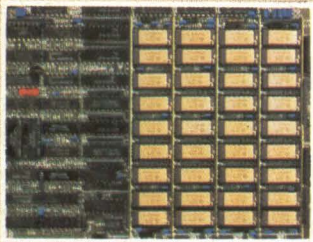


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Digital Design

Computers • Peripherals • Systems

Compatible Computer Memory 12



This report examines auxiliary memory technology, markets and selection criteria. Rapid changes require you to more actively examine shorter lead times, costs, supposedly compatible boards and other pitfalls.

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How much system insurance should you buy? It varies. Here is a designers' guide to UPS and selection criteria guidelines.

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Color is making rapid inroads in computer graphics. Here are recent product technology advances, system design changes and future trends that will affect you.

Principles of Designing 52 and Specifying Power Supplies

Specifying linear or switching supplies is a new game: failure to carefully consider vendors, supplies and rapidly-changing technology is an invitation to disaster.

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This showcase is a roundup of recent power supply products, specifications, prices and vendors to contact.

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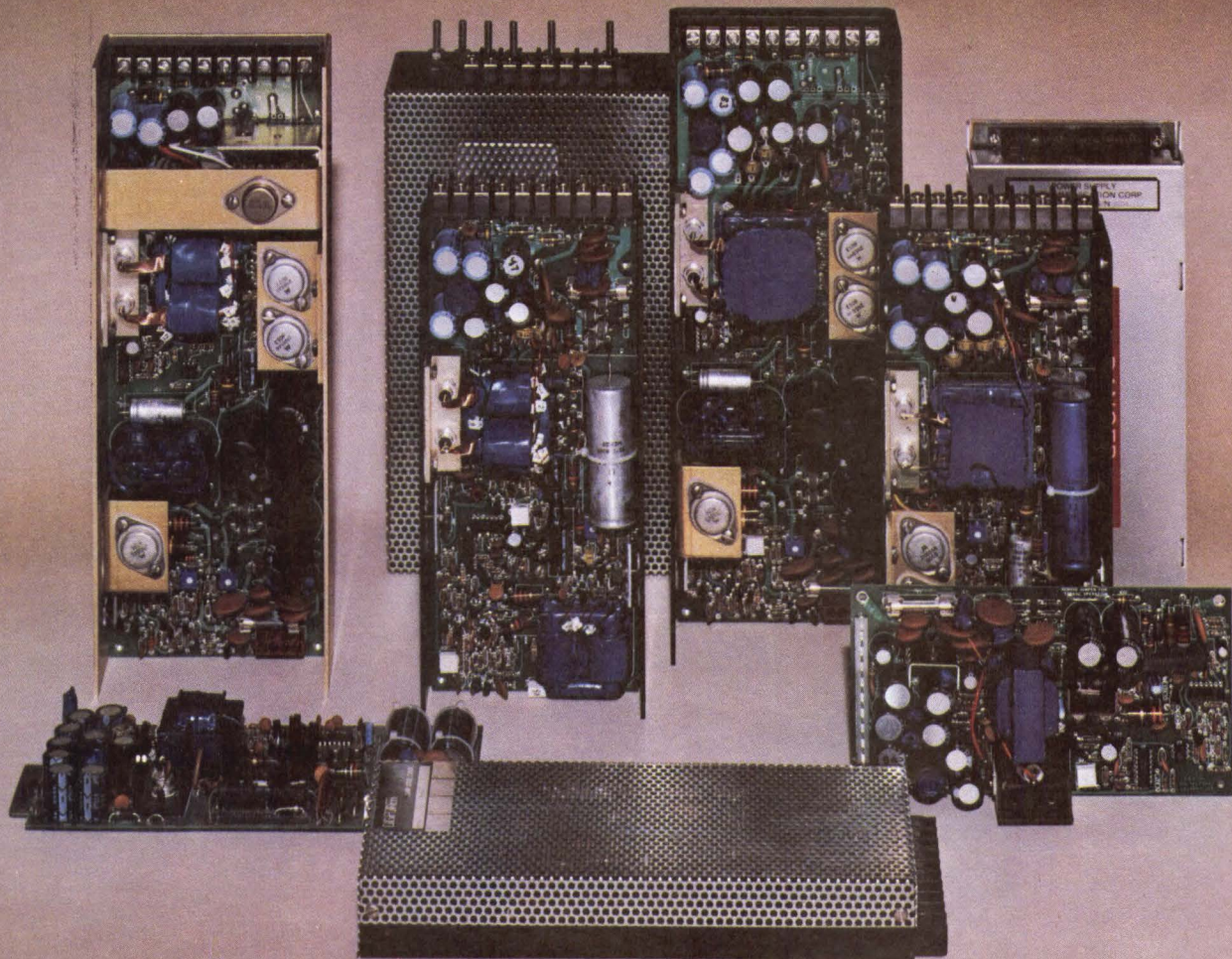
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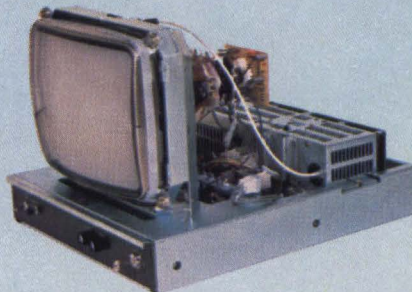
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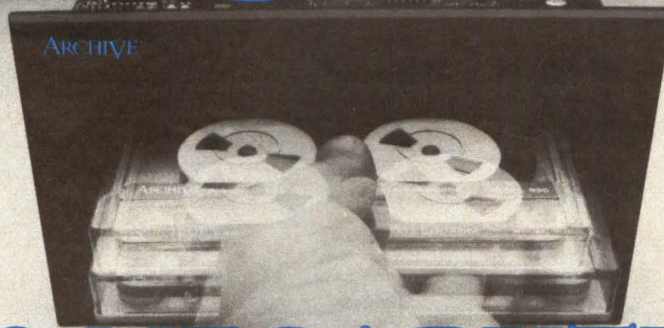
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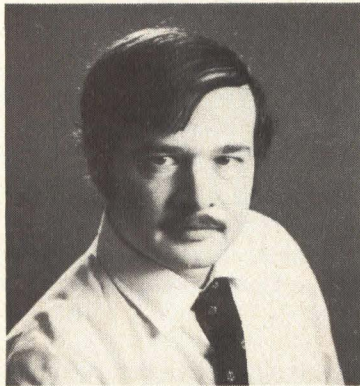
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Will Ternary/Quaternary Logic Overcome VLSI Problems?



Paul Snigier, Editor

Increasing activity in the area of ternary and quaternary logic may alter the computer industry. Historically, ternary and quaternary logic development was low-keyed and under-financed. Earlier I²L ternary logic chips were slow, suffered from mediocre operation, and were a dead-end technology. But now the picture is rapidly changing. Technological developments are increasing chip capacity. Unfortunately, this aggravates VLSI on-chip wiring, creating design headaches.

As semi-makers shoehorn more devices onto VLSI chips, more real estate must be devoted to on-chip wiring and overhead functions. So serious is this now that if storage element dimensions were to halve, then overall density would not significantly improve!

Other problems are surfacing: on-chip wiring and inter-chip interconnection problems aside, the physical limits of silicon will soon be asymptotically approached. Already the speed of light (11.8 inches/nsec) is posing problems. For example, Cray-1, using only MSI, grappled with this problem and solved it by means of its unusual and small, cylindrical geometric configuration. Other potential solutions include Josephson Junctions, gallium arsenide, multiprocessing and non-Von Neumann architectures. The VHSIC program will also have its affect upon future directions. But we cannot wait.

Most of these and other solutions will extend and accelerate computer development well into the next century. Unfortunately, most of them will have no short term effect. In the near-term, however, on-chip wiring problems are growing and it looks like higher-logic could be a solution.

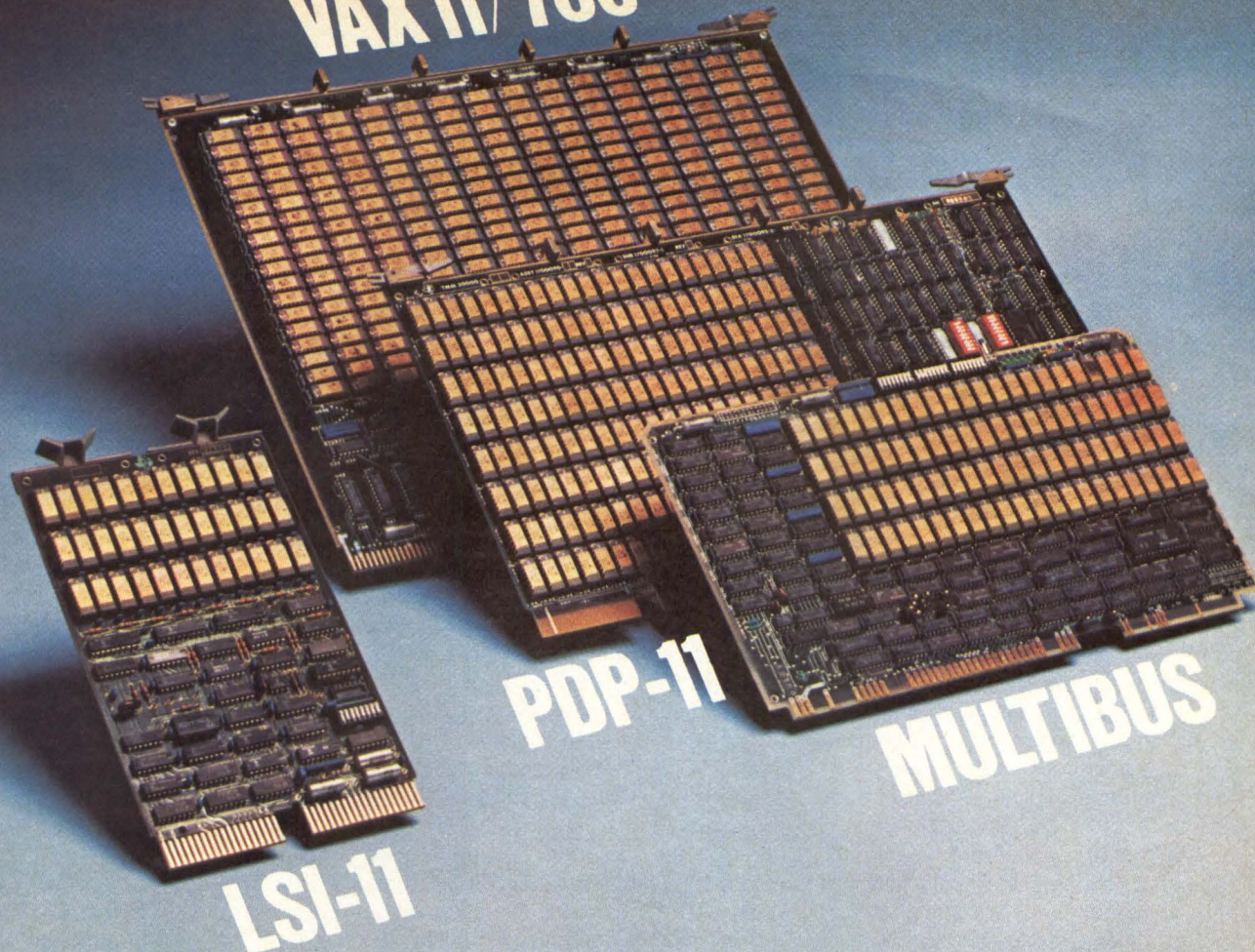
Once ignored as a "dark horse" technology, higher logic is now receiving increased attention from National Semiconductor, Intel, IBM and others. If these firms can successfully manufacture higher logic devices in quantity—and it proves to be the solution to increasing on-chip wiring woes—then ternary or quaternary logic will require modified and new logic functions. In ternary logic, subtractors, multipliers, half-adders and JK master-slave flip-flops will all exist, but will be different than in binary. New functions will include predecessors (decrementors), successors (incrementors) and replicators (double inverters).

Unfortunately, problems exist with fabrication complexity. Ternary and quaternary logic is not necessarily simpler in terms of fabrication: in ternary, a SRAM cell needs 14 transistors; quaternary will require even more! This certainly won't help improve yields. Fortunately, this problem does not extend to read-only ternary or quaternary memory cells. This may be a partial solution and was used in quaternary memory cells on Intel's 32-bit iAPX 432.

Is this a precursor? Or will higher logic become a niche technology? It may depend on funding. Although research activity in ternary and quaternary logic is picking up, it isn't yet adequate in terms of the potential payoff. It may be for the Japanese to exploit the technology properly. D

Paul Snigier

VAX11/780



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PDP-11 [†]	TMM20000 ²		X	X	X	X		X
VAX [†]	TMM30000					X	X	X
Multibus [‡]	TMM40010 ²	X	X		X	X		

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Trends Alter Testing And Maintenance Of Peripherals

The need for off-line peripheral test equipment lags the growth of add-on peripherals markets only by a few months. Major methods for testing peripherals come in many different forms, depending on attitudes of the QC manager, production manager and service/repair manager. In some instances, there is a trend toward including the engineering staff. Larger manufacturers of both peripherals and hardware systems are spending an incredible amount of dollars to support their peripherals with test equipment all the way from the manufacturing floor to end user support.

When asked about the variety of means of testing peripherals that are now available, or will be in the near future, Philip J. Lagestee of Wilson Laboratories, Orange, CA, provided the following comments.

testing methods

"The three most common methods of testing, evaluating and repairing peripherals (such as the mag tape drive) are: computer assisted diagnostic system test routines, off-line test equipment designed specifically for the peripheral which is to be tested and an exercise routine (or hardware exerciser) and a scope. Most manu-

facturers and some systems houses use all three. The service technician and the end user use the exerciser and scope concept to maintain and repair peripheral equipment after trouble shooting with a diagnostic routine. The fastest and most accurate method of determining the status of a peripheral is to use an off-line dedicated piece of test equipment which induces all the modes of operation to be tested along with WRITE/READ data comparison in order to pinpoint the specific trouble spots, if they exist, and to perform routine maintenance, such as head alignment.

"In order to find the preferable method of testing mag tape drives (on-line, off-line, or scope and exerciser), the test's use is determined. It is safe to say that in most cases the scope and exercise routine can be eliminated; however, there are a very few instances which are almost impossible to solve in any other manner. This leaves a choice between off-line testing (the hardware test box) and on-line testing (diagnostic and other software routines).

"On-line testing, while needing a significantly higher dollar investment than off-line testing, is the best method for performing long term evaluations and long term data reliability tests.

Other than these exceptions, off-line testing via a comprehensive hardware test box is the most economical, the fastest and the most determinate method for incoming inspection, manufacturing QC problem detection, and field service and depot level repair.

"Advantages of off-line testing include lower capital expense, portability, comprehensive testing of the important functions of peripheral, ease of use of device, time saving over other methods, useability (by entry level technicians) and doubling as a marketing demo tool.

trends

"Availability of inexpensive and highly reliable off-line test equipment for all major peripherals is being addressed by many major manufacturers who are referring customers to independent manufacturers of test equipment. Price, performance, lead time, and major engineering and production investment costs for OEMs, third party maintenance organization, and manufacturers, are overriding factors in selection and/or referral to independent vendors for off-line test equipment. In some cases the independent is the only source for the equipment needed."

Top Management Wants More Computer Graphics

Business graphics markets will average a hefty 59% annual growth over the next five years. Revenues from sale of business graphics equipment will swell from a mere \$126 million in 1979 to over \$1.02 billion by 1984. Leading the way will be display equipment, accounting for revenues of \$476 million in 1984, followed by hard copy devices with \$222 million, and business/personal computers with \$210 million.

The most frequent applications are management presentations, of which 85% are involved, and financial planning (59%). Business graphics are

Business Graphics Equipment Market Forecast (Worldwide Shipments of US Manufacturers) (Revenues in \$Millions)						
Product Category	1979	1980	1981	1982	1983	1984
Displays	\$65	\$100	\$170	\$275	\$360	\$476
Hard Copy Devices	45	75	100	135	180	222
Photographic	3	12	24	35	58	85
Business/Personal Computers	8	22	50	85	140	210
Other	5	8	11	15	22	27
Total	\$126	\$217	\$355	\$545	\$760	\$1,020
Growth		72.2%	63.6%	53.5%	39.4%	34.2%

Displays, hard copy and personal business computers will take over the market in 1984.

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being produced in many different departments throughout the organizations surveyed. The most common location is the dp department, followed by the corporate planning department. Many different people are now producing graphics, ranging from secretaries/assistants, to end users, graphic art departments and computer graphic specialists. Most of the busi-

ness graphics output is employed by middle and upper level management (59%).

When queried about what they look for in choosing graphics equipment for business applications, respondents repeatedly cite low cost and ease of use. Feature-wise, image quality of hard copy printout and application software are other factors deemed important by users.

Most companies now using business graphics are pleased with results and plan to expand their systems still

further in the next year or two. Some 45% of the sites polled are planning to buy at least one graphics terminal before the end of 1981, and 64% of these specified color terminals as their preference. Graphics hard copy equipment is planned by 33%, and 11% are planning to purchase additional graphics systems. Other items on their "wish lists" (desires, but not firm plans at this point) include: additional software (20%), large screen projection systems (9%), and color displays and hard copy (48%).

Clearly the fact that a 71% majority of users are forging ahead with business graphics is a good indication of the potential for add-on business in this market. In most every case, cost justification played an important role in the buy decision. Savings in time and money over manual methods are the chief factor leading to implementation of business graphics applications.

Two major divisions of the business graphics market are emerging: one for graphic peripheral devices and graphic software for existing central computer systems. The other is for small systems primarily intended for business graphics. There is definitely a market for such systems, but they must be reasonably priced and easy to use. Look for these systems to increasingly find their way into the planning and financing departments of large companies.

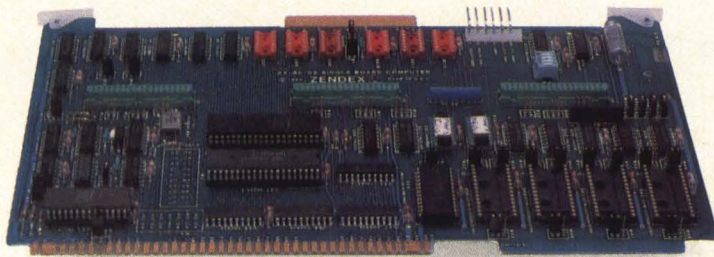
This report was condensed from a \$2,500 study, "Computer Graphics: The Business Applications Market," from IDC at 214 Third Avenue, Waltham, MA 02254. (617) 890-3700.

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Saturated Transistors Boost IC Speed

Using saturated transistors as capacitors rather than as switching elements can increase IC speed and power and cut cell size. IBM feels that the "Dorler-Mosley Saturated Transistor Effect" may allow chip designers to squeeze over 10,000 high-performance logic circuits on a chip. Applied to memory decode circuits, the effect is expected to improve speed and reduce power by more than 30%.

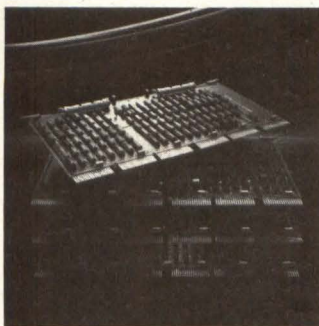
Engineers at IBM's General Technology Div. at East Fishkill, NY implemented the effect by using a switchable, saturating current source in

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DESIGN

PERFORMANCE

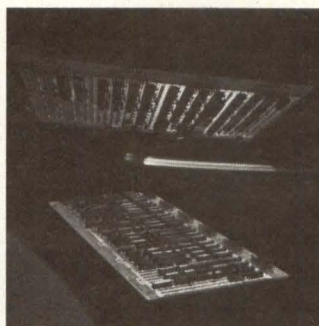
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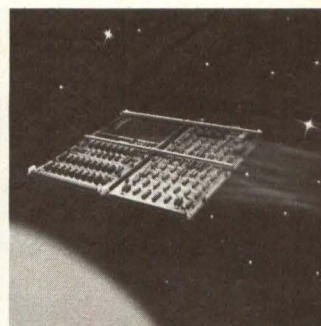
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The IPS 7811—
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an experimental NOR circuit. The result is a measured speed-power product of 0.4 pJ. This contrasts with a rating of 4.0 to 8.0 pJ for ECL and approximately 1.2 for TTL.

The experimental NOR circuit was fabricated as a 15-stage ring oscillator using standard 2.5 μm manufacturing processes. It has a rating of 1.0 pJ without the Dorler-Mosley Effect. The

saturated transistor improves the rating by approximately 60%, mostly by virtue of reduced power consumption.

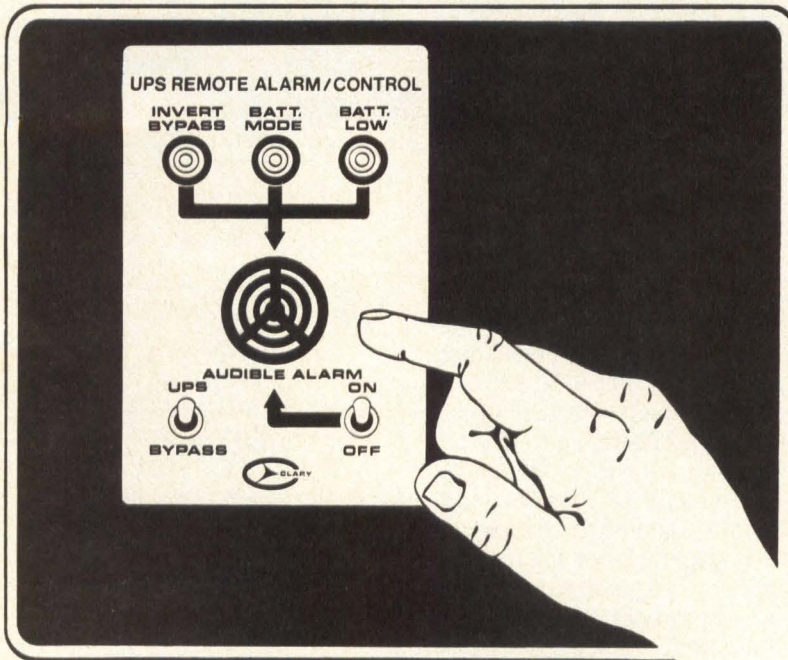
In memory, the effect is expected to transform a 20 ns, 2-3W chip into a 12 ns, 1.5W chip, while density could be doubled from 1024 to 2048 bytes. The effect yields a high value of capacitance at low power.

A transistor is saturated when both the emitter and the collector junctions are forward biased during the "on" condition. Circuit designers avoid this because under most circumstances it

increases the delay considerably.

The Dorler-Mosley Effect improves efficiency because power is spent most during transitions, and only enough DC power is used to assure noise margin. The effect may give circuit designers a large variety of speed-power options, depending on intended applications. For example, in large systems, circuits in which the effect is used might be packed at densities exceeding 10,000 per chip utilizing 0.15 mW per circuit. Power of this magnitude means performance sacrifices at the circuit level, but high-performance achievements at the machine level. In systems where speed is the priority, performance at the level of ECL might be achieved utilizing 1 mW per circuit.

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IBM Fabricates 288K-Bit DRAM

IBM's Burlington development laboratory in Essex Junction, Vermont has fabricated an experimental 288K-bit dynamic RAM. It stores four times as much as IBM's 72-K bit RAM now in volume production.

The new chip is an extension of IBM's silicon and aluminum metal oxide semiconductor (SAMOS) technology used to manufacture the company's 64K-bit and 72K-bit RAMs and several other high-density memory components. The 288K-bit RAM was fabricated on the same manufacturing line that produces the 72K-bit device. A batch of fully functional 288K-bit chips was produced on this line to demonstrate the manufacturability of the new design. In this trial, 65 chips were fabricated on each of 32 silicon wafers 82 mm (3.228") in diameter.

IBM currently has no plans to include this 288K-bit chip in its manufacturing program. A 256K-bit (256K × 1 organization) RAM is currently being provided in sample quantities by a Japanese firm. Another firm offers a 256K-bit hybrid IC made of four 64K chips. Industry observers predict that 1982 could see several semiconductor companies offer 256K × 1 RAMs. If so, this could take some of the momentum out of the 64K RAM. IBM was first with a 64K RAM; and, although industry spokesmen criticized the chip's inefficiencies, it proved admirably suited to IBM's in-house needs. What approach IBM will take to the next generation RAM is uncertain.

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Compatible Computer Memory

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It was two years ago that IBM's aggressive memory price-cutting triggered the independent add-in/add-on memory makers and semiconductor manufacturers into a price-cutting panic. Independents, under pressure from the growing number of IC houses — IC manufacturers that entered the memory business — certainly fell upon lean times; for a time, losses experienced by these independents made it look like many would leave the business. Despite the gloomy outlook, the situation improved, and most survived the price cutting. But the new round in the price wars will see a shakeout coming. This article examines the technological and marketing changes now taking place and what OEMs must do to survive.

by Paul Snigier, *Editor*

Auxiliary memory remains a buyers' market. It is a fiercely competitive, low profit-margin business. We will discuss new changes now occurring and how they will affect you.

fierce competition and low profit margins

Independents are out of the vise that IBM's aggressive price-cutting put them starting in late 1979. Some folded, others survived, and some finally prospered. Semiconductor makers, however, have grown more than expected, emerging as a dominant force in this market. Competition is fierce, and profit margins small. The partials debate has subsided, and it should be non-existent as we reach the mass markets with the 64-K RAMs. Much delayed, partly because of the problems of going to a single 5-V source, 64-K RAMs stumbled on the way to market, and it looks like the Japanese will take this round. They will establish a greater share of market and maintain it; and, as a consequence, will emerge as a more potent force in the add-in/add-on memory market.

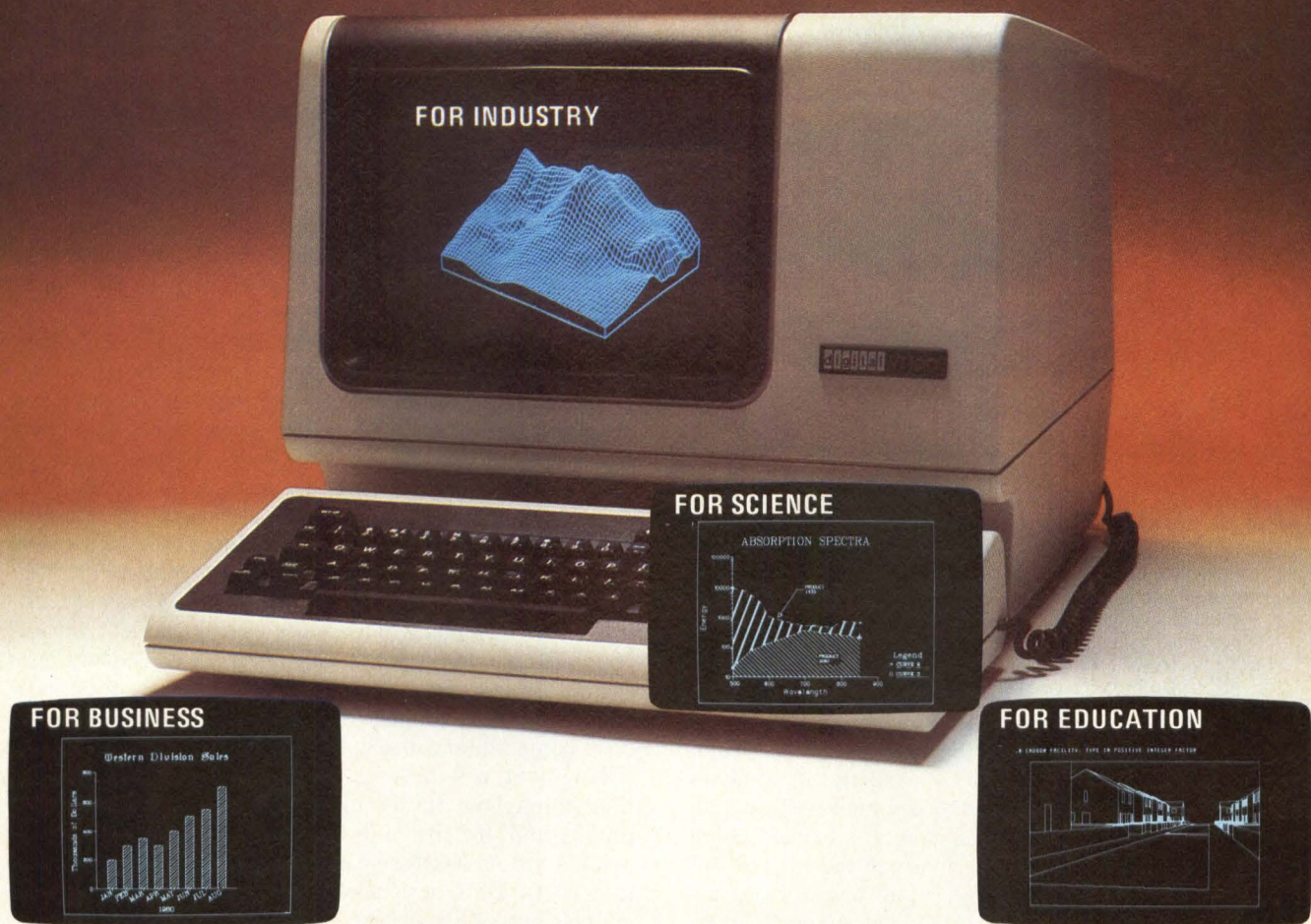
The make-or-buy memory board decision continues to trend to the buy side, with the crossover dollar-volume ratios rising. Improved customer support of the add-in/add-on makers is a relief over the lower-quality support too many gave just two years ago. Fly-by-night board makers, of course, still exist, but the bigger independents and semi makers offer security, brand name recognition, lower prices and faster delivery. The market has shed its seedy image.

But, the other side of this coin is: the slowdown (AMD, TI and a few other semi makers have forced workers to take vacation days off), shortened lead times, fierce competition and low profit margins. It hasn't really hurt the system houses as much — which aren't so dependent on small profit margins, cutthroat competition and large volumes that the memory and semi makers have — but will affect the mini and microcomputer makers for different reasons. DEC, DG, HP, PE, IBM all should be able to ship more memory. This can only hurt independents and semi houses (mostly the independents).

buying market share

Despite the rapidly growing market for add-in memory boards, price-cutting will create a shakeout. Cutthroat competition between independents has worsened, profit margins are slim, and there is no turnaround in sight. New independents continue to enter this market, offering new products; and, judging from the number of product releases that our editors receive, we estimate that between five and ten memory boards are introduced each day. (On the other hand, we never receive releases of those memory boards that are discontinued, generally with little fanfare.) An estimated \$100M in sales drew many independents into the field and caused others to expand their product lines. The competition, which resulted from more manufacturers cutting the pie into smaller pieces, meant that the competition should drive prices down, seriously eroding profit margins and producing a shakeout of add-in memory manufacturers. Already, firms like Control Data Corp., Dataproducts Corp., Fabri-Tek, Periphonics and several others have left the market.

With most OEMs prepared to switch vendors for less than



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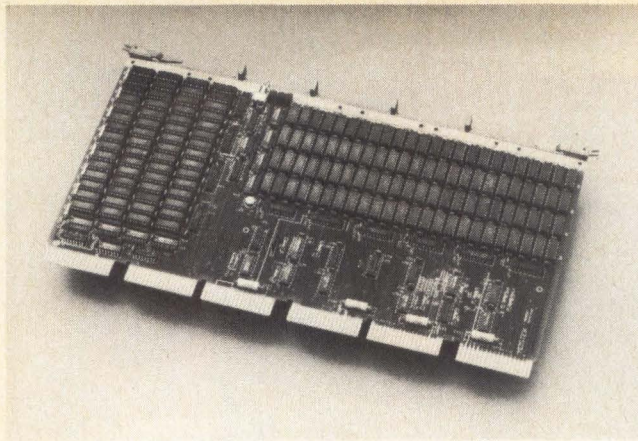


Figure 1: The add-in memory market for the PDP-11/70 grew rapidly. This Mostek MK8070 (\$3395) has a 64K word \times 39 bit capacity, allowing the 11/70's full 4MB of addressable memory to be contained in one box. It can be used in any MK 11-compatible interleaving scheme (no interleaving, internal, external 2-way or external 4-way). LEDs indicate on-line-status with selection by the controller and an on-line/off-line switch.

75 cents per board, the market is price sensitive. So, to take advantage of this, larger board manufacturers are buying market share at the expense of short-term profitability. Unfortunately for smaller independent board makers, who cannot afford such tactics, they face a dilemma: their lack of financial staying power makes it hard to buy market share with lower prices, conduct needed research and expand. With over 50 add-in memory manufacturers in the field at last count, it is only a matter of time before several leave the business. This is true in spite of add-in memory markets growing over 35% last year with continued growth ahead.

The ongoing price war created an ideal situation for OEMs: intense competition, lower prices, intense research, earlier next-generation 64-K RAM boards, improved service and better reliability. Prices dropped 50% in 1980 for larger memories (such as the VAX) and 20% for smaller, less commonly-used computer compatible boards.

VAX memory: easier to design

The VAX computer-compatible memory market did not prove to be the highly profitable market for everyone as anticipated two years ago. Some independents are losing money in this market sector. The 32-bit add-in memory market, which promises to far exceed the 16-bit memory board market, suffered a 50% price drop for certain boards. The VAX-11/780 and /750 auxiliary memory market was quite profitable for the initial entrants, who initially charged more and recaptured their R&D, engineering and production costs. For late entrants, who had not established their share of market, things were tougher. For them, the alternative was to buy a share of market by cutting costs or adding extra features and functions. But due to the nature of the VAX, this was not possible. Unfortunately for the independents, VAX's memory functions are in the controller and CPU. Their memory boards must be, of necessity, rather simple. So, VAX memory boards are easier to design. This means it's difficult to add value.

All that is left for competing in the VAX memory market is to offer lower prices and better service. Because VAX compatible memory cards are more dependent on low chip costs, semiconductor manufacturers and large independents have a distinct edge over medium to small-sized independents. Smaller independents are forced into a corner; and, looking

for value-added features, they are forced to compete on the basis of service. Unfortunately, larger and established independents generally have superior track records when it comes to field service and maintenance of their boards. In addition, the large independents can offer one-stop shopping for OEMs. Since many OEMs, particularly smaller OEMs, prefer to purchase most of their peripherals through one vendor, these larger independents have an additional advantage in the VAX memory market. As for those who entered the market earlier, Standard Memories and Mostek, they were able to capitalize on these advantages and expand upon them.

Fortunately for the independents and semiconductor manufacturers, DEC attempted to ship as many units as possible. To do so requires shipment of systems with less than desired memory. With 2600 VAX systems now in the field, each requiring the potentially full 4 Mbytes, the market should remain good for some time. Late entrants, including Motorola, Texas Instruments and Intel, are large enough with sufficient resources to succeed in this market. Since these firms have tremendous semiconductor manufacturing capability, they have an edge over medium- and smaller-sized independents. It is these firms that will introduce great quantities of boards populated with 64-K RAMs at a lower price. The long term outlook in this market is bleak for all but the largest independents and semiconductor makers. Price erosion and efficient competition will keep price margins low.

