A PREVIEW OF BUSCON/91 WEST
SWITCHING SUPPLY HAS LINEAR CHARACTERISTICS

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CIRCLE 139
Our new function generator has all the bells and whistles.

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As a function generator, Model 95 produces remarkably pure square waves, triangles and sines, from 1 mHz to 20 MHz with synthesized accuracy up to 0.001%. It has the power to output 15 Vp-p into 50Ω, and includes sweep, pulse and modulation modes plus four user-selectable output impedances. There’s even an internal trigger generator for trigger, gate and burst.

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Circle 130 for Literature
Circle 131 for Demo
Did you hear about the 74-pounder they caught in the Columbia River?
It worked without a snag.

This is a story about the one that got away. And then came back as reliably as ever.

In 1987, bandits stole four HP signal generators from a truck in Spokane, Washington. Luckily, police managed to recover three of them. But the last one disappeared without a trace.

Six months later, a man fishing the Columbia River hauled in a heavy metal box. Well, within a few days, we had the missing signal generator back. There was mud in every nook and cranny.

But rather than clean this catch, one of our Service Engineers decided to plug it in. To his surprise, the instrument emitted a signal. Even more remarkable, it met specifications.

Stories like this underscore why HP rates highest for reliability among engineering managers. We're still not satisfied. In fact, in 1979 we started a Total Quality Control program to increase quality ten-fold in 10 years. We'll reach that goal this year.

It just goes to show you that when design and manufacturing productivity are at stake, there is no reliable substitute for HP. And that sometimes the best fish stories are actually true.

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• A new breed of low-cost, high-speed op amps
• Plus regular features: Pease Porridge Ideas for Design Technology Advances Quick Look

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Jesse H. Neal Editorial Achievement Awards

Cover: Jock Leung

E L E C T R O N I C  D E S I G N
JANUARY 31, 1991
IN THE ERA OF MegaChip™ TECHNOLOGIES

A lot has been said about company is doing a lot about
testability, but only one it. Texas Instruments.

You've seen the headlines and read the stories. Design-for-test (DFT) is a challenge but one that's now easier to live with. The reason: Texas Instruments is the first to develop products for implementing the JTAG/IEEE 1149.1 testability standard quickly and effectively.

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- Reduced capital investment in test equipment
- Increased system fault coverage and reliability

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Everything you need to start your LCD application . . . create complex screens in just a few hours!

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Interface to 6 soft keys or 4 x 4 key matrix.

Dial 0-255 ohms for LCD contrast.

Wire-wrap area for custom circuitry or backlight.

240 x 64 pixel Supertwist LCD mounts directly onto CY8003 prototyping board.

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- Alternate Power DIN.
- Add your own 8051 CPU for stand alone operation.
- Sample routines in 8051 Assembler and QuickBasic.
- LCD Paint® for creating your own graphics images.
- Demo routines preprogrammed into 8751 for immediate gratification.

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$495 - Kit

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Tel: 415-726-3000 - Fax: 415-726-3003

CIRCLE 98

THE CAE SOLUTION

In a recent issue of the London-based newsweekly The Economist, the editors point out Japan's strength in technical workers, its "army of engineers." The numbers spell this out: Japan has 5000 engineers per 1-million population vs. the U.S.'s 3500 and western Germany's 2500, with no other country coming close. This strength, says The Economist, is one reason Japanese companies can develop new products in a third to half the time spent by their western counterparts—at a tenth of the cost. How can others compete against that?

It's clear this situation will not change in the U.S. any time soon. Secondary-school science education is in a dismal state, and technical universities are recruiting foreign students to fill out engineering classrooms, both undergraduate and graduate. And, as repeatedly pointed out by the engineers themselves, employers often misuse the engineering talent they already have, relegating engineers to non-creative, rote jobs. The handwriting on the lab wall heralds that the U.S. electronics industry, the largest employer in the country, will have a tough time competing in the ever-more-global electronics marketplace.

U.S. engineers not only must work harder, but also work smarter. One hope is that computer-aided engineering, in which the U.S. still leads the world, will enable the proportionately fewer engineers to improve their design leverage to offset other countries' advantages of sheer numbers. Is there any alternative? Assigning routine tasks to the computer and leaving the innovator with more time to create can stick a pin in this ballooning problem.

All members of the electronics industry must increase their investments in capital equipment to become more competitive. There is a strong ongoing debate regarding government support of the semiconductor industry, with cogent arguments on both sides. But the far greater part of the electronics industry, the equipment builders, are perhaps in more need. Investments in CAE hardware and software—intellectual capital equipment—could have lasting payoffs for the industry as a whole.

Stephen E. Scrupski
Editor-in-Chief
The opportunity for automated, low-cost assembly is a key benefit of surface-mount technology, but is often wiped out by the high price of surface-mount components. Now, Mini-Circuits offers a new series of mixers to meet the pricing demands of SMT—only $3.30 in 1,000 quantity ($3.95 ea. in quantity of 10)—at a cost even lower than most conventionally-packaged mixers.

The SCM-1 spans 1 to 500MHz and the SCM-2 covers 10 to 1,000MHz. Housed in a rugged, non-hermetic 0.4 by 0.8 by 0.3 in. high (maximum dimensions) plastic/ceramic package. Spacing between connections is 0.2 in. The mixer is offered with leads (SCM-L) or without leads (SCM-NL) to meet a wide range of pc board mounting configurations.

Each SCM is built to meet severe environmental stresses including mechanical shock/vibration as well as temperature shock. The operating and temperature storage range is -55°C to +100°C. Each SCM, designed and built to meet today's demanding reliability requirements, carries Mini-Circuits' exclusive 0.1% AQL guarantee of no rejects on every order shipped (up to 1,000 pieces).

When you think SMT for low-cost production, think of Mini-Circuits' low-cost SCM mixers.
The IBM RISC System/
The power you’ve been seeking

It's a never-ending quest for power seekers. You're always looking for ways to run your favorite applications faster. Well, search no more. The RISC System/6000 family of POWERstations and POWERservers gives you power that soars as high as 23 MFLOPS and 56 MIPS.

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<th>MFLOPS</th>
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When it comes to porting, your ship has come in. Of course, all the speed in the world wouldn’t mean much without the applications you need. So the RISC System/6000 family already has more than 2,000 of the most popular technical and commercial applications up, running, and running fast. And if you think you know a good thing when you see it, so do software vendors. That’s why you’ll also be seeing more and more applications coming on board the RISC System/6000 platform all the time. And if you like to build your own solutions, there’s a full arsenal of enablers and relational databases from leading vendors, as well as CASE tools and a host of popular programming languages.

A smorgasbord of solutions. Applications already announced include the IBM engineering design packages CADAM; CAEDS; CBDS;

MFLOPS are the results of the double-precision, all FORTRAN Linpack test 100x100 array suite. The Dhrystone Version 1.1 test results are used to compute RISC System/6000 Integer MIPS value where 1.757 Dhrystones/second is 1 MIPS (VAX 11/785). SPECmark is a geometric mean of ten benchmark tests. All performance data are based on published benchmark information.

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for all your applications.

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For the Power Seeker.
**Concurrent Design: Then and Now**

The announcement of Interop Inc.'s first Achievement Award, presented to Motorola Inc., Phoenix, Ariz., for its peer-to-peer network, gave me cause to reflect on my previous career in the engineering world. At the dawn of the microprocessor era, I was a project engineer with a small company that designed and manufactured specialized instruments for spectrographic analysis. These products embodied an interesting mix of engineering disciplines. The instruments were designed to determine the composition of materials for the steel, oil, medical, and other industries. Most designs were customized for specific industry requirements.

We prototyped our instruments with lenses and prisms from Edmund Scientific, op-amp modules from Philbrick, electrical-power devices from local supply houses, and precision mechanical fixtures from local machine shops. Our data base for these multidiscipline designs was highly paper-intensive, making it very difficult to track and retrieve design data quickly. And applying concurrent design techniques was totally out of the question. Consequently, the design of an instrument progressed painfully from stage to stage, often dragging out to a year or more. Eventually, more sophisticated and complex instrumentation demanded by advancing spectroscopic techniques caught up with and outdistanced our ability to produce designs efficiently. The company went under.

If controlling the flow of information became the downfall of our little company, consider the challenge faced by operations with globally dispersed engineering, manufacturing, assembly, and marketing facilities. Project management insists on daily updates of text files and graphics data for immediate access by anyone who needs it, regardless of geographical location. This is particularly crucial for shortening time to market by proceeding concurrently with the various aspects of the design. To solve the problem, more and more manufacturers are turning to networking technology so that projects can be managed from a central group. Nowhere is this application better illustrated than in Motorola's network.

Interop, the organization that runs the annual INTEROP Conference in San Jose, Calif., imparted the award to Motorola in recognition of its network. The network ties together the design and manufacturing facilities of 12 of the company's domestic plants and 8 of Motorola's plants deployed in Europe and Asia. In all, the network spans 17 time zones and has 13,000 nodes. The systems installed on the network include mainframe computers, minicomputers, workstations, file servers, and desktop computers from over a dozen different vendors.

Motorola's prior network consisted of many group-owned asynchronous and X.25 lines that linked together loosely coupled groups of local-area networks (LANs) with very low connectivity. Using store-and-forward techniques, transferal of a typical design database for an integrated circuit, which can range from 500 kbytes to 10 Mbytes, took up to several days. The updated network now links the distributed LANs through T1 communications land lines, optical-fiber links, and by satellite transmission. With database transfer time cut to a matter of minutes, a typical circuit design cycle can be reduced by as much as 40%. Equipped with such tools, an engineer in Munich can check the interface specifications of other parts of a chip being designed in Austin, Texas.

Motorola's system is acknowledged as a hallmark of global internetworking design. But I can't help wonder what might have been if our little company had been equipped with just a fraction of this networking capability those many years ago.
Bar none, Mill-Max is America's leading source for interconnect components. Here's a brief medley of our top selling hits:

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- Pin receptacles
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- Wrapost receptacles and terminals
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- surface-mount • over 100 off-the-shelf models • immediate delivery

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### Low Pass dc to 1200MHz

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<tr>
<td>PLP-1200</td>
<td>DC-1200</td>
<td>1200</td>
<td>1820</td>
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### High Pass dc to 2500MHz

<table>
<thead>
<tr>
<th>MODEL NO.</th>
<th>PASSBAND, MHz (loss &lt;1dB)</th>
<th>fco, MHz (loss &lt;3dB)</th>
<th>STOP BAND, MHz (loss &gt;20dB)</th>
<th>VSWR</th>
<th>PRICE</th>
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<tr>
<td>PHP-50</td>
<td>41</td>
<td>200</td>
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<td>PHP-100</td>
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<tr>
<td>PHP-150</td>
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<td>95</td>
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<td>PHP-175</td>
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<td>800</td>
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<td>185</td>
<td>1000</td>
<td>164</td>
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<tr>
<td>PHP-250</td>
<td>225</td>
<td>1200</td>
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<tr>
<td>PHP-400</td>
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<td>1600</td>
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<td>500</td>
<td>1600</td>
<td>454</td>
<td>480</td>
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<td>1600</td>
<td>545</td>
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<td>2200</td>
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<td>940</td>
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### Bandpass 20 to 70MHz

<table>
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<tr>
<th>MODEL NO.</th>
<th>CENTER FREQ. MHz</th>
<th>PASS BAND, MHz (loss &lt;1dB)</th>
<th>STOP BAND, MHz (loss &gt;10dB)</th>
<th>VSWR</th>
<th>PRICE</th>
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<tr>
<td>PIF-21.4</td>
<td>21.4</td>
<td>18</td>
<td>25</td>
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<td>PIF-30</td>
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<td>25</td>
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<td>PIF-40</td>
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<td>PIF-60</td>
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<td>11.5</td>
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<td>PIF-70</td>
<td>70</td>
<td>58</td>
<td>82</td>
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### Narrowband IF

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<th>MODEL NO.</th>
<th>CENTER FREQ. MHz</th>
<th>PASS BAND, MHz (LL &gt; 1dB max.)</th>
<th>STOP BAND, MHz (LL &gt; 20dB)</th>
<th>STOP BAND, MHz (LL &gt; 35dB)</th>
<th>PRICE</th>
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<tr>
<td>PBP-10.7</td>
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<td>9.5-11.5</td>
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<td>PBP-21.4</td>
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<td>19.2-23.6</td>
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<td>PBP-30</td>
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<td>27.0-33.0</td>
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<td>PBP-70</td>
<td>70</td>
<td>63.0-77.0</td>
<td>51</td>
<td>94</td>
<td>6.0</td>
</tr>
</tbody>
</table>
IR announces Ultra Fast IGBTs: our 600V power transistors that switch faster and run cooler than any you've ever used. Forget about bipolar. Put these breakthrough devices in your high-voltage, high-current, medium-frequency applications and get performance unparalleled for the price. Which should come as no surprise. IR IGBTs build on the same proprietary technology that made IR's HEXFETs® world leaders.

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CAPACITIVE SENSING TRIMS MACHINING COST

By sensing electric fields before and after a machining tool passes over a surface, a high-resolution capacitive imaging sensor (HIRCIS) promises to lower the finishing cost. Developed at Sandia National Laboratories, Albuquerque, N.M., the sensor works by measuring changes in capacitance between two conductive surfaces. When a third surface (the workpiece) enters the electric field set up by the two conductive surfaces, it alters the capacitance. Then the alteration is sensed. Additional processing of this sensed data enables the system to delineate surfaces, edges, and other features. Raised discontinuities (burrs), beveled edges (chamfers), or other surface variations cause capacitance changes. These changes are picked up by the sensors and processed by a computer to identify the features for machine control and graphical display. By placing multiple sensors on a substrate, a complete two-dimensional picture of the surface can be created with one mechanical scan. Once the surface profile is generated, a machine tool, rather than a human operator, can perform the finishing automatically. And, because HIRCIS employs non-contact sensing, it isn’t prone to erroneous signals or excessive wear due to machine-induced vibration. It’s also less sensitive to misalignment errors. Contact Jim Novak, (505) 844-4227. DB

PC-BASED SOFTWARE CONTROLS CROSSTALK

A PC-based CAE program called KG Line Design helps designers avoid crosstalk on multiwire, high-bit-rate lines. The program calculates the transmission-line matrices and the impedance-matching network elements from the geometry of a multiwire line. It determines crosstalk due to mismatch for any termination network, as well as the crosstalk that develops as a pulse propagates along the line. In addition, the program calculates the gains for an unscrambler-decoder to undo the crosstalk, if that’s the best solution. KG Line Design can analyze lines containing up to 45 wires. An on-line help function serves as a complete user’s manual. KG Line Design runs on PCs, and is available now for $475. A demo version costs $5. Call Kenneth Granzow at (719) 528-6784. LM

80486-BASED MOTHERBOARD RUNS AT 50 MHZ

By combining a cooling technology and the UM82C480 chip set on a motherboard with a 33-MHz 80486 processor, you get the IceJet-486 board with a processor that runs at 50 MHz and has a benchmark of 35.6 MIPS. The board, from Velox Systems, Santa Clara, Calif., derives its speed from the company’s patented Peltier-effect chip cooling, called IceCap, which cools the processor down to 0°C. The UMC chip set supplies stable operation at 50 MHz by using 1.0-μm CMOS and a “one-times” system clock. Most other chip sets use a two-times clock, where the clock-signal generator is twice the speed of the system clock. This means that a 50-MHz processor would require a 100-MHz rather than a 50-MHz clock. The IceJet-486 is built on a baby AT board (8.5 by 13 in.) with seven ISA expansion slots. It carries up to 16 Mbytes of RAM and supports a Weitek 4167 coprocessor that’s also cooled to 0°C. Prices for the board start at $3400 in OEM quantities. RN CIRCLE 514

ANALOG ARRAY FILLS MILITARY NEEDS

A dielectrically isolated (DI) analog tile array is now available from Harris Semiconductor, Melbourne, Fla. The HTA2000 bipolar array adheres to space class-S and military class-B requirements, which include overlapping metallization at contact windows and double bond/probe pads. DI isolation eliminates substrate parasitics between transistors. Moreover, DI, thin-film resistors, and high-gain narrow-base transistors result in high-radiation tolerance. The HTA2000 has ten tiles of 60 transistors each, plus capacitor and NiCr resistor trim areas to provide good integration. Also, p-channel FETs and buried Zener diodes are included. Up to ten 12- to 70-MHz op-amp equivalents can be on one tile array. Engineers can design the array using the Harris Fastrack design system. NRE costs start at $40,000. Call (800) 442-7747, ext. 1086. LM

3D MULTICHIP MODULES COME DOWN IN COST

Heat dissipation is generally the limiting factor in high-density packaging techniques, such as 3D multichip modules. But thanks to a joint development effort between Quadrant Technology Inc. and Electrochem Corp., both from Hayward, Calif., viable manufacturing techniques and materials are now available. These advances offer much-improved heat dissipation and an order-of-magnitude cost reduction compared with existing thin-film methods. The firms have developed a 3D module incorporating internal thermal layers that dissipate high heat levels. Electrochem’s Electroflex material is used as a thin-film interconnection medium with lines under 2 mils. The company’s Thermostate substrate material is bonded in multiple layers using a proprietary technique that results in very low production costs. Call John Woodman at (415) 785-9873. DM
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For more information about how Avantek's new technologies can help your business thrive in the most predatory marketplace, call:

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Putting microwave technology to work for you.
TRANSLATOR ACCELERATES VERILOG SIMULATIONS
IC designs that are described and simulated in the Verilog hardware description language can now be converted automatically for high-speed simulation on an Ikos hardware-assisted simulator. The Verilog-Language-to-Ikos Translator (VLIT) software from Ikos Systems Inc., Sunnyvale, Calif., reads Verilog net lists and translates them into Ikos-compatible files. The Ikos simulators can operate on 1.2 million gates at speeds up to 75 million events/s. VLIT processes all structural constructs and notes behavioral constructs with diagnostic messages. The translator operates as a hierarchical netlist compiler, and generates a timing file with delay information for each primitive within top-level Verilog modules. VLIT runs on HP-Apollo and Sun workstations. It's available now for a $5000 license fee per node. Call (408) 245-1900. LM

QUICK TURNAROUND FOR MODULE SUBSTRATES
Lower product-cycle times for assemblies containing multichip modules could result from a successful demonstration of a quick-turnaround program for module substrates. The Microelectronics and Computer Technology Corp. (MCC), Austin, Texas, can now mass-produce substrates and "personalize" them later for specific applications. The quick-turnaround interconnect technology (QTAI) program begins with blank substrates that have the basic power and ground layers along with the X-Y signal layers. Then, the top layers are custom-made to user requirements. Two of the consortium's shareholders, Harris Corp., Melbourne, Fla., and Eastman Kodak Co., Rochester, N.Y., have already benefited from their collaboration in the technology's development. For Kodak's vehicle, a 2-Mbyte nonvolatile-memory card, substrate personalization was completed within seven working days from receipt of the photomasks. Harris used the technology in a crossbar switch that incorporates both tape-automated bonding and wire bonding. The switch's 16 VLSI chips each have 103 inputs and outputs. According to MCC, the flexible approach sacrifices little in performance compared with full-custom approaches and is viable at clock speeds well above 100 MHz. Contact MCC at (512) 343-0978. DM

FIRST BiCMOS PLDs CUT PROPAGATION DELAYS
Although the popular 22V10 architecture has been implemented in either bipolar or CMOS processes, designers have yet to attain a version that mixes the best of both. That will soon change when the first biCMOS versions of a 22V10 will be sampled by Cypress Semiconductor Corp., San Jose, Calif. The chips will deliver a worst-case propagation delay of just 7.5 ns, which is as fast as the GaAs version offered by another company. They will be usable in systems that operate with clock rates of 40 MHz. To achieve the short delay, designers at the company's Aspen Semiconductor subsidiary implemented the speed-critical paths in ECL circuits and used bipolar technology to implement the level-conversion circuits. Outside the speed-critical path, the control logic employs CMOS circuits to minimize total chip power consumption to about 850 mW. One-time-programmable metal fuses are employed by the logic to minimize the propagation delays in the programmable logic paths. Another advantage of biCMOS is the ability to program the signal edge rates to reduce ground bounce to just 1.1 V by matching output time-constants to packages and loads. Cypress offers a 22V10 and a superset version, the 22VP10. The superset permits bidirectional I/O signals on the registered outputs. Contact Don Tuite, (408) 943-2653. DB

MICRO-CHANNEL CHIP SET PUTS LOGIC INTO 4 ICS
Although i486 PC motherboard chip sets are becoming common, relatively few companies opt to implement a chip set to build systems compatible with the IBM PS/2 series computers that employ the Micro Channel Architecture (MCA) bus. By the pairing of the system-design expertise of Minneapolis, Minn.-based Micral, an independent affiliate of Groupe Bull, and the manufacturing strength of Toshiba America Electronic Components Inc., Irvine, Calif., designers now have a high-performance 4-chip motherboard implementation of the IBM MCA. The chip set employs Micral's short-line interface kernel. It's a system architecture that sets up the CPU and expanded external cache as a subsystem. As higher speed CPUs are introduced, just the CPU portion of the system need be upgraded for higher speed. The chip set consists of a bus master DMA controller (TC85M911), an address and data buffer (TC85M921), a memory and bus controller (TC85M931), and a peripheral support chip (TC85M951). A 32-bit system can be built with the four chips plus a second address and data-buffer chip to form a five-chip "motherboard"—just add the BIOS, cache, and desired peripheral functions. Contact Amar Dhillon, (714) 455-2000. DB
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Design in the Maxim MAX163 Family of complete single-chip A/D converters, and eliminate multi-component design problems, such as slew-rate limitations, settling time delays, signal droop, hold-step errors, and noise/distortion. Also, save board space, design time, and cost.

- 8.33μs Conversion Time
- 12-Bit No Missing Codes
- 100kHz Sampling Rate
- DC and Dynamic Specs 100% Tested
- 1μs Acquisition Time Track/Hold
- 25ppm/°C Voltage Reference
- High Input Resistance (500MΩ)
- Analog Input Range: MAX163-0V to +5V, MAX164 ± 5V, MAX167 ± 2.5V
- Pin Compatible with AD7572

MAX167 Replaces AD7572 and Sample/Hold

Pin compatible with the AD7572, Maxim's MAX163 Family can plug into existing sockets and eliminate an external sample/hold and a high performance amplifier. Unlike other A/Ds with low-resistance inputs, the high input resistance (500MΩ) of Maxim's converters allow the use of a lower cost amplifier to drive the A/D input. Compare the MAX167 specs to an AD7572KN05 used with an external sample/hold and see how well Maxim's performance looks—at a lower cost.

<table>
<thead>
<tr>
<th>Specifications (S/H used with ADC†)</th>
<th>MAX167</th>
<th>LF398A†</th>
<th>AD585†</th>
<th>HA-5320†</th>
<th>SHC803†</th>
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<tbody>
<tr>
<td>Hold Step + Offset (LSB max)</td>
<td>6</td>
<td>16</td>
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<td>Full Power Bandwidth (MHz typ)</td>
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<td>Aperture Delay/Jitter (ns/ps typ)</td>
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<td>150/?</td>
<td>35/500</td>
<td>25/300</td>
<td>15/50</td>
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<td>Power Dissipation (mW typ)</td>
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<td>270</td>
<td>375</td>
<td>465</td>
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<tr>
<td>Price Range**</td>
<td>$20</td>
<td>$27</td>
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</table>

† S/Hs assumed to be used with AD7572KN05.
* Price 1,000 up, FOB USA.
** Based on 100-up, FOB USA prices.

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A 150-mile 2.5-Gbit/s fiber-optic link that runs from Valencia to Cuenca, Spain, increases the transmission rate about four times that of the fastest system in use. With a capacity of either 30,720 64-kbit/s voice channels or 16,140-Mbit/s TV channels, it's the highest-capacity communications line installed to date. The new link, which is the first part of a larger network, employs synchronous-digital-hierarchy (SDH) technology. It was installed by Philips Kommunikations Industrie AG (PKI) of Nuremberg, Germany, an affiliate of Holland's Philips International NV.

The SDH standard is based on the U.S. Sonet (synchronous optical network) standard. SDH gets around the limitations resulting from different national and applications-specific standards as does ISDN, the integrated services digital network. ISDN overcomes the drawbacks arising from multiplex protocols, etc.

SDH allows any or all of the three main systems recommended by the CCITT (the International Consultative Committee for Telegraphy and Telephony) to operate within one system. The three systems are the North American and Japanese systems that are based on 24, 1,544-Mbit/s channels, and the 30-channel 2,048-Mbit/s European system. The SDH system uses distributed-feedback (DFB) Philips lasers that provide narrow bandwidths at a spectrum of 1550 nm, yielding excellent results (see the photo).

SDH can work with plesiochronous networks (networks in which each signal source has its own clock), enabling present systems to further develop. Its big advantage is that flexible networks can be realized. Transmission capacity can be switched according to need. There's also the possibility that individual digital-signal channels, such as a 2-Mbit/s channel, can be added or dropped from an SDH multiplexed signal of higher order. The SDH signal thus needn't be demultiplexed.

The main transmission channel for the Philips system is driven by up to 16 synchronous transport modules. The basic element is the STM-1 signal with a bit rate of 155.520 Mbits/s. All higher-order transmission signals are multiples of the STM-1. Multiplexing to a 2.5-Gbit/s line using pointers is performed according to CCITT recommendations.

It's possible to access SDH overhead channels for bit-error monitoring and maintenance purposes. The equipment in-
OPTICAL POLYMER ASSURES IMPROVED INTERFEROMETER

A Mach-Zehnder interferometer, developed with an optical polymer, promises to reduce the cost of integrated optics devices and increase their performance. Designed by the PA Consulting Group Ltd., Royston, Hertfordshire, United Kingdom, which is under contract to the Dutch chemicals group AKZO nv that developed the polymer, the device is one of the first of its type.

The interferometer controls and modulates a lightwave output from a communications laser diode to increase fiber-optic transmission system data rates beyond what's currently possible. A 10-GHz modulation bandwidth was achieved in laboratory prototypes, allowing the interferometer to switch lightwaves at 10 Gbits/s. This switching rate is an order-of-magnitude improvement over commercially available interferometers that are generally fabricated from lithium niobate (LiNbO₃).

Moreover, the low-cost polymer used in the fiber-optic device could bring its price down to between $100 and $9000, compared with $2000 to $9000 for LiNbO₃ devices, according to its designers. The ultimate goal is for prices in the tens of dollars, like those of passive optical components (e.g. splitters and couplers), states project leader Dr. Robin Godfrey of the PA Consulting Group.

Godfrey believes that the device could reach commercial production within two to three years.

Polymer films used in the interferometer are about 1-µm thick. Its dimensions are several times smaller than those of LiNbO₃ devices, suitable for integration within optical receiver-transmitter "light-to-logic" modules. And because the fabrication process of the polymer device is very simple, it will be easy to integrate multiple-channel devices into one package.

The device is made with photolithographic techniques similar to those used in semiconductor IC manufacturing. Chip size for the device is about 1 cm by a few µm. When packaged, its dimensions are about 1 cm by 1 cm. The interferometer is designed to be compatible with "silicon-voltage" levels of 5 to 12 V. As a pure field-effect device, it doesn’t consume electrical power.

The development is part of a larger effort of using low-cost polymer materials to mass-produce nonlinear optoelectronic components. According to Godfrey, such components could start a new "photonics" industry that could replace electronics in the long term. He says that photonics developments are being stimulated by the need for ever-increasing speed in information transfer, storage, processing, and display.

“The development of new polymeric integrated optics devices represents a major breakthrough on the road towards broadband optical communications,” Godfrey says. The materials provide low dielectric constants and thus very large bandwidths, as well as large nonlinear optical coefficients and good compatibility with low-voltage microelectronic circuits, he claims.

For more information, contact the PA Consulting Group, Cambridge Laboratory, Melbourne Royston Herts, SG8 6DP.

S T A Y I N T E R E S T E D

PCB PROCESS TAKES LINES DOWN TO 3 MILS

A fine-line process for fabricating the inner layers of printed-circuit boards will result in volume production of boards with 3-mil line widths by the end of 1991. With a liquid-photoimageable-resist process as the key element, Praegitzer Industries, Dallas, Oreg., is now seeing significant yield increases at 5 mils and expects to be at 3 mils by this summer. The developments are aimed at satisfying the burgeoning need for much higher board densities for surface-mounted assemblies.

The Primecoat photoimageable resist was developed by DuPont Electronics, Wilmington, Del. It’s applied by electrodeposition in a process called electrophoresis.

In that process, a copper board is uniformly coated by individually depositing resist molecules in an electrically charged bath. First, the copper substrate is placed in an electrolytic bath with oppositely charged electrodes on either side. Charged resin micelles are added to the bath and current is applied. This draws the molecules to the board, where they chemically react with the copper and form an insoluble resin. The deposition process continues until the resist layer coats all charged-copper surfaces. The coating thickness is from 0.25 to 1 mil, with 0.6 mils being ideal. Deposition is self-limiting and stops at a given thickness.

The liquid-resist process overcomes the high degree of difficulty that lies in the use of existing dry-film technology on the inner layer of boards. Dry resist has a process limitation at line and space widths below 5 mils. It requires an anchor on the panel, several mils wide, to tent reliably. Liquids applied in the traditional manner exhibit inconsistencies in coating uniformity on laminate surfaces. Although the dry-film chemistry is essentially the same, the yields become cost prohibitive below 5 mils.

Aside from the electrodeposition step, Praegitzer’s process uses conventional pc-board equipment. But the electrodeposition method gives them the advantages of increased resolution, adhesion, and reproducibility. According to Praegitzer, the electrodeposition process will give them a technological advantage over Japanese competitors, for whom electrodeposition of pc-board traces has been a priority for several years. Those competitors, he claims, are achieving yield rates over 80% at 5-mil lines and spaces.

DAVID MALINIAK
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TECHNOLOGY ANALYSIS

BUSCON/91-WEST PROVES THAT FUTUREBUS+ IS STILL THE STAR

AS THE FUTUREBUS+ ROLLOUT HITS ITS FIRST ANNIVERSARY, PRODUCTS ARE NOW APPEARING.

