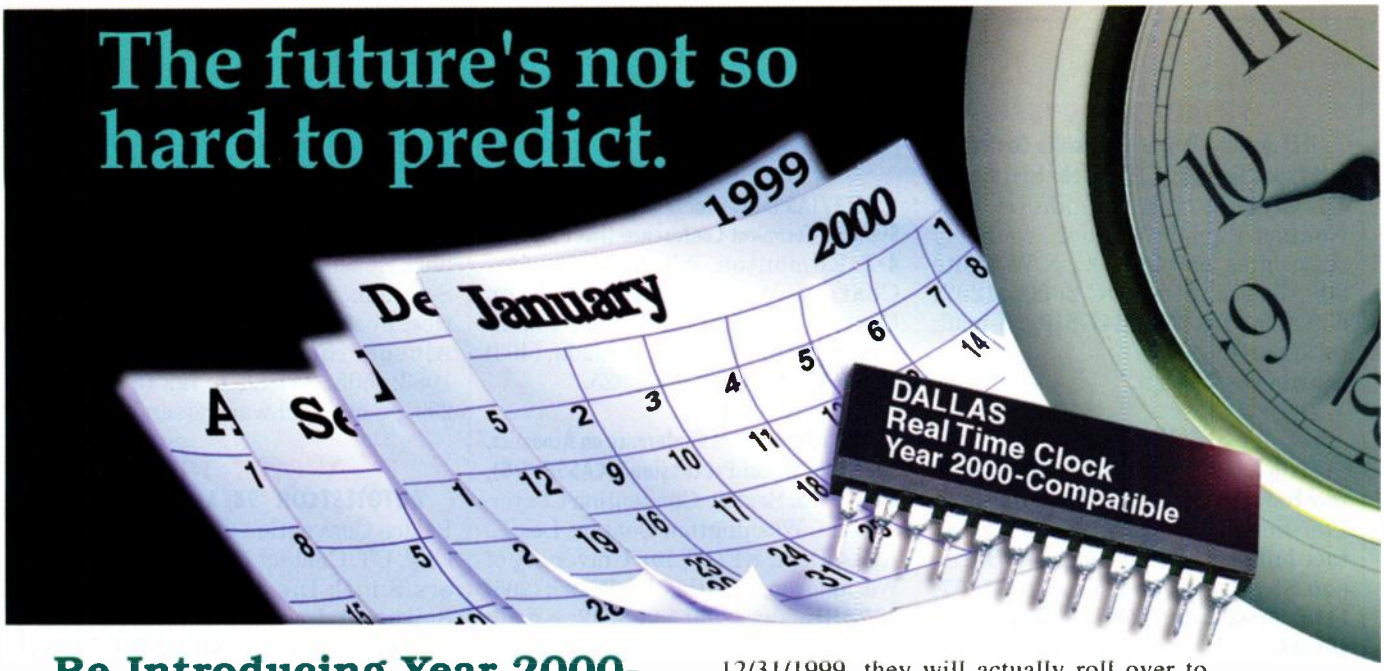
IEEE Global Telecommunications Conference (Globecom '98), November 9-13. Sydney, Australia. Contact Sam Reisenfeld, School of Electrical Engineering, University of Technology, Sydney, Post office Box 123; Broadway, NSW 2007, Australia; (61) 2-330-2435; e-mail: samr@trnasmit.ee.uts.edu.au.

DECEMBER 1998

12th Systems Administration Conference (LISA '98), December 6-11. Marriott Hotel, Boston, Massachusetts. Contact USENIX Conference Office, 22672 Lambert Street, Suite 613, Lake Forest, California 92630; (714) 588-8649; (714) 588-9706; e-mail: conference@usenix.org; Internet: http://www.usenix.org.

JANUARY 1999

Annual Reliability & Maintainability Symposium (RAMS), Jan. 19-21. Washington Hilton, Washington, DC. Contact V.R. Monshaw, Consulting Services, 1768 Lark Lane, Cherry Hill, New Jersey 08003; (609) 428-2342.



Re-Introducing Year 2000-Compliant Clocks from Dallas Semiconductor

In 1992, Dallas Semiconductor introduced the first Y2K-compatible clock. We figured that barring the destruction of Earth by hostile aliens, January 1, 2000 is coming and we'd better help our customers get ready for it.

As the millennium creeps ever closer, operating system manufacturers and application software developers are working to convert from a 2-digit to a 4-digit year system. The date-handling algorithms in millions of lines of code will have to be updated; entire database systems may have to be redefined and rebuilt to incorporate 4-digit years. All in all, an overwhelming undertaking. However, with all due respect to these activities, we humbly ask whether such changes are being made on a firm foundation.

A Hardware Fix

Of course you expect the operating system to return a 4-digit year to any application program that asks for the date after you've upgraded to Y2K-compliant software. We suggest you should also expect the real time clock to return a 4-digit year to the operating system. While it's true that the 2-digit date that other clocks output can be changed in the operating system or through application software, are you absolutely certain that your system will give the correct date and year when 2000 rolls around?

All Dallas Semiconductor Year 2000-compatible clocks extend the 2-digit year to 4 digits with the addition of a century counter. As the time changes from 11:59:59 p.m. on 12/31/1999, they will actually roll over to 12:00:00 a.m. - 01/01/2000 and not even think about it. As a matter of fact, the Y2K clocks will even show 02/29/2000 without breaking into a sweat.

Added Benefits

Dallas Y2K clocks do more than just tell the correct time. Here are some useful features they provide:

- 114 bytes of user RAM to store any critical data requiring nonvolatility
- From 128 bytes to 8Kbytes of extended, general-purpose RAM to store even more critical data
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Super Chip Is The First To Get The Cable Modem Down To Size

Industry Demands For Products To Be On The Superstore Shelves At Less Than $200 Continues To Spur Very Fast Integration Efforts.

Paul McGoldrick

Industry pundits are telling us that the consumer price for the subscriber cable modem must be under $200 for them to be widely accepted. That price will,of necessity, be the one seen in the electronics superstores, and by working the costs backwards to the manufacturing end it seems that the price of a single IC for the communications designer must be around $25. This single IC must contain both the receiver for the downstream channels and the transmitter for the upstream data link for interactive and/or Internet access.

Stanford Telecom's STEL-2176, their "Super Chip," is the first commercial IC to combine these functions. They are closely monitoring the work of the MultiMedia Cable Network Systems (MCNS) Group, which is moving ahead at a rapid pace to obtain commercial solutions *(see "The cable industry unveils its own cable modem standard," p. 70)*. Solutions also must be compliant with the current, but lagging, work of the IEEE 802.14 Standards Committee, the international DAVIC (digital audio-visual committee), and the European DVB (Digital Video Broadcasting) Project.

The IC contains the previously separated downstream demodulator and the upstream modulator ASICs *(Fig. 1)*. But until standards continue to progress, the media access control (MAC) will still be on a separate FPGA, the STEL-1133. The chip is a 0.35-µm, 3-V part.

By year's end, the part will be rereleased as the STEL-2177, fabricated on a 0.25-µm process, still at 3 V, and with the same target price. At that time, the part also will have the MAC integrated on board.

The downstream demodulator has 16-, 64-, and 256-quadrature amplitude modulation (QAM) capability with switchable Annex A & B forward error correction (FEC), allowing for the chip to meet both DVB/DAVIC and MCNS/IEEE 802.14 requirements. The upstream burst modulator can produce binary phase-shift keying (BPSK), quadrature phase-shift keying (QPSK), and 16 QAM with FEC, and covers both the U.S. range up to 42 MHz and the extended DAVIC band to 65 MHz. It is expected that QPSK will be the modulation of choice for the upstream.

What's Inside?

On the receiver side of the chip, the down-converted signal passes through an external IF amplifier and filter at either the U.S 44-MHz or European 36-MHz standards with a bandwidth of 6 and 8 MHz, respectively *(Fig. 2)*. Gain and frequency control signals are available from the STEL-2176 to the IF, which directly feeds an on-board, high-frequency, 10-bit analog-to-digital converter (ADC) being sampled at 25 Msample/s (the external crystal oscillator is operated at approximately 25 MHz.) The digital IF passes through a 4-sample/symbol interpolator into the direct digital down converter (DDC). The converter produces the baseband data signals plus both analog and fast digital automatic gain control (AGC) and automatic frequency control (AFC) signals. A feedback loop from the adaptive equalizer also corrects inter-symbol errors.

The received signal level can be at 2 V pk-pk within ±15 dB with a signal-

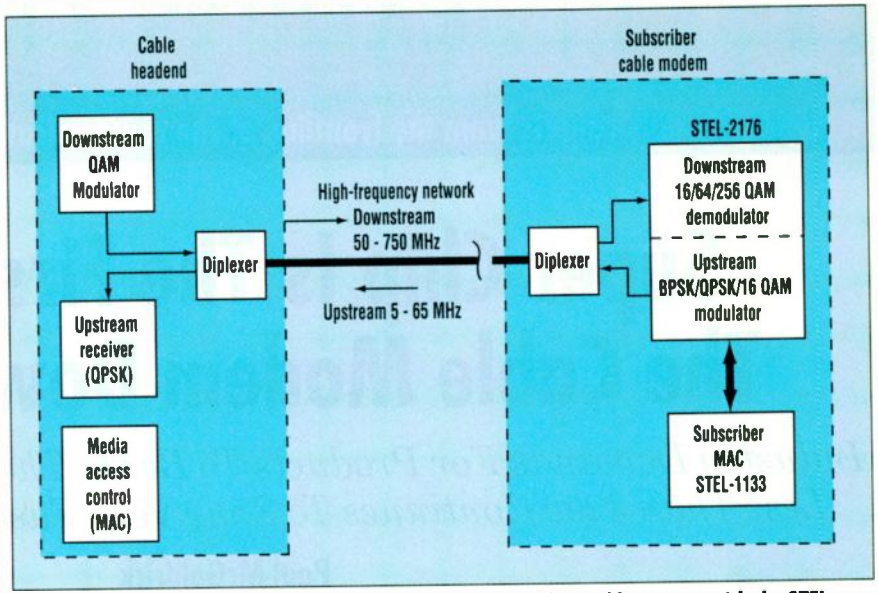
to-noise ratio (SNR) of 17 dB (16 QAM) to 30 dB (256 QAM) for a corrected bit-error rate (BER) of 10^{-8}. Symbol rates can be handled from 5 to 5.360537 Mbaud within a 6-MHz bandwidth, and 6 to 6.952 Mbaud with an 8-MHz bandwidth.

The data passes through a programmable Nyquist filter (set from 0.12 to 2.0) and into the clock-recovery circuit, which drives one side of the clock synthesizer PLL. The adaptive channel equalizer is a high-speed, 20-tap circuit, which will equalize up to 2 ms. The completion of the digital carrier-tracking loop is implemented so that data acquisition is less than 50 ms for 256 QAM.

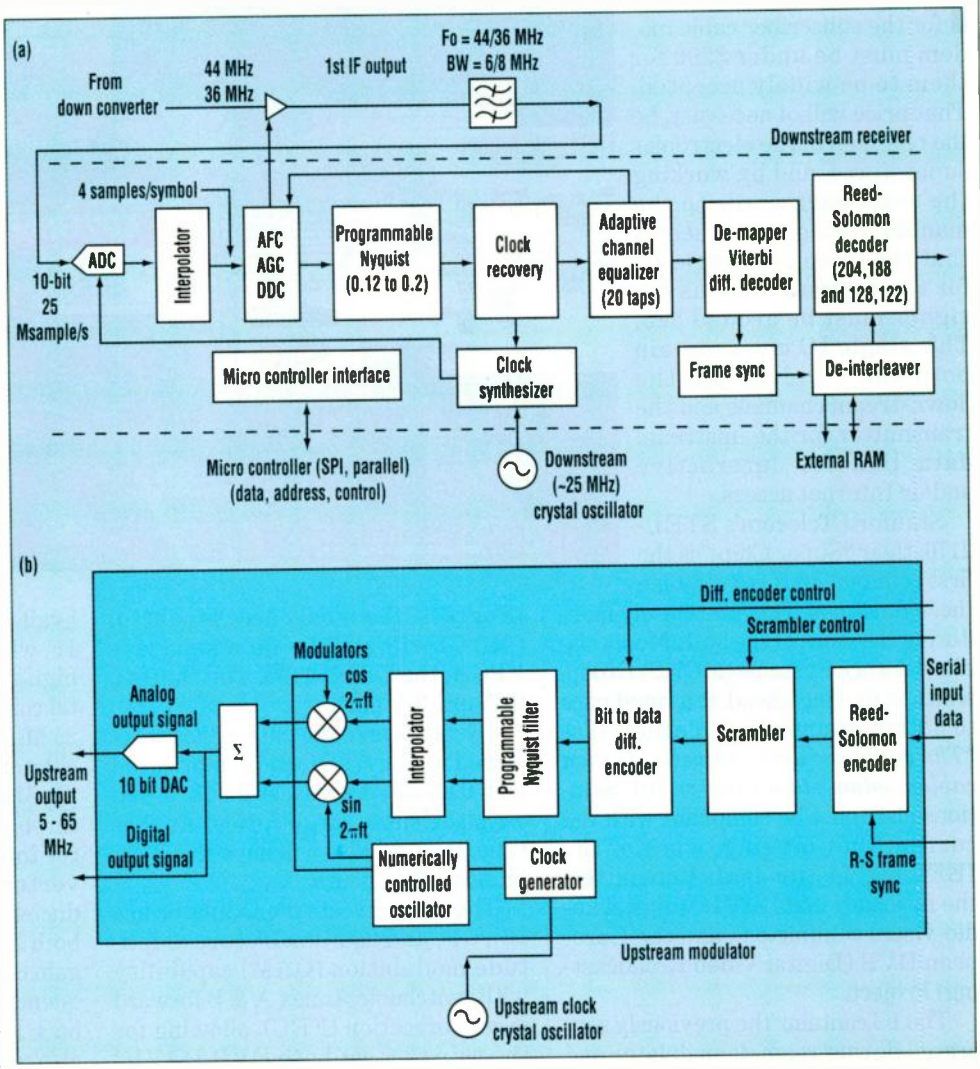
The FEC path consists of a demapper and Viterbi (4/5) differential decoder, frame sync circuits, and a de-interleaver followed by a Reed-Solomon decoder (128,122 for Annex B and 204,188 for Annex A) to provide the system output. Deep de-interleaving (above 12) can be achieved with externally-connected RAM. (The standards seem to be heading toward 128 as the deepest de-interleave to be provided for.) The microcontroller interface allows for SPI or parallel connection to the MAC.

Stanford Telecom holds a U.S. patent involved in the upstream modulator implementation. Patent #5,412,352, "Modulator having direct digital synthesis for broadband RF transmission," is already under some pressure. However, the upstream data input feeds a Reed-Solomon (two polynomials, $3 \le N \le 255$, $0 \le T \le 10$) encoder into a programmable polynomial scrambler and two-channel differential encoder (which can be turned on and off) through dual, roll-off-programmable Nyquist filters to the dual interpolators *(Fig. 2, again)*.

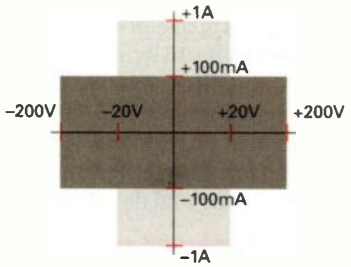
The sine and cosine modulators are fed from the separate upstream oscillator, clock generator. and numerically controlled oscillator. The quadrature modulator outputs are summed and fed directly to a



1 Depicted is the basic arrangement of a high-frequency, duplex, cable system with the STEL-2176 providing a nearly-single chip solution for the set-top modem.



2 A block diagram of the Stanford Telecom Super Chip, the STEL-2176. The IC provides a 16/64/256-QAM demodulator (a) and a BPSK/QPSK/16-QAM upstream modulator (b).



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	±100mA/200V	±20mA/1100V	±1A/60V	To IEEE-488 = 1ms	Digital I/O	Ohms	0.04%
Power	22W	22W	66W	Range change = 13ms	Component handler		

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10-bit ADC to provide the RF output between 5 and 65 MHz.

The RF output level is 960 mV peak into 50 Ω, while the symbol rate that can be handled is between 0.128 and 4.096 Msymbol/s. The step size of the RF carrier frequency is <10 Hz, while the transmit clock frequency is within 50 ppm or can be locked to the cable headend. The typical preamble length is expected to be 16 symbols, and the design can handle from 0 to 127 with variable burst lengths up to the continuous mode.

The chip is highly programmable to allow for existing and developing standards, and other optional clock plans can be implemented for both downstream and upstream. The MAC provides automatic data sync for the upstream transmission, and a synchronized clock with the serial bit or baud-rate output data. The MAC also gives a QAM acquisition flag, an

The Cable Industry Unveils Its Own Cable Modem Standard

Cable modems are one part of the technological arsenal that the cable television industry has amassed in hopes of boosting its flagging revenues and staving off attacks on its empire by a horde of emerging technologies. Most cable operators agree that their best hope is to roll-out reasonably priced, IP-based, 2-way multimedia and high-speed data services ahead of the competing telco-based ventures. To coordinate their efforts, they formed the Multimedia Cable Network Systems (MCNS) Group in cooperation with their industry R&D consortium, CableLabs, Louisville, Colorado.

Moving very quickly, MCNS unveiled a draft specification for cable modems last December, and its RF interface portion was updated and ratified at the Cable '97 show this past March. Its stated purpose is to "allow transparent bi-directional transfer of Internet Protocol (IP) traffic, between the cable system headend and customer locations, over an all-co-axial or hybrid-fiber/coax (HFC) network."

When completed, the specification will define functional requirements and interface protocols for all the elements in a cable data system, including headend equipment, cable modems, and their interfaces to customer premises equipment. Under the plan, cable modems will employ the TCP/IP and point-to-point protocols (PPP) to allow connection with World Wide Web sites, or any other IP service.

Robert Cruickshank III, director of Digital Network Technologies at CableLabs, explained that the entire MCNS specification will be a formidable body of work, probably requiring one or two more years to complete. The MCNS members are currently developing priorities to decide which features and functions will be developed and tested first. Efforts have already begun on the MAC and PHY, along with protocols to implement security, IP, and simple network management (SNMP).

The recently approved version of the RF interface defines the physical and logical interfaces between a cable modem and its associated cable network, a cable network to a headend, and a media access control (MAC) for all devices using the cable. Since only 15% of the cable networks in operation today have infrastructures that support two-way data, the specification also gives operators the option of using a telephone line for upstream communication between the subscriber and headend.

The standard describes the building blocks required to build a network capable of sending digital data to subscribers at up to 30 Mbits/s across distances up to 100 miles. Downstream transmission will be done over one or more unused 6-MHz video channels within the broadcast cable spectrum, using either 64-or 256-state QAM. This data will be sent from the headend across a coax or fiber backbone to a local node where it will be simultaneously broadcast over cable to a sub-network of of 200 to 2000 homes. Thanks to a data packet addressing scheme adapted from Internet protocols, only the data packets intended for for a particular user will be intercepted by their modem.

The upstream RF channel for data returning to the headend is located in the 5- to 42-MHz sub-split band, just below the normal cable channels. Upstream data modulation can employ either QPSK or16-QAM. This can support data rates of between 320 kbits/s and 10 Mbits/s, depending upon the equipment used and channel conditions. The upstream channel will also be shared by hundreds of users, using a carrier sense, multiple access, collision detect (CSMA-CD) MAC protocol to manage traffic.

It is hoped that, once finished, the MCNS standard will be a foundation upon which equipment manufacturers can build interoperable products, using standard semiconductor products (such as the Stamford Telecom modem described in this article) wherever possible. Broadcom Corp., Irvine, Calif., among others, has already introduced a 3-part modem chip set that will be integrated into a single die later this year. By taking advantage of economies of scale and common technologies, manufacturers should be able to enjoy large cost- as well as time-to-market savings.

While the finalization of the standard should be a big step towards interoperability of equipment between manufacturers, a true plug-and-play environment may take a while longer. Details for issues like security and network management will need to be hashed out some more before cable operators can mix-and-match equipment from different vendors at will.

Despite initial growing pains, the MCNS specification could provide the cable industry with a solid path for expansion of its services and resultant revenues. Plans are already under way for accommodating advanced features into the specification as the need arises. Cable networks of the future may carry data interleaved within MPEG digital video frames, and subscribers may be able to access real-time multimedia over the Internet using the quality of service (QOS) and resource reservation (RSVP) protocols adopted by the new IPv6 protocol.

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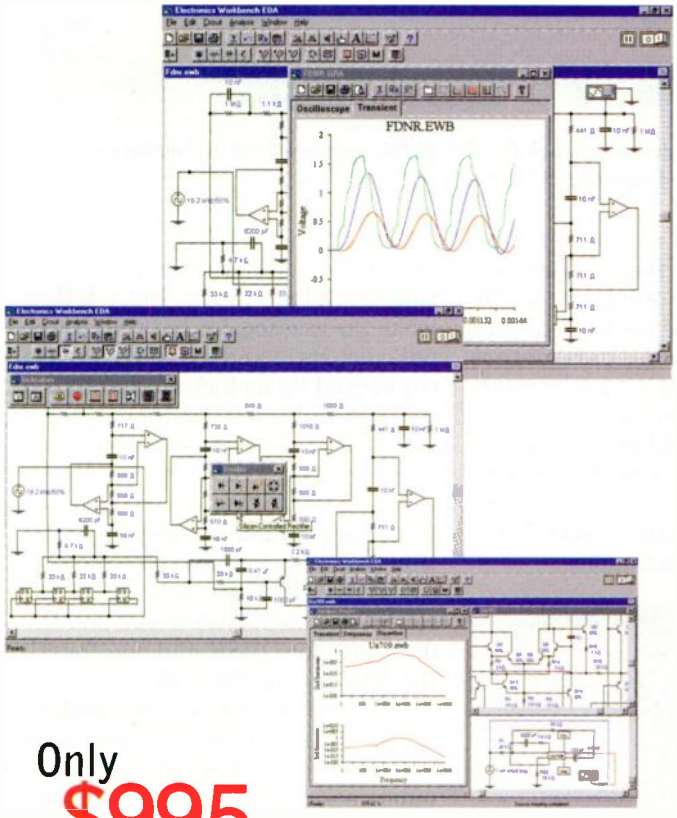

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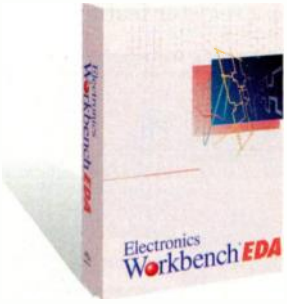

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0497

READER SERVICE 135

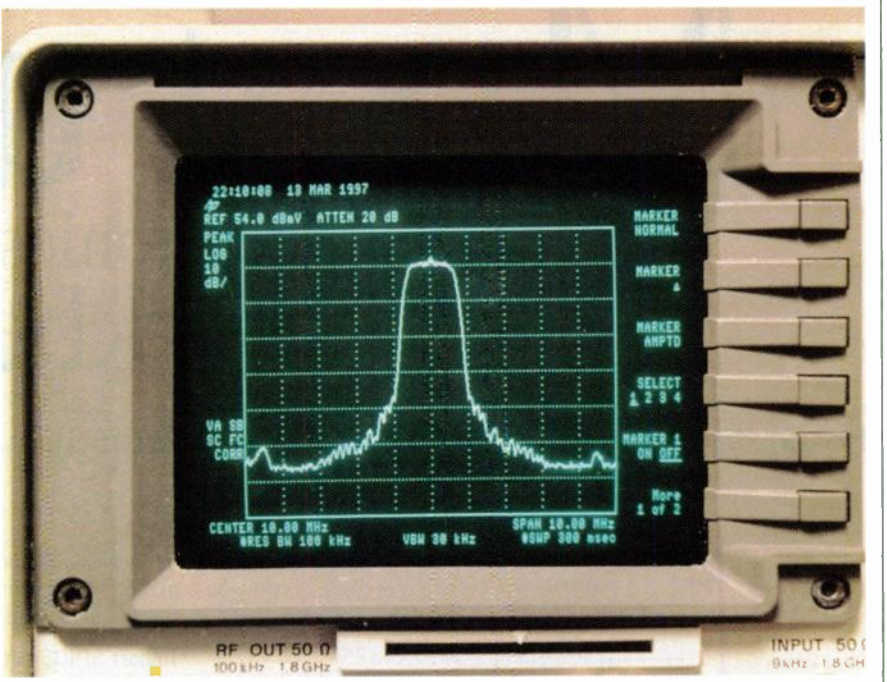
SNR, and an FEC error-count readout.

Evaluation Board

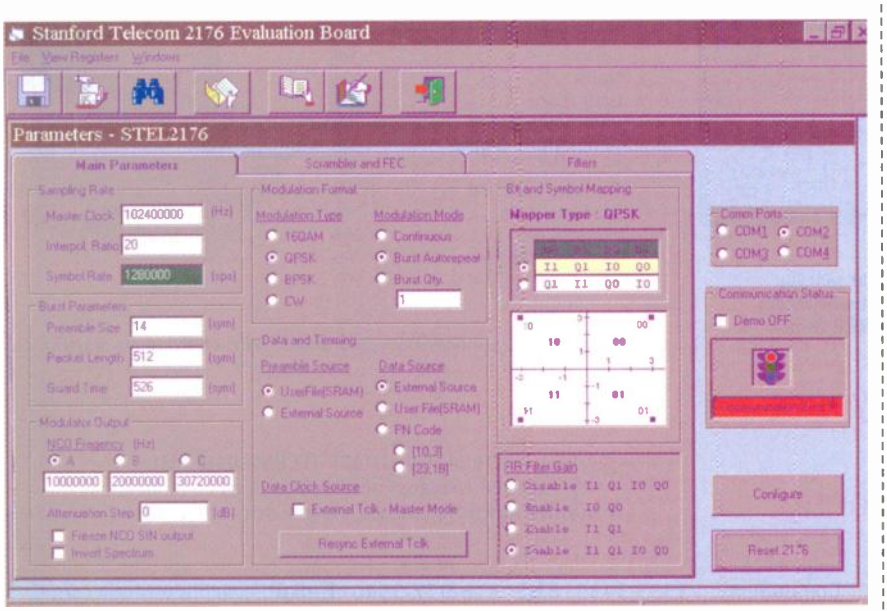
A STEL-2176 evaluation board is available with the MAC STEL-1133 FPGA allowing for flexibility in the way it can be programmed into specific customers' environments. Digital test pins are provided for easy monitoring of the functional timing relationships. For the upstream oscillator, a 102.4-MHz crystal oscillator is on-board. With the output modulated carrier programmable to about 40% of the oscillator frequency, this allows testing up to 40 MHz. An external clock (at +10 to +13 dBm) also can be selected to cover the full output range to 65 MHz.

The evaluation board's operating modes can be modified by writing new values to the STEL-2176 and the burst controller's registers. These registers can be read and written through a graphical-user interface (GUI) that comes with the board. The GUI software allows the user to select options such as different modulation methods, preamble size, and interpolation ratio on a PC running Windows 95 *(Fig. 3)*. Communication is on a serial com port. At power-up or reset, the default values are for repeating QPSK modulation (50%) centered at 10 MHz.

Menus on the GUI include the ability to only view the registers or to alter a register feature on the main dialog box. The main parameters, the control signals, and the finite impulse response (FIR) coefficients can be modified in separate parameter-entry screens. On the main parameters screen, all the fields are programmable with the TAB key moving the cursor from field to field *(Fig. 3, again)*. The CONFIGURE button downloads all the parameters to the evaluation board and a traffic light icon indicates the status of communications.



4 A typical spectrum analyzer display of the STEL-2176's upstream QPSK modulation of 1.28 Msamples/s at a center frequency of 10 MHz.



3 An example of a GUI screen for changing the main parameters on the STEL-2176 evaluation board giving control of sampling, burst, modulation and timing.

Within the window, the master clock frequency must be set to the actual clock rate (here, 102.4 MHz), while the relationship between interpolation ratio and symbol rate are connected by a clock that equals 4 times the interpolation times symbol rate. When either the interpolation ratio or symbol rate are entered by the user, the software calculates the remaining parameter. The interpolation ratio determines the sampling rate of the FIR filter while the symbol rate of the modulator is one-half the data rate for QPSK and one-fourth the data rate for 16 QAM.

The sum of the burst parameters cannot exceed 16384 with a preamble between 0 and 255 symbols, a minimum packet length of 1, and a maximum of 16383 minus the guard minus the preamble, with a default of 512 symbols, and a guard time that is a minimum of 2 symbols. Default on the guard time is 526 symbols giving a preamble plus guard of 526 symbols to offer a 50% duty cycle with the packet length BER testing.

Frequency can be quickly changed by going between three preset codes while the output attenuation can be varied in 1-dB steps from 0 to 15 dB. The "Freeze NCO SIN output" collapses the I-axis and can be used in the BPSK mode to rotate the constellation 45°, while the in-

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vert spectrum function reverses the I-axis to interchange the upper and lower sidebands of the spectrum.

In addition, the modulation type and mode for the upstream signal can be changed as well as the sources for both preamble and data from either on-board or external SRAM. A bit and symbol mapping window is provided.

On the screen for Control Signals (not shown), the Reed-Solomon en-

By year's end, the part will be rereleased as the STEL-2177, fabricated on a 25-µm process, still at 0.2 V

gine can be enabled with either hardware or software control, as can the scrambler and differential encoder control for changes in the synchronization, initial, mask, primitive polynomials, block-code parameters, and MSB or LSB locations or sources for first bit in serial conversions.

On the FIR screen, the filter may be completely bypassed or the shape can be changed between raised-cosine, root-raised-cosine, or a user's custom shape. The bandwidth can be set between 0 and 1.0 with a display of coefficients following such changes; the calculated coefficients can be scaled down to avoid saturation of the accumulators in the STEL-2176.

A typical spectrum from the upstream output of the STEL-2176 shows a 10-MHz modulator output frequency with QPSK modulation (*Fig. 4*).

Price And Availability

The STEL-2176 is now sampling and will be in full production by this September in a 100-lead TQFP. It is priced at $25 each in 100,000-unit lots. The evaluation board is available now.

Stanford Telecommunications Inc., Telecom Communications Products, 480 Java Dr., Sunnyvale, CA 94089; (408) 745-2660; fax (408) 541-9030; e-mail: tpg.marketing@stelhq.com; Internet: http://www.stelhq.com. **CIRCLE 500**

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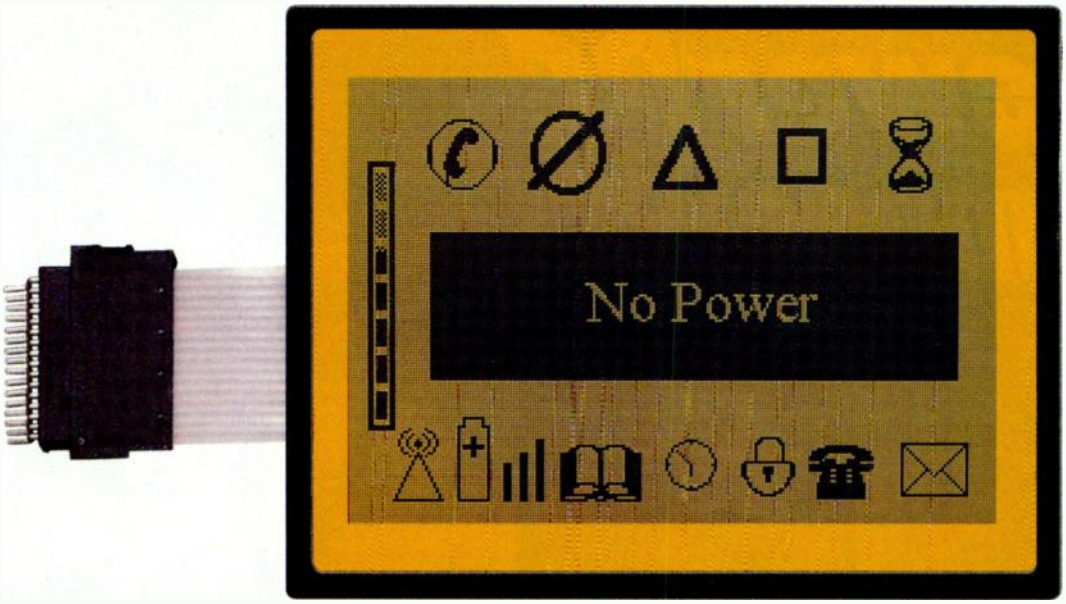

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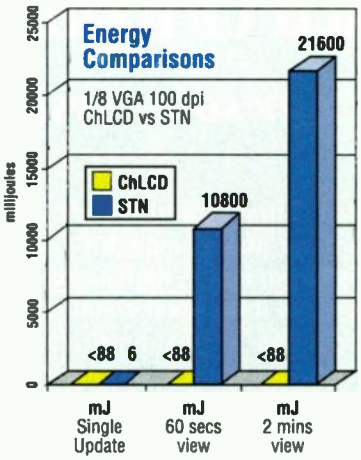

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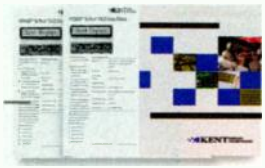

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Multimode Cellular/PCS Handsets: The Quest For The Ultimate Phone

It's Pandemonium In The Wireless World! Here's A Look At The Key Issues And Technical Challenges Engineers Are Facing When Designing Handsets For This Rapidly Changing Market.

Lee Goldberg

SPECIAL REPORT

In the turbulent world of wireless communications, it's difficult to decide whether to feel sorrier for consumers or engineers. Thanks to a misguided experiment in "free market dynamics," the North American airwaves have become a free-fire zone where both designers and users are caught in a shoot-out between the incumbent 800-MHz cellular providers and the personal communication system (PCS) operators conducting insurgent operations at 1900 MHz.

Adding to the confusion is the emergence of three digital air interface standards (TDMA, CDMA, and GSM), each competing for its share of the market. In this environment, it's difficult to tell which combination of these technologies should be stuffed into a handset to make it most useful.

It will be at least two to three years before consumer trends coalesce and attrition among providers decides which services will dominate the scene. In the interim, we can attempt to make some educated guesses about which technology combinations will be most successful, and examine the technical challenges of implementing them. First, let's take a quick look at the environment that these phones will be operating in.

Art Courtesy: Motorola

A Balkanized Patchwork

The rollout of digital services has been slower and less unified than predicted for both cellular and PCS providers. This has turned the U.S. into a balkanized patchwork of noninteroperable services. Digital cellular's ability to squeeze between three and six times the amount of traffic into the same bandwidth makes it an invaluable tool for relieving congestion in the larger urban areas.

While most urban areas will see the arrival of CDMA or TDMA cellular service in the next two years, it will take considerably longer to deploy a digital infrastructure in less densely populated areas. Since there is less incentive to move quickly in these outlying areas, we can expect to see islands of digital service floating in an ocean of analog-only coverage well into the next century.

Market forces should eventually consolidate or harmonize the competing networks to give subscribers universal digital coverage. From today's vantage point, however, it's difficult to tell how long it will be before a digital phone infrastructure emerges in the U.S. that's as seamless as the older AMPS system. For this reason, nearly all 800-MHz digital handsets now on the market also can access the AMPS network in their fallback mode.

PCS has followed a similar pattern, placing its first networks in urban areas where it can attract the most customers. While PCS service typically extends into a metropolitan area's suburbs, it will probably not provide the seamless service between cities that cellular offers for a long time—if ever. Users that travel infrequently may be satisfied with this limited coverage in exchange for lower rates, but many will need the option of a dual-frequency handset to stay in touch on the beyond city limits. A likely solution for this problem will be a dual-frequency phone that can access the cellular infrastructure when out of earshot of its native PCS system.

Whether you're adding another band, another mode, or both, to a handset, you will add to its complexity and cost; but don't panic! Most 800-MHz digital phones currently on the market are de-

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The **MAX2411A*** performs RF front-end amplification and frequency conversion in both receive and transmit modes. Its unique differential IF interface allows a single SAW filter to serve as a receive and transmit IF filter.

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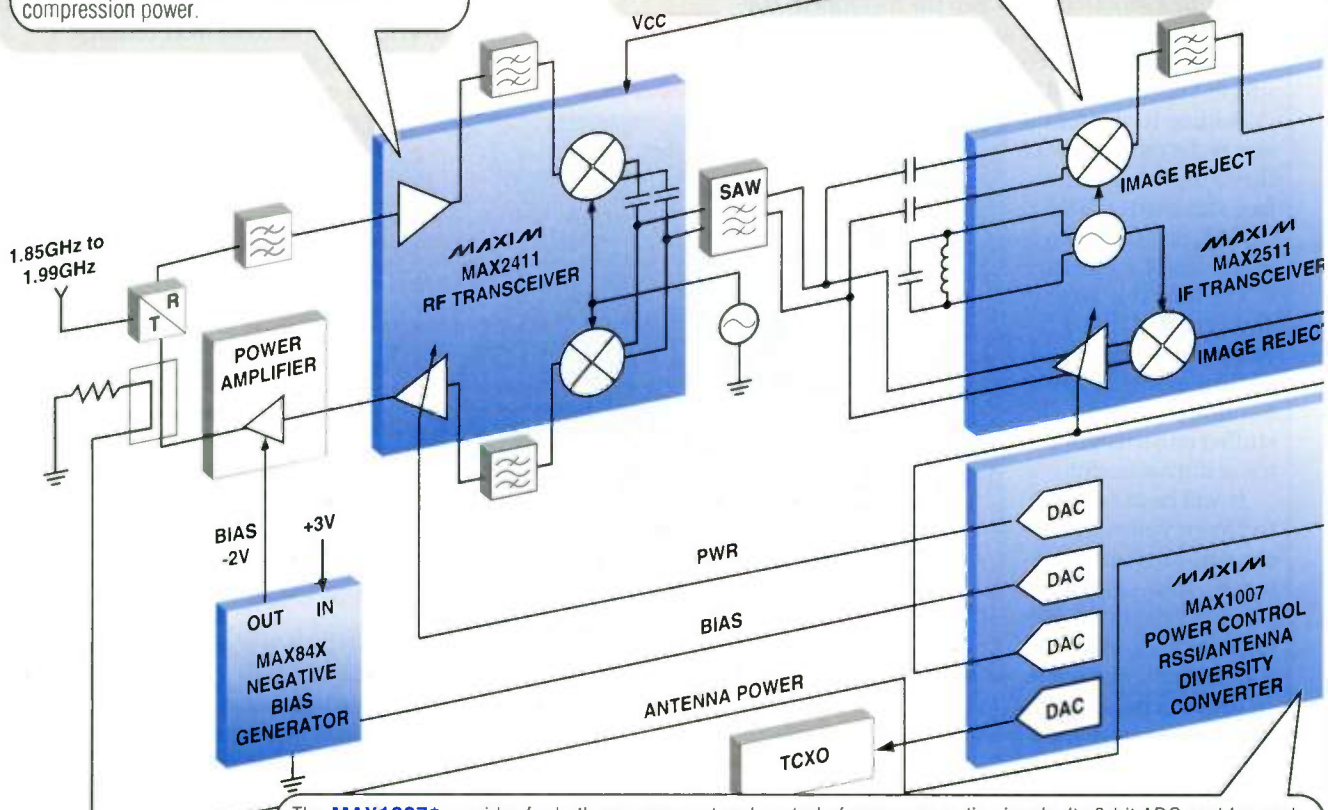
The **MAX2511** performs IF frequency conversion, receive gain, transmit frequency conversion, and gain control functions. The receive mixer input and the transmitter output interface directly to one differential SAW IF filter to save space and cost.

The low-noise receive mixer has a unique image-rejection feature to keep spurious signals or image noise from mixing to the second IF. The RSSI output has excellent dynamic range (>90dB monotonic) and linearity (±2dB error over an 80dB range).

The transmit image-reject mixer generates a clean output spectrum to minimize filter requirements. It is followed by a variable-gain amplifier with +2dBm maximum output power.



The **MAX1007*** provides for both measurement and control of numerous radio signals. Its 8-bit ADC enables peak detecting and measuring of RSSI and PS (power sense) signals. Its internal conditioning circuit converts a PS signal into a DC signal, which is then converted by the ADC. For antenna diversity, the power detector circuit compares two RSSI signals.

The MAX1007 also includes four DACs. XDAC is designed to tune varactor diodes, while SDAC and KDAC adjust power-amplifier output power levels. GDAC provides bias control for GaAs amplifiers. All of the DACs are double buffered, allowing for simultaneous updating of the outputs.

*Available after July 1997. Contact factory for engineering samples.

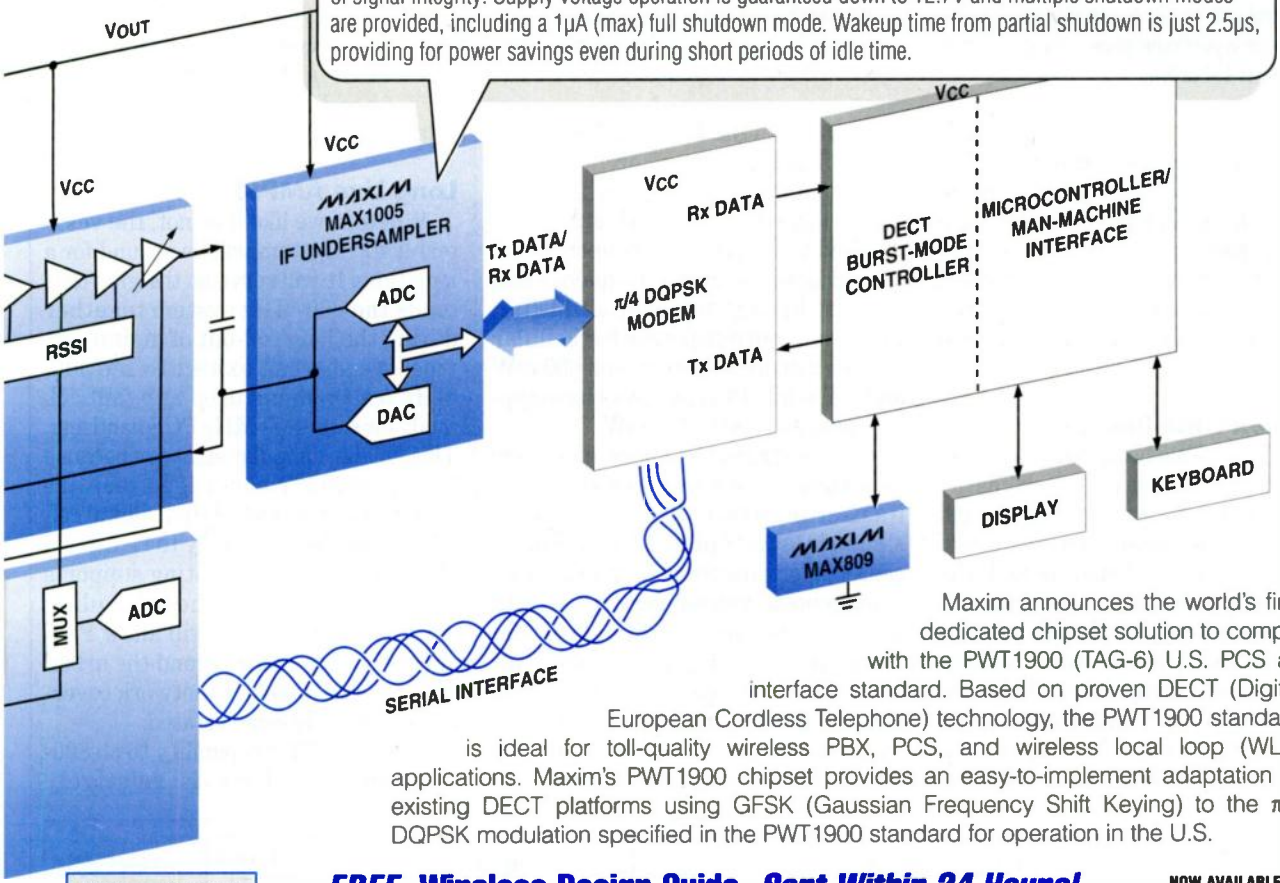
PWT1900 Rev 1

PWT1900 CHIPSET

Design Ready for the U.S. Market

The **MAX1005** includes an Rx ADC and Tx DAC plus voltage reference. In Rx mode, the ADC undersamples the data signal bandwidth centered on the IF. The ADC's 15Msps conversion speed provides for 10-times oversampling of a 1.5MHz data signal. The wide input converter bandwidth provides for IFs in excess of 10.7MHz.

The MAX1005 requires very little power (13mA in Rx and 5.5mA in Tx mode) while providing a high level of signal integrity. Supply voltage operation is guaranteed down to +2.7V and multiple shutdown modes are provided, including a 1µA (max) full shutdown mode. Wakeup time from partial shutdown is just 2.5µs, providing for power savings even during short periods of idle time.



Maxim announces the world's first dedicated chipset solution to comply with the PWT1900 (TAG-6) U.S. PCS air interface standard. Based on proven DECT (Digital European Cordless Telephone) technology, the PWT1900 standard is ideal for toll-quality wireless PBX, PCS, and wireless local loop (WLL) applications. Maxim's PWT1900 chipset provides an easy-to-implement adaptation of existing DECT platforms using GFSK (Gaussian Frequency Shift Keying) to the π/4 DQPSK modulation specified in the PWT1900 standard for operation in the U.S.

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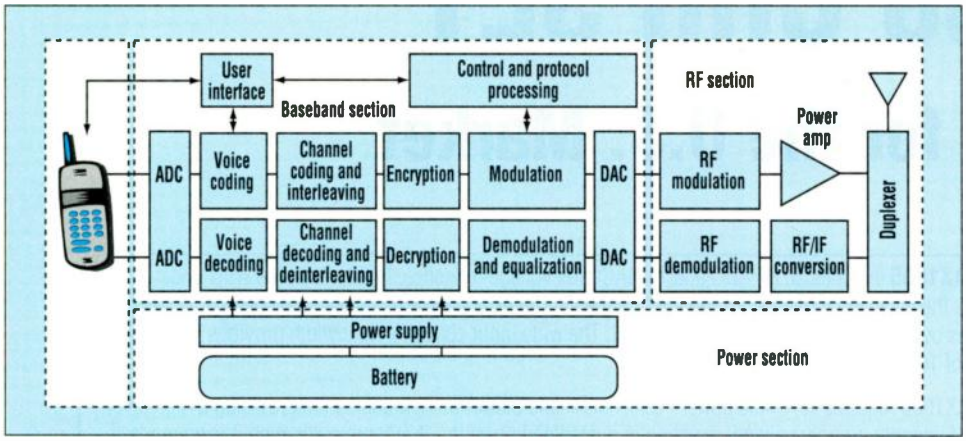


1. A typical cellular phone contains the functions shown in this block diagram. Depending on the architecture employed in a particular phone, more or less of the baseband functions will be incorporated into a single DSP or other LSI circuit.

signed for dual-mode operation, and there are a number of strategies being employed that avoid having to build two completely independent phones in the same package. As we shall see, designers can creatively reuse much of a phones' digital circuitry and even part of the RF section to create a hybrid handset.

Complex Little Beasties

This is possible because today's digital cellular phones are extraordinarily complex animals, usually built around very powerful, programmable digital signal processors (DSPs). In fact, the amount of processing power (in terms of MIPS) packed into a $200 handset is nearly as much as is found in many $2000 personal computers! This is not surprising considering the complex tasks a cell-phone is asked to perform.

In the baseband section, speech is digitized and compressed to an 8- to 13-kbit/s bit rate using one of several algorithms such as CELP, VSELP, or EVRC *(Fig. 1)*. Next, the bitstream is subjected to channel encoding and interleaving, and creation of the in-phase (I) and quadrature (Q) signals.

This is followed by narrow (TDMA or GSM) or wideband (CDMA) baseband modulation. While this is usually done by the DSP for TDMA phones, the three layers of coding and wideband modulation scheme used in CDMA are complex enough that it must currently be handled by dedicated logic instead of a DSP. At this point, most phones produce a digital representation of the baseband signals that are converted back to analog and passed to the IF and RF sections for transmission. Some architectures go even further, leaving the signal in digital form through the IF stage.

Finally, the RF section upconverts the signal to the carrier frequency and runs it through a power amplifier. Maximum output power for cellular phones usually runs between 600 mW and 3W, while PCS handsets have typical outputs of 50 to 500 mW.

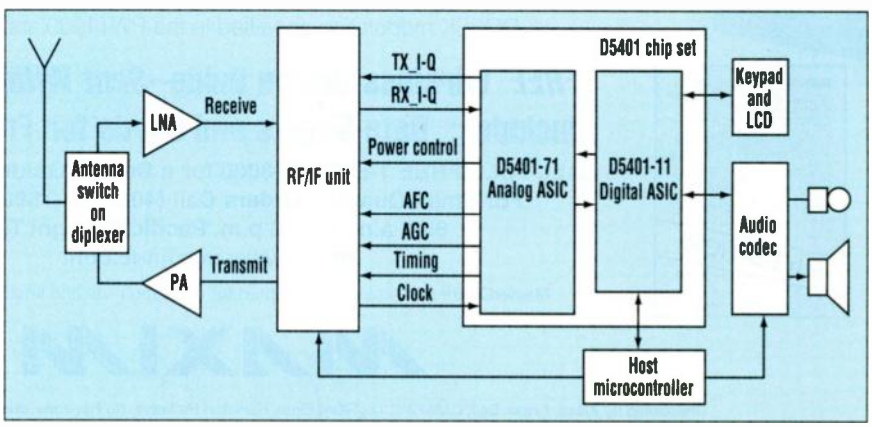
On top of this, the phone must perform call control functions and manage its user interface. While relatively simple in AMPS phones, establishing calls, performing frequency and power management, and supporting security protocols become significant in the more advanced digital systems. Advanced features like messaging, caller ID, and direct data connections add smaller, but noticeable, loads to a phone's processing requirements. In most chip sets, a separate microcontroller is employed for these functions, although companies like Texas Instruments and Analog Devices are developing DSPs with enough processing power to absorb the controller's tasks.

Because so much of a CDMA or TDMA phone's signal chain is digital, it has not been difficult to add a second, less complicated operating mode like AMPS to the design. As we shall see, dual-mode capability involves more than adding some code to the controller and DSP and tweaking the baseband circuitry, but it is still a relatively inexpensive thing to do.

Long Live AMPS!

Whether we like it or not, the vestigial AMPS system will be around for a long time. It will serve as the glue that binds the 800-MHz system together during the long roll-out of digital service. We also can expect to see 800-MHz AMPS being used as a fallback mode for some 800-MHz PCS handsets. This will be a popular strategy because PCS provider's coverage areas are even more fragmented than digital cellulars, and there's no way to be certain that the city you're visiting supports the air interface you need. Adding AMPs capability also will allow PCS subscribers to roam beyond the urban areas where 1900 MHz network coverage is currently concentrated.

Adding AMPS capability to an 800-MHz digital phone is relatively



2. Since it has much simpler speech processing requirements, AMPS functionality can be integrated into a digital baseband chip set relatively easily. In this example, the DSPCommunications D5401 CDMA baseband chip set can perform the baseband processing for either CDMA or AMPS. I and Q signals are passed to a dual-mode RF section for modulation and upconversion.

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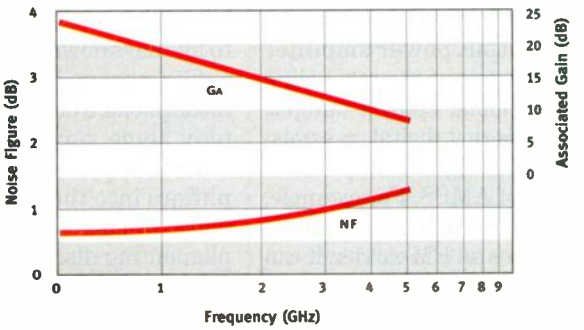

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straightforward since its baseband processing requirements are simpler, and its FM modulation scheme is less demanding of the radio section. Most experts interviewed for this article said that including an AMPS mode is "simply a matter of adding software" to the baseband processor and making some relatively straightforward changes to the RF section. There already are several semiconductor manufacturers (including Comquest, DSP Communications, Phillips Semiconductor, Lucent Semiconductor, Motorola, Qualcomm, and VLSI Technology) offering dual-mode baseband solutions today.

This is not to say that designing a dual-mode is not without its problems. Most AMPS-only phones today employ dedicated circuitry to perform voice and baseband processing. To eliminate this redundancy, software must be generated to perform AMPS-related tasks and then are embedded in the baseband DSP or ASIC *(Fig. 2)*.