How long will the VAX-11 survive? Growth should continue throughout this decade and perhaps into the next, continuing until the size of its typical memories approaches the VAX's virtual address space. In designing the VAX in the mid-1970s DEC designers did not choose a 24-bit virtual address but 32 bits instead. An assumption had been made: long-term halving of memory cost-per-bit would occur each year. This translates into an increase of one extra bit of physical address per year. Although this has not held strictly true to form, the 50% reduction in certain VAX memory that was witnessed last year was interesting. Virtual storage management permits a CPU storage capacity that is much greater than that which it physically has. The program is divided into segments external to the CPU. By calling the segments or pages up as they are needed, memory costs can be kept down and the computer can process much longer programs than can be stored in the CPU memory. The only problem with virtual storage is the swapping of these sections of coding in and out of main memory. Mainframes have large virtual address spaces broken down into numerous segments. Now, VAX's address space is linearly addressable and no further segmentation is possible. As contrasted with most mainframes, the earlier PDP-11 operating systems had negligible virtual memory management. Their smaller programs were swapped complete. With a large virtual address space, VAX-11 runs programs often longer than the physical memory. For those independents choosing not to compete in the VAX auxiliary market, their fate is sealed. For this reason, most manufacturers of DEC compatible memories have been forced to compete in this sector of the market.

S-100 compatible memory renaissance

Last year saw the unexpected resurgence of the S-100 bus (IEEE-696) and an unexpected rate of growth. In addition, Intel's Multibus grew faster than expected.

The S-100 bus, developed by MITS' founder Edward Roberts back in the mid-1970s for their Altair hobby computer, was hastily designed for the personal computing market. This bus was designed with no consideration for

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such factors as termination, multiple returns, bus length, ground planes and even compatibility. MITS had a surplus of 100-pin edge connectors and simply designed a bus around it. Different manufacturers assigned designations to the unassigned pins; and, supposedly-compatible equipment was anything but (causing great frustration to hobbyists). Only a year ago it looked like the S-100 was headed for gradual oblivion, with only smaller manufacturers using it.

Fueling the unexpected renaissance of S-100-compatible auxiliary memories is the accelerating penetration of μ Ps into the industrial and control market. Since μ Ps and their controllers are growing increasingly memory-intensive, they require more add-in memory. Unlike the Multibus memory compatible market, which is dominated by its maker, Intel, the S-100 memory compatible market is not dominated by any major firm. Traditionally, manufacturers of S-100 products have been small cottage shops serving the hobbyist field. Although the S-100 still remains strongly entrenched in the hobbyist field, it continues to gain increasing acceptance in the industrial, engineering, laboratory and small business markets. In Europe, where the Multibus never established the dominance that it enjoys here, the S-100 achieved and maintained greater popularity. Nevertheless, manufacturers here report growth rates increasing threefold in the last year.

The S-100 bus is attractive: it has one of the most widely-installed computer system bases in existence. Over 70 firms provide S-100 compatible boards, and over a dozen 8-bit CPUs and 16-bit CPU boards of significance are available. Unfortunately, the original S-100 bus left 19 pins undefined. The IEEE-696 standard eliminates the incompatibility and expands memory addressing beyond 64 Kbytes up to 16 Mbytes, and I/O addressing to 64,000 ports. Its vectored interrupt system is expanded to 11 inputs and provides for up to 16 bus masters. The 8- and 16-bit data transfer enables 8- and 16-bit masters to coexist in one system. It's partly for this reason that OEM interest in the S-100 bus has increased.

Increasing growth rates are due to the new bus standards. The IEEE 696 Standard Committee completed the final revision of the S-100 bus standard, the result of two years of work. The delays were due to new changes that included the

new 16-bit micros, some with over 16 Mbytes of direct addressing. Multiprocessing systems was a new development. The new standards push processing speed beyond 6 MHz. Some micros on the S-100 will run at 10 MHz and perhaps faster. The committee left a number of pins undefined to take into account unforeseen developments. OEMs feel safer with the S-100 now.

Designers interested in obtaining addendums of the last S-100 Standards Committee meeting may receive copies (\$2) by writing to: Sol Libes, **Microsystems Magazine**, Box 1192, Mountainside, NJ 07092.

Multibus experiences resurgence

Intel's Multibus has had more manufacturers making plug compatible peripherals and boards than perhaps any other μ P bus. Manufacturers have included large firms such as Motorola, National Semiconductor, Dataram, Ampex and others.

Multibus (IEEE-796) supports two independent address buses, memory and I/O. It directly addresses up to 16 Mbytes with 24-bit addressing during memory cycles. It addresses up to 64K through I/O ports with 16-bit addressing going through I/O bus cycles. Memory and I/O cycles support 8- or 16-bit data transfers. Employing a master-slave configuration, it permits modules running at different speeds to interface over the Multibus. Multibus permits 5-Mbyte transfers per second. It supports μ Ps with word sizes from 8 through 32 bytes. With new μ P CPUs with greater addressable memory, and with memory prices dropping (and programmer salaries rising), it makes sense for OEMs to make the tradeoff for looser code over tighter code and greater programming costs. The rapid growth of μ P-based systems contributed to the sudden resurgence of the Multibus computer-based compatible peripheral boards market. This sector of the market is projected to grow fourfold in 1982. With the growth of small business computer systems and more μ Ps in process control, small business computer systems and related areas, Multibus-based computer compatible boards are a safe bet.

new computer-compatible markets

Just two years ago the add-in/add-on computer compatible memory market centered primarily on DEC's PDP-11. Some manufacturers made compatible memory boards for other computer manufacturers such as Data General, Hewlett-Packard, Varian and a few others. These took a distant second place to DEC. But today, these other markets are emerging rapidly. Why? Reasons for this are twofold. First, with profit margins so thin in the VAX computer compatible market, and with the anticipated dwindling of the PDP-11 market, more independents are forced to seek out new market positions. Although these computer compatible markets remain limited in size, it may be better for many independents to carve out a share of market in these previously neglected sectors. As these other markets grow, the firms that initially repositioned a portion of their technical and marketing efforts into these sectors also will grow with these markets. Should all independents consider repositioning themselves? No. To penetrate some of these computer compatible markets requires good in-house design expertise. Since certain independent board makers do not design their own boards, it would take some time for them to establish such a design team. In addition, there are only so many directions an independent can go; and to spread themselves too thin could invite trouble.

Second, Data General's loss of the anti-trust lawsuit

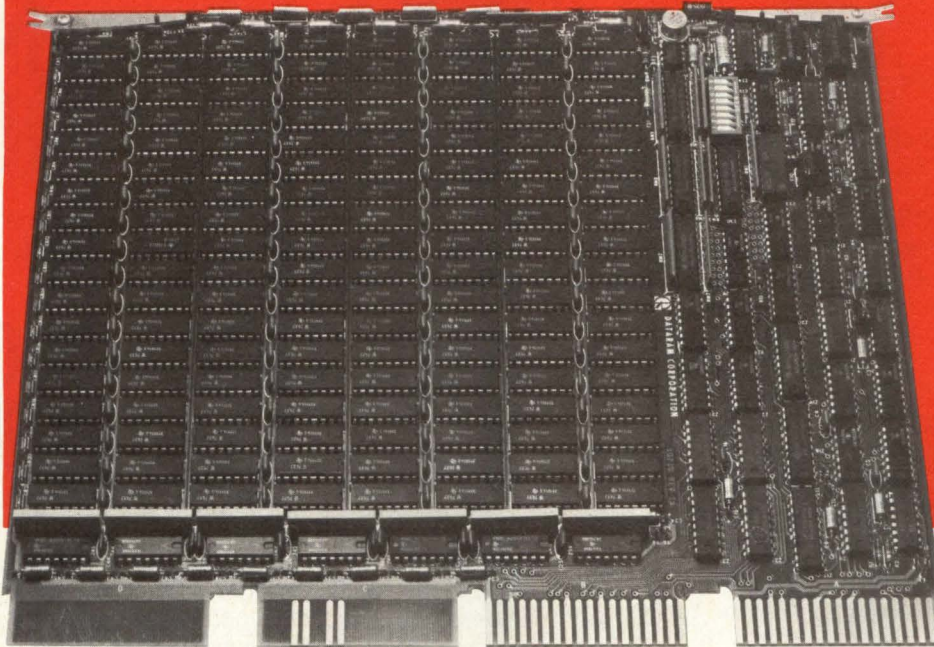
Add-On Memory Provides Flexibility

Add-on memory provides an advantage over add-in boards. Although they are less common today, except for mainframes, add-ons will continue to exist. Certainly, add-in memory has advantages: lower cost, no additional power supply, no extra cooling and slides into the backplane with minimal problems. And, designing is easier. Contrast this with add-on memory; the box is a total unit complete with power supplies, cooling fans or blowers, enclosure, extra hardware and even interface software.

Large minis and mainframes will create new markets for boxes. Still, the 256-K RAM lurks around the corner; and, after a short renaissance, will add-ons fade into a new twilight? By then, micro-mainframes — like Intel's iAPX 432 μ P and Motorola's entry — will emerge in 32-bit TRS-80-type desktops with insatiable appetites for memory. Will this be met by boards carrying 4116-type (16K) RAMs? Perhaps not. The add-in/add-on balance (in terms of market volume and dollars) will be set by a development race between CPU chip designers and memory chip designers.

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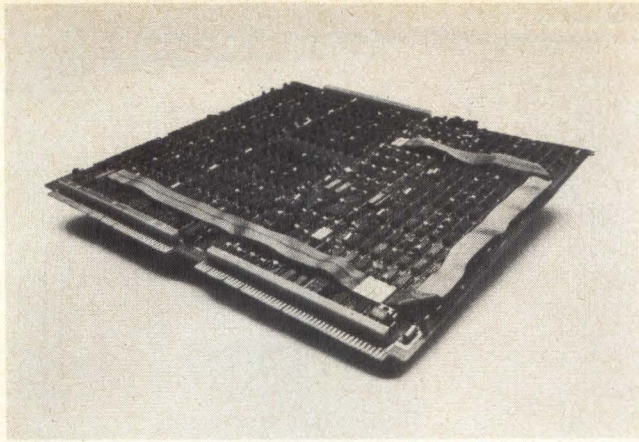


Figure 2: Typical computers idle too much, waiting for information filed on track-per-head disks. Solid state memory, like Integrated Digital's "Minimeg", function as a cache to store data used most frequently; it gets that data in and out of main memory fast. This board houses both controller and up to 2 Mbytes on one 15" x 15" board, with an address-selection DIP switch to allow use of multiple boards — sharing the same device code — for a total possible capacity of 32 Mbytes.

means DG cannot force tying arrangements onto its customers and use other methods to discourage OEMs from shopping for plug compatible bargains. Will this open up the Data General market to computer compatible memory makers? The outlook is favorable, and we already notice an increase in DG-compatible peripherals and boards over a year ago. DG, experiencing slowed growth, may rebound with its MV/8000 and MV/6000.

dynamic vs. static

Dynamic RAMs, containing a single MOS cell, must be refreshed every 2 ms and need row- and column-address strobing clock signals. With address multiplexing, extra circuitry increases system complexity, lowers performance and creates design headaches. Since they use only one cell per bit, rather than two as in the static flip-flop, dynamic RAMs are more dense, occupying less silicon real estate. Although suffering from lower reliability than the static RAM, dynamic RAMs offset this, since the larger size of the static RAM necessitates more DIPs, thus lowering overall memory system reliability. Most memory chips that fail after being screened fail due to poor soldering and interconnections. Since the dynamic cell consumes current only when active, overall power dissipation is less. However, this can present a problem with decoupling, since huge current spikes create noise. Ceramic multilayer capacitors are used for decoupling because of lower series inductance versus bulk-type electrolytic capacitors. Fortunately for static devices, power consumption is fairly constant, unlike dynamic RAMs. With the dynamic RAM, low power is consumed for short periods. If you are designing with a dynamic RAM that requires three separate voltages, and the computer provides those three voltages, that's fine; if not, too bad: you must provide additional voltage levels. Fortunately, +5-V-only memory devices are more common and eliminate this traditional problem. With such n-channel dynamic RAMs the -5 V substrate bias must be stabilized before the +12 V level is applied. If not, the dynamic RAM automatically enters the high-current state and remains latched up, even causing the device to exceed its temperature rating. With the +5-V-only chips, this problem was eliminated.

Pseudo-static RAMs offer the best of both worlds: dynamic RAM storage cells with refresh circuitry on the substrate.

With higher packing density, lower cost-per-bit and with a byte-wide organization, the pseudo-static is well suited for μ P designers looking for low-power dissipation, organizational compatibility with μ Ps and design ease. Since main-frame manufacturers dictated the early development of RAMs, byte-wide devices were not developed until later.

Static RAM access time can be 20 ns; dynamic RAMs, however, do not reach much below 100 ns. With static devices, access time is the same length as cycle time; unlike dynamic RAMs, whose access time is less than cycle time.

Chip organization (whether bit-, nibble- or byte-wide) is an important factor to consider. Byte-wide devices typically consume less power. The denser chips were more likely to be organized as single-bit-wide devices. Therefore dynamic chips, unlike static chips, did not provide a selection choice. Organization depends upon application. Bit-slice and regular μ Ps are more suitable with byte-wide memory devices. However, if you have a CPU with an uncommon word length (such as 12) or if you apply error detection and correction, then it might be better to go with a single-bit organization.

If all dynamic RAMs are refreshed at once, and there are a large number of them, current draw could be significant and create spiking. Bypass capacitors should be near the devices and the capacitor discharge path should be kept short. Runs must be kept short to prevent increasing line-to-line distributed capacitance, which slows data rates. Multilayer boards, though more expensive, are sometimes used for power and ground bus systems. Despite all design efforts spent on buffering, decoupling, timing and careful board layout, problems still crop up.

testing sequence is important

Testing bare boards eliminates the possibility of shorts; later testing with a loaded board tests the memory. Worst case tests should also be conducted. Whether you build or buy your memory boards, some form of testing is mandatory. Of course, if you go the build-your-own route, there's a lot more testing needed.

High-volume purchasers of memory devices can dictate that their orders be guaranteed to very low defect levels. Although high volume users typically find defect levels around 2%, it can range from 1% to 5%. As a low volume purchaser, however, your devices will probably come through distributors with much higher defect levels. Can you avoid this? No. Solution: conduct simple screening tests. From analyzing the data, you will develop an idea of the defect rate from various distributors and can use it to develop an empirical model for future use to predict the number of defects in a lot that can be detected by various tests.

As a rule, LSI has a defect rate that is lower than for SSI or MSI. Almost half the defects in plastic-DIP ICs originate in the plastic enclosure; of the remainder, over half originate in the die. On the other hand, in ceramics only one-third of the defects originate in the ceramic enclosure as case defects. Screening tests accelerate time, causing errors to show up sooner. These tests do not degrade good memory ICs.

The sequence of these tests is critical, since it is important to conduct those tests that screen out the greatest proportion of defective devices early in the testing sequence.

Stressing tests include those well-known tests that subject memory chips to high temperature or temperature cycling, overvoltages, shock and vibration, and ultrasonic vibration. Heat stress tests, if done first, weed out three-quarters of all device defects. Temperature cycling causes chip expansion and contraction to widen die microcracks. It accelerates ion diffusion and impurities further into improperly-diffused

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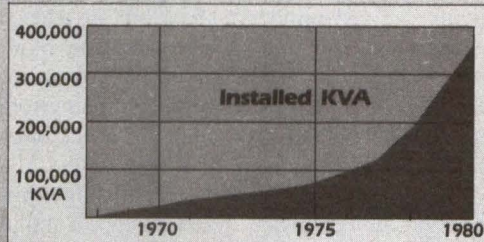
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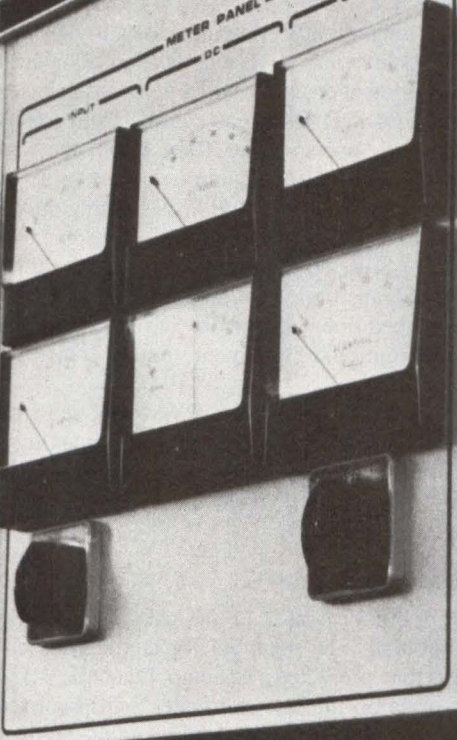
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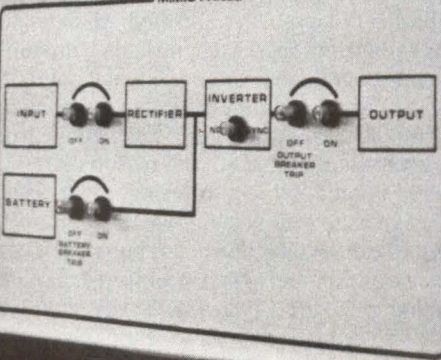
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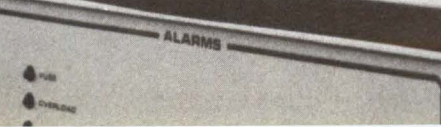
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regions. This alters device characteristics, ruining the device before it is inserted into a memory board or socket. Poor bonds on the chip or substrate are exposed. Burn-in stress tests heat chips to 100°C for typically 170 hours or down to 155°C for anywhere from 50 to 20 hours. Other temperature-stressing tests involve one-hour stepping in test ranges from the low-end to high-end of the temperature range (-55 to 125°C). Once the chips are inserted in their sockets or wave-soldered, final temperature stressing will weed out any final memory chips that could fail (55°C for 70 to 50 hours).

Next, over-voltage testing forces higher-than-usual current through and forces weak conductors to open. Checking chips for shock and vibration may not uncover that many defects (perhaps under 3%). Ultrasonic stress tests, still not commonly used in screening ICs, could one day replace shock and vibration tests for memory devices. However, thermal cycling and heat testing will eliminate most defects.

Once enough data is collected, statistical plots are made, plotting total percentage defects detected as a function of cumulative test times in hours on semi-log paper. Typically, this is a linear function. If defects detected in a specific inspection are plotted as a function of elapsed test time on semi-log paper, the distribution usually is a bell-curve. Total defects can be calculated by integrating the area beneath the curve. If the defect emergence rate is plotted as a function of operational time, this plot of the product life cycle will show three phases: the infant mortality period (reduced by screening), life period and wear-out period. Unfortunately, each model depicts a different situation; yours may be an exception and not be linear on semi-log paper.

error detection and correction

As we mentioned earlier, an $N \times 1$ organization lends itself better to memory with error detection and correction. Error detection and correction is used with larger memories because the number of errors generated justify the added cost. LSI chips handle the error detection and correction, therefore cutting costs.

Basically, there are three categories: parity bit, Fire code and Hamming code. Parity code, which is most commonly used, merely records the number of binary ones in a register or memory location and adds up the number of even or odd bits. This simple code detects single-bit errors. If multiple bits erroneously change, but end up with the correct parity, it is undetectable. Fire code can detect and correct up to 12 incorrect bits. A fixed number of check bits are added to each record, generated from the iterative division of the data train. Now, when that record is read back from memory, check bits are used to detect, locate and correct error bursts. Hamming codes attach a fixed number of check bits to each byte. Now, on reading from that device, the Hamming checkbits are used to detect and correct all single-bit errors. Hamming code, first published in 1954, was not until recently implemented much in memory systems.

The level of error detection and correction needed will depend upon several factors. The probability of error, the potential damage in your customers' applications and the added cost must be traded off.

did 64-K RAMs stumble?

Will the 64-K RAM have a shorter-than-anticipated marketing half life? Since the 16-K RAMs remained lower in cost-per-bit relative to the 64-K RAMs, the 64-K RAM "design-in" window is shorter than predicted just two years ago. The 64-K RAM makers lost time in going to the 5-V-only 64-K RAM — with many taking a step backward and developing

the 5-V-only 16-K RAM first. Many memory makers stopped to develop 5-V-only 16-K RAMs before developing 64-K RAM devices that generated substrate bias internally on their 64-K chips.

Other problems surfaced. The times between initial memory device announcement and sampling and its availability in quantity to the memory board designers is lengthening. Then, there's the cost-per-bit of previous memory devices preventing designers from specifying newer chips, as happened with the 64-K RAMs. The 16-K devices remained most cost effective for longer than was anticipated only a year ago. Will this change for the next-generation chips? Probably not. The old "bird in the hand" proverb applies doubly-so with memory chips.

The 256-K RAM has arrived, and is now available in sample quantities from OKI. A hybrid 256-K RAM (four 64-K RAM chips) is available. Will it take even longer to be designed into boards than the 64-K RAMs? Many of the product releases that come to us are populated with 4-K and 16-K RAMs. With this in mind, the common availability of 256-K RAM memory boards may come later than predicted. Perhaps not, but there is a slowing down in memory capacity. Moore's Law said that quadrupling of memory capacity per device occurred every two years; or, between any two periods in time that: $C_2 = C_1 \cdot 2^{(t_2 - t_1)}$.

Moore's Law no longer holds. Slowing was caused by new problems: alpha particle radiation, new fabrication techniques, skyrocketing development costs and wider application bases. Going from a 1-K to 4-K RAM is easy; going from a 64-K RAM to 256-K RAM, not so easy. Then again, the time spread between sampling and common availability is growing. Another scenario of 256-K RAMs shutting out the projected growth of 64-K RAMs is looming.

The move from 4-K to 16-K RAMs used in-place lithographic equipment. Transitions were smooth. With the 64-K RAMs, scaling reduced line widths from 5 to 3.5 μm or less and pushed the lithographic equipment. Future transitions will come slower.

Over the past 18 months, the 16-K RAM dropped from \$5.50 to \$1.00. Profit margins also dropped, making it impossible to compensate with increased volume. The incentive for semi makers to compete more in the add-in market is stronger than ever.

bubble trouble ahead?

The big news in memory boards in the last year (as far as devices go) is bubbles. The potential for auxiliary bubble memory is far less than predicted a year ago. Dynamic RAMs are dropping in price on the low end faster than predicted, and rotating memory costs are falling rapidly on the high end of the memory spectrum.

The Rockwell, National and Texas departure is a reflection on yield and production problems and more fundamental technical and marketing reasons. After investing immense effort into R&D — a program that was nearing the point of a big payoff in applications — is it reasonable that Texas bailed out on a whim? Unlikely. When Rockwell bailed out earlier this year (except for military markets), the reason many felt was that Rockwell goofed by not offering off-the-shelf boards, forcing designers to design their own (a big turnoff). Now, with Texas and National bailing out of bubbles, it is an indication that there was far more to that Rockwell departure.

On the accounting side, the 1978, 92K Texas price was 100 mcent/bit. It didn't drop much in three years! Intel's 1-M bubble came on the scene three years ago at double that. Predictions from the bubble makers have been grossly opti-

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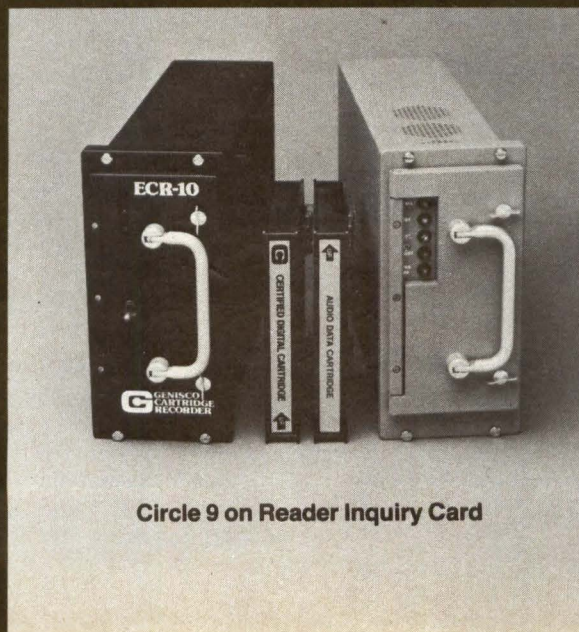
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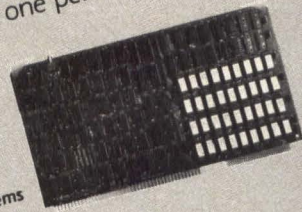
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mistic: they predicted a 10-cent/bit price three years ago to occur last year. Intel now predicts a 30-cent/bit price next year, but allegedly concentrated its best designers on RAM/PROM development — not bubbles.

If bubbles aren't falling fast enough (due to lower-than-predicted yields), disk and RAM memory certainly is declining. Bubble makers aren't able to capitalize on high volumes and drop costs/bit. The earlier rumor-mongering was just that, and the upcoming challenge is further off than anyone predicted. Will bubbles remain for hostile environments, portable terminals and little else? It looks that way.

Perhaps a bubble renaissance will come by 1985 from an unexpected direction — Japan. With its emphasis on reliability, Japan's yields are higher. For reasons discussed in "Keys To Quality" (Speakout, **Digital Design**, June 1981, pp. 9-10), the U.S. attempt to copy Japanese Quality Circles is not likely to duplicate the Japanese successes here. It's no surprise that bubbles are doing better in Japan. Nippon, for one, continues to replace fixed disks with bubble memory. If bubble memory enjoys a renaissance by 1985, Intel, Hitachi and Fujitsu may own the bubble market. As for bubble memory, it stumbled badly and will never fully recover. Its bubble hasn't burst, but bubble memory's star is tarnished: it will remain a smaller-than-predicted niche market for the foreseeable future.

Long-term results will produce more activity in RAM/PROM/disk markets. More R&D money will shift to bubble's competitors. Expect more R&D in fast CMOS. As a brief aside, the Japanese have an edge in CMOS development; and, aside from two U.S. firms, the Japanese can be expected to turn this technological lead into a rapidly-growing market share over the next four years.

auxiliary memory's future: rapid growth

Compatible computer memory will grow even more rapidly with the mini makers cranking out MV/8000s, VAXes and other 32-bit machines like jelly beans. The large logical-address of a 32-bit machine is 4,294,967,296 bits. Such machines directly address 4.3 billion bits. Multiply needed memory by existing and anticipated user base and subtract the memory the mini makers will likely provide and plot this as a function of time. Although we haven't done this, it takes no insight to predict that the needed memory will grow rapidly.

The upcoming "micromainframes" will add their insatiable appetites for more memory to the 32-bit minis in a couple of years.

Intel's iAPX 432, with its 32-bit word, will demand computer compatible memory. The address, a 24-bit number, means the 432 can address 2²⁴ or 16.777 Mbytes. The 432 has virtual memory. The 432 can address 2⁴⁰ or about 1.094 trillion bits. As the result of Project Aloha, the 432 took six years of development work by William Lattin and Jean-Claude Cornet. Other 32-bit micros will be introduced before 1985 — a sign that larger systems are being integrated into chips. These systems will have insatiable appetites for add-in memory boards.

Other factors will demand more memory. Software is costly to develop today; imagine what it will cost in two years — or four years. Loosely-written code reduces the problem (except where tight code is needed for speed) and will be the trend. Limited capacity memory boards and higher-cost memory is less of a problem. The faster speed of the 32-bit machines certainly will be a force aiding the trend to looser code. The market for computer compatible memory never looked better for OEMs buying memory. **D**

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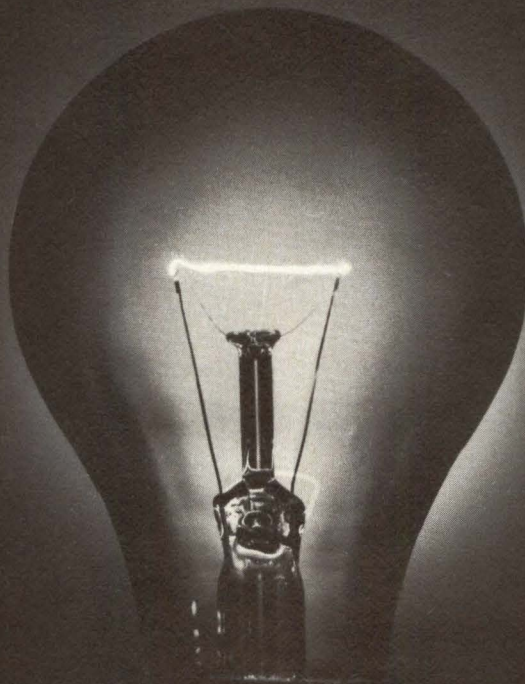
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by Paul Snigier, *Editor*

Commercial AC power lines are inherently noisy and susceptible to spikes and transients from diverse sources. These may include lightning, motors, inductive kickback, power network switching and other line disturbances. Momentary power dropouts, many so brief that they were undetectable in the past, are increasing.

line disturbance categories

Power line disturbances fall into three groups: oscillatory overvoltages and transients, blackouts, and momentary over/under voltages. Oscillatory overvoltages and transients are generally caused by lightning. A lightning discharge supplies a definite current, disturbing the power line's steady voltage. The lightning discharge behaves as if it has a surge impedance of 5,000 ohms. The earth-to-cloud system may be considered a capacitor; and, thus, in some cases a resonant system with a frequency of 46 kHz or so is set up. If the column, ground and cloud resistance is great, the system may not oscillate. Power line protection is provided by a shielded earthed wire above the power lines; and all but 0.1% of the strokes are eliminated, provided the power lines fall within a wedge of vertical angle of 60° having the shielding wire as the apex. The earth connection to the shielding wire must be under a few hundred ohms. Even with this protection, line disturbances from lightning remain a problem. Where the level of thunderstorm activity is 30 thunderstorm days per year, there are 10 ground strokes per square mile per year; an unshielded power line would receive 1 stroke per mile per year. With higher pylons, the striking frequency is up to 10 times greater.

But lightning is not the only cause of oscillatory overvoltages and transients; power network switching and operation of other loads contribute their share to power line disturbances. Disturbance threshold levels run two to four times rated RMS voltage — perhaps greater. Disturbance duration with spikes is 0.5 μ sec to 200 μ sec wide. If oscillatory, disturbance duration is 1 cycle (16.7 msec) at 0.2 to 5kHz.

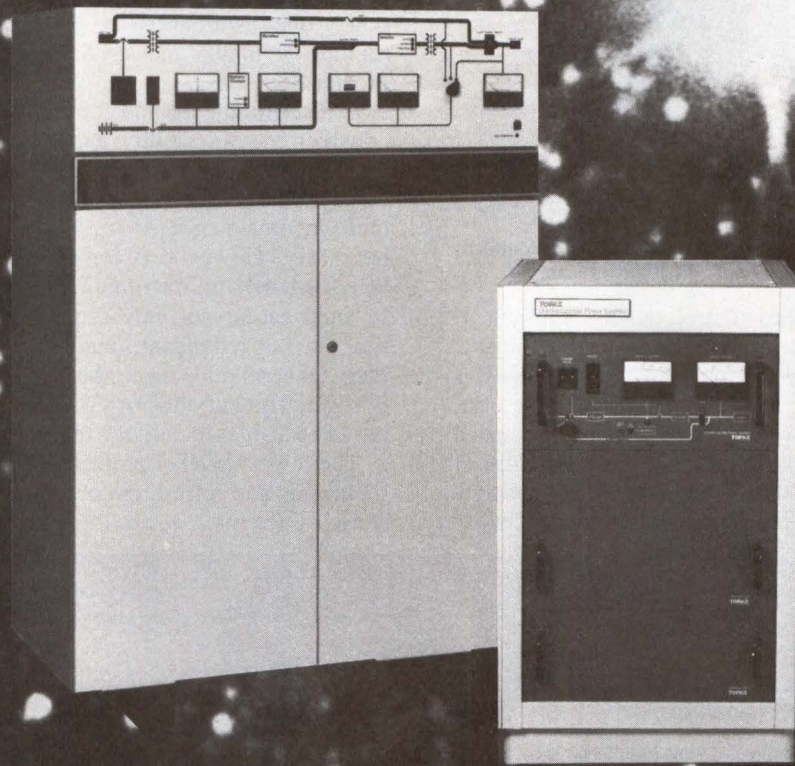
Although not as serious as transients and oscillatory overvoltages, momentary over/under voltages are caused by large loads coming on-line, equipment malfunctions or even power system faults. The threshold level of these disruptions falls below 85% and above 110% of rated RMS voltage. Typically, these disturbances last 67msec to 1.0 sec. Obviously, this will vary, depending upon power distribution systems.

Blackouts and outages are caused by utility equipment malfunctions or other causes. They may last from a matter of seconds to many hours.

power line noise headaches

Noise on power lines entering a system may cause extra bits or missing bits, thus altering a control process application, cause data transmission errors, create incorrect recorded

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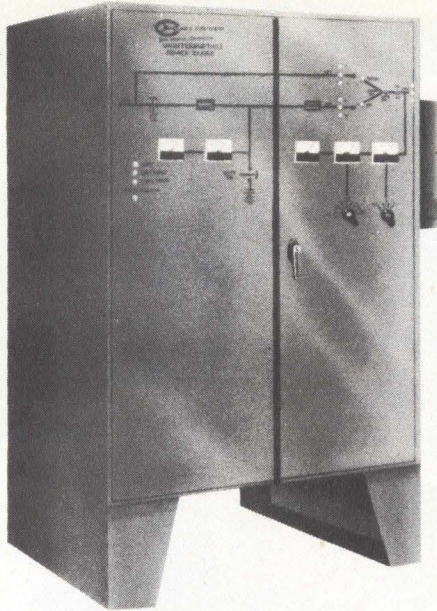


Figure 1: System insurance varies from the smallest AA cells, to large static/inverter systems such as this one from Clary.

data, alter precise motor speed control, damage equipment, cause processing malfunctions and cause the loss of valuable data. Furthermore, real-time and financial users or processes may not be able to tolerate such disturbances. In the past, improper specification of power backup systems created headaches for end users and OEMs, and probably loss of business. Today, however, this is (and will be) increasingly regarded as negligence. This poses serious legal problems —

even significant lawsuits — for the OEM who fails to specify the proper power system backup and noise suppression.

Although most interruptions are under a few msecs, those exceeding 10 msecs cause problems. Most power supplies maintain full output for 15 msecs to 50 msecs after power is lost. Switchers, obviously, hold up longer than linears. Frequency of power line disturbances was studied by IBM. They found spikes and oscillatory decaying transients occurred 114 times per month at typical computer facilities. Voltage spikes of 10 msecs to 100 msecs took place 50.7 times per month. Oscillating decaying transients (400 Hz to 5,000 Hz) took place 62.6 times each month. The combination of these two disturbances accounted for 88.5% of all power line disturbances affecting computers. In areas where power line disturbances are greater, such as lightning-prone regions or highly industrial locales, these figures will be greater.

In determining the power backup needs of your customers, consider the probability and duration of computer errors resulting from transients, brownouts or blackouts. Also, consider the effect these would have upon the end user. Is it a mere inconvenience? If so, a high level of protection is not necessary. However, if computer system downtime cannot be risked, then the maximum level of protection is necessary. In such cases, not only is the highest level of protection needed, but redundant, parallel power supplies are a good idea. Generally identical, the backup supply is set at a slightly lower voltage, thus being isolated from the load, with its diode back-biased until the main supply fails.