When the curtains are drawn open for this year’s Buscon/91-West show, Futurebus+ will take center stage. It’s been one full year since the architecture’s rollout, and products are just starting to emerge. While the show’s technical sessions cover all of the bus architectures, including VMEbus, Multibus II, PC platforms, and embedded systems, the balance still swings toward Futurebus+.

One full day of Buscon’s technical sessions is devoted to Futurebus+, while the major other architectures merit half days. Day One kicks off with an introduction to Futurebus+ by Ray Alderman, Director of VITA (VMEbus International Trade Association). Futurebus+’s history and major features will be discussed. That’s followed by the bus’ technical details and its specifications.

A second Futurebus+ session offers an overview of the Futurebus+ Profiles. The number of profiles changes because a few are currently in the idea stage. Profile A is a 64-bit general-computing specification that uses a hard metric form factor. It’s intended for board-level products. Profile B is a Futurebus+ I/O definition. Here, none of the high-performance mechanisms, including caches, packet modes, and message passing, are permitted. This profile also eliminates multiprocessing.

Profile F, for “fast,” mandates all of the mechanisms not allowed in Profile B. This is because the bus has a minimum bandwidth of 500 Mbytes/s. In an earlier stage is Profile T, for “telecommunications.” The standards group working on this profile has yet to define many of the necessary specifications. Profile D, for “desktop,” fits an EISA form factor and uses an EISA connector. Desktop systems don’t fit into a Profile A, B, or F chassis. The remaining profiles are M for “military” and C for “cable.” The latter specification involves cache-coherent flat-cable networks.

Boards from different profiles may be able to operate in the same system, but performance may be hindered. This means that the boards are intermatable and interoperable, but not necessarily interworkable.

One of the first working system boards to follow the Futurebus+ specification is the NR3000-1 CPU module based on the MIPS R3000 microprocessor (Fig. 1). The board, from Nanotek Inc., Idaho Falls, Idaho, is compatible with Profile A. The

1. THE NR3000-1 CPU MODULE is one of the first built to the Futurebus+ specification. The Profile A board from Nanotek is constructed with the MIPS R3000 processor and a 3010 coprocessor.
NR3000-1 is intended for use in systems ranging from diskless single-board computers to multiprocessor Unix-based systems. Both cache-coherent shared-memory and message-passing multiprocessor systems are supported. It includes a two-level cache hierarchy consisting of a 128-kbyte primary cache and a 1-Mbyte secondary cache, enabling efficient use of processor and bus resources. The board will be in production by the end of the first quarter at a price of $9900.

At Buscon/90-East in October, Philips Components-Signetics, Sunnyvale, Calif., and Texas Instruments, Dallas, announced a joint development and alternate-source agreement for several products. Each company agreed to second-source a broad range of transceivers, controllers, and data-path circuits. Signetics plans to introduce the FB2000 chip set's transceivers in the early part of this year with the LSI chips coming soon after.

The Signetics chip set includes pins to accommodate a future JTAG upgrade. JTAG's core features support external tests that drive the chips' outputs and sample tests to observe the inputs coming into a chip at any given time.

Another chipset, this one being introduced at the show, comes from National Semiconductor Corp., Santa Clara, Calif. (see "Futurebus+ Builds Momentum with New Chip Set," p. 115). National's five-chip set is already being sampled and will be in production in March.

Texas Instruments and Force Computers Inc., Campbell, Calif., will jointly develop an IC that will implement Futurebus+'s parallel protocol functions. The part offers parallel protocol control (PPC) of the Futurebus+ interface, as well as transaction support for cache-coherent multiprocessing shared-memory systems.

The PPC chip will also have support for processor and intelligent I/O transactions across the Futurebus+ backplane in high-performance shared-memory systems. The ability to implement this cache-coherency technology enhances the processing power of each bus segment in multiple-bus systems.

**VMEbus Gets Its Day**

Day Two's technical session is split between VMEbus and Multibus II. On tap is a review of the VMEbus architecture. Details will be provided by various VMEbus board manufacturers, including Force Computers, Heurikon, Ironics, Motorola, and Radstone, on ways to enhance VMEbus performance through daughter-board buses, multiprocessing configurations, and implementing mezzanine buses and modules. Bus and memory requirements, power considerations, and I/O connections will all be explored.

A VMEbus issue to be debated involves the performance benefits of advanced RISC and CISC processors. Current silicon trends suggest that a merger of the two processor types may be the best alternative. But history reveals that RISC, while still a relatively young technology, outperforms CISC in terms of MIPS, and may continue to do so in the future (Fig. 2). In the session entitled "Microprocessor implementations: RISC and CISC," Fred Rehauesser of Force Computers tracks the histories of the two processor types and offers insight into their futures.

A host of VMEbus products are being released at the show. Xylogics Inc., Burlington, Mass., will show off its IPI-2 controller, the SVM892. The disk controller supports the 24-Mbyte/s transfer rates of Seagate Technology's recently announced Sabre Parallel Transfer Disk. It also supports IPI-2 drives from other manufacturers.

General Micro Systems Inc., Montclair, Calif., will release its V05sx dual-ported memory board. The board is configured with 64 Mbytes of DRAM, ported to the VMEbus with VME64 and to a 32-bit expansion bus for direct CPU access. The board uses two-way interleaved static-column DRAM and supports synchronous-termination read and write cycles from the CPU. Hence, it acts as a block-mode slave that allows sub-zero wait-state accesses over the local bus.

The CMC-1150 series, from CMC, Santa Barbara, Calif., is a second generation of FDDI adapters for various VMEbus systems. The adapters are available as single- or dual-attach stations built to a 6U form factor. Performance is improved over the first generation due to an enhanced RAM buffer and data-path controller. The board runs at 25 MHz thanks to its AMD 29000 RISC processor. A second improvement is the addition of 512 kbytes of content-addressable memory.

The Multibus II seminar also begins with a brief overview of the bus standard. The sessions move into the software issues beginning with the initialization process. This process contains four phases: reset, board initialization, system initialization, and bootstrap loading. The specifics of each phase are discussed at
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length. The next phase of platform software analyzes the transport issue. It details what it is, why it's needed, and how it works. Hardware issues, such as bus expansion and bridging to other buses, are tackled later in the day.

Multibus II product offerings at the show include a 25-MHz, 80486-based networking board from Concurrent Technologies Inc., Champaign, Ill. The CC 486/258 supplies eight high-performance asynchronous synchronous serial channels, each with modem control and optional full-duplex DMA support.

Users can create custom interfaces without the delay or cost of a new pc board by using the Multibus II programmable-logic interface from General Standards Co., Huntsville, Ala. The MB2-PGA56T offers 56 TTL interface transceivers and six Xilinx programmable gate arrays. The board can be programmed to operate as a bus link, digital I/O with handshake, or other device. An optional EPROM configures the board as a DMA interface between Multibus II and other architectures.

The remaining two days of the technical conference cover PC-bus platforms, embedded systems, military applications, and emerging architectures, such as Sun's Sbus and DEC's TurboChannel. The PC-platform sessions cover software and hardware, as well as STDbus. There's a discussion based on STD 32, the 32-bit standard that offers all of the features found on 386- and 486-based PC's.

A session on operating systems is presented by James Ready of Ready Systems Corp., Sunnyvale, Calif. This seminar explores the issues surrounding the choice of the appropriate software environment for a particular PC-based application. It discusses application requirements as well as various aspects of DOS.

3. THE 50-MHZ AT&T DSP PROCESSOR is the heart of WinSystems' MCM-DSP32C STDbus board. Users can customize the board by connecting a 16-bit daughterboard.

An industrial family of multiprocessor products is used for real-time applications. The family, from Paracom Inc., West Chicago, Ill., includes the TPCM-ADC, an analog-to-digital-converter board that offers up to 16 single-ended channels referenced to ground, or up to eight differential channels. The data-acquisition function includes internal and external trigger and handshake capabilities as well as autoranging. A sample rate of 200 kHz/s at 12 bits/sample can be achieved. This enables the board to scan all lines equally or focus on a specific area of activity. Both Paracom products are busless modules that can be integrated into PC/XTC/AT systems.

**STD Teams With DSP**

An STDbus-based DSP board, the MCM-DSP32C, hails from WinSystems Inc., Arlington, Texas. The board is built around AT&T's DSP-32C floating-point processor. The board executes independently of an STDbus host CPU. A data-transfer rate of up 3.5 Mbytes/s between the board and the host is achieved through programmed I/O that doesn't interfere with the MCM-DSP32C's operation. The board also contains a daughterboard adapter for customization (Fig. 3). At the military end, Matrix Corp., Raleigh, N.C., released two VMEbus products: a digital I/O board and a memory board. The former, MR-D10, comes with either 48 or 96 lines of data and 16 interrupt sources. The data lines, handled on two or four 24-bit ports, can be accessed from the front panel through right-angle latching 50-pin headers. Each input has a minimum of 0.4 V of hysteresis to ensure accurate readings. The memory board, MR-RAM, contains up to 4 Mbytes of battery-backed RAM. The double-height board is addressable as a 24- or 32-bit address slave and supports 8-, 16-, or 32-bit data transfers. The memory is organized in two banks, with each bank having its own battery and power monitor. Data retention is 10 years.

Along the lines of emerging standards, Rapid Systems Inc., Seattle, Wash., will unveil its PCXI EISA industrial PC. The system combines PCXI modularity with EISA's 32-bit capability. PCXI is completely backward-compatible with all PC instrumentation, data-acquisition, and control cards. The PCXI modules offer an excellent hardware environment to enhance EISA performance as theemi/rfi-shielded modules solve noise and emission problems.

**How Valuable?**

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*From a 1990 study conducted by Washington Labs Inc., a subsidiary of Vionite Engineering Corporation.
ANALOG EEPROMs STORE 16 SECONDS OF AUDIO ON SILICON DIE 1/10 THE AREA DIGITAL EEPROMs NEED TO DO THE JOB.

IC HOLDS 16 SECONDS OF AUDIO WITHOUT POWER

FRANK GOODENOUGH

Every designer using nonvolatile analog memory dreams of a solid-state solution to replace magnetic tape. The need is particularly severe if the ability to erase and re-record is required. During the early 1960s, magnetic-core memory was tried as a solution, albeit unsuccessfully, with a dynamic range of only about 18 dB. Now, Trevor Blyth, Sakhawat Khan, and Richard Simko at startup Information Storage Devices (ISD) successfully extended EEPROM technology to the task with a technique they call direct analog storage (DAS).

With DAS, they can achieve a signal-to-noise ratio of 40 dB, a 3-dB bandwidth of 3400 Hz, and a total harmonic distortion of 2% at 1 kHz. All of this performance is achieved while the input signal is sampled according to the Nyquist theorem, not quantized or digitized (for a look at how it works, see “Analog EEPROMs,” p. 41). The DAS technique will affect many areas in the future (to see where it’s headed, see “Analog Memory Futures,” p. 44).

The ISD1016 is the first of a large family of ICs and multi-IC modules from ISD (see the figure). It stores 16 seconds of better-than-telecom-quality audio. After a signal is stored, the IC can be powered-down or removed from the circuit forever without losing the recorded signal. By putting it back in the circuit and powering up, you can play it back as often as you want or record a new signal, before or after erasing previous ones. If desired, multiple messages/signals can be recorded and accessed at will. The chip is complete: If it’s connected to 5 V, a microphone, a speaker, and a few other parts, you have a record-playback system.

A point might be raised as to whether or not such performance can be achieved using EEPROMs together with an ADC and a DAC. It would take 1 Mbit of digital memory to store the same 16 seconds of data. As a result, a far larger and more expensive chip would be required than the 44,100 mls2 of silicon the ISD1016 uses, which is about the size of today’s 64-kbit EEPROMs. Such an EEPROM
solution ranges in cost from under $10 per chip to over $100 each, depending on sound quality, volatilility, the ability to record and playback, and, of course, how many chips are needed. That doesn't include other system costs, such as signal conditioning, sampling, analog-to-digital and digital-to-analog conversion, and analog and digital I/O. By comparison, the ISD1016 costs $20 each in 1000-unit lots.

INFINITE USES

By now you've thought of a dozen applications for this chip or its technology. Say you're a surgeon watching a Celtics-Lakers basketball game in a $100 seat. The score is 101 to 101 and it's about a minute to the buzzer. Your pager beeps. Rather than head for a phone and miss the end of the game, you put the pager to your ear, hit a button, and get a 16-second message. A few additional voice applications include the out-going message on a standard phone recorder (within a few years, the incoming message as well) and next-generation cellular phones. Annunciators represent another area of use. Examples include talking appliances/vending machines, prompts/alarms in vehicles and aircraft, toys, theater/event information, and hotel wake-up calls.

While such voice-band applications quickly become obvious, non-voice applications for direct analog storage are the realm of the truly creative individual. ISD divides non-voice use into three broad categories based on input-vs.-output considerations: data capture (recording a single event), data acquisition (continuous sampling of an analog signal or signals), and the generation of analog signals.

Signal-generation applications, in most cases playback-only, are subtle. They include arbitrary-waveform generators, programmable-voltage references, and tone generators. The chip could be the heart of a built-in, or battery-powered, portable calibrator for an EKG recorder and/or other medical instruments.

INSIDE AND OUT

An application, such as a voice-message system, best illustrates both the ISD1016's operation and its features (see the figure, again). As noted earlier, all that's needed to handle both record and playback for working hardware (in addition to the chip) are a few external parts: a microphone, speaker, switches, resistors, and capacitors. The IC itself performs preamplification, filtering, automatic gain control (age), power amplification, control logic, and the analog storage.

Amplification is performed in two stages: with an input preamplifier and with a fixed-gain amplifier, each connected by a second external capacitor. This architecture allows system-design flexibility, particularly...
for non-voice applications, and adds a pole for low-frequency cutoff response.

The preamplifier's gain is adjusted automatically to maintain an optimum non-clipped signal level at the filter input. The preamplifier's 20-dB gain-compression range compensates for variations in microphone characteristics and speech volume. It maintains signal integrity without clipping, or other major forms of distortion, while increasing dynamic range by 20 dB.

As stated previously, because this chip represents a true sampled-data system, an antialiasing filter follows the amplifiers to ensure that the Nyquist response is served. The filter essentially reduces the input signals that are above one-half the sampling rate to insignificance. The ISD1016 samples at 8 kHz and its filter’s cutoff frequency is 3.4 kHz. The filter has 5 poles and rolls off at 40 dB/octave at that frequency. Such specifications essentially ensure that telecommunications requirements are met, even though the audio from the ISD1016 sounds better than telephone-line audio—even while using a typical handset as a microphone.

The signal is passed from the filter to the analog transceivers to write into the analog storage array, which can be viewed as 128,000 sample-and-hold amplifiers. Sequential samples are taken, under the direction of the sample clock, at 8 kHz, and level-shifted to produce the high voltages needed for the nonvolatile writing procedure. At the same time, com-

**NONVOLATILE ANALOG MEMORY CHIP**

Information Storage Devices employs the analog storage property of the nonvolatile floating-gate EEPROM cell. Up to now, digital information was stored in these cells one bit at a time. If the floating gate is strongly programmed to a positive charge, the floating-gate transistor’s channel is made strongly conductive. This state corresponds to a binary digital value, say, a logic 1.

If the cell is erased, the floating gate is rendered strongly negative. Thus the EEPROM cell is rendered nonconductive, corresponding to the complementary binary value, a logic 0. By programming or erasing cells in an array, a digital memory is created. ISD takes advantage of the intermediate conductivity values between strongly conductive and nonconductive states to create a nonvolatile analog memory.

An EEPROM cell is a MOS transistor that stores electrical charge on an electrically isolated, conductive, capacitor plate—or “floating gate.” The floating gate is located above the transistor channel (Fig. 1). The charge on the floating gate creates an electric field that modifies the conductivity of the channel of the MOS transistor.

The charge on the gate, composed of electrons, is increased or decreased by a current-conduction mechanism called Fowler-Nordheim tunneling. The tunneling current is conducted through insulating gate-oxides, which are excellent insulators under typical, low-voltage bias levels. When high voltage is applied, the oxides conduct sufficiently via the electron tunneling to charge or discharge the floating gate. Tunnel current is a very sharp exponential function of the bias voltage across the oxide (Fig. 2).

The polarity and location of the bias voltages applied to the transistor control the charging and discharging of the gate. The potential on the floating gate, and the potentials across the oxides, are manipulated by electrostatic capacitive coupling through the overlaying control gate and by various capacitances to the other transistor terminals.

When the bias values are reduced to low values, the oxides again behave like excellent insulators. The amount of charge on the floating gate can be retained for many years—even at high temperatures—in the low-bias condition. The voltage on the floating gate can now be “read” without disturbing the charge, and therefore not disturbing the stored voltage. The sensed, or measured, value of the cell’s conductivity corresponds to the value of the analog level stored.

In digital memories, the high erase-and-programming voltages are applied in a binary fashion to cause large amounts of tunneling current to write a one or a zero. However, in the analog memory, the erase and programming voltages are applied in a more controlled fashion. The floating-gate charge levels are intelligently written to the proper analog values. The technology takes care of cell-to-cell variations due to processing, temperature, bias differences, and cell aging.

**ANALOG EEPROMS**

- **Control gate**
- **Floating gate**
- **Tunneling paths**

![Diagram of an EEPROM cell](image-url)
The D interface may look familiar, but our latest I/O connectors have some special temptations all their own. Density, for instance. Mating contacts in a .050" by .100" pattern shrink I/O real estate dramatically, with sizes to 120 positions. Our staggered .075" by .100" pcb layout frees up more board, too, but still leaves trace routing uncomplicated. And shielding, for another instance. All the effectiveness you expect from steel front shells and AMP engineering—plus our make-first/break-last design to handle electrostatic discharge concerns as well. Add superior strain relief, consider our squeeze-to-release option, and you have a compelling package.

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AMP Interconnecting ideas

CIRCLE 156
Nonvolatile Analog Memory Chip

Pension is provided for problems caused by Fowler-Nordheim tunneling. (see “Analog EEPROMs,” again, p. 41). The clock also increments the array decoders, mapping the samples into the array (details of the writing circuitry will be described at the International Solid State Circuits Conference, Feb. 13-15 at the San Francisco Hilton).

During playback, the analog-recorded voltages are read sequentially from the storage array, again under the control of the sample clock, for wavefrom reconstruction. The smoothing filter in the output path removes the sampling-frequency components, restoring the original signal. It’s vital that the sampling frequency be the same for both recording and playback modes to avoid a loss in voice quality. Shifts in clock rate as little as 2% are perceived as a change in the “mood” of the speaker—for example, more excited or tired. The on-chip oscillator (which needs no external components) is constant within 1% over changes in supply voltage and temperature. Consequently, even though conditions may vary greatly between record and playback modes, reproduction quality isn’t affected.

The smoothing filter’s output connects to the output power amplifier through an analog multiplexer. The power amplifier can directly drive a 16-Ω speaker with 50 mW of rms power (100 mW pk).

Digging Deeper

Not only can the ISD1016 be used by itself, but several ISD1016s can be cascaded to increase recording time to several minutes. The limit is mostly set by the number of 28-pin DIPs that are connected. In fact, by late spring, ISD will be offering multichip modules with record times of 32 and 64 seconds in the same 28-pin DIP footprint.

The address pins can preset a start address at the beginning of a record or a playback. With a processor-controlled system, this addressability makes it possible to link sounds together. Short utterances, or words, can be used to construct longer, more complicated messages. In non-voice applications, very complex waveforms can be created with the same technique. Once a particular arbitrary waveform (lasting say 500 ms) is “designed” and recorded, it can be played back repeatedly.

The ISD1016 typically needs about 20 mA from one 4.5- to 9-V rail. Three grades are available, depending on required power-supply voltage range: 4.5 to 5.5 V (standard), 4 to 4.4 V (communications), and 6 to 9 V (extended). The high voltage required to program the array and the internal 1.5-V “analog ground” (which permits handling ac signals) is generated on the chip.

The storage array consists of 160 segments, each 100-ms long. Each segment is addressable individually during both record and playback modes through the eight address pins A0 through A7. To start recording, the power-down (P/D) and playback-record (P/R) pins are pulled low. The former action powers-up the chip, and the latter selects the record function. Recording starts at the addressed segment when the Chip Enable (C/E) pin is brought low. Recording stops when the C/E pin is brought high, with an end-of-message marker being written into memory to indicate the location of the end of the recording.

For playback, P/R is pulled high, P/D is brought low, and C/E is pulsed low. Playback starts from the addressed location, continuing to the end-of-message marker, at which time the end-of-message pin pulses low and playback stops. If the end-of-message pin is continuously held low, playback continues over the marker to the next segment.

The eight address pins can address up to 256 segments. But because only 160 segments are used, space is available for other purposes. In the ISD1016, this space reconfigures the control functions for different modes.

For example, the chip can be set up to record messages into sequential memory spaces without external address control. It can also be made to fast-forward onto the next message or to loop on a message until the C/E pin is brought high. That is, the control functions can be optimized for a specific application.

Price and Availability

The ISD1016 comes in 28-pin plastic DIPs, SOICs, and PLCCs. In quantities of 1000, plastic DIP versions go for $20 each. Initial devices are rated for commercial-temperature-range operation. Small quantities are in stock.

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CIRCLE 149
IT'S NOT A SIMPLE MATTER TO OPTIMIZE BOTH PROTECTION AND POWER OUTPUT.

PROTECT THOSE EXPENSIVE POWER OP AMPS

Hybrid, power op amps can reliably deliver large power outputs as long as proper protection is carefully considered. Unlike their discrete brethren, in which individual components can be replaced relatively easily, proper protection represents a key factor in making these devices cost effective. A failure of just one component—within an amplifier in its hermetically sealed metal can—necessitates a new amplifier.

The challenge to the designer, then, is optimizing both protection and power output. Because amplifier limits are described by safe-operating-area (SOA) graphs, to which the protection circuits must be designed to adhere, the task isn’t as simple as it seems. Depending on the expected fault conditions, much of the amplifier’s apparent current or voltage capacity must often be sacrificed. In addition, the protection circuitry usually shouldn’t interfere with the passage of normal signals in any way.

Limiting output current is the most complex area to consider when designing amplifier protection. Either protection must be traded off against performance or a lengthy design involving more complex protection methods must be used. While current-limiting considerations are the most important aspect of power-amplifier protection, the amplifiers can also be overstressed by power supplies, the load itself, and even by input signals.

All power op amps are equipped with current limiting. In some, it is fixed internally to a single value. Others may have externally programmable current limiting. To fully protect an amplifier, it must be kept within SOA limits. The first task is to determine what constitutes the worst-case expected load fault (Fig. 1). For instance, must the amplifier tolerate shorts to either supply rail, or will tolerance of shorts to ground be adequate? The designer then refers to the SOA curves to determine where to set current limits (Fig. 2). The PA04 with its MOSFET output stage can handle more current at high voltage. Unlike the bi-

1. WHEN USING POWER op amps, designers must define whether worst-case load faults include shorts (dashed lines) to ground or to either rail. Extremely reactive loads or motor reversals can be equivalent to shorts to either supply rail.
polar output PA12, it has no secondary breakdown.

With resistive loads, the worst-case fault condition is likely to be a short circuit to ground. In a split-supply application, the voltage stress is then simply equal to one of the supply voltages, or half the total rail-to-rail voltage.

With a resistive load to ground in a single-supply application, ground is the negative supply rail. In this case, the voltage stress is equal to the total supply voltage rail-to-rail. The voltage stress also equals the total rail-to-rail voltage in split-supply applications with load faults to either supply rail—or when driving inductive loads.

Once the fault condition is defined, it’s up to the designer to ensure that the current is limited to a value, coincident with the voltage stress, that’s safe for the amplifier. What is safe depends on several other factors. In general, the dc SOA limit at 25°C should be some minimum value for amplifier protection. Realistically, however, such a limit can’t be sustained indefinitely due to the amplifier’s temperature rise.

By knowing the highest temperature the amplifier’s case will reach, due to both ambient temperature and dissipation, a completely reliable voltage stress can be selected along the dc SOA lines—generally at temperatures of 70°, 85°, and 125°C when available. While these lines don’t appear in figure 2, most amplifier SOA curves do supply them.

Using the bipolar output PA12 as an example, refer again to the SOA curves in figure 2 for the bipolar output PA12. Point 1 will be a safe current limit for shorts to ground. Point 2 will be safe for shorts to either rail or for reactive loads.

**LIMITED SAFETY**

Amplifiers with a fixed internal current limit are safe under a very limited set of conditions. In many applications, these amplifiers will not be safe even for short circuits to ground. However, external current limiting can be applied to any internally limited amplifier to meet SOA requirements under load faults (Fig. 3).

In this circuit, a biasing current is supplied to Q₁'s base at all times by R₁. The value of R₁ is determined by the minimum beta of Q₂ and the minimum supply voltage:

\[ R₁ = \frac{(V_s - V_{beq2})}{\beta Q₂} \]

where the \( V_{beq2} \approx 1.2 \) V.

The current limit is activated when the drop across \( R_{CL} \) is enough to turn on Q₁, so the current limit is equal to:

\[ I_{lim} = \frac{V_{beq1}}{R_{CL}} \]

where \( V_{beq1} \approx 0.7 \) V.

\( R₂ \) and capacitor C keep the current-limit circuit from oscillating.

Two of these current limiters are used, one between each supply rail and the op amp’s power-supply pins. A single-supply bridge circuit however, where one is confident that load faults will occur only between amplifier outputs and not to ground, can be protected with one current limiter in the positive supply line of each amplifier.

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CIRCLE 150
er to keep within their SOA. Though they’re simpler, all simple current-limit methods make great sacrifices in amplifier current-handling capability in the interest of reliability. It’s not unusual for a seemingly robust 10-A amplifier to be reduced to a 600-mA weakling in order to remain within the SOA under load-fault conditions. Point 2 in figure 2 represents the resulting capability of a typical bipolar amplifier, the PA12, when total load fault safety is a requirement. A MOSFET amplifier, the PA04 (also shown), indicates that while MOSFETs offer some improvement, by eliminating the secondary breakdown region, even simple power limits greatly reduce safe attainable currents.

**Foldback Limiting**

Unfortunately, amplifier manufacturers believe that designers will be attracted by the simplicity and reduced component count offered by amplifiers with programmable current limiting which use one external resistor. What actually is needed, however, is multislope foldback (or foldover) limiting.

As will be pointed out later, this technique requires not only a two-resistor current limit—but also free access to the bases of the current-limit transistors inside the op amp. That is the only way to get the flexibility needed to optimize both protection and power output.

Perhaps this obsession with reducing component count is the same trap that reliability people fall into: The higher the component count, the lower the reliability. This fallacy results in many power-op-amp failures because about a dollar’s worth of extra diodes to protect an unrepairable, $50 amplifier aren’t included. The effect of foldover limiting compared to fixed current limiting can be graphically illustrated with the PA12 (Fig. 4). The PA12 was selected because it features an internal, single-slope, foldover current limit. The coordinates of the graph, –5 A to +5 A and –50 V to +50 V, represent the limits of the combinations of output voltage and current attainable from a PA12 using a fixed current limit. The lines represent the SOA limits of the PA12. There are significant opportunities (operating points), however, to exceed the SOA. Making the circuit safe for a short to ground, or other load faults, requires a significant reduction in current available (from the supply).

To improve these limitations, foldover current limiting is added to increase the available current as the output swings closer to the rail that’s supplying the current. This equates to reducing current available as the output voltage approaches the opposite supply rail. Foldover limiting is often referred to as “load-line limiting” because it can be designed to conform to a specific resistive load.

Foldover limiting essentially “tilts” the output map so that it presents a better fit to SOA limitations (Fig. 5). The 10-Ω load line illustrates the power output ability of the circuit. This foldover limiting is built into the PA12 and PA10. This limiting is “activated” in split-supply applications by connecting pin 7 to ground.

In single-supply bridge applications, pin 7 should be returned to a low impedance (less than 2 kΩ) point at half the supply voltage. In single-supply applications with a load to ground (equivalent to a load to the negative supply rail), it’s feasible and probably desirable to connect pin 7 to ground. To reduce the slope of the foldover action, a resistor can be inserted in series with pin 7.

Two techniques can implement foldback current limiting: the subtractive and the additive (Fig. 6a and Fig. 6b, respectively). However, the...
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6. FOLDBACK SUBTRACTIVE current limiting is used inside the PA10 and PA12 power op amps (a). Additive limiting isn’t adaptable to any current power op amps (b).

additive approach doesn’t adapt to currently available power op amps.

The subtractive circuit obtains its foldback characteristic from the slight voltage divider effect of \( R_B \) and \( R_F \). As the output swings toward a supply rail, the divider effectively reduces the \( V_{be} \) drive available to the current-limit transistor \( Q_x \) from the current limit resistor \( R_{CL} \).

As the output swings away from a rail, the divider adds drive to the base of \( Q_x \). The technique increases the available current when the output is close to a supply rail, and reduces it when the output is away from a supply rail.

While the PA10 and PA12 are the only amplifiers currently available with foldover limiting built-in, the four-wire limiting on a PA04 lends itself to implementing foldover current limiting with two external resistors and a capacitor (Fig. 7). The capacitor prevents oscillation during current limit. The base resistor \( R_B \) is set to the same value as the base resistor in the previous example using the PA10 and PA12. The same equations apply with adjustments made for the value of \( R_F \).

An additional op amp adapts virtually any amplifier hosting an externally settable current limit to foldover limiting (Fig. 8). The high-voltage small signal IC on the right (such as a Harris HA-2645 or a National LM343), modifies the base-emitter voltage of the current-limit transistors, inside the power device, by driving their emitters through pins 2 and 8. The resistors \( R_B \) and \( R_F \) serve identical functions, and have identical values with their equivalents in the PA10 and PA12. No resistance should ever be located between the op-amp output and current-limit emitters. They would soften the current-limit transistors’ clamping action on the power-device base drive. Initially, \( C_1 \) and \( C_2 \) should be at least 100 pF, and then increased to the minimum value necessary to overcome any oscillations that occur during current limit.

