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Standards Update

Uncle Sam Cracks Down on Computer Interference

Last Fall's COMDEX show in Las Vegas had a special kind of visitor. Federal marshals were there to seize equipment the FCC had tagged as non-compliant and to serve notice that arrests may follow. The computers were found to be in violation of Part 15 of the FCC rules, which bans sales of most electronic hardware unless tested for compliance.

The event did not surprise most computer executives, some of whom paid their share of more than $800,000 in fines issued by the FCC last year. Said one disgruntled manager, "These guys walk around here like Matt Dillon."

The need to comply has spawned a whole new kind of test business, companies specially skilled in designing and testing for compliance. One of these, the Boxborough, MA-based laboratory of Dash, Straus & Goodhue, combines testing, design and even legal services under one roof, permitting manufacturers to go to COMDEX with their minds on sales, not sanctions. The company even offers a "Guaranteed Rate/Guaranteed Date" plan under which equipment is tested, modified for compliance, and retested per FCC standards for a fixed price guaranteed in advance. The laboratory has been accredited by the National Bureau of Standards for telecommunications and emissions testing, and can be reached at 617-263-2662.

Canada Lays Out the Welcome Mat for Telecom Firms

The Canadian government has swung its doors wide open for US telecom manufacturers. The open door policy is a welcome change for US manufacturers who have found most foreign markets closed to their goods. Canada's free trade telecom policy has allowed savvy manufacturers to increase their sales by up to 20%. But to sell north of the border, firms still need to follow a few simple steps. Most importantly, the equipment has to be registered under Canadian regulations in Part 68. The government of Canada has already approved a number of firms in the United States to do the required telecom testing and submissions. Onesuch firm, Dash, Straus & Goodhue of Boxborough, MA (617-263-2662), has seen a sharp rise in requests for Canadian approvals, especially among the industry's most successful firms. "There seems to be a correlation between economic success and willingness to enter foreign markets," says firm founder Glen Dash.

Fed's Own Instruments Help Manufacturers Comply

What kind of tools can best convince an agency that equipment complies? Why, their own, of course. Now the FCC's own designs are available through a company called Compliance Design. Key to emissions compliance is the use of the Roberts Antenna® developed for the FCC in the 1950's. Willmar Roberts, its inventor, is a former Assistant Chief Engineer of the FCC Laboratory in Laurel, MD.

The antennas are renowned for their near-lossless characteristics. Compliance Design, the exclusive vendor of the Roberts brand, also offers a complete laboratory assembly package. The firm will supply antennas, masts, turntables, site design; and will even perform the crucial "site attenuation" tests the FCC requires. The Boxborough, MA-firm can be reached at 617-264-4968.

Safety Violation Sends a CEO to Jail

On February 13, Kenneth Oden, prosecutor for Travis County, TX, won a landmark case that sent a shiver down corporate backbones nationwide. For the first time, company executives were sentenced to jail terms for negligence that cost a worker his life. The case highlighted a nationwide trend in which prosecutors are holding executives criminally liable for the death of a customer or employee.

For too long, the death of an employee or customer due to a defective or non-compliant product has been viewed as a corporate expense. This latest case, however, noted a change in corporate behavior... and referred 15 cases for criminal prosecution.

For telecom manufacturers, Compliance Design also supplies a Part 68 Workstation containing everything that's needed to comply with FCC, CS-03 (Canada) and EIA standards. The Workstation makes setting up Part 68 laboratories practical for just about everyone.

Overseas, marks such as Canada's CSA and West Germany's GS are required, and foreign courts have been even less tolerant of corporate negligence than have our own. With the profusion of worldwide standards, obtaining those marks has proven to be quite a chore. Fortunately, certain key test labs have set up liaison services which permit worldwide product approvals at one location. Dash, Straus & Goodhue is one such lab and is regularly visited by agents of UL, CSA and West German TuV. Required marks for fourteen countries can be initiated from DS&G's location. Since the Travis County case, according to execs, its business has been brisk. Dash, Straus & Goodhue, Inc. can be reached at 617-293-2902.
rugged plug-in
amplifiers

0.5 to 1000MHz from $13.95

Tough enough to meet full MIL-specs, capable of operating over a wide -55° to +100°C temperature range, in a rugged package... that’s Mini-Circuits’ new MAN-amplifier series. The MAN-amplifier’s tiny package (only 0.4 by 0.8 by 0.25 in.) requires about the same pc board area as a TO-8 and can take tougher punishment with leads that won’t break off. Models are unconditionally stable and available covering frequency ranges 0.5 to 500MHz and 0.5 to 1000MHz, and NF as low as 2.8dB.

Prices start at only $13.95, including screening, thermal shock -55°C to +100°C, fine and gross leak, and burn-in for 96 hours at 100°C under normal operating voltage and current.

Internally the MAN amplifiers consist of two stages, including coupling capacitors. A designer’s delight, with all components self-contained. Just connect to a dc supply voltage and get up to 28dB gain with +9dBm output.

The new MAN-amplifier series... another Mini-Circuits’ price/performance breakthrough.

---

<table>
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<tr>
<th>FREQ RANGE (MHz)</th>
<th>GAIN dB</th>
<th>MAX OUT/PWR dBm</th>
<th>NF dB</th>
<th>DC PWR mA</th>
<th>PRICE $ ea.</th>
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<td>t1 to t2</td>
<td>min</td>
<td>flatness±</td>
<td>max</td>
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<td>10</td>
<td>0.8</td>
<td>15</td>
<td>3.7</td>
</tr>
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CIRCLE NO 189
Tiny SPDT Switch

dc to 4.6GHz... $32.95 (1-24)

Tough enough to pass stringent MIL-STD-202 tests, useable from dc to 6GHz operation, and smaller than most RF switches, Mini-Circuits' hermetically-sealed KSW-2-46 offers a new, unexplored horizon of applications.

Unlike pin diode switches that become ineffective below 1MHz, this GaAs switch can operate down to dc with control voltage as low as -5V, at a blinding 2ns switching speed.

Despite its extremely tiny size, only 0.185 by 0.185 by 0.06 in., the KSW-2-46 provides 50dB isolation (considerably higher than many larger units) and insertion loss of only 1dB. The surface-mount unit can be soldered to pc boards using conventional assembly techniques. The KSW-2-46, priced at only $32.95, is yet another example of components from Mini-Circuits with unbeatable price/performance.

Switch fast...to Mini-Circuits' KSW-2-46

SPECIFICATIONS

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<th>FREQ. RANGE</th>
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<td>200-1000MHz</td>
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<td>1-4.6GHz</td>
<td>1.3 1.7</td>
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<tr>
<td>ISOLATION (dB)</td>
<td>typ min</td>
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<tr>
<td>dc-200MHz</td>
<td>60 50</td>
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<td>200-1000MHz</td>
<td>45 40</td>
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<tr>
<td>1-4.6GHz</td>
<td>30 23</td>
</tr>
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<td>VSWR (typ)</td>
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| SW. SPEED (ns/)
| rise or fall time | 2(typ) |
| MAX RF INPUT (dBm)
| up to 500MHz | +17 |
| above 500MHz | +27 |
| CONTROL VOLT. | -5V on, OV off |
| OPER/STOR TEMP. | -50 to +100°C |
| PRICE | $32.95 (1-24) |

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Setting higher standards

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CIRCLE NO 188

EDN December 10, 1987
DESIGN FEATURES

Hardware and Interconnect Devices

Cooling devices take the heat from SMDs

Shrinking board size has changed the rules for thermal design: A surface-mount assembly that occupies only 40% of the space of its through-hole counterpart can nevertheless dissipate as much power. Achieving adequate reliability requires that you understand and apply the new rules.—Dan Strassberg, Associate Editor

Software

Debuggers help you perfect high-level and real-time code

Because of the increasing use of high-level languages and real-time operating systems, assembly-language debuggers no longer suffice. They’re giving way to debuggers that can correlate target-system activity with high-level source code and ones that can manipulate real-time operating systems.—Charles H Small, Associate Editor

Power Sources

DC/DC converters simplify system power distribution

Although practically every electronic circuit requires a dc power source, not all can operate from the same dc level. For systems that require multiple dc voltages, you may have to design complex power-distribution schemes. Point-source power devices—dc/dc converters—can ease your power-distribution design task.—Tom Ormond, Senior Editor

Integrated Circuits

Cache-memory systems benefit from on-chip solutions

As μP clock frequencies increase, the access time of the memories serving the μPs must decrease. When you use a cache memory, you can use low-cost, relatively slow main memory and still keep up with the microprocessor.—David Shear, Regional Editor

Continued on page 7

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The Primary Source Worldwide®
In the first part of December's showcase, you can read about hardware and interconnect devices, beginning on pg 115; software, beginning on pg 169; power sources, beginning on pg 205; and integrated circuits (shown above), beginning on pg 263.

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THE FIRST PROGRAMMER WITH A SINGLE SITE FOR EVERY DEVICE.

NEW UNISITE 40 HANDLES LEADING-EDGE DEVICES WITH SPEED AND EASE.
Now you can program and test the latest programmable devices and packages, fast and accurately — all in a single site. The first true universal pin drivers support any device of a given package type in the same site. The UniSite™ 40's single DIP socket handles any device up to 40 pins, including PLDs, PROMs, IFIs, FPLAs, EPROMs, EEPROMs, and microcontrollers. The same site accommodates the most popular PLCCs and SO packages. A 16-bit processor, coupled with custom ICs and high-speed RAM, set new speed records for programming and testing.

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A service-based economy may not be a prescription for growth.

PROFESSIONAL ISSUES 363

An experimental graduate-engineering program opens new study opportunities.—Deborah Asbrand, Associate Editor

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A product-oriented design aid

To save you time in your efforts to keep current, EDN’s editors have surveyed the new-product offerings from thousands of companies, screening and selecting only the most significant of those offerings introduced in the last six months. We present our findings—the best of the best—in a format devised to make your product selection as easy as possible. You can keep this Product Showcase as a reference until the next one that covers these four key product areas appears in July.
ONE T800 TRANSPUTER GIVES 2.5 DOUBLE PRECISION MEGAWHETSTONES... SO WHEN IT COMES TO PROCESSING POWER SEVEN INMOS T800 CHIPS COULD GIVE THE MIGHTY CRAY 1.5 RATED AT 163 MEGAWHETSTONES A REAL RUN FOR ITS MONEY!

### SINGLE PRECISION WHETSTONE LEAGUE
- INMOS T800 TRANSPUTER, 4.6 MEGAWHETSTONES.
- INTEL 386/387 16 MHz, 1.8 MEGAWHETSTONES.
- MOTOROLA 68020/68881 20 MHz, 1.5 MEGAWHETSTONES.
- DEC VAX 11/780/VPA, 1.1 MEGAWHETSTONES.

### DOUBLE PRECISION WHETSTONE LEAGUE
- ONE T800 TRANSPUTER GIVES 2.5 DOUBLE PRECISION MEGAWHETSTONES.
MORE MULTIPROCESSOR MUSCLE.
MORE RAW PERFORMANCE.

When you’re out in the trenches fighting it out with ordinary microprocessors, running out of muscle is all too easy. That’s why you should look to the new T800 Transputer from INMOS.

The T800 is the fastest 32-bit, single chip, floating-point microprocessor available today. A quick glance at its statistics will show why nothing else is in its league...

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- 4K Bytes on-chip 50ns static RAM
- Four 20 MBits/sec interprocessor communication links
- Eight independent DMA engines

All on a single chip capable of sustained 1.5 MFLOPS...and 4.6M Whetstones!

And, if that’s not enough raw power, the T800’s links allow multiprocessor systems to be constructed quickly and easily — giving you 6 MFLOPS with four T800s...30 MFLOPS with 20...150 MFLOPS with 100...In fact, there’s no limit to the number of Transputers you can use!

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Want to turbocharge your current system? No problem. Our exclusive Link Adaptor IC’s allow Transputers to be connected to other microprocessors or peripherals.

Other team members include the pin compatible T414 Transputer, offering lower cost, 10 MIP performance and 0.75M Whetstones.

Lined-up to provide all the I/O processing you need, the T212 16-bit Transputer is the ideal high performance controller and the M212 Disk Processor combines disk controller hardware and a Transputer on a single chip, supporting both Winchester and floppy disks. And the C004 Link Switch makes the design of software reconfigurable multiprocessor systems as easy as kicking an extra point.

Whatever field you’re in — from real-time distributed systems to high-performance graphics, from fault-tolerant systems to robotics, Transputer technology can give you scalable performance at a cost you can afford.

Transputers are manufactured using an advanced 1.5 micron CMOS process which keeps the power consumption under one watt. So your system stays cool while under fire.

Transputers to MIL-STD 883C will be available in the first half of 1988.

If this all sounds like your kind of game, put the ball in play by contacting your local INMOS sales office today. And get ready to score.

---

**DESCRIPTION**

<table>
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<tr>
<th>Port No.</th>
<th>Description</th>
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<td>IMS C012</td>
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**THE TRANSPUTER TEAM**

INMOS, Colorado Springs, Colorado 80935. Tel. (303) 630-4000.

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To get your hands on TAXI, just call 1(800) 634-TAXI. And when someone says "You can't move data that way!" you can just smile and say, "Watch."

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That's why we always take a conservative approach to the design process. Giving you realistic worst case specs that no production device will exceed.

Guaranteeing a minimum 90% utilization of all gates. And giving you a simulation-to-production correlation of 99%.

It's also why we control every step of the production process. From design to wafer fab to assembly and final test, including 100% AC testing at frequency. So nothing is left to chance.

To us, reliability in the field is everything. And when you remember we've taken over 8,000 ASIC devices from design through mass production, you can see that we'll give you a level of confidence no one else can offer.

So count on parts that have longer life expectancies.

Call our Hot Line today at (800) 556-1234, Ext. 82; in California (800) 441-2345. Look into ASICs you can send out the door. Never to return again.
More power for less than the cost of a TO-126 bipolar 50-Volt HEXDIPs

When it comes to motor drive control or high-side switching of grounded loads, our new N- and P-Channel 50V HEXDIP power MOSFETs deliver more at less cost than do equivalent bipolar devices.

Here are some reasons why.

Unlike traditional die-mounting, HEXDIP chips are mounted on a dual-drain copper tab, resulting in power dissipation of up to 1 Watt—more than any FET in its class.

Designed for automatic insertion, our 4-pin HEXDIP packages are end-stackable on 100 mil centers. This cuts assembly time. And there’s no wasted board space in high density packing applications.

Four new HEXDIP 50V Series are available in N- and P-Channel types for today’s state-of-the-art designs in automotive electronics, power supplies, and motor drive control circuits.

Rds(on) ranges from a low of 0.10 Ohms, with current ratings up to 2.4 amps depending on die size. For complete data, call (213) 607-8842. Today.

Most HEXFETs now in stock for immediate delivery!
Only one company has the technology, the resources, and the vision to top the 68020.
Introducing the 68030.

The next generation.

In 1984, we introduced the 68020. Now, three years later, it has the largest installed and broadest application base of any 32-bit MPU on the market. Having set that standard in the first place, we feel qualified to raise it. Which is why the only microprocessor that really surpasses the 68020 is our second generation 68030.

Meet the '030!
The '030 is twice the microprocessor its predecessor is. It's the first to sport an instruction cache, data cache and MMU on-chip. Combined with a Harvard-style parallel bus architecture that allows simultaneous, multiple fetches of instructions and data, processor throughput is pushed to unmatched levels.

What can you do with all that performance? Anything you like—from low-cost personal workstations to super-computers—and the 68030 will help you to do it less expensively.

With its burst fill mode for the dual caches, you'll be able to squeeze SRAM performance from low-cost DRAMs. It gives you graphics capability without the need for a graphics co-processor. And there's true object-code compatibility between the '030 and the '020. All this adds up to economies you can count on.

An architecture you can build on.
And count on.

Application software that runs on any 68000 family MPU runs on the 68030. There's also a full array of development tools, and a new 68882 floating point co-processor, with up to 4x the performance of its predecessor. All of which gives your product plans an enormous amount of continuity. And that's not going to change. Since the 68030 supports both MS-DOS® and UNIX® V3, you can have your pick of over $12 billion worth of applications—and the broadest possible market.

With Motorola, you can see forever.

Our plans for the rest of the 68000 family extend well into the future, offering continuing compatibility and leading-edge performance. So you can go with Motorola, not just for what our microprocessors can do now, but what you'll be able to do with them later on.

For more information about the new 68030, call us toll-free at 800-521-6274 or write, Motorola Semiconductor Products, Inc., P.O. Box 20912, Phoenix, AZ 85036.
Now scan and record temperatures from freezing to scorching.

The new Fluke 52 goes to great extremes to outperform any other handheld thermometer.

With extra features, like our exclusive SCAN mode. Touch the button, and your Fluke 52 sequentially scans the readouts of two temperature inputs, and their difference.

Hit the RECORD button, walk away, and record the minimum and maximum from any one of these three channels for up to 1,200 hours. For troubleshooting intermittent problems, overnight monitoring, inlet/outlet servicing, and comparing trend information, it can't be beat.

If you don't need the scanning and recording features, you may prefer the single-point Fluke 51. Like the 52, it's easy to use, offers unsurpassed accuracy with resolution to 1/10th of a degree, and can use any K or J type thermocouple probe to fit your application.

Even the warranty goes to great extremes: three years on parts and service — the longest in the industry. And prices start as low as $119.

But you don't have to go to extremes to get one.

Just contact your local supplier now for immediate delivery.

Or for more information, call toll-free 1-800-227-3800, Ext. 229.

FROM THE WORLD LEADER IN HANDHELD TEST INSTRUMENTS.

**Fluke 51** Single Input

Measurement range: K-type: -200°C to +1370°C (-328°F to +2498°F)
J-type: -200°C to +760°C ( -321°F to +1400°F)

Accuracy: K-type is ±(0.1% of reading +0.7°C or 1.3°F)
J-type is ±(0.1% of reading +0.1°C or 1.4°F)

°C or °F Selectable

**Fluke 52** Dual Input

Scan, Differential, and Min/Max Recording Modes (52 only)

Standard mini-connector input

1200 hour 9V battery life

3-year warranty

General-purpose K-type bead probe included (two with 52).
THE LONG-AWAITED MC68030 FINALLY ARRIVES

The MC68030 32-bit μP from Motorola (Phoenix, AZ, (512) 440-2839) is now available. The 68030, which is fully compatible with the 68000 family, has on-chip data and instruction caches, a parallel (Harvard-style) architecture, and an on-chip memory-management unit. The vendor claims the 68030 achieves twice the performance of the 32-bit MC68020. The 68030 is currently available in 16- and 20-MHz versions priced at $400 and $550, respectively. The MC68882 math coprocessor (its 16- and 20-MHz versions cost $245 and $375, respectively) offers two to four times the performance of the MC68881, with which it is pin and software compatible.—David Shear

INSTRUMENT MONITORS FREQUENCY AND TIME-INTERVAL VARIATIONS

For more than a generation, engineers have been able to buy digital counters that sit on a benchtop and monitor time intervals, frequency, and phase. Some of these instruments provide outputs that can drive recording devices to indicate how the measured quantities vary over minutes, hours, or days. Now, Hewlett-Packard (Santa Clara, CA) is introducing the HP 5371A frequency and time analyzer, which, though it measures frequency and time, is quite unlike conventional counters. For example, it measures frequencies as high as 500 MHz, using sampling intervals as short as 100 nsec, with no dead time between measurements.

The analyzer performs a variety of firmware-based calculations on data it acquires, and it incorporates a CRT, which can display such information as histograms and plots of measured values vs time. HP expects the $21,500 analyzer to find application in development and testing of frequency-agile and digital communications systems, radar, electronic warfare systems, data-storage peripherals, and electromechanical devices.—Dan Strassberg

VME BUS INTERFACE CARD LINKS TO 96 RS-232C DEVICES

Using 1M-bps serial links to communicate with as many as six SYS336M16 Deltalink servers, the $1800 MVME336K Deltalink hub card from Motorola Inc’s Microcomputer Div (Tempe, AZ, (600) 441-2345 ext 230) connects 96 full-duplex, RS-232C devices to a VME Bus-based system. Each $1800 server provides 16 RS-232C ports, and links to the hub card by means of as much as 800 ft of unshielded, twisted-pair cable (including telephone cord.) The Deltalink protocol encapsulates RS-232C transmissions in HDLC packets that provide both transport and error checking. Motorola currently incorporates drivers for this product in release 3 of its System V/68 operating system; the company will provide source code for driver routines to customers who wish to use the hardware with other operating systems.—Steven H Leibson

MODEM GIVES STD-BUS SYSTEMS PROGRAMMABLE COMMUNICATION

Supporting the full Hayes AT command set for modem control, the MCM-Modem from WinSystems (Arlington, TX) is the first STD-bus card that can provide systems with programmable, full-duplex 1200/300-bps Bell 212A/102 and CCITT V.22 and V.21 communications. The onboard Data Access Arrangement connects an STD-bus system directly to dial-up telephone lines. The modem card also offers self-test, autoanswer, autodial, and call-monitoring functions. An auxiliary RJ-11 jack lets you plug in a separate telephone handset. You can program this $395 modem to communicate at speeds ranging from 50 to 1200 bps.—J D Mosley
REAL-TIME OPERATING SYSTEM FOR RISC µP

Ready Systems (Palo Alto, CA, (415) 326-2950) has signed a contract with Advanced Micro Devices (Sunnyvale, CA) to port Ready's VRTX32 to AMD's forthcoming Am29000. VRTX32 is a multitasking executive designed for real-time embedded computer applications. It will work on the Am29000 without modification, so you should be able to move your high-level-language code from other processors to the Am29000 without revising the code. The Am29000 is a 32-bit µP based on a reduced-instruction-set computer (RISC) architecture and targeted at embedded applications. VRTX32 for the Am29000 will be available in May 1988 and will cost $9000.—David Shear

WORKSTATION TRANSFORMS 300,000 VECTORS/SEC

The HP 9000 Series 330CHX and 350CHX workstations transform as many as 250,000 and 300,000 vectors/sec, respectively. The workstations, from Hewlett-Packard (Fort Collins, CO), can achieve this level of performance because they each include an HP 98556A graphics accelerator. The accelerator is also available separately for $6000; you can use it with the vendor's 330CH and 350CH workstations. The 330CHX costs $22,250; the 350CHX sells for $38,550.—Jim Wiegand

SYSTEM AUTOMATES PLACEMENT, ROUTING, AND POSTPROCESSING

Combining hardware and software tools that automate the entire pc-board-design task, the PCB design system from Intergraph (Huntsville, AL, (205) 772-2000) helps you develop your concept from package placement through photoplotting. It costs $120,000. The design system includes a Micro II data-processing unit with tape drive, two InterPro 32C workstations, and software for pc-board design, automatic packaging and placement, automatic routing, and photoplotting.—J D Mosley

PLOTTERS SPEC 32-IPS PEN SPEED; OFFER SCANNING OPTION

For $4695, you can buy a DMP-61 single-pen plotter with an axial pen speed that reaches 32 ips and a maximum axial acceleration of 4g for A- through D-size drawings. For E-size drawings, the $6495 DMP-62 provides a maximum pen speed of 24 ips with a 2g acceleration. Both of these 68000-µP-based plotters from Houston Instruments (Austin, TX, (512) 835-0900) accept options such as the $750 MP-60 pen changer, the $2995 Scan-Cad optical scanner, a $995 1M-byte-buffer board with a replot feature for drawing multiple originals, and a $495 Kanji character-set board.—J D Mosley

CAD/CAE/CAM VENDOR CLIMBS ABOARD STANDARD PLATFORM

Cadnetix Corp (Boulder, CO, (303) 444-8075) has ported its CAD and CAE software packages to Sun Microsystems' (Mountain View, CA) workstations and become an OEM for those systems. The vendor calls these new workstation/software packages the Concept 3 family. The company offers the CDX-9600, a $15,900 CAE workstation based on the Sun 3/60, and the CDX-56000, a $89,900 CAD system that's also based on a Sun 3 workstation. The CAD system incorporates a graphics processor developed by the vendor that performs 400,000 vector clips and transformations per second. The Concept 3 family also includes a CAM workstation, the CDX-61000, for $88,900. Because the vendor's proprietary offerings incorporate Sun's LAN communications protocols, all of the vendor's existing products (which the company continues to offer), including its route engines, are compatible with the Concept 3 family.—Steven H Leibson
Imagine what you could do with a little quick cache.

A quick cache like DisCache, the unique drive-resident caching feature available on Quantum Q200 Series of half-high 5¼" intelligent disk drives.

A Quantum 53 or 80-megabyte (formatted) drive with its integrated SCSI controller and DisCache can help your system perform faster and smarter. Depending upon the application, DisCache can actually cut disk transaction times in half by reducing seek and rotational latency delays.

DisCache acts as a high-speed memory between the disk and the host system. DisCache anticipates sequential host requests by looking beyond the current data request and storing adjacent data in cache memory. When the host requests this data, it is accessed in microseconds from the 60 KB of high-speed memory instead of in milliseconds from the disk.

Since typically 50% or more of all disk requests are sequential, DisCache can make your systems substantially faster. And that can help your systems sell faster.

DisCache is as flexible as it is fast, with programmable options to tailor caching parameters to suit your system.

DisCache is an option on both our Q250 and Q280 drives. Each drive features Quantum's innovative design and exceptional reliability.

Call or write for more information about DisCache and the Q200 Series of half-high 5¼" intelligent disk drives.

We'll show you what a little quick cache can do for your business.


Quantum
First In Intelligent Disk Drives
CHANNELLESS GATE ARRAYS SUIT A VARIETY OF ASIC REQUIREMENTS

Combining the resources and technologies of its merged parent companies (SGS and Thomson Semiconductors), Innovative Silicon Technology (Agrate Brianza, Italy, TLX 330131) has introduced 1.5- and 1.2-μm, single-level-poly, double-level-metal gate-array families based on the sea-of-gates principle. The ISB8000 family comprises four 1.5-μm arrays having gate counts of between 3500 and 21,000. They suit random logic designs, and have output drivers with 24-mA capability.

Suitable for use in high-pin-count designs, the 1.5-μm ISB9000 family comprises 10 gate arrays with gate counts of between 288 and 21,000. The 1.2-μm ISB12000 family comprises 10 gate arrays with gate counts of between 8000 and 128,000. The ISB12000 arrays have a typical layout efficiency of 40% for random logic, but they easily accommodate large blocks of RAM and ROM. The 2-input NAND-gate propagation delays for the ISB8000, ISB9000, and ISB12000 arrays are 0.7 nsec, <0.7 nsec, and 0.6 nsec, respectively. The vendor expects to offer the larger ISB8000 gate arrays for between $0.18 to $0.19 (10,000) per gate for devices packaged in plastic leaded chip carriers.

—Peter Harold

IC-DESIGN SOFTWARE ENVIRONMENT ADAPTS TO CHANGING TOOL SETS

The Spirit IC-design software environment from Integrated Circuit Design (Enschede, The Netherlands, TLX 72280) provides you with a stable user interface through which you can access a variety of proprietary or commercial IC-design software tools. If you add to or change the set of design tools, the user interface remains the same, eliminating the need to learn a new user interface for each tool. In addition to the user interface, the tool set is surrounded by a design manager, a design database, and a foundry interface that allows you to meet the requirements of different silicon foundries. System-management software allows the system administrator to create and change information about users, projects, foundries, libraries, and process parameters. Priced at approximately $175,000 (including a tool set), Spirit is intended for use by teams that create full-custom IC designs. It is available for use on the Apollo Domain 3000 workstation, HP 9000 Series 300 and Series 500 computers, and the PCS Cadmus computer.—Peter Harold

16-BIT PARITY GENERATOR/CHECKER OPERATES AT 30 MHz

You can generate parity for 16-bit data with a single device by using the CMOS-compatible PC74HC7080 or TTL-compatible PC74HCT7080 parity generator/checker from Philips’ Components Div (Eindhoven, The Netherlands, TLX 51573; in the US, Signetics Corp, Sunnyvale, CA, (408) 991-2000). For 16-bit data, the device operates at speeds as high as 30 MHz. Two cascaded devices generate parity for 32-bit systems at speeds as high as 20 MHz. You can select even or odd parity generation on an active-high or active-low output. At 20 MHz, both versions dissipate 17 mW typ. They operate over -40 to +125°C and come in 20-pin DIPs or small-outline surface-mount packages. Approximately $0.25 (100).—Peter Harold

ADAPTER CONVERTS 68-PIN PGA TO PLCC

If you’re developing a design that will incorporate a device in a 68-lead plastic leaded chip carrier (PLCC), but you can only obtain the device in pin-grid arrays (PGAs), the 308-1846-XX Series adapter from Methode Electronics Inc (Chicago, IL, (312) 667-9600) can solve your problem. The top of the adapter accepts a 68-pin PGA; PLCC leads protrude from the bottom. The adapter is available in 10x10 and 11x11 grid patterns and costs $265 in production quantities.—Steven H Leibson
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- 12 Volt Power Supply Required
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- 256 Canned Messages in CMOS RAM
- 1/2" Characters Utilizing Gas Plasma Technology
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- Full and Half Duplex Communication

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Accepts RS232 & 20mA Serial ASCII Input

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The tiny, non-hermetic package houses RF transformers, a ceramic-alumina substrate, and a four-diode assembly. A unique edge-plated design eases the job of making reliable solder connections to a printed-circuit board. A protective-barrier layer on top of the package’s conductive layer retards the harmful effect of electromigration which may occur during soldering. The RMS can be attached to a pc-board by conventional manual soldering or with automatic equipment; mixers can be supplied in a tape-and-reel format for automated pick-and-place machines.

When you think SMT, think small, low-cost... think Mini-Circuits RMS series.

Finding new ways... setting higher standards

Mini-Circuits

SPECIFICATIONS

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<th>RMS-1</th>
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<td>FREQUENCY RANGE, MHz</td>
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<td>LO, RF</td>
<td>0.5 — 500</td>
<td>5 — 1000</td>
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<td>IF</td>
<td>DC — 500</td>
<td>DC — 500</td>
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<td>7.0</td>
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<tr>
<td>PRICE (10-49)</td>
<td>$6.95</td>
<td>$7.95</td>
</tr>
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</table>

f_L = lowest frequency in range
f_H = highest frequency in range
dc to 3GHz
- less than 1dB insertion loss over entire passband
- greater than 40dB stopband rejection
- 5 section, 30dB per octave roll-off
- VSWR less than 1.7 (typ)
- over 100 models, immediate delivery
- meets MIL-STD-202
- rugged hermetically sealed package (0.4 x 0.8 x 0.4 in.)
- BNC, Type N, SMA available

<table>
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<tr>
<th>LOW PASS Model</th>
<th>*LP-</th>
<th>10.7</th>
<th>21.4</th>
<th>30</th>
<th>50</th>
<th>70</th>
<th>100</th>
<th>150</th>
<th>200</th>
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<th>600</th>
<th>750</th>
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<td>32</td>
<td>48</td>
<td>60</td>
<td>98</td>
<td>140</td>
<td>190</td>
<td>270</td>
<td>400</td>
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<td>580</td>
<td>750</td>
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<tr>
<td>Max. 20dB Stop Frequency (MHz)</td>
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<td>47</td>
<td>70</td>
<td>90</td>
<td>147</td>
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<td>290</td>
<td>410</td>
<td>580</td>
<td>750</td>
<td>840</td>
<td>1000</td>
<td>1100</td>
<td>1340</td>
<td>1500</td>
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Prices (ea.): P $9.95 (6-49), B $24.95 (1-49), N $27.95 (1-49), S $26.95 (1-49)

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<tr>
<th>HIGH PASS Model</th>
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<th>50</th>
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<th>700</th>
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<tr>
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<td>41</td>
<td>90</td>
<td>133</td>
<td>185</td>
<td>225</td>
<td>290</td>
<td>395</td>
<td>500</td>
<td>600</td>
<td>700</td>
<td>780</td>
<td>910</td>
<td>1000</td>
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<tr>
<td>end, min.</td>
<td>200</td>
<td>400</td>
<td>600</td>
<td>800</td>
<td>1200</td>
<td>1200</td>
<td>1600</td>
<td>1600</td>
<td>1600</td>
<td>1800</td>
<td>2000</td>
<td>2100</td>
<td>2200</td>
<td></td>
</tr>
<tr>
<td>Min. 20dB Stop Frequency (MHz)</td>
<td>26</td>
<td>55</td>
<td>95</td>
<td>116</td>
<td>150</td>
<td>190</td>
<td>290</td>
<td>365</td>
<td>460</td>
<td>520</td>
<td>570</td>
<td>660</td>
<td>720</td>
<td>1500</td>
</tr>
</tbody>
</table>

Prices (ea.): P $12.95 (6-49), B $27.95 (1-49), N $30.95 (1-49), S $29.95 (1-49)

* Prefix P for pins, B for BNC, N for Type N, S for SMA example: PLP-10.7

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Tel: 08-732-8200. Telex: 13839 NECSCAN S.
France
Tel: 1-3945-9617. Telex: 69948 NEC EF.
Italy
Tel: 02-6701508. Telex: 315355 NEC IT.
UK
Tel: 0908-691133. Telex: 826791 NEC UK G.

Asia
Hong Kong
Tel: 1-829-9008. Telex: 546561 HKNEC HX.
Taiwan
Tel: 02-522-4192. Telex: 223722 HKNEC TP.
Singapore
Tel: 4018081. Telex: 39726 NECES N.

Oceania
Australia
Tel: 02-267-6355. Telex: AA38343 NECCD.
Motor's inductance is unlikely to decrease

In his article, "Proper design trade-offs translate to a precise position-control system" (EDN, August 6, pg 167), Yoram Hirsch writes (on pg 173) that the winding inductance of the motor used in his tests “actually decreases with increasing frequency.” He continues: “As unlikely as this might seem, measurement results indicate that, even though the winding inductance is about 3 mH at 1 kHz, it is only 0.8 mH at 100 kHz.” Yet, the thing that he describes is, in my opinion, easily explained.

The simple equivalent circuit of a motor’s winding, whose impedance appears simply as an inductor and a resistor in series, is not usable at high chopping frequencies. Here the distributed winding capacitance, eddy-current losses, and other factors come into play, and you account for them by adding a few more components to the old model.

The accompanying figure shows one attempt at such a model (a). It consists of two inductors, two resistors, and one capacitor. Its complex impedance, calculated at 20 kHz and 100 kHz, is seen to be inductive. Yet the imaginary parts are at a ratio of 2.3:1 instead of 5:1. If you measured the equivalent series inductance on a bridge, you would read 3.3 mH at 1 kHz, 1.2 mH at 20 kHz, and 0.6 mH at 100 kHz, is seen to be inductive. Yet the imaginary parts are at a ratio of 2.3:1 instead of 5:1. If you measured the equivalent series inductance on a bridge, you would read 3.3 mH at 1 kHz, 1.2 mH at 20 kHz, and 0.6 mH at 100 kHz.

**NOTE:**

At 20 kHz
\[ z = 149 + j148; \]

At 100 kHz
\[ z = 180 + j349. \]
Anatomy of a dot.

EXEMPLARY THIXOTROPIC QUALITIES
higher dot aspect ratio with no sacrifice in flow or reproducibility.

WIDE PROCESS FLEXIBILITY
variable cure cycles to meet your production speed.

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superior chip shear strength after cure ensures reliability and reduces rework.

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mH at 100 kHz. Furthermore, the current waveforms shown in the accompanying figure (Spice simulation at ±40V square wave) are strikingly similar to the oscilloscope photos in Fig 8 of the article (pg 172).

As a consequence, it is unlikely that the motor's inductance decreases with increasing frequency. But if in fact it happens, then let us have some explanation of the mechanism causing such a strange effect.

Claudio de Sa e Silva
Unitrode Integrated Circuits Corp
Merrimack, NH

Misplaced resistor
Please note a correction to the Design Idea "Low-power circuit splits supply voltage" (EDN, October 1, pg 198). The 5-kΩ resistor belongs after the 0.01-µF capacitor, as shown below, and not in series with the op amp's inverting input as in the original figure.

Correction
The News Breaks section of the September 17 issue (EDN, pg 21) listed an incorrect phone number for James Electronics, a Chicago, IL, maker of 4W adapters. The correct number is (800) 438-1400; in IL, (312) 463-6500. Please also note that the company offers a line of sixteen 4W adapters (not 16 and 4W adapters as the article states.)

Solenoid control design tips
if you ramp the input current. Used as a hydraulic valve actuator, you can eliminate hydraulic shock.

Solenoids are used to control the performance of devices such as valves, gates, and dampers. New research and development provides better design capability over solenoid parameters and characteristics to make them a system designer's dream come true. Designers are specifying solenoids in applications that once used other actuators.

Some hot solenoid applications
- Variable, repeatable positioner
- Fly-by-wire
- High speed liquid metering
- Safe-arm locks
- Fuel injection

Design benefits
The simpler control required by solenoids means faster product development cycles, higher reliability from fewer interfaces, high force and speed capabilities. A solenoid is practically made for digital control because it's a pulsed device. And its few components can be optimized.

Example: Want higher speed actuation than a given solenoid allows? Consider using two or more smaller, faster solenoids and take advantage of their multiplied force.

Example: A designer wanted a solenoid to operate within a millisecond, in a window only 70 microseconds wide. With a specified life of 500 million cycles! Ledex solenoids are repeatable, predictable, reliable.

Workhorse
Ledex Soft Shift™ variable positioning solenoid starting force is 3 to 5 times conventional, using the same power. It can actuate in milliseconds, or its plunger velocity can be controlled smoothly and noiselessly.

5 Controllable characteristics
Look at the variety of parameters and characteristics the designer can optimize. Force Speed Life Acceleration Quality Noise Repeatability Reliability. Design flexibility also comes by using controls, such as: Current limiting Pulse (A to D) Position sensing Packaged switches. Call on Ledex to discuss your application. Often just a phone call will start a shelf-stocked solenoid on its way.

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Finally, 14 different standalone workstation and high-performance terminal products let you shape and reshape each configuration to fit your evolving needs.

For more information on the graphics workstations that run circles, cylinders and solids around the competition, contact your local Tektronix representative.

Or call 1-800-225-5434. In Oregon, 1-235-7202.
Motorola announces one of the smallest advances in the history of VME.
Motorola puts awesome multiprocessing performance on two new single-board computers.

As computer applications get more complex, OEMs are turning more to multiprocessing designs. To handle things like CAD/CAM, robotics, signal processing, simulation and large-scale data acquisition, a single processor simply can't keep up.

Adding several CPUs to a system off-loads the main processor, but what happens to the system bus? It frequently reaches saturation, slowing down the entire system.

Motorola introduces a single chip solution to this problem. The VME Subsystem Bus, a fast, 32-bit secondary bus, has been implemented on a gate array at Motorola. The end of the multiprocessor traffic jams.

The VSB sub-bus removes traffic from the VMEbus, increasing total system throughput. And by saving space on the VSB—and other components—Motorola has been able to pack an impressive array of multiprocessor functions onto two standard VME boards: the MVME135 and MVME136. These highly integrated microcomputers include all the functions usually required for high-performance multiprocessing. In addition to the VSB, they feature the MC68020 with floating-point coprocessor, both running at either 16.67 or 20.0MHz.

For virtual memory environments, a demand-paged memory management unit can also be added. Plus 1 Megabyte of shared local dynamic RAM is included—with optional parity—designed to operate with zero wait states.

Included in the 135/136 modules are many special hardware features that facilitate multiprocessing. Things like MP control and status registers. An expanded interrupt-handling mechanism. And master/slave control bit settings.

Hardware alone is hardly enough.

Complete multiprocessing hardware on a single board saves you design time and system space. But to get your application up and running on a tight schedule, it takes software and support tools too. Like those available from Motorola.

If you're building a multi-user/multi-tasking system, you can use our version of AT&T's UNIX® System V Release 3, with Remote File Sharing. For real-time tasks, there's our full-featured VERSAdos® operating system, as well as debugging firmware with on-board diagnostics. Then too, you have access to third-party software such as OS-9™, MTOS™, PDOS™, pSOS™, RTUX™, and VRTX™.

Add to that Motorola's in-depth technical support. We have more experience in building reliable, high-performance VME system components than any other vendor. Plus a specialized systems and support staff available at over 100 field offices worldwide.

To see how good multiprocessors can come in small packages, call us toll-free today: 1-800-556-1234 Ext. 230 (in California, 1-800-441-2345 Ext. 230). Or write: Motorola Microcomputer Division, 2900 South Diablo Way, Tempe, AZ 85282.

MVME135/136 Highlights

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MVME135</td>
<td>VMEbus 32-bit SBC; 16.67-MHz MC68020 CPU; MC68881 FPU; 1Mb on-board DRAM; up to 512 Kbs EPROM; two RS-232-C serial ports; two 16-bit timers; master/slave interface; MP control and status registers; system controller</td>
</tr>
<tr>
<td>MVME135-1</td>
<td>Same as MVME135, but with 20-MHz MC68020 CPU</td>
</tr>
<tr>
<td>MVME136</td>
<td>Same as MVME135, but with MC68851 PMMU</td>
</tr>
</tbody>
</table>

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CALENDAR


Third Annual Battery Conference on Applications and Advances, Long Beach, CA. Cecile Duong, Department of Electrical Engineering, California State University at Long Beach, 1250 Bellflower Blvd, Long Beach, CA 90840. (213) 498-4605. January 12 to 14.


Modern Electronic Packaging (seminar), Orlando, FL. Technology Seminars, Box 487, Lutherville, MD 21093. (301) 269-4102. February 9 to 11.
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- An exciting industry first, InSight blends analyzer/emulator techniques to give you continuous, real time monitoring of key processor functions. See changing register contents, I/O lines, ports, user-defined memory windows. With your own labels. And all at once. Interactively. Without stopping your program.

- InSight is made possible by the 8620's advanced bus state analyzer, its 2750-bus-cycle trace buffer, and a new high-speed parallel interface that eliminates RS-232 bottle necks.

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- On top of that, you get a new, crystal-controlled 1μsec clock for super precise event timing.

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- Look into it.


Computer Integrated Instrumentation
702 Marshall Street, Redwood City, CA 94063
Telex: 530942

InSight is a trademark of Orion Instruments, Inc.
CALENDAR

Unix Technical Conference, Dallas, TX. Usenix Conference Office, Box 385, Sunset Beach, CA 90742. (213) 592-1381. February 9 to 12.


Modern Electronic Packaging (seminar), Torrance, CA. Technology Seminars, Box 487, Lutherville, MD 21093. (301) 269-4102. March 16 to 18.


IEEE Instrumentation/Measurement Technology Conference (IMtc/88), San Diego, CA. Bob Myers, IMtc, 1700 Westwood Blvd, Los Angeles, CA 90024. (213) 475-4571. April 19 to 22.

Modern Electronic Packaging (seminar), Washington, DC. Technology Seminars, Box 487, Lutherville, MD 21093. (301) 269-4102. April 21 to 23.


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Over 80 Dual and Quad Models Available

<table>
<thead>
<tr>
<th>Model Number</th>
<th>No. of Channels</th>
<th>Isolation Between Input/Output Channels</th>
</tr>
</thead>
<tbody>
<tr>
<td>PWR5038</td>
<td>2</td>
<td>500VDC</td>
</tr>
<tr>
<td>PWR53XX</td>
<td>2</td>
<td>1000VDC (1), 1000VDC (2)</td>
</tr>
<tr>
<td>Series</td>
<td></td>
<td></td>
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<tr>
<td>PWR8XX</td>
<td>2</td>
<td>1000VDC (1), 1000VDC (2)</td>
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<tr>
<td>Series</td>
<td></td>
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</tr>
<tr>
<td>PWR74</td>
<td>2</td>
<td>1500VDC (1), 750VDC (2)</td>
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<tr>
<td>Series</td>
<td>4</td>
<td>1000VDC (2), 1000VDC (3)</td>
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<tr>
<td>PWR55XX</td>
<td>4</td>
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</tr>
<tr>
<td>PWR71</td>
<td>4</td>
<td>1000VDC (2), 1000VDC (3)</td>
</tr>
<tr>
<td>PWR1017</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

(1) Available with multiple input/output voltage combinations.
(2) Tested at 2 times rating +1000VDC.

SGS-THOMSON Microelectronics--The Brighter Power--of course. The L6100 and L6102 are implemented in our unique Multipower-BCD™ technology, which allows complete isolation of the output MOSFETs. With prices starting at less than $2 in 10K quantities, the 100V, 5A/8A devices open up a whole spectrum of design possibilities.

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Regardless of whether you’re driving unipolar DC motors, stepper motors, needle solenoids or many other types of loads—the fast switching, easily paralleled L6100/2 delivers the economy and reliability to turn design possibilities into realities.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V_{DS\text{ Max}} )</td>
<td>100V min</td>
</tr>
<tr>
<td>( I_D ) (Powerdip)</td>
<td>1.5A cont., 5A peak</td>
</tr>
<tr>
<td>( I_D ) (Multiwatt)</td>
<td>2.0A cont., 8A peak</td>
</tr>
<tr>
<td>( R_{DS(\text{ON})} )</td>
<td>1.2 Ohms max</td>
</tr>
</tbody>
</table>

Packages
- Powerdip (18 pin) L6100
- Multiwatt (15 pin) L6102
FOUR ISOLATED IN A SINGLE CHIP?

SGS-THOMSON's exclusive Multipower-BCD™ technology—that's integrated Bipolar, CMOS, DMOS—has a lot more to offer. What other smart power IC technology isolates the DMOS output power transistors to let you connect as many as you need on a chip anyway you like? None.

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So you can see that we have the capability to supply the memory products you want—when you want them.

That's memory power; that's Toshiba.

### Toshiba Memory Product Summary

<table>
<thead>
<tr>
<th>PART NO.</th>
<th>ORG. PROCESS</th>
<th>SAMPLES Proc.</th>
<th>SPEED SORTS AVAILABLE (ns)</th>
<th>PACKAGE OPTIONS</th>
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<tbody>
<tr>
<td>DYNAMIC RAMS</td>
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<td></td>
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<tr>
<td>TMM41256AP</td>
<td>CMOS YES</td>
<td>100 120 150</td>
<td>P,F,Z</td>
<td></td>
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<tr>
<td>TMM41256AZ</td>
<td>CMOS YES</td>
<td>100 120 150</td>
<td>P,F,Z</td>
<td></td>
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<tr>
<td>TC5516AP</td>
<td>CMOS YES</td>
<td>120 150</td>
<td>P,F,Z</td>
<td></td>
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<tr>
<td>TC5516AZ</td>
<td>CMOS YES</td>
<td>120 150</td>
<td>P,F,Z</td>
<td></td>
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<tr>
<td>TC5516CP</td>
<td>CMOS YES</td>
<td>120 150</td>
<td>P,F,Z</td>
<td></td>
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<tr>
<td>TMM41256BZ</td>
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<td>120 150</td>
<td>P,F,Z</td>
<td></td>
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<tr>
<td>TC5516FP</td>
<td>CMOS YES</td>
<td>120 150</td>
<td>P,F,Z</td>
<td></td>
</tr>
</tbody>
</table>

### STATIC RAMS

| TMM3016AP | CMOS NO YES | 90 120 150 | 150 |
| TMM3016AZ | CMOS NO YES | 90 120 150 | 150 |
| TMM3016CP | CMOS NO YES | 90 120 150 | 150 |
| TC57100P | CMOS YES | 120 150 | P,F,Y |
| TCS664AI | CMOS YES | 120 150 | P,F,Y |
| TCS664AP | CMOS YES | 120 150 | P,F,Y |
| TCS664P | CMOS YES | 120 150 | P,F,Y |
| TCS664JP | CMOS YES | 120 150 | P,F,Y |

### HIGH SPEED STATIC RAMS

| TMM2416P | CMOS YES | 120 150 | P,F,Y |
| TMM2416AP | CMOS YES | 120 150 | P,F,Y |
| TMM2416BP | CMOS YES | 120 150 | P,F,Y |
| TMM2416CP | CMOS YES | 120 150 | P,F,Y |
| TCS256AI | CMOS YES | 120 150 | P,F,Y |
| TCS256AP | CMOS YES | 120 150 | P,F,Y |
| TCS256P | CMOS YES | 120 150 | P,F,Y |
| TCS256JP | CMOS YES | 120 150 | P,F,Y |
| TCS256P | CMOS YES | 120 150 | P,F,Y |

### EPROMS

| TMM2063P | CMOS YES | 100 120 150 | 100 120 150 |
| TMM2063AP | CMOS YES | 100 120 150 | 100 120 150 |
| TMM2063BP | CMOS YES | 100 120 150 | 100 120 150 |
| TMM27256AI | CMOS YES | 100 120 150 | 100 120 150 |
| TMM27256AP | CMOS YES | 100 120 150 | 100 120 150 |
| TMM27256BP | CMOS YES | 100 120 150 | 100 120 150 |

### ONE TIME PROGRAMMABLES

| TMM24512P | CMOS YES | 100 120 150 | 100 120 150 |
| TMM24512P | CMOS YES | 100 120 150 | 100 120 150 |
| TMM24512P | CMOS YES | 100 120 150 | 100 120 150 |
| TMM24512P | CMOS YES | 100 120 150 | 100 120 150 |
| TC57100P | CMOS YES | 120 150 | P,F,Y |
| TC57100P | CMOS YES | 120 150 | P,F,Y |
| TC57100P | CMOS YES | 120 150 | P,F,Y |

### MASK ROMS

| TMM2416P | CMOS YES | 100 120 150 | 100 120 150 |
| TMM2416AP | CMOS YES | 100 120 150 | 100 120 150 |
| TMM2416BP | CMOS YES | 100 120 150 | 100 120 150 |
| TMM2416CP | CMOS YES | 100 120 150 | 100 120 150 |

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**Specialty FIFOs.** Use our serial/parallel FIFOs for superb data handling flexibility.

**Raw speed.** All of our FIFOs are the fastest available today and will become even faster in the coming months. Our winning CEMOS™ technology puts you ahead today and tomorrow.

**Architectural speed.** All of our FIFOs are built with a dual-ported RAM array that gives you zero fall-through time.

**Flexible system architecture.** Thanks to innovative features like multiple flags and serial shifters.

**Introducing the world’s largest and fastest serial/parallel FIFOs.**

The **IDT7204/7104 4Kx9 and IDT7203/7103 2Kx9 FIFOs** will compact your serial interface by allowing you to perform serial-to-parallel, parallel-to-serial, serial-to-serial and parallel-to-parallel operations without any external circuitry.

- Fast 50ns parallel port access time and 40MHz serial input/output rate.
- Flexishift™ logic allows you to set serial word widths to be anything from 4 bits wide to as wide as you need.
- Separate serial input/output clocks for true asynchronous operation. Simple depth and width expansion in both serial and parallel modes without any additional logic.
- Six status flags, including almost full and empty, indicate well in advance how much data is available — thus giving your system plenty of time to react.

The read retransmit capability enables you to resend data — a useful feature for telecommunications and digital filter applications.

These FIFOs give you superb data handling flexibility for serial-parallel data transfer applications such as digitized video and audio, high-speed data links, high-density media storage and local area networks.

**Introducing the world’s first 4Kx9 and 2Kx9 CMOS FIFOs.**

The **IDT7204 50ns (access time) 4Kx9 and IDT7203 50ns 2Kx9 are the world’s largest FIFOs.** Both are pin and functionally compatible with the **IDT7202 35ns 1Kx9, the IDT7201 35ns 512x9 and MK4501 512x9 FIFOs.** asynchronous and simultaneous read/write — can buffer any data rate, with or without system clock □ empty, full and half-full flags □ easily expandable — built-in hooks to make deeper and wider FIFOs without external logic □ retransmit capability in single device mode □ 28-pin DIP and 32-pin LCC and PLCC.

**Introducing the world’s fastest CMOS 64x4/5 FIFOs.**

**IDT72401/02/03/04 and IDT72413** operate at shift rates up to 35MHz. □ low power CMOS operates at 1/4 bipolar power □ zero fall-through time RAM array.

**High-density FIFO modules.**

We also surface mount four IDT7203 or IDT7204 FIFOs, packaged in LCCs, on a co-fired multilayered ceramic DIP substrate. The result is two extraordinarily dense, fast, rugged, low-power FIFO modules: **IDT7M206 16Kx9 and IDT7M205 8Kx9.**

**May we be of assistance?** Call your local IDT representative or 1-800-IDT-CMOS. Ask for a copy of our Application Note — explaining how to use deep, fast FIFOs — and a Product Selector Guide on high-speed CEMOS products.
tion of fast FIFOs.

- the fastest big FIFOs
- the fastest small CMOS FIFOs
- the only parallel/serial FIFOs.

Standard DIP packages:
(a) 28-pin, 600 mil wide plastic DIP
Surface mount packages:
(b) 32-pin PLCC
c) 44-pin PLCC
d) 20-pin SOIC
Space saving packages:
e) 28-pin, 300-mil wide Sidebraze THINDIP

CIRCLE NO 65
People have been talking about optical drives for years. But have you ever actually seen one work?

Well, now you can. Because while others were talking about optical drives and solutions, Maxtor was developing them. And now we're shipping our 800MB 5¼-inch optical WORM drive in volume.

It's the first in our family of optical drives. And it's perfect for high-volume back-up, image or archival storage.

It's offered with a full complement of integration software and hardware, including media, cable and host adapter. Or it's available as a fully-configured plug-and-play mass storage subsystem.

Either way, it's fully compatible with most popular computers.