The real area of difficulty for a dual-mode handset is in the RF section, especially the output power amplifier (PA). The PA is one of the major line items in a cell-phone's power budget, and the demands that digital transmission puts on it are significantly different than those of AMPS. For example, take the PA's operating bias point. Since AMPS uses an FM carrier, it can run in a deeply saturated portion of the bias curve without worrying about the amplitude distortions it introduces. While very good for power efficiency, a deeply saturated amplifier is not suitable when trying to accurately transmit phase and amplitude information used in the QPSK-based TDMA and CDMA modulation schemes.

If you look at the requirements for a CDMA handset's final stage, you will see that it must be biased to run in an extremely linear operating region to minimize distortion-induced noise that could seriously affect a system's channel capacity. This requires an amplifier to run fairly close to class-A mode, resulting in poor power efficiency.

Fortunately, CDMA's typical output power levels are relatively low (10 to 200 mW), and a handset further conserves its batteries by automatically lowering its data rate and output power whenever there are pauses in a caller's speech. A TDMA handset also has fairly stringent linearity requirements, along with a substantial peak power of 800 mW or more. This is not as big a problem as it might appear because TDMA doesn't transmit continuously. Thanks to its time-slotted access protocol, the transmitter's duty cycle is only around 30%. AMPS, on the other hand, requires that the transmitter run continuously at high power settings for the duration of the call. An amplifier optimized for digital applications can easily transmit an AMPS FM signal, but it will cut the handset's battery life by a factor of 50% or more.

A good example is the first-generation of CDMA handsets that are now available from Qualcomm/Sony. While no official comparison of talk times could be found, an informal survey of users uncovered that a handset's standby times shrunk considerably when using the phone moderately outside digital service coverage areas. With even 10 or 20 minutes of calling in AMPS mode, the phone's standby capability fell from its nominally rated three to five days down to 24 hours or less.

To improve battery life in a dual-mode phone, a designer must either employ some sort of adjustable bias scheme, or put two separate power amplifiers into the phone. While many phone manufacturers are currently implementing discrete or hybrid power amps with adjustable bias, firms like Anadigics, MA/Com, RF Micro Devices, and TriQuint are introducing one-chip power amplifiers that can have their bias adjusted using control lines or external switched resistor networks.

Barok Maoz, product manager for RF products at Anadigics, Warren, N.J., points out that the handset's frequency conversion sections is another significant challenge in the design of dual-mode phones. Since CDMA signals occupy a wider chunk of spectrum than either AMPS or TDMA, CDMA handsets must employ mixers with much better linearity and bandwidth. Maoz also notes that CDMA's wide IF bandwidth places intermodulation noise within the band of interest. To reduce intermodal distortion, a designer will have to use an extremely linear receiver section.

Since an amplifier's power efficiency is inversely proportional to its linearity, Maoz speculates that an advanced RF section may have a smart amplifier that produces a signal that is "just clean enough." In such a CDMA radio, the amplifier might sense the channel's interference level and transmit leakage, and adjust the transmitter's bias until it has just enough linearity to meet current conditions. Under low traffic conditions, the amplifier could be run in a "dirtier," more efficient mode to conserve power.

Two Frequencies, One Radio

Depending on the cellular or PCS provider you talk to, dual-frequency phones are either an absolute necessity or an artifact of an immature market. Actually predicting whether or not 800- to 1900-MHz handsets will suffer the same ignoble fate as 8-track tape players and Beta-format VCRs is a task that is best left to psychics, shamans, and marketeers.We can be fairly certain, however, that engineers will be called upon to design them.

Much like dual-mode phones, most of the critical areas reside in the RF section. The power amplifier, mixer, and modulator in a dual-band radio all require special attention. There seems to be a wide variety of opinion about the right way to build a dual-frequency handset. Some experts interviewed felt that the best approach for today's first-generation units was to build two separate radio subsystems which shared a common baseband section and antenna. Surprisingly, this approach adds only 10 to 15% to the cost of a phone, while allowing each radio to be optimized for efficiency and performance.

Others believe that parts of the RF section can be successfully adapted to dual-frequency operation, thereby keeping system cost and size in line. Barok Maoz of Anadigics speculates that a dual-band radio will eventually be able to share a single power amplifier, VCO, Synthesizer/PLL, and a single wideband mixer. In this scenario, the radio would be coupled to the antenna via two different matching networks, and two sets of filters would need to be employed throughout the signal chain. Already, Anadigics has introduced a dual-frequency integrated power amplifier that incorporates two separate amplifier chains on the same chip *(Fig. 3)*. Texas Instruments (TI) also intends to take a similar approach by offering a dual-frequency PA in its next generation of

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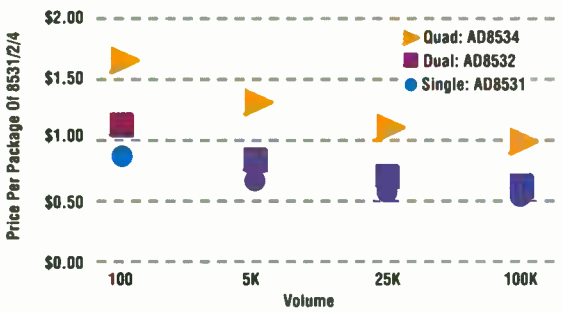

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cellular components.

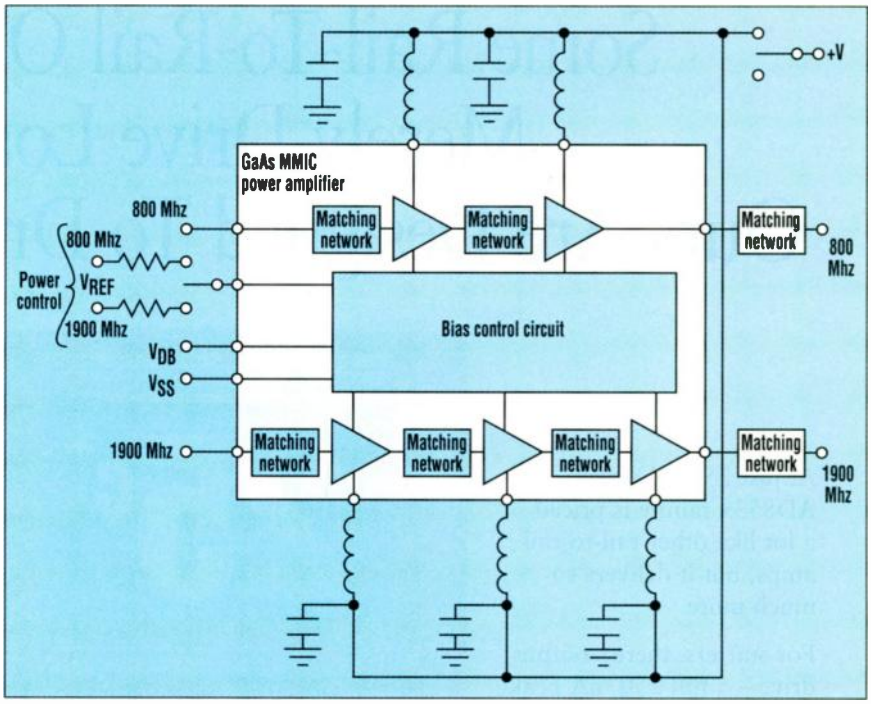
TI's vision of a second-generation dual-band front end includes a 900-MHz modulator/oscillator section that employs a frequency doubler and filter for 1900-MHz operation. The modulator's output would be externally filtered via separate filter paths and fed to a single-chip power amplifier with power sensing and level control. Their proposed dual-band receiver would have duplicate high frequency components, but share a common IF section.

According to Tim Mcafree, New Product Development manager at TI's RFIC group, there is a trend toward moving baseband frequencies higher to improve image separation, a technique that makes it easier to control spur generation and intermodulation distortion. A higher baseband also allows the use of smaller, less expensive filters with fewer poles because the image frequencies generated during mixing are further away from the desired band. This is especially true in PCS products, where a typical IF can run from 120 to 240 MHz versus 45 MHz for a typical AMPS application.

While using higher IF frequencies will simplify the RF section somewhat, they also place more demands on the baseband section. To perform accurate demodulation, the baseband processor will have to sample the signal proportionally faster, thereby increasing the speed requirements of the DSP and its associated circuitry.

Cliff Vaughn, marketing manager at OKI Semiconductor, also points out that developing a dual-frequency phone is not as simple as running things at twice the frequency. One of the hidden "gotchas" explains Vaughn is that at 1.9 GHz, the CDMA and TDMA schemes become slightly incompatible, since the standards are not precisely identical for both frequencies. He also notes that the sidebands are much wider for PCS operation, raising the need for a detector with much greater bandwidth than required for an 800-MHz-only phone.

Looking a bit further into the future, David Varn, technical marketing manager for wireless applications at Cadence Design's Alta Group, imagined how advanced design, simulation, and analysis tools might help engineers fine-tune a dual-band handset design. According to Varn, a designer might theoretically be able to use a more efficient, less linear power amplifier in the design, if they were able to compensate for its nonlinearities using pre-distortion of the input signal, adaptive equalization, and other signal processing techniques. Using advanced integrated design software such as that offered by the Alta Group, it should be possible to use an end-to-end simulation to perform trade-off studies between various components. This would permit a global optimization and verification of performance, power efficiency, and cost, before a single chip is fabricated.



3. This dual-band RF power amplifier can operate in the frequency ranges for both 800-MHz cellular and 1900-MHz PCS services. Rather than attempt to get a single amplifier to span the entire range, the Anadigics AWT919D actually incorporates two separate amplifier chains sharing a single bias control circuit.

If You Build It, Will They Call?

While it is now possible to cram nearly any combination of modes and frequencies into a reasonable-sized phone, the burning question arising from this discussion is: "Do we really need such complicated phones?" Much like the technology involved, there are nearly as many answers as there are service providers.

It turns out that there will probably be more than one formula for creating an ideal "superphone," with combinations of technologies aimed at various market "sweet spots." This is in part because there are varying levels and types of digital cellular and PCS coverage from region to region (and sometimes from city to city).

These phones will be designed to accommodate the different tiers of service that will probably emerge as the market matures. For example, a person living and working in a metropolitan area might select a low-priced PCS-only phone using upbanded IS-136 or PCS1900 (GSM) technology. Others might require a dual-frequency PCS handset with cellular AMPS capability to stay connected on the occasions they travel outside of their area.

Frequent travelers might elect for a more expensive, tri-mode PCS/Digital Cellular/AMPS phone that allowed them to roam nationally, while taking along most of the features they enjoy with their lower-priced local PCS service. Those who travel nationally or internationally on business might have a bi-mode phone that could access the U.S. PCS infrastructure for national coverage, and the capability of hooking into Europe's universally deployed GSM network.

Fuzzy Choices

For many people, however, the choice will be less clearly defined as the

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distinction between services becomes increasingly blurred. PCS providers are attempting to band together to provide larger service areas, while cellular operators have begun to offer the "intelligent services" (text messages, caller ID, voice-dialing, etc.) that were only available from PCS networks. Likewise, the cellular market is having a rough time convincing its many analog subscribers to upgrade to more expensive digital handsets when they are having no more than the usual amount of problems with their AMPS service.

Given this uncertain environment, the challenges engineers will face in designing next year's handsets are as much an issue of marketing as of technology. Both IC and handset manufacturers should answer a few basic questions before committing the millions of dollars required to develop their new products:

1) What digital technology (TDMA or CDMA) will be most popular in the 800-MHz cellular spectrum, and how widely will it be deployed?

2) Will the same technology that wins in cellular also dominate in the 1900-MHz PCS band, or will the PCS1900 (upbanded GSM) or Omnipoint (a TDMA/CDMA hybrid standard) emerge as a dark-horse winner?

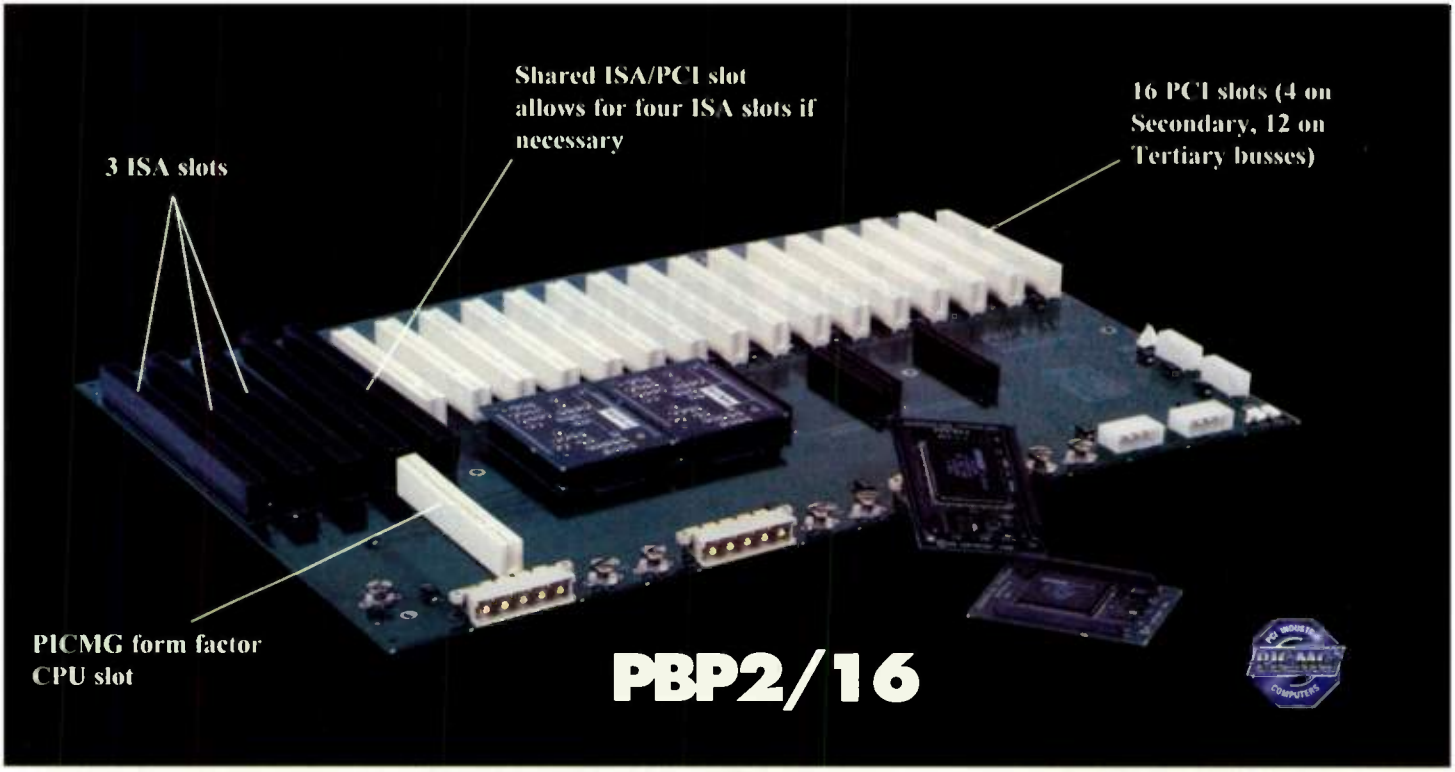
3) What will the relationship between cellular and PCS services be?

4) Will there be a real need for a dual-frequency handset that handles both cellular and PCS traffic, and will a subscriber be able to access to both services using a single phone number?

At the moment, there aren't many firm answers, and we may have to wait another year or two before they begin to appear. During this time, the fragmented market will keep the cost of digital handsets high unless easily configurable, common-technology platforms are developed.

Eventually, we will see an inevitable shakeout of players and technologies. Until then, we can expect to see an interesting mix-and-match hodgepodge of technologies being tucked into multimode, multifrequency handsets.

How Valuable	Circle
Highly	563
Moderately	564
Slightly	565



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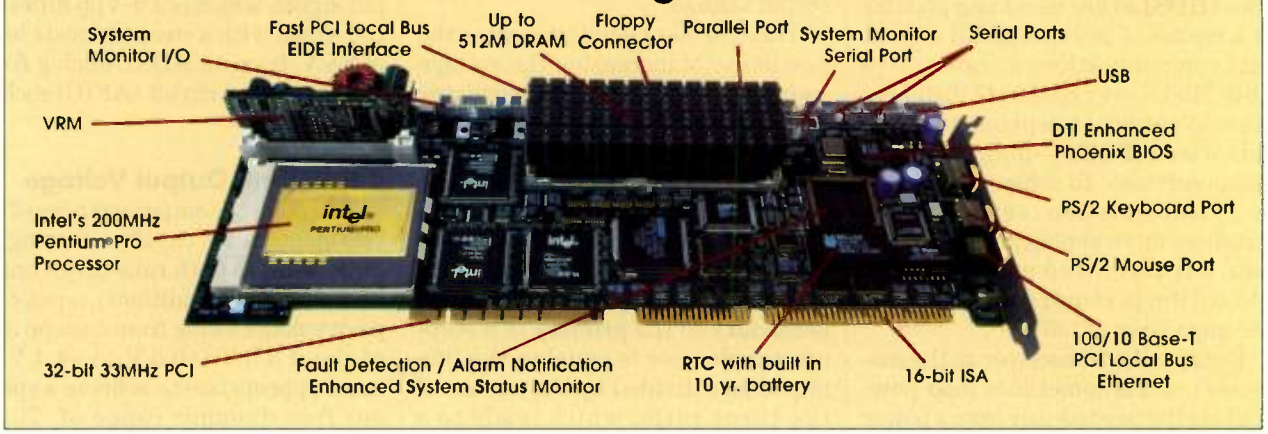

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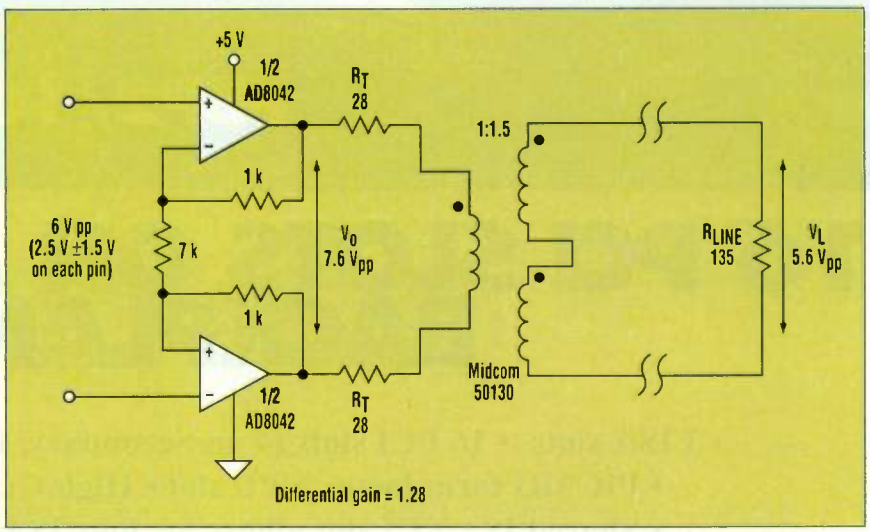
Line driving is a critical function in all wired digital communications applications. In general, the line driver is required to deliver a specific power level to the line over a specific bandwidth. Depending on the application, there may be additional requirements on the line driver such as low-power consumption or low-signal distortion that will influence the choice of device used. High-speed rail-to-rail swing operational amplifiers can be an excellent fit in these applications. Some types of these devices offer a combination of low-power consumption and high-output drive current while maintaining low-signal distortion. By exploiting these characteristics, output signal swing can be maximized, thereby reducing the dynamic power consumed in the device to a minimum.

High-bit-rate digital subscriber lines (HDSLs) are becoming popular as a means of providing full duplex data communications at rates up to 2.048 Mbit/s over moderate distances via conventional telephone twisted-pair wires (POTS—plain old telephone service). To achieve repeaterless transmission service over distances up to approximately 12,000 feet, a transmitted power level of +13.5 dBm is required, assuming a line impedance of 135 W .[1]

Because the transceiver at the customer's end is sometimes loop-powered via the twisted-pair from a power source at the central office, low-circuit power consumption is critical.

Even when using a rail-to-rail operational amplifier as a line driver, the amplifier's output voltage swing is clearly limited to the power supply rails, or twice the supply rails in the case of a differential output. Furthermore, if the amplifier output is back-terminated, the voltage delivered to the line will be only half the amplifier's output voltage.



1. Depicted is a single-supply, two op-amp HDSL transmitter acting as a line driver circuit.

Transformer coupling creates the possibility of increasing the voltage swing on the line to levels greater than the supply voltage. The peak-to-peak amplitude of a voltage can be increased to an arbitrarily high level by choosing a step-up transformer with the appropriate turns ratio.

However, the drawback is that the reflected impedance from the secondary to the primary of a step-up transformer is equal to the line impedance divided by the square of the turns ratio, which leads to a higher current demand on the driver amplifier. As a result, the designer must look for amplifiers with high output current drive capability, even when the amplifier is swinging close to the rails.

A line-driver circuit is powered from a single +5-V supply using an AD8042 (dual rail-to-rail op amp) to create a classic differential amplifier *(Fig. 1)*. The amplifier receives its input signal, which is a 6-Vpp differential signal with a common mode level of 2.5 V, from an HDSL analog front end integrated circuit (AFIC) such as the AD6472.

Calculating Output Voltage

Although the output voltages of the two op amps are capable of swinging quite close to both rails (even under heavy loading conditions), a peak-to-peak voltage swing from each op amp of about 3.8 V (+0.6 V to +4.4 V) is more appropriate to achieve a spurious free dynamic range of -79 dB (measured on the line at 200 kHz.) The spurious-free dynamic range (SFDR) degrades as output signal swing is increased *(Fig. 2)*.

The resulting peak-to-peak differential output voltage from the amplifier is 7.6 V (twice 3.8 V.) The impedance reflected from the 135-W line is

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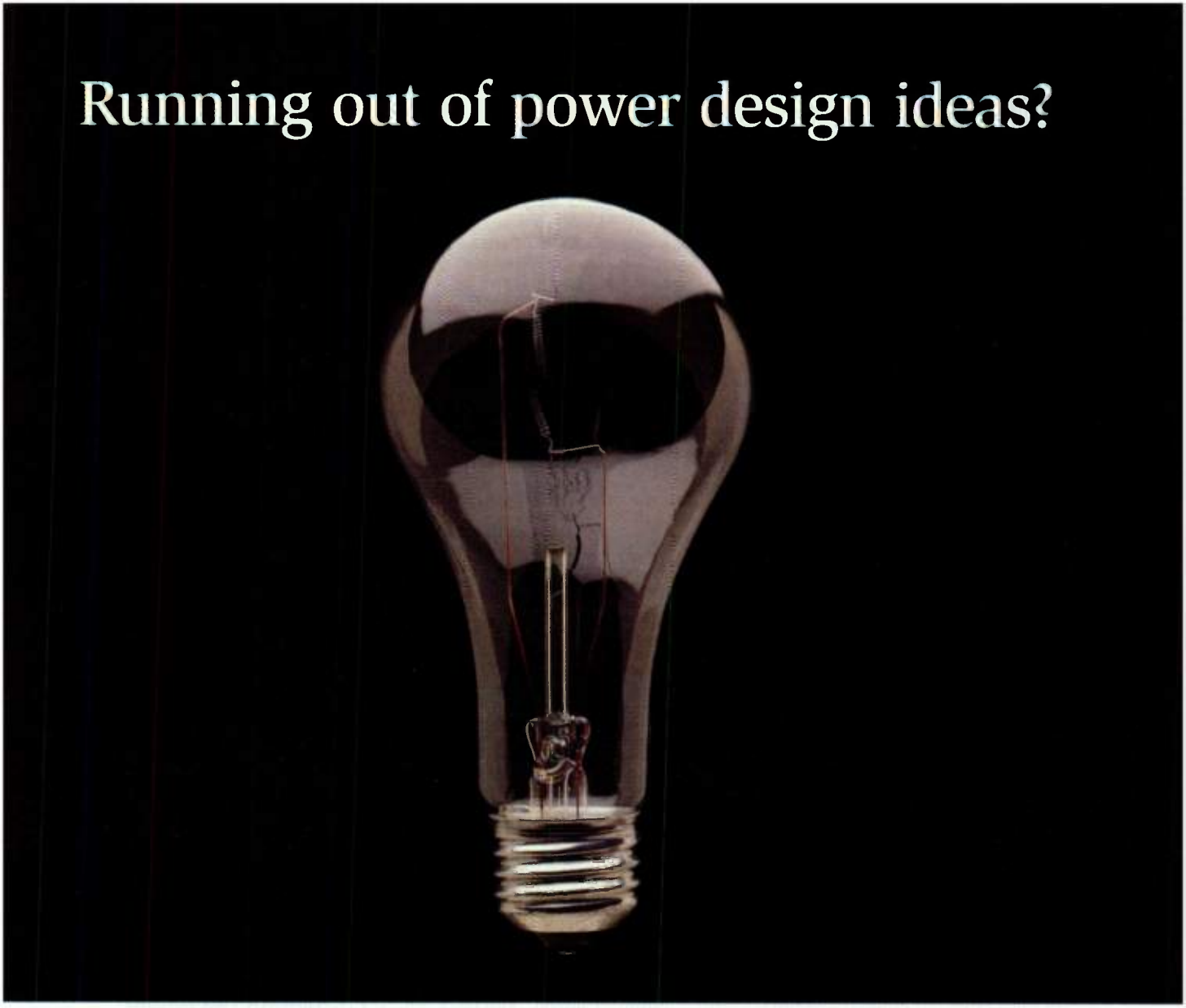

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approximately 60 W as determined from the 1:1.5 turns ratio. The transformer primary has a dc impedance of 3 W, so the two back-termination resistors (R_T) are chosen slightly smaller than the ideal value of 30Ω, with 28 W being the nearest standard resistor size available.

Because of the presence of the back-termination resistors, the peak-to-peak voltage across the transformer primary (3.8 V) is half the amplifier's output voltage. This voltage is stepped up to a value of 5.6 Vpp by the 1 to 1.5 turns ratio of the transformer, which corresponds to the maximum peak-to-peak transmit voltage required by ETSI's HDSL Standard.[2]

The circuit's primary feature is its relatively low total power consumption. The total power (P_{TOTAL}) consumed in the transmitter has three components:

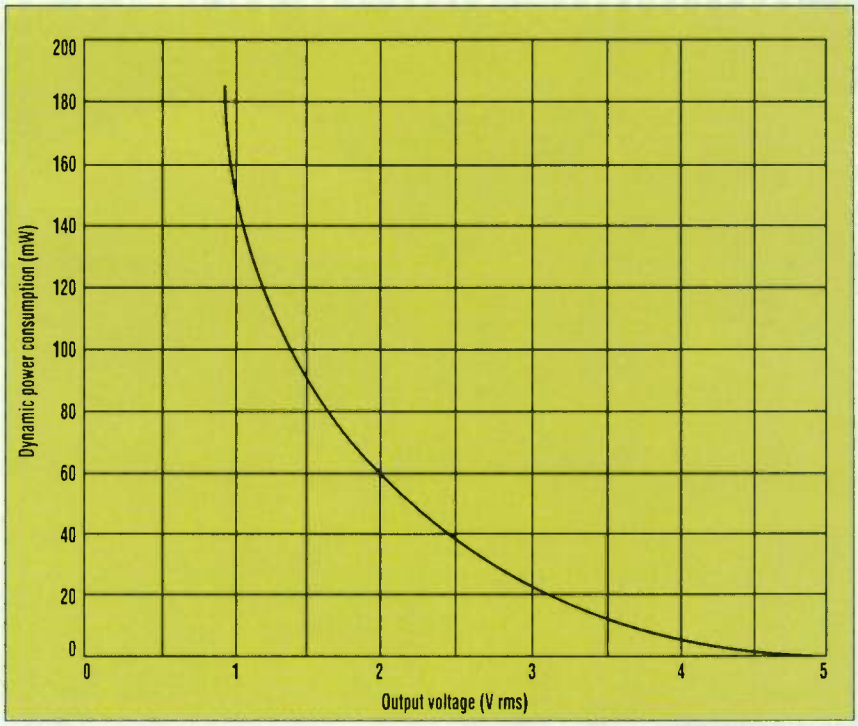
A. Quiescent Power (P_Q) consumed by the driver op amps, which is simply the power supply voltage multiplied by the total quiescent current (12 mA) of the two op amps, about 60 mW.

B. Output Power (PL_{OAD}) that the amplifier delivers to its load.

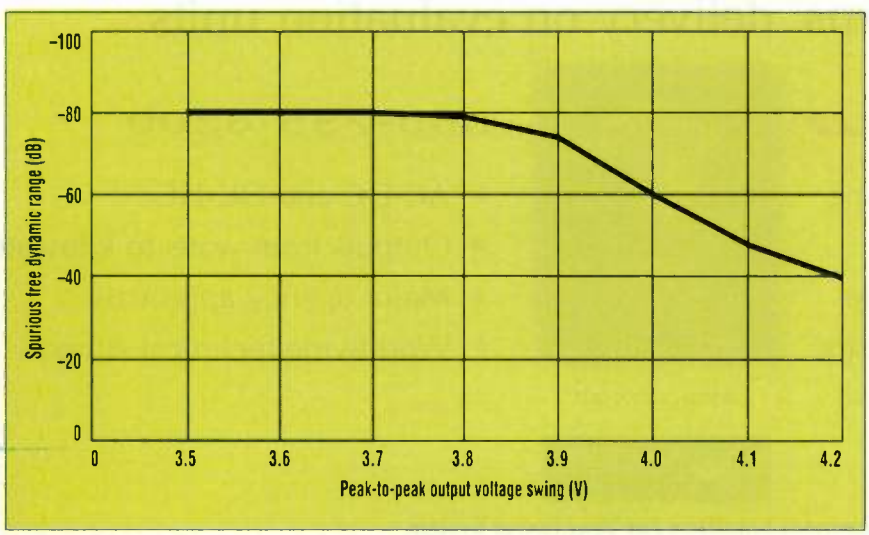
C. Dynamic Power (P_D) consumed in the two op amps as a result of delivering power to the load.

The power the amplifier delivers to its load (P_{LOAD}) consists of both the power delivered to the line P_{LINE} and the power consumed in the back-termination resistors. Therefore, the load consists of the sum of the back-termination resistors, the impedance reflected from the secondary to the primary, together with the dc resistance of the primary (2.5 W) and the secondary (4 W) windings, giving a total of 120.27 W.

With the 7.6 Vpp across the differential amplifier output, the peak output current that the op amps must each deliver under these load conditions is 32 mA; under ETSI test loop 6, the line impedance can be as small as 68 W.[3] In this case, the differential amplifier would see a smaller load of 90.5 W, and this increases the peak current to 42 mA, still comfortably within the 50-mA drive capability of the op amps.



3. This power vs voltage plot shows how dynamic power consumption in an amplifier approaches zero as the amplifier's output voltage swings to the supply rail.



2. Shown is a spurious free dynamic range variation of the AD8042 rail-to-rail amplifier with peak-to-peak output voltage swing at 200 kHz with a single +5-V rail.

Calculating The Power

The load power is calculated as the square of the rms voltage across the load divided by the size of the load. In addition, because we are transmitting a signal which is modulated according to the two-binary, one-quaternary (2B1Q) scheme[4], the crest factor of the voltage will be greater than the familiar Ö2 that we associate with a pure sine wave.[4] In practice, a peak-to-peak line voltage of 5.6 V corresponds to an rms power level of 22.4 mW, or +13.5 dBm. Knowing this power level and the peak-to-peak voltage, the crest factor of the 2B1Q signal can be calculated at 1.61; the 7.6 Vpp across the load represents an rms value of 2.36 V and a load power of 46.3 mW.

The amplifier's dynamic power is defined as the power that the amplifier consumes internally to deliver the requisite power to the load. Consider

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that the amplifier is outputting an rms voltage of 2.36 V, and the dynamic power consumption in the amplifier (P_D) is the product of the voltage drop in the amplifier from the power supply value (+5 V) to 2.36 V, and the rms current that is delivered to the load which can be calculated from the load power as 19.6 mA.

As the rms output voltage approaches the rails, the dynamic power consumed in the amplifier decreases to zero *(Fig. 3)*. In practice, zero dynamic power consumption would only be possible if the crest factor was unity and the amplifier had an ideal rail-to-rail output.

The important point is that dynamic power consumption of an amplifier decreases as the output voltage approaches the supply voltage. This is an important feature of using rail-to-rail amplifiers.

The total power consumed in the transmitter is the sum of the quiescent, dynamic, and load powers, totaling about 158 mW. This low overall power consumption has two sources: Operating the circuit on a single +5V power supply halves the power, compared to a circuit running from a bipolar ±5-V supply. And by minimizing the headroom between the op amp output voltage and the supply rails (+5 V and ground), dynamic power consumption in the op amps is reduced to a minimum.

Eamon Nash is an applications engineer at Analog Devices' Advanced Linear Products division, specializing in communications applications. He holds a Bachelor of Engineering degree in electronics from University of Limerick, Ireland.

References:

1. ETSI Technical Report: "High-bit-rate Digital Subscriber Line (HDSL) transmission system on metallic local lines," *ETSI TC-TM, Reference: RTR/TM-03036, Second Edition*, June 1995, p. 71.
2. *Ibid.*, p. 70.
3. *Ibid.*, p. 114.
4. *Ibid.*, p. 25.

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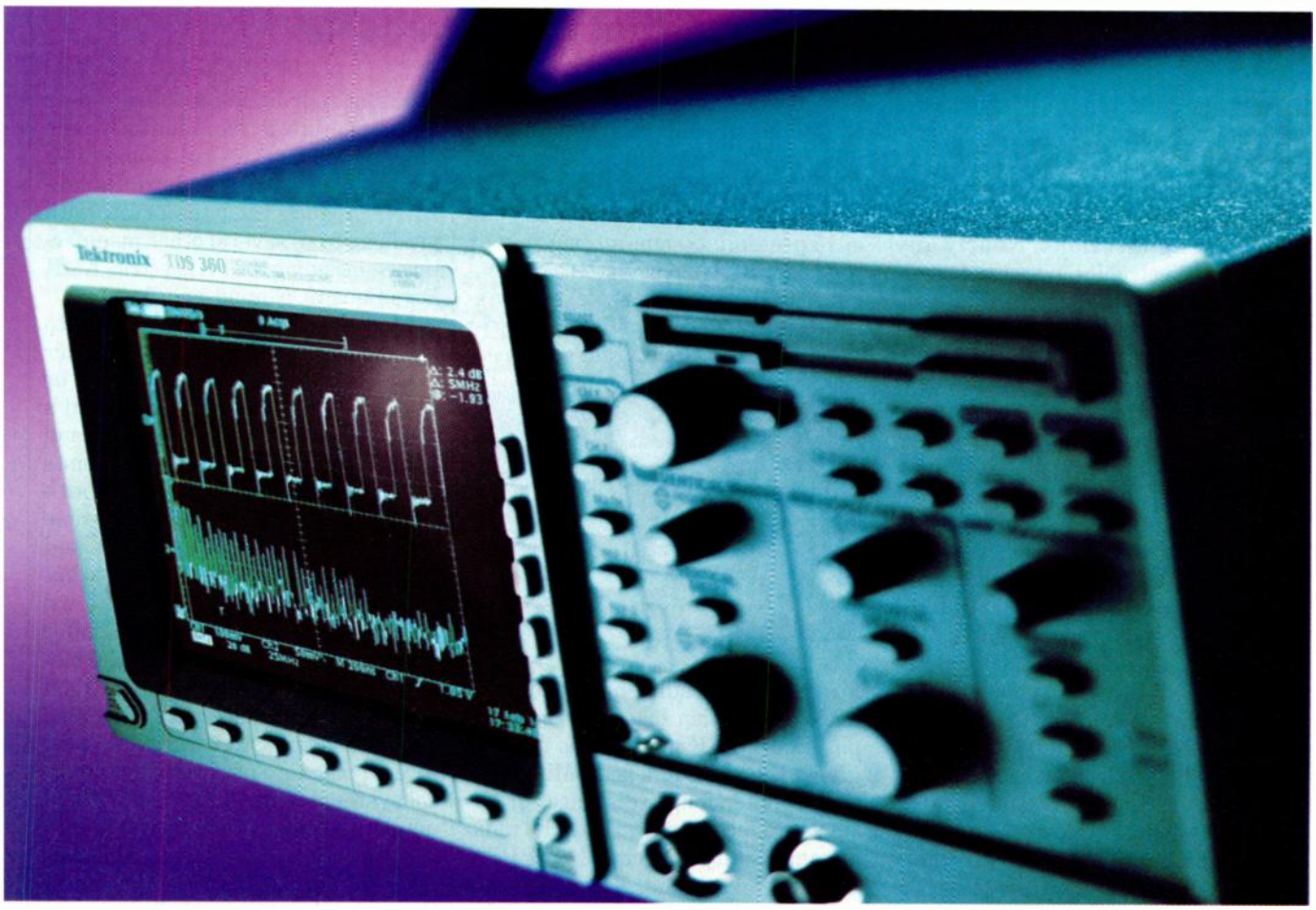

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Ultra-Compact Transceiver Modules Make Embedded Wireless Networking Capabilities Both Practical And Affordable

By offering an unprecedented level of integration and performance, the RangeLAN2 6330 Micro design-in module can bring wireless networking capabilities to a surprising range of applications. Nearly any handheld electronic device can benefit from a wireless data connection. Whether it's medical instrumentation, a point-of-sale terminal, or bar-code scanners for inventory control, they are all much more useful when they can send and receive information from a LAN or other central infrastructure.

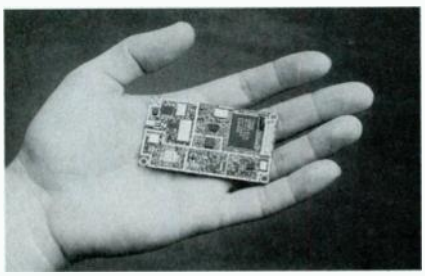
Until now, however, the size, cost and power requirements of high-performance radios often made it impractical. Capable of supporting data rates of 1.6 Mbits/s, the 6330 weighs just 0.7 oz., has a footprint of only 1.6 by 2.65 in., and costs less than $300 in OEM quantities. It draws just 300 mA of 5-V power when transmitting, 150 mA when actively receiving data, and has two standby modes that can shrink its power drain to as low as 2 mA.

The compact radio system makes embedded applications extremely straightforward. It interfaces to the host system much like a wired network adapter card— via a 40-pin parallel interface connector that's electrically similar to the ISA bus. Licensable software drivers for ODI, NDIS, and Windows 95 environments are available, as well as for Windows CE. This makes it possible to link portable devices to servers, data bases, e-mail, the Internet, and any other resource available on a wired network. For applications in non-PC platforms, the CLLD may also be licensed.

To cope with the challenges of a wireless environment, the 6330 uses a frequency-hopping spread-spectrum radio and an optional antenna diversity scheme. Using on-board circuitry, it can drive an external switch to select between two antennas that are in physically different locations or orientations. This allows it to overcome the fading and multipath phenomena common in indoor environments.

Frequency-hopping allows the radio to operate in the presence of narrowband interference with only minor performance degradation. Selecting one of 79 different frequencies every 0.2 to 0.4 seconds, the radio "hops" between them in a pre-defined pattern. The radio can be programmed to use any one of 15 pre-defined non-interfering, or "orthogonal," hopping patterns, allowing up to 15 separate networks to coexist within the same physical space.

To ensure optimum range and performance, the radio employs a dual-mode modulation scheme. Whenever possible, QPSK modulation is used, giving the radio link a 1.6-Mbit/s capacity. When longer distances or obstacles reduce signal quality, the radio automatically switches to a BPSK modulation scheme. Even with this more interference-resistant modulation, the 6330 exchanges data at 800 kbits/s. This allows the system to typically achieve operating ranges of 500 ft. indoors and over 1000 ft. outdoors.



Network security also is built into the 6330's architecture. It uses software encryption and hardware scrambling of IDs to achieve security levels equivalent or better than standard wired networks. Each of the 15 channels can support 16 separate domains, with over a million ID choices per domain.

Though the 6330 is unique, it's compatible with a wide array of other products that employ the RangeLAN2 wireless data protocol. RangeLAN2 is a proven technology which uses frequency-hopping spread-spectrum transmission in the 2.4-GHz U.S. unlicensed radio band (other frequencies are available for Europe, Asia, and other countries). When combined with a modified carrier-sense, multiple-access, collision-avoidance (CSMA-CA) protocol, it can provide a seamless bridge to Ethernet or other wired networks, or support ad-hoc, peer-to-peer networks in environments where there's no infrastructure. Compatible with the WLANA standard, RangeLAN2 products can interoperate with products from several other manufacturers, including ALPS Electric, AMP, Data General, Norand, and Toshiba.

Under RangeLAN2, connections to a wired LAN can be facilitated either by a dedicated access point module, or via a general-purpose PC that's equipped with a wireless adapter and special driver software. Access points can be configured to support both IEEE 802.2 and 802.3 Ethernet frame types, as well as Ethernet II and SNAP in up to 16 overlapping domains.

Each access point has its own unique IP address and serves a buffer between the wired LAN and the mobile units. When a unit is powered on within a network, it waits for an open time slot and registers with the closest access point via a password and protocol system identical to wired Ethernet. Upon registration, the radio gets assigned a sub-net address that it uses wherever it roams. Another portion of the proprietary protocol allows seamless roaming between access points, with hand-off between base stations occurring within one frequency hop.

Intended for use nearly anywhere in the world, the 6330 can be ordered with the standard 2.4-GHz operating frequency certified for North America, or in other frequencies to comply with Asian, European, and other markets. It's certifiable in the U.S. under FCC parts 15.209 and 15.247, as well as ETSI ETS 300.328 in Europe, and RDR STD 33 in Japan. Application information to ease the certification process is available as well.

Designers of wireless applications with the 6330 will have access to a wide array of development tools. A complete evaluation and development kit is available. It comes with all of the hardware, software, support, and documentation needed to quickly establish a two-node network, evaluate its performance, and begin an integration. In addition to licensable drivers

(continued on page 96)

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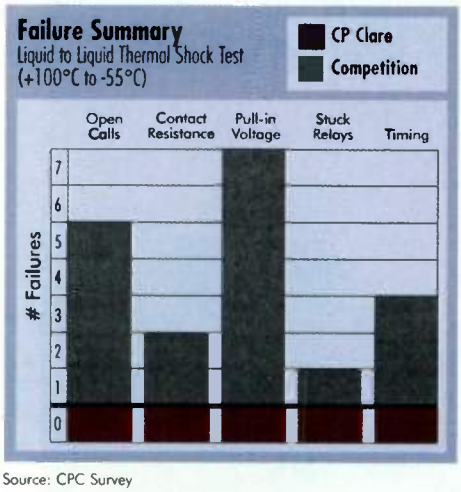

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for DOS and Windows-based clients, there is a complete suite of driver development tools. A portable version of the driver can be licensed in source-code form for porting to non-DOS platforms. Finally, site analysis software is available to help end users install their RF network to provide the best coverage in their physical environment.

Priced at around $350 each, the 6330 is anticipated to sell for less than $300 in larger OEM quantities. The development kit lists for $4995.

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CDMA Chips Improve Performance Of Base Stations And Handsets

A pair of second generation CDMA baseband processing chip sets promises to lower the cost and reduce the power requirements for both handsets and base stations. The first is the MSM2300, a single-chip mobile station modem (MSM) intended for handsets. It incorporates a proprietary implementation of several key CDMA functions, along with several

microprocessor cores and DSP cores. Target applications include subscriber units for multimode cellular, PCS, and wireless local-loop systems.

While it's pin-for-pin-compatible with its predecessor, several improvements distinguish the MSM2300, including a code-division searcher function that's eight times faster. This allows the handsets it's used in to acquire contact with a base station much more rapidly, during both power-up and hand-off operations. The fast searcher also significantly reduces the host microprocessor's overhead by incorporating an advanced pre-processing engine into its core logic.

The reduced processing load allows the host's load to either save power by running at a slower speed or spend more time in power-saving idle modes. When combined with other power-saving enhancements, the MSM is expected to demonstrate power savings of up to 75% in idle mode and 25%

(continued on page 98)

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when operating in CDMA transmit or receive mode. This should yield significant improvements in a handset's standby and talk time. In addition, the MSM2300 fast searcher reports the position of multipath peaks with higher resolution.

Another interesting feature of the MSM's design is a fourth demodulating finger, which improves reception quality in areas with high multipath levels and other difficult RF environments. These can include downtown areas with tall buildings, mountainous areas, or building interiors. Moreover, the chip's Viterbi decoder has been substantially enhanced for higher forward link capacity.

The MSM2300 will support both 8-kbit/s and 13-kbit/s vocoders. Initially, a QCELP implementation will be included, with support for the EVRC algorithm being added later in 1997.

No less significant is the CDMA infrastructure chip set, which will allow the economical construction of compact, efficient, low-power base stations. This presents a major advantage when designing mini-stations intended for use in highly congested service areas. Consisting of the Q5165 cell site modem (CSM) and the Q5182 frame interface and router module (FIRM), the two devices can be combined with most standard microprocessors to implement the main baseband elements of a cellular or PCS CDMA base station. This will allow designers using the CSM and FIRM to realize significant power, cost, and space savings in their next design project.

The Q5165 QSM is a digital baseband modem that incorporates the CDMA modulator/demodulator and serial Viterbi decoder. It can operate on 2.7 to 3.6 V, and requires 40% less power than the first generation device it replaces. Its flexible microprocessor interface makes it easy to interface to nearly any CPU architecture.

The Q5182 FIRM is an ASIC that can play an important role in the base station's communication network. It processes, buffers, and routes packets containing digital voice data. This type of processing enables various subsystems in a CDMA cellular land network to communicate with each other. By combining the functions of several HDLC controllers, FIFOs, and other controllers in one chip, significant savings in cost, power dissipation, and pc-board area can be realized by equipment manufacturers. Also included in the FIRM is an asynchronous interface that enables the host microcontroller to directly access its registers.

Available in engineering samples by summer, the MSM2300 will be in full production in early 1998. Call for pricing of both products and for information about the availability of the Q5182 FIRM.

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Dual-Band, Dual Mode RF Power Amplifier Supports Cellular And PCS Handsets

Capable of operating in the 800-MHz cellular band or the 1900-MHz PCS band, the AWT919D power amplifier can support transmission of analog (AMPS) signals and digital (D-AMPS) cellular and PCS 1900 signals. It consists of two highly integrated RF amplifier chains in one 28-pin thermally enhanced SSOP package. Consequently, the amplifier should help engineers meet the demanding space, power, and performance requirements of the upcoming generation of dual-band wireless handsets. Both amplifier chains operate at 5.8 V.

The cellular amplifier section is a two-stage chain that operates in the 824-to-849 MHz band and can operate in two externally selectable modes. In one mode it can be biased closer to its saturation point in order to meet the power and efficiency requirements of the U.S. analog AMPS standard. A second mode is available to create bias settings that meet the more stringent linearity requirements of the digital D-AMPS standard. In the analog mode, class B operation, the AWT919D can deliver an average output power of 288.5 dBm, with a typical gain of 24 dB. In addition, typical power added efficiency is approximately 45%.

In the digital mode, running in Class AB, it will deliver 31.5-dBm peak envelope power, with a typical gain of 25 dB. It boasts a digital-mode power-added efficiency of 40% and third-order intermodulation products greater than 24 dBc.

The 1900-MHz section is a three-stage power amplifier operating in class AB mode to achieve the linearity and adjacent channel power requirements of cellular-phone transmitters using the PCS1900 D-AMPS digital-modulation standard. It can deliver 31 dBm of peak envelope power, with a typical gain of 25 dB and a power-added efficiency of over 30%, and third-order intermodulation products greater than 24 dBc.

To help designers manage power requirements, both amplifier chains permit external control of quiescent operating currents. By reducing quiescent current during idle and low-power transmit operations, battery life can be extended, resulting in longer talk and standby times.

Fabricated in high-performance GaAs MESFET technology, the AWT919D is packaged in a 28-pin, thermally enhanced SSOP housing. Available now, it's priced at $10 each in quantities of 100,000.

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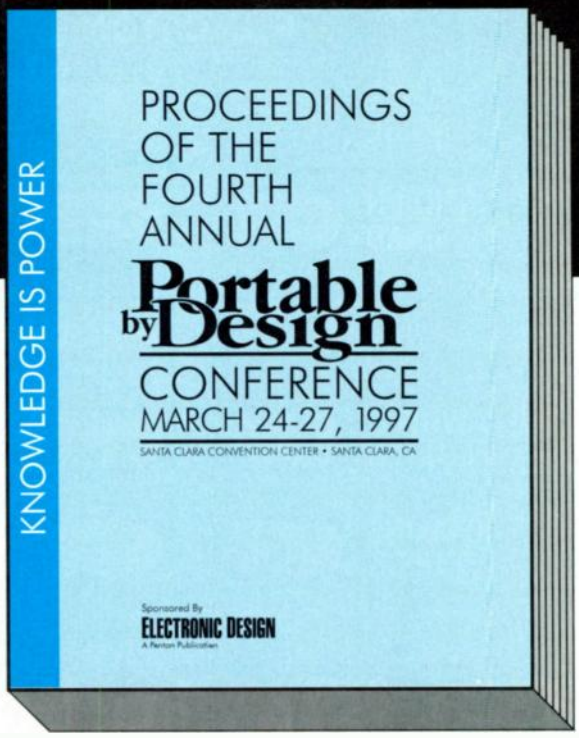

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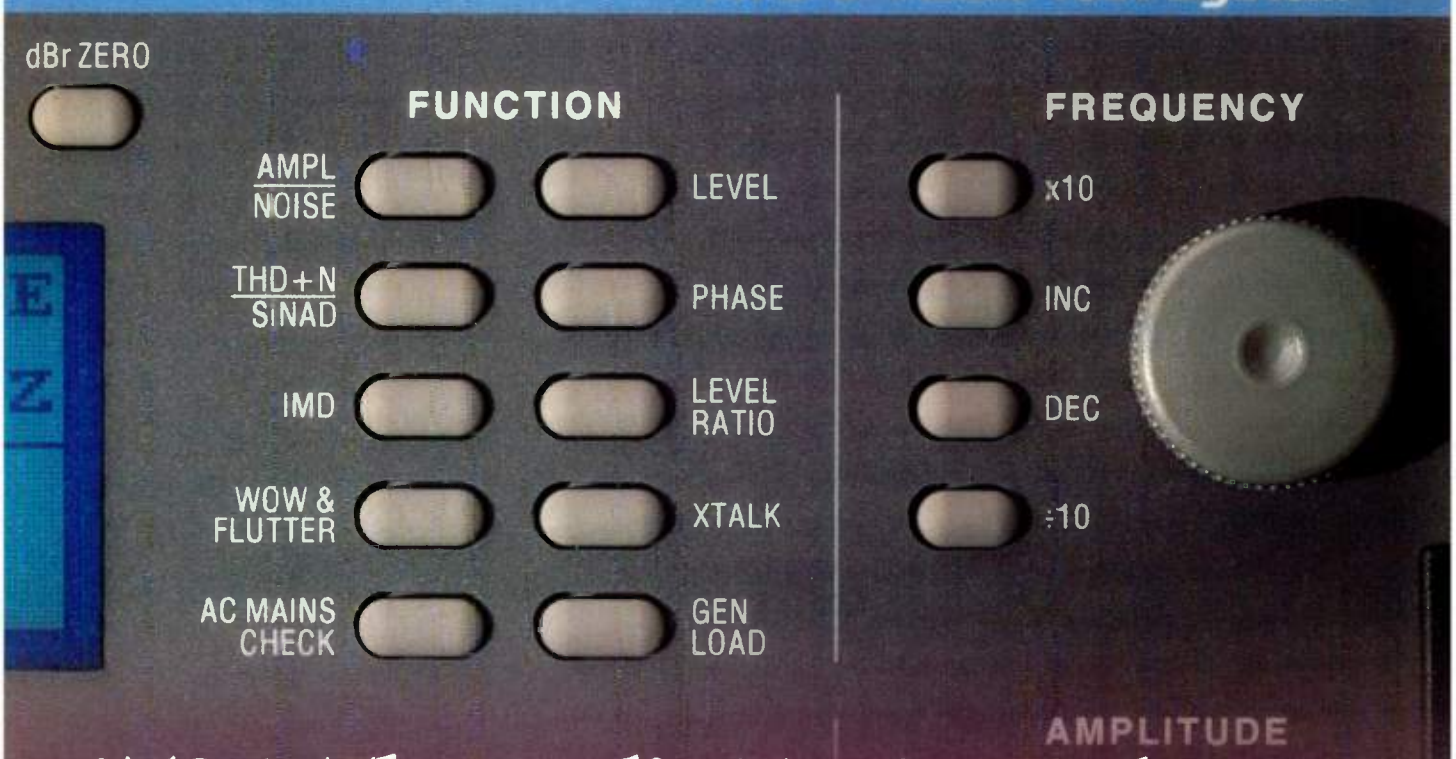

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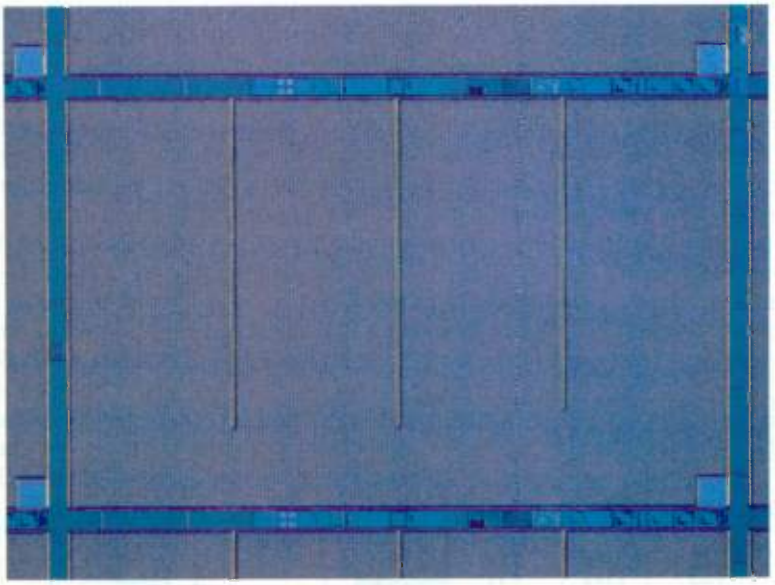
Smaller Packages On Tap For Low-Voltage Power MOSFETs

Processing Advances Allow Low-Voltage Power FETs To Squeeze Into Small Surface-Mount Packages, But Heat Removal Remains Critical.