There’s a maximum benefit which can be realized by using the single-slope foldover limiting built into the PA12, or the add-on universal foldover limiting. By referring back to the foldover-limiting output map, it can be seen that the current available at full output swing is twice that at zero-volts out (Fig. 6, again). Moreover, the current available when the output voltage is at the rail opposite the one supplying current is nearly 0.

This 2-to-1 relationship between maximum available current and the current for zero-volts out—is the maximum attainable with this basic method of foldover limiting. Setting \( R_F \) to too low a value will activate the opposite-side current limit before full output voltage swing has occurred, clamping any drive that would otherwise be available to swing the output voltage in the opposite direction. This then leads to a nondestructive latch-up in output voltage, which can only be recovered from by removing power.

\[ R_F = \frac{V_o}{0.7/R_B} \]

**REACTIVE LOADS**

Reactive loads require special consideration with foldover limiting. A reactive load in the circuit of figure 6 would have an elliptically shaped load line that may be difficult to contain within the SOA and the output characteristic map.

If it extends outside the limiting curve, current limiting and distortion will occur. Reducing reactance or raising current limits are the only solution. In addition, foldover current limiting with a reactive load will produce a sharp flyback pulse that mandates using external, ultra-fast-recovery flyback diodes.

It’s this limitation of foldover limiting that could make the designer wish that not only were two current
8. FOLDBACK CURRENT LIMITING can be adapted to virtually any power op amp by adding a high-voltage, small-signal op amp externally.

Limit resistors used, but that both current-limit device bases were brought out separately—and independently—of any other connections.

The foldover limiting techniques described so far have a single slope. But referring back to the output map of figure 6 and looking at the SOA lines, it indicates that a steeper slope of foldover limiting is acceptable in the regions where output voltage and current have the same polarity. In fact, the SOA regions are nonlinear on the output map, suggesting a multislope foldover can offer an even better fit.

Multislope foldover can only be implemented if the current-limit transistor bases are separated both from each other and from the output transistors. No currently available power amp lends itself to this arrangement. However, the technique can be used if you’re building power boosters for available amplifiers—or are building your own power op amps from scratch.

The most basic multislope technique is a two-slope method offering a steeper foldover characteristic as the output passes through zero (Fig. 9). \( R_B \) serves the same function as in typical current limiting. Depending on output polarity, diodes \( D_1 \) and \( D_2 \) provide different values for the resistance \( R_F \). Looking at the positive limiter for instance, when the output voltage swings positive, \( D_1 \) is forward biased, and the value of \( R_F \) is equivalent to \( R_1 \). During this interval, \( D_2 \) is reversed biased and \( R_F \) for the negative limiter is equal to \( R_2 + R_3 \). If the output swings negative, \( D_1 \) is off and \( D_2 \) is forward biased. Now the positive current limiter \( R_F \) is equal to \( R_1 + R_2 \).

This problem can be solved by adding yet another breakpoint in the foldover curve.

In a three-slope foldover circuit, the first break occurs around 0 \( V \) out with the activation of either \( D_1 \) or \( D_2 \), depending on output signal polarity (Fig. 10). At a higher output voltage, either Zener diode \( DZ_1 \) or \( DZ_2 \) turn on to further reduce the effective value of \( R_F \). This three-slope foldover offers the best fit yet to the amplifier SOA. A totally independent circuit is used on both halves of the multislope limiting to avoid any possible interaction that could latch-up the amplifier.

HEAT’S THE ENEMY

The destruction of an amplifier’s power transistors is first and foremost a function of temperature. For a MOSFET operated within current and voltage limits, failure is only a function of temperature. Therefore sensing power device temperature is an essential element to any ideal protection scheme. It’s currently used on several power op amps and power transistors. The Apex PA03 and the National LM12 are both equipped with power-output-device temperature sensing.

Power-die temperature sensing should not be confused with the thermal shutdown available on many power and high-voltage op amps, such as the Apex PA80 series high-voltage amplifiers and PA21 and PA07 power amplifiers. The most common form of thermal shutdown is a slow-action case temperature-sensing system that protects amplifiers from excessive temperatures. However, it doesn’t provide load-fault protection.

The Apex PA03 is an example of a hybrid realization of power-die temperature sensing. It’s accomplished by mounting a small-signal temperature-sense transistor directly on top of the power die. This intimate thermal sensing acts rapidly enough so that when the op amp is operated within proper voltage limitations, it’s fully protected from load faults. This output-transistor temperature

9. WITH TWO-SLOPE, FOLDBACK current limiting, the diodes let \( R_1 \) and \( R_2 \) set the current limits at low currents. Their combination with the resistance of \( R_2 \) sets the current limit at high currents.
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sensing is coupled with a package-temperature sensor that thermally shuts the whole PA03 down in the event of sustained excessive package temperatures.

Though thermal sensing is the most sophisticated form of protection, it does have its peculiarities. It is not a "clean" form of limiting, and can result in odd-looking waveforms when it becomes activated. Due to secondary breakdown, thermal limiting becomes less effective as higher voltages are used with the currently available bipolar power output stages. Secondary breakdown creates isolated "hot spots" on a die that can escape sensing by the thermal protection. This causes thermal runaway, destroying the power device.

Yet to be seen is a power op amp combining MOSFET outputs with thermal sensing. Without secondary breakdown limitations, thermal sensing should be very effective with MOSFETs. In theory, a MOSFET develops a hot spot, the local on-resistance rises, shifting the load into the lower resistance remainder of the MOSFET.

In the process, the thermal load is spread. Moreover, tests of prototypes of the 90-V (rail-to-rail), 20-A PA77 (the first power op amp with MOSFET outputs and thermal protection), indicates that the theory holds. The device stands up under continuous shorts to ground while trying to put out maximum voltage (it will be out early in 1991). Final proof will have to wait until the Apex PA77 becomes available.

Operating a power op amp within an SOA doesn't eradicate all of the possibilities of destroying it. For example, any time current is interrupted in inductive or even partly inductive loads, a flyback kick will be generated. This kick will reach whatever voltage level is necessary to maintain current flow—and will apply it to the amplifier's output.

Most amplifiers with built-in flyback diodes (for protection from inductive kicks) use the substrate diode of their output transistor. In bipolar devices, these substrate diodes are slow, their continued use is inefficient, and it generates heat. Consider also that certain loads, such as brush-type DC motors, have a continuous interruption of current flow due to commutation. This produces a continuous train of kickback pulses that, averaged over time, can cause power-device failure.

The need for external flyback diodes was discussed in connection with inductive loads and foldover current limiting. Anytime inductive loading is expected, external flyback diodes are an inexpensive reliability enhancement. Ideally, these diodes should be ultra-fast-recovery types, but fast recovery or standard recovery is often better than none at all.

Power-supply transients are another source of amplifier overstress. In fact, adding flyback diodes merely couples flyback pulses into power supply lines—it's usually assumed that the power supply has the storage capacity to absorb them. If the only energy storage on the power supply is a large electrolytic filter capacitor, its high series inductance won't absorb extremely fast transients. A regulated power supply isn't a guarantee of safety either. Most regulated supplies are excellent current sources and lousy current sinks.

Ultimately, the only protection from power supply transients is Zener-diode transient suppressors. No other type of transient protection is fast enough. The Zeners must be rated below the amplifier maximum rating, but greater than the expected maximum supply voltage. Unregulated supplies where this transient protection is mandatory often neces-
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CIRCLE 103
Protecting Power OP Amps

The need to keep an amplifier's inputs within the supply rails generally falls under the heading of common-mode protection of amplifier inputs. This is in contrast to differential-mode protection considerations. Differential-mode input protection is easily implemented with the diode clamps shown between amplifier inputs. With FET input amplifiers (when the low bias current of the FET is important to the application), these may need to be low leakage diodes. Alternatively, if high slew rates are important, multiple diodes may have to be used in series to allow for overdrive.

There are many opportunities to develop excessive differential-input over-stress. Essentially, it can occur any time an op amp becomes nonlinear, such as during clipping or slew-rate limiting. Paths for input over-stress may be difficult or impossible to find. These include breakdown paths through circuit board material in high-voltage circuits.

Figure 11 shows schematically some of these final details of amplifier protection. D1 and D2 provide flyback protection. D3 and D4 provide supply transient and reversal protection. D5 and D6 offer differential-mode protection for the amplifier input. D7 and D8 represent an example of another type of common-mode protection most often used on noninverting circuits and required on the non-inverting input only.

Not all of these protection methods are always needed. But until the designer knows just what isn't necessary, there isn't such a thing as too much protection. It may seem like a lot of additional componentry just for protection. But only a few dollars worth of additional diodes and components are invested to protect amplifiers that could cost up to $300–$500. Don't fall into the mental trap of taking it for granted that reduced component counts and reliability always go together.

Jerry Steele, a senior applications engineer with Apex Microtechnology, has 15 years of experience in electronic engineering, application engineering, and seminar presentations.

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Capacitance or cable loads with currents of 100 mA can be driven by an amplifier circuit that has over 20 MHz of small-signal bandwidth. The circuit's input capacitance is below 1.5 pF, bias current is about 100 pA, and the output is fully protected. These features make this amplifier suitable for use as an automatic-test-equipment (ATE) pin amplifier, a video analog-to-digital converter input buffer, or a cable driver. The circuit also permits wideband probing when oscilloscope probing isn't tolerable.

The overall amplifier consists of a low-input capacitance FET, two LT1010 buffers, and a gain stage—Q3 and Q4 (Fig. 1).

A3 acts as a dc restoration loop. The 33-k resistors sense A1's operating current, biasing Q3 and Q4. These devices furnish complementary voltage gain to A2, which supplies the circuit's output. Feedback is from A2's output to A1's output, which is a low impedance point. The "current-mode" feedback permits fixed bandwidth over a wide range of closed-loop gains. This contrasts with typical feedback schemes where bandwidth degrades as closed-loop gain increases.

A3's stabilizing loop compensates for large offsets in the signal path, which are dominated by a mismatch in transistors Q3 and Q4. A2 measures the dc difference between the amplifier's input and its output and biases the signal path to correct for offset. Correction is implemented by controlling Qi's channel current through Q6. The channel current sets Qi's VGS, enabling A3 to control overall circuit offset. The 9- to 1-kΩ divider that feeds A3 is selected to equal the gain ratio of the circuit, in this case 10.

The feedback scheme makes A1's output look like the amplifier's negative input, with closed-loop gain set by the ratio of the 470- and 51-Ω resistors. The outstanding feature of this connection is that the bandwidth becomes relatively independent of closed-loop gain over a reasonable range. For this circuit, small-signal bandwidth exceeds 20 MHz over gains of 1 to 20. The loop is quite stable, and the 10-pF value at A2's input supplies good damping over a wide range of gains.

Large signal performance can be seen at a gain of 10 when driving 10 ft. of cable (Fig. 2). The response displayed at the output is quick and clean and has no slew residue or poor dynamics.

**IFD Winner**

**IFD Winner for September 27**

David Johnson, 10198 W. Berry Dr., Littleton, CO 80127; (303) 973-8408. His idea: "Convert Waveform Period To Voltage."
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The new MAN-amplifiers series... another Mini-Circuits' price/performance breakthrough.

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†Midband 10f1 to f2, ±0.5dB  †dB Gain Compression  †Case Height 0.3 in.
Max input power (no damage) +15dBm; VSWR in/out 1.8:1 max.
*Active Directivity (difference between reverse and forward gain) 30 dB typ.

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IDEAS FOR DESIGN

CIRCLE

522

RELAY SELECTS BETWEEN TWO LEDs

JOHN DUNN
Centroid Inc., 3 Aerial Way, Syosset, NY 11791; (516) 822-4770.

If two LEDs must be switched on a front-panel display using only an SPST relay, this circuit proves quite useful. LED1, in series with the 1N4148 diode, is lit if the switch is open (Fig 1). When the switch closes, LED2 lights. LED2's forward voltage drop is too low for current to flow through LED1 and the 1N4148, turning off LED1. In this alignment, the current (in mA) passing through the two LEDs is:

\[ I_{LEDD} = \frac{5 - V_{LED}}{330} = 10.6 \]

If the differing currents flowing through the LEDs cause an objectionable difference in brightness, the currents can be equalized by using a current source (Fig. 2). Now,

\[ I_{LEDD} = \frac{5 - V_{LED}}{330} = 8.79 \]

The differing forward voltage drops of the two LED paths won't affect the value of current injected into them by Q2. □

CIRCLE

523

BUILD SIMPLE 32-BIT PATTERN GENERATOR

MICHAEL A. WYATT
SSO Honeywell Inc., MS 931-4, Clearwater, FL 34624; (813) 539-5653.

A simple 32-bit pattern generator with four 8-bit shift registers can operate at high speeds. The four registers comprising the 32-bit parallel-to-serial converter—U8 to U5—are connected in series (see the figure).

Each shift register receives its eight parallel inputs from DIP switches S1 through S4, which set the 32-bit pattern to be shifted out serially after the parallel load (SH/LD) goes low. A parallel load is initiated by pressing the Load pushbutton, which causes U1B and SH/LD to go low. The 0.1-µF capacitor connected to U1B's input eliminates chatter caused by the Load pushbutton switch. Cyclic pattern output is achieved by feeding the last shift register's output (U5) back to the first register's serial input. As a result, data is continuously cycled through the four shift registers.

Each data bit is shifted on the falling edge of the clock input.

Data Output is taken from the serial input of the first shift register (U0) and buffered by the parallel combination of U1D, U1E, and U1F. The three 140-Ω resistors and the parallel gates form a high-speed 50-Ω driver for Data Output. Data phase can be inverted with switch S5.

This design comes in handy when used with digital communications, and it can operate beyond 10 Mbits. Higher-speed operation could be achieved by replacing the 74HC165 and 74HC14 chips with a faster logic family. If different data-pattern lengths are desired, adding (or removing) additional shift registers is all that's required. □

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CIRCLE 155
IDEAS FOR DESIGN

THIS 32-BIT PATTERN GENERATOR uses four DIP switches at its input. Each switch sends eight parallel signals to the four shift registers. A parallel load of the registers is initiated by pressing the Load pushbutton. By feeding U₅'s output back to U₂'s serial input, a cyclic pattern is achieved.
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ASIC Tools?

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CIRCLE 85
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CIRCLE 116
WHAT'S ALL THIS RZAMBLE STUFF, ANYHOW?

Sometimes I go on hikes with my sons and my wife. Sometimes I go on hikes without them; sometimes they go on hikes without me. Here in Northern California, just in the San Francisco Bay area, there are many dozens of parks, and many hundreds of miles of trails in these parks.

Sometimes my wife leads a hike for the local chapter of the Sierra Club. Sometimes my son Benjamin (age 25, he has a full Red Cross certificate and I don’t, so I am not eligible to lead hikes) leads the same hike. I have been on some of their hikes. What they amount to is a Ramble. Sometimes I go on hikes with amusing. Art Hoppe is another. I have big thick envelopes full of columns by Stanton Delaplane and Charles McCabe who wrote for the Chronicle for many years, but they died a few years ago. I must say, I have always been impressed with people who can assemble a few hundred words, every 14th day, and I must admit, that ratio of 14:1 or 10:1 is a huge difference. I maintain an awesome respect for people who can put out a column every day.

When I took on this project, I knew immediately that if I had to meet a deadline, I would be in deep trouble. So, I would have to write a whole bunch of columns, and get way ahead of the game. Fortunately, I have had a little help from my friends, and I think I’m ahead of schedule—thanks to Frank Good enough, ELECTRONIC DESIGN’s editor in Boston. I have been encouraged and am making good progress at keeping ahead. I’m sure if I start to fall behind, Frank will chew on my ankles and get me straightened out.

How can I crank out all these words? Well, it helps to have a decent word-processing machine to write on. Why am I typing this on an IBM-compatible Personal Computer (made by Compaq)? Well, I own an old Coleco ADAM word-processor at home and it works perfectly adequately for writing memos and letters. But, it’s not set up to transmit text encoded in ASCII, neither by modem nor by floppy, to Frank Goodenough in Boston or to the editors back in New Jersey. So I have this IBM-compatible machine, with processing by PC-Write-Lite* from Quicksoft, which works pretty well.

And while I’m a great fan of analog computers, I must say they’re not terribly successful at saving and storing and transmitting text. I once set up a pair of voltage-to-frequency converters to put the X-Y coordinates of some letters and words onto a stereo cassette recorder. It did work. I was able to store the words. But the resolution was marginal, the throughput rate was awful, and the amount of tape to store 100 words would be absurd.

And when we played it back, using a brace of frequency-to-voltage converters and a pen-plotter, the words and letters were shaky due to the jitter and wobble and wow of the time-base of even the best (analog) audio tape recorder. So, I’m not going to even try to use an analog-computer word processor—even though it’s not absolutely impossible. I’ll use one of these new-fangled digital word-processors (which is not yet as user-friendly as my old ADAM) and plunk down my words. It works, and I don’t gripe much about things that work.

What I really want is a word processor like that new Super Food Processor: You can feed in a 2 X 4, and the processor will grind it up into sawdust. Then you can put the sawdust into its hopper, and it will extrude them out into a rigid 2 X 4.

I just want to be able to do that with words, too!

All for now. / Comments invited! / RAP / Robert A. Pease / Engineer

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*PC-Write-Lite, available for $79 from Quicksoft Inc., 219 First Ave. N #224, Seattle, WA 98109—a very reasonable price, and a plausible, darned-nearly user-friendly piece of software. I recommend.

p.s.—Herb Caen just announced in June that—after 52 years in the game,—he’s going to cut back from 6 columns to 5 columns per week. That’s still a huge number of words per week. But, no more “Sunday columns” from Herb Caen.
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CIRCLE 181
The market for surface-mounted technology manufacturing equipment is growing at more than 24% a year. Last year, 27,800 units of SMT manufacturing equipment were shipped. This equipment was worth $1.3 billion, according to the Market Intelligence Research Corp. (MIRC). Most of the equipment revenue comes from placement equipment, which accounted for about 45% of world revenue in 1989. The Mountain View, Calif., market researcher predicts that the total market will grow to $4.6 billion by 1996.

The largest user of SMT manufacturing equipment is the computer industry, which, along with the consumer electronics segment, accounted for about half of equipment sales in 1989. Fastest growing are the telecommunication and aerospace sectors. SMT boards meet requirements for high-performance, I/O intensive jobs in these areas. SMT boards also meet the tough thermal and reliability demands for these applications.

Look for big changes in inspection equipment, where manual inspection is being replaced by powerful but costly automatic optical systems.

As in other areas of electronics, users are demanding standards that do not limit them to proprietary products from one vendor. Establishing SMT standards also would help U.S. companies develop products that are internationally competitive.

A free newsletter offers tips on working with Spice. Intusoft Newsletter discusses the modeling of pulse-width modulators, with diagrams and program listings. Contact Intusoft, P. O. Box 6607, San Pedro, CA 90734-6607; (213) 833-0710; fax (213) 833-9658.

Data-acquisition tasks are falling to PCs these days. To cope with such issues as connection of thermocouples and various types of hardware, Dianachart Inc. offers a free 66-page booklet, "How to Measure with your PC," along with a demo disk. Also covered: thermists, strain gages, and pressure transducers. Systems are described for portable measurement, rack mounting, high speed, and data-acquisition workstations. Contact the company at 101 Round Hill Dr., Rockaway, NJ 07866; (201) 625-2299.

As numeric coprocessors become more popular so grows the need for arithmetic standards for consistency and accuracy. Cyrix Corp., Richardson, Tex., is offering a free test suite to check coprocessors for conformance to the IEEE standard for 80-bit arithmetic (IEEE 754-1990).

The test, developed at the University of California at Berkeley, evaluates performance in all data formats supported by 386-based PCs. For a free disk, contact the company at 1850 N. Greenville, Suite 184, Richardson, TX 75081; (900) 327-6284.
HOT PC PRODUCTS

Windows have been out of reach for PC users working with 640k, XT machines—Windows 3 works best on 386 machines with 2 Mbytes of RAM [Quick Look, Nov. 8, 1990, p. 119]. Now users of lower end machines can have their graphical user interface and keep their hardware too. With a street price of about $150, GeoWorks Ensemble offers a multitasking environment and seven integrated applications. Ensemble runs with 512k RAM, a hard disk, mouse, and graphics—Hercules, CGA, EGA, VGA, or MCGA. It complies with the OSF/Motif GUI.

The environment's operating system supports object-oriented programming, multitasking, WYSIWYG printing, and virtual memory management. Ensemble includes a word processor with outline fonts and page-layout capabilities, an object-oriented drawing program, file manager, address book, and phone dialer.

For more information contact the company at 2150 Shattuck Ave., Berkeley, CA 94704; (415) 644-0883; fax (415) 644-0928.

Now there's a way to save designs hatched on blackboards without recopying them by hand. From Quartet Manufacturing Co., the Ovonics Electronic Copyboard combines proprietary sensors with an erasable white board. Its porcelain, enamel-on-steel surface suits it for plants or other industrial environments. An electronic scanner feeds digital signals into a printer that can produce multiple copies of the material written on or attached to the board's surface. Prices start at about $3100.

For more information, contact the company at 5700 Old Orchard Rd., Skokie, IL 60077; (708) 965-0600.

Icoh Corp. says it has come up with the world's smallest fax machine. So the PF-1 portable fax takes its place among other achievements recorded in The Guinness Book of World Records for 1981. The portable fax has dimensions of 11 by 7 by 2 in. and weighs 5.5 pounds.

For better accuracy with a cellular phone, the fax has built-in error correction. It works from a car's cigarette lighter, a rechargeable battery pack, or a wall outlet; list price is $1,695. Contact the company at 5 Dedrick Pl., West Caldwell, NJ 07006; (201) 882-2000; fax (201) 882-2506.

DID YOU KNOW?

... that the investment climate for high-tech start-ups is cooling off. Venture capital investments in high-tech companies dropped to $249 million in the third quarter of last year. That's a 14% decline compared with the $290 million worth of venture-capital investments that were made in the third quarter of 1989.

Technologize Computer Letter

...Perspectives on Time-to-Market

BY RON KMETOVICZ
President, Time to Market Associates Inc.
Cupertino, Calif.; (408) 446-4458

Organizations that don't plan adequately may find themselves in a new-product development situation like the one described in the Jan. 10 column (beginning development without a planning phase). To improve time to market, these companies must change the way they operate. The good news is that most of the techniques and tools needed to make the transition are readily available and can be obtained for relatively low cost.

You need not equip your entire product development team with the latest project management software to produce quality results. Following the process described below produces excellent results quickly and at minimal cost.

The modeling portion of the process works like this: Members of the product development team are sought out for input on their part of the project where they provide information on aspects of the project's hierarchical decomposition, milestone sequence, task list, task-duration estimates, suggested task resource assignments, and task networks. Information must be collected horizontally and vertically throughout the organization—the final network model should be the collection and summation of individual plans with appropriate intragroup and cross-functional linkages built into the model. People can model their work activities using simple manual tools while developing and refining their estimation and network modeling skills. I've found that a calendar, paper, a pen or pencil, and Post-its make an excellent tool kit. Once complete, the results produced by individuals and functional teams are entered onto a computer for integration and analysis.

Hierarchical production of the model builds confidence in the results. And it gives managers and supervisors the opportunity to interact with team members in creating the model's structure and information content.

<table>
<thead>
<tr>
<th>Definition estimates</th>
<th>Computer tools</th>
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<tr>
<td>Resource allocator</td>
<td>Database creation</td>
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<td>Data analysis</td>
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<td>Comparison</td>
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<td>Project targets</td>
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<td>Reports and charts</td>
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he new tax legislation recently signed into law by President Bush could affect engineers' investment portfolios as well as their wallets. That legislation eliminated the 33% marginal tax bracket and replaced it with a new 31% federal tax bracket.

Engineers could end up paying taxes at an effective rate even higher than 31%. Certain provisions phase out personal exemptions and reduce itemized deductions for higher income taxpayers. As a result, some engineers in the 33% bracket may not see any tax cut at all. High-income engineers formerly in the 28% bracket may find themselves in the 31% "plus" bracket.

If you are one of the many engineers who face a tax increase next year, municipal bonds should be more attractive to you than ever before. Since almost all municipal bonds are exempt from federal taxation, the prospect of higher federal taxes makes them more practical. As tax rates rise, tax-exempt income becomes more attractive. Similarly, to remain competitive, the yield needed on a taxable investment would have to rise to provide the same after-tax return as a municipal bond.

Consider, for example, an engineer in the new 31% marginal federal income tax bracket. He or she will have to earn 10.14% from a taxable investment to provide the same after-tax return as from a tax-free municipal bond yielding 7%.

A municipal bond is simply a promissory note issued by a municipality, state, or local government. The government issues bonds to borrow money for any number of reasons: a new road, a school, sewer line, or courthouse. The promissory note states how long the local government has to repay the loan, and the amount to repay and the interest rate for use of the funds. The government must repay the loan, the amount to repay, the interest rate for use of the funds.

Besides the increase in federal tax rates, many states have increased their tax rates or may be forced to do so in the future. Generally, municipal bonds issued by the holder's own state are exempt from state and local taxes. Therefore, if you face a high tax rate, consider municipals issued in your home state.

In addition, engineers who do not need the income can choose municipal zero coupon bonds for funding a future investment goal such as a child's education or retirement. The interest income from tax-free municipal zero coupon bonds grows tax-free, allowing a small investment today to benefit from the powerful compounding effect of interest being earned on interest until the bonds mature. Since tax planning is an important consideration in making investment decisions, the engineer should discuss this particular situation with a professional tax adviser. However, the recent tax increase does make municipal bonds more appealing to many taxpayers. If interest rates fall during 1991 this may be the time to lock in high tax-free yields.

If you'd like a free copy of Municipal Bonds—Now More Than Ever, a Shearson Lehman Brothers publication, call or write to me at the address below.

Henry Wiesel is financial consultant with Shearson Lehman Brothers, 1040 Broad St., Shrewsbury, NJ 07702; (800) 631-2221 (U.S.) or (800) 221-0073 (N.J.) He is also a qualified pension coordinator. Wiesel invites questions and comments, which should be addressed to him c/o the news editor.

From Integrated Circuit Engineering Corp. comes a chart showing the top 10 merchant semiconductor suppliers in 1990. The Scottsdale, Ariz., company also displays sales figures for four companies close to ranking among the top 10. Intel Corp. has the highest growth rate—20%—which helped propel it from eighth place in 1989 to fifth place in 1990. Intel's growth spurt stems from its sole-sourcing of the 80386 microprocessor, ICE says.

<table>
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<tr>
<th>RANK</th>
<th>COMPANY</th>
<th>1990 IC SALES ($M)</th>
<th>1990 DISCRETE SALES ($M)</th>
<th>1990 TOTAL SEMI SALES ($M)</th>
<th>1990/1989 PERCENT CHANGE</th>
<th>1990 PERCENT MARKETSHARE</th>
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PERCENT OF WORLDWIDE TOTAL

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<th>1990 DISCRETE SALES ($M)</th>
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CIRCLE 117
• A USER’S GUIDE TO
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• MANUFACTURER’S
  LISTINGS
• NEW PRODUCTS
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New Technology Shrinks 500 Watt Power Supply

TODD’s MAX-500 switchers pack 25% more power into TODD’s 400 watt package size (11.5” x 5” x 2.5”). The series incorporates a new SMT circuit, newly-available components, improvements to TODD’s VERI-DRIVE current-fed inverter topology, monocoque construction, and a high efficiency FLUX-GATE switching mag-amp auxiliary post regulation. Result: higher performance, higher reliability (approaching 100,000 hours MTBF) and lower cost.

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TODD has just released its 1991 switching power supply catalog of over 100 standard switching power supplies ranging from 150 to 1000 watts, including several new products. Available in single and multiple outputs, ac to dc and dc to dc, these switchers meet a broad range of requirements for telecom, computers, industrial controls and medical electronics applications.

The catalog also provides details on TODD’s approach to quality and innovative manufacturing, and capabilities for producing modified, repackaged and fully custom switching power supplies.

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TODD’s DC to DC converters provide up to 350 watts from 48 volts DC input. Designed as companion units to TODD’s standard line of AC input power supplies, they are fit, form, and function compatible with the MAX-350, MTC-250, MTC-350, and certain single output redundancy, replacing one “shoebox” switcher with two MAX-750’s in the same space.

The small package size, high power density of 4 watts/in., high peak current for motor starting, and cooling options, make the MAX-750 the power supply of choice for VMEbus systems, workstations, file servers and mini-computer systems. The switcher provides 120 amps of ±5 volts for logic and memory, and features up to three auxiliary outputs providing high efficiency, tightly regulated 12 volts or ±5.2 volts at up to 20 amps. Designed for world wide use, the series offers AC power fail, AC auto-line select, and meets International Safety standards and Class A RFI requirements of FCC and VDE 0871.

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More information on these and the full line of TODD Switching Power Supplies can be obtained in EEM File 4000, by circling the response card numbers, or by contacting:

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FAX (516) 231-3473
A User’s Guide To Applying Power-Conversion Modules

Today’s High-Density Modules Call For Some Attention To Design Detail.

By Charles E. Mullett

Mullett Associates Inc., 5301 Beethoven St., Los Angeles, CA 90066; (213) 306-4075

The effects of present-day power-conversion modules on the electrical- and electronic-product manufacturing industries have been significant and positive. Small, efficient dc-dc converters not only make products more compact, but also drastically reduce the non-recurring cost and time-to-production elements of system manufacturing.

Product and system manufacturers now have a new way to build a power supply for their products. They can design their own system-power supplies with dc-dc converters and get into production months earlier and for tens of thousands of dollars less than required for a typical custom design.

High-density dc-dc converters are typically less than 0.5 in. tall and have a footprint of about 2.5 by 4.5 in. In this size range, typical power-handling capability is 100 or 200 W, which implies power densities as high as 35 W per cubic inch. Conversion efficiencies are typically above 80%, which is a requirement for reasonable heat management. They are, however, dc-input devices. They can be used within ac-to-dc power supplies, but doing so requires adding at least a rectifier or filter at the input. This reduces the power density, of course, but the overall result still is very good. Higher power (above 200 W) can be achieved by connecting the modules in master-slave configurations or by adding current-sharing circuitry to the design.