So don't wait to make optical drives a reality for your system.

Contact the Maxtor distributor or sales office listed below for complete technical and ordering information.

Because seeing is believing.
The service-economy myth

The economists and consultants who see a service-based economy as the salvation for the US haven't faced reality. It's obvious they haven't taken a car in for servicing, stood in line at a bank, or tried to have an electrician make a house call. There are many reasons why an economy based mainly on services is headed for rough times. Here are several:

Most service jobs offer low pay, little chance for advancement, and few benefits. In fact, some service businesses hire only part-time workers just to avoid paying for benefits that would be available to full-time employees. In short, many service jobs are a dead end. Few customer-service representatives or muffler-replacement workers have the chance to become store managers—and they know it. So, with few benefits and little chance for advancement, service jobs attract just the people who shouldn't be in those positions.

Besides offering few monetary and professional rewards, many companies offer service employees little training, scant motivation, and no sense of mission or importance. Most managers view service people as disposable resources. If these "throwaway" employees don't work out, there are usually others who want the jobs.

There are notable exceptions. A chain of lumber and hardware outlets in the greater Boston area provides employee benefits that include pension and profit-sharing plans. Employees are loyal, have low absenteeism, and know the products the company sells. Service people are abundant, helpful, and cheerful, even on Saturday morning.

Unlike a manufacturing endeavor, a small service business is easy to start, so some people view such businesses as an easy way to make money. Unfortunately, those businesses often leave behind distressed customers and much ill will. For example, if after six months the accounting software you got as a bargain from a consultant goes haywire, it may be impossible to locate the programmer or the consultant, despite a contract and guarantees. Because many service businesses require little investment, it's difficult to hold the owners financially responsible for their work—or the lack of it. There's little gain in tracking down and suing someone who has limited resources.

Certainly, businesses that manufacture products can have problems, too. However, the potential for poor quality seems higher in service industries. Before we treat service businesses as an economic panacea, let's examine how we're treating service people, how they treat customers, and how we can hold small service businesses accountable to customers.

Jon Titus
Editor
The time and space saving Signetics PLHS501.

Our instant gate array blows away your development bottleneck.

No ifs, AND/ORs or buts!
An "instant gate array" with no "gate-a-risk." The high-speed ($t_{pd} = 22\text{ns}$) Signetics PLHS501 Programmable Random Logic unit blows away your gate array development time. And with it your NRE, inventory problems and quality concerns. It's programmable or reprogrammable within hours—not weeks. And delivered on schedule, fully tested.

**No interconnect restrictions.** The unique single NAND array architecture of the PLHS501 eliminates the design constraints of AND/OR gates by delivering more utilization of on-chip resources. There are no interconnect restrictions because any NAND gate connects with any other NAND gate.

**Third generation single NAND array architecture with NAND foldback paths. The direct internal foldback supports multiple levels of logic without wasting I/O resources or suffering routing channel congestion.**

**Single-chip space saver.** The PLHS501 provides 1300 effective gates—a complete solution on a single 52-pin PLCC package.

**Powerful software support.** All Signetics Programmable Macro Logic devices, including the PLHS501, are supported by our powerful AMAZE software that makes complex designs easy by simplifying logic entry, simulation and device programming.

**Break your bottleneck.** When you want your gate array development time blown away in an instant—call Signetics. (800) 227-1817, ext. 978D. Or mail the coupon below for the PLHS501 Development Kit, including a **free sample.** We have only one standard—zero defects. And one goal—customer satisfaction.

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**One standard. 0 defects.**

Signetics

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First, we create the most innovative design introducing tomo
Cadnetix has been looking into the future. Two years of research, development and strategic planning have culminated in a significant breakthrough in electronic design. Concept 3 is a standard platform from Sun Microsystems and a whole lot more. It's a new world of system design capability.

Emerging technologies demand a new set of design solutions. Advances in ASICs, high-frequency components and fine-line design are creating new challenges in engineering, design and manufacturing. A new level of CAE/CAD/CAM sophistication is required to get the job done, and stay competitive. Companies must have even tighter integration between engineering, design and manufacturing, plus open access to all the equipment that's needed to produce a product quickly.

That's why we developed Concept 3, the convergence of advanced design tools and open systems, and more. We've redesigned our tools from the database up, to meet your design future. Concept 3 is Flexible Field™ routing and high-frequency design. It's a global data structure designed to handle off-grid components. It's RISC-based simulation acceleration, extraordinary ease-of-use and a seamless data path from schematic to manufactured product.

Concept 3 is also Cadnetix and Sun. Front-to-back system design on an industry-standard workstation. It's a perfect fit. Both companies have established reputations for delivering advanced technology. Both are committed to open systems and networking. And both base their products on industry standards such as UNIX®, Ethernet and NFS™. Now you get ease-of-use, state-of-the-art design, and a UNIX workstation that runs all Sun third-party software. We take full advantage of an open environment, so that Sun Workstations can share the network with Cadnetix systems and DOS PCs. It's the best balance of cost and performance available. Moreover, every workstation has access to the advanced capabilities of multiprocessor, RISC Engines for accelerated simulation, physical modeling or accelerated 100% routing.

The Cadnetix CAE Sun Workstation is a complete desktop solution, with tools for schematic creation, analog and digital simulation and ASIC design. The CAD/CAM Sun Workstation includes Cadnetix' industry-famous tools for PCB layout, routing, tooling, assembly and test. Cadnetix front-to-back CAE, CAD and CAM eliminate netlists, data conversions and design to manufacturing hold-ups. It's a level of integration unmatched in the industry.

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Because tomorrow's design problems demand solutions today.

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EDN December 10, 1987
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CIRCLE NO 62
CMOS FIFO memory has 15-nsec access time and two free-running clock inputs

You can now purchase a clocked 1k×5-bit FIFO memory with a 40-MHz cycle rate and a 15-nsec access time. The MK4505 has two independent, asynchronous, free-running clock inputs. These inputs provide automatic read- and write-protection logic for the device by creating an input stage that's similar to a rising-edge-triggered, D-type flip-flop. The clocked interlace eliminates any need for external registers, buffers, or pulse-shaping circuits.

In addition, several status flags warn you when the buffer is full, empty, half-full, almost full, or almost empty. The almost-full and almost-empty flags warn you when only eight bytes remain before the device is completely full or empty. The device also provides Data Ready and Output Valid status flags. The MK4505 latches all the status flags, and it won't change states until it's triggered.

You can order the MK4505 in either master (MK4505M) or slave (MK4505S) versions. You can't read the master when it's empty or write to it when it's full. However, you can force the slave to read and write continuously regardless of the FIFO buffer's status, so you can take advantage of the slave's edge-triggered 3-state output. Further, the MK4505M provides you with all the control necessary for width and depth expansion. You'll need an MK4505M for each 1k bit of depth you add to your FIFO array, and you'll require an MK4505S for each additional 5 bits of width. The practical expansion limit, however, is 40 bits: Beyond that point, you'll encounter drive-capability problems.

Because the MK4505 contains dual-port RAM, the device isn't susceptible to the ripple-through delay times that plague shift-register FIFO buffers. The device's separate read- and write-enable inputs let you enable or disable read and write operations on command in the presence of a continuous periodic clock. Internal read and write address pointers automatically provide the RAM with correct addresses, but data moves only on the rising edge of the clock pulses. If a clock is turned off, the MK4505 latches the previous cycle, regardless of any further input changes. Besides allowing simultaneous read and write activity, the FIFO memory's asynchronous design lets you stop either the read or the write clock without disrupting the other part's activity.

You can use the MK4505 as a digital delay by using one free-running clock and one control clock that has a programmable counter for determining the duration of the delay. The delay can last from two to 1022 cycles. Because of its pipelined architecture, the MK4505 is suitable for use in high-speed data links, fiber-optic circuits, and digitized video/graphics applications.

You can order the MK4505-25, a version with a 25-nsec cycle time and a 15-nsec access time, for $48.43 (100). A slower version, the MK4505-50, specs a 50-nsec cycle time and a 25-nsec access time; it sells for $33.67 (100). Both parts come in 300-mil DIPs with TTL-compatible inputs and outputs.

—J D Mosley
Thomson Components-Mostek Corp, 1310 Electronics Dr, Carrollton, TX 75006. Phone (214) 466-6000. TLX 730643.

Circle No 729
IF YOU'RE DESIGNING DISK DRIVES AND HAVE ONLY USED OUR READ/WRITE CIRCUITS— THIS CHART IS FOR YOU.

Our Extended Family

If you’re designing disk drives, you’re probably already familiar with Silicon Systems. Chances are good that you are presently using one or more of Silicon Systems’ Read/Write amplifier IC’s in your HDD designs. But maybe you don’t know that we also offer the industry’s most extensive line of mass storage ASIC’s.

The adjacent chart illustrates that Silicon Systems growing families of IC’s for all the electronic functions in hard disk drives, many leading HDD designers are finding they can now easily mix-and-match SSI products to implement their specific design features. This powerful design approach allows them to reduce board area, eliminate external passives, and lower costs by simplifying their designs.

The Mix-and-Match Design Approach

With Silicon Systems growing families of IC’s for all the electronic functions in hard disk drives, many leading HDD designers are finding they can now easily mix-and-match SSI products to implement their specific design features. This powerful design approach allows them to reduce board area, eliminate external passives, and lower costs by simplifying their designs.

Call Now!
(714) 731-7110, Ext. 575

For more information, send for our Disk Drive mailers. Silicon Systems, 14351 Myford Road, Tustin, CA 92680.

MICROPERIPHERAL IC SELECTION CHART

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<th>Max Input Capacitance (pf)</th>
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<tr>
<td>32R048</td>
<td>104</td>
<td>Farnese</td>
<td>4</td>
<td>2.4</td>
<td>23</td>
<td>35</td>
<td>15 to 45</td>
<td>+6V to -4V</td>
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<td>15 to 45</td>
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<td>501</td>
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<td>4.5, 6</td>
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HDD PULSE DETECTION

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<td>320535</td>
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TAPE DRIVER CIRCUITS

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Where we design to your applications.

Circle 115 for Career Information
Circle 76 for Product Information
PRODUCT UPDATE

High-density ASIC family achieves 100k-cell arrays

By using 1-μm drawn gate lengths, 1.2-μm design rules, and three metal layers to route signals and power, the vendor has developed the Max HDCl00 family of ASICs, which are CMOS macrocell arrays that encompass as many as 100,000 cells. The largest chip in the family measures only 483 mils per side. In addition, the ASICs feature internal gate speeds of 400 psec (with a fanout of 2) and offer as many as 512 configurable I/O cells.

You can use the vendor's $7500 Modular Design System software and $500 HDC library to develop designs for the Max family on a Mentor Graphics workstation. The library contains several hundred macrocell designs, including designs from the company's existing BiMOS and CMOS ASIC libraries, as well as ALUs, UARTs, timers, and several designs equivalent to AMD's 2900 family of bit-slice parts.

You execute the first design phase by developing the schematic and performing functional and timing simulations on the workstation. The vendor then uses the resulting design files to place and route an HDCl00 ASIC of suitable size on its DEC VAX 8800. This process takes about two days. Sample parts arrive 12 to 14 weeks after you approve the final chip layout.

Initially, the company plans to offer three members of the Max family: the HDC016, HDC031, and HDCl00, which have 16,416, 31,290, and 104,832 cells, respectively. It estimates that nonrecurring engineering (NRE) charges for these arrays will be $35,000 to $250,000. Eventually, the vendor plans to offer 10 devices having 5670 to

Three layers of metal carrying signals and power (labeled M1, M2, and M3) allow the Max HDCl00 family of macrocell arrays to use about 75% of the available transistors on arrays with as many as 104,832 8-transistor cells.
True Grey Shades at High Speeds for Less than $5000

Raytheon's TDU-850, Thermal Display Unit, produces photo quality images on an 8 1/4" x 200 ft. roll. The TDU-850 prints 16 shades of grey in less than 20 milliseconds per line; black and white images at 5 milliseconds per line. Price per unit from $4950, depending on interface and application. (Slightly higher overseas). Discounts for OEM large volume quantities. Fixed thermal head assures perfect registration. Resolution better than 200 dots/inch. Direct thermal technology requires no toners or developers. Standard or custom interfacing. For details, contact Marketing Department, Raytheon Ocean Systems Company, 1847 West Main Rd., Portsmouth, RI 02871 Telephone (401) 847-8000 Telex 0927787

CIRCLE NO 8

DID YOU KNOW?

EDN is distributed at every major electronics/computer show in the U.S., France, and Germany.

EDN

UPDATE

104,832 cells. Part costs range from about $37 for the 16k-cell array in a plastic quad flat pack to approximately $624 for a 100k-cell array in a multilayer, ceramic pin-grid array. Because it uses all three metal layers for both signal and power traces, the company believes that it can achieve an average cell utilization of 75% on the channelless array.

These three initial offerings also incorporate 136, 180, and 300 I/O cells, respectively, for devices placed in packages that require wire bonding, and 204, 280, and 512 I/O cells, respectively, for devices put in TAB (tape-automated bonding) packages. You can configure each I/O cell to be an input; an output driver with 2-, 4-, or 8-mA source and sink capability; or a bidirectional I/O pin. Although 512 I/O cells may seem like a very large number, the company points out that these cells have additional applications. You can gang as many as six cells to create a 48-mA (source and sink) I/O driver, and you can use an I/O cell as an internal buffer for heavily loaded signals such as a clock line.

The Max arrays feature an 8-transistor primary cell. You can construct gates or bits of ROM and RAM with each cell. A bit of RAM requires six transistors; a bit of ROM requires only a single transistor. The memory achieves a 10-nsec access time for blocks having less than 1k bits and a 30-nsec access time for blocks with as many as 32k bits. You can merge bits of RAM and ROM in a primary cell; one cell can be used to build a RAM bit and two bits of ROM or as many as eight ROM bits. This interleaving scheme also allows memory-address decoders and drivers to perform double duty by simultaneously driving both RAM and ROM arrays.

—Steven H Leibson
Motorola Inc, Box 52073, Phoenix, AZ 85072. Phone (602) 821-4426.

Circle No 727

EDN December 10, 1987
WE TAUGHT THE WORLD TO DRIVE WITH OUR FULL-SIZE MODELS.
INTERNAL 19,200-BPS MODEM SPEEDS PC COMMUNICATIONS

Permitting a range of communication speeds from 300 to 19,200 bps on a single IBM PC-compatible plug-in expansion card, the PC-Race 24/96 internal PC modem provides error correction, autodial, auto-answer, and full-duplex operation. The modem is compatible with the Hayes AT command set as well as with the manufacturer's extended communication commands.

The PC-Race 24/96 costs $995. If you need only CCITT V.22 compatibility for 300-, 1200-, and 2400-bps communication, you can purchase the PC-Race 24 for $595. If you want faster speeds and don't need V.22 compatibility, you can buy the $795 PC-Race 96, which gives you 9600-bps communication and a 19,200-bps BMX file-transfer mode.

Because of the modem's modular design, you can begin with the PC-Race 24 card and upgrade to a PC-Race 24/96 by plugging in a daughter card. Similarly, if you begin with the PC-Race 96 and decide later to add V.22 compatibility, you can plug in a daughter card to do just that.

Each version includes built-in error correction, which reduces data-transmission overhead between your PC and host computers by eliminating any need for special error-protection protocols. For PC-to-PC and PC-to-host communication over standard phone lines, you can use popular MS-DOS communication software such as Crosstalk, Carbon Copy, and Mirror.

The PC-Race 96 uses full-duplex asymmetrical frequency division to divide the voice telephone band into a high-speed, wideband CPU-to-screen channel and a slow-speed, narrowband keyboard-to-CPU operator input channel. It achieves 9600-bps operation over dial-up lines. If the receiving modem is another Data Race high-speed modem, the company's proprietary data-compression algorithm lets the two computers communicate at file-transfer rates reaching 19,200 bps, with error protection and EIA or X-On/X-Off flow control. This modem also accepts half-duplex, block-mode file transfers.

An internal speaker with external volume control lets you monitor the progress of your data transfer. The board interfaces with your IBM PC or compatible computer via a COM1 or COM2 bus assignment; COM3 and COM4 bus assignments are available by special order.

—J D Mosley


Circle No 730
OUR COMPACTS HAVE SOLD MILLIONS.
**PRODUCT UPDATE**

**ASIC verification tester has 100-MHz clock and data rates**

The Logic Master XL100 allows you to perform verification testing of devices at 100-MHz clock and data rates. Testing devices at these speeds requires more than just fast clock rates, however. You need to be able to place timing edges accurately in order to test timing margins. The XL100 can place timing edges with 100-psec resolution; the manufacturer claims that a calibration routine keeps the channel-to-channel skew levels within ±1 nsec.

It's also important for ASIC verification testers to provide a flexible environment for developing test programs. You need to be able to make test-program modifications quickly without being constrained by the test system's hardware. The XL100 uses a shared-resource architecture that gives you four drive-high voltage levels (−0.8 to +5.5V), four drive-low levels (−2 to +3.5V), and four compare levels (−2 to +5V). The XL100 also provides 12 timing sets that support two edges each. The resources are not constrained by channel; in other words, any or all of the channels can select a particular time set, drive level, and so on.

The modular design of the XL100 supports as many as 224 I/O channels or any combination of input and output channels to a maximum of 448. Each channel has 16k bits of drive-pattern memory and 16k bits of response memory. An optional dc parametric measurement system is available.

To help you develop test programs, the vendor provides software that converts the functional and timing data from your ASIC simulation into pattern-generation and expected-response data for the XL100. When you're ready to begin production of your ASICs, you can use the vendor's software to convert the test vectors you've generated into a format that's compatible with production testers.

The XL100 uses 6000-gate ECL arrays to perform timing generation and formatting. The channel drivers and receivers of the XL100 are implemented with linear arrays. A typical system with 128 I/O pins costs about $250,000. Delivery is 12 weeks.—Doug Conner

Mentor Graphics Corp, Integrated Measurement Systems Div, 9525 SW Gemini Dr, Beaverton, OR 97005. Phone (503) 626-7117.

Circle No 728
NOW YOU CAN DRIVE
OUR SUBCOMPACTS.

Seagate's family of 3½” hard disc drives.

As computers grow smaller, the demand for high-quality drives grows larger. But if you're looking for 3½" drives for your small computer systems, you don't have a lot to choose from. Except at Seagate.

We offer six 3½" drives with 21, 32 and 48 MB formatted capacities. You also have a choice of interfaces: SCSI or ST412 with RLL or MFM encoding. All with 28 msec access time.

Our 3½" drives use Seagate's field-proven, proprietary stepper motors to achieve fast access times normally found only with more expensive voice coil actuators.

Seagate's 3½" drives are not only fast — they're power savers, using as little as 8 watts. And for added data integrity, the drives feature autopark with a balanced positioner.

All of Seagate's 3½" drives are built with the precision and quality that have made us the world's leading independent manufacturer of 5¼" full-height and half-height hard disc drives.

Only Seagate has the worldwide, high-volume manufacturing efficiency to meet the growing demand for 3½" drives.

Once you evaluate Seagate's subcompacts, you'll be ready to go for a little drive. Call us today. 800-468-DISC.
MILITARY
16-BIT A/D's
FIRST IN
THEIR CLASS

MIL-STD-1772 CERTIFIED
MN5295/MN5290 & MN6290

High Speed:
- MN5295: 17µsec Max. Conversion Time
- MN5290: 40µsec Max. Conversion Time
- MN6290: 20kHz Min. Sampling Rate
Small 32-Pin Double-Wide DIP
14-Bit "No Missing Codes"
- 55°C to +125°C Operation
MIL-STD-883 Screening

In the two speed classes of 16-bit A/D's that have emerged, only one supplier designs its devices to meet all of your military and aerospace requirements: Micro Networks.

In the high-speed (15-20µsec) class, our MN5295/96 are the fastest (17µsec), smallest (by 31%), and only devices to offer -55°C to +125°C operation and MIL-STD-883 screening.

In the general-purpose (40-50µsec) class, our MN5290/91 offer these same advantages; while our MN6290/91 add an internal T/H, plus FFT testing for improved performance, ease of specification, and significant space savings.

And most critical to your designs, these are the only devices that operate over the extended military temperature range with full military screening.
MN5295/MN5296

The newest in our expanding line of high-performance, military, 16-bit A/D's are at the top of their class.

Fastest Conversion Time: 17µsec Max. (16 Bits)
Smallest Package by 31%: Double vs. Triple DIP
Widest Temperature Range: -55°C to +125°C
Only Devices Available with 883 Screening

In the top speed class, our MN5295/96 excel, providing outstanding 16-bit performance in a DIP package that is fully 31% smaller than any competitor's. No other supplier can meet your requirements for high-speed, high-resolution, military A/D's. When your design demands the best, demand Micro Networks MN5295/96.

MN5290/MN5291

They're the best in their speed class of workhorse 16-bit A/D's. Specify them for all your applications that don't require the added performance of our MN5295/96.

Fastest Conversion Time in Their Class: 40µsec Max.
Smallest Package by 31%: Double vs. Triple DIP
Widest Temperature Range: -55°C to +125°C
Only Devices Available with 883 Screening

Like our MN5295/96, our MN5290/91 A/D's are ideal for any design where you need true 14 or 13-bit performance over an extended temperature range. These devices were the first 16-bit military A/D's. Since their introduction, their broad acceptance and proven performance have made them industry standards.

MN6290/MN6291

In a class by themselves, these FFT-tested sampling A/D's are ideal for traditional data acquisition and DSP applications.

Single Package Sampling A/D
High Resolution/Sampling Rate: 16 Bits @ 20kHz
Signal-to-Noise Ratio: 84dB
Harmonics: -88dB
Temperature Range: -55°C to +125°C
Available with MIL-STD-883 Screening

These devices eliminate the hassle of evaluating T/H specs that are difficult to understand and often don't relate.

For more detailed information, send for our comprehensive data sheets. For rapid response, call Russ Mullet at Ext. 208.

Micro Networks
324 Clark Street
Worcester, Massachusetts 01606
(617) 852-5400

Micro Networks
Advancing Data Conversion Technology
Your next destination:
The ACL Computer Age.

The future belongs to computers and peripherals built with RCA Advanced CMOS Logic (ACL).

The pressure is on to make your systems smaller, faster, cheaper.

Some of your competitors are doing just that by incorporating ACL into their new designs. If you want to stay on the fast track, you can’t afford not to consider ACL for your new designs.

**The computer of the future.**

Imagine a computer with power dissipation so low you could eliminate all cooling systems. Or design a sealed system to prevent dust problems.

And get dramatically improved reliability, thanks to the far lower heat generated. As well as far smaller system size.

You’d also be able to use it in a far wider operating temperature range (-55°C to +125°C). Even in high-noise environments.

**FAST** speed, CMOS benefits.

Advanced CMOS Logic gives you high speed (less than 3ns propagation delay with our AC00 NAND gate) and 24 mA output drive current.

But unlike FAST, it gives you a whole new world of design opportunity for computers, peripherals, telecommunications and other speed-intensive applications.

ACL dissipates less than 1/8 Watt while switching, compared to 1/2 Watt for a FAST IC (octal transceiver operating at 5 MHz). And quiescent power savings are even more dramatic: ACL idles at a small fraction of the power of a FAST IC.

In addition, ACL offers balanced propagation delay, superior input characteristics, improved output source current, low ground bounce and a wider operating supply voltage range.

**Latch-up and ESD protection, too.**

Latch-up concern is virtually eliminated, because ACL uses a thin epitaxial layer which effectively shorts the parasitic PNP transistor responsible for SCR latch-up.

And a dual diode input/output circuit provides ESD protection in excess of 2KV.

**A broad and growing product line.**

Our line already includes over 100 of the most popular types (SSI, MSI and LSI). More are coming soon. And many are available in High-Rel versions.

**All this at FAST prices.**

Our ACL line is priced comparably to FAST. So you get better performance at no extra cost. Why wait, when your competition is very likely designing its first generation of ACL products right now?

Get into the passing lane, with RCA ACL from the CMOS leader: GE Solid State. Free test evaluation kits are available for qualified users. Kits must be requested on your company letterhead. Write: GE Solid State, Box 2900, Somerville, NJ 08876.

For more information, call toll-free 800-443-7364, extension 24. Or contact your local GE Solid State sales office or distributor.

*FAST is a trademark of Fairchild Semiconductor Corp.

In Europe, call: Brussels, (02) 246-21-11; Paris, (1) 39-46-57-99; London, (276) 68-59-11; Milano, (2) 82-291; Munich, (089) 63813-0; Stockholm (08) 793-9500.

GE/RCA/Intersil Semiconductors

These three leading brands are now one leading-edge company. Together, we have the resources — and the commitment — to help you conquer new worlds.
"Sierra's new power supplies got VDE."

Why not?! From 45 to 500 watts, every open frame switching power supply in our new wide line meets VDE 0806 for safety. And all have a TUV logo on the side to show they've been approved to these precise VDE standards; not "designed to meet." Of course, none of this should surprise you. After all, every switcher we've introduced since 1983 meets VDE.

In addition, these power supplies all meet VDE 0871, Level A for conducted noise. Some even meet the more stringent Level B requirement, including the new "10 to 120KHz" standard.

Oh, since we got VDE, we figured we ought to get approvals for UL and CSA plus conform to FCC, IEC and other international regulatory agencies as well.

So if your product needs a power supply PDQ that meets VDE, UL, CSA, ETC., call ASAP. Sierra Power Systems (formerly Sierracin), 6275 Nancy Ridge Drive, San Diego, CA 92121. Call toll-free (800) 423-5569. In California, (619) 458-1471.

"Should they really be talking about something like that in an ad?"
READERS' CHOICE

Of all the new products covered in EDN's October 1, 1987, issue, the ones reprinted here generated the most reader requests for additional information. If you missed them the first time, find out what makes them special: Just circle the appropriate numbers on the Information Retrieval Service card, or refer to the indicated pages in our October 1, 1987, issue.

**ANALOG I/O PORT**

The AD7569 combines an 8-bit A/D converter, an 8-bit D/A converter, a track/hold amplifier, a buffer amplifier, and a 1.25V bandgap reference on a monolithic chip that includes both CMOS and bipolar transistors (pg 212).

Analog Devices Inc.
Circle No 601

**PROJECT PLANNER**

Project:Vision Level 2 is an enhanced version of the vendor's project-planning software package, which runs on IBM PCs and compatible computers (pg 232).

Inmax Corp.
Circle No 605

**POWER MOSFETs**

Designed for high-voltage applications, these power MOSFETs are available in TO-3 and TO-3P packages and have continuous-current ratings to 8.1A (pg 206).

International Rectifier.
Circle No 603

**GRAPHICS ADAPTER**

The VGA Extra is a plug-in board for the IBM PS/2 Model 30 as well as the IBM PC, PC/XT, and PC/AT. The adapter is compatible with all the modes of IBM's Video Graphics Array (VGA) standard (pg 216).

STB Systems Inc.
Circle No 602

**HANDHELD SCOPE**

The Scout SC01 is a handheld, multipurpose instrument that functions as a digital oscilloscope, a frequency counter, and a dual-channel DMM (pg 226).

Dolch American Instruments Inc.
Circle No 604
Metamorphosis

DSP designs take wing using new C program from Motorola, convert 320 software to powerful 56001 source code.

Now the power and efficiency of the DSP56001 can be incorporated into your designs without the cost or delay of rewriting outdated 32010 software. Motorola's new DSP320to56001 Translator Software opens new worlds by simply and inexpensively converting any 32010 code into 56001 source code. Now your DSP designs can truly stretch their wings while you save thousands of dollars worth of programmer hours.

Reach new heights in performance.

The DSP56001 is far more than a general-purpose Digital Signal Processor (DSP); it's a high-performance, fourth generation DSP that was created for speed and versatility. Built with Motorola's proven HCMOS technology, the DSP56001 features 512 words of full-speed on-chip Program RAM (PRAM), 512 words of on-chip data RAM, two preprogrammed data ROMs, and special on-chip bootstrap hardware that permits easy dynamic loading of user programs into the Program RAM.

Motorola's '56001 leads the way in DSP technology. Not having to program ROM makes it an off-the-shelf item able to realize quick program development at low cost. The unusually large assortment of on-chip, MCU-style peripheral functions, and the memory expansion port, gives the '56001 a level of versatility its competitors only dream about.

Using the DSP56001, customers can do development work more easily, facilitate their speed-critical programs on-chip for real time performance, and realize the full power of DSP without the expense and delay of ROM mask patterns. These features make the '56001 perfect for many applications in communications, speech, imaging, audio, computers, instrumentation, and high-speed controls.

A translator that works with you.

The one double-sided, double-density, 5¼ inch diskette includes not only the PC object code but also the C source code for the DSP320to56001 program. With it, users can modify the software for 32020 and 320C25 translations. A registration card is also provided so that users can obtain future, optimized versions of DSP320to56001 software, hand-coded macro routines, and other pertinent updates and information.

One-on-one design-in help.

Get an engineer-to-engineer update on the newest Motorola Digital Signal Processor technology.

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Call toll-free any weekday between 8:00 a.m. and 4:30 p.m., MST, from anywhere in the U.S. or Canada. If the call can't answer your needs we'll have a local DSP specialist contact you.

For published data on Motorola's newest DSP technology, send in the completed coupon below.

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P.O. Box 20912, Phoenix, AZ 85069

Please send me more information on Motorola's newest DSP technology.

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Address __________________________
City ____________________________ State ______ Zip ______

Call me (_______)__________________

MOTOROLA
Mega DRAMs. Mega options.
Fast access from OKI:

CMOS 1 Meg DRAMs
in great working shape.

Maintaining a leading edge in CMOS technology and packaging, OKI meets your fast DRAM specs with unique flexibility.

Anyway you look at it, OKI’s fast-track CMOS knowhow has got the one megabit DRAM shaped up to go. Now. No matter how demanding your parameters may be in performance or packaging, it’s easy to work it out with OKI.

Need super high speeds? Tell us to jump, and all we ask is “how fast?” OKI is shipping megabit Dynamic RAMs stripped down to 85ns. (With 80ns on the way...and 60ns not far behind!)

Organization options? OKI offers both 1 Meg x 1 and 256K x 4 single-chip DRAMs. Both from the same die. To cut qualification time and expense, we built a bonding option into our basic chip design. Qualify one die, and you’ve got every OKI option covered!

Want more space-saving package solutions? OKI maintains a high profile in low profile memories—a complete range of package options to handle just about any real estate problem. Today and tomorrow. OKI package enhancements have been developed to carry you through upcoming DRAM generations: from 1-megabit to the 4- and even 16-megabit memories.

Need a tidier single chip than the DIP? Ask us about the new SOJ package that provides the megabit DRAM in J-lead surface mount. Or, get still more compactness with the OKI ZIP package’s very narrow profile.

Also turning space problems on end: OKI’s SIMM packages load 9 to 18 megabits onto a single easy-to-use module. An instant surface mount capability that packs up to 18 million bits into half the conventional space. And OKI’s highly-automated production capabilities will be consolidating DRAMs in a TAB package too.

Mega DRAMs.
Mega CMOS options.
OKI wouldn’t have it any other way. Why should you?

Get a Byte of DRAM for only $186.00!

Limited Time Offer: To help you work up your DRAM specs, OKI offers you a BYTE with parity of 1 Meg x 1 CMOS DRAMs (9 plastic DIPs, fast page mode, 120ns) for only $186.00 per Byte Kit.

Please send ___ Kits containing a Byte of 1 Megabit CMOS DRAMs. Price per Kit is $186.00, plus $3.00 for shipping/handling. $189.00 Total/Kit, sales tax included. Offer limited to 3 Kits per customer.

Check or money order for $___. enclosed. (Sorry, no company purchase orders please.)

Send complete data on OKI Megabit DRAMs.

OKI Semiconductor
CIRCLE NO 101
Sometimes, keeping a low profile pays off.

The survival of today's combat helicopter depends on keeping a low profile. Abbott's BC100 triple output, switching DC-DC converter helps the Lynx helicopter achieve this low profile.

The BC100's low 1.875" profile allowed 100 watts to fit into a tight space requirement. At the same time, the Lynx helicopter was able to take advantage of the economy and reliability that come from using a standard product, the BC100.

Because the BC100 meets the requirements of MIL-STD-810C, and MIL-S-901C, the Lynx program's decision to go with Abbott's BC100 will also pay off in extra survivability. Plus the BC100 features low ripple/noise and EMI within the limits of MIL-STD-461B.

For other applications that call for small yet powerful converters, Abbott offers both 100 and 200 watt models. Each available in single and triple configurations. And all with a wide array of options available.

For more information and a copy of our 1988 Military Power Supply Product Guide, call or write today.


WHEN RELIABILITY IS IMPERATIVE®

Abbott
MILITARY POWER SUPPLIES
CIRCLE NO 93
## Leadtime Index

Percentage of respondents

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</table>

Source: Electronics Purchasing magazine's survey of buyers
Not only do we know who it's for, we know who's calling and what the message is. That's because an NCR 286 CPU board is at the heart of an innovative new voice mail system. Handling the calls for as many as a thousand users, sixteen at a time. All in a single personal computer chassis. And the next call we take may be for you.

The message we want to leave you here, of course, is that NCR PC technology is at work in many places beyond accounting and data processing. Like manufacturing control systems in factories everywhere. Diagnostic imaging equipment in clinics and hospitals. Even a new CD ROM jukebox at play in record stores.

What's behind this frenzy of applications activity?

We know for whom the bell tolls.

For some it's the versatility of split board architecture. For others it's the compact size and low power requirements of VLSI and surface mount technology. But for everyone it's the way we configure the pieces to meet the specific demands of the application. Without chewing up the calendar or your budget in the process.

In short, we're easy to work with. Because we have the engineering know-how and the manufacturing can-do to deliver the goods. Without hitches, without surprises, and without fail.

So, as you look into developing new products, or improving your existing ones, look into NCR.

For more details about how NCR PC technology can fit into your plans, call us at (513) 445-0670. Our response is sure to ring your chimes.

A SMART FOUNDATION TO BUILD ON.

NCR Corporation
Personal Computer Division
OEM/Technology Sales
Dayton, Ohio 45479

CIRCLE NO 94
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Now you can layout in the Sun.
You can also layout with Apollo. And on the DEC.* With complete access to GDS II.

Introducing the EDS III™ IC Design System.

GE Calma's new Electronic Design System puts the automated IC design tools you need onto the industry's hottest platforms. Without sacrificing control or your investment in CDS II.

You see, we've linked the most popular engineering workstations to the GDS II library. So you can retrieve and work on any existing design. Or create entirely new designs in such modern, easy-to-use environments as Sun, Apollo and MicroVAX.*

Visit your GDS II library anytime.

EDS III provides a direct library-level interface to any GDS II design on the network.

Just give the "OPENLIB" command and the GDS II library you want will appear on your workstation. Without going through time-consuming STREAM®-level conversions.

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You'll cut design time while making the most of your GDS II library and its powerful capacity for GaAs, hybrids and mixed analog/digital design.

And as upgrades for GDS II are released, EDS III will still be your standard platform access.

Route any block and cell automatically.

You can save more time by routing standard cells and blocks of all shapes and sizes automatically. And you have the same capability with standard cell placement and floor planning.

But even though the system is automated, you're still in charge. With control of die size, power and ground distribution, and placement. And you can document your design as you go along.

What's more, you can customize the EDS III interface to fit your needs. Whether you prefer the latest pulldown menus and windows in EDS III, the familiar GDS II menus or your own personal setup.

And because EDS III is open, you can take advantage of database access routines to integrate your own tools.

Now everyone shines.

With design tracking that automatically reflects any change throughout the system, EDS III keeps everyone on your design team informed. And you in complete control. No matter how many revisions are made.

For more hot news, call our hot line.

So if you're interested in connecting your industry standard workstations with the industry standard CAD system, ask for our free brochure. Call us at 1-800-GE-CALMA, ext. 430.

And start getting some Sun.

*Apollo and MicroVAX platforms available early 1988.

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DESIGN

NATIONAL ELECTRONIC PACKAGING AND PRODUCTION CONFERENCE

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Anaheim Convention Center • Anaheim Hilton • Anaheim Marriott
Anaheim, California

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PLEASE PRINT IN BLACK INK

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First Name __________________________ Last Name __________________________

Job Title __________________________

Company __________________________

Division __________________________

Mailing Address __________________________ Dept. or Mail Stop ___

City __________________________ State Zip __________

Country __________________________

Telephone __________________________ Telex C2

2. Job Category (Check only one)

A □ Circuit/System Packaging
B □ Circuit/System Design
C □ Production/Manufacturing
D □ Quality Control, Test & Inspection
E □ Purchasing
F □ Corporate Management
G □ Sales
H □ Research/Development
I □ Other ________

3. Business Category (Check only one)

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B □ Office or Business Machine
C □ Communications, Systems/Equipment
D □ Industrial Electronic Control Systems/Equipment
E □ Medical Electronics
F □ Aircraft, Missiles, Space, Military
G □ Test and Measurement Equipment, Inst.
H □ Electronic Components and Sub-Assemblies
I □ Consumer Elec. Products
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K □ Independent Research, Test, Design
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M □ Other ________

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D □ Circuit Packaging
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□ My company is interested in exhibiting at future events.

EDN December 10, 1987
You told us what you wanted in digitizing oscilloscopes,

and we took your advice...
Introducing HP's new high-perfo

You told us what would best meet your measurement needs. So in '84 and '85 we brought you digitizing oscilloscopes with pioneering features like full programmability, 1 GHz repetitive bandwidth, color displays, automatic answers, single-shot pulse reconstruction, infinite persistence, and instant hardcopy output.

And now, we bring you the new HP 54111D/54112D/541120T series.

These high-performance digitizing oscilloscopes let you measure what you've never measured before, with superb accuracy and ease of use.

You'll find innovations such as 20 GHz bandwidth, 4-channel simultaneous 400 MSa/sec with 64k memory per channel, time domain reflectometry (TDR) with normalization, 10 psec time interval accuracy, and more.

**HP 54111D: the hot single shot.**

The HP 54111D offers two simultaneous channels operating at up to 1 Giga-sample per second...allowing you to capture high-speed single-shot phenomena such as high-speed pulses, plasma discharge, high voltage arcing, high frequency bursts, laser pulses and high energy events.

You get the single-shot performance of analog storage oscilloscopes with all of the performance advantages of digitizing oscilloscopes.

The HP 54111D also offers a 500 MHz bandwidth, so it will perform admirably in a wide variety of repetitive as well as non-repetitive applications.

**HP 54112D: 64,000 bytes times 4.**

The HP 54112D offers you simultaneous 4-channel capture at 400 Megasamples per second with 64k of memory per channel. Just right for the long data streams found in serial data communication applications.

---

**HP 54111D**
- 1 GigaSample/sec digitizing rate
- 500 MHz repetitive bandwidth
- 250 MHz single-shot bandwidth
- 8k memory per channel
- 1 mV/div sensitivity

**HP 54112D**
- 400 Megasamples/sec digitizing rate
- 100 MHz repetitive or single-shot
- 4 simultaneous channels
- 64k memory per channel
rmance digitizing oscilloscopes.

Four simultaneous channels enhance critical timing measurements on multiple test points...single-shot. And the HP 54112D's four channels are always real-time correlated for every trigger occurrence.

In automated test, four channels with 64k memory per channel boost your throughput by capturing 256k of data simultaneously.

HP 54120T: excels in high-speed applications.

With its 20 GHz bandwidth and 10 psec accuracy, the HP 54120T lets you measure propagation delays of ICs or switching times of high-speed diodes. Characterize microwave switches. Verify signal path impedances in computer backplanes and test fixtures. And more.

You get high sensitivity, resolution, and accuracy for repeatable time-interval and voltage measurements, with stability and ease-of-use comparable to lower-performance oscilloscopes.

The HP 54120T offers four channels for logic gate characterization. Time and voltage histograms to help you quantify noise and jitter. Normalization to correct for imperfect connectors in reflection (TDR) and transmission measurements.

Probing to 6 GHz. And the list goes on.

Contact HP today!

For more information on our new high-performance digitizing oscilloscopes, fill out and mail the postage-paid reply card today. Call us direct at 1-800-367-4772, Ext. 215L. Or contact your local HP sales office listed in the telephone directory white pages. Ask for the electronic instruments department.

HP 54120T
- dc-20 GHz bandwidth with averaging
- 10 psec time interval accuracy
- 0.25 psec time interval resolution
- Time and voltage histograms
- Stable TDR with normalization
- 0.4% voltage accuracy
- 4 channels
The specs you need, and the features you want.

In addition to their outstanding individual contributions, the new HP 54111D/54112D/54120T digitizing scopes offer you full programmability, automatic measurements, instant hardcopy output to printers and plotters, waveform storage, and multiple-color displays.

You also have HP's excellent reliability, documentation, and support to make you productive with your HP instrument quickly and ensure your satisfaction for years to come.

HP 54111D $23,900.00*

**VERTICAL:**
- Rep. bandwidth: 500 MHz
- S.S. bandwidth: 250 MHz
- Inputs: 2 chan & 2 trig
- Resolution: 8 bit to 25 MHz, 7 bit to 100 MHz, 6 bit to 250 MHz
- Sensitivity: 1 mV/div to 5 V/div
- Coupling: ac, dc; 50 Ohm & 1 MOhm

**HORIZONTAL:**
- Digitizing rate (max): 1 GSa/sec
- Resolution: 10 pssec
- Pre-trigger viewing: YES

**MEMORY:**
- Acquisition/chan: 8k
- Waveform storage: 2 pixel, 4 rep wfm, 4 ss wfm
- Nonvolatile: instrument setups 10

HP 54112D $22,900.00*

**VERTICAL:**
- Rep. bandwidth: 100 MHz
- S.S. bandwidth: 100 MHz
- Inputs: 4 chan & 1 trig
- Resolution: 6 bit to 100 MHz
- Sensitivity: 5 mV/div to 5 V/div
- Coupling: ac, dc; 50 Ohm & 1 MOhm

**HORIZONTAL:**
- Digitizing rate (max): 400 MSa/sec
- Resolution: 40 pssec
- Pre-trigger viewing: YES

**MEMORY:**
- Acquisition/chan: 64k
- Waveform storage: 2 pixel, 4 rep wfm, 4 ss wfm
- Nonvolatile: instrument setups: 10

HP 54120T $27,850.00**

**VERTICAL:**
- Rep. bandwidth: 20 GHz
- S.S. bandwidth: NO
- Risetime: 17.5 pssec
- Accuracy: 0.4%
- Inputs: 4 chan & 1 trig
- Resolution: 12 bits
- Sensitivity: 1 mV/div to 80 mV/div
- Coupling: 50 Ohm

**HORIZONTAL:**
- Accuracy: 0.25 pssec
- Resolution: 10 pssec
- Pre-trigger viewing: NO
- Range: 10 pssec/div-1 s/div

**MEMORY:**
- Acquisition/chan: 0.5k
- Waveform storage: 2 pixel (volatile), 4 rep wfm (nonvolatile)
- Nonvolatile: instrument setups: 10

TDR
- Pulse source: 0-200 mV
- Amplitude: 1 Mv/div
- Risetime: 100 pssec
- Flatness: 1%
- Normalization: YES
- Waveform histograms: YES

*U.S. list price only.
Varies according to options selected.
**U.S. list price only.
Includes both the HP 54120A and HP 54121A.
Specifications subject to change without notice.

HEWLETT PACKARD
*Fluoronics Resources:
An exclusive 3M combination of innovative products backed by research and development, manufacturing expertise, technical data and service assistance built on more than 35 years' experience of pioneering in fluorochemistry.

3M has had a whole generation of experience in the development, manufacture and refinement of perfluorinated liquids. We first introduced these versatile liquids to electronics design, testing and production professionals in the fifties. Since then, Fluorinert Liquids have become the mainstays in electronic cooling, high reliability testing and vapor phase soldering.

Fluorinert Liquids, used as a direct contact heat transfer medium, offer a range of physical properties that make them particularly suitable for electronic uses. They are non-polar and exhibit no solvent action. They are colorless, low in toxicity, non-flammable and offer exceptionally high dielectric strength plus thermal and chemical stability. Most important, they have almost no chemical reactivity and they evaporate without leaving a residue on parts.

**Buy the numbers**
Our FC™ numbers — FC-40, FC-70, FC-77, etc. — are used to identify Fluorinert Liquids that offer certain physical characteristics to meet specific application needs. These FC numbers are solely 3M designations for various fluorochemical products.

Fluorinert Liquids are being used cost-effectively in cooling, high reliability testing and vapor phase soldering operations. When you are interested in applying these versatile liquids in your own production, 3M can provide an abundance of technical information and support.

**Technical assistance: the main benefit of Fluoronics Resources**
3M offers prompt assistance to help you solve many production and testing problems. We provide comprehensive technical recommendations for specific fluids. We consult with you on the proper application equipment and help you evaluate production methods and results. Our service bulletins bring you up to date on the most recent advances in vapor phase soldering and high reliability testing. Ask us about 3M’s audiovisual materials and on-site application training seminars.

**Discover Fluorinert™ Liquids’ heat transfer capability**
What are your needs? A precise degree of temperature control? Fast, uniform heat transfer? High dielectric strength? Fluorinert Liquids offer the broad range of physical characteristics required in most applications.

Fluorinert Liquids are an effective direct contact heat transfer medium whether used in a liquid or vapor state. Their unique properties enable you to use them in contact with sensitive components and substrates.

Major differences between the various products in the Fluorinert Liquids family can be seen in their boiling points. These can range from 56°C to 253°C. Should you need products with intermediate boiling temperatures, the 3M staff will work with you to fashion a product especially for your needs. It’s an example of how 3M’s Fluoroni resources provide you with “customized” service to solve special problems.

**EDN December 10, 1987**
the heat transfer medium and the device under test. Fluorinert Liquids reduce testing costs by reducing testing time substantially. They do this by rapidly reaching test temperature and providing precise and uniform temperature control. You’ll minimize the number of faulty units by detecting defects before they become rejects.

These liquids provide cost-effective tests such as gross leak, thermal shock, liquid burn-in, ceramic crack detection, electrical environmental, temperature calibration and failure analysis/short detection. Gross leak testing.

Fluorinert Liquids are specified in the MIL-STD’s for thermal shock and gross leak testing.

**THERMAL SHOCK TEST CONDITIONS**

<table>
<thead>
<tr>
<th>Military Standard 883-1011</th>
<th>Military Approved Fluorinert Liquids</th>
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<tbody>
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<td>Test Condition</td>
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<tr>
<td>A</td>
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<td>B</td>
<td>125°C</td>
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<tr>
<td>C</td>
<td>150°C</td>
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<td>D</td>
<td>200°C</td>
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<td>E</td>
<td>150°C</td>
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<td>F</td>
<td>200°C</td>
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**GROSS LEAK TEST CONDITIONS**

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<th>Military Standards</th>
<th>Military Approved Fluorinert Liquids</th>
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<td>MIL-STD 883-1014</td>
<td>FC-40, FC-43</td>
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<td>MIL-STD 750-1017</td>
<td>FC-40, FC-43</td>
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<tr>
<td>MIL-STD 202-112</td>
<td>FC-40, FC-43</td>
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</tbody>
</table>

Discover higher yields in vapor phase soldering
Fluorinert Liquids have been the industry's fluid of choice since the vapor phase reflow soldering (VPS) process was introduced in 1975. There are a number of good reasons for this universal acceptance. VPS with Fluorinert Liquids produces highly reliable solder joints. The system reduces reject rates, increases production, and lowers production costs. With Fluorinert Liquids, you can be assured that your products will never be exposed to a temperature higher than the selected liquid’s boiling point. (See above.)

You’ll avoid those problems usually associated with other systems — shadowing, uneven heating, and overheating. The liquids are non-flammable. Their low surface tension helps them evaporate quickly from the work pieces without leaving a residue.

VPS with Fluorinert Liquids is especially suited for boards with high mass or complex geometries. The liquid vapors completely surround the assembly and penetrate remote recesses to heat all surfaces evenly. The vapors are 15 to 20 times heavier than air so they can be contained easily within the work area. The system offers an oxygen-free, non-corrosive environment to minimize rejects from oxidation contamination.

Some typical applications using Fluorinert Liquids in VPS include surface mounted leaded or leadless components, through-hole leads and wire-wrap pins, lead frame attachment, reflow of electroplated solder or tin and miscellaneous metal joining.

**VPS SELECTION GUIDE**

<table>
<thead>
<tr>
<th>Fluorinert Liquid</th>
<th>Boiling Point</th>
<th>Typical Solders</th>
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<tbody>
<tr>
<td>FC-43</td>
<td>174°C/340°F</td>
<td>70 Sn/30 Pb/12 In</td>
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<td>FC-70, FC-5311</td>
<td>215°C/419°F</td>
<td>63 Sn/37 Pb</td>
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<tr>
<td>FC-5312</td>
<td></td>
<td>62 Sn/36 Pb/2 Ag</td>
</tr>
<tr>
<td>FC-71</td>
<td>253°C/487°F</td>
<td>100 Sn</td>
</tr>
</tbody>
</table>

Discover the unique cooling benefits of Fluorinert Liquids
As the package size decreases, your need for more efficient heat dissipation increases in proportion. 3M Fluorinert Liquids are very efficient as a direct contact heat transfer medium, with the added advantage of having the high dielectric characteristics needed to meet stringent demands of the diversified electronics industry. We offer 11 liquids with boiling points that range from 56°C to 253°C.

These stable liquids allow you to maximize power density and miniaturize your package. Yet they reduce failure rates and increase reliability. Fluorinert Liquids are used in such demanding applications as:
- Radar transmitters • Power supplies
- High voltage transformers • Lasers
- Radar klystrons • Computer modules
- Computer memories • Fuel cells

Typical properties of Fluorinert Liquids used in cooling are:

<table>
<thead>
<tr>
<th>Fluorinert Liquid</th>
<th>Room Temp. (°F)</th>
<th>Boiling Point (°F)</th>
<th>Boiling Point (°F)</th>
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<tbody>
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<td>FC-77</td>
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Shrinking board size has changed the rules for thermal design: A surface-mount assembly that occupies only 40% of the space of its through-hole counterpart can nevertheless dissipate as much power. Achieving adequate reliability requires that you understand and apply the new rules.
Cooling devices take the heat from SMDs

Dan Strassberg, Associate Editor

Small fan suited to spot cooling (Indek)

Surface mounting is about the hottest technology in electronic packaging today, and if you don't heed the advice of fan and heat sink vendors, you might find that claim to be literally true. They advise you to consider thermal management early in the design cycle. Otherwise, your customers might be the first to know about thermally induced reliability problems.

Surface-mount technology (SMT) is moving reliability concerns well beyond the purview of packaging engineers, power-supply designers, and designers of the traditionally temperature-sensitive low-level analog circuits. Fortunately, vendors are offering products ranging from CAD tools to heat sinks to help you develop and implement a strategy to limit semiconductor junction temperatures to a level that delivers the desired reliability.

Thermal design is now part of logic design

Thermal considerations pervade every aspect of SMT-based circuit design. For example, if you design high-speed SMT-based logic circuits, then your concerns encompass not only propagation delays and reflections in signal lines but thermal management as well. IC vendors normally don't offer their highest power devices in surface-mount packages (see box, “High-speed logic: toward even hotter technology”). But compared with their through-hole counterparts, the logic surface-mount devices (SMDs) that vendors do offer dissipate just as much power, mount closer together, and transfer a larger percentage of the heat they develop out of their packages through the leads. Close spacing between devices and widespread use of multilayer boards, whose inner layers exhibit fairly high thermal conductance, make it likely that the temperature of an SMD will affect—and be affected by—that of nearby devices more than would the temperature of a leaded through-hole device.

Among the army of products that stand ready to help you battle high temperatures is PCB Thermal, a CAD software package from Pacific Numerix, which allows you to impose thermal as well as electrical constraints when determining where to place components on a circuit board. PCB Thermal presents you with a graphic interface; it runs on many 32-bit CAE workstations and performs a finite-element thermal analysis. When configured for a Sun 3, it costs $15,000.

If your product is going to be manufactured in high volumes or will be quite complex, and if you feel that solving its thermal problems will take help from people who specialize in thermal management, you might
SMT is moving reliability concerns well beyond the purview of packaging engineers and power-supply designers.

consider EG&G Wakefield Engineering. Wakefield is probably best known as a supplier of heat sinks, but its product line includes other types of cooling devices as well. The company's applications engineers will work with you to develop a comprehensive thermal-management proposal if your application has the potential for requiring more than $25,000 worth of Wakefield products per year.

SMD heat sinks pose unusual design problems

You won't find a wide variety of heat sinks designed especially for SMDs. Those that do exist require you to mount the SMDs in leaded sockets that you solder into through holes, just as you would solder other conventional components. One reason for the scarcity of SMD heat sinks is the wide variety of SMD packages; no single package yet accounts for enough of the market to make it attractive for vendors to provide matching heat sinks. Furthermore, SMD packages make it difficult to attach heat sinks. Thermally conductive adhesives can be used, but applying them is a messy job, distasteful to supervisors of pc-board assembly groups. Worse yet, if you add the mass of a heat sink to an SMD, particularly one with J or gull-wing leads, you create a mechanically resonant system. During transit the device might vibrate severely enough to cause metal fatigue, which could weaken or fracture the leads or solder joints.