The lowest level of protection maintains power to volatile memories and refresh circuits for a short time. This makes sense, since most power line disturbances are of short dur-

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	Spikes from utility network switching				
	Transients from machines, air conditioners, lighting, office equipment, etc.				
	Ringling from PF — correction capacitor switching by utility				
2. Voltage Fluctuations	Brownouts				
	Under/overvoltages from faults/fault — clearing units				
	Heavy equipment on the same source causes voltage changes				
	Frequent low line voltage				
3. Power Outages	User-owned generators create voltage fluctuations				
	Rotary system start-up causes temporary outage				
	Momentary interruptions from faults/overloads on line				
4. Other Problems	Blackouts				
	Ground not dedicated/isolated				
	Shock hazard to systems, operators, users				
	User-owned generators cause frequency variations				

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UPS become user-oriented

UPS are used infrequently, and with personnel turnover (not to mention night shift operations), it's no surprise that operator error is causing an increasing number of computer shutdowns. In fact, some industry experts claim that more computer shutdowns are caused by operator error than UPS malfunctions! Unfortunately, many UPS are not exactly user-friendly. Because of this, the occurrence of abnormal conditions can frustrate computer system personnel, making it difficult to follow the alarm condition with proper action in time to avert system shutdown.

In an attempt to improve the situation, some UPS makers are adding video display terminals and printers. Improved diagnostics and fault monitoring watch different system test points and provide alerts whenever abnormal alarm conditions occur. Some VDTs display alarm messages and corrective procedures. Some also display a functional block diagram, indicating problem areas. Unlike earlier UPS that merely provided a few LEDs, these systems provide information telling if the power line failed, if UPS is now battery powered, if the inverter is out-of-phase with the AC source, or if UPS' temperature is excessive, threatening imminent shutdown. They also indicate battery unavailability, AC power line restoration and battery recharge. Some UPS provide more than one VDT at different locations.

Monitored test points provide updated information on all voltages, frequencies, currents, AC power line, inverter input/output, UPS output, battery input, real and apparent power, power factor, and capacity loading (to determine spare UPS capacity).

If providing a history of events occurring prior to failure, the UPS system provides a diagnostic tool that permits later troubleshooting. This alleviates the guess-work previously needed when corrective action was taken. By stepping through the various alarms and test point conditions as they occurred prior to the outage, test personnel can rapidly locate the source of the outage. Some of these UPS systems communicate in other languages, also. Many OEMs sell to foreign end users, and this may be a factor to consider when specifying such sophisticated UPS systems.

Unfortunately, sophisticated as some of these UPS systems have become, they are not totally user-friendly. This will change as future UPS systems become even more sophisticated. The emergence of intelligence in lower-priced UPS — maybe even including voice synthesis/speech recognition — will certainly come before the end of 1985.

ation. For these cases, rechargeable and primary batteries and data-retention modules incorporating a battery may suffice. With the increasing speed of CMOS, and with its greater noise immunity and lower power requirements, the rechargeable battery data-retention modules will become more commonplace. Of course, the eventual emergence of non-volatile RAMs will ultimately decrease the need for more expensive UPS. This may not occur until the latter half of this decade. Until then, sales for UPS look bright.

UPS basics

Comprised of a rectifier, battery and charger, and inverter, the on-line UPS provides power to the load constantly, with the battery smoothing out any voltage drops on the inverter's DC input. Constantly in use, these units will fail much earlier. When this happens, a static switch following the inverter automatically bypasses the inverter, thus connecting load to the AC power line. If this bypass switch operates with sufficient speed, there is no need for any power disturbance.

Although far less common, the off-line UPS will last much longer, since the inverter is usually not operating and is isolated from the load. Unfortunately, switching the load to the inverter takes time, and if the load is sizeable, this may risk introducing a disturbance. In an attempt to eliminate this problem, the "idling inverter" operates constantly, but since it is at a slightly lower voltage, provides no current to the load until an AC power line failure.

Other innovative designs are cropping up in the power backup field. For example, the "PoweRotor" variable-speed, constant frequency generator provides a continuous 60 Hz whether the rotor frequency remains constant or varies. It provides 10 to 30 secs of ride-through power during a brief outage, for an orderly shutdown. (See "Flywheel UPS Produces 60Hz At Any Speed", by B. Hirshon, *Digital Design*, August, 1981 pp. 96-99.) Like a giant tape recording write head, the UPS is able to print poles on a spinning magnetic motor drum. By varying the poles, depending upon rotational speed, the UPS can maintain a constant rate. Although the rotational speed may be decreasing, the reprinted number of poles (which will be increased) will counteract this slowdown. Thus, the number of poles/sec will remain constant. Furthermore, this unusual UPS isolates a load from the utility power line, thus effectively isolating the load from line noise. If an orderly shutdown is acceptable, this system is an alternative; if, on the other hand,

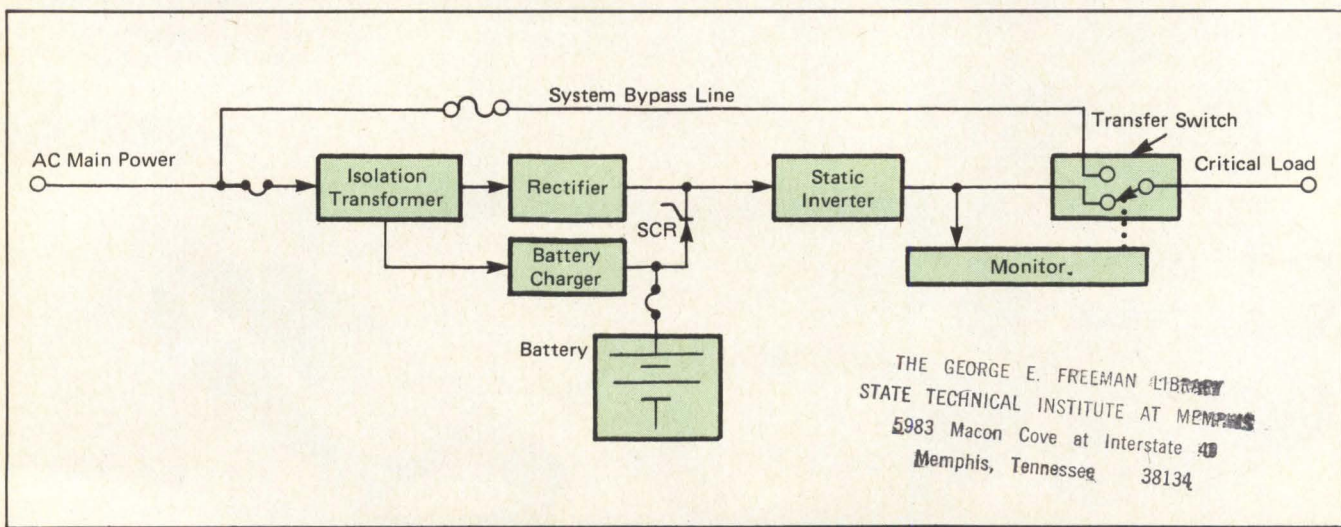


Figure 2: The on-line UPS, the most popular category, always supplies the load. To combat the shorter lifetime, a system bypass can be transferred to the load if the UPS fails.

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optimum backup is mandatory — as in the case of airlines and sensitive industrial processes — then more costly backup is needed.

Unlike other industrial segments of the computer industry, UPS systems are more frequently customized for OEMs or end users. Furthermore, these backup systems are commonly used in data communications, chemical manufacturing, process control and many other industrial segments that have nothing to do with computers.

As an example of a non-computer user, the glass production industry requires a stable, constant power source. Line variations, transients, spikes, brownouts or blackouts cannot be tolerated. Optimum UPS, although expensive, is mandatory. Since AC-powered synchronous rollers are used in the float glass part of the manufacturing process, and since motor speed cannot vary, these manufacturers cannot afford line voltage variations or momentary blackouts. Even a 2 msec interruption will cause the synchronous motors to slow slightly, thus scratching the glass. Since most glass production facilities operate around the clock, seven days a week, every week of the year, not only must their UPS systems isolate the load from any transient spikes, surges, faults and line noise, but they must also be able to ride through long blackouts. An orderly shutdown is unthinkable. Other manufacturers, such as DuPont, also cannot afford any shutdown. Computer system users are a bit more fortunate in this respect.

if unorderly shutdown is acceptable . . .

The minimum level of protection — and the cheapest power backup — is provided from low discharge-rate batteries. If an orderly computer system shutdown, with its transfer of

data from volatile to mass memory, is not needed, then this UPS system is the way to go. Batteries can provide a few minutes of backup or several hours.

Battery selection for UPS is a topic in itself. Suffice it to say, that mere amp-hr ratings are insufficient in making comparisons. Since voltage does not remain constant as the battery discharges, and since its internal resistance increases, this creates a problem. To maintain the same UPS input power, more current is drawn from the batteries. Unfortunately, as the battery discharges, the rising internal resistance causes a greater voltage drop and more current must be drawn. This is a vicious cycle, and it drives terminal voltage lower, drawing more current. Battery manufacturers, needless to say, are not about to highlight such things. The rated capacity is in ampere-hours (Ah) or milliampere-hours (mAh). Generally speeded at a 20-hr discharge rate, a 2.5 Ah battery will deliver 147 mA for 17 hrs. If discharging at 4 A or more, the battery won't last more than 15 min. This is an effective output capacity of 30% of its spec sheet rating. Higher discharge rates than anticipated can occur if an extra load is later added in a system upgrade. If you feel that the mere addition of extra batteries or a new external battery pack can solve future system upgrades that involve larger load capacity, remember that this will also require a larger charger. If not, the recharge rate may become excessively long. Thus, a second outage within a few hours of the first may no longer permit the battery pack to recharge in that interval period. UPS holdup time will drop, providing far less system protection. Other factors that affect batteries are shelf life, salting, low-temperature performance (below 32° F) and other environmental and operating conditions. Perhaps it's best to specify conservatively. **D**

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OVP: Output #1
OVL D Protect: Auto. Current Limit, feedback
Temp: 0 to 50°C at full current
Temp. Co-efficient: ± .01% 1°C max.
See EEM-Pg. 3324 & Goldbook, Vol. 1-Pg. 423

Model	Output 1	Output 2	Output 3	Output 4	Output 5	Case	1-9 Pr.
FDBB-149	+ 5V @ 15A	+ 24V @ 2/4.5A PK	+ 12V @ .8A	- 5V @ .8A	- 12V @ 1A	DBB	\$169.00
FNBB-119	+ 5V @ 9A	+ 24V @ 2/4.5A PK	+ 12V @ .8A	- 5V @ 1A	- 12V @ 1A	NBB	140.00
FCBB-89	+ 5V @ 6A	+ 24V @ 1.5/4.5A PK	+ 12V @ .8A	- 5V @ .8A	- 12V @ .8A	CBB	130.00
FDBB-148	+ 5V @ 15A	+ 24V @ 2/4.5A PK	N/A	N/A	- 5V or - 12V @ 1.2A	DBB	149.00
FNBB-120	+ 5V @ 7A	+ 24V @ 3.5/5.5A PK	N/A	N/A	- 5V or - 12V @ 1.2A	NBB	120.00
FNBB-118	+ 5V @ 9A	+ 24V @ 2/4.5A PK	N/A	N/A	- 5V or - 12V @ 1.2A	NBB	120.00
FCBB-88	+ 5V @ 6A	+ 24V @ 1.5/4.5A PK	N/A	N/A	- 5V or - 12V @ .8A	CBB	110.00

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Color Penetrates Computer- Graphics Industry

enticed by stronger technology and software, new and old users alike are converting to color equipment in droves

Color products' share of the computer-graphics market will grow from one-fifth of 1979's \$1-billion revenues to more than half 1984's \$4.5 billion. Four-fifths of all display, terminal and system (DTS) sales in 1984 will represent polychromatic machines, almost double the color penetration of this segment in 1979. Although few computer-aided design, drafting and manufacturing turnkeys offered color before 1980, color systems will comprise a third of CAD/CAM revenues in 1984. Multicolored devices will more slowly expand into the hard-copy sector, increasing from about a fifth of 1979's output-unit revenues to one-third of 1984's. Graphics software and services, the fourth market segment, although not analyzed in dollars, exhibits rapid growth in the form of a wide variety of companies offering new color products and support.

by Lawrence C. Elliott

This survey examines the entire computer-graphics industry first, then looks at color's growth by product sector. Accounting computation techniques begin the report. Next, a graphics-industry overview includes: basic product, application and end-user definitions; 1984 sales-revenue projections by product type; and major manufacturers' market shares. After color-device revenues are summarized, color's penetration of the four product segments (DTS, turnkey, hard-copy, and software/services) is analyzed.

Nineteen pie charts help illustrate the tremendous growth of both monochrome and color graphics. Dashed lines outside some pies separate market segments dominated by color and monochrome technologies and products. The computer-generated graphics images placed inside each pie appear courtesy of participants at the SIGGRAPH '81 conference sponsored by the Association for Computing Machinery. Image creators include: Dicom Corporation, which furnished the images in both the left (L) and right (R) pies in Figure 1; Daniel Sadowski of the University of Illinois (UI): Fig. 2; Richard E. Parent of Ohio State University (OSU): Fig. 3L; Jeff Kaiser, Don Leich, Stan Cohen and Randal Kleiser of Digital Effects (DE): Fig. 3R; Nelson Max of Lawrence Livermore National Laboratory (LLNL): Fig. 4L; Michael Potmesil and Al Baar of Rensselaer Polytechnic Institute (RPI): Fig. 4R; David Cox, Judson Rosebush, George Parker, Don Leich, Bob Hoffman, D.L. Deas and Gene Miller of DE: Fig. 5L; Stephen Keith: Fig. 5R; Thomas Butler of Los Alamos Scientific Laboratories (LASL): Fig. 6L; J. Ferguson of LASL: Fig. 6R; Dick Shoup of Aurora Imaging Systems (AIS): Fig. 7L; J. Breedlove of LASL: Fig. 7R; Copper Giloth of UI: Fig. 8L; Tom DeFanti and Dean Sandin of UI: Fig. 8R; Robert Marshall and R. Wilson of OSU: Fig. 9L; and Loren C. Carpenter of Boeing: Figs. 9R, 10L and 10R.

analysis techniques

Accounting-principle definitions explain, beginning with the exceptions, how the survey uniformly presents information. Hard-copy and DTS market shares may vary slightly as individual company fiscal years (FYs) end in different months. The turnkey segment's percentages are exact, as all FYs (Applicon's and Gerber's are adjusted) end December 31. Industry totals approximate all firm FYs into calendar years. Each chart's internal numbers display constant magnitude and units. Equipment prices include most graphics software and services, so revenues for this fourth market segment are distributed between DTS and turnkey sales in all charts. Shipment revenues always incorporate equipment (hardware and software) sales-on-delivery, plus performed-service charges. The survey and all charts record only end-

Lawrence C. Elliott, a freelance science writer, is currently performing market research and analysis on special assignment for Digital Design.

user purchases, and exclude sales to OEMs, to avoid counting equipment revenues twice.

graphics-industry overview

The displays, terminals and systems (DTS) market segment encompasses all graphics machines from simple viewing screens up to turnkey configurations. Monitors (usually CRTs) are bought mainly by OEMs, so DTS excludes them. Low-end products, geared to work on host mainframes, minimally contain one monitor, video driver/controller, keyboard and graphics processor, plus interfaces and some memory. Standalones can optionally replace external dependence with built-in, programmable μ Ps and memory, and support operating-system (OS) and application software and one hard-copy unit. Complete μ C- and minicomputer-based systems offer extensive peripheral I/O-device and programming capabilities. End-user DTS prices span from \$1000 to \$60,000.

Powerful, expensive CAD/CAM and real-time systems comprise the high-end, turnkey market segment. Both centrally located and physically distributed configurations include a minicomputer or mainframe, mass memory, OS and application programs, displays, peripheral I/O units, interfaces and, if necessary, optional, remote-communication devices. CAD/CAM, or design-and-drafting, types create schematics, drawings and numerical-control (NC) tapes for automated manufacturing machines. Real-time, or image processing and simulation (IP&S), systems analyze, update or transform previously created images, and require some kind of continuous data I/O. Typical turnkeys cost \$100,000, but others can range from \$25,000 to large, multi-workstation models priced as high as \$500,000.

Hard-copy devices make permanent reproductions of view-screen or graphics-system images. Machines include pen, electrostatic and thermal plotters; photographic cameras and computer-output microforms (COM). Plain and treated paper, transparent plastic and light-sensitive films are typical media for the completed pictures. Plots, starting at 35mm slide and microform sizes, can run over 5 feet high with unlimited width. Output units often sell under \$25,000, with technology, media and copy-size variations creating a price range from under \$1000 to \$300,000.

Equipment companies offer most software and services, while new, independent specialty firms provide the remainder. Device prices usually include the OS and high-level

languages, while young software houses sell some unique programming variations. Buyers can purchase self-contained, specific application-area packages, ranging widely from \$25 to \$100,000, from either vendor type. Six-month to one-year seller warranties typically cover maintenance. Manufacturers handle nearly all post-guarantee repairs. Retail contractors, recent industry entries, tackle custom graphic-art, CAD/CAM and programming projects, or rent access channels to time-sharing systems.

Three general application areas describe all the uses of

graphics products (**Table 1**). Data display mainly involves generating charts for industrial marketing departments, using management-information (MIS) or DTS systems. Real-time includes mapping, process-controlling and process-monitoring (PC/M), medical-diagnostic and military IP&S functions. CAD/CAM, the third broad application area, covers creating specifications for physical objects such as mechanical parts, electronic circuitry, buildings, cars and clothes.

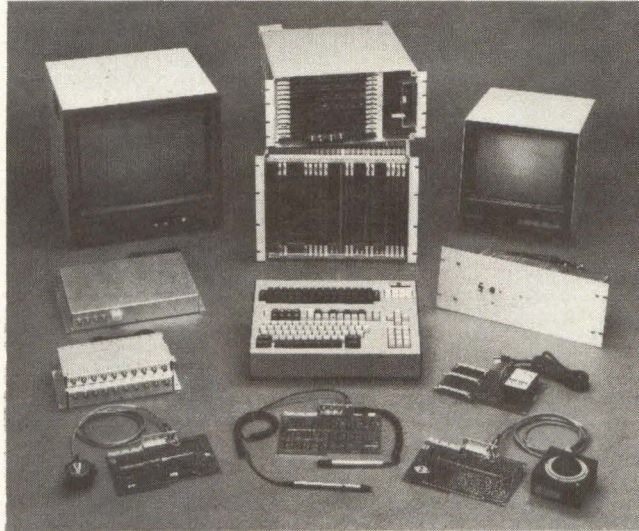
A wide, end-user spectrum divides into three similar categories. Data display owners include hobbyists and executives who buy personal computers, as well as universities and various-sized manufacturing businesses. Electrical utilities, oil companies, the U.S. Defense Department and Geological Survey, and other huge organizations utilize real-time configurations. Automobile, aerospace and electronics manufacturers comprise most CAD/CAM customers.

graphics revenues and manufacturers

Three major, product-type segments each carried about one-third of the graphics industry's \$1-billion revenues in 1979 (**Figure 1**). The DTS and hard-copy sectors each collected

approximately \$290 million, capturing 29% of the total market dollars. Splitting turnkey's \$345-million, 34.5% majority pie-slice, CAD/CAM held 30.5% and real-time 4%. Category other, representing input devices, especially digitizers and data tablets, gathered 8%.

Changes in segment revenues projected from 1979 to 1984 indicate users' growing demand for complete systems and shrinking interest in peripheral devices. Turnkeys will gain 10 percentage points, boosting their sector to almost half 1984's \$4.5-billion graphics market. Sub-group real-time shall expand from one-ninth of 1979's turnkey sales to a quarter of 1984's, reflecting a boom in IP&S applications. Representing a mix of systems and smaller units, the DTS category will rise slightly to 31.5%, clearly taking second



Well over 150 companies now offer color-graphics equipment or software. Rapid vendor growth and CAD/CAM's productivity gains are generating intense interest in financial and corporate circles. Conglomerates are stepping into the market, and large graphics firms are consolidating their bases by acquiring smaller manufacturers. Industry leaders remain heavily dedicated to R&D. They are stressing color software, systems integration and stronger services to stay on top.

Data Display

Entertainment

video games

Home

computer hobbies
finances and investments

Industrial Marketing

art generation for presentations
decision support
financial analysis, planning and research

Computer-Aided Design, Drafting and Manufacturing

Architectural

buildings

Electrical and Electronics

electrical wiring
ICs
PCBs

Mechanical and Transportation

aerospace vehicles
automobiles
garments
NC tapes for automated manufacturing machinery

Plants and Piping Flows

manufacturing plants
petrochemical piping flows
fossil-fuel- and nuclear-powered, electrical generating plants

Real-Time (Image Processing and Simulation)

Control and Monitoring of Automated Industrial Processes

component measurement
electrical power-plant operation
inspection and quality control
manufacturing assembly
plant management, including climate control
and energy consumption

Entertainment

electronic art
motion pictures, including animation
television

Graphic Arts

publication layouts

Industrial and Scientific Mapping

astronomical
geological exploration
information retrieval and analysis from satellites and
remote-sensing instruments
terrain
weather

Medical

output and analysis from diagnostic scanners such as
computer-aided tomography, electron microscopes,
ultrasound and X-ray devices
patient status monitoring

Military

aircraft and projectile course plotting
command and control
radar and sonar tracking
satellite information retrieval and analysis
training simulators for air and ground vehicles

Non-Destructive Testing

materials
structures

Table 1: Graphics Applications

place in the revenue race. The output-device division, and other division, both describing add-on, I/O machines, shall drop about 8 and 6 percentage points, respectively.

Graphics-industry manufacturers generally exhibit moderate levels of vertical integration. System makers often build modular equipment and software units in-house. DTS

revenue-leaders Tektronix, Sanders and Hewlett-Packard (HP) construct both components, such as CRTs, μ Ps and semiconductor memories, and complete devices. CAD/CAM giant Computervision (CV) generates more products internally than any other turnkey company.

Acquisitions were both proposed and completed recently

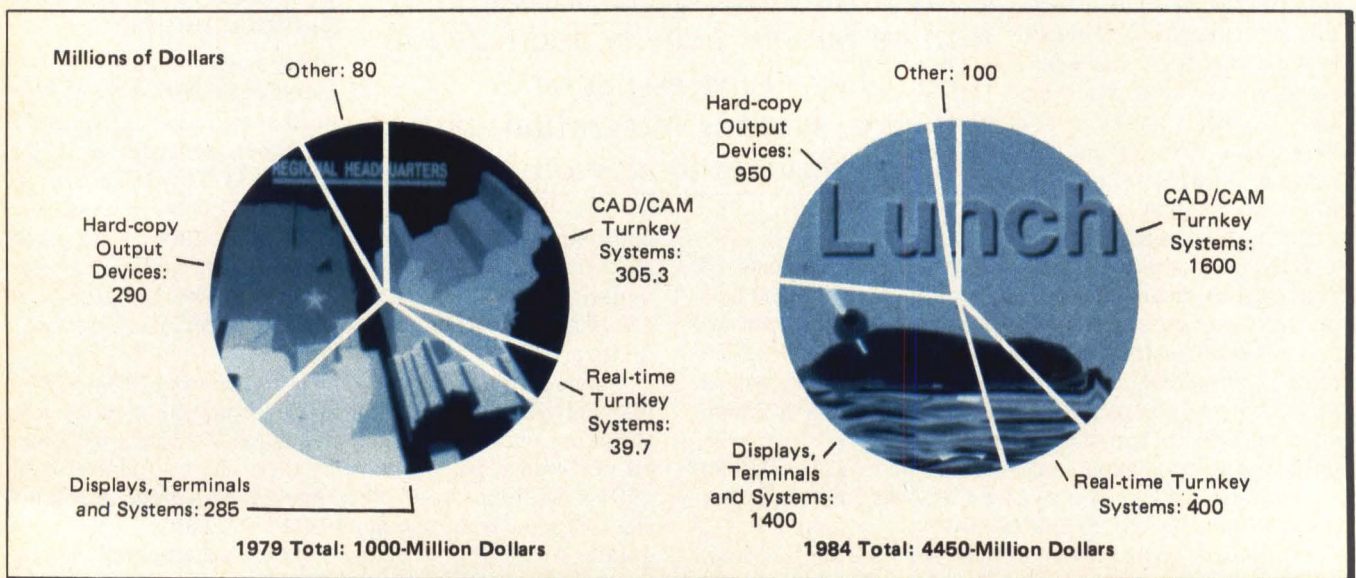


Figure 1: Graphics' shipment revenues by product type, 1979 and 1984

in all industry segments. Eight of twenty interviewed DTS manufacturers, including large-revenue firms, said they received advances from potential purchasers several times since 1979. DTS-constructor Sanders bought plotter-maker California Computer products (CalComp) and digitizer-builder Talos in February and June 1980, respectively. Of ten turnkey vendors questioned by **Digital Design**, eight said they were approached often. Nicolet's CAD appropriation in July 1979 complemented subsidiary Zeta Research's hard-copy product line. Schlumberger now woos CAD/CAM-designer Applicon. General Electric took over United Telecommunications' subsidiary, Calma, in 1981. In March 1980, 3M obtained real-time company Comtal, and Gould presently courts DeAnza.

Four of about fifty firms held more than three-quarters of the \$285-million, DTS revenues in 1979 (**Figure 2**). Tektronix's monopoly of storage-tube technology helped the company garner a 41.1% share, greater than the next three manufacturers' shares combined. Sanders' 16.5% incorporated CalComp and Talos revenues, adjusted to simulate January 1, 1979 take-overs. Getting 13%, HP ran third. Notable vendor percentages included Evans and Sutherland's 7, Ramtek's and Aydin's 5.3 each, Intelligent Systems's 3.3 and Adage's 2.2. Over 40 other DTS makers together carried 6.3%. A list of alphanumeric- and graphics-terminal producers and descriptions of typical products appear in **Digital Design**, August 1981, pp. 43-55.

Turnkey (including real-time) manufacturer sales in 1979 totaled \$345 million: four corporations controlled two-thirds of this market segment (**Figure 3a**). CV's 29.9% led Calma's 13.9% and Applicon's 13.2%. Gerber's 10.2% represented receipts from three subsidiaries that manufacture CAD/CAM equipment — Gerber Scientific Instrument (minus non-system, output-device receipts), Gerber Systems Technology and Gerber Garment Technology (minus cutting-machine sales). Revenues from both design-and-drafting and real-time configurations comprised Auto-trol's and Intergraph's (formerly M&S Computing) 9.7% and 8.5% totals, respectively. All real-time slices together made up 11.5%. More than 15 other firms collectively held 8.2%.

The real-time sub-segment of turnkey sales was \$39.7 million in 1979; this total was divided among six companies (**Figure 3b**). Heavy involvement in mapping and PC/M applications gained Intergraph more than one-third of the real-time dollar volume. DeAnza controlled a fifth. International Imaging Systems (IIS) and Sanders each held one-eighth. Comtal and Auto-trol carried one-tenth and -twelfth, respectively.

More than 25 hard-copy-device vendors took their sector's \$290-million revenues in 1979. Eight major firms included Benson-Varian (now separate companies), CalComp, Gerber Scientific, HP, Houston Instrument, Nicolet Zeta, Tektronix, and Xerox's subsidiary Versatec. For more complete manufacturer listings, see "Plotter Showcase," **Digital Design**, May 1981, pp. 23-8.

Excluding most equipment vendors, more than 60 independent companies and university departments now offer software and services. Integrated Software Systems (ISSCO), MicroSoft, Personal Software, Scientific Calculations and similar corporations provide complete application packages. Harvard University's Laboratory for Computer Graphics and Spatial Analysis, AUI Data Graphics and others develop custom programs and perform data analysis, plotting and charting functions. Algorex and Interactive Design Systems represent many individualized, CAD-job contractors. Vectron Graphics Systems, a typical time-sharing bureau, supplies

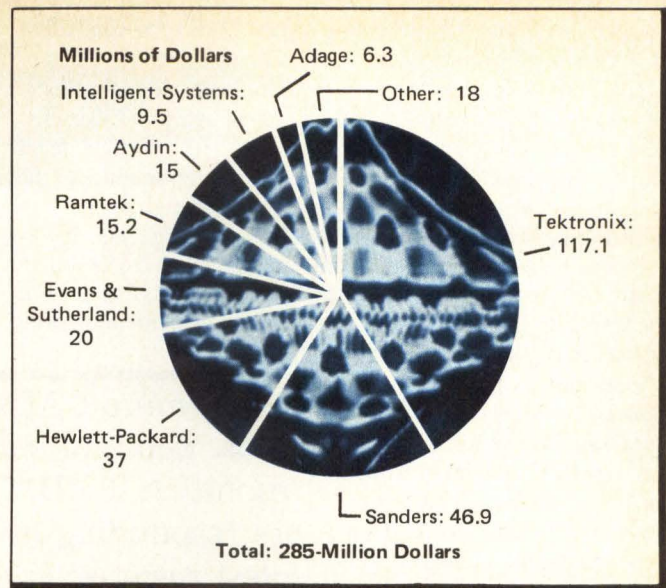


Figure 2: Graphics displays, terminals and systems' shipment revenues by firm, 1979

electronic design and hard-copy output by renting the access channels to its configured facility.

color penetration of graphics industry

The graphics industry's *color* market segment will also show users shifting away from peripheral machines and toward configured systems from 1979 to 1984 (**Figure 4**). The DTS group will remain the largest-revenue section, despite dropping from 57% of color products' \$200-million revenues in 1979 to 47.4% of 1984's \$2.4 billion. In 1979, real-time systems comprised all of the turnkey segment's 11.5%. In 1984, real-time's 15.2%, plus CAD/CAM's new 23.1%, will increase turnkey's share of the color graphics industry to 38.3%. Output device's revenue sector will fall to 14.3% from 31.5% over the five years.

DTS segment

Three out of four DTS display technologies create CRT images. Raster-scan, also called digital-TV or digital-refresh, offers television's shadow-mask electronics with tri-color phosphor cells. Raster's electron beam constantly redraws the entire screen using display lists and bit maps. Stroke-writing, alternately named vector-refresh, random-scan or random-position, creates and updates images using only display lists. Direct-view storage-tube (DVST) screens preserve everything displayed, minimizing memory requirements. Plasma-panel, holding a miniscule market share, replaces CRT's curved screen and electron gun with gas cells embedded between multiple layers of flat, glass plates. Plasma-panel view-ports also store displayed information.

Each technology's functional advantages and limitations determined 1979's competitors for application areas. Raster-scan's fast interactivity, unlimited-hue palette and variable-intensity screen suited data-display and most real-time functions. Moderate resolution and large, per-unit memory costs prevented raster from satisfying CAD/CAM's high-quality-image and multi-workstation requirements. Providing fine-line graphics, smooth curves, dynamic transformation of images and the speed necessary for animated movies, stroke-writing met the standards of both turnkey sub-groups. However, expensive beam-penetration stroke-writing's three colors did not support the prerequisites of industrial marketing. Offering superb resolution, highly detailed

images without flicker and low prices, DVST matched all of CAD/CAM's needs except selective (piecemeal) erasure. Storage-tube's slow repaint velocity and monochromatic drawback failed to meet the criteria of real-time systems. Plasma-panels found only military use, where ruggedness and a flat screen fulfilled priorities more important than the technology's one color, poor resolution and high price.

Changes in the designs of CRT display systems, incorporating advances in electronic components, meet buyer demands for fast, friendly, self-contained machines, while keeping prices stable. Low-cost, semiconductor memories

efficiently buffer communication channels and viewscreens. Small-sized, inexpensive μ Ps expand the machines' internal computing power. Built-in number-crunchers and memory together upgrade device independence from CPUs, allow flexible configurations and offset growing programming costs. OS software utilizes pipeline processing, boosting analysis speed. High-level languages provide English-language input commands, enhancing user interac-

tivity. Ergonomic, or human-oriented engineering, features such as glare and radiation filters, swivelling screens and detachable keyboards support operator comfort and safety.

Recent view-screen developments reduce each technology's important drawbacks. Phosphor dots circled by black bands increase raster's resolution. The penetration-tube's three-color capability enhances stroke-writing. Tektronix's hybrid DVST, incorporating a two-phosphor mix, provides a limited amount of selective erasure and dynamic image transformation. (Second-color highlighting of refreshed areas is optional — see **Digital Design**, August 1981, pp. 98-9.) Utilizing dual-signal gas discharges, Burroughs's new plasma-panel upgrades viewing angles and picture brightness, offers piecemeal deletion and lowers power consumption; however, unit prices remain high so far.

As a result of these display and design improvements, the products whose technologies provide color will dominate DTS revenue shares by 1984 (**Figure 5**). Color, raster-scan devices, already representing one-third of DTS's \$285-million sales in 1979, shall total three-quarters of DTS's \$1.4 billion in 1984. Monocolor stroke-writing machines' dollar volume will shrink to a tenth of 1984's DTS pie from one-fifth of 1979's. Three-colored, beam-penetration stroke-writers, however, shall capture one-twentieth-sized slices both years. Remaining virtually monocolor into 1985, storage-tube devices' one-third of 1979's receipts will diminish to a tenth of 1984's.

Equipment offering color raster technology shall overwhelm DTS unit-shipment shares in 1984 (**Figure 6**). Color raster product shipments will increase to 87% of 1984's 250,000 DTS units, from 47% of 1979's 32,300. In comparison, from 16% of 1979's unit shipments, monocolor raster machines shall decline to 7% of 1984's. Monocolor stroke-writing devices' 4% share of 1979's shipments will fall to 1% of 1984's. DVST products' cut of the shipments shall dwindle dramatically, dropping from 1979's 32% to 4% in 1984.

turnkey segment

Turnkey design changes, incorporating improvements in

both electronic components and new peripheral units, address users' needs for distributed processing, integrated information storage and friendly systems. Utilizing inexpensive μ Ps and semiconductor memories, remote workstations function either as standalones or as network components. Dual-CPU architecture and OS software handle the hierarchical analysis and communication routing required in multi-terminal configurations. Many systems interconnect with buyers' MIS and other computers, providing unified, graphics, data-base management (DBM). Turnkey equipment incorporates the ergonomic features of DTS devices and some new

color hard-copy and application-package options. Recently introduced input devices controlled by vocal commands, and some new screens activated by touch for menu selection, simplify operator interaction with the machines.

Illustrating manufacturers' awareness of customer desires, the latest improvements in view-screen technology seem tailor-made for turnkey buyers. Most importantly, raster-scan's increased resolution gives owners an unlimited-hue

palette at the level of image accuracy required for CAD/CAM applications. Beam-penetration tubes offer stroke-writing users three colors without forcing them to change display technologies and the attendant software. And finally, piecemeal erasure and dynamic transformations circumvent DVST's slow screen-repainting speed.

Five of six interviewed CAD/CAM manufacturers initiated product-line changes since 1978 involving color, raster-scan displays as a response to avid user interest. Calma and Applicon said they recently discontinued DVST systems, and offer only raster types with color options. Three other major design-and-drafting companies reported they now provide both color, raster- and their previous, monochromatic-technology terminals. All five firms agreed buyers' demand for color raster jumped and remained higher than originally anticipated. The manufacturers accordingly expected strong sales to continue through 1984. Vendors forecasted that by 1984 customers will average one color raster terminal in every system holding four or five workstations.

Projected 1984 turnkey (including real-time) revenues, categorized by the display technology employed in each system, reflect buyers' and vendors' expanded interest in color (**Figure 7**). Configurations using raster-scan captured one-sixth of the \$345-million, monocolor turnkey revenues in 1979. Raster systems' share shall increase to three-fifths of 1984's \$2 billion. In 1984, two-fifths of those raster-system sales will represent color-system purchases. Stroke-writing systems will decline from about one-third of 1979's total to approximately one-fifth of 1984's, mainly due to reductions in monocolor systems' percentage of total revenues. Monocolor storage-tube systems' one-half of 1979's dollar volume shall drop to one-fifth of 1984's, with hybrid-DVST systems' revenues double that of systems using regular DVSTs.