A representative module schematic looks like one of a typical dc-dc converter—which it is (Fig. 1). However, it operates at high frequency (usually over 200 kHz) and is packaged with state-of-the-art techniques to minimize size and optimize thermal performance. The simplest application is a single-output dc-to-dc power supply. In this case, the design task may be nothing more than prescribing a mounting and connection scheme for the module. Most modules will operate without heat sinks at a small fraction of their maximum power limit. To get the most out of these modules, however, a well-designed heat sink is mandatory.

Most OEM power-supply requirements are for multiple outputs. Although most modules are single- or double-output types, they come in many shapes and power levels, which makes them well-suited for multiple-output applications. For example, a triple-output power supply with outputs of 5 V at 10 A, +15 V at 5 A, and −15 V at 10 A would be difficult to find in an off-the-shelf switching power supply. That’s because the +15-V output currents are usually small compared to the 5-V current. With modules, one can mix and match the units to fit the requirements of the application and not waste space and cost on capability that’s not needed.

An advantage of this approach is that the output capability of the +15-V outputs is independent of the load on the 5-V output. In most triple-output switching power supplies, this isn’t the case: The 5-V output must have a minimum load to allow a heavy load on the other outputs.

A further advantage is that the noise and regulation performance of the +15-V outputs can be vastly different from that of the 5-V output if necessary. In addition, there’s inherently more isolation (less crosstalk) between the 5-V output and the other outputs. This can be an
important consideration in precision analog applications involving digital circuitry.

Most applications involve conversion from ac mains to various dc voltages within electrical and electronic equipment. These require a front-end circuit, which delivers acceptable voltages to the modules. In many cases, this circuitry is quite similar to the modules. In many applications, this may be all that's needed. The design task, then, is in choosing the rectifier and capacitor carefully.

The modules usually have a specified ripple-attenuation characteristic, wherein a given amplitude of ripple at the input will produce a specified amount of ripple at the output. The right input capacitor ensures that the output ripple is acceptable. The capacitor's ripple-current rating must also be checked against predicted or actual ripple-current measurement to be sure that the capacitor isn't overstressed by the application.

Higher-power applications usually require inrush current limiting and perhaps some EMI filtering at the input. Power-factor correction may also be desirable. Inrush limiting enables the energy-storage capacitor, which follows the rectifier, to charge gently when the input switch is closed. The result is reduced stress on the switch and other components. It also avoids tripping circuit breakers or blowing the input fuse.

The primary purpose of the EMI filter is to reduce the amount of high-frequency noise coupled from the switching converter to the mains. Without this filtering, the power converter may cause interference with radios, television sets, and other EMI-sensitive electronic appliances.

Power-factor correction allows more useful power to be drawn from the mains by shaping the input current to match the sinusoidal shape and phase of the input voltage. The power-factor-correction circuit usually supplies wide-range input as a fringe benefit, which permits the unit to operate on mains voltages from 90 to 260 V ac without setting a switch or jumper for the appropriate voltage range (Fig. 3).

Systems requiring over several hundred watts are often candidates for distributed power conversion. This is particularly true when the power is mostly at low voltage (implying high current) and the load is spread out over a rack chassis or one or more cabinets.

With distributed power conversion, the power can be conveyed to the loads at higher voltage (and lower current) and then regulated by individual converter modules at the load locations. As a result, each load site receives clean, well-regulated power. Moreover, power distribution at lower current makes the job much easier and less critical.

The most common approach to distributed power conversion with input from the ac mains begins with a simple rectifier and filter to produce a dc bus that feeds the modules. The rectifier is a four-diode bridge, configured as a half-wave doubler for 115-V ac inputs and as a full-wave bridge for 230-V ac inputs (Fig. 2, again). The distribution bus is the natural voltage that appears after the rectifier, which, in both cases, is 320 V dc. This scheme has the advantage of simplicity—only a rectifier is required at the input. Furthermore, the current is relatively low. The disadvantage is that the voltage is dangerously high and may require special insulation for safety's sake.

By adding a step-down converter or ac-to-dc power supply at the input, the bus voltage can be made compatible with a backup battery (Fig. 4). Here, the battery is charged while the mains voltage is present, and then is switched to the bus when
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line failure is detected. The switch connecting the battery to the load can be opened before the battery discharges to an unacceptably low level. The switch also allows the charging voltage to rise above the bus voltage to ensure full charge. This type of uninterruptible power supply, known as a dc UPS, is simpler than an ac UPS, which provides an uninterruptible ac input to the system. The dc-UPS technique is very useful in instruments, computers, communication equipment, and so forth.

In some cases, the required power exceeds the maximum power available in one module, and yet the demand is concentrated at one location rather than distributed over a chassis or rack. Such applications can be satisfied by adding booster modules, which are connected in parallel with the master module. Other connections between the modules pass synchronization and regulation signals from the master to the slaves. Boosting can also be provided by paralleling two or more identical modules.

Current sharing, however, isn't automatic in most cases. Either the modules must have this feature built in (most don't), or it must be added outside the modules. Current-sharing circuitry must monitor the current from each module and cause these currents to be equal. At the same time, it must maintain proper control of the output voltage.

In one possible current-sharing scheme, each module's output is "trimmed" by applying an adjusting signal to the trim pin (Fig. 5). The circuit, which is appended to each module, is comprised of a conventional dual op amp (U1), a precision reference (VR1), a current-sensing resistor (R1), and an optional isolation diode (CR1). Typically, a group of these circuits is placed in parallel. Among them, one will have its reference and voltage-sensing circuit set for a higher voltage than the others, and will command the voltage on the current-sharing bus. This, in turn, equalizes the current in each module by demanding that the same voltage appear across all of the sensing resistors. Consequently, the currents will match within the tolerance of the resistors.

There's growing interest in systems that tolerate internal failures and continue to function normally. Such systems must have a power system at their heart that performs in the same manner. The usual approach is called n+1 redundancy, which means there are n+1 modules sharing the load (n is the number required to satisfy the load requirement). In such a scheme, one module may fail without compromising system performance as long as the failure doesn't damage or overload the common power bus.

A natural accompaniment of n+1 redundancy is "hot swapping," which means modules can be removed and replaced while the system is powered up. Without this feature, the system would have to be shut down to repair the fault. That would compromise the spirit of the fault-tolerant feature.

Although hot swapping is conceptually simple and would seem to be inherent in an n+1 redundant system, it's not so simple in practice. One reason is that capacitors appear at the output. This can cause issues during hot swapping, as the capacitance can affect the system's stability.

In conclusion, power-conversion modules are crucial components in modern electronic systems. They ensure that power is delivered reliably and efficiently, even in the face of failures or changes in demand. The ability to share current and tolerate failures is an essential feature in many applications, and the techniques for achieving this vary depending on the system's requirements.
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module inputs and outputs as well as on the load bus. Another is that the control loops must gracefully survive the transient that occurs when the replacement module is installed.

The problem can be illustrated simply (Fig. 6). Before module number 3 is installed, its output capacitor is discharged. All other capacitors on the bus are charged to the bus voltage. When the capacitor of module 3 contacts the bus, a huge transient current flows into it and a voltage transient occurs on the bus. If the modules are few and the module capacitance is comparable to the load capacitance, this transient can be large enough to upset all of the logic circuits served by the bus.

Obviously, this is a serious problem, but there are two possible solutions. One is to precharge the output capacitor of module 3 as it is inserted (Fig. 7a). The other is to place a diode in series with each module output (Fig. 7b). The latter approach has the disadvantage of power loss in the diode (with its attendant heat dissipation) and the advantage of isolating any faults at the failed module's output.

For example, if the output capacitor in a module fails as a short circuit, the diode prevents it from pulling down the power bus and interfering with system operation. After the module is inserted, the converter circuit turns on and the output rises smoothly according to its soft-start circuitry, perhaps as a 100-msec ramp up to the output-bus voltage. If the ramp rises slowly compared to the loop-response time of the other modules, the new module will not upset the bus voltage.

Heat generated by the modules is typically removed by mounting them to a cold plate or finned heat sink that's cooled by moving air. The design problem is similar to choosing a heat sink for a semiconductor. Excellent guidelines are supplied in the application information provided by the heat-sink manufacturers.

The economy of power modules has improved considerably because of higher power densities and new automated manufacturing techniques. Putting more power capability into a small package reduces the overhead costs per watt. For example, housing cost for today's 200-W modules is comparable to that of a 10- or 20-W module in the past. Packing and shipping costs follow the same example. Because the circuit complexity of a 200-W module compares to that of the smaller modules, assembly costs are much less on a per-watt basis. The result is that new-generation modules significantly reduce cost in terms of dollars per watt. Present pricing for production quantities is in the area of $0.50 per watt, compared to $1 to $2 and more per watt in the past.

The new modules, then, are more economical than earlier generations. But how do they stack up with other alternatives? This depends on several considerations, some that are intangible or at least difficult to measure. Designing and building the power supply with modules has certain advantages. These include a short design cycle, low nonrecurring costs, and high reliability. The reliability owes to the fact that modules are mature designs. One alternative is to farm out the modular design and...
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Today in North America, Philips Components Discrete Products Division supplies the marketplace with thousands of quality electronic products. Passive components such as resistors, capacitors and trimmers. Discrete semiconductors including power, surface mount, MOSFET and small signal devices. Ferrite cores, beads, chokes, recording heads and other specialty products. And professional components such as camera tubes, photomultipliers and image intensifiers.

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Surface Mount Film Capacitors Keep Cost And Size Small.

Thinking of ways to do away with encapsulation and shrink dimensions even more? Philips' new surface mount metalized film capacitors are what you need.

Made of high-temperature resistance dielectric polyvinylphenylene sulphide (PPS) film in stacked construction, they're among the smallest capacitors on the market today. Three case sizes are available.

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Rated voltage is 25V DC with capacitance tolerances of ±5 and ±10%. Capacitors are available in blister tape or reel in bulk.

First Schottky Rectifier In SOT-223 SMD® Package.

Philips has introduced the world's first Schottky power rectifiers in an industry-standard SOT-223 surface mount package: PBYR235CT, PBYR240CT and PBYR245CT feature a center-tapped pair of Schottky diodes. Each is capable of delivering an average output current of 1A and is perfectly matched through single monolithic substrate fabrication.

To assure highly efficient operation, the new rectifiers' forward voltage drop is less than 0.45V at a current of 1A. Leakage current at the diodes' maximum continuous reverse voltage is less than 100μA.

Key features of the Schottky series include small size — just 0.5 x 3.5 x 1.8mm — a 2A current rating and surface mount capability.

The series offers reverse voltage ratings of 35, 40 and 45 volts that make it especially suited for low-voltage switch mode power supply applications such as 5V/2A units.

They're available on standard 12mm tape for SMD pick and place equipment. Samples and data sheets available. Production quantities delivered from 6 to 8 weeks ARO.

SOT-223 SMD® Package: Another Design First.

Few things have advanced medium-power surface mount design flexibility as much as Philips' introduction of its SOT-223 package.

A one-watt discrete semiconductor package when mounted on FR4 PCB, the SOT-223 allows you to achieve higher power dissipations and maximize board space without relying on conventional through-hole components. The new package dissipates 1 to 2 watts, and board mounting is possible with either reflow or wave soldering.

The SOT-223 is designed with flexibility of application in mind. The package can accommodate bipolar transistors, small signal MOSFETs, Schottky diodes, rectifier diodes, power MOSFETs, wide band/RF transistors, triacs and thyristors.

The surface mount package is especially suited to all applications where circuit board space is severely limited and power dissipations approaching 1W are required.

Flanged Varistors Improve Solderability.

An exclusive flanged design is key to the improved solderability of a series of Philips zinc oxide disc varistors.

The new design also makes component insertion easier. Available in 5mm and 7mm diameters, the new flanged varistors further expand Philips' line of straight-line and kinked-lead devices.

By defining the mounting height of the varistor, the flanged lead minimizes stress on the component from automatic insertion equipment. The flange also improves solderability by allowing flux to escape through the PCB holes during soldering.

The new varistors offer maximum AC voltage ratings from 14V to 400V, maximum DC voltages from 18V to 615V. With maximum nonrepetitive transient current ratings from 100A to 1200A, and transient response times of less than 20 nsec.

Use them to suppress voltage transients in telecommunications, data processing, consumer and automotive electronics applications. They're available in bulk or tape and reel. Delivery 6-12 weeks.

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SMD® is a servicemark of North American Philips Corporation.
Electrostatic deflection reduces both the tube’s length and overall “in-coil” diameters, making it an ideal fit for compact cameras. Its conical shape helps reduce operation scanning voltage. And because of the electrostatic deflection, corner and center resolution are better than that offered by magnetic deflection tubes.

The 88XQ is especially suited for medical imaging. It offers the highest modulation depth of all lead oxide tubes, resolving more than 2500 TV lines in the center and more than 1600 in the corner. Short response time is another advantage. And the camera tube’s lag is tunable, a major design benefit for such dynamic applications as cardiac study.

Other 88XQ features: a low output capacitance (LOC) window; and a diode gun capable of handling 4 µA of peak signal with minimal loss of resolution and deterioration of lag characteristics.

**Flat E-Cores Reduce Height In Transformers.**

Making use of low-loss 3F3 material, Philips is introducing a series of flat E-cores designed to cut the height of transformers in DC/DC power modules.

The EFD (Economic Flat Design) cores come in four types:

- **15/16/5** for board areas 15 x 15 mm and 500 kHz operation
- **20/10/7** for board areas 20 x 20 mm and 300 kHz operation
- **25/15/5/9** for board areas 25 x 25 mm and 100 kHz operation
- **30/15/5/9** for board areas 30 x 30 mm and 100 kHz operation

All the new flat cores can be operated at up to 1 MHz and can be used in transformers with power throughput densities as high as 20 W/cm². That’s possible because of the cores’ high-frequency ferrite materials and computer-aided design.

EFD cores come with matching bobbins and clips suitable for automated production lines. Sample cores — with bobbins and clips — are now available from Philips.

**SMD® Tantalum Chips Offer Extended Capacitance.**

Philips is introducing a new line of conformally coated tantalum chip capacitors for use in high-reliability and medical applications.

The 49EC Series capacitors offer high capacitance density with low ESR values at 100 kHz and low DC leakage current. They’re designed for operation from −55 °C to +85 °C with rated DC voltage applied. At 67% of rated voltage, the temperature range can be extended to +125 °C.

The new capacitors, though non-military, are pad-compatible and interchangeable with established MIL-G-55365/4 CWR06 conformally coated and CWR09 molded tantalum chips.

Depending on the voltage rating, 49EC chips offer two to three times the capacitance values of CWR06 and CWR09 products in the same case size. Rated DC voltages of 4, 6, 10, 15, 20, 25 and 35 volts are available in each of eight case sizes. These sizes are identical to those of CWR06 devices. Gold-plated or hot solder-dipped terminals are available. Standard capacitance tolerances include ±20%, ±10% and ±5%. Delivery is 12 to 14 weeks ARO.
build the supply in-house. Non-recurring costs may be lower in this instance if the outside resource is more experienced with the technology.

Yet another option is to design and build the power supply with discrete components. This option depends heavily on in-house design and production, and has potentially the longest design cycle. In its favor as a strategy, though, is that it can be less costly for volume production. A third alternative is to purchase a semicustom power supply from a vendor. In this case, users are totally dependent on vendor ability, which can be an excellent, trouble-free situation with the right vendor. It probably involves an intermediate time-to-production delay. One drawback is that in most cases, the customer doesn’t own the design.

Thanks to lower assembly costs, today’s power modules significantly cut costs in terms of dollars per watt.

The bottom line is that each case must be evaluated in its own context. For example, it’s likely that the module approach has the shortest design cycle. If the power supply is the critical-path item in a very time-sensitive new product, this advantage may overshadow all other considerations. In another case, with time less critical and considerable in-house power-supply design and manufacturing resources, the design-from-scratch approach may be best. Finally, it may make sense to use a “hybrid” approach that mixes the aforementioned alternatives. Sometimes, the optimum power system will include standard and custom power supplies, modules, and a portion of in-house designed circuitry. Choosing properly among these alternatives will result in the maximum overall benefit.

In conclusion, the new power-conversion modules expand the range of choices in power system design. They can reduce the risk of new designs and shorten the design cycle. Multiple vendors offer security in future production, and continue to invest in product improvement to the ultimate benefit of the OEM customers.

Charles E. Mullett, president of Mullett Associates Inc., Los Angeles, holds BSEE and MSEE degrees from the Univ. of Illinois and is a registered professional engineer in California.

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(51S) To 500 V
(500S) Over 500 V
(10S) To 10 W
(11S) 1 to 200 W
(200S) Over 200 W

Types
(1A) Laboratory
(RM) Rack mounting
(OF) Open-frame OEM
(CV) Constant voltage/current
(OF) Precision ac output
(OF) Remote programming
(MD) Military designs

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(continued on p. 87)

KEY

Power Supplies

Output

-5S) To 50 V
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▶ CIRCLE 732

48 VOLT MULTI-OUTPUT SUPPLIES RANGE FROM 50 TO 1500 W

Forty-eight multiple-output supplies offer a range of output power from 50 to 1500 W. The supplies come in three series. The SMLC Series has 20 models with up to four outputs in power ranges from 50 to 100 W. Prices start at $110. The HSS Series has 25 models with up to five outputs and power outputs from 100 to 180 W. Pricing begins at $185. The SMM/SMS Series has four models with up to five outputs and power ranging from 300 to 1500 W. Prices start at $385. All prices are for lots of 100. Delivery is from stock.

Lambda Electronics Inc.
515 Broad Hollow Rd.
Melville, NY 11747
(516) 694-4200
▶ CIRCLE 733

Lambda SUPPLY MANUFACTURERS

Lambda Electronics Inc.
515 Broad Hollow Rd.
Melville, NY 11747-3700
(516) 694-4200
(505) (515) (105) (115) (CV)
(RP) (MD)
CIRCLE 357

MIL Electronics Inc.
106 Perimeter Rd.
Nashua, NH 03063
(603) 882-3200
(505) (515) (105) (115) (CV)
CIRCLE 358

Melcher Inc.
200 Butterfield Dr.
Ashland, MA 01721
(506) 281-4715
(11S) (RM) (RP) (MD)
CIRCLE 359

Micropac Industries Inc.
905 E. Walnut St.
Garland, TX 75040
(214) 272-3571
(505) (515) (105) (115) (CV)
(MD)
CIRCLE 360

Modular Devices Inc.
4115 Spencer St.
Torrance, CA 90503
(213) 542-8561
CIRCLE 361

Modupower Inc.
374 Turquoise St.
Milpitas, CA 95035
(408) 263-6115
(505) (105) (CV)
CIRCLE 362

Multi Products International
250 Lackawanna Ave.
West Paterson, NJ 07424

POWER-SUPPLY MANUFACTURERS

Lambda SUPPLY MANUFACTURERS

Lambda Electronics Inc.
515 Broad Hollow Rd.
Melville, NY 11747-3700
(516) 694-4200
(505) (515) (105) (115) (LA) (CV)
(CV)
CIRCLE 363

NH Research Inc.
1601 Hale Ave.
Irvine, CA 92714
(714) 474-3900
(PP) (RP) (MD)
CIRCLE 364

Micropac Industries Inc.
905 E. Walnut St.
Garland, TX 75040
(214) 272-3571
(505) (515) (105) (115) (CV)
(MD)
CIRCLE 360

Modular Devices Inc.
4115 Spencer St.
Torrance, CA 90503
(213) 542-8561
CIRCLE 361
TRIPLE-OUTPUT SWITCHER POWERS HARD DISKS

Systems including high-capacity hard-disk drives can be powered by the model NFS75 75-W triple-output switcher. The unit delivers 110 W to operate from any line voltage worldwide without setting switches or jumpers. Pricing is $103 in lots or 100. Delivery is from stock.

Computer Products Inc.
3797 Spinnaker Ct.
Fremont, CA 94538
(415) 657-6700
CIRCLE 735

PC SUPPLY/UPS DROPS REPLACES OLDER TYPES

The model 2210 supply is a drop-in replacement for existing AT 80386-type supplies. The unit includes an integral UPS that protects the PC and its data against power loss, dips, or surges. In the event of a total power loss, the system can keep the PC operating long enough for an orderly shutdown. Retail pricing is $495 in single quantities. Delivery is from stock.

PC Power & Cooling
31510 Mountain Way
Bonsall, CA 92003
(619) 729-9713
CIRCLE 736

UNIVERSAL-INPUT SUPPLY OFFERS FOUR OUTPUTS

As many as four outputs are offered in a compact 7-by-4.25-by-1.25-in. package in the SRW-115 Series power supplies. The forward topology of the 115-W unit accepts any input voltage from 85 to 264 V ac without user intervention. A low 50 mV pk-pk of noise is found on all outputs. Other features include 1% regulation for the main output and 20-ms holdup time. Call for pricing and delivery.

Integrated Power Designs Inc.
9C Princess Rd.
Lawrenceville, NJ 08648
(609) 896-2122
CIRCLE 737

POWERSUPPLY MANUFACTURERS

<table>
<thead>
<tr>
<th>Company Name</th>
<th>Address</th>
<th>Phone Numbers</th>
</tr>
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<tbody>
<tr>
<td>Reich Associates Inc.</td>
<td>Rte. 4, Box 4620, Lakehills, TX 77063</td>
<td>(512) 751-3200, (505) 522-8828</td>
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<tr>
<td>Salesforce.com</td>
<td>2615 Missouri Ave., Bldg. 5</td>
<td>(210) 439-2800</td>
</tr>
<tr>
<td>Sierra West Power System</td>
<td>1717 Busse Rd. Elk Grove Village, IL 60007</td>
<td>(708) 439-2800</td>
</tr>
<tr>
<td>Solare Electric</td>
<td>675 Dearborn Dr. Columbus, OH 43085</td>
<td>(614) 846-7500</td>
</tr>
<tr>
<td>Solidstate Controls Inc.</td>
<td>5555 N. Elston Ave. Chicago, IL 60630</td>
<td>(312) 775-0843</td>
</tr>
<tr>
<td>Sorenson Company</td>
<td>126 Queens St. New Dundee, Ontario, Canada</td>
<td>(508) 982-0200</td>
</tr>
<tr>
<td>Speco/Econo Electronics</td>
<td>1172 Rt. 109, Linden, NJ 07106</td>
<td>(516) 957-8700</td>
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<tr>
<td>Semiconductor Circuits Inc.</td>
<td>49 Range Rd.</td>
<td>(516) 953-2350</td>
</tr>
<tr>
<td>Shindengen America Inc.</td>
<td>9999 New Wilke Rd., #406</td>
<td>(708) 523-8555</td>
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<tr>
<td>Superior Electric Co.</td>
<td>383 Middle St. Bristol, CT 06010</td>
<td>(203) 582-9561</td>
</tr>
<tr>
<td>Switching Systems International</td>
<td>500 Porter Way, Rockdale St.</td>
<td>(708) 593-8585</td>
</tr>
<tr>
<td>Tamura Corp. of America</td>
<td>1150 Dominguez St.</td>
<td>(516) 466-0911</td>
</tr>
<tr>
<td>Unipower Corp.</td>
<td>2981 Gateway Dr.</td>
<td>(505) 522-8828</td>
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<tr>
<td>Universal Voltronics</td>
<td>100 School St. Bergenfield, NJ 07621</td>
<td>(201) 385-0500</td>
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<tr>
<td>VICO Corp.</td>
<td>23 Frontage Rd. Andover, MA 01810</td>
<td>(978) 470-2900</td>
</tr>
<tr>
<td>Viteq Corp.</td>
<td>10000 Aerospace Rd. Lanham, MD 20706</td>
<td>(301) 731-0400</td>
</tr>
<tr>
<td>Voltex Co. Inc.</td>
<td>3460 Great Neck Rd. N. Amityville, NY 11701</td>
<td>(516) 842-2772</td>
</tr>
<tr>
<td>Walker Scientific Inc.</td>
<td>1250 Feehanville Dr.</td>
<td>(508) 522-8828</td>
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KEY

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<td>Remote programming</td>
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<td>(MD)</td>
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Sorensen

The People, The Products, The Service For The OEM Market
World Class Customer Satisfaction: From A World Class Company.

Consider yourself a world class customer! In an increasingly global economy, high quality standards are vital to staying in the market. Companies everywhere are putting new strategies into action for improving their manufacturing processes.

For almost half a century, Sorensen has consistently established new benchmarks for innovation and quality performance in power supply manufacturing. Today, with facilities in both the U.S.A. and Scotland, we are competing among the best as a World Class Manufacturer. But that is not enough for us because when all is said and done, it is not enough to be able to eliminate defects, reduce inventory, shorten cycle times and provide the incremental improvements that make up a World Class Manufacturer, unless, of course, it benefits you, the customer.

At Sorensen, every customer is a world class customer. In all our efforts, no matter how big or small, we are committed to delivering the benefits to you. From listening to your application needs, to designing the right reliable product, to on-time deliveries and, of course, the right pricing. All Sorensen people have their eyes on the prize: your ultimate satisfaction.

Meeting The Highest Possible Standards ... YOURS!

When every customer counts, every aspect of the total process from product design through pricing is of the utmost importance. For Sorensen, that means we work in fully integrated product teams comprised of the various functions necessary to build a complete product. The goals of each team are two-fold and closely related. The operational goal is to sustain the habit of quality improvement while the target is perfection. The team pursues the target. From conception, to procurement, to production, to shipping ... it's a total team effort focused on your satisfaction!

We are committed to producing your power supply products that meet your needs, and to continuously improving our process for your satisfaction. At Sorensen, we believe that world class customer satisfaction is a lifestyle that we all share equally, from conference rooms to loading dock. And that belief makes all the difference in the world when it comes to the quality you receive.

The principles of World Class Manufacturing are available to any company. The energy and drive to push further and give the customer world class attention to every detail ... that comes from people who make up the company. That is the difference Sorensen makes.

It begins with Sorensen Total Quality Management, which is a guideline that involves everyone in a totally integrated effort to improving performance at every level.
The use of Statistical Process Control methods of data collection and analysis is used throughout operations as well as the rest of the organization. This provides a common language by which to communicate information so that every process can continually improve.

Automatic Testing Equipment for state-of-the-art processing to assure exacting levels of performance for product applications.

Just In Time production makes us flexible enough to respond to your needs even on the shortest notice.

And a dedication to Continuous Improvement to challenge ourselves at even the smallest milestones to meet ever-increasing standards for quality and responsiveness to your needs.

These are the components of a World Class Manufacturer. A company working not just to be good, but to be one of the best.

We can sum it up in two words: the customer. The customer is our measure for continuing world class quality. Meeting your every expectation, then exceeding it. It's not just better manufacturing, it's better design, better response to your needs, better turnaround time — and doing it all better the next time.

STATUS BOARDS
Team Status Boards allow everyone to be aware of any problems, assigns responsibility for corrective action and date by which problem is to be rectified.

SIGNAL LIGHTS
Unique signal light system notifies all team members as to the status of a given product run. Should a problem arise, a team member has only to turn on their light and all members respond to help solve the problem.

ENGINEERING
Using today's latest technology in CAD/CAM and simultaneous engineering techniques, our teams are constantly developing new and better product designs.

ASSEMBLY LINE
Components are assembled on a pull basis and tested using computerized state-of-the-art Automated Test and Burn-in Equipment to assure 100% defect free finished product.

TEAM MEETING
Weekly team meetings provide a forum for the exchange of ideas and suggestions. This not only promotes pride in workmanship, but also encourages constant improvement in every process.)
Leon Blackwell, Design Engineer

"To me, Sorensen quality means robust designs and thorough testing to provide the reliable products that the market is demanding."

Jeff Corn, Development Technician

"Sorensen quality?...it's something we all believe in. It means no compromises, it must be done right or not at all."

S Series switching power supplies offer thousands of models with 1 to 5 outputs and power levels of 500, 750, 1000, 1250, 1500 & 2000W. High power and reliability in high packaging density are achieved through power MOSFET design resulting in high switching speeds, low noise and ease of filtering. S Series supplies have fast load response (even at low input voltages), absolute current sharing and 2-stage limiting.

- Thousands of models with 500W, 750W, 1000W, 1250W, 1500W, & 2000W power levels
- One through 5 outputs: 2V, 5V, 12V, 15V, 18V, 24V, 28V, 36V & 48V
- Dual inputs (selectable) 90-130 Vac or 180-260 Vac (500W to 1250W), 180-264 Vac (1500W & 2kW). Optional inputs available
- Dc inputs (-42 to -56 Vdc) on 500W, 750W & 1000W models
- Switching speeds up to 144 kHz
- No minimum output loading required
- Designed to meet UL 1950, CSA Electrical Bulletin CSA C22.2 #220, IEC 950, IEC 308 & VDE 0806 (selected models)
- Remote sense protection standard on outputs V1, V2 & V3
- Current sharing, reverse polarity protection, power fail warning & thermal shutdown
- Current monitoring & +5V logic voltage
- OVP standard on V1, V2, V3 & V4 outputs
- Low noise bandgap reference voltage
- High packaging density: up to 5 outputs in standard 5" x 8" case profile
- Options: DC input power (selected models); 208/230 Vac, 3Ø input power; FCC class A line filter; reverse air flow; and current sharing on V1 and V2 outputs
- 5-year warranty

SPECIFICATIONS

**INPUT**

**Input Voltage:** Standard dual range 90-130 Vac or 180-260 Vac single phase (500W to 1250W), 180-264 Vac single phase (1500W & 2kW). 180-264 Vac, 3 phase option available.

**Frequency Range:** 47-440 Hz, single phase
Fusing: All units are internally fused.

Inrush Current: Limited to 40A rms max. for 20 ms.

Line Regulation: 0.2% over full input range.


OUTPUT

Voltage Adjustment Range: ±10% (Except V5 which tracks V2).

Load Regulation: 0.2% no load to full load (except V5 is 5%).

Cross-Regulation: 0.1% max. except V5 is ±5%.

Overvoltage Protection: Standard on V1, V2, V3, V4 and not available on V5. If any output exceeds nominal voltage by 20-30%, OVP circuit activates and turns off all outputs. Ac input or remote On/Off must be recycled to restart supply.

Hold-Up Time: In regulation of 30 ms (min.) after loss of nom. power.

Overshoot/Undershoot: None during turn-on or turn-off.