Attaching a heat sink to a component also increases the amount of heat you must deliver to it to solder it to a pc board. Prolonging the exposure of an SMD (or any other semiconductor device) to the high temperatures necessary to melt solder is likely to degrade its reliability. Therefore, if you attach heat sinks to SMDs, several IC vendors advise you to do it after the reflow-soldering operation. If you are using SMDs packaged in leadless ceramic chip carriers (LCCCs), heat sinks such as Thermalloy's 2313B ($1.27 (1000)) teamed with AMP's 55159-1 or -2 socket and cover ($5 (OEM qty)), or EG&G Wakefield's 830-20B ($0.31 (5000)) coupled with 3M-Textool's 268-5400-00-1102 socket ($12.13), allow you to wait until after soldering to mount not only the heat sinks but also the SMDs themselves. You place the IC in its socket, put the heat sink on top of it, and snap the two into place. You can use thermal compound to improve heat transfer from the IC to the heat sink. When used in air moving at 600 linear ft/minute, heat sinks of this type can reduce the junction-to-air thermal resistance (and hence the junction temperature rise above ambient) of an IC packaged in a 68-lead LCCC by approximately 60% compared with that of a similar device without a heat sink in still air.

Although the primary mechanism for heat transfer in solids is conduction (for instance, from a chip to its package, from the package to a pc board, and from one area of the board to another), air is not a particularly good conductor of heat, so the primary mechanism for heat transfer in air is convection—transfer of heat by air motion. With natural convection, temperature differences within your product will cause air to move and thus to transfer heat from the hotter parts to the cooler regions. If you use a fan or blower to increase the amount of air that passes by the heat sink, the heat-transfer mechanism is called forced convection. Temperatures reached by electronic components normally aren't high enough for the third heat-transfer mechanism—radiation—to play a significant role.

You can use some simple rules of thumb to help determine the point at which natural convection becomes inadequate: If your pc board dissipates <0.5W/in², natural convection will almost surely be adequate. From 0.5 to 1W/in², natural convection might be adequate. From 1 to 2.5W/in², conventional forced convection, where airflow parallels the plane of the boards, is likely to provide sufficient cooling. Above 2.5W/in², you will probably have to resort to newer methods of forced convection, such as impingement cooling, in which you force air in a direction perpendicular to the plane of the board—directly at hot devices. At power densities greater than 5W/in² you will probably have to abandon
forced convection and resort to techniques like mounting hot components against a plate chilled with a cold liquid.

Many factors affect choice of cooling mode

Factors affecting the point at which you change from one cooling mode to another include your product's maximum specified operating ambient temperature and its internal configuration. Products that have generous spacing between boards (>1 in. center to center) are likely to operate reliably with natural convection at pc-board power densities that require the use of forced convection in more densely packed products.

If you determine that you need forced convection, you should not lightly approach the task of selecting the optimal air-moving device and the best scheme for moving air through your product. If you have to move air through the product from its surroundings, two of the problems you will face are noise and dust. Therefore, keep in mind that where cooling requirements are modest, you might not have to draw in air from outside the enclosure; you may be able to provide adequate cooling by stirring—using forced convection to move air from the warm interior of the product to the relatively cool inside surface of the enclosure. The enclosure is cooled, in turn, by the natural convection of the outside air.

Piezo Electric Products' LP Series air-moving de-

High-speed logic: toward even hotter technology

You won't find surface-mount versions of the logic devices that exhibit the highest dissipation. Many ECL gate arrays, for example, dissipate too much power for today's surface-mount packages, commercial-grade boards, and processes. LCCCs (leadless ceramic chip carriers) exhibit about the best heat-transfer properties of commonly used surface-mount packages. Their junction-to-case thermal resistance is approximately 30% lower than that of plastic leaded chip carriers (PLCCs) with the same number of leads. Because LCCCs have no leads at all, only solder holds them to the board (unless you place them in through-hole-mounted sockets, thereby surrendering the advantages of surface mounting). Because expansion coefficients of packages differ from those of most boards, increasing temperature causes stress to build up on the solder joints and make the connections between the package and the board unreliable.

On the other hand, with ICs in pin-grid-array (PGA) packages, if you don't use sockets, you solder the parts into through holes that have plenty of sidewall friction; because solder isn't all that holds the devices, retention is more reliable. Reliable retention is one reason that IC vendors prefer to package high-dissipation logic devices in PGAs rather than in LCCCs. Moreover, the vendors can get PGA packages with 300 pins; at present, the maximum pin count for LCCCs is 84.

One company, Texas Instruments (Attleboro, MA), has devised a solution to the problem of differing coefficients of expansion between boards and LCCCs. TI makes the clad metals now used in US coinage. Clad-metal technology makes it possible for TI to fabricate Invar-copper-Invar sheets that pc-board vendors can use as the embedded power and ground planes in multilayer boards. Because Invar has a much lower expansion coefficient than copper or glass-epoxy, by using the clad metal layers you can design boards whose expansion closely matches that of LCCC packages. TI will not design your printed-circuit boards for you, but it will assist you in selecting the clad-metal material that your board supplier can use to deliver the properties you want.

The Microwire process, developed by the PCK Technologies division of Kollmorgen Corp (Melville, NY), can take advantage of TI's clad metals as well as the extraordinary circuit densities possible with Microwire, a high-density version of Kollmorgen's older Multiwire process, to deliver boards that have controlled expansion and, because of their thinner insulating layers, heat conduction superior to that of boards with equivalent circuit density made either by multilayer or Multiwire processes.
One CAD software package allows you to impose thermal as well as electrical constraints when determining where to place components on a circuit board.

Vicels are well suited to stirring or spot cooling (cooling of a small number of hot devices in an otherwise cool unit). These 1.5×1.5-in. low-profile units attach to your PCB close to the device you want to cool. They use a piezoelectric, rather than electromagnetic, transducer to convert electrical energy to mechanical energy and are so quiet in operation that you can't hear them above the ambient room noise. They are only 0.16 in. thick, and you space them another 0.25 in. from the board. You power them with either 12 or 24V dc. The volume of air they move is modest—less than 2 cfm, but the air velocity is respectable—as much as 1000 linear ft/minute. Evaluation kits, which include a dc/ac inverter, cost $250; production units cost from $10 to $25 (10,000).

Another device well suited to spot cooling is the FDC40-05H from Indek. Like the vast majority of fans, it's an electromagnetic device, but it measures only 1.5×1.5×0.79 in. You can mount it on a PCB and power it from 5V dc. It consumes 3W, its free-air delivery is 8 cfm, and its noise rating is 45 dBA. It costs $16.65 (500).

If you know how much power your product dissipates, the formula

\[ \text{AIRFLOW} = 1.756 \times \frac{P}{\Delta T} \]

(where airflow is measured in cfm, P is power in watts, and \( \Delta T \) is temperature rise in degrees Celsius) tells you how much air you must move through it to limit the difference between incoming and outgoing air temperature to a specified rise.

For example, suppose that an IBM PC/AT work-alike computer has a power supply capable of delivering 220W. Further, suppose that the supply is 75% efficient, so that the power dissipated within the computer case is 1.33×220W, or 293.3W, if the supply is fully loaded. According to the airflow formula, to maintain the exit air temperature at 15°C above the entry air temperature (that is, 15°C above ambient room temperature), 34.3 cfm must move through the case.

At first, the required flow sounds quite reasonable; several vendors supply fans with free-air delivery of approximately 50 cfm in a 3.62×3.62×1-in. package. However, with a very small back pressure—approximately 0.07 in. of H2O—such fans deliver less than the required 34.3 cfm, and they rotate at 3300 rpm, which makes them quite noisy for the computer's intended office environment.

When deciding about the overall scheme for directing air through a product, designers have traditionally considered two approaches—evacuation, where a fan pulls air through the product, and pressurization, where the fan pushes the air. Even though it adds the fan's own power dissipation to the heat load in the cabinet, pressurization is the more common of the two. A reason often given for selecting pressurization is that with a pressurized cabinet, dust doesn't enter through small openings; you can keep dust out by placing a filter over the opening directly in front of the fan.

Filters are a mixed blessing, however. Many designers believe that filters create at least as many problems as they solve. A filter clogged with dust severely restricts air flow, and users of electronic products are notorious for forgetting to clean or change filters. If you must use a filter, you should consider monitoring the temperature within your product so that you can warn the user, or shut power off, if the temperature becomes excessive.

When opting for cabinet pressurization, what many designers forget is that air moving at relatively low velocities picks up much less dust than does air moving rapidly. If the fan is not directly behind an air inlet, and air enters the product through many small, unfiltered openings, it will enter the enclosure slowly, thus minimizing dust buildup.

Because you can't easily control the path by which air...
enters a fan, you will usually find the highest air velocities, hence the greatest heat-transfer capabilities, directly in front of the air discharge. You might be able to combine these good heat-transfer properties with low dust buildup and freedom from filter maintenance by placing a fan in the middle of your product, as Fig 1 shows, so that it draws air past the elements that dissipate little power and discharges directly over the hottest components.

Use pressure/volume curves to select fans

Fig 2 shows the pressure-vs-volume curve of a 4.69×4.69×1.5-in. fan—in this case, EBM Industries’ 5-bladed W2G110-A048-31, a 24V dc unit that consumes 6W. (In production quantities—1000 to 50,000 pieces—a number of vendors sell dc-powered, ball-bearing fans of this size for $11 to $17.) Overlaid on the pressure-vs-volume curve is the pressure-vs-volume curve of a product in which you might use the fan (for example, a cabinet filled with pc boards and power supplies).

Unfortunately, the only accurate way of establishing the pressure-vs-volume characteristic for your product is through airflow measurements on a mockup or an actual unit. Note that the volume of air that the fan can deliver is a function of the back pressure, and the back pressure is a function of the volume of air delivered. You can solve the simultaneous equations graphically—the operating point lies at the intersection of the two curves. Note also that the pressure-vs-volume curve of the cabinet is not linear; if you attempt to double the volume of air, the back pressure more than doubles. A nonlinear pressure-vs-volume curve is characteristic of turbulent flow. Although it’s noisier than laminar flow, designers usually attempt to create turbulence because it aids in transferring heat from hot components to the moving air.

Choices you must make when selecting an air-moving device include whether to use a fan or a blower, whether to use ac or dc power to drive the air-moving device, whether to use an air mover with ball or sleeve bearings, and whether to control fan speed in response to changes in temperature of the components you are cooling.

Understand how blowers differ from fans

Fans deliver air along their axis of rotation; blowers usually deliver air in a direction perpendicular to their axis of rotation—either radially or tangentially. In general, for a given physical volume, a fan will deliver...
No single SMD package yet accounts for enough market share to make it attractive for vendors to provide matching heat sinks.

More air at zero back pressure than a blower, but a squirrel-cage blower will deliver air at higher velocities and will do so even at back pressures that would completely cut off airflow from a fan.

Squirrel-cage blowers, such as Comair Rotron's Biscuit ($30.40), deliver air tangentially. At zero back pressure, the Biscuit delivers only 20% of the air volume of a fan with similar dimensions. However, because of the Biscuit's smaller discharge area, the exit velocity is more than twice as high, and the Biscuit can deliver air against back pressures nearly twice as high as those that would cut off airflow from a fan of comparable size. Their small exit area and high discharge velocity make small squirrel-cage blowers good choices for blowing air directly on very hot components.

The percentage of small fans and blowers sold that use dc power is growing rapidly. All manufacturers now offer dc-powered—typically 12 or 24V—fans as well as ac-powered ones. Despite slightly higher cost for dc (approximately 20% for the air mover itself, not including costs you incur if you have to increase the capacity of your product's dc power supplies) and occasional concerns about controlling the inverter ripple current that some dc fans inject into the dc supplies, the trend exists for good reason:

- With dc power, your company can stock a single type of fan for use in products to be powered from any line frequency and any line voltage. With fans operated directly from the ac line, you usually have to install different units in products you ship to 120V and 220V areas. Furthermore, the rotational speed of dc-operated fans is independent of line frequency, so you don't have to select a fan whose rotational speed is too high at 60 Hz in order to have it turn fast enough at 50 Hz.
- You can get your product approved by regulatory bodies more easily if the fans don't connect to the ac line.
- You can control the speed of fans that employ dc motors more easily and over a wider range than you can those employing ac motors; hence you can operate such dc fans at a speed that minimizes mechanical noise.
- Small dc fans do not use mechanical commutators but instead use integral solid-state inverters based on the Hall effect; therefore, their reliability is as good as that of ac fans.
- The efficiency of dc fans is two to four times higher than that of ac fans; therefore, in applications where a fan pressurizes an enclosure, the reduced heat load imposed by the fan can be significant.
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Keep in mind the effects of back pressure when calculating fan or blower performance requirements.

The majority of small fans and blowers sold today use sleeve bearings. They are quieter and, in production quantities, cost roughly 8% less than fans with ball bearings. Ball bearings, on the other hand, have a reputation for exhibiting longer life than sleeve bearings. Fan manufacturers don't argue about the greater longevity of ball-bearing fans operated at air temperatures greater than 40°C or in applications in which airflow direction is not horizontal. However, some vendors claim that if end-of-life ratings were established by noise level, then fans with sleeve bearings, operated with horizontal airflow at temperatures below 40°C, last at least as long as those with ball bearings. Indeed, the probability is greater than 90% that a fan with either type of bearing, operated according to its manufacturer's recommendations, will still be running after five years of around-the-clock service. Nevertheless, if you are buying power supplies with integral fans, you might want to pay your vendor a premium to provide units with ball-bearing fans because power supplies—even those with switching regulators—usually run hot.

If you need to minimize the audible noise created by the fans in your product, you can regulate the speed of the fans so that they turn only as fast as necessary to maintain the desired operating temperature. Reducing the fan speed usually also reduces the fan's power dissipation. You can control the speed of a dc-operated fan simply by varying the voltage you apply to it. You can produce the voltage variations either by driving the fan with pulse-width-modulated dc or by using purely linear techniques, although the linear approach can introduce additional hot components into your product.

The solid-state commutators within dc-operated fans generate a pulse train whose repetition rate is proportional to the fan's rotational speed. For a modest additional charge (typically about 5% in production quantities), many fan manufacturers will bring the

For more information...

For more information on the CAD tools, fans and blowers, fan-speed controllers, heat sinks, and sockets discussed in this article, circle the appropriate number on the Information Retrieval Service card or contact the following manufacturers directly.

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Smartfan provides controllers you can use to control the speed of de- and ac-operated fans and blowers that, themselves, incorporate no special speed-control features. For example, Smartfan’s PC-DC Series controllers, intended for fans operating from 12 to 26V dc, attach to fans with mounting-hole spacing of 1.969, 2.812, 3.250, and 4.125 in. An evaluation kit, which includes three controllers, costs $38.44.

Acknowledgment

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Article Interest Quotient (Circle One)
High 473 Medium 474 Low 475
Temperature Measurement Using the LTC1090/91/92 Series of Data Acquisition Systems

William Rempfer
Guy Hoover

Introduction
Accurate temperature measurement is a difficult and very common problem. Whether recording a temperature, regulating a temperature or modifying a process to accommodate a temperature, the LTC1090 family of data acquisition systems can provide an important link in the chain between the blast furnace temperature and the microcontroller. Features of the LTC1090 family can make temperature measurement easier, cheaper and more accurate.

The features of the LTC1090 family members make them very useful in temperature measurement applications. High DC input resistance and reduced span operation allow direct connection to many standard temperature sensors. Multiplexer options allow one chip to measure up to 8 channels of temperature information. Single supply operation, modest power requirements (~5mW) and serial interfaces make remote location possible. Switching power on and off lowers power consumption (560µW) even more for battery applications. Finally, because few sensors have accuracies as good as 0.1%, the 10-bit resolution and 0.05% accuracy of the LTC1090 family are just right for most temperature sensing applications.

Thermocouple Systems
The circuit of Figure 1 measures exhaust gas temperature in a furnace. The 10-bit LTC1091A gives 0.5°C resolution over a 0°C to 500°C range. The LTC1052 amplifies and filters the thermocouple signal, the LT1025A provides cold junction compensation and the LT1019A provides an accurate reference. The J type thermocouple characteristic is linearized digitally inside the MCU. Linear interpolation between known temperature points spaced 30°C apart introduces less than 0.1°C error. The code for linearizing is available from LTC. The 1024 steps provided by the LTC1091 (24 more than the required 1000) insure 0.5°C resolution even with the thermocouple curvature.

Figure 1. 0°C-500°C Furnace Exhaust Gas Temperature Monitor with Low Supply Detection
Offset error is dominated by the LT1025 cold junction compensator which introduces 0.5°C maximum. Gain error is 0.75°C max because of the 0.1% gain resistors and to a lesser extent the output voltage tolerance of the LT1019A and the gain error of the LTC1091A. It may be reduced by trimming the LT1019A or gain resistors. The LTC1091A keeps linearity better than 0.25°C. The LTC1052’s 5µV offset contributes negligible error (0.1°C or less). Combined errors are typically 0.5°C or less. These errors don’t include the thermocouple itself. In practice, connection and wire errors of 0.5°C to 1°C are not uncommon. With care, these errors can be kept below 0.5°C.

The 20k/10k divider on CH1 of the LTC1091 provides low supply voltage detection (the LT1019A reference requires a minimum supply of 6.5V to maintain accuracy). Remote location is easy, with data transferred from the MCU to the LTC1091 via the 3 wire serial port.

Thermilinear Networks

Figure 2 shows an 8 channel 0°C to 100°C temperature measurement system with 0.1°C resolution. The high DC input resistance and adjustable span of the LTC1090 allow it to measure the outputs of the YSI thermilinear components directly. Accuracy is limited by the sensor repeatability and precision resistors to 0.25°C.

Sensor input voltage (V_in), not critical because of ratiometric operation, is set to around 1.5V to minimize self heating. The zero scale (COM pin) and full-scale (REF+ pin) of the LTC1090 are set by the precision resistor string to directly digitize the roughly 0.2V to 1V sensor output. The LT1006 buffers the 10kΩ reference resistance of the LTC1090. 0°C and 100°C correspond to unipolar output codes of 0 and 1000 (decimal), respectively with an overrange of 102.3°C.

Thermistors

A thermistor is a cheaper alternative to thermilinear components in narrower temperature range applications. In Figure 2, CH7 is being used to digitize the output of a 5kΩ thermistor. The resistor shown linearizes the output voltage around the 30°C point. The output remains linear to 0.1°C over a 20°C to 40°C range but gets nonlinear rapidly outside this range. By correcting for the non-linearity in software this range can be extended to 0°C to 60°C. Beyond that, the repeatability error of the thermistor increases above 0.2°C making correction difficult.

Silicon Sensors

Because of its high DC input impedance and reduced span capability, the LTC1090 family can directly measure the output of most industry standard silicon temperature sensors, both voltage and current mode. Popular sensors of this type include the LM134 and AD590 (current output) and silicon diodes.

Figure 3 shows a simple connection between the LTC1092 and industry standard 1µA/°K current output sensors. Resolution is 0.25°C and accuracy is limited by the sensor and resistors. Standard 10mV/°K voltage output sensors can also be connected directly to the LTC1092 input in a similar manner.

For LTC1090/91/92 literature call 800-637-5545. For help with an application call (408) 432-1900, Ext. 361.
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Designed for maximum flexibility, proven in millions of applications—Burndy's TRIM-TRIO contact/connector family lets you meet all your application needs—no matter how often they change—without changing your contact system! Your tooling! Or your installation procedures!

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THE TRIM-TRIO CONTACTS SYSTEM:
Closed barrel Machined Contacts for both crimp and wire-wrap power applications up to 13 amps. Open barrel Precision Formed contacts for power and signal applications. Sub-miniature Coax (one-piece or 2-piece) for coaxial cable, shielded conductors and twisted pairs. These three basic types (with variations for different conductors, contact platings and termination options) make up the TRIM-TRIO contact system. All can be intermixed in any of scores of Burndy connector housings designed around this contact system.

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VACREL® lets you design more electrical

The performance of VACREL gives you the added design freedom you need when using surface-mount technology (SMT), the state of the art in printed wiring board and printed wiring assembly design.

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functions into less real estate at less cost.

per board, with high first-pass assembly yields, less solder bridging, fewer retests and rejects, and less potential for field failures. Lower incoming inspection costs are possible, thanks to the accuracy of VACREL.

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VACREL photopolymer film solder mask is made only by Du Pont.

CIRCLE NO 138
If your present I/O connector can completely cover the new Fujitsu Series 230 pictured on this page, you've got a large problem.

You're wasting valuable board space. Space you could use to cram in a few extra components. Or space you could eliminate entirely to reduce manufacturing costs.

Fact is, the Series 230's remarkably compact 1.27mm (.50") pitch and remarkably efficient 4-row, zig-zag terminal layout pack provides all the pinout you're used to in 40% less real estate.

Impressive.

But that's just one small accomplishment. The big news is that you don't have to give up full-size connector convenience or reliability.

Every Series 230 connector includes features like a standard “D” shape polarization header, EMI shield, plug/socket lock and minimum-pressure insertion/withdrawal fitting. All with no extra size.

So before you run out of space in your next compact or portable system design, call us at (408) 562-1000. Or for a complete list of local distributors and representatives write to Fujitsu Component of America, Inc., 3320 Scott Boulevard, Santa Clara, California, 95054-3197.

We'll keep you from coming up short.
Hardware and Interconnect Devices

Aluminum enclosures help to dissipate heat as well as provide EMI shielding

The SL Series consists of seven small aluminum enclosures that vary in size from 3.5×1×3.7 to 7.75×3×8 in. The enclosures are built from flat, removable aluminum panels that you can easily punch, silkscreen, or laminate. The extruded aluminum sides have a variety of slots that accept pc boards. You can place the pc boards in various locations within the enclosures. You can also remove the top and bottom covers to obtain access to the subassemblies you place inside.

The enclosures offer such options as a mounting bracket, belt clip, pistol grip, and chassis. The injection-molded polycarbonate bezels conceal the front- and rear-panel screws. The enclosures also feature pull-down, nonskid feet at no extra charge. The SL Series ranges in price from $21 to $26.

Tracewell Enclosures, 7032 Worthington Galena Rd, Columbus, OH 43085. Phone (800) 848-4525; in OH, (614) 846-6175.

Circle No 715

Enclosures for VME Bus and Multibus II are completely wired

The MaxChassis line of enclosures consists of 50 models: 34 for the VME Bus and 16 for the Multibus II. Each chassis includes a backplane and wiring appropriate for the bus system you choose. The enclosure comes with one or two card cages, a power supply, a fan, cabling, and wiring-control switches. Each card cage has 20 slots. The enclosures are available with either 20- or 26-in. depths. The 20-in. model can house cards as long as 280 mm; the 26-in. version holds cards as long as 400 mm.

The dual-card-cage enclosure holds cards as long as 220 mm; you mount the cards in the front and rear of the enclosure. The 8.75-in. MaxChassis houses single-height cards while providing an air-intake and exhaust area for cooling; the 14-in. model accommodates double-height cards. The company plans a 19.25-in. enclosure that will suit Futurebus, Nubus, and custom applications.

The enclosures come completely wired and include ac and dc power connections, fans, a system-failure indicator, an ac-power-failure indicator, and a system-reset function. The MaxChassis comes with either a 400 or a 600W power supply. When you purchase two card cages for the enclosure, the vendor provides two 400W power supplies. The 400W supplies provide 60A at 5V and three channels of ±12V at 8A. Each of these supplies includes its own internal fuse in addition to the fuse that's part of the enclosure. Each supply also includes an internal fan. The MaxChassis costs $3295 to $3929, depending on configuration.

Scanbe, Box 4159, El Monte, CA 91731. Phone (818) 579-2300. TWX 910-587-3437.

Circle No 717
Glass-epoxy leadless chip carriers eliminate thermal-expansion problems

Fabricated from glass-epoxy pc-board laminate, Epic leadless chip carriers (LCCs) eliminate TCE (thermal coefficient of expansion) mismatch problems when you surface-mount them on glass-epoxy pc-board substrates.

The chip carriers feature a double-sided glass-epoxy base that is metalized with leadouts and a bonding pad for the semiconductor die. A spacer laminated to the base provides a cavity for the die. Each chip carrier also has a lid that you attach with adhesive after you've mounted the die. The base metalization allows you to use standard wire-bonding techniques between the die and the carrier. You attach the die to the chip carrier with thermal epoxy that is loaded with metal to improve its thermal resistance. The standard package's total thermal resistance is around 92°C/W; carriers having a thermal resistance as low as 4°C/W are available as an option.

The leadout metalizations have a typical resistance of <0.10 and an inductance of <5 nH. Combined with a lead-to-lead capacitance of approximately 0.2 pF, these parameters provide lead-induced propagation delays as low as 25 psec. Epic chip carriers are available in versions with 8 to 256 leadouts. A typical 16-leadout carrier costs £0.20 (1000), and a typical 84-leadout carrier costs between £1.50 and £2 (1000).

Tectonic Products Ltd, Oxford Rd, Wokingham, Berks RG11 2YD, UK. Phone (0734) 782340. TLX 847569.

Blowers use permanently lubricated ball bearings for long operating life

The Muffin DC, Sprint DC, Biscuit DC, Patriot DC, and Major DC are precision-aligned blowers. The latest models of these fans have permanently lubricated ball bearings that give them an operating life of 85,000 hours at 40°C and allow them to operate in temperatures as high as 72°C.

The fans take advantage of the manufacturer's ThermaPro-V technology, which allows you to program the fans, regulate their voltage, and thermally control their speed. The blowers' current-limiting features lower the start-up and rotor currents. The ThermaPro-V controls internal temperature variations automatically; the fan's motor speed is controlled by a temperature-sensitive resistor that provides continuous temperature monitoring. Because the fan's speed is directly related to temperature, you can use a much smaller fan than your system would otherwise require. Muffin DC, $19.10; Sprint DC, $21.60; Biscuit DC, $38.75. With thermal speed control, the Patriot DC and Major DC cost $73.61 and $75.40, respectively.

Comair Rotron, North St, Saugerties, NY 12477. Phone (914) 246-3615. TWX 510-247-1941.

EDN December 10, 1987
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And its small package size, analog output, and 30 mW power consumption make the sensor compatible with microprocessors and other electronic devices like those used in environmental and process control systems. For more information, write The Sensor Consultants at MICRO SWITCH, Freeport, IL 61032. Or call 815-235-6600.
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• Selectively gold-plated press-fit contacts
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Hardware and Interconnect Devices

LCC SOCKETS
The IC75 Series sockets are used with 68-pin LCC devices. An aluminum heat sink is optional. Two versions accommodate either a 68-pin JEDEC type A or a 68-lead JEDEC type B ceramic LCC. The sockets feature polyphenylene sulfide bodies, stainless-steel covers, and beryllium copper with gold-over-nickel-plating for the contact material. The maximum operating temperature is 150 °C. $4.01 (1000). Delivery, stock to six weeks ARO.

Nepenthe, 2471 E Bayshore Rd, Palo Alto, CA 94303. Phone (800) 637-3684; in CA, (415) 856-9332. TWX 910-373-2060.

Circle No 526

STEEL SLIDES
The 475/476 compact steel slide series accommodates the multiple-load ratings required in both low-cycle, high-load industrial applications and in high-cycle, low-load furniture environments. The series features a ball-bearing design in a ½ x 2½-in. configuration. Load ratings for the series vary from 175 lbs in high-cycle applications to 250 lbs in low-cycle applications. Slide lengths of 12 to 30 in., with travels of 13 and 31 in. respectively, are available.

The slides incorporate cushion stops at both the open and closed positions. A closed position detent holds the drawer of the chassis closed, and sequential slide action enhances slide life. Optional locking provisions are offered on some versions. The slides are fabricated of C1010 cold-rolled steel for strength, and they feature a full complement of ball bearings. $5 (OEM qty). Delivery, eight to 12 weeks ARO.

Jonathan Mfg Corp, Box 3J, Fullerton, CA 92634. Phone (714) 526-4651. TWX 910-592-1241.

Circle No 525

HEAT SINK
The 5922B heat sink features spring-action clips that permit quick mounting to TO-218 semiconductor devices. Because of the tight metal-to-metal contact provided by its spring-clip mounting, the black heat sink minimizes the problem of air gaps between the semiconductor device and the heat sink. Such air gaps decrease the efficiency of the device's thermal transfer. The device's dual-channel fins produce additional surface area for air circulation and heat removal. With an input of 8W, the 5922 has a thermal resistance of 8.75 °C/W under conditions of natural convection. $0.43 (1000).

Aavid Engineering Inc, Box 400, Laconia, NH 03247. Phone (603) 528-3400.

Circle No 528

BREADBOARDS
According to the vendor, the JE20 Series solderless breadboards provide a quick and efficient way to build circuits. They feature screen-printed coordinates that allow you to easily locate contact points, and slide-together strips that allow you to form larger-than-usual working areas. They are available with nickel-plated spring clips, which can withstand over 5000 insertion cycles; they are covered by a lifetime warranty. From $2.49 for a 100-contact breadboard strip to $39.95 for a 3220-contact board with an aluminum grounding plate and four binding posts.

Jameco Electronics, 1355 Shore-
The new HP PaintJet color graphics printer.
Great color is only ½ the story.

Hardware and Interconnect Devices

way Rd, Belmont, CA 94002.
Phone (415) 592-8097. TLX 176043.
Circle No 527

HEADERS
The 609-xxxxx-x family of pin-strip headers provide an interface to Ansley female sockets, Flexpac female socket systems, and other connector interfaces. The devices are available in single- or double-row versions and can be cleaned and separated at any desired length.

ENCLOSURES
The E Series enclosures feature a built-in fan-tray compartment that helps reduce design and fabrication costs. You can use them for 3U and 6U 19-in. subrack applications. Complete companion subracks and accessories that accommodate VME Bus and Multibus II applications are also available. The enclosures are constructed of aluminum extrusions, sheet metal, and die-cast bezels. Retractable feet with nonskid rubber inserts are standard features. You can specify that from one to nine fans be installed in a variety of locations within the enclosures. A 3M filter media is also available in a variety of six densities to serve in different applications. The filters
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It can also print a page of text in 30 seconds flat.

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**Hardware and Interconnect Devices**

- **TEST SOCKETS**
  This line of sockets for either test or burn-in applications is available with 24, 28, 32, 40, or 48 pins. The sockets' contacts are tin- or gold-plated beryllium copper for temperatures to 105°C (tin) or 150°C (gold) and for 200°C (50 µm NiBo over CuNiSn spinodal alloy). The sockets' broad contact area allows devices on 0.3-, 0.4-, and 0.6-in. centers to be tested in the same socket. The contacts are normally closed. This configuration provides consistent force of contact and prevents contact deformation due to over-sized loads. It also eliminates dependence on plastic to sustain contact.

  The socket bodies are UL94VO-rated plastic, with 1000-MΩ min insulation resistance, 1000V ac min dielectric withstanding voltage, and a 1A contact rating. The devices can sustain more than 50,000 insertion cycles, and the socket contacts accept leads that are from 0.015- to 0.045-in. wide. The sockets can be mounted directly on a pc board on either 0.3- or 0.6-in. DIP hole patterns. A 24-pin tin-plated socket, $3.87; a 24-pin gold-collet, tin-shell receptacle, $3.62 (100).

- **F-O CONNECTORS**
  Optimate ceramic-ferrule, single-mode connectors offer physical contact (PC) tip geometry to minimize connector loss and back reflections. The insertion loss averages <0.3 dB; the return loss loss averages -36 dB. The 2.5-mm threaded, 2.5-mm bayonet, and 2.0-mm threaded...
styles are compatible, respectively, with most FC/PC, ST/PC, and D4/PC types. They provide accurate and repeatable fiber-optic termination for 125-µm single-mode fiber in either a 2.5- or a 3.0-mm-diameter cable jacket.

The threaded styles are spring loaded. The spring loading and a cable-strength member crimp absorb cable stresses, thus maintaining undisturbed optical transmission during cable use. All three styles use a precision ceramic ferrule to maintain low insertion loss. These enhanced fiber-optic connectors are available as field-installable kits for fast termination, using the vendor's hand tools or as pigtails, jumpers, and hybrid assemblies. From $27 to $30 (100).

AMP Inc, Box 3608, Harrisburg, PA 17105. Phone (717) 564-0100. Circle No 532

BACKPLANE

The High Density Plus Two line of modular-backplane and daughterboard connectors is a 6-row version of the manufacturer's High Density Plus family. Each connector module, no wider than a conventional 4-row connector and measuring no more than 2-in. long, contains four rows of signal contacts on a 0.1-in. grid plus two additional rows of low-inductance contacts placed on the edges of the insulator housing. These additional contacts are useful for ground or power applications, and eliminate the use of signal pins for power and ground routing.

The modular continuous-grid architecture of the connectors allows you to combine individual modules end to end in any high-density configuration. In addition to the standard signal modules, the system provides other modules for power distribution, polarizing, and guidance. From $0.20 to $0.26 per mated signal-contact pair. Delivery, eight to 12 weeks ARO.

Teradyne Connection Systems Inc, 44 Simon St, Nashua, NH 03060. Phone (603) 889-5156. TWX 710-228-1431. Circle No 533

ARCNET INTERFACE

The S871P ArcNet network-interface module links STD PC-compatible computers to the ArcNet local area network. It features an activity LED, which indicates proper network operation and remains lighted while the token is passed through the network. The device is also compatible with standard PC-network operating systems such as Novell's Netware and provides a low-impedance or fiber-optic output. The design is implemented in CMOS and features a 2k-byte data-packet buffer, which is memory-mapped. The control status ports are I/O mapped. The network provides a 2.5M-bit/sec token-passing protocol. $495.

Contemporary Control Systems Inc, 2500 Wisconsin Ave, Downers Grove, IL 60515. Phone (312) 963-7070. TLX 314990.

Circle No 534

TERMINAL STRIPS

The 223 Series terminal strips provide a high-density printed-circuit-solderable terminal strip on 0.1-in. or 2.5-mm pin centers. Because they are modular, they can be quickly assembled to any desired length. The strips also incorporate an integral actuating lever that's used to open the clamp for wire insertion and removal. The stainless-steel cage clamp has high vibration, corrosion, and thermal resistance and can handle 28- to 20-AWG solid or stranded wire, or as high as 18 AWG, if the wires are not placed in adjacent positions. A version without an actuating lever is available, which can be factory or field wired with a small plastic tool or a small-bladed screwdriver. $0.22/position (1000).

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THE ACTIVE LEADER IN PASSIVE COMPONENTS

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Introducing the Weidmuller BLA/SLA Plug and Socket Connector System.

For years Weidmuller terminal blocks and connectors have set the standard all over the world in electrical and electronic connection systems. Now, our design engineers have come up with another brilliant solution. Our compact new BLA/SLA System for machine and process control circuit boards.

Our new design makes it quick and easy to install and repair wiring at the factory and in the field without expensive tools. Refinements include funnel-shaped wire entries, captive screws, and an improved zinc-plated steel clamping mechanism for a secure connection.

The glass-filled polyester insulating material of BLA/SLA connectors is non-burning (UL94VO) and heat and humidity resistant to maintain pin-to-pin spacing in adverse operating environments.

Marking surfaces on the sockets are large and angled for ease of labeling and reading. The design of BLA/SLA connectors prevents misalignment. And, thanks to our simple new coding system, the BLA/SLA System provides protection against misconnection of plug and socket when you’re using more than one connector. All without loss of poles. Weidmuller BLA/SLA connectors are available in 2 to 24-pole modules. They come in both vertical and horizontal configurations. A double-header version is available for applications requiring even greater wiring density.

With so many standard features and with such options as supplementary mechanical mounting blocks and strain relief covers, we’re confident you’ll find BLA/SLA the best system available for connecting discrete wiring to printed circuit boards.

Call or write for more information about the Weidmuller BLA/SLA.

A system whose brilliance you’ll appreciate even if you’re color-blind.

You can’t make a better connection.™

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Write Weidmuller, Inc., 821 Southlake Boulevard, Richmond, Virginia 23236. Phone (804) 794-2877. Telex 828376.

CIRCLE NO 131
**TERMINAL STRIPS**

The Beau Eurostyle Series 85 PCB-board-mounted terminal blocks are constructed of thermoplastic and maintain center-to-center spacing when they're mounted end to end; they feature dead-front construction to prevent shocks and shorting. The manufacturer claims that the blocks' captive wire protectors provide better connection and hold wires more securely than other techniques.

The devices have a high-density, 0.197-in. contact spacing in the terminal blocks. They provide as many as 5 terminations/in. and have an estimated UL current rating of 15A. The strips also feature captive screws that won't fall out and damage your equipment; large-wire entry that accepts wire to 14 AWG; and a closed side that acts as a wire stop. $0.12 per circuit (500).

**DESKTOP ENCLOSURE**

The Vario-Case desktop enclosure features sidewalls of extruded aluminum sections; the covers and rear wall are made of ABS plastic. ABS is self-extinguishing in accordance with UL 94 VI. The enclosure's design allows the mounting of either 19-in. subracks or modules, as well as direct modular assembly and insertion of PCB boards.

The extruded aluminum sidewalls feature 0.49-in. vertical grooves that enable the 19-in. card frames and modular assemblies to be mounted at variable positions. The sidewalls also have tapped inserts at various depth positions.

The enclosure's feet, made of fiberglass reinforced polyamid, can be unfolded to ensure the safe stacking of several enclosures, without the risk of slipping. The feet cover the screw attachments when completely folded and can be unfolded to two positions, providing two angles of tilt with respect to the desk top. Vario-Case, $109.31 to $296.24; Vario-Rack, $799.88 to $1235.25.

**TEST CLIP**

According to the manufacturer, the Bug Catcher PLCC (plastic leadless-chip carrier), a test-clip adapter for integrated circuits, provides you with the first available method to help debug software and hardware in a PLCC. The device mates with a plastic leadless-chip carrier socket via the side pins and spacer block assembly. This interconnection scheme eliminates the need for long cables between the UUT and the test equipment, lowering the capacitance and inductance introduced in the circuit by the test setup.
Your Best Source for Test Clip Accessories is POMONA ELECTRONICS

DO-IT-YOURSELF MICRO-GRABBER™ TEST CLIP: MODEL 4233

DO-IT-YOURSELF MAXI-GRABBER™ TEST CLIP: MODEL 4225

DO-IT-YOURSELF SMD GRABBER™ TEST CLIP: MODEL 5243

DO-IT-YOURSELF MINI-GRABBER™ TEST CLIP: MODEL 3925

PATCH CORD: MINIGRABBER™ TEST CLIP BOTH ENDS: MODEL 3781

16 PIN DIP CLIP™ TEST CLIPS: MODEL 3916A (LEFT) STANDARD; MODEL 4236A (RIGHT) HIGH DENSITY

FREE 1987 GENERAL CATALOG

SOIC CLIP™ TEST CLIP: MODEL 5250 (8 PIN); 5251 (14 PIN); 5252 (16 PIN) SHOWN; 5253 (20 PIN); 5254 (24 PIN)

Our Products are available through your favorite electronics parts distributor.

EDN December 10, 1987
Hardware

The device utilizes two double-sided circuit boards, one JEDEC standard PLCC socket, 68 test points that are each 0.025-in², 68 side pins, one spacer block, and one overlay template. The spacer block prevents the collapse of the side pins from the force exerted by the PLCC socket after the adapter is inserted in the socket, and it ensures a secure fit. The template aids in pin identification. $160.

Emulation Technology Inc, 422 Ives Terrace, Sunnyvale, CA 94087. Phone (415) 960-0652. TLX 184817.

Circle No 538

MIXED CONNECTOR

Designed for an industrial ink-jet manufacturer, the Peek mixed connector combines fluidic/pneumatic contacts with coaxial, high-voltage, and standard signal contacts. The connector is housed in the vendor's size 5B shell. Four 50Ω coaxial contacts, two 5-kV contacts, eight signal contacts, and four fluidic contacts permit the fluid to be transmitted to and from the printheads.

ENCLOSURES

The 508 Series enclosures come in 3¾-, 5¾-, 7-, and 8¾-in. sizes with four to 10 available card slots in the enclosures. The units are constructed of aluminum with a brushed or polyurethane textured finish. The configurations include the desktop model with EIA mounting flanges that allow you to remove the front panel when it is loaded in the 19-in. rack.

All the units feature positive pressurized filtered plenum air cooling for controlled air flow throughout the enclosure, as well as even cooling for both the power supply and the card rack. You can reach the fans by removing just two screws, and because of the airflow design, you can slide-mount the fans without any loss in the cooling capabili-

EDN December 10, 1987
Working closely with customer engineers the RN "P/Q Team" designed, produced, tested and delivered a state-of-the-art connector that had never been made before. And they did it within the 16-week time frame required by this major OEM customer. Four major connector firms had already indicated that it could not be done!

The incorporation of this new RN connector enabled our OEM customer to reduce his product size by 80%...improve operating reliability by 300%.

This is the RN "Partners in Quality Team" in action. It brings all of our engineering, production and quality control resources together with customer experts to solve socket and connector problems with speed and efficiency. Call on the RN "P/Q TEAM" for your interconnect solutions.

This is the connector competition couldn't make! It is a state-of-the-art compression connector with contacts on 50-MIL centers. It features retent solder tails for robotic board placement and withstands IR reflow surface mount soldering. It also maintains contact integrity in extremely difficult operating environments.

CIRCLE NO 112
RN offers a wide variety of DIN Connectors. Half-size, standard and high density DIN connectors—120 or 150 positions. Completely repairable solderless FLEX PRESS™ contacts in male and female styles. Custom Early Mate/Late Break grounding pin location. Available in “better than gold” ROBEX® plating. Write for complete catalog.

CIRCLE NO 113

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R. A. Lindenmuth
President/CEO

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CIRCLE NO 114

The RN “P/Q TEAM”...your Partners in Quality
Hardware and Interconnect Devices

The enclosures also accommodate any Mupac backplane for Multibus, Multibus II, and VME Bus systems. From $1400.

Mupac Corp, 10 Mupac Dr, Brockton, MA 02401. Phone (800) 225-0398; in MA, (617) 588-6110. TWX 710-345-8458.

Circle No 540

CONNECTORS

The Lat-Con 2-row transition connectors are 0.05-in. flat-cable connectors. Designed for permanent attachment to pc boards, they eliminate the need for headers. They are furnished with a preassembled socket and cover but are open on one end for lateral cable insertion. The manufacturer claims that this arrangement significantly speeds and simplifies the mass termination of 28-AWG flat cable. They are available for 10 to 64 circuits, with 0.1-in. row spacing. You can get them with either 0.118- or 0.157-in. solder pins plated with 315 µin. of tin. From $0.53 to $3.67.

Panduit Corp, 17301 Ridgeland Ave, Tinley Park, IL 60477. Phone (312) 532-1800.

Circle No 541

PROTOBOARDS

According to the manufacturer, the Protoboard Series prototyping panels have several advantages over wire-wrap prototyping panels. The boards are 100% tested on a bed-of-nails tester, allowing the debugging effort to concentrate on circuit design, rather than wiring errors; they feature a 0.1-in. hole pattern that allows you to use a variety of packaging types; the use of 38-AWG wire provides high packaging densities; and you can mount the boards in single slots, allowing greater utilization of card racks. The boards' matrix of plated-through holes, all of which are drilled, makes it easy to add components at the bench. Four of the five new Protoboards are Mupac compatible and the other is Multibus compatible. Mupac 326-328-compatible Protoboard, $850; the Mupac 347-compatible board, $1500; Mupac 9U x400-compatible board, $1700; Mupac 9U x220-compatible, $830; and Multibus I-compatible, $485.

Multiwire/East, 250 Miller Pl, Hicksville, NY 11801. Phone (516) 933-8300.

Circle No 542

DATA CABLES

These 62.5/125-µm fiber-optic data cables for data and LAN applications are available in two performance levels: a high-performance 3.75 dB/km attenuation at 850 nm and a 160-MHz-km bandwidth; and a lower-performance cable that attenuates 5.0 dB/km at 850 nm and a 100-MHz-km bandwidth. The higher-performance cable's specifications meet the requirements of the IBM 3044 channel-extender system.

The cables come in both loose and tight buffer constructions with strength members of Kevlar, fiberglass epoxy rod, steel, or a combination of fiberglass, epoxy rod, and Kevlar. The number of fibers in each cable varies from one to 18. Standard lengths for the cables are 500, 1000, 3280, and 6560 ft. From $218 to $4321.

Belden Wire and Cable, Box 1980, Richmond, IN 47375. Phone (800) 235-3364.

Circle No 543

SOCKETS

The IC134 Series SOJ autoeject burn-in sockets are intended for use in high-density burn-in applications. The low-insertion-force sockets have two options for loading and unloading: manual or automatic. Using the sockets' autoeject feature, you can easily extract the device after testing. The side gaps provide thermodynamic airflow for efficient heat dissipation. The socket material is polyetherimide, and the contact material is beryllium copper with

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Choosing the right fan for your application is easy when you choose PAPST. Simply because PAPST offers the broadest line of AC and DC tubeaxial fans in the world.

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LOCTITE
NUVA-SIL 30-Second Silicone
Hardware and Interconnect Devices

gold-over-nickel plating. The operating temperature ranges from -40 to +175°C. The 26-lead model, $7 (1000). Delivery, stock to six weeks ARO.

Nepenthe, 2471 E Bayshore Rd, Palo Alto, CA 94303. Phone (800) 637-3684; in CA, (415) 856-9332.

Circle No 544

ADAPTERS

These form-factor adapters for interface to Sun Microsystems Computers provide size conversion from a standard 6U VME Bus to a Sun 9U configuration. They are available in five different models. Versions 1 and 2 are used as direct replacements for Sun models 160A and 160B. They differ from one another in that version 1 passes the A and C row signals to the Sun P2 proprietary bus, but version 2 doesn’t. Version 2 isolates the P2 connector A and C signals from the Sun backplane. Both versions connect P2 A and C row signals to a 64-and a 50-position ribbon header.

Version 3 is a low-cost adapter for direct installation of a standard VME board into a Sun configuration. Version 4 is similar to version 1 except that it brings the front panel of your board forward to make it an integral part of the Sun front-panel system. This movement of the front panel provides you with direct access to connectors and displays. Version 5 performs a similar function for version 2 adapters. Versions 1 and 2, $400; version 3, $175; versions 4 and 5, $565.

Dawn VME Products, 47073 Warm Springs Blvd, Fremont, CA 94539. Phone (415) 657-4444.

Circle No 545

ACTIVE HUB

The 4012 rack-mounted active hub interconnects devices in an ArcNet local-area network and retransmits data to all nodes on the network. It supports various cabling schemes, such as coaxial, fiber-optic, and twisted-pair cabling. It supports these cabling schemes by using low-impedance, high-impedance, and fiber-optic expansion modules that plug into the hub.

The device’s master/slave design allows one master node to drive as many as 11 slave nodes. The hub is expandable from four to 48 nodes in groups of four: Twelve slots have four points/slot. The 7-in. panel height allows the hub to fit into a standard 19-in. rack. Further, you don’t need to terminate any of the device’s unused ports. $1095.

Contemporary Control Systems Inc, 2500 Wisconsin Ave, Downers Grove, IL 60515. Phone (312) 963-7079. TLX 314990.

Circle No 546

CABLE

The Trans-E-Twist Interconnect cable features alternating lengths of 18-in. sections of twisted pairs followed by 2 in. of flat parallel wires.

The cable is UL listed for internal and external interconnections on electronic systems. The twisted pairs have alternating lay directions to keep crosstalk at a low level. The flat areas allow mass termination of the cable. The cable is compatible with standard insulation-displacement connectors. The cable is available with as many as 36 twisted pairs, using 26-, 28- and 30-AWG stranded tin copper. Low-loss high-speed insulation systems are also available. For each 1000-ft length of twisted-pair cable, $50.

Brinetc Corp, Brand-Rex Cable Systems Div, 1600 W Main Street Willimantic, CT 06226. Phone (203) 456-8000.

Circle No 547

CONNECTORS

The D3 (also called NFC) Series fiber-optic connectors are compatible both performance-wise and mechanically with the industry standard FC fiber-optic connectors. They are packaged as a kit with only three pieces: a ferrule, housing, and a rubber boot. Because the connector uses a glass capillary instead of a ceramic capillary, it can be polished with inexpensive alumina films and water, rather than diamond films and ultrasonic cleaning. The connector also features four keyways that are built-in, allowing you to easily select the lowest-loss key position. Multimode ferrule and housing, $12; single-mode ferrule and housing, $18; multimode 5m patchcord, $93; single-mode 5m patchcord, $169.

NEC Electronics Inc, Box 7241, Mountain View, CA 94039. Phone (415) 963-7079. TLX 314990.

Text continued on pg 138

EDN December 10, 1987
Plug new sales appeal into your system with DuPont Latch-N-Lok Shielded Assemblies.

Any color. Angled or straight. "Click"—it's connected. The smallest package.

Only Latch-N-Lok™ modular interconnections offer so many attractive, functional combinations in cords, colors and connectors to give your system the sales appeal it deserves.

Now you can specify the most compact plugs and receptacles available, in straight, right-angle or combination designs, with the latch on top, bottom or side of the plug. Receptacles come with panel, chassis or board mounts. Order your cords coiled or straight, in any length, with any number of conductors, with foil, serve or braid shielding, and in a variety of jacket textures. All elements can be color-coordinated to your system. You can even put your logo, trademark or pictogram on your connectors.

Uses the patented PV™ Receptacle and BergStik® Header.

The contact design used in Latch-N-Lok™ has been proven in millions of applications. This means Latch-N-Lok™ will stay on the job,
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What's more, Latch-N-Lok™ is the industry's only quick disconnect pin-and-socket system. An audible "click" tells you a positive plug-to-receptacle connection has been made.

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Latch-N-Lok™ assemblies cost no more than standard types. Call toll-free 1-800-233-1173* or write on your company letterhead to request a sample, our Latch-N-Lok™ brochure, or a demonstration.

Latch-N-Lok™ modular shielded interconnections: another development of Du Pont Electronics,
SOCKETS
The IC120 Series sockets are a group of low-insertion-force, auto-eject PLCC sockets for use in high-density, burn-in applications. Both dead-bug and live-bug versions are available. The sockets feature an insulation resistance of 1000 MΩ min at 500V dc, breakdown voltage is listed at 700V ac for one minute, and contact resistance is specified as 30 mΩ max at 10 mA/20 mV. The operating temperature ranges from -40 to +170°C. The typical socket life is specified as 10,000 insertions min. A 68-lead device, $17.35 (250).

Nepenthe, 2471 E Bayshore Rd, Palo Alto, CA 94303. Phone (800) 637-3684; in CA, (415) 856-9332.

Circle No 549

PROTOBOARDS
The JE400 Series prototyping boards feature a silkscreened legend on the component side which depicts the foil pattern and hole coordinate for the solder side of the board. The series covers a wide variety of sizes and applications that range from 2.7×4.5 in. to 5.0×13.25 in. It also includes a Commodore-compatible user-port interface pc board. The protoboards are made of laminated glass epoxy with 0.062-in.-thick, 2-oz copper that's clad with a solder-tin finish; all holes have a 0.042-in. diameter on a 0.1×0.1-in. grid pattern. From $7.95 to $19.95.

Jameco Electronics, 1355 Shoreway Rd, Belmont, CA 94002. Phone (415) 592-8097. TLX 176043.

Circle No 551

HEADER
Compatible with flat-cable female-socket connectors, the Flex-Fit pliant contact header minimizes pc board, plated-through hole deformation and conforms to the requirements of MIL-STD-2166. It can be removed and replaced without compromising the part's mechanical or electrical performance.

The header, with contacts on a 0.1×0.1-in. grid pattern, is available in contact sizes from 10 to 64 pin positions, and it offers a number of options such as lock/eject latches for positive-contact easy ejection. Polarization options include center key, dual key, and MIL-C-83503 (612 version). The header's insulation material is a glass reinforced thermoplastic. The contacts are plated in the contact area with gold over nickel. The header has a temperature rating of -55 to +125°C. $1.15 (1000).

Thomas and Betts Corp, 920 Route 202, Raritan, NJ 08869. Phone (201) 469-4000.

Circle No 552

EXTENDER BOARDS
These two extender boards for the Apple Macintosh II consist of a multilayered design that offers high performance, low noise, and little crosstalk; and a 2-sided board for general-purpose use. The multilayered extender features a 5-layer design of copper-clad FR4 material with two 9-pin DIN connectors installed on the board. This board features decoupling capacitors and has a jumper field that allows each signal to be individually opened for testing. An additional DIN connector provides access to a bus analyzer, and a mounting bracket is available for attachment to the computer chassis. The 2-sided extender is constructed of 2-sided copper-clad FR4 material. Two 96-pin DIN connectors are installed on the board and a chassis mounting bracket is included. Multilayer version, $295; 2-layer version, $69.

Vector Electronic Co, 12460 Gladstone Ave, Sylmar, CA 91342. Phone (818) 365-9661. TLX 269303.

Circle No 553

SOCKETS
The company offers four versions of sockets for single in-line memory modules. These burn-in sockets accommodate 256k×8- or ×9-bit dynamic RAMs and 1M×8- or ×9-bit dynamic RAMs. The sockets are...
Now, high performance vacuum/pressure blowers that operate from 120 VAC

Compact units feature brushless dc motors with integral controller and variable speed capability

These new Windjammer® blowers combine electronics, motor, and fan system in a compact, cost-effective package that operates from a standard 120 VAC input. An exclusive Lamb Electric design, they were developed for demanding, limited space applications such as business machines, medical equipment and materials handling applications.