Frank Goodenough

SPECIAL REPORT

Semiconductor process technology has made great inroads into cutting the specific on-resistance of discrete power MOSFETs in the last few years. As a result, a device's on-resistance specification is often less than that of its entire package resistance (bond wires plus leadframe). With decreasing on-resistance comes smaller die sizes, which, in turn, gives rise to power devices that fit into compact, advanced, surface-mount packages. These new packages are designed to provide low electrical resistance between drain and source, with steadily declining specified enhancement (gate-to-source) voltage.



Art Courtesy: Temic

To get the silicon-destroying heat out of these packages, they are being designed with unique leadframes that provide a low thermal resistance path between the die and the pc board's mounting surface. To ensure successful heat transfer, most advanced devices are designed concurrently with their packages. Today, current ratings are a function of the package, not the die.

Since users are demanding ever-smaller surface-mount packages, it looks like the previously popular TO-3 metal can, albeit cheap and able to handle lots of power, is finally dead. New devices are not appearing in it. On the other hand, the ability to get the heat generated in the die and in the package wiring out of smaller packages now determines the suitability of a power MOSFET for a specific application. Tiny, advanced surface-mount packaged devices now handle equal or more power than many larger die in the older TO-220 package or its surface-mount equivalent, the TO-263, also known as the D^2PAK.

Placed into these new packages are vertical MOSFETs or DMOSFETS, which are separated from both a process technology and applications standpoint into two classes—low voltage and high-voltage. Power FETs rated at or above 150 V (drain-to-source voltage) fall into the high-voltage class; those rated below 150 V fall into the low-voltage class. Some manufacturers make the break at alternative voltages and/or divide them into more than two classes. However, for the purposes of this report, and a report on the high-voltage class devices to follow in an upcoming issue, 150 V will stand as the dividing line.

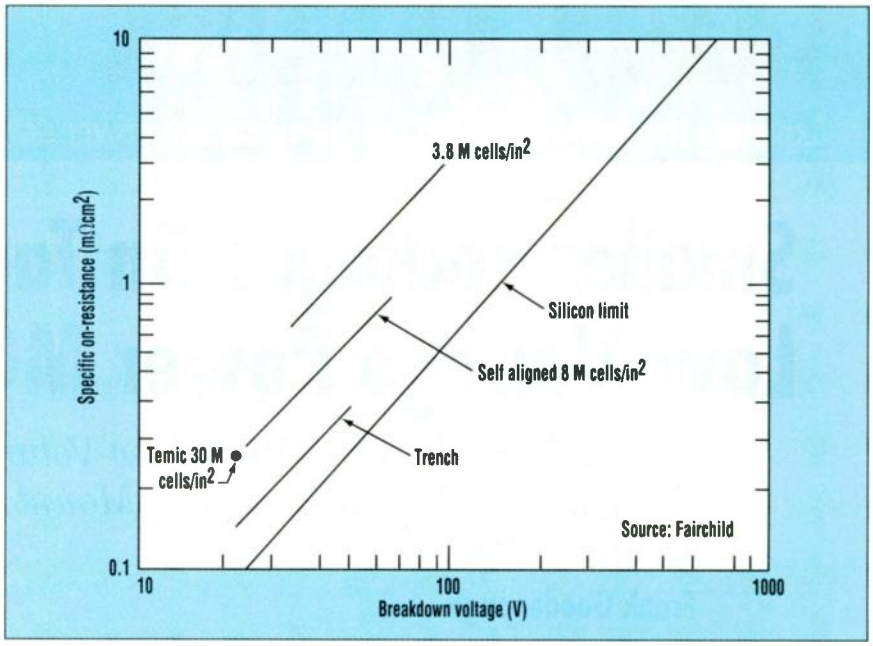
While a few power ICs have integrated vertical DMOSFETs, most employ self-isolating lateral CMOS or DMOSFETs. Vertical DMOSFETs do not easily integrate due to the complex processes required to provide some form of isolation (ELECTRONIC DESIGN, *April 1, p. 53*). In addition, at all but the lowest V_{DS} (drain-to-source voltage rating), lateral MOSFETs exhibit higher specific on-

resistances ($R_{DS(on)}$) when compared with vertical DMOSFETs. Therefore, most power FETs today are discrete devices (although their construction and interconnection makes them true ICs). Single and dual n- and p-channel FETs are available, as well as isolated CMOS devices containing one p-channel and one n-channel device. However, their designers solve the isolation problem another way. These duals are built on unique two-part lead frames to electrically isolate the die from each other. Essentially, each die is bonded to its own leadframe.

Applications Galore

Where do these low-voltage power FETs find homes? Most applications fall under the general category of "power management." They range from the power switches in controller-run, buck and boost (step down and step up) topology PWM switching regulators, to the protection devices that open up the circuit to Li-Ion batteries to keep them from overcharging or overdischarging. They are often used in the software-controlled switches that cut power from portions of a microprocessor when not in use and as the power device in a low dropout (LDO) linear regulator.

Most nonsynchronous switching regulators (switchers) use a single n-channel FET and a Schottky diode. On the other hand, some use a single p-channel FET plus the Schottky. They suffer the higher on-resistance of the p-channel device to eliminate the need for the charge pump or bootstrap circuit required to pull the FET's gate 5 to 10 V positive with respect to its drain.



2. The specific on-resistance of bulk silicon used in semiconductor processes increases exponentially with increasing breakdown voltage rating. The ultimate goal of power MOSFET process and device designers is to bring device performance as close as possible to the specific on- resistance characteristics of bulk silicon. At present, Temic's devices and Fairchild's curves indicate TrenchFET technology is the way to go.

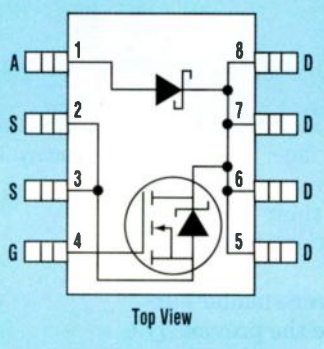
Recently, battery-powered systems such as laptop PCs used NiCd battery stacks, all running at voltages well above the 5-V rail required by the PC. They needed buck regulators to step down the voltage. However, with the advent of the Li-Ion battery, many systems—cell-phones, pagers, and PDAs—are running off just one or two Li-Ion cells and they need efficient boost regulators.

When greater efficiency is required, or for better control of a system's heat generation (to keep the plastic case from melting), supply designers switch to synchronous switchers that require two power FETs (ELECTRONIC DESIGN, *April 1, p. 64*). Depending on the power required, these synchronous switchers use either two discrete FETs or a dual FET. Some designs employ one p- and one n-channel device, also as two separate devices or a dual.

When the ultimate in efficiency is required, a Schottky diode is connected in parallel with the synchronous FET. Because of the need for a Schottky diode and a low-voltage FET in the same package, International Rectifier (IR), El Segundo, Calif., came up with what they call a FETKEY (*Fig. 1*). In IR's FETKEY, connecting the drain of the FET to the cathode of the diode creates a very low inductance between the die for maximum efficiency in fast switching. FETKEYs, which integrate two power die in a tiny Micro-8 package, are made possible by advances in both process and package technology.

The Micro-8 package, with a

Part number	Package style	BV_{DSS}	$R_{DS(ON)}$	V_F	I_D @ 70°C
IRF7421D1	SO-8	30 V	0.035 Ω	0.42 V	3.3 A
IRF7422D2	SO-8	−20 V	0.090 Ω	0.52 V	−2.3 A



1.This IR/Motorola FETKEY puts a low-voltage, low on-resistance n- or p-channel FET in a tiny package (SO-8 or Micro-8) with a Schottky diode. In many applications, such as switching regulators, this type of packaging fits two devices in the place of one.

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footprint of 3 mm by 5 mm and only 1 mm high, is half the size of Temic's 6.4 mm by 3 mm "Litefoot" package. It also is smaller than Fairchild's 4 mm by 4.5 mm "Super SOT" package. IR jointly developed the Micro-8 with Maxim Integrated Products, Santa Clara, Calif., who uses it for analog ICs, including switching regulator controllers that might drive a FETKEY in power supply applications.

LOW-VOLTAGE POWER MOSFET PERFORMANCE AT 25°C

					On resistance					
Company	Part number	Rated breakdown voltage, V_{DS} (V)	Number of FETs and polarity	Package	V_{GS} = 10 V	V_{GS} = 4.5 V	V_{GS} = 2.7 V	Power (W)	Continuous drain current (A)	Comments
Harris	RF1K49086	30	2n	micro-8	60 mΩ	NA	NA	NA	3.5	
	RF1K49157	30	1n	micro-8	30 mΩ	NA	NA	NA	6.3	
	RF1S60P03SM	30	1p	TO-263	27 mΩ	NA	NA	NA	60	
	RF1S70N03SM	30	1n	TO-263	10 mΩ	NA	NA	NA	70	
	RF1S25N06SM	60	1n	TO-263	47 mΩ	NA	NA	NA	25	
Fairchild	NDS335N	20	1n	SuperSOT-3	NA	110 mΩ	140 mΩ	0.5	1.7	
	NDS355N	30	1n	SuperSOT-3	85 mΩ	125 mΩ	NA	0.5	1.7	
	NDS336P	20	1p	SuperSOT-3	NA	200 mΩ	270 mΩ	0.5	1.2	
	NDC7002N	50	2n	SuperSOT-6	2 Ω	4 Ω	NA	0.7	0.51	
	NDM3000	30 30	3n 3p	SOIC-16 SOIC-16	90 mΩ 160 mΩ	130 mΩ 250 mΩ	NA NA	2.5 3	3 3	Complementary n/p 3-Φ brushless dc motor drivers.
	NDB/NDP7052	50	1p or 1n	TO-263	10 mΩ	NA	NA	150	75	
Motorola	MMSF33DR2	30	1n	SO-8	11 mΩ	20 mΩ	NA	2.5	12	
	MMFTPD3HD	30	1p	SOT-223	100 mΩ	150 mΩ	NA	3.13	5.2	
	NTD1302	30	1n	TO-263	220 mΩ	310 mΩ	NA	74	20	
	MMDF1300	25	2n	SO-8	100 mΩ	200 mΩ	NA	1	NA	Future
	MMDF1300	25	2p	SO-8	220 mΩ	400 mΩ	NA	1	NA	Future
	MMDF3304	25	2n	SO-8	25 mΩ	35 mΩ	NA	2	6.2	Future
	MMDF3200	20	1n	SO-8	NA	15 mΩ	20 mΩ	2	11	Future
	MTSF2P02HD	20	1p	Micro-8	NA	90 mΩ	120 mΩ	0.78	3	
Samsung	SSD2101	60	1n	SO-8	30 mΩ	NA	NA	NA	7	
	SSD2102	20	1p	SO-8	60 mΩ	NA	NA	NA	5.3	
	SSD2009	50	2n	SO-8	130 mΩ	NA	NA	NA	3	
	IRFR014A	60	1n	TO-263	200 mΩ	NA	NA	NA	8.2	
Temic	Si2302DS	20	1n	SOT-23	NA	70 mΩ	<85 mΩ	1.25	2.8	
	Si2301DS	12	1p	SOT-23	NA	130 mΩ	<190 mΩ	1.25	2.3	
	SUP/SUB75N05-06	50	1n	TO-220/TO-263	6 mΩ	NA	NA	1.87	75	Trench
	Si4425DY	30	1p	SO-8	14 mΩ	23 mΩ	NA	2.5	11	Trench
	Si4420DY	30	1n	SO-8	9 mΩ	13 mΩ	NA	2.5	12.5	Trench
	Si3456DV	30	1n	TSOP-6	45 mΩ	NA	NA	NA	5.1	Advanced Trench
	Si6410DQ	30	1n	TSSOP-8	14 mΩ	NA	NA	NA	7.8	Advamced Trench
	Si4420DY	30	1n	SO-8	9 mΩ	NA	NA	NA	12.5	Advanced Trench
	Si3457DV	30	1p	TSOP-6	NA	65 mΩ	NA	NA	4.3	Advanced Trench
	Si6415DQ	30	1p	TSSOP-8	NA	19 mΩ	NA	NA	6.5	Advanced Trench
	Si4425DY	30	1p	SO-8	NA	14 mΩ	NA	NA	11	Advanced Trench

NA = not available

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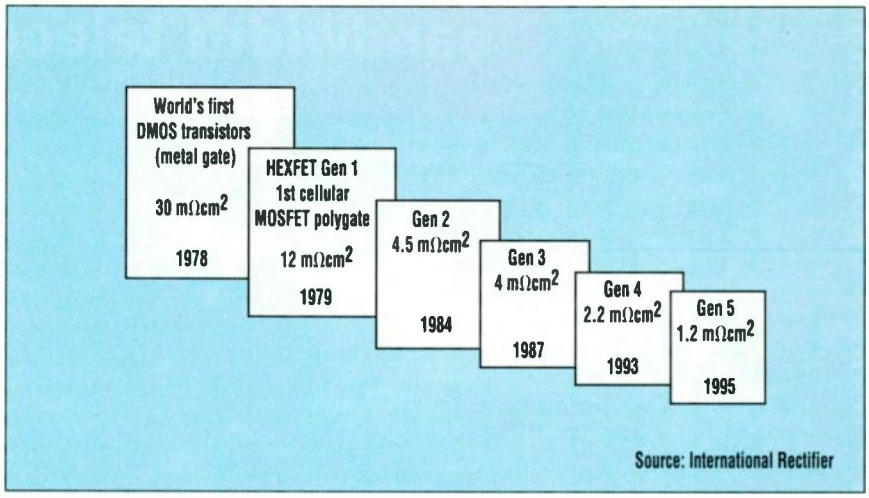
Most power FETs are built on 6-in. wafers and employ anywhere from four to six mask processes. To further reduce on-resistance, Temic (formerlly Siliconix), Santa Clara, Calif., is building low-voltage power FETs on a more complex TrenchFET process (ELECTRONIC DESIGN, *April 14, p. 45*). Other companies also have begun using this process, including Phillips, Eindhoven, The Netherlands, Fairchild, Santa Clara, Calif., and Samsung, San Jose, Calif.

On the other hand, IR and Motorola, Phoenix, Ariz., have cut their mask steps from six to four. And TrenchFET technology requires several additional process steps. Other major device makers including Harris, Melbourne, Fla., claim their latest non-cellular planar technology provides similar performance. And Motorola and IR have simultaneously achieved the low specific on resistance and simplified their process (cut mask steps) which raises productivity.

Harris is the first supplier to move their power FETs from 6-in. to 8-in. wafers, which is intended to increase yield, improve productivity and reduce costs. These devices will be manufactured at a new fab at their Mountain Top, Pa. facility, built especially for power FETs and IGBTs.

Specific on-resistance has long been the figure of merit by which to judge or compare the processes used to fabricate silicon devices, particularly those used as power switches. Independent of die size, it is the product of the resistance of a specific device times its area in square centimeters. Its units are defined in milliohm-centimeters square (mΩ-cm2). This value varies exponentially with breakdown voltage rating (the voltage that a device can stand off). Specific on-resistance increases about as the 5/2 power of its rated breakdown voltage. That is, the higher the breakdown voltage, the higher the specific on-resistance. Pure bulk silicon is the ideal or limit. That is, it has the lowest specific on-resistance of any material in the semiconductor manufacturing process *(Fig. 2)*. The lower the specific on-resistance provided by a process, the smaller the die size for a given on-resistance and breakdown voltage.



3. Since they announced their first cellular power MOSFET in 1979 (GEN 1), International Rectifier has marched through four additional process generations each with ever lower specific on- resistance. Their present 4-mask GEN 5 process provides a specific on-resistance of just 1.2 mΩ-cm², an order of magnitude less than that offered by GEN 1.

On-resistance is a function of the enhancement (drive or turn-on voltage) applied between gate and source, and if not stated, 10 V is assumed. However, early on, Harris created a line of so-called "Logic Level" MOSFETs whose on-resistance was specified at 5 V or 4.5 V of gate-to-source voltage. Most of the latest FETs are similarly specified, and IR has added an $R_{DS(ON)}$ specification at 2.7 V. Meanwhile, Temic specifies some of their latest devices at 2.5 V.

Since IR announced their first HEXFET, process advances have taken them to what they now call GEN-5 devices in terms of specific on-resistance *(Fig. 3)*. From the GEN-1 process to the GEN-5, specific on-resistance dropped by a factor of 10 times from 12 to just 1.2-mΩ-cm2. But according to projections by Fairchild, TrenchFET technology will eventually bring this number below 0.1 *(Fig. 2, again)*. If Temic's latest TrenchFET process is any indication, these projections are not that far-fetched. They have achieved a specific on-resistance of 0.18mΩ-cm2 on a 20-V, n-channel TrenchFET process with 10 V of enhancement *(Fig. 2, again)*.

Tiny, advanced surface-mount packages now handle equal or more power than many larger die in the older TO-220 package.

Looking at the performance of a sampling of the actual devices brought about by these process advances, some are now available *(see the Table)*. Usually, the larger the package, the lower the on-resistance. However, in many cases, FETs in larger packages are rated at a higher breakdown voltage (V_{DS}); therefore, the on-resistance is higher.

Prices are not given in the table because power MOSFETs are usually purchased in large OEM quantities, and volume prices are negotiated. They are, like memory chips, very competitive. However, to provide a frame of reference, most power FETs run less than $1.00 each even in small quantities (1000).

Until recently, power FETs were cellular devices. Each cell consisted of a separate DMOSFET. A true IC, the gates, drains, and sources of all the cells, are connected in parallel. IR's patented cells are hexagonal (HEXFETs). Most other manufacturers use square cells. The trick is minimizing cell size to cram as many as possible into a minimum area. The greater the cell density offered by a low-voltage process (usually ex-

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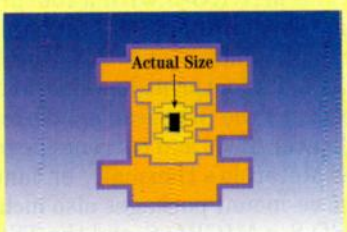

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These devices feature an input common-mode range that extends beyond the supply voltage rails.

MICREL PART NUMBER	TECHNOLOGY	V_{SUPPLY}	I_{SUPPLY}	GBW	TCV_{OS}	GAIN ERROR	SR	V_{OS}	Ib	RESPONSE TIME
Op Amps										
MIC6211	Bipolar	±2.5V to ±18V	2.0mA	2.5MHz	4µV/°C	–	6V/µs	2mV	50nA	–
MIC7101	CMOS	2.4V to 15V	250µA	1.0MHz	1µV/°C	–	1V/µs	3mV	1pA	–
MIC7102	CMOS	2.4V to 15V	250µA	1.0MHz	1µV/°C	–	1V/µs	3mV	1pA	–
MIC7111	CMOS	2.4V to 10V	25µA	50kHz	2µV/°C	–	15mV/µs	3mV	1pA	–
Comparators										
MIC6270	Bipolar	±2.5V to ±18V	300µA	–	–	–	–	2mV	25nA	1.3µs
MIC7211	CMOS	2.4V to 10V	7µA		1µV/°C	–	–	3mV	0.04pA	4.0µs
Instrumentation Amp				–						
MIC6251/2	Bipolar	±2.5V to ±18V	2.0mA	2MHz	7µV/°C	0.5% max.	6V/µs	4mV	50nA	–

IttyBitty SOT-23-5 Packaging

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pressed in cells per square inch), the lower its specific on-resistance. Increasing the cell density lowers the specific on-resistance in the FET's lateral channel region. In high-voltage MOSFETs, most of the resistance is in the vertical epitaxial material that stands off the voltage.

To compete with advance cellular processes such as TrenchFET, IR and Motorola use the non-cellular planar process where they essentially replace the cells with stripes. This turns the die into a single large transistor which IR calls its GEN 5 and Motorola calls waveFETs.

As it turns out, when shrinking cell size "you don't get something for nothing." That is, at some cell density the resistance of the parasitic JFET—through which a MOSFET's current must flow—starts to dominate andcauses the specific on-resistance to increase. To get around the problem, technologists tried etching a trench into the JFET region (using techniques developed for DRAMS). They coated the trench walls with oxide, and back-filled the remaining trench with polysilicon, thereby creating a gate for the MOSFET and significantly reducing the JFET resistance. This is the basis of Temic's TrenchFET MOSFET process.

It's A Small, Small World

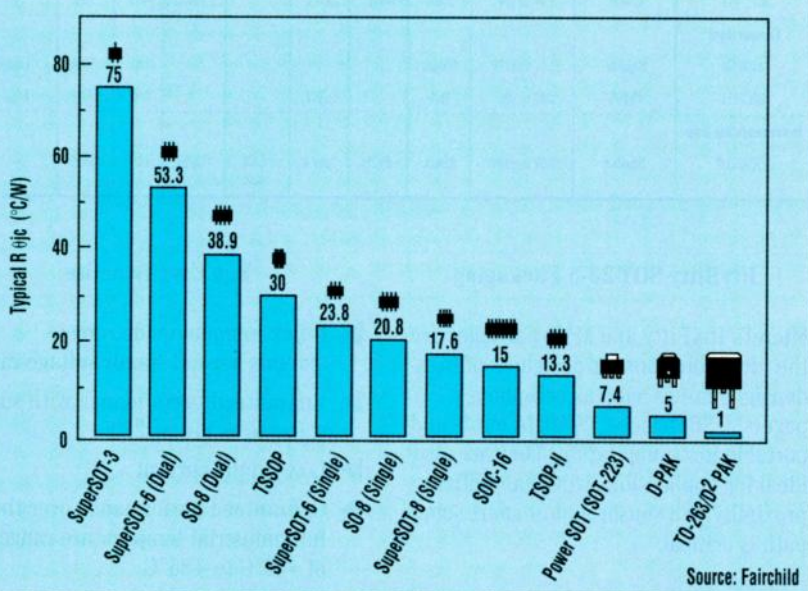
The packaging of the newest low-voltage power FETs is as critical as device and process design. As a result, the new low on-resistance FETs have appeared in a plethora of proprietary, non-standard, surface-mount packages, all designed to offer minimum electrical and thermal resistance.

For example, Fairchild houses FETs in a total of 12 surface-mount packages, with the smallest, their Super SOT-3, offering the lowest typical thermal resistance junction-to-case, $R_{\theta jc}$, in units of degrees C per Watt (°C/W) *(Fig. 4a)*. It should be noted that the original power surface-mount packages, the DPAK and the TO-263/D^{2}PAK, still provide the best $R_{\theta jc}$—just 5- and 1-°C/W respectively, while the smallest device, the SuperSOT, has the poorest at 75°C/W. It dissipates only 500 mW while the TO-263 can handle well over 50 W if mounted with a good thermal bond to a well-cooled heat sink. Fairchild puts most of their latest powerFETs in just six of the packages ranging from the SuperSOT-3 to the SO-16 *(Fig. 4b)*.

IR offers their GEN-5 power FETs in five thermally enhanced surface-mount packages ranging from an SO-8, which can handle over 7 A, to the MICRO-3, a SOT-23 on the outside but a power handler on the inside that can carry currents up to 1 A. The earlier SOT-223 with its wide tab is used for older devices with ratings to 100 V.

The MICRO-8 with a footprint just 1/2 that of an SO-8 and only 1 mm high handles up to 2 A. The MICRO-6, its footprint just one-fourth the size of the SO-8, can handle similar power (2 W) and currents beyond 2 A. Motorola's thermally enhanced surface-mount packages also include an SO-8, a MICRO-8, and the TSOP-6 ,which provides a junction-to-ambient $R_{\theta ja}$ of 90°C/W. It runs at 50°C/W for the thermally enhanced SO-8 package.

(a)



Source: Fairchild

(b)

Reference Part Number		$R_{DS(ON)}$* (Typical mΩ)		Package Type *Shown at actual size*
N	P	N	P	
NDS355AN	NDS356AP	75	140	SuperSOT™-3
NDC651N	NDC652P	42	95	SuperSOT™-6
NDH853N	NDH854P	15	29	SuperSOT™-8
NDS8410A	NDS8435A	10	21	SO-8
NDT455N	NDT456P	13	26	Power SOT
NDM3000**		70	125	SO-16

*V_{GS}=10V

**SO-16 Contains 3 N-Channel and 3 P-Channel die in one package

Source: Fairchild

4. A sampling of surface-mount power packages (a) range in thermal resistance from a low of 1°C/W to a high of 75°C/W. Six of these packages are shown actual size (b).

How Valuable	Circle
Highly	581
Moderately	582
Slightly	583

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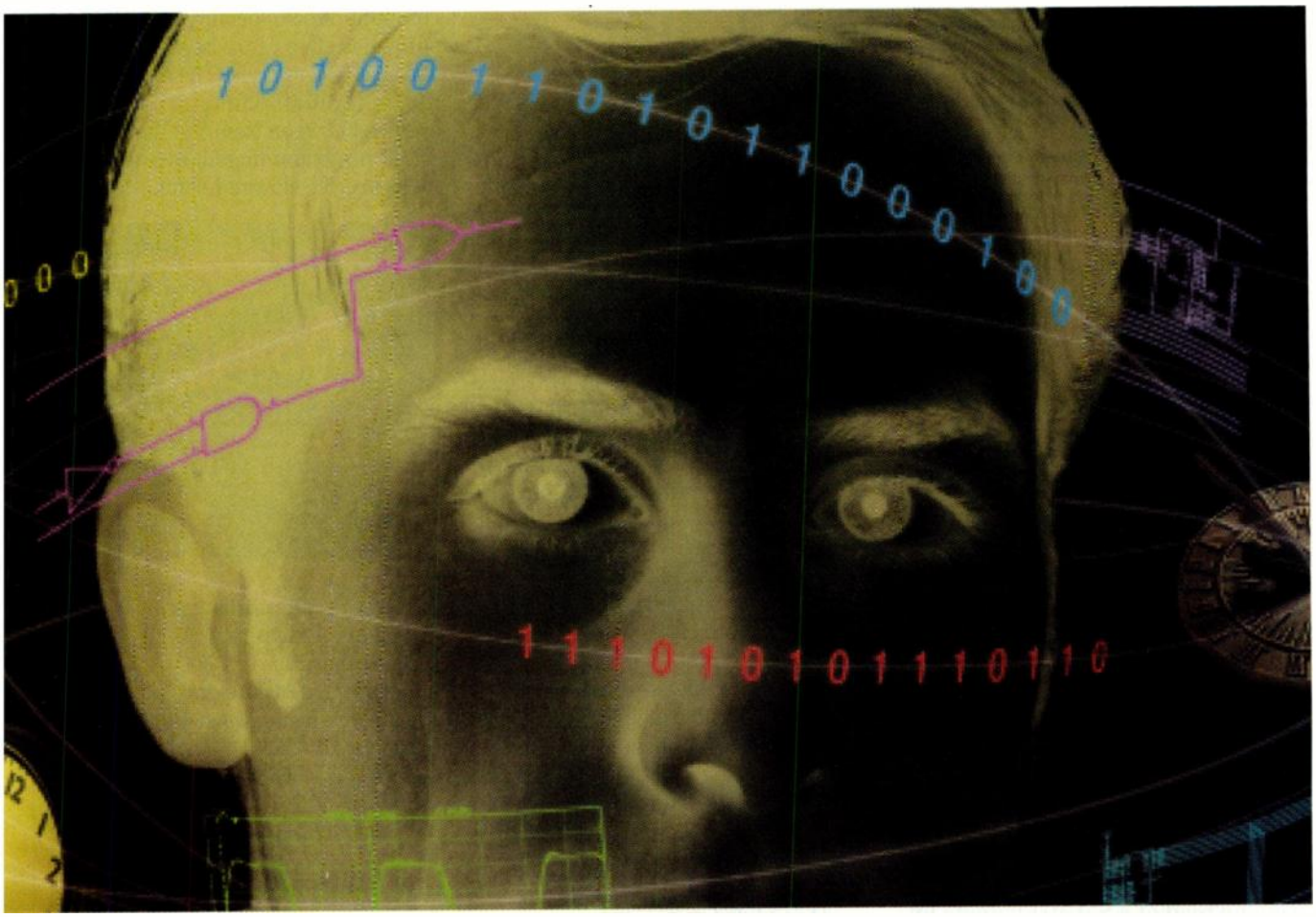

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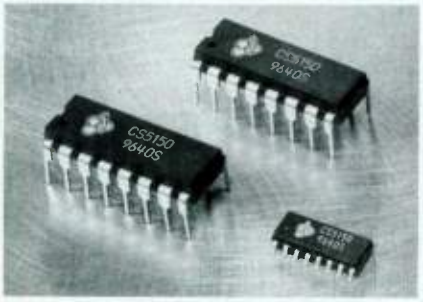
PRODUCT FEATURE

Data sheets on products like these can be found at www.penton.com/ed/

Dual N-Channel Buck Controller Chip Powers Pentium Pro Core Logic

An asynchronous, dual n-channel buck controller chip created by Cherry Semiconductor is designed specifically to power the core logic circuits in Pentium Pro microprocessors and other high-performance processors in personal computers and file servers. The CS-5150 contains a 4-bit DAC that sets its output voltage based on the value encoded in the Pentium Pro. The DAC also can be hardwired to set the output gate-drive voltage in 100-mV steps between 2.14 and 3.54 V. The controller drives two n-channel MOSFET power transistors. Using an n-channel MOSFET in the bottom switch position instead of a Schottky diode improves overall system efficiency.



A complete Pentium Pro power supply can by built using just 16 components. The device's fast transient response times stem from its dual feedback topology. The 100-ns fast feedback has a loop response time 10 to 50 times faster than power-supply solutions currently available. The slower feedback loop is compensated for by using an external 0.1-μF capacitor to ensure accuracy and stability over a range of load and layout conditions.

Built-in features of the CS-5150 include a programmable soft-start and lossless short-circuit protection. Programmable soft-start minimizes both inrush current and output overshoot. Under short-circuit conditions, the controller moves into a hiccup mode with a 3% duty cycle to protect the IC and power MOSFETs from catastrophic failure. The CS-5150 operates from either 5- or 12-V power supplies, runs at a frequency greater than 1 MHz, and can be used in any Intel-based motherboard. The output drivers deliver 1.5 A peak.

Offered in a 16-lead narrow SO package and 16-lead plastic DIP, the CS-5150 sells for $3.50 each in quantities of 10,000.

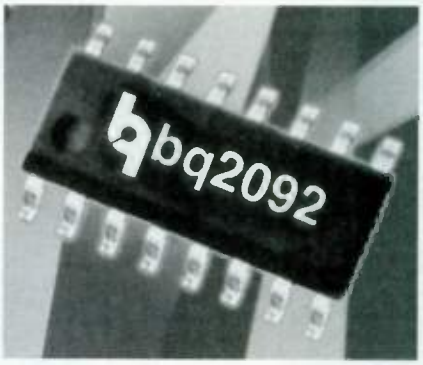
Cherry Semiconductor Corp.
2000 South County Trail
East Greenwich, RI 02818-1530
(401) 885-3600
CIRCLE 611
MILT LEONARD

"Gas Gauge" Device Monitors Capacity Of Different Battery Types

The bq2092 Gas Gauge IC monitors battery capacity for NiCD, NiMH, and Li-Ion battery types. It uses the SMBus protocol that supports many of the Smart Battery Data commands as well as SBData charge control. The capacity-monitor chip provides battery state-of-charge, remaining capacity, remaining time, and chemistry over the two-wire SMBus serial link. Battery charge state can be directly indicated using a four-segment light-emitting-diode display to graphically depict battery full-to-empty in 25% increments.

The chip estimates battery self-discharge based on an internal timer and temperature sensor, and user-programmable rate information stored in external EEPROM. The device also automatically recalibrates battery capacity in the full course of a discharge cycle from full to empty. The bq2092 can operate directly from three nickel-chemistry cells. Operating voltages for other battery-cell configurations can be provided by building an inexpensive regulator. This is accomplished using the chip's voltage reference output and an external transistor.

Packaged in a 16-pin 150-mil SOIC, the bq2092 and its necessary external components can occupy less than 0.8 square inches of pc-board space for use in a battery pack. The complete solution is small enough to fit in the crevice between two A cells. Flexible ΔT/Δt programming allows designers more precise charge termination, particularly in higher discharge-rate applications. Pricing starts from $5.00 each in quantities of 10,000.



Benchmarq Microelectronics Inc.
17919 Waterview Pkwy.
Dallas, TX 75252
(972) 437-9195
CIRCLE 612
MILT LEONARD

Low Emitter Inductance Ups Gain At 2 GHz For LNA Use

The NE696M01, a silicon epitaxial npn transistor, is manufactured in a process featuring an f_T of 14 GHz. It comes in a six-pin SOT-363; four leads are used for the emitter to reduce emitter inductance. The resulting gain of approximately 14 dB at 2 GHz is about 3 dB higher than would be if the part was in a SOT-23 or SOT-143 package. Noise is typically 1.6 dB at 2 GHz. The part is designed for low-noise amplifier and pre-driver applications up to 2.4 GHz, operates from 3 V with a typical collector current of 10 mA, and has a maximum dissipation of 150 mW. The SOT-363 package measures 1.25 by 2.00 mm, and the part is priced at $0.29 in 100,000-lot quantities. PMcG

California Eastern Laboratories (for NEC), 4590 Patrick Henry Dr., Santa Clara, CA 95054; Mark Navarre, (408) 988-3500; fax (408) 988-0279; Internet: http://www.cel.com.
CIRCLE 613

PRODUCT FEATURE

Data sheets on products like these can be found at www.penton.com/ed/

Switch-Mode Controllers, Voltage-Reference Chips Combine To Regulate Pentium Power

The LX1660/1661 switch-mode controllers and LX1670 5-bit programmable voltage reference chips are aimed at power systems for high-end processors, such as Intel's Pentium Pro (P6), IBM's PowerPC, Cyrix's 6x86 and 6x86L, and AMD's K5 and K6. Together, the chips convert a +5-V or +12-V input to a digitally adjustable output ranging from 1.8 to 3.5 V dc in 100-mV steps (50-mV

steps below 2.1 V) that feature a 1% dc accuracy.

The switch-mode controllers feature synchronous switch drive and pulse-by-pulse current limiting with adjustable hiccup, soft-start capability, and synchronous-switch shutdown input for increased efficiency in light-load applications. The LX1660 is for accurate dc regulation, while the LX1661 is recommended for applications requiring better transient response. The PWM controllers are designed to interface with the LX1670 voltage identification-code (VID) IC, but they also can be used as a standalone controller.

A 0.5% 2-V reference voltage is available on an external pin for using the controller as a standalone function. Also available are an enable function and an undervoltage lockout function. The LX1670 reads a 5-bit VID code from the microprocessor and sets the output- voltage reference to be used in programming the controller. Using a voltage-mode constant off-time scheme, the reaction scheme is less than 1 µs, which is about ten times faster than conventional control schemes. An off-time-adjust function eliminates frequency modulation due to output-voltage variations.

The LXE9007 design kit is available for evaluating all three chips. In quantities of 1000, pricing for the LX1660, LX1661, and LX1670 devices is $2.20 each.

Linfinity Microelectronics Inc.
11861 Western Ave.
Garden Grove, CA 92841
(714) 898-8121 or (800) 877-6458
CIRCLE 614
MILT LEONARD

DC-DC Converter Features Programmable Output Level

A programmable dc-dc converter developed by Micro Linear allows designers to keep up with the trend toward lower supply voltages for ICs used in battery-powered products. The output level of the ML4950 is programmable from 2.0 to 3.0 V through the use of two small external resistors. A small inductor and two small capacitors also are required.

The chip supplies up to 100 mA of output current. A fixed-output version, the ML4850, delivers either 2.2 V or 2.5 V. Both chips convert and regulate the voltage from a single alkaline battery in the range of 1.5 to 1.0 V with ±3% accuracy and an efficiency exceeding 90%. The chips also work with single-cell batteries, such as nickel-metal hydride or nickel cadmium. High efficiency results from the use of synchronous rectification, which replaces a power-sapping catch diode with an intelligent circuit that switches a built-in, low-resistance MOSFET for conducting inductor flyback current.

Both devices generate a low-battery signal that has a programmable threshold set with a resistor pair. This signal can activate a battery-low indicator or trigger a battery-low routine in a microcontroller. The converters are available in an 8-pin SOIC package in the commercial and extended-commercial temperature ranges. Prices for the commercial temperature range in 1000-piece quantities are $2.05 for the ML4950 and $1.98 for the ML4850.

Micro Linear Corp.
2092 Concourse Dr.
San Jose, CA 95131
(408) 433-5200
CIRCLE 615
MILT LEONARD

Enhanced Camera Control With Massive Changes

A range of new camera-control and robotics systems include a novel component triax system, and a range of advanced camera robotics pan/tilt mechanisms and accessories together with a software-driven auto-tracking system. The TM-9660 component triax system provides portable cameras with component output and full-featured studio operation while still using triax cable between the camera and base station. This allows the signals to remain in the component format longer before encoding.

The PT-MP mini-pan/tilt head is designed for applications with limited space. Measuring only 2.75 in. at its base and weighing 2 lb., the mechanism can be side- or top-mounted. The unit is dc-servo driven and offers high-precision feedback potentiometers for both pan and tilt axes, with the pan range at ±150° and tilt at 50° up and 90° down when top-mounted.

The company's range of camera robotics systems has been enhanced with a 360° continuous pan/tilt option that allows the HP-PT pan/tilt head to be connected via a single coax cable to the TM-9255 coax camera control system. The new CP-SRD serial receiver drives pan, tilt, zoom, and focus servos for the pan/tilt mechanisms, while the People Tracker auto camera tracking software uses pattern recognition and doesn't require any device to be worn by the person or object being tracked. It can be used with any of the company's camera robotics systems and touch-screen control panels. PMcG

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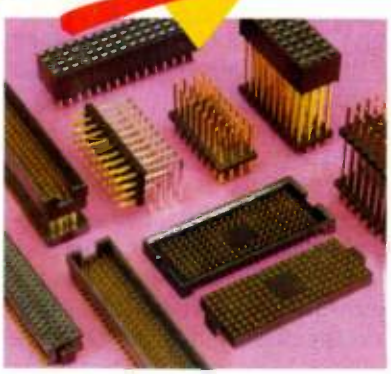

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Air-Cooling Electronic Systems: An Introduction

As Component Density Spirals Upward, Careful Enclosure Design And Fan Placement Is Essential To Avoid System Failure.

AL EISAIAN,
NMB Technologies Inc., 9730 Independence Ave.,
Chatsworth, CA 91311; (818) 341-3355; fax (818) 341-8207.

With higher-performance systems coming in increasingly smaller boxes, the task of providing adequate cooling for critical components is more challenging than ever. Because of the increasing power densities, thermal-management issues must now be considered up front in the product development cycle to prevent complete system failure. Along with early planning, good thermal design within an enclosure requires the proper application of two simple concepts. First, the system must provide for adequate airflow around heat-generating components and heat-dissipating elements (such as heat sinks). Second, the system must allow for adequate space and power for the incorporation of the required cooling fans. The remaining design issues, from a thermal management standpoint, consist primarily of determining fan positioning and ducting, and selecting the proper number and type of fans.

1. As more components are packed into a single enclosure, the design engineer must factor in cooling earlier in the design cycle than ever before. Issues such as space, location, enclosure ducting, type, size, number of fans, and enclosure resistance must all be considered if overheating followed by system failure is to be avoided.

Until recently, natural air convection provided adequate cooling for virtually all pc-board-based electronic systems. However, the upward spiral in generated heat is making the use of forced-air convection using fans and blowers a necessity *(Fig. 1)*. In combination with heat sinks, they have proven to be highly effective for low- to mid-range systems. These fan-cooled electronic systems include everything from notebook PCs to set-top boxes aimed at home Internet access. Their presence in such high-volume, highly competitive markets forces designers to perform a delicate balancing act between cost and performance, placing greater burdens on the design of an active cooling system.

Other factors also must be taken into account. Since Jan. 1, 1996, the European Union has imposed a strict EMC (electromagnetic compatibility) directive on equipment makers selling their wares in Europe. The relatively airtight package required to shield from electromagnetic and radio frequencies makes it even tougher to cool the system. In addition, many markets are experiencing a lower tolerance for overall system noise, providing an even greater design task for small systems that require high-

speed fans for adequate airflow.

Forced-Air Trends And Solutions

With an eye toward the mobile computers implementing fans this year, one thing is clear—the trend toward hotter systems is not going away. Designers must incorporate active thermal management elements, such as fans, into small enclosures, or at least be ready to do so very soon. But small portable computers represent just one of many different electronic systems that use fans. Single-fan systems still represent the most common implementation. However, some of the more mature products that employ forced-air cooling technology, like high-speed test equipment and desktop PCs or larger computers, use multiple fans. In fact, many fan-cooled systems incorporate subsystems, such as power supplies, that are actually cooled by fans.

There has been a recent resurgence in the use of variable-speed fans in mobile systems to maximize battery life. At idle, when the processor is not active, the fan slows down to its minimum RPM. At peak load, when cooling is needed, the fan speeds up.

Another important trend includes the use of airflow or temperature monitors to increase overall system reliability. Since the entire system depends on the ability of the cooling fan to deliver the required amount of air, if it fails, damage to the system could be considerable. Even if the fan never fails, blockage of the air-intake vents can significantly reduce airflow.

Airflow Estimation

The first step in designing a forced-air cooling system requires an estimation of the necessary airflow. This calculation depends on two things: The heat generated within the enclosure, and the maximum temperature rise permitted inside. A very good estimate of power dissipation in a system is ac input power. Most battery powered systems typically include an ac input for a power source, so this estimate is simple to obtain.

It is essential, when calculating total power, that a designer allow for possible future changes or the addition of heat-generating subsystems. The power dissipation estimate also should be based on a worst-case power appraisal of a fully loaded system. In fact, when a compact product is not a priority, it is considered a very good practice to design the enclosure so that an additional fan can be added in series or parallel—just in case mistakes are made and additional cooling is required later on.

An estimate of required airflow required in a hypothetical enclosure can be obtained from:

$$Q = \frac{3.16W}{T_F}$$

or

$$Q = \frac{1.76W}{T_C}$$

where:

Q = Airflow required in cfm (ft^3/min.)

W = Heat dissipated in Watts

T_C = Temperature rise above inlet temp in °C

T_F=Temperature rise above inlet temp in °F

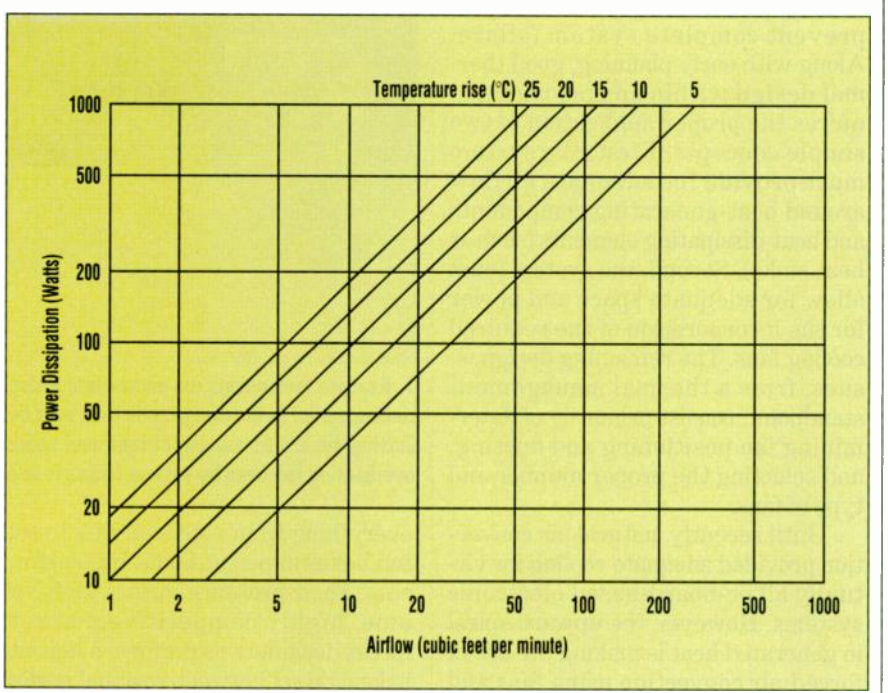
For example, 32 cfm (cubic feet per minute) of airflow is required for a system that dissipates 200W and allows a 20°F temperature rise. By keeping maximum temperature rise as a constant, and plotting the power dissipation and required airflow on the x and y axes, we can create a simple lookup table *(Fig. 2)*.

In this graph, the vertical axis represents the heat to be removed in Watts, while the horizontal axis represents airflow in cfm. Both axes are logarithmic. The sloping lines define the temperature rise in degrees centigrade. To use the graph, find the sloping line that represents the permitted temperature rise, then find the point on the line that corresponds to the heat to be removed. The horizontal position of this point shows the airflow required to cool the enclosure.

System Impedance

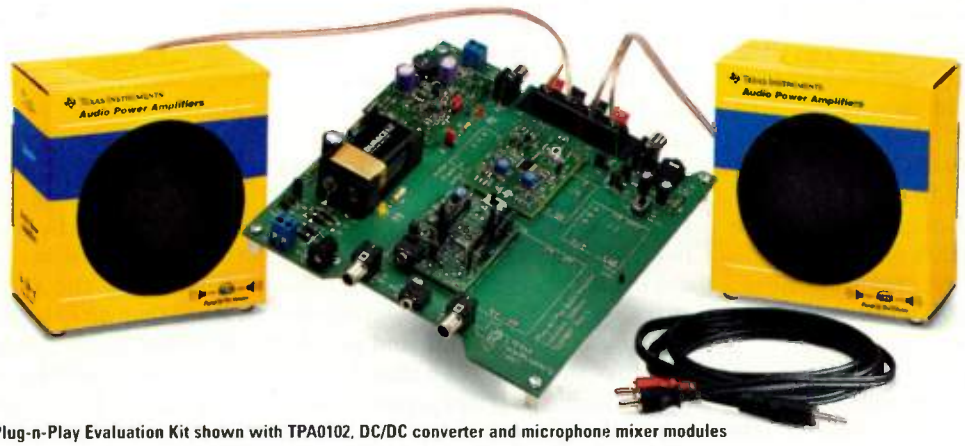
Measuring the actual airflow produced by a fan mounted in an enclosure is much more difficult and costly than simply estimating the airflow required. Obstructions in the airflow path cause static pressure within the enclosure, reducing the efficiency of the fan. The nonlinear relationship between airflow and static pressure is plotted for a typical axial cooling fan *(Fig. 3)*.

Obviously, to achieve maximum air-



2. By keeping maximum temperature rise as a constant, and plotting the power dissipation and required airflow on the x and y axes, we can create a simple lookup table to estimate the required airflow in a hypothetical enclosure. To use the graph, find the sloping line that represents the permitted temperature rise, then find the point on the line that corresponds to the heat to be removed. The horizontal position of this point shows the airflow required.

PLUG-N-PLAY AUDIO EVALUATION KIT.



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TEXAS INSTRUMENTS

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flow, obstructions should be minimized. But in many cases, it may be necessary to include obstructions in the form of baffles so that the airflow can be directed through hot subassemblies or specific components that need cooling. In fact, in small systems, it may even be necessary to use the components themselves as baffles to direct airflow.

Determining actual airflow through a sample of the finished system is very accurate, yet extremely costly, time-consuming, and cumbersome. In practice, empirical methods are typically used to estimate airflow resistance. In fact, based on experience, the following guidelines may prove helpful in estimating system impedance.

- An empty enclosure usually reduces airflow by 5 to 20%.
- A densely packaged enclosure reduces airflow by 60% or more.
- Most electronic enclosures have a static pressure of between 0.05 and 0.15 inches of H_2O.

Assuming a dense package, the airflow requirement we calculated to be 32 cfm previously should, in fact, be capable of delivering at least 80 cfm in free air.

Fan Positioning And Ducting

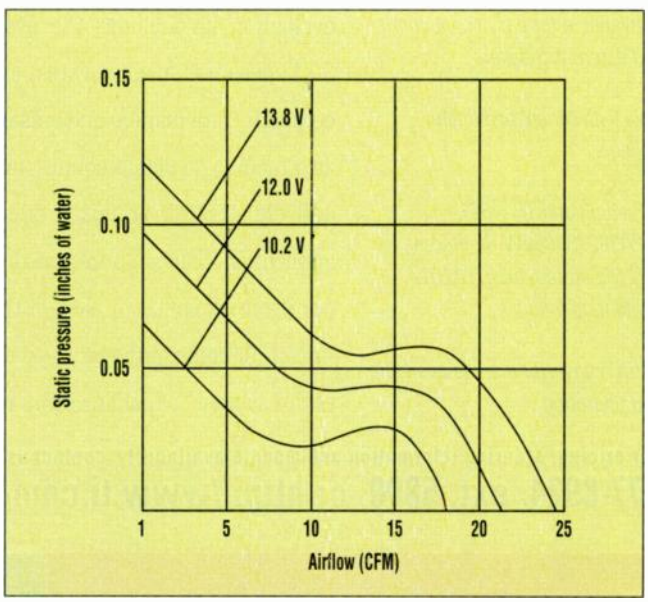
Designers have a choice of using a fan to exhaust air from, or blow air into, an enclosure. Given no other variables, the same volume of air should be required for exhaust or intake. But in real-world applications, each situation has other factors that must be factored into the equation.

Air is drawn into the fan in a laminar fashion, while air exhausted is turbulent. Theoretically, heat dissipation in a turbulent flow can be up to double that of a laminar flow with the same rate of air volume. But the region of turbulent airflow near a fan exhaust is limited. Therefore, a well defined airflow path must be designed through the enclosure.

Vents at the beginning and end of the airflow path should be 50% larger in area than the fan opening—possibly larger if it's an intake fan and includes a filter. Also, baffles should be utilized to prevent air from recirculating in the fan. Up to 90% or more of potential airflow can be lost because of recirculation problems.

Implementing the fan as an intake rather than an exhaust can double or triple its operational life.

Subassemblies and components should be located so as to direct the flow of air to places that require cooling. Natural convection can greatly aid in this process for larger enclosures by placing warm components above cool components and placing exhaust vents higher than intake ports. During pc-board layout, keep in mind that large components can shield smaller components from the flow of air. Components with critical cooling requirements should be placed close to air intakes. On the other hand, components with resistance to high temperatures should be placed close to outlets.



3. Obstructions in the airflow cause static pressure in the enclosure, reducing fan efficiency. The plot shows the typical nonlinear relationship between airflow and static pressure for an axial cooling fan.