Turn-On Delay: All outputs in regulation in <500 ms.

Transient Response: Recovery to 1% regulation within 100 μs (25% step load change).

Polarity: All outputs floating; reference determined by user.

Reverse Polarity Protection: V1 & V2 outputs protected to Imax; other outputs protect to 6A.

Reference Voltage: 5.1V ± 1% @ 0.1 mA low noise bandgap voltage is available at J1-3.

Minimum Loads: None required on any output.

Current Sharing: Terminals are provided for V1 and V2 outputs; when terminals are connected to same terminals (and share lines) at same voltage on another supply, paralleled outputs share current within 1%.

Thermal Shutdown: Supply shuts down when temperatures are exceeded; restarts automatically upon cool-down.

GENERAL

Temperature Coefficient: Output change <0.02%/°C after 30 minute warmup.

Efficiency: 70% min. for multi-outputs; 75% min. for single output (outputs 5V or greater).


Ripple & Noise: (PARO): Differential mode, 1% max. or 50 mV whichever is greater. Measurements made at output terminals with 20MHz scope.

Remote Sense: Outputs V1, V2, V3 compensate for 500 mV of load cable loss. With lines open, output is sensed through internal resistors. Reversing sense lines causes no damage.

Current Monitor: Calibrated voltage proportional to V1 current is provided; 1V ± 5% for full load.

Remote Margin: ±3% to ±10% for V1. (see Installation Instructions.)

Logic Voltage: +5V (up to 50 mA current) is available when ac is applied. Voltage is reference to logic common, V1.

Power Fail: Internal resistor to +5V for pull-up is provided for external connection.

Remote Enable: Internal resistor to +5V for pull-up is provided for external connection.

Power Fail Warning: Logic signal is supplied through an optical coupler and may be referenced as desired. Signal is provided at least 5 ms before loss of any output voltage, but is not activated for at least 20 ms after loss of nominal ac power.

Ambient Operating Temperature & Humidity Range: Full power to 50°C (122°F), derate to 60% @ 70°C (158°F).

Storage Temperature & Humidity Range: -55 to +85°C (-67 to +185°F), 90% RH max.

Cooling: Brushless 24 Vdc fan for efficient operation at low input voltages. Reverse air movement optional.

OPTIONS

Option D: Dc input (-42 to -56 Vdc) on 500W, 750W & 1000W models

Option F: FCC Class A line filter

Option H: Current Share, V1 output

Option I: Current Share, V2 output

Option R: Reverse air flow on fan

Option T: 3 phase ac power input
# S SERIES SPECIFICATIONS

## SINGLE OUTPUT

<table>
<thead>
<tr>
<th>Power Level (W)</th>
<th>500W</th>
<th>750W</th>
<th>1000W</th>
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<td>36V, 14A</td>
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**Q1**

# DUAL OUTPUTS*

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## TRIPLE OUTPUTS*

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</table>

## OPTIONS

- **D** = Dc Input (-42 to -55 Vdc)²
- **F** = FCC Class A Line Filter
- **H** = Current Share, V1¹
- **I** = Current Share, V2
- **R** = Reverse Fan Air Flow
- **T** = 36 Power

**NOTE:** V5 output not available if line filter is specified.

---

**Part Number System**

- **S** = Series
- **V1**, **V2**, **V3**, **V4**, **V5** = Outputs
- **Q1**, **Q2**, **Q3**, **Q4**, **Q5** = Outputs
- **P1**, **P2**, **P3**, **P4**, **P5** = Power Level (W)
- **O1**, **O2**, **O3**, **O4**, **O5** = Options

---

²Total output power is limited to power rating shown.
³Peak output for 30 seconds.
⁴Contact Sorensen
"Sorensen quality to me means taking the time and effort to make sure that every unit we assemble will perform the way it was designed to, and that means meeting or exceeding the customers expectations."

The KSA400 switching power supply incorporates features for stable, heavy duty operation, including parallel MOSFETs in a forward converter technology and conservatively rated electrolytic capacitors. Five outputs are available: main output V1, and outputs V2 through V5 (which are adjustable over a wide range). KSA 400 is designed for demanding service in computer and data processing equipment, as well as others needing multiple, adjustable outputs. KSA 400 is built to meet UL, CSA, and TUV requirements, and provides EMI protection to FCC and VDE 0871, level 1.

- 5 Voltage ranges: Main output V1, 5V; outputs V2, V3 & V4, 5-15V; output V5, 12-24V
- 300W output (convection); 400W output (forced air cooling)
- 115/230 Vac selectable inputs, 47-63 Hz, single phase
- Overvoltage protection standard (V1 output)
- Overload protection standard (all outputs)
- Remote sense standard (V1 output)
- Power fail standard
- Remote inhibit standard
- UL, CSA, VDE recognized*
- 2-year warranty

Voltage/Current Ratings:

Output No. 1: 5V nom/40A max. (convection). 5V nom/50A max. (forced air).
Output No. 2: Adjustable 5-15V nom/0-6A max.
Output No. 3: Adjustable 5-15V nom/0-6A max.
Output No. 4: Adjustable 5-15V nom/0-6A max.
Output No. 5: Adjustable 12-24V nom/0-6A max.

Size: 2.5" H × 5.0" W × 12.992" D.
The advanced packaging of the KE600 Series 600 Watt power supply is due to state of the art 150 kHz switching technology, which allows for high component density, low profile and light weight. This unit is designed with the end user in mind, providing maximum flexibility in the areas of Remote On/Off, N+1 redundancy capabilities, selectable ac inputs, remote output monitoring, selectable remote sense or PALS (Programmable Automatic Load Sensing) for fixed load line applications. PALS eliminates the need for external sense line harnessing.

- Compact size, 150 kHz switching speed, 2.3W/in.\(^3\)
- 110 or 220 Vac input (selectable), single phase
- EMI filtered to FCC 20780 class A
- Meets UL, CSA & VDE (TUV) 0871, class A safety standards
- Remote On/Off (TTL-H = on, L = off) or contact relay shutdown (open = on, short = off)
- Remote output monitoring
- Voltage Adjustment ±10%
- Selectable remote sense or Programmable Automatic Load Sensing (PALS)
- Automatic thermal shutdown
- Parallel operation, up to 4 units
- Fault tolerant (N+1) redundancy.
- DC fan cooled. Fan OK circuit turns off output if fan fails to operate.
- DC OK status LED
- 2 year warranty

### Specifications Table

<table>
<thead>
<tr>
<th>Model</th>
<th>Adjustment Range Vdc</th>
<th>Current ADC</th>
<th>Regulation Line %</th>
<th>Regulation Load %</th>
<th>PARD mV</th>
<th>Efficiency %</th>
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<td>KE600-2</td>
<td>1.8 - 2.2</td>
<td>0-120</td>
<td>±0.2%</td>
<td>±0.2%</td>
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<tr>
<td>KE600-5</td>
<td>4.5 - 5.5</td>
<td>0-120</td>
<td>±0.2%</td>
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<td>KE600-48</td>
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<td>0-13</td>
<td>±0.2%</td>
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**Size:** 3.78” H × 7.87” W × 9.44” D
Compact, light weight, low cost KVB Series has a single 5V, 12V, 15V, or 24V output with choice of 10W, 15W, or 25W output power level. All units are UL recognized and CSA listed. EMI conforms to FCC Class B requirements.

- 10W, 15W, 25W outputs
- Output voltages: 5V, 12V, 15V, 24V; ±10%
- Ac or dc input: 85-132 Vac, 47-440 Hz, single phase or 110-170 Vdc
- Overvoltage & overcurrent protection standard
- UL recognized and CSA listed
- EMI protection conforms to FCC Class B
- 2-year warranty

SIZES:

1.063" H × 2.913" W × 3.819" D.

Models: KVB010-05, KVB010-12, KVB010-15, KVB010-24.

1.378" H × 3.583" W × 4.726" D.


1.378” H × 3.583” W × 5.433” D.

Donna Herrin, Purchasing Department

"Sorensen quality means implementing such plans as our Vendor Certification program that ensures quality material and timely delivery to the production line."

New KVL Series offers both low cost and small package size. Three outputs are available with combinations of +5V, ±12V & ±15V at 15, 25, or 40W power levels. Overload and overvoltage protection are standard, and all models conform to UL and CSA safety requirements. All outputs can be used at full ratings simultaneously. 2 year warranty.

- 15W, 25W & 40W outputs
- Output voltages: +5V, ±12V & ±15V (in combinations)
- AC or dc input: 85-132 Vac, 48-440 Hz.
- Overvoltage protection standard on +5V output
- Overcurrent and inrush current protection standard
- Separate ground return on +5V output
- Outputs 2 & 3 are post-regulated (on selected models)
- Class B Line filter and mounting brackets are standard
- UL recognized & conforms to CSA safety requirements
- Options: covers
- Sizes:
  - KVL 15: 1.378” H × 3.347” W × 3.858” D
  - KVL 25: 1.575” H × 3.347” W × 5.118” D

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<th>Model</th>
<th>Output No. 1</th>
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<th>Output No. 3</th>
<th>Post Reg. Outputs 2&amp;3</th>
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<td>+12/1</td>
<td>0.3- 1</td>
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<tr>
<td>KVL 25-01T</td>
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<td>+12/0.5</td>
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<td>+15/1</td>
<td>0 - 1</td>
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</table>

150 kHz switching technology affords compact size, low cost and high wattage/in.³
Output voltages are 5V, 12V, 15V, 24V at 50W, 100W and 150W levels. Standard features include: OVP and overcurrent protection, inrush current limiting, remote sense and dual input power. Covers are optional. UL recognized and meets CSA requirements.

- 12 models with 50W, 100W & 150 W power levels
- 5V, 12V, 15V & 24V output for each power lead

---

### Adjustments

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<tr>
<th>Model</th>
<th>Adjustment Range Vdc</th>
<th>Current Adc (max.)</th>
<th>Regulation Line/Load (mV)²</th>
<th>PARD mV</th>
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1. ±2% ±4%
These pages are only the beginning of a World Class Line-Up

The switching power supplies contained in this brochure represent only a fraction of what we offer. We're also ready to bring you total quality in your specific applications for programmable power supplies as well. Our skilled team of engineers will consult with you to provide the exact power source you need, for custom assemblies, and complete turn-key DC systems.

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Fax: (312) 775-7432

Sorensen Ltd., Kelburn Business Park
Port Glasgow, Scotland UK PA14 6 PD
Tel: 44 0475 45231
Fax: 44 0475 44046
\textbf{\textsection{ISOLATED CONVERTERS}
KEEP PC BOARDS CLOSE}

An ultra-thin profile of 0.35 in. means that the AS Series of isolated dc-dc converters let pc boards be mounted in a high-density orientation. Efficiencies of up to 81\% are offered in power ranges from 1.5 to 25 W. The series includes 62 models with inputs from 4.5 to 72 V dc. Outputs of 5, 12, 15, and 24 V are offered in all package sizes. All specs are guaranteed over the operating range of -20 to +71°C. Pricing starts at $30 for single quantities and delivery is from stock.

\textbf{Lambda Electronics Inc.}

515 Broad Hollow Rd.
Melville, NY 11747
(516) 694-4300
\textsection{CIRCLE 738}

\textbf{\textsection{EXTRA-WIDE INPUT RANGE
FOR DC-DC CONVERTER}}

An extra-wide input range (4:1) is featured in an 8.5-W, triple-output dc-dc converter. The JWT Series offers two input ranges of 9 to 36 V dc and 18 to 72 V dc. The modules operate at a typical switching frequency of 55 kHz. Ripple and noise is 75 mV pk-pk and 3 mV rms. An encapsulated, six-sided case reduces excessive noise radiation. Case size is 2.56 by 3.08 in. The series is especially suitable for applications within the telecommunication and transportation industries. Samples are available now. Call for pricing and availability.

\textbf{International Power Devices Inc.}

155 N. Beacon St.
Brighton, MA 02135
(617) 782-3331
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FREE Engineering Design Kit
**ULTRA-MINI CONVERTERS SATISFY LAN SYSTEMS**

Local-area-network applications are the target for the LAN Series of ultra-miniature dc-dc converters. The units, which measure 0.5 by 0.4 by 0.28 in., are single-output devices offering short-circuit protection, regulated and unregulated outputs, and isolation voltage to 2500 V dc. Input voltages of 5 and 12 V dc provide up to 2 W of power in 5-, 9-, 12-, and 15-V dc output configurations. Call for pricing and delivery.

**Wall Industries Inc.**
5 Watson Brook Rd.
Ezecur, NH 03833
(603) 778-2300
▷ CIRCLE 740

**LOW-PROFILE CONVERTER DOUBLES OTHERS' OUTPUT**

The MTR Series of dc-dc converters doubles the power available from standard board-mountable packages and reduces cost by 20%. The 30-W aerospace-military-grade converters take up less than 2.4 in. of board area and are just 0.4 in. tall. Thanks to their 600-kHz switching frequency, their power density is 35 W/in.², which permits smaller components to generate more power. In lots of 100, pricing starts at $362. Small quantities are available for delivery from stock.

**Interpoint Corp.**
P.O. Box 97005
Redmond, WA 98073-9705
(206) 882-3100
▷ CIRCLE 741

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**POWER CONVERTER MANUFACTURERS**

<table>
<thead>
<tr>
<th>Company</th>
<th>Address</th>
<th>Phone/Contact Details</th>
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<tbody>
<tr>
<td>EPSCO Inc.</td>
<td>1092 W. Fullerton Ave. Suite D Addison, IL 60101</td>
<td>(708) 543-0410</td>
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<tr>
<td>Electronic Measurements Inc.</td>
<td>405 Essex Rd. Neptune, NJ 07753 (201) 922-9300</td>
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<tr>
<td>Endicott Research Group Inc.</td>
<td>P.O. Box 267 Endicott, NY 13760 (607) 754-9187</td>
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<tr>
<td>Ericsson Components Inc.</td>
<td>403 International Pkwy. #500 Richardson, TX 75081</td>
<td>(214) 997-6561</td>
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<tr>
<td>Fiskars Electronics Corp.</td>
<td>P.O. Box 1400, Newton Rd. Littleton, MA 01460</td>
<td>(508) 486-9651</td>
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<td>Fiskars Electronics Corp.</td>
<td>1096 N. U.S. Hwy. #1 Ormond Beach, FL 32174</td>
<td>(904) 244-0043</td>
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<tr>
<td>Geator Corp.</td>
<td>9617 Center St. Manassas, VA 22110 (800) 523-9398</td>
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<td>Geator Corp.</td>
<td>17032 Armstrong Ave. Irvine, CA 92705 (714) 261-2200</td>
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<td>ILC Data Device Corp.</td>
<td>105 Wilbur Pl. Boheria, NY 11716 (516) 577-5602</td>
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<td>IMC Magnetics Corp. Florida Div.</td>
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<td>Integrated Power Designs Inc.</td>
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<td>International Power Sources</td>
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<td>Interpoint</td>
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<tr>
<td>Jerome Industries</td>
<td>730 Division St. Elizabeth, NJ 07201 (201) 353-5700</td>
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<td>Keltec Florida</td>
<td>P.O. Box 2917 Ft. Walton Beach, FL 32549 (904) 244-0043</td>
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<td>Kepco Inc.</td>
<td>131-38 Sanford Ave. Flushing, NY 11392 (718) 461-7000</td>
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<td>Lloyds Electronics</td>
<td>8051 Cessna Ave. Galesburg, MD 20879 (301) 921-9440</td>
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<td>Lambda Electronics Inc.</td>
<td>515 Broad Hollow Rd. Melville, NY 11747-2700 (516) 694-4200</td>
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<td>Linear Technology Corp.</td>
<td>1630 McCarthy Blvd. Milpitas, CA 95035 (408) 721-2641</td>
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<td>LZR Electronics Inc.</td>
<td>8051 Cessna Ave. Galesburg, MD 20879 (301) 921-9440</td>
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<td>Microsemi Inc.</td>
<td>500 W. Fullerton Ave. Lawrenceville, NJ 08648 (609) 882-3200</td>
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<td>Microsemi Inc.</td>
<td>106 Perimeter Rd. Nashua, NH 03062 (603) 882-3200</td>
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<td>Marathon Power Technologies</td>
<td>P.O. Box 8233 Waco, TX 76714-8233 (214) 778-2300</td>
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<td>Melcher Inc.</td>
<td>200 Butterfield Dr. Ashland, MA 01721 (508) 881-4715</td>
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<td>Micropac Industries Inc.</td>
<td>905 E. Walnut St. Garland, TX 75040 (214) 272-3571</td>
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<td>Modular Devices Inc.</td>
<td>4115 Spencer St. Torrance, CA 90403 (213) 542-8561</td>
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<td>Multi Products International</td>
<td>250 Lackawanna Ave. West Paterson, NJ 07424 (201) 890-1344</td>
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When you're looking for solutions that work today, call us. We have products that'll give you some real help.

ROHM makes a great line of components—monolithic and hybrid ICs, LEDs, displays, LCDs, discretes, passives, printheads and more. In fact, we're among the world's top 25 semiconductor companies.

**Dual Digital Transistors**

Take our digital transistor series. These combine up to four resistors and two transistors in a SOT-36— a neat little package we developed so we could put more stuff into the same space as the good old SOT-23. And save you a lot of real estate on the circuit board.

You can get $V_{ce}$ ratings from 11 to 120 volts, and current ranges from 30 to 100 mA. Whichever configuration you choose, they're all the same size, which sure helps simplify your layout. And their surface-mount packaging makes them popular with the manufacturing folks, too.

---

**SRAMs**

If you're looking for a way to cram 2 Mbits of static RAM into a 1 Mbit space, take a look at our BPS81288P.

It's a standard 32-pin DIP module loaded with eight TAB-type CMOS memory ICs, plus chip select logic and on-board capacitors. IC memory is organized as 32,768 x 8-bit words.

TAB fabrication makes this SRAM low—in profile and in problems. CMOS logic makes the device low in power requirements, too. Typical operating power for each of the eight memory ICs is 40 mW ($f=1$ MHz), with standby at only 10 mW.

Access time is 100 nsec, with chip select times running 150 nsec maximum. No clock or refresh is required, and all I/Os are TTL-compatible.

---

**E PROMs**

Maybe you need a PROM with low power consumption and high reprogrammability. If so, take a look at our new CMOS 1024-bit EEPROM, the best alternative to traditional NMOS we know of.

In addition to all the standard features you'd expect, the BR93CS46 operates at a low 2.7 volts, drawing only 20 µA with minimum read voltage of 2 V. And you can even run it at a full 1 MHz.

The BR93CS46 gives you external read/write memory in sixty-four 16-bit registers, and interfaces with standard microprocessors like Intel's 8048/49/51/96, National's COP4XX, Motorola's 6801/05, TI's TMS1000, and Zilog's Z8. Seven 9-bit instructions control everything.

Next time you're trying to figure out a solution that works today—or tonight—FAX us an S.O.S. Thank-you.

Then turn off the light and go home. Your family will thank you, too.
CONVERTERS SPORT ONE OR THREE OUTPUTS

The telecommunication, instrumentation, and computer industries will find use for the KZ200 Series of single- and triple-output dc-dc converters. The single-output devices have outputs of 5, 12, or 15 V dc. The triple-output configuration offers outputs of 5 and ±12 V dc or 5 and ±15 V dc. Input ranges of 20 to 60 V dc and 36 to 72 V dc are available. There are 10 models in the series. Line and load regulation is ±1% on main outputs and ±5% on others from 20% to 100% load. In lots of one to nine, the single- and triple-output models cost $92 and $110 each, respectively. Delivery is in four weeks after receipt of order.

Intronics Inc. 150 Dan Rd. Canton, MA 02021 (617) 828-4992  ▶ CIRCLE 742

COMPONENT SYSTEM BUILDS ISOLATED CONVERTERS

The PWST750 component system makes it easy to design and build isolated dc-dc converters for various applications. The basic system consists of oscillator-driver, isolation transformer, and diode-bridge building blocks in very small surface-mounted packages. The components can be assembled into single- or multiple-output configurations with 15-V dc outputs and 750-V rms isolation from input to output and channel to channel. In lots of 100, each set of building blocks goes for under $9. Delivery for small quantities is from stock to four weeks.

Burr-Brown Corp. P.O. Box 11400 Tucson, AZ 85734 (800) 548-6132  ▶ CIRCLE 743
TWISTITE™
MAGNET WIRE

For superior performance and tighter control over twisted wire construction.

Developed for use in the production of custom toroid, ferrite or recording head coils, specialty audio and R.F. transformers, TWISTITE offers a number of distinct advantages.

TWISTITE is custom produced to offer a wider range of twisting construction. Manufacturing capabilities include:
- Up to 33 Twists Per Inch on fine wire.
- Twisting tolerance as tight as ±1%.
- Tightly controlled capacitance, inductance and impedance characteristics.
- Up to 10 colors in some sizes for conductor identification.
- Wide range of sizes: 24 AWG and finer.
- Wide variety of conductor materials: copper, silver, plated conductors, and special alloys.

Call or write for your free copy of our new Technical Data and Capabilities Brochure. It contains valuable information on all wire produced and inventoried by MWS Wire Industries. Samples of TWISTITE are available upon request.

MWS Wire Industries
31200 Cedar Valley Drive, Westlake Village, CA 91362
CALL TOLL FREE 800 423-5097
818 991-8553 FAX 818 706-0911
### Power Converter Manufacturers

<table>
<thead>
<tr>
<th>Company Name</th>
<th>Address</th>
<th>City, State, Zip</th>
<th>Phone</th>
<th>Note</th>
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<tr>
<td>Tamura Corp. of America</td>
<td>1150 Dominguez St.</td>
<td>Carson, CA 90745-3518</td>
<td>(213) 638-1790</td>
<td>CIRCLE 506</td>
</tr>
<tr>
<td>Technology Dynamics Inc.</td>
<td>100 School St.</td>
<td>Bergenfield, NJ 07621</td>
<td>(201) 385-0500</td>
<td>(SOC) (S1C) (11C) (DC) (MO) (IC)</td>
</tr>
<tr>
<td>Teledyne Components</td>
<td>1300 Terra Bella Ave.</td>
<td>Mountain View, CA 94033-7267</td>
<td>(415) 968-9241</td>
<td>CIRCLE 571</td>
</tr>
<tr>
<td>Todd Products Corp.</td>
<td>50 Emjay Blvd.</td>
<td>Brentwood, NY 11717</td>
<td>(516) 231-3366</td>
<td>(SOC) (S1C) (10C) (11C) (200C) (DC) (MO) (IC)</td>
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<tr>
<td>Toko America Inc.</td>
<td>1250 Foxhall Dr.</td>
<td>Mount Prospect, IL 60056</td>
<td>(708) 297-0070</td>
<td>(SOC) (10C) (11C) (DC)</td>
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<tr>
<td>Total Power International</td>
<td>418 Bridge St.</td>
<td>Lowell, MA 01850</td>
<td>(508) 453-7272</td>
<td>CIRCLE 572</td>
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<tr>
<td>Transistor Devices Inc.</td>
<td>274 S. Salem St.</td>
<td>Randolph, NJ 07869</td>
<td>(201) 361-6622</td>
<td>(SOC) (10C) (11C) (DC) (AC) (MO) (IC)</td>
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<tr>
<td>U.S. Elco Inc.</td>
<td>2930 Scott Blvd.</td>
<td>Santa Clara, CA 95054</td>
<td>(408) 980-5144</td>
<td>(SOC) (10C) (DC)</td>
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<tr>
<td>Unipower Corp.</td>
<td>2981 Gateway Dr.</td>
<td>Pompano Beach, FL 33069</td>
<td>(305) 974-2442</td>
<td>CIRCLE 578</td>
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<tr>
<td>Universal Voltronics</td>
<td>27 Radio Circle Dr.</td>
<td>Mt. Kisco, NY 10549</td>
<td>(914) 241-1500</td>
<td>(SOC) (200C) (DC) (MO) (IC)</td>
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<tr>
<td>VSR Corp.</td>
<td>4609 S. 33rd Pl.</td>
<td>Phoenix, AZ 85040</td>
<td>(602) 243-6200</td>
<td>(SOC) (10C) (11C)</td>
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</tbody>
</table>

### Power Converters

**Output**
- (SOC) To 50 V
- (S1C) 51 to 500 V
- (SOOC) Over 500 V
- (10C) To 10 W
- (11C) 11 to 200 W
- (200C) Over 200 W

**Types**
- (DC) Dc to dc
- (AC) Dc to ac
- (MO) Modular
- (IC) IC DIP
- (MI) Military designs

---

**Push For Perfection**

**Mini-Tast Switches Lead the Way**

Offering excellent quality, long life and high reliability, our new Mini-Tast miniature switches are perfect for digital electronics.

- Snap action contacts tested to 10 million cycles
- Self cleaning contacts are maintenance free
- Available with LEDs, colored inserts, 6 cap colors
- Suitable for custom printing

These compact miniature switches are designed for high density packaging. In the push for perfection, push for Mini-Tast Switches. We build in quality so you can too.
The L4963 high-current switching regulator IC is a step-down converter that operates in discontinuous mode. The device, which is optimized for low-cost applications, can deliver up to 1.5 A with an input voltage up to 46 V. The output voltage is variable from 5.1 to 40 V. Packaging is an 18-lead DIP with a 12x3x3 lead frame. The IC operates without a heat sink and needs just a few square centimeters of pc-board copper on the ground plane to dissipate heat.

Discontinuous-mode operation permits the use of an inductor of just 40 µH, which keeps circuit costs low. Various protection and supervision functions are included. Pricing is $2.50 in lots of 1000. Small quantities are delivered from stock.

SGS-Thomson Microelectronics
1000 E. Bell Rd.
Phoenix, AZ 85022
(602) 867-6100
> CIRCLE 744

3-A SWITCHING REGULATOR EASES DC-DC DESIGNS

An on-chip output switch capable of controlling currents of more than 3 A is featured in the MC34163 switching-regulator IC. The device contains the primary functions needed for dc-dc converters and is designed to implement step-up, step-down, and voltage-inverting applications with a minimum of external components. The IC operates from a 2.5-to-40 V input and includes a 2% reference. Standby current is just 6 mA. The device costs $1.14 for the commercial version and $1.34 for the industrial type in lots of 10,000. Delivery is from stock.

Motorola Inc.
Bipolar Analog IC Div.
2100 E. Elliot Rd.
Tempe, AZ 85284
(602) 897-3615
> CIRCLE 745

**POWER-REGULATOR MANUFACTURERS**
POWER-REGULATOR MANUFACTURERS

M.S. Kennedy Corp.
8170 Thompson Rd. Clay, NY 13041
(315) 699-9201
(50R) (11R) (10R) (LI) (SW) (MU) (ML)
CIRCLE 615

MIL Electronics Inc.
106 Perimeter Rd. Nashua, NH 03063
(603) 862-3200
(50R) (51R) (10R) (11R) (SW) (ML)
CIRCLE 616

Melcher Inc.
200 Butterfield Dr. Ashland, MA 01721
(508) 881-4715
(50R) (10R) (11R) SW) (MU) (ML)
CIRCLE 617

Micrel Semiconductor
560 Oakmead Pkwy. Sunnyvale, CA 94086
(408) 245-2500
(ID) CIRCLE 618

Micro Linear Corp.
2092 Concourse Dr. San Jose, CA 95135
(408) 721-2641
(50R) (11R) (200R) (SW) (MU)
CIRCLE 619

Micropac Industries Inc.
905 E. Walnut St. Garland, TX 75040
(214) 272-3571
(50R) (10R) (11R) (LI) (SW) (MU) (ML)
CIRCLE 620

Modular Devices Inc.
4115 Spencer St. Torrance, CA 90503
(213) 542-8561
(SW) (MU) CIRCLE 621

Modupower Inc.
374 Turquoise St. Milpitas, CA 95035
(408) 263-6115
(50R) (10R) (11R) (SW) (ID) (MU) (ML)
CIRCLE 622

Multi Products International
250 Lackawanna Ave. West Paterson, NJ 07424
(201) 890-1344
(50R) (10R) (11R) (LI) (SW) (MU)
CIRCLE 623

NH Research Inc.
16901 Hale Ave. Irvine, CA 92714
(714) 474-9900
(SW) (MU) CIRCLE 624

National Semiconductor
2900 Semiconductor Dr. M/S 16-300 Santa Clara, CA 95052
(408) 721-2641
(50R) (10R) (11R) (LI) (SW) (MU) (ID) (ML)
CIRCLE 625

Omniriel Corp.
205 Crawford St. Leominster, MA 01453
(508) 534-5776
(50R) (10R) (11R) (LI) (SW) (ML)
CIRCLE 626

Onan Power/Electronics
9713 Valley View Rd. Minneapolis, MN 55344
(612) 943-4600
(50R) (51R) (10R) (11R) (200R) (LI) (SW)
CIRCLE 627

PDS Technologies
875 Bridgport Ave. Shelton, CT 06484
(203) 925-0123
(50R) (11R) (200R) (LI) (SW) (MU)
CIRCLE 628

Panasonic Industrial Co.
Power Supplies Div. 1600 McCandless Dr. Mt. Vernon, NY 10552
(914) 699-5514
(50R) (10R) (11R) (LI) (MU) (ML)
CIRCLE 629

Phoenix Contact Inc.
P.O. Box 4100 Harrisburg, PA 17111
(717) 944-1300
(50R) (11R) (LI) (MU)
CIRCLE 630

Pico Electronics Inc.
453 N. MacQuesten Pkwy. Briarcliff Manor, NY 10510
(914) 699-5614
(50R) (10R) (11R) (LI) (MU) CIRCLE 631

Polytron Devices Inc.
P.O. Box 398 Paterson, NJ 07544
(201) 345-5885
(50R) (10R) (11R) (LI) (SW) (MU) (ML)
CIRCLE 632

Power Conversion Products
42 East St., P.O. Box 380 Crystal Lake, IL 60014
(815) 459-9100
(LI) (SW) CIRCLE 633

Power General
Unitrode Corp.
152 Will Dr. Canton, MA 02021
(617) 828-6216
(SW) (MU) CIRCLE 634

Power Systems Inc.
45 Griffin Rd. South Bloomfield, CT 06002
(203) 725-1300
(50R) (51R) (500R) (10R) (11R) (200R) (SW)
CIRCLE 635

Power Trends Inc.
1101 N. Raddant Rd. Batavia, IL 60510
(708) 406-0900
(50R) (10R) (11R) (SW) (ML)
CIRCLE 636

Power-One Inc.
740 Calle Piano Camarillo, CA 93010-6090
(805) 889-5084
(50R) (51R) (10R) (11R) (200R) (LI) (SW) (MU)
CIRCLE 637

Powercube Corp.
18810 N. Glenview #102 Richardson, TX 75081
(214) 480-3281
(50R) (11R) (200R) (LI) (SW) (MU) (ML)
CIRCLE 638

Preferred Electronics Inc.
Main Line Dr., P.O. Box 248 Westfield, MA 01086
(413) 568-2301
(50R) (11R) (200R) (LI) (SW)
CIRCLE 639

Qualityyne Systems Inc.
2055 OSU Blvd. San Diego, CA 92154
(619) 575-1100
(50R) (11R) (200R) (LI) (SW) (MU)
CIRCLE 640

RO Associates Inc.
246 Caspian Dr. Sunnyvale, CA 94089
(408) 744-1450
(50R) (11R) (200R) (LI) (SW) (MU) (ML)
CIRCLE 641

Rantec Microwave & Electronics
9401 Osso Ave. Chatsworth, CA 91311
(818) 885-8223
(50R) (11R) (200R) (LI) (SW) (MU)
CIRCLE 642

Reich Associates Inc.
Rts. 4, Box 4820 Lakehills, TX 78083
(512) 751-3220
(LI) (SW) CIRCLE 643

Reliance Comm/Tec Loran Products
1122 F St. Lorain, OH 44052
(216) 298-1122
(50R) (200R) (SW) (MU) CIRCLE 644

(continued on p. 98)

KEY

Power Regulators

Output

(50R) To 50 V
(51R) 51 to 500 V
(500R) Over 500 V
(10R) Over 10 W
(11R) 11 to 200 W
(200R) Over 200 W

Types

(50R) (11R) (200R) (SW) (MU) (ML)

Loran Products

1122 F St. Lorain, OH 44052
(216) 298-1122
(50R) (200R) (SW) (MU) (ML)

CIRCLE 644

Proven Reliability

... 100% Burn-In Tested
• 0.001 Mfd. to 22 Mfd.
• ± 10% Std. ± 1%, ± 2%, ± 5% Opt.
• -55°C to +125°C.
• Self-Healing, Non-Inductive
• Low ESR, Low ESR
• Tape and Reel Available

IC type MCW round axial lead Metallized Polycarbonate film capacitors with epoxy end fill and Polyester tape wrapped construction, are used where stability and small size are essential. High IR, low DF and very stable capacitance makes type MCW ideal for precision test equipment applications. Non-inductive extended foil windings are electronically welded to lead wire terminations to provide excellent electrical and mechanical performance. Applications include timing, storage, integrating and filter circuits. The low capacitance drift demonstrates good stability over time. Type MCW is available in voltage ratings from 63 WDC through 400 WDC. Operating temperature is -55°C to +125°C.