Color, traditionally bought only where needed, now slowly penetrates the monochromatic, turnkey application areas (**Figure 8a**). Only the operators of real-time systems, who required intricate images to interpret and code information, utilized expensive, multicolor machines in 1979. Since then, electronics designers found color systems imperative to con-

As more CAD/CAM end-users demand color along with high resolution, CAD/CAM manufacturers are responding by switching to the latest raster-scan displays. By 1984, sales of turnkey systems that employ raster color will total \$486.4 million, representing one-quarter of turnkey revenues.

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tinue the miniaturization of complex schematics. Developers of manufacturing plants and petrochemical-piping flows now increasingly employ color systems, as planners learn how color makes designs more clear. Builders of architectural structures, mechanical parts, automobiles and aerospace vehicles also are beginning to express interest in color to separate the moving and stationary objects in line drawings.

Two of three rapidly expanding, real-time application areas extensively use color configurations (**Figure 8b**). The prolific mapping and PC/M sector boasts two recent entries by CAD/CAM vendors, who join three original firms that sell only color raster systems. A small application area combines nondestructive (ND) testing and graphic arts. Offerings here mainly consist of multi-color equipment, including some new systems based on μ Ps and costing under \$100,000. Both of this double-category's relatively untapped markets may experience further growth before 1984. The key to future expansion lies with the conglomerate corporations that recently bought most of the area's vendors. The medical division's

color systems code the output of computer-aided tomography and ultrasound diagnostic scanners. The equipment enhances the market of gray-scale, X-ray, hard-copy machines. Employing mostly monochromatic, plasma-panel configurations, the well-established, military area's revenue size remains stable.

Color's successful penetration into the turnkey segment will cause the sales of color systems to increase dramatically. From 7% of the \$345-million, turnkey revenues in 1979, color-system sales will grow to 45.6% of turnkey's \$2 billion in 1984 (**Figure 9**). Monochromatic configurations comprised virtually all of CAD/CAM's 88.5% of 1979's turnkey revenues. User acceptance of raster-scan shall both support the revenue growth of color CAD/CAM systems to 27.5%, and help shrink the sales of monochrome CAD/CAM configurations to 52.5% of 1984's dollar volume.

In comparison, in 1979, real-time's monochromatic configurations held 4.5%, and its color systems 7%. By 1984, real-time's monochrome-system revenues will recede to 1.9%, while color systems' sales advance to 18.1%. Intergraph initiated this sub-sector's current return to color domination. The firm's entry into real-time applications, providing monochrome, storage-tube systems, had successfully captured one-third of the real-time revenues in 1979. Today, Intergraph's color, raster-scan system (introduced in March 1981) shall soon move the sales percentages back to color.

hard-copy output-device segment

Ten hard-copy technologies fit into five device categories. A pen-plotter division incorporates both drum and flatbed assemblies. Electrostatic machines represent the second category. Dry-silver and thermal units comprise a third class. Category four includes photographic and film products. The fifth group, called other, collects recently introduced ink-jet, impact-matrix, laser and COM equipment.

Readers unfamiliar with output-machine technologies should refer to three articles in two previous issues of **Digital Design**. "Plotters: Charting a Course for the '80's," by Bob Hirshon, May 1981, pp. 30-1, outlines all ten copying technologies. September 1980's "Designers' Guide to Pen Plot-

ters," by Maurie D. Wagner, pp. 66-8, provides the fundamentals of drum and flatbed pen plotters. Bob Hirshon's "Guide to Color Hard Copy," also September 1980, pp. 46-55, compares new photographic, film, laser, impact-matrix and ink-jet color devices.

Presently, just three product technologies cannot provide color output. Although electrostatic and thermal machines generate copies using methods that are analogous to the way raster-scan creates an image, both output technologies remain monochromatic. Light-sensitive, dry-silver devices from Tektronix reproduce the monochrome images of DVSTs.

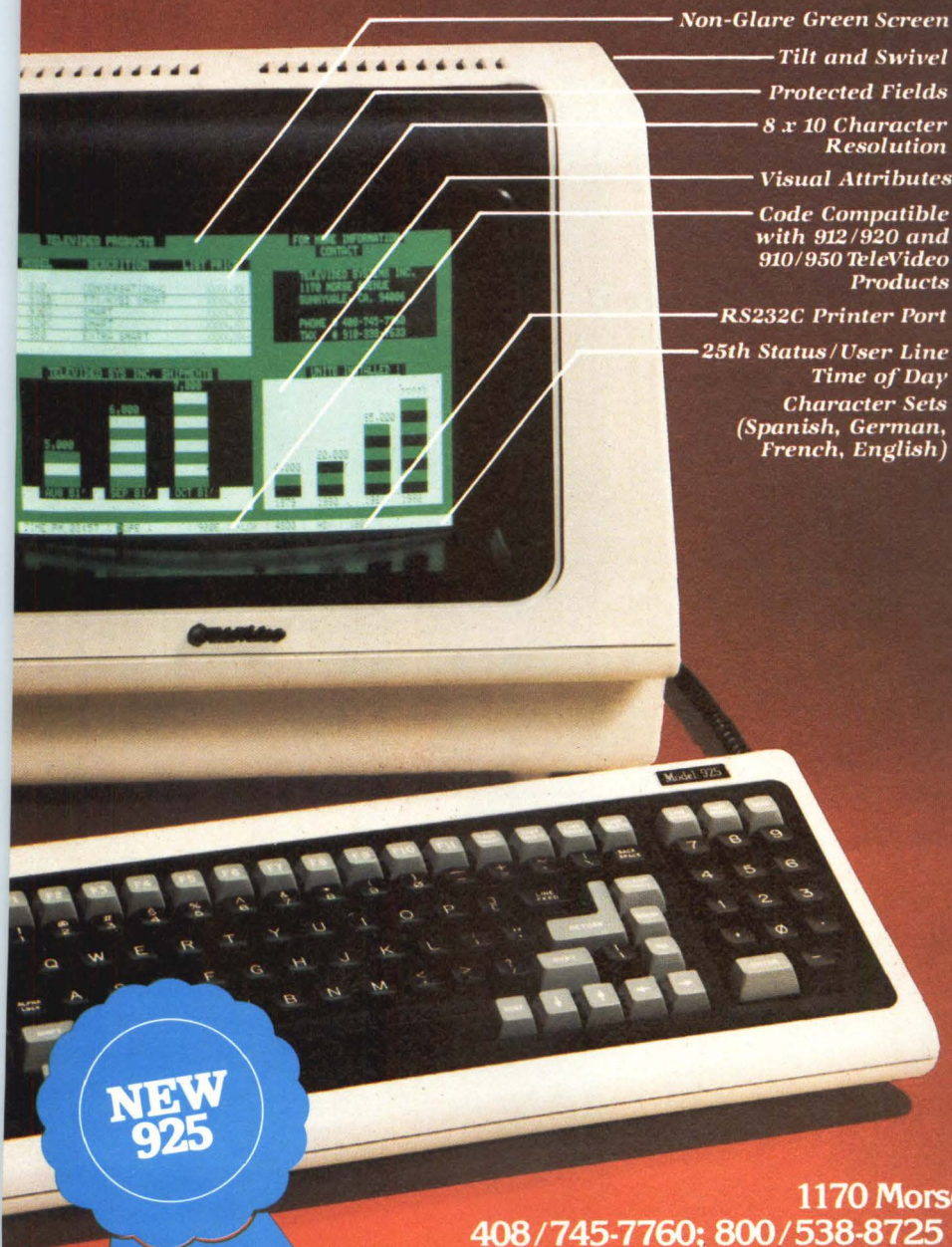
Manufacturers of another four technologies recently upgraded or introduced multi-chromatic products, increasing buyers' options in color output devices. Makers of pen plotters invented carriages that store, or load-on-demand, many color pens. This feature freed the operator from the task of changing pens manually, as color pen plotters previously required. Gerber and Optronics added color to their expensive, very-high-resolution, gray-scale film recorders. Ramtek, Selanar, IBM and other vendors, following the lead of Trilog in 1979, developed four-color ribbons for impact-matrix printers. COM firms' newest devices produce multi-colored microforms using three additive exposures of a monochrome CRT screen, each shot through a color-wheel filter.

Two of the three new, color technologies finally provide hard-copy devices at the inexpensive price levels most business purchasers require, thus opening up a large application area. Low-cost cameras from Dunn Instruments, Image Resource and Matrix produce color output at the good resolution quality necessary for industrial-marketing presentations and other business applications. PrintaColor offers executives desktop-sized, ink-jet color devices at prices cheaper than Applicon charges for its larger, high-resolution model. Xerox's unit, priced above the camera and desk-top ink-jet machines, combines laser accuracy with the company's color reproduction methods.

Color machines' net share of the revenues from hard-copy equipment will grow slowly through 1984, focusing in only two device categories (**Figure 10**). Multichromatic pen plotters' 22.2% share of output machines' \$290-million sales in 1979 shall expand slightly, reaching 26.1% of hard-copy's \$950 million in 1984. Monochrome pen plotters' 33.3% of 1979's total output sales will drop to 17.4% of 1984's. High output speed and compatibility with raster-scan displays shall cause electrostatic's revenue percentage to increase from 25.9 in 1979 to 28.2 in 1984. For similar reasons, thermal's part of a pie-slice will also expand. However, dry-silver's dependence on the shrinking percentage of DVST sales shall dominate thermal's gains. A net contraction of the dry-silver and thermal category will occur, going from 1979's 13.7% to 1984's 11.7%. The photographic-and-film division's color section shall rise from 1979's 0% to 1984's 9%. This division's gray-scale group will advance from 3.5% to 6% over the same five years. The poor quality of color impact-matrix output, color laser's higher prices and color COM's slow speed shall severely limit the percentage growth of the category labelled "other color" through 1984, despite gains by the new color ink-jets.

(text continued on page 48)

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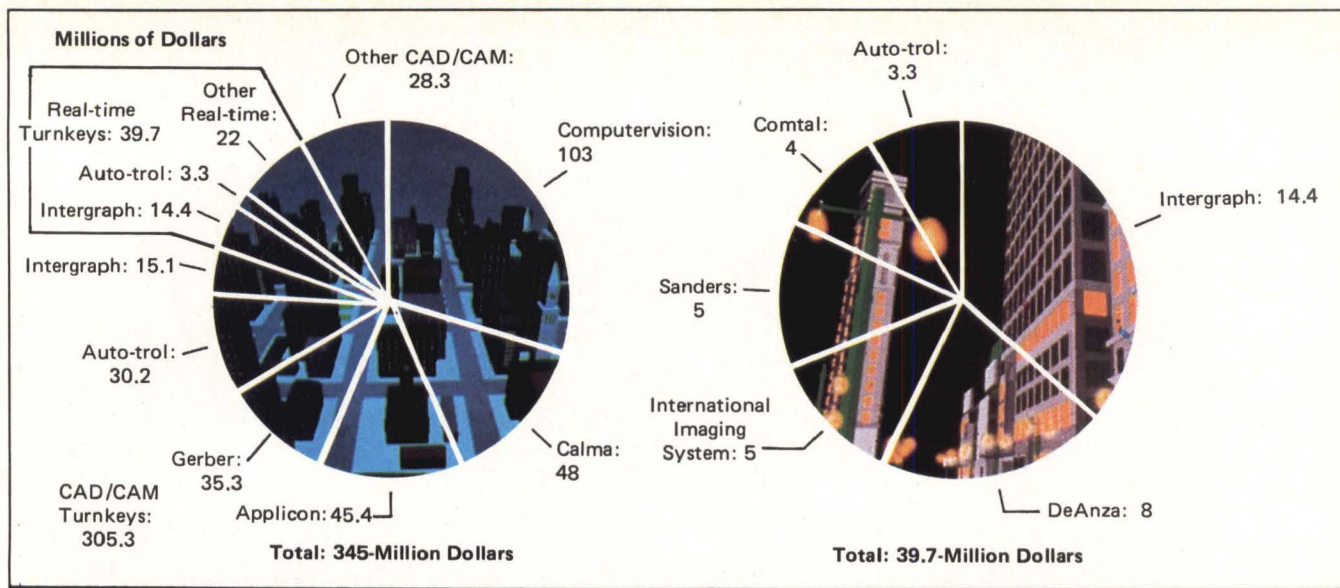


Figure 3: Graphics turnkey (a) and real-time turnkey (b) systems' shipment revenues by firm, by system type, 1979

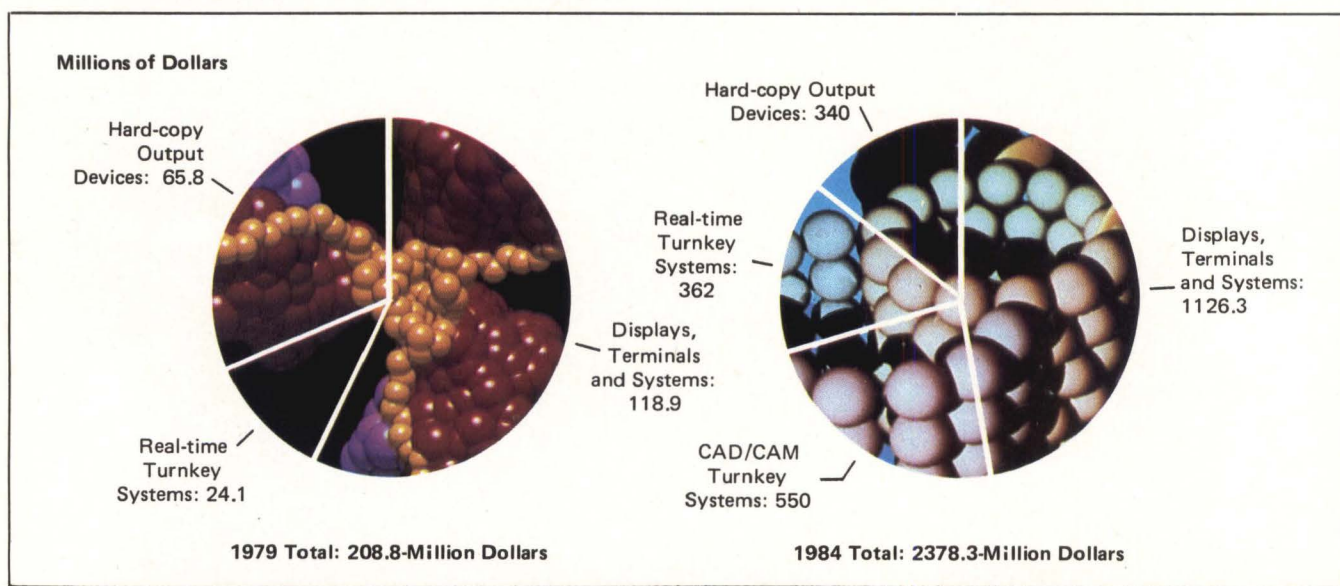


Figure 4: Color graphics' shipment revenues by product type, 1979 and 1984

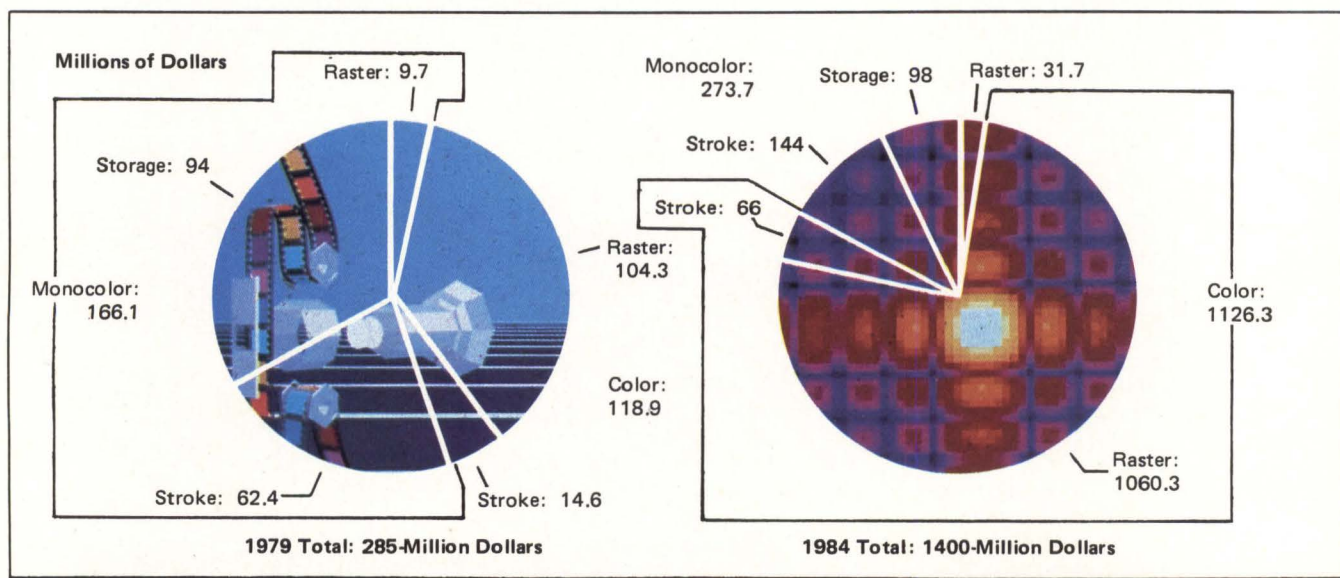
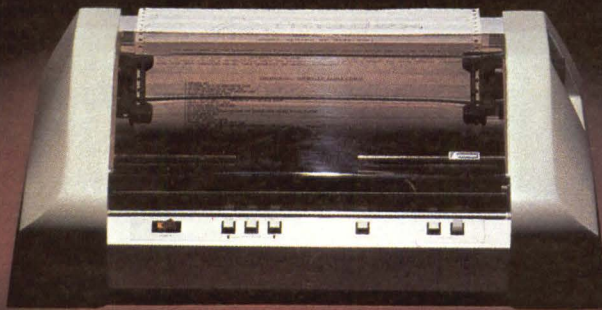


Figure 5: Color penetration of graphics displays, terminals and systems' shipment revenues by display technology, 1979 and 1984

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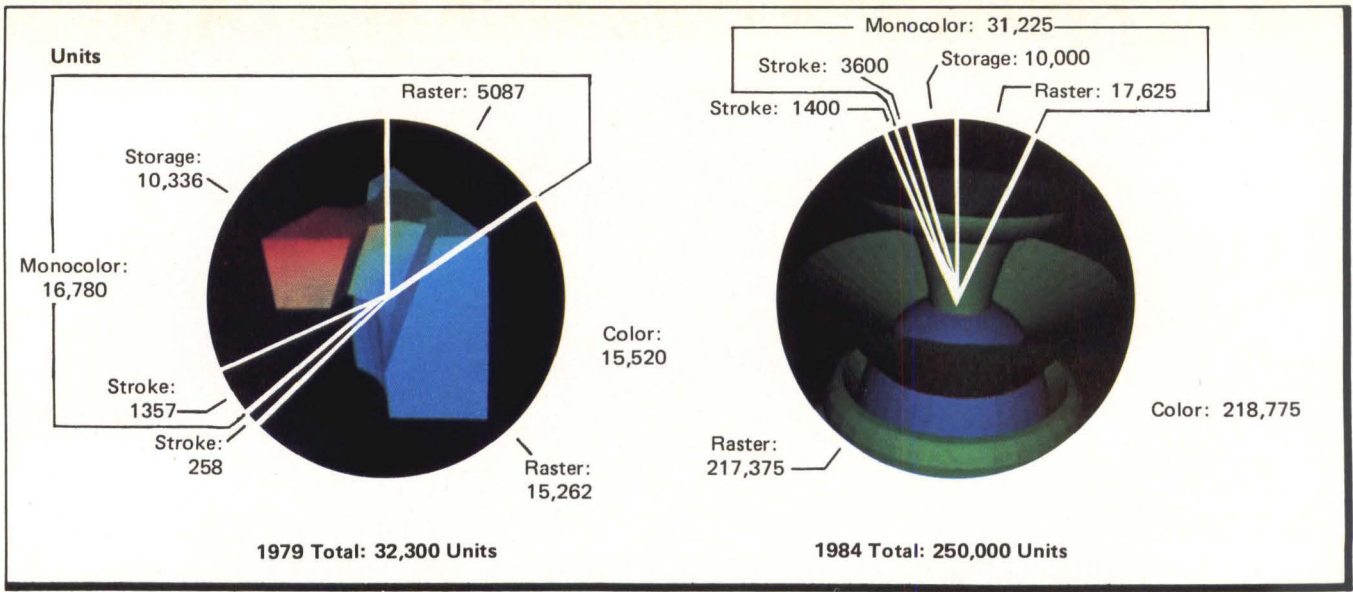


Figure 6: Color penetration of graphics displays, terminals and systems' unit shipments by technology, 1979 and 1984

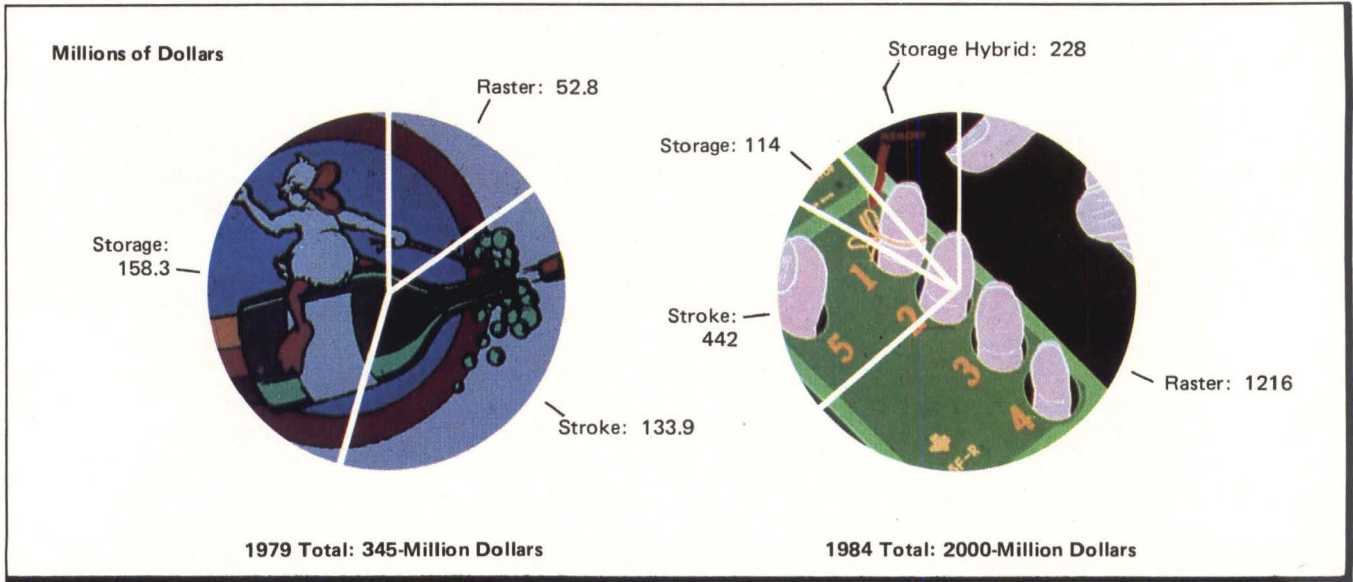


Figure 7: Graphics turnkey systems' shipment revenues by employed display technology, 1979 and 1984

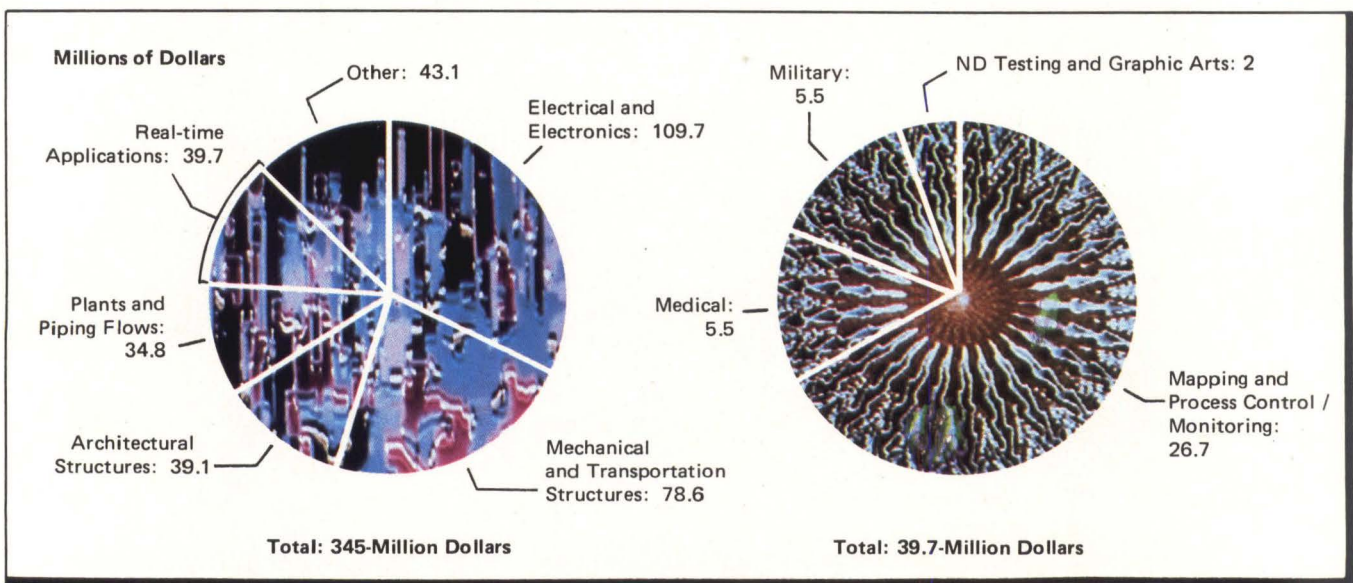


Figure 8: Graphics turnkey (a) and real-time turnkey (b) systems' shipment revenues by application, 1979

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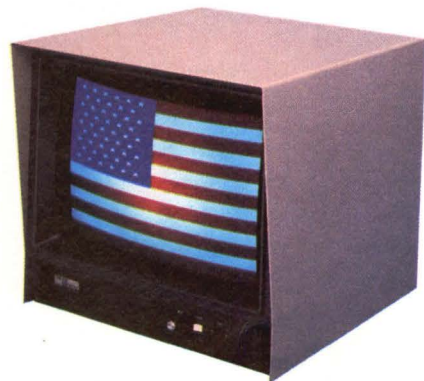
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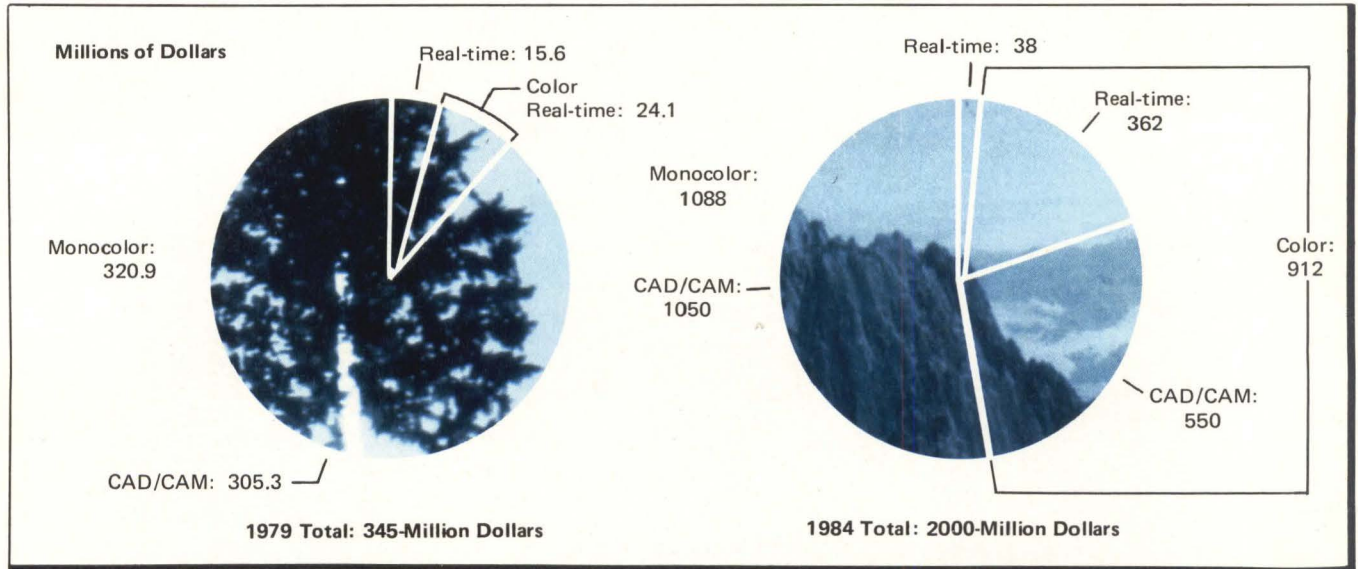
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(text continued from page 40)

software and services segment

Although software and services are not analyzed in terms of market dollars, the expansion of existing equipment vendors and new firms show color's growth in this sector. Turnkey manufacturers' heavy expenditures on research and development recently generated many multichromatic application packages. This software expanded turnkey systems' color applications by broadening their color capabilities.

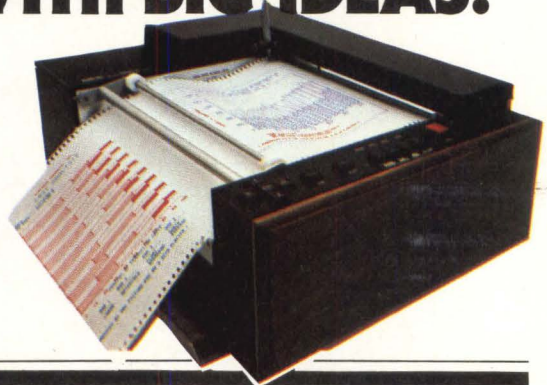
Out of six interviewed CAD/CAM vendors, five answered questions on R&D. Each firm's R&D investments, measured as a percentage of company revenues in 1979, averaged 13.9%. All five manufacturers said they will annually spend over half their R&D dollars on color programming through 1984. Counted together, the six CAD/CAM firms recently introduced ten application packages. The four most important programs, long desired by many users, create highly accurate representations of objects utilizing a technique called three-dimensional, solid-geometry modelling.



Images courtesy of OSU and Boeing

Figure 9: Color penetration of graphics turnkey systems' shipment revenues by system type, 1979 and 1984

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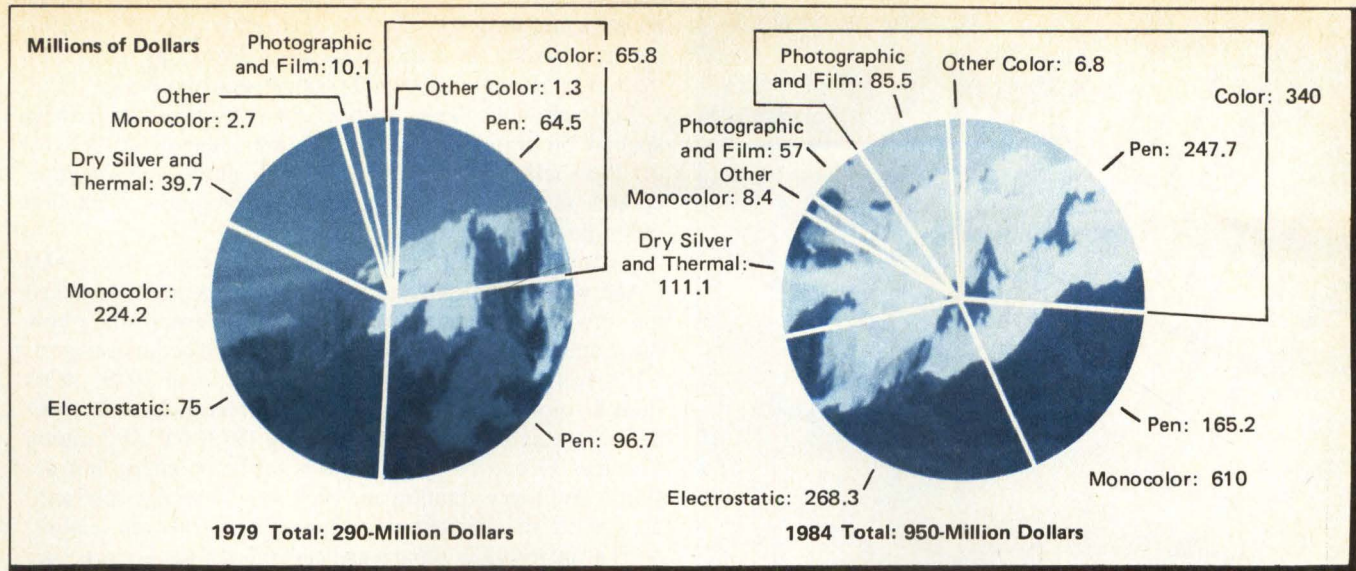


Figure 10: Color penetration of graphics hard-copy output devices' shipment revenues by technology, 1979 and 1984

Similarly, out of six interviewed real-time manufacturers, the two respondents devoted an average of 11.3% of 1979 sales to R&D outlays. The companies said they usually split R&D funds evenly between color equipment and color software. Nine of the ten latest real-time application programs now, or will soon, offer color options. They include six devoted to various mapping functions, and two that address the new, ND-testing application area.

Equipment vendors and young, independent software houses and retail stores offer users of home and business computers diverse, self-contained, color-graphics programs.

Many DTS manufacturers now sell color application packages designed for households and offices. Personal Software, a typical independent firm, is small and only three years old. VisiTrend/VisiPlot, one of the company's popular graphics programs, provides market forecasting and color chart generation for financial executives. ISSCO, a much larger independent, offers its widely purchased Tell-A-Graf product for presentation- and publication-quality graphs. The firm added color to the upgraded version of the package in 1981. Programs Unlimited, Lifeboat Associates and other software supermarkets carry various new, multicolor, plot-

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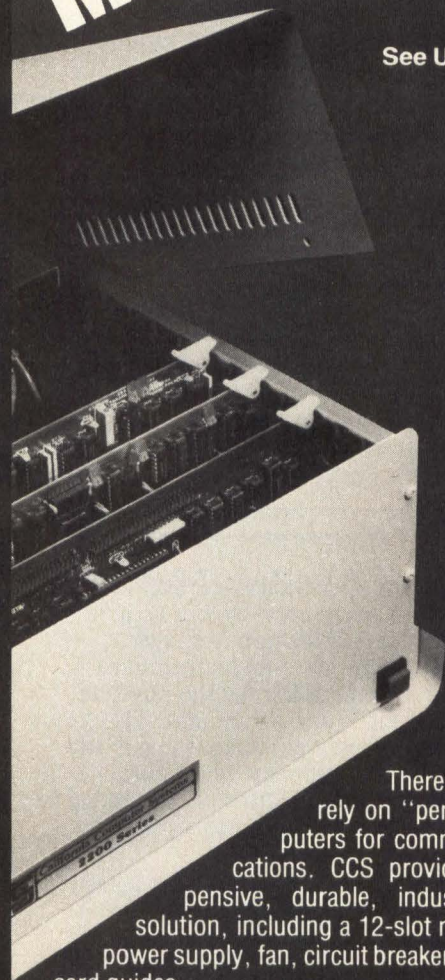
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constructing programs. Sample applications include advertising and marketing graphics for small firms, and charts for tracking personal investments such as stock portfolios.