Exhaust fans reduce the pressure within the enclosure, which increases the airborne dust that may be drawn in through vents and cracks in the enclosure. In fact, if dust exclusion is a requirement, fan placement at the intake is better. A filter at the intake removes airborne contaminants from the incoming air, plus the enclosure is slightly pressurized so that dust is not drawn into the enclosure.

The downside is that filters must be changed regularly to eliminate dust buildup. Accumulated dust can severely restrict airflow, causing elevated temperatures, and potential failure for the system. Another factor to take into account when implementing an intake fan is that the heat dissipated by the fan motor slightly warms the incoming air.

Fan reliability and longevity also can be affected by placement within the system. In many applications, implementing the fan as an intake, rather than an exhaust, can double or triple its operational life. Heated air passing over an exhaust fan strains its bearings, and although most fans are rated at a life of 50,000 hours, this can be reduced by as much as 20,000 hours for each 10°C increase in fan operating temperature.

Fan Selection

Once the system's required airflow is calculated, the proper-size fan can be selected. Other requirements then come into play, including the decision of whether to go with an ac or dc version. In the past, the high cost of dc fans led to an almost exclusive use of ac fans by designers. This price differential has since disappeared. Factors that make dc fans a better choice include a longer life and a power consumption of up to 60% less than a comparable ac fan. Other advantages include the fact that speed is directly proportional to voltage, EMI/RFI levels are lower, and that they make it simpler to implement an airflow alarm system.

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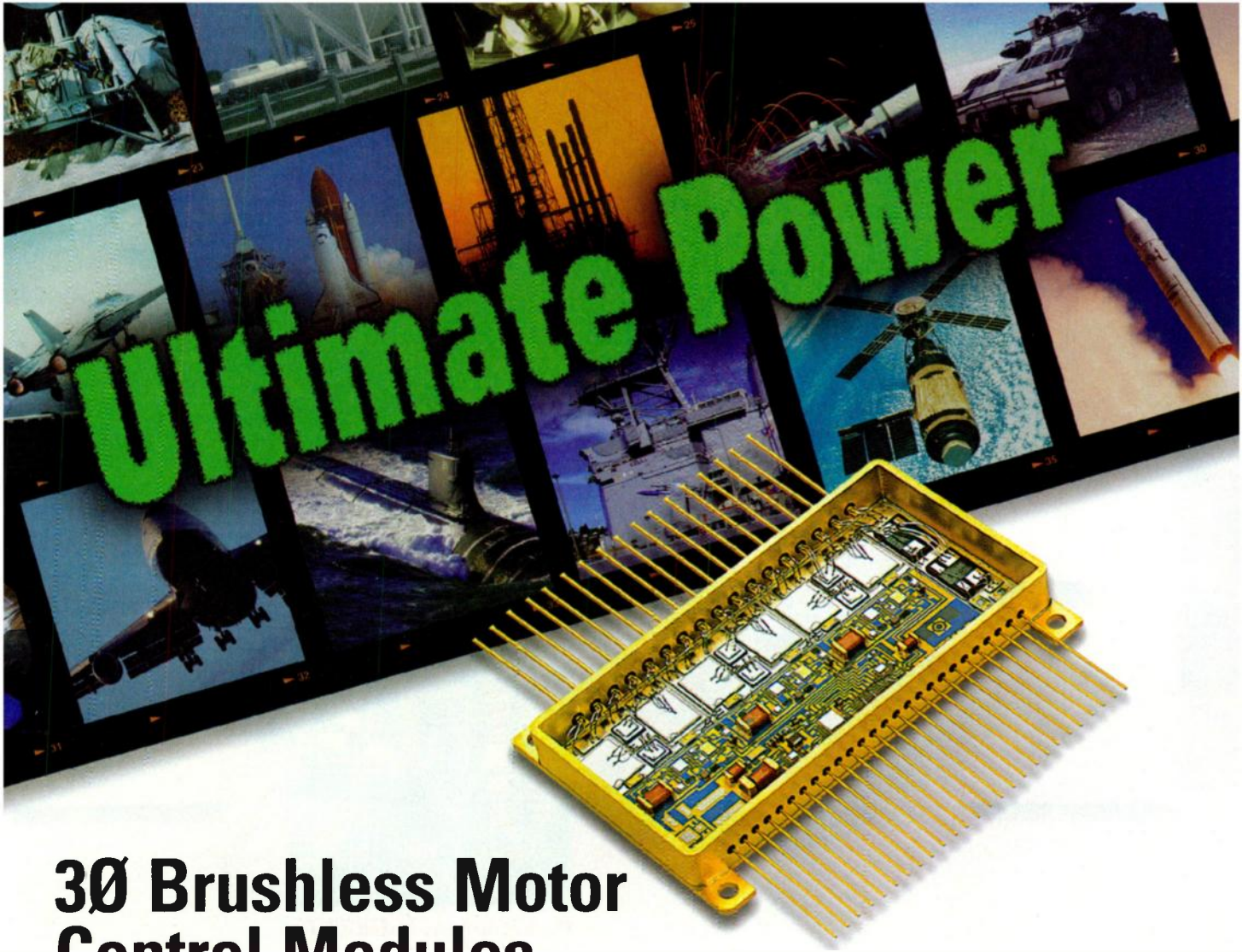
higher voltage is generally preferred since higher current means lower current and less overall power dissipation. The frequency and amount of noise generated by a fan increases with rotational speed. When presented with an option, a lower-speed motor will help to minimize noise and, potentially, increase the useful life of the fan.

Once the enclosure's airflow and static pressure estimates have been made, the fan manufacturer can provide airflow curves that allow a fan to be selected with adequate cooling potential. Designers should use these curves with caution though. In some cases, it may not be clear whether the curves represent nominal or worst-case fan performance. A further word of caution, fan performance may vary as much as 10% from nominal specifications. In addition, fan comparisons should not be based on performance in free air—which doesn't exist in a real enclosure. To be considered accurate, airflow comparisons should be made at pressures of between 0.05 and 0.15 in. of H_2O.

Noise has no effect on cooling, but may be important to the product's end user. One way to minimize noise is to use the largest possible fan. For a given airflow rate, a larger fan will run at a slower speed and therefore create less noise.In areas where this is not possible, such as in high-performance laptops that must use tiny high-speed fans, other components of the audible noise may be addressed. Many fan manufacturers offer custom fans given sufficient production volumes. Aerodynamic, mechanical, and resonant noise are components that may all be addressed.

Al Eisaian has been in fan product marketing for NMB Technologies since 1989. He is currently the fan product manager and is responsible for all aspects of axial cooling fan sales. He holds a BS degree in electrical engineering from Oklahoma State University and an MBA from Pepperdine University.

How Valuable	Circle
Highly	549
Moderately	550
Slightly	551



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The **NJM2178** is a stand-alone monolithic SRS three dimensional sound IC with analog signal processing. The **NJM2178** is suitable for application in Computer, TV, Radio, Electronic Game, Keyboard, Musical Instrument, Home Stereo and other typical Audio Systems. The **NJM2178** uses analog signal processing derived from a patented Sound Retrieval System technology developed by SRS labs to achieve a "three dimensional" audio image from only two standard speakers.

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UPDATE ON ENCLOSURE MANUFACTURING

Powder-Coat Spray Finishing System Ruggedizes, Protects Electronic Cabinetry

A few years ago, a home-decorating center aired a commercial with the punch line, "It ain't just paint." That same line holds today for a coating process applied to electronic enclosures to improve their durability, performance, and appearance. Actually, it isn't paint at all, it's plastic. The process is called powder-coat finishing, and it is replacing paint on all sorts of electronic equipment enclosures such as racks, cabinets, chassis, and boxes made by Bud Industries Inc., Willoughby, Ohio.

The company recently brought online its new powder-coat-finishing system after five years of research and development. The process itself is not new (it has been used in Europe for many years), but powder-coat technology has been upgraded significantly over the years, offering a stronger protective medium than paint and many more colors and finishes than previously offered. According to Dan Lucas, Director of Manufacturing at Bud, "powder-coating is more plastic technology than paint. It is a dry product applied electrostatically to a part. It melts, cross links, and creates a nice finish." A big advantage of powder coat over paint is that it offers benefits for both enclosure buyers and product manufacturers.

For example, powder coating produces colors that are much richer in appearance than paint. The colors are more consistent—they vary little from run to run. Users also get a much more rugged product that will stand up to both environmental and man-made abuses. Bud uses an independent lab to run salt spray tests on its coated parts, and finds that after 504 hours, all test panels pass. Manufacturers of the powder that Bud buys claim that with the proper priming and pretreatment of the surface, parts could pass a 1000-hour salt spray test. By comparison, liquid paints cannot pass a 100-hour test. In addition, resistance to chemicals and scratching is much greater in the case of the powder. One test for chemical resistance is the MEK (Methyl Ethyl Ketone) rub, in which a strong solvent is rubbed across the surface of the test part. Lucas says that powder-coated parts can withstand 50 double rubs with no damage to the surface, while painted parts fail after 15 to 20 such rubs. Resistance to solvents is a direct consequence of the coating's plastic nature.

Powder coating also provides benefits to Bud in a number of ways. First, it's very customizable in terms of the colors available. Manufacturers of the powder will match any color in the Federal Standard Color Chart (which comprises thousands of hues), but this has only come about in the past year. Lucas says that powder coat's popularity is growing as more finishes are made available, and that there are as many finishes as there are for paint. A metallic finish which was unavailable last year is now in the line.

A big part of powder coating's appeal to enclosure manufacturers such as Bud is its relatively benign environmental impact compared to paint. When spraying liquid paint, the liquid that misses the target—the overspray—has to be collected and hauled away in drums at very high cost to the company. The cost is mainly due to the presence of hazardous materials such as lead in the paint. Additionally, the federal government often forces manufacturers to change the solvents used in their paints in the interests of environmental protection. But this hurts enclosure makers who find that changing solvents leads to inconsistent finishes and a longer and more costly procedure to paint parts.

The bottom line is that powder coat is less expensive from a manufacturing standpoint, and less dangerous to users because it is lead-free. These factors should result in lower prices for buyers of enclosures. Another savings comes from the fact that powder-coat finishing is a dry process. Up to 95% of the powder coat that doesn't stick to its target can be reclaimed and reused.

The powder has the consistency of face powder with particles measuring about 35 to 40 microns. It consists of pigments, binders, and fillers ground together and dry blended. The resultant material then goes through an extruder and is heated to almost the melting point. When it comes out of the oven, it has the consistency of taffy. It is rolled out to a thickness of 1/8 in. and cooled. Next comes a

In Bud Industries' clean room, powder-coat spray guns (left) apply powder to parts (right) as they move along a conveyer belt. The company has two such spray booths which feature a series of 14 programmable guns that dispense the powder onto the parts.

grinding process which breaks the material into the fine powder used in coating process.

Before parts can be powder coated, they must be cleaned thoroughly to remove all residue and fluids from the machining process. This step is important to achieving a strong bond and consists of four stages: an alkyd cleaner to remove sludge and oils, a rinse, a wash to apply a coat of iron phosphate, and a final rinse and dry.

After the cleaning and washing process, parts proceed through a drying booth fitted with a high/low velocity heated-air-knife system. From there it's on to the powder-coat spray process which is performed in a special booth *(see figure)*. The process is electrostatic; the guns apply a charge to the powder as it is being sprayed, so the powder is at a potential while the part being sprayed is grounded. The powder clings to the part until it arrives at the curing room where the strong bond between powder and metal surface is achieved. Before curing, the powder can be blown off with an air hose, a useful side effect of the process that allows small errors to be easily corrected. Complete color changes can be acomplished in less than 1 hour.

The 95% of excess powder that doesn't stick is reclaimed in large cyclones attached to the side of the spray booth.

In the curing process, the parts enter a uniquely designed combination infrared/convection oven where the heat makes the powder melt, flow, and bind to the substrate (the metal part). The oven is unique in that its walls can expand and contract from 48 in. to 15 in. to accommodate a wide range of part shapes. Curing is critical part of the process because it is here that bond strength and quality of finish are established. A human operator monitors the baking temperature to ensure that parts meet high standards.

For further information, contact Bud Industries Inc., 4605 E. 355th St., Willoughby, OH 44094; (216) 946-3200; fax (216) 951-4015.

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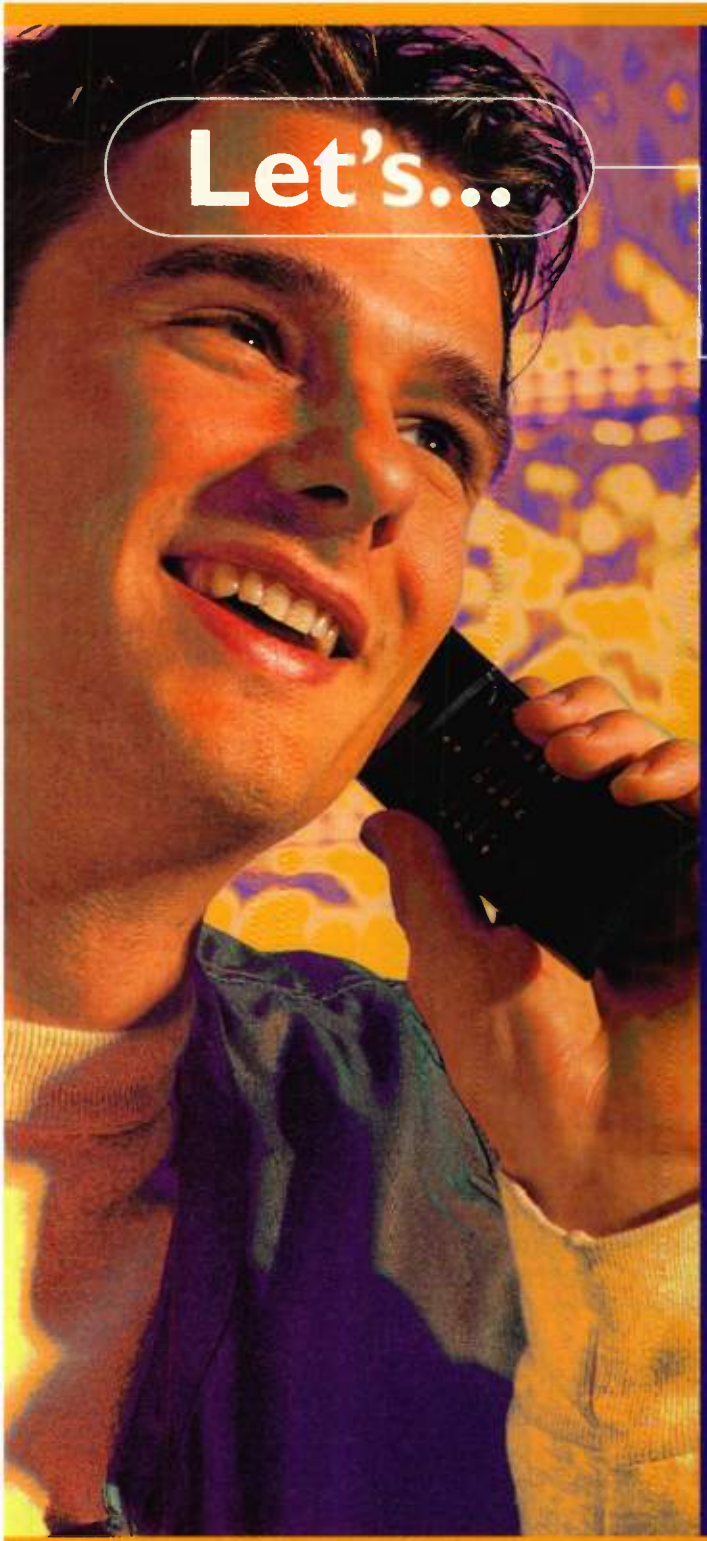

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UPDATE ON COOLING

Vapor-Phase Cooling Lays Foundation For Higher-Performance, Lower-Cost Systems

With customers continuing to demand ever-higher performance and reliability levels at lower cost, system designers are struggling to find ways of successfully embedding high-performance, commercial-off-the-shelf (COTS) boards in an inexpensive, well-cooled, rugged enclosure. As microprocessor speeds grow at an accelerated rate, getting rid of the excessive heat generated by the electronics is no mean feat. To prove themselves up to the task, Themis Computer has implemented vapor-phase cooling in their ColdLogic system that allows high-density COTS VMEbus boards to be used in harsh environments (see the figure). This design eliminates the 5- to 15-times premium that can typically be paid for rugged, conduction-cooled boards.

The vapor-phase cooling system mists the interior of the enclosure with a dielectric fluid that vaporizes on contact with the heated electronics. The vapor carries the heat away to the walls of the enclosure where it condenses and is recycled back into the spray. This system allows Themis to embed COTS VMEbus boards in harsh environments usually reserved for expensive, specially ruggedized boards.

The vapor-phase cooling system mists the interior with a dielectric fluid that vaporizes on contact with the heated electronics. The mist then carries that heat away to the walls of the enclosure. Here, the vapor condenses and is recycled back into the atomizer in a closed-loop system. Key advantages over previous thermal management systems include reduced size and mass of the cooling system, improved shock and vibration tolerance, isolation from dirty/corrosive air, and elimination of expensive ruggedization or repackaging.

The vapor-phase cooling system is based on research performed by Isothermal Systems Research (ISR) (Colton, WA) in response to changes in military procurement policy, and the shift towards increased use of COTS electronics in military systems. While this shift to COTS has paid off in many areas, the benefit to harsh-environment applications is largely unrealized due to the difference in packaging and cooling approaches. Traditional rugged or MIL-spec VMEbus boards use conduction cooling with a thermal sandwich of copper (or some other heat-pipe technology) to fashion a thermal shunt that covers the entire circuit-board area. The shunt provides a path from all the components to a coldwall. However, including this shunt is so expensive that a great deal of effort has gone into finding ways of embedding regular COTS boards into these harsh environments without the system overheating.

Methods used to cool these boards range from using fluid-filled heat-transfer bags, to recirculating conditioned air, to filling enclosures with a dielectric perfluorocarbon fluid such as Fluorinert from 3M. All of these methods have their problems, whether it's an inability to provide for mezzanine boards, in the case of the heat-transfer bags, or just the sheer weight issues associated with filling an enclosure with a liquid that has a density 1.68 times that of water.

The simple fans and heat sinks used in traditional heat-management systems also have their problems. Both the number and size of the heat sinks are increasing as multiple processors are added to the board, thus reducing available space. Also, attaching heat sinks to components reduces their immunity to shock as the added mass amplifies the shock loading according to the well-known equation: force = mass x acceleration. With regard to the fans, blowing in air tends to add impurities, no matter how much filtering is used. And there can be as much as a 10°C rise in air temperature from the intake to the exhaust.

It also is difficult to provide adequate air flow within allowable noise and EMI constraints. As clock rates go up, the size of the perforations in EMI shields must go down. The resulting turbulence due to higher air speed gives rise to unacceptable levels of cooling-system noise.

According to Bill Kehret, president of Themis, spray-cooling addresses all these issues. "You want a standard off-the-shelf board with its high-packing density, and you'd like the same thermal management as you'd get out of a MIL-spec conduction-cooled board. Along comes vapor phase," he says. "It maintains something near a 1°C isotherm throughout the environment of the board—and it does that with great efficiency. You can remove the heat sinks to save space and reduce shock loading, and have only a very moderate rise in temperature."

Themis's ColdLogic, SPARC 20 MP-based server is a prototype implementation comprising standard COTS VMEbus electronics mounted in a

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commercial card cage. The card cage is vibration/shock mounted within a sealed box to protect the electronics from corrosive ambient conditions.

The miniature atomizers spray the electronics and the resulting mist vaporizes off the surface of the heated electronics. This process uses the latent heat of vaporization (heat required to change a liquid to a vapor) to absorb enormous amounts of heat per unit volume of fluid, at a constant temperature. Up to 1000 W per board is achievable. The vapor creates its own convection currents which carry it to the coldwall of the enclosure where it is cooled and condensed.

According to Kehret, "You can do the same things with the coldwall as you've done in the past with various heat sinks—blow air, liquid heat exchangers etc. Another variant takes the condensed liquid and plumbs that out to the heat exchanger integrated with the existing environmental control system." The condensate is returned to the pump, repressurized, and resprayed in a closed-loop system.

ColdLogic uses standard Vicor power modules (minus the heat sinks), and can be mounted in a three-quarter ATR chassis. The enclosure meets MIL 5400 and ARINC 404 specifications. ISR designed and integrated the thermal-fluid system components and fail-safe controller.

While ISR says the cost of a vapor-phase thermal-management system is not much more than a quality air-cooled system, practically speaking, Kehret hasn't seen those price points yet. He believes the price point is at least 2:1 higher for vapor-phase cooling, although it is working its way down the curve now. "It'll come down when they have volume. Unfortunately the gestation period for these kinds of designs is fairly long, with production deployment taking up to three years."

For more information on the ColdLogic system, contact Bill Kehret at Themis Computer, 6681 Owens Dr., Pleasanton, CA 94588; (510) 252-0870.

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Lab-PC-1200	AT	8 channel in, 2 channel out, 12-bit, 100 kS/s, DIO, counters	$695
Lab-PC-1200AI	AT	8 channel in, 12-bit, 100 kS/s, DIO, counters	$595
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DAQCard-516	PCMCIA	8 channel in, 16-bit, 50 kS/s, DIO, counters	$495
DAQCard-700	PCMCIA	16 channel in, 12-bit, 100 kS/s, DIO, counters	$595
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PACKAGING

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MANUFACTURERS OF VMEbus ENCLOSURES

Manufacturer	Available sizes	Power supplies	Number of slots	EMI/RFI protection	Standards compliance	Optional backplanes	Other main features	Delivery time	Other bus-based enclosures
AP Labs San Diego, CA Steve Gills (619) 546-8626 fax (619) 546-6278 e-mail: steve@sd.aplabs.com http://www.sd.aplabs.com CIRCLE 525	6U, 9U, 3U, rackmount, ATR	100 to 1200 W	3 to 42	MIL-STD-461C	EIA rack, ATR, MIL-STD-810E	Yes	Shock/vibration isolation, split backplanes, dual redundant power, thermal monitoring	2 to 10 weeks	PC/AT, Multibus, CompactPCI
Calmark Corp. San Gabriel, CA R.L. Rosenthal (818) 287-0451 fax (818) 287-7350 CIRCLE 526	3U up sub-racks	None	Unlimited	Whatever required	DIN 41494, IEC 297	No	Cooling fans, custom features	8 to 10 weeks ARO	None
Carlo Gavazzi Inc. Brockton, MA Steve Curbesero (508) 588-6110 fax (508) 588-0498 e-mail: stevec@mupac.com CIRCLE 527	2U to 15U	100 to 2000 W	1 to 21	FCC Class A with conductive metal-to-metal interfaces	UL 1950, CSA, EN 60950, VDE Class A	Yes	Redundant power supplies, hot-swap backplanes, system monitoring	6 to 8 weeks	VXI, Futurebus, CompactPCI, Sun, PC/AT, Multibus I and II
Dawn VME Products Fremont, CA Sales (510) 657-4444 fax (510) 657-3274 e-mail: dawnsales@aol.com http://www.dawnvme.com CIRCLE 528	3U, 6U, 9U	150 to 1000 W	3 to 21	N/A		Yes	Voltage, fan-fail, and over-temperature monitoring; attitude/tilt switch	3 days to 6 weeks	CompactPCI
DY4 Systems Inc. Kanata, Ontario, Canada Duncan Young (613) 599-9199 fax (613) 599-7777 e-mail: dyoung@dy4.com http://www.dy4.com CIRCLE 529	1/2 ATR short, 3/4 ATR short, 1 ATR long	78 to 250 W	5 to 15	MIL-STD-461C	ARINC 404A, IEEE 1101.2, ANSI/VITA 1994	No	Conductive cooling, configured front panel, fans, dc or ac supplies	6 to 26 weeks	None
Electro Space Fabricators Inc. Topton, PA Lisa Keller (610) 682-7181 fax (610) 682-2133 e-mail: sales@esfinc.com CIRCLE 530	3U to 12U high and 160 to 140 mm deep, or custom	N/A	1 to 27	Shielding per custom requests	ANSI IEEE STD. 1014-1987	Yes	Custom and standard enclosures and front panels	4 to 6 weeks	VXI, Multibus II
Elma Electronic Inc. Fremont, CA Sandhya Kedlaya (510) 656-3400 fax (510) 656-3783 sales@elma.com http://www.elma.com CIRCLE 531	3U, 6U, 9U, 12U	100 W	3 to 21	FCC Class A & B, VDE-B, CE, MIL-STD-461C	UL, CSA, FCC, TUV	Yes	Auto daisy chain	2 to 4 weeks	VXI, PC, Multibus II, CompactPCI
Hybricon Corp. Ayer, MA Karen Harrington (508) 772-5422 fax (508) 772-2963 e-mail: Karen@hybricon.com http://www.hybricon.com CIRCLE 532	3U to 13U	80 to 1350 W	2 to 21	FCC Class A & B, EN	IEEE 1101.1, 1101.10, 1101.11	No	Optimized air flow, accommodations for peripheral devices, easy access	6 to 8 weeks ARO	VME64x, CompactPCI, Futurebus, custom
Interlogic Industries Melville, NY Bert Freifeld (516) 420-8111 fax (516) 420-8007 e-mail: infoview@ix.netcom.com http://www.infoview.com CIRCLE 533	3U, 6U	120, 200, 400, 600, 800 W	4 to 21	FCC 2780 and VDE 0871	Within ISO9002 and DIN 41494 framework	Yes	VSB, VMX bus, extender and transition cards	Stock to 2 weeks	AT, ATX
Knurr USA Inc. Simi Valley, CA Curtis Schatz (805) 526-7733 fax (805) 584-8376 CIRCLE 534	3U, 5U, 6U, 8U	400, 600 W	12 to 20	Full	EMC MIL-810E, VG, DIN	No	EMC, full grounding, injector/ejector, board locating pins	2 to 6 weeks	Table top
Powerbox USA Broomfield, CO Peter Wagner (303) 439-7220 fax (303) 439-7211 peter.wagner@powerbox.sc CIRCLE 535	3U, 6U	30 to 600 W	1 to full rack	FCC/VDE Class A or B	Various safety, EMI/RFI, packaging	Yes	Dc inputs, hot swap, redundant	1 to 12	CompactPCI

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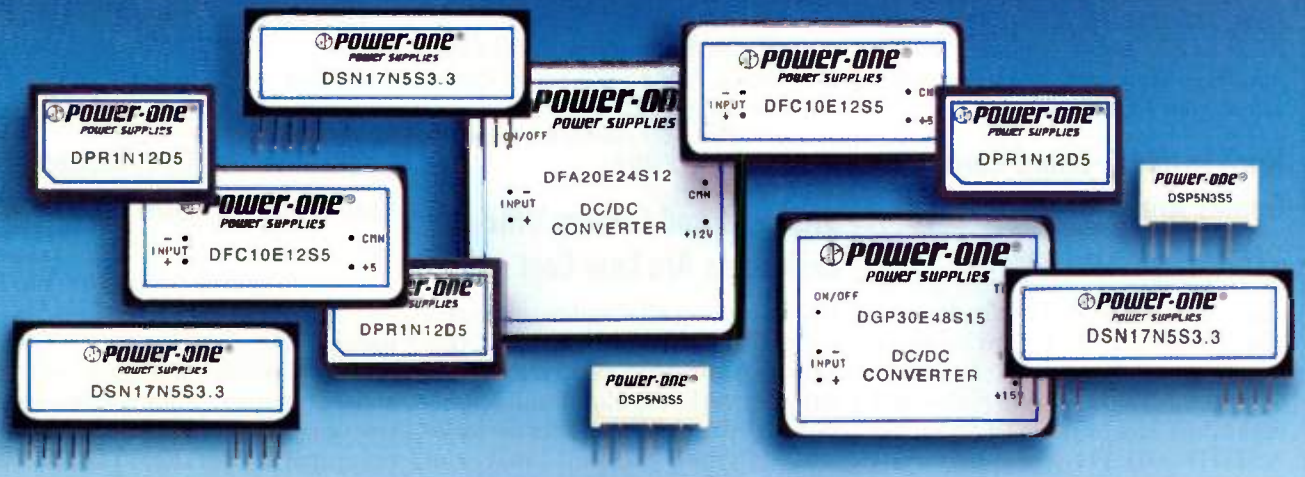

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DFA6	6	9-27, 20-60		•	•		•		•	
DFC6	6	3.5-16		•	•		•		•	
DFC10	10	9-18, 18-36, 36-72	•	•			•		•	
DGP12	12	3.5-16		•			•		•	
DFC15	15	20-60		•			•		•	
DSN17	17	4.5-6, 6.5-15.5	•	•						
DFA20	21	9-18, 18-36, 36-72	•	•			•		•	
DGP30	30	36-72		•			•		•	
Dual Output products provide the indicated Vout as one positive and one negative output										
DSP1	1	4.5-5.5		+/-		+/-	+/-	+/-	+/-	+/-
DFC10	10	9-36, 18-72		+/-			+/-		+/-	
DGP12	12	3.5-16		+/-			+/-		+/-	
DFC15	15	20-72					+/-		+/-	
DFA20	20	9-18, 18-36, 36-72		+/-			+/-		+/-	
Triple Output products provide a main output (•) and two symetrical outputs (+/-)										
DGP20	20	9-18, 18-36, 36-72		•			+/-		+/-	

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19-in. VMEbus Enclosures Mount Horizontally

The H6-21 PR Series of 19-in. rackmount enclosures are designed for mounting of up to 12 6 U by 160-mm cards. Measuring 21 in. deep, the enclosures use the company's VMEbus monolithic J1/J2 backplane, in standard and high-performance versions. Other features include a 400-, 500-, or 750-W power supply mounted on the rear, and two tube axial fans for side-to-side cooling. The front panel comes with LEDs for voltage monitoring, a system reset switch, and an on/off switch.

Hybricon Corp., 12 Willow Rd., Ayer, MA 01432; Sales Dept. (508) 772-5422; fax (508) 772-2963; info@hybricon.com; http://www.hybricon.com. CIRCLE 490

Horizontal PC-Board Card Guides Are Dual-Sided

Designed for 1/16-in. pc boards, the HCG Series card guides come in both single- and dual-sided configurations. The guides enable mounting of pc boards parallel to existing boards or onto metal drawers, metal plates, and enclosures. Molded from 66 Nylon per ASTM D4066 PA111, the guides are 94 V-O rated with an oxygen index of over 28%. Bifurcated prongs on the base of the guides snap into other boards or 0.047-in.-thick metal plates.

Bivar Inc., 4 Thomas, Irvine, CA 92618-2593; Anthony Vilgiate, (714) 951-8808; fax (714) 951-3374; Bivar@interserv.com; http://www.bivar.com. CIRCLE 491

Polycarbonate And ABS Enclosures Resist Corrosion

The QLINE series of polycarbonate and ABS enclosures are UL Type-4X-rated and provide protection in wet, dusty, and corrosive environments. The enclosures are available with clear or opaque covers in over 150 different models. Options include flexible pc-card mounting, adjustable panel depths, rear-mount covers, and tamper-resistant designs.

Hoffman Engineering, 900 Ehlen Dr., Anoka, MN 55303-7504; Robert Sheldon, (800) 355-3560; fax (612) 942-6940; http://www.hoffmanonline.com. CIRCLE 492

Standard And Custom VME Enclosures Are Low Cost

Encompassing all standard sizes and versions of 3U, 6U, 9U, and 12U, this line of VMEbus sub-racks are made of rugged, stylized, aluminum extrusions. All plastic components are made from flame-retardant material (UL94V-O). A card-guide with a molded-in loop eliminates the need for additional snap-in pieces. Pricing for a typical 6U by 220-mm enclosure, fully assembled, is from $80 to $220, depending on quantity. Delivery is from two to four weeks ARO.

ESF Inc., 300 W. High St., P.O. Box 67, Topton, PA 19562-0067; Mark Sismour, (610) 682-7181; fax (610) 682-2133. CIRCLE 493

Enclosures Meet NEMA Type 4, 4X, And 12 Standards

To augment its line of semi-custom enclosures, this company has introduced a line that meet NEMA Type 4, 4X, and 12 standards. Available options include free standing, continuous hinge, pushbutton, single door, and two-doors.

CMP Enclosures, 3932 Grove Ave., Gurnee, IL 60031-2117; Mike Gober, (847) 244-3230; fax (847) 244-3257. CIRCLE 494

Solid-State Air Conditioners Cool At Up To 1500 Btu/hr

The TechniCOOL line of solid-state air conditioners provide up to 1500 Btu/hr cooling and can be arrayed in series or parallel. The devices use the Peltier effect to provide cooling (or heating) and feature precise temperature control capability, no acoustical/electrical noise, and dc operation. The fans can be mounted in any orientation.

Melcor, 1040 Spruce St., Trenton, NJ 08648; Kathy Salvatore, (609) 393-4178; fax (609) 393-9461. CIRCLE 495

MANUFACTURERS OF VMEbus ENCLOSURES

Manufacturer	Available sizes	Power supplies	Number of slots	EMI/RFI protection	Standards compliance	Optional backplanes	Other main features	Delivery time	Other bus-based enclosures
Rose and Bopla Enclosures **Frederick, MD** **George Miller (301) 696-9800** **fax (301) 696-9494** **CIRCLE 536**	100 by 160 to 200 by 220 mm; 9 to 84 TE	N/A	1 to 28	EMI/RFI spray and gaskets	IP, NEMA, DIN, UL	Yes	Portable and rackmount, cassettes, flexible sizing	Stock or 6 to 8 weeks	Eurocard
Schroff Inc. **Warwick, RI** **Jennifer D'Amico (800) 451-8755** **fax (401) 738-7988** **CIRCLE 537**	2U to 12U	160 to 750 W	1 to 21	CE compliance	DIN, IEEE 1101.10, VITA	Yes	Full range of accessories, cases for aesthetics	6 to 8 weeks	CompactPCI, VME64x, VXI, custom
Tracewell Systems Inc. **Westerville, OH** **Fred Meyer (614) 846-6175** **fax (614) 848-4525** **CIRCLE 538**	3U, 6U, 9U; 160 to 400 mm; or custom	65 to 1200 W or custom	1 to 21	Any requirement including tempest	DIN, EIA, VME Rev. C.1, VXI 1.4	Standard or sold separately	Automatic BG/IACK SMT backplane, power plane, power/air monitoring	4 to 6 weeks	VME64x, VXI, CompactPCI, PC/AT
VERO Electronics Inc. **Wallingford, CT** **John Bratton (800) 642-VERO** **fax (203) 949-1101** **e-mail: vero@vero-usa.com** **http://www.vero-usa.com** **CIRCLE 539**	1U, 17 in., 12 in., and up	50 to 1500 W	2 to 21	FCC Class B	UL, FCC, DIN/IEEE, MIL	Yes	Cooling, strengthening, custom	1 to 8 weeks	CompactPCI, VXI, VME64, VME64x

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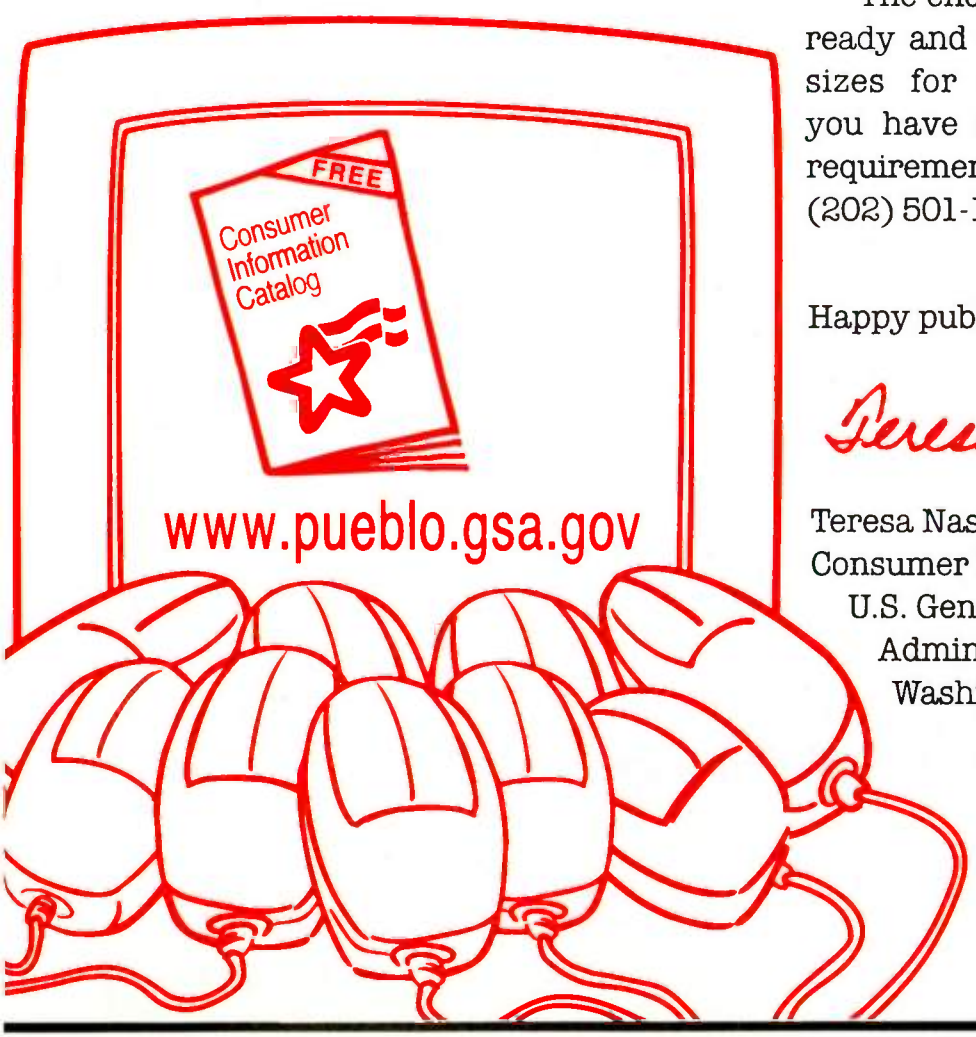

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Teresa Nasif

Teresa Nasif, Director
Consumer Information Center
U.S. General Services Administration
Washington, DC 20405

PRODUCT FEATURE

Data sheets on products like these can be found at www.penton.com/ed/

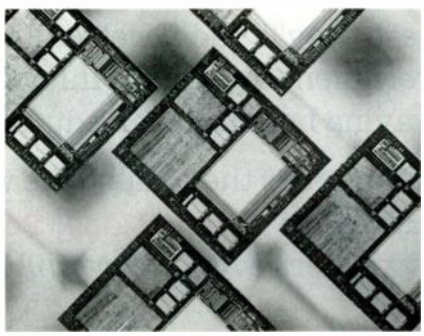
Single-Chip NTSC Color Camera Uses One External Crystal, Single-Rail Power Supply

Designed for portable cameras and video-conferencing applications, the VV6405 integrates the complete color camera function and delivers it on a single chip. All that needs to be added is an external crystal and a single-rail, 5-V power supply. The camera leverages the company's expertise in CMOS-based imaging technology with its inherently lower cost, power consumption, and smaller size, relative to the popular CCD-based alternative used to date.

Although CMOS-based imaging actually pre-dates the CCD, initial designs were limited to the PMOS and NMOS technology and 2- to 8-µm processes available at the time. An example is Reticon's 256-by-256 array that measured over 1-in. square. With CMOS processes now down in the 0.18-µm region, sensor sizes are a bit more realistic. CMOS-based imaging also has the advantage of full compatibility with current logic manufacturing processes, allowing the support chips to be integrated on the same package. CCDs have been handicapped by the fact that support chips had to be added separately and tended to be expensive.

Other advantages to CMOS include inherently low power consumption and low-voltage operation, radiation immunity, small size, and the ability to access specific pixel information without reading out the whole image. On the negative side, it exhibits relatively poor sensitivity, resolution ability, and pixel consistency. Consequently, it's reasonable to predict that CCDs will remain the sensors of choice for high-end applications such as astronomy and medical imaging, while CMOS sensors will quickly eat into previously CCD strongholds such as portable cameras and video conferencing applications.

The VV6405 sensor from VLSI Vision uses a 1/4-in. ColorMOS™ photoplane and combines it with a video timing controller, an 8-bit ADC, a 300-MIPS color DSP engine, and a



video DAC to drive a 75-Ω load. Also included on the chip are five video line memories, auto exposure control, auto color balance, and an NTSC-compatible video encoder.

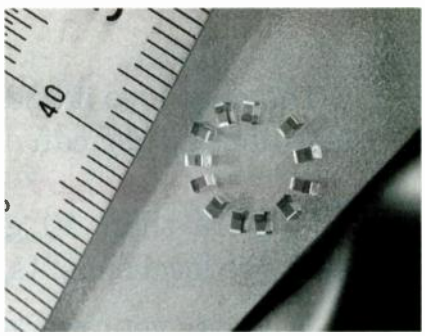
The device is packaged in a standard 48-LCC and works in ambient lighting from 100k lux down to under 25 lux. The camera is suited to 15-frame/s applications. Power consumption is 100 mA at 5 V.

VLSI Vision Ltd.
18805 Cox Ave.
Suite 260
Saratoga, CA 95070
Don Lake (408) 374-5323
fax (408) 374-4722
dl@vvl.co.uk
http://www.vvl.co.uk
CIRCLE 590
PATRICK MANNION

Low-ESR Tantalum Capacitors Come In Ultra-Miniature 0603 Package

Offered as the world's smallest tantalum capacitor, the TACmicrochip Series developed by AVX Corp. comes in an 0603 package with CV ratings of 1.0 µF at 10 V. The device also features a change in the design of the cathode end that results in a reduction in ESR by 3.5 times that of conventional tantalum capacitors.

According to Willing King, AVX product manager, the TACmicrochip achieves the reduction in size by applying popular semiconductor manufacturing techniques. This allowed AVX to eliminate the less-efficient leadframe methods by depositing the capacitor material directly on a tantalum wafer substrate. The devices then can be built up in a series of automated process steps. "While the active



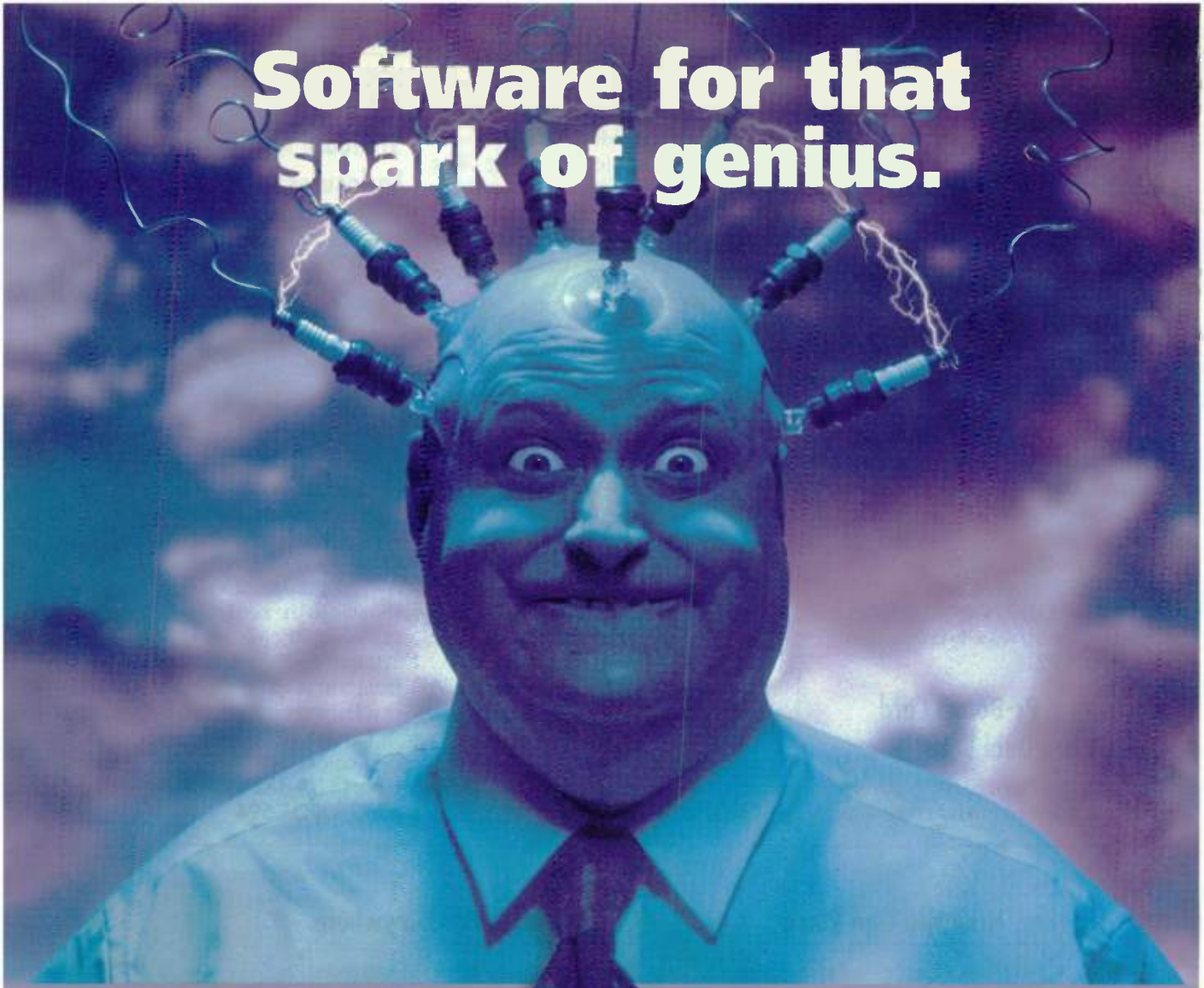
tantalum element comprises just 30% of the volume of a leadframe device, our process increases this volume to more than 70% while dramatically reducing the overall size of the capacitor," says King.

In addition, changing the geometry of the cathode end to a flat plate instead of a rod increases the contact area with the tantalum powder by a factor of 30. This lowers the ESR to 10 Ω at 100 kHz, a reduction of 3.5 times that of capacitors produced by conventional methods.

The end product is a tantalum capacitor in an 0603 package that measures 1.6 by 0.85 mm with a board height of 0.85 mm. The new construction method has also improved the device's tolerances. Unlike molded or conformally-coated capacitors, the TACmicrochip's dimensions can be precisely controlled to facilitate more efficient automated assembly processes. Other available CV values include 1.5 µF at 6.3 V; 2.2 µF at 4 V; 3.3 µF at 3 V; and 4.7 µF at 2 V. The 10-Ω ESR is maintained throughout. Pricing is from $0.50 to $0.60 each per 10,000, and delivery is from stock.

AVX Corp.
P.O. Box 867
Myrtle Beach, SC 29578
(803) 946-0414
fax (803) 448-1943
http://www.avxcorp.com
CIRCLE 591
PATRICK MANNION

Software for that spark of genius.



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READER SERVICE 233

PACKAGING

Data sheets on products like these can be found at www.penton.com/ed/

19-in. VMEbus Enclosures Mount Horizontally

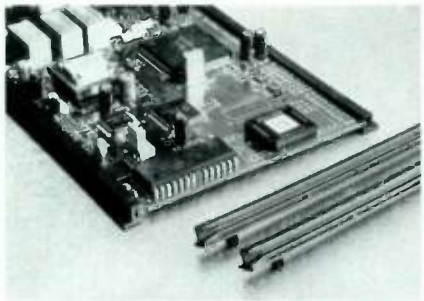
The H6-21 PR Series of 19-in., rack-mount enclosures are designed for mounting of up to 12 6U by 160-mm cards. Measuring 21 in. deep, the enclosures use the company's VMEbus monolithic J1/J2 backplane, in standard and high-performance versions. Other features include a 400-, 500-, or 750-W power supply mounted on the rear, and two tube axial fans for side-to-side cooling. The front panel comes with LEDs for voltage monitoring, a system reset switch, and an on/off switch.

Hybricon Corp., *12 Willow Rd., Ayer, MA 01432; Sales Dept. (508) 772-5422; fax (508) 772-2963; info@hybricon.com; http://www.hybricon.com*

CIRCLE 592

Horizontal Pc-Board Card Guides Are Dual Sided

Designed for 1/16-in. pc boards, the HCG Series card guides come in both single- and dual-sided configurations. The guides enable mounting of pc boards parallel to existing boards or onto metal drawers, metal plates, and enclosures. Molded from 66 Nylon per ASTM D4066 PA111, the guides are



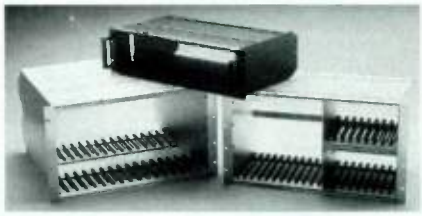
94V-O rated with an oxygen index of over 28%. Bifurcated prongs on the base of the guides snap into other boards or 0.047-in.-thick metal plates.

Bivar Inc., *4 Thomas, Irvine, CA 92618-2593; Anthony Vilgiate (714) 951-8808; fax (714) 951-3374; Bivar@interserv.com http://www.bivar.com*

CIRCLE 593

Standard And Custom VME Enclosures Are Low Cost

Encompassing all standard sizes and versions of 3U, 6U, 9U, and 12U, this line of VMEbus subracks are made of



rugged, stylized, aluminum extrusions. All plastic components are made from flame-retardant material (UL94V-O). A card-guide with a molded-in loop eliminates the need for additional snap-in pieces. Pricing for a typical 6U-by-220-mm enclosure, fully assembled, is from $80 to $220, depending on quantity. Delivery is from two to four weeks.

ESF Inc., *300 W. High St., P.O.Box 67, Topton, PA 19562-0067; Mark Sismour (610) 682-7181; fax (610) 682-2133.* **CIRCLE 594**

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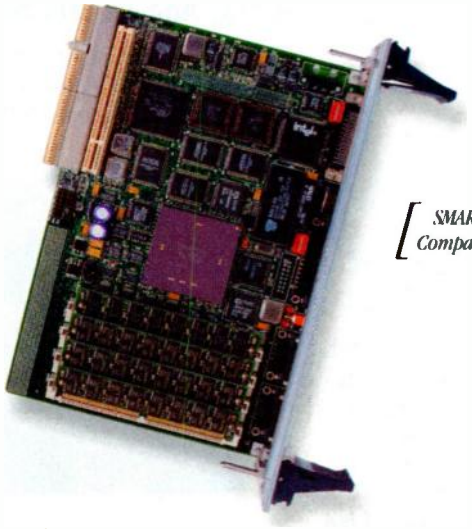

[SMARTengine/50PCI CompactPCI Computer]

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Powered by a 200 MHz 64-bit MIPS R5000 processor, the SMARTengine/50PCI is designed to provide top performance in embedded applications such as internetworking, telecommunications and imaging. The CPU, memory and logic all run at 3.3 volts to minimize power consumption. And the dual-issue superscalar R5000 CPU provides programs with a generous on-chip 32 KB of instruction and 32 KB of data caches for blazing performance.

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A full complement of subsystems—including capacity for up to 128 MB of RAM, serial interfaces, watchdog timer, nonvolatile memory, ethernet, and SCSI—completes the high-performance picture. Software support for third-party real-time operating systems is comprehensive and complete.

The SMARTengine/50PCI is the *first* R5000 CompactPCI computer on the market—not surprising when you consider it comes from SMART Modular Technologies, Inc., a technology leader in modular memory, input/output and computing products for OEMs. With state-of-the-art manufacturing facilities in Fremont, California, Puerto Rico, and Scotland, SMART is uniquely qualified to be your long-term embedded computer partner.

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CompactPCI

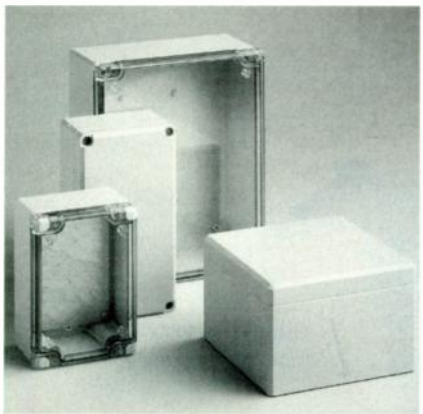
READER SERVICE 197

PACKAGING

Data sheets on products like these can be found at www.penton.com/ed/

Polycarbonate And ABS Enclosures Resist Corrosion

The QLINE series of polycarbonate and ABS enclosures are UL Type 4X-rated and provide protection in wet, dusty, and corrosive environments.