THE SOURCE FOR QUALITY. PERFORMANCE AND DELIVERY.
### POWER-REGULATOR MANUFACTURERS

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<tr>
<th>Company</th>
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<tr>
<td>Resonant Power Technology Inc.</td>
<td>3350 Scott Blvd., Bldg. 42/01</td>
<td>(408) 982-0200</td>
<td>645</td>
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<tr>
<td>Santa Clara, CA 95051</td>
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<td>(SW) (MU) (ML)</td>
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<td>Ritz Electronics Ltd.</td>
<td>196 Queens St. N.</td>
<td>(519) 696-2616</td>
<td>646</td>
</tr>
<tr>
<td>New Dundee, Ontario, Canada</td>
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<td>Canada NOB 2EO</td>
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<td>(50R) (51R) (10R) (11R) (200R) (LI) (ML)</td>
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<tr>
<td>SGS-THOMSON Microelectronics</td>
<td>1000 E. Bell Rd.</td>
<td>(914) 241-1300</td>
<td>647</td>
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<tr>
<td>Phoenix, AZ 85022</td>
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<td>(50R) (200R) (SW) (ID)</td>
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<tr>
<td>Samsung Semiconductor</td>
<td>3725 N. First St.</td>
<td>(508) 954-7264</td>
<td>648</td>
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<tr>
<td>San Jose, CA 95131-1708</td>
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<td>(50R) (51R) (LI) (SW)</td>
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<tr>
<td>Silicon General Inc.</td>
<td>11661 Western Ave.</td>
<td>(714) 996-0909</td>
<td>650</td>
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<tr>
<td>Garden Grove, CA 92641</td>
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<tr>
<td>Sola Electric</td>
<td>A Unit of General Signal</td>
<td>(513) 322-6500</td>
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<tr>
<td>1717 Busse Rd.</td>
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<tr>
<td>Elk Grove Village, IL 60007</td>
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<td>(51R) (11R) (200R) (LI) (SW)</td>
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<tr>
<td>Switching Systems International</td>
<td>500 Porter Way</td>
<td>(714) 996-0909</td>
<td>652</td>
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<tr>
<td>Placentia, CA 92670</td>
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<tr>
<td>Technology Dynamics Inc.</td>
<td>675 Dearborn Dr.</td>
<td>(312) 775-0843</td>
<td>653</td>
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<tr>
<td>Columbus, OH 43085</td>
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<td>(51R) (10R) (LI)</td>
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<tr>
<td>Sorensen Co.</td>
<td>5555 N. Elston Ave.</td>
<td>(415) 968-9241</td>
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<tr>
<td>Chicago, IL 60300</td>
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<tr>
<td>Texas Instruments</td>
<td>500 Porter Way</td>
<td>(312) 775-0843</td>
<td>655</td>
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<tr>
<td>Semiconductor Div.</td>
<td>Placentia, CA 92670</td>
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<tr>
<td>P.O. Box 809066</td>
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<tr>
<td>Dallas, TX 75380-9066</td>
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<td></td>
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<tr>
<td>(800) 232-3200</td>
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<td>(50R) (10R) (LI) (SW) (IC)</td>
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<tr>
<td>Todd Products Corp.</td>
<td>50 Enjay Blvd.</td>
<td>(513) 322-6500</td>
<td>656</td>
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<tr>
<td>Brentwood, NY 11717</td>
<td></td>
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<td>(50R) (11R) (10R) (11R) (200R) (SW) (48U)</td>
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<tr>
<td>Vicor Corp.</td>
<td>23 Frontage Rd.</td>
<td>(508) 470-2900</td>
<td>657</td>
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<tr>
<td>Andover, MA 01810</td>
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<tr>
<td>Viking Industrial Products</td>
<td>729 Farm Rd.</td>
<td>(508) 481-4600</td>
<td>658</td>
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<tr>
<td>Marlboro, MA 01752</td>
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<tr>
<td>Voltex Co. Inc.</td>
<td>3460 Great Neck Rd.</td>
<td>(516) 860-2972</td>
<td>659</td>
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<tr>
<td>N. Amityville, NY 11701</td>
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<tr>
<td>Wells-Gardner Electronics</td>
<td>2701 N. Kildare</td>
<td>(508) 470-2900</td>
<td>660</td>
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<tr>
<td>Chicago, IL 60639</td>
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<tr>
<td>(512) 252-9200</td>
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<td>(50R) (51R) (11R) (200R) (LI) (SW) (MU) (ML)</td>
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</table>

### SPECIAL RF Coils & Chokes in 2 Weeks

Sample RF coils and RF chokes designed to meet your special requirements are shipped within 10 days to 2 weeks. Production quantity shipments start within 3 to 4 weeks after approval of samples. Intensive specialization in coil design and manufacture assures a high degree of optimum performance.

Most popular standard inductors available from stock for immediate shipment. Full line catalog on request.

---

**J.W. Miller Division**

**BELL INDUSTRIES**

306 E. Alondra Blvd. • Gardena, CA 90247

(213) 537-5200 • FAX (213) 631-4217

Since 1924, leading manufacturer of standard and custom inductors.
POWER-ONE'S International Switcher Series incorporates the latest state-of-the-art switching technology while providing POWER-ONE's traditional high quality at low prices. With certification to the world's toughest safety agency requirements, the series is especially suited for products sold not only domestically, but internationally as well. • 85 models...40 watts to 400 watts • Efficient...reliable...economical • VDE construction • Up to 5 fully regulated outputs • Full international safety and EMI approvals

POWER-ONE'S International Linear Series is the world's undisputed leader in versatile, cost-effective linear power supply products. A long-time favorite of designers and engineers worldwide, the series is the most widely purchased power supply line through distribution in the industry. The most popular voltage and current combinations are available in a wide variety of off-the-shelf standard models. • Popular industry standard packages • 77 models...6 watts to 280 watts • ± 0.05% regulation • Up to 4 fully regulated outputs • Worldwide safety approvals

POWER-ONE'S International High Power Series is the industry's only true fully-modular high power product line. Specify a power system that meets your exact requirements from a wide selection of single, dual and triple output plug-in power modules. Virtually any combination of output voltage and current rating can be delivered from stock. • 500 watts to 1500 watts • Fully modular construction • Up to 15 fully regulated outputs • UPS battery backup option • Parallelable outputs with current sharing

POWER-ONE offers one of the largest selections of switcher, linear, and high power standard models in the world. So, whatever your D.C. power supply requirement calls for, make POWER-ONE your first choice and be sure you're getting the best—not only in quality, but selection and value as well. Call today for our new 1990 catalogs.
**Coilcraft Designer's Kits**

**First they save you time.**
**Then they save you money.**

These kits make it easier than ever to pick the right coils, chokes and other magnetics for your project. Why waste hours calling around for samples or trying to wind them yourself. Coilcraft’s low-cost kits put dozens of values right at your fingertips!

You not only save time on engineering. You also save money when you go into production because we stock just about all the parts in our kits at low off-the-shelf prices.

Call in today, and you can have your kit tomorrow!

To order, phone 800/322-COIL.

<table>
<thead>
<tr>
<th>Kit</th>
<th>Description</th>
<th>Values</th>
<th>Models</th>
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<tr>
<td>M102</td>
<td>&quot;Unicoil&quot; 7/10 mm Tuneable Inductors</td>
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<tr>
<td></td>
<td>0.0435 µH - 1.5 µH</td>
<td>49</td>
<td>2</td>
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<td>49 shielded, 49 unshielded (2 of each)</td>
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<td></td>
<td>Kit M102 $60</td>
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<tr>
<td>M100</td>
<td>&quot;Slot Ten&quot; 10 mm Tuneable Inductors</td>
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<tr>
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<td>0.7 µH - 1143 µH</td>
<td>18</td>
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<td></td>
<td>18 shielded, 18 unshielded (3 of each)</td>
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<tr>
<td></td>
<td>Kit M100 $60</td>
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<tr>
<td>C100</td>
<td>Surface Mount Inductors</td>
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<td></td>
<td>4 nH - 33 µH</td>
<td>48</td>
<td>3</td>
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<td>48 values (10 of each)</td>
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<td>Kit C100 $125</td>
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<td>F101</td>
<td>Axial Lead Chokes</td>
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<td>0.1 µH - 1000 µH</td>
<td>25</td>
<td>5</td>
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<td>25 values (5 of each)</td>
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<td></td>
<td>Kit F101 $50</td>
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<td>M104</td>
<td>Horizontal Mount Inductors</td>
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<td></td>
<td>Tuneable and fixed</td>
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<td></td>
<td>Inductance: 31.5 - 720 nH</td>
<td>33</td>
<td>6</td>
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<tr>
<td></td>
<td>33 Values (6 of each)</td>
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<td></td>
<td>Kit M104 $60</td>
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<tr>
<td>D101</td>
<td>Common Mode Data Line Filters</td>
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<td></td>
<td>Attenuation bandwidth: 15 dBm, 1.5-30 mHz</td>
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<td>DC current capacity: 100 mA</td>
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<td></td>
<td>2, 3, 4 and 8 line styles (4 of each)</td>
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<td>Kit D101 $65</td>
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<td>P202</td>
<td>Common Mode Line Chokes</td>
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<td>Current: 25 - 9 amps RMS</td>
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<td>Inductance: 900 µH - 10.5 mH</td>
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<tr>
<td></td>
<td>8 styles (2 of each)</td>
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<td></td>
<td>Kit P202 $100</td>
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<tr>
<td>P203</td>
<td>Current Sensors</td>
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<td></td>
<td>Sensing range: 0.5-35 amps</td>
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<td></td>
<td>Freq. resp.: 1 - 100 kHz, 50 - 400 Hz</td>
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<tr>
<td></td>
<td>Transformer and sensor-only versions</td>
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<td></td>
<td>8 styles (15 total pieces)</td>
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<td>Kit P203 $50</td>
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<tr>
<td>P204</td>
<td>Base/Gate Driver Transformers</td>
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<td>Inductance: 1.5 mH Min.</td>
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<td>Frequency: 10 - 250 kHz</td>
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<td></td>
<td>2 single, 2 double section (2 of each)</td>
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<td>Kit P204 $50</td>
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<td>P205</td>
<td>Mag Amp Toroids</td>
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<td>Current: 1, 5 amps</td>
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<td>Volt-time product: 42 - 372 V-µsec</td>
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<td></td>
<td>6 styles (2 of each)</td>
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<td>Kit P205 $75</td>
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<td>P206</td>
<td>Power Filter Chokes</td>
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<td>Current: 3, 5, 10 amps</td>
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<td>Inductance: 9 - 300 µH</td>
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<td>18 styles (48 total pieces)</td>
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<td>Kit P206 $100</td>
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<td>P209</td>
<td>Axial Lead Power Chokes</td>
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<td></td>
<td>Current: 0.03-4.3 amps</td>
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<td>Inductance: 3.9 µH - 100 mH</td>
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<td></td>
<td>60 styles (2 of each)</td>
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<td>Kit P209 $150</td>
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</table>
LITHIUM-CELL PAIRS BACK UP MEMORIES

Two-cell encapsulated lithium-battery sets are designed for backup of computer memory. The 2ER6K bat-
teries offer a capacity of 1900 mAh and are available in a 6.8-V format with a resistor and diode and a 7.2-V format with diode only. The pairs can be customized with various lead-wire-connector configurations as well as different values of resistors and diodes. The operational-temperature range is from +55 to 85°C.

Maxell Corp. of America
22-08 Route 208
Fair Lawn, NJ 07410
(201) 794-5938
▶ CIRCLE 746

NICKEL-METAL HYDRIDE CELL DOUBLES NICAD LIFE

With twice the run time of same-sized nickel-cadmium batteries, the first of a line of nickel-metal hydride cells can make portable products smaller and lighter. The Cs-sized cell offers 2300 mAh of capacity for applications in cellular phones and notebook computers. Limited production quantities of the cell are available. Shortly, limited quantities will be available of an AA-sized cell with 1100-mAh capacity and a 7/5Ah-sized cell with 2300-mAh capacity.

Gates Energy Products Inc.
P.O. Box 861
Gainesville, FL 32602
(904) 462-3911
▶ CIRCLE 747

ZINC-AIR BATTERIES GO BEYOND HEARING AIDS

The first zinc-air batteries not designed for hearing aids are the PR1662 and PR2330 models. The 1.4-V cells are intended for wrist-watch-type pagers, but are also suited for use in pocket-type hearing aids. The PR1662 button cell is rated at 1100 mAh and offers extremely high capacity for its size. The PR2330 coin cell is rated at 700 mAh. Activation is by removal of a tab. Applications for the coin cell include smart cards. Call for pricing and delivery.

Panasonic Industrial Co.
Battery Sales Group
Two Panasonic Way
Secaucus, NJ 07094
(201) 348-5266
▶ CIRCLE 748

BATTERY MANUFACTURERS

A E S Corp.
P.O. Box 209
Peabody, MA 01960
(508) 525-7310
(LC)
CIRCLE 669

AT&T Power Supplies
3000 Skyline Dr.
Mosquite, TX 75149
(214) 298-2426
(LC)
CIRCLE 670

Battery Engineering Inc.
1638 Hyde Park Ave.
Hyde Park, MA 02136
(617) 361-7555
(LT)
CIRCLE 672

Battery Fabricators Inc.
P.O. Box 88716
Atlanta, GA 30338
(404) 449-4651
(AL) (LC) (LT) (NC)
CIRCLE 673

Catalyst Research Corp.
3706 Crandall Ln.
Owings Mills, MD 21117
(301) 356-2400
(LT)
CIRCLE 674

Computer Power Inc.
124 W. Main St.
High Bridge, NJ 08829
(908) 629-8000
(LC)
CIRCLE 675

East Penn Mfg. Co. Inc.
Deka Road
Lyons Station, PA 19356
(215) 682-6961
(LC)
CIRCLE 676

Electrochem Industries
10000 Wehrle Dr.
Clarence, NY 14031
(716) 759-7313
(LT)
CIRCLE 677

Gates Energy Products Inc.
P.O. Box 861
Gainesville, FL 32602
(904) 462-3911
(LC) (NC)
CIRCLE 678

Hydromac Corp.
975 N.W. 95th St.
Miami, FL 33150-2095
(305) 696-2504
(LC) (NC)
CIRCLE 679

Marathon Power Technologies
P.O. Box 8233
Waco, TX 76714-8233
(817) 776-0650
(NC)
CIRCLE 680

Maxell Corp. of America
22-08 Route 208
Fair Lawn, NJ 07410
(201) 794-5938
(AL) (LC) (LT) (NC) (SO)
CIRCLE 681

Panasonic Industrial Co.
Battery Sales
Two Panasonic Way 7A-1
Secaucus, NJ 07084
(201) 348-5266
(AL) (LC) (LT) (ME) (NC) (SO) (ZA) (ZC)
CIRCLE 682

Power Conversion
Two Power Card Corp.
391 Totten Pond Rd.
Waltham, MA 02154
(617) 890-7899
(AL) (LC) (LT) (NC)
CIRCLE 683

Plainview Batteries Inc.
23 Newtown Rd.
Plainview, NY 11803
(516) 249-2873
(LC) (LT) (NC)
CIRCLE 684

Power-Sonic Corp.
3106 Spring St.
Redwood City, CA 94063
(415) 364-5001
(LC) (NC)
CIRCLE 686

Shogyo International Corp.
287 Northern Blvd.
Great Neck, NY 11021-4799
(516) 486-0800
(AL) (LC) (LT) (ME) (NC) (SO)
CIRCLE 687

Tadiran Electronic Industries
Batteries Div.
40 Seaview Blvd.
Port Washington, NY 11050
(516) 621-4980
(AL) (LT) (SO)
CIRCLE 688

Tauber Electronics Inc.
4901 Morena Blvd. #314
San Diego, CA 92117
(619) 274-7242
(AL) (LC) (LT) (ME) (NC) (SO) (ZA) (ZC)
CIRCLE 689

Yuasa Battery (America)
9728 Alburits Ave.
Santa Fe Springs, CA 90670
(213) 949-4266
(LC) (NC)
CIRCLE 691

Batteries
(AL) Alkaline
(CZ) Carbon zinc
(LC) Lead acid
(LT) Lithium
(ME) Mercury
(NC) Nickel cadmium
(SO) Silver oxide
(ZA) Zinc air
(ZC) Zinc chloride

KEY
The ultimate enclosure with sleek, sophisticated styling, computer-aided, high-tech design and functionality and Bud's legendary built-in quality.

The new Jaguar Cabinet offers the contoured elegance of a modern classic in perfect harmony with advanced engineering and inspired technical innovation. Beneath the graceful curves of its removable top cover, you'll discover a rugged steel frame engineered to be incredibly strong and stable. The sophisticated, functional design provides a precise environment for today's, and tomorrow's, high-tech equipment.

Utilizing Bud's standard option packages and our engineer-assisted custom capabilities, we can create a unique Jaguar Cabinet to meet your specific technical requirements.

Bud East, Inc.
4805 East 355th Street
P.O. Box 331
Willoughby, Ohio 44094
(216) 964-3500
FAX: 216-951-4015

Bud West, Inc.
7733 West Olive Avenue
P.O. Box 1025
Peoria, Arizona 85345-0350
(602) 794-0300
FAX: 602-878-3371

BUD...Your Single Source Enclosure Company.
CIRCLE 99
STANDARD TRANSISTORS ARE PACKAGED IN ARRAY

Industry-standard 2N2222, 2N2907, 2N3467, and 2N3725 transistors are now available in an array containing dual, quad, or NPN/PNP complementary-pair configurations. The SGQ line of arrays (SGQ2222, 2907, 3467, and 3725) comes in ceramic DIP, flat pack, and leadless-chip-carrier packages and are fabricated in a MIL-S-19500 facility. Volume pricing for the quad-PNP and quad-NPN arrays is under $4. Delivery is in two weeks from receipt of order.

Silicon General Semiconductor
11861 Western Ave.
Garden Grove, CA 92641
(714) 896-8121
► CIRCLE 749

MOSFET TURN-OFF DEVICE SIMPLIFIES CIRCUITS

An economical and space-saving method of turning off a power MOSFET which achieving a level of circuit improvement is available in the MDC1000 series of MOSFET turn-off devices. One MDC1000 device replaces a Zener diode, a signal diode, a resistor, and a PNP transistor, which frees pc-board space. The device quickly discharges the gate-source and gate-drain capacitances when the input signal is removed. It also provides protection of the gate-source in the event of an overvoltage condition on the control line. Pricing for lots of 100 and up is $0.40 in the TO-92 package, $0.35 in the SOT-23 package, and $0.70 in the SOT-223 package. Samples are available now and lead times are six to eight weeks for large quantities.

Motorola Inc.
5005 E. McDowell Rd.
Phoenix, AZ 85008
(602) 244-5504
► CIRCLE 750

POWER-SEMICONDUCTOR MANUFACTURERS

<table>
<thead>
<tr>
<th>Abacus Electronics</th>
<th>Gennum Corp.</th>
<th>Advanced Power Technology</th>
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<tbody>
<tr>
<td>P.O. Box 534</td>
<td>P.O. Box 489, Station A</td>
<td>405 S.W. Columbia St.</td>
</tr>
<tr>
<td>South River, CA 08882-0534</td>
<td>Burlington, Ontario</td>
<td>Bend, OR 97702</td>
</tr>
<tr>
<td>(201) 236-4631</td>
<td>Canada, L7R 3Y3</td>
<td>(503) 382-8026</td>
</tr>
<tr>
<td>(BI) (MF) (TH) (PI) (PC)</td>
<td>(416) 632-2996</td>
<td>(MF)</td>
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<th>Apex Microtechnology Corp.</th>
<th>Germanium Power Devices Corp.</th>
<th>Central Semiconductor Corp.</th>
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<tr>
<td>5980 N. Shannon Rd.</td>
<td>P.O. Box 3065, SVS</td>
<td>145 Adams Ave.</td>
</tr>
<tr>
<td>Tucson, AZ 85741</td>
<td>Anodoer, MA 01810-3065</td>
<td>Hauppauge, NY 11788</td>
</tr>
<tr>
<td>(800) 421-1865</td>
<td>(508) 475-5982</td>
<td>(516) 435-1110</td>
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<td>(REC)</td>
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<th>Linear Technology Corp.</th>
<th>Marconi Circuit Technology</th>
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<tr>
<td>2000 S. County Trail</td>
<td>1630 McCarthy Blvd.</td>
<td>160 Smith St.</td>
</tr>
<tr>
<td>Warwick, RI 02818</td>
<td>Milpitas, CA 95055-7487</td>
<td>Farmingdale, NY 11735</td>
</tr>
<tr>
<td>(401) 865-3600</td>
<td>(408) 432-1900</td>
<td>(516) 393-8886</td>
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<th>Elantec Inc.</th>
<th>Micrel Semiconductor</th>
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<tr>
<td>1996 Tarob Ct.</td>
<td>560 Oakmead Pkwy.</td>
<td>2092 Concord Dr.</td>
</tr>
<tr>
<td>Milpitas, CA 95035</td>
<td>Sunnyvale, CA 94086</td>
<td>San Jose, CA 95131</td>
</tr>
<tr>
<td>(408) 945-1323</td>
<td>(408) 245-2500</td>
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<th>Optek Technology Inc.</th>
<th>Panasonic Industrial Co.</th>
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<tr>
<td>Yorkers, NY 10710</td>
<td>Carrolton, TX 75006</td>
<td>1600 McCandless Dr.</td>
</tr>
<tr>
<td>(914) 965-4400</td>
<td>(214) 323-2447</td>
<td>Milpitas, CA 95035</td>
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<tr>
<td>411 Clyde Ave.</td>
<td>11861 Western Ave.</td>
<td>11861 Western Ave.</td>
</tr>
<tr>
<td>Mountain View, CA 94043</td>
<td>Garden Grove, CA 92641</td>
<td>Garden Grove, CA 92641</td>
</tr>
<tr>
<td>(415) 960-3572</td>
<td>(714) 896-8121</td>
<td>(401) 791-5050</td>
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<tr>
<td>11861 Western Ave.</td>
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<td>1215 W. Crosby Rd.</td>
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<tr>
<td>Garden Grove, CA 92641</td>
<td>Garden Grove, CA 92641</td>
<td>Carrolton, TX 75006</td>
</tr>
<tr>
<td>(714) 895-8121</td>
<td>(714) 896-8121</td>
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<tr>
<td>2201 Laurelwood Rd.</td>
<td>393 Plantation St.</td>
<td>1225 Bordeaux Dr.</td>
</tr>
<tr>
<td>Santa Clara, CA 95056-9951</td>
<td>Worcester, MA 01613</td>
<td>Sunnyvale, CA 94086</td>
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<tr>
<td>(800) 554-5565</td>
<td>(508) 795-1300</td>
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<th>Texas Instruments Semiconductor Div.</th>
<th>Unitrode Integrated Circuits</th>
<th>Teledyne Components</th>
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</thead>
<tbody>
<tr>
<td>P.O. Box 809066</td>
<td>7 Continental Blvd.</td>
<td>1300 Terra Bella Ave.</td>
</tr>
<tr>
<td>Dallas, TX 75380-9066</td>
<td>Merrimack, NH 03054-0399</td>
<td>Mountain View, CA 94039</td>
</tr>
<tr>
<td>(800) 232-3200</td>
<td>(603) 424-2410</td>
<td>(415) 968-9241</td>
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KEY

- Power Semiconductors
  - (BT) Bipolar transistors
  - (MF) MOSFETs
  - (PI) Power-control ICs
  - (RE) Rectifiers
  - (TH) Thyristors
**VACTROLS™ resistance decreases with increasing input current source (LED, neon, incandescent).**

Provides unique control where higher speed phototransistor isolators are not suitable.

For example:
- power limiters for audio amplifiers
- AGC circuits for DC-5MHz carriers
- remote gain control for amplifiers
- noiseless potentiometers or switching
- signal modulators

An example of the AGC application and a characteristic for VTL5C3 are illustrated.

EG&G Vactec manufactures many optoelectronic components. Included are Blue Sensitive and High Speed Photodiodes, Phototransistors, Photodarlingtons, I-R LEDs (GaAs and GaAlAs), I-R Reflective and Slotted Switches, Light Activated Switches, and a variety of Custom Sensor Assemblies.

Call or write for catalog:
EG&G Vactec Inc., 10900 Page Blvd., St. Louis, MO 63132
(314) 423-4900 or TWX 910-764-0811 or FAX 314-423-3956

**0.100-IN. STRAIGHT HEADERS WITHSTAND IR REFLOW**

Reflow-solder processing can be used on the 9100-2 series of 0.100-in. straight headers from Methode Electronics Inc. An insulator-standoff design permits solder paste to be screened around through-board holes and reflowed along with surface-mounted components. This eliminates dual solder processing for boards. The connectors can be supplied with up to 80 circuits. Single- or dual-row versions are available in various pin lengths and with standard platings. Call for pricing and delivery information.

*Methode Electronics Inc.*
*Interconnect Products Div.*
*1700 Hicks Rd.*
*Rolling Meadows, IL 60008*
(800) 323-6864
>CIRCLE 762

**LATCHED SIMM SOCKETS IMPROVE RETENTION**

Increased retention of SIP modules and baby boards that are larger and heavier than earlier styles is provided by four SIMM socket options with metal latches. The stainless-steel latches are designed to take heavy abuse on the manufacturing floor and during application by non-technical end users. With an audible click, they signal users that the memory module is fully seated in the socket. The latch design also aids in module extraction. Latches are available in 0.100-in., single-row-vertical 30-circuit SIMM sockets and in 0.100-by-0.400-in. dual-row products. Pricing for the vertical, single-row, 72-circuit socket is $3.25 in quantities of 5000 to 9999. Delivery is in six weeks.

*Molex Inc.*
*2222 Wellington Ct.*
*Lisle, IL 60532*
(708) 969-4550
>CIRCLE 763
**CARBON-FIBER CONNECTORS LINK PLANAR SURFACES**

Connections between two planar surfaces, such as flat-panel displays and their driver boards, can be made with AMP's conductive carbon-fiber connectors. The devices are composed of alternating layers of non-woven conductive carbon-fiber mats and insulating silicone rubber. They're said to be more economical than elastomer alternatives, to carry more current (up to 100 mA), to offer 10 times the conductivity, and to require less compression. Call for pricing and delivery.

AMP Inc.
P.O. Box 3608
Harrisburg, PA 17105-3608
(800) 522-6752
CIRCLE 768

**HIGH-DENSITY SYSTEM MEETS SCSI II NEEDS**

A highly reliable contact-termination process from ITT Cannon's Components Div. is embodied in the MD-50 connector. The device features 0.050-by-0.100-in centerlines and is fully compatible with SCSI II interface requirements. The connectors assure a reliable link by means of a proprietary contact-termination system. A brace on the contact terminator secures the contact in place during the termination process and eliminates the possibility of contact deformation. The unit costs $3.40 each in lots of 1000 for a size-50 cable plug and $3.90 each for the receptacle. Sizes range from 26 to 120 positions. Production quantities ship in the first quarter of 1991.