Just 5.7” in diameter, the blowers have 1-, 2-, or 3-stage fans for performance from 50” H2O vacuum at 0 CFM to 110 CFM at 0” H2O. With one version, a 0 to 10 VDC signal from a sensor or other device will control motor speed and adjust air performance from 0 to 100%. Or, a second model provides manual speed control by means of a potentiometer located in the blower housing.

These blowers also feature low noise performance and are UL/CSA component recognized. Get complete details by contacting AMETEK, Lamb Electric Division, 627 Lake Street, Kent, OH 44240. (216) 673-3451. Telex: 433-2140. Cable: LAMETEK.
available in 30, 35, and 72 pins (50- and 100-mil spacing, single or double density). Actuation latches provide quick insertion and extraction of memory modules. The sockets' body material is polyethersulphone/polyetherimide. The contact material is beryllium copper with gold-over-nickel plating, and the operating temperature ranges from -40 to +170°C. 30-pin sockets, $25 (1000).

Nepenthe, 2471 E Bayshore Rd, Palo Alto, CA 94303. Phone (600) 637-3684; in CA, (415) 856-9332.
Circle No 554

TERMINAL BLOCK
The Dik 1.5 3-level terminal block is designed to save cabinet space and labor time when terminating 3-wire process control devices. The 3-level configuration allows for 12 terminations/in. The two lower levels of the terminal block serve as the positive and negative power supply terminals, and the top level is used to terminate signal lines. Wiring and busing of the voltage-supply lower levels is done with one screw/position. The device mounts on any conventional DIN rail and is rated for 25A at 600V. It can accept wire sizes to 14 AWG. $2.30 (100).

Phoenix Contact, Box 4100, Harrisburg, PA 17111. Phone (717) 944-1300.
Circle No 555

COOLER
The Slimboy 17 Series air conditioner cools electronic controls housed in narrow enclosures. It features a cooling capacity of 2000 BTU/hr and has an overall package width of 12 in. The unit employs high-flow-rate ball-bearing fans and has built-in condensate evaporation. It's available in three mounting configurations: The standard model comes without mounting rails; a second model is available with top and bottom mounting rails; and a third model comes with side mounting rails. Its closed-loop design protects the sealed-in electronic controls and...
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A SOURCE OF DELAY?

Look at the Tek 2465A with a 17-bit Word Recognizer. It's an easy, economical scope option that makes the critical difference when you need to trigger on data to monitor digital system performance. Parallel bus information triggers your display, so you can view up to four channels of real-time information. Add standard features such as 350 MHz bandwidth, on-screen cursors, 500 ps/div time base and trigger level readout, and you have a scope made for solving tough problems in digital design!

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Please send me your free 22-page brochure.

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In a hurry? Call Tek direct 1-800-426-2200

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You can tailor the 2465A for special needs. Or choose one of three multiple-option packages, the 2465A Special Editions. They are configured for specific application areas at a significant savings over the separately ordered options.

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prevents shutdowns caused by heat, humidity, dust, or other contaminants. $585 (25).

McLean Midwest, 4000 83rd Ave N, Brooklyn Park, MN 55443, Phone (612) 561-9400. TLX 290883. TWX 910-576-2951.

Circle No 556

CONNECTORS

These miniature DIN connectors offer pc-board and right-angle mount, a selection of four to eight pins, and male- and female-molded cable versions. They are available in either shielded or nonshielded models and have complete custom-design capabilities. From $0.40 (OEM qty).

Shogyo International Corp, 287 Northern Blvd, Great Neck, NY 11021. Phone (516) 466-0911. TLX 12218.

Circle No 557

CABLES

The vendor's two low-loss miniature RGB coaxial cables are used with broadcast systems and color monitors. These 75Ω units eliminate the need for decoding equipment. They have a nominal capacitance of 17.3 pF/ft and a propagation-velocity factor of 78%.

The 1164A and 1167A Series consist of mini coaxial cables under an overall Mylar tape and black PVC jacket. Each cable has a Datalene-insulated stranded 26-AWG silver-plated copper-alloy conductor that is surrounded by a Duobond II foil tape and a tinned copper-braid shield. The 1164A Series has an RGB color-coded jacket, and the 1167A Series has a color-coded jacket of red, green, blue, and white. Per 1000 ft, in 500- and 1000-ft pull-ups, 1164A, $1092; 1167A, $1473.

Belden Wire and Cable, Box 1980, Richmond, IN 47375. Phone (800) 235-3364.

Circle No 558

F-O MODEM
The Series 9481-1G RS-232C fiber-
Hardware and Interconnect Devices

Optic modem extends the range at which you can operate an RS-232C link to 2 km and links data-communication equipment (DCE) and dataterminal equipment (DTE) via fiber-optic cable. It accommodates either duplex plastic or glass fiber-optic cables and handles data rates as high as 19.2k baud (asynchronous). In addition to transferring data in both directions, the modem provides support for six control/handshake lines via the same fiber.

You can apply power to the modem directly through the DB25 pin connector or the optional external plug-in-jack power supply. The unit is available with either male or female contacts, in DCE or DTE configurations, and is compatible with ST-type fiber-optic connectors. The use of fiber-optic cabling with these modems eliminates ground loops, and the use of these modems requires no modifications for existing RS-232C equipment. $54 (500).

Thomas & Betts Corp, 920 Route 202, Raritan, NJ 08869. Phone (201) 685-1600.

Circle No 559

F-O KIT

The JE310 fiber-optic kit is an educational package, designed to give students and engineers hands-on experience with fiber-optic technology. It features separate transmitter-and-receiver circuit boards with separate test points for each signal on the board. The kit also includes fiber-optic cables and connectors, and requires a 6 to 9V power supply. $19.95.

Jameco Electronics, 1355 Shoreway Rd, Belmont, CA 94002. Phone (415) 592-8097. TLX 176043.

Circle No 560

EXTENDER BOARDS

The 3690-30 and 3690-31 extender boards are compatible with IBM PS/2 Series computers. The 3690-30 extender addresses PS/2 models 50 and 60; it's compatible with the PS/2's microchannel architecture and can be used with a 16-bit connector. The 3690-31 extender board is compatible with the PS/2 model 80, including a 32-bit connector, which you can use either with or without the matched-memory extension.

Both boards use a 3-layer design of copper-clad FR4 material. The inner layer is a crosstalk-reducing ground plane. The 3-layer design is impedance matched to the PS/2 backplane. The boards' edge-con-nector tabs are laid out on 0.05-in. centers on the backplane edge and an installed connector is located on the other edge of the board. Instructions and mounting brackets are included. 3690-30, $195; 3690-31, $248.

Vector Electronic Co, 12460 Gladstone Ave, Sylmar, CA 91342. Phone (818) 365-9661. TLX 269303.

Circle No 561

SOCKETS

These test and burn-in sockets for fine-pitch plastic-quad flatpack (PQFP) packages come with hinged lids to accommodate naked in-house handling or as a socket/carrier combination for internal/external transport. They have pin counts of 84, 100, 132, and 196. The sockets' body material is made of polyethersulphone/polyetherimide, and the contact material is beryllium copper with gold-over-nickel plating. The operating temperature ranges from -50 to +175°C. The insulation resistance is 1000 MΩ min at 500V dc. The dielectric withstanding voltage is 700V ac for 60 sec, and the contact resistance is 30 mΩ max at 10 mA/20 mV. The rated current for the devices is 1A max, and the sockets can withstand 25,000 insertion cycles. 100-pin model, $67.42 (100).

Nepenthe, 2471 E Bayshore Rd, Palo Alto, CA 94303. Phone (415) 856-9332.

Circle No 562

CONNECTORS

The Pre-Cap Series fiber-optic connectors are compatible with SMA, ST, and FC connectors. They combine the advantages of a composite polymer alloy with the precision tolerance of a glass capillary; as a result, insertion losses are <0.3 dB for multimode fiber applications. The connectors offer crimp and polish termination, and accommodate 125- and 140-µm multimode fibers.

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EDN December 10, 1987
**MULTIPLE CHOICE**

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Because of the increasing use of high-level languages and real-time operating systems, assembly-language debuggers no longer suffice. They're giving way to debuggers that can correlate target-system activity with high-level source code and ones that can manipulate real-time operating systems.
Debuggers help you perfect high-level and real-time code

Charles H Small, Associate Editor

To help you adopt high-level languages and formal real-time operating systems, vendors are providing high-level-language debuggers that offer such features as breakpoints, program-trace capabilities, and memory-manipulation commands that accept the names of high-level-language constructs as arguments.

C is the language that debuggers cover most widely—followed by Pascal. However, Concurrent Sciences' Soft-Scope debugger works with Intel compilers for PL/M, Pascal, Fortran, C, and—amazingly enough—Jovial. The Tektronix Ada 68020 system includes a debugger for Ada code that you compile for the 68020 µP.

Older debuggers (see box, “Evolving requirements for debuggers”), based on a target-system ROM monitor and a simple CRT human interface, are like reluctant but entirely truthful witnesses; they answer all questions you put to them faithfully but never volunteer anything. Such monitor-ROM programs and preprogrammed ROMs are still available from all µP makers and from third parties like Allen Systems.

Genesis Microsystems' GeneScope ROM-based debug monitors for the 8086 family have a full-screen user interface, which comes in three versions. One is the company's standard interface. Two others mimic the interfaces of Applied Microsystems and Zax in-circuit emulators' interfaces. You can debug a target system with both the ROM monitor and an in-circuit emulator without having to contend with two different interfaces.

Newer, screen-oriented debuggers use multiple windows to display a wealth of information at each break in execution. Many, like Microtec Research's Paragon Xray debugger, allow you to set up your own windows to display any area of memory in any format you choose. Such capability proves useful, for example, when you are pulling data from one buffer, processing it, and writing the processed data out to another buffer. You could set up windows to display both buffers and then stepover (see box, “Glossary of high-level debugging terms”) the data-processing routine repeatedly to observe its effect on the data.

Not just a passive window

Like many window-oriented debuggers, Sun Microsystems Inc's DBX has windows for source code, captured execution traces, and memory and register dumps. DBX's source-code window is more, however,
Engineers will be adopting high-level languages and formal real-time operating systems simply because software projects continue to grow in size and complexity.

than just a passive window into the source code. You can also edit programs in this window without leaving the debugger. Most other debuggers do not have such a direct path back from the realm of finding bugs to the realm of correcting them.

Some of the software engineer's difficulties stem solely from working in a cross-development environment. Cross-development simply means developing programs on a computer other than the target—the one on which the code will execute. An example would be writing programs to control a microwave oven. Obviously, you cannot develop programs on a microwave oven, because it has no keyboard, screen, or mass storage.

If the high-level-language debugger is not intended as a universal debugger for a variety of high-level languages, then its vendor can make the debugger's command interface resemble a single high-level language. For example, the command language of both Oasys's C source-level debugger, CDEBUG, and Microtec Research's Paragon Xray debugger conform to standard C notation. TekDB from Tektronix has a strong expression evaluator that understands nearly any C expression.

Universal debuggers, on the other hand, force you to learn what amounts to another programming language if you are to take advantage of the debuggers' macro facilities.

High-level-language debuggers have commands that suit the style of high-level-language programming. In fact, using them resembles editing as much as it does classical debugging. For example, most have a so-called breakdown command that allows you to get out of a subroutine and back into your main program without stepping through the remainder of the subroutine. This command comes in handy when you inadvertently find yourself stepping through, or breaking into, an uninteresting subroutine.

**Debuggers still come up short**

Although new debuggers are more powerful than their forebears, they do have shortcomings. High-level-language debuggers purport to be symbolic debuggers, but not all so-called symbolic debuggers are equal. As a minimum, a symbolic debugger takes a symbol name as an argument for a memory reference. This simple-to-
implement feature is a time saver: You needn't refer to your compiler's cross-reference table each time you want to access a program location in the target system.

But this so-called symbolic capability speaks not at all to the data at the named location; simple symbolic debuggers are of little help when confronting multiple levels of indirection. Suppose, for example, that you are trying to de-reference a pointer. Your debugger will accept the pointer's name in lieu of the pointer's hex address as the argument of an examine-memory command. The debugger will return the hex value of what the pointer points to. But that pointer could be pointed at a named object. Unless the debugger has the ability to correlate the symbol table with fetched data, you will not be able to avoid flipping through the symbol table manually yourself.

Systems & Software's SoftProbe II has a command format that, taking a cue from C-programming operators, allows you to go through as many as seven levels of indirection by appending a corresponding number of asterisks to a pointer reference. Similarly, Ready Systems' RTscope real-time operating-system debugger has a debugging command that traverses linked lists.

**Name matching often fails**

Further, not all symbolic debuggers can match an area in memory with the symbolic name for that area when fetching data from data structures. Suppose that your program is accessing an array. The compiler's symbol table will have an address only for the start of the array. The debugger will find an exact match, therefore, only between the address of the first entry in the array in the target system and the array's name in the symbol table.

Unless the debugger works like Computer Dynamics' RDSD debugger for the firm's line of single-board computers, the debugger will not be able to match a reference to the array's subsequent entries. RDSD attempts to find the nearest symbolic reference to a memory access (it displays the offset from the access to the symbol as well as the symbol's name). RDSD performs a similar match when decoding return addresses on the stack because the compiler supplies addresses for the entry points of a routine and not the exit points a routine calls other routines from.

Tektronix's debugger for its Pascal compilers can even format the contents of enumerated variables according to your Type declaration for the enumerated variables. For example, suppose you declare a variable STOPLIGHT that can only store enumerated variables of the type RED, GREEN, and AMBER. If you interrogate STOPLIGHT, the debugger will reply with RED, GREEN, or AMBER as appropriate; debuggers for other compilers could not make this correlation without your first writing an elaborate conditional macro.

**Four new forms**

In general, the new debuggers come in four forms:

- Software simulators that run on the host computer;
- ROM-based high-level-language debug monitors that reside in the target system and communicate with the host computer;
- Hardware-based debuggers that integrate control software on the host computer with in-circuit emulators and logic analyzers that monitor and control the target system; and
- ROM-based real-time operating-system debug monitors that reside in the target system and communicate with the host computer.

These debuggers are not mutually exclusive; you can employ one or all of them on a given project (although having a high-level-language debug ROM and a real-
Until recently, debuggers were not keeping up with advancements in high-level languages and real-time operating systems.

Until recently, debuggers were not keeping up with advancements in high-level languages and real-time operating systems. Time operating-system debug ROM in the same target system can cause conflicts).

For years, the Boston Systems Office has supplied a powerful simulator, BSO/Debug, along with its VAX-based cross-development assemblers and compilers. The simulator was recently upgraded with a window interface that works with DEC's new color workstations and terminals. One user simulated an entire Intel iRMX real-time operating system, including simulated I/O and asynchronous interrupts, using BSO/Debug. Because of the wide diversity of target environments and emulators that the firm's customers use, BSO has only recently begun working on interfaces to common development hardware. Mecklenburg Engineering also makes μP simulators that can run assembly-language programs.

Several companies already make debuggers that use the same command interface when overseeing programs running in the host computer on a simulator or in the target system. Systems & Software's SoftProbe II for 8086 μPs is one such combination. This high-level-language debugger works with C, PL/M, Pascal, and assembly languages that use the Intel OMF file-output format. It runs as a simulator on VAX computers and IBM PCs and runs in target systems with the aid of a ROM-based monitor. It cannot, however, trace register variables.

A target-system's ROM-based debugger cannot debug certain portions of code. Because debug ROMs (or monitors, as they are sometimes called) use a software-based breaking mechanism, they can trace execution only through RAM-resident code and not through ROM-resident code without the aid of an in-circuit emulator's emulation memory. Intel debugger ROMs, for example, set breakpoints by replacing the instruction at the breakpoint with a software trap instruction. Also, ROM-based debuggers usurp target-system facilities. Typically, the debuggers need exclu-

In-circuit-emulator makers do an about face

The problems associated with debugging cross-developed code that was written in a high-level language are reversing a longstanding trend toward stand-alone, unbundled emulators. The first emulators came as a part of bundled development systems from μP makers and large instrument firms. These development systems were expensive. When the personal computer emerged, smaller manufacturers not involved in semiconductor production seized an opportunity to break out the in-circuit emulator from the bundled development system. They started a trend toward stand-alone in-circuit emulators.

The stand-alone in-circuit emulator is a good, low-cost approach for debugging small, cross-developed programs written in assembly language. But the pressure of big programs written in high-level languages is propelling third-party, stand-alone-emulator makers to link up with compiler and debugger vendors. For example, Applied Microsystems can now supply versions of two compiler/debugger combinations targeted for the firm's emulators: The Validate/Xray debugger that works with Microtec Research's Paragon compiler and the Validate/SoftScope debugger that works with Intel compilers. Intermetrics now has versions of its XDB debugger that interface to common third-party in-circuit emulators from firms such as Applied Microsystems, Zax (Irvine, CA), and Microtek Labs (Gardena, CA), as does First Systems Corp for its MicroScope ROM-based target-system debugger.

These pre-existing debuggers now have simple additions to their command languages that allow them to function as transparent terminals to the emulator's native command language. The debugger and emulator software continue to operate more or less independently. Despite the availability of these package deals, the debuggers and emulators are not as well integrated as the packages from Hewlett-Packard, Tektronix, and Arium.

Another example of a high-level-language debugger coexisting with a lower-level debugger is Andyne Computing's PCMascot real-time operating-system kernel. This system runs on the IBM PC and comes with a suite of debugging commands for the real-time operating-system constructs. If you enter the PCMascot debugger via the native MS-DOS debugger, keying in a Break command on the PC's keyboard returns you to the DOS debugger.
sive use of at least one software interrupt and also the use of a communications port.

Even a cursory examination of the triggering schemes of software-based versus hardware-based debugging tools reveals one essential difference: Software-based tools have only a single level of conditional triggering; hardware-based tools (in-circuit emulators and logic analyzers) feature multiple levels of sequential triggering.

A software tool breaks whenever the program reaches a breakpoint or alters a watchpoint; you can set up a hardware-based tool to break only after a certain sequence of events occurs. Thus, a hardware-based tool can filter out extraneous activity and focus on problem areas more closely than software-based tools do. For example, you could set up a hardware-based tool to break execution only after a real-time operating system's supervisor program activates a certain task and that task jumps to a portion of re-entrant code or accesses a common data structure. A software-based tool would break no matter which task used the re-entrant code or accessed the data structure.

Once you've gotten into a procedure, you might want to find out how you got there, especially if this procedure has many different potential callers. A stack traceback command works directly from the current program stack; therefore, you need not have made any previous setup or issued any explicit trace-collection command, as you would have to do with a hardware-based tool. Unless your target-system debugging hardware includes logic-analysis capability, you could not collect such linkage information without slowing down execution anyway.

Finding your way

Stack traceback commands come in two forms. Simple traceback commands print out the stack and show you the sequence of calls that preceded the activation of the routine you are currently debugging. These commands let you view the results of dynamic, run-time nesting of the program as opposed to static, lexical nesting in your source code.

More advanced traceback commands allow you to retrace your steps to a higher-level calling routine or to adjust the stack to bypass a called routine that isn't working properly without recompiling and downloading the corrected module. In this case, you would have to use the debugger's commands to manually perform the correct action that the malfunctioning subroutine isn't performing.

Real-time operating-system debugger (Andyne Computing Ltd)

For serious hardware-level debugging, you need an independent, non-intrusive window into the target system—in short, an in-circuit emulator.

Having special hardware evaluate conditional breakpoints speeds up the debugging session and points out one of the advantages of debugging with in-circuit emulators. For example, when Tektronix's TekDB is working with one of the company's emulators, the firmware in the emulator determines whether the breakpoint condition qualifiers are True each time the software under test reaches a breakpoint. The debugger running on the host computer gets no notification of the Stop unless the condition being checked is True. This system eliminates your checking a variable manually each time the program stops to determine when the variable's value goes out of bounds. Tektronix's hardware can evaluate approximately 90 conditional expressions per second (including the time consumed by restarting execution).

Arium's Echo µP-development system serves as an example of the benefits of a closely integrated host, compiler, debugger, and in-circuit emulator. The unit costs $12,980 for 16-bit and $8960 for 8-bit µPs. The Echo's computer has a pair of 68000s—one for display and one to run the Regulus operating system (a Unix look-alike with real-time extensions).

The unit has two high-speed links: one optional Ethernet link for quickly downloading large files from other host computers and a serial link to its companion in-circuit emulator. Because the Echo's main memory is expandable to 2M or 4M bytes, the computer can hold your entire source file in RAM for very quick correlations between captured traces from the in-circuit emu-
labor and the corresponding portion of source code; most other such systems have to get the source code from disk. The unit can not only disassemble and decompile captured code using your labels, it even appends the appropriate comments from your source code to captured traces.

The Echo understands the conventions of the Green Hills (Glendale, CA) C and Pascal compilers. These single-pass compilers (ones that produce no intermediate assembly-language file) compile code faster than some other, two-pass compilers.

The in-circuit emulator can reload its event recognizers dynamically. Once armed with stack offsets for local variables, the emulator can add the offsets to the value of the stack-pointer at the point that the software under test enters a routine to be debugged. The emulator can thereby set up its event recognizers to trace and trap on local variables. Hewlett-Packard's 64000 system is the only other system on the market that can trace and trap on local variables in real time without halting program flow.

Nearly all vendors of real-time operating systems, such as Ready Systems (RTscope), JMI Software Consultants (CE-View), Intelligent Machinery Co (imx/51), and Software Components Group (Probe), offer debuggers that allow you to examine and change the state of

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**Optimization and what it does to your program**

Optimizing compilers further obscure the correspondence between your source code and the compiled object code. If you write real-time programs in a high-level language, in order to meet response-time specifications you might find yourself having to switch on your compiler's optimizer and then be forced to debug optimized code.

Among the many techniques optimizing compilers employ is register allocation by coloring. Coloring keeps the most commonly used values in registers at all times. The compiler examines the entire subroutine to determine which local variables and parameters get used most often in the routine. It allocates them to registers.

Further, the register allocator can use data-flow analysis to find the lifetime of each variable, they may even allocate several variables to the same register if there are no places in the program in which both variables hold a value that will be needed later.

In addition, if the lifetime of a variable does not include any function calls, the variable can be put into scratch registers that do not need to be saved and restored, thus reducing variable overhead even further. Using these schemes to keep variables in registers can speed program execution but can also confuse your debugger horribly because it does not know just where a variable is at a given time or, conversely, just what the contents of a given register mean at a given time.

By default, your compiler can consider any integral, floating-point, or pointer variable as a candidate for register allocation if it never gets passed by reference and its address does not get taken by the C "&" operator at any point in the routine.

In other words, don't be fooled by the C-language mechanism that allows you to specify "automatic" variables; compilers will try to put as many variables as possible into registers. Conversely, if you specify more variables as automatic than there are registers in your target system's µP, the compiler may put your register variables on the stack. Worse yet, some compilers ignore the automatic-variable assignments altogether and put everything on the stack. The point here is that unless you are very familiar with your compiler's habits, you cannot be nearly as sure of just where your program's variables are as you would be if you were programming in assembler and making all the variable assignments explicitly yourself.

An optimizing compiler normally removes all dead code—code that never gets executed. Such code could be subroutines that never get called. Dead-code removal also includes removing WHILE loops that never get executed and DO-FOR loops that get executed only once. Obviously, if you set a breakpoint on a
the operating system's tables and also to manipulate the operating system's mechanisms for scheduling tasks and managing intertask communication. For instance, you can freeze one task while leaving the remainder of the tasks up and running. What these debuggers generally do not allow you to do is to debug the code that the individual tasks are running.

Tektronix's Ada debugger is one high-level-language debugger that allows you to qualify a breakpoint by task. In addition to selecting which program you want to debug, you can also select a task to be the current task under debugging.

On the other hand, if you use a conventional ROM-based, high-level-language debugger to debug a task's code, jumping to the debugger ROM has the effect of changing context from the real-time operating system to the debugger. In other words, halt one process and you halt all task activity. Imagine that you're debugging a real-time system for a robot. Perhaps you want to halt the task that moves the robot's arm back and forth. If you use a high-level-language debugger instead of a real-time operating-system debugger, all the robot's software will halt. But just because you've stopped the arm doesn't mean it's okay for the robot to relax its grip.

Real-time operating-system debuggers, such as Soft-
Several firms make debuggers that use the same command interface for programs running on the host computer or on the target system.

ware Components Group's Probe, do allow you to set breakpoints on addresses in your programs, but these simple facilities are a far cry from the power of high-level-language symbolic debuggers.

Microware Systems Corp has a pair of debuggers for its OS-9 real-time operating system. One, sysdbg, is a system debugger that takes over the entire operating system and halts all tasks. It communicates using the normal system port and its associated device handler and operating-system calls. The other, Debug, runs as a task and invokes the task to be debugged as a child process of the debugger. Debug can also access the symbol table produced by the firm's OS-9 linker. Therefore, it combines both a high-level-language debugger and a real-time operating-system debugger in one.

Loading multiple debuggers into one target system can present problems if both debuggers use the same software trap to gain control of the target system. You would have to develop a software mechanism for saving and restoring the software trap's contents when switching contexts from one debugger to the other.

Despite their different implementations, the various debuggers have many similar strengths and weaknesses. Delving into how the debuggers accomplish

---

**Glossary of high-level debugging terms**

Programmers sometimes use old words in different ways, coin useful, but obscure, new words, or—confusingly enough—use several words to describe more or less the same thing, depending on which language they are using—subroutine, procedure, pragma, object, or module, for example. Here is a glossary of words you may encounter in the literature of high-level-language debuggers.

**Automatic variable**—Another name for local variable (see Stack frame).

**Breakdown**—Not a reference to the mental state of the software engineer. A breakdown command sets a breakpoint in the procedure that called the current procedure (that is, one frame down from the current frame on the stack). This breakpoint allows you to get out of a subroutine and back into the main program automatically with one command.

**Coloring**—The process of a compiler examining variables' usage over an entire subroutine and then assigning the most commonly used local variables to registers and the less commonly used ones to the stack.

**Conditional breakpoint**—A breakpoint that distinguishes between two events: first, merely reaching a breakpoint, and second, a condition being true. If the condition is False when the program reaches the breakpoint, the program continues.

**De-reference**—Etymologically unsound (compare to "delouse," for example), but useful, neologism current among C programmers. It signifies getting the object pointed to by a pointer as opposed to directly referencing the pointer itself.

**Disambiguate**—Homing in on the specific instance of a specified name. It's a useful feature because many high-level languages allow a breakpoint, and use the same name in different parts of the program (see overload); thus, if you ask the debugger to find something for you, it may discover several different references.

**Local variable**—See Stack frame.

**Maintenance**—That portion of the software design and debug process that continues after the program is shipped to a paying customer (as opposed to a beta-site customer).

**Overload**—A condition in Ada attributed to a name that can refer to several things in different modules (called "pragmas"). See disambiguate.

**Root**—Used as a verb; for example: "For Ada programs, this name need not be fully rooted as in standard.math.sin—the simple name, sin may be used." It's derived from the notion of having a-root directory in a hierarchical directory scheme.

**Scope**—Delimits the portion of a program over which a given instance of a named program construct is valid. An example is a local variable that gets used only in a subroutine. Its scope does not extend beyond the subroutine, and hence you can use the name with impunity in other subroutines.

**Stack frame**—A variable-length data structure. Languages such as Pascal and C use the stack, instead of main memory, for storing variables that will be used only inside a given subrou-
their tasks helps explain these characteristics.

Concurrent Sciences' Soft-Scope serves as an example; when Soft-Scope first opens a module of your source program, it searches the listing file to find the beginning of each line and records these file locations. At the same time, the debugger searches the executable load file to find and record the address of each executable line. The association between source and executable code makes displaying source code during program execution possible. The debugger stores this information in a temporary disk file, so it needs to make this correlation only once during a debugging session for a given module. Note that Concurrent Sciences' debuggers work only with Intel compilers; the firm maintains that other compilers do not produce enough cross-reference information to power a comprehensive debugger.

Debuggers cannot always resolve all ambiguities when matching up raw hex data with the compiler's symbol tables. If the program is jumping to an address, or accessing a given address, the debugger can unequivocally substitute the name it finds in the compiler's symbol table for the raw hex address. But suppose the program is moving a hex number into a register. That

tine. They also use the stack for passing parameters and pointers to data structures between routines. And, of course, the stack still has to do its normal job of holding return addresses of calling procedures. Therefore, the compiler sets up a stack frame each time the program enters a routine. If you know the structure of the stack frame, the exit points of calling routines, and the form (type) of the variables on the stack, you can decode the stack frame to determine the sequence of calling routines from the return addresses and the state of local variables both in the currently active routine and in the suspended calling routines. Static breakpoints—Sometimes called sticky breakpoints. They are active no matter how many times the program halts at them. Some debuggers distinguish between static and dynamic breakpoints. These debuggers insert a temporary—or dynamic—breakpoint as a part of a Go command that takes an argument (Go until <argument>). When the debugger reaches the point in the program signified by the argument, it halts and removes the breakpoint. Stepover—An extension of the concept of single-stepping. A stepover operation allows you to execute subroutines in a single step while still single-stepping line by line through a higher-level routine. Trigger and trap—Features that break program execution. Some debugger makers distinguish between triggers and traps. They use trigger to mean a hardware event recognizer in an in-circuit emulator or logic analyzer that can break execution, and they use trap to refer to a break in execution caused by a special instruction inserted in the program under test. Viewport—Synonym for a CRT window that shows a formatted, predefined segment of memory. Visibility—A debugger's rule that determines which named variable, structure, and other program constructs are visible at a given point in the program's execution. Generally, debuggers, by default, comply with the high-level language's scoping schema. However, a good debugger will allow you to exceed the high-level language's scoping and accord you visibility beyond the current procedure if you desire it (see scope). Watchpoint—A breaking mechanism. Some software-debugger makers distinguish between a breakpoint and a watchpoint. To them, a breakpoint is a command inserted in a program's commands that causes the program to stop and transfer control to the debugger. A watchpoint is a macro that first examines a designated memory location after each instruction cycle to see if the memory location has been changed and then stops execution if necessary. Because of the different breaking mechanisms, software-debugger makers think of breakpoints and watchpoints as being different entities; hardware debugging tools do not, of course, distinguish between the two because they are both definable states of the µP's address, data, and status lines.
No matter how powerful your debugger is, you will probably always have to use your creativity and imagination to debug your programs.

number could simply be data that will be used in an arithmetic or logical operation, or it could easily be an address or pointer. If the debugger finds that particular hex value in the symbol table, the match could be pure coincidence.

Periscope's debuggers handle this ambiguity by displaying possible matches in the comment field of a disassembled listing rather than by plugging in the match in the instruction field (Fig 1).

Not all programmers bother to put line numbers in their source code. Therefore, several debugger makers, including Systems & Software, supply utilities that insert line numbers in a file. Systems & Software also supplies utilities that print out Intel OMF files in a readable form so that you can study your program's symbol tables.

Oasys's CDebug high-level-language debugger comes with a utility program that goes even further than merely inserting line numbers into your source program. The firm's XPP preprocessor is an automatic editor (or stream editor) that will parse your source code, looking for anything a debugger might be interested in later on. When XPP finds something interesting, it sets up a pointer to it using the native C pointer mechanism and puts the pointer in a table.

Later, when you compile the preprocessed source file, the compiler will produce a custom-made symbol table in just the form the CDebug debugger is looking for. Thus, Oasys sidesteps the issue of accommodating different, and possibly incomplete, symbol tables from various compilers. The Periscope debuggers, for example, accept symbol information only from MAP files produced by Microsoft compilers.

No matter how powerful your debugger is, you will probably always have to use your creativity and imagination to debug your programs. Software engineers sometimes employ run-time schemata that pose the same problem to debuggers as the compilers' local and register variables do. Take, for example, overlays. If you load the overlays into the same area of memory every time, then you will be able to set up breakpoints within the overlaid code. Of course, if you're using a software-based debugger, you will have to set software breakpoints after your program loads the overlays, or else the software traps will get overwritten; conversely, you can set up hardware traps in advance.

If, however, your program determines the location of overlays dynamically, then you cannot determine memory locations in advance. The Intermetrics XDB has a mechanism for handling this problem. During the debugging session, you can extract the offset for the overlay and instruct the debugger to add the offset to all the addresses in the symbol table. Obviously, you cannot do this in real time.

Real-time systems pose problems similar to overlays—especially if they create and destroy tasks dynamically. Further, in real-time systems, different tasks can use the same piece of re-entrant code. If you set a breakpoint in the re-entrant code, you won't necessarily catch the task you are trying to debug. Generally, software-based debuggers offer no solution to this problem; luckily, hardware-based debuggers offer sequential triggering that can resolve this ambiguity.

Fig 1—Although most symbolic debuggers can decompile or disassemble a program's activity using the names of your defined memory references and subroutines in place of raw hex values, few can resolve ambiguous data fetches. Note the references to TMMEMORY and AMEMORY that appear in the comment field of this Periscope CO Inc disassembly listing. The disassembler inserted these references as possible matches with the data in the argument of the corresponding MOV commands on the same lines.

Debuggers serve other uses

A high-level-language debugger's ability to relate the source code to the flow of execution makes it a useful tool when you must modify or debug code that someone else has written.

You can use a source-level debugger for learning the high-level language itself, and you can use it for maintenance and testing. If you choose to write your code with a high-level language, you may have planned to eventually port your software from one hardware environment to another. A debugger can help smooth the porting process. Further, you can use a debugger to demonstrate, document, and profile a program.

Many high-level-language debuggers can optionally keep a record, or journal, of your debugger commands in a file. You can edit this file and rerun the commands from the file. In this way, you can gradually build
For more information...
For more information on the debuggers described in this article, circle the appropriate numbers on the Information Retrieval Service card or contact the following manufacturers directly.

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A debugger’s ability to relate the source code to the flow of execution makes it a useful tool when you must modify or debug code that someone else has written.

Custom software tools that not only can save you time when repetitively performing complex debugging operations, but that can also serve as test programs for manufacturing and field service.

Many high-level-language debuggers, such as Introl’s idb debugger for the firm’s line of C compilers for single-chip µPs, have debugger variables that you can declare and use in debugger expressions. These variables reside in the debugger and not in your target system. Such variables prove useful as local variables in debugger macros.

Patch programs with debuggers

Using a high-level-language debugger’s in-line assembler (or perhaps just jamming in a manually assembled set of machine-code instructions), you can patch programs without taking the time to recompile or reassemble. First, you replace the instruction at the beginning of the area you want to patch with a jump to a spare chunk of memory. You put the patch code in the unused area and finish it off with a jump back to the starting point or to the address just beyond the area you want to bypass. If your program doesn’t have a scratch-memory area, you can reserve a portion of memory for patching by setting up a high-level data array that you do not use in the program. Your high-level language debugger can find the data array when given the array’s name. You can then overwrite the data array with impunity.

You can also patch programs with a high-level-language debugger without bothering to go back to edit your source file and recompile it. You can use the debugger to break execution just before the section of code that needs patching. Then, you can execute a macro you have written that performs the correct operation on your data. Last, the macro can resume execution at the end of the code to be patched. If your debugger’s command language mirrors that of your high-level language, you can later incorporate the patch in your source code with little effort.

Doing without source code

In some cases, you can trick the code under test into jumping to the debugger even if you do not have source code for it. For example, you could be calling your own assembly-level programs from another program written in a high-level language for which you have no source code. You could break on the entrance to your program and then use your debugger’s backtrace feature to identify the calling routine. Then, using the examine and change routines in the debugger, you could replace the calling routine’s jump command with a software trap to the debugger’s entry point. That way, the next time you run the program, it will jump to the debugger just before entering your subroutine.

Generally, high-level-language compilers issue line-number symbols at the end of each statement or each line, whichever comes first. Therefore, if you concatenate statements on a single line (using a semicolon in C, for example), you can’t set a breakpoint between the two statements because the high-level-language debugger can only find the beginning and end of the line. And if you write multiline statements—for instance, an IF statement with several phrases on separate lines for clarity—the high-level-language debugger will only be able to find the beginning of the IF statement and the beginning of the THEN and ELSE clauses, not the individual phrases.

Possible new favorites

Some debuggers have unique features that may become industry standards once they are better known. For example, Visual Age’s TurboSmith debugger for TurboPascal programs written on an IBM PC lets you assign breakpoints to groups by appending a number ranging from 1 to 98 to your breakpoints’ definitions. Later, you can activate, or deactivate, an entire group of breakpoints, signified by a given number, at once rather than turning them on and off one at a time.

Periscope’s debuggers have a set of editor-like search commands, which can look through a range of addresses for instructions that reference a given memory address. This command comes in handy if you are debugging your code by first finding the symptoms of a program bug in the form of corrupted data. Once you find a variable going awry, you then need to find which instructions are modifying it. The firm’s debuggers have similar search commands for subroutine calls and return addresses as well as groups of assembly-language statements.

Under the heading of eliminating excessive flipping through related listings, some debuggers, such as Concurrent Sciences’ Soft-Scope, can let you look at other files of source code besides the one being debugged.
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CIRCLE NO 144
Software

User interface integrates incompatible computer-aided software-engineering tools

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Atherton Technology, 1333 Bordeaux Dr, Sunnyvale, CA 94089. Phone (408) 734-9822. Circle No 640

CASE tools facilitate the design of real-time, embedded systems

Cardtools, a set of software-design and development tools for CASE (computer-aided software engineering), provides the facilities to develop real-time, embedded systems. The tools automate the early, critical phases of software development such as high-level design, detailed design, documentation, and the analysis of system and software requirements.

Using the Control Maps Builder (CMB), you can define functional and data specifications and verify that the definitions are complete and consistent. From these definitions, you can use the Data Flow Diagram (DFD) Builder to define data flow through the system. You can use the Package Definition Facility to build a component library.

If you don't wish to construct your own DFDs, the Taskbuilder tool will do it for you automatically, using the specifications that you generated with the aid of the CMB. The Taskbuilder provides you with diagrams representing the required real-time, multitasking components such as hardware devices, tasks, mailboxes, semaphores, and queues; it also shows the intertask synchronization and communication requirements.

The Real-Time Performance Verification tool analyzes the synchronization and communication overhead. The Software/Hardware Interface facility prompts you for complete, detailed specifications of all signals and data that are processed both by hardware and software.

The specifications and definitions that the tools create are stored in a central database, Cardbus, from which the documentation tools can generate various reports, including reports that conform to DoD-STD-2167. Cardtools runs under VMS on VAX machines and under PC-DOS on IBM PCs and compatibles. Prices range from $10,000 to $60,000.

Ready Systems, Box 61029, Palo Alto, CA 94306. Phone (415) 326-2950. FAX 415-326-1427. Circle No 641
PC-DOS extension lets C and assembly languages address 16M-byte RAM

DOS/16M lets C and assembly-language programs run in protected mode on 80286- or 80386-based computers. Programs written for DOS can address as much as 16M bytes of RAM without using code overlays, EMS bank switching, or data paging. The program and its data can reside in RAM, eliminating frequent disk accesses and speeding execution. DOS/16M switches to real mode only to process DOS functions or hardware-interrupt requests for which protected-mode handlers do not exist.

The package’s run-time library contains routines for managing extended memory and for running programs in protected mode under PC-DOS version 3; a separate component allows you to start programs in protected mode. The package also includes a symbolic debugger for protected-mode programs, source code for the run-time library and start-up code, and a program to convert a real-mode .EXE program to a protected-mode .EXE program.

DOS/16M first adjusts your program for protected-mode addressing, then switches the computer into protected mode before executing the adjusted program. You don't usually need to rewrite or recompile your programs to use DOS/16M; you need only relink them with the run-time library. For example, you don't have to modify programs to omit EMS bank switching, and DOS/16M handles direct I/O and writes directly to video RAM without switching to real mode or adding overhead. You may have to modify any arithmetic operations that your program performs on segment-register values, and any parts of your program (such as interrupt handlers) that write into code segments of memory. If you have to recompile modified programs, you can use Microsoft C version 4.0, or a Lattice compiler, versions 2.15, 3.1, or 3.2. For linking object modules to the run-time library, you can use either Microsoft's Link or Phoenix's PLink86.

An initial-development license costs $5000 and includes replacement libraries for the supported compilers, the protected-mode debugger, and the .EXE file converter. The license confers the right to distribute as many as 200 copies (in .EXE form) of a program you have developed with DOS/16M. A royalty-free, 1-time fee of $29,000 allows you unlimited use and distribution and a source-code license.

Rational Systems Inc, Box 480, Natick, MA 01760. Phone (617) 653-6194.

Circle No 639

Expert system performs structured analysis of real-time software

Prosa, an expert system for software development, supports the structured analysis and design of data-flow, state-transition, and entity-relationship diagrams. It runs on an IBM-PC/AT or compatible and allows you to analyze real-time or data-processing systems. The system interactively maintains consistency between hierarchical data-flow diagrams and control transformations and their associated state-transition diagrams.

You can use Prosa to produce hierarchical designs. Its push-and-pop functions and consistency checking allow you to produce or evaluate systems on a top-down or bottom-up basis. Pop-up menus provide you with only functions that are legal in the context of the current design phase. The system's editing facilities include the placement, movement, and scaling of diagram elements, as well as on-the-fly text editing. You can store user-defined elements in a data dictionary for future use, and you can pan and zoom the display to support diagrams with page sizes equivalent to ISO standards A4 to A0, or ANSI standards A to E.

To ease the transfer of design information to other development tools, Prosa establishes a graphics database in ASCII files and a knowledge database in Prolog format. PC/AT add-ins required include an EGA card, two RS-232C ports, and either Mouse Systems' PC mouse or Logitech's mechanical mouse. Output is to an HP7475 or HPGL-compatible plotter. $3700.

Insoft Ky, Ilmarinkatu 16B, 90120 Oulu, Finland. Phone 981-226128. TLX 32004.

Circle No 642

AutoCAD's new release builds on the strengths of its eight predecessors. Here's how:

**Pull-down Menus.**

Release 9's pull-down menus let you choose all of AutoCAD's fundamental commands with a click of your mouse or digitizer. You can also customize menus to provide your own frequently used commands. Pull-down menus are compatible with AutoCAD's proven system of screen and tablet menus.

**Icon Menus.**

When you wish to select 3-D objects, text fonts, or hatch patterns, for example, you can pick them from an icon menu that appears on the screen. You can do the same thing with objects you create on your own. Icon menus make it easier and faster to choose the option you want.

**Dialogue Boxes.**

These let you converse with AutoCAD; give it instructions by “filling in the blanks.” They can simplify many of your tasks—entering layer information, for example.

**File Portability.**

With Release 9, drawing files are directly compatible without any conversion steps across four different operating systems on four different machine architectures: PC-DOS/MS-DOS, Apollo AEGIS, DEC VMS, Sun UNIX.*

On a network with different types of computers you can access a single copy of a drawing from any machine.

**More New Features.**

Release 9 also offers you twenty additional text fonts from the industry standard Hershey library, B-spline curve generation, and a direct link to the newly released AutoShade.*

**Release 9 = More Power + Easier Access.**

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You’ll be able to put its extraordinary capabilities to work faster than you ever thought possible.

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EDN December 10, 1987

CIRCLE NO 143

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standard graphics applications. To present your work at its best, there's a 1280x1024 pixel high-resolution display and 256 simultaneous colors from a palette of 4,096 (with 16.7 million colors optional), and a monochrome display with the same high-resolution and four grey levels. There's even a mathematical co-processor to help speed up your calculations.

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CIRCLE NO 142

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Target Microprocessor Families Supported

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1802/1803 68000/68020 COP400
6502/6502 68020 HD680
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6809 8096 Z8
68HC11 8085 Z80
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"Handling performance is up there next to speed in Formula 1 racing. TI's TMS320 gives us a real advantage — enough to win a Grand Prix." Peter G. Wright, Technical Director, Lotus Engineering

Lotus designed the active suspension in their Camel-Lotus-Honda Formula 1 car to approach the theoretical maximum-control point which gives the best balance between handling and performance. At racing speeds, each wheel is positioned by the TMS320-controlled hydraulics. A single TMS320 chip measures wheel forces and displacements and reads data from a body-mounted inertial platform. Then, in real time, the chip computes wheel position and controls actuators that adjust the suspension components to precise settings.

The TMS320 can also handle closed-loop engine control and more responsive braking systems, as well as many other automotive applications.

"The TMS320 helps us with one of our toughest tasks — designing toys with exciting features at prices that will sell." Dave Small, VP Engineering, Worlds of Wonder, Inc.

Worlds of Wonder is a pioneer in developing interactive toys and now has an innovative new doll named Julie*. Using a single TMS320 chip, Julie's designers are able to give her voice-recognition ability, coupled with synthesized speech and coordinated facial movement.

The TMS320 design expands the applications for affordable consumer products like solid-state answering machines, cellular phones, improved hearing aids, and animated electronic games.

---

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There are 15 compatible members in the TMS320 family (see the road map below), featuring two new DSPs with on-chip EPROM, the TMS320E15 and the TMS320E17. For applications requiring off-chip memory, there is the new CMOS EPROM, the TMS27C292, with 35-ns speed.

New interface alternatives include the low-cost CMOS TCM29C18/19 Combo Codecs with A/D, D/A, and filters all on a single chip.

The high-performance TLC32040 Analog Interface Circuit has 14-bit A/D and D/A and programmable filters.

For higher performance in digital signal processing, you can use building-block products like TI's microcodable ACT88XX 32-bit processor family.

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**From $5 to 33 Mflops:** With three generations covering 15 products, the TMS320 family offers software compatibility to protect your development investment and provide a smooth path to future applications.

For more information on support for the TMS320 family, please turn the page.
From hands-on training to a "C" compiler, TI has the tools you need to get your designs to market fast.

Whether you're moving into DSP or moving up in DSP, Texas Instruments can help you move your design into production faster. Hands-on DSP Workshops using the TMS320 development tools cover all you need to know from architecture to software. Courses are scheduled at TI Regional Technology Centers. Get Started in DSP with the TMS320 Design Kit, which contains datasheets, chip samples, and applications notes to make starting easy. Count on EPROM DSPs for realtime code development, form-factor emulation, and early production runs, with the option for last-minute changes.

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For more information on the Julie doll from Worlds of Wonder, Inc., call (415) 656-3171.

"MegaChip is a trademark of Texas Instruments Incorporated. Julie is a trademark of Worlds of Wonder, Inc.

More than 80 Third-party Hardware Suppliers and Consultants are featured in our TMS320 Family Development Support Reference Guide and in our DSP newsletter Details on Signal Processing. TMS320 Bulletin Board is an on-line service that provides you with the latest technical and application information.

The TMS320 Technical Hotline is staffed by applications experts and is ready to take your call.

How to get a fast start
For more information on TI's TMS320 DSP family, call 1-800-232-3200, ext. 3508. Or use the coupon below.
REAL-TIME OS
VRTX32 is a real-time, multitasking operating-system kernel intended for use with embedded computers based on the Motorola 68020 or Intel 80386 µPs. The kernel employs a pre-emptive, priority-based scheduler that lets you create, delete, resume, and suspend tasks. It also handles all service calls, including those for task services, intertask synchronization and communication, memory allocation, real-time clock services, character I/O, and interrupt handling. You can combine the kernel with the vendor's IOX (Input-Output Executive), which provides advanced device-level I/O facilities for character, disk, and general-block peripherals. You can also combine the kernel with FMX (File-Management Executive), which implements the PC-DOS file system. The system is position-independent; it uses program-counter-relative and base-relative addressing, and you can locate it anywhere in the available address space without modification. The vendor guarantees that interrupts-off time will never exceed 15 µsec on a 16.7-MHz 68020 processor. Versions are available for 68000, 68010, 68020, and 80386 µPs; $6775 each.

Ready Systems, Box 61029, Palo Alto, CA 94306. Phone (800) 228-1249; in CA, (415) 326-2950. TLX 711510608.

PASCAL COMPILER
The Pascal-2 compiler runs on and generates code for 68000-, 68010-, and 68020-based computers. Two versions are available. One runs under the vendor's VersaDOS real-time, multitasking, multiprocessing operating system; the other runs under System V/68, which is the vendor's version of Unix System V, release 3. The compiler, developed for the vendor by Oregon Software Inc (Beaverton, OR), is configured so that the same package runs on any of the three µPs; you use a compiler directive to select the target machine for which the compiler will generate code. Both versions can generate code that makes use of the 68881 FPU. The compiler can generate ROMable code for both VersaDOS and System V/68 target machines; it can also generate position-independent code (PIC) and code for targets that don't have memory-management units (MMUs). System V/68 can't use PIC and doesn't run on non-MMU targets. The compiler provides new string-handling capabilities and I/O switches, and the package includes an assembler interface, an execution profiler, and several cross-reference utilities. If a run-time error occurs, the compiler's error-walkback feature generates a special listing showing (in Pascal notation) each procedure call that was performed, from the point of failure back to the main program. Each version, $2800.

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Software

four breakpoint/trigger control tag bits for each of the µP's memory locations, the emulator has four 48-bit hardware breakpoint comparators. You can break on the nth occurrence of a comparator's break condition, or on logical combinations or logical sequences of breakpoint conditions. The emulator has an 8k×48-bit trace memory, which you can reconfigure to 4k×96 bits for time-stamped trace results. The emulator has a total memory map of 16M bytes, with 256k bytes of relocation RAM, and another 256k bytes of shadow memory. During program development on the host computer, the emulator provides a transparent link between the computer and a terminal. After developing your program, you can download program code and symbol tables to the emulator for use in debugging. £4300, including a target adapter board for one µP; additional target adapter boards, £1790.

Pentica Systems Ltd, Station Industrial Estate, Oxford Rd, Wokingham, Berks RG11 2YQ, UK. Phone (0734) 792101. TLX 848210.

OPERATING SYSTEM
Suitable for use on IBM PC/AT and compatible computers, the RT/iX operating system allows you to execute real-time multitasking operations under MS-DOS (version 3.0 and up). The operating system controls application programs written in C, and after program execution MS-DOS remains available for the user without any rebooting. All access to mass storage remains under the control of the MS-DOS file manager, allowing you to transfer data from the application program to standard MS-DOS-based programs. The system comes on a 3½- or 5¼-in. disk, and includes source code for sample drivers, which you can use for interrupt-driven or polled systems. Around DM 1000.

Kontron Messtechnik, Oskar-von-Miller-Strasse 1, 8057 Eching/Munich, West Germany. Phone (08165) 77601. TLX 526719.

DATA ACQUISITION
Laboratory Workbench software greatly simplifies the setup and control of high-performance data-acquisition modules operating under the Unix OS on the vendor's Series MC5000 real-time signal-processing computers. A file menu allows you
to save or to select previously created command files that control the sequence of operations; a timebase menu lets you choose timing and synchronization parameters; a hard-copy menu permits you to direct output to any one of a variety of printers and plotters; and a help menu lets you select on-line help screens. The package includes built-in signal-processing modules such as FFT, inverse FFT, and filtering functions; signal averaging; and power-spectrum calculations. You can also process data through a Fortran expression that you write into a window on the screen. You can display data as an X-Y plot or an oscilloscope trace, or, if you are dealing with slowly changing data, as a number that the program updates at specified intervals. Prices range from $3000 to $4500, depending on the host system configuration.

Masscomp, 1 Technology Park, Westford, MA 01886. Phone (617) 692-6200.

Circle No 412

PROCESS CONTROL

K-SCAN utilities configure process-control systems that run the vendor’s Forum system on DEC computers. The utilities let you define the I/O devices to be read or controlled; these devices can include sensors, alarms, operator displays, data recorders and plotters, and controlling elements. You can logically relate digital I/O bits with AND, OR, or Exclusive-OR functions and write programs for GPIB communications and device protocols. The menus also allow you to define the dynamic relationships between inputs, outputs, and storage elements by means of mathematical functions. The utilities store your definitions in a central database, together with calculations for PID loops, ramping functions, polynomial conversions, lead/lag functions,

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and other relational functions. A sequencer-control utility lets you define sequential operations in steps; each step can compare as many as nine variables to each other or to constant values. Prices range from $15,000 to $25,000, depending on the host configuration and the options selected.

Kinetic Systems Corp., 11 Maryknoll Dr., Lockport, IL 60441. Phone (815) 838-0005.

Circle No 413

OS FOR 80386

PC-MOS/886 version 1.02 is a multitasking, multiuser operating system for 8088-, 8086-, 80286-, and 80386-based computers, and it takes advantage of all the 80386's features. Those features specific to the 80386 CPU are isolated in a single system-driver file used only when an 80386 is present in the system. Systems based on the other chips in the family can use the extended-memory facilities of the OS, provided that the systems include extended-memory hardware. The OS provides software tools that let you assign 640k bytes of RAM to each task or user, including "ill-behaved" tasks that write directly to video hardware. You can also run multiple tasks in systems that don't have extended-memory-management hardware, but you are then limited to a total of 640k bytes (minus system overhead) for all tasks. Single-user version, $195; 5-user version, $595; 25-user version, $995.

The Software Link Inc., 3577 Parkway Lane, Atlanta, GA 30092. Phone (404) 448-5465. TWX 4996147.

Circle No 411

DATA ACQUISITION

LabWindows software helps you use your PC to develop software for data-acquisition, data-reduction, data-analysis, data-presentation, and instrument-control applications. The package consists of an interactive, menu-driven module that lets you select either Microsoft C or Microsoft QuickBasic as your programming language, and of libraries that contain routines for instrument control, data analysis, graphics, data formatting, and GPIB control. If you plan to work on complex applications, you can obtain other modules containing routines

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EDN December 10, 1987
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TimeStamp™ and variable display are two further features that are a must for real-time C-debug. Note the display of two instances of a structure in array “starray.” The contents of these structures, as for any C variable, can be changed right on the screen.