Software consultants, also recent industry entries, handle special programming needs that users cannot satisfy with off-the-shelf packages. AUI Data Graphics, for example, creates all kinds of unique business programs, including color charting.

Services, as well as software, are growing. The CAD/CAM vendors holding the largest revenues recently opened nationwide, customer-aid divisions. These groups show how most manufacturers are expanding maintenance and support. CV's call-in Response Center, created in mid-1979, offers their buyers the advice and expertise of hardware and application specialists. Organized early in 1979, CV's Education Services Group provides users with the operating instructions, employee training and productivity strategies associated with the company's systems. For software analysis, worker instruction, repairs and general consultations, device owners telephone Calma's field-service network or centralized Response Center.

Proliferating retail-service contracting firms provide individualized color-graphics design and hard-copy for many companies. Clients include firms experiencing overloaded schedules or small or infrequent projects, small offices that cannot afford the equipment, and anyone interested in investigating the potential of color graphics. Harvard University's Laboratory for Computer Graphics and Spatial Analysis performs research-related, multichromatic mapping tasks, such as constructing an atlas or a demographic distribution. At Computer Pictures's walk-in center, employees analyze raw data and generate color charts, plots and slides, either while customers wait or overnight. Using color CAD systems, Algorex helps clients design custom PCBs and electronic chips. Vectron Graphic Systems represents many other time-sharing bureaus. Its fully configured, color facility handles the portable, remote-input terminals used at client locations to lay out PCBs and ICs.

the overall graphics picture

In summary, color-product revenues will grow rapidly for the following reasons: manufacturers, by improving technologies and designs and expanding software and services, are actively meeting users' needs and enlarging color's applications. Vendors' upgrading of the three view-screen technologies widens the application areas of CAD/CAM systems and gives all graphics clients more color options. In four established, hard-copy technologies, color-product introductions increase buyers' previously limited choices. Two new, inexpensive, multichromatic technologies — ink-jet and color camera — finally reach the low-cost criteria of general-industry purchasers. Manufacturers' design changes, incorporating inexpensive μ Ps and semiconductor memories, better programming and ergonomic features, satisfy customer desires for various fast, friendly system configurations. Recently introduced, multichromatic software packages expand both design-and-drafting and real-time turnkey color applications by broadening the systems' color capabilities. Self-contained color programs from DTS sellers and independent corporations and consultants approach young markets, providing the performance features required by owners of new home and business computers. Turnkey firms create the strong maintenance and support services that users want. And finally, for any companies either without, or unwilling to buy, special equipment, retail contractors handle color-graphics design and plotting jobs.

D

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1. Before writing your article, send us an abstract and general outline. Then, after receiving the OK from our editors, begin writing the article itself.
2. Don't worry excessively about grammar or punctuation: simply write as though you are talking to a fellow engineer. Use simple language. Our editors will — if necessary — assume the responsibility of improving the presentation of your ideas to our readers.
3. How much material should you submit? Write as much as you feel necessary to explain the points you're trying to put across. We will cut it down to an appropriate size or assist you in expanding any section.
4. Submit your articles with double-spaced line copy and with one and a half inch margins top, bottom and sides. Type the article at approximately 58 characters per line. If possible, submit the article in duplicate: keep the original for yourself in the event the article gets lost in the mail.
5. Submit only glossy, original photographs. We cannot reproduce photographs from brochures or company catalogs.
6. Submit camera-ready artwork whenever possible. If this is impossible, our art department can make line drawings from pencil sketches, but you must identify all important parts of these drawings. Please double-check all printouts and callouts for legibility in the photocopies.

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7. Submit tables, figures, photographs on separate sheets with clearly identified, three-line captions. Don't feel that you may be saying too much about an illustration. Say what you feel is important so that if the reader looks only at your illustration and reads its caption, he still retains a significant bit of information about your article. Graph and plot captions should state significant interpretations of what the graph or plot displays. A caption for a graph that says merely "Parameter A vs Parameter B" is unsuitable.
8. Number all pages and figures appropriately. Use a soft pencil when writing on an overlay (tissue) sheet.

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Principles of Designing And Specifying Power Supplies

specifying earlier cuts overall system costs

The trend in power supplies is to purchase rather than build. This is particularly true with switchers, but it is also a trend with linear supplies. In large quantities, it is better in most cases to build. In either case, ignorance of power supply basics can result in a supply that is either over-or under-specified. With this in mind, we present specifying and design principles.

by Paul Snigier, *Editor*

Aside from hardware and packaging, no other electronic or computer subsystem has been so ignored in specification and design than the power supply. Consequently, this article will attempt to summarize power supply design and selection principles from the viewpoint of the engineer faced with designing or building a supply.

avoid the custom supply

If possible, avoid specifying customized power supplies. Not only are they higher in cost than standard supplies, but you risk logistics and delivery difficulties. Since customized power supplies are not really field-proven, the question of reliability is an added problem. In an attempt to circumvent logistics troubles in delivery, some OEMs purchase through more than one source. Unfortunately, such a split quantity raises prices.

When is it best to specify a custom supply? If the production quantity exceeds 4,500 supplies per year, you may be justified in specifying a customized unit: if care is taken, prices will be lower. MTBFs can be just as good with a customized supply. It will be to the advantage of you and the power supply maker to take extra care when large quantities are involved. However, if your annual production quantity is expected to fall below 1,500 supplies per year, specifying standard, off-the-shelf supplies is the best route. In such relatively-low annual production quantities, the design costs, new noise emission/conduction tests, and other unique costs cannot be economically amortized.

thermal considerations

Put off power supply selection, fail to develop specifications and avoid contacting power supply representatives until the last minute and you could get away with it — 10 years ago. Back then, since power supplies took a smaller percentage of overall system costs, the late specification of an odd-shaped, overheating supply had little effect. Often, allowances were made from the start of the design project for this. With the advent of LSI and VLSI, circuitry costs plummeted relative to power supply costs. With the rising prices for raw materials which make up supplies, supply costs could not decrease as rapidly as other system costs. Less space in today's system enclosures make the early allocation of extra space difficult. The chances for miscalculation are far greater today. The numerous and rapid product introductions today, the greatly decreased product lifetimes, the narrowing marketing windows, and the time lost by unnecessarily redesigning a system all can prove disastrous in terms of lost sales and smaller market share. Initial power supply projections

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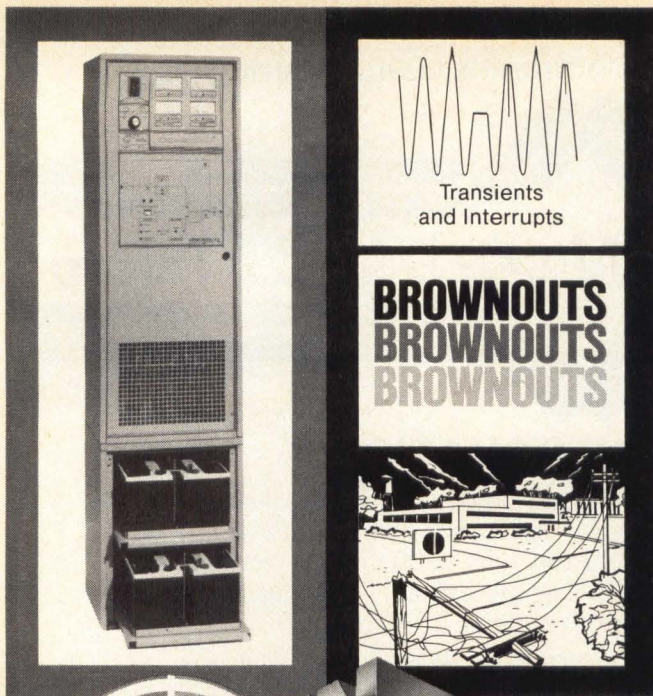
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inevitably are underestimated. To avoid unpleasant surprises, include an extra 30% to allow for system growth. Also, allow extra space, as determined from dimensions in catalogues. Add approximately one inch on all sides for proper convection cooling.

Early allowances made for the power supply allow an optimum layout of heat-sensitive PC boards and components. If allowances are made early enough, it will be easier to mount the supply's longest surface against an outer enclosure, thus allowing better conduction to the outside. In some cases, application of a thermally-conductive compound dramatically increases conductive heat transfer. This alone can lower temperatures by up to 10°C. Since certain sides of a power supply (particularly linears) are much higher than other sides, proper orientation should be considered. Temperatures can thus be lowered by as much as 30°C.

To obtain lowest possible thermal resistance, power supplies come with an endless variety of finspacing, and in a number of sizes and shapes. Air heated close to the fin surfaces expands slightly and moves upward, pulling cooler air upward from below. As the heated air rises by the fins, it moves outward. Obviously, the greater the number of fins, the greater the surface area and the greater the cooling effect. Taller fins provide greater air drag, creating vortices, and thus slowing the heated air boundary layer. This lowers efficiency. For a heat sink with the same amount of area, but with shorter fins, efficiency is higher; and, thus more calories are removed per unit of time. At higher temperatures, heat sink efficiency is greater because the boundary layer is traveling faster.

Empirically, thermal resistance as a function of area (in °C per watt) roughly equals 80 times the area in square inches to the -0.70 power. This relationship works over a heat sink area range of 5,000 sq. in. down to 0.14 sq. in. For these two end points, thermal resistance is respectively, 0.21 and 300. Thermal resistance is affected by fin height, but not much for standard power supply heat sinks. Since the previous formula holds for a power dissipation of 1W, a multiplying factor adapts it to commonly-used power supply heat sinks. Certain heat sinks are superior by up to 30%, but require all surfaces to be oriented vertically.

Forced convection cooling can lower thermal resistance. Fan or forced convection cooling increases thermal heat transfer more for small area heat sinks than for larger ones. Obviously, the large area heat sink is already well-exposed, with more natural convection of its boundary layers. In this case, the increase in forced convection, though producing an increase in CFM (cubic feet per minute) air flow will not add much more over what occurs with natural convection.

Empirical graphs plot thermal resistance at a given CFM per natural convection thermal resistance as a function of air flow in CFM. Obviously, as air flow increases, the ratio decreases. At a CFM of 5.0 and a heat sink area of 50 sq. in., the ratio is 0.33; at 20 CFM, it drops to 0.2; and at 50 CFM, it drops to 0.14. For a 500 sq. in. heat area sink, the values are higher: 1.0, 0.65 and 0.4. These graphs suffice for an initial design; exact figures can be provided later by the manufacturer. Although forced air cooling obtains the same result as natural convection cooling in a smaller volume, take into account the fan's noise and MTBF. Also, consider inlet/outlet blockage. If this occurs, the improved reliability of your system and its power supply may not be increased by four or more times — it may be decreased by this amount. Also, consider the effects of fan or blower failure. Will this require a system to operate in a reduced mode? Can the end user afford this? And, in considering a switcher versus a

linear, if the greater switcher efficiency and its smaller volume are offset by lower reliability and greater cost, is this worth it in terms of end user needs? Is the system a cost-sensitive product where reliability is not as significant? A professional or personal computer user can afford the downtime that a business or bank could not afford.

Switchers dissipate less dc power, since the switch is either saturated or totally off. This is unlike the linear series-pass government of the linear power supply. It operates in the linear region, therefore dissipating more power during its operation. Basically, switcher operation begins when the comparator compares output voltage to an internal voltage reference and closes the switch when output voltage falls below the reference. An LC filter, possessing a long time constant, produces a dc output almost at the reference voltage by averaging the switched input. Output alternates slightly below and above the nominal output voltage (ripple).

Linear power supplies provide a shorter (8 msec) hold-up, or storage, time than do switchers. Switchers can provide up to 30 msec, depending upon switcher type and the load. They are able to ride through longer power outages without sacrificing their efficiency. This also provides more time for an orderly shutdown.

selecting a vendor

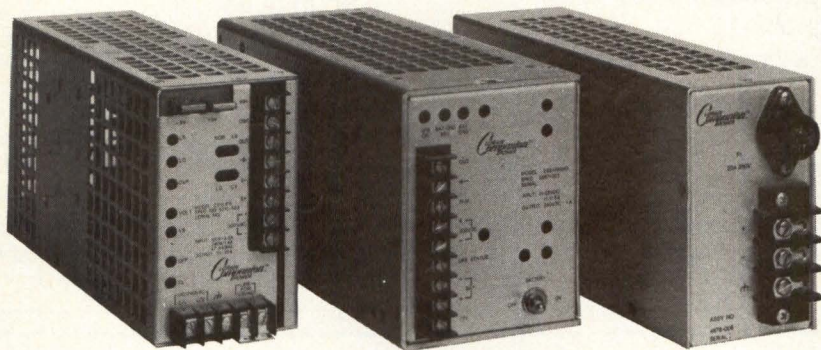
Keep in mind that power supply manufacturers are prone to playing the specsmanship game, juggling specs and MTBFs to get figures that make their products compare favorably. Unfortunately, MTBFs can be calculated and measured in many different ways. For example, if ambient temperature is unspecified and load condition and line voltage are not mentioned, the vendor may juggle his mathematics to obtain

an optimistic MTBF. Some vendors have been known in the past to reduce line voltage, perhaps by 10%, thus lowering power supply temperatures by 25°C. Fly-by-night manufacturers have been known to integrate lower quality parts while using military part failure rates in their MTBF calculations. Also, calculated MTBFs, unfortunately, simply do not always agree with empirical values.

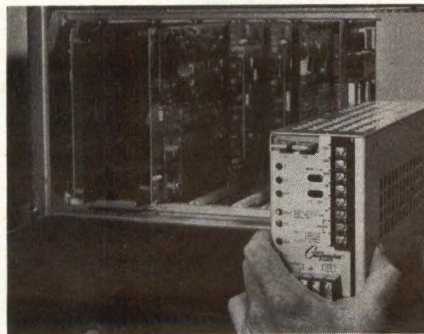
In selecting a power supply vendor, be sure that the vendor has a commitment to the particular type of power supply you are specifying and has a significant portion of his business devoted to the product areas that you are in. Some vendors carry a full product line, but may carry several supply categories only as a mere convenience for their customers. If the vendor is making 2.5 million per year, has been around for over three years and can provide references, then chances are he'll survive. To determine vendor commitment, go beyond references; determine if his EEs are familiar with leading-edge technology, particularly for switchers.

Computer systems failure can be caused in several ways. During burn-in, infant mortality failures will be weeded out. Unfortunately, heat-induced failures do not occur within this period of burn-in, but may occur weeks or many months after operating at the end users' installation. For reasons of aesthetics, plain carelessness, or in an attempt to keep out hostile atmospheres, objects or liquid, designers are tempted to use less than adequate ventilation. Remember, each 10°C operating temperature reduction will double supply reliability.

Efficiency is not the only factor affecting MTBFs. Efficiency, or rather the lack of it, does not necessarily reduce reliability; it is the temperature rise that does that. Therefore, a well-sinked supply that has a lower efficiency may be more reliable and improve overall system performance more than



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another higher-efficiency supply. In this regard, a power supply that can operate reliably in a computer system can fail at a lower current inside a plastic enclosure. Better power supply makers will use higher-rated pass transistors, more heat sinking and higher-rated rectifiers. Bigger filter capacitors' rectifiers should be rated for a half cycle surge of 20 times the dc current surge at the diode's maximum junction temperature. Peak inverse voltage should be three times dc voltage or more.

Paralleling rectifiers can create troubles. Upon turn-on, the uncharged filter capacitor is a short; thus peak rectifier current is limited only by the transformer's source impedance. Since rectifier surge currents drop with higher temperatures, and must be derated, this may not seem to represent a source of rectifier failure. Unfortunately, the smaller diodes possess lower surge ratings. If switched off and on several times while hot, these paralleled rectifiers are more prone to fail.

Other sources of premature power supply failure are caused by operating power supplies with heavy inductive loads that can create inductive kickbacks, even temporarily reverse-biasing the series-pass transistor and destroying it. If operating with such inductive loads, connect a diode in reverse across the series-pass transistor so that the conductive kickback is bypassed and dissipated into the main filter capacitor.

OVP: a costly waste?

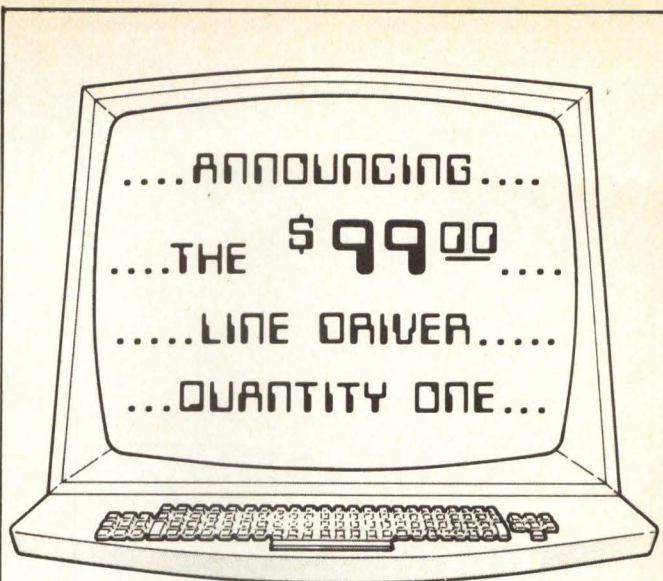
Although certainly not a waste, overvoltage protection (OVP) is less commonly used than in the past. With improved components, series-pass transistor shorting, which would double output bus voltage and damage load circuitry, occurs less frequently. With today's low cost circuitry, total OVP cost is seldom justified.

Where would OVP be justified? If you must specify a low quality supply, OVP may make sense. And, if multiple supplies are used with danger from connecting a higher supply to a lower bus, use OVP. Also, if a customized supply is entering production, and little is known about its failure profile, OVP makes sense, at least until data is gathered. Finally, if the cost of the circuitry that you are considering protecting costs over \$700, consider OVP.

If the danger exists of shorting together opposite polarity lines of a multiple output supply — either accidentally during servicing or through external IC failure — connect a reverse-polarity diode across each supply. Each diode has no effect upon the supply lines until the buses are connected. When this happens, rather than one supply being destroyed, both supplies survive — assuming the diodes are of efficient current-handling rating.

Cutting costs on filter capacitors is risky. Main filter capacitors' RMS ripple current rating should be 1.5 times dc current at the lowest operating frequency and maximum anticipated operating temperature. For supplies with low currents, greater ripple is tolerable and can be offset by a higher dc voltage, since lower dissipation is less important.

These are but a few of the many points to keep in mind when considering the specification or construction of linear or switching power supplies. Few good, up-to-date texts exist on the subject and it receives far less attention in trade publications than it deserves. With this in mind, it is more important than ever to acquire catalogues, vendor literature, spec sheets and, finally, be sure to contact several power supply representatives early in the project's design phase. Power supply design or selection can no longer be put off until the design project is well along. Today's cost of failure is too great. D



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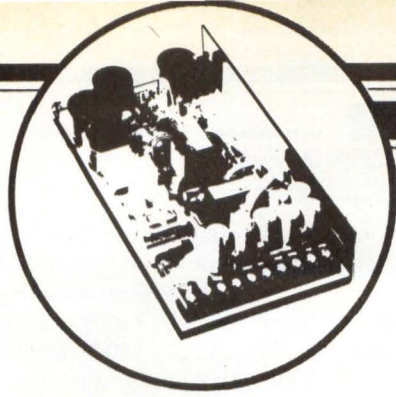
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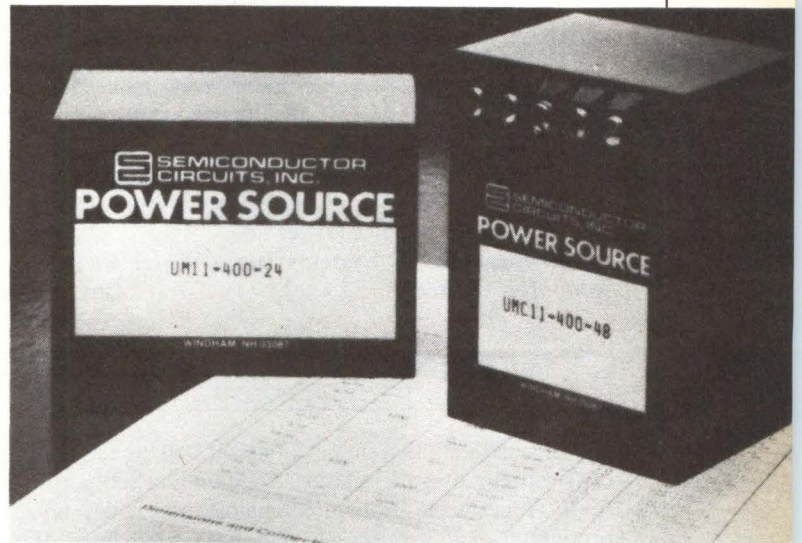
22-100MK

Mini system power pack consists of a \pm 15V at 100mA modular power supply on a printed circuit board. Has a built-in 15 pin connector with card guides. Unit measures 6.9" \times 3.5" \times 2.2" including the connector. The key to the flexibility of the system is in a series of jumper options that allow the +15V, -15V and common to be programmed to any of the 15 pins.

Calex Mfg Co Inc., 3355 Vincent Rd, Pleasant Hill, CA 94523. **Circle 255**

UPS 30kVA

Operates between the utility or motor driven generator power source. It functions to protect against spikes, EMI and RFI sags in brownout and protects against power failure by supplying battery backup without any glitches that impair logic and destroy memory. "Ours is a maintenance-free unit," says the company. "Once on



Switching power supplies provide advantages of higher efficiency, smaller size, lower weight and longer hold-up time.

line it will provide years of service as your insurance policy for computer grade power."

Clary Corp., 320 W. Clary Ave, San Gabriel, CA 91776. **Circle 256**

OL25/50

High efficiency, mini size, open frame switching power supply. Up to 50W on a board 5.92" \times 3.82" \times 2.00". Mechanically and electrically interchangeable with the Boschert OL25; however, it can be specified up to 50W instead of 25W. Input voltages strappable 110/220 Std. Efficiency greater than 75%. High frequency switching 30 KHz. cold start circuitry.

Compower, 548 Division St, Campbell, CA 95008.

Circle 257

Fixed Disk Memory Power Supply

Seven open-frame power supplies for Shugart, Micropolis and other fixed disk memories. These modules have 5

outputs (+5V, +24V, +12V, -5V and -12V). Four models have 4 outputs (+5V, +24V, -5V and -12V). International transformer is standard.

Condor Inc, 4880 Adohr Lane, Camarillo, CA 93010.

Circle 258

PowerRotor

New UPS designed to overcome power outage and erratic power supply problems. The power unit generator is based on a unique variable speed, constant frequency technology. The new UPS will supply power to computer during utility interruptions for up to 30 seconds. The unit automatically adjusts itself to hold output power frequency constant, despite variations in the speed of the generator produced by outside line power.

Continental Power Systems Inc, One Landmark Sq, Stamford, CT 06901.

Circle 259

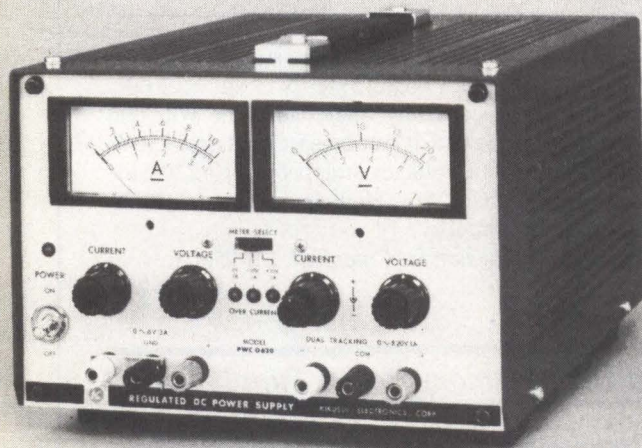
Series 800

Power purification systems. Constant voltage transformers for line voltage regulation, conditioning and purification. Guaranteed protection against transients, noise, brownouts, line surges, and other line disturbances. Protection designed for minicomputers, microcomputers, μ P's, numerical control systems, programmable controllers and all sensitive electronics equipment.

Controlled Power Co, Robbins Executive Park East, 567 Robbins Dr, Troy, MI 48084.

Circle 260

Over-voltage protection is usually screwdriver-adjustable from the front of the power supply.



Model SP 1871

High voltage power supply. Less than 35 cubic inches in size. Designed and constructed for use in Airborne Cockpit Display applications — 6 per aircraft. Stated specifications: Anode: 18 kV to 22 kV at 300 μ A; Focus: 2.88 kV at 100 μ A; G2: 180 V to 550 V at 100 μ A; Input: 20 to 30 VDC. Dynamic Focus: 0 to -300 V with -10 V input. Price: under \$900 each in OEM quantity lots.

CPS, (A division of Vector General Inc) 110 Wolfe Rd, Sunnyvale, CA 94086.

Circle 261

Model AC-160

Specially designed switched-mode power supply for the unique requirement of Winchester drives (very low noise and high motor starting currents). Specs: 5V, 12A; -5V, 3A; +12V, 1.5A; -12V, 1.0A; 24V, 5A (7A peak). Power-fail/power-good signal. 4000V RMS input-output isolation.

Conver Corp, 10629 Bandlely Dr, Cupertino, CA 95014.

Circle 262

Switching Power Supply

Offers a wide range of input voltages. Operates 90-250 VAC or 10 to 40 VDC or any voltage between without jumpers, taps or switches. 15 through 75 W switchers. Also available, a new uninterruptible power supply and battery charger system. Free book of specs available.

Converter Concepts Inc, 435 Main St, Pardeeville, WI 53954.

Circle 263

Ferro-Resonant Series

A low cost Ferro-Resonant line regulation series of power supplies featuring simple design and high reliability for high voltage applications and displays, copiers, precipitators and a variety of other electrical and industrial equipment.

Del Electronics Corp, 250 East Sandford Blvd, Mt. Vernon, NY 10550.

Circle 264

DSU1220

Uninterruptible power system providing 1200 VA of clean computer grade power. Can use battery modules that will give up to 130 minutes of backup AC output. Specs: output power, 1200 VA; current, 19.0 A. Regulation $\pm 3\%$; waveform, sine wave less than 5% dist. Input/output = 12 VAC. Also makes isolation transformers, line conditioners, UPS, etc. Sized to meet majority of minicomputer back-up requirements. Simplified installation, automatic re-transfer of static transfer switch.

Deltec (Div of Gould Inc), 2727 Kurtz St, San Diego, CA 92110.

Circle 265

HUQ

New series of linear open frame supplies at low competitive prices (5 V at 3 A with OVP=\$21). Four single output regulated models have nominal voltages of 5 to 24 V with current ratings up to 3 A. All 5 V models have built-in fixed crowbar OVP available for 12, 15 and 24 V models.

Deltron Inc, PO Box 1369, Wissahikon Ave, North Wales, PA 19454. **Circle 266**

DS 150

Switching power supply. A 150W low profile switching power supply with up to 150W continuous output when operated within the specified limits. Many combinations of output voltages are available. Used to power small computers and μ P's. \$250 each. \$204 in quantity. "The advantages of an enclosed unit," says the manufacturer, "are its open frame price, reduced noise on output, low profile and light weight."

Digital Power Corp, 686 East Gish Rd, San Jose, CA 95112. **Circle 267**

Multiple Output Switchers

New design offers improved performance and reliability as well as reduced costs. All outputs are regulated to within 0.05% for both line and load variations with cross-regulation of 0.025%. Remote sensing on all outputs which eliminates need for on-board regulations — saving in both cost and space. Efficiencies are 85% for 5V outputs and over 90% for others.

Efflo Inc, 455 Los Gatos Blvd, Suite 103, Los Gatos, CA 95030. **Circle 268**

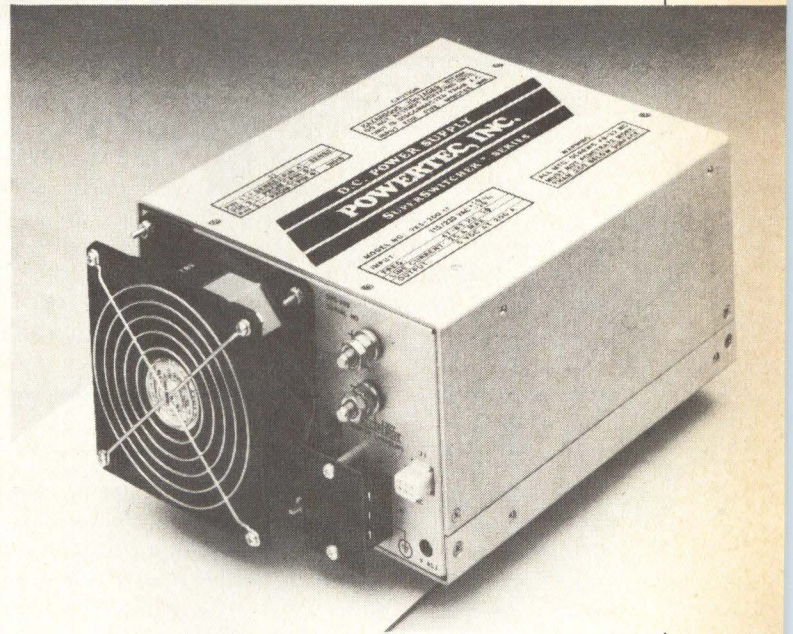
ATR-100

Linear automatic power supply. Suitable for automatic test equipment, bench top and laboratory applications. Fully programmable in 3 automatic operating ranges, offering 3 times more power than single-range unit. Has a ripple of less than 1mV RMS and produces up to 32 VDC or 10 ADC with an output limit of approximately 100 W. \$495 each.

Electronic Measurements Inc, 405 Essex Rd, Neptune, NJ 07753. **Circle 269**

Two New Computer Power Controls

LOAD RAMP controls provide a gradual and stepless application of voltage when turning on computer. Time delay on starting is adjustable from 0 to 5 seconds. OVERVOLTAGE PANEL senses voltage conditions. If the voltage exceeds prescribed limits for a selected length



Linear power supplies still command a major portion of the OEM market because switching power supplies cannot equal engineering advantages.

of time, the device will remove voltage from the computer. **Donald C Harder Co**, 2580 K St, San Diego, CA 92102.

Circle 270

HP 6034A

DC power supply combines an internal μ P-based HP-1B programmer with FET switching technology. It provides laboratory grade performance specifications and auto-ranging in a compact lightweight package. Unit has an overvoltage protection circuit which can be programmed directly in volts with 8-bit resolution.

Hewlett-Packard, 1501 Page Mill Rd, Palo Alto, CA 94304. **Circle 271**

SCB 174-01

Multiple (4) output, switch-mode regulated power supply for electronic system application. Universal input (115/230 VAC; 47-400 Hz) 4 outputs: 5 VDC (15A); +12 VDC (4A); -12 VDC (4A); +24 VDC (4A). 170 W total power. 75% efficient overload protected, rated at 50°C.

KEC Electronics Inc, 19300 South Vermont Ave, Gardena, CA 90248. **Circle 272**

EFX Series

Four output single board "open frame" switching power supply. Available in 4 sizes: 50W, 100W, 150W and 210W. Each size is made in a selection of volt-ampere combinations. "Our unit," says the company, "offers high efficiency (70%-80%). Built in EMI filtering to meet FCC specs, soft start circuit to minimize surges, automated production for high volume capability."

Kepeco Corp, 131-38 Sanford Ave, Flushing, NY 11352.

Circle 273

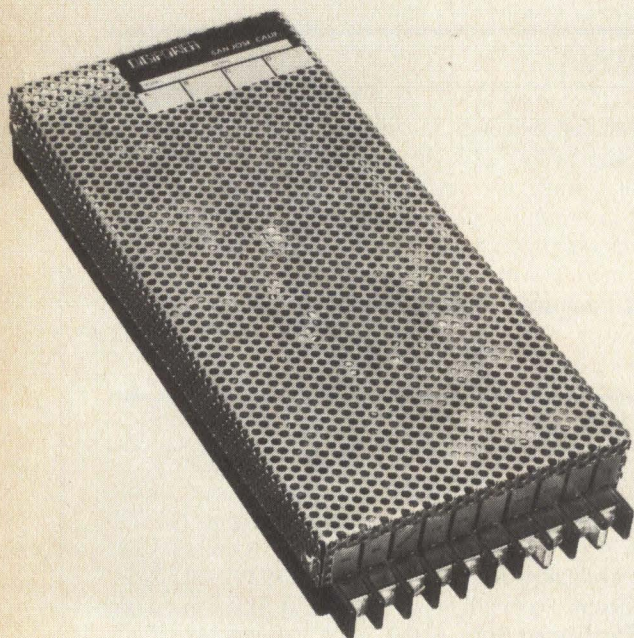
PWC-0620

A triple output dual tracking DC power supply. This product comes equipped with overvoltage protection. Crossover points can be set independently for each output. Convenient 1/2 rack size. Will not overshoot when power is turned off. 1 to 6 V, 10 turn potentiometer at 3A output and two $0 \pm 20V$ (dual tracking) 10 turn potentiometer output ($0-40V$ in series at 1A).

Kukusui International, 17819 S. Figueroa St, Gardena, CA 90248.

Circle 274

Over-voltage protection on a UPS is not intended to absorb power from the load.



SM Series

1000 W power supply. Four multiple 1000W switching regulated power supplies for large add-on memory systems. Has a main output of 5 VDC at 150A. Up to 3 additional outputs are offered from 2 VDC to 28 VDC at 18 to 2A. Remote sense power fault detector signal, remote on/off current.

LH Research, 14402 Franklin Ave, Tustin, CA 92680.

Circle 275

MPD-416

Three-phase AC power controller. For use in DEC's VAX or any other system utilizing 3 phase AC power. Electrically and mechanically interchangeable with DEC model 869 AC Power Controller. Rated at 240/416 VAC at 45 A (15 A per phase). Six unswitched and 12 remotely switchable outlets. High performance EMI filter, transient suppressors, magnetic circuit breakers, local-off-remote switch, delayed output for multi-controller sequencing, remote disable and emergency shut down.

Marway Products Inc, 2421 S Birch St, Santa Ana, CA 92707.

Circle 276

CP140

Five-output DC power supply. Specifically designed to keep pace with up-to-minute technology. Interfaces with 8" Winchester hard disk drives from IMI, BASF, Shugart and Micropolis. Supplies all required voltages for voice coil actuator, spindle motor and ECL controller/formatter circuitry. Outputs 5V at 8A; 24V at 5A; 12V at 1.2A; -12V at 0.5A; and -5V at 3A.

Microcomputer Power Inc, 2272 Calle de Luna, Santa Clara, CA 95050.

Circle 277

PS-80

$\pm 5V$ and $\pm 12V$ power supply on a card. Standard 22 pin edge connector. Power cord and line switch connect to card with 4 pin connector. Overall size 4.5" \times 6.5" \times 1.5". Specifications: 115 VAC input. Output: +5 at 800 mA; -5 at 75 mA; -12 at 75 mA; +12 at 150 mA. \$35 as kit. \$60 assembled and tested. (Quantity prices available.) Company also makes SBC's and software. Models from 15 kVA to 150 kVA.

Miller Technology, 16930 Sheldon Rd, Los Gatos, CA 95030.