ITT Cannon
Components Div.
1851 E. Deere Ave.
Santa Ana, CA 9270
(714) 757-8442
CIRCLE 769

**MINI-DIN SOCKETS BOAST EMI SHIELDING**

Get maximum EMI/RFI/ESD protection from a line of sockets for Cinch's circular mini-DIN interconnects. They come in six connector sizes of three, four, five, six, seven, and eight positions, and offer space saving of 69% vs. standard circular DIN sockets. A six-position unit costs $0.60 in 10,000s. Stock delivery.

Cinch Connector Div.
1500 Morse Ave.
Elk Grove Village, IL 60007
(708) 981-6000
CIRCLE 770

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Short Circuit & Reverse Polarity Protected
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Ferranti Venus
399 SMITH STREET, FARMINGDALE, N.Y. 11735
(516) 293-4100 • TWX: 510-224-6492 • FAX: 516-752-7976
CIRCLE 147

**Rack Mount TEMPEST PC**

RMPC is IDEAS' family of highly reliable, rack mount TEMPEST PCs. It accommodates various motherboards, including INTEL's 33 MHz System 303 and 25 MHz System 120, and matched high-performance peripherals. Up to 10 full-size, AT card slots are available to tailor the RMPC's power to any application.

The RMPC family of TEMPEST personal computers combines high performance with enhanced functionality in a small footprint. All RMPC products are designed to use only 7 inches of standard 19 inches rack space.

Quality constructed of cold rolled steel, the chassis is designed for flexible system configuration. The TEMPEST gasketed front door allows easy access to the six half-height slots which can house removable drives.

For more information on IDEAS, the RMPC family, or other quality products available, call Bill Howard at (301) 312-2060.

IDEAS Inc., 7120 Columbia Gateway Dr., Columbia, MD 21046 (301) 312-2000
CIRCLE 104
PASSIVES

▼ SMD TRIMMER KIT STAYS UP TO DATE
The surface-mount design kit from Bourns features over 200 SMT trimmers in popular sizes with many resistance values and pin styles. The kit can be registered with an enrollment card for a Sample Update Program. As new products are released, kit owners will automatically receive free samples with data sheets, for an up-to-date source of product information and evaluation samples. Call for pricing and availability.

Bourns Inc.
1200 Columbia Ave.
Riverside, CA 92507
(714) 781-5071
▶ CIRCLE 751

▼ MIL RESISTOR LINE HAS BEEN EXPANDED
Qualification to MIL-R-122 standards has been extended to the value range of 4.99 Ω through 50 kΩ for Vishay's M122/1, M122/3, and M122/10 QPL lines. In the past, qualification was down to 100-Ω values. The M122/1 and /10 lines are qualified for A, B, and C characteristics. The /3 line is qualified for E and F. Call for pricing and availability.

Vishay Resistive Systems
63 Lincoln Hwy.
Malvern, PA 19355
(215) 644-1300
▶ CIRCLE 752

▼ SMT CHIP RESISTORS BOAST TIGHT TOLERANCES
Offered in five standard sizes including the 0805 and 1206 styles, the BCR series of thick-film chip resistors from Beckman industrial Corp. features tight dimensional tolerances. Power-rating options are 1/16, 1/10, 1/8, 1/4, and 1/2 W. Standard resistance values range from 10 Ω to 1 MΩ with tolerances of 1%, 2%, and 5%. Zero-ohm jumper chips are also available. The devices are packaged on paper tape in 5000-piece reels. Call for pricing and availability.

Beckman Industrial Corp.
4141 Palm St.
Fullerton, CA 92635
(714) 447-2345
▶ CIRCLE 753

▼ BRIGHT-WHITE LED REPLACES INCANDESCENTS
Intended as a replacement for incandescent lamps, a multi-chip white LED from Ledtronics Inc. is 100% brighter than present amber-yellow LEDs. The WhiteLite can be used to light pushbuttons, pilot lights, backlights, and indicators. Light is generated in an amber-yellow color spectrum between 565 nm (green) and 635 nm (red) with illumination of 75 mcd, which is much higher than the 40 mcd of present pure amber-yellow (585-nm) LEDs. In lots of 1000, the WhiteLite LED costs from $2 to $3, depending on the base style and circuit requirements. Delivery is in from four to six weeks.

Ledtronics Inc.
4009 Pacific Coast Hwy.
Torrance, CA 90505
(213) 544-9995
▶ CIRCLE 754

▼ 5-GHz SPDT SWITCH HAS BUILT-IN DRIVER
Operation at a 3-ns switching speed over a wide dc-to-5-GHz range is offered by the YSW-2-50DR single-pole, double-throw switch with built-in driver. Packaged in a 0.327-in. plastic case, the GaAs switch-driver combination offers better than 40-dB isolation in the off state, less than 1-dB insertion loss in the on state, and a +1-dB compression point of +20 dBm. The TTL-controlled switch costs $19.95 in quantities of one to nine. Delivery is from stock.

Mini-Circuits
P.O. Box 350166
Brooklyn, NY 11235-0003
(718) 934-4500
▶ CIRCLE 755

▼ CHIP MICA CAPACITOR CAN TAKE OVERVOLTAGES
Featuring the stable electrical characteristics of natural mica, the SM series of chip mica capacitors possess excellent crack-free capability and outstanding solderability. The devices can take twice their rated voltages for 1 to 5 seconds without damage, arcing, or breakdown. In addition, their minimum capacitance tolerance is ±0.25% or ±0.25 pF, whichever is greater. The capacitors are well suited for high-frequency surface-mounted applications. Prices start at $0.55 in 1000s. Delivery is stock to eight weeks.

Tecate Industries Inc.
P.O. Box 711509
Santee, CA 92072
(619) 448-0912
▶ CIRCLE 754
Your Make/Buy Decision
Just Got A Lot Easier!

BURR-BROWN'S OEM MICROTERMINALS SATISFY ALL YOUR OPERATOR INTERFACE/CONTROL PANEL NEEDS - INCLUDING PRICING THAT'S SO LOW YOU NO LONGER NEED TO EVEN CONSIDER BUILDING YOUR OWN!

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These devices will save you valuable design, tooling, and development costs and time so you can concentrate on your product designs. Plus, their low pricing makes them very easy to cost-justify. From $195, with generous quantity discounts.

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Burr-Brown brings you fourteen models from which to choose...from the most basic device to multifunction microterminals to rugged, industrial units. Plus multiple customization options designed specifically with the OEM in mind. Whatever your requirements, we have models to fit your particular needs.

Years of Experience
For over a decade, Burr-Brown has been supplying quality, high-performance microterminals, worldwide. For applications such as control systems, instrumentation, communications, test & monitoring, machine setup, medical, and many, many more.

For a copy of our new brochure, or information about demonstration units, write Burr-Brown Corp., P.O. Box 11400, Tucson, AZ 85734. Or, call Toll-Free 1-800-548-6132.

BURR-BROWN®

Burr-Brown OEM Microterminal allows operator to interface to a precision laser.
Bigger.

### Micro-Key Switches Handle Logic Levels

Two lines of micro-key switches are suited for analog and digital circuit functions for logic-level switching. The CDS710 (9-mm) and CDS720 (7-mm) lines are TTL- and MOS-compatible switches that feature snap-dome construction with positive feedback and a pleasant audio response. Both also offer low profiles, excellent solderability, a lifespan up to 1 million operations, and compatibility with pick-and-place insertion. In lots of 10,000, the 710 series costs $0.219 each while the 720 series goes for $0.145. Small quantities are delivered from stock.

**CRL Components Inc.**
Highway 20 West
Fort Dodge, IA 50501-9006
(515) 573-1300

▶ CIRCLE 764

### Membrane-Switch System is Highly Reliable

Available in round and square push-buttons, EAO Switch’s membrane-switch system is for use under a customer-supplied embossed membrane assembly. The rugged illuminated or non-illuminated Series 96 push-buttons are highly reliable and are suited for heavy-duty use. The switches are sealed to IP67 specifications and feature distinct, constant tactile operation and single-pole, double-throw snap-acting gold contacts. Pricing starts at $4.35 list and delivery is from stock to four weeks.

**EAO Switch Corp.**
198 Pepe’s Farm Rd.
Milford, CT 06460
(203) 877-4577

▶ CIRCLE 766

### Rotary-Coded Switch is First SMD Type

The industry’s first surface-mounted rotary-coded switch is the S-7000 series from Mepcopal Co. The 7-mm-square device is a sealed unit that comes in BCD or BCH codes. With the switch, operators with no knowledge of digital codes can make settings. It eliminates the complicated bit settings that piano-key-type DIP switches require. Features include gold-plated contacts and an O-ring seal that prevents solder-flux contamination during processing. In lots of 1000, the switch costs $2. Delivery time is from stock to eight weeks.

**Mepcopal Co.**
11468 Sorrento Valley Rd.
San Diego, CA 92121
(619) 453-0332

▶ CIRCLE 765

### BCD-Coded DIP Switches Halve Size of Others

The ultra-miniature dimensions of the ND series rotary DIP switches make them suitable for many applications where space saving is essential. The binary-coded switches feature gold contacts and a precision detent design for crisp, positive action. The devices are completely washable and wave-solderable. All terminals (straight and right-angle) are crimped to ensure secure pc mounting. The switches are rated at 100 mA at 5 V dc. Call for pricing and delivery.

**NKK Switches**
7850 E. Gelding Dr.
Scottsdale, AZ 85260
(602) 991-0942

▶ CIRCLE 767
CONNECTOR ADDED TO ENCLOSED SWITCH
Connector capability has been added to the 914CE series miniature enclosed switch. The plug-in, quick-connect termination offers an efficient way to install or quickly change switches. Versions are offered with bottom-exit or side-exit connectors. Mating quick-connect cables can also be provided. The switch’s operating-temperature range is from 10 to 200°F. Applications include robotics, machine tools, material handling, and others. List price ranges from $61 to $86 and delivery is from stock.

Micro Switch
11 W. Spring St.
Freeport, IL 61032
(815) 235-6600
CIRCLE 757

CUSTOM KEYBOARD IS SEALED TIGHT
Design and production of 0.25-in.-high, environmentally sealed custom keyboards is now available. The units incorporate a 2-in.-diameter dual-durometer rubber keypad, a pc board, liquid-crystal display, flexible printed circuit, polycarbonate overlay, and elastomeric connector. Productiontooling costs about $18,000 and piece price is $5.72 in lots of 10,000. Tooling takes 10 weeks and production pieces start in six weeks.

Conductive Rubber Technology
22125 17th Ave. S.E., Suite 117
Bothell, WA 98021
(206) 486-8559
CIRCLE 759

MINI PC-BOARD RELAY HAS AC OR DC COIL
Either ac or dc coils can be installed in the RKS Series miniature relays. The devices switch loads up to 20 A at 277 V ac or 24 V dc on pc boards. The UL-recognized and CSA-certified relays meet VDE 8-mm coil-to-contact spacing specs. Input-to-output dielectric strength is 4000 V rms. From contact to contact, isolation is 1000 V rms. Available contact arrangements include 1 Form A, 1 Form B, and 1 Form C. Additionally, de-coil models come in 2 Form A and 2 Form C types. A relay with 1 Form C contacts and a 24-V ac coil costs $2.88 in lots of 5000. Small quantities are delivered from stock.

Potter & Brumfield Inc.
200 S. Richland Creek Dr.
Princeton, IN 47671-0001
(812) 386-2147
CIRCLE 760

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Space is the first thing you save at PHM. You can expect a 1:10 reduction in size with our hybrids, 1:4 with surface-mount boards.

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You also save time. Send us your design parameters and you’ll get a prototype in 4 to 6 weeks (sooner if you need a miracle).

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10575 SW Cascade Blvd. Portland, OR 97223
(503) 684-5657 FAX (503) 620-8051

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For applications such as embedded control, where space is at a premium, these new high density, high performance PROMs let you build a smaller system, or pack more functions into your existing space.

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They are available in a wide variety of packaging, including plastic DIP, CERDIP, and PLCC.

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2-kW DC Switching Supply Banishes Noise at Output

An Elaborate Filtering Scheme and Careful Design Give a High-Power Switcher Distinctly Linear Characteristics.

When seeking to enter the high-power supply market close to four years ago, the main complaint heard from potential customers of Hewlett-Packard’s New Jersey Division concerned the switching supplies that were available to them. No matter how good the linear portion of their switching preregulated supplies were, common-mode switching noise still corrupted the supplies’ outputs. In the course of its design work on the problem, Hewlett-Packard’s engineers found that higher-order common-mode filtering could help mitigate the problem.

Now, the research into filtering has borne fruit in a pair of 2-kW system dc power supplies that take a switching supply to a level of performance that was previously attained only by pure or post-regulated linear supplies. But in reaching that performance level, Hewlett-Packard’s HP 6671A and HP 6674A supplies offer the efficiency and compactness of a switching-based power mesh.

The pair of supplies are the vanguard of a planned five-supply series. Their outputs are rated at 0 to 8 V and 0 to 220 A for the HP 6671A, and at 0 to 60 V and 0 to 35 A for the HP 6674A. At 2 kW, the supplies are the company’s highest-output supplies with a built-in GPIB interface.

Normal-mode noise, a key yardstick for determining a power supply’s usefulness in an application, is about 50 mV pk-pk maximum for a switching supply. For a post-regulated linear supply, it’s about 5 mV. The HP 6671A is specified at 7 mV pk-pk, bringing it as close as can be to pure-linear performance while still remaining a switcher.

Another measurement of power-supply worthiness is common-mode noise, which is the noise current present in both the plus and minus outputs of the supply, with earth ground completing the path. Common-mode noise is the source of "unexplained" noise that’s often associated with switching power supplies. It can convert to substantial normal-mode noise at the device under test (DUT). The noise results from subtle differences in the output-distribution network’s common-mode impedance. These differences are typically found in either the load-lead inductances or the capacitive coupling of the plus and minus DUT inputs to earth ground.
When it comes to common-mode noise, which is best characterized as a current and not a voltage, the HP 6670A series supplies again find themselves bordering on linear territory. Switchers are typically in the 50-to-500-mA pk-pk range. Linear post-regulated supplies run from 500 \( \mu \)A to 5 mA pk-pk. The HP 6671A sits atop the linear range at 5 mA pk-pk.

Many power-supply vendors don't even specify common-mode noise performance for their supplies. That's because controlling it can be very costly. Linear supplies inherently have less of a problem with it because they don't have the high-frequency content found in most switchers. That's why linear systems have traditionally been preferred for noise-sensitive tasks. In the HP 6671A and 6674A supplies, Hewlett-Packard has mitigated the common-mode noise problem. As a result, either load lead can be connected to ground with very little difference in noise performance at the load.

The keys to the supplies' low-noise performance are in controlled-slope switching, careful layout, a six-pole normal-mode output filter, a five-pole common-mode-current filter, and an uncompromising design approach (see the figure). The controlled-slope switching approach limits the voltage slew rates in the switching portion of the power mesh, which minimizes conduction of common-mode current through the power transformer. Controlled-slope switching does sacrifice some efficiency, but the resulting gains in noise abatement are well worth it. Efficiency is still 76% at full output.

The filtering scheme is even more remarkable when compared to the efforts of other supply vendors. Most incorporate either a two-stage or four-stage filter for normal-mode noise, and simple decoupling capacitors for common-mode noise. In addition, Hewlett-Packard took pains to make the ground points within the common-mode filter network into single-point grounds, which minimizes ground loops within the network. Those grounds are brought out to the back of the box, giving users access to the quietest ground on the unit. It makes for an ideal point to connect the shield of a remote-sense cable.

In designing the supply, careful attention was paid to its layout. The power path is in a direct line in a U-shape from the right rear (line input) to left rear (output) of the box. A pair of large heat sinks running from front to back bisect the box and form a channel through which cooling air is forced by a fan. The power FETs are electrically isolated as much as possible from the heat sinks, which decreases the heat sinks' dv/dt.

The 20-kHz switchers meet level B of the German VDE 0871/6.78 spec for radiated emissions. And for programmability, the HP 6670A series emulates the earlier HP 6650A and 6030A series.

After discovering that users still prefer the feel of knobs to control voltage and current, Hewlett-Packard incorporated them in the HP 6670A series. That gives users five ways to shape the power-output's makeup: knobs, the HP-IB bus, increment keys, analog programming, and keypad entry. The supply is calibrated from the front panel.

**Price and Availability**

List prices for the HP 6671A and HP 6674A system dc power supplies are $4450 and $4300, respectively. Availability for both models is currently estimated at four weeks or less from receipt of order.

Hewlett-Packard Co., 19310 Pruneridge Ave., Cupertino, CA 95014; (800) 752-0900.

**How Valuable?**

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Since its introduction a year ago, Futurebus+ has branded itself as the standard bus specification of the 1990s and beyond for high-performance systems. However, designers have had to contend with only sample quantities of a few Futurebus+ chips. Now the standard has been given a further boost with a new Futurebus+ chip set from National Semiconductor Corp., Santa Clara, Calif.

The chip set differs architecturally from another set introduced earlier by Philips-Signetics (ELECTRONIC DESIGN, May 10, 1990, p. 63). National integrated some extra functionality onto the chips, such as glitch filters and competition logic. Because of Futurebus+'s noise margins, tightly controlled thresholds are needed. $Q_{cc}$ and $Q_{ground}$ signals ($Q$ denotes quiet) that tie into one central logic point on the chips were incorporated to maintain the thresholds. This controls the receiver thresholds so that the devices' internal ground bounce doesn't affect the receiver circuitry. Furthermore, all of the chips are housed in 44-pin packages, as opposed to the 52 pins on the Philips-Signetics parts.

Futurebus+ is a scalable, multiprocessor bus architecture that can handle data widths from 32 to 256 bits and address up to 64 bits. It includes a protocol bandwidth from 25 to 100 Mtransfers/s. At a data width of 256 bits, 100 Mtransfers/s produces a bus bandwidth of 3.2 Gbytes/s. VME, the previous standard for high-end systems, delivers a throughput of 30 Mbytes/s.

With National's chip-set introduction, the first Futurebus+ system (probably a cacheless system) should arrive around the middle of this year. Later, Futurebus+ systems will migrate to telecommunications, high-end workstations, servers, and graphics platforms.

The chip set consists of four BTL (backplane transceiver logic) transceivers and an arbitration controller. Specifically, they are the DS3883 and DS3886 9-bit data transceivers, the DS3884 handshake transceiver, the DS3885 arbitration transceiver, and the DS3875 Futurebus+ arbitration controller.

Now an IEEE standard, BTL was invented by National Semiconductor in 1985. It's currently used as a Futurebus+ technology, enabling a Futurebus+ system to pass data at very high transfer rates. BTL also solves the bus-driving problems created by the deficiencies in TTL drivers. TTL devices aren't suited to drive characteristically low-impedance buses due to a capacitive load in each system slot.

The chip set handles all of the transceiver functions for driving signals across the backplane (see the figure). There are four different transceivers because different transceivers, or different numbers of transceivers, are required for diverse applications. For instance, in one application, four transceivers are used in the data path for a 32-bit system; a 64-bit system would require eight transceivers. Moreover, two more transceivers are needed for the control logic.
The end result is six transceivers in a 32-bit system and ten in a 64-bit system.

The data transceiver comes in two versions. The DS3883 is a straight converter and driver from the TTL signals on the board to the BTL levels on the backplane. The DS3886 contains latches for additional system performance.

Determining if designers should use the DS3883 or the DS3886 depends on the data-path construction. Most applications require the DS3886's ability to latch the data at the transceiver level to get the highest performance. Less time-critical applications may not the need the complex latching in the data paths. However, a majority of designs go the DS3886 route.

The DS3884 handshake transceiver has a programmable glitch filter on board. The filter is required by the Futurebus+ specification, but it doesn't have to be incorporated into the chip set. By including filters in the devices, National eliminates one extra step for system designers. Also, by putting the filters into the chip set, there will be one less skew delay going through the output buffers and into the filter. This increases system reliability.

The filters are used for the handshake lines in the Futurebus+ protocols. Three lines are needed for each board in the system. When signals are wire-ORed in the backplane, a glitch will occasionally pop up due to current matching when a signal releases. Hence, a filter is needed to eliminate the glitches. The chip includes programmable filters for 5-, 10-, 15-, and 25-ns delays. The correct time is determined by the length of the backplane.

The DS3885 arbitration transceiver and the DS3875 arbitration controller form what National calls a complete arbitration solution. This combination of devices handles the distributed part of the arbitration as well as the message-passing protocols. The DS3885 contains the Futurebus+ arbitration logic. National decided to put the portion that needed a higher performance level—the competition logic—directly on the transceiver, rather than have a transceiver go straight to the controller. The remaining logic was put into the controller chip. Placing the competition logic on the chip reduces arbitration time by 30 to 50% for the distributed mode.

Competition is a continuous process, unlike the latch data transceiver, where one skew delay is eliminated from the input buffer to the output buffer when data is taken in. As a result, multiple magnitudes of the skew get added into the calculations, causing a considerable delay.

Some special features were added in the latter part of the design stage. An LI (live insertion) pin was included in the transceivers. This pin adds some special logic that the Futurebus+ committee included in the specification. The spec lets users insert boards into a running system without causing a glitch in any other boards in the backplane. Therefore, the system needn't be shut down to insert a board, because everything isn't powered on the board.

To eliminate the glitches, the Futurebus+ committee decided to add a Vcc pin to each end of the board. The pin goes directly to the transceiver devices. This LI pin reverse-biases some of the circuitry, making it look like the transceiver is on even though Vcc isn't applied. That reduces the capacitance in the unpowered state to about 2 pF, rather than 10 to 15 pF. The small 2-pF capacitance won't be detected on the backplane upon insertion. Some special circuit-
FUTUREBUS + CHIP SET

ry also appears on the pinouts. BTL inherently has a 1-V signal swing. Consequently, tight receiver thresholds are required. National used separate circuitry with an alternate Vcc and ground to connect into the board's logic. As a result, there are no ill effects from ground bounce. This is especially important in noise-marginal calculations, because there's very little margin when working with 1 V.

The chips also use a separate ground for each BTL output to reduce crosstalk and ground bounce on each driver. It's like having nine separate drivers as far as the grounds are concerned, rather than having one connected together.

One remaining part is a protocol or data-transfer controller. A generic controller can't get the performance that's required by Futurebus+. It has to be tailored to the specific architecture, depending on the processor and memory configuration and the type of local bus and I/O that's being employed. National hasn't released this part yet, and they probably won't until the Futurebus+ committee defines the protocols.

All of the chips except the DS3875 arbitration controller are housed in 44-pin quad flat packs and PLCC packages. The quad flat packs result in a 25 to 30% space savings. National strived to keep the designs as small as possible because it's important to have a chip in close proximity to the connector. The company will eventually include JTAG board-level testing on the chips. But that would require more pins, making for larger chips.

PRICE AND AVAILABILITY
All five devices are available in sample quantities and will be in production in March. In quantities of 1000, the DS3882 costs $6.50, the DS3884 and DS3885 are priced at $11.75, the DS3886 costs $7.75, and the DS3875 goes for $28.75.

National Semiconductor Corp., 2900 Semiconductor Dr., P.O. Box 58090, Santa Clara, CA 95052; (408) 721-5000. CIRCLE 513

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SMART CONTROLLER AUTOMATICALLY RESTARTS SYSTEMS FROM WHERE THEY LEFT OFF  DAVE BURSKY

One chip can prevent microprocessor systems from crashing by maintaining the current state of the CPU in battery-backed-up memory. The Micro Softener replaces up to eight LSI and MSI chips. The chip can even initiate a call for help to a remote system in an emergency so that diagnostic software can be downloaded.

Versions of the DS53XX Softener—the DS5340, 5311, 5396 and 5303—will be available for the 8086-compatible high-integration NEC V40, the Motorola 68HC11, the Intel 80C196, and the Hitachi HD6301/6303. Embedded in the chip is power monitoring logic, watchdog timer, nonvolatile controller, address decoder, bootstrap ROM, parallel I/O ports, dual-ported register file, and interrupt controller.

The IC connects directly to the host microprocessor's address, data, and control lines. It also does decoding and control for off-chip lithium-backed-up CMOS SRAM that can retain data for at least 10 years. The chip converts as much SRAM as the host can address into nonvolatile battery-backed memory. Should power fail, the nonvolatile storage can be used to save as much data as possible from the host—register states, critical data in local memory, etc.

The CMOS battery-backed RAM can be dynamically partitioned so that areas can be set aside to specifically hold programs or data, for example. The built-in bootstrap loader initializes the storage area with application code downloaded from a remote system, such as PC, eliminating the need for a customized boot EPROM.

Early warning of a system failure is signaled to the system by the Softener so that the system’s operational state can be saved in the few micro to milliseconds before power is lost.

When operating power returns to the system, the Softener automatically resets the processor. After reset, the processor continues its program as if no failure or fluctuation had occurred. Additional crash-proof operations are included for electrically noisy environments.

Depending on the particular version of the Micro Softener, up to four byte-wide parallel I/O ports are available to provide extended system or diagnostic I/O capabilities. Furthermore, all versions also have two ports that can be configured as an interface to the internal dual-port register file. Such a feature turns the two ports into a high-speed parallel interface to a host processor.

The dual-ported register file consists of eight input buffer registers, eight output buffer registers, a status register, and some interrupt control circuitry that handles inputs from the host processor and the Softener's internal controller.

The first version of the Micro Softener will tie into the V40 microprocessor and turn the CPU into an embedded control system. Because the V40 contains a superset of instructions that include all those of the Intel 8086 CPU, application software can be directly developed on a PC and easily moved to the end system.

The 8-MHz V40 version of the DS5340 Softener chip comes in an 80-lead plastic quad-sided flat package and sells for $9.20 in 1000-unit lots. Samples are immediately available.

Dallas Semiconductor Corp., 4350 South Beltwood Parkway, Dallas, TX 75244-3292; Don Folkes, (214) 450-0400.

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REDESIGNED CPUs RUN FASTER, CONSUME LESS

Targeting low-power and high-speed applications, NEC Electronics has reimplemented its V20 and V30 16-bit microprocessors to consume less power and run faster. The just-released V20H and 30H use static CMOS logic to trim power consumption to less than 8 mA/MHz—one of the lowest levels in the market for 16-bit processors. Furthermore, the static logic allows the clock to actually be stopped—without any data loss—to further reduce the power consumption.

An improved fabrication process lets designers increase the maximum clock speed to 16 MHz. This makes the H-grade CPUs some of the fastest 16-bit CPUs available today.

Both chips, like their predecessors, have instruction sets that are supersets of the Intel 8086. The V20H has an 8-bit interface similar to the 8088, while the V30H has a full 16-bit bus interface. Both processors operate from 5- or 3-V supplies. At 5-V power, the chips can operate at a maximum clock rate of 16 MHz and have a minimum instruction cycle time of 125 ns. At 3 V, the maximum operating frequency is reduced to 8 MHz, doubling the instruction execution time.

Samples of the chips are available in 40-pin DIPs, 52-lead quad-sided flat packages, and 44-lead plastic leaded chip carriers. Industrial and automotive temperature-range grades are available. Prices start at $6 each in 10,000-unit quantities. Delivery is from stock.

NEC Electronics Inc., 401 Ellis St., Mountain View, CA 94043; Farshad Zarghami, (415) 965-6117.

CONTROLLER TARGETS CONSUMER EQUIPMENT

Directed toward advanced consumer applications, an 80C51-based microcontroller includes an 8-bit a-d converter with a nonlinearity of ±1 LSB and a dual d-a converter circuit with pulse-width-modulated outputs to drive step-motors. With these features, the PCB83C562 can control consumer equipment, including satellite television and satellite radio sets, videotape recorders, and high-end CD players.

The CMOS microcontroller also has 8 kbytes of mask-programmed ROM, 256 bytes of RAM, a full-duplex serial interface, and five I/O ports. These ports make the chip ideal for controlling general-purpose equipment, such as real-time instrumentation and industrial control gear.

Besides incorporating all of the standard features of an 80C51 microcontroller, the PCB83C562 microcontroller has an extra 16-bit counter-timer circuit, a 16-bit watchdog timer circuit, and idle and power-down modes for low-power operation.

Samples are currently available for the PCB83C562 microcontroller, which will sell for around $10 each in quantities of 100.

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**SPEEDY 3-1/2-IN. DRIVE INCREASES RELIABILITY**

By incorporating a dedicated servo mechanism, the reliability in the latest entry of Microscience’s high-capacity 3-1/2-in. hard-disk-drive family has been increased. The Model 7200 boasts an 18-ms average access time and a data-transfer rate of 12.5 Mbits/s. Also, the drive’s integrated device electronics interface makes it simple to integrate into a system. The high capacity results from the 7200’s four disk platters and seven thin-film data heads. The drive carries an MTBF rating of 60,000 power-on hours. It’s priced at $1350. Evaluation units are now available.

*Microscience International Corp., 90 Headquarters Dr., San Jose, CA 95134; (408) 433-8988.*

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Using the TwinSplit, QuadSplit, or OctoSplit VGA splitters, up to eight monitors can display VGA output simultaneously from any PC. Moreover, the monitors can be located up to 200 ft. from the computer. The splitters are fully compatible with all VGA, Super VGA, and 8514/A graphics cards. A front-panel switch supplies individual gain selection for each output to compensate for any extra-long cable lengths. High-performance equalized video circuits are combined with individual buffering of each output to help supply the high-quality output. TwinSplit, used to drive two monitors, is priced at $235. QuadSplit, for four monitors, sells for $435. OctoSplit, for eight monitors, costs $895. All come standard with a 6-ft. cable. The cable contains a standard high-density 15-pin connector. All are available now.

*Communications Specialties Inc., 89A Cabot Ct., Hauppauge, NY 11788; (516) 273-1638.*

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**Analog Designers...**

**COMTRAN® is Now On The 386™**

Automatically optimizes selected component values of your topology to make its response fit your arbitrary target curves in magnitude, phase, \( f_{\text{in}}, f_{\text{out}} \), or any combination. Multiple passes allow standard value capacitors in precision filters or other networks.