For a demonstration call 800/862-7486 (CA 714/978-9531)
Software

for advanced analytical and processing functions and advanced graphics. The function menus let you construct and interactively execute function calls by selecting the function and entering the parameters; after you've done so, the Lab-Windows module automatically generates source code in the chosen language. The compiler creates a list of all errors that it detects during compilation; using the editor, you can correct all of these in one pass before recompiling. The package also provides run-time debugging tools. When you have created and debugged your program, you can save it as a QuickBasic or C source-code file; with an external compiler, you can compile this code and link it to the appropriate library modules to produce a stand-alone executable program. $495.

National Instruments, 12109 Technology Blvd, Austin, TX 78727. Phone (800) 531-4742; in Texas, (800) 433-3488.

C COMPILER

SC-C is a C compiler that runs on the vendor's PC4000—a RISC coprocessor card that plugs into IBM PCs and compatibles. The PC4000's CPU is a Novix NC4016 RISC µP with 512k bytes of onboard memory, which delivers processing speeds in the 4- to 8-MIPS range. The C compiler provides all the features of the Kernighan and Ritchie standard, along with newer extensions of the language, such as void and enum data types, functions returning structures, structure assignment, const and volatile attributes, and others. The compiler generates a mixture of in-line and threaded code to improve efficiency; you can adjust the proportions of the mixture to optimize your program either for greatest execution speed or for smallest code size. The library includes routines that interface to the vendor's PCX executive; you can substitute other routines for use in a different run-time environment. PC4000 coprocessor board, from $1295; SC-C compiler, $595.

Silicon Composers, 210 California St, Palo Alto, CA 94306. Phone (415) 322-8763.

Circle No 415

CROSS-COMPILERS

The InterTools line of C and Pascal cross-compilers and cross-assemblers runs on IBM PC/XT or PC/AT hosts, as well as on a variety of workstations, and generates code for Intel and Motorola µPs and other 8-, 16-, and 32-bit target µPs. The most recent additions to the line are compilers, assemblers, and debuggers for 68020 target µPs; these compilers let you use all of the 68020's addressing modes and bit-
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Archimedes Software Inc.
2159 Union Street
San Francisco, CA 94123

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Software

C FOR 8096 µC
The C cross-compiler C-8096 runs on a variety of hosts, such as the IBM PC and compatibles and VAX and MicroVAX machines, and generates code for applications that will run on an embedded Intel 8096 microcontroller. The compiler provides all of the standard Kernighan and Ritchie features of the language, as well as the enhancements in the proposed ANSI standard. To simplify the development of embedded systems, the compiler also provides some 8096-specific enhancements such as enable interrupt and disable interrupt. The compiler supports the IEEE 32-bit floating-point arithmetic standard, and the library includes functions for trigonometric, logarithmic, and exponential functions, as well as the most important I/O functions for embedded-controller applications. All of the library functions are re-entrant to allow recursive code and interrupt handlers. The compiler provides the features necessary for generating ROMable code, including statically initialized variables. IBM PC hosts must have at least 512k bytes of RAM and MS-DOS 2.0 or later; MicroVAX and VAX versions will run under Unix or VMS. IBM PC version, $995; MicroVAX version, $3995; VAX version, $5995.

Archimedes Software Inc, 2159 Union St, San Francisco, CA 94123. Phone (415) 567-4010.

Circle No 417

CONTROL LANGUAGE
The HP Basic instrument-control language embodies many enhancements of the Basic language. These enhancements provide advanced I/O capabilities and facilitate the control and acquisition of data from instrumentation equipment. A new version of the instrument-control language is built into the HP 82300A Basic card, a 68000-based language-processor card that plugs into the vendor's Vectra PC or into an IBM PC or compatible. You can easily switch back and forth between HP Basic and applications such as Lotus 1-2-3 or a text processor. The features of the language card include a syntax-checking editor for writing or correcting programs, control structures that allow structured programming, and single-statement commands. The language-processor card includes 512k bytes of RAM (expandable to 4M bytes), an interface that provides access to an optional GPIB interface card, and a shared-resource manager that allows the host access to the vendor's workstation networks. $1320.

Hewlett-Packard Co, 1820 Embarcadero Rd, Palo Alto, CA 94303. Phone local office.

Circle No 418

PROLOG INTERPRETER
The interactive Prolog interpreter WProlog runs on IBM System/370 mainframes under the VM/SP CMS operating system. It provides command-line editing. You can use its CMS editor to edit your programs. The interpreter provides extensive syntax-checking and diagnostic features, and includes a built-in trace facility for debugging. This facility allows you to view the operation of selected predicates, even if these predicates are activated from within the body of a "hidden" predicate. Modules are independent; you can change and reload them individually. They are simple to use, because you need only declare the name and number of arguments of exported predicates—you don't have to make statements about the symbols within a module. The interpreter's programs use conventional CMS file-support statements to open, close, read, or write files, and they can directly execute any CMS Subset commands. Yearly license fees, $900 for educational users, $1800 for commercial users, and $3600 for third-party users.

Watcom Products Inc, 415 Philip St, Waterloo, Ontario N2L 3X2, Canada. Phone (519) 886-3700. TLX 06955458.

Circle No 419

MULTIUSER OS
The multiuser, multitasking operating system Wendin-DOS will run on any IBM PC or compatible and on 80386-based machines, but requires at least the computing power of a PC/AT to provide effective multiuser operation. The OS provides all of the PC-DOS commands and switches, and will run most popular MS-DOS application programs. Moreover, it provides many additional facilities that make operation easier. Among these are the Alias command, which lets you initiate a complex sequence of DOS commands with a single command name; the assignment and display of your
access rights; a log-in command that grants you the privileges and attributes associated with your user name; a log-out command that resets these privileges and attributes; and many other features derived from the VAX/VMS operating system. The OS has a windowing facility. You can order an optional application-developer's kit to help you develop multitasking applications. Wendin-DOS, $99; Application-Developer's Kit, $99.

Wendin, Box 3888, Spokane, WA 99220. Phone (509) 624-8088. Circle No 420

REAL-TIME OS
D-Nix/MP is a multiprocessor version of a real-time operating system that is fully compatible with Unix and conforms to the System V Interface Definition (SVID), yet offers features that make it particularly suitable for on-line transaction processing (OLTP). The OS runs on 68020-based machines; implementations for other processors are planned. A small and efficient kernel, a pre-emptive scheduler, and memory-resident processes allow the OS to provide the fast, predictable responses essential in real-time systems. The system provides extensive networking and data-communications facilities. It uses a bit map for file allocation, a technique that permits the creation of files with completely contiguous disk space and thereby reduces disk-head movement. According to the vendor, this technique also results in faster disk I/O and more predictable access time. A mirror-disk feature guarantees data integrity by writing all data to two disk drives simultaneously. Price depends on host configuration and other factors; licensing, from $25,000.

Diab Systems Inc, 323 Vintage Park Dr, Foster City, CA 94404. Phone (415) 571-1700. TLX 516020. Circle No 421

ADA COMPILER
Tandem Ada runs on all the vendor's NonStop systems and has been validated by the Ada Joint Program Office (AJPO). The compiler meets all the requirements of the current ANSI/MIL-STD-1815A and ISO/8652-1987 Ada standards. It generates code that is native to the vendor's NonStop architecture and Guardian-90 operating system. The compiler supports as much as 4M bytes of code space and 128M bytes of user-data space in main memory. Because NonStop systems have multiple processors, compilations can run concurrently and can put object code into different libraries, thereby reducing the total compilation time for many programs. The Ada package consists of the compiler, a library manager, a binder that
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links compiled modules together into an executable program, and a symbolic debugger. Prices start at $10,475 per system, with a monthly license fee of $400, for NonStop EXT and CLX systems.

Tandem Computers Inc, 19191 Vallco Parkway, Location 4-40, Cupertino, CA 95014. Phone (408) 725-6000.

Circle No 422

C COMPILER
Optimum-C runs on the IBM PC and compatibles and provides two modes of operation. During program development, you can increase compilation speed by running the compiler without optimization. The built-in EZ editor allows you to compile, link, and execute your program without leaving the editor; further, the editor will step through the errors detected by the compiler and allow you to correct them before recompiling. When you achieve error-free compilation, linking, and execution, you can switch to command-line operation and recompile the program using the global-optimization feature; because both compilation and linking in this mode require more free memory, you may not be able to work from within the editor. The resultant program will, according to the vendor, execute 30% faster than will corresponding code generated by any other compiler. $139.

Datalight, 17505 68th Ave NE, Suite 304, Bothell, WA 98011. Phone (206) 367-1803.

Circle No 423

CICS EMULATOR
UniTECS runs on Unix systems and emulates the major features of IBM's widely used transaction monitor, CICS (Customer Information Control System). On an IBM machine, CICS supplements the functions of the DOS or MVS operating system in order to facilitate the development and operation of transaction-processing systems. In a similar way, UniTECS supplements Unix by providing an environment that emulates CICS. This emulator allows you to transfer much of the program-development and maintenance load from your IBM mainframe to a Unix machine. On the Unix machine you can develop or maintain any application program that is written in Cobol, uses command-level CICS Release 1.6/1.7 standards, processes files organized under VSAM/DL1, and handles 3270-type displays through Minimum-Function BMS. During the development/maintenance, you have complete access to Unix development tools such as SCCS, Shell scripts, file-comparison programs, and Make facilities. Upon completion of the work you can transfer...
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CIRCLE NO 119
your application back to the mainframe for normal production use. UniTECS also allows you to run a mainframe application on a Unix machine at a smaller site where the installation doesn’t justify the cost of a mainframe. Price depends on the Unix machine configuration, and starts at $8000 for a system in which the combined cost of the processor, disk, and memory is less than $20,000. Versions are available for a number of different machines, including the Sequent Balance, NCR Tower 600, IBM 6150, and Hewlett-Packard systems that run HP/UX.

UniSoft Corp, 6121 Hollis St, Emeryville, CA 94608. Phone (415) 420-6400.

Circle No 426

FORTH DEVELOPMENT

The M/E260 is a standard 8080 fig-Forth system contained in an EPROM that plugs into the vendor’s M/E200 or M/E300 Z80-based, STD-Bus, single-board computers. The system provides the following facilities: a system for editing source code and providing hard copy for documentation; a simple means of compiling ROMable code; and a means of linking the new code to the system on power-up. In developing your program, you can mix high-level language with assembly-language code for words that must execute at top speed (such as interrupt service routines). The Forth 8080 assembler is compact, simple, and well-known; you can poke in any Z80-specific instructions that you need, or define them and add them to the assembler’s vocabulary. The Forth system contains words for performing GPIB controller, talker, and listener functions; you can add Forth words for nonresident GPIB functions. You can also route console input and output streams to the GPIB port. When you’ve completed your program development, you can use the included Forth utilities to download the code to an EPROM programmer. $125.

Mitchell Electronics, 8481 Rock Riffle Rd, Athens, OH 45701. Phone (614) 594-8532.

Circle No 428

GPIB DEVICE DRIVER

The memory-resident, BIOS-level device driver ROUTE-488, which runs under MS-DOS on the IBM PC and compatibles, lets you transfer data at high speed between a PC and devices connected to it via an IEEE-488 bus interface. In order to use the device driver, your system must have 96k bytes of free memory and must be running DOS 2.0 or higher. According to the vendor, the driver operates at least four times as fast as the DOS Device Handler. Moreover, the DOS Device Handler can transfer only one character at a time, whereas the vendor’s driver allows DMA block transfer to and from the GPIB. Programs written in any language that runs under DOS can make use of the GPIB device driver by virtue of a multilanguage software interface. Although designed primarily for use with the vendor’s LabPac software and IEEE-488 interface cards, the driver is also compatible with other vendors’ IEEE-488 cards. $125.

Scientific Solutions, 6225 Cochran Rd, Solon, OH 44139. Phone (216) 349-4030.

Circle No 424

PL/M COMPILER

The PLM8051 cross-compiler runs on VAX machines and compiles PL/M source code to 8051 assembly language, using standard Intel mnemonics. The compiler provides the standard features of Intel’s PL/M-51 compiler and lets you exercise the 8051’s functions, such as indirect addressing, bit manipulation, and direct I/O; in addition, both the compiler and the assembler take into account the 8051’s multiple address spaces and very small stack, and generate fast, efficient code. The full package consists of the compiler; an assembler with linker, librarian, and format converter to match the downloading requirement of various in-circuit emulators; and a debugger. Prices depend on the configuration of the VAX host, starting (for a VAXStation) at $3750 for the compiler, $1500 for the assembler package, and $2000 for the debugger.

Boston Systems Office, 128 Technology Center, Waltham, MA 02254. Phone (617) 894-7800. TWX 710-324-0760.

Circle No 427

GRAPHICS SOFTWARE

This GKS development kit operates under the MS-DOS operating system and features a language interface between the Alsys ADA programming language and the vendor’s GKS graphics kernel. The development kit includes the GKS kernel and its associated device libraries, and permits programs written in Alsys ADA to use the peripherals supported by the kernel.

The GKS kernel supports display controllers ranging from CGA-level to 1280x1024-pixel resolution; A3 and A4 digitizers and plotters; and a mouse. The kit also contains a configuration utility that allows you to install your application program on a particular workstation.

Together, the kernel, display-controller library, and input/output device libraries occupy about 100k bytes of RAM. Options include a device driver for A0 digitizers and plotters, and an interactive graphics editor. The MS-DOS environment requires 640k bytes of RAM and a math coprocessor. $995.

Metadesign SA, 2 Avenue Salomon, 59800 Lille, France. Phone 20740124.

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EVERY HAND-HELD TERMINAL YOU CAN THINK OF
Although practically every electronic circuit requires a dc power source, not all can operate from the same dc level. For systems that require multiple dc voltages, you may have to design complex power-distribution schemes. Point-source power devices—dc/dc converters—can ease your power-distribution design task.
Today's dc/dc switching converter modules significantly simplify the task of powering electronic systems. These pc-board-mountable converters provide the necessary power exactly where it’s needed, so you don’t have to design a complex power-distribution network for your system. Neither do you have to worry about intricate grounding and filtering systems. And although you must still take your system’s noise performance into consideration, dc/dc converter modules can help minimize noise problems.

DC/DC converters come in various designs; which design you select depends upon the requirements of the circuitry you need to power. Most off-the-shelf dc/dc converters offer very similar performance. Although the available models do exhibit some differences in specifications—notably size, switching frequency, output power, and regulation—your choice of a converter will depend for the most part on your application. You might have to make a few tradeoffs among these features, but those tradeoffs will depend strictly on the system you’re designing. Consult Table 1 for the salient parameters of a representative selection of available off-the-shelf dc/dc converters.

As you peruse the table, you might want to give special consideration to the converter’s size and its input voltage requirement. Both these items can severely limit your choice of a converter. No matter how well a particular converter suits your system’s other requirements—such as output voltages, regulation, and isolation, for example—if it occupies too much pc-board space or if it requires an input voltage that’s not available in your system, you may have to choose another converter.

As Table 1 shows, today’s dc/dc converter modules are very compact point-source power devices: Most require only 3.2 to 11 in.² of pc-board space. Some manufacturers offer converters that require even less board area. Conversion Devices, for example, offers converters that require only 2 in.² of board space. And International Power Sources and Melcher Inc offer converters that require even less pc-board area—only 1 and 1.07 in.², respectively. These numbers represent fairly significant reductions in board-space requirements. Note, however, that these converters provide fairly low output power, so you face a tradeoff of space vs power.

Converters offer input-voltage flexibility
When you go shopping for a dc/dc converter module, you’ll find that a number of standard devices call for...
DC/DC converters simplify the task of power distribution by providing power right where it's needed.

very specific input voltage requirements; they may need 5, 12, 15, or 24V, for instance. This requirement isn't necessarily a problem as long as the voltage in question is available in your system. But if that voltage isn't readily available in your system, your choice of a converter may be limited.

Fortunately, not all converters place such specific limits on their input voltage parameters. Power General and Wall Industries, for instance, offer converters with 2:1 input voltage ranges. Computer Products and Converter Concepts offer converters having input voltage ranges of 3:1. Converter Concepts also produces converters with a 4:1 range, and the input voltage range of converters from Calex is greater than 5:1. (Table 1 gives the exact ranges for the converters listed.)

These wide-input converters offer you a little more flexibility than models that require very specific voltages. For example, a converter with an input voltage range of 9 to 18V dc will accommodate either 12 or 15V inputs—very popular voltage levels in today's systems. As a result, one converter can satisfy two different applications.

Radiation-hardened dc/dc converters

Some dc/dc converters also provide features that are useful in specific applications. The Model HPS-3015 dc/dc converter from IRT Corp, for example, is hardened against high radiation levels. It can deliver operate-through power in the presence of gamma-radiation rates as high as $5 \times 10^{10}$ rad(Si)/sec, and it can survive as much as $1 \times 10^{12}$ rad(Si)/sec without damage.

The converter continues to meet all its performance specs after exposure to a neutron flux of $1 \times 10^{13}$ neutrons/cm$^2$ and a total gamma-radiation accumulation of $1 \times 10^5$ rad(Si). To certify each converter's operate-through characteristic, the vendor tests each device

### Table 1—Representative DC/DC Converters

<table>
<thead>
<tr>
<th>MANUFACTURER</th>
<th>MODEL</th>
<th>INPUT VOLTAGE</th>
<th>OUTPUT VOLTAGE</th>
<th>TOTAL OUTPUT POWER</th>
<th>TYPICAL EFFICIENCY</th>
<th>ISOLATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>BURR-BROWN CORP</td>
<td>PWR5104, 5105</td>
<td>5V</td>
<td>±12V (5104), ±15V (5105)</td>
<td>9W</td>
<td>75%</td>
<td>750V DC</td>
</tr>
<tr>
<td>CALEX MFG CO INC</td>
<td>12S5.50000W</td>
<td>7 TO 40V</td>
<td>5V</td>
<td>25W</td>
<td>91%</td>
<td>NS</td>
</tr>
<tr>
<td>COMPUTER PRODUCTS INC</td>
<td>LPS SERIES</td>
<td>20 TO 60V</td>
<td>5, 12, 15, ±12, ±15V</td>
<td>15W</td>
<td>80 to 85%</td>
<td>500V DC</td>
</tr>
<tr>
<td>CONVERSION DEVICES</td>
<td>E SERIES</td>
<td>5, 12, 24, 28, 48V</td>
<td>5, 12, 15, ±12, ±15V</td>
<td>2 TO 3W</td>
<td>65%</td>
<td>500V DC</td>
</tr>
<tr>
<td>CONVERTER CONCEPTS</td>
<td>VT15/VX15</td>
<td>10 TO 40, 20 TO 60, 100 TO 350V</td>
<td>5, 12, 15, −5, −12, −15V</td>
<td>15W</td>
<td>70 TO 75%</td>
<td>250V DC</td>
</tr>
<tr>
<td>INTERNATIONAL POWER</td>
<td>BA/BC SERIES</td>
<td>5, 12, 24, 28, 48V</td>
<td>5, 12, 15, ±12, ±15V</td>
<td>BA: 1.5W BC: 6W</td>
<td>65%</td>
<td>500V DC</td>
</tr>
<tr>
<td>IRT CORP</td>
<td>HPS-3015</td>
<td>18 TO 32V</td>
<td>±15V</td>
<td>30W</td>
<td>70%</td>
<td>500V DC</td>
</tr>
<tr>
<td>MELCHER INC</td>
<td>1WR1</td>
<td>5, 12, 15, 24, 28, 48V (2 INPUTS MAX)</td>
<td>5, 12, 15V (4 OUTPUTS MAX)</td>
<td>1W, 2W</td>
<td>58%</td>
<td>3000V P-P</td>
</tr>
<tr>
<td>POWER GENERAL</td>
<td>720 SERIES</td>
<td>9 TO 18, 18 TO 36, 36 TO 72V</td>
<td>±12, ±15V</td>
<td>30W</td>
<td>85%</td>
<td>NS</td>
</tr>
<tr>
<td>RELIABILITY INC</td>
<td>—</td>
<td>42 TO 56V</td>
<td>5, 12, 15V (POSITIVE OR NEGATIVE)</td>
<td>5W</td>
<td>NS</td>
<td>500V DC</td>
</tr>
<tr>
<td>WALL INDUSTRIES INC</td>
<td>SI SERIES</td>
<td>12, 24, 48V</td>
<td>5, 12, 15V (SINGLE, DUAL, TRIPLE OUTPUTS)</td>
<td>15W, 30W</td>
<td>85%</td>
<td>500V DC</td>
</tr>
</tbody>
</table>

NS=NOT SPECIFIED
with simulated ionizing radiation.

Most switching converters have some sort of isolation between the input and output. Typical designs consist of an input circuit (filter and modulator), a transformer, and an output circuit (demodulator and filter).

The available dc/dc converters perform the conversion task by using one of three schemes: Royer, flyback, or forward conversion. In the classical Royer circuit, the transformer's secondary windings drive switching transistors (or FETs) that are configured in a push-pull arrangement. A voltage applied to the converter input causes one of the transistor switches to turn on. The transformer provides positive feedback, which turns this transistor on hard. The transistor remains on until the magnetic flux of the transformer saturates. The saturation causes the transformer voltages to reverse, turning off the first transistor and turning on the second one.

The resultant square wave is rectified and filtered, and then it passes through an output regulator. In addition to developing a constant output voltage, the regulator also provides current limiting and short-circuit protection for the converter's output.

To achieve a wide input voltage range (±20% min), today's switch-type dc/dc converters typically employ pulse-width-modulation techniques with a flyback- or forward-conversion circuit. Both types of conversion circuit use an IC-driven, switching-circuit signal. The flyback converter stores energy in the transformer's output winding. This energy transfers to the output when the modulator's switch is not conducting. Although the flyback converter is more cost-effective for the manufacturer than are the Royer or forward converters, it has the highest ripple of the three schemes. In the forward converter, the output inductor stores the energy. This design provides a low-noise, full-wave frequency input regulation protection size cost comments

<table>
<thead>
<tr>
<th>REGULATION</th>
<th>SWITCHING FREQUENCY (kHz)</th>
<th>PROTECTION</th>
<th>INPUT FILTER</th>
<th>SIZE (IN.)</th>
<th>COST</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>±0.2% LINE, 0.04% LOAD</td>
<td>50</td>
<td>SHORT CIRCUIT</td>
<td>YES</td>
<td>2 x 2 x 0.41</td>
<td>$29.75 (1000)</td>
<td>SIX-SIDED SHIELD, 0-40 TO ±100°C OPERATING RANGE</td>
</tr>
<tr>
<td>0.02% LINE AND LOAD</td>
<td>75</td>
<td>OVERVOLTAGE, SHORT CIRCUIT</td>
<td>NS</td>
<td>3 x 2.56 x 0.83</td>
<td>$130</td>
<td>SIX-SIDED SHIELD, REMOTE ON/OFF CONTROL, ADJUSTABLE OUTPUT</td>
</tr>
<tr>
<td>SINGLE OUTPUTS: 0.5% LINE AND LOAD</td>
<td>200</td>
<td>OVERVOLTAGE, OVERTEMPERATURE</td>
<td>NO</td>
<td>1.6 x 2.0 x 0.46</td>
<td>$62.70 TO $65.35 (100)</td>
<td>REMOTE ON/OFF CONTROL</td>
</tr>
<tr>
<td>±0.3% LINE AND LOAD</td>
<td>200</td>
<td>OVERVOLTAGE, SHORT CIRCUIT</td>
<td>YES</td>
<td>1 x 2 x 0.35</td>
<td>$45 TO $54</td>
<td>SIX-SIDED SHIELD</td>
</tr>
<tr>
<td>0.3% LINE, 1 TO 1.5% LOAD</td>
<td>20</td>
<td>OVERLOAD, SHORT CIRCUIT</td>
<td>NS</td>
<td>VT15: 2.06 x 4.19 x 4.56 VX15: 2.13 x 3.58 x 4.50</td>
<td>$56 (100)</td>
<td>SINGLE, DUAL, OR TRIPLE OUTPUTS</td>
</tr>
<tr>
<td>BA: 0.3% LINE, 0.5% LOAD BC: 0.05% LINE, 0.1% LOAD</td>
<td>25</td>
<td>SHORT CIRCUIT</td>
<td>YES</td>
<td>BA: 0.8 x 1.25 x 0.4 BC: 2 x 2.0 x 0.4</td>
<td>$18 TO $29 (1000)</td>
<td>—</td>
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<tr>
<td>NS</td>
<td>125</td>
<td>OVERVOLTAGE, SHORT CIRCUIT</td>
<td>YES</td>
<td>3.6 x 3.0 x 0.6</td>
<td>$3500</td>
<td>RADIATION HARDENED</td>
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<tr>
<td>0.2% LINE, 0.1% LOAD</td>
<td>25</td>
<td>NS</td>
<td>YES</td>
<td>1.3 x 0.83 x 0.4</td>
<td>$53 TO $63</td>
<td>—</td>
</tr>
<tr>
<td>±0.2% LINE, ±1% LOAD</td>
<td>100</td>
<td>OVERVOLTAGE, SHORT CIRCUIT</td>
<td>YES</td>
<td>2.56 x 4.56 x 0.83</td>
<td>$169</td>
<td>REMOTE ON/OFF CONTROL, SIX-SIDED SHIELD</td>
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<tr>
<td>NS</td>
<td>NS</td>
<td>SHORT CIRCUIT</td>
<td>YES</td>
<td>2.0 x 2.0 x 3.75</td>
<td>$48.50 (1000)</td>
<td>—</td>
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<tr>
<td>±0.5% LINE, ±1 TO ±5% LOAD</td>
<td>100</td>
<td>OVERVOLTAGE, SHORT CIRCUIT</td>
<td>NS</td>
<td>15W: 2.56 x 3.0 x 0.83 30W: 2.56 x 4.56 x 0.83</td>
<td>15W: $80 TO $110 (100) 30W: $95 TO $110 (100)</td>
<td>REMOTE ON/OFF CONTROL</td>
</tr>
</tbody>
</table>

EDN December 10, 1987
Although you must still take system noise performance into consideration, dc/dc converter modules can help minimize noise problems.

output. With the addition of a push-pull input, the circuit becomes a high-efficiency modulator circuit.

Transformer provides isolation

Today's dc/dc converters employ high-frequency ferrite materials for the transformer, which provides isolation and voltage translation. Because these ferromagnetic elements have high resistivity, ferrite-core transformers have much better loss properties than do laminated and powdered-iron-core transformers.

Bobbin and toroidal transformers are the two most common types of transformer used in today's converters. Because the bobbin lends itself to machine-automated winding, it is the more economical choice. To construct a transformer, the manufacturer typically lays the windings one over the other; isolation is provided by the wire insulation or a barrier molded into the bobbin.

Toroidal transformers have much better isolation and much closer coupling than bobbin transformers do. To provide isolation for a toroidal transformer, the manufacturer forms a barrier by physically separating the primary and secondary windings on the toroid. For applications in which isolation is critical (medical applications, for example), the toroidal transformer is the only practical choice. It does have one drawback, however—small-diameter toroids often must be hand-wired.

The converter's output stage includes demodulators and filters. The rectifier (either a full- or a half-wave type) is the most common type of demodulator. Once rectified, the transformer's signal is then filtered to minimize the output ripple or the EMI/RFI generated by the switching operation. The filter employed in modern converters can range from a simple capacitive design to a more complex pi-type circuit. Besides incorporating filtering, most switching converters come in a metal box that's shielded on all six sides to further minimize radiated interference.

Cleaning up converter outputs

As noted, modern dc/dc-converter modules do moderate system noise problems: Many include output filters that curtail noise. However, in noise-sensitive applications such as medical electronics, you'll probably have to provide some external filtering as well.

By their very nature, switching dc/dc converters represent an inherent source of system noise. The noise appears as switching-frequency-related spikes on the converter's output voltage. Although considerations of size and cost can limit the amount of filtering it provides, a converter's internal filtering is usually adequate for most applications. If the inherent filtering capability is inadequate, one of two types of external filter—an LC filter or an output filter capacitor—can help.

If your application demands high accuracy, it's best to employ an LC filter on each converter output channel to attenuate high-frequency noise. Most converters feature an internal output filter capacitor, so adding an external inductor and capacitor creates a low-cost pi filter. You must select the filter components carefully, however.

For example, the inductor's wire size must be able to carry the load current (plus a safety factor), and its core must not saturate under the expected load conditions. Note also that the inductor's dc resistance is outside the feedback loop of regulated converters, and that it can degrade the units' inherent regulation.

LC filters provide superior performance in applications that require very accurate analog measurements or that exhibit poor power-supply rejection at the ripple frequency. However, a much more common way to reduce noise is to use an output filter capacitor.

In selecting an output capacitor for a switching dc/dc converter, it's not a good idea to try to add some safety margin by overspecifying the capacitor, because the converter's basic design equations rule out any brute-force approach. The most critical capacitor parameter is effective series resistance (ESR). ESR results from
"Ultimate" simply defined, it means the best! Without equal! And in the case of POWER-ONE's 1500W Power System, we think you'll agree the description fits. Specify Up To 15 DC Outputs... From Stock. Fully modular design allows the user to specify a proven multiple output power system from a wide selection of single, dual and triple output power modules. Virtually any combination of output voltage and current ratings, including UPS capabilities, can be delivered from stock. No more time consuming and costly custom designs to contend with.

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Converters with wide input-voltage capabilities typically employ pulse-width-modulation techniques.

stray resistance inside the electrolytic capacitor, and is more critical at (and above) the switching frequency of the converter.

ESR is also a function of temperature, decreasing in value as temperature increases. A capacitor's temperature dependence is also very strong for temperatures below zero; capacitance value tends to decrease with decreasing temperature. This temperature dependence can severely degrade the performance of a converter that operates well at room temperature.

In effect, ESR combines with the converter's internal output resistance to form a voltage divider. A capacitor with very low ESR will perform best as an output filter. The capacitors' ripple current will increase as the load increases and causes a larger drop across the ESR (noise). One way to circumvent the ESR problem is to add capacitors in parallel to develop the needed filtering value.

Choose aluminum or tantalum capacitors

In implementing an external filter, you can choose from two basic families of electrolytic capacitors: aluminum and tantalum. Aluminum types are available in many different quality grades and fabrication techniques. Tantalum devices come in foil, solid, and wet-slug types.

It's a good idea to avoid using low-cost (which might mean low-quality) aluminum electrolytic capacitors: In many cases, they'll actually generate, rather than attenuate, noise. If you must trade off cost against performance, high-quality aluminum electrolytics offer you the best compromise. Typically listed as "computer-grade" units, these capacitors are designed specifically for switching power supplies and converters. These devices are not inexpensive, but some are worth the premium because they employ a specialized construction that results in very low ESR.

High capacitance-to-volume efficiency is the outstanding feature of all tantalum capacitors, but particularly of the wet-slug types. Solid tantalum capacitors are the best choice for applications in which longevity (both shelf and operating life) is a critical design concern. Although the foil types are quite compatible with switching power supplies, they cost more than aluminum devices. If your system's switching frequencies will be high (1 MHz and above) and its current demands low, you can probably employ a nonelectrolytic capacitor for the filter. Such units are very effective at high frequencies, at which the equivalent series inductance (ESL) of electrolytics increases significantly.
Efficiency 79–85%

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10 OPEN "DEV: EEOU" OUT FOR OUTPUT AS #1
20 PRINT #1, "ABORT"
30 PRINT #1, "CLEAR 16"
40 PRINT #1, "OUTPUT 16:RTX"

Typical IEEE board with "CALLS"**
10 CLEAR, 50000
20 IBINT = 50000
30 IBINT2 = IBINT + 1 + 3
40 BLOAD = IBM, IBINT
50 CALL IBINT2: IBFIND, IBTRG, IBCLR, IBPRINT, IBPP, IBM
60 IBIND, IBINC, IBSE, IBREV, IBM, IBAD, IBST, IBM, IBES, IBTM, IBSET
70 CALL IBINT3: IBGTS, IBAC, IBWAIT, IBPOKE, IBWRIT, IBWRT, IBCMD, IBMCDATA, IBRD, IBRADE, IBSTOP, IBWRP, IBSP, IBAG, IBTREC, IBSTA, IBERR, IBCT
80 AS [S], [S], [S], [S]
90 CALL IBFIND (AS), [S], [S]
100 IF IBSTA = 0 THEN STOP
110 CALL IBCLR (M195%), [S], [S], [S], [S], [S]
120 IF IBSTA = 0 THEN STOP
130 BCMD = [STX]
140 CALL IBWRIT (M195%, [CMD]
150 IF IBSTA = 0 THEN STOP

√ DOS installable device driver - automatically loads at power up
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* Both programs clear the bus and configure a digital multimeter.
If you already own a compatible IEEE board our Driver488 software makes it IEEE-Z.

For more information . . .
For more information on the dc/dc switching converter modules discussed in this article, circle the appropriate numbers on the Information Retrieval Service card or contact the following manufacturers directly.

Burr-Brown Corp
Box 11400
Tucson, AZ 85724
(602) 746-1111
Circle No 704

Calex Mfg Co Inc
3355 Vincent Rd
Pleasant Hill, CA 94523
(415) 922-3911
Circle No 705

Computer Products Inc
7 Elkins St
South Boston, MA 02127
(617) 268-1170
Circle No 706

Conversion Devices Inc
101 Tusca Dr
Stoughton, MA 02072
(617) 341-3296
Circle No 707

Converter Concepts Inc
Industrial Parkway
Pardeeville, WI 53954
(608) 428-2144
Circle No 708

International Power Sources Inc
10 Cochituate St
Natick, MA 01760
(617) 651-1818
Circle No 709

IRT Corp
Box 85317
San Diego, CA 92138
(619) 458-3990
Circle No 710

Melcher Inc
10 Cochituate St
Natick, MA 01760
(617) 653-9979
Circle No 711

Power General
Box 189
Canton, MA 02021
(617) 828-6216
Circle No 712

Reliability Inc
Box 218370
Houston, TX 77218
(713) 492-0550
Circle No 713

Wall Industries Inc
2 Franklin St
Lawrence, MA 01840
(617) 688-1287
Circle No 714

Your filtering task doesn't end with capacitor selection. To get good performance from the filter you've chosen, you need to use good circuit-layout techniques. For example, inductance can become a problem if you fail to use good wiring techniques. You need to place the capacitor as close as possible to the load instead of to the converter. This scheme allows you to take advantage of the inductance of the pc-board traces (or wires) and the converter's internal output capacitor to form a small pi filter that optimizes noise reduction. You should also minimize the lead length (including circuit wiring) on both sides of the capacitor. It's best to use short, wide straps, and run them in parallel to further reduce self-inductance in the leads.

EDN

Article Interest Quotient (Circle One)
High 476 Medium 477 Low 478

EDN December 10, 1987
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EDN December 10, 1987
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Building quality, reliable power supplies that meet specifications, is not new at ACDC Electronics. We’ve been doing that for over 30 years.

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No one else offers such extensive coverage in high power. Check the chart below to solve your 500–1600W power requirements.

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Our power supplies have been PROVEN and PROVEN. Our NEW power supplies are based on these PROVEN designs. Need more proof? Call for a DEMO TODAY. (619) 439-4200

<table>
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<th>WATTS</th>
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<tr>
<td>500</td>
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</tbody>
</table>

1600w 1500w 1000w 800w 750w 500w 400w 300w 220w 175w 135w 70w 40w 15w
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Power Sources

Uninterruptible ac power source protects data 100% of the time

The Lifeline is an uninterruptible ac power source that protects computers from power outages. The unit is always on line, so even when the utility fails, there's no chance of losing data while the computer waits for a standby system to switch over to battery power.

A maintenance-free internal battery handles the full power of the system for 5 or 10 minutes. An external battery may be used to extend operation for one hour or longer. When the utility comes back on, the unit will recharge the batteries automatically.

The unit accepts 120V ac at 60 Hz (with +10% to -15% tolerance) from a wall outlet and delivers 120V ac at 60 Hz (with ±3% regulation). Its output power is rated at 200 VA, 600 VA, and 1000 VA. It also offers a load power factor from 0.8 to unity; 90% efficiency when the line is present; a sine-wave output waveform with 5% maximum total harmonic distortion; and a NEMA 5-15R duplex output receptacle. It operates over 0 to 50°C.

Prices range from $1235 for a 200-VA unit with 7 minutes of internal battery backup to $2780 for a 1000-VA unit with 25 minutes of internal battery backup. A 200-VA and a 600-VA unit come with no internal battery but are ready for an external battery hook-up. They cost $1180 and $1570, respectively.

Instrumentation and Control Systems Inc, Electro-Pac Div, 520 Interstate Rd, Addison, IL 60101. Phone (312) 543-6200. TLX 271503.

Circle No 719

Single-output ac-to-dc switching modules come in low-profile packages

FMP Series single-output switching modules come in low-profile plastic-encased packages. The series consists of two groups that have 3W and 16W outputs, respectively, at 50°C. The 3W versions are rated at 5V at 0.6A, 12V at 0.25A, 15V at 0.2A, and 24V at 0.13A. The 10W models are rated at 5V at 2A, 12V at 0.85A, 15V at 0.7A, and 24V at 0.45A. Both groups measure 2.17x0.75x3.16 in. The 3W units weigh 0.15 lb; the 10W units weigh 0.2 lb.

The switchers employ flyback circuitry to achieve 68 through 81% efficiency at maximum load. Their switching frequency ranges from 40 to 75 kHz, and their switching ripple voltage ranges from <50 to <100 mV, depending on the model. The units accept power from a 115V ac source and provide built-in overvoltage protection and current limiting.

All models' output voltages are adjustable to 10% of the nominal output voltage. The units are UL recognized and CSA certified, and they meet the FCC class B specification for conducted EMI. Prices range from $29 to $32.

Kepco Inc, 131-38 Sanford Ave, Flushing, NY 11352. Phone (718) 461-7000. TWX 710-582-2631.

Circle No 720
1500W switching power supply accepts a 3-phase ac input voltage

The PM-2501B-2-3P is a switching power supply that delivers 5V dc at 300A (1500W) and 50°C. It accepts a 3-phase input voltage of between 184 and 250V ac within a frequency range of 47 to 63 Hz. The unit comes in a 5x8x11-in. enclosure and weighs 20 lbs.

The supply meets VDE 0806 Class I SEL V, IEC 380 and 435, and CSA 22.2-142/143/154 specifications. It is UL recognized (to UL 114, 1012, and 478 requirements), and it meets VDE 0871, level A, and FCC Docket 20180 standards for EMI protection. The supply has foldback-current overload protection at 105 to 120% of full output current: When the current exceeds that level, the supply reduces it to 65% of full output current. Overvoltage protection shuts down the unit at 125±10% of the nominal output.

The power supply's switching ripple and noise spec is 1% of the nominal output voltage measured in the bandwidth from 20 Hz to 20 MHz. The output voltage is brought out on a pair of 5/16-in., size 18 threaded-head studs. The ac inputs are on a terminal block that uses size 8-32 screws. The switcher's soft-start circuitry minimizes in-rush surges at power-on. Options for the supply include a crowbar circuit for overvoltage protection, 5-msec warning of ac power loss, and control of current-foldback circuitry (which allows you to parallel supplies). Another option lets you use a logic signal to turn the supply on. The supply's output is adjustable to ±10% of the nominal output voltage. $1200.

**Pioneer Magnetics**, 1745 Berkeley St, Santa Monica, CA 90404. Phone (800) 233-1745; in CA, (800) 848-1745. TWX 910-343-6249.

Circle No 721

**Pioneer Magnetics**, Kingswick House, Sunninghill, Ascot, Berkshire, SL57BJ, UK. Phone (990) 23491. TLX 848980.

Circle No 722

2 and 3.3V switching power supplies are suitable for use with IBM memory chips

Six different models of V Series switching power supplies provide dc outputs at 2 or 3.3V. Their low voltages make them ideal for use with IBM's memory chips and VLSI circuits. The six models are rated at 2V dc at 54A, 3.3V dc at 54A, 2V dc at 72A, 3.3V dc at 72A, 2V dc at 100A, and 3.3V dc at 100A.

The units accept 90 to 132V ac or 180 to 264V ac inputs in the frequency range from 47 to 440 Hz. They also have built-in overvoltage protection, remote sensing, and a soft-start feature. They maintain their current specifications over 0 to 50°C. Above 50 to 70°C, the current should be derated by 2.5%/°C.

For cooling, the V501G and the V501H units require 60 cfm of forced air; the other four units require 30 cfm of forced air. An option provides for current sharing and redundant parallel operation. No isolation diodes are needed. The V Series provides an optional power-fail monitor in the form of a TTL signal that occurs 2 msec prior to the loss of output power. Prices range from $145 to $210 in OEM quantities. Delivery, six to eight weeks ARO.

**Deltron Inc**, Box 1369, Wissahickon Ave, North Wales, PA 19454. Phone (215) 699-9261. TWX 510-661-8061.

Circle No 723
Power General delivers PERFORMANCE. A full line of standard “off-the-shelf” switching power supplies that are small yet meet the toughest international safety standards. A variety of single and multiple output models are offered over a range of 25 to 200 watts. Standard features include input line filters, high efficiency operation, pulse load capability and tight output regulation.

Power General delivers RELIABILITY. All production switching power supplies are subjected to a 12 hour burn-in at 55 deg. C with input power being cycled on and off. 100% of production — no exceptions. Stringent workmanship standards and tough documentation control procedures are just some examples of a total commitment to quality that stretches from the Design Engineering Group to the Production Shipping Department.

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Put Power General to work for you. Call us. Be demanding and watch us deliver.
Power Sources

Multichannel, isolated dc/dc converter provides multiple-channel outputs

The PWS740 is a multichannel, isolated dc/dc converter with a 1500V ac continuous isolation rating. It consists of three integrated components: the PWS740-1, a 400-kHz oscillator and driver in a TO-3 package; the PWS740-2, a trifilar-wound isolation transformer with a ferrite core encapsulated in a plastic package; and the PWS740-3, a rectifier bridge in a plastic, 8-pin miniature DIP. A typical isolation system using the PWS740 would consist of a transformer and rectifier for each channel; the oscillator would drive as many as eight channels.

The Sync pin on the oscillator module allows you to synchronize several oscillators. You can connect the Frequency Adjust pin to an external potentiometer to lower the oscillator frequency, thereby avoiding beat-frequency interference with other system signals. The Enable pin provides for output shut-down. Isolated dc outputs track the input voltage and can range from ±7 to ±20V at currents as high as ±30 mA.

Transformer impedance limits the converter's maximum input current to about 700 mA for a 15V input—a level that is within the unit's thermal limits. The unit operates over -25 to +85°C. Its typical efficiency for eight channels at rated loads is 80%. PWS740-1, $12.75; PWS-2, $2.50; PWS740-3, $1.25 (100).

Burr-Brown Corp, Box 11400, Tucson, AZ 85734. Phone (602) 746-1111. TWX 910-952-1111.

Circle No 725

350W switcher offers 3.10W/in³, comes in a 9×5×2.5-in. package

The MAX-350 350W switching power supply comes in a 9×5×2.5-in. package, which yields a power density of 3.10W/in³. The MAX-350 offers three models, all of which provide 5V at 50A, 12V at 8 or 12A pk, and -12V at 4A. The MAX-354-1205 provides an additional output of -5.2V at 2A; the MAX-354-1224 has an additional output of 24V at 1.5A. The supplies are compatible with VME Bus and Multibus specifications and are designed with an ac-power-fail circuit that exceeds the ac-power-fail requirements (48-mA sink capacity) of the standard VME Bus.

The supplies accept 90 to 132V ac or 180 to 264V ac inputs in the frequency range from 47 to 63 Hz. They come with thermal, brownout, and overload protection, and they require 30 cfm of moving air for cooling.

The units' typical efficiency is 75%, and the vendor specifies an MTBF of 100,000 hours. Their ripple and noise spec is 0.2% rms, 1% p-p, or 100 mV, whichever is greater. The units retain their full ratings over 0 to 50°C. An optional TTL ac-power-fail command provides an indication 5 msec before the 5V output goes out of regulation. $336 (100). Delivery, stock to six weeks.

Todd Products Corp, 50 Emjay Blvd, Brentwood, NY 11717. Phone (516) 231-3366. TWX 510-227-4905.

Circle No 724
The latest Advance

New Powerflex 350-watt
5-output switching power supply

Go ahead. Design your microprocessor-based equipment any way you want, and don’t worry about the power supply. Whatever voltages you require, from 2V to 50V in either polarity, the Powerflex 350 switching power supply can provide them.

Because it’s modular, we can easily configure the P350 for up to five outputs in standard or special voltages. And if your design changes, you can easily change outputs without changing your physical dimensions.

Just 2.9” x 7.5” x 11.8”, this high efficiency (75% at full load) 350-watt power supply takes both 110V and 220V inputs. Overvoltage and overcurrent protection on outputs is standard, along with margin testing (4.750V — 5.250V) on the main +5V 50A output. An optional signals board provides TTL compatibility.

The magnetic amplifier and soft switching technique assure high reliability and enable regulated auxiliary outputs to function without any minimum load on the main +5V output. Filtering is to VDE 0871, Curve A. The P350 is UL listed, CSA certified and meets other VDE, EC and FCC requirements.

Compare the calculated MTBF of over 52,000 hours with other power supplies in its class. There’s no compromise on quality when you build around the P350 from Advance.

Contact your Advance Power Supplies representative for complete data on the P350 and other open and closed frame units from 25 to 1000 watts. Or call 1-216-349-0755 for more information.
Power Sources

Switch-mode power supplies offer 40W to 1-kW outputs

Series 190 open-frame switch-mode power supplies include single- and multiple-output versions that have power ratings of between 40 and 1000W. The vendor can also customize standard versions. All the supplies spec an MTBF of 40,000 hours under full load at 40°C. The five power ratings currently available are 40, 60, 150, 200, and 1000W; you can increase the power ratings of the 150 and 200W supplies to 220 and 300W, respectively, by using forced-air cooling.

The single-output versions of the 40, 60, and 200/300W power supplies each provide a 5, 12, or 24V output. (The user can adjust the 12V output to 15V.) The multiple-output versions of the 40 and 60W supplies typically provide ±12 or ±15V outputs, or a 5V output and ±12 or ±15V outputs. The multiple-output 150/220W supplies and multiple-output versions of the 200/300W supplies typically provide a 5V output and two 12/15V outputs. In the 150/220W supplies, the two 12/15V outputs have a common zero; in the 200/300W supplies they are isolated. Some versions of the 150/220W and 200/300W supplies provide an additional 5, 12, or 24V output. The 1000W supply is an enclosed, fan-cooled single-output unit providing 5V at 200A.

Series 190 supplies operate from the 110/220V ac line. They incorporate overload and overtemperature protection and have overvoltage protection on the 5V outputs. All versions are UL approved, CSA certified, and VDE registered. Typical prices for the 40W power supplies range from $80 to $100; the 60W models are $100 to $120.

Philips, Industrial and Electroacoustic Systems Div, Box 218, 5600 MD Eindhoven, The Netherlands. Phone (040) 788620. TLX 35000.

Circle No 726

POWER PLUS...

Quality and Support You Can Rely On

The Panasonic® K Series of low-cost single output Switching Power Supplies. Their efficiency and reliability are clear from features like these:

- Single output: 95-132 VAC, 47-440Hz input
- 12 models — 15, 30 and 50 Watt configurations: with 5-24 VDC, 0.1A to 10A
- 3-year limited warranty
- Off-the-shelf availability
- Versatile, inexpensive and compact
- Recognized by UL 114, 478; certified by CSA
- Meets FCC Class B and VDE Class B noise regulations
- Over-current protection
- Over-voltage protection
- Compact, light, durable and efficient. Ideal for use in process control and environmental equipment, computers and computer peripherals, robotics, and comparable applications.

Panasonic
Industrial Company
Power Supplies Department
Two Panasonic Way
Secaucus, NJ 07094
(201) 392-4290

CIRCLE NO 103

EDN December 10, 1987
1500W SUPPLY
The Model 6D Multimod is a 1500W modular switching power supply. It features a mainframe that houses six separately selectable output modules. The mainframe accepts 115 or 230V ac inputs and converts the ac power to 300V dc. Each module is a dc/dc converter that receives power from the 300V dc bus. The supply employs 100-kHz MOSFET switching components and meets international electrical safety and emission standards, such as VDE, CSA, and UL standards. You can choose single-output 300W modules ranging from 2 to 48V dc. Multiple-output modules will be available soon. All of the output modules are capable of current sharing. Outputs are adjustable to ±10% of nominal voltage, and line and load regulation are each 0.2% of the rated output. Current limiting, overvoltage protection, reverse-voltage protection, and remote sensing are standard features. The entire supply measures 5x8x13.5 in. A supply equipped with six single-output modules costs $1500.

Jerome Industries Corp, 730 Division St, Elizabeth, NJ 07201. Phone (201) 353-5700. TLX 132001. Circle No 432

DISK SUPPLY
Designed specifically for hard-disk-drive applications, the quad-output SQV350 350W switching supply provides power for two 8-in. drives or for as many as eight 5¼-in. drives. The unit features a 5V main-output rating of 10A. One of the three auxiliary outputs is rated for 12 or 24V at 16A peak to accommodate initial turn-on/spin-up loads. The remaining two outputs are rated at 5A each with 7A peak loads. The supply features built-in overload and overvoltage protection and remote sense capability. $251 (100). Delivery, three to six weeks ARO.


DC/DC CONVERTER
The 12Q15.050 operates from a 12V dc input and provides two ±15V dc outputs at ±50 mA each. Both dual output sections are isolated from the input and from each other. The unit has a 6-sided shielded case that eliminates RFI problems. The internal switching frequency (63 kHz free running) is unaffected by load or line changes. A switching-frequency synchronization pin lets you run the converters at frequencies ranging from 70 to 110 kHz. The input/output and output/output isolation equals 500V dc and the operating temperature range spans -25 to +90°C. $110. Delivery, stock to six weeks ARO.

Calex Mfg Co Inc, 3355 Vincent Rd, Pleasant Hill, CA 94523. Phone (415) 932-3911. TLX 338506. Circle No 435

SWITCH-MODE SUPPLY
The Model SA1000-3104 is a 1-kW switch-mode power supply that delivers 5V at currents as high as 200A. You can adjust the output voltage by ±2% with a potentiometer, or you can digitally program the output voltage from 4.2 to 5.75V. The supply's line regulation is 10 mV max over the full operating input-voltage range, and its zero-to-full-load regulation is 20 mV max. The power supply operates from line input voltages ranging from either 90 to 135V or 180 to 265V, within a frequency range of 47 to 63 Hz. Its input voltage rating, built-in over-voltage protection, and a typical efficiency of 65%. The line regulation, from low to high line, is 0.4%; the load regulation (from no load to full load) is 1%. All models provide a 20-msec min holdup time. $24.90 (1000).

Computer Products Inc, 2900 Gateway Dr, Pompano Beach, FL 33069. Phone (305) 974-5500. TWX 510-956-3098. Circle No 433

POWER SOURCES

25W SUPPLIES
The X and Y desktop linear power supplies provide 25W of output power and are available in single- and multiple-output versions. The standard outputs are 5, 12, and 24V dc. The supplies offer input voltage ranges of 105 to 130V ac or 220 to 240V ac. Their dielectric strength is 1500V, and they operate over 0 to 40°C. The output regulation is 5%. The supplies meet UL, CSA, and VDE requirements and feature short-circuit protection. The housings are made of durable fire-retardant plastic. $40 (100).

Jerome Industries Corp, 730 Division St, Elizabeth, NJ 07201. Phone (201) 353-5700. TLX 132001. Circle No 432

SWITCHING SUPPLIES
Pony Series switching power supplies come in 14 models that deliver 15 to 30W. The supplies are enclosed units and are UL recognized and CSA certified. Each model features an input EMI filter, a 115V ac input voltage rating, built-in over-voltage protection, and a typical efficiency of 65%. The line regulation, from low to high line, is 0.4%; the load regulation (from no load to full load) is 1%. All models provide a 20-msec min holdup time. $24.90 (1000).

Computer Products Inc, 2900 Gateway Dr, Pompano Beach, FL 33069. Phone (305) 974-5500. TWX 510-956-3098. Circle No 433
thermal protection includes a high-temperature alarm output that is activated at 50±5°C, as well as an overtemperature alarm output that is activated when the power-supply temperature exceeds 75±5°C. The supply automatically shuts down within 10 to 30 sec of an overtemperature alarm. It also provides output overvoltage and overcurrent protection. For applications requiring more than 200A, you can add slave units to the power supply. The device measures 8×4.5×11 in. From approximately £500.

**Power Sources**

**Astec (USA) Ltd, 2880 San Thomas Expressway, Suite 200, Santa Clara, CA 95051. Phone (408) 748-1200. TLX 6839191.**

**Circle No 434**

---

**DC/DC CONVERTERS**

B Series converters are available in 15, 24, and 25W models and have outputs ranging from 5 to 12V dc. The units are nonisolated, accept inputs ranging from 9 to 36V dc, and are optimized for battery operation. Each model offers continuous short-circuit protection, automatic restart, overvoltage protection, and remote logic on/off control. The 15 and 24W converters come in RFI-shielded cases measuring 2.5×3.0×0.4 in. $53.90.