The enclosures are available with clear or opaque covers in over 150 different models. Options include flexible pc-card mounting, adjustable panel depths, rear-mount covers, and tamper-resistant designs.

Hoffman Engineering, *900 Ehlen Dr., Anoka, MN 55303-7504; Robert Sheldon (800) 355-3560; fax (612) 942-6940; http://www.hoffmanonline.com.* **CIRCLE 595**

Convection-Cooled ATR VMEbus Enclosure Is Rugged

The FS-7276 is a 6U VMEbus-based, convection-cooled, ATR rugged enclosure that accommodates from two to 18 slots. The enclosure is part of the

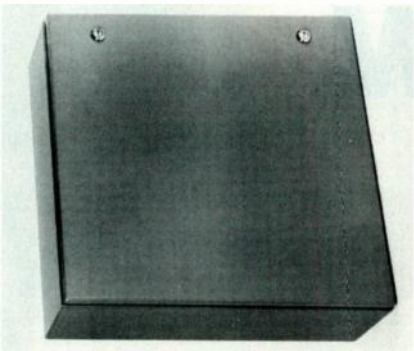
company's Fullspectrum line that spans from commercial through to MIL-spec. and meets ARINC 404 guidelines for a Number 1 1/2 Long Tall ATR device. Standard configuration provides 12 slots and a 600-W power supply. Options include a disk bay and an ARINC-style shock tray. Pricing is from $9950 and delivery is from 60 days ARO.

AP Labs, *5871 Oberlin Dr., San Diego, CA 92121; Steve Gills, (619) 546-8626; fax (619) 546-0278; steve.gills@sd.aplabs.com; http://www.sd.aplabs.com*

CIRCLE 596

Enclosures Meet NEMA Type 4, 4X, And 12 Standards

To augment its line of semi-custom enclosures, CMP Enclosures has introduced a line that meets NEMA Type 4,



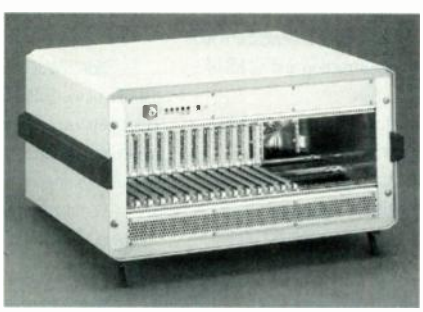
4X, and 12 standards. Available options include free standing, continuous hinge, pushbutton, single door, and two doors.

CMP Enclosures, *3932 Grove Ave., Gurnee, IL 60031-2117; Mike Gober (847) 244-3230; fax (847) 244-3257.*

CIRCLE 597

Modular Chassis Combines Flexibility With Ruggedness

PRIMUS is a 19-in. modular chassis that, in its most basic version, meets the EMI/RFI and shock-proofing re-



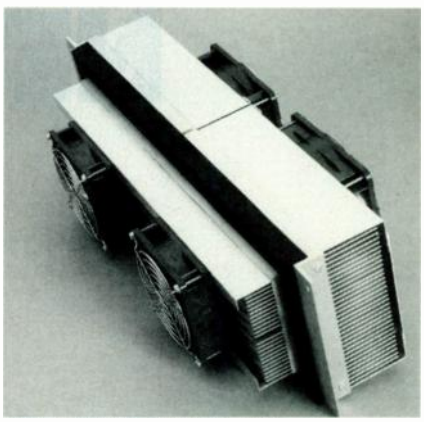
quirements of MIL-STD-810E. A push-fit connection system makes the chassis easy and fast to assemble. PRIMUS comes integrated with enclosure, backplane, power supply, thermal management, cabling, and shielding. Standard retrofittable components are available

Knurr USA Inc., *1890 North Voyager Ave., Simi Valley, CA 93063; (805) 526-7733; fax (805) 584-8371.*

CIRCLE 598

Solid-State Air Conditioners Cool At Up To 1500 BTU/hr.

The TechniCOOL line of solid-state air conditioners provide up to 1500 BTU/hr. cooling and can be arrayed in series or parallel. The devices use the



Peltier effect to provide cooling (or heating). Features include precise temperature control capability, no acoustical/electrical noise, and dc operation. The fans can be mounted in any orientation.

Melcor, *1040 Spruce St., Trenton, NJ 08648; Kathy Salvatore (609) 393-4178; fax (609) 393-9461.*

CIRCLE 599

Thin-Film, Ceramic Packages Target Wireless Applications

The VIA/PAK is a thin-film, ceramic, surface-mount package for wireless applications in the range of dc to 21 GHz. The package is available in 0.250-in^2. and 0.450-in^2. versions with four leads in each case. Key specifications include an insertion loss of less than 0.25 dB per port (typical), port-to-port isolation of over 30 dB, and a VSWR of less than 1.5:1.

Micro Substrates Corp., *2400 South Roosevelt St., Tempe, AZ 85282; Bob Griffin, (602) 731-6230; fax (602) 731-6229.*

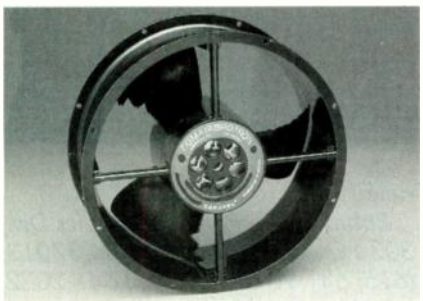
CIRCLE 600

PACKAGING

Data sheets on products like these can be found at www.penton.com/ed/

Die-Cast Aluminum, 550-CFM AC Fan Dissipates 60 W

The Caravel is 60-W ac tube-axial fan with 550 CFM performance in a rugged die-cast aluminum housing. The fan also comes with a feathered-edge blade for lower noise . Available in 115- or



220/230-V ac versions, the fan has an operating temperature range of -30° to 60°C, and includes an automatic reset thermal protector. The fan weighs 4.4 lb. and measures 10 in. in diameter by 3.5 in. deep. It is TUV- and CSA-certified as well as UL-listed, and comes in leadwire and terminal models.

Comair Rotron, 2675 Customhouse Court, San Ysidro, CA 92173; (619) 661-6688; fax (619) 661-6057; sales@comairrotron.com; http://www.comairrotron.com
CIRCLE 601

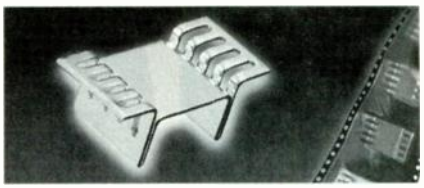
Fan/Heat-Sink Combination Cools Up To 32 W

The FanSink III is a fully integrated fan/heat sink combination for high-end processors that dissipate up to 32 W. Less than 1-in. high, the device uses a ball-bearing design with a patented, lightweight, aluminum plenum. The thermal resistance is 0.6°C/W and the power consumption is less than 2 W at 12 V. Other features include a lifetime of 56,000 hours, an operating temperature range of -10° to 70°C, and various tach and signal options. Pricing for a model with mounting clips and soft-shell power connector is $22.95. Delivery is 16 weeks.

***Nidec Corp.**, 152 Will Dr., Canton, MA 02021; (617) 828-6216; fax (617) 828-3215.* **CIRCLE 602**

Surface-Mount Heat Sink Suits D^{3}Pak Power Device

This surface-mountable heat sink for is designed for the D^{3}Pak power device. The heat sink decreases the devices' case temperature by 17°C at 2 W, or increases the devices' maximum



power-handling capability by 1 W. The heat sink is coated with a 63/37 tin/lead solder and has an all-flat surface to make it ideal for assembly using standard vacuum pick-and-place equipment. Pricing is $0.34 each per 10,000 in tape-and-reel form.

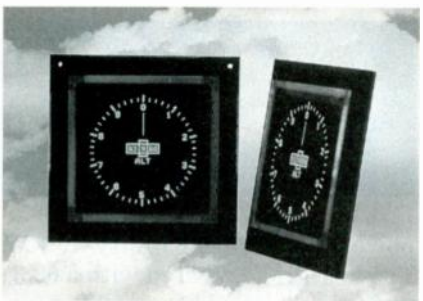
***Aavid Thermal Technologies Inc.**, One Kool Path, PO Box 400, Laconia, NH 03247-0400; (603) 528-3400; fax (603) 528-1478; http://www.aavid.com*
CIRCLE 603

OPTOELECTRONICS

Data sheets on products like these can be found at www.penton.com/ed/

EL Display Is Readable In High Ambient Light

By using a patented "black layer construction" between its phosphor and counter-electrode layers, the S-II-ETL3 EL display offers reduced specular and diffuse reflection from 75% to



2%. As a result, legibility in high ambient light conditions is increased up to 10,000 footcandles. The thin-film EL display has a viewing area of 2.4 by 2.4 in. with a resolution of 152 by 152. The contrast ratio is 100:1, dropping to 2:1 at 10,000 footcandles ambient light. The operating temperature range is from -55° to 85°C.

Luxell Technologies Inc., *5170A Timberlea Blvd., Mississauga, Ontario, Canada L4W2S5; (905) 206-1708; fax (905) 206-9174.* **CIRCLE 604**

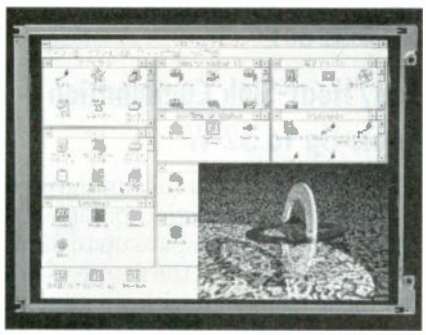
Positive-Bias VLDs Target DVD Applications

The NDL3410SU and NDL3320SU are AlGaInP-based laser diodes with emission wavelengths of 635 and 650 nm, respectively. Specifically aimed at DVD applications, the devices use a positive-bias pinout and come in a 5.6-mm CAN package. A multiple-quantum-well epitaxial design allows a low operating power of 60 mW and stable temperature operation up to 60°C. Pricing is $60 for the NDL3410SU and $45 for the NDL3320SU in quantities of 2500.

NEC Electronics Inc., *2880 Scott Blvd., P.O. Box 58062, Santa Clara, CA 95052-8062; (408) 588-6000; fax (408) 588-6130.* **CIRCLE 605**

CSTN LCDs Come In 15.5 XGA And 12.1 SVGA Versions

The SX39X001 is a 15.5-in. XGA color supertwist nematic (CSTN) display with enhanced Hi-Addressing technology. This technology eliminates ghosting, shadowing, and crosstalk to allow for higher display quality and resolution. The display



measures 358.0 by 264.0 by 12.0 mm, has a viewing area of 314.9 by 236.1 mm, and weighs 1400 g. The brightness, contrast ratio, and response time are 150 cd/m^2, 40:1, and 150 ms, respectively. A 12.1-in. SVGA version also is available.

Hitachi America Ltd., *Converging Technologies Group, Flat Panel Display Div., 3850 Holcomb Bridge Rd., Suite 300, Norcross, GA 30092; (770) 409-3000; fax (770) 409-3028.*

CIRCLE 606

330,000-Pixel Image Sensor Uses CMOS Technology

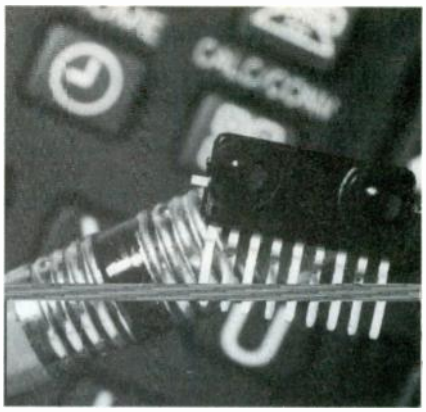
This 1/4-in., 330,000-pixel image sensor is fabricated using CMOS technology which has the potential to realize significant structural and functional advantages over CCD image sensors. The sensor operates off a single 5-V supply, consumes 30 mW, and supports VGA resolution. Overall dimensions are 6.4 by 5.4 mm.

Toshiba Corp., *1-1-1, Shibaura, Minato-ku, Tokyo 105, Japan; 81-3-3457-2105; fax 81-3-3456-4776.*

CIRCLE 607

Transceiver Is IrDA- And ASK-Compatible

The RPM-850CB is an infrared transceiver IC that meets both IrDA and ASK requirements. Comprising an infrared LED, PIN photodiode, and hysteresis amplifier, the IC features a power-down function, a supply voltage range from 2.7 to 5.5 V, and overall measurements of 12 by 5.5 by 4.25 mm. The LED has a peak current of 250 mA and the operating temperature



range is -10° to 70°C.

Rohm Corp., *Rohm Electronics Div., 3034 Owen Dr., Antioch, TN 37013; (615) 641-2020; fax (615) 641-2022; http://www.rohmelectronics.com.*

CIRCLE 608

Laser Components Come In Surface-Mount DIP Format

Designed for intermediate and long-reach telecom rates of 155 Mbits/s and 622 Mbits/s, this line of laser sources and PIN diode detectors comes in surface-mountable DIPs. The devices use detachable pigtails featuring MT-connector technology.

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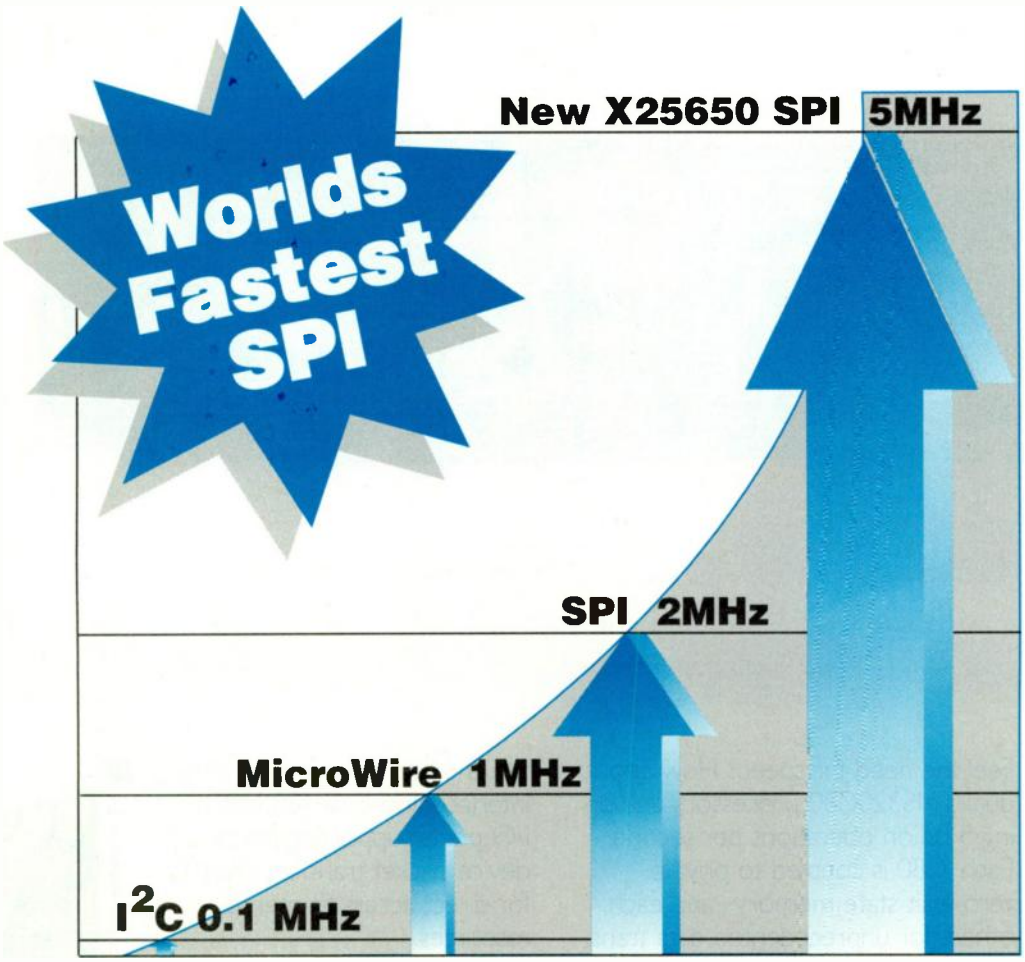

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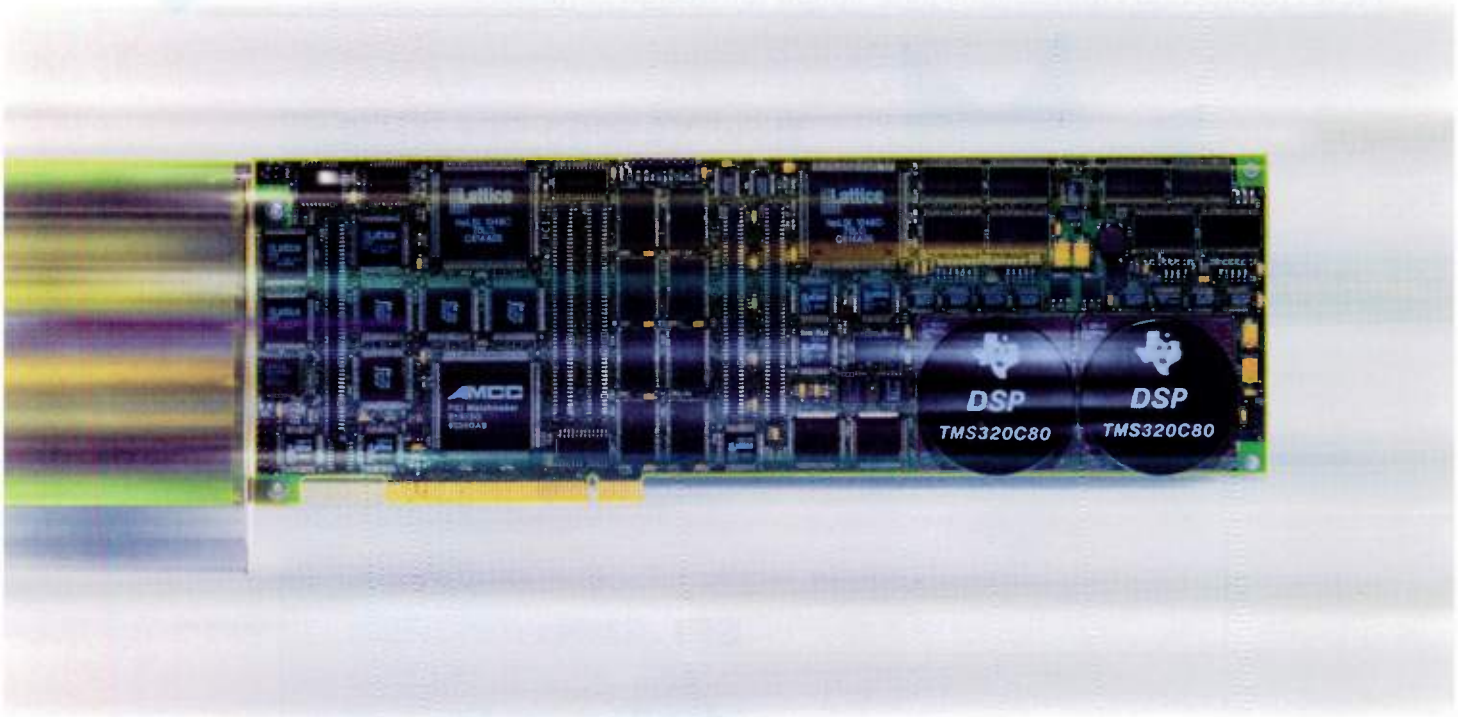

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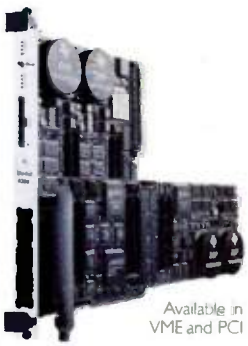

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Looking Ahead At The Display Interface

Ian Miller, IBM U.K. Ltd.

Members of the Video Electronics Standards Association (VESA) have been working over the past few months to define a new display-interface standard that supplies the optimal attachment and support needed for a wide variety of displays. Work on the standard will soon be completed, and it is expected that the industry will benefit greatly from the association's efforts.

VESA's Plug and Display Committee includes representatives from companies in many areas of technology, including manufacturers of PCs and workstations, graphics boards and subsystems, semiconductors, connectors, cables, CRTs, and flat-panel displays. The standard will allow interoperability of display devices, system units, and graphic subsystems from a wide range of manufacturers, independent of display technologies and operating systems. The draft standard, which is now being proposed to the entire VESA membership, should be ratified within the next 60 days.

Of particular interest to many of the committee members is the potential growth of the LCD monitor market. Forecasts show the use of a digital interface between the graphics subsystem and the monitor is a natural choice. The proposed interface requires some level of interaction between the display and graphics subsystem to provide automatic configuration as well as the use of an optimal data-transfer path.

The new standard specifies a connector with provisions for traditional analog video-signal protocols (red, green, and blue video, plus horizontal and vertical synchronization pulses), multiple digital-interface standards, and the VESA Display Data Channel (DDC). The DDC transmits the VESA Extended Display Identification Data (EDID) structure to the host system. The revised EDID standard, still being defined by the VESA Monitor Committee, has new features specifically targeted at upcoming display technologies.

The standard being proposed by the Plug and Display Committee defines a new connector, with two host receptacle variants, based on the VESA Enhanced Video Connector (EVC). Together, these connectors form a comprehensive high-performance connector family, with each connector optimized to support specific interface implementations targeted at different market segments.

The standard includes three digital interfaces: Transition Minimized Differential Signaling, based on the PanelLink technology developed by Silicon Image; the Universal Serial Bus (USB); and IEEE 1394 (Firewire). OEMs may opt to employ just the TMDS and one of the other two serial interfaces (USB or IEEE 1394). Depending on the characteristics and requirements of the display, as well as the intended application, any one of these interfaces may be used for video data.

It's expected that CRT-based displays will employ the analog interface, while flat-panel monitors (typically LCDs) will use the TMDS interface. Other display types, mostly those with built-in frame buffers, will take advantage of the IEEE 1394 interface. The plug-and-display nature of the interface serves to act as a universal display interface, regardless of the display type.

Of course, there are many short-term challenges standing in the way of achieving a single video port capable of handling multiple display types and interface technologies. Manufacturers must decide how to manage the transition from a widespread use of the current "VGA connector" for analog interface displays and a multitude of special-purpose adapter cards to the new displays that require a digital interface.

However, the benefits are overwhelmingly in favor of such a transition. These benefits include a single video port completely independent of display and interface technology; a cost savings by eliminating the digital-analog and analog-digital conventions; and improved image-display quality for those applications best served by digital data. The IBM PC Company, one of the committee's active participants, displayed elements of the proposed plug-and-display interface at CeBit '97 trade show in Hanover, Germany.

Does the draft standard's approval signal the end of the plug-and-display road? For some market segments, the answer may be yes. However, further developments are expected to extend the capabilities of the plug-and-display interface, ensuring that it remains at the leading edge of display interface technologies. Some potential future enhancements are included in the standard. But one of the keys to its future success is that backward-compatibility should be maintained.

For more information on the plug-and-display standard or any related developments, contact the VESA office at (408) 435-0333, or on the Internet at http://www.vesa.org.

Pump Up Your Graphics Subsystem For Tomorrow's Applications

Video Graphics Controllers Help Designers Get The 30 Frames/s Needed For Realistic 3D Graphics.

STUART MCKECHNIE AND KLAUS LEHNER, Philips Semiconductors, 811 E. Arques Ave., Sunnyvale, CA 94086; (415) 335-2568.

Designers in the 3D-graphics market are very concerned about producing increasingly realistic, interactive 3D games. Yesterday's state-of-the-art arcade game is becoming today's mainstream PC product. In the past, the platform of choice was a dedicated games player rather than a PC. With falling PC prices and new developments in hardware (video and graphics controllers) and software (APIs, GUI), the PC is becoming a more attractive medium for consumer games.

In interactive 3D graphics, speed is everything. Games with an update rate slower than 20 frames/s are somewhat difficult to play; update rates faster than 30 frames/s are preferable. It's not surprising that current games offering 3D realism are only semi-interactive, stepping users through a sequence and/or video of prerendered scenes.

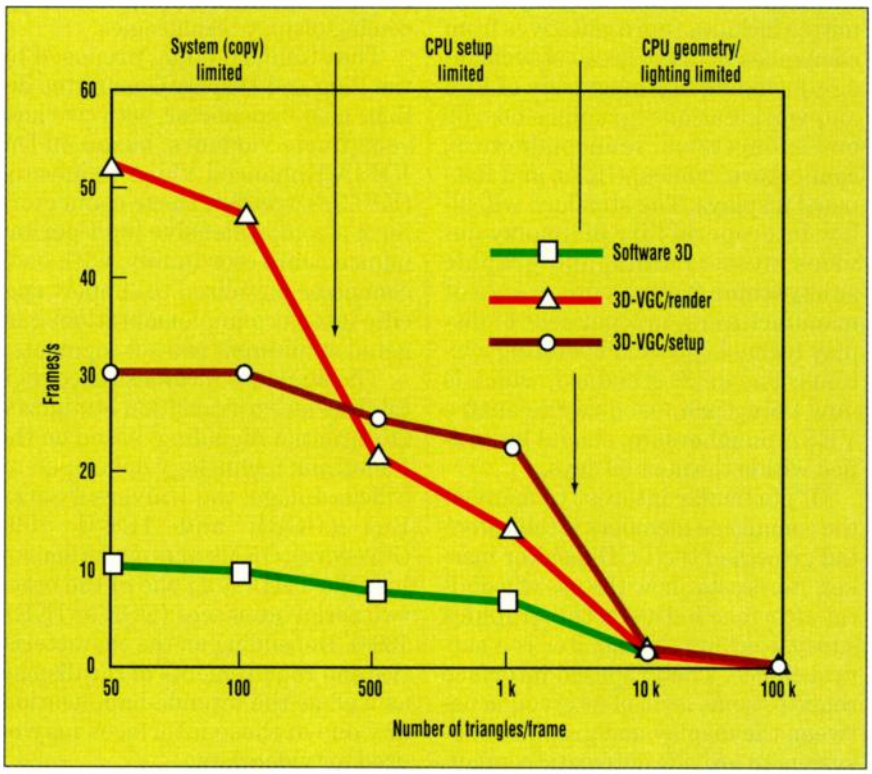
The heart of the multimedia subsystem is the video-graphics controller (VGC). New generations of VGCs have added bus mastering, video acceleration, and 3D rendering capabilities, with 3D-triangle setups expected in the next generation of products. In 3D-gaming applications, the bottleneck is still the lack of processing power for floating-point-intensive geometry and lighting calculations.

3D Phases

To understand 3D phases, let's examine the 3D pipeline where we project the view of a moving collection of objects in a 3D database onto a 2D screen. It starts with the modeling phase in which the application determines the changes to and movements of the objects in the database. These determinations are based on the objects' interactions with each other, as well as input from the player or players. As games get more complicated, so does the modeling. Imagine, for example, trying to coordinate the movements at 30 frames/s of more than several thousand intermeshed triangles to generate a realistic-looking running person. Or trying to accurately convey facial expressions (typically, a face can take up to 400,000 triangles for realistic rendering).

Next comes the floating-point-intensive geometry processing, where the system calculates which objects are seen from which angle, and the lighting phase where the colors and hues of objects are calculated. Being able to work with several light sources which generate a combination of effects is of key importance in generating realistic images.

In the setup phase, the triangle vertex data streams (x, y, z, color, etc.) are organized for presentation to the rendering engine. Triangles are sorted, culled, and clipped, and edge slopes are calculated for input into the raster engine. Subpixel corrections are needed to avoid anomalies such as



1. Three different platforms are compared when performing full 3D geometry lighting-model simulations using fixed 10-pixel triangles. The first is a software solution on a 100-MHz Pentium with a 2D Windows accelerator. The second is a 3D VGC with 30 Mpixel/s performance. And the third is a hardware-assisted 3D VGC.

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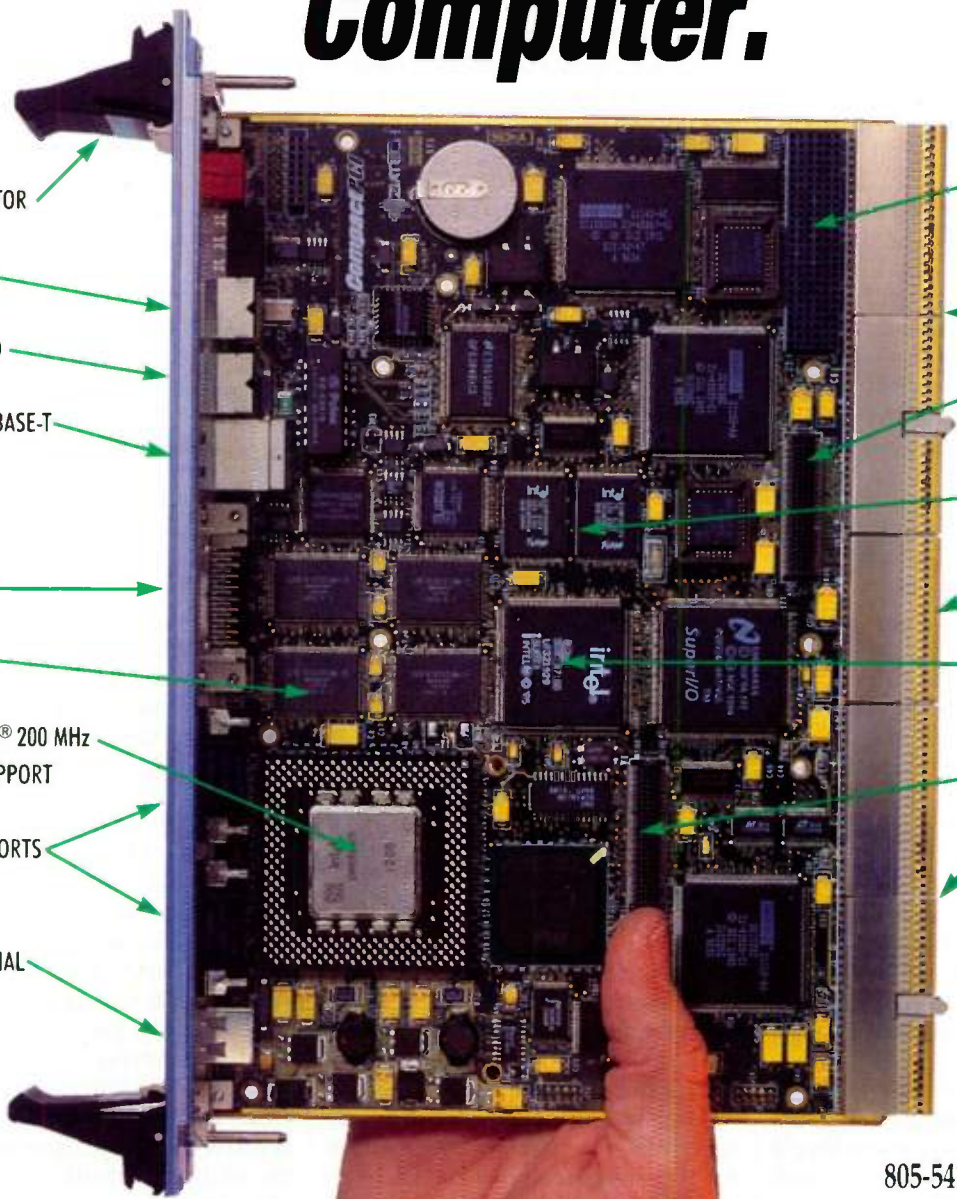

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poke-throughs and frayed edges. Converting from the floating-point "software" domain to the fixed-point "hardware" domain also is necessary. Doing all this in the host processor burns a lot of CPU cycles.

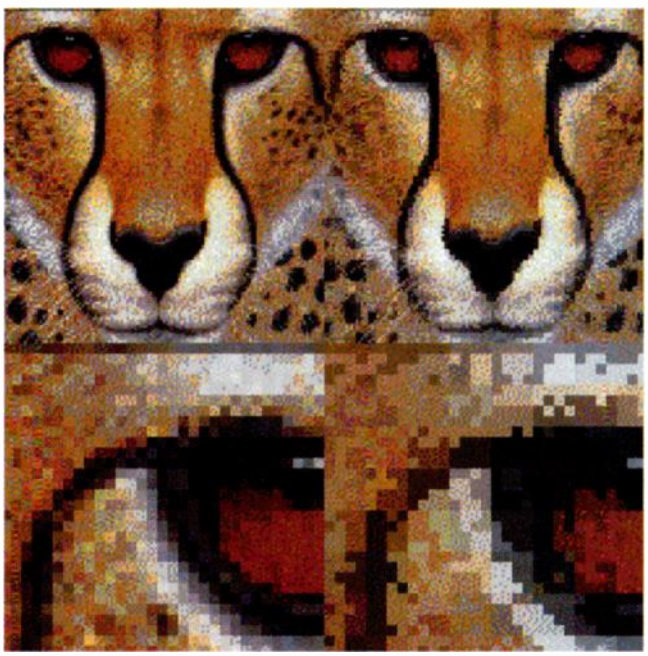
Finally, in the rasterisation phase, triangles are shaded, sorted, texture mapped, blended, and mapped to the display. Antialiasing and dithering functions are applied to help correct for a number of different artifacts, such as those seen on near-horizontal edges. Quality is not necessarily guaranteed here—some VGCs use simpler scanning techniques which can, for example, result in bleed-through along triangle boundaries.

System Performance

Let's take a look at how three contemporary systems perform full 3D-geometry lighting-model simulations using fixed 10-pixel triangles. They run 3D software on a 100-MHz Pentium processor with a 2D Windows accelerator, a 3D VGC with 30-Mpixel/s performance, and a hardware-assisted 3D VGC *(Fig. 1)*.

For small numbers of triangles, the performance is dominated by system copy calls. They occur most often in the case of the software 3D system (which composes the picture in system memory). The 3D VGC with setup shows lower frame rates due to a double-buffer approach synchronized to the monitor frequency. Above a rate of 500 triangles/s, the rapid falloff in performance of the 3D VGC demonstrates the need for hardware assist. At 10,000 triangles/frame, the 3D hardware is almost irrelevant, and the system is limited by the CPU's geometry and lighting performance.

What does this all mean in practice? Most 3D games available today use about 1000 to 2000 rendered triangles/frame, from a total of about 5000, corresponding in a depth complexity of about three. Both software 3D and 3D-VGC systems struggle to reach 20 frames/s in this scenario, though having hardware setup helps a lot *(Fig. 1, again)*. Even with rich texturing, 1000 to 2000 triangles for the scene or subject doesn't allow for a very realistic game. The next generation of 1-million-triangles/s games will require scene complexities of 10,000 triangles and beyond. In a typical scene breakdown, the larger triangles represent the greatest area. With rich texture mapping, the larger triangles are essential to the gaming experience. However, the small triangles are essential for realistic details.



2. 3D graphics often result in exteremly large images. Fortunately, full texture mip-maps can be compressed. As shown, factors of 10:1 or better are achievable with minimal texture degradation (compressed image on right).

Current software and 3D-VGC systems will be completely CPU bound at a few frames per second for this scene complexity, well below the level of 30 frames/s required for interactivity. Using a faster CPU, such as a 200 MHz Pentium II, will raise the performance level by a factor of about three, but the 8 frame/s performance is still too low.

Handling Textures

Sooner or later, all textures have to travel from system memory to the VGC. Today, those bandwidths are typically in the tens of megabytes, and are predicted to double each year. The Advanced Graphics Port (AGP) increases available bandwidths from 266 Mbyte/s for 1X mode (twice the rate of the PCI bus), to 1 Gbyte/s for 4X mode. But increased bus bandwidth is not enough. As required screen resolutions increase above 800 by 600 pixels and realism demands more sophisticated techniques such as trilinear texture filtering and antialiasing, it will be easy to exceed even the 4X AGP bus bandwidth if full texture mip-maps are stored in system memory.

Fortunately, it's not necessary to store and transmit full-texture mip-maps. Compression factors of 10:1 or better are achievable with minimal texture degradation *(Fig. 2)*. Compressed textures are stored in system memory transparent to the application, and are transmitted compressed to the VGC which decompresses them on the fly as needed.

Scatter-gather PCI/AGP bus mastering is the next essential feature. It has the potential to double system performance. The VGC's own Memory Management Unit (MMU) can autonomously fetch texture maps from the system memory without interrupting the CPU to provide scattered addresses of data blocks.

Advanced systems achieve a further reduction in bandwidth by building a texture cache into the VGC, and by deferring texturing until clipping and visability are performed. Other key features to look for are perspective-correct texture mapping and the ability to handle generated and video textures.

Although texture compression allows next-generation games to run without saturating PCI-bus bandwidths, there's still a need for enhancements suchy as geometry- and lighting-acceleration hardware. Microprocessor performance is not increasing fast enough and, until 1999, the best we can expect is a 2X improvement in the CPU's floating-point performance. It's reasonable to assume that this improvement will be absorbed by the requirements of 3D applications. Hardware geometry and lighting also helps minimize the bus-bandwidth requirement.

In the meantime, overall system

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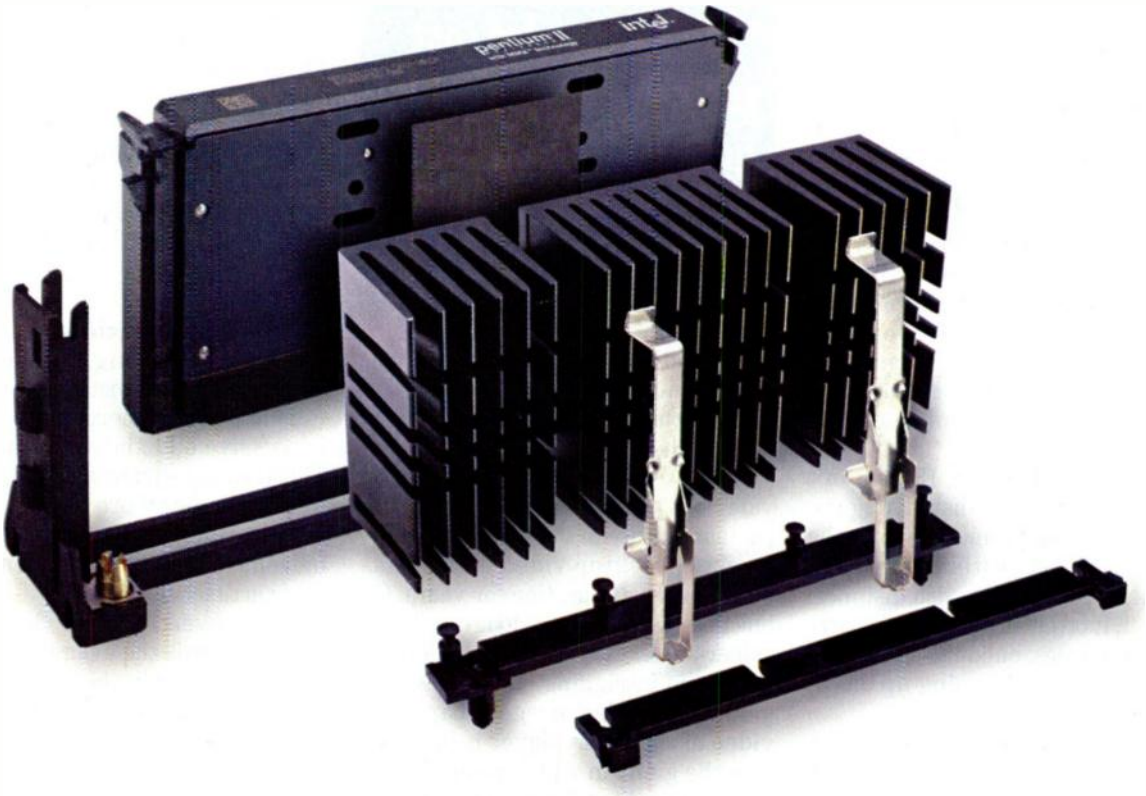

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performance can be improved by implementing some hardware-based software techniques.

2D Can't Cut It

In a sense, the fastest way to render an object is not to have to render it. To squeeze the maximum performance from a limited 2D system, independent software vendors (ISVs) have long exploited techniques like sprites, level-of-detail (LOD), 3D layering, and affine transforms. Sprites allow relatively complex, active objects to be stored as bitmaps and superimposed on a scene. However, as we become accustomed to more sophisticated games, conventional 2D sprites often look disconnected and unrealistic.

With LOD filtering, ISVs don't bother to render more distant objects. It's a sensible compromise because the number of objects within the field of view increases rapidly with distance. However, it often leads to the disturbing effect of trees, buildings, and other objects suddenly popping up out of nowhere.

Use of 3D layering allows for a more efficient exploitation of system resources. Objects are grouped according to their distance from the viewer. Background objects like mountains and clouds change very slowly and require infrequent updating. Alternatively, foreground objects need frequent rendering. Combined with an affine warping capability (which can be described as transformations like stretching and skewing), 3D scene updates can be even less frequent. For example, an approaching midground group of buildings, can be slowly zoomed without rendering, and only needs rerendering when the perspective changes by more than a certain amount and/or new surfaces become visible.

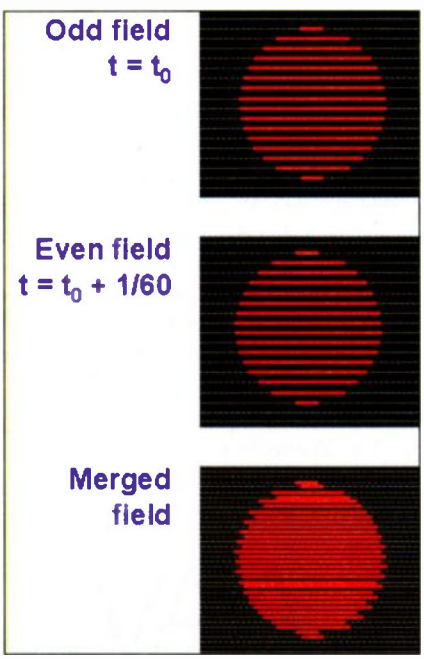
Because sprites, 3D layering, and affine warping are all well suited to being handled in hardware, these features will soon appear in the next generation of advanced 3D VGCs. The Talisman initiative from Microsoft represents a multimedia reference platform that incorporates other advanced architectural concepts. These include chunking to avoid frame-buffer memory and minimize bus bandwidth, as well as a range of other

Many users will use a large-screen TV as a PC display for cost reasons, more exciting gaming experiences or for presentation purposes.

multimedia functions such as DVD and video-conferencing.

The other main function of the 3D VGC is the bus-mastered handling of video I/O. During the last few years, video has become an increasingly important feature in the mainstream PC market. Desktop video-editing has been a niche application for years. On business platforms, the long-predicted "killer-application" is video-conferencing. In an intriguing example where games and video merge, a captured video of the game player is inserted into the game in which he or she becomes, quite literally, a leading character in the game.

The underlying problem behind most PC-based video capabilities relates to the differing environments of the PC and the television. For historic reasons, PAL/NTSC TVs use an interlaced scanning system at 50 or 60 half-fields/s with 480 or 512 lines/field. PC monitors typically operate in excess of 75 noninterlaced fields/s with 600 or more lines/field. When analog video is imported into the PC, a number of artifacts must be corrected. Similarly, a PC monitor outputting a PAL/NTSC signal runs into the same problem but in reverse.



3. Weaving two successive "odd" and "even" half fields helps maintain a picture's maximum detail when working with video data. But the slightest object movement can cause artifacts.

Video Deinterlacing

When importing DVD or video data, the simplest method to produce a full picture is to merge or weave two successive odd and even half fields. This technique maintains the picture's maximum detail provided there's no motion. But even the slightest object movement causes a disturbing feathering artifact *(Fig. 3)*.

The conventional line-doubling solution discards the even fields and repeats each line in the odd field. This way solves the feathering effect, but at the cost of lower vertical resolution. Interpolation helps, but the missing clarity is especially noticeable with (near) static pictures. The best approach, found on some VGCs, is to combine both solutions so that resolution is only lost when needed to correct for motion artifacts.

TV Output

Many users will use a large-screen TV as a PC display for cost reasons, more exciting gaming experiences, or for presentation purposes. Making video information that was specifically generated for the PC look good on a TV presents new challenges to both PC and application designers.

A three-line flicker filter is the VGC's most essential TV-out feature. To maintain the proper standards, we must correct for the 25 or 30 Hz flickering of (near) horizontal edges. Good horizontal and vertical upscaling (with interpolative filtering) of video data is mandatory. It's also important to correct for the TV's over-scanning, which may be suitable for a movie, but disastrous when the lost information is a menu item or scroll bar.

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can be equally important in making sure the right information is sent to the TV. For example, in a home-movie editing application, the TV output might only be a window on the PC monitor, while on a VCR it will appear as a full-screen image.

Critical performance Issues

The consumer PC must be equipped for the next generation of 3D games, which will soon be rendering scenes at rates of 1 million triangles/s. The CPU and VGC need to offer a much better balanced system for handling the critical performance demands of the 3D pipeline. In the near term, VGCs offering features like scatter-gather bus mastering, texture compression and caching, 3D layering, and off-line warping off-load the CPU and dramatically enhance system performance.

Most designers agree that full-triangle setup belongs in the VGC, although there's some division of opinion on whether geometry and lighting processing belongs in the CPU or the VGC. Hardware accelerations for geometry and lighting aim to enhance the performance of today's CPU-bound systems. Designers need to trade off the silicon investment in the CPU against that in the multimedia/VGC subsystem on the basis of the relative importance of the various applications.

Advanced 3D VGCs for consumer-entertainment PCs must also handle high-quality video I/O. For video input and output, it's essential that the VGC correctly deals with the interlaced/progressive-scan conversion artifacts.

Stuart McKechnie is strategic marketing manager with Philips Semiconductors' multimedia PC product group. He holds a Ph. D. in Physics from Southampton University.

Klaus Lehner is a managing director of SP3D GmbH in Munich, Germany. SP3D is a joint venture with Philips Semiconductors. Lehner holds a degree in Physics from the University of Munich.

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Add PowerPC To CompactPCI For Real-Time Embedded Solutions

Single-Board Computer Combines PowerPC Microprocessor With Dual PCI Buses In A 6U CompactPCI Form Factor.

Richard Nass

CompactPCI, a high-performance industrial bus, is based on the standard PCI electrical specification, but has different mechanical characteristics. It's based on the rugged 3U and 6U Eurocard packaging. Applications that best suit CompactPCI include telecommunications, real-time machine control, and industrial automation.

The majority of the CompactPCI boards that are shipping today are built with Intel-based microprocessors, specifically the Pentium or PentiumPro. A new player to the field, Motorola Computer Group, Tempe, Ariz., is bringing a CompactPCI board to market with a PowerPC microprocessor. The company's MCPCI2600 single-board computer will employ the fastest available PowerPC microprocessor, somewhere in the 233- to 266-MHz range.

One of the features that differentiates traditional desktop PCI from CompactPCI is that it supports twice as many PCI slots (eight), and is better configured for industrial applications. For example, the cards are loaded and removed from the front of a card cage. Vertical mounting allows for better cooling.

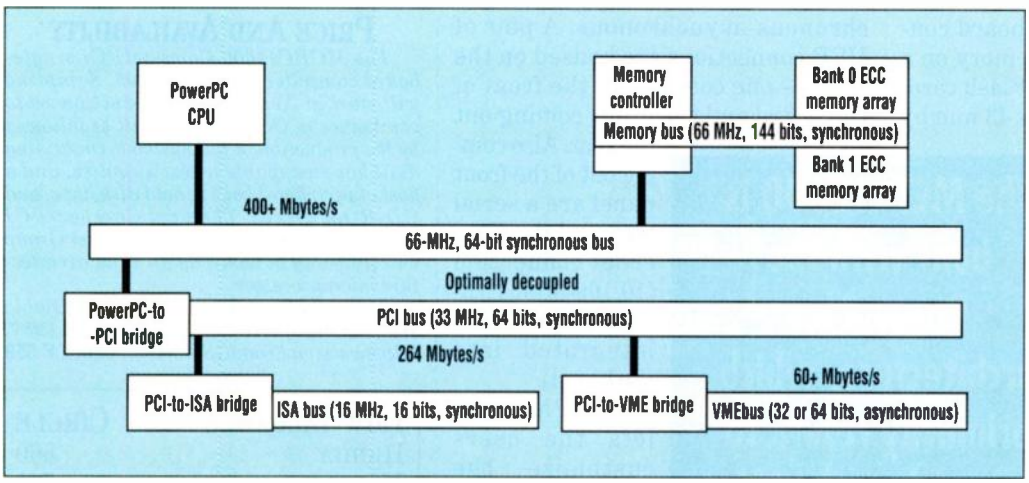
CompactPCI, by definition, is a processor-independent architecture. But because the volume of desktop Pentium-based PCI is so large, most of the ICs needed to bring a Pentium-based product are readily available to designers. The huge volume also lets the industrial-board manufacturers enjoy the margins on the ICs that typify the desktop market. Hence, most of the CompactPCI boards are built with Pentium microprocessors.

Motorola traditionally employs a processor-independent architecture on its high-end, PowerPC-based single-board computers. As a result, the company has already completed the design of a PowerPC-to-PCI bridge chip. This same part is employed on the MCPCI2600 CompactPCI board. While the company's latest generation of high-end single-board computers contain the processor on a module (making it easy for users to upgrade the processor), the PowerPC CPU (in a ball-grid array package) on the MCPCI2600 is soldered directly onto the board.

In a typical application, the PowerPC microprocessor requires a heat sink for proper operation. That fact, coupled with the tight spacing between boards, virtually eliminates the possibility of putting the processor on a plug-in module. The only other way to get around that space problem is to employ a dual-slot architecture, and the Motorola designers elected to not go that route.

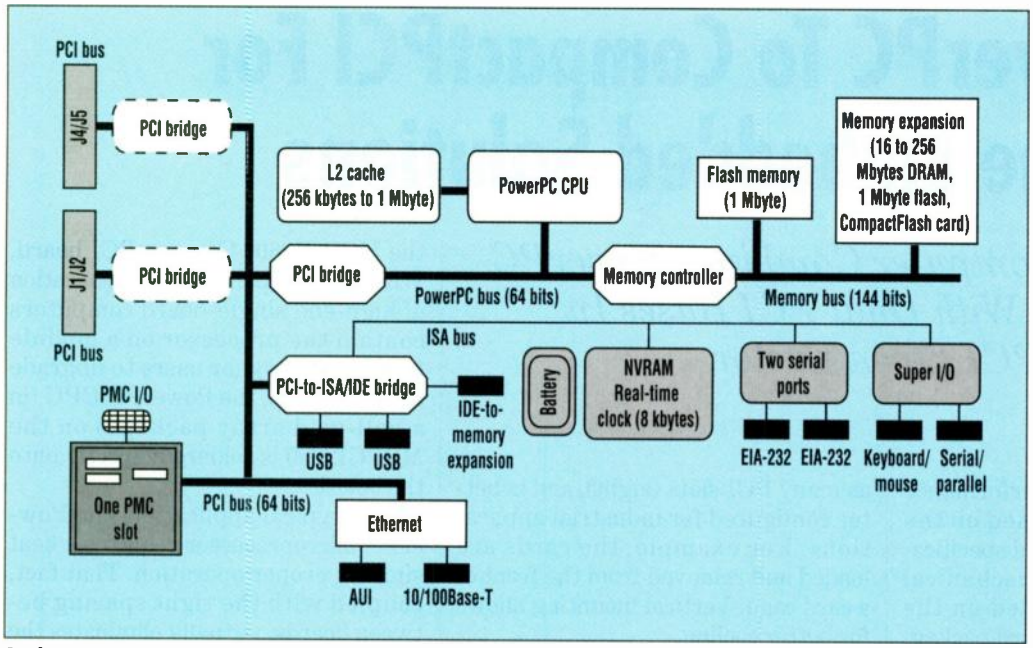
PowerPlus Architecture

The MCPCI2600 is built with the company's PowerPlus architecture. That primarily refers to two on-board ASICs, a memory controller, and the PowerPC-to-PCI bridge. According to Greg Novak, Product Marketing in Motorola's Embedded Technologies Group, "This is the fastest PowerPC bridge on the market. We developed the parts internally, spending about ten man-years between the two ASICs."



1. The PowerPlus architecture is employed on the MCPCI2600 board to eliminate data bottlenecks and improve data throughput. The architecture consists of a PCI-to-PowerPC bridge and a memory controller.