Circle 278

99 Series

Switching mode modular power supply. Modular construction with plug-in modules and having no wires other than lead-in within the enclosure. Simplified design pro-

vides major switching functions on separate PWB modules. Configuration available to provide single or multiple outputs in 50 to 1200 W range. Prices \$1000 to \$6000 (average \$2900). Quantity (50 or more) discounts available. **Modular Power Systems Inc.**, 8900 Shoal Creek Blvd, #127, Austin, TX 78758. **Circle 279**

TQI-4.

Silenced power unit for 400 Hz computers, including the new IBM 3081. Styled to match typical computer hardware (IBM, Amdahl, Control Data, Univac and Cray). Available at 50 kVA, 75 kVA or 150 kVA. Illuminated controls. Noise level less than 57 dBA.

Manufacturing Processes Ltd. (MPL), Bilton Way, Hayes UB3 3ND, Middlesex, England. **Circle 280**

NQ130 Series

Open frame switched power supplies. Feature triple and quad output capability with post regulated auxiliary outputs in an industry standard configuration. Built-in line filtering and soft start circuitry. 115/230 VAC input capability. Main output 5V at 20A. Aux No. 1, 5V/12V/15V/24V at 4A. Aux No. 2, 5V/12V/15V/24V at 1.5A. Aux. No. 3, 5V/12V/15V/24V at 1.5A. Unit price is \$259. Quantity discounts available.

National Power Technology, 2111 Howell Ave, Anaheim, CA 92806. **Circle 281**

RS, RX and RJ Series

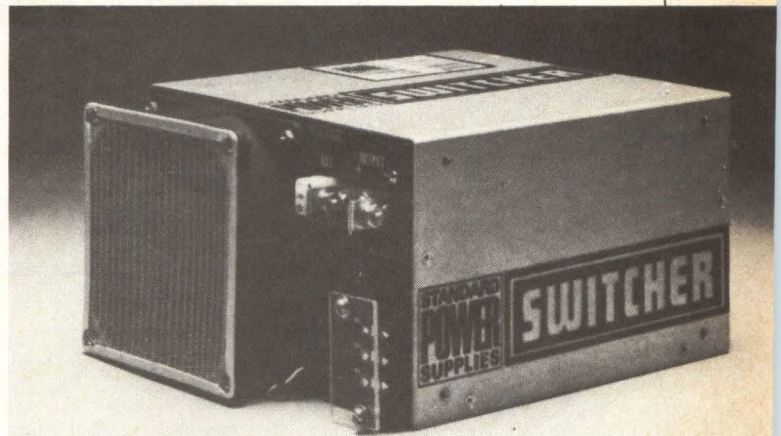
Regulated modular power supplies. Designed for high performance OEM applications. These supplies offer high reliability, excellent line and load regulating. Very low output ripple and noise, fast transient response and remote programming capability. Option available: over-voltage protection.

NJE Division Technology Development Corp., PO Box 50, Culver Rd, Dayton, NJ 08810. **Circle 282**

VTCOIA

Super-mini lightweight, 50W multi-output switching regulator power supply (made in Japan). Size 1.5" x 7.19" x 3.86". Convection cooled. Input range 90 to 132 V, screw adjustable. High frequency switching at 50kHz. Soft start circuitry. \$159. (Quantities: \$93 each). Close line and load regulator. Low noise. Other products: 25, 50 and 100 W single output switching power supplies.

Pacific Electronics, 4125 Blackford Ave, Suite 215, San Jose, CA 95117. **Circle 283**



A properly rated UPS can provide power to an entire data processing facility including logic, memory, disk drives, tape drives, output devices, terminals and system cooling equipment.

MG Series

A new switching power supply series offers output power levels of 200 W. The units are small sized (15" x 2.56" x 5.12"), lightweight with 75% efficiency. Wide input line variations. Modular construction for ease of service and repair; short-circuit protection, dual input and multiple outputs (6). \$320 each in low volume.

Panasonic, One Panasonic Way, Secaucus, NJ 07094. **Circle 284**

Model 3050

Triple output switcher. 50 W switching power supplies are small and lightweight. Their prime purpose is to generate all the necessary voltages to power microcomputer, CRT terminals, disk drive and modems. Manufacturer says: "Lowest cost, lowest weight, smallest size of any triple output switcher in the world." Company also makes a complete line of 25, 50 and 100 W AC/DC and DC/DC switching power supplies.

Power General Corp., 152 Will Dr, Canton, MA 02021. **Circle 285**

622

A high performance filter. Designed specifically to reduce noise emissions conducted from switching power

supplies to a level compatible with FCC and VDE requirements. They provide high insertion loss in both common and differential modes from 0.1 MHz to 20 MHz. Current rating of 3, 6, and 10 A are available and units come with wire leads or a combination solder-lug/quick-connect terminal.

Potter Co., Div of Varian Assoc., PO Box 337, Wesson, MS 39191.

Circle 286

PS-826

Sealed, rechargeable gel-type batteries. Rating: 8V, 2.6A hours. Fills gap between 6V and 12V batteries. Offers stand-by power for electronic memory protection, communications equipment and alarm systems. Also serves as primary power for portable instruments. Delivers up to 40A in temps. of -40°F to +140°F.

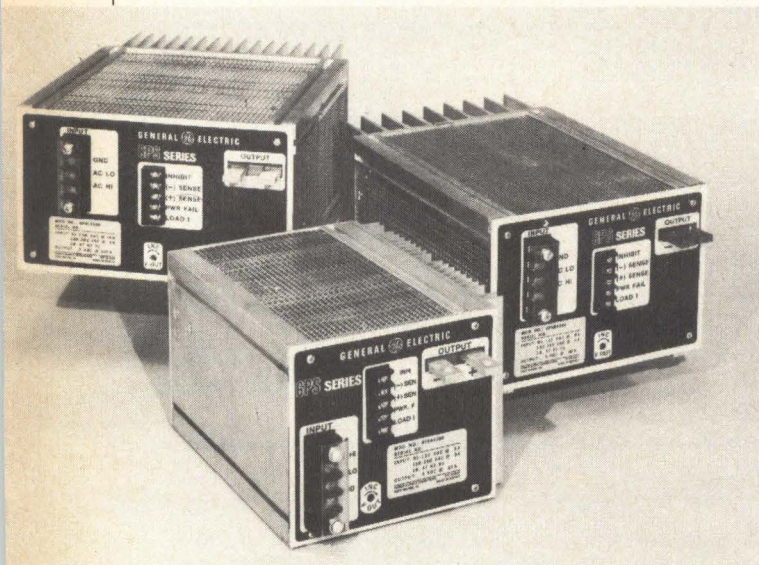
Power Sonic Corp., 3106 Spring St, PO Box 5242, Redwood City, CA 94063.

Circle 287

SM Series

Switching power supplies. 400W single output switcher series. Models available: 5V, 80A; 12V, 33.4A; 15V, 26.7A; 24V, 16.7A; 28V, 14.3A. Has brownout protection on all models. Dual input capability: 90-130 VAC,

Differences between the specifications for a switcher and a linear supply would be primarily in the performance requirements (I/O specs).



and 180-260 VAC. Internal RFI/EMI filtering is included.

Power-One Inc., Power One Dr, Camarillo, CA 93010.

Circle 288

Hybrid Power Supply

The first power supply offered in the Hybrid series. Provides a DC output of 5V at 3A. It is available in PC mounts and chassis mountable models. Primary size of the supply utilizes "flyback" PMW switching technique, operating in conjunction with a linear regulated output with an overall efficiency of 60%.

Power Products, Div of Computer Products Inc, 2801 Gateway Dr, Pompano Beach, FL 33060.

Circle 289

MINI UPS

Uninterruptible power supply. Provides continuous regulated noise-free AC power to critical-load applications. These are totally integrated units containing rectifier/battery charger, battery and inverter. The rectifier converts the input AC line to DC, maintaining the battery fully charged and simultaneously providing DC power to the inverter. The battery continues to power the inverter when the input AC line fails. The inverter converts DC power to regulated sine wave AC output.

Power Group Trust, 1809 Eagle Ridge Dr, Burnsville, MN 55337.

Circle 290

Model 5031

A new, 3-output 50 W switching regulator power supply. Outputs: +5 VDC at 7.5A, +12 VDC at 0.5A and -12 VDC at 0.5A. This miniature switcher (3" x 9½" x 2") has been developed for OEM applications including μ P's, multiplexers, modems and CRTs.

Power Systems Inc, 12 Tobey Rd, Bloomfield, CT 06002.

Circle 291

9K

1000 W switching power supply, 165-205 VAC input. Strappable 115/230 VAC available. Brownout to 85/160 VAC 4DC voltage levels, 5-24V. 100% output at 50°C, 50% at 70°C. High efficiency up to 80%. Overload, overvoltage protection. Remotely programmable. Other products by company: 9N Super Switcher; 19C (165 W Value Switcher). "Fully self protected," says the manufacturer. "Fail-safe remote sensing; meets all the latest requirements for EMI. Built in the tradition of series 9N Super Switcher, the most copied switcher in the industry."

PowerTec, 20550 Nordhoff St, Chatsworth, CA 91311.

Circle 292

SS-120-M

Power surge control device. Has 6 receptacles to protect computers, data communication, medical or other μ P-controlled system from destructive voltage transients. Plugs into standard 120V outlet and shunts all unwanted or dangerous voltage transients in picoseconds. Has rate energy dissipation of 1,000,000W at up to 100 μ s. Also has neon indicator light to indicate if device is functioning properly.

RKS Enterprises Inc., 643 South 6th St, San Jose, CA 95112. **Circle 293**

UM, UM Series

Switch mode regulated, encapsulated DC/DC converters. In single outputs up to 30W (5, 12, and 15 VDC at 1 to 4A range). The series is ideally suited for industrial applications where poorly regulated input sources are prevalent, as in process control and telecommunications.

Semiconductor Circuits Inc., 49 Range Rd, Windham, NH 03087. **Circle 294**

5F Series

Single and multiple output line of switching power supplies rated at 250 W. Single output units are available in 5, 12, 15, and 24V outputs. Multiple-output units feature 5 outputs rated at 5V (30A), +12V (5A), -12V (3A), -5V (2A), +24V (3.2A). Ideal for small business computer systems.

Sierracin/Power Systems, 20500 Plummer St, Chatsworth, CA 91311. **Circle 295**

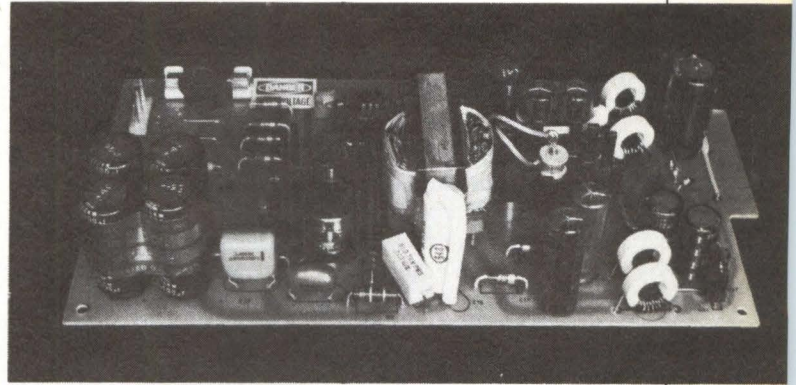
Power Island

Developed to meet unique power requirements of the medium to large scale computer user. Power ratings 15 to 225 kVA. Modular and flexible. Keeps computer performing at maximum efficiency. Unusual power conditions are reported by visual and audible alarms. Each unit contains an electrostatically-shielded isolation transformer, designed and manufactured specifically for use with computer loads.

Sola Electric, Div of General Signal, 1717 Busse Rd, Elk Grove Village, IL 60007. **Circle 296**

SRX 5-200

Designed to meet the power demands of computers, memories and large digital systems. Input voltage 190-250 VAC single phase. Standard 47-63 Hz. Output: 4.75 to 5.25 VDC. Current: 0.200A. Regulation: 1% max. combined line and load variations. Ripple and noise: 20 mV max. RMS ripple efficiency: 75% typical. Hold up time: 40 ms at nominal line and load. Unit price \$795.



A UPS is a continuously-on-line solid state device which accepts utility grade AC input and provides precise, computer grade DC output.

Manufacturer's statement: "The Sorensen SRX 5-200 is the ideal supply for high density electronic packages. Although housed in an industry standard package (5" x 8" x 11") the SRX produces 1/3 more output power than comparable units. In addition it is covered by a 5 year warranty."

Sorensen Co., 676 Island Pond Rd, Manchester, NH 03103. **Circle 297**

WRM. 38P18KQ

New miniature, high efficiency, high voltage power supply. Unit is fully regulated high efficiency DC/DC converter designed to operate from +245, \pm 5% and provides adjustable output range of +15 to 380V at 40 mA. Using linear techniques, 70% efficiency is achieved at full rated output. Line regulation is 0.1%. Load regulation is 0.25% for rated input variations and zero to full load conditions.

Spellman High Voltage Electronics Corp., 7 Fairchild Ave, Plainview, NY 11803. **Circle 298**

SWS 750-5

A regulated DC switching power supply with low component count, high efficiency, modular design, soft start, low weight, fast transient response, and pulse-width IC's. Specs: 750W at 5V, 0.2% regulation, 1 ms response time. UL listed. Thermal protected, remote sense, current limit, logic inhibit and remote shutdown. Also makes regulated and unregulated power supplies. Manufacturer claims it is the highest quality switcher available through distribution.

Standard Power Inc., 1400 S. Village Way, Santa Ana, CA 92706. **Circle 299**

WP Series

Ultra-wide input. Isolated 5V, 5A single DC/DC supply module. Offers: 1) ultra wide input range; 2) isolation; 3) direct output paralleling; 4) remote on-off control input. "Our goal was to offer a low profile, high power density module that is very reliable and thermally safe," says the company. "We have done that with a high efficiency design, switching at 100 KHz with state of art semiconductors and a regulation loop to permit DIRECT output paralleling by the user."

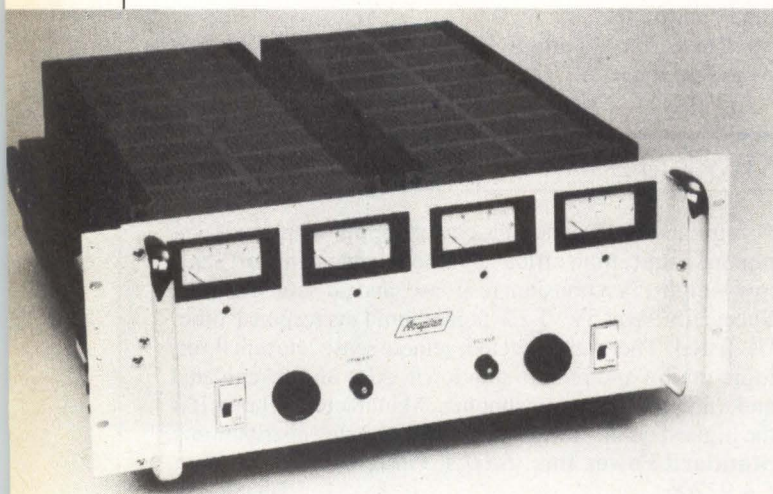
Stevens Arnold Inc, 7 Elkins St, South Boston, MA 02127. **Circle 300**

OFS-65

Up to 5 outputs and 65 W are available from these PC-board mounted DC power supplies. The unit measures 5" x 9½" x 2½" and provides soft start, 110/120 VAC input protection from overwattage and overcurrent. High performance filtering is provided through use of output capacitors with low ESL and ESR.

Switching Power Inc, 4835 Veterans Highway, Holbrook, NY 11741. **Circle 301**

Over-voltage protection is recommended whenever a load could be damaged by excessive voltage caused by power supply failure.



PHR Series

Company offers a line of power supplies you control by hand, analog signals, or GPIB. Each P-series power supply is a voltage current stabilizer with automatic cross-over. Set it on a bench and it performs like a laboratory grade supply that sinks current and limits voltage to safe levels.

Systron Donner Instrument Div, Power Supply Sales Dept, 2700 Systron Dr, Concord, CA 94518. **Circle 302**

MOS Series

Open frame switcher line. Has five 100 W models varying from 1A to 15A. Open frame construction measures 9.5" x 5" x 2.5". Current limits on all outputs to protect user's load as well as power supply. 115 VAC or 230 VAC available by changing a jumper. Low impedance outputs. 75% minimum efficiency.

Todd Products Corp, 50 Emjay Blvd, Brentwood, NY 11717. **Circle 303**

Line 2 Power Conditioner

Protects computers and computer-based systems from power line noise and voltage sags and surges that can effect computer operations. This power conditioner features 5 optional panels to make equipment "plug-in compatible" with Line 2. 5-10 kVA models, 94% efficiency minimum. 0.001 pF coupling capacitance between input and output. Less than 20% total harmonic distortion. Topaz "guarantees that Line 2 Power Conditioners will solve computer problems resulting from power line noise and voltage variations—or your money back."

Topaz Electronics Div, 9192 Topaz Way, San Diego, CA 92123. **Circle 304**

Ferroresonant Supplies

A series of switch mode and ferroresonant regulated DC power supplies conforming to LIL, European safety standards and RFI standards. Power supply units start at 50W with outputs from 5 to 30 V. Overvoltage and overload protection are standard. Company offers ferroresonant regulated power supplies from 1 to 400 W with up to 7 outputs for application in "dirty" electrical environments.

Ulveco Co, PO Box 43 S-184 00, Akersbergen, Sweden.

Circle 305

AC 9231

Low cost, high reliability switching power supplies. +5V at 6A; +12V at 2.5A; -12V at 0.5A; -5V at 0.5A. 50W continuous Max. 0 to 50°C operation. 4.25" x 7.75" x 2"

16% min. efficiency; input: 90-135 VAC or 180-270 VAC, 47-63 Hz. TTL compatible. DC ok signal inclusion.

US Astek Electronics, 1011 Space Park Dr, Santa Clara, CA 95050.
Circle 306

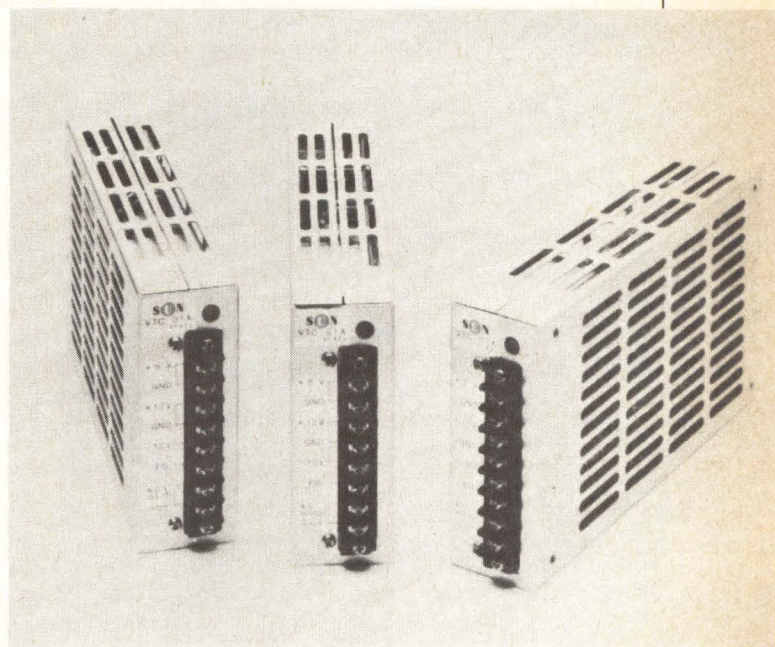
DNS, DND Series

DC/DC converter. Designed for those who have limited PC board space. The dual output models rated below ± 135 mA can deliver full rated power output from either the positive or negative output terminal. Input voltages 5 to 12. Output 5V, 12V, $\pm 12V$, $\pm 15V$.

Wall Industries Inc, 2 Franklin St, Lawrence, MA 01840.

Circle 307

Noise riding on a power line, momentary highs or low voltage transients, dips and surges, can all cause errors, shutdowns or even equipment damage depending on their magnitude and duration.



Starting January 1, 1982, we will pay authors an honorarium for articles and Designers' Notebooks submitted after this date at a rate of \$35 to \$75 per printed page for feature articles and \$70 for Designers' Notebooks: The exact amount depends upon how well the article is written and organized, the amount and quality of artwork (we prefer camera-ready art, but it's not essential), and how much extra work must be done by our editors and artists on your text and figures. Upon receipt of your article, we will mail you an "acknowledgement of receipt." After a review, your article will be accepted, rejected, or tentatively accepted (subject to your revisions). Upon publication of your article, you'll receive a complimentary magazine copy and your check.

Topics. What do we want? Problem and solution topics include, but are not limited to: microcomputers, minicomputers, buses and interfaces, power supplies, software (Ada, Pascal, assembly, etc.), printers, plotters, tape drives, floppy and hard disk drives, voice I/O, video display terminals, microcomputer development systems, logic analyzers, etc. Occasionally, we also run submitted engineering management and product buying guides. The technically "heavier" your article is, the more we (and our readers) like it.

Article Categories. Contributed articles fall into four categories:

- Design Articles — specific schemes or methods used to solve a problem.
- Tutorial Articles — educational discussion of a subject, including examples.
- Survey (Special Report) Articles — covers a specific subject, including technology, products, marketing, industry trends and selection criteria. A manufacturers' listing and chart of models with specs is often included.

We're Looking For Authors...

- Application Articles — describes how equipment, system or subsystem(s) were applied using a case history format. Emphasis is upon the application — not upon the heavy design aspects, as in a design article.

Although these are the four major submitted categories, they are not always distinct and may overlap.

Designers' Notebook. Known as "design ideas" or "cookbook" circuits or software, these short descriptions of design problems and solutions, circuits or brief programs/subroutines are clipped by EEs and used in designs. Have you designed and breadboarded a novel and useful circuit that would interest other engineers? Or have you written a unique microcomputer (or even program-mable calculator) subroutine or program? If so, then we invite you to share your experiences with our readers. Circuits and software programs must not be previously published (house organs or scientific/technical journals excepted). Finally, we ask one more thing — that you include schematics, block diagrams and that your program be debugged and your circuit bench-tested.

Guidelines. For guidelines to **Digital Design** article requirements, format, submission and acceptance, write to: Features Editor, **Digital Design**, 1050 Commonwealth Ave, Boston, MA 02215.

Digital Design

68000 μ P Development System Works With PDP-11

Reportedly the only development system available for the Motorola 68000 μ P, the CMS-16/DS1 combines direct memory addressing, PDP-11 code development and single instructions to create an extremely simple program development unit for only \$6995.

The system, marketed by CM Technologies, includes a 68000 CPU board with on-board firmware, a serial I/O board and cabling for communication with the PDP-11 from the operator's terminal, a 9-slot Multibus card cage with power supply and protective enclosure. The system uses the Intel Multibus, because it accepts virtually any peripheral. The Motorola-developed 8MHz Versabus, which has recently been designed specifically for 16/32-bit μ Cs, can't make the same claim, since so many peripherals still operate at the lower 5MHz level.

The CMS-16/DS1 operates in two basic configurations. In one configuration, it functions as a pass-through system connected between the CRT and the host PDP-11 (Figure 1). You unplug the CRT from the host, plug it into one I/O port, and connect a second RS232 cable from a second port to the PDP-11 terminal input. Programs can then be downloaded to the 68000. The CRT controls either system or the CMS-16/DS1 can act as the PDP-11 preprocessor with software that you supply.

In a second configuration, the development system functions as a back-end processor by connecting to the PDP-11 via a high-speed link through a port separate from the CRT (Figure 2). The CRT still controls the 68000 system, but commands must pass through the PDP-11 operating system.

Computer-to-computer instruction translation via a 68000 cross-assembler comes on RT-11 formatted 8" disks, so that you can develop CMS-16/DS1 programs. Cross-compilers for Pascal, C and FORTRAN which allow mini-computers to write and debug μ C programs will be available early in 1982.

by Peter Lichtgarn

CM Technologies, 525 University Ave.,
Palo Alto, CA 94301. **Circle 198**

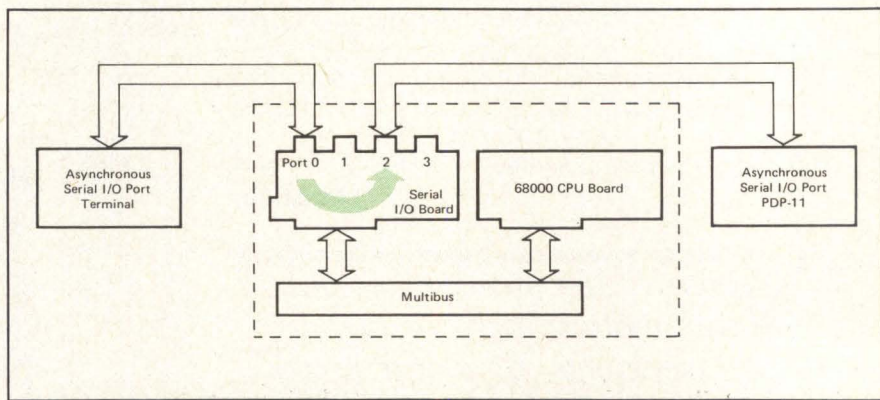


Figure 1: Operating the PDP-11 from the terminal illustrates the pass-through system. Program/data passes in through the serial I/O board port 0 and out to the PDP-11 via port 2 — circumventing the 68000 CPU board altogether. As far as the terminal knows, it is connected only to the PDP-11. Conversely, the PDP-11 can talk directly to the terminal without involving the CPU board.

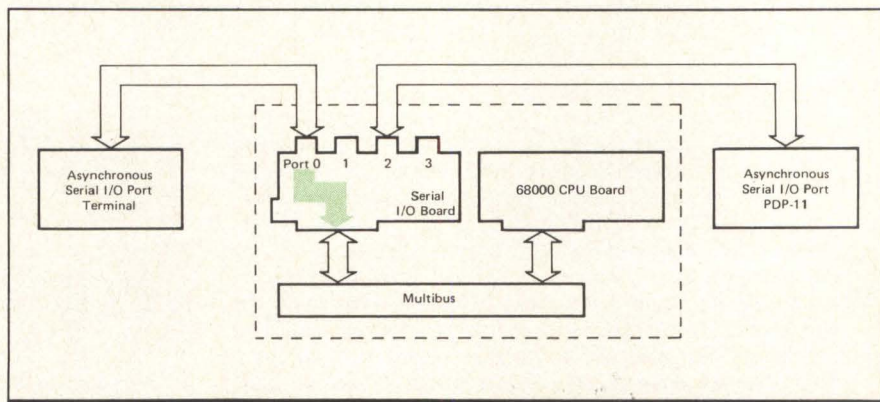


Figure 2: In the back-end processor configuration, to operate the 68000 from the terminal, the CMS-16/DS1 uses port 0 to go out to the Multibus and talk to the CPU board. The program/data is processed through the 68000, returns down the Multibus and back up through port 0 to the terminal, without involving the PDP-11.

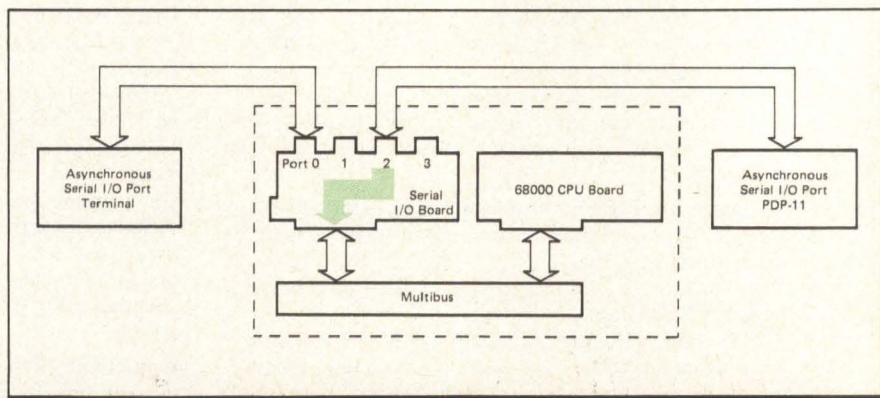


Figure 3: Data may be downloaded to the 68000 programmed on the PDP-11 in conjunction with a cross-compiler. Your program/data, which theoretically works on the PDP-11, is coded through the talk function at port 2, proceeds through the Multibus and loads onto the 68000 CPU board.

Floppy Alignment Without A Scope

Traditionally, bulky oscilloscopes handled floppy disk drive alignment. But Lynx Design and Technology, a group of electrical engineers in the Ontario, Canada area, recently came up with a tool-box sized instrument specifically designed for verifying and adjusting the alignment of floppy drives. Called Lynx-300, the unit attaches to the standard test points on any floppy drive and indicates with LEDs what radial and index/sector adjustments are necessary.

According to Lynx, the 300 creates internal timing to capture and sample various parts of the waveform generated by the alignment diskette. By sampling different sections of the waveform lobes, the unit makes sure it has the cat's eye waveform it needs for testing. It then uses a precision rectifier to cut the waveform off in the middle, rather than sample positive and negative peaks on both sides. Next, the 300 stores the sample, takes others to obtain an overall average for the waveform, and compares a number of these average values to evaluate the radial alignment. To overcome the problem of variance in the radial waveform outputs of different companies' drives, the 300 uses a self-adjusting comparator that allows the unit to compare without setting a specific threshold.

To make sector/index alignments, the Lynx-300 creates internal timing based on a crystal oscillator. With this oscillator, there are no adjustments to be made — it creates an exact window the same every time. Adjusting auto-

matically to signal input, the unit never requires calibration.

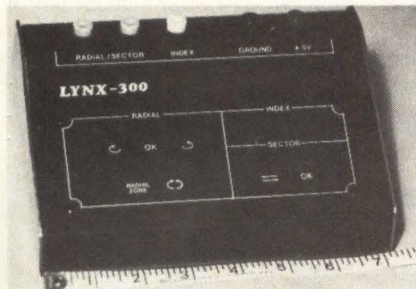
"With oscilloscopes, you throw the thing in a car, drive out to a customer site, and by the time you get out to the customer site your scope's out of calibration," said one Lynx engineer. "We wanted something we could toss at the wall a million times and still have the same calibration."

Art Wosinski, LDT president, says his company will soon be introducing

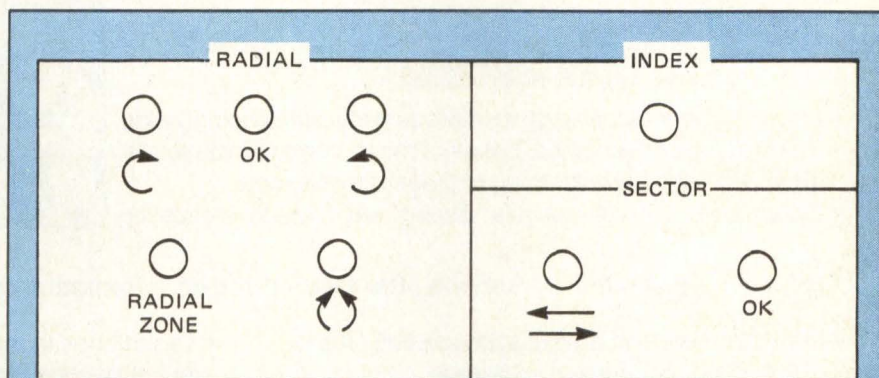
an excersiser for actually stepping the floppy drive motor to a specific track for testing purposes. As for the Lynx-300, it is available immediately and sells for \$379 in unit quantities, with volume discounts. Wosinski is currently seeking dealer distribution inquiries.

by Bob Hirshon


Lynx Design & Technology Inc, 3880 Chesswood Dr, Downsview, Ontario, M3J 2W6. **Circle 200**





Eliminating the need for an oscilloscope, the Lynx-300 aligns floppy disk drives by sampling and comparing sections of the cat's eye waveform generated by the floppy test disk.




Radial Adjustments:

- 

This LED, and either of the Directional LEDs, (↺, ↻) indicates that the alignment is within 80% of specifications. When this LED is on and both Directional LEDs are flashing alternately, then the adjustment is at 100%.
- 

These LEDs indicate which direction the stepper motor should be rotated to bring the disk drive within specifications.
- 

This indicates that the head is on the correct track, but not within specifications. The stepper motor should be rotated in the direction indicated by the directional LEDs.
- 

When the head is positioned on the track used for the radial alignment, this LED will illuminate if the head is not within range. It indicates rotation of the stepper motor is required to position it at its proper location.

Index/Sector Adjustment:

The potentiometer adjustment should be made until the INDEX LED is on. The adjustment should be made so that the potentiometer is set midway between the extremes where this LED goes out. The LED marked OK must be illuminated for the disk drive to be within specification. The LED marked (↔) indicates when the setting is at the low end of the specification.

FOURTH ANNUAL

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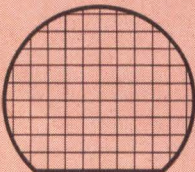
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- Linewidth measurement: equipment; techniques; edge recognition; focus sensitivity; "standards"
- Laser annealing measurement and control
- Techniques to measure and control interface and insulator charge states
- Dry processing and plasma end-point measurements
- Toxic gas monitoring: chemical trace level/particle counter for VLSI/bubble memory production
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Microelectronics Measurement & Test Conference

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Eliminating Solenoid From Minifloppy Reduces Media Wear

Remex claims a number of exclusive innovations for their model RFD960, a 2/3-sized, 5-1/4" floppy drive: it operates without a head-activating solenoid; it incorporates 96 tpi data storage with a two-sided recording capability; and it uses a direct drive brushless motor.

Removing the solenoid provides two major benefits: it minimizes media and head wear for maximum data integrity; and, since no head-activating solenoid resides near the R/W head, electrical interference is reduced.

tap-tap eliminated

The head loads directly onto the media when the door is closed instead of waiting to be actuated by a solenoid. The new design eliminates wear problems associated with constant loading and unloading or "tap-tap." The RFD960 actuates a clutch whenever the door is opened or closed. With the door open, you unload, reinsert the diskette and close the door. The head is loaded again. The continuous-contact head proves less stressful to media than tap-tap head load wear. Remex predicts other manufacturers will eventually follow the RFD960 design.

The 2/3-sized RFD960 reads/writes on 96 tpi on both diskette surfaces and provides a total unformatted data capacity of 1 Mbyte. Since the drive is ANSI-compatible, it is also compatible with 5-1/4" Shugart drives and is interchangeable with BASF low-profile drives. As a matter of course, Remex manufactures its drives at the 96 tpi plateau rather than upgrading from 48 tpi as do many vendors. To capture an extra portion of the market, however, Remex offers a 48 tpi option.

brushless motor increases MTBF

Remex claims that the RFD960 is the first 5-1/4" drive to be equipped with a direct drive brushless motor. This motor not only does away with belts that can stretch or fall off, but also reduces sideloads on the bearings. This relief for the bearings means that the accuracy and work-life of the spindle drive mechanism increase. In a conventional design, a brush-type

motor and pulley drive the spindle via a belt. In the brushless Remex motor, only the bearings can wear. Unique as it may be, using a brushless motor caused no design problems. A Remex spokesman said, "It's just a new way of doing a job to satisfy a function."

The closed loop servo control regulates motor speed to 1% vs. 2-1/4% for other small drives. Close regulation stabilizes the data stream, reduces jitter and assures media interchangeability between Remex drives. The design of the drive allows Remex to rate the

brushless motor at 30,000 hours vs. 3000 hours for most brush-type motors.