**Semiconductor Circuits Inc, 49 Range Rd, Windham, NH 03087. Phone (603) 893-2330. TWX 710-366-0505.**

**Circle No 436**

---

**SUPPLY SERIES**

The Series-1000 Mk II range of power supplies includes 26 different models with output-voltage ranges of between 0 to 35V and 0 to 1000V and current ratings of between 10A and 30 mA. All the models are fully programmable, providing either constant-voltage or constant-current operation with automatic crossover between operating modes. Line regulation in both modes is ±0.015% for ±10% line-voltage variation. In constant-voltage mode, zero to full-load regulation is 0.015% or 5 mV, whichever is greater, and in constant-current mode, it's 0.05% or 3 mA for a 50% output-voltage change. Options provide 0.01% regulation in constant-current mode and crowbar output protection. Programming inputs allow you to adjust the output voltage via a 0 to 5V input signal, and the current via a 0 to 1V input signal. The power supplies are housed in 19-in. rack- or
# MILITARY POWER SOURCES

## CUSTOM AND STANDARD MILITARY POWER SUPPLIES

### DC/DC

<table>
<thead>
<tr>
<th>INPUT</th>
<th>NO. OF OUTPUTS</th>
<th>VIA</th>
<th>SIZE (IN)</th>
<th>FEATURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-36VDC</td>
<td>SINGLE</td>
<td>5, 12, 15, 24, 28 (50W-150W)</td>
<td>4.64 x 2.81 x 0.84</td>
<td>• HIGH EFFICIENCY, HIGH DENSITY&lt;br&gt;• STABLE 500KHZ CONVERSION FREQUENCY&lt;br&gt;• MIL-TYPE COMPONENTS&lt;br&gt;• HIGH GRADE&lt;br&gt;• I/O ISOLATION&lt;br&gt;• MIL-STD-704A / D&lt;br&gt;• MIL-STD-1275A (AT)&lt;br&gt;• MIL-STD-461 / 462&lt;br&gt;• TEMP: -55°C / +85°C BASE PLATE&lt;br&gt;• MIL-STD-810C</td>
</tr>
<tr>
<td>18-36VDC</td>
<td>DUAL</td>
<td>±5, ±12, ±15, ±24, ±28 (80W-125W)</td>
<td>5.9 x 2.81 x 0.84</td>
<td></td>
</tr>
<tr>
<td>18-36VDC</td>
<td>DUAL</td>
<td>±5, ±12, ±15, ±24, ±28 (150W-170W)</td>
<td>6.3 x 3.5 x 0.84</td>
<td></td>
</tr>
<tr>
<td>18-36VDC</td>
<td>TRIPLE</td>
<td>5V / 10A, ±12V / 1-5A&lt;br&gt;5V / 10A, ±15V / 1.5A</td>
<td>6.10 x 3.14 x 2.16</td>
<td></td>
</tr>
<tr>
<td>6-100VDC</td>
<td>TRIPLE</td>
<td>5V / 5A, 2x12V / 2.5A&lt;br&gt;5V / 5A, 2x15V / 2.5A</td>
<td>5.7 x 4.68 x 2.75</td>
<td></td>
</tr>
</tbody>
</table>

### AC/DC (115V / 3 Phase / 400HZ)

<table>
<thead>
<tr>
<th>INPUT</th>
<th>NO. OF OUTPUTS</th>
<th>VIA</th>
<th>SIZE (IN)</th>
<th>FEATURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>115 +35%</td>
<td>SINGLE</td>
<td>5, 12, 15, 22, 24, 28 (200W-225W)</td>
<td>6 x 4.2 x 1.57</td>
<td>• EXTERNAL OUTPUT ADJUSTMENT&lt;br&gt;• MIL-TYPE COMPONENTS&lt;br&gt;• MIL-STD-704 A/D&lt;br&gt;• MIL-STD-461&lt;br&gt;• TEMP: -55°C / +85°C BASE PLATE&lt;br&gt;• MIL-STD-810C</td>
</tr>
<tr>
<td>115 +35%</td>
<td>SINGLE</td>
<td>5, 12, 15, 22, 24, 28 (500W-600W)</td>
<td>10 x 6.2 x 1.57</td>
<td></td>
</tr>
<tr>
<td>115 +35%</td>
<td>DUAL</td>
<td>±5, ±12, ±15, ±22, ±24, ±28 (120W-150W)</td>
<td>6 x 4.2 x 1.57</td>
<td></td>
</tr>
</tbody>
</table>
A good idea is a powerful thing. It drives ordinary technology to the extraordinary. At Converter Concepts, ideas make our technology superior and our power supplies more reliable.

We specialize in wide-input AC/DC and DC/DC, high efficiency switching power supplies for worldwide OEM use. That means your product can operate anywhere in the world without modification.

Think about that for a moment.

Too good to believe? Well, believe it. Because only Converter Concepts' power supplies operate on any
IDEAS
THAT POWER
TECHNOLOGY

Find out what we can do for you. Contact the Converter Concepts' representative nearest you or call us directly. You'll discover that at Converter Concepts, the difference is people with ideas.

Converter Concepts Inc.
Industrial Parkway • Pardeeville, WI 53954
(608) 429-2144 • TWX: 910-280-2630
Toll-Free 800/253-5227
FOUR-OUTPUT SUPPLY
The Model 510EU 200W switching power supply has four outputs. Transient suppression devices allow it to withstand the 6000V IEEE 587 voltage transient test. The unit employs 50-kHz MOSFET switching circuitry. It accepts 105 to 130 or 198 to 265V ac, selectable on the barrier strip. The device delivers 5V at 20A, ±12V at 4A, and ±5V at 0.5A. Its secondaries are adjustable to ±15V at 3A. All its outputs are current limited and have continuous overload and ac-input protection, short-circuit protection, overtemperature protection, self-recovering overvoltage protection, and no minimum load requirement. You can specify a power-failure signal and logic-inhibit capability as options. $395.

CONVERTER SERIES
Series BA and Series BC isolated dc/dc converters have five output voltage configurations: 5, 12, 15, ±12, and ±15V dc. All of these outputs are available with nominal input voltages of 5, 12, 24, 28, and 48V dc. Series BA converters are housed in 24-pin DIPs and provide 1.5W of output power. Series BC converters come in industry-standard 2.0×2.0×0.4-in. packages and provide 6W of output power. Both series feature an input π-network filter; a 50-mV p-p ripple-and-noise specification; operation to 70°C without derating; and 500V dc isolation. The converters have a 25-kHz switching frequency and typical efficiency of 65%. Single-output Series BA units, $18; dual-output units, $19 (1000). Series BC single-output units, $25; dual-output units,
$27 (1000). Delivery, stock to eight weeks ARO.

**International Power Sources Inc, 10 Cochituate St, Natick, MA 01760. Phone (617) 651-1818. FAX 617-655-7984.**

**Circle No 440**

**BUTTON CELL**
The 4DK battery is a 1.2V NiCd button cell for solar-converter applications. The cell has a nominal capacity of 4 mAh. It measures 2.1×9.5 mm and weighs 0.6g. The battery operates over -20 to +50°C. Its mass-plate construction allows it to retain 75% of its capacity when stored for 28 days at room temperature. You can charge the cell with 0.4 mA applied for 14 hours. The length-of-service-life specifications are 1000 IEC cycles within one year; 500 full cycles within two years; and 2000 shallow cycles within four years. You can trickle charge the battery with 40 µA for as many as six years, in the temperature range of 0 to 45°C. A pressure-relief vent protects the cell under abusive conditions. $0.87 (1000). Delivery, six weeks ARO.

**Varta Batteries Inc, 300 Executive Blvd, Elmsford, NY 10523. Phone (914) 592-2500.**

**Circle No 439**

**DC SUPPLY**
BPS Series regulated adjustable dc power supplies deliver 12 to 24V dc voltages. Their amperage ratings range from 1 to 15A for 12V dc models and from 1 to 10A for 24V dc models. All of the units in the series are UL and CSA listed, except the 1A versions, which use UL-recognized ac sections. Screw terminals are provided for line-voltage input and dc output. Faston battery clips are provided for attachment of sealed lead-acid (gel) batteries. The supplies come in UL-listed hinged knockout boxes. All models with capacities greater than 1A include eight individual fused outputs for powering multiple loads; consequently, if a short circuit occurs on a load, only one of the eight fuses will blow. $110.

**Securitron, 1815 W 205th St, Suite 103, Torrance, CA 90501. Phone (800) 624-5625; in CA, (213) 618-0204.**

**Circle No 442**

---

**Only POWEREX.**

Now, POWEREX—a joint venture of GE, Westinghouse and Mitsubishi—has acquired the GE/RCA line of low-power triacs, SCRs and D66/D67 power Darlington transistors. And added them to our already broad line of power semiconductors.

More evidence POWEREX provides what no one else has provided before.


POWEREX versus the competition. Our advantages are obvious.

Nobody else now offers you GE/RCA low-power triacs and SCRs as part of the broadest line of power semiconductors available.

Only POWEREX offers as complete a line of isolated power modules, triacs, power transistors, Mosfet (FETMOD™) modules, Mos-and-Bipolar (MOBIP™) modules, rectifiers, thyristors, power hybrids, GTOs, RCTs, asymmetric SCRs and stack assemblies.

For more information, contact your POWEREX distributor or sales representative. For product literature, call 1-800-451-1415, Extension 200. In New York, call (315) 457-9334. For application assistance, call (412) 925-7272 or write POWEREX, Inc., Hills Street, Youngwood, PA 15697.

**CIRCLE NO 29**
VME SUPPLIES
Series VMEP multiple-output switching power supplies comprise 104 models. The supplies are designed specifically for the VME Bus and include VME Bus AC Fail and SYSReset signal lines. The series is divided into four groups according to power rating: 200, 400, 600, and 800W. Voltage outputs of 5, 12, 15, 24, and 48V de are available in two VME Bus-height formats: 6U and 3U. Designed for operation in standard VME Bus card racks, the supplies also come in modified packages for universal mounting outside the rack. The supplies accept inputs from 90 to 132V ac or from 180 to 264V ac over 47 to 63 Hz. Their switching frequency is 50 kHz, and all models provide three voltage outputs. Other features include load and line regulation to ±0.2% or 10 mV max; a 1% or 50-mV p-p noise-and-ripple specification; 70% min efficiency at full load; overvoltage and overcurrent protection for all outputs; and parallel power-sharing capabilities. $450 to $1200.

Power Pac Inc, Box 777, Norwalk, CT 06856. Phone (203) 866-4484.

Circle No 443

DC/DC CONVERTERS
Series E900VF quad-output dc/dc converters (with an auxiliary ac filament output) are for use with vacuum fluorescent displays. They provide two dc anode and two ac filament voltages to power two-color vacuum-fluorescent displays or two dissimilar displays requiring as much as 12W of total output power. The converters power standard displays from Noritake, Futaba, and NEC. You can order custom units for displays that require voltages not specified in the series. The units accept 5, 9, 12, 15, and 24V dc and have ±10% tolerance. They operate over 0 to 70°C and provide 600V rms I/O isolation at 60 Hz for one minute. The converters weigh 122g and come in aluminum pc-board mounts.
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You've chosen precision Airpax stepper motors before, so when you find yourself in the market for a linear actuator, here's something to remember. When we modify a stepper motor to become a linear actuator, the change lies in the threaded shaft and resulting linear motion, not in the Airpax quality you've come to know. Our linear actuators come in an array of low, medium and high force models with push/pull ratings of less than 21 ozs. to 25 lbs. in increments of .001 to .004" per pulse. Whenever rapid response and precision movement are called for, our engineers are ready to help you design the linear actuator for your specific application. Airpax linear actuators are the ones to depend on, for valve actuation, medical pumps, robotics, HVAC systems and much, much more.

To get your designs in motion, contact the Airpax Corporation, Cheshire Division, West Johnson Avenue, Cheshire, CT 06410. (203) 272-0301. A North American Philips Company.
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INTRODUCING EL 2000 SERIES
Complete AC to DC and DC to DC multi output systems.

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Save Space: Completely protected AC-DC systems with rugged high density packaging to 8 watts/in^3.

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Higher Reliability: MTBF to 500,000 hours with conservative design criteria including NAVMAT guidelines.

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- 1Ω, 3Ω and DC inputs.
- -55°C to +85°C operation.
- Mil-Std-704A-D, 1399 and 1275 input surge and spike protection.
- Meets many provisions of Mil-Std-810D, Mil-E-5400 and Mil-E-16400.

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CIRCLE NO 201
that measure 2.0×2.5×0.98 in. $29.72 (250).

Endicott Research Group Inc, Box 269, Endicott, NY 13760. Phone (607) 754-9187.

Circle No 444

EVALUATION BOARDS
Series VI-MEB modular boards are designed to evaluate the vendor's Series VI-100 and VI-200 dc/dc converters. The VI-MEB-LV accepts modules with input voltages to 100V dc, whereas the VI-MEB-HV handles modules with input voltages to 400V dc. Each board comes with a barrier terminal, output lugs, measurement test points, and fuse. The 10×12-in. boards accept one, two, or three modules; you can configure the boards as single-, dual-, or triple-output power supplies. The boards deliver as much as 400W when configured as single-output supplies. Triple-output configurations deliver as much as 200W per output. A 32-pg manual covers measurement techniques and provides application hints. $295.

Vicor Corp, 23 Frontage Rd, Andover, MA 01810. Phone (617) 470-2900. TWX 910-380-5144.

Circle No 445

SUPPLY SERIES
Mustang Series switching power supplies comprise 34 models at 25, 50, 70/80, 100, and 150W. Each model is encased and has a barrier screw-type terminal connector. Every power supply features an input EMI filter, inrush current limiting, ±5% minimum output-voltage adjustment, 72 to 75% efficiency typ, and overload protection. The units have line regulation of 0.4% from low line to high line, and their load regulation is 0.8% from no load to full load. All models provide a 20-msec min hold-up time. Their ripple-and-noise specification is 1% or 50 mV p-p max, whichever is greater. Multiple- and single-output models accept ac input voltages from 90 to 132V ac. In addition, the multiple-output models accept voltages between 180 and 250V ac. Their input frequency ranges from 47 to 440 Hz, and their switching frequency is 100 kHz. The units operate over 0 to 71°C, with derating between 50 and 71°C. The series is UL recognized and CSA certified. From $59.50 (1000).

Computer Products Inc, 2900 Gateway Dr, Pompano Beach, FL 33069. Phone (305) 974-5500. TWX 510-956-3098.

Circle No 446

SWITCHER
The SPM5 is part of the International High Power series of switching power supplies. It provides 1500W in a 5×8×11-in. fan-cooled package. Its modular design lets you specify as many as 15 outputs from a selection of off-the-shelf single-, dual-, and triple-output plug-in modules. This modular construction can achieve a power density of 3.4W/in². The unit accepts input ac voltages from 90 to 132V ac and from 180 to 264V ac, in the field-selectable range of 47 to 440 Hz. An optional UPS (uninterruptible power system) module provides loss-of-power protection via battery backup to 1000W of dc output power. You can use the UPS module with parallel, connected dc output modules for redundant-mode operation in fault-tolerant systems. The supply meets VDE, IEC, CSA, and UL safety standards; it also meets FCC and VDE emission standards. $924 (250).


Circle No 447

POWER CONDITIONER
This series of µP-based electronic power conditioners (EPC) comprises models with 500, 1000, and 2000 VA output capacities. Each model regulates the output voltage to within ±5% of the nominal output for input voltage variations from +15 to −25%. The devices continuously measure output voltage and correct it every 16 msec. The units suppress to safe levels Class A and Class B input surge voltages of as much as 6000V peak per ANSI C 62 41-1980 (IEEE-587-1980). The units

Text continued on pg 233
Flexible Power At Your Fingertips
Acme gives you power by design — your design — with The Spectrum 400A. Five factory/user-adjustable outputs, unavailable in the industry up until now, let you set the exact output ratings you need for virtually any application: computers, telecommunications, instrumentation, and industrial controls. A simple turn of the trim pot and you have the flexibility of 120 power supplies all from one stock unit... available through authorized Standard Power distributors. And, The Spectrum 400A gives you 400 watts of switching power in a mere 13" x 5" x 2.5" package.
For more information on The 400A — the first in the Spectrum Series — or on any of our standard, quasi or custom linear and switch-mode power supplies, contact Acme Electric. We’re putting power supplies in a whole new light.
☐ 400W air, 300W convection
☐ Five factory/user-adjustable outputs

<table>
<thead>
<tr>
<th>Outputs</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vdc</td>
<td>5 ±5%: 12.24</td>
<td>5-15</td>
<td>5-15</td>
<td>5-15</td>
<td></td>
</tr>
<tr>
<td>Current Air</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Current Conv</td>
<td></td>
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</tbody>
</table>

☐ ±0.2% regulation on all outputs
☐ The most compact unit on the market - measures only 13".
☐ UL, CSA, IEC and TUV approved, FCC and VDE approved for noise level A.
☐ Power fail and remote inhibit standard

Acme Electric
Power Products Group
Cuba, New York 14727
(716) 988-2400
CIRCLE NO 202
attenuate transverse-mode noise by 60 dB and common-mode noise by 130 dB. Each unit in the series maintains a sine-wave output and adds less than 0.5% harmonic distortion to the input waveform. The units shut down when the input voltage is more than 24% above or 40% below the nominal input voltage. The units automatically enable the output voltage when the input voltage returns to acceptable limits. The 60-Hz units are UL listed and CSA certified, and they conform to FCC Class B requirements. The 50-Hz models meet VDE and IEC requirements. The 60-Hz models are rated for nominal outputs of 120, 208, or 240 V ac; they have rated outputs of 110, 220, 230, or 240 V ac.

Sola, 1717 Busse Rd, Elk Grove Village, IL 60007. Phone (312) 439-2800. TLX 280538.

Circle No 448

POWER PACKS
Perfomaxx lithium power packs are designed to power downhole equipment. The line of power packs includes battery packs for several standard downhole tools and for custom models. The basic cells have a 3.9 V dc open-circuit voltage (OCV) rating, come in four sizes, and have four capacities rated for 3.6 V (loaded) at 150°C. These sizes and capacities are RMM 150 AA at 1.3 Ahr, RMM 150 C at 5.1 Ahr, RMM 150 D at 12 Ahr, and RMM 150 DD at 22 Ahr. The basic cells are packaged in an integral pack to meet a specific tool's power requirements. The integral-pack construction incorporates Kapton spacers (rated at >200°C) to allow for thermal expansion of the cells; welded nickel tabs to ensure cell-to-cell continuity; a nonconductive heat-resistant Nomex housing material; and a field-replaceable external fuse. The packs comply with DOT E-7052 safety standards, including altitude testing at 50,000 ft. The units are shock tested to 5000 G and temperature tested to 150°C under heavy current drains. Individual cells, from $32.25 to $54.25.

Electrochem Industries/DRM, Box 50, Buffalo, NY 14226. Phone (716) 759-2828.

Circle No 449

BACKUP SUPPLY
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Panamax Inc, 150 Mitchell Blvd, San Rafael, CA 94903. Phone (800) 472-5555; in CA, (800) 472-5540. FAX 415-472-5540.

Circle No 450

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Xentek, 760 Shadowridge Dr, Vista, CA 92083. Phone (619) 727-0940. TWX 910-322-1155.

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Circle No 454

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EDN December 10, 1987
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As μP clock frequencies increase, the access time of the memories servicing the μPs must decrease. When you use a cache memory, you can use low-cost, relatively slow main memory and still keep up with the microprocessor.
Cache-memory systems benefit from on-chip solutions

David Shear, Regional Editor

The motivation behind using a cache is to improve a CPU's throughput by eliminating wait states. Not too many years ago, only those engineers designing advanced mainframes concerned themselves with cache memories. Nowadays, with the proliferation of high-performance 16- and 32-bit µPs and inexpensive, though rather slow, dynamic-RAM main memory, almost all systems can benefit from cache memories (see box, “Caches increase CPU throughput”). Your next µP design may very well require the performance gains afforded by an architecture with a cache.

To address this need, many IC vendors have introduced cache-memory controllers. You have a slew of choices, from simple cache-tag RAMs to complex and complete 4-way, set-associative subsystems. Before you can make an intelligent decision about which product to use, you have to be able to evaluate the various approaches and determine the effect each approach will have on the performance of the system you're designing.

The goal in using a cache is not necessarily just to achieve optimal cache efficiency—or even optimal processor performance. Rather, it is usually a more global objective, typically involving optimizing system performance within certain cost, size, and power limits. Simply stated, your main design goals are as follows:

- Minimize the probability of not finding a memory reference's target in the cache (the miss rate)
- Minimize the time to access information that is indeed in the cache
- Minimize the delay due to a miss
- Minimize the overhead of updating main memory and maintaining coherency.

The miss rate is a key parameter

One of the key variables in evaluating a cache implementation is the miss rate, the ratio of memory misses to the total number of memory accesses. The miss rate is a statistical estimate derived from the results of simulation or by actual measurement. (For more information on determining the performance advantage in using a cache, see box, “Estimate the performance gains possible with a cache.”)

Using a cache requires many design decisions

You'll find many approaches to using a cache. The major differences you'll have to evaluate are the size of the cache, the placement policy, the use of either a write-through or a copy-back memory-update policy, the choice of a real or virtual implementation, the coherency policy, the single-vs-split implementation, and the replacement scheme.

The size of the cache is the most dominant cache parameter in terms of both cost and potential performance tradeoffs. You can't just make a large cache and expect great performance; you must use this resource well. Common cache sizes range from a few hundred bytes inside a µP chip to a few hundred kilobytes inside a mainframe. The cache controllers from Austek, Chips and Technologies, and Intel, for example, all have a size of 32k bytes (Table 1). The NEC single-chip implementation has only an 8k-byte cache, but because of its design it maintains a miss rate that's comparable to the others'.

Although a cache's miss rate varies significantly with the software that is being executed, it has been shown that increasing the size of the cache increases the hit rate (Ref 1). As the cache size increases, the miss rate is asymptotic to a miss rate of 0. Therefore, the increase in performance with an ever-increasing cache size reaches a point of diminishing returns. The main penalty in increasing the size of a cache is the cost incurred.

Another cache-design decision you'll be confronted with involves the placement policy. Placement determines how the main memory is mapped into the cache. You have three choices: direct mapped, set associative, or fully associative.

A direct-mapped cache is implemented as a RAM addressed by some of the low-order memory address bits (Fig 1). The incoming address bits (index) select
The most important, and elusive, parameter for evaluating the performance gains possible with cache memories is the miss rate.

one of the cache entries and the most significant address bits are compared to the stored tag. If a match is detected, then a hit has occurred. Direct mapping is the simplest of the placement policies, but has the disadvantage that the miss rate increases sharply when two or more references are made to memory locations with the same lower address bits (index).

A set-associative cache is similar to a direct-mapped cache, but the index selects a set of two or more entries. Each entry can use the same lower address bits. In a 4-way set-associative cache, for example, four separate addresses can use the lower address bits (Fig 2). This approach greatly decreases the miss rate as compared with the direct-mapped approach.

A fully associative placement policy is implemented as a content-addressable memory by means of including a tag comparator with each entry. Few caches use this placement policy because it is such a complex approach, and because the decrease in miss rate (compared with that of a 4-way set-associative approach) is so small.

Fig 3 shows the decrease in miss rate possible with the various placement policies. All of the available cache-memory controllers use the set-associative approach (although Intel's 82385 can use a direct-mapped mode, too). Both Intel's and Chips and Technologies' ICs are 2-way, set-associative caches, whereas Austek's and NEC's are 4-way, set-associative types.

Keeping main memory up to date

You'll also have to determine which memory-update policy is best for your application; when data in the cache is modified, it is important that the main memory be modified as well. To meet this end, there are two basic approaches: write through and copy back.

In the write-through approach, all memory-write operations are written to both the cache and the main memory simultaneously. This approach greatly simplifies the updating process because the main memory always contains an up-to-date copy of the data. The drawback is that each write is treated as a cache miss because the CPU must wait for the main memory to be written to.

Using a buffered write alleviates this problem. The buffer holds the data that's to be written to main memory to meet the timing of the main memory, and it allows the CPU to continue processing without having to wait. The buffered write through is by far the most popular implementation: All of the controllers available use it. A good write-through implementation seldom has to wait while a write operation to main memory finishes.

Copy-back main-memory updating allows writes to the cache, but main-memory updates occur at a later time. Almost always, this approach results in less main-memory traffic because data is written to the main memory only when the data leaves the cache—when a miss requires that a cache location be relinquished, for example, or when task switching takes place.

Should it be virtual or real?

Your next design decision will involve the cache's implementation, which can be either virtual or real. The difference centers on where the cache is placed in the data and address paths relative to the CPU and the memory-management unit (MMU). If the cache is between the CPU and the MMU, then it'll deal with virtual addresses—hence the name "virtual implementation." This implementation can cause confusion when you consider that a virtual address can point to many

<table>
<thead>
<tr>
<th>TABLE 1—CACHE-MEMORY CONTROLLERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMPANY</td>
</tr>
<tr>
<td>AUSTEK MICROSYSTEMS</td>
</tr>
<tr>
<td>CHIPS AND TECHNOLOGIES INC</td>
</tr>
<tr>
<td>INTEL CORP</td>
</tr>
<tr>
<td>NEC ELECTRONICS INC</td>
</tr>
</tbody>
</table>
Caches increase CPU throughput

According to Webster’s, a “cache” is a hiding place for concealing and preserving provisions. In the case of computers, the provisions are prefetched data stored separately from the main memory. When the µP accesses memory, the cache supplies the concealed provisions (data) if it is able. If it is unable, the main memory will supply the data while the CPU waits for the main memory to respond. At the same time, the cache stores the most recently requested data for future reference.

In essence, caches are small, fast memories placed between a processor and the main memory of a computer system to reduce the amount of time necessary for memory accesses (Fig A). The only reason for having a cache is to increase CPU throughput with a rather small number of static RAMs (albeit more expensive) to make up for the rather slow access times of the dynamic RAMs.

When a cache satisfies a main-memory access, the overhead resulting from accessing the main storage memory is eliminated. This elimination frees the system bus for DMA or multiple-processor activity and provides a significant improvement in the cost/performance ratio of memory design. The µP can therefore operate at cache speeds while maintaining the economic advantages of a slower main-storage memory.

A cache works by means of what is called the property of locality. This property has two aspects, temporal and spatial. According to temporal locality, information that’ll be in use in the near future is likely to be in use already. You can expect this type of behavior from program loops in which both data and instructions are reused.

According to spatial locality, portions of the address space that are in use generally consist of a fairly small number of individually contiguous segments of that address space. A cache memory buffers segments of information that have been used recently, and thus the property of locality implies that the needed information is likely to be found in the cache.

Fig A—On a cache hit, the cache memory supplies data to the µP with no wait states (a). On a cache miss, the main memory supplies data to both the µP and the cache memory (b). The next time this same data is needed, it will already be in the cache.

<table>
<thead>
<tr>
<th>WRITE BUFFER</th>
<th>BUS WATCHING</th>
<th>SPEED</th>
<th>ADDRESS SPACE</th>
<th>PACKAGE</th>
<th>COST</th>
<th>SPECIAL FEATURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>YES</td>
<td>NO</td>
<td>16 OR 20 MHz</td>
<td>4G BYTE</td>
<td>84-PIN PLCC</td>
<td>$58 (16 MHz)</td>
<td>80386-BASED SYSTEMS; 5-CHIP SOLUTION</td>
</tr>
<tr>
<td>YES</td>
<td>NO</td>
<td>20 OR 25 MHz</td>
<td>64M BYTE</td>
<td>100-PIN PFP</td>
<td>$169.80 (20 MHz)</td>
<td>INTEGRATED DYNAMIC-RAM CONTROLLER</td>
</tr>
<tr>
<td>YES</td>
<td>YES</td>
<td>16 OR 20 MHz</td>
<td>4G BYTE</td>
<td>132-PIN PGA</td>
<td>$130 (16 MHz)</td>
<td></td>
</tr>
<tr>
<td>YES</td>
<td>YES</td>
<td>READY, 70 nSEC</td>
<td>256M BYTE</td>
<td>132-PIN PGA</td>
<td>$260 (100)</td>
<td>16-OR 32-BIT CPUs; SINGLE-CHIP SOLUTION</td>
</tr>
</tbody>
</table>

EDN December 10, 1987
The size of the cache is the most dominant parameter in terms of both cost and potential performance.

real addresses. In a real implementation, the cache is situated after the MMU, so each address in memory has only one address.

A virtual cache's advantage is that it doesn't have to wait while the MMU translates an address, and thus it can respond much faster. Faster response time notwithstanding, a virtual cache complicates the hardware design and adds some complexity to the software design because it has to keep track of which real address the virtual address is pointing to. As µP technology advances, however, more CPUs will have the MMU on chip. This will leave you with no choice—you'll have to use a real cache.

Another potentially critical design decision of which you should be aware is a cache's coherency policy. When several sources, such as multiple CPUs and a DMA controller, can change data in main memory, you can have a problem with the data's coherency (or consistency). You must make sure that the data you're using from the cache isn't stale. For example, if data from main memory also exists in a cache, and a DMA controller or other processor modifies the data in main memory, the computer must invalidate the old data in the cache.

There are many methods for maintaining coherency. The Intel 82385 takes one of the most sophisticated

Fig 1—A direct-mapped cache implementation is the simplest approach. The µP's address is split into an index, which points to a tag. The tag is then compared to the rest of the address. Note that only one main-memory location can be stored in the cache for each index.
approaches, the bus-watching approach (Fig 4). By keeping an eye on all of the transactions on the system bus, the cache controller automatically invalidates data in the cache when an external source modifies main memory. The NEC µPD43608 also has bus-watching capability to maintain coherency.

As far as a split-vs-single cache implementation is concerned, most, if not all, of the available controllers are single-cache implementations. You can have more than one cache in a system, though. A split cache is an architecture that uses more than just a single cache. A typical approach is to have an instruction cache and a

### Estimate the performance gains possible with a cache

You can use the equations below to evaluate the increase in performance afforded by a cache implementation. By playing with various values of the miss rate, you can see how much of an improvement is possible.

The average memory-access time is often useful in evaluating the performance gains that various cache implementations can provide. You can calculate the average access time from a combined relationship between cache use and main-memory use:

\[
T_{av} = R((1-M)T_{cr} + M T_{mr}) + W T_{w},
\]

where \(T_{av}\) is average memory-access time, \(R\) is percentage of memory cycles that are reads (typically 85%), \(W\) is percentage of memory cycles that are writes (typically 15%), \(M\) is miss rate, \(T_{cr}\) is cache read-cycle wait states, \(T_{mr}\) is main-memory read-cycle wait states, \(T_{w}\) is write-cycle time (main-memory for unbuffered systems or cache-memory for buffered systems).

Many times, you can gain further insight by estimating the average number of wait states that a system will require when accessing memory:

\[
N_{cw} = R((1-M)N_{cr} + M N_{mr}) + (W N_{w})
\]

Evaluate throughput increase

It is possible to evaluate the increase in system performance by comparing the speed of a design using a cache with one that doesn't. You can define CPU throughput as the CPU clock frequency divided by the number of clock states per memory cycle. The CPU clock frequency is constant, and therefore the speed improvement provided by the cache can be expressed as a ratio: the clock states per memory cycle provided with a cache to the clock states per memory cycle with full wait states.

\[
FC = (N_{o} + N_{m})/(N_{o} + N_{cw})
\]

where \(N_{o}\) is number of processor states per memory cycle with no wait states, \(N_{m}\) is number of wait states for main memory, and \(N_{cw}\) is average number of wait states with cache system.

For example, a 68010 µP requires four clock states per memory cycle (\(N_{o}=4\)). Assume you have a 12.5-MHz clock and a 250-nsec main memory requiring two wait states (\(N_{m}=2\)). With a buffered write and a cache requiring no wait states, having an access time of 50 nsec, and having a miss rate of 10% (\(M=0.1\)), you end up with the following estimation: average memory-access time=67 nsec, average number of wait states=0.170, and increase in CPU throughput=44%.

Note that with a RISC-based CPU, the potential for increasing performance by using a cache is higher. Because a RISC machine has only one clock state per memory cycle, the number of wait states makes a much larger difference. If you use a RISC machine with a memory that has two wait states, a cache similar to the one in the previous example would yield a 156% increase in throughput.
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The secret to all this flexibility and performance is our unique multiple-chip, modular approach. Rather than trying to squeeze all the important graphics functions onto a single chip — which would require some significant design and performance compromises — we've partitioned appropriate functions onto individual building-block ICs. This allows us to optimize the design of each chip, and allows you to optimize your own design for your particular application.

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For more information and availabilities, just contact your local National Semiconductor Sales Engineer or write: National Semiconductor Advanced Graphics, MS 23-200 P.O. Box 58090 Santa Clara, CA 95052-8090
When data in the cache is modified, it is important that the main memory be modified as well.

data cache or to have separate user and supervisor caches.

Next, you'll have to consider the replacement scheme. When a cache miss occurs and all of the available cache memory is used up, you have to ensure that the data in the cache is replaced with the most recently requested data. If you have a direct-mapped cache, you have no choice but to replace the data pointed to at the index. With a set-associative approach, you have to decide which set to replace. Common replacement schemes employ random, FIFO, or LRU (least recently used) algorithms. The LRU algo-

Fig 2—In a set-associative cache, each index points to more than one tag. In this diagram, the Fujitsu MB81C50 provides four different tags to decrease the probability of a miss. The MB81C50 also includes the logic for the LRU replacement policy.
Fig 3—As the number of sets increases in a set-associative cache, the miss rate decreases. The gain in system performance with a cache larger than an 8-way, set-associative type rarely outweighs the increase in system cost.

Fig 4—It is important to ensure that the data within the cache isn’t stale. The Intel 82385 has a bus-watching capability that nullifies any cache references that may no longer be valid.
NS32532 Block Diagram

DHRYSTONE BENCHMARK COMPARISON

Dhrystone
Version 1.1
The NS32532: Real-world performance for real-world applications.

At National, we believe that a high-performance 32-bit microprocessor should be worked with, not around. That's why the NS32532 offers you some of the highest performance specs in the industry. Yet it's performance you can use. Because the NS32532 was created for real-world designers working on real-world systems to meet real-world needs.

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The NS32532 is capable of delivering 15 MIPS peak performance, 8-10 MIPS sustained, at 30 MHz. Not "no-ops" MIPS. Not benchmarking MIPS. Not RISC MIPS. But genuine VAX® 11/780 MIPS.

You're looking at 16,600 Dhrystones per second. Not to mention high integer performance and high floating-point performance. With a range of FPU solutions that deliver up to 8 million double-precision Whetstones per second.

Below: NS32532 chip
Left: VME532 evaluation board; NS32532 block diagram; competitive performance comparison*

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The NS32532 achieves its superior performance because it integrates key systems functions on a single piece of silicon.

Only the NS32532 incorporates on-chip data and instruction caches, demand-paged virtual memory management, and a 4-stage instruction pipeline. With instruction prefetches and branch prediction. Plus a hardware cache invalidate mechanism that ensures cache coherency.

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National Semiconductor
With 242 passengers on final approach into O'Hare, the last thing they're thinking about is your voltage regulator.

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All with 60-volt load-dump and reverse-transient protection. And all with "drop-in" design ease, regardless of your applications:

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Which means you get the highest reliability available in the industry, while sharply cutting the cost of your own incoming testing program, and without having to pay a price premium for ours.

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**National's Low Dropout Regulator Family**

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>LM2925</td>
<td>Low dropout, 5 V, 750 mA with delayed reset</td>
<td>5 V, 150 mA, 0.75 mA</td>
</tr>
<tr>
<td>LM2930</td>
<td>Low dropout, 3-terminal, 5 V or 8 V, 150 mA</td>
<td>0.75 mA, 150 mA, 150 mA</td>
</tr>
<tr>
<td>LM2931</td>
<td>Low dropout, low quiescent current, 5 V or adjustable, 100 mA</td>
<td>0.75 mA, 100 mA, 100 mA</td>
</tr>
<tr>
<td>LM2935</td>
<td>Low dropout, dual 5 V for memory keep-alive, 750 mA or 10 mA</td>
<td>750 mA, 10 mA, 0.75 mA</td>
</tr>
<tr>
<td>LM2940C</td>
<td>Low dropout, 5 V, 12 V, or 15 V, 1 A</td>
<td>12 V, 15 V, 1 A</td>
</tr>
<tr>
<td>LP2950 /2951</td>
<td>Low dropout, micropower, 5 V or adjustable, 100 mA</td>
<td>5 V, 100 mA, 0.75 mA</td>
</tr>
<tr>
<td>LM2984</td>
<td>Low dropout, 3 tracking 5 V outputs with watchdog</td>
<td>5 V, 3 outputs, watchdog</td>
</tr>
</tbody>
</table>

National Semiconductor
Linear Solutions
P.O. Box 58090
Santa Clara, CA 95052-8090

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One problem with having a cache in a system is the difficulty of determining the execution speed of an application.

implementations, but suffer in large caches because of their high chip count.

As you can see by looking at Table 2, the cache-tag RAMs from Integrated Device Technology, Saratoga, Texas Instruments, and Thomson/Mostek have a 4- or 8-bit tag width. The Saratoga SSL2152/4 has a 9-bit width. The Thomson/Mostek MK4202 is a 2048-index×20-bit device, and it can map a simple 2k-word cache into a 31-bit address.

The Fujitsu MB81C50 cache controller provides the flexibility of a cache-tag RAM, but also includes some of the control logic for implementing a complete cache-memory system. The device contains the circuitry for a 2- or 4-way set-associative placement policy as well as the LRU algorithm.

Once you’ve evaluated the various approaches and determined your design needs, you can measure various important performance ratios. You can easily do this, at least to a first-order approximation, by using a

<table>
<thead>
<tr>
<th>TABLE 2—CACHE-TAG RAMs</th>
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<tbody>
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<td>COMPANY</td>
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<tr>
<td>FUJITSU INTELLIGENT CACHE-TAG RAM</td>
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<tr>
<td>INTEGRATED DEVICE TECHNOLOGY INC CACHE-TAG RAM</td>
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<tr>
<td>SARATOGA SEMICONDUCTOR TAGRAM SSL4180</td>
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<td>TAGRAM SSL4181</td>
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<tr>
<td>TAG-CACHE SSL2152</td>
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<tr>
<td>TAG-CACHE SSL2154</td>
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<tr>
<td>TEXAS INSTRUMENTS INC CACHE ADDRESS COMPARATOR</td>
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<td>CACHE ADDRESS COMPARATOR</td>
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<td>CACHE ADDRESS COMPARATOR</td>
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<tr>
<td>THOMSON COMPONENTS/ MOSTEK CORP TAGRAM MK41H80</td>
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<tr>
<td>TAGRAM MK48H74</td>
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<tr>
<td>TAGRAM MK4202</td>
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One PC data acquisition system grows up: PCI-20000.

Analog input modules: programmable gain or high speed (180kHz).

Analog output modules: 2 or 8 channel, 12 or 16 bits, V0 or l0.

Special function modules: trigger/ alarm, simultaneous sample/hold.

Counter/timer, clock, pulse generator & frequency measurement module.

Expandable digital I/O module (to 128 points per carrier).

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The others just grow old.

Some personal computer data I/O systems make you pay for functions you don't need. These same inflexible systems can't be updated—at any price.

The unique PCI-20000 modular system, on the other hand, is easily configured to provide literally thousands of data acquisition, test, measurement and/or control options. Just plug the application-specific modules you need into a carrier board. Then plug the carrier into your IBM/compatible PC. Change or add modules as your needs change. In other words, the PCI-20000 grows up, not old!

Up to 128 digital I/O points or 80 analog inputs can be configured on a single carrier board. A unique DMA carrier/module combination transfers analog, digital and/or counter data at speeds limited only by your computer. Capture, analyze and react to real-world events in real-time. Plus, ruggedly constructed termination panels provide long-lasting screw-in connections to analog and digital I/O signals.

No programming experience needed. Many easy to use, menu driven software packages support the entire PCI-20000 family. Multiple language software drivers are also available. Best of all, years from now when other systems are collecting cobwebs, your PCI-20000 will still be collecting data.

The Handbook

Free 300 Page PC Data Acquisition Handbook.
For fast service, call 602-746-1111, or return the coupon to Burr-Brown PCI Handbook, P.O. Box 11400, Tucson, AZ 85734.

Name
Title
Company
Address
City-State-Zip
Phone ( )

Circle 78 for General Information
Circle 117 for OEM/VAR Program
In the future, you can expect to see large, high-speed cache systems on single chips, tightly coupled to the CPU and to the system bus for bus watching.

For more information . . .

For more information on the cache-memory controllers and cache-tag RAMs discussed in this article, contact the following manufacturers directly or circle the appropriate numbers on the Information Retrieval Service card.

**Austek Microsystems Inc**
444 Castro St, Suite 1020
Mountain View, CA 94041
(415) 909-1315
FAX (415) 960-0799
Circle No 458

**Chips and Technologies Inc**
3060 Zanker Rd
San Jose, CA 95134
(408) 434-0000
Circle No 459

**Fujitsu**
3320 Scott Blvd
Santa Clara, CA 95054
In CA, (800) 556-1294
Outside CA, (808) 441-2345
Circle No 460

**Integrated Device Technology Inc**
3236 Scott Blvd
Santa Clara, CA 95054
(408) 727-6110
TLX 957766
Circle No 461

**Intel Corp**
3065 Bowers Ave
Santa Clara, CA 95051
(800) 548-4725
Circle No 462

**NEC Electronics Inc**
401 Ellis St
Mountain View, CA 94049
(415) 969-6000
TWX 910-379-6985
Circle No 463

**Saratoga Semiconductor**
10500 Ridgeview Ct
Cupertino, CA 95014
(408) 884-0500
Circle No 464

**Texas Instruments Inc**
Semiconductor Group (SC-725)
Box 809066
Dallas, TX 75380
(800) 232-3200
Circle No 465

**Thomson Components/Mostek Corp**
1310 Electronics Dr
Carrollton, TX 75006
(214) 466-6000
TLX 463-0093
Circle No 466

A couple of counters. Put one counter on the read line of the µP and the other on the hit output of the cache controller (Fig 5). Run your application software and look at the counters after an appropriate period of time. You may have to put a divide-by-10 or -1000 circuit in front of the counters so that they won't overflow, but this extra circuitry won't have any effect because all you need is the counters' ratio.

You can also determine the ratio of reads to writes and the ratio of writes without wait states to writes with wait states. With a small amount of software overhead, you can even enable the counters in certain sections of your code by controlling a bit on an output port to isolate where a low hit rate occurs.

You should be aware, however, that in the real-time control world it's difficult to determine the response time of the system. When using worst-case analysis, you have to assume that all memory accesses will be misses, and thus you have to assume that the cache doesn't even exist. In such applications, therefore, you may decide against using a cache at all.

Although cache-memory controllers provide subsystem-on-a-chip solutions, they don't have many options to offer—most are cast in silicon. Their advantage lies in the fact that you can capitalize on the knowledge and insight of the chip designers when you design your system, thereby avoiding a lot of reinvention of the wheel. The NEC µPD43608, for instance, is a complete cache subsystem, including the data RAM.

In the future, you can expect to see large, high-speed cache systems on single chips, tightly coupled to the CPU and to the system bus for bus watching. The devices available are already quite complex: The Austek part has 128,000 transistors; the NEC chip has 680,000 transistors. With the speed of CMOS RAMs getting close to 10 nsec and the promise of BiCMOS around the corner, it should be easy for cache memories to keep up with the ever-increasing speeds of µPs.

**References**

**Article Interest Quotient (Circle One)**
High 479 Medium 480 Low 481
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PMI's OP-44 also guarantees a 15 MHz GBW and full power BW of 1.5 MHz. And no compromises on accuracy...

<table>
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<tr>
<th>OP-44 HA-2520</th>
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<tr>
<td>$V_{OS}$</td>
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<td>$T_{CV_{OS}}$</td>
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<td>$A_{VOL}$</td>
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<td>$I_B$</td>
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<td>CMR</td>
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</table>

The OP-44 is available now... in 883 too. Get the high-speed facts from our 12-page OP-44 data sheet. Circle the reader service number or call 1-800-843-1515.

Precision Monolithics Inc.
A Bourns Company
Santa Clara, California USA
408-727-9222
Integrated Circuits

Chip set provides physical-layer interface to fiber-optic data links

The SP9960 encoder/LED-driver, SL9901 transimpedance amplifier, and SP9921 decoder provide most of the interface hardware required to implement a 50M-bps Manchester-encoded fiber-optic communications link. The SP9960 encoder/LED-driver accepts either TTL- or ECL-level clock and data signals and encodes them by using Manchester biphase-mark coding. It has an output that can directly drive the fiber's transmission-end LED, and you can program the LED drive current to 15, 25, 45, 80, 115, or 150 mA by using dedicated IC inputs.

The SL9901 transimpedance amplifier accepts the output of the fiber's receiving-end PIN-diode detector and converts it to a voltage drive for the decoder IC. The amplifier has a 3-dB bandwidth of 50 MHz, so it is suitable for use in systems having NRZ data rates reaching 100 M bps.

The SP9921 decoder can operate at a data rate of between 20 M and 50 M bps, recovering both clock and data signals from the received signal. It incorporates two phase-lock-loop circuits in a Costas-loop circuit, which gives the recovered clock signal a high degree of immunity to input signal noise. In addition, the decoder can detect idle-code patterns that violate normal Manchester codes; it can operate in links that utilize burst-data modes. The decoder has ECL-level outputs.

All three devices are available in die form or in surface-mount packages. The encoder and decoder ICs are also available in DIPs. The chip set requires a single 5V supply and operates over -40 to +85°C. In surface-mount packages, the SP9960, SL9901, and SP9921 sell for £11.74 ($21.04), £4.66 ($7.78), and £23.17 ($38.69) (1000), respectively. Delivery, 60 days ARO.

Plessey Semiconductors Ltd, Cheney Manor, Swindon, Wiltshire SN2 2QW, UK. Phone (0793) 36251. TLX 449637.

Gallium arsenide comparator features a data rate of dc to 2G bps

The HMD-11685-2 is a gallium arsenide (GaAs) ultra-high-speed comparator for use as a line driver, line receiver, system clock-driver, pulse driver, or buffer amplifier. All its inputs and outputs are both GaAs and ECL compatible. With an input-to-output propagation delay of 500 psec, the chip's processing speed is typically four times faster than ECL products of equivalent function.

The comparator's output capability is adequate for driving a fan-out of 3 into a 50Ω terminated transmission line. The HMD-11685-2 also provides a latch function that lets you use the part in sample/hold mode. The comparator functions normally when the latch-enable input is held high. At the time of the latch input transition, when the latch enable is driven low, the outputs are locked into their existing logical status.

The device features a Ti/Pt/Au metalization system and operates over -55 to 85°C. Packaged in a 16-pin hermetic flat pack, the HMD-1165-2 costs $155 (100).

Harris Microwave Semiconductor, 1530 McCarthy Blvd, Milpitas, CA 95035. Phone (408) 433-2222.

Plessey Semiconductors, 9 Parker, Irvine, CA 92718. Phone (714) 472-0303.

EDN December 10, 1987
Integrated Circuits

Analog I/O port includes an 8-bit ADC, an 8-bit DAC, and a T/H amplifier

The AD7569 is a monolithic, analog I/O port that combines an 8-bit A/D converter, an 8-bit D/A converter, a track-and-hold (T/H) amplifier, a buffer amplifier, and a voltage reference. The ADC's maximum conversion time (to 0.5 LSB) is 2 µsec; the DAC is buffered by the on-chip amplifier and settles to 0.5 LSB in 1 µsec max. The AD7569 can replace as many as five separate ICs.

The manufacturing process combines low-power CMOS devices and high-speed, high-accuracy bipolar transistors on a single chip. The IC uses CMOS transistors for the converters' switches, the T/H amplifier, and the chip's logic interface. Bipolar devices are used to build the high-speed JFET-input buffer amplifier, comparator, bandgap reference, and DAC current sources.

Because all the necessary conversion circuitry is on the chip, the AD7569 simplifies logic timing; a single command generates a hold signal for the T/H amplifier, delays an A/D conversion until the T/H amplifier has acquired the signal, and initiates the conversion. The fast logic interface, compatible with high-speed µPs and DSPs, is a result of the 75-nsec bus-access time and the <80-nsec write-pulse width.

The AD7569 consumes <60 mW and is suitable for battery operation. The part comes in six grades for use over three temperature ranges. Package options include a 24-pin plastic DIP, a 24-pin ceramic DIP, a 28-pin LCC, and a 28-pin PLCC. The commercial version in a plastic DIP costs $6, the industrial version in a ceramic DIP is $9, and the military part in a ceramic DIP is $27 (100).

Analog Devices, Box 9106, Norwood, MA 02062. Phone (617) 320-4700. TLX 174506.

Circle No 586

CMOS erasable programmable logic device features 25-nsec propagation delay

According to the manufacturer, the 5AC312 is the first CMOS erasable programmable logic device (EPLD) to combine a total propagation delay of 25 nsec with previously unavailable architectural features in a 24-pin package. Based on the company's advanced CHMOS technology, the 5AC312 accommodates logic functions—such as decoding, wait-state generation, data latching, and bus arbitration—in critical timing paths of high-performance applications, such as 80286- and 80386-based systems. Under typical high-speed operating conditions, the device draws <50 mA of current, which is reportedly 45% less than other techniques require.

To accommodate the latching or holding of incoming data, the 5AC312 offers a flexible input structure that you can configure in one of five different ways. The 5AC312 also features a user-controllable product-term (P-term) allocation scheme that reallocates unused logic resources to functions with high P-term demand.

The 5AC312 is supported by the vendor's Programmable Logic Development System II (IPLDS II) version 1.5, which contains the software and hardware necessary to turn EPLD design concepts into working silicon on an IBM PC/XT, PC/AT, or fully-compatible system. The 5AC312, in a 24-pin ceramic DIP sells for $22.50 (100). IPLDS II V1.5 costs $3450.

Intel Corp, Dept W-388, Box 55065, Santa Clara, CA 95052. Phone (916) 351-2747.

Circle No 587
Happy days are here again.

New production capabilities make the most advanced EEPROM MCU available to everyone.

We're celebrating and you're the guest of honor—our new increases in production capacity mean we can deliver enough HCMOS 68HC11s for everyone: giants and start-ups alike.

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Motorola's MC68HC11 microcontroller with EEPROM has long been the most advanced single-chip MCU in the industry. Its advanced features created such an immediate success that we were unable to meet the enormous demands. To those who had to wait, we apologize; the backlogs are unjammed and a steady supply of HC11s is now available to everyone. Increased production schedules and technology advances have improved our output, assuring that a constant inventory will be on hand to meet both your immediate and future needs.

The MC68HC11 was the first HCMOS microcomputer with on-chip EEPROM and it's still the best. Besides 512 bytes of EEPROM, the HC11 features 256 bytes of RAM, 8 bytes of mask ROM, two serial ports, an enhanced timer subsystem, an 8-channel A/D converter, a pulse accumulator, and a COP watchdog system. But best of all, it's now available for delivery in quantity.

Additional design support is available with our HDS300 Evaluation Module and our 68HC11EVB Evaluation board which makes designing and debugging your system a breeze.

One-on-one design-in help.

Get an engineer-to-engineer update on designing-in Motorola's MC68HC11 microprocessor. Call toll free any weekday, 8:00 a.m. to 4:30 p.m., M.S.T. If the call can't answer your question we'll have a local applications engineer contact you. For published data on the HC11 return the completed coupon below to Motorola.

To: Motorola Semiconductor Products, Inc.
P.O. Box 20912, Phoenix, AZ 85036

Please send me more information on the MC68HC11 and its evaluation products.

Name ____________________________
Company __________________________
Address ____________________________
City __________________ State ______ Zip ________
Call me (_________)

EDN December 10, 1987
Integrated Circuits

SCSI protocol IC employs dual data bus, performs 20M-byte/sec host transfers

The AIC-6250 CMOS IC supports asynchronous and synchronous data transfers across the SCSI bus. The chip includes a dual data-bus interface on the host side, and the host interface supports data transfers as fast as 20M bytes/sec. Single-ended bus transceivers are included on chip, but you can also interface directly with external differential transceivers to the on-chip logic.

The AIC-6250 includes state machines for performing the SCSI protocol, and it automatically performs such functions as arbitration, selection, and preselection. The IC fits both target and initiator applications. As a target, the IC automatically generates a response to selection or reselection.

The chip's architecture serves to offload the host's bus. The chip uses a 16-bit bus to handle 8- or 16-bit data transfers in DMA or programmed I/O modes. A separate 8-bit data port allows the controlling µP to access the control registers at all times, even during DMA transfers.

On the SCSI-bus side, the IC performs 3M-byte/sec asynchronous transfers and can achieve 5M-byte/sec synchronous transfers. An 8-byte FIFO buffer links the SCSI bus and the host-bus interface. The chip can burst data into or out of the buffer at 20M bytes/sec.

The chip also features automatic parity generation and checking, and it has two general-purpose I/O ports. In differential applications, the I/O ports control the differential transceivers. You can interface the SCSI chip to a µP without using glue logic, even if the µP uses a multiplexed data/address bus. The IC costs $20 (1000) and comes in a 68-pin plastic leaded chip carrier.

Adaptec Inc, 580 Cottonwood Dr, Milpitas, CA 95035. Phone (408) 432-8600.