The memory controller links the processor with main memory, which is organized as two 72-bit blocks *(Fig. 1)*. This architecture results in a processor-to-memory bandwidth in excess of 400 Mbytes/s. The bridge chip helps eliminate bottlenecks between the PowerPC CPU and the PCI bus. During write operations, a FIFO buffer stores the data to be transferred and immediately acknowledges the transaction. The



2. The MCPCI2600 is a CompactPCI single-board computer that's built with a PowerPC microprocessor. Another differentiating feature is that it's built with dual PCI buses to increase the amount of I/O.

processor bus doesn't have to wait for the PCI-bus arbitration and transfer to occur, so it's free for other operations. The memory controller manages the completion of the task, further freeing the host for other operations.

One of the unique features of the MCPCI2600board is its dual 64-bit PCI bridges. These bridges increase the number of peripherals the board can connect to, thereby increasing the amount of user I/O options and ultimately, the board's flexibility *(Fig. 2)*.

The board contains 1 Mbyte of socketed flash memory and from 16 to 256 Mbytes of ECC-protected DRAM. In addition, the board contains IDE-based flash memory on a standard 50-pin CompactFlash card. The card, which measures 43 mm by 36 mm by 3.3 mm, is removable. It lets users update firmware and run a real-time operating system with a very small footprint. For example, with the Lynx operating system, the entire platform could boot from the IDE flash memory on the CompactFlash card.

Says Novak, "Our customers like the removability factor of the CompactFlash card. If it's popular, we may use it on our upcoming VMEbus boards." The memory also could be used to store diagnostic utilities. In this configuration, users can update their diagnostics easily, then run them on the board without using any extra cables or an external disk drive.

The board also contains a standard ISA/IDE bridge. The ISA bus is for the real-time clock, non-volatile RAM, and serial ports. Two of the board's four serial ports are asynchronous only, while the remaining pair are synchronous-asynchronous. A pair of USB connections are housed on the board—one coming out the front of the board and the other coming out the rear. Also coming out of the front panel are a serial port and the Ethernet connection (10/100-Mbit Ethernet capability is integrated into the board).

The MCPCI2600 is built with the PowerPlus architecture, which primarily refers to two on-board ASICs.

One PMC slot lets the users customize the MCPCI2600 board for their specific products. The PMC is a module that's popular on VMEbus products, and it brings a specific functionality to the board. In addition, a CompactPCI-to-IndustryPack carrier board is available from a third-party vendor. Other features of the board include four 32-bit timers; a real-time clock and watch-dog timer; and floppy, parallel, keyboard, and mouse ports.

The MCPCI2600 runs the Windows NT operating system. It also can handle a host of real-time operating systems from such vendors as Chorus, ISI, Lynx, Microware, and Wind River Systems.

One potential feature of CompactPCI that could open the door to myriad applications is hot-swap—the ability to plug and unplug boards without having to power down the system. That's an area that the Motorola designers are hard at work on and have pledged to bring to market as soon as the technology is available. Other coming features include bridging (employing more than eight slots); a VME64 extension, which will allow for a standardized hybrid CompactPCI-VME64 system; and the use of computer-telephony buses on CompactPCI, such as MVIP and SCSA.

PRICE AND AVAILABILITY

The MCPCI2600 CompactPCI single-board computer starts at $3995. Sampling will start in August, with production set to commence in October. That will be followed by the production of full systems, containing dual hot-swappable power supplies, and a host of peripheral bays to hold disk, tape, and CD-ROM drives. The next CompactPCI products from the Motorola Computer Group will probably be based on an Intel architecture microprocessor.

Motorola Computer Group, 2900 Diablo Way, Tempe, AZ 85282; (602) 438-4237; http://www.mot.com/GSS/MCG. **CIRCLE 559**

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WHAT'S ON BOARD

By combining a fast-Ethernet controller and a 40-Mbyte/s SCSI controller on one PCI-compatible chip, designers at Symbios Logic, Colorado Springs, Colo., can reduce PCI loading to the host system. The SYM53C885 provides both communications and storage control while presenting a one PCI load to the host system, thereby freeing up a valuable PCI load for another function. Taking aim at the workstation, server, and NT desktop systems, the controller supplies a 16-bit single-ended Ultra SCSI port for synchronous data transfers up to 40 Mbytes/s. Also integrated as part of the SCSI controller are 4 kbytes of RAM for SCSI scripts storage, a 536-byte DMA FIFO buffer that allows bursts of 128 double-words across the PCI bus, and support for extended PCI access cycles. The Fast Ethernet portion of the chip supports full-duplex operation for both 10- and 100-Mbit/s data transfers. Separate 3-kbyte transmit and receive FIFO buffers enhance the performance of the full duplex operation and, in conjunction with a DMA controller, help reduce the PCI bus overhead. The port also includes an early-transmit/early-receive feature that helps improve throughput. The chip features a TP-PMD (symbol) interface to provide a low-cost 100Base-TX solution, and an MII interface for 10Base-T and 100Base-T support with just one RJ-45 connector. Housed in a 160-lead PQFP, the dual-function controller sells for $49.90 in lots of 10,000 units. Samples are immediately available. Contact Symbios at (719) 596-5795; Internet: http://www.symbios.com.

Trimming power consumption to a bare minimum, the HM62W8512A is a 4-Mbit static RAM developed by Hitachi America Ltd., Semiconductor and IC Div., Brisbane, Calif. The part consumes just 35 mW/MHz when active and 30 µA in its standby mode when powered by a 3.3-V supply. In its 3-V data retention mode, the memory current drain drops to 15 µA. Organized as 512 kwords by 8 bits, the memory can access its contents in 70 or 85 ns (depending on the speed grade selected), and provides a good speed-power balance for devices such as smart phones, GPS systems, personal data devices, and other portable systems. The chips have LVTTL-compatible I/O lines and are fully static, thus keeping the system design very simple. Package options include SOP, TSOP, and reverse TSOP with JEDEC-standard pinouts to ensure device interchangeability. A wide-temperature-range version that operates from -40 to +85 °C is under development. In 1000-unit lots, the 70-ns version sells for $18 apiece when housed in a 32-lead, 400-mil TSOP. Samples are immediately available. Contact Brett Etter at (800) 285-1601; Internet: http://www.hitachi.com.

A high-speed multiport switch that provides PCI-to-PCI-bus connectivity turns a one primary PCI port into two PCI secondary ports, each of which can handle multiple PCI loads. The HX121 and HX122 PCI-to-PCI switch chips developed by HiNT Corp., Fremont, Calif., can replace the equivalent of up to three PCI-to-PCI bridge chips and allow concurrent operations among all three PCI buses (the primary and the two secondary buses). The HX121 can drive up to four bus masters on each of the its two secondary PCI ports, with all ports operating at 33 MHz. To ensure proper timing on those ports, the chip provides four phase-locked output clocks. The HX121 also supports PCI I/O transaction forwarding and external arbitration, PCI memory transaction forwarding, PCI type 1 to type 0, and type 1 configuration command conversion, and many other PCI operations. Able to drive more PCI loads, the HX122 operates its primary port at 66 MHz and its secondary ports at 33 MHz, while driving up to eight bus masters on each secondary bus. Initial versions of the chip will operate the secondary buses at 25 MHz. The chip also has twice the number of phase-locked output clocks and like the other chip, includes an output-enable pin that can control an external buffer to provide side-band status monitoring. Housed in a 208-lead PQFP and a 256-lead BGA respectively, the HX121 and HX122 also support posted-write buffers on all ports, live insertion, and enhanced 32-bit I/O and memory address decoding. Prices for the chips are expected to be in the $25 to $40 range in 1000-unit quantities. Samples are immediately available. Contact the company at (510) 623-0932; Internet: http://www.hintcorp.com.

Development Kit Simplifies I_2O-based Board Design

Designers looking to integrate I_2O technology can take advantage of a development kit offered by Symbios Logic. The kit contains all the components needed to build a PCI/SCSI I_2O-ready motherboard. Based on the company's SYMplicity software architecture, the kit employs an Intel I960 I/O processor.

The integration kit supplies I_2O-ready UltraSCSI host connections. The kit can be customized for users that require an Ultra2 SCSI connection. For RAID applications, designers can port existing i960-based RAID software or implement shell- or core-level implementations of I_2O architecture RAID software.

The kit includes a PCI-based SCSI host adapter with a cable, a user's guide, software, and installation documentation. The single-ended version (I_2O-SYM8751SP) costs $231, while the differential model (I_2O-SYM8751D) sells for $380.

Symbios Logic Inc., *2001 Danfield Court, Fort Collins, CO 80525; http://www.symbios.com.*

CIRCLE 516

Graphics Board Accelerates Displays To Extreme Resolutions

The TwinTurbo 128P8 can drive the higher resolutions needed by CAD, imaging, and graphics designers. The board supports large-screen monitors from Panasonic, Sony, and Viewsonic, among others. The TwinTurbo 128P8S is built with a 128-bit graphics engine, 8 Mbytes of fast dual-ported VRAM, and a 240-MHz digital-to-analog converter. High resolution modes reduce the need to scroll because the user can view larger images in their entirety on-screen. At 1920- by 1200-pixel resolutions, two full-size 8-1/2- by 11-in. pages can be displayed side-by-side. Also supported are 16:9 video formats up to 1920 by 1080 pixels in True Color mode, providing high-definition video on a wide screen. Available now, the TwinTurbo 128P8 sells for $599.

Integrated Micro Solutions, *2085 Hamilton Avenue, Third Floor, San Jose, Calif., 95125; (408) 369-8282.*

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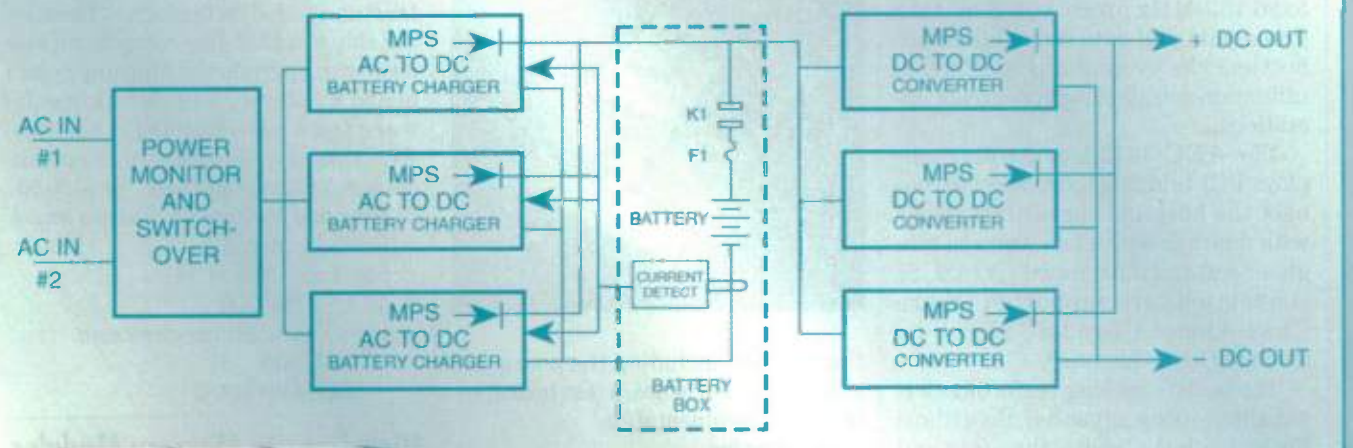

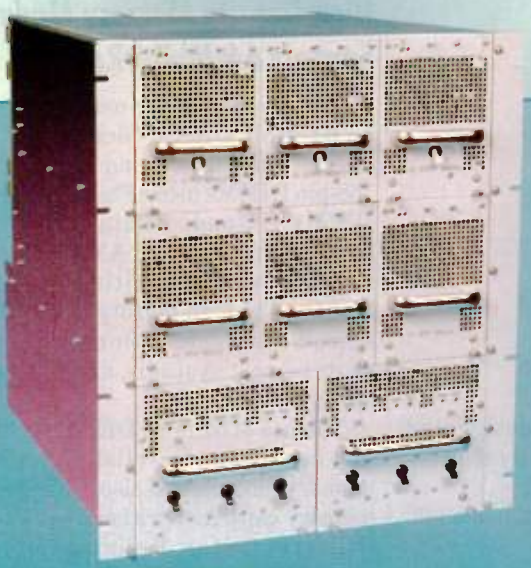

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PRODUCT FEATURES

Data sheets on products like these can be found at www.penton.com/ed/

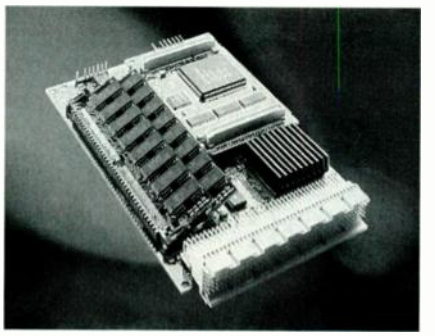
External RAID Controller Supports 40-Mbyte/s Wide UltraSCSI Per Channel

The AEC-4312A intelligent external array controller has set its sights on the Windows NT and Unix markets. The three-channel SCSI-to-SCSI devices incorporate multichannel SCSI technology to deliver an UltraWide SCSI performance level of 40 Mbytes/s on each channel. At the heart of the board lies an AMD 5x86 133-MHz processor. Separate processors and data buses eliminate bottlenecks by minimizing PCI bus utilization and allowing concurrent operations.

The AEC-4312A controller employs PCI bridging technology to connect the host and server interfaces with multiple back-end channels. Single-ended and differential UltraSCSI connections are supported (Fibre Channel and Ultra2 SCSI will be available later this year).

The board's caching performance is enhanced using advanced algorithms for write-back, write-through, and read-ahead cache. Two independent XOR memory controllers permit separate parity and data caching. Up to 32 Mbytes of cache memory is available. The board can operate with up to 270 Gbytes of storage, and supports RAID levels 0, 1, and 5. By combining multiple controllers, capacities beyond 1 Tbyte are possible.

The 3.5-in. form factor lets designers embed the board inside a standard disk enclosure. As a design kit, the AEC-4312A contains everything an OEM needs to evaluate and integrate



the product, including the board and appropriate software, a test board, cables, and documentation.

Adaptec Inc.
691 South Milpitas Blvd.
Milpitas, CA 95035
(408) 945-8600
http://www.adaptec.com
CIRCLE 504
RICHARD NASS

PCI-Based Audio Accelerator Handles Positional 3D Sound

Delivering CD-quality sound for interactive 3D games, the Monster Sound PCI-based audio accelerator supports Microsoft's DirectX APIs under Windows 95. The board can handle multistream audio—up to 24 streams—allowing for 3D positional audio. It also features a signal-to-noise ratio under 80 dB and a quad-speaker output. The board helps reduce the drain placed on the host processor. This leaves enough bandwidth to handle video and communications (in the case of the multiplayer game).

The DirectX technology consists of software algorithms to accelerate 3D graphics and sound. The APIs are able to run using the host CPU, but the quality and speed of the designated tasks are raised significantly if an accelerator is employed.

Three-dimensional positional audio blends well with 3D graphics. For example, as objects come and go onscreen, the audio follows the sound, such as with an airplane flying overhead. This enhances the game-playing experience. While extended stereo enhancement provides a wider stereo field, it presents sound in a half circle on a horizontal plane. This gives the listener the perception of sound coming from farther positions to the left and right. But this technique doesn't allow for sounds to be positioned above, below, or behind the ears.

True 3D positional sound produces imaging that appears to come from behind, above, below, and the sides, and can be heard with either headphones or speakers. The 3D algorithms consume an abundance of processing horsepower. As a result, an audio accelerator like the Monster Sound is required. It's also a reason to employ a PCI-based accelerator, where data can be passed at 132 Mbytes/s.

The heart of the Monster Sound board is the Freedom 5600 multimedia audio processor, which integrates DSP and codec technologies. Because the chip is a DSP-like component, end users can upgrade the Monster Sound board by simply downloading software from a BBS or Internet site. Available now, the Monster Sound audio accelerator board sells for $199.95.

Diamond Multimedia Systems Inc.
2880 Junction Ave.
San Jose, CA 95134
(408) 325-7000
http://www.diamondmm.com.
CIRCLE 505
RICHARD NASS

High-Density Memory Modules Support 64-Mbit DRAMs

A new line of memory modules, based on 64-Mbit DRAM technology, includes 72-pin SIMMs and 72-, 144-, and 168-pin DIMMs using Fast Page Mode (FPM), Extended Data Out (EDO) and Synchronous DRAM (SDRAM) memory, with capacities up to 256 Mbytes. The high-density modules are suited for workstations, servers, routers, test systems, and high-end desktop systems.

The use of 64-Mbit DRAM technology increases the reliability of the memory module, and also can increase memory capacities without increasing the form factor. Reliability is increased because using fewer components to achieve the same memory capacity reduces the possibility of malfunction while lowering power consumption. Circuitry integrated into the 3.3-V modules provide a smooth transition from systems using 5-V parts.

Simple Technology Inc., 3001 Daimler St., Santa Ana, CA 92705; (800) 367-7330 or (714) 476-1180; http://www.simpletech.com.
CIRCLE 506

Data sheets on products like these can be found at www.penton.com/ed/

200-MHz Pentium-Based VME CPU Fits In One Slot

Users who require a single-slot PC-compatible CPU board for a VMEbus system can take advantage of the Pentium-based VS SBC/Pxx. The board combines a host of interfaces with access to the PCI bus to maximize flexibility. The PCI connections allow for expansion using PMC modules. The board supports Pentium processors running at 133, 166, or 200 MHz, as well as 512 kbytes of 64-bit wide secondary cache with synchronous burst SRAMs. Up to 64 Mbytes of 64-bit wide EDO DRAM can be installed using standard SIMMs. Up to 1 Mbyte of flash EPROM is supported, in addition to the 512 kbytes of flash memory used for the BIOS. Operating systems such as VxWorks and WindowsNT are supported.

A SCSI, SCSI 2, or Ultra SCSI interface is provided using a Symbios Logic 33-MHz 53C860 SCSI processor. The interface supports single-ended asynchronous or synchronous transfers with active termination and signal negation. The interface is accessed through the P2 DIN connector. The Ethernet interface (IEEE 802.3 10Base-5) is implemented using an AMD 79C970A device. A front-panel graphics interface, provides resolutions of up to 1600 by 1200 pixels using a 2-Mbyte EDO frame buffer. Two RS-232C serial channels also are provided. Other peripheral interfaces include a PC-AT compatible keyboard interface, a floppy-disk interface, and a parallel port.

The VS SBC/Pxx's functionality can be further expanded by adding a PMC carrier board. This carrier board, taking a second slot, allows the addition of two standard PMC modules.

Concurrent Technologies Inc., *10921 Reed Hartman Hwy., Cincinnati, OH 45242; (513) 791-0073; Internet: http://www.sales.gocct.com.*

CIRCLE 507

PC Graphics Accelerator Priced Under $100

High-performance 3D graphics can now be had for under $100, thanks to the Ultimate 3D accelerator board. The PCI-based board takes advantage of the Rambus DRAM technology and is optimized for the Microsoft Direct3D APIs. Rambus memory offers a bandwidth of up to 600 Mbytes/s. PCI bus support enables the dynamic use of main memory for 3D graphics structures like textures, z-buffering, and alpha blending. The Ultimate 3D comes in four configurations: Model 642, which uses 2 Mbytes of memory; Model 644, with 4 Mbytes; Model 646, with 6 Mbytes; and Model 648 with 8 Mbytes. In addition, Models 642 and 644 can be upgraded with another 2 or 4 Mbytes of graphics memory. The Ultimate 3D graphics accelerator card is available immediately. The 2-Mbyte version (Model 642) costs 99.95, the 4-Mbyte model (Model 644) sells for $129.95, the 6-Mbyte unit (Model 646) is priced at $179.95, and the 8-Mbyte board (Model 648) $199.95.

TechWorks Inc., *4030 West Braker Lane, Austin, TX 78759; (800) 688-7466 or (512) 794-8533; Internet: http://www.techworks.com.*

CIRCLE 508

Host-Controller Kit Speeds Product To Market

The USB Host Controller Development Kit (HDK) can help peripheral manufacturers get their USB-based products to market quickly, particularly for legacy PCI platforms. Using the kit, USB peripherals would plug directly into the PCI bus. The kit consists of the Open-HCI-compliant CSA-6700 PCI-to-USB controller board, beta versions of the company's Windows 95 and DOS host-controller drivers, and API specifications for device-driver development. As a result, there's no need to wait for USB support to appear in the operating system.

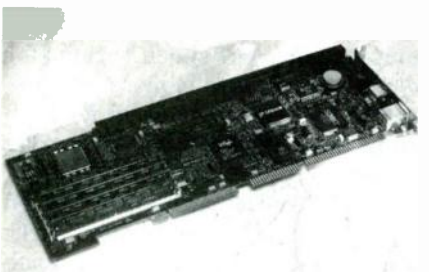
The CSA-6700 card, which is based on a PCI-to-USB controller ASIC, contains dual USB connectors. Available immediately, the USB Host Controller Development Kit sells for $199.

CMD Technology Inc., *1 Vanderbilt, Irvine, CA 92618; (714) 454-0800; http://www.cmd.com.* **CIRCLE 509**

Data sheets on products like these can be found at www.penton.com/ed/

Industrial Single-Board Computer Packs A Wallop

Hailed by the company as the most highly integrated PICMG-compatible industrial single-board computer to date, the PCI-936 features a 200-MHz Pentium microprocessor, integrated IDE, OCI and fast SCSI-2 interfaces, a 100Base-T Ethernet port, video, and a host of standard I/Os, including Universal Serial Bus (USB). The board's

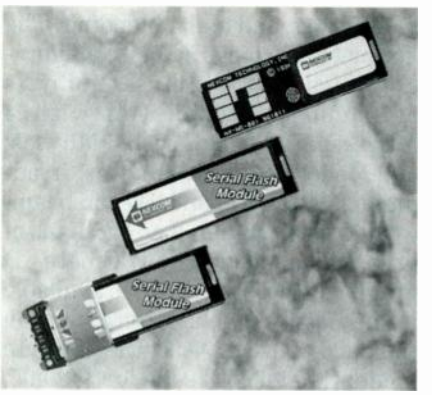


Triton II chip set is fully compliant with the PCI 2.1 specification and supports a transfer rate of 112 Mbytes/s. The chip's 65550 64-bit graphics accelerator drives up to 2 Mbytes of video memory top handle 1280-by-1024-pixel resolutions. The board's thermal-management circuitry senses the CPU's temperature. When it gets too hot, a subroutine kicks in to slow the CPU clock until the temperature returns to an acceptable level. A PCI-936 board equipped with a 100-MHz processor and 1 Mbyte of video memory sells for $1691. Large-quantity discounts are available.

Teknor Industrial Computers Inc., 616 Cure-Boivin, Boisbriand (Quebec), Canada J7G 2A7; (800) 354-4223 or (514) 437-5682; Internet: http://www. teknor.com. **CIRCLE 510**

Tiny Flash Module Holds Up To 4 Mbytes

Applications that have limited space requirements are targets for the NexFlash serial flash memory. These applications include cellular telephones, PDAs, digital cameras, and portable industrial and test equipment. The 15- by 45-mm memory modules connect to the system using simple electrical contacts, similar to those used in smart cards. Access to the modules is through the Serial Peripheral Interface (SPI-bus). Capacities range from 128 kbytes to 4 Mbytes. The modules can be read from and written to at supply voltages of 3.3 or 5 V, drawing just 5 mA in active mode and 1 µA in standby mode. Writes occur at a rate of 200 kbytes/s. Other features of the module include on-chip SRAM, elec-



tronic ID, flexible write protection, and insertion and removal detection. A 1-Mbyte module (NX-SFM-1MB) sells for $13.50 each in lots of 10,000. A development kit (NX-SFK-1) is available that contains a circuit board that plugs into a PC's parallel port, as well as software utilities for reading from and writing to the device, and C-code examples of all interface commands. The development kit costs $95.

Nexcom Technology Inc., 532 Mercury Dr., Sunnyvale, CA 94086; (408) 730-3690. **CIRCLE 511**

CompactPCI Board Supports I_2O Standard

The industrial market has seen much activity in the area of CompactPCI, with a host of board introductions over the past few months. The latest editions, the CPCI-940, CPCI-941, and CPCI-942, add a new wrinkle—support for the I_2O standard. I_2O provides an I/O device driver architecture that's independent of both the specific device being controlled and the host operating system. This is achieved by logically separating the portion of the driver responsible for managing the device from the specific implementation details for the operating system.

The three boards help improve overall system throughput by offloading tasks from the host processor. The main difference between the three boards is in the resident processor. The 940 is built with an i960RP; the 941 employs an i960RD66; and the 942 contains an i960HD66. All three include two PMC sites, a software development environment, and support for standard real-time operating systems as well as Windows NT.

The boards support I_2O for interprocessor communications by implementing the message queues required by the specification for communications and drivers between an I/O processor and the host. Available now, prices for the boards start at $590 each in lots of 1000.

Cyclone Microsystems Inc., 25 Science Park, New Haven, CT 06511; (203) 786-5536; Internet: http://www.cyclone.com. **CIRCLE 512**

SCSI Expansion Box Connects To 105 Devices

Not only can the SCSI Expander interface with Wide SCSI devices, it can connect to up to 105 of them using just one port on the host. The increased storage capacity that's gained comes without any performance degradation, and no controllers need to be added or software to be reconfigured. High-end storage applications that can take advantage of the SCSI Expander include digital video, prepress, imaging, database servers, CD-ROM libraries, and disk drives. The stand-alone unit offers a transfer rate of 20 Mbytes/s. Because it conforms to industry standards, any SCSI-based PC or workstation can be employed as the host.

The SCSI Expander is able to overcome the conventional seven-device limitation using its ability to translate SCSI bus IDs into SCSI Logical Unit Numbers (LUNs). The LUNs are used as a means of subaddressing a group of devices under a single SCSI bus ID. This allows for the support of seven standard devices at each ID. Other features include backward compatibility with earlier versions of SCSI; operating-system independence, disconnect and reconnect support; flash ROM for field upgrades; staggered device spin-up; removable active termination; and support for multiple block sizes. Available in various configurations, prices start at $495.

ATTO Technology Inc., Audubon Technology Park, 40 Hazelwood Dr., Bldg. 106, Amherst, NY 14228; (716) 691-1999; http://www.attotech.com. **CIRCLE 513**

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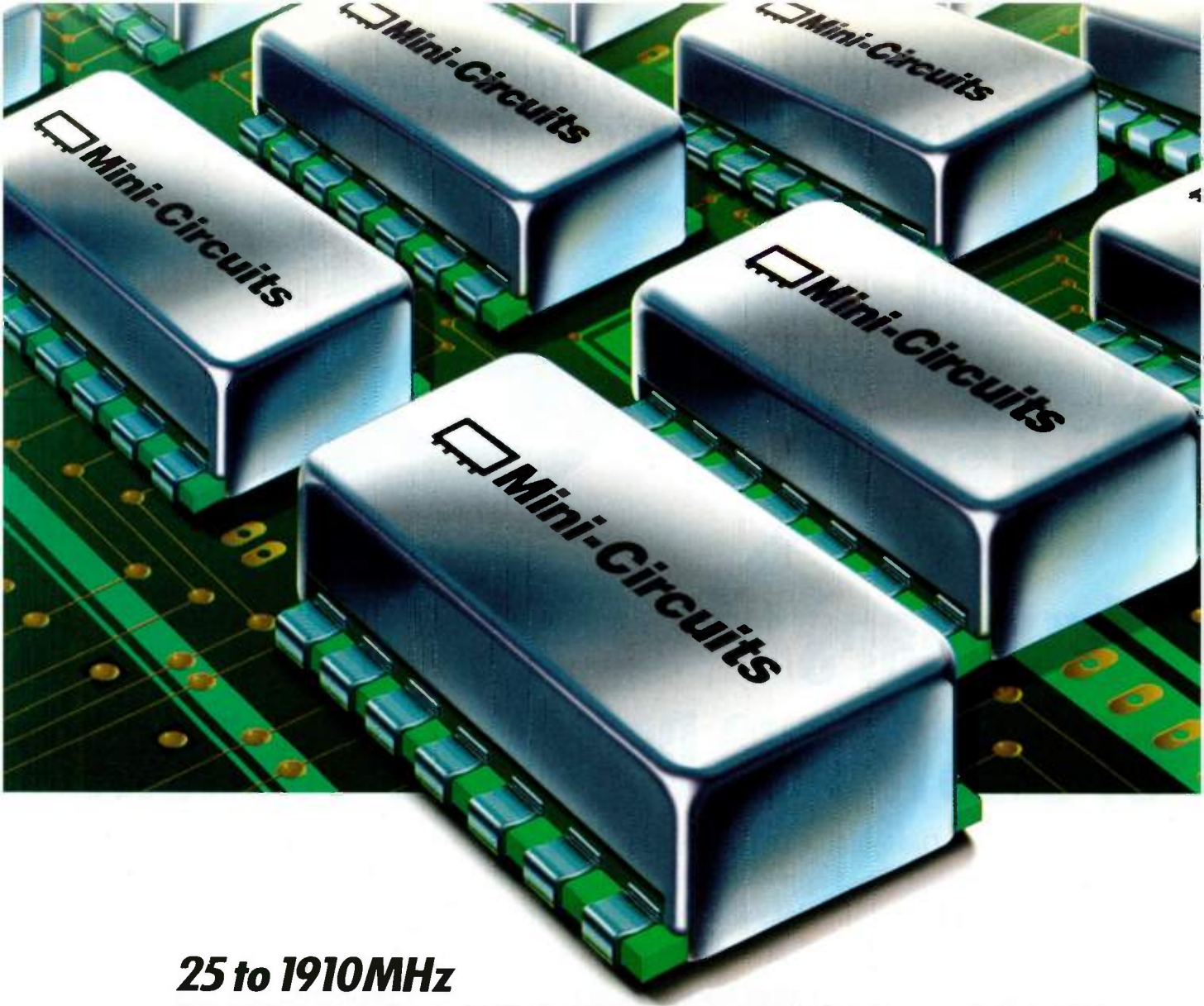

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Circle 520

Varactor Diode Stabilizes Temperature For FM Quadrature Demodulator

MICHAEL G. ELLIS
Electronic System Products, ANTEC Technology Center,4920 Avalon Ridge Pkwy., Suite 600, Norcross, GA 30092; (770) 734-0100.

quency of the tank circuit can be held more closely to 10.7 MHz at the temperature extremes, providing the results shown in Figure 2. Many other variations of this technique exist, including the use of an op-amp integrator in the feedback loop to hold the resonant frequency to exactly 10.7 MHz over any specified temperature range. Although the MC13156 IC was used in this example, the same approach can be taken with other discrete or integrated quadrature detectors.

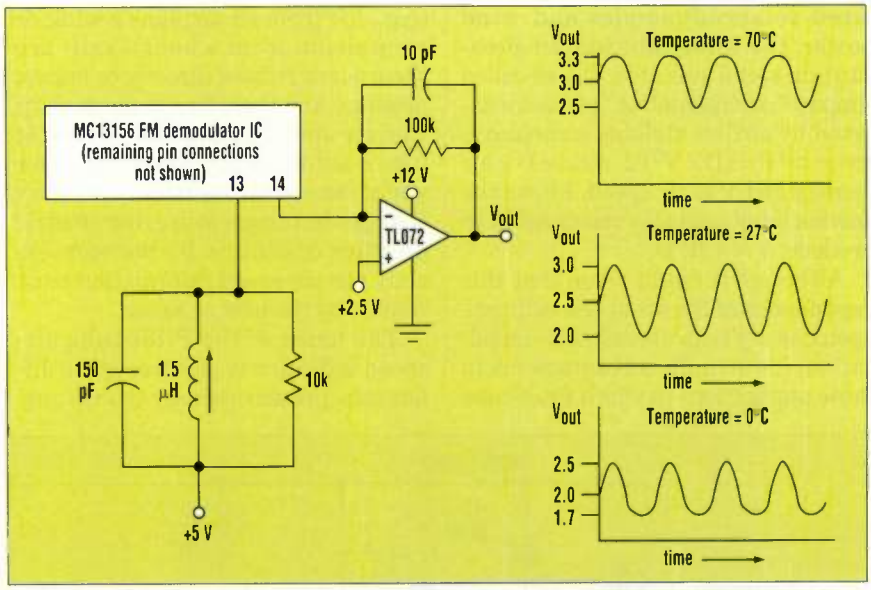
A quadrature detector is used to demodulate frequency shift keying (FSK) and other types of FM signals. The MC13156 shown is an FM subsystem integrated circuit that downconverts the RF to a 10.7-MHz intermediate frequency (IF), amplification, and limiting prior to the quadrature detector *(Fig. 1)*.

The quadrature circuit inside the MC13156 relies upon the external tank circuit connected to pin 13. The tank consists of the 150-pF capacitor and the 1.5-µH inductor. It must be reliably tuned to 10.7 MHz and must not drift from that center frequency over the full specified temperature range. The TL072 op amp in Figure 1 is part of an external data slicer with a current source output provided at pin 14 of the MC13156 for the demodulated data.

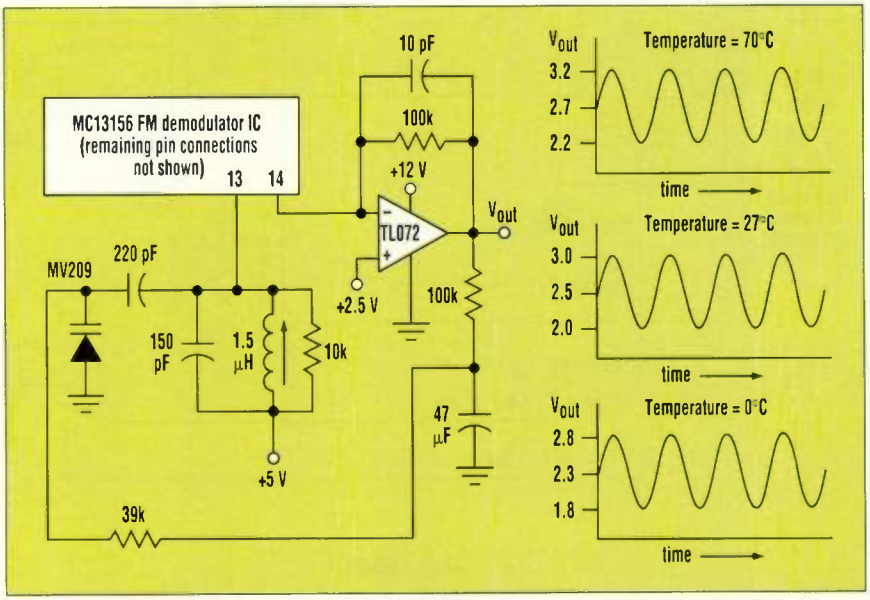
However, depending on the temperature tolerance of the inductor and the capacitor in the tank circuit, the deviation of the input FM signal, and the Q of the tank circuit, the demodulated waveform will vary over temperature. Figure 1 shows the distortion that can occur at the temperature extremes. A common method for reducing the temperature effects is to decrease the Q of the tank. However, this also reduces the gain of quadrature detector.

It's possible to take advantage of the shift in the dc output level over temperature in the output waveform *(Fig. 1, again)*. The shift in the average dc level is caused by the change in the resonant frequency of the tank circuit as the ambient temperature changes. By filtering out the ac voltage at the output of the TL072, the dc level can be fed back to a varactor diode that's been added in parallel with the 150-pF capacitor *(Fig. 2)*.

In this manner, the resonant fre-



1. This typical quadrature detector arrangement has no provision for temperature compensation. Consequently, the demodulated waveform will vary over temperature, resulting in signal distortion at both the upper and lower temperature extremes.



2. When operating with additional temperature compensation circuitry, the resonant frequency of the quadrature detector's tank circuit can be held more closely to 10.7 MHz at the upper and lower temperature extremes, significantly reducing distortion in the output waveforms shown.

Circle 521

Linear Pitot-Tube Air-Speed Indicator

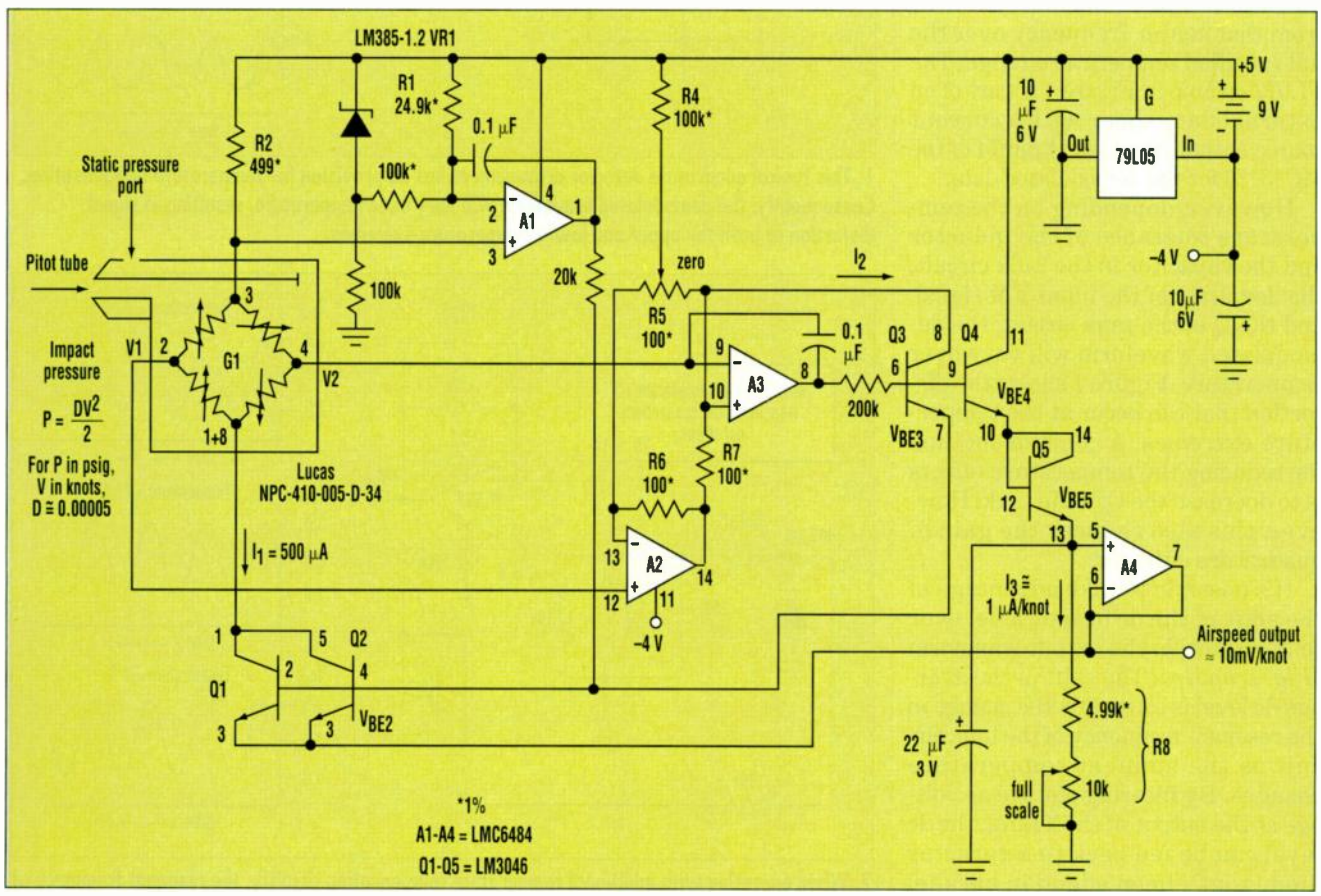
W. STEPHEN WOODWARD
Venable Hall, CB3290, University of North Carolina, Chapel Hill, NC 27599-3290; Internet: woodward@net.chem.unc.edu.

Among the many methods used for measuring air speed, one approach excels in applications related to aerodynamics and wind power: the Pitot-tube impact-pressure air-speed indicator. The so-called "impact" or "stagnation" pressure exerted by airflow striking a surface is given by $P = (D \times V^2)/2$, where D = air density and V is air speed. Pitot tube anemometry uses this relationship to produce: $V = \sqrt{2P/D}$.

Although it might seem that this dependence of the air-speed estimate upon density is an undesirable complication, it's actually advantageous in those applications to which Pitot-tube anemometers are uniquely suited. This is true because, in these applications, the forces of primary interest (e.g., lift from an airplane's wing or propulsion from a boat's sail) are themselves related directly to impact pressure and therefore to air density. The air speed measured by a Pitot tube is automatically compensated for variations in air density caused by changes in temperature, barometric pressure, or altitude. It's therefore exactly the air-speed information most wanted by the pilot or sailor.

The heart of the Pitot tube air-speed indicator is piezoresistive differential pressure sensor G1. Op amp A1, in combination with VR1 and R1, R2, and R3 controls Q1 and Q2 to generate constant-current-bridge bias I1 = 500 µA. In response, G1 produces a differential voltage ($V_1 - V_2$) equal, after zero compensation via R4, R5, R6, and R7 to approximately 8 mV/psig of impact pressure. The A2, A3 differential pair controls Q3 so as to convert ($V_1 - V_2$) to impact-pressure-proportional current $I2 \approx 160$ µA/psig.

Calculating $\sqrt{I_2}$ works as follows: Due to the logarithmic behavior of silicon transistors, base-emitter voltages $V_{be2} = A\log(I_1/2) + B$, and $V_{be3} = A\log(I_2) + B$, where A and B are constants common to all five transistors in the LM3046 array. Because addition of logs is equivalent to multiplication, $(V_{be2} + V_{be3}) = (A\log(I_1 \times I_2/2) + 2B)$. Series/parallel connection makes $(V_{be2} + V_{be3}) = (V_{be4} + V_{be5})$ and, because of the implicit matching between transistors in a monolithic array, $V_{be4} = V_{be5}$. Therefore, $V_{be4} = V_{be5} = (A\log(I_1 I_2/2)/2 + B)$. Division of logs is equivalent to inverse exponentiation. Hence, $V_{be5} = \log(\sqrt{I_1 \times I_2/2}) + B$.



Lying at the heart of the Pitot-tube impact-pressure air-speed indicator, which is ideal for measuring air speed in aerodynamics and wind-power applications, is a piezoresistive differential pressure sensor. The battery-powered unit can provide more than 100 hours of operation.

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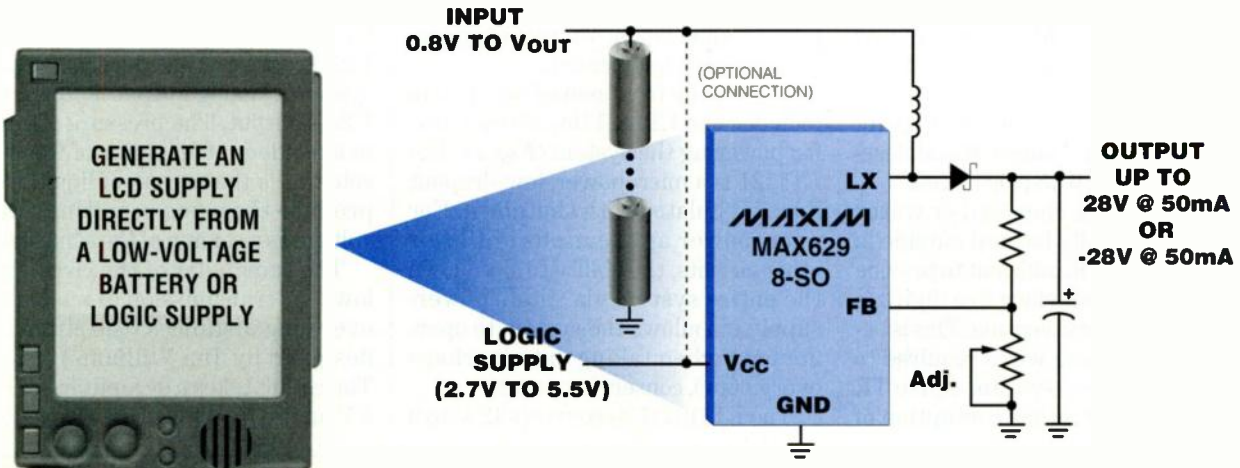

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This makes $\log(I_3) = \log(\sqrt{I_1 \times I_2/2})$. I1/2 = 250 µA, so substitution and exponentiation yields $I_3 = \sqrt{I_2 \times 250\mu A}$.

With the components and circuit values shown, $I_3 \approx 1$ µA/knot. With suitable adjustment of R8, a wide range of full-scale air speeds can be calibrated for. If R8 ≈ 10k, for example, V_{out} = 10 mV/knot for a 1-V full-scale output at 100 knots. This is just about right for duty as a primary air-speed indicator in an ultralight aircraft. Of course, suitable adjustment of R8 can accommodate different preferences in air-speed measurement units, such as meters per second or statute miles per hour.

Supply-voltage regulation for this circuit isn't critical and power demand is modest, easily allowing battery operation. The simple power supply shown will provide more than 100 hours of operation from a 9-V alkaline battery.

Circle 522

A Fluid Solution For Water-Tank Pressure Sensing

RICHARD MARKELL
Linear Technology Corp., 1630 McCarthy Blvd.,
Milpitas, CA 95035-7417; (408) 432-1900.

Liquid sensors require a media-compatible, solid-state pressure sensor. The pressure range of the sensor depends on the height of the column or tank of fluid that must be sensed. Described here is a way to sense water height in a tank or column using EG&G IC Sensors' Model 90 stainless-steel diaphragm, 0-15 psig sensor.

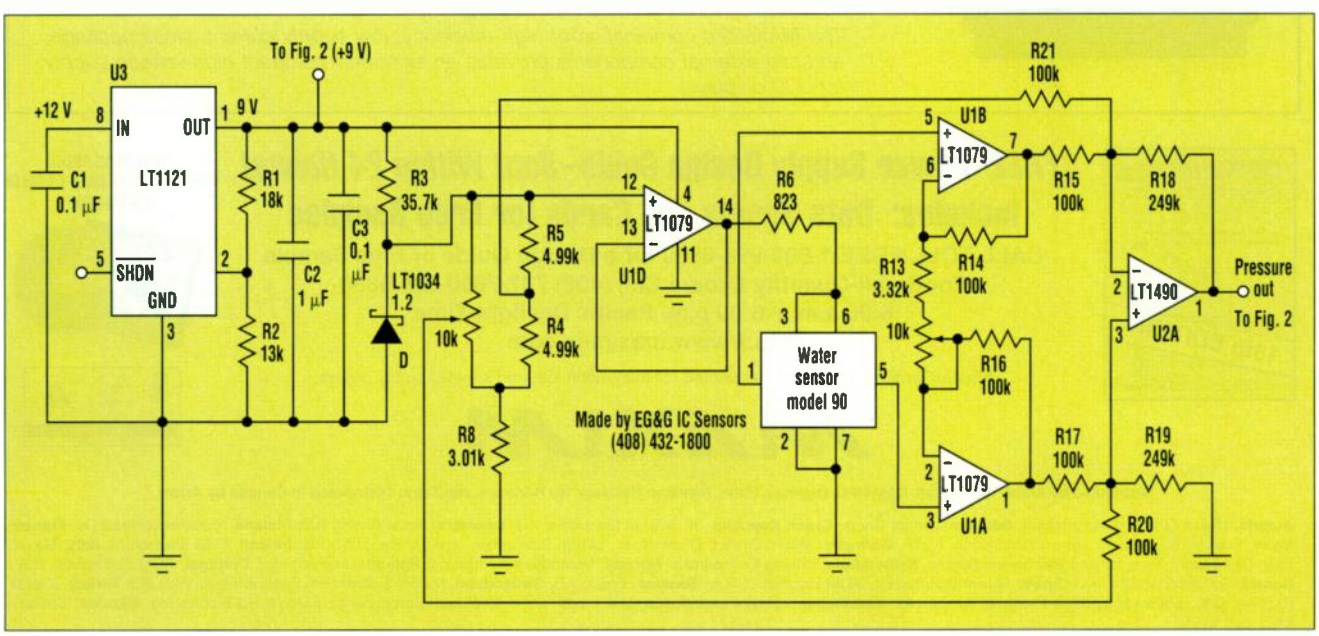
Because large chemical or water tanks are typically located outside in "tank farms", it's insufficient to provide only an analog interface to a digitization system for level sensing. This is because the very long wires required to interconnect the system cause IR drops, noise, and other corruption of the analog signal. The solution is a system that converts the analog-to-digital signals at the sensor. In this application, a "liquid height-to-frequency converter" was implemented.

The analog front end of the system includes the LT1121 linear regulator for powering the system *(Fig. 1)*. The LT1121 is a micropower, low-dropout linear regulator with shutdown. For micropower applications of this or other circuits, the ability to shut down the entire system via single power-supply pin allows the system to operate only when taking data (perhaps every hour), conserving power.

The LT1121 (U3) converts 12 V to 9 V to power the system. The 12 V may be obtained from a wall cube or batteries. The LT1034, a 1.2-V reference, is used with U1D, 1/4 of an LT1079 quad low-power op amp, to provide a 1.5-mA current source to the pressure sensor. The reference voltage also is divided down by R4, R5, R6, and the 10k potentiometer. It's used to offset the output amplifier (U2A) so that the signals don't swing around the supply rails.

Op amps U1A and U1B (each 1/4 of an LT1079) amplify the bridge's pressure-sensor output and provide a differential signal to U2A (an LT1490). U2A must be a rail-to-rail op amp; the system's analog output is taken from U2A's output. The pressure change is independent of diameter of the water column, so that a tank of liquid would produce the same resulting output voltage as a column of the same height.

The remainder of the circuitry allows for transmission of analog data over long distances (the circuit was designed by Jim Williams) *(Fig. 2)*. The circuit takes a dc input from 0 V to 5 V and converts it to a frequency. For



1. This cost-effective water-tank pressure-sensing design utilizes IC Sensors' Model 90 stainless-steel diaphragm, 0-15psig fluid pressure sensor.