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- COMTRAN®'s tolerance mode graphically shows the effect of real world components. Impedance mode plots impedance at ANY node in your circuit.
- COMTRAN® can create, capture and analyze time domain data, then use it to stimulate your circuit and plot the result in either time or frequency domain.
- COMTRAN® has over 10 years of field experience on HP computers. Now it runs on 386™ machines, too. And it still drives HPGL plotters.
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**NEW PRODUCTS**

**COMPUTERS & PERIPHERALS**

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**EL E C TR O N I C D E S I G N**

JANUARY 31, 1991
Wide Range of Drives Suits Most Systems

Resulting from a burst of product activity, more than half-a-dozen disk drives, ranging in size from 2.5-in. units for notebook computers to 5.25-in. high-performance drives for minisupercomputers, fit almost any system need. In the 2.5-in. area are the ST9096A, 51A, and 25A, which pack 84, 42, and 21 Mbytes (formatted), respectively, and come with an embedded AT interface. The drives weigh in at 6.4 oz. and can withstand nonoperating shocks of up to 150 Gs. Access times are sub-20 ms and internal power management keeps the average power dissipation to less than 1 W.

In 3.5-in. drives, there are two new members—a low-profile ST3120A and the half-height ST1480. The 3120A includes an embedded AT-interface and stores 107 Mbytes (formatted). It has an average seek time of 18 ms and an internal data rate of 12 Mbits/s. Like the 2.5-in. drive, the 3120A has four power levels—active, idle, standby, and sleep—with the power consumed ranging from 5.1 to 0.6 W. The ST1480A packs 426 Mbytes (formatted) and consumes 8 to 13 W.

Bigger members of the 5.25-in. Wren family include the ST4767E and 4769E ESDI models, and the largest member, the ST41650, which packs 1.42 Gbytes. The 4767E and 69E both pack 766 Mbytes, and the 69E transfers 24 Mbits/s and has an average seek time of 11.9 ms. The 67E is slightly slower. The ST41650 has an average seek time of 15 ms and a data rate from 17 to 32 Mbits/s. A pair of drives in the 5.25-in. Elite family offer a dual-channel SCSI adapter. The ST41520N and 41600 also pack 1.352 Gbytes and have an average seek time of 11.5 ms.

Sea gate Technology Corp., 920 Disc Dr., Scotts Valley, CA 95066; Bob Maeser, (408) 438-6550.

DATA COMPRESSION PUSHES STORAGE CAPACITY TO 25 GBYTES

By adding data compression to its EXB-8500 8-mm cartridge tape subsystem, Exabyte Corp. has significantly increased the unit’s transfer rate and storage capacity. The drive can store up to 25 Gbytes on one cartridge while transferring data at 2.5 Mbytes/s. In addition, the 5-1/4-in.-form-factor subsystem can search for data at speeds up to 187.5 Mbytes/s.

The data compression incorporated by Exabyte uses an IBM algorithm that’s currently implemented in IBM’s improved data-recording capability (IDRC). The compression method offers a unique data-integrity verification feature. After data is compressed, it’s decompressed immediately and compared to the original data prior to being written on tape. This compression-integrity check ensures that the failure of any electronic component within the compression implementation won’t compromise the integrity of the data written to tape.

In addition to increasing storage capacity, transfer rates, and search speeds, the data compression reduces backup time, data-cartridge requirements, and tape mounts. The compression option can be added to existing 8500 or 8200 drives. It will be available in 1991.

A second announcement made by Exabyte concerns their EXB-10 cartridge-handling subsystem. A new version, the 10i, will offer random as well as sequential access. This means that the cartridges (up to 10 in a system) can be accessed randomly or sequentially. The 10i will be shipping in the second quarter of 1991. Samples will be available in the first quarter.

Exabyte Corp., 1685 38th St., Boulder, CO 80301; (303) 442-4333.

Richard Nass
It's time to say goodbye to expensive engineering workstation based CAD systems. Why should management tie up $100,000.00 or more in a workstation when the same (and often better) performance is obtained with PADS-PCB, a PC based CAD system?

PADS-PCB is a high performance printed circuit board design software that offers a degree of functionality a designer could expect only from an expensive engineering workstation, including Logic Simulation, Circuit Analysis, and Thermal Analysis.

Powerful auto/interactive features are a part of what makes PADS-PCB the best selling CAD system on the market today!

• 1 mil database-32"x32" board size-30 layers
• Large circuit capabilities: In excess of 400 equivalent 14 pin IC's
• Automatic and interactive component placement aids
• Automatic and interactive track routing
• Automatic design rule checking
• Superior Surface Mounted Device capability
• Fine line design
• Superb analog design capability
• Inputs from Futurenet, OrCAD, Schema, PADS-LOGIC and others
• 100% routing with PADS-SuperRouter, the accepted standard for rip-up and reroute autorouting


CAD Software asks you to try its Evaluation Package, at no charge, so you can judge for yourself how PADS-PCB can be the solution to your design problems. Ask about our Leasing Program. Call our Sales Hotline today at (800) 255-7814; in Massachusetts, (508) 486-8929.

119 Russell Street
Suite #6
Littleton, MA 01460

CIRCLE 82
5-GBYTE DAT DRIVE FITS 3-1/2-IN. FORM FACTOR

Using WangDAT’s Model 3600 digital-audio-tape (DAT) drive, users can store up to 5 Gbytes of data. The drive fits in a standard 3-1/2-in. form factor. The actual drive dimensions are 1.625 by 4 by 5.75 in.

The 3600 offers a high level of performance: It features a sustained transfer rate of 520 kbytes/s with burst rates of 4 Mbytes/s (asynchronous) and 5.3 Mbytes/s (synchronous).

The high storage capacity results from a combination of hardware-based data compression and long-length tapes. WangDAT uses the Stac 9703 coprocessor and a Stac variant of the LZ1 (Lempel-Ziv) compression algorithm. This approach prevents data expansion. If compression doesn’t decrease data size, the compressed data is discarded and the original uncompressed data is stored.

The drive’s ultra-slim mechanism employs a vertical-hub-engagement feature that assures consistent reliable cassette engagement and disengagement. Using this technique, the cassette is positioned straight into the drive in a one-step action. This eliminates the usual step of positioning the cassette down onto the reel spindles.

Designed using just one board with a reduced chip count, the drive’s MTBF rises to 60,000 hours. The Model 3600 sells for $1400 in OEM quantities and is available now.

WangDAT Inc., 141 Kalmus Dr., K-3, Costa Mesa, CA 92626; (714) 241-9613. CIRCLE 719

RICHARD NASS

MULTIFUNCTION OPTICAL DRIVE HOLDS 1 GBYTE

The RF-7010 multifunction optical disk drive combines the high capacity of optical-disk storage systems with the choice of write-once or erasable media.

The 5-1/4-in. drive has a capacity of 1 Gbyte. It incorporates a positive filtered air pressure design that lengthens head life and improves performance. The drive’s MTBF is rated at 20,000 hours. It also contains a push-button SCSI switch that simplifies daisy chaining. The maximum transfer rate is 4 Mbytes/s synchronous, or 1.5 Mbytes/s asynchronous. Average seek time is 90 ms. The drive can either be mounted internally or exist as an external unit. It’s compatible with IBM PC/XT/AT, PS/2, and Macintosh computers. Its SCSI interface permits easy integration with most MS-DOS, Mac, OS/2, or LAN-based systems. Available now, it costs $3995.

Reflection Systems Inc., 99 W. Tasman Dr., San Jose, CA 95134; (408) 432-0943. CIRCLE 780

RICHARD NASS

This is the most significant

It’s Aurora™ phosphor. Developed by Loctite Luminescent Systems, this remarkable product is setting a standard far above the performance levels of all other illuminative phosphors.

Electroluminescent (EL) technology, in its search for brighter and longer-lived lamps, has been dependent on a limited choice of phosphors. To overcome this restriction and produce the industry’s most efficient EL lamps, we initiated an intensive research program to develop a phosphor dramatically better than any in existence. The result was Aurora.

With this new phosphor, we are making a new generation of ELs - the Aurora™ lamp line, with longer life and higher sustainable brightness than any ELs on the world market. Our green and white Aurora lamps outperform any competitive light...
**NEW PRODUCTS**

**COMMUNICATIONS**

**VIDEO CHIP INTEGRATES WINDOWING, SCALING, AND ZOOM FUNCTIONS**

**DESIGNED FOR MULTIMEDIA APPLICATIONS**

Designed for multimedia applications, the 82C9P001 PC Video IC from Chips and Technologies controls display-window size and positioning, and allows motion video to be merged with a mix of computer graphics still-video pictures. PC Video also supports scaling of both interlaced and noninterlaced inputs down to 1/64th of the original image size, in 1/64 increments. Video-input formats can be NTDS, PAL, SECAM, S-VHS, and RGB. Zooming ranges from 200% to 400% to 800%.

The chip accepts digitized and formatted video inputs from any standard video digitizer chip set. These signals pass through the PC Video into external video memory comprised of 256-kword-by-4-bit RAMs. By integrating AT and CMA bus interfaces, the host CPU can access video memory for capturing and displaying images stored on disk.

Windowing control is obtained through programmable position registers, color keying, or patterns written in external RAM. Digital color data for color keying comes from the feature connector on a VGA monitor.

At the PC Video's output, YUV signals are converted to analog RGB. The VGA and video data pass to a VGA monitor through an external multiplexer controlled by the PC Video. The chip supports video output rates up to 45 MHz, and 640-by-480, 800-by-600, and 1024-by-768 interlaced VGA and Super VGA modes. Packaged in a 160-pin plastic flat pack, the PC Video is now sampling and will be available in volume quantities in April 1991 for $40 each.

**CHIPS AND TECHNOLOGIES, INC.**, 3050 Zanker Rd., San Jose, CA 95134; (408) 433-6000. — CIRCLE 134

**ILLUMINATION BREAKTHROUGH IN DECADES.**

Greater design flexibility and cost-efficiency. Aurora's spectacular life/brightness advantages, as shown in the chart, offer the designer more opportunities than ever before. Combining these benefits with our advanced fabrication techniques, we can produce solid-state, flexible Aurora lamps in almost any size and shape, even complex forms with multiple holes and cutouts. With no glass bulbs or fragile filaments to break, lamp maintenance is minimal with few, if any, replacement costs. And able to withstand shock and vibration as well as temperature and humidity extremes without catastrophic failure, lamp life is phenomenal. In fact, with three times the life of any other EL, Aurora lamps can be expected to last the life of the products in which they are used.

Get the most from the Aurora breakthrough with our performance matched EL systems. By creating perfectly matched combinations of LLS dc-to-ac inverters and Aurora lamps, our engineers can design an EL system to precisely meet your lighting requirements. With our broad product range, and over 20 years of EL experience, we welcome your questions, especially challenging ones concerning unique applications. Call or Fax the LLS Marketing Department.

**SOURCE FOR LCD BACKLIGHTING, PANEL ILLUMINATION, MEMBRANE SWITCH AND GRAPHICS BACKLIGHTING, TO NAME A FEW APPLICATIONS.**

source for LCD backlighting, panel illumination, membrane switch and graphics backlighting, to name a few applications.

Greater design flexibility and cost-efficiency. Aurora's spectacular life/brightness advantages, as shown in the chart, offer the designer more opportunities than ever before. Combining these benefits with our advanced fabrication techniques, we can produce solid-state, flexible Aurora lamps in almost any size and shape, even complex forms with multiple holes and cutouts. With no glass bulbs or fragile filaments to break, lamp maintenance is minimal with few, if any, replacement costs. And able to withstand shock and vibration as well as temperature and humidity extremes without catastrophic failure, lamp life is phenomenal. In fact, with three times the life of any other EL, Aurora lamps can be expected to last the life of the products in which they are used.

Get the most from the Aurora breakthrough with our performance matched EL systems. By creating perfectly matched combinations of LLS dc-to-ac inverters and Aurora lamps, our engineers can design an EL system to precisely meet your lighting requirements. With our broad product range, and over 20 years of EL experience, we welcome your questions, especially challenging ones concerning unique applications. Call or Fax the LLS Marketing Department.

©1990 Loctite Luminescent Systems, Inc.
CHIP SET BRINGS MULTIMEDIA TO DESKTOP

Consisting of the 82750PB pixel processor and the 82750DB display processor, Intel's i750 video processor integrates digital motion video, special effects, stills, audio, graphics, and text for presentation on PCs and workstations. The 25-MHz pixel processor links with video RAM to compress and store, or to retrieve and decompress data. Microcode instructions executed from an on-chip instruction RAM use leftover frame time to perform special effects, or to overlay fast graphics and text.

The 82750DB display processor retrieves bit-map image data from VRAM, performs post-processing operations such as 2D UV interpolation, translates it from YUV digital format to RGB analog format, and generates CRT synchronization and control signals. The 28-MHz processor delivers the pixel processor's output to a range of video displays, including VGA, NTSC, PAL, and SECAM.

Besides executing the JPEG (Joint Photography Experts Group) algorithm, full programmability enables the i750 family to run a variety of other algorithms for video and audio processing, and such special effects as scaling and zooming. In quantities of 1000, the 82750PB is $49 each in a 132-lead plastic quad flat pack, and the 82750DB in the same package is $56 each. A sample kit containing one of each device costs $550. Production quantities will be available in the first quarter of 1991, with an application design kit that has an evaluation board, run-time system software, software development tools, board design information, and a microcode developer's toolkit.

Intel Corp., 3065 Bowers Ave., P.O. Box 58065, Santa Clara, CA 95051; 1-800-548-4725. CIRCLE 763

COMPANDER IC BOOSTS SIGNAL-TO-NOISE RATIO

The MC33110 compander chip from Motorola improves the signal-to-noise ratio in audio applications by reducing the transmitted dynamic range. The device has two variable-gain circuits that combine to compress an 80-dB dynamic range to 40 dB, and then re-expand it to 80 dB. Each circuit has a full-wave rectifier that provides average-value data to a variable-gain cell located in either the input stage or the feedback path. A temperature-stable bandgap reference provides precision voltages and currents. The compander runs on supply voltages from 2.1 V to 7.0 V, has an adjustable response time, and a preset unity-gain level of 100 mV rms. Five external capacitors and two resistors are required, all non-precision. The MC33110 compander chip comes in a 14-pin DIP or SO package and costs $0.80 in quantities of 10,000.

Motorola Inc., P.O. Box 52073, Phoenix, AZ; (602) 897-3615. CIRCLE 783

NEW CHO-THERM® Conformable Elastomer Heat Sinks

CHO-THERM T274 and T386 materials are pliable elastomers which blanket over uneven component surfaces to draw heat away from PC boards into metal covers, frames or spreader plates. Unlike liquid-filled plastic bags, these CHO-THERM materials interface with pointed, sharp surfaces without risk of punctures.

For highest conformability and good thermal performance choose CHO-THERM T274 material. For exceptional thermal conductivity select CHO-THERM T386. Both materials come in 6 thicknesses ranging from 40 to 200 mils, in sheets and custom die-cut configurations. Custom thicknesses are available on request.

Let CHO-THERM Cool A Hot Product For Longer Life.

© Chomerics, Inc. 1990
PLD TOOL OPTIMIZES DEVICE RESOURCES

Enhancements to Version 2.0 of PLDesigner expand the tool's ability to optimize a design. PLDesigner, a synthesis tool for programmable logic devices (PLDs), has new features that include automatic DeMorganization, automatic don't care capability, and increased device support. PLDesigner now generates the DeMorgan equivalent of all equations automatically, and for a given device, selects the equation that uses the fewest device resources for fitting. Automatic generation of don't care outputs can be enabled by the user for If-Then-Else, Case, or state machine designs. With this feature, unspecified output values are assumed to be don't cares. When the equations are reduced, the compiler will assign a 0 or 1 value to the output, depending on which value produces the optimal equation. Also, more devices have been added to the PLDesigner libraries, bringing their total to almost 3200. Shipping now, PLDesigner runs on Sun workstations and 80286- and 80386-based PCs. Pricing ranges from $1950 to $10,500, depending on platform and options. 

Gold Logic Inc., 6755 Earl Dr., Colorado Springs, CO 80918; (719) 590-1155.

DESIGN FPGAS FROM BEHAVIORAL ENTRY

The Plustran Behavioral Entry System (BES) is a field-programmable gate array (FPGA) toolset that lets designers bypass schematic capture and create chips with behavioral descriptions. Behavior can be entered with Abel, CUPL, Palasm, and other Boolean descriptions. Consequently, designers familiar with PLDs and PALs can have access to FPGA technology without changing their design tools or methodology. Plustran BES doesn't require that designers partition logic equations to fit a smaller series of PALs. In addition, existing design implementations using multiple PALs can be converted to an FPGA with Plustran. The tool processes these existing designs as an integrated set, automatically removing the artificial partitions. Plustran BES is available now in DOS or Sun Unix versions for $475. Pluss Logic Inc., 1255 Parkmoor Ave., San Jose, CA 95126; (408) 293-7587.

A new user interface, better on-line help, and faster options setting with integrated configuration utilities have made Maxroute version 3.20 easier to use than previous autorouter versions. Maxroute is an interactive pcb-board autorouter that uses shove technology to select the shortest and most efficient path for each trace by shoving existing traces out of the way whenever necessary. Also, version 3.20 places vias better and ensures proper entry to and from pads. New algorithms allow for automatic routing of surface-mounted components in the same way that it would be done manually. In addition, Maxroute's algorithms have been fine-tuned to reduce the number of vias. Maxroute version 3.20 runs on PCs, and is available now for $6500. Maintenance costs $750. A free demonstration disk or evaluation copy of Maxroute is available by calling the company. Massteck Ltd., 95 Russell St., Littleton, MA 01460; (508) 886-0197.

MAXROUTE IS EASIER TO USE

SPREADSHEET CREATES ANALOG MODELS

Analog-circuit designers can build custom Spice models with SpiceMod, a modeling spreadsheet that creates circuit models quickly and accurately based on data-sheet parameters. The program models all types of diodes, Zener diodes, bipolar-junction transistors, power transistors, Darlington transistors, and field-effect transistors. Built-in intelligence lets designers determine model parameters even if the appropriate data isn't available. SpiceMod understands both data-sheet parameters and Spice model parameters, and converts from one to the other. Designers can create entire model libraries, search for individual models, and update them as desired. Because all models made with SpiceMod are stored in ASCII files, designers can view and edit models with their favorite editor or word processor. The program contains complete on-line help with information on data-sheet parameter requirements, the Spice model, and the subcircuit parameters produced. Critical equations for device operation are also given. SpiceMod runs on PCs and costs $200. It is shipping now.

Intusoft, P.O. Box 6607, San Pedro, CA 90734-6607; (213) 833-0710.

NEW PRODUCTS
24 FILTERS ADDED TO SYSTEM SIMULATOR
Version 1.1 of the Tess block-diagram simulator incorporates a long list of new features, including 24 new filters. With a filter-response calculator, users can compare simulated and ideal filters. Designers can specify nonlinearities with intercepts and compression points using the rf mixer and amplifier models. Also new to version 1.1 are high-quality graphics with interfaces to publishing software and plotting devices. The tool’s memory management can handle large model libraries and can run other tools, such as Orcad and P-CAD schematic software. The new release maintains compatibility with existing Tess simulations and user-created models, and the user interface is the same. Tess version 1.1, which runs on PCs, costs $695 and is shipping now. A demonstration disk is available by calling the company.

Tesoft, 205 Crossing Creek Ct., Roswell, GA 30076; (404) 751-9785.

CAD TOOLSET GETS A NEW USER INTERFACE
The newest generation of Cadstar design tools are easier to use thanks to a Motif-like user interface. Cadstar’s new interface no longer has several menu filters, improving click and move performance. The interface provides consistency across all functional operations. Its features include Macintosh-like operation with a menu top bar. Cadstar helps users with surface-mounted technology and high-density board design, combining auto-rename-by-side for two-sided boards with surface-mounted parts. Analog design features include curved track, curved copper, teardrop pads, maximize copper, and copper cutout. These features support layout technologies for rf, microwave, and high-power applications. Cadstar, which is shipping now, costs $4850 and runs on PCs.

Racal-Redac, 1000 Wyckoff Ave., Mahwah, NJ 07430; (201) 848-8000.
**NEW PRODUCTS**

**COMPUTER-AIDED ENGINEERING**

**FASTER VERIFICATION, PLACE AND ROUTE SPEEDS ASIC DESIGN**

Improved verification and place-and-route tools available from Mentor Graphics Corp. can speed ASIC design. Explorer CheckMate is an IC physical-verification tool that was co-developed with Texas Instruments. Across most designs, users can expect throughput improvements of 20 to 300%. Parade is an ASIC place-and-route tool that the company claims works up to 10 times faster than any other router today.

In addition to being fast, Explorer CheckMate also has high capacity. These two benefits are the result of network distributed processing, efficient database management, and efficient memory and disk-space use. Special algorithms minimize much of the repetitive data found in most hierarchical designs. CPU time is reduced by checking only one of many identical cells in a design. High capacity is achieved by compressing polygonal data and taking advantage of repetitive, hierarchical data.

The Parade tool can place and route gate arrays as well as complex-block and standard-cell designs in any combination of architectures. Moreover, Parade can handle any number of routing layers and over-the-cell routing. Its speed is obtained through network distributed processing, improved architecture and database efficiency, and a new placement technology called Spectral Derivatives. Spectral Derivatives provides better component placement of ASIC cells, which results in less work during placement improvement and 5 to 15% better gate utilization.

Both Explorer CheckMate and Parade are available now for $98,500 and $800,000, respectively. A parallel-processing option for the Parade software costs $45,000 per node.

**UPGRADED PC-BASED CAD SYSTEM PERFORMS AUTOMATIC T-ROUTING**

The latest version of CAD Software Inc.'s PC-based Pads-2000 PCB design system now executes T-routing. Version 2.0 is the second release of the 32-bit CAD system, which features many functions of the workstation-based systems.

T-routing is the ability to route from any track within a net to any other pin, via, or track segment in the same net. Users can start from or tie into a track using a "T" without having to finish at a component pin. In addition, the T-routing feature automatically removes excess track where necessary.

A new graphics engine has been added to Pads-2000. The new engine facilitates the use of Number Nine, ELSA, and Metheus graphics, as well as many others. Also, Postscript and HP LaserJet outputs are available.

Other features include micro, thru, and blind and buried vias. Users can rotate text and 2D designs, and can rotate components and component pads in 0.1 increments.

Pads-2000 Version 2.0 is shipping now for $6995. It runs on 80386- or 80486-based PCs. Pads-2000 Version 3.0 will be shipping in a few months. It will include all of the Version 2.0 features, plus automatic mitering of 90° angles and curved tracks.

**CLASSIFIEDS**

**EMPLOYMENT OPPORTUNITIES**

**ELECTRONIC ENGINEER - Surface Mount Technologies & Production Coordination Engineer required to participate in the mechanical configuration design of miniature surface elements, design of miniature wiring technology, development of assembly facilities, and development of operating miniature bonder. The applicant will also participate as an engineer in the development of the manufacturing process for full scale production and will be responsible for the coordination between the development group and the manufacturers of the surface mount elements. Position also requires the development of computer programs for trouble shooting of the product as well as the design and implementation of computer programs for stock monitoring and recording. Applicants should apply in person or by resume to Georgia Dept. of Labor, Job Order #GA54559889, 1275 Clarendon Ave., Avondale Estates, GA 30002, or to the nearest Georgia Job Service Center.**

**BUSINESS SERVICES**

HARDWARE AND SOFTWARE DEVELOPMENT SERVICES

S/W: Assembler, PL/M, C, MS-DOS & OS/2
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**DEVELOPMENT SERVICES**

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NEW PRODUCTS

DATABASE SYSTEM GIVES USERS GRAPHICAL HELP
The second generation of an object-oriented database from Ontologic Inc.—Ontos Release 2.0, a graphical design tool—automatically generates C++ header files and database schema. In addition, interactive database inspection and maintenance are simplified with a graphical browser. Ontos is an object-oriented database management system targeted at network-based, data-intensive applications. Ontos supports full data distribution across local-area networks and has support for multiple inheritance. Ontos Release 2.0, which is shipping now, runs on Apollo, DEC, and Sun workstations. Four development licenses for Ontos cost $22,500, not including software support.

Ontologic Inc., Three Burlington Woods, Burlington, MA 01803; (617) 272-7110. CIRCLE 791

HP CASE TOOLS RUN ON SUN SPARCSTATION
HP’s SoftBench, which now runs on Sun Sparcstation computers, is a tool-integration framework used for computer-aided software engineering (CASE). It offers a common interface and communication among tools used to analyze, design, debug, test, and maintain software products. This is the first offering for SoftBench outside the HP-Apollo environments. In addition, HP’s Encapsulator tool is now available for Sparcstations. The software integrates third-party CASE tools into SoftBench. Both tools should be available in April, each for about $3000 per seat.

Hewlett-Packard Co., 19310 Pruneridge Ave., Cupertino, CA 95014; (800) 752-0900. CIRCLE 792

MAC COMMAND SHELL ADDS FEATURES OF DOS AND UNIX
By combining the convenience of a Macintosh with the flexibility of a DOS or Unix-style command-line interface, users get a simple-to-use interface for their Macintosh. Envyre, an interactive command shell for the Mac, offers the ability to rapidly manipulate files, manage directories, or view source code or hexadecimal listings of source code. The software supports any ASCII printer that connects to a Mac. Because of Envyre’s command-line interface, users can easily switch between DOS, Unix, and Mac environments. It’s available now for $99.95.

Appropriate Solutions Inc., 145 Grove St., P.O. Box 458, Peterborough, NH 03458; (603) 924-6079. CIRCLE 793

PLOT ENGINEERING DATA USING COMPLEX OPERATORS
Graph Version 3 retains many features of the previous editions of the plotting software, but also adds many new features. Designed for plotting scientific and engineering data, the tool permits data transformations with operators that include log, exponential, square root, add, subtract, reciprocal, integral, and derivative functions. Plots can have linear or log axes and data can be presented in histogram form. Some of the new features include extended-memory support, multiple Y-axis plotting, and importing of Lotus, dBase, and ASCII files. Graph Version 3 costs $149 or $69 to upgrade from an earlier version.

MicroMath Scientific Software, 2469 East Firt Union Blvd., Suite 200, P.O. Box 21550, Salt Lake City, UT 84121; (801) 943-0290. CIRCLE 794

CIRCLE 88
SERIAL I/O CONTROLS, READS, OCTAL LOW-SIDE SWITCH IC

Driving up to eight separate 1-A, 30-V loads, the TPIIC2801 from Texas Instruments consists of eight low-side switches, host-controlled through a bidirectional, serial I/O interface. Applications for the IC are numerous, and range from office machines and computer peripherals to medical instrumentation, vehicles, and industrial controls.

Typical loads for the device include lamps, relays, print-heads, small solenoids, and stepping motors. The IC’s outputs can also be used to drive larger bipolar and power DMOS transistors.

The condition of each of the eight switches in the IC is set by an 8-bit word from a host computer via one of the two I/O lines. The second line, a clock, drives the serial-in, parallel-out shift register fed by the serial input word. The eight shift-register outputs set latches that, in turn, set the power switches on or off. A serial-out pin permits daisy chaining multiple 2801s or other compatible serial I/O ICs. Alternatively, switches can be paralleled to handle higher currents.

Each switch is monitored by a voltage-comparator circuit that checks its output voltage against an internal, out-of-saturation, voltage reference level. When the output voltage exceeds the 2-V reference (if the switch is closed), the switch is latched open. Current-limiting keeps the current in each output below 1.05 A, and a 90-kΩ pull-down resistor keeps switch outputs low when in the off state.

The eight npn-transistor switches in the TPIIC2801 IC all have 35-V, collector-base, Zener-diode clamps, which eliminate the need for external snubber circuits when switching inductive loads. The Zener diodes turn the switch on, preventing avalanching and providing a 40-mJ unclamped inductive-energy rating.

If an overvoltage or overcurrent fault occurs, the chip identifies the recalcitrant output and notifies the host computer via the I/O port while the unaffected switches remain in operation. The host computer checks for an open-circuit output by turning it off. Another control byte is then clocked into the chip. If the diagnostic bit returning to the host computer is low, the output is open. The host computer detects a current overload by turning a switch on. A second control byte is sent and a logic-high returning check-bit indicates current overload.

The TPIIC2801 low-side switch circuit is available in a 15-pin power SIP and is rated for operation at case temperatures ranging from -55 to 150°C. In quantities of 1000, the chip is priced at $3.20 each.

Texas Instruments Inc., Semiconductor Group, (SC-9076), P. O. Box 809066, Dallas, TX 75380-9066; (800) 336-5236, ext. 700.

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<table>
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<tr>
<th>Pin Model</th>
<th>Connector Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>KSW-2-46</td>
<td>ZFSW-2-46</td>
</tr>
<tr>
<td>KSWA-2-46</td>
<td>ZFSWA-2-46</td>
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</table>

<table>
<thead>
<tr>
<th>SPECIFICATION</th>
<th>DC-4.6 GHz</th>
<th>DC-4.6 GHz</th>
<th>DC-4.6 GHz</th>
<th>DC-4.6 GHz</th>
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<tbody>
<tr>
<td>FREQ. RANGE</td>
<td>typ</td>
<td>typ</td>
<td>typ</td>
<td>typ</td>
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<tr>
<td>INSERT. LOSS</td>
<td>typ max</td>
<td>typ max</td>
<td>typ max</td>
<td>typ max</td>
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<tr>
<td>dc-200MHz</td>
<td>0.9</td>
<td>1.1</td>
<td>0.8</td>
<td>1.1</td>
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<tr>
<td>200-1000MHz</td>
<td>1.0</td>
<td>1.3</td>
<td>0.9</td>
<td>1.3</td>
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<tr>
<td>1-4.6GHz</td>
<td>1.3</td>
<td>1.7</td>
<td>1.5</td>
<td>2.6</td>
</tr>
<tr>
<td>ISOLATION (dB)</td>
<td>typ min</td>
<td>typ min</td>
<td>typ min</td>
<td>typ min</td>
</tr>
<tr>
<td>dc-200MHz</td>
<td>60</td>
<td>50</td>
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<td>45</td>
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<td>1-4.6GHz</td>
<td>30</td>
<td>23</td>
<td>30</td>
<td>25</td>
</tr>
</tbody>
</table>

- **SW. SPEED (nsec)** rise or fall time: 2(typ), 3(typ)
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