Circle No 578

Programmable video RAM controller can drive arrays as large as 64M bytes

Part of an advanced graphics chip set, the DP8522 video RAM controller/driver can directly address and drive an array of 4M-bit video RAMs as large as 64M bytes in size. The company's chip-set architecture permits resolutions as high as 16k×16k pixels and a virtually unlimited number of color planes under the control of a single rastergraphics processor. By employing a separate video RAM or dynamic RAM controller, the advanced graphics chip set lets you decide which type of memory component best fits your system's cost and performance goals.

The fully programmable DP8522 works with a variety of computer systems. Its adjustable control-signal pulse widths let you use microprocessors operating at frequencies to 20 MHz. The device supports video RAMs that provide simultaneous read/write functions through a dual-port configuration. The DP8522 also supports dual accessing, provided that a second graphics controller, CPU, DMA, or LAN controller has access to the same memory bank.

The DP8522 supports memory interleaving, and the chip's programmable wait-state logic helps to improve the overall performance of this CMOS device. All major aspects of video-RAM interface, control, and drive functions are fully integrated in the DP8522. Features such as on-chip address latches, bank-select logic, dual-porting, a refresh counter, and a high-speed row/column/refresh multiplexer are built in. The DP8522 comes in an 84-pin plastic chip carrier and costs $28 (1000).

National Semiconductor Corp, Box 58090, Santa Clara, CA 95052. Phone (408) 721-5404. TLX 346353.

Circle No 581

EDN December 10, 1987
A compact 1553 that carries a busload.

The UT1553B BCRT data bus system proves that big things do come in small packages. It's loaded with features including both MIL-STD-1553B Bus Controller and Remote Terminal functions and advanced, specialized memory management—all on one low-power CMOS chip.

It's the next generation product in our 1553 family. The BCRT was designed to reduce host intervention with automatic DMA and address generation. It automatically executes message transfers, provides interrupts, and generates status information. UTMC’s BCRT allows you to implement a pseudo-transparent dual-port RAM configuration.

The BCRT’s bus controller uses a linked-list message scheme to provide the host with message “chaining.” Memory space is optimized by using programmable address pointers. As an RT, the BCRT implements time tagging and message history functions. It also supports multiple-message buffering—up to 128—including variable-length messages to any subaddress.

The BCRT complies with the standard LAN used for military systems while meeting selected tests in MIL-STD-883C. It is available in 84-pin LCCs, PGAs, or Cerquads.

Don’t miss the bus on your 1553 system needs. Call UTMC.
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We also offer a new high-speed op amp especially well-suited to driving ADC's or video cables.

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10-bit CMOS serial ADC.

The CDP68HC68A2 is selectable for either 8- or 10-bit resolution and has an 8-channel multiplexer allowing up to 8 channels of inputs. The device can be used directly with our CDP68HC05C4, C8 or D2 microprocessors or other similar SPI (Serial Peripheral Interface) buses.

8-bit CMOS R-2R video-speed DAC's.

These CMOS/SOS digital-to-analog converters operate from a single 5V supply at video speeds and can produce "rail-to-rail" output swings. Typical update rate is 50 MHz. Settling is fast (20 ns typical) to 1/2 LSB. "Glitch" energy is minimized by segmenting and bar graph decoding of upper 3 bits.

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Access to the right technology

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Integrated Circuits

Fast CMOS multiplier-chip family offers high speed for DSP applications

This family of four multiplier chips derives its speed from an optimized architecture implemented in a 1.8-µm CMOS process. Three of the devices (the 8-bit, 12-bit, and 16-bit parts) are straight multipliers that can compute a product in as little as 35 nsec. The fourth device is a 12-bit multiplier that has a built-in accumulator and can compute a product and add it to the accumulator in 45 nsec.

The 16-bit LMU18 multiplies two 16-bit inputs and then delivers the full 32-bit product in 35 nsec. Much of the LMU18's speed advantage (twice that of its nearest competitor, according to the manufacturer) comes from its ability to produce the entire 32-bit product at once. Other multipliers can produce only 16 bits at a time, so they require a 2-step process.

The 12-bit LMU12 multiplies two 12-bit inputs and produces a 24-bit product in 35 nsec. It is pin and function compatible with TRW's MPY-12HJ. The 8-bit LMU08 can multiply two 8-bit inputs to produce a 16-bit product in 35 nsec. You can choose a 16-bit output that's read in parallel or an output that's multiplexed to a single 8-bit bus for more compact designs. You can also load the inputs in parallel, or individually from an 8-bit bus.

The LMA1009 multiplier-accumulator (MAC) chip has a built-in accumulator, which lets you build algorithms that require the successive addition of products. The device multiplies the values loaded into its two 12-bit inputs, adds the resultant product to the accumulator, and produces the result in 45 nsec. The LMU18 (in a PLCC package) costs $30.53. In DIPs, the LMU12 is $22.29, the LMU08 costs $17.06, and the LMA1009 (DIP) sells for $26.95 (100).

Logic Devices Inc, 628 E Evelyn Ave, Sunnyvale, CA 94086. Phone (408) 720-8630.

Flat-panel display driver scans LCDs at multiplex rates as high as 1:256

Providing an interface between industry-standard flat-panel display controllers and liquid-crystal displays, the PCF2201 LCD driver can control as many as 81 row lines or 80 column lines of a dot-matrix LCD. As a result, you need only 21 of the drivers to scan a 640×400-pixel display. The PCF2201 can drive twisted-nematic LCDs and super-twisted birefringence-effect LCDs at multiplex rates as high as 1:256.

To operate the device as a row driver, you serially clock row-select data through an internal 81-stage shift register. The maximum clock rate for the shift register, and hence the maximum row-scan rate for the display, is 100 kHz. When the IC operates in column-driver mode, the shift register functions as a set of static latches that holds parallel output data for 80 of the display's column lines. A data buffer, provided by 80 more data latches, allows you to assemble more column information while the driver sends the current column information to the LCD. You can enter data in the data buffer either serially or in 4-bit nibbles.

The PCF2201 provides internal level shifters that shift the logic-level row/column data contained in the shift register to the voltage levels required by the LCD. The driver can handle drive voltages as high as 25V, and the level shifters require four bias voltages between 5V and -25V.

The display driver draws a typical operating current of 0.4 mA and a standby current of 15 µA, and it provides on-chip overtemperature protection. All its data and control inputs are 5V CMOS compatible. The driver is supplied on reels in a tape-automated-bonding package with 120 leadouts. It costs around Swiss Fr 8 (10,000).

Philips, Elcoma Div, Box 523, 5600 AM Eindhoven, The Netherlands. Phone (040) 757005. TLX 51573.

Circle No 579

Signetics Corp, 811 E Arques Ave, Sunnyvale, CA 94088. Phone (408) 991-4571.

Circle No 580
16-bit, sampling A/D converters
digitize high-frequency signals

The MN6290 (10V input span) and MN6291 (20V input span) are high-speed, 16-bit, sampling A/D converters designed for digital-signal-processing (DSP) applications. The devices feature internal, user-transparent, track-and-hold (T/H) amplifiers that let these ADCs accurately sample and digitize dynamically changing input signals at sampling rates to 20 kHz. When sampling and digitizing at 20 kHz, both devices maintain an 84-dB min S/N ratio and a minimum of 88 dB of harmonic-distortion attenuation.

The T/H amplifier is necessary because of the device's successive-approximation (SA) technique. By itself, the SA type of ADC is inherently incapable of accurately converting rapidly changing analog input signals. The T/H amplifier overcomes this shortcoming by holding the signal constant whenever the ADC performs a conversion. A high-impedance input buffer isolates the T/H amplifier from its signal source, and the T/H amplifier's operational mode is internally controlled by the ADC's status line.

The vendor tests each device both statically and dynamically with a series of 512-point FFTs on the stored digital output data. The devices come in 32-pin, double-width DIPs and are available in commercial, industrial, and military temperature grades. Pricing varies from $180 to $270 (100), depending on the bit-accuracy specification and the temperature range.

Micro Networks, 324 Clark St, Worcester, MA 01606. Phone (617) 852-4000. Circle No 589

CMOS DSP IC offers 80-nsec cycle time;
operates on IEEE floating-point numbers

The Model WE DSP32C CMOS floating-point digital signal processor (DSP) features cycle times as low as 80 nsec. The processor is compatible with the IEEE standard floating-point format. Three 512x32-bit banks of RAM on the IC ensure fast access to memory.

The chip includes 15 general-purpose registers, five increment registers, two external interrupts, eight vectored interrupts, and a 16M-byte address space. You can program the DSP chip for 8-, 16-, or 32-bit accesses to external memory. The chip automatically inserts as many as three wait states when used with slow main memory. On-chip I/O resources consist of a 16-bit parallel port and a serial port capable of operating as fast as 22.5M bps.

The DSP32C can fetch two 32-bit numbers from memory, multiply and accumulate the result, and write it to memory in one 80-nsec instruction cycle. Because the DSP32C is source- and object-code compatible with its predecessor, the NMOS WE DSP32, you have direct access to a large library of applications code.

The DSP32C internally uses a 24-bit mantissa and 8-bit exponent floating-point format. For access to IEEE databases, it includes logic that converts between the IEEE floating-point format and the IC's internal format in a single cycle. To support access to external data, the DSP32C interfaces to codecs, other DSP32s and DSP32Cs, and time-division-multiplexed lines without requiring glue logic. The on-chip serial port is double buffered, and an on-chip DMA controller supports simultaneous DMA transfers between the serial port and the parallel port without program intervention.

A full complement of development tools—including a C-like assembler, a link editor, a simulator/debugger, and a C compiler—support software development for the DSP IC. The software-development package executes on systems running MS-DOS and costs $995. Samples are available now, and production quantities will be shipped in the first quarter of 1988. The $70 (10,000) device will be packaged in a 133-pin PGA.

AT&T Technology Systems, 555 Union Blvd, Allentown, PA 18103. Phone (800) 372-2447. Circle No 577
Bubble memories as a technology seem to be bursting all over the place. Which is one sound reason why—if you use bubbles for non-volatile memory—you may want to replace them with high-density EEPROMs from SEEQ. Because let's face it, bubbles just don't stack up against SEEQ E²'s.

Compare speed, for example. Since bubble memories access data serially—like tape drives—they're slower than molasses in January. A typical bubble read cycle will get you about 17-18.5K bytes per second. In that same time, a SEEQ E² gives you 5 Megabytes. Write times for E²'s are also faster by an order of magnitude.

SEEQ E²'s not only work faster, they work harder in harsh environments. They operate over extended and full military temperature ranges, with greater inherent reliability than any electromagnetic bubble. Or any other E².

SEEQ E²'s aren't a lot of toil and trouble for designers, either. For one thing, with all their coils and support circuits, bubbles can be real current hogs. But not E²'s. A 256K part from SEEQ draws just 60 mA in active mode, 150 µA in standby. And by including many peripheral functions on board, SEEQ E²'s make it easy to build hardware and software interfaces to popular microprocessors. Plus E²'s fit comfortably on most system boards, using surface mount packages.

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CIRCLE NO 80
Integrated Circuits

Bipolar/CMOS bus-interface devices
cut total system power consumption

Six bus-interface devices fabricated in a new digital bipolar/CMOS technology are the first members of the SN74BCT product family. The devices are 10-bit bus drivers, 10-bit memory drivers, and 10/9-bit transceivers, all with 3-state outputs. The SN74BCT2827 and -2828 are designed specifically for driving the capacitive inputs of MOS memories; each chip's outputs have 25Ω damping resistors, which eliminate the need for external components. The outputs of the -2827 and -2828 provide true data and inverted data, respectively.

The -29827 and -29828 are buffers and bus drivers for high-performance bus interface with wide data paths or buses that carry parity.

The devices are functionally equivalent to the AM29827 and AM29828. The -29861 and -29863 are 10- and 9-bit bus transceivers, respectively; they are functionally equivalent to the AM29861 and AM29863.

Characterized for operation over 0 to 70°C, the devices are available now in 24-pin DIPs. The company plans to offer plastic leaded chip carriers and SOIC packages for surface mounting. In DIPs, the -29827, -29828, -29861, and -29863 cost $3.46 (1000) each. The -29827 and -29828 are $3.60 (1000). The vendor plans to offer versions for the military temperature range; they'll be available in ceramic DIPs and leadless ceramic chip carriers.

Texas Instruments, Semiconductor Group, Box 809066, Dallas, TX 75380. Phone (800) 232-3200 ext 700.

Single-chip microcontroller offers analog and digital I/O facilities

Targeting automotive applications, the 80C51-based PCB83C552 single-chip CMOS microcontroller is also suitable for medical, instrumentation, and industrial-control equipment. The chip's functional enhancements include an 8-channel, 10-bit A/D converter; two PWM outputs; additional parallel I/O ports; an additional timer/counter; and an I/F-bus interface.

The microcontroller has six 8-bit parallel I/O ports. Ports P0, P1, P2, and P3 are identical in function to those on the 80C51. Port P1's I/O lines also provide control inputs for the chip's additional counter/timer and for its serial clock and data lines.

The parallel I/O capabilities of port P4 allows you to couple it to one of the on-chip timer/counters. When the timer/counter reaches predetermined points, six of P4's outputs are set or reset, and two of its outputs are toggled. Port P5 operates only as an input port, but you can use it either as an 8-bit digital port or as an 8-channel analog port for the A/D converter's input multiplexer.

The two PWM outputs, driven by push-pull drivers, have dedicated output pins. An 8-bit control register allows you to select a common repetition frequency for both outputs, and two more registers allow you to define the mark/space ratio for each individual channel.

The analog input circuitry includes an 8-channel analog input multiplexer and an A/D converter with 10-bit resolution. The A/D-conversion time is 50 µsec with a 12-MHz clock frequency. An 8-bit control/status register allows you to select a particular input channel and software-trigger the ADC.

The PCB83C552 includes 8k bytes of mask-programmable ROM, and it lets you expand ROM and RAM externally to as much as 64k bytes. The device comes in a 68-pin PLCC and sells for around DM 26 (10,000).

Philips, Elcoma Div, Box 523, 5600 AM Eindhoven, The Netherlands. Phone (040) 757065. TLX 51573.

Signetics Corp, 811 E Arques Ave, Sunnyvale, CA 94088. Phone (408) 991-4571.
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Integrated Circuits

Dual-output 5V regulators simplify battery-backup circuitry

To simplify the design of systems that require battery backup for some of their circuitry, the L4901, L4902, L4903, and L4904 voltage regulators have two separately regulated 5V outputs, one of which specs a leakage current of <1 µA.

The low-leakage regulator sections' quiescent input-current drain is only 0.6 mA, so it's suitable for operation from battery input sources. The second 5V output is suitable for driving circuitry that doesn't require backup.

The regulators also generate a µP-compatible reset signal during power-up conditions, after brief supply interruptions, or when the output to the battery-backed section of your circuit falls below a safe value—4.9V typically. You can control the reset-period timing with a single external capacitor.

The L4901 and L4902 are housed in 7-lead Heptawatt plastic packages. They provide a 5V/0.3A output for battery-backed circuitry and a 5V/0.4A output for other circuitry. The L4903 and L4904 come in 8-pin miniature DIPs. Both their outputs are rated at 5V/0.1A, and both devices have separate inputs to their two regulator sections. The L4901 has a separate input for each of the two regulator sections.

The L4902 has a common input for both regulator sections. Both the L4902 and the L4903 have a TTL/CMOS-compatible disable input that controls the output that's not designed for battery back-up circuitry. All the regulators have input overvoltage protection to 60V, as well as output short-circuit and thermal-overload protection. They cost around $1.30 (1000).

SGS Microelettronica SpA, Via C Olivetti 2, 20041 Agrate Brianza, Italy. Phone (039) 65551. TLX 330131.

Circle No 596

SGS Semiconductor Corp, 1000 E Bell Rd, Phoenix, AZ 85022. Phone (602) 867-6100. TLX 249976.

Circle No 597

Single-chip token-bus modem supports MAP networks

The SAB82511 baseband modem provides the functions of layer 1 of the OSI communications model for IEEE-802.4 token-bus networks. It is therefore suitable for use in MAP (manufacturing automation protocol) networks. The modem is also compatible with Motorola's token-bus controller.

Using phase-coherent FSK modulation, the modem transmits data at 5M or 10M bps. It also includes a digital demodulator to decode received data. The modem chip generates the receive and transmit clock signals from a 20-MHz crystal or an external frequency source. It also provides station-management functions, and it has an electrical interface that you can connect directly to a network-medium coupling transformer.

The modem recognizes five distinct transmission states from the media-access control (layer 2) functions of the token-bus controller—silence, non-data, pad-idle, data one, and data zero—and modulates the transmit carrier signal accordingly. The SAB82511 also supports station-management functions that include a loop-back mode for use in fault diagnosis. In addition, it incorporates a watchdog timer that prevents the modem from going into continuous-transmit mode and thus locking up the network.

The SAB82511 comes in a 44-pin ceramic leadless chip carrier or plastic leaded chip carrier and operates over 0 to 70°C. It operates from a single 5V supply and draws a maximum supply current of 290 mA. All inputs and outputs that interface the modem to the token-bus controller are TTL compatible. Samples are available at $175 each.

Siemens AG, Zentralstelle für Information, Postfach 103, 8000 Munich 1, West Germany. Phone (089) 2340. TLX 5210025.

Circle No 592

Siemens Components Inc, 2191 Laurelwood Rd, Santa Clara, CA 95054. Phone (408) 980-1500.

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EDN December 10, 1987 277
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1-GHz, 3000-gate GaAs array targets high-speed digital applications

The TQ3000 GaAs gate array is fabricated in the company’s Q-ED process, a 1-µm enhancement/depletion MESFET (metal-epitaxial-semiconductor FET) construction that features two layers of interconnect metal, including air-bridge technology for the second layer. The gate array supports 64 dedicated high-speed I/O pins that the user can program to interface with TTL, CMOS logic, or ECL. Internally, the array has 1020 cell locations containing 3000 equivalent gates. You can, for example, create 255 master/slave flip-flops by using the available gates. The part’s power consumption is 0.75 mW per equivalent gate and 2.4 mW per cell. The array operates from a single 2.6 or -2.6V supply. The cell library for the TQ3000 is fully supported on Daisy, Mentor, and Tektronix CAE workstations.

The TQ3000 is available in die form or in a 132-pin multilayer ceramic package. A high-speed evaluation board with a quick connect socket is available for rapid prototyping and system characterization. Nonrecurring engineering cost for the TQ3000 is $80,000 and includes design manuals and workstation software. The vendor delivers five tested and packaged parts plus a high-speed evaluation board. The typical turnaround time from customer input to delivery of the packaged parts is 16 weeks.

TriQuint Semiconductor, Group 700, Box 4935, Beaverton, OR 97075. Phone (503) 629-3535.

Circle No 585

IC supports PS/2 graphics modes and 800×600-pixel, 16-color resolution

The PVGA1 is a single-chip graphics controller for use with IBM’s Video Graphics Array (VGA), which is the standard graphics interface for the Personal System/2. The company also offers two VGA-compatible boards based on the chip.

Because the chip is compatible with the VGA at the register level, you can program the graphics hardware directly instead of programming only through the software-interface portion of the VGA BIOS (basic input/output system). This hardware compatibility confers a greater degree of confidence that a PVGA1-based board will be VGA compatible: In the past, application programs for the PC have bypassed the BIOS and accessed the graphics hardware directly to gain a speed advantage.

Besides supporting the VGA functions, the chip also supports the graphics standards developed for MS-DOS systems: the EGA (enhanced graphics adapter), MDA (monochrome display adapter), CGA (color graphics adapter), and Hercules and AT&T Model 6300 graphics boards. Note, however, that the chip supports the EGA standard only to the BIOS level, not to the register level.

The PVGA1 implements a proprietary mode that offers 16 colors and a resolution of 800×600 pixels. Its monochrome mode provides 1280×1024-pixel resolution. The vendor’s proprietary bus interface for the PVGA1 allows data transfers of 8 bits over the PC bus and 16 bits over the PC/AT bus.

Another mode, Mode 13, specifies a resolution of 320×200 pixels and 256 colors. In your search for higher resolutions, don’t forget that although pixel resolution is the most important factor in 2-D images, when you perceive 3-D images your eye is most sensitive to color resolution.

The PVGA1 chip costs $60 (100) and comes in a 100-pin plastic pin-grid array, plastic leaded chip carrier (PLCC), or plastic flat pack. It comes with a VGA-compatible BIOS.

Paradise Systems Inc, 217 E Grand Ave, South San Francisco, CA 94080. Phone (415) 588-6000.

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EDN December 10, 1987
CIRCLE NO 75
Integrated Circuits

Echo-canceling chip set links ISDN to existing subscriber lines

By using DSP techniques to perform echo cancellation at either end of a telephone line, the PCB2390 ISDN (Integrated Services Digital Network) chip set allows existing 2-wire subscriber wiring to carry ISDN information over distances as great as 8 km. Two of the chip sets, incorporated in a repeater, can span distances as great as 14 km. The chip set's operation complies with the West German PTT's U80 specification for the CCITT U-interface.

Capable of operating at a data rate of 144k bps, the chip set provides full-duplex transmission of two 64k-bps B channels of encoded voice or data and a 16k-bps D channel of signaling and low-speed data—the requirements for basic ISDN access. To achieve this transmission rate, the PCB2390 encodes the bit stream by using a 4B/3T line code (four binary digits compressed into three ternary digits) so that the data-signaling rate is reduced to 108k bps. A 1-kHz maintenance channel, and 11-bit frame words added to the bit stream, results in a line-signaling rate of 120k baud. In addition to its U-point interface, the chip set has an industry-standard IOM (ISDN-oriented modular) interface that connects it to circuits that implement other CCITT interfaces.

At initial power-up, the PCB2390 injects a signal into the telephone line to evaluate the required filter coefficients for its adaptive DSP echo-cancellation and equalization filters. Additional adaptive filters allow you to connect the devices to loops that contain bridged taps. The 2-chip CMOS implementation of the PCB2390 currently costs around $80. A single-chip version is under development.

Philips, Elcoma Div, Box 523, 5600 AM Eindhoven, The Netherlands. Phone (040) 757005. TLX 51573. Circle No 594

Signetics Corp, 811 E Arques Ave, Sunnyvale, CA 94088. Phone (408) 991-4571. Circle No 595

Data-acquisition chip contains 10-bit ADC, S/H circuit, and multiplexer

The LTC1090 data-acquisition system contains a 10-bit A/D converter, an S/H circuit with a 1-µsec acquisition time, and an analog input multiplexer, all on a single piece of silicon packaged in a 20-pin DIP. The secret of its low pin count is the device's full-duplex, serial µP interface. Selected versions of the part feature a total unadjusted error of ±0.5 LSB over the full operating temperature range.

You can configure the analog input multiplexer as eight single-ended inputs, four differential inputs, or a combination of single-ended and differential inputs by means of the chip's 8-bit input data word. This data word selects a multiplexer input channel, picks single-ended or differential operation for the selected analog input, sets the polarity of the input pins for a selected differential-input pair, selects unipolar or bipolar A/D operation, defines the output word width, and determines whether the LSB or the MSB of the conversion will emerge first from the serial output. The internal S/H circuit operates only for single-ended conversions.

You can select either 10-bit unipolar or 9-bit-plus-sign bipolar conversions by means of the chip's serial input data word. A conversion requires 20 µsec. The total unadjusted error for either the unipolar or the bipolar conversion mode over the device's full temperature range is ±0.5 LSB for the LTC1090A and ±2 LSB for the LTC1090. The LTC1090CN, in a plastic package and rated for -40 to +85°C operation, costs $11.95 (100). A similarly packaged LTC1090ACN costs $18.95 (100).

Linear Technology Corp, 1630 McCarthy Blvd, Milpitas, CA, 95035. Phone (408) 942-0810. TLX 172110. Circle No 574
You've seen the advantages offered by the A100 Digital Signal Processor. The single-chip DSP solution that features 32 multiply-accumulators, executes up to 320 MOPS, and easily attaches to microprocessors.

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INMOS Corporation, PO Box 16000, Colorado Springs, Colorado 80935, Tel (303) 630-4000
INMOS Limited, PO Box 424, Bristol BS9 7DD, Tel (0454) 616616.
Integrated Circuits

Low-power precision op amp needs only 600 µA of supply current

The OP-97 is a low-power alternative to the industry-standard OP-07 precision amplifier. Except for its noise specification, the OP-97 maintains the original standards of performance set by the OP-07, but needs only 600 µA of supply current—less than 1/6 that required by the OP-07.

Several of the OP-97’s specs are improved over those of its predecessor. The OP-97’s bias current is 100 pA max at 25 °C, and it remains below 250 pA over the full military temperature range. These characteristics let you use the OP-97 without external offset adjustments in the majority of applications. The device’s 25-µV offset voltage and 0.6-µV/°C drift, combined with its low bias current and improved common-mode rejection (114 dB), practically eliminate the op amp as a contributor to system error.

The OP-97’s guaranteed noise specs (at 10 Hz) are <30 nV/√Hz. At 1 kHz, the noise drops to 22 nV/√Hz max; at 10 kHz, the typical noise level is 17 nV/√Hz.

Suitable for battery-powered equipment, the OP-97 is characterized for use with supply voltages from ±2 to ±20V. Its power-supply-rejection spec is 114 dB. The OP-97 is available in 8-lead, TO-99 metal cans and in ceramic and plastic miniature DIPs. Prices start at $2.50 (100) for an OP-97 in a plastic miniature DIP for use over the industrial temperature range.

Precision Monolithics Inc, 1500 Space Park Dr, Box 58020, Santa Clara, CA 95052. Phone (408) 727-9222. TWX 310-371-9541.

Circle No 591

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CIRCLE NO 34
Score the MS-DOS-Compatible System On a Chip from NEC

Now you can score on your next round of systems designs and parlay your MS-DOS investment. Simply use our CMOS V25™ Whole in One™ — the new 16-bit microcomputer on a chip from NEC.

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FOR REAL-TIME DESIGNERS THAT DEMAND THE MOST, THE CONTROLLER THAT DEMANDS THE LEAST.

Our new 80C196 delivers the highest performance and the highest integration of any 16-bit microcontroller available. While demanding the least power, the least design time, the
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The 12 MHz 80C196 is the latest member of our proven MCS-96 family of embedded controllers. It offers the low-power requirements of CMOS technology while doubling the performance of the 16-bit 8096. Which means that it can perform a 16 x 16 multiply in 2.3 microseconds. That's faster than any other microcontroller.

Yet you still get all the features of the 8096. And more. Resident on the highly-integrated 80C196 are a 16-bit cpu with an 8/16-bit bus (reconfigurable), 256 bytes of RAM, PWM, 10-bit A/D, two 16-bit timer/counters, 40 I/O pins, full duplex serial port, and a high-speed I/O subsystem. And speaking of getting more features in less space, we’re working on an EPROM version of the 80C196 for an even easier design path (available Q2 1988).

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So you see, there's really no easier or more powerful answer to embedded real-time control than Intel's 80C196. For complete technical information, call toll-free (800) 548-4725 and ask for Literature Department W398.

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RF Devices has the talent and the experience it takes. We are RF amplifier performance artists. With our palette of products and capabilities, we can meet your needs – from RF and microwave power transistors and hi-rel hybrids to complete UHF high-power modules and systems – from 100KHz to 4GHz, from under 1W to 1KW.

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Let us paint you a masterpiece.
FLASH A/D CONVERTER
The HS1068 20M-sample/sec, flash A/D converter includes all necessary analog-support circuitry in the package: a wideband input amplifier, a precision 1.2V voltage reference, and a 3-state output register. The 8-bit device comes in a 24-pin DIP that occupies less space than the original 28-pin-DIP TDC1048. You pin-program the converter to accept an input range of either 0 to 1V or ±0.5 V, and you can select straight binary, inverted binary, 2's complement, or inverted 2's complement output code. Separate digital outputs flag input overranges at zero and full scale.

Power supplies are 5V and -5.2V, drawing 101 and 207 mA, respectively. Power dissipation is 1.67W. Other key specs are ±½-LSB integral and differential linearity errors, 60-psec aperture time, 2% differential gain, and 1° max differential phase. HS1068C, $295; HS1068B, $375 (100). Delivery, eight to 12 weeks ARO.

HYBRID SYSTEMS CORP, 22 Linnell Circle, Suburban Industrial Park, Billerica, MA 01821. Phone (617) 667-8700. TWX 710-347-1575. Circle No 351

CMOS D/A CONVERTER
The PM-7548 CMOS D/A converter combines 12-bit resolution with an 8-bit data-bus interface that accepts left- or right-justified data. The digital inputs are buffered; you can update the converter immediately or retain data in the input latches for later use. In addition, a data-override function lets you load the converter with all zeros or all ones without altering data in the input latches. It features ± ½-LSB integral and differential linearity error over temperature, ±1-LSB gain error, and 0.03-LSB max zero-scale error.

Compared with the original industry-standard equivalent, the converter offers a 30% reduction in glitch energy, a 30% reduction of input capacitance, and a 20-dB improvement in PSR. The internal voltage regulator ensures TTL compatibility while operating with supply voltages from 5 to 15V. The device comes in two electrical grades for each of the commercial, industrial, and military temperature ranges. From $7.58 to $30.92 (100). Delivery, eight to 10 weeks ARO for the commercial grade; the industrial and military grades are available from stock.

Precision Monolithics Inc, Box 58020, Santa Clara, CA 95052. Phone (408) 727-9222. TWX 310-371-9541. Circle No 352

CMOS EPROM
The 35-nsec WS57C49B is the world's fastest 8k×8-bit CMOS EPROM, according to the manufacturer. As a pin-compatible, programmable alternative to bipolar PROMs, the device consumes a fraction (400 mW) of the power bipolar PROMs use. Available in a 35-nsec commercial version or a 45-nsec mil-
for the requirements of BS9450/CECC63000. To evaluate the LCC versions, you can obtain a Eurocard pc board with an LCC socket from the company. From $103 (100). Delivery, stock to eight weeks ARO.  

**Burrr-Brown Corp, Box 11400, Tucson, AZ 85734. Phone (602) 746-1111. TLX 666491.**  

Circle No 354

**ANALOG SWITCH**  
The LR404 is a 4 x 1 crosspoint analog switch that comes in a 14-pin plastic DIP. The device is suitable for use in video signal-switching matrices; using multiple devices, you can switch many outputs to a common output. The chip provides differential phase and gain of 0.05° and 0.05%, respectively, at 3.58 MHz. Crosstalk amounts to <-77 dB at 10 MHz. $4 (moderate quantities).  

**Linear Technology Inc, Box 489, Station A, Burlington, Ontario, Canada L7R 3Y3. Phone (416) 632-2996. TLX 0618525.**  

Circle No 355

**A/D CONVERTER**  
The TSC827 is a CMOS integrating-type A/D converter that includes on-chip drivers for a 101-segment bar-graph LCD. The internal resolution is 1000 counts (±0.1%), and the result of each conversion is available as an additional serial digital output for use in driving numeric displays. The converter accepts positive inputs with full scale ranging from 0.1 to 2V, and the differential signal and reference inputs simplify the interface to a variety of signal sources. You can use switches or software programming to specify two setpoints; separate annunciators then flag underrange and overrange inputs. The typical conversion rate is 7.5 samples/sec. The device consumes 15 mW and operates from a 9V battery. It comes in a 68-pin PLCC or a 60-pin flatpack. From $10.80 (100).  

**Teledyne Semiconductor, Box 7267, Mountain View, CA 94039. Phone (415) 968-9241. TWX 910-379-6494.**  

Circle No 356

**CHIP SET**  
The FE3400 chip set provides PC/AT peripheral-control and CPU functions with only four ICs. Implemented in 2-µm HCMOS technology, the four chips replace eight support ICs, including the 8284 and 82284 clock generators, the 82288 bus controller, two 8237 DMA controllers, two 8259 interrupt controllers, an 8254 timer, and numerous SSI and MSI logic chips. Using the chip set reduces the area of a typical PC/AT mother board from 142 to 21.5 in² and reduces the typical chip count from 95 to 19. In addition, the chip set reduces the power requirement by 50% (16W). The FE3400 chips operate under the company's copyrighted BIOS to ensure IBM PC/AT compatibility and are software-programmable for 6-, 8-, 10-, or 12-MHz operation. Starter kits and design-support tools are available. $118 (100). Delivery, 10 weeks ARO.  

**Faraday Electronics, 749 N Mary Ave, Sunnyvale, CA 94086. Phone (408) 749-1900. TLX 706738.**  

Circle No 357

**QUAD OP AMP**  
Suitable for use in compact-disk players and other digital-audio systems, the LM837 quad op amp generates less than 0.0015% distortion over a 140-dB dynamic range. The output stage can drive a 600Ω load. The standard pinout (in a 14-pin DIP) lets you upgrade an existing system with few or no design changes. The chip is also available in a molded small-outline package. The monolithic, unity-gain-stable device specs an 8-V/µsec slew rate, a 140-kHz power bandwidth, and a 15-MHz gain-bandwidth product. The input noise voltage is 0.5 µV rms. $1.25 (25,000).  

**National Semiconductor Corp, Box 58090, Santa Clara, CA 95052. Phone (408) 721-5856. TLX 346353.**  

Circle No 358

Text continued on pg 300
A LOT OF PEOPLE THINK WE ONLY HANDLE GIANT PROJECTS.

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The Silicon Integrator™ module handles the design and simulation of complex ASICs ranging from a few hundred to 100,000 usable gates. Its Silicon Compilers allow you to automatically develop logic and memory. Your compiled designs, of course, all have complete simulation and test vectors.

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The EG&G Wakefield 840 Series (patent pending) Pin Fin heat sinks are ideally suited for natural convection, serial-flow forced convection, and impingement cooling of critical components. The 840 Series utilizes a pedestal base for optimal heat transfer from the heat source — the die itself. The pedestal base will minimize thermal fatigue and cracking of the ceramic substrate with application of an appropriate adhesive to the substrate at the point of contact.

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EDN December 10, 1987 CIRCLE NO 176 299
Integrated Circuits

LSB (at 14 bits) over 0 to 70°C. The reference-voltage temperature coefficient is ±5 ppm/°C. Supply voltages are ±5 and ±15V; the maximum power dissipation is 8.4W. The converter is packaged in a 6x4x0.375-in. black enameled-steel module. $999. Delivery, stock to eight weeks.


Circle No 360

CMOS STATIC RAMs
The 35-nsec M5M5257 (256k×1 bit) and M5M5258 (64k×4 bits) are the fastest 256k-bit static RAMs available, according to the manufacturer. Combining silicon-gate CMOS peripheral logic and a high-density NMOS memory array, the devices are suitable for use in cache and main-memory applications. Both chips are also available in 45- and 55-nsec versions. They come in 300-mil, 24-pin plastic DIPs or plastic SOJ (small-outline J) packages for surface-mount applications. 35-nsec M5M5257P in DIP, $142; M5M5258P, $152 (100).

Mitsubishi Electronics America Inc, 1050 E Arques Ave, Sunnyvale, CA 94086. Phone (408) 730-5900.

Circle No 359

MOTOR DRIVER
Housed in an 18-pin plastic DIP, the L6202 motor-driver IC can deliver 70W of power. It has a full H-bridge output and interfaces directly to TTL-level control logic. Operating at a switching frequency of 100 kHz and a junction temperature of 120°C, the driver can deliver continuous rms currents as high as 1.5A at motor supply voltages as high as 54V. The peak nonrepetitive output current limit is 5A. Within this limit, the available output current is limited only by power dissipation.

Color by

CalComp's new graphics subsystem pumps new excitement into Micro Vax II, turning up to four terminals into high performance, high resolution graphic workstations. Brooktree® RAMDACs pump out the color, enabling CalComp to do it all on a single board.
Six pins on the 18-pin DIP connect to copper traces on the PC board that function as a heat sink. A similar device, the L6202, can deliver as much as 4A rms to provide 250W of motor power. The L6202, $5 (100).

SGS Microelettronica SpA, Via C Olivetti 2, 20041 Agrate Brienza, Italy. Phone (039) 65551. TLX 330131.

Circle No 732
SGS Semiconductor Corp, 1000 E Bell Rd, Phoenix, AZ 85022. Phone (602) 867-6100. TLX 249976.

Circle No 361

TELEPHONE IC

The MA534 CMOS loop disconnect dialer IC features an integrated speech circuit that complies fully with BS-6305 and -6317 requirements for Class A complex matched telephones. The IC also features a 21-digit last-number-redial memory, a selectable make/break ratio of 2:1 or 3:2, and a selectable interdigit pause of 800 or 400 msec. The dialer can perform earth-loop and timed-break recall, and no dial output is generated if more than one dial-pad key is pressed simultaneously.

All timing is derived from an external, low-cost, 560-kHz ceramic resonator. To compensate for the lower attenuation characteristics of short lines, the device automatically adjusts the gain of its speech circuits so that the volume of received speech is independent of line length. The speech circuits are suitable for dynamic or electret transducers. The MA534 is housed in a 16-pin DIP, and you can power it directly from the telephone line. £3 (100).

Marconi Electronic Devices Ltd, Doddington Rd, Lincoln LN6 3LF, UK. Phone (0522) 688121. TLX 56380.

Circle No 362
Marconi Electronic Devices Inc, 45 Davids Dr, Hauppauge, NY 11788. Phone (516) 231-7710. TLX 275801.

Circle No 363

PS/2 CHIP SET

The 82C100 system-control chip supports 8086/V20 and 8086/V30 microprocessors at speeds to 10 MHz and is targeted for high-performance IBM PS/2 Model 30s, PC/XTs, and compatible computers. It includes a memory controller that supports the Lotus-Intel-Microsoft expanded memory specification and offers power-management features for laptop systems to help reduce battery drain.

The 82C101 chip supports 8088 and V20 8-bit processors. It’s aimed at lower-cost PC/XT-compatible computers and terminals and does not include power-management features. The three companion chips are the 82C606 ChipsPak and the 82C605 ChipsPort—both multifunc-
**New Instruments**

**µP-based Programmable E/I de Calibrator**

**Model 520/A**

The Model 520/A is micro-processor based and is compatible with IEEE-488, (GP-IB).

The height is only 3 1/2 inches, features current mode outputs from 100 nA to 110 milliamperes (mA), in 2 ranges, with extraordinary compliance of 100 Vdc. Even with this power, ideal for transducer instrument testing (4-20 and 10-50 mA), the accuracy is ± 0.00%..

All ranges and both modes resolve to 1 ppm.

**System 408**

1 to 8 AC Voltage outputs independently and remotely controlled, variable and simultaneous in a single 5 1/4" high chassis.

A phase angle of 0° and 180° is also in a single 5 1/4" high chassis.

**Availability:** 60 days.

**Price:** $2,895. 1000V option $550.

**GSA contract GSOOF-86293**

**Engineering Contact:** Bob Ross

**Tel:** (617) 268-9696 **CIRCLE NO 110**

**Integrated Circuits**

**DUAL-PORT RAM**

The MK4511 512×9-bit dual-port RAM features independent interrupt outputs for each port, you can software control via two interrupt registers. Each port, which operates with multiplexed address and data signals, can simultaneously access RAM locations. The RAM is available with access times of 120, 150, or 200 nsec. The MK4511 is supplied in a 28-pin DIP or 28-pin plastic leaded chip carrier. From $9.56 to $12.65 (1000), depending on access-time rating.

**Thomas Semiconducteurs, 45 Ave de l'Europe, 78140 Velizy, France. Phone (1) 39469719. TLX 204780.**

**CIRCLE NO 364**

**GATE ARRAYS**

The four devices in the BC series of BiCMOS gate arrays offer densities from 430 to 2160 3-input gates. Their propagation delay is 550 psec, and the typical power dissipation is 0.25 mW/gate. The input and output buffers' propagation-delay times are 3.0 and 5.5 nsec, respectively. The BC family offers either 10-mA or 24-mA TTL-compatible output drive; the output buffer's power dissipation is 4 mW at 10 mA and 8 mW at 24 mA. BC400 in a 44-pin PLCC, from $7.85 (1000). Delivery, eight weeks ARO for initial silicon samples; 14 weeks ARO for production quantities.

**Fujitsu Microelectronics Inc, 3320 Scott Blvd, Santa Clara, CA 95054. Phone (408) 727-1700. TWX 910-338-0190.**

**Circle No 367**

**MOSFET DRIVERS**

The SG1626 and SG3626 are dual, inverting drivers suitable for driving power MOSFETs and for applications that require digital signals to drive large capacitive loads. The devices' 3A-peak current capability can drive 2500-pF loads in less than 40 nsec. The drivers use high-voltage Schottky logic that converts TTL signals to 18V outputs without driving the outputs deeply into saturation. The package options include 8-pin plastic and ceramic DIPs and 16-pin plastic leaded chip carrier. From $9.56 to $12.65 (1000), depending on access-time rating.

**Thomas Components-Mostek Corp, 1310 Electronics Dr, Carrollton, TX 75006. Phone (214) 466-6000. TLX 730643.**

**Circle No 365**

**CLOCK IC**

The CDP68HC68Ti is a CMOS real-time clock for µP systems. The monolithic chip indicates seconds, minutes, hours, day of the week, and date. It also lets µC systems implement timer, power up/down, and power-sensing functions. The IC communicates with the µC over the SPI (Serial Peripheral Interface) bus of the 68C05 or 68HC11, or the four I/O/porte lines of µCs such as the 1804A, 80C51, and the 65C02. The chip also includes a power-monit...
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In which three goes into
one just once.

1. Low power dual redundant transceivers

2. Dual decoder, encoder and protocol processor for Remote Terminal, Bus Controller and Bus Monitor

3. Dual port RAM with 8K words of memory and full memory management

You are looking at the most powerful, flexible and unique MIL-STD-1553B interface currently available. Bar none. Now, in one 2 x 3.1” package, this new ARX 2427 Universal Bus Interface Unit (UBIU) combines all the functions it takes three competitive hybrids to perform. Fact is, of all hybrids today, only the ARX 2427 reduces interface and hardware time to absolute zero.

The powerful ARX 2427 contains a dual port RAM that's double-sided and double-buffered to eliminate contention problems and wait states. Data can be mapped into RAM blocks by subaddress or alternately stacked. Memory is accessed for read and write using address lines and a select line, treated as subsystem memory. The host system is therefore freed from critical timed response to Bus traffic and communication overhead is kept to a bare minimum. The unit also includes extensive error checking, which eliminates handling bad data. Fault monitoring plus many other features make the ARX 2427 clearly the most useful of 1553 interfaces.

So forget complex interconnect schemes. Forget special glue logic circuitry design for subsystem compatibility. Forget using up valuable PC board real estate. The ARX 2427 is the UBIU to remember when you want to solve your 1553 problems—once—and for all.

For additional information call toll-free: 1-800-THE-1553 or TWX 510-224-6417. Or write Aeroflex Laboratories Inc., Microelectronics Division, 35 South Service Road, Plainview, NY 11803.
Integrated Circuits

tor function and a 50-Hz, 60-Hz, or crystal-clock reference.

The chip's 32 bytes of internal static RAM provide parameter storage, computer handshaking, and an interrupt structure. Any one of three internal sources can provide an interrupt: the alarm circuit (seconds, minutes, hours); one of 15 periodic signals (subsecond to daily events); or power failure. The timer functions include a 12- or 24-hour format with an AM/PM indicator. The calendar counters provide day of the week and day/month/year with automatic leap year. The device operates on 3 to 6V; at 2.2V, it can maintain timekeeping functions while drawing 10 µA of supply current. The package options are a 16-lead plastic or ceramic DIP or a 20-lead SO (small-outline) package.

16-byte FIFO memory; single-ended, 48-mA bus transceivers; and a sustained transfer rate of 3M bytes/sec (asynchronous) or 4.8M bytes/sec (synchronous). It comes in a 68-pin PLCC. $25 (1000).

**Emulex Corp, Box 6725, Costa Mesa, CA 92628. Phone (800) 368-5393; in CA, (714) 662-5600.**

Circle No 368

**INTERFACE ADAPTER**

The monolithic CMOS R65NC22 provides 68000-based systems with two 16-bit counters, one serial bidirectional port, and two 8-bit bidirectional parallel I/O ports. Other features include 5V operation, TTL-compatible control lines, an expanded handshake capability that allows positive control of data transfers between the processor and peripheral devices, and latched input and output registers on both I/O ports. Commercial- and industrial-temperature versions are available in a 40-pin plastic or ceramic DIP or a 44-pin PLCC. Including a 5-year warranty, $5.20 (1000).

**Rockwell International Corp, Box C, Newport Beach, CA 92658. Phone (714) 833-4700.**

Circle No 369

**FIFO MEMORIES**

The SSL7401-SSL7404 family comprises four BiCMOS FIFO memories that are suitable for use in high-speed communications and controller applications, as buffers between digital systems with widely differing bit rates, and as A/D-converter buffers. All parts offer a 50-MHz throughput rate, a 15-nsec data-access time, a 2-nsec data-set-up time, and a 1-nsec data-hold time. Each device is expandable in width and depth and conforms to industry-standard pin configurations: SSL7401, 64×4 bits in a 16-pin DIP; SSL7402, 64×5 bits in an 18-pin DIP; SSL7403, 64×4 bits with output enable in a 16-pin DIP; and SSL7404, 64×5 bits with output enable in an 18-pin DIP. Products come graded for 10-, 15-, 25-, 40-, or 50-MHz operation. 50-MHz SSL7401, $68.18 (100).

**Saratoga Semiconductor, 10500 Ridgeview Ct, Cupertino, CA 95014. Phone (408) 864-0500.**

Circle No 370

**QUAD POWER DRIVER**

Combining NAND logic gates and high-current bipolar outputs, the UDN-2540B power and relay driver provides an interface between low-level signal-processing circuits and power loads to 350W. In the On state, each of the four independent outputs can sink as much as 1.5A. In the Off state, the drivers can withstand at least 60V. Internal clamp diodes and a minimum 35V sustaining voltage allow the use of these drivers with many inductive loads. Applications include relay and solenoid drivers and dc stepping-motor drivers. $0.97 (1000). Delivery, eight to 12 weeks ARO.

**Sprague Electric Co, Box 9102, Mansfield, MA 02048. Phone (617) 853-5000.**

Circle No 373

**FM RECEIVER**

A narrowband-FM, dual-conversion low-voltage (2V) receiver, the MC3362 IC incorporates all essential VHF-receiver functions from the antenna input to the audio preamp output. The chip handles RF inputs as high as 180 MHz, or over 400 MHz if you provide the first local-oscillator signal externally. It consumes between 6 and 35 mW and features dual-conversion circuitry, a

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**INQUIRY DIRECT**

**SCSI PROCESSOR**

The ESP chip is a VLSI device that implements the communications protocol of the SCSI bus. As a host adapter embedded on a CPU motherboard or as a controller embedded with drive electronics, the chip replaces existing discrete devices, external drivers, and any earlier SCSI-interface chip. It features a dual-ranked command and transfer counter; bus sequences implemented without µP intervention; a

---

**FM RECEIVER**

A narrowband-FM, dual-conversion low-voltage (2V) receiver, the MC3362 IC incorporates all essential VHF-receiver functions from the antenna input to the audio preamp output. The chip handles RF inputs as high as 180 MHz, or over 400 MHz if you provide the first local-oscillator signal externally. It consumes between 6 and 35 mW and features dual-conversion circuitry, a

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**TEXT CONTINUED ON PG 309**

EDN December 10, 1987
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Still going strong after 10,000 hours. Philips brings you the world’s first infrared LEDs based on a single heterojunction gallium aluminum arsenide technology. A new technology that allows them to operate at 80% of their initial intensity after 10,000 hours of continuous operation. When you get that kind of longevity in your remote controls, why settle for anything less?

New technological advantages: Faster response (50ns). Complementary technology for use with existing circuits. Ability to operate at low and high currents makes them well suited to carrier frequencies up to 1MHz. 830nm emission wavelength for standard photodiodes and transistors, 740nm for integrated photoreceivers. Available in 3mm, 5mm and flat pack packages. In stock now.

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EDN December 10, 1987
Our new X.25 Link Level Controller opens new lines of communications.

Announcing the MK5025 X.25 Link Level Controller, the CMOS device that provides complete Link Level data communications control in a single-chip. Our monolithic design saves you months of programming time and valuable board space.

Fluent in X.25 LAPB, ISDN LAPD, X.32, and X.75, the MK5025 also features a transparent mode making it compatible with other HDLC protocols. And it can be used with virtually all of the popular 8 and 16-bit microprocessors.

At up to a 7 Mbs transfer data rate, it's one of the fastest controllers available, performing in systems clocked up to 10MHz. Internal DMA and buffer control of independent receive and transmit memory rings provide high-speed data packet transfers. And for quicker diagnostics in complicated systems, 25% of the MK5025 ROM code is dedicated to a BIST (built-in self test) feature.

Available in a 48-pin DIP, the MK5025 shares a similar pin-out with our Ethernet controller, making future design for both LAN and wide area network implementations easy. In addition, a 52 PLCC package is planned.

So if you have a data communications control project you'd like to simplify—from central office and packet switching to PBX and point-to-point communications—call us at 214/466-6316. Or write SGS-Thomson, 1310 Electronics Drive, Carrollton, Texas 75006, MS2205.

Dual 64 byte FIFOs for XMIT and RCV make system interface much easier. And FIFO watermarks make for efficient DMA and host processor bus utilization.

DMA and Buffer Management takes the load off the host CPU and software engineering staff.

On-chip ROM is configured for X.25 LAPB, ISDN LAPD, X.32 and X.75 operation.

Microcontroller allows transparent mode of operation with or without address filtering.

Three loop back features simplify system troubleshooting.
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CIRCLE NO 165

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**FILTER**

You can configure the XR-1020 as one of 10 filters that can characterize telephone lines and other telecommunications links. It conforms to the IEEE standard 743/Bell Systems technical reference 41009 and the CCITT (International Consultantative Committee for Telephony and Telegraphy) Series 0 recommendations. The device requires only external 3.579-MHz-crystal and digital control inputs. The repertoire of filter functions includes a C-message and a C-notch filter, a psophometric filter, and an 825-Hz notch filter. The device also functions as a program-weighting filter, 3- and 15-kHz flat filters, a 1-kHz bandpass filter, the lowpass portion of a 50-kbps filter, and a peak-to-average ratio filter. It has a power-down mode for battery-powered operations and comes in a 28-pin ceramic DIP. $63 (100).

*Motorola Inc, Box 52073, Phoenix AZ 85072. Phone (602) 897-3842.*

**Circle No 371**

**CMOS EEPROMs**

The 38C16 (2k×8-bit) and 38C32 (4k×8-bit) CMOS electrically erasable PROMs (EEPROMs) offer 35-nsec access times. This speed matches that of traditional bipolar-type PROMs. The EEPROMs offer low power consumption (350 mW) and in-circuit programmability. The key features include a guaranteed 10k erase/write cycles/byte (1M cycles typical), a 50-msec chip erase, 5V operation, and power up/down protection circuitry. In addition, the chips have data-bar polling, a 20-nsec chip-enable output time, a JEDEC-approved pinout, and a latched timer that allows an automatic byte-erase before write. The 38C16 comes in a 24-pin ceramic DIP, and the 38C32 is available in a 28-pin ceramic DIP. Both models are also available in a 32-pin chip carrier. 38C16, $27; 38C32, $38 (100).

*Seeq Technology Inc, 1849 Fortune Dr, San Jose, CA 95131. Phone (408) 432-9550.*

**Circle No 372**

**SUPPLY MONITOR**

The S2862 power-supply monitor can detect positive or negative transients that appear on any one of the three power-supply voltages it monitors simultaneously. The device contains three window comparators with external resistor-programmable switch points, a 2.5V bandgap reference, a hold comparator, and four open-collector output drivers. All four drivers turn on (low) when the chip detects a fault on any of the three supplies, and they remain low for an interval determined by an external hold capacitor. You can set thresholds within 1.25% of desired values. Available in a 16-pin DIP or SO (small-outline) package, the device operates with supply voltages in the range from 4.3 to 16V. $3.20 (1000).

*Siltronics Ltd, 436 Hazeldean*
**DSP EEPROM**
The DSP320EE12 is the industry's first monolithic digital-signal-processing µP that includes EEPROM, according to the manufacturer. Operating at 20.5 MHz, the CMOS device is pin compatible with the standard 32010, and it runs software written for that µP. The EEPROM's ability to accept and store new commands enables the chip to fine-tune its performance without intervention by an operator. Applications for it include intelligent FIR filters, adaptive LANs, equipment diagnostics, and instrument self-calibration. The device features an 8- and a 16-bit data interface, special operating modes for improved factory testing, the capability for reprogramming on a standard PROM programmer, and an inhibit circuit that prevents inadvertent data writes during power-up or supply glitches. Security mechanisms prevent unauthorized internal or external access to the EEPROM code. $100 (100).

*General Instrument Microelectronics, 2355 W Chandler Blvd, Chandler, AZ 85226. Phone (602) 963-7373.*

**VIDEO BUFFER**
The hybrid LH4002 is a unity-gain buffer amplifier that can drive 50Ω and 75Ω loads at frequencies greater than 200 MHz. The device is suitable for video distribution, for impedance transformation, and for increasing the output-current capability of conventional op amps. Intended for operation with ±5V supplies, the buffer provides a 1000V/µsec min slew rate, 2° phase linearity (from 1 to 20 MHz), and less than 0.1% distortion. The LH4002 is pin compatible with the industry-standard LH0002, and it comes in a 10-pin plastic DIP or an 8-pin TO-5 metal can. The plastic DIP has better heat transfer than the metal can, providing a thermal impedance of 120°C/W (vs 125°C/W for the metal can). MIL-processed versions are available. From $9.50 (100).