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- Linear Regulator Output (1.25V to 5.0V adj.)
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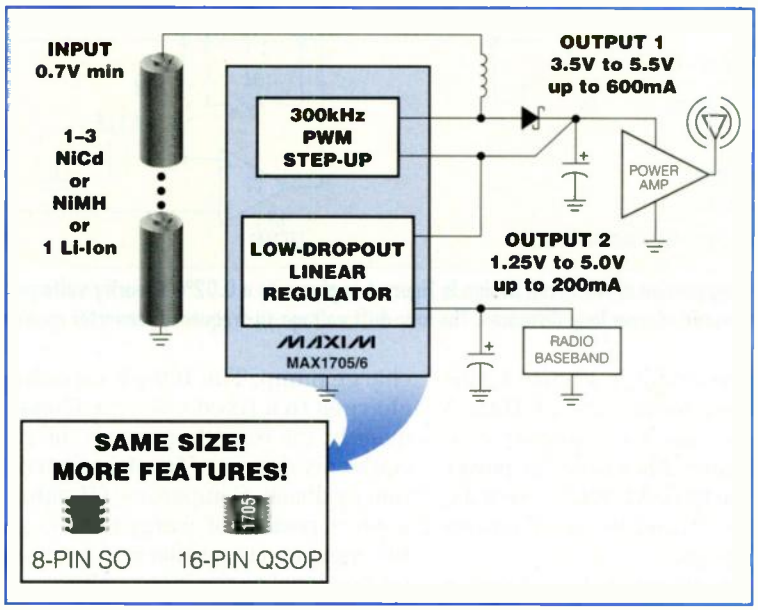
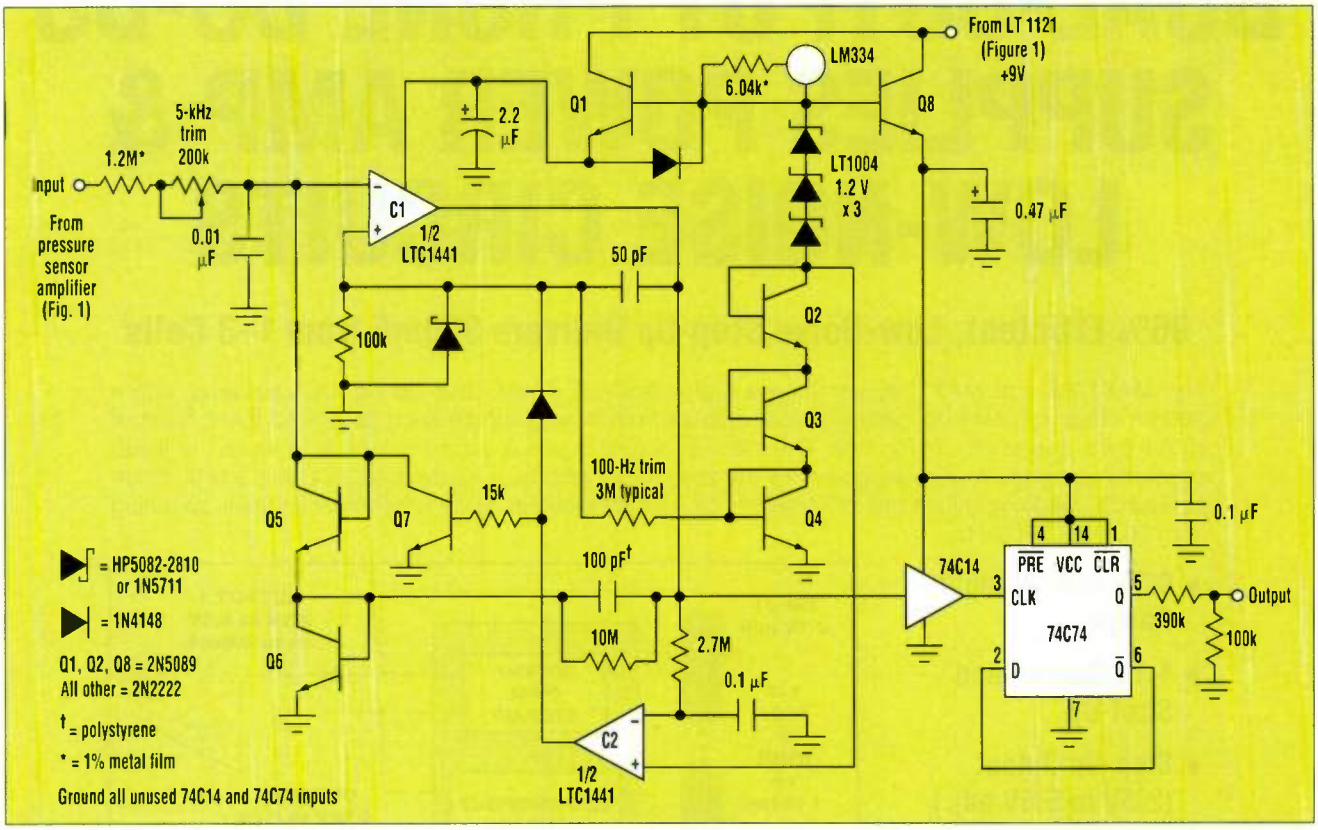
- MAX1705 EV Kit Speeds Designs



The combination of a high-efficiency, step-up DC-DC converter and a low-dropout linear regulator provides high power for the transmitter power amplifier and a low-noise supply for wireless handset applications.



2. The remaining portion of the circuit design in Figure 1 implements a 0.02% linearity voltage-to-frequency converter which allows the analog data to be transmitted over long distances. The low-drift voltage-to-frequency converter requires only 26-µA of supply current.

the pressure circuit in Figure 1, this translates to approximately 0 Hz to 5 kHz. The voltage-to-frequency converter in Figure 2 has very low power consumption (26 µA), 0.02% linearity, 60 ppm/°C drift, and 40 ppm/V power-supply rejection.

When operating, C1 switches a charge pump, consisting of Q5, Q6, and the 100-pF capacitor, to maintain its negative input at 0 V. The LT1004s and associated components form a temperature-compensated reference for the charge pump. The 100-pF capacitor charges to a fixed voltage. Consequently, the repetition rate is the circuit's only degree of freedom to maintain feedback. Comparator C1 pumps uniform packets of charge to its negative input at a repetition rate precisely proportional to the input-voltage-derived current. This action ensures that circuit output frequency is determined strictly and solely by the input voltage.

Figure 3 shows the output frequency versus column height for two different Model 90 transducers. Note the straight lines, which are representative of excellent linearity.

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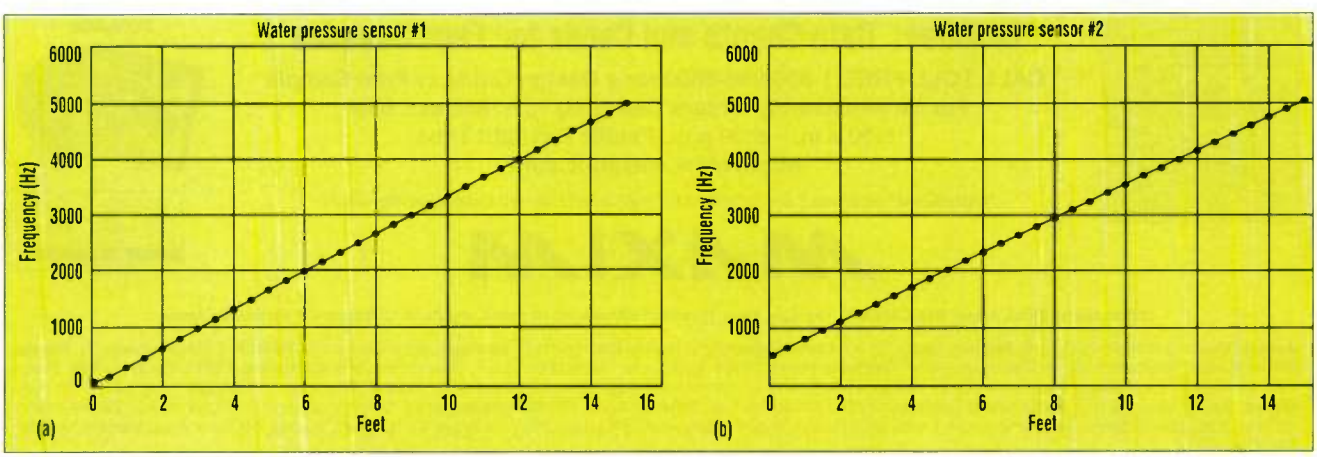

3. Shown is the output frequency versus column height for two different Model 90 water-pressure sensors (a and b).

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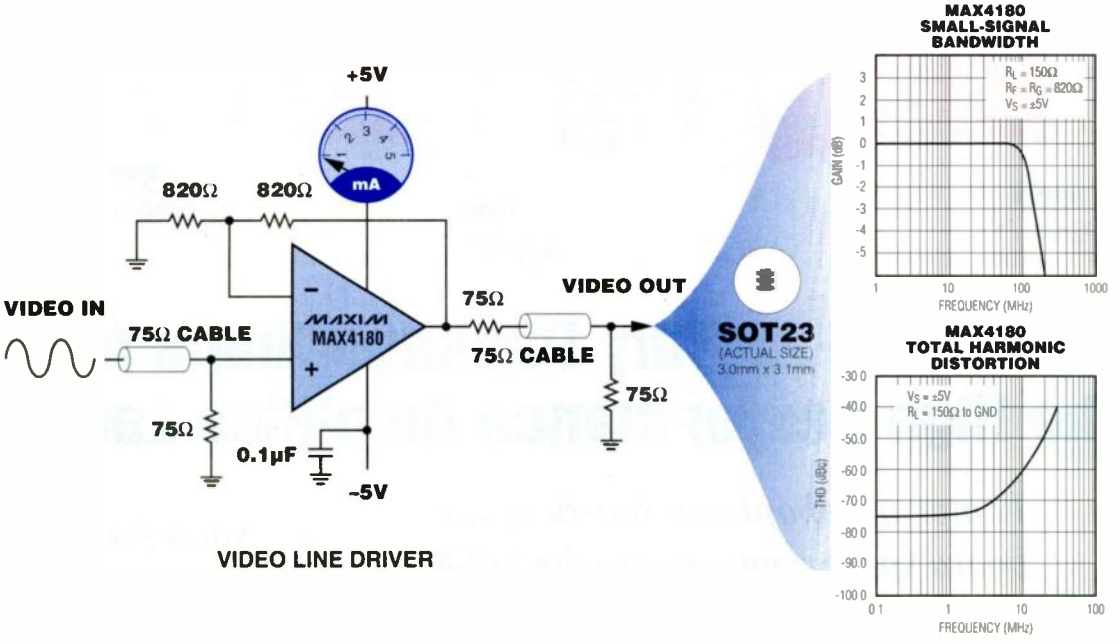

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MAX4182*/4184*	2	2/1	245/270	90/60	0.08/0.03	20	450/340	No	8-pin SO
MAX4183*/4185*	2	2/1	245/270	90/60	0.08/0.03	20	450/340	Yes	10-pin µMAX, 14-pin SO
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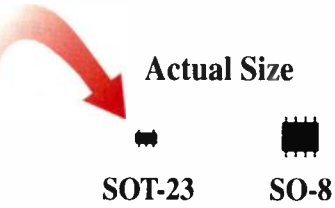

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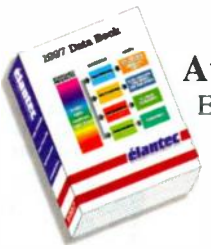

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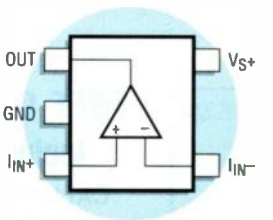

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READER SERVICE 128

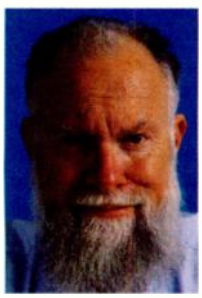
BOB PEASE

What's All This Tempco Stuff, Anyhow?

In the recent picoammeter circuit I wrote about in the column entitled "What's All This Thermistor Stuff, Anyhow?"(ELECTRONIC DESIGN, *Jan. 6, p. 171-172*), I showed a circuit for compensating for the tempco of some high-megohm resistors with a fat tempco such as –250 ppm/°C, or larger.

But what if the UNCERTAINTY of that tempco was sloppy, too? What if its tempco was –250 ±150? What if other RN55D resistors added enough slop to the tempco, that it was not performing nearly as well as desired? Well, here's a semi-classical solution—an improvement that needs 2 new trim pots, and a new trim procedure.

The basic circuit (*Fig. 1*) is very similar to the original, except that we have added new components P1, P2, and two new 10k resistors (*). Formerly, R_f was just tied to the juncture of the two resistors marked ** that were connected to the thermistor network.



BOB PEASE OBTAINED A BSEE FROM MIT IN 1961 AND IS STAFF SCIENTIST AT NATIONAL SEMICONDUCTOR CORP., SANTA CLARA, CALIF.

Why did we add these extra resistors? It's very simple. If we rotate P1 so that the wiper is connected to the left end, the tempco will be overcompensated. If we slide it to the RH end, it will be under-compensated. SOMEWHERE IN THE MIDDLE, IT WILL BE JUST RIGHT. So here is the Calibration Procedure:

- Start at room temperature.
- Put in I = 0 and trim P3 for zero output (well below 10 mV).
- Put in I = –10 pA, and turn the pot P1 to the LEFT end. Trim P4 to get 1.00 V.
- Keep I = –10 pA and turn P1 to the RIGHT end. Trim P2 to get 1.00 V also.
- Now, repeat the calibration sequence, as there may be minor interactions. When you have it right, turning P1 from end to end will have *no effect*. (This is true because the impedance of the pot P1 is more than 1000 X lower than R_f.)
- Now, put the whole thing in an oven, and allow it to warm up to some suitable temperature in its working range, such as +35 or 40°C.
- Put in +10, 0.00, and –10 pA. Before, if you moved the P1 pot from one end to the other, the output stayed at 1.0 V. Now, as you turn the pot, the output voltage goes both above and below 1.0 V. So ,just reach into the warm oven and trim P1 to get 1.0 V to match the room-temp value. (Better yet, if I_{in} *alternates* between +10 and –10 pA, trim P1 to get the output voltage to be 2.0 V p-p. This helps to simplify the rejecting of the op amp's V_{os}.)

And how do we generate an accurate, stable +/– 10 pA current?? You should refer to *Fig. 2*. A3 is an integrator and A4 is a detector that turns the integrator around when it hits +/– 4 V. This is a basic triangle-wave generator that I have been building over the last 30 years. When A4's output is LOW (–1.3 V) A3's output is ramping up at +0.5 V/s. When the integrator gets to +4 V, the 1 µA through R_J just balances the 1 µA coming through the diode bridge, and A4 will switch its output to + 1.3 V. The triangle wave changes direction about every 16 seconds. This gives everything time to settle.

The ±1 µA coming through the diode bridge into A3 gets integrated nice and slow; it is effectively attenuated by a factor of 100,000—by the ratio of the 2-µF to the 20-pF capacitor—down to ±10 pA. Therefore, as that voltage ramps up and down at ±0.5 V/s, the current through the 20 pF cap is ±10 pA.

It's not hard to measure and confirm the peak + and – voltages at V_j. It's easy to measure the time it takes for each half cycle. As a result, you

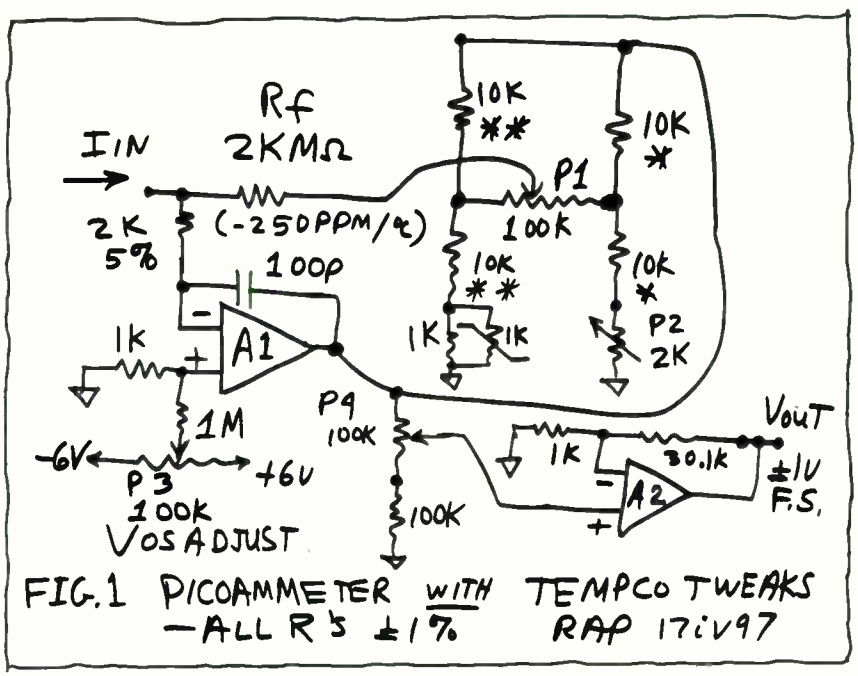


FIG. 1 PICOAMMETER WITH TEMPCO TWEAKS —ALL R'S ±1% RAP 17iv97

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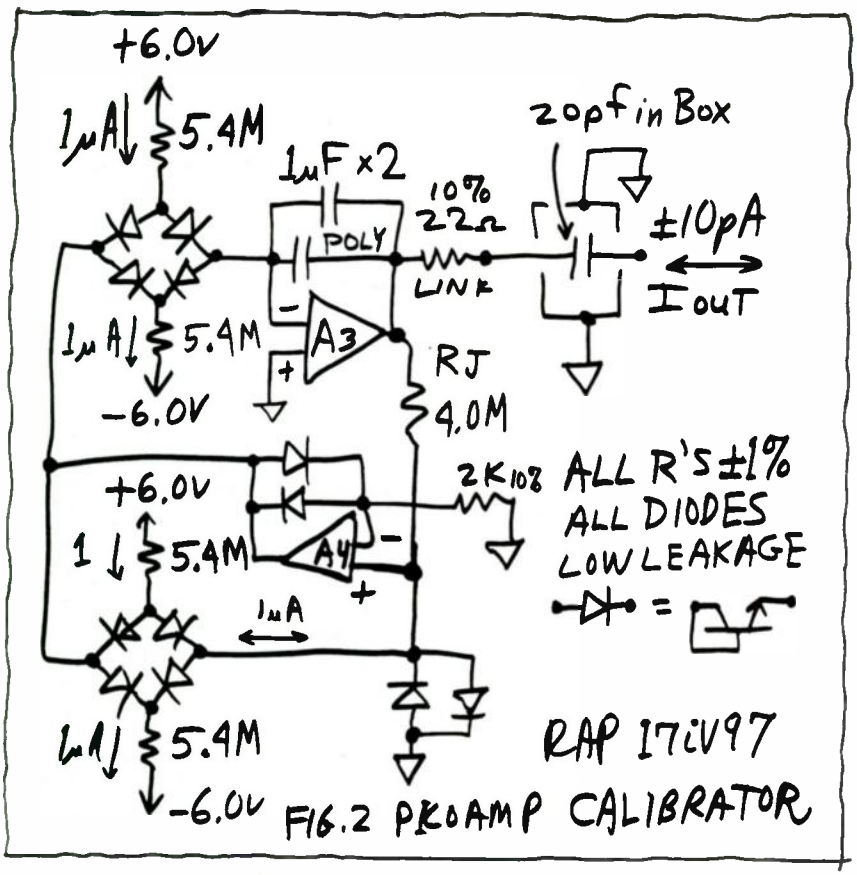

can compute the ramp rates easily. The accuracy of this calibration depends on the fact that you can measure a 20-pF capacitance at 1 MHz and its capacitance at 30 milliHertz will be the same. Many capacitors will not do that, but silver-mica is pretty good, and Teflon, NP0 or C0G ceramics are very good: The capacitance does not change much over this wide range of frequencies. Of course, to measure a 20-pF capacitor with 1% accuracy, you will need to mount it securely and stably in a hole in a metal guard wall, and use a meter such as the Boonton Bridge (ELECTRONIC DESIGN, *"What's All This Picofarad Stuff, Anyhow?" Jan 22, 1996, p. 99.*) I inserted a 22-Ω resistor in the path, to make it easy to disconnect the capacitor from the amplifier for measuring....

Note, almost every 20-pF ceramic capacitor is NP0. You can check that by heating it 100 degrees and watching the capacitance change less than 1/2%. Good stuff!

A3 and A4 can be any op amp with less than 1 nA of input current. Just be sure to use low-leakage diodes, such as the emitter of a transistor with C and B tied together. Avoid those leaky 1N914s or 1N4148s, as in this kind of circuit, their 20-nA leakage could cause over a percent of error compared to 1 μA.

The actual current fed out of the calibrator to the picoammeter will be:

$$I = C \times (\Delta V/\Delta t).$$

The temperature coefficient of the polypropylene integrating capacitor is down near –200 ppm/°C. The tempco of the NP0 ceramic is ±30 ppm/°C, max. The tempcos of the 4-MΩ and 5.4-MΩ resistances will all track if they are made out of a lot of 1-MΩ 1% resistors. The tempco of the 1 μA currents will be about + 300 ppm/°C, due to the tempco of the diodes, which adds to the –200 ppm of the Poly to cause the dV/dt to increase at about +500 ppm/°C. Thus, the calibrator should be used in an air-conditioned room, unless you wanted to use a trick circuit for the 1-μA current sources.

Ya gotta admit, a "tempco adjust knob" that has no effect on room-temp gain or offset is an attractive concept!

I showed this improved temp-compensated picoammeter to the guy in South Africa who was originally trying to get good tempco despite imperfect parts. He thought about it. He tried it. He decided it was worth doing. The added complexity of adding 2 pots and a trim cycle in a warm oven was worth it, compared to the uncertainty of the tempco of your whole *instrument* if you didn't.

I also showed this to Ed Walker at DAC/I: *http://www.cyberspy/daci*. He had suspected my original circuit could lose accuracy if the conspiracy of all the resistors' tempcos ganged up to hurt you. I pointed out to him that this trim scheme would compensate out the tempco of every resistor in the gain path. It didn't really matter if some of the gain resistors were + or –50 ppm/°C. Ed did some analysis and indicated that if all the resistors were at ±100 ppm/°C, in the *worst possible directions*, you might run out of trim range. I agreed that it was possible—but unlikely. So, while my original circuit did make some good *nominal* improvements, and could also cancel out any *consistent* tempco trends of the main feedback R, this improved circuit could fix almost *any* tempco, even if the tempcos moved around considerably. Even if the tempco of some resistors has a little curvature, this does a pretty good job fixing it. Ya gotta admit, a "tempco adjust knob" that has no effect on room-temp gain or offset is an attractive concept!

All for now. / Comments invited!
RAP / Robert A. Pease / Engineer

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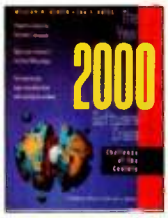

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Readers Respond:

A Mailbag Of 'Tool & Tip' Reactions.

With five installments of "Tools And Tips" under the belt thus far, it seems like a good time to sample some reader reaction since this monthly analog column started in January. Due to inevitable delays between writing and appearance, the comments below pertain to the first three columns (i.e., through March).

Getting Net Connected: (Jan. 6). This topic stirred up a variety of responses, fortunately mostly positive. One general one was an "OK, good info, but why didn't you discuss (say) Netcom or MSN as ISPs?" Well maybe it wasn't obvious to everyone, but that original ISP listing was basically limited to firsthand experiences. Of course, there are thousands of others which might be just fine for you. The general concepts (and caveats) still hold.

Another comment was that working people can use their company's Internet services, as dialup services are too slow. The answer to this is that sure, obviously a high-speed connection (when and if you have it) is preferable to any dialup service. But, it can't be assumed that all companies will allow free web-surfing. That leaves a lot of folks that still must suffer with a dialup's low throughput. It is just those situations where the "Getting Net Connected" details can be most useful.

Managing an ISP's vagaries could be another ongoing chapter in the Net connecting saga, as since the first column was cast, I've now been through two more! Sure, I know it sounds crazy, but service records for many ISPs these days are scandalous. E-mail (POP, SMTP, or both) goes out intermittently; you sometimes can't connect (busy or simply no answer); you can't connect at full modem speed; the list goes on. You pay for unlimited service, but many times it's anything but. And by now, we've all read reports about access problems America Online has had shortly after they went to their unlimited rate plan (also echoed by some readers). If anything, maybe the ISP service picture painted in that first column was a bit rosy.

So, let's suppose you need reliable e-mail service from your ISP, as many of us do. If so, my advice to you is that you'd better have more than one ISP lined up, and be prepared to switch your e-mail routing. Huh, you say? As it turns out, there are ways to do this, and rather simply at that.

A solution can be found with what is known as an e-mail **reflector service**. They are very popular due to the fact that some of them are nominally free to the user via advertising (see the comments below). Two extremely good examples are USA.NET at *http://www.usa.net/*, and Bigfoot at *http://www.bigfoot.com*, which, in addition, offers search capabilities.

WALT JUNG

An e-mail reflector is simply used to redirect incoming e-mail to another specified address. In using a reflector, you give out the reflector service e-mail address to correspondents, then your incoming mail to that address bounces to another ISP address, say *jdoe@shakyisp.com* (which you don't give out). That way, when good old *shakyisp.com* goes down the tubes, you simply re-reflect your mail to a new ISP. **TIP:** The advantage of the reflector is that not only does your mail service continue uninterrupted, your correspondents needn't know a thing about all the subterfuge.

Like I said, it sounds crazy. But, when you depend upon e-mail for bread-and-butter communications, you really wish you could depend entirely on just one ISP and a sole e-mail address. The reality is, you can't.

E-mail Starter Kit: (Feb. 3). This one drew a variety of lively responses. The folks at ConnectSoft wrote saying the E-mail Connection program is no longer available in a freeware version. The current version (v3.1) is available for $49.95 (800) 889-3499).

A couple of e-mail messages were received from users of the Juno "free" e-mail system. One reader was rather adamant in the opinion that my column missed a real opportunity to tell readers about truly free e-mail service—namely, his provider. While I'd heard of the company before, I hadn't tried it then, and probably won't (since I'm happy with my present e-mail setup).

If you're interested, check it out by calling (800) 654-JUNO (5866) or *http://www.juno.com*. You'll need a Windows computer and modem, but no direct Internet access is required. Juno mail can go both to/from the Internet. Access to the Juno system is via their U.S. dial-in numbers (about 400).

An alternative "free" e-mail system is offered by HotMail: *http://www.hotmail.com*. This service provides e-mail via conventional Internet access, using a Web browser.

With these and other advertising-supported systems, the hidden price paid for the "free" services is (guess what?) piggy-back advertising, sometimes appended to your e-mail, or just on-screen (details here will vary). You also may be asked for your personal profile for database records, so be wary of any potential privacy intrusions.

Looking back to that e-mail column, the original concept was to give the *Electronic Design* technical readership some working insight into minimum requirements for Internet e-mail and the truly broad array of services implicit to that. But, little consideration was given to other forms of e-mail, since it seemed obvious that the power of full-featured e-mail and the associated Internet services would likely point most readers that way.

As noted, this approach isn't free—you do pay for underlying Internet access. It does get you the most feature-packed e-mail form at no additional cost. I'd venture a guess that most readers of this publication would prefer high-octane e-mail, and full Internet access.

Finally, no readers actually wrote concerning this particular e-mail related problem, but it sure is one for virtually anyone using Internet e-mail services. Here, I'm referring to

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what's commonly known as SPAM, i.e., unsolicited and/or undesired e-mail advertising. Very similar to junk paper mail, junk e-mail seems to be about as prevalent. It is difficult to control, but part of this lies in watching where your e-mail address gets posted. Be careful of posting to the USENET news/discussion groups, as these seem to be magnets for junk e-mail (when you post using your real address). Any solutions toward combating this real problem of junk e-mail will likely be welcomed by everyone using e-mail service.

Analog Book Reviews: (March 3). In this column reviewing two new op amp books, it was mentioned in passing that I do have a lot of them on my shelf. Out of those, the ones I use most often number about 10 or so. As you would expect, one reader questioned just what was this "Top 10" of op amp books. Well, if they are useful to me, they are very likely useful to some of you out there, so here's the Top 10 list with some comments added on each. The listing (in published order) has an initial "available" section (1-5), followed by an out-of-print section (OOP) (6-10).

1 R. Meyer, *Integrated Circuit Operational Amplifiers*, IEEE Press, 1978, ISBN 087942-116-9. This one's a collection of classic IEEE papers on op-amp design; a must-have tome of information from the early IC developmental years.

2 S. Franco, *Designing with Operational Amplifiers and Analog Integrated Circuits*, McGraw-Hill, 1988, ISBN 0-07-021799-8. Good general coverage of op amps and applications such as active filters, as well as other popular analog ICs.

3 P. Horowitz, W. Hill, *The Art of Electronics*, 2d. Ed., Cambridge University Press, 1989, ISBN 0-521-37095-7 Not solely devoted to op amps, this encyclopedic work is nevertheless well worthwhile overall for its good coverage. Nice touch with the "good circuit"—"bad circuit" cameos.

4 D. Sheingold, Analog Devices Staff, *The Best of Analog Dialogue 1967 to 1991*, Analog Devices, 1991, ISBN 0-9-916550-10-9 (free on request from ADI literature center, 1-800-262-5643). This 25 year indexed compilation isn't solely devoted to op amps, but does offer lots of valuable information on them, plus many other design engineering topics as well.

5 J. Dostal, *Operational Amplifiers* 2d Ed., Butterworth-Heinemann, 1993, ISBN 0-7506-9317-7. One of the best op-amp books currently available, with good technical analyses and discussions on basic and applied circuits.

6) D. Sheingold, Philbrick Staff, *Applications Manual for Operational Amplifiers*, Philbrick/Nexus, 1968. This classic is the original sourcebook of op-amp applications, and in many ways it defined directions of later developments. It has been OOP for some time, but its well worth having when and if you do find it.

7) G. Tobey, J. Graeme, and L. Huelsman, *Operational Amplifiers: Design and Applications*, McGraw-Hill, 1971, ISBN 07-064917-0. One of the first broadly popular major publisher books on op amps, emphasizing both op-amp design and applications, plus some notable coverage on active filters.

8) G. Korn, T. Korn, *Electronic Analog and Hybrid Computers*, 2d Ed., McGraw-Hill, 1972, ISBN 0-07-035363-8. Another classic, probably second only to the Philbrick book in its early design influence. System-oriented, but still valuable for its fundamental coverage.

9) D. Stout, M. Kaufman, *Handbook of Operational Amplifier Circuit Design*, McGraw-Hill, 1976, ISBN 0-07-061797-X. Very good, practically-oriented design handbook with step-by-step approach to standard applications and many example designs.

10) W. Jung, *IC Op Amp Cookbook*, 3d Ed., MacMillan, 1986, ISBN 0-672-22453-4. In terms of a disclaimer, I'm not exactly disinterested vis-à-vis this one—but many others have valued it for the practical coverage of IC op-amp applications.

Book sources: TIP: In purchasing these or any tech books, you'll be better served to deal directly with a technical book store, as opposed to the local mall's computer book rack, or a generic on-line book service. Why? Because the technical book store understands your needs and is better equipped to serve them.

Two technical book stores that should be able to supply books 1-5 are Stacey's Books at (415) 326-0681 *http://www.staceys.com/*, and OPAMP Technical Books, at (800) 468-4322 *http://opampbooks.com/*.

The only major caveat about shopping OOP engineering classics is availability. Don't expect to pick all of them up with one simple phone call, or any one stop (see below). Even if you can't buy a particular title for some time, you'll still be better informed in the long run, once you do have it. Keep a sharp lookout at book fairs, garage sales, hamfests, and the like.

Amazon Books, (800) 201-7575 *http://amazon.com*, offers an order service for OOP books. Although I've bought several books from them, none were OOP. A bit more encouraging in this regard is Powell's Technical Books, which as part of Powell's Books of Oregon, advertises "used, new, and out of print books," (800) 225 6911; *http://www.powells.com/*. I can report good success in buying my OOP IC Op Amp Cookbook at Powell's, which was delivered in timely fashion.

It's worth noting that they also have an active OOP section, at (800) 878 7323, x217 (or by e-mail; *op@powells.com*). A search for an OOP book can be started for $2 per title, which goes for an international advertisement. You get postcard results in 6 to 8 weeks, with OOP books usually priced at $20 and up.

Finally, here's an idea concerning OOP books that can be useful. Note that availability of a recent OOP book will vary in the first year or so, as distributor stock dwindles. **TIP:** This means you can buy some fresh OOP titles within this period, but only if do your legwork, calling known suppliers of that type of book to locate stock.

That's it for our 'Tools And Tips' mailbag for now. Good luck with ISPs and e-mail, and finding those good new or old analog books out there. When you do find any real mother lodes, drop us a note to share with the readers.

Walt Jung is a corporate staff applications engineer for Analog Devices, Norwood, Mass. A longtime contributor to Electronic Design, he can be reached via e-mail at Walter.Jung@Analog.com.

Bit-True ADPCM Macrocell For Standard-Cell ASICs

A bit-true, fully configurable, multichannel, G.726 adaptive differential pulse-code modulation (ADPCM) macrocell for low-power standard-cell ASICs has been developed by Lucent Technologies' Bell Labs. The ADPCM is a key building block used in telecommunications for speech compression according to the ITU G.726 standard.

Because the ADPCM is developed in VHDL, users have free choice of Lucent's process technology, as well as free configuration of the number of channels from 1 to 64 (0.35 μm). Compression rates are 16k, 24k, 32k, and 40k. Each channel can be used individually for either encoding or decoding and can handle A-Law or μ-Law data streams.

The macrocell takes only 16 clock cycles per channel for bit-true encode or decode operations, resulting in very low latency and power consumption. It supports full-scan testing and include built-in self test (BIST) for the memory. The cell's engine consists of 8k gates, one multiplier (independent of the number of channels), and 348 bits of memory per channel. *RE*

Lucent Technologies, Bell Labs Innovations, *Hilary Lane, Marketpoint Europe Ltd., Osprey House, Berkeley Business Park, Finchampstead, Berks RG11 4YJ, United Kingdom; phone: +44-118-932 4299; fax +44-118-932 8148.*

CIRCLE 569

Smart-Card Interface IC Suits Low-Voltage, Low-Power Apps

With the increased use of smart cards in handheld portable equipment (e.g., GSM phones) and fixed equipment applications (e.g., ATM machines, set-top boxes) comes the requirements of low power and low voltage. Philips Semiconductors has come up with a smart-card interface IC that operates at supply voltages as low as 3 V and features a typical sleep-mode current consumption of only 70 μA.

The TDA8002 smart card's features are based on GSM11.11 EMV and ISO 7816 standards. Supervisory circuits are included to detect fault conditions, and there's enhanced ESD protection on its three I/O card pins. The card has ISO 7816-compliant activation and deactivation sequences. Also, synchronous and asynchronous data transfers are supported.

An on-chip dc-dc converter maintains the card supply at 5 V over the card's 3-V to 6.5-V operating voltage range, enabling it to be used in 5-V or 3.3-V systems. The TDA8002 comes in 28-lead SO or 32-lead LQFP options, or in naked die form. *RE*

Philips Semiconductors, *5600 MD, Eindhoven, The Netherlands, phone: +31 40 272 20 91; fax: +31 40 272 48 25.* **CIRCLE 570**

Full-Bridge Motor-Driver IC Incorporates Nonlinear DAC

Bidirectional pulse-width-modulated (PWM) control is possible with the A3955 motor-driver IC. Included in the device a 3-bit/8-level nonlinear digital-to-analog converter. The A3955, which is capable of continuous output currents of up to ±1.5 A and operating voltages of up to 50 V, is optimized for the digital microstepping control of 2-phase bipolar stepper motors.

Internal fixed off-time PWM current control circuitry can be used to regulate the load current to a desired value, with the fixed off-time pulse duration set by a user-selected external RC timing network. The control circuitry can operate in a slow recirculating current decay mode, a fast regenerative mode, or a mixed current decay mode. The full-scale load-current limit is set by selecting an input reference voltage and an external sensing resistor.

The A3955 comes in a 16-pin dual in-line plastic package or a 16-lead SOIC package, both with copper heatsink tabs. For both package types, the power tab is at ground potential and needs no electrical isolation. *RE*

Allegro MicroSystems Inc., *Balfour Houses, Churchfield Rd., Walton-on-Thames, Surrey, KT12 2TD, England; phone: (44-1932) 253-355; fax: (44-1932) 246-622.*

CIRCLE 571

Frequency Counters Operate From An External Standard

Two new high-resolution frequency counters developed by Thurlby Thandar Instruments—the TF810 and the TF820—can operate from their own internal timebase or from an external 10-MHz reference. The internal timebase offers an initial adjustment accuracy of ±2 parts in 10^6, with a typical temperature coefficient of 0.3 parts in 10^6 per °C.

Both low-cost, benchtop counters feature a wide frequency range and are highly sensitive. The large eight-digit displays employ red LEDs for easy viewing, while the simple front-panel layout and clear annunciators enhance ease of use. The models differ in maximum measurement frequency: The TF810 is 200 MHz, while the TF820 is 1.3 GHz, allowing for applications in the UHF area. Both offer a choice of gate times from 0.1 second up to 10 seconds, and they provide a frequency resolution down to 0.1 Hz. Sensitivity is typically 10 mV rms.

The TF810 and TF820 can operate from either ac mains power, or disposable or rechargeable batteries. The case has a built-in carrying handle that doubles as an adjustable tilt stand. *RE*

Thurlby Thandar Instruments Ltd., *2 Glebe Rd., Huntingdon, Cambs., PE18 7DX, England; phone: (01480) 412451; fax: (01480) 450409.* **CIRCLE 572**

Edited by Roger Engelke

ANALOG

Data sheets on products like these can be found at www.penton.com/ed/

ADC Architecture Needs One Comparator/Bit For High-Speed

The AD9054 is an 8-bit monolithic, high-speed, low-power, ADC offering a full Nyquist, 200-Msample/s encode rate capability. The device, which can be used direct-IF and under-sampling applications, has a full-power analog bandwidth of 380 MHz implemented in a 0.6-mm biCMOS process. It dissipates less than 500 mW from a single +5-V supply.

With an internal +2.5-V reference and a track-and-hold circuit, the part provides a conversion solution for applications such as RGB video processing, digital-data storage channels, medical imaging, and digital communications and instrumentation. The folding bit-per-stage architecture dramatically reduces power consumption and die size for the 8-bit conversion, with costs at least 50% lower than flash-converter technology. The encode input of the AD9054 directly interfaces to TTL, CMOS, or positive ECL logic, and will operate with either single-ended or differential inputs. The demultiplexed mode interleaves ADC data through two 8-bit channels at one-half of the clock rate.

The AD9054 comes in a 44-lead TQFP and is available in two speed grades, the -135 with a 135-Msample/s rate and the -200 with a 200-Msample/s rate. In lots of 10,000 pieces, the AD9054BST-135 costs $28.00 each, and the AD9054BST-200 goes for $48.00. PMcG

Analog Devices Inc., *804 Woburn St., Wilmington, MA 01887; (617) 937-1428; fax (617) 821-4273; Web: http://www.analog.com.* **CIRCLE 690**

Silicon Driver Provides 0.5 W At 60% Collector Efficiency

The AT-38086 is a low-cost, silicon npn bipolar transistor designed for use as a pre-driver or driver in 800-/900-MHz cellular and wireless markets. Housed in a surface-mount package (outline 86), the transistor features +28-dBm pulsed output power at 4.8 V and +23.5-dBm CW output. It's manufactured in HP's SAT (self-aligned transistor) process with an f_T of 10 GHz. Die are nitride-passivated for surface protection. Overall, the process possesses good device uniformity and reliability.

Pulsed collector efficiency at 900 MHz is typically 60% while third-order intermodulation distortion is typically -35 dBc. No-damage mismatch tolerance is 7:1. Collector leakage current runs less than 15 mA, while h_{FE} is a typical 150 and power gain is 11 dB. It's expected that the transistor will be used as a driver in GSM Class IV phones as well as in AMPS, ETACS, 900-MHz NMT cellular handsets, and as the output device in ISM 900 applications and special mobile radio and other wireless applications. The part is priced at $0.80 in quantities of 10,000 pieces. PMcG

Hewlett-Packard Co., *Components Response Center, 3175 Bowers Ave., M/S 88U, Santa Clara, CA 95054; (800) 537-7715, ext. 9913; Internet: http://www.hp.com.* **CIRCLE 691**

Gigabit Ethernet And Fibre Channel Evaluation Board

The LAB25 Logic Analyzer Board can evaluate both the VSC7125 Fibre Channel and the VSC7135 gigabit-Ethernet transceivers, using easy-to-use tools for signal quality and performance evaluations such as output jitter, waveform integrity, and basic functionality. The unit is self-contained, but uses a pattern generator (10 bits at either 106.25 MHz for the VSC7125 transmit clock, or 125 MHz for the VSC7135) connected to board pods for transmit data and control signals. A logic analyzer monitors receive data and status signals. Also, an on-board voltage regulator may be used to provide 3.3 V to either in-test IC. Multiple media choices are supported, including SMA or DSUB-9 connectors to interface with the appropriate test equipment. The VSC7125 and its VSC7135 derivative are both available in the 64-lead, 14-mm PQFP packages; the 7125 also comes in a 64-pin, 10-mm PQFP. The LAB25 is in production and is available at $600.00. PMcG

Vitesse Semiconductor Corp., *741 Calle Plano. Camarillo, CA 93012; (805) 388-3700; fax (805) 987-5896.* **CIRCLE 692**

Making Basic Math Solutions Easy For The Novice Or Expert

MATHANSR, a spreadsheet program that runs on Microsoft's Excel, is intended to make math solutions easy. It reduces the chances for errors as well as saves time in solving triangles, circles, roll dimensions, bolt circles, polygons, spheres, cones, and others. When solving for triangles, for example, entering two numbers is all that's needed for a right-angled triangle. The same philosophy is followed in the other solution areas, with all of the solutions being delivered both graphically and in table form. The program was developed for the shop floor of a mold-making business, but is suitable for all businesses. Learning time is short, as the user is only able to load numbers into "unlocked" cells in the program. Colors are used extensively to aid in the displays. A sample solution for circles is available on disk at no charge. PMcG

Solveware, *P.O. Box 7669, Jupiter, FL 33468; (561) 575-4502; fax (561) 575-9841; http://www.solveware.com.* **CIRCLE 693**

AC97 Codec Is An 18-Bit Full-Duplex Part For PC Audio

The STAC9701T is one of the early products to conform to the analog component specification of the industry's AC97 for PC audio. The product is a full-duplex 18-bit stereo ADC and DAC (codec) with a protocol-compliant control link (at either 3 or 5-V) and a compliant mixer for the digitized inputs and internal PC digital sources. Six analog inputs are provided at line-level, and the chip is powered with a single supply of between 3 and 5. An energy-saving power down mode is provided. The SD converter technology offers a greater than 90-dB dynamic range with sampling at 48 kHz.

This first product will be followed by others with additional AC97 features, such as a modem codec, tone control, headphone output, and a separate, additional ADC. Those parts may come in a 64-pin TQFP; the STAC9701T is packaged in a 48-lead TQFP. Pricing is $6.50 for 10,000 piece lots with production quantities available now. PMcG

SigmaTel Inc., *6101 W Courtyard Drive, Building 1, Suite 100, Austin, TX 78730; (512) 343-6636; fax (512) 343-6199; jims@sigmatel.com; http://www.ccsi.com/~sigmatel.* **CIRCLE 694**

COMPONENTS

Data sheets on products like these can be found at www.penton.com/ed/

Li-Ion Batteries Feature High Density

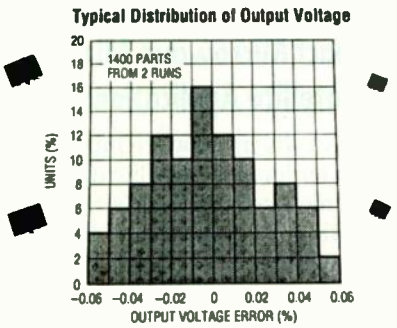
The ELI-18650 series of Li-Ion 3.6-V cells provide 1350 mAh of power in an 18-by-65-mm cell size. The batteries use a graphitic carbon anode and a

lithium cobalt oxide cathode in an organic electrolyte. Other features include a weight of 40 g (typical), flat contact terminals, and a minimum discharge cutoff voltage of 2.5 V. Pricing is approximately $15 per cell, including electronic protection for charge control. PM

Energizer Power Systems, P.O. Box 147114, Gainesville, FL 32614-7114; (800) 677-6937; fax (704) 391-3283. CIRCLE 695

Voltage Reference Is Accurate To 0.075%, 10 ppm/°C

The LT1460 is a 2.5-V output, precision series bandgap voltage reference with a guaranteed initial accuracy of

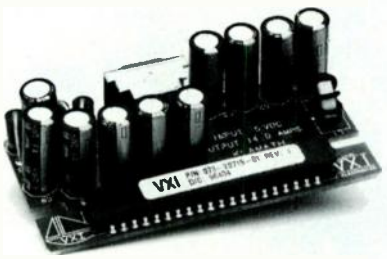


0.075% (max) and a maximum drift of 10 ppm/°C (A-grade version). The device draws a maximum of 130 µA and will source up to 20 mA of output current. The minimum input-to-output differential is 0.9 V. The LT1460 operates off 0.9 to 20 V and comes in 8-pin PDIP, 8-pin SO, and TO-92 packages. Pricing is $1.60 each per 1000. PM

Linear Technology Corp., 1630 McCarthy Blvd., Milpitas, CA; (800) 4-LINEAR; http://www.linear-tech.com. CIRCLE 696

Voltage-Regulator Module Targets High-End Processors

The VRM 8.1 voltage-regulator module provides point-of-load regulation, and supports current swings from 0.8



to 13 A in 350 ns. The module features 5-bit voltage identification capability, an operating temperature range of 0° to 60°C, and an efficiency of 81%. Other features include overvoltage, overcurrent, and short-circuit protection, as well as current sharing, remote enable, and an open-collector Power Good signal output. Pricing is $10 each. PM

VXI Electronics Inc., 4607 S.E. International Way, Milwaukie, OR 79222; (503) 652-7300; fax (503) 786-5011. CIRCLE 697

Buck Controllers Lower Cost Of Processor Power Supplies

The CS-5120 and CS-5121 buck controller ICs are designed for processors that work from a single supply voltage such as the Pentium with MMX, Cyrix's M2, and the K6 from AMD. The CS-5120 is a synchronous device with two gate outputs for switching a pair of external n-channel power MOSFETs. The CS-5121 is a non-synchronous device with one gate output for driving a single external MOSFET. Both use the company's V^2 architecture, which provides a dual feedback loop reaction to load transients. Packaging is either 16-pin plastic DIP or 16-lead plastic SMT narrow body. Pricing is $1.75 for the CS-5120 and $1.67 for the CS-5121. PM

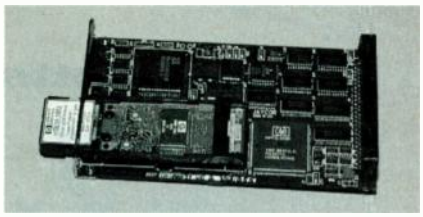
Cherry Semiconductor Corp., 2000 South County Trail, East Greenwich, RI 02818 (800) 272-3601; (401) 885-5786. CIRCLE 698

COMMUNICATIONS

Data sheets on products like these can be found at www.penton.com/ed/

Adapter Boards Expand Fibre Channel Line

FibreStar adapter boards are PCI plug-and-play Fibre Channel adapters for networking and Internet/intranet applications demanding high-speed communications links, and for high-performance video editing/broadcasting, fault-tolerant, and network stor-



age applications. Boards with PCI-bus compatibility bring Fibre Channel capability to Windows NT and Solaris X86 platforms. SBus adapter boards are compatible with all Sun Solaris operating environments.

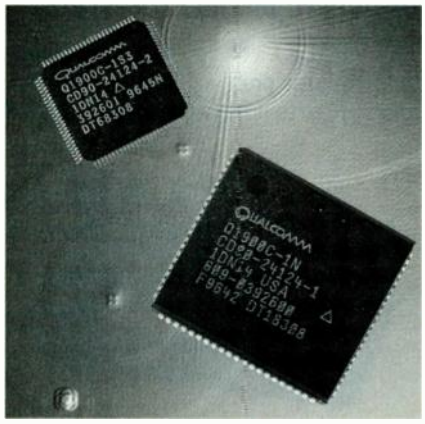
The FibreStar boards provide a Fibre Channel solution for storage, client/server and enterprise networks, intranets, and clustered computing applications. PCI-slot installation facilitates field upgrading. Changing from copper to an optical interface, as well as from 266 Mbits/s to 1063 Mbits/s, is done by replacing the interface module. No further hardware or software changes are needed.

The boards support switched and arbitrated loop configurations and all classes of service, including an intermix of Fibre Channel classes 1, 2, and 3. . Five models of PCI boards have unit pricing ranging from $1995 (1063 Mbits/s with integrated copper interface) to $3680 (1063 Mbits/s with removable optical interface module). Pricing for three SBus FibreStar adapters ranges from $2970 to $3655. LG

***Jaycor Networks Inc.**, San Diego, CA; (619) 535-3121.* **CIRCLE 699**

Single Chip Combines Viterbi/Trellis Decoding

The Q1900 decoder IC from Qualcomm combines Viterbi and Trellis decoding on a single chip. The device operates with data rates up to 25 Mbits/s in the Viterbi mode and 75 Mbits/s in the Trellis mode. The Viterbi mode supports four convolutional code rates: 1/3, 1/2, 3/4, and 7/8. This mode also supports channel bit-error-rate measurements and built-in phase synchronization for BPSK, QPSK, and OQPSK modulation techniques. The Trellis mode supports two convolutional code rates: 2/3 for 8 PSK and 3/4



fpr 16 PSK. Also supported is built-in phase synchronization for 8 PSK and 16 PSK. Full duplex encode and decode is available in both modes.

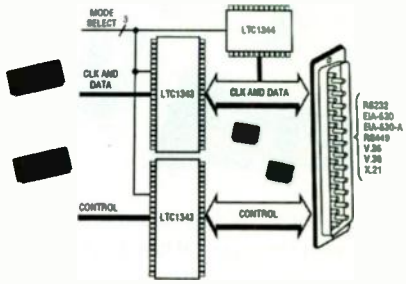
The Q1900 is suited for commercial satellite communication networks such as INMARSAT and INTELSAT. It also meets forward-error-correction requirements of direct broadcasting satellites, microwave point-to-point data links, VSATs, digital modems, digital-video-transmission systems, high-speed data modems, and military and NASA communications systems. The Q1900 is available in an 84-pin PLCC or 100-pin VTQFP for PCMCIA applications. Unit pricing for 1000-piece quantities is $16 (PLCC) and $18 (VTQFP). LG

***Qualcomm Inc.**, 6455 Lusk Blvd., San Diego, CA 92121; Kim Rutland, (619) 658-5005.* **CIRCLE 700**

Multiprotocol Chip Set Eases Network Interfacing

The LTC1343 multiprotocol transceiver and LTC1344 cable terminator form a software-selectable serial port that operates from a single 5-V supply. The port supports all major telecom protocols for remote-access serial ports. The LTC1343 contains four drivers, four receivers, and the configuration logic for protocol selection. The LTC1344 cable terminator contains six switchable resistive terminations to configure one DB-25 connector for up to 8 different serial protocols. Two transceivers and a single terminator form a DTE or DCE interface port capable of supporting RS-232 (V.28), RS-423 (V.10), EIA530, EIA530-A, RS-449, V.35, V.36, and X.21 protocols.

Typically, the LTC1343 is connected to the clock and data lines along with the diagnostic RL (remote loop-back) signal. Three internally latched mode pins on each device allow sharing of the select lines between multiple interface ports. The mode also may be selected



by the interface cable. Other routing tasks, such as loopback testing and echo clocking, are included on-chip. The LTC1343 comes in a 44-lead SSOP and the LTC1344 in a 24-lead SSOP. Together, the three chips occupy just 8 square centimeters of board space. The NET1- and NET2-compliant chip set is screened to the commercial temperature range with pricing for 1000 pieces or more beginning at $27.95. LG

***Linear Technology Corp.**, 1630 McCarthy Blvd., Milpitas, CA 95035-7414; (408) 434-1900; fax: (408) 434-0507; http://www.linear-tech.com.* **CIRCLE 701**

Compact Microwave Mixer For Satellite Applications

The SKY-7G microwave mixer is intended for low-cost satellite uplink and downlink applications. It's capable of operating over the 2-to-7 GHz frequency range, with a typical conversion loss of only 7.0 dB. The mixer offers 20 dB of isolation and a usable IF response to 2 GHz. Available now, the SKY-7G comes housed in a compact, low-profile surface-mount package. The mixer costs $16.95 each, with volume discounts available for production quantities. LG

***Mini-Circuits**, P.O. Box 350166, Brooklyn, NY 11235-0003; (718) 934-4500; fax (718) 332-4661; Internet: www.minicircuits.com.* **CIRCLE 702**

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READER SERVICE 169

300 Power Semiconductors Debut In Short-Form Catalog

Over 300 new power semiconductors are included in the 1997 short-form catalog from IXYS Corp., Santa Clara, Calif. The 48-page document provides specifications for more than 1000 power devices, including rectifier bridges and ultra-fast switching IGBTs. The catalog is available free through the company's network of sales representatives and distributors. For more information, call (408) 982-0700; fax (408) 496-0670; or visit the IXYS web site at http://www.ixys.com. *LM*

CIRCLE 573

Filtering Product Guide Offers Ways To Rid Systems Of EMI

Spectrum Control Inc., Erie, Pa., has published a 226-page catalog that provides details on products and services aimed at eliminating EMI. Among the products covered are: resin-sealed, solder-in, and hermetically sealed filters; filter-plate assemblies; filtered terminal blocks; and power-line filters. The guide also includes application notes for using filters to eliminate EMI, details on EMC testing services, a part-number index, and military cross reference of qualified components. Product descriptions are complete with photographs, line drawings, insertion-loss curves, and ordering information. Call (814) 835-4000, or fax (814) 835-9000. *LM*

CIRCLE 574

Magnetic Materials Are This Catalog's Main Attraction

Learn about magnetic materials for wireless applications with TransTech's (Adamstown, Md.) latest catalog titled *Microwave Magnetic and Dielectric Materials*. The comprehensive microwave ceramic materials catalog has information on a large selection of garnets (including calcium vanadium), ferrites, and dielectrics. It also includes technical briefs that cover a basic introduction to the properties and uses of microwave ferromagnetic materials. For a free copy of the catalog, call (800) 290-7200, ext. 903; fax (301) 695-7065; or e-mail: transtech@alphaind.com. *LM*

CIRCLE 575

Digital Motor Drives' Benefits Are Outlined In Brochure

The advantages of Indramat's digital drives when used with linear asynchronous motors are outlined in the company's 16-page, full-color brochure. It explains how the drives replace mechanical transmission elements, enabling high speed and accuracy that are unattainable with standard mechanical systems. Multiple constructions, capabilities, and application benefits are explored for the LAR fully enclosed linear motor and the LAF single-primary frameless linear motor. Also described are theDDS digital drives, which use the international SERCOS interface standard for real-time communication between controls and drives. Technical data is included for all models. To obtain the brochure, call (847) 645-3600 , or surf into their Internet address at http://www.industry.net/indramat. *LM*

CIRCLE 576

Catalog Showcases Hundreds Of Industrial I/O Products

Browse through the hundreds of industrial I/O products detailed in the latest catalog from Acromag Inc., Wixom, Mich. The 50-page catalog features a broad range of VMEbus boards, ISA bus cards, and IP mezzanine modules that perform analog I/O, digital I/O, and communication functions. Easy-to-use product-selection tables and diagrams help engineers specify accessories to complete the I/O system and ease installation. The accessories include signal-conditioning systems, termination panels, cables, adapters, and software support. Contact Acromag's sales department at (810) 624-1542; fax (810) 624-9234; or e-mail sales@acromag.com. Information also is available at http://www.acromag.com. *LM*

CIRCLE 577

Handbook Covers The Basics Of Light Measurement

A 68-page *Light Measurement Handbook* covers the principles, units, and theory surrounding light measurement. It also provides application assistance. Topics include light-measurement geometries, how to interpret various graphs, and instructions for setting up an optical bench. *Light Measurement Handbook* is available for free from International Light Inc., Newburyport, Massaschuseets Call (508) 465-5923; fax (508) 462-0759; or e-mail il-sales@intl-light.com. *LM*

CIRCLE 578

Connector Catalog Serves As Quick Reference Guide

A 16-page catalog from Wieland Electric Inc., Burgaw, N.C. can be used as a quick reference guide to the company's industrial multipole connectors. Wieland provides dust- and watertight multipin rectangular connectors for industrial and outdoor use. The guide contains photos, dimensions, catalog numbers, and brief descriptions for inserts, hoods, and housings. Call (800) WIELAND, or fax (910) 259-3691 for a free copy of the catalog. *LM*

CIRCLE 579

Product Brochure Details Standalone Controllers

The newest product brochure from Bailey-Fischer and Porter includes all the details on its Command Series standalone controllers. More specifically, the 20-page publication discusses the capabilities and features for each model in the Command Series, including Strategic Loop controllers for one- and two-loop applications, Sequence Command products for digital applications, and Batch Command products for recipe-oriented processes. For a free copy of the brochure, call (215) 674-6000. *LM*

CIRCLE 580

CALL FOR PAPERS

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n many wireless designs, portability is a critical goal. For wireless designers who must address portability issues, **The WIRELESS & PORTABLE Design Conference** is an educational forum to learn new design and measurement techniques and share ideas with engineering colleagues. Technical sessions and engineering workshops at **The WIRELESS & PORTABLE Design Conference** examine wireless concerns, such as modulation, downconversion, baseband processing, and digital signal processing, as well as portable issues, such as choice of battery, DC converter, microprocessor, communications bus, and analog circuitry for most efficient low-power operation. Technical sessions will feature papers with practical design ideas, software simulation methods, and measurement techniques that can be applied to solving wireless and portable design problems.

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n portable design:
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MCUs and CPUs for portable devices
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Systems, buses, and architectural issues

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E-mail: barrymanz@msn.com.

Richard Nass, Technical Program
Co-Chairman (Portable topics)
Electronic Design
Penton Publishing
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REV. A

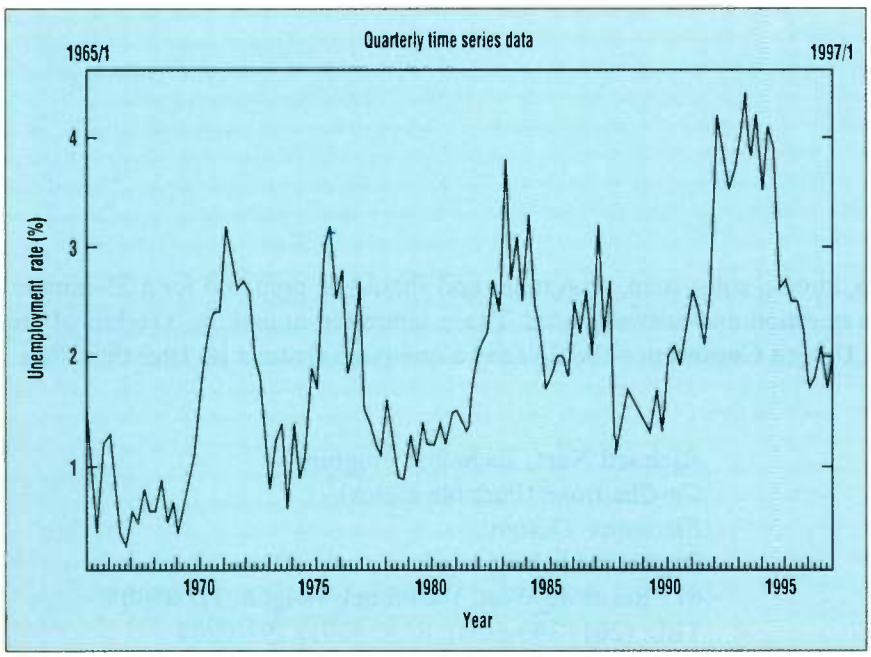
The Engineering Job Market—How To Read The Tea Leaves

Robert A. Rivers

Anyone who has held an engineering job for more than a few years knows that the job market has its share of peaks and valleys. Most of the time, the demand for electronic engineers is fairly steady, but having the misfortune to fall into one of the valley periods when demand slackens can bring financial hardship to some and uncertainty about the future to many. The crux of the problem is not the turbulent employment situation (it will always occur in a market economy), but finding a way to peer into the future to predict impending weak periods. If you could read tea leaves to forecast future periods of strong and weak demand, you would have an invaluable tool for career planning.

To begin to understand the engineering job market, you need a historic view of the unemployment rate of electronic engineers (*Fig. 1*). Over the past 32 years (1965-1997) there have been some significant bumps along the road, but they must be placed in perspective. The thing to note is that the jobless rate ranges from below 1% between 1965 and 1970 to over 3% from 1992 through 1995, with a historic high of 4.4% in 1993. To some (the unemployed), 4.4% could be called a crises, but compared with unemployment in the general population this is small percentage of engineers. Compared with other professionals these numbers are about average. More importantly, a rise in unemployment signals problems in the profession for both job holders and the jobless.

For example, inflation can be decreasing the real value of present compensation during an economic downturn. Employers find it unnecessary to offer raises in the face of soft demand, and may even institute wage freezes. Downsizing, mergers, and bankruptcies can drive engineers out into an already saturated marketplace. And pressure to produce more work because of increased competition can result in engineers working longer hours without compensation.



1. The quarterly time-series unemployment rate for electronic engineers shows some sharp upward spikes over a 32-year span. But the absolute rate over that period has never been higher than the 4.4% reached in 1993.

Spotting The Trend

Of the reams of economic information that spew out daily from the public and private sectors, is there any single statistic that can serve as a precursor of future business activity that applies to the market for engineers? One piece of data that seems to be a reliable indicator—if any lone statistic qualifies—is the federal funds rate. The federal funds rate is an interest rate set by the Federal Reserve System (otherwise known simply as the Fed) for bank borrowing *(see "The Federal Reserve System's Iron Grip", p. 186)*. In general, any actions that the Fed takes have an enormous impact on business and economic conditions in the U.S. (and the world, for that matter) because the Fed controls the money supply. As the money supply goes, so goes the economy. Thus, it is not too surprising that a Fed activity such as setting the federal funds rate, has far-reaching consequences for the economic well being of engineers.

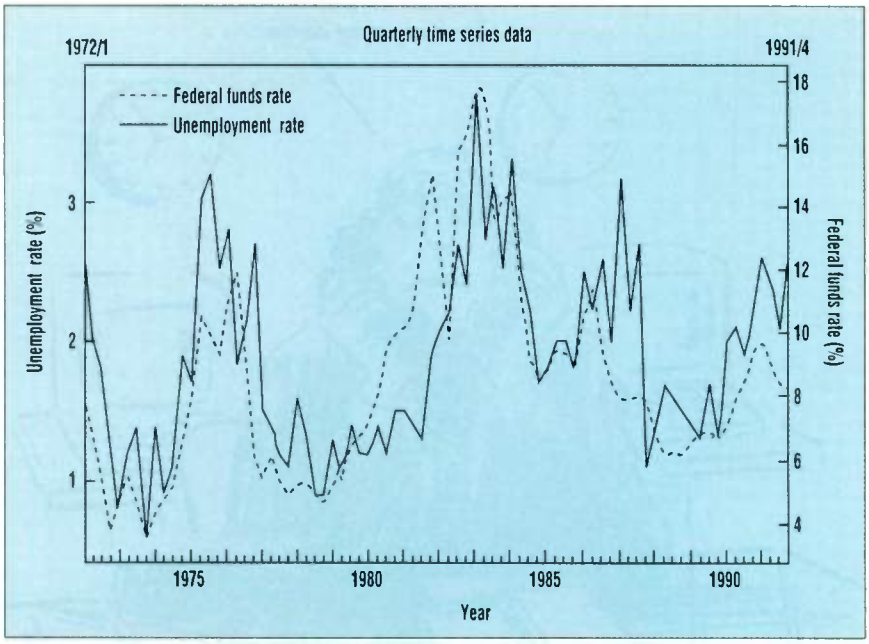
The federal funds rate (referred to by insiders as the funds rate), is the interest rate that banks in the Federal Reserve System charge each other for overnight borrowing of funds to meet reserve requirements. Although the funds rate is the shortest of any short-term interest rate, its impact on the economy and engineering employment over the long haul is profound.

To see the effect of the funds rate on engineering unemployment, look at a plot over time of one against the other (*Fig. 2*). This time-series plot covers the period between the first quarter of 1972 through the fourth quarter of 1991. It is the same unemployment data shown in Figure 1, but only for the

smaller period mentioned above. Superimposed on the unemployment data is the change in the funds rate, but not over the same time period. The reason is that the funds rate is a leading indicator. That is, it takes a certain amount of time after a change in the funds rate for it to ripple through the economy and have an effect on business and employment conditions. Therefore, the funds rate curves in the figure have been shifted in time to show their later effect on the unemployment rate.

For example, the funds rate shown for say, the fourth quarter of 1975, on the time line was actually in effect at an earlier time. That time difference between the occurrence of a particular funds rate and its effect on the unemployment rate is seven to eight quarters or one and three-quarters to two years. So the funds rate that produced the unemployment rate at the end of 1975 was in effect at the end of 1973 and early 1974.

By shifting the funds rate ahead in time, you can see its effect on the unemployment rate at a given time and the coincidence between its rise and fall and the unemployment rate's rise and fall. Using some statistical analysis, the correlation coefficient (the relationship between changes in the funds rate and changes in the unemployment rate) between the funds rate and the unemployment rate can be calculated. It turns out that the correlation value is 0.701 over the 1972-1991 period, indicating a highly linear relationship between the two variables, or a strong degree of agreement between the two. So the tea leaf that predicts changes in the unemployment rate is the funds rate. If you want to look ahead to the state of the job market just before the turn of the century, start tracking the funds rate now.



2. A time-series plot of the federal funds rate against the engineering unemployment rate over 20 years indicates a high degree of confirmation between changes in the two rates. The federal funds rate has been shifted forward in time by seven to eight quarters to show how its changes force a corresponding change in the unemployment rate.

The Fed's Dilemma

Although the Fed usually has a clear idea of where it wants to guide the money supply, it's not that easy to accomplish that goal. The Fed's attempts to control the money supply have been likened to pushing on a

The Federal Reserve System's Iron Grip

Established in 1913, the U.S. Federal Reserve System (the Fed) serves as the nation's watchdog and controller of the banking system. The overseer of the system is the Federal Reserve Board (the FRB), consisting of seven members chosen by the President with the advice and consent of the Senate. However, members are appointed for a 14-year term, so theoretically, the Fed through the FRB has the power of an independent monetary authority not directly controlled by the government.

A key major function of the FRB is to establish reserve ratios for banks within limits set by congress. Reserves are the key barometer of business conditions because free reserves are a measure of the banking system's liquidity. If banks are highly liquid—ample free reserves and excess cash— large quantities of funds are available nationwide for lending to business and individuals to finance business investment and economic growth. If reserves are small, banks have less or little to lend, and an economic contraction usually results.

Banks like to keep as low a reserve position as possible to maximize their loan making capability, but the Fed requires them to hold a certain percentage of cash in reserve. If a bank falls short of its reserve requirement it must borrow to cover its position, either from the Fed itself at its discount rate or from another bank in the Federal Reserve System at the federal funds rate. Loans at the federal funds rate are very short term, usually overnight, and just to cover small deficiencies in a bank's reserve requirements. Whether it's the discount rate or the federal funds rate, banks don't like to borrow for the same reason individuals don't—interest is charged on the loan.

A second source of the Fed's tremendous leverage is its ability to buy and sell government securities through open market operations. This process has a direct effect on the amount of reserves in the banking system. The greater the reserves, the greater the money available for loans and the lower the federal funds rate.

string. It's easy to pull with a string, but hard to push with it. It is easy to tighten money by cutting back on the reserves of member banks in various ways, but it is more difficult to increase the money supply. When money is tight, business activity decreases, retail volume decreases, manufacturing activity falls, and eventually engineers get laid off.

When the Fed raises rates once, the tea leaves say that business will probably be worse 21 months downstream. When it increases rates several times, you can be sure that business will slow with a corresponding increase in unemployment and job insecurity. In fact, the Fed's curbing of the money supply in an attempt to control inflation sometimes throws the economy into a recession.

When the Fed wants to increase the money supply by pumping reserves into the banking system and stimulating business activity, there is a certain amount of failure that comes with that system. The reason is that the Fed can't force banks to make loans, it can only provide an economic climate that is conducive to such activity. Normally, banks want to make loans during hard times, but they may opt instead to build up their reserves rather than venture into an uncertain loan market. And the public may be pessimistic, holding onto its money, just when the Fed wants it to be upbeat and in a spending mood to revive a sluggish economy. That's the second aspect of reading the fund-rate tea leaves: Watch for drops in the rate to be followed by increased commercial loan volume to see that the lower rates are having the desired effect. Other factors important to engineering employment are the volume of exports, defense expenditures, supported R&D programs, and investor support of entrepreneurial activities.

Robert A. Rivers is an Orange, Mass.-based consultant who publishes the Engineering Manpower Newsletter which covers employment trends in the industry. he can be reached at (508) 544-3942.

How Valuable	Circle
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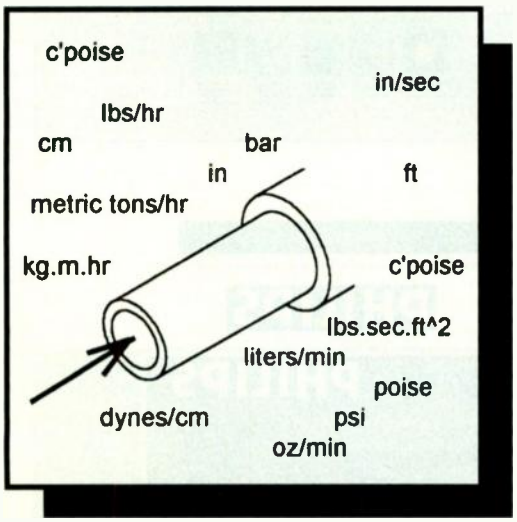

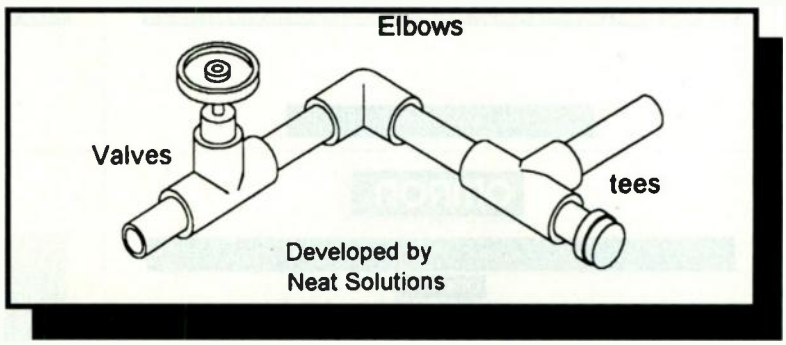

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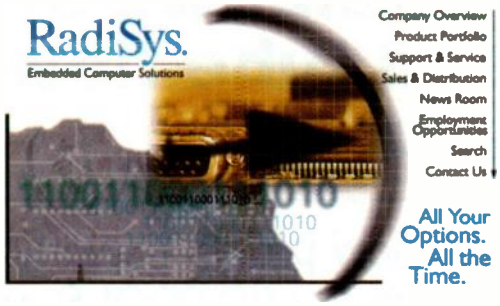

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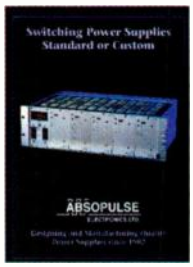

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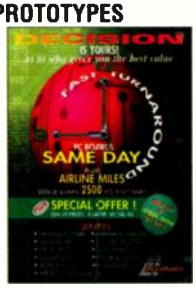

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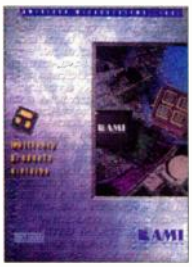

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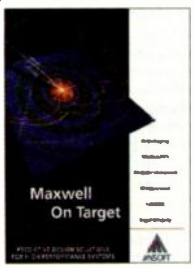

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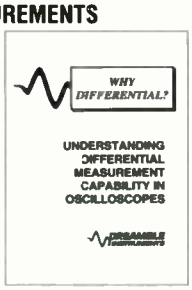

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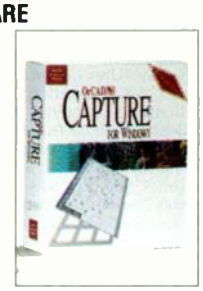

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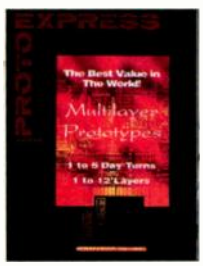

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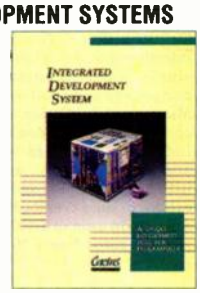

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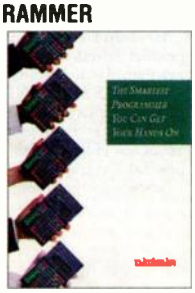

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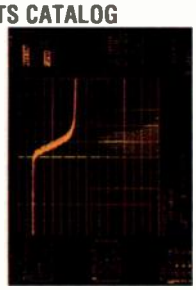

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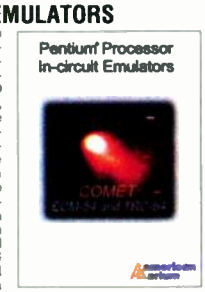

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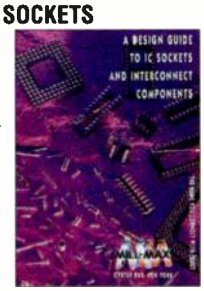

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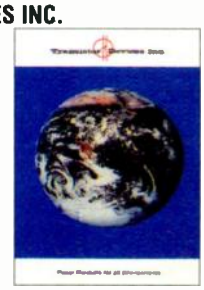

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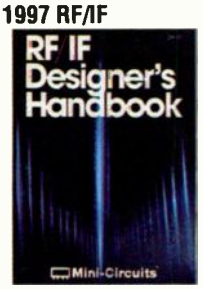

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ITW VORTEC

BOARD INTERFACE ATLAS

Samtec's Board Interface is the perfect companion to Samtec's Full Line Sudden Solution Guide. It fully illustrates capabilities for developing and producing micro pitch, surface mount, board-to-board and application specific interconnects. Capabilities include flexible board stacking and "skyscraper" interconnects, ultra-high density interconnects and micro I/O interconnects.

CIRCLE 324

SAMTEC USA

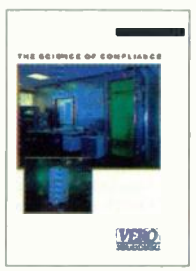
Dual Channel FFT Spectrum Analyzer

The SR780 is a two channel FFT analyzer with a frequency range of 102.4 kHz and a dynamic range of 90 dB. Features include ANSI standard octave analysis, swept sine measurements, transient capture, and computed order tracking. The SR780 comes with a low distortion source (-80 dBc), 8 MB of memory (up to 32 MB opt.), a 3.5 inch DOS disk drive and RS-232 and GPIB computer interfaces.

CIRCLE 282

STANFORD RESEARCH SYSTEMS, INC.

NEW EMC GUIDE AVAILABLE FROM VERO

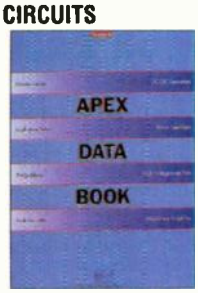


"Science of Compliance" brochure from VERO Electronics, provides information on electronic enclosures and EMC. Included are: definition of terms; regulations; materials; design, manufacturing and installation practices. Brochure also covers VERO EMC modules; enclosures; subracks, and caseframes. Phone: (800) 642- VERO, Fax: (203) 949-1101; email: vero@vero-usa.com.

CIRCLE 283

VERO ELECTRONICS

POWER INTEGRATED CIRCUITS



The 7th edition Apex Power Integrated Circuits data book contains complete product data sheets and applications notes for Apex Microtechnology's power Amplifier PWM Amplifier and DC/DC Converter product lines.

Call: 1-800-862-1021; Fax:1-520-888-3329 Email: Prolit@TeamApex.com

CIRCLE 284

APEX

HI PERF CABLE ASSEMBLIES

Brochure for engineers needing to know the current level of advanced capabilities in the integrated design and manufacture of miniature cables and high density terminations.

CIRCLE 285

PRECISION INTERCONNECT

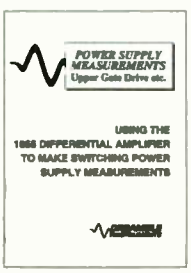
FREE! FREE! FREE!

Xicor's broad line of in-the-system programmable semiconductor integrated circuits retain information even when system power is lost or turned off. In-the-system programmability telecommunications, consumer, computer industrial, automotive and military products to adapt to changing software and operation environments. Call (408) 432-8888 Ext. 3336.

CIRCLE 286

XICOR

APPLICATION NOTE

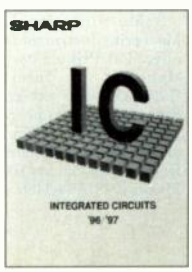


Covers how to make safe and reliable measurements on switching power supplies operating on line. Includes such difficult measurements as upper gate drive and transistor saturation characteristics. Tells how to quantity measurement corruption caused by high dv/dt common mode. 1-800-376-7007

CIRCLE 287

PREAMBLE INSTRUMENTS

SHARP FIFOs



First-in, First-out memories are just the stuff the no-nonsense design environment of the '90s is meant to build on. Used as data buffers between systems operating at different speeds, FIFOs conserve valuable board space, streamline design tasks and reduce system cost. Sharp's new 1997 IC Short Form Catalog is packed with information about Sharp FIFOs.

CIRCLE 288

SHARP MICROELECTRONICS

YOUR CATALOG COULD BE HERE

For information regarding this section, circle the number below, or call your local sale representative. Our SALEs Offices are in the back of the magazine

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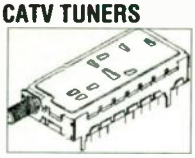
YOUR COMPANY

ELECTRONIC DESIGN CATALOG/LITERATURE REVIEW

SINGLE CONVERSION CATV TUNERS



Designed for reception of modulated digital data streams, CASD-series tuners are ideal for consumer set-top or PC add-in receivers. They feature PLL tuning, 62.5 kHz step sizes and low noise, with a return-path low pass filter in some models. F connector and PCP pin inputs available. Call 800-642-0261 for product information. For details via FASTFAX, call 800-833-9437, ext. 3000

CIRCLE 289

SHARP MICROELECTRONICS

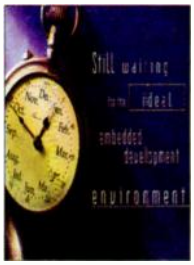
JUMBO CATALOG

APEM's jumbo 340 page catalog features: Submini & mini toggles, rockers, paddles & pushbuttons, including washables. DIP switches including models for automatic insertion, surface mounting and washables. Industrial toggles, rockers, paddles & pushbuttons, including lighted models and antivandal pushbuttons. Extensive offerings of switch hardware and accessories, including sealing boots and indicator lights.

CIRCLE 290

APEM

SPECTRA® DEVELOPMENT SYSTEM



Microtec's Spectra development system combines our renowned development tools - including the XRAY debugger and C & C++ compilers - with VRTX, the most proven, robust RTOS in the industry. Spectra addresses the full range of embedded applications, from austere, minimal resource systems with no real-time operating system requirements, up to complex, resource-intensive systems. 1-800-950-5554

CIRCLE 291

MICROTEC

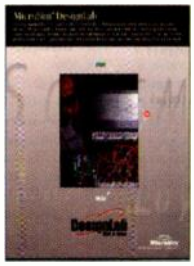
FREE CATALOG ON DISK

Vicor's interactive electronic catalog guides users through the selection and configuration process for the company's complete line of modular power solutions.
Contact: Vicor Express.
Phone: 800-735-6200
E-mail: vicorexp@vicr.com

CIRCLE 292

VICOR

MicroSim® DesignLabä

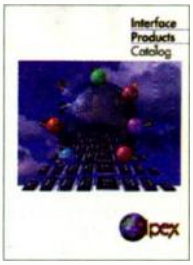


Interface Technologies distributes Version 7.1 of MicroSim DesignLab and MicroSim Pspice A/D with Schematics. Version 7.1 supports long file names in Windows 95 and Windows NT, includes DXF export, enhanced simulation libraries, library browser and search engine, and automated move, select and edit in MicroSim PCBoards. Call 1-800-357-1636 or browse http://www.i-t.com for more information.

CIRCLE 293

INTERFACE TECHNOLOGIES

INTERFACE PRODUCT CATALOG



Sipex's 1996/1997 Interface Products Catalog provides the most up-to-date information for our full line of single, dual and multiprotocol interface transceivers. Over 200 pages of technical specifications, application notes and ordering information for RS-232, RS-485, RS-422, V.35, etc., transceivers are available.

CIRCLE 294

SIPEX CORPORATION

SOFT LOGIC SYSTEM SOLUTIONS

This brochure features VMIC's wide variety of hardware solutions, coupled with its IOWorks™ software components. VMIC offers the user a total solution for their industrial application based on its line of VMEbus products such as I/O, CPU's , interfaces of third-party PLC's, PLC ACCELERATIONO solutions, deterministic networking with reflective memory, and IOWorks Soft Logic Software packages. Phone:1-800-322-3616

CIRCLE 318

VMIC

Virtual Instrument Developers Tools

The new software Showcase CD-ROM includes free evaluation versions of the industry LabVIEW graphical programming and LabWindows/CVI C/C++ development tools for virtual instrumentation. Also included are ActiveX controls for Visual Basic, Excel tools, and analysis and visualization software. Phone: (512) 794-0100. E-Mail: info@natinst.com

CIRCLE 295

NATIONAL INSTRUMENTS

Flat Panel Systems Designer's Guide

The best selection of flat panel display systems available! Our new 1997 edition "Designer's Guide to Flat Panel Display systems and single Board Computers" offers an extensive range of OEM/end user flat panel display solutions: complete flat panel computers, plug-in flat panel monitors, the latest displays and several touchscreen technologies. Includes complete information on our PC-compatible single board computers.

CIRCLE 296

COMPUTER DYNAMICS

C&K's EXPANDED BROADLINE CATALOG

C&K's expanded Newton Division Catalog #9609 is the most extensive switch catalog in the industry with 360 pages of models and options featuring miniature, subminiature and ultra-miniature toggle, rocker, lever handle, slide, rotary, dip, thumbwheel, pushbutton, surface mounted and process compatible switches. It now includes our line of trimming potentiometers, too.

CIRCLE 297

C&K COMPONENTS, INC.

MOTION CONTROL CATALOG

GESPAC' intelligent motion controller uses a 40MHz MC56002 DSP to control 2 or 4 DC, AC or brushless motors. Versions of the board are available for the VME, G-64 and soon for the ISA and Compact-PCI buses. The board comes with a powerful PC based software package that helps you automatically determine the mechanical characteristics of the drive assembly and more.

CIRCLE 298

GESPAC

M/S ASIC CAPABILITIES

The Mixed-signal Division of American Microsystems, Inc., is continually improving its analog, digital, and Mixed-signal design and simulation tools. Adding cells to its cell library, reducing cost and time required to develop Mixed-Signal ASICs. For more information on MPD, call (208) 233-4690 or visit our home page
http://www.amiscom

CIRCLE 299

AMERICAN MICROSYSTEMS

SWITCH PRODUCT DATA BOOK

Get complete specifications on Omron's broad line of switches. This 316-page reference describes basic snap action switches, mechanical keyswitches, DIP switches, lighted/non-lighted pushbutton switches, and thumbwheel switches. Three families of watertight snap action switches, new economical in-line DIP switches and surface mount keyswitches are featured. The data book can only be sent to addresses in the Americas.

CIRCLE 316

OMRON ELECTRONICS, INC

MEASURE WITH A PC OR LAPTOP

8 Multifunctional PC Measuring Instruments are offered as Printer Port Peripherals or Interface Cards. Software integrates Storage Oscilloscope, Spectrum Analyzer, voltmeter on Transient Recorder. Demo disks are available. Phone: (908) 464-5486

CIRCLE 317

TIEPIE ENGINEERING (USA)

YOUR CATALOG COULD BE HERE

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ELECTRONIC DESIGN CATALOG/LITERATURE REVIEW

FREE PRODUCT HANDBOOK

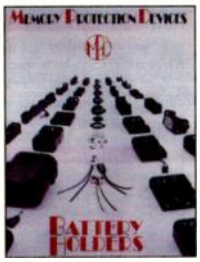
Completely updated and expanded. The CDI product handbook provides full electrical and mechanical specifications on hundreds of standard power conversion products, including 230 new models. Also included: a 50 page application guide with in-depth information on power conversion topics including product testing, theory of operation, distributed power systems, thermal characteristics, safety/ reliability approvals. Tel: (508) 559-0880 Fax: (508) 559-9288

CIRCLE 301

CONVERSION DEVICES, INC.

BATTERY HOLDERS

Featured products: SMT button cell holders, battery snaps, case hardware, computer clock backup holders, multi-cell holders with covers, auto cigarette lighter plugs. For computers, alarms, controls, instruments, toys, appliances, ect.



CIRCLE 302

MEMORY PROTECTION

PRECISION SWITCH FOR APPLICATIONS

New Catalog 106 has 80 pages featuring new sealed snap-in rockers and toggles with available illuminated indication, plus an in-depth line of precision pushbutton, toggle, rocker, limit and basic switches. Sealed and unsealed construction. Industrial, commercial and military grades. Environment-free sealed. Sub-subminiature, subminiature, miniature and standard sizes.

CIRCLE 303

OTTO Control

TRANSFORMER CATALOG

Signal Transformer Co., an operating unit of the Insilo Technologies Group, has just released a new 40-page, 4 color catalog that is an ideal reference source for engineers and buyers. signal Transformer offers the most extensive line of 50/60 Hz transformers available in a power range of 1 VA to 10 KVA.

CIRCLE 304

SIGNAL TRANSFORMER

HARSH ENVIRONMENT CONNECTORS

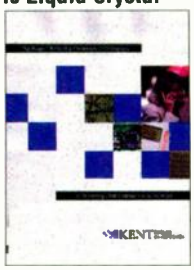
Find exactly the connector you need in this well organized guide including illustrations, dimensions, layouts, & assembly instructions from PEI Genesis, Phone: 1 800-858-6903

CIRCLE 305

PEI GENESIS

"No-Power" Cholesteric Liquid Crystal Displays

Kent Displays' brochure details the benefits of No-Power™ Reflective Cholesteric Liquid Crystal Displays. This technology requires no energy to maintain an image. Displays have wide viewing angels and are flicker free. Call (330) 673-8784.



CIRCLE 306

KENT DISPLAYS

Lucent Technologies Power Systems Selection Guide

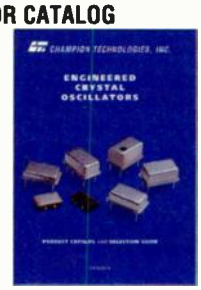
The Lucent Technologies Power Systems Selection Guide is a 140-page, product-packed catalog featuring a showcases of power components and end-to-end system solutions. Technical Questions 1-800-526-7819. Documentation request 1-800-372-2447

CIRCLE 307

LUCENT TECHNOLOGIES

CRYSTAL OSCILLATOR CATALOG

A new product catalog and selection guide from Champion Technologies features their full line of crystal oscillators. Technocal information, specifications and mechanicals are featured in this catalog for over 60 of Champion's VXCOs, TCXOs, VCTCXOs, data clocks and related products. frequency ranges up to 155.52 MHz for general purpose to high frequency or tight stability applications. Phone: (847) 451-1000



CIRCLE 308

CHAMPION TECHNOLOGIES

A WEALTH OF SWITCH INFORMATION

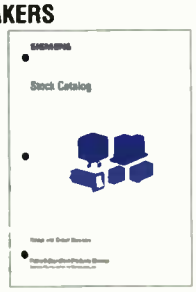
Grayhill's 320 page catalog provides you with electromechanical switch data, reference material, dimensional drawings and photos. Catalog No. 1 includes information on DIP Switches, rotary Switches, Keyboards and Keyboard Modules. the detailed information allows the catalog user to select the proper product for their application right down to the part number. Phone: (708) 482-2131. Fax: (708) 345-2820.

CIRCLE 309

GRAYHILL, INC.

P&B RELAYS & BREAKERS

Catalog lists stock relays and circuit breakers from Potter & Brumfield products division. Describes electromechanical, solid state and time delays, as well as thermal and magnetic circuit breakers. Numerous options. Fax: (812) 386-2072, email: info@ae.sec.siemens.com

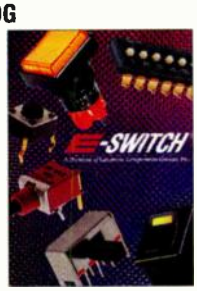


CIRCLE 310

SIEMENS ELECTROMECHANICAL

NEW SWITCH CATALOG

The ALL-NEW, color E-Switch catalog contains 28 additional pages, including new lines of DIP, pushbutton, and gold tact switches. The catalog gives complete specifications for pushbutton, toggle, rocker, power, lever, slide, rotary, keylock, DIP, and tact switches. SMT and lighted versions available. 612-504-3525, http://www.e-switch.com.

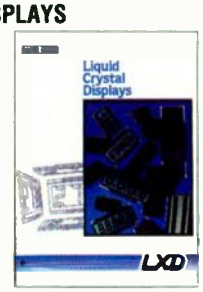


CIRCLE 311

E-SWITCH

LIQUID CRYSTAL DISPLAYS

World renowned leader and innovator of LCD technology, LXD Inc., details their broad line of indoor and outdoor displays in this 25-page catalog guide. Included is LCD technology information, standard illustrations, performance specifications, functional descriptions and ordering information. Phone: (216) 786-8711.



CIRCLE 312

LXD INC.

NEW SWITCHING REGULATORS

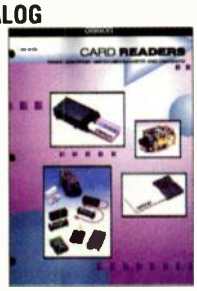
Power Trends, Inc. has released a new 80 page full-line catalog for its complete line of Integrated Switching Regulators and DC to DC converters. the catalog introduces significant new products along with extensions to existing product lines. Complete specifications, photos and standard applications are provided for each product along with mechanical configuration options and ordering information.

CIRCLE 313

POWER TRENDS, INC.

CARD READERS CATALOG

Find the latest in card reader technology, including smart card-ready devices, in Omron's 100-page catalog. Included are swipe readers, motorized card readers/encoders and insertion readers designed to handle magnetic stripe and/or IC chip cards. Contact Omron for application assistance in selecting among the 22 product families shown. the catalog can only be sent to addresses in the Americas.



CIRCLE 314

OMRON ELECTRONICS

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YOUR COMPANY

ELECTRONIC DESIGN CATALOG/LITERATURE REVIEW

"X86 and 683xx/HC16 Design Tips"

Free application note shows how to use in-circuit emulation to isolate real-time events. Set clock-edge triggers, and then use trace to display system status and the source code leading up to the event. For immediate response: WEB page: www.microtekintl.com Voice: 800-886-7333

CIRCLE 327

MICROTEK INTERNATIONAL

A NEW TECHNICAL BULLETIN

A new technical bulletin on Polyester disposable air filters has been released by Universal Air Filter Co. Polyester Air Filters are designed to protect electronics, computer, telecommunications, medical and general purpose equipment. The two-sided, full-color bulletin provides detailed information on the filters' non-woven, non-migrating synthetic media, frame construction and Uni-Grid support design. Phone: 800-541-3478 or Fax: 618-271-8808.

CIRCLE 328

UNIVERSAL AIR FILTER

MINI COAX CONNECTOR SYSTEM

New 4-color brochure graphically illustrates the new har-pak© Mini Coax connector System. color photographs, detailed technical data, drawings and part numbers provide comprehensive information.

CIRCLE 329

HARTING ELEKTRONIK

CD-ROM PRODUCT CATALOG

Get your free CD-ROM product catalog featuring over 400 high performance linear and mixed signal products. The catalog employs a parametric search engine, product selection trees, keyword search, and applications support. Phone: 800-548-6132

CIRCLE 330

BURR-BROWN

SuperTAP™ Emulator for x86

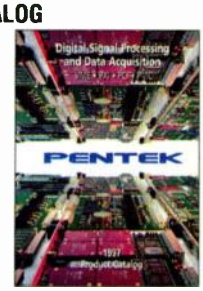
The new standard in high-end in-circuit emulators, SuperTAP solves tough hardware/software integration problems, debugs firmware and software, maximizes embedded system quality and performance. Palm-sized, full processor speed, easy set up, at half the price of chassis-based emulators. 1-800-426-3925.

CIRCLE 331

APPLIED MICROSYSTEMS

1997 PRODUCT CATALOG

Pentek's new 1997 Product Catalog provides specifications on our VME, VXI, PCI and PMC products. You'll also find tutorials, case studies and applications stories. Get all the information on the broadest line of DSP processors, analog and digital I/O, digital receivers and world-class software tools. Send for your free copy today, or call (201) 818-5900 Ext. 669. www.pentek.com, info@pentek.com

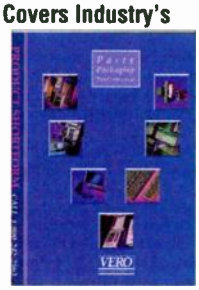


CIRCLE 332

PENTEK, INC.

New VERO Shortform Covers Industry's

New VERO shortform summarizes industry's broadest range of electronic packaging hardware, including: IMRAK cabinets for electronic component housing and cable management; cardframes; Diplomat desktop enclosures; IBX and Veronex plastic eclosures ; and a full range of blackplanes, microracks and plug-in power supplies. Phone: 800-642-VERO ; Fax: (203) 949-1101.



CIRCLE 333

VERO ELECTRONICS

New Stacked Film Radial-Lead Capacitors

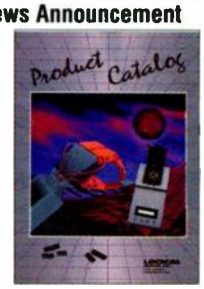
New STR series polyester film and polyarylate radial-lead stacked film capacitors offer small size and values from 0.01µF to 2.2µF at voltage ratings to 100WVDC. +85°C performance, with full-rated voltage and ripple or 105°C with WVDC derated by 50%.

CIRCLE 334

ILLINOIS CAPACITOR, INC.

Product Literature News Announcement

Our 28 page four color catalog is an excellent buyers guide for design and production engineers shopping for EPROM /FLASH/PLD/FPGA design, programming, erasing and test tools. The catalog offers products for every budget and level and also includes a host of Socket converters and adapters for DIP, PLCC, TSOP, QFP technologies. For more information call Logical Devices at 800-331-7766. web: http://www.logicaldevices.com



CIRCLE 335

LOGICAL DEVICES

KEPCO HEAVIER-DUTY POWER

Kepco, Inc. has extended its RCW heavy-duty industrial grade power supplies with its new 1500 watt models ranging from 3.3V@300A to 48V@30A. The RCW line now includes models from 350 watts to 750 watts to 1500 watts; are single output modules featuring wide-range input with power factor correction to reduce the harmonics fed back to the mains to below IEC norms; meet EN 60950 safety standard, carry Cd mark. Phone: 718-461-7000. Fax: 718-767-1102.

CIRCLE 336

KEPCO, INC.

PFC POWER SUPPLIES

New F Series catalog describes 0.99 power factor corrected switching power supplies from our Moduflex® family of switchers. FT and FS Series models are available in 1 to 7 outputs with power ratings of 400 to 1000 watts. FX Series units feature the 7 outputs required by VXIbus standards. Send for your free copy today or call 800-523-2332.

CIRCLE 337

DELTRON INC.

AMPLIFIER SPECIFICATIONS

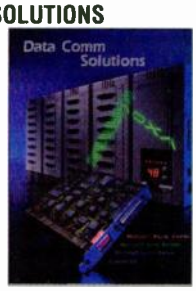
Techron's new brochure features twelve power amplifiers for power utilities, research, industrial and medical applications including magnetic resonance imaging. The amplifiers operate in power ranges from 50 to 2800 watts. Techron products are used also for chemical analysis, space exploration, vibration test systems, radar installations, automotive research, particle acceleration studies, and noise reduction research.

CIRCLE 338

TECHRON

MULTIPORT SERIAL SOLUTIONS

Find the right products for your multiport serial connectivity in this catalog. Moxa Technologies provides full product line of multiport serial solutions, such as asynchronous boards with 2 to 32 ports equipped with programming library, synchronous boards, terminal server and converters. Call: 1-408-734-2224, http://www.moxa.com.



CIRCLE 340

MOXA TECHNOLOGIES

NEW DATA ACQUISITION CATALOG

Keithley MetraByte has just published a 1997 short-form catalog of its popular line of analog and digital I/O boards, data acquisition software, and PC instruments. this new catalog also includes several application examples and technical selector guides that make it easy to compare specs and determine the best solution for your needs.

CIRCLE 339

KEITHLEY METRABYTE

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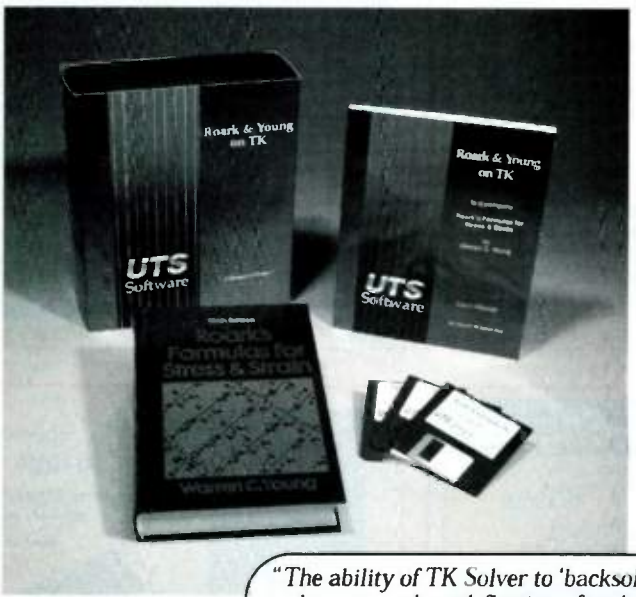
YOUR COMPANY

— Just Released —

Roark's Formulas for Stress & Strain on Windows®

See special offer below

You're 20, 50, 100 times more productive when you use Roark & Young on TK.



Easy to Learn, Easy to Use Roark & Young on TK gives you a nice and compact report, plus the inputs and outputs are neatly organized. You don't get lost in page after page of output as in an electronic handbook or a scratch pad.

Includes every table in the 6th edition.
Shows plots of deflection, stress, bending moment, shear force, and cross sections at the touch of a key – no setup required.
Handles superposition of loads.

And now with TK for Windows:

- Use multiple fonts, cut & paste, the clipboard, and more Windows features.
- View multiple windows/plots at one time.
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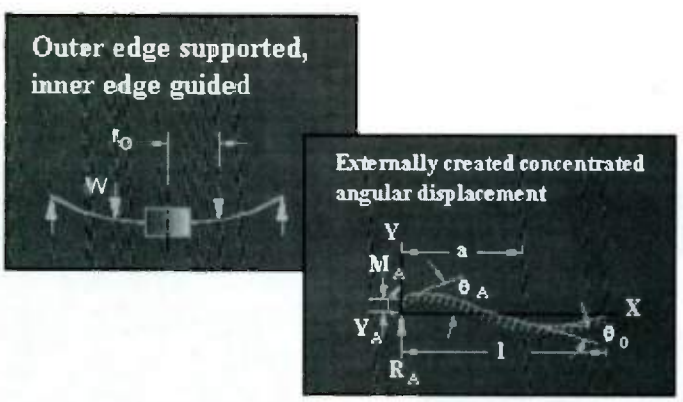

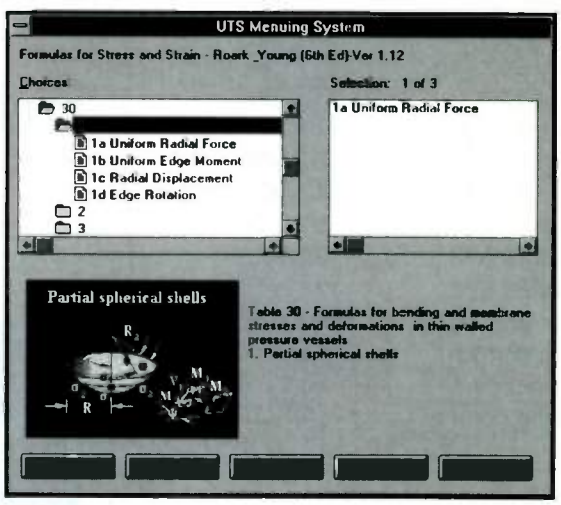

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08 ☐ RISC uPs/uCs
16 ☐ Digital Signal Processors
32 ☐ Video Controller
A2 01 ☐ Video Compression/Decompression
02 ☐ Logic ICs
04 ☐ Storage Controller
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16 ☐ Memory - ROM, PROM, EPROM, EEPROM, Flash
32 ☐ Memory Modules
A3 01 ☐ ICs, other

B Analog/Mixed-Signal Circuits
01 ☐ Mixed Signal Devices
02 ☐ Converter ICs & Modules
04 ☐ Linear ICs & Modules
08 ☐ Communications ICs
16 ☐ Audio Processing
32 ☐ Power Semiconductor Devices
B2 01 ☐ RF Devices
02 ☐ Hybrid Devices
04 ☐ OP Amps

C ASICS
01 ☐ Gate Arrays
02 ☐ FPGA
04 ☐ Programmable Logic Devices (PLD)
08 ☐ Standard Cells
16 ☐ Custom LSI/VLSI
32 ☐ Megacell Functions (CPU cores, etc.)
C2 01 ☐ Analog Cells

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01 ☐ Capacitors, Resistors, Potentiometers
02 ☐ Display Devices
04 ☐ Relays, Switches, Keypads
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16 ☐ Sensors & Transducers
32 ☐ Microwave Components–Hardware & Crystals
D2 01 ☐ Fiber-optic/Optoelectronics
02 ☐ Transformers & Inducters
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08 ☐ Blowers & Fans
16 ☐ Circuit Breakers

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02 ☐ Wire & Cable
04 ☐ Fiber-optic Cable
08 ☐ Enclosures
16 ☐ Materials
32 ☐ Printed Circuits
E2 01 ☐ EMI/EMC Components & Materials

F Power
01 ☐ Power Supplies
02 ☐ Batteries

G Test & Measurement
01 ☐ Logic Analyzers
02 ☐ Development Systems
04 ☐ Oscilloscopes
08 ☐ Other Test Instruments
16 ☐ ATE
32 ☐ Field Test & Service Equipment
G2 01 ☐ Communications/Test Equipment
02 ☐ Data Acquisition Hardware/Software
04 ☐ EMI/EMC Test Equipment

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02 ☐ Workstations
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02 ☐ Analog I/O & Converter Boards
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08 ☐ Disk/Tape Controllers
16 ☐ Communication/Interface
32 ☐ Graphics & Imaging Boards
I2 01 ☐ DSP Boards
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J Communications
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02 ☐ LAN/WAN Hardware & Software
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08 ☐ Graphics Terminals
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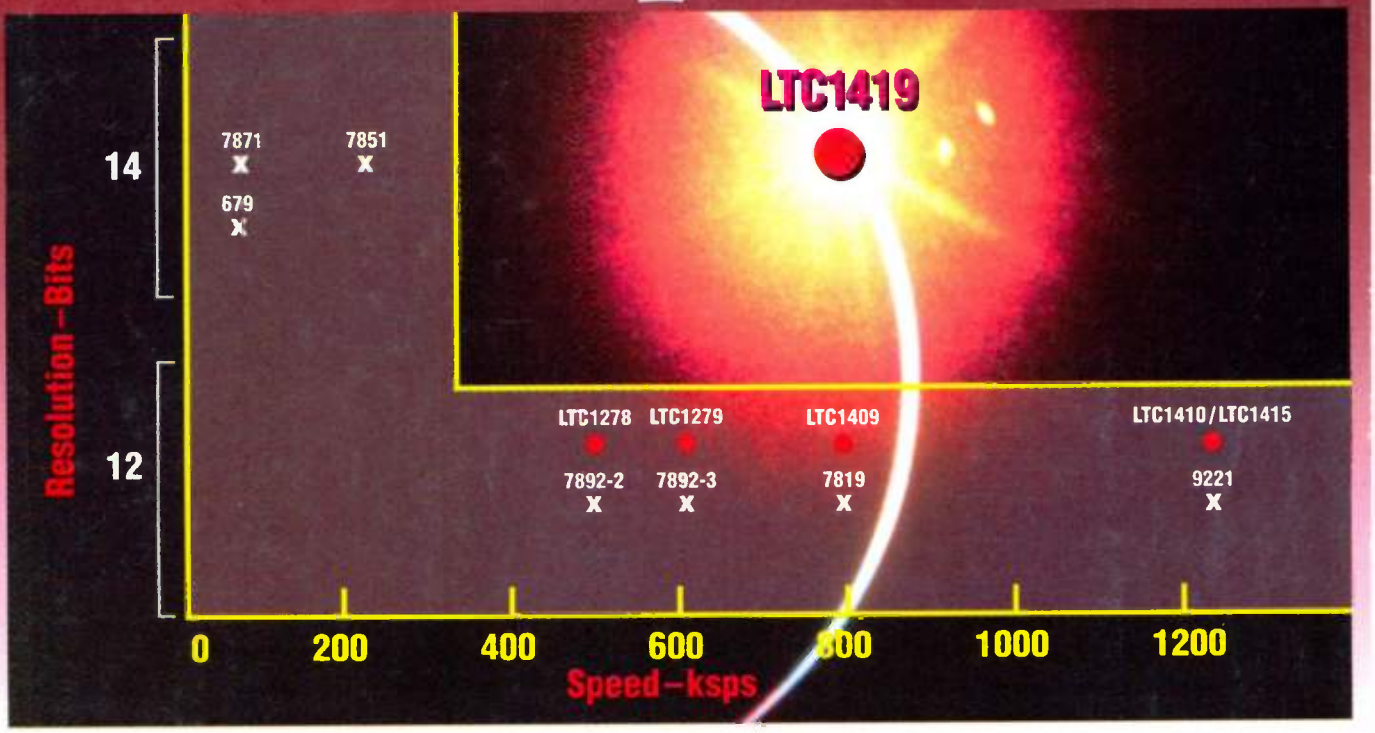

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