The RFD960 measures 2-1/2" high at the bezel. A 3.4" "standard-sized" bezel is available for buyers who don't require the small size, but want the drive's other advantages. The drive will cost approximately \$275 in OEM quantities.

by Peter Lichtgarn

Remex Division of Ex-Cell-O Corp.,
PO Box C-19533, 1733 Alton St.,
Irvine, CA 92713. **Circle 197**

DEC TERMINALS

VT100-AA	EIA	\$1,300
VT100-AA	EIA w/Advanced Video	1,375
VT100-WA	EIA Word Proc.	1,575
VT132-AA	EIA, Blk, Mode, Editing	1,525
LA34-DA	EIA	825
LA34-AA	EIA w/Forms	875
LA34-RA	EIA, Receive Only	850
LA38-GA	EIA, KP, & Tractor	1,000
LA38-HA	EIA, KP, Tractor, Stand	1,100
LA38-AA	EIA, KP, Forms, Tractor Stand	1,150
LA120-RA	EIA, Receive Only	1,795
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New Products

FIRST 3-D GRAPHICS SYSTEM

Introduced At Siggraph '81

SpaceGraph produces a 3-D image by reflection of a standard CRT image in a vibrating, variable focal length mirror. Under control of a high-speed graphics computer, the timing of the image on the CRT screen is coordinated with the position of the mirror so that individual planes of the object or scene are reflected at progressively deeper positions of the mirror image. By refreshing at a 30Hz rate, the retentive characteristics of the human eye cause the graphic/image to appear to be suspended in space. Since the mirror is much wider than the display volume, the viewer can see some side view of the object by head movement up to 30 degrees to either side of center. The system computer is a processing system which incorporates a bipolar bit slice/ALU with direct decoding programmed logic arrays. The advanced architecture of the ADC makes possible instruction times as fast as 160 ns with word transfer rates to 3 MHz. Data and program storage totals 128 kB in standard configuration. A complete SpaceGraph system, with 32 MB of mass storage is \$120K. **Genisco Computer Corp**, 3545 Cadillac Ave, Costa Mesa, CA 92626.

Circle 173

GRAPHICS WORKSTATION

Aids 3-D Design

UltraGraf, which employs a bit slice μ P, contains up to 128K words of buffer and refresh memory to allow a wide range of design functions without mainframe intervention. The 21" vector refresh display provides a large 19" x 15" viewing area. A .010" spot size renders fine line definition. Standard



viewable resolution is 4K x 4K x 4K with 32K x 32K virtual map. Dual buffering gives instantaneous refreshing on the screen from one 32K word refresh memory while the other is being filled with new data. Control panel options include light pen, data tablet, function keyboard, A/N keyboard, joystick and control dials. \$52,995. **Lundy Electronics and Systems**, Glen Head, NY 11545.

Circle 174

IBM PERSONAL COMPUTER

Advanced Features and Ease of Use

Available with the system are an 83-key adjustable keyboard, up to 262,144 characters of memory, a bidirectional printer at 80 cps, self-testing and a 16-bit μ P. It can generate charts, graphs, text and numerical information. Color graphics capabilities provide 256 characters in 16 foreground and 8 background colors, and graphics in 4 colors. Features compact size, expandable



memory and a built-in speaker. It may be expanded from a keyboard and system unit connected to a home TV set, to a system with display, printer and auxiliary storage. Information from centralized data banks can be accessed and displayed. A growing program library is available. From \$1565. **IBM**, Information Systems Div, Box 1328, Boca Raton, FL 33432.

Circle 126

BOOK REVIEW

Computer Soul

Tracy Kidder's non-fictional novel, "The Soul Of A New Machine," is recommended reading. We have never seen a book like this: we loved it. This intensely personal, emotionally-charged and uncensored novel digs deep into the mind, soul and emotions of the team that designed the MV/8000. More than that, it is the first book that accurately portrays who we are. Kidder understands us. If you are an EE, you will recognize yourself in this book; if not, and you must understand engineers (particularly if you are an executive), read this novel. 294 pp. Hardcover \$12.95. On sale in bookstores or from **Little, Brown & Co**, 34 Beacon St, Boston, MA 02106.

Inquire Direct

DISK BACKUP TRANSPORT

Fully Compatible With PDP-11, LSI-11 & Nova

Model 401 uses special read-after-write recording heads that provide bidirectional tape



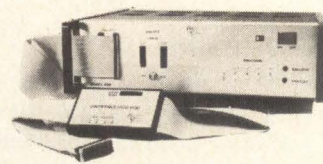
operation thus avoiding rewind time. It allows the user to run DEC operating software with no modification. The new interfaces include encoding, decoding, formatting, error checking and handshaking logic, allowing full software compatibility. Model 401 stores up to 17MB on a DC-300XL tape cartridge. The Wespercorp interfaces include the TC-180 (\$2500) for the PDP-11, the TC-160 (\$2750) for the LSI-11, and the TC-170 for DG computers (\$2200). All offer 6400 bpi serial MFM and control up to 8 drives. Model 401 Cartridge Tape Drive is \$1835. **North Atlantic Industries**, Qantex Div, 60 Plant Ave, Hauppauge, NY 11788.

Circle 164

EMULATOR/LOGIC ANALYZER

Speeds System Integration and Development

Model 4009 combines the best features of both a real-time 68B09/E emulator and a 12/20 MHz 18-channel logic analyzer in one instrument. The menu-oriented display allows the user to disassemble his program in mnemonic form and easily control all available 4009 features. Two RS232-C communication cards and one cassette interface are included. IEEE-488 and Centronics printer interface with RS422 planned are



optional. Four breakevents, in conjunction with the real-time 2K by 56-bit wide trace memory, provide a powerful debug tool. \$4995. **Advanced Digital Technology Inc**, 13400 Northrup Way, Bldg. #15, Bellevue, WA 98005.

Circle 128

512KB MEMORY MODULE

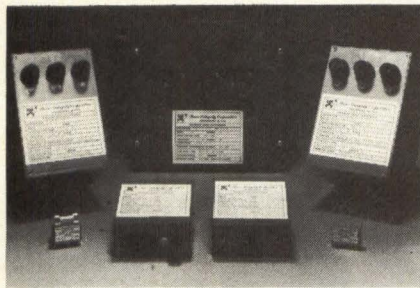
Utilizes Latest Industry Standard 64K Dynamic RAM

This card will operate with both 8-bit and 16-bit Multibus-compatible microcomputer cards. Refresh is automatically implemented by on-board circuitry or can be achieved externally. The MCB-512 automatically detects and corrects all single-bit errors without interrupting the system and notifies the processor of all double-bit errors. LED indicators identify the type of error, syndrome bits and the failing row. Operates with the Multibus battery back-up option. \$5295 for 512kB, \$3350 for 256kB, \$1593 for 128kB. **Intersil Systems Div**, 1275 Hammerwood Ave, Sunnyvale, CA 94086. **Circle 160**

TRANSIENT SURGE SUPPRESSORS

Greater Protection From Transient Energy

The Unipolar Line is a shunt family of products that absorbs 95 to 98% of the transient energy. It reduces the transient energy to a level where it can be more easily controlled and managed by the zero time series product line. The Zero Time AC Product Line incorporates a line filter to eliminate differential and common mode EMI-RFI and a special TSS circuit to delay the electric transient wavefront and totally eliminate overshoot. US and European packages are available. The Zero Time DC Product Line, for PCB



mounting, provides bidirectional protection from EMI-RFI and transient glitches that occur on board. Available in 7 voltages. All units are responsive to restrict transients and interference travel out of as well as into the protected device. **Power Integrity Corp**, Box 9682, 300 E. Wendover Ave, Greensboro, NC 27408. **Circle 170**

CAD SOFTWARE

3-D Solids Modeling

ITS-10 software is a powerful 3-D design and drafting package to increase productivity in the design process. Target markets are the automotive, aerospace, industrial, architectural and general mechanical design industries. 3-D design capabilities include solids modeling. This, coupled with a powerful CAD database, gives the designer the tools required to model complex objects. Geometrically, the objects or models are described by areas, volumes, holes, and voids combined into true 3-D object repre-

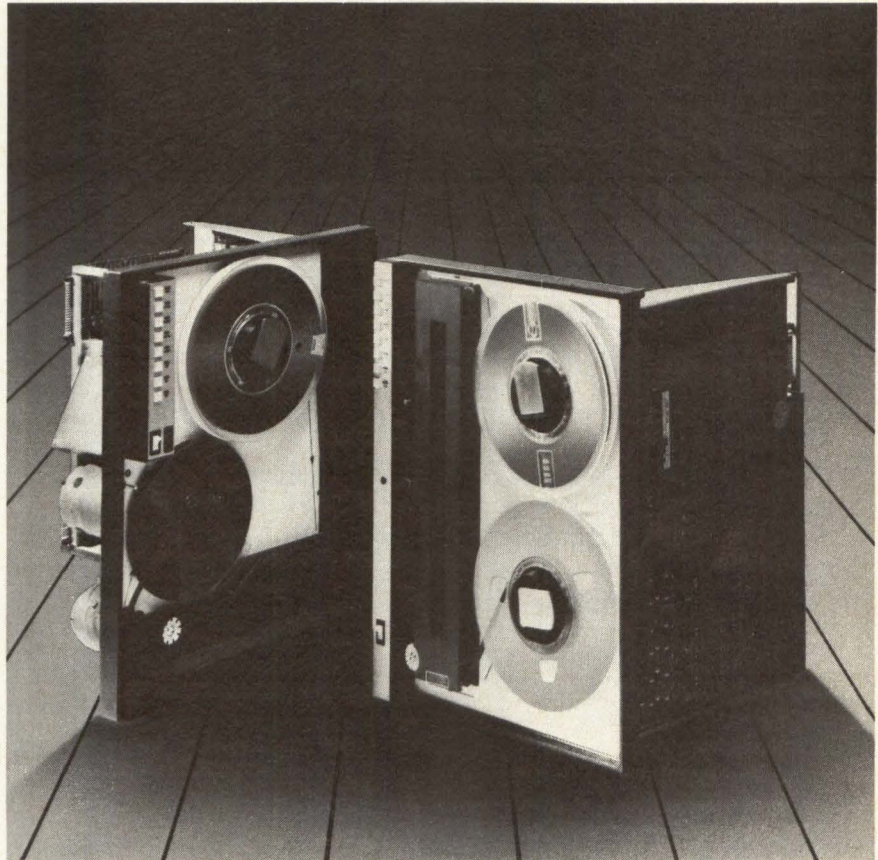
sentation. ITS-10 runs on 32-bit computers including Prime, DEC's VAX and IBM computers. \$87,500. \$2750/month lease. **MARC Software International**, CAD Marketing Dept, 525 University Ave, Palo Alto, CA 94301. **Circle 176**

CONCEPT/32 SYSTEMS

32-Bit Family Of Compatible Processors

At the low end of this 32-bit computer family is the Concept 32/27, a compact processor on a single-slot plug-in module. At the other end is Concept 32/87, with up to

6 times the computing power. Concept 32/27 offers up to 16 MB of memory, dual-bus architecture for a choice of interface methods (SelBUS for high-speed transfers of 26.67 MB/sec or MP Bus for lower speed transfers of 1.5 MB/sec) and high-speed Schottky TTL LSI technology. Concept 32/87 features high-speed ECL technology. In the basic CPU is a fast floating-point arithmetic processor, 64-bit wide internal busses, and 16 kB or 32 kB of cache memory. The CPU also features a 4-stage instruction pipeline and alterable RAM control store. **Systems Engineering Labs Inc**, 6901 W. Sunrise Blvd, Ft. Lauderdale, FL 33313. **Circle 171**



There are other vacuum column drives, but only CIPHER's 900 Series gives you these exclusive features:

- quiet operation
- internal diagnostics
- low power usage
- no changing of 50/60Hz belts or pulleys

The 900 Series uses built-in Z-80 intelligence and far simpler mechanical design to provide total closed loop control for gentle tape handling. That means it uses 60 per cent less power and is so quiet you can even use it in office environments.

Catch the excitement!

Cipher is your source for all your tape drive needs. Call us at (714) 578-9100. Or write for our free product brochure—10225 Willow Creek Road, San Diego, California 92131.

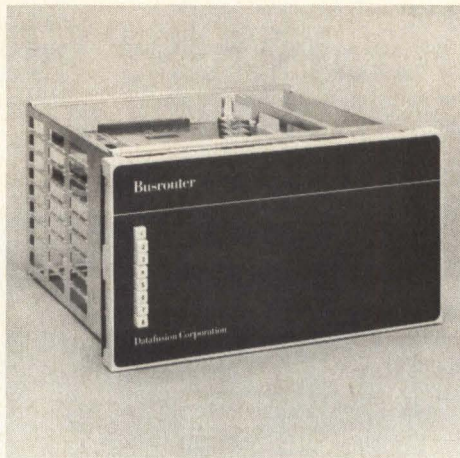
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data products, inc.
the exciting company

See Us At COMDEX, Booth 1738

Circle 49 on Reader Inquiry Card

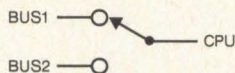
Reconfigure your PDP11 Unibus* with the push of a button.

Do you need to share peripherals?
Do you have multiple cpu's with a limited number of peripherals?
Do you need to selectively choose which peripheral is on the bus?

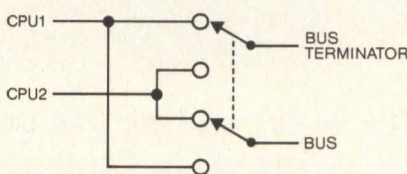


If so, Datafusion Corporation's OSR11-A Busrouter can help. It is a passive, manually operated device to perform the physical and electrical switching of the Unibus* for PDP11 series computer systems: up to eight switching planes (i.e., configurations); electromechanical switching relays (simple, high reliability, minimal electrical loading).

Essentially, each Busrouter switching plane can be viewed as a single pole, multiple throw switch.



The application shown here is a situation opposite the first, where one peripheral bus can be switched between two cpu's with the cpu not selected being terminated.



Many more configurations are available such as sharing multiple peripheral devices between multiple cpu's and then selectively choosing to switch each one or all to one cpu or another.

Other PDP11 products available are a bus repeater, bus cable tester, and an associative processor for high speed text search — a hardware approach.

We also have some ideas for the application of our products which might not have occurred to you. If you can't get the performance that you would like from your PDP11 system, maybe we can help. Please telephone our Marketing Manager at (213) 887-9523 or write to Datafusion Corporation, 5115 Douglas Fir Road, Calabasas, California 91302.



*TRADEMARK OF DIGITAL EQUIPMENT CORPORATION

Circle 45 on Reader Inquiry Card

New Products

EXTENDER CARDS

Aids PDP-11 Testing

Available with either a Zero Insertion Force (ZIF) connector or a standard PC edge connector, the ZIF TENDER makes it easy to remove test boards without undue wear and tear on the connector contacts. Each connector pin is identified for easy location of pins. A removable card guide rigidly holds the board under test for easier probing of the circuits. **Pacific Digital Systems**, 878 Hollenbeck Ave, Sunnyvale, CA 94087.

Circle 136

ADA COMPILER

First Commercial Release Of A Portable Ada Compiler

The compiler performs full Ada syntax checking and produces code for all but the most complex features of the new language. It supports packages, tasks, exceptions, identifier over-loading and separate compilation (with limitations). Further releases will be made as Ada's full specification is revised by the DOD as part of ANSI standardization of Ada. The Ada and Pascal compilers produce an intermediate code which can be translated or interpreted to execute on new processors with a minimum amount of adaption. **TeleSoft**, 10639 Roselle St, San Diego, CA 92121.

Circle 137

HEAD ALIGNMENT TESTER

Provides LCD Readout Of Moving Head Alignment

The HAT-500 is a hand-held instrument for measuring the alignment of moving heads in Storage Module type disk drives. It provides an absolute voltage measurement indicating

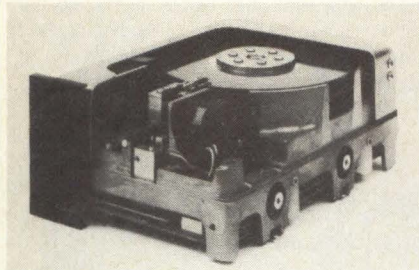


the plus and minus variation of a selected head to a nominal track center, shown in mV's by a 4 digit LCD readout. Comes with a set of coaxial cables and connectors for both the CDC/SMD and the CDC/CMD. \$550. **Wilson Laboratories Inc**, 2237 N. Batavia St, Orange, CA 92665. Circle 140

5-1/4" DISK DRIVE

6.4 And 12.8 MB Unformatted Storage

Employing Winchester technology, the MiniScribe I is available in one disk and two disk models providing 6.4 and 12.8 MB unformatted storage. It is Seagate ST506 interface compatible. An advanced design



provides high areal recording densities (3.46 Mbits/sq. in.). Reliable performance is achieved through the use of a rack and pinion motion translator. Positioning repeatability characteristics over the operating temperature range are enhanced by an efficient temperature compensation technique. \$745 (6.4MB) and \$845 (12.8MB) in OEM qty. **MiniScribe Corp**, 410 S. Sunset, Longmont, CO 80501. **Circle 132**

Q-BUS INTERFACE

Manages Complex Protocols

With a 4 MHz Z80 microcomputer, the PCP-11E provides 16kB of RAM; provision for up to 24kB of EPROM; an RS-232 serial channel with async and sync operating modes and full modem control; an auxiliary async serial channel; an 8 bit parallel port, 4 counter/timer circuits; and a 16 bit programmed I/O interface to the host Q-bus processor, with interrupt driven handshaking. By off loading management and data buffering functions for complex protocols, it increases throughput within the host and also reduces host memory demands. PCP-11E is \$950, \$665 in hundreds. **Nortek Inc**, 2432 NW Johnson St, Portland, OR 97210. **Circle 135**

μC DEVELOPMENT SYSTEM

Low Cost 1802 μP System

The CDP18S693, with ROM-based floating point BASIC interpreter and system utility software, includes a CMOS single-board μC, memory/audio cassette controller board, one audio cassette tape drive, a 5-card chassis and case, and a 5V power supply (\$499.) The CDP18S694 additionally includes a ROM-based 1802 assembler/editor PROM programmer board, and a second cassette tape drive. (\$799.) By adding a user supplied RS232 or 20 mA compatible terminal, the system generates 1802 software for use in any microboard system. With the 1802 assembler/editor, writing applications software in assembly level or mixing both BASIC and assembly level software is possible. Can be expanded in both memory (up to 65kB) and I/O capability. **RCA, Solid State Div**, Box 3200, Somerville, NJ 08876. **Circle 153**

CRT TERMINAL

Emulates DG D200 At Lower Cost

The Emulog 200 is fully compatible with the DG D200 with additional features. It includes a sculptured key cap set for ease of entry, a green phosphor display for reduced eyestrain, a tilting screen and separate numeric key pad. Another standard feature is a printer port that operates under program control or from the keyboard. It has two modes, page print of data displayed on the screen, and pass-through operation which allows data from the CPU to bypass the screen and be transmitted directly to the printer. \$1250. **Emulog**, 3730 Yale Way, Fremont, CA 94538. **Circle 129**

LOGIC ANALYZER

Includes Desktop Computer And IEEE-488 Controller

The NPC-764, a 64-channel logic analyzer, includes a 9" CRT with an 80 character × 25 line display, an integral 5" double-density floppy disk, a CP/M operating system, and a full ASCII keyboard with 6 software-directed soft keys. It represents a trend in the test and measurement industry where internal computing power will be available to the user for automatic testing, post-processing,

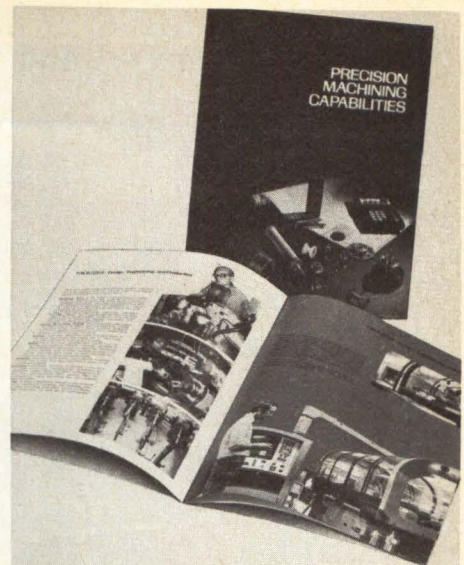


expansion of test functions, and execution of engineering and other standard or custom software packages. Thus, the NPC-764 can be used continuously in the design, simulation, development, production and field service phases of a digital product. \$15,000 to \$18,000. **Nicolet Paratronics Corp**, 2140 Bering Dr, San Jose, CA 95131. **Circle 149**

512 KB MEMORY CARD

Increased System Throughput For PDP-11/44

Utilizing 64k RAMs with max capacity of 512kB per board, the NS44F is configured as 256k × 26 bits. Five ECC bits are added to each byte allowing ECC to be performed on a byte basis. This eliminates the need for read/modify/writes which increases system throughput. The ECC configuration also corrects 2 single bit errors per word rather than one single bit error per 2 words for greater data integrity. Additional features include battery backup compatibility, an on-board control status register and timing improvements over the MS11. \$3995, qty discounts avail. **National Semiconductor Corp**, 2900 Semiconductor Dr, Santa Clara, CA 95051. **Circle 134**



SMALL, PRECISION MACHINED COMPONENTS

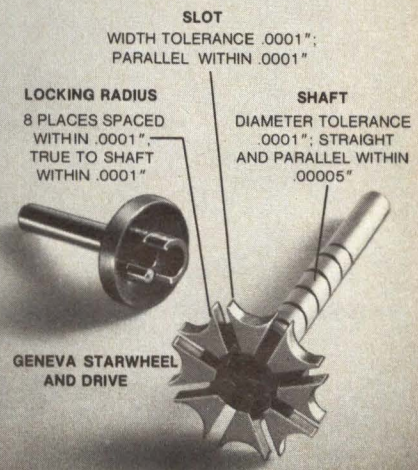
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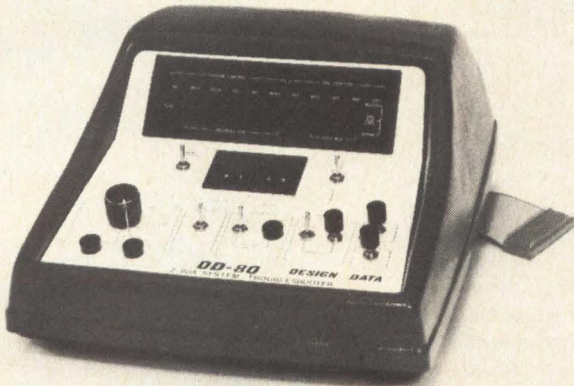


Circle 37 on Reader Inquiry Card

Z80-A SYSTEM TESTER

Controls Operations For Program Development, Debugging And In-Circuit Emulation

The DD-80 Troubleshooter features user-selectable breakpoint conditions including memory or I/O port address, memory read, memory write, I/O read, I/O write, M1 and 2 external user inputs (pos.

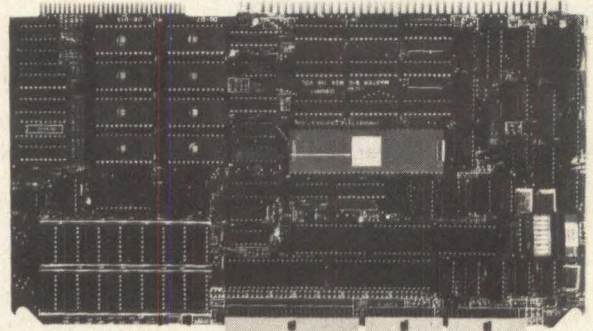


and neg. edge-triggered). Breakpoint conditions can either impose μ P wait states or output an oscilloscope trigger pulse as selected by the user. Full display of the μ P status includes readout of the address bus, data bus, system control bus, CPU control bus, CPU control bus signals, and clock. \$1250. **Design Data Corp**, 3056 37th W., Seattle, WA 98199. **Circle 159**

MC68000 CPU BASED SBC

Multibus/IEEE P796 Bus Compatible

The OB68K1 is a powerful 16-bit CPU computer capable of functioning as a stand-alone system, or as the central processor card in a large microcomputer system. Can be ordered with either 32kB or 128kB of RAM, 8 sockets for up to 64kB of EPROM (any combination of 2716, 2532, or 2564s in pairs), 7 prioritized-vectored interrupts (including one non-maskable interrupt), and a 16MHz crystal controlled clock (8MHz processor clock). Other features include 2 RS232C serial ports, 2 programmable 16-bit parallel ports, a crystal controlled baud rate generator with 16 standard rates (50 to 19.2K



baud), a triple 16-bit programmable timer/counter, and user programmable memory mapping PROMs. From \$1495 (32K RAM) to \$1995 (128K RAM), OEM discounts avail. **Omnibyte Corp**, 245 W. Roosevelt Rd, West Chicago, IL 60185. **Circle 150**

Eaton Printer Mechanisms

The Eaton M-4 family of alphanumeric dot matrix impact printer mechanisms feature a simple, proven design with a minimum of moving parts, and a unique long life printhead for dependable, reliable operation. All units feature built-in drive electronics for easy interfacing.

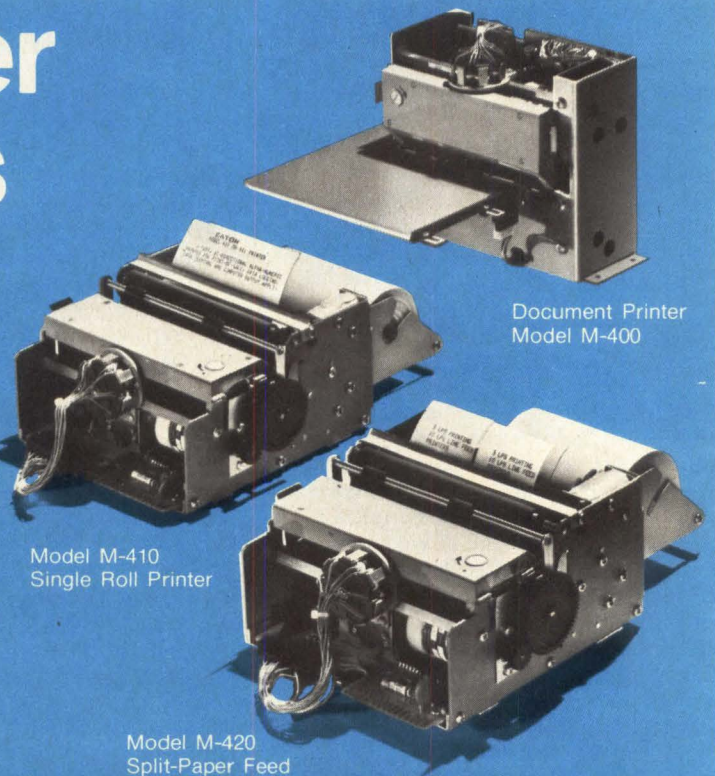
Three basic mechanisms.

The M-4 Series consists of three basic mechanisms: the M-400 document printer, M-410 single roll printer, and the M-420 split-paper feed printer. The entire line of mechanisms boasts a print speed of 3 lines per second (bi-directionally) and a line feed of 10 lines per second and features the Eaton printhead capable of 100 million character operation with roll paper mechanisms.

Wide range of applications.

Eaton printer mechanisms are ideal for business systems, point-of-purchase terminals, electronic cash registers, banking terminals, instrumentation, data acquisition, test systems and more.

For additional technical information, call or write:
Eaton Corporation, Printer Products Operation,
Riverton, Wyoming 82501.
Phone: 307/856-4821.



Document Printer
Model M-400

Model M-410
Single Roll Printer

Model M-420
Split-Paper Feed

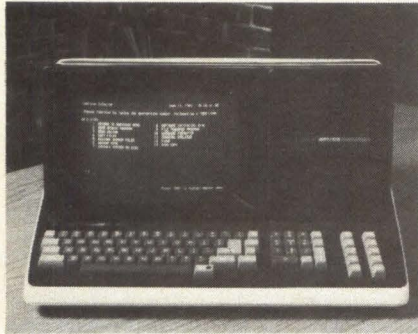
EATON Printer Products

Circle 43 on Reader Inquiry Card

TECHNICAL DESKTOP COMPUTER

For OEM System Developers And Professional End-Users

With the MP/OS operating system, the MPT/100 can be used for program development in Fortran IV, Basic, Pascal and assembly languages. It has 64kB of local memory and 716kB of minidiskette storage, a 12"



green phosphor video screen, 83-key board, two 5¼" floppy diskette drives and two RS232-C programmable sync/async ports. Software utilities include linkers, editor, debugger, and file transfer programs. In addition, the MPT/100 microNOVA I/O bus will interface with microNOVA peripherals such as the 1.26MB flexible disks and the 25MB Winchester fixed disk subsystems. With the microNOVA expansion chassis, it can be connected to a complete line of data communications and sensor I/O devices. \$5350. **Data General Corp**, Route 9, Westboro, MA 01581. **Circle 144**

MICRO FLOPPY

Compact System With Large Capacity

Measuring 4-1/4 × 6 × 1-7/8 inches and weighing only 25 ounces, this micro floppy disk drive uses a cassette with a recording capacity of 512 bytes/track on 16 tracks, for a total of 8.192kB on a single side. It features random access and ease of handling. Encoding method is FM, recording density is 698 bpi and track density is 25.4 tpi. Media rotation speed is 100 RPM, data transfer rate 8.33Kbits/sec. **Canon U.S.A. Inc**, Electronic Components Div, One Canon Plaza, Lake Success, NY 11042. **Circle 165**

BOOK REVIEW

Computer Contract Negotiations

This book, by Joseph Auer and Charles E. Harris, provides interdisciplinary tools necessary for experienced or inexperienced computer users to plan, negotiate and document a complex data processing transaction. Design engineers will find it useful in selecting compatible computer peripherals for applications to the systems they design. Portions of the book include the negotiating process, general contract provisions, third party leasing, equipment acquisitions, maintenance agreements, software agreements and miscellaneous transactions. An especially interesting chapter is on

popular vendor ploys. This book is recommended to individuals marketing computers; it could prevent a lot of misunderstanding and promote confidence and credibility. 400 pp, \$34.50. **Van Nostrand Reinhold**, 135 West 50th St, New York, NY 10020.

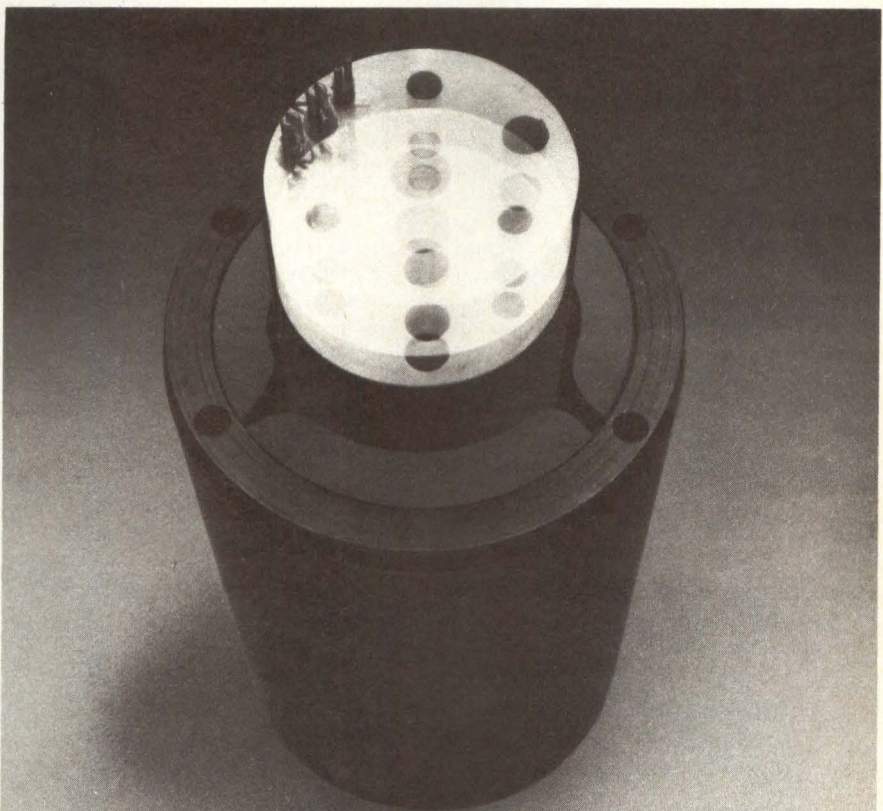
Inquire Direct

BOOK REVIEW

Selecting Electronic Components

"The User's Guide to Selecting Electronic Components," by Gerald L. Ginsberg, discusses 6 functional components: resistance, capacitance, electromagnetic components, power sources, special function components

(function modules, delay lines, crystal oscillators, filters), and solid state devices (diodes and rectifiers, transistors, thyristors, optical electronic devices and special function solid state devices). It is a practical guide to help design engineers simplify the selection of components for a variety of electronic circuits. It contains evaluations and selection criteria and can save hours of searching through technical literature and vendor catalogs for basic applications data essential to the design of cost effective, reliable circuits. 249 pp, \$27.50. **John Wiley and Sons**, 1 Wiley Dr, Somerset, NJ 08873. **Inquire Direct**



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Circle 38 on Reader Inquiry Card

OPERATING SYSTEM

With Record And File Locking

Minimum requirements for MP/M II are: an 8080, 8085 or Z-80 processor, 48K RAM, a clock timer interrupt, one disk subsystem and a console. It can support up to 16 consoles, 16 printers and 16 disk drives with up to 512MB of storage each, for total on-line storage of 8GB. MP/M II can manage up to 400kB of RAM. Since the nucleus of the operating system requires only 16kB, the remainder can be switched in 48K banks among 8 users. Utilities include RMAC, a relocatable macroassembler; LINK-80, a linker with overlay facilities; and LIB, a program library management utility. Its files are fully compatible with CP/M files, and it supports CP/NET. The record and file locking features prevent inaccuracies which can result when users are updating the same files at the same time. \$450, OEM discounts avail. **Digital Research**, Box 579, Pacific Grove, CA 93950. **Circle 146**

COMMUNICATIONS INTERFACE

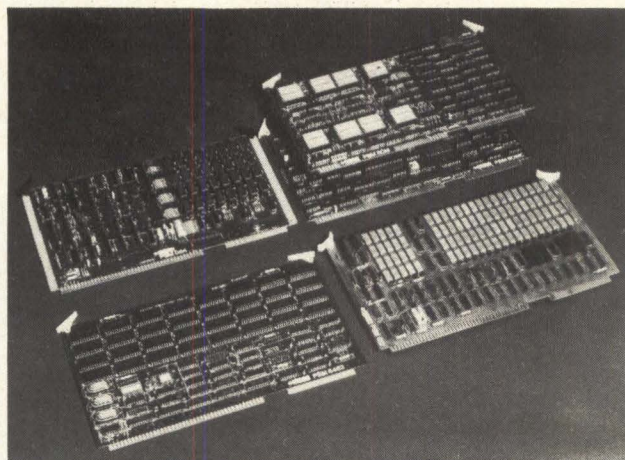
Single Channel Fiber Optic Converter

The converter provides an effective solution for connecting remote RS-232 devices to P-E computer systems. It supports full duplex async data communication transmission speeds of up to 19.2K baud over a fiber optic cable at distances up to one km. Provides a communications solution where environmental problems such as corrosive and explosive atmospheres or electrical interference exist or applications which require long distances between host and remote RS-232 devices. Includes 2 converters and 98.5' of optical cable for \$2130. **Perkin-Elmer Corp**, Data Systems Group, 2 Crescent Place, Oceanport, NJ 07757. **Circle 151**

MULTIBUS MEMORY BOARDS

Capacity From 16KB To 2 MB

The PSM512 gives 1/2MB with error detection and correction circuitry on one board. Operation can be in 16 bit or 8 bit mode. \$4750. Versions with and without ECC, depopulated to 384K, 256K, and 128K bytes are also available. The PSM 064 gives 64kB of dynamic RAM. This is 8 and 16 bit compatible and is available depopulated down to 16K. \$550 in large qty. For non-volatility, the



PSM 6463 has 64kB of CMOS RAM with on-board battery backup. Depopulated versions of 16K and 32K can be supplied. \$2995. If large amounts of non-volatile memory are required, the PBM 80M system provides bubble memory in 256 kB increments up to 2MB. The system consists of a controller board handling 1 to 8 storage boards. Software handler is supplied. \$7000 for 1/4MB and controller. OEM qty discounts avail on all. **Plessey Microsystems**, 19546 Clubhouse Rd, Gaithersburg, MD 20879. **Circle 152**

**EXATRON'S
RS-232C STRINGY/FLOPPY
MASS STORAGE SYSTEM.**



Mini-disk speed, capacity and reliability for only \$399.50.

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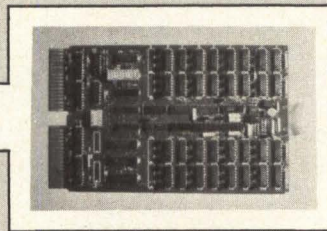
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Circle 27 on Reader Inquiry Card

**256 KB MOS MEMORY
for LSI-11/23™**



4MB Addressing Standard/Parity Option

for **\$1200.00**

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PDS

2670 Walnut Avenue / Suite C
Tustin, CA 92680

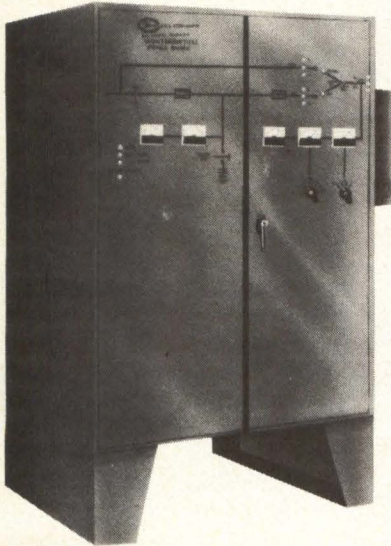
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Circle 26 on Reader Inquiry Card

UPS

Three Phase 30kVA

The 30kVA provides clean power that eliminates power outages and power disturbances, saving down time. It has low harmonic sine wave distortion (2.5%) and



controls output frequency (60 HZ \pm .5 HZ) and voltage to the critical load (\pm 2%). The dc bus is floated at 137V dc and uses a battery voltage of 120V dc. The unit includes a Static Bypass Switch (4 ms fault transfer time). UL Listed File No. E68909. **Clary Corp**, 320 W. Clary Ave, San Gabriel, CA 91776. **Circle 142**

MATRIX SERIAL PRINTER

Bar Code, OCR Capability

The M-132 includes full ASCII OCR-A or -B resident character set. It can be interface selected to print any one of 7 popular bar code types; symbol height is also programmable. For forms handling efficiency, paper can be bottom loaded or rear loaded. Optional second set of tractors allow 2 separate documents to be handled simultaneously. It is ruggedly constructed to withstand heavy industrial use, and designed for continuous print runs. Specs include 132 column, 140 cps bidirectional printing, RS-232 interface and 600 character buffer. From \$2795, OEM discounts avail. **Manesmann Tally**, 8301 S. 180th, Kent, WA 98031. **Circle 167**

15V POWER BLOCK

Designed For Rugged Applications

This completely encapsulated power source measures only 2.5" \times 3.5" \times 1.56" high yet can put out 15V at 0.6A for 9W of power. Two can be stacked to provide 30V for aircraft power simulation or \pm 15V for opamp power. Specifications for the Model 1.15.600 include: Line & Load regulation, \pm 0.05%; noise & ripple, 2mVrms; temperature coefficient, \pm 0.01%/°C; and isolation, 50 megohms. Designed with fold back



current limiting and has a max design case temperature operating of 71°C. \$88, 5 year warranty. **Calex**, 3355 Vincent Rd, Pleasant Hill, CA 94523. **Circle 158**

MAGNETIC TAPE HEADS

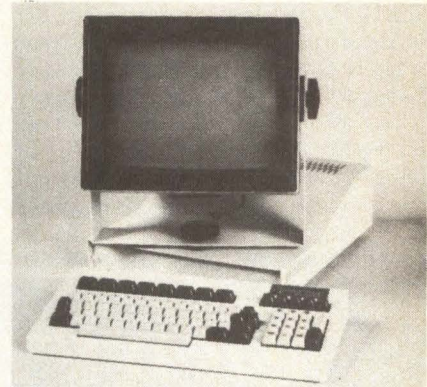
For Use With Verbatim Mini Data Cassettes

The Series A head measures .200 \times .480 \times .50 inches and incorporates two .057" channels in a fully drawn case for max shielding; balanced core/coil structure to assure write symmetry; center tapped windings standard. Available with terminal pins or flexible leads. Variations in gap, inductance, and lamination thickness will be tailored to customer requirements for either analog or digital applications up to 6400 FCI. Works on any cassette or cartridge using a .150" tape. Under \$9. **Data Recording Heads Inc**, 690 Mendelssohn Ave, Minneapolis, MN 55427. **Circle 161**

CRT TERMINAL

Ergonomic Features

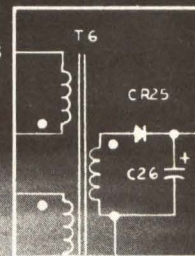
The AVANT 300 features user or host programmable function keys, smooth scroll, and line and block graphics capability. The package includes all metal construction consisting of 3 modules. The user may raise



or lower the monitor and tilt or rotate for ease of viewing. Maintenance access is convenient because of the modular design. The unit has a standard detached keyboard with features such as keyclick and editing. AVANT 300 allows the intermixing of normal, double high, double wide or double high/wide characters on the same line. Also standard is 10K down-line loadable RAM user memory. \$1249. **General Terminal Corp**, 14831 Franklin Ave, Tustin, CA 92680. **Circle 166**

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New Products

PRINTER/CONTROLLER

*Mates P-E Minis With Printers
To 1500 LPM*

The NPC-20 controller and printer are easily installed at the computer location, no software or hardware modifications required. Contained on a 7" x 15" board, the controller accepts 7-bit ASCII data, buffers and transfers it to the printer via high-speed Schottky logic. Hexadecimal switches on

the card permit address selection. It interfaces directly with BDS' band printers with speeds of 300, 600, 900, 1200 and 1500 lpm. Standard bands have 64- or 96-character sets with special or foreign-language bands optionally available. \$6250 to \$28,850 depending upon speed. **BDS Corp.**, 1120 Crane St, Menlo Park, CA 94025. **Circle 163**

NETWORK MANAGEMENT SYSTEM

*Enables Prediction Of Line Failures
Before They Happen*

The ALPHA STAR is a floppy-disk based

μ C that permits users to monitor and control a statistically multiplexed data communications network consisting of up to 768 channels transmitting over as many as 32 independent data links — all from a single central site. A report generated from the data base is automatically printed out every 24 hours, or at any time by operator command. The report indicates what links, if any, are degrading and at what rate; and, shows the level of system activity for each data link so the datacomm manager knows who's using the system, and when. The ALPHA STAR ASM-1 is a complete, integrated network management system including controller, video terminal, printer and desk console.

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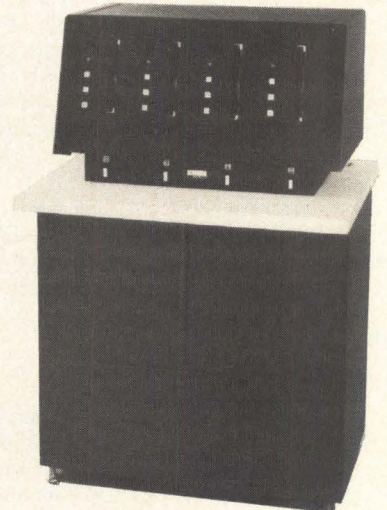


\$14,500. The ASM-2 component configuration consists of a rack mountable control unit and a terminal. \$13,750. **Timeplex Inc.**, One Communications Plaza, Rochelle Park, NJ 07662. **Circle 156**

DISK CERTIFIER SYSTEM

For 5-1/4" And 8" Flexible Disks

The 3PX 115/118 is a multi-spindle certifier. Initially, only one spindle need be installed and others added as requirements dictate. The spindles can be either 5-1/4", 8" or combinations of both. Each spindle is totally independent and is μ P/RAM/ROM controlled. Independency improves throughput since it eliminates time costs and down time difficulties associated with "ganged"



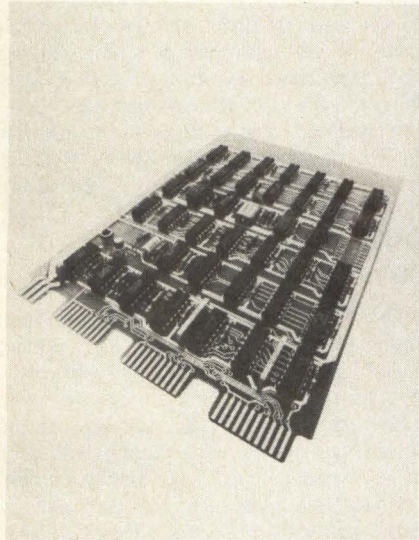
spindle certifiers. A Sort Assist feature eliminates the need to perform complex computations or memorize error codes. **Three Phoenix Co.**, 21639 N. 14th Ave., Phoenix, AZ 85027. **Circle 138**

Circle 42 on Reader Inquiry Card

DATA SEPARATORS

Simplify 5-1/4" Winchester Disk Integration

Data Express/2 supports RMS advanced code that provides run-length limited code to allow recording of up to 50% more information per track. It requires less total circuitry, because the advanced code is handled by 2 custom VLSI encoder/decoder IC's. Higher data rate of 7.5 MHz speeds data transfer. NRZ input, NRZ output provides stable de-

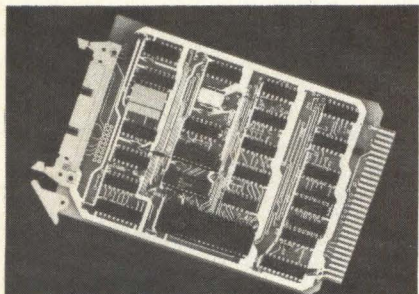


coded information. Data Express/1 provides system integrators with standard MFM coding and 5 MHz data rates. It handles NRZ input and output, and supplies address mark generation and detection. Both support 2 drives. Data Express/1 is \$197; Data Express/2 is \$250. **Rotating Memory Systems Inc.**, 1031-A E. Duane Ave, Sunnyvale, CA 94086. **Circle 154**

DISK CONTROLLER

Provides STD Bus With Variety Of Floppy Disk Configurations

The ANC-7393 can control up to four 5-1/4" or 8" single or double sided disk drives in single or double density mode. A digital



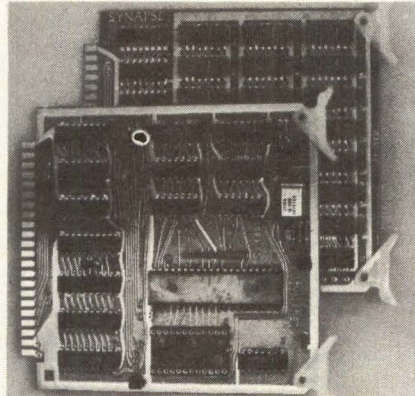
phase locked loop performs read data separation, while write precompensation circuitry supports double-density operation. User's Manual contains complete software listings for Z80/8085 operation of reading, writing and formatting disks. CP/M 2.2 is available to provide development of Basic, Fortran, Pascal or Assembly Language programs. All signal and I/O lines are fully buffered and user may select the I/O port

address to suit system requirements. \$389; \$4714 with CP/M 2.2. **Antona Corp.**, 13600 Ventura Blvd, Suite A, Sherman Oaks, CA 91423. **Circle 157**

CPU-RAM CARD PAIR

Only 4.5" Square

These cards give a N-44 bus system a 3-MHz Z-80 processor and 48K of 5V only RAM. The CPZ-80 card has power-on reset, and jumps to an onboard 2K EPROM

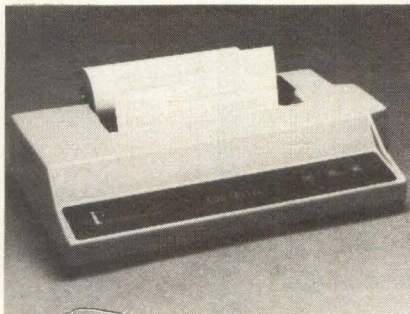


socket addressed at F800 on reset. Four interrupts are decoded on the card and brought to the bus. They are fully compatible with other I/O and memory cards of the N-44 bus, and can be used in combination with these other cards and card racks to make Z-80 based computer systems in volumes as small as 5.5" on a side. \$150 (CPZ-80), \$450 (RAM-48). **Synapse Corp.**, Box 1016, N. Falmouth, MA 02556. **Circle 155**

DATA IMPACT PRINTER

Continuous Duty Cycle

With standard 10 line and optional 2K buffer, the DIP-81A is suited for such applications as CRT dump for hard copy. It can accept data while printing; thus, it can be readily interfaced with dumb CRT terminals, modems or teletype replacement equipment. It features 7 x 7 or expanded 14 x 7 matrix printing, U/L case character set,



100 cps bi-directional print-out, finger clean ribbon cartridge loading, and a low profile. It uses ordinary bond paper in sheets, roll or fanfold form. With full 96 character ASCII, it prints at both 40 and 80 char/line. Operator control includes Power, Select/Deselect, Line Feed, Top of Form and Self Test. \$499, OEM qty prices avail. **Dip Inc.**, 745 Atlantic Ave, Boston, MA 02111. **Circle 145**

CHRISTMAS SPECIALS!

INTERTEC SUPERBRAIN 64K RAM	\$2799
QD SUPERBRAIN	\$2999
NEC 5510 SPINWRITER (7710)	\$2345
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NEC 5530 SPINWRITER (7730)	\$2345
NEC PC 8023 Printer	\$ 639
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HAZELTINE 1420	\$ 799
NORTHSTAR HORIZON II 32K QD	\$2925
ANADEX DP-9500/9501	\$1199
TELEVIDEO 912C	\$ 669
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LEEDEX/AMDEK 100G	\$ 169
LEEDEX/AMDEK COLOR-1 13" Color Monitor	\$ 339
MICROTEK 16K RAMBOARD for Atari	\$ 79
MICROTEK 32K	\$ 149
ATARI 800 16K	\$ 749
ATARI 400 16K	\$ 349
ATARI 810 Disk Drive	\$ 449
ATARI 820 40 Column Printer	\$ 299
ATARI 822 40 Column Thermal Printer	\$ 349
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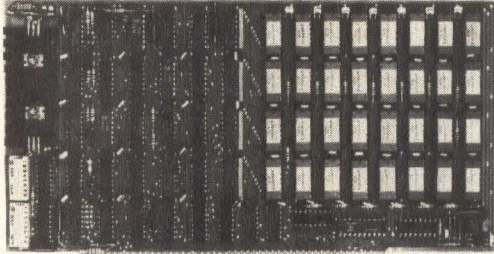
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New Products

64KB MEMORY

For S100 Microcomputers

CI-S100 dynamic RAM memory module requires no wait states at 2 or 4 MHz. It is designed to plug directly into the memory slots of most S100 microcomputers. Features include expandability to



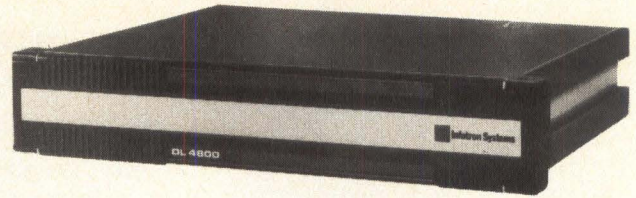
1/2MB with a bank select feature. This allows user to select up to eight 64KB memory cards. On board hidden refresh requires no outside intervention making the CI-S100 look like a static RAM, even during block DMA write applications. Addressable in 4K increments up to 512 bytes of memory. Available with battery backup. \$575. **Chrislin Industries Inc.**, 31352 Via Colinas #102, Westlake Village, CA 91361. **Circle 143**

MULTIDROP MODEM

μP-Controlled 4800 BPS Unit

The DL 4800 is a sync modem for multidrop-polled and point-to-point applications. It operates full-duplex at 4800 bps over 4-wire

and half-duplex over 2-wire type 3002 unconditioned lines. The RTS/CTS turnaround time is 50 ms. It is end-to-end compatible with the Bell 208. The error rate of the automatic equalization is typically



less than one bit in a million. It can rapidly readjust following a line interruption without requiring the transmitter to send a training message. Extensive self-testing capabilities are also featured. Tests include analog and digital loopbacks of remote unattended units. \$3600, \$3200 when integrated into Infotron multiplexers. **Infotron Systems Corp.**, Cherry Hill Industrial Center, Cherry Hill, NJ 08003. **Circle 147**

CARTRIDGE MODULE

Reduces Printhead To Thin Cartridge

Mounted horizontally, the Cartridge Module is as thin as the ribbon cartridge and can be encased within the cartridge, an important space saver. Multiple cartridges accomplish the same effect as dot-overlay printing. With the cartridge method, multi-pass printing can be replaced with mono-pass printing by using a cartridge head of several modules. Additional features are color graphics and very high thruput speeds out of conventional machines. Printing multiple lines, 2 cartridges can provide 400 cps as each cartridge is rated at 200 cps. By adding cartridges, the thruput speed is increased electronically rather than by introducing the very high speed carriage acceleration. **Baudex Corp.**, 49 Richmondville Ave, Westport, CT 06880. **Circle 141**

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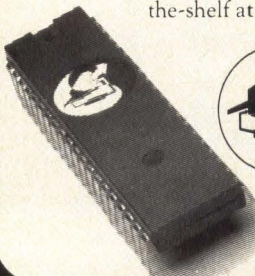
- Faster stepping (8K steps/second at 11 MHz).
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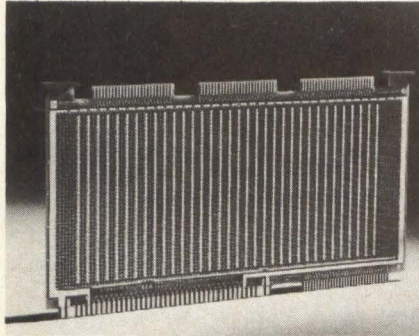
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Circle 46 on Reader Inquiry Card

MULTIBUS PROTOTYPING CARD

Independent Power Bus Strips

These cards have locations for up to 84 16 pin-dip IC's plus discrete components, 34 independently-strappable bus strips, and 3 gold-plated 50-pin I/O connectors. Features include provisions for mounting an on-board

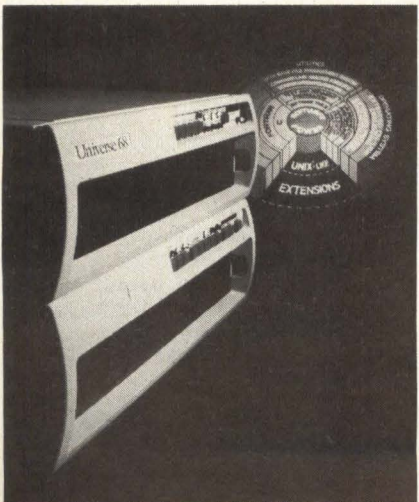


3-terminal regulator. The layout is on a grid of 0.1" holes, with bus strips individually strappable to any desired voltage. A ground bus runs around the perimeter of the board on both sides, and locating symbols are provided. Model PR-80H is \$85 (1-9); \$80 (10-24). **Electronic Solutions**, 5780 Chesapeake Ct, San Diego, CA 92123. **Circle 162**

32 BIT SUPERMICRO

32 Bit Flexibility With Economy Of μ P Technology

The Universe 68 system is built around the Motorola 68000 μ P and runs UNOS, a UNIX-compatible operating system. It is a multi-user, multi-processing system. Its 32 bit architecture provides a 16MB addressing capability. Initial models offer up to 6MB of memory and support for as many as 34 users. The Universe 68/10 system includes 2 serial ports and one parallel port, 256 kB of main memory, 8MB Winchester disk, and floppy disk backup (\$18,500). The larger 68/80 model has greater expansion capacity and an 80MB cartridge disk (\$38,500). Base price for a single UNOS operating system license is \$3000. OEM discounts are avail. The company offers licenses for both Universe 68 hardware manufacturing and UNOS distribution. OEMs can thus integrate their



products vertically to as great a degree as they wish. **Charles River Data Systems Inc.**, 4 Tech Circle, Natick, MA 01760. **Circle 178**

GRAPHICS TERMINAL INTERFACE

Links 8 Async Terminals to VAX-11/780

Developed for CAD applications, the 11C03 provides more rapid graphic image updates. Character output from a VAX-11/780 to a graphics terminal can achieve rates to 125 kilobaud. Any graphics display terminal adhering to RS-232 or RS-422/423

standards can be used with the interface. Up to 8 terminals can be connected as far as 4,000' from the 11C03. Available in 2 models, the 11C03-EA for 115-VAC 60-Hz operation, and the 11C03-EB for 240-VAC 50Hz operation. Benefits include increased productivity and more efficient use of the VAX computer. Buffered data output is handled by a DMA channel for efficient transfer of blocks of data. This lowers the overhead of the VAX/VMS operating system. The 11C03 is a stand-alone, 30" high cabinet subsystem; \$18,500. **Digital Equipment Corp.**, Maynard, MA 01754. **Circle 179**

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Circle 88 on Reader Inquiry Card

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New Products

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DISK/TAPE CONTROLLER

Performance Of Several Boards On One Card

Model 8200, a 15" x 15" card, allows maximum flexibility in already-crowded NOVA, Eclipse or emulating computers. It can support up to 8 formatted tape transports, interfacing to a single disk drive at the same time. The disk controller portion will run a variety of Winchester. DMA transfer rate is up to 1.25MB/sec. An 8 kB FIFO provides a full 16-sector, 512-byte buffer area as immunity to data late conditions with minimum laten-

cy. The magnetic tape portion supports drives at speeds of 12.5, 25, 37.5, 45, 100 and 125 ips. Encoding formats include IBM-compatible 800 bpi NRZI, 1600 bpi PE or formats for streaming tape. \$2030 (qty 25). **Quentin Research Inc.**, 19355 Business Center Dr., Northridge, CA 91324.

Circle 181

MINICOMPUTER FAMILY

Winchester-Based Systems With Streaming Tape Backup

The new family — available in 7 basic configurations — includes a high-speed, 16 bit minicomputer and 64 kB of RAM memory on a single board. All models support a variety of hard disks, from 10MB on a single spindle to as much as 732MB on 4 spindles. Available in 27- or 60" cabinets. The smallest computer, the System 50, includes a CPU with 64K of memory; 4 serial I/O ports; a 20MB Winchester disk drive with a 20MB streaming tape backup drive and controller; a 27" cabinet; and IRIS. \$14,950. Optional printers and CRTs are also offered. The top of the line, the System 400, includes a POINT 4 computer with 64K of memory and battery backup; a 158MB Winchester disk and microstreamer tape backup; a controller; 4 serial I/O ports and the Mighty MUX multiplexor; a 27" cabinet; and IRIS. \$36,000. **Microtech Business Systems**, 3180 Pullman St., Costa Mesa, CA 92626. **Circle 180**

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Data Entry Mechanisms: Mathematical Analysis And Implementation of N-Key Rollover

In data entry mechanisms such as keyboards and switches, there exists a requirement — N-key rollover — which is defined as identifying each individual key or event — even in the case of multiple key-closure or multiple event occurrence — simultaneously. This article outlines a mathematical analysis which shows that to obtain a full N-key rollover, it is necessary to have individual sensing of each key or data point.

We consider the occurrence of an event as being similar to key-closure. For simplicity, consider the following structure of 4 keys A, B, C, D, as shown in **Figure 1**. We would like to identify which keys or combinations of keys are pressed.

The possible key stroke combinations of a 4-key keyboard are given in **Table 1**. The results of Table 1 can be mathematically expressed and conveniently extended to any number of keys or data points.

Number of Combinations	Type of Key Combinations	Mathematical Equivalence and Representation
1	None	$4C_0$ Combination of 0 variables out of 4
4	A B C D	$4C_1$ Combination of 1 variable out of 4
6	AB AC AD BC BD CD	$4C_2$ Combination of 2 variables out of 4
4	ABC ABD ACD BCD	$4C_3$ Combination of 3 variables out of 4
1	ABCD	$4C_4$ Combination of 4 variables out of 4
Total		
$T = 16$		

Table 1: Key Stroke Combinations of 4-Key Keyboard.

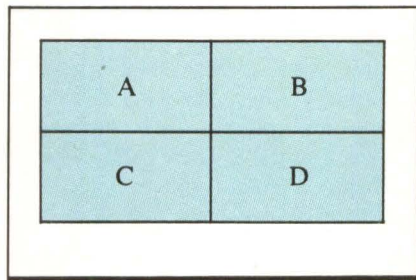


Figure 1: 4-Key Structure.

Let us suppose

- n = Number of keys or data points
- T = Total number of key stroke combinations

n_{Cm} = Combination of 'n' variables taken 'm' at a time,

Then,

$$T = n_{C0} + n_{C1} + n_{C2} + \dots + n_{Cn-1} + n_{Cn}$$

With $n = 4$

$$T = 4C_0 + 4C_1 + 4C_2 + 4C_3 + 4C_4 = 16$$

$$T = 1 + 4 + 6 + 4 + 1 = 16$$

$$(n=4)$$

$$4C_0 = 4C_4 = 1$$

$$4C_1 = 4C_3 = 4$$

$$4C_2 = (4 \times 3) / (1 \times 2) = 6$$

To distinguish the 16 possible combinations we require 4 binary variables ($2^4 = 16$). Thus each key will have to provide a binary sense signal which

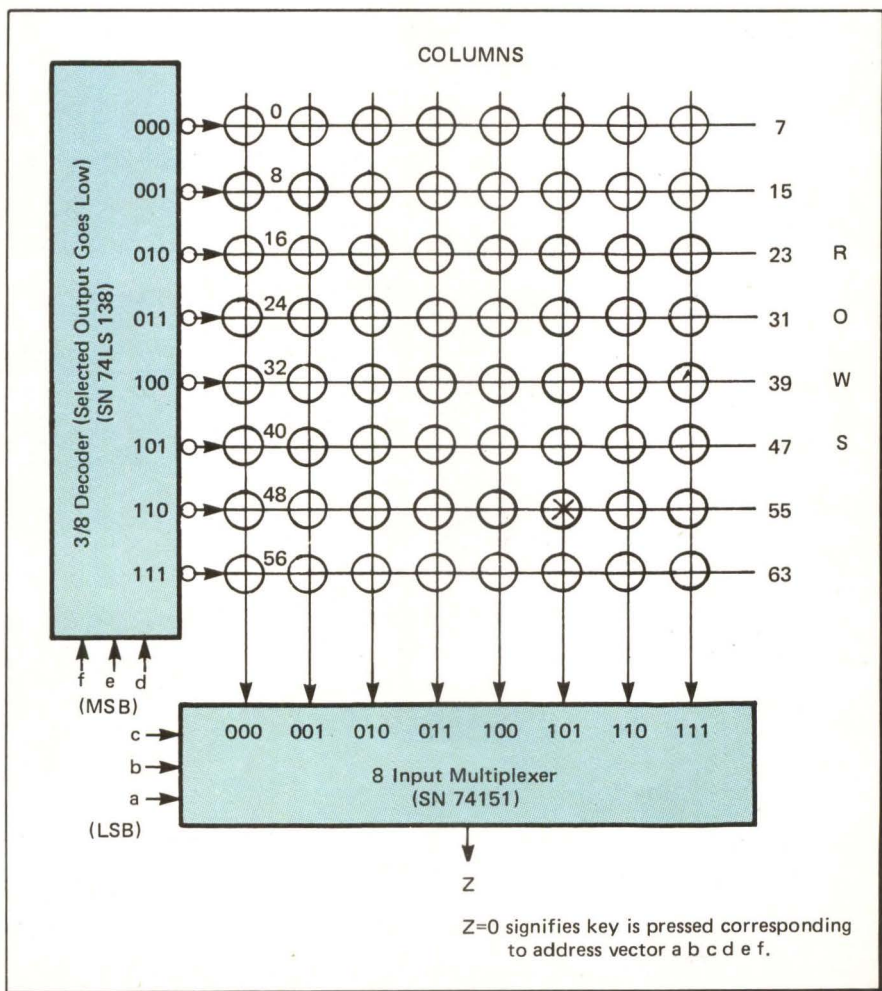


Figure 2: Conceptual 8x8 Keyboard With Simulated 64 Sense Points (Row Scan & Column Sense).

results in individual sensing.

Similarly let us consider $n = 6$:

$$T = 6C_0 + 6C_1 + 6C_2 + 6C_3 + 6C_4 + 6C_5 + 6C_6$$

$$T = 1 + 6 + 15 + 20 + 15 + 6 + 1 = 64$$

($n=6$)

$$6C_0 = 6C_6 = 1$$

$$6C_1 = 6C_5 = 6$$

$$6C_2 = 6C_4 = (6 \times 5) / (1 \times 2) = 15$$

$$6C_3 = 6 \times 5 \times 4 / (1 \times 2 \times 3) = 20$$

In order to distinguish 64 different and possible combinations, we require 6 binary variables ($2^6=64$). Thus 6 keys will provide 6 binary sense signals.

Consequently, to obtain N-key rollover, for a system with n keys or data points, there should be n number of

sense signals.

As for practical implementation for N-key rollover, consider a 64-key keyboard arranged as an 8x8 physical matrix. We need 64 equivalent sense signals to accomplish full identification of the keyboard. 64 individual electronic sensors will be too expensive and cumbersome. However, using the time division multiplexing and scanning methods, 64 sense points can be easily simulated. Each key is allotted a time window to be examined, and its state can be easily ascertained, as shown in **Figure 2** (Row Scan & Column Sense). When a key is pressed, the column will pick up the row information and present it to the multiplexer. If $Z=0$, when $f e d c b a = 1 1 0 1 0 1$, it corresponds to Key 53. All the rest of the 63 keys are eliminated.

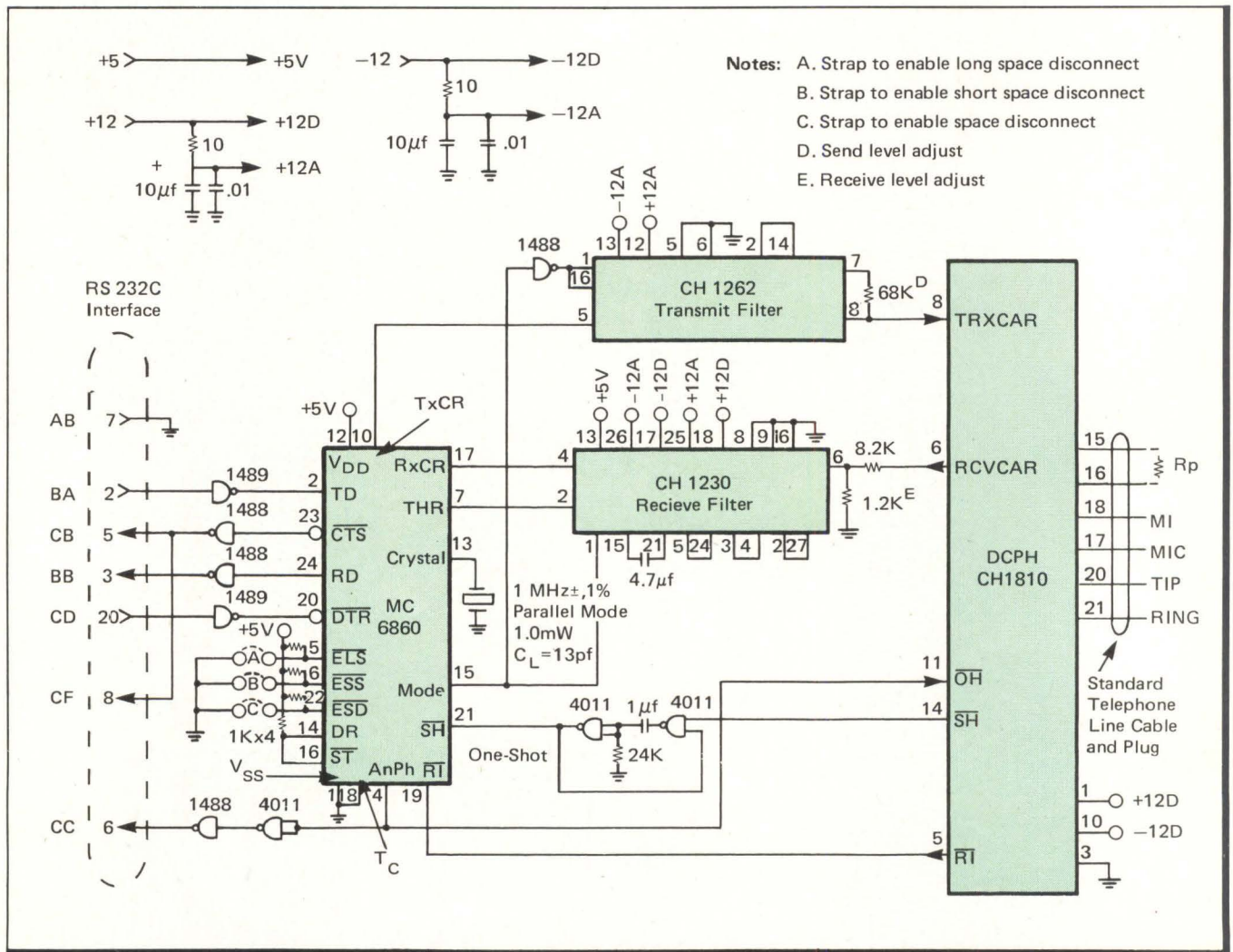
The 6 logic variables, a b c d e f, driving the 3/8 decoder and 8 input multiplexer, effectively formulate the address vector for the key being pressed, which is unique for each key. Thus on practical grounds, with 6 logic variables and time division multiplexing, it is completely possible to simulate individual sensing of each of the 64 keys and obtain full N-key rollover. This concept can be extended to any number of keys or data points.

In the present μP -based systems, the decoder and multiplexer functions can be conveniently accomplished by the input/output ports of the micro, thus further simplifying the hardware.

by W. V. Subbaroa

Assoc. Prof of EE Florida International University

Schematic For A 300-Baud Answer/Originate Modem



Digital Design's September Designers' Notebook was inadvertently run schematic-less. For those frustrated readers who called and wrote us concerning the omission, here's the complete and somewhat updated schematic for designing a 300-baud answer/originate modem using off-the-shelf components. The design is identical to that described in the original article, except that Stephen Durham, author of the article, from Cermetek (1308 Borregas Ave, Sunnyvale, CA 94086) replaced the CH1267 channel receive filter and limiter with the newly introduced CH1230, which takes up some of the extra logic and provides a cleaner circuit board.