*National Semiconductor Corp, Box 58090, Santa Clara, CA 95052. Phone (408) 721-5856. TLX 346353.*

**SCSI CONTROLLER**
You can directly substitute the L5380 asynchronous SCSI-controller chip for existing devices without modifying your circuit board. Substituting the CMOS part gives you 2.5 times the speed (4M bytes/sec) and one tenth the power dissipation (75 mW typ) of the NMOS device it replaces. The L5380 implements the asynchronous SCSI interface as defined by the ANSI X3T9.2 committee in the X3.131-1986 document.

Further, the part works in both the initiator and the target modes, so you can use it in both the computer and the disk drive. It comes in a 40-pin plastic DIP or a 44-pin PLCC and is graded for 2- or 4-MHz operation. 2-MHz version in a DIP, $8.53; 4-MHz version in a PLCC, $18.71 (100).

*Logic Devices Inc, 628 E Evelyn Ave, Sunnyvale, CA 94086. Phone (408) 720-8630.*

**OP AMP**
The AD9610 is a hybrid transimpedance op amp. Using current feedback instead of voltage feedback, the amplifier provides bandwidth that is relatively independent of closed-loop gain: 100 MHz at unity gain, 95 MHz at a gain of -10, and 75 MHz at a gain of -20. In addition, different gains have little effect on the op amp's 3.5-nsec rise and fall times, its 18-nsec settling time (to within ±0.1%), and its 3500V/µsec slew rate. Laser trimming reduces the input offset voltage to ±0.3 mV; the $V_{os}$ drift is 4 µV/°C. The equivalent input noise over the frequency range from 5 to 150 MHz is 0.7 nV/√Hz typ and 23 pA/√Hz typ.

The amplifier has internal frequency compensation and an internal 1.5-kΩ feedback resistor; you add one resistor to set the closed-loop gain. The AD9610 comes in a 12-pin TO-8 metal can, operates with ±15V supplies, and dissipates 630 mW typ. Industrial-tempera-
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**SMPS IC**

The TDA-4918 and -4919 are switch-mode power-supply control ICs for push-pull and single-ended driver outputs, respectively. Their output stages are optimized for driving MOSFET power transistors, sinking a current of 1A to turn the MOSFET off, and sourcing 300 mA to turn it on. This asymmetrical drive current helps to match the turn-off and turn-on times of the MOSFET, so that the MOSFET switching is symmetrical, even at clock frequencies as high as 200 kHz.

The ICs have an integral frequency generator that operates to frequencies as high as 300 kHz. In addition, the ICs have three on-chip comparators that monitor the supply's output for overvoltage and undervoltage conditions and provide dynamic current limiting. The ICs also provide soft-start facilities. The maximum supply current to the devices in standby mode is 2 mA. The TDA4918 comes in an 18-pin DIP; the TDA4919 is housed in an SO-20L surface-mount package. $2.50 (1000).

Siemens AG, Zentralstelle für Information, Postfach 103, 8000 Munich 1, West Germany. Phone
MICROCONTROLLER

In addition to the 80C51’s usual on-chip functions, the PCB83C552 CMOS microcontroller includes an 8-channel analog multiplexer, a 10-bit, 50-μsec A/D converter, two PWM outputs, additional parallel I/O ports, an additional timer/counter, and an FC-bus interface. It retains the 80C51’s internal architecture and instruction set.

In total, the microcontroller has six 8-bit parallel I/O ports, several of which function either as conventional I/O ports or as control inputs and outputs for the chip’s additional functions. The two PWM outputs have dedicated output pins, and you can control a repetition frequency, common to both outputs, in the range of 92 Hz to 23.5 kHz for a clock frequency of 12 MHz. You can then define the mark/space ratio for each individual output in the 0 to 1 range, with 8-bit resolution. Only simple external filtering is required to derive analog outputs from the PWM outputs. You can arrange for the on-chip timer to automatically set, reset, or toggle certain I/O bits, and to generate interrupts.

The 83C552 has a 15-source, 2-level interrupt structure and incorporates the 80C51 instruction set; a watchdog timer detects program crashes. The microcontroller has an 8k-byte on-chip program ROM and a 256-byte on-chip RAM, both of which are externally expandable to
Integrated Circuits

64k bytes. The 83C552 is packaged in a 68-pin plastic leaded-chip carrier. A ROMless version is also available. Approximately DM 26 (10,000).

**MTC-2083**

The MTC-2083 telephone IC incorporates a DTMF/pulse repertory dialer that supports on-hook dialing, and speech circuits that provide 4-wire/2-wire conversion and background-noise reduction. It also contains line impedance matching and load/gain regulation circuitry so that it provides all the functions necessary to interface telephone sets with PSTN or PABX networks. The speech circuit incorporates an additional receive amplifier that you can use either to drive a loudspeaker or to increase the receiver gain in phones made for people who are hard of hearing.

For the PABX or central-office end of the line, the MTC-2083 provides a single-chip solution to many of the Borsht functions of the subscriber-line interface. These functions include a high- or low-ohmic-value battery feed, overpower, and 2-wire/4-wire conversion circuitry, and supervisory functions that monitor hook-switch status, ring-trip, and ground-wire conditions. The MTC-6042 also has a driver for re-

**PHONE ICs**

The MTC-2083 telephone IC incorporates a DTMF/pulse repertory dialer that supports on-hook dialing, and speech circuits that provide 4-wire/2-wire conversion and background-noise reduction. It also contains line impedance matching and load/gain regulation circuitry so that it provides all the functions necessary to interface telephone sets with PSTN or PABX networks. The speech circuit incorporates an additional receive amplifier that you can use either to drive a loudspeaker or to increase the receiver gain in phones made for people who are hard of hearing.

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**D/A CONVERTER**

The ZN559A is a µP-compatible 8-bit D/A converter with an on-chip 2.5V bandgap reference. After a full-scale output change, the output settles to ±1 LSB typically within 1.25 μsec. The typical settling time for a 1-LSB output change is 800 nsec. The maximum linearity error is ±1 LSB, and maximum differential nonlinearity is ±¼ LSB, with monotonicity guaranteed over the full operating temperature range. The maximum zero offset is 6 mV, and the full-scale output is typically 2.55V with a full-scale output temperature coefficient of 2 ppm/°C.

On-chip latches with TTL/CMOS-compatible inputs allow you to load 8-bit parallel data into the device under the control of a latch-enable input. The ZN559A operates from a single 5V supply and typically consumes 20 mA of supply current. It's available in a 16-pin DIP that operates over the commercial or military temperature range, or you can order it in an SO-16 surface-mount package that operates over the commercial temperature range. $2.98 (100) for commercial-temperature-range devices.

**GATE ARRAYS**

The MAF Series gate arrays employ a 1.2-µm, silicon-gate CMOS technology to achieve typical gate delays of 1 nsec—making the devices suitable as low-power replacements for bipolar PLDs. Gate complexities range from 250 to 1200 gates. Typical power dissipation for the 1000-gate array, operating from a single 5V supply at a clock speed of 10 MHz, is around 250 mW.

Because they are architecturally the same as the company's MA Series gate arrays, you can use the same design tools and libraries that are supplied for the MA Series. Software that allows you to develop
DRAMATIC!

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CIRCLE NO 163
ICs

designs on a range of computers and workstations, including the IBM PC, Daisy workstations, or VAX computers, is available.

The package options include DIP and surface-mount packages, and pin-grid arrays. Packages can have as few as eight or as many as 68 pins. 40-pin plastic DIP, from $2.30 to $4.30 (100), depending on gate complexity.

Matra-Harris Semiconducteurs, Centre de Guyancourt, 38 Blvd Paul Cezanne, BP 309, 78054 Saint-Quentin-Yvelines Cedex, France. Phone (1) 30607000. TLX 697317.

Circle No 398

HIGH-SIDE DRIVER

Targeted at automotive applications, the L9801 high-side driver suits 12V/6A, inductive or resistive load-switching applications where one side of the load is connected to ground. It is manufactured with the company’s Multipower-BCD process. The chip incorporates a DMOS power transistor having an $R_{on}$ of 0.08Ω, and it includes on-chip control, diagnostic, and protection circuitry.

The driver is suitable for lamp switching because it limits the inrush current to 25A, using a linear technique, which does not generate EMI. It has a TTL/CMOS-compatible control input and an open-drain diagnostic output, which is activated when output short-circuit, open-circuit, or overvoltage conditions occur, or when the device goes into thermal shutdown. The L9801 is housed in a 5-lead Pentawatt package with the tab connected to the ground terminal. Approximate-
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EDN News for news of products, technology, and careers.
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At the transmission end of the link, the ZN1444E generates a synchronizing word and injects it into the PCM data highway during time slot 0 of alternate transmission frames. At the receiving end of the link, the ZN1445E detects the frame synchronization word and synchronizes the receiver. It also flags synchronization errors. The ZN1446E operates at either end of the data link, transmitting or receiving signaling information during each frame’s time slot 16. It accepts information in either binary or AMI format.

All the devices operate from a single 5V supply, and all their relevant inputs and outputs are TTL compatible. They are available in either ceramic or plastic 16-pin DIPs and are pin and function compatible with corresponding MJ1440 Series devices. ZN1440E, $6.20; ZN1444E, $10.18; ZN1445E, $6.20; ZN1446E, $7.38 (1000).

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ZTO thyristors are gate-assisted turn-off devices that require only small commutation components and simple gate-drive circuitry. The advantages over GTO (gate turn-off) thyristors include a maximum controllable current approximately 10 times greater than that of a similarly-sized GTO, and no minimum on-time or off-time requirement. In addition, because the anode current falls to zero before the anode voltage starts to increase, turn-off switching losses are small. As a result, you can use ZTO devices at higher frequencies than GTOs. From $200 to $300 (1000).

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EDN December 10, 1987
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EDN December 10, 1987 CIRCLE NO 160
It's time you met our highly flexible LT1054 voltage converter. The bipolar LT1054 uses switched-capacitor circuitry for power conversion and requires no inductors. It has several features not previously available in voltage converters.

Power conversion functions include voltage inversion, voltage doubling or negative voltage doubling. The LT1054 can be used as a simple voltage changer or with feedback to obtain a regulated output. Only two resistors are required to set the output voltage.

The LT1054 provides roughly ten times as much output current as previous voltage converters. When used as a voltage inverter, the LT1054 can supply up to 100 mA of output current with a voltage loss of only 1.1V, and it can do this over its entire input voltage range of 3.5 to 15V. Quiescent current ($I_q = 0\text{mA}$) is only 2.5mA. In addition, the LT1054 can be shut down, lowering quiescent current under 100$\mu\text{A}$, for battery powered applications.

The LT1054 is ideal for use in a wide variety of applications where a supply voltage is needed that is either higher, lower, or of a different polarity than what is available.

LT1054 is pin-compatible with switched capacitor voltage converters such as LTC1044 and ICL7660, and it comes in 8-pin plastic or ceramic DIP configurations. Military versions are also available.

Pricing begins at $2.95 for the 8-pin plastic LT1054CN8, and $3.90 for the LT1054CJ8 ceramic version, in quantities of 100 up.

For technical details on the LT1054 and a free T-shirt (featured above), just tell us your shirt size and input voltage. We'll see you get the shirt (first 5000 responses) and a datasheet. For further details, contact Linear Technology Corporation, 1630 McCarthy Blvd., Milpitas, CA 95035. Or call 800-637-5545.
Circuit protects solenoids in dot printer

Emile Hebert
Comtrex Systems Corp, Mount Laurel, NJ

In Fig 1, chips IC1 through IC4 constitute a drive circuit for seven solenoids of a dot-matrix printer. Following the activation of one or more solenoids, the remaining chips (IC5 through IC9) protect the solenoid coils by automatically de-energizing them. (The alternative is software protection, in which the µP de-energizes the coils by asserting an all-zeros control word and another latch pulse.) Fuse F1 provides backup protection.

During operation, the system writes a control word to the latch IC1. The latch pulse transfers this word via the buffer IC2 to the Darlington drivers IC3 and IC4, where each high input produces a low output, placing 28V across the corresponding solenoid coil. This voltage must be removed immediately after the coil-activation time (550 µsec in this case) to avoid heat damage.

A 200-nsec pulse at the CLR input (pin 1) of latch IC1 deactivates the coils by setting the latch outputs to zero. The circuit generates this pulse as follows: NOR gates IC6A through IC6C monitor the control lines. The all-lines-low condition prevents the 250-kHz clock signal from reaching counter IC6A by producing a low level at the pin-1 input of gate IC6A. This gate opens when one or more control lines are high, allowing the clock signal to drive the IC6 counters. Decoder IC8 issues a 4-µsec pulse 548 µsec later. The leading edge of this pulse produces a 200-nsec pulse that first resets the counters and then resets the IC1 latch, deactivating the solenoids.

To Vote For This Design, Circle No 748

EDN December 10, 1987 325
Compressed amplifier improves dynamic range

Ralph Lu
Litton Applied Technology, Sunnyvale, CA

You can increase the dynamic range of an absolute-value circuit by adding a preamplifier that reduces the comparator's minimum required overdrive. The basic circuit of Fig 1, for example, has a maximum $V_{IN}$ of 5V and a minimum $V_{IN}$ of 1.5 mV, set by the comparator (part of IC1). The dynamic range is $20 \log(5\text{V}/1.5\text{mV})=70.5$ dB.

In Fig 2, the preamplifier (compressed amplifier), IC2, has a gain of 1.1 for $V_{IN}$ near 5V, and it has a gain of 20 for a small $V_{IN}$. Thus, a $V_{IN}$ of 80 $\mu$V, for instance, produces enough overdrive for the comparator (80 $\mu$V x 20=1.6 mV), yet a $V_{IN}$ of 5V won't saturate the comparator's input. The resulting dynamic range is $20 \log(5\text{V}/80\text{\mu V})=95.9$ dB.

The comparator's time error in sensing $V_{IN}$'s zero crossing increases for smaller amplitudes of $V_{IN}$. Conversely, the significance of a given comparator error increases with frequency. For the Fig 2 circuit, dynamic range exceeds 95 dB for input frequencies as high as 1 kHz.

Fig 1—In this absolute-value circuit, the main amplifier's gain is 2 or -2, depending on the polarity of $V_{IN}$ as sensed by the zero-crossing comparator within IC1.

Fig 2—By amplifying low levels of $V_{IN}$, this absolute-value circuit's compressed amplifier (IC2) adds 26 dB to the overall dynamic range.
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Amp provides 100V common-mode range

Mark Stitt
Burr-Brown Corp, Tucson, AZ

The unity-gain amplifier of Fig 1 can reject common-mode voltages as high as 100V. For an application that does not require galvanic isolation, this circuit is an inexpensive alternative to the conventional isolation-amplifier solution.

IC₁ is a monolithic gain-of-10 difference amplifier. By reversing normal connections to the on-chip resistor network, you place 100-kΩ resistors (instead of the 10-kΩ ones) at the amplifier's input, which attenuates the normal- and common-mode signals by a factor of 10. Then, resistors R₁, R₅, and R₆ form a T network in the feedback path that boosts the normal-mode gain to unity.

Because the addition of R₅ and R₆ degrades common-mode rejection by unbalancing the internal resistor ratios, you should restore the balance by adding about 158Ω (R₇) in series with R₃. A fixed-value R₇ that differs by 2% from the T network's equivalent value degrades CMR by only a few dB, but note that IC₁'s CMR is already 20 dB below its specified value (100 dB min) because the amplifier is operating at a gain of 0.1 instead of 10. You can improve the CMR by using a 500Ω potentiometer for R₇, as shown.

The differential-gain accuracy is within 2% if you use 1% resistors for R₅ and R₆. Adjusting the R₅/R₆ ratio can improve the gain accuracy, but calibration is difficult because the gain and CMR adjustments interact. You can eliminate this interaction and improve the gain accuracy by using the Fig 2 circuit. In Fig 2, IC₂ preserves IC₁'s CMR by buffering the R₅/R₆ network. Again, IC₁'s gain-of-0.1 connection reduces the guaranteed CMR by 20 dB—to 80 dB min. (This CMR estimate is reliable because the IC₁ amplifi-
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er (distinct from its thin-film resistor network) contributes only −120 dB of CMR error. Therefore, the resistor network is responsible for most of the residual CMR error that remains after laser trimming. This trim error affects CMR by about the same amount whether operating with a gain of 10 or a gain of 0.1. You can improve this circuit's CMR by adding 10Ω in series with R₁ (pin 2) and adding a 20Ω potentiometer in series with R₃ (pin 3). To adjust CMR, connect the inputs and drive them with a 1-kHz square wave whose amplitude is in the range from ±10V to ±100V. (A sine wave will introduce unwelcome CMR-vs-frequency effects.) Adjust the 20Ω pot for a minimum-amplitude signal at E₀.

As before, 1+R₆/R₅ sets the gain. The tolerance on this expression plus ±0.01% (contributed by IC₁) determines the overall gain accuracy. You can improve gain accuracy by using higher-precision resistors or by adding the optional gain-adjust network shown (R₇ and R₈). Gain and CMR adjustments don't interact in the Fig 2 circuit.

One application for the circuit of Fig 1 or Fig 2 is in monitoring high-side load current in a regulator or power supply. By connecting the difference amplifier across a 1Ω resistor in series with the supply's output, you can interpret the difference amplifier's output as one ampere of load current per volt for supply voltages in the range from −100V to 100V.

**Multiplexers enhance timer's capabilities**

Dan Sporea  
*Central Institute of Physics, Magurele, Romania*

You can use a single 8253 programmable timer to accomplish multiple timing jobs by multiplexing the timer's clock and gate signals and demultiplexing the output (Fig 1). The timing jobs must not overlap.

One or more I/O ports control the multiplexers as shown, allowing the system to optimize timer use by executing various tasks in sequence. Moreover, the demultiplexed timer outputs can drive an interrupt controller that dynamically selects the appropriate servicing subroutines. Different combinations of input clock and gate signals can summon the same subroutine. Or, by selecting different outputs, you can service the same input conditions with different subroutines.

**Fig 1**—In this circuit, multiplexers let you port a single programmable timer (IC₁) from one timing job to the next. The interrupt controller IC₅ lets the system select a desired service subroutine.
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Power op amp forms position controller

Dennis Eichenberg
WL Tanksley & Associates Inc, Brook Park, OH

You can build an inexpensive closed-loop position controller by driving a permanent-magnet motor with a power op amp (Fig 1). Bipolar power supplies allow the op amp to provide bidirectional motor operation. The motor is a 6V permanent-magnet type whose starting current must not exceed 0.5A.

![Power op amp forms position controller](image)

You configure the op amp as a differential amplifier in which the gain equals \( R_2 / R_1 \). A gain of 100 is optimum for this configuration. Gains from 10 to 500 provide good response times but cause increasing oscillation at the higher values, and a gain of 1000 causes instability. Resistor \( R_6 \) sets the amplifier's input-stage bias current.

Potentiometer \( R_6 \) lets you adjust the desired set point. Potentiometer \( R_7 \) connects to the motor shaft through a 10:1 gear ratio and provides position feedback to the amplifier's inverting input. The diodes in series with these potentiometers ensure that the magnitudes of the voltages applied to the amplifier's inputs don't come within 1.75V of the magnitude of either supply rail, as the amplifier requires. Using the ±6V supplies shown, the amplifier can apply as much as ±5.2V to the motor.

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Catalog presents static and dual-port RAMs

The 121-pg 1987-88 CMOS Static Memory catalog describes the vendor's line of high-speed static RAMs and dual-port RAMs for use in minicomputers, control-system applications, and graphics systems. Covered are 16k×8-bit, 8k×8-bit, and 32k×8-bit static RAMs. The publication also includes data sheets for 1k×8-bit and 2k×8-bit dual-port RAMs.

Vitelic Corp, 3910 N First St, San Jose, CA 95134.

Publication covers buses

The vendor's 1988 Standard Bus Catalog Products Engineered for High Reliability highlights over 400 board-level products, development systems, software, and support products. It features the CDI-Ladder system, which implements relay ladder logic, programming on the STD Bus, new SBX boards, an expanded card cage line, and an enlarged process-control software section. Also included are sections on CPU boards, memory boards, communications boards, controller boards, industrial I/O boards, stepper-motor controllers, and ADCs. The 44-pg booklet includes engineering specs, block diagrams, and illustrations.

Computer Dynamics, 107 S Main St, Greer, SC 29651.

Reference set details HCMOS programming

The M68HC11PM/AD, a Programming Reference Manual, is the basic software reference document for the MC68HC11 family of high-speed, CMOS single-chip µC devices. Besides general information, it presents descriptions of CPU register and addressing modes, instruction-set details, cycle-by-cycle CPU bus activity, and miscellaneous conversion tables. The MC68HC11A8RG/AD, a pocket programming reference guide, includes sections on programming models, crystal-dependent timing, interrupts, memory and opcode maps, addressing modes, execution times, Hex/Decimal conversions, and an ASCII chart.

Motorola Inc, Microprocessor Products Group, 6501 William Cannon Dr W, Austin, TX 78735.
Brochure features industrial computer
This 12-pg pamphlet details the features, specifications, configuration options, packaging and power supplies, and pricing information for the System 2 IBM PC/XT-compatible industrial computer. Also included in the brochure is a list of STD Bus cards (peripheral, I/O, memory, and utility) that can be configured for users' needs as well as PC/XT-compatible programs for use with the System 2.

Pro-Log Corp, 2560 Garden Rd, Monterey, CA 93940.

Circle No 682

Book references computer industry
According to recent figures published in the Computer Industry Almanac, a 780-pg reference book, the US can lay claim to more than half of the world's computing power. The volume presents an inside view of the computer world. It includes a computer industry overview; a ranking of companies, company award winners, and a company business directory; a ranking of hardware and software companies; product trends and product award winners; a ranking of international companies and statistics; financial facts; forecasts; organizations and agencies; publications; and research activities. Soft cover, $29.95; hard cover, $49.95.

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Networking system described in brochure
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Computervision, Dept 615, 100 Crosby Dr, Bedford, MA 01730.

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The R200 series PC-based instrumentation laboratory courses contains a 500-pg course text with a variety of hardware packages. The applications include teaching labs, PC-based workstations, university courses, vocation technology for classrooms, and company training courses. Topics cover assembly and high-level programming languages, data acquisition, instruments, operating systems, and data links and buses. The text, with a selection of hardware packages, is priced from $999 to $2995.

Rapid Systems Inc, 433 N 34th St, Seattle, WA 98103.

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Catalog of VME Bus products
This 4-color, 16-pg catalog describes the manufacturer's VME Bus boards, systems, and software. The short-form catalog covers such products as systems and packaging, CPUs, multiprocessing engines, system resources, single-board computers, memory, analog I/O and DSP devices, displays, special-function products, and peripherals.

Ironics Inc, 798 Cascadilla St, Ithaca, NY 14850.

Circle No 686

Literature package has app notes, product guide
This package of publications comprises four application notes, a VAXBI Third-Party Directory, and a product guide entitled New Opportunities. The notes explain how the vendor's products interact with other companies' products to make manufacturing tasks easier. The directory lists tool and service vendors and licensed option vendors. Finally, the guide describes the company's microcomputer systems, local-area networks, and local-area VAX-cluster systems.

Digital Equipment Corp, Channels Marketing Group, 2 Mont Royal Ave, Marlborough, MA 01752.

Circle No 687

Bus products described
Everything for the EXORbus is a 6-pg product guide that provides information on a family of EXORbus-compatible boards, modules, and accessaries. It features a product overview on 6800/6809 µP modules that are suitable for use in systems dedicated to production automation, process control, data acquisition, and materials testing. Other sections deal with processor modules, memory modules, I/O modules, microcomputer systems, enclosures, and packaging and accessories.

Creative Micro Systems, 3822 Cerritos Ave, Los Alamitos, CA 90720.

Circle No 689
Guide details
STE Bus products
The fourth edition of The STEbus Product Guide presents more than 750 products for the 8-bit STE Bus backplane computer system. Published on behalf of the STE Bus Manufacturers' and Users' Group, the publication describes products from more than 30 manufacturers and lists STE Bus product suppliers. New items include processor boards based on the Z80 µP and the Transputer, and Bitbus interface, DSP, speech synthesis, and motor controller cards.

The STE One Number Source, Dean Microsystems Ltd, 7 Horseshoe Park, Pangbourne, Reading, Berks RG8 7JW, UK.

Circle No 690

Report addresses
use of laser for graphics
The 8-pg paper, Lasers in Graphic Arts, discusses laser technology as a bridge between typographic output, and hardware and software used for publishing. The report deals with three graphics-arts applications: image setting, scanning, and printing.

Compugraphic Corp, Literature Div, 65 Industrial Way, Wilmington, MA 01887.

Circle No 683

Slide chart features
specs for pc boards
This double-sided slide chart makes it easy to refer to material specifications for pc boards. For example,
Current Mode Control
DC/DC Converters

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- Excellent Line Rejection
- Cycle-by-Cycle Current Limiting
- Stock to 3 Week Delivery

International Power Devices
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Brighton, MA 02135

(617)782-3331

LITERATURE

you can specify a manufacturer and grade of material to see physical, mechanical, electrical, or thermal properties at a glance. The reverse side of the chart explains tooling concepts and includes a recommended panel layout for the maximum use of raw materials.

Dynacircuits Inc, 11230 Addison St, Franklin Park, IL 60131.

Circle No 688

Brochure examines key features of Futurebus

This 6-pg awareness brochure covers key features of the IEEE-896 (Futurebus) specification. Formatted as a set of questions and answers, the brochure addresses such issues as which processors and architectures you can use on the bus, how Futurebus overcomes the bus driving problem, how the bus handles multiprocessing, and how it supports cache memories. Also included is information about message passing, fault-tolerant systems, and silicon support.

Futurebus Information Service,
Unit 2, Rowan Close, St Peters Park, Brackley, Northants NN13 5UP, UK.

Circle No 691
LITERATURE: COMPONENTS

Guide summarizes thyristor product line
The fifth edition of the vendor's Thyristor Selector Guide includes sections on SCRs, triacs, and trigger devices. The vendor has reduced its thyristor product offering by eliminating odd-value voltage parts and replacing them with the next highest voltage part.

Motorola Inc, Literature Distribution Center, Box 20924, Phoenix, AZ 85063.

Circle No 663

LED source book
Light Years Ahead is the vendor's 48-pg, 1987-88 users' guide to LEDs. It covers a range of products: pc-board-mounted LEDs; standard or snap-in panel lights; and LED multichip, lamp-based incandescent replacements. The product specifications include dimensional drawings, actual-size photos, applications, and electrical specifications. You can order custom configurations from a wide range of lenses, bezels, LEDs, bases, and terminations. The catalog also provides an alphanumeric index and selector guide.

Data Display Products, Box 91072, Los Angeles, CA 90009.

Circle No 666

Packet explains circuit-protection devices
This literature kit contains a brochure, data sheets, and application notes that provide an overview of the company's circuit-protection products. It includes descriptions of devices that provide protection for subscriber-line interface circuits, PBX and key telephone systems, telecommunications networks, loudspeakers, and batteries. The kit contains a press release introducing the company's newest family of devices.

Raychem Corp, 300 Constitution Dr, Menlo Park, CA 94025.

Circle No 666

Miniature switches categorized
The 288-pg catalog provides information on the vendor's full line of miniature and subminiature switches. A table of contents and an alphanumeric product index will assist you in locating a particular device. The book also includes a price list.

Augat/Alocoswitch, 1551 Osgood St, North Andover, MA 01845.

Circle No 668
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For product specs or application assistance, contact The Resistor People: IRC, Inc., Greenway Road, P.O. Box 1860, Boone, NC 28607. Phone 1-800-255-4-IRC.
(In NC, 704-264-8861.)
Synchro/resolver LVDT converters described

This short-form catalog presents more than 45 families of products for conversion of synchro-, resolver-, Inductosyn- and linear-variable differential transformer (LVDT) signals to digital codes. The listing includes single- and 2-speed converters, having 8- to 24-bit resolution. Applications for the devices include portable testers, multichannel data acquisition, airborne attitude synchro amplifiers, and angle-position indicators.

Control Sciences Inc, 9509 Vassar Ave, Chatsworth, CA 91311.

Circle No 667

Listing of digital switches

This catalog describes a wide range of switches, including Digiswitch, Minilever, Digivider, and Digi-decade switches, as well as Minkey keypad systems. Its easy-reference format guides you through military and commercial switch selection. The catalog also includes a features and options chart, truth tables listed by product series, engineering parameters, and layout drawings. It covers thumbwheel switches, lever/toggle switches, pushbutton switches, custom products, accessories, and switch-and-assembly ordering instructions.

Digitran, 3100 New York Dr, Pasadena, CA 91107.

Circle No 671

Paper discusses PWM amplifiers

The 6-pg reprint, Pulse Width Modulated Power Amplifiers, introduces PWM amplifiers, starting with their basic principles. It discusses applications and compares PWM-amplifier technology with alternative linear amplifiers and SCR power systems. The article explains how applications fit into four broad categories: coil drivers, ac/dc power sources, motion control, and high-power function generators. Photographs and schematics highlight the text.

Copley Controls Corp, 375 Elliot St, Newton, MA 02164.

Circle No 674
"EDN NEWS PROVIDED AN OVERWHELMING RESPONSE OF HIGH-QUALITY LEADS FOR OUR MICRÔ PEDESTAL ENCLOSURE."

Barry Holman
Sales Manager
Everest Electronic Equipment, Inc.

"As a result of a full-page, four-color ad we ran in EDN News, interest in our product has increased substantially," says Barry Holman, sales manager at Everest Electronic Equipment, Inc., a manufacturer of enclosures. "Sales are climbing steadily by roughly 45%, and we have found new market segments for our products, such as publishers of automotive parts manuals."

"Everest has a reputation for high-quality enclosure products," says Holman, "and EDN News has brought us more than 170 high-quality leads. We consider the association a tremendous success!"
Data sheet summarizes manufacturing aids

This data sheet describes three circuit-board manufacturing aids: connector protectors, a gold-fingers glove, and pc-board stiffeners. Product specifications are included in each description.

Stevens Products Inc, 128 N Park St, East Orange, NJ 07019.
Circle No 670

Brochure discusses traveling-wave tubes

This brochure covers the vendor's line of microwave tubes and amplifiers for manufacturers of communications and military products. It describes products for military electronic counter measures (ECM) and radar. It also details products you can use for stationary and mobile transmitters, transmitter amplifiers for satellite up-link ground stations, and point-to-point satellite transmission of business data. The 20-pg booklet includes a section on product safety.

Stantel Components Inc, 636 Remington Rd, Schaumburg, IL 60173.
Circle No 672

Catalog aids in choosing ceramic filters

Ceramic EMI/RFI Filters features descriptions of filter-circuit configurations and functions. It includes a filter-selection flow chart, installation guidelines, definitions of terms, and military test procedures. Catalog FD-129 is divided into dc-rated and ac/dc-rated sections. Subcategories are defined by circuit function. Within each general circuit category, devices are shown in...
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NDK 1300 Series Compact Crystal Clock Oscillators

AVAILABLE FREQUENCIES

<table>
<thead>
<tr>
<th>MHz</th>
<th>28</th>
<th>50</th>
<th>70</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other Brands</td>
<td></td>
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</tbody>
</table>

Product guide to panel displays
This 40-pg catalog of flat-panel plasma displays is divided into three sections: segmented displays; displays with drive electronics/interfaces; and bar-graph displays. A product guide and a list of customer representatives are included on the inside covers.

Dale Electronics Inc, 2064 12th Ave, Columbus, NE 68601.

Guide details optoelectronics products
The 45-pg, 4-color Optoelectronics Product Guide is a combination data book/selector guide that provides electrical and optical characteristics, package outlines, and pinout specifications. It also describes product features and applications. The book provides sections that cover visible-light lamps; single- and multiple-digit displays; integrated displays; custom capabilities; infrared emitters and detectors; and optocouplers.

Three-Five Semiconductor Inc, Box 111, Tempe AZ 85282.
Brochure details miniature ceramic-plate capacitors

The 20-page color brochure entitled Miniature Ceramic-Plate Capacitors describes a range of ceramic-plate capacitors that are suitable for use in such applications as coupling, decoupling, timing, and resonant circuits. The brochure also describes the manufacture, quality control assessment, and ordering information for these components, and outlines some advantages of their mechanical design.

Philips, Elcoma Div, Box 523, 5600 AM Eindhoven, The Netherlands.

Circle No 677
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Instrument-rental catalog
Featuring instruments from vendors such as Hewlett-Packard, Tektronix, and Fluke, this illustrated catalog presents more than 1000 models of electronic test, industrial, and telecommunications equipment that the company offers for rental. The instruments listed include oscilloscopes, analyzers, signal sources, recorders, temperature equipment, power-line monitors, and laser-measurement equipment. Also included are protocol analyzers, microwave analyzers, fiber-optic test equipment, signal generators and video equipment, µP test-and-development systems, logic analyzers, PROM programmers, plotters, and printers. The publication features a manufacturers' index and a product index.
Leasametric, Instrument Rental Div, 1164 Triton Dr, Foster City, CA 94404.
Circle No 647

App notes discuss waveform digitizing
Application notes AN-2017, Principles of Digital Waveform Recording, and AN-2018, Digital Signal Processing, provide an overview of waveform digitizing and analysis. The two papers fill 28 pages with text, diagrams, and illustrations. They address such topics as the fundamentals of ADC technology, understanding digitizer specifications, digitizer applications, digital signal processing, and computer-aided-test system design.
LeCroy, 700 S Main St, Spring Valley, NY 10977.
Circle No 651

Product guide for dc power supplies
The 132-pg 1987/88 DC Power Supply Catalog describes the vendor's manually controlled and computer-controlled dc power supplies. It's divided into three general categories: system, analog-programmable, and special-purpose and lab-bench power supplies. The book includes voltage-rating and model-number indexes, a guide for replacing discontinued models, a listing of sales and support offices, and a section on applications-information and terminology.
Hewlett-Packard Co, 1820 Embarcadero Rd, Palo Alto, CA 94303.
Circle No 648

Oscilloscope-probe kits and test accessories
The 32-pg, 4-color publication Perfection for Quick Connection presents the vendor's clip, insulator, test-lead, and interconnect offerings from A to W (adapters to wire). It lists product specifications, presents engineering drawings, and describes applications.
Mueller Electric Co, 1583 E 31st St, Cleveland, OH 44114.
Circle No 650
Booklet depicts test and measuring instruments

The 16-pg short-form catalog, Test & Measuring Instruments, focuses on the company’s complete line of oscilloscopes. It also features scope wagons, trace-recording camera systems, a selection chart of oscilloscope accessories, and a passive- and active-probes chart.

Iwatsu Instruments Inc, 430 Commerce Blvd, Carlstadt, NJ 07072. Circle No 652

Test and measurement instruments categorized

This 16-pg catalog on test and measurement instruments outlines performance features, applications, and specifications for 22 instruments. The products featured include digital multimeters, data-acquisition and logging instruments, dynamic analysis and vibration equipment, and communications test sets.

Solartron Instruments, 2 Westchester Plaza, Elmsford, NY 10523. Circle No 655

Brochure highlights electronic products

This 4-color brochure (Publication No 5953-7040) presents information on 22 basic electronic measuring instruments that are grouped into four types: digital multimeters; counters; pulse and function generators; and power supplies. Included in the leaflet are brief product descriptions, specifications, and prices.

Hewlett-Packard Co, 1820 Embarcadero Rd, Palo Alto, CA 94303. Circle No 653

Instrument catalog

This 32-pg catalog presents the company's line of products for industrial and laboratory test and measurement applications. Products covered include handheld thermometers, temperature controls, panel meters, calibration equipment, temperature loggers, IR thermometers, thermocouples, RTDs, handheld probes, humidity instruments, anemometers, digital voltimeters, temperature baths, pH meters, oxygen analyzers, and tachometers. Also listed are multifunction instruments that can measure several different parameters by using plug-in modules and sensors; the listing describes each product, giving its operating specifications and price.

Keithley Instruments Inc, 28775 Aurora Rd, Solon, OH 44139. Circle No 657

Listing of test and measurement instruments

This 64-pg catalog presents more than 1400 products from A W Sperry, Ampprobe, B&K Precision, Check-It, Fluke, Simpson, TIF, and Yokogawa. Among the products listed are leak detectors, counters, oscilloscopes, a variety of meters, and power supplies. The products described fill the requirements of electronic-, electrical-, and industrial-equipment users.

W W Grainger Inc, 1250 Busch Parkway, Buffalo Grove, IL 60015. Circle No 654

Booklet summarizes features of spectrum analyzer

The 16-pg, 4-color brochure 400-MHz Spectrum Analyzer 2382 illustrates Model 2382's RF design and details specifications. A section on measurement problems shows you how to speed up measurements at a single frequency, how to display demodulated FM signals, and how to get permanent records of tests.

Marconi Instruments, 3 Pearl Ct, Allendale, NJ 07401. Circle No 650

Signal sources bulletin

This 4-pg technical bulletin describes the series 6150A AM/FM signal sources. It details the modulation, harmonics, and stability of the instruments, which are solid-
state oscillators employing a GaAs FET as the active element. The pamphlet also contains specifications and a description of the vendor's 6140 GPIB adapter. Marconi Instruments, 3 Pearl Ct, Allendale, NJ 07401. Circle No 659

Book describes licensing of broadcast equipment
Procedures for Granting Licenses for the Operation of RF Devices, Radio and TV Receivers in Western Germany, an EMI guide published in English, provides information to help equipment manufacturers understand West German regulations. The 206-pg booklet examines the laws and VDE regulations concerning radio-interference suppression. It also presents a list of Deutsche Bundespost decrees on the subject along with brief summaries of the decrees. A flow chart depicts approval procedures for equipment, and the final chapter gives examples of test setups prescribed by a number of VDE regulations. DM 23. Rohde & Schwarz, Muhldorfstrasse 15, 8000 Munich 80, West Germany.

Note discusses programming on simulator system
Product Note 8770S-2, Effective Use of the HP 8770S Signal Simulator System, offers programming help with the HP 1177A Waveform Generation Language. The 64-pg document presents principles of digital synthesis and provides product-specific information about the features and operation of the HP 8770S. It explains how to program six different waveforms, from sine waves to frequency-hopped and multiple-tone carriers. Another section examines pulsed waveforms, pulsed carriers, and those with phase tagging, variable repetition rates and jitter, and pulse trains with AM and scan characteristics. Seven appen-
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CIRCLE NO 207

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LITERATURE

dices complete the booklet.

Hewlett-Packard Co, 1820 Embarcadero Rd, Palo Alto, CA 94303.
CIRCLE NO 656

Frequency synthesizers described

This catalog gives general information about frequency synthesizers and outlines their characteristics. It lists specifications for the product line and provides illustrations of each device. The 20-pg catalog also includes ordering information, and data sheets for the company’s newest models.

Programmed Test Sources Inc, Box 517, Littleton, MA 01460.
CIRCLE NO 660

Technical report describes modal analysis

To help you evaluate the complex behavior of vibrating structures, the technical report Modal Testing Principles describes the steps involved in using the company’s model 1202 structural analyzer in modal analysis experiments. With the aid of diagrams, the 100-pg report highlights the factors involved in setting up the experiment, in analyzing the problem theoretically, and in assessing the quality of the modal data. Some of the chapters focus on how to identify modal parameters and how to achieve structural modifications. The report also provides a detailed explanation of 42 different equations related to modal analysis.

Solartron Instruments, Victoria Rd, Farnborough, Hants GU14 7PW, UK.
CIRCLE NO 662
Digital plotter media for computer-aided design

This brochure describes digital-plotter materials for computer-aided design. It describes the vendor's Diplomat and PermaScale media, and provides an applications guide of media characteristics. Further, its plotter-suitability charts list the products available for flatbed or drum plotters.

Dietzgen Corp, 250 Wille Rd, Des Plaines, IL 60018.

Circle No 643

Catalog features CAD products

This 37-pg product guide deals with the vendor's Diplomat and PermaScale media, and provides an applications guide of media characteristics. Further, its plotter-suitability charts list the products available for flatbed or drum plotters.

Dietzgen Corp, 250 Wille Rd, Des Plaines, IL 60018.

Circle No 643

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Newsletter provides CAE coverage

Design Line, a quarterly newsletter, publishes news about and editorial comment on CAE trends, applications, and events. It features user stories as well as articles on workstations (large systems), simulation, performance, and testability analysis.

Aida Corp, 5155 Old Ironsides Dr, Santa Clara, CA 95054.

Circle No 645

Brochure on data-acquisition system

This brochure describes the P-CAM system, which includes software packages for data acquisition/analysis and process control applications. The 4-color publication covers the product's applications and provides illustrations, figures, and specifications.

KineticSystems Corp, 11 Maryknoll Dr, Lockport, IL 60441.

Circle No 646

Newsletter contains CAD/CAM information

Published since 1981, the Computer Aided Design Report newsletter covers computer-aided design and manufacturing topics. The May and June issues provide a comparison of personal-computer CAD software features, specifications, and system requirements. The SmartWork section describes how SmartWork makes pc-board design easier and less tedious.

Wintek Corp, 1801 South St, Lafayette, IN 47904.

Circle No 644
When your eyes need high quality displays, you need the Toshiba ST LCD.

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ST LCD Module Specifications

<table>
<thead>
<tr>
<th>Model name</th>
<th>Number of dots</th>
<th>Duty</th>
<th>Dot pitch (mm)</th>
<th>Outline dimensions (mm)</th>
<th>EL Back Light (Option)</th>
<th>Recommended controller</th>
</tr>
</thead>
<tbody>
<tr>
<td>TLX-1181*</td>
<td>640 × 400</td>
<td>1/200</td>
<td>0.35 × 0.35</td>
<td>276 × 168 × 12</td>
<td>Yes</td>
<td>T7779</td>
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<tr>
<td>TLX-932</td>
<td>640 × 200</td>
<td>1/200</td>
<td>0.375 × 0.375</td>
<td>293 × 97.8 × 14</td>
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<td>TLX-561</td>
<td>640 × 200</td>
<td>1/200</td>
<td>0.35 × 0.49</td>
<td>275 × 126 × 14</td>
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<tr>
<td>TLX-711A*</td>
<td>240 × 64</td>
<td>1/64</td>
<td>0.53 × 0.53</td>
<td>180 × 65 × 12</td>
<td>Yes</td>
<td>T6963C**</td>
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<tr>
<td>TLX-341AK*</td>
<td>128 × 128</td>
<td>1/64</td>
<td>0.45 × 0.45</td>
<td>93.2 × 86.6 × 12</td>
<td>No</td>
<td>T6963C</td>
</tr>
</tbody>
</table>

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News of Products, Technology, and Careers for Engineers and Engineering Managers
An experimental graduate-engineering program opens new study opportunities

Deborah Asbrand, Associate Editor

Design engineer Daniel Sternlicht has always been good at making the most of opportunities. Shortly after graduating from the University of Pennsylvania with a degree in marine biology, Sternlicht abandoned a planned oceanographic career and decided instead to pursue an interest in engineering. He headed for the mecca of engineering, California, and after several months of door-knocking, succeeded in getting a job as an engineering technician at Teledyne Microwave in Mountain View.

To supplement his on-the-job learning, Sternlicht immediately began taking courses in advanced math and electronic technology at local colleges. Two and a half years after joining Teledyne Microwave, he was promoted to design engineer. But there was one area in which there were few opportunities available to him: education. What he really wanted was a master's degree in engineering, but without a bachelor's degree in the subject, the chances were slim that he would gain admission to a traditional program.

Now, though, Sternlicht is enrolled in a master's program and slowly working his way toward an advanced engineering degree. He's one of many students taking advantage of an innovative program that the University of Santa Clara has set up to aid people who, like him, have technical positions in electronics companies but who have risen through the ranks minus undergraduate engineering degrees.

Nearly 100 students are enrolled in the university's largely experimental program, known as Program 2. Although many of them are studying graduate-level material, others have been accepted into the program on the condition that they first complete undergraduate math requirements. Only one student has been graduated to date, and Ken Haughton, dean of engineering at the small Jesuit college, says the school wants to keep the program's enrollment small while it fine-tunes the curriculum.

Haughton expects that engineering education will someday be conducted primarily on the graduate level in professional schools, much as medical and legal education is today.

While Sternlicht was wondering how he'd get the advanced engineering education that he wanted, Haughton was wrestling with the educator's side of the same problem. Engineers weren't the only ones looking for programs that offered alternative forms of study. From time to time, marketing and administrative professionals in the electronics industry would phone Haughton looking for part-time engineering programs that would complement their business expertise. Except for recommending that the callers enroll in undergraduate night classes, Haughton had no solutions.

The phone conversations nagged at him, though, because the callers' dilemmas were not new to him; he had known many people in similar predicaments during his 25-year career at IBM. "I often saw people who'd had their responsibilities expanded to the point where they felt frustrated at not having a technical background," he recalled. "No matter where you start [in a technology company], if you have the inclination, you're somehow going to wind up involved in the technology."

When Haughton left industry in 1982 to become dean of the University of Santa Clara's engineering school, he suddenly found himself in a position to solve the problem. During informal round-table discussions
between the university and industry representatives, Haughton broached the idea for a graduate engineering program tailored for individuals with undergraduate degrees in liberal arts and natural sciences. The participants' reactions were positive. “Typically, the response was ‘My God, I wish I had had a chance at a program like that,’” Haughton remembers.

The changing face of education

Haughton had another reason for wanting to start Program 2: his expectation that engineering education as a whole will someday be conducted primarily on the graduate level in professional schools, much as medical and legal education is today. “I think the . . . day is coming when we're going to have to re-evaluate engineering education in this country . . . . We are experiencing enormous technical progress, and it's becoming increasingly difficult for undergraduate programs to keep up.”

With those thoughts in mind, Haughton decided in 1983 to undertake his grand experiment. Students in the program give it rave reviews. Sternlicht says the five-credit course in microelectronics that he's currently enrolled in taught him the theories behind the work he's been doing. “I've used a lot of the equipment and devices that we learn about, and now I'm really learning the theory.”

Design engineer Andrei Bostan believes that Program 2 has given him an opportunity to study that he might not otherwise have had. In 1978, Bostan and his family immigrated to the United States from Rumania, where he had been a violinist with the state-national orchestra. Arriving in San Francisco, he joined the musicians' union and paid his $400 dues only to discover that he was one of roughly 240 out-of-work professional violinists in the Bay Area. Looking for a field that offered a better chance of employment, Bostan took a job as a badge assembler. After climbing the ladder through a variety of engineering-technician positions, he was promoted to design engineer in 1982. Although Bostan questions whether a person must have a degree to succeed as an engineer—“I don't think Edison or Faraday had degrees”—he expects the degree he's working toward to "legitimize" his engineering work. Bostan has taken 20 undergraduate classes in mathematics, C and assembly languages, and microprocessor design. In 1983, he was conditionally accepted into Program 2. He's been gradually completing his mathematics requirements while taking engineering courses, but nonetheless anticipates another four years of study before he graduates.

Haughton concede that because the program is largely an experiment—as he carefully explains to each enrollee—there are still aspects of it to be worked out. For instance, he fears that Program 2 graduates, though skilled in their areas of expertise, will miss out on the breadth of engineering experience from which typical engineering students benefit. "That's the thing that worries me most," he says. "Our undergraduate civil engineer-
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EDN December 10, 1987
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Should possess a BS or MS in EE, Physics or Chemistry with 5 years experience in semiconductor processing technology. This Team Leader position provides technical direction, work-flow control, and hands-on expertise while coordinating the Process Team efforts in pilot production and InGaAsP/InP devices research and development. Requires understanding of processing techniques and equipment, such as: photolithography, wet and dry etching, dielectric and metal deposition, diffusion and alloying. Prefer experience with InGaAsP/InP material.

**Digital Circuit Design Engineers**

BSEE and a minimum of 4 years experience in high frequency analog and digital circuit design. Position requires experience in discrete amplifier design (15mhz +), clock recovery circuit design, phase lock loop design (15mhz +) and line conditioning for line buildout circuits. Telephony background and knowledge of DS1-DS3 signals are required. Experience in functional partitioning is desirable.

**Opto-Electronic Device Design Engineers**

Requires a PhD/MSSEE/Physics with 5-10 years of optoelectronic device experience. Should be familiar with longwave length (1.2-1.6 microns) InP based source and/or detectors design and characterization. Position involves design and characterization of devices including PIN photodetectors, GaAs avalanche photodiodes, semiconductor lasers and LED's. Record of scientific accomplishment and publication is desirable.

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Requires BSEE/MSEE with 6-8 years experience in telephony digital hardware design. Experience with CMOS or ECL logic design, VLSI gate array design, and Daisy CAE Design techniques necessary. Desire experience with 40-50 mhz CMOS, DS3 and/or DS1 signals and modulation techniques. Recognized ability to address systems redundancy, signal integrity and system monitor and control must be demonstrated.

**Software Engineers**

Positions call for a BSCS or BSEE and 5 years software architecture/design experience OR an MSCS or MSEE and 3 years software architecture/design experience. Involves software development for distributed microprocessor network control systems. Experience in circuit switched and packet switched network control is necessary. Team software development experience for Motorola 68000 systems is desirable. Candidates with "C", UNIX™ ADA and OSI data communications experience will be given special consideration.

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Responsibilities involve product planning and product application of Digital Transmission Systems Products. Good working knowledge of the telecommunications network is essential, with emphasis on network applications of multiplex, Digital Cross Connects and Operational Support Systems. Technical familiarity with SONET, SYNTRAN, HDLC/X.25 protocols required. Network experience with circuit grooming, hub planning development and capability of working closely with customer network planners to assess product requirements and trends are necessary. Network experience and strong interpersonal skills are essential.

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*EDN December 10, 1987**
Erasable optical drives to surge into marketplace

As erasable optical disk drives become a commercial reality, they promise to alter dramatically the revenue pie currently shared by the two other optical storage methods, read-only drives and write-only, read-many (WORM) devices, according to the management-consulting firm Freeman Associates (Santa Barbara, CA). Over the next several years, substantial numbers of OEMs and system integrators will choose the erasable optical drives. Indeed, revenues from sales of these drives will overtake the annual earnings of read-only devices by 1990, even though samples of the erasable optical drives are just now entering the market.

For the three categories of drives, Freeman Associates distinguishes between revenues and units shipped. In 1990, for example, vendors will ship 338,100 read-only drives, 235,600 WORM drives, and only 119,100 erasable optical drives. But revenues in that year are projected to be $124.3 million, $1.032 billion, and $155.5 million, respectively. By 1992, the total market should yield $2.3 billion (see EDN, June 25, pg 350, for a related report on the same market).

Read-only drives will dominate the market from 1986 to 1992 in terms of unit shipments, although WORM drives will maintain a strong lead in revenues each year, ranging from 79% of optical-drive revenues in 1986, to 76% in 1992. In 1986, 97% percent of all read-only shipments were CD ROMs, and these will continue to constitute the great majority of read-only units shipped.

Because the CD-ROM business is totally dominated by a combination of various Japanese makers and by Philips of the Netherlands, US manufacturers are unlikely to enter it. US activity, albeit substantial, will be in publishing, marketing, systems integrating, and disk manufacturing.

For market analysis, the write-once market can be divided into three groups defined by drive stor-

Unexpected growth seen for enclosure sales

The electronic-enclosure market is far from mature, according to Venture Development Corp (VDC) of Natick, MA. The industrial market for electronic enclosures, estimated at $383 million for 1987, will top $640 million by 1992. These numbers translate into a 10% compound annual growth rate. Three segments—telecommunications, military/aerospace, and medical/scientific—will consume more than 60% of the total shipments for this market throughout the period.

VDC defines an electronic enclosure as any covering or package used to house electronic components and equipment.
From power supply to power distribution, Molex makes the connection.

Molex, the industry leader, now offers the most complete line of pin and socket connectors available. From standard wire-to-wire and wire-to-board versions, to the new high-performance "Mini-Fit Jr."

**Mini-Fit Jr. meets today's demand for miniaturized design components.**

With current handling capability of up to 9 amps per circuit, and a connector mating force of only 1.54 pounds per circuit, the Mini-Fit Jr. offers the ideal solution to your high current and high density interconnection requirements.

Molex is THE source for immediate delivery of pin and socket products.

Molex has factory stock and distributor inventory around the world. Our pin and socket connectors meet full UL, CSA, VDE, and EAMCL standards. Features include silo protected terminals, positive lock, and pull tabs. They're available in brass or phos-bronze, with tin or selective gold plating for low cost and high performance.

Molex has the pin and socket connector you need, in the size and configuration you need, for every discrete wire application.

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**Mini-Fit Jr.** is our new generation power connector for your panel-to-wire, wire-to-wire, and board-to-wire applications.
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The special requirements of data communications OEMs have resulted in some pretty exotic custom modem cards from Universal Data Systems.

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UDS has successfully handled more than 3,000 custom OEM modem design assignments — and we can handle yours. To begin an exotic custom, contact Universal Data Systems, 5000 Bradford Drive, Huntsville, AL 35805. Telephone 205/721-8000; Telex 752602 UDS HTV.
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Just let our competition try to play "follow the leader" with that!

Of course, if we don't have a standard stock item that fits your needs, our custom engineering department will gladly quote your specific requirements. PRONTO